

Healy 1803 Cruise Report

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Introduction and General Description

USCGC *Healy* cruise 1803 took place from 25 October to 18 November 2018, departing from and returning to Dutch Harbor, AK. The cruise was part of the project entitled “Monitoring the Western Arctic Boundary Current in a Warming Climate: Atmospheric Forcing and Oceanographic Response”, funded by the National Science Foundation as part of the Arctic Observing Network. The purpose of the cruise was to service the long-term mooring deployed in the Pacific Arctic Boundary Current on the continental slope of the Alaskan Beaufort Sea. In addition to recovering and re-deploying the mooring, the other primary objective of the cruise was to collect hydrographic measurements to further our understanding of the nature of the boundary current and its downstream evolution. A number ancillary projects were also carried out by independent investigators taking advantage of a ship of opportunity. These are summarized in the Ancillary Scientific Objectives section.

Due to the late timing of the cruise, plus the fact that 2018 was a heavy ice year, this meant that the operating conditions were challenging. In particular, the ice cover was substantial, with multi-year ice floes amidst newly formed ice, and air temperatures were substantially below freezing (as cold as -15°C). This meant that special care had to be taken in order to keep the mooring from being trapped under ice when it was released, and, for deployment, we had to carry out the anchor-first technique. For the hydrographic work it was generally impossible to find open-water leads near the designated station sites, so *Healy* had to create holes in the ice in order to deploy the conductivity-temperature-depth (CTD) rosette. Furthermore, operational adjustments were necessary in order to keep the CTD sensors from freezing during the deployment and recovery of the rosette.

Despite these challenges, the cruise was immensely successful. This is largely due to the impressive efforts and ingenuity of *Healy*'s crew, both in terms of ship handling and deck work. The AON mooring was successfully turned around, and we occupied 194 CTD stations. A map of the station sites along the North Slope of Alaska and western Canada is shown in Figure A-1. The section where the mooring is located extended into the basin. This is the DBO-6 line (one of the Distributed Biological Observatory standard lines). It is the 8th occupation of the section during the time period of our AON project, providing information about the Atlantic water portion of the boundary current (seaward of the Pacific water shelfbreak jet). The heavy ice cover prohibited us from progressing east of Mackenzie Canyon so we focused on the Alaskan Beaufort shelf and shelfbreak. Occasionally we used expendable CTDs (XCTDs) to save time and increase the sampling domain. Near the end of the cruise we conducted a Barrow Canyon outflow survey (an enlarged view of the survey is shown in Figure A-2). Finally, the DBO3 line near Pt. Hope, AK was occupied during our steam south (not shown), and we recovered a passive acoustic mooring in the central Bering Sea for another investigator. As noted above, a

number of ancillary projects were carried out during the cruise. These are summarized in the Ancillary Scientific Objectives section.

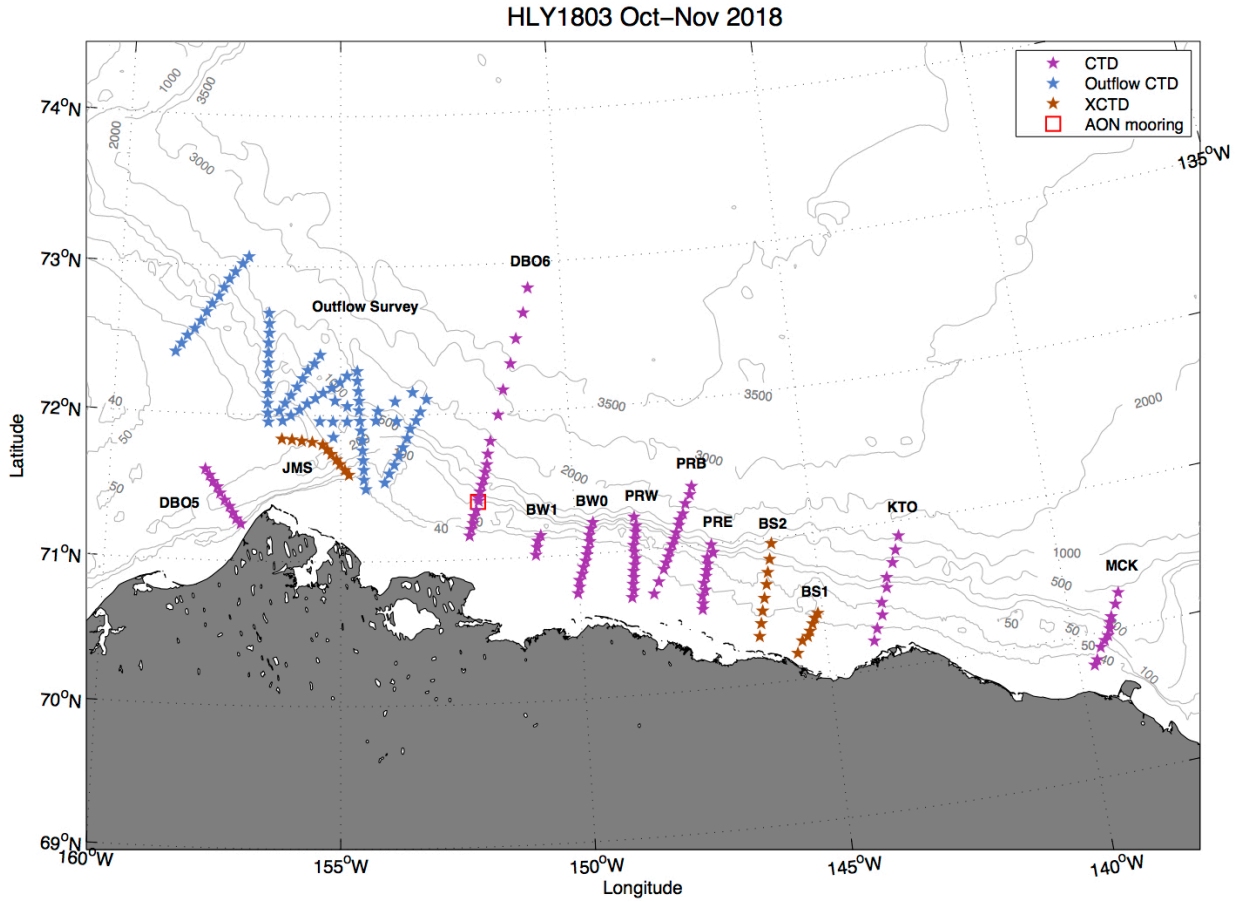


Figure A-1: Stations occupied during the 2018 AON cruise (see the table below for section names).

