Semi-annual project progress report

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Introduction

Living organisms are essential in ocean geochemical and ecosystem processes, but their diversity and complex interactions present challenges to understanding those processes. Understanding the role of biodiversity in marine ecosystem processes is a major frontier in ocean science, with implications for global climate models, carbon budgets, fishery management, and public health. So far, the rapidly growing of the field of ocean observing has not adequately incorporated biodiversity. Hence, the call for Marine Biodiversity Observing Networks is timely and has great implications for understanding ocean processes and regulating and mitigating human-ocean interactions.

The goal of the Arctic Marine Biodiversity Observing Network (AMBON) project is to build an operational marine biodiversity observation network (MBON) for the US Chukchi Sea continental shelf as a prototype network for the nation. The importance of the Arctic Ocean to global climate and ecosystem processes, and the speed at which climate changes are already occurring in the Arctic, elevate the urgency for coordinated observations of Arctic marine biodiversity. In an end-to-end approach, from microbes to whales, AMBON science experts work with the Alaska Ocean Observing System (AOOS) to coordinate data streams from past and ongoing programs into one observation network for the US Arctic. Important collaborative links connect AMBON to other BON efforts in the nation and on the global scale. Effective data management, integration and dissemination will provide critical information on the status of Arctic ecosystem health and resilience to decision makers and local, regional and global communities.

Purpose

The AMBON has four main goals: 1. To close current gaps in taxonomic and spatial coverage in biodiversity observation on the Chukchi shelf, 2. To integrate with past and ongoing research programs on the US Arctic shelf into an Arctic biodiversity observation network, 3. To demonstrate at a regional level how a MBON could be developed in other regions and ecosystems, and 4. To link with programs on the pan-Arctic level. The AMBON aims to develop a sustainable model of continuous biodiversity observation in an end-to-end approach including all levels of diversity from genetic to organismal to ecosystem. The AMBON will fill taxonomic (microbes, nano- to microplankton, meiofauna, epibenthic, fishes), functional (food web structure) and spatial (middle shelf) gaps of other field programs to sample

the full ecosystem scale and link to environmental oceanographic observing systems. The AMBON will also continue recent efforts to extend much-needed time series. These time series are essential for detecting any trends in the Arctic ecosystem because of the extremely high seasonal and interannual variability and because climate changes in this system are accelerated compared to elsewhere in the nation. Only long-term datasets can provide the basis to distinguish the "noise" of natural variability and regular cycles from the directional change driven by climate changes or other stressors. The Arctic is experiencing the most dramatic temperature increases of all oceans, leading to significant alterations of marine ecosystem structure and function. An important purpose of this demonstration project is to evaluate the level of observations necessary to provide sounds data, to determine biological/diversity metrics that are useful indicators, to link to other BONs on the national and global level to achieve a cohesive program that can function on multiple levels.

Approach

Coordinate AMBON goals with principal investigators (PIs, annual PI meetings) and collaborating projects to build an integrative network of all ecosystem components, from microbes to upper trophic levels, through workshops, review of historical information, database planning, data agreements, and field data collection planning. Collaborate with other BONs on national and international level to identify useful and practical biodiversity metrics on regional, national and international scales. This coordination is through working groups, regular virtual meetings or phone calls, and in-person meetings where feasible.

AMBON will have two field seasons – one in 2015 and one in 2017. During those field efforts, AMBON will collect ecosystem level biodiversity information along five cross-shelf and one along-shelf transect in the Chukchi Sea. State of the art genetic techniques will complement traditional taxonomic approaches to include the small size fractions (microbes, nano- to microplankton, meiofauna) into biodiversity assessments.

Through working with the Alaska Ocean Observing System (AOOS), we will create open access data and coordinate with other national BON demonstration projects. Outreach will be pursued through a website (through AOOS), and interactions with local communities, specifically the Native Alaska communities of the north that are most directly affected by the changes in the Arctic. Various stakeholders will be engaged through direct communications (e.g., BOEM, Shell, IOOS), workshops, database, scientific meetings, etc.

Collaborating PIs on the AMBON project are: Eric Collins, Seth Danielson, Russ Hopcroft, Franz Mueter (all University of Alaska Fairbanks), Bodil Bluhm (University of Tromsø, Affiliate Associate Professor at University of Alaska Fairbanks), Jacqueline Grebmeier, Lee Cooper (University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory), Kate Stafford (University of Washington, Applied Physics Laboratory), Kathy Kuletz (USFWS), Sue Moore (NOAA).

