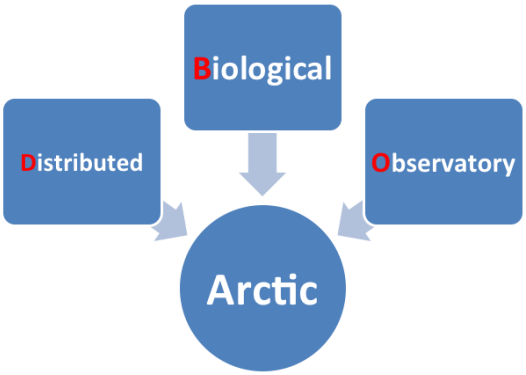
Distributed Biological Observatory

Annex 2_1_3 DBO Report



The Distributed Biological Observatory (DBO) 2nd Data Workshop Final Report

October 29 – 31, 2014
NOAA / PMEL
Seattle, Washington, USA

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AOOS Alaska Ocean Observing System

NSF

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A. Introduction

Since 2010 the Pacific Arctic Group (PAG) has endorsed the Distributed Biological Observatory (DBO) that is focused on ship-based research in the northern Bering and Chukchi Seas (http://www.arctic.noaa.gov/dbo/). The PAG established the DBO as the organizing framework for research that consists of standardized sampling at oceanographic stations in five regions in the Pacific Arctic. Collectively, the DBO is a "change detection array" along a latitudinal gradient extending from the northern Bering Sea to the Chukchi Sea and into the Beaufort Sea. DBO sampling is focused on stations centered on locations of high productivity, biodiversity and rates of biological change. Research cruises networked by PAG members through national support include a collection of standardized measurements of physical, chemical and biological measurements at set station locations.

The DBO sampling framework was initially tested during the successful 2010 Pilot Study, which consisted of international ship occupations of two of the DBO regions, one in the SE Chukchi Sea (DBO 3) and one across upper Barrow Canyon (DBO 5) in the NE Chukchi Sea. Provisional results of the 2010 Pilot Study were the central topic at the December 2010 PAG meeting in Tokyo, Japan, and at the March 2011 DBO workshop in Seoul, Korea, held immediately prior to the international Arctic Science Summit Week (ASSW). Subsequently, the 1st DBO data workshop was held February 27-March 1 2013 at the US National Oceanic and Atmospheric Administration (NOAA)/Pacific Marine Environmental Laboratory (PMEL) facility in Seattle, Washington. The purpose of the meeting was to discuss the results from the 2010-2012 DBO effort under PAG leadership, share data sets, develop a draft international data policy for this observing effort, and organize collaborative publications.

The 2nd DBO data workshop was held October 29-31, 2014 at the NOAA/PMEL in Seattle, Washington, USA. The 2nd DBO data workshop continued development and implementation of the DBO through presentation of available results, breakout group discussion on measurement protocols and findings, and development of visualization products for disseminating DBO findings to the science community, resource managers and the general public. Potential new DBO lines in the western and eastern Beaufort Sea and the development of collaborative-type DBO lines in the northern Barents Sea were also discussed. We also identified manuscript topics for a special issue of the DBO findings. The workshop consisted of over 50 international participants, with financial support from national and international agencies. In the USA, support for the workshop was provided by NOAA, NSF, BOEM, USFWS, and the Alaska Ocean Observing System (AOOS). Internationally, the IASC Marine Working Group provided support for the DBO workshop. Note that most of the workshop participants obtained national support to attend the workshop.

This report provides a summary of the 2nd DBO data workshop presentations, discussions and results.

B. Wednesday-29 October 2014

B1. Welcome and Logistics

Welcome (Sue More, NOAA/Fisheries) (ppt1)

Sue welcomed the group to the workshop and provided an overview of the IARPC (U.S. Interagency Arctic Research and Policy Committee). She presented a map of the DBO transects and defined the DBO as regions centered on biological "hotspots" along a latitudinal gradient in the northern Bering and Chukchi seas. The hotspots exhibit high productivity, biodiversity, and rates of change. The DBO serves as a *change detection array* and has been the basis for a pilot study from 2010-14. Over this period there have been between 9-11 cruises per year with multiple reoccupations of the transect lines seasonally during each year. The IARPC is collaboration of 12 teams comprised of 16 U.S. agencies, including NSF/AON, BOEM, NASA, NOAA, and AOOS, as well as state and academic partners. The DBO Collaborative Team (CT) milestones specifically relevant to this workshop include:

- **3.1.3.g** Update DBO concept and national/international plan for decadal-scale implementation to include identification of satellite resources that will be critical to the DBO
- **3.1.3.j** Ensure DBO data access and archiving are coordinated across agencies and among international partners
- **3.1.3.h** Starting in 2015, DBO partners execute decadal-scale plans and prepare periodic assessments on the physical and ecological state of the Pacific Arctic marine environment using not only DBO data, but also from BOEM, NPRB and other sources

More information on the DBO is available at: http://arctic.noaa.gov/dbo/about.html/
For information on the IARPC DBO CT visit:
http://www.iarpccollaborations.org/teams/Distributed-Biological-Observatory

Introduction (Jackie Grebmeier, UMCES/CBL) (ppt2)

Jackie provided the agenda for the 2nd DBO data workshop and a summary of the rationale and goals of the DBO. Part of the rationale for the DBO is that tracking biological responses to physical drivers in the Arctic requires coordinated, multidisciplinary field sampling. In addition, many developing observational systems in the Arctic are focused on physical sensors, but biological sampling across a range of spatio-temporal scales is required to detect ecological shifts in response to environmental forcing. Standardized sampling protocols that are used by national and international programs are needed, and the DBO includes core ship-based sampling for: temperature and salinity using a CTD, currents via ADCP measurements, chlorophyll, nutrients, ice algae/phytoplankton, zooplankton, benthos, seabirds, and mammals. Second tier sampling includes fish acoustics and bottom trawling. Finally, a coordinated ship-

based sampling, coincident with data streams from satellites and moorings, will provide an early detection system for biological shifts in the Arctic. The program's strengths are its national and international relationships, including being part of the Circumpolar Biodiversity Monitoring Program (CBMP) and Sustaining Arctic Observing Network's (SAON) committees of the Arctic Council.

Workshop objectives included:

1. Present results from the 2010-2014 DBO field program and determine a basis for multi-disciplinary papers to showcase results of the DBO international effort,
2. Evaluate the DBO data submission effort through the AOOS-DBO data workspace, EOL open data site, and discuss linkage to national archives,
3. Determine the location of new DBO transect lines in the Beaufort Sea, western Chukchi Sea, and possibly other international lines, such as in the northern Barents Sea, and
4. Discuss a plan for full implementation for the DBO.

B2. Physical Oceanography (Discussion lead: Bob Pickart)

Bob Pickart (WHOI) (ppt3a) provided an introduction to the session and suggested that DBO data integration is big, but it must start with small steps. Physical oceanographic data is the most rapid data type to collect, and these data are being used in DBO publications that are in development or submitted. Also, physical oceanographic data need to be provided to the community to help produce publications within the DBO effort.

Motoyo Itoh (JAMSTEC) (ppt3a) examined water properties and volume, heat and freshwater fluxes in Barrow Canyon (DBO5) during the summer of 2010. From mid-July to late-September DBO teams completed 6 repeated CTD casts and ADCP transects. The flows generally followed the isobars. Most of the heat was maintained by the Alaskan Coastal Water (ACW), and the heat flux was 3-5 times larger than in 1993 due to the warming of the ACW. Barrow transport and along-coast wind speeds were found to be highly correlated (r=0.93). Volume transport calculated from wind and along-canyon flow measurements from mooring data were also significantly correlated (r=0.74). This finding supports the estimation of volume transport obtained from the wind forcing. The DBO5 results can also be compared to the JAMSTEC line nearby. DBO data allowed better interpretation and calibration of the mooring data. Please see the slide presentation providing graphical and statistical summaries of their analyses.

Svein Vagle (Fisheries and Oceans Canada) (ppt3a) – Results from the annual DBO/C30 (Canada's Three Oceans) cruises on the CCGS Sir Wilfrid Laurier including sampling on all 5 DBO lines, with the ship departing on the same date every year, thus allowing reliable comparison between the years. This year's activities included 47 DBO stations, 47 CTD/Rosette casts (with nutrients), 30 150 kHz ADCP over-the-side deployments, 33 bongo net collections for zooplankton, 32 benthic station collections, an optical package, and phytoplankton incubations and taxonomic collections. Data on temperature, salinity, and fluorescence showed similar patterns in 2010, 2013 and 2014. It was suggested that it is important to notify others on the DBO website whether data such as fluorescence are calibrated or not, so that people can

calibrate the results themselves. Data collection varies annually from 26-50 stations due to weather and sea ice conditions. Seabird and marine mammal observations were also conducted from the ship.

