Research Cruise Report:

USCGC Maple, July 20 – August 21, 2017

Northwest Passage Transit

Final Reporting Date: 4/17/2018

Joshua M. Jones, Chief Scientist
Scripps Institution of Oceanography
University of California, San Diego

Marine Physical Laboratory Technical Memorandum # 624

Cover photo credit: Government of Canada

Report prepared by:

Joshua M. Jones
PhD Candidate, Biological Oceanography

Scripps Institution of Oceanography
University of California, San Diego
9500 Gilman Dr. MC 0205
La Jolla, CA 92093-0205

Email: jmjones@ucsd.edu
Tel: (858) 822-1836

Note: Figures and tables included in this report may be revised with further analyses of data and should be treated as unpublished data. Please contact the author of the report for additional information.

SUMMARY

The USCGC MAPLE (WLB-207) completed a transit of the Northwest Passage in summer, 2017, departing Sitka, Alaska on July 12 and arriving in Baltimore, Maryland on August 28. While the ship was in Alaskan and Canadian Arctic waters, substantial ship time and crew effort was dedicated to conduct operations in support of oceanographic studies in the Arctic. The primary scientific objective of the cruise was to service oceanographic moorings maintained by the Scripps Institution of Oceanography for long-term acoustic monitoring of Arctic marine mammals and underwater noise. Additional scientific data was collected opportunistically at a total of 21 stations along the trackline of the ship (Fig. 1) to support estimates of abundance and distribution of major zooplankton species, microbial metagenomic and transcriptomic research, and studies of surface circulation and wave energy.

Two High-frequency Acoustic Recording Packages (HARPs) were serviced, one in the NE Chukchi Sea and one in the Canadian Arctic near NW Baffin Island. Additional data collected included temperature and salinity profiles, zooplankton samples, and seawater samples. Three Miniature Wave Buoys were also deployed in the Chukchi and Beaufort Seas and visual observation for marine mammals was maintained during all daylight hours. This report will summarize scientific operations and data collected aboard the MAPLE during the 2017 transit through Arctic waters of the US and Canada. A status report on data analyses will also be included in each section. The data and samples are archived at the Scripps Institution of Oceanography and will be made available to interested researchers upon request.

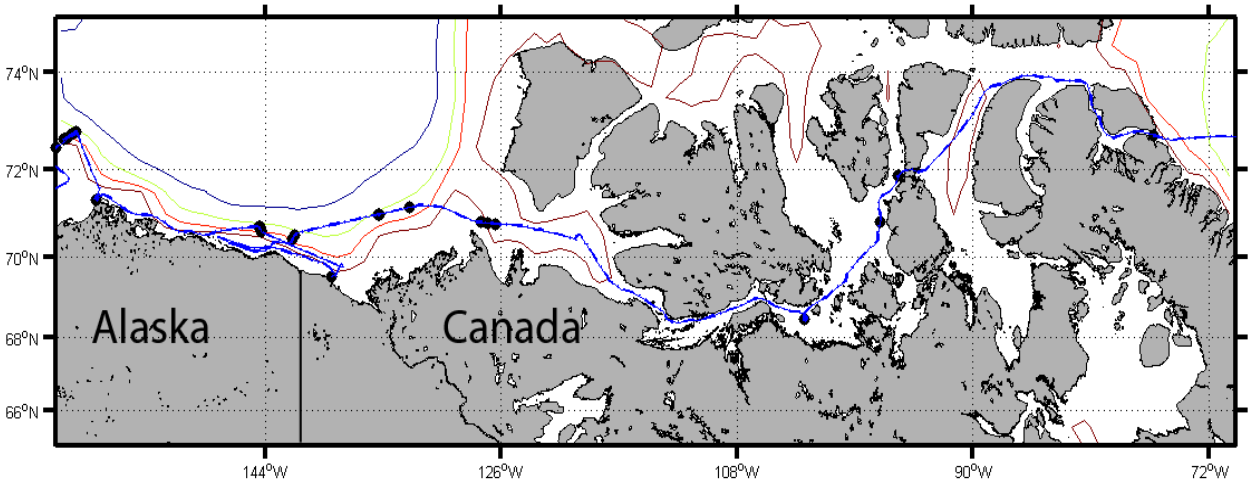


Figure 1. Trackline of the USCGC MAPLE Arctic cruise during the period when scientific operations were conducted. Ship track and scientific stations are plotted as the light blue line and black circles, respectively. Depth contours are approximated and represent 200, 400, 1000, and 2000 m.

ACKNOWLEDGEMENTS

The efforts of many people made this research aboard the US Coast Guard Cutter MAPLE possible during its transit through the Northwest Passage. Thanks to Dave Seris (17th Coast Guard District), who made the initial contacts with scientists from the Scripps Institution of Oceanography and Dave Forcucci (Healy Marine Science Coordinator) who coordinated the formal request through the US State Department to conduct scientific research aboard the MAPLE in Canadian Arctic waters. Special

thanks to MAPLE Commanding Officer Patrick Armstrong, Executive Officer Lisa Hatfield, and Operations Officer Kyle Sutschek for making ship time and resources available for scientific effort throughout the cruise and amidst many other considerations vital to safely completing the passage. Mobilization and demobilization of science equipment and all science-related deck operations, although outside the normal operations of the MAPLE, were carried out to the highest standards of safety and professionalism by Robert Nendza, John Stephenson, Justin Lujan and their hardworking 'deck force' crew.