Results during Reporting Period

The Arctic Marine Biodiversity Observing Network (AMBON) project successfully completed its first field sampling in summer 2015. The 2015 cruise took place 8 August – 5 September on the Norseman II, starting in Prudhoe Bay and ending in Wainwright. The science crew consisted of 16 members from the University of Alaska's School of Fisheries and Ocean Sciences, the University of Maryland, University of Washington, and the US Fish and Wildlife Service. Science objectives included physical oceanographic measurements, water, sediment and tissue sampling for microbes and eDNA, zooplankton net samples,

grab sampling for sediment characteristics and infauna, trawl sampling for epibenthos and fish, and marine bird and mammal observations.

Survey lines were observed in the following order: DBO-3, CL, ML6, ML4 (incl. DBO4), ML3, ML5, ML1 (see Fig. 1). Science operations included 12-h observations of seabirds and marine mammals during daylight hours and 12-h stations work during night time hours. The typical sampling/gear order at a station was: CTD, vertical zooplankton net (150 µm), van Veen grabs (0.1 m^2), HAPS core (not at every station), Bongo net (505 µm), modified Plump-staff beam trawl (PSBT-A), Isaak Kit Midwater Trawl (IKMT; not at every station). Along some of the lines, we took additional CTD stations for better resolution of the hydrography (CL, ML3). The cruise objectives also included the recovery and deployment of several moorings, especially the CEM mooring south of Hanna Shoal (see Fig. 1).

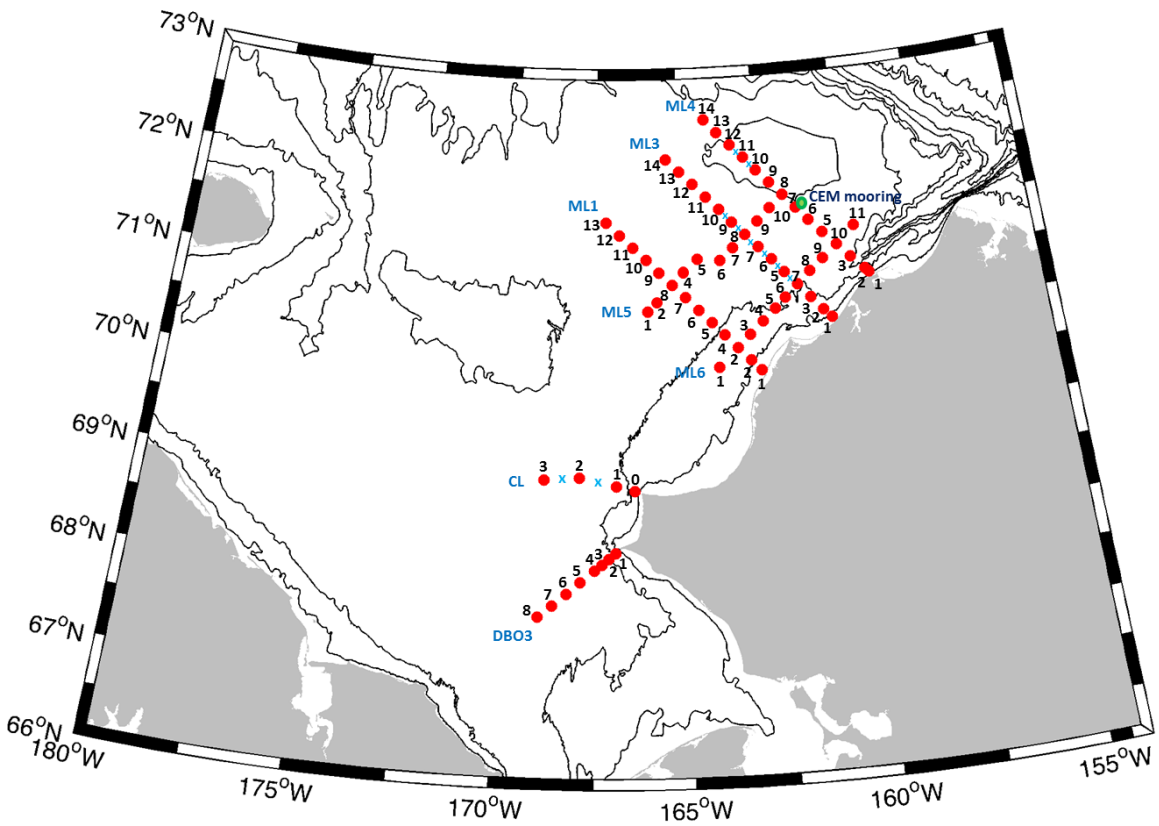

Figure 1: Station map of the AMBON 2015 cruise. Red dots indicate full stations, blue X indicates CTD stations only, green circle indicates CEM mooring.

