THE OFFSHORE NORTHEASTERN CHUKCHI SEA: A COMPLEX HIGH-LATITUDE ECOSYSTEM

Robert H. Day (bday@abrinc.com),[a] Lisanne A. M. Aerts,[b] Arny L. Blanchard,[c] Adrian E. Gall,[a] Benny J. Gallaway,[d] David E. Hannay,[e] Brenda A. Holladay,[c] Russell R. Hopcroft,[c] Jeremy T. Mathis,[c] Brenda L. Norcross,[c] Thomas J. Weingartner,[c] Sheyna S. Wisdom,[f] Caryn L. Rea,[g] A. Michael Macrander,[h] and Steinar Eldøy[i]

(a) ABR, Inc.—Environmental Research & Services, P.O. Box 80410, Fairbanks, AK 99708-0410 USA; (b) LAMA Ecological, 4311 Edinburgh Drive, Anchorage, AK 99502 USA; (c) School of Fisheries and Ocean Sciences, Institute of Marine Sciences, P.O. Box 757220, University of Alaska, Fairbanks, AK 99775-7220 USA; (d) LGL Ecological Research Associates, 721 Peach Creek Cut-off Road, College Station, TX 77845 USA; (e) JASCO Applied Sciences, Ltd., 2101—4464 Markham Street, Victoria, BC V8Z 7X8 Canada; (f) Fairweather LLC, 9525 King Street, Anchorage, AK 99515 USA; (g) ConocoPhillips Company Alaska, Inc., P.O. Box 100360, Anchorage, AK 99510-0360 USA; (h) Shell Exploration & Production Company, 3601 C Street, Suite 1334, Anchorage, AK 99503 USA; (i) Statoil USA E+P, Inc., 2700 Gambell Street, Anchorage, AK 99507 USA

ABSTRACT

In 2008–2010, we conducted an interdisciplinary ecological study (Chukchi Sea Environmental Studies Program; funded by ConocoPhillips, Shell, and Statoil) in and near three proposed exploratory oil and gas prospects in the offshore northeastern Chukchi Sea during the open-water season. Some aspects of this ecosystem function as a classical pelagic–benthic dichotomy, whereas others suggest unusual ecosystem-level attributes. The Klondike study area functions as a pelagic system, whereas the Burger study area is primarily a benthic system; the Statoil study area has both pelagic and benthic attributes. Klondike has lower benthic abundance and biomass and more oceanic zooplankton, fishes, zooplankton-feeding seabirds, and pelagic-feeding seals than does Burger, which has benthic communities with high abundance and biomass, primarily neritic zooplankton, and more benthic-feeding marine mammals than Klondike; Statoil has characteristics of both ecosystems. Various water masses impinge onto all study areas seasonally and interannually, and patterns of sea-ice retreat vary interannually. These variations alter some of this pelagic–benthic dichotomy, and some aspects of this ecosystem suggest unusual structure.

BACKGROUND

There is great interest in offshore oil and gas development in the northeastern Chukchi Sea, off of northwestern Alaska. Because of this interest, there is a need for recent information on the oceanography and ecology of the region, both new information and information needed to update historical data sets. This information can help to provide a better understanding on the ecology of the area and to provide perspective on long-term environmental change that may have happened, or be happening, in the area.

To help to provide this information, we began in 2008 the Chukchi Sea Environmental Studies Program (CSESP), an integrated interdisciplinary, ecosystem-level approach to studying the environment in this area that was jointly funded by ConocoPhillips, Shell, and Statoil. This program recently completed its fifth year of studies (2008–2012).

We are in the process of publishing a Special Issue of *Continental Shelf Research* (due out in the first half of 2013) on the ecology of the northeastern Chukchi Sea that synthesizes information across the first 3 years of the study within each of the ecosystem components and for the system as a whole. This paper presents the evidence for our interpretation of two very different ecosystems lying side-by-side in the northeastern Chukchi.

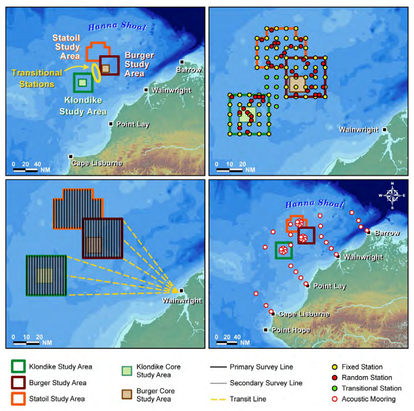


Figure 1. Klondike, Burger , and Statoil study areas in the Chukchi Sea, Alaska, 2008-2010., showing study areas, oceanographic stations, bird and mammal lines, and acoustic moorings.

