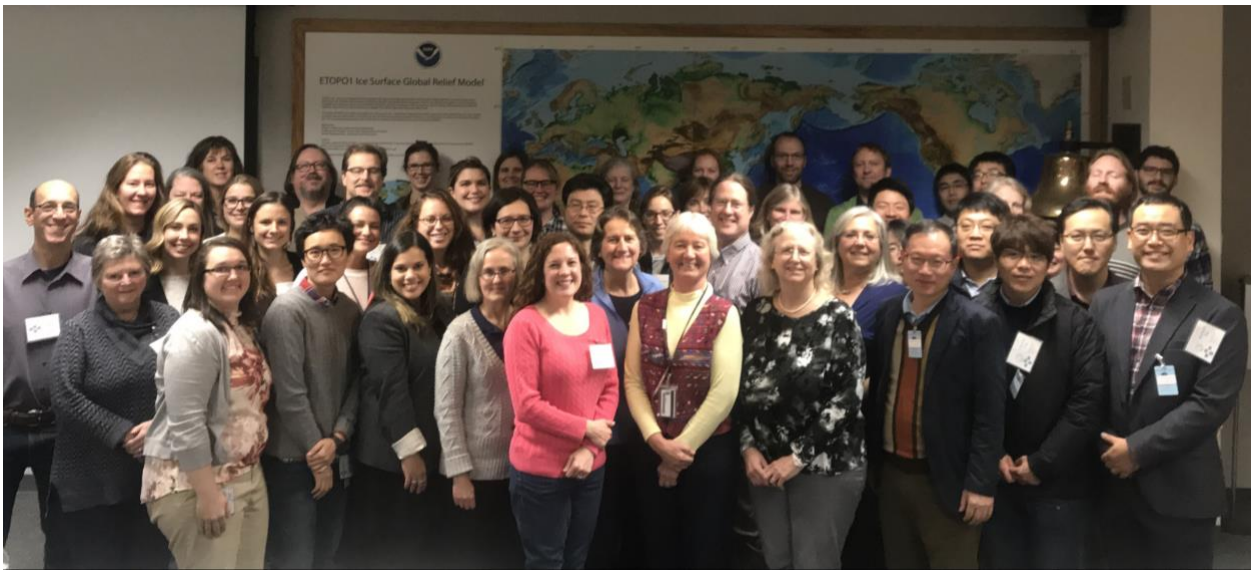
Distributed Biological Observatory

The Distributed Biological Observatory (DBO)
4th Data Workshop Final Report

November 8-9, 2017
NOAA / PMEL
Seattle, Washington, USA



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https://www.pmel.noaa.gov/dbo/

Introduction

Since 2010 the Pacific Arctic Group (PAG) has endorsed the Distributed Biological Observatory (DBO), which is focused on ship-based research in the northern Bering, Chukchi and western Beaufort seas. The PAG established the DBO as the organizing framework for standardized sampling of select physical, chemical and biological measurements at stations set along transect lines. The DBO serves as a "change detection array" along a latitudinal gradient extending from the northern Bering Sea to the Barrow Arc, and a longitudinal gradient east from there to Cape Bathurst in the Canadian Beaufort Sea. DBO sampling regions are centered on locations of high productivity, biodiversity and rates of biological change.

The DBO sampling framework was initially tested during a **2010-2011 Pilot Study**, which consisted of international ship occupations of two of the DBO sites, one in the SE Chukchi Sea and one across upper Barrow Canyon in the NE Chukchi Sea. Results of the DBO Pilot Study were the central topic at the a **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 USA NOAA/PMEL in Seattle, Washington, USA. This data workshop continued development and implementation of the DBO through presentation of data results, breakout group discussion on measurement protocols and findings, development of visualization products for disseminating of the DBO findings to the science community, science managers and the general public. We also discussed proposed new DBO lines in the western and eastern Beaufort Sea and development of collaborative-type DBO lines in the northern Barents Sea through input from Norwegian collaborators. During the **3rd DBO data work held March 9-13, 2016** at the US NOAA/PMEL in Seattle, Washington we discussed the results from the DBO efforts for the DBO1-5 sites, results from the new Beaufort Sea lines DBO6-8, and developing plans for an Atlantic DBO network that were subsequently presented at the 2016 ASSW in Prague, Czech Republic by Dr. Marit Reigstad (lead in Norway). We also identified manuscript topics for a planned special issue of the DBO results. The 3rd workshop consisted of over 50 international participants, with financial support for participants from national and international agencies. In the USA, support for the workshop logistics was provided by US NOAA and NSF.

The following report provides a summary of the **4th DBO data workshop held November 8-9, 2017** attended by 55 national and international participants. The workshop had three objectives:

1. Present results from the 2010-2017 DBO field programs, including summaries from DBO DSR special issue papers,
2. Develop a conceptual model for the Pacific DBO and discuss ongoing or developing modeling efforts, and
3. Discuss data parameter file and data archiving.

We provide summaries related to the final workshop agenda (Appendix A), with the relevant presentation hyperlinked to this report and available on a public website (http://arctic.cbl.umces.edu).

Wednesday-8 November, 2017

Welcome & Logistics

Logistics (Sue Moore, NOAA/NMFS)
Sue provided information on local logistics, including informing all participants to have their NOAA id's with them at all times and that visitors must be accompanied by a NOAA employee when walking about the building.

Introduction (Jackie Grebmeier, UMCES CBL) (ppt1)
Jackie provided the agenda for the 4th DBO Data Workshop, including the following 3 objectives:

1. Present results from the 2010-2017 DBO field programs, including summaries from DBO DSR special issue papers,
2. Develop a conceptual model for the Pacific DBO and discuss ongoing or developing modeling efforts, and
3. Discuss data parameter file and data archiving.

Highlights of DBO 2010-2017 data time series

Remote Sensing

Kristen Shake (for Karen Frey, Clark University) (ppt2.1)
Kristen presented satellite measurements across the DBO including the monthly mean DBO climatologies for DBO1-5. Trends in annual sea ice persistence (days/year) for time periods 1979-2016 and 2000-2016 were shown for the Pacific Arctic (summer loss of multi-year sea ice) and the Atlantic Arctic (winter loss of first-year sea ice). Trends in annual sea ice persistence for DBO1-8 were also shown and it was noted that trends is annual sea ice persistence have accelerated since 2000. Other satellite measurements were shown including: timing of sea ice breakup for 2013-2016, July sea ice concentration (where it was noted that there was high interannual variability, but less ice in 2015 and 2016), and chlorophyll-a (chl-a) concentrations analyzed for 2013-2017 where it was noted that the most extensive bloom for DBO3 was in 2017). Monthly and interannual variability of chl-a was graphed for DBO1-5 from 2013-2016. Field observations of chl-a for DBO1-3 showed large interannual variability. Years 2013 and 2015 chl-a concentrations indicated lower production near DBO3 in July, and years 2014 and 2016 chl-a indicated higher production near DBO3 in July. Chlorophyll-a anomalies and mean sea ice extent for May-August 2017 were also shown in relation to value compared the 2003-2016 period.

Physical Oceanography

Kyoung-Ho Cho (KOPRI) (ppt2.2)
Kyoung-Ho presented results for KOPRI CTD observations in the US EEZ for DBO3. Patterns of salinity and temperature were shown for 2014-2017. Additionally, results for Sea Surface Temperature (SST) (4km) and LADCP (surface currents) from the MODIS-Aqua satellite were shown.

Leah Trafford McRaven (with Robert Pickart, WHOI, ppt2.3)
Leah presented highlights of the DBO 2010-2017 physical oceanographic DBO time series. One focus was on DBO6 in the Beaufort Sea shelfbreak based on the paper: "Characteristic and Dynamics of wind-driven upwelling in the Alaskan Beaufort Sea based on six years of mooring data" (Lin et al. 2017). Leah's notes that pwelling is very common here. Roughly 95% of strong storms (where easterly wind speeds exceed 10 m s^{-1}) result in upwelling. Wind-driven upwelling is one of the primary mechanisms of shelf-basin exchange in the Alaskan Beaufort Sea. Results indicated that a single (strong) storm can flux enough heat offshore to melt a considerable amount of ice in the region. Also, the freshwater fluxed offshore is enough to significantly influence the year-to-year variations in the freshwater content of the Beaufort Gyre. The boundary current system of the Beaufort Sea consists of two components: a Beaufort shelfbreak jet and eastward-flowing Atlantic water located downslope and offshore of the shelfbreak jet. The shelfbreak jet advects both Pacific summer water and winter water, and the very warm and fresh Alaskan Coastal Water. The rest of the year it is bottom intensified and advects Bering Sea summer water and winter water. The Atlantic water resides deeper than 180 m beneath the layer of Pacific winter water and is part of the large-scale cyclonic boundary current system of the Arctic Ocean. Questions posed to address using DBO data include: Understanding the cross-isobath flow (or structure with depth) during an upwelling event – in the context of DBO, what is the physical driver of nutrient upwelling in this region? Similar to the DBO5 study, what determines the underlying reason why some of the events advect only Pacific water onto the shelf while others flux Atlantic water as well?

Atlantic Water (AW) vs. Pacific Water (PW) upwelling composites were also shown. During roughly two thirds of the events, AW is upwelled to the shelf break, whereas for the remaining events only PW is upwelled. Most of the PW events occurred during summer, while the majority of the AW events occurred during the remainder of the year (with a peak in spring and fall). Notably, the easterly wind strength was, on average, the same for both types of events. During the PW-type events the hydrographic responses was more muted and both the primary and secondary circulation was weaker. Positive (negative) values refer to eastward (westward) in the along-isobath direction and offshore (onshore) in the cross-isobath direction.

Carin Ashjian (WHOI, ppt2.4)
Carin discussed the relationships among the Beaufort Sea High, sea ice melt back and Pacific-origin and melt water masses in Barrow Canyon (also presenting for Steve Okkonen and Robert Campbell). Their transect line 2 was sampled each year from 2005-2015 during the third week in August. Water mass nomenclature follows that of Dong and Pickart. Seven water masses were observed, but for this analysis, she will concentrate only on four: Winter Water (WW), Chukchi Summer Water (CSW), Late Season Melt Water (LSMW), and a combination of Alaska Coastal Water (ACW) and Kotzebue Sound Water (KSW). Some years have a lot of ACW and low MW (warm years), whereas some years had the opposite combination of water masses (cold years). Cross correlations between volume anomalies for different water masses showed that MW and WW were positively correlated with each other and negatively correlated with ACW and CSW**.** Cross correlations between volume anomalies for different water masses showed that MW and WW were positively correlated with each other and negatively correlated with ACW and CSW. From April 1 – Late May, ice extent doesn't vary from year to year in Barrow Canyon so there is no correlation with water mass anomalies. From 20 May – 10 August, the water mass anomalies in Barrow Canyon are significantly correlated with the sea ice extent in the eastern Chukchi Sea. Studies attribute low late summer sea ice extent in the Arctic with strong summer easterlies and ensuing northward movement by Eckman drift. The amount of ice and water in Barrow Canyon in August reflects an integrated result of the previous months. In summary: late August volumes

of Pacific-origin and melt water masses in Barrow Canyon are significantly correlated with daily sea ice areas in the Eastern Chukchi Sea for much of the melt back season, specifically:

- early melt back → more open water → solar warming of surface waters → more ACW, CSW
- late melt back → more ice cover → less solar warming of surface waters → more LMW, WW
- The Pacific-Arctic pressure head responds to changes in wind forcing over the western Chukchi and eastern Siberian Sea (not shown).

