The Distributed Biological Observatory (DBO) Data Workshop

Final Report

February 27 – March 1, 2013
NOAA / PMEL
Seattle, Washington, USA

Citation Workshop Report: Grebmeier, J.M, E.M. Bailey, L.S. Guy, and S.E. Moore, 2013. DBO Data Workshop Report, CBL/UMCES, 29 pp.

Distributed Biological Observatory

BACKGROUND

The dramatic seasonal retreat and thinning of sea ice, record-setting seawater temperatures and multiple observations of biological changes in the Pacific Arctic sector precipitated planning for an international workshop to evaluate ecosystem response to climate forcing. In May 2009, NOAA convened the Biology-Sea Ice Workshop (Grebmeier 2011, see http://www.arctic.noaa.gov/dbo/) comprised of 20 national and international scientists, including physical, geochemical and biological field scientists and modelers. A key outcome of the workshop was an EOS (Transactions of the American Geophysical Union) article entitled "Biological Response to Recent Pacific Arctic Sea Ice Retreats" (Grebmeier et al. 2010). In addition to an overview of observed biophysical changes in the ecosystem, the article suggested a framework for the development of a *biological observatory* by international members of the Pacific Arctic Group (PAG; http://pag.arcticportal.org).

The "Distributed Biological Observatory (DBO)" is envisioned as a ***change detection array*** along a latitudinal gradient extending from the northern Bering Sea to the Barrow Arc [map of sites and example of change in sea ice and Chlorophyll-*a*]. DBO sampling is focused on transects centered on locations of high productivity, biodiversity and rates of biological change. The DBO sampling framework was initially tested during the successful 2010 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. Provisional results of the 2010 Pilot Study were the central topic at the December 2010 PAG meeting in Tokyo, Japan, and at the March 2011 DBO workshop in Seoul, Korea, held immediately prior to the international Arctic Science Summit Week (ASSW). Approximately 90 people attended the one-day DBO workshop in Seoul, including invited speakers who presented ideas for efforts to expand the DBO concept to the Eastern Arctic. In addition, provisional data sets were presented and planning efforts for the 2011 Pilot Study were initiated that were continued through field programs in 2012.

Notably, several U.S. agencies have endorsed the DBO concept in the Arctic research planning documents, including: (1) the 2011 NOAA's Arctic Vision & Strategy Plan, (2) aspects in the Bureau of Ocean Energy Management (BOEM) Alaska Region planning efforts in the Chukchi Sea as part of the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) Hanna Shoal, (3) statements in the United States Geological Survey (USGS) Science "Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas Alaska" document (Bartels and Price 2011; http://pubs.usgs.gov/fs/2011/3048/), and (4) initiated within the Chukchi Sea Environmental Studies Program (CSESP), funded by Shell-ConocoPhillips-StatOil environmental program. The DBO is specifically included in the US National Ocean Policy Strategic Plan. In the international arena, the Marine Working Group (MWG) of the International Arctic Science Committee (IASC) has endorsed the DBO, co-sponsoring the first DBO workshop for the pilot program in Victoria, Canada in November 2011 (PAG Project Office, 2011; final pag meeting report - sidney british columbia canada - november 2011.pdf .

The MWG also supports development of similar activities in the Atlantic sector of the Arctic. Finally, the IASC-SCAR (Scientific Committee for Antarctic Research) bipolar action group for the Arctic and Antarctic recently identified the DBO concept of latitudinal transects and stations as a possible mode for biological observations in the Antarctic, too.

INTRODUCTION

A data workshop focused on the results from the Distributed Biological Observatory (DBO) pilot study was convened from 27 February – 1 March 2013 at the NOAA Pacific Marine Environmental Laboratory (PMEL), Seattle, Washington USA. The meeting brought together scientists and associated project data sets collected during the Pacific Arctic Group sponsored DBO pilot effort during 2010-2012. The purpose of the meeting was to discuss the results from the 2010-2012 DBO effort under the Pacific Arctic Group (PAG) leadership, share data sets, develop an international data policy for this observing effort, and organize collaborative publications. There were ~30 participants at the meeting, including colleagues from Canada, Korea and Japan. Significant progress was made on all four objectives (see below) of the workshop.

DATA MEETING OBJECTIVES

The DBO Data Workshop was focused on 4 objectives:

- Present results from the 2010-2012 pilot study and determine a basis for multidisciplinary paper(s) to showcase the DBO international effort
- Archive metadata with either link to data set in a national archive or submitting the DBO data to common data archive
- Discuss DBO site criteria and identify NE Chukchi Sea DBO4 line and other DBO lines, and
- Determine how to plan for full implementation for the DBO.

The objectives and presentations are outlined in the Workshop Agenda (Appendix A).

Day 1

Welcome & Logistics
Chris Sabine (Director NOAA/PMEL) welcomed everyone to PMEL .

Sue Moore (NOAA/Fisheries ST7) explained meeting logistics including check-in procedures, location of cafeteria facilities and other items of interest.

Jackie Grebmeier (UMCES/CBL) welcomed participants (Appendix B) and initiated self-introductions by all workshop participants.

Presentations

Jackie Grebmeier (UMCES/CBL) (ppt1**)** provided an introductory presentation giving an overview of the DBO rationale, location of sites and details of proposed sampling. The DBO is described as a "change detection array" with the goal of collecting the same data every year and processing the information in near real time (<6 months) to detect rapid changes and regime shifts. Biological response and shifts in ecosystems are ecologically significant requiring multidisciplinary field collections in time and space. Many developing observations systems in the Arctic are focused on physical sensors, but biological sampling at different scales is required to detect biological changes in response to environmental forcing. Coordinated ship-based observations on a regular basis, coincident with satellite and moorings could provide an early detection system for biological systems in the Arctic. DBO occupations include national and international science programs.

The core standardized ship-based sampling includes:

- CTD (conductivity-temperature-depth) and ADCP (Acoustic Doppler Current Profiler)
- Chlorophyll
- Nutrients
- Ice algae/phytoplankton (size, biomass and composition)
- Zooplankton
- Benthos (size, biomass and composition)
- Seabird observations
- Marine mammal observations

Dr. Grebmeier presented an overview of the DBO 2010-2012 Pilot Program. Sampling occurred on ships based out of the USA, China, Japan, Korea, Russia and Canada (Table 1). For detailed information on cruises and research programs please see the Pacific Arctic Group website (http://pag.arcticportal.org/index.php?option=com_content&view=section&layout=blog&id=6&Itemid=6).

Examples of time series products are available on the DBO website (http://www.arctic.noaa.gov/dbo/workshop_products.html) including sea ice extent, surface sea water temperatures, shifts in sea ice persistence and chlorophyll-*a* concentrations. Dr. Grebmeier showed a selection of observed changes in the Pacific Arctic region and hot spots of interest including Barrow Canyon.

