Distributed Biological Observatory – Northern Chukchi Integrated Study

Healy 1702 Cruise Report

Chief Scientist: Robert S. Pickart, Woods Hole Oceanographic Institution
Co-Chief Scientist: Jacqueline M. Grebmeier, Chesapeake Biological Laboratory

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Contributing author: Leah McRaven (ltrafford@whoi.edu)

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Contributing authors: Calvin Mordy (calvin.w.mordy@noaa.gov) and Phyllis Stabeno (phyllis.stabeno@noaa.gov)

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Contributing author: J. Creamean (jessie.creamean@noaa.gov)

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Contributing authors: Charles Wright, Brian Hoover, and Kathy Kuletz (kathy_kuletz@fws.gov)

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Contributing author: Jessica Cross (Jessica.Cross@NOAA.gov)

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Section A: Overview

The inaugural cruise of the Distributed Biological Observatory – Northern Chukchi Integrated Study (DBO-NCIS) was successfully carried out from 26 August to 15 September 2017 aboard the US Coast Guard Cutter *Healy*. The overall goal of DBO-NCIS is to document and understand ongoing changes to the Pacific-Arctic ecosystem in light of the changing physical drivers. The main objectives for the 2017 cruise were (1) to occupy DBO lines 3-5 in the Chukchi Sea with an extensive suite of water column and benthic measurements; and (2) to carry out a process study of the northeastern Chukchi shelf designed to understand the physical-biological links that result in the biological hot spots in this region. In addition to the core components of the program, a number of ancillary projects were added which enhanced the breadth of the scientific measurements conducted during the cruise. The list of activities and associated PIs is as follows:

- Water mass properties and circulation, R. Pickart (WHOI)
- Nutrients and chlorophyll, C. Mordy (PMEL)
- Dissolved inorganic carbon and total alkalinity, J. Cross (PMEL)
- Mesozooplankton and larval fish, J. Duffy-Anderson (NMFS)
- Macrofauna, sediment characteristics, and sea ice melt tracers (δ18), J. Grebmeier and L. Cooper (UMCES)
- Aerosols, J. Creamean (NOAA)
- Dissolved nitrous oxide and isotopes, A. Bourbonnais (WHOI)
- Water sampling biases (C. Paver, UMCES)
- Dissolved methane and underway methane sampling, C. Magen (UMCES)
- Ostracod distributions, L. Gemery (USGS)
- Microbes, E. Collins (UAF)
- Marine mammals, S. Moore (NMFS)
- Seabirds, K. Kuletz (USFWS)

In addition to these activities, sediment samples were collected at two sites adjacent to the coast of Alaska to assay for harmful algal species (D. Anderson, WHOI); an UptempO buoy was deployed to measure the temperature structure of the upper water column (M. Steele, UW; psc.apl.washington.edu/UpTempO/); four Surface Velocity Program (SVP) drifters were deployed to measure SST and sea level pressure (I. Rigor, UW); and calibration measurements were taken adjacent to two Saildrones at the DBO-3 line (J. Cross, PMEL).

Due to the generally favorable weather conditions and the lack of sea ice in the study region, the pace of work was faster than originally envisioned. As such, the number of stations occupied significantly exceeded our initial plan. In particular, the shelf survey was enhanced by tightening the station spacing in certain areas and adding an additional line; two transects were occupied into the Canada Basin to bottom depths > 2000 m; and most of the stations on the DBO-1 line were occupied in the northern Bering Sea at the end of the cruise. A map of the station sites is shown in A-1 indicating the locations of DBO lines 1, 3, 4, and 5, and the shelf survey.

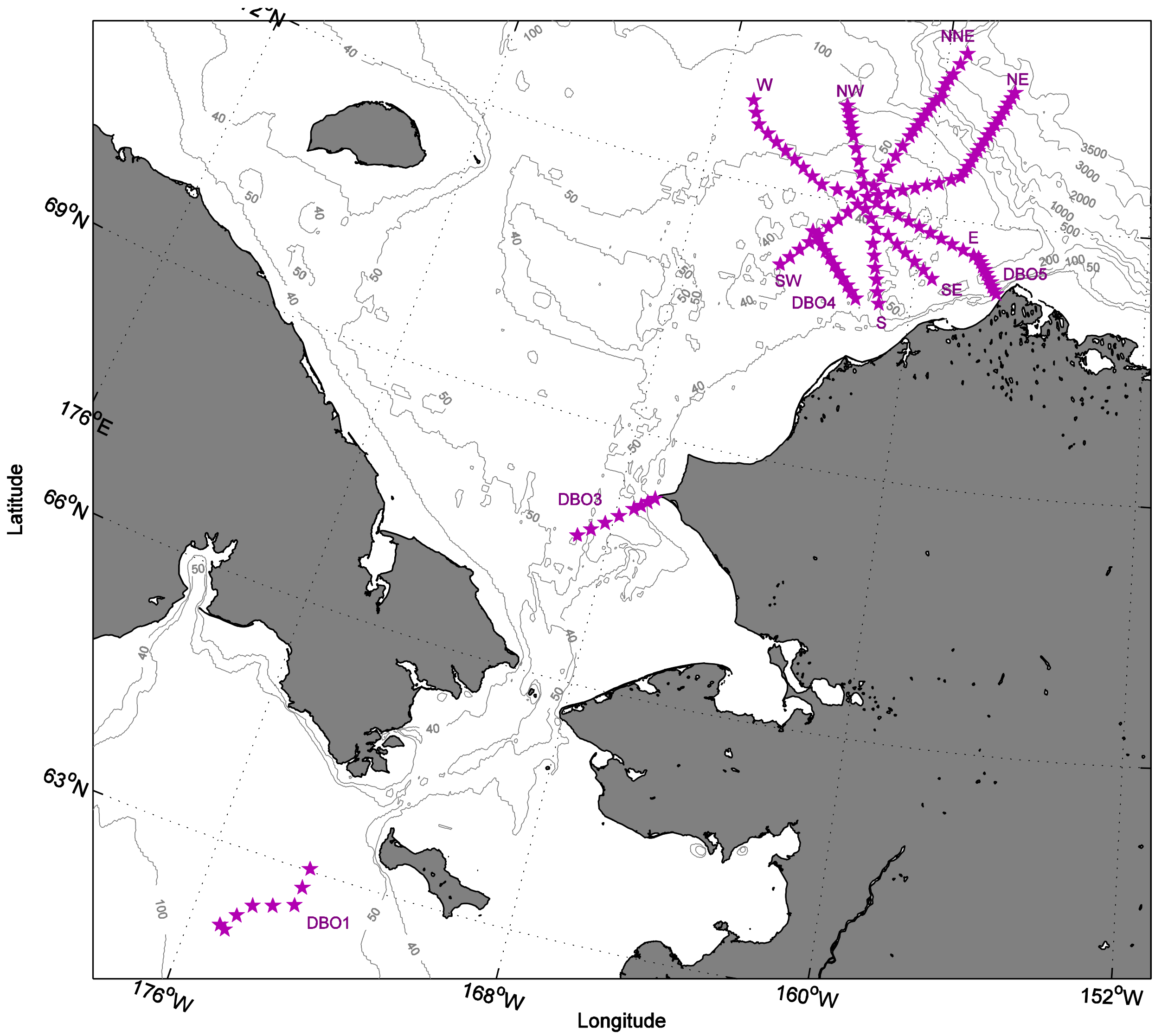


Figure A-1: Stations occupied during the 2017 DBO-NCIS cruise (magenta stars).

A conductivity-temperature-depth (CTD) cast was done at each site, while a subset of the stations included water sampling, net tows, and benthic work (see the individual sections of the cruise report below). The DBO lines 3-5 were occupied first, followed by the shelf survey, and lastly the DBO 1 line. *Healy's* two vessel-mounted acoustic Doppler current profilers (ADCPs) were operational throughout the cruise, as were the underway CTD and the ship's meteorological sensors. An enlarged view of the shelf survey is shown in Figure A-2. The survey was occupied in the clockwise direction starting at the Southwest line and ending at the South line.

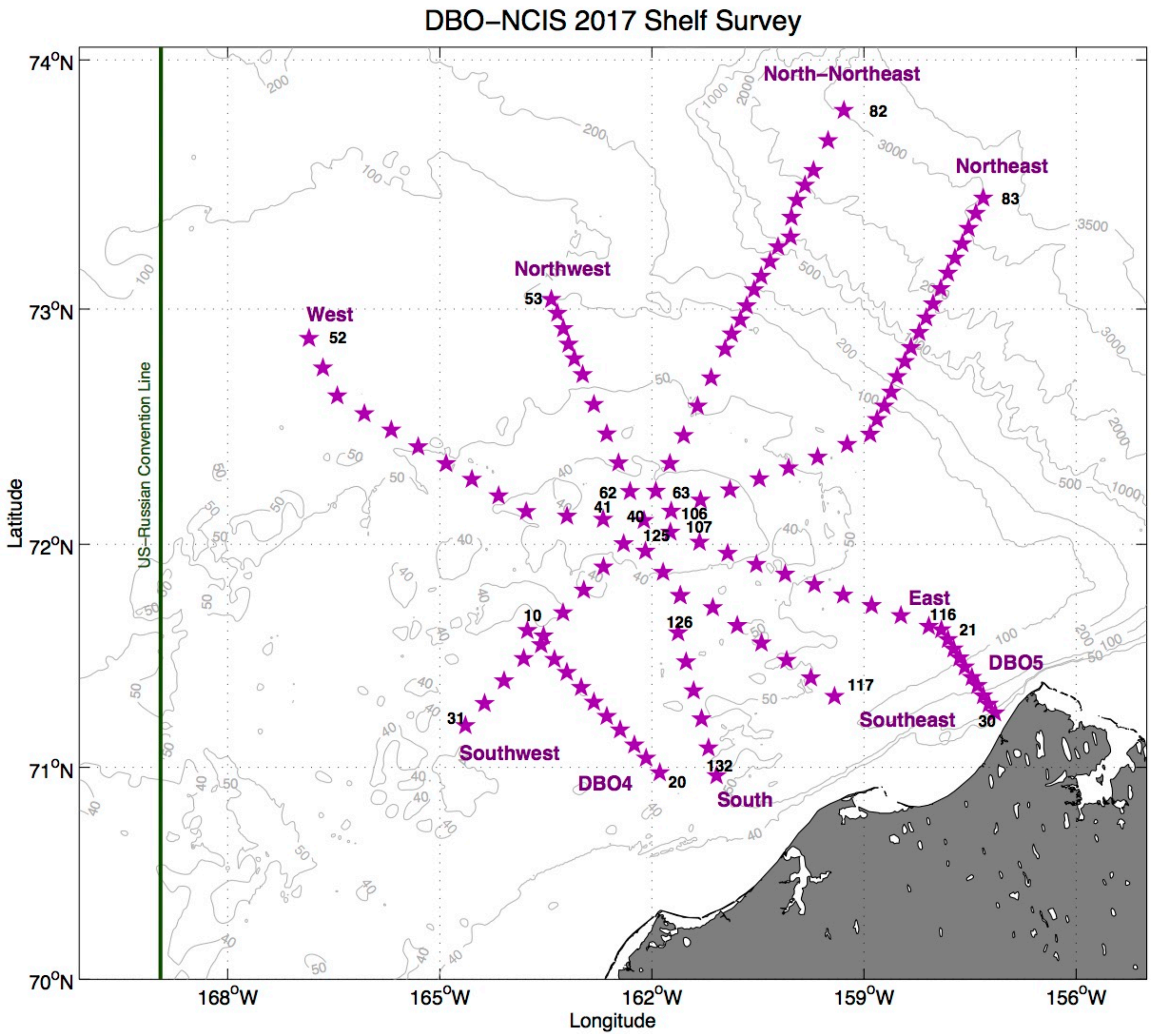


Figure A-2: Enlarged view of the shelf survey, including DBO lines 4 and 5 (magenta stars). Section names are indicated (magenta font) as well as the endpoint station numbers of each line (black font). The US-Russian convention line is marked by the green line.

Below are the individual reports for each component of the cruise. These include descriptions of the operations, locations of sampling, and, where possible, some brief highlights of initial results. We acknowledge the officers and crew of the *Healy*, whose hard work and dedication enabled us to carry out our science operations in a safe and productive environment. The team of STARC technicians kept the ship's science systems running smoothly throughout the cruise.

Lastly we acknowledge Dr. Jeremy Mathis, director of NOAA's Arctic Research Program, for supporting the fieldwork and participating on the cruise.

Section B: Physical Oceanographic Measurements

Contributing author: Robert Pickart (rpickart@whoi.edu)

Personnel

Robert Pickart, senior scientist, WHOI
Leah McRaven, research associate, WHOI
Peigen Lin, post-doc, WHOI
Astrid Pacini, graduate student, WHOI-MIT
Min Li, visiting graduate student, WHOI

Overview

A total of 141 CTD casts were occupied on the cruise, comprising 12 sections (Figures B-1 and B-2; Table B-1). The instrument package consisted of a Sea-Bird 911plus CTD measuring temperature and conductivity (dual sensors), pressure, oxygen, beam transmission, fluorescence, and PAR. This was mounted on a 24-position rosette with 10 liter Niskin bottles. An altimeter was used to bring the package approximately 2 m above the sea floor on the shelf stations (5 m in rough weather), and approximately 10 m above the sea floor on the stations seaward of the shelfbreak. Water samples were taken every 10 m on the shelf, including at the bottom of the cast, just below the surface, and at the subsurface fluorescence maximum (when it was present). For the two transects extending into the basin, the depth of the CTD casts was limited to 500 m except for the two endpoint stations and an additional station on the Northeast line, which were full-depth casts (Table B-1). Bottle salinity samples were taken at the bottom of most of the shelf stations (usually in a bottom mixed-layer), and over a range of depths at the deeper stations. See the CTD calibration report below for details regarding the instrument set up, data processing, and in-situ calibration of the two conductivity sensors.

The overall CTD data quality was excellent. Downcast 1-db pressure-averaged files were produced following each cast. At the conclusion of the cruise a small number of density inversions were interpolated over, and the salinity data were calibrated using the deep bottle measurements. The resulting accuracy is 0.002 for both the primary and secondary sensors (see the CTD calibration report). The final quality-controlled, calibrated CTD files will be posted to a web site for use by the science party.

HLY1702 CTD Stations							
Section	Station Name	CTD Station	Time Occupied (UTC)	Latitude (deg/min N)	Longitude (deg/min W)	Corrected Bottom Depth (m)	Notes
Misc.							
	Test Cast	0	Aug 28 2017 10:14	64 24.26	166 13.35		NMEA time is incorrect
DBO3							
	DBO3-8	1	Aug 29 2017 15:49	67 40.59	168 56.91	50.7	
	DBO3-7	2	Aug 29 2017 19:52	67 47.00	168 35.78	50.4	
	DBO3-6	3	Aug 29 2017 19:52	67 53.85	168 14.07	58.3	
	DBO3-5	4	Aug 29 2017 22:35	68 00.78	167 52.51	53.2	
	DBO3-4	5	Aug 30 2017 01:44	68 07.97	167 29.22	49.4	
	DBO3-3	6	Aug 30 2017 04:43	68 11.20	167 17.70	47.9	
	DBO3-2	7	Aug 30 2017 06:29	68 14.81	167 07.30	43.2	
	DBO3-1	8	Aug 30 2017 10:17	68 18.25	166 55.42	34	
Misc.							
	HAB	9	Aug 30 2017 18:58	69 34.88	164 46.89	30.8	
DBO4							
	DBO4-6	10	Aug 31 2017 04:43	71 37.19	163 45.74	41.2	
	DBO4-5a	11	Aug 31 2017 06:46	71 33.34	163 33.99	42.2	
	DBO4-5	12	Aug 31 2017 07:39	71 29.42	163 22.61	42.1	
	DBO4-4a	13	Aug 31 2017 09:21	71 25.88	163 12.18	42.7	
	DBO4-4	14	Aug 31 2017 10:28	71 21.82	163 00.03	44.8	
	DBO4-3a	15	Aug 31 2017 13:11	71 17.82	162 49.15	45.6	
	DBO4-3	16	Aug 31 2017 14:11	71 13.96	162 38.21	45.5	
	DBO4-2a	17	Aug 31 2017 15:56	71 10.24	162 26.91	45	
	DBO4-2	18	Aug 31 2017 16:56	71 06.11	162 14.86	45.9	
	DBO4-1a	19	Aug 31 2017 19:07	71 02.50	162 04.85	45.2	
	DBO4-1	20	Aug 31 2017 20:06	70 58.47	161 53.23	44.7	
DBO5							
	DBO5-10	21	Sep 01 2017 03:40	71 37.35	157 54.28	62.7	
	DBO5-9	22	Sep 01 2017 05:55	71 34.72	157 48.68	64.6	
	DBO5-8	23	Sep 01 2017 07:31	71 32.19	157 43.99	71.9	
	DBO5-7	24	Sep 01 2017 09:18	71 29.82	157 38.86	83.8	
	DBO5-6	25	Sep 01 2017 11:03	71 27.34	157 34.46	109.3	
	DBO5-5	26	Sep 01 2017 14:06	71 24.56	157 28.37	124.6	
	DBO5-4	27	Sep 01 2017 17:28	71 22.37	157 23.55	112.8	
	DBO5-3	28	Sep 01 2017 19:29	71 19.60	157 18.87	88.4	
	DBO5-2	29	Sep 01 2017 21:40	71 17.29	157 14.07	56.8	
	DBO5-1	30	Sep 01 2017 23:14	71 14.89	157 08.81	45.9	
SW							

	SW-1	31	Sep 02 2017 10:24	71 11.42	164 38.27	44.8	
	SW-2	32	Sep 02 2017 13:03	71 17.49	164 21.93	46	
	SW-3	33	Sep 02 2017 14:11	71 23.60	164 05.43	44.4	
	SW-4	34	Sep 02 2017 16:11	71 29.63	163 48.70	44.8	
	SW-5	35	Sep 02 2017 17:11	71 35.70	163 31.90	42.1	
	SW-6	36	Sep 02 2017 18:05	71 41.87	163 15.42	41.3	
	SW-7	37	Sep 02 2017 20:39	71 47.92	162 57.76	38.8	
	SW-8	38	Sep 02 2017 21:35	71 54.00	162 41.04	41.5	
	SW-9	39	Sep 02 2017 23:24	72 00.14	162 24.01	32.7	
	SW-10	40	Sep 03 2017 00:25	72 06.24	162 06.63	26.9	
W							
	W-1	41	Sep 03 2017 02:39	72 06.51	162 41.26	37.8	
	W-2	42	Sep 03 2017 03:47	72 07.33	163 12.00	40.1	
	W-3	43	Sep 03 2017 06:08	72 08.53	163 46.67	38.2	
	W-4	44	Sep 03 2017 07:13	72 12.62	164 10.05	40.4	
	W-5	45	Sep 03 2017 09:15	72 16.90	164 32.78	45.2	
	W-6	46	Sep 03 2017 10:21	72 20.96	164 54.62	47.6	
	W-7	47	Sep 03 2017 13:06	72 25.28	165 18.32	49.6	
	W-8	48	Sep 03 2017 14:19	72 29.52	165 41.11	50.5	
	W-9	49	Sep 03 2017 16:10	72 33.72	166 03.96	51.7	
	W-10	50	Sep 03 2017 17:15	72 38.23	166 26.97	52.4	
	W-11	51	Sep 03 2017 19:02	72 45.26	166 39.25	53.9	
	W-12	52	Sep 03 2017 20:05	72 52.69	166 50.90	56.4	
NW							
	NW-1	53	Sep 04 2017 02:44	73 02.36	163 25.38	98.3	
	NW-2	54	Sep 04 2017 05:08	72 58.92	163 20.08	81.9	
	NW-3	55	Sep 04 2017 05:52	72 55.11	163 15.13	74.6	
	NW-4	56	Sep 04 2017 06:37	72 51.24	163 10.66	71.5	
	NW-5	57	Sep 04 2017 08:25	72 47.58	163 05.67	66.2	
	NW-6	58	Sep 04 2017 09:22	72 43.62	162 58.69	55.7	
	NW-7	59	Sep 04 2017 11:46	72 36.07	162 49.13	42.7	
	NW-8	60	Sep 04 2017 13:11	72 28.58	162 38.24	41.4	
	NW-9	61	Sep 04 2017 15:22	72 21.12	162 28.35	40.1	
	NW-10	62	Sep 04 2017 16:26	72 13.74	162 18.45	35.9	
NNE							
	NNE-1	63	Sep 04 2017 18:06	72 13.84	161 56.64	35.5	
	NNE-2	64	Sep 04 2017 19:04	72 20.97	161 44.72	41.5	
	NNE-3	65	Sep 04 2017 20:01	72 28.14	161 32.97	44.8	
	NNE-4	66	Sep 04 2017 21:35	72 35.65	161 21.23	45.8	
	NNE-5	67	Sep 05 2017 00:03	72 42.77	161 09.72	50	
	NNE-6	68	Sep 05 2017 01:07	72 50.00	160 57.82	53.5	

	NNE-7	69	Sep 05 2017 02:47	72 53.79	160 52.11	56.2	
	NNE-8	70	Sep 05 2017 03:28	72 57.28	160 44.93	70.4	
	NNE-9	71	Sep 05 2017 05:01	73 00.80	160 39.47	135	
	NNE-10	72	Sep 05 2017 05:44	73 04.74	160 33.32	188.2	
	NNE-11	73	Sep 05 2017 07:59	73 08.08	160 27.17	257.7	
	NNE-12	74	Sep 05 2017 09:06	73 11.70	160 19.71	346	
	NNE-13	75	Sep 05 2017 12:26	73 15.29	160 12.89	748.4	
	NNE-14	76	Sep 05 2017 13:53	73 17.71	160 02.20	1260	Deep CTD
	NNE-15	77	Sep 05 2017 20:17	73 22.49	160 01.49	1462.2*	500m CTD
	NNE-16	78	Sep 05 2017 23:50	73 26.64	159 56.95	1731.9*	500m CTD
	NNE-17	79	Sep 06 2017 01:36	73 30.24	159 50.03	1992.4*	500m CTD
	NNE-18	80	Sep 06 2017 02:51	73 33.77	159 42.72	2228.1*	Deep CTD
	NNE-19	81	Sep 06 2017 06:43	73 40.94	159 30.40	2604.6*	500m CTD
	NNE-20	82	Sep 06 2017 08:15	73 48.11	159 17.06	2997.3*	500m CTD
NE							
	NE-1	83	Sep 06 2017 13:23	73 27.15	157 18.66	3034.3*	Deep CTD
	NE-2	84	Sep 06 2017 17:03	73 23.46	157 25.01	3048.9*	500m CTD
	NE-3	85	Sep 06 2017 18:07	73 19.81	157 31.17	2905.1*	500m CTD
	NE-4	86	Sep 06 2017 19:32	73 16.06	157 36.50	2829.4*	500m CTD
	NE-5	87	Sep 06 2017 20:38	73 12.56	157 42.82	2665.6*	500m CTD
	NE-6	88	Sep 06 2017 22:13	73 08.87	157 48.71	2422.4*	500m CTD
	NE-7	89	Sep 06 2017 23:14	73 05.05	157 54.82	1949.2*	500m CTD
	NE-8	90	Sep 07 2017 00:25	73 01.29	158 01.36	1875.6*	500m CTD
	NE-9	91	Sep 07 2017 01:32	72 57.78	158 07.12	1766.6*	500m CTD
	NE-10	92	Sep 07 2017 03:18	72 54.16	158 13.09	1362.1*	500m CTD
	NE-11	93	Sep 07 2017 04:27	72 50.37	158 20.03	629	
	NE-12	94	Sep 07 2017 06:29	72 46.91	158 25.25	294.8	
	NE-13	95	Sep 07 2017 07:49	72 43.12	158 31.84	225.6	
	NE-14	96	Sep 07 2017 10:30	72 39.21	158 36.69	161.6	
	NE-15	97	Sep 07 2017 11:35	72 35.64	158 42.73	76.5	
	NE-16	98	Sep 07 2017 17:18	72 32.23	158 48.78	57.8	
	NE-17	99	Sep 07 2017 18:10	72 28.50	158 54.67	53.4	
	NE-18	100	Sep 07 2017 19:36	72 25.87	159 14.18	51.4	
	NE-19	101	Sep 07 2017 21:04	72 22.58	159 39.26	48.2	
	NE-20	102	Sep 07 2017 22:31	72 19.83	160 04.01	47.1	
	NE-21	103	Sep 07 2017 23:47	72 17.01	160 28.73	42.7	
	NE-22	104	Sep 08 2017 01:08	72 14.18	160 53.75	35.8	
	NE-23	105	Sep 08 2017 02:36	72 11.53	161 18.63	34.9	
	NE-24	106	Sep 08 2017 03:53	72 08.65	161 43.62	31.9	
E							
	E-1	107	Sep 08 2017 05:06	72 03.18	161 44.28	29.9	

	E-2	108	Sep 08 2017 06:14	72 00.52	161 19.44	34.4	
	E-3	109	Sep 08 2017 15:40	71 57.62	160 55.65	37.7	
	E-4	110	Sep 08 2017 16:58	71 54.72	160 31.27	41.1	
	E-5	111	Sep 08 2017 19:02	71 52.16	160 06.85	44.3	
	E-6	112	Sep 08 2017 20:21	71 49.41	159 41.93	49.9	
	E-7	113	Sep 08 2017 22:31	71 46.61	159 17.59	51.5	
	E-8	114	Sep 08 2017 23:45	71 43.81	158 53.45	53.5	
	E-9	115	Sep 09 2017 01:38	71 41.16	158 28.64	55	
	E-10	116	Sep 09 2017 02:48	71 38.26	158 04.99	60.2	
SE							
	SE-1	117	Sep 09 2017 06:11	71 19.41	159 25.05	54.6	
	SE-2	118	Sep 09 2017 08:03	71 24.41	159 45.05	48.9	
	SE-3	119	Sep 09 2017 09:18	71 29.13	160 05.73	48.9	
	SE-4	120	Sep 09 2017 11:59	71 33.83	160 26.96	49.2	
	SE-5	121	Sep 09 2017 13:25	71 38.48	160 47.52	49.1	
	SE-6	122	Sep 09 2017 16:03	71 43.24	161 08.37	44.6	
	SE-7	123	Sep 09 2017 17:14	71 46.44	161 35.96	43.1	
	SE-8	124	Sep 09 2017 19:04	71 52.64	161 50.44	40.3	
	SE-9	125	Sep 09 2017 20:29	71 58.18	162 05.40	32.6	
Misc.							
	CEO	127	Sep 10 2017 01:12	71 35.96	161 32.27	46.1	
S							
	S-1	126	Sep 09 2017 23:36	71 36.57	161 37.66	45.9	
	S-2	128	Sep 10 2017 02:51	71 28.75	161 30.97	47.3	
	S-3	129	Sep 10 2017 05:37	71 20.91	161 24.53	47	
	S-4	130	Sep 10 2017 07:51	71 13.27	161 17.81	48.8	
	S-5	131	Sep 10 2017 10:13	71 05.31	161 11.91	46.6	
	S-6	132	Sep 10 2017 12:40	70 57.68	161 05.11	45.2	
Misc.							
	HAB	133	Sep 10 2017 18:32	70 33.94	163 44.61	43.5	
DBO1							
	DBO1.8	134	Sep 12 2017 19:58	63 01.46	173 27.72	70.8	
	DBO1.7	135	Sep 12 2017 23:25	62 47.13	173 30.10	68.9	
	DBO1.6	136	Sep 13 2017 00:56	62 33.46	173 33.07	65.1	
	DBO1.5	137	Sep 13 2017 03:52	62 27.97	174 05.00	67.6	
	DBO1.4	138	Sep 13 2017 05:14	62 23.25	174 34.46	71.1	
	DBO1.3	139	Sep 13 2017 08:12	62 13.09	174 52.95	75.4	
	DBO1.2	140	Sep 13 2017 09:39	62 02.66	175 12.61	80.8	
	DBO1.1	141	Sep 13 2017 11:37	62 00.40	175 03.12	79.4	

Table B-1: List of completed HLY1702 hydrographic stations. The blue horizontal dividers denote the start for a given section. Time shown (in UTC) marks the beginning of the CTD cast. *For stations with no CTD altimeter reading, the nearest knudsen depth (sound speed corrected) is chosen as the bottom depth.