Abbreviation	Transect Name
MCK	Mackenzie
KTO	Kaktovik
BS1	Beaufort Shelf 1
BS2	Beaufort Shelf 2
PRE	Prudoe East
PRB	Prudoe Bay
PRW	Prudoe West
BW0	Beaufort West 0
BW1	Beaufort West 1
DBO6	Distributed Biological Observatory 6
OS	Outflow Survey
JMS	JAMSTEC
DBO5	Distributed Biological Observatory 5

HLY1803 Outflow Survey

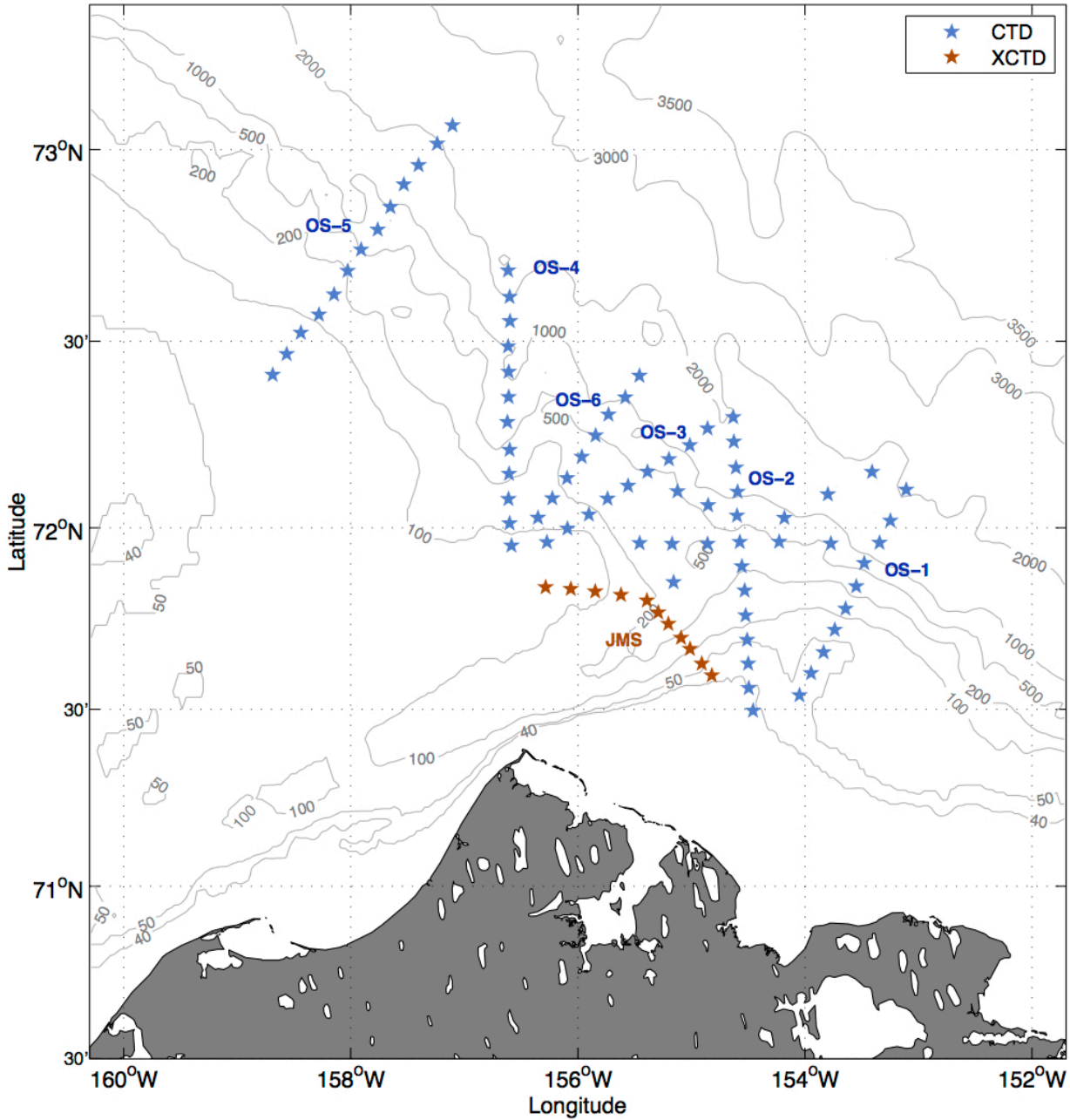


Figure A-2: Enlarged view of the Barrow Canyon outflow survey, including an expendable CTD (XCTD) section across the mouth of the canyon.

Acknowledgements. We thank 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.

Hydrographic Measurements

A total of 194 CTD casts were occupied on the cruise, comprising 10 transects plus the Barrow Canyon outflow survey (Figures A-1 and A-2). 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. Water samples were taken every 10 m on the shelf, including at the bottom of the cast, and just below the surface. Seaward of the upper slope, all CTD casts were terminated at 300m. The exceptions to this were the DBO6 transect, where the offshore stations extended to 800m, and two deep CTD casts (> 1500m) to collect salinity samples in weakly stratified water for calibrating the Sea-Bird conductivity sensors. 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. Using these data, we constructed vertical sections of potential temperature, salinity, and potential density for each transect. 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-1 for the DBO5 line.

