ConocoPhillips

STUDY PLANS FOR THE ENVIRONMENTAL STUDIES PROGRAM IN THE CHUKCHI SEA, 2008

FINAL

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ACRONYM LIST

AC	Amphipods Chemistry
ACC	Alaska Coastal Current
ACW	Alaska Coastal Water
ADF&G	Alaska Department of Fish and Game
BASIS	Bering-Aleutian Salmon International Survey
BC	Bivalve Chemistry
BOWFEST	Bowhead Whale Feeding Ecology Study
BRD	Biological Resource Division
BRP	Bioacoustics Research Program
BSW	Bering Shelf
cm	centimeters
CMarZ	Census of Marine Zooplankton
C/N ratio	carbon to nitrogen ratios
COC	chain of custody
CPAI	ConocoPhillips Alaska, Inc.
CTD	conductivity-temperature-depth
DOT	Department of Transportation
EB	Equipment Blank
EIS	Environmental Impact Statement
GPS	global positioning system
ISHTAR	Inner Shelf Transfer and Recycling
MARUs	marine autonomous recording units
MMO	Marine-Mammal observations
MMS	Minerals Management Service’s
MSDS	Material Safety Data Sheets
NEPA	National Environmental Policy Act

ACRONYM LIST *(Continued)*

nm	nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPRB	North Pacific Research Board
NSF	National Science Foundation
OCSEAP	Outer Continental Shelf Environmental Assessment Program
ONR	Office of Naval Research
QA/QC	Quality-assurance/Quality-control
RL	received levels
RUSALCA	Russian-American Long-term Census of the Arctic
SBI	Shelf-Basin Interaction
SC	Sediment Chemistry
SCC	Siberian Coastal Current
SOI	Shell Offshore, Inc.
SOP	Standard Operating Procedure
SSTSF	surface temperature, salinity, and fluorescence
TOC	total organic carbon
UAF	University of Alaska, Fairbanks
USCG	United States Coast Guard
US EEZ	United States Exclusive Economic Zone
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
ZO	Zooplankton

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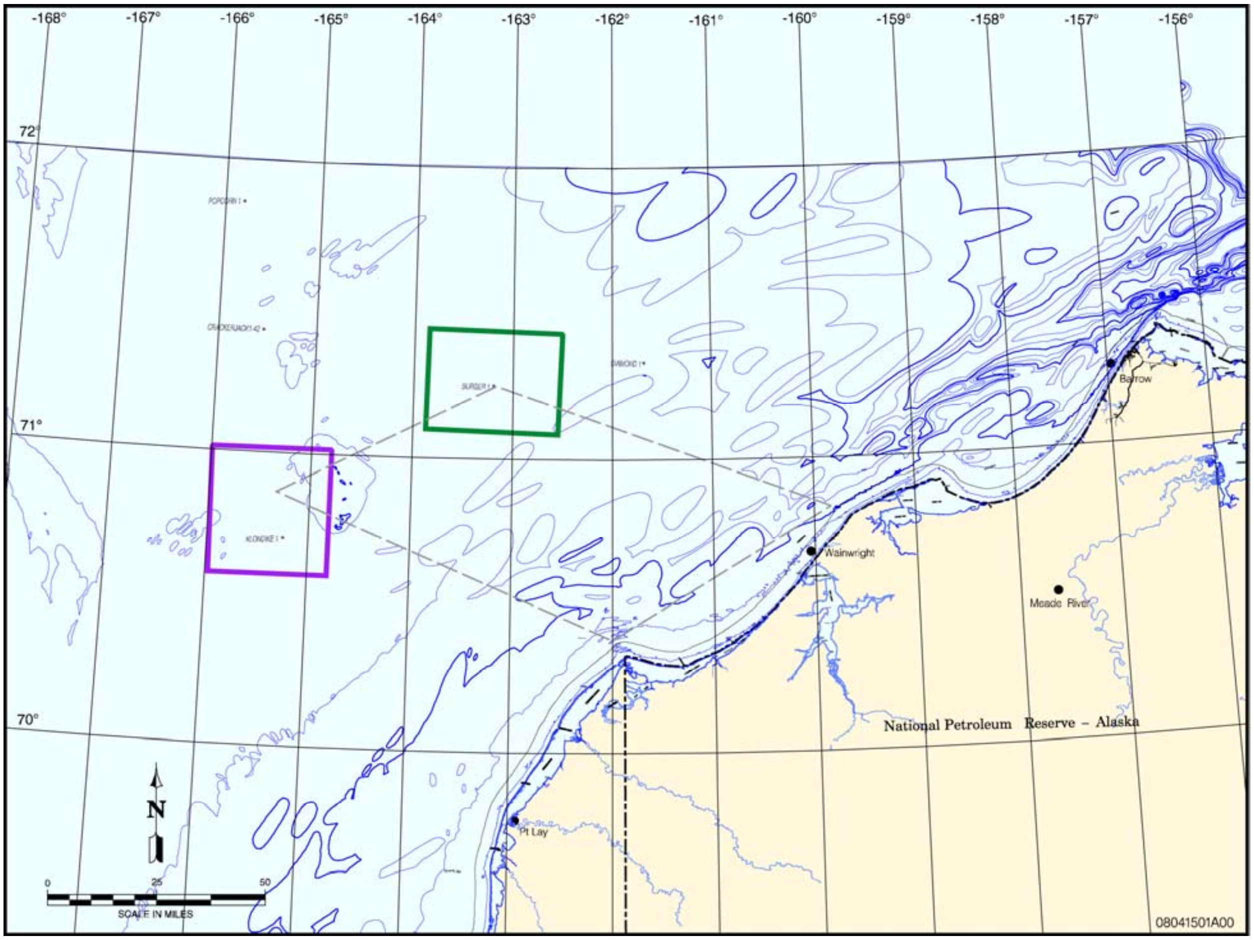
INTRODUCTION

In February 2008, ConocoPhillips Alaska, Inc. (CPAI) obtained 98 lease blocks in federal waters of the Chukchi Sea as part of the Minerals Management Service's (MMS) Lease Sale 193. Lease blocks are concentrated within two main prospect areas: the Klondike prospect and the Burger prospect (see Introduction Figure 1). Prior to exploratory drilling and development of these lease blocks, CPAI will conduct a variety of surveys and engineering studies such as 3-dimensional seismic surveys, shallow hazard, or site-clearance surveys, and pipeline routing studies. This document contains information on the multidisciplinary studies program proposed by CPAI in an effort to gather baseline, or pre-exploration and development data. These environmental studies will be conducted during the summer/fall of 2008. We anticipate that additional disciplines will be added to the program in 2009 and beyond. Because of the short time period between acquisition of lease blocks in February 2008, and the planning of the 2008 program, some studies such as epifaunal and fisheries components could not be pulled together in time for 2008.

The environmental studies program for 2008 covers numerous facets of the marine ecosystem in the Lease Sale area, including physical oceanography, phytoplankton abundance, zooplankton ecology, benthic infaunal communities, a variety of baseline contaminant studies (including sediments, infaunal biota, and zooplankton), seabird communities, marine mammals, and the hydroacoustic environment for marine mammals. The data collected will be used in future permit applications to explore and develop, as part of a required National Environmental Policy Act (NEPA) document. The data will also serve as knowledge of baseline of environmental conditions that can be used for comparison with post-development conditions. CPAI will be responsible for managing the 2008 Study Program, with costs shared equitably with Shell Offshore, Inc. (SOI). It is anticipated that future studies in the lease areas will also involve additional partners and collaborators such as MMS, the North Pacific Research Board (NPRB), the National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS). Discussions with these entities are ongoing.

The Studies Plan is outlined as follows:

- Section 1: Physical Oceanography
- Section 2: Planktonic Communities
- Section 3: Benthic Communities
- Section 4: Contaminants
- Section 5: Seabirds
- Section 6: Marine Mammals
- Section 7: Hydroacoustic Monitoring



Introduction Figure 1. Map of 2008 study areas with the Klondike prospect outlined in purple and the Burger prospect outlined in green.

SECTION I

PHYSICAL OCEANOGRAPHY OF THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

Excerpt from Proposal by

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1. INTRODUCTION

The Chukchi Sea is properly a part of the western Arctic Ocean, but it is intimately linked, atmospherically and oceanographically, to the Pacific Ocean. The atmospheric connection is primarily via the Aleutian Low, whose varying position and strength and interactions with polar air masses affects the regional meteorology. The oceanographic connection is solely through Bering Strait, where the mean northward flow transports waters and organisms from the Bering Sea shelf and basin. This Pacific connection profoundly 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

The shallow (~50 m) Chukchi Sea shelf extends ~800 km northward from Bering Strait to the shelf-break at about the 200-m isobath. The mean flow over much of the shelf is northward due to the Pacific–Arctic oceanic pressure gradient and opposes the prevailing northeasterly winds. The Bering Strait influx of heat, nutrients, carbon, and organisms bestows 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 Coachman et al. (1975) and Walsh et al. (1989) and, more recently (since 1985), in the papers by Aagaard et al. (1985), Aagaard and Roach (1989), Weingartner et al. (1998), Weingartner et al. (1999), Münchow and Carmack (1997), Münchow et al. (1999), Münchow et al.(2000), Weingartner et al. (2005), and Woodgate et al. (2005). The physical oceanographic summary of the Chukchi shelf is drawn primarily from these papers.

1.1 Mean Circulation

The Bering Strait through-flow crosses the Chukchi Sea along three principal pathways associated with distinct bathymetric features (Figure I-1). A western branch flows northwestward from the strait and exits the shelf through Herald Valley. While most of this outflow probably descends through Herald Valley, some of it spreads eastward across the central shelf. A second branch flows northward across the central channel shelf and then probably splits; with some water continuing eastward toward the Alaska coast while the remainder flows northeastward toward the continental slope. The third branch flows northeastwards along the Alaska coast towards Barrow Canyon, which lies at the junction of the Chukchi and Beaufort shelves. In summer, this flow includes the northward extension of the Alaska Coastal Current (ACC) that originates south of Bering Strait. Within the canyon, the ACC is joined by waters flowing eastward from the central shelf; the merged flow then moves down-canyon toward the shelf-break. Mean current speeds within the Herald and Barrow canyons are swift (~25 cm s-1), are more moderate in the central channel (~10 cm s-1), but generally are ≤5 cm s-1 elsewhere on the shelf. Long-term transport estimates for these three pathways are only approximate but suggest that the flow across the central Chukchi shelf is ~200,000 m3 s-1 while the branches in both Herald Valley and Barrow Canyon carry ~300,000 m3 s-1. In summer and fall, the influence of the warm Bering Sea inflow along these pathways is manifested in the form of “melt-back embayments” indenting the ice edge (Paquette and Bourke 1981). Finally, there is also a small fraction of the strait through-flow that flows westward through Long Strait into the East Siberian Sea and appears to be an important nutrient source to this shelf (Codispoti and Richards 1968; Codispoti et al. 1991).

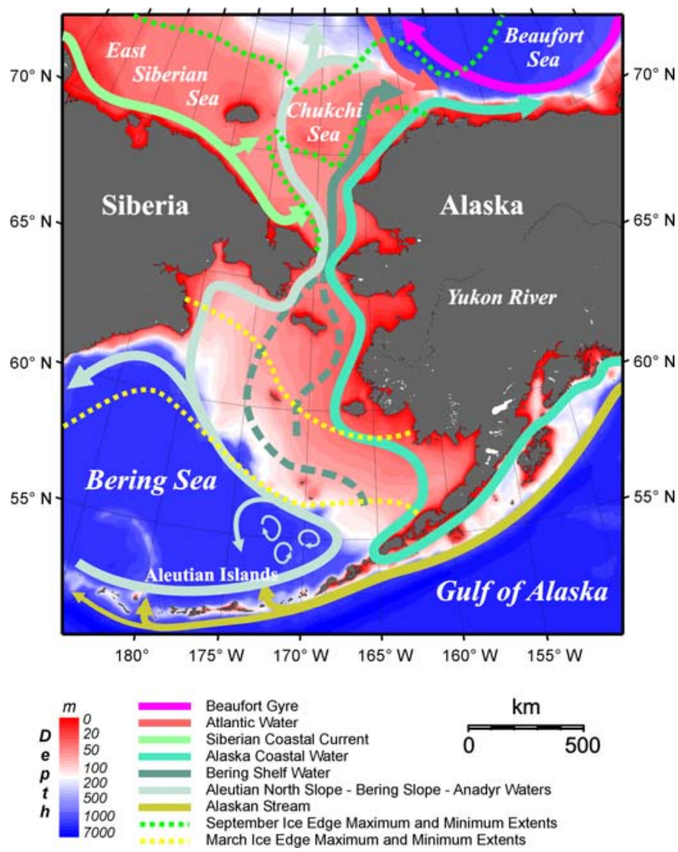

Figure I-1. Schematic circulation map of the Bering–Chukchi–Beaufort seas ecosystem.

The nutrient and carbon loads carried along these branches differ (Walsh et al. 1989, Hansell et al. 1993; Cooper et al. 1997). The Herald Valley outflow is saltier, colder, and richer in nutrients and marine-derived carbon than the waters transported in the Alaska Coastal Current, whereas waters crossing the central shelf have intermediate properties. In winter, shelf waters decrease to the freezing point and salinities increase due to salt rejection from growing sea ice. These seasonal changes in shelf salinities have important implications on the fate of the nutrients and carbon in the Chukchi shelf waters that enter the basin. Low-density summer waters are confined to the upper 75 m of the shelf-break and slope, whereas denser winter waters descend to 100–150 m depth.

There are two other aspects of the Chukchi shelf circulation of importance. The first is the buoyancy-influenced Siberian Coastal Current (SCC) that originates in the East Siberian Sea and flows southeastward along the Siberian coast into the Chukchi Sea. The SCC carries cold, low-salinity, nutrient-poor ice-melt, and river waters that enter the East Siberian and Laptev seas. The SCC is confined to within ~60 km of the Chukotka coast and is bounded on its offshore side by an unstable front, which appears to be an important bowhead whale foraging zone (Moore et al. 1995). Nearing Bering Strait, the SCC narrows and turns offshore to mix with waters exiting the strait. Most of the resulting mix is most likely transported through Herald Valley and across the central shelf. It also appears likely that surface waters over the outer shelf and slope are flowing westward on average (Muench et al. 1991), bringing sea ice and cold, low-salinity waters of the polar mixed layer over the outer shelf and slope.

The mean circulation results from the large scale pressure field between the Pacific and Arctic oceans and opposes the mean winds, which are from the northeast. The winds are, however, the principal cause of flow variability. Wind forcing varies seasonally with both wind magnitude and variability being largest in fall-winter and smallest in summer. In particular, in fall and winter, the winds can frequently reverse the shelf flow field or re-distribute the flow from one branch to another (Weingartner et al. 1998). As a consequence of this seasonality, transit times along the three flow pathways across the Chukchi shelf are 3–6 months in spring and summer but are longer in fall and winter.

In general, wind-forced current fluctuations are coherent over much of the shelf, although, for reasons not known, the correlation is substantially weaker over the western shelf than for the eastern shelf (Woodgate et al. 2005b). Westward winds induce upwelling at the continental slope, which could be an important nutrient source at the shelf-break. While no measurements have been made of this phenomenon along the Chukchi slope, data from Barrow Canyon indicate that wind-forced upwelling carries waters from ~250 m depth or more toward the head of the canyon, which lies ~150 km from the canyon mouth (Aagaard and Roach 1990; Weingartner et al. 1998). Winds also appear to be important in the dynamics of the SCC. For example, in some years, the winds along the Chukotka coast are persistently upwelling and prevent the SCC from entering the Chukchi Sea (Münchow et al. 1999; Weingartner et al. 1999). The consequences of this variability are unknown, but if the SCC front is an important foraging zone for bowhead whales, its absence in some years could affect whale foraging behavior.

The other major sources of current variability are associated with mesoscale (10–50 km) instabilities associated with large cross-frontal density gradients. Mesoscale flows can be vigorous (>20 cm/s) and uncorrelated with winds. The instabilities initially appear as meanders along the front but can rapidly grow in strength and/or detach into eddies that move across the axis of the front. Eddies and meanders are very prominent within the SCC front and promote cross-shore mixing between SCC and Bering Strait waters flowing northward through the Hope Sea Valley. Eddies and cross-shore mixing result from frontal instabilities along the edge of polynyas due to the large salinity differences between high salinity polynya waters and less saline offshore waters (Gawarkiewicz and Chapman 1995). Finally, fronts associated with melting along the ice-edge often include vigorous three-dimensional mesoscale motions (Liu et al. 1994; Muench et al. 1991) that often lead to enhanced biological production at the ice edge. Moreover, the mixing and circulation fields associated with the mesoscale motions associated with the SCC and ice edge may also be important in establishing biologically-rich mesoscale patches.

1.2 Measurement History

Prior to the 1970s, several hydrographic expeditions were collected throughout the Chukchi Sea and summarized by Coachman et al. (1975). In the 1970s and 1980s, several year-round moored measurement programs were conducted in the United States Exclusive Economic Zone

(US EEZ) and supported by the Outer Continental Shelf Environmental Assessment Program (OCSEAP), as summarized by Aagaard (1988). Beginning in 1990, National Science Foundation (NSF), Office of Naval Research (ONR), and MMS supported a number of physical-oceanographic programs, the results of which were summarized above. Most recently, these included the NSF-ONR sponsored Shelf–Basin Interaction (SBI), which recently completed a three-year field program (2001–2004). The SBI program focused primarily upon biogeochemical processes over the outer shelf and shelf-break, and the data from this program are still undergoing analysis.

1.3 Purpose of Study and Rationale

Prior to any exploration, development, or production activities are conducted in the Chukchi Sea lease blocks, MMS requires the collection of specific baseline information in order to adequately evaluate the potential effects to the marine environment from oil and gas activities. Multiple years of data will be necessary to support exploratory drilling and eventual development activities. Circulation characteristics and physical-oceanographic influences on biological oceanography and production form one aspect of these baseline studies. The physical oceanography may influence design considerations, and it may affect spatial and temporal patterns of biological production and the distribution and abundance of organisms.

1.4 Objectives of Study

The primary objective of the physical oceanography program is to describe spatial and seasonal characteristics of the water masses and circulation in the two study areas. In future years, it will be essential to survey the broader region to provide the oceanographic context in which development activities will take place. In particular, we recommend that these future investigations consider the recommendations in Section 1.3. The main objective of the 2008 oceanographic data should be to combine the physical-oceanographic data with the various biological measurements planned. This will help determine spatial and temporal patterns of biological production and the distribution and abundance of organisms in this region. [Note that CPAI will pursue collaboration with other entities such as the MMS to obtain data representative of the regional scale recommendation of University of Alaska Fairbanks (UAF)].

2. STUDY AREA

2.1 Location

As part of this post-leasing process, CPAI will be initiating a multi-year scientific field program in 2008 for two prospect areas, termed Klondike and Burger (see Introduction Figure 1). Both study areas consist of three lease-block areas within one larger block that is ~15 nautical miles (nm) on one side and ~25 nm on the other side with a buffer zone around it. To provide appropriate physical and biological context, coarser resolution sampling in future years will be required over a broader area (i.e., from 161–167°W and from 69–72°N).

2.2 Period of Study

The study's program is anticipated to be multi-year, but this proposal is limited to the 2008 season. The current proposed 2008 schedule would consist of approximately three 30-day cruises occurring between July and October. The exact length of the cruises will depend on reasonable access to the study sites. The first half of each cruise is proposed to collect data in the Klondike study area, and the second half would collect data in the Burger study area. To establish seasonality and increase the statistical confidence of our observations, the pelagic biological-oceanography surveys will be conducted concurrently with physical-oceanographic observations during the first two cruises.

3. METHODS AND PROCEDURES

3.1 Sampling or Survey Design and Technical Rationale

We propose to sample a 30 X 30 nm survey block, with a grid of 5 x 5 stations, at ~7.5 nm spacing, within each study site, on both cruises. These will be conductivity-temperature-depth (CTD) stations at the same sites at which samples are collected for zooplankton, nutrients, and chlorophyll. The CTD includes a fluorometer (as an index of chlorophyll biomass) and a transmissometer (as index of water-column turbidity). In addition, surface temperature, salinity, and fluorescence (SSTSF) data will be captured as the vessel transits. Finally, using a vessel-mounted ADCP will allow for the collection of current data to provide an estimate of the water-column current structure and its spatial and temporal variability.

3.2 Field Team Size and Composition

Marine technicians with Aldrich Offshore, Inc. will conduct the field work in 2008, responsible for deploying, recovering, and collecting the various physical-oceanographic data sets. This team has extensive experience and will have ultimate technical oversight by Dr. T. Weingartner.

3.3 Data-Collection Procedures

CTD data will be collected with a Seabird system with a descent rate of no more than 30 meters/minute. The SSTSF system will also include a flow monitor in the intake system, and the data stream will be blended with the ship's navigation system so that global positioning system (GPS) time and position are recorded. At each CTD cast, the marine technician will record the time of CTD deployment and position. The technician will also record the temperature and salinity values of the SSTSF system once the CTD is ready to descend through the water column. (This will allow us to compare the underway system values with the CTD data; which is usually more accurate than the underway system.) Vessel-mounted ADCP (VM-ADCP) data will be collected from a 150-kHz Teledyne RDI system. The instrument should be run in bottom-track and broadband modes with a 2-m bin size and 2-second ensemble rate. Both raw (single-ping) and 10-minute averaged data should be stored (with duplicate copies). The ADCP data stream must also include the GPS position and time.

We also propose to collect and process remotely-sensed imagery during the field season. This will include thermal infrared for sea surface temperature, ocean color (chlorophyll or suspended sediment), sea ice, and QuikSCAT (satellite-borne scatterometer). Imagery will be processed and made available at least bi-weekly.

3.4 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 be used for assessing the SSSTF 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. ADCP data processing may be time-consuming (see below). We have allocated a month for this task and will attempt to provide summary statistics on the ocean currents for each cruise. At the very least, the analyses will provide CPAI with an estimate of data quality and simplified analyses of the circulation within the boxes (e.g., means and variances). Time permitting, we will examine shorter-period variations in the currents.

3.5 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.

3.6 Quality-control Procedures

We require the manufacturer's pre- and post-calibration values for the CTD data. The underway sensors should 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, following Joyce et al. (1989). Note, however, that ADCP quality control and data processing can be a time-consuming process if there are problems with the installation of the ADCP on the vessel. Moreover, 90 days of ADCP data could require several months of processing time. We have allocated one month for processing and analysis of the ADCP data.

4. COORDINATION

4.1 CPAI

The PI will attend all proposed meetings and interact regularly as needed with CPAI.

4.2 Current Studies in the Region

Recent and ongoing studies have been described in Section 1.1. Weingartner is a PI in the NSF and National Oceanic and Atmospheric Administration (NOAA)-funded Russian-American Long-term Census of the Arctic (RUSALCA) program that began in 2004 and that involves year-round current meter sampling in both the US and Russian EEZs of Bering Strait. Weingartner is also involved with research in the Bering and Beaufort seas in 2008 and 2009.

5. REFERENCES

Aagaard, K. 1988. Current, CTD, and pressure measurements in possible dispersal regions of the Chukchi Sea. Outer Continental Shelf Environmental Research Program, Final Reports of Principal Investigators 57: 255–333.

Aagaard, K., and Roach. 1990. Arctic ocean-shelf exchange: measurements in Barrow Canyon, Journal of Geophysical Research 95: 18163–18175.

Aagaard, K., C. H. Pease, A. T. Roach, and S. A. Salo. 1989. Beaufort Sea Mesoscale Circulation Study—Final Report. NOAA Technical Memorandum ERL PMEL-90. 114 pp.

Aagaard, K., J. H. Swift, and E. C. Carmack. 1985. Thermohaline circulation in the Arctic mediterranean seas. Journal of Geophysical Research 90: 4833–4846.

AMAP (Arctic Monitoring and Assessment Programme). 2003. AMAP Arctic Pollution 2002: Persistent organic pollutants, heavy metals, radioactivity, Human health, changing pathways. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 112 pp.