Hydrography

We occupied a total of 87 CTD stations for hydrographic measurements. Indications of ice melt water were seen on line ML4 (and to a lesser extent, ML3). These relatively cool (T ~ 4-5 C) and low-salinity (S < 29) waters overlaid much colder and saltier remnant winter waters (T < -1; S > 31.5). Close to the Alaskan coast, waters were generally warmer than found offshore (consistent with expectations of Alaskan Coastal Waters), but we did not find a corresponding (and generally expected) decrease in salinity at the nearshore stations of ML3 and ML4. We did observe both warming and freshening near the coast on the ML1, DBO3 and CL transects.

Elevated chlorophyll-a concentrations were recorded by the CTD fluorometer at the farthest offshore stations of the DBO3 line, on the southern side of Hanna Shoal near to the CEM mooring site (station ML4.7 and those nearby), and at a few stations along the ML1 line. The bloom at DBO3 was found in the upper mixed layer, while the Hanna Shoal bloom was found at the base of the mixed layer and on ML1, the phytoplankton were distributed over most of the water column. PAR measurements showed some light down at 25-35 m below the surface during CTD casts that occurred when the sun was above the horizon (casts early in the evening and late in the morning). The elevated ML1 phytoplankton concentrations may have been in response to a new injection of nutrients into the euphotic zone caused by the major wind event of Aug 25-29.

Chlorophyll a was measured from water samples at sea using a Turners Designs AU-20 fluorometer. In addition, sediment chlorophyll from van Veen grab samples (see below) was measured. Higher inventories of water column chlorophyll (Figure 2a) correspond to expected areas of higher productivity offshore along the DBO 3 transect (most southerly transect line) and to the southeast of Hanna Shoal (most northeasterly transect sampled). Surface sediment chlorophyll *a* inventories (Figure 2b, see sampling details below) reflect lower inshore deposition rates and higher current flow compared with offshore.

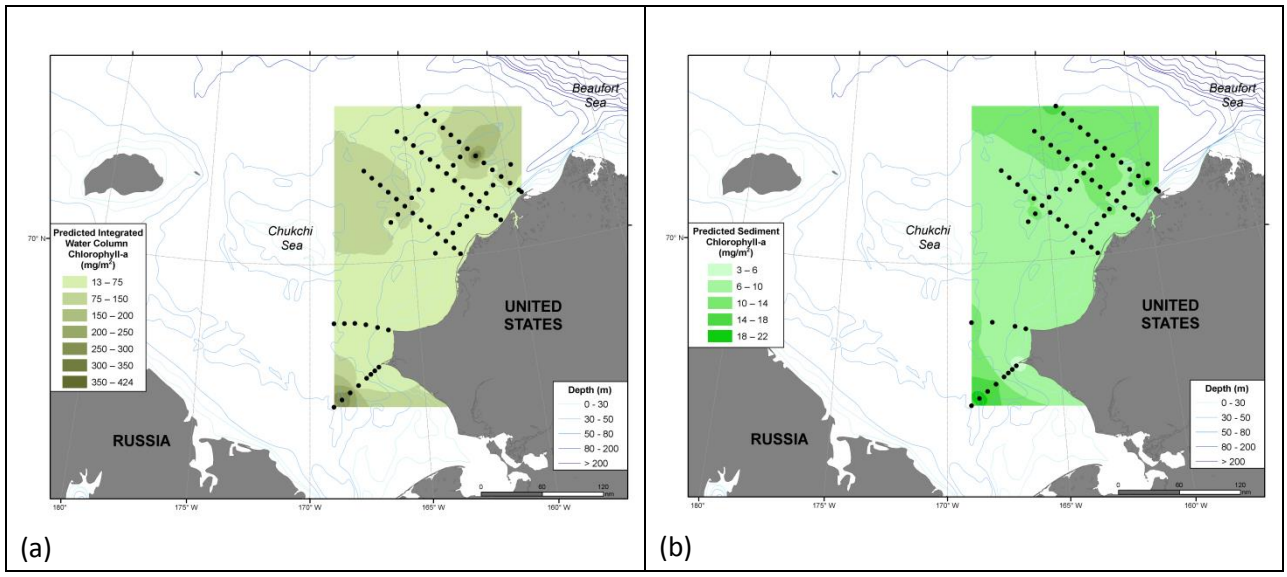

Figure 2. Integrated chlorophyll a (plot a) and surface sediment chlorophyll a (plot b) present in study area during the 2015 AMBON cruise

Microbes

A total of 458 samples were collected for microbial and genetic analysis. These included 178 of seawater bacteria and 30 samples of seawater viruses, 15 samples for eDNA analysis (through collaborator Batelle), 83 meiofauna and 21 bacterial samples from sediments, 20 zooplankton-associated and 43 microplankton-associated microbe samples, and 68 benthic invertebrate (body wall and gut flora) microbial samples. All samples are still in transit and will be analyzed once back at the UAF home lab.