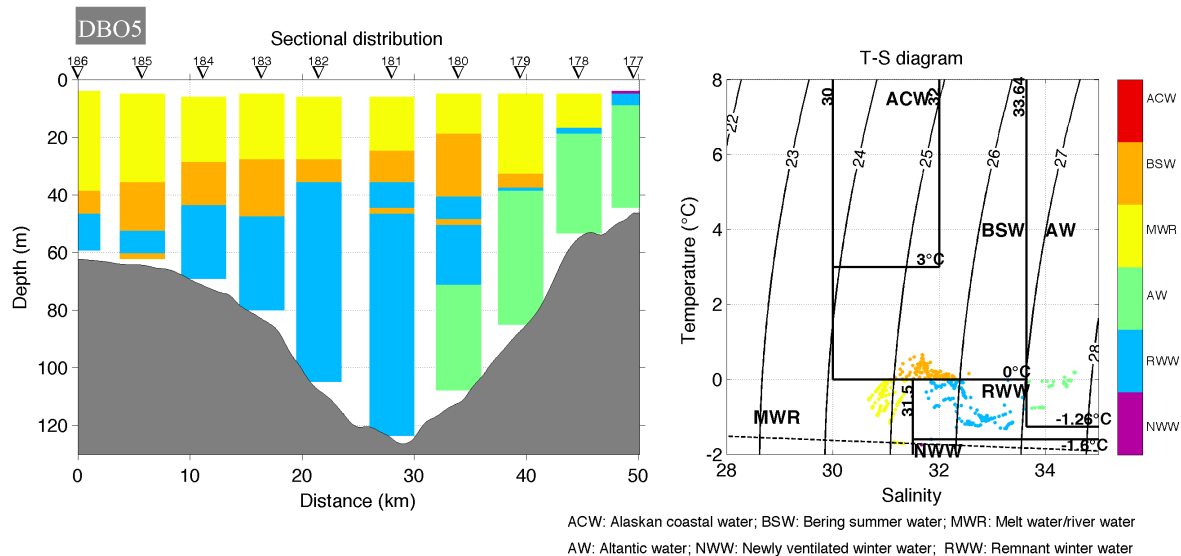
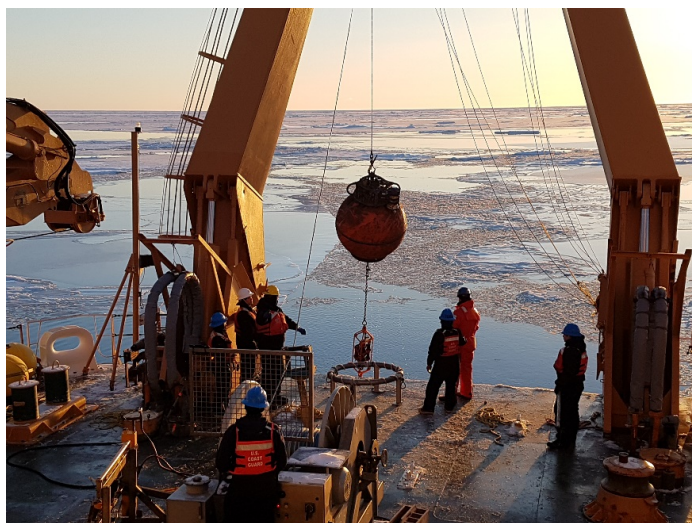


Figure B-2: Left-hand panel: Distribution of water masses at the DBO5 line, based on the definitions shown in the T-S diagram in the right-hand panel. The water masses are color-coded according to the colorbar on the right. The abbreviations are: ACW = Alaskan coastal water; BSW = Bering summer water; 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 during the cruise. This is 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 will construct a quality-controlled timeseries of wind speed and direction, post-cruise.

Mooring Operations

On October 30, recovery of the AON 2016 Mooring BS-3 started out with an acoustic survey to verify the mooring position. Upon reaching the location and seeing that the mooring was underneath a frozen lead, the release command was sent and the mooring's top float easily broke through the thin layer of ice. The *Healy's* preferred method of launching a small boat to hook the sphere could not be used due to the substantial ice concentration. Instead, the ship carefully maneuvered up to the released mooring until the sphere was near the starboard CTD A-frame, where a hook attached to a long winch leader was snapped into the sphere by the *Healy's* deck crew. Once the line was walked back to the aft A-frame, operations to bring the mooring aboard commenced, and were completed within 90 minutes. The two-year deployment had generated significant bio-fouling, but all hardware appeared in good condition.



The re-deployment on November 1 was changed on short notice from anchor-last to anchor-first, again due to the substantial ice cover. This type of operation keeps the mooring components under high tension during the entire deployment process, and thus requires significant skill and safety awareness. The mooring wire needed to be end-for-ended to keep the marked instrument locations at their proper depth. Further, the leader line needed to be cleared from the winch in order to load the mooring wire onto the bare drum to avoid damaging it under the high deployment load. The mooring was then deployed with the aid of a vertical stopper line, with operations completed in two hours. A post-deployment acoustic survey was not required as there is no fall-back during an anchor-first deployment.



Most of the recovered BS3 sensors have been downloaded at this point. Initial processing of the eight microcats indicated that the instruments collected high-quality data over the entire deployment. A first check of the fluorometer record showed that this instrument recorded through July of 2018. The ice sonar data as well as the data from the deep ADCP have been downloaded, but the processing requires shore-side personnel. We were able to connect the external STORX data recorder of the SUNA nitrate sensor for a status message, but it has since gone into hibernation mode. After repeated attempts with an external power supply and two software/cable combinations, we await further assistance from the company once ashore. Unfortunately, the ADCP on the top float flooded. However, we were able to retrieve its data card and hope to find some useful data on it with appropriate gear at home. Lastly, the data disk of the AURAL whale recorder was recovered and will be shipped to Seattle for downloading.

New sensors had been prepared for the re-deployment of BS3 with the exception of the whale recorder, which was refurbished with new batteries and a new external hard drive. The sensor suite included an additional ADCP on the top sphere from a manufacturer we had not used before (Rowe). We gratefully acknowledge the assistance of STARC personnel to fabricate a cable for its deployment.

