San Elijo Joint Powers Authority
San Elijo Water Reclamation Facility

OUTFALL INTEGRITY REPORT

FINAL | January 2020

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Contents

Appendices

Figures

Section 1

PROJECT BACKGROUND

The San Elijo Joint Powers Authority (SEJPA) owns and operates the San Elijo Water Reclamation Facility (Facility), located in Cardiff-by-the-Sea, California. The Facility provides wastewater treatment and recycled water treatment and distribution to their member agencies of Solana Beach and Encinitas. The Facility also holds leases from The City of Del Mar and Rancho Santa Fe Community Services District (RSFCSD).

At the Facility, secondary effluent not sent to tertiary treatment is discharged to the ocean through an outfall, which has both a land portion (land outfall) and an ocean portion (ocean outfall). The Hale Avenue Resource Recovery Facility (HARRF) is owned by the City of Escondido and also discharges secondary effluent through the land outfall. The outfall is located on lands owned by the State of California.

The SEJPA maintains the outfall through lease No. PRC 3228.9 issued by the State Lands Commission. As part of the special provisions of the lease, the outfall must have periodic structural integrity evaluations. In response, Carollo Engineers, Inc., (Carollo) partnered with Marine Taxonomical Services (MTS) to inspect the SEJPA's ocean outfall system and prepare an integrity report. This report describes the procedures, findings, and recommendations for the structural evaluation of both the land and ocean outfall.

Section 2

OUTFALL DESCRIPTION

The Facility's outfall consists of two sections: a land outfall portion that extends from the Facility to the shore of the Pacific Ocean and an ocean outfall portion that extends from the shore approximately 8,000 feet into the Pacific Ocean. The location and routing of the outfall can be found on Figure 1. This section will review both the land and ocean portions of the outfall and their components.

2.1 Land Outfall

The land outfall, originally constructed in 1965 as Asbestos Cement (AC) Pipe, begins at the Facility's effluent pump station, running below grade of the Facility's driveway entrance. All AC pipe has been replaced with either polyvinyl chloride (PVC) or high-density polyethylene (HDPE) pipe. In 1974 the City of Escondido built a 14-mile land outfall and the Escondido Regulator Structure, located on the west side of Manchester Avenue, to receive effluent from Escondido before combining with the SEJPA land outfall. The pipe then runs beneath the San Elijo Lagoon before connecting to the ocean outfall below grade at Cardiff State Beach.

In 2018, SEJPA constructed a new land outfall with 30-inch HDPE pipe that connected to the existing 30-inch PVC pipe at the edge of the Facility, and abandoned the existing 30-inch AC pipe. The project also replaced the piping that connects the Escondido Regulator Structure to the outfall. The new land outfall was constructed utilizing horizontal directional drilling (HDD), which used remote micro tunneling to drill and install the new HDPE piping beneath the San Elijo Lagoon, the North County Transit District (NCTD) railroad, and Pacific Coast Highway. The drilling began at a launching site at San Elijo State Beach, shown on Figure 2, near the existing ocean outfall. The pipe descends to a depth of 70 feet below grade before ascending to a receiving site at the Facility for final connectivity.

Figure 1 San Elijo Outfall Map

Figure 2 Land Outfall Launch Site

2.2 Ocean Outfall

First constructed in 1965, the ocean outfall consisted of 30-inch diameter reinforced concrete pipe (RCP) and extended approximately 4,000 feet into the ocean before discharging. Along the original 30-inch section are five portholes equipped with cathodic protection.

In 1974, the outfall was extended to a water depth of 150 feet below the Mean Lower Low Water (MLLW), approximately 8,000 feet offshore using 48-inch diameter reinforced concrete pipe. The diffuser ports in the original 30-inch diameter line were blocked with fiberglass covers at the completion of the extension. Effluent is presently discharged through a single 1,176-foot long diffuser section that is composed of two hundred 2-inch nominal diameter diffuser ports at the end of the 48-inch extension.

Throughout the life of the ocean outfall, several projects were implemented to keep the outfall in stable, clean, and efficient operating condition. The projects included several ballasting and reballasting projects, pile supports for the inshore portion of the outfall, and cathodic protection.

For the numerous ballasting projects, 4-inch quarry rock, pile support assemblies, and rip-rap were installed to stabilize the pipe. Because beach sediment erosion has occurred all along the southern California coast, pile support assemblies were installed in 1993 on the inshore portion of the outfall for increased stabilization.

In 1993, 35 pile support assemblies were installed on the inshore portion of the original 30-inch outfall for further support and to prevent movement and cracks or defects. The supports were driven through the sand and into the underlying bedrock on both sides of the pipe and were secured around the pipe with bolted clamps.

To protect the piles from corrosion, anodes were clamped to the pile boxes to provide cathodic protection. The pile supports are surveyed approximately every year, and the amount of remaining life for each anode is recorded.

Section 3

EVALUATION PROCEDURE AND SUMMARY

3.1 Land Outfall

As mentioned in Section 2, the HDPE land outfall was constructed beneath the San Elijo lagoon, so no visual inspection was performed prior to pullback. During installation, the pipe was fused by welding the ends of the pipe together as it was pulled into the drilled tunnel. Each weld was inspected prior to insertion, with no defective welds identified. Before being put into service, the new land outfall had to pass pressure testing, per the design engineer's requirements. As a result, the land outfall was pressure tested with air for 4 hours, at a pressure of 80 pounds per square inch (psi). To identify leaks, joints were covered with soapy water. None were found, meaning the new land outfall passed the initial pressure test. Pressure test data of the land outfall can be found in Appendix A. Due to the recent construction, inspection, and successful pressure tests of the land outfall, the pipe is in good operating condition and at the beginning of its useful life.

3.2 Ocean Outfall

In late August and early September of 2019, MTS completed several dives to inspect the ocean outfall from the end cap to where burial begins close to shore. The divers used video recording equipment to record both the northern and southern sides of the ocean outfall.

This section summarizes the divers' findings and the condition of the ocean outfall. MTS' full report can be found in Appendix B.

3.2.1 Evaluation Equipment

MTS used a 22-foot aluminum survey vessel, shown on Figure 3, to perform their dives and inspect the ocean outfall. For each dive, the vessel launched from the Oceanside Harbor and transported the dive equipment to the dive site. The dive equipment included rebreathers for the two-person dive team and handheld video cameras for each side of the pipeline. The divers used a Nikon COOLPIX AW130 camera and a GoPro digital camera. After each dive, the dive equipment was inspected to ensure it was working properly.

Figure 3 MTS Dive Vessel

3.2.2 Areas of Inspection

The dives focused on the overall condition of the ocean outfall and on surveying signs of exposed concrete spalling, cracks or other deficiencies, leaks, joint integrity, and other hazards. The inspection included a pile support survey, cathodic protection evaluation, porthole inspections, pipe joint inspection, and diffuser port inspection.

3.2.2.1 General Inspection

General inspection of the ocean outfall consisted of visual examination of the exposed sections of the RCP. The visible portions were in good condition and showed no signs of spalling or other deficiencies. All observed joints were in alignment and showed no signs of leaking.

Growth of marine plants and animals on artificial surfaces is a common occurrence when they are submerged for an extended period of time. Although some evidence of marine growth was found, it was minimal and not believed to affect the outfall piping. Figure 4 shows a portion of the outfall pipe showing signs of marine growth.

Figure 4 Marine Growth on Joint and Piping

3.2.2.2 Ballasts

The ocean outfall has undergone several reballasting projects with the most recent reballasting project occurring in 2005. The 2005 project replaced ballast rock that had shifted away from the structure due to ocean currents and wave energy. Upon MTS' 2019 inspection, the ballast rock on the pipeline showed no significant signs of movement since the last reballasting project.

3.2.2.3 Pile Supports

The anodes were recently replaced as part of a preventative maintenance project. Efforts were made to uncover buried pile supports and record anode life. However, only 5 of 35 were able to be recorded. The anodes recorded had an estimated 100 percent anode mass remaining. Readings from this survey and previous surveys can be found in the MTS Report in Appendix B.

3.2.2.4 Porthole Inspection

The original 30-inch section of the ocean outfall has five potholes that consist of a circular Ni-resist plate bolted to a flanged riser. Ni-resist is a type of cast iron alloy specified for handling salt solutions and is corrosion resistant. For this type of alloy, a neoprene gasket creates a seal between the cover and the flange, and the portholes have anodes to protect exposed metal surfaces from corrosion.

All portholes and anodes were visually inspected and were found to be in good condition. Cathodic protection readings were taken, all having an estimated remaining anode mass of

60 percent. The portholes showed no signs of spalling, leaks, or fractures. Figure 5 shows Porthole No. 3 and surrounding rock ballast with marine growth.

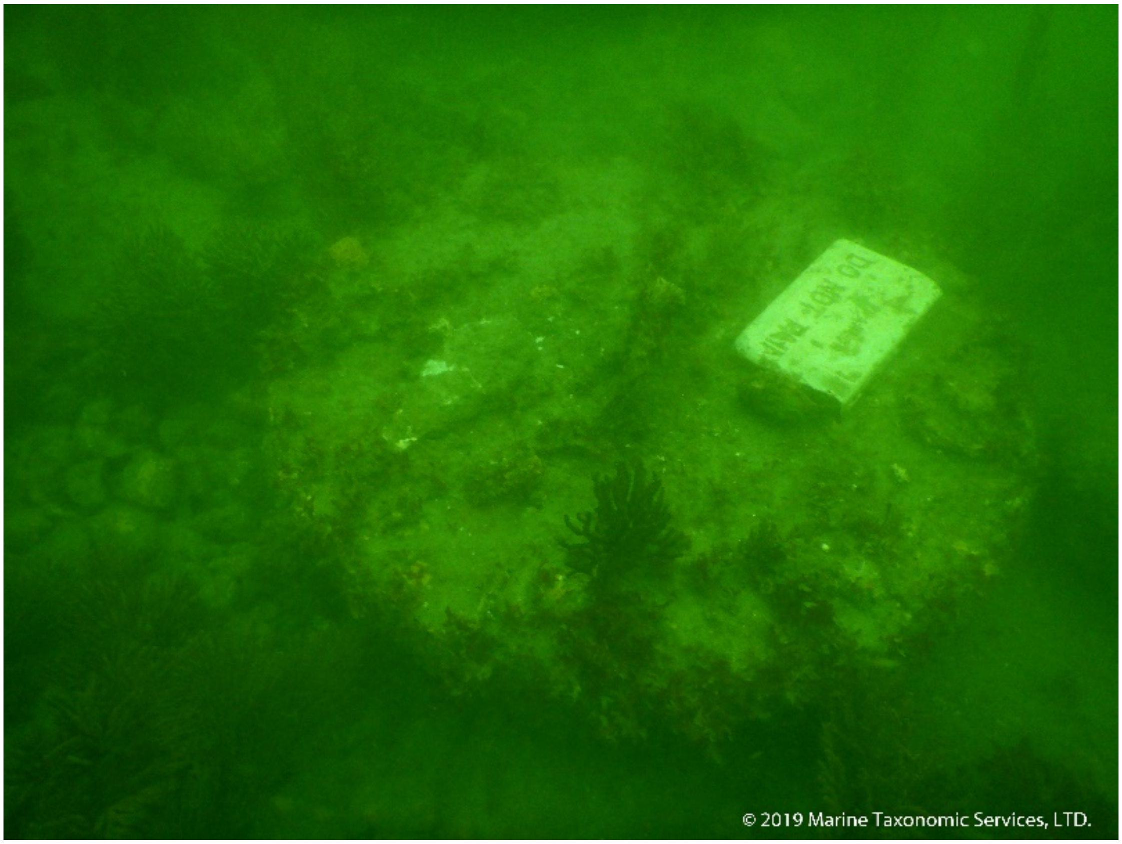

Figure 5 Porthole No. 3

3.2.2.5 Diffusers

The final diffuser section is composed of two hundred 2-inch nominal diameter diffuser ports for effluent discharge. Diffuser holes will often become partially clogged due to growth of marine life. Figure 6 shows an open and clear diffuser port. All diffusers were flowing well, and any marine growth that was found immediately around the diffuser ports was removed.

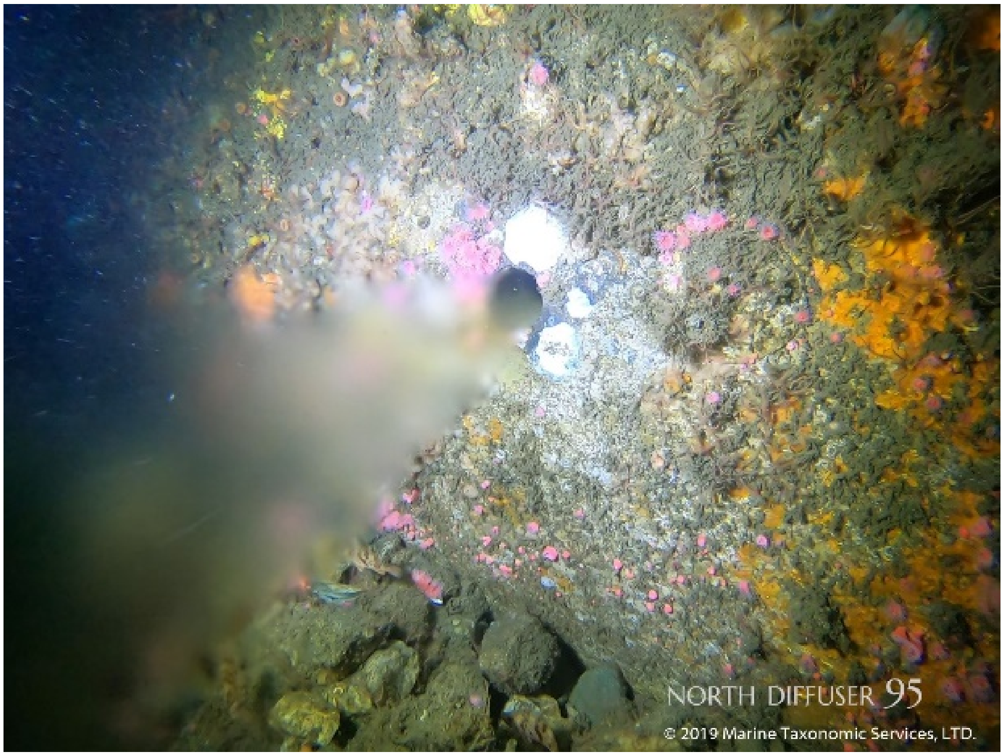

Figure 6 Clear Diffuser Port

Section 4

RECOMMENDATIONS

In general, the ocean outfall was in excellent overall condition, with no signs of corrosion, deteriorating conditions, or concerns of the pipe's integrity. The land outfall portion is new and only recently installed. As a result, it maintains a high integrity.

MTS' report mentioned the following general and specific recommendations for continued structural integrity and environmentally safe operation of the ocean outfall.

4.1 General Recommendations

- Continue performing "rapid-response" overview inspections after periods of extremely high surf or earthquakes to identify damage and the potential for failure due to scour, high-velocity currents, or major seafloor movements.
- During future inspections, replace anodes when they can no longer protect corrosion to pipe and pile structures.
- Continue preventative maintenance and detailed biannual inspections of the entire pipeline using SCUBA, rebreather, and/or remote-operated vehicle (ROV) surveys.

4.2 Specific Recommendations

- Complete a ROV or rebreather-based dive survey of the diffuser section of the outfall pipe as needed to clear any blocked ports.
- Continue to survey for and cut kelp on the pipeline and ballast pile to keep additional ballast from moving away from the pipeline.
- Monitor for re-emergence of all 35 pile support structures, complete structural inspection of anodes, and add them once they re-emerge from the littoral sands. The anodes seem to be exposed the most in the winter months.

Appendix A
LAND OUTFALL PIPE TESTS

PIPE PRESSURE TEST

Line Service Description: 10" Dual Force Mains	Pressure Test Date: 01/19/18 ☑ Initial Test ☐ Retest
Pipe Size & Material: 10" PVC/fPVC	Reference Dwgs:
Test Duration: ☑ 4 hrs. ☐ 2 hrs. ☐ 15 min.	Test Medium: Water
Max System Operating Pressure:	Test Pressure: 60psi

Test Start Time:	Test End Time:	Test Start Pressure:	Test End Pressure:
7:15	11:15	62 psi	62 psi

Comments & Notes:

Line was pressurized at 1430 pm on 1-18-2018.
Pressure was maintained over night with no decrease.

		Name (Print)	Signature
Test Performed By:	J.R. Filanc	Luis Rubio	[signature]
Witnessed & Accepted by:	B&V	Zak Sh[illegible]	[signature]

TEST MEDIUM	Pipe Material /Service	TEST PRESS (psi)	TIME (hr)
Water	DIPB	150	4 hr
	DIPF	150	4 hr
	PVC-1	200	4 hr
	PVC-4	100	4 hr
	Force Mains (Based of Pump Curve_per RFI 019)	60	4 hr
	HDPE	80	4 hr
Air	HDPE	80	4 hr

PIPE PRESSURE TEST

Line Service Description OUTFALL	Pressure Test Date: ☑ Initial Test ☐ Retest
Pipe Size & Material: 30" HDPE	Reference Dwgs:
Test Duration: ☑ 4 hrs. ☐ 2 hrs. ☐ 15 min.	Test Medium:
Max System Operating Pressure:	Test Pressure: 80 PSI

Test Start Time:	Test End Time:	Test Start Pressure:	Test End Pressure:
10:17 A.M.	02:17 P.M.	80 PSI	81 PSI

Comments & Notes:

Clear and sunny for duration of test. No visible leakage of air during "soaping" of joints. Pressure increased slightly during test.

		Name (Print)	Signature
Test Performed By:	J.R. Filanc	AARON RAMIREZ	[signature]
Witnessed & Accepted by:	B&V	Lafe Shaw	[signature]

TEST MEDIUM	Pipe Material	TEST PRESS (psi)	TIME (hr)
Water	DIPB	150	4 hr
	DIPF	150	4 hr
	PVC-1	200	4 hr
	PVC-4	100	4 hr
	fPVC		4 hr
	HDPE	80	4 hr
Air	HDPE L.S. A.R.	80	4 hr

PIPE PRESSURE TEST

Line Service Description 30" OUTFALL (HDD Portion)	Pressure Test Date: 02-07-18 ☑ Initial Test ☐ Retest
Pipe Size & Material: 36" HDPE	Reference Dwgs:
Test Duration: ☒ 4 hrs. ☐ 2 hrs. ☐ 15 min.	Test Medium: HYDROSTATIC
Max System Operating Pressure:	Test Pressure: 80 psi (84 psi L.S)

Test Start Time:	Test End Time:	Test Start Pressure:	Test End Pressure:
11:00 Am	03:00 Pm	84 PSI	84 PSI

Comments & Notes:

		Name (Print)	Signature
Test Performed By:	J.R. Filanc	AARON RAMIREZ	
Witnessed & Accepted by:	B&V	Lafe Shaw	

TEST MEDIUM	Pipe Material	TEST PRESS (psi)	TIME (hr)
Water	DIPB	150	4 hr
	DIPF	150	4 hr
	PVC-1	200	4 hr
	PVC-4	100	4 hr
	fPVC		4 hr
	HDPE	80	4 hr
Air	HDPE	80	4 hr

J.R. FILANC CONSTRUCTION COMPANY, INC.

FILANC

SAN ELIJO OUTFALL REPLACEMENT PROJECT

PIPE PRESSURE TEST

Line Service Description 10" Pressure relief line Escondido	Pressure Test Date: 3-15-2018 ☑ Initial Test ☐ Retest
Pipe Size & Material: 10" PVC C-900	Reference Dwgs: C-5
Test Duration: ☒ 4 hrs. ☐ 2 hrs. ☐ 15 min.	Test Medium: Water
Max System Operating Pressure:	Test Pressure: 110 psi

Test Start Time: 10:00am	Test End Time: 1410	Test Start Pressure: 110 psi	Test End Pressure: 110 psi
Comments & Notes:			

		Name (Print)	Signature
Test Performed By:	J.R. Filanc	Aaron Ramirez	[signature]
Witnessed & Accepted by:	B&V	Lafe Shaw	[signature]

TEST MEDIUM	Pipe Material	TEST PRESS (psi)	TIME (hr)
Water	DIPB	150	4 hr
	DIPF	150	4 hr
	PVC-1	200	4 hr
	PVC-4	100	4 hr
	fPVC		4 hr
	HDPE	80	4 hr
Air	HDPE	80	4 hr

J.R. FILANC CONSTRUCTION COMPANY, INC.

SAN ELIJO OUTFALL REPLACEMENT PROJECT

FILANC

PIPE PRESSURE TEST

Line Service Description 30" HDPE from 20" reducer at St-5+64 to 30" Butterfly Valve at St ~ 4+10.5		Pressure Test Date: 4-19-2018 ☑ Initial Test ☐ Retest
Pipe Size & Material: 30" HDPE DR11	Reference Dwgs:	
Test Duration: ☑ 4 hrs.+ ☐ 2 hrs. ☐ 15 min.	Test Medium: Hydro test (water)	
Max System Operating Pressure:	Test Pressure: 92 psi	

Test Start Time:	Test End Time:	Test Start Pressure:	Test End Pressure:
7:45am	12:20pm	92psi	92 psi

Comments & Notes:

4" stainless steel saddle spool was not tested

		Name (Print)	Signature
Test Performed By:	J.R. Filanc	Jaime Sanchez	[signature]
Witnessed & Accepted by:	B&V	Lafe Shaw	[signature]

TEST MEDIUM	Pipe Material	TEST PRESS (psi)	TIME (hr)
Water	DIPB	150	4 hr
	DIPF	150	4 hr
	PVC-1	200	4 hr
	PVC-4	100	4 hr
	fPVC		4 hr
	HDPE - 30"	~~80~~ 92	4 hr
Air	HDPE	80	4 hr

Appendix B

MTS 2019 ANNUAL INSPECTION REPORT

San Elijo Ocean Outfall
2019 Annual Inspection Report

Prepared for Carollo Engineering
Walnut Creek, CA

August 2019

Prepared By:
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CONTENTS

FIGURES

PROJECT SUMMARY

Marine Taxonomic Services, Ltd. (MTS) performed the Year 2019 San Elijo Ocean Outfall annual inspection at the request of Carollo Engineering in early August 2019. MTS is an environmental consulting firm committed to providing innovative solutions to help our clients create valuable scientific knowledge while promoting growth in a sustainable manner. MTS provides its clients with a full range of services in marine environments along with technical dive and inspection services. The inspection involved diver examination of the outfall from the end cap to burial at shore, evaluation of exposed portholes, evaluation of cathodic protection at exposed anodes, a pile support survey, diffusor section survey, and photos at every exposed pipe joint.

Photo and video documentation were collected along the entire outfall. The purpose of the inspection was to look for evidence of spalling of the exposed concrete surfaces, cracks or other signs of wear or degradation of the outfall structure. This includes inspecting joint integrity for leaks or evidence of degradation, inspecting diffuser flow, evaluating for other potential hazards and checking attrition or the loss of efficacy of the pipe ballast material.

In general, the San Elijo Ocean Outfall was found to be in excellent overall condition. All areas of the pipeline were stable and the ballast showed no signs of movement based on the diver survey. The outfall showed no signs of spalling, rust staining, or cracking. Leakage was not detected on the outfall. Anodes on all of the manholes were in good condition and have greater than 50% remaining life expectancy. The pile support section of the outfall was about 3/4 buried with sand. All exposed metallic structures are currently protected.

FORWARD

The San Elijo Ocean Outfall was commissioned in 1965 to discharge treated effluent from the San Elijo Water Reclamation Facility (formally known as the San Elijo Water Pollution Control Facility). In 1974, the Hale Avenue Resource Recovery Facility was connected to the original outfall structure, and the outfall was extended to its current length of 8,000 feet. Given environmental regulations regarding discharges into marine waters and increasing demands on the infrastructure over the past 4 decades, it has been imperative that the pipeline be maintained and monitored for potential damage. To this end, the San Elijo Joint Powers Authority (SEJPA) has contracted numerous surveys of the outfall pipeline. This report presents the results of the 2019 annual survey performed by Marine Taxonomic Services, Ltd. (MTS). Given the large volume of information collected during previous monitoring events, it would be inappropriate to compile this report without including data and information presented in previous reports. For this reason, some of the language, figures, and data presented in this report originated from previous monitoring reports prepared for the SEJPA. The contribution of numerous individual Thales reports are acknowledged here but are not cited in this document. The reports and their contents are the property of the SEJPA.

INTRODUCTION

Carollo Engineering contracted MTS to complete the Year 2019 San Elijo Ocean Outfall annual inspection. Diving operations were conducted late August through early September 2019. Data analyses immediately followed the field effort. The inspection effort included the following elements:

- General diver overview inspection of the outfall corridor from the end cap to burial inshore attentive to the following criteria: Evidence of spalling of the exposed concrete surfaces, cracks or other deficiencies in the outfall, joint integrity, leaks or evidence of degradation, potential hazards, attrition or the loss of efficacy of the ballast material as a result of physical, biological, or geological processes, scouring of the nearby marine sediments, and manmade debris;
- Inspection of portholes;
- Evaluation of cathodic protection at exposed anodes;
- Clearing kelp that hindered inspection activities or threatened the ballast material;
- Photographic and video documentation; and
- Pile support survey;

Procedures, results, analyses, and implications are reviewed here for all elements comprising this project. This report also contains background information regarding the San Elijo Ocean Outfall and a discussion of oceanographic processes (Appendix A) that could affect its structural integrity. Digital video and still images support written descriptions. Full copies of the video records are included on DVD with this report. Representative photographs are included as Appendix B.

Outfall Configuration

The San Elijo Ocean Outfall carries treated effluent from the San Elijo Water Reclamation Facility and the Hale Avenue Resource Recovery Facility. It is then transported through the outfall and discharged into the ocean; the discharge is approximately one-and one-half miles from shore at an approximate water depth of 150 feet. The general location of the outfall is shown in Figure 1.

Construction of the original San Elijo Ocean Outfall was completed in 1965. It consisted of a 30-inch diameter reinforced concrete pipeline terminating approximately 4,000 feet offshore. Effluent was discharged through two diffuser legs at a water depth of 60 feet below the Mean Lower Low Water (MLLW) datum. In 1974, the outfall was extended to a water depth of 150-feet MLLW, approximately 8,000 feet offshore using 48-inch diameter reinforced concrete pipe. The diffuser ports in the original 30-inch diameter line were blocked with fiberglass covers at the

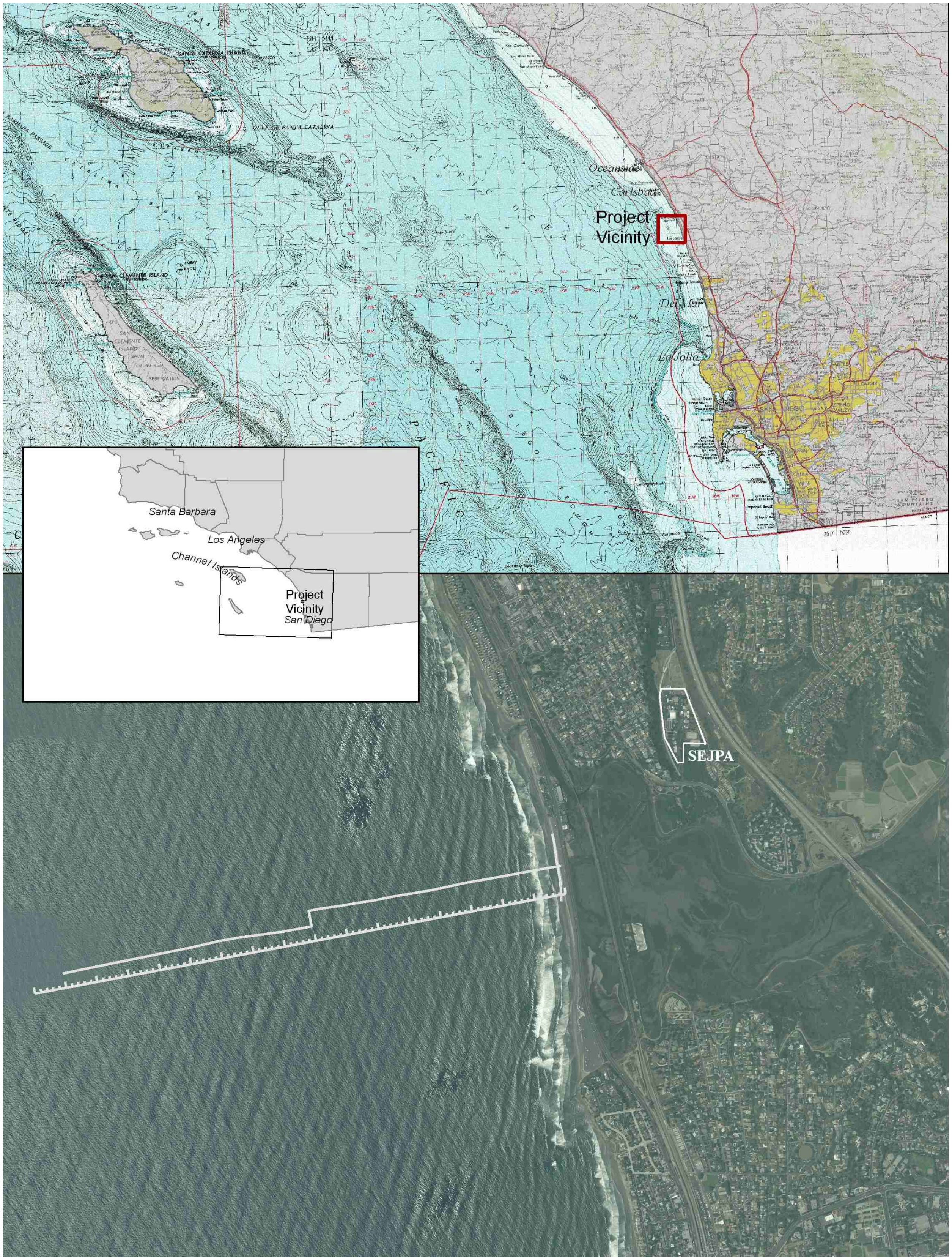


Figure 1. Map displaying San Elijo Joint Powers Authority (SEJPA) location relative to project vicinity.

completion of the extension. Effluent is presently discharged through a single 1,176-foot long diffuser section that is composed of two hundred individual two-inch nominal diameter diffuser ports at the end of the 48-inch extension.

Several projects have been executed to keep the outfall in a stable, clean, and efficient operating condition. Reballasting projects were conducted inshore of the 55-foot isobath in 1982, 1987, 1993, 1996 and 2005 to replace ballast that had been moved away from the outfall by ocean processes. The erosion of beach sediments from the shoreline, which is occurring all along the southern California coast, has caused exposure and undermining of the most inshore portion of the outfall that was previously buried well beneath the beach sand. To secure this vulnerable stretch of pipe, the pipe was clamped to piles driven into the surrounding sediments in the summer of 1992. In late 1993, additional ballast was placed around the pipe between the water depths of 55 and 85 feet. This 1993 reballasting spans the deepest portion of the 30-inch pipe, including the old diffuser section, and the shallow portion of the 48-inch pipe. The new large ballast replenished and augmented the original four-inch quarry rock that was placed around the outfall at the installation of the pipeline. Prior to placing the ballast in 1993, the fiberglass covers that had previously sealed the diffuser ports in the 30-inch leg of the outfall were all replaced by titanium expansion plugs.

The 1996 reballasting project stabilized the inshore zone of the ballast pile where a significant drop in the sand level had caused the ballast to move away from a protective position around the pipe. The zone where the pipeline support transitions from pile/clamp assemblies to rip-rap ballast was significantly enhanced, creating an overlap between the two support systems. In addition, several areas within two hundred feet of this transition that had exhibited low ballast coverage were augmented.

The 2005 reballasting project included the replacement of zinc anodes used to protect metal supports and access ports, replacement of ballast rock that had shifted away from the structure due to ocean currents and wave energy and the cleaning of the diffuser ports at the end of the structure. Construction commenced in September 2005 and was completed by mid-October 2005. More than 7,365 tons of ballast rock was placed along the length of the outfall and the outfall's 200 diffuser ports were cleaned.

METHODS AND MATERIALS

Numerous techniques were incorporated in executing the inspection tasks, which were tactically arranged to maximize diver efficiency. Generally, dive staff worked from deep water to shallow in the interest of maximizing daily bottom time.

Vessel

The MTS marine research vessel, The Koffler (Figure 2), was mobilized for the outfall inspection. The Koffler, a 22-ft aluminum survey vessel, was selected as the diving platform. The vessel was equipped with all essential diving, navigational and inspection equipment.

Figure 2. The Koffler.

Mobilization of the Koffler was completed on August 14th, 2019 at the San Marcos, CA MTS office. The vessel was then transported to and launched at Oceanside Harbor on each day of the survey. After every launching of the survey vessel, all equipment was inspected to ensure that it was in working order.

General Diver Inspection

MTS conducted a general overview inspection of the entire exposed portion of the outfall from the end cap toward shore. During operations, diving staff was attentive to the following criteria:

- Evidence of spalling of the exposed concrete surfaces;
- Cracks or other deficiencies in the outfall;
- Joint integrity;
- Leaks or evidence of degradation;
- Potential hazards;
- Attrition or the loss of efficacy of the ballast materials as a result of physical, biological, or geologic processes;
- Grading of ballast according to size as a result of oceanographic forces;
- Scour of the nearby marine sediments; and
- Man-made debris

General pipeline inspection was achieved by divers with the use of rebreathers. A two-person dive team swam with a hand-held video camera on each side of the pipeline. The divers operated a Nikon Coolpics AW130 and a Go-Pro digital video camera

Porthole Inspection

A visual evaluation was conducted of the exposed surfaces for mechanical/structural integrity including examination for leaks, fractures, gasket seal integrity, concrete spalling, etc. The sacrificial anodes were inspected for signs of unusual degradation. There are five portholes along the original 30-inch diameter portion of San Elijo Ocean Outfall. These portholes consist of a circular, Niresist plate bolted to a flanged riser. A 5/16-inch thick gasket, composed of neoprene, creates a seal between the cover and the flange. Sacrificial zinc anodes provide cathodic protection to the exposed metallic surfaces of the porthole covers and risers. All portholes were inspected and are in good condition. Most of porthole 4 and 5 were covered by a one-foot thick layer of gravel and shell hash that has sluffed down from the adjacent ballast rock placed in 1993. We move enough away to inspect the entire cover, anode, and cathodic protection.

Pile Support Survey

In 1993, thirty-five pile-support assemblies were installed around the pipe between stations 4+41 and 9+69. Piles were driven through the sand to underlying bedrock on both sides of the pipe. Clamps between each pair of pile supports were bolted securely around the pipe and grouted to the piles in pile boxes. Anodes were welded to the pile boxes to provide cathodic protection to the metallic clamps and the piles. In 2005 additional anodes were clamped onto exposed pile supports but broke loose because of poor construction. Roughly each year broken or exhausted anodes are replaced. A complete visual inspection of the five exposed pile supports and metal pipe shield were inspected as well. These piles and the metal pipe shield adjacent to support #35 were all surveyed and found to be cathodicaly protected and the anodes with enough life expectancy to last through the next biannual survey. The anodes were new and at 100% weight in August 2019 from an anode replacement project.

RESULTS

General Diver and Deep Inspection

During this present inspection, a visual examination of San Elijo Ocean Outfall's reinforced concrete pipeline could only be completed on exposed portions. The condition of the visible portions of the pipeline was generally found to be good. There was no evidence of spalling, cracking or other deficiencies in the concrete pipe. All observed joints were in alignment with no evidence of leaks. There were minimal debris items that could potentially affect the pipeline. A few lobster pot ropes were removed as well as line tangled on and around the end cap. Biofouling, or the undesirable accumulation of microorganisms, plants and animals on artificial surfaces, of the deeper pipeline sections was minimal and not expected to have an impact on the pipeline. No Kelp was found growing on the pipeline or ballast. Finally, there was no evidence of oceanographic impacts to marine sediments or ballast along the pipeline.

Porthole Inspection

All portholes were inspected. Visual inspection of the portholes revealed the portholes and associated zinc anodes to be in fair to good condition (Figure 3). There were no signs of concrete spalling, leaks, or fractures. Cathodic protection (CP) readings on zinc anodes were also conducted. Data from the 2019 survey, as well as for CP readings from the previous three years of surveys, are presented in Table 1.

Figure 3. Porthole cover with zinc with approximately 60% remaining life expectancy.