Carmack, E. C. 1986. Circulation and mixing in ice-covered waters. *In* N. Unstersteiner (Ed.). The geophysics of sea ice. Plenum Press, New York, NY. Pp. 641–712.

Carmack, E. C., and D. C. Chapman. 2003. Wind-driven shelf/basin exchange on an Arctic shelf: the joint roles of ice cover extent shelf-break bathymetry. Geophysical Research Letters 30 (14): 1778. [available at: doi: 10.1029/203GL017526]

Coachman, L. K., K. Aagaard, and R. B. Tripp. 1975. Bering Strait: the regional physical oceanography. University of Washington Press, Seattle, Washington, Seattle, WA. 172 pp.

Codispoti, L., G. E. Friederich, C. M. Sakamoto, and L. I. Gordon. 1991. Nutrient cycling and primary production in the marine systems of the Arctic and Antarctic. Journal of Marine Systems 2: 359–384.

Codispoti, L., and F. A. Richards. 1968. Micronutrient distributions in the East Siberian and Laptev seas during summer 1963. Arctic 21: 67–83.

Cooper, L. W., J. Grebmeier, T. Whitledge, and T. Weingartner. 1997. The nutrient, salinity, and stable oxygen isotope composition of Bering and Chukchi sea waters in and near Bering Strait. Journal of Geophysical Research 102: 12563–12578.

Gawarkiewicz, G., and D. C. Chapman. 1995. A numerical study of dense water formation and transport on a shallow, sloping continental shelf. Journal of Geophysical Research 100: 4489–4508.

Joyce, T. 1989. On *in situ* “calibration” of shipboard ADCPs. 1989. Journal of Atmospheric and Oceanographic Technology 6: 169–172.

Hansell, D., T. E. Whitledge, and J. J. Goering. 1993. Patterns of nitrate utilization and new production over the Bering-Chukchi shelf. Continental Shelf Research 13: 601–627.

Liu, A. K., C. Y. Peng, and T. J. Weingartner. 1994. Ocean–ice interaction in the marginal ice zone using SAR. Journal of Geophysical Research 99: 22391–22400.

Muench, R. D., C. H. Pease, and S.A. Salo. 1991. Oceanographic and meteorological effects on autumn sea-ice distribution in the western Arctic. Annals of Glaciology 15: 171–177.

Münchow, A., E. C. Carmack, and D. A. Huntley. 2000. Synoptic density and velocity observations of slope waters in the Chukchi and East Siberian Seas. Journal of Geophysical Research 105: 14103–14119.

Münchow, A., T. Weingartner, and L. Cooper. 1999. The summer hydrography and surface circulation of the East Siberian Shelf Sea. Journal of Physical Oceanography 29: 2167–2182.

Münchow, A., and E. C. Carmack. 1997. Synoptic flow and density observations near an Arctic shelfbreak. Journal of Physical Oceanography 6: 461–470.

Paquette, R. G., and R. H. Bourke. 1981. Ocean circulation and fronts as related to ice melt-back in the Chukchi Sea. Journal of Geophysical Research 86: 4215–4230.

Walsh, J. J., C. P. McRoy, L. K. Coachman, J. J. Goering, J. J. Nihoul, T. E. Whitledge, T. H. Blackburn, P. L. Parker, C. D. Wirick, P. G. Shuert, J. M. Grebmeier, A. M. Springer, R. D. Tripp, D. A. Hansell, S. Djenedi, E. Deleersnijder, K. Henriksen, B. A. Lund, P. Andersen, F. E. Müller-Karger, and K. Dean. 1989. Carbon and nitrogen cycling within the Bering/Chukchi seas: source regions for organic matter affecting AOU demands of the Arctic Ocean. Progress in Oceanography 22: 277–359.

Walsh, J. J., D. A. Dieterle, F. E. Muller-Karger, K. Aagaard, A. T. Roach, T. E. Whitledge, and D. Stockwell. 1997. CO2 cycling in the coastal ocean. II: Seasonal organic loading of the Arctic Ocean from source waters in the Bering Sea. Continental Shelf Research 17: 1–36.

Weingartner, T., K. Aagaard, R. Woodgate, S. Danielson, Y. Sasaki, and D. Cavalieri, Circulation on the north-central Chukchi Sea shelf. 2005b. Deep-Sea Research (II) 52: 3150–3174.

Weingartner, T. J., S. R. Okkonen, and S. L. Danielson. 2005c. Circulation and water-property variations in the nearshore Alaskan Beaufort Sea. Final Report, OCS Study No. MMS 2005-028. 103 pp.

Weingartner, T. J., S. Danielson, Y. Sasaki, V. Pavlov, and M. Kulakov. 1999. The Siberian Coastal Current: a wind- and buoyancy-forced arctic coast current. Journal of Geophysical Research 104: 26697–29713.

Weingartner, T. J., D. J. Cavalieri, K. Aagaard, and Y. Sasaki. 1998. Circulation, dense water formation, and outflow on the northeast Chukchi shelf. Journal of Geophysical Research 103: 7647–7661.

Woodgate, R. A., K. Aagaard, and T. J. Weingartner. In press. Changes in the Bering Strait fluxes of volume, heat and freshwater between 1991 and 2004. Geophysical Research Letters.

Woodgate, R. A., and K. Aagaard. 2005. Revising the Bering Strait freshwater flux into the Arctic Ocean. Geophysical Research Letters 32: L02602. [available at doi:10.1029/2004GL021747]

Woodgate, R. A., K. Aagaard, and T. Weingartner. 2005. Monthly temperature, salinity, and transport variability for the Bering Strait throughflow. Geophysical Research Letters 32: L04601. [available at doi:10.1029/2004GL021880]

Woodgate, R. A., K. Aagaard, and T. Weingartner. 2005. A year in the physical oceanography of the Chukchi Sea: moored measurements from autumn 1990–91. Deep-Sea Research (II) 52: 3116–3149.

SECTION II

PLANKTONIC COMMUNITIES OF THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

Excerpt From Proposal by
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1. INTRODUCTION

1.1 Brief History of Planktonic Biological Oceanography in the Chukchi Sea

The Chukchi Sea in particular represents a complex gateway into the Arctic, where variation in climate may have profound impacts due to the complex interplay of several distinct water masses of Pacific origin with those of the central Arctic Ocean and its marginal seas. Large quantities of Pacific nutrients, phytoplankton, and zooplankton 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 (Springer et al. 1989; Coyle et al. 1996). 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 (Grebmeier et al. 1995). The influx of the “rich” Pacific water determines the reproductive success of both the imported and resident zooplankton communities (Plourde et al. 2005). Both interannual and long-term variation in climate will affect the relative transport of these various water masses and, hence, the composition, distribution, standing stock, and production of zooplankton and their predators within the Chukchi Sea.

Historically, the zooplankton of the Western Arctic and Northern Bering Sea have not been well studied compared with most US oceanographic regions because of their remoteness and extensive seasonal ice coverage. Much of what is known comes from sporadic, spatially-restricted, and non-repeated surveys that often undertake incomplete analysis of their samples. Consequently, much of what has been done does not appear in the primary scientific literature but remains buried in the “gray literature. ” Although physical-oceanographic measurements typically have earlier histories, the first scientific records of planktonic work in the Bering Strait and Chukchi Sea appear to be those of Johnson (1934), Stepanova (1937), Bogorov (1939), and Jaschnov (1940), all of whom noted the significant influence of Pacific fauna in the Chukchi Sea.

Further work resumed after World War II, with the results of the early Russian sampling reported in Brodsky (1950, 1957), the English translation of which still remains a primary reference source for the region. Work more specific to this region appeared in Virketis (1952). North American work in the region initially maintained a quantitative and taxonomic dimension (Johnson 1953, 1956, 1958), but then interest waned. The results of the 1959 and 1960 Brown Bear cruises were never published as more than displacemnt volumes (English 1966) and, although the United States Coast Guard (USCG) Cutter Northwind appears to have sampled zooplankton in the Bering Strait and Chukchi Sea during the 1960s, the data are either unpublished or buried in the gray literature. Chukchi Sea collections by the USCG Glacier in

1970 as part of WEBSEC were reported quantitatively (Wing 1974), while samples collected in the Northern Bering and Chukchi seas (Cooney 1977) by the Alaskan OCSEAP (OCSEAP; 1960–1981) were never published as more than presence–absence data (although raw data still exist at UAF). Only limited additional quantitative zooplankton sampling occurred in the Chukchi Sea under the OCSEAP program (English and Horner 1977), as most effort became focused on the nearby waters of the Beaufort Sea (ibid; Redburn 1974; Horner 1981; Horner and Schrader 1984) and the southeastern Bering Sea (Cooney 1977; followed by PROBES, FOCI). It was the mid-1980s before quantitative sampling resumed in Bering Strait and the Chukchi Sea with the Inner Shelf Transfer and Recycling (ISHTAR) program (see below). Russian research in this region has undoubtedly continued since the 1950s, but the results are often buried in their own gray literature and are generally unavailable to the international community (see Herman 1989). No doubt, the relative paucity of information north of Bering Strait is a consequence of limited commercial harvesting there in comparison with the Bering Sea.

From the North American perspective, post OCSEAP science begins with the ISHTAR program in 1985 and 1986 (Springer et al. 1989) and, more peripherally, the 1994 Trans-arctic Section (Thibault et al. 1999) and the SHEBA drift across the Chukchi Plateau in 1997–1998 (Ashjian et al. 2003). In the past decade, our knowledge of plankton in the Chukchi Sea and Western Arctic has improved considerably due to ongoing efforts such as NSF's SBI program (2002–2004) on the Beaufort and Chukchi shelves (e.g., Plourde et al. 2005; Llinas 2007; Lane et al. 2008), plus cross-sea cruises by NOAA's RUSALCA Program (e.g., Lee et al. 2007; Hopcroft and Kosobokova, in review), and the Northward extension of the Bering–Aleutian Salmon International Survey (BASIS) into the Chukchi Sea beginning in 2006. More limited sampling in the Chukchi has occurred during northward transit of Canadian ice breakers during the past decade, and the Japanese ship Oshoro Maru began last year extending its annual cruise into northward into the Chukchi Sea. A notable exception to the political boundaries imposed on most post-WWII sampling in the Bering and Chukchi seas has been the Joint US-USSR BERPAC program. Five such cruises were executed between 1977 and 1993 (Tsyban 1999). BERPAC 1988 is particularly relevant to this proposal because it encompassed stations from the southern Bering Sea to the mid-Chukchi Sea (Kulikov 1992). The RUSALCA program, which begun sampling in 2004 and will re-sample in 2008 and 2012, continues this bi-national sampling effort.

A regional and basin-wide review of Arctic zooplankton, their composition, seasonal life cycles, and trophic interactions was completed nearly two decades ago (Smith and Schnack-Schiel 1990). The review emphasizes the larger copepods in the genus Calanus. A more recent effort emphasizing the Russian literature for just the Bering Sea has also been completed (Coyle et al. 1996). One common shortcoming of all this initial work is that sampling techniques were not standardized; in particular, the use of only a single net of 303 to ~600 µm mesh as employed in these studies missed the majority of the zooplankton community numerically and missed a substantial proportion of the community biomass and diversity. For the most part, Arctic studies have now standardized on 150-µm mesh nets (e.g., Kosobokova and Hirche 2000; Ashjian et al. 2003; SBI and OE program) that more completely sample the numerically-dominant copepods in the genera Oithona, Oncaea, Microcalanus, and Pseudocalanus (ibid; Auel and Hagen 2002; Hopcroft et al. 2005). In fact, to ensure that all developmental stages of these species, including nauplii, are sampled, a mesh as fine as 53 µm is required (Hopcroft et al. 2005). Furthermore, these more recent studies have been conducted primarily in deeper waters, while in the shallow target area of this project we can expect an even larger contribution of smaller neritic species in several of the water masses that will be encountered (e.g., Grice 1962; Conover and Huntley 1991).

Although we now have a fairly complete idea of the species that have been described regionally in the Arctic (e.g., Sirenko 2001), we still lack unbiased and comprehensive estimates of the abundance, biomass, and composition of the zooplankton in the Chukchi Sea due to sampling inadequacies of the past. Significant progress was made toward this end by the RUSALCA and SBI programs. Within the Chukchi Sea, there is considerable diversity of both small and large jellyfishes, hydromedusae, and ctenophores that are often overlooked: more than a dozen species were encountered in RUSALCA 2004 (Hopcroft and Kosobokova, in review), and more are reported from the nearby deep basins (Raskoff et al. 2005, in review). There were also considerable populations of larvaceans, particularly the large arctic Oikopleura vanhoeffeni throughout the sampling area. Larvaceans are increasingly implicated as key players in polar systems (e.g., Acuna et al. 1999; Hopcroft et al. 2005; Deibel et al. 2005) due to their high grazing and growth rates. At times, the biomass of larvaceans in 2004 rivaled that of the copepods, particularly at the ice-edge stations in Herald Valley, where some of the highest recorded densities for Oikopleura vanhoeffeni were observed. Shifts from copepod-dominated communities to larvacean-dominated can have large consequences on the export of phytoplankton to the benthos (Gorsky and Feanaux 1998; Alldredge 2005). As in many ecosystems, chaetognaths remain an important and neglected predatory group (Ashjian et al. 2003; Hopcroft et al. 2005; Lane et al. 2008; Hopcroft and Kosobokova, in review), The meroplanktonic larvae of benthic organisms were also exceptionally common throughout the sampling region in 2004, and better knowledge of their abundance and distribution is of high relevance to understanding recruitment to the rich benthic communities in this region. To a large extent, the spatial distribution of these zooplankton communities is tied to the different water masses present in this region (Hopcroft and Kosobokova, in review).

In terms of mechanisms, planktonic communities of the Chukchi Sea could undergo climate-related changes either through shifts in the absolute transport rate, and thus penetration, of Pacific species into the Arctic, or by environmental changes that ultimately affect their survival. It has been estimated that 1.8 million metric tons of Bering Sea zooplankton are carried into the Chukchi Sea annually (Springer et al. 1989) and that this, along with the entrained phytoplankton communities, are responsible for the high productivity of the Chukchi Sea in comparison with adjoining regions of the Arctic Ocean (e.g., Plourde et al. 2005). In the summer of 2004, one would characterize the southern Chukchi zooplankton fauna as primarily Pacific in character, and there were clear signs that Pacific species were carried northward as far as the eastern side of Wrangel Island and Harold Canyon (Hopcroft and Kosobokova, in review), while in the northeastern Chukchi transitions to fully Arctic communities did not occur until the shelf break (Lane et al. 2008). Future increases in transport could carry even more Pacific zooplankton through Bering Strait, with even further penetration into the Arctic. In contrast, a reduction in transport of Bering Sea water would not only decrease the overall productivity of the Chukchi Sea but would give it a more Arctic Ocean faunal character. Thus, changes in the transport rates ultimately affect the species-composition of this region as well as the absolute zooplankton biomass, and such shifts may result in changes in the size-structure of zooplankton communities. Since most higher trophic levels select their prey based on size, the consequences of size-structure shifts could be more important than changes in zooplankton biomass.

1.2 Purpose of Study and Rationale

Chukchi Lease Sale 193 occurred in February 2008. Prior to any exploration, development, or production activities being conducted in a lease block, MMS requires specific baseline information to be collected. Multiple years of data will be necessary to prepare a defensible NEPA document to support exploratory drilling and future development. Pelagic biological oceanography forms one aspect of these baseline studies because the productivity of the water column determines the flux of energy to the seafloor and to productivity transferred through zooplankton to higher trophic levels such as fishes, seabirds, and marine mammals. Alterations to water-column productivity as a result of development activities, or long-term climate change, could therefore have direct impact on the ecosystem, including the more visible vertebrates. Long-term studies with direct observations of community composition and biomass are the only means to compare temporal variation in biological communities with environmental change.

1.3 Objectives of Study

The primary objective is to describe spatial and seasonal characteristics of the plankton (phytoplankton and zooplankton) communities with specific detail in the two study areas. In future years, it will be essential to survey the surrounding 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 zooplankton. It will therefore become critical to assess typical communities in both these water masses, concurrent with physical and chemical (i.e., nutrients) oceanographic measurements to ensure that appropriate baselines are available for both water masses, regardless of which occupies the study areas during future assessments. Secondarily, we will 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.

2. STUDY AREA

2.1 Location

As part of the post-leasing process, CPAI is initiating a multi-year scientific field program in 2008 for two prospect areas, termed Klondike and Burger (see Introduction Figure 1). Both study areas consist of a smaller area measuring 12 x 12 nm, s within a larger block that is ~30 by 30 nm.

2.2 Period of Study

The studies program is anticipated to be multi-year, but this plan is specific to the 2008 season. The current schedule consists of three 30-day cruises occurring between July and October. The first half of each cruise will collect data in the Klondike study area, and the second half will collect data in the Burger study area. To establish seasonality, and increase the statistical confidence on our observations, the pelagic biological-oceanography surveys will be conducted concurrent with physical oceanographic observations described in Section I.

3. METHODS AND PROCEDURES

3.1 Sampling or Survey Design and Technical Rationale

A 30 X 30 nm box will be sampled , with a grid of 5 X 5 stations, at ~7.5-nm spacing, within each study site on both cruises (see Figure II-1). Both phytoplankton (as chlorophyll) and zooplankton will be sampled because the phytoplankton is the major prey for the zooplankton and for the benthos once it settles. Together, nutrients, phytoplankton, and zooplankton form effective biological tracers of the waters masses present in this region. In general, re-sampling of fixed sampling locations over time along transects/grids (a model-based rather than a probability-based design) will provide the highest power for statistical comparisons between years (but limit inferences) and will result in spatially and temporally correlated data. Thus, statistical methodologies considered will include methods for analyzing data in the presence of correlated error structures (e.g., linear models through SAS Proc Mixed, SAS Institute, Cary, NC, or geostatistical methods) and multivariate procedures. Additional sets of collections will be conducted in any area where bowhead whales are observed to feed, with a pair of collections taken inside the feeding area and a pair taken outside for reference.

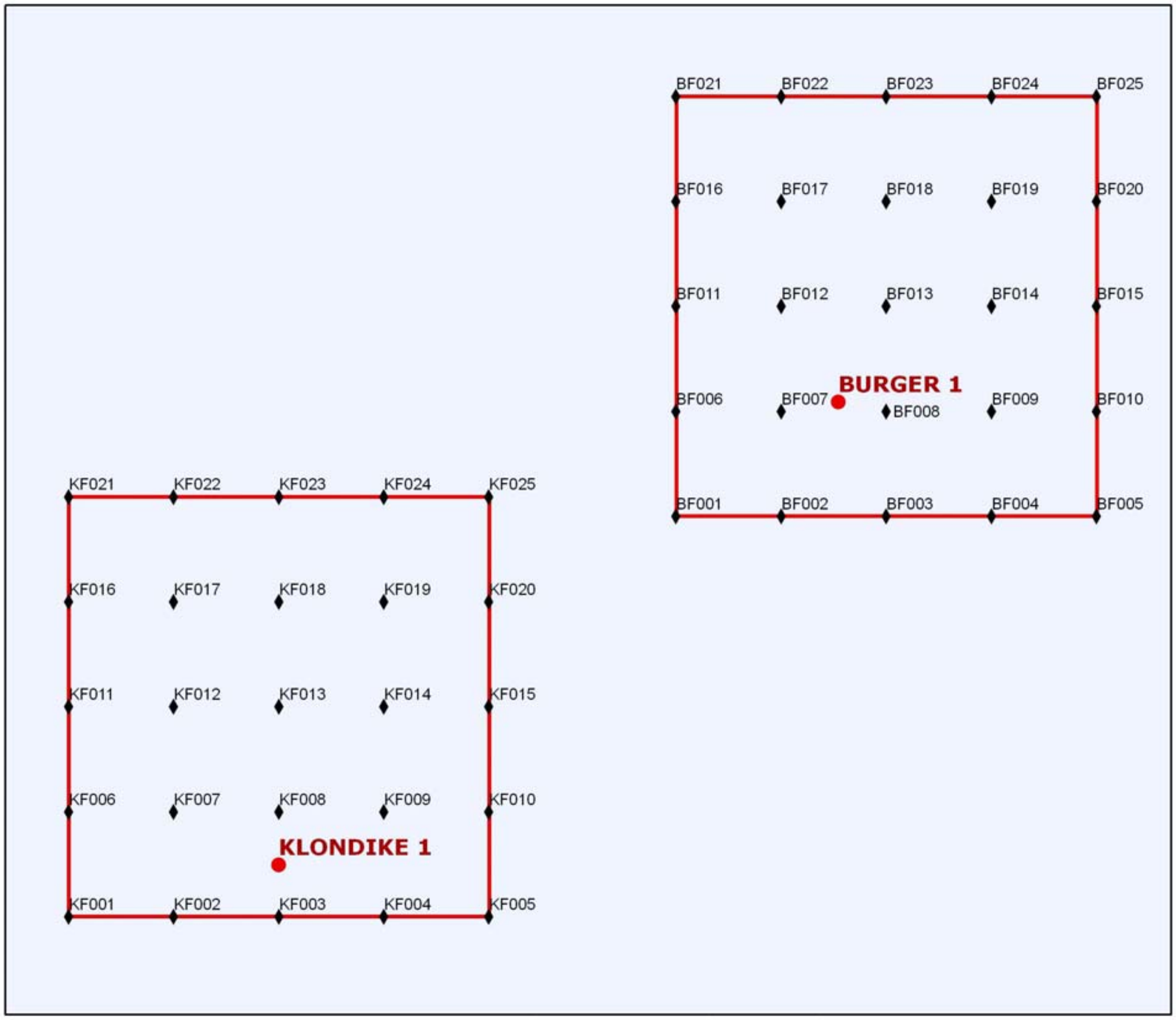

Figure II-1. 30 nm Grids and Fixed Sampling Stations

Figure II-1. 30nm Grids and Fixed Sampling Stations

3.2 Field Team Size and Composition

The field team will consist of one graduate student from the University of Alaska Fairbanks, assisted by marine technicians from Aldrich Offshore, Inc.

3.3 Data-collection Procedures

Routine methods are similar to those employed during the 2004 and 2008 RUSALCA expeditions and on the 2006 and 2007 BASIS cruises. Phytoplankton will be assessed as Chlorophyll a concentration from samples collected with a CTD rosette on upcasts at ~5 depths/station. Samples will be filtered under low pressure onto a Whatman GFF filters, with extracted Chlorophyll a being determined fluorometrically on board ship or post-cruise from frozen samples (Parsons et al. 1984). Measurements will be used to calibrate the in vivo fluorescence profiles measured at all stations. Nutrient samples will be taken from the same bottles as chlorophyll, frozen immediately, and measured post-cruise using an Alpkem Rapid Flow Analyzer (Whitledge et al. 1981); analyses will conform to WOCE standards (Gordon et al. 1993).

Zooplankton will be collected routinely by a pair of 150-µm mesh Bongo nets of 60-cm diameter hauled vertically from within 3 m of the bottom; the volume of water filtered will be measured by GO flow meters in each net that are rigged not to spin during descent. 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.

Opportunistic samples of zooplankton where bowhead whales are observed feeding will employ only the 505-µm net because they exploit only larger prey items. These samples will be collected after the mammals have left the area. Upon retrieval, one sample of each mesh size will be preserved in 10% formalin, and the other in 100% non-denatured ethanol (required for molecular identification). A quantitative subsample of fresh material from the sample to be preserved in ethanol will be made available to the contaminants team upon request.

3.4 Analytical Procedures

Formalin-preserved samples will be processed for quantitative determination of species -composition and biomass (predicted). During taxonomic 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, copepodites will be classified to stage, and will be enumerated and measured (Roff and Hopcroft 1986). Each larger subsample will be examined to identify, measure, enumerate, and weigh the larger, less-abundant taxa. The three lead zooplankton technicians at UAF each have been working in Alaska waters from 8–20 years. When needed, specimens will be compared with the voucher set housed at UAF or will be sent to an appropriate taxonomic expert.