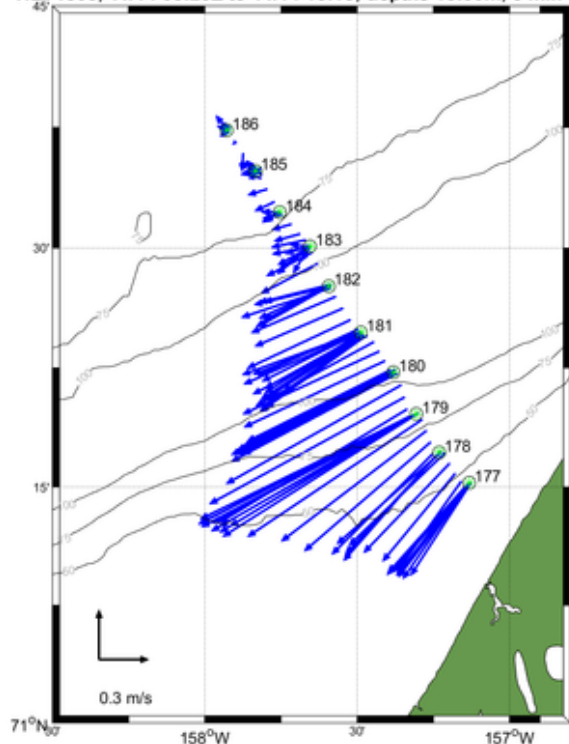
Shipboard ADCP Survey

The shipboard ADCP system was run throughout HLY1803, collecting data from the OS150 and the OS75 units using narrowband mode only. Shipboard current measurements require very accurate heading information, and the Healy provides feeds from several devices. After investigating several combinations for primary heading and heading correction, we selected the gyro 39 and SEAPATH units, respectively, with very good results.

Collecting shipboard measurements in the ice poses many unique challenges. For the high percent coverage encountered during HLY1803, ice can get swept under the ship and block the transducers. This occurred primarily when the ship was underway, but occasionally a piece of ice would get stuck at the transducers during station work as well. When this became apparent during a CTD station, the ship would attempt to clear the transducers by using propeller blasts or other measures to collect a few more on-station data before departing.

The ADCP data were processed in near-real time, revealing an excellent dataset. As an example, the figure below shows the upper layer depth-averaged flow vectors in Barrow Canyon measured during the occupation of the DBO 5 line. This revealed that an upwelling event was occurring in the canyon with remarkably strong southward flow.

HLY1803, 11/14 08:28Z to 11/14 18:18; depths 18:30m, 5 min avg.



Ancillary scientific objectives

Distribution and Prevalence of Harmful Algal Blooms in Arctic Waters

Principal Investigator: Donald Anderson, Woods Hole Oceanographic Institution

Contributed by: Evie Fachon

The objective of this program is to determine the distribution of toxic algal species in the Chukchi and Beaufort seas. Sediment samples were collected for analysis of *Alexandrium catenella* resting cysts. Water samples will be used to determine abundance of planktonic *A. catenella* cells as well as the community composition and domoic acid (DA) content of diatoms in the genus *Pseudo-nitzschia*. Additionally, an Imaging FlowCytobot (IFCB) was configured to sample from the ship's underway seawater, recording high resolution images of phytoplankton encountered along the cruise track

Heterogeneous sediment-water interaction and halocline ventilation

Principal Investigator: Matthew Charette, Woods Hole Oceanographic Institution

Contributed by: Jessica Dabrowski

Radium isotopes are being used as chemical tracers of sediment-water interaction to investigate the spatial and temporal heterogeneity of processes on the Chukchi and Beaufort shelves. Measurements of water column and sediment samples will allow for potential calculations of shelf residence time, observations of off-shelf transport, and halocline ventilation rates that are patchy in nature and likely to be seasonally variable.

Turbulence near the shelfbreak of the Canada Basin

Principal Investigator: Ruth Musgrave, Woods Hole Oceanographic Institution

Measurements of temperature and velocity microstructure were obtained using a Rockland Scientific Microrider 1000 and a 2MHz Nortek Aquadopp HR profiler mounted on the CTD rosette during routine hydrographic cross-shelf sections. These data will be used to calculate the dissipation of turbulent kinetic energy (epsilon) and temperature variance (chi), turbulent quantities that are important in understanding how water mass properties are modified via diapycnal mixing in the region. Our aim is to understand the processes that lead to mixing and their spatial and temporal dependence.

Primary productivity driven by escalating Arctic Ocean nutrient fluxes? (PEANUTS)

Principal Investigator: Yueng-Djern Lenn

PEANUTS seeks to quantify the seasonal signal in nitrate fluxes across the Arctic nutricline along the continental shelf, and evaluate their impact on ocean chlorophyll and primary productivity. To achieve this we will be measuring turbulent mixing rates, nitrate concentrations and chlorophyll-a fluorescence from moorings (including AON), and during the upcoming MOSAIC drift to be combined with novel ecosystem models to estimate primary productivity. This project is funded through UK's NERC and Germany's BMBF research councils as part of NERC's Changing Arctic Ocean project.

Particulate organic matter distribution and dynamics during the late fall in Chukchi and Beaufort Seas

Principal Investigators: Yueng-Djern Lenn

The primary objectives of Goni/Juranek project associated with the HLY1803 cruise were to 1) collect high resolution samples of natural particles from surface waters to determine organic matter elemental (carbon and nitrogen) compositions in the region and 2) measure dissolved gases (oxygen and argon) to evaluate net productivity in surface waters of the study area. For these objectives, we primarily used the Healy's surface underway system to collect samples and data from surface waters along the ship's pathway. We also collected samples and data from selected CTD locations to investigate distributions in subsurface waters. The combination of particulate matter distributions and dissolved O₂/Ar ratios will be used to evaluate carbon dynamics and net productivity of the study area during the late fall season.

Final Data Access

Information and final processed data products, including final mooring, CTD, and SADCPC data, will be made available to the public at <http://aon.who.edu/>. All additional shipboard underway data, including Multibeam and bathymetric data, will available to the public at <https://www.rvdata.us/search/cruise/HLY1803>. All datasets relevant to AON scientific objectives and research will be submitted to the Arctic Data Center [<https://arcticdata.io/>] for long-term archival two years after the completion of the cruise. Please contact the Principal Investigators for additional information.

Appendix A.