Zooplankton

Zooplankton was collected from 67 Bongo net casts (505 µm mesh). One side of the Bongo net was examined using a light table to identify and measure delicate ctenophores and cnidarians prior to preservation. *Mertensia ovum* was the dominant ctenophore in the study area. *Beroe cucumis* and

Bolinopsis infundibulum were also present, although in lower abundances. The cnidarian community was dominated by the hydrozoan *Aglantha digitale.* The hydrozoans *Melicertum octocostatum*, *Halotholis cirratus*, and *Catablema vesicarium* were also observed. *Calanus glacialis* was the dominant copepod captured in the Bongo net. The copepods *Eucalanus bungi* and *Neocalanus* spp. were observed in the southern portion of the study area; however, the relative contribution of these taxa declined toward the northern portion of the study area. The second side of the Bongo net was immediately preserved in molecular grade ethanol. In addition, 73 vertical net casts (150 µm mesh) were done and samples were immediately preserved in formalin for processing in the laboratory. A subset consisting of samples from ~25 stations was preserved in molecular grade ethanol for future genetic analysis. All zooplankton samples are still in route from the research vessel to the UAF lab.

Macro-infauna and sediment characteristics

Van Veen grab samples were taken where possible (because of substrate limitations) for sediment characteristics and macro-infauna. The sediments over the Chukchi Sea ranged from sand and rock near the Alaska coastline to muddy sediments in the offshore regions, with coarse sediments in portions of Hanna Shoal that were sampled. Gravel mixed with mud was encountered in the Central Channel flow paths across the central Chukchi Shelf, which is significant in terms of increasing effort required for macrofaunal identification and biomass determinations. The highest bivalve biomass was observed in fine sediment in the DBO 3.6-3.8 sites in the southern Chukchi Sea and just south and SE of Hanna Shoal along the ML4 line, particularly in the location of the biophysical CEM mooring just SE of Hanna Shoal. Notably, the apparent high bivalve biomass region was north of the current DBO4 line. Astartid bivalves were dominant in the NE Chukchi Sea, along with maldanid polychaetes, whereas tellinid bivalves dominated the offshore SE Chukchi Sea DBO3 hotspot. Sand dollars dominated a band of coarse sand on the nearest alongshore transect under faster current regimes in the Alaska Coastal Water. Detailed analysis of the macrofauna community will occur once samples have been shipped to the Chesapeake Biological Laboratory of the University of Maryland Center for Environmental Sciences.

Epibenthos

Epibenthic communities and demersal fishes were collected with a 3-m plumb-staff beam trawl (PSBT-A) with 7 mm mesh and 4 mm cod end liner. Epifauna was dominated in number of taxa by gastropods, amphipods and decapods. Epibenthic biomass was particularly high in the lower region of the ML6 transect due to very high abundance and biomass of sand dollars (Fig. 3a). This dominance was also reflected in the corresponding low epifauna diversity in that region (Fig. 3b). Epifaunal richness was highest in the central part of the northern study region. AMBON sampling produced about 80% of the expected epifaunal species richness in the region, based on a Chao estimator of expected species richness.

