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The benthic ecosystem of the northeastern Chukchi Sea: An overview of its unique biogeochemical and biological characteristics

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ABSTRACT

In February 2008, Lease Sale 193 generated renewed interest for oil and gas exploration in the northeastern Chukchi Sea and prompted a series of studies designed to increase our scientific knowledge of this biologically rich area. We present in this special issue the results from major field expeditions during open-water periods in the summers of 2009 and 2010. Our work focused on the biological and chemical characteristics of the benthos with the goal of establishing a strong baseline for assessing future changes that may occur in response to (1) impacts from oil and gas activities, and (2) variations in hydrography, circulation or ice retreat associated with climatic change. We found concentrations of aliphatic hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and 17 trace metals in sediments at natural background levels throughout the study area except at two previous (1989) drilling sites; there was no evidence that showed bioaccumulation of these substances above natural concentrations. Inorganic-N was recycled within one day throughout the water column, with evidence of substantial remineralization of organic matter in the sediments. Active efflux of sediment NO_3^- supports water column primary production that, in turn, sustains a rich benthos dominated by crustaceans and echinoderms that also receive, based on isotopic evidence, a benthic carbon subsidy. Benthic food webs are complex, with high trophic redundancy based on the diversity of both infaunal and epifaunal populations. The highest trophic levels in the benthos were dominated by predatory gastropods. Comparisons of gray whale and walrus distributions from aerial sightings showed a large difference between the two study years relative to the more stable benthic prey base for these animals over that period. A nearly ice-free shelf by early summer 2009 compared to 2010 revealed that walrus distributions were more closely linked to sea ice rather than to benthic prey items, indicating that rapid retreat of sea-ice could threaten traditional feeding grounds.

1. Introduction

Heightened interest for Lease Sale 193 in the northeastern Chukchi Sea by the oil and gas industry, as demonstrated by $2.7 billion in bids during February 2008 (Dinkelman et al., 2008), led the U.S. Bureau of Ocean Energy Management (BOEM) to conduct an array of studies to better characterize this biologically rich ecosystem. One resulting project, entitled Chukchi Sea Offshore Monitoring in Drilling Area-Chemical and Benthos (COMIDA CAB), focused on benthic resources from a regional perspective. Here, we present the products of that investigation to provide a valuable addition to the initial baseline conducted in the 1970s and 1980s by the U.S. Department of Commerce Outer Continental Shelf Environmental Assessment Program (OCSEAP). The COMIDA CAB project was carried out concurrently with the Chukchi Sea Environmental Studies Program (CSESP) that was funded by a consortium of three oil and gas companies including ConocoPhillips Alaska, Shell Exploration and Production, and Statoil USA E&P (Hopcroft and Day, 2013). The industry program focused on specific areas where future drilling may occur. Results from the CSESP were reported in nine papers (summarized by Day et al., 2013) that complement the 12 papers in this volume and greatly enrich our knowledge about this Pacific gateway to the Arctic Ocean.

The COMIDA CAB study provided baseline information on (1) the biological, chemical and physical characteristics of the Chukchi Sea prior to renewed oil and gas exploration, and (2) trophic structure and benthic processes during a period of sea-ice loss and climate change. Biological surveys (reported here in four papers) were carried out to determine the abundance and

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distribution patterns of benthic infauna and epifauna in relation to circulation, hydrography, and sediment characteristics. Two papers present and explain patterns for sediment grain size, accumulation rates, organic carbon, trace metals, aliphatic *n*-alkanes and polycyclic aromatic hydrocarbons (PAHs). Organic carbon dynamics and nitrogen cycling were the focus of three papers. Several papers address food web structure and linkages between lower and upper level trophic consumers. Finally, one paper evaluates the caloric value of potential benthic prey species for marine mammals and another paper investigates the distribution patterns of mercury in seawater, sediments and benthic biota. Collectively, the results of the study have provided several new perspectives on the biogeochemical and biological characteristics as described below.

2. Stations, data, and setting

2.1. Sampling approach

Station locations were initially determined using a general randomized tessellation stratified (GRTS) design in the core COMIDA CAB area (30 stations) as described in Hersh and Maidment (2014). We then added additional stations over the GRTS grid (18 in 2009 and 15 in 2010) to fill spatial gaps, sample areas of known historical or biological significance and to ensure a random but even distribution in a region that spans over 107,000 km^2. This arrangement resulted in the placement of 30 GRTS core stations in a spatial grid (Fig. 1). Of the 30 GRTS stations, 10 were chosen as overlapping stations for cross-calibration of various benthic measurements. We also added stations in the "upstream" Bering Strait/SE Chukchi region (station 103) and in the core grid (station 105; Fig. 1) in 2010. A subset of the 2009 stations ($n=25$) was reoccupied in 2010 and scientific sampling was expanded to enable a systems' approach to our broad spatial analysis of the Chukchi Sea using ArcGIS.

2.2. Data management and GIS

In support of the extensive datasets generated during the COMIDA CAB study, this project included a large data management component as outlined by Hersh and Maidment (2014). Data management was carried out using an observations data model (ODM) that incorporated a significant ArcGIS component. The graphical displays from this effort show spatial patterns of broad significance with respect to the complex nature of the Chukchi Shelf. The ODM developed for this project proved highly effective. Field products, reports, data, and shapefiles are available on the COMIDA CAB website maintained at The University of Texas at Austin (http://www.comidacab.org).

2.3. Ice conditions

Sea-ice conditions varied considerably between the 2009 and 2010 field seasons (Fig. 2). In 2009, sea-ice remained in the Hanna Shoal area until late July, after which it completely retreated. In contrast, sea-ice remained over both Herald and Hanna Shoals into late July 2010 (Weingartner et al., 2013) and over Hanna Shoal and other areas of the northeastern Chukchi Sea well into August. Interestingly, Schonberg et al. (2014) observed that walrus concentrated offshore near Hanna Shoal as long as sea-ice was available but moved nearer to shore and coastal haul-out locations when the ice disappeared. Ice retreat also was linked to the timing and duration of ice algal deposition on the seabed, as addressed by McTigue and Dunton (2014) in their work to establish trophic

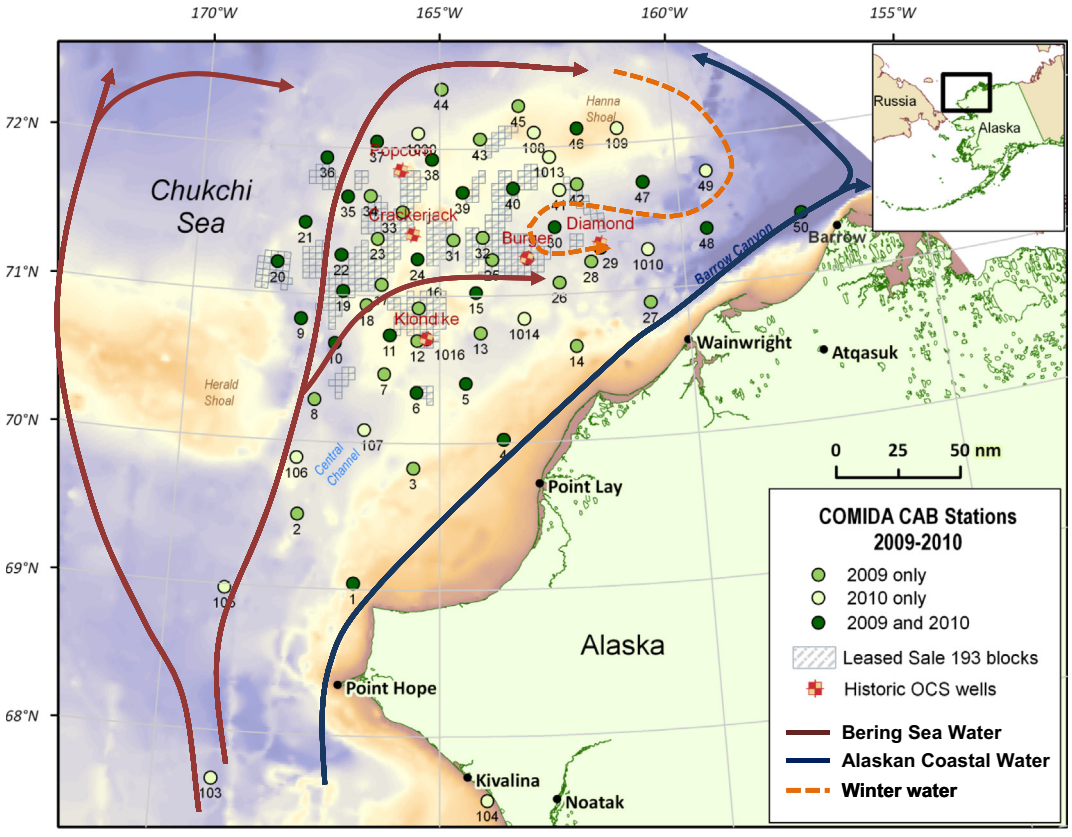

Fig. 1. Stations in the northeastern Chukchi Sea during summer 2009 and 2010 for the COMIDA CAB project in relation to oil and gas tracts for Lease Sale 193, historic well sites (see Day et al., 2013; Blanchard and Feder, 2014), and mean circulation (adapted from Spall, 2007 and Weingartner et al., 2013).