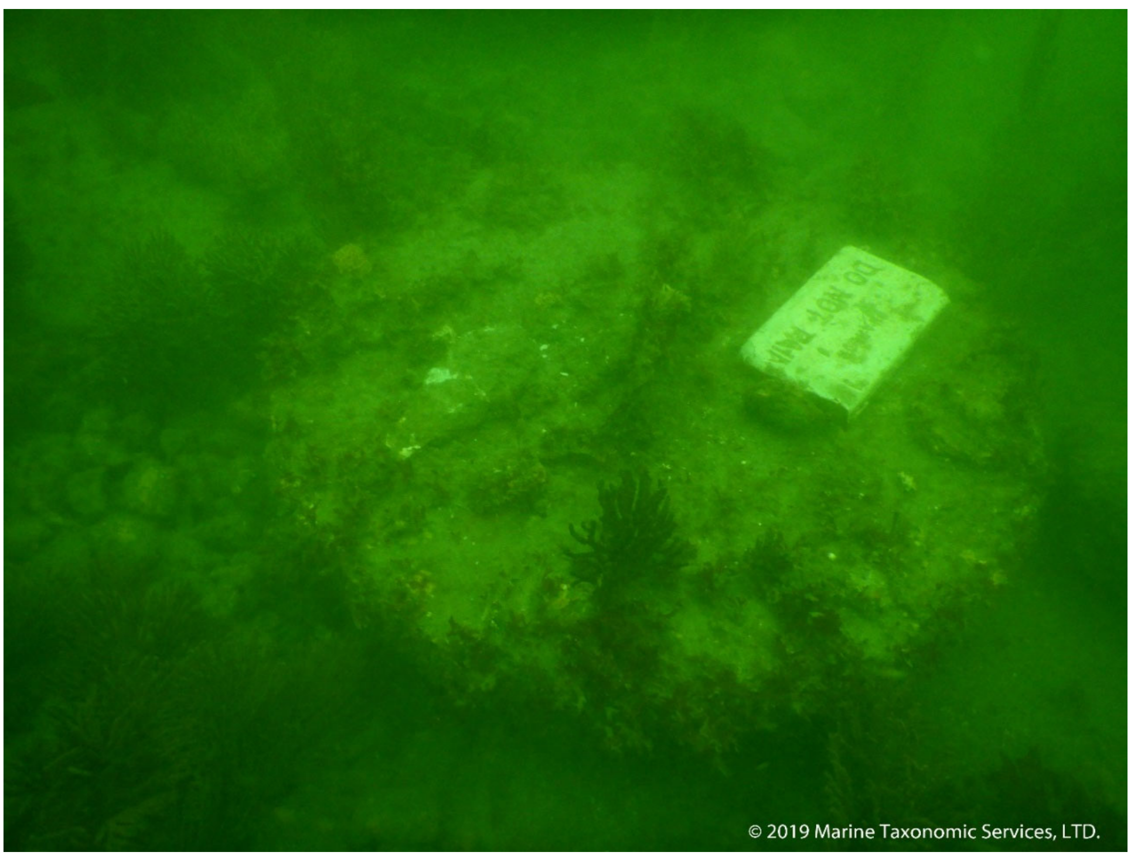


Table 1. Cathodic protection (CP) readings and associated % estimated remaining anode mass results from the 2016-2019 porthole surveys. Readings were not taken in 2018.

Porthole #	2016		2017		2019	
	CP VDC	% Estimated Remaining Anode Mass	CP VDC	% Estimated Remaining Anode Mass	CP VDC	% Estimated Remaining Anode Mass
1	-1.130	>60%	-1.035	>50%	-0.957	>60%
2	-0.980	>60%	-1.025	>50%	-0.941	>60%
3	-1.040	>60%	-0.993	>50%	-1.011	>60%
4	-0.970	>60%	-	-	-0.975	>60%
5	-0.950	>60%	-	-	-0.970	>60%

Pile Support Survey

Efforts were made to locate pile supports that were partially exposed, pile supports were recorded unless buried. Cathodic protection (CP) reading data from the 2019 survey, as well as for CP readings from the previous three years of surveys, are presented in Table 2.

Table 2. Cathodic protection (CP) readings and associated % estimated remaining anode mass results from the 2016-2019 pile support surveys. Readings were not taken in 2018.

Pile Support #	2016		2017		2019	
	CP VDC	% Estimated Remaining Anode Mass	CP VDC	% Estimated Remaining Anode Mass	CP VDC	% Estimated Remaining Anode Mass
1	Buried	Buried	Buried	Buried	Buried	Buried
2	Buried	Buried	Buried	Buried	Buried	Buried
3	Buried	Buried	Buried	Buried	Buried	Buried
4	Buried	Buried	Buried	Buried	Buried	Buried
5	Buried	Buried	Buried	Buried	Buried	Buried
6	Buried	Buried	Buried	Buried	Buried	Buried
7	Buried	Buried	Buried	Buried	Buried	Buried
8	Buried	Buried	Buried	Buried	Buried	Buried
9	Buried	Buried	Buried	Buried	Buried	Buried
10	Buried	Buried	Buried	Buried	Buried	Buried
11	Buried	Buried	Buried	Buried	Buried	Buried
12	Buried	Buried	Buried	Buried	Buried	Buried
13	Buried	Buried	Buried	Buried	Buried	Buried
14	Buried	Buried	Buried	Buried	Buried	Buried
15	Buried	Buried	Buried	Buried	Buried	Buried
16	Buried	Buried	Buried	Buried	Buried	Buried
17	Buried	Buried	Buried	Buried	Buried	Buried
18	Buried	Buried	Buried	Buried	Buried	Buried
19	Buried	Buried	Buried	Buried	Buried	Buried
20	Buried	Buried	Buried	Buried	Buried	Buried
21	Buried	Buried	Buried	Buried	Buried	Buried
22	Buried	Buried	Buried	Buried	Buried	Buried
23	-1.010	>70/70%	Buried	Buried	Buried	Buried
24	Buried	Buried	Buried	Buried	Buried	Buried
25	-0.980	>80/80%	Buried	Buried	Buried	Buried
26	Buried	Buried	Buried	Buried	Buried	Buried
27	-0.940	>90/30%	Buried	Buried	Buried	Buried
28	Buried	Buried	Buried	Buried	Buried	Buried
29	-0.910	>70/70% And >20/20%	Buried	Buried	-1.005	100%
30	Buried	Buried	Buried	Buried	Buried	Buried
31	-0.950	>50/50%	-0.0950	>40/50%	-0.991	100%
32	-0.930	>50/50%	-0.0939	>50/50%	Buried	Buried
33	-0.950	>40/40%	-0.950	>40/40%	-1.007	100%
34	Buried	Buried	-1.005	>50/50%	-0.979	100%
35	-1.000	>50/50%	-0.0950	>40/40%	-1.004	100%
Pipe Protection Cowling	-0.890	>40%	-0.872	>30%	-0.960	100%

SUMMARY AND RECOMMENDATIONS

The following points summarize the major findings of this inspection:

- In general, the San Elijo Ocean Outfall was found to be in excellent overall condition.
- Ballast rock on the pipeline showed no significant signs of movement since the last reballasting project.
- The outfall showed no signs of spalling, rust staining, or cracking.
- Anodes were in good condition and have greater than 60% remaining life expectancy where these were visible and could be inspected.
- No Kelp was found growing on the pipeline or ballast.
- The 5 exposed pile supports surveyed during this inspection were found to be completely protected with cathodic protection.
- Barnacle growth and other biofouling was removed around diffusor ports.
- All diffusors were flowing well.

The following items are recommendations for continued structural integrity and environmentally safe operation of the San Elijo Ocean Outfall. Some of the comments made below were mentioned in previous reports, but are included again because they are still valid points.

Specific Recommendations

- Complete a ROV or rebreather-based dive survey of the diffuser section of the outfall pipe as needed to clear any blocked ports.
- Continue to survey for and cut kelp on the pipeline and ballast pile so further ballast is not moved away from the pipeline.
- Monitor for re-emergence of all 35 pile support structures and complete structural inspection and addition of anodes once these re-emerge from the littoral sands. They seem to be the most exposed in the winter months.

General Recommendations

- Continue to perform “rapid-response” overview inspections after periods of extremely high surf or earthquakes in order to identify damage and potential for failure due to scour, high-velocity currents, or major seafloor movements.
- During future inspections, anodes should be replaced when they become ineffective against preventing corrosion to pipe and pile structures.
- Continue preventative maintenance and detailed biannual inspections of the entire pipeline using SCUBA, rebreather, and/or ROV surveys.

APPENDIX A

Important Oceanographic Processes

General Oceanographic Forces and Processes

(Adapted from prior Thales GeoSolutions Pacific, Inc. reports)

Several phenomena within the ocean environment exert a significant influence on the San Elijo outfall and ballast material. These processes include the hydrodynamic forces due to waves, longshore currents, and sediment transport. The arrival of large waves from local or distant storms increases localized water particle velocities, amplifies the effects of these processes and is capable of damaging the outfall. Each of these phenomena will be discussed in general terms and as they might apply to the San Elijo Ocean Outfall.

Waves and Currents

Beneath deep-water waves, water particles move in a circular orbit. The water particle velocity decreases with depth; the maximum depth of wave-induced particle motion is a function of wave height and period. The larger the wave and longer the period, the deeper the effects of the wave are felt in the water column. As a wave advances toward shore and enters shallow water, it begins to experience the effects of friction with seafloor. The frictional interaction of waves with the seafloor modifies the waveform, causing the wave height to increase, the wavelength to decrease, and the circular orbit of the particles to become increasingly elliptical. As each wave progresses into shallower water, it eventually reaches a height where the wave will break, which typically occurs in a depth of water with is nearly 1.3 times the height of the wave. The highest energy release occurs where waves are breaking. It is in this high-energy area that a pipeline is most likely to be damaged during a storm.

In addition to the wave-induced oscillatory particle motion, waves approaching a straight coastline at an angle can generate a steady longshore current. This longshore current is largely responsible for the erosion and longshore transport of sediment. The impact of this current and sediment load directly affects any structure, which could interrupt the current flow. At San Elijo, current is generally southward from November through April due to the arrival of waves generated by persistent north and northwest winds from large North Pacific storm systems. The longshore current direction occasionally reverses itself during the remaining months due to exposure to Southern Hemisphere swell or infrequent tropical storms. Other components of the nearshore current include tidal currents with semi-diurnal reversing of the onshore/offshore and upcoast/downcoast flow, regional oceanic circulation patterns, and currents produced by local winds such as sea breeze or thunderstorms and squalls. The combination of these wave- and current-related forces make the nearshore a very dynamic environment in terms of sediment transport and generating forces with act on costal structures.

Hydrodynamic Forces

Dynamic forces acting on a submerged object are comprised of the direct impact of the water particles against the object, varying hydrostatic pressure as a wave passes, and the lift/drag forces caused by increased fluid velocities over and around the object. Currents generated by waves can cause movement of the entire water mass, which can cause forces similar to a flowing river. The flow over the top of the San Elijo outfall can cause lift forces due to pressure gradients and drag on the pipe in the direction of the current flow. The lift caused by currents, coupled with the increased oscillation lift associated with localized water particle velocities and drag forces, can cause large objects such as ballast rock to move as a wave passes.

Liquefaction

Shock from breaking ocean waves or earthquake surface waves can cause unconsolidated, water-saturated sediments to go into suspension. This process, called liquefaction, results in the sediment losing its shear strength and therefore it ability to support higher density objects. This process causes objects such as ballast rock resting on the liquefied area to settle.

Sediment Scour and Transport

The forces discussed in previous sections apply to sediments as well as to an ocean outfall pipe. Longshore sediment transport and seasonal beach migration (inshore/offshore) occur when the water particle velocity is great enough to suspend sediment particles and transport them in agitated water as suspended-load and bed-load. The suspension and movement of unconsolidated sediments in the water column may result in lower bottom elevation. Eroded sand may or may not be re-deposited at the same level, depending on the resultant mean current and the up-current sediment supply.

Coastal Sediment Transport and Erosion

The transport of sediment parallel to the shore along Southern California beaches is due primarily to the longshore current generated by waves breaking at an angle to the coastline. The majority of the transport occurs within the littoral zone, extending from shore to just beyond the seaward limits of the breaker zone. The Southern California coast can be divided into a series of cells between the natural features of headlands and submarine canyons (Figure 5-1). At a headland or promontory, the upcoast supply of sand is effectively blocked or deflected offshore into deeper water and lost to the system. Similarly, submarine canyons capture the beach sand and channel it offshore into deeper water where it is also permanently lost to beach replenishment.

The local littoral sediment budget determines whether the coast is likely to experience net erosion or deposition. A beach may be considered to be in a state of equilibrium if the longshore transport into a cell or coastal segment equals the transport out of the cell. However, the coast is a dynamic environment with naturally occurring periods of erosion and deposition. Thus, an imbalance in the budget is difficult to predict due to uncertainty in estimating the magnitude of the various sediment sources and losses. The primary sources of beach material are longshore transport from upcoast segments, river transport, sea cliff erosion, onshore transport, dredging, and sand bypass at harbor entrances. The primary losses of beach material are longshore transport out of area, offshore transport, deposition within submarine canyons, accumulations at harbor entrances, and mining. In general, the contribution of sediment from river transport and runoff has been significantly reduced by the construction of dams and reservoirs. Lagoons normally contribute little to the coastal sediment budget and many actually constitute a net sediment loss. River-transported sediments deposited in shallow coastal lagoons are not normally available to nearby beaches unless there is sufficient tidal exchange to suspend and transport sand-size particles. In some instances, tidal currents may carry sediment into a lagoon where it is deposited due to lower velocity. The exception to this may occur after periods of heavy rainfall when the increased flow due to excessive runoff and coastal flooding may flush deposited sediments onto adjacent beaches.

The Oceanside Littoral Cell extends from Dana Point to the Scripps-La Jolla Submarine Canyon, which is a distance of approximately 50 miles. Within this cell, the net annual transport is toward the south due to the prevailing wind and wave direction from the northwest during October/November through April/May. During the summer months, the arrival of swell from Southern Hemisphere or tropical storms can reverse the longshore current, producing periods of northward longshore transport. The estimated annual transport offshore through Scripps-La Jolla Submarine Canyon of 260,000 cubic yards is roughly equivalent to the total littoral transport reaching the adjacent upcoast beach (Chamberlain, 1964). Surveys within the Carlsbad Submarine Canyon concluded that it was not currently an active site of beach material loss. No other canyons affect the Oceanside Littoral Cell.

U.S. Army Corps of Engineers studies have suggested the division of littoral cells into segments or subcells based on the following criteria:

Distinctive sediment characteristics due to natural or man-influenced processes such as beach nourishment programs;
Known natural (lagoons and submarine canyons) or man-made (jetties and breakwaters) barriers to littoral sand transport.

The eight-mile-long costal segment between San Marcos Creek at Batiquitos Lagoon and the San Dieguito River includes the communities of Leucadia, Encinitas, Cardiff and Solana Beach. Based on data from 1954 through 1988, the sea cliffs in this area have retreated an average of approximately 0.1 to 0.2 feet per year. This sediment source contributes relatively small amounts of sand, gravel and cobble to the coastal sediment budget. Analysis of aerial photographs and beach profiles for the 50-year interval from 1938 through 1988 showed a nearly stable shoreline position, indicating a close balance in the sediment budget. The normal seasonal onshore/offshore sediment transport and localized changes near the outfall due to the effects of severe storm events or scour are not reflected in the long-term average.

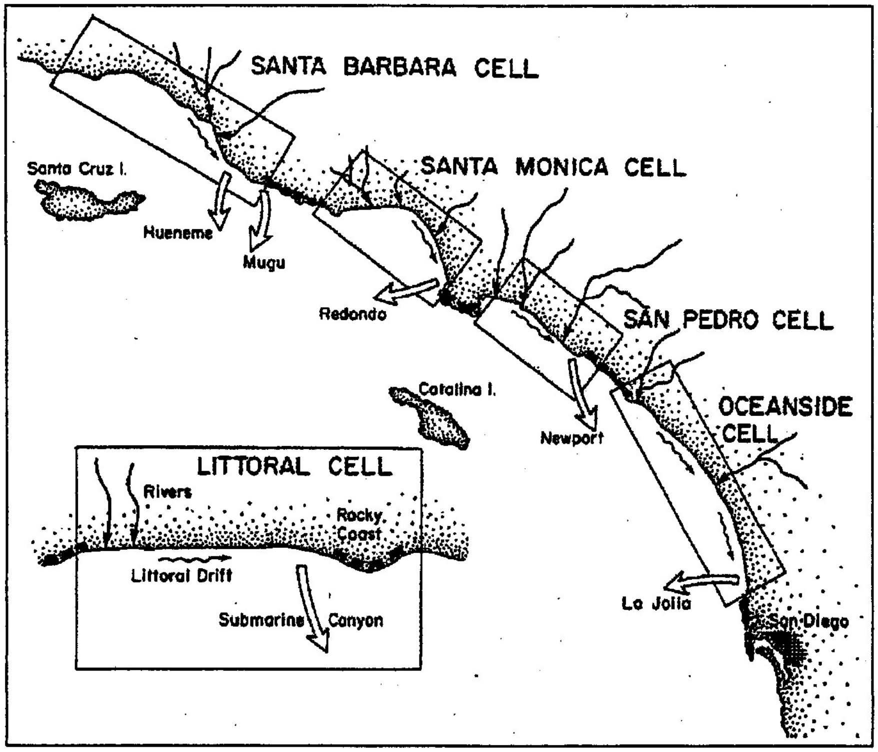


Figure 5-1 Southern California Coast Littoral Transportation Cells

Scour

Depletion of sediment occurs adjacent to offshore structures that have readily transportable sediment near their perimeters. This localized depletion of sediment around an object is called scour. Flow velocity increases as it passes around the edge of a structure, causing a localized increase in the energy proportional to the square of the velocity. This increased energy allows water to transport more sediment and larger size particles. In the case of the San Elijo Ocean Outfall, the sediment typically available for transport is sand. Therefore, at the toe end of a ballast pile, or the outfall terminus, flow passes around stationary or non-transportable material, the area will be more susceptible to scour.

Scour around an outfall can also be noted on a larger scale as differences in bottom elevation of the nearfield sediment distribution around a pipe and ballast pile. On the up-current side of the pipe, the seawater slows down as it approaches the ballast pile and loses some of its energy. As a result, its ability to transport sediment is reduced, thus causing deposition on the up-current side of the pipe. As fluid passes over the pipe and ballast pile it gains energy but not enough to displace correctly designed ballast. As the seawater leaves the down-current edge of the ballast pile, its energy is increased because of the turbulence around the ballast pile and a return to non-deflected flow. This increased energy level enhances the ability to transport sediment. Thus, sediment deposited at the ballast pile is re-suspended and transported away, which results in a lower level of sand on the down-current side. This same phenomenon is typically visible around a jetty where the up-current side experiences buildup of material and the down-current side shows a loss of material.

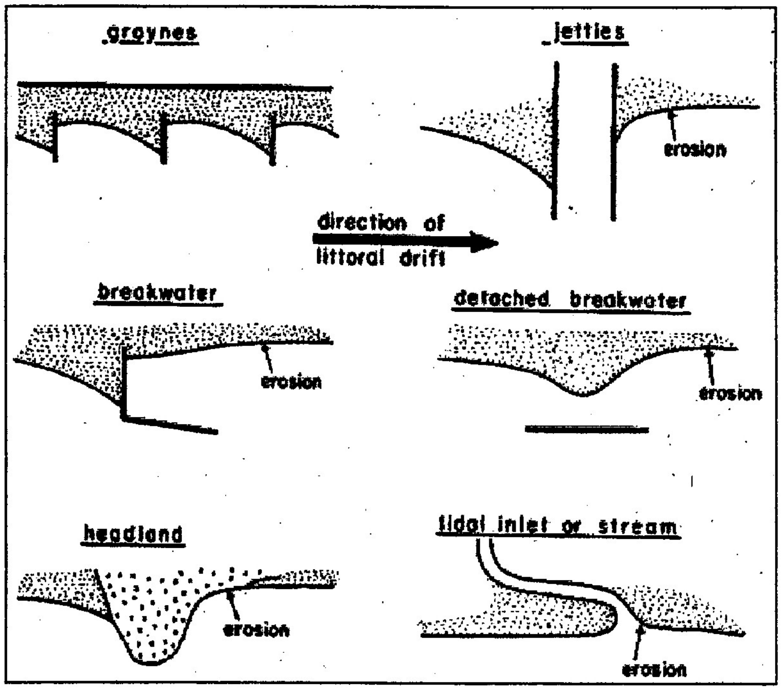


Figure 5-2 Deposition and erosion due to interruption of longshore transport

Scour results in the loss of sand around the toe of the ballast pile, around the pipe, and supporting structures where no ballast exists. Excessive scour can lead to ballast pile setting or collapse and weakened support foundation, which eventually may result in unsupported spans of pipe.

Metallic Corrosion

The galvanic process commonly referred to as corrosion arises when two dissimilar metallic alloys or different areas of the same metal are immersed in an electrolyte (e.g., generally a liquid capable of conducting electricity such as seawater). The connection created between the two metals that has a sufficient voltage potential different to initiate an oxidation reaction. The location of this reaction is known as the anode and is characterized by a negative charge. Once liberated, electrons flow as current through the metallic pathway to a more positively charged region within the cell and begin to generate a reductive reaction at an area known as the cathode.

The circuit is completed by the migration of hydroxide ions from the cathodic region to the anode. The major point of interest is that the rate at which these reactions occur is governed in large part by the rate at which oxygen can be reduced at the cathode. In basic terms, this means that the reduction rate and thus the rate of corrosion are controlled by the amount of dissolved oxygen available in the water column.

Metals immersed in seawater are susceptible to corrosion due to galvanic action, which produces an electrical current in an electrolyte (conducting) solution. Seawater is an electrolyte since it contains a significant percentage of chlorine ions found in solution. More specifically, there are approximately 35 grams of dissolved salt per kilogram of seawater. Sites on the surface of the metal where corrosion or oxidation (electron loss) is occurring are referred to as anodes. The chemical reaction at an anode results in the production of metal ions and free electrons. These electrons pass through the seawater to other sites (referred to as cathodes) where a reaction (electron gain) is occurring. Metal ions can go into solution or react to form corrosion products such as oxides on the surface of the metal, forming the classic reddish-brown rust commonly observed.

All exposed metallic fixtures on the outfall, including the steel pipeline, are susceptible to corrosion. The rate of corrosion can be significantly reduced by attachment of sacrificial zinc alloy anodes. Zinc has a higher corrosion potential than most metals and therefore the resulting loss of material is from the zinc anode and protected parts remain relatively inert.

Kelp Settlement and Growth

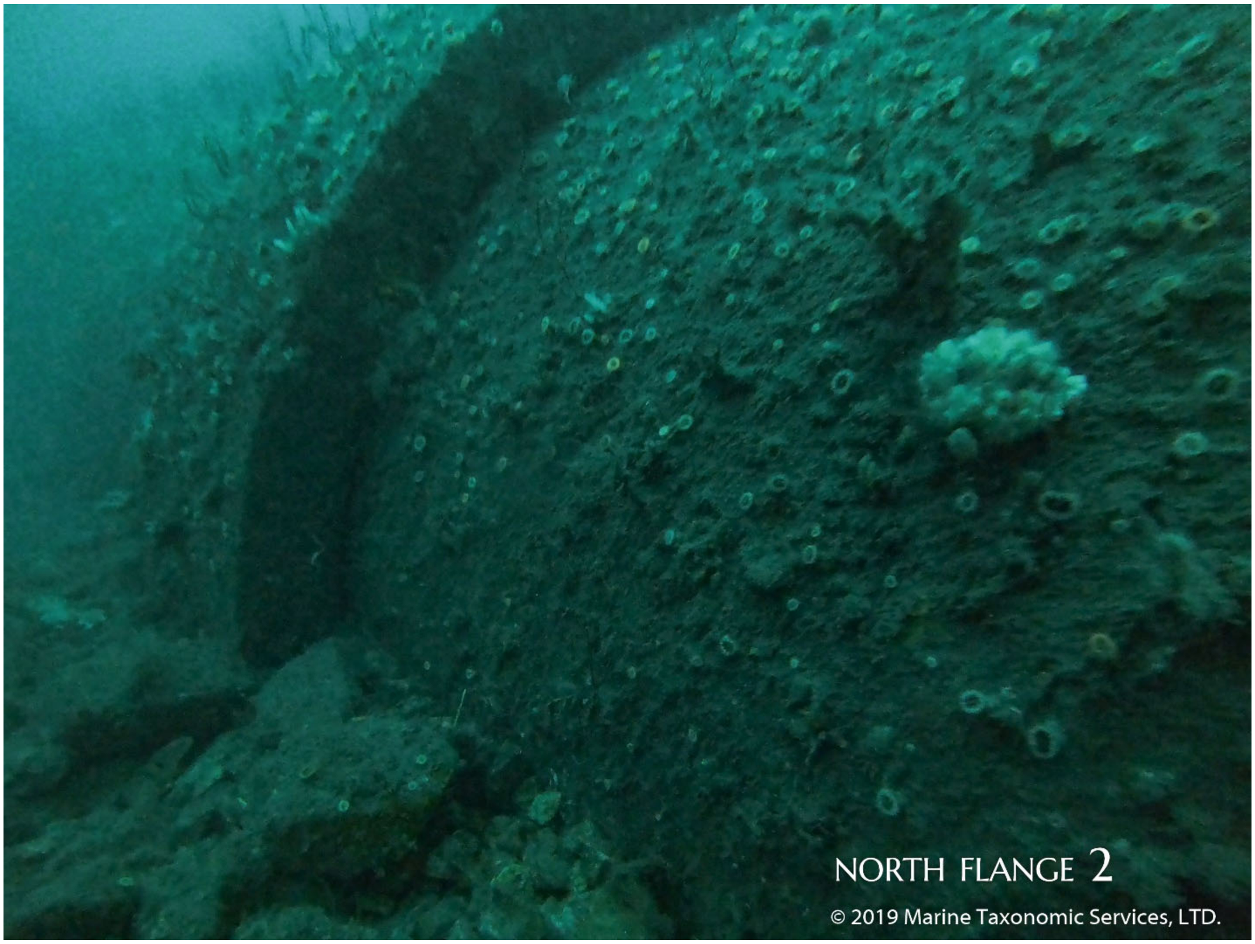
Kelp (*Macrocystis sp*.) is a marine alga, which grows in the Shallow Littoral Zone. It grows on hard substrate such as rocks, boulders, outcrops, concrete, and pipeline ballast rock. Substrate attachment is by means of a rhizome-like base called a holdfast. Under suitable nutrient, light, and thermal conditions, kelp plants grow to lengths in excess of 200 feet, with daily growth rates in excess of one percent of plant size. The major parts of a kelp plant are:

Holdfast – Base that anchors the kelp to the ocean floor;
Stipe – A stem-like section that connects the pneumocysts and blades to the holdfast;
Pneumatocyst – A small, ball-like, gas-filled float between the stipe and the blades, which provides buoyancy;
Blades – Leaflike sections, 0.8 feet to 1.3 feet long and approximately 0.2 feet wide.

Multiple stipes can grow from a single holdfast clump. Kelp has considerable buoyancy and drag potential in the water column.

The entire kelp plant is quite elastic, allowing it to survive high-energy sea conditions. However, under extreme wave and current conditions, a stipe may break and the plant will float away if the stipe elasticity and strength are exceeded by drag forces. Under certain conditions at very low ocean-energy levels, the entire kelp plant, including the holdfast, can be transported away. This occurs when the substrate to which the kelp has attached has insufficient mass to anchor the kelp. Obviously, the smaller the ballast rock, the easier it is for individual kelp plants to carry it away from an outfall. While inspecting San Elijo outfall prior to the most recent reballasting, previous inspectors witnessed kelp growing on small units of ballast in the sand field away from the pipeline. Following reversal of tidal current direction, those same plants were found alongside the pipeline. By this process, a ballast pile can be significantly depleted even during moderate wave conditions if the ballast is not of a suitable size to prevent its removal by kelp drag.