In addition to the work aboard the USCGC MAPLE, Environmental Protection Specialist Bethany Hill (US Coast Guard) provided invaluable support in appropriately disposing of and shipping science-related hazardous materials upon completion of the cruise. Sean Nix and Ryan Jordan, of the University of California San Diego, coordinated safe transportation of those materials to and from the Scripps Institution of Oceanography. Data collection was made possible in large part through equipment provided on loan by scientists from the Scripps Institution of Oceanography. Special thanks to Sarah Giddings for providing the conductivity temperature depth (CTD) probe. Thanks also to Mark Ohman and Linsey Sala with the SIO Pelagic Invertebrates Collection for making zooplankton sampling equipment, chemicals, and protocols available for the cruise.

DATA COLLECTION, METHODS, AND ANALYSES

Acoustic recordings

Two HARP moorings (Wiggins and Hildebrand, 2007) were recovered, serviced, and redeployed (Figs. 2, A.1; Table 1). The HARPs record underwater sound continuously at a sampling rate of 200 kHz for periods of up to a year at a time. Mooring operations involved releasing the instrument packages from their anchors, bringing them on deck, replacing hardware hard drives and batteries, and deploying the HARP at the same location. Both instruments recorded nearly a full year of underwater sounds. They will continue to record until they are recovered again in summer, 2018. The HARPs are passive acoustic monitoring devices that do not emit sound into the water.

Acoustic data recovered aboard the MAPLE have been processed to create x.wav and long-term spectral averaged files to facilitate analyses (Wiggins and Hildebrand, 2007). SIO graduate students and students at the Mt. Edgecumbe High School (MEHS) in Sitka, Alaska are working together through a program called SeaTech to analyze these data for the acoustic presence and behavior of Artic marine mammals. SeaTech is a technology training and research internship partnership between SIO and MEHS, started in 2008. Thirteen MEHS students will travel to SIO in May, 2018 to present the results of these analyses at a research symposium hosted by SIO.

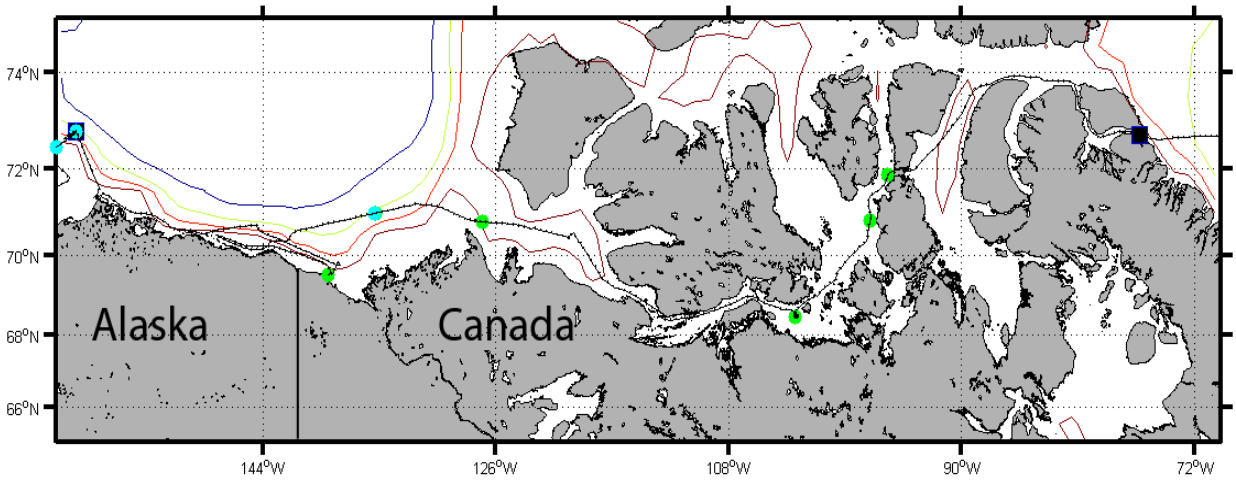


Figure 2. Plot showing the location of two HARP moorings serviced (black squares), microbial samples collected (green circles), and Miniature Wave Buoy drifters deployed. Depth contours are approximated and represent 200, 400, 1000, and 2000 m. The ship's track is plotted as a continuous black line.

Table 1. HARP mooring locations and recording information. Start and end dates listed are the start of the previous year deployment to the last day the instrument recorded acoustic data before being recovered. A CTD cast was made at each mooring location to provide sound speed profile information.

		Deployment info.			Recording info.		
Time (GMT)	CTD stn.	Lat. (deg N)	Lon. (deg W)	depth (m)	Start date	End date	Sample rate
8/14/17 20:48	23	72.725	-76.230	670	10/5/2016	8/4/2017	200 kHz
7/23/17 17:38	5	72.801	-158.466	340	9/9/2016	7/23/2016	200 kHz

Salinity and temperature profiles

We collected 30 vertical profiles of temperature, conductivity, and pressure (Table 2; Figs. 3, 4) using two CTD systems. Nineteen casts to 100 m were made with a CastAway CTD. An additional profile was collected at 11 stations using an Ocean Sensors OS200 CTD (depth rating 1000 m). The OS200 was attached to the wire one meter above a zooplankton net frame or was lowered independently for several casts deeper than 200 m.

CTD data are being utilized at SIO to model underwater sound propagation at the HARP locations. These data are useful for predicting sound propagation loss around the recordings sites and for estimating detection ranges to calling marine mammals. Additionally, CTD cast data obtained at each zooplankton station have been archived with their respective samples at the Scripps Pelagic Invertebrate Collection.

Table 2. CTD stations occupied during the MAPLE 2017 cruise.