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. Wet-weight measurements are generally taken to ±1 µg (or where needed to ±0.1 µm) on a Cahn Electrobalance. Measured weights will be periodically compared to those predicted from length-weight equations to compare the two methods. 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 (Coyle and Pinchuk 2003, 2005; Hopcroft and Kosobokova, in review) and will be coducted with the Primer software package.

Ethanol samples will be scanned for representatives of the species and contribute to a growing international “molecular bar-coding” effort by the Census of Marine Zooplankton (CMarZ) at the

University of Connecticut for determination of the Cytochrome Oxidase I sequence. This sequence has been identified for the universal molecular “bar-coding” of eucaryotic organisms (Hebert et al. 2003) and is currently being employed for global analysis of zooplankton (e.g., Bucklin et al. 2003, in preparation). Initially, these sequences will simply serve to catalogue the species encountered, but they ultimately will become the preferred method of ensuring taxonomic consistency of identification within long-term studies.

3.5 Data-storage Procedures

Data files collected during cruises will be backed up periodically, and multiple copies will be transported back to UAF. At UAF, data are backed up routinely onto departmental servers.

3.6 Quality-control Procedures

In the field, samples are always collected in duplicate, so any discrepancy in the flowmeter readings become readily apparent. Replicate samples are not routinely analyzed but serve as insurance in the event that one sample is compromised. Periodically, the same subsamples are processed by several technicians to ensure taxonomic consistency. As indicated previously, the three lead zooplankton technicians at UAF each have been working in Alaska waters from 8 to 20 years. When questions arise, specimens will be compared with the voucher set housed at UAF, will be sent to an appropriate taxonomic expert, or will be identified through emerging molecular-identification libraries.

4. COORDINATION

4.1 CPAI

The PI will attend all proposed meeting and interacts regularly as needed with CPAI.

4.2 Other Studies in the Chukchi Sea Program

The PI regularly interacts with other PIs currently at UAF and has a long collaborative relationship with Weingartner, in particular, through the GLOBEC and NPRB Seward Line time-series. Hopcroft oversaw a recent multidisciplinary synthesis of studies from the Chukchi and Beaufort region, which has connected him to investigators in many other disciplines.

4.3 Current Studies in the Region

Recent and ongoing studies have been described in Section 1.1. Hopcroft is a PI within the NOAA-funded RUSALCA program begun in 2004, which will be a re-sampling over a broad domain of the Chukchi Sea in September 2008. Hopcroft and his students are actively involved with the BASIS sampling program in the Chukchi Sea (which has stopped at 70°N), as well as in the deep Canada Basin. Hopcroft is also a lead PI in the ongoing Arctic Ocean Biodiversity project (www.arcodiv.org), which, among other goals, is compiling biological data from the Chukchi Sea, in conjunction with colleagues and ongoing efforts by NOAA-NMFS, ArcOD has digital access to much of the zooplankton data from OCSEAP, ISHTAR, WEBSEC, SBI, Ocean Exploration cruises. Recently, several of these datasets have been made available on-line at http://ak.aoos.org/op/data.php?region=AK&name=obis or http://www.st.nmfs.gov/plankton/content/area_bering/index.html. Thus far, we have been unsuccessful in locating all BERPAC data, but such efforts and others are ongoing.

5. REFERENCES

Acuna, J. L., D. Deibel, A. B. Bochdansky, and E. Hatfield, E. 1999. *In situ* ingestion rates of appendicularian tunicates in the Northeast Water Polynya (NE Greenland). Marine Ecology Progress Series 186: 149–160.

Alldredge, A. 2005. The contribution of discarded appendicularian houses to the flux of particulate organic carbon form oceanic surface waters. *In* G. Gorsky, M. J. Youngbluth, and D. Deibel (Eds.). Response of marine ecosystems to global change: ecological impact of appendicularians. Gordon and Breach, Paris, France. Pp. 309–326.

Ashjian, C. J., R. G. Campbell, H. E. Welch, M. Butler, and D. V. Keuren. 2003. Annual cycle in abundance, distribution, and size in relation to hydrography of important copepod species in the western Arctic Ocean. Deep-Sea Research (I) 50: 1235–1261.

Auel, H., and W. Hagen. 2002. Mesozooplankton community structure, abundance and biomass in the central Arctic Ocean. Marine Biology 140: 1013–1021.

Bogorov, V. G. 1939. The characteristics of seasonal phenomena in the plankton of the Arctic seas and their significance for ice forecastings. Zoologicheskii Zhurnal 18 (5): XXX–XXX. *[in Russian]*.

Brodsky, K. A., 1950. Copepods (Calanoida) of the far-eastern seas of the USSR and the polar basin. Zoological Institute of the Academy of Sciences of the USSR, Leningrad.

Brodsky, K. A., 1957. The copepod fauna (Calanoida) and zoogeographic zonation of the North Pacific and adjacent waters. Akademiya Nauk SSSR, Leningrad.

Bucklin, A., B. W. Frost, J. Bradford-Grieve, L. D. Allen, and N. J. Copley. 2003. Molecular systematic and phylogenetic assessment of 34 calanoid copepod species of the Calanidae and Clausocalanidae. Marine Biology 142: 333–343.

Bucklin, A., R. R. Hopcroft, K. N. Kosobokova, and K. A. Raskoff. In preparation. Molecular sequencing of marine zooplankton communities: COI sequences of the western Arctic.

Conover, R. J., and M. Huntley. 1991. Copepods in ice-covered seas—distribution, adaptations to seasonally limited food, metabolism, growth patterns, and life-cycle strategies in polar seas. Journal of Marine Systematics 2: 1–41.

Cooney, R. T. 1977. Zooplankton and micronekton studies in the Bering-Chukchi/Beaufort seas. NOAA OCSEAP Annual Reports 10: 275–363.

Coyle, K. O., V. G. Chavtur, and A. I. Pinchuk. 1996. Zooplankton of the Bering Sea: a review of Russian-language literature. *In* A. O. Mathisen and K. O. Coyle (Eds.). Ecology of the Bering Sea: a review of the Russian literature. Alaska SeaGrant College Program, University of Alaska, Fairbanks, AK. Pp. 97–133.

Coyle, K. O., and A. I. Pinchuk. 2003. Annual cycle of zooplankton abundance, biomass and production on the northern Gulf of Alaska shelf, October 1997 through October 2000. Fisheries Oceanography 12: 227–251.

Coyle, K. O., and A. I. Pinchuk. 2005. Cross-shelf distribution of zooplankton relative to water masses on the northern Gulf of Alaska shelf. Deep-Sea Research (II) 52: 217–245.

Deibel, D., P. A. Saunders, J. L. Acuna, A. B. Bochdansky, N. Shiga, and R. B. Rivkin. 2005. The role of appendicularian tunicates in the biogenic carbon cycle of three Arctic polynyas.

In G. Gorsky, M. J. Youngbluth, and D. Deibel (Eds.). Response of marine ecosystems to global change: ecological impact of appendicularians. Gordon and Breach, Paris, France. Pp. 327–356.

English, T. S. 1966. Net plankton volumes in the Chukchi Sea. *In* N. J. Wilimovsky, and J. N. Wolfe (Eds.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Washington, DC. Pp. 809–915.

English, T. S., and R. Horner. 1977. Beaufort Sea plankton studies. NOAA OCSEAP Annual Reports 9: 275–627.

Gordon, C., A. A. Jennings, and J. M. Krest. 1993. A suggested protocol for continuous flow automated analysis of seawater nutrients (phosphate, nitrate, nitrite, and silicic acid) in the WOCE Hydrographic Program and the Joint Global Ocean Fluxes Study. Oregon State University, Corvallis, OR. P. 51.

Gorsky, G., and R. Fenaux. 1998. The role of Appendicularia in marine food chains. *In* Q. Bone (Ed.). The biology of pelagic tunicates. Oxford University Press, New York, NY. Pp. 161–169.

Grebmeier, J. M., W. O. Smith, Jr., and R. J. Conover. 1995. Biological processes on Arctic continental shelves: ice-ocean-biotic interactions. *In* W. O. Smith, Jr., and J. M. Grebmeier (Eds.). Arctic oceanography: marginal ice zones and continental shelves. American Geophysical Union, Washington, DC. Pp. 231–261.

Grice, G. D. 1962. Copepods collected by the nuclear submarine *Seadragon* on a cruise to and from the North Pole, with remarks on their geographic distribution. Journal of Marine Research 20: 97–109.

Hebert, P. D. N., A. Cywinska, S. L. Ball, and J. R. deWaard. 2003. Biological identifications through DNA barcodes. Proceedings of the Royal Society of London (B) 270: 313–321.

Hopcroft, R. R., C. Clarke, R. J. Nelson, and K. A. Raskoff 2005. Zooplankton communities of the Arctic's Canada Basin: the contribution by smaller taxa. Polar Biology 28: 197–206.

Hopcroft, R. R., and K. N. Kosobokova. In review. Distribution and production of *Pseudocalanus* species in the Chukchi Sea. Deep-Sea Research (II).

Hopcroft, R. R., and K. N. Kosobokova. In review. Zonation of zooplankton communities in the Chukchi Sea. Deep-Sea Research (II).

Horner, R. 1981. Beaufort Sea plankton studies. NOAA OCSEAP Final Reports 13: 65–314.

Horner, R. 1984. Analysis of Harrison Bay zooplankton samples. NOAA OCSEAP Final Reports 25: 65–314.

Huntley, M. E., 1996. Temperature and copepod production in the sea: a reply. American Naturalist 148: 407–420.

Jaschnov, V. 1940. Plankton productivity of the northern seas of the USSR. Moscovskoe Obshestvo Ispytatelei Prirody Press, Moscow, Russia.

Johnson, M. W. 1934. The production and distribution of zooplankton in the surface waters of the Bering Sea and Bering Strait, Part II. Report of the oceanographic cruise U.S. Coast Guard Cutter *Chelan*—1934. Pp. 45–82.

Johnson, M. W., 1953. Studies on the plankton of the Bering and Chukchi Seas and adjacent areas. Proceedings 7th Pacific Science Congress (1949), Vol. 4, 'Zoology'. Pp. 480–500.

Johnson, M. W., 1956. The plankton of the Beaufort and Chukchi Sea areas of the Arctic and its relation to hydrography. Arctic Institute of North America, Montreal, Canada.

Johnson, M. W. 1958. Observations on inshore plankton collected during the summer 1957 at Point Barrow, Alaska. Journal of Marine Research 17: 272–281.

Kosobokova, K., and H.-J. Hirche. 2000. Zooplankton distribution across the Lomonosov Ridge, Arctic Ocean: species inventory, biomass and vertical structure. Deep-Sea Research (I) 47: 2029–2060.

Kulikov, A. S. 1992. Characteristics of zooplankton communities. *In* P. A. Nagel (Ed.). Results of the third Joint US–USSR Bering and Chukchi seas expedition (BERPAC), summer 1988. U.S. Fish and Wildlife Service, Washington, DC. Pp. 161–XXX.

Lane, P. V. Z., L. Llinás, S. L. Smith, and D. Pilz. 2008. Zooplankton distribution in the western Arctic during summer 2002: hydrographic habitats and implications for food chain dynamics. Journal of Marine Research 70: 97–133.

Lee, S. H., T. E. Whitledge, and S.-H. Kang. 2007. Recent carbon and nitrogen uptake rates of phytoplankton in Bering Strait and the Chukchi Sea. Continental Shelf Research 27: 2231–2249.

Llinás, L. 2007. Distribution, reproduction, and transport of zooplankton in the western Arctic, University of Miami, Coral Gables, FL.

Parsons, T. R., Y. Maita, and C. M. Lalli. 1984. A manual for chemical and biological methods in seawater. Pergamon Press, Toronto, Canada.

Plourde, S., R. G. Campbell, C. J. Ashjian, and D. A. Stockwell,. 2005. Seasonal and regional patterns in egg production of *Calanus glacialis/marshallae* in the Chukchi and Beaufort seas during spring and summer, 2002. Deep-Sea Research (II) 52: 3411–3426.

Raskoff, K. A., R. R. Hopcroft, K. N. Kosobokova, M. J. Youngbluth, and J. E. Purcell. In review. Jellies under ice: ROV observations from the Arctic 2005 Hidden Ocean Expedition. Deep-Sea Research (II).

Raskoff, K. A., J. E. Purcell, and R. R. Hopcroft. 2005. Gelatinous zooplankton of the Arctic Ocean: *in situ* observations under the ice. Polar Biology 28: 207–217.

Redburn, D. R. 1974. The ecology of the inshore marine zooplankton of the Chukchi Sea near Point Barrow, Alaska. M.S. thesis, University of Alaska, Fairbanks, AK.

Roff, J. C., and R. R. Hopcroft. 1986. High precision microcomputer based measuring system for ecological research. Canadian Journal of Fisheries and Aquatic Sciences 43: 2044–2048.

Sirenko, B. I. 2001. List of species of free-living invertebrates of Eurasian arctic seas and adjacent deep waters. Russian Academy of Sciences, St. Petersburg, Russia.

Smith, S. L. 1990. Egg production and feeding by copepods prior to the spring bloom of phytoplankton in Fram Strait, Greenland Sea. Marine Biology 106: 59–69.

Springer, A. M., C. P. McRoy, and K. R. Turco. 1989. The paradox of pelagic food webs in the northern Bering Sea. II: Zooplankton communities. Continental Shelf Research 9: 359–386.

Stepanova, V. S. 1937. Biological indicators of currents in the northern Bering and southern Chukchi Seas. Issled. Morei SSSR 25: 175–216 *[in Russian]*.

Thibault, D., E. J. H. Head, and P. A. Wheeler. 1999. Mesozooplankton in the Arctic Ocean in summer. Deep-Sea Research (I) 46: 1391–1415.

Tsyban, A. V. 1999. The BERPAC pProject: development and overview of ecological investigations in the Bering and Chukchi seas. *In* T. R. Loughlin and K. Ohtani (Eds.). Dynamics of the Bering Sea. Alaska SeaGrant College Program, University of Alaska, Fairbanks, AK. Pp. 713–731.

Virketis, M. 1952. Zooplankton of the Chukchi Sea and Bering Strait. *In* K. A. Brodsky (Ed.). The extreme north-east of the USSR. 2. Fauna and flora of the Chukchi Sea. Akademiya Nauk SSSR, Moscow, USSR. XXX pp. *[in Russian]*.

Whitledge, T. E., S. C. Malloy, C. J. Patton, and C. D. Wirick,. 1981. Automated nutrient analyses in seawater. Brookhaven National Laboratory, Upton, NY. 216 pp.

Wing, B. L. 1972. Preliminary report on the zooplankton collected on WEBSEC-70. *In* M. C. Ingham, B. A. Rutland, P. W. Barnes, G. E. Watson, G. J. Divoky, A. S. Naidu, G. D. Sharma, B. L. Wing, and J. C. Quast (Eds.). An ecological survey in the eastern Chukchi Sea. U.S. Government, Washington, DC.

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SECTION III

BENTHIC COMMUNITIES OF THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

Excerpt from Proposal by

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1. INTRODUCTION

1.1 Brief History of Subject Research in Chukchi Sea

The last 30 years have seen tremendous development and resource use in the North Slope of Alaska. Development and extraction of petroleum reserves and associated industrial and urban growth has increased the potential for adverse anthropogenic effects on the environment (Naidu et al. 1997). Concern for the Arctic environment is growing, and efforts continue to be directed toward understanding the environment of the North Slope, its seas, and adjacent arctic areas (Hopcroft et al. 2006). Resources in the Chukchi Sea are of great cultural and economic value to a broad variety of stakeholders, including Native subsistence hunters, environmental organizations, and those interested in extracting resources of economic value. In the Chukchi Sea, cultural and subsistence resources of interest mainly include marine mammals and seabirds, some of which feed on sediment-dwelling (benthic) organisms (e.g., Lovvorn et al. 2003; Grebmeier et al. 2006). Disturbance to the short food chains in the arctic has the potential for large effects on higher trophic levels, making assessment of benthic community species-composition and structure important components for monitoring.

The first investigation of infaunal community structure in the northeast Chukchi Sea was performed in 1971 to 1974 by Stoker (1978). This study was followed in 1985 and 1986 by investigations of the benthos/environmental interactions by Feder et al. (1994b) and of pelagic/benthic coupling by Grebmeier et al. (1988). A rich epifaunal community is also known for the area, including mollusks, crabs, and echinoderms (e.g., Feder et al. 1994a; Ambrose et al. 2001). These studies provided insights into the benthic fauna present and factors structuring infaunal communities. The benthic biomass of the region is high in spite of the seasonal ice cover due to the tight coupling of pelagic and ice-edge primary production and benthic community structure and production (Grebmeier et al. 2006). Current investigations in the region include the Shelf-Basin interaction study (SBI; see http://sbi.utk.edu) and the Russian-American Long-term Census of the Arctic (RUSALCA) investigating ecosystem dynamics, food-webs, and benthic ecology; however, long-term studies in the region are lacking.

The northeastern Chukchi Sea is a productive shallow sea influenced by advective processes (Grebmeier et al. 2006). Water advected into the region includes Bering Shelf (BSW) and Alaska Coastal water (ACW; Coachman 1987). The BSW has high nutrient concentrations (derived in part from water from the Gulf of Anadyr off Russia) that enhance benthic biomass, whereas the ACW along the Alaska coast is comparatively nutrient poor (Feder et al. 1994b; Codispoti et al. 2005; Grebmeier et al. 2006). The differences in nutrient concentrations in water masses lead to substantial differences in primary production, and thus, benthic community structure (Feder et al. 1994b) and benthic food web structure (Iken et al., in review). Factors influencing benthic community structure of the Chukchi Sea include sediment granulometry and sediment organic carbon to nitrogen ratios (C/N ratio) and have been identified as important predictors of community structure (Feder et al. 1994b). Sediment granulometry (e.g., percent gravel, sand, or mud) reflects a number of environmental processes, including hydrodynamics (strong currents, storms, ice gouging, etc.), sediment deposition, and proximity to sediment sources. The C/N ratio in sediments reflects the availability of particulate organic carbon to benthic animals, which is of particularly high nutrient value when derived from phytoplankton as opposed to terrigenous carbon.

The benthic community in the Chukchi Sea and northern Bering Sea is an important feeding ground for higher-trophic-level organisms such as walruses and gray whales (e.g., Oliver et al. 1983; Moore et al. 2003; Highsmith et al. 2006; Bluhm et al. 2007). Traditional feeding hot spots are located south of St. Lawrence Island and the Chirikov Basin (both in the Bering Sea) and the south-central Chukchi Sea, but recent marine-mammal observations have shown that these hotspots may be changing because of changes in both sea ice as resting platforms for walruses and seals between feeding bouts and in the benthic community structure. While the ConocoPhillips Burger and Klondike prospect areas currently are not known feeding grounds for gray whales or other higher trophic levels, monitoring effects need to include the possibility that these areas may become feeding grounds in the future. Therefore, the benthic studies suggested here will be an opportunity to provide valuable baseline information, should these areas become more important for marine mammals and seabirds in the future.

1.2 Purpose of Study and Rationale

This program constitutes the first year of a multi-year program to collect benthic macrofaunal invertebrates within the Burger and Klondike prospects, determine community structure, and assess historical environmental data from the Chukchi Sea. This is one component of a larger ConocoPhillips Chukchi Science Program for 2008. This work will provide background information for environmental impact statements (EIS) and future monitoring efforts. Results of the first year of this study will assist with planning of future sampling efforts, designing a long-term monitoring program, and contributing data to an EIS.

Long-term studies provide the means to compare temporal variation in biological communities to environmental change and assess community readjustment. Gray and Christie (1983) suggest that effects of direct anthropogenic disturbance can be observed as a difference in changes over time between a location experiencing the disturbance and a location unaffected by that disturbance. This approach helps to distinguish between anthropogenic disturbance (which shows time differences between test and control sites) and other exogenous disturbance (which is more likely to affect all sites at the same time). For example, an Alaska environmental study program assessing the effects of treated ballast-water effluents on fauna has investigated the marine environment in Port Valdez since 1971 (Hood 1973; Colonell 1980; Shaw and Hameedi 1988). Comprehensive investigations of Port Valdez in 1971 to 1980 comprised a nearly complete ecological and oceanographic assessment of the fjord (Hood et al. 1973; Colonell 1980). The current environmental studies in Port Valdez are now focused on monitoring sediments in the fjord for increases in sediment hydrocarbons and associations with changes in benthic biota (Blanchard et al. 2002, 2003, 2007). The project has been very successful at detecting small increases in sediment hydrocarbons and associated adverse responses by fauna (Blanchard et al. 2002, 2003). Similarly, long-term monitoring in the Chukchi Sea is a necessary step in understanding and protecting the environment where human impacts are planned to provide an early detection to prevent undesirable ecosystem-level effects.

Invertebrate community data from soft sediments are widely used to survey marine environments for anthropogenic effects. Infauna are excellent indicators of environmental conditions because they are not highly mobile and move small distances compared with the scale of anthropogenic stressors (Clarke 1999). Measurement of change in infaunal communities is particularly useful when assessing effects from the point-source dispersal of pollutants and sources with defined spatial limits. Investigations of infauna in the North Sea have demonstrated long-term changes in fauna in association with contaminants (drilling mud and associated contaminants including hydrocarbons) and climatic variability include increases in the abundance of the small, opportunistic polychaete families (Olsgard and Gray 1995; Pearson and Mannvik 1998; see also May and Pearson 1995). The primary source of disturbance in North Sea oil and gas platforms has been drill cuttings (particularly oil-based drilling cuttings) discharged into the sea (Olsgard and Gray 1995).

1.3 Objectives

The objective of this study will be to describe the spatial trends in macrobenthic infaunal communities. This addresses the benthic ecology component of the 2008 environmental studies program in the Chukchi Sea for CPAI. Specific objectives of the proposed work are to:

Task 1: Assessment of historical data.

- Search for and acquire historical databases of benthic fauna and relevant environmental data from the Chukchi Sea; and
- Summarize and synthesize the relevant historical databases with respect to macrofaunal community structure.

Task 2: Benthic ecology.

- Sample the benthos within the Chukchi Sea to describe benthic macrofaunal community structure;
- Sample the benthos where gray whales are observed feeding in the area; and
- Assess species-composition, abundance, and biomass of macrobenthic communities within the study area.

2. STUDY AREA

2.1 Location

The study area is located in the northeastern Chukchi Sea. Work is proposed for benthic sampling in the CPAI Klondike and Burger prospects (Introduction Figure 1)

2.2 Period of Study

The period of data collection for the 2008 program will range from mid-July to mid-October 2008.

3. METHODS AND PROCEDURES

3.1 Sampling or Survey Design and Technical Rationale

Benthic sampling will focus on sites within the Burger and Klondike prospects. Opportunistic samples will be collected in locations where gray whales are observed feeding by the marine-mammal team, but this should be, at most, a small number since the prospects are not known as feeding areas for gray whales (Highsmith et al. 2006). Thus, benthic sampling will include:

- sampling at fixed stations within the prospect sites (40 locations at each site); and
- opportunistic sampling where marine mammal scientists observe gray whales and/or walruses feeding.

We propose to sample a grid of stations from a 30 X 30-nm grid within each study site during the mid-August cruise. There will be 25 sampling points on each grid. Benthic sampling for infauna and contaminants will sample 13 of these systematic grid points and 13 randomly-selected points from the grid. (see Figure III-1). Additionally, benthic sampling will occur at the two old drill sites located in the prospects. Sampling points surrounding the drill sites will consist of a radial design with 4 transects located at 90° to each other and sampling points located at 1 km and 3 km from each drill site, for a total of 8 sampling points/grid. Additionally, it is estimated that 6 subjectively-chosen sites will be located within each grid. These subjectively-chosen sites will be opportunistic sites sampled due to marine-mammal feeding activities or for other aspects of interest. In general, re-sampling of fixed sampling locations over time along transects/grids (a model-based rather than a probability-based design) will provide the highest power for statistical comparisons between years (but will limit inferences) and will result in spatially- and temporally-correlated data. Thus, statistical methodologies considered will include methods for analyzing data in the presence of correlated error structures (e.g., linear models through SAS Proc Mixed, SAS Institute, Cary, NC, or geostatistical methods) and multivariate procedures. In terms of benthic studies, the sampling of the fixed design allows for a direct association with physical oceanography and zooplankton sampling (for which the fixed-grid design is more appropriate). Together, nutrients, phytoplankton, and zooplankton form effective biological tracers of the waters masses present in this region, and sampling the water column and benthos will allow assessment of the connections between the two. The strength of design-based sampling is that inferences are applicable to the whole of a study area. Thus, the combination of sampling approaches allows both for connections to the other oceanographic studies and inferences appropriate for the scale of the study area.