APPENDIX B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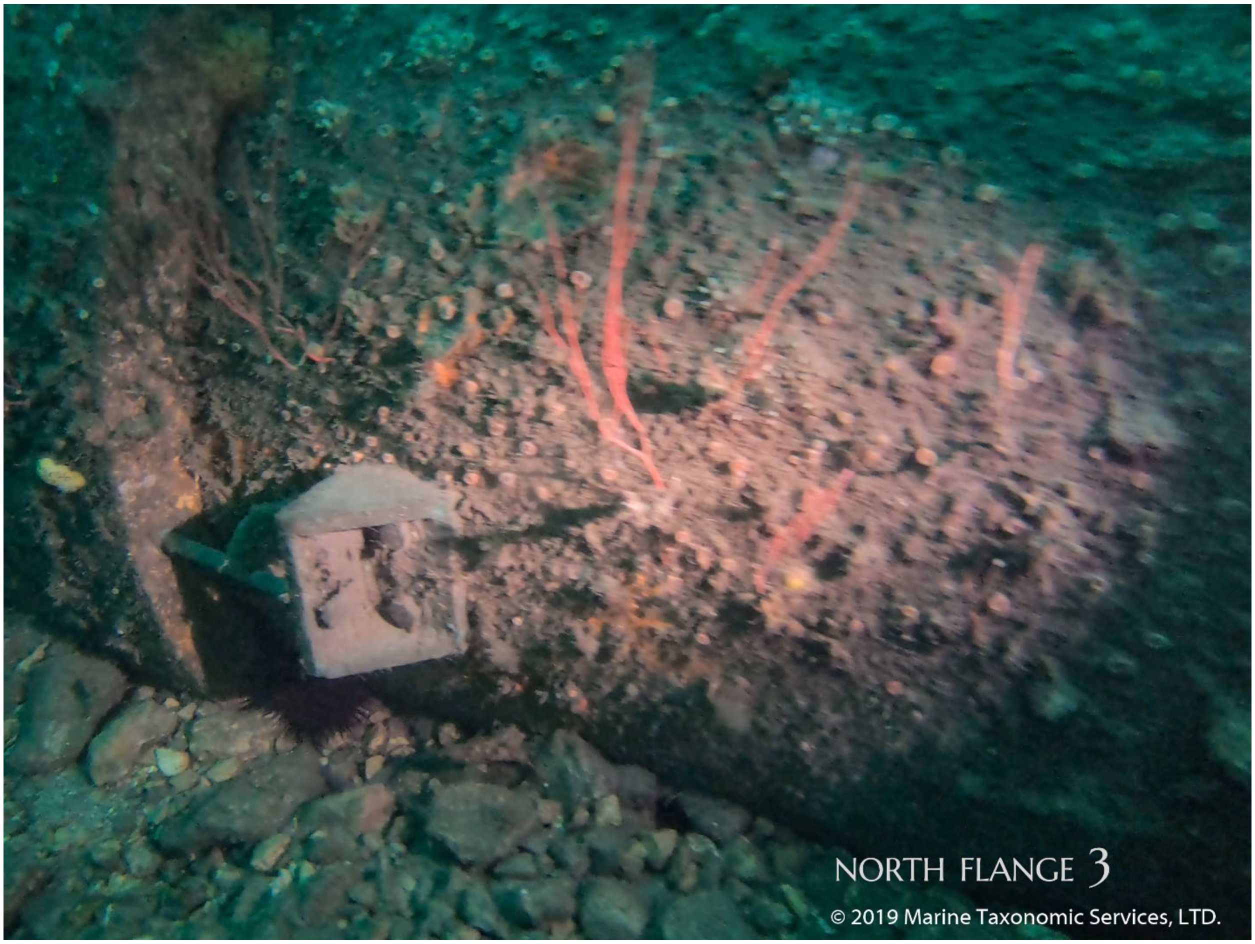
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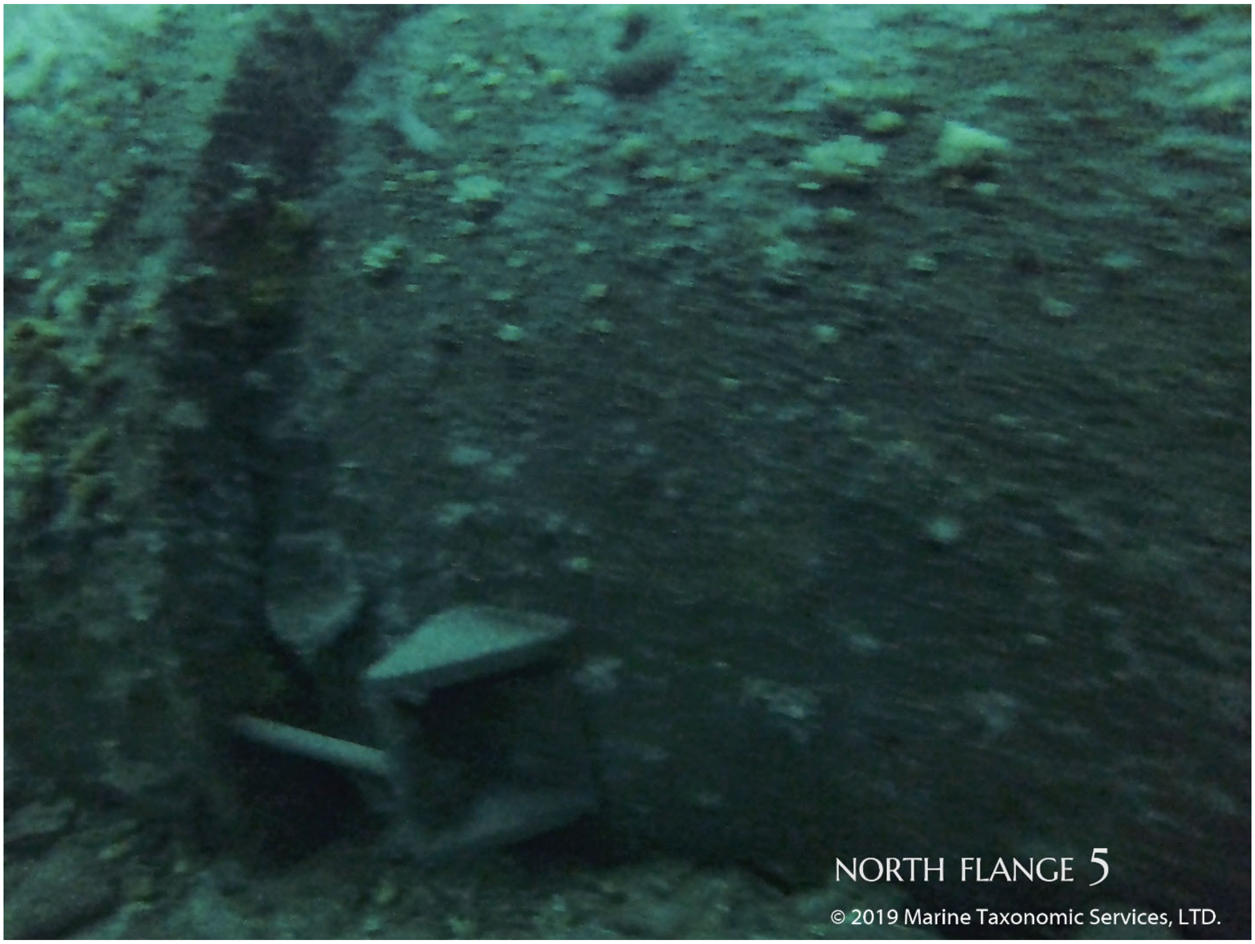
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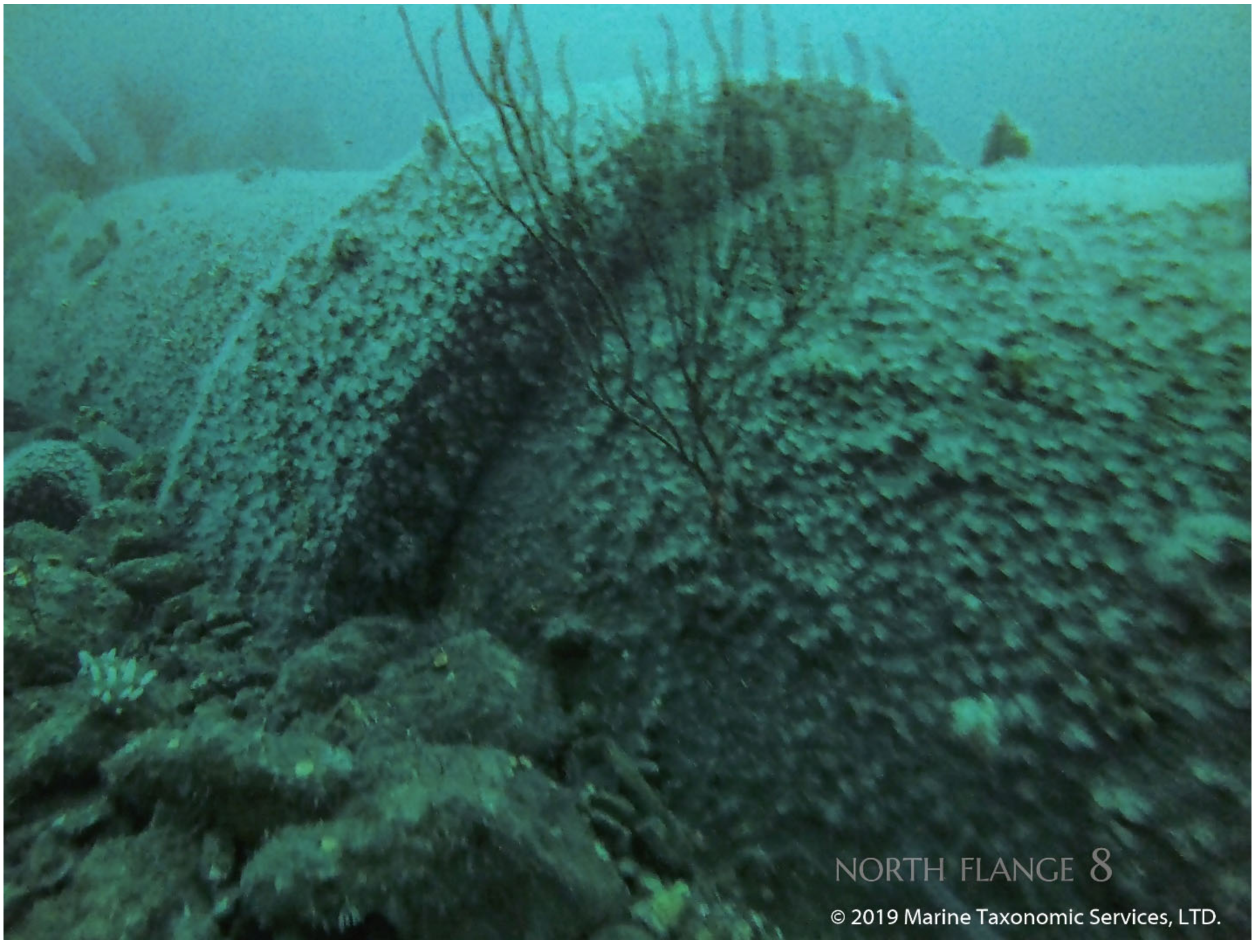
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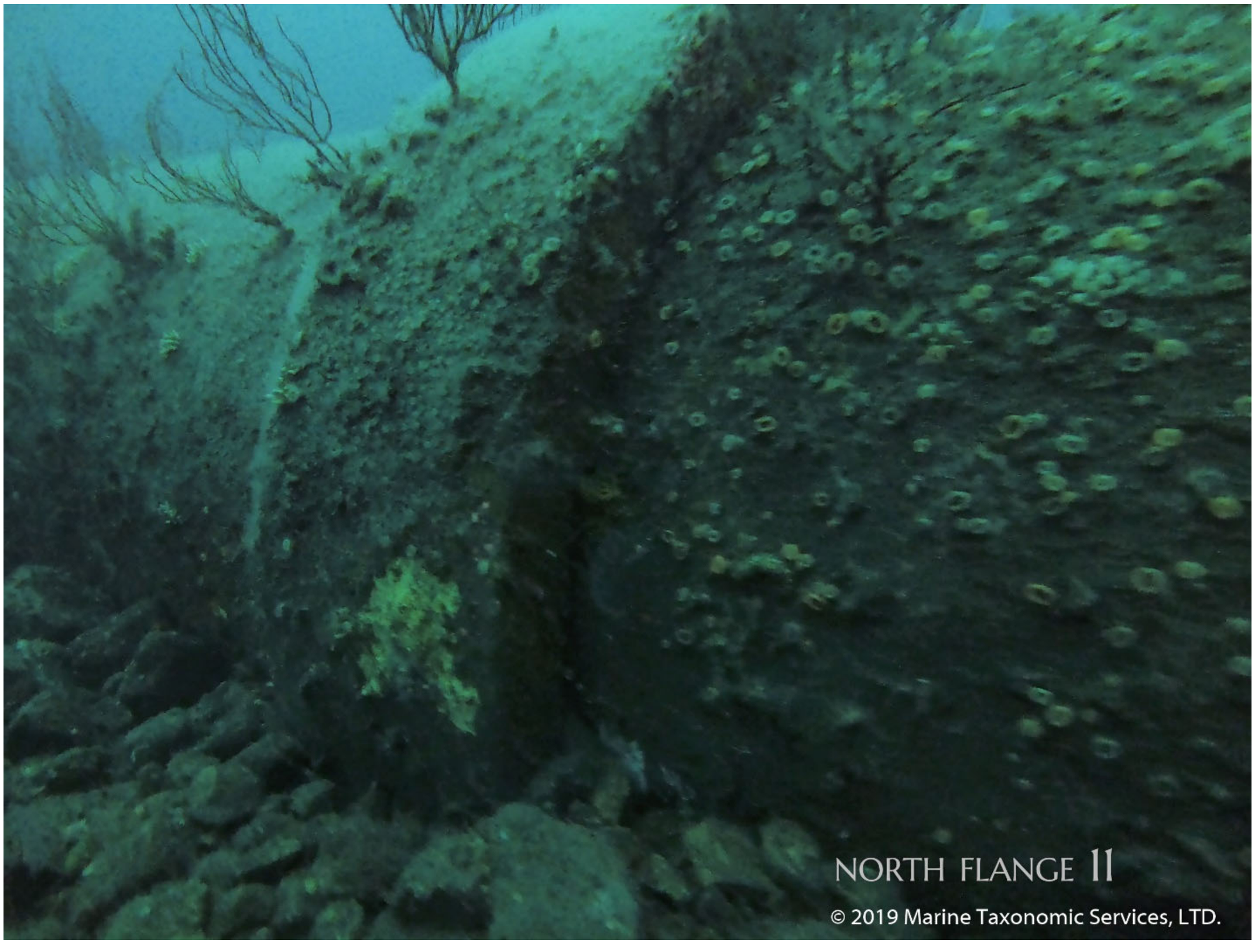
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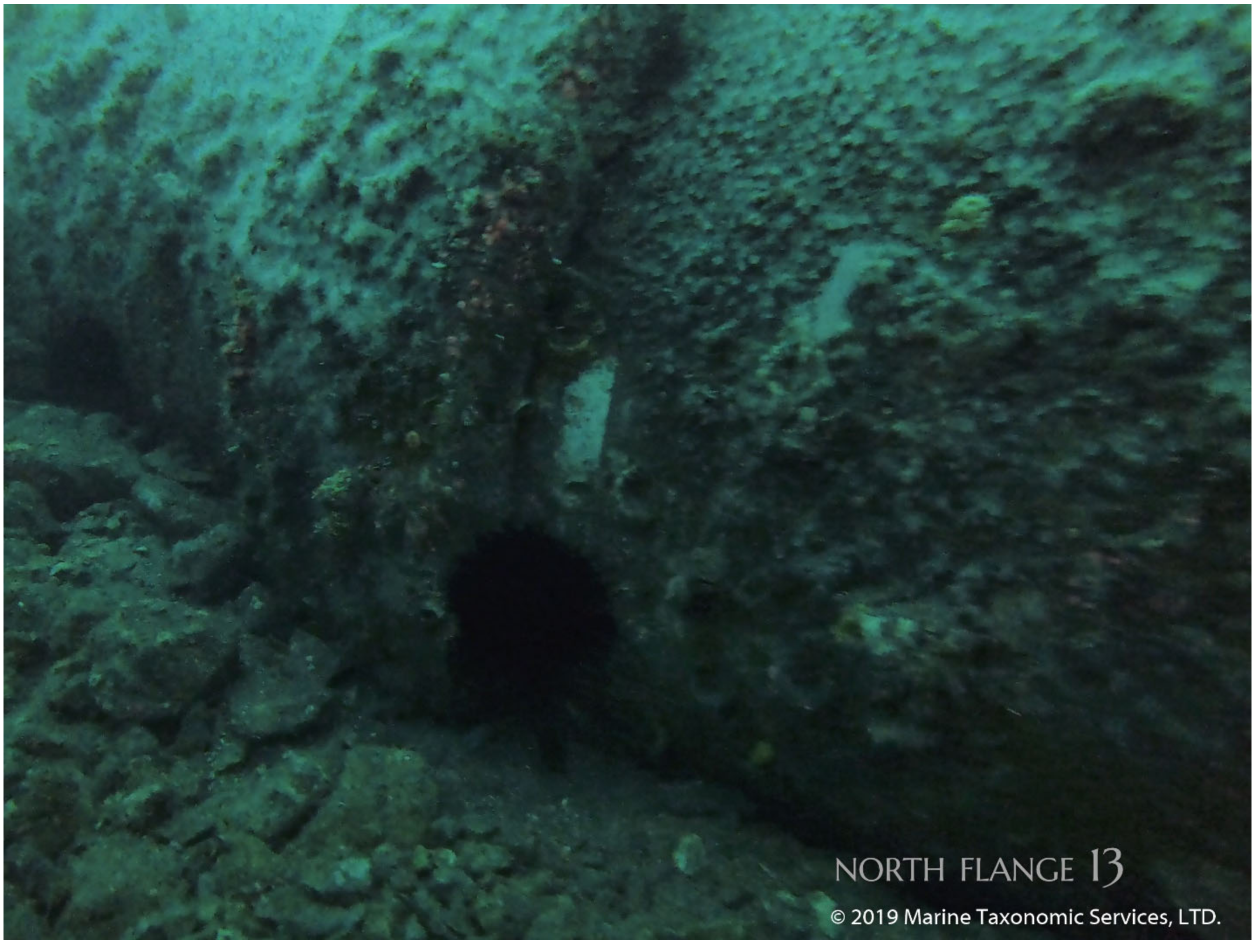
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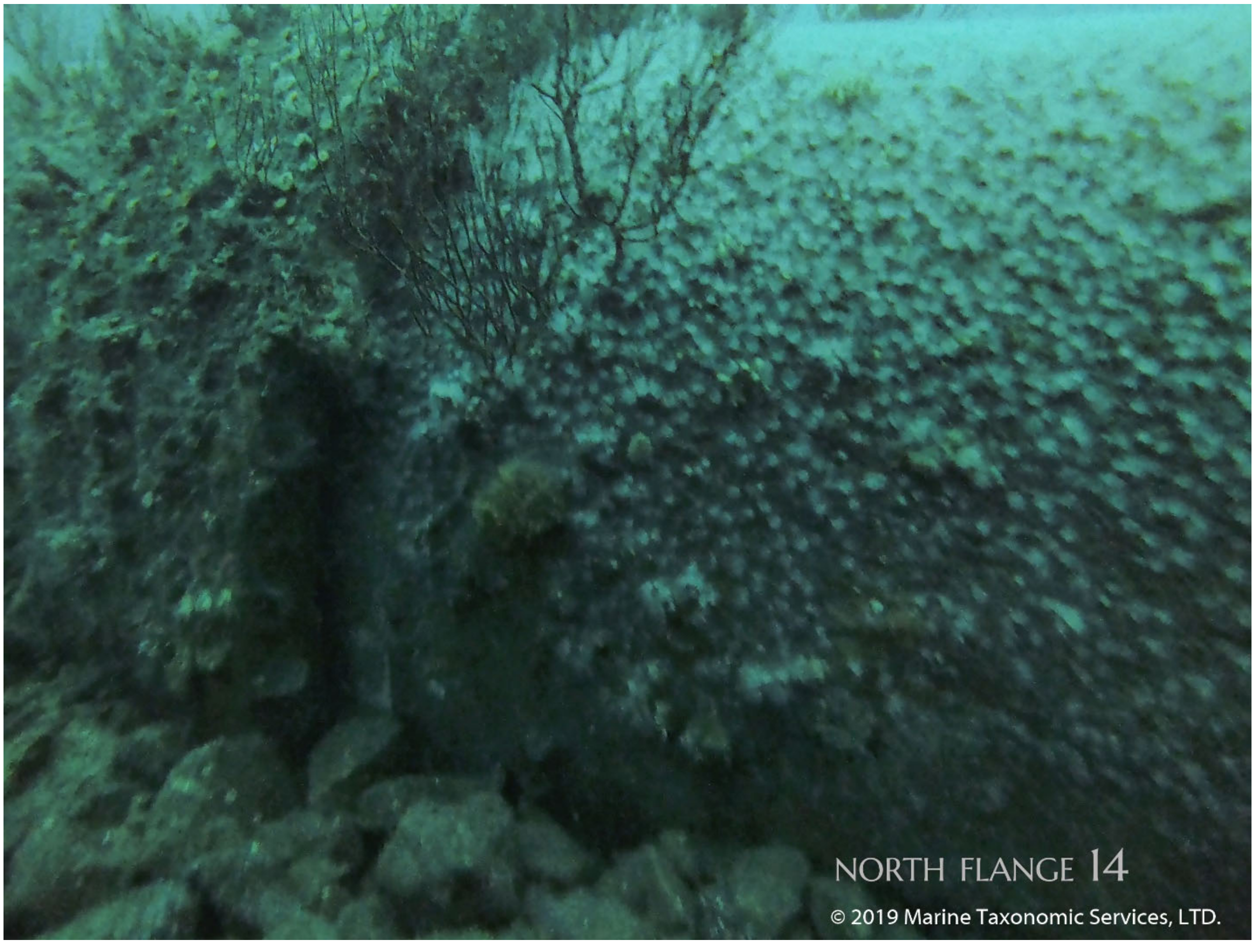
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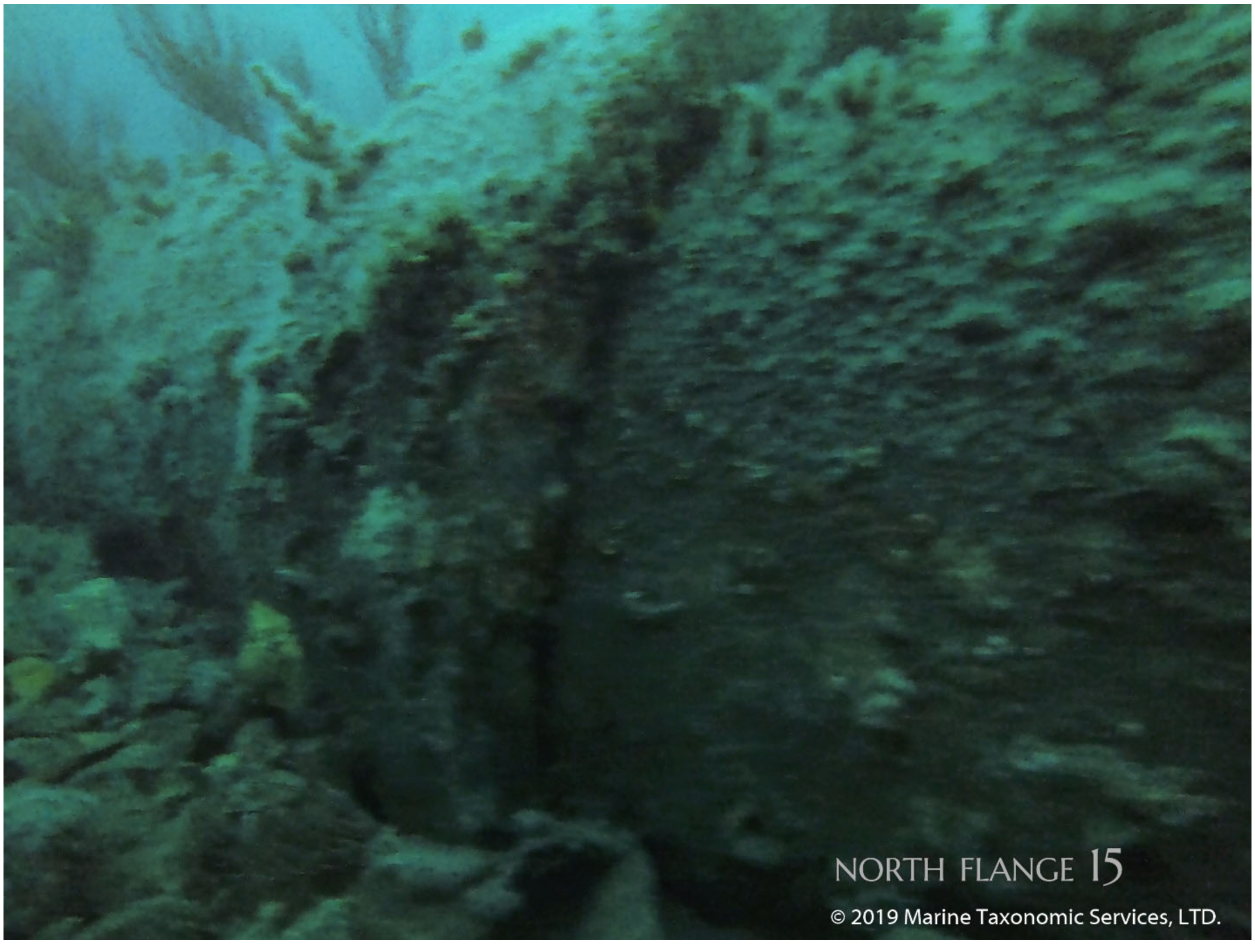
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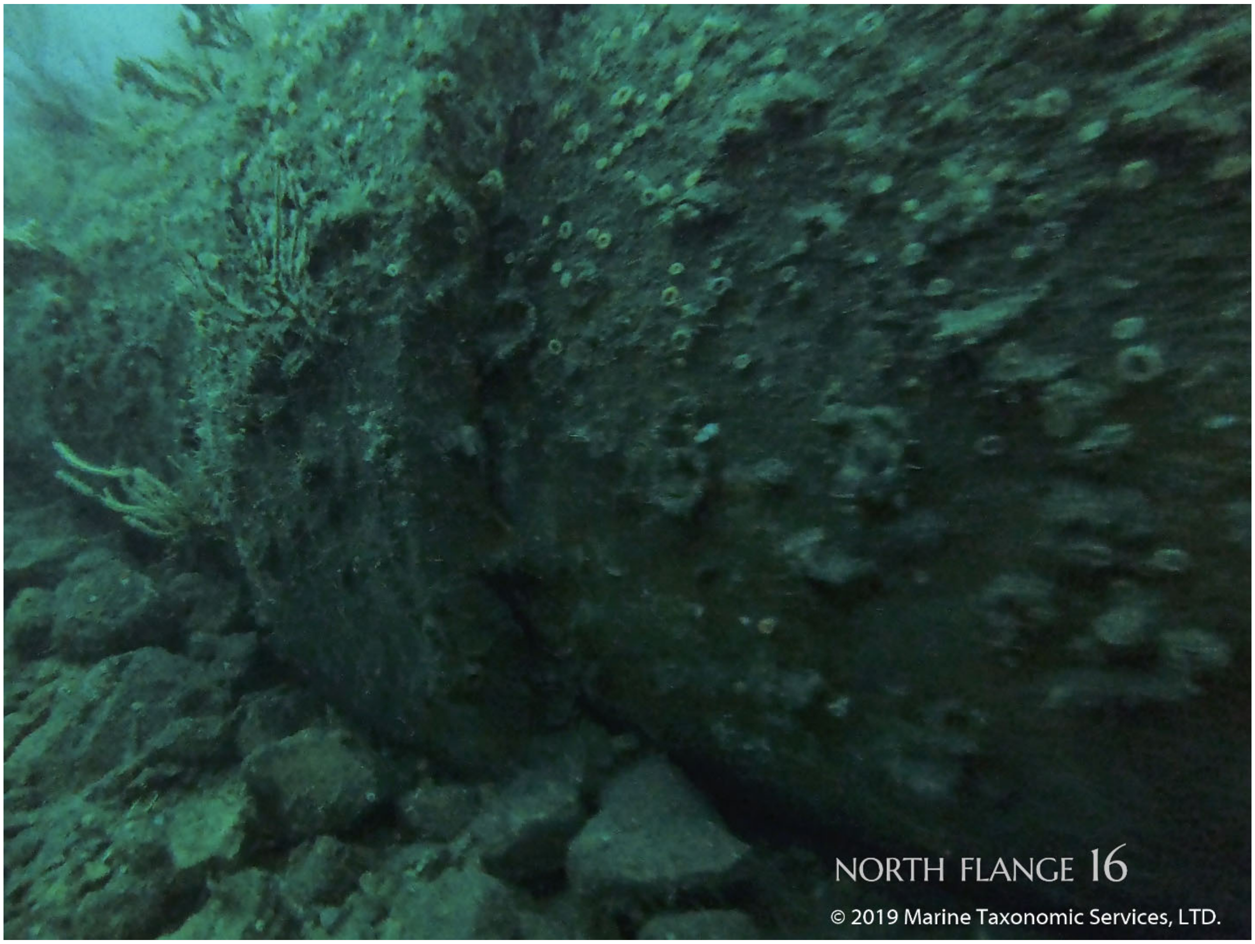
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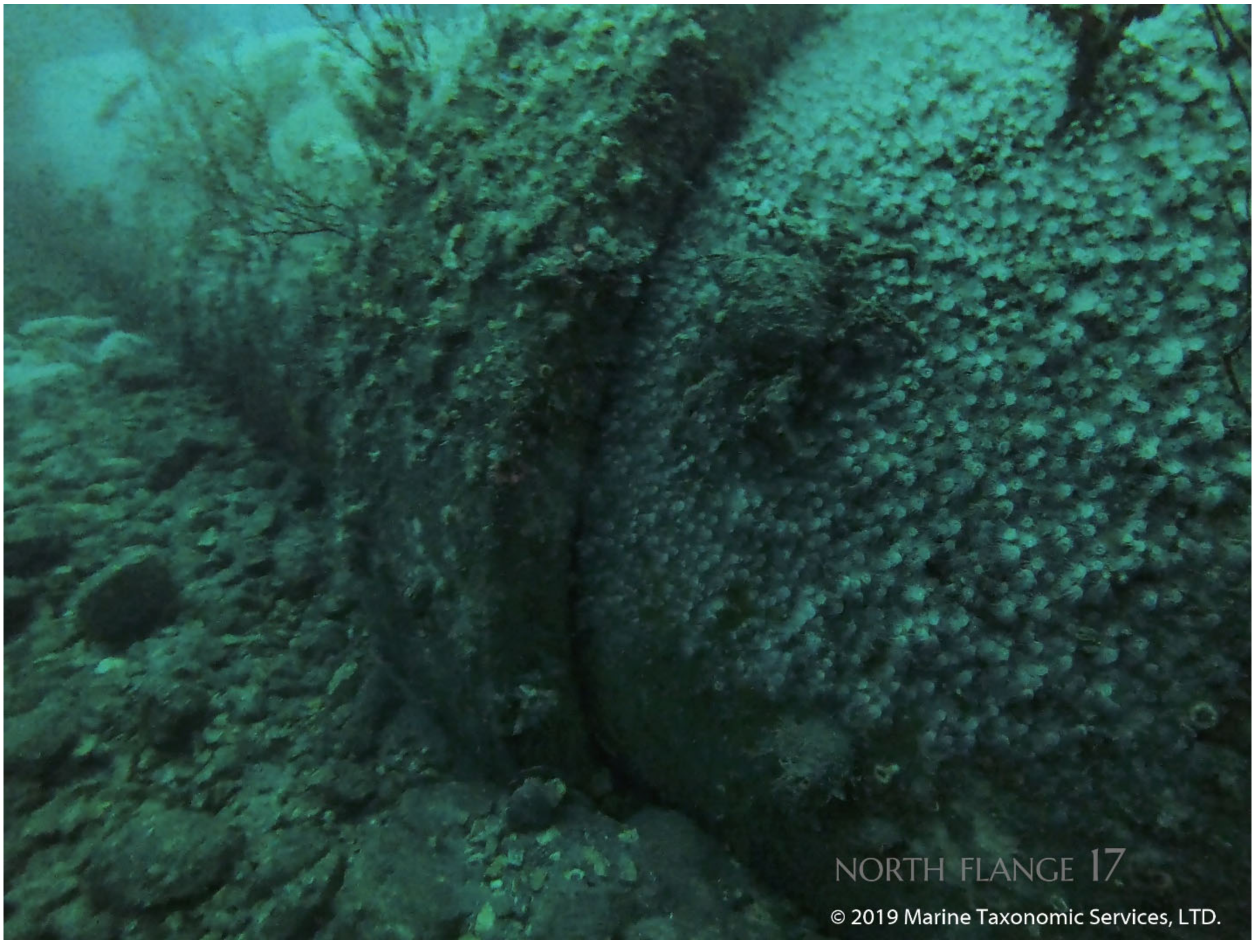
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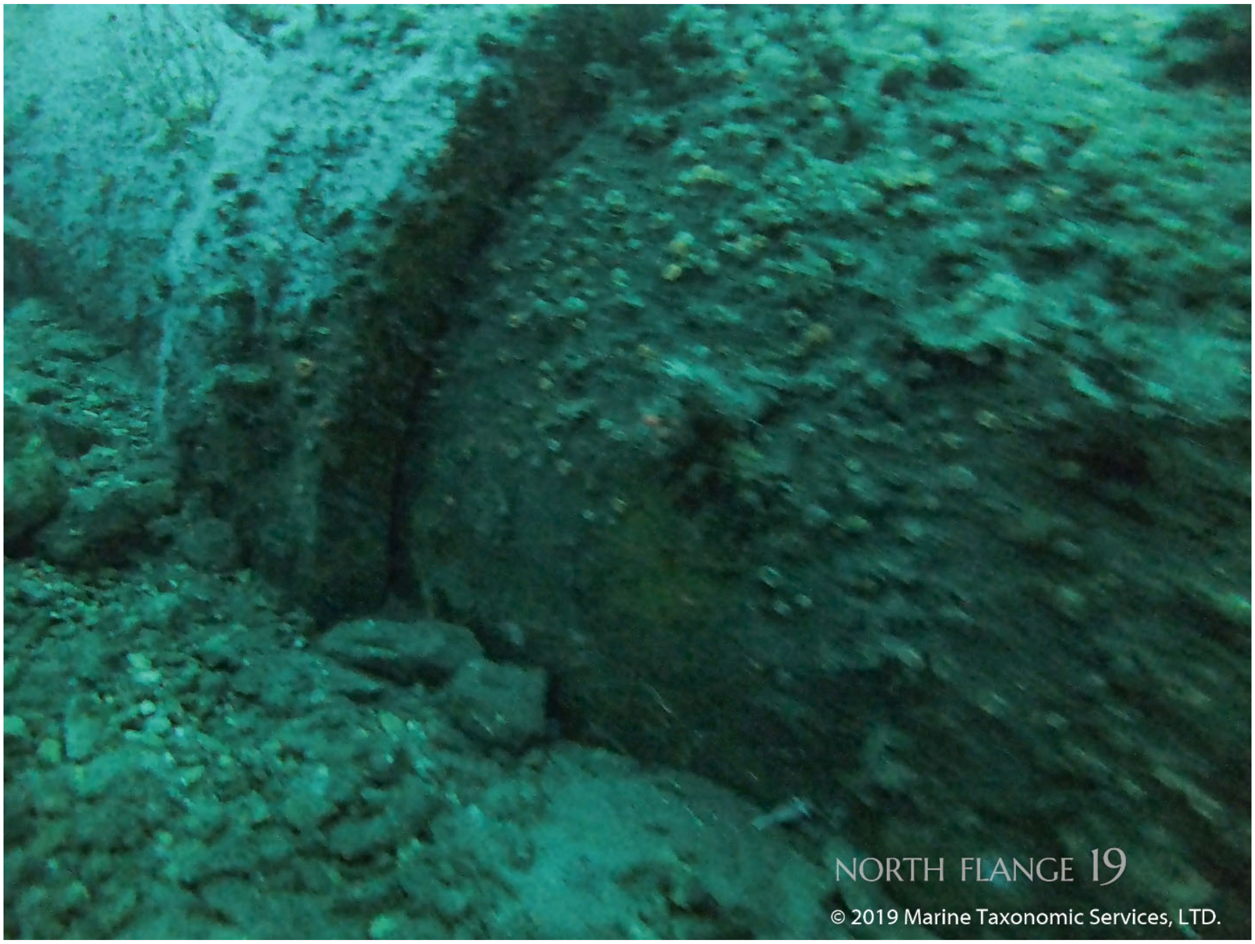
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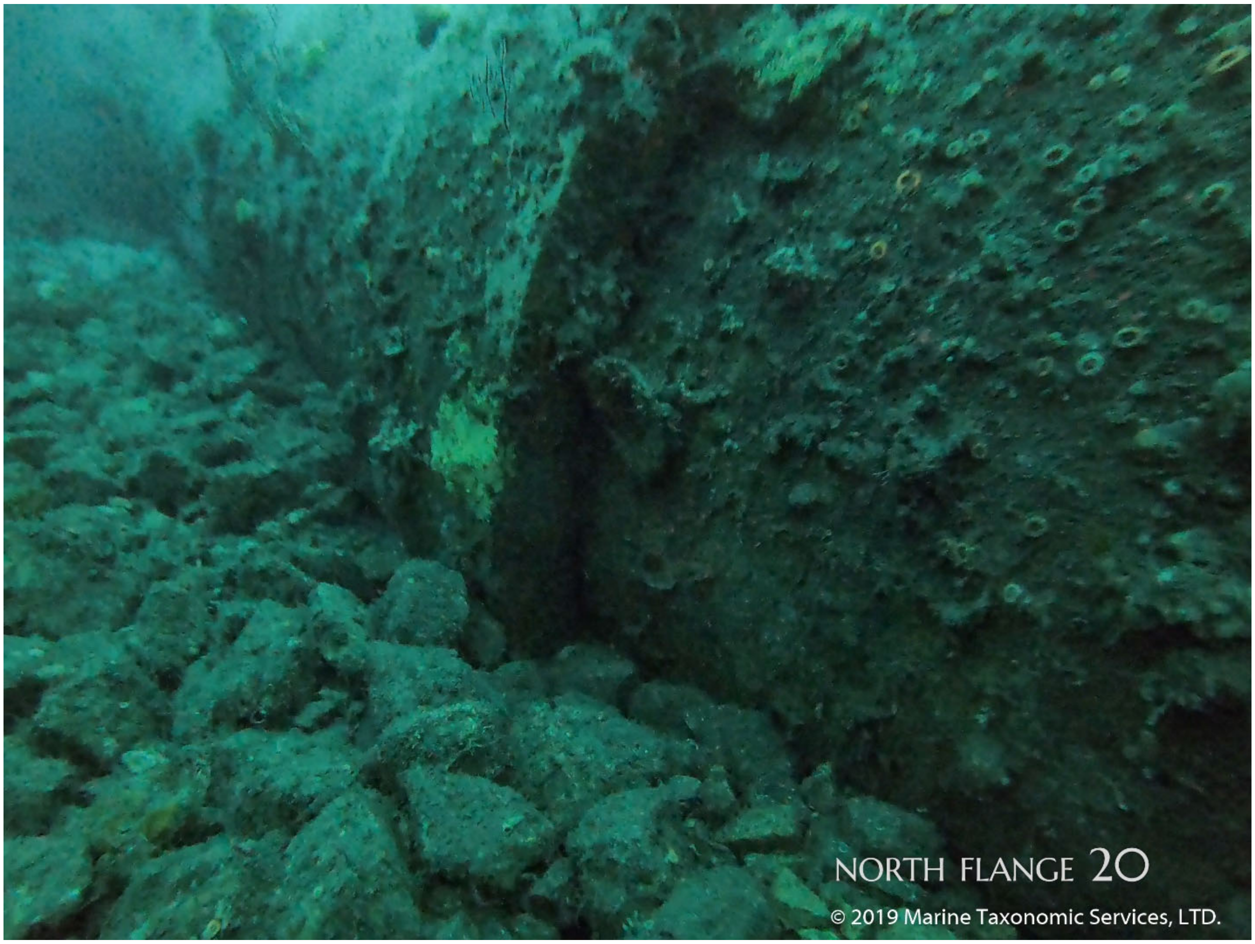
