

Cruise Report for the 2017 Fisheries and Oceans Canada and Oceana Canada Mission using the ROPOS in the Gulf of St. Lawrence

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by

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ABSTRACT

Faille, G., Méthé, D., Thériault, M.-H., Thorne, M., Roy, V., Chiasson, M., Benjamin, R. and Rangeley, R. 2019. Cruise Report for the 2017 Fisheries and Oceans and Oceana Canada Mission using the ROPOS. Can. Manuscr. Rep. Fish. Aquat. Sci. 3171: v + 22 p.

A collaborative scientific expedition between Fisheries and Oceans Canada and Oceana Canada (a non-profit organization) took place between 23 and 30 August 2017 on the Canadian Coast Guard Ship *Martha L. Black*. Four sites in the Gulf of St. Lawrence were visited: 1) sea pen fields and sponge grounds in the Laurentian Channel North, 2) the American Bank area of interest, 3) the Cape Breton Trough Ecologically and Biologically significant Area, and 4) sea pen fields in the Laurentian Channel South. The ROPOS (Remotely Operated Platform for Ocean Science) was used for benthic imagery and sampling (organisms, water, and sediments). Nineteen stations were visited, from which the data obtained will serve to provide insight on benthic habitats, biodiversity, species associations, species biology, and pelagic-benthic coupling. This report provides the details of each activity and the data collected. The mission was promoted in social media in part through the partnership with Oceana Canada, an organization that enhances habitat protection by informing the general public about the ocean seafloor and scientific work.

RÉSUMÉ

Faille, G., Méthé, D., Thériault, M.-H., Thorne, M., Roy, V., Chiasson, M., Benjamin, R. and Rangeley, R. 2019. Cruise Report for the 2017 Fisheries and Oceans and Oceana Canada Mission using the ROPOS. Can. Manuscr. Rep. Fish. Aquat. Sci. 3171: v + 22 p.

Une mission scientifique de Pêches et Océans Canada en collaboration avec Oceana Canada (un organisme à but non lucratif) s'est déroulée du 23 au 30 août 2017 sur le navire de la Garde côtière canadienne *Martha L. Black*. Quatre sites du golfe du Saint-Laurent ont été visités: 1) des zones de forte concentration de coraux et d'éponges du chenal Laurentien nord, 2) le site d'intérêt du Banc-des-Américains, 3) la cuvette du Cap-Breton, située à l'intérieur d'une zone d'importance écologique et biologique, et 4) un champ de plumes de mer dans le chenal Laurentien sud. Le ROPOS («Remotely Operated Platform for Ocean Science») a été utilisé pour effectuer de l'imagerie benthique et des récoltes d'échantillons (organismes, eau et sédiments). Un total de 19 stations ont été visitées, pour lesquelles les données obtenues serviront à fournir des informations sur les habitats benthiques, la biodiversité, les associations d'espèces, la biologie des espèces et le couplage pélagique-benthique. Ce rapport fournit les détails de chaque opération et les données récoltées. Le partenariat avec Oceana Canada a également permis de promouvoir la mission à travers les médias sociaux pour favoriser la protection de l'habitat en informant le grand public sur les fonds marins et sur les travaux scientifiques.

1. MISSION OBJECTIVES

The main objective of this mission was to explore and survey benthic habitats, biodiversity, and species associations at four sites considered as having a high conservation interest: the American Bank area of interest (AOI), the Cape Breton Trough region, and areas with high concentrations of corals and sponges in the Laurentian Channel. Benthic imagery (videos and photos) and sampling were used to achieve this goal using the remotely operated vehicle (ROV) ROPOS, which stands for Remotely Operated Platform for Ocean Science. The specific objectives were:

1. Collect videos and photos of the seabed to describe the biodiversity and density of organisms from epibenthic communities;
2. Explore significant benthic areas for sea pens and sponges (Kenchington et al. 2016) of the Laurentian Channel (north and south) to describe species composition, density, and associated fauna from high-resolution videos along transects;
3. Collect water and sediment samples to gather biogeochemical information on benthic habitats;
4. Collect high-resolution still images for photographic records and communication products;
5. Collect sponge samples for classical and molecular (genetic analysis) identification;
6. Collect sea pen and sediment samples for stable isotope analysis to investigate spatial variations in sea pen trophic level and in their primary carbon source(s) (pelagic–benthic coupling).

A secondary objective of the mission was to produce videos promoting ocean science, conservation, and the technology used. Videos were intended to inform the public about the scientific activities aboard the vessel and to allow them to discover the benthic habitats of the Gulf of St. Lawrence. This goal was achieved through a partnership between Oceana Canada, a non-profit international organization promoting the oceans' protection, and Fisheries and Oceans Canada (DFO). The Contribution Agreement included:

1. Livestream video of the ROPOS dives on the internet;
2. Interactions with the public on social media;
3. Promotion of the mission on the Oceana Canada and DFO websites;
4. Production of a documentary and other video products for general audiences;
5. Supporting habitat protection and providing evidence of habitat use by benthic and pelagic at-risk species through data and images.

2. VESSEL AND SAMPLING EQUIPMENT

2.1 CCGS *MARTHA L. BLACK*

This one-week expedition took place on the Canadian Coast Guard Ship (CCGS) *Martha L. Black* (MLB) from 23 to 30 August 2017 (Figure 1). The original departure date was 9 July 2017 on the CCGS *Hudson*, but due to delays in maintenance, the vessel was not available. The CCGS MLB is based out of DFO's Québec Region and is primarily a buoy-tending vessel (total length 83 m) that can perform light ice-breaking duties in the Estuary and Gulf of St. Lawrence

(<http://marinfo.gc.ca/fr/Flotte/MarthaBlack.asp>). Twenty berths were allocated to participants of this mission.



Figure 1. CCGS Martha L. Black with the ROPOS equipment on board, August 2017. Photo credit: Neil Ever Osborne, ©Oceana Canada.

2.2 ROPOS EQUIPMENT

The main sampling platform for this mission was the remotely operated vehicle known as ROPOS (Figure 2a–d), which is owned and operated by the not-for-profit Canadian Scientific Submersible Facility (www.ropos.com). The ROPOS was configured to operate at 1,000 m depth. Due to interference with the crane on the CCGS *MLB*, the ROPOS Launch and Recovery System could not be installed on the vessel, limiting operations to good weather conditions (< 20 kt winds and sea state < 2 m).

The ROPOS is equipped with high-tech imaging systems that include two high-definition cameras, a high-sensitivity full-frame 12.1 megapixel digital still camera and over 3,700 watts of far-reaching lighting (Figure 2a). Once at the surface, all video and images are geo-referenced and recorded in a digital format that can easily be used for detailed image analyses. The two video cameras are the Zeus, which is forward facing, and the mini-Zeus, which is downward facing. When the ROPOS is deployed on the bottom, it can be in either 1) “transect mode,” a constant low speed (0.3–0.5 kt) following a straight transect line, or 2) “explorer mode,” a faster speed (0.6–0.7 kt) for opportunistic sampling.

The ROPOS was equipped for this expedition with different tools to collect various samples (Figure 2a–d). Two robotic manipulators (or robot arms) that have the dexterity and accuracy necessary to perform fine movements collected larger organisms and placed them in divided bio-boxes fixed on the platform. Hydraulically controlled lids kept samples safely stowed in the bio-box during each dive. The suction sampler, with eight plastic collecting jars (2L each), was used to sample small sea pens. Five core tubes (push-cores) were used to collect sediment samples, and four Niskin bottles (5L each; not shown) were used to collect water samples at specific depths. A CTD (not shown) recorded temperature, salinity, and dissolved oxygen.



Figure 2. ROPOS sampling equipment: a) front view, with cameras, lights, robotic arms, b) bio-box, c) suction sampler jars, d) core tubes. Photo credit: Mireille Chiasson, DFO.

3. CRUISE PARTICIPANTS

Seven scientists, biologists, and technicians from three DFO regions (Gulf, Québec, and Maritimes) worked collaboratively with Oceana Canada and ROPOS operators on board the CCGS *MLB* (Table 1). The chief scientist for this mission was Geneviève Faille, DFO biologist for Marine Protected Areas (Québec Region), based at Maurice Lamontagne Institute (MLI).

A second vessel, the *Leaway Odyssey*, followed the CCGS *MLB* during the mission and had onboard a team associated with Oceana Canada and one DFO biologist (Table 2). Boarding of passengers from one vessel to the other occurred at sea on 26 and 28 August during daylight hours. Transshipment was carried out using the *Leaway Odyssey's* rigid inflatable boat and the CCGS *MLB's* rescue boat.

Table 1. Cruise participants, affiliation, and primary role on the mission.

Name	Affiliation	Role
1. Benjamin, Robert	DFO-MAR (Science)	GIS-Data Management
2. Chiasson, Mireille	DFO-GULF (Oceans)	Communication / logger / lab
3. Méthé, Denise	DFO-GULF (Science)	Logger / lab / hot seat
4. Thériault, Marie-Hélène	DFO-GULF (Oceans)	Logger / lab
5. Roy, Virginie	DFO-QUÉBEC (Science)	Benthic specialist / hot seat / lab
6. Faille, Geneviève	DFO-QUÉBEC (Science)	Chief Scientist
7. Thorne, Marilyn	DFO-QUÉBEC (Science)	Benthic specialist / hot seat / lab
8. Cousteau, Alexandra	Oceana Canada	Media
9. Rangeley, Robert	Oceana Canada	Science Director
10. Whyte, Jennifer	Oceana Canada	Media-Communication
11. Leader, Allan	Oceana Canada	Film crew
12. Stevensen, Mark	Oceana Canada	Film crew
13. Morgan, Ray	ROPOS	ROPOS operation
14. Tamburri, Keith	ROPOS	ROPOS operation
15. Lee, Jonathan	ROPOS	ROPOS operation
16. Milne, Peter	ROPOS	ROPOS operation
17. Brake, Barry	ROPOS	ROPOS operation
18. Lockhart, Peter	ROPOS	ROPOS operation
19. Hannaford, Michael	ROPOS	ROPOS operation
20. Girard, Luke	ROPOS	ROPOS operation

Table 2. Cruise participants that came on board the CCGS Martha L. Black during at-sea boarding.

Name	Affiliation	Date on board the CCGS <i>MLB</i>
1. Mélançon, Josiane	DFO-Québec (Oceans)	26, 28 August
2. Vance, Alexandra	Oceana Canada	26 August
3. Osborne, Neil	Oceana Canada - Photo crew	26 August
4. Oliver, Daren	Oceana Canada - Film crew	26 August
5. Worm, Boris	Ocean School	26, 28 August
6. Hurley, Isabelle	Ocean School	26, 28 August
7. Mills, Jacquelyn	National Film Board	26, 28 August
8. Simpson, Scott	National Film Board	26, 28 August

4. CRUISE TRACK AND MAJOR WORK LOCATIONS

The mission (MLB2017001) departed from CCGS *MLB*'s homeport in Québec City, Québec (Canada) at approximately 13:30 on 23 August. The vessel proceeded to the first work location (29 h sail time). Four work locations (sites) were planned: 1) Laurentian Channel north, 2) American Bank, 3) Cape Breton Trough, and 4) Laurentian Channel south; sampling was conducted at multiple stations at each work location. The travel times and operation hours at each of the work locations and the overall cruise track are presented in Table 3 and Figure 3, respectively. The mission ended on 30 August at approximately 07:00 in Sydney, Nova Scotia, at the Provincial Energy Ventures Terminal.

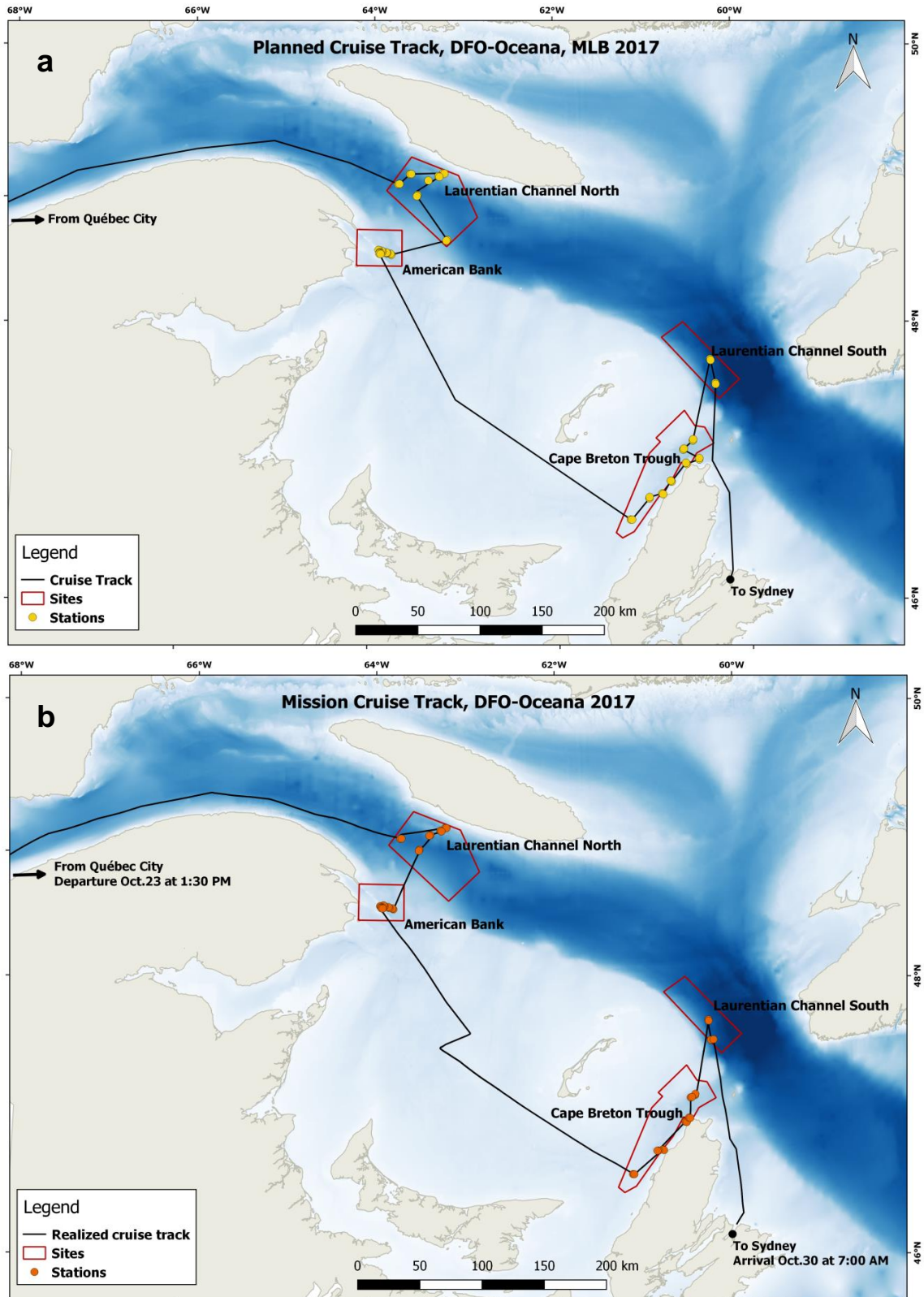


Figure 3. a) Planned and b) completed work locations (sites; red polygons), stations (yellow/orange circles), and cruise tracks (black lines) for the MLB2017001 mission.

Table 3. Mission itinerary with detailed information for each station.

Station	Date and start time (GMT)	ROV activity type	Depth (m)	Comment
Departure from Qc	2017-08-23 17:35			
Laurentian Channel North				
LCN_SP1B_1	2017-08-25 00:48	transect	377	
LCN_SP1B_2		cancel		Cancelled to catch up time, problem with the winch and crane
LCN_SPNG2_1	2017-08-25 10:09	transect	222	
LCN_SPNG2_explo*	2017-08-25 12:15	transit	216	ROPOS stayed in water through transit to next station
LCN_SPNG2_2	2017-08-25 16:11	transect	243	
LCN_SPNGalt	2017-08-25 21:44	transect	311	New station added from the planning
LCN_SP_1		cancel		Cancelled due to bad weather, too much wind > 25 kn, operation delayed for approx. 5 h
LCN_SP_2	2017-08-26 07:50	transect	381	
LCN_SP3B_1		cancel		Cancelled to catch up time
Transit to next site	2017-08-26 10:50			
American Bank				
AB_PH2	2017-08-26 16:55	transect	147	Delayed for dayboarder to embark. Aborted 200 m before the end due to bad weather. Operation delayed for approx. 3 h
AB_AV38	2017-08-26 23:07	transect	153	
AB_transit_AV38_180*	2017-08-27 00:41	transit	149	ROPOS stayed in water through transit to next station
AB_180	2017-08-27 03:02	transect	183	
AB_transit_180_AB2*	2017-08-27 04:19	transit	102	ROPOS stayed in water through transit to next station
AB_AB2	2017-08-27 06:16	transect	165	
AB_transit_AB2_AB1*	2017-08-27 08:42	transit	38	ROPOS stayed in water through transit to next station
AB_AB1	2017-08-27 09:16	transect	157	
AB_transit_AB1_AB3*	2017-08-27 11:47	transit	50	ROPOS stayed in water through transit to next station
AB_AB3	2017-08-27 12:37	transect	33	
Transit to next site	2017-08-27 15:00			Delayed approx. for 5 h for a rescue call
Cape Breton Trough				
CBT_09	2017-08-28 11:12	transect	81	Delayed for dayboarder to embark
CBT_08		cancel		Cancelled to catch up time
CBT_07_V	2017-08-28 16:43	transect	98	
CBT_05	2017-08-28 22:27	transect	142	
CBT_transit_05_04*	2017-08-29 00:00	transit	107	ROPOS stayed in water through transit to next station
CBT_04_V	2017-08-29 03:17	transect	137	
CBT01_V		cancel		Cancelled to catch up time

Station	Date and start time (GMT)	ROV activity type	Depth (m)	Comment
CBT03	2017-08-29 07:51	transect	165	ROPOS stayed in water through transit to next station
<i>CBT_transit_03_02*</i>	2017-08-29 09:35	transit	164	
CBT02	2017-08-29 12:07	transect	155	
Transit to next site	2017-08-29 14:15			
Laurentian Channel South				
LCS_SP_Slope_3	2017-08-29 17:54	transect	446	
LCS_SP_Slope_4	2017-08-29 23:40	transect	411	
Arrival in Sydney	2017-08-30 11:00			

* These are not “true” stations, but while the ROPOS stayed on bottom through transit between two neighbouring stations, video footage was also collected and could be used for qualitative analyses.

5. SUMMARY OF ACTIVITIES

During the one-week mission, a total of 19 stations were explored at the four sites (Table 4). The term “station” refers to one video transect and the associated sampling using various ROPOS tools that occurred at the start, during, or at the end of it. Moreover, seven “transit videos” were done while the ROPOS stayed on bottom to move between stations and continued to film in explorer mode.

In summary, the CCGS *MLB* was at sea for 162 h; scientific activities occurred for nearly half the time (78 h) while the other half was transit (69 h) or delays (15 h). Unforeseen delays were mainly due to bad weather (winds over 20 kt). A search and rescue call was also made on 27 August, so the CCGS *MLB* deviated from its track for approximately 6 h to tow a fishing vessel between New Brunswick and the Îles-de-la-Madeleine (QC). While sampling occurred on all four sites, unforeseen delays led to cancellation of three stations in the Laurentian Channel North site and two stations in the Cape Breton Trough (Table 3).

Table 4. Summary of activities for the four sites.

Sites	Station (n)	Total time (h)	Activity (h)	Transit (h)	Delayed (h)	Total video (h)	Transect video (h)
Transit from Québec		29		29			
Laurentian Channel North	5	36	26	4	6	12	8
Transit to next site		4		4			
American Bank	6	24	20	2	3	15	9
Transit to next site		19		13	6		
Cape Breton Trough	6	28	23	5		15	9
Transit to next site		3		3			
Laurentian Channel South	2	10	9	1		5	4.5
Transit to Sydney		8		8			
TOTAL	19	162	78	69	15	46	31

At each station, a predetermined 1 km transect was carried out. For all transects combined, 31 h of video footage were taken (Table 4). These videos will be analyzed in future steps using specific protocols to acquire quantitative data. Video footage (15 h) was also taken during some transits (explorer mode) between stations when the ROPOS stayed in water. High-resolution still images were collected to have photographic records for identification and promotional purposes. During some transects, video footage was also taken using a 360° camera (GoPro™) deployed from the ROPOS for the Oceans School program.

To complement the video data, samples were also collected. More than 50 specimens including sea pens ($n=17$), sponges ($n=33$), and other organisms ($n=8$) were sampled with the ROPOS and processed in the portable laboratory on the CCGS *MLB*. Sea pens and sponges were preserved in either 95% ethanol or 4% buffered formaldehyde, or were frozen (-80°C). All samples were brought to MLI for further processing (e.g., stable isotope analysis) and/or shipped to the University of Bergen (c/o Dr. Joana R. Xavier) for identification (sponges only). Some specimens will be incorporated into the MLI reference collection or used for the DFO Gulf Region Atlantic Science Enterprise Center. Thirty-three sediment core tube samples were taken with the ROPOS and frozen for granulometry ($n=17$), pigments ($n=33$), and stable isotope ($n=33$) analyses. When appropriate, sediment samples were collected near sea pen samples. The paired sediment – sea pen samples will be processed for stable isotope analysis and used later for pelagic–benthic coupling interpretation.

Thirty water samples were collected using Niskin bottles to be later processed for pH and alkalinity measurements at MLI. Fixed depths were determined for water samples: on bottom, 25 m below the surface, and 1 m below the surface. During all the dives (ascent and descent included), the ROPOS CTD measured temperature, salinity, and dissolved oxygen. Unfortunately, the dissolved oxygen data cannot be used because of a calibration problem.

Concurrently, social media activities were being carried out by the Oceana Canada team. Most ROPOS dives were broadcasted live via the Oceana Canada website (www.oceana.ca). During the broadcast, viewers could interact with DFO participants. Short video clips were also taken and broadcasted throughout the week with Ms. Alexandra Cousteau, Oceana Canada Senior advisor, commenting on the expedition's goals and explaining the work being done on board the CCGS *MLB*.

6. DETAILED ROPOS ACTIVITIES

6.1 LAURENTIAN CHANNEL NORTH SITE

Objectives

The general objective for the Laurentian Channel North site (LCN; Figure 4) was to gather as much information as possible on sea pens, sponges, and associated species within the areas of high species concentration. Significant benthic areas (SBA) of corals (sea pens) and sponges have been identified within the Estuary and Gulf of St. Lawrence (Kenchington et al. 2016), and two sea pen SBAs and one sponge SBA are present in the Laurentian Channel North site. These organisms are the target of a federal conservation strategy (DFO 2015) that includes conservation measures as well as the development of research projects to better characterize the biology and ecology of corals and sponges. Bottom images are inexistent or scarce for these three specific SBAs. The specific objectives were to:

1. Describe species composition and density of sea pen and sponges from high-resolution videos along transects;
2. Document associated epibenthic fauna;
3. Gather information on biogeochemical conditions in surface sediments and water samples;
4. Collect photographic records (high-resolution still images);
5. Collect sponge samples for classical and molecular identification and to enhance MLI's reference collection.

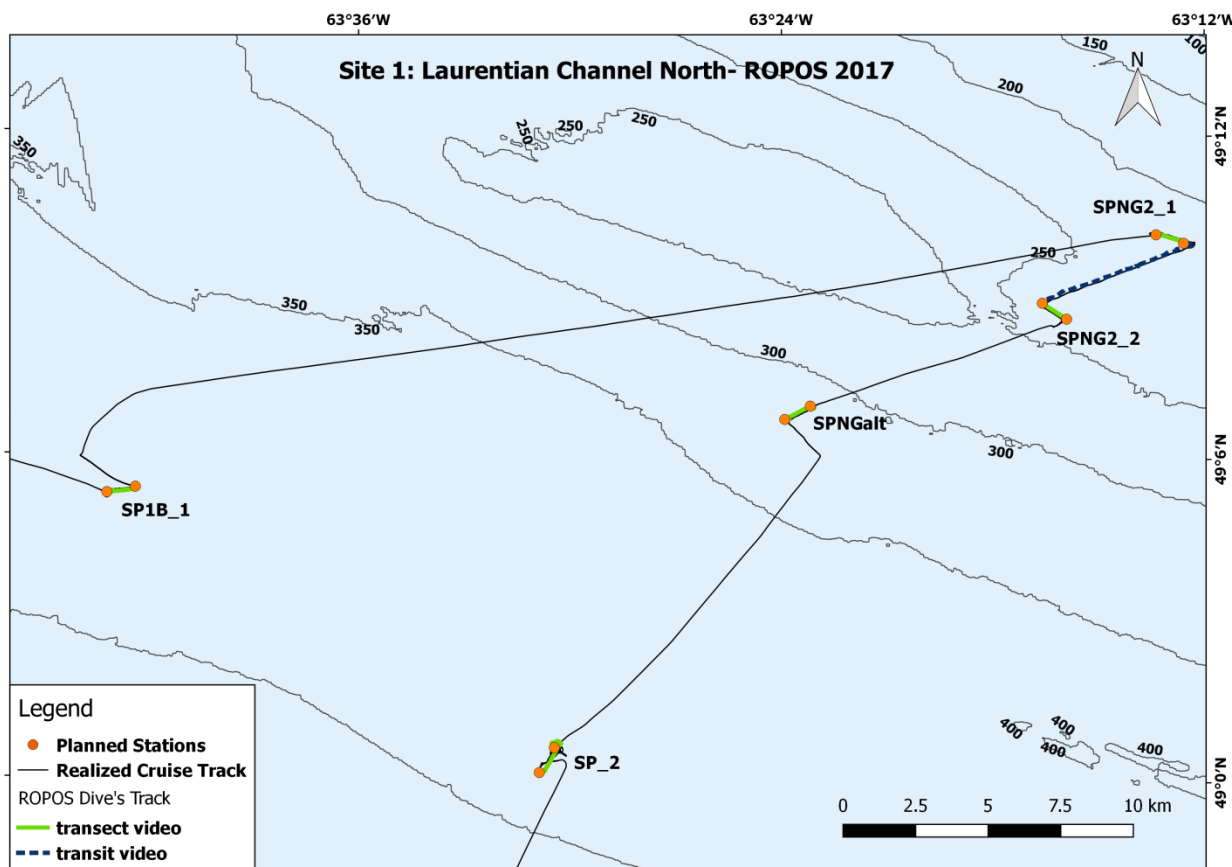


Figure 4. Stations at the Laurentian Channel North site.

Summary of activities

Four ROPOS dives allowed us to complete five stations at this site (Table 5, Figure 4). At each station, a 1 km video transect was done with the ROPOS in transect mode in the Laurentian Channel (ROV \approx 1 m above seafloor), at depths ranging between 218 m and 381 m. Two stations (LCN_SP1B_1, LCN_SP_2) were situated in sea pen fields and three stations (LCN_SPNG2_1, LCN_SPNG2_2, LCN_SPNGalt) in sponge grounds. The ROPOS stayed in explorer mode between stations LCN_SPNG2_1 and LCN_SPNG2_2, providing an additional 5 km of video footage.

Water samples were taken at three distant stations at the LCN site to provide broad-scale information on pH and alkalinity levels for the area (Table 6). Sediment samples were taken at

each station, but the number of replicates varied (2–5 core tubes). Six sponge samples were preserved for classical taxonomic purposes and genetics analysis, and 13 sea pens were collected.

Table 5. Summary of metadata associated with ROPOS dives in the Laurentian Channel North site. Position, time, and depth are from the ROPOS logging device.

ROPOS dive	Station	ROV mode	Action	Date-time (GMT)	LAT (DD)	LONG (DD)	Depth (m)
R2016	LCN_SP1B_1	transect	START transect	2017-08-25 02:13	49.0881	-63.7161	377
			END transect	2017-08-25 03:46	49.0891	-63.7030	381
R2017	LCN_SPNG2_1	transect	START transect	2017-08-25 10:37	49.1695	-63.2204	222
			END transect	2017-08-25 11:39	49.1669	-63.2072	218
	LCN_SPNG2_2	transect	START transect	2017-08-25 16:16	49.1482	-63.2761	243
			END transect	2017-08-25 18:05	49.1432	-63.2648	241
R2018	LCN_SPNGalt	transect	START transect	2017-08-25 22:11	49.1160	-63.3854	311
			END transect	2017-08-25 23:36	49.1119	-63.3975	325
R2019	LCN_SP_2	transect	START transect	2017-08-26 09:11	49.0108	-63.5028	381
			END transect	2017-08-26 10:21	49.0030	-63.5095	374

Major highlights

- High densities of the four sea pen species present in the Gulf of St. Lawrence, *Pennatula aculeata*, *P. grandis*, *Anthoptilum grandiflorum*, and *Halipteris finmarchica*, were observed.
- Juvenile redfish (*Sebastes* spp.) were present among sea pens and sponges.
- Several sponge species were found and samples are well preserved for further identification.

Table 6. Samples collected at each station of the Laurentian Channel North site.

Station	Samples collected		
	Water	Sediment	Organism
LCN_SP1B_1	4 Niskin bottles: start of transect (bottom), end of transect (bottom, 25 m and 1 m from surface)	2 core tubes: start of transect; 3 core tubes each near sea pen samples, end of transect	5 sea pens: 3 with the suction sampler and 2 in bio-boxes
LCN_SPNG2_1	None	2 core tubes: near sea pen sample, end of transect	3 sea pens with the suction sampler
LCN_SPNG2_2	4 Niskin bottles: start of transect (bottom), end of transect (bottom, 25 m and 1 m from surface)	3 core tubes: end of transect near sea pen sample	3 sponges 2 sea pens
LCN_SPNGalt	None	2 core tubes: end of transect	3 sponges 1 sea pen with the suction sampler
LCN_SP_2	3 Niskin bottles: end of transect (bottom, at 25 m and 1 m from surface)	2 core tubes: near sea pen samples, end of transect	2 sea pens with the suction sampler

6.2 AMERICAN BANK SITE

Objectives

In 2011, DFO selected the American Bank as an Area of Interest to create a Marine Protected Area (MPA) under the *Oceans Act*. This 1,000 km² area encompasses the American Bank (AB), a submarine bank (15 m to 70 m depth) lying off the eastern tip of the Gaspé Peninsula, and part of the adjacent plains (70 m to 200 m depth) (Figure 5). The goal of the proposed MPA is to foster the productivity and diversity of fishery resources associated with the American Bank and adjacent plains, and the recovery of species at risk. One of its conservation objectives is to preserve and protect benthic habitats. In recent years, extensive work with benthic imagery has been done on the bank and adjacent plains to characterize the habitat and its epibenthic fauna (Savenkoff et al. 2017). However, some parts of the AB remain unexplored, more specifically a steep 120 m cliff at the tip of the bank. The specific objectives for the AB site were to:

1. Describe the biodiversity, density, and spatial organization of benthic communities along vertical transects on the cliff (from 40 m to 160 m depth) at the southeast end of the AB and along horizontal transects in the surrounding troughs (around 180–200 m depth);
2. Obtain a continuous view of the AB crest from high-resolution videos to complement existing (but discontinuous) drop-camera and diver-based information. This transect could provide additional information on the distribution and density of benthic or demersal organisms of interest;
3. Gather additional information on physical features of AB and surrounding pockmarks (deep depressions on the seabed caused by erupting fluids) and furrows from high-resolution videos and, possibly, core sampling in troughs;

4. Collect photographic records (high-resolution still images);
5. Collect samples of rare or new organisms for classical and molecular identification and to enhance MLI's reference collection.

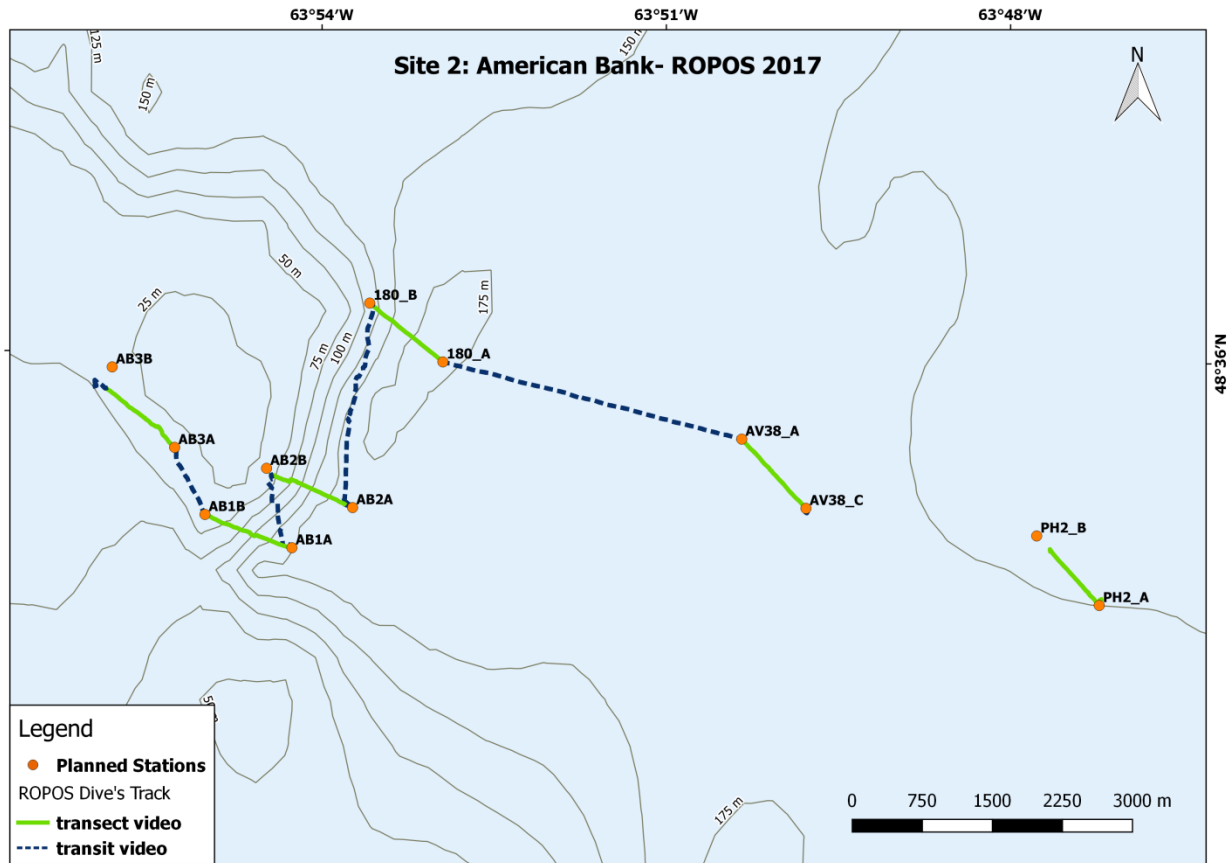


Figure 5. Stations at the American Bank site.

Summary of activities

Two ROPOS dives allowed us to complete six stations at this site (Table 7, Figure 5). At all but one station, a 1 km video transect was done with the ROPOS in transect mode; at station AB_PH2, the transect ended after 0.8 km due to bad weather conditions. The ROPOS stayed 1 m above the seafloor except when it went up the cliff, when the goal became to stay 1 m from the cliff wall. The first three stations were situated on the southeast shelf of American Bank near some pockmarks (AB_PH2), a glacial furrow (AB_AV38), and a trough (AB_180) at the bottom of the cliff. Two transects were done along the cliff with the ROPOS moving up from 165 m to 35 m of depth. The last transect was done on the crest of the bank (mean depth 30–40 m) but not directly over the top portion because it was too shallow (less than 25 m) for secure use of the ROPOS. Due to the short distance between stations, the ROPOS stayed in explorer mode between all stations, except the first one (AB_PH2), and collected video footage.

At the AB site, sampling was more limited for each station of the R2021 dive because it included five stations without surfacing and offloading the collected samples. Water samples were taken at four of the six stations at different depths and sediment samples were taken at only two

stations; some stations were too rocky for core sampling (Table 8). Eight sponge specimens were sampled, including five directly off the cliff, and two soft coral samples were collected.

Table 7. Summary of metadata associated with ROPOS dives at the American Bank site. Note that position, time, and depth are from the ROPOS logging device.

ROPOS dive	Station	ROV mode	Action	Date-time (GMT)	LAT (DD)	LONG (DD)	Depth (m)
R2020	AB_PH2	transect	START transect	2017-08-26 17:22	48.5768	-63.7864	147
			END transect	2017-08-26 18:14	48.5819	-63.7934	144
R2021	AB_AV38	transect	START transect	2017-08-26 23:23	48.5857	-63.8290	153
			END transect	2017-08-27 00:41	48.5923	-63.8384	149
	AB_180	transect	START transect	2017-08-27 03:09	48.5995	-63.8821	183
			END transect	2017-08-27 04:19	48.6049	-63.8925	102
	AB_AB2	transect	START transect	2017-08-27 06:45	48.5857	-63.8960	165
			END transect	2017-08-27 08:42	48.5882	-63.9066	35
	AB_AB1	transect	START transect	2017-08-27 09:37	48.5815	-63.9042	157
			END transect	2017-08-27 11:47	48.5844	-63.9161	51
	AB_AB3	transect	START transect	2017-08-27 12:38	48.5909	-63.9207	33
			END transect	2017-08-27 14:07	48.5972	-63.9324	43

Major highlights

- On the southeastern plain, video footage was taken of cod preying on a school of tens of thousands of capelin, providing unique images of the capelin food chain.
- A high diversity and density of colourful species were observed on the cliff wall, especially of sponges and anemones providing habitat for other fauna.
- Whole sponge specimens were collected with the ROPOS that will be used for further identification.

Table 8. Samples collected at each station of the American Bank site.

Station	Samples collected		
	Water	Sediment	Organism
AB_PH2	2 Niskin bottles: end of transect (bottom, 1 m from surface)	None	None
AB_AV38	1 Niskin bottle: end of transect (bottom)	2 core tubes: end of transect	2 sponges
AB_180	None	None	None
AB_AB2	None	None	3 sponges off cliff
AB_AB1	1 Niskin bottle: start of transect (bottom)	2 core tubes: start of transect (bottom) and off the cliff	2 sponges off cliff 2 soft corals
AB_AB3	2 Niskin bottles: end of transect (25 m and 1 m from surface)	None, too rocky	1 sponge

6.3 CAPE BRETON TROUGH SITE

Objectives

The Cape Breton Trough (CBT) site is situated within an Ecologically and Biologically Significant Area (DFO 2007). The bottom structure of western Cape Breton varies considerably from north to south. The southern part of the area is located in shallow water (<60 m) which is typical for the southern Gulf, while in the north, the CBT area also includes a deeper depression (150–200 m) (DFO 2007). The CBT is surveyed by the DFO multi-species autumn survey and the snow crab survey, but some parts are inaccessible to the trawls. Moreover, some parts of the CBT have not been accessible to divers or by other sampling means. The main goal for this site was therefore to obtain baseline information on the broad ecosystem of the CBT and gather data on a variety of different habitat types with a focus on sensitive benthic habitat (such as sponge grounds) and on habitat that is used by species at risk (such as Atlantic wolffish, *Anarhichas lupus*). The observation and localization of large gatherings of female snow crab, resulting from a podding behaviour, were also of interest. The specific objectives for the CBT site were to:

1. Describe the biodiversity and density of the benthic community and its organization on a complex structure (ledge/cliff of the trough) such as the southeast ridge adjacent to the tip of Cape Breton;
2. Provide additional information on the distribution and density of wolffish and other benthic or demersal organisms of interest;
3. Gather information on biogeochemical conditions in surface sediments and water samples.

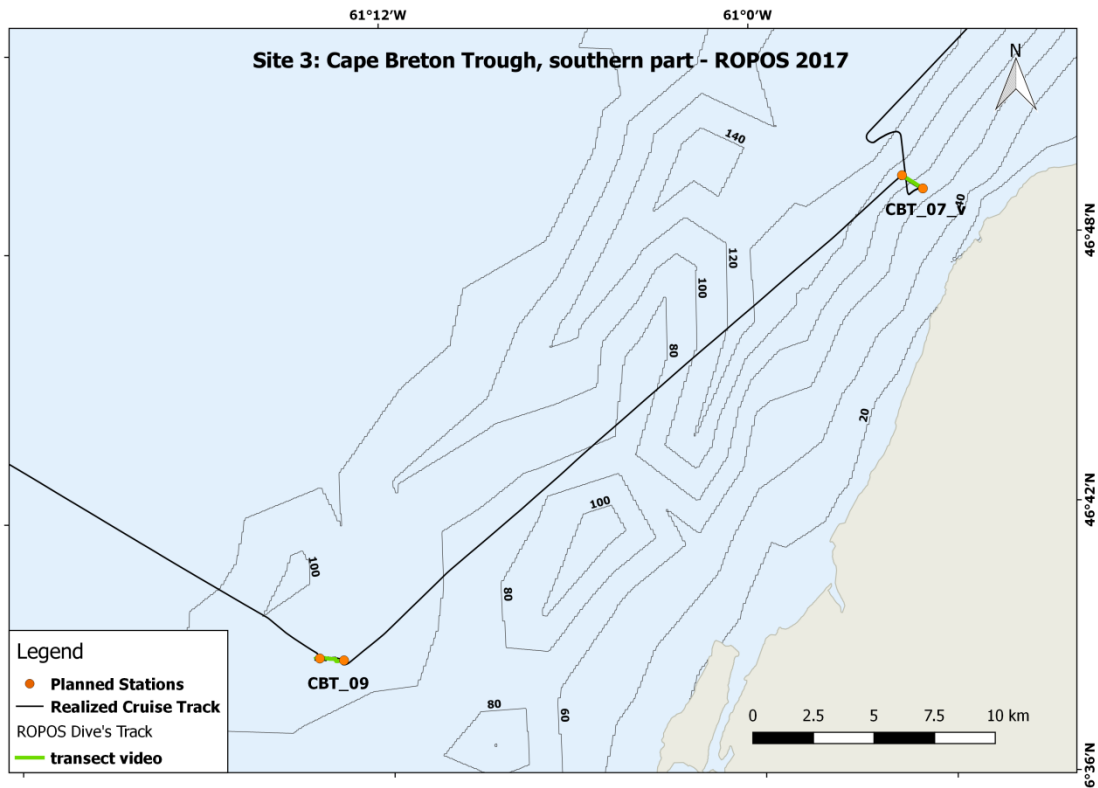


Figure 6. Stations in the southern part of the Cape Breton Trough site.

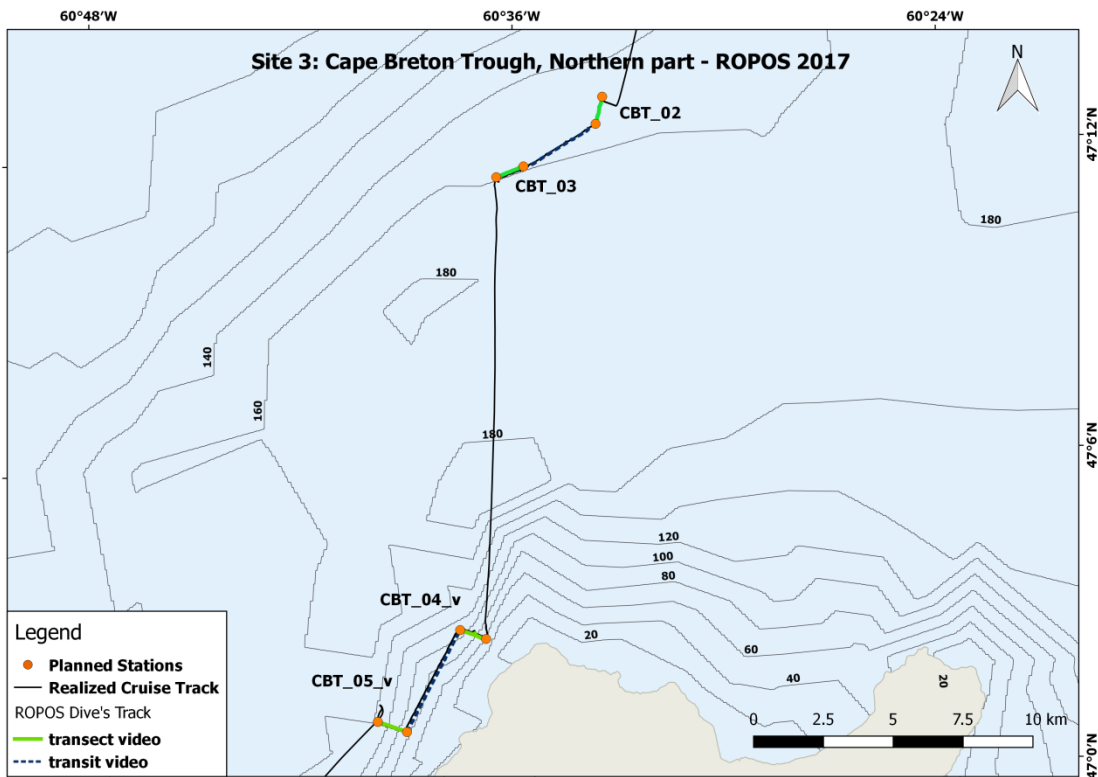


Figure 7. Stations in the northern part of the Cape Breton Trough site.

Summary of activities

Four ROPOS dives allowed us to complete six stations at the Cape Breton Trough site (Table 9, Figures 6, 7). Each transect was designed to record video over 1 km in explorer mode (1 m from the seafloor) at depths between 54 m and 165 m. Explorer mode allowed for opportunistic sampling. Stations CBT09 and CBT07v were on the shelf of the southern part of the site in fishing area nineteen, which is known for high densities of snow crab (Hébert et al. 2016) and where podding behaviour (dense cluster/aggregation of female snow crabs) might occur. Two stations (CBT05, CBT04v) located at the tip of Cape Breton had a significant slope and a more complex habitat. Finally, two stations (CBT03, CBT02) in the northern and deepest (150–180 m) part of CBT were situated in an area known to have Atlantic wolffish. The ROPOS stayed in explorer mode between some stations, which allowed for additional video footage.

Water samples were taken at three stations in the CBT site, and sediment samples were taken at all stations except one (CBT_04_v) that was too rocky (Table 10). The suction sampler and bio-boxes were used to test their suitability for snow crab sampling. Using the suction sampler, two snow crabs were sampled off the seafloor and placed in two bio-boxes. The bio-boxes successfully contained the snow crabs as the ROPOS was brought back onboard the vessel. Various other specimens were also collected: sponges, bryozoans, and soft corals (Table 10).

Table 9. Summary of metadata associated with ROPOS dives in the Cape Breton Trough site. Note that position, time, and depth are from the ROPOS logging device.

ROPOS dive	Station	ROV mode	Action	Date-time (GMT)	LAT (DD)	LONG (DD)	Depth (m)
R2022	CBT_09	explorer	START transect	2017-08-28 11:41	46.6482	-61.2403	81
			END transect	2017-08-28 13:27	46.6476	-61.2261	85
R2023	CBT_07_V	explorer	START transect	2017-08-28 16:56	46.8221	-60.9187	98
			END transect	2017-08-28 18:44	46.8170	-60.9076	70
R2024	CBT_05	explorer	START transect	2017-08-28 22:37	47.0182	-60.6730	142
			END transect	2017-08-29 00:00	47.0147	-60.6595	107
	CBT_04_V	explorer	START transect	2017-08-29 03:17	47.0470	-60.6331	137
			END transect	2017-08-29 04:54	47.0437	-60.6211	54
R2025	CBT_03	explorer	START transect	2017-08-29 08:09	47.1923	-60.6095	165
			END transect	2017-08-29 09:35	47.1952	-60.5965	164
	CBT_02	explorer	START transect	2017-08-29 12:07	47.2085	-60.5618	155
			END transect	2017-08-29 13:27	47.2171	-60.5580	148

Table 10. Samples collected at each station of the Cape Breton Trough site.

Station	Samples collected		
	Water	Sediment	Organism
CBT_09	3 Niskin bottles: end of transect (bottom, 25 m and 1 m from surface)	3 core tubes: end of transect	2 snow crabs 1 <i>Alcyonacea</i> (soft coral)
CBT_07_V	None	3 core tubes: end of transect (1 discarded)	1 sand dollar 1 shell sample
CBT_05	None	2 core tubes: end of transect	1 sponge sample
CBT_04_V	None	None, too rocky	2 samples: hydrozoan, bryozoan
CBT_03	1 Niskin bottle: end of transect (bottom)	2 core tubes: end of transect	Rocks collected with many sponge samples 1 sea pen
CBT_02	3 Niskin bottles: end of transect (bottom, 25 m and 1 m from surface)	3 core tubes: end of transect	1 sea pen with the suction sampler

Major highlights

- Many female and male snow crabs (*Chionoecetes opilio*) were observed on the soft, muddy seafloor.
- Some schools of Atlantic herring (*Clupea harengus*) were seen in the southern part of the CBT site.
- At the tip of the Cape Breton peninsula, a rocky habitat with a nearly vertical cliff covered with multiple species of anemones and sponges was observed.
- On two transects, there was potential suitable habitat for wolffish.
- Other species observed included Atlantic cod (*Gadus morhua*), redfish (*Sebastes* spp.), skates (Rajiformes), and Atlantic halibut (*Hippoglossus hippoglossus*).

6.4 LAURENTIAN CHANNEL SOUTH SITE

Objectives

The general objective for the Laurentian Channel South Site (LCS) was to gather information on sea pens and associated species in an SBA of corals (sea pens) and sponges defined by Kenchington et al. (2016). This area is known to have high densities of a very large sea pen species, *Anthoptilum grandiflorum*. Until the present expedition, bottom images were nonexistent in this SBA. Specific objectives were to:

1. Explore the SBA to describe the composition and density of sea pens from high-resolution videos along transects;

2. Document the fauna associated with the sea pens and sponges to increase our understanding of their role in supporting benthic biodiversity and productivity;
3. Gather information on biogeochemical conditions in surface sediment and water samples;
4. Collect photographic records (high-resolution still images).

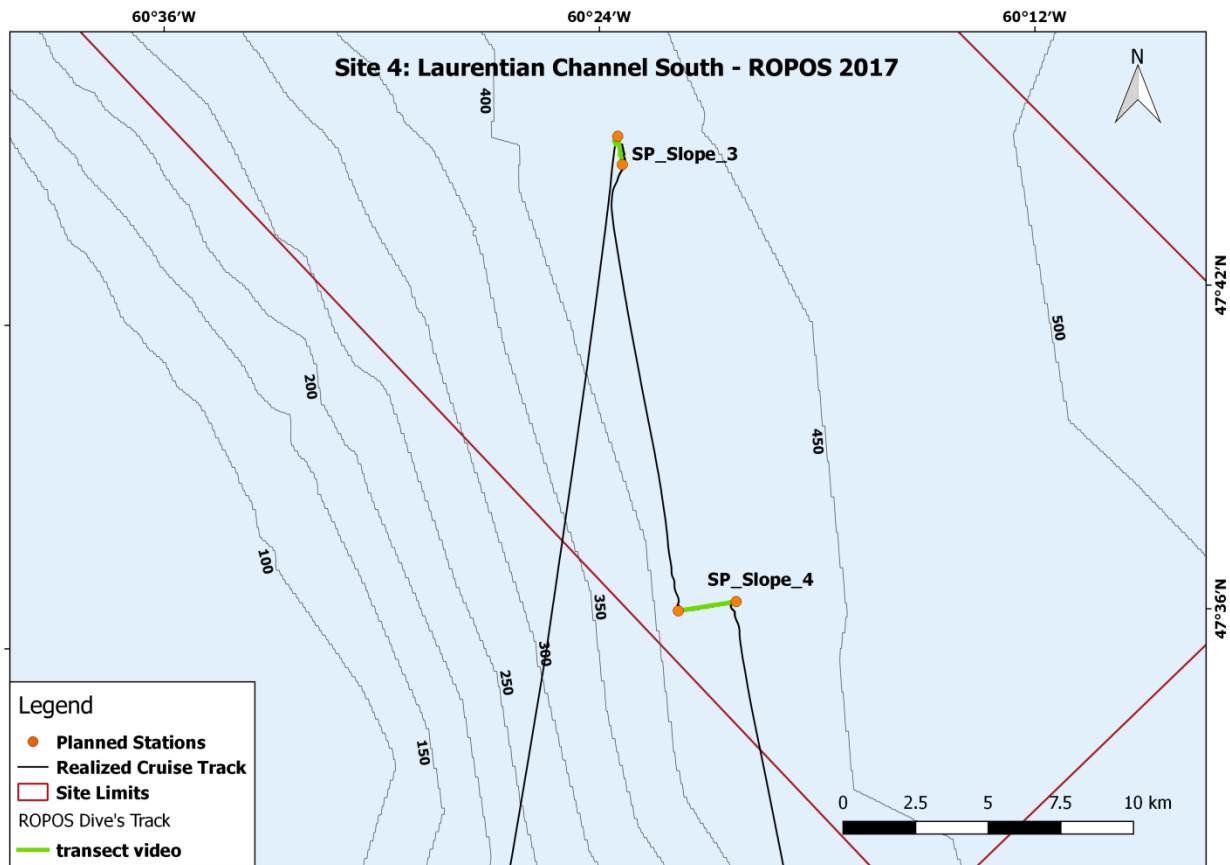


Figure 8. Stations at the Laurentian Channel South site.

Summary of activities

Two ROPOS dives, the deepest stations of the mission, were done at this site (Table 11, Figure 8). The dives were planned to record video in transect mode (1 m off the seafloor) along a 1 km transect at the first station and along a 2 km transect at the second station, at depths between 411 m and 450 m. The two stations were located in sea pen fields.

Water and sediment samples were taken at the two stations. Four samples of the large sea pen *Anthoptilum grandiflorum* and one sponge specimen were collected (Table 12).

Table 11. Summary of metadata associated with ROPOS dives in the Laurentian Channel South site. Note that position, time, and depth are from the ROPOS logging device.

ROPOS dive	Station	ROV mode	Action	Date-time (GMT)	LAT (DD)	LONG (DD)	Depth (m)
R2026	LCS_SP_Slope_3	transect	START transect	2017-08-29 18:17	47.7527	-60.3933	446
			END transect	2017-08-29 20:45	47.7437	-60.3916	450
R2027	LCS_SP_Slope_4	transect	START transect	2017-08-30 00:06	47.6052	-60.3728	411
			END transect	2017-08-30 02:20	47.6074	-60.3462	437

Table 12. Samples collected at each station of the Laurentian Channel South site.

Station	Samples collected		
	Water	Sediment	Organism
LCS_SP_Slope_3	3 Niskin bottles: end of transect (bottom, 25 m and 1 m from surface)	3 core tubes: in transect, 2 end of transect (near sea pen samples)	2 sea pens 1 sponge
LCS_SP_Slope_4	3 Niskin bottles: end of transect (bottom, 25 m and 1 m from surface)	2 core tubes: end of transect (near sea pen samples)	2 sea pens

Major highlights

- Dense fields of the sea pen *Anthoptilum grandiflorum* were observed at this site, with redfish (*Sebastes* spp.) among the sea pens.
- The sea pen *Pennatulula aculeata* was also observed, but it was less abundant than *Anthoptilum grandiflorum*.
- Other species observed included spoonarm octopus (*Bathypolypus bairdii*), spiny crab (*Lithodes maja*), witch flounder (*Glyptocephalus cynoglossus*), spinytail skate (*Bathyraja spinicauda*), marlin spike (*Nezumia bairdii*), longfin hake (*Phycis chesteri*) and a porbeagle shark (*Lamna nasus*) swimming at 100 m depth as the ROPOS was being retrieved.

7. CONCLUSION

This mission in the Gulf of St. Lawrence was globally a success. All science objectives were met and only a few amendments to the dive plans were made, mainly as a consequence of bad weather. All four study sites were adequately surveyed with multiple stations ($n=19$) even if less time was allocated to the mission because of the last-minute vessel change. High-definition videos and still images were successfully recorded and samples from all sites were collected and will be used for detailed analyses. Communications, including broad public outreach, were also a

success, with a total of 52 media events (TV, radio, print) reaching an audience of more than 11 million during the expedition.

Despite the overall success of the mission, a few recommendations can be made for future missions using an ROV such as the ROPOS.

- When the ROPOS is used without its own launch and recovery system, the mission schedule should take into account a longer period of time for launching and recovery on board of the ROV (1 h for each), especially for the first dives.
- If the main objective of video footage is quantitative data analyses of species and seabed, be sure that both cameras (Zeus and mini-Zeus) are always in the same exact orientation during all video transects.
- Each time specimen samples are collected, it would be helpful to take high-resolution still images with the ROV. That way, samples can be linked to a precise underwater image once they are processed.
- When using complementary instruments such as CTD, oxygen, and pH sensors, be sure they are properly calibrated and bring backup equipment for those already on the ROPOS.
- Daily dive plans could be made electronically accessible to both science and communications teams onboard the vessel to facilitate coordination.

There were also some lessons learned about communications. For example, the preparation of a clear communication plan before departure is essential.

- The science staff should be notified and prepared for narrating the live broadcast of the ROPOS dive videos prior to the mission.
- Walkie-talkies onboard the ship would have greatly improved communication efficiency among the science team.
- Communications contingency plans for at-sea outreach need to be prepared for the possibility of satellite connection failure (this happened during the mission). A back-up plan should use shore-based support personnel.

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