Using the downcast files, we constructed vertical sections for each transect, an example of which is shown in Figure B-1 for the Southwest line. The variables are potential temperature, salinity, potential density, dissolved oxygen (uncalibrated), fluorescence, and absolute geostrophic velocity referenced using the de-tided ADCP data. The plots include the soundspeed-corrected bottom topography from the ship's Knudsen recorder (smoothed to remove noise). We also constructed sections of the primary water masses present at each transect, an example of which is shown in Figure B-2 for the DBO-5 line. These vertical sections of properties and water masses will be posted to the website (other variables can be plotted upon request, such as beam transmission, buoyancy frequency, potential vorticity, etc.).

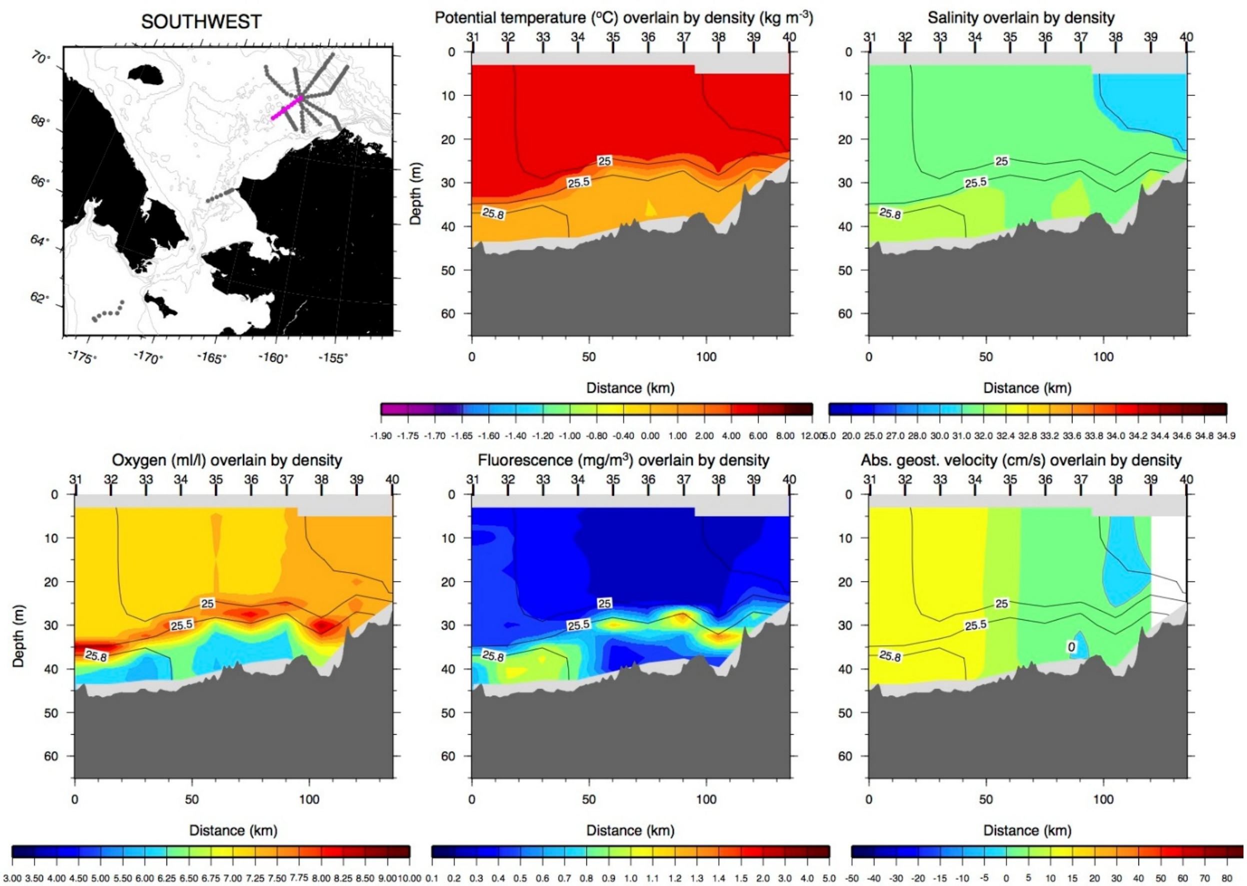


Figure B-1: Vertical sections for the Southwest transect. The location of the transect is indicated in the upper left panel. The different variables are identified in the panel titles. The contours are potential density. The viewer is looking to the northwest, which is the direction of positive velocity (lower right panel). Station numbers are marked along the top of each panel.

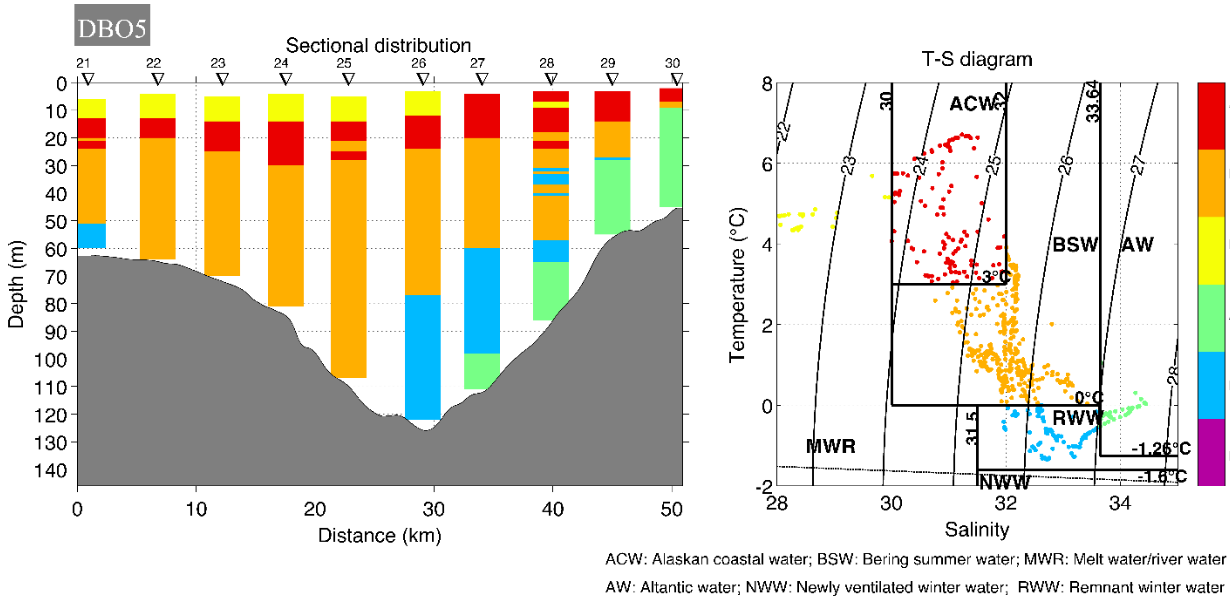


Figure B-2: Left-hand panel: Distribution of water masses at the DBO-5 line, based on the definitions shown in the T-S diagram in the right-hand panel. The water masses are color-coded according to the colorbar on the right. The abbreviations are: ACW = Alaskan coastal water; BSW = Bering summer water; NWW = newly ventilated Pacific winter water; RWW = remnant Pacific winter water; MWR = melt water / river runoff; AW = Atlantic water.

Both of *Healy's* hull-mounted ADCPs – an Ocean Surveyor (OS) 150 kHz unit and a 75 kHz unit – collected measurements of the water column velocity throughout the cruise. Only the OS150 returned good data on the shallow shelf, while both the OS150 and OS75 returned good data on the continental slope. Ocean current products are described below in the Shipboard ADCP report. The underway throughflow system provided timeseries of temperature, salinity, and various other properties at a depth of 8 m. Using data from the different wind sensors on the ship, we constructed a quality-controlled timeseries of wind speed and direction. Both the underway throughflow and wind products are described below in the Underway shipboard data report.

Brief Highlights

While the scientific analysis of the DBO-NCIS physical data has yet begun in earnest, preliminary inspection of the data during the course of the cruise revealed several exciting findings. During the occupation of DBO lines 3-5 at the beginning of the cruise, and later during the eastern part of the shelf survey, winds were blowing strongly out of the east / northeast at greater than 10 m/s. We have isolated the time periods of strong winds in Figure B-3, which shows the ship's wind data and the depth-averaged currents from the OS150 ADCP. One sees that the Alaskan coastal current (ACC) was reversed at both the DBO-3 line near Pt. Hope and the DBO-5 line in Barrow Canyon (normally at this time of year the ACC flows northward from Bering Strait into

Barrow Canyon). The southward flow was particularly strong at the DBO-5 line, exceeding 1 m/s on the eastern flank of the canyon. The upwelling was so pronounced that Atlantic water was found only 10 m from the surface at the shoreward most station on the line (Figure B-2). We thus sampled the northeast Chukchi shelf in a strongly wind-forced state during part of the survey, with peak wind speeds between 15-20 m/s. Notably, the flow at the DBO-4 line was strongly to the west, implying that water from the basin was progressing onto the central portion of the shelf. Furthermore, shelf water appeared to be draining into Barrow Canyon to the east of Hanna Shoal (Figure B-3), instead of near the head of the canyon, which is the norm (Weingartner et al., 2017). It will be interesting to investigate the ramifications of these anomalous flow conditions using the full suite of biological and chemical data collected during the cruise.

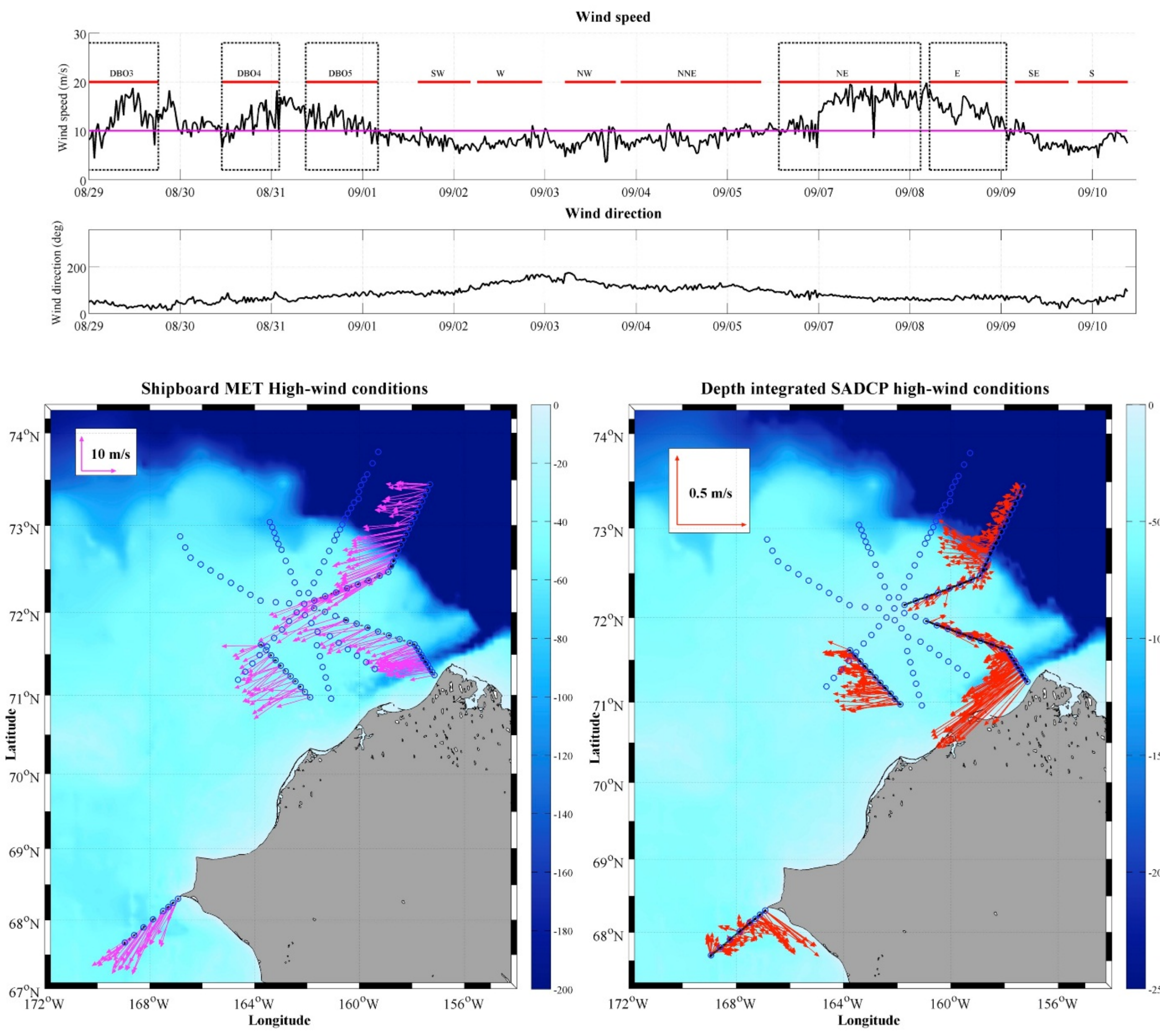


Figure B-3: Top panels: Timeseries of shipboard wind speed and direction during the cruise (black lines). The magenta line denotes the 10 m/s threshold used to divide the record into high-wind versus low-wind conditions. The times of occupations of the sections are denoted by the red line segments. The boxes mark those sections occupied during strong easterly /northeasterly winds. Bottom panels: Wind vectors (left) and depth-averaged ADCP velocity vectors (right) during the high wind conditions.

Recently it has been documented that there is a westward-flowing current along the continental slope of the Chukchi Sea, dubbed the Chukchi slope current (Corlett and Pickart, 2017). It has been argued that the current is fed by the outflow from Barrow Canyon (Brugler et al., 2014; Corlett and Pickart, 2017). Our cruise provided two valuable crossings of the slope current, which were striking in two regards. First, in both instances there was a subsurface warm-core eddy situated on the seaward side of the current. Second, the westward transport of the current far exceeded the mean summertime value reported by Corlett and Pickart (2017). The North-Northeast occupation is shown in Figure B-4. The slope current is centered at station 75, and the anti-cyclonic warm-core eddy is centered at station 80 immediately adjacent to the slope current. The core of the eddy is near 80 m depth. There are a host of important questions that need to be addressed based on our two crossings, including: what is the nature/origin of these warm-core eddies and how are they affected by the slope current? What causes the slope current transport to be enhanced as such? What are the ecosystem impacts of both the eddies and the slope current? The data collected during the 2017 DBO-NCIS survey will help us begin to answer such questions.

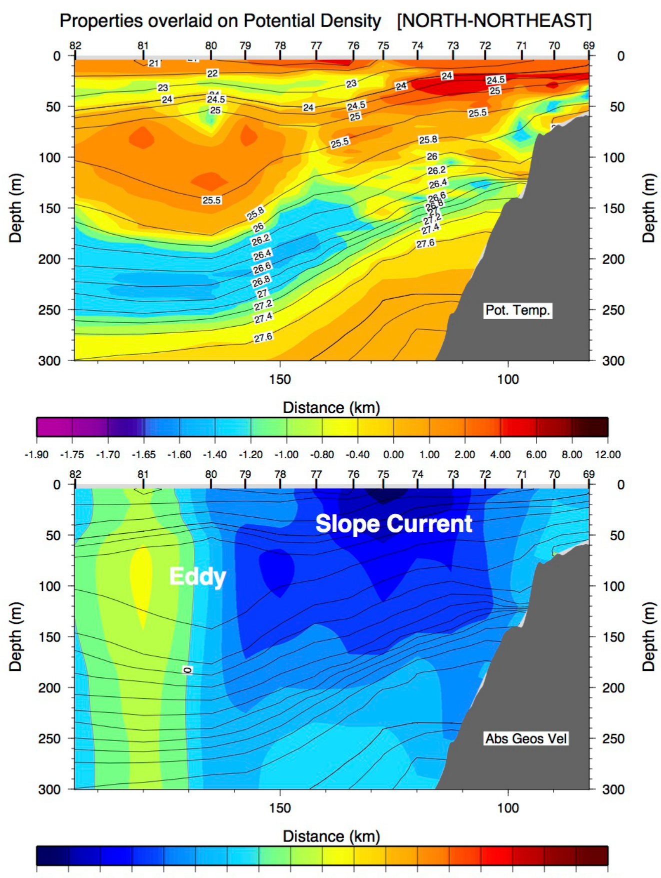


Figure B-4: Top: Vertical section of potential temperature (color, °C) overlain by potential density (contours, kg m^{-3}) for the North-northeast section. The station numbers are marked along the top of the plot. Bottom: vertical section of absolute geostrophic velocity (color, cm s^{-1}) overlain by potential density (contours, kg m^{-3}). The viewer is looking to the southeast which is the direction of positive velocity.

References

Brugler, E.T., R.S. Pickart, G.W.K. Moore, S. Roberts, T.J. Weingartner, and H. Statscewich, 2014. Seasonal to Interannual Variability of the Pacific Water Boundary Current in the Beaufort Sea. *Progress in Oceanography,* **127**, 1-20, http://dx.doi.org/10.1016/j.pocean.2014.05.002

Corlett, W. B. and R. S. Pickart, 2017. The Chukchi slope current. *Progress in Oceanography*, **153**, 50-56, http://dx.doi.org/10.1016/j.pocean.2017.04.005.

Weingartner, T. J., R. A. Potter, C. A. Stoudt, E. L. Dobbins, H. Statscewich, P. R. Winsor, T. D. Mudge, and K. Borg, 2017. Transport and thermohaline variability in Barrow Canyon on the Northeastern Chukchi Sea Shelf, *J. Geophys. Res. Oceans*, **122**, doi:10.1002/ 2016JC012636.

Section C: Shipboard ADCP report

Contributing author: Leah McRaven (ltrafford@whoi.edu)

Shipboard ADCP configuration

Underway hull-mounted ADCP data were collected throughout the cruise using two independent systems. These were a 75 kHz Ocean Surveyor (OS75) and a 150 kHz Ocean Surveyor (OS150) ADCP (both from Teledyne RD Instruments). UHDAS data acquisition software from University of Hawaii was used to collect raw ADCP data from each instrument. Throughout the cruse, the OS75 was set up to collect 80 8-meter bins of data every ping in narrowband mode, and the OS150 was set up to collect 80 4-meter bins of data every ping in narrowband mode. Bottom tracking was used for calibration purposes during the initial and final transit to and from the study site.

Shipboard ADCP processing

Raw single ping data were processed on board using the CODAS shipboard ADCP (SADCP) processing software developed at University of Hawaii's School of Ocean and Earth Science and Technology. Single ping data were averaged and edited to remove ship heading and motion from the measured velocity. Five-minute final processed data were available in absolute velocity profiles throughout the cruise. Barotropic tidal velocities were then removed using Matlab OTIS tidal predictions, kindly provided by Laurie Padman, Earth Systems Research.

Shipboard ADCP survey

The OS150 and OS75 systems recorded data throughout the entire cruise. Special care was taken to steam at a slower speed (12 kts, or 10 kts during high-wind conditions) during survey sections to ensure higher data quality and greater data return. The overall quality of the SADCP data was good, with the exception of survey locations associated with water depths of 30 m or less. In areas with shallower water depths, the SADCP data return was minimal due to the frequency ranges used. Broadband mode was used (with 2-meter bins) during a short section of the SADCP survey in a successful effort to acquire more bins of data near the coast of Alaska. Figure C-1 shows the completed HLY1702 cruise track north of Bering Strait. The SADCP sections to be used in the scientific analysis are coincident with the CTD hydrographic survey lines shown. Figure C-2 provides an example of the SADCP depth-integrated currents for the DBO5 line.

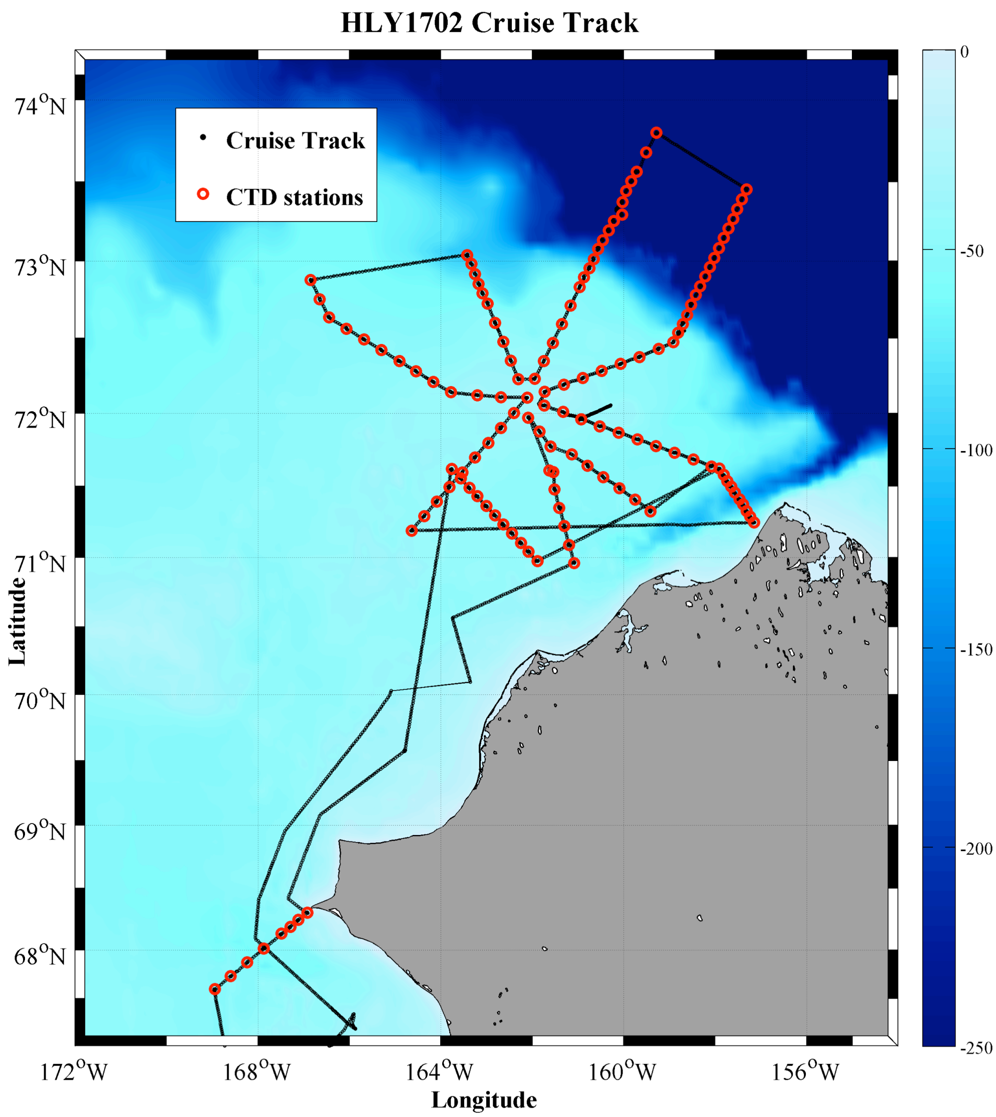


Figure C-1: Completed HLY1702 cruise track north of the Bering Strait. The SADCP sections to be used in the scientific analysis are coincident with CTD hydrographic survey lines shown.