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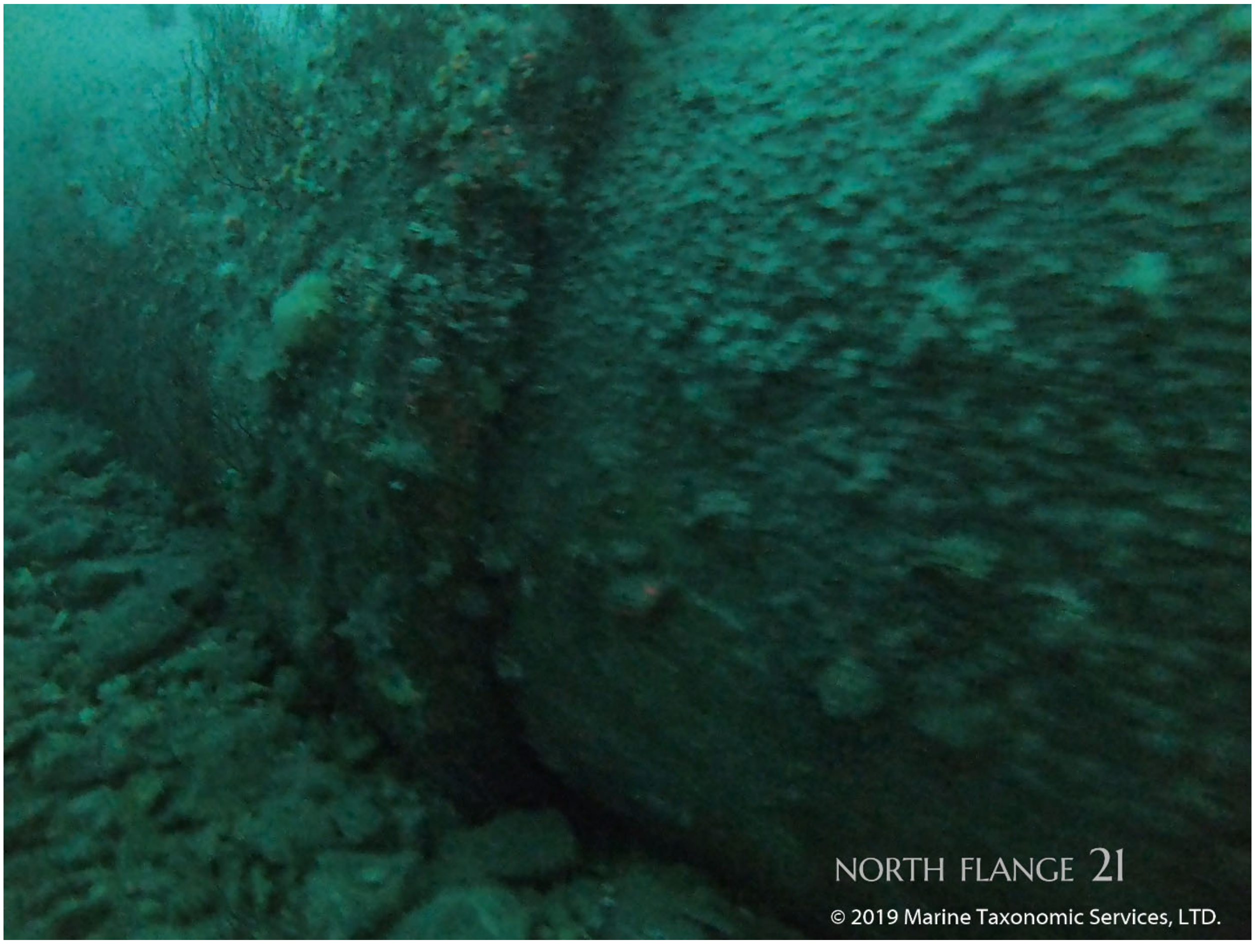
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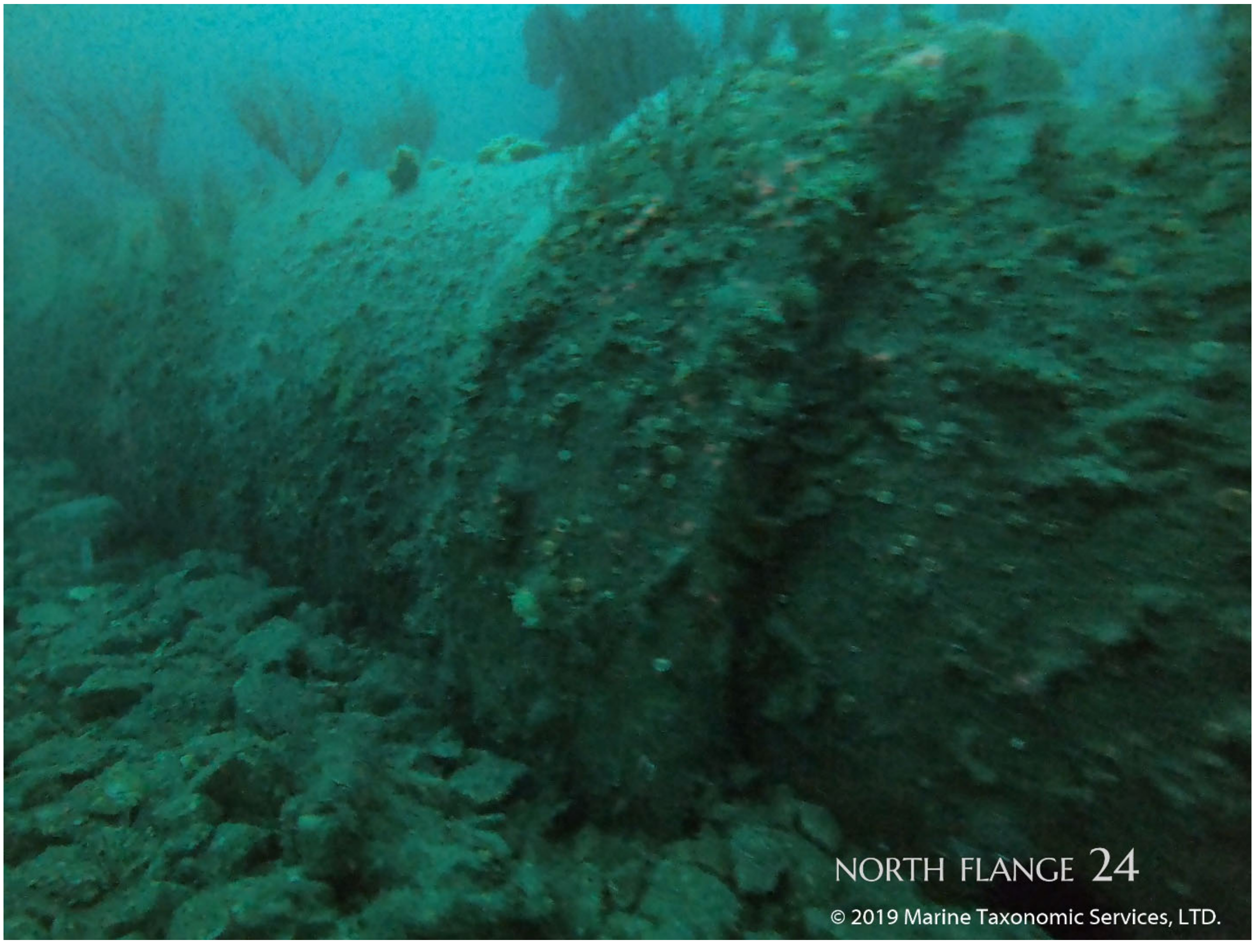
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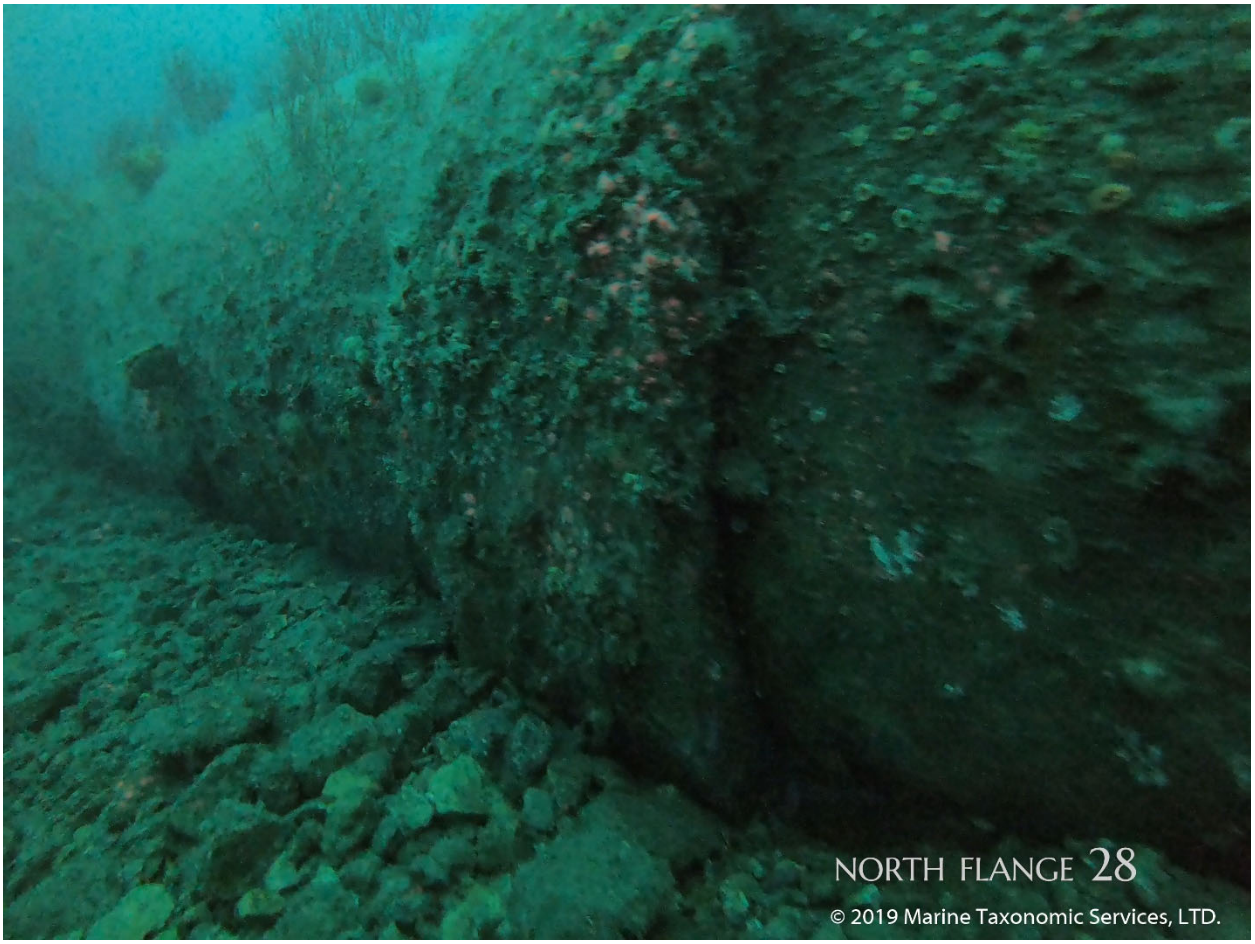
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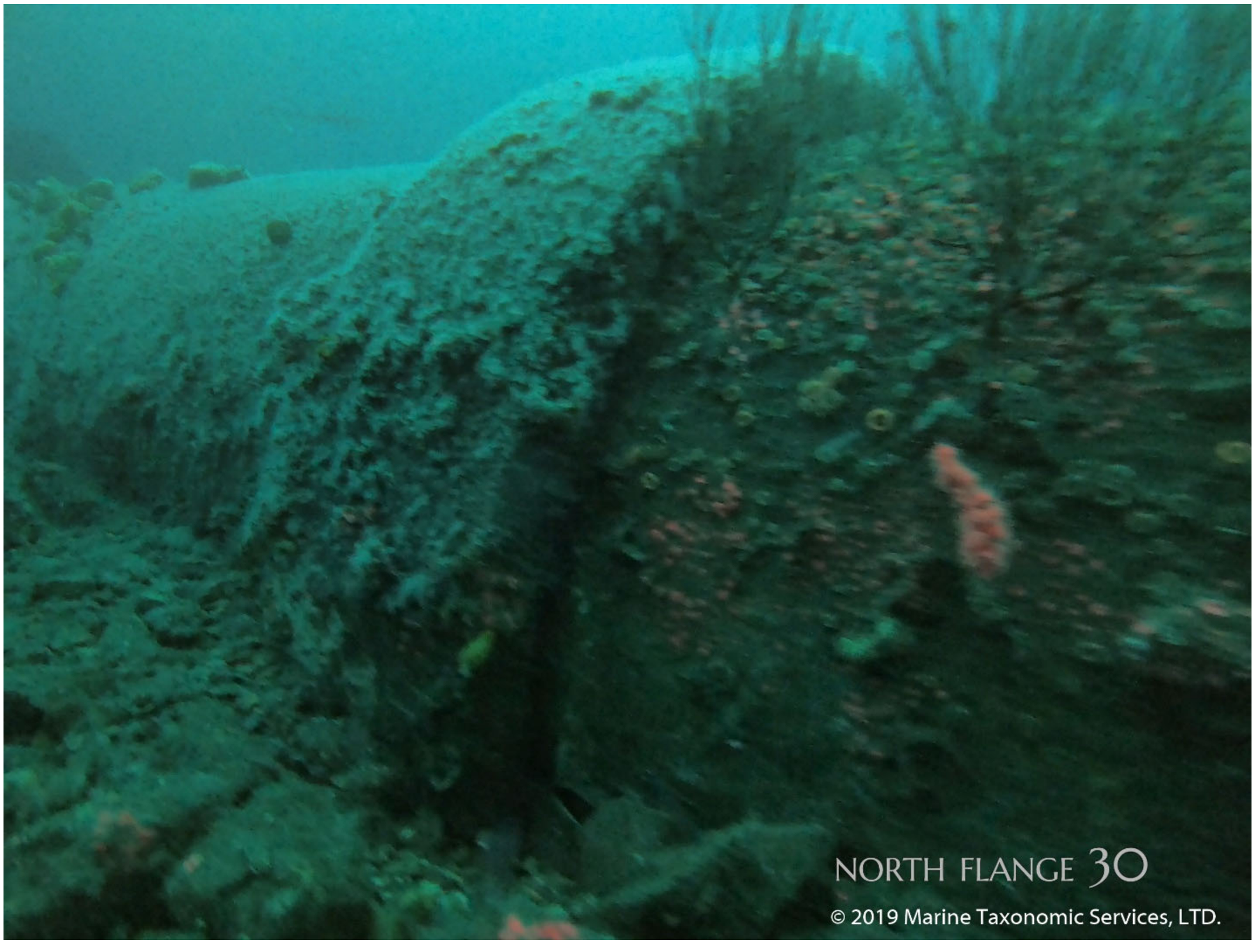
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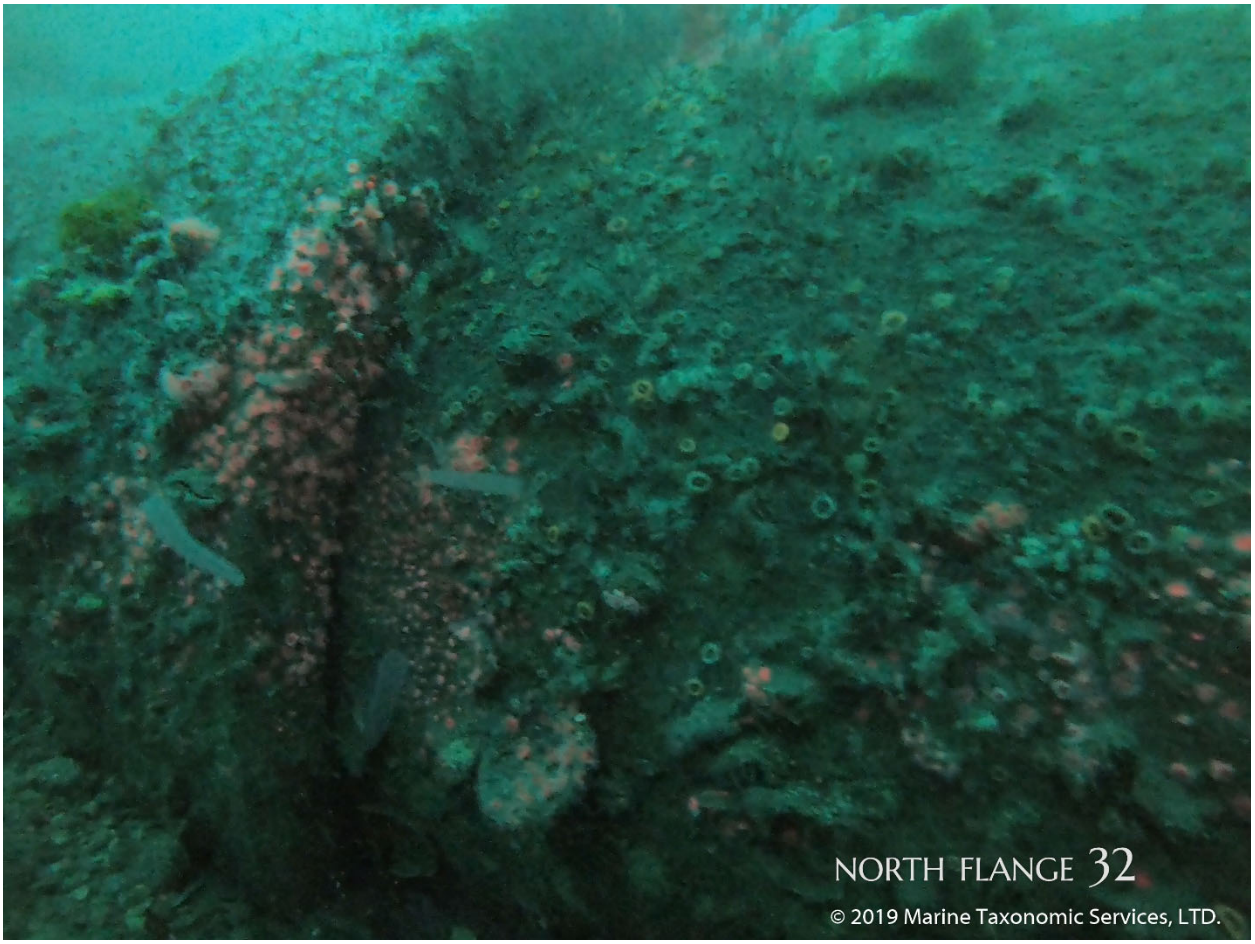
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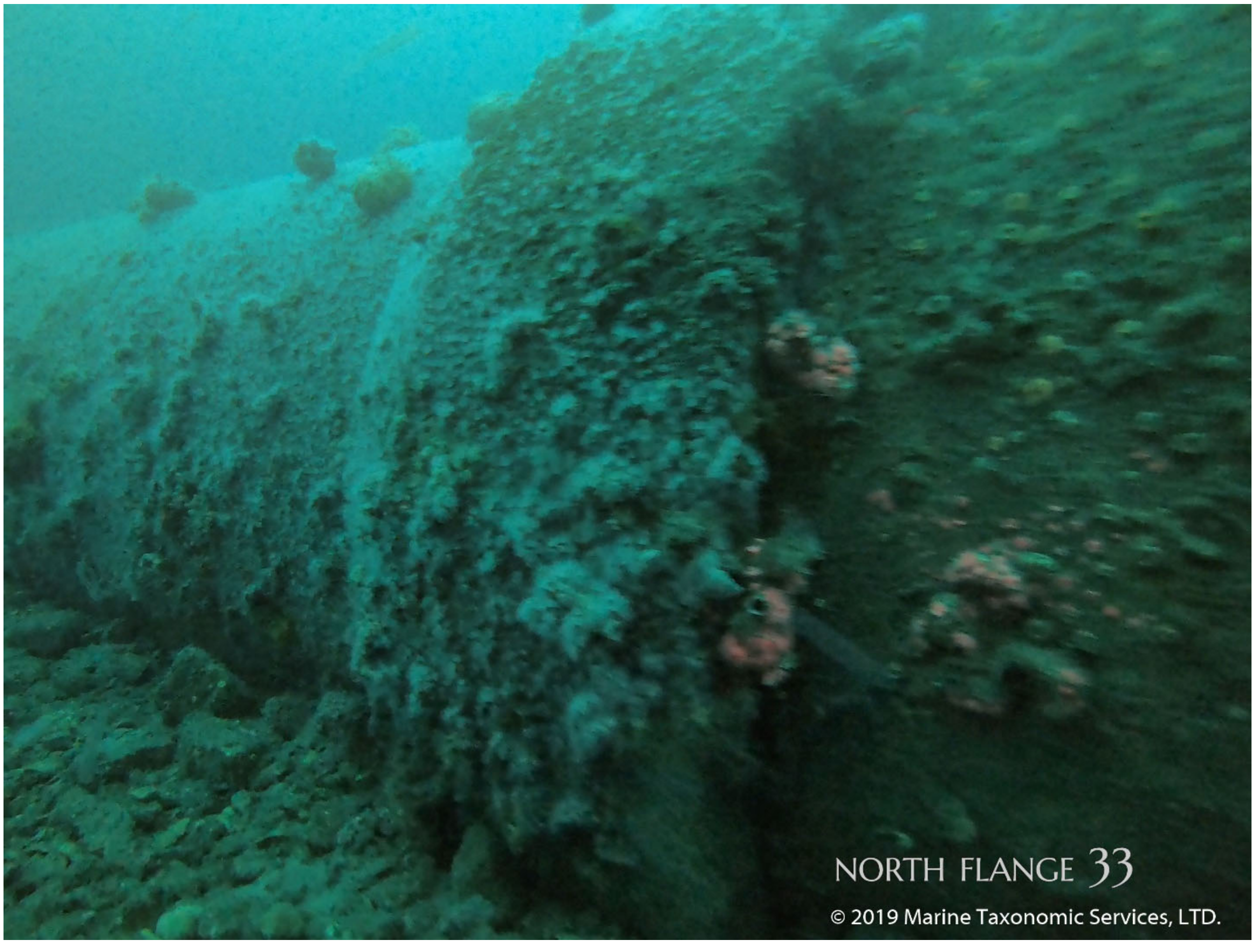
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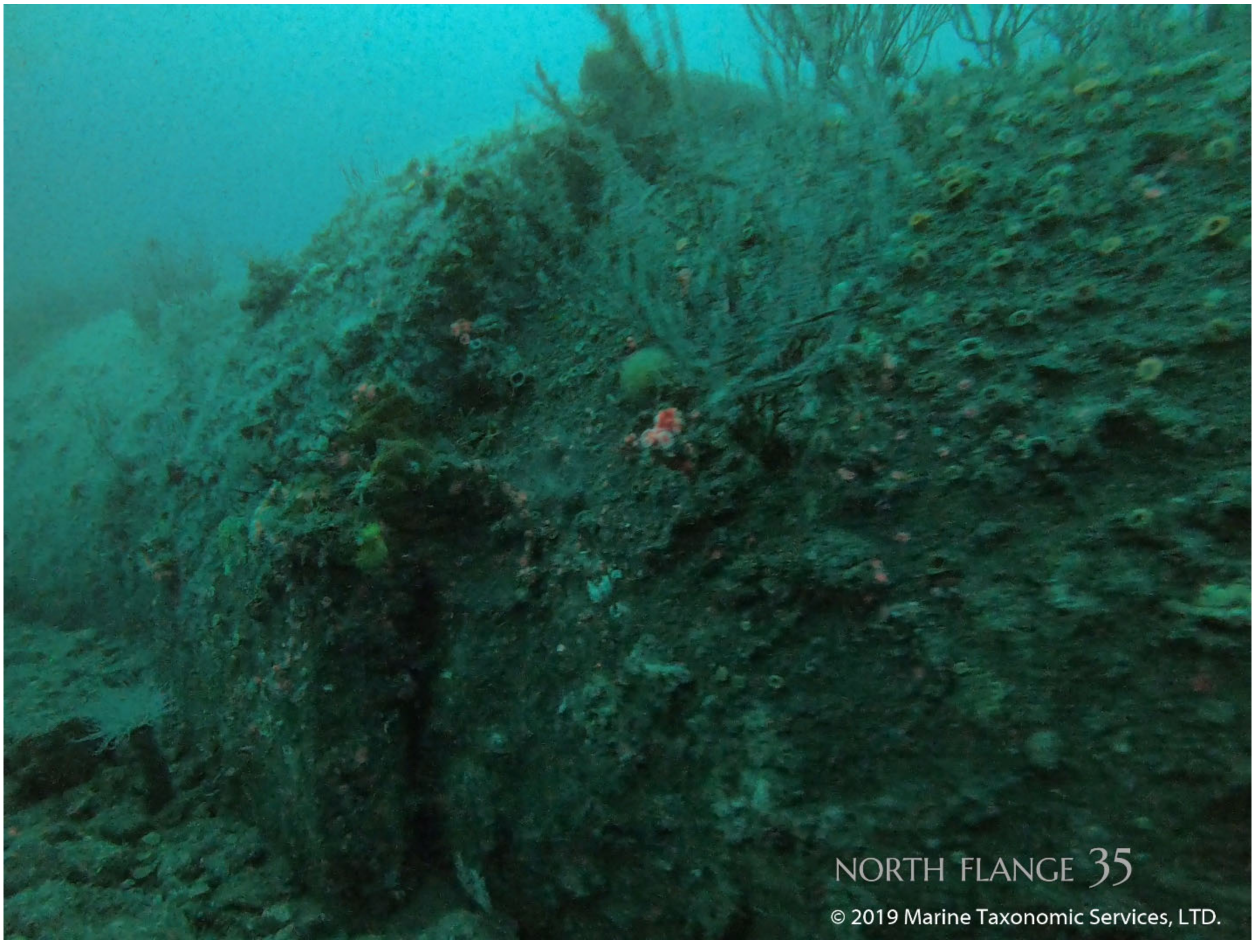
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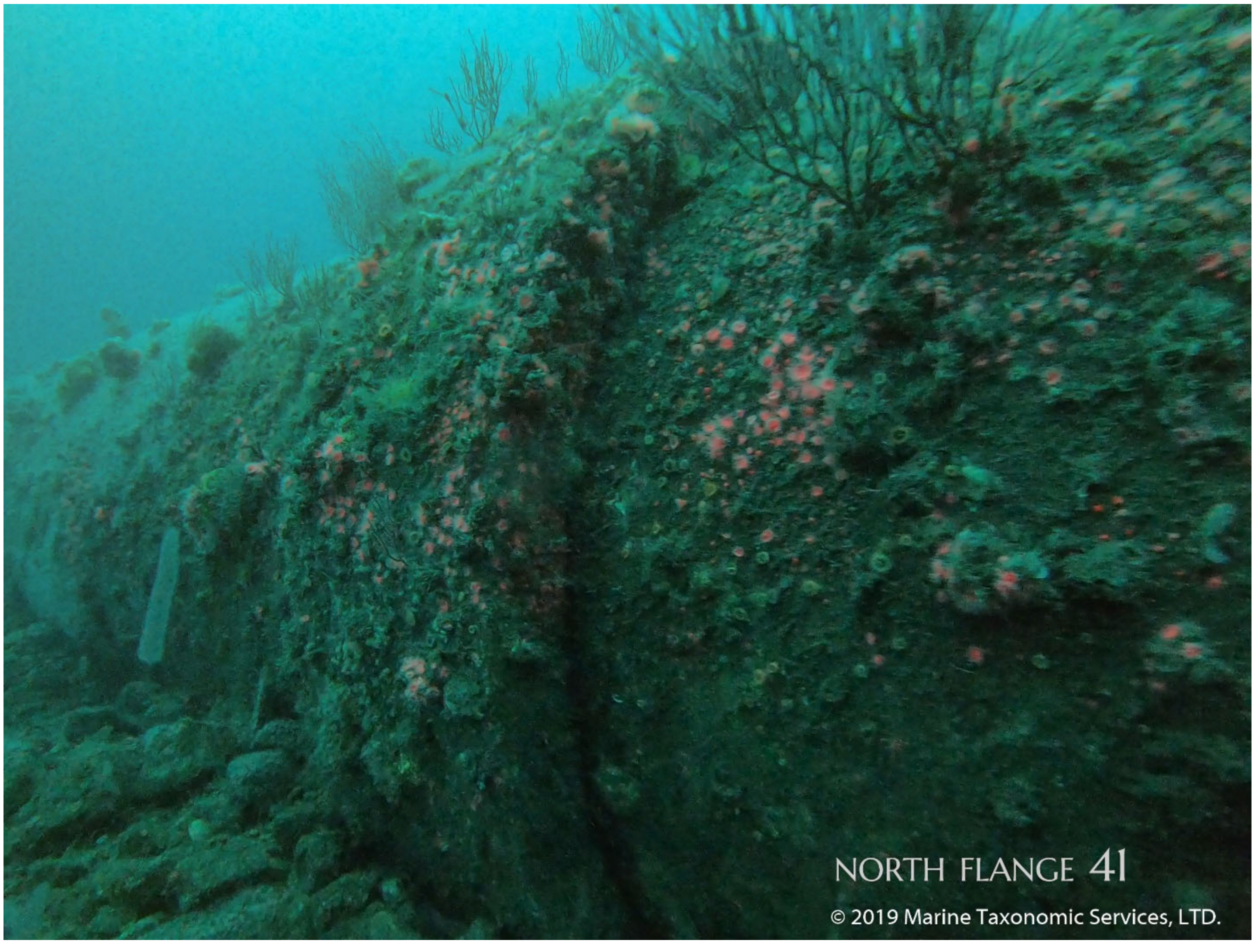
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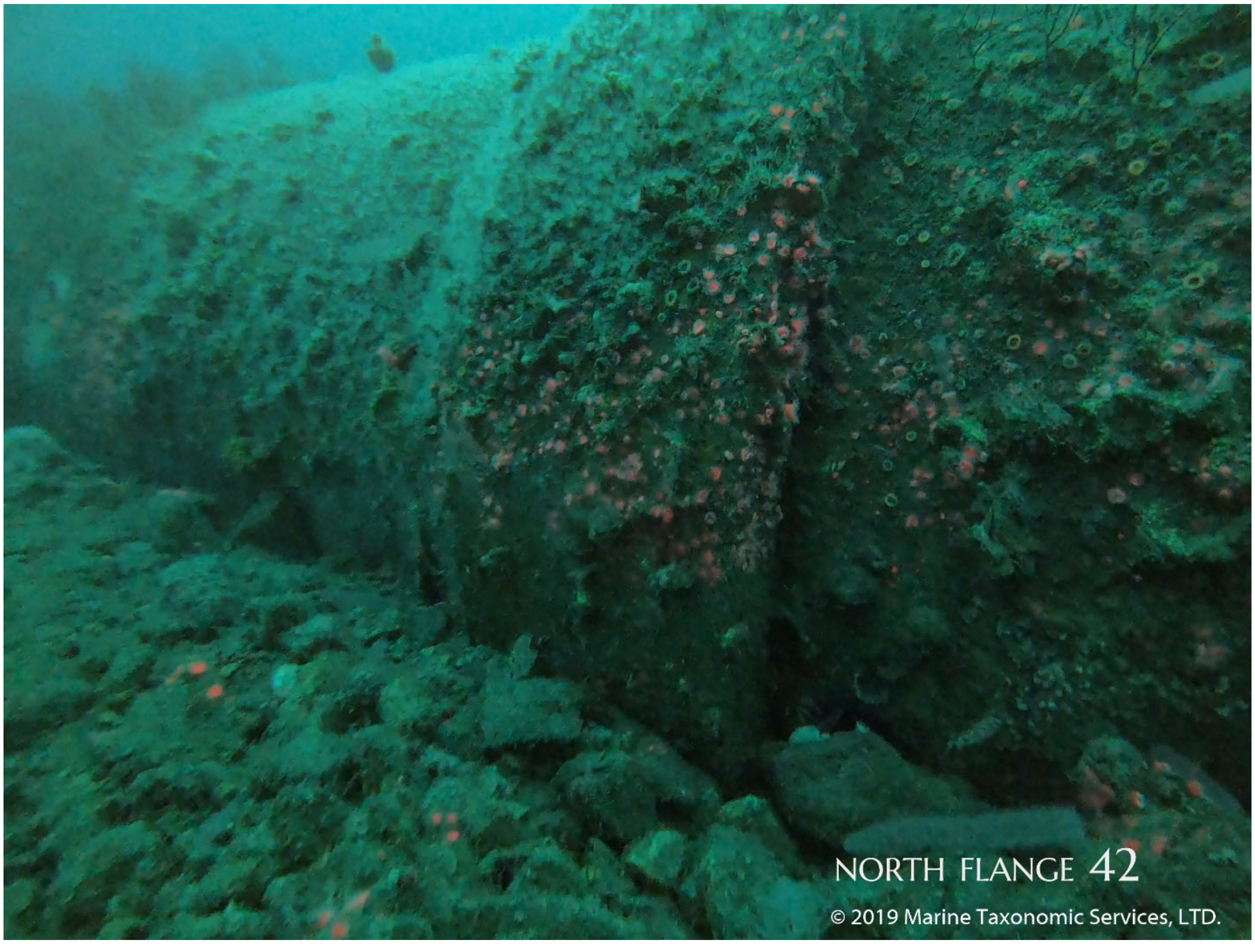
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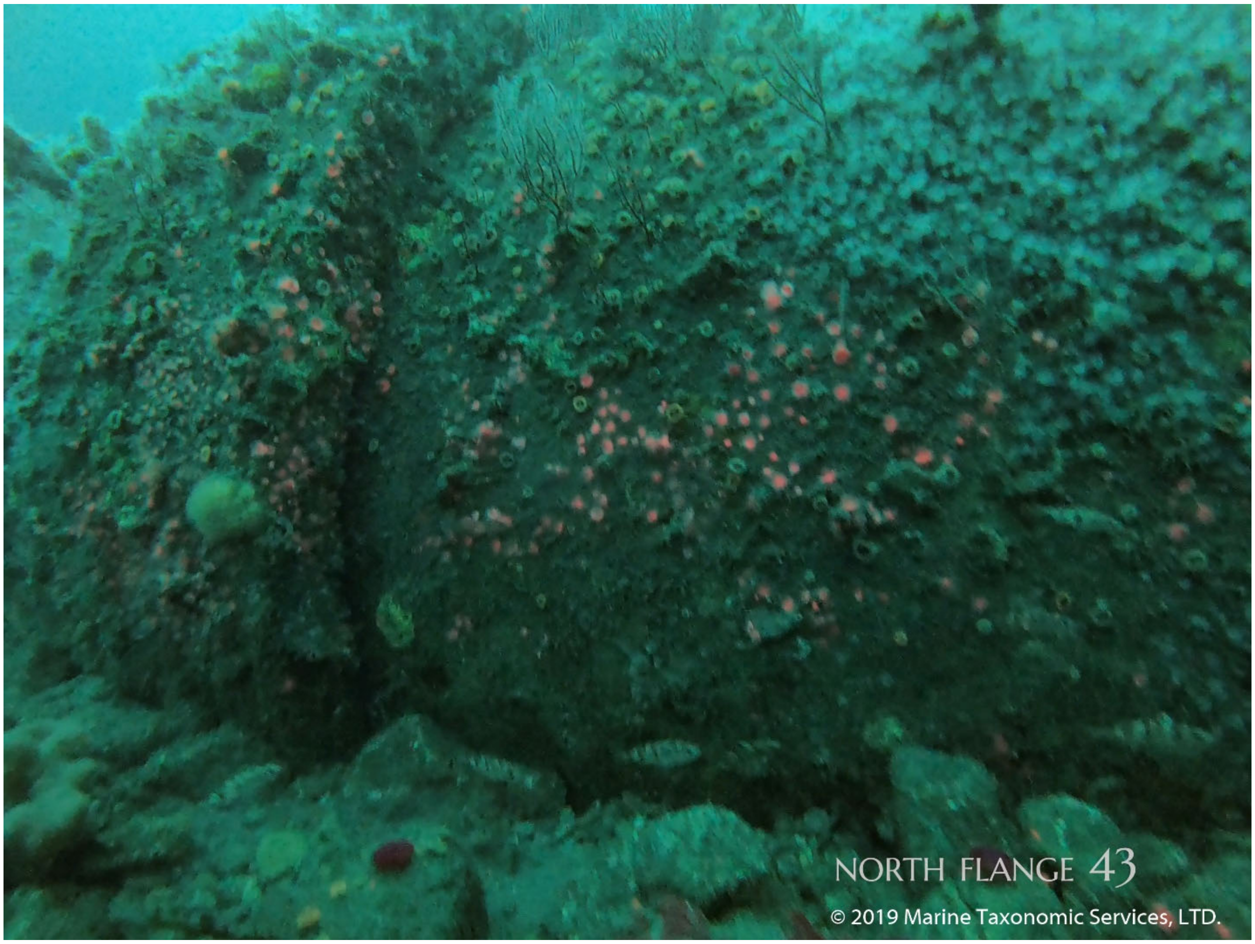