Dr. Grebmeier presented DBO data management considerations with topics for this meeting and as an introduction for presentations and further detailed discussions:

- Develop an International DBO data policy and exchange protocol (including priority measurements) to facilitate:
    - Dataset exchange and access
    - Preparation of datasets for data integration, inter-comparison and modeling studies
- Encourage broad access to data and metadata beyond national restrictions through scientific collaboration/cooperation

Table 1. Summary of Distributed Biological Observatory (DBO) sampling program by year, ship, researc program, Pacific Arctic Group (PAG) contact/science lead and Chief Scientist involved in the DBO pilot program sampling. Key for acronyms at bottom of table.

Year	Ship	Program	PAG contact / Science Lead	Chief Scientist
2010	Moana Wave	COMIDA-CAB	Jackie Grebmeier	Jackie Grebmeier
2010-2011	Araon	Korean Expedition	Sang Lee (2010) Sung-Ho Kang (2011)	Kyungho Chung
2010-2011	Healy	ICESCAPE	Robert Pickart	Kevin Arrigo
2010, 2012	Mirai	JAMSTEC	Motoyo Itoh (2010) Takashi Kikuchi (2012)	Motoyo Itoh (2010) Takashi Kikuchi (2012)
2010, 2012	Xuelong	CHINARE	Jingfeng He	Yu Xingguang
2010–2012	Alaskan Enterprise (2010), Mystery Bay (2011), Aquila (2012)	CHAOZ	Sue Moore Jeff Napp	Catherine Berchok Tom Weingartner (2010) Phyllis Stabeno (2012)
2010-2012	Annika Marie Ukpik	BOWFEST & AON (2010-2011) AON (2012)	Carin Ashjian	Carin Ashjian
2010-2012	Healy	AON	Robert Pickart	Robert Pickart
2010-2012	Khromov	RUSALCA Leg 1	Kathy Crane	Rebecca Woodgate
2010-2012	Sir Wilfrid Laurier	C30	Jackie Grebmeier	Svein Vagle
2011-2012	Westward Wind	CSESP	Tom Weingartner	Bob Day John Burns
2012	Khromov	RUSALCA Leg 2	Kathy Crane Robert Pickart	Terry Whitledge
2012	Healy	COMIDA HS	Jackie Grebmeier	Jackie Grebmeier

KEY: AON=Arctic Observing Network, BOWFEST=Bowhead Whale Feeding Ecology Study, C3O=Canada's Three Oceans, CHAOZ=Chukchi Acoustics, Oceanography and Zooplankton Study, CHINARE=China Arctic Expedition, COMIDA=Chukchi Offshore Monitoring in Drilling Area-HS=Hanna Shoal, CSESP=Chukchi Sea Environmental Studies Program, C30=Canada's Three Oceans, DBO=Distributed Biological Observatory, ICESCAPE=Impacts of Climate on the Eco-Systems and Chemistry of the Arctic Pacific Environment, JAMSTEC=Japan Agency for Marine-Earth Science and Technology, KOPRI=Korea Polar Research Institute, RUSALCA=Russian-American Long-term Census of the Arctic.

- Coordinate with other National and International Projects
- Consider data format and documentation guidelines to enhance international data exchange and analysis
- Document and standardize (if possible) data collection protocols (time, sensors, processing, parameters, units)

Short presentations were provided by workshop participants on the physical and chemical aspects of the Pacific Arctic region (11 presentations) and the biological components of the system (9 presentations). This background served as the foundation for discussions at the

remainder of the meeting. All presentations will be available on the DBO website (http://www.arctic.noaa.gov/dbo/workshop_products.html) and on the CBL Arctic website (http://arctic.cbl.umces.edu/DBO/).

Robert Pickart (WHOI) (ppt2) provided an update on the DBO pilot program in Barrow Canyon (DBO site 5). It was decided to start a time series of vertical sections across Barrow Canyon since this region is considered a biological "hotspot." This was the first ever top to bottom time series across the canyon (different than what data would be collected just using moorings) and because of the DBO structure, data was shared quickly and available before researchers went out on the cruises. Immediate questions were generated just from the first year of DBO data such as "why does the winter water get colder as the summer progresses and become higher in nitrate?" There were 6 occupations of the DBO line in Barrow Canyon in 2010 which included data collected using the USCGC Healy (USA), CCGS Sir Wilfrid Laurier (Canada), R/V Xuelong (China), R/V Annika Marie (USA) and R/V Mirai (Japan). In 2011 there were 5 occupations and in 2012 there were 6 occupations. Interannual data is proving to be very valuable. The DBO pilot study has shown:

- The concept can work (17 occupations by 4 nations since 2010)
- Immediate data sharing is advantageous
- The more occupations the better to help sort out season versus interannual variability
- The information can help with the interpretation of individual studies by providing temporal context
- Requires coordination and commitment
- Need for spatial resolution of water sample variables (e.g. nitrate)
- Data quality, processing, submission

Dr. Pickart has set up a website for physical oceanography component of the DBO. Data will be in a table matrix that can be searched by transect, vessel, chief scientist, parameters sampled, year and month. The physical oceanography data will have maps and plots (station positions, CTD transects, ADCP transects). Provisional data will be available as soon as possible with post-calibration corrections added as completed.

James Overland (NOAA/PMEL) (ppt3) provided a presentation on Arctic sea ice. Since 1999 there has been a 50% decline in multiyear sea ice coverage and 75% loss in sea ice volume. Climate change in the Arctic is a complicated issue including large temperature anomalies (largest on planet), large open water areas and changes in wind patterns.

Svein Vagle (DFO Canada) (ppt4) provided an update of sampling on board the Canadian Coast Guard Ship (CCGS) Sir Wilfrid Laurier. Long term monitoring has been occurring since the 1980's with the ship's track going from Victoria, BC to Barrow, AK and beyond. Most data is collected underway (while ship is moving) as extra funding is needed to stop the ship and take samples, something that has occurred since 1998 with international partners. Good data is collected for surface water conditions and CTD data can be taken to about 400 m.

Takashi Kikuchi (JAMSTEC) (ppt5) provided a presentation on the DBO pilot program results for the Japanese. In 2012 the R/V Mirai cruised in the Arctic from September 13th – October 4th. Measurements included conductivity-temperature-depth (CTD)/lowered acoustic doppler current profilier (LADCP) water sampling and expendable conductivity temperature depth (XCTD), mooring recovery/deployment, plankton net sampling, bio-geochemical measurements, multiple corer sampling, general meteorological monitoring, surface water sampling/monitoring, shipboard acoustic doppler current profilier (ADCP) monitoring and seabird and marine mammal surveys. Sea ice conditions were monitored in the Chukchi Sea and they found that some sea ice remained around Wrangel Islands until early September. Surface salinity was compared for 2008, 2009, 2010 and 2012. A multi-frequency acoustic zooplankton fish profiler (AZFP) was deployed at a mooring at a biological "hot spot" in the southern Chukchi Sea. Dr. Kikuchi would like to compare his data with others and get input.

Shigeto Nishino (JAMSTEC) (ppt6) provided a presentation on the biogeochemistry in the hotspots of the Chukchi Sea. Data were shown for three different types of biological hotspots: Hope Valley, Barrow Canyon and Shelf Slope. The Hope Valley hotspot had a dome-like structure of high nutrients. In the Barrow Canyon hotspot nutrients were supplied through upwelling and eddies. The Chukchi Shelf slope was a site for an effect biological pump.

Phyllis Stabeno (NOAA/PMEL) (ppt7) provided a presentation on data from Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) and Chukchi Acoustics, Oceanography and Zooplankton study (CHAOZ).

Rebecca Woodgate (UW) (ppt8) provided updates of Bering Strait data. Topics included cruises and moorings (past, present and future), sea-ice fluxes, Bering Strait Observing System Design (for physics), interannual change and spatial and temporal variability of the system.

Lee Cooper (UMCES/CBL) (ppt9) provided a presentation on the DBO hydrography for Impacts of Climate change on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICESCAPE) and CCGS Sir Wilfrid Laurier cruises. Data included nutrients and chlorophyll from the CCGS Sir Wilfrid Laurier cruises (2010-2012), CTD, nutrients and chlorophyll from the USCGC Healy (2012-2013) and nutrient and chlorophyll data from ICESCAPE (2011).

Terry Whitledge (UAF) (ppt10) provided a presentation of data from the Russian-American Long Term Census of the Arctic (RUSALCA) from 2004-2012 on board the Professor Khromov (Russia). Data included physical oceanography, video plankton profiles, water samples, phytoplankton, zooplankton, sediments, benthic epifauna, fish, mammals and birds.

Jackie Grebmeier (UMCES/CBL) (ppt11) provided a presentation that summarized 2012 cruise tracks and DBO station lines, with some data, from the Xuelong (CHINARE), Fairweather (NOAA Hydrography), Khromov (RUSALCA Leg 1 and 2), CCGS Laurier, CSESP, and Healy (AON-Mathis).

Sang Heon Lee (Pusan National University) (ppt12) provided a presentation about field-measured primary productivity in the Chukchi Sea. Results from the studies in the northern

Bering Sea (Lee et al. 2012) show productivity is about three times lower than previous work (Lee et al. 2007). Data sets available from June through September 2002 to 2009. Recent (3rd RUSALCA cruise in 2012) data is being processed right now.

Diana Varela (University of Victoria) (ppt13) provided a presentation on her team's contribution to the DBO. They participated in DBO cruises in July 2011 and 2012 and plan to continue in 2013 (and future) dependent on ships, funding and staff availability. Sampling and measurements done at 6 depths (euphotic zone) including dissolved nutrients (NO_3, PO_4 and $Si(OH)_4$), size-fractionated chlorophyll-*a* concentrations, biogenic silica concentrations, particulate C and N concentrations, C and N update rates and phytoplankton composition samples.

John Nelson (University of Victoria) (ppt14) provided a presentation on zooplankton biogeography, population genetics, production and functional diversity. Cluster analysis on data collected since 2000 show fairly clear structure with geographical location. Future plans are to continue biogeography analysis, genetics, functional traits and estimates of secondary production.

Kohei Matsuno (Hokkaido University) (ppt15) provided a presentation on the year-to-year changes in the mesozooplankton community in the Chukchi Sea. Data from 1991/92 and 2007/08 were compared.

Jackie Grebmeier (UMCES/CBL) (ppt16) provided a presentation on the DBO benthic sampling. Data included infaunal abundance, biomass, and composition, sediment grain size, total organic carbon and nitrogen and chlorophyll-*a*.

Catherine Berchok (NOAA) (ppt17) provided a presentation on data from the Chukchi Acoustic, Oceanographic and Zooplankton (CHAOZ) study. CHAOZ activities included oceanographic moorings, drifter buoys, sonobuoy deployments, CTD deployments, tucker sled collections, visual surveys for marine mammals using Big Eye binoculars and the deployment of long-term passive acoustic recorders that sample for marine mammal calls over one year.

Jeremy Mathis (NOAA) (ppt18) provided information about ocean acidification and the Arctic Observing Network (AON). Water with low pH (from increased CO_2 created during the remineralization of spring bloom organic matter) is being observed at depth in the Beaufort and Chukchi seas. This water is undersaturated in aragonite and will impact shell-building organisms. Ocean acidification is an example of a process being monitored in the Arctic and could be important to include in DBO activities.

Sue Moore (NOAA) (ppt19) provided a presentation on seabird and marine mammal observations during the 2010-2012 DBO pilot study. Seabird surveys have a standard survey protocol (2009 USFWS Pelagic Seabird Observer's Manual and Data Entry Software). Marine mammal data is collected using watches and standard surveys and there is a need for development of a standardized watch protocol. During the DBO pilot study there were 15

cruises with seabird surveys, 3 cruises with marine mammal surveys and 12 cruises with marine mammal watches.

Robert Day (ABR) (ppt20**)** provided a presentation on data from the Wainwright DBO line (NE Chukchi Sea) in 2008-2012. Data was collected as part of the Chukchi Sea Environmental Studies Program (CSESP) funded by Conoco Phillips Alaska, Shell Exploration and Production, Inc. and Statoil USA. The sampling design includes station sampling grids with emphasis on offshore areas and nearshore areas to be added when surveys begin for pipeline routes. Data collected includes physical oceanography, nutrients, ocean acidification, zooplankton, benthic macrofauna, benthic megafauna, fishes, seabirds, marine mammals and marine mammal acoustics. There is an opportunity here for adjustment of sampling station locations to help with DBO effort.

Tiffany Vance (NOAA) (ppt21**)** provided a presentation about data access and analysis tools for the Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program. This program includes physical and biological studies for fisheries oceanography in the Bering Sea, Gulf of Alaska and Arctic. Data existed in separate databases for ichthyoplankton, zooplankton, chemistry and CTD data. A unified Oracle© database was created with an ArcGIS (ESRI 2012. ArcMap, ArcGIS Desktop, and ArcINFO Workstation 10, Environmental Science Research Institute. Redlands, California) application for data selection (front end) using a web-based interface.

Day 2

Jackie Grebmeier (UMCES/CBL) (ppt22**)** reviewed the highlights from day 1, went over the four objectives of the DBO data meeting, breakout group logistics, and the day 2 agenda.

Karen Frey (Clark University) (ppt23**)** joined the meeting and provided a presentation on her work. Frey outlined her contributions to DBO data including point-based *in situ* measurements, matrix-based *in situ* measurements, and gridded satellite products. Dr. Frey provided a website (http://rapidfire.sci.gsfc.nasa.gov/gallery/), depicting georeferenced jpeg images from NASA.

Amy Holman (NOAA) (ppt24**)** provided an overview of anticipated Arctic shipping routes and port access planning (see presentation for map of proposed routes). A draft shipping route will be available for public comment soon. The Army Corps identified Barrow, Nome, and Port Clarence as potential deep-draught ports. NOAA is now considering areas where new charts should be created (see presentation for map). It typically takes 2 years for a new chart to be completed. Hydrosurvey ships may be able to provide platforms of opportunity for DBO data collection as in 2012. They survey at 5 kts and could potentially tow instruments that don't interfere with the survey. Ms. Holman would like group members to contact her by email with any relevant information or comments.

Molly McCammon (AOOS) (oral presentation) provided an update on Alaska Ocean Observing System (AOOS) activities. AOOS is working with Senators Begich and Murkowski (Alaska) on funding for monitoring and observing in Alaska. AOOS was originally funded with earmarks, but is now funded by a line item in the Federal budget. They are looking into funding for routine, sustained observations. Much of the current Arctic research is funded because of industry interest. A draft plan and map will be posted on the AOOS website. Priorities include adoption of two DBO lines with moorings. Please contact Ms. McCammon with comments and feedback.

Dan Holiday (BOEM) (ppt25) discussed the planned continuation of the Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA), 2004-2010 project. This project is gathering baseline and long-term monitoring data to evaluate potential effects from oil and gas development and production in the Beaufort Sea. They are still open to input on sampling locations. Monitoring indicates no contamination or other stressors are impacting the offshore environment. Data can be queried and downloaded from the web at: http://www.duxbury.battelle.org/CANIMIDA/.

Steve Williams (NCAR) (ppt26) provided a summary of the DBO data questionnaire. He received 15 responses and shared the results for each question with the group. A detailed list of questions and responses is available in the presentation file. DBO metadata should be standardized and in a usable format. Metadata files, at a minimum, need to be archived and searchable. Arctic data archives are housed at the Earth Observing Lab (EOL). The EOL DBO Draft Data Policy is included in Appendix C.

Breakout Groups

Jackie Grebmeier (UMCES/CBL) (ppt27) reviewed the goals of the break out group sessions. The groups were to discuss available data sets with specific evaluation of current data types, needs, gaps, standardization of data collections, networking needs, data exchange, metadata and data submissions, publication plans and any issues or concerns. Two breakout groups were formed: physical oceanography, including chemistry, and biological oceanography. Groups returned to plenary session for summary presentations of results and discussion.

Breakout Group 1 – Physical Oceanography

Participants: Cooper, Williams, Holman, Frey, Woodgate, Vagle, Whitledge, Pickart, Kikuchi, Nishino, Bailey

Lee Copper (UMCES/CBL) (ppt28) provided the presentation for the physical oceanography breakout group discussion. The Physical Oceanography group discussed the availability of data sets, different types of data to be submitted, time tables for submission, and who is responsible for contributing the data. There was a discussion of how to determine who is participating in the DBO, what stations they plan to visit, and when. AOOS has something set up on their website that could be used for coordination of DBO activities. Contact information is needed for

scientists at sea (email and phone) and a Point of Contact (POC) should be identified for each entity on the NOAA DBO website.

The group discussed submitting data via a web-based portal (FTP) or to EOL. Data could potentially be submitted while underway, upon returning from a cruise, or even years later after data have been processed and post-calibration. Data sets that will be submitted annually to the DBO include metadata on participants, ships used, and data type collected. A table of DBO data collections should be posted on NOAA DBO project sites.

The group discussed publication of DBO results. The first publication could be a physics paper submitted to the Journal of Geophysical Research (JGR) in summer 2013. A second potential publication is an interdisciplinary paper on water transformations and biological processes submitted to JGR in winter 2014. Finally, a news piece targeting a wider audience would also be good to highlight this coordinated international effort, potentially EOS (Transactions American Geophysical Union) front page. In the future, a special DBO issue in Deep Sea Research II or Progress in Oceanography could be considered. An Ocean Sciences special DBO session was also discussed as a good potential publication outlet.

Breakout Group 2 – Biological Oceanography

Participants: Moore, Grebmeier, Holiday, Nelson, Varela, Berchok, Matsuno, Lee, Day, Guy

Sue Moore (NOAA) (ppt29**)** provided a summary of the biological oceanography breakout session. The Biological Oceanography group focused on DBO stations 3 and 5. They created a table of available data for DBO3 and DBO5 by year, cruise, and data type (Table 2). The group discussed potential data gaps and data access issues. There are few measurements of primary production and the group will need to rely on satellite data to fill in the gaps. Hydrography data are more complete. Marine mammal data are available from both sites in all 3 years. Seabird data are available from the North Pacific Pelagic Seabird Database (http://alaska.usgs.gov/science/biology/nppsd/index.php). Please see table for details on available data.

There is interest in producing a paper that puts biology in the context of physics. A possible strategy is to compile the pilot study data into a single high-end paper that discusses the value-added strategy of the DBO. This first paper will be a 'mile-wide, inch-deep' in scope, showcasing examples, not heavy analyses.

A plan is needed for inter-calibration and standardization of biological data. It is important to rule out lab variability. One way to do this is to have people from different labs take the same samples back to their home labs and compare results. Readme files could provide some structure for metadata. Steve will set up a metadata form and people should send Steve examples. Methods of data collection need to be explicit in the metadata.

The group discussed potential data issues by data type:

Table 2. DBO Data matrix for DBO 3 and DBO 5. See Appendix D for acronym list of projects.

		DBO 3			DBO 5		
		2010	**2011**	**2012**	**2010**	**2011**	**2012**
Physics T/S	**CTD**	C30, CHAOZ, CHINARE	C3O, CHAOZ	C3O, CHINARE, RUSALCA, GRENE, CHAOZ	C30, CHAOZ	C30, CHAOZ	Comida HS, GRENE, CHAOZ, AON, (Pickart, Ashjian)
Currents	**ADCP**	C30, AON	C30, AON	C30, AON	C30, AON	C30, AON	C30, AON
Nutrients	**Nutrients**	C3O, CHAOZ, CHINARE	C3O, CHAOZ, CHINARE	C3O, CHAOZ, CHINARE	C3O, AON-Ashjian, CHAOZ	C3O, AON-CA, CHAOZ	Comida, HS, CHAOZ
	Satellite Primary Prod	K.Frey	K.Frey, C3O(1stn)	K.Frey, Sang Lee 2, Diana 1	K.Frey	K.Frey	K.Frey
Phytoplankton	**chl**	C3O	C3O	C3O	C3O	C3O	C3O
	species			RUSALCA, C3O			Comida HS,
Zooplankton	**standing stock**	C3O, CHAOZ	C3O, CHAOZ	C3O July, CHAOZ Aug, Greene Sept, Acoustic	C3O, CHAOZ	C3O, CHAOZ	Comida HS, Ashjian, CHAOZ, Greene
	species	C3O	C3O	C3O	C3O	C3O	C3O
Benthos	**standing stock**	C30-Grebmeier, CHINARE	C30-Grebmeier, CHINARE	C30-Grebmeier, CHINARE	C30-Grebmeier	C30-Grebmeier	C30-Grebmeier
	species	C30-Grebmeier	C30-Grebmeier	C30-Grebmeier	C30-Grebmeier	C30-Grebmeier	C30-Grebmeier
Marine mammals	**survey**	CHAOZ	CHAOZ	CHAOZ	CHAOZ	CHAOZ	CHAOZ
	watch	COMIDA, RUSALCA	C3O, RUSALCA	RUSALCA GREENE, Acoustic	COMIDA, BOWFEST	C3O BOWFEST, AKMAP	COMIDA, GRENE
Seabirds	**survey**	Kuletz, C3O-Bentley?, AOOS, Greene	Kuletz, C3O-Bentley?, AOOS,,GRENE	Kuletz, C3O-Bentley?, AOOS,, GRENE	Kuletz	Kuletz, AKMAP	Kuletz, GRENE

Chlorophyll standing stock

Chlorophyll standing stock measurements can be made using either acidification or non-acidification methods. There is much variability between methods. Cross calibrations are necessary.

Zooplankton

Mesh size issues complicate zooplankton sampling – 5 different sizes are used. Correction factors are needed to make these data comparable. Cross-calibration and voucher specimens are needed. Metadata must capture explicit methods providing details on complete enumeration, size fractionation, subsampling, etc.

Benthos

People collecting data are using the same screens/sieves. Chinese researchers are using grabs, but identification methods are uncertain. A Chinese scientist will be spending 3 months in Jackie Grebmeier's lab in 2014. Sometimes Russian scientist use a smaller screen size and only collect one grab for diversity. The Alaska Monitoring and Assessment Program (AKMAP) has completed inshore sampling and an occupation of DBO5 (2012) and analyzed one grab sample per station, but is seeking funds to analyze their other two grab samples. Cross calibration is needed with RUSALCA and other projects benthic data. Both the COMIDA and CSESP field programs are using high-definition camera systems to observe the benthic system.

Seabirds

Seabird survey methodology has been standardized via the Pacific Seabird Group, but there are complications with how to count flying birds, birds on the water and (possible) repeat birds. Metadata need to be explicit regarding continuous counting or snapshot methods.

Marine Mammals

Ship-based marine mammal visual surveys using Big Eye binoculars and rotating teams of 3 observers are standardized, with data entered and stored on laptop computers using a Windows Real Time Sighting-Event Logger (WinCruz) program. Conversely, marine mammal watches are not standardized and rely on single or sometimes two observers scanning a ~120 arc in front of the ship using hand-held binoculars. A standardized Marine Mammal 'Watch' protocol is desirable, to guide sampling when only one or two observers with hand-held binoculars are available. A 2013 version is provided Appendix E. Similarly, acoustic data, gathered either via long-term recorders or by deployment of sonobuoys along the ship track are not standardized and an acoustic-focused metadata file structure needs to be developed.

Day 2 Action Items

1. Send metadata example of your (DBO participants) data to Steve Williams. Steve will setup up a metadata form online.
2. Give comments to Amy Holman via email on Arctic shipping and ports.
3. Give comments to Molly McCammon on moorings.
4. Have subgroups deal with sampling variability, issues and calibration needs.
5. Consider what data might be immediately available for a DBO Pilot Study 'key highlights' paper.

Day 3

Jackie Grebmeier (UMCES/CBL) (ppt30) welcomed everyone back to the meeting and provided an overview of results from the previous day's breakout groups (physical oceanography and biology). Day 3 discussions focused on DBO lines: where we have sampled and where we should be sampling. It was also planned to discuss what funding and effort it will take to occupy the DBO lines.

One final short background presentation (same format as Day 1 presentations) was made.

Carin Ashjian (WHOI) (ppt31) provided a presentation on DBO sampling from the R/V Annika Marie (DBO5-Barrow transect). Oceanographic sampling occurred from the middle of August to the middle of September 2005-2012 at multiple transects in the region. Sampling included CTD (with fluorescence and PAR=photosynthetic active radiation), acrobat towed vehicle (CTD, chlorophyll, DCMU (3-(3,4-dichlorophenyl)-1,1-dimethylurea)) fluorometer and optical backscatter), ACDP, ring nets and Tucker trawl, microzooplankton, extracted chlorophyll, flow cytometry and nutrients (0, 10 & 40 m depths), along with seabirds and marine mammal counts. Dr. Ashjian also showed data from cruise HLY1104 (USCGC Healy) including copepod data.

General Group Discucssion

The group discussed placement of DBO transects and stations (ppt32). For DBO4, the discussion was informed by Bob Day's presentation on Day 1 on the industry-funded activities in the NE Chukchi Sea. The group decided on a 6-station line, focused on the 'walrus hotspot' on the SE flank of Hanna Shoal. A working group was formed (Grebmeier, Day, Moore, Vagle) to finalize the sampling locations and region boundary. Additional DBO transects and regions were discussed for the Beaufort Sea. A working group was formed (Moore, Pickart, Holiday, Nelson) to discuss the location of two possible DBO regions in the US Beaufort and at least one region in the Canadian Beaufort Sea. There was general consensus to keep the sampling offshore and near hot spots of biological activity.

Robert Pickart (WHOI) (ppt33) presented a figure from Impacts of Climate on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICESCAPE) showing winter water flow paths and movement around Hannah Shoal. There was discussion of walrus hot spots and where the ultimate DBO4 line should be placed in this area.

Rebecca Woodgate (UW) (ppt1) discussed the physical oceanography of Bering Strait and the past and current mooring arrays. Recently the transport through Bering Strait has increased. Characterized by warmer and fresher seawater. Further figures available at her website: http://psc.apl.washington.edu/HLD/Bstrait/bstrait.html.

Bob Day (ABR) (ppt34) provided a presentation about the sampling plan for the Wainwright line.

Dan Holiday (BOEM) (ppt35) provided figures on transects and stations in the Beaufort Sea. Most stations are nearshore, but some stations are located offshore. Dr. Holiday asked for coordinates from Bob Pickart, including UAF and AON projects, to help decide where to sample.

Jackie Grebmeier (UMCES/CBL) (ppt36) provided figures showing benthic data for the Chukchi Sea. Spatial distributions of sediment chlorophyll, grain size, infaunal biomass, and abundance shows areas of hot spots.

Sue Moore (NOAA) (oral presentation) summarized how the DBO fits with the Interagency Arctic Research Policy Committee (IARPC). In the US there are 14 agencies with interest and or research activities in the Arctic. In an attempt to coordinate actions among these agencies, the IARPC leadership developed 7 research themes, each with multiple activities. There are 4 activities listed under the Sea Ice and Marine Ecosystems theme, where the DBO is listed as activity #3. A DBO Interagency Implementation Team (IT) has been formed as is charged to "*Complete deployment of a DBO in the Arctic Ocean to create long-term data sets on biological, physical and chemical variability and ecosystem response"*. There are now 12 implementation teams with a 5-year plan tasked to move forward the full implementation of various arctic-related research activities. The IARPC is national, but DBO is considered an international project, due to its development through the Pacific Arctic Group (PAG) and need for international collaboration to occupy the DBO lines. Thus, each country can point to the DBO as something the US supports internationally.

2013 Sampling Plans

Lee Cooper (UMCES/CBL) (ppt37) provided a presentation on the CBL sampling for 2013. They will occupy Hanna Shoal using the USCGC Healy (July/August) and will occupy the Barrow Canyon line. There will also be a CBL team on the CCGS Sir Wilfrid Laurier (July) that will sample all the DBO lines (1-5, see below for DFO Canada).

Shigeto Nishino (JAMSTEC) (ppt38) provided details about the R/V Mirai 2013 sampling plan. They plan to depart Dutch Harbor in late August and occupy DBO3 and DBO5. The R/V Oshoro Maru will sampling in July and occupy DBO3 and possibly DBO5.

Svein Vagle (DFO Canada) (oral presentation) summarized the Sir Wilfrid Laurier's 2013 cruise plans. The ship will be cruising from about July 2-22, 2013. They will sample DBO1-5 and Takashi will turnaround moorings on DBO 3 & 5.

Amy Holman (NOAA) (ppt39) showed the proposed cruise track for the NOAA coast survey using the R/V Fairweather. The work is scheduled to take place from the middle of July through August. The ship will be conducting hydrographic surveys with potential for other work to occur.

Catherine Berchok (NOAA) (ppt40) provided information on the Arctic Whale Ecology Study (ArcWEST) 2013 sampling. They plan to tag fin, gray, humpback whales from around Bering Strait to Pt. Hope with 39 moorings, 51 stations and bird observations.

Bob Day (ABR) (ppt35) provided a presentation about the sampling plan for the Wainwright line as part of the Chukchi Sea Environmental Studies Program (CSESP) program. They will have intensive surveys in 3 areas (Klondike, Burger and Stat Oil) and will do sampling on the finalized DBO location.

Robert Pickart (WHOI) (oral presentation) provided information on the Arctic Observing Network (AON) sampling for 2013. They will have an array of moorings, CTD surveys and seabird observers.

Carin Ashjian (WHOI) (ppt31) provided information on the zooplankton sampling plan for 2013. Sampling may not occur on the R/V Annika Marie, but will take place in middle August and they will have a bird observer on board.

Sang Heon Lee (Pusan National University) (oral presentation) summarized the proposed 2013 sampling plan. In 2014 the plan is to sample almost 30 days for oceanography and they will occupy one of the DBO lines.

Rebecca Woodgate (UW) (oral presentation) provided information on proposed sampling for 2013 using the Khromov (now the Norseman II).

The following **ACTION ITEMS** were identified at the end of the workshop:

1. First step survey involve DBO:

- Survey of all DBO participant as to which DBO lines and stations will be occupied in 2013; results will be linked to AOOS site (Grebmeier)
- Need point of contact each entity involved in DBO activities; update list on NOAA DBO website (Grebmeier)
- Need contact at sea information (email, phone, fax) beyond just email)-send to PAG Secretariat

2. Data Recap

- Submit examples of metadata files to Steve Williams to finalize a standard metadata format for DBO: a short, interoperability file (Steve Williams-lead)
- Submit "Readme" file on how measurements were made to accompany data-send to Steve Williams/EOL
- Develop a DBO data policy (Steve Williams, see Appendix C for draft).

3. Working Group

- Biology; subgroups once standard metafile form filled out
- Physics: Pickart-CTD/ADCP lead; develop bottle file from CTD data
- Hydrography: Lee Cooper-incorporate nutrients and chlorophyll into bottle file
- Subgroup 1: Beaufort Sea DBO planning sites: Bob Pickart and Sue Moore-initiates discussion

- Subgroup 2: Determine DBO4 focused location NE Chukchi Sea: Jackie Grebmeier lead
- Determine Boundary boxes for DBO regions (Jackie Grebmeier)

4. Publications

- Nature Climate Change: Commentary (Sue Moore and Jackie Grebmeier-lead)
    - Biology-Physics Matrix – need finalize (Grebmeier)
- Physics and physics/chemistry- 2 papers

5. Future meeting

- The DBO working group plans to meet yearly around the same time (~March) and continue to connect with other groups such as PAG and IARPC (Interagency Arctic Research Policy Committee) for coordination of ship time and funding opportunities.

Jackie Grebmeier thanked everyone for participating the DBO data workshop and closed the meeting.

Citations

Grebmeier, J.M, S.E. Moore, J.E. Overland, K.E. Frey, and R. Gradinger, 2010. Biological Response to Recent Pacific Arctic Sea Ice Retreats, *Eos*, Transactions, American Geophysical Union Vol. 91, No. 18, pg. 161-162.

Grebmeier, J.M. 2011. Biological Response to Reduced Sea Ice in the Pacific Arctic Region. Summary statement and workshop report available at http://www.arctic.noaa.gov/dbo/

Holland-Bartels, Leslie, and Pierce, Brenda, eds., 2011. An evaluation of the science needs to inform decisions on Outer Continental Shelf energy development in the Chukchi and Beaufort Seas, Alaska: U.S. Geological Survey Circular 1370, 278 p. (Also available at http://pubs.usgs.gov/circ/1370/).

NOAA 2011. Arctic Vision & Strategy Plan. 2011 NOAA's Arctic Vision & Strategy Plan, 23 pp.

PAG Project Office, 2011. PAG Meeting Report on the DBO Workshop. Available on the PAG Project office website, 38 pp. final pag meeting report - sidney british columbia canada - november 2011.pdf

Appendix A

Workshop Agenda

DBO Data Meeting • February 27–March 1, 2013 • NOAA/PMEL
7600 Sand Point Way NE, Bldg. 3, Seattle, WA 98115in Seattle, WA, USA

Four Objectives for the DBO Data Meeting:

- Present results from the 2010-2012 pilot study and determine a basis for multidisciplinary paper(s) to showcase the DBO international effort;
- Archive metadata, either with a link to data set in a national archive or by submitting the DBO data to a common data archive;
- Discuss DBO site criteria and identify NE Chukchi Sea DBO4 line and other DBO lines; and
- Determine how to plan for full implementation for the DBO.

Wednesday-27 February

0630 Complimentary breakfast in hotel lobby area (each day)
0745 Meet in lobby for van shuttle to PMEL
0830 Welcome and Logistics: Chris Sabine & Sue Moore
0845 Meeting objectives and overview of the DBO: Jackie Grebmeier
0915 DBO pilot program results summaries by field collections (10 min max), plus discussion

a. Physical/chemical

- Robert Pickart
- James Overland
- Svein Vagle
- Takashi Kikuchi
- Shigeto Nishino
- Phyllis Stabeno
- Rebecca Woodgate
- Karen Frey (Thursday)
- Lee Cooper
- Terry Whitledge
- Jeremy Mathis

b. Biological

- Sang Lee
- Diana Varela
- John Nelson
- Koheii Matsuno
- Carin Ashjian (Friday)
- Jackie Grebmeier
- Catherine Berchok
- Sure Moore
- Bob Day
- Others?

1030 Coffee break
1050 Continuation of DBO pilot program data results and discussion
1200 Lunch in PMEL cafeteria
1330 Continuation of DBO pilot program data results and discussion
1500 Coffee break
1520 Continuation of DBO pilot program data results and discussion
1600 Open discussion on presentations and outline of Day 2 activities
1700 End Day 1 and shuttle back to hotel
1830 Dinner (self-pay) at local restaurant – Mamma Melina (5101 25th Ave NE; walking distance from Silver Cloud)

Thursday-28 February

0745 Meet in hotel lobby, van to PMEL
0830 Highlights of Day 1 and outline Day 2 activities
0845 Summary of DBO Questionnaire Results, EOL Mapserver, data policy and use issues: Steve Williams
1000 Break
1020 Breakout into two groups: Physical/hydrography (leads: Pickart/Cooper) and biology (leads: Grebmeier/Moore) for discussion of available data sets for physical/chemical data and biological data, with specific questions related to data collection, needs, standardization of data collection, gaps, etc.
1200 Lunch in PMEL cafeteria
1330 Meet as full group for discussion of breakout group activities - summary presentations and discussions
1430 Second breakout wave (cross-fertilization) to begin data exchange discussion, metadata and data submissions, publication plans
1530 Break
1550 Return to plenary session, summary presentations and discussions, possible high-level publication?
1700 Summary of day's activities and plans for Day 3
1700 End Day 2 and shuttle to hotel
1730 Dinner on your own

Friday-1 March

0745 Meet in hotel lobby, van to PMEL
0830 Highlights of Day 2 and objectives for morning session
0845 Discussion of criteria for DBO sites, location for DBO 4 in northern Chukchi Sea, and location of other DBO international lines
1000 Coffee break
1020 Plans for future DBO activities (5-10 min)

- US IARPC DBO Interagency Team milestones-Sue Moore
- US Industry activities

- Japan, Canada, Korea, other foreign activities
- Others?

1200 Lunch in PMEL cafeteria

1330 DBO data issues, central data link at EOL and links to international data portals for direct access for DBO data products (Steve Williams, others)

1500 Break

1520 Open discussion of workshop action items, plans for publications, field plan, future activities

1700 Close of workshop and shuttle to hotel

1830 Meeting reception at local restaurant, then dinner as group or on own (TBD)

Appendix B

Workshop Participants

Meeting attendees, affiliations and email addresses.

Last Name	First Name	Affiliation (see table below for abbreviations)	Email
Ashjian	Carin	WHOI	cashjian@whoi.edu
Bailey	Eva	CBL/UMCES	bailey@umces.edu
Berchok	Catherine	NOAA/AFSC/NMML	Catherine.Berchok@noaa.gov
Bosch	Jennifer	NOAA/UMCES	jbosch@umces.edu
Cooper	Lee	CBL/UMCES	cooper@umces.edu
Crane	Kathy	NOAA Arctic Research Program	kathy.crane@noaa.gov
Day	Robert	ABR, Inc.--Environmental Research & Services	bday@abrinc.com
Frey	Karen	Clark University	kfrey@clarku.edu
Grebmeier	Jacqueline	CBL/UMCES	jgrebmei@umces.edu
Guy	Lisa	NOAA/PMEL	lisa.guy@noaa.gov
Holiday	Dan	BOEM	dan.holiday@boem.gov
Holman	Amy	NOAA Alaska Regional Collaboration Team	amy.holman@noaa.gov
Key	Erica	NSF/OPP/ARC	ekey@nsf.gov
Kikuchi	Takashi	Japan Agency for Marine-Earth Science and Technology	takashik@jamstec.go.jp
Lee	Sang H.	Department of Oceanography, Pusan National University	sanglee@pusan.ac.kr
Mathis	Jeremy	NOAA/PMEL	jeremy.mathis@noaa.gov
Matsuno	Kohei	Hokkaido University	k.matsuno@fish.hokudai.ac.jp
McCammon	Molly	Alaska Ocean Observing System	mccammon@aoos.org
Moore	Sue	NOAA/Fisheries – ST7	sue.moore@noaa.gov
Nelson	John	University of Victoria	jnelson@uvic.ca
Nishino	Shigeto	Japan Agency for Marine-Earth Science and Technology	nishinos@jamstec.go.jp
Overland	James	NOAA/PMEL	james.e.overland@noaa.gov
Pickart	Robert	WHOI	rpickart@whoi.edu
Stabeno	Phyllis	NOAA/PMEL	phyllis.stabeno@noaa.gov
Vagle	Svein	Department of Fisheries and Oceans, Canada	Svein.Vagle@dfo-mpo.gc.ca
Vance	Tiffany	NOAA/AFSC	tiffany.c.vance@noaa.gov
Varela	Diana	University of Victoria	dvarela@uvic.ca
Wang	Muyin	NOAA/PMEL	muyin.wang@noaa.gov
Whitledge	Terry	University of Alaska Fairbanks	terry@ims.uaf.edu
Williams	Steve	NCAR/EOL	sfw@ucar.edu
Woodgate	Rebecca	University of Washington	woodgate@apl.washington.edu

Appendix C

DBO Data Policy and Release Guidelines
DRAFT (as of May 2013)

1. DBO DATA POLICY, RELEASE, AND DISSEMINATION GUIDELINES

Release of Data in Compliance with WMO Resolution 40 (CG-XII) and WMO Resolution 25 (CG-XIII)

The DBO is a multi-disciplinary international project and as such it is appropriate that any policy for release and dissemination of DBO data should also principally comply with the World Meteorological Organization (WMO) policy, practice and guidelines for the exchange of meteorological, hydrological, and related data and products, as embodied in Resolution 40 of the Twelfth WMO Congress 1995 (CG-XII), and Resolution 25 of the Thirteenth WMO Congress 1999 (CG-XIII); that is, free and unrestricted exchange of essential data and products:

"As a fundamental principle of the World Meteorological Organization (WMO), and in consonance with the expanding requirements for its scientific and technical expertise, the WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products."

The no-restriction principle shall in particular mean that no financial implications are involved for the DBO data exchange. DBO *data providers* and Archives shall provide their measured data to users free of charge.

No Commercial Use or Exploitation

It is understood that all DBO data shall be delivered to *data users* only for scientific studies designed to meet DBO objectives. Commercial use and exploitation by neither the *data users* nor the DBO Archives is prohibited, unless specific permission has been obtained from the *data providers* concerned in writing.

No Data Transfer to Third Parties

One restriction which will be imposed on all *data users* concerns the re-export or transfer of the original data (as received from the *data providers* or related archives) to a third party. Such restriction shall apply to all categories of DBO data, and is in the best interests of both the *data providers* and the potential users. Unrestricted copying of the original data by multiple, independent users may lead to errors in the data and loss of identity of its DBO origin and is strictly prohibited.

The DBO Archives or *Data Providers* will offer DBO data files to potential *data users* through electronic means, (e.g. the internet) or other designated media (e.g. CD/DVDs). The DBO Archives shall install technical means to keep protocol on all data transfers to *data users* thus maintaining a catalogue of all *data users*, and the data files they have obtained.

Timing for Release of DBO Data

The timing issue clearly involves some conflicting aspects. The *data user* will obviously be interested in obtaining data as soon as possible after the time of measurement. The *data provider* as well as the Archives will wish to ensure the highest attainable quality of the data. The latter will generally be time consuming, particularly in view of the shortage of manpower in many cases as *data producers* may be in the field obtaining measurements.

In addition, the *data provider*, or instrument Principle Investigator (PI), may have for good reasons an interest to exploit the respective data, or part of it, for his/her own scientific interest, or for another funded project or experiment, before these data are made openly available to a larger community.

Ideally, data should be ready for general release after some specific period following its acquisition, during which the exchange process between the *data provider* and the archives, including quality control and assurance, will have been completed. **Six months** is generally a suggested guideline as an appropriate length for this *data turn-around period*.