Mooring Data Results

Hiroto Abe (Faculty of Fisheries Science, Hokkaido University, ppt2.5)
Hiroto presented results from the research cruise in the northern Bering and southern Chukchi Seas by the training ship Oshoro-Maru in 2017. The surveys were undertaken both for oceanography and ecosystem studies. Observational data included:

- CTD and ADCP (Acoustic Doppler Current Profiler)
- biological and chemical analyses of water
- bio-optical measurements for satellite oceanography
- plankton collections
- sediment sampling
- fish larvae collection
- seabird and mammal sighting surveys

Two mooring systems, which were deployed in summer were recovered by T/S Oshoro-Maru in summer 2017. Samples/data collected included:

- Sinking particles collected at ~25 m depth
- Turbidity and chlorophyll *a* concentration data at ~3 m above the bottom
- Currented speed and direction between ~5 m and ~50 m depth

The same mooring systems were re-deployed at the same places for 2018 recovery. The aim is to quantify processes of vertical and/or horizontal transportation of particulate organic carbon (POC) and nitrogen (PON) in the Bering Strait area**.** Preliminary results based on a time series analysis of chlorophyll *a* concentration estimated from moored chlorophyll fluorescence sensor and ocean color satellite sensor indicated occurrence of spring phytoplankton bloom in early May, which is one month earlier than usual year. This may be caused by rapid retreat of sea ice in spring 2017.

Seth Danielson (UAF, ppt2.6)
Seth presented results of data collected from the Chukchi Ecosystem Observatory (CEO) moored near Hanna Shoal (DBO4) that includes two moorings: CEM1-17 and CEM2-17. Parameters collected by these two moorings included: passive acoustic and biogeochemical measurements. New water samples were also collected in 2017. A third mooring is collecting real-time freeze-up buoy data that can be downloaded from: http://www.aoos.org/ice-detection-buoy/. Comparative graphs were shown for September through August that included: ice draft, PAR, ice algae, copepods, 38 KHz acoustic backscatter, and acoustic sound recording with an example of April. For example, acoustic records from below the surface pick up copepods and probably Arctic cod and bearded seals that indicate varying phenologies of upper to lower trophic levels to changing physical conditions.

Phyllis Stabeno (NOAA/PMEL, ppt2.7)
Phyllis showed a comparison of monthly average transport at Icy Cape for 2016 and 2017 as well as the fraction of Icy Cape transport vs. Bering Strait. Additionally monthly averages from 2010-2016 were provided which showed a much stronger seasonal cycle (June-July) in 2016/2017 than previous years. Maps from the satellite tracked drifters (~32 m depth) that were deployed during the EcoFOCI and DBO-NCIS programs were also shown. A sectional distribution for DBO5 in August 2017 was shown using a T/S diagram outlining water masses. The Icy Cape C5 line showed three strong events of high salinity and warm temperatures. A map of mean number of days in March and April with ice cover near DBO1 (M8 long term mooring) was also shown, along with % ice cover for M8 (1972-2010) and a graph of monthly temperatures for M8 in the DBO1 region. Plots of surface and bottom temperatures at DBO1 indicated that last year temperatures reached 10° at the surface vs. a cold year 2008-2009 when there was a lot of sea ice in northern Bering Sea. Warmest bottom temperatures were last December 2016 that were still in place in January 2017, and these warm waters will likely cause ice to retreat earlier and arriving later in 2017.

Calvin Mordy (UW/JISAO/NOAA, ppt2.8)
Calvin presented results of temporal variability of nitrate in the eastern Chukchi Sea. Nitrate sensors have been collecting data for the last few years at ~40 m depth, with drifter trajectories shown for 2013. A time series for chlorophyll, oxygen, and PAR (photosynthetic active radiation) from August 2010 to August 2011 was shown. PAR was measureable at 39 m prior to ice retreat and sea ice was absent in early June. Chl and O_2 at 39 m (the depth of the mooring equipment) showed initial increase with sea ice retreat and undersaturated O_2 thereafter. Even though there was ice, light still penetrated to depth. Calvin posed the question: What are the sources of nitrate to support these blooms? Monthly nitrate and salinity graphs were shown for C1, C2, and C3 from September 2016 to August 2017. Last year there was not as much flush with freshwater (salt related to nutrients). "Potential nitrification rates" were highest in the winter when competition with phytoplankton was minimal and ammonium concentrations were the highest.

In summary:
ICY CAPE LINE / MOORINGS (Northern Chukchi Sea)
- High interannual variability in transport in winter
- Transport is ~40% of Bering Strait flow

CARBON EXPORT
- Two patterns of phytoplankton blooms in the eastern Chukchi
- Source of ammonium for nitrification

NITRATE REPLENISHMENT
- Advection – large interannual variability
- Nitrification – supported by substantial export of organic matter

Shigeto Nishino (JAMSTEC, ppt2.9)
Shigeto showed DBO3 mooring results on fall blooms, ocean acidification, and zooplankton dynamics. Results from three papers included in the presentation:
1. Nishino et al., *Biogeosciences,* 2016
2. Yamamoto-Kawai et al., *Biogeosciences,* 2016
    - a graph of seasonal variation of $CaCO_3$ saturation state of bottom water in the southern Chukchi Sea between July 2012 and August 2013.
3. Kitamura et al., *Cont. Shelf Res.*, 2017

- graphs of the world's first observational evidence of seasonal change on zooplankton dynamics in the Hope Valley of the southern Chukchi Sea revealed by Acoustic Zooplankton Fish Profiler

Briefly, interannual variabilties of fluxes in Barrow Canyon (BC) for 2010-2015 (DBO-5) from Itoh et al, 2015 were shown. Itoh et al (2015) examined volume and heat fluxes in Barrow Canyon during summer 2010 using 6 occupations of DBO-5 repeat hydrographic section. Heat flux was consistent with that estimated from mooring (T) and wind data nearby the section. Now, there are 22 CTD and ADCP occupations for 2010-2015 for the DBO5 section. Results indicate that DBO5 volume transport and along-coast wind are well correlated and that DBO5 heat flux is well estimated from along-coast wind and ACW temperature at the BC mooring site. Time series results of flow fields and water properties in 2013 were completely different from those in 2010 and 2011, with time series of volume and heat transports useful indicators to understand this year to year variations. Estimated fluxes are correlated with DBO5 data and can be used to understand the mechanism of annual and interannual variations and their effects on water characteristics observed on the DBO5 line. Mooring observations in the Barrow Canyon were collected including measurements for T, S, and Velocity for 2000-2008 as well as 2010. Since 2016, several chemical sensors (DO, Chl-a, pH) are also attached. Time series graphs of volume, freshwater, and heat flux were shown for 2000-2017 for Barrow Canyon. Time series graphs for temperature, salinity, oxygen, and velocity were shown for September 2016-September 2017. Finally, vertical sections along a 500 m depth isobaths for temperature, beam transmission, oxygen saturation, fluorescence, and nitrate were shown for 2016 and 2017.

Rebecca Woodgate (UW, ppt2.10)

Rebecca provided an update on the 2017 Bering Strait Mooring Program. In July 2017, the R/V Norseman 2 cruise recovered and redeployed the 3 Bering Strait moorings, and collected CTD sections data, finding the Chukchi Sea remarkably warm and fresh. She noted that it was hard to do interannual analyses since water mass conditions change quickly in the region. Notable points included: Oct 2016 & June 2017, both with 3°C warmer than normal climatologies: ~20 day late cooling in 2016, ~15 day early warming in 2017, and salinities 0.5-1 psu fresher than climatology. Her finding indicate the Bering Strait region has:

- Significantly increasing annual mean fluxes, mostly driven by volume flux increase due to far-field pressure head forcing
- No trend in local wind impacts
- Warming and freshening waters
- No trend in Alaskan Coastal Current parameters

A new monthly climatology for the 2000s was shown that included the Alaskan Coastal Current and stratification (2003-2015). Graphs for velocity, temperature, salinity, transport, heat flux, and freshwater flux were shown including moorings A3, A4, Alaskan Coastal Current, SST/stratification, and totals including ACC and stratification. For the 2000s, annual average was ~ 1.0Sv (not 0.8Sv of 1990-2004 climatology). Changes were SEASONAL, with the greatest change in summer (flow increase, early warming), plus winter freshening. The question was posed: What drives Bering Strait change? Not local wind. GRACE (Ocean Bottom Pressure) satellite findings indicate variability is significantly correlated with the strait's pressure head driven flow. Changes are strongly linked to Arctic wind patterns (westward wind along the Arctic coasts). There was a year round (35%) of pressure-head variance and in summer up to 71% pressure head variance linked to East Siberian Sea variations. In the winter, the Bering Sea shelf was more important. Recent papers document trends in seasonal changes, flow increase driven by pressure head, far field forcing, and patterns of the pressure head forcing, finding flow dominantly driven from the Arctic *(Woodgate 2018)*; *Peralta-Ferriz & Woodgate 2017).*

Biogeochemical Oceanography and Export Production

Jackie Grebmeier (for Lee Cooper, UMCES CBL, ppt2.11)
Jackie presented results for the Pacific DBO, including SWL17 and AMBON17 hydrography. For SWL17, section profile patterns of July salinity, temperature, chl-a, nitrite+nitrate, silicate, and ammonia were shown for DBO1-5. For DBO2 there are higher nitrate concentrations to the west, with very little ammonia. DBO3 is a biological hotspot and DBO4 shows sub-surface chl-a, except for a small increase in surface waters moving east-west. Examples of mapped integrated and sediment chl-a were shown for AMBON17. Analyses are in progress including:

- SWL17: O-18, phytoplankton IDs, C-13 and N-15 of sediments, macrofaunal population measurements, benthic video analyses for DBO1-5 lines
- AMBON17 (Norseman 2): Nutrients, O-18, phytoplankton IDs, C-13 and N-15 of sediments, macrofaunal population measurements (other components of AMBON project on the DBO3 and 4 lines)
- DBO-NCIS (HLY1702): O-18, phytoplankton IDs, C-13 and N-15 of sediments, macrofaunal population measurements (other components of project on the DBO1, 3-5 lines)

Catherine Lalande (Université Laval, ppt2.12)
Jackie presented for Catherine on the annual cycle of biogenic matter exported on the Chukchi Sea continental shelf: 2015-2016. Continuous biological and biogeochemical measurements were collected in the Pacific Arctic Ocean using a sequential sediment trap system deployed at the Chukchi Ecosystem Observatory (CEO). It was noted that collection of sinking material over annual cycles is important to track biological and biogeochemical processes occurring when *in situ* sampling is not possible. Sinking particulate matter collected at intervals ranging from 1 week to 1 month using a deployed sediment trap. The second deployment from Aug 10 2016 to Aug 1 2017 failed and the sediment trap motor unit is under examination in Germany. Ice and particulate matter parameters were graphed monthly showing: Enhanced total particulate matter and particulate organic carbon fluxes during the open water period = absence of ice and all storms led to resuspension on the shallow shelf