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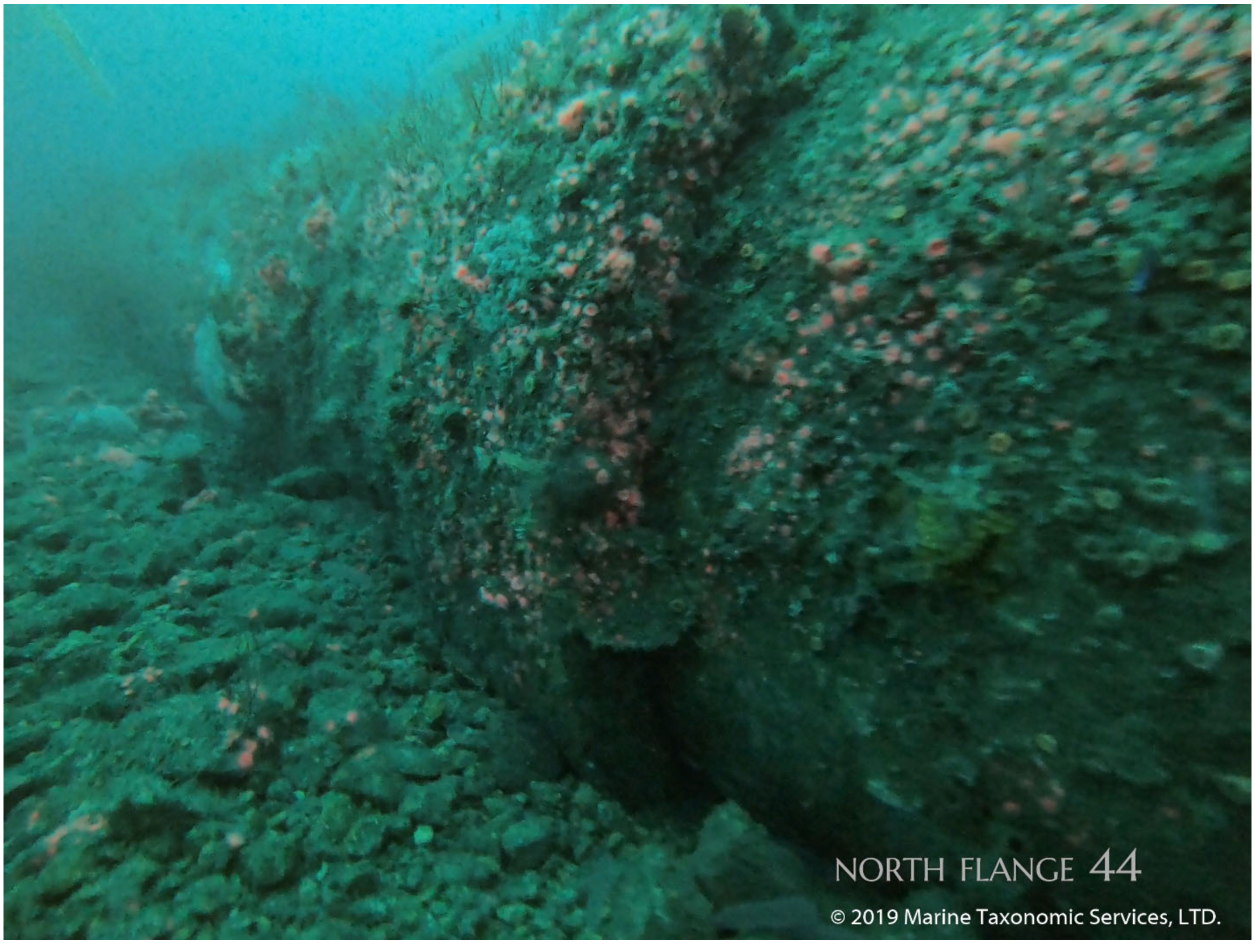
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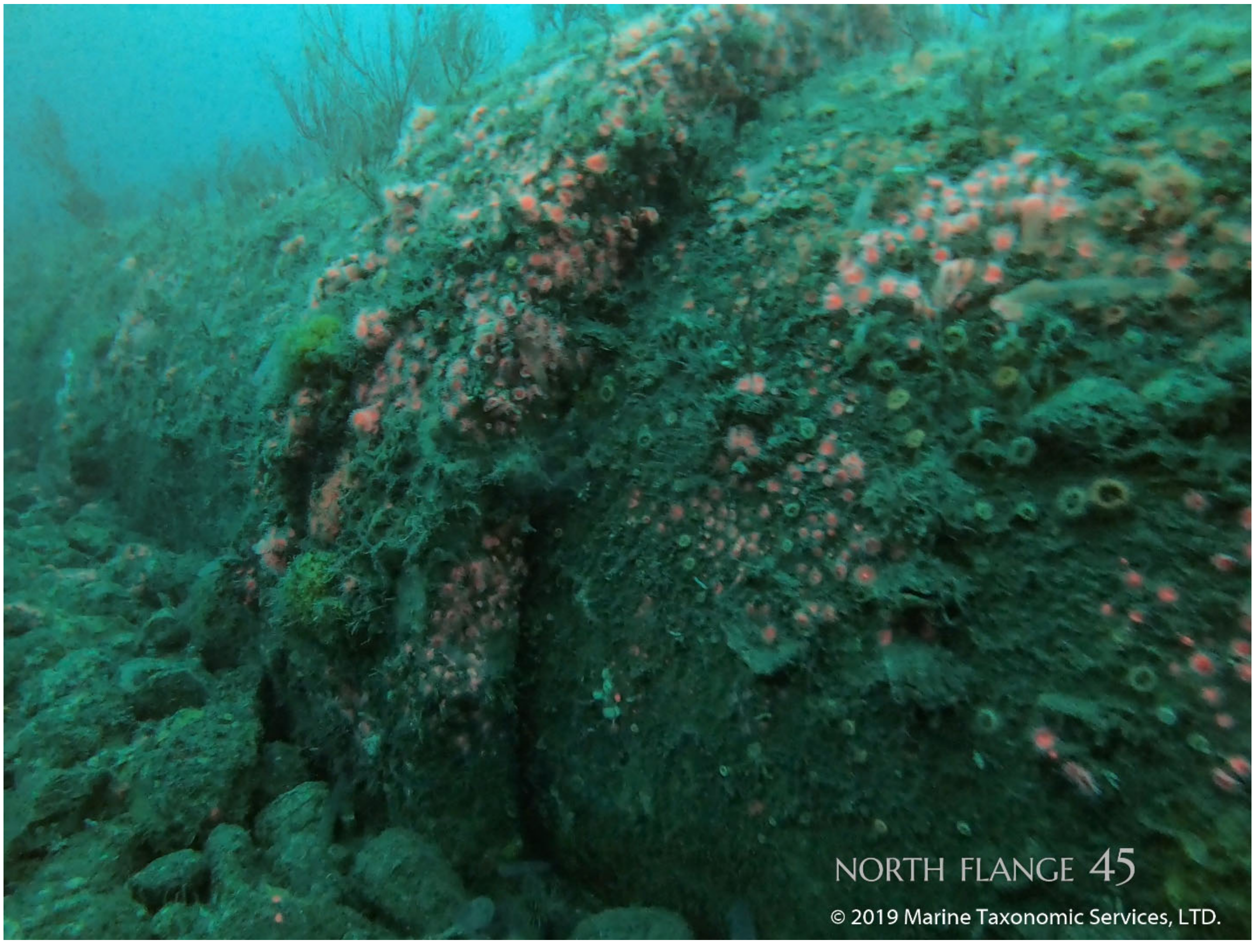
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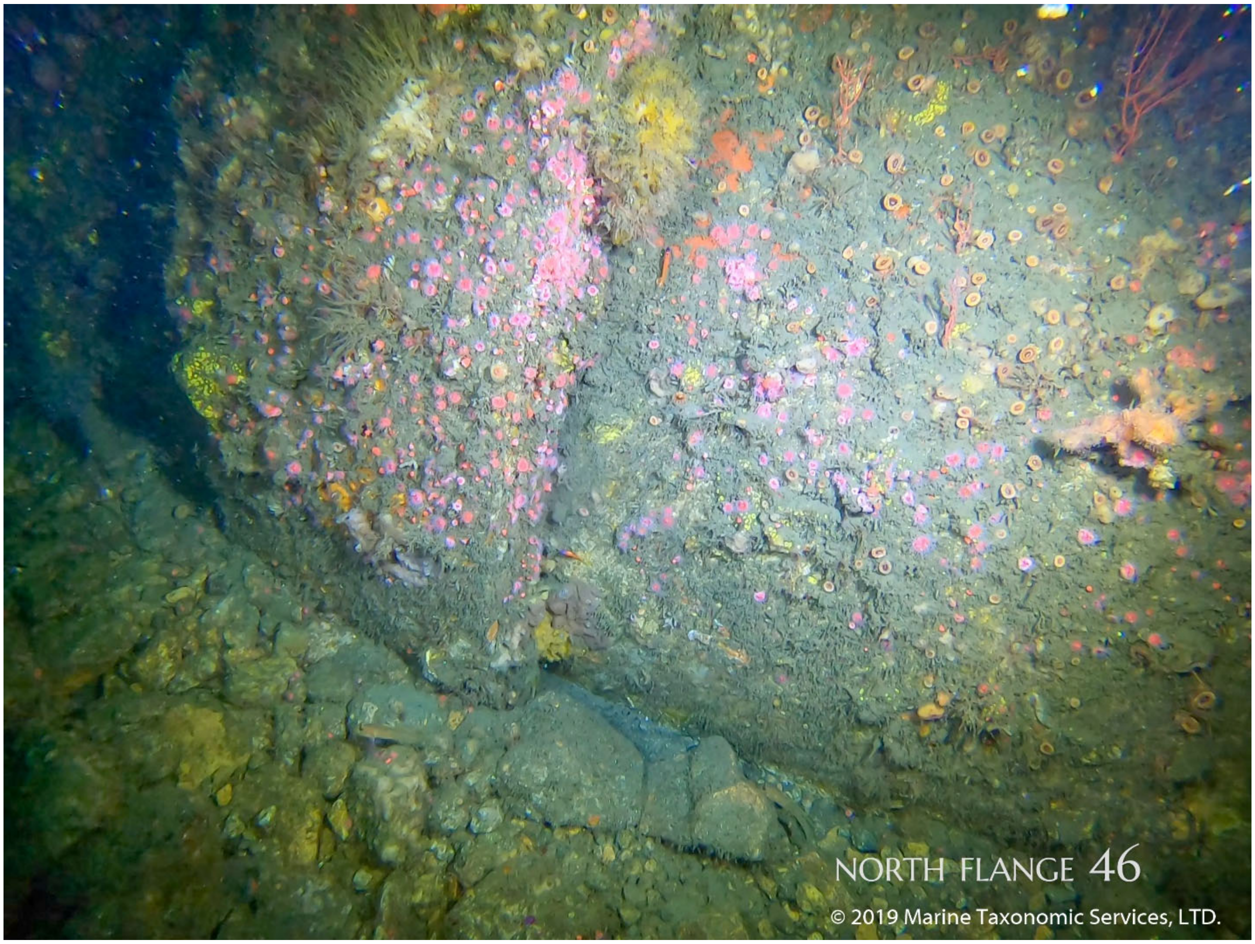
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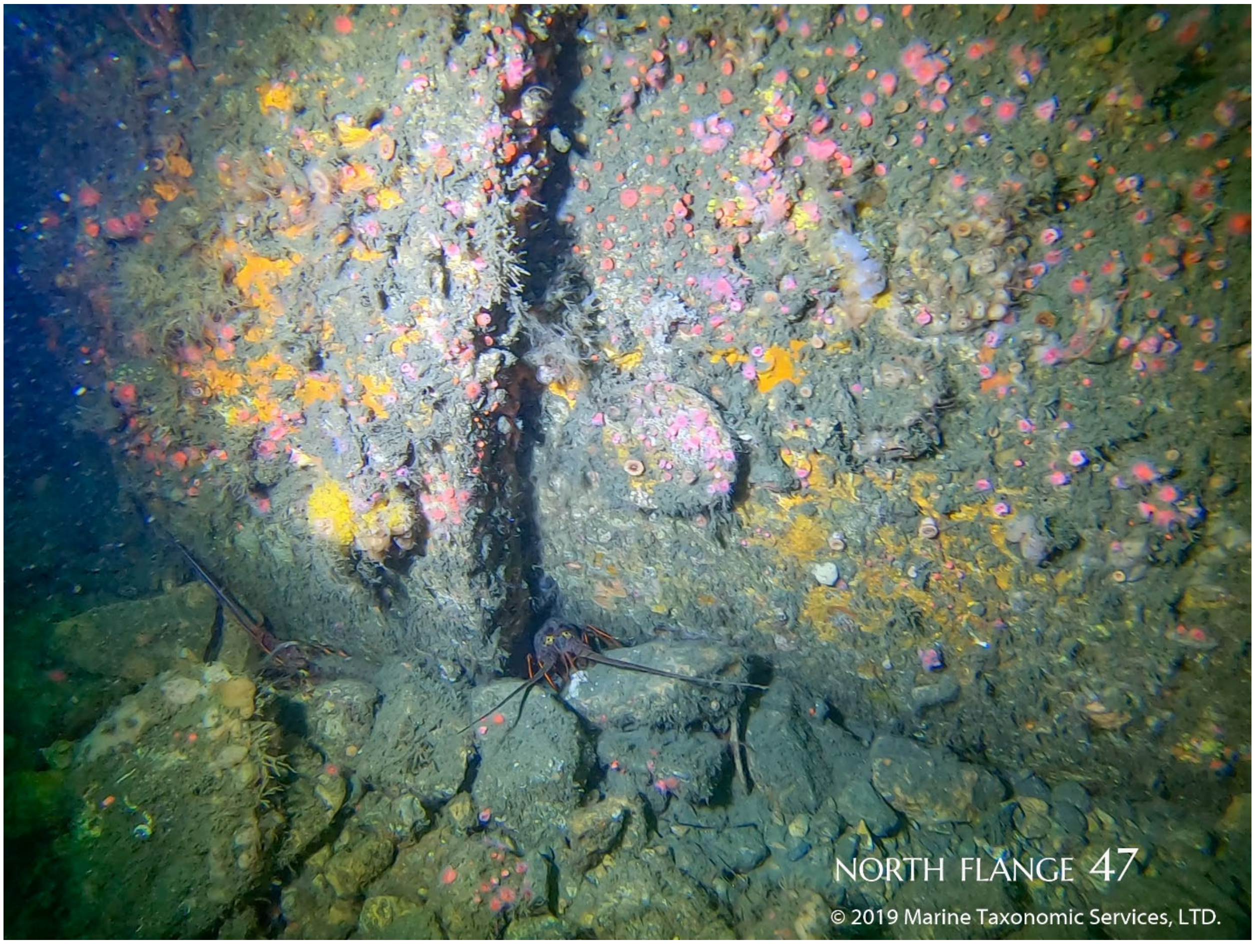
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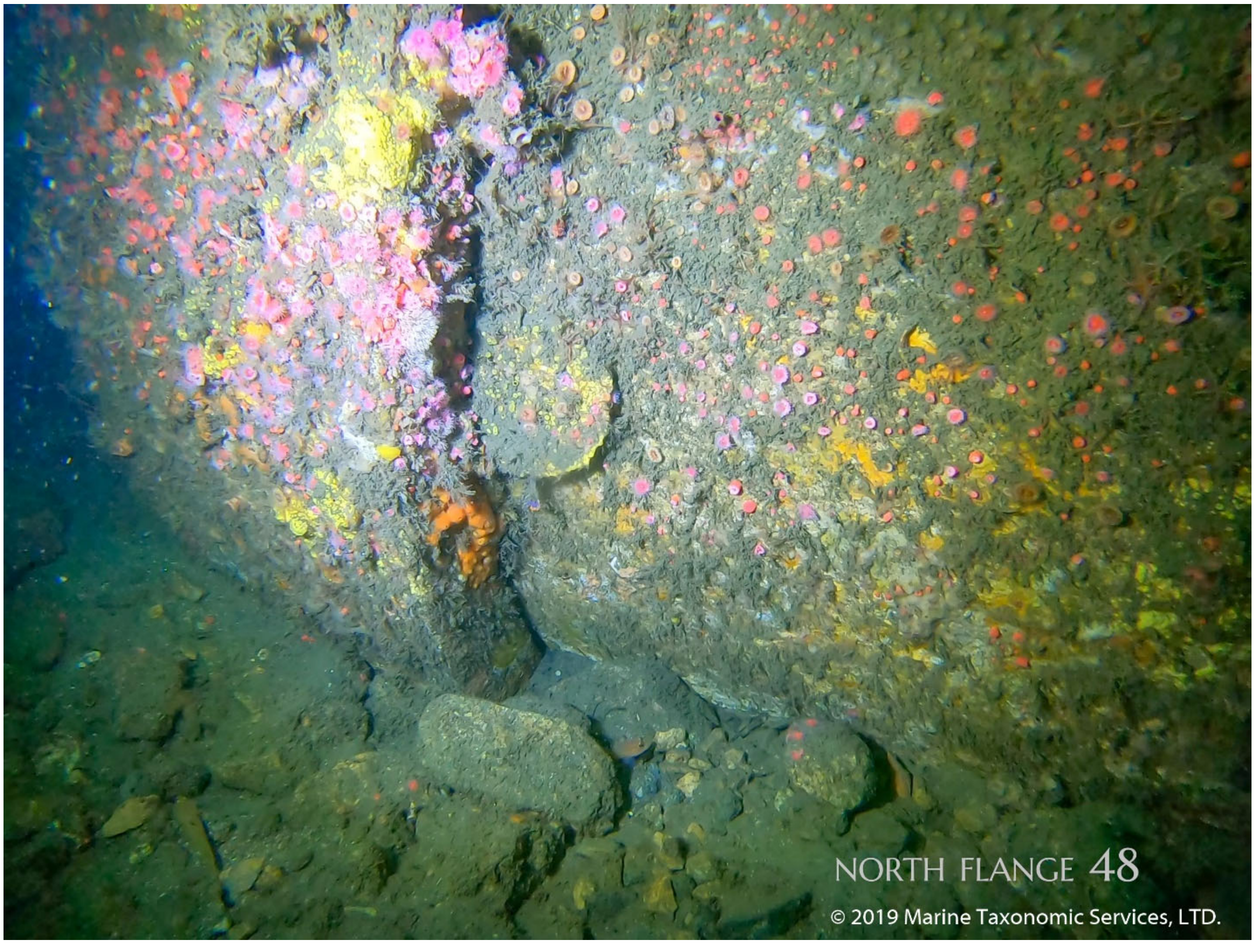
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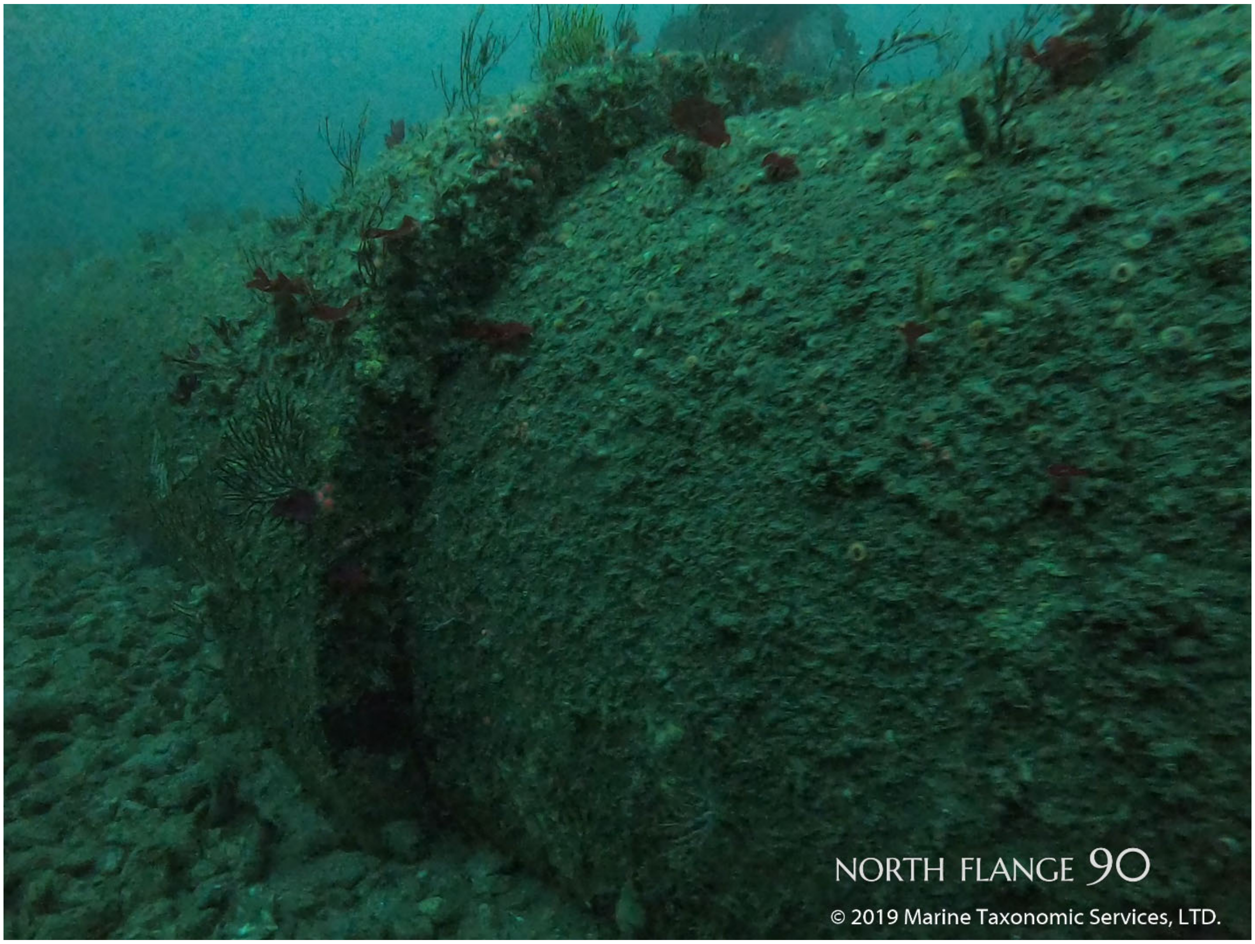
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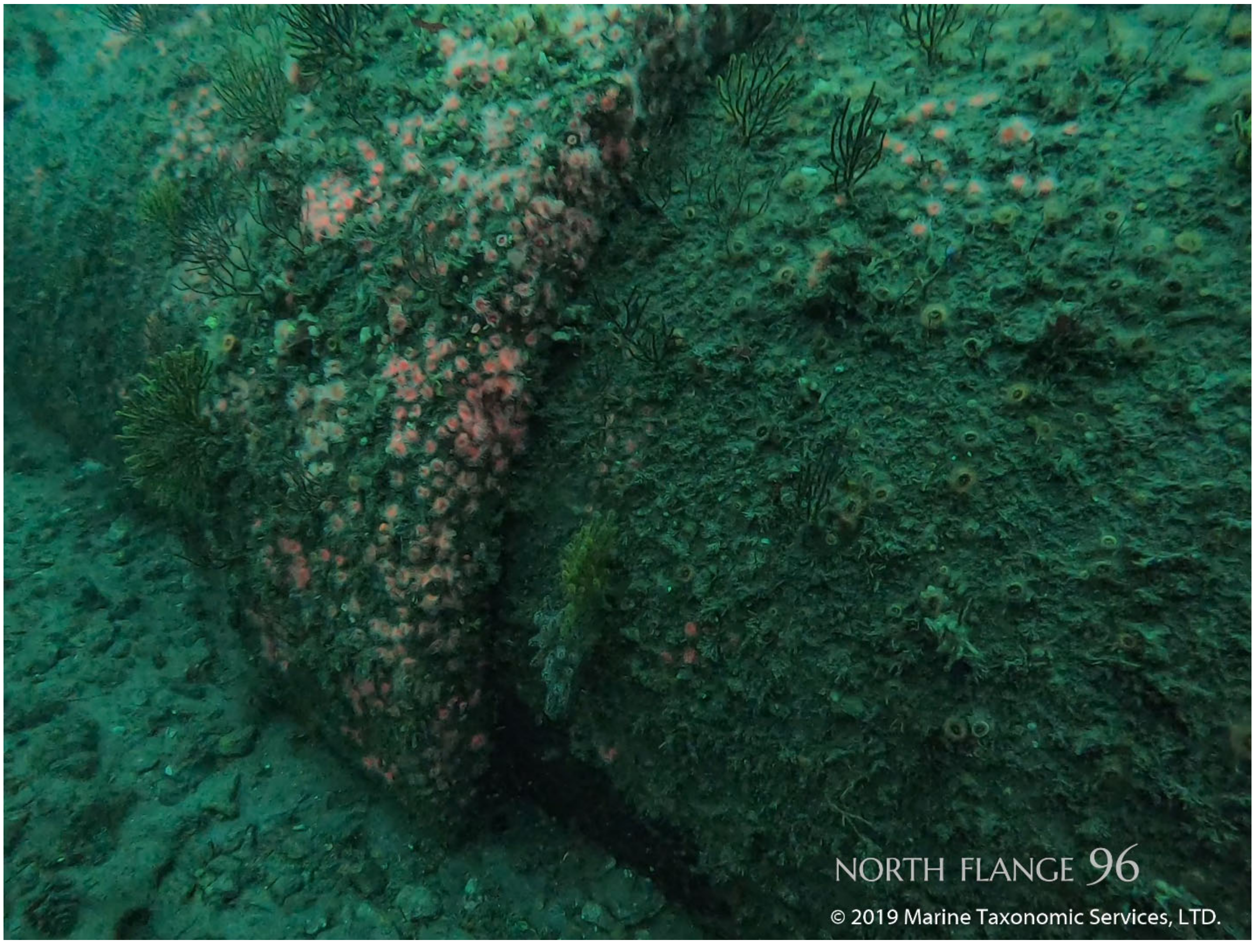
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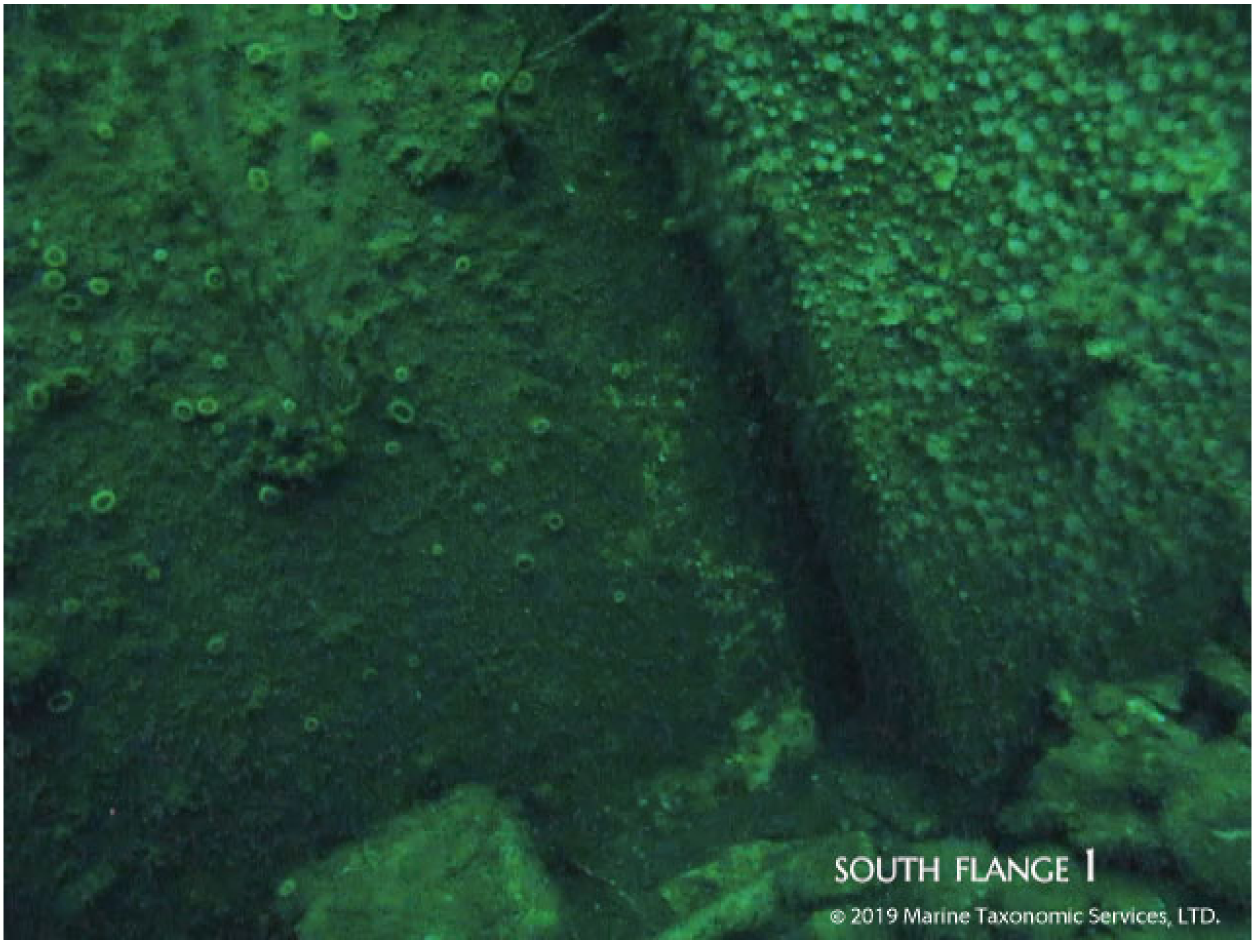
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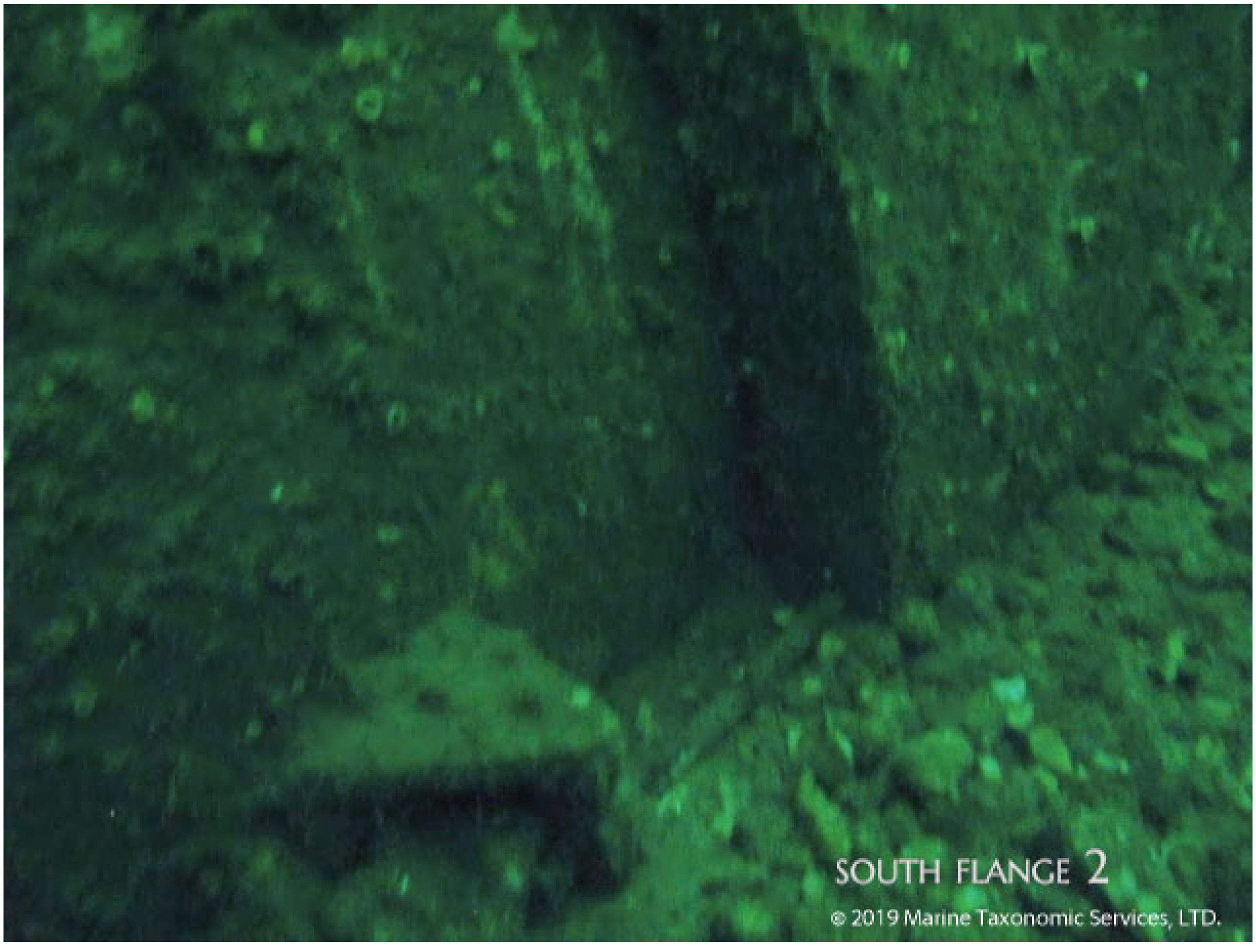
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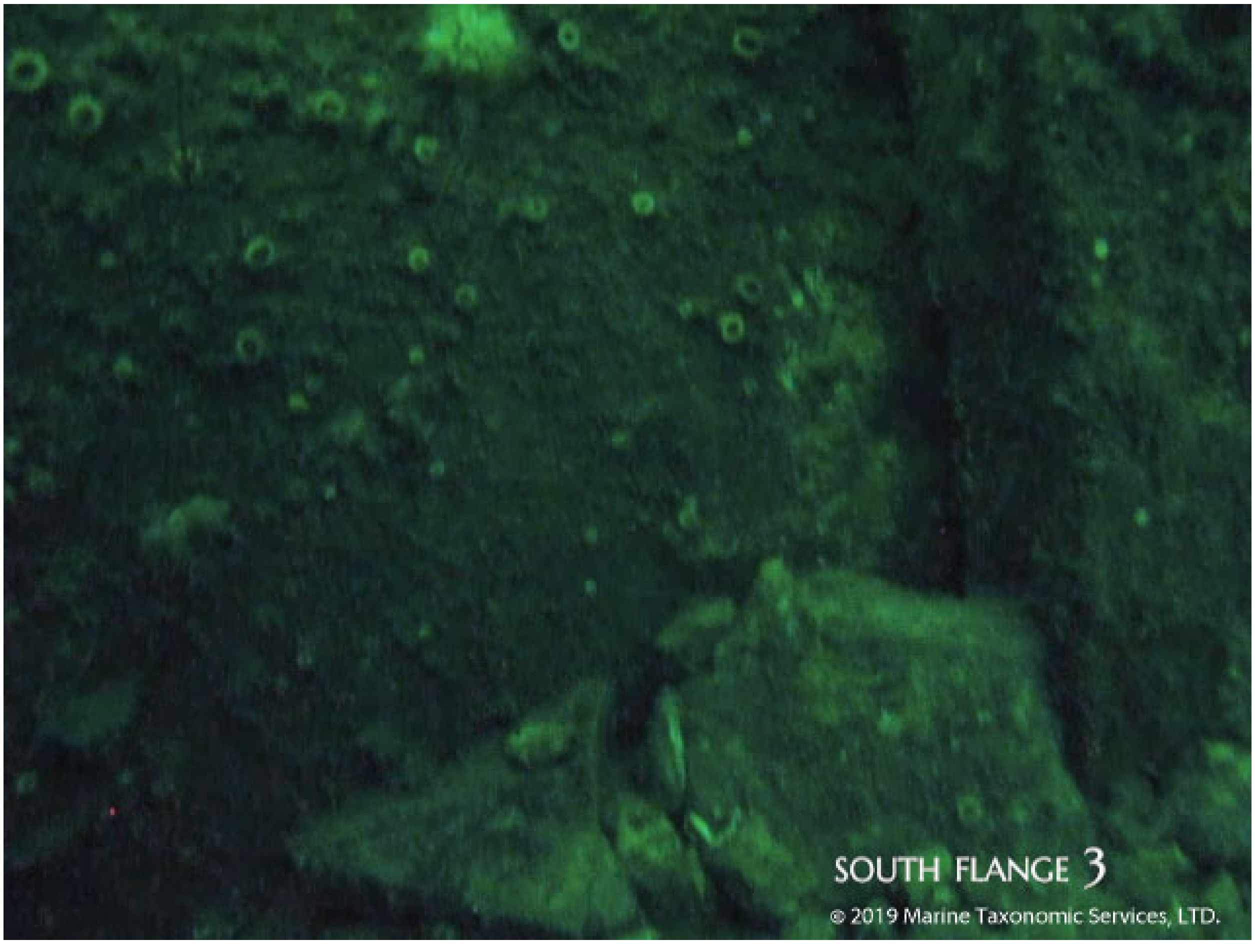
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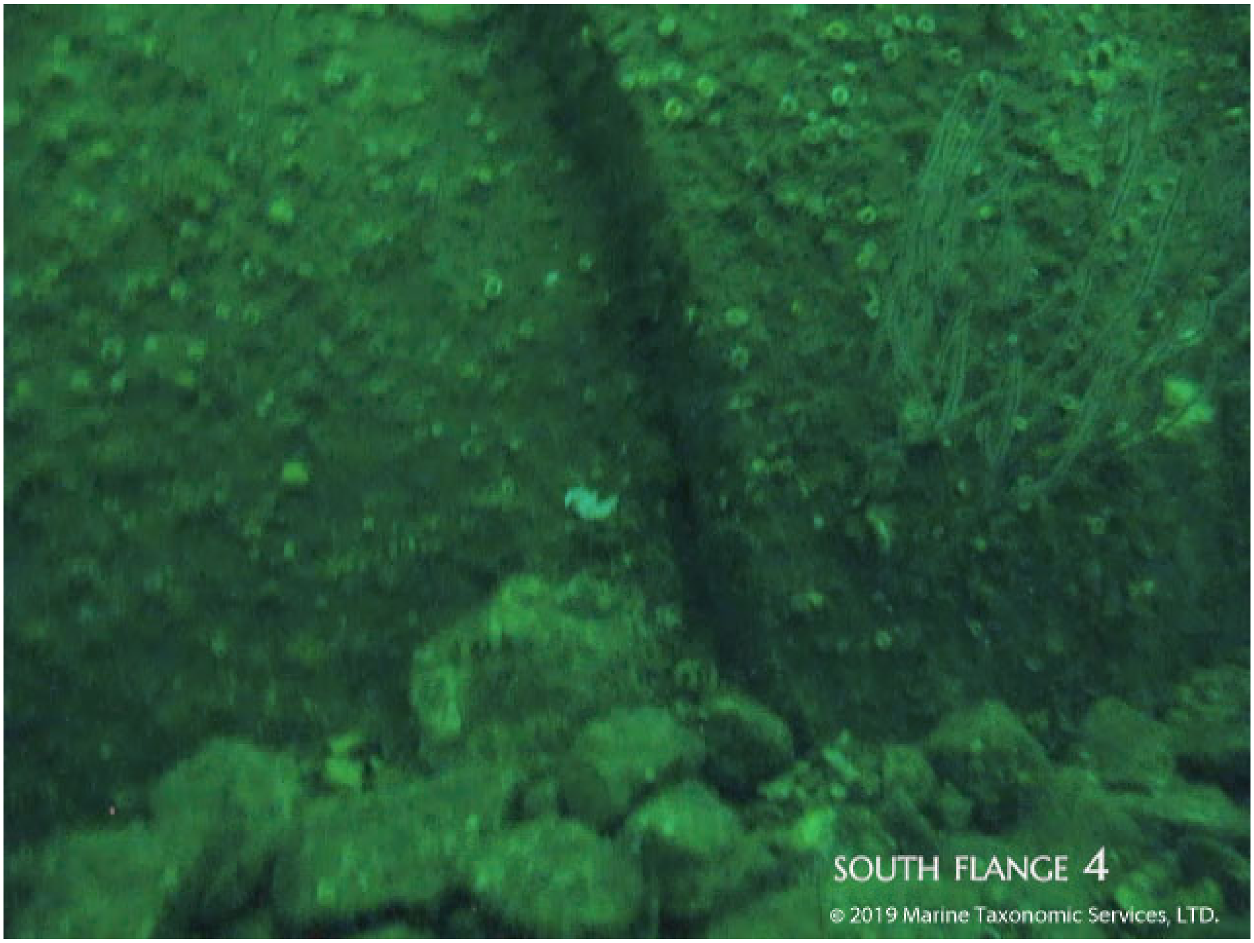