Carolina Nobre (WHOI) (ppt3a) presented data on the DBO5 transect line from 2010 -2013 that included 24 occupations of the Barrow Canyon transect and a total of 202 CTD casts. These occupations are fairly well distributed seasonally and annually, and they added more occupations in 2014. In order to understand how wind events forced upwelling, they compared the wind speed with the along canyon component with the density anomaly in the eastern part of the Canyon. The highest correlation occurred in a timeframe of 3 days with wind speed exceeding 6.5m/s. This 6.5 m/s speed was used as a metric to differentiate between the upwelling effect and the upwelling results in the 24 occupations; 7 occupations qualified as upwelling events. There is a stark difference between the isotopic signals of the slope waters and the saltier, cold water that coincides with the upwelling events. Future studies include continued water mass composition studies along Barrow Canyon and further quantifying of upwelling events.

Carin Ashjian (WHOI) (ppt3b) sampled near the DBO2 transect line on the RV Annika Marie from 2005-2014. This line (which is not the DBO line) is a sentinel line and has been sampled consistently since 2005, with support from three programs: NSF/SNACS, BOEM/BOWFEST and NSF/AON. It was noted that when wind blew warm water from the south, the data showed that it was 3˚C on 21 August and 6˚C on 5 September within the ACW. It was considered cold in 2014, but was it really? The stark temperature change in the Chukchi Sea was most likely from the wind speed and direction that had changed, bringing in warm ACW. Carin showed the impact of short- and long-term winds on the ocean and noted how remarkable it was to watch the warm water come in from the south. Maps of “warm” water years vs. “cold” years, with arrows of the prevailing winds, showed large-scale pressure patterns that drive these winds. She noted a unique change in temperature in 2014.

Phyllis Stabeno (NOAA/PMEL) (ppt4a) began by noting that 4 of the 5 DBO regions have at least one mooring. In DBO region 1, the currents were persistently westward during the ice-free period, independent of wind direction, and have been sampled since 2004. This northern region may be more impacted by seasonal acidification compared to other areas in the Bering Sea. Temperature became warmer on the lower shelf and persisted until just before the ice cover in October and winds were consistently westward. The atmosphere cooled this northern DBO1 site as compared to further south in the Bering Sea, which was cooled by ice. DBO region 4 also has long-term moorings. Ice thickness measurements from the moorings, supplemented with satellite data, show that ice arrives in October and persists into July or August, with 30 m ice recorded as the deepest keel in late spring. Marine mammal passive acoustic devices in the region showed that bowheads disappear when ice becomes thicker than 1 meter. In addition, one can observe the daily migration of plankton in the water column.

Takashi Kikuchi (JAMSTEC) (ppt4b) has been focusing on sampling during July in DBO regions 3 and 5 since 2012, with moorings deployed in each region. The southern DBO3 Chukchi Sea

mooring indicated possible diurnal vertical motion of zooplankton in mid-winter. During the 2013-2014 period, JAMSTEC also monitored volume, heat and freshwater fluxes of the Barrow Canyon by long-term moorings both at the DBO5 site and further down the canyon. The yearly averaged total heat flux through Barrow Canyon in 2007, 2010 and 2012 was over 3 TW (terawatt), meaning that it could melt 360,000 km^2 of 1 m thick ice. As there were no sediment trap moorings this year, they plan to deploy them in the year 2015. Echograms show interesting diurnal vertical motion of zooplankton in mid-winter in this region, too.

Bob Pickart (WHOI) (ppt4c) stated that the NSF/AON (Arctic Observing Network) Beaufort Slope monitoring group has long-term moorings at 152˚W on the Beaufort slope, deployed from 2002 - 2016. The mooring site is not in Barrow Canyon, but downstream of the canyon to measure the outflow of Pacific water from the Chukchi shelf. In the first two years an array of 8 moorings were deployed to understand the overall characteristics of the area. The Beaufort Slope has a narrow shelfbreak jet with strong seasonal dependence. In spring, there is a bottom intensified shelfbreak jet carrying very cold Pacific Winter Water (PWW), while in the summer, a surface intensified shelfbreak jet imports warm ACW and Bering Sea water. This system was found to be highly sensitive to winds and strong upwelling events. Considering these characteristics, they identified an effective long-term current monitoring site, which was well placed to obtain winter, spring, and summer configurations and to monitor transport with along-stream and cross-stream measurements. The dominant variability is a pulsing current rather than a meandering current, which means that using only one mooring will be effective. Seasonal variation in volume and heat transport indicates that most of the transport of the current, and nearly all the heat flux occurs in the summer months. The boundary current has drastically diminished transport in the winter. Most of the inter-annual variation in transport occurs during summer. This total transport is eastward, but was caused by weaker winds in the earlier part of the decade and more winds in the present decade. The winds increased from the Beaufort High and Aleutian Low. The individual years indicate that sea level has been enhanced by the Beaufort High and the Aleutian Low atmospheric systems. These results lead to the question, is this change a climate shift or just an inter-annual oscillation? Bob will continue evaluating the mooring data for his hypothesis.

Seth Danielson (UAF) indicated that the NPRB has recently supported the long term monitoring ecosystem program in the Chukchi Sea. The mooring, situated in a region of high benthic biomass of bivalves, is just north of the DBO 4 line and was deployed for the first time in 2014. This is a long term monitoring project on the Chukchi ecosystem year-round with the advantage of data collections of multiple disciplines across multiple trophic levels and with high temporal resolution. The upwelling events along Barrow Canyon had a remarkable correlation between wind events south of Bering Strait and hydrographic events in the vicinity of Barrow Canyon via modeling studies. He also related timing and magnitude of fluctuations of nutrient and carbonate chemistry, particulate, phytoplankton, zooplankton, and fish parameters to variations in each other and the currents, waves, wind, light and ice. These data can provide resource managers with a multiyear referenced arctic shelf biogeochemical dataset.

B3. Chemical Oceanography and Export Production (Discussion lead: Lee Cooper)

Lee Cooper (UMCES/CBL) (ppt5) provided a list of data available from various DBO transect lines across multiple years, including from the annual DBO/C30 cruise and other research cruises (COMIDA, RUSALCA, BEST). Comparisons of the spatial pattern changes for 2013 and 2014 were presented for several variables, including chlorophyll *a* (chl *a*), ammonia, and silica, indicating seasonal and interannual variability. For example, silica declines northward of the DBO1 transect line annually. There is data for NH_4 for almost the same date every year that shows interannual variability. Silica is available for all 5 DBO transects and declines as you go north along DBO1, indicating continual biological use. In the summer of 2015, collaborators will deploy a multi-sampler sediment trap on the NE Chukchi Ecosystem Mooring, using a different design that is more suitable to a shallow shelf that will allow links of biological processes (e.g. plankton production) to be coupled with primary production (discussed below). In addition, satellite measurements of chl *a* and field collections of chl *a*, phaeophytin-*a*, and CDOM (colored dissolved organic matter) at different wavelengths, and suspended particulate matter have been collected for the period 2013-14 via NSF and NASA support. The spectral slope for Barrow Canyon in July was very interesting and anomalous.

Catherine Lalande (ArcticNet) spoke about the Initiation of a collaborative project between ArcticNet in the region of DBO4 that will consist of the deployment of a long-term sequential sediment trap. Export fluxes of biogenic matter on the existing Chukchi Ecosystem Mooring will be established on the DBO4 line and will be managed by Seth Danielson at the University of Alaska Fairbanks.

B4. Satellite Coverage (Discussion lead: Karen Frey)

Josefino Comiso (NASA) (ppt6a) provided updates on remote sensing visualizations of sea ice over time. There was a record low in the extent of perennial/multiyear ice in 2012 and a rapid decline of thick, multi-year sea ice from 1980-2012. He also presented monthly averages of chl *a* by year showing some anomalies as well monthly cloud fraction. The rapid decline of perennial sea ice cover in the Arctic is having a system-level changes. Satellite data of Arctic chlorophyll indicate changing plankton distribution in spring and summer as sea ice retreats. The peaks in the Sea of Okhotsk, Bering and Barents seas are in May, but move northward through August. In 2014, high plankton concentrations in certain areas were observed. The anomalies in chl *a* from satellite data indicate a negative trend from May – August 2014. Productivity is changing, but trends are difficult to interpret due to large variability in the data sets. DBO and other data are needed to improve the accuracy of satellite chl *a* concentration estimates, although satellite data provides the means to look at large scale productivity of plankton concentration and identify location and spatial extent of hotspots. The sea ice and surface winds animation for August 2012 indicated that storms can be a large factor in the increase in seasonal sea ice retreat during this year.