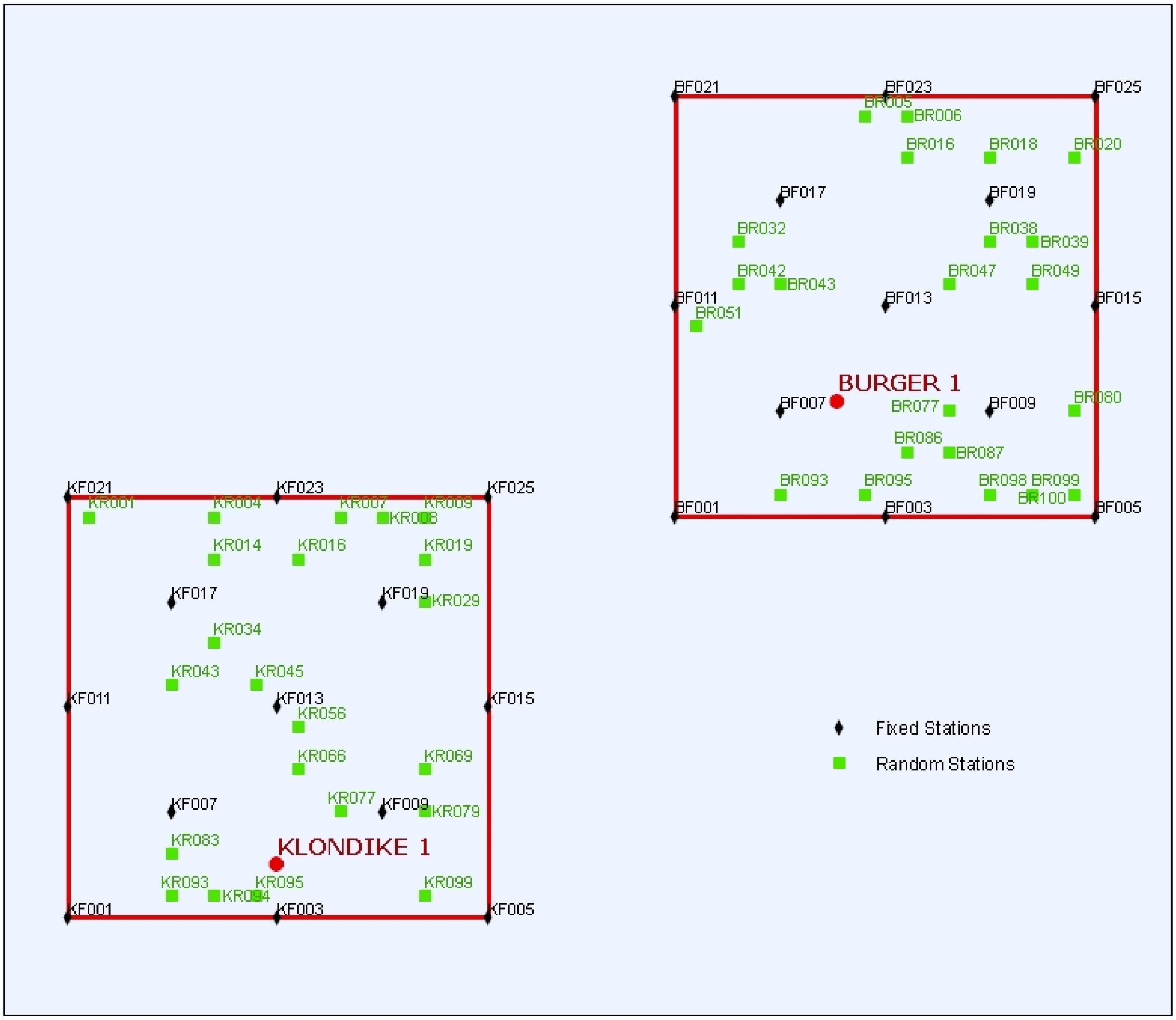

Figure III-1. Benthic/Contaminant Sampling Stations

Figure III-1. Benthic/Contaminant Sampling Stations

3.2 Field Team Size and Composition

The benthic-ecology field team will consist of two personnel. The team will consist of a research technician trained in field sampling and a Ph.D. graduate student.

3.3 Data-collection Procedures

Benthic fauna will be sampled at two prospect sites in the summer of 2008. Infaunal benthic invertebrates will be sampled with a 0.1-m2 double van Veen grab sampler (with ~30 kg of extra weight to increase penetration of the sediments) at a series of benthic stations. Three replicate samples will be collected at each station, although five replicates may be collected at some sites to help address small-scale variability. Samples will be washed through a 1.0-mm-mesh stainless-steel screen until all that is left is biological material and larger sediments. Samples will be preserved in 10% buffered formalin. Identifications of each organism will be made to the lowest practical taxon (likely family level with dominants identified to species for the first year), counted and weighed (blotted wet weight). Average faunal abundance (individuals m-2) and biomass (g m-2) will be estimated for each site. Information from the ship's bridge collected at the time of sampling includes sampling depth and GPS coordinates. This information will be recorded for every grab sample taken. Preserved specimens will be kept aboard the vessel until the vessel returns to Seward and will be shipped to Fairbanks from there. Sediments for grain-size analyses will be collected from the first grab at each station. Surface sediments will also be collected for percent organic carbon and nitrogen determinations and separately for chlorophyll and phaeopigment concentrations. These sediment samples will be frozen until delivery to UAF.

A double van Veen grab will be used to sample sediments. Contaminants and benthic samples will be taken from the grab, with each team using one of the single grabs. Sediment samples, sediment isotopes, fauna for tissue isotopes, and chlorophyll samples will be taken from the surface sediments of additional van Veen samples using one of the two van Veen grabs but will not be taken directly from the biology grab.

Biological samples will be sieved through a 1.0-mm screen, and the remains will be placed into a plastic jar with spoons and forceps. Once all animals and sediments are removed, a UAF sample tag from the sample log book (for in-lab identification only—not fort chain of custody) will be completed and placed inside the jar. The jar then will be filled with 10% buffered formalin. The sample will be listed on a chain of custody (COC) form, and an identification number written or bar-code label will be placed on the outside of the jar. The COC number will be written in the UAF sample log book as well. (Estimated total of 300 samples.)

The sample will be placed into a marine cooler or other similar packing crate. The cooler should be lined with a heavy-duty 55 gallon garbage bag. The bottom of the bag will be covered with vermiculite in which the sample shall be placed. Vermiculite will be used to fill in the spaces around samples and should cover all samples when the cooler is filled. The full bag should be closed with a cable tie. A full cooler will be wrapped with duct tape to ensure that it stays closed. This system serves as Hazmat-certifiable packaging for shipment.

A single sediment sample will be taken from one van Veen grab at each station. This sample will consist of a large tablespoon scoop of surface sediment from the top of the grab that is placed into a plastic whirl-pak bag. A UAF sample tag from the sample book will be placed in the sample bag with the sediments. The COC number will be written or the bar-code will be placed on the outside of the bag. The sample can then be double-bagged and placed into the freezer. (Estimated total of 80 samples)

Single samples for chlorophyll and isotope analysis will be collected at each station. A clean scoop will be used to scrape surface sediments and place them in a pre-cleaned vial. The COC form will be completed, and the COC information/bar-code will be placed on the vial; then, the contents ill be frozen. Tissue samples for isotope analysis, collected opportunistically from the grabs not sampled for biology, will also be placed in vials and handled accordingly. Station and replicate information will be written on the outside of each sample. (Estimated total of 200 samples.)

Sediment, isotope, and chlorophyll samples are not classified as hazardous material.

3.4 Analytical Procedures

3.4.1 Historical data assessment

Historical infaunal benthic data for the Chukchi Sea will be synthesized to understand better the ecological context of the study area and potential anthropogenic effects. Investigations of infaunal community structure include Stoker (1978), Feder et al. (1994), Grebmeier et al. (2006), the Shelf-Basin interaction study (SBI; http://sbi.utk.edu), and the (RUSALCA; http://www.arctic.noaa.gov/aro/russian-american/cruise2-objectives.htm). Other investigations of importance in the Chukchi Sea include physical oceanography (e.g., Weingartner et al. 2005), nutrient transport (e.g., Codispoti et al. 2002), distributions of epifaunal mollusk (Feder et al. 1994a), contributions of ophiuroids to benthic remineralization (Ambrose et al. 2001), and distributions of fishes (Barber et al. 1997) as well as ongoing work on infauna, epifauna, and ecosystem processes (SBI and RUSALCA). The benthic data from Stoker (1978) and Feder et al. (1994) are available from the IMS benthic data archive (A. L. Blanchard). Other data are available from IMS investigators, the SBI website (http://sbi.utk.edu), the Ocean Biogeographic Information System (www.iobis.org), the Global Biodiversity Information Facility (www.gbif.org), and the Arctic Ocean Diversity Census of Marine Life database (www.aoos.org). Available data will be integrated and synthesized as appropriate to understand spatial and temporal variability in fauna and community structure. With the addition of the proposed sampling in 2008 to the infaunal database, faunal variability will be better known, helping to guide planning of further investigations in the Chukchi Sea and assist with the required EIS. Statistical methods used may include regression, analysis of variance, correlation testing, geostatistical analyses, and multivariate methods such as cluster analysis, nonmetric multidimensional scaling, and principal components analysis. The methods applied will be determined by the data quality, but an emphasis will be placed on linear models (regression and ANOVA) whenever possible.

3.4.2 Benthic Sampling

The number and location of sampling locations is estimated as more than 300 individual samples, with potentially as many as 400 collected for processing. Thus, it is expected that many benthic samples will not be completed in time for the draft report and possibly by 1 May 2009. To ensure that a spatially-dispersed collection of samples are available for the draft report, the samples will be sorted according to established priorities. Samples will be sorted according to the following priority structure:

- First-priority samples: the first three replicates at sites from the outer edges of the prospects, every other site within the prospect, and sites of any observed gray whale feeding sites.
- Second priority: The first three replicates for each of the remaining grid point sites will be worked up.
- Third priority: the remaining replicates from the first and second priority sites.
- Fourth priority: additional random samples collected to describe smaller-scale variability.

Processing time for the any samples not completed by 31 May 2009 would be included in the next funding period, and the full data reported in a Final Report of May 2010. The priority structure above will allow for completion of a suite of stations and replicates to provide preliminary information on macrofaunal community structure. Identification of organisms to the family level for the first year will make more data available within the short time frame for the CPAI study. Alternatively, large, sandy or gravelly samples can be subsampled, an approach successfully used by Jewett et al. (1999) in describing effects from the *Exxon Valdez* oil spill.

3.4.3 Benthic Community Analyses

Benthic community data will be analyzed with appropriate and available statistical techniques. Descriptive measures, average abundance (individuals m-2), biomass (g wet weight m-2), number of taxa, and diversity measures are useful for summarizing benthic-infaunal information. Transformations of data are often required to meet assumptions of normality when using parametric statistical methods and will be considered. Expected transformations include the *ln*(x+1) transformation for abundance data and the *ln*(x) transform for biomass data. Data will be analyzed as appropriate with a range of methods including analysis of variance, linear regression, cluster analysis, and multidimensional scaling; geostatistical methods may also apply. The emphasis in these analyses will be to describe community structure of the benthic communities and to determine their spatial variability. Depending on availability of results from the other components of the CPAI Chukchi science team, such as contaminant concentrations, physical oceanography, and zooplankton ecology, other methods such as canonical correspondence analysis may be used to assess baseline associations between infaunal communities and environmental factors. Sediments for sediment-grain-size analyses will sub-contracted to an established laboratory. Surface sediments will be analyzed for percent organic carbon and nitrogen by the University of Alaska's Stable Isotope Laboratory. Chlorophyll will be determined with the fluorometer purchased for zooplankton ecology, and phaeopigment concentrations will be determined by trained IMS personnel.

3.5 Data-storage Procedures

Data for this project will be entered and stored in computer systems at UAF. A benthic data-entry system has been in use for a number of years at IMS. This data system was created to eliminate transcription errors from hand-written data sheets and other data-entry mistakes. With its use, transcription and data entry errors decreased by over 95%. This data system will be used for this study as well. The resulting data are stored in a MS Access database, but hard copies are printed out and archived separately. The data-storage system is located on a secure computer not connected to the internet. For the UAF system, backups of all data maintained there will be conducted weekly. The data on the UAF computer system will be incorporated into MS Access databases and MS Excel spreadsheets. The resulting data sets will be archived at CPAI as one of the project deliverables. Ultimately, the data will be archived with the Arctic Ocean Diversity Census of Marine Life database (www.aoos.org). The data archive at IMS also includes the original work in the Chukchi Sea conducted by Dr. Howard Feder in 1986. These data are available and will be used for temporal comparisons.

Voucher collections will be maintained at the University of Alaska, Fairbanks. 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 IMS. Sorted sediments, those with all biological material removed, will be stored for a short time to allow for validation of the sorting via quality-control procedures and then will be discarded.

3.6 Quality-control Procedures

The following quality-control procedures are followed in processing samples. The work of sorters is monitored throughout the project. At a minimum, 25% of samples sorted by student employees are checked, but more often up to 50% of the samples are checked. Of the samples checked, the sorted material is examined to be certain that 100% of the organisms in each sample are removed. One-hundred percent of the work performed by junior taxonomists is checked and verified by a senior taxonomist. Work is verified to ensure that all counts are accurate and that all organisms are correctly identified. The verification of identifications by junior taxonomists tapers off as they approach the skill level expected for a senior taxonomist. A voucher collection is maintained at IMS and includes examples of organisms found throughout the thirty-year study period in Port Valdez. This collection is used to ensure that the identification of organisms is consistent from year to year. Sorted debris from each annual survey collection is archived in sealed containers for one year. Sorted debris will be kept for one year, and organisms identified in the samples will be archived at IMS and museum repositories.

4. COORDINATION

4.1 CPAI

Safety training will be provided by CPAI. Specific training on the safe use of benthic sampling equipment will be provided by Dr. Arny Blanchard.

4.2 Other Studies in the Chukchi Sea Program

Coordination and collaboration with scientists who are working on CPAI projects in the Chukchi Sea is expected through the coordination meetings and report preparation. It is anticipated that results from the other CPAI Chukchi Sea projects will be available for determining benthic community structure. These include sediment grain-size, trace metal, and contaminants concentrations, measures of water-column productivity, and oceanographic variables.

4.3 Current Studies in the Region

A number of projects will be sampling in the Chukchi Sea in the summer of 2008. These include the RUSALCA cruise and research sponsored by Shell. Drs. Bodil Bluhm and Katrin Iken are part of the RUSALCA project and will help coordinate information transfer between the studies. Dr. Jaqueline Grebmeier, a biological oceanographer specializing in the benthos, is also part of the RUSALCA project and is managing the Shell-funded studies in the Chukchi Sea. It is anticipated that this project can be coordinated in many ways with Dr. Grebmeier's work.

5. REFERENCES

Ambrose, W. G., L. M. Clough, P. R. Tilney, and L. Beer. 2001. Role of echinoderms in benthic remineralization in the Chukchi Sea. Marine Biology 139: 937–949.

Barber, W. E., R. L. Smith, M. Vallarino, and R. M. Meyer. 1997. Demersal fish assemblages of the northeastern Chukchi Sea, Alaska. Fishery Bulletin 95: 195–209.

Blanchard, A. L., H. M. Feder, and D. G. Shaw. 2002. Long-term investigation of benthic fauna and the influence of treated ballast water disposal in Port Valdez, Alaska. Marine Pollution Bulletin 44: 367–382.

Blanchard, A. L., H. M. Feder, and D. G. Shaw. 2003. Variations of benthic fauna underneath an effluent mixing zone at a marine oil terminal in Port Valdez, Alaska. Marine Pollution Bulletin 46: 1583–1589.

Bluhm, B. A., K. O. Coyle, B. Konar, B., and R. Highsmith. 2007. High gray whale relative abundances associated with an oceanographic front in the south-central Chukchi Sea. Deep-Sea Research (II) 54: 2919–2933.

Clarke, K. R. 1999. Nonmetric multivariate analysis in community-level ecotoxicology. Environmental Toxicology and Chemistry 18: 118–127.

Coachman, L. K. 1987. Advection and mixing on the Bering-Chukchi Shelves. Component A: Advection and mixing of coastal water on high latitude shelves. ISHTAR 1986 Progress Report, Vol. 1. Institute of Marine Science, University of Alaska, Fairbanks, AK. Pp 1–42.

Codispoti, L. A., C. Flagg, V. Kelly, and J. H. Swift. 2005 Hydrographic conditions during the 2002 SBI process experiments. Deep-Sea Research (II) 52: 3199–3226.

Colonell, J. M. (Ed.). 1980. Port Valdez, Alaska: environmental studies, 1976–1979. Institute of Marine Science, University of Alaska, Fairbanks, AK. XXX pp.

Feder, H. M., S. C. Jewett, and A. Blanchard. 2005. Southeastern Chukchi Sea (Alaska) epibenthos. Polar Biology 28: 402–421.

Feder H. M, S. C. Jewett, and A. L. Blanchard. 2007. Southeastern Chukchi Sea (Alaska) macrobenthos. Polar Biology 30: 261–275.

Feder, H. M., N. R. Foster, S. C. Jewett, T. J. Weingartner, and R. Baxter. 1994a. Mollusks of the northeastern Chukchi Sea. Arctic 47: 145–163.

Feder, H. M., A. S. Naidu, S. C. Jewett, J. M. Hameedi, W. R. Johnson, and T. E. Whitledge. 1994b. The northeastern Chukchi Sea: benthos–environmental interactions. Marine Ecology Progress Series 111: 171–190.

Grebmeier, J. M., L. W. Cooper, H. M. Feder, and B. I. Sirenko. 2006. Ecosystem dynamics of the Pacific-influenced northern Bering and Chukchi seas in the Amerasian Arctic. Progress in Oceanography 71: 331–361.

Grebmeier, J. M., C. P. McRoy, and H. M. Feder. 1988. Pelagic–benthic coupling on the shelf of the northern Bering and Chukchi seas. I: Food supply source and benthic biomass. Marine Ecology Progress Series 48: 57–67.

Highsmith, R. C., K. O. Coyle, B. A. Bluhm, and B. Konar. 2006. Gray whales in the Bering and Chukchi seas. *In* J. Estes, D. P. DeMaster, D. F. Doak, T. M. Williams, and R. L. Brownell (Eds.). Whales, whaling and ocean ecosystems. University of California Press. Pp. 303–313.

Hood, D. W., W. E. Shiels, and E. J. Kelley (Eds.). 1973. Environmental studies of Port Valdez. Institute of Marine Science, University of Alaska, Fairbanks, AK. 495 pp.

Hopcroft, R., B. Bluhm, R. Gradinger, T. Whitledge, T. Weingartner, B. Norcross, and A. Springer. 2006. Arctic Ocean synthesis: analysis of climate change impacts in the Chukchi and Beaufort seas with strategies for future research. Final Report to North Pacific Research Board. 152 pp.

Iken, K., B. Bluhm, and K. Dunton. In review. Benthic food web structure serves as indicator of water mass properties in the southern Chukchi Sea. Deep-Sea Research.

Jewett, S. C., T. A. Dean, R. O. Smith, and A. Blanchard. 1999. The *Exxon Valdez* oil spill: impacts and recovery in the soft-bottom benthic community in and adjacent to eelgrass beds. Marine Ecology Progress Series 185: 59–83.

Lovvorn, J. R., S. E. Richman, J. M. Grebmeier, and L. W. Cooper. 2003. Diet and body condition of Spectacled Eiders wintering in pack ice of the Bering Sea. Polar Biology 26: 259–267.

Moore, S. E., J. M. Grebmeier, and J. R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. Canadian Journal of Zoology 81: 734–742.

Naidu, A. S., A. Blanchard, J. J. Kelley, J. J. Goering, J. M. Hameedi, and M. Baskaran. 1997. Heavy metals in Chukchi Sea sediments as compared to selected circumpolar shelves. Marine Pollution Bulletin 35: 260–269.

Oliver, J. S., P. N. Slattery, E. F. O'Connor, and L. F. Lowry. 1983. Walrus, *Odobenus rosmarus*, feeding in the Bering Sea: a benthic perspective. Fisheries Bulletin 81: 501–512.

RWJ Consulting. 2001. DeLong Mountain terminal 2000 environmental studies. Final Report to Cominco Alaska, Inc., 108 pp. + appendices.

Shaw, D. G., and M. J. Hameedi (Eds.). 1988. Environmental studies in Port Valdez, Alaska: a basis for management. Springer-Verlag, New York, NY. 423 pp.

Stoker, S. W. 1978. Benthic invertebrate macrofauna of the eastern continental shelf of the Bering and Chukchi seas. Ph.D. dissertation, University of Alaska, Fairbanks, AK. XXX pp.

Weingartner, T. J., K. Aagaard, R. Woodgate, S. Danielson, Y. Sasaki, and D. Cavalieri. 2005. Circulation on the north-central Chukchi Sea shelf. Deep Sea Research (II) 52: 3150–3174.

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SECTION IV

MEASUREMENTS OF CONTAMINANTS IN THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

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1. INTRODUCTION

CPAI is sponsoring a multi-year scientific field program in two large prospect areas, called Klondike and Burger, where exploratory drilling occurred in 1989 and 1990 (see Introduction Figure 1). The field program will provide needed baseline (pre-drilling) information on the physical, chemical, and biological oceanography, including assessment of zooplankton, fishes, and benthic biological communities, and on the distribution and concentrations of chemical contaminants associated with offshore oil and gas operations (metals and hydrocarbons) in the Klondike and Burger prospect areas. Field studies of seabirds and marine mammals, will share the field vessel, which is contracted for this program by CPAI.

This Survey Plan includes site locations; numbers, types, and locations of samples/devices to be deployed/collected; and sampling procedures.

1.1 Objectives

The objective of the CPAI Chukchi Sea Environmental Studies Program is to develop necessary baseline information about the marine environment in the CPAI lease areas for submission to the MMS. The multiple years of pre-drilling baseline information will be used as part of an analysis of potential effects of on-shore and offshore oil and gas activities on the Chukchi Sea marine environment and its resources, including particularly valued resource species such as bowhead whales, gray whales, walruses, and subsistence-fishery resources. This analysis will be used in the preparation of several regulatory documents, including National Pollutant Discharge Elimination System (NPDES) permits, NEPA documents, and IHA and LOA for incidental, unintentional takes of marine mammals and protected marine birds. Because area-wide environmental information would substantially enhance the value of the site-specific information that will be developed for the two CPAI prospect areas, every effort will be made to coordinate with and collaborate in similar environmental studies in the Chukchi Sea by other lease holders, MMS, and resource trustee agencies (NMFS, USFWS).

The objective of the 2008 Contaminants Program is to collect baseline (pre-drilling) data on metals and hydrocarbons in sediments, zooplankton, and benthic invertebrates in the Klondike and Burger prospect areas. The target chemical contaminants include selected metals and hydrocarbons that may be present in permitted or accidental discharges during drilling and during oil and gas production, as well as metals and hydrocarbons that will be useful in identifying potential sources of the metals and hydrocarbons in sediments and tissues. The target marine biota includes species that are important in the food webs leading to marine mammals (bowhead, gray, and beluga whales, walruses, and ice seals) and seabirds.

Specifically, the Contaminant Study's objectives are:

- Describe spatial and seasonal characteristics of the zooplankton and benthic-invertebrate communities in the two study areas.
- Obtain opportunistic samples of zooplankton where bowhead whales are observed feeding, or samples of benthic invertebrates where gray whales are observed feeding.
- Describe spatial characteristics of various contaminants (hydrocarbons and metals) in the two study areas to provide a baseline before exploratory drilling.