- High POC fluxes during biologically productive periods (fall and spring)
  Graphs for monthly phytoplankton parameters were shown including chl-a, diatoms, *Nitzschia frigida*, and *Cylindrotheca closterium.* In summary:
- High chl *a* and diatom fluxes from August-October and in June-July showed high primary productivity both just after ice melt and in the late summer-early fall period
- Peaks in fluxes of the ice algae *Nitzschia frigida* reflect ice algae release due to snow melt in May and June
- Elevated fluxes of the benthic-planktonic diatom *Cylindrotheca closterium* during fall indicated rapid growth during and following mixing events in shallow waters

Graphs for various species of copepods over monthly distributions were also shown indicating:

- *Calanus glacialis/marshallae* transitioned from a dominance of young copepodites C1, C2, C3 and C4 to overwintering C5 during fall
- The presence of nauplii at the onset of the spring bloom at the end of June followed the observation of *C. glacialis/marshallae* females in April when ice algae were first released
- *Pseudocalanus* spp. nauplii, in contrast to *Calanus,* were present at the end of summer and during fall = less dependent on the spring bloom

Monthly meroplankton distribution showed large abundance of early stages polychaetes and bivalves in the water column during fall. Ongoing and upcoming deployments include: currently in the water and replyment of trap arrays in 2018 for DBO2 and DBO3 (ASGARD) and DBO 4 (CEO).

Karina Giesbrecht (University of Victoria, ppt2.13)

Karina presented a summary of results for a decade of primary production measurements collected from SWL July 2006-2016 SWL sampling in the DBO1-5 regions. Measurements included: nutrients, size fractionated chl-a, primary productivity (^{13}C uptake rates), and nitrate uptake rates ($^{15}NO_3$ uptake rates). Graphs of DBO1-5 for chl-a, primary production and new production were shown comparatively from 2006-2016. A long-term trend wasn't found but trends in DBO3 being a hotspot concur with Jackie. Box plots for nitrate, chl-a, primary production, and new production were shown for DBO1-5 and it was noted that there was a large range of values. Phytoplankton taxonomy pie charts for July 2013 were shown for DBO1-5 with diatoms being dominant group in general for DBO1. Centric diatoms are dominant over pennate diatoms, except in DBO4 region which may have ice algae coming from sea ice, but actively growing in the water column. For DBO3, primary production is much higher on the west side as compared to the east.

Jinyoung Jung (KOPRI, ppt2.14)

Jinyoung provided results observed in DBO3 from 2014-2016. Parameters collected from the three cruises included: Nutrients (NH_4, NO_2+NO_3, PO_4, SiO_2), dissolved organic carbon (DOC), and particulate organic carbon (POC). Profiles comparing 2014-2016 salinity, temperature, and NO_2+NO_3 showed:

- West: colder, saltier, nutrient-rich (Anadyr Water or Bering Shelf Water)
- East: warmer, fresh, nutrient-poor (Alaska Coastal Water)

Profiles shown comparing 2014-2016 DOC, NH_4, and chl-a showed:

- High DOC concentration was observed in the eastern side where the influence of Alaska Coastal Water was strong.
- Active remineralization by heterotrophic bacteria occurred in DBO3.

Questions posed included: 1) Did the influence of Alaska Coastal Water become stronger in 2016? and 2) Was there any change of river discharge rate from the Yukon River? Distributions of DOC and POC for 2015 and 2016 were also shown during his talk.

Melishia Santiago (Clark University, ppt2.15)

Melishia discussed chromophoric dissolved organic matter (CDOM) measurements across the DBO 5 lines from 2013-2017. She noted that CDOM sources can be allochthonous or autochthonous. She provided results based on field observations for DBO1-3 from July 2013-2016 and compared salinity, temperature, and chl-a and asked how these results compare to CDOM distribution from 2013-2016. Field observations for absorbance of CDOM $a254$ (m^{-1}), $a443$ (m^{-1}), and slope of CDOM 275-295 nm were shown for DBO1-3 from 2013-2017. Terrestrial influence in the CDOM signal was indicated for DBO3 in July 2015 and it was noted that values for July 2017 have skyrocketed. Continuous measurements of CDOM across the Bering and Chukchi Seas were shown for July 2016 and July 2017. Similar CDOM absorbance at 254 and 443 nm occurred across the Bering and Chukchi sea.

Laura Juranek (Oregon State University, ppt2.16)

Laura presented results of late season productivity in the Pacific Arctic: carbon, nutrients, and gases. Cruises occurred in September 2016 and August 2017, with most work focused on DBO4 and 5, with the following data collected as part of an investigation of fall blooms:

- Continuous surface underway nutrients, TCO_2, pCO_2, POC, O_2/Ar

- High-resolution towed surveys with suite of sensors (O2, backscatter, transmission, fluorescence) as well as fast-response chemistry for pumped flow (nutrients, inorganic carbon)
- CTD sampling (surface, chl max, bottom)
- Multi-core sediment sampling
- In 2017 only: lowered ADCP, microstructure measurements

Highlights from the 2016 research cruise included: finding *'hotspots'* of biological activity apparent between Barrow and Wainwright and that highest net biological oxygen saturation measured off of Wainwright with 8% biological supersaturation persisting for 3 weeks (NCP ~1000 mg C m^{-2} d^{-1}). "Supersucker" instrument observations indicated fine scale structure in temperature as well as some patchiness for DBO4. A section graph of NH_4 from a towed survey on the WT line (9/18/16) and a 3rd WT pass from offshore to onshore showed NH_4 in surface waters at ~1 µM and NH_4 in deeper waters >3 µM. Surface POC concentrations for September 3-10, 2016 and September 10-26, 2016 were compared which indicated a peak POC at DBO3 that dissipated quickly. Laura also showed an example of data collected this year (2017). Observations/conclusions included:

- Evidence of episodic activity
- Significant temporal change in observations between repeat occupations
- Evidence of substantial net surface oxygen production (implies export) in 2016, less so in 2017

Diana Varela (University of Victoria, ppt2.17)

Diana presented results on the contribution of different diatom genera to whole-assemblage silica production in surface waters of the DBO Western Arctic DBO3 hotspot in July 2015. Using fluorescent tracer and signal euphotic-zone chl-a and biogenic SiO_2, results were compared for stations SLIP4 (DBO1), UTBS1 (DBO2), UTN4 (DBO3), DBO4.4 (DBO4), and BarC5 (DBO5). The results showed the highest SiO_2 since they've been collecting data in the Pacific Arctic region. Euphotic-zone production rates showed that UTN4 (DBO3) was very high (hotspot) than eastern Arctic hotspots. ^{13}C uptake was 7 times higher, $^{15}NO_3$ uptake was 2.5 times higher, and ^{32}Si uptake was 4 times higher than in the Eastern Arctic. Diana provided examples of fluoresced diatoms noting that quantification can be done for all groups or by species. Graphs were used to summarize euphotic-zone % phytoplankton cell numbers and surface area by taxa, noting that "all diatoms are not equal" in contribution to production.

Biological Oceanography (Lower Trophics)

Lisa Eisner (NOAA Fisheries, ppt2.18)

Lisa presented a summary of data collected as part of the Arctic Integrated Ecosystem Survey (Arctic EiS) from August 1 – September 28, 2017, including primary production stations. She noted that they didn't get all DBO5 or DBO6 stations. Basic patterns of temperature, salinity, and fluorescence at depths of 5 m, 20 m, and 35 m were mapped. An example of Pt. Hope (DBO3) showed different water masses from inshore to offshore and a lot of different diatoms in these water masses. A rapid zooplankton assessment of large copepods, small copepods, euphausiids, and decapods showed more large copepods in the north of the coast and smaller to the south.

Hyoung Sul La (KOPRI, ppt2.19)

Hyoung provided major observations from 2014-2017 for DBO3. The summary was related to:

- Phytoplankton community structure, primary production, and physiology
- Microzooplankton community structure and grazing impact
- Mesozooplankton population and community structure

Phytoplankton community structure for 2015-2017 showed strong seasonal variation and a positive relationship with salinity. Phytoplankton biomass is likely to be influenced by water mass contribution. Phytoplankton physiology indicated similar physiological metrics in the two different sea ice retreat time periods of 2015 and 2016. Physiology might not be controlled by stratification and nitrate limitation. For zooplankton community and grazing effect, the microzooplankton community showed that ciliate and HDF (heterotrophic dinoflagellate) are significant components of microzooplankton populations. Picophytoplankton is the important factor for spatial dynamics of protozoa. For the mesozooplankton community, planktonic larvae and copepods were dominant groups in the zooplankton. Also, species diversity and proportion of copepods has increased from 2014 to 2016.

John Nelson (Fisheries and Oceans Canada, ppt2.20)
John presented results of DBO zooplankton related to genetics and measurements through the underway system, along with an update on microplastic components. The fate of zooplankton transport from Bering Strait to the Chukchi Sea (how far north transport goes) using *Metridia pacifica* as an example was discussed. It was shown that *M. pacifica* follows Pacific waters, but there seems to be a limitation to how far and how long they persist. There is also an intraboundary shift in genetic type within a species. Collection samples (in formalin) from 2002 to present are being used to examine patterns of species distribution and genetics. 16S-ribosomal DNA has been sequenced for the Pacific copepod *Calanus glacialis* and the Arctic copepod *C. glacialis* as well as *Calanus marshallae* distributions. Maps and pie charts of data from 2008, 2009, and 2013 indicate that *C. glacialis* might be shifting northward. Also, the underway system gas tension device is being used to estimate net community production from 2007-2008 and we are currently working on data from 2007 to 2017 with the aim of developing a time series analysis of zooplankton populations.

Zooplankton microplastics were also evaluated in 2017 including:

- contents of bongo nets frozen for examination of microplastic gut contents in zooplankton
- incubation experiments to examine viability and for effects of microplastics in their guts, and
- individual copepods were picked for later RNA analyses to judge physiological state and gut contents.

Morgan Busby (NOAA/NMFS/Alaska Fisheries Center, ppt2.21)
Morgan presented preliminary results of icthyo – and zoo-plankton observations based on the 2017 DBO-NCIS (DBO-Northern Chukchi Integrated Study) survey. The goal of the effort was to do a plankton tow at all stations that did a benthic grab. Most common taxa were Arctic cod (shelf, slope, Barrow Canyon) and they were measured in three size classes (cohorts). A map of the distribution of Arctic cod is pretty typical for every cruise, with results indicating small copepods in DBO3, crab larvae in DBO4 (Hanna Shoal), jellies between DBO4 and DBO5, large copepods and fish hotspot for DBO5, and large copepods in DBO5.