Karen Frey (Clark University) (ppt6a, ppt6b) presented updates on sea ice shifts using remotely-sensed data and noted that there have been changes in ice over the entire DBO area. She looked at the number of days per year of sea ice persistence, timing of breakup/formation, sea surface temperature, and ocean color data used to determine chl *a*. Ocean color is often impacted by ice and clouds and can be more difficult to interpret. It is also impacted by terrestrially-derived turbidity in estuaries and regions of high coastal erosion that may have more particulates. Trends in annual sea ice persistence show that over the past decade there has been a decline in ice in the Chukchi Sea (summer) and an increase in the Beaufort Sea (winter). Overall, the trend is that sea ice has been declining at all DBO sites, except DBO1. Bifurcation in the data show that for 2000-2013 there has been a sea ice decline northward and an increase southward of St. Lawrence Island in the northern Bering Sea. It is difficult to place trend lines through biological (e.g., chl *a*) data as they are spotty, with chl *a* trends calculated at the 0.1 probability level. Karen highlighted that CDOM (colored dissolved organic matter) is important to accurately measure and quantify because it confounds the chlorophyll signal. CDOM can limit light impacting photosynthesis, which is an important component to the microbial food web and also impacts light absorption in the upper ocean. She noted that just removing sea ice won't necessarily increase primary production because nutrients are required. She posed the question: Can we incorporate surface nitrate into our studies of sea ice and ocean color measurements?

Satellite products are being compiled across the five DBO regions, including sea ice concentration, sea surface temperature, and chl *a* concentrations. Despite the presence of clouds, chl *a* concentrations can be remotely sensed. However, the lack of sunlight, especially in the beginning of fall, complicates data collections. In particular, the interpretation of chl *a* data, coincident with turbidity and CDOM levels, is challenging. Biology is complex and making it difficult to quantitatively use remote sense for interpreting biological processes, requiring field data calibrations.

C. Thursday-30 October 2014

C1. Biological Oceanography

C1.1 Lower trophic levels (Discussion lead: Jackie Grebmeier)

Kyoung-Ho Cho (KOPRI) (ppt7a) gave a summary on the DBO survey undertaken during the 2014 RV ARAON Arctic Cruise. They departed Nome on July 31 and arrived in Barrow in 25 August. They occupied 6 stations on DBO3 and obtained data on temperature and salinity from CTDs that showed relatively cool saline water at the bottom offshore, but relatively warm and fresh water nearshore. There was low concentration of dissolved oxygen and maximum turbidity at the bottom. Maximum fluorescence was found at mid-depth where a maximum concentration of dissolved oxygen existed. ADCP data showed water velocity vector direction and strength of currents at different depths. Fluorescence and chl *a* were analyzed from water samples at several depths. Nutrients, such as ammonium, phosphate, nitrate, nitrite and silicate were analyzed from water samples at several depths. Phytoplankton and zooplankton data are in process of being analyzed and these data will be presented during the next meeting.

Lisa Eisner (Auke Bay Laboratories) (ppt7b) summarized quantitative surveys and sampling from the 2012 and 2013 Arctic EIS (Ecosystem Integrated Survey) effort, supported through UAF and NOAA, that showed that future climate impacts to the marine system are uncertain. According to fish and acoustic data from NOAA in 2013, saffron cod was 4 times more abundant than 2012 and in 2013 arctic cod was 3 times more abundant compared to 2012. Additionally, there were differences in temperature and salinity values between 2012 and 2013. It seems the Alaska Coastal waters were cut off in 2013 in regions of the Chukchi Sea. Also more nutrients, especially ammonium, were found at the bottom in 2013 compared to 2012 and there were hotspots near DBO2 and DBO3. The Alaska Coastal Current seemed to have had more retention in 2013 as some drifters were found to have exited Barrow in 2012, while in 2013 the drifters stayed mainly on the shelf. This implies that the Alaskan Coastal Current was stronger in August 2012 and weaker August 2013.

Diana Varela (University of Victoria, BC, Canada) (ppt7c) described euphotic zone measurements undertaken during the annual DBO/C30 cruise on the CCGS Sir Wilfrid Laurier cruises at all the DBO transect lines in 2006, 2008, and 2011-2014 [note that the phytoplankton taxonomic data was identified by scientists from IOPAN in Poland via NSF support). The C30/DBO data in July 2013 indicates that the diatoms were most abundant on DBO line 3, which was unexpected as their abundance usually decreased toward the coast. On DBO lines 3 and 4 coccolithophores and small flagellates were next in abundance after diatoms. The interesting trends from 2006-2012 indicate that biogenic silica concentrations in the Bering and Chukchi Seas decreased, but there was no clear trend for chl *a*. However, in 2013 there was a sudden increase in the biogenic silicon concentration and chl *a* concentrations, perhaps due to a dramatic increase in the contribution of non-siliceous large cells to phytoplankton dynamics in the Chukchi Sea. This means that chlorophyll alone cannot explain the whole story. Therefore, integrating all the physical data in understanding the trends is crucial. Jackie suggested that it

would be interesting to combine this information with water mass data as well as looking at the influence of wind on changing patterns in nutrient and biological parameters.

Carin Ashjian (WHOI) (ppt7d) summarized oceanographic sampling that occurred from mid-August to mid-September 2005 – 2014. In 2006 their program sampled along 7 – 8 lines and from 2007 they sampled on 3 - 4 sentinel lines (which are not quite on the DBO5 line, but in the region). The 10 years of data collected show dramatic variation, such as the presence of *Synechococcus* spp., as measured by flow cytometry between 2002 – 2013, which was not present in any abundance until the water reached 4˚C. The interannual variability in copepod abundance did not have a consistent trend between the copepod species and water masses. Interestingly, abundances in taxa seemed to dominate for 2-3 years, then fade out and be replaced by new dominant taxa. So, will these blooms be present all year, or do they occur just in the right temperature range? The Healy winter cruise in November – December 2011 had full ice cover with sea ice forming. Nutrients, such as nitrate and silicate, were low on the DBO5 line as winter water was forming. Likewise, there was low phytoplankton – chlorophyll – found throughout the cruise, with the highest values at locations where ice formed last. From August-September compared to November, abundance of krill was lower at Barrow in summer than in the northern Bering Sea in November, but more abundant at Barrow in summer than at the location in winter. Also, *Furcilia* sp. dominated in late summer while juveniles and adults dominated in early winter.

Russell Hopcroft (UAF) (ppt7e) noted that UAF holds a very large amount of zooplankton data from multi-year and multi-program investigations in the NE Chukchi Sea. He showed examples of distribution and relative abundance for three zooplankton species, including *Calanus glacialis, Neocalanus*, and *Eucalanus*. These data show a lot of variability over the time period of 2008-2013 from the industry-supported CSESP (Chukchi Sea Environmental Studies Program) studies that included occupation of DBO4. He noted that these zooplankton species often do not reach DBO4 in the NE Chukchi Sea because they are blocked by oceanographic frontal line. Jackie pointed out that DBO4 is one of the most heterogeneous regions. Russ has sampled zooplankton communities for 6 years (2008-2013) on an extended length of the DBO4 transect line from nearshore Alaska to further offshore waters (by comparison, the international DBO4 line is only focused on the hotspot site offshore). Measurements included microplankton, taken by CTDs with niskin bottles, nutrients and chlorophyll surface concentrations, and 150µm vertical and 505µm bongo nets for macrozooplankton. *Calanus glacialis* studies show variability from year to year where they are mostly abundant in cold water with high abundance in 2012-2013 and moderate abundance in 2010-2011. *Neocalanus* and *Eucalanus* were mostly found in the southeast area that seemed to be associated with warmer waters. Temperature and water masses seem to be the driving factors for zooplankton clustering into separate groups. The DBO line 4 seemed to be the borderline for interannual variability in the zooplankton groups. Through studying zooplankton prey, the role of microzooplankton seems to be greatly underestimated in cold waters and Russ felt it was important to emphasize that they should not be ignored.

John Nelson (Stantec) (ppt7f) provided DBO zooplankton updates from CCGS Sir Wilfrid Laurier as part of the annual DBO/C30 cruise in 2013 using a multi-frequency acoustic instrument for characterization of vertical ecosystem structure in the northern Bering and Chukchi Seas, along with zooplankton nets. As his team has been sampling since 2000, the accumulation of data helps to interpret current trends of zooplankton with the genetic history. Multidimensional scaling of parameters by region indicates a very clear biogeographic regional structure. In addition, there was variability between stations, seasonally, and interannually. They are sampling different water masses, but looking for large-scale biogeographic community structures that are largely driven by latitude and chl *a* levels. Biogeographic structure for DBO1-3 in 2012 seems to be reproducible from year to year (via similarity cluster analysis). Multi-frequency acoustic instrumentation was used to characterize vertical ecosystem structure in 2013, with a focus on the SLIP (DBO1) stations. SLIP4, for example, shows some obvious vertical structure in zooplankton populations that could be calibrated with more discrete vertical zooplankton sampling. Also, using four frequencies to classify the backscatter in the acoustic patterns can act as signatures for organisms. A lot more work needs to be done on extracting information from the water column layers. For the next sampling effort, they'd like to point the transducer sideways instead of down. John aims to find the correlations between the large biogeographic zooplankton structures of the region and the environmental variables (see Pomerleau et.al., 2014, J. Plankton Research for reference).