Time (GMT)	Station no.	Cast no.	Latitude (N)	Longitude (W)	Water depth (m)	CTD depth (m)
7/23/17 18:48	1	1	72.637	-159.398	74	62
7/23/17 20:01	2	1	72.689	-159.103	131	70
7/23/17 20:50	3	1	72.741	-158.771	216	76
7/23/17 21:53	4	1	72.804	-158.429	343	76
7/23/17 22:11	4	2	72.801	-158.466	332	250
7/24/17 18:33	5	1	72.332	-156.878	45	48
7/26/17 18:11	6	1	70.712	-144.441	320	98
7/26/17 21:04	7	1	70.677	-144.427	259	85
7/26/17 22:30	8	1	70.638	-144.279	228	78
7/26/17 23:34	9	1	70.607	-144.326	119	81
7/28/17 3:07	10	1	69.547	-138.954	18	15
8/1/17 1:15	11	1	70.443	-141.953	67	65
8/1/17 1:30	11	2	70.383	-141.965	67	45
8/1/17 2:56	12	1	70.518	-141.772	408	250
8/1/17 3:37	12	2	70.524	-141.772	408	93
8/1/17 17:29	13	1	71.001	-135.324	552	250
8/1/17 18:05	13	2	70.990	-135.336	552	101
8/1/17 23:49	14	1	71.162	-132.972	314	283
8/2/17 0:28	14	2	71.155	-132.973	314	100
8/2/17 15:11	15	1	70.823	-127.505	175	163
8/2/17 15:37	15	2	70.823	-127.505	175	86
8/2/17 17:14	16	1	70.804	-127.000	273	220
8/2/17 17:46	16	2	70.807	-126.967	273	94
8/2/17 19:00	17	1	70.788	-126.463	313	254
8/2/17 20:03	17	2	70.795	-126.484	313	92
8/10/17 16:03	18	1	68.486	-102.873	94	79
8/12/2017 1:00	19	1	70.841	-97.070	106	103
8/12/2017 1:00	19	2	70.841	-97.070	106	91
8/12/2017 23:00	20	1	71.860	-95.735	173	169
8/14/2017 20:48	21	1	72.725	-76.230	670	399

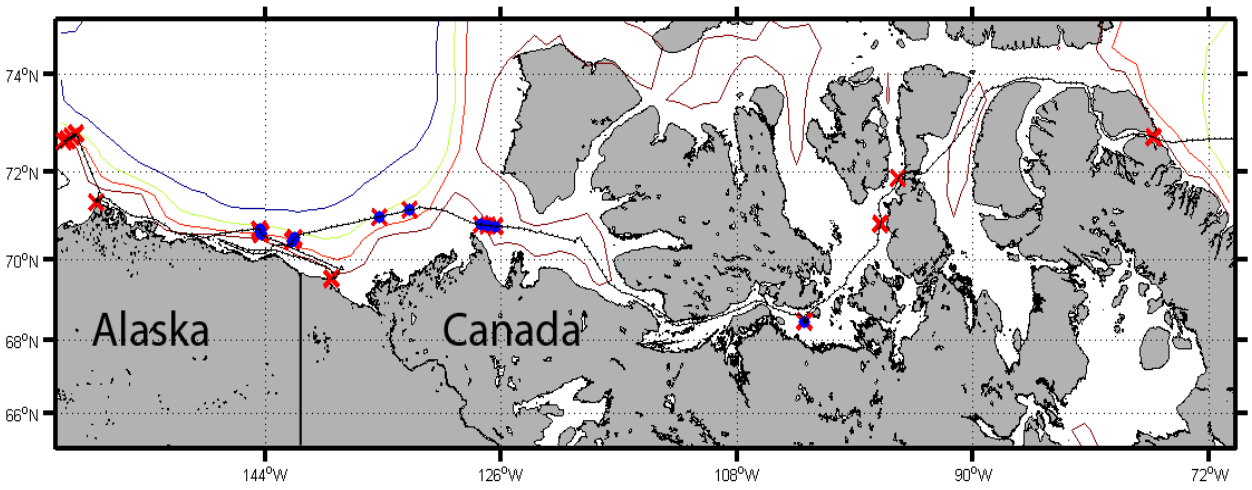


Figure 3. CTD and zooplankton sampling stations (red x and blue circles, respectively) were occupied at points along the trackline. Depth contours are approximated and represent 200, 400, 1000, and 2000 m. The ship's track is plotted as a continuous black line.