Jackie Grebmeier (UMCES CBL, ppt2.22)
Jackie presented examples of SWL17 (Sir Wilfrid Laurier), AMBON17 (Arctic Marine Biodiversity Observing Network) and HLY1702 (DBO-NCIS cruise) macrofauna and sediment results for the Pacific Arctic DBO. Predicted benthic macrofaunal biomass was shown overlain by the HLY1702 sampling plan, including the new fiber optic cable track in the region. Sediment grain size for SWL17 DBO1-5 was also presented. Observations included:

- Highest % total organic carbon content in silt & clay regions in lower current areas
- High silt & clay in DBO1, offshore DBO3 sites, DBO4.4, and western half of DBO5

- High TOC (Total Organic Carbon) and silt/clay coincident with higher benthic biomass
- Lowest silt & clay content in sandy area of DBO 2 (Chirikov Basin), eastern part of DBO3-DBO5 in Alaska Coastal water

Examples of AMBON15 and AMBON17 datasets were shown including: predicted sediment chl-a, sediment grain size (AMBON17), predicted biomass (hotspot of sand dollars in red), and predicted TOC. Also shown were time series maps of benthic biomass and dominant macrofauna type in the northern Bering Sea (DBO1) as well as for southeast Chukchi Sea (DBO3).

Monika Kedra (Institute of Oceanology Polish Academy of Sciences, ppt2.23)
Monika presented summaries of benthic biodiversity and trophic relations along the DBO lines. Benthic biodiversity along DBO1-5 were explored showing that each DBO site has a different benthic community. Results indicate the lowest biodiversity is in DBO3, the highest biodiversity is in DBO5, and changes in species composition seem to moving more toward smaller, opportunistic species. There is high diversity in DBO1 and DBO2, but lower biomass. Also of note is a new online database of marine species photos from the DBO regions that can be accessed here: http://www.iopan.gda.pl/projects/DBO/index.html**.** Variation in utilized food sources (2015) were explored using stable isotope ($\delta^{13}C$) specific compound analysis of amino acids (AA). Also, trophic relations and trophic level estimations were examined using stable isotope ($\delta^{15}N$) specific compound analysis of amino acids. A degradation index was used as a measure of the relative re-synthesis of the original autotrophic AA pool in different organisms as the mean deviation of $\delta^{15}N$ of individual trophic AAs. This approach provided better trophic level (TL) estimations. Changes in species TL and feeding behavior depends on the area sampled. In DBO1 and DBO3 (and some DBO4 stations), AA of organisms were more enriched in $\delta^{15}N$ and utilized more reworked material. DBO3 (station UTN5) seems to show changes in clam size (*M. calcarea*).

Christina Goethel (UMCES CBL, ppt2.24)
Christina used a dynamic factor analysis model to describe trends in abundance and biomass of *Macoma calcarea* in the DBO 1 and DBO 3 regions from 1998-2012. Results indicate that abundance and biomass of this clam are increasing to the north at some time series stations. She mentioned her ocean acidification publication (COMIDA DSR II special issue) that was undertaken in the DBO4 region and that the work on the dynamic factor analysis has been submitted to the DBO DSR special issue (under revision). She is doing the same analysis with the bivalve *Serripes groenlandicus* in the DBO 3 region and adding in several covariates to the model (sea ice extent, bottom water temperature, integrated water column chlorophyll-a, sediment chlorophyll-a concentration, grain size, and TOC).

Caitlin Meadows (The University of Chicago, ppt2.25)
Caitlin presented on community response to climate variability during warming and steady conditions in the north Pacific Arctic. Her research addresses three points: 1) high latitude death assemblages as archives of ecological information (mostly shells), 2) creating a 150-year history of benthic climate and ecology in the north Pacific Arctic, and 3) community response to climate variability. Questions she addresses with this research include: 1) how well do death assemblages reflect living assemblages, 2) can live-dead analysis detect known ecological shifts due to environmental change, and 3) is biomass more sensitive than numerical abundance in the live-dead analysis. Data gathered for DBO1-5 include: 1-4 Van Veen grabs per station, 22 bivalve families, abundance (individual/m^2), and biomass (gC/m^2), with a paper by Meadow et al. in preparation. She showed examples of her statistical analysis based on bivalves using the Spearman Rank Correlation and the Jaccard-Chao Index. Her analysis shows that death assemblages are generally grouped by hotspot and within those hotspots they are each dominated by specific environmental conditions. When the stations within the death assemblages fall

off these clusters of hotspot sites, the data indicate that those stations have changed in key driving variables recently. She posed more questions based on the power of high latitude live-dead discordance, including: 1) how well do death assemblages reflect living assemblages that have not yet changed (they do), 2) can live-dead analysis detect known ecological shifts due to environmental change (yes), and 3) is biomass more sensitive than numerical abundance in live-dead analysis (yes). One of her messages was not to throw out the dead as they contain valuable ecologic information about the ecologic baseline in areas without a long history of monitoring. Also, death assemblages can capture habitual human alteration of a shelf habitat or inlet. For example, in conditions of high pollution the dead assemblages will disagree with the live assemblages, meaning the dead assemblage has a different community composition and functional processing in the past.

Biological Oceanography (Upper Trophics, ppt2.26)

Robert Levine (UW)

Robert presented results for the Arctic Integrated Ecosystem Research Program for late summer research surveys including 2017 and 2019. The question was posed: how will warming likely affect abundance of fishes and invertebrates, such as the relationships between Arctic cod, saffron cod, Pacific herring, capelin, snow crab, jellyfish, pink salmon, and chum salmon? Fish sampling gear included Nordic Trawl (measure surface and top 25 m), Marinovich Trawl (measures midwater), and 3 m Plumb staff beam trawl (measures bottom communities). Acoustics were also collected to obtain abundance estimates for fishes and krill. In 2017, age-0 Arctic cod dominated the fish community in the northern Chukchi Sea at a 95.4% level and were highly abundant. Fish abundance was highest in the western part of the survey area and around 70.5° N. Trawl samples indicate that most backscatter is from 3.2-6.2 cm Arctic cod. Abundances in 2017 also appear substantially higher (8-10x) than in 2012 and 2013. Moored systems were used to quantify fish abundance and movement under ice. There will be year-round data collection until fall 2019.

Libby Logerwell (NOAA/NMFS/AFSC)

Libby showed maps of the distribution of 4 different species of fish, by numbers, in the DBO region, including: Arctic cod (beam trawl, age 1+), saffron cod (in the south), Walleye Pollock (not commercial or reproductive size), and snow crab. She noted that there were a lot of benthic invertebrates and a fair number of snow crabs (caught females with eggs) in the trawl catches.

Kathy Kuletz (USFWS)

Kathy presented results of seabird surveys, including from platforms in 2017. Seabird surveys have been conducted by the USFWS since 2006. The seabird surveys rely on funding from NPRB and BOEM (varied over the years); currently BOEM has funded seabird surveys 2017- 2020. USFWS seabird surveys also rely on collaboration with a variety of vessel-based projects. In 2017 there were six Arctic cruises, with most of those anticipated to continue at least one more year through 2020. She showed distribution maps of three seabird species, including auklets and two species of murres for June, July, August, and September 2017. She also looked at total birds by latitude using a linear prediction of expected average number of birds. She found that abundance is generally lower with latitude, but there is a peak near Bering Strait and sharp decline north of 70°. A cluster analysis was also performed using at-sea survey data from 2007-2015. Six main “clusters” of species appear to align with: shelf domains, major currents, and regional features. Pie charts were shown for each cluster with the size of the circle representing relative densities (e.g. where lots of species are present but at low density). Proportion of total seabird density by DBO region were shown based on at-surveys from 2007-2015 where sizes of circles reflect

total density. She would like to compare these patterns with oceanographic data. The question was posed: Do seabirds show more variance by year (interannually) or locations? She looked at variance in seabird densities among-years and locations (DBOs, or outside DBO boxes, within region) and found that it is "LOCATION LOCATION LOCATION" that matters. Exceptions include highly migratory species such as Short-tailed shearwaters, Phalaropes (mostly Red Phalaropes), and murrelets (Ancient Kittlitz). Also, there was a large bird die-off in Alaska in 2017 that was probably due to being food starved, but possibly impacted by harmful algae. She noted that all science projects need to do consultation with USFWS (Ecological Services) for operations in Ledyard Bay Critical Habitat Area (Spectacled Eider, walrus).

Janet Clarke (Leidos)

Janet presented effort results of Aerial Surveys of Arctic Marine Mammals (ASAMM) July-October 2010-2017 cetacean sightings for DBO 3-7. The ASAMM completely encompasses DBO 4,5,6, and 7 regions, as well as the eastern half of DBO 3. The survey effort occurred throughout study area in all years, although the effort slide is limited to 2010-2016 because 2017 data are being processed). Effort looks greater in the Beaufort Sea, but actually is less than in the Chukchi due to how the transect lines were flown in the former area. All effort sightings give an idea of sightings outside DBO areas, too. DBO areas in the Chukchi Sea are particularly well-situated, from a cetacean point of view. DBO 3 was sampled south of 68°N in 2014-2017, although with limited effort. DBO-4 and 5 were flown in 2010-2017, with fairly equivalent coverage from July through October. Sitings included bowhead, gray and beluga whales, with no subarctics, except killer whales. For DBO 6 and 7 in the Beaufort Sea, the 2010-2011 survey coverage occurred from September and October; by comparision, during the period 2012-2017, survey coverage occurred from mid-July through early October, where bowhead and beluga whales were seen, but no subarctic species. For on-effort cetacean sightings in DBO3 from 2010-2017, there was less effort south of 68°N and only from 2014-2017. Subarctics and gray whales were seen in all months. For 2010-2017 cetacean sightings were observed in the DBO 4-5 regions, with some subarctic species observed near shore. For DBO 4, gray whales were observed in the SE quadrant, mainly in July and August. By comparison, bowhead whales were broadly distributed, mainly in September and October, and only limited sitings of belugas occurred during the survey. In DBO 5 region gray whales were both shoreward and in Barrow Canyon, while bowhead whales and belugas mainly were observed in Barrow Canyon. For 2010-2017 on-effort cetacean sightings in DBO6-7 had sightings in the Alaskan Beaufort Sea. For the DBO 6 and 7 regions, similar patterns of bowheads and belugas were seen in both areas. Bowheads were observed on both the shelf and slope in summer and almost exclusively on the shelf in the fall. Belugas were predominantly on slope in both seasons, with far fewer belugas observed in fall compared to summer. It was also noted that walruses were observed in DBO 4-5 only. The largest groups of walruses were observed on Hanna Shoal in summer (July and August) when ice is sometimes still present, where the largest groups are hauled out on ice. In fall (September and October), smaller groups of walruses were observed in water when ice is absent.