Arny Blanchard (UAF) (ppt7g) outlined benthic findings from the CSESP program where team members sampled the extended DBO4 transect line in 2012 – 2013 (the extended DBO4 transect line runs from nearshore Alaska to further offshore waters; by comparison, the international DBO4 line is only focused on the benthic hotspot site offshore). The extended DBO4 line crosses strong physical and depth gradients that show the degree of environmental change. The physical conditions of the extended DBO4 line show dynamic coarser sediments and shallow water nearshore. The sea floor was found to be colder with more saline waters offshore, while the nearshore waters were fresher and warmer. There was a strong spatial benthic biomass gradient, being low nearshore and high offshore, with high biomass bivalves along the line. The physical-biological interactions were measured by the average of benthic density of 9 repeatedly sampled stations in the CSESP study area and the Arctic Oscillation (AO) index. Seabirds and marine mammals were also observed in 2013 on the DBO4 line. In summary, the distribution of benthic fauna, seabirds and marine mammals, may reflect the physical conditions of the Chukchi Sea. For more information on the CSESP program, see: http://www.chukchiscience.com/.

Jackie Grebmeier (UMCES/CBL) (ppt7h) presented data on chlorophyll and annual distribution of macroinfaunal biomass for all the DBO regions combined that indicates that the benthic biomass increases from DBO1 to DBO3. Jackie gave an update of the climatology of the 5 DBO sites for sea ice and temperature. The DBO3 line had benthic diversity higher nearshore as it becomes rockier and more heterogeneous. As one example, the offshore hotspot for tagged gray whales was near the DBO3 line in the southeast Chukchi Sea, a region of a known very high benthic biomass. The benthic crustaceans had their highest abundance and biomass in this region for the DBO3 line.

C1.2 Upper trophic levels (Discussion lead: Catherine Berchok)

Catherine Berchok (NOAA/AFSC/NMML; ppt8) summarized marine mammal occurrence in the northern Bering and Chukchi seas using the combined data from visual surveys from vessels or planes, and by passive acoustic detections using expendable sonobuoys and long-term moorings. During the BOEM-funded CHAOZ, CHAOZ-X, and ARCWEST cruises from 2010-2014, there have been attempts to tag marine mammals in the DBO sites 1-3, although these have been largely unsuccessful. Visual and acoustic detections in 2011 at DBO1 showed large numbers of humpback and fin whales in the region. Many gray whales were observed at DBO2 DBO3 has the most diverse species grouping of whales, including gray, humpback, killer and fin whales, along with pinnipeds. The best survey coverage was in DBO4 with observations of bowheads, bearded seals, walruses, and beluga whales. Bowhead whales were commonly seen in the eastern portion of DBO5, and bearded seals and gray whales were also observed in the region. There are long-term passive acoustics moorings in almost all DBO regions to record marine mammal sounds year-round.

Yoko Mitani (Hokkaido University) summarized acoustic monitoring and visual survey data of marine mammals conducted in the Chukchi Sea and Barrow Canyon via Japanese cruises. In total, this team conducted sighting surveys for 15 days, ~69.5 hours during 2007 and 2012. They observed gray whales (two groups, three animals), bowhead whales (two groups, three animals) and two unidentified whales with dorsal fins. From 2012 July - September marine mammal calls from the southern Chukchi Sea and Barrow Canyon were analyzed from acoustic recorders. The results indicated that bowhead and fin whales were often found in late summer in the southern Chukchi Sea, although they were not found in Barrow Canyon.

Sue Moore (NOAA/NMFS) discussed the CCGS Sir Wilfrid Laurier marine mammal 'watch' on the annual DBO/C30 cruises conducted each July 2011-2014. A marine mammal watch is conducted by one observer scanning for marine mammals to the horizon using binoculars when the weather permits. Marine mammal sighting maps and data are available for each cruise on the AOOS/AXIOM DBO workspace.

Janet Clarke (NMFS/Leidos) presented a time series of aerial surveys of arctic marine mammals that have been conducted since 1979; see Aerial Surveys for Arctic Marine Mammals (ASAMM, http://www.afsc.noaa.gov/NMML/cetacean/bwasp/index.php). During 2010-2014 sampling occurred at various levels in the DBO 3, 4 & 5 regions. However, Janet noted that they do not survey directly along the DBO transect lines as the aerial survey transects go perpendicular to the coast. They have surveyed south of 68˚N on DBO3 in the southern Chukchi Sea that is biologically-rich, although they only had a few sightings of walruses as these animals are usually observed further north near the sea ice. Gray whales are common in the DBO3 region, with fin and humpback whales seen by September in this region. However, fin and humpback whale distributions were different the two years they were seen. In the DBO4 region, bowhead whales were mainly sighted in 2012, while gray whales were sighted in all years. Walruses were

seen south of Hanna Shoal. In the DBO5 region, gray whales were found nearshore east of Barrow Canyon. There have been relatively few walrus sightings in the DBO5 region. There are more aerial surveys in the Beaufort Sea, where bowheads are observed nearshore and on the shelf, and farther offshore in the summer. Bowheads seem to fan out rather than follow a path in the Beaufort Sea.

Cathy Coon (BOEM) summarized walrus tagging efforts. Lori Quakenbush (ADF&G) has tagged 60 walruses in 2013-2014 and Chad Jay (USGS) has tagged 572 walruses. However, the track lines alone do not depict utilization either spatially or temporally. A possible way to incorporate these data would be through Chukchi Sea monthly distributions that capture the foraging behavior at benthic hotspot areas, DBO regions, or other spatial parameters. They have data that is not directly on the DBO lines, but this information may still be useful. Cathy is also looking into how seabirds respond to changes in SST, currents, and prey abundance/distribution. They have distribution data of auklets and murres from 2013-14 for most of the DBO areas and noted that there are more birds in the northern Bering Sea than the Chukchi Sea. There is variation in shearwater distribution between sites and years. For example, shearwaters were dominant in the NE Chukchi in the past, but were absent in 2014. She noted that it would be helpful to have fish diet data, too.

Kathy Kuletz (USFWS) – At-sea surveys of marine birds were conducted by US Fish and Wildlife (P.I. Kathy Kuletz) as part of a project funded by BOEM and NPRB from 2006-2012. Observers joined research ships of opportunity, and during that time surveyed about 35,000 km of transects in the northern Bering, Chukchi and Beaufort Seas. Kathy used these data to examine marine bird communities and their distribution in the Barrow Canyon region. Auklets were abundant in the Chirikov Basin (DBO2 region), and phalaropes and shearwaters were abundant in Hope basin (DBO3 region). Shearwaters and auklets were abundant in the northeast Chukchi Sea (DBO4 region). It was also noted that phalaropes tend to follow gray whales and exploit materials from whale feeding. The total seabird density was higher in 2012 and 2013, especially in the northern Chukchi Sea. In short, the seabird distribution varies among the years while also reflecting the fish populations.

C2. Modeling

Muyin Wang (NOAA) described modeling efforts and the Arctic flux field campaign. An animation of observed ice presence and retreat using satellite data was presented. The data shows that by the end of the century most of the Chukchi Sea will be ice-free. Modeling is relatively coarse in order to cover the globe, but some of the results match fairly well with global climate models, suggesting that the global climate models can be used to drive the regional models, like ROMS. She noted that researchers should be careful with NCEP surface data since there is vertical structure for ocean studies.

Seth Danielson (UAF) presented observed and modeled storm surges for the Bering Sea. These data were fairly high resolution and they were able to reproduce variability with high fidelity. In

the model of Bering Sea winds, no Chukchi Sea winds were included, but it was determined that winds bring currents far north into Barrow Canyon. They conducted a northern Bering Sea water mass analysis from Aug-Sept using CTD data. Nutrient distributions and spatio-temporal variation over the Bering Strait were examined using Russian data. Seth also described the Pan-Arctic ROMS (PAROMS) project that is working on a high-resolution hind-cast model from 1979 to present. Results are available on request. They will be re-seeding floats for tracking experiments, including fish larval locations and advection patterns. Seth is also conducting a water mass analysis of the northern Bering Sea. It was noted that up to 11 water masses are identifiable in T-S space in late summer. There was also evidence of near-bottom lateral mixing in 2012.

Maria Pisareva (WHOI) (ppt9) reported on the physical oceanography of the western Chukchi Sea from the RUSALCA program. It was noted that part of DBO3 was occupied in 2004, 2009 and 2012 as the CS line during the RUSALCA process cruises. During their studies it was found that the Alaskan Coastal Water (ACW) was relatively fresh. In 2009, the maximum velocity of the bottom region was surprisingly intensified. Flow reversals in Bering Strait were observed between August 1 and October 1, 2009 from mooring data collected on the western side of Bering Strait. The mooring data also indicated that in September 2009 that winds were anomalously strong compared to climatological mean winds for September. The winds in September 2009 were anomalously southward and strongly pushing the ACW by Ekman transport to the Russian side of the strait. The impact of the wind reversals resulted in the ACW flowing through the Russian side of the Bering Strait and ACW was observed throughout the western Chukchi Sea and Herald Canyon. They are continuing research with 2004 and 2012 data to look into connections with biology.