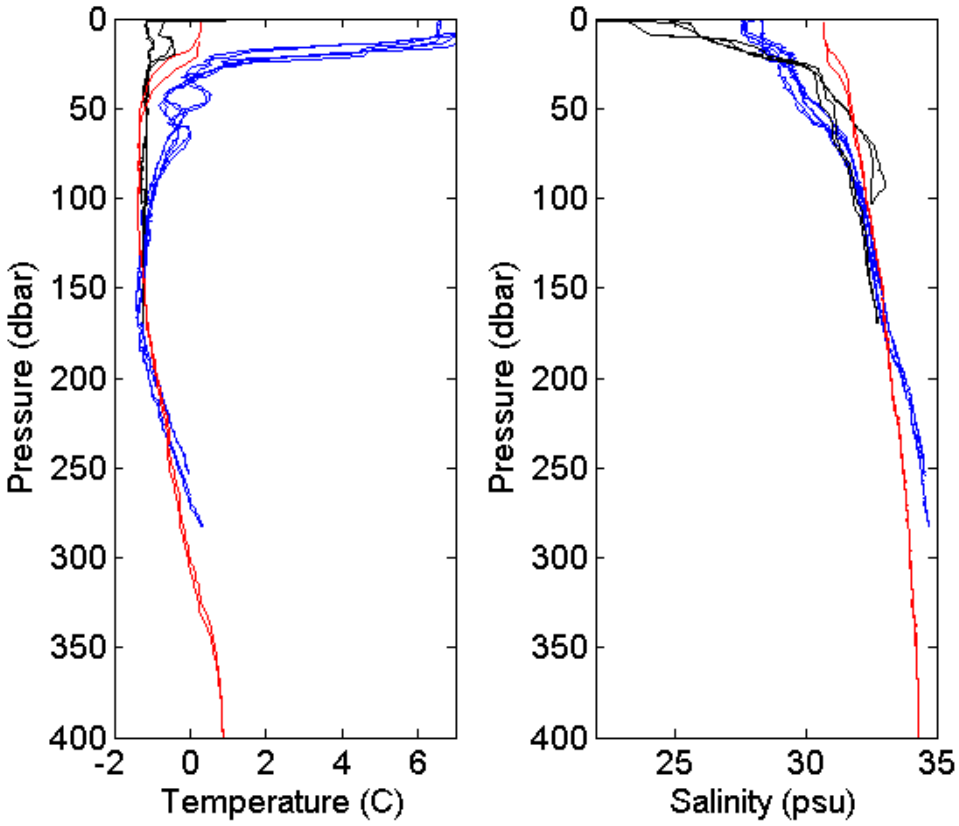


Figure 4. Example temperature and salinity profiles for CTD stations along the Beaufort slope (blue; CTD stn. 14-17), Amundsen and Queen Maud Gulfs (black; CTD stn. 19-20), and NW Baffin Bay (red; CTD stn. 21).

Zooplankton sampling

Quantitative zooplankton samples were obtained (Fig. 3, Table 3) using a bongo net assembly towed obliquely. Two 0.7 meter opening five meter length nets with 505 μm mesh size were attached to the net frame (Fig. A.2). Up to 350 m of line was paid out at an average rate of 50 m per minute. The nets were towed at depth for 30 seconds and retrieved at an average rate of 20 m per minute. A wire angle of approximately 45 degrees was maintained during deployment and recovery and the actual wire angle estimated every 25 m of line out. Wire angle was estimated using a navigational protractor held at arm's length with the zero angle aligned to the block at the end of the boom from which the net was towed. A flow meter was fixed in the center of one net opening to estimate volume of water filtered on each cast. The flow meter malfunctioned during the first three net tows, but was repaired and functioned normally for the rest of the trip. Contents of the codend from the outboard net were placed in a pint jar with clean seawater, 25 ml of 37% formaldehyde, and 10 ml of a super-saturated solution of sodium borate. Contents of the inboard codend were placed in a pint jar, which was then filled with a solution containing 125 ml tris buffer per 10 L 95% ethanol.

Zooplankton samples collected during the MAPLE transit of the Northwest Passage have been accessioned into the Scripps Pelagic Invertebrates Collection. Analyses planned for spring and summer, 2018 will estimate local abundance of two important bowhead whale prey species, *Calanus glacialis* and

Calanus hyperboreus (e.g. Fig. 5). Adult and late copepodid stages will be identified and enumerated along with sex for individuals of both calanoid species.

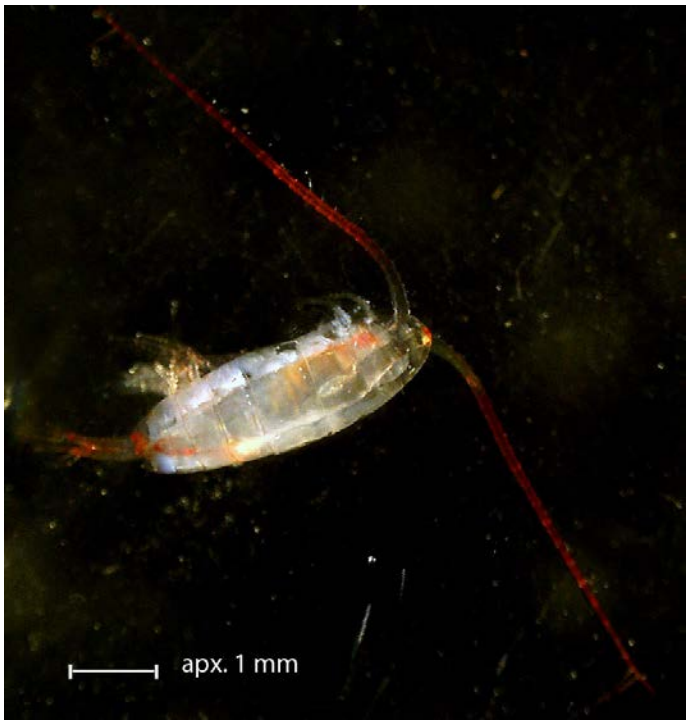


Figure 5. Microscope image of *Calanus hyperboreus* collected in the zooplankton net aboard the MAPLE August 1, 2017.

Table 3. Zooplankton samples collected during the MAPLE17 cruise. Tows 1-11 were made obliquely. Tows 12-13 were deployed codend first, then retrieved vertically.