HLY1803 CTD Stations and Mooring Operations								
Section	Station/serial Number	Station Name	Time (UTC) mm/dd/yyyy hh:mm	Latitude (deg/min N)	Longitude (deg/min W)	Corrected Depth (m)	Station Notes	Problems/Solutions
TEST								
*	0	TEST-1	10/28/18 21:24	66 43.41	168 27.61	33.6		
*	1	TEST-2	10/28/18 22:40	66 43.77	168 25.96	33.5		
DBO6								
*	2	DBO6-1	10/30/18 13:13	71 9.86	152 15.32	31		pump failed
*	3	DBO6-2	10/30/18 14:33	71 12.55	152 13.06	40.9		
*	4	DBO6-3	10/30/18 15:24	71 14.90	152 10.30	49.2		pump failed
	5	DBO6-4		71 23.98	152 2.11			CTD pumps did not turn on, recovered CTD to fix and moved on to mooring survey
	Mooring			71 23.64	152 3.025	147		
*	5	DBO6-6	10/30/18 20:58	71 23.98	152 2.11	164.1		
*	6	DBO6-4	10/30/18 22:45	71 17.80	152 8.88	56.8		
*	7	DBO6-5	10/30/18 23:35	71 20.14	152 5.73	70.7		
*	8	DBO6-7	10/31/18 0:58	71 25.22	152 2.33	192.4		
*	9	DBO6-8	10/31/18 2:41	71 27.75	152 0.03	240.3	radium double CTD	
*	10	DBO6-8	10/31/18 3:43	71 27.68	151 59.60	240.3	radium double CTD	
*	11	DBO6-9	10/31/18 4:28	71 30.46	151 57.55	370		
*	12	DBO6-10	10/31/18 5:46	71 32.85	151 54.80	727.1		
*	13	DBO6-11	10/31/18 7:07	71 35.70	151 52.34	914.4	stop cast at 800m	
*	14	DBO6-12	10/31/18 8:40	71 38.78	151 49.73	1331.2	stop cast at 800m	
*	15	DBO6-13	10/31/18 10:19	71 43.09	151 48.02	1693.4	stop cast at 800m	
*	16	DBO6-14	10/31/18 12:03	71 48.25	151 43.99	2121.9	stop cast at 800m	
*	17	DBO6-15	10/31/18 14:16	71 58.83	151 32.57	2419.1	stop cast at 800m	
*	18	DBO6-16	10/31/18 17:33	72 8.96	151 24.50	3033	stop cast at 800m	
*	19	DBO6-17	10/31/18 19:58	72 19.44	151 12.95	3469.3	stop cast at 800m	Winch stopped twice, once at 390 m on downcast and once on upcast
*	20	DBO6-18	10/31/18 22:31	72 29.43	151 4.34	3656.8	stop cast at 800m	Winch stopped at 426m and 142m on upcast (23:00 and 23:23)
*	21	DBO6-19	11/1/18 4:54	72 39.73	150 52.67	3815.9		Two NAV files at the beginning

*	22	DBO6-20	11/1/18 6:53	72 49.70	150 44.81	3835.1	stop cast at 800m	NOTE: watchstander accidentally clicked NAV button instead of FIRE, so went up ~100m and then realized. Watchstander and winch operator decided to go back down and fire bottom bottle, then come back up. Last station of transect (originally we were scheduled to do two more stations, including one deep cast, but in order to reach the mooring in daylight we broke off the line early and changed the last two stations (21 and 22) from salts only to one radium and one biochem).
	Mooring			71 23.661	152 3.043	147	Deployment only	Meeting at 1000, deployment began at 1200, finished at 1419
*	23	DBO6-6	11/1/18 22:43	71 23.84	152 02.43	152.1	CTD: full biochem, mooring post-deployment calibration cast	
PRB								
*	24	PRB-1	11/2/18 8:08	70 41.49	148 26.60	22.3		
*	25	PRB-2	11/2/18 9:18	70 46.31	148 19.54	34.2		Surface radium pump officially broken
	26	PRB-3	11/2/18 10:32	70 51.31	148 12.19	41.5		
*	27	PRB-4	11/2/18 11:14	70 53.85	148 8.59	42.9		
*	28	PRB-5	11/2/18 11:58	70 56.31	148 5.30	43.3		
*	29	PRB-6	11/2/18 12:38	70 58.67	148 2.29	51		
	30	PRB-7	11/2/18 13:27	71 1.17 1	147 58.56	56.4		
	31	UPE	11/2/18 16:11	71 11.96	148 44.51	97.1		
							2-Nov-2018 0900 UPE80 mooring survey	
							2-Nov-2018 1000 UPE120 mooring survey	
	Mooring	UPE120		71 12.339	148 48.078	114.3	Recovery only	We did not recover due to difficult ice conditions. We spent daylight hours breaking ice over the position but were unsuccessful. Note that the lat, lon, and bottom depth are the new values calculated during the survey

	Mooring	UPE80		71 11.668	148 43.495	78.6	Recovery only	We did not recover due to difficult ice conditions. We spent daylight hours breaking ice over the position but were unsuccessful. Note that the lat, lon, and bottom depth are the new values calculated during the survey
	32	PRB-8	11/3/18 2:33	71 3.31 1	147 55.53	61.3		
*	33	PRB-9	11/3/18 3:35	71 5.90 1	147 52.71	702.7	stop cast at 300m	
*	34	PRB-10	11/3/18 4:57	71 8.81 1	147 48.16	1321.2	radium double CTD, stop cast at 300m	5:05 am: lost control of the winch at 130.1m for about 5 minutes
*	35	PRB-10	11/3/18 5:53	71 08.56	147 48.76	1321.2	radium double CTD, stop cast at 300m	
*	36	PRB-11	11/3/18 7:11	71 11.11	147 46.77	1714.1	stop cast at 300m	
*	37	PRB-12	11/3/18 8:24	71 13.38	147 41.59	1917.5	stop cast at 300m	
*	38	PRB-13	11/3/18 9:40	71 17.48	147 37.53	2184.7	stop cast at 300m	
*	39	PRB-14	11/3/18 11:47	71 20.97	147 30.80	2338.3	stop cast at 300m	
*	40	PRB-15	11/3/18 13:39	71 24.32	147 27.53	2447.9	stop cast at 300m	
MCK								
*	41	MCK-1	11/4/18 18:46	69 48.99	139 36.60	37.2		
*	42	MCK-2	11/4/18 20:36	69 53.88	139 29.54	43.3		
*	43	MCK-3	11/4/18 21:51	69 56.36	139 23.18	52		
*	44	MCK-4	11/4/18 22:49	69 58.03	139 17.99	57.5		
*	45	MCK-5	11/4/18 23:30	70 0.72	139 14.29	115.4		
*	46	MCK-6	11/5/18 0:31	70 3.35	139 12.79	163.4		
	47	MCK-7	11/5/18 1:13	70 5.51	139 9.81	196.4		
*	48	MCK-8	11/5/18 2:23	70 10.30	139 1.67	364.4	radium CTD, stop cast at 300m	
*	49	MCK-9	11/5/18 3:19	70 14.74	138 55.56	428.2	stop cast at 300m, SVP deployment	
*	50	MCK-0	11/5/18 7:19	69 47.04	139 40.71	35		
KTO								
	51	KTO-1	11/5/18 18:04	70 12.04	144 1.29	22.2		
	52	KTO-2	11/5/18 19:15	70 16.94	143 55.86	35.9		
	53	KTO-3	11/5/18 20:22	70 22.27	143 47.14	42.9		
	54	KTO-4	11/5/18 21:31	70 27.52	143 45.67	49.1		
	55	KTO-5	11/5/18 22:38	70 33.30	143 36.89	97.2		