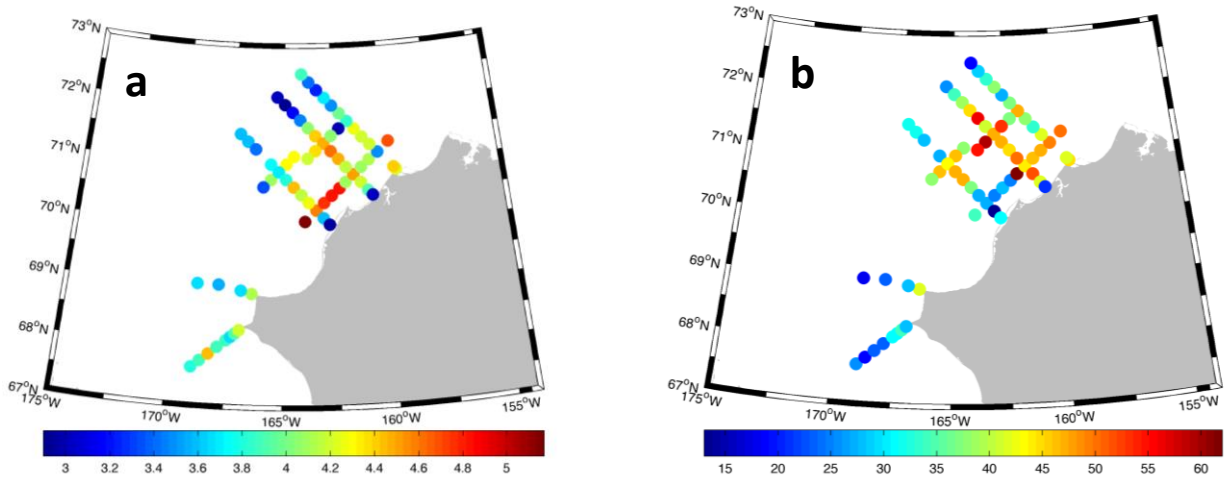

Figure 3. Epifaunal biomass (plot a) and species richness (plot b) in study area during the 2015 AMBON cruise. Biomass is g wet weight 1000 m^{-2} plotted on a log_{10} scale.

Fish

Fish were sampled at 69 stations with the PSBT-A and 30 stations with the IKMT. A total of 28 fish taxa representing 10 families were identified, amounting to a total of 7335 fish identified and measured. Fish taxa were dominated by sculpins (Family Cottidae, N=2015), and within that family, *Gymnocanthus tricuspis* was most common. Pricklebacks (Stichaeidae, N=1821) and cods (Gadidae, N=1280) were the next most common family groups. Fish biomass overall was low, but highest values were found in coastal regions (Fig. 4a). Fish species richness was highest in the southern part of the northern sampling grid (Fig. 4b). The AMBON sampling collected close to 100% of the expected fish species richness in the region based on a Chao estimator (Fig. 5).

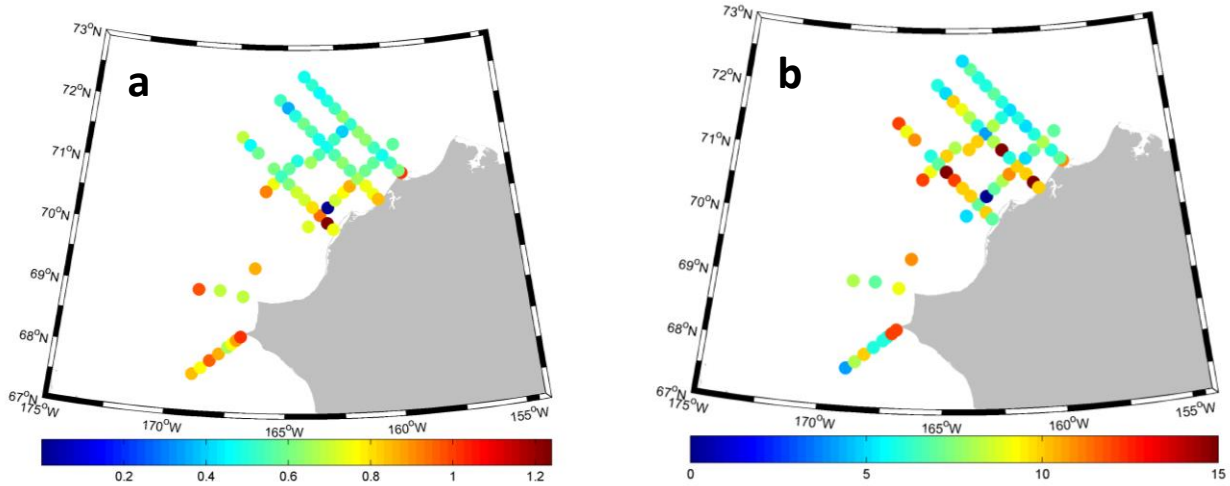

Figure 4. Demersal fish biomass (plot a) and species richness (plot b) in study area during the 2015 AMBON cruise.