It is nevertheless recognized that there may be instances when this turn-around time shall deviate from **six months**. This may be the case in particular for protecting the *data provider's* own interest for the data of a specific instrument (or several instruments) at his/her site. In order to avoid a too complex data availability system, it is suggested that all data taken for DBO shall be categorised into *standard* (category 1) and *enhanced or experimental* (category 2) data. See section 2 for definition of these categories. ***Standard*** data shall be freely open to the science community after the basic turn-around period of **six months**. ***Enhanced or Experimental*** data shall be freely open to the science community after a prolonged turn-around period of **12 months** at maximum. Each DBO *data provider* will be responsible to decide on the category of specific data at the respective site.

It shall be possible in special cases for a potential *data user* to establish direct contact to a *data provider* (or a PI) in order to agree on exceptions (i.e. shortenings of the turn-around period) to these rules for specific data or data periods. It is suggested that these communications shall be performed with co-ordination of the DBO Scientific Steering Committee.

Acknowledgement and Citation

Whenever DBO data distributed by the Archives are being used for publication of scientific results, the data's origin must be acknowledged and referenced. A minimum requirement is to

reference DBO and the *Data Provider(s).* If only data from one site (or limited collaborators) has been used, additional acknowledgement to the site(s) and (their) maintaining institutions or organizations shall be given.

Maintaining continuous, high-quality measurements, performing quality and error checking procedures, and submitting data and related documentation to the archives may require substantial financial and logistical efforts of the *data providers*. The necessary support for these activities originate from a variety of international, national, and institutional sources. The archives shall make proper reference to all DBO *data providers* and, if required, to their funding sources.

Co-Authorship for DBO Principal Investigators (PIs)

Co-authorship of DBO PIs on publications making extensive use of DBO data is justifiable and highly recommended, in particular, if a PI has responded to questions raised about the data's quality and/or suitability for the specific study in question, or has been involved in directly contributing to the publication in other ways. It is highly recommended that any *data user* should contact the responsible PI and ask him/her if he/she wants to become co-author, or if an acknowledgement would be sufficient. If co-authorship is requested, the PI and the *data user* should establish a basis for collaboration. A PI in this context means the responsible site or instrument scientist or any person (student, collaborator) that he/she may suggest. *Data users* of DBO data are encouraged to establish direct contact with PIs or *data providers* for the purpose of complete interpretation and analysis of data for publication purposes. This is in particular recommended for category 2 data.

DBO Publication Library

Whenever DBO data distributed by the archives are being used for publication of scientific results, the author(s) shall sent a copy of the respective publication, preferably in electronic form, to a central repository (to be determined) in order to build up a DBO publication library. The designated repository will maintain this library and will it make public, for example via the DBO website, for a continuous monitoring of the DBO data applications and DBO's achievements in general.

2. DBO DATA CATAGORIES

In order to set up data release guidelines which balance the interests of both *data users* and *data providers* in the light of the above mentioned constraints it was considered useful to divide DBO data into the following two categories:

Category 1: *Standard* data.

[e.g. physical measurements such as cruise/mooring data, rawinsonde, surface standard meteorology, etc.]
Low or common exploitation value, measurement technology common, generally well understood, little or no problems with data interpretation.

Category 2: *Enhanced or Experimental* data.
[e.g. biological (zooplankton, mammals, birds, etc.), chemical, remote sensing, flux, etc.]
High exploitation value, measurement technology sophisticated and/or of experimental nature, contact to PIs recommended for correct interpretation of data, high efforts necessary to maintain continuous measurements and high quality of data. These data are often taken for specific research purposes and always maintained by a specific research group and/or the station or instrument PI.

Appendix D

List of Abbreviations

Abbreviations for DBO-related institutions, agencies and programs.

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

PMEL	Pacific Marine Environmental Laboratory (NOAA)
NSF	National Science Foundation
OPP	Office of Polar Programs (now Division of Polar Programs)
PAG	Pacific Arctic Group
RUSALCA	Russian-American Long-term Census of the Arctic
R/V	Research Vessel
SCAR	Scientific Committee for Antarctic Research
UAF	University of Alaska Fairbanks
UMCES	University of Maryland Center for Environmental Science
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution

Appendix E

DBO Marine Mammal Watch Protocol
Version May 24, 2013

A visual watch for marine mammals is generally conducted during daylight hours when the ship is in transit between sampling stations; this effort can be augmented by ~10 minute scans around the ship each hour when the ship is on station. The watch stander adopts a position on the bridge, on whichever side is least intrusive to the ship's captain and crew. The single observer stands a watch using naked eye and handheld binoculars to scan a 130º arc forward of the ship (abeam, to +30° of the bow) out to the horizon when the ship is underway; this can be augmented by 360º scans around the ship when on station. If two people are available to stand watch, the full 180° arc forward of the ship should be scanned to the horizon. The watch stander can be assisted by other scientific party personnel and the ship's crew whenever possible. A watch is curtailed when sea state exceeds Beaufort 05, or visibility is <1 km.

All marine mammal sightings are noted by (i) time, (ii) position, (iii) species and (iv) number of animals (Table 1). Position can be read directly from the ship's GPS, or linked from a handheld unit to a laptop computer, if available. All marine mammals are identified to species when possible, but observers are encouraged to enter sightings as 'unidentified' if they are uncertain. If there are many animals in a group (as often happens when walrus are sighted), a high-low estimate of animals can be noted.

Associated environmental conditions to routinely note on the data form include: (v) an estimate of ice cover (percent), (vi) sea state (Beaufort scale), (vii) weather and (viii) approximate visibility range (Table 1). In lieu of sightings, the ship's position and environmental conditions should be noted once per hour or whenever there is a change in ice cover, sea state, weather, visibility, or noteworthy biophysical features (e.g. obvious convergence zone). Photos should be taken whenever possible to verify species identification and to augment humpback whale (fluke) or killer whale (eye patches, dorsal fins & saddles) photo catalogs.

A short cruise report is required, to include a summary table of watch effort and sightings, short descriptive text of cruise highlights, maps depicting marine mammal distribution and photos, whenever possible. A sample report is attached.

DBO Marine Mammal (MM) Watch Data Codes

Reason for Entry (RFE)
1 = Station: position of ship during ocean sampling operations
2 = Position on Search: position of ship when weather, sea state &/or visibility conditions change
3 = Sighting on Search: position of ship when animal is seen

Ice Cover (Ice) = decimal percent **Sea State (SS) = Beaufort scale**

Weather (WEA)
1 = clear
2 = partly cloudy
3 = fog
4 = overcast
5 = precipitation
6 = low ceiling
7 = haze
8 = glare

Visibility (VIS)
1 = < l km
2 = 1-2 km
3 = 2-3 km
4 = 3-5 km
5 = 5-10 km
6 = unlimited

Species
1 = bowhead whale
2 = gray whale
3 = beluga
4 = fin whale
5 = humpback whale
6 = minke whale
7 = right whale
8 = killer whale
9 = harbor porpoise
10 = polar bear
11 = walrus
12 = bearded seal
13 = ringed seal
14 = spotted seal
15 = ribbon seal
16 = unidentified cetacean
17 = unidentified pinniped
18 = sperm whale
19 = Dall's porpoise