	56	KTO-6	11/5/18 23:52	70 37.49	143 35.33	291.6	stop cast at 300m	Frozen Niskin 19 (surface)
*	57	KTO-7	11/6/18 1:58	70 43.19	143 25.47	467.7	stop cast at 300m	
	350089	TEST-3	11/6/18 2:31	70 43.5459 0	143 26.85610	467.7		Test XBT T-5 launched at station KTO-7
*	58	KTO-8	11/6/18 4:30	70 48.24	143 19.50	770.5	stop cast at 300m	pumps did not turn on, had to recover and re-deploy. All surface Niskins froze.
*	59	KTO-9	11/6/18 6:11	70 53.80	143 13.18	1027.7	stop cast at 300m, SVP	ADCP issue, wiggled stern for a while and got the 75kHz then the 150kHz
BS1 XCT D								
	12057559	BS1-1	11/6/18 13:57	70 26.54	145 6.16	41.4		
	12057563	BS1-2	11/6/18 14:24	70 24.67	145 10.88	38.5		
	17025060	BS1-3	11/6/18 14:53	70 22.49	145 14.33	37.5		
	17025062	BS1-4	11/6/18 15:17	70 19.54	145 18.51	33.3		
	17025063	BS1-5	11/6/18 15:45	70 17.53	145 21.93	31.3		
	17025065	BS1-6	11/6/18 16:13	70 15.93	145 29.25	29		
	17025066	BS1-7	11/6/18 16:34	70 13.06	145 32.81	26.2		XCTD failed at 3m, launched XBT as well
	350093	BS1-7	11/6/18 16:52	70 12.9121 0	145 32.78600	26.2		
	17056861	BS1-8	11/6/18 17:19	70 11.01	145 36.72	20.8		
BS2 XCT D								
	17056862	BS2-1	11/6/18 19:52	70 19.75	146 21.02	26.2		
	17056863	BS2-2	11/6/18 20:37	70 25.04	146 17.42	34.9		
	17056864	BS2-3	11/6/18 21:16	70 30.16	146 13.97	38.7		
	17056865	BS2-4	11/6/18 21:57	70 35.32	146 10.06	40.6		
	17056867	BS2-5	11/6/18 22:50	70 40.86	146 5.53	56		17056866 failed--pin fell out on deck
	17056868	BS2-6	11/6/18 23:25	70 45.78	146 2.28	61.9		
	17056869	BS2-7	11/7/18 0:05	70 51.11	145 58.16	127.1		
	17056871	BS2-8	11/7/18 0:57	70 57.46	145 53.85	579.8		
PRE								
*	60	PRE-1	11/7/18 4:04	70 59.59	147 9.53	375.5		Niskin 7 did not fire

	61	PRE-2	11/7/18 5:25	70 56.32	147 8.38	89.6		Bad spike in all variables at ~33m depth, decided to terminate cast and examine on surface. Issue resolved--turns out package was stopped on downcast to deal with ice.
	62	PRE-2	11/7/18 6:01	70 56.37	147 08.44	99		Repeat of cast 61 over sensor concern
	63	PRE-3	11/7/18 6:48	70 54.42	147 16.35	52.8		
	64	PRE-4	11/7/18 7:27	70 51.87	147 16.21	50.3		stopped at 4m and 35m on downcast because of ice
	65	PRE-5	11/7/18 8:11	70 49.24	147 18.36	47.9		Niskin 7 did not fire
	66	PRE-6	11/7/18 8:59	70 46.81	147 20.09	43.4		
	67	PRE-7	11/7/18 9:45	70 44.11	147 23.43	41		
	68	PRE-8	11/7/18 10:25	70 41.15	147 22.83	39.6		
	69	PRE-9	11/7/18 11:06	70 38.89	147 26.67	37.7		
	70	PRE-10	11/7/18 11:44	70 35.63	147 26.75	34.9		
	71	PRE-11	11/7/18 12:26	70 33.31	147 27.88	30.5		Knudsen was reading wrong depth (19m)
PRW								
	72	PRW-1	11/7/18 18:16	70 40.74	148 54.47	22.4		
	73	PRW-2	11/7/18 19:04	70 43.42	148 52.01	21.8		
	74	PRW-3	11/7/18 19:39	70 46.19	148 51.99	27.9		
	75	PRW-4	11/7/18 20:13	70 48.94	148 50.31	31.9		
	76	PRW-5	11/7/18 20:59	70 51.54	148 50.09	33.9		
	77	PRW-6	11/7/18 21:31	70 54.14	148 48.20	35.9		
	78	PRW-7	11/7/18 22:07	70 56.71	148 46.55	38.4		
	79	PRW-8	11/7/18 22:50	70 59.48	148 47.57	38.8		
	80	PRW-9	11/7/18 23:27	71 2.16	148 47.90	42.1		
	81	PRW-10	11/8/18 0:02	71 4.83	148 45.26	48.1		
	82	PRW-11	11/8/18 0:39	71 7.67	148 43.95	49.6		
	83	PRW-12	11/8/18 1:08	71 10.11	148 43.08	52.4		
*	84	PRW-13	11/8/18 1:49	71 13.79	148 44.37	398.8		Niskin 7 did not fire
OS								
*	85	DEEP (OS1-0)	11/8/18 14:49	72 6.19	153 6.45	1722.4		Deep cast for salt calibration

