FINAL

EL 1165B DRILLING DISCHARGES FOLLOW-UP PROGRAM: DRILL CUTTINGS MEASUREMENTS AND MONITORING 2020 REPORT

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ABBREVIATIONS

%	percent
^{0}C	Celsius
C-NLOPB	Canada-Newfoundland & Labrador Offshore Petroleum Board
CEA Agency	Canadian Environmental Assessment Agency
cm	centimetres
CWC	cold water coral
EIS	Environmental Impact Statement
EL	Exploration license
EMCL	ExxonMobil Canada Ltd.
g	gram
GIS	Geographic information system
HD	High definition
HiPAP	High precision acoustic positioning system
km	kilometres
m	metres
m^2	square metres
mm	millimetres
mg/kg	milligrams per kilograms
MODU	Mobile offshore drilling unit
NAD83	North American Datum 1983
OWTG	Offshore Waste Treatment Guidelines
PSA	Particle size analysis
RDL	Reportable detection limit
ROV	Remotely operated vehicle
SBM	Synthetic-based mud
SOC	Synthetic-on-cuttings
UTM	Universal Transverse Mercator
WBM	Water-based mud

1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, a division of Wood Canada Limited (Wood), was contracted by ExxonMobil Canada Ltd. (EMCL) to conduct seabed surveys at target locations on the eastern slopes of the Flemish Pass within Exploration Licence (EL) EL 1165B formerly EL 1135 (Figure 1-1). This is part of the follow-up monitoring program as set out in the Eastern Newfoundland Offshore Exploration Drilling Project Environment Impact Statement (EIS) (EMCL 2017) as well as requirements set out in the *Canadian Environmental Assessment Act* (2012) Decision Statement (CEA Agency 2019). The follow-up program is based upon a regulatory agency approved monitoring plan (EMCL 2020) that was submitted in March 2020.

The follow-up monitoring results are reported as part of a series of reports. The Drill Cuttings Measurements and Monitoring Report provides details on the synthetic-on-cuttings (SOC) monitoring, and drill cuttings deposition sampling and visual survey and addresses Decision Statement Conditions 3.12.1, 3.12.2.1, and 3.12.2.3. The Benthic Habitat Monitoring Report (Wood 2020) provides details on benthic faunal observations and addresses Decision Statement Conditions 3.12.2.2.

1.1 Scope

The objective of this follow-up program is to meet conditions 3.12 of the Decision Statement and verify the accuracy of the predictions made during the environmental assessment as it pertains to marine fish and fish habitat and determine the effectiveness of the mitigation measures (CEA Agency 2019):

> **Condition 3.12.1:** for every well, measure the concentration of synthetic-based drilling fluids retained on discharged drill cuttings as described in the Offshore Waste Treatment Guidelines to verify that the discharge meets, at a minimum, the performance targets set out in the Guidelines and any applicable legislative requirements, and report the results to the Board
>
> **Condition 3.12.2:** for the first well in each exploration licence, and for any well where drilling is undertaken in an area determined by coral and sponge surveys to be sensitive benthic habitat, and for any well located within a special area designated as such due to the presence of sensitive coral and sponge species, or a location near a special area where drill cuttings dispersion modelling predicts that drill cuttings deposition may have adverse effects, develop and implement, in consultation with Fisheries and Oceans Canada and the Board, follow-up requirements to verify the accuracy of the environmental assessment and effectiveness of mitigation measures as they pertain to the effects of cuttings discharges on benthic habitat. Follow-up shall include:
>
>> **Condition 3.12.2.1**: measurement of sediment deposition extent and thickness post-drilling to verify the drill waste deposition modeling predictions;
>>
>> **Condition 3.12.2.2** benthic fauna surveys to verify the effectiveness of mitigation measures; and
>>
>> **Condition 3.12.2.3** The Proponent shall report the information collected, as identified in conditions 3.12.2.1 and 3.12.2.2, including a comparison of modelling results to in situ results, to the Board within 60 days following the drilling of the first well in each exploration licence; and

Decision Statement Conditions 3.12.1, 3.12.2.1, and 3.12.2.3 are addressed in this report and Condition 3.12.2.2 is addressed in the Benthic Habitat Monitoring Report (Wood 2020).

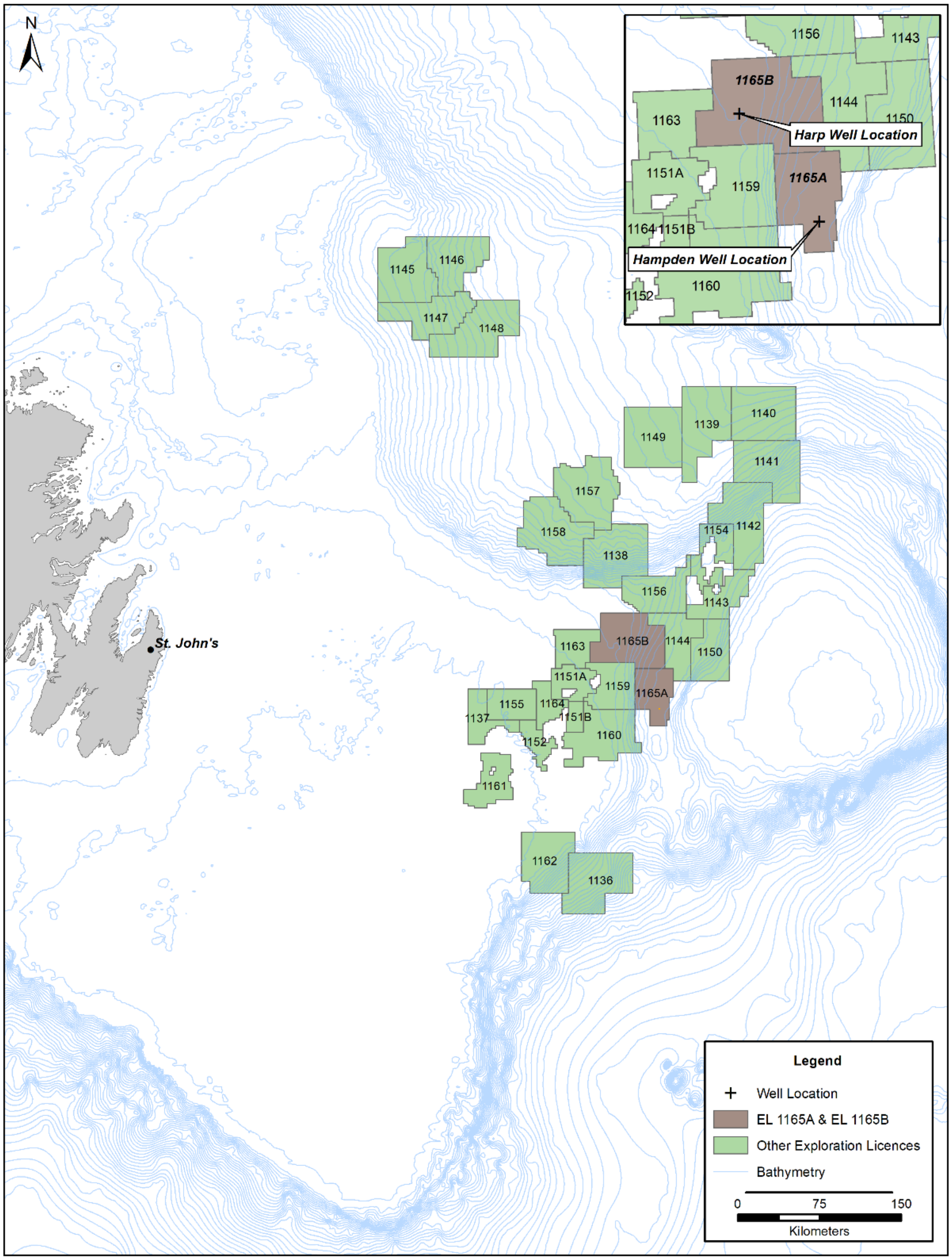


Figure 1-1 Location of EL 1165B Harp L-42 well.

1.2 Drill Cuttings Modelling

A drill cuttings model (Southern Project Area; Amec Foster Wheeler 2017, EMCL 2017) was used to predict the extent of released water-based muds (WBM) and synthetic-based muds (SBM) using four seasonal scenarios, to account for variable environmental conditions throughout the year (Amec Foster Wheeler 2017). A numerical computer model was used that employs a transport computation to simulate the advection of dispersed drill cuttings materials in three dimensions through the water column, following release into the sea, until the particles come to rest on the sea bottom. Key inputs for the model include cuttings particle characterizations and ocean currents. The primary outputs are predictions of the deposition pattern of released drill cuttings on the seabed (e.g., weight, density, thickness of cuttings). With the potential to drill multiple wells and at any time during the year, four model simulation runs or 'scenarios' (for March, June, September, December) were considered to capture the associated seasonal variation in ocean currents at each location. Each scenario model run provides a prediction of the initial cuttings footprints from drilling of a representative (i.e., similar water depth and current regime) well at one of the four locations for a given time of year (Amec Foster Wheeler 2017).

Drilling operations took place from November to April and both WBM and SBM were used during the drilling at Harp L-42. The predicted dispersion of the drill cuttings in all seasonal scenarios (March, June, September, and December) was mainly to the south / south west of the wellsite, with the majority of the cuttings deposited within 1 km of the drilled well (Table 1.1). A majority of drill cutting thickness beyond 1 km were predicted to have average depths of 0.01 mm or less, with maximum thicknesses ranging from 0.03-0.06 mm. The largest thicknesses were predicted to settle within 500 m from the wellsite, with a predicted thickness of 5.7 to 8.0 cm (Figure 1-2) (Amec Foster Wheeler 2017). The follow-up survey was designed in consideration of the combined seasonal scenarios for the drill cuttings model (RPS 2018).

Table 1.1 Modelled cuttings thickness by distance, Southern Project Area (Amec Foster Wheeler 2017).

Southern Project Area		Distance from Well Site									
		0-10m	10-100m	100-200m	200-500m	500m-1km	1-2km	2-4km	4-5km	5-31km	>31km
Cuttings Type	Metric	Cuttings Thickness (mm)									
March											
WBM	Mean	3	0.4	0.3	2.4	4	-	-	-	-	-
	Maximum	12	10	1	80 [1]	20	-	-	-	-	-
SBM	Mean	-	-	-	<0.01	<0.01	<0.01	-	-	-	-
	Maximum	-	-	-	0.05	0.06	0.04	-	-	-	-
June											
WBM	Mean	4	0.3	3	3	2	-	-	-	-	-
	Maximum	13	8	54	66 [2]	15	-	-	-	-	-
SBM	Mean	-	-	-	<0.01	<0.01	<0.01	-	-	-	-
	Maximum	-	-	-	0.03	0.06	0.06	-	-	-	-
September											
WBM	Mean	2	0.6	-	2	3	0.6	-	-	-	-
	Maximum	9	11	-	57	74 [3]	1	-	-	-	-
SBM	Mean	-	-	-	-	<0.01	<0.01	<0.01	-	-	-
	Maximum	-	-	-	-	0.03	0.03	0.03	-	-	-
December											
WBM	Mean	2	0.6	-	3	1	2	-	-	-	-
	Maximum	7	7	-	77 [4]	10	18	-	-	-	-
SBM	Mean	-	-	-	-	<0.01	<0.01	<0.01	-	-	-
	Maximum	-	-	-	-	0.04	0.04	0.04	-	-	-
[1] maximum located at (0.32 km, 194°) [2] at (0.20 km, 188°); [3] at (0.52 km, 194°); [4] at (0.34 km, 204°)											

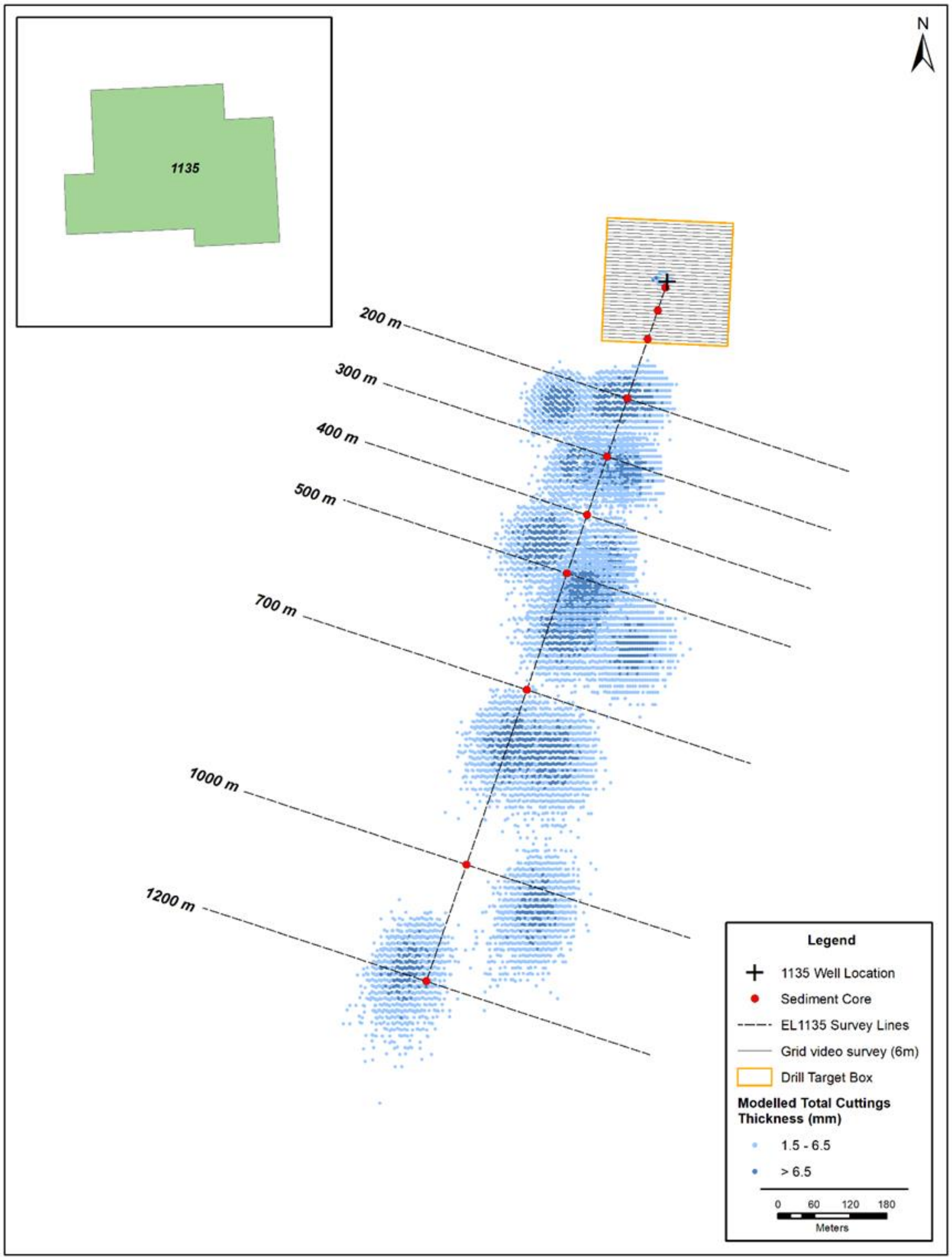


Figure 1-2 Pre-drilling survey design at EL1165B (formerly EL 1135) with modeled drill cutting distribution (combined seasonal scenarios) of thicknesses >1.5 mm.

2.0 METHODOLOGY

2.1 Synthetic-on-Cuttings

The concentration of synthetic-based drilling fluid was measured to assess whether the discharge met the Offshore Waste Treatment Guidelines (OWTG) (Condition 3.12.1). As part of the OWTG, the concentration of non-aqueous SBM retained on discharged drilling solids from all sources should be measured every 12 hours. This is reported as a mass-weighted rolling 48-hour average calculated in units of oil per 100 grams wet solids. The target for this SOC discharged to sea should not exceed 6.9 g / 100 g oil on wet solids. Cuttings were treated aboard the West Aquarius mobile offshore drilling unit (MODU) using cuttings dryer technology and are detailed in a separate report (EMCL 2018a).

2.2 Pre-Drilling Survey

Pre-drilling surveys were conducted from August 22nd-23rd,2018 and July 11th-12th, 2019 to assess the Harp L-42 wellsite area against the Canada-Newfoundland and Labrador Offshore Petroleum Board's (C-NLOPB) guidance for coral colonies (RPS 2018, Wood 2019). Project activities included the collection of Remotely Operated Vehicle (ROV) high resolution video and camera data for the purposes of identifying cold water coral (CWC) and sponges. The 2018 and 2019 surveys were conducted from the MV *Paul A. Sacuta.* The 2019 surveys were focused on the anchor chain locations and were not assessed as part of the evaluation drill cuttings dispersion.

2.2.1 Survey Design

The 2018 survey consisted of a 200 m by 200 m grid ('grid box') composed of 31 spaced approximately 7 m apart centred around the proposed wellhead location. The survey also included a series of 750 m long video transects at 200 m, 300 m, 400 m, 500 m, 750 m, 1000 m and 1200m over the cuttings dispersal model footprint (RPS 2018, EMCL 2018b).

2.2.2 Analysis

The primary and secondary substrate was identified by substrate type along 50 m transect sections. Substrate type was determined using the Wentworth Scale and categorized into a substrate class (Table 2.1) (Wentworth 1922, Kelly et al. 2009). Surficial substrate was compared among the 2018 pre-drilling and 2020 drill cuttings monitoring surveys.

Table 2.1 Surficial substrate categories used to categorize benthic environment

Substrate Class	Substrate Type	Definition
Bedrock		Continuous solid bedrock
Coarse	Boulder	Rocks greater than 250 mm
	Rubble	Rocks ranging from 130 mm to 250 mm
Medium	Cobble	Rocks ranging from 30 mm to 130 mm
	Gravel	Granule size or coarser, 2 mm to 30 mm
Fine	Sand	Fine deposits ranging from 0.06 mm to 2 mm
	Mud	Material encompassing both silt and clay < 0.06 mm
Organic/Detritus		A soft material containing 85 percent or more organic materials
Shells		Calcareous remains of shellfish or invertebrates containing shells

2.3 Post-Drilling Survey

The 2020 survey was conducted from the MV *Paul A. Sacuta* with a Millennium 191 remotely operated vehicle (ROV) and a Seaeye Leopard ROV from April 30th to May 8th, 2020 (Figure 2-1). Both ROVs were equipped with forward facing pan/tilt/zoom high-definition (HD) cameras which were used to collect high-definition video during the duration of the survey and still images taken opportunistically. Video and still imagery were used to identify the benthic fauna (including corals and sponges) and visible drill cuttings. Physical sediment samples were collected using acrylic push cores deployed from the Millennium 191 ROV (Figure 2-1, A). The push cores were deployed and retrieved manually from a push core container attached to the ROV's tether management system. Both lasers were equipped with line lasers spaced 10 cm apart and a metal ruler deployed by the ROVs was used to take sediment depth penetration measurements.

ExxonMobil Canada Ltd. was responsible for chartering the vessel and Oceaneering Canada Ltd. was responsible for the operation of the ROVs. Wood provided onboard marine biologists responsible for providing direction to ROV operators to ensure collection of video and images appropriate for characterizing cold-water corals and sponge groups and general characterization of fish and other invertebrates.

The survey video and imagery were geo-referenced using the ships high precision acoustic positioning system (Hi-PAP) system. The HD video was encoded with a digital overlay that displayed depth (m), coordinates (UTM and NAD83), heading, date and time, and altitude above seafloor. Still images were encoded with a datetime stamp and numbered sequentially.

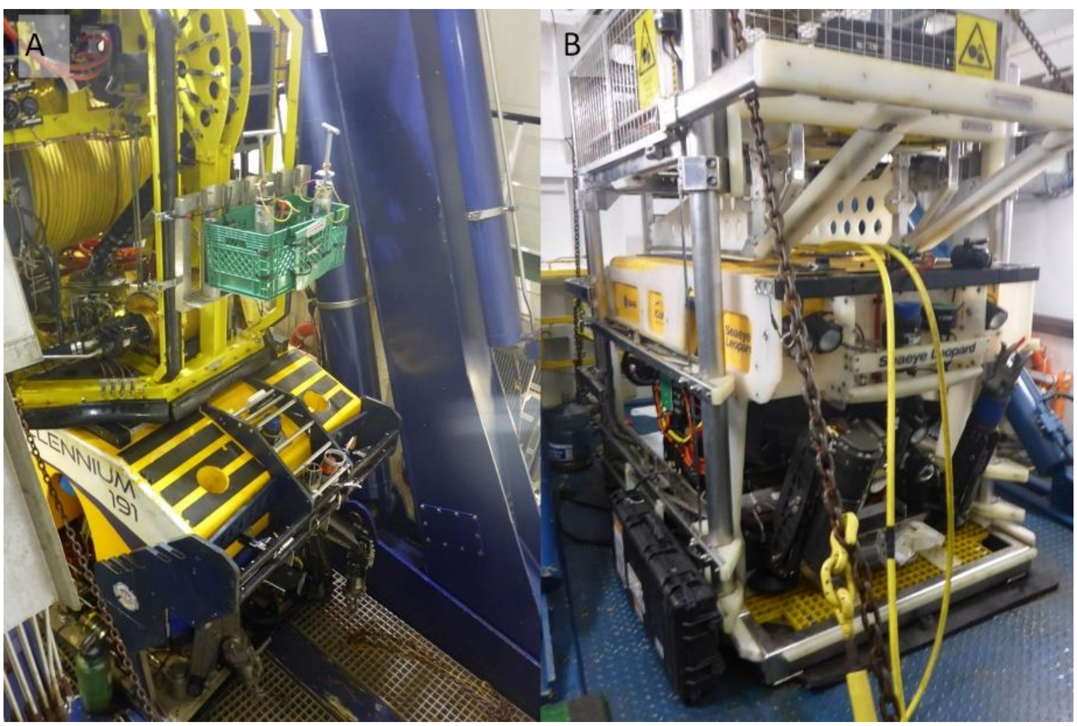


Figure 2-1 ROVs used for the 2020 EL 1165B post-drilling survey, A) Millennium 191 and B) Seaeye Leopard.

2.3.1 Survey Design

The survey consisted of a 200 m by 200 m grid composed of 36 surveys lines spaced 6 m apart centered around the wellhead (in place after the well was drilled) and eight transects within the modeled drill cutting footprint (Figure 1-2). The cuttings transects consisted of one 1,200 m long center transect (originating from the well head) with seven 750-m long transects perpendicular to the center transect at predetermined distances (Figure 1-2) (RPS 2018, EMCL 2020). During drilling operations, the initial drilling location was determined to be unsuitable and a new drill center was located approximately 20 m to the northwest of the initial drill center. The post-drilling survey was centered around the final drill center. The ROV operated in two modes: survey (visual analysis) and sampling (sediment measurements).

2.3.2 Analysis

Benthic video imagery was analyzed visually for the presence or absence of deposited drill cuttings, which can be visibly distinct from undisturbed seafloor sediments (Gates et al. 2017, Jones et al. 2019, Cochrane et al 2019). Areas of visually distinct drill cuttings were geo-referenced and mapped. The start and end of large drill cutting patches are depicted by lines and consolidated drill cutting patches are depicted by points.

The primary and secondary substrate was identified by substrate type along 50 m transect sections. Substrate type was determined using the Wentworth Scale and categorized into a substrate class (Table 2.1) (Wentworth 1922, Kelly et al. 2009). Surficial substrate was compared among the 2018 pre-drilling and 2020 drill cuttings monitoring surveys.

2.3.3 Sediment Measurements

The visual analysis of the drill cuttings extent was further quantified and supplemented by depth penetration measurements and sediment cores.

Depth Penetration Measurements

A ruler (in 10 cm increments) was penetrated into the seafloor using the ROV manipulator arm at opportune times to see the depth of refusal, that is depth where the ruler will no longer penetrate (Figure 2-2). As penetration measurements were not taken during the pre-drilling survey, these measurements are of combined natural seabed sediment and drill cutting accumulations in areas of visible cuttings. In areas with no visible cuttings, these measurements provide an indication of the depth of soft sediments in the area. Measurements were taken at the start and end of all transects within the predicted drill cutting footprint and transects G9 to G36 within the 200 m by 200 m grid survey (the ruler was lost on the seafloor after G9). Additional physical measurements were taken opportunistically along center transect T1. Physical measurements were not taken during the pre-drilling survey.

Sediment Sample Collection (Chemical Analysis)

Sediment samples for chemical analysis were collected at pre-determined distances from the wellhead along the cuttings area transect lines. Samples were taken using a push core with the ROV 10 m from the wellhead, 50 m, 100 m, 200 m, 300 m, 400 m, 500 m, 700 m, 1,000 m, and 1,200 m. The push core (2.5 inch/6.35 cm diameter, 18 inch/45.72 cm length) scooped the sediments horizontally so that the top 6 cm of seafloor was sampled with a target of 750 mL of volume for each site. Photographs of each sample were taken to determine the presence of visible drill cuttings. Samples were then placed in glass jars and maintained at 4^{0}C in coolers onboard. Samples were analyzed (in order of priority as there was limited sediment volume for analysis) for barium concentration, weak-acid barium concentration, and particle size. Barium is a commonly used tracer to identify drill cuttings and is a key component of WBM and SBM. Sediment samples were not collected during the pre-drilling survey.

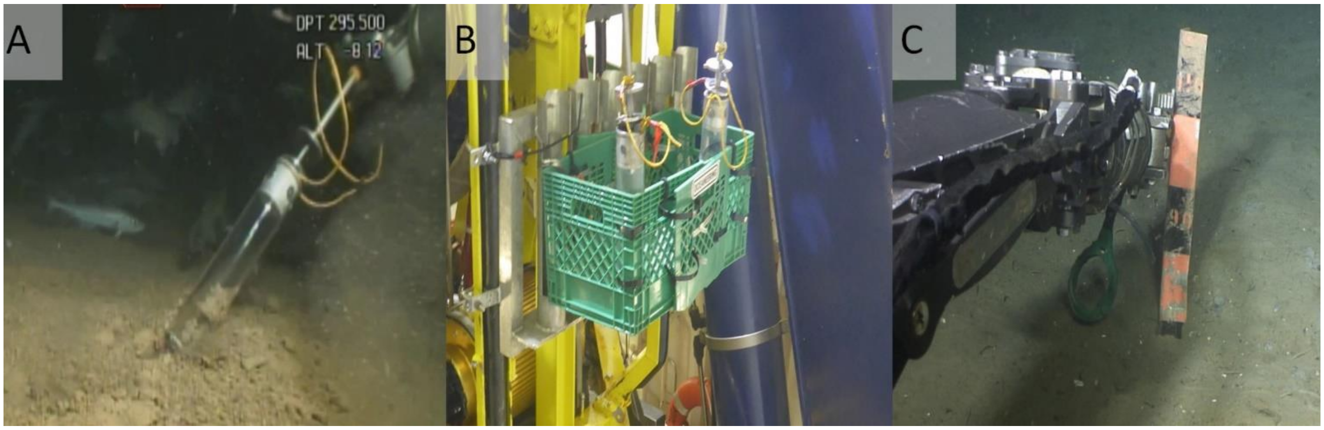


Figure 2-2 Push core sediment sampling with the Millennium 191 ROV (A),push core container (B), and ruler (C).

2.4 Mapping

The ROV transects were plotted using GIS software ArcGIS 10.5 (ESRI) in NAD83 datum. Fixes were taken for start and end of each transect, measurements, and core samples. Overlay coordinates were used for coral and sponge locations and mud cuttings delineation (visual analysis).

3.0 RESULTS

3.1 Synthetic-on-Cuttings

The concentration of SOC discharged to sea after treatment aboard the West Aquarius was measured every 12 hours and reported as a mass-weight rolling 48-hour average (Figure 3-1). The highest concentration reported on March 3rd, 2020, was 4.02 g of oil per 100 g of wet solids. The OWTG limit for SOC of 6.9 g/100g is shown in Figure 3-1, and was not exceeded as part of this drilling program. Secondary mitigations of transporting cuttings with SOC exceedances to shore for additional treatment was not needed.

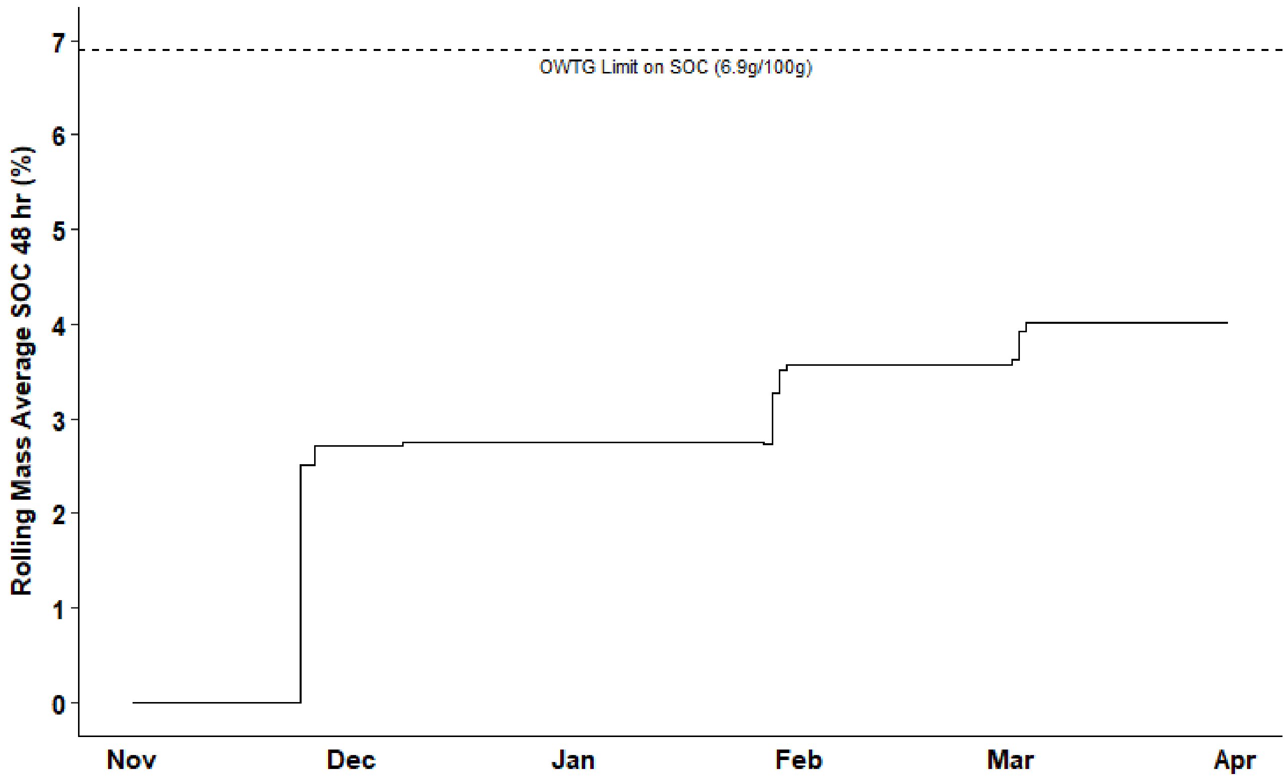


Figure 3-1 Synthetic-on-Cuttings (SOC) concentration (g of oil per 100 g wet solids, or %) discharged to sea after treatment aboard the West Aquarius from November 1st, 2019, to March 31st, 2020.

3.2 Pre-Drilling Survey (2018)

Grid Box

Within the grid box lines (200 m x 200 m) for the pre-survey analysis, the substrate was predominantly fine (85.5%), with coarse (8.1%) and medium (6.3%) making up the remainder. The fine substrate showed evidence of bioturbation, such as holes and paths created by fauna, throughout the area. In general, the area alternated between open areas of fine substrate, with rocky substrate clustered throughout (Figure 3-2). The majority of benthic fauna was attached to rocky substrate in these areas, though the most common species group, anemones, were found throughout regardless of substrate. Compared to the cuttings transect area lines, the grid box had less fine substrate overall and more areas of medium or coarse substrate. This explains the distribution of species such as redfish (plank-piscivore), which were more abundant in the grid box lines as they were typically found near rocky substrate in large numbers. From these pre-drill surveys, it was determined that no *Desmophyllum pertusum* (formerly *Lophelia pertusa*) complexes or C-NLOPB-defined coral colonies were observed within the surveyed area at the Harp L-42 wellsite; therefore, drilling preceded at the site.

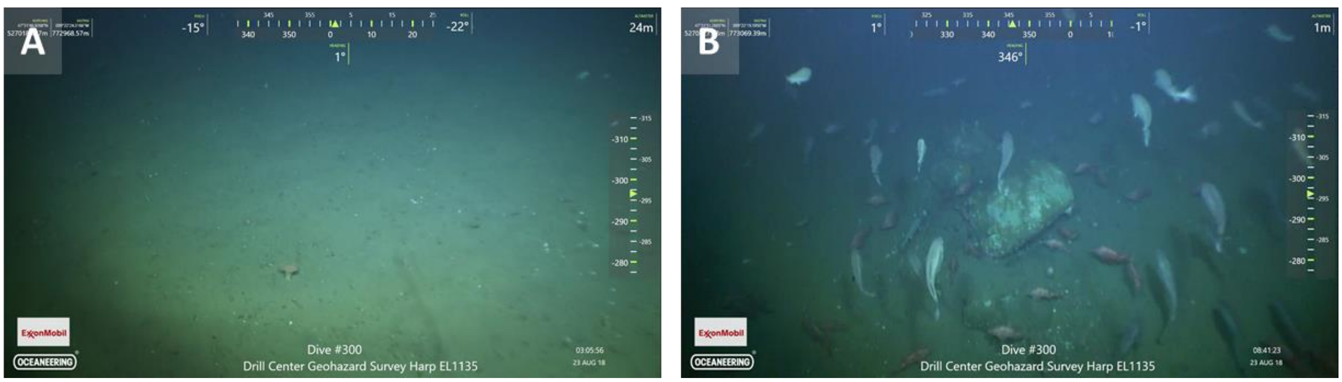


Figure 3-2 Representative pre-drilling survey gridbox seabed images of A) fine substrate and B) rocky substrate.

Transect Area (T200-T1200)

Within the cuttings transect lines in the pre-survey, the substrate was also primarily fine (89.9%), followed by coarse (7.1%) and medium (3.0%). Similar to the grid box lines, fine substrate showed evidence of bioturbation by fauna, with small holes and trails from molluscs and annelids throughout. The patchy distribution of rocky substrate throughout was similar to the grid lines as well, though in general hard substrate (e.g., gravel, cobble, rubble, boulder) was less common in the cuttings transect lines (Figure 3-3). Species such as soft coral, which was primarily found within fine substrate areas, were more common in the cuttings transect lines compared to the grid box.

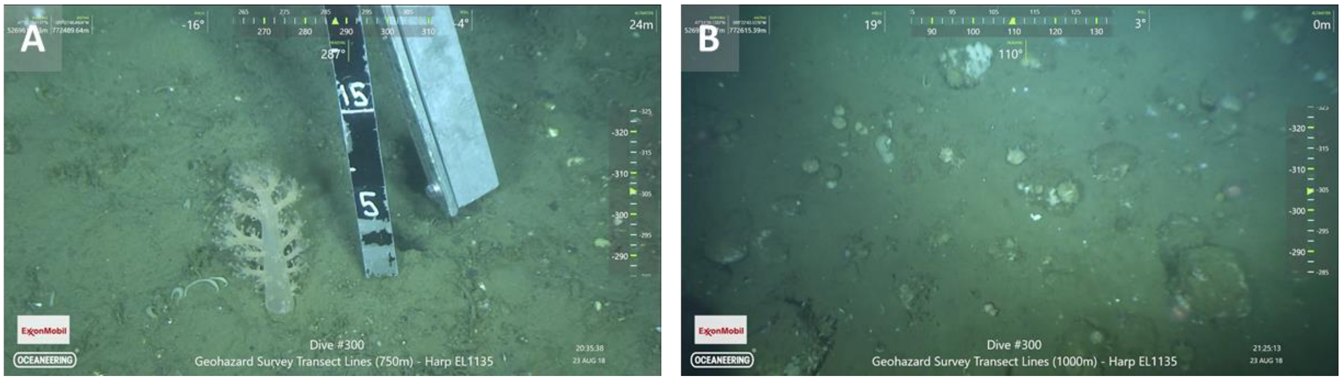


Figure 3-3 Representative pre-drilling survey transect area seabed images of A) fine substrate and B) rocky substrate.

3.3 Post-Drilling Survey (2020)

Drill cuttings were visibly distinct from seafloor sediments in color, texture, and particle size. Drill cuttings appeared light brown/rusty in color and had a fine-grained (e.g., silt and clay), soft fluffy texture (Figure 3-4). Drill cuttings were easily disturbed by the ROV and remained in loosely confined clumps in the water column. Visual differences among drill cuttings and seafloor sediments were also apparent in collected sediment samples (Figure 3-5, Figure 3-6). The distribution of drill cuttings observations relative to the predicted model footprint is shown in Figure 3-7. Start and end coordinates for all transect lines is presented in Appendix A. Details on sediment penetration depth measurements is presented in Appendix B and images from all sediment samples are presented in Appendix C.

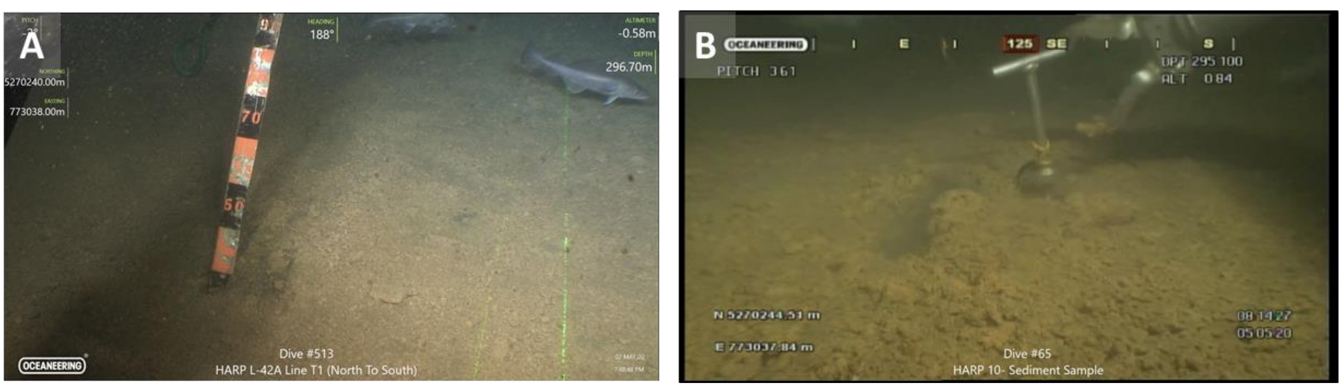


Figure 3-4 Representative images of drill cuttings during A) depth penetration measurements, and B) sediment core sampling.

Figure 3-5 Grid box push core and associated extruded samples for A) station HRP-10A (drill cuttings), B) station HRP-10B (drill cuttings), C) station HRP-100, D) station HRP-10A (drill cuttings), E) station HRP-10B (drill cuttings), and F) station HRP-100.

Figure 3-6 Transect Area push core and associated extruded samples for A) station HRP-500, B) station HRP-700, C) station HRP-1200B, D) station HRP-500, E) station HRP-700, and F) station HRP-1200B.

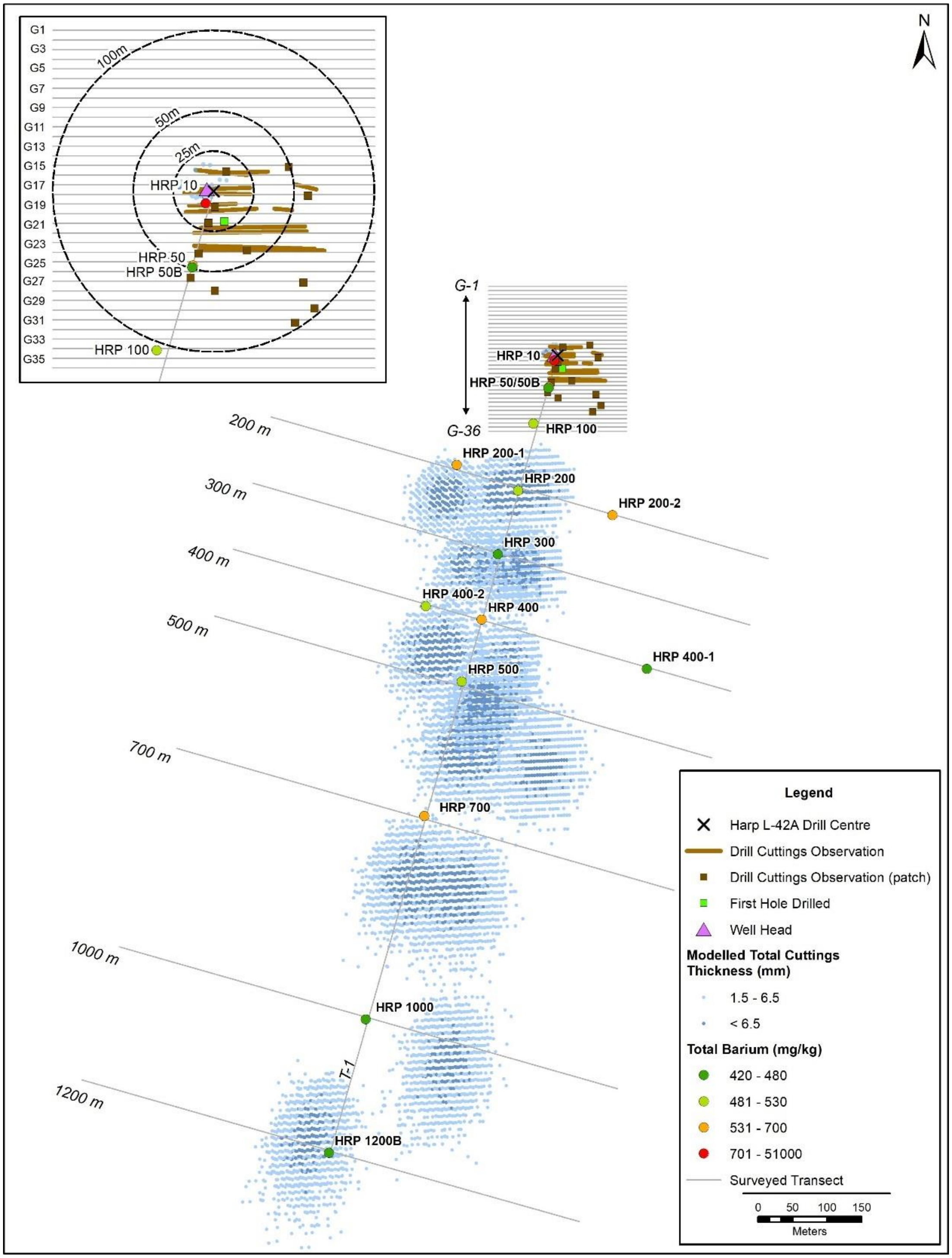


Figure 3-7 Distribution of visually observed drill cuttings and total barium concentrations (mg/kg) in relation to the two drill centers and the predicted drill cutting footprint (all seasonal scenarios).

Grid Box (≤25 m from the Wellhead)

At the wellhead, drill cuttings were mounded unevenly, consisting of light brown fluffy textured sediments interspersed with patches of dark grey sediments (Figure 3-8). Based on measurements of known structure sizes and distances to the seabed, drill cuttings deposition was approximately 1.4-1.6 m high adjacent to the wellhead. Observations of benthic invertebrate fauna on the drill cuttings deposition area were rarely observed, though pelagic fauna such as cod and shrimp were present.

Drill cuttings further from the wellhead were visually similar; consisting of light brown fluffy textured sediments interspersed with patches of dark grey sediments Approximately 4-14 m distance from the wellhead, three combined (natural seabed and potential drill cuttings) depth penetration measurements conducted in areas of visible drill cuttings ranged from 0.35-0.85 m. This suggests that drill cuttings deposited in this range around the wellhead was <0.85 m depth. Drill cuttings were observed to extend throughout this range, up to 25 m to east, south, and west from the wellhead. Drill cuttings were observed up to approximately 14 m north on G15 (Figure 3-7, Figure 3-8). Sediment recovered at site HRP-10 (10 m from the wellhead) consisted of light brown fine-grained (e.g., silt and clay) sediment with darker coarser sediment layers (Figure 3-5). Very high levels of barium (51,000 mg/kg and 1,100 mg/kg) were in sediments collected at HRP-10 in visibly distinguishable drill cuttings areas as described above (Table 3.1). Relatively higher levels of weak-acid barium was also observed in these samples (Figure 3-9). Similar to the areas adjacent to the wellhead, observations of benthic invertebrate fauna on drill cuttings deposition area up to 25 m were rarely observed, though pelagic fauna such as cod and shrimp were present.

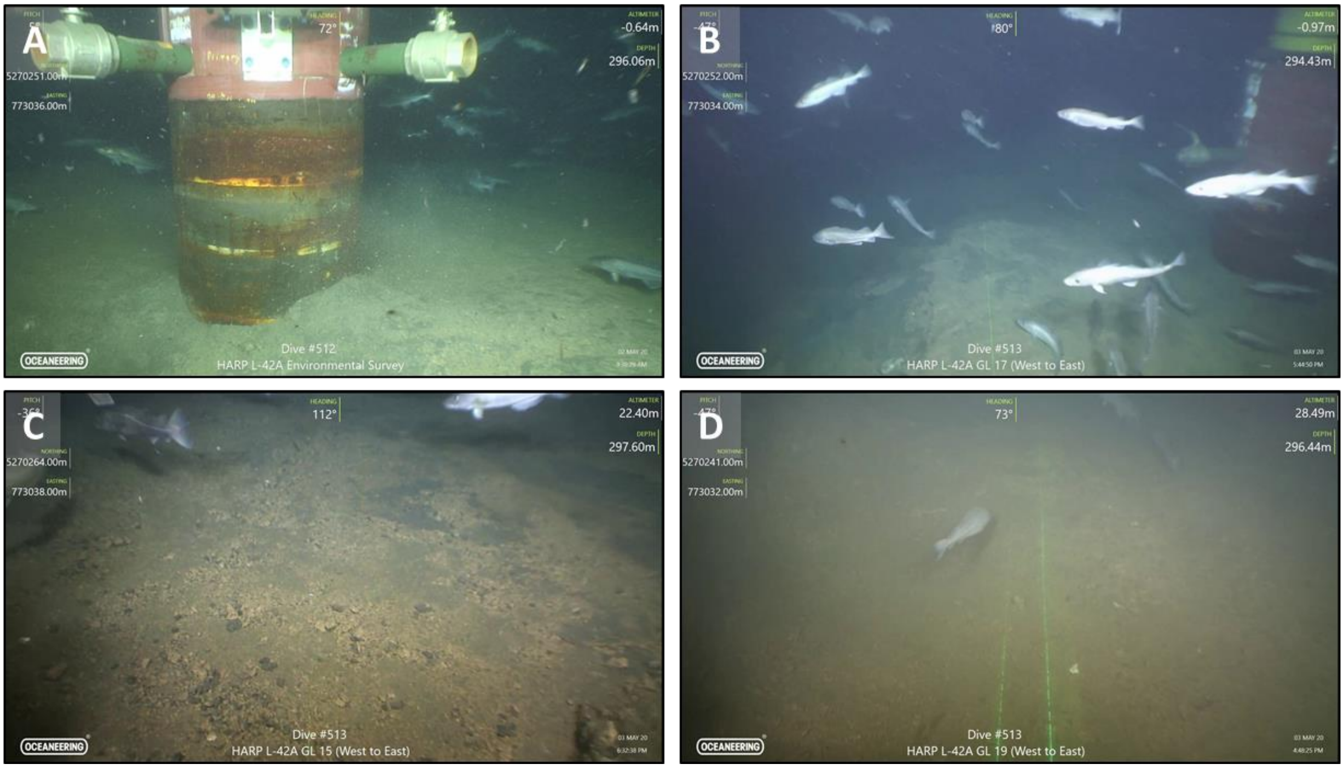
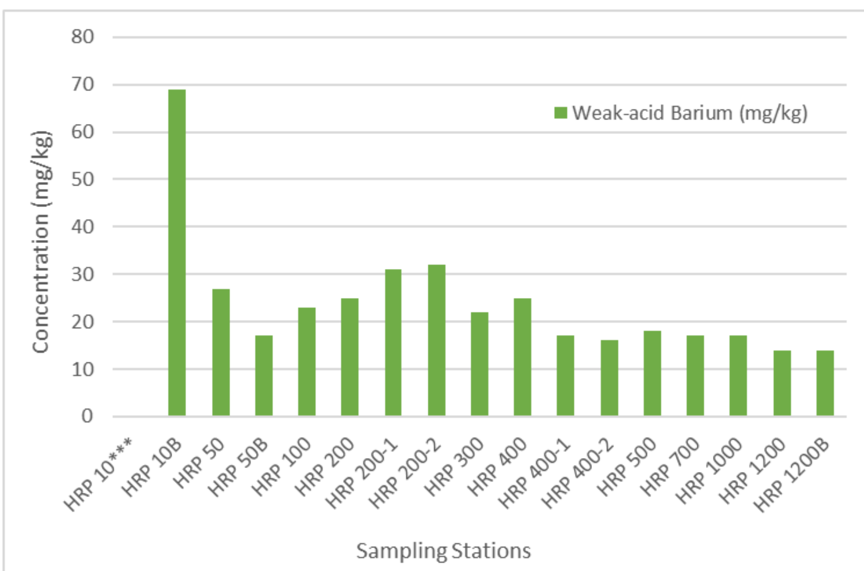


Figure 3-8 Drill cuttings observations within 25 m of the wellhead: A&B) Seabed observations at the wellhead, C) Transect GL15 (north of the wellhead), and D) Transect G19 (south of the wellhead).



*** Sample did not dry sufficiently for all Weak-acid barium analysis.

Figure 3-9 Weak-acid barium sediment concentrations (mg/kg) from at sediment sampling sites.

Table 3.1 Chemical analysis for recovered sediments: Total Barium, Weak-acid Barium, and Particle Size Analysis.

Station	Distance* (m)	Northing	Easting	Depth (m)	Total Barium (mg/kg)	Weak-acid Barium (mg/kg)	RDL** (mg/kg)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	RDL** (%)
HRP 10***	10	5270243.359	773033.362	-296	51000	N/A	5000	N/A	N/A	N/A	N/A	
HRP 10B	10	5270243.359	773033.362	-296	1100	69	5	<0.10	65	23	12	0.1
HRP 50	50	5270204.606	773025.395	-295	570	27	5	0.26	71	15	14	0.1
HRP 50B	50	5270203.498	773024.933	-296	420	17	5	0.28	82	9.2	8.7	0.1
HRP 100	100	5270151.833	773002.909	-295	520	23	5	0.22	74	14	11	0.1
HRP 200	200	5270054.490	772980.885	-296	510	25	5	0.58	73	13	13	0.1
HRP 200-1	200	5270091.673	772891.697	-297	700	31	5	9.4	66	14	11	0.1
HRP 200-2	200	5270019.052	773117.436	-296	630	32	5	1	76	13	10	0.1
HRP 300	300	5269962.228	772951.491	-298	480	22	5	24	62	7.6	6.3	0.1
HRP 400	400	5269867.329	772927.692	-299	600	25	5	1.8	69	15	14	0.1
HRP 400-1	400	5269795.901	773167.326	-299	460	17	5	3.3	80	8.8	7.8	0.1
HRP 400-2	400	5269887.000	772847.000	-303	490	16	5	1	74	13	11	0.1
HRP 500	500	5269777.633	772899.080	-303	530	18	5	5.9	66	15	13	0.1
HRP 700	700	5269582.541	772844.726	-306	580	17	5	0.13	69	16	14	0.1
HRP 1000	1000	5269287.315	772760.013	-304	480	17	5	1.8	69	15	14	0.1
HRP 1200	1200	5269093.415	772706.323	-304	470	14	5	<0.10	71	15	13	0.1
HRP 1200B	1200	5269093.415	772706.323	-304	460	14	5	0.31	74	15	11	0.1

* Distance from wellhead. ** RDL= reportable detection limit, *** Sample did not dry sufficiently for all analyses

Grid Box (>25 m from Wellhead up to 200 by 200 m boundary)

Visibly distinct drill cuttings were observed in patches and along portions of the transect in the 25-100 m range. Areas of natural undisturbed seabed sediment that was relatively lighter in colour and with a smoother texture was more frequently observed compared to areas <25 m from the wellhead. Drill cuttings extended mainly to the south and southeast and mostly within 50 m of the drill centre. Areas of drill cuttings <15 m in length were observed to the east of the wellhead. Three depth penetration measurements (combined natural seabed and potential drill cuttings) conducted in areas of visible drill cuttings approximately 26-37 m distance from the wellhead ranged from 0.70-0.75 m. This suggests that drill cuttings deposited in this range around the wellhead was <0.75 m depth. From 50-100 m from the wellhead, drill cuttings deposition areas extended primarily to the southeast.

Small drill cuttings patches (<1-3 m^2) were also observed 25-100 m from the wellhead to the south, east, and southeast (Figure 3-7). Drill cutting patches closer to the wellhead had distinguishable interface between drill cuttings and natural seafloor relative whereas drill cutting patches further away from the wellhead were less pronounced and harder to distinguish (i.e., ribbons of drill cuttings mixed with natural sediments).

Beyond 100 m in grid box, drill cuttings were not observed. Sediment penetration depth measurements in areas >100 m from the wellhead with no visible drill cuttings (n=50) were highly variable, ranging from 0.05-0.65 m. Relative to pre-drilling survey results, substrates remained similar, being primarily comprised of fine substrates (e.g., mud) with lesser quantities of medium (e.g., cobble, gravel) and coarse (e.g., rubble, boulder) substrates. Sediment recovered at sites 50-100 m from the drill center were darker with a brown olive-grey coloration and silty sand texture (Figure 3-2). Sediment samples recovered 50 m southwest of the wellhead had relatively lower concentrations of barium ranging from 420-570 mg/kg with similar values (520 mg/kg) in the sediment sample collected up to 100 m from the wellhead.

In general, aside from areas of visible drill cuttings deposition, which had noticeably less fauna, faunal occurrences in the grid box were similar to what was observed in the remainder of the survey area (i.e., transect area lines).

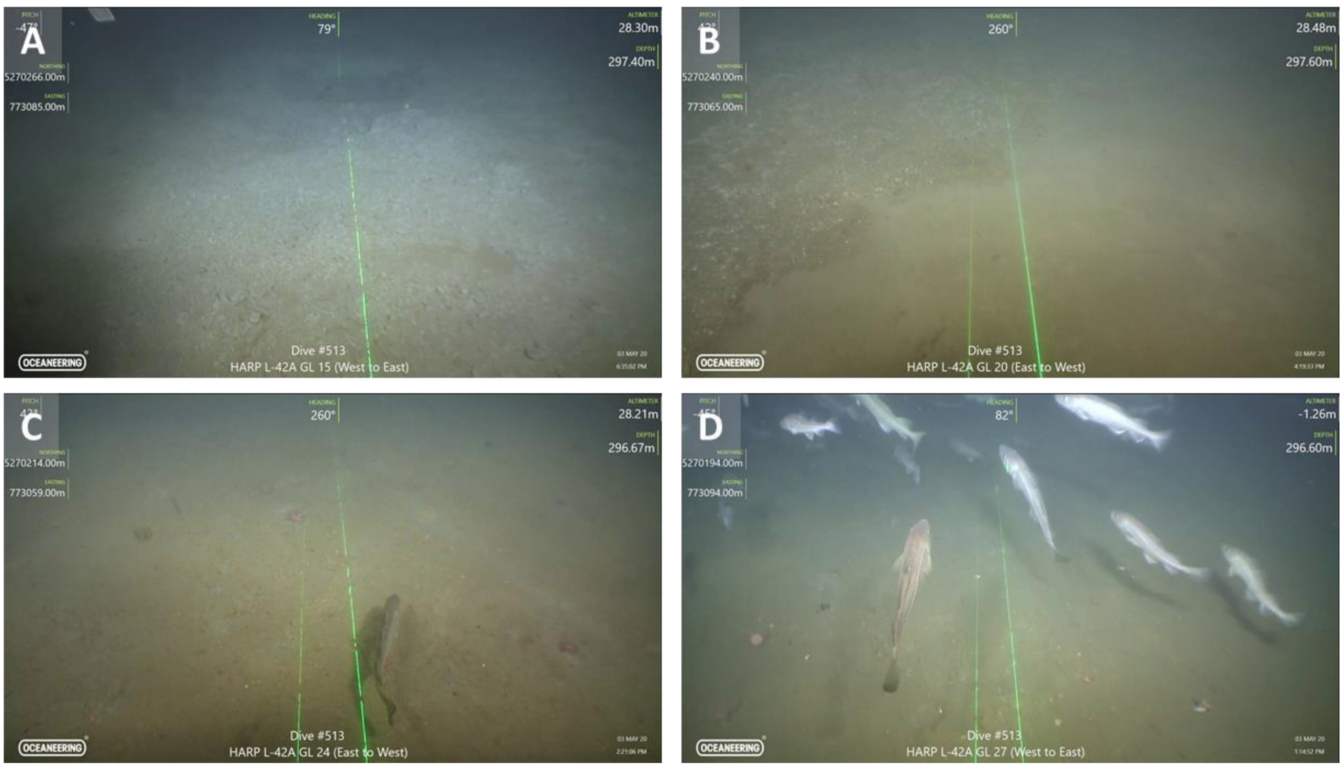


Figure 3-10 Drill cuttings patches observations: A) fluffy drill cuttings patch observation at G15, B) drill cuttings (top left) and natural seafloor (bottom right) interface at G20, C) drill cuttings and natural seafloor interface at G24, D) drill cuttings and natural seafloor interface at G27.

Transect Area (T200 and T1 [>100-200 m from wellhead])

Drill cuttings were not visibly apparent or visibly distinguished in core samples along this portion of T1 and the T200 transect (Figure 3-11). Surficial sediment in this area were dominated by fine sediments (~89%) with roughly equal amounts of medium and coarse substrate making up the remainder with patchy distribution of benthic fauna (e.g., sea anemones) throughout. Sediment penetration depth measurement was 0.28 m at T1 (200 m from the wellhead) and 0.10 m and 0.25 m at stations along T200. Core sediment samples were comprised of grey-brown mud with no discernable layer of soft drill cuttings as was typically observed within 25 m of the wellhead. Barium concentrations in sediment samples within 200 m from the wellhead towards the south were relatively elevated, ranging between 510 to 700 mg/kg. Though no visible drill cuttings were observed, the elevated barium concentrations may indicate some deposition of drill cuttings in this area.

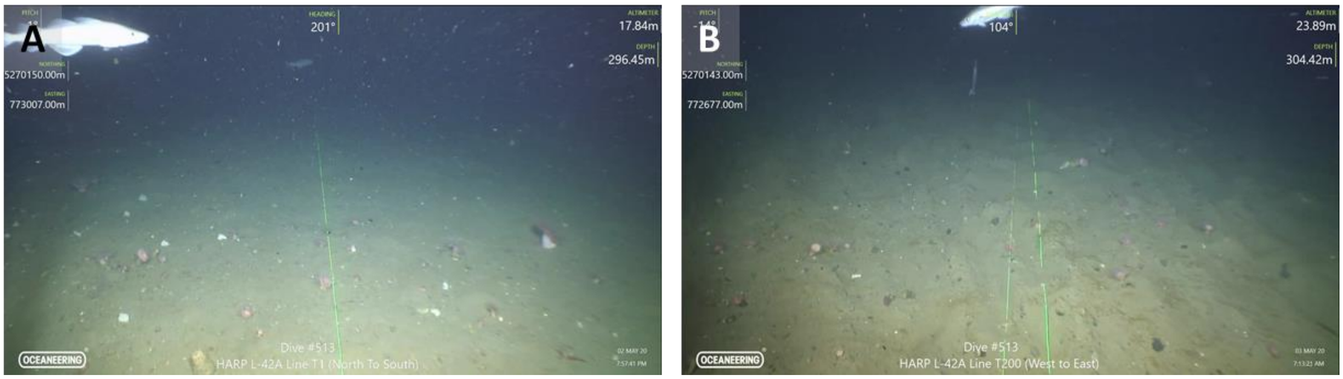


Figure 3-11 Representative post-drilling survey seabed images along A) T1 between 100-200 m from wellhead and B) T200.

Transect Area (T300, T400, T500, and T1[>200-500 m from the Wellhead])

Drill cuttings were not visibly apparent or visibly distinguished in core samples along this portion of T1 and the T300, T400, and T500 transects (Figure 3-6, Figure 3-12). Sediments in this area were dominated by fine sediments (~88%) with roughly equal amounts of medium and coarse substrate making up the remainder, with various benthic fauna (e.g., sea anemones) throughout. Sediment penetration depth measurements ranged from 0.20-0.25 m along T1, within 500 m of the wellhead. Similar penetration depth measurements were observed along T300, T400 and T500, ranging from 0.15 m to 0.25 m. Barium concentrations in samples collected 300-500 m from the wellhead were relatively elevated, ranging between 460 to 600 mg/kg, but generally lower than values along the T200 transect.

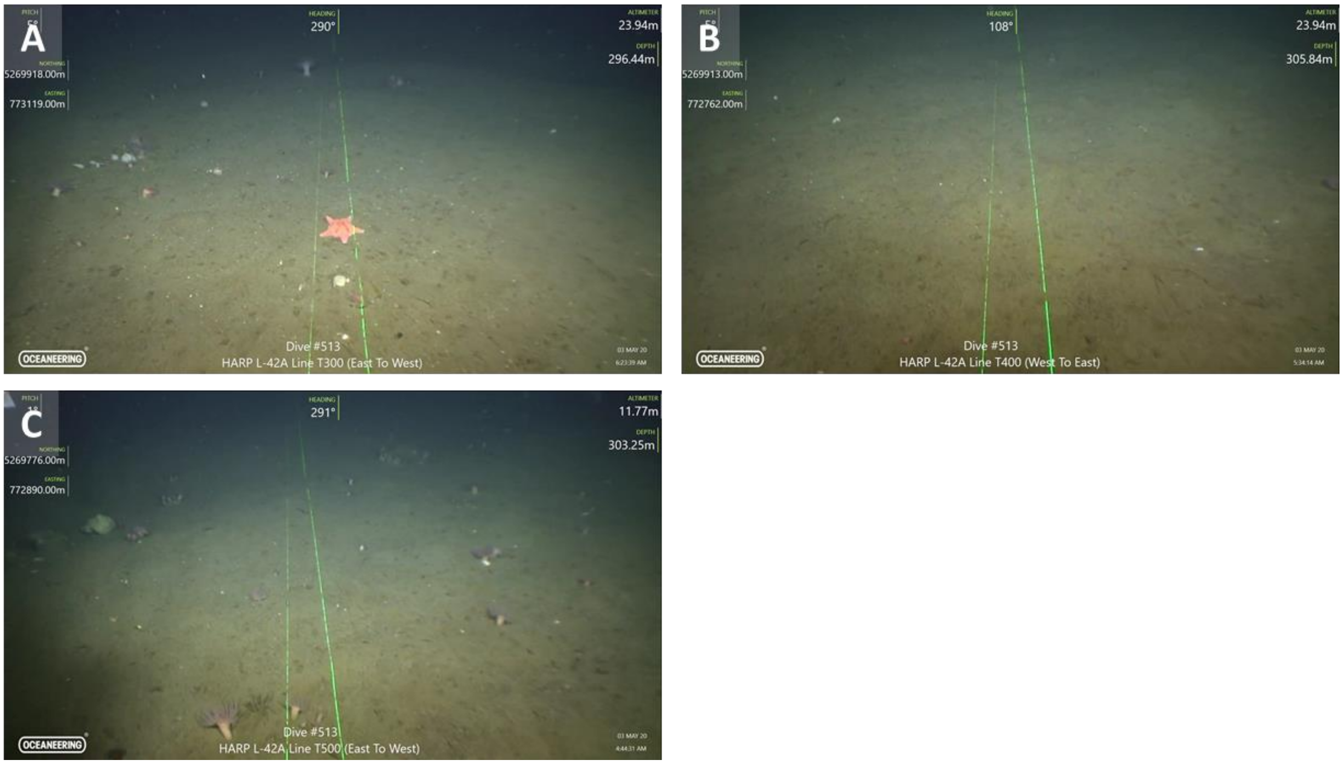


Figure 3-12 Representative post-drilling survey seabed images along A) T300, B) T400 and B) T500.

Transect Area (T700, T1000, and T1 [>500-1000 m from the wellhead])

Drill cuttings were not visibly apparent or visibly distinguished in core samples along this portion of T1 and the T700 and T1000 transects (Figure 3-6, Figure 3-13). Sediments in this area were dominated by fine sediments (~92%) with coarse and medium as the second and third most common substrates, with various benthic fauna (e.g., sea anemones) throughout. Five sediment penetration depth measurements were conducted in this area ranging from 0.05-0.35 m. Barium concentrations in sediment cores collected 700 m and 1000 m from the wellhead were 580 mg/kg and 480 mg/kg, respectively.

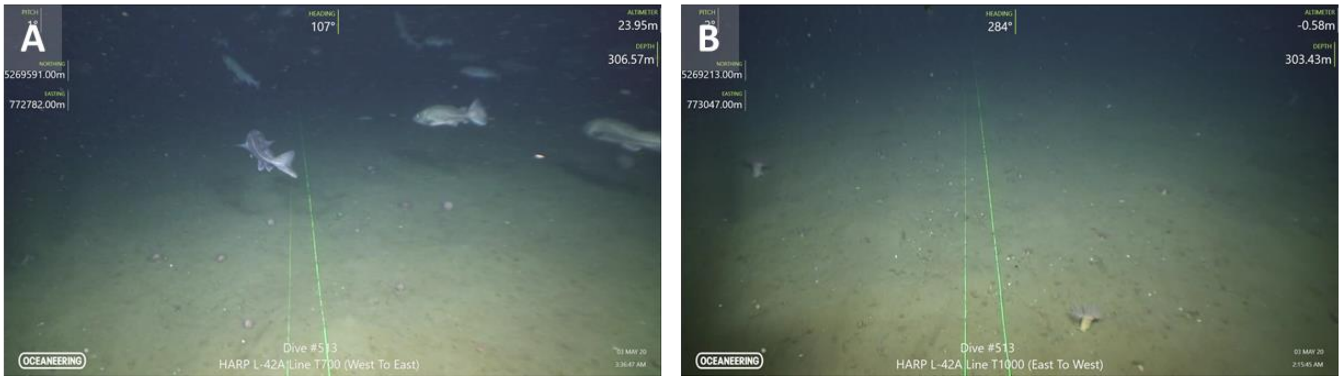


Figure 3-13: Representative post-drilling survey seabed images along A) T700 and B) T1000.

Transect Area (T1200, and T1 [>1000-1200 m from the wellhead])

Drill cuttings were not visibly apparent or visibly distinguished in core samples along this portion of T1 and the T1200 transect (Figure 3-6, Figure 3-14). Sediments in this area were dominated by fine sediments (~92%), followed by coarse (~5%) and medium (~3%), with various benthic fauna (e.g., sea anemones) throughout. Two sediment penetration depth measurements were conducted in this area, ranging from 0.25-0.35 m. Barium concentrations in sediment cores collected 1200 m from the wellhead ranged between 460 to 470 mg/kg.

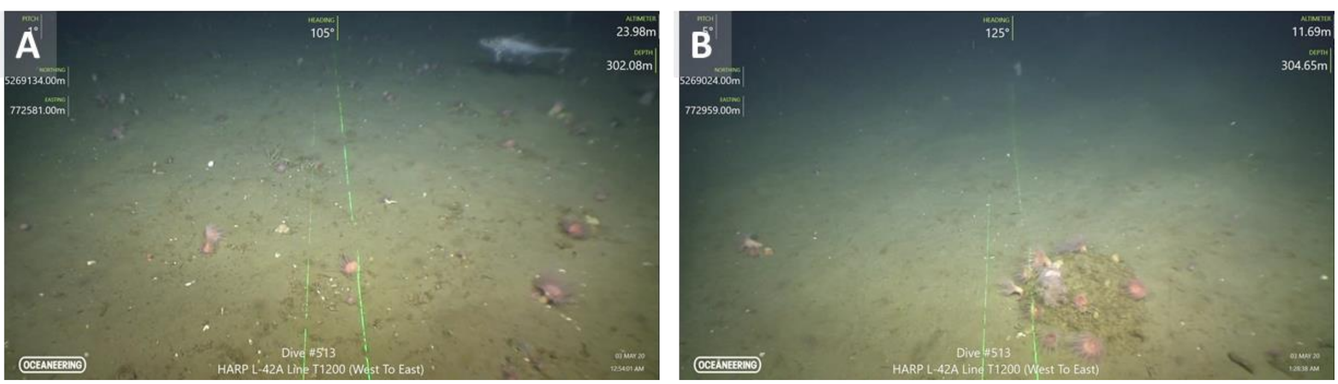


Figure 3-14 Representative post-drilling survey seabed images along T1200.

3.4 Assessment of Model Predictions

For the post-drilling survey, fine (sand, mud, or drill cuttings) was the dominant surficial substrate class observed. Other substrate present throughout the Harp L-42 area were predominantly coarse (boulders and rubble) with lesser amounts of medium (cobble and gravel) substrate. Similar substrates were present during the 2018 pre-drilling survey, with small variations for each substrate type (Wood 2020).

Exploration drilling occurred between November and April, therefore, drill cuttings model scenarios for December and March were compared to the survey results. Visually distinct drill cuttings were mainly observed within 25 m of the wellhead with deposition areas extending to the south and southeast 50-100 m from the wellhead. Drill cuttings were visibly mounded adjacent to the wellhead and were approximately 1.4-1.6 m high. Although depth penetration measurements did not allow for distinguishing the top layer of drill cuttings against natural seafloor, combined measurements in areas of visible cuttings 4-37 m from the wellhead indicated maximum thicknesses 0.35-0.85 m. Further from the wellhead, drill cuttings observations were patchy and discontinuous in nature. Based on visual observations and penetration measurements, the observed deposition was higher than modelled values with the modeled average thickness ranging from 0.4-3.0 mm and maximum modeled thickness ranging from 7-12 mm in areas <100 from the wellhead.

The highest concentrations of barium (51,000 mg/kg and 1,100 mg/kg) were in sediments collected at HRP-10 in visibly distinguishable drill cuttings approximately 10 m from the wellhead. Barium levels decreased rapidly in sediment samples >10 m from the wellhead to 420-700 mg/kg (Table 3.1). Similar trends were observed with weak acid leachable barium as well (Figure 3-9). This is consistent with studies of offshore platforms that show steep gradients of decreasing barium concentrations with distance from the wellhead as the barite in WBMs are deposited rapidly to the sediment (Neff 2002). Although background barium levels were not established for the area, global average concentrations for soils and sediments are generally about 400 mg/kg and may range from 1-2,000 mg/kg (Neff 2002). Background barium levels of Grand Banks sediments have been described in baseline surveys for other drill centers (e.g., Terra Nova, Hibernia) and reported barium concentrations of 70 to 280 mg/kg for the Terra Nova baseline survey (DeBlois et al. 2014) and 0 to 299 mg/kg in sediments from the Hibernia baseline survey (Stantec 2014). However, barium in marine sediments is generally elevated in deep-water sediments and may vary with sediment composition and depth. For example, Neff (2002) indicates that coarse grained carbonate and silicate marine sediments generally contain barium levels that are <100 mg/kg, whereas fine-grained sediments that are rich in clay minerals may have barium concentrations of >1000 mg/kg. Therefore, background barium levels would be higher for the survey area relative to the drill centres on the Grand Banks that occur at shallower depths (<100 m) with coarser-grained sandier sediments.

Minimal drill cuttings deposition was predicted between 100-200 m from the wellhead (average thickness 0.0-0.003 m) in December and March scenarios. This is consistent with survey results that indicated no visible drill cuttings along transects beyond 100 m from the wellhead.

In areas 200-500 m from the wellhead, the drill cuttings modelling predicted higher average thicknesses of 2.4-3.0 mm. Areas of higher deposition 320-340 m away south of the wellhead were also predicted for December and March scenarios with maximum thicknesses of 77-80 mm. Barium levels were relatively elevated in samples collected along T200 (700 mg/kg) that was 217 m from the wellhead. Therefore, drill cuttings may have drifted to this area resulting in slightly higher barium levels. However, the drill cuttings deposition was limited relative to the model as quantities were not sufficient to form visible patches of appreciable thicknesses.

The model predicted drill cuttings deposition >500 m from the wellhead ranging in average thickness from 1-4 mm with maximum thicknesses of 10-20 mm. In transects >500 m from the wellhead, drill cuttings were lower than predicted with no visible areas of drill cuttings, no observations of drill cuttings in core samples, and relatively low barium values.

4.0 SUMMARY

The objective of this follow-up program is to meet conditions 3.12 of the Decision Statement and verify the accuracy of the predictions made during the environmental assessment. The following summarizes the follow-up monitoring results with the specific Conditions.

Condition 3.12.1*:for every well, measure the concentration of synthetic-based drilling fluids retained on discharged drill cuttings as described in the Offshore Waste Treatment Guidelines to verify that the discharge meets, at a minimum, the performance targets set out in the Guidelines and any applicable legislative requirements, and report the results to the Board*

The OWTG specifies that SOC levels should not exceed 6.9 g/100 g oil on wet solids. As detailed in Section 3.1, the highest reported levels from the drilling unit was 4.02 g/100 g oil on wet solids. Therefore, the discharges meet the performance targets set out in the OWTG and addresses Condition 3.12.1 of the decision statement.

Condition 3.12.2: *for the first well in each exploration licence, and for any well where drilling is undertaken in an area determined by coral and sponge surveys to be sensitive benthic habitat, and for any well located within a special area designated as such due to the presence of sensitive coral and sponge species, or a location near a special area where drill cuttings dispersion modelling predicts that drill cuttings deposition may have adverse effects, develop and implement, in consultation with Fisheries and Oceans Canada and the Board, follow-up requirements to verify the accuracy of the environmental assessment and effectiveness of mitigation measures as they pertain to the effects of cuttings discharges on benthic habitat. Follow-up shall include:*

Condition 3.12.2.1 *- Measurement of sediment deposition extent and thickness post drilling to verify the drill waste deposition modeling predictions;*

Drill cuttings were predicted to be distributed to the south, south west from the wellhead with the majority of cuttings deposited within 1 km. Sediment deposition extent and thickness was evaluated through a combination of visual assessments, depth penetration measurements, and sediment chemistry. Based on these combined survey methodologies, the observed drill cuttings footprint was limited to within 100 m from the wellhead with potential drift of low quantities of drill cuttings approximately 200 m from the wellhead (T200 line) based on sediment chemistry. Overall, the observed drill cuttings deposition had a lower extent but higher thickness relative to model predictions.

The EA predictions indicated that the physical and chemical effects of drill cuttings was anticipated to have localized habitat disturbances less than two km from the well site. As the primary mechanism for environmental effects on benthic organisms is burial and smothering (EMCL 2017) and visible drill cuttings deposition was limited to within 100 m of the wellhead, the potential effects are within what was assessed for the Eastern Newfoundland Offshore Exploration Drilling Program.

Condition 3.12.2.2 *- Benthic fauna surveys to verify the effectiveness of mitigation measures;*

This condition is discussed in the EL1165B Benthic Habitat Monitoring Report (Wood 2020). The report concluded that pre- and post-drilling surveys observed similar benthic fauna species present and abundances.

Condition 3.12.2.3 *– Report the information collected as identified in conditions 3.12.2.1 and 3.12.2.2, including a comparison of modelling results to in situ results, to the C-NLOPB within 60 days following the drilling of the first well in each exploration licence.*

As identified directly above and in the preceding sections of this report, model results were compared to *in situ* results and found that cuttings were more localized with higher thicknesses relative the model's predictions.

5.0 CONCLUSIONS

Based on knowledge gained from EMCL's operations experience completing various drilling operations in the Jeanne d'Arc Basin, it is reasonable to conclude that the risks associated with drill cuttings release seen in the Flemish Pass are inconsequential. This conclusion is further supported by the following:

- Smothering effects of drill cuttings have been demonstrated through our operations to be limited to within 500 m of a release site based on effects monitoring in the shallow water of the Jeanne d'Arc Basin,
- Relative to releases in shallow water, the seafloor thickness can be expected to be less due to longer residence time in the water column and increased lateral dispersion and loss of fines to the water column,
- Relative to releases in shallow water, the SOC concentration reaching the seafloor can also be expected to be less due to longer residence time in the water column and transition of fluid into the water phase, and
- In shallow water such as the Jeanne d'Arc Basin, effects associated with multiple years of drilling by multiple operators have been demonstrated to be limited, minor and acceptable to the C-NLOPB. These conclusions were reached when SOC limit were at 15% whereas the present day limit is 6.9%.

If additional measurements required to inform mitigations for future exploration campaigns, consideration could be given to affixing graduated posts to the seafloor at predetermined intervals (ex. 100m, 250m, and 500m) during the initial pre-drill survey. This would provide a zero-reference baseline and during the post-drill survey the amount of cuttings dispersed at each point could be visually estimated.

6.0 CLOSURE

This report of the biological environment observed at EL 1165B has been prepared for the exclusive use of ExxonMobil Canada Ltd.. The project was conducted using standard practices by qualified Wood staff and in accordance with verbal and written requests from the client.

Yours sincerely,

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APPENDIX A: SURVEY COORDINATES

Table A-1 Start and end coordinates for the central box grid and radial transects surveyed in EL 1165B

Transect	Length (m)	UTM Coordinates (NAD83, Zone 22)			
		Start Northing	Start Easting	End Northing	End Easting
200 x 200m Survey Grid Lines					
G-01	200	5270350.254	773138.096	5270351.521	772933.202
G-02	200	5270344.254	772930.508	5270345.135	773144.748
G-03	200	5270337.785	773142.148	5270340.959	772932.331
G-04	200	5270334.083	772933.487	5270334.437	773144.666
G-05	200	5270323.14	773144.869	5270325.99	772936.478
G-06	200	5270321.301	772938.078	5270320.093	773139.272
G-07	200	5270315.216	773145.755	5270313.286	772934.218
G-08	200	5270306.326	773151.731	5270308.218	772934.152
G-09	200	5270303.401	772934.075	5270305.349	773141.699
G-10	200	5270298.029	773150.772	5270297.503	772933.38
G-11	200	5270288.284	772937.514	5270290.891	773146.493
G-12	200	5270286	773145.512	5270284.488	772932.651
G-13	200	5270277.871	772932.524	5270278.203	773144.497
G-14	200	5270272.189	773150.284	5270271.033	772934.237
G-15	200	5270266.874	772939.656	5270268.633	773150.844
G-16	200	5270263.449	773146.408	5270262.564	772934.971
G-17	200	5270255.278	772940.299	5270255.354	773141.021
G-18	200	5270250.721	773140.224	5270247.732	772937.001
G-19	200	5270243.425	772937.68	5270242.359	773136.851
G-20	200	5270238.658	773143.288	5270237.902	772936.876
G-21	200	5270230.654	772939.619	5270230.488	773138.705
G-22	200	5270224.23	773144.385	5270227.167	772933.751
G-23	200	5270220.349	772940.576	5270217.214	773136.739
G-24	200	5270214.327	773140.267	5270213.982	772937.04
G-25	200	5270207.493	772938.7992	5270207.184	773139.045
G-26	200	5270201.226	773139.881	5270201.076	772939.041
G-27	200	5270193.961	772937.821	5270194.511	773139.215
G-28	200	5270190.044	773140.321	5270188.576	772936.419
G-29	200	5270182.462	772938.755	5270182.045	773137.856
G-30	200	5270178.456	773140.944	5270177.927	772939.481
G-31	200	5270171.459	772940.029	5270170.694	773140.229
G-32	200	5270165.193	773145.41	5270165.009	772937.851
G-33	200	5270158.368	772938.576	5270158.28	773137.359
G-34	200	5270154.154	773140.233	5270153.536	772939.298
G-35	200	5270146.55	772939.301	5270147.125	773138.182
G-36	200	5270141.908	773138.223	5270140.184	772938.96
Predicted Drill Cuttings Deposition Area Transects					
T-1	1200	5270243.034	773038.738	5269096.106	772709.441

Transect	Length (m)	UTM Coordinates (NAD83, Zone 22)			
		Start Northing	Start Easting	End Northing	End Easting
T-200 m	750	5270159.463	772623.358	5269954.132	773347.433
T-300 m	750	5269856.813	773317.478	5270067.779	772594.454
T-400 m	750	5269971.649	772568.236	5269761.322	773288.077
T-500 m	750	5269666.68	773262.154	5269875.928	772540.335
T-700 m	750	5269682.218	772484.749	5269471.573	773207.759
T-1000 m	750	5269186.706	773125.088	5269397.173	772403.023
T-1200 m	750	5269200.901	772345.618	5268991.336	773069.758

APPENDIX B: PHYSICAL MEASUREMENT DATA

Table B 1 Depth penetration measurements.

Location	Waypoint	Easting	Northing	Depth (m)	Measurement (cm)	Comments
G-09	Measurement 87	772934.205	5270303	295.466	5	
G-09	Measurement 88	773141.892	5270305	297.797		ruler dropped
G-10	Measurement 84	773150.241	5270298	32.303	65	
G-10	Measurement 85	773050.5	5270298	296.641	45	
G-10	Measurement 86	772932.969	5270298	295.884	8	
G-11	Measurement 82	772937.509	5270288	296.453	12	
G-11	Measurement 83	773146.478	5270291	299.338	25	
G-12	Measurement 79	773144.772	5270286	299.996	25	
G-12	Measurement 80	773048.655	5270286	296.789	25	
G-12	Measurement 81	772932.244	5270284	297.643	25	
G-13	Measurement 77	772932.198	5270278	298.041	55	
G-13	Measurement 78	773145.721	5270278	298.396	15	
G-14	Measurement 74	773150.582	5270272	299.784	12	
G-14	Measurement 75	773046.689	5270274	297.387	40	
G-14	Measurement 76	772934.293	5270271	299.102	29	
G-15	Measurement 72	772940.256	5270267	299.229	28	
G-15	Measurement 73	773150.731	5270268	298.719	8	possibly DC, disturbed sediment
G-16	Measurement 70	773146.784	5270263	296.256	60	not visible drill cuttings
G-16	Measurement 71	772934.879	5270263	299.282	25	
G-17	Measurement 68	772940.28	5270255	298.92	25	
G-17	Measurement 69	773141.916	5270255	295.511	15	
G-18	Meaurement 65	773140.308	5270251	295.432	15	
G-18	Measurement 66	773041.716	5270249	293.707	35	visible drill cuttings
G-18	Measurement 67	772936.812	5270248	299.913	60	not visible drill cuttings
G-19	Measurment 63	772937.676	5270243	300.003	90	not visible drill cuttings
G-19	Measurement 64	773137.157	5270242	295.36	15	
G-20	Measurement 60	773143.244	5270239	295.516	10	
G-20	Measurement 61	773034.07	5270238	295.828	85	visible drill cuttings
G-20	Measurement 62	772937.138	5270238	300.17	50	
G-21	Measurement 58	772939.802	5270231	299.386	44	
G-21	MEasurement 59	773138.899	5270231	295.465	35	
G-22	Measurement 55	773144.162	5270224	295.337	18	
G-22	Measurement 56	773034.496	5270226	295.654	75	visible drill cuttings
G-22	Measurement 57	772933.737	5270227	299.302	25	
G-23	Measurement 53	772940.449	5270221	298.504	15	
G-23	Measurement 54	773136.933	5270217	295.525	57	
G-24	Measurement 50	773140.509	5270214	295.928	49	
G-24	Measurement 51	773029.207	5270215	296.067	70	visible drill cuttings
G-24	Measurement 52	772937.02	5270214	297.996	22	
G-25	Measurement 48	772939.1038	5270208	297.7282	12	
G-25	Measurement 49	773139.2471	5270207	296.0808	27	
G-26	Measurement 46	773139.859	5270201	296.23	30	
G-26	Measurement 47	772939.083	5270201	297.068	15	
G-27	Measurement 44	772937.984	5270194	297.111	25	
G-27	Measurement 45	773139.269	5270195	296.184	18	
G-28	Measurement 41	773140.321	5270190	296.308	15	
G-28	Measurement 42	773022.269	5270190	296.456	40	
G-28	Measurement 43	772937.344	5270188	297.505	30	
G-29	Measurement 39	772938.855	5270182	297.47	10	
G-29	Measurement 40	773137.888	5270182	296.331	10	
G-30	Measurement 36	773140.93	5270178	296.536	25	
G-30	Measurement 37	773015.097	5270178	296.198	20	
G-30	Measurement 38	772939.213	5270178	297.832	30	
G-31	Measurement 34	772939.981	5270172	298.379	20	
G-31	Measurement 35	773140.285	5270171	296.529	25	
G-32	Measurement 32	773145.37	5270165	296.783	15	
G-32	Measurement 33	772937.649	5270165	299.187	40	
G-33	Measurement 30	772938.571	5270158	299.006	40	
G-33	Measurement 31	773137.76	5270158	296.678	15	
G-34	Measurement 28	773140.359	5270154	296.691	10	
G-34	Measurement 29	772939.055	5270154	299.856	20	
G-35	Measurement 26	772939.494	5270146	299.413	20	
G-35	Measurement 27	773138.839	5270147	296.128	20	
G-36	Measurement 24	773138.223	5270142		15	
G-36	Measurement 25	772939.164	5270140	299.949	30	
T-1	Measurement 1	773038.663	5270240	299.4283	40	visible drill cuttings
T-1	Measurement 2	772984.073	5270059	298.4139	28	
T-1	Measurement 3	772961.895	5269977	298.7586	20	
T-1	Measurement 4	772928.556	5269878	298.8774	25	
T-1	Measurement 5	772900.403	5269771	298.0409	22	
T-1	Measurement 6	772763.506	5269294	298.988	25	
T-200	Measurement 22	772623.245	5270160	300.5264	25	
T-200	Measurement 23	773347.188	5269955	297.132	10	
T-200	Measurement 24	773137.595	5270142	296.666		
T-300	Measurement 20	773317.529	5269857	291.0542	20	
T-300	Measurement 21	772594.47	5270067	303.766	65	No visible Drill Cuttings, next to anchor chain
T-400	Measurement 18	772568.597	5269970	300.0751	15	
T-400	Measurement 19	773288.266	5269761	290.5253	20	
T-500	Measurement 16	773262.517	5269667	289.6422	25	
T-500	Measurement 17	772540.157	5269876	304.0625	60	No visible Drill Cuttings
T-700	Measurement 14	772484.688	5269682	299.3706	35	
T-700	Measurement 15	773207.35	5269472	290.2359	5	
T-1000	Measurement 12	773125.167	5269186	297.4653	15	
T-1000	Measurement 13	772402.633	5269398	299.3305	5	
T-1200	Measurement 10	772345.697	5269201	301.9617	25	
T-1200	Measurement 11	773070.285	5268991	299.4028	35	

APPENDIX C: SEDIMENT SAMPLE IMAGES

Figure C 1 Push core samples A) HRP-10A, B) HRP-10B, C) HRP-50A, D) HRP-50B, E) HRP-100, F) HRP-200, G) HRP-200-1, H) HRP-200-2

Figure C 2 Push core samples A) HRP-300, B) HRP-400, C) HRP-400-1, D) HRP-400-2, E) HRP-500, F) HRP-700, G) HRP-1000, H) HRP-1200, I) HRP-1200B

Figure C 3 Extruded sediment samples A) HRP-10A, B) HRP-10B, C) HRP-50A, D) HRP-50B, E) HRP-100, F) HRP-400, G) HRP-400-1, H) HRP-400-2, I) HRP-500

Figure C 4 Extruded sediment samples A) HRP-700, B) HRP-1000, C) HRP-1200, D) HRP-1200B