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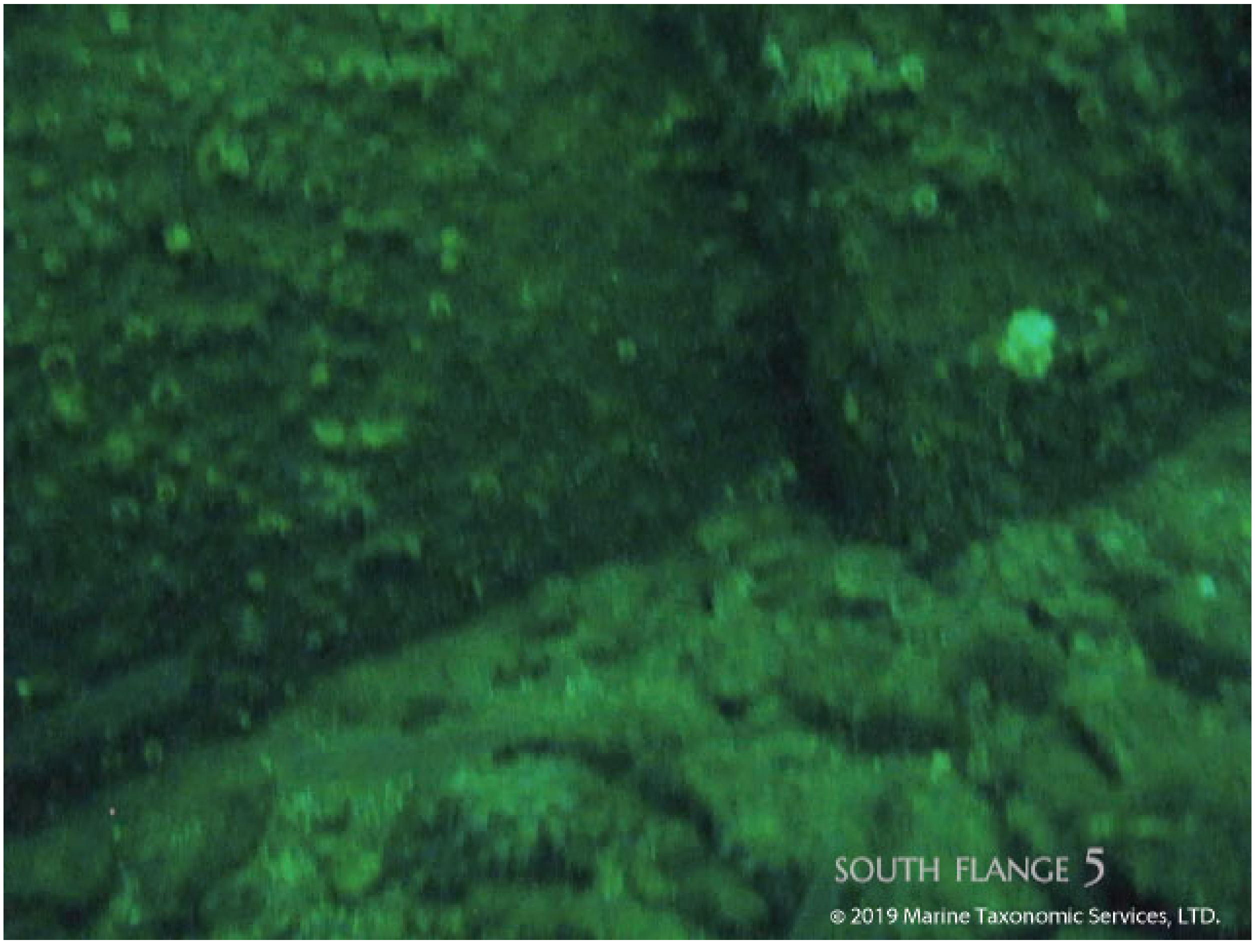
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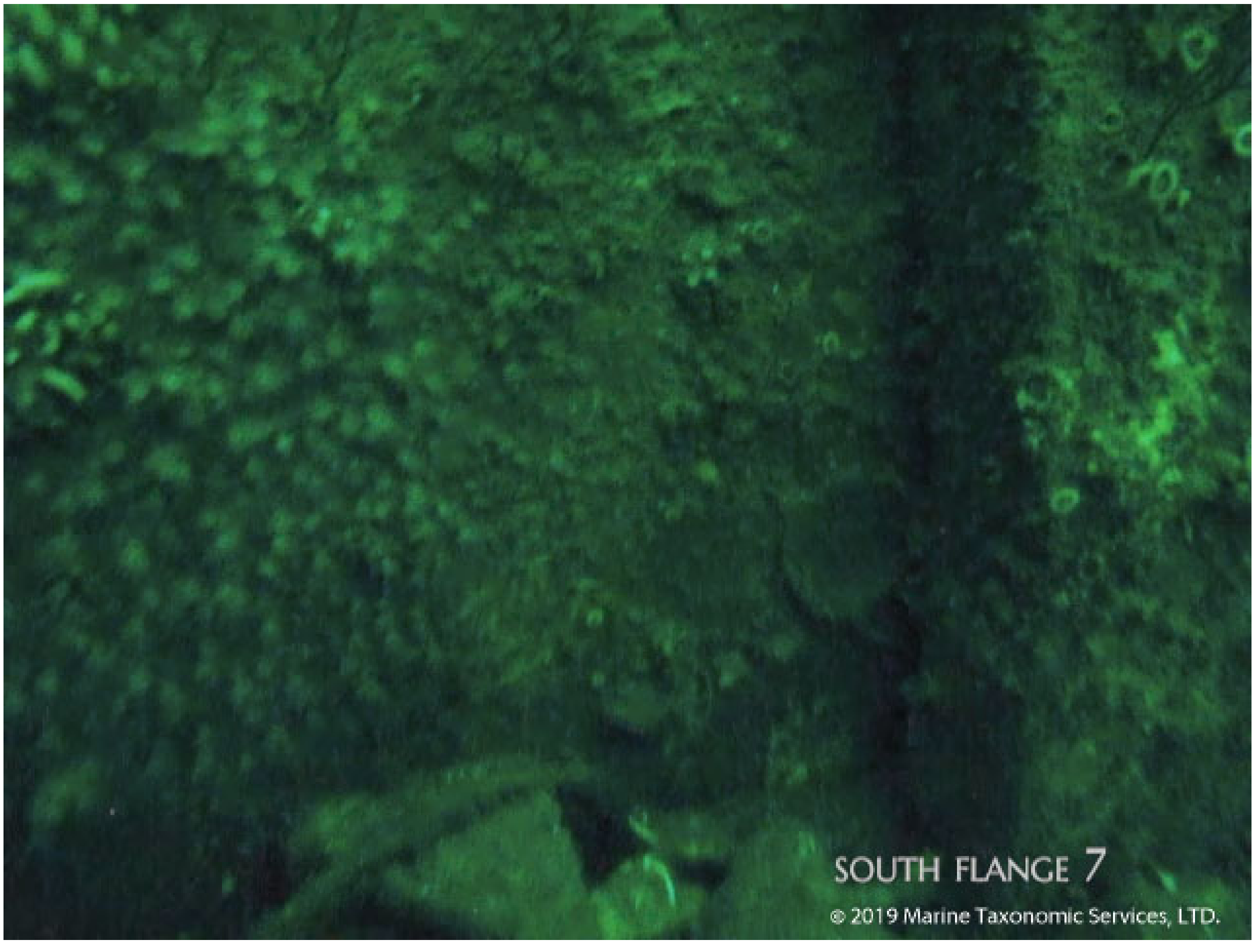
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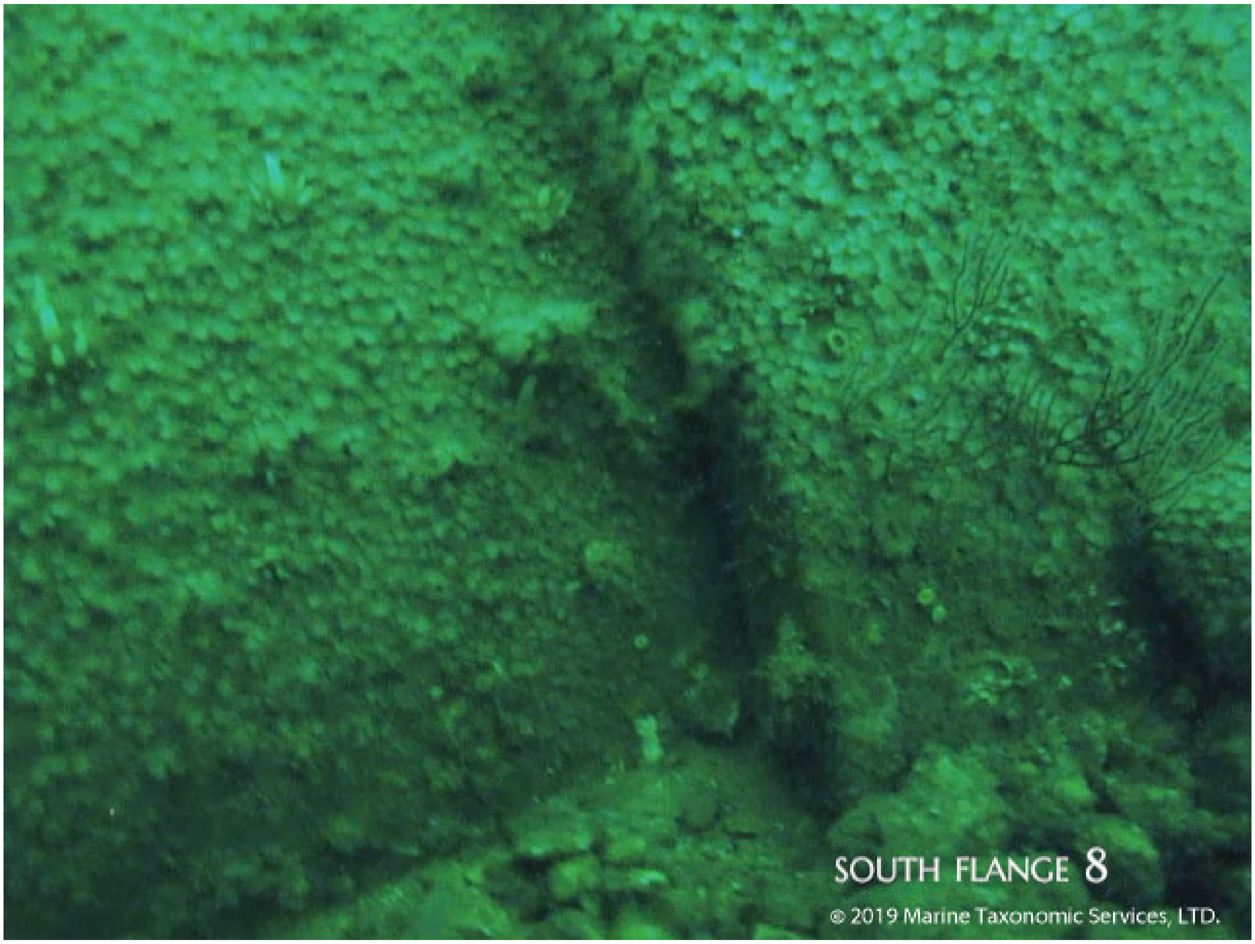
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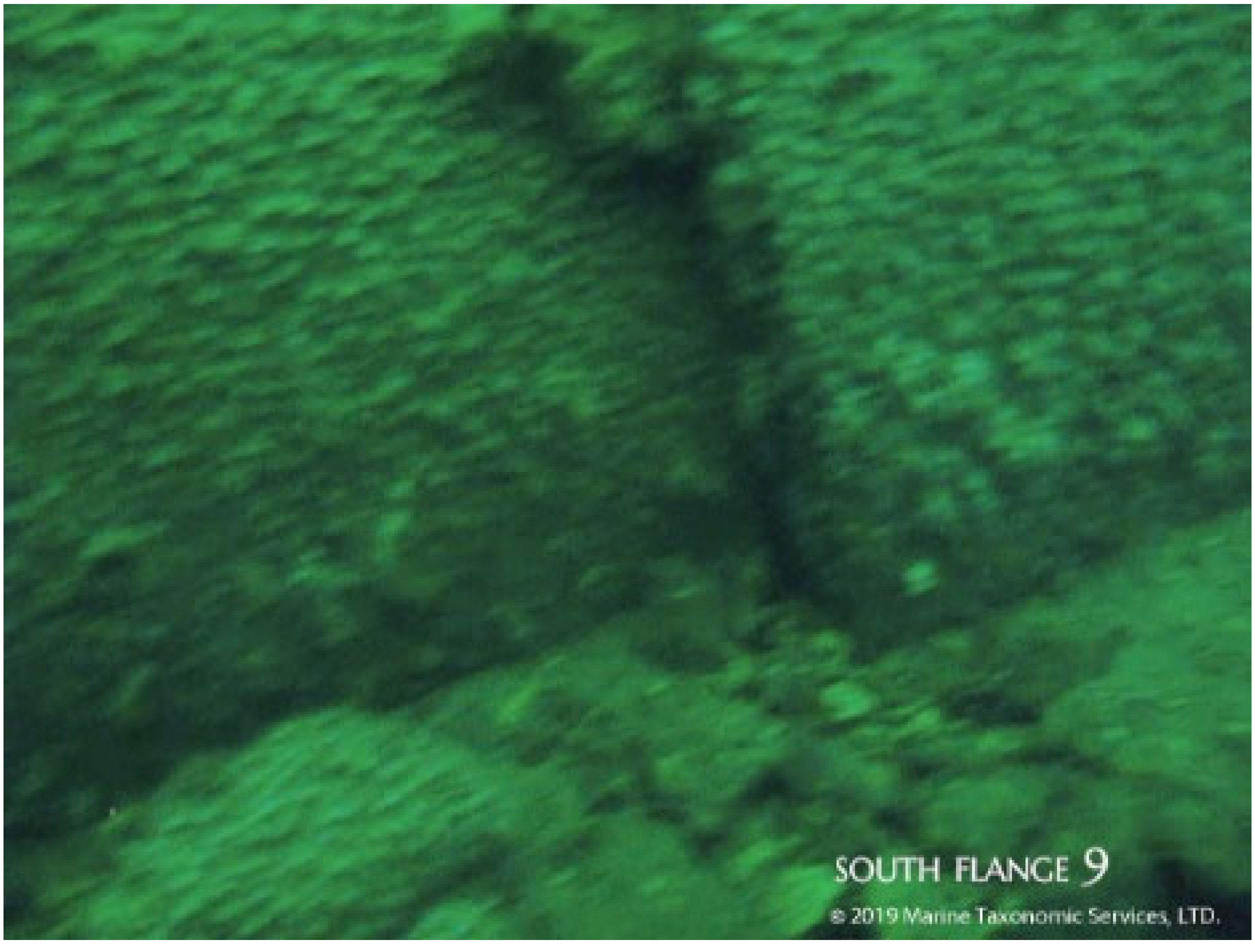
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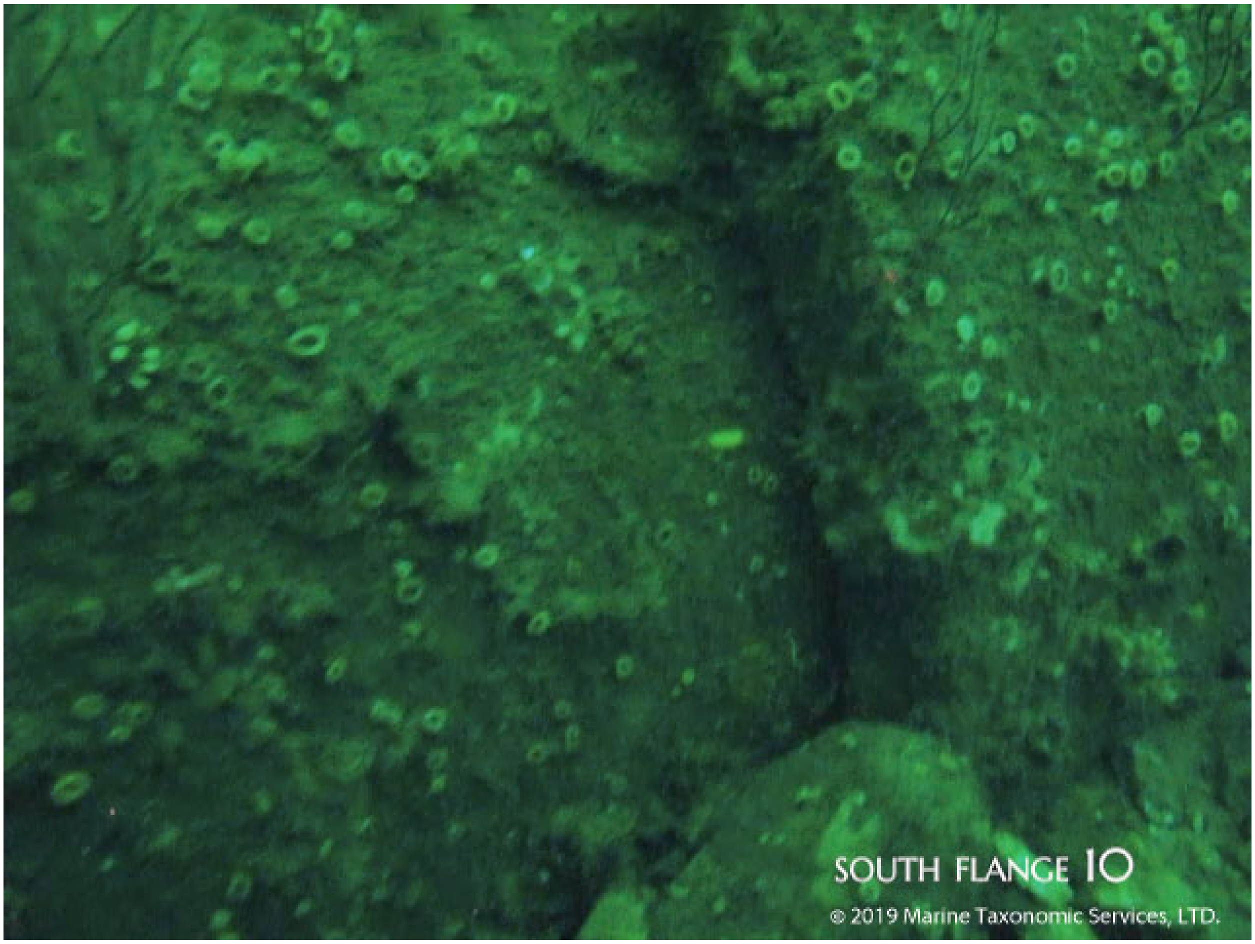
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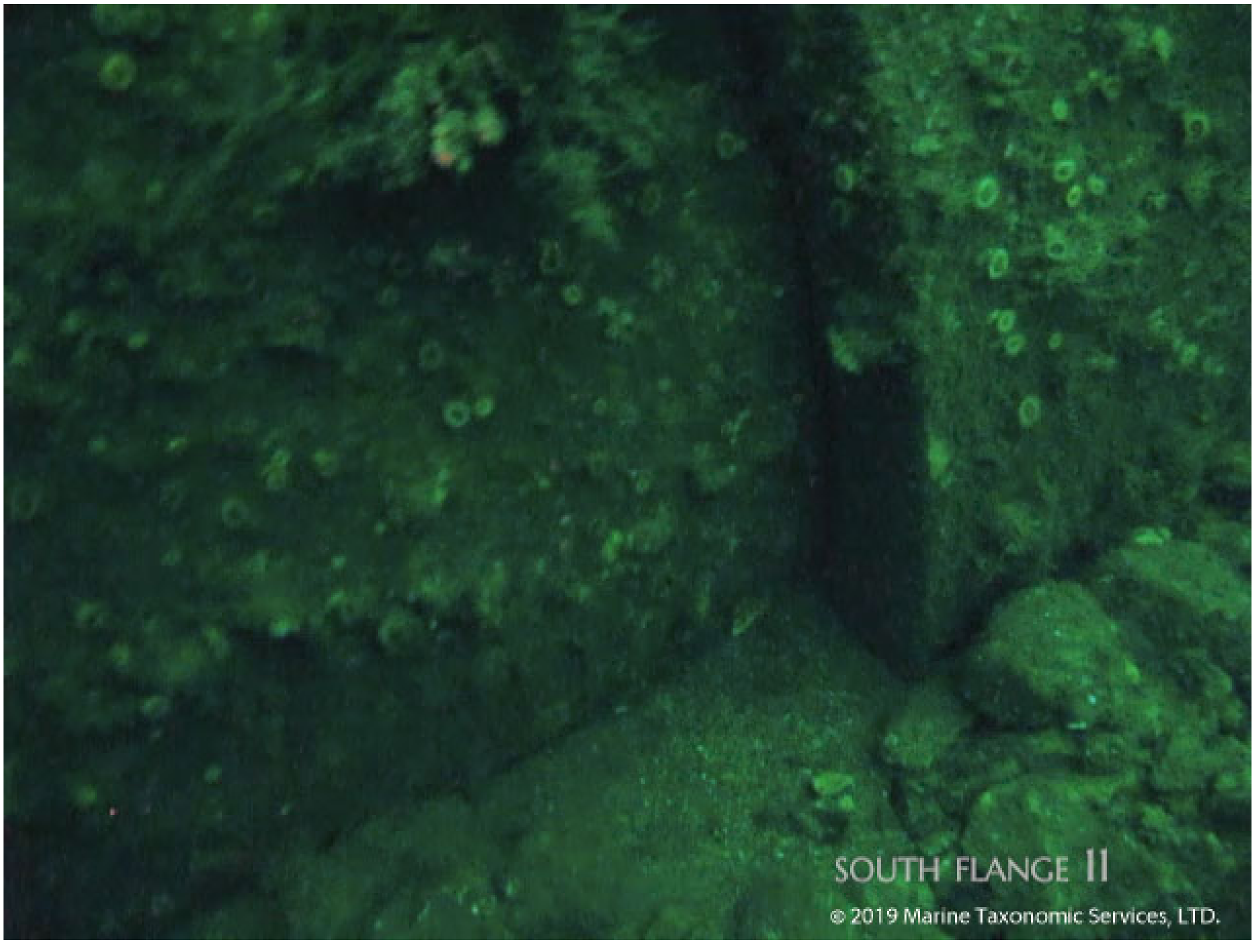
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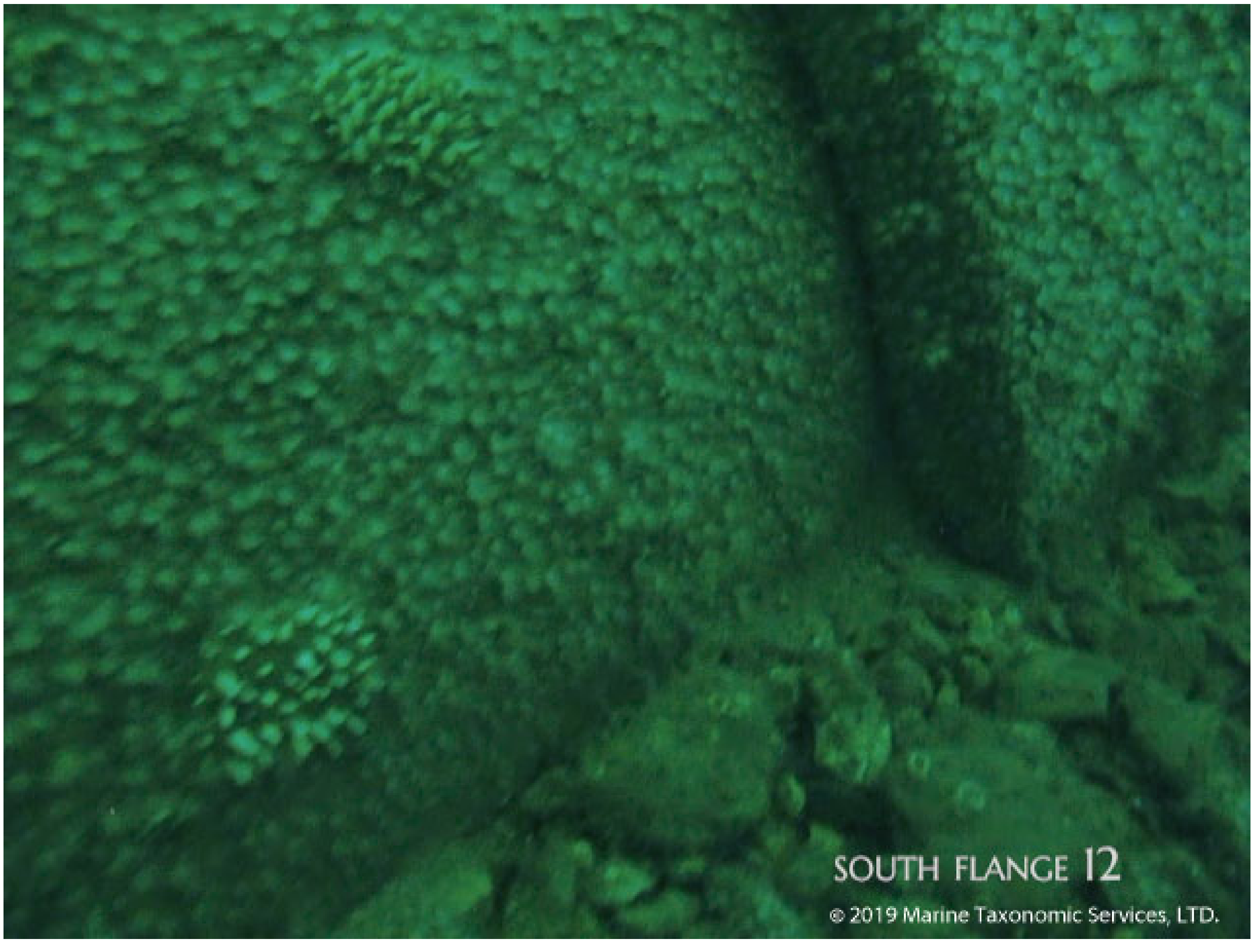
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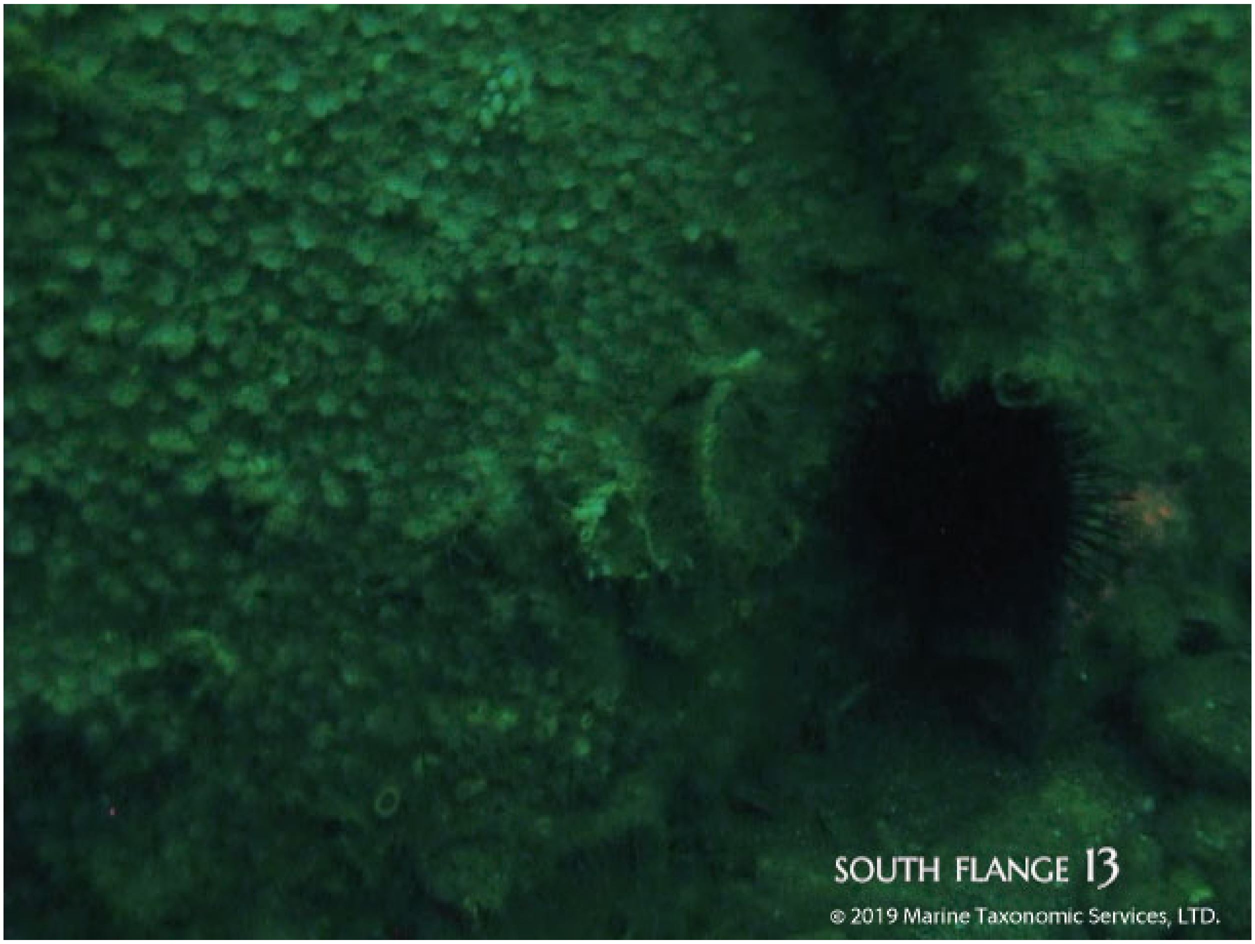
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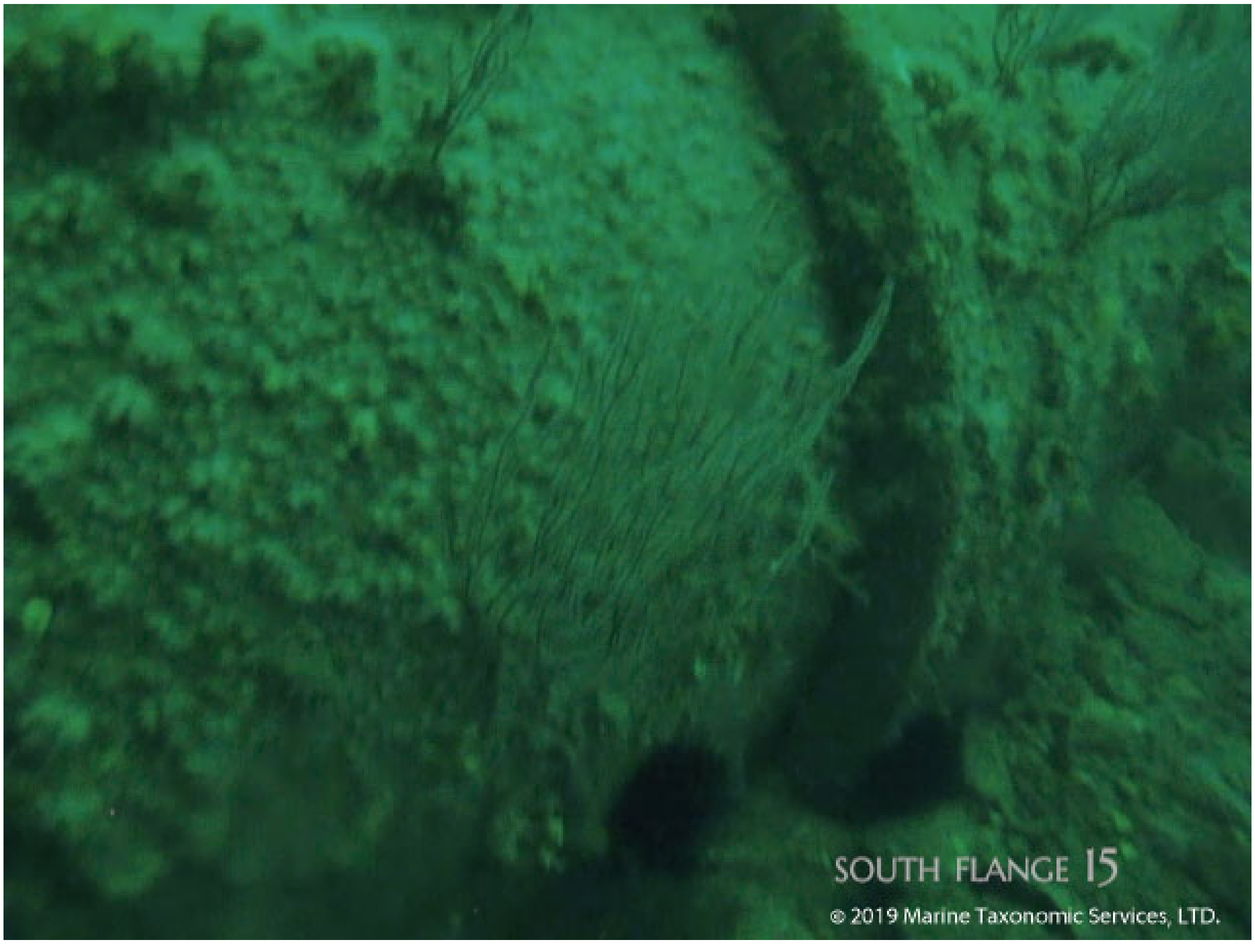
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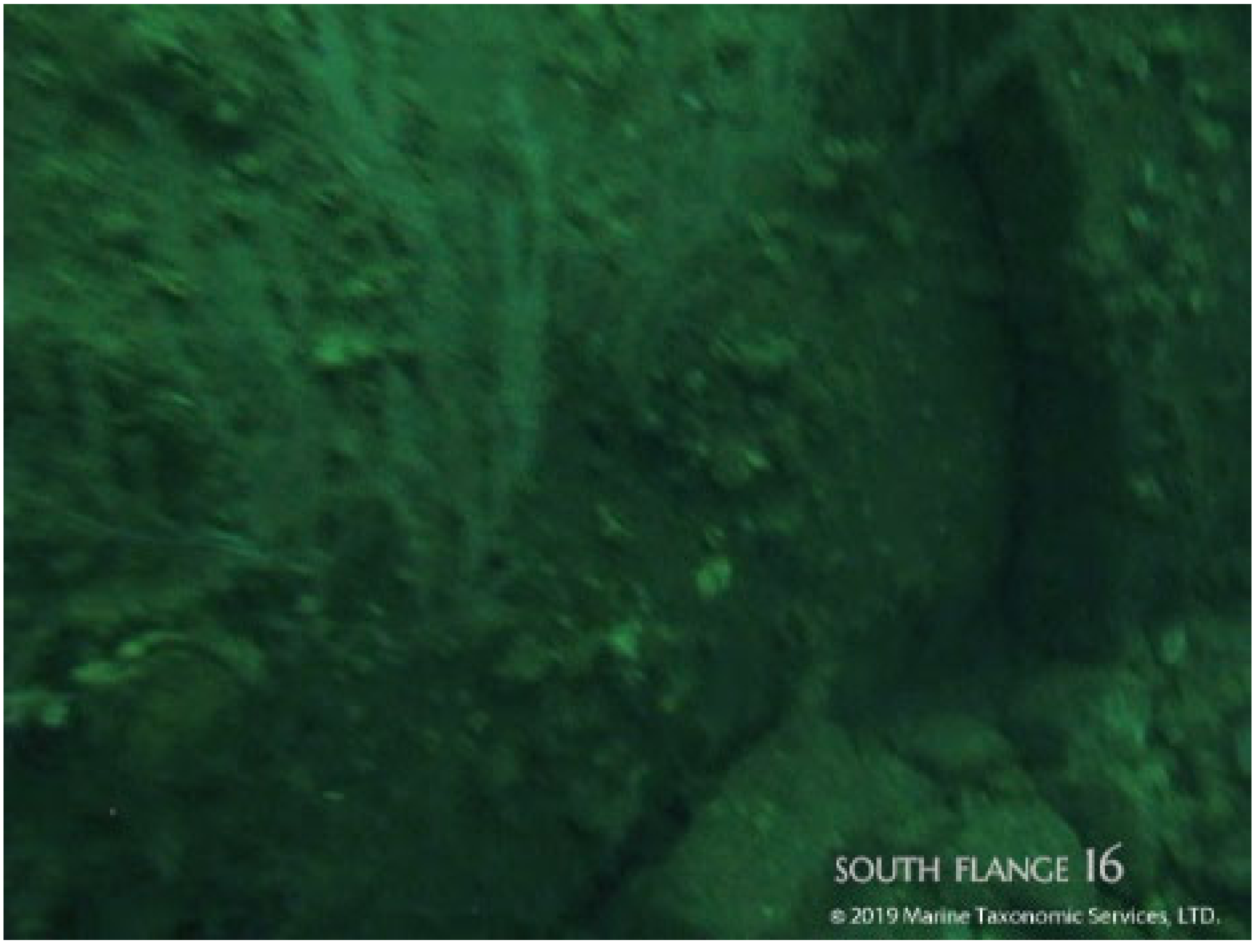
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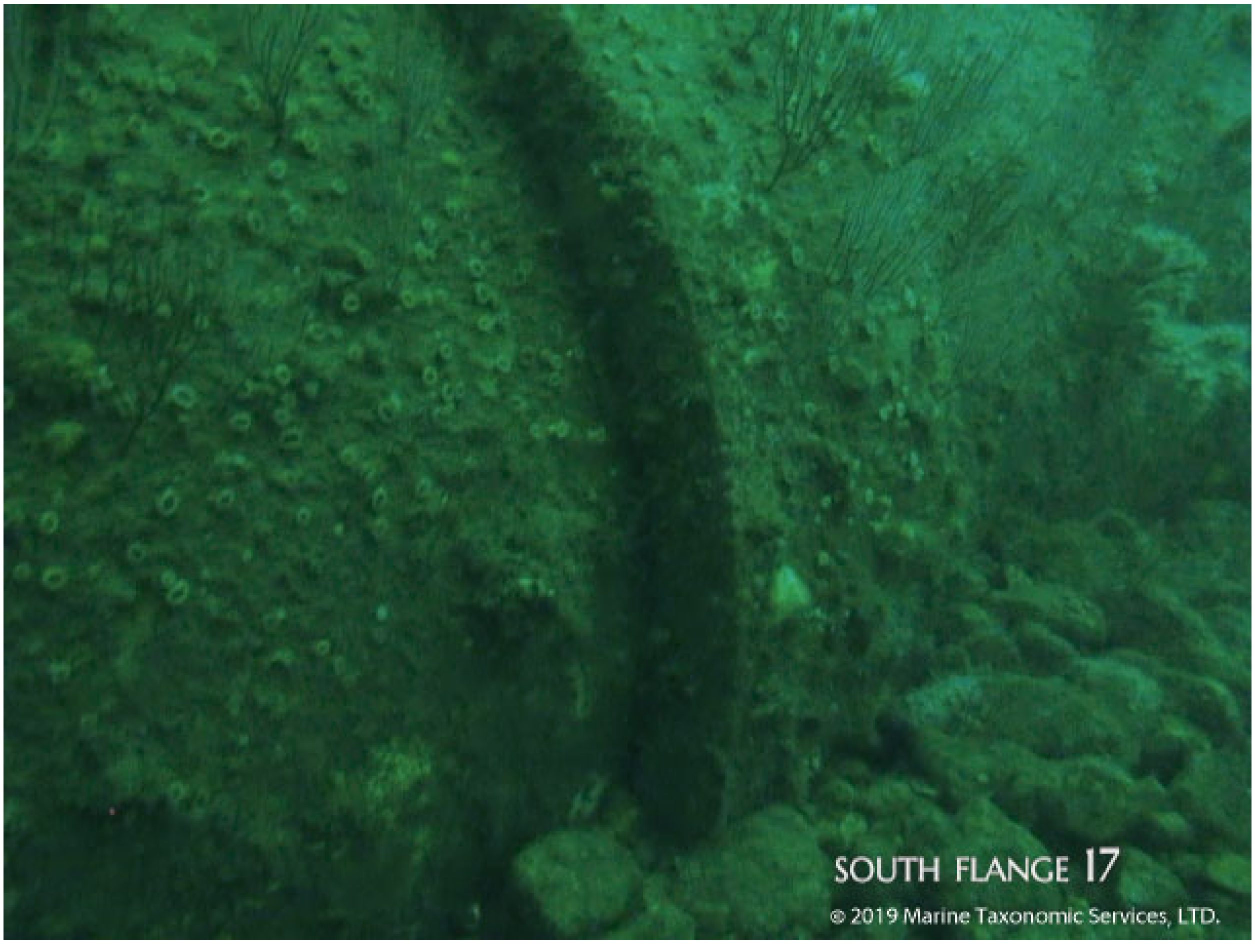