*	86	OS1-1	11/8/18 17:04	72 1.14	153 14.86	1694.5	stop cast at 300m	Niskin 7 did not fire. STARC cleaned housing for pin, thinks it's bigger issue with the shaft.
*	87	OS1-2	11/8/18 18:26	71 57.55	153 20.60	1443.2	stop cast at 300m	
*	88	OS1-3	11/8/18 19:25	71 54.22	153 28.64	520.8	stop cast at 300m	
	89	OS1-4	11/8/18 20:21	71 50.41	153 32.89	194		
	90	OS1-5	11/8/18 21:27	71 46.72	153 38.50	132.5		
	91	OS1-6	11/8/18 22:14	71 43.24	153 44.22	56.9		
	92	OS1-7	11/8/18 22:58	71 39.53	153 50.18	48.9		
	93	OS1-8	11/8/18 23:45	71 36.04	153 56.70	46.5		
	94	OS1-9	11/9/18 0:29	71 32.37	154 2.79	43.5		
OS2								
	95	OS2-1	11/9/18 1:34	71 29.76	154 27.34	34.6		
	96	OS2-2	11/9/18 2:13	71 33.55	154 29.69	37.3		
	97	OS2-3	11/9/18 2:55	71 37.62	154 30.02	42.3		
	98	OS2-4	11/9/18 3:36	71 41.57	154 30.56	49.7		
	99	OS2-5	11/9/18 4:19	71 45.61	154 31.30	116.1		
	100	OS2-6	11/9/18 5:09	71 49.70	154 31.77	168.7		
	101	OS2-7	11/9/18 5:56	71 53.68	154 33.33	194.9		
	102	OS2-8	11/9/18 6:47	71 57.66	154 34.39	273.5		
	103	OS2-9	11/9/18 7:43	72 1.96 1	154 35.83	913	stop cast at 300m	
	104	OS2-10	11/9/18 8:48	72 5.85 1	154 35.56	1422.9	stop cast at 300m	
*	105	OS2-11	11/9/18 9:47	72 9.75 1	154 36.40	1188.6	stop cast at 300m	
*	106	OS2-12	11/9/18 10:58	72 13.95	154 37.57	1605.1	stop cast at 300m	
OS3								
*	107	OS3-1	11/9/18 11:55	72 17.86	154 37.79	1996	stop cast at 300m	
*	108	OS3-2	11/9/18 12:53	72 16.06	154 51.51	1744.7	stop cast at 300m	
*	109	OS3-3	11/9/18 13:43	72 13.37	155 0.85	1099.2	stop cast at 300m	
*	110	OS3-4	11/9/18 14:33	72 11.10	155 11.85	952.1	stop cast at 300m	
*	111	OS3-5	11/9/18 15:23	72 9.09	155 23.25	397.5	stop cast at 300m	
FILL								
*	112	FILL-1	11/9/18 16:41	72 05.90	155 07.34	395.7	stop cast at 300m	
*	113	FILL-2	11/9/18 17:49	72 03.67	154 51.13	459.8	stop cast at 300m	
*	114	FILL-3	11/9/18 19:03	71 57.38	154 51.45	428.8	stop cast at 300m	

	115	FILL-4	11/9/18 20:50	71 57.69	154 13.61	266.4	stop cast at 300m	
*	116	FILL-5	11/9/18 22:10	71 57.43	153 46.28	413.3	stop cast at 300m	
	117	FILL-6	11/10/18 1:26	71 51.10	155 09.40	238.4		
	118	FILL-7	11/10/18 2:30	71 57.37	155 10.17	266.4		
	119	FILL-8	11/10/18 3:30	71 57.50	155 27.36	189.6		
OS3								
	120	OS3-6	11/10/18 4:49	72 6.83	155 33.44	283.6		
	121	OS3-7	11/10/18 5:43	72 4.74	155 44.27	212.2		
	122	OS3-8	11/10/18 6:28	72 2.14	155 54.16	158.4		
	123	OS3-9	11/10/18 7:11	71 59.86	156 5.45	78.6		
	124	OS3-10	11/10/18 7:50	71 57.65	156 16.31	59		
OS4								
	125	OS4-1	11/10/18 8:43	71 57.09	156 35.03	70.5		
	126	OS4-2	11/10/18 9:26	72 0.72	156 36.07	101.3		
	127	OS4-3	11/10/18 10:11	72 4.67	156 36.58	142		
	128	OS4-4	11/10/18 11:00	72 8.75	156 36.34	191		
	129	OS4-5	11/10/18 11:49	72 12.62	156 36.07	238.9		
	130	OS4-6	11/10/18 12:52	72 17.10	156 37.20	297.4		
*	131	OS4-7	11/10/18 13:44	72 21.11	156 36.57	352.8	stop cast at 300m	
*	132	OS4-8	11/10/18 14:41	72 25.14	156 36.52	622.4	stop cast at 300m	
	133	OS4-9	11/10/18 15:36	72 29.18	156 36.78	823.6	stop cast at 300m	
*	134	OS4-10	11/10/18 16:28	72 33.18	156 35.89	1592.2	stop cast at 300m	
	135	OS4-11	11/10/18 17:22	72 37.02	156 36.06	1588.6	stop cast at 300m	
*	136	OS4-12	11/10/18 18:26	72 41.16	156 36.87	1786.5	stop cast at 300m	
OS5								
*	137	OS5-1	11/10/18 21:23	73 3.72 1	157 6.16	2451.4	stop cast at 300m	
*	138	OS5-2	11/10/18 22:12	73 0.89 1	157 14.28	2329.9	stop cast at 300m	
*	139	OS5-3	11/10/18 23:19	72 57.56	157 24.11	2102.8	stop cast at 300m	
*	140	OS5-4	11/11/18 0:10	72 54.60	157 31.94	1906.9	stop cast at 300m	
*	141	OS5-5	11/11/18 1:04	72 51.09	157 39.07	1576.4	stop cast at 300m	
*	142	OS5-6	11/11/18 1:57	72 47.55	157 45.69	1123.8	stop cast at 300m	
*	143	OS5-7	11/11/18 2:50	72 44.45	157 54.54	429.4	stop cast at 300m	
	144	OS5-8	11/11/18 3:46	72 41.09	158 1.63	279.7		