2. STUDY AREA

The outer continental shelf of the Chukchi Sea is the least-developed continental shelf area of the United States. The northeastern Chukchi Sea lies north of latitude 70°N and is covered with sea ice for much of the year. However, it is a biologically-rich area with high biological productivity that is supported by nutrient inputs from the Bering Sea, upwelling from the Arctic continental slope, and inflow from the western (Russian) Chukchi Sea.

Portions of the Chukchi Sea were offered in lease sales in 1988 and 1991. Five exploratory wells were drilled, plugged, and abandoned between 1989 and 1991. Two wells drilled by Shell Oil Co., Klondike and Burger (see Introduction Figure 1), showed promising formation geology and potential shows of hydrocarbons, primarily gas and condensate. CPAI was a successful bidder in Lease Sale 193 for lease blocks in the Klondike and Burger prospects. These prospects lie approximately 75 miles offshore of Wainwright, AK, in about 30-50 m of water.

3. FIELD SAMPLING METHODS AND PROCEDURES

CPAI has arranged the use of the multipurpose vessel M/V Bluefin for the field surveys. The CPAI ship's contractor—Tulugaq, LLC (Fairweather Marine)—will equip the vessel with the major equipment and supplies required for the conduct of the Contaminant Study. The Contaminant Study field team will provide the specialized equipment (e.g., sample jars, amphipods traps, grab sampler) required for the trace organic and inorganic chemistry sampling. All Contaminant Study field staff will be available for boarding the vessel in Wainwright, AK, on about 18 August 2008.

3.1 Field Team

The field team for the Contaminant Study will be comprised of two experienced field chemists who have extensive knowledge in the deployment of sampling equipment and the collection and sampling of sediment and biota for trace-chemical analyses. It is currently expected that the contaminant field-sampling task will be completed during the 32-day August–September field survey (Cruise 2). However, if all of the contaminant study field components cannot be completed during the first survey due to weather, schedule, or other factors, two field personnel will participate in the September–October field survey (Cruise 3) to complete the 2008 Contaminant Study field-sampling objectives. Mr. John Hardin of Battelle and Dr. Waverly Thorsen of Exponent will participate in the August–September survey. If necessary, Mr. John

Brown of Exponent and/or other Exponent or Battelle field chemists will support the Contaminant Study field sampling task during Cruise 3.

3.2 Survey Schedule

The contaminants survey is scheduled for the second cruise of the 2008 field survey. The second survey cruise is scheduled to begin on about 19 August and continue to about 20 September 2008. The Field Team will arrive in Wainwright, Alaska, on about 19 August 2008 where they will depart for the study area. The first half of the cruise will focus on Site One, and the second half of the cruise will target Site Two.

3.3 Sampling Design and Numbers of Samples

The overall design of the Contaminant Study field sampling will be based on a stratified-random strategy, where each of the two the prospect areas will be gridded for random-sample collection locations and the historic drill sites in each prospect will be considered a central location for site-specific sample locations, along with other fixed locations based on oceanographic and biological features (e.g., depositional basins, productive shoals, whale and walrus feeding areas). Figure IV-1 shows the layout of fixed sample stations at each prospect.

3.3.1 Fixed-station Strategy

- The Contaminant Study design will include 13 fixed stations from each prospect area that will be selected based on establishing a 7.5 nautical mile (nm) grid on the 30 X 30 nm prospect block and establishing stations on the grid corners and every other grid block intersection.
- In addition, another six fixed stations (per prospect) will be selected opportunistically to include potential depositional areas or bathymetric features (e.g., shoal areas), whale or walrus feeding sites identified during the survey, areas that may not be adequately covered by the random sampling, and potentially several reference or special-interest sites outside of the two study areas (i.e., reference sites located up current from any prospective development activities).

3.3.2 Site-Specific Sampling Strategy

- The site-specific stations will be established as four radials around each of the historical exploratory drill sites in the prospect blocks (Klondike and Burger drill sites) (see Figure IV-2).
- The radials will be oriented along the axis of and perpendicular to the prevailing currents in the study area (roughly north–south and east–west).
- Each radial will include stations at 1.0 and 3.0 km from the central point, yielding eight site specific stations for each of the lease blocks (16 total stations).
- However, these radial dimensions may be modified (expanded to encompass the specific lease block) if a central point or drill location is not known at the time of the survey.

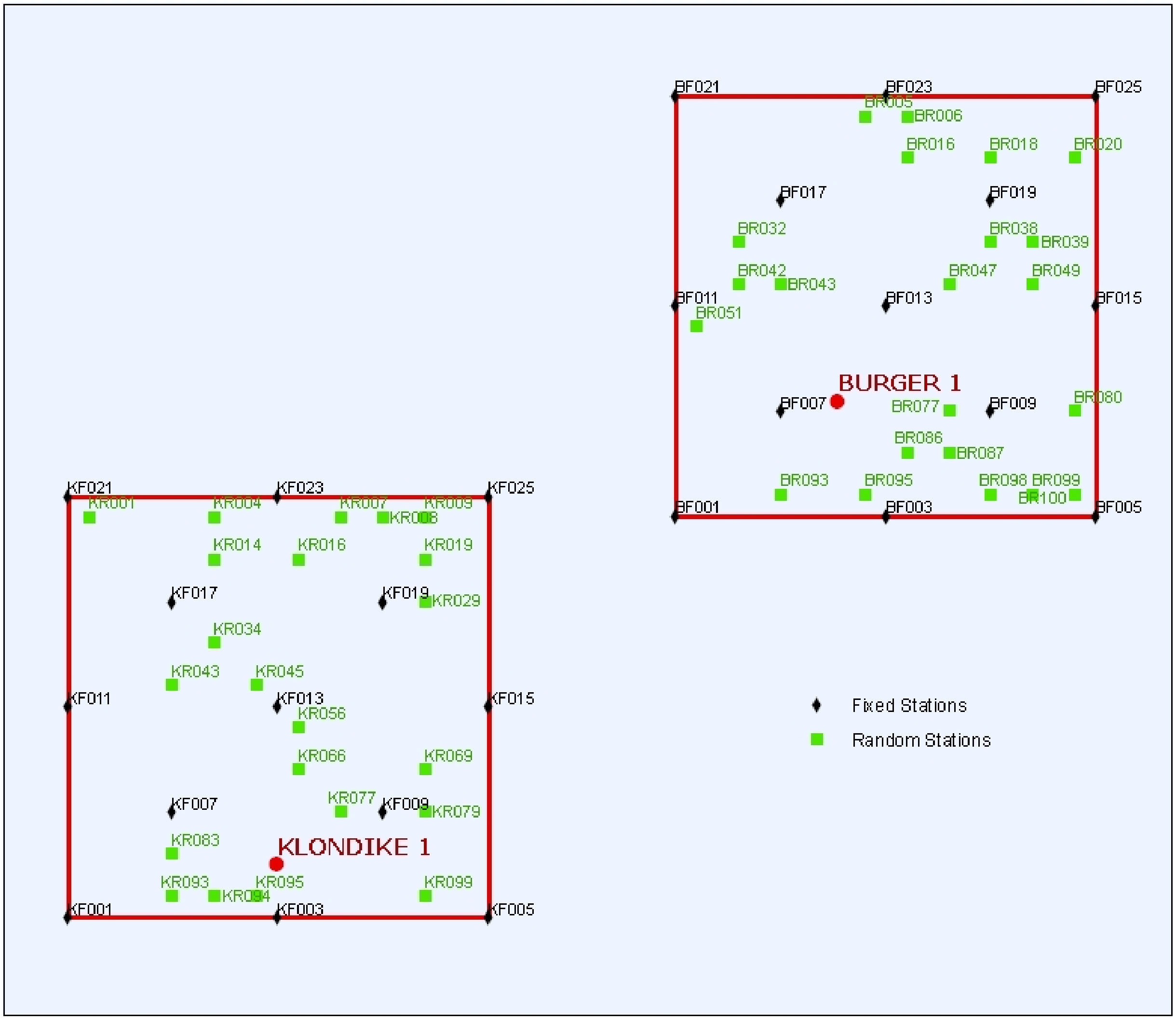

Figure IV-1. Contaminant Sampling Stations

Figure IV-1.   Contaminant Sampling Stations

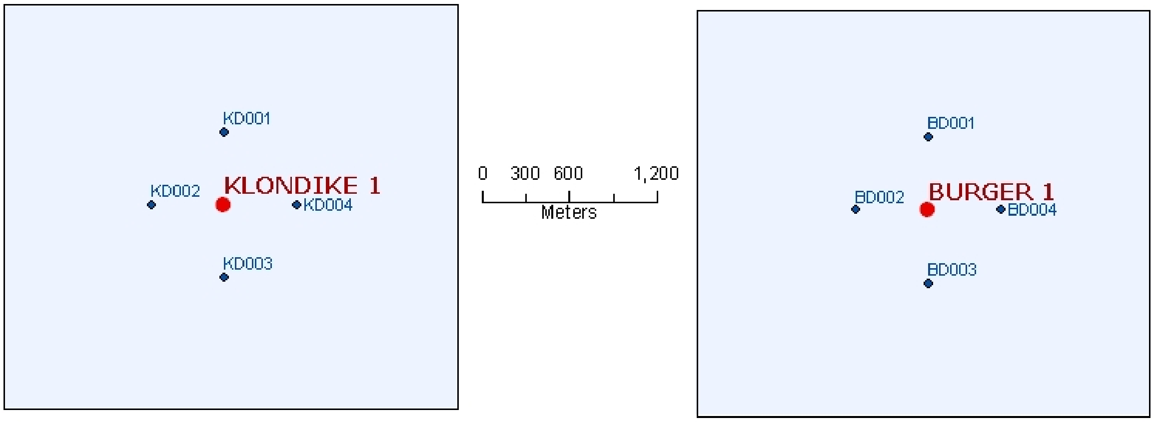

Figure IV-2. Historic Drill Site Sampling Stations

Figure IV-2 Historic Drill Site Sampling Stations

3.3.3 Random-sampling Strategy

- The random station design will involve establishing a 3 nm square grid throughout each of the two 30-nm-square study blocks (900 nm2).
- Each block will be sequentially numbered, and 13 stations will be randomly selected for contaminant sampling from each of the two study areas.
- Alternate random stations will also be established in case a selected random station does not yield acceptable depositional sediment substrate (e.g., coarse gravel).
- The selection of stations with depositional sediment (>20% silt/clay) is essential for the Contaminant Study, as little monitoring information on chemical contaminants will be gained from sampling sediments from coarse-grained (i.e., net erosional) areas.

All stations selected for sediment contaminant sampling will be candidates for biota-contaminant samples (bivalves, amphipods, and zooplankton). However, it is expected that, due the patchiness of biota in the study areas, only a subset of stations will yield sufficient biota for contaminant measurements. The current estimate is that approximately one-third of the stations will yield one or more species of biota for contaminant sampling. Wherever possible, biota sample collection will be coordinated with the benthic biology study, so split samples can be obtained. A list of the proposed number of Contaminant Study stations and expected number of samples (sediment and biota) is presented in Table IV-1. The contaminant sampling will be conducted in conjunction with the benthic infaunal study and it is expected that benthic infaunal samples (3–5 replicates) will be collected at each contaminant station.

Table IV-1. Estimated number of stations and samples for the Contaminant Study

Study Area	Block Dimensions	Block Size (nm^2)	No. Site Specific Stations	No. Random Stations	Fixed Stations	Total Stations	Total Sediments[a]	Total Tissues[a]
Klondike	30 x 30 nm	900	8	13	19	40	**44**	23
Burger	30 x 30 nm	900	8	13	19	40	**44**	23
Total						**80**	**88**	**46**

[a] Includes field triplicates

3.4 Sample-identification Scheme

The sample identification scheme will follow the format described below. To accommodate the specific type of sampling for this survey, the code for each digit in the sample identification is provided in Table IV-2, below.

Example Station ID: 08-01-######-01-SC

Table IV-2. Sample-identification Code

Positions	Code	Example
1-2	Year	08 (2008)
3-4	Survey	01
5-10	Site Code	???
11-12	Replicate	01, 02, etc.
13-14	Sample Type	SC, AC, EB, etc.

Sample Type:
SC – Sediment Chemistry
AC – Amphipods Chemistry
BC – Bivalve Chemistry
ZO – Zooplankton
EB – Equipment Blank

3.5 Sampling

Standard sampling procedures will be followed at each sampling station according to standard Exponent procedures as detailed in this field-sampling plan. The sequence of events at each sampling station will follow the procedures described below, including:

- Identify target station (latitude and longitude)
- Navigate to station position within 0.1 nm radius of location
- Deploy and retrieve zooplankton nets (as required)
- Deploy amphipod traps (as required)
- Collect sediment using a modified van-Veen grab sampler
- Collect bivalves using a mechanical clam dredge

- Retrieve amphipod traps (as required, may be retrieved after sampling at other stations)
- Navigate to next station

Photodocumentation, station logs, and field notes will be produced during the field survey. The station logs for each sampling station will be included in the field report and photographs will be provided electronically. Station logs include a description of the sampling location, observations, number and type(s) of samples collected, and comments.

3.5.1 Sediment Sampling

Sediment sampling will be performed using a modified double van Veen grab-sampler constructed of stainless steel and Kynar coated. During the collection and handling of sediment samples from the grab sampler, extreme care will be taken throughout the subsampling process to avoid contact with metals and hydrocarbon sources. Samples will be taken away from the sides of the sampler, and no metal spatulas will be used for the trace-metal samples. The grab sampler will be protected from stack smoke, grease drips from winches and wire, and other potential airborne contaminants during the sampling process.

The double van Veen grab-sampler is designed to be deployed from a vessel equipped with a power winch and A-frame or boom system and to collect undisturbed surface sediment samples to a maximal depth of approximately 19 centimeters (cm). The double van Veen grab sampler provides the added benefit of allowing contaminate and benthic-infaunal samples to be collected from the same sampler deployment. The operation of the grab sampler for collection of a bulk sediment sample and the collection and handling of subtidal sediment chemistry samples is summarized below.

The grab-sampler has the ability to add weight (for stiff sediment) or ‘floatation’ (to prevent sinking in soft sediment to successfully collect samples in a variety of conditions, including deep stations and heavy seas. When the grab sampler is returned to the deck of the vessel, the sample will be visually inspected to ensure the bucket is closed and the scissors are extended upright. The doors will be opened and the sample visually inspected for sediment and overlying water in the bucket. Overlying water indicates that the sediment sample is undisturbed and that surface sediments remain intact (i.e., there was no leakage of water and, hence, fine sediment from the grab). When a grab is determined successful, samples will be collected; otherwise, the grab's contents will be discarded and the grab sampler will be redeployed.

Subsamples will be removed from the grab sampler through the hinged doors on the top of the bucket. Overlying water is removed from the grab by siphoning through a pre-cleaned Teflon® tube using a siphon bulb or by carefully cracking the grab jaws to allow the water to flow out without disturbing the sediments. When used, the Teflon® tube will be decontaminated prior to use.

Sediment samples will be collected from the top 2 cm of the grab, which represents recent accumulation. Unconsolidated sediment 2 cm deep will be removed from the grab with a Kynar-coated scoop. The 2 cm-deep scoop design facilitates accurate depth collection of the sediment. The top 2 cm will be collected with several scoops up to the volume needed for the sample aliquots and placed directly in appropriate sample containers for organics, metals, total organic carbon (TOC), and grain-size analyses. Trace metal samples will be removed from the grab sampler with a Teflon® spatula, placed into pre-cleaned plastic vials, and refrigerated. Samples to be used for grain-size analysis will be doubled-wrapped in labeled Ziploc® storage bags or polyethylene jars and refrigerated. Organic samples will be placed in pre-cleaned, 250 mL wide-mouth glass jars and frozen.

After the desired subsamples are collected, an open basin is placed beneath the grab on the grab stand. The grab jaws will be opened by releasing tension on the lifting wire and collapsing the scissor mechanism. Any remaining sediment that falls into the basin is discarded. The grab is rinsed with clean seawater from a deck hose and decontaminated with distilled water and ethanol/isopropanol rinses prior to deployment at a new station.

Surface sediments will be shipped to Battelle (Duxbury, MA) and Chemistry Laboratories at FIT (Melbourne, FL) in coolers packed with blue ice and custody sheets. Upon receipt, each sample will be logged and transferred to a refrigerator (trace metals) or freezer (organics) pending sample analysis.

3.5.2 Benthic-biota Sampling

Bivalve and amphipod samples will be collected at selected stations as part of the sampling survey. A Fish Resource Permit will be obtained from the State of Alaska Department of Fish and Game (ADF&G) to allow for the collection of benthic-biota samples.

Amphipods will be collected with Nitex® mesh-lined, polyethylene minnow traps baited with sardines. The traps will be deployed for approximately 2–6 hours (depending on other sampling activities at adjacent stations) with an anchor and float equipped with a radar reflector to facilitate retrieval of the traps. The sardine bait is placed in an enclosed Nitex® mesh pouch to reduce the possibility of sardine particles becoming entrained with the amphipods. Multiple amphipods will be collected at each sampling station to obtain enough mass for a single sample. The target sample volume is 50 milliliter (mL) for amphipods. If amphipods are scarce at some sampling stations, less volume may be collected and submitted as a sample. Amphipods will be removed from the traps, washed with clean seawater, and placed in a clean sieve for sorting. Non-target amphipods, zooplankton, or any isopods will be removed with clean forceps prior to transfer of the sample into the appropriate sample container. Based on previous species-abundance data from the Chukchi Sea, it is expected that target amphipods will include Byblis breviramus and Paraphoxus spp. (Feder et al. 1989).

Clam samples will be collected with a double van Veen grab sampler if target species are encountered in sufficient abundance and density. Multiple grab samples will be sieved through a 1.0–2.0 cm sieve with clean site water. Target clam species in good condition will be carefully removed to a clean sieve, rinsed with site seawater, and transferred into the appropriate sample containers using clean forceps or spatulas. Multiple clams will be collected at each sampling station to obtain enough mass for a single sample. The target clam sample volume is 200 mL (with shells). Clams are determined to be in good condition if they are alive with unbroken shells. Clam samples for organics and metals will be stored frozen in pre-cleaned 250-mL glass jars.

If sufficient clams for a sample are not found after 4 grab-sampler attempts, a scientific clam dredge will be used to collect clams. The dredge will be deployed from the ship with a powered winch and dragged along the bottom at 250-m intervals and checked for the presence of target clam species. Dredged clam samples will be handled in the same manner described for the grab-sampler technique. It is expected that the most abundant target bivalves will be Nucula bellotti and Macoma calcarea but may also include Astarte spp. (Feder et al. 1989). The large gastropod Neptunea heros, which is abundant in the Chukchi Sea (Feder et al. 2005), may also be collected as an alternate mollusk if clam samples are difficult to obtain.

3.5.3 Zooplankton Sampling

Zooplankton samples will be collected at a series of stations (currently, all fixed-grid stations are designated for zooplankton sampling) with a plankton tow net with a screened sample bucket attached to the end and equipped with a flowmeter. The tow net will be lowered to ~20 m and raised at a constant, slow speed to collect the samples. Once the net is lifted out of the water, it will be gently rinsed from the outside to free organisms from the side of the net and to concentrate them into the sample bucket. The screening and the sides of the bucket are rinsed very gently with a hose to collect the entire sample into the 250-mL sample container. The target sample volume is 25 mL for zooplankton. If insufficient zooplankton biomass is collected with the first tow, additional tows will be conducted and/or less volume may be collected and submitted as a sample. The zooplankton samples will be transferred to a sample container and preserved by freezing. The flowmeter reading, depth of tow(s), and angle of tow will be recorded in the field sampling log. If large numbers of the preferred foods of bowhead whales (calanoid copepods and euphausiids) are collected, these species will be separated from the bulk zooplankton and analyzed separately.

3.5.4 Field Quality Assurance/Quality Control.

Field quality control samples will be collected during the field-sampling program to assess overall accuracy and representativeness of the sampling efforts. The number of quality-control (QC) samples to be collected for this effort will be based on the total number of field samples collected; one QC sample will be collected for every 20 discrete field samples. Quality-assurance (QA) techniques will be used in sampling activities to avoid potential contamination and cross-contamination, including the use of pre-cleaned sample containers, clean sampling equipment, equipment decontamination, and good laboratory practices. Standard sampling procedures and protocols will be followed.

3.5.4.1 Equipment Decontamination.

All field-sampling equipment will be decontaminated prior to use at each sampling station. The equipment-decontamination procedure is as follows:

- Scrub with brushes and liquid soap-and-water mixture to remove accumulated sediment;
- Wipe clean with a sorbent pad, paper towel, or rag (if necessary);
- Rinse with clean site seawater (from hose or buckets, as appropriate);
- Rinse with distilled water;
- Rinse with isopropanol solvent, or acetone wipe (optional); and
- Rinse with deionized water (optional).

The clean equipment is prevented from being recontaminated prior to sampling by either decontaminating immediately prior to use or protection by wrapping securely in clean aluminum foil. Precautions will be taken to ensure that clean equipment does not contact anything other than the sample, air, or other clean equipment. Clean equipment is prevented from contacting the deck (except for the immediate sampling area), hands, clothing, plastic bags, buckets, trays, and other surfaces.

3.5.4.2 Sample Handling.

At all times after collection, sample integrity and custody will be maintained. COC procedures are followed for all sample-storage and shipment activities. COC seals and sample labels will be applied to each sample container, ensuring sample integrity. All field samples will be unambiguously labeled in waterproof ink with the following information:

- Sample site;
- Unique field-sample number;
- Date and time of sample collection; and,
- Details of preservation used.

Pre-cleaned sample containers that have been certified as such by the vendor will be used for the program. In the field, sediment, biota, and QC samples for chemical analysis will be immediately inventoried and stored frozen (–20°C) in a secure area after collection and until the completion of the cruise. Inventorying includes counting the samples to ensure that all samples will be collected and returned to the custody area on board, documenting all samples in field logs, and preparing the COC forms.

Table IV-3. Sample Volume Containers and Preservation.

Sample Type/Analysis	**Minimum Volume/Weight**	**Sample Container and Preservation**	**Ship to:**
Sediments - Organics	100 mL	250 mL glass jar – frozen (-20°C)	Battelle Attn: Heather Carlson 397 Washington St. Duxbury, MA 02332-0601
Sediment – Metals, TOC, Grain Size	200 mL	500 mL plastic jar – frozen for metals and TOC and refrigerated (4°C) for grain size	Florida Institute of Technology (FIT) Attn: John Trefry 150 West University Blvd. Melbourne, FL 32901
Amphipods – Organics and Metals	50 mL	250 mL glass jar – frozen	Battelle
Bivalves – Organics and Metals	200 mL	250 mL glass jar or cleaned foil pouches in Ziplock bags - frozen	Battelle
Equipment/Field Blanks – Organics	200 mL	250 mL glass jar - frozen	Battelle
Equipment/Field Blanks – Metals	200 mL	250 mL plastic jar - refrigerated	FIT

3.5.4.3 Site Documentation and Reporting

The field team will complete the following site documentation for each site visited.

<u>Type of Documentation</u>	<u>Frequency</u>
1) Daily sampling logbook	daily
2) Station log or logbook	1/station
3) COC forms and labels	as needed/site
4) Photodocumentation of each station	as needed/site

3.5.4.4 Daily Sampling Logbook

The daily-sampling logbook is intended to summarize activities on a daily basis, including stations visited, sampling activities, list of samples collected, and other activities. The report will consist of a summary of the station(s) sampled, samples collected, and notations of any deviations from standard operating procedures (SOPs) or difficulties in sampling.

3.5.4.5 Station Log/Logbook

The log will be used to record the station name, code, date, time, latitude/longitude, and personnel involved in sampling.

3.5.4.6 Chain of Custody Forms and Labels

Sample labels will be pre-printed to the extent practical. Sample containers will be labeled prior to the collection at the sampling site. The COC Forms will be completed prior to sample shipment.