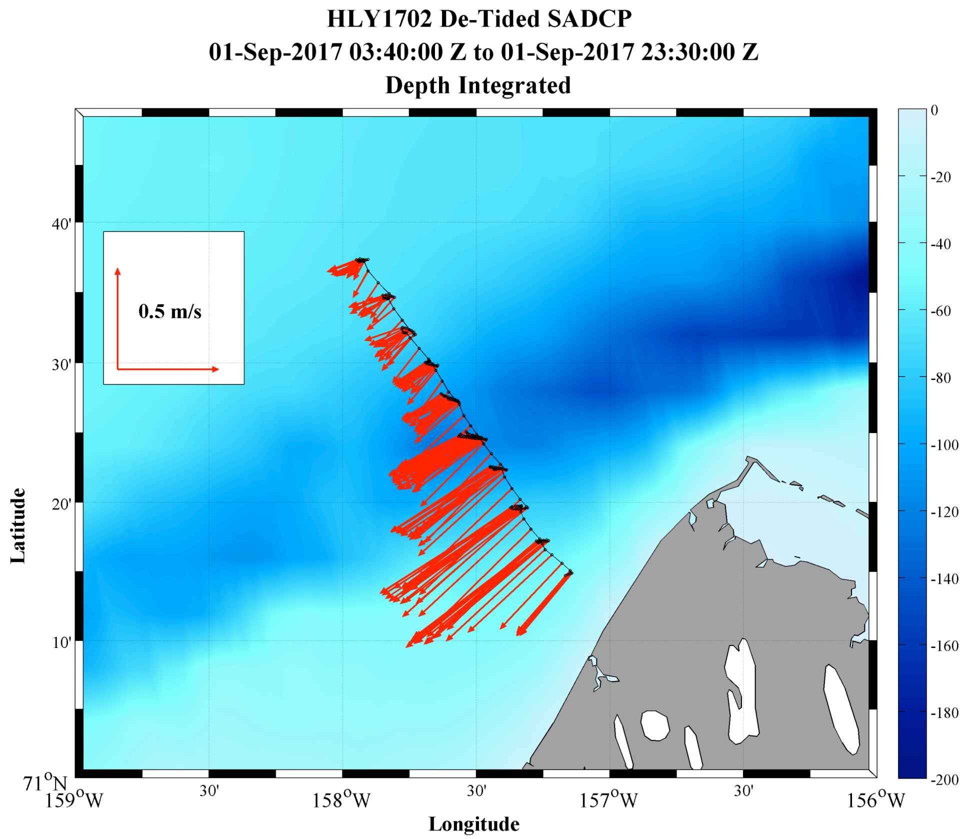


Figure C-2: De-tided SADCP depth-integrated currents for the DBO5 line sampled during 1 September.

Section D: Underway shipboard data report

Contributing author: Leah McRaven (ltrafford@whoi.edu)

Summary

A standard Shipboard Meteorological System is installed on the USCGC *Healy*. The system measures air temperature, barometric pressure, wind speed/direction, relative humidity, short wave radiation, long wave radiation, seawater temperature and seawater conductivity. Sensor information is combined with time and GPS position information and recorded in daily data files. Shipboard wind and underway CTD data were used during the HLY1702 survey.

Shipboard Wind data

The shipboard MET system recorded data from two sonic anemometers: one located on the bow jack staff, and one on the main mast yardarm above the bridge. Data files included ship speed/heading, relative wind speed/direction, and true wind speed/direction. By comparing data from both sonic anemometers with the ship speed/direction, it was determined that the anemometer located on the bow jack staff suffered from modified airflow around the structure of the ship, often resulting in anomalously low wind speed values and slow response to wind speed changes. As there were no other available recorded shipboard wind measurements, it was decided to use the anemometer located on the main mast yardarm for the entire HLY1702 survey. Figure D-1 shows the true wind speed/direction along the survey sections north of Bering Strait.

Underway CTD data

The shipboard MET system recorded ocean temperature and salinity through a water intake located at 8 m depth on the bow of the ship. A Seabird Electronics sensor measured water temperature close to the seawater intake. Farther down the seawater intake line an SBE21 Thermosalinograph (TSG) measured conductivity and temperature. Throughout the cruise, the TSG temperature consistently measured ~0.5 °C warmer than the Seabird temperature sensor closer to the bow intake. Since there was such a large discrepancy in available temperature readings, the TSG temperature was used (despite being anomalously warm) to be consistent with the TSG conductivity. Figure D-2 shows the TSG temperature along the HLY1702 cruise track north of Bering Strait.

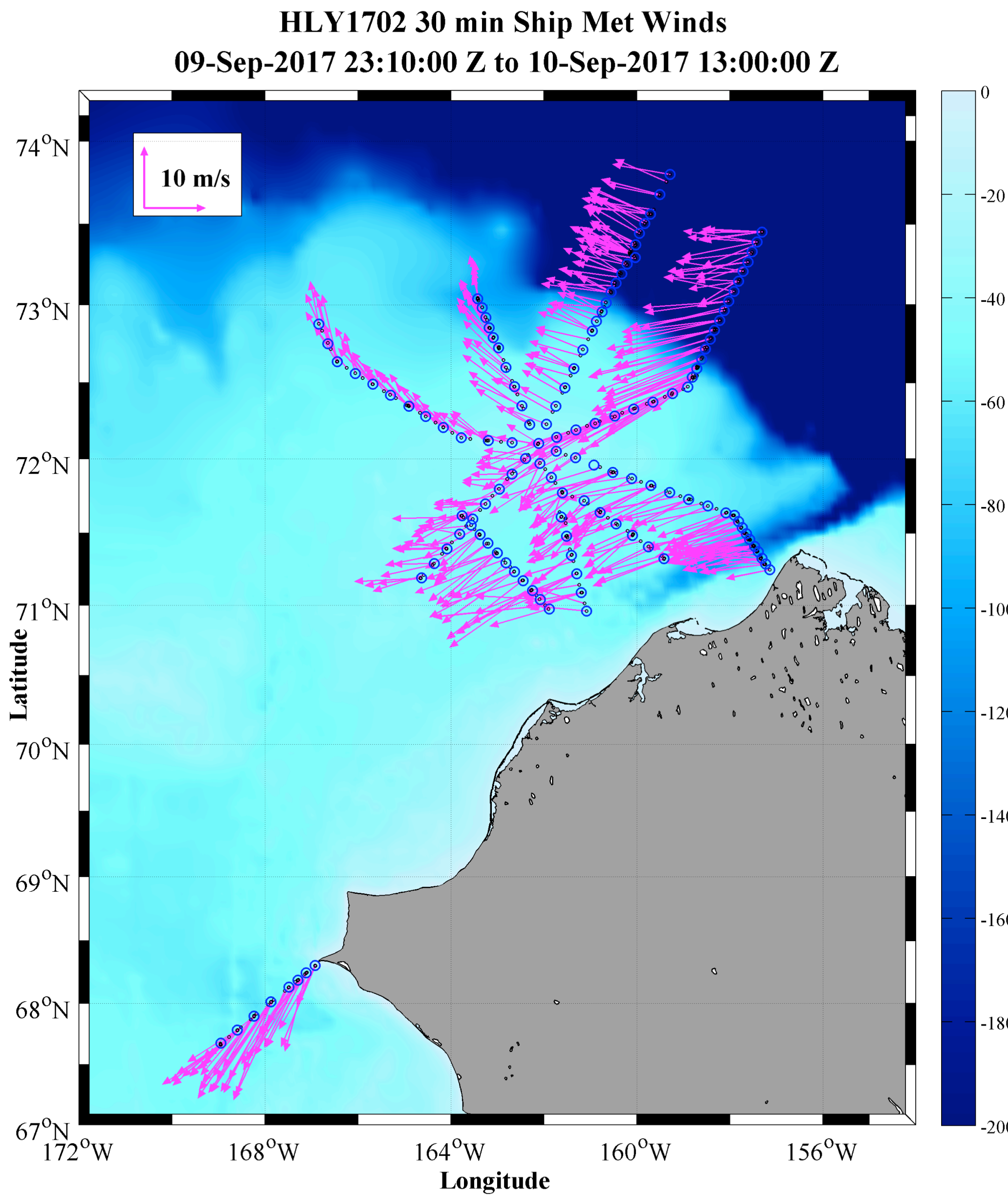


Figure D-1: True wind speed/direction along survey sections north of the Bering Strait. Wind vectors show the direction that the wind is blowing towards.

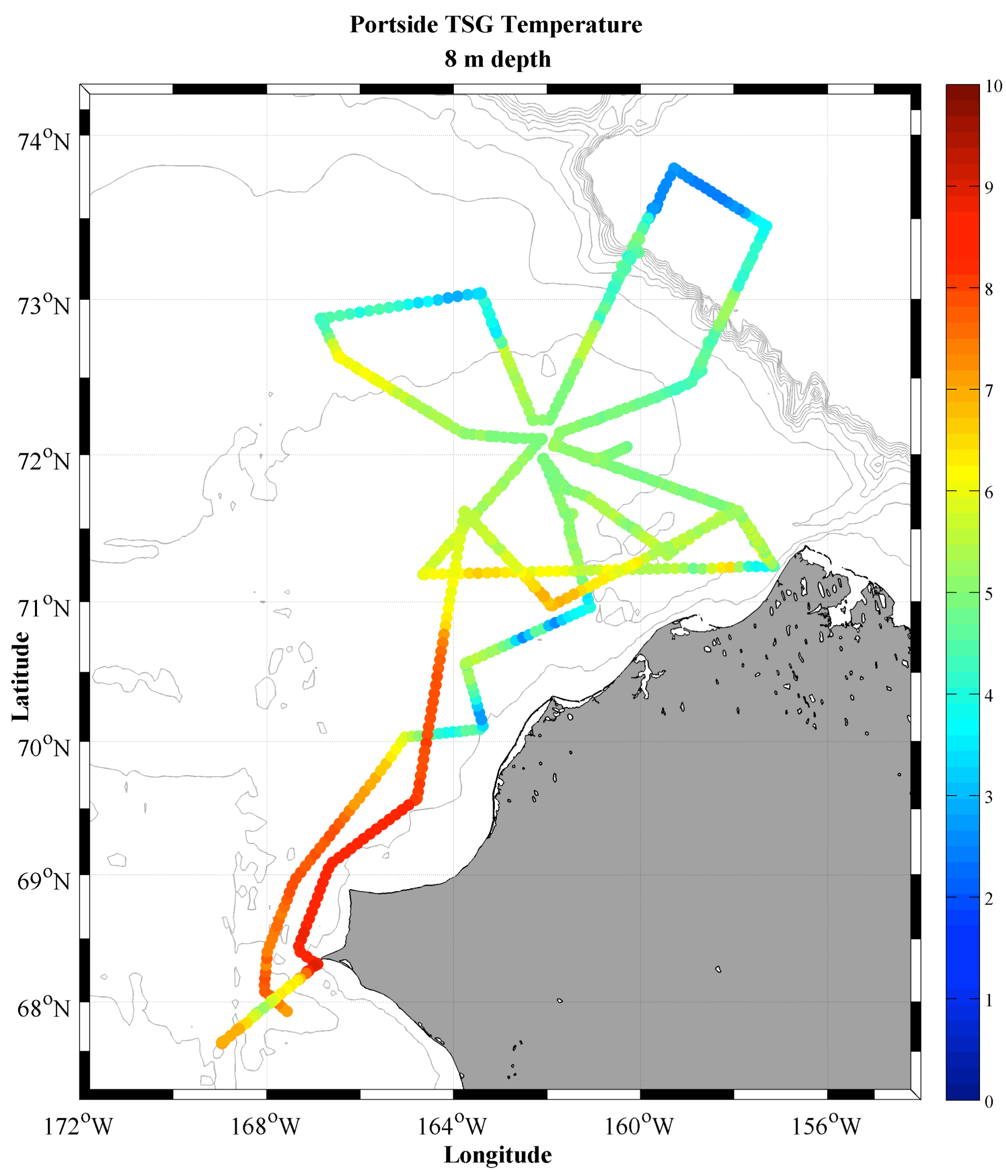


Figure D-2: Ocean temperature at 8 m depth along the HLY1702 cruise track north of Bering Strait (°C, color).

Section E: Bottle oxygen, nutrients and chlorophyll

Contributing authors: Calvin Mordy (calvin.w.mordy@noaa.gov) and Phyllis Stabeno (phyllis.stabeno@noaa.gov)

Overview

For calibration of the CTD oxygen probe, 48 samples were collected for dissolved oxygen. The samples were fixed with Winkler reagents, and the flare of each oxygen flask was filled with distilled water and sealed. The samples will be transferred to the NOOAS Oscar Dyson for analysis.

Nutrients and chlorophyll samples were collected at all process stations in support of the benthic studies and net tows. A total of 410 nutrient samples were filtered through 0.45 micron polycarbonate filters and stored frozen at -80 degrees C. The samples will be transported to the Pacific Marine Environmental Laboratory (PMEL) for determination of nitrate, nitrite, ammonium, silicic acid and phosphate concentrations. Total chlorophyll was collected at 71 stations at standard depths, which were surface, 10 m, 20 m, 30 m, 40 m, and 50 m, or bottom depth when stations were shallower than any standard depth. Samples were filtered through GF/F glass fiber filters under low vacuum, and the filters were stored frozen at -80 degrees C. The samples will be transported to PMEL for analysis.

Section F: Carbonate Chemistry

Contributing author: Jessica Cross (jessica.cross@noaa.gov)

Project Title Acidification in the Distributed Biological Observatory

Funding Source NOAA Arctic Research Program

Principal Investigators

Jessica Cross
Oceanographer
National Oceanic and Atmospheric Administration (NOAA)
Pacific Marine Environmental Laboratory (PMEL)
7600 Sand Point Way NE
Seattle, WA 98115
Ph: 206-526-4314 Fax: 206-526-6744
Email: Jessica.Cross@NOAA.gov

Cruise Participants Jessica Cross, NOAA/PMEL

Taylor Armstrong, 2016-2017 Knauss Sea Grant Fellow

Project Summary

The Distributed Biological Observatory is a network of rapidly changing and biologically important sites designed as a change detection array from the northern Bering Sea to the Arctic Basin. Since 2010, The DBO has provided a framework to focus and coordinate sampling and analytical efforts that link biological changes to physical drivers in a rapidly changing Arctic. While these biophysical connections are extremely valuable for ecosystem research, this 'physics to whales' perspective often skips over another key element of Arctic change—ocean biogeochemistry. A growing body of recent research is showing that the oceans in the Pacific Arctic Region (and the DBO) have rapidly acidified over the last several decades, in part due to the intrusion of anthropogenic CO2. This ocean acidification (OA) can create corrosive conditions that can cover up to 40% of the Chukchi Sea benthos seasonally, and persist for more than 80% of the year in some hotspots. These vulnerable ecosystems are experiencing sustained exposure to corrosive waters every year. This project is designed to provide a comprehensive carbonate chemistry assessment of US DBO activities during FY17-FY19.

Methods

In conjunction with the DBO-NCIS sampling plan outlined earlier in this cruise report, carbonate chemistry samples were collected at every DBO station at standard depths for the hydrographic sampling team: Surface, 10m, 20m, 30m, 40m, and bottom. Discretionary samples were also taken in deeper waters and at depths identified as chlorophyll maxima. In the NCIS region, sampling was prioritized for one deep-water chemistry station and the southwest side of Hanna Shoal. Overall, 511 samples were collected at 90 stations (including the test cast).

At each CTD/hydrocast station, seawater samples for Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA) were drawn from Niskin bottles into pre-cleaned ~200 mL borosilicate bottles and poisoned with mercuric chloride ($HgCl_2$) to halt biological activity. Samples were analyzed for Total Inorganic Carbon (TIC) using a precise and accurate system based on gas extraction and IR detection of CO_2 (Marine Analytics and Data Automated Infra-Red Inorganic Carbon Analyzer, or MARIANDA-AIRICA). Samples were also analyzed for Total Alkalinity by potentiometric titration using a MARIANDA Versatile Instrument for the Detection of Total Alkalinity (VINDTA, model 3S).

Routine analysis of Certified Reference Materials (CRMs, provided by A.G. Dickson, Scripps Institute of Oceanography) ensured that the accuracy of the DIC and TA measurements averaged 4.3 µmol kg^{-1} and 2.4 µmol kg^{-1} respectively and were stable over time.

Problems

During this cruise, we did encounter some problems. Our main challenge was the output of the VINDTA3S, which calculated sample and CRM alkalinity values that were excessively high. We believe that this issue may be related to the milli-q water that was provided shipboard. This MQ water is used to make the titration reagents. Excessive alkalinity in the water used may have altered the pH of our regents and artificially increased alkalinity readings of our samples. Although test kits were not available to confirm issues with the MQ system, and the MQ system readings indicated ultrapure water of 18Ω conductivity, no instrumental problems could be identified that may have contributed to this excess alkalinity. Other teams also encountered insufficiently pure MQ. Although not ideal, samples were still analyzed onboard and corrected per our usual method using certified reference material. Alkalinity concentrations remained stable over time, indicating no further instrumental issues. Precision of repeat CRMs was < 2 μmol kg^{-1}, and precision of replicate samples corrected using CRMs averaged 2.4 μmol kg^{-1}.

Additionally, during this cruise we did collect some samples that were analyzed for TA where samples were not also collected for nutrients. TA measurements should always be supplemented with phosphate and silicate concentrations, as these nutrients can substantially contribute to TA values. While TA measurements without corresponding nutrient values will help provide context to the overall sampling effort, TA measurements that cannot eventually be corrected using silicate and phosphate should not be reported in the literature. In the future, we recommend expanded support for nutrient sampling.

Preliminary Data

Preliminary data was provided for use in the bottle file generated at the end of this cruise. To provide some context, here we include transects of DIC and TA for the 4 DBO lines occupied as well as surface and bottom heat maps showing DIC and TA concentrations for the NCIS portion of this study below. Scatter plots showing the entire data record are also shown. As in previous years, we noted high DIC concentrations associated with Pacific winter waters, which were present in Barrow Canyon and on the southeast side of Hanna Shoal.

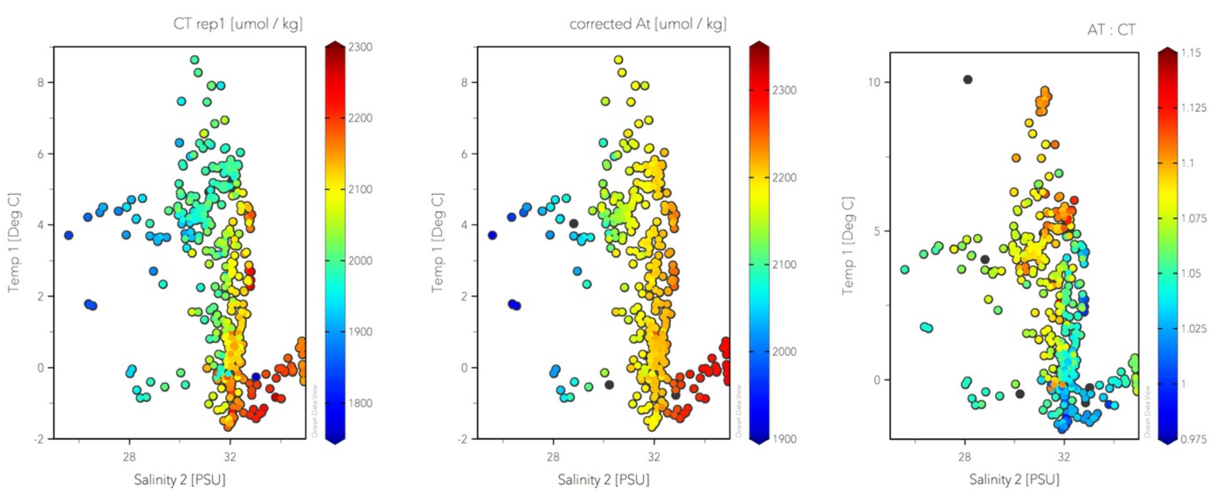


Figure 1. Scatter plots showing the distribution of total inorganic carbon (CT, μmol kg^{-1}, left) and total alkalinity (AT, μmol kg^{-1}, center) and the ratio of AT to CT (right), in temperature and salinity space. Note

that in PWW (coldest observed here), the ratio of AT to CT is low, indicating an environment enriched with CT.

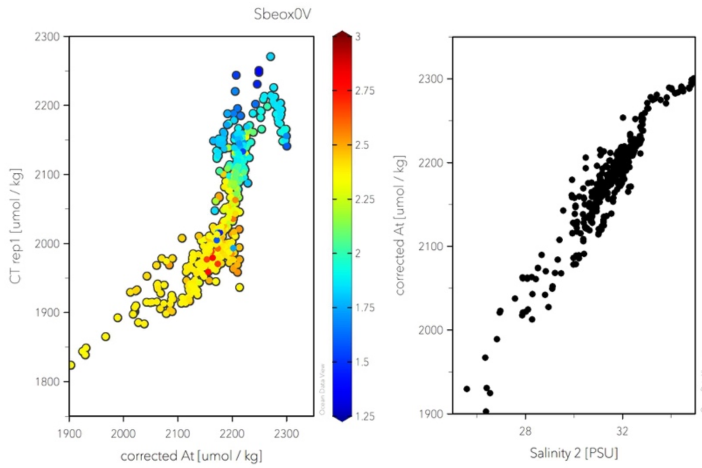


Figure F-2. Scatter plots showing some critical biogeochemical processes. At left, CT is depleted with respect to AT in areas of high oxygen concentration, indicating primary production (e.g., see 2200 µmol AT kg SW^{-1}). CT is increased in areas of low oxygen concentration, indicating respiration (e.g., 2200 µmol CT kg SW^{-1}). At right, the relationship between AT and S shows mostly conservative behavior, indicating that we may not have observed excess alkalinity resulting from corrosive conditions during this study.

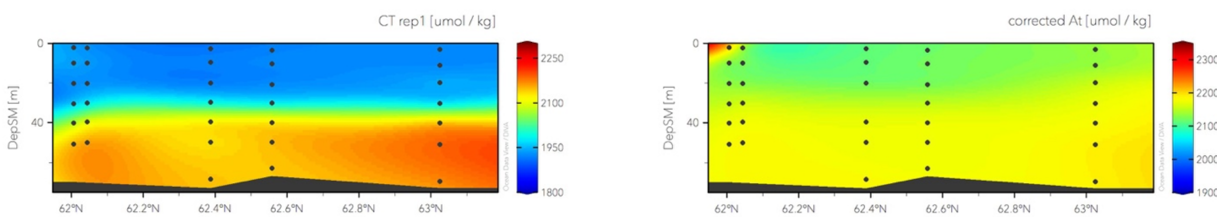


Figure F-3. CT and AT concentrations along the DBO1 line.

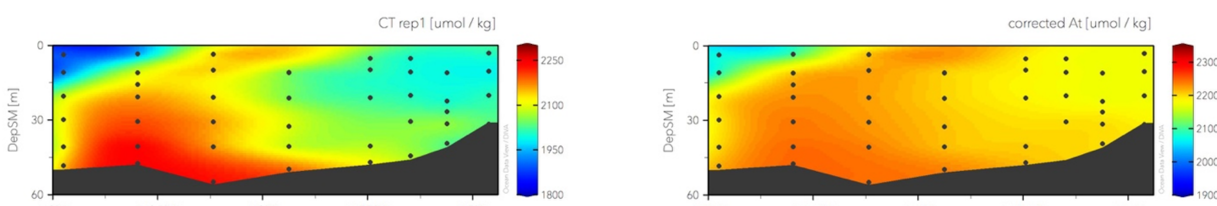


Figure F-4. CT and AT concentrations along the DBO3 line.

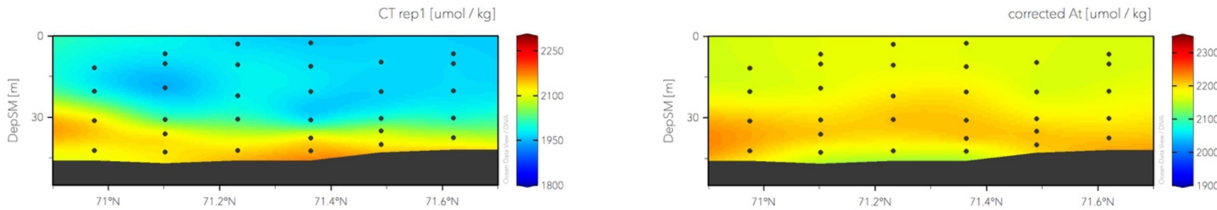


Figure F-5. CT and AT concentrations along the DBO4 line.

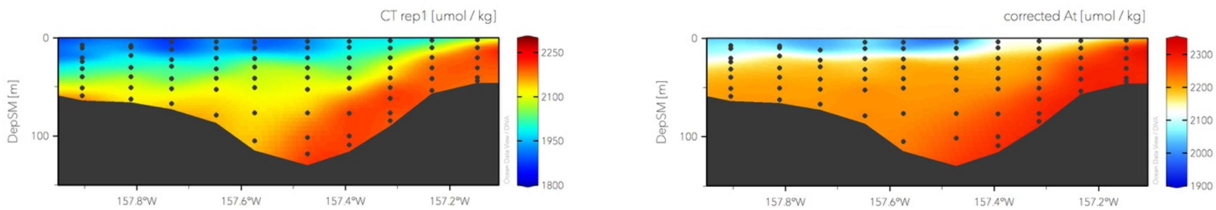


Figure F-6. CT and AT concentrations along the DBO4 line.

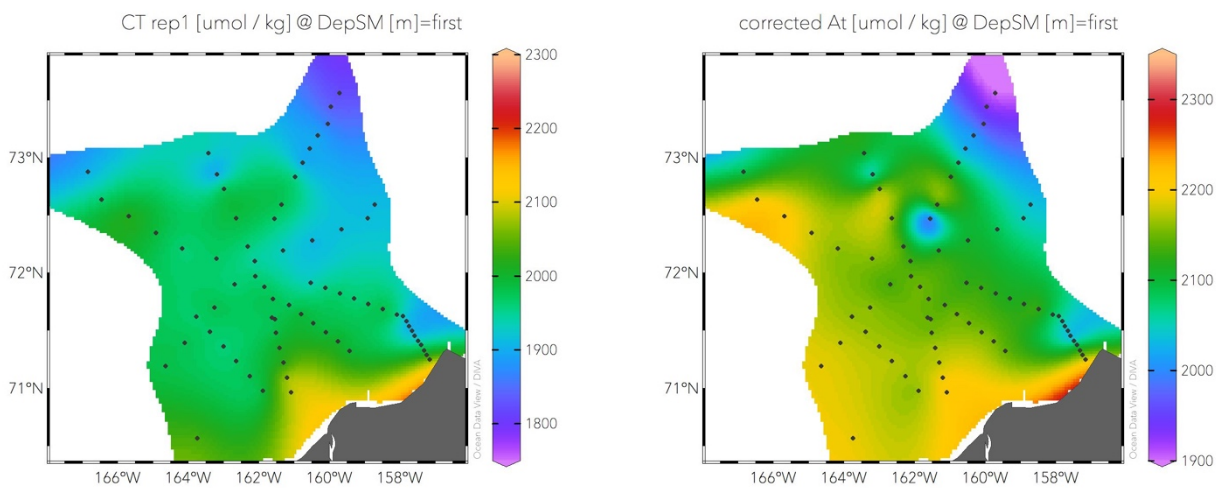


Figure F-7. CT and AT concentrations at the surface in the NCIS region.