C3. DBO Data Discussions

Carolina Nobre (WHOI) (ppt10a) manages WHOI's physical oceanographic database for the DBO lines. She noted that the website aims to be simple and straightforward and encouraged all members to upload their data. Carolina presented the steps for submitting data and added that the group should not worry about adding full ADCP data as a technician can process the ADCP data. The steps include: 1) Submit name and email; 2) Chose files to upload; and 3) Hit upload button. Cruise pages show contact information, maps and data types. There have been 81 occupations of all DBO lines so far and they have been increasing. DBO lines 3 and 5 have the most occupations and Carolina presented a slide that showed DBO lines that do not have data. She noted that Svein Vagle (the NSF-supported DBO and Canadian–supported C30 collaboration) has submitted the most data so far. For more information see: www.whoi.edu/science/PO/dbo.

Chris Turner (AXIOM) – The AOOS data integration and visualization website was introduced. This site is password protected (for example, you can use a Google account to set up a log in, once invited). Not everyone can upload data to a project, but anyone can download. AOOS has

data outside of Alaska and have both aquatic and terrestrial data. They partner with many agencies and organizations, including US Federal and Tribal organizations. A user may select themes from the catalog to search for data. The ability to manipulate data is meant to be easy and offers a slider to look at time series data. There are also "dynamic" (or real-time) datasets, such as wind speed and direction, on the AOOS home site. There are also many DBO-relevant datasets. It was noted that it would be helpful to have a real-time mooring option for research planning. Another suggestion was that it would be helpful to export maps as graphics for publications. This research workspace is available as a data-sharing platform and for project management. Metadata is included, but can be sparse. Chris showed examples of how to navigate on the website and how the tools can be used for extracting data. For more information, contact Jackie Grebmeier or Sue Moore; also see: http://www.aoos.org/aoos-data-resources/.

Don Stott (NCAR/EOL) (ppt10b) provided the group with a tour of the EOL-based DBO website https://www.eol.ucar.edu/ by clicking through the live website. Registration is necessary to submit data. Don noted that a workflow is needed such as: where does the data go first? WHOI, DBO Archive, AOOS, etc. To register, see: http://dbo.eol.ucar.edu/ (this website will go live in 2015 and all DBO participants will need to complete a simple, interactive metafile for cross-talk between the different components of the DBO program. See Appendix E3 for the DBO data policy and metafile format.

James Moore (NCAR/EOL) (ppt10c) – A draft of the data policy to protect the users and providers of data was proposed, and the revised version as of February 2015 is presented in Appendix E3. Dealing with the data issues is complex since there are a lot of data collection groups involved and many different examples of data formats. Ideally, this policy would allow continuity for a long term DBO data submission archive and access as well as encourage data exchange between members. The DBO Data Policy is essential in defining data submission procedures, handling and accessing data, providing guidelines for the community on data access, and defining the extent of responsibility on the data archives. The DBO data policy is in compliance with IASC, WMO, IPY policies and metadata standards. The policy would discourage data redistribution to third parties, add data submission timing and guidelines to the archive, and allow for fair use and appropriate credit to the data collectors as part of the agreement to use the DBO data. Additionally, acknowledgment and citation information are being defined. From discussions within the group, it was concluded that the wording, "no commercial use or exploitation of data" be clarified and/or removed. Note that a revised DBO Data Policy was discussed with international partners over the subsequent months after the workshop and a final version as of February 2015 is provided in Appendix E3.

D. Friday-31 October 2014

D1. Pan-Arctic DBO and Other DBO Relevant Websites

D1.1 Pan-Arctic DBO

Lis Lindal Jørgensen (Institute of Marine Science, IMR) (ppt11) - The Institute of Marine Research (IMR) in Norway aims to scientifically explore the environment and biology of all four Norwegian seas. The Barents Sea is divided between Russia and Norway with a few gray areas on the border. The Atlantic water is advected northward into the Barents Sea with the Arctic water transiting southward into the region. The Barents Sea has a complex set of processes that influence fisheries resource stock assessment, thus IMR undertakes annual ecosystem surveys in the region. Dr. Jørgensen proposed to establish a new DBO line around Svalbard and across the northern Barents Sea, based on limited historical data. For more information see: www.imr.no/forskning/forskningsdata/en

D1.2 Other DBO-Relevant Websites

Josefino Comiso (NASA) introduced the NASA website and how NASA is connected to DBO and the various datasets available; see https://neptune.gsfc.nasa.gov/csb/index.php?section=270/.

Jessica Rohde (IARPC) outlined how IARPC aims to coordinate Arctic research amongst the various agencies in the US and would also like to extend this coordination internationally. There are 12 different collaborative teams (CT), including a DBO CT, a Chukchi Beaufort CTD, a Sea Ice CT, and a data CT, which meet via conference calls monthly to update their agency-supported activities. A website was created for uploading relevant information to the CTs and is open to those who have expertise in the CT topics. You can join the DBO team at: http://www.iarpccollaborations.org/index.html. The member portion of site is not open to the general public so you will need to click to sign in to request an account. There is a public side of the website, too.

D2. Breakout Session Summaries

D2.1 Physical/Chemical (Lee Cooper, UMCES/CBL)

- Not all the ship cruises and data were uploaded by all Pacific Arctic countries. Robert Pickart, Lee Cooper and Carolina Nobre will draft a letter to ask the lead PIs for information on full datasets.
- Although much data is available, there is not enough time or funds to analyze the data.
- There needs to be an incentive to those who contribute papers.
- There needs to be efficient communication to avoid duplication of research on the DBO transect lines.

- Phyllis will compile a list of moorings and their locations, as well as what datasets can be shared from those moorings and when.
- There is a need to develop guidelines for scaling issues for using remote sensing data, so that the appropriate quality of data is used for analyzes.
- The questions "how far back in time does data need to go and how is a "transect built" were posed.

D2.2 Biological (Jackie Grebmeier, UMCES/CBL)

Group participants: Sue Moore, Jackie Grebmeier, Carin Ashjian, Kathy Coon, Arny Blanchard, Russ Hopcroft, Jessica Rhode, Dan Holiday, Danielle Dickson, Lisa Guy, Kathy Kuletz, Lisa Eisner, Catherine Berchok, Janet Clarke, Yoko Mitani, Diana Varela, Mi Sun Yun, John Nelson

- DBO regions 1-3 are rich biologically, but DBO4 is particularly complex and heterogeneous, with DBO5 being influenced by canyon effects.
- A list of contacts for each dataset is needed (visual matrix?) so that there is a subgroup of experts available to describe datasets and answer questions. Would there be funding support for a meeting about this issue?
- It was asked if there was a seasonal way to look at the development of the Pacific Arctic system (which would be the strength of the synergy) and provide a foundation for ecosystem response studies.
- Collaborators need to share visualizations on the AOOS site.
- Multiple occupations need to be emphasized in order to build rich datasets.

For some types of observations it is better to use the entire DBO region block rather than just the line, specifically for airborne marine mammal surveys or ship-based seabird data and marine mammal surveys. However, for oceanographic measurements, transect lines are appropriate in an observing mode. Spatial differences between lines and bounding boxes need to be addressed.

There are spatial differences at an eco-region scale between DBO areas 1, 2, and 3 and DBO areas 4 and 5. At a finer scale, each DBO region has unique features and biological communities. The group discussed the specific characteristic of several DBO regions:

- DBO1 is anchored with the NOAA/PMEL M8 biophysical mooring and has a passive acoustic recorder. It feeds into the Pacific Arctic region efforts. The DBO1 line is informative, but it would be good to look at the whole box when possible. The hydrography information in this area is very valuable and the chlorophyll signal changes annually.

- DBO3 is very dynamic with impacts from the Bering Strait inflow. We know that bowhead whales are consuming euphausiids in the Bering Sea (not just copepods) and that euphausiids are found here. There appears to be a prey-switching signal at DBO region 3 and it would be interesting to find out when krill are moving through the area and how that relates to the hydrography. We also have benthic data for DBO3 from the Chinese and

Korean groups. There are strong year-round data from moorings at DBO3, plus ship-based and aerial observations, and the RUSALCA CS line.

- DBO4 is a frontal system with high variability. If you sample before or after front, it can look like a very different ecosystem. Visual data from aerial surveys and from vessel interactions around DBO4 are underway (Janet Clarke). There is probably enough information to layer zooplankton data with whale detections from ship and aerial data for DBO4 and 5. DBO4 is primarily occupied by the U.S. and Canada. The gap between regions 3 and 4 is a bit large and relocating DBO 4 could be beneficial.

For higher trophic studies, DBO regions provide ecological context for years of sighting data. Incorporation of information on hydrography and prey availability permits a deeper and more synthetic interpretation of survey data for marine birds and mammals. DBO data can help construct the phenology, seasonal, and annual cycles in the region. Each project has snapshots of observations, but the system is dynamic and collating these independent projects is extremely valuable.