Sue Moore (NOAA/NMFS OST)

Sue provided a summary for DBO related bridge watches and standard surveys of marine mammals. Watch effort is defined as 1-2 people using hand-held binoculars and using an Excel form or mini-Wincruz for data recording. A standard survey is defined as 3-person teams using Big Eye binoculars and Wincruz program. For the 2017 DBO-NCIS marine mammal watch, highlights include:

- DBO 3: gray whale 'hotspot' stations DBO 3.5-DBO3.8, with 80 humpback whales in the SE sector
- DBO 4: few walruses (due to zero ice), but 'ship-curious'
- DBO 5: gray whale 'hotspot' stations DBO5.1-DBO5.2, with 'juvenile cluster' in the SE sector

- 9 Sept highlight: large number of bowhead and gray whales, seals, and thousands of shearwaters in the northern DBO4 region in the 'hotspot' near the UAF/CEO mooring

She provided a summary table of marine mammal watches (n=18) and surveys (n=7) and asked "what are we missing" and requested input from PAG colleagues.

Catherine Berchock (NOAA/AFSC)
Catherine provided a summary of visual surveys and passive acoustic monitoring of marine mammals. She included a list and map of projects related to these studies from 2010-2017, including:

- CHAOZ: Chukchi Acoustics, Oceanography, 2010-12 and Zooplankton Study
- CHAOZ-X: CHAOZ Extension Study 2012-15 (Hanna Shoal)
- ARCWEST: Arctic Whale Ecology Study 2012-16, 2012-2017
- ALTIMA: Arctic Long-Term Integrated 2017 Mooring Array

She presented maps of visual surveys for August-October 2010-2016 DBO regions as well as monthly species distribution maps for 2014 including: bowhead whales, gray whales, and walrus, as well as bowhead whales for 2010. There was a hotspot of gray whales at DBO3, for example, as well as for walrus at DBO4. She also provided examples of passive acoustic data products for DBO 1-5 for years 2011-2015 for bowhead whales, walrus, gray whales, and humpback whales. She posed the question: Can marine mammals be proxies/sentinels for open water over winter?

Modeling Discussion

Mike Steele (APL/UW, ppt2.27)
Mike presented a summary related to ice retreat and ocean warming. He looked at Sea Surface Temperature anomalies of summer relative to 1982-2007 mean daily (NOAA OI.v2). He's exploring Upper Temperature of the Polar Oceans (UpTempO) and Warm buoys to measure these parameters by instrumentation. He suggested that there are 3 L4 SST (global gridded interpolation) validations, including: OISST ("Reynolds"), CMC, and GMP. Looking at warming and irradiance measurements he found a bloom under the sea ice using ICESCAPE data. He provided a SST update from 2007-2014 and 1982-2006. He found that 2007 was ~3 times warmer than 2012 and suggested that this was due to early (June/July) 2007 sea ice retreat and late (August/September) 2012 sea ice retreat, thus developing a SST "phenology". He provided an example of predicting fall advance using spring/summer sea ice retreat (1974-2014) but noted that the correlation was not that great. There may be funding for phase 2 for a Sea Ice Prediction Network (2018-2021). New foci would include AK Arctic and ocean's role.

Discussion of DBO4 Transect Line Location (ppt3.1)

Jackie showed slides to encourage discussion of the DBO4 update and revision. Seth also showed slides that emphasized the Hanna Shoal mooring site (**ppt3.2**) as a hotspot overlapping with walrus (noted also by Chad Jay/USGS), bivalves (Arny Blanchard), and chl-a (Lee Cooper). Sue suggested 6 stations that go through the starred mooring such as having 3 stations SW and 3 stations NE of the mooring so that the front that moves back and forth could be tracked. It was noted that Arny Blanchard's CSEAP and Susan Schonberg's COMIDA HS data should be referenced as it is where the mooring site now sits. Jackie suggested moving the new line a bit further northeast and stay within an area where a time series with high biomass/diversity could be done. Monika wanted to factor in that biomass/diversity change from station to station on the current DBO4 line. It was noted that with the heterogeneity of the current

DBO4 line, it is difficult to find patterns – are we seeing a regime shift or just natural variability in the system? Leah requested (per Bob) that the line be perpendicular to the isobath flow pattern. (Note, Jackie's slide 5 in ppt3.1 showing an enlargement of the DBO4 predicted biomass is a helpful reference for the current line and the mooring). Rebecca noted the issues with data continuity and shifting the line. She suggested keeping the current line and proposed that both would be sampled in the same season but not necessarily during the same project/platform. It was noted the Morgan's data confirms diversity of DBO4. Heather Crowley noted that DBO4 was investigated for oil drilling but the industry doesn't think it economically viable to drill in the Chukchi unless the price of oil goes up. Jessica noted that since the hotspot is the goal of DBO, the gap between DBO lines 3 and 4 does not necessarily miss anything. Sue suggested that a small group meet at the Ocean Sciences meeting in February 2018 in Portland, OR.

Heather Crowley (BOEM, ppt4.1)
Heather provided a BOEM perspective of the Beaufort Sea ecosystem. She showed maps of potential Arctic oil and gas resources as high, medium, and low petroleum potential as they relate to DBO3-7. This mapping was based on geological research of technically recoverable resources. There are green dots that represent locations where BOEM has interest and where there is high petroleum potential. The Trump administration may start leasing and BOEM hopes to develop the research for the environmental analyses. She noted that DBO6-7 provided a "bookend" a bunch of these intersections (green dots). Some projects include:

- Wave and Hydrodynamic Observations and Modeling in the Nearshore Beaufort Sea
- Marine Arctic Ecosystems Study (MARES)
- ANIMIDA III: Boulder Patch and Other Kelp Communities in the Development Area (coordinated with the NSF-funded LTER led by Ken Dunton)

Jackie Grebmeier (UMCES CBL, ppt4.2)
Jackie provided an update on the eastern Beaufort Sea DBO8 and possibly ones in Baffin Bay. She provided a map of DBO lines in the Canadian Beaufort Sea for DBO6-8. She noted that there is interest in developing DBO-type time series in Baffin Bay and that a more detailed update will be provided at the Spring 2018 meeting.

Thursday-09 November, 2017

Jackie Grebmeier (UMCES CBL, ppt4.3)
Jackie provided an updated agenda for Day 2.

Marie Porter (Scottish Association for Marine Science, ppt4.4)
Marie provided updates on an Atlantic DBO initiative inspired by the Pacific Arctic DBO. She noted that special focus will be given to comparing and contrasting the seasonal sea ice zones of various Arctic Seas and pan-Arctic integration and that it is a challenge to get good biological time series in the Arctic, and a challenge to get good data from the upper water column. The Atlantic inflow is a prominent feature of the eastern Arctic. Several countries run time series including biology in the region but generally only sampled once per year and that they were not coordinated in sample collections. This inspired an Atlantic DBO workshop in 2016 that resulted in an agreement on the importance of and need to coordinate and extend the existing efforts. Achievements of the workshop include:

- Project leader team established:

    - Randi Ingvaldsen (IMR), Marit Reigstad (UiT), Maria Włodarska-Kowalczuk (IOPAS), Thomas Soltwedel (AWI), Janne Søreide UNIS/PRiS, Finlo Cottier (SAMS/UK), contact person in DBO
- Core parameters identified as well as a list of optional parameters
- Relevant process studies identified
- Sampling strategies (moorings, ship based, ferry boxes, benthic observatories, satellites, gliders, other), but that the basic program should be kept simple at the start

The identified tasks include:

- Metadata overview of existing data
- Establish protocols (coordinate with DBO)
- Find an Organizational home– not clear
- Make an Implementation Plan
- Identify pilot cruise to initiate the project

Five Atlantic DBO transect lines have been suggested in addition to moorings in in Kongsfjord and Rjipfjord operated by SAMS/UiT. She also provided a list of projects:

- PRIZE – how does more light and a change in momentum flux in an ice-free Arctic Ocean affect productivity?
- ARISE – Using changes in isotopes to detect and attribute changes to Arctic food webs during periods of decadal change.
- ChAOS - Quantifying the effect of changing sea ice cover on organic matter quality, benthic biodiversity, biological transformations of carbon and nutrient pools, and resulting ecosystem functioning at the Arctic Ocean seafloor.
- DIAPOD – Developing a predictive understanding of status and trends of the biomass of dominant marine zooplankton taxa. Calanus spp. will be affected by future climate change in the Arctic.

Summer 2017 field work included collection of data related to: pelagic (nutrients, phytoplankton, zooplankton, isotopes, hydrography); benthic (same as pelatic plus benthic photography, grabs, and trawls); and, additional (hydrography and nutrients). Glider use in the Barents Sea will have CTD, PAR, CDOM, Chla, backscatter and DO with three Slocum gliders during January – April and three Slocum gliders April – July. She also provided information about the current and future cruise program, including:

- 2017 summer – Barents Sea (Arise, PRIZE & Chaos)
- 2017 – autumn – Rijpfjorden (PRIZE)
- 2018 – winter – Barents Sea (PRIZE + UiT)
- 2018 – spring – Barents Sea (PRIZE + UiT)
- 2018 summer – Fram Strait x1 (Arise & DIAPOD), Barents Sea x2 (PRIZE & Chaos)
- 2019 – Barents Sea (Chaos)

Cross project agreements on core measurements include nutrients and chl-a analysis by SAMS and the Nansen/NERC line will also have glider occupation during January-June 2018.

Discussion of the Atlantic DBO: Carin suggested that to minimize work (time)/data collection, just collect benthic samples once a year and focus on upper water rather than the full water column. Jackie suggested that it would be great if folks could standardize data collection methods. Jessica Cross suggested that the Atlantic be included as part of the Pan Arctic research of hotspots. Mike Steele

advocated sampling deeper since that is the character of the region (compared to the Pacific Arctic), but how would the biology be different? Sue suggested that passive acoustics are a relatively inexpensive and painless method, but Marie noted that this in not included at this point. Rebecca asked about Greenland and Marie said the focus is on the Barents Sea for now. Jackie said a stepwise process could be used to add lines later and suggested this could be discussed further at the ASSW18 meeting. Kathy inquired about including bird observers, but Marie noted that berth limitations could be a problem. Monika noted that there is some overlap on some lines with work by IOPAN. Danielle suggested Calvin and Phyllis as contacts for sampling the water column.

Modeling

Sue Moore (NOAA/NMFS, ppt5.1)
Sue described the 8 DBO regions in relation to the Arctic Marine Pulses conceptual model (AMP), including:

- DBO 1-4: located on the northern Bering and Chukchi Sea continental shelvess
- DBO 5-8: located in Barrow Canyon and on the outer continental shelf and slope of the Beaufort Sea
- All regions are focused on areas of high productivity
- All regions are within the seasonal ice zone domain

Building the AMP conceptual model is based on the work of Moore and Stabeno (2015) and Grebmeier et al. (2015/PacMARS). Sue provided a slide showing this concept whereby a synthesis of synthesis (SOS – or building models out of models) is illustrated. A pelagic-benthic coupling model (northern Bering and Chukchi Sea, DBO regions 1-4) are related to an advective model. The northern Chukchi and Beaufort Seas, DBO regions 4-8) are related to an Arctic marine pulses model (dynamic seasonal model linking contiguous domains). Is a benthic dominated past ecosystem becoming a pelagic dominated future? There is an emphasis on phenology in the AMP model. Pulses are events in a yearly cycle that result in advection, upwelling, and eddies that provide prey resources for upper trophic species. Case studies are in the SOAR special issue. Next steps for AMP model components include work based on: Wei Cheng and Al Hermann, Muyin Wang, and Carin Ashjian's WHOI group), and Al Herman and Wei Cheng. DBO data and the AMP model include:

- Pelagic-benthic coupling (P-b): DBO 1-4
    - Note: DBO 1-2 'upstream'; DBO 3-4 'downstream' from Bering Strait inflow
- Bering Strait inflow from long-term moorings
- Advection: DBO 1-8
    - Note: DBO 1-4 Advection & P-b coupling are combined; DBO 5-8 Advection & Upwelling are combined as well as including eddies
- Note: DBO data seems particularly relevant to further development of the AMP model, which aims to predict seasonal variability in ocean processes in the Pacific Arctic over an annual cycle.