Time (GMT)	Tow no.	CTD Stn.	Latitude (N)	Longitude (W)	Water depth (m)	line out (m)
7/26/17 17:33	1	6	70.715	-144.431	330	350
7/26/17 20:30	2	7	70.673	-144.430	251	350
7/26/17 22:04	3	8	70.633	-144.297	198	200
7/26/17 23:11	4	9	70.604	-144.338	96	150
7/31/17 1:15	5	11	70.443	-141.953	67	75
7/31/17 2:56	6	12	70.518	-141.772	408	350
8/1/17 17:29	7	13	71.001	-135.324	552	350
8/1/17 23:49	8	14	71.162	-132.972	314	350
8/2/17 15:11	9	15	70.823	-127.505	175	200
8/2/17 17:14	10	16	70.804	-127.000	273	300
8/2/17 0:00	11	17	70.788	-126.463	313	350
8/10/17 15:30	12	18	68.479	-102.860	106	100
8/10/17 16:03	13	18	68.486	-102.873	94	100

Visual observation

Three to four watch-standers were posted on the bridge at all times and kept a sharp lookout for marine mammals. All sightings of bowhead whales, belugas, narwhals, and polar bears were entered into a sighting log, including species, estimated number of animals, date, and position (Fig. 6, Table 4). Species identification was confirmed by the chief scientist in most cases. With two exceptions to confirm species identity, the ship did not deviate from course or speed in response to marine mammal visual sightings. Time, relative bearing, and estimated distance to the sighted animals was not routinely recorded by the watch-standers.

During the transit along the Beaufort Sea shelf Between Jul. 27 and Aug. 2 a total of 27 bowhead whale sightings were recorded. The best estimate total number bowheads sighted was 70 individuals, in groups ranging from one to five animals. Bowheads were again sighted three times during Aug. 12 and 13 after the ship passed through Bellot Strait into Prince Regent Inlet. These sightings were presumably of individuals belonging to the Baffin Bay Davis Strait or Hudson Bay Foxe Basin. Only one beluga sighting was recorded in the Amundsen Gulf on August 02. The ship was briefly moved off track to confirm the identity of the sighting, then returned to course. During August 11 and 12, MAPLE was escorted by Canadian Coast Guard icebreaker Terry Fox through heavy sea ice in Victoria Strait and Franklin Strait. While following the icebreaker five polar bear sightings were made, including three sightings of an adult bear with cubs (Fig. A.3). Pinniped sightings were numerous along the trackline and were not recorded.

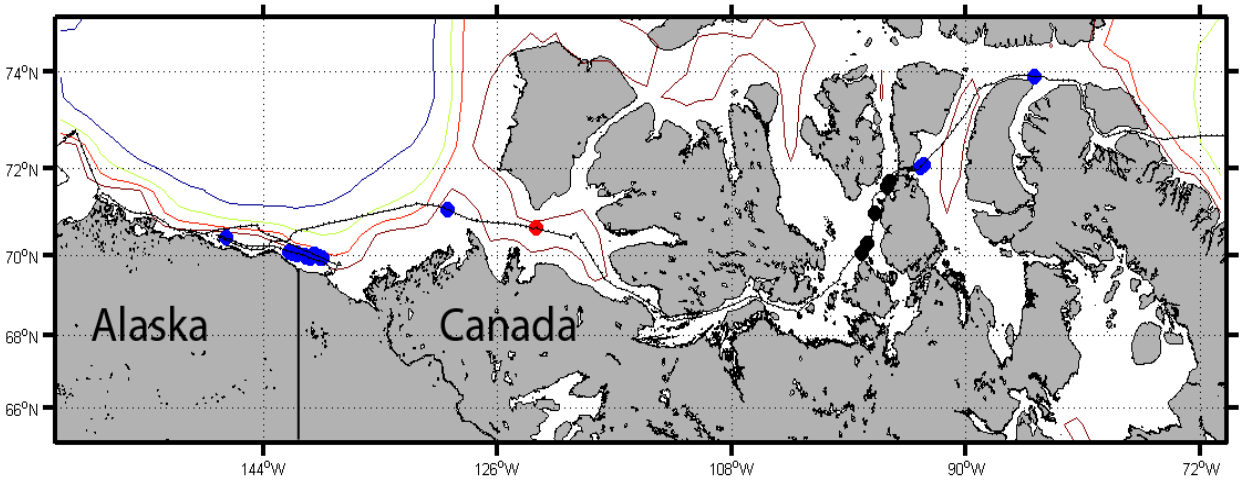


Figure 6. Whale and polar bear sightings along the MAPLE17 trackline. Bowhead whales (blue circles) were sighted along the Beaufort Sea shelf and slope, a single group of belugas (red circle) was sighted in the Amundsen Gulf, and polar bear sightings (black circles) made in Victoria Strait. Depth contours are approximated and represent 200, 400, 1000, and 2000 m. The ship's track is plotted as a continuous black line.