The DBO provides a value-added approach to ecosystem science because:

- The DBO allows observation of seasonality on a scale that is not possible with individual studies
- The DBO network provides a nested way to look at baseline changes and anthropogenic effects by looking at individual or combined regions
- The DBO is a platform for international collaborations, especially occupations of DBO lines 3 and 5

Now that the pilot phase of the DBO has ended, there is enough useful information from the five DBO regions to develop a special volume over the next year. Studies within the DBO region need to anchor of papers in the special volume, but it would also be interesting to look at the DBO lines in comparison with larger datasets. What is it that DBO observations can and can not do? How can DBO data be used to construct the phenology of physical, chemical and biological processes over the season? Topics and names were suggested; alternatively, one focal area, for example, a “soup to nuts” study of the DBO3 region, was also suggested.

Potential paper topics and participants considered for a DBO special volume

- Phytoplankton production data - Sang Lee, Lisa Eisner
- Aerial survey data for DBO3, 4, and 5 from Janet Clarke; lead author TBD
- Zooplankton – Russ Hopcroft, Carin Ashjian, Lisa Eisner
- Benthos – Jackie Grebmeier, Arny Blanchard, others from Xuelong and Oshoru-maru sampling
- Marine mammals, seabirds, and fish – Janet Clarke, Kathy Kuletz, Ed Farley
- Bering Strait – John Nelson
- Possible management application paper by various DBO program managers – NSF and other IARPC representatives

Action items included: (1) create a table with DBO Point of Contact information for each study subject on each DBO cruise; (2) description of science applications possible from DBO studies no possible or in addition to process studies (aka make an explicit statement on the value of the DBO as an observing system?; (3) provide additional manuscript plans for DBO DSR special issue; and (4) update matrix of DBO observations in AOOS DBO workspace page, including past and future work.

D2.3 Data Products (Carolina Nobre, WHOI)

- Comments regarding data policy should be sent to Jim Moore
- The issue on uploading data twice into two different websites still needs to be discussed. The data group had discussed the possibility of streamlining the submission process. The idea was to submit to data to AOOS and AOOS would set up a process to then send these datasets to WHOI and EOL. This would also, in theory, simplify and standardize the metadata process.
- After discussion, the group decided that the current process of submitting data and metadata to: WHOI, AOOS, and EOL in the US separately should stay the same.

D3. Proposed Beaufort Sea DBO lines

Jackie Grebmeier presented a draft DBO Beaufort sea map and other participant input on these lines for discussion **(ppt12a).**

Bob Pickart (WHOI, ppt 12b) proposed 152˚W as an Alaskan Beaufort Sea DBO line as it has a shelf break jet with mooring monitoring from 2002-2016. As the flow turns the corner eastward winter water sinks as it moves along the canyon and this is not too close to the DBO5 transect line.

Dan Holiday (BOEM) – There are over 400 collection sites in the Beaufort and a lot of them are from nearshore (Prudhoe Bay). ANIMIDA Beaufort Sea collection is willing to go further east or west to accommodate the DBO lines. There will be some areas where sampling is constrained by village activities (e.g. August is a prime time for sampling and hunting). It was asked if there any areas of high productivity that are not necessarily “hotpots” along the Beaufort stretch, but that are not in constrained areas?

Kathy Kuletz (USFWS) gave a summary of the SOAR manuscript she is leading, including survey effort for seabirds and marine mammals for 2007-2012 combined. Benthic foragers had hotspots along the coast near the 152W line as well as Camden Bay. Black-legged Kittiwakes and other surface feeders had a hotspot just west of Barrow. Black Guillemot also had a hot spot associated with colonies east of Barrow. There were hotspots for bowhead and belugas along the Beaufort coast and gray whales were mostly in the Chukchi, but also at Barrow Canyon in the fall. Finally, there a lot of pinniped hotspots along the Beaufort coast.

ACTION: Jackie will send out a draft of the Beaufort DBO lines and ask for comments as well as for potential data layers.

John Calder (NASA) – Planning for new PAG Climate Observations in Chukchi Region (ppt13)
A letter of intent will be developed among the interested countries to help move the ideas forward and signed by all participating countries. A small workshop will be considered for further discussion between modelers and field scientist. The success of the Pacific Climate Line depends strongly on international cooperation.

D4. End of workshop

Jackie Grebmeier closed the meeting and reminded participants about the deadline for ASSW 2015 ICARP III abstracts and thanked everybody for their participation and presentations for the meeting.

E. Appendices

E1. 2nd DBO Data Workshop Final Agenda

2nd DBO Workshop (Oct 29 - 31, 2014)

Wednesday-29 October 2014

1330 Welcome, Logistics and Overview of US-IARPC DBO CT activities: Sue Moore (**ppt1)**
1345 Meeting Objectives and Overview of the DBO: Jackie Grebmeier (**ppt2**)
1400 DBO composite result summaries by field collections (2010-2014) (max = 30 min/each bulleted and sub-bulleted topic; BOLD is discussion lead; Session lead: Grebmeier)

- Physical oceanography: Pickart et al. (**ppt3a**), Ashjian (**ppt3b**), Cho, Danielson, Itoh, Kikuchi, Nobre, Pisareva, Stabeno, Vagle
- Mooring data results: Stabeno (**ppt4a**), Danielson, Kikuchi (**ppt4b**), Pickart (**ppt4**c)
- Biochemical oceanography and export production: Cooper (**ppt5**), Frey, Lalande
- Sea Ice, atmosphere, chl satellite coverage: Frey (**ppt6**), Comiso, Qun, Kim (**ppt6c**)
- Biological oceanography
    - Lower trophics: Cho (ppt7a), Eisner (ppt7b), Varela (**ppt7c)**, Yang, Yun, Ashjian (ppt7d), Hopcroft (**ppt7e**), Nelson (**ppt7f)**, Blanchard (**ppt7g**), Grebmeier (**ppt7h**)
    - Upper trophics: Berchok (**ppt8**), Clarke, Ferguson, Kuletz, Coon, Mitani, S. Moore
- Broad scale studies to put DBO in perspective: M Wang, Danielson, Pisareva (**ppt9**)

1530 Coffee break
1600 Continuation of DBO data results (2010-2014)
1700 End Day 1 and van transport back to hotel, Dinner on own

Thursday-30 October 2014

0830 Brief summary of Day 1 and objectives for Day 2 (Grebmeier)
0845 Continuation of Invited participant summaries (2010-2014)
1015 Coffee break
1045 Open discussion on presentations – possibilities for group analyses & papers
1230 Lunch in PMEL cafeteria (no-host)
1330 DBO Data Policy & Discussion (Grebmeier)
1400 DBO WHOI physical oceanography DBO website (Carolina Nobre, **ppt10a**)
1415 DBO Data Visualization AXIOM website (Chris Turner/William Koeppen)
1445 DBO Data Archive EOL DBO website (Don Stott/Jim Moore (**ppt10b**)
1515 Coffee break
1545 Finalize DBO Data Policy (Grebmeier)
1600 PAG data needs/direction; Open discussion (Grebmeier)
1700 End day and van transport to hotel

1800 Group Dinner at local restaurant (Piatti Ristorante & Bar, University Village), 2695 NE Village Lane, Seattle, WA 98105, 206-524-9088 (meet in Silver Cloud Inn lobby at 6:45 pm if you want to walk over together)

Friday-31 October 2014

0830 Lis Jorgensen (Norway; **ppt11**), Joey Comiso (NASA website), Jessica Rohde (IARPC website)

0845 Breakouts to 3 Groups for detailed discussion and identification of available data sets for physical/biochemical data and biological data, in preparation for publication DSR DBO Special issue? Data products

- Physical/chemical
- Biological
- Data products

1000 Coffee break

1030 Group presentation from breakout groups (10 min each) and open discussion; list of analysis projects and anticipated papers

1130 Start New DBO regions in Beaufort Sea/Climate Line; possible pan-Arctic lines (Grebmeier lead discussion, with 5-10 min presentations, **ppt12a**), D. Holiday (Beaufort Sea), Bob Pickart (**ppt12b**), others