Wei Cheng's ROMs modeling would address time scale issues and variance (week vs seasonal). It was noted that Rebecca Woodgate's observational data in Bering Strait would be helpful. Seasonal pulses will be examined. Muyin Wang will explore sea ice change over the Bering, Beaufort, and Chukchi Seas including breakup and freeze-up rates (1990-2017). This will include a fine spatial structure comparison with other models. In regards to the reduction in sea ice in the Chukchi and Beaufort Seas, it is the delay in freeze-up that is more important than spring retreat. By comparison, changes in spring ice retreat are

more important for biological processes, along a delay in sea ice freeze up can influence the development of fall blooms.

Carin Ashjian (WHOI, ppt5.2a, ppt5.2b-particle tracking video)
Carin presented results about the formation and persistence of benthic biological hotspots in the Pacific Arctic. She noted that benthic biological hotspots have been observed in the shallow northern Bering Strait and Chukchi Sea continental shelves for more than four decades (NE Chukchi Sea, SE Chukchi Sea, Chirikov Basin, and St. Lawrence Island Polynya) and that changing physical and biological drivers in a warming climate are having fundamental impacts on the ecosystem of the Pacific Arctic. The study explores the sympagic-pelagic-benthic coupling and delivery of organic carbon to the benthos under the changing environmental conditions (export vs. retention). The overarching question is: what physical and biological processes contribute to the formation of the benthic biomass hotspots and how will changes in the Arctic system affect the persistence of these hotspots? Two approaches are being taken for the study:

- Diagnosing physical-biological model output to identify causes of hotspot formation
- Particle tracking using physical model and particle sinking rates to identify sources of OM at hotspots

The study uses a new model that has both physical and biological components as forcing components. The biogeochemical model was developed using the framework of NEMURO model, a collaborative effort from a PICES working group a decade ago. We have adapted the NEMURO model to the Arctic Ocean. Carin provides a conceptual diagram for the BIOMAS pelagic ecosystem model. She then goes on to show mapped examples of parameters used in this model including: gross primary production and phytoplankton standing stock, BIOMAS-simulated nitrate, BIOMAS-simulated ammonium, surface vs bottom temperature/salinity difference, and BIOMAS-simulated total kinetic energy.

Carin also provided conceptual diagrams of forward-in-time and backward-in-time tracking showing the relationship of carbon source/deposition and benthic hotspot site and described methods related to the Lagrangian tracking for sinking particles, including: a. Particles (n = 1065) are released daily from the region south of St. Lawrence Island, b. Experiment Day-100 and -129 to mimic spring bloom timing, and c. Constant sinking velocities are added to background flow velocities, including 1.0 m/d (small cells), 10.0 m/d (large cells), and 100.0 m/d (marine snow). All particles are tracked for a total of 60 days. The ArcIBM code is modified to allow particles sink and settle to the seafloor. She showed maps of examples of particle settling of different size groups (listed above) as well as a video that shows potential particle locations over time for DBO regions.

Carin also presented, “What determines the range of organisms and how might climate change modify this?” As an example, to persist, *Calanus* has to develop from egg to diapausing stage during the available growth season (food available for the copepod). For the annual life cycle of *C. glacialis*, an endemic copepod that is well adapted to the strong seasonality of the Arctic environment and pulsed food supply from ice algal and pelagic phytoplankton blooms, was presented. In the springtime, female adults utilize sea ice algae to fuel egg reproduction. During the summer bloom season, the offspring feed on phytoplankton to develop and molt and accumulate body mass and energy reserves. Over the winter, the matured copepodids descend to deep waters and overwinter. This is a state in its life cycle, usually called diapause or dormancy. In that way, they can reduce their metabolic activities. But how does this picture change with ongoing climate change? The goal is to model *Calanus* spp.to identify locations to which animals could be transported and successfully achieve an overwintering stage and thus persist. Notes to achieving this include:

- Individual based modeling study
- Temperature and food dependent development rates
- Modeled circulation and water temperature
- Growth season length for each node point from satellite ocean color or from snow melt/radiation levels

Modeling results indicate that a 2°C temperature increase greatly expands the potential range over which C. glacialis species can persist. Lengthening of the growth season has a somewhat lesser effect. Results indicate that *C. glacilalis* individuals can successfully develop to diapausers in the Arctic shelf/slope seas and sub-arctic sea, but cannot do so in the vast central basins and in the northern Canadian Arctic Archipelago. Decrease in sea ice extent leads to an increase of annual success rate of the transition-zone individuals with a surprisingly high correlation: (r = -0.94; p < 0.01). The annual percentages of successful *C. glacialis* diapausers in the transitional zones dramatically increase over the 35-year period with a linear trend of +1.9%/year.

Prompted discussion included: Jackie thinks there needs to be a network of models. John noted the challenge to bringing datasets together to address the temporal issues. Could there be subgroups such as a zooplankton "czar". Jackie said that NSF has suggested some funding for such subgroups but not for all groups. Sue mentioned the issues of time, communication, and funding are limiting. Is there interest in the subgroups such as: Calvin Mordy: nutrient, Jackie/Monika: benthic, other…? It was suggested that this could be part of the next PAG report.

Mike Steele (APL/UW, ppt5.3)
Mike presented results about sea ice – ocean modeling, including 1) high resolution and 2) floe size distribution based on the work by Jinlun Zhang. Zhang modeling taxonomy includes: PIOMAS, BESTMAS, BIOMAS, MIZMAS, and HIOMAS. The MAS (Modeling and Assimilation System) includes:

- PIO = Parallel Ice-Ocean *(N. Pole in Greenland)*
- BEST = Bering Ecosystem Study *(N. Pole in AK)*
- BIO = Biology/Ice/Ocean *(AK)*
- MIZ = Marginal Ice Zone *(AK)*
- HIO = High Resolution Ice/Ocean *(AK)*

PIOMAS offers a useful, widely-used product that provides a consistent Arctic sea ice volume time series from 1979 on. PIOMAS is high resolution (2 km) ice/ocean modeling and assimilation system for short-term analysis and forecasting. Mike posed the question: how do models simulate sea ice floe geometry comparing the model using 50% ice concentration that is 1 m thick? The answer was that "they don't". Floe diameter was also modeled in MIZMAS for March, June, and September 2014 noting that floes shrink in size between March and September.

Discussion: Wei Chang noted that floe size can be smaller than resolution. Carin suggested biological links to upper trophics to floes.

Data Access and Management

Leah Trafford McRaven (and Robert Pickart, WHOI, ppt6.1)

Leah presented on DBO data access and management related to physical oceanography. The goals of DBO data collection include: track down DBO physical oceanography data products, assess quality and coverage of the data, create proper documentation of the data, and submit the data to the Arctic Data Center. They have been migrating data to the new web database (https://arcticdata.io). As of the meeting, CTD data from the 2010-2012 period should be available and 2013 was ready to submit.

She provided a summary of the DBO data quality process:
Sampling design:

- Close to completing DBO sections
- Completing stations with minimum breaks
- Grad students important component of analyses

CTD Instrumentation

- Ensuring recent calibration dates
- Asking for dual sensors
- Time is more important than pin pointing exact station locations

Shipboard ADCP

- We are no longer quality controlling this for DBO, *but* data are automatically saved to R2R
- Please ensure the system is turned ON
- 10 kts or less steaming along DBO lines

She noted that any CTD data would really be helpful and valuable, especially occupying any DBO station/region in order to get a proper snapshot of the water column. If anyone needs a grad student to help, contact Leah. She also asked that CTD operator focus on instrumentation quality and try for 10 knots or less to help with ADCP quality. Leah will help as much as possible with submitting ADCP files for DBO lines and when you send files to her let her know what CTD station goes with what DBO line/station. She's focusing on CTD but also ADCP (especially if processed). Leah also provided information on DBO data submission:
Data collection

- Do the data exist?
- If possible, document when occupying a DBO station (log sheet or header)

Data submission (include in your submissions)

- The data in acceptable format
- Metadata: parent program, file formats, etc.
- Description of the DBO program

Formats

- Seabird CNV files are best
- Please no Excel!

Moving Forward

- Please talk to me!
- ltrafford@whoi.edu

Discussion: Jackie mentioned that international partners are extracting DBO data and submitting them to ADC. Also, pertaining to Rebecca's question, Leah does do some "removal of spikes" in the CTD data. She's not sure this data will go directly to NODC, but is trying to format appropriately. Jackie suggested that it might be best to submit all file data with clear notation which DBO station was occuppied so user can extract subunits of the data themselves. Leah noted that Bob is only interested in submitting the DBO lines. Mike noted that when you cite data you should include the date of download to help with resolving issues.

Jackie Grebmeier (UMCES CBL, ppt6.2)
Jackie presented on the DBO data parameter file and archiving. The DBO data management broad perspective includes:

- Strong international collaboration in a data policy for sharing and access
- International collaboration in data collection in 8 sampling transects
- DBO parameter file profile to inventory data parameters collected on transect lines, upper trophic level surveys, moorings, and satellites
- DBO data effort to facilitate data sharing and synthesis activities
- National and International distributed archive centers can rely on the DBO parameter file for exchange and access

She also provided information on the 2015 DBO Data Policy, including a summary of information:

- DBO has an agreed international data policy
- All participants fill out DBO parameter file of what core data type were collected at each station on each DBO line and/or within each DBO regional bounding box (interactive at http://dbo.eol.ucar.edu). In 2018 there will be a transition to new CBL DBO project website for data parameter templates to submit as well as links to the US Arctic Data Center, other national and international DBO partners data archives
- Participants then submit data + metafile to own national archives, with agreement to share results on set DBO transect lines and within bounding boxes
- We hold a DBO data workshop about every 18 months

She included a snapshot example of the DBO parameter file that contains information about what data was collected per cruise and who to contact. It is suggested to be a "glue" to show what parameters have been collected between researchers and where in the DBO network.

Jackie Grebmeier (UMCES CBL, ppt6.3)
Jackie also provided some snapshots of pages from the Arctic Data Center web portal (https://arcticdata.io) and noted that this site is publicly available data. She said to make sure that "DBO" is keyword for searching data. They accept international data for upload, but you have to register with an ORCID ID.