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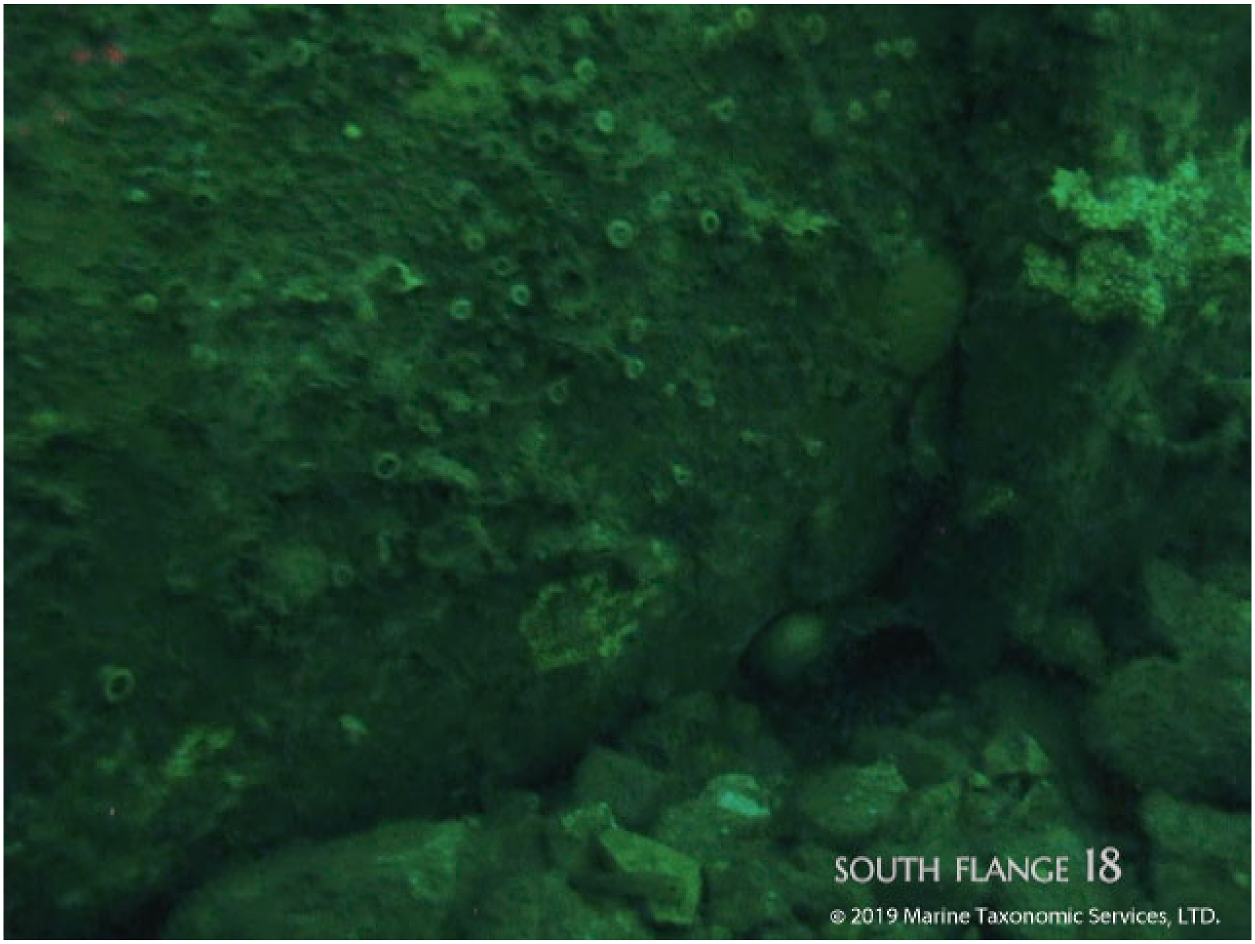
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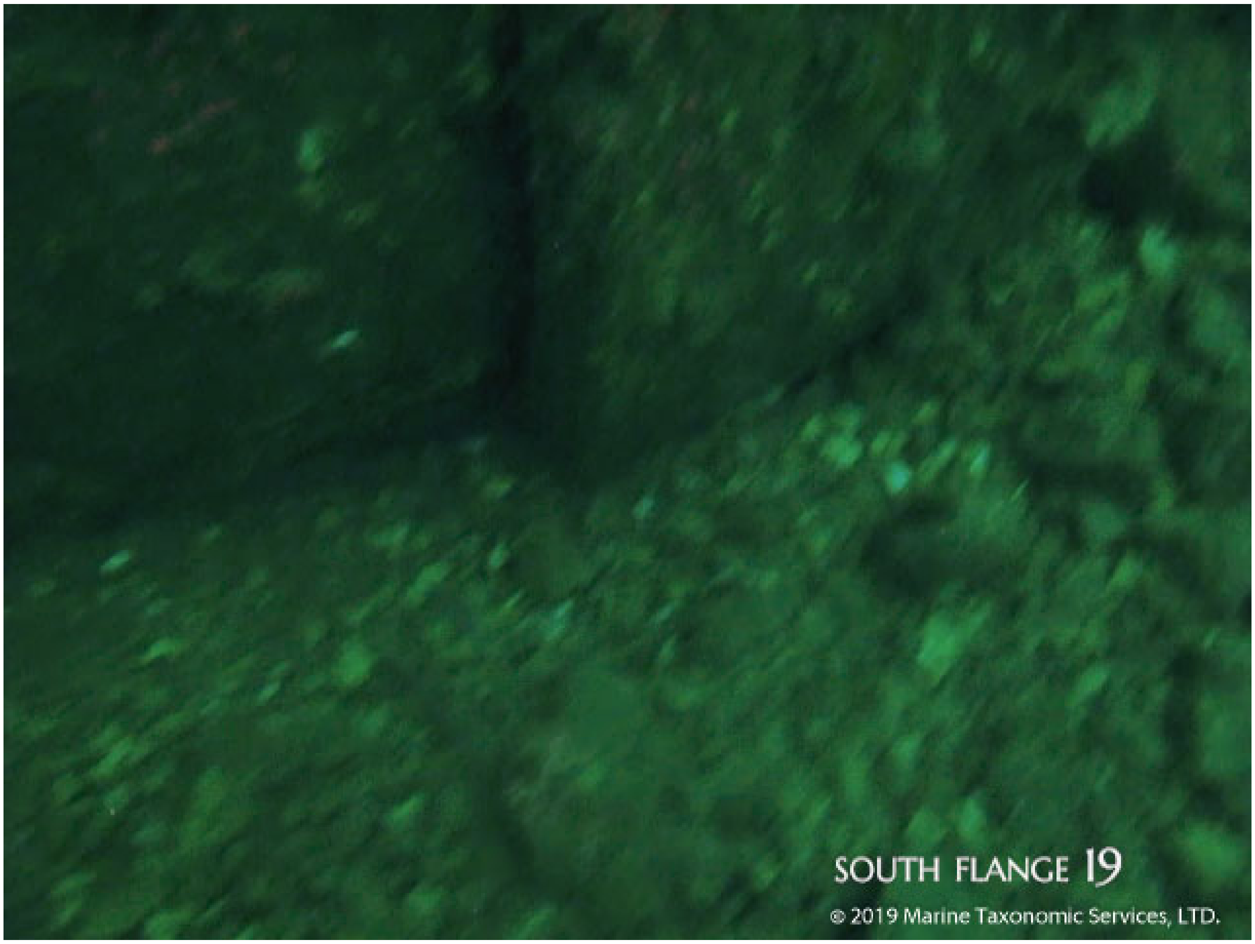
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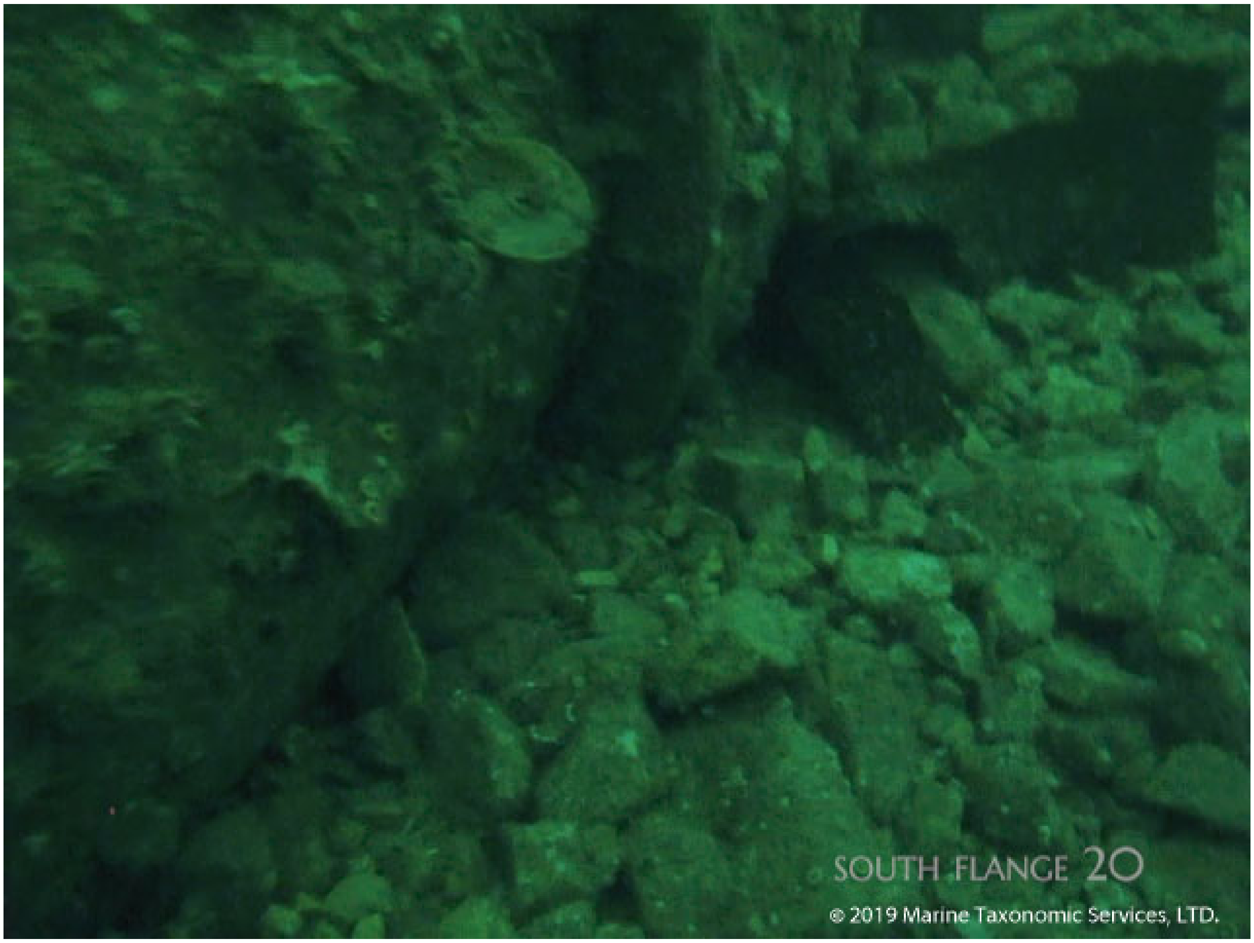
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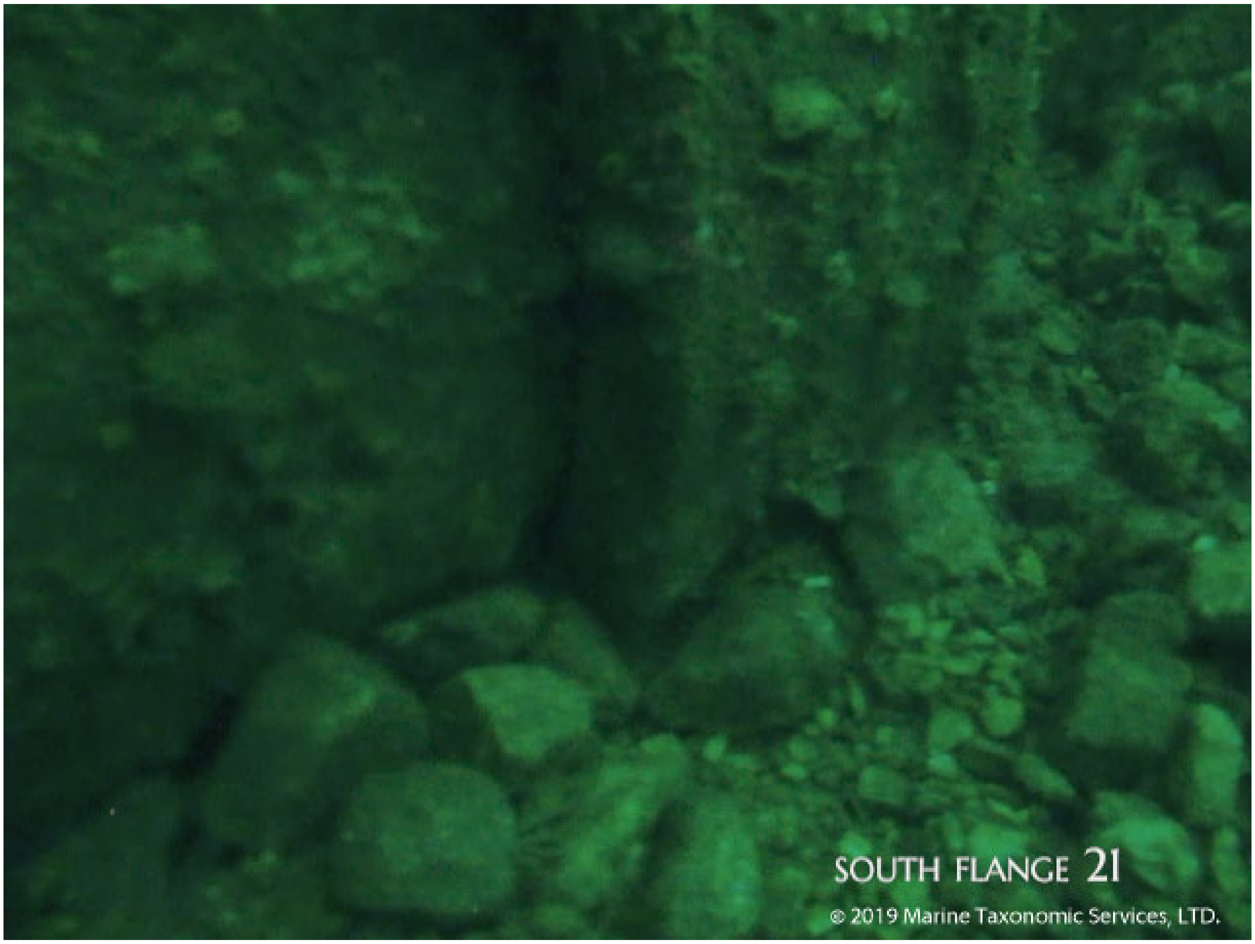
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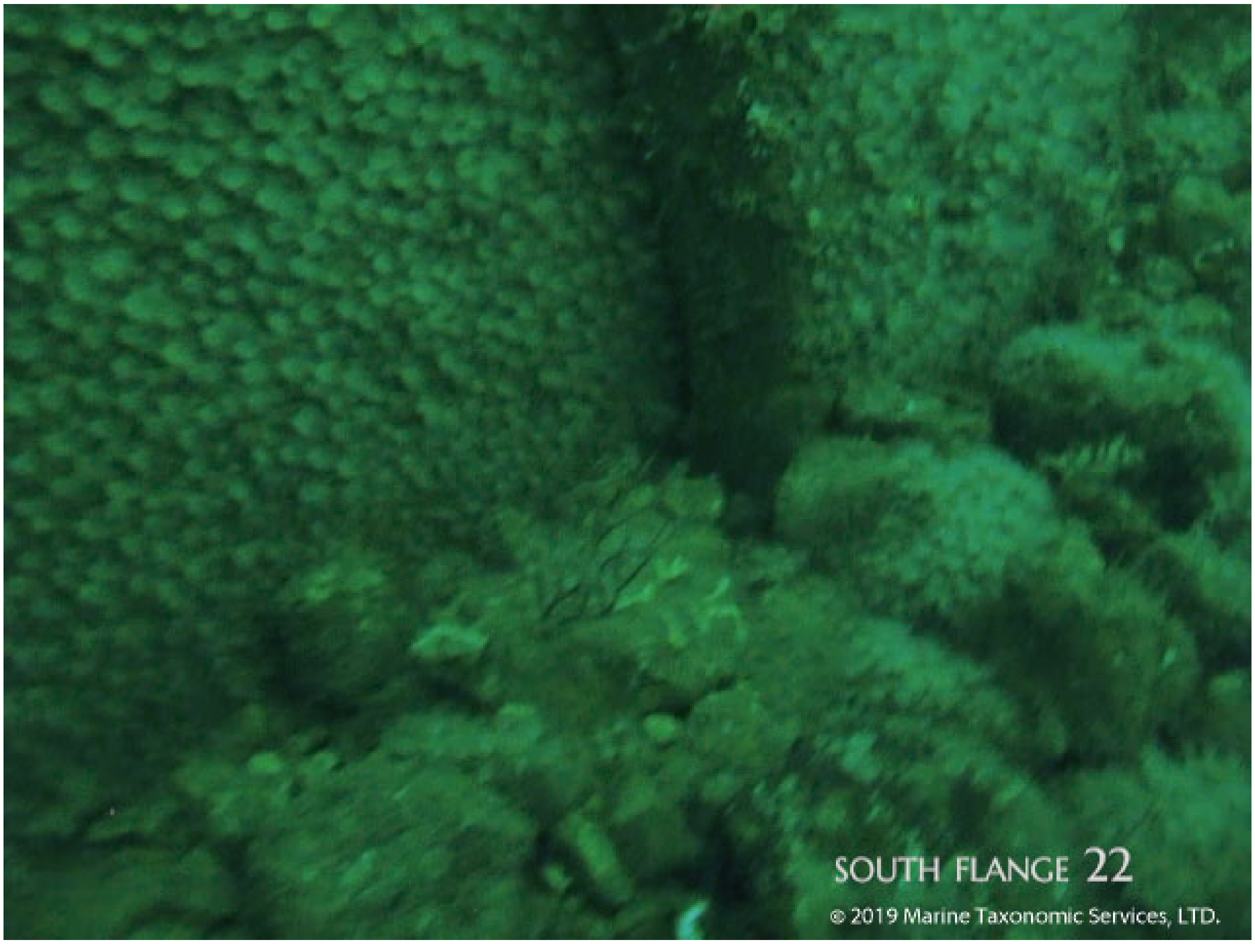
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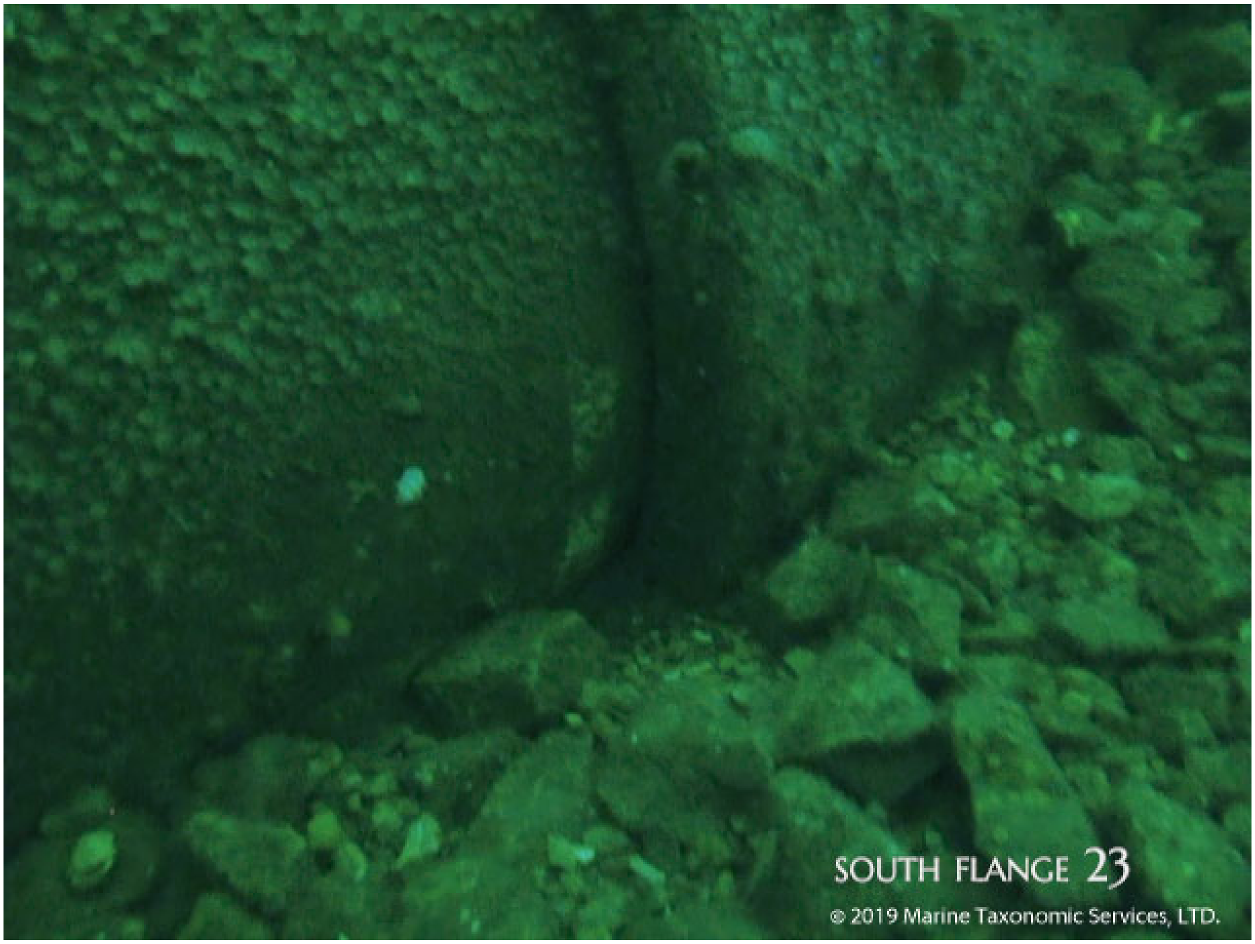
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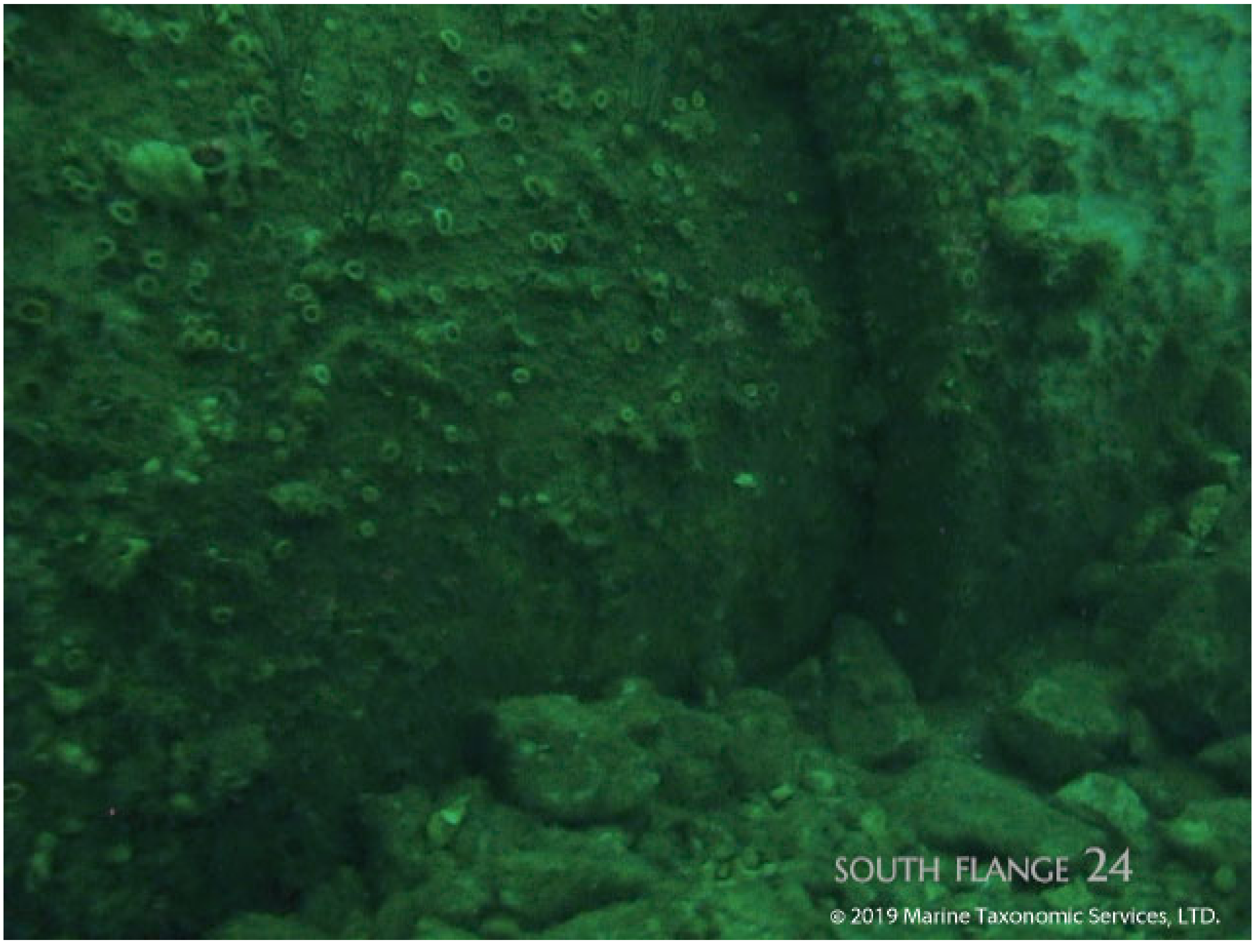
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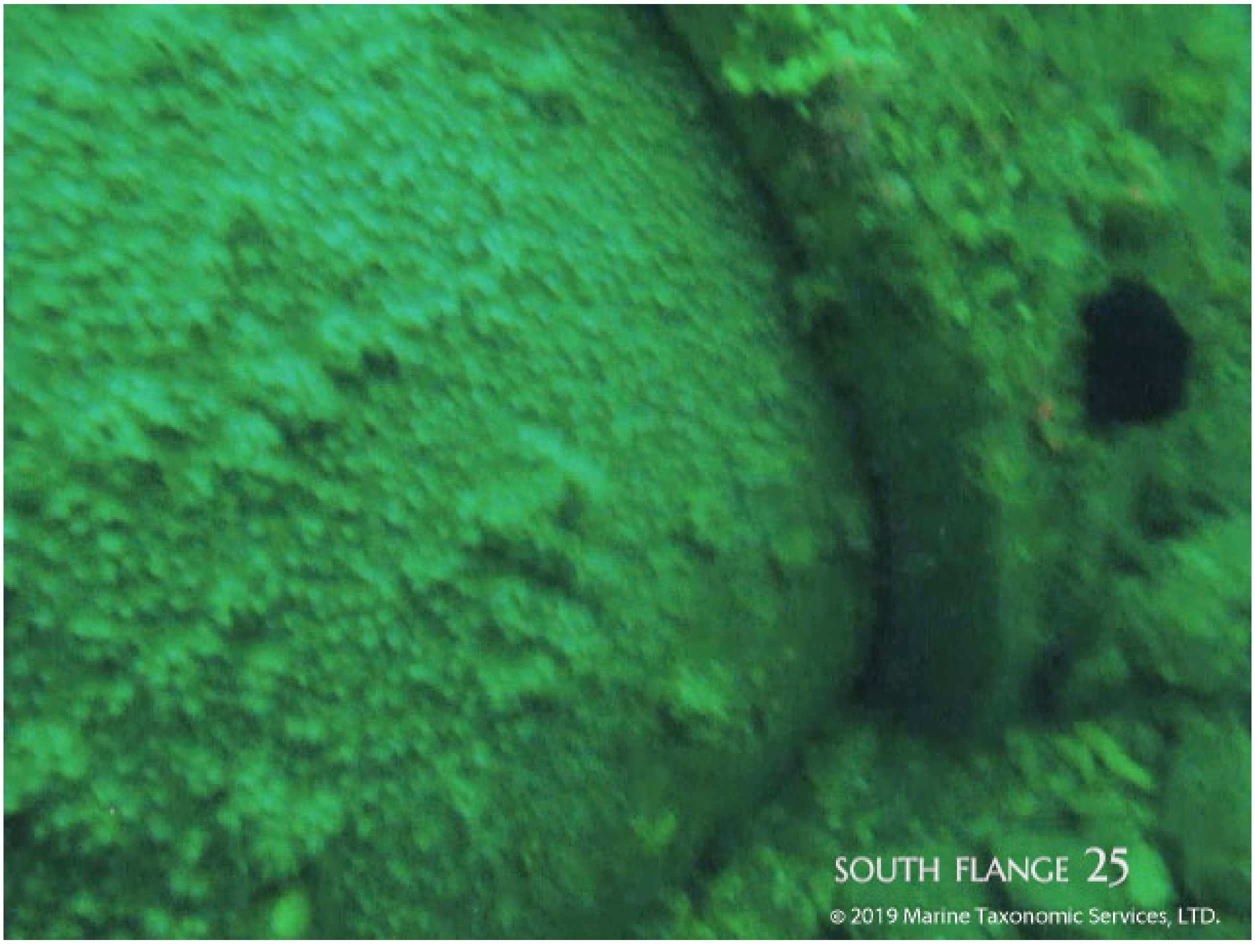
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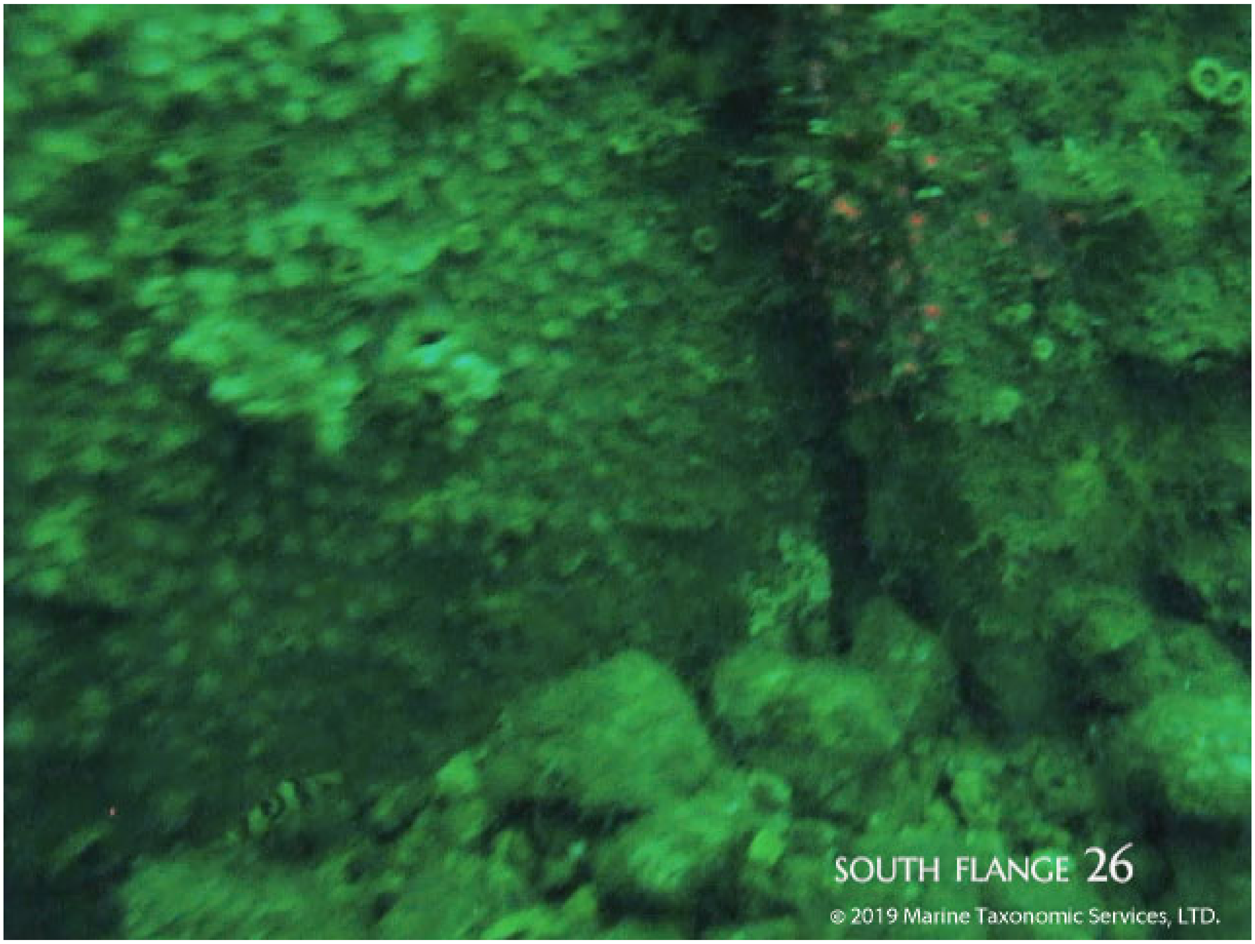
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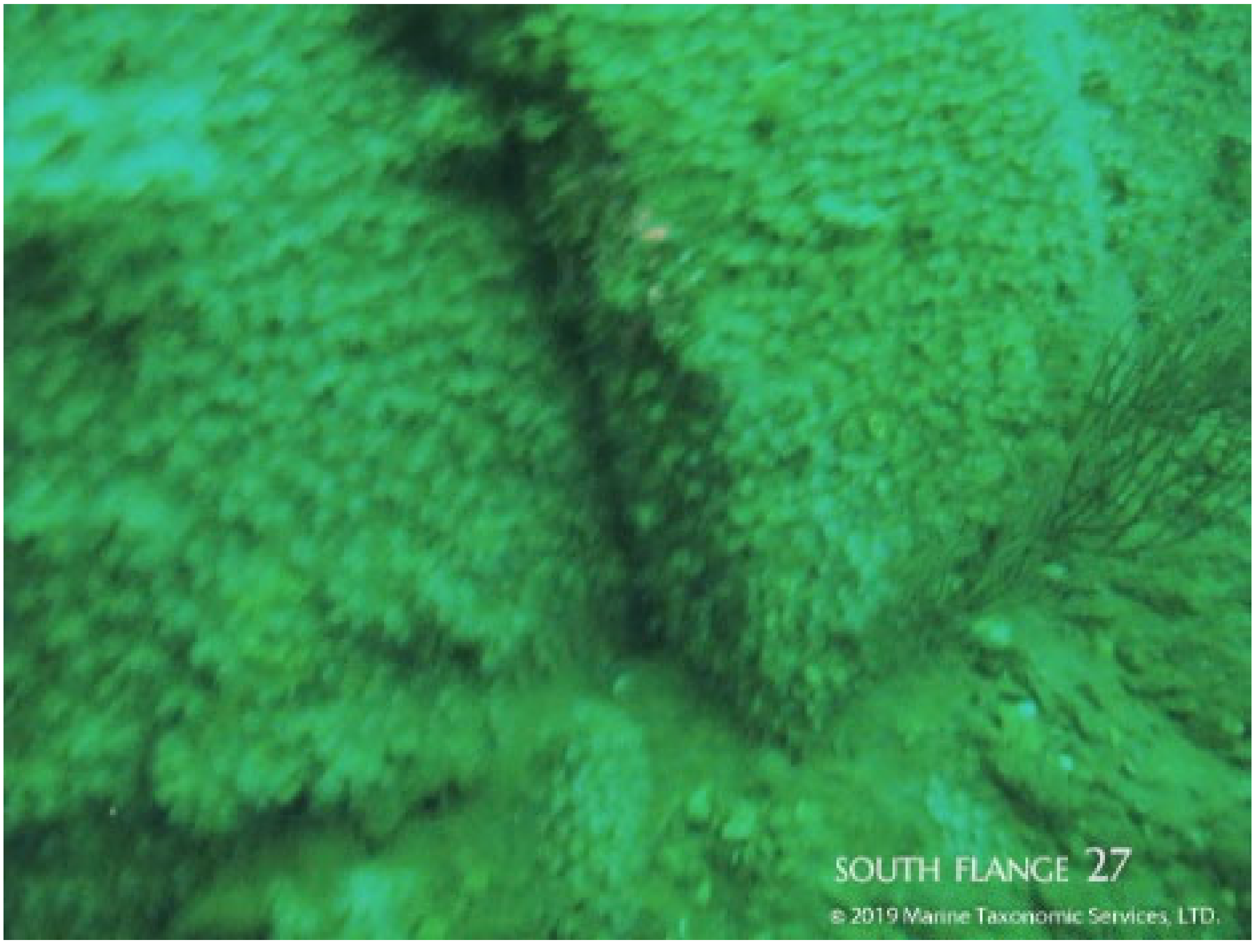
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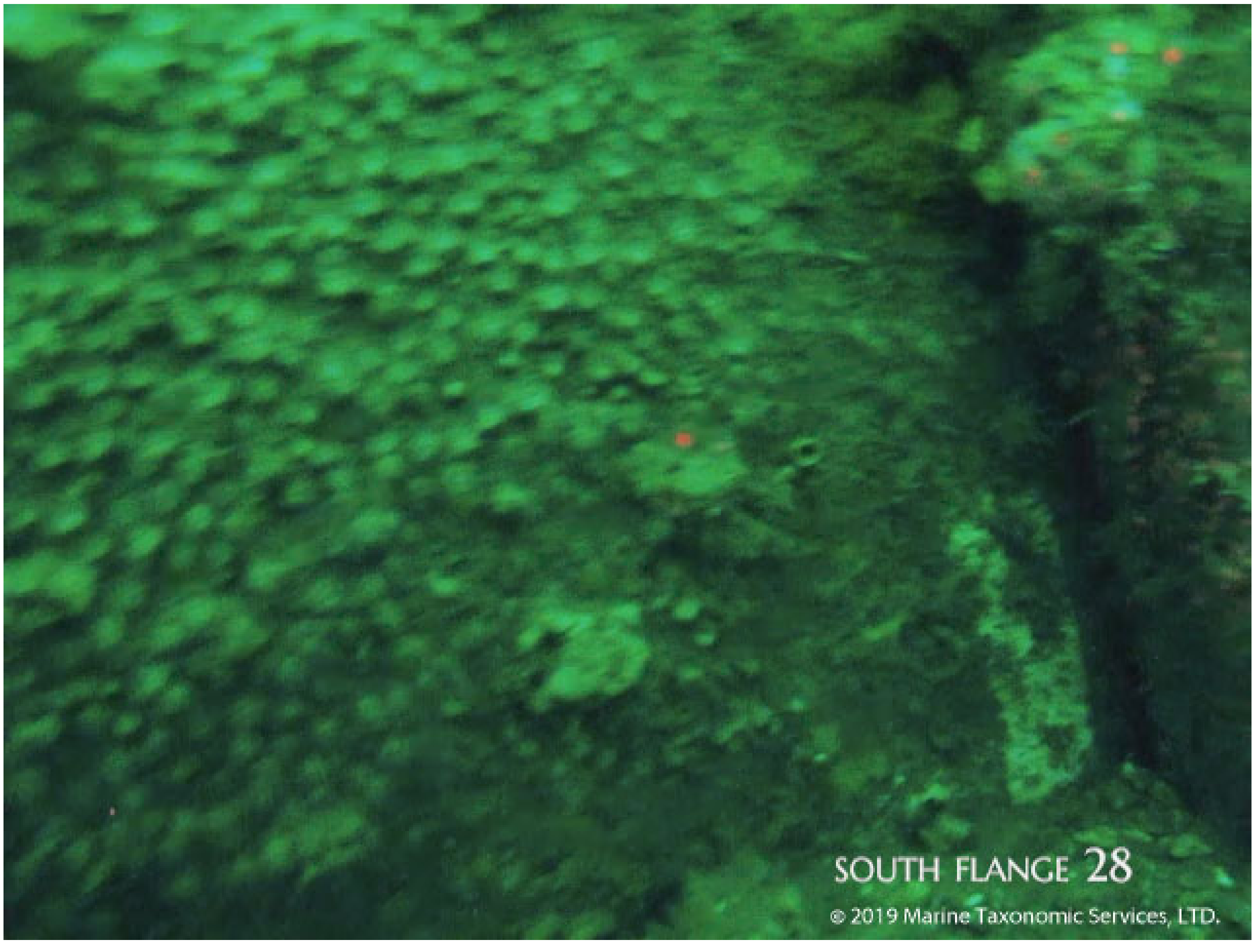