3.5.4.7 Photodocumentation

Sample grabs and collection activities will be photodocumented with a digital camera. Photographs, from the digital camera will be downloaded to a computer at the end of each survey day.

3.5.4.8 Sample Shipment

Following completion of the cruise, samples will be packed in coolers for overnight shipment via Federal Express airfreight courier. The samples will be frozen prior to transportation and shipped to the appropriate analytical laboratories; either frozen, packed on blue ice, or refrigerated packed with blue ice via overnight service. Custody seals will be used on all shipping coolers to maintain custodial security while the samples will be in the possession of a third party (i.e., airfreight courier).

3.5.4.9 Field Quality-control Samples

Several types of field QC samples will be collected during the field survey, including equipment blanks, field blanks, source samples and/or field replicates. For all field QA/QC samples, one sample aliquot will be collected for each analysis type (e.g., metals, organics).

3.5.4.10 Equipment Blanks

Equipment blanks will be collected during sampling to assess the possibility of sample cross-contamination due to the field-sampling equipment. Five equipment blanks will be collected throughout the survey and will be representative of the different sample-collection techniques. The procedure used for collecting the equipment blank samples will be to decontaminate the grab sampler following the defined procedure, rinse with high-purity deionized water, and collect samples of the rinsate for each analysis type. Equipment blanks are collected directly into pre-cleaned, pre-labeled water sample containers. A pre-cleaned stainless-steel funnel may be used to assist in the collection. The equipment blank samples will be preserved by refrigeration at 4°C.

3.5.4.11 Field Blanks

Field blanks may be collected during sampling to assess the possibility of atmospheric or other contamination that the field samples may have been subject to. Since the equipment blanks will also be exposed to potential atmospheric and other contamination sources, field blanks will be collected only if there is a situation possibly impacting the samples that needs to be investigated independently from the equipment blanks. Field blanks are collected by carrying a pre-cleaned, pre-labeled sample jar into the working area, opening and removing the cover during the collection of one sample, and returning the empty jar to the laboratory with the field samples. The field blanks will be stored under the same conditions as their associated field samples.

3.5.4.12 Field Replicates

Field-replicate (triplicates) sediment samples (and biota samples of sufficient volume) will be collected during sampling to assess reproducibility and within station variability. Two sediment triplicates and two biota triplicates (assuming sufficient numbers of organisms are encountered) will be collected during the survey. Separate aliquots of the sediment or tissue sample will be placed into multiple sample containers for organics, metals, TOC, and grain-size analyses (as appropriate) and assigned unique identifiers. The field replicates will be stored under the same conditions as their associated field samples.

3.5.4.13 Field-source Sample

Field-source samples may be collected during sampling to characterize any potential sample contamination believed to originate from the shipboard diesel fuel (e.g., exhaust, surface sheen). A pre-cleaned filter will be used to collect samples representative of diesel fuel and exhaust residue by wiping impacted surfaces. The wipe samples will be placed into pre-cleaned glass jars. The field source samples will be stored under the same conditions as their associated field samples.

3.6 Safety Considerations

All field team members are required to attend a three-day safety training course prior to the survey cruises and to adhere to all policies, procedures, and guidelines presented during the training sessions.

3.6.1 Personnel Protection

Field procedures may require the use of several hazardous chemicals, including isopropanol and/or acetone wipes. Personnel should avoid direct contact with all chemicals and avoid breathing fumes. Contact with solvents will cause irritation of eyes, nose, throat, and/or skin. Acetone is a flammable organic solvent that may be used for equipment decontamination. Material Safety Data Sheets (MSDS) will be available for each hazardous material on board. MSDS describe chemical properties, health hazards, and protection and safety measures. Refer to the MSDS if you are unsure of the characteristics of a chemical. Follow these general guidelines when handling chemicals:

- Wear rubber gloves (household or laboratory nitrile, if possible).
- Wear safety glasses (most sunglasses and corrective glasses are not safety glasses).
- Work in a well-ventilated area (on the open deck of ships, if possible).
- Store chemicals securely and well padded.
- Store chemicals away from living quarters and away from heat and ignition sources.

Waste solvents (if generated) must be collected and disposed of separately from other waste streams. Collect all waste solvents (used to rinse equipment) in a compatible container that is clearly labeled as waste solvents.

All personnel will adhere to health and safety precautions established by the vessel contractor and CPAI. Specific safety requirements include the following:

- Learn the location of all fire equipment, life rings, life preservers, and survival suits and know their proper use.
- In the event of an emergency, know what your duties are.
- Smoking in bunks is strictly prohibited.
- No open-toed shoes will be worn when working on the deck.
- No equipment will be deployed over the side without permission from the captain. All gear must be aboard and secured before moving between stations.
- When working on deck at night, use the buddy system. During rough weather, do not go out unless necessary and always tell someone if you must go out.

Personal protection equipment will be used by all personnel during the survey. Mustang suits or float coats must be worn at all times while working on the deck of the ship.

Safety glasses are to be worn when decontaminating equipment or when using any chemicals. Nitrile gloves will be worn during sampling activities or when handling any samples.

3.6.2 Shipping of Samples and Hazardous Materials

There are no specific Department of Transportation (DOT) regulations related to the shipment of frozen biota and sediment samples. The shipping requirements for Federal Express shipping are summarized below.

- Chemistry samples will be packed in a clean plastic cooler with sufficient blue ice to keep the samples frozen for 3 days. Seal the cooler with strapping tape and affix custody seals.
- Use clear tape to fix address label to the top of the cooler or use plastic handle tags. The address label must contain the shipper's full name and address and the recipient's full name and address and phone number.

4. COORDINATION

4.1 CPAI

The contaminants field survey will be closely coordinated with Caryn Rea of CPAI. Coordination will be in the form of email, phone calls, a field-survey report (from Exponent), and the field-debriefing meeting.

4.2 Other Studies

The contaminants field program will be closely coordinated with the other studies in the program. As noted previously, the contaminants program will sample the same suite of stations as the benthic-infaunal program and will collect sub-samples of zooplankton (if sufficient volume is obtained) at a subset of stations where zooplankton will be collected. In addition, the contaminants survey will coordinate with the marine-mammal observation team to designate potential contaminants-sampling stations where significant whale or walrus feeding is observed.

5. REFERENCES

Feder, H. M., A. S. Naidu, M. J. Hameedi, S. C. Jewett, and W. R. Johnson. 1989. The Chukchi Sea continental shelf: benthos–environmental interactions. U.S. Dept. of Commerce, NOAA, OCSEAP Final Reports 68: 25–311.

Feder, H. M., S. C. Jewett, and A. Blanchard. 2005. Southeastern Chukchi Sea (Alaska) epibenthos. Polar Biology 28: 402–421.

SECTION V

SEABIRDS OF THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

Adapated from proposal by
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1. INTRODUCTION

1.1 Brief History of Subject Research in the Chukchi Sea

Data on the at-sea distribution and abundance of seabirds in the northeastern Chukchi Sea during the open-water season are very limited. This limitation is caused by the area's inaccessibility and because most of the interest in seabirds in this area has concentrated on seabird colonies and on seabirds at sea in the vicinity of the Hope Basin, which is north of Bering Strait and in the southern Chukchi. The primary seabird colony to be studied is located at Cape Lisburne, which is part of the Alaska Maritime National Wildlife Refuge; a few years of data also have been collected at Cape Thompson, which is south of there. In addition, there has been some research on birds in the coastal-lagoon systems of the northeastern Chukchi Sea—probably as much as has been conducted on birds at sea in this area.

There are few historical at-sea data for this area. The first research was conducted by Jacques (1930), who surveyed birds in the Bering Sea and western Chukchi Sea in July–August 1928. Later, Swartz (1967) examined the at-sea distribution of seabirds in the southern and central Chukchi during the environmental studies at Cape Thompson for a short time in 1960.

The interest in oil development in arctic Alaska in the 1970s led to a burst of research on seabirds and other marine organisms. However, this area also has had little recent research, to a great extent because of its inaccessibility. The main research in recent years has been conducted by (1) Divoky (1970), who studied seabirds in this area from a USCG Icebreaker; (2) Divoky (1979), who described some aspects of the Chukchi Sea open-water avifauna; and (3) Divoky (1987), who studied seabirds at sea in the Chukchi Sea in the early 1980s as part of the OCSEAP. Unfortunately, the latter report was never released by OCSEAP as part of its "Environmental Assessment of the Alaskan Continental Shelf" publication series, so it is difficult to locate. The massive at-sea seabird database summarized by Gould et al. (1982) included no data from the Chukchi Sea. As part of OCSEAP studies, Johnson (1993) studied the importance of nearshore lagoons to migrating geese.

More recently, there has been some ship-of-opportunity sampling of seabirds in the Chukchi conducted primarily by the U.S. Fish and Wildlife Service and some aerial surveys for migrating and staging Spectacled and Steller's eiders, both of which are protected under the Endangered Species Act. The latter surveys have indicated that Ledyard Bay in particular is an important stopover area for migrating Spectacled Eiders in late summer and the fall (Balogh 1997). Finally, there has been extensive research conducted on seabird colonies in the eastern Chukchi Sea for many years by David Roseneau, primarily at the Alaska Maritime National Wildlife Refuge unit at Cape Lisburne; these studies have built on earlier work begun on nesting seabirds at Cape Thompson by Swartz (1966).

This lack of information on seabirds at sea in this area is discussed by the National Research Council (1994), which said:

> "There are few published data on the at-sea distribution of marine birds in the Chukchi Sea during the open-water season, but unpublished reports of Divoky (1987) provides a useful overview and documents a moderately high number of shearwaters and alcids using the central and southern Chukchi sea. Studies by Piatt et al. (1992), Andrew and Haney (1993), and Schauer (1993) provide a useful overview of the pelagic distribution of birds in the Bering Strait and the southern Chukchi Sea, in which large concentrations of birds are to be expected between June and September. Data for the northern Chukchi Sea are inadequate to assess the potential effects of offshore oil development in that region, and data are lacking on the mechanisms and locations that might lead to predictable, large concentrations of foraging seabirds in the central and eastern Chukchi Sea."

We point out, however, that all of the studies cited in this critique of the lack of information are from the southern Chukchi and the Hope Basin. Hence, the National Research Council apparently did not even consider the available at-sea information on seabirds in the northern Chukchi (see review above) to be useful enough to mention.

1.2 Purpose of Study and Rationale

The overall purpose of the study is to provide to CPAI necessary baseline information about the marine environment in the CPAI lease areas that can be used in applications for permits, in an EIS, and in other documents and to help manage these resources. This information will be needed to inform applications for permits such as NPDES permits, and to provide information that can be used to help prepare an EIS that examines possible effects of this offshore drilling and oil production.

1.3 Objectives of Study

The specific objectives of the seabird component of this study are to:

- describe spatial and seasonal characteristics of the seabird community in the overall development area and the area covered by the EIS;
- 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 in 2008.

2. STUDY AREA

2.1 Location

The general study area is in the northeastern Chukchi Sea, where there are two prospects called "Klondike" and "Burger" (see Introduction Figure 1). These two areas are located ~60 nm offshore from the villages of Wainwright and Icy Cape, in ~40–60 m of water. This area is ice-covered during much of the year, being available for ship-based sampling only during the summer–fall months.

The field study will be concentrated in two study-area boxes called "Klondike" and "Burger." Each box consists of three lease-blocks within a core area and is 30 nm on a side when a buffer zone for marine mammals is included around the perimeter. (This buffer zone must be added because of the possible effects of noise on marine mammals, especially cetaceans.) These two 900-nm2 (~3,367-km2) study-area boxes will be the focus of the seabird (and other oceanographic) sampling.

2.2 Period of Study

The field component of the seabird study will be conducted from mid-July to late October 2008. It will consist of three research cruises: 12 July–16 August; 16 August–19 September; and 19 September–23 October 2008.

3. METHODS AND PROCEDURES

3.1 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 these 900-nm2 boxes. Lines will be spaced 2 nm apart, creating a set of 26 parallel survey lines each 30 nm long; hence, every fifth line will coincide with a line of oceanographic stations that will be sampled by other researchers on the boat (see Figure V-1). At a ship's speed of ~9–10 kt, each line can be surveyed in ~3 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, each study area will be surveyed at least once over a period of ~16 days on each of the three cruises. The same survey lines will be surveyed on each subsequent cruise, so that inter-cruise comparisons can be made.

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

3.2 Field Team Size and Composition

The seabird team will consist of 8–10 observers total who will rotate though the three cruises planned for the summer, with each individual cruise team consisting of two observers who will trade off observation duties throughout the day. One member of the seabird team also will function as the Chief Scientist of the cruise and will be primarily responsible for assessing survey conditions, managing data collection and processing,

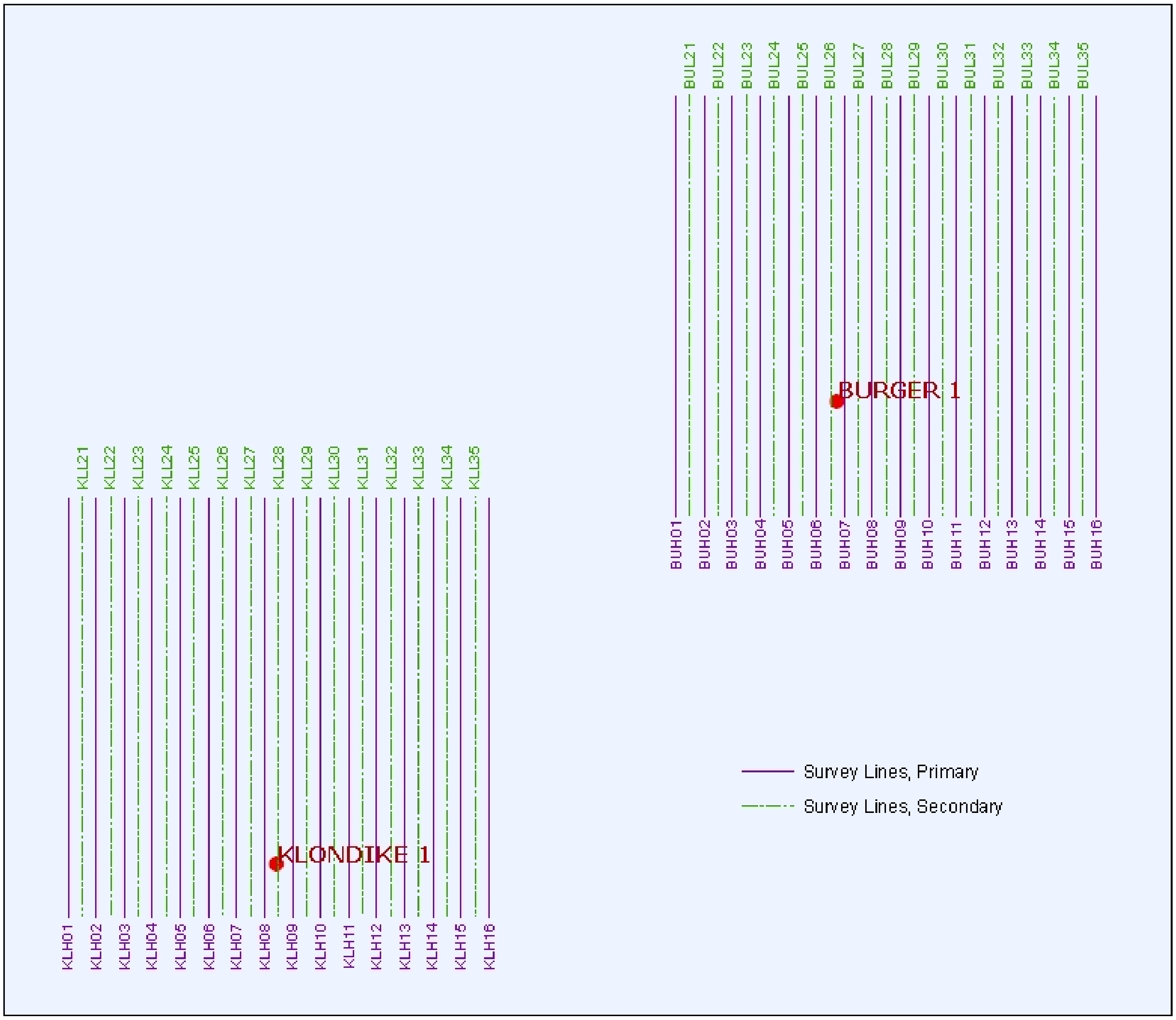

Figure V-1. Seabird Survey Lines

Figure V-1. Seabirds Survey Lines

submitting daily and weekly progress reports, and coordinating with other research groups and crew on the vessel.

3.3 Data-collection Procedures

The survey 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 higher seas if inclement weather has limited our ability to sample. 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 the bridge of the vessel 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 reticule binoculars to determine distance) and ensure that the bird is within 300 m of the ship;
- radial angle of the observation from the ship (to the nearest 10°);
- 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.

Observations of all birds will be entered directly into a computer that is connected to a GPS by using DLog software (R.G. Ford Consulting, Portland, OR), so that every observation will be time-stamped and geo-referenced. The time stamp will be synchronized with data from on-board computers to facilitate matching bird observations with other environmental measurements (e.g., depth, sea-surface temperature, sea-surface salinity).

3.4 Analytical Procedures

After each day's sampling, we will download additional data from the ship's automated data-collection system and attach those data either to specific records that we have collected or to all data collected within an hour or within a transect. Examples of data that will be attached to specific records that we have collected include GPS readings, positional accuracy of those readings, sea-surface temperature, sea-surface salinity, fluorometry reading, and water depth. Examples of data that will be synchronized to all data collected within an hour include average ship's speed and average true wind speed. Examples of data that will be attached to all data collected within a transect include the average ship's heading.

We will estimate density (birds/km2) for each species or species-group by using distance-sampling analyses available in the program DISTANCE (Thomas et al. 2006). The analysis consists of three steps. First, a detection function for each species will be 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 will be used to estimate the mean flock size for the population. Finally, the density of birds will be estimated for the entire study area by incorporating the probability of detection, the area surveyed, and the mean flock size. These estimates also may be stratified to examine possible relationships between physical- and biological-oceanographic features and the distribution and abundance of seabirds.

We will summarize species-richness and species-composition of the bird community by cruise and area to examine temporal and spatial patterns in these community-level attributes (Magurran 1988). 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 on the water's surface (birds observed/km2) to compare our data with historical data (e.g., Divoky 1987) compiled in the "Alaska Pelagic Seabird Database," which is maintained by the U.S. Geological Survey—Biological Resources Division (USGS—BRD) in Anchorage, AK. This database is available to the public.

We will partition out those historical data that apply to the general vicinity of the CPAI study-area boxes and will summarize the data to determine the abundance of seabirds in the general area and, if needed, in the two study areas separately. If enough data are available for analysis, we may be able to partition the data by larger units of time (e.g., decades) to evaluate temporal trends in abundance of selected species.

3.5 Data-storage Procedures

We will enter data electronically on a laptop computer or Pocket PC real-time during the surveys. We then will back up those data files onto a portable hard drive at least once every 24 hours in the field. We will import the output files from DLog into the project database for data storage, management, and archiving every day onto the laptop, the hard drive, and the daily data upload to CPAI via satellite. Upon conclusion of a cruise, we will bring the observational data and data from the ship's computers back to Fairbanks and will load it onto the secure server at ABR, Inc. We will deliver archived data to ConocoPhillips as a deliverable item, following the guidelines in CPAI document "Data Protocols Version 3.4b April 2008."

3.6 Quality-control Procedures

Prior to surveys, the Principal Investigator or his designee will conduct data-collection, identification, and data-entry training for personnel who will be participating on these cruises. The data-collection training will emphasize 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 or Pocket PC 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 line, 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, and any changes to records will be noted in a separate table within the Access database.

4. COORDINATION

4.1 CPAI

We will coordinate with CPAI on all aspects of the study. We will attend a pre-cruise meeting to coordinate planning. The Principal Investigator or his designee also will provide daily information to the Chief Scientist on each cruise so that a daily report can be sent to CPAI from the field. In addition, we will attend a post-field meeting in Anchorage to discuss the research program and will provide a written summary of monthly activities to CPAI via the Monthly Contractor Reports.

4.2 Other studies in the Chukchi Sea Program

This research will be conducted at sea as part of an interdisciplinary team of oceanographers and ecologists who are part of the Chukchi Sea program. We will make every attempt to coordinate the sampling with the other researchers who will be aboard at that time. The seabird sampling will be coordinated with the marine-mammal observers, in particular, because of the similarity in sampling methods and requirements.

The Principal Investigator has conducted collaborative research with some of the other members of the Research Team. He has conducted research at sea with Dr. Weingartner (physical oceanographer) as part of the oceanographic study GLOBEC (Global Ocean Ecosystem Dynamics), which was a joint research program of the National Science Foundation and the National Oceanic and Atmospheric Administration. He also has been involved in research on the effects of the *Exxon Valdez* oil spill with the hydrocarbon-chemistry team and has led many cruises as Chief Scientist, whose primary role is coordinating among the various studies.

Biologists at LGL Alaska also will be conducting studies at sea in the Chukchi in 2008 for Shell Alaska. We have attempted to coordinate with them in terms of sampling methods, but Robert Rodrigues (in litt.) indicated that they will not be conducting systematic surveys for seabirds and instead will be concentrating on marine mammals.

4.3 Current studies in the region

There are few, if any, dedicated at-sea studies of seabirds occurring at this time in the Chukchi Sea. The U.S. Fish and Wildlife Service conducts ship-of-opportunity data collection on seabirds at sea in Alaska, but it is not clear at this time whether they will be doing any in the Chukchi Sea in 2008 (K. Kuletz, in litt.). In addition, Dr. Lames Lovvorn of the University of Wyoming has collected some data from icebreakers in the northern Bering Sea and the southern Chukchi Sea in the past few years, but he will not be doing any research in this specific area in the foreseeable future (J. Lovvorn, in litt.).

5. REFERENCES

Balogh, G. R. 1997. Status report of the Spectacles Eider (*Somateria fischeri*), a threatened species. Unpublished report prepared by U.S. Fish and Wildlife Service, Anchorage, AK. 62 pp.

Divoky, G. L. 1970. Pelagic bird and mammal observations in the eastern Chukchi Sea, early fall 1970. Pages 111–172 *in* WEBSEC–70: An ecological survey in the eastern Chukchi Sea, September–October 1970. U.S. Coast Guard Oceanographic Report No. 50 (CG 373–50).

Divoky, G. J., 1979. Sea ice as a factor in seabird distribution and ecology in the Beaufort, Chukchi, and Bering Seas. Pp. 9–17 *in* Conservation of marine birds of northern North America (J. C. Bartonek and D. N. Nettleship, Eds.). U.S. Fish and Wildlife Service, Wildlife Research Report No. 11.

Divoky, G. J. 1987. The distribution and abundance of birds in the eastern Chukchi Sea in late summer and early fall. Unpublished report prepared for National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program (NOAA/OCSEAP), Boulder, CO, by Arctic Environmental Information and Data Center, Anchorage, AK. 96 pp.

Gould, P. J., D. J. Forsell, and C. J. Lensink. 1982. Pelagic distribution and abundance of seabirds in the Gulf of Alaska and eastern Bering Sea. U.S. Fish and Wildlife Service, Biological Services Program, Report No. FWS/OBS-82/48. 294 pp.

Gould, P. J., and D. J. Forsell. 1989. Techniques for shipboard surveys of marine birds. U.S. Fish Wildlife Service Technical Report No. 25. 22 pp.

Johnson, S. R. 1993. An important early-autumn staging area for Pacific Flyway Brant: Kasegaluk Lagoon, Chukchi Sea. Journal of Field Ornithology 64: 539–548.

Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, NJ. 179 pp.

National Research Council (Committee to Review Alaskan Outer Continental Shelf Environmental Information). 1994. Environmental information for outer continental shelf oil and gas decisions in Alaska. National Research Council, Washington, DC. 270 pp.

Swartz, L. G. 1966. Sea-cliff birds. Pp. 611–678 in Environment of the Cape Thompson Region (N. J. Wilimovsky and J. N. Wolfe, Eds.). U.S. Atomic Energy Commission, Oak Ridge, TN.