Discussion: Danielle asked whether ADC will accept just metadata files without data to help with the cross-walk of who is collecting what, etc?. And, can ADC import XML files from AXIOM (for example)? Seth asked if ADC can ingest data from other programs than NSF since # for NSF grant is still "required information"? Jackie said that international partners have submitted data to ADC, but only those who want to. Everyone sampling in US waters is supposed to submit data "somewhere". Danielle mentioned that she might be able to add time for someone dedicated to extracting just DBO data. Jackie mentioned that a research coordinator is not really fundable, even workshops, in the current funding model. Leah noted that using certain characters, such as parentheses are not searchable. Jackie suggested there should be standard titles for datasets. Also, can we include bounding boxes by DBO region to extract data from ADC (e.g. NASA runs statistics based on the DBO bounding boxes)? Jackie mentioned that the DBO bounding box coordinates are already available on the NOAA DBO website. She will work with the ADC to put them on the DBO project page at the ADC, too.

Sustained DBO Sampling

Jackie Grebmeier (UMCES CBL, ppt7.1)
Jackie presented a timeline of activities in the development of the DBO that are outlined in the recent Moore and Grebmeier (2018, *Arctic 71, Suppl. 1, 1-7*_ summary DBO paper):

- 2009 – Biology-Sea Ice Workshop, development of Pilot DBO plan
- 2010-2014 – DBO Pilot Phase, sampling coordinated by the Pacific Arctic Group (PAG)
- 2012 – Interagency Arctic Research Policy Committee (IARPC) DBO Collaboration Team: *Sea Ice and Marine Ecosystems* theme
- 2012 – NSF Arctic Observing Network (AON) program provides $upport to sample DBO regions 1-5
- 2012-2015 – IARPC DBO CT Completes Milestones, including expansion of sampling into the Beaufort Sea and development of guidelines for the periodic assessment of the physical and ecological state of the Pacific Arctic marine environment
- 2015-2024 – Implementation Phase, 8 DBO regions and initiation of a decadal Pacific Arctic Regional Marine Assessment (PARMA) (Moore and Grebmeier, *Arctic*, citation mentioned previously); also current development of Atlantic DBO and other regions
- 2017-2021 – DBO included in IARPC MECT (co-chairs: Auad, Dickson, Grebmeier)
- 2017 onwards – NSF AON and NOAA ARP core field $upport, with BOEM, NASA, NPRB, DOI USFWS and USGS DBO studies within ongoing programs

She provided a summary of how the DBO goals of linking physics to biology:

- DBO sites (red boxes) are regional "hotspot" transect lines and stations located along a latitudinal gradient (DBO1-5) and longitudinally (DBO6-8)
- DBO sites exhibit high productivity, biodiversity, and/or overall rates of change
- DBO sites serve as a change detection array for consistent monitoring of biophysical responses
- Sites occupied by national and international entities with shared data plan

Jackie then reminded all about the standardized sampling for the DBO station as outlined below:

a. Core ship-based sampling:

- CTD and ADCP
- Chlorophyll
- Nutrients
- Ice algae/Phytoplankton (size, biomass and composition)
- Zooplankton (size, biomass and composition)
- Benthos (size, biomass and composition)
- Seabird standard surveys (no additional ship time)
- Marine mammal watches & surveys (no additional ship time)

b. Second tier ship-based sampling:

- Fishery acoustics (less effort than standardized bottom trawling)
- Bottom trawling (every 3-5 years)

c. Shipboard measurements

- Record underway measurements from the seawater loop, meteorological sensors, sounder, and navigation information

Jackie also provided examples of additional sampling on various DBO cruises in 2017 (national and international). She noted that DBO sampling is also embedded in larger process-study cruises depending of the direction of the core funded research.

- Optical studies for satellite calibration
- Colored dissolved organic matter (CDOM) and dissolved organic carbon (DOC), alkalinity
- Sea ice tracers (e.g., Oxygen-18)
- Ocean acidification and carbon cycling
- Phytoplankton growth rates (primary production)
- Lower trophic production studies
- Epifaunal and fish biodiversity studies
- Benthic camera for videos of benthos
- Genetics for microbial, meiofaunal, macrofaunal, and epifaunal studies
- Moorings and saildrones, gliders
- Contaminants and potential HABs impacting various trophic levels

Jackie then updated the group on the IARPC "performance element" examples from the Marine Ecosystem Collaborative Team activities (see https://www.iarpccollaborations.org/).

Performance Element 4.3.1 Continue Distributed Biological Observatory (DBO) sampling in regions 1-5 and make data publicly available through upload of metadata to the Earth Observing Laboratory/DBO data portal.

- Agency: NASA, NOAA, NSF, DOI-BOEM, DOI-FWS
- Aligns with 2016 Arctic Science Ministerial Deliverable: 4, 5

Examples:

1. NASA provides up-to-date data and visualization of weekly sea ice cover, winds, chlorophyll a distribution, surface temperature and cloud cover in the study regions and the entire Arctic. Sea surface salinity, which is very relevant to the project, is now included as one of the parameters. The values have been validated in a recent study published in JGR Oceans (on line in September 2017).
2. NSF provides core research support for the annual July DBO cruise with Canadian colleagues on the CCGS Sir Wilfrid Laurier for DBO sampling in DBO regions 1-5. Both NOAA and USFWS also involved in upper trophic level surveys. Co-supported with scientists in DFO/Canada who also occupy DBO4 and DB lines in the Beaufort later in the season.
3. NOAA provides core research support for the Aug-Sept USCGC Healy 2017 and planned USCGC Healy 2018 cruises for both DBO sampling and NCIS (Northern Chukchi Integrated Study) process efforts.
4. BOEM through the AMBON (Arctic Marine Biodiversity Observing Network) project occupied DBO3 and DBO4 in 2015 and 2017 on RV Norseman II. NOAA, NSF and USFWS and previous Shell Oil supports science in AMBON.
5. NPRB Arctic Program projects (ASGARD) occuppied DBO2 and 3 lines in 2017-2019.

Performance element 4.3.2-Continue DBO coordination activities including annual workshops, via participation in the Pacific Arctic Group (PAG), and produce the first Pacific Arctic Regional Marine Assessment (PARMA) in 2018.

- Agency: DOI-BOEM, NOAA, NSF

- Aligns with 2016 Arctic Science Ministerial Deliverable: 4, 5

Examples:

1. NOAA sponsored DBO data meetings, such as the upcoming 4th DBO data meeting in November 2017 in Seattle.
2. US and international agency support for scientists to attend DBO data workshops.
3. International Arctic Science Committee (IASC) Marine Working Group (MWG) providing early career support for participants to the 4th DBO data meeting, similar to previous DBO data workshops.
4. New paper outlining the development of the DBO project in the journal *Arctic* (Moore and Grebmeier, 2018), including description of a 10 yr DBO implementation plan and the PARMA.
5. She is in discussions with the IASC MWG to coordinate the first Pacific Arctic Regional Marine Assessment (PARMA) in 2018).
6. Participation in annual fall and spring PAG meetings for coordination of DBO studies.

Performance element 4.3.3-Build connections between DBO and existing community-based observation programs and encourage data sharing. For example, the DBO Implementation Plan discusses fostering connections to existing community-based observation programs in an effort to link offshore observations of biological change to local observations and Indigenous Knowledge.

- Agency: NASA, NOAA, NSF, DOI-BOEM, DOI-FWS
- Aligns with 2016 Arctic Science Ministerial Deliverable: 4, 5

Examples:

1. "The Arctic Marine Pulses Model: Linking Annual Oceanographic Processes to Contiguous Ecological Domains in the Pacific Arctic" by Sue Moore is relevant to this PE (http://www.iarpccollaborations.org/members/events/8927); also see Moore et al. 2018 DSR2 152, 8-21 paper.
2. Continue to develop connections of conventional science mode with local community groups evaluating seasonal events by conventional science and indigenous knowledge

Jackie noted that she is working towards an International Pan-Arctic DBO with Norway, Germany, Poland, UK, France, and the USA. Data collection and planning topics include: physical oceanography, plankton, benthos, vertical flux, molecular studies, moorings, time series, coordinating activities, and planned initiatives. For more information contact: marit.reigstad@uit.no

Monika Kedra (Institute of Oceanology Polish Academy of Sciences, ppt7.2)

Monika provided information about two meeting session for Polar2018: A SCAR and IASC Conference in Davos, Switzerland, 15-26 June 2018. Below is a summary of the session and an abstract for Arctic and Antarctic talks and a focused workshop for future presentations and discussions.

a. Session: Productivity, Biodiversity & Ecosystem Shifts at Cryosphere-Ocean Boundaries (BE-5)

Category: Biology, Ecology, Ecosystems, Biodiversity

- Keywords: Productivity, Antarctic, Arctic, Ecosystems, Biodiversity, Fjords, Ecosystem Function, Climate Warming, Glaciers, Sea Ice
- Lead Convener: Lee Cooper
- Co-conveners: Monika Kędra, Craig Smith, Irene Schloss, Paul Renaud, Mikael Sejr
- Submission deadline: 12th November 2017

Session Abstract. The boundaries between the cryosphere and ocean are shifting as the climate warms in both the Arctic and Antarctic. This session will explore the possible responses of biological systems to

changing ice cover, and expand our understanding on how climate warming is likely to further alter ecosystem processes across this boundary. High latitude productivity and associated ecosystem adjustments is a key organizing principle that could help bridge information and insights from across multiple disciplines. We invite contributions from studies investigating ecosystem consequences of cryosphere changes in glacially influenced systems such as fjords and adjacent coastal ecosystems, ice shelves and underlying ocean waters, as well as continental shelves impacted by retreating sea ice, including recent changes that are already apparent. Observational, experimental, and modeling studies leading to a mechanistic understanding of processes that are related to productivity and its influences on biodiversity and ecosystem structure are equally welcome. This session aims to bring together diverse perspectives on the future of Arctic and Antarctic productivity and impacts on ecological structure. The session will also seek to identify knowledge and/or data gaps, which might limit our collective ability to understand connectivity across polar systems.

b. Antarctic and Arctic Ecosystems and their Functioning
(open to anyone)
Sunday, 17 June 2018, 1pm – 5pm, Room C Aspen
contacts: Julian Gutt
other: Lee Cooper, Monika Kedra, Cinzia Verde, Ian Hogg

Workshop Abstract. The SCAR Antarctic Thresholds - Ecosystem Resilience and Adaptation (AnT-ERA) research programme has been instrumental in developing a better understanding of biological responses to environmental change and the functioning of Antarctic ecosystems. Somewhat in parallel, the Distributed Biological Observatory (DBO) in the Arctic has been a bottom-up scientist initiative to evaluate ecosystem response to environmental change that has been supported by the IASC Marine Working Group and the Pacific Arctic Group in addition to national science agencies in six countries with Arctic research programmes in the Pacific Arctic. This meeting will bring together the science communities working at both poles who will jointly discuss topical scientific issues in Antarctic and Arctic biological processes. The major focus will be amphipolar comparisons and contrasts related to the response of organisms and ecosystems to climate change, including ocean acidification at all levels of biological organization. Core questions/issues that are anticipated for this session include increases or decreases in biodiversity and changes in ecosystem functioning (e.g. net primary production and biological CO2 uptake). Identification of challenges for future investigations, knowledge gaps, and dissemination of results are additional goals of this session.