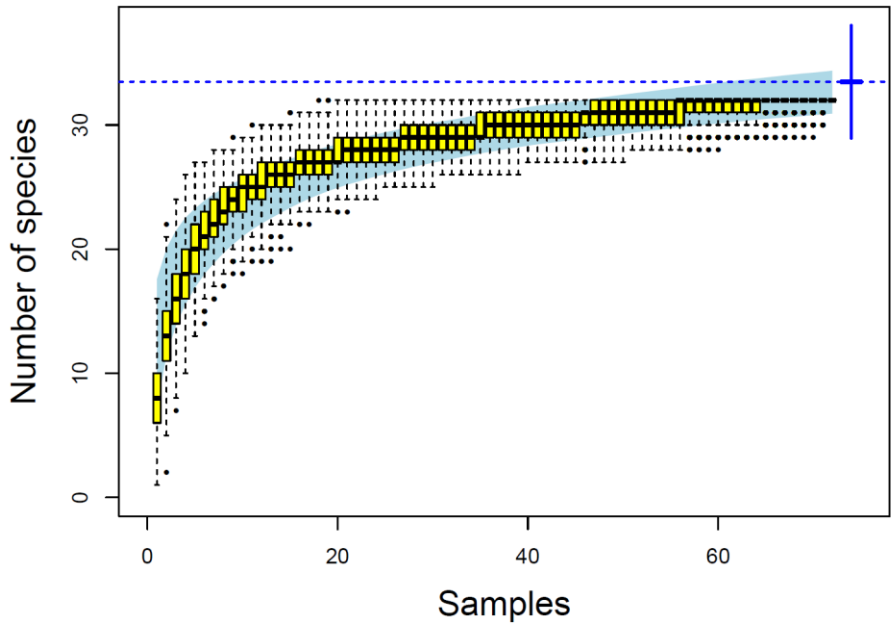

Figure 5: Estimate of total number of fish species in the area, based on Chao estimator.

Seabirds

Seabirds were observed during ship transit times with observations made from the port side of the wheelhouse using line transect methods. We conducted 227.5 hours of seabird surveys covering 3384.7 km. We observed a total of 10,914 individuals of 32 species of marine birds on the AMBON transects and an additional 5,451 individuals, including one additional species in between transects. The most frequently observed taxa were shearwaters (primarily short-tailed shearwater, *Puffinus tenuirostris*), least auklet (*Aethia pusilla*), crested auklet (*Aethia cristatella*), phalaropes (primarily red phalarope, *Phalaropus fulicarius*), thick-billed murre (*Uria lomvia*), common murre (*Uria aalge*), and black-legged kittiwake (*Rissa tridactyla*).

Marine birds that utilize different foraging strategies occurred in distinct spatial patterns. Shearwaters feed on fish and zooplankton and forage both at the surface and underwater, and were broadly distributed, with dense aggregations near Barrow Canyon (Figure 6a). Barrow Canyon is an area where physical processes concentrate pelagic prey, attracting an abundance of marine birds and mammals. Surface-feeding marine birds, a group that includes gulls, terns, and phalaropes, were also broadly distributed, with high densities near Pt. Barrow (Figure 6b). Aggregations of subsurface-feeding marine birds occurred in several areas (Figure 6c). Benthic-feeding marine birds such as eiders primarily occurred nearshore (Figure 6d). Least auklets and murres were abundant near Pt. Hope and Cape Lisburne, an area of strong currents and high productivity. Large numbers of crested auklets, many of them apparently molting, occurred South of Hanna Shoal. Other notable sightings included unusually high numbers of Kittlitz's murrelets (*Brachyramphus brevirostrus*) in the vicinity of Icy Cape. We also observed small numbers of ancient murrelets (*Synthliboramphus antiquus*) and dovekies (*Alle alle*). We observed one dead bird (71.48084 N, 167.143646 W), possibly a medium-sized alcid such as an auklet.

We spent a total of 17 hours within the boundaries of the Ledyard Bay Spectacled Eider Critical Habitat Area, during August 14-15 and September 2-3. On September 3, two groups of spectacled eiders (*Somateria fischeri*) were observed, totaling 11 individuals. The eiders did not flush from the water. We

also observed two groups of king eiders (*Somateria spectabilis*) totaling 5 individuals, and two groups of unidentified eider spp., totaling 20 individuals.