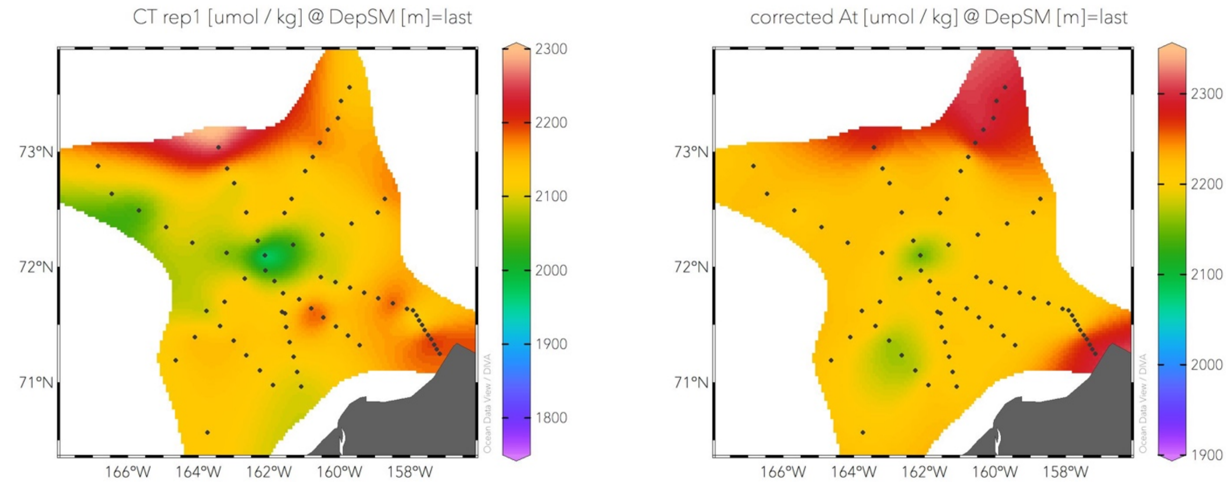


Figure F-8. CT and AT concentrations at the bottom in the NCIS region.

Next Steps

Critically, TA samples will be corrected using phosphate and silicate data analyzed by PI Mordy. This post-processing may substantially change the alkalinity of some samples collected in nutrient-rich areas. DIC data and post-processed TA data will be used to resolve other components of the marine carbonate system (e.g., pH, calcium carbonate saturation states) using the CO_2 calc software (Robbins et al., 2010). This program relies on specified carbonate dissociation constants. While there are many sets of equilibrium constants commonly used in the literature, we expect to apply those from Millero et al. (2006). These were shown to provide the best comparison between calculated system variables and discrete samples for $p$$CO_2$ in the Arctic (Evans et al., 2015). Full post-processing should be completed by the end of FY2018.

Usage Guidelines

Data provided with the bottle file associated with this cruise during September 2017 should be considered preliminary data. This data can be used for qualitative exploration, but should not be used for publication or quantification. Images and text associated with this cruise report may be used for presentations or white papers with permission from the managing PI.

Final post-processed data will be shared via the NOAA-NCEI Ocean Carbon Data System (OCADS), the data repository designed to replace DOE/CDIAC during FY2018. Public release and access will be arranged through NCEI's Geoportal. This data will become publically available by the end of FY19 in conjunction with federal requirements for public release, accessibility, and archiving of federal scientific data.

Prior to free public release, post-processed data may be shared with cruise participants for research and publication purposes on a case-by-case basis. Data access should be arranged through the managing PI on this project, Jessica Cross. Contact information is provided in the initial section of this cruise report. Data usage prior to public release entails co-authorship on any produced manuscripts, presentations, abstracts, or white papers.

Section G: *Macrofauna, sediment characteristics, and sea ice melt tracers ($\delta^{18}O$)*

Section G.1: **Contributing authors: Jacqueline M. Grebmeier (jgrebmei@umces.edu) and Lee W. Cooper (cooper@umces.edu)**

FUNDING: NOAA Arctic Program Office (ARP), Silver Spring, MD

SUMMARY: The Chesapeake Biological Laboratory (CBL) research group of the University of Maryland Center for Environmental Sciences (UMCES) undertook both water column and sediment sample collections during the HLY1702 (Aug 26-Sept 15, 2017) cruise. There were two aspects to the study: first to occupy the Distributed Biological Observatory (DBO) transect lines in the southeast Chukchi Sea (DBO3), in the NE Chukchi Sea (DBO 4), and upper Barrow Canyon (DBO5), all areas of high benthic biomass, diversity, and observed change evaluated through time-series studies. The second aspect of the cruise was to undertake a Northern Chukchi Integrated Study (NCIS). Our component included measurements in the water column of oxygen-18/oxygen16 ratios (a tracer of melted sea ice content in surface waters) and a subsampling of phytoplankton taxonomy along the DBO lines and at select sites in the NECS. Surface sediment sample measurements included sediment chlorophyll, total organic carbon and nitrogen content, grain size, and isotopic content of the organic fractions. We also undertook sediment oxygen metabolism experiments, using sediment oxygen consumption as an indicator of organic carbon supply to the benthos as well as measurements of nutrient fluxes. Finally, we are determining macroinfaunal community structure and biomass through use of multiple grabs from the sea floor at each station. Additional measurements were made during the cruise by the UMCES team that included investigating methane concentrations in water and sediment pore waters, and collections for sedimentary paleo markers, ostracod communities, and phytoplankton cysts. Continuous measurements were also made from the bow of the ship of methane concentrations and isotopic composition using a cavity ring-down spectrometer and studies undertaken of biases associated with insufficient mixing of water during CTD sampling.

PERSONNEL:

Dr. Jacqueline Grebmeier, CBL/UMCES; jgrebmei@umces.edu
Dr. Lee Cooper, CBL/UMCES; cooper@umces.edu
Reed Brodnik, PhD student, CBL/UMCES; brodnikreed@gmail.com
Laura Gemery, US Geological Survey; lgemery@usgs.gov
Caitlin Meadows, PhD student, University of Chicago; meadows@gmail.com
Dr. Cedric Magen <magen@umces.edu>
Dr. Emily Osborne, NOAA/OAR, ARP Knauss Fellow; <Osborne@noaa.gov>
Chris Paver, NOAA christopher.paver@noaa.gov (participating as an UMCES graduate student)
Chelsea Wegner, CBL/UMCES, PhD student; chelsea.wegner@gmail.com

Overview: Water column samples for assays of $^{18}O/^{16}O$ ratios were collected from the CTD/rosette cast. A subset of water samples were also collected for phytoplankton taxonomy. Sediment and macrofaunal samples were collected at a subset of the stations as listed below.

The following description briefly outlines the measurements made by our core team, with additional summary paragraphs by collaborators collecting from water column collections and our sediment collections (Gemery, Meadows, Megan, Osborne, Paver, Wegner).

A. SAMPLING AND METHODOLOGY: We will use the water column temperature and salinity measurements at 141 stations during the cruise in conjunction with our own analyses (Table G.1-1). Water samples were collected from the CTD rosette at 77 stations for O-18/O-16 ratio water samples, with subsamples for phytoplankton identifications collected at 16 stations. Sediment and macrofaunal samples were collected at 70 stations and benthic cores from approximately 20 stations (Table G.1-1). The following description briefly outlines the measurements made by our CBL/UMCES team (Section A), along with associated sampling by collaborative scientists (Section B).

1. Water column

a. Water column collections included sampling stable oxygen isotopes from the CTD/rosette system.

b. We collected 100 ml of seawater for phytoplankton identifications. These water samples were immediately preserved in Lugol's solution and formaldehyde for post-cruise species identification. Briefly, 100 ml of seawater from each standard depth were gently mixed in a small polyethylene container, with a 100ml aliquot preserved by addition of 2.5 ml of Lugol's solution and subsequently stored in the refrigerator for 24 hrs. At the end of that period 5 mL of 37% formaldehyde was added to the 100ml seawater sample to a final concentration of ~2% (v/v), gently mixed, and stored for subsequent shipment to Poland for phytoplankton identifications. These methods have been recommended to us by colleagues at the Institute of Oceanology, Sopot, Poland, who will be analyzing the species identifications of phytoplankton collected.

2. Sediment

a. Surface sediments were collected throughout the cruise from the top of the 0.1 m^2 single van Veen grab on the first grab before it was opened to minimize disturbance of surface sediments. These collections included determination of inventories of chlorophyll *a* in surface sediments as well as subsamples to determine total organic carbon (TOC) and nitrogen (TON) content, C/N ratios, $\delta^{13}C$ and $\delta^{15}N$, and grain size determination. Below is a description of the parameters measured or to be measured in post-cruise processing activities, with Table G.1-1 listing all the parameters collected at each station by the Grebmeier/Cooper component.

i. Surface sediment chlorophyll *a* (chl a). Replicate 0-1 cm surface sediments were collected using cut-off 10 cc syringes, with sediment plugs extruded into tared and labelled Falcon centrifuge tubes for fluorometric analyses. 10 mL of 90% acetone were added to each tube, mixed, and then stored in the dark in the temperature controlled (<4°C) room for 12 hrs. Subsequently measurements for chl a were made shipboard using a Turner Designs Model AU-20 flourometer (non-acidification or Welschmeyer method) following the dark extraction period in 90% acetone. Calibration of the fluorometer was performed using Turner Designs liquid chlorophyll standards acquired immediately before the cruise and kept frozen shipboard. The liquid chlorophyll standards were measured at the start and end of the cruise to check for instrument drift. We also monitored performance of the instrument by use of Turner Designs dry standards throughout the cruise.

ii. Surface sediment for TOC/TON, $\delta^{13}C$ and $\delta^{15}N$, and grain size. The top 0-1 cm of surface sediments was collected and placed into a labeled 4 ounce Whirlpak bag (filled 2/3 full) and frozen for post-cruise analyses. TOC/TON, and $\delta^{13}C$ and $\delta^{15}N$ values of the organic fraction of these sediments will be measured at CBL using the same stable isotope mass spectrometer used for the oxygen isotope analyses mentioned above, but using a combustion peripheral to oxidize carbon and oxidize and reduce nitrogen in the organic fraction of the sediments. Sediments will be de-carbonated using 0.1 N HCl prior to analysis. Grain size will also be determined using standard methods in our laboratory.

Table A1. HLY1702 station listing from CTD header file and data parameter listing of water, sediment and macrofauna.

Station Number	Station Name	Time Occupied (GMT)	Latitude (deg/min N)	Longitude (deg/min W)	Bot Depth (m)	O-18	Phyto ID	Sed Chl	TOC & phi size	Macrofauna l grabs (# reps)	Sediment oxygen demand
1	DBO3-8	Aug 29 2017 15:49	67 40.59	168 56.91	50.7	x	x	x	x	x (4)	x
2	DBO3-7	Aug 29 2017 19:52	67 47.00	168 35.78	50.4	x		x	x	x (4)	x
3	DBO3-6	Aug 29 2017 19:52	67 53.85	168 14.07	58.3	x		x	x	x (4)	
4	DBO3-5	Aug 29 2017 22:35	68 00.78	167 52.51	53.2	x	x	x	x	x (4)	
5	DBO3-4	Aug 30 2017 01:44	68 07.97	167 29.22	49.4	x	x	x	x	x (1)	
6	DBO3-3	Aug 30 2017 04:43	68 11.20	167 17.70	47.9	x		x	x	x (1)	
7	DBO3-2	Aug 30 2017 06:29	68 14.81	167 07.30	43.2	x	x	x	x	x (1)	
8	DBO3-1	Aug 30 2017 10:17	68 18.25	166 55.42	34	x		x	x	x (1)	
9	HAB1	Aug 30 2017 18:58	69 34.88	164 46.89	30.8					x-3 (DA)	
10	DBO4-6	Aug 31 2017 04:43	71 37.19	163 45.74	41.2	x	x	x	x	x (1)	x
11	DBO4-5a	Aug 31 2017 06:46	71 33.34	163 33.99	42.2	CTD only					
12	DBO4-5	Aug 31 2017 07:39	71 29.42	163 22.61	42.1	x		x	x	x (1)	
13	DBO4-4a	Aug 31 2017 09:21	71 25.88	163 12.18	42.7	CTD only					
14	DBO4-4	Aug 31 2017 10:28	71 21.82	163 00.03	44.8	x	x	x	x	x (1)	x
15	DBO4-3a	Aug 31 2017 13:11	71 17.82	162 49.15	45.6	CTD only					
16	DBO4-3	Aug 31 2017 14:11	71 13.96	162 38.21	45.5	x		x	x	x (1)	
17	DBO4-2a	Aug 31 2017 15:56	71 10.24	162 26.91	45	CTD only					
18	DBO4-2	Aug 31 2017 16:56	71 06.11	162 14.86	45.9	x	x	x	x	x (1)	x
19	DBO4-1a	Aug 31 2017 19:07	71 02.50	162 04.85	45.2	CTD only					
20	DBO4-1	Aug 31 2017 20:06	70 58.47	161 53.23	44.7	x	x	x	x	x (1)	
21	DBO5-10	Sep 01 2017 03:40	71 37.35	157 54.28	62.7	x		x	x	x (2)	x
22	DBO5-9	Sep 01 2017 05:55	71 34.72	157 48.68	64.6	x		x	x	x (1)	
23	DBO5-8	Sep 01 2017 07:31	71 32.19	157 43.99	71.9	x	x	x	x	x (1)	
24	DBO5-7	Sep 01 2017 09:18	71 29.82	157 38.86	83.8	x		x	x	x (1)	
25	DBO5-6	Sep 01 2017 11:03	71 27.34	157 34.46	109.3	x		x	x	x (1)	x
26	DBO5-5	Sep 01 2017 14:06	71 24.56	157 28.37	124.6	x	x	x	x	x (1)	
27	DBO5-4	Sep 01 2017 17:28	71 22.37	157 23.55	112.8	x		x	x	x (1)	
28	DBO5-3	Sep 01 2017 19:29	71 19.60	157 18.87	88.4	x		x	x	x (1)	
29	DBO5-2	Sep 01 2017 21:40	71 17.29	157 14.07	56.8	x	x	x	x	x (1)	
30	DBO5-1	Sep 01 2017 23:14	71 14.89	157 08.81	45.9	x		x	x	x (1)	
31	SW-1	Sep 02 2017 10:24	71 11.42	164 38.27	44.8	x	x	x	x	x (1)	x
32	SW-2	Sep 02 2017 13:03	71 17.49	164 21.93	46	CTD only					
33	SW-3	Sep 02 2017 14:11	71 23.60	164 05.43	44.4	x		x	x	x (1)	
34	SW-4	Sep 02 2017 16:11	71 29.63	163 48.70	44.8	CTD only					
35	SW-5	Sep 02 2017 17:11	71 35.70	163 31.90	42.1	CTD only					
36	SW-6	Sep 02 2017 18:05	71 41.87	163 15.42	41.3	x		x	x	x (1)	x
37	SW-7	Sep 02 2017 20:39	71 47.92	162 57.76	38.8	x		x	x	x (1)	
38	SW-8	Sep 02 2017 21:35	71 54.00	162 41.04	41.5	x		x	x	x (1)	
39	SW-9	Sep 02 2017 23:24	72 00.14	162 24.01	32.7	CTD only					
40	SW-10	Sep 03 2017 00:25	72 06.24	162 06.63	26.9	x		x	x	x (1)	
41	W-1	Sep 03 2017 02:39	72 06.51	162 41.26	37.8	CTD only					
42	W-2	Sep 03 2017 03:47	72 07.33	163 12.00	40.1	x		x	x	x (4)	
43	W-3	Sep 03 2017 06:08	72 08.53	163 46.67	38.2	CTD only					
44	W-4	Sep 03 2017 07:13	72 12.62	164 10.05	40.4	x		x	x	x (1)	
45	W-5	Sep 03 2017 09:15	72 16.90	164 32.78	45.2	CTD only					x
46	W-6	Sep 03 2017 10:21	72 20.96	164 54.62	47.6	x		x	x	x (4)	x
47	W-7	Sep 03 2017 13:06	72 25.28	165 18.32	49.6	CTD only					
48	W-8	Sep 03 2017 14:19	72 29.52	165 41.11	50.5	x		x	x	x (1)	
49	W-9	Sep 03 2017 16:10	72 33.72	166 03.96	51.7	CTD only					
50	W-10	Sep 03 2017 17:15	72 38.23	166 26.97	52.4	x		x	x	x (1)	
51	W-11	Sep 03 2017 19:02	72 45.26	166 39.25	53.9	CTD only					
52	W-12	Sep 03 2017 20:05	72 52.69	166 50.90	56.4	x	x	x	x	x (4)	
53	NW-1	Sep 04 2017 02:44	73 02.36	163 25.38	98.3	x	x	x	x	x (4)	x
54	NW-2	Sep 04 2017 05:08	72 58.92	163 20.08	81.9	CTD only					
55	NW-3	Sep 04 2017 05:52	72 55.11	163 15.13	74.6	CTD only					
56	NW-4	Sep 04 2017 06:37	72 51.24	163 10.66	71.5	x		x	x	x (1)	
57	NW-5	Sep 04 2017 08:25	72 47.58	163 05.67	66.2	CTD only					
58	NW-6	Sep 04 2017 09:22	72 43.62	162 58.69	55.7	x		x	x	x (4)	
59	NW-7	Sep 04 2017 11:46	72 36.07	162 49.13	42.7	CTD only					
60	NW-8	Sep 04 2017 13:11	72 28.58	162 38.24	41.4	x		x	x	x (1)	x
61	NW-9	Sep 04 2017 15:22	72 21.12	162 28.35	40.1	CTD only					
62	NW-10	Sep 04 2017 16:26	72 13.74	162 18.45	35.9	x		x	x	x (1)	
63	NNE-1	Sep 04 2017 18:06	72 13.84	161 56.64	35.5	CTD only					
64	NNE-2	Sep 04 2017 19:04	72 20.97	161 44.72	41.5	CTD only					
65	NNE-3	Sep 04 2017 20:01	72 28.14	161 32.97	44.8	x		x	x	x (4)	
66	NNE-4	Sep 04 2017 21:35	72 35.65	161 21.23	45.8	x		x	x	x (1)	
67	NNE-5	Sep 05 2017 00:03	72 42.77	161 09.72	50	CTD only					
68	NNE-6	Sep 05 2017 01:07	72 50.00	160 57.82	53.5	x		x	x	x (1)	
69	NNE-7	Sep 05 2017 02:47	72 53.79	160 52.11	56.2	CTD only					
70	NNE-8	Sep 05 2017 03:28	72 57.28	160 44.93	70.4	x		x	x	x (1)	
71	NNE-9	Sep 05 2017 05:01	73 00.80	160 39.47	135						

Table A1. HLY1702 station listing from CTD header file and data parameter listing of water, sediment and macrofauna (cont)

Station Number	Station Name	Time Occupied (GMT)	Latitude (deg/min N)	Longitude (deg/min W)	Bot Depth (m)	O-18	Phyto ID	Sed Chl	TOC & phi size	Macrofauna l grabs (# reps)	Sediment oxygen demand
72	NNE-10	Sep 05 2017 05:44	73 04.74	160 33.32	188.2	x		x	x	x (1)	
73	NNE-11	Sep 05 2017 07:59	73 08.08	160 27.17	257.7	CTD only					
74	NNE-12	Sep 05 2017 09:06	73 11.70	160 19.71	346	x		x	x	x (1)	
75	NNE-13	Sep 05 2017 12:26	73 15.29	160 12.89	748.4	CTD only					
76	NNE-14	Sep 05 2017 13:53	73 17.71	160 02.20	1260	x		x	x	x-from HAPS	x
77	NNE-15	Sep 05 2017 20:17	73 22.49	160 01.49	1462.2	500m CTD bottom					
78	NNE-16	Sep 05 2017 23:50	73 26.64	159 56.95	1731.9	500m CTD bottom					
79	NNE-17	Sep 06 2017 01:36	73 30.24	159 50.03	1992.4	500m CTD bottom					
80	NNE-18	Sep 06 2017 02:51	73 33.77	159 42.72	2228.1	x					
81	NNE-19	Sep 06 2017 06:43	73 40.94	159 30.40	2604.6	500m CTD bottom					
82	NNE-20	Sep 06 2017 08:15	73 48.11	159 17.06	2997.3	500m CTD bottom					
83	NE-1	Sep 06 2017 13:23	73 27.15	157 18.66	3034.3	x		x	x	x (1)	
84	NE-2	Sep 06 2017 17:03	73 23.46	157 25.01	3048.9						
85	NE-3	Sep 06 2017 18:07	73 19.81	157 31.17	2905.1						
86	NE-4	Sep 06 2017 19:32	73 16.06	157 36.50	2829.4						
87	NE-5	Sep 06 2017 20:38	73 12.56	157 42.82	2665.6						
88	NE-6	Sep 06 2017 22:13	73 08.87	157 48.71	2422.4						
89	NE-7	Sep 06 2017 23:14	73 05.05	157 54.82	1949.2						
90	NE-8	Sep 07 2017 00:25	73 01.29	158 01.36	1875.6						
91	NE-9	Sep 07 2017 01:32	72 57.78	158 07.12	1766.6						
92	NE-10	Sep 07 2017 03:18	72 54.16	158 13.09	1362.1						
93	NE-11	Sep 07 2017 04:27	72 50.37	158 20.03	629						
94	NE-12	Sep 07 2017 06:29	72 46.91	158 25.25	294.8						
95	NE-13	Sep 07 2017 07:49	72 43.12	158 31.84	225.6						
96	NE-14	Sep 07 2017 10:30	72 39.21	158 36.69	161.6						
97	NE-15	Sep 07 2017 11:35	72 35.64	158 42.73	76.5	x		x	x	x (1)	
98	NE-16	Sep 07 2017 17:18	72 32.23	158 48.78	57.8	x					
99	NE-17	Sep 07 2017 18:10	72 28.50	158 54.67	53.4	x					
100	NE-18	Sep 07 2017 19:36	72 25.87	159 14.18	51.4	CTD only					
101	NE-19	Sep 07 2017 21:04	72 22.58	159 39.26	48.2	x					
102	NE-20	Sep 07 2017 22:31	72 19.83	160 04.01	47.1						
103	NE-21	Sep 07 2017 23:47	72 17.01	160 28.73	42.7	x					
104	NE-22	Sep 08 2017 01:08	72 14.18	160 53.75	35.8	CTD only					
105	NE-23	Sep 08 2017 02:36	72 11.53	161 18.63	34.9	x					
106	NE-24	Sep 08 2017 03:53	72 08.65	161 43.62	31.9	CTD only					
107	E-1	Sep 08 2017 05:06	72 03.18	161 44.28	29.9	CTD only					
108	E-2	Sep 08 2017 06:14	72 00.52	161 19.44	34.4	CTD only					
109	E-3	Sep 08 2017 15:40	71 57.62	160 55.65	37.7	CTD only					
110	E-4	Sep 08 2017 16:58	71 54.72	160 31.27	41.1	x		x	x	x (1)	
111	E-5	Sep 08 2017 19:02	71 52.16	160 06.85	44.3	CTD only					
112	E-6	Sep 08 2017 20:21	71 49.41	159 41.93	49.9	x		x	x	x (1)	
113	E-7	Sep 08 2017 22:31	71 46.61	159 17.59	51.5	CTD only					
114	E-8	Sep 08 2017 23:45	71 43.81	158 53.45	53.5	x		x	x	x (1)	
115	E-9	Sep 09 2017 01:38	71 41.16	158 28.64	55						
116	E-10	Sep 09 2017 02:48	71 38.26	158 04.99	60.2	x		x	x	x (1)	
117	SE-1	Sep 09 2017 06:11	71 19.41	159 25.05	54.6	x		x	x	x (1)	
118	SE-2	Sep 09 2017 08:03	71 24.41	159 45.05	48.9						
119	SE-3	Sep 09 2017 09:18	71 29.13	160 05.73	48.9	x	x	x	x	x (1)	x
120	SE-4	Sep 09 2017 11:59	71 33.83	160 26.96	49.2						
121	SE-5	Sep 09 2017 13:25	71 38.48	160 47.52	49.1	x		x	x	x (1)	x
122	SE-6	Sep 09 2017 16:03	71 43.24	161 08.37	44.6						
123	SE-7	Sep 09 2017 17:14	71 46.44	161 35.96	43.1	x		x	x	x (1)	
124	SE-8	Sep 09 2017 19:04	71 52.64	161 50.44	40.3	x					
125	SE-9	Sep 09 2017 20:29	71 58.18	162 05.40	32.6	x		x	x	x (1)	
126	S-1	Sep 09 2017 23:36	71 36.57	161 37.66	45.9	x		x	x	x (4)	
127	CEO	Sep 10 2017 01:12	71 35.96	161 32.27	46.1						
128	S-2	Sep 10 2017 02:51	71 28.75	161 30.97	47.3	x		x	x	x (4)	x
129	S-3	Sep 10 2017 05:37	71 20.91	161 24.53	47	x		x	x	x (4)	
130	S-4	Sep 10 2017 07:51	71 13.27	161 17.81	48.8	x	x	x	x	x (4)	x
131	S-5	Sep 10 2017 10:13	71 05.31	161 11.91	46.6	x		x	x	x (4)	
132	S-6	Sep 10 2017 12:40	70 57.68	161 05.11	45.2	x		x	x	x (1)	
133	HAB2	Sep 10 2017 18:32	70 33.94	163 44.61	43.5			x	x	x (1)	
134	DBO1.8	Sep 12 2017 19:58	63 01.46	173 27.72	70.8	x		x	x	x (1)	
135	DBO1.7	Sep 12 2017 23:25	62 47.13	173 30.10	68.9	CTD only					
136	DBO1.6	Sep 13 2017 00:56	62 33.46	173 33.07	65.1	x		x	x	x (1)	x
137	DBO1.5	Sep 13 2017 03:52	62 27.97	174 05.00	67.6	CTD only					
138	DBO1.4	Sep 13 2017 05:14	62 23.25	174 34.46	71.1	x		x	x	x (1)	x
139	DBO1.3	Sep 13 2017 08:12	62 13.09	174 52.95	75.4						
140	DBO1.2	Sep 13 2017 09:39	62 02.66	175 12.61	80.8	x		x	x	x (1)	x
141	DBO1.1	Sep 13 2017 11:37	62 00.40	175 03.12	79.4	x					
n=						**77**	**16**	**70**	**70**	**70 (116)**	**20**

iii. One to four additional grabs were collected at 70 stations and sieved through one-mm metal sieve screen boxes with running seawater, with the retained animals placed in labeled plastic containers and preserved in 10% buffered seawater formalin for post-cruise analyses at CBL. Post-cruise analyses including identification to lowest taxon possible, at a minimum to family, but in most cases to species, and include, abundance and biomass determinations.

iv. Surface sediment was collected for ostracod samples (Gemery) and phytoplankton cysts (Wegner) and frozen for post-cruise analyses (see Section G.3).

v. The remaining sediment in the first grab was sieved through a one-mm metal sieve screen boxes with running seawater periodically for Caitlin Meadows, who is undertaking studies of the relationships between live and dead shell assemblages (See Section G.4).

vi. Haps benthic corer

A multi-HAPS benthic corer (133 cm^2 diameter cores) was used to collect sediment core samples for metabolism experiments (sediment oxygen uptake and nutrient exchange). For the DBO regions, two sites were collected on the DBO3 line (DBO3.7 and DBO 3.7), three on the DBO4 line (DBO4.6, 4.4, and 4.2), and two stations on the DBO5 line (DBO5.10 and DBO5.6). We then did additional stations in the NE Chukchi Sea "spiral" sampling plan. Cores were sieved and macrofauna retained on 1 mm screen mesh were preserved in 10% buffered seawater formalin for post-cruise processing. Sediment cores were also collected for pore water methane studies by Cedric Magan (see Section G.2) and for nitrous oxide pore water studies by Annie Bourbonnais.