1230 Lunch in PMEL cafeteria (no host)

1330 Continue discussions, including PAG Climate line subgroup report (**ppt13**)

1500 End workshop and van transport to hotel

Appendix E2. 2nd DBO Data Workshop Participant List

First Name	Last Name	Affiliation	Email Address
Carin	Ashjian	WHOI	cashjian@whoi.edu
Alynne	Bayard	UMCES CBL	bayard@umces.edu
Catherine	Berchok	NOAA/AFSC/NMML	Catherine.Berchok@noaa.gov
Arny	Blanchard	Institute of Marine Science, University of Alaska Fairbanks	alblanchard@alaska.edu
John	Calder	NOAA retired	jcalder.usa@gmail.com
Kyoung-Ho	Cho	Korea Polar Research Institute (KOPRI)	kcho@kopri.re.kr
Janet	Clarke	NFMS/Leidos	janet.clarke@leidos.com
Josefino	Comiso	NASA/Goddard Space Flight Center	josefino.c.comiso@nasa.gov
Cathy	Coon	BOEM	catherine.coon@boem.gov
Lee	Cooper	UMCES CBL	cooper@umces.edu
Kathy	Crane	NOAA	kathy.crane@noaa.gov
Seth	Danielson	UAF	sldanielson@alaska.edu
Danielle	Dickson	North Pacific Research Board	danielle.dickson@nprb.org
Lisa	Eisner	ASFS/NOAA	lisa.eisner@noaa.gov
Megan	Ferguson	NOAA/NMFS/AFSC/NMML	megan.ferguson@noaa.gov
Karen	Frey	Clark University, Graduate School of Geography	KFrey@clarku.edu
Jackie	Grebmeier	UMCES CBL	jgrebmei@umces.edu
Ho Kyung	Ha	Dept. of Ocean Sciences, Inha University	hahk@inha.ac.kr
Dan	Holiday	BOEM	dan.holiday@boem.gov
Russ	Hopcroft	Institute of Marine Science, University of Alaska Fairbanks	rrhopcroft@alaska.edu
Motoyo	Itoh	JAMSTEC	motoyo@jamstec.go.jp
Lis Lindal	Jørgensen	Senior Scientist	lis.lindal.joergensen@imr.no
Jinyoung	Jung	Korea Polar Research Institute (KOPRI)	jinyoungjung@kopri.re.kr
Sung-Ho	Kang	Korea Polar Research Institute (KOPRI)	shkang@kopri.re.kr
Takashi	Kikuchi	JAMSTEC	takashik@jamstec.go.jp
Joo-Hong	Kim	Korea Polar Research Institute	joo-hong.kim@kopri.re.kr
William	Koeppen	Axiom/AOOS	will@axiomalaska.com

Appendix E2. 2nd DBO Data Workshop Participant List (cont.)

First Name	Last Name	Affiliation	Email Address
Kathy	Kuletz	U.S. Fish and Wildlife Service	kathy_kuletz@fws.gov
Catherine	Lalande	Takuvik/ArcticNet, Université Laval	catherine.lalande@takuvik.ulaval.ca
Dasom	Lee	Pusan National University	ldasom@pusan.ac.kr
Jane	Lee	Korea Polar Research Institute (KOPRI)	jhnjlove@kopri.re.kr
Humfrey	Melling	DFO Canada	Humfrey.Melling@dfo-mpo.gc.ca
Yoko	Mitani	Field Science Center for Northern Biosphere, Hokkaido University	yo_mitani@fsc.hokudai.ac.jp
James	Moore	NCAR/EOL	jmoore@ucar.edu
Sue	Moore	NOAA/NMFS ST7	sue.moore@noaa.gov
John	Nelson	Stantec	john.nelson@stantec.com
Carolina	Nobre	Woods Hole Oceanographic Institution	carolinanobre@gmail.com
Aleksey	Ostrovskiy	Alliance Group-Russia	aao7777@gmail.com
Robert	Pickart	WHOI	rpickart@whoi.edu
Maria	Pisavera	WHOI/Shirshov	mnpisareva@gmail.com
Lisa	Sheffield Guy	UW/JISAO	lisa.guy@noaa.gov
Jessica	Rohde	ARCUS	jrohde@arcus.org
Lisa	Sheffield Guy	UW/JISAO	lisa.guy@noaa.gov
Koji	Shimada	Tokyo University of Science and Technology	koji@kaijodai.ac.jp
Phyllis	Stabeno	PMEL	phyllis.stabeno@noaa.gov
Don	Stott	NCAR/EOL	stott@ucar.edu
Chris	Turner	Axiom/AOOS	chris@axiomalaska.com
Svein	Vagle	Fisheries and Oceans Canada	Svein.Vagle@dfo-mpo.gc.ca
Diana	Varela	University of Victoria	dvarela@uvic.ca
Eun Jin	Yang	Korea Polar Research Institute	ejyang@kopri.re.kr
Mi Sun	Yun	Pusan National University	misunyun@pusan.ac.kr
Jinping	Zhao	Ocean University of China	jpzhao@ouc.edu.cn

Appendix E3. DBO Data Policy and Release Guidelines (Feb_ 20_2015)

1. INTRODUCTION

The Distributed Biological Observatory (DBO) was established as an Arctic change detection array along a latitudinal gradient currently extending from the northern Bering Sea to the boundary between the Beaufort and Chukchi seas, near Point Barrow, Alaska. The current DBO regions may be modified or expanded as DBO objectives and requirements change. An international team of scientists and facilities are contributing to this unprecedented set of observations to be made for a decade or more. DBO sampling is focused on transects that cross areas of high productivity, biodiversity and rates of biological change. The Marine Working Group of the International Arctic Science Committee (IASC) has endorsed the DBO concept.

2. DEFINITION OF THE DBO DATA ARCHIVE

The "DBO distributed data archive" is defined as a set of distributed international data centers (e.g. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Korea Polar Research Institute (KOPRI), NCAR Earth Observing Laboratory (EOL)) with a commitment to long-term data stewardship practices (e.g. discovery and access), bringing together data from DBO sampling efforts and demonstrating the value added results from this sampling and coordinated shared-data approach to the investigation of biological responses in a rapidly changing Arctic marine ecosystem. The DBO EOL data archive (http://dbo.eol.ucar.edu) is the designated site for submission of metadata that meet the standard DBO metadata profile (hereafter referred to as the metadata profile) as shown in template form in Appendix E3.1. This template may be linked from other sites that are supporting the DBO effort (e.g., the Alaska Ocean Observing System (AOOS) DBO workspace). The DBO can serve as a framework for international research coordination, specifically as being part of the Arctic Council Circumpolar Biodiversity Monitoring Program (CBMP) and is a recognized task of the pan-Arctic Sustaining Arctic Observing Networks (SAON) program, facilitated by the Arctic Council.

There is interest in making DBO data (defined and listed in Appendix E3.2) available to researchers in a timely manner for analysis, and for the larger community once data are finalized. The principal steps in the flow of data from the researcher's lab to the DBO data archive have been organized into a process that encompasses: (1) the required completion of a standard DBO metadata profile to the DBO EOL archive, (2) the encouraged sharing of data among DBO members in a common, password-protected work space in the short-term (AOOS DBO workspace), and (3) the final submission of data to a national data archive. The DBO data flow requirement for a standard DBO metadata profile submission will be met by use of an interactive form on the DBO EOL website (supported by US National Science Foundation) that has been developed to ensure consistency of information cataloging data collections annually within the DBO data network.

The data centers that make up the "DBO distributed archive" will coordinate their data management activities including developing consistent metadata generation, curation, and

interoperability. When data submitted directly to the DBO AOOS Workspace or National archive are deemed ready for long term storage and distribution, a final version of these data and metadata will then be updated or linked to the DBO EOL archive.

3. DBO DATA POLICY AND RELEASE GUIDELINES

3.1 Data Policy in Compliance with IASC and other Collaborative Arctic Activities

It is appropriate that any policy for release and dissemination of DBO data should be consistent and in compliance with International standards and agreements such as the IASC Statement of Principles and Practices for Arctic Data Management, data sharing commitments made during the International Polar Year (IPY), and the World Meteorological Organization (WMO) policy, practice and guidelines for the exchange of meteorological, hydrological, and related data and products, as embodied in Resolution 40 of the Twelfth WMO Congress 1995 (CG-XII), and Resolution 25 of the Thirteenth WMO Congress 1999 (CG-XIII); that is, free, timely, and unrestricted exchange of essential data and products to the maximum extent possible. The DBO data policy approach is fully compatible with the CLIVAR Data Policy. The DBO will follow the WMO Core Profile of the ISO 19115: Geographic Information - Metadata standard. This DBO policy is not meant to conflict or supersede any national or international agency policy related to public access to these data, such as the U.S. Public Access to Research Results (PARR).

3.2 Broad Community Access to Data

It is in the best interests of both the data providers and the potential users to maintain the latest version of the data and metadata in the DBO archive. The reason is that this will allow the DBO archive to potentially alert users of revised or updated data. The unrestricted copying of the original data from source other than the DBO archive to multiple users may lead to propagation of errors in the data analysis, confusion on inconsistent versioning, incomplete metrics, and loss of identity of its DBO origin. The sharing of data through the AOOS DBO Workspace allows for the distribution of preliminary data amongst DBO Science Team members and collaborators before it is submitted to National archives and made fully accessible to the community.

3.3 Acknowledgement and Citation

Whenever DBO data distributed by the archive are being used for publication of scientific results, the data's origin should be acknowledged and referenced. The user is responsible to reference the PI responsible for creating the dataset and the dataset's source at the DBO. If multiple sources have been used, acknowledgement should be provided for each dataset used.