Table 4. Marine mammal sightings

Date	Lat (Deg N)	Lon (Deg W)	Species	No. indiv.
02-Aug-17	70.661	-123.04435	Beluga	13
27-Jul-17	70.030	-140.103667	Bowhead	2
27-Jul-17	70.024	-140.05	Bowhead	1
27-Jul-17	70.018	-140.007	Bowhead	4
27-Jul-17	70.010	-139.95925	Bowhead	3
27-Jul-17	69.971	-139.685167	Bowhead	1
27-Jul-17	69.954	-139.640417	Bowhead	3
27-Jul-17	69.956	-139.559333	Bowhead	1
27-Jul-17	69.940	-139.415783	Bowhead	2
28-Jul-17	70.086	-142.029	Bowhead	2
28-Jul-17	70.102	-141.927167	Bowhead	4
28-Jul-17	70.099	-141.896333	Bowhead	1
28-Jul-17	70.094	-141.852017	Bowhead	3
28-Jul-17	70.087	-141.798867	Bowhead	2
28-Jul-17	70.078	-141.722683	Bowhead	1
28-Jul-17	70.073	-141.611833	Bowhead	1
28-Jul-17	70.071	-141.583383	Bowhead	1
28-Jul-17	70.067	-141.5454	Bowhead	1
28-Jul-17	70.064	-141.507833	Bowhead	1
28-Jul-17	70.054	-141.41025	Bowhead	4
28-Jul-17	70.052	-141.391483	Bowhead	2
28-Jul-17	69.995	-140.788933	Bowhead	1
28-Jul-17	69.988	-140.72	Bowhead	3
28-Jul-17	69.979	-140.64	Bowhead	5
28-Jul-17	69.955	-140.42985	Bowhead	4
28-Jul-17	69.948	-140.356317	Bowhead	3
29-Jul-17	70.427	-146.891117	Bowhead	3
02-Aug-17	71.093	-129.873833	Bowhead	5
12-Aug-17	72.026	-93.5363167	Bowhead	1
12-Aug-17	72.086	-93.28825	Bowhead	3
13-Aug-17	73.892	-84.7975	Bowhead	1
11-Aug-17	70.294	-97.5833333	Polar bear	3
11-Aug-17	70.074	-98.0698667	Polar bear	1
12-Aug-17	71.005	-97.0213833	Polar bear	3
12-Aug-17	71.611	-96.0456667	Polar bear	1
12-Aug-17	71.709	-95.8946667	Polar bear	3

Microbial sampling

Microbial samples (Fig. 6, Table 5) were obtained by filtering one to two liters of seawater through a 0.2 μm Strevex filter. The water samples were collected by dipping a bucket over the side of the ship. After filtering the volume of seawater, the filter was drained of seawater, 1.5 ml of RNA Later added, and the ends sealed. Samples were stored at room temperature, then frozen after shipment to SIO.

Microbial samples have been shipped to Dr. Federico Lauro at the Singapore Center for Environmental Life Sciences Engineering. They will be analyzed as a part of the Indigo V project using metagenomics and metatranscriptomic techniques to improve understanding of marine microbial communities and ecosystem function.

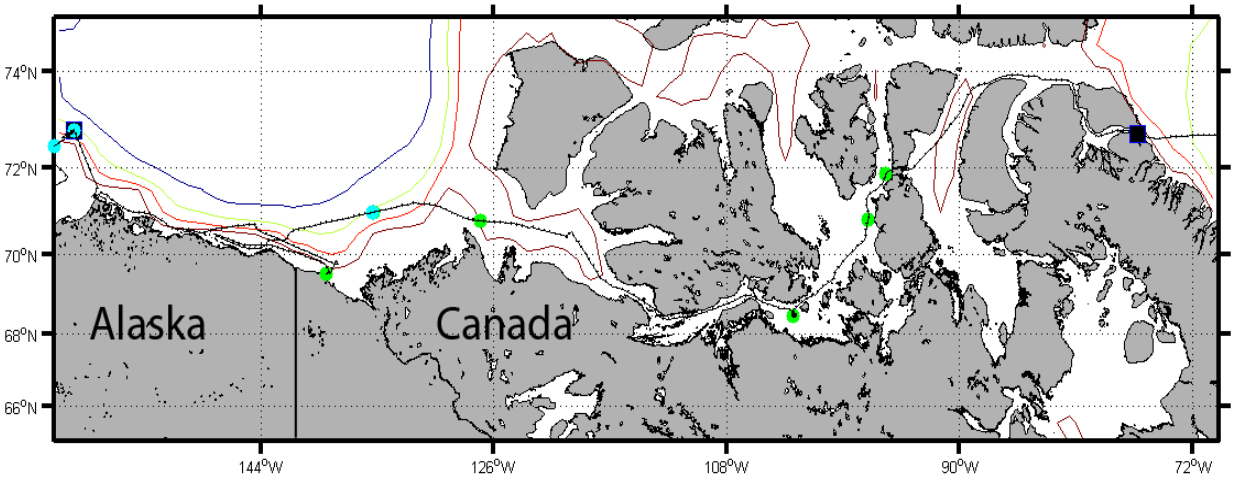


Figure 6. Plot showing the location of microbial samples collected (green circles) and Miniature Wave Buoys (lt. blue circles) deployed. Depth contours are approximated and represent 200, 400, 1000, and 2000 m. The ship's track is plotted as a continuous black line.

Table 5. Microbial samples collected during the MAPLE 2017 transit of the Alaskan and Canadian Arctic.

Time (GMT)	Sample no.	CTD stn.	Latitude (deg N)	Longitude (deg W)	Water depth (m)	Sample depth (m)
7/28/17 0:00	1	11	69.547	-138.954	18	<2
8/1/17 17:29	2	14	71.001	-135.324	552	<2
8/2/17 17:14	3	17	70.804	-127.000	273	<2
8/10/17 16:03	4	20	68.486	-102.873	94	<2
8/12/17 1:00	5	21	70.841	-97.070	106	<2
8/12/17 23:00	6	22	71.860	-95.735	173	<2

Wave buoy deployments

We deployed three Miniature Wave Buoys (MWBs) in the Chukchi and Beaufort Seas (Table 6, Fig. 7). The buoys were developed by the Coastal Observing Research and Development Center at the Scripps Institution of Oceanography to characterize the ocean surface wave field and gather wave climate data in extreme and remote environments. MWBs consist of a single float connected to a drogue sea anchor. The floats contain a GPS transceiver and several instruments to measure sea surface temperature, and wave period, energy, and direction. Data are transmitted back to shore via satellite every three hours with a total average battery life of >300 days.