Preliminary Results

The pattern of sediment chlorophyll during HLY1702 indicates recent phytodetritus deposition in the offshore DBO3 (SE Chukchi Sea) hotspot and in the NE Chukchi Sea primarily southeast of Hanna Shoal (Figure G.1-1). Noticably the great deposition is to the SE of Hanna Shoal, an area also known for high benthic biomass in the NE Chukchi Sea as prey for walrus. The SE Chukchi DBO3 offshore stations continue to be the highest benthic biomass region in the Chukchi Sea (previous observations and qualitative review of HLY1702 samples).

The sediments over the Chukchi Sea ranged from sand and rock in the central channel and closer to the Alaska shoreline, whereas muddy sediments occurred in the offshore regions, with coarse sediments in the shallow portions of Hanna Shoal that were sampled. Gravel mixed with mud was encountered in the Central Channel flow paths across the central Chukchi Shelf. The highest bivalve biomass was observed in fine sediment at both the DBO 3.6-3.8 sites in the southern Chukchi Sea and just south and SE of Hanna Shoal, particularly in the location of the Chukchi Environmental Observatory (CEO) biophysical mooring SE of Hanna Shoal, and in the central stations of DBO4. Notably the apparent higher bivalve biomass region located on the northern transect line includes the biophysical mooring, meaning that it is north of the current DBO4 line. Astartid bivalves were dominant in the NE Chukchi Sea, along with maldanid polychaetes, whereas tellinid bivalves dominated the offshore SE Chukchi Sea DBO3 hotspot.

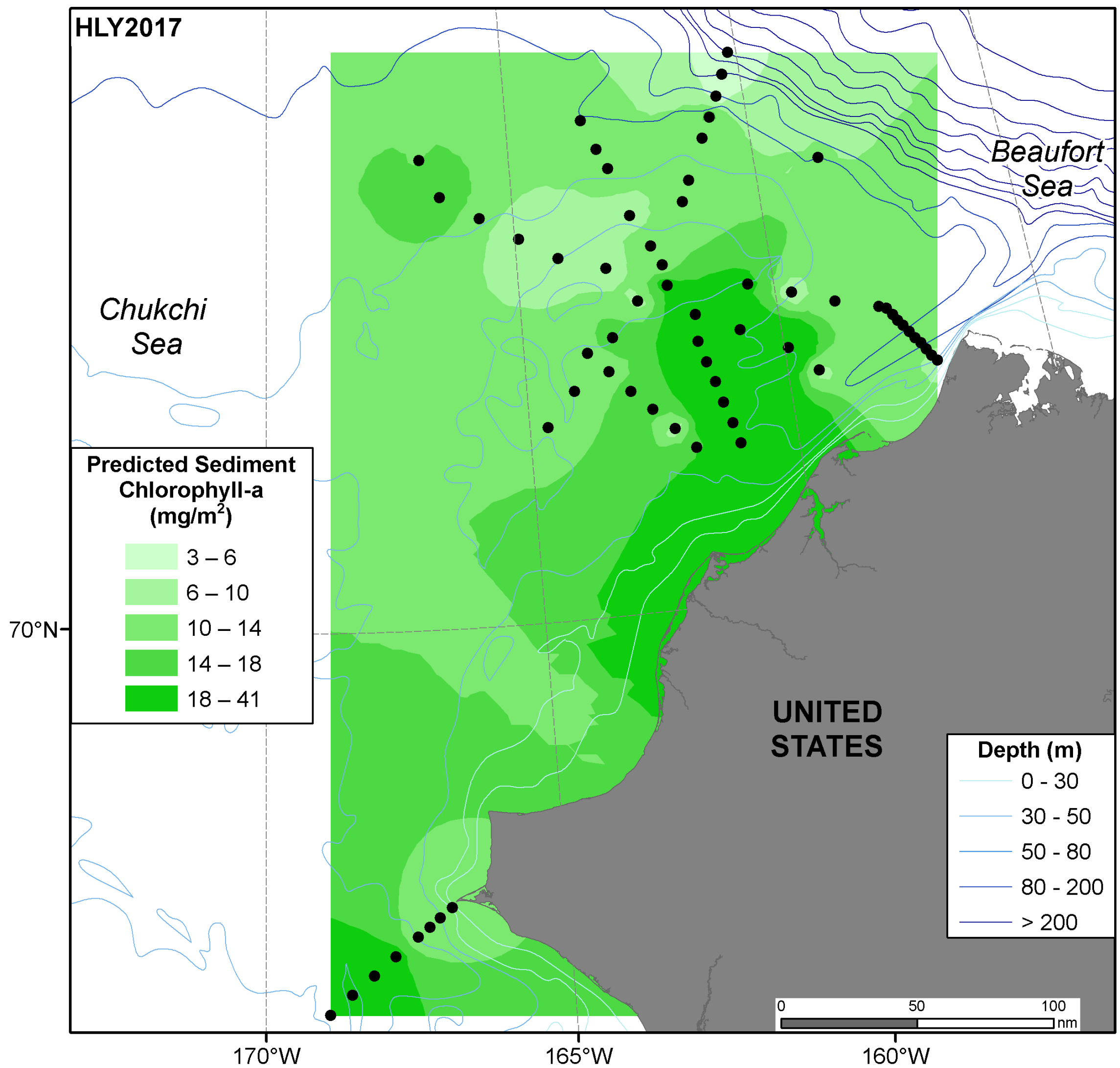


Figure G.1-1. Distribution of surface sediment chlorophyll *a* during HLY1702.

G.2 – G.7 Summary Statements from Other Team Water Column and Benthic Components

G.2 Cedric Magen: Methane studies (CBL/UMCES)

Background: The Arctic Ocean is showing alarming signs of rapid warming, illustrated principally by the shrinkage of multi-year sea-ice extent. One of the consequence of this warming is the melting of the permafrost on land and under on the continental shelf. Studies in the Siberian Sea have shown a release of methane from the sediment to the water column and to the atmosphere, attributed to permafrost melting under the seafloor. Whether this a consequence of a warming Arctic Ocean, or this has being taking place for a long time is not known.

Objective: Similar observations were not made in the Chukchi Sea, and recent data from 2012 shows low methane concentrations in the water column. Here, we revisited stations previously visited in 2012 in order to see if any change has happened in the release of methane. We also visited other locations that had never been investigated for methane in an effort to monitor methane at the scale of the Chukchi Sea. In addition, we measure methane stable isotopes in order to discriminate between potential sources of methane. We also experiment using a G2201-I Picarro methane and CO2 analyzer at sea. This device analyzes both these gases in air for concentrations and $\delta^{13}C$- signature on a continuous basis.

Methods:

- 46 stations were sampled for water column methane concentrations and stable isotopes

- Table G.2-1). All samples were analyzed on board using a Picarro G2201-I analyzer.

- While not in use for discrete water column samples, the analyzer measured continuously for methane for concentrations and stable isotopes at the bow of the ship, ~5m above sea level. This was conducted to identify potential source of high methane release on the path of the ship.

- 15 stations were sampled for concentrations of methane in the sediment, in order to find out how much the sediment contribute water column methane, and 13 stations were sampled for porewater sulfate and nutrients (NH_4, NO_3, NO_2). The analysis of carbon stable isotope of CH_4 should allow discriminating between methane issued from recent methanogenesis, and methane release from melting permafrost.

Table G.2-1. List of stations sampled during the Healy 1702 cruise.

Station #/Name	CH4 in water	CH4 in sediment	Porewaters extracted
DBO3.8	×	×	×
DBO3.6	×	×	
DBO3.4	×		
DBO3.1	×		
DBO4.6	×	×	×
DBO4.4	×	×	×
DBO4.2	×	×	×
DBO5.10	×	×	×
DBO5.6	×	×	×
DBO5.3	×		
DBO5.1	×		
36/SW-6	×	×	×
38/SW-8	×		
40/SW-10	×		
42/W-2	×		
44/W-4	×		
48/W-8	×		

50/W-10	×		
52/W-12	×		
53/NW-1	×	×	×
56/NW-4	×		
60/NW-8	×		
62/NW-10	×		
66/NNE-4	×	×	×
72/NNE-10	×		
76/NNE-14	×	×	×
80/NNE-18	×		
83/NE-1	×		
87/NE-5	×		
91/NE-9	×		
95/NE-13	×		
99/NE-17	×		
101/NE-19	×		
103/NE-21	×		
105/NE-23	×		
110/E-4	×		
112/E-6	×		
114/E-8	×		
126/S-1	×		
128/S-2	×	×	×
130/S-4	×	×	×
132/S-6	×		
134/DBO1.8	×		
136/DBO1.6	×		
138/DBO1.4	×	×	×
140/DBO1.2	×	×	

G.3 Laura Gemery, USGS: Ostracode, foraminifera and dinoflagellate sampling

A main objective of HLY1702 sampling was to survey the benthic ostracode and foraminiferal assemblages of the Bering Sea (DBO1) and Chukchi Sea (DBO 3,4, and 5) during the late summer season. Both foraminifers and ostracodes are constituents of the sediment meiofauna and are robust proxies for temperature, salinity, oxygen, productivity, and sea-ice presence, and serve as indicators for changing environmental conditions. Seventy-three microfaunal samples were collected during this cruise (see Table B2). Ostracode assemblages from HLY1702 will be compared to 1300 samples in an existing Arctic Ostracode Database (AOD) with a goal of understanding past and recent-past climate change through calibrations of modern-day assemblages with environmental parameters. In addition, we will further develop ecological data on dominant indicator species, which can be used for down-core paleoceanographic reconstructions in the Arctic region.

From a preliminary ship analysis of selected surface sediment samples, the dominant taxa in DBO 3 line of the Chukchi Sea include *Sarsicytheridea bradii*, *Paracyprideis pseudopunctillata, Munseyella kiklukhensis, Normanicythere leioderma,* and *Semicytherura* spp*.* Twenty dinoflagellate samples will be sent to Dr. Anne de Vernal at GEOTOP (Université du Québec à Montréal) for palynological analyses (i.e. the analyses of organic-walled remains, which may include pollen, spores, organic linings of foraminifers, tintinnid lorica, dinoflagellate cysts, etc). Specifically, the samples will be used for dinoflagellate cyst counts, with the aim of making statistical analyses to define the relationships with sea-surface conditions, including sea-ice cover and productivity. Ultimately, the data will be included into a hemispheric database of the dinoflagellate cyst distribution and also serve for reconstruction of paleoceanographic conditions.

Table B2. Ostracode sample collection from sediments.

Cruise	Station #	Station I.D.	Lat	Long	Depth	collection type	Benthic Ostracode notes	Foram notes	Sediment & station notes	dino collection	Date
HLY1702	Test	Test	64.4072	-166.2264	38	HAPS core, 0-16cm, sectioned every 2cm	(scraped top of another core) in 0-1cm: P.pseduopunctillata dominates, 2xNormanicythere leioderma, H. sorbayana, S. bradii, Elofsonella				Aug 28 2017
HLY1702	1	DBO3.8	67.6658	-168.9615	50	VV grab	no ostracodes	very few	some diatoms		Aug 29 2017
HLY1702	2	DBO3.7	67.7844	-168.6005	48	VV grab	no ostracodes	no forams	diatoms		Aug 29 2017
HLY1702	2	DBO3.7	67.7844	-168.6005	48	HAPS coret	no ostracodes	no forams	diatoms		Aug 29 2017
HLY1702	3	DBO3.6	67.9008	-168.2352	56	VV grab	no ostracodes	no forams	diatoms		Aug 29 2017
HLY1702	4	DBO3.5	68.0132	-167.8730	51	VV grab	Normanicythere leioderma dominates, S.affinis, Semicytherura spp., S.bradii	some forams	muddy, more sandy		Aug 30 2017
HLY1702	5	DBO3.4	68.1277	-167.4943	48	VV grab	Normanicythere leioderma dominates, S.affinis, Semicytherura spp., S.bradii, A.dunelmensis, Jonesia	abundant forams, Elphidium excav and E. excavatum clavata	rocky, pebbly, sandy		Aug 30 2017
HLY1702	6	DBO3.3	68.1871	-167.3028	46	no sample collected					Aug 30 2017
HLY1702	7	DBO3.2	68.2420	-167.1193	44	VV grab	abundant ostracodes, esp N.leioderma, Munseyella, S.bradii, P.pseudopunctillata, Elofsonella, Kotoracythere, C.pararcticum, H.sorbayana, Paradoxastoma, Semicytherura	abundant forams, Elphidium excav and E. excavatum clavata	lots of gravel, rocks, diatoms		Aug 30 2017
HLY1702	8	DBO3.1	68.3011	-166.9147	33.4	VV grab	abundant ostracodes, esp N.leioderma, Munseyella, S.bradii, P.pseudopunctillata, Elofsonella, Jonesia	abundant forams	very pebbly, rocky, sandy, fewer diatoms		Aug 30 2017
HLY1702	9	HABS	69.5911	-164.7914	31	VV grab	2xSemicytherura affinis, P. pseudopunctillata, A. dunelmensis, Hemicythere spp., Semicytherura spp.,	some forams	very sandy		Aug 30 2017
HLY1702	10	DBO4.6	71.6191	-163.7724	42	HAPS core,	sectioned every 2cm				
HLY1702	10	DBO4.6	71.6191	-163.7724	42	VV grab					Aug 31 2017
HLY1702	12	DBO4.5	71.4930	-163.3966	41	VV grab					Aug 31 2017
HLY1702	14	DBO4.4	71.3608	-163.0165	46	VV grab					Aug 31 2017
HLY1702	16	DBO4.3	71.2368	-162.6418	46	VV grab					Aug 31 2017
HLY1702	18	DBO4.2	71.1023	-162.2658	45	VV grab					Aug 31 2017
HLY1702	20	DBO4.1	70.9733	-161.9095	46	VV grab	Munseyella, Kotoracythere, Cluthia, Semicytherura			yes	Aug 31 2017
HLY1702	21	DBO5.10	71.6213	-157.9239	64	HAPS core,	2-cm sections to 10cm				
HLY1702	21	DBO5.10	71.6213	-157.9239	64	VV grab				yes	Sept 1 2017
HLY1702	22	DBO5.9	71.5768	-157.8286	66	VV grab				yes	Sept 1 2017
HLY1702	23	DBO5.8	71.5357	-157.7617	71	VV grab					Sept 1 2017
HLY1702	24	DBO5.7	71.5016	-157.6761	87	VV grab					Sept 1 2017
HLY1702	25	DBO5.6	71.4552	-157.5778	113	VV grab	C. elaeni, P.pseudopunctillata, N. leioderma, Cluthia	Elphidium, Nonion, agglutinated spp.	diatoms		Sept 1 2017
HLY1702	26	DBO5.5	71.4935	-157.4935	130	VV grab	P.pseudopunctillata, Munseyella, Paracytherois, Semicytherura spp., Kotoracythere	Elphidium ex clav, C. neoteretis, Nonion, Stainforthia	brittle clam shells, high CO2 values		Sept 1 2017
HLY1702	27	DBO5.4	71.3740	-157.4063	116	VV grab	Roundstonia globulifera, Kotoracythere, Munseyella, Semicytherura spp.	C. neoteretis	big rocks, sandy, no diatoms		Sept 1 2017
HLY1702	28	DBO5.3	71.3290	-157.3310	90	VV grab	C. elaeni, Munseyella, Finmarchinella spp., C.pararcticum, S. bradii, Schizocythere, Semicythere spp., Palmenella limacola	C. neotertis, Nonion, agglutinated	sandy, pebbly	yes	Sept 1 2017
HLY1702	29	DBO5.2	71.2872	-157.2558	57	VV grab	Elofsonella, P.pseudopunctillata, S.bradii, Munseyella, C. elaeni, Schizocythere	abundant, Nonion, Buccella frigida, agglutinated			Sept 1 2017
HLY1702	30	DBO5.1	71.2487	-157.1633	46	VV grab	5xP.pseudopunctillata, 2xH.sorbayana, 1x Schizocythere ikeya, 1xS.bradii, Munseyella, Elofsonella, Semicytherura spp.	abundant forams, i.e. Nonion, Buccella frigida	very pebbly;some rocks	yes	Sept 1 2017
HLY1702	31	SW1	71.1902	-164.6518	46	VV grab					Sept 2 2017
HLY1702	33	SW3	71.3961	-164.0942	46	VV grab					Sept 2 2017
HLY1702	36	SW6	71.6858	-163.2628	42	VV grab					
HLY1702	36	SW6	71.6856	-163.2617	42	HAPS coret	A. dunelmensis, Semicythereura spp, S.bradii	few forams, Elphidium, Nonion	pebbly, sandy		Sept 2 2017
HLY1702	38	SW8	71.9027	-162.6870	40	VV grab				yes	Sept 2 2017
HLY1702	40	SW10	72.1046	-162.1134	27	VV grab				yes	Sept 3 2017
HLY1702	42	W2	72.1238	-163.2350	41	VV grab				yes	Sept 3 2017
HLY1702	44	W4	72.2125	-164.1642	41	VV grab				yes	Sept 3 2017
HLY1702	46	W6	72.3514	-164.9195	48	VV grab					Sept 3 2017
HLY1702	48	W8	72.4935	-165.6806	51	VV grab					Sept 3 2017
HLY1702	50	W10	72.6368	-166.4575	54	VV grab					Sept 3 2017
HLY1702	52	W12	72.8718	-166.8425	58	VV grab				yes	Sept 3 2017

Table B2. Ostracode sample collection from sediments (cont)

Cruise	Station #	Station I.D.	Lat	Long	Depth	collection type	Benthic Ostracode notes	Foram notes	Sediment & station notes	dino collection	Date
HLY1702	53	NW1	73.0360	-163.4280	100	VV grab				yes	Sept 3 2017
HLY1702	56	NW4	72.8516	-163.1643	74	VV grab				yes	Sept 4 2017
HLY1702	58	NW6	72.7279	-162.9789	58	VV grab					Sept 4 2017
HLY1702	60	NW8	72.4267	-162.6409	42	VV grab					Sept 4 2017
HLY1702	62	NW10	72.2274	-162.2986	37	VV grab					Sept 4 2017
HLY1702	65	NNE-3	72.4705	-161.5522	45	VV grab				yes	Sept 4 2017
HLY1702	66	NNE-4	72.5932	-161.3600	47	VV grab					Sept 5 2017
HLY1702	68	NNE-6	72.8345	-160.9667	54	VV grab					Sept 5 2017
HLY1702	70	NNE-8	72.9560	-160.7612	72	VV grab					Sept 5 2017
HLY1702	72	NNE-10	73.0755	-160.5517	193	VV grab					Sept 5 2017
HLY1702	74	NNE-12	73.2020	-160.3581	352	VV grab					Sept 5 2017
HLY1702	76	NNE-14	73.3291	-160.1618	1231	HAPS core , 0-20cm	sectioned every 1cm, in 0-1cm: 4x Krithe hunti, few ostracodes	abundant agglutinated, some pachyderma, Triculina frigida , Quinqueloculina	Mn reddish-brown sed; fine-grained mostly washed thru sieve; At 10cm gray glacial sediment		Sept 5 2017
HLY1702	110	E-4	71.9135	-160.5003	42	VV grab	a few, 2xP.pseudopunctillata	few, Nonion	very silty mud , some diatoms		Sep 08 2017
HLY1702	112	E-6	71.8234	-159.6816	50	VV grab	few ostracodes, 1xP.pseudopunctillata	agglutinated forams, few others	sandy, diatoms		Sep 08 2017
HLY1702	114	E-8	71.7234	-158.8761	55	VV grab	few ostracodes ie Jonesia, P.pseudopunctillata, C.elaeni, H.sorbayana, S. complanata	agglutinated forams,Nonion	muddy, very little sand, diatoms		Sep 08 2017
HLY1702	116	E-10	71.6418	-158.0645	59	VV grab	few ostracodes, 1xP.pseudopunctillata	agglutinated forams, few others	abundant diatoms		Sep 09 2017
HLY1702	117	SE-1	71.3263	-159.4047	55	VV grab	5xJonesia, 2x Argilloecia, A.dunelmensis, P.pseudopunctillata, S.complanata	agglutinated, few benthic Quinqueloculina, Nonion	muddy, mud worm casings, some diatoms	yes	Sep 09 2017
HLY1702	119	SE-3	71.4928	159.915	50	HAPs core	2xJonesia, 1xP.pseudopunctillata, 1xH.sorbayana,	few forams, Nonion	"vegetation" few diatoms	yes	Sep 09 2017
HLY1702	121	SE-5	71.6469	-160.7862	54	HAPs core	no ostracodes	few forams, ie Nonion, few aggultinated	few diatoms		Sep 09 2017
HLY1702	125	SE-9	71.975	-162.07717	33	VV grab	Semicytherura spp., S. bradii, Jonesia, A.dunelmensis, P. pseudopunctillata	very few forams	very sandy		Sep 09 2017
HLY1702	126	S-1	71.6123	-161.6193	47	VV grab	few ostracodes, ie Jonesia, S. complanata, H.sorbayana, Paracypris	few forams	sandy, some diatoms	yes	Sep 09 2017
HLY1702	128	S-2	71.4810	-161.5094	48	VV grab	few, i.e. Jonesia, Paracypris, Argilloecia	few i.e. Nonion, Quinqueloculina			Sep 10 2017
HLY1702	128	S-2	71.4811	-161.5094	48	HAPs core	very few ostracodes, 2xJonesia,1x Robertsonites	very few forams /some agglutinated	muddy with some sand; diatoms abundant	yes	Sep 10 2017
HLY1702	129	S-3	71.3535	-161.3976	48	VV grab	H.sorbayana, Robertsonites, A.dunelmensis, Elofsonella, Cytheropteron spp, Paracypris	no aggultinated, very few forams, a few Nonion	some diatoms	yes	Sep 10 2017
HLY1702	130	S-4	71.2237	-161.30	50	VV grab					Sep 10 2017
HLY1702	131	S-5	71.0901	-161.18	47	VV grab					Sep 10 2017
HLY1702	132	S-6	70.9610	-161.08	46	VV grab					Sep 10 2017
HLY1702	136	DBO1.8	63 1.80	173 27.60	69	VV grab		few forams, Elphidium	black mud , silicious	yes	Sep 12 2017
HLY1702	138	DBO1.6	62 33.60	173 33.00	71	VV grab		few forams, Elphidium	fine silty mud , abundant diatoms	yes	Sep 12 2017
HLY1702	138	DBO1.6	62 33.60	173 33.00	71	HAPs scrape core top			fine silty mud		Sep 12 2017
HLY1702	140	DBO1.4	62 23.40	174 34.20	81	VV grab		few forams, Elphidium	fine silty mud		Sep 12 2017
HLY1702	142	DBO1.2	62 3.00	175 12.60	87	VV grab					Sep 13 2017

G.4 Caitlin A Meadows, The University of Chicago, Paleoecology

Purpose. The North Pacific Arctic waters are able to quickly erode aragonite. To understand the rate and process of erosion of biogenic aragonite, I planned to collect bivalve shells from key stations during the HLY1702 cruise and to preserve them with minimally erosive methods. The damage patterns found on these shells will help determine the rate of dissolution of cold water carbonate, the extent of pre-mortem erosion in acidic environments, and the effects of formalin and other preservation methods on shell integrity. The bivalves gathered here will also be added to ecologic data gathered throughout the DBO region.

Materials. 1 full Van Veen grab of material was collected from select stations (Table G.4-1). Of this material, only bivalve remains were kept. Each live collected bivalve was dissected to remove flesh, and each shell (live or dead collected) was cleaned in fresh water and dried. The rest of the grab was discarded.