Swartz, L. G. 1967. Distribution and movement of birds in the Bering and Chukchi seas. Pacific Science 21: 332–347.

Tasker, M. L., P. H. Jones, T. J. Dixon, and B. F. Blake. 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101: 567–577.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J. R. B. Bishop, and T. A. Marques. 2006. DISTANCE 5.0 (Release 2). Research Unit for Wildlife Population Assessment, University of St. Andrews, United Kingdom. [available at: http://www.ruwpa.st-and.ac.uk/distance/]

SECTION VI

MARINE MAMMALS OF THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

Adapted from proposal by
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1. INTRODUCTION

1.1 Brief History of Subject Research in Chukchi Sea

Marine mammal research in the Chukchi Sea has been very limited in the last ten years. Recent research has included surveys of bearded and ringed seals by Bengtson et al. (2005), polar bear by Evans et al. (2003), and beluga whales by Suydam et al. (2005). In addition, CPAI and Shell have conducted marine-mammal monitoring programs in 2006 and 2007 for seismic operations. Except for these programs, marine-mammal research programs in the Chukchi Sea occurred over 15 years ago by Brueggeman, Moore, and Ljungblad. Consequently, research needs to be conducted to provide current information on the use of the Chukchi Sea by marine mammals for planning oil and gas exploration and development programs.

1.2 Purpose of Study and Rationale

The purpose of this study is to provide current information on marine-mammal use of the Chukchi Sea, specifically in areas proposed by CPAI for oil and gas exploration. The information will provide a baseline for planning oil and gas operations and future research programs.

1.3 Objectives of Study

The objectives of the study are to:

- Determine the species composition;
- Determine the seasonal abundance and distribution; and
- Identify important areas for marine mammals, including feeding areas based on distribution and behavior.

2. STUDY AREA

2.1 Location

The location of the study area is defined by CPAI as two rectangular areas (survey areas) west of Wainwright in the Chukchi Sea, named Burger and Klondike (see Introduction Figure 1). Each area is 30 X 30 nm square and contains several potential oil and gas drilling sites. The location of the study area is provided in the RFP and is not repeated in this study plan.

2.2 Period of Study

The period of study will begin on about July 18 and will end on about 23 October. There will be three vessel-based research cruises, each ~ 28 days long.

3. METHODS AND PROCEDURES

3.1 Sampling or Survey Design and Technical Rationale

Surveys will be conducted from the research vessel within each survey area. Trained observers will record marine mammals along north–south transect lines equidistantly spaced across each survey area. Each transect line will extend 30 nm and be spaced 2 nm apart, representing 16 transect lines. (see Figure VI-1). Each survey area may shift to ensure coverage 6 nm beyond the outer edge of any potential drilling site to capture the area affected by drilling sounds to a 160 dB level; this is the sound level that NMFS defines for potentially causing behavior disturbance to marine mammals. Transect lines will be surveyed sequentially from south to north or north to south to minimize fuel usage and maximize time.

Each survey area will be surveyed at least once during each 32-day cruise, depending on the weather conditions. The order of the surveys will depend on the location of the ice and seismic activity, but it is anticipated that the first survey will begin at Klondike (southernmost area) and the last survey will begin at Burger (northernmost area). It is anticipated that a full survey will require a minimum of 5 days to complete/survey area or 10 days for both areas, assuming a cruising speed of 10 kt. Because of ice and/or bad weather, it is likely that fully completing the surveys will require the entire time allocated per cruise. The number of north–south transect lines surveyed may be modified to accommodate changing weather conditions, particularly in the fall, to ensure that surveys cover the entire survey area for each cruise period.

3.2 Field Team Size and Composition

Two marine mammal observers will be on each cruise. Observers will be experienced and trained in vessel surveys.

3.3 Data-collection Procedures

Vessel based observer(s) will watch for marine mammals from the best available vantage point on the vessel, which is usually the bridge or flying bridge. The observer(s) will scan systematically with the naked eye and 7 X 50 reticle binoculars. Observer(s) will focus on the 180° area centered on the vessel's trackline, with occasional scans of the area behind the vessel. Marine-mammal observations will occur for up to 16 hours/day, depending on weather conditions and day length. Observers will alternate 4-hour watches, so each observer is on watch for no more than 8 hours/day. Observations will begin one hour before sunrise. Data will be recorded on field forms and transferred to an MS Excel spread sheet loaded into a laptop computer.

When a mammal sighting is made, the following information will be recorded:

- Species, group size, age/size/sex categories (if determinable), behavior, heading (if consistent), bearing and distance from vessel;

- Date, time, and location of the vessel, sea state, ice cover (10% increments), visibility, and sun glare; and
- The positions of any other vessel(s) in the vicinity of the research vessel.

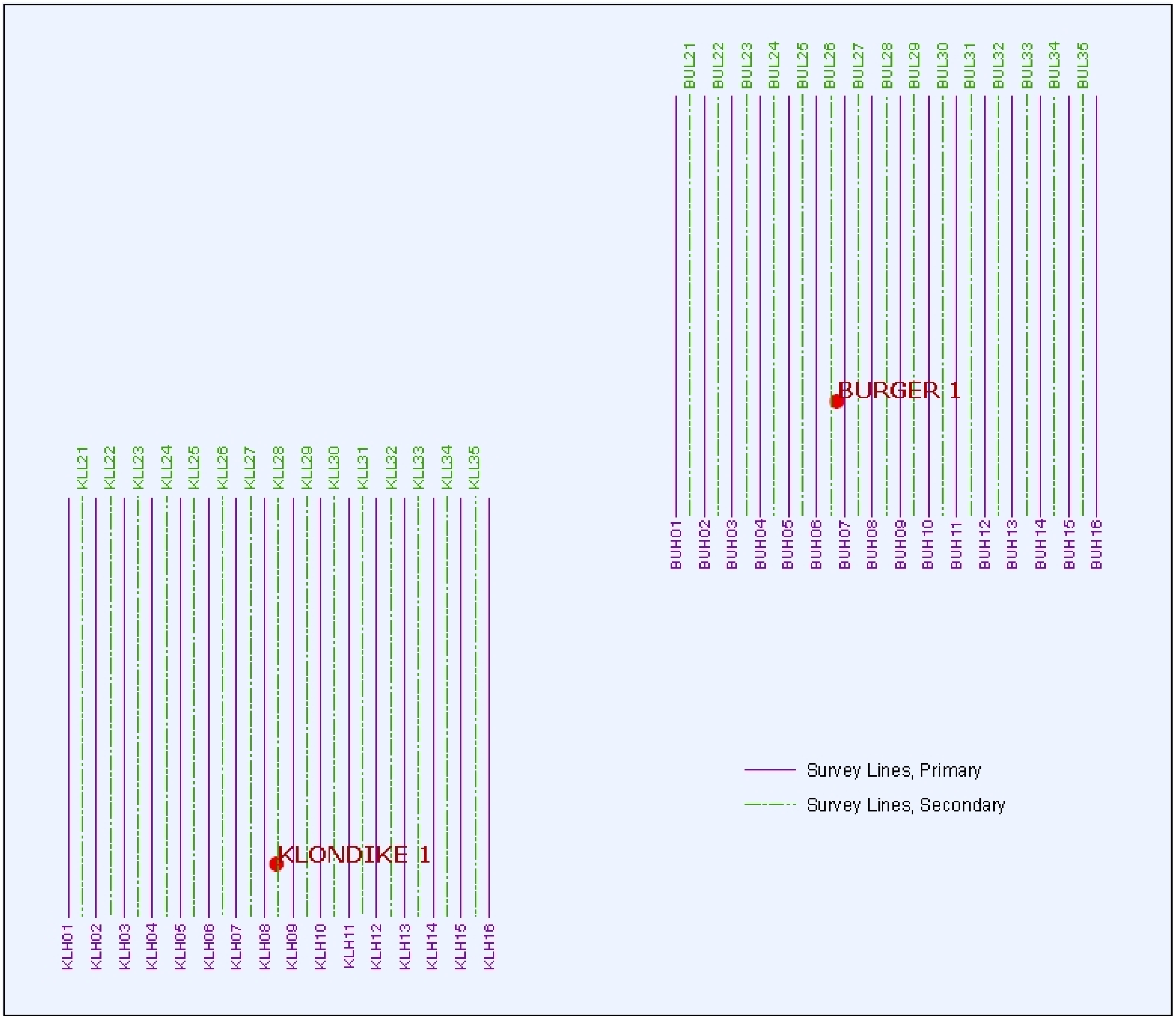

Figure VI-1. Marine Mammal Survey Lines

Figure VI-1. **Marine Mammal Survey Lines**

The ship's position and water depth, sea state, ice cover, visibility, and sun glare will be recorded at the start and end of each observation watch and, during a watch, every 30 minutes and whenever there is a change in one or more of those variables. Location will be obtained from either a hand-held GPS or the navigation system on the ship.

Distances to nearby marine mammals will be estimated visually or with sighting aids (e.g., laser range-finder, fixed points, clinometer, reticule in binoculars). Observers will use sighting aids to test and improve their abilities for visually estimating distances to objects in the water. Surveys will generally not be conducted during sea states exceeding a Beaufort 5 because marine mammals become too difficult to detect in seas this high. (See Appendices 1–3 for data-collection codes and Appendix 4 for the field form).

3.4 Analytical Procedures

The analytical procedures will largely be determined by the sample sizes of the data collected on each marine-mammal species. However, standard approaches will be used, including Chi-square and regression analysis for spatial and temporal relationships and line-transect analysis for density estimates.

3.5 Data-storage Procedures

Field data will be recorded on an MS Excel spreadsheet stored on a laptop computer. The MS Excel spreadsheet will have all of the fields for data collected in the field. The data entered into the computer will be backed up onto CDs and USB keys. If possible, data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data CDs carried back to the MMOs' contractor office during crew-replacement rotations.

3.6 Quality-control Procedures

Observers on the vessel will record observations onto datasheets and then will enter them into an MS Excel file loaded on a laptop. During periods between watches and periods when operations are suspended, those data will be cross-checked by the observers. The accuracy of the data entry will be verified in the field by manually checking of the data sheets for completeness, accuracy, legibility, and logic. Additional checking will occur in the office after the field season.

4. COORDINATION

4.1 CPAI

Field studies, data analysis, and reporting will be closely coordinated with Caryn Rea of CPAI. Coordination will be in the form of emails and phone calls from Principal Investigator Jay Brueggeman and from meetings.

4.2 Other Studies in the Chukchi Sea Program

The marine-mammal study will be closely coordinated with the other studies in the program. This coordination will especially include the seabird program, whose observers will work closely with the MMOs on the vessel, sharing sighting information. The study will also be closely coordinated with the zooplankton studies for obtaining samples in areas of feeding marine mammals. Marine-mammal observations will also be closely coordinated with the acoustic study to assist in linking a species with recorded sounds of calling marine mammals. The overall coordination effort will be fully discussed between investigators of the studies at a meeting scheduled before the field program begins.

4.3 Current Studies in the Region

The MMS is funding a bowhead whale feeding study in the Beaufort Sea off Barrow, Alaska, which is referred to as BOWFEST (Bowhead Whale Feeding Ecology Study). This study includes aerial surveys of bowhead whales and corresponding vessel sampling of the physical and biological oceanography. In addition, there will be an acoustic study to determine spatial and temporal distribution of bowhead whales, and various characteristic of bowhead calls. The marine mammal study that is the subject of this proposal to CPAI will closely coordinate with the BOWFEST lead, Dave Rugh, of the National Marine Mammal Laboratory.

5. REFERENCES

Bengston, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999–2000. Polar Biology. 28: 833–845.

Brueggeman, J. J., R. A. Grotefendt, M. A. Smultea, G. A. Green, R. A. Rowlett, C. C. Swanson, D. P. Volsen, C. E. Bowlby, C. I. Malme, R. Mlawski, and J. J. Burns. 1992. 1991 Marine Mammal Monitoring Program, Walruses and Polar Bears, Crackerjack and Diamond Prospects, Chukchi Sea. Shell Western E&P, Inc., and Chevron USA, Inc. 109 pp. + appendices.

Brueggeman, J. J., R. A. Grotefendt, M. A. Smultea, G. A. Green, R. A. Rowlett, C. C. Swanson, D. P. Volsen, C. E. Bowlby, C. I. Malme, R. Mlawski, and J. J. Burns. 1992. 1991 Marine Mammal Monitoring Program, Whales and Seals, Crackerjack and Diamond Prospects, Chukchi Sea. Shell Western E&P, Inc., and Chevron USA, Inc. 62 pp. + appendices.

Brueggeman, J. J., C. I. Malme, R. A. Grotefendt, D. P. Volsen, J. J. Burns, D. G. Chapman, D. K. Ljungblad, and G. A. Green. 1990. 1989 Walrus Monitoring Program, Klondike, Burger, and Popcorn Prospects in the Chukchi Sea. Shell Western E&P, Inc . 121 pp. + appendices.

Brueggeman, J. J., D. P. Volsen, R. A. Grotefendt, G. A. Green, J. J. Burns, and D. K. Ljungblad. 1991. 1990 Walrus Monitoring Program, Popcorn, Burger, and Crackerjack Prospects in the Chukchi Sea. Shell Western E&P. Inc. 53 pp. + appendices.

Evans, T. F., A. S. Fischbach, S. Schliebe, S. Kalxdorff, G. York, and B. Manly. 2003. Polar Bear Aerial Survey in the Eastern Chukchi Sea. Arctic 56: 359–366.

Ljungblad, D. K., S. E. Moore, and D. R. Van Schoik. 1984. Aerial surveys of endangered whales in the Beaufort, eastern Chukchi, and northern Bering seas, 1983: with a five year review, 1979–1983. Report from Naval Ocean Systems Center, San Diego, CA, for U.S. Minerals Management Service, Anchorage, AK. NOSC Technical Report No. 955. 356 pp. [NTIS AD-A146 373/6]

Ljungblad, D. K., S .E. Moore, and D. R. Van Schoik. 1986. Seasonal patterns of distribution, abundance, migration, and behavior of the Western Arctic stock of bowhead whales, *Balaena mysticetus*, in Alaskan seas. Reports of the International Whaling Commission, Special Issue 8: 177–205.

Ljungblad, D. K., S.E. Moore, J. T. Clarke, and J. C. Bennett. 1987. Distribution, abundance, behavior, and bioacoustics of endangered whales in the Alaskan Beaufort and eastern Chukchi seas, 1979–86. Report from Naval Ocean Systems Center, San Diego, CA, for U.S. Minerals Management Service, Anchorage, AK. NOSC Tech. Rep. 1177; OCS Study MMS 87-0039. 391 pp. [NTIS PB88-116470]

Ljungblad, D. K., B. Würsig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41: 183–194.

Moore, S. E. 2000. Variability in cetacean distribution and habitat selection in the Alaskan Arctic, autumn 1982–91. Arctic 53: 448–460.

Moore, S. E., and R. R. Reeves. 1993. Distribution and movement. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (Eds.). The bowhead whale. Society of Marine Mammalogy, Lawrence, KS. Special Publication No. 2. Pp. 313–386

Suydam, R. S., L. F. Lowry, and K. J. Frost. 2005. Distribution and movements of beluga whales from the eastern Chukchi Sea stock during summer and early autumn. Final Report, OCS Study No. MMS 2005-035. 48 pp.

APPENDIXES

APPENDIX 1. FIELD CODES FOR VESSEL SURVEY DATA.

STUDY AREA

K	KLONDIKE
B	BURGER
O	OTHER

DATE

Two number values (i.e., 01, not 1)

WATCH START–END

WS	Watch Start
WE	Watch End

OBSERVER

Two letter initials of on-duty observer

LEG TYPE

S	Systematic leg for survey along transect lines
D	Deadhead leg for survey between connecting transect lines
T	Transit leg for transiting between study areas or between land and study area

LEG NUMBER

Leg number sequentially ordered from east to west along transect lines; deadhead or transit legs are not numbered so leave blank

TIME

Two number values (i.e., 01, not 1)

POSITION

Two digit Degrees
Two digits, two decimal minutes

SEA STATE

0	Glassy
1	Ripple
2	Small wavelets
3	Large wavelets, scattered white caps
4	Small waves, frequent white caps
5	Moderate waves, many white caps with chance of spray
6	Large waves, white foam crests with some spray

7–11 See handbook table

VISIBILITY (# KM)

0–10 km
Or > < 3.5 if variable

GLARE AMOUNT

NO	None
LI	Little
MO	Moderate
SE	Severe

WATER DEPTH

In meters

SIGHTING ID

Consecutive #
Use same number for repeat record of same group/individual

MARINE MAMMAL SPECIES

Whales/Porpoises

BW	Bowhead Whale
WW	Beluga Whale
GW	Gray Whale
HW	Humpback Whale
FW	Fin Whale
KW	Killer Whale
UD	Unidentified Dolphin
HP	Harbor Porpoise

Pinnipeds

RS	Ringed Seal
BS	Bearded Seal
SS	Spotted Seal
RB	Ribbon Seal
SL	Northern Sea Lion
US	Unidentified Seal
PW	Pacific Walrus
UP	Unidentified Pinniped

Bears

PB	Polar Bear

MOVEMENT

AB	Across Bow
ST	Swim Toward

SA	Swim Away
FL	Flee
SP	Swim Parallel
MI	Mill
NO	No movement
DE	Dead
UN	Unknown

INDIVIDUAL OR GROUP BEHAVIOR

MA	Mating
DI	Dive
LO	Look
TR	Travel
BR	Breach
LT	Lobtail
SH	Spyhop
FS	Flipper Slap
FE	Feeding
FL	Fluking
BL	Blow
BO	Bow Riding
RE	Resting
MI	Milling
OT	Other (describe)
NO	None (sign seen only)
UN	Unknown

ESTIMATE METHOD

R	Range Finder
E	Estimate by eye
F	Relative to fixed point
B	Binocular reticules (0–16)

Where At/Where To

Numbers on a 12-hr clock

CLOSEST POINT OF APPROACH (CPA)

Nearest distance of individual/group (m)

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APPENDIX 2. WIND SPEED, BEAUFORT WIND FORCE, AND SEA-STATE CODES

The Beaufort Scale: Sea-based specification

Sea State Code (Force)	Speed (10 m above ground)		Description	Specifications for use on land
	Miles per hour	knots		
0	0-1	0-1	**Calm**	Sea like a mirror
1	1-3	1-3	**Light air**	Ripple with the appearance of scales are formed, but without foam crests.
2	4-7	4-6	**Light Breeze**	Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break.
3	8-12	7-10	**Gentle Breeze**	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.
4	13-18	11-16	**Moderate Breeze**	Small waves, becoming larger; fairly frequent white horses.
5	19-24	17-21	**Fresh Breeze**	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.
6	25-31	22-27	**Strong Breeze**	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.

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APPENDIX 3. RETICLE-BINOCULAR DISTANCE SCALE (BASED ON FUJINON 7 X 50 BINOCULARS AND A DECK HEIGHT OF 6.1 M ABOVE THE WATER).

Reticle	Distance (m)
0.5	1623.9
1	967.1
1.5	690.9
2	537.9
2.5	440.5
3	373.0
3.5	323.5
4	285.6
4.5	255.7
5	231.4
6	194.5
7	167.8
8	147.6
9	131.7
10	118.9
11	108.4
12	99.6
13	92.1
14	85.7

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SECTION VII

ACOUSTIC MONITORING AND ANALYSIS OF MARINE-MAMMAL SOUNDS AND SEISMIC EXPLORATION IN THE KLONDIKE AND BURGER PROSPECT REGIONS OF THE CHUKCHI SEA

Adapted from proposal by
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Bioacoustics Research Program
Cornell University and Laboratory of Ornithology
Ithaca, NY

1. INTRODUCTION

1.1 Brief History of Subject Research in the Chukchi Sea

Marine mammals depend on the production and perception of sounds for reproduction and survival. They produce and perceive sounds for communicating, navigating, finding food, and sensing predators. Human-generated underwater sounds and noise can interfere with these critical biological functions. For example, noise may affect an animal's ability to detect sounds such as the calls of other animals of the same species, echoes from prey, and natural sounds that aid in navigation or foraging. Noise also may affect physiological functions and cause more generalized stress.

1.2 Brief History of Bioacoustic Research in the Chukchi Sea

There has been little effort to study marine mammal bioacoustics in the Chukchi Sea. In 2006, the Bioacoustics Research Program at Cornell (BRP), which was under contract with Fairweather, deployed suites of autonomous seafloor acoustic recorders, referred to as "pop-ups," in the Chukchi Sea from mid-July through mid-October. The primary objectives of the field and data-analysis efforts were to detect the occurrence and approximate offshore distributions of bioacoustically active beluga whales (*Delphinapterus leucas*) and bowhead whales (*Balaena mysticetus*), measure and characterize ambient noise, document the occurrences of seismic airgun array events, and measure the received levels of seismic airgun array events for 79 selected time periods from late summer to early fall throughout a broad region from Cape Lisburne to Point Barrow. In 2007, a further summer-fall bioacoustic research and monitoring field effort was undertaken by JASCO in support of Shell. This study expanded the size of the area acoustically sampled to detect the occurrence of whales and seals over a broad region.

1.3 Purpose of Study and Rationale

The marine mammal bioacoustic research to be conducted in the Chukchi Sea in 2008 is in many ways a continuation of these earlier studies. We will sample acoustically for the occurrence of bowhead whales, beluga whales, and walruses in the Chukchi during the summer–fall period. These species are acoustically active in the Chukchi during this period, and we know that acoustic monitoring is a very effective mechanism for detecting their presence and general occurrences throughout the sea. However, there is still uncertainty as to the density, distributions, and movement patterns of these animals in the specific geographic areas for which CPAI and Shell have interests. Therefore, more bioacoustic data are needed to understand better and constrain the biological risks from industry exploration and development activities on marine mammals, and the business risks relative to the compliance with regulatory requirements and the mandated need for appropriate monitoring plans and mitigation protocols. Based on nearly thirty years of practical experience in this domain, in BRP's opinion, a proactive approach is a far more effective path toward achieving compliance with marine-mammal requirements and reducing risk than is a reactive approach.

1.4 Objectives of Study

The primary objectives of this study are to:

- Obtain acoustic data from the Klondike site and the Burger site for the period mid-July through mid-October 2008;
- Process the acoustic data sets from the Klondike and Burger sites for the occurrences of calling marine mammals, primarily bowhead whales, beluga whales, and walruses and secondarily other cetacean and pinniped species;
- Process the acoustic data from the Klondike and Burger sites to locate and track calling marine mammals; primarily bowhead whales;
- Process the acoustic data from the Klondike and Burger sites to estimate the relative densities and distributions of bowheads, belugas and walruses; and
- Process the acoustic data from the Burger site to measure the received levels (RLs) of seismic airgun sounds.

2. STUDY AREA

2.1 Study Area

The two study areas are the Klondike site and the Burger site (Introduction Figure 1).

2.2 Study Period

The field-study period is from approximately mid-July through mid-October 2008. During this period, acoustic data-collection equipment will be deployed, operating, and recovered.

3. METHODS AND PROCEDURES

3.1 Sampling or Survey Design and Technical Rationale

Cornell is providing a total of 33 marine autonomous recording units (MARUs). Twenty-eight (28) of these units will be configured as single spheres and are scheduled to record continuously at a 2-kHz sampling rate for an effective recording bandwidth of 5–1,000 Hz. The other five (5) of these units will be configured as double spheres (so as to provide 2.5 times the normal battery power) and are scheduled to record on a 50% duty-cycle schedule (alternating periods of 0.5 h on and 0.5 h off) at a 10-kHz sampling rate for an effective recording bandwidth of 5–5,000 Hz. All MARUs are expected to operate throughout the entire 90-day period, from approximately 15 July through approximately 15 October. Five of the 2-kHz units are provided as back-ups to mitigate the unlikely chance that some MARUs do not pass all of the on-deck pre-deployment tests.

3.1.1 Deployment Geometry at Klondike

Figure VII-1 shows the deployment-geometry design for the acoustic spatial-sampling scheme at Klondike that uses 18 MARUs, with 15 sampling at 2 kHz and 3 sampling at 10 kHz.