International agencies, professional societies, and research organizations are moving towards the formal citation of data and sources that led to a given research result. Consequently, there has been an increased use of DOIs (Digital Object Identifiers) as a simple, standard way to reference datasets. DOIs allow for linkages between datasets and respective publications, thus providing the ability to track the use of these datasets in the literature and provide metrics of their use or influence. DOIs are considered "perpetual" and provide proper attribution, even if a dataset has been moved to another archive over time. EOL is willing to assist all DBO data

providers with developing DOIs should the distributed archives be unable to provide the service. Standards have been established for the creation of data DOIs and have been supported by international coordination groups such as the Research Data Alliance (RDA).

3.4 Co-Authorship for DBO Principal Investigators (PIs)

DBO ship platforms and site measurements are equipped with sophisticated, state-of-the-art instrumentation and comply with strict requirements of maintenance, exposure of instruments, calibration, quality assurance procedures and the like, in order to achieve the highest attainable standards of measurement, accuracy, representativeness, stability and repeatability. To ensure that this goal is reached, PIs who are leading experts for their instruments are taking responsibility for individual instruments operated on the respective DBO ship platforms and sites.

Data users of DBO data are encouraged to establish direct contact with PIs as *data providers* for the purpose of complete interpretation and analysis of data for publication purposes. Co-authorship of the DBO PIs on publications making extensive use of DBO data is highly recommended if their work has contributed to the study in question, or has been involved in directly contributing to the publication in other ways. It is highly recommended that any *data user* should contact the responsible PI and to discuss whether the PI's data collection and Quality Assurance (QA) or Quality Control (QC) work warrants co-authorship or an acknowledgement.

3.5 DBO Publication List

The DBO EOL archive will develop a DBO publication list from citations submitted whenever DBO data are used for publication of scientific results. Whenever possible, the DBO archive will utilize DOIs to link to the publication's source. If you use the DBO data in a publication, please provide the DBO EOL archive with a citation via its data portal any time during the life of the project. The DBO EOL archive will maintain this list and make it public via the archive website in order to provide a continuous record of applications and analyses of DBO data and of DBO's scientific achievements.

4. REFERENCES

Arctic Council Circumpolar Biodiversity Monitoring Program (CBMP) http://www.arctic-council.org/index.php/en/

Distributed Biological Observatory (DBO) http://www.arctic.noaa.gov/

International Arctic Science Committee (IASC) http://www.iasc.info/

Research Data Alliance (RDA) https://rd-alliance.org/

Sustaining Arctic Observing Networks (SAON) Program http://www.arcticobserving.org/

U.S. Public Access to Research Results (PARR) http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf

World Meteorological Organization (WMO) Climate and Ocean: Variability Predictability and Change (CLIVAR Project) Data Policy http://www.clivar.org/resources/data/data-policy

Appendix E3.1 – DBO METADATA PROFILE

	Metadata Field Name	Definition
General	title	A name given to the data set.
	dataset author(s)	The person(s) receiving credit for the data set, as in a citation (usually the PI).
	description	A summary of data set content
	language	Language of the data set (e.g. English, Japanese, Korean)
Dataset Details	cruise number	Cruise ID or Number
	funding agency	The Agency providing funding (e.g. JAMSTEC, NSF, NOAA)
	Grant, project or award number	Agency assigned Grant or Award number
	temporal coverage start	Begin date of full data set
	temporal coverage end	End date of full data set
	temporal resolution	The sampling or reporting frequency of an instrument or platform
	northernmost latitude	Northern extent of data collection in decimal degrees
	southernmost latitude	Southern extent of data collection in decimal degrees
	westernmost longitude	Western extent of data collection in decimal degrees
	easternmost longitude	Eastern extent of data collection in decimal degrees
DBO Specific		Note: Each transect has its own DBO Specific metadata
	regions occupied	DBO region 1 to 5, Transect 1 to 5 (plus future DBO lines)
	DBO line occupation start	Begin date of DBO transect data collection (each DBO line will have separate form)
	DBO line occupation end	End date of DBO transect data collection (each DBO line will have separate form)
	transect	DBO line (up to 5 resubmissions of this section), with additional submission for any new DBO lines (e.g., pending Beaufort Sea lines)
	station	Unique DBO transect Station Name ID (DBO1.1, DBO1.2, etc.) to be cross-linked to what each cruise uses as a station name for their cruise (e.g SWL14, DBO1.1=SLIP5). Please Note: A unified list of all DBO stations and an associated list of station identifiers from each cruise will be required and posted on the DBO data portal. *Also Note: If the station occupied is not a specified DBO location, but close, we need the exact latitude and longitude of the station sampled*
	DBO keyword	Suite of data type collected, with pull down menu of parameters from DBO data matrix: e.g., CTD, ADCP, bottle data for chlorophyll, nutrients; abundance, biomass and composition of Ice algae, phytoplankton, zooplankton, benthic

		fauna (infauna and epifauna) and fish; seabird and marine mammal surveys; Mooring data (T, S, Currents, fluorescence, nutrients, sediment trap); Satellite data (surface T, S, winds)
Contact Info	point of contact	Person who is responsible for the content of the metadata and data.
	principal investigator	The PI responsible for leading the project
	publisher	The Institution where the data resides and responsible for distributing the data set (e.g. KOPRI, JAMSTEC, PRIC, UCAR/NCAR, CCIN)
	Weblink to dataset	Electronic link to location of dataset (e.g., at KOPRI, JAMSTEC, AOOS, EOL)
Data Details	platform	The vessel or vehicle from which instruments are deployed
	instrument	The name of the instrument used to acquire the data
	science keywords	GCMD Science Keywords
	data version	Version number of the data set available
	dataset last revision date	Date the data set was last revised
	distribution format	Distributed file format of the data set (e.g. excel, ascii, multiple)
	data set progress	Amount of progress through to data publication (i.e. in progress, or completed)
	access restriction	Password protection required
		Any additional citations;
Citation		Listed of known
DOI		

Appendix E3.2 – Definition of DBO Data

The suite of selected DBO data types and parameters include:

- Conductivity, Temperature, Depth (CTD), Acoustic Doppler Current Profiler (ADCP) data
- bottle data for chlorophyll and nutrients
- abundance, biomass and composition of Ice algae, phytoplankton, zooplankton, benthic fauna (both infauna and epifauna), and fish
- sediment parameters (grain size, organic carbon content, chlorophyll *a* content)
- seabird and marine mammal surveys
- Mooring data (temperature (T), salinity (S), Currents, fluorescence, nutrients, sediment trap
- Satellite data (data presented are weekly averages of most recent data on: (1) Chlorophyll Pigment Concentration; (2) Sea Surface Temperature (SST); (3) Sea Ice Concentration; (4) Cloud Fraction, and (5) Winds and Sea Level Pressure (SLP).)
- Other (a text entry): model output, other parameters being collected on DBO lines, but not a core DBO measurement listed above.

Appendix E4. List of Abbreviations

Abbreviation	Institution / Agency
ABR	ABR, Inc. Environmental Research and Services
AFSC	Alaska Fisheries Science Center (NOAA)
AKMAP	Alaska Monitoring and Assessment Program
AOOS	Alaska Ocean Observing System
AON	Arctic Observing Network
ARC	Division of Arctic Sciences (NSF)
BOEM	Bureau of Ocean Energy Management
BOWFEST	Bowhead Whale Feeding Ecology Study
cANIMIDA	Continuation of the Arctic Nearshore Impact Monitoring in the Development Area
C3O	Canada's Three Oceans
CBL	Chesapeake Biological Laboratory (UMCES)
CCGS	Canadian Coast Guard Ship
CHAOZ	Chukchi Acoustics, Oceanography and Zooplankton Study
CHINARE	Chinese National Arctic Research Expedition
COMIDA-CAB	Chukchi Sea Offshore Monitoring in Drilling Area – Chemical and Benthos
CSESP	Chukchi Sea Environmental Studies Program
COMIDA-HS	Chukchi Sea Offshore Monitoring in Drilling Area – Hannah Shoal
DBO	Distributed Biological Observatory
DFO	Department of Fisheries and Oceans, Canada
EcoFOCI	Ecosystems and Fisheries-Oceanography Coordinated Investigations
EOL	Earth Observing Laboratory
GRENE	Japanese Arctic Climate Change Research Program
IARPC	Interagency Arctic Research Policy Committee
IASC	International Arctic Science Committee
ICESCAPE	Impacts of Climate on the Eco-Systems and Chemistry of the Arctic Pacific Environment
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
KOPRI	Korean Polar Research Institute
MWG	Marine Working Group of IASC
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research (EOL)
NMML	National Marine Mammal Laboratory (NOAA)
NOAA	National Oceanic and Atmospheric Administration
PMEL	Pacific Marine Environmental Laboratory (NOAA)
NSF	National Science Foundation
OPP	Office of Polar Programs (now Division of Polar Programs)
PAG	Pacific Arctic Group
RUSALCA	Russian-American Long-term Census of the Arctic

Appendix E4. List of Abbreviations (cont.)	
Abbreviation	**Institution / Agency**
R/V	Research Vessel
SCAR	Scientific Committee for Antarctic Research
UAF	University of Alaska Fairbanks
UMCES	University of Maryland Center for Environmental Science
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution