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V.E. Kostylev, L.M. Broom, A.G. Robertson, T.E. Carson, and S.E. Hayward

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Publications in this series have not been edited; they are released as submitted by the author.

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1. BACKGROUND AND OBJECTIVES

A new Marine Geoscience for Marine Spatial Planning (MGMSP) Program lead by Natural Resources Canada (NRCan) aims at providing innovative regional geoscience products to support the Department of Fisheries and Oceans (DFO) Marine Spatial Planning and evidence-based decision-making. In August 2019 a joint Geological Survey of Canada (Atlantic) and Canadian Hydrographic Service team carried out multibeam bathymetry mapping and sub-bottom profiling on board the Canadian Coast Guard ship *Louis S. St. Laurent* (LSSL) in the northern part of Orphan Basin, as well as along the shelf break and slope from Orphan Spur to Notre Dame Trough. The multibeam survey gave new insight into surficial geology, geohazards and benthic habitats of the northeast Newfoundland slope, northern part of Orphan Basin and Orphan Spur.

Better interpretation of geomorphological features observed in multibeam bathymetry and validation of preliminary interpretations of morphology and backscatter data required the collection of ground-truth information on grain size distribution, stratigraphy, the age of slope failures, and on the nature of seabed habitats. Specifically, the expedition was planned to augment the existing geophysical data coverage of the area by carrying out new multibeam bathymetry and sub-bottom profiler surveys, and to carry out piston and gravity coring, sampling of surficial sediments, and seabed imaging.

The scientific objectives of the *Amundsen* 2020804 expedition included geological and habitat mapping, identification and dating of geological hazards, and gaining better understanding of geological controls on ecological processes. The sites of interest were located in the West Orphan Basin and northeast Newfoundland slope (Labrador Sea) within Canada's Exclusive Economic Zone, and included the Northeast Newfoundland Slope Closure - an area known for high-density populations of deep-sea corals, sponges and sea pens.

The expedition was supported by Amundsen Science - the not-for-profit corporation responsible for the management of the scientific mandate of the research icebreaker CCGS *Amundsen*.

2. PARTICIPANTS

For the Geological Survey of Canada purposes, five participants led the different operations on board the ship (Table 1, Figure 1).

Table 1. Participants for the Geological Survey of Canada expedition 2020804 (ArcticNet Leg 2a).

First name	Last name	Organization	Role
Vladimir	Kostylev	Geological Survey of Canada	Chief Scientist
Laura	Broom	Geological Survey of Canada	Physical Scientist
Tom	Carson	Geological Survey of Canada	Technician
Angus	Robertson	Geological Survey of Canada	Technician
Scott	Hayward	Geological Survey of Canada	Hydrography and GIS

Figure -1. GSC participants of the Amundsen 2020804 expedition. Left to right: Angus Robertson, Scott Hayward, Laura Broom, Thomas Carson, Vladimir Kostylev. Photograph by V. Kostylev. NRCan photo 2020-597.

3. SUMMARY OF ACTIVITIES

The *Amundsen* 2020804 (*Amundsen* Science 2020 Leg 2a) expedition took place in the northeast Newfoundland slope and northern Orphan Basin (Figure 2) region between Latitudes 50.1 – 52.6 N and Longitudes 51.1 – 48.8 W. The expedition took place during August 14th – 24th 2020, departing from and returning to St. John's, Newfoundland on board CCGS *Amundsen*. The cruise activities consisted of sampling the seabed by collecting piston cores, gravity cores, box cores, grabs and bottom camera imagery (Figure 3) during daylight hours (approximately 6 am – 6 pm) and surveying the seabed using sub-bottom profiler and multibeam echosounder during night hours with sound velocity measurements taken along the track.

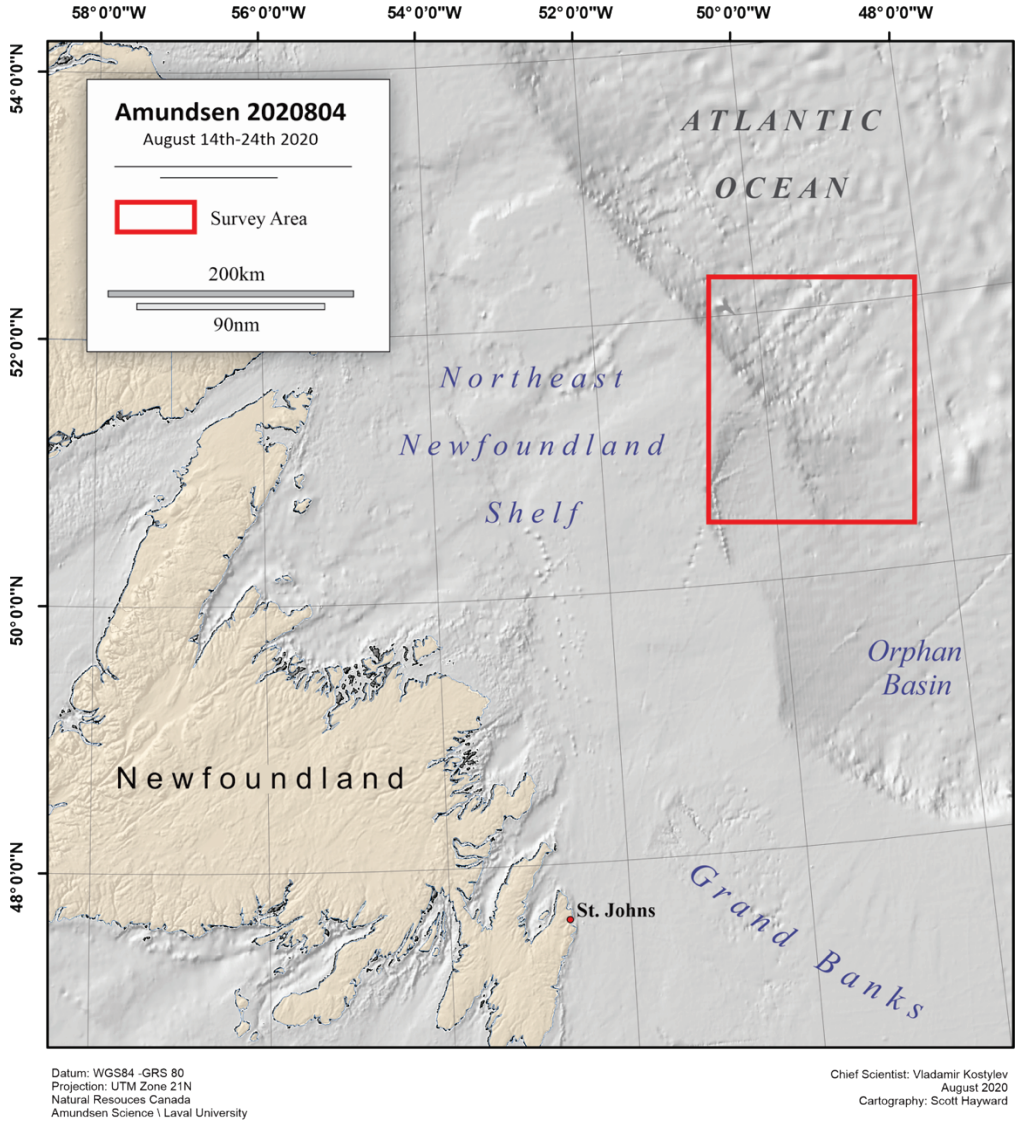

Figure 2: Region of field work for CCGS Amundsen 2020804 expedition (ArcticNet Leg 2a) August 14 – 24th 2020.

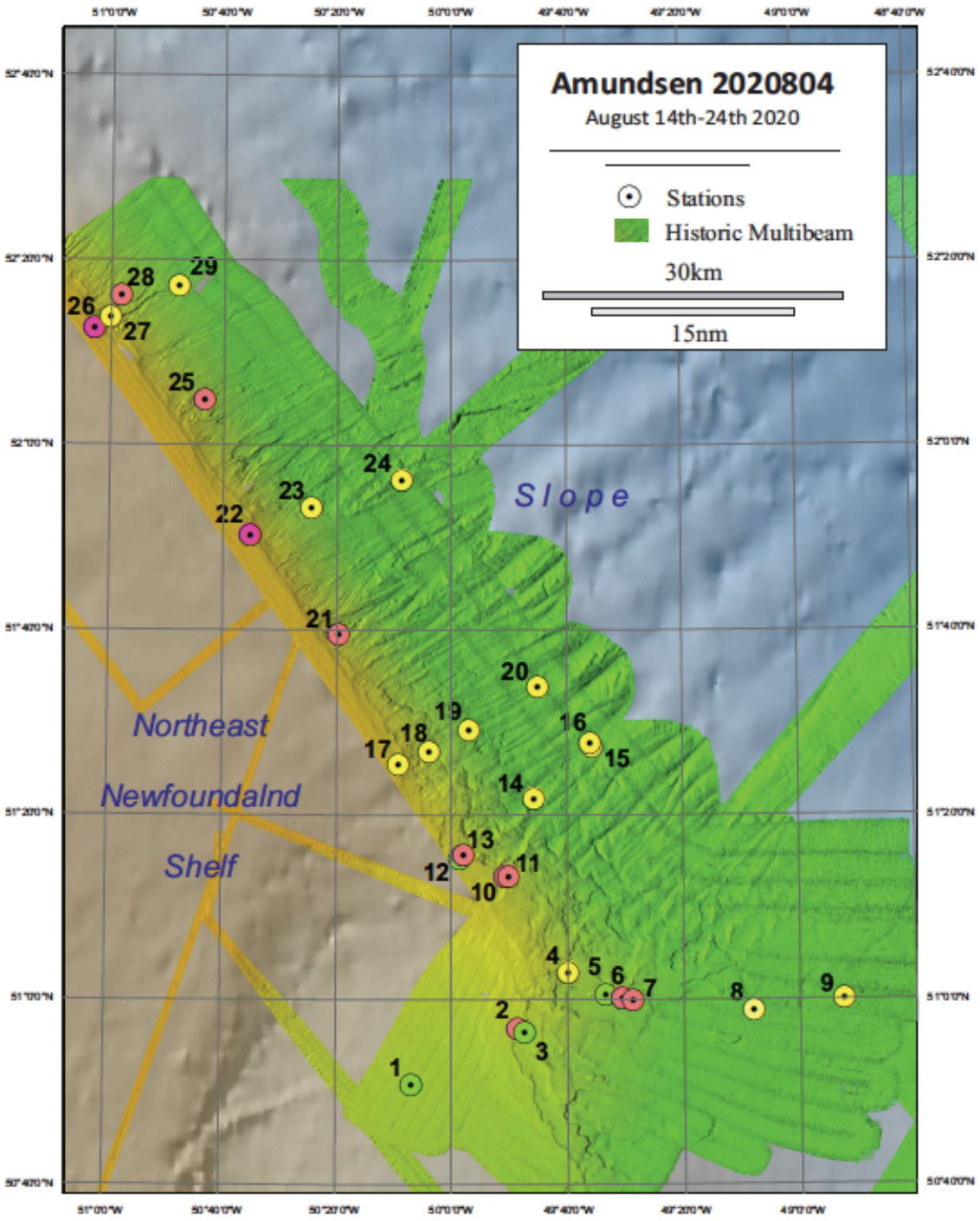

Figure 3. Planned MSP stations locations plotted on top of multibeam bathymetry available for the expedition, including LSSL 2019 data.

4. EQUIPMENT AND PROCEDURES

4.1 Knudsen 3260 Echo-Sounder

Since May 2016, a new Knudsen 3260 deck unit has been installed onboard the *Amundsen*. Sub-bottom profiles were acquired continuously at a frequency of 3.5 kHz to image the sub-bottom stratigraphy of the seafloor. The system was intermittently disabled during drop camera because camera bottom contacts were monitored using a hydrophone. Approximately 1014 NM of data were acquired during this expedition. The original Knudsen .keb files were converted to SEGY and JP2 on board using Courtney tools.

4.2 Simrad EK80 echo sounder

Hull-mounted Simrad EK80 wide band scientific echo sounder was collecting water column data continuously during the expedition (Figure 4). The Simrad EK80 is the most modern "high end" split beam scientific echo sounder in the scientific market. The system is controlled through a dedicated Microsoft Windows computer. Data were collected at 25khz to 50khz by ES38-7c transducer, 85 to 170khz by ES120-7c transducer and 150 to 300khz by ES200-7c transducer and stored as .idx and .raw files.

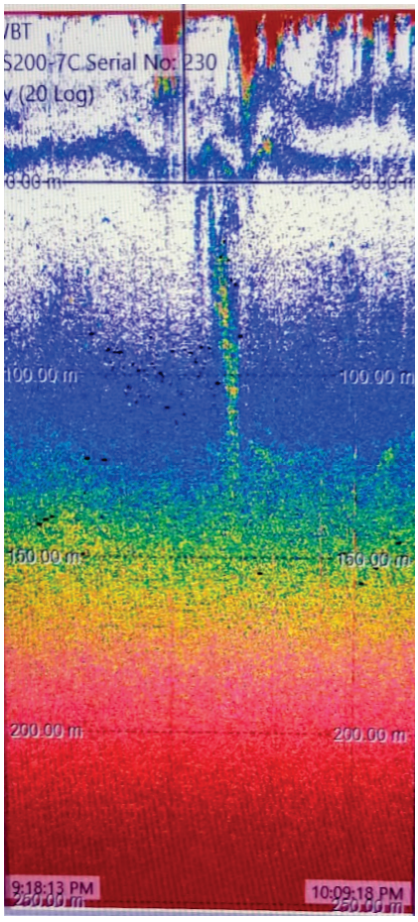

Figure 4. Screen grab of EK80 sounder showing possible natural gas flare over a pockmark.

4.3 EM-302 multibeam echosounder

The *Amundsen* is equipped with an EM302 multibeam sonar operated with the Seafloor Information System (SIS). Attitude is given by an Applanix POS-MV receiving RTCM corrections from a CNAV 3050 GPS receiver. Position accuracies were approximatively < 0.8 m in planimetry and < 1 m in altimetry. Beam forming at the transducer head is done by using an AML probe. All the data acquired during the expedition were post-processed in real-time using the CARIS HIPS&SIPS 11.1 software. Approximately 5900 km^2 of new multibeam data was acquired (Figure 5).

Lockheed Martin MK21 Expendable sound velocity system was used to collect sound velocity profiles for sound speed corrections using XSV-02 probes at up to 6 knots vessel speed (Table 2). They were deployed using 3 m-LA handheld, one to several times a night during multibeam survey to produce reasonable spatial coverage for the survey area. Data were saved in an

ASCII text format (.edf,) so the user can generate the measured profiles to transfer data to Kongsberg SIS. A total of 16 successful launches were performed during the expedition. A CTD Rosette cast was carried out once for comparing accuracy of derived sound velocity profiles to the probes.

Table 2. Times and locations of XSV casts.

Date of Launch	Time of Launch (UTC)	Latitude	Longitude
08/15/2020	10:10:48	50° 51' 14.3703" N	50° 07' 01.1762" W
08/15/2020	22:42:59	50° 43' 07.5988" N	49° 58' 14.6635" W
08/16/2020	02:28:24	50° 25' 51.2292" N	49° 29' 36.0718" W
08/17/2020	00:36:20	50° 31' 59.7833" N	49° 24' 40.0712" W
08/18/2020	00:03:58	51° 25' 58.3379" N	49° 14' 21.8333" W
08/18/2020	03:53:58	51° 49' 14.0298" N	49° 40' 56.5510" W
08/19/2020	02:49:23	51° 41' 43.5608" N	49° 28' 20.3040" W
08/19/2020	07:03:09	51° 34' 48.7236" N	49° 16' 36.2876" W
08/19/2020	22:20:46	51° 10' 09.0156" N	49° 55' 23.3018" W
08/20/2020	05:15:08	51° 18' 04.3007" N	50° 07' 41.3389" W
08/20/2020	05:31:06	51° 17' 07.3870" N	50° 08' 51.1885" W
08/21/2020	04:26:39	52° 19' 22.4847" N	50° 34' 21.1122" W
08/22/2020	01:44:15	52° 19' 10.1571" N	50° 23' 32.9106" W)
08/22/2020	06:49:07	52° 27' 54.9574" N	50° 30' 17.7112" W
08/22/2020	23:07:55	52° 27' 24.2907" N	50° 35' 59.7082" W
08/23/2020	06:02:42	51° 40' 11.7000" N	49° 34' 47.8572" W

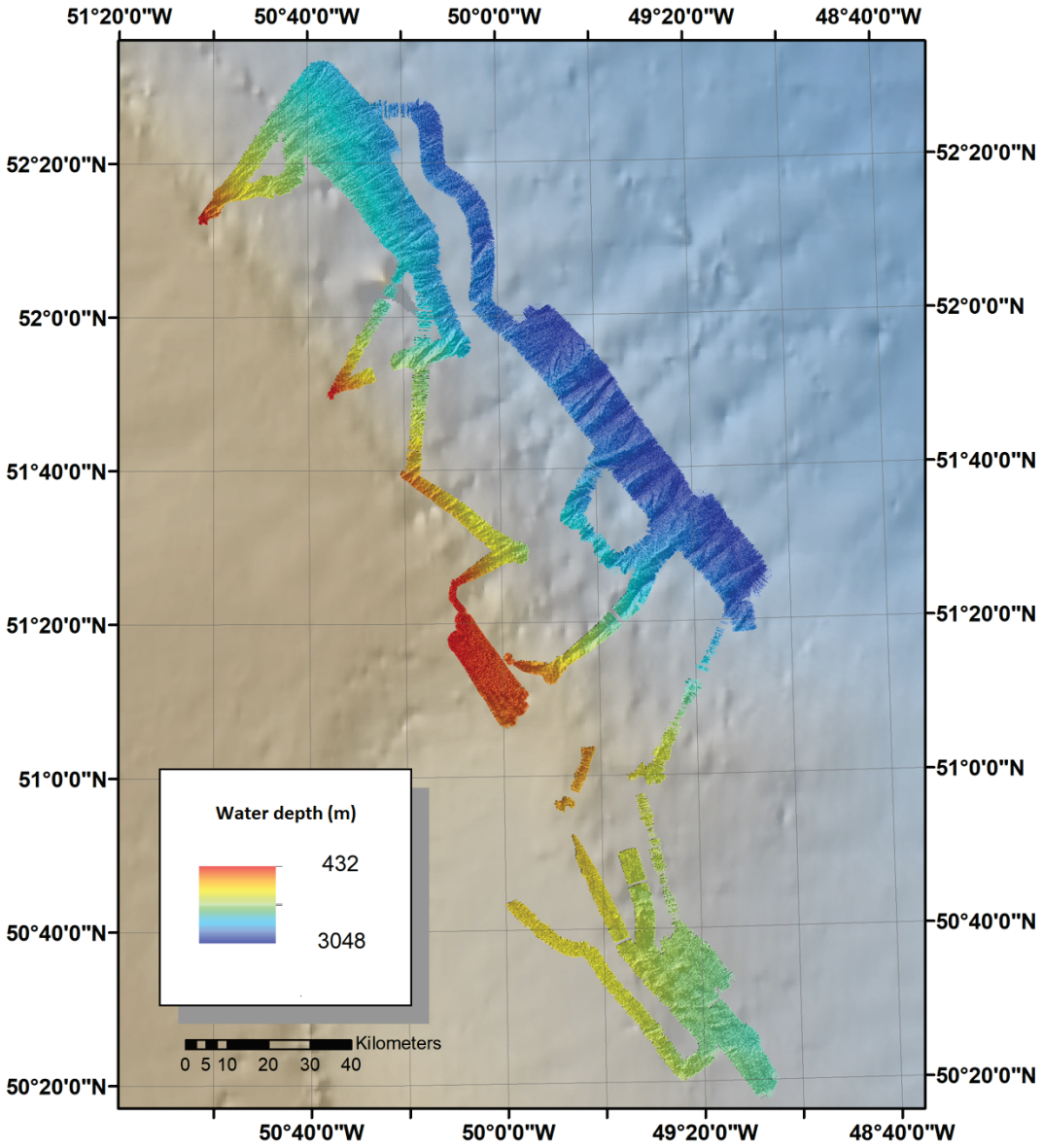

Figure 5. Extent of the newly collected multibeam echosounder data in the study area.

4.4 Piston and gravity coring

The standard Amundsen Science piston coring equipment was used for the mission and configured with three barrels that together totalled just over 9 m in length and an 800 kg head. The trigger weight core used in conjunction with the piston core was a new GSCA Mk 3 gravity corer (Figure 6) and this mission was its first trial. This gravity corer incorporates a butterfly valve and a lower centre of gravity due to thinner lead weights placed lower on a core barrel, and is composed of aluminum 6061-T6 construction as opposed to steel. Ten piston cores (Table 3) were achieved, typically giving maximum recovery of over 5 m and penetration of over 6 m. The gravity corer worked well and

usually gave good recovery, typically 2 m or more. It was also used as a standalone gravity corer at several stations.

Table 3. Piston core (PC) and gravity core stations for Leg 2a. Some depths (indicated by asterisk) are estimated from multibeam bathymetry.

Amundsen station #	GSC-A station #	Core type	Latitude	Longitude	Depth (m)	PC length (cm)	Gravity core length (cm)
MSP-002B	0003	Piston	50.9461	-49.8128	1008	511	175
MSP-003A	0004	Piston	50.9415	-49.7897	1060*	524	197
MSP-005B	0007	Piston	51.0102	-49.5626	1250*	215.5	193
MSP-006	0008	Piston	51.0048	-49.5157	1340*	420	62
MSP-007A	0009	Piston	50.9992	-49.4770	1443*	370.5	224
MSP-020B	0015	Gravity	51.5609	-49.7534	2315*	n/a	29
MSP-010	0016	Piston	51.2219	-49.8441	936	400.5	228
MSP-010	0017	Piston	51.2220	-49.8445	933	435	0
MSP-011	0018	Piston	51.2237	-49.8355	969	530	118
MSP-012B	0020	Gravity	51.2555	-49.9768	705	n/a	0
MSP-013	0021	Gravity	51.2612	-49.9657	755	n/a	70
MSP-021	0026	Piston	51.6577	-50.3253	803	170	0
MSP-028	0037	Piston	52.2677	-50.9703	1015	528.5	235

Figure 6. The new GSC(A) MK 3 gravity core head. Photograph by V. Kostylev. NRCan photo 2020-598.

A total of 56.36 m of sediment was obtained from 20 cores (Table 2). All cores were processed according to standard GSC Atlantic core procedures (Mudie et al., 1984). The following detailed description of the processing steps is quoted from Normandeau et al. (2019), because the processing and sub-sampling was carried in identical manner with the same equipment:

All core barrels were kept in sequence, from the bottom to the top, as the barrels were taken apart. Starting with the bottommost barrel each 10 ft length of liner was extruded from the barrel and cut in half, using a modified pipe cutter. The sediment in the liner was cut using a wire saw and the section ends were carefully capped to minimize disturbance to the sediment surface. The top end cap was labelled with the cruise number, station number, section label and as top. The base of the piston core is designated with the letter A and the top of the base section is designated as B. Each core, starting with the base section AB, was processed using the following procedure. The core liner was labelled with an up arrow, cruise number, station number, section label and the top and base of the section were labelled with the appropriate letter. End caps were removed if the sediment was not too fluid, and the section length was measured and recorded. Undrained shear strength measurements and constant volume samples were taken at the top and base of each section where possible. Inert packing was placed in the voids created by the constant volume sampling. The ends of each core section were recapped, taped and sealed with beeswax to prevent further oxidation and drying. The sealed core sections were stored upright in custom-made whole core portable racking units in the starboard refrigerated reefer container and maintained at 4°C. All core cutters and catchers were measured, labelled, placed in split liners, waxed and stored upright in buckets in the reefer container.

Undrained shear strength measurements and constant volume samples were taken at the ends of each section when possible. The constant volume sampler was inserted into the end of the section, the undrained shear strength measurement was taken and then the constant volume sampler was removed. The undrained shear strength was measured using a hand-held Hoskin Scientific Torvane according to ASTM Test Method D2573 Field Vane Shear

Test in Saturated Fine Grained Soil. The dial on the Torvane was zeroed, the fins on the vane were gently pushed into the sediment until they were completely inserted. The Torvane was rotated at a constant rate until the sediment failed.

Constant volume samples for bulk density and water content determinations were taken by inserting stainless steel samplers of a known volume. Prior to insertion, the sampler was lightly sprayed with PAM oil and gently wiped with a small Kimwipe tissue. The bevelled edge of the sampler was placed on the flat sediment surface and the carefully inserted into the sediment using two flat-headed spatulas. The sampler was inserted at a constant rate to minimize compression of the sediment within the sampler. The sampler was then carefully removed and the sediment was trimmed using a wire saw and extruded into a pre-weighed 1 oz screw-top glass bottle. The bottle cap was then labelled and sealed using electrical tape to prevent the lid from loosening. A total of 20 constant volume samples and 15 Torvane measurements were taken during the cruise (Table 4, Table 5).

Table 4. Summary of Physical Property sampling

Station Number	Sample Type	# of Torvane Measurements	# of Constant Volume samples
0003	PC	2	4
0004	PC	4	4
0008	PC	1	1
0017	PC	3	3
0018	PC	4	5
0037	PC	1	3

Table 5. Summary of Torvane measurements.

Sample No.	Type	Section	Top/Base	Vane used	Reading (1 - 10)	Shear strength (kg/cm2)
0003	PC	AB	Top	Large	2.50	0.63
0003	PC	BC	Base	Large	2.00	0.50
0004	PC	AB	Top	Large	3.40	0.85
0004	PC	BC	Base	Large	4.30	1.08
0004	PC	BC	Top	Large	4.90	1.23
0004	PC	CD	Top	Large	0.90	0.23
0008	PC	BC	Top	Large	0.50	0.13
0017	PC	AB	Top	Large	3.40	0.85
0017	PC	BC	Base	Large	3.70	0.93
0017	PC	BC	Top	Large	1.90	0.48
0018	PC	AB	Top	Large	2.60	0.65
0018	PC	BC	Base	Large	2.80	0.70
0018	PC	BC	Top	Large	3.50	0.88
0018	PC	CD	Top	Large	1.60	0.40
0037	PC	BC	Base	Large	1.80	0.45

4.5 Box core and Van Veen samples

A standard Benthos style box core owned by *Amundsen* Science was used and gave very good results considering the substrate contained some gravel in every sample. Five deployments were undertaken and all but one received a reasonable amount of recovery (Table 3). The box core sample was sub-sampled upon retrieval with three push cores when a sufficient amount of relatively undisturbed sediment was retrieved. Push cores were inserted in three of the recovered box cores, and a new battery operated vacuum pump (Laerdal Medical vacuum) was used to prevent compression during the push (Figure 7). This appeared to work well and eliminated the need for an electrical cable on the deck. A surface layer (approximately 3 cm thick) was also saved as a separate sample for bulk grain size measurements. On one of the stations the box core did not trigger properly at the seabed and came back to the surface with the recovery wire and swivel tangled under an edge on the upper mast. It was safely landed on deck and re-armed and deployed again with subsequent success.

The GSC-A Van Veen grab sampler was deployed at five stations (Table 6) and gave approximately half full recoveries. It was very easy to arm and recover and presented an efficient sampling tool for obtaining a representative sample of the seabed. The whole contents of the grabs were stored in one or several plastic bags, and refrigerated.

Table 6. Box core and Van Veen grab sample stations for Amundsen 2020804.

Amundsen station #	GSC-A station #	Sample type	Latitude	Longitude	Depth (m)	Recovered length (cm)
MSP-015B	0011	Box core	51.4558	-49.5939	2358	8
MSP-016A	0012	Box core	51.4620	-49.6008	2371	5
MSP-017B	0023	Van Veen	51.4224	-50.1596	548	Bulk sample
MSP-019A	0024	Box core	51.4872	-49.9497	1623	30
MSP-024B	0028	Van Veen	51.9388	-50.1443	2288	Bulk sample
MSP-023B	0030	Van Veen	51.8871	-50.4057	1535	0
MSP-022	0031	Van Veen	51.8395	-50.5861	502	0
MSP-026A	0032	Van Veen	52.2103	-51.0473	474	Bulk sample
MSP-027B	0036	Box core	52.2288	-51.0003	836	39
MSP-029B	0039	Box core	52.2837	-50.7901	1550	35

Figure 7. Use of vacuum pump for obtaining push cores on board Amundsen 2020804. Photographs by V. Kostylev. NRCan photos 2020-599, 2020 – 600.

4.5 Camera stations

GSC-A - designed and owned drop camera (4k Cam, Figure 8) was used for acquiring images of the seafloor (Table 4). A backup camera of the same design owned by DFO-BIO was also used on a number of stations. The camera consists of an aluminum frame that supports a pressure housing containing a Canon Rebel digital SLR and wide angle 28mm f 1.8 lens. Two canon flashes are synced with the digital camera and all power is provided by a 12 v/80 AHr Deep Sea Power & Light pressure compensated sealed lead acid battery. A drop weight (metal disk, 10.5 cm in diameter) on a 1.5 m wire is attached to a plunger trigger switch to close the shutter when close to the seabed. A 12 kHz pinger is also controlled and shutoff by the same trigger mechanism when the camera is close to the seabed.

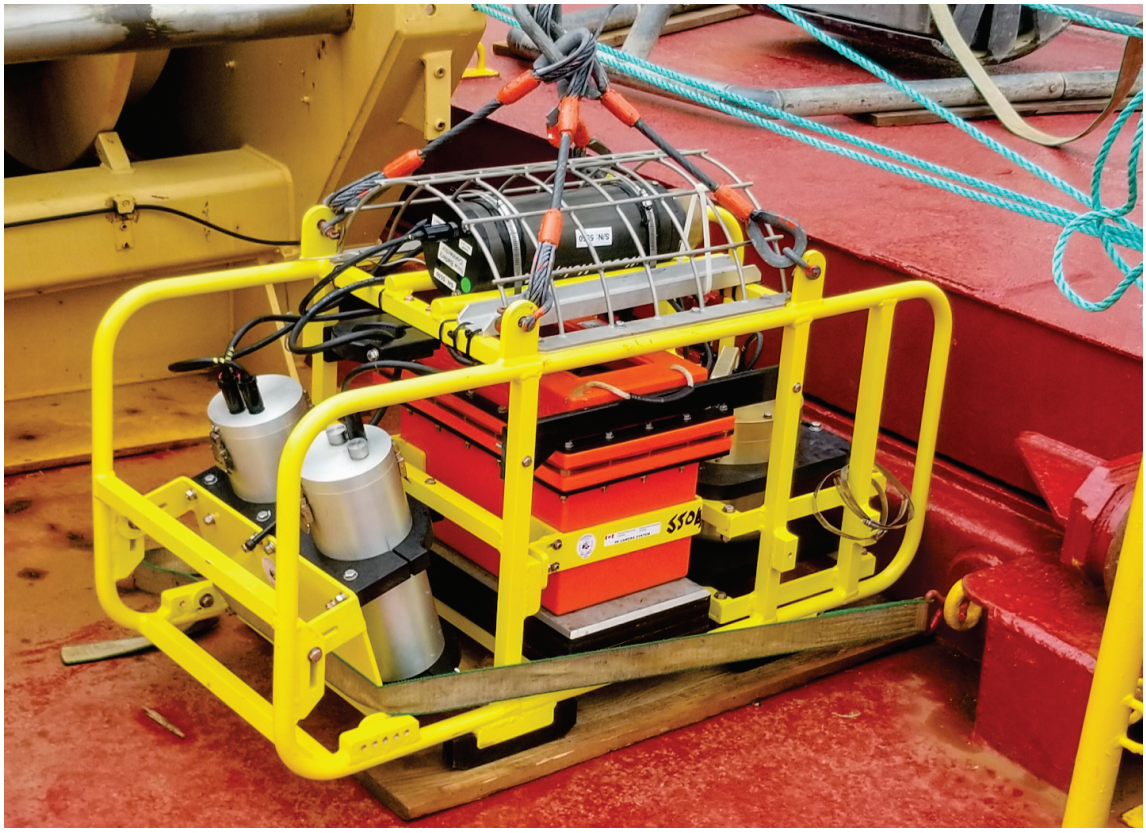

Figure 8. GSC 4K camera was used for bottom imaging. Photograph by V. Kostylev. NRCan photo 2020-601.

Eighteen stations were completed in water depths from a few hundred metres to 2300 m (Table 7). At each location, a drift over features of interest was attempted at low vessel speed over ground (less than 1 knt) and the camera spent up to 30 minutes on bottom at each station.

Generally, the cameras worked very well. There were some issues with the trigger on the NRCAN 4k Cam so camera triggers were switched and after experiencing further problems we started to use the DFO 4k camera. Initially, a GSC-A-built listening device was used to listen for the 12 kHz pinger closure but it was very difficult to detect the signal with harsh background interference. After that an ORE 12 kHz mooring release box owned by Amundsen Science was used instead, with much better success in detecting bottom contact. Overall, the bottom photos were well illuminated with sharp focus.

Table 7. Camera stations for Amundsen 2020804.

Amundsen station #	GSC-A station #	Latitude	Longitude	Depth (m)
MSP-001A	0001	50.8503907	-50.1101662	1092
MSP-002A	0002	50.9420300	-49.8022358	1060
MSP-004A	0005	51.0607835	-49.7030838	972
MSP-005A	0006	51.0092080	-49.5626168	1168
MSP-015A	0010	51.4549277	-49.5931518	2363

MSP-016B	0013	51.4617197	-49.6005852	2375
MSP-020A	0014	51.5614377	-49.7524807	2311
MSP-012A	0019	51.2555245	-49.9766070	705
MSP-017A	0022	51.4244258	-50.1540978	557
MSP-019B	0025	51.4847535	-49.9555805	1598
MSP-024A	0027	51.9418530	-50.1496000	2276
MSP-023A	0029	51.8870067	-50.4060718	1542*
MSP-022B	0032	51.8393785	-50.5861227	501
MSP-026B	0034	52.2100440	-51.0433228	476
MSP-027A	0035	52.2308947	-51.0075723	785
MSP-029A	0038	52.2855920	-50.8035850	1543
MSP-008	0040	50.9808543	-49.1325942	1910
MSP-009	0041	50.9948592	-48.8648673	2288

5. PRELIMINARY RESULTS

The *Amundsen* 2020804 expedition collected (Figure 9):

1. 10 gravity cores and 10 piston cores (56.36 m total length of sediment cores)
2. 5 box cores
3. 5 Van Veen grabs
4. 18 drop camera stations, yielding 784 high-resolution photographs of sea bed
5. 5900 km^2 of seabed mapped with multibeam echosounder in water depths of 433 m to 3049 m
6. 1878 km of 3.5 kHz sub-bottom profiler survey lines

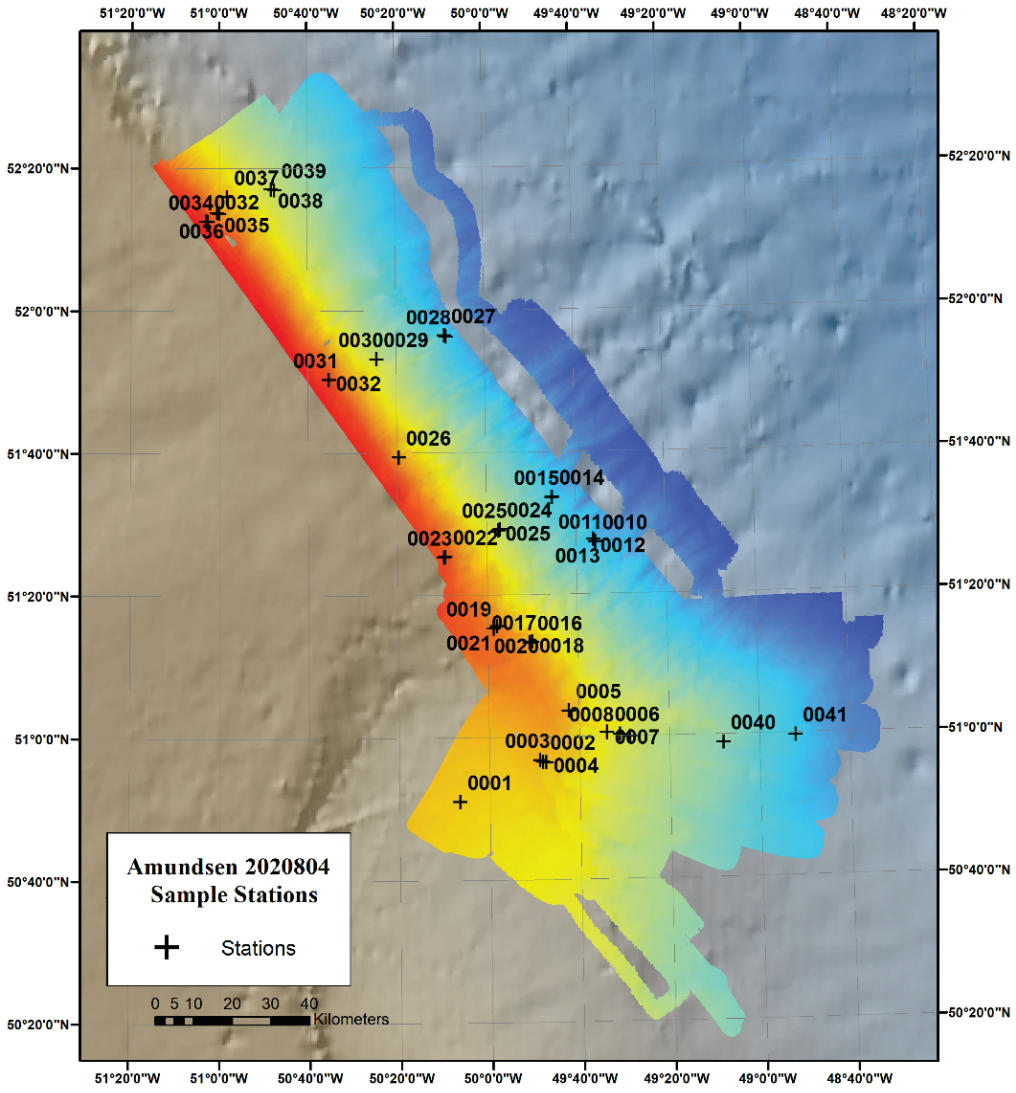

Figure 9. Positions of sampling stations occupied during the Amundsen 2020804 expedition. Multibeam bathymetry collected during LSSL 2019 and Amundsen 2020804 expeditions is shown in the background.

Preliminary results show that multibeam backscatter variability in the lower slope (2000 – 3000 m water depth) is related to the presence of coarse-grained sediment and hard substrate (patches of boulders (Figure 10) and bedrock outcrops(Figure 11)) in the lower slope, likely caused by upper slope instability and down-slope sediment migration. The conspicuous pockmark features in the lower slope contain winnowed gravel, possibly indicating gas or liquid escape leading to active removal of sediment. A possible gas flare was observed in Simrad EK80 echosounder over one of such features.

Northern canyons have steep walls and U-shaped cross-sections, A thick layer of sediment observed on the bottom suggest that the canyons are inactive. Northern Orphan Basin exhibits mass transport deposits, similar to those described by Campbell (2005) in the south of the basin. These features were piston cored, and laboratory analysis may allow for dating these events. The pagoda-like features readily identifiable in sub-bottom profiler, similar to those found along Sackville Spur (Campbell et al. 2002), did not show unique surficial morphology or conspicuous megafauna at seabed photograph scale. Piston and gravity cores will be analysed at GSC lab to gain insight regarding the age of the slope failures. While the study area is a part of the Northeast Newfoundland Fishery closure, established mostly for the purpose of protecting corals and sponges, the seabed imagery rarely showed presence of hard corals, and soft corals occurred in moderate abundance (Figure 12).

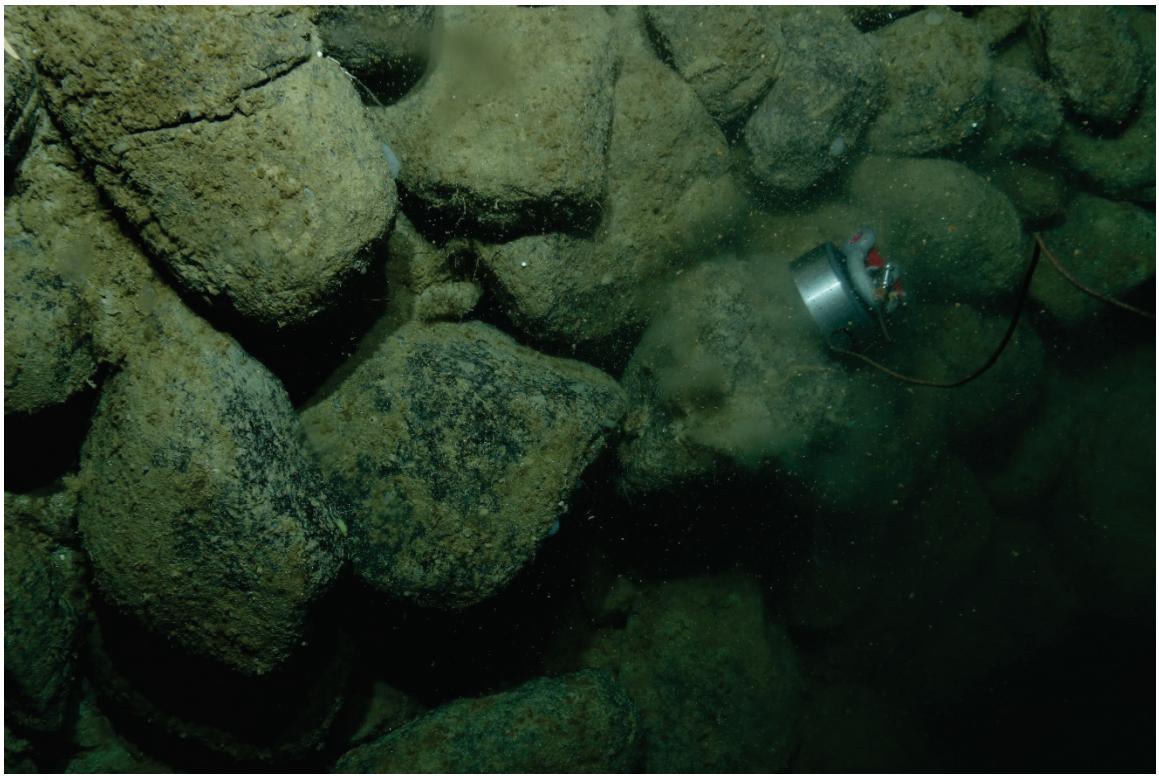

Figure 10. Station GSC 0013. Conspicuous patches of well-rounded boulders observed at water depth 2375m. Photograph by V. Kostylev. NRCan photo 2020-602.

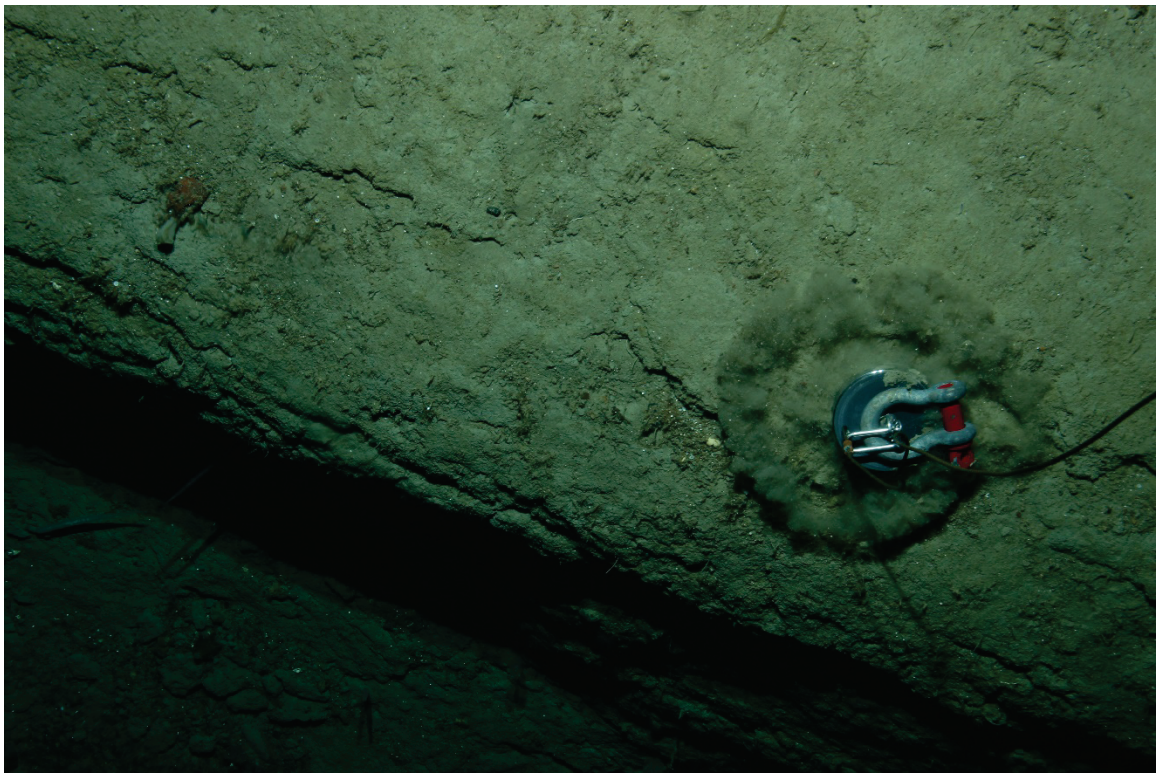

Figure 11. Bedrock outcrop at 2360 m at station GSC 0010. Photograph by V. Kostylev. NRCan photo 2020-603.

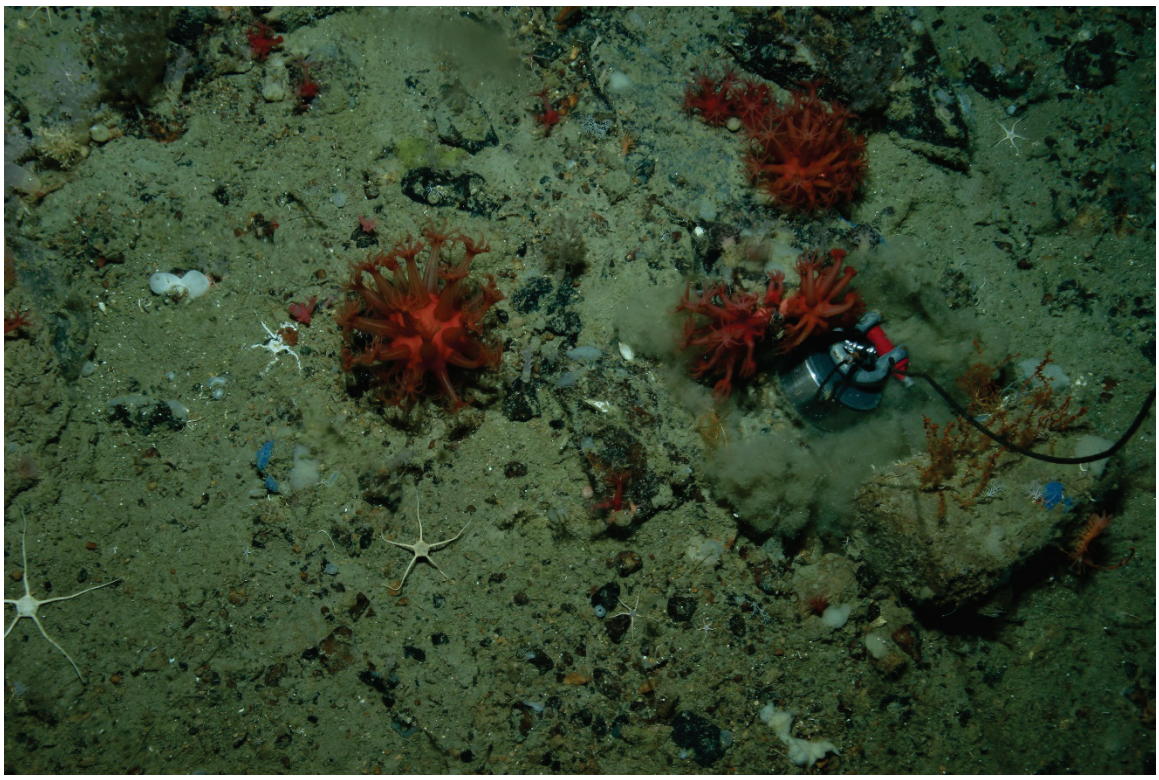

Figure 12. Station GSC 0025, showing presence of soft and hard corals (Anthomastus sp. and Acanella sp.), water depth 1500 m. Photograph by V. Kostylev. NRCan photo 2020-604.

The statements above are just quick observations from the field. Quantitative analysis of bottom imagery, cores and sediment samples will enable better interpretations on megafauna species composition and diversity, seabed habitats and geohazards in the study area. Future fieldwork in this area may include Autonomous Underwater Vehicles, upgraded live-streaming seabed imaging system and a deep-towed broad frequency sub-bottom profiler. The latter would allow for high-resolution mapping of both surficial and buried features of interest.

6. ACKNOWLEDGEMENTS

We are thankful to Captain Alain Gariepy for ensuring a safe and successful expedition. His experience, interest in ocean science and suggestions on operations were much appreciated. The officers and deck crew were most helpful and engaged in our work.

We were fortunate to take advantage of *Amundsen* ship time cancellations of other research groups who cancelled their planned expeditions because of COVID-19 situation in Canada. Amundsen Science team was very helpful in helping us organise the expedition, plan the expedition schedule, provided us with all the necessary information and forms for arranging permissions to travel and collect data. The Amundsen Science crew on board ship was extremely helpful with operation and troubleshooting of scientific gear, and all the operations were carried in safe and secure manner. We are particularly thankful to the following persons: Lou Tisne for fixing the problem with the forward deck winch, without which we would not be able to carry our operations at all; to Daniel Amirault for his diligent work in collecting multibeam echosounder data, and troubleshooting Kongsberg hardware problems; to Shawn Meredyk, who provided his help and gear for monitoring the underwater camera pinger, and to Camille Wilhelmy for assisting with core processing in the evenings, when GSCA staff was exhausted. Overall, we are very satisfied with conducting our research on board the CCGS *Amundsen* and we are looking forward to opportunities to use this research platform in the future.

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APPENDIX A: Daily log of events

DAY # 1, Date: 2020-08-13

SUMMARY OF LAST 24h: Thomas Carson, Angus Robertson, Scott Hayward, Laura Broom and Vladimir Kostylev arrived at Shell AFB in Halifax. 10:56 boarded the charter flight to St. Johns joining the Coastguard crew who travelled from Quebec. Taken by bus from YYT to Coastguard base. Joined the ship by 13:50 NLT.

Moved gear from cargo container to labs and offices. Familiarisation tour 18:00 – 19:00. VK made Life on Board presentation at 19:30 – 21:00. Captain Alain Gariepy presented the officers (Chief Officer, Chief Engineer, Chief Medical officer, Logistics officer). We were given medical forms to fill and return next day.

WEATHER TODAY: Air temperature: 21 – 24, high humidity, low ceiling, followed by broken clouds, light drizzle in the afternoon. Wind speed: 10 – 15 knt, Sea state: Calm, Visibility: Good

OPERATIONS COMPLETED: Gear and work place preparation. Tying down gear for transit.

WEATHER FORECAST: Seas 1.5 – 2 m, wind 20 knt.

PLANNED OPERATIONS FOR NEXT 24h: Transit to station 1. Safety meetings with captain and crew.

HEALTH AND SAFETY: COVID measures observed. Distancing works. Hand sanitizer issued to team members. Hearing protection prepared for dealing with propeller noise. IR thermometer is available for daily self-checks.

DAY # 2, Date: 2020-08-14

SUMMARY OF LAST 24h: Left St John's Harbour at 9:00. Day was spent in transit to the location of the first station. 13:00 CTD safety meeting was led by Camille Wilhelmy from Amundsen Science. Present – captain and deck crew. Robertson and Carson attended too. At 14:00 Piston core, boxcore and camera safety meeting with safety instructions presented by Robertson. Present – captain and crew. All GSC personnel attended. Kostylev has updated and used Power Point presentations available from Amundsen Science. 16.00 Fire and abandon ship drill. Shawn Meredyk was staying in his cabin for the purpose of this exercise. Drill completed successfully**.** Daniel Amirault and Hayward working on fixing MBES issues. Rough 20 hr transit to the first station.

WEATHER TODAY: Morning **-** 10 knt wind, overcast, foggy. 18 degrees air temperature near land. At sea air temperature lowered to 15 degrees. The wind picked up to 20 – 24 knts, seas 2 – 3 m. Wind may calm down overnight to 15 knt. Sun broke out around 17:30. Visibility: Poor.

OPERATIONS COMPLETED: The day of transit to survey area. First mate warned that 7 planned sample locations were too close to underwated cables. Most were adjacent to abandoned cables, but one of them was close (several miles) to the active cable. A new location (NW from the planned one) was given to the bridge for MSP-01. At least 1 mile distance from the abandoned cables was considered for the remaining stations.

WEATHER FORECAST: Funk Island Bank forecast Issued 03:00 AM NDT 14 August 2020. Wind north 15 to 20 knots diminishing to variable 10 to 15 Saturday morning then becoming west 15 Saturday evening. Today Tonight and Saturday. Seas 1 to 2 metres. Showers and fog banks ending this afternoon with a risk of thunderstorms.

PLANNED OPERATIONS FOR NEXT 24h: 3 stations to acquire, Piston coring and camera work.

HEALTH AND SAFETY: No issues.

DAY # 3, Date: 2020-08-15

SUMMARY OF LAST 24h: Weather calming down.

6am - Multibeam system would not power up. Amirault contacted Kongsberg, replaced lithium battery on the main motherboard, system started but warning lights are up during pinging.

At 6am arrived at station MSP01. Assembled piston core by 7:20. Using the new gravity core setup for trigger arm. Forward deck winch control problem was identified at 7:30. Lou Tisne was working on fixing the winch control software. This is the main and only winch for piston coring. If not fixed we would try to use the moon pool winch.

Trip wire and piston wire for piston coring could not be located. Called Anissa Merzouk for help. After few hours the crew found the trigger wire and piston wire. Iridium phones in chief scientist cabin did not work – bad SIM card. Purchased PIN ($35) for using in cabin Iridium.

Camera battery on 4K camera was charging very slowly. Replaced charger with a similar charger from DFO 4K camera - success.

Hayward installed Regulus computer in electronics container on forward deck. Robertson Prepared compass vanes for underwater camera.

11:20 Lou reported that winch control cannot be fixed. A specific module has crashed, and we need a replacement. A new one cannot be shipped because it is custom made. Waiting for Luc and Thomas (techs on leg 1) to contact the company. Reported the issue to the captain.

12. Roberton called Peter Pledge to update on status.

12.30 Kostylev called Merzouk to inform about the winch problems.

Tried camera for MSP-01 deployment from the moon pool. Experienced a lot of noise interference from props and HiPap. HiPap experienced communication failure and did not

acquire beacon data. Turned it off. Lost acoustic response from camera pinger at 190 m. It came back on board not pinging.

Replaced camera trigger weight with a heavier one. Success on second deployment. About 50 good quality images collected over 20 min drift. HiPap test carried on the camera's way up. The beacon was probably not functioning properly. Tisne will continue testing tomorrow.

Multibeam fully operational. Test run around 18:00 and XBT cast. MBES survey started at 18:50, south-east tack, surveying southern arm of Orphan Spur.

19:00 science debriefing with the captain. Successful day of troubleshooting. Beautiful cloud-free starry night!

WEATHER: Air temperature: 13 C. Wind speed: The wind calmed down overnight to 5-10 knt W. Sunny. Sea state: 1 – 2 m waves. Visibility: Good.

OPERATIONS COMPLETED: Camera station at MSP-01 completed.

WEATHER FORECAST: Funk Island Bank forecast Issued 10:00 AM NDT 15 August 2020: Wind variable 10 to 15 knots becoming west 15 this evening. Wind west 15 Sunday. Seas 1 to 2 metres.

PLANNED OPERATIONS FOR NEXT 24h: XBT drop at night. Continue Drop Camera work, wait for the news on the winch repairs. Test HiPap beacons on the first station. Possibly re-schedule sampling locations.

HEALTH AND SAFETY: COVID testing results for CCG crew did not arrive yet.

DAY # 4, Date: 2020-08-16

SUMMARY OF LAST 24h: Started with a drop camera station in the moon pool. Used NRCan camera. Replaced HiPap beacon with the one having wider beam angle. Camera was deployed at station MSP-02. By time camera reached the bottom the ship has drifted SE about 0.5 miles. Took several pictures, then lost control. Spooled about 1180 m of wire looking for bottom. Pooled camera up to 1000 and descended again, successfully taking several more bottom photographs. HiPap was tested during the deployment. There were no signal from the beacon for most of the deployment, it connected once on the ascent and then disappeared again. It is suspected that it is being shadowed by camera frame or because the cable is at an angle, so the ship side transponder does not receive the beam. Obtained about 15 good bottom photos.

MB system was off during morning hours.

Piston core operations started at 9 am. It took 1hr 10min to prepare the core for deployment. Core descent took 20 minutes and it was winched up in 15 minutes (110 m water depth). By 11:15 core was on deck and it took 45 minutes to extrude, label, clean up and stove the samples from the piston core. Gravity core was dealt with after lunch (took another 45 min). Successful operation. Retrieved approximately 5 m in piston core and 1.8 in gravity core. A sample was

stored from the core head of the piston core. There may be a need to modify the piston to obtain a longer core sample.

Continued coring operations after lunch at station MSP-03. Successful core retrieval, approximately 7 m long. ¾ of the gravity core filled with sediment. Operations went smoothly, faster than the first time. Liners were retrieved while transiting to camera station (MSP-04).

Camera station was challenging. Water depth approximately 970 m. It was difficult to hear the pings from the camera beakon. Carson was the only one who could hear. Too much winch wire was let out and camera was dragging on the bottom, pinging constantly. It was winched up and re-deployed again, while observing the A-frame block. While there was a lot of motion of the block related to sea state, the moment the camera touched the bottom the block suspended on A-frame shook differently. After that the winchman was told to yo-yo the camera up and down within 1-2 m range. About 37 successful shots of seabed were taken over 20 minutes.

Broom continued core sampling and labeling during camera station and at night hours. Bridge has reminded Kostylev to update on the night survey results before 6pm crew change, so they can plan their night work accordingly. I gave them the location for survey start. After supper the survey plans were discussed with the captain, Amirault and Haywardt, and the plan was agreed upon.

WEATHER: Air temperature: 13C, Wind speed: 10 knt W. Sunny. A bit hazy. Weather improved during the day, sea state at night about 1 m or less, calm. Cirrostratus clouds. Sea state: 1 – 2 m waves, decreasing to 1 or less by night. Visibility: Good.

OPERATIONS COMPLETED: Camera stations at MSP-02, MSP-04 and piston core at MSP-02 and MSP-03 completed.

WEATHER FORECAST: Funk Island Bank forecast Issued 10:00 AM NDT 16 August 2020: Wind west 15 knots becoming variable 10 to 15 Monday morning. Wind west 15 Sunday. Seas 1 to 2 metres.

PLANNED OPERATIONS FOR NEXT 24h: XBT drop at night. Continue Drop Camera and piston core work at stations 5, 6 and 7.

HEALTH AND SAFETY: COVID testing results for CCG crew did not arrive yet.

DAY # 5, Date: 2020-08-17

SUMMARY OF LAST 24h: Camera deployment (MSP-005) in the morning was challenging. The trigger weight wire wrapped around the camera frame, had to re-deploy. At 1000 m water depth repetitive camera deployments consume extra long time. Ship has drifted from the initial camera station and had to be repositioned. In order to keep to schedule yo-yo movements of the camera were rushed and camera station was cut short after 10 minutes, only 6 good images obtained.

Piston core at the top of failure (MSP-05) successful. Gravity core sample was short, about 1 m. Piston core about 2 meters. Piston core at the edge of MTD (MSP-06), where sediments were pinching to the surface was successful, about 5 m long. Coarse sand and gravel sediments on top of core. Bridge positioned ship extra accurately, within 40 m from the planned location.

Piston core at MSP-07 – good penetration. Gravity core completely full, piston core about 4.5 m.

Camera operation (last planned station of the day) was cancelled upon retrieval of the last core at 5:30pm because cores needed to be processed and crew worked since 6 am.

Discussed MB operations with MB crew. Adjusted MB setting to deep water. Turned down 60khz sonar for interference. This should improve successful ping rate. The rate is low for the MB because it is old, and outer beams are bad, so it operates at +-60 degrees. Deep water setting seems to bring better quality data. Surveying at 7.5 knt.

Discussed HiPap and 12 kHz tracking with Tisne. She may come up with some ideas tomorrow.

Confirmed to Alex Forest that we can use 1 – 2 days extra on the boat.

WEATHER: Air temperature: 11C, Wind speed: Sunny, NE wind 15 knt picking up in the afternoon. Sea state: 1 – 2 m waves. Visibility: Good.

OPERATIONS COMPLETED: Camera stations at MSP-05, and piston cores at MSP-05 MSP-06 and MSP-07 completed.

Weather forecast: Wind 15 – 20 Wednesday with waves 2.5m Wednesday by end of day. Thursday and Friday 10 – 15 knt, waves 1 – 2 meters.

PLANNED OPERATIONS FOR NEXT 24h: XBT drop at night. Continue Drop Camera and piston core work.

HEALTH AND SAFETY: COVID testing results for CCG crew have arrived. Everyone tested negative!

DAY # 6, Date: 2020-08-18

SUMMARY OF LAST 24h: EK80 sounder was turned off, MB set to deep water, side range extended to 4000m, good data collected overnight.

Camera station successful (MSP-015A, GSC# 2020_804_0010). The station was chosen because of high backscatter, suggesting turbidites. Sediment varies from muddy to bedrock outcrop to fine gravel with gastropod shells, and back to muddy. Drift was south from the planned position. 60 good images taken.

3.5 Echosounder turned on for logging subsurface before core station.

Box core successful (MSP-015B, GSC# 2020_804_0011). About 10 cm surface sampled. Undisturbed. Poor penetration because of cohesive clay close to surface. Some gravel particles, some clay concretions. Few bryozoans and broken off brittlestar arms. Sandy mud on surface.

One short push core taken and half of volume stored as a mixed sample in a plastic bag. One vial with surface sample.

Box core at MSP-016A. A very small sample, stored in a plastic bag. Poor retrieval because of deep water and very short bottom contact (1 sec). Sandy mud, sponge spicules.

Camera station at MSP-016B. Used mooring release sounder and beacon on the camera frame (provided by Shawn Meredyk). Very clear acoustic response. On approaching bottom the signal doubles because of the bottom echo. HiPap installed 30 m above camera on the wire. Very interesting station with rounded boulders, xenophyophores, few corals and sponges, molpadia (sea cucumber), and mesh-like bryozoan/sponge of green colour, which could be confused with algae. Approximately 60 good pictures.

Great news: received permission to use two extra days for field work from Amundsen Science. Planning to return to St. John's on Monday August 24th before breakfast. This means that Saturday is our last sampling day.

While positioning for camera station 12 kHz and 60 kHz sonars were monitored. 12 kHz sonar showed camera path to bottom clearly.

Camera station at MSP-020 took 30minutes. The pinger sounded muffled, and turning MBES off did not help. It was a bit difficult to control bottom contact of the camera. 60 kHz sonar showed what appeared to be a gas flare at the station. It is possible that the 'rabbit ears' depressions in lower slope are pockmarks, which could serve as nucleation sites for canyons in slope development. The soft sediment must have been eroded by seeping gas, and the surface was gravelly and cobbly (as seen on photos). As expected, the hard substrate contained more benthic epifauna species. 36 good images.

Gravity core at Camera station at MSP-020, inside the pockmark. Core brought about 2 feet of sediment. Coarse particles on top.

WEATHER: Air temperature: 12.5C. Wind speed: Sunny, N wind 7-10 knt at noon. Clear skies. Sea state: 1 m waves. Visibility: Good.

OPERATIONS COMPLETED: MB survey in NE sector. Camera stations at MSP-015A, 016B and 020A, piston cores at MSP-015A, MSP-016B and gravity core at MSP-02oB completed.

WEATHER FORECAST: Wind southeast 15 knots increasing to southeast 25 this evening. Wind southeast 25 Wednesday. Seas 1 to 2 metres building to 2 to 3 this afternoon. Rain Wednesday.

PLANNED OPERATIONS FOR NEXT 24h: XBT drop at night. Continue multibeam operations in NE sector.

HEALTH AND SAFETY: A crew member was grabbing core head with his fingers inside the barrel. A warning was required to avoid this dangerous practice which could cut fingers off in case the core barrel hit a hard surface.

DAY # 7, Date: 2020-08-19

SUMMARY OF LAST 24h: Piston core retrieved at MSP-010. Undisturbed sediment over a fresh failure. About 10 cm of core between core head and liner was squeezed out of the liner because sediment was sliding out, and similar amount between section 1 and 2 when liner was cut. Sediment was sliding out of the core because it was slant on deck. Saved lost segments in core caps, and marked with prime letters. About a foot of sediment on top of the core got separated from the rest of sediment and suspended in water within the upper part of the liner. Made a decision to take a repeat core.

Successful retrieval of piston core at MSP-011, the area of presumably recent sediment failure where 10 m of surface was removed and one should be able to see deeper strata. Approximately 5 m long core. Camille Wilhelmy was helping Broom to process cores in the geology lab.

Drop camera at MSP-012A, with HiPap attached, using Meredyk's hydrophone. 30 good pictures obtained, showing muddy bottom, infrequent soft corals and crinoids. Gravity cores at MSP-012B, MSP-013. Poor retrieval, about 50 cm, gravelly sandy mud.

CTD Rosette was deployed in the evening for comparing sound velocity to XBT cast. Ship crew was simultaneously trained to use new winch controls.

WEATHER: Air temperature: 12C. Wind speed: Sunny, N wind 10-15 knt. Overcast, drizzle. Sea state: 1-2 m waves, picking up by evening. Visibility: Good.

OPERATIONS COMPLETED: 3 Piston cores, 2 gravity cores, a camera station, CTD cast and XBT cast.

WEATHER FORECAST: Today Tonight and Thursday: Wind southeast 15 to 20 knots diminishing to southeast 10 to 15 this evening then veering to south 15 to 20 Thursday afternoon. Seas 2 metres subsiding to 1 Thursday afternoon. Showers. Fog patches forming overnight.

PLANNED OPERATIONS FOR NEXT 24h: Multibeam operations overnight, XBT, Drop camera, Van Veen grab, Box corer next day.

HEALTH AND SAFETY: Fully assembled piston corer is tied on port side of forward deck during all operations. Normally the core barrels are parallel to the deck, supported by wooden blocks under core head, and by 6 jacks along the corer barrels. Core retrieval however today was done with the corer barrels alighed horizontally to prevent sliding of core contents out and potential loss of parts of sample (as at MSP-010). During the day the core cutter side of the corer was supported by several wooden blocks, with jacks on top of them, elevating the cutter by approximately 2 feet over "normal" position. After day operations were completed the corer was tied to the ship with this support setup still in place. During 12 knt transit to the CTD location the structure collapsed in place. There was no one on forward deck, the core barrels were tied down for transit, and there was no damage to the ship. One pneumatic jack was broken. The ship crew removed the wooden blocks and re-tied the corer to the deck. Custom made stable supports need to be employed for adjusting corer level on deck.

DAY # 8, Date: 2020-08-20

SUMMARY OF LAST 24h: Carried a long (30 min drift) at MSP-017 camera station. Retreived 54 good bottom images. Soft corals, few *Acanella*, *Antomastus*, sponges, glass sponges. Sandy mud with infrequent boulders and cobbles.

MSP-017: VanVeen grab. Grab was retrieved 1/3 full. Gravelly mud, a purple soft coral on a cobble. All retrieved sediment is stored in a plastic bag.

MSP-019A: box core sample obtained successfully. Full bucket retrieved. Several cobbles overgrown with benthic epifauna stored in a plastic bag. 3 push cores taken with undisturbed surface layer of sediment. The new battery-operated suction pump was used for push core extraction. Upper 3 cm of remaining surface was preserved in a second plastic bag. The rest of sample was discarded.

MSP-019B drop camera deployment: On the first attempt the signal from the camera did not stop even when the water depth was exceeded by 30 meters (according to the winch wire counter). Made several attempts to ascend and descend at different speeds, but the pinger did not stop pinging. Retreived the camera to discover that the trigger cable is badly mangled and the camera trigger is covered with clay. Replaced the trigger and the cable, and carried a second deployment. Similarly to the first deployment the pinger signal did not get interrupted for longer than 1 ping, which led us to believe that the camera was not taking pictures. Kept trying to obtain pictures by altering start and end length of the wire while searching for bottom contact. The bridge has adjusted wire angle to vertical, but that did not lead to audible success. Camera malfunction was suspected and the station was cut short. Upon retrieval there was no visible damage to the camera, and testing the trigger on the deck has shown that it indeed does not stop pinging when triggered but pictures are taken. Over these two deployment 30 good pictures were obtained. High biodiversity, soft and hard corals, *Anthomastus*, sponges. Boulders and cobbles in sandy mud. The station was located at the head of a canyon.

During the camera operation the bridge has lost the feed from multibeam sounder. Tisne and I tried to restart SIS, reboot MB transponder and restart all controls. Upon failure to make MB operational we woke up Amirault who has fixed the problem.

Piston core was deployed after supper (MSP-021).

WEATHER: Air temperature: 12C, Wind speed: Overcast, drizzle, foggy. Wind 10 knt SE. Sea state: 2 m waves. Visibility: Foggy, ship's horn was used during transit.

OPERATIONS COMPLETED: 3 box camera stations, a boxcore and a piston core.

WEATHER FORECAST: Today Tonight and Friday. Wind southeast 10 to 15 knots veering to south 15 to 20 this afternoon then to west 25 overnight. Wind west 25 Friday. Seas 1 to 2 metres building to 2 to 3 Friday morning. Showers and fog patches ending Friday morning.

PLANNED OPERATIONS FOR NEXT 24h: MBES survey, Drop camera, Van Veen grab, Box corer.

HEALTH AND SAFETY: Robertson complained about shoulder pains, presumably from lifting cores and pulling loads on deck. Was ordered by chief scientist (Kostylev) not to lift cores for the rest of the cruise and offered an alternative watch.

DAY # 9, Date: 2020-08-21

SUMMARY OF LAST 24h: Camera and Van Veen grab at MSP 024. Cobbly gravelly mud. Camera station at MSP 023 was good, with transect going uphill and capturing habitat variability. Van Veen grab at MSP 023 returned empty, MSP-022A Van Veen grab unsuccessful, MSP-022B camera done.

Kostylev gave science presentation to the crew describing the work carried by GSC and its significance to the society and marine industries.

WEATHER: Air temperature: 12C. Wind speed: Overcast, Wind 15 knt S picking to 22 in the evening. Fog banks, showers. Sea state: 1- 2 m waves building up by evening to 2 - 3. Visibility: Foggy.

OPERATIONS COMPLETED: 3 drop camera stations, 1 box core and 2 Van Veen grabs.

WEATHER FORECAST: Seas 1 to 2 metres building to 2 to 3 Friday morning. SW 15 – 20 knt. Sunday – light variable.

PLANNED OPERATIONS FOR NEXT 24h: MBES survey, Drop camera, Van Veen grab.

HEALTH AND SAFETY: No issues.

DAY # 10, Date: 2020-08-22

SUMMARY OF LAST 24h: MSP-026 long camera drift from iceberg scours east, over shelf break. Van Veen grab recovery half-full, mud. Full sample stored. MSP-027 – accurate positioning of camera on top of canyon wall and drifting East from 750 to 850 m water depth. Despite steep canyon walls no bedrock outcrops were recorded on the photographs. Full box core at MSP-027, 3 subsamples taken. Surface sample was preserved in a plastic bag. MSP-029 camera drift did not show the expected seabed features, mostly muddy bottom. Box core at MSP029 was retrieved empty, although with some mud on the edges of the corer. It was re-armed and re-deployed for a second attempt. Full box core retrieved on the second deployment. 3 push cores and a surface sample were taken. 18:00 - started MB survey.

WEATHER: Air temperature: 11C, water temperature 11C. Wind speed: Overcast, Wind 10-15 knt S diminishing by evening. Fog banks, low skies. Sea state: calmed down overnight, 1- 2 m waves. Visibility: Foggy.

OPERATIONS COMPLETED: 3 camera stations, 2 box cores, 1 Van Veen grab.

WEATHER FORECAST: Seas 1 to 2 metres and wind light variable. Expecting a smooth ride back to St. John's.

PLANNED OPERATIONS FOR NEXT 24h: MBES survey overnight, with an intention to patch the holes in multibeam coverage along eastern extent of the survey area. This will bring us to the southeastern-most deep camera station. Two Drop camera stations to be finished before noon. Storing gear during transit to St. Johns.

HEALTH AND SAFETY: HOIR form filled for Robertson. OSH committee notified. Discussed the incident with the nurse and the captain. Robertson has requested a medical report from the nurse.

DAY # 11, Date: 2020-08-23

SUMMARY OF LAST 24h: Camera station at MSP-008. Long drift, 30 min, about 60 photographs taken. Drift was over the "pagoda-like structure". Seabed images did not show anything immediately conspicuous, although one of the photos has registered presence of *Acanella arbuscula*, which is unusual for muddy habitat at this water depth.

Second camera station at MSP-009 was successful in deeper water.

CTD cast was performed for training deck crew in operating the new winch.

In the afternoon the GSC team demobilised all the gear and stored it in a container for future pick-up in Quebec. A CARIS/ArcGIS computer, as well as XBT laptop and Regulus computer will remain on board for Hayward's participation in *Amundsen* Leg 3 cruise.

WEATHER: Air temperature: 12.5C, sea water 13.3, Wind speed: 5 knt W**.** Sea state: seas 1 m or less**.** Visibility: good, some haze on the horizon. Thin stratus clouds. Sun breaking out by noon. Good weather overall.

OPERATIONS COMPLETED: Two final camera stations of the expeditions.

Weather forecast: Wind light today tonight and Monday. Seas 1 to 2 metres. Showers overnight and Monday.

PLANNED OPERATIONS FOR NEXT 24h: Return to St. John's, with arrival at dock at 10am NST. Departure on commercial flight to Halifax at 13:50

HEALTH AND SAFETY: Worked on Incident investigation report with Chief officer Jean Gaumond.

DAY # 12, Date: 2020-08-24

SUMMARY OF LAST 24h: Overnight transit to St. John's. Within sight of land by 6 am. Transiting at speed 13 – 14 knt overnight. Cameras were moved from forward deck to the starboard container by crew before our departure from the ship. A Nav computer, XBT laptop and CARIS

computer will remain on board for future use by Hayward. Kostylev debriefed the new chief scientist on the situation on board. Robertson debriefed Pledge on our status. 11:30 the science crew departed to the airport and at 1:20pm boarded flight AC8993 to Halifax.

OPERATIONS COMPLETED: Partial demob of equipment and preparation for shipping.

WEATHER: Air temperature: 15 degrees water 16 degrees air. Wind light. Sea state: seas 1 m or less. Visibility: good, Sunny offshore, broken stratocumulus over land. Heavy rain in St. John's.

APPENDIX B: Summary of bottom sampling events.

Table legend for activities: DC – Drop Camera, BC – Box Core, PC – Piston Core, GC – Gravity Core. For events: REC – Recovery, BOT – Bottom contact, DEP – Deployment.

Time (UTC)	Arctic Net Station ID	GSC Station ID	Latitude	Longitude	Activity	Event
2020/08/23 14:56:34	MSP-09	0041	50.987313	-48.856510	DC	REC
2020/08/23 13:50:14	MSP-09	0041	50.994859	-48.864867	DC	BOT
2020/08/23 12:47:32	MSP-09	0041	51.000763	-48.870422	DC	DEP
2020/08/23 11:41:38	MSP-08	0040	50.974124	-49.121234	DC	REC
2020/08/23 10:40:56	MSP-08	0040	50.980854	-49.132594	DC	BOT
2020/08/23 10:03:46	MSP-08	0040	50.982564	-49.132404	DC	DEP
2020/08/22 21:16:08	MSP-029B	0039	52.282838	-50.788003	BC	REC
2020/08/22 20:50:55	MSP-029B	0039	52.283678	-50.790104	BC	BOT
2020/08/22 20:26:43	MSP-029B	0039	52.284454	-50.793620	BC	DEP
2020/08/22 20:19:34	MSP-029B	0039	52.284573	-50.795580	BC	REC
2020/08/22 19:48:08	MSP-029B	0039	52.285797	-50.802627	BC	BOT
2020/08/22 19:21:40	MSP-029B	0039	52.285426	-50.803397	BC	DEP
2020/08/22 19:10:04	MSP-029A	0038	52.284509	-50.788793	DC	REC
2020/08/22 18:16:08	MSP-029A	0038	52.285592	-50.803585	DC	BOT
2020/08/22 17:48:35	MSP-029A	0038	52.285580	-50.805684	DC	DEP
2020/08/22 16:37:52	MSP-028	0037	52.268099	-50.965592	PC	REC
2020/08/22 16:19:34	MSP-028	0037	52.267685	-50.970283	PC	BOT
2020/08/22 15:56:26	MSP-028	0037	52.266975	-50.966908	PC	DEP
2020/08/22 14:30:06	MSP-027B	0036	52.228054	-50.996473	BC	REC
2020/08/22 14:13:12	MSP-027B	0036	52.228787	-51.000292	BC	BOT
2020/08/22 13:54:51	MSP-027B	0036	52.228906	-51.003369	BC	DEP
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2020/08/22 12:50:53	MSP-027A	0035	52.230895	-51.007572	DC	BOT
2020/08/22 12:19:30	MSP-027A	0035	52.230142	-51.009280	DC	DEP
2020/08/22 11:47:29	MSP-026B	0034	52.211793	-51.025631	DC	REC
2020/08/22 11:04:29	MSP-026B	0034	52.210044	-51.043323	DC	BOT
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APPENDIX C: Contact sheets for 4K camera stations

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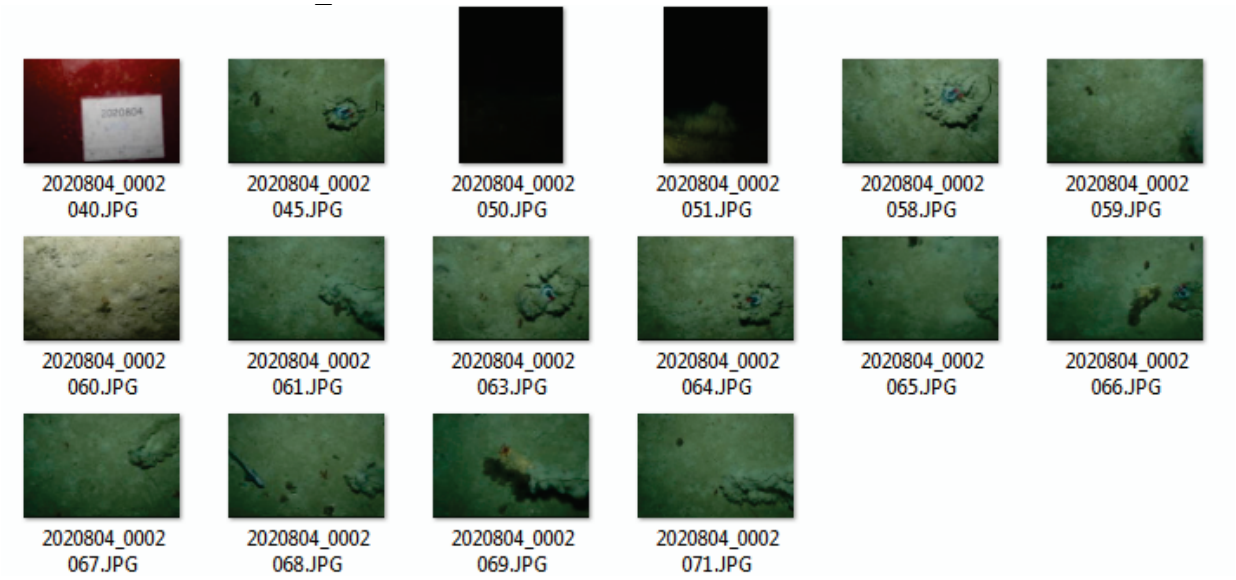

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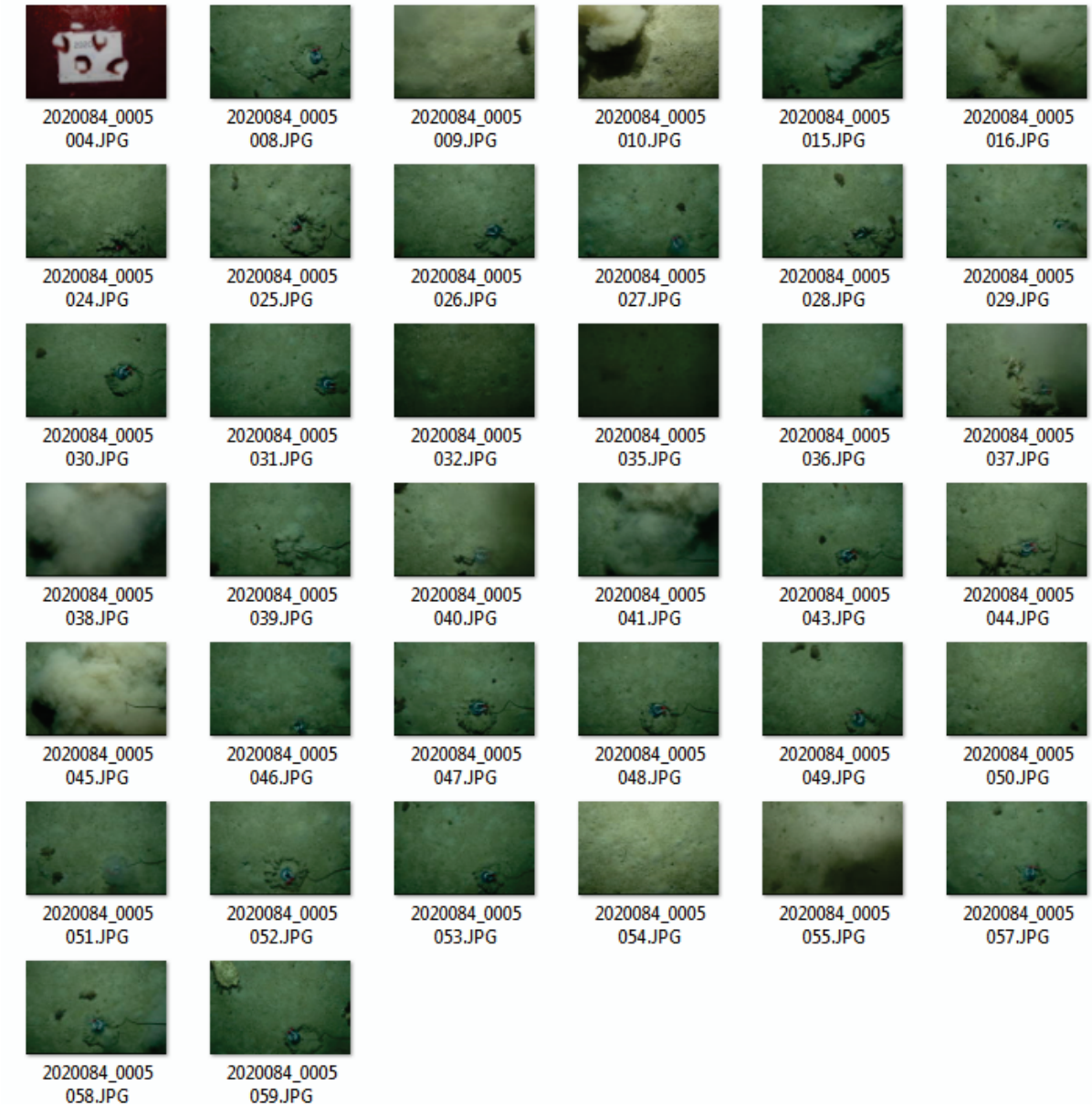

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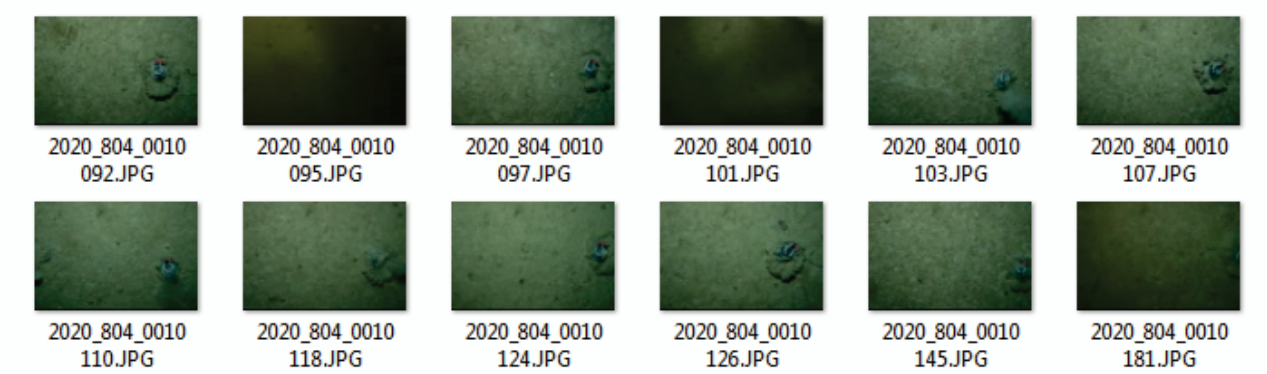
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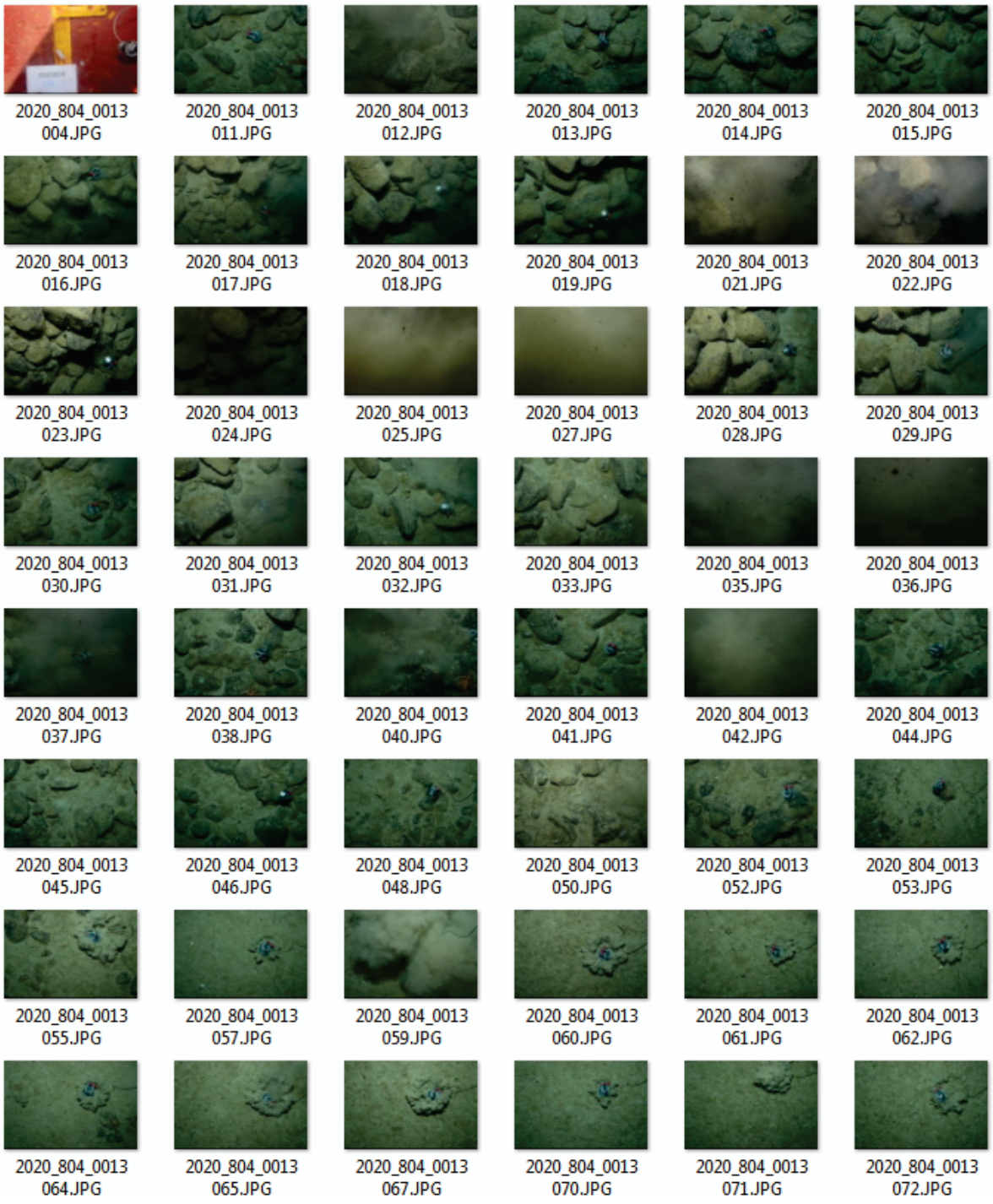


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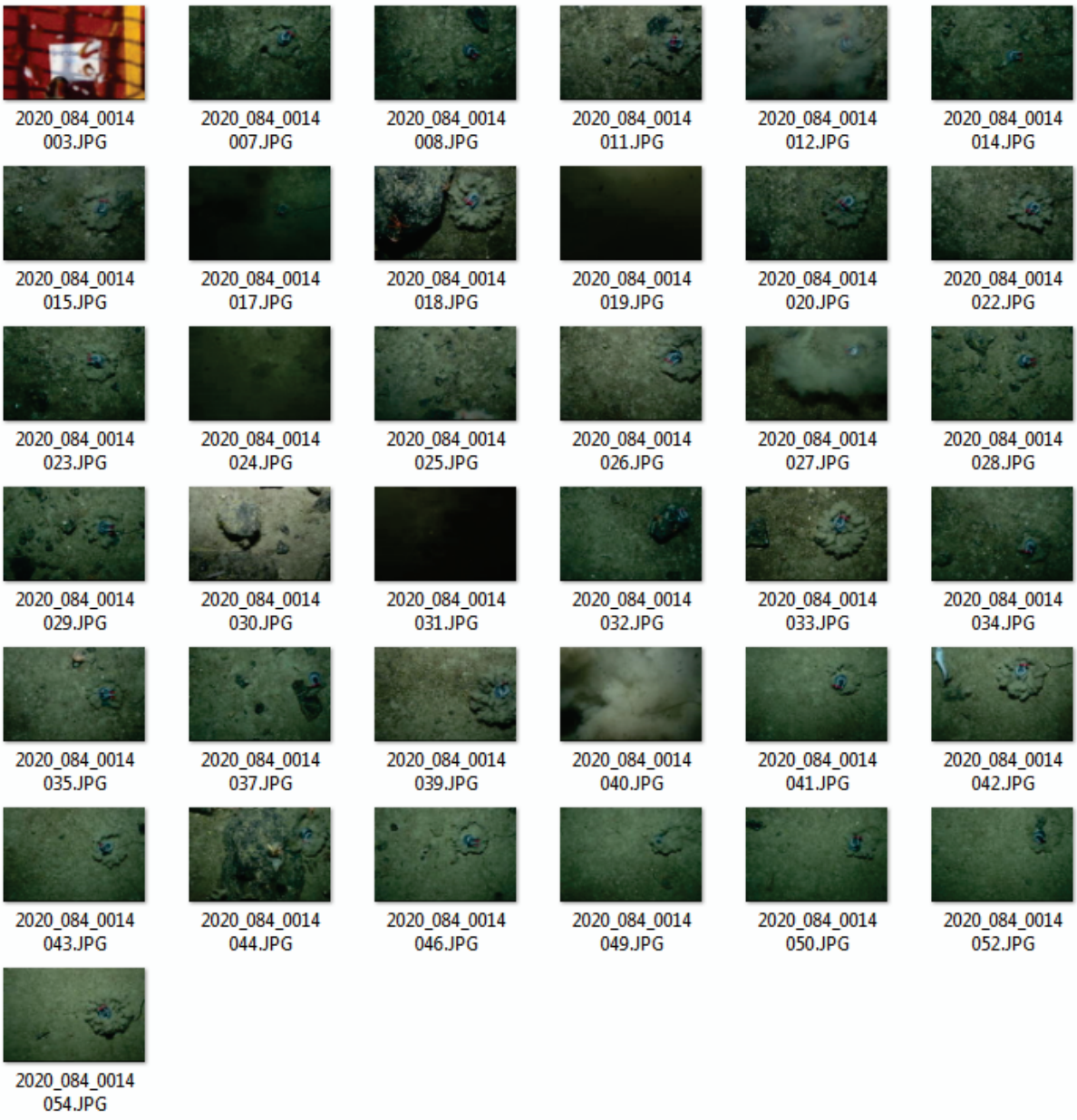

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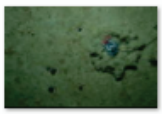
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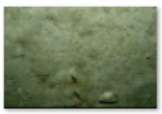
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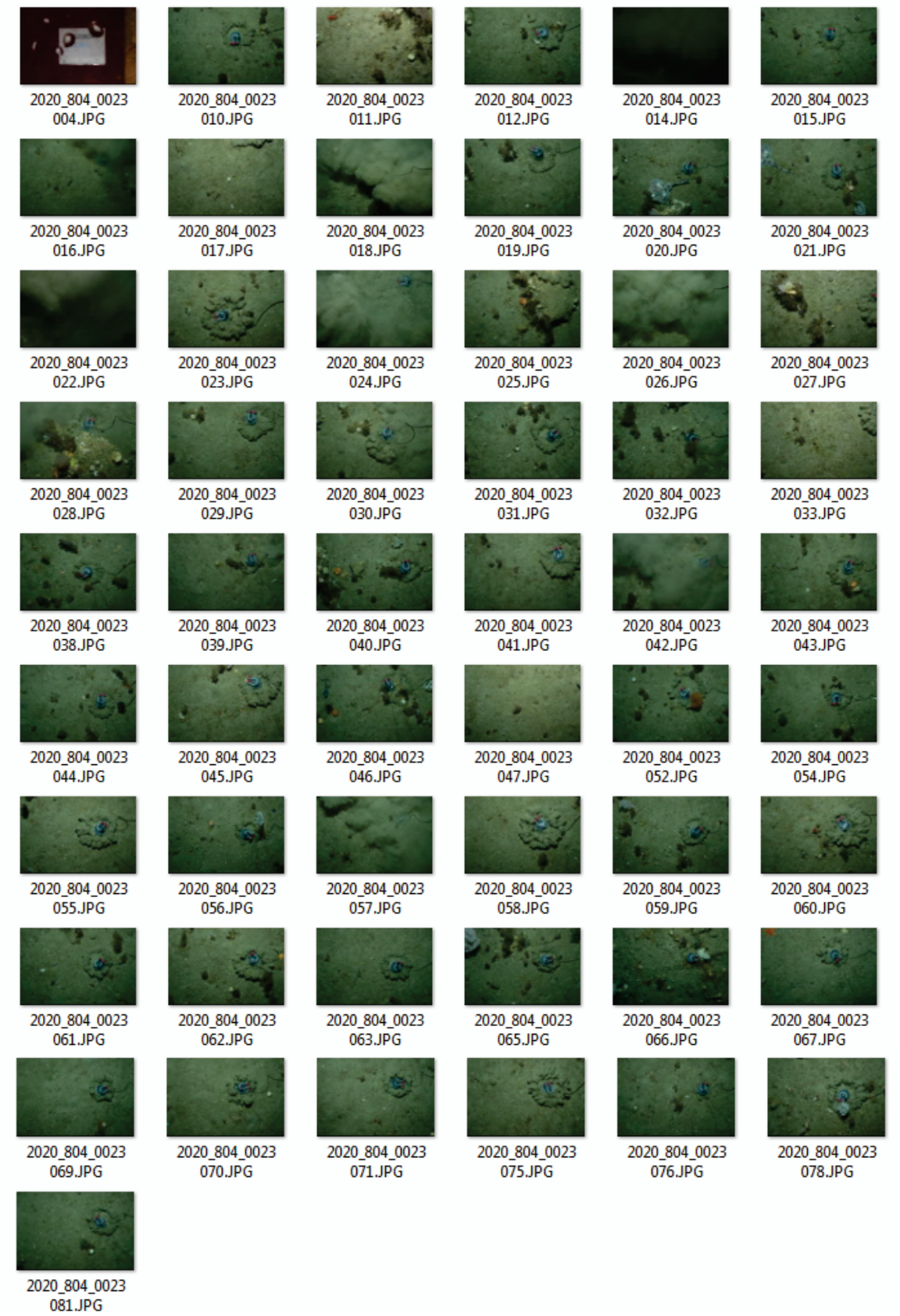

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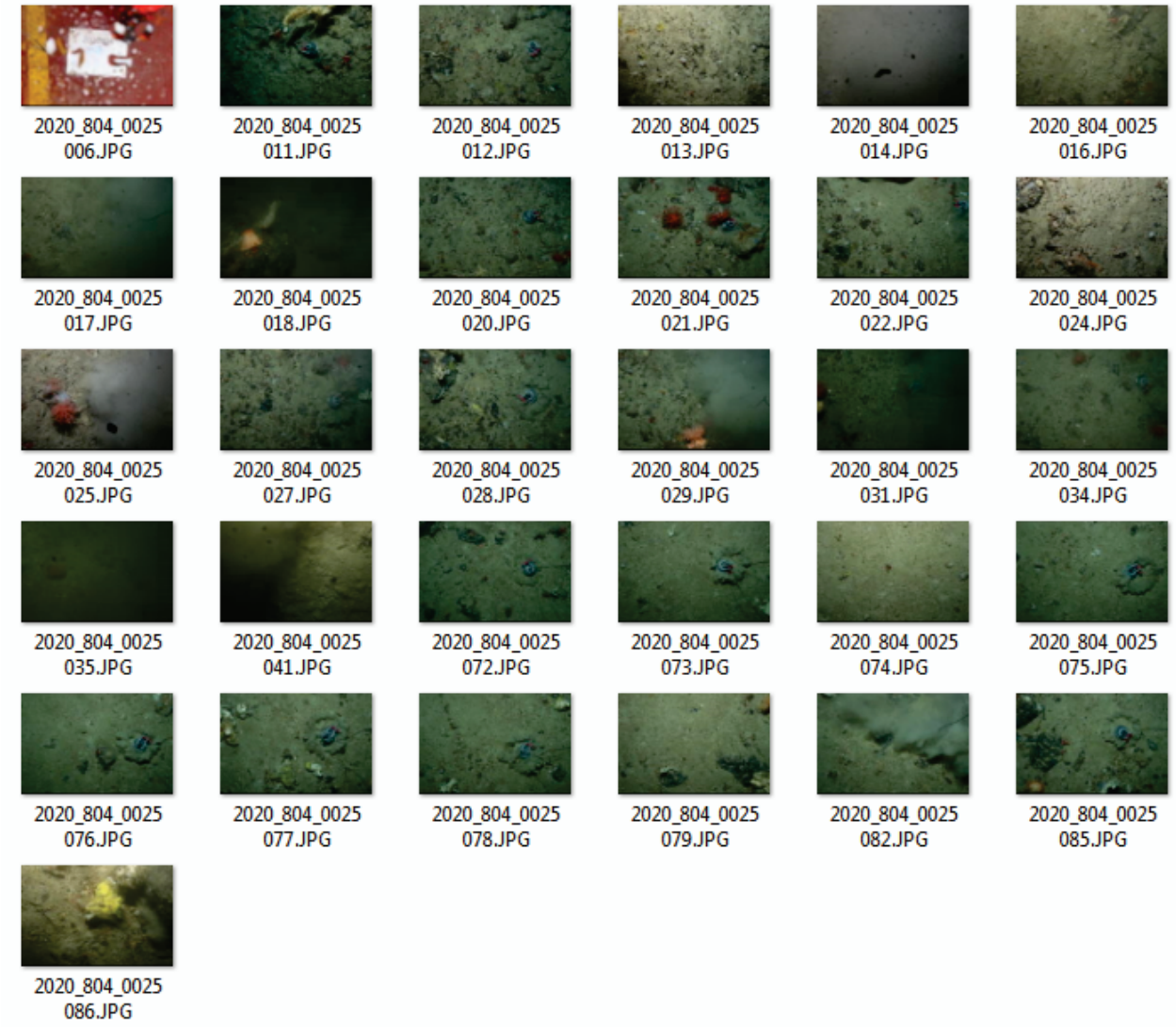

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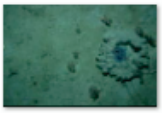
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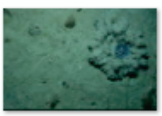
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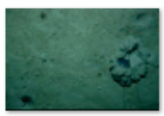
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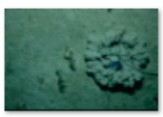
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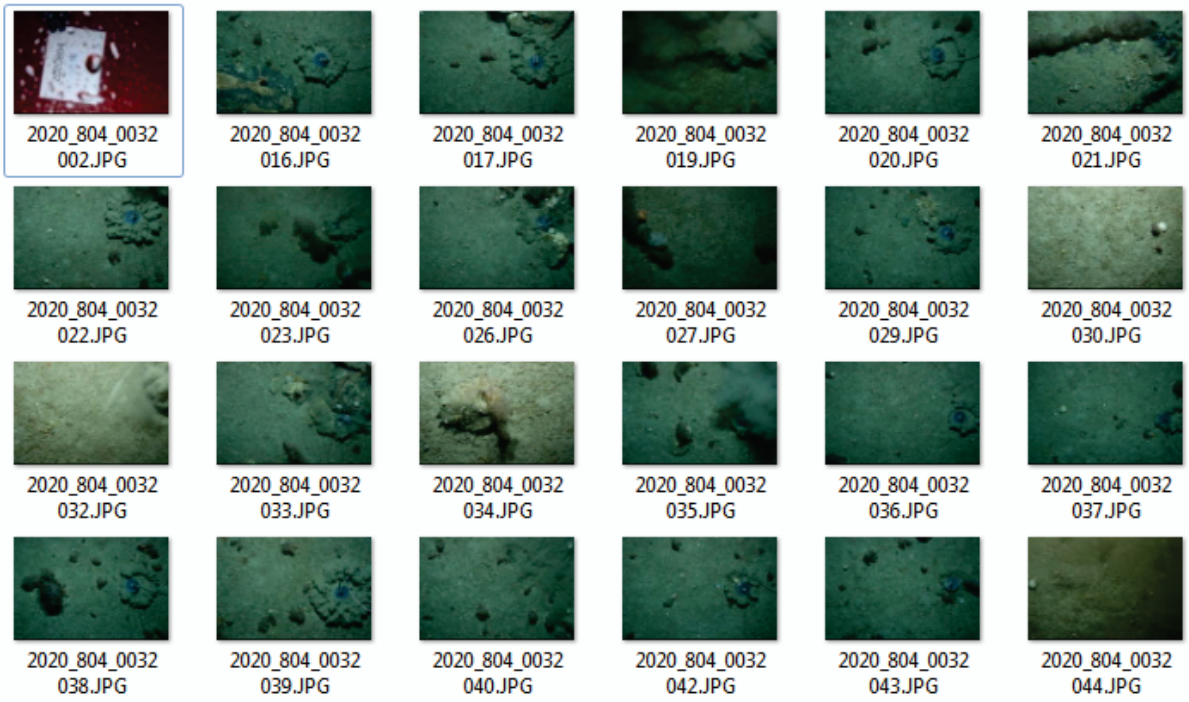

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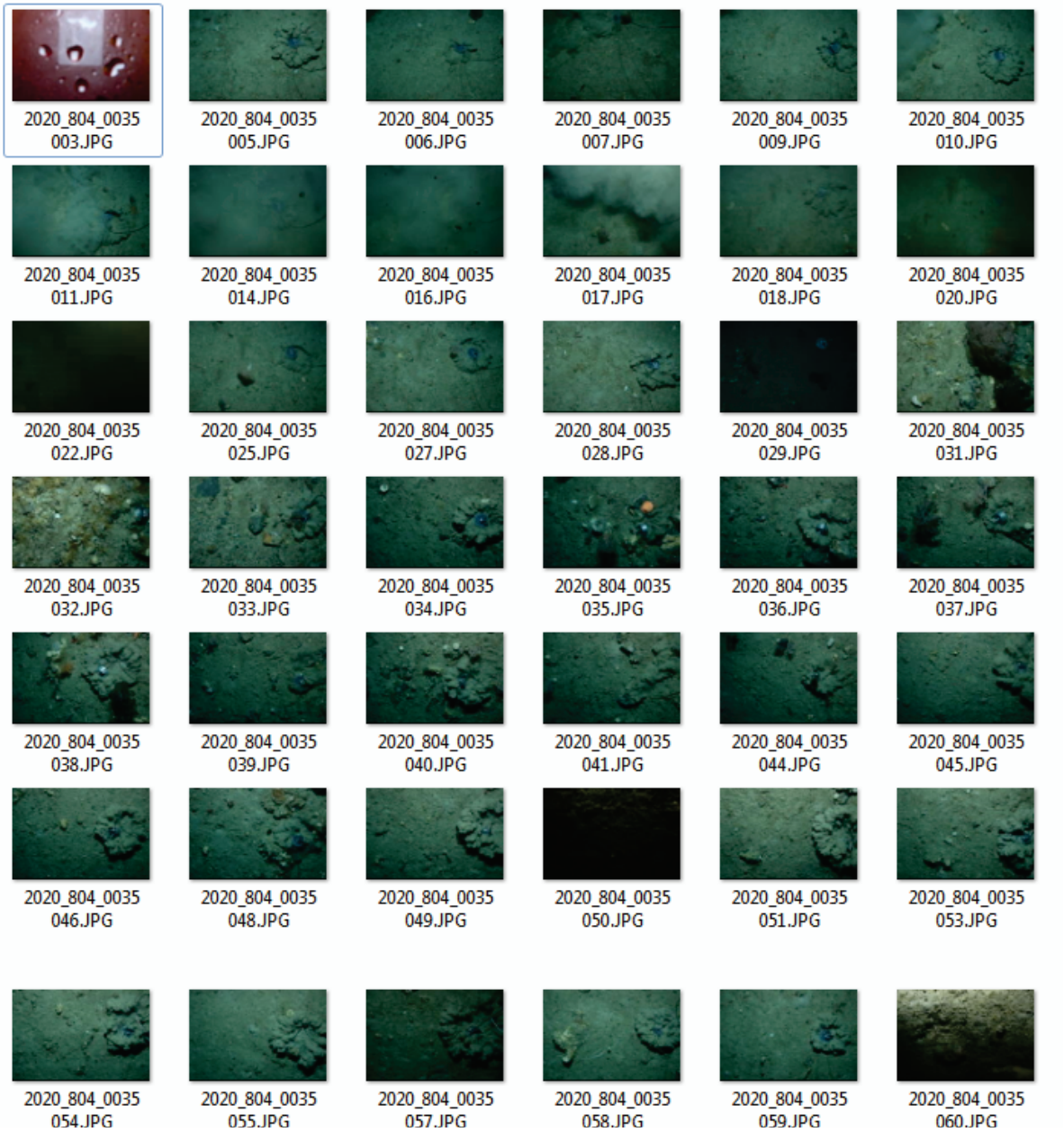


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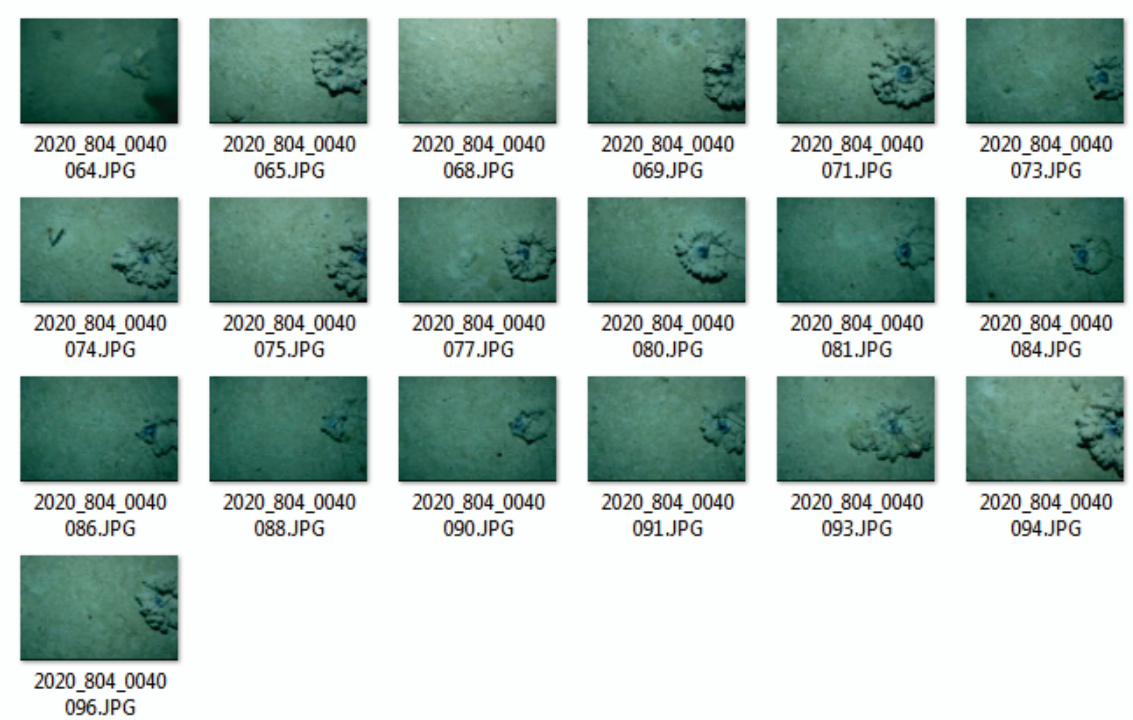
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APPENDIX D: Deck photos (Box core and Van Veen grab).

D 1. Deck photo of Van Veen grab contents at station 0011. Photograph by V. Kostylev. NRCan photo 2020-605.

D 2. Deck photo of box core contents at station 0012. Photograph by V. Kostylev. NRCan photo 2020-606.

D 3. Deck photo Van Veen grab contents at station 0023. Photograph by V. Kostylev. NRCan photo 2020-607.

D 4. Deck photo of box core contents at station 0024. Photograph by V. Kostylev. NRCan photo 2020-608.

D 5. Deck photo of Van Veen grab contents at station 0033. Photograph by V. Kostylev. NRCan photo 2020-609.

D 6. Deck photo of box core contents at station 0036. Photograph by V. Kostylev. NRCan photo 2020-610.

D 7. Deck photo of box core contents at station 0039. Photograph by V. Kostylev. NRCan photo 2020-611.

D 8. Deck photo of Van Veen grab contents at station 0028. Photograph by V. Kostylev. NRCan photo 2020-612.