	145	OS5-9	11/11/18 4:36	72 37.38	158 8.74	206.9		
	146	OS5-10	11/11/18 5:31	72 34.22	158 16.82	147.6		
	147	OS5-11	11/11/18 6:13	72 31.33	158 26.32	81.8		
	148	OS5-12	11/11/18 6:55	72 27.97	158 33.84	54.9		
	149	OS5-13	11/11/18 7:34	72 24.66	158 41.21	50.8		
OS6								
	150	OS6-1	11/11/18 11:36	72 1.63	156 21.05	101		
	151	OS6-2	11/11/18 12:27	72 4.79	156 13.48	158.5		
	152	OS6-3	11/11/18 13:22	72 8.07	156 5.67	211.4		
	153	OS6-4	11/11/18 14:25	72 11.50	155 57.90	276		
*	154	OS6-5	11/11/18 15:27	72 14.94	155 50.57	462.3	stop cast at 300m	
*	155	OS6-6	11/11/18 16:33	72 18.30	155 43.72	1005.3	stop cast at 300m	
*	156	OS6-7	11/11/18 17:27	72 21.06	155 34.93	1083.6	stop cast at 300m	
*	157	OS6-8	11/11/18 18:39	72 24.51	155 27.42	1520.7	stop cast at 300m	
FILL								
*	158	FILL-9	11/11/18 22:47	72 01.60	154 10.84	896.5	stop cast at 300m	
*	159	FILL-10	11/12/18 0:12	72 05.42	153 47.81	1616.2	stop cast at 300m	
*	160	FILL-11	11/12/18 1:31	72 09.07	153 24.46	2038.6		Deep cast for salt calibration
BC XCT D							(JAMSTEC)	
	17110527	BC-11	11/12/18 9:11	71 50.26	156 17.05	78.6		
	17110528	BC-10	11/12/18 9:45	71 49.99	156 3.64	84.3		
	17110529	BC-09	11/12/18 10:14	71 49.55	155 50.83	88.7		
	17110530	BC-08	11/12/18 10:41	71 49.01	155 37.18	116.8		
	17110531	BC-07	11/12/18 11:11	71 48.09	155 23.45	147.7		
	17110532	BC-06	11/12/18 11:32	71 46.11	155 17.46	200.1		
	17110533	BC-05	11/12/18 11:50	71 44.22	155 12.15	307.2		
	17110534	BC-04	11/12/18 12:14	71 41.90	155 5.45	171		
	17110535	BC-03	11/12/18 12:29	71 40.06	155 0.67	104.7		
	17110537	BC-02	11/12/18 13:04	71 37.61	154 54.48	54.2		17110536 failed
	17110538	BC-01	11/12/18 13:23	71 35.65	154 49.13	42.1		
BW1								
	161	BW1-1	11/12/18 22:40	71 0.77	150 52.15	21.6		VERY cold! Air temp -14 deg C

	162	BW1-2	11/12/18 23:19	71 3.87	150 50.26	21.9		
	163	BW1-3	11/12/18 23:54	71 6.51	150 49.12	29.4		
	164	BW1-4	11/13/18 0:28	71 8.74	150 44.87	43.9		
BW0								
	165	BW0-1	11/13/18 6:05	70 43.89	150 1.75	18.6		Pumps froze on first deployment, recovered and redeployed.
	166	BW0-2	11/13/18 6:43	70 46.57	149 59.41	19.8		Latch mechanism froze, 6 bottles did not fire.
	167	BW0-3	11/13/18 7:29	70 49.38	149 58.93	22.3		
	168	BW0-4	11/13/18 8:30	70 51.84	149 54.87	26.4		
	169	BW0-5	11/13/18 9:15	70 54.60	149 52.84	25.9		
	170	BW0-6	11/13/18 10:18	70 57.13	149 49.55	27.6		
	171	BW0-7	11/13/18 10:59	70 59.71	149 47.65	31.4		
	172	BW0-8	11/13/18 11:39	71 2.21	149 45.66	31.7		
	173	BW0-9	11/13/18 12:16	71 5.04	149 42.86	37.9		
	174	BW0-10	11/13/18 12:56	71 7.69	149 42.80	44.8		
	175	BW0-11	11/13/18 13:36	71 10.23	149 40.69	57.8		
	176	BW0-12	11/13/18 14:12	71 12.78	149 37.34	325.2		
DBO 5								
	177	DBO5-1	11/14/18 8:38	71 15.27	157 7.94	46.8		
	178	DBO5-2	11/14/18 9:33	71 17.18	157 13.86	54.9		
	179	DBO5-3	11/14/18 10:13	71 19.61	157 18.37	87		
	180	DBO5-4	11/14/18 11:31	71 22.23	157 22.87	112		
	181	DBO5-5	11/14/18 12:37	71 24.73	157 29.26	124.6		
	182	DBO5-6	11/14/18 14:22	71 27.62	157 35.57	108		
	183	DBO5-7	11/14/18 15:08	71 30.11	157 39.33	83.1		
	184	DBO5-8	11/14/18 16:06	71 32.24	157 45.23	71.3		
	185	DBO5-9	11/14/18 16:46	71 34.79	157 49.99	64.3		
	186	DBO5-10	11/14/18 18:06	71 37.32	157 55.66	61.9		
DBO 3								
	187	DBO3-1	11/15/18 13:35	68 18.38	166 54.96	35		
	188	DBO3-2	11/15/18 14:35	68 14.78	167 07.67	45		
	189	DBO3-3	11/15/18 15:21	68 11.22	167 17.76	49		
	190	DBO3-4	11/15/18	68 07.94	167 29.22	50		

			16:07					
	191	DBO3-5	11/15/18 17:34	68 00.76	167 52.65	54		
	192	DBO3-6	11/15/18 19:15	67 53.82	168 14.02	60		
	193	DBO3-7	11/15/18 20:56	67 46.99	168 35.32	50		
	194	DBO3-8	11/15/18 22:08	67 40.36	168 56.93	50		