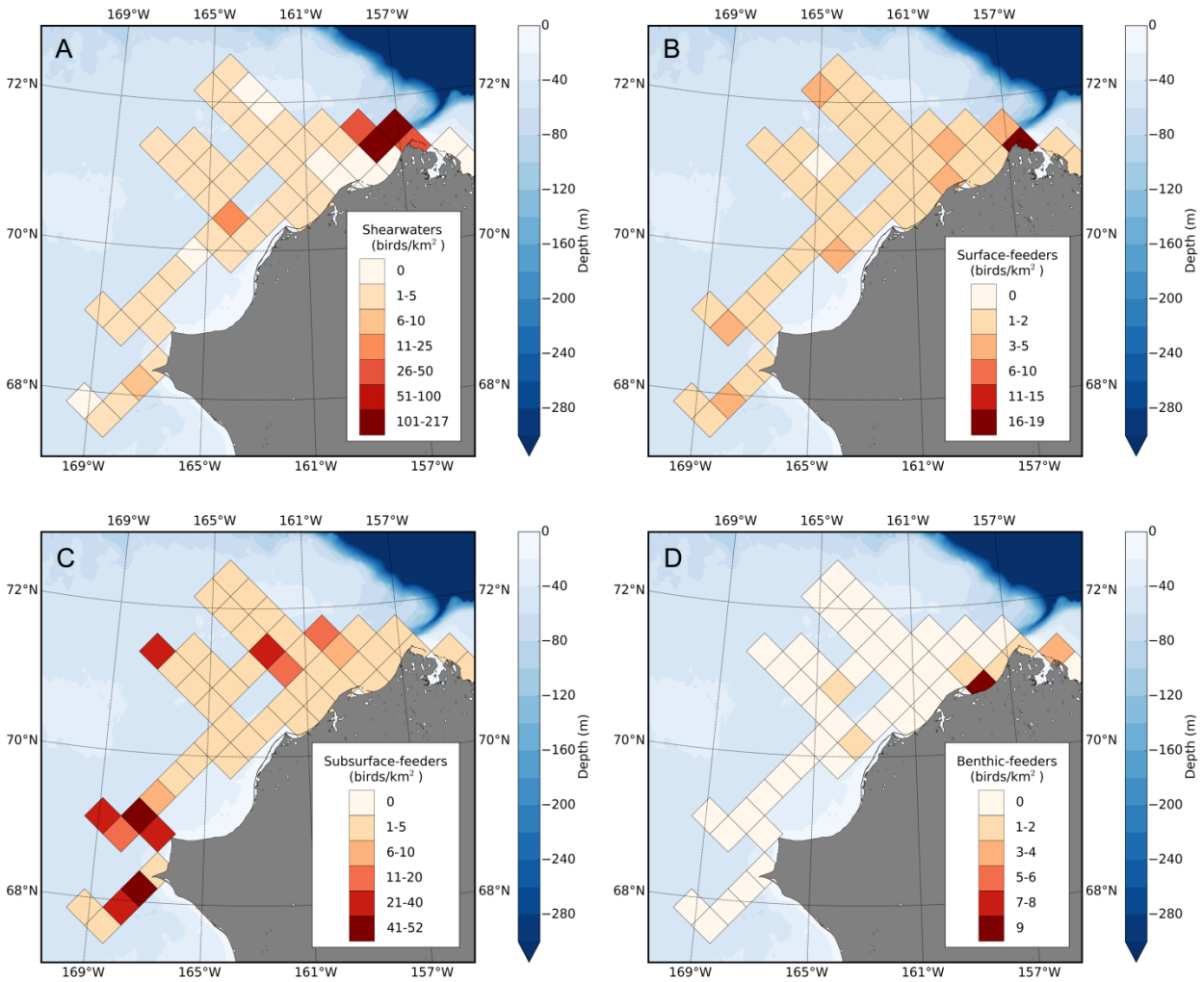

Figure 6: Distribution of seabirds, classified by foraging strategy (Shearwater, Surface-feeder, Subsurface-feeder, or Benthic), during the 2015 AMBON cruise. Map depicts average observed densities within each 40 km by 40 km grid cell.

Marine mammals

Among the marine mammal observations, walrus (*Odobenus rosmarus*) were the most commonly identified marine mammal (Fig. 6), and there were 23 sightings of bearded seals (*Erignathus barbatus*). Unidentified phocids were the most common occurrence and these were likely a combination of spotted and ringed seals, which can be very difficult to identify in the field. Unidentified large whales were the most common cetacean category, with difficulties in identifications due to overall poor sighting conditions (high winds, waves and fog). Gray whales (*Eschrichtius robustus*) were the most abundant identified cetacean, followed by bowhead whales (*Balaena mysticetus*). Sightings were most abundant

on lines ML4 and ML3 with fewest on DBO3 and CL. The sighting conditions on these two lines were quite poor (Fig. 7).