METHODS

STUDY AREAS

In 2008-2010, we sampled three study-area boxes in the northeastern Chukchi Sea known as Klondike, Burger, and Statoil (Figure 1). Each study-area box is 900 NM² in size and contains within it a smaller box that represents the area of greatest interest for oil exploration. These study areas lie ~60-150 NM (~110-270 km) west of the village of Wainwright.

Oceanographically, Klondike lies in more oceanic water on the edge of the Central Channel Current, whereas Burger lies in more neritic water on the southern slope of Hanna Shoal and Statoil has attributes of both areas; however, oceanic water sometimes covers this area too. Both study areas lie in waters ~40 m (~20 fa) deep.

DATA COLLECTION

We collected data during the open-water seasons of 2008–2010 on multiple cruises/year to each of three study-area boxes that were located in areas of interest for oil and gas exploration (Fig. 2). Each study area was 900 NM² (3,030 km²) in area. We sampled the Klondike and Burger study areas 3 times each in 2008–2009 and sampled the Klondike and Statoil study areas 2 times each and the Burger study area 3 times in 2010; we also added a set of 6 Transitional stations in 2010 to increase our understanding of the area between the study-area boxes. We sampled a series of fixed and random oceanographic stations for physical oceanography, nutrients, chlorophyll-a, zooplankton abundance and biomass, benthic abundance and biomass (both infaunal and epifaunal), fish distribution and abundance (both mid-water and demersal), and ocean acidification. We used line-transect sampling to determine the distribution and abundance of seabirds and marine mammals and used acoustic moorings to study marine-mammal acoustics throughout the year.

RESULTS

PHYSICAL OCEANOGRAPHY

The area consists of three main water types: Bering Sea Water, Meltwater, and Winter Water (Fig. 2). Bering Sea Water always occurs over Klondike (2008–2010), whereas it occurs over Burger and Statoil only in some years (2009–2010). There was substantial interannual variation in the overall system among years, with a cold year (2008), and warm year (2009), and an intermediate year (2010; Table 1). These variations resulted in substantial interannual variation in how fast the area warmed, the amount of ice cover, and the spatial extent of Bering Sea Water.

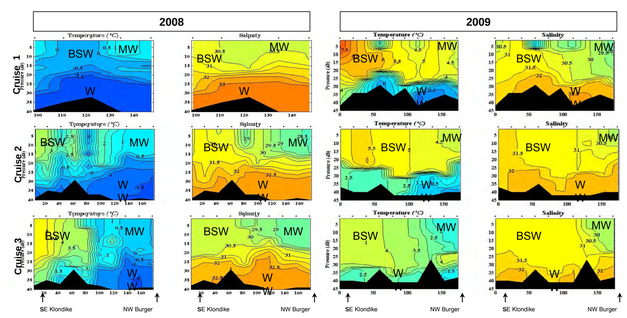


Figure 2. Vertical sections of temperature (° C), and salinity in the Klondike and Burger study areas for three cruises in 2008 and 2009. Data from 2010 were similar to those for 2009.

NUTRIENTS AND CHLOROPHYLL

In general, nutrients and chlorophyll are low in concentration and below the pycnocline, having been stripped out by the spring bloom prior to our arrival. Because of the late year in 2008, we saw the end of the spring bloom at the ice edge upon our arrival. Nutrients and chlorophyll were essentially gone the entire open-water season in 2009, but there was a small amount of both in 2010. In fact, a small bloom seemed to persist over the entire summer in Burger (Fig. 3).

CHLOROPHYLL AND NITRATE (2010)

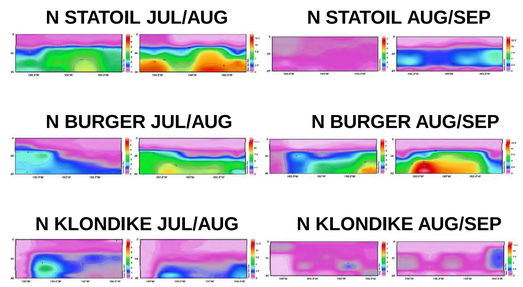


Figure 3. Vertical sections of Chlorophyll-a (left) and nitrate (right) in the three study areas, 2008–2010.

ZOOPLANKTON

In general, zooplankton communities differ among the study areas, although there is obvious leakage of organisms between the two areas. Most oceanic zooplankton occur in Klondike, whereas the Burger area is dominated more by shelf-type species. In general, abundance is highest in Klondike, although there is great interannual variation (Fig. 4). Although 2009 was the warmest year, 2010 had the highest zooplankton biomass; we suspect that it was cool enough to have a somewhat late bloom but warm enough to have some zooplankton growth occur before the bloom ended.

ZOOPLANKTON BIOMASS

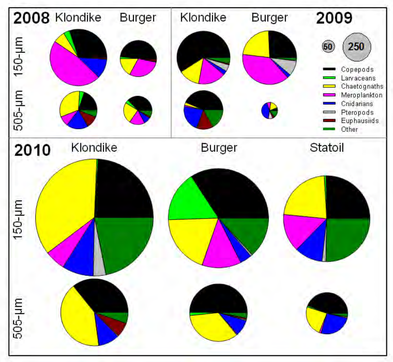


Figure 4. Biomass of major zooplankton groups in the three study areas, 2008-2010.

OCEAN ACIDIFICATION (COMPONENT ADDED IN 2010)

The strongest evidence for acidification was seen with the aragonite saturation state in Burger. There, the bottom layers experienced acidification levels at which aragonite would begin to dissolve (Fig. 5). However, acidification levels in Klondike and Statoil never reached the point at which they would dissolve aragonite in 2010.

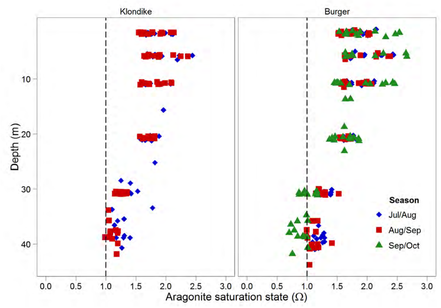


Figure 5. Aragonite saturation states in Klondike and Burger study areas, by cruise, 2010.

BENTHIC COMMUNITIES

Benthic communities differ greatly among the study areas in both macrofauna and megafauna. The same species occur in the same area, but abundance in Burger is several times that in Klondike and Statoil, and biomass in Burger and Statoil are several times that in Klondike. Macrofaunal communities are most similar between Burger and Statoil, but megafaunal communities are largely different among study areas (Fig. 6).

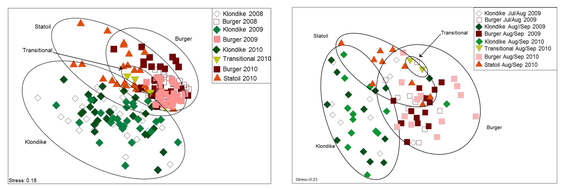


Figure 6. nMDS plots of benthic macrofaunal (left) and megafaunal (right) communities in Klondike, Burger, and Statoil study areas and Transitional stations, 2008-2010.

FISHES

The fish community is odd in that it has no large fishes and the abundance of pelagic fishes is low. The community is dominated numerically by arctic cod. The demersal community shows odd attributes, in that most of the species and most of the fishes occur in Klondike, rather than Burger and Statoil, which is where most of the food actually occurs (Fig. 7). We believe that this odd distribution occurs because the Winter Water under Burger and Statoil is so cold that it barely is above the freezing point of seawater, forming an effective thermal barrier. Hence, most of the species in Klondike follow the Central Channel current from the Bering Sea.

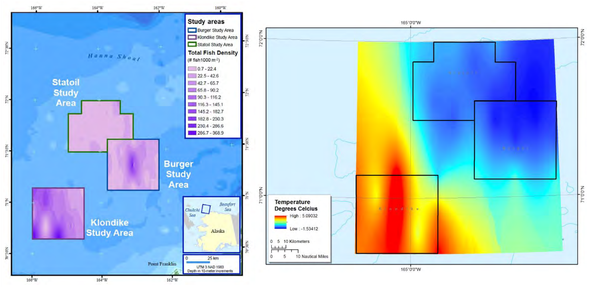


Figure 7. Biomass of demersal fishes (left) and bottom temperatures in the northeastern Chukchi Sea, 2010.

SEABIRDS

The seabird community is dominated numerically by deep-diving zooplankton-feeders such as auklets and shallow-diving euphausiid-feeders such as shearwaters. Few fish-feeding species occur here, reflecting the low abundance and very small size of fishes here. Surface-feeding generalists such as gulls occur everywhere, but in low numbers. Overall, abundance is greatest in Klondike, reflecting the higher abundance of zooplankton in the Bering Sea Water. Bird communities were most similar between Klondike and Statoil , reflecting the presence of Bering Sea Water over both in 2010, whereas Burger was considerably more variable (Fig. 8).

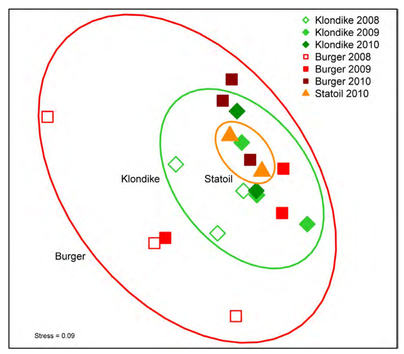


Figure 8. nMDS plot of seabird communities, by study area and cruise.