Table G.4-1: Material collected while on board Healy, Live = live collected animals, only dissected and dried shells retained, Dead = dead collected, cleaned and dried shells.

#	Station Name	Lattitude (deg/min N)	Longitude (deg/min W)	Depth (m)	Equipment	Reps.	Live?	Dead?	Taxonomy Collected
0	Test	64 24.26	166 13.35	38	VV grab	1	N	Y	Bivalvia, Brachiopoda, Gastropoda
1	DBO3.8	67 40.59	168 56.91	50.7	VV grab	1	Y	Y	Bivalvia
2	DBO3.7	67 47.00	168 35.78	50.4	VV grab	1	Y	Y	Bivalvia, Gastropoda
8	DBO3.1	68 18.25	166 55.42	34	VV grab	1	Y	Y	Bivalvia
12	DBO4.5	71 29.42	163 22.61	42.1	VV grab	1	Y	Y	Bivalvia, Gastropoda
14	DBO4.4	71 21.82	163 00.03	44.8	VV grab	1	Y	Y	Bivalvia, Brachipoda, Gastropoda
26	DBO5.5	71 24.56	157 28.37	124.6	VV grab	1	Y	Y	Bivalvia, Brachiopoda, Bryozoa
121	SE-5	71 38.48	160 47.52	49.1	VV grab	1	Y	Y	Bivalvia
140	DBO1.4	62 23.25	174 34.46	71.1	VV grab	1	Y	Y	Bivalvia

G.5. Emily Osborne, NOAA OAR/Arctic Research Program Knauss Fellow

Based on modern time-series observations, the Arctic Ocean is experiencing ocean acidification at mid-depths and in the surface ocean at an expedited rate and it is expected to experience the largest net decline in pH over the coming century. While modern observations are critical to our understanding, they are especially limited in the Arctic, highlighting the need and importance for paleo reconstructions that can shed light on past change. Recent developments in paleo-pH proxies provide exciting opportunities to reconstruct past carbonate chemistry of seawater and have yet to be applied to the Arctic sedimentary record. Sediment cores (20 cm) collected at approximately 60 (52/W-12; 72˚52’79, 166˚50’94) and 1,200 (76/NNE-76; 73˚19’28, 160˚08’92) meters water depth on the Chukchi shelf and slope will be used to generate paleo-pH reconstructions. The shallow shelf core will likely have considerably higher sedimentation rates and will allow for a more detailed pH history while the deeper slope sediment core will likely represent a longer period of time facilitating a glacial-interglacial reconstruction. The shelf and slope cores will be spliced together to compare relative changes forced by recent anthropogenic and long-term natural variability/change over short and long time-scales. Surface and bottom water pH will be estimated based on the trace boron concentrations of planktonic and benthic foraminifera. Dissolved boron in seawater is present in two chemical species, borate ion and boric acid, that shift in relative concentration based on the carbonate chemistry or pH of seawater. Foraminifera secrete their calcium carbonate shells in equilibrium with ambient seawater and incorporate only the tetrahedral form, borate ion, therefore trace amounts of boron in carbonate shells has proven to be an excellent paleo-pH proxy. Due to the limited number of individual foraminifera that are expected in these sediment records, we plan on analyzing individual foraminifera shells (rather than bulk population geochemistry) by using laser ablation ICP-MS capable of measuring 30 µm spots. Existing modern calibrations relating boron concentrations or B/Ca ratios of species that are commonly found in the Arctic (*Neogloboquadrina pachyderma* (planktic), *Cibicidoides spp.* (benthic) and *Uvigerina spp.* (benthic)) will be use to quantitatively estimate surface and bottom water pH (e.g. Yu and Elderfield, 2007; Quintana Krupinski et al., 2016; Osborne et al., *in prep*). A series of core-top samples and coeval CTD carbonate chemistry profiles collected as a part of the HLY1702 mission will also be analyzed to supplement modern pH-boron relationships, increasing the robustness of existing relationships and applicability to the Arctic environment. In addition to B/Ca we also plan to measure magnesium to calcium ratios (Mg/Ca) as a temperature proxy and $\delta^{18}O$ as a temperature/salinity/ice mass proxy. Total abundance and species counts of planktonic and benthic foraminifera species, % opal and inorganic carbonate, sediment grain size analyses and bulk sediment geochemistry will also be analyzed to improve the interpretation of these paleo records.

G.6 Chelsea Wagner, CBL/UMCES

Sediment collected from the van Veen grabs and the HAPS corer will be used to investigate primary production and POC fluxes to the benthos, further exploring the concept of a sediment "food bank" important for the benthic community. Diatoms are the primary producers of interest. There have been limited studies in the Arctic regarding the abundance and contributions of diatom resting spores (RS) in the sediment. There is not yet consensus about which conditions trigger RS formation (e.g. nutrient limitation, light availability, temperature, etc.). The identification of resting spores in the sediment could help to answer questions about when and where these blooms have occurred, identifying open-water versus sea ice species, POC fluxes to the sea floor, viability in the sediment, resuspension processes, and contributions to the Chukchi Sea benthic food web.

A number of surface sediment samples have been collected throughout the cruise that could lend to a spatial analysis, investigating latitudinal gradients in diatom community composition. Diatoms may also be useful indicators of sea ice conditions over the past few decades and through the deglacial. The deep core at station 76/NNE-14, among others collected, and the diatoms within are of key interest for possible IP-25 analysis. This study of diatoms in the sediments could lend to a better understanding of the historical, modern and future conditions of the Chukchi Sea (Table B5).

Table B5. L ist of stations sampled during the Healy 1702 cruise by Chelsea Wegner.

HAPS Core Summary

Station	Site ID	Latitude N	Longitude	Approximate Depth (m)	Core Length	Core Sections (cm)
0	Test Cast	64.4072	-166.2264	38	16	2
2	DBO3.7	67.7844	-168.6005	59	18	2
10	DBO4.6	71.6191	-163.7724	43	18	2
20	DBO5.10	71.6213	-157.9239	65	18	2
52	W-12	72.8718	-166.8425	58	22	2
60	NW-8	72.4267	-162.6409	43	18	2
76	NNE-14	73.3292	-160.1618	1281	20	1
76	NNE-14	73.3292	-160.1618	1281	~16*	1
138	DBO1.4/SLIP3	62.39	-174.5700	81	22	2

*Core barrel slipped off while sectioning and disrupted the bottom of the core.

Surface Sediment Summary

Station	Site ID	Latitude N	Longitude	Approximate Depth (m)
0H	Test Cast	64.4072	-166.2264	38
2	DBO3.7	67.7844	-168.6005	59
2H	DBO3.7	67.7844	-168.6005	59
3	DBO3.6	67.9008	-168.2352	62
4	DBO3.5	68.01317	-167.8730	54
5	DBO3.4	68.1277	-167.4943	50
9	HAB Station	69.5815	-164.7790	32
10	DBO4.6	71.6191	-163.7724	43
10H	DBO4.6	71.6191	-163.7724	43
20	DBO4.1	70.9733	-161.9095	46
21	DBO5.10	71.6213	-157.9239	65
21H	DBO5.10	71.6213	-157.9239	65
22	DBO5.9	71.5767	-157.8286	70
29	DBO5.2	71.28715	-157.2558	58
30	DBO5.1	71.2487	-157.1633	65
36	SW-6	71.6990	-163.2610	41
38	SW-8	71.9027	-162.6870	39
40	SW-10	72.1046	-162.1134	33
42	W-2	72.124	-163.2350	33
44	W-4	72.2125	-164.1642	44
52	W-12	72.8718	-166.8425	58
52H	W-12	72.8718	-166.8425	58
53	NW-1	73.0360	-163.4280	100
56	NW-4	72.8516	-163.1643	74
60	NW-8	72.4267	-162.6409	43
65	NNE-3	72.4705	-161.5522	47
66	NNE-4	72.5932	-161.3600	47
68	NNE-8	72.8345	-160.9667	91
70H	NNE-8	72.8345	-160.9667	91
112	E-6	71.8243	-159.6928	49
119	SE-3	71.4853	-160.0930	51
128	S-2	71.4823	-161.5130	49
128H	S-2	71.4823	-161.5130	49
130	S-4	71.2237	-161.3008	49
132	HAB #2	70.56633	-163.7445	N/A
134	DBO-1.8	63.0300	-173.4600	69
136	DBO-1.6	62.5600	-173.5500	71
138	DBO-1.4	62.3900	-174.5700	81
140	DBO-1.2	62.0500	-175.2100	87

H=HAPS Core Surface Material

G.7 Chris Paver, NOAA
Two tests were made via collection of silica nutrients in relation to errors associated with CTD rosette bottle collections. In additon, approximately 7 tests were made of the impacts of botte integrity on salinity measurements.

G.8 Acknowledgments

We thank the Captain and crew of the USCGC Healy for operational logistics and support for deck sampling during the cruise. We also thank Dr. Robert Pickart/WHOI for serving as Chief Scientist on the cruise. STARC technical support was appreciated for scientific data collections and computer support. We thank the DBO-NCIS collaborators and their shipboard teams for assistance in sampling and processing, as well as help with data management during the cruise. We also appreciate all the effort provided by graduate students during the cruise. Salary stipend support by these participants was provided by the following institutions: Reed Brodnik (UMCES), Caitlin Meadow (University of Chicago), and Chelsea Wegner (UMCES). Salary support for the following non-graduate student participants during the cruise is indicated in parentheses: Ms. Laura Gemery (USGS), Dr. Cedric Magan (UMCES), Chris Paver (NOAA), and Emily Osborne (ARP Knauss Fellow Program). Travel support for almost all of the graduate students and early career scientists on our was provided through the NOAA ARP program courtesy of Dr. Jeremy Mathis.

Section H: Mesozooplankton and larval fish

Contributing authors: Morgan Busby (morgan.busby@noaa.gov) and Elizabeth Logerwell (libby.logerwell@noaa.gov)

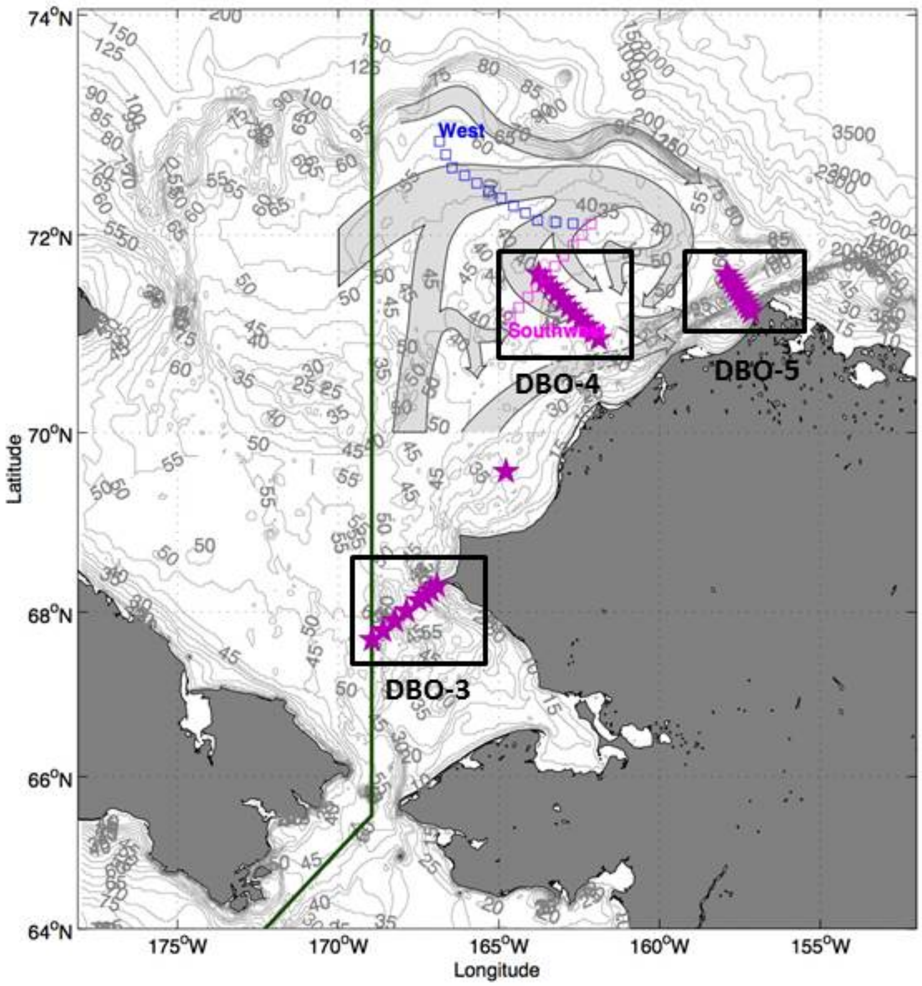
Healy DBO/NCIS Cruise update 30 August 2017

We arrived at the outer DBO3 station on Tuesday morning (29 August) around 7:00 am (local time) and completed the 8 station line by around 4:00 am on Wednesday morning (30 August). Samples collected at the two outermost stations were clogged with filamentous algae and gelatinous macrofauna including some bratwurst sized ctenophores with cilia tracts that glowed blue when agitated. Some crab larvae and numerous larvaceans were also present. The next station inshore (sampled in daylight) was very clean and had numerous small euphausids and a lone Arctic cod larva. Copepods and pteropods (*Clione* spp., no shells) began to show up in samples in the middle stations of the line in moderate numbers. Several larvae of capelin, and single yellow fin sole and Bering flounder were seen in samples from the two nearshore stations along with large euphausids (collected at night) and small pteropods (*Limnacina* spp. with shells). We arrived at the outermost station of DBO4 at 7:30 pm local time Wednesday 30 August. Weather was outstanding during the transit and generally good with the exception of a brief gale (about 4-6 hours) yesterday afternoon.

Healy DBO/NCIS Cruise update 02 Sept 2017

Sampling generally progressed smoothly and as of Friday evening we are nearly two days ahead of schedule. We completed the DBO4 line (Map H-1) around 12:00 pm on Thursday 31 August. Six of 11 stations were "full" sampling stations. This consisted of a CTD with 24 bottles, 60 + 20 cm bongo tow, and 2 or more Van Veen grabs and Haps core samples at some. The demand for seawater from the bottles is great with several projects going on including ocean acidification, microbes, and of course nutrients and chlorophyll to name just a few. Zooplankton along this line was more consistent than DBO3 with small jellies, pteropods, euphausids, and crab larvae present at all stations. Copepods were abundant at the outer half (three stations) of the line.

We arrived at the outermost DBO5 station at 7:30 local time on Thursday, 31 August and completed the 10 station line by 4:30 local time Friday 01 September. We had finally arrived in the realm of ichthyoplankton as transformation and early juvenile stage Arctic cod were caught at every station and several were frozen for stable isotope and otolith studies. Other species encountered were pricklebacks (slender eelblenny, *Lumpenus faricii* and daubed shanny, *Leptoclinus maculatus*), and sculpins (*Myoxocephalus scorpius* and *Gymnoanthus tricuspis*). Taxonomic composition of zooplankton on this line was relatively consistent on this line compared to others. Small-medium sized light-colored copepods were present throughout but in higher abundances at the inshore stations. Chaetognaths were abundant at the central stations and crab larvae were also present. The map shows the DBO stations we completed as of Friday afternoon. We are now beginning Phase 2 of our survey; The "Northern Chukchi Integrated Survey" (NCIS) that will take us to the shelf break, slope' and beyond. Some of these stations are shown in pink and blue squares labelled southwest and west.



Map H-1. DBO/NCIS Surveys as of Friday Evening 01 September 2017

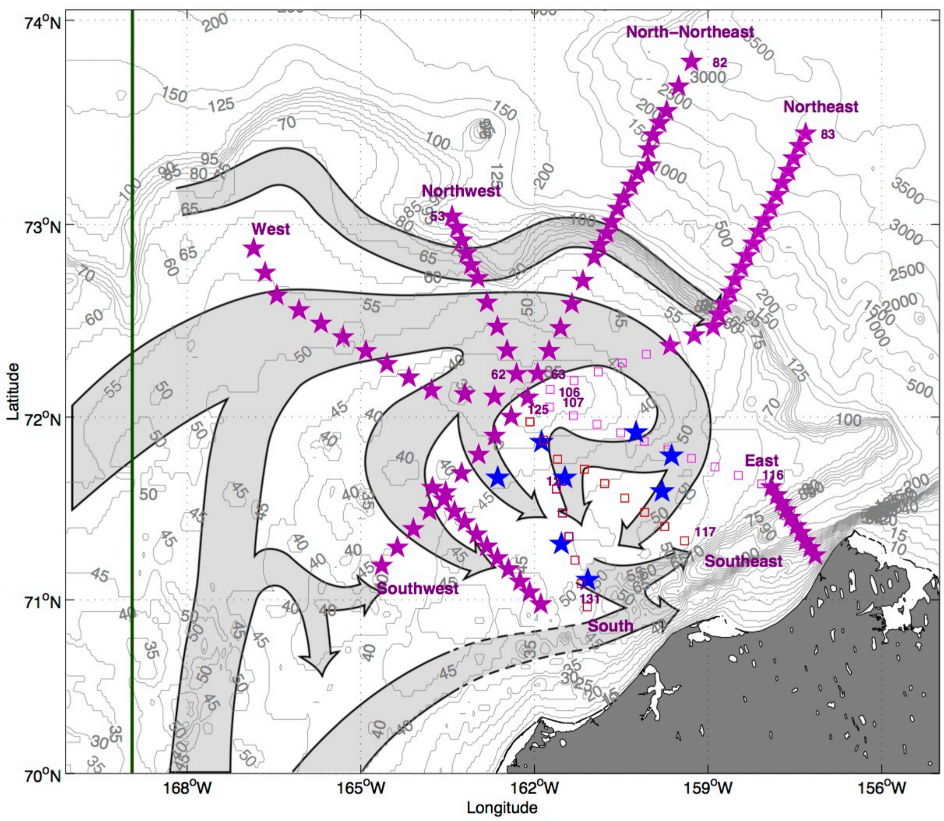
Healy DBO/NCIS Cruise update 08 Sept 2017

We began sampling the Northern Chukchi Integrated Survey (NCIS) stations around 2:00 am local time Saturday 2 Sept at the westernmost end of the southwest line (Map H-2). The lines of stations are oriented like spokes in a wagon wheel radiating out from Hana Shoal in the center. Five evenly-spaced stations were occupied on this "spoke" that included each end. Transformation stage Arctic cod were caught only at the most western station as were numerous crab zoea. Copepod abundances increased at the next three stations with the 4th being the greatest density seen on the entire cruise thus far; large orange-colored individuals. Small ctenophores, hydromedusae, and a few amphipods and pteropods were also caught. The largest pteropods with shells (*Limnacina*) I've ever seen, close to the size of peas, were at the eastern station. There were also several *Clione*.

A few fish were caught on the six stations we sampled on the West Line including Arctic alligatorfish, Arctic sand lance (single individuals), and a few Arctic Cod. Zooplankton was taxonomically diverse and included some euphausids, mysids, and hermit crab larvae. Chaetognaths appeared towards the outer half of the line as did large jellies; *Chrysaora* and *Cyanea*. Thick filamentous green algae was present at the outermost station similar to stations 1 and 2 on DBO3 and copepods were smaller. Zooplankton species composition (and presence of algae) on the Northwest Line was similar to the West and for the first time we noted the presence of echinoderm larvae. Quite a few more Arctic cod were caught on this line and the first Saffron cod *(Eleginus gracilis)* at the station closest to the hub. Slender eelblenies (*Lumpenus fabricii*) were also present.

Seven stations were sampled along the North-Northeast Line beginning early Monday afternoon. Arctic cod larvae or juveniles were caught at all but one station (including one in a Van Veen grab) and were also caught in 20 cm bongos. Copepods near the center were small and light colored in appearance but were replaced by much larger reddish colored individuals when we reached the slope and deep basin. Large chaetognaths also became prevalent. We decided to do a bongo to 300 m at the final scheduled station (80; NNE-18 on the 2000 m isobath) just to see if there were any fish far off of the shelf. The answer was yes but even more interesting is the Chief Scientist determined that the station was in the center of an anticyclonic warm-core eddy. Two CTD stations were added to find the edge of it. These features are uncommon but are the main process by which Chukchi Shelf Water is forced into the Beaufort Gyre.

Weather deteriorated severely as we worked our way towards the hub on the Northeast Line. We had planned to collect a slope series of samples at 300, 200, 100, and 75 m depths but only completed the first two before operations were stopped. However, Arctic cod larvae were present at both the 300 and 200 m stations. As of 0800 local time on Friday 08 Sep, were are sampling on the East Line from the hub out and are no longer ahead of schedule.



Map H-2. DBO/NCIS Surveys as of Thursday night 07 September 2017. Blue stars represent known benthic "hot spots".

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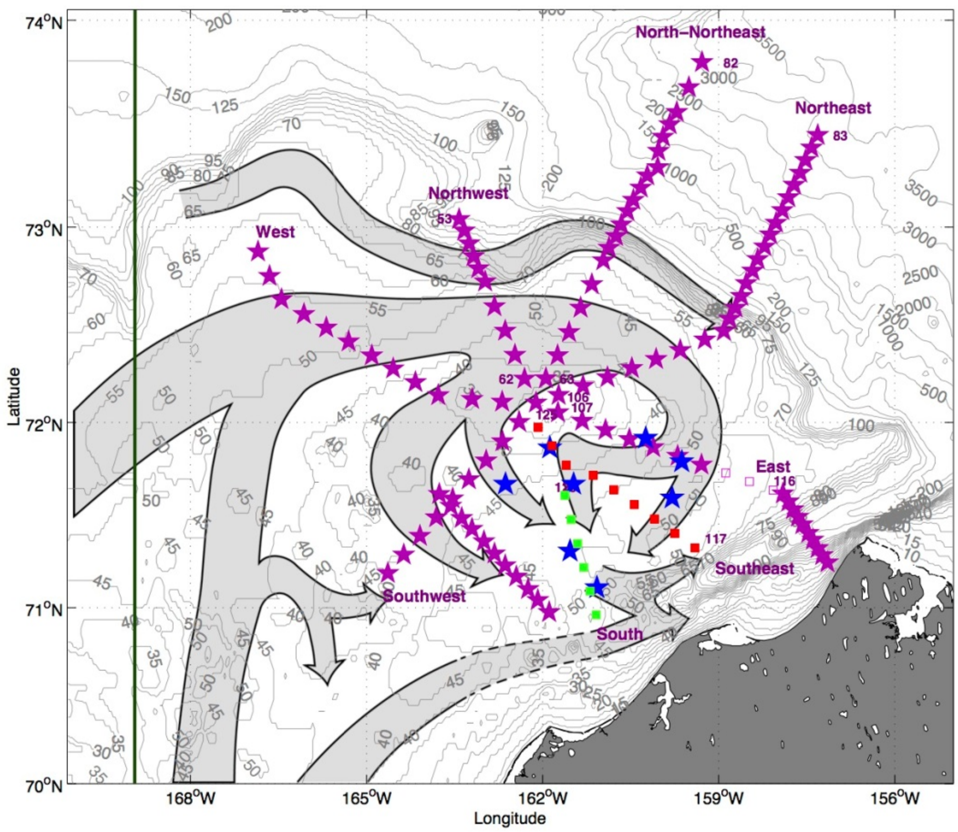
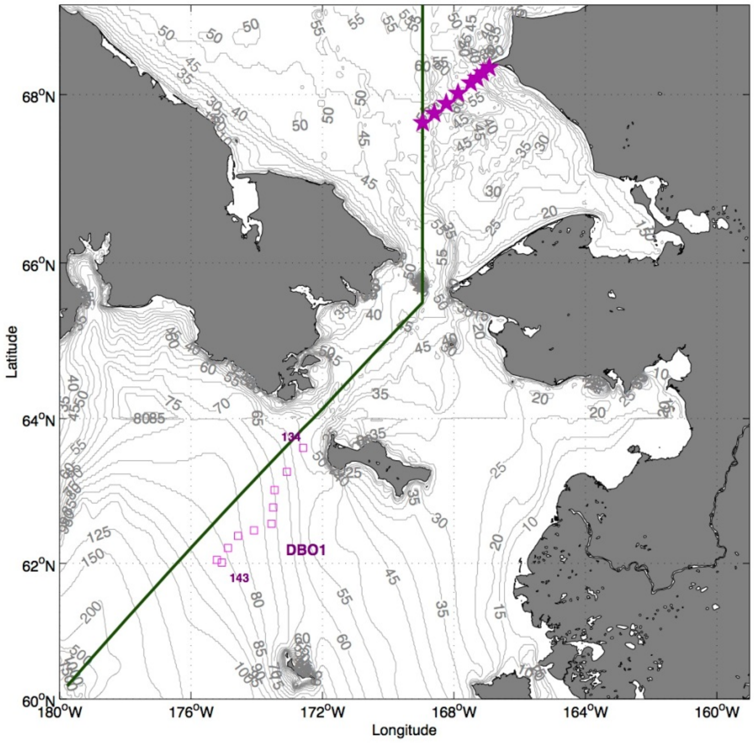
We completed four stations on the east spoke of the wheel around 2000 local time on Friday 08 September. The "E" line (Map H-3) was generally the lowest diversity and also likely the lowest biomass of the entire survey with samples dominated by small, clear, gelatinous zooplankton mostly hydromedusae and ctenophores. The outermost station, E-10, was the exception with juvenile fish (sculpin, *Gymnocanthus tricuspis* and prickleback , *Lumpenus fabricii*), with many both small and large copepods, chaetognaths, and a very large *Clione* (30 mm). Over the next two days (9 and 10 Sept.) we sampled the southeast and south spokes. More fish were caught at these stations; mostly transformation stage Arctic cod, but also Arctic alligatorfish and pricklebacks. Copepods (not in great abundance) dominated samples on the "SE" line. Euphausids, mysids pteropods, echinoderm larvae and a few crab larvae were also present as were large *Chrysaora*. On the south ("S") line we made a slight diversion to the east between stations S-1 and S-2 to do a calibration tow near a UAF mooring. Samples at three stations along or near this line were also generally low zooplankton diversity and low biomass but several more fish were caught including the first snailfish (*Liparis tunicatus*) seen.