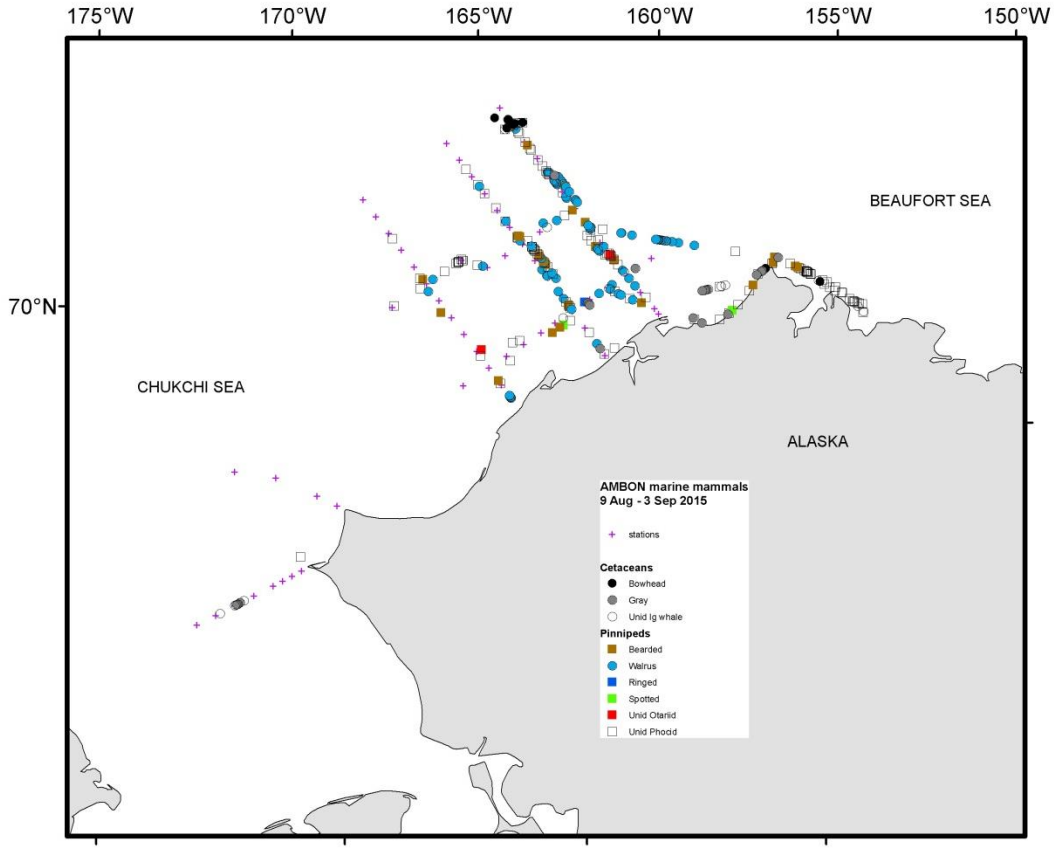

Figure 7: Marine mammal sightings obtained from 12-h ship-board observations during AMBON 2015.

Presentations/Publications (presenters underlined)

AMBON – a US Arctic Marine Biodiversity Observing Network. Iken K, Bluhm BA, Collins RE, Cooper LW, Danielson S, Grebmeier JM, Hopcroft R, Kuletz K, Mueter F, Moore SE, Stafford K, Bochenek R. **Poster** presentation at the Arctic Observing Open Science meeting, 17-19 November 2015, Seattle

AMBON – Arctic Marine Biodiversity Observing Network. Iken K, Danielson S, Cooper LW, Grebmeier JM, Hopcroft R, Kuletz K, Stafford K, Mueter F, Collins RE, Bluhm BA, Moore SE, Bochenek R. **Oral** presentation at the X-MBON meeting, 14-15 October, Monterey Bay.

Arctic Marine Biodiversity Monitoring Network: Towards integrating seabird monitoring with a multi-disciplinary program for the Arctic. Iken K, Bluhm BA, Kuletz K, Collins E, Cooper LW, Danielson S, Grebmeier JM, Hopcroft R, Mueter F, Moore SE, Stafford K, Bochenek R. **Poster** presentation at the World Seabird Union meeting, 26-30 October 2015, Cape Town, South Africa.

Provided slide on AMBON for MBON presentation at the GEO-XII Plenary & Mexico City Ministerial Summit, 11-12 November 2015, Mexico City.

Significant Meetings

AMBON – Arctic Marine Biodiversity Observing Network. Iken K, Danielson S, Cooper LW, Grebmeier JM, Hopcroft R, Kuletz K, Stafford K, Mueter F, Collins RE, Bluhm BA, Moore SE, Bochenek R. **Oral** presentation at the X-MBON meeting, 14-15 October, Monterey Bay.

Outreach

Daily log provided during cruise to >40 individuals in management agencies and local representatives of villages on the North Slope. See http://ambon-us.org/field-work/

AMBON website developed: http://ambon-us.org/

Website entry at UAF School of Fisheries and Ocean Sciences
https://web.sfos.uaf.edu/wordpress/news/?p=1960

Changes/Problems encountered

A major change in the program, both in terms of finances as well as scope of work, came through the decision of Shell Industry to cease all operations in the Arctic, and effectively withdrawing funds planned for the AMBON project. This cut 1/3 of the AMBON funds, with a subsequent need to seriously re-consider the scope of work that can be accomplished. As a first step, the originally planned field work for 2016 was canceled as three field seasons is now no longer financially viable. We are still planning on a field season in 2017 but will have to reconsider length and scope of this field work. An additional re-budget of all program components will be necessary. This will be discussed in detail during the PI meeting planned for 1-2 February 2016 in Fairbanks, Alaska.

Sample analysis from the first cruise in 2015 has been slightly delayed because the research vessel is returning back to port about 6 weeks later than anticipated. We currently expect samples to get off the ship and being shipped to their lab destinations by late November.