MARINE MAMMALS

Marine mammals respond both to the oceanography of the area and to indirect effects such as sea ice, which is affected by the oceanography of the area. Similar to what was seen for the benthic data, benthic-feeding marine mammals such as Walruses and Bearded Seals are more common in Burger than in Klondike; in contrast, pelagic-feeding seals such as Ringed and Spotted seals are more common in Klondike than in Burger but may be similar in abundance in both study areas in years in which Bering Sea Water floods the entire study area (Fig. 9). The preference of benthic-feeding walruses for Burger and Statoil is seen in the map of walrus call counts in 2009 (Fig. 10).

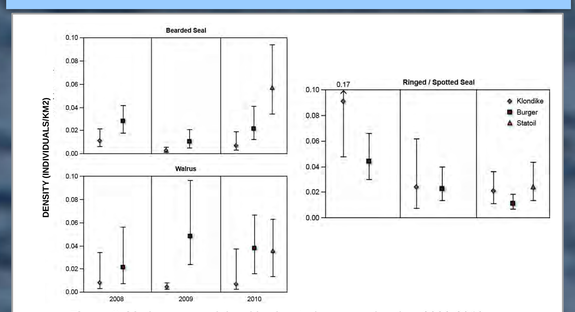


Figure 9. Marine mammal densities by study area and cruise, 2008-2010.

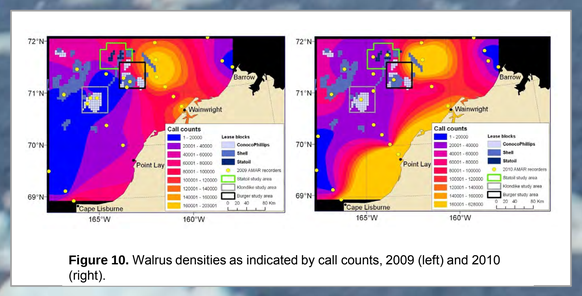


Figure 10. Walrus densities as indicated by call counts, 2009 (left) and 2010 (right).

DISCUSSION & CONCLUSIONS

Although these study areas are very close, they represent two very different ecosystems.

- Klondike appears to be a pelagic ecosystem at all times. This is because it is bathed in Bering Sea Water flowing in the Central Channel. Klondike has higher densities of oceanic zooplankton, more zooplankton-feeding seabirds (especially auklets), and generally more pelagic-feeding seals than the other two study areas.
- Burger appears to be a benthic ecosystem most of the time, although Bering Sea Water occasionally flows over it. Burger has a higher concentration of mud in the sediments, much denser and more robust benthic communities, and generally more benthic-feeding seals than the other two study areas.
- Statoil is intermediate between the two areas, with high infaunal biomass but low epifaunal biomass and generally more benthic-feeding marine mammals than the other two study areas; on the other hand, the bird community tends to be similar to Klondike. These differences occur because the western end is along the edge of the Central Channel but the eastern end is over the southern edge of Hanna Shoal.
- The demersal fish community shows a pattern unlike that predicted from the benthic data, but it appears that the cold pool of Winter Water over Burger and Statoil forms an effective barrier to these fishes.

2011 AND BEYOND

Although this poster describes activities in 2008–2010, the study continued and expanded in 2011. Efforts expended in 2011–2012 include:

- Continued sampling in Klondike, Burger, and Statoil
- The 2011 expansion of the study area to all of Hanna Shoal (Fig. 11).
- Continued collaboration with local co-management groups on scientific studies (e.g., tagging of Belugas, Walruses, and ice seals) and Traditional Ecological Knowledge (e.g., TEK study of Polar Bears).
- Production of annual and synthesis reports.
- Production of scientific publications, both by discipline and as a synthesis of the ecology of this area (*Continental Shelf Research*).

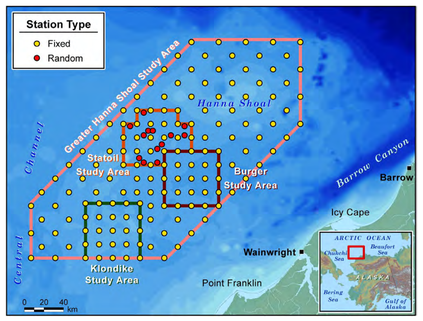
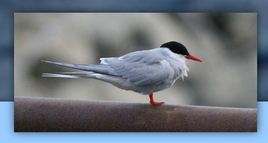


Figure 11. Broad-scale surveys begun in 2011.



ACKNOWLEDGMENTS

Funding for this study has been provided by ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. Olgoonik Fairweather LLC provided overall project management and coordination and somehow herded all of these cats in the same direction. Aldrich Offshore and Aldrich Offshore Services provided ships and support personnel, and Olgoonik Oilfield Services provided logistical support at Wainwright. We thank all of the captains, crews, marine techs, medics, HSE personnel, scientific teams, and Iñupiaq communicators who came together and safely conducted some great science in a rather remote corner of Alaska.