Table 6. Miniature Wave Buoy deployments

Time (GMT)	Buoy ID	Latitude (deg N)	Longitude (deg W)	Water depth (m)
7/23/2017 5:00	537	72.305	-160.840	150
7/24/2017 2:50	535	72.804	-158.436	1000
8/1/2017 17:29	538	71.002	-135.380	1765

Four months after deployment, all three buoys remained in the Chukchi and Sea and were operating nominally (Fig. 7). One buoy (538) apparently grounded at Wrangell Island. A buoy deployed in the Beaufort Sea (537) had become entrained in sea ice west of the Chukchi Plateau (data Fig. 8).

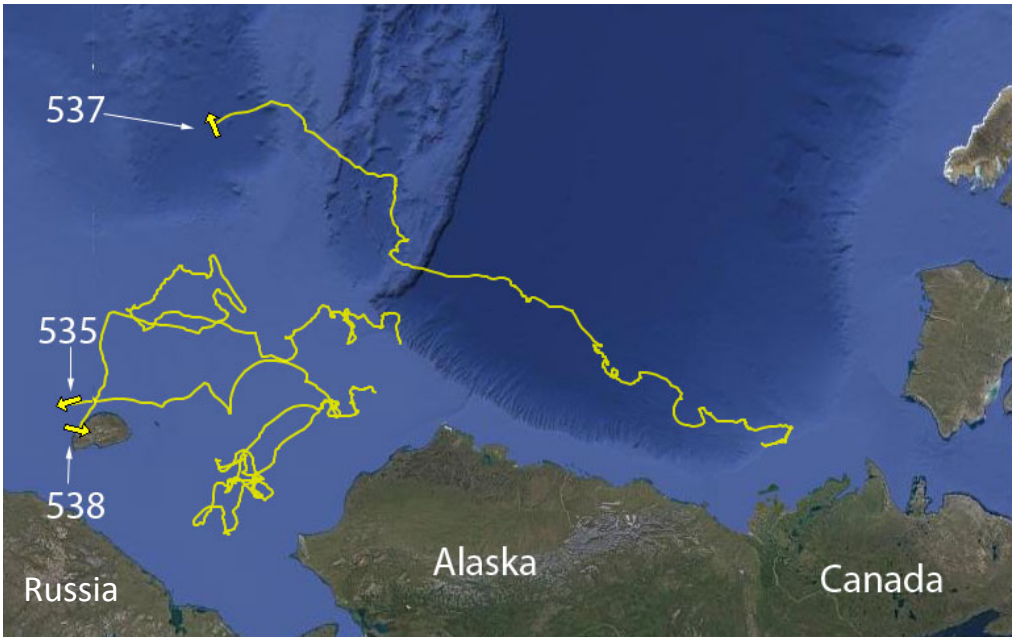


Figure 7. Tracks of three Miniature Wave Buoys approximately four months after deployment. Buoys report GPS position, wave energy, wave height, and wave direction via satellite every three hours.

Deployment 537-01

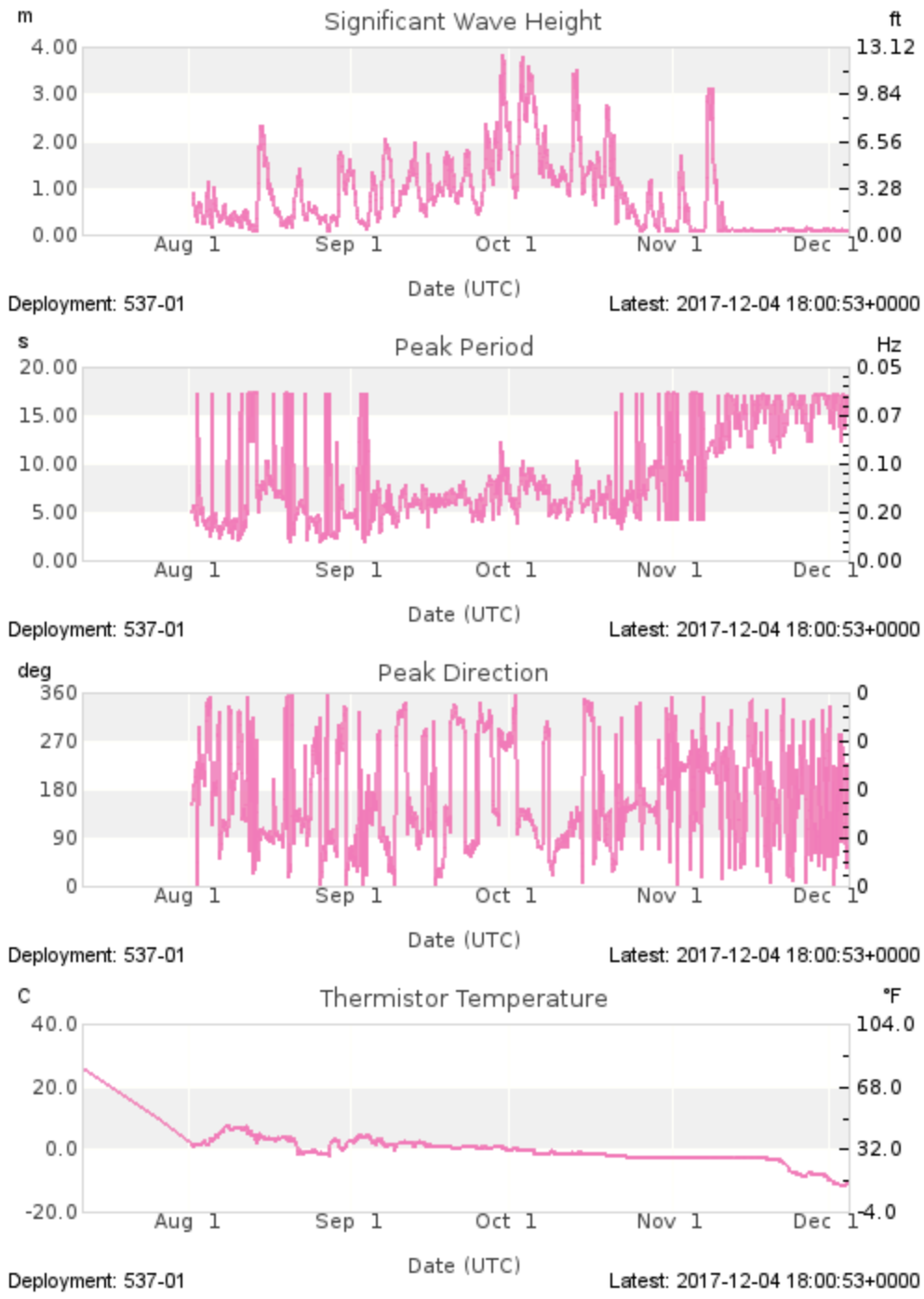


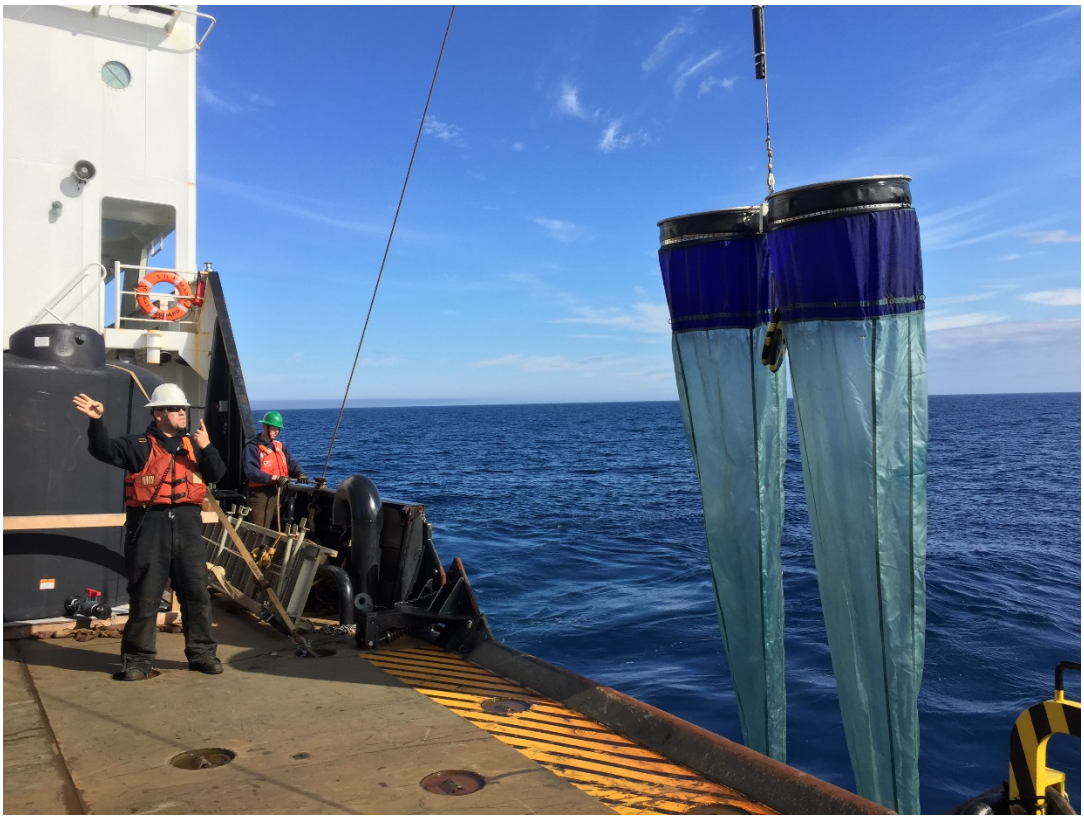
Figure 8. Wave height, period, direction and instrument internal temperature data transmitted from Miniature Wave Buoy 537, deployed August 1, 2017 in the Beaufort Sea.

Ship's navigational data

Data from the ship's ECTIS navigational server was recorded at intervals of 10 seconds and downloaded at the end of the cruise. These navigational data include position, heading, course over ground (COG), speed over ground (SOG), as well as water depth from the ship's sonar, true wind speed and direction, along-track and transverse through the water speed, and ocean temperature at the keel depth of 13-feet.

APPENDICES

A.1. Deck crew aboard MAPLE carry out a safety and operational planning meeting prior to deploying the HARP in the NE Chukchi Sea July 24, 2017 (photo: USCG)



A.2. Zooplankton net being recovered aboard the MAPLE on August 2, 2017. A bongo net frame was used with two 0.7 m opening 5 m length nets and 505 µm mesh size. A conductivity temperature depth probe (CTD) was mounted on the towing line one meter above the net openings. (photo: SIO)

A.3. Photo of polar bear adult and cub taken August 12 in Victoria Strait (photo: SIO)