Update on DBO DSR special issue and upcoming meetings

Jackie Grebmeier (UMCES CBL, ppt8.1)
Jackie provided updates regarding the: a. DBO DSR Special Issue, b. Ocean Sciences Meeting (OSM) 2918_DBO Session, and c. MECT Town Hall at OSM.

a. The list of DBO DSR articles are outlined on slide #2 of the powerpoint.

b. AGU/ASLO/TOS Ocean Science Meeting 2018_DBO Oral and Poster Session
Co-Chairs: Jackie Grebmeier (CBL/UMCES) and Sue Moore (NOAA)
Monday, February 12, 2018 , 10:30 AM - 12:30 PM; Oregon Convention Center- B110-B112

Abstract. The Distributed Biological Observatory: An Expanding Change Detection Array in the Marine Arctic

Arctic marginal seas are undergoing historically unprecedented reductions in sea ice volume and extent, concomitant with increasing ocean temperatures. It is uncertain how the marine ecosystem is responding to these sea ice thinning trends and alterations in the timing of seasonal sea ice retreat and formation. The scope of these possible changes include primary production, planktonic and benthic biomass, migration patterns of upper trophic level consumers, and overall biogeochemical cycling. In order to systematically track biological responses to sea ice loss and associated environmental changes, an international consortium of scientists have developed the "Distributed Biological Observatory" (DBO), which integrates biological measurements at multiple trophic levels with physical oceanographic sampling from ships, satellites and moorings. The DBO initially focused on five biological "hotspot" regions distributed along a latitudinal gradient extending from the northern Bering Sea through the Chukchi Sea; subsequently, three DBO regions were added in the Beaufort Sea. An Atlantic-DBO, comprised of five transect lines, is being developed in the northern Barents Sea and Fram Strait, and DBO lines have been proposed for Baffin Bay. This session provides a forum to present recent multi-disciplinary scientific findings associated with physical forcing and ecosystem response detected through the DBO change detection array.

c. OSM 2018 IARPC MECT Town Hall

Town Hall Title: Activities of the Marine Ecosystems Collaboration Team within the US Interagency Arctic Research Policy Committee (Jacqueline Grebmeier (CBL/UMCES), Guilllermo Auad (BOEM), Danielle Dickson (NPRB) Date and Time: Wednesday, February 14, 2018: 12:45 PM - 1:45 PM Location: Oregon Convention Center, D139-D140

Abstract. The Marine Ecosystems Collaboration Team (MECT) is one of nine teams within a unique U.S. Federal/Non-federal collaboration framework created within the Interagency Arctic Research Policy Committee (IARPC). The MECT is a new team created as part of U.S. Arctic Research Plan 2017-2021, combining elements of the previous U.S Arctic Research Plan 2013-2017's Distributed Biological Observatory Collaboration Team and Chukchi & Beaufort Seas Collaboration Team. This Town Hall session will provide a general description of IARPC's unique Federal/non-federal collaboration model and then highlight the particular workings and achievements of the MECT to address its 13 research objectives and associated performance elements. Case studies of ongoing interagency collaborative research projects will be presented. We will also provide recent organizational updates as well as an outlook of potential leveraging opportunities within ongoing and planned research programs through a planned community input link via the MECT web portal. The co-chairs of the MECT are Guillermo Auad (Bureau of Ocean Energy Management), Danielle Dickson (North Pacific Research Board), and Jackie Grebmeier (University of Maryland Center for Environmental Science). Further information on the MECT is available at: https://www.iarpccollaborations.org/teams/Marine-Ecosystems.

ACTION ITEMS:

- Continue to develop overview of DBO science results
- Development of a Conceptual model in discussion
- Formation of interdisciplinary teams TBD
    - Jackie: virtual, small groups to report on what and who collected; fill-in parameter files; Jackie to think about it some more
    - If have collaborations between meetings, we can have breakout groups during the DBO data workswhops

    - Research coordination effort (Jackie to ask NSF about leveraging support)
- Leah – list of DBO PIs/Chief Scientists (Jackie noted the cruise table is available on the PAG website -https://pag.arcticportal.org/; also, the parameter file will have this information).
- Jackie suggested a possible 6 month newsletter with updates on progress
- Danielle asked about the AXIOM workspace. Jackie said she would talk to Molly at AXIOM about data products on the site (e.g. cruise maps)
- It was noted the NODC (National Ocean Data Center) is now the NCEI (National Centers for Environmental Information)
- Sue suggested that a small group meet at the Ocean Sciences meeting in February 2018 in Portland, OR to discss the potential new location of the DBO4 line

End of Meeting

Acknowledgements. We thank Sue Moore/NOAA for acting as the local host for the workshop**.** Individual national grants provided travel support for the DBO participants. Support for some early career scientists and workshop refreshments were provided through funding obtained through the IASC Marine Working Group.

Appendix A

AGENDA-FINAL

4th DBO WORKSHOP
November 8-9, 2017
PMEL/NOAA, Bldg. 3, Oceanographer Room
7600 Sand Point Way NE, Seattle, Washington, USA
WIRELESS username = PAG/DBO; password = $cience

Workshop Overview - We have 3 objectives for this workshop:

4. Present results from the 2010-2017 DBO field programs, including summaries from DBO DSR special issue papers
5. Develop a conceptual model for the Pacific DBO and discuss ongoing or developing modeling efforts
6. Discuss data parameter file and data archiving

November 8, 2017 – Wednesday (0800 – van transport from Silver Cloud Hotel to PMEL)

0900 Welcome and Logistics: **Sue Moore**

0910 1. **Meeting Objectives and Overview** of the DBO: **Jackie Grebmeier (ppt1)**

0930 **2. Highlights of DBO 2010-2017 data time series** (~20 min each subsection, so just a 2-5 slides from each speaker (~5 min); **BOLD is discussion Lead**)

- Remote Sensing: sea Ice, SST, chl-a: **Jackie Grebmeier;** speaker: Kristen Shake (for Karen Frey **(ppt2.1)**
- Physical oceanography: **Jackie Grebmeier;** speakers: Kyoung-Ho Cho **(ppt2.2),** Leah Trafford McRaven (for Robert Pickart) **(ppt2.3)**,
- Mooring data results: **Phyllis Stabeno;** speakers: Carin Ashjian **(ppt2.4),** Hiroto Abe **ppt2.5)**, Seth Danielson (**ppt2.6),** Phyllis Stabeno (**ppt2.7)**, Calvin Mordy **(ppt2.8**), Shigeto Nishino (**ppt2.9)**, Rebecca Woodgate (**ppt2.10)**
- Biochemical oceanography and export production: **Jackie Grebmeier;** speakers: Jackie Grebmeier (for Lee Cooper; **ppt2.11),** Karina Giesbrecht (**ppt2.12)**, Jackie Grebmeier for Catherine Lalande (**ppt2.13)**, Jinyoung Jung **(ppt2.14)**, Melishia Santiago (**ppt2.15),** Laura Juranek **(ppt2.16**), Diana Varela (**ppt2.17**)

10:30 Coffee Break

11:00 Continue Highlight Presentation (cont.)

- Biological oceanography
  - Lower trophics: **Jackie Grebmeier;** speakers: Lisa Eisner (**ppt2.18**), Hyoung Sul La (**ppt2.19)**, John Nelson (**ppt2.20**), Morgan Busby (**ppt2.21**), Jackie Grebmeier (**ppt2.22)**, Monika Kedra (**ppt2.22**), Christina Goethel (**ppt2.24**), Caitlin Meadows (**ppt2.25**)

- Upper trophics: **Catherine Berchok;** speakers: composite (**ppt2.26**): Robert Levine, Libby Logerwell, Kathy Kuletz, Janet Clarke, Sue Moore, Catherine Berchok et al.
- Modeling: Mike Steele (**ppt2.27**)

1220 Lunch (NOAA Cafeteria, no host)

1330 Continue overview presentations; also highlight from papers for DBO Special Issue if not included in discussions above

1500 Coffee break

1530 **3. Discussion of DBO4 transect line** location (**Grebmeier):** Grebmeier **(ppt3.1),** Danielson **(ppt3.2),** with group input

1600 **4. Status of efforts for pan-Arctic DBO** (Atlantic, Beaufort Sea, Baffin Bay): **Grebmeier**
- Beaufort Sea: Heather Crowley, BOEM perspective) **(ppt4.1)**
- Eastern Beaufort DBO8 and Baffin Bay status report: Grebmeier **(ppt4.2**)

1630 Discussion & wrap up

1700 End day and van transport to hotel - **Group Dinner (no host, 7 pm, location Piatti Restaurant in University Village)**

November 9, 2017 – Thursday (0800-van transport from Silver Cloud Hotel to PMEL)

0900 **Overview of Day 1 and plan for Day** 2 **(Jackie Grebmeier) (ppt4.3)**

0915 4**. Status of efforts for pan-Arctic DBO (cont.)**
- Atlantic-DBO update (Marie Porter, Scottish Association For Marine Science) **(ppt4.4)**

0935 **5. Modeling efforts within the DBO** and development of DBO conceptual model (**Sue Moore)**
- Arctic Marine Pulses conceptual model (Sue Moore) **(ppt5.1)**
- Upwelling at the Beaufort Sea slope (Carin Ashjian) **(ppt5.2a,b)**
- Ice Retreat and Arctic Warming (Mike Steele) **(ppt5.3)**
- Other Ideas for DBO conceptual model and/or part of DBO effort? (Calvin Mordy: **ppt5.4 drifter movie**)

1030 Coffee break

1100 **6. Data access and management**: National and International Data Access (**Jackie Grebmeier**);
- Physical oceanography (Leah Trafford McRaven for Bob Pickart) (**ppt6.1**),
- DBO data parameters file (Jackie Grebmeier) **ppt6.2**),
- NSF Arctic Data Center (Jackie Grebmeier) **ppt6.3**)
- Canada (C3O, JAMSTEC, KOPRI, PRIC), others?

1220 Lunch (NOAA Cafeteria, no host)

1330 7**. Sustained DBO sampling**: National & International/Pan-Arctic colleagues **(Jackie Grebmeier)**

- DBO within the US-IARPC Marine Ecosystem Collaborative Team (Jackie Grebmeier) **(ppt7.1**)
- DBO and the IASC Marine Working Group Antarctic-Arctic activities (Monika Kedra) **(ppt7.2)**

1500 Coffee break

1530 Update on DBO DSR special issue ad 2018 OSM DBO session and MECT town hall meeting, Polar 2018 side meeting: AnT-ERA and DBO (June 17, 2017 in Davos, Switzerland) **(Jackie Grebmeier-ppt8.1)**

1600 Action Items & Timeline: DBO Special Issue, future plans

1700 End day and van transport to hotel

Appendix B-4th DBO Data Workshop Participants

First Name	Last Name	Affiliation	Email Address
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