Video footage captured by fishing gear during scientific missions to characterize biodiversity and benthic habitats in coastal environments

Olivia Lacasse and Virginie Roy

Maurice Lamontagne Institute,
C.P. 1000 / P.O. Box 1000
850 De la Mer Road
Mont-Joli, QC, G5H 3Z4

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Video Footage Captured by Fishing Gear during Scientific Missions to Characterize Biodiversity and Benthic Habitats in Coastal Environments

by

Olivia Lacasse and Virginie Roy

Fisheries and Oceans Canada
Maurice Lamontagne Institute
850 De la Mer Road
Mont-Joli, QC, G5H 3Z4

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ABSTRACT

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Different camera-light systems have been attached to fishing gear as part of a research and development project to optimize the collection of information during scientific surveys on epibenthic invertebrates in the northern coastal zone of the St. Lawrence Estuary onboard the CCGS *Leim*. The fishing gear chosen corresponds to that used during the snow crab (beam trawl) and common whelk (Digby type dredge) stock assessment surveys. All the tests were carried out on the beam trawl, most of them during a research survey on coastal bentho-demersal biodiversity in summer 2019. Among the different cameras and lights tested on the beam trawl moving at a speed of two knots, the combined use of the Paralenz's Dive Camera+ in 4K 30 fps and Keldan's Video8X light at an intensity of 15,000 lumens has proven to be the best way to obtain images of superior quality, and is sufficient to allow the identification of benthic invertebrates in the recorded images. Preliminary results from the analysis of four videos revealed that several epibenthic invertebrates that would normally be collected by the gear, such as crabs and whelks, appeared to pass under the pocket of the trawl and therefore not all of them were fished. Additionally, burrowing-type species, such as the sea cucumber *Psolus phantapus*, were not collected by the trawl. The results also showed that the small organisms that are sometimes present in the catch of the trawl, such as amphipods, were not visible in the recorded images.

RÉSUMÉ

Lacasse, O. and Roy, V. 2021. Video footage captured by fishing gear during scientific missions to characterize biodiversity and benthic habitats in coastal environments Can. Manuscr. Rep. Fish. Aquat. Sci. 3220: v + 40 p.

Différents systèmes caméras-lampes ont été fixés sur des engins de pêche dans le cadre d'un projet de recherche et développement pour optimiser la collecte d'informations lors de missions scientifiques sur les invertébrés épibenthiques dans la zone côtière du nord de l'estuaire maritime du Saint-Laurent à bord du NGCC *Leim*. Les engins de pêche choisis correspondent à ceux utilisés lors des missions d'évaluation de stock du crabe des neiges (chalut à perche) et du buccin commun (drague de type Digby). Des tests préliminaires en mer ont été réalisés sur le chalut à perche à l'été 2019, en majorité lors d'une mission de recherche sur la biodiversité bentho-démersale côtière. Parmi les différentes caméras et lampes testées sur le chalut à perche se déplaçant à une vitesse de deux nœuds, l'utilisation combinée de la caméra Dive Camera$^+$ en 4K 30 ips de Paralenz et la lampe Video8X de Keldan à une intensité de 15 000 lumens s'est avérée le meilleur moyen d'obtenir des images de qualité supérieure et suffisante pour permettre l'identification des invertébrés épibenthiques sur les images enregistrées. L'analyse préliminaire de quatre vidéos a révéléque plusieurs invertébrés épibenthiques qui devraient normalement être collectés par l'engin, tels que les crabes et les buccins, semblent passer sous la poche du chalut et ne seraient donc pas tous pêchés. De plus, des espèces de type fouisseur, comme le concombre de mer *Psolus phantapus*, n'étaient pas collectées par l'engin. Les résultats ont également démontré que les organismes de petite taille qui sont parfois présents dans la prise du chalut, comme les amphipodes, ne sont pas visibles sur les images enregistrées.

1. INTRODUCTION

The subtidal coastal zone (10–50 m) of the St. Lawrence Estuary is a productive ecosystem where many benthic invertebrate species (e.g. crustaceans, echinoderms, mollusks) are fished commercially. Scientists at Fisheries and Oceans Canada (DFO) conduct scientific surveys in this area on a recurrent basis as part of stock assessments (Chabot et al. 2007). The objective of these assessments is to obtain information regarding the health of commercial stocks in order to properly manage these resources. The main objectives of these surveys generally target commercial species and limited time is devoted to the identification of bycatch caught by fishing gear (e.g. benthic invertebrates and small demersal fish) and to the collection of environmental data. In addition, images of the seabed taken during a set are necessary to extract certain ecological information from the vessel's total catch. This information includes the spatial organization of the species on the seabed (e.g., homogeneous distribution on the seabed compared with heterogeneous in groups). Furthermore, it is impossible to confirm the efficiency of the fishing gear without these images as confirmation. The objective of this project is to fill in some of these information gaps, while respecting the time constraints for this type of activity during scientific surveys on the stocks. This objective will be realized through the research and development of a versatile and light-weight video imaging system (with cameras and lights) that can be installed directly on the fishing gear and whose image analysis results can be generated after the mission at sea.

The use of underwater cameras during fishing activities seems to have emerged in the late 2000s (PCC 2008). The system developed at the time was autonomous and included a battery-powered camera and light in waterproof boxes, which were attached to the net inside the fishing trawl (PCC 2008). Today, there are a wide variety of trawl camera systems such as OCEAN-CAM's Poly-Solid, Williamson & Associates's SOLO Series III camera or Vonin's Colour Camera Unit (OCEAN-CAM 2020, Williamson & Associates 2020, Vonin 2020). Most of these cameras are wireless systems. However, some, such as the SeaTrex HD, are connected to the surface by a coaxial cable that allows a live display to be transmitted (Ocean Systems 2020). Each system has advantages and disadvantages that may vary depending on the user and the needs, but all are designed to see into the trawl to assess its fishing capacity and selectivity of the desired catch (i.e., reduce bycatch). These systems have, for the most part, been developed by and for the commercial fishing industry and are designed to be easily attached to a trawl net. In order to find the most suitable all-in-one autonomous camera-light system suitable for the fishing gear used during the stock assessment scientific survey of commercial invertebrates in costal environment, a search for the latest camera and underwater light technology was conducted. Only the cameras and lights tested within this project are presented here. The specific characteristics sought include low maintenance, ease of use, robust shock resistance, light weight, dimensions adapted to the fishing gear, long battery life, large storage capacity, excellent resolution, etc. In addition, note that the system selected must require as little effort as possible on the part of the scientific team at sea and the least amount of downtime during the sampling days.

This project was conducted as part of the DFO's Coastal Environmental Baseline Program for the Quebec region, an initiative of the National Oceans Protection Plan (OPP). The national objective of this program is to establish a baseline of six Canadian coastal marine ecosystems (DFO 2020). For the Quebec region, the study area of the program includes the north shore of the St. Lawrence Estuary from 2017 to 2022. Therefore, the project falls under this program by demonstrating the potential to acquire additional data on biodiversity and benthic habitats in the coastal environment using video footage taken during stock assessment missions of commercial epibenthic invertebrates in the estuary. In addition, the scope of the project can extend to other DFO sectors, such as Fisheries Management, to help achieve ecosystem objectives for fisheries resource management (DFO 2007a) and Integrated Oceans Management to help identify species and attributes of ecologically significant communities or ecologically and biologically significant areas (DFO 2007b).

This report is built around the three main phases of the project: 1) researching a versatile, lightweight, underwater camera-light system, 2) developing and installing the system on a beam trawl and a Digby dredge, and 3) conducting at-sea trials on a beam trawl.

2. MATERIALS AND METHODS

2.1. FISHING GEAR USED

The fishing gear chosen for this research and development project on camera-light systems corresponds to that used during snow crab and common whelk stock assessment scientific surveys in the estuary. When a vessel is performing trawling or dredging maneuvers, the speed of the vessel, and therefore that of the gear on the seabed, reaches approximately two knots. The speed will have a significant influence on the maximum quality of the images obtained from cameras installed on the gear.

2.1.1. Beam trawl

The beam trawl is a rigid frame trawl consisting of a pole connected at the top by two trawl shoes (2.8 m wide and 0.9 m high). On the lower portion of the gear, three tickler chains are stretched across the base of the trawl heads. A cod end with a lifting strap is attached to the beam and the trawl heads are attached to a supporting bar towed by a towing line connected to the vessel's trawl warp (Figure 1a). Beam trawls are used during snow crab stock assessment surveys (Lambert and Dallaire 2016).

2.1.2. Digby dredge

The Digby dredge is a type of fishing gear with four baskets. Each basket has a steel rectangular frame with teeth at its top and bottom openings. Each basket is made of a mesh of iron rings connected by rubber washers. This mesh is installed behind the basket. The baskets are held together by drag bars located at the front and back of the baskets and connected by chains (Figure 1b). The Digby dredge is used on common whelk stock assessment surveys (Brulotte 2019). The common whelk stock evaluation survey was scaled back over time and the planned camera-light tests on the Digby dredge could not be completed.

a)  b) 

Figure 1. a) Launching a beam trawl from the stern deck of the *CCGS Leim* and b) Digby dredge.

2.2. CAMERAS AND LIGHTS CONSIDERED

2.2.1. The GoPro HERO6 Camera

The GoPro HERO6 camera is small with good image quality (Figure 2a). It can shoot in 4K, 60 frames per second (4K 60 fps) and offers image stabilization. It is waterproof to a depth of 10 m and can be submerged down to 60 m in the GoPro waterproof case, sold separately (Table 1). Because of its small size and low cost, this type of camera is often used for various field projects. However, this camera was not selected for this project because of the constraints related to shock resistance and shallow waterproofing depth (without an additional case). Although other companies (e.g. GroupBinc, CamDo) manufacture other GoPro camera cases, this model was not chosen because it did not meet certain criteria, including prioritizing fast and less frequent operating.

2.2.2. The OCEAN-CAM Poly-Solid camera and light system

OCEAN-CAM's Poly-Solid camera-light system was created by and for fishermen (Figure 2b). It has an anodized aluminum base and can be used to a maximum depth of 1,000 m. The system is equipped with a Sony FDX action camera and a 4,500-lumen light source. The camera-light system is operated by magnetic controls (Table 1).

2.2.3. The Paralenz Dive Camera+

The Paralenz Dive Camera+ was created by and for divers (Figure 2c). Like most action cameras, video recording on the Dive Camera+ is continuous and videos are saved in 10-minute files to avoid complete loss of data if a file becomes corrupted. The Dive Camera+ is waterproof up to 250 m without additional housing. This camera also automatically records the water temperature and depth every second (CSV file format). This information can be recorded in the video and transferred along with the video to a computer. The video and the dive profile can also be displayed in the Paralenz application. The battery insulation inside the camera allows for recording in 4K 30 fps for 120 minutes (Paralenz 2020). However, tank tests, which involved continuous 4K 30 fps recording in water temperatures around 1°C, showed that the battery life decreased to 80 minutes (Table 1). In addition, the Dive Camera+ can be pre-programmed to start and stop recording video at a specified depth (either 0.3 m, 0.9 m or 1.5 m) and this feature can be disabled. For the purpose of this project, the cameras were programmed to start recording at 1.5 m with video recording in 4K 30 fps format. The option to start recording when the camera reaches 1.5 m in depth allows the size of the recorded videos to be reduced. This option is practical since, occasionally during the sampling mentioned above, a significant amount of time (e.g. 5 to 20 minutes) may elapse between when the gear leaves the deck of the vessel and when it is lowered to the seabed to start fishing (e.g. when the vessel is repositioned on the water).

Figure 2. a) the GoPro HERO6, b) the Poly-Solid OCEAN-CAM, and c) the Paralenz Dive Camera+.

Table 1. Comparison of the main characteristics of the HERO 6 (SpotMyDive 2017), Dive Camera+ (SpotMyDive 2017) and Poly-Solid (OCEAN-CAM 2020). N/A: Information not available; mAh: milliampere hour.

Characteristics	HERO 6	Poly-Solid	Dive Camera+
Maximum video resolution	1080p 240 fps/ 2.7K 120 fps/ 4K 60 fps	Full high definition: 1,920 x 1,080 pixels (1080p) 30 fps	720p 200 fps/ 1080p 100 fps/ 2K 60 fps/ 4k 30 fps
White balance	Automatic colour correction or light source correction	Colour filters or light source required	Automatic colour or light source correction
Integrated light source	No	Yes, 4,500-lumen LED	No
Materials	N/A	Anodized aluminum	Aluminum, polycarbonate
Shock resistance	N/A	Yes	Yes
Watertight case	Yes	Yes	Yes
Fogging	Possible when in the GoPro case	No	No
Waterproof	10 m (60 m with the additional GoPro case)	1,000 m	250 m
Charging capacity	1,220 mAh	20,100 mAh	1,600 mAh
Battery life example	1 h of recording in 4K	+20 h for recording in 1080p	+2 or 3 h for recording in 4K or 1080p respectively
Temperature rating	-5°C to 50°C	N/A	-10°C to 85°C
Mobile application	Yes	Yes	Yes
Use with gloves	Hard	Easy	Easy
Dimensions	62 x 45.4 x 33 mm	N/A	116 x 35 x 38 mm
Weight	117 g	N/A	155 g

2.2.4. The BigBlue VL7200 light

BigBlue's lights can reach a maximum depth of 100 m. They offer three intensity settings in a cool white setting (6500K) and three intensity settings for warm white (5500K). The colour rendering index (CRI) for this light is 75 (information gathered through personal communication with the company). For this project, cool white was used because it is the first setting available when the light is turned on. At the time this report is being written, this model has been discontinued and replaced with a light that produces 8,000 lumens (BigBlue Dive Lights 2020). The latter was not tested for this project. Two 7,200-lumen lights (total 14,400 lumens) were used with a Dive Camera+.

2.2.5. The Keldan Video8X light

Keldan's lights can operate to a maximum depth of 200 m. They offer one white setting (5600K) and can be used at nine different intensity levels, ranging from 240 to 15,000 lumens. The CRI for the Video8X 15,000 lumen lights is 82 (Keldan 2017). A Video8X 15,000 lumen light was used with a Dive Camera+. Since the battery, when the light illuminates at 15,000 lumens, allows for approximately 30 minutes of battery life (may vary slightly depending on water temperature), this light was used for only two stations of 15 min each per day (randomly selected stations).

2.3. MOUNTS FOR CAMERAS AND LIGHTS

The width of the beam trawl requires a minimum of two camera-light systems in order to obtain sufficient video coverage to see the entire surface of the bottom between the two trawl heads in a resolution that is high enough for the organisms observed to be identified.

2.3.1. Aluminum mounts for the Poly-Solid cameras

The Poly-Solid cameras were installed on aluminum mounts designed by Michel Rousseau, a technician at the DFO's Maurice Lamontagne Institute (MLI) in Mont-Joli, Quebec, and manufactured by Usifab Enr in Mont-Joli, Quebec. The mounts (dimensions 18 x 27 cm) allow the angle of the cameras to be changed in order to cover the entire area trawled. The cameras were positioned on either side of the beam, directed towards the front of the trawl and arranged so that their weight was evenly distributed in order to reduce as much as possible the effects of the additional weight on the performance of the fishing gear (Figure 3).

Figure 3. Aluminum mounts for Poly-Solid cameras (extreme left and right): a) mounts without cameras, b) mounts with cameras.

2.3.2. Polyethylene (UHMW) mounts for the Dive Camera+ and BigBlue and Keldan lights

In order to attach the Dive Camera+ and the various lights to the fishing gear, it was necessary to build two different mounts, one for each set of fishing gear. The mounts for the beam trawl and Digby dredge tests were designed by René Thériault, a deckhand on the CCGS *Leim*, and Olivia Lacasse, an aquatic biologist at the MLI, and then manufactured by Usifab Enr (Mont-Joli, Qc). Both types of mounts were constructed from ¾-in. (1.9 cm) thick plates of ultra high molecular weight (UHMW) polyethylene. The devices are attached to the plates with brackets (the AX SUB® Advanced Head Bracket System model, Rimouski, Qc), which allow the cameras and lights to be quickly changed without needing to remove the mount from the fishing gear.

The beam trawl mounts (3 x 9 in. or 7.62 x 22.86 cm) are attached with cable ties to the top of the diagonal post located inside each of the trawl heads. The cable ties fit into grooves (1/4 x 3/16 in. or 0.64 x 0.48 cm) located at either end of the mount's plate (Figure 4a and b). Other types of stronger, permanent fasteners (e.g., metal brackets) could also be used. Each plate is designed to hold one or two lights and a camera pointing towards the front of the trawl, at a 45° angle in relation to the trawl's orientation. In addition, a safety line attaches the devices to the inside of the trawl with a carabiner so that the cameras and lights can be retrieved if the cable ties break.

a) b)

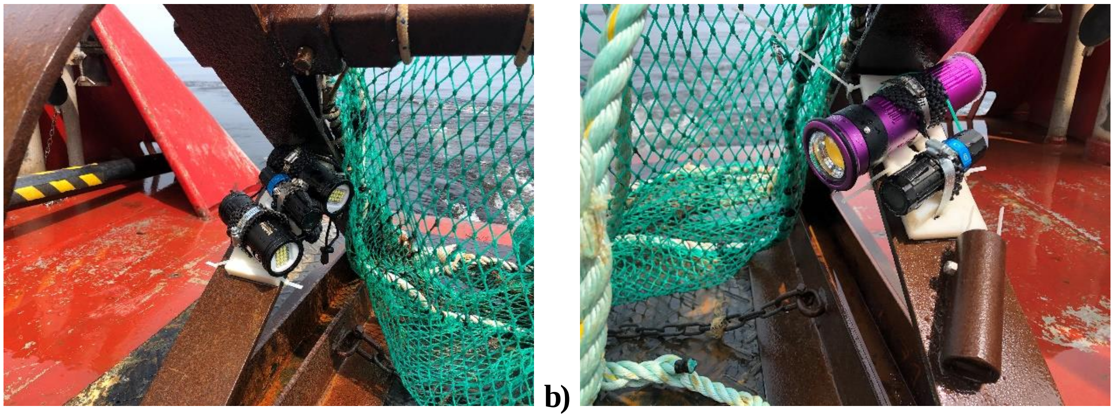


Figure 4. Prototypes of the Dive Camera+ UHMW camera mount with a) two BigBlue VL7200 lights and b) a Keldan Video8X light for the beam trawl.

The camera-light mount for the Digby dredge is designed with two overlapping UHMW plates (7 x 11 x 14 in. or 17.78 x 27.94 x 35.56 cm) and connected by four metal rods (figures 5a and b). One (Figure 5a) or two (figures 5d and f) Dive Camera+ cameras and two Video8X lights can be attached to the mount. The mount is equipped with four rings and four carabiners to attach it to the links of the chains that connect the trawl warp to the towing line (Figure 5c). Non-compressible buoys should be attached to the upper plate to compensate for the weight of the mount (maximum weight of 6.8 kg out of the water) and to avoid affecting the performance of the fishing gear on the seabed (see Annex 2 for the list of tools needed to operate the mounts).

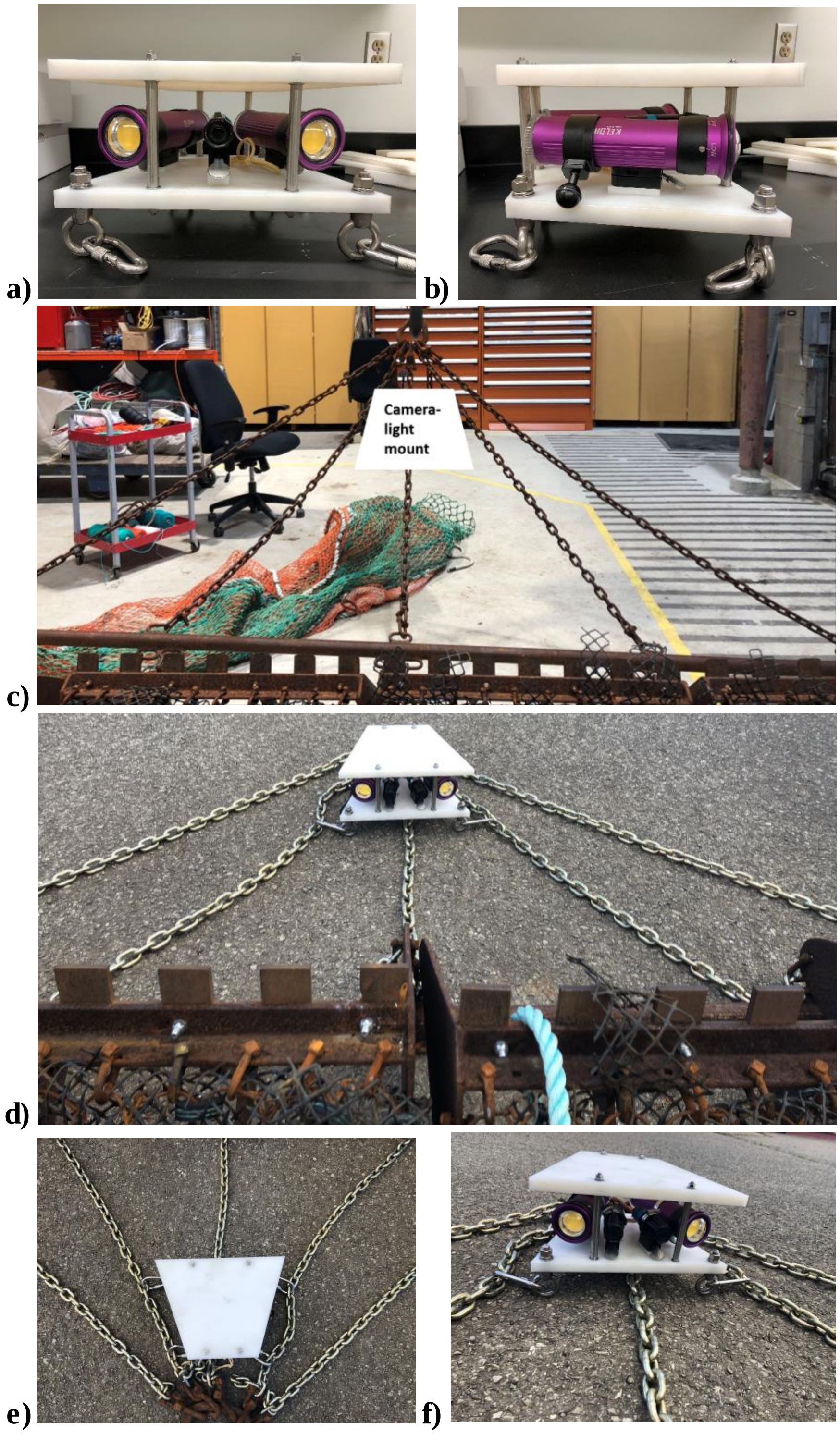


Figure 5. a) and b) UHMW mount that can accommodate one a) or two d) and f) Dive Camera+ and two Video8X lights for the Digby dredge; c) intended position of the camera-light system mount; and d), e), and f) mount installed on the dredge chains.

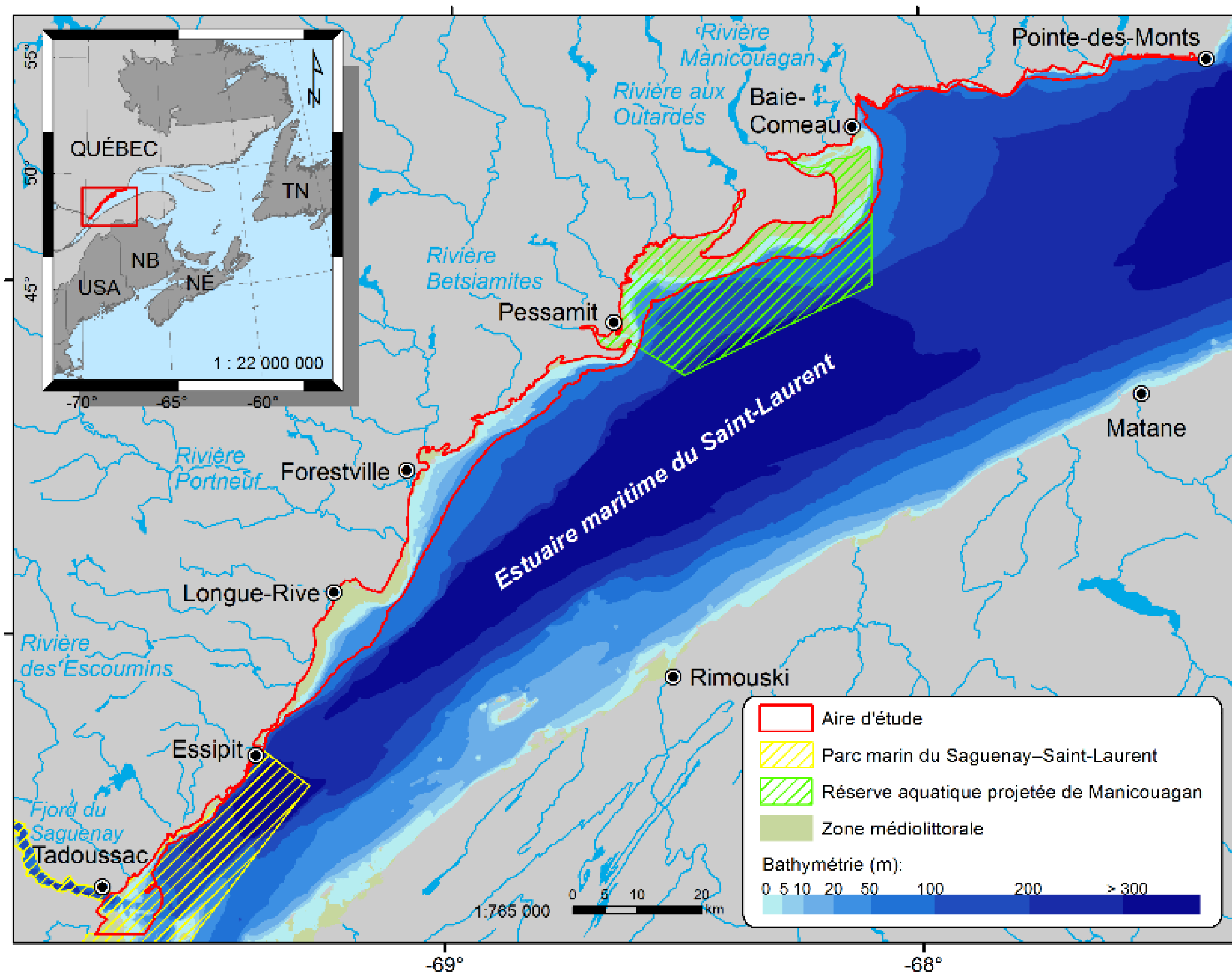
2.4. STUDY AREA AND TESTS USING FISHING GEAR

The at-sea surveys and stations considered in summer 2019 for the camera-light system tests on the beam trawl are located in the Quebec Region study area of the Coastal Environmental Baseline Program (Fisheries and Oceans Canada, National Ocean Protection Plan). The study area is located in the coastal zone (10–50 m) of the north shore of the St. Lawrence Estuary, between the cities of Tadoussac and Pointe-des-Monts (Figure 6a).

The camera-light systems were installed on the beam of the beam trawl during a snow crab stock assessment survey (engagement MLI-2019-023, which covered the north and south shores of the estuary). Other such systems were installed on the trawl heads of the beam trawl during a coastal benthic-demersal biodiversity research mission (mission MLI-2019-021_Leg 1, north shore of the estuary). These projects were conducted aboard the CCGS *Leim* between July 6 and August 6, 2019. However, most of this testing occurred during the coastal biodiversity research mission between July 27 and August 6, 2019 (Table 2, Figure 6b). The primary objective of these projects was, as their names suggest, snow crab stock assessment and coastal biodiversity characterization, respectively. The camera-light systems were therefore tested in a complementary manner and a preliminary operating procedure was developed. Considering the project's priority objectives, no time was strictly allocated to testing different camera-lamp configurations (e.g. testing the difference in image sharpness between 4K 30 fps and 1080p 100 fps camera settings).

Only three stations were tested using the Poly-Solid system during the MLI-2019-023 mission. Out of a total of 40 stations tested during the MLI-2019-021_Leg1 mission, 33 stations could be filmed. Footage was captured at 21 stations using both cameras (one on each trawl head) and at 12 stations using cameras on only one trawl head. Of these 12 stations, 5 were filmed using the camera installed on the right (starboard) trawl head and 7 using the camera installed on the left (port) trawl head.

a)



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Pessamit
Matane
Rivière Portneuf
Forestville
Estuaire maritime du Saint-Laurent
Longue-Rive
Rivière des Escoumins
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Réserve aquatique projetée de Manicouagan
Zone médiolittorale
Bathymétrie (m):
0 5 10 20 50 100 200 > 300

b)

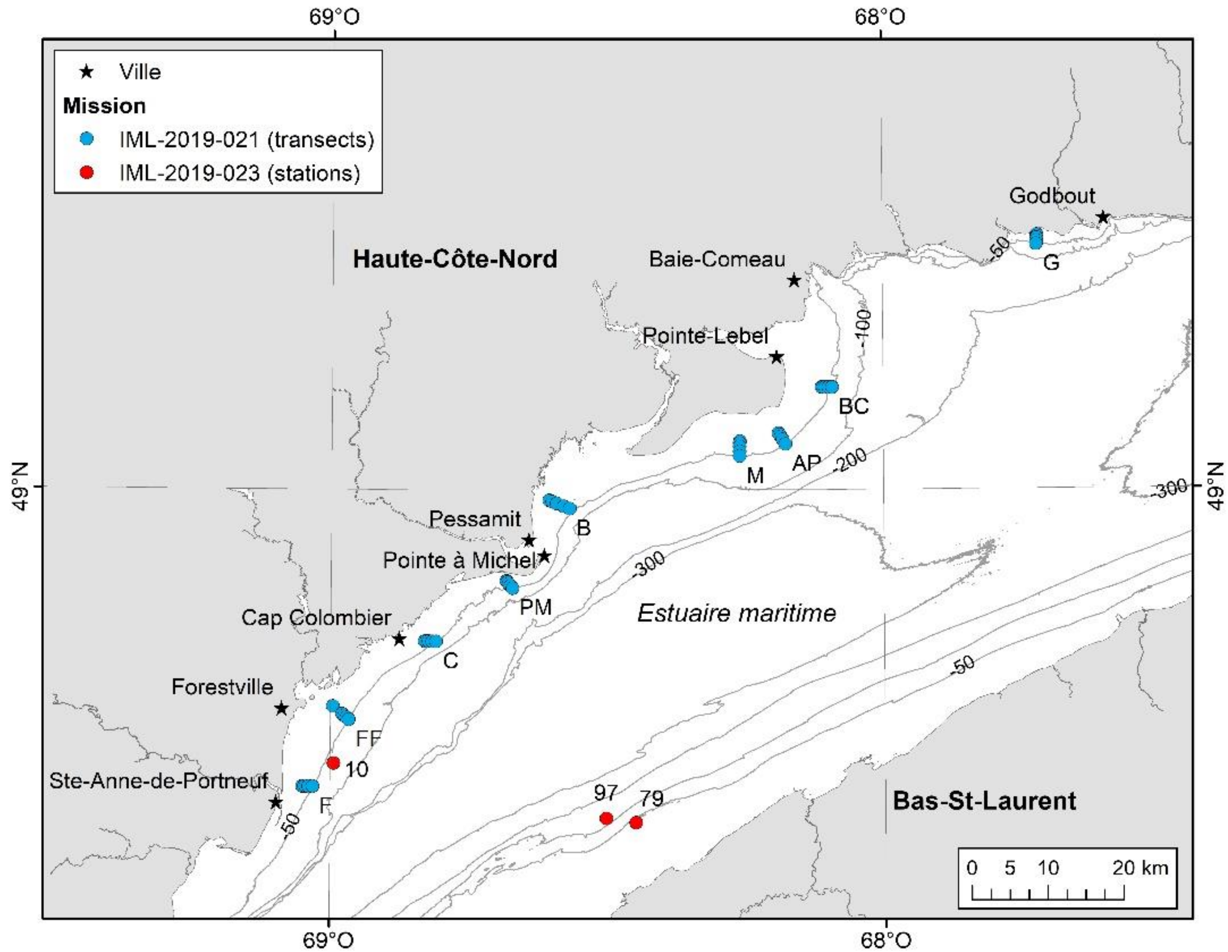

Figure 6. a) OPP Coastal Environmental Baseline Program study area (red: study area; yellow: Saguenay–St. Lawrence Marine Park; green: Manicouagan projected aquatic reserve; solid green: mediolittoral zone) and b) sites sampled in summer 2019 where video images were recorded (red: stations filmed during the snow crab assessment survey; turquoise: transects of close together stations along a depth gradient established during the coastal biodiversity mission).

Table 2. Geographic coordinates of the sites (stations for MLI-2019-023 or transects for MLI-2019-021_Leg 1) where video images were obtained, average distance trawled and the type of camera-light system used at each site. Transect legend: AP: Anse-Peinture; B: Betsiamites; BC: Baie-Comeau; C: Cap Colombier; F: Forestville; FF: Forestville2; G: Godbout; M: Manicouagan; PM: Pointe à Michel. Note that when the Dive Camera+ was used, the Keldan and BigBlue lights were always used (each light on a trawl head).

Mission (MLI-2019-xx)	Date (2019-mm-dd)	Site	Latitude (North)	Longitude (West)	Distance trawled (m)	Camera-light system
023	07-07	10	48.6783	-68.9910	652	Poly-Solide
023	07-07	79	48.6019	-68.4523	916	Poly-Solide
023	07-08	97	48.6068	-68.5088	988	Poly-Solide
021_Leg 1	07-30	BC	49.1224	-68.1035	447	Dive Camera+
021_Leg 1	07-31	M	49.0504	-68.2611	444	Dive Camera+
021_Leg 1	08-01	G	49.2923	-67.7186	429	Dive Camera+
021_Leg 1	08-02	AP	49.0606	-68.1841	447	Dive Camera+
021_Leg 1	08-02	B	48.9828	-68.5897	438	Dive Camera+
021_Leg 1	08-03	PM	48.8877	-68.6786	454	Dive Camera+
021_Leg 1	08-04	FF	48.7282	-68.9710	434	Dive Camera+
021_Leg 1	08-04	C	48.8194	-68.8166	453	Dive Camera+
021_Leg 1	08-05	F	48.6481	-69.0406	435	Dive Camera+

2.5. Classification and analysis of video footage

All videos were renamed with unique names consisting of the station name, year, camera position on the trawl (right trawl head: PD; left trawl head: PG), and depth (example: BC2019PD50). The unique names of the videos were entered in an Excel file along with the metadata of the stations where the tests were conducted (GPS coordinates, time, depth, etc.). The videos were then reviewed and classified in the Excel file based on the quality of the video (visibility and turbidity). Visibility refers to the level at which the observer can detect epibenthic species. It can be good, average, poor or zero. The turbidity index (five levels, from + to +++++) was determined according to the quantity of suspended matter visible in the water column (Annex 3). Note that visibility in these videos is not necessarily related to the turbidity index. For example, a turbidity index of +++ could mean that visibility is poor at one station but average at another (Annex 3). It is possible that this difference is due to the angle of the camera and the light relative to the direction of the suspended particles in the water column. Footage quality was deemed sufficient to make epibenthic invertebrate identification in videos with good or average visibility and a turbidity index between + and +++ (Annex 3). As such, only the videos whose quality was deemed sufficient were selected for analysis, the others were archived (Annex 1). Visibility and turbidity index are two criteria that are subjective to the observer. The information found in Annex 3 can be used as an example of whether or not the videos are high enough quality to be analyzed. Furthermore, these two criteria are in no way intended to evaluate the effectiveness of the camera-light system used or the position of the latter on the gear.

A total of 64 videos were filmed during the course of this project. Of these videos, 37 had poor or zero visibility due to high water turbidity and therefore did not have a high enough quality to be analyzed. The total size of the recorded and archived videos (n = 64) is 261.5 GB. With the exception of three videos that were filmed at 1080p 30 fps (the camera's default resolution), the videos were all filmed at 4K 30 fps resolution. Only four videos were filmed during the snow crab stock assessment survey at three different stations using the Poly-Solid camera-light system (Annex 1). A total of 60 videos were filmed with the Dive Camera+. Of those 60 videos, 32 videos were filmed using the Keldan light (15,000 lumens) and 28 videos with the two BigBlue lights (7,200 lumens each). However, as previously mentioned, 37 videos had to be archived without being analyzed, including 18 videos filmed with the Keldan light, 15 videos with the two BigBlue lights and four videos with the Poly-Solid system (Annex 1).

Of the 27 videos identified for analysis, 11 were classified as having good visibility, but only two (BC2019PG40p1 and BC2019PG40p2) have related biodiversity data from the trawl catch. The remaining 9 videos were recorded at site G2019 (near Godbout), but no tows could be performed at this site due to the presence of boulders on the seabed. The rest of the videos (n = 16) have moderate visibility with 2 scoring a turbidity index of ++ (M2019PD20 and M2019PD30) and the remaining scoring a turbidity index of +++. Due to time constraints, only 4 videos (BC2019PG40p1, BC2019PG40p2, AP2019PG20 and AP2019PD20) were fully analyzed.

The software used to analyze the footage was Hafmynd v1.4. Hafmynd is a free software that was developed in Iceland by Björn Darri Sigurðsson (from Iceland's Marine and Freshwater Research Institute) and is currently being tested at MLI (Mont-Joli, Qc; contact Olivia Lacasse or Claude Nozères). The protocol for image analysis using this software consisted of playing the video in 0.25 second sequences and identifying all the epibenthic fauna present in the image at the lowest possible taxonomic level. The process was repeated for the video from the other corresponding camera when available. Where possible, only organisms in the area between the camera and halfway along the trawl are identified and counted. However, the limits of this area are subjective to the observer and some organisms may be identified twice (i.e. they were also identified during the analysis of the video from the second camera).

These data were validated by comparing the two videos (left and right trawl head for the same station) simultaneously in the software. The validation process involved using three simultaneously running copies of the software on three hard drives (two external drives and the computer drive). The changes were made on the main copy, which was on the computer's hard drive. The other two copies of the software were used to view the videos and the information recorded on each at the same time. To synchronize the footage, the videos were viewed in 0.25 second sequences from the time the trawl hit the seabed. The images were reviewed simultaneously and a taxon was considered duplicated if it appeared in the same location on both videos. It was then removed from the video in which its distance from the camera lens was greater.

3. RESULTS AND DISCUSSION

3.1. BEAM TRAWL TESTS

3.1.1. The Poly-Solid camera-light system

Technical problems were encountered with the Poly-Solid camera system. For an unknown reason, the batteries of the cameras and lights were not rechargeable and they were only able to film for a few hours during the first day of testing. The positioning of the screws and the sharp corners of the camera mounts caused the mesh of the cod end to snag on the mounts. This problem was easily solved by reversing the screw positions and rounding the corners of the mounts. However, the addition of extra weight to the trawl from the two systems (approximately 18 kg in total) seemed to affect the trawl's performance. In fact, when the trawl was being launched and lifted out of the water, the trawl tilted noticeably towards the side where the Poly-Solid camera system was installed. In light of the various problems encountered with the Poly-Solid camera-light system, it was decided that the system would be excluded from future missions.

The few images obtained revealed that visibility at the stations was very poor. They also revealed that during swell periods, the trawl's warp and support beam hit the seabed, causing sediment to rise, considerably reducing visibility. The poor visibility prevented us from concluding whether the positioning of the cameras at both ends of the beam is good for the observation and identification of epibenthic organisms. Therefore, videos captured using this system were not analyzed.

3.1.2. The Paralenz Dive Camera+ system and BigBlue and Keldan lights

The difference between the number of stations filmed using the cameras installed on the right and left trawl heads was caused by technical problems with one of the cameras (e.g. firmware problems that caused the camera not to start filming at a depth of 1.5 m) or a lack of battery power. The batteries in the BigBlue lights did not run out of power, unlike the Keldan light, because less power is required to operate a light at 7,200 lumens than at 15,000 lumens.

The initial playback of the videos allowed us to observe the performance of the trawl as it was being launched and to determine the start and end of the trawl tow, which would allow for accurate calculation of the area trawled in the future. It is indeed possible to observe the precise moment when the fishing gear touches the seabed, when it starts to move and when it leaves the seabed. These observations allow, according to the time of the video, the exact duration of the trawling to be calculated. By using the data on the speed of movement of the vessel, and therefore of the gear, the time spent in contact with the seabed and the width of the gear, it is possible to obtain precise data on the area of the seabed trawled. This information is important to calculate the density (abundance/m^2) and biomass (weight/m^2) of epibenthic organisms.

The placement of the cameras on the trawl heads, although an ideal place to protect the equipment, when combined with the speed of movement of the gear, is not optimal for the identification of small epibenthic organisms. It does, however, provide information on the spatial distribution of organisms, which was one of the objectives of the project. In addition, the camera footage provided information about the presence of organisms collected in the trawl catch and made it possible to verify the effectiveness of the seabed gear, another objective of the project. Some burrowing animals, for example the sea cucumber, *Psolus phantapus*, may be found in very large numbers in a transect, but may not be captured by the beam trawl (Figure 9 and Table 4).

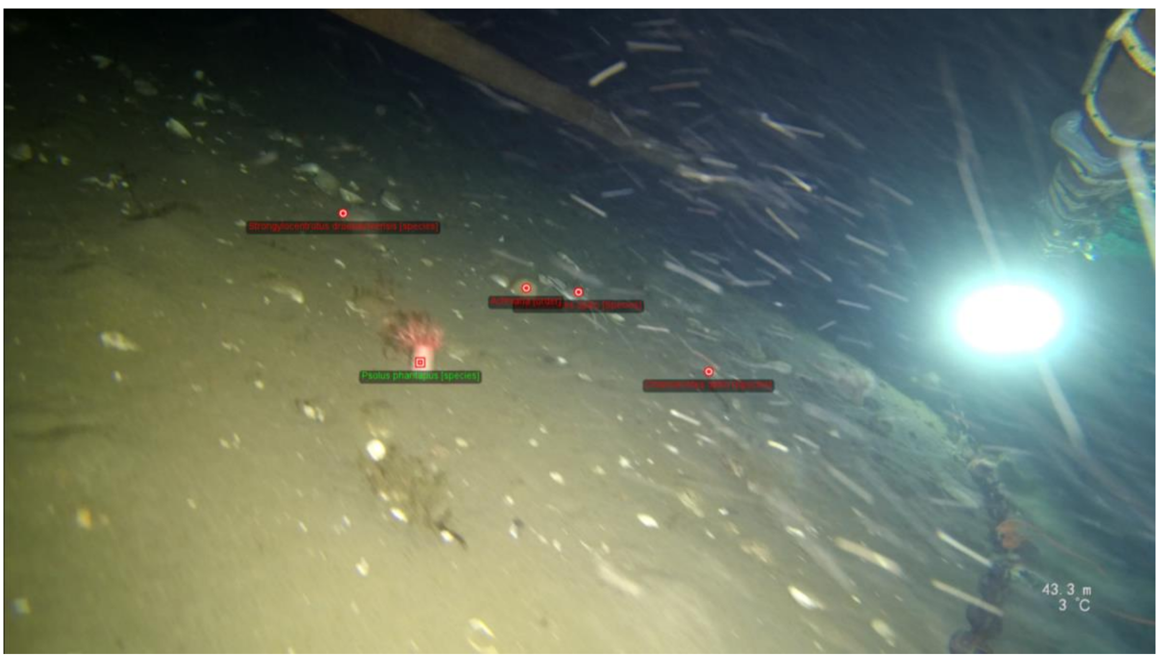

Figure 9. Video still (Dive Camera+ camera and Keldan lamp) from site BC201940m extracted using Hafmynd software, showing the presence of five organisms, including a sea cucumber, *Psolus phantapus* (highlighted in green).

The location of the camera also created a blind spot: a triangular area below the camera prevents organisms that are passing near the inside of the trawl head from being recorded. This blind spot was discovered when the videos were viewed and it covers approximately 5–10% of the total image. Figures 10 and 11 show a series of images from the videos where it can be seen that the camera on the right trawl head (right images) records an object that is near the inside of the left trawl head. However, the images captured by the camera located on this trawl head (images on the left) make it impossible to identify this object, because it passes in the blind spot of the camera (Figure 10). Figure 11 shows another object located near the inside of the left trawl head. This object is also captured by the camera installed on the right trawl head. It is possible to identify the object from the footage captured by the camera on the left trawl head, but not on the right trawl head.

Camera installed on the left trawl head (with a Keldan light of 15,000 lumens)

Camera installed on the right trawl head (with two BigBlue lights of 7,200 lumens)

Figure 10. Images from the videos recorded at station AP201920m by the cameras installed on the left trawl head (left images) and the right trawl head (right images) indicate the presence of a blind spot in the footage. The objects in blue circles demonstrate that the two sets of images are synchronized, while the objects in red are captured by the right trawl head camera, but not by the left trawl head camera.

Camera installed on the left trawl head (with a Keldan light of 15,000 lumens)

Camera installed on the right trawl head (with two BigBlue lights of 7,200 lumens)

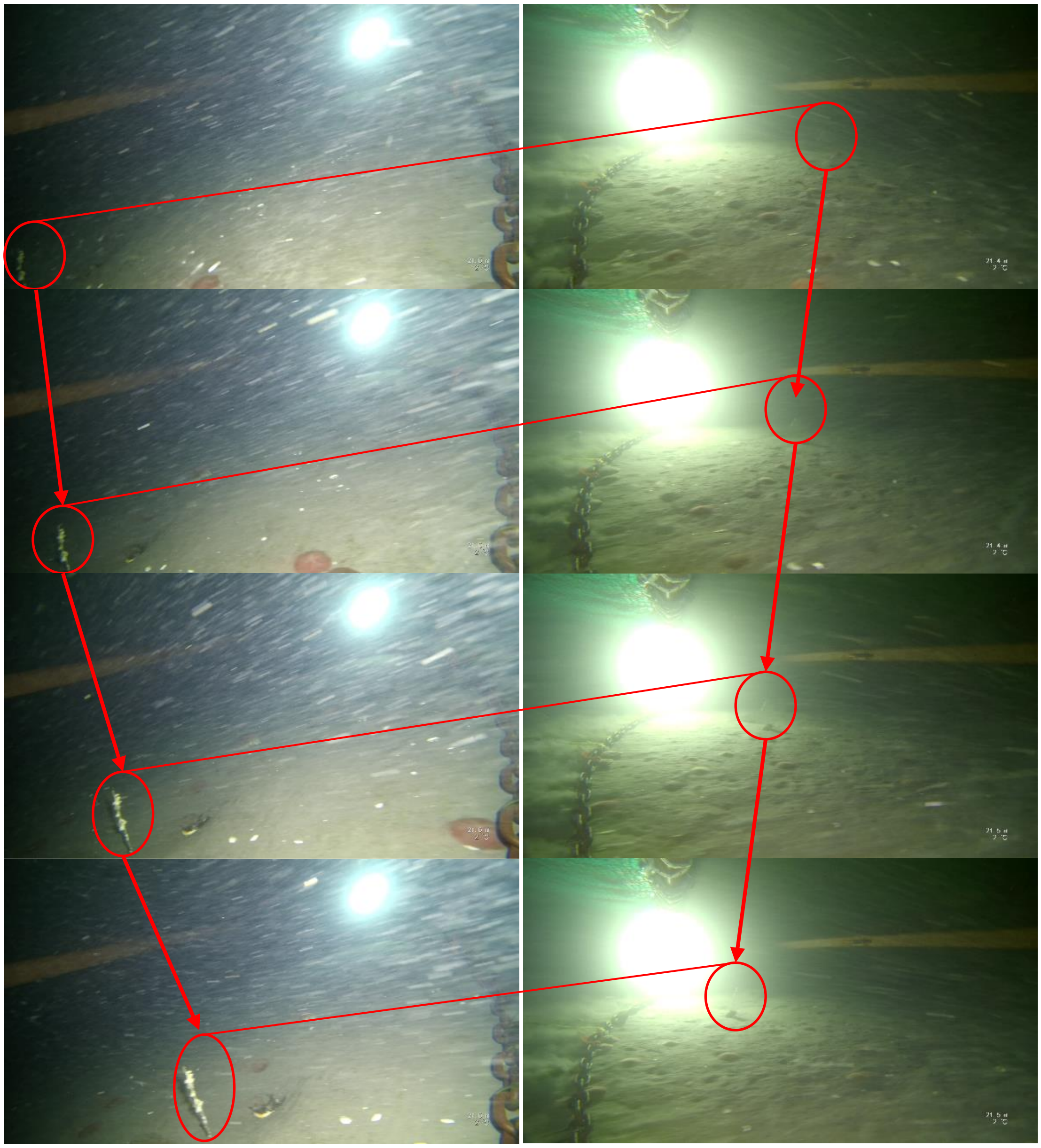

Figure 11. Images extracted from the videos recorded at site AP201920m by the cameras installed on the left trawl head (left images) and right trawl head (right images). Objects in red are captured by the right trawl head camera as well as the left trawl head camera.

When the images are compared to each other, it is clear that the illumination provided by the Keldan light provides better definition to details than the BigBlue lights in an environment where visibility was rated as average and with a +++ turbidity index (Figure 12). The two images in Figure 12 show common crabs (*Cancer irroratus*) and whelk egg clusters (the white balls near the crabs). The top image was captured by the camera with the Keldan light while the bottom image was captured by the BigBlue lights. Although the observed difference is small, the details in the top image are clearer than those in the bottom image. There are two possible reasons for this difference. First, it is possible that this is due to the fact that the Keldan light has a higher CRI than the BigBlue light. Secondly, it may be the combination of the CRI and light temperature (5600K for the Keldan light and 6500K for the BigBlue light) that affects the image quality obtained. Further testing would be needed to better explain these observations (e.g. changing the angle of the camera in comparison to the light, trying a different location to install the camera and light, etc.).

Figure 12. Comparison of the lights at AP201920m. The top image is from the Dive Camera+ with the Keldan light (15,000 lumens). The bottom image is from the Dive Camera+ with the two BigBlue lights (7,200 lumens each).

Figure 13 compares images taken with the Dive Camera+ at 4K resolution at a speed of 30 frames per second with images shot at 1080p resolution at a speed of 30 frames per second (1080p 30 fps). The footage captured in 4K resolution provides better definition of the organisms than that in 1080p. In a lowlight environment, the 1080p 30 fps resolution is not optimal when the vessel is moving at a speed of two knots. Again, further testing (e.g.

testing at 1080p 100 fps, 1080p 200 fps, 4K 60 fps) will be necessary to determine which resolution is best to obtain high-quality images for identifying epibenthic organisms.

Figure 13. Comparison images captured using the Dive Camera+ at 4K resolution at 30 fps with the Keldan light (15,000 lumens) (top image) and using 1080p resolution at 30 fps with the two BigBlue lights (7,200 lumens each) (bottom image) at site BC201940m.

3.2. Analysis of video footage

The data extracted from these videos were compared with the data recorded from the trawl catch. Results are found in tables 4 and 5. Note that fish were counted in the images, but were not identified to species level.

The results on epibenthic invertebrates show that small organisms sometimes present in the trawl catch, such as amphipods, are not captured in the footage. It may also be difficult to identify fast moving organisms, such as fish or shrimp, in the footage. Preliminary results also suggest that the beam trawl is not well adapted for the collection of certain organisms (e.g. *Chionoecetes opilio*, *Cancer irroratus*, *Cucumaria frondosa*, *Buccinum* indet.). These organisms are easily flushed out by the first chain but then seem to roll under the other chains and under the cod end and are therefore not collected. Some small organisms may be collected by the trawl mesh when it comes into contact with the seabed.

Table 4. Comparison of the sum of taxa identified in videos BC2019PG40p1 and BC2019PG40p2 (n_video) and from data counted from trawl catches (n_trawl). The "-" indicates that no data were collected for this taxon. Taxa are listed in alphabetical order using the nomenclature recommended by Horton et al. (2021).

	Taxon	**n_vidéo**	**n_chalut**
Invertebrates	Actiniidae *stet.*	1	-
	Argis dentata	-	46
	Buccinidae (amas d'œufs)	3	weight only (0.392 kg)
	Buccinum indet.	45	3
	Cancer irroratus	15	13
	Chionoecetes opilio	100	42
	Chlamys islandica	4	1
	Crossaster papposus	1	5
	Dendronotus frondosus	3	-
	Eualus indet.	11	-
	Gersemia rubiformis	3	2
	Hemithiris psittacea	-	2
	Hyas indet.	56	47
	Hydrozoa *stet.*	303	abundance index (1)
	Leieschara coarctata	2	-
	Leptasterias groenlandica	-	1
	Leptasterias polaris	1	1
	Margarites costalis	-	3
	Melita dentata	-	1

	Taxon	n_vidéo	n_chalut
Invertebrates	*Pagurus indet.*	56	2
	Pandalus indet.	728	1749
	Psolus phantapus	102	-
	Pentamera calcigera	-	1
	Polynoidae *stet.*	-	1
	Scabrotrophon fabricii	-	1
	Sclerocrangon boreas	1	12
	Serripes groenlandicus	-	2
	Solaster endeca	3	1
	Spirontocaris spinus	-	2
	Stomphia coccinea	148	18
	Strongylocentrotus droebachiensis	714	196
	*Urticina felina**	4	-
Chordata	Ascidiacea : *Styela indet.*	11	2
Fish	*Artediellus uncinatus*	-	12
	Eumicrotremus terraenovae	-	4
	Gadus morhua	-	1
	Gymnocanthus tricuspis	-	1
	Hippoglossoides platessoides	-	23
	Limanda ferruginea	1	2
	Total fish	7 (unidentified)	41

* This species may be mistaken for *Urticina crassicornis* and *Cribrinopsis similis* if there is no genetic confirmation (Sanamyan et al. 2020)

Table 5. Comparison of the sum of taxa identified in videos AP2019PG20 and AP2019PD20 (n_video) and from data collected from trawl catches (n_trawl). The "-" indicates that no data were collected for this taxon. Taxa are listed in alphabetical order using the nomenclature recommended by Horton et al. (2021).

	Taxon	n_vidéo	n_chalut
Invertebrates	*Argis dentata*	-	1
	Asterias rubens	1	1
	Buccinidae (amas d'œufs)	107	weight only(15.68 kg)
	Buccinum indet.	438	42
	Cancer irroratus	39	28
	Chionoecetes opilio	2	2
	Echinarachnius parma	5734	199
	Gammaridea *stet.*	-	6
	Hyas indet.	-	9
	Leptasterias polaris	-	1
	Hydrozoa *stet.*	283	-
	Mytilus edulis	12	141
	Nudibranchia stet.	-	1
	Onchidoris bilamellata	-	26
	Pagurus indet.	8	14
	Pandalus montagui	18*	3840
	Pentamera calcigera	-	1
	Polychaeta *stet.*	-	2
	Polynoidae *stet.*	-	9
	Sclerocrangon boreas	-	1
	Stomphia coccinea	7	71
	Strongylocentrotus droebachiensis	27	23
Fish	Ammodytidae *stet.*	-	4
	Artediellus uncinatus	-	49
	Eumicrotremus terraenovae	-	8
	Hippoglossoides platessoides	-	10
	Leptoclinus maculatus	-	2
	Limanda ferruginea	-	2
	Liparis indet.	-	1
	Mallotus villosus	-	1
	Total fish	35 (unidentified)	77

* *Pandalus indet.*

4. CONCLUSION AND RECOMMENDATIONS

The system combined of the Paralenz Dive Camera+ and the Keldan Video8X light installed on the trawl heads of the beam trawl proved to be the best camera-light system that was tested during the summer of 2019. The low weight of these devices does not appear to influence the fishing performance of the beam trawl. In addition, the simultaneous use of 4K camera resolution and the 15,000 lumen light intensity resulted in organisms being captured in the highest quality definition in the tests conducted. The addition of a third camera-light system, positioned in the middle of the beam, could give a better overall view of the area covered by the trawl. Some studies have demonstrated the influence of a light source on the catchability of organisms by fishing gear (Nguyen et al. 2017). However, for mobile fishing gear such as a beam trawl moving at an average speed of two knots, light-related attraction is too fleeting to influence catchability. In addition, the noise and vibrations generated by the gear seem to have an opposite and greater effect than the attraction of the light source.

Additional tests (i.e. changing the settings of the cameras and lights as well as their positioning on the fishing gear) will be planned in the coming years to further optimize the quality of the images. Firstly, in the short term, tests will be conducted using the equipment included in this report (e.g. the image quality of a Keldan 15,000 lumen light and the Dive Camera+ in the 4K 30 fps mode will be compared to the 1080p 100 fps camera). Secondly, in the medium term, as new and more efficient equipment becomes available, it will be necessary to carry out new tests to find the optimal camera and light settings.

This camera-light system was designed to provide supplemental information to research surveys of commercial invertebrate stocks in the coastal environment, not to conduct comprehensive and accurate inventories of epibenthic organisms (see Larocque and Thorne 2012). Using the information collected by this system, it would eventually be possible to estimate the percentage of organisms that are not collected by the fishing gear after more footage is collected during stock surveys. This information could be useful for more accurately estimating the stocks of a species in question, such as snow crab or common whelk.

The full set of operating protocols as well as the reports from MLI-2019-021 and MLI-2019-023 are available from the authors.

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ANNEX 1

Inventory of videos recorded during the summer of 2019 during the snow crab stock assessment survey (MLI-2019-023) and the coastal biodiversity research mission (MLI-2019-021_Leg 1). Videos are listed by visibility, from good to zero visibility, and whether or not they could be analyzed.

Chart legend

Name of file: p1 and p2 indicate that the video recording from this station has two parts and name_2 and name_3 indicate that these videos were taken at the same station, but are from different trawl attempts; Transect: AP: Anse-Peinture; B: Betsiamites; BC: Baie-Comeau; C: Cap Colombier; F: Forestville; FF: Forestville2; G: Godbout; M: Manicouagan; PM: Pointe à Michel; Depth: depth; Temp.: temperature of the light in Kelvin; Place on trawl: placement of the camera-light system on the beam trawl; r.t.h.: system placed on the right trawl head; l.t.h.: system placed on the left trawl head; c.r.b.: system placed on the centre right of the beam head; Video res.: resolution of the video recording; Visibility: refers to how well the observer can detect epibenthic species, it can be good, average, poor or zero; Turbidity index: determined according to the amount of suspended matter visible in the water column (five levels, from + to +++++); Analysis to do: indicates whether the video is of sufficient quality to be analyzed or not.

File name	Mission (MLI-2019-xx)	Transect	Depth (m)	Date (2019-mm-dd)	Light	Lumens	Temp.	Place on trawl	Res. video	Visibility	Turbidity index	Analysis to do
BC2019PG40p1	021_Leg 1	BC2019	40	07-30	Keldan	15,000	5600K	l.t.h.	4K	Good	+	Analyzed
BC2019PG40p2	021_Leg 1	BC2019	40	07-30	Keldan	15,000	5600K	l.t.h.	4K	Good	+	Analyzed
G2019PD40	021_Leg 1	G2019	40	08-01	BigBlue	2*7 200	6500K	r.t.h.	4K	Good	+	Yes
G2019PD50_2	021_Leg 1	G2019	50	08-01	BigBlue	2*7,200	6500K	r.t.h.	4K	Good	+	Yes
G2019PD50_3	021_Leg 1	G2019	50	08-01	BigBlue	2*7,200	6500K	r.t.h.	4K	Good	+	Yes
G2019PD50p1	021_Leg 1	G2019	50	08-01	BigBlue	2*7,200	6500K	r.t.h.	4K	Good	+	Yes
G2019PD50p2	021_Leg 1	G2019	50	08-01	BigBlue	2*7,200	6500K	r.t.h.	4K	Good	+	Yes
G2019PG40	021_Leg 1	G2019	40	08-01	Keldan	15,000	5600K	l.t.h.	4K	Good	+	Yes
G2019PG50	021_Leg 1	G2019	50	08-01	Keldan	15,000	5600K	l.t.h.	4K	Good	+	Yes
G2019PG50_2	021_Leg 1	G2019	50	08-01	Keldan	15,000	5600K	l.t.h.	4K	Good	+	Yes

File name	Mission (MLI-2019-xx)	Transect	Depth (m)	Date (2019-mm-dd)	Light	Lumens	Temp.	Place on trawl	Res. video	Visibility	Turbidity index	Analysis to do
G2019PG50_3	021_Leg 1	G2019	50	08-01	Keldan	15,000	5600K	l.t.h.	4K	Good	+	Yes
M2019PD10	021_Leg 1	M2019	10	07-31	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	++	Yes
M2019PD20	021_Leg 1	M2019	20	07-31	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	++	Yes
M2019PD30	021_Leg 1	M2019	30	07-31	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	++	Yes
M2019PG10	021_Leg 1	M2019	10	07-31	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
M2019PG20	021_Leg 1	M2019	20	07-31	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
M2019PG30	021_Leg 1	M2019	30	07-31	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
AP2019PD20	021_Leg 1	AP2019	20	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	Analyzed
AP2019PD30	021_Leg 1	AP2019	30	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	Yes
AP2019PG20	021_Leg 1	AP2019	20	08-02	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Analyzed
AP2019PG30	021_Leg 1	AP2019	30	08-02	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
PM2019PD30	021_Leg 1	PM2019	30	08-03	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	Yes
PM2019PG30	021_Leg 1	PM2019	30	08-03	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
F2019PD20	021_Leg 1	F2019	20	08-05	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	Yes
F2019PD30	021_Leg 1	F2019	30	08-05	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	Yes
F2019PG20	021_Leg 1	F2019	20	08-05	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
F2019PG30	021_Leg 1	F2019	30	08-05	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	Yes
BC2019PD40p1	021_Leg 1	BC2019	40	07-30	BigBlue	2*7,200	6500K	r.t.h.	1080p	Good	+	No
BC2019PD40p2	021_Leg 1	BC2019	40	07-30	BigBlue	2*7,200	6500K	r.t.h.	1080p	Good	+	No
BC2019PD50	021_Leg 1	BC2019	50	07-30	BigBlue	2*7,200	6500K	r.t.h.	1080p	Good	+	No
BC2019PG50	021_Leg 1	BC2019	50	07-30	Keldan	15,000	5600K	l.t.h.	4K	Good	+	No
C2019PG30p1	021_Leg 1	C2019	30	08-04	Keldan	15,000	5600K	l.t.h.	4K	Good	+	No
C2019PG30p2	021_Leg 1	C2019	30	08-04	Keldan	15,000	5600K	l.t.h.	4K	Good	+	No
M2019PG40	021_Leg 1	M2019	40	07-31	Keldan	15,000	5600K	l.t.h.	4K	Average	+++	No
M2019PD50	021_Leg 1	M2019	50	07-31	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	+++	No

File name	Mission (MLI-2019-xx)	Transect	Depth (m)	Date (2019-mm-dd)	Light	Lumens	Temp.	Place on trawl	Res. video	Visibility	Turbidity index	Analysis to do
M2019PG50	021_Leg 1	M2019	50	07-31	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
AP2019PD40	021_Leg 1	AP2019	40	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	++++	No
AP2019PD50	021_Leg 1	AP2019	50	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	++++	No
B2019PD30	021_Leg 1	B2019	30	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	++++	No
B2019PD40	021_Leg 1	B2019	40	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	++++	No
B2019PD50	021_Leg 1	B2019	50	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	++++	No
B2019PG50	021_Leg 1	B2019	50	08-02	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
PM2019PD40	021_Leg 1	PM2019	40	08-03	BigBlue	2*7,200	6500K	r.t.h.	4K	Poor	++++	No
PM2019PG10	021_Leg 1	PM2019	10	08-03	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
C2019PG40	021_Leg 1	C2019	40	08-04	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
C2019PG50	021_Leg 1	C2019	50	08-04	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
FF2019PG30	021_Leg 1	FF2019	30	08-04	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
F2019PG40	021_Leg 1	F2019	40	08-05	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
F2019PG50	021_Leg 1	F2019	50	08-05	Keldan	15,000	5600K	l.t.h.	4K	Poor	++++	No
PM2019PD50	021_Leg 1	PM2019	50	08-03	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	No
C2019PD30	021_Leg 1	C2019	30	08-04	BigBlue	2*7,200	6500K	r.t.h.	4K	Average	+++	No
PM2019PG40	021_Leg 1	PM2019	40	08-03	Keldan	15,000	5600K	l.t.h.	4K	Average	++++	No
B2019PD10	021_Leg 1	B2019	10	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Zero	+++++	No
B2019PD20	021_Leg 1	B2019	20	08-02	BigBlue	2*7,200	6500K	r.t.h.	4K	Zero	+++++	No
B2019PG10	021_Leg 1	B2019	10	08-02	Keldan	15,000	5600K	l.t.h.	4K	Zero	+++++	No
B2019PG20	021_Leg 1	B2019	20	08-02	Keldan	15,000	5600K	l.t.h.	4K	Zero	+++++	No
PM2019PD20	021_Leg 1	PM2019	20	08-03	BigBlue	2*7,200	6500K	r.t.h.	4K	Zero	+++++	No
PM2019PG20	021_Leg 1	PM2019	20	08-03	Keldan	15,000	5600K	l.t.h.	4K	Zero	+++++	No
FF2019PG40	021_Leg 1	FF2019	40	08-04	Keldan	15,000	5600K	l.t.h.	4K	Zero	+++++	No
FF2019PG50	021_Leg 1	FF2019	50	08-04	Keldan	15,000	5600K	l.t.h.	4K	Zero	+++++	No

File name	Mission (MLI-2019-xx)	Transect	Depth (m)	Date (2019-mm-dd)	Light	Lumens	Temp.	Place on trawl	Res. video	Visibility	Turbidity index	Analysis to do
T792019CD36	023	T79	36	07-07	OCEAN-CAM	4,500	N/A	c.r.b.	4K	Zero	+++++	No
T972019CD137	023	T97	137	07-07	OCEAN-CAM	4,500	N/A	c.r.b.	4K	Zero	+++++	No
T972019CD137_2	023	T97	137	07-07	OCEAN-CAM	4,500	N/A	c.r.b.	4K	Zero	+++++	No
T102019CD66	023	T10	65.8	07-08	OCEAN-CAM	4,500	N/A	c.r.b.	4K	Zero	+++++	No

ANNEX 2

Many tools are required to adjust the mounts:

- 9/32 in. ratchet to loosen and tighten the AX SUB support brackets,
- a star-shaped screwdriver for the AX SUB bracket screws,
- 7/16 in. adjustable wrench to loosen the rod bolts on the UHMW mount for the Digby dredge,
- 11 in. cable ties to connect the UHMW mounts to the trawl heads of the beam trawl (four cable ties on each mount, two at each end),
- a pair of scissors to cut the cable ties, if necessary.

ANNEX 3

To facilitate the decision-making process of whether a video can be analyzed or not, the following images are included as examples of images captured at different stations on the MLI-2019-021 mission where visibility levels and turbidity indices vary.

VISIBILITY: GOOD **TURBIDITY:** +
VIDEO DEEMED ANALYZABLE: YES

Example from the BC2019-40m station using the camera (4K 30 fps) with the Keldan light (15,000 lumens) (top photo) and the camera (1080p 30 fps) with the two BigBlue lights (2 x 7,200 lumens) (bottom photo).

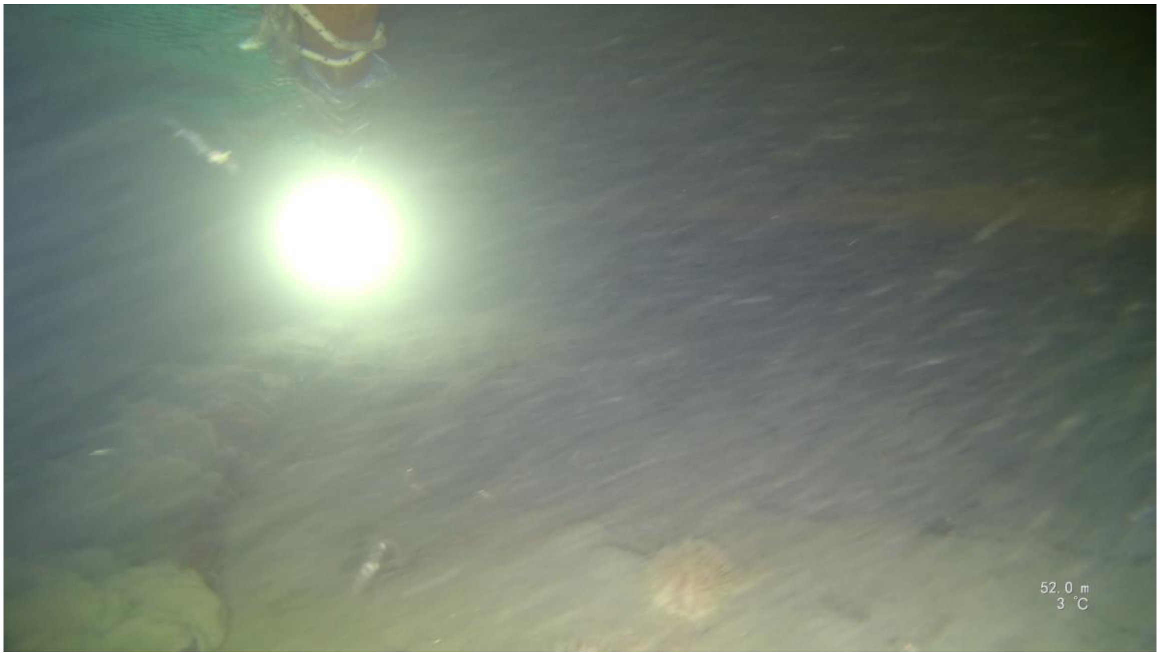
VISIBILITY: AVERAGE **TURBIDITY:** ++
VIDEO DEEMED ANALYZABLE: YES

Example from the M2019-30m station using the camera (4K 30 fps) with two BigBlue lights (2 x 7,200 lumens).

VISIBILITY: AVERAGE **TURBIDITY:** ++
VIDEO DEEMED ANALYZABLE: NO

Example from the M2019-40m station using the camera (4K 30 fps) with two Keldan lights (15,000 lumens).

VISIBILITY: POOR **TURBIDITY:** +++
VIDEO DEEMED ANALYZABLE: NO



Example from the M2019-50m station using the camera (4K 30 fps) with two BigBlue lights (2 x 7,200 lumens).

VISIBILITY: POOR **TURBIDITY:** ++++

VIDEO DEEMED ANALYZABLE: NO

Example from the BC2019-50m station using the camera (4K 30 fps) with the Keldan light (15,000 lumens) (top photo) and the camera (4K 30 fps) with the two BigBlue lights (2 x 7,200 lumens) (bottom photo).

VISIBILITY: ZERO **TURBIDITY:** ++++
VIDEO DEEMED ANALYZABLE: NO

Example from the BC2019-20m station using the camera (4K 30 fps) with the Keldan light (15,000 lumens) (top photo) and the camera (4K 30 fps) with the two BigBlue lights (2 x 7,200 lumens) (bottom photo).