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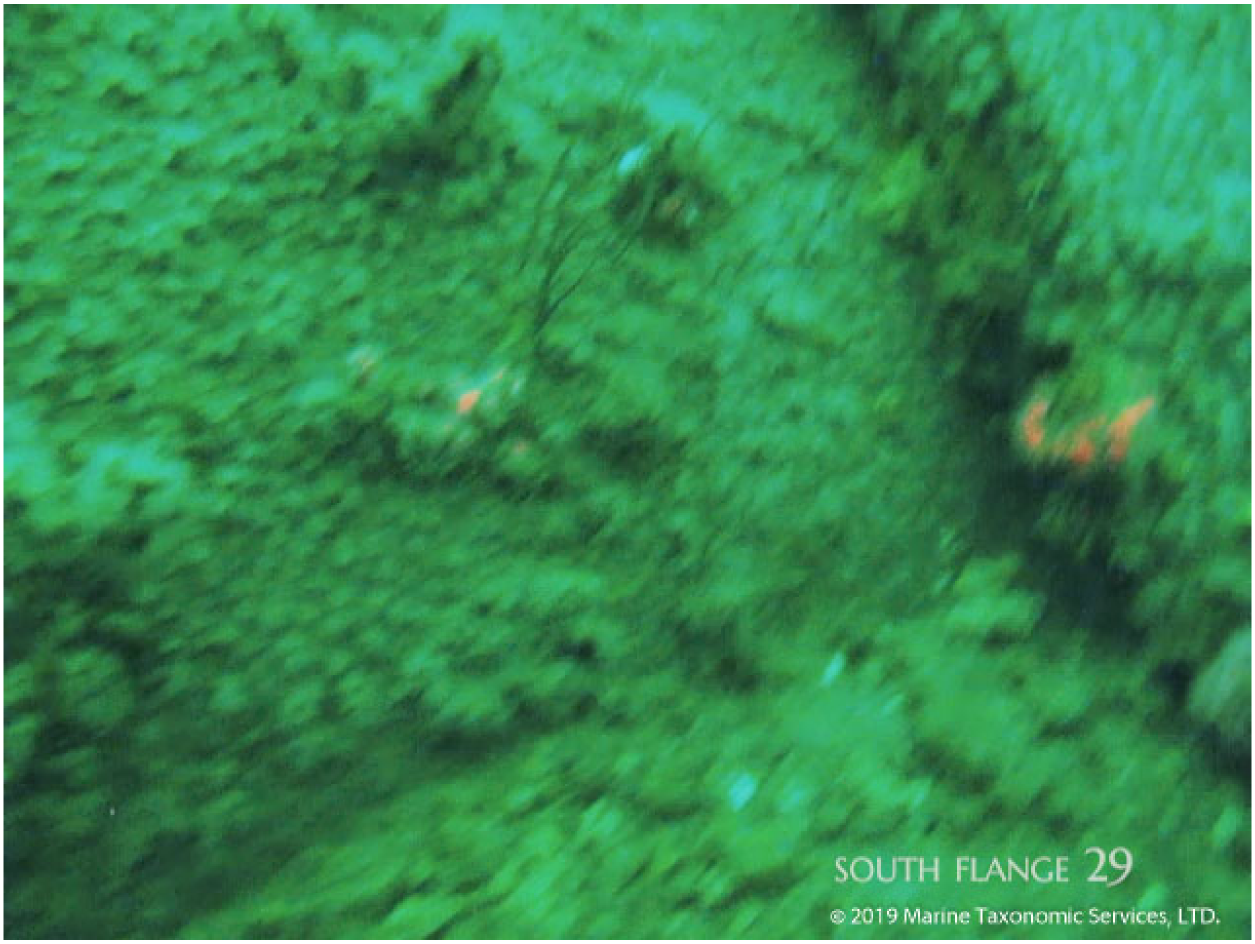
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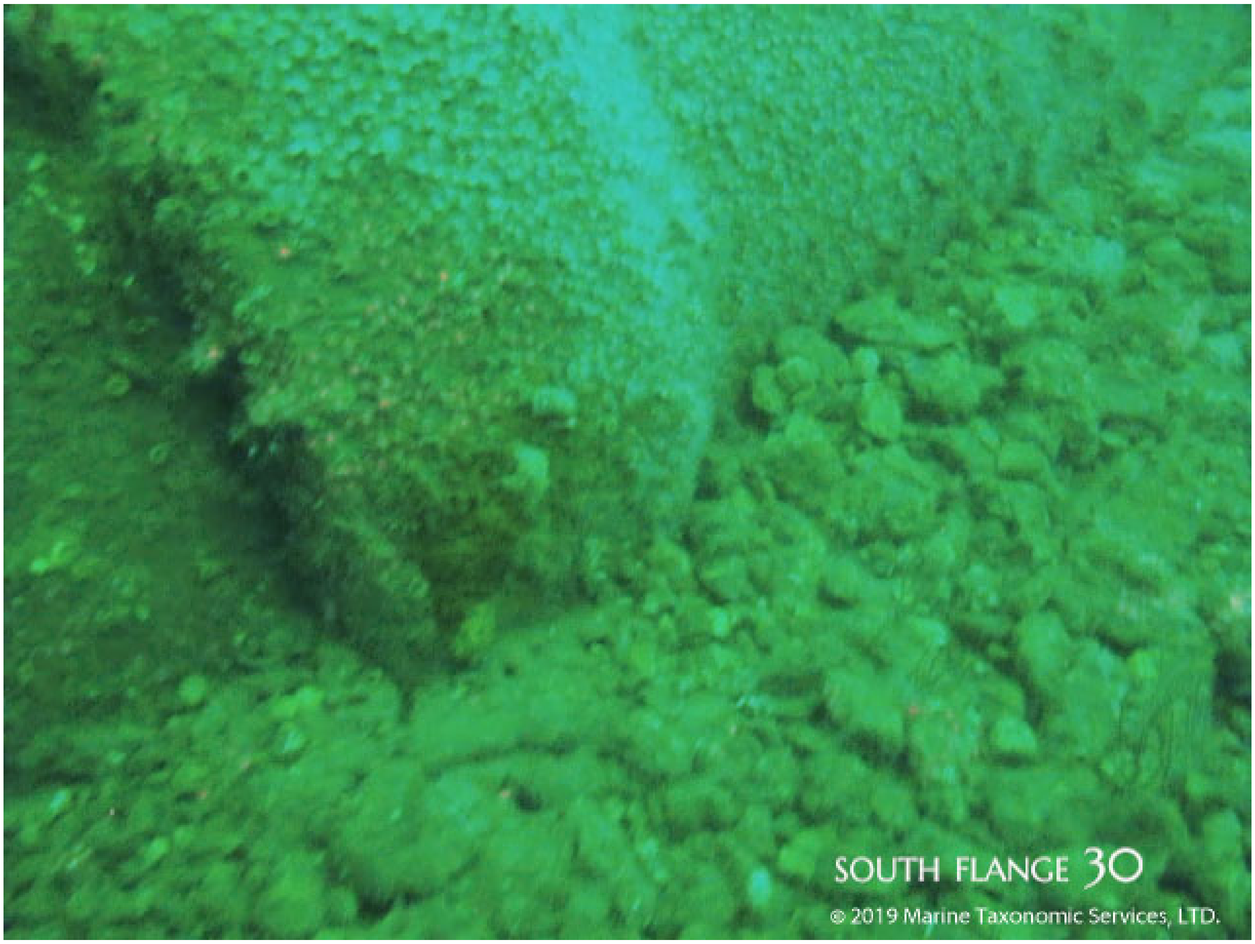
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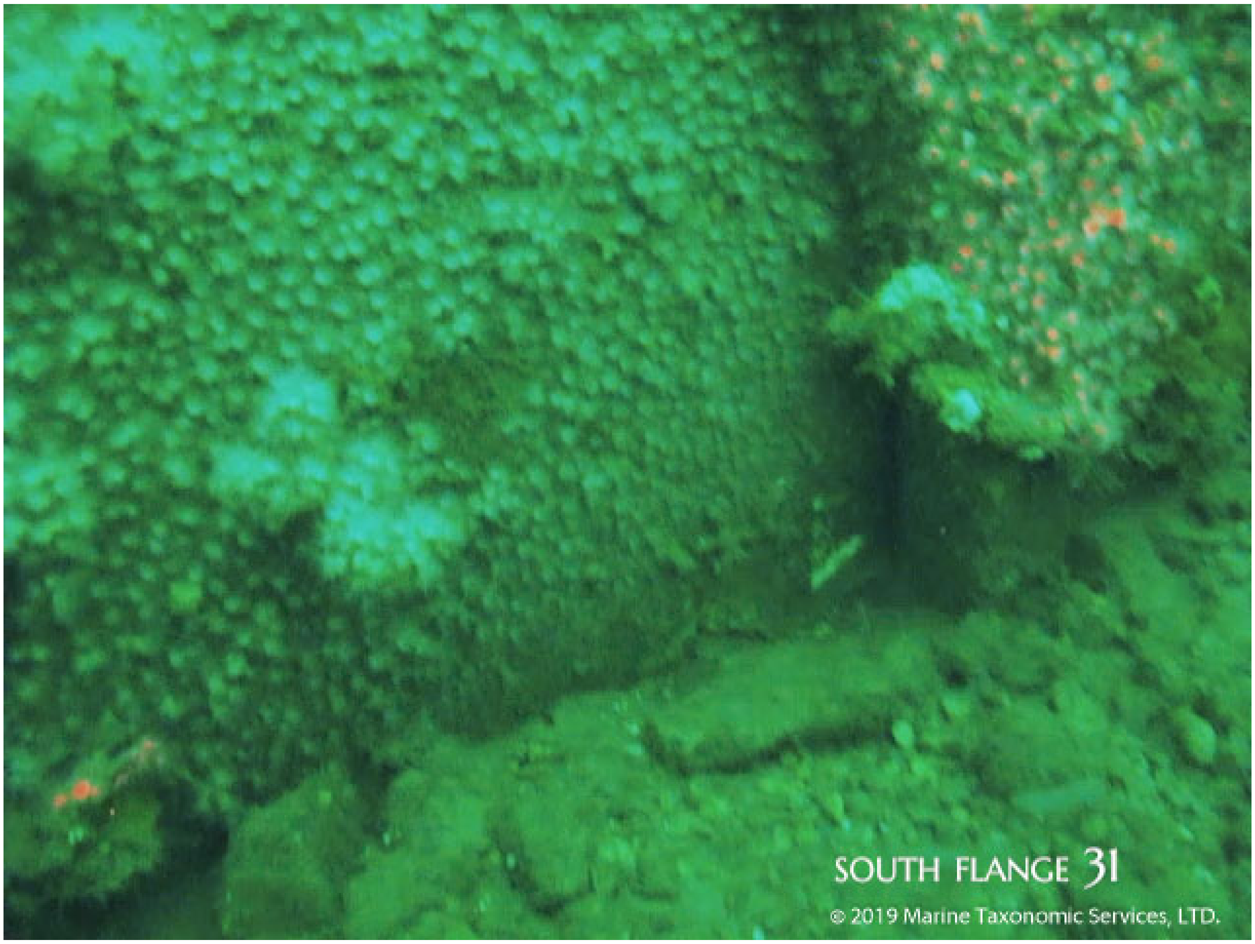
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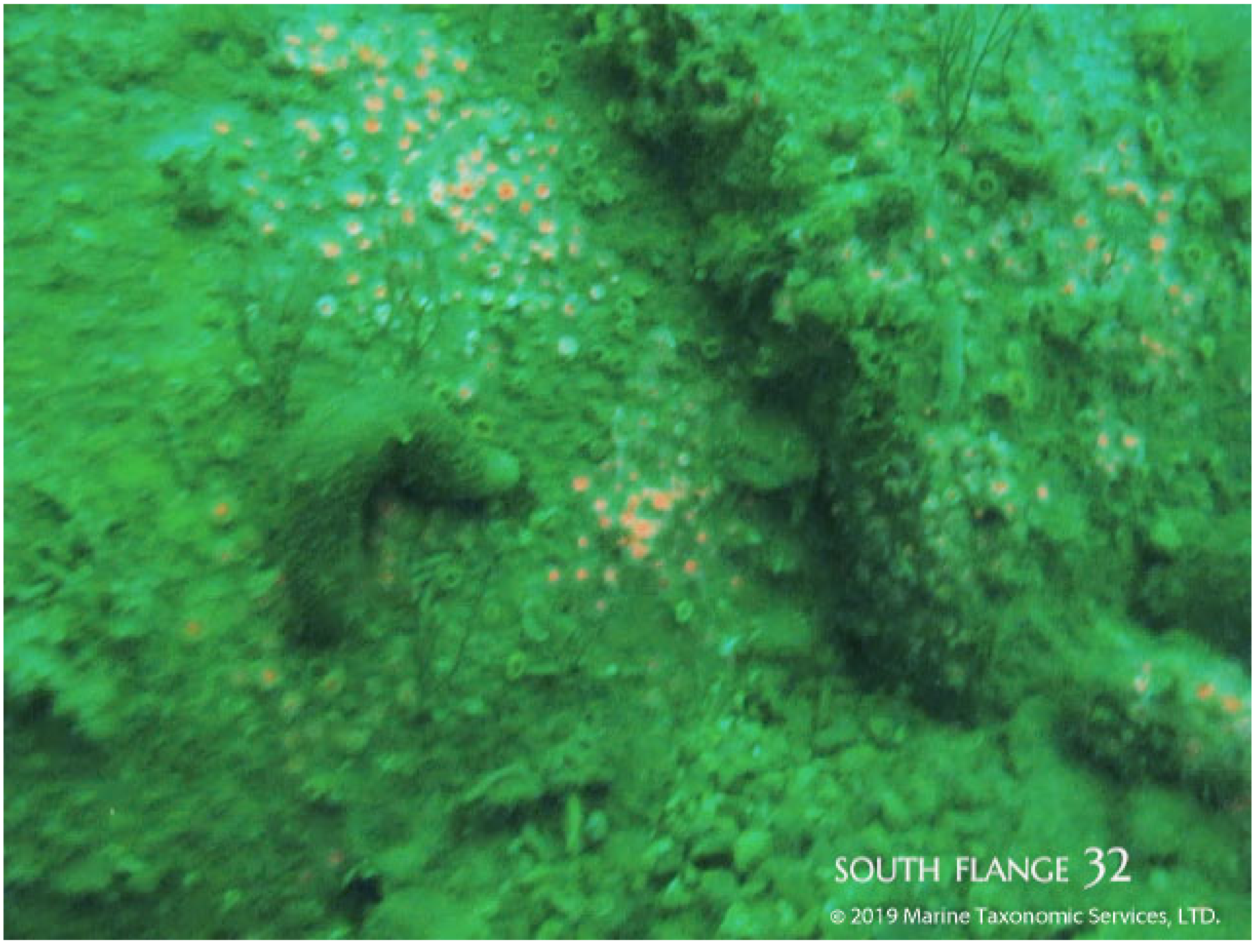
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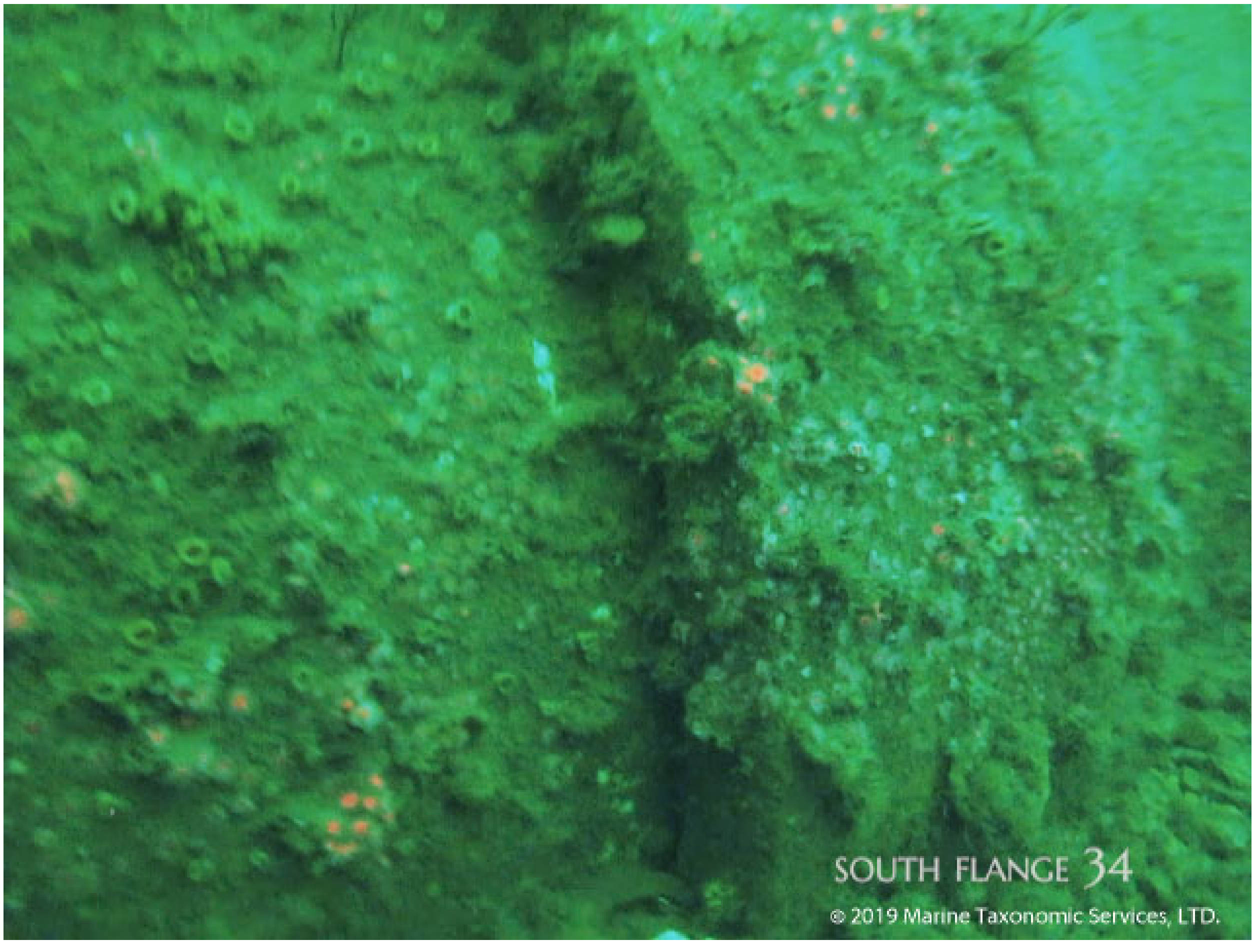
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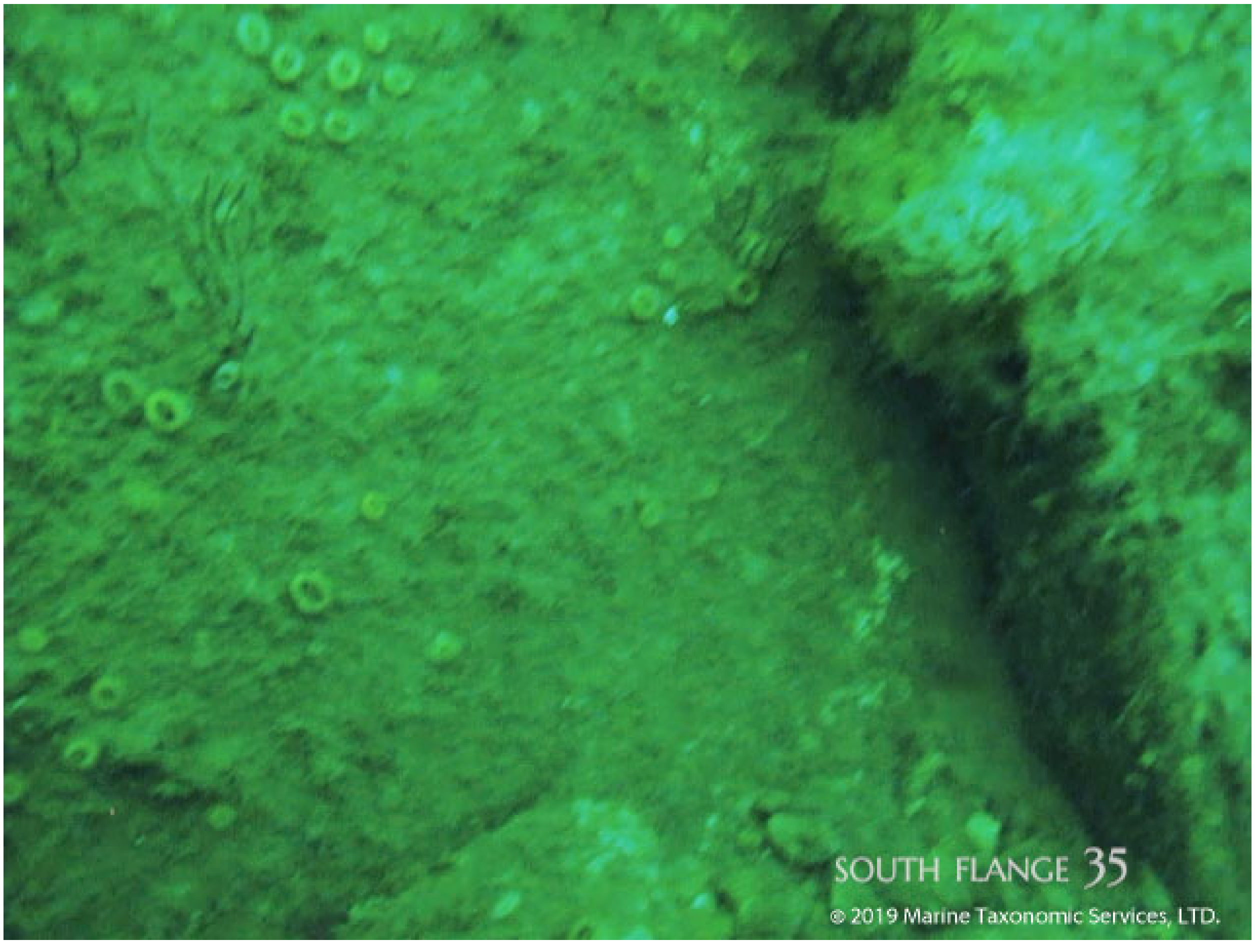
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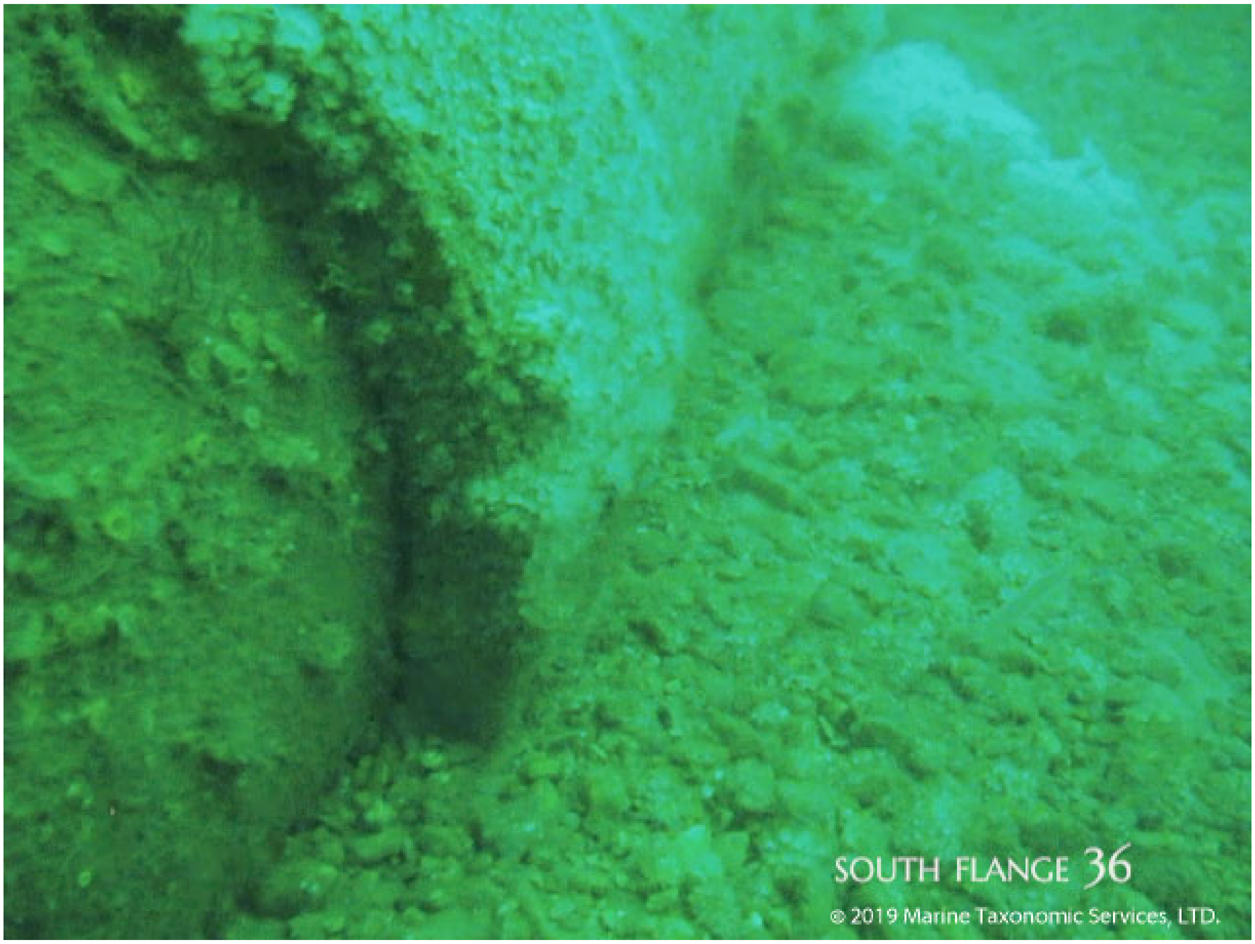
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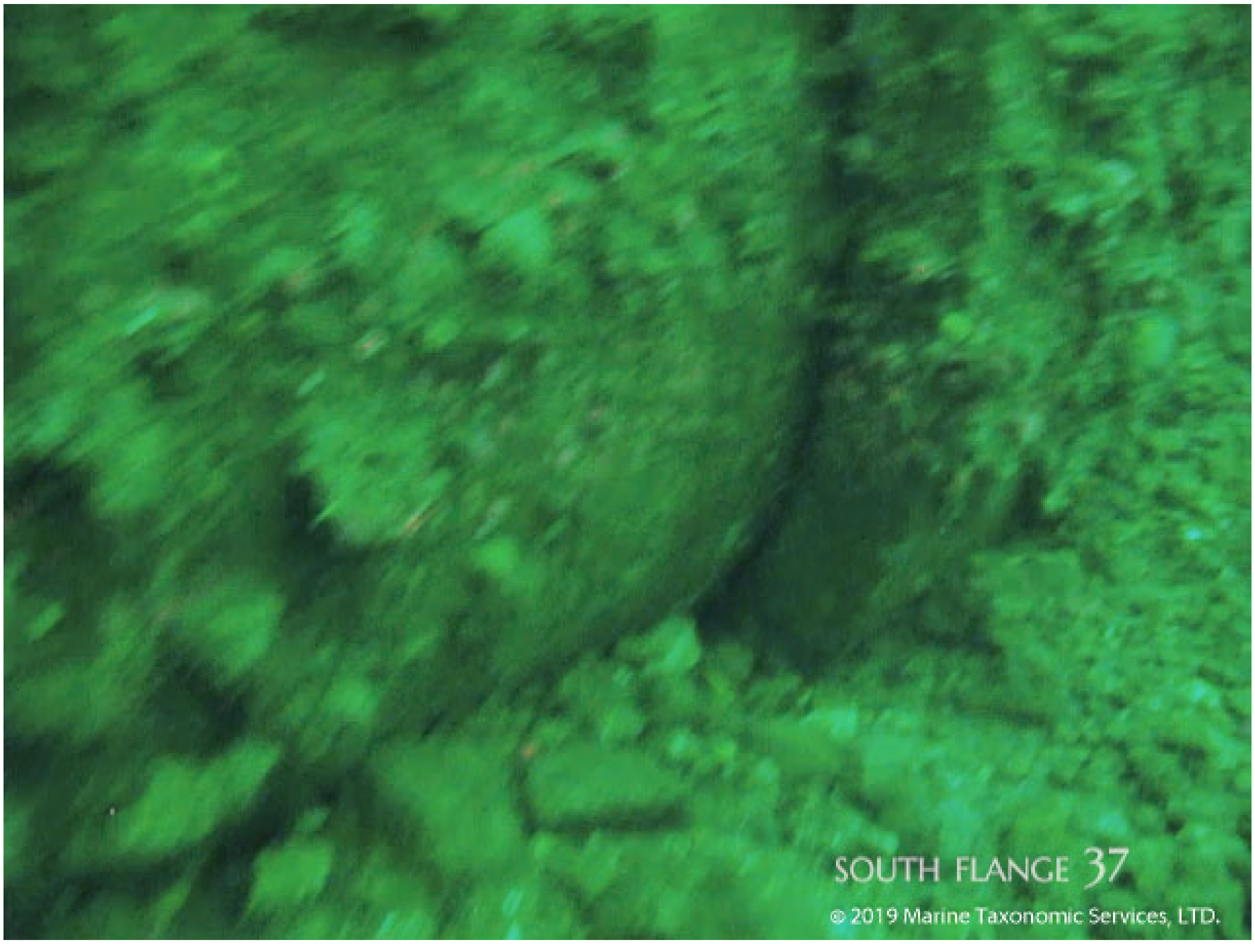
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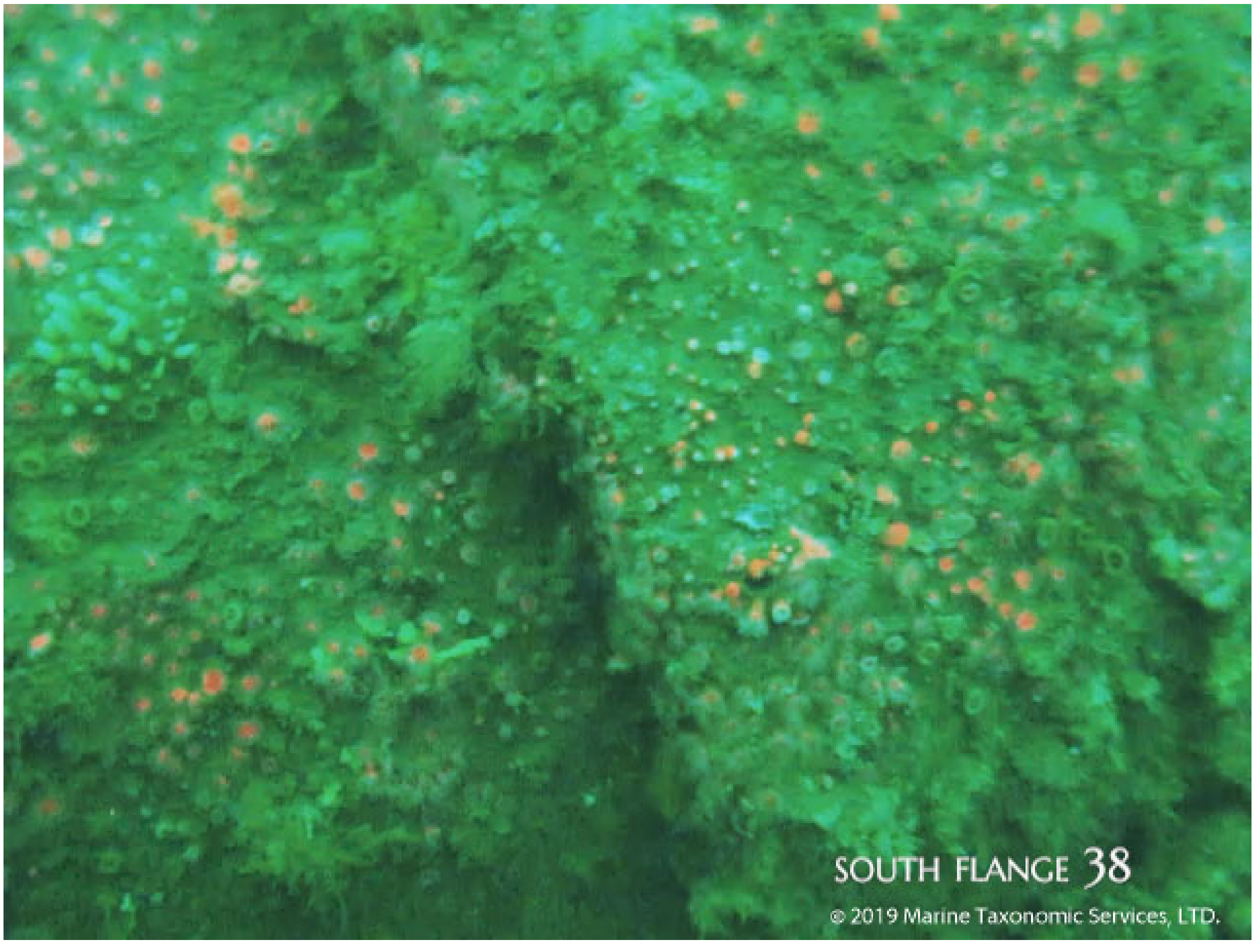
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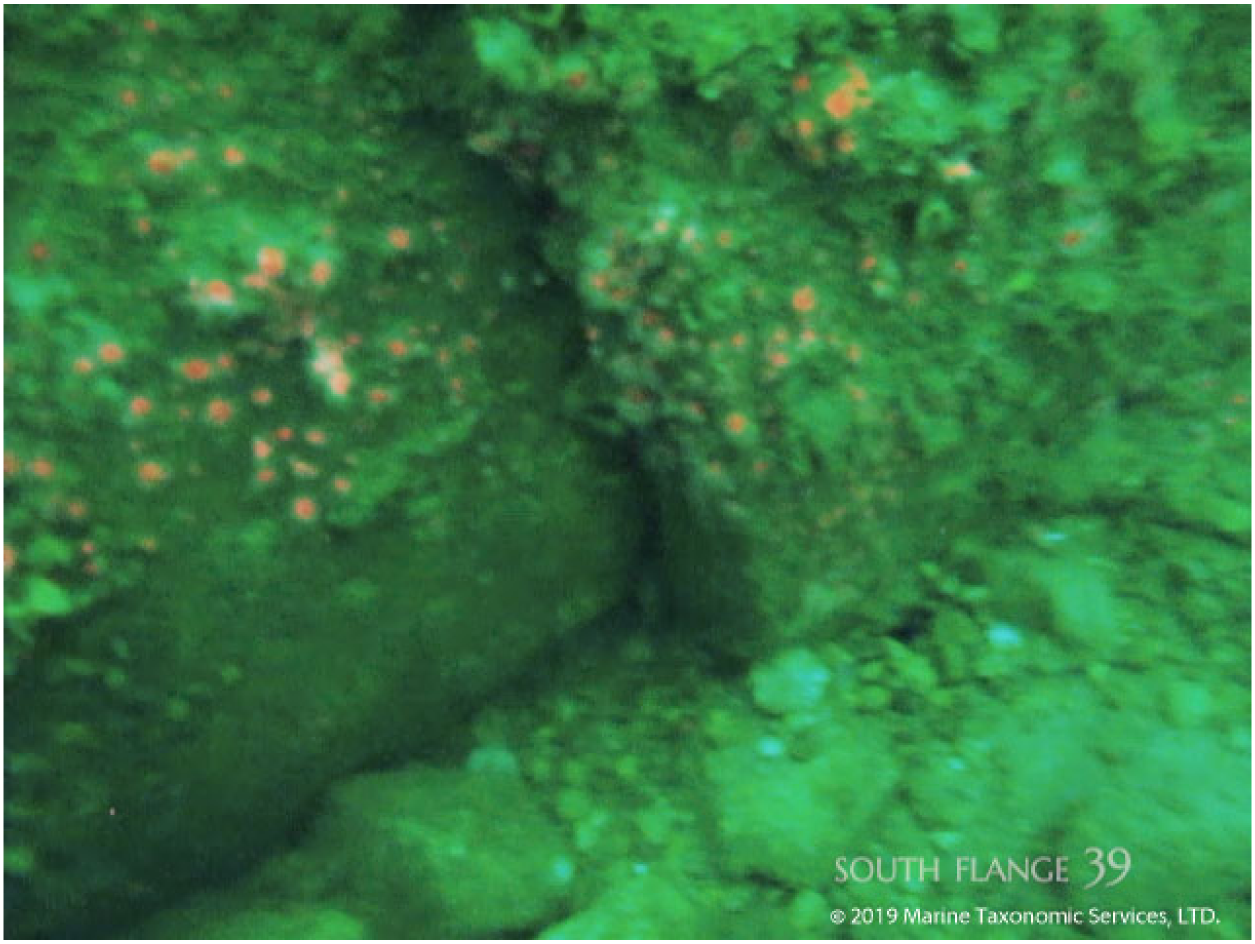
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