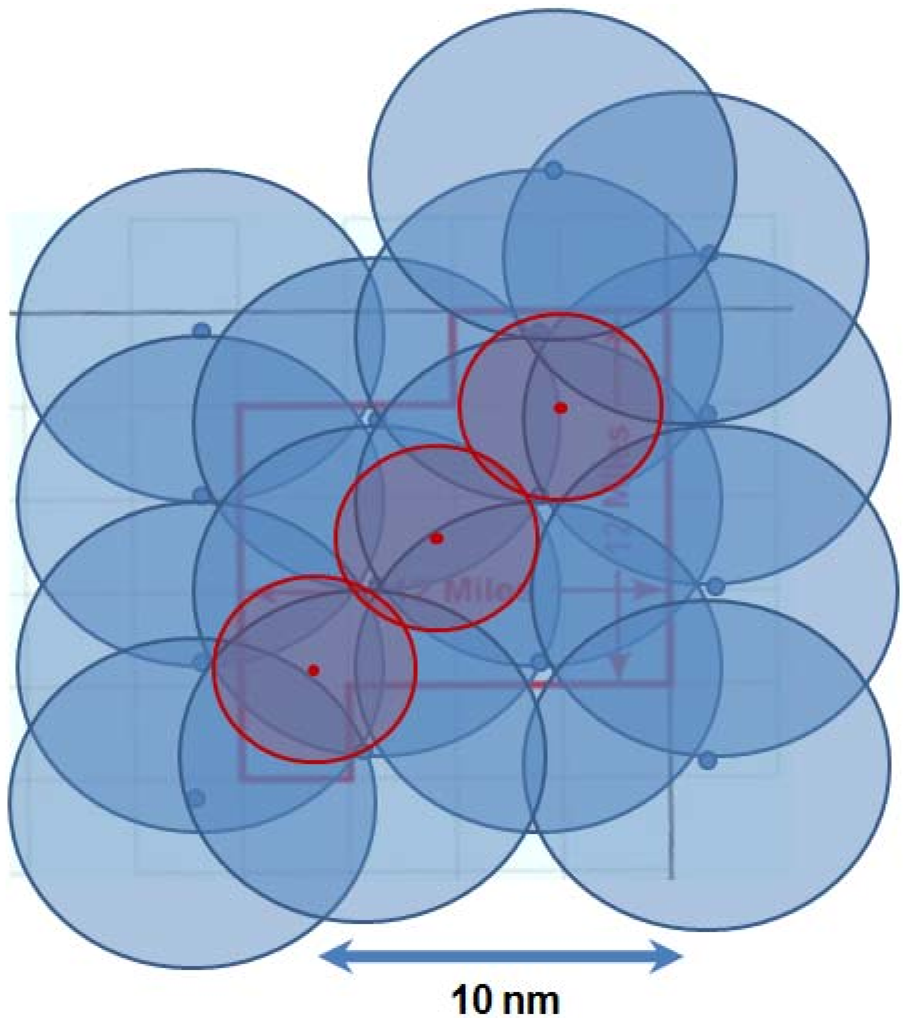

Figure VII-1. Deployment geometry of 15 2-kHz MARUs (blue) and three 10-kHz MARUs (red) at the Klondike site.

3.1.2 Continuous recording at Klondike

Fifteen (15) MARUs will record continuously at a 2-kHz sampling rate. All units will be synchronized at the start of their deployment and end of their recovery. The combination of the geometric spacing and continuous sampling over the entire 90-day field study period is designed to detect and locate calling bowheads (and other animals if they produce calls loud enough to be detected on three or more MARUs). In cases in which an individual animal produces a series of calls over time, it also is possible to track the movements of that individual. All of these data-processing results provide the mechanism for detecting the occurrence of specific species of interest. In cases in which we can locate an animal, we can estimate the relative density and distribution for species that occur within the study site. Note, since the initial proposal, the lease blocks proposed for coverage have been modified as shown in VII-2.

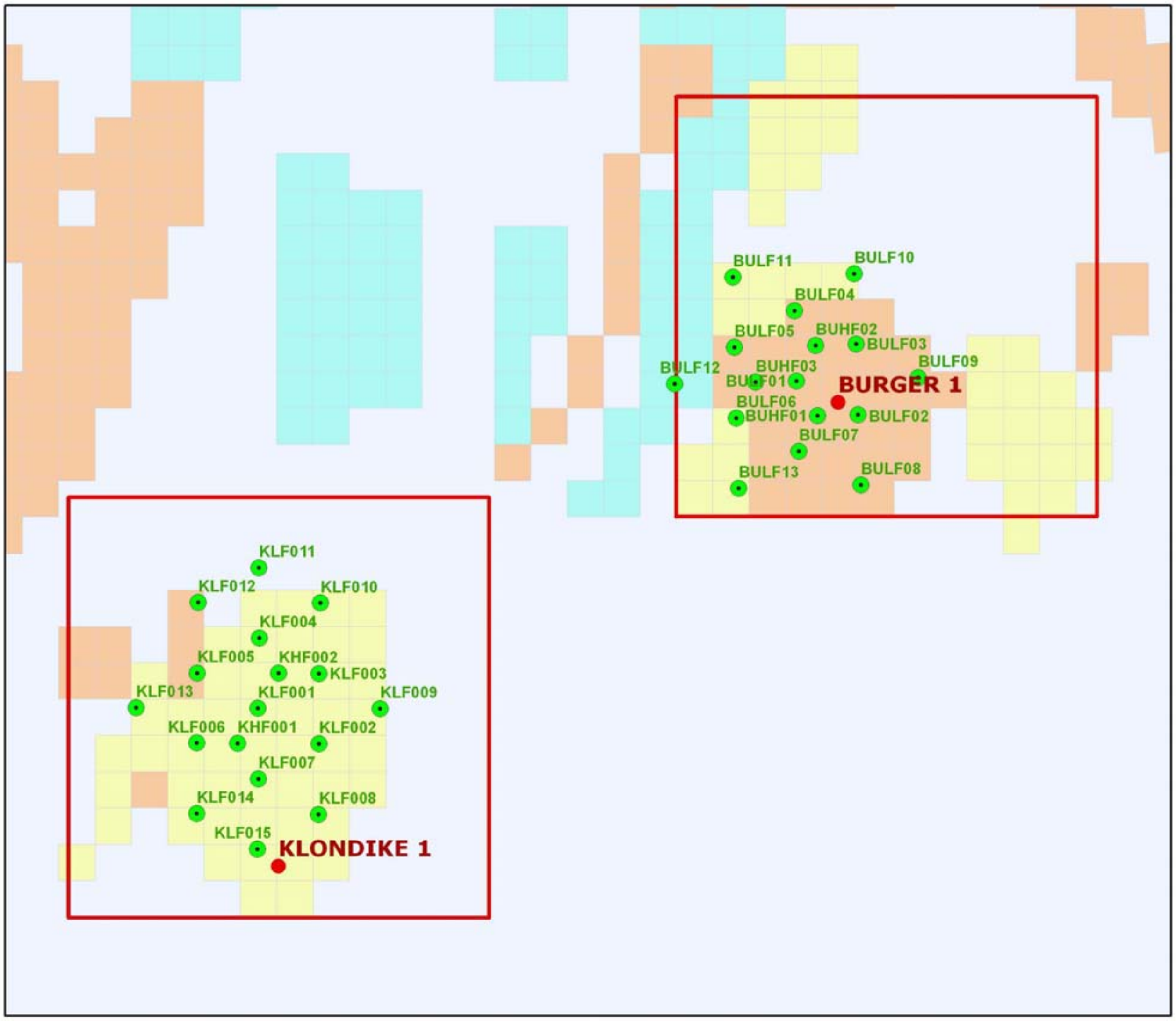

Figure VII-2 MARU units

3.1.3 Discontinuous recording at Klondike

Two MARUs will record on a 50% duty-cycle (e.g., alternating periods of 0.5 h on and 0.5 h off) at a 10-kHz sampling rate. All units will be synchronized at the start of their deployment and end of their recovery. The starting times of the two 10-kHz MARUs will be staggered (i.e., the first starts at 12:00, and the second starts at 12:30, and the third starts at 12:20; Figure VII-3), so that at least one MARU always is recording. (However, this might not always be the case because of differences in clock drift.) This sampling rate and 50% duty-cycle sampling is designed to detect high-frequency sounds from beluga whales (and other animals if they produce calls loud enough to be detected) over the entire 90-day field-study period.

Klondike

10kHz	Time interval	00:00	00:10	00:20	00:30	00:40	00:50	01:00	01:10	01:20	01:30	01:40	01:50	02:00
MARU#	1													
MARU#	2													

Figure VII-3. Sampling schedule for the two 10-kHz MARUs at Klondike.

3.1.4 Deployment Geometry at Burger

After deployment of the 15 2-kHz MARUs at Klondike, we will determine the total number of remaining 2-kHz MARUs available for deployment at Burger. If, as expected, there are backup 2-kHz MARUs available, we will deploy them in a 9-, 10-, 11-, 12-, or 13-element array configuration, depending on the total number available. Figure VII-4 shows the design for one possible acoustic spatial-sampling scheme for Marine Autonomous Recording Units (MARUs) with eight 2-kHz MARUs and two 10-kHz MARUs.

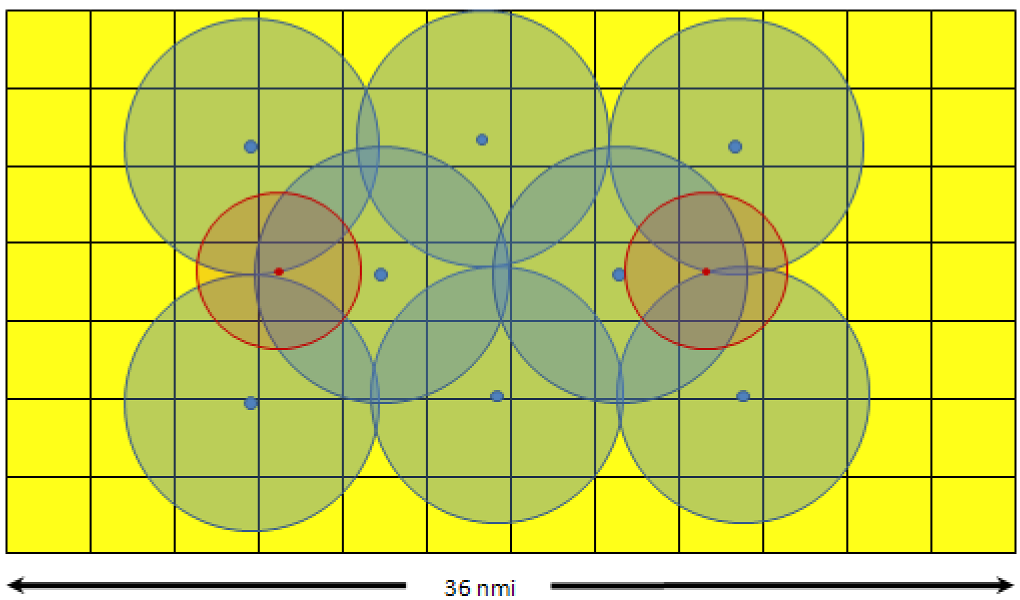

Figure VII-4. Deployment geometry of eight 2-kHz MARUs (blue) and two 10-kHz MARUs (red) at the Burger site.

3.1.5 Continuous Recording at Burger

As described above, an unknown number of MARUs recording continuously at a 2-kHz sampling rate will be deployed at Burger. All units (at least 8 and as many as 13) will be synchronized at the start of their deployment and end of their recovery. The combination of the geometric spacing and continuous sampling over the entire 90-day field-study period is designed to detect calling bowheads (and other animals if they produce sounds below 1 kHz). In all likelihood, the number of MARUs deployed at Burger will be greater than eight; the more units deployed, the greater the chances of being able to locate and track calling whales. In cases in which we can locate an animal, we can estimate the relative density and distribution for species that occur within the study site.

3.1.6 Discontinuous Recording at Burger

Tree MARUs recording on a 50% duty cycle (e.g., alternating periods of 0.5 h on and 0.5 h off) at a 10-kHz sampling rate will be deployed at Burger. All units will be synchronized at the start of their deployment and end of their recovery. The starting times of these three MARUs will be staggered (i.e., the first starts at 12:00, the second starts at 12:20, and the third starts 12:40; Figure VII-5) so that at least one MARU always is recording. (However, this might not always be the case because of differences in clock drift in the three units.) This sampling rate and 50% duty-cycle sampling is designed to detect high-frequency sounds from beluga whales (and other animals if they produce calls loud enough to be detected) over the entire 90-day field -study period.

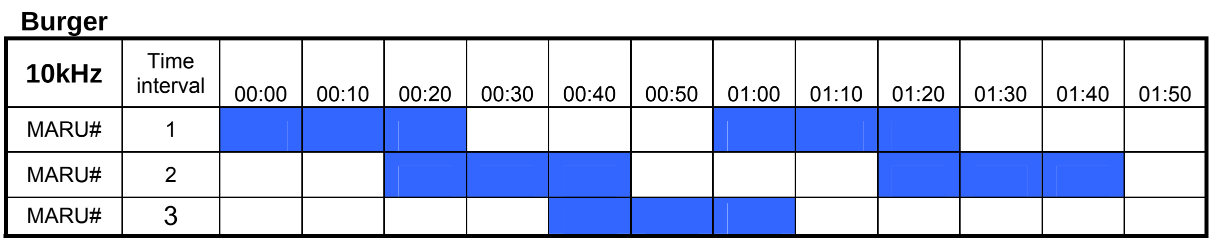

Figure VII-5. Sampling schedule for the two 10-kHz MARUs at Burger.

3.2 Field Team Size and Composition

Two Cornell field technicians will conduct the deployment and recovery operations. Each of these tasks is expected to require only 2–3 days of time. The technicians do not need to, and are not expecting to, remain on board the deployment/recovery vessel once those tasks are successfully completed.

3.3 Data-collection Procedures

All data-collection procedures are confined to acoustic recordings collected by the MARUs during the approximately 90-day field season (see above).

3.4 Analytical Procedures

3.4.1 Data Extraction

After all MARUs are recovered and returned to Ithaca, NY, data will be extracted from each unit's hard drive. All 2-kHz Klondike data sets will be merged and converted into standard-formatted, 15-channel sound files, and the three 10-kHz Klondike data sets will be merged and converted into standard-formatted, 3-channel sound files. All 2-kHz Burger data sets will be merged and converted into standard-formatted, multi-channel sound files, and the two 10-kHz Burger data sets will be merged and converted into standard-formatted, 2-channel sound files.

3.4.2 Detection and Occurrence of Bowhead Whale, Beluga Whale, and Walrus Sounds

All MARU data will be analyzed for the occurrences of bowhead whales, beluga whales, and walruses (Figure VII-6) at a 24-h resolution for each of the four data sets (i.e., Klondike 2-kHz continuous; Klondike 10-kHz 50%; Burger 2-kHz continuous; and Burger 10-kHz 50%).

Detections of these sounds will be accomplished by experienced analysts who are using a combination of automatic detection-recognition algorithms, screening and validation of the auto-detection-recognition results, and scrolling through continuous multi-channel spectrographic displays while visually searching for calls (using XBAT, a MatLab-based extensible, bioacoustic-analysis software tool developed at BRP; see www.xbat.org). As an example, Figure VII-7 shows a three-channel spectrogram display containing a series of bowhead calls recorded off of Point Barrow, Alaska, in 2006.

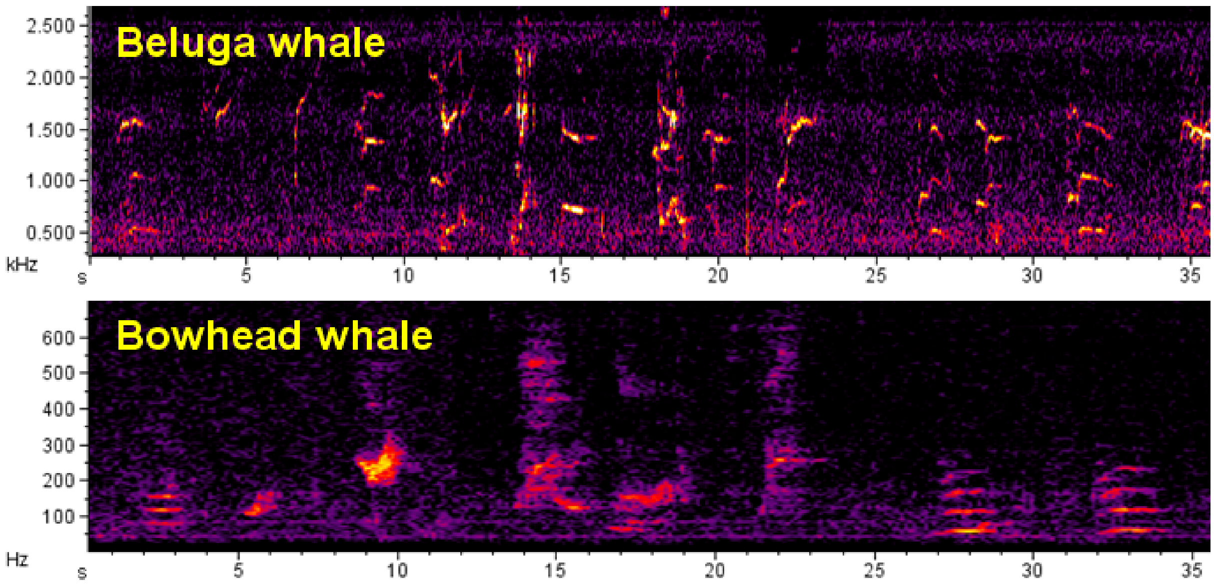

Figure VII-6. Spectrographic examples of beluga and bowhead whale sounds collected MARUs pop-ups off of Alaska in the summer of 2006.

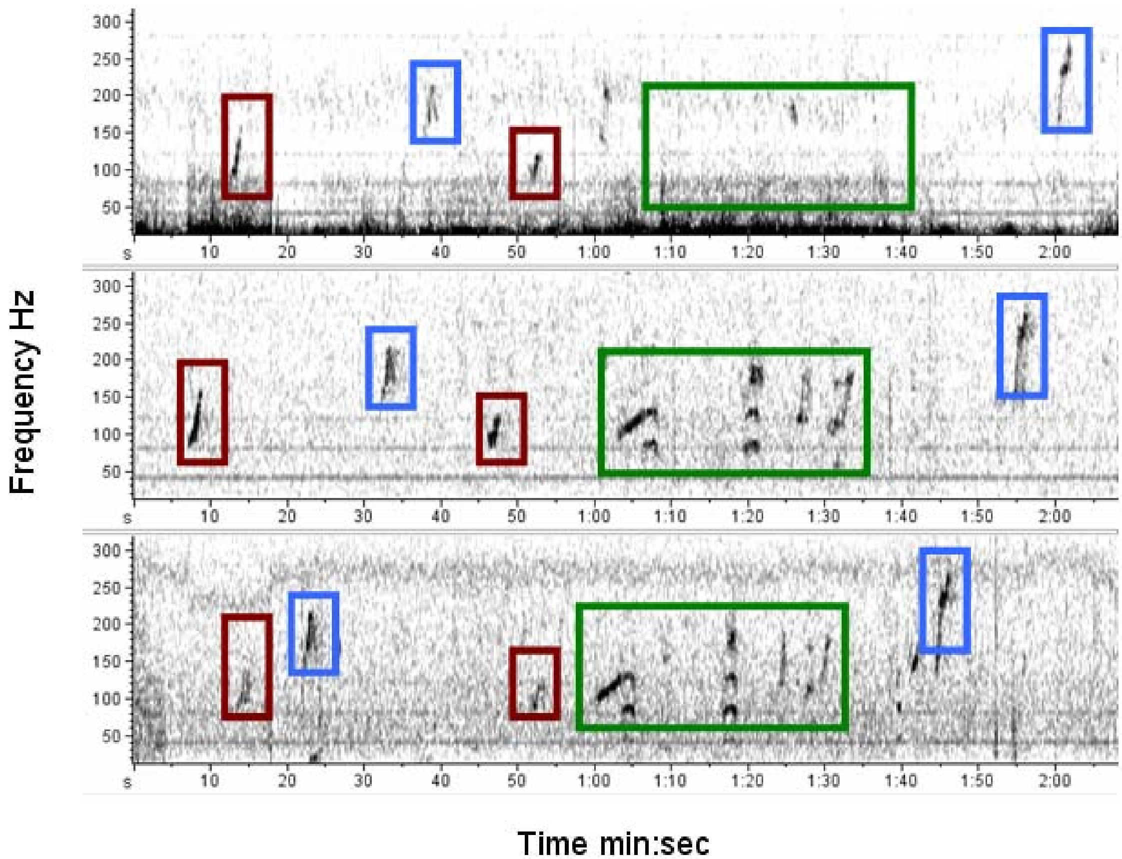

Figure VII-7. Three-channel spectrogram generated when three different bowhead whales are calling, as indicated by the different colors and different patterns of call-arrival times.

3.4.3 Location and Tracking of Bowhead Whale, Beluga Whale, and Walrus Sounds

Acoustic detections of bowhead whales, beluga whales, and walruses will be analyzed further to locate the positions and to track the movements of calling animals, when possible. It is expected that most of this location and tracking analysis will focus on bowhead whales.

3.4.4 Received Levels (RLs) and Probability of Detection of Bowhead Whale, Beluga Whale, and Walrus Sounds

The RLs of all species-specific sounds for which reliable locations are computed will be calculated for multiple MARUs. We will use these data and transmission-loss data to estimate the source levels of calls and the probability of detection for calling animals.

3.4.5 Densities and Distributions of Bowhead Whale, Beluga Whale, and Walrus Sounds

All processed data (detections, locations, and tracks) will be synthesized to estimate relative densities and overall distributions of animals at the Klondike and Burger sites.

3.4.6 Acoustic Occurrence of Seismic Activity

All data from Burger will also be analyzed for the occurrence of seismic-airgun-array sounds by using a three-step procedure. Detections and measurements of seismic–airgun-array sounds will be accomplished by analysts who are using a combination of automatic detection-recognition algorithms, screening and validating of the auto-detection-recognition results, and scrolling through continuous multi-channel spectrographic displays to confirm seismic sounds. All confirmed detections will be annotated and their RLs will be calculated. By this procedure, we will determine the time of occurrence of seismic sounds and the RLs of each airgun sound on multiple MARUs. This task will have to be coordinated closely with acoustic work being done by JASCO in and around these lease blocks.

3.5 Data-storage Procedures

All waveform data will be organized into a networked database on a Pillar mirrored server system. All acoustic detections will be annotated and automatically entered into the XBAT database system. This procedure provides an efficient mechanism by which we can rapidly go to any annotated sound, export data tables, and run an automatic-location program. All data files will be organized into a networked database. All of these data and the original waveform data will be stored on dual Pillar (mirrored storage) systems, one of which will be available via a server system over a distributed network and that also will be accessible via the internet. There also will be working versions of all data and results.

3.6 Quality-control Procedures

All MARUs go through an extensive quality-control procedure prior to shipping, and each unit must pass a thorough on-deck testing procedure immediately prior to being deployed in the ocean. All resulting acoustic data are carefully and consistently evaluated with standardized sound-analysis software during the application of detection, location, and tracking analyses.

4. COORDINATION

4.1 CPAI

The PI will attend all proposed meeting and interacts regularly as needed with CPAI.

4.2 Other Studies in the Chukchi Sea Program

This acoustic program will be logistically coordinated with other components that are being supported by Fairweather. We do not expect a need for coordination with other programs beyond deployment and recovery logistics.

4.3 Current Studies in the Region

The Cornell acoustic field effort will involve coordination with only one other current study in the region. A critical coordination issue is the placement of the Cornell MARUs near areas in which JASCO will be deploying its acoustic recorders for Shell. JASCOs recorders are recovered by trawling, so we need to be certain that they will not be trawling in an area where a MARU is deployed.

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