It was determined before the completion of the "S" line that we had enough time to sample at DBO-1 near St. Lawrence Island on the return to Dutch Harbor (Map H-4). We arrived around noon local time on 12 September and were able to collect samples at four stations on this line. These samples were full of large orange copepods visibly full of lipids. Chaetognaths were also very abundant. One postflexion yellowfin sole (*Limanda aspera*) larva was picked from net 2 and the presence of a walleye pollock egg was noted in a dish of plankton that we closely examined (there were likely more). This area can be generally categorized as high biomass and low species diversity for zooplankton. Operations were suspended at 0400 local time 13 Sept. to steam to Dutch Harbor ahead of a building low pressure cell. As a side note, DBO regions 1-5 were all sampled by bongo and CTD within one month as the northern Bering Sea EMS cruise (Jim Murphy et al.) sampled DBO-2.



Map H-3. DBO/NCIS Survey plan on Friday night 08 Sept. 2017. By Sunday Morning 10 September all South and Southeast stations were completed. Blue stars represent known benthic "hot spots".



Map H-4. Stations of DBO-1 (pink squares). Stars represent DBO3 stations completed earlier in survey.

Preliminary conclusion:

Larval and early juvenile Arctic cod (*Boreogadus saida*) were generally more abundant in Barrow Canyon and over the Chukchi slope than on the shelf.

Section I: Ice Nucleating particles over the Arctic Ocean

Contributing author: J. Creamean (jessie.creamean@noaa.gov)

Objective: To evaluate the efficiency in which aerosol particles from local and distal sources have the potential to impact Arctic cloud ice formation.

Methods:

1. Real-time measurements of total particle mass concentrations, number concentrations, and chemical composition (i.e., concentrations of select trace metals including Al, As, Ca, Cr, Cu, Fe, K, Mn, Ni, Pb, S, Si, Ti, V, and Zn)
2. A series of two collectors for physical samples of aerosols for size-resolved offline ice nucleation measurements
3. One collector for physical samples of aerosols for size-resolved single-particle chemistry

4. Three Petri dish vanes to collect samples for offline culturing and DNA sequencing
5. Collection of seawater samples from underway system and CTD for source characterization
6. Offline ice nucleation analysis includes using a Peltier cold plate and circulated refridgerant to conduct drop freezing assays (DFAs). The fraction of frozen drops per 0.5°C-increment is used to calculate the number of ice nucleating particles (INPs) per mL. Triplicate tests are run per sample.

Initial results: The ultrapure water system onboard was not clean enough for ice nucleation (i.e., DFA) analysis of aerosol samples from collectors on O2 deck. Thus, daily underway samples collected around 1500 – 1600 UTC were analyzed in addition to select CTD profiles at various DBO, NCIS, and HAB locations. Figure I-1 shows cumulative ice nucleation spectra for the daily underway samples, demonstrating the range of INP concentrations at subzero temperatures at the surface. Freezing was initiated as high as -8°C and finished at as low as-28°C, indicating these particles are relevant for Arctic mixed phase cloud (AMPC) formation. These results have not yet been corrected for salt freezing point depression. Figure I-2 shows similar spectra from the CTD cast at DBO5.1, indicating very efficient (i.e., warm temperature) INPs at the surface, and less—but still on the higher end of—efficient INPs at all levels below the surface.

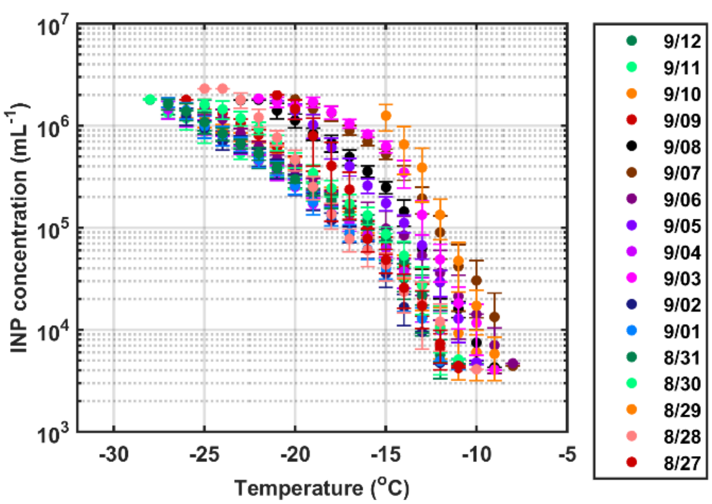


Figure I-1. Cumulative ice nucleation spectra from the daily underway seawater samples.

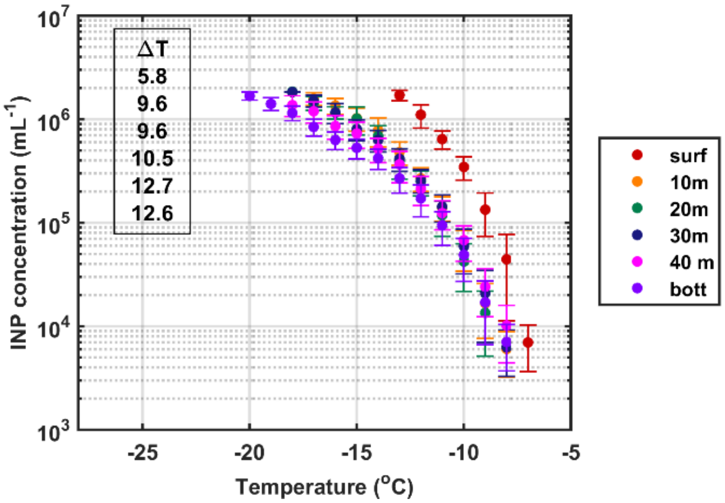


Figure I-2. Cumulative ice nucleation spectra from the CTD bottles of DBO5.1.

Other remarks: The crew was very helpful with equipment placement and loading. In particular, Miguel Espinosa (electrician) helped waterproof equipment and power cables, and modified one of my samplers to prevent electrical grounding. I want to acknowledge the crew for the extra effort in making these measurements successful.

Section J: N_2O isotopomers, dissolved gas concentrations (N_2, Ar), and NO_3^- and NO_2^- isotopes

Contributing author: A. Bourbonnais (abourbonnais@whoi.edu)

N_2O isotopomer

Samples for N_2O isotopomer analysis were collected at 59 stations. We generally collected duplicates at each depth. In total, approximately 620 samples were collected.

Samples for dissolved N_2O were collected in a similar fashion as for dissolved $O_2/N_2/Ar$ samples (see Charoenpong et al., 2014). Tygon tubing was attached to the Niskin bottle and a 165 mL serum glass bottle was filled and overflowed with seawater at least 2 times before capping with a butyl stopper and crimp sealed with aluminum seal. This procedure was executed underwater in a plastic container to avoid air bubbles. After collection, 0.2 mL of a saturated $HgCl_2$ solution was injected to prevent biological activity.

Samples will be analyzed at UMass Dartmouth using a GV IsoPrime Continuous Flow, MultiCollector, Isotope-Ratio Mass Spectrometer (CF-MC-IRMS) coupled to an automated gas extraction system similar to what is used for $O_2/N_2/Ar$ samples (Charoenpong et al., 2014). Our IRMS has the necessary collector configuration for simultaneous determination of masses 30, 31 (for SP) and 44, 45, and 46 (bulk $\delta^{15}N$ and $\delta^{18}O$). A multiple point calibration of several N_2O

gases of known $^{15}N^{a}$-$^{15}N^{b}$ (as well as bulk $\delta^{15}N$ and $\delta^{18}O$) will be applied (see Mohn and al., 2014). Standard deviations for triplicate measurements of our N_2O standards are typically below 0.1‰ for $\delta^{15}N^{bulk}$-N_2O, 0.1‰ for $\delta^{18}O$-N_2O and 1.0‰ for SP.

N_2O concentrations in our samples will be calculated from relative peak heights between the samples and a seawater standard of known N_2O concentration equilibrated with seawater at 5°C (12.5 nmol L^{-1} at salinity 34 as calculated using the Weiss and Price (1980) equation). Equilibrium N_2O concentrations will be estimated using the global mean contemporary atmospheric N_2O dry mole fraction at the time of sampling (http://agage.mit.edu/data/agage-data).

N_2O production from ^{15}N-labeled incubations

We performed ^{15}N-labeled incubations to measure N_2O production at selected depths and stations (stations 5, 20, 27, 42, 56, 91, 116, one depth per station) with the following treatments:

1) 10 µM ^{15}N-NH_4^+ + 1 µM ^{14}N-NO_2^-
2) 10 µM ^{15}N-NO_2^- + 1 µM ^{14}N-NH_4^+
3) 1 µM ^{15}N-NH_4^+ + 1 µM ^{14}N-NO_2^-
4) 10 µM ^{15}N-NH_4^+ + 1 µM ^{14}N-NO_2^- + 0.2 mL 12.5% HCl to decrease the pH (0.3 to 0.4 units)

All treatments were incubated at *in-situ* temperature (about 0 ºC) at 3 different time points: 0, 48 and 72 hrs in duplicate at station 116 and triplicate at all other stations.

Sediment core sampling for N_2O concentrations

Sediment cores (HAPS corer) were collected at 11 stations and sub-sampled using 3 mL syringes. 4 samples (3 mL subcores) were collected every cm down to about 20-30 cm depth in the sediments. These samples will be analyzed for N_2O concentrations and stable isotopes and isotopomers if possible (see above).

Pore water was also extracted using Rhizons by Cedric Magen at all core stations. Sub-samples were collected for nutrient concentration (NO_3^-, NH_4^+, PO_4^{3-}, and Si_4^+) and stable isotope analysis if possible.

References:

Charoenpong, C. N., L. A. Bristow, and M. A. Altabet (2014), A continuous flow isotope ratio mass spectrometry method for high precision determination of dissolved gas ratios and isotopic composition, *Limnol. Oceangr.: Methods*, *12*, 323–337.

Mohn, J. et al. (2014), Inter-laboratory assessment of nitrous oxide isotopomer analysis by isotope ratio mass spectrometry and laser spectroscopy: current status and perspectives, *Rapid Commun. Mass Spectrom.*, *28*(18), 1995–2007.

Dissolved gases

Samples for N_2/Ar analysis were collected at 53 stations. In total, approximately 600 duplicate N_2/Ar samples were collected at each depth in 60 mL serum glass bottles and preserved with

500 µL HCl 25%.

N_2/Ar and $\delta^{15}N_2$ analyses will be made onshore in Dr Altabet's laboratory at UMass Dartmouth. Water samples will by pumped, at 5 to 10 ml min^{-1}, through a continuous sparger which transfers dissolved gases quantitatively to a continuous flow of He carrier gas. Dissolved gas samples require no preparation in the lab and analysis time is about 10 min. Carrier gas is passed through water, CO_2, and software selectable hot-Cu O_2 traps before admittance via an open split to an IRMS. O_2 removal improves the precision of the N_2/Ar and $\delta^{15}N_2$ measurements and eliminates analytical bias associated with changing sample O_2/N_2. Our GV IsoPrime IRMS is fitted with sufficient collectors for simultaneous measurement of N_2 (masses 28 and 29), O_2 (masses 32, 33, and 34), and Ar (mass 40). Gas and isotopic ratios are measured against artificial compressed gas mixtures of N_2, O_2, and Ar close to expected dissolved gas ratios. These reference mixtures are in turn calibrated against compressed air cylinders provided and certified by Ralph Keeling (Scripps Institution of Oceanography). Reproducibility of N_2/Ar and $\delta^{15}N$-N_2 is better than 0.5 ‰ and 0.05 ‰, respectively. Daily calibration is against water equilibrated with air at precisely controlled temperatures of 10.0 and 20.0 °C. Excess (biogenic) N_2 will be initially calculated against equilibrium values expected from *in situ* temperature and salinity (see Charoenpong et al., 2014 for more methodological details).

Reference:

Charoenpong, C. N., L. A. Bristow, and M. A. Altabet (2014), A continuous flow isotope ratio mass spectrometry method for high precision determination of dissolved gas ratios and isotopic composition, *Limnol. Oceangr.: Methods*, *12*, 323–337.

NO_3^- and NO_2^- isotopes

Samples for dissolved nitrogen isotope (NO_3^- and NO_2^-) analysis were collected at approximately 60 stations (no duplicate). In total, approximately 400 samples have been collected for NO_3^- and NO_2^- isotope analysis.

Samples for N and O isotopic composition of NO_3^- were collected in 60 mL plastic bottles and frozen. For NO_2^- isotopic analysis, samples were collected and preserved with NaOH (1 mL of 6M NaOH, pH=12.5) to prevent oxygen isotope exchange with water during storage.

The stable isotopic compositions ($\delta^{15}N$ and $\delta^{18}O$) of NO_3^- and NO_2^- will be analyzed onshore in Dr. Altabet's laboratory at the University of Massachusetts (UMass) Dartmouth using the "azide method" (McIlvin and Altabet, 2005). For NO_3^- and NO2- isotopic analysis, NO_3^- will be quantatively converted to NO_2^- and then N_2O using sodium azide in acetic acid. N_2O gas will be automatically extracted, purified, and analyzed on-line using a purge-trap preparation system coupled to an IsoPrime CF-IRMS. Standard sample size is generally 20 nmol N_2O for NO_3^- isotope analysis and 15 nmol N_2O for NO_2^- isotope analysis. N and O isotope ratios are reported in per mil (‰), relative to AIR-N_2 for $\delta^{15}N$ and to V-SMOW for $\delta^{18}O$. NO_3^- and NO_2^- isotope data will be calibrated using the publicly and certified references materials (e.g. USGS32, USGS34, and USGS 35) and other in-house standards; see Casciotti and McIlvin, 2007). The reproducibility is generally better than 0.2‰ for $\delta^{15}N$ and 0.5‰ for $\delta^{18}O$ in NO_3^- and NO_2^-.

References:

Casciotti, K. L., and M. R. McIlvin (2007), Isotopic analyses of nitrate and nitrite from reference mixtures and application to Eastern Tropical North Pacific waters, *Mar. Chem.*, *107*(2), 184–201.

McIlvin, M. R., and M. A. Altabet (2005), Chemical conversion of nitrate and nitrite to nitrous oxide for nitrogen and oxygen isotopic analysis in freshwater and seawater, *Anal. Chem.*, *77*(17), 5589–5595.

Table J-1. Summary of stations sampled for N_2O isotopomers, N_2/Ar and NO_3^- isotopes during HLY1702. Samples were taken at every depth in duplicates for N_2O isotopomers and N_2/Ar. * indicates that duplicates were only taken at every other depth for N_2O isotopomers. No duplicate was taken for NO_3^- isotopes samples.

Station #	N_2O isotopomers	N_2/Ar	NO_3^- isotopes	HAPS core
000	√	√	√	
001	√	√	√	√
003	√	√	√	√
005	√	√	√	
008	√	√	√	
010	√	√	√	√
012	√	√	√	
014	√	√	√	
016	√	√	√	
018	√	√	√	
020	√	√	√	
021	√	√	√	√
023	√	√	√	
025	√	√	√	√
026			√	
027	√	√	√	
030	√	√	√	
031	√	√	√	
033	√	√	√	
036	√	√	√	√
038	√	√	√	
040	√	√	√	
042	√	√	√	
044	√	√	√	
046	√	√	√	
048	√	√	√	
050	√	√	√	
052	√	√	√	
053	√	√	√	√
056	√	√	√	
060	√	√	√	
062	√	√	√	

066	√	√	√	√
070	√	√	√	
072	√	√	√	
074	√	√	√	
076	√	√	√	√
080	√	√	√	
083	√	√	√	
087	√	√	√	
091	√	√	√	
095	√*		√	
099	√*	√	√	
101	√*		√	
103	√*		√	
105	√*		√	
110	√*		√	
112	√*		√	
114	√*	√	√	
116	√	√	√	
124	√	√	√	
126	√	√	√	
128	√	√	√	√
130	√	√	√	
132	√	√	√	
134	√	√	√	
136	√	√	√	
138	√	√	√	√
140	√	√	√	
141			√	

Section K: Microbes

Contributing author: E. Collins (recollins@alaska.edu)

Aims

The goal of the Microbes group was to collect samples representing the full diversity of marine microbes in the Chukchi Sea, including free-living, particle-attached, host-associated, and benthic microbes, along with important metadata. In the lab at UAF we will conduct DNA barcoding to identify the bacteria, archaea, phytoplankton, and protists using 16S and 18S ribosomal RNA gene sequencing. In addition, we conducted experiments to assess functional gene expression of nitrogen cycling microbes with Annie Bourbonnais by RNA sequencing and shotgun metagenomics.

Our primary protocol was to filter microbes onto 0.2um filters to collect free-living microbes in different water masses. Second, we added a protocol to separate the microbial fraction by size class (>20um, 20um -> 3um, 3um -> 0.2um) to investigate the diversity of microzooplankton and particle-associated compared to free-living microbes. To characterize the associated particles, we also filtered seawater onto GFF filters to measure the mass of suspended particulate matter (SPM) and a chemical analysis of the SPM including POC, PON and nitrogen isotopes (A. Bourbonnais section). We collected zooplankton, microzooplankton and phytoplankton from the 153um BONGO net, and vertical profiles of sediment from HAPS cores.

During the cruise, an internal website was maintained to make data from the underway flow-through system and CTD casts easily available. Automatically-updated plots were provided of each flow-through parameter over time and space, along with plots of vertical profiles from CTD casts, section plots for each sampling line, and timelapse videos made from aloftconn imagery. Example plots are provided in Appendix 2. The website is provided on the Public folder under 'collinslab' and R scripts will be made available online at http://www.github.com/rec3141/underway.

Table K-1. Number of samples collected for each protocol.

Protocol	Total
Bacterial diversity	195
Microzooplankton diversity	96
Particle-associated microbial diversity	96
Suspended particulate matter/POC/PON	97
Sediment	100
Zooplankton	24
Total	**608**

Methods

Algae, protists, bacteria and archaea were collected from surface seawater, mid-depth waters (e.g. subsurface chlorophyll maximum), and bottom water by filtration of 1–5L of seawater through a 0.2µm Sterivex filter. For particle-attached microbes, seawater was filtered sequentially onto a 20um nylon filter, a 3um polycarbonate filter, and then onto a 0.22um Sterivex filter. Filters were preserved with RNA later and frozen. For measurements of suspended particulate material (SPM), 25mm GFFs were pre-weighed; for POC/PON, 25mm GFFs were pre-combusted. For each protocol, a known volume of water (500--1000 mL) was filtered onto each filter. Zooplankton and large microplankton were collected with a 153 µm net hauled obliquely; plankton were frozen immediately. One HAPS core from a number of stations was sampled for sediment microbes and meiofauna using 3cc syringes placed horizontally into the core at intervals of 1-2cm.

Incubation experiments for nitrogen cycling were conducted at stations DBO3.5, DBO4.1, DBO5.3, W-2, NW-4, NNE-9, and E-10. Sediment samples were collected at stations DBO3.6, DBO4.6, DBO5.10, DBO5.6, W-1, NNE-14, S-2, and DBO1.4.

Acknowledgements

Thanks to Annie Bourbonnais, Doug Shepard, and the Benthic Team for sediment sampling. Thanks to Morgan Busby and Emily Chandler for zooplankton sampling.

Section L: Marine mammal watch summary

Contributing author: S. Moore (sue.moore@noaa.gov)

A watch for marine mammals was conducted from the bridge of the USCGC HEALY (height = 18.3m) during the transit from Dutch Harbor to Nome, then to the DBO-NCIS study area in the NE Chukchi Sea, then southbound to DBO1 and return to Dutch Harbor. Most watches were conducted between 0730 and 2130, and included periodic scans around the ship when on station. The lone marine mammal watch stander was aided in spotting mammals by two seabird observers and the ship's crew. The purpose of the watch is to detect marine mammals and identify sightings to species at temporal and spatial sampling scales coincident with the oceanographic sampling. The overarching goal is to improve integration of upper-trophic species distribution and relative abundance with measures of biophysical variability in the Pacific Arctic marine ecosystem.

A total of 138 hours of watch effort was completed between 26 August and 14 September (Table L-1). Marine mammal sightings were tallied as the total number of sightings/total number of animals seen, by species. Gray whales were the most common cetaceans seen, with high counts in DBO regions 3 and 5, as well as along transits southwest of DBO region 5 (Table L-1). Humpbacks were also common, both in the southern Chukchi Sea and along the southbound track to Dutch Harbor. Bowhead whales were seen only on 9 September, near station S2, in the company of a variety of marine mammal species. Walruses were seen near Hanna Shoal, as the ship completed 'inner-spokes' along the sampling wheel (Table L-1: 30 August-4 September). Surprisingly, walruses were never seen in large groups near the shoal, only as threesomes, pairs (including Cow/calf) and singletons. Ringed and bearded seals were seen mostly in the northern half of the sampling wheel, while spotted seals were common nearshore and south. Humpback whales and Dall's porpoise were seen leaving and returning to Dutch Harbor, as usual.

Highlights

> 29 August: 97 gray whales, mostly between **DBO stations 3.8-3.5**. This is the center of the DBO 3 'hotspot', sometimes referred to as the 'gray whale garden'. Hundreds of gray whales

were reported feeding here in early June, during the ASGARD cruise.
> 1 September: 40 gray whales, comprised of 23 whales seen between **DBO stations 5.1-5.2,** and 15 whales on transit southwest of DBO 5. Several whales in the latter group were juvenile or recently-weaned animals that spy hopped, breached, lunged, and rolled on their sides with one in particular looking at the ship.
> 9 September: 10 bowhead whales seen between **stations S1-S2**, along with gray whales and 10,000s shearwaters. These stations are in the vicinity of the Chukchi Environmental Observatory (CEO) mooring (UAF/Seth Danielson), and appeared to be a dynamic 'hotspot' for foraging whales and seabirds.
> **11 September**: at least 80 humpback whales seen just north of Bering Strait, in an area roughly corresponding to the front between Alaska Coastal Water (ACW) and Bering Sea Water (BSW); approximate area boundary: 6650N-6625N, between 16730-16805W. Whales were actively and cooperatively feeding in groups of 3-5-8. Due to the dynamic nature of the feeding behaviors, numbers of whales in each group were rounded to the nearest five.

Table L-1. HEALY 1702: Marine Mammal Watch Summary
Hours of watch effort (EFT) and number of sightings/number of animals, by species

DATE	EFT	GW	HW	FW	CT	DP	WS	BS	RS	SP	FS	PN	BH	MW
8/26	6		5/16	1/2	1/1	3/21				2/5	2/2			
8/27	10											1/1		
8/28	4	3/14				1/5								
8/29	6	12/97												
8/30	11	1/1					4/12					1/1		
8/31	7						4/8					2/3		
9/1	8	7/40			1/1		2/4	5/8		3/20				
9/2	8	2/4					5/18	2/2				1/2		
9/3	11						2/4	1/2						
9/4	5						2/6		1/1					
9/5	2						1/1							
9/6	6								2/2					
9/7	--				**Gale**	**No**	**Watch**							
9/8	8								2/2					
9/9	10	2/10			1/2*		5/11	2/2		5/6			2/10	
9/10	6						4/27			3/3				
9/11	6	2/4	5/80	2/3	1/1					2/2				1/1
9/12	9		1/10		2/7	2/9				1/1				
9/13	12	1/2	2/3		3/7	3/19					2/4			1/1*
9/14	3		5/8	1/3	2/2	4/44					2/3			
Total	**138**	**30/172**	**18/117**	**4/8**	**11/21**	**13/98**	**29/91**	**10/14**	**5/5**	**16/37**	**6/9**	**5/7**	**2/10**	**2/2**

KEY: GW=gray whale; HW=humpback whale; FW=fin whales; CT=unID Cetacean (*likely bowhead) DP=Dall's porpoise; WS=walrus; BS=bearded seal; RS= ringed seal; SP = spotted seal; FS=fur seal; PN=unID Pinniped; BH = bowhead whale; MW = minke whale *seen with 2 Orca following!

Note: Orca pair seen on last two days: ½ = 2/4 total

Section M: Marine bird surveys

Contributing authors: Charles Wright, Brian Hoover, and Kathy Kuletz (kathykuletz@fws.gov)

At-sea observers: Charles Wright and Brian Hoover
Principal Investigator: Dr. Kathy Kuletz
U.S. Fish and Wildlife Service
Migratory Bird Management, Anchorage, Alaska

Background

In conjunction with the 2017 DBO-NCIS project, marine bird and mammal surveys were conducted by Charles Wright and Brian Hoover onboard the *USCGC Healy*. The cruise began in Dutch Harbor Alaska on 26 August, 2017. Surveys were conducted while the ship was underway across the Bering Sea and during all transits between stations in the Chukchi Sea study area. This report contains summarized data collected from 26 August to 12 September, although additional surveys were conducted through 14 September. The seabird component of this cruise was funded by BOEM (project AK-17-03: Marine Bird Distribution and Abundance in Offshore Waters). Data will be available for integration with the Arctic Integrated Ecosystem Research Project and will be archived in the North Pacific Pelagic Seabird Database (http://alaska.usgs.gov/science/biology/nppsd).

Methods

Surveys were conducted using U.S. Fish and Wildlife Service (USFWS) protocols. Observations were made from the port side of the bridge during daylight hours while the ship was underway. The observer scanned the water ahead of the ship and used hand-held 8 x 42 binoculars if necessary for identification. We recorded all birds and mammals within a 300 m, 90^o arc from the bow to the beam. We used strip transect methodology and four distance bins extending from the vessel's center line of transit: 0-50 m, 51-100 m, 101-200 m, and 201-300 m, and recorded the animal's behavior (flying, on water, on ice, foraging). Rare birds, large flocks, and mammals beyond 300 m or on the port side (off-transect) were also recorded but will not be included in density calculations. Birds on the water or on ice, or actively foraging were counted continuously. Flying birds were recorded during quick 'Scans' of the transect window, with scan intervals based on ship speed (typically about 1 per min). Observations were entered directly into a GPS-integrated laptop computer using the program DLOG3 (A.G. Ford Consultants, Portland, OR). Location data was also recorded automatically at 20 sec intervals, providing continuous records on weather, Beaufort Sea State, ice coverage, glare, and observation conditions.

Preliminary Results

A total of 2779.7 km were surveyed during the cruise, with 847.1 km in the Bering Sea and 1932.6 km in the Chukchi Sea. Sea ice was not encountered during the cruise. During this cruise we had to end survey effort twice due to fog (5 September), and were unable to survey on 7 September due to rough seas.

We recorded a total of 28 identified species of marine birds plus six identified genera comprising 8750 individuals (Table M-1). The most numerous species (in order of number of observations) included: short-tailed shearwaters (*Ardenna tenuirostris*) 60.4%, crested auklets (*Aethia cristatella*) 12.4%, long-tailed ducks (*Clangula hyemalis*) 5.3% and black-legged kittiwakes (*Rissa tridactyla*) 4.3%.

Seabird surveys were conducted during the transits from and to Dutch Harbor and during transits along DBO stations 1, 3, 4, and 5 in the northern Bering and Chukchi Seas. Surveys were also conducted along several transects originating from the Hanna Shoal region, as well as transits extending along the northwest Alaska coastline. These transect lines thus afforded the opportunity to survey coastal, shelf, and basin waters in the Chukchi, as well as parts of the northern and southern Bering Sea.

Short-tailed shearwaters were the most prevalent species observed in all regions of the survey, comprising 68.0% in the Chukchi Sea, 47.0% in the northern Bering Sea, and 37.4% in the southern Bering Sea (Fig. M-1a). Several large foraging aggregations of short-tailed shearwaters were observed on 9 September in the Chukchi Sea (*71.599998, 161.549332*), with 3032 shearwaters observed on effort during this day alone.

Three species of *Aethia* auklets (crested, least, and parakeet) comprised 16.9% of seabird observations in the Chukchi Sea, representing the second most commonly observed genera of seabirds (Fig. M-1b). These auklet species were less commonly observed in the northern Bering Sea, comprising only 8.0% of the seabird observations there. Black-legged kittiwakes (Fig. M-2a) were the second most common seabird observed in the northern Bering Sea (9.2%), while northern fulmars were the second most common seabird observed in the southern Bering (23.2%).

Several dead or visibly ill seabirds were observed during surveys (Fig. M-2b), but collection was not possible. Dead seabirds included a horned puffin, juvenile murre, and two short-tailed shearwaters. In addition, several weak or ill short-tailed shearwaters were recorded in the large foraging aggregation observed on 9 September. These individuals did not take flight or dive when the vessel transited nearby, and appeared to be too weak to fly or swim away.

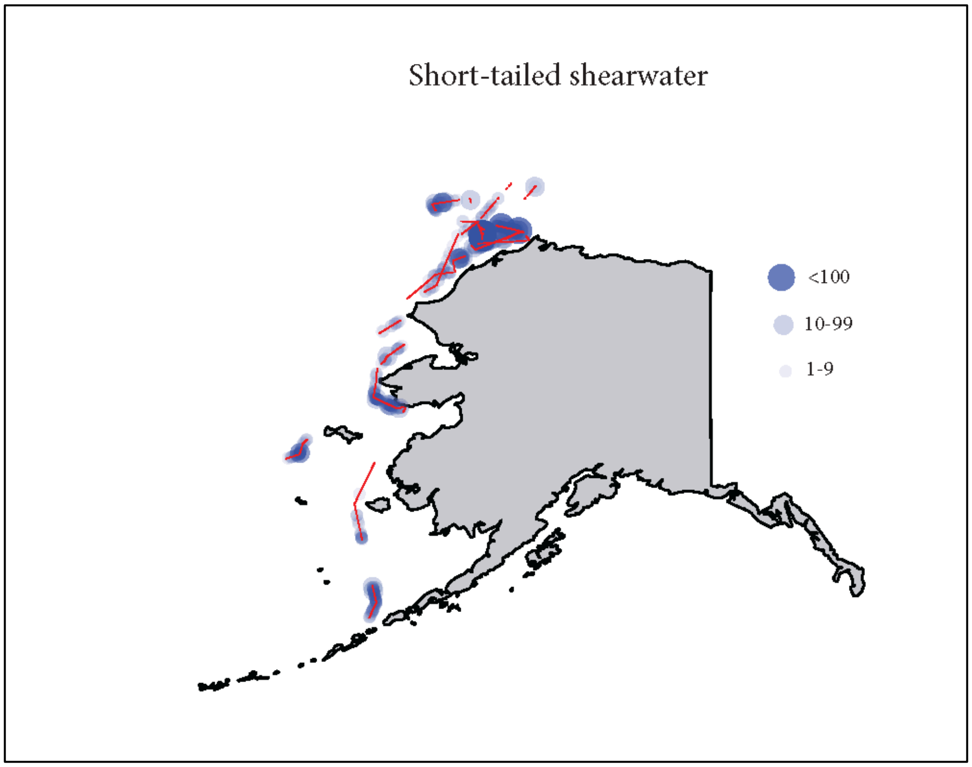
We conducted marine mammal observations as part of our survey on HLY1702. Marine mammal data presented in Table M-2 was collected using USFWS seabird survey protocols, and thus cannot provide corrected density calculations. During this cruise, marine mammal watches were conducted by Sue Moore from the NOAA National Marine Mammal Lab. The USFWS marine mammal observations documented 10 species and 314 sightings during the cruise. Species composition included bowhead whales, walrus, bearded seals, ringed seals, and unidentified seals and pinnipeds.

Table M-1. Marine birds recorded on-transect during HLY1702, 26 Aug – 12 Sep, 2017.

		Chukchi		**N. Bering Sea**		**S. Bering Sea**		**Total**	
Common Name	Scientific Name	No.	% total	No.	% total	No.	% total	No.	% total
Laysan Albatross	*Phoebastria immutabilis*					6	1.2	6	<0.1
Short-tailed Shearwater	*Ardenna tenuirostris*	4627	68.0	405	47.0	177	34.8	5209	63.8
Northern Fulmar	*Fulmarus glacialis*	11	.2	41	4.8	118	23.2	170	2.1
Fork-tailed Storm-Petrel	*Oceanodroma furcata*			1	.1	44	8.7	45	.6
Yellow-billed Loon	*Gavia adamsii*	4	<0.1			1	.2	5	<0.1
Pacific Loon	*Gavia pacifica*	45	.7	1	.1			46	.6
Loon spp.	*Gavia spp.*					1	.2	1	<0.1
Red-necked Grebe	*Podiceps grisegena*	3	<0.1					3	<0.1
King Eider	*Somateria spectabilis*	3	<0.1	1	.1			3	<0.1
Eider spp.	*Somateria spp.*			4	.5			84	1.0
White-winged Scoter	*Melanitta deglandi*			1	.1			1	<0.1
Long-tailed Duck	*Clangula hyemalis*	166	2.4					166	2.0
Red Phalarope	*Phalaropus fulicarius*	219	3.2	11	1.3			230	2.8
Red-necked Phalarope	*Phalaropus lobatus*	2	<0.1	53	6.2			55	.7
Phalarope spp.	*Phalaropus spp.*	63	.9	1	.1			64	.8
Parasitic Jaeger	*Stercorarius parasiticus*	11	.2	2	.2			13	.2
Pomarine Jaeger	*Stercorarius pomarinus*	11	.2	5	.6	4	.8	20	.2
Jaeger spp.	*Stercorarius spp.*	3	<0.1					3	<0.1
Arctic Tern	*Sterna paradisaea*	29	.4					29	.4
Black-legged Kittiwake	*Rissa tridactyla*	221	3.2	79	9.2	72	14.2	372	4.6
Glaucous Gull	*Larus hyperboreus*	43	.6	6	.7			49	.6
Glaucous-winged Gull	*Larus glaucescens*			2	.2	3	.6	5	<0.1
Herring Gull	*Larus argentatus*			5	.6			5	<0.1
Sabine's Gull	*Xema sabini*	20	.3			1	.2	21	.3
Gull spp	*Larus spp*	1	<0.1					1	<0.1
Common Murre	*Uria aalge*	1	<0.1	19	2.2	2	.4	22	.3
Thick-billed Murre	*Uria lomvia*	20	.3	26	3	9	1.8	55	.7
Murre spp	*Uria spp*	14	.2	10	1.2			24	.3
Ancient Murrelet	*Synthliboramphus antiquus*	17	.2					17	.2
Crested Auklet	*Aethia cristatella*	1016	14.9	24	2.8			1040	12.7
Least Auklet	*Aethia pusilla*	133	2.0	26	3	2	.4	161	2
Parakeet Auklet	*Aethia psittacula*	12	.2	20	2.3	1	.2	33	.4
Horned Puffin	*Fratercula corniculata*	8	.1	71	8.2	25	4.9	104	1.3
Tufted Puffin	*Fratercula cirrhata*	11	.2	44	5.1	39	7.7	94	1.2
Auklet spp	*Alcidae spp*	5	<0.1	2	.2	3	.6	10	.1
	total	6800	100	861	100	508	100	8166	100

Table M-2. Marine mammals recorded on-transect (within 300 m on port side) and off-transect (>300 m from vessel or on starboard side) during seabird surveys on the HLY1702 aboard the *USCGC Healy*, 26 Aug – 12 Sep, 2017.

Common name	Scientific name	On transect	Off transect
Gray Whale	*Eschrichtius robustus*	11	65
Humpback Whale	*Megaptera novaeangliae*	4	69
Bowhead Whale	*Balaena mysticetus*		7
Fin Whale	*Balaenoptera physalus*	1	1
Dall's Porpoise	*Phocoenoides dalli*	17	22
Northern Fur Seal	*Callorhinus ursinus*	2	2
Bearded Seal	*Erignathus barbatus*	10	3
Ringed Seal	*Pusa hispida*	2	
Seal spp	*Phocidae spp*	6	5
Walrus	*Odobenus rosmarus*	30	34



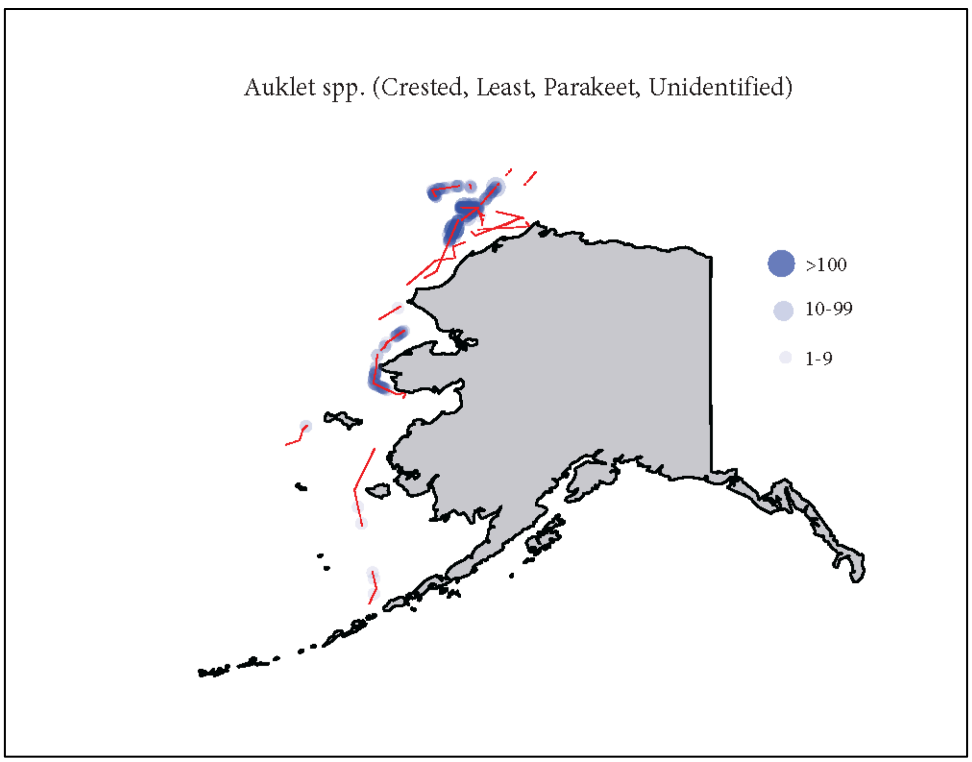


Figure M-1. Distribution of (a) short-tailed shearwaters, (b) Auklet spp. (crested, least, parakeet, and unidentified auklets) observed on transect during pelagic surveys aboard HLY1702 26 Aug – 12 Sep, 2017.

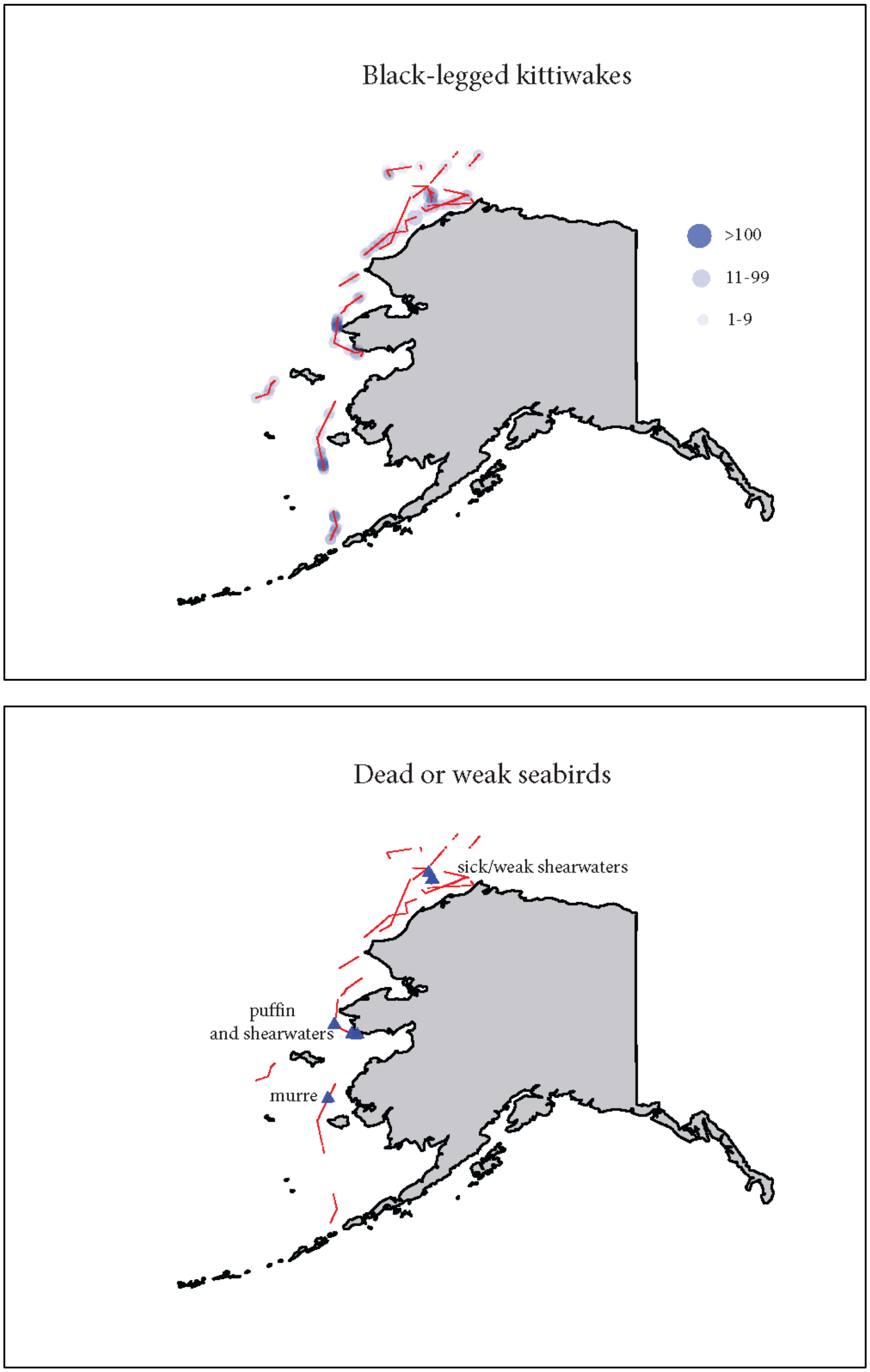


Figure M-2. Distribution of (a) black-legged kittiwakes, (b) dead or weak birds recorded on transect during pelagic surveys aboard HLY1702 26 Aug – 12 Sep, 2017.

Section N: Saildrone Survey

Contributing author: Jessica Cross (Jessica.Cross@NOAA.gov)

Project Title Arctic Glider Program

Funding Source NOAA Arctic Research Program

Principal Investigators

Jessica Cross
Oceanographer
National Oceanic and Atmospheric Administration (NOAA)
Pacific Marine Environmental Laboratory (PMEL)
7600 Sand Point Way NE
Seattle, WA 98115
Ph: 206-526-4314 Fax: 206-526-6744
Email: Jessica.Cross@NOAA.gov

Christian Meinig
Director of Engineering
National Oceanic and Atmospheric Administration (NOAA)
Pacific Marine Environmental Laboratory (PMEL)
7600 Sand Point Way NE
Seattle, WA 98115
Ph: 206-526-6149 Fax: 206-526-6744
Email: Christian.Meinig@NOAA.gov

Cruise Participants Jessica Cross, NOAA/PMEL

Project Summary

Climatic pressures are causing Arctic sea ice to melt back earlier, retreat over increasingly large areas, and freeze later. These changes have important implications for the marine environment and ecosystem services in this area. However, traditional ship-based mission operations are time, space, and cost-limiting in this harsh and expansive area. Now, new technologies are rapidly expanding NOAA's operational capacity in this region. These new tools represent a unique opportunity to cost-effectively monitor the continuing environmental transitions.

For this project, the NOAA Arctic Research Program partnered with the Innovative Technology for Arctic Exploration (ITAE) testbed with support from the NOAA Ocean Acidification Program to deploy two wind- and solar-powered autonomous surface vehicles ASVs in conjunction with the DBO-NCIS mission. These ASVs were equipped with new sensing technologies for sea-air carbon dioxide (CO_2) flux measurements. Adding this capability to ASVs is key to the NOAA

Climate Observation Division's central goal to constraining global anthropogenic CO_2 storage. Like ocean heat, increased open water area allows for great exchange of CO_2 between the atmosphere and upper ocean, contributing to accelerating rates of ocean acidification and decreases in ocean pH. saildrone CO_2 flux measurements represent a clear technological breakthrough that could fully survey the regional CO_2 sink and constrain the extent, duration, and intensity of ocean acidification events.

Methods and Mission Summary

The saildrone, a novel wind- and solar-powered ASV has been used with great success by the ITAE program during several development missions. ITAE scientists have co-developed this platform with Saildrone, Inc. to tailor its capabilities to NOAA's unique observational needs. Dramatically enhanced speed, endurance, and maneuverability allow the saildrone to launch and recover from shore and cover extremely large areas over extended research missions. These types of platforms are critical for growing Arctic research and monitoring needs.

The basic saildrone sensor suite measures a total of 58 parameters, providing information about meteorological and atmospheric conditions (winds, air temperature and humidity, barometric pressure, ocean skin temperature) and water properties (temperature, salinity, dissolved oxygen, and fluorescence) near the sea surface. This particular mission build also included sensing for surface water and atmospheric pCO_2 through the newly developed ASVCO2 system, from which sea-air CO_2 fluxes can be calculated.

Two saildrones were launched from Dutch Harbor in mid-July and initial calibration activities were conducted at the M2 mooring site in the Bering Sea alongside a long-term time series mooring that measures pCO_2. During this comparison, the ASVCO2 systems on the Saildrone and the MAPCO2 system at the M2 mooring matched closely, with a difference averaging < 5 µatm CO_2.

The saildrones then proceeded through Bering Strait, arriving in early August. From there, one saildrone SD1003 conducted six repeat observations of the DBO4 hydrographic line from August 10 – 12, and 7 repeat observations of the DBO5 hydrographic line from August 14-21. The other saildrone, SD1002, proceeded north across the center of Hanna Shoal and into the basin, reaching approximately 75 °N, approximately 7 nm from the ice edge. This transit was made safely using publically available ice products from the National Snow and Ice Data Center (NSIDC; MASAM-2) and a custom ice product from the U.S. National Ice Center (NIC). Together, these products help show a daily ice concentration and a 24-hour forecast for the 0% ice edge. SD1002 returned south to the outside edge of DBO5, and then proceeded west across the center Hannah Shoal, and south through the central channel in the Chukchi Sea.

Following these surveys, the saildrones each proceeded to DBO3 for a ship-to-saildrone calibration activity from USCGC *Healy*. Six repeat transects of DBO3 were conducted between August 25 and August 28. On August 29, the saildrones rendezvoused with *Healy* near 68 °N. Calibration samples were collected from the hydrolab underway system on *Healy* at 68° 00.867' N, 167° 52.066' W on 30 August 2017 01:38:06 UTC.

Following this activity, the Saildrones proceeded south through Bering Strait. Assistance with safety and operations of this crossing was provided by R. Pickart and M. Pisareva at Woods Hole Oceanographic Institute, who provided mean winds and currents as well as an ADCP transect of Bering Strait to show the ideal crossing point, and provide confirmation that wind direction is mostly southerly during this time of year, which aided us in navigation. The southerly crossing was made in approximately 17 kts of wind directly to the south.

After crossing through Bering Strait, the drones conducted a brief survey of the inner shelf of the Bering Sea north of Nunivak Island. Recovery took place in Dutch Harbor on 29 September 2017.

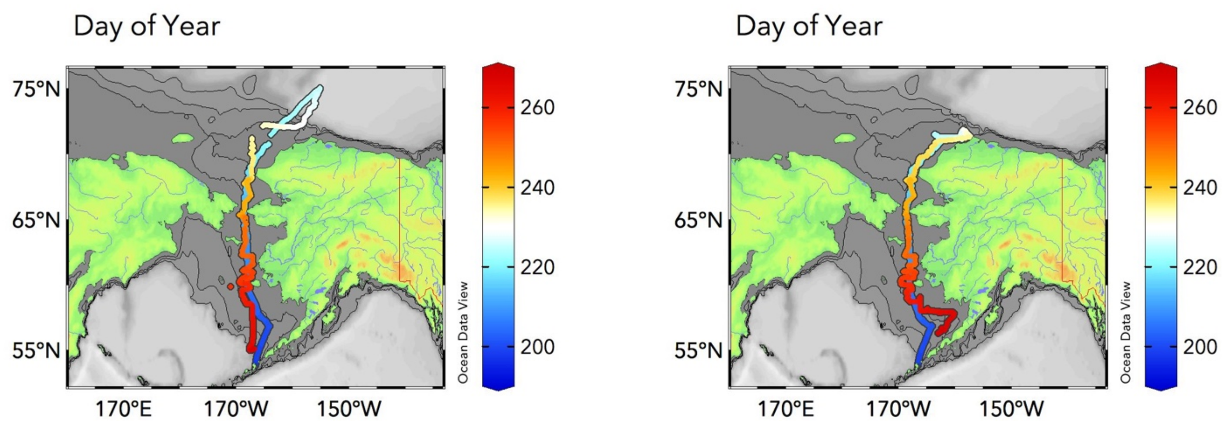


Figure N-1: Maps showing the transect of SD1002 (left) and SD1003 (right) are given below. Data gaps indicate GPS transmission dropouts, which may be remedied when the full data record is obtained following platform recovery.

Problems

During several periods of this mission, the saildrones encountered extremely high winds. While the platform is readily capable of safely transiting storms without capsizing, high winds and chaotic seastates appeared to regularly waterblock the ASVCO2 system, resulting in anomalously high CO_2 values. This water blocking can be identified through anomalously low equilibrator pressure readings. These readings were apparent for brief periods on 8/9, 8/11, 8/27, 8/31, 9/7, 9/8, 9/12, 9/13, 9/15, and 9/17 – 9/24 for SD1003. Low pressure readings were recorded for SD1002 from 8/27 through the end of the mission on 8/29. Despite these low pressure readings on SD1002, pCO_2 values appeared to reasonably match SD1003, and may have been a bad reading rather than a problem. This issue will be investigated once the instrumentation is returned to the lab.

Slow winds (< 7 kt) south of Bering Strait on the way back hampered navigation for SD1003 from 09/1 to 09/5. At this time, SD1003 was lagging SD1002 and SD1002 was not affected. This was the longest sustained period of slow wind speeds during the mission, and resulted in the only navigational difficulties. The second-longest period of slow winds was recorded during 8/19 to 8/20, and did not result in navigational challenges.

Solar power generation was also of some concern during periods of this mission, especially given that rapidly declining light levels in the Arctic occur late in the season, based on previous records of daily downward-facing shortwave radiation (DDSR) from moorings in the Chukchi Sea. Although weather seemed to reduce the capacity of solar panels on the boats to fully charge each day during some periods, we did experience full charge in good weather through 9/7. After this point, power did recover during good weather periods, and recovered beyond daily power expended, but did not recover full battery charge. At no point during the mission did available battery power drop below 46%.

Next Steps

Data collected by this program will be processed using the US IOOS QARTOD QA/QC standards for most variables, and post-processed for CO_2 data by the Pacific Marine Environmental Laboratory and the Ocean Acidification Research Center at the University of Alaska, Fairbanks.

Usage Guidelines

Given that this project contains experimental platforms and sensors, data will be released publically only once the data quality can be verified. If public release is deemed appropriate, and is approved by each partner in this project, final, post-processed data will be shared via the NOAA-NCEI National Oceanographic Data Center (NODC) and Ocean Carbon Data System (OCADS) programs for oceanographic and ocean carbon data. Public release and access will accordingly be arranged through NCEI's Geoportal.

Prior to free public release, experimental data may be shared on a case-by-case basis for research and QA/QC purposes. Data access can be requested through the managing PIs on this project. Contact information is provided in the initial section of this cruise report. Publication of these data and associated results will also be assessed on a case-by-case basis. Images and text associated with this cruise report may be used for presentations or white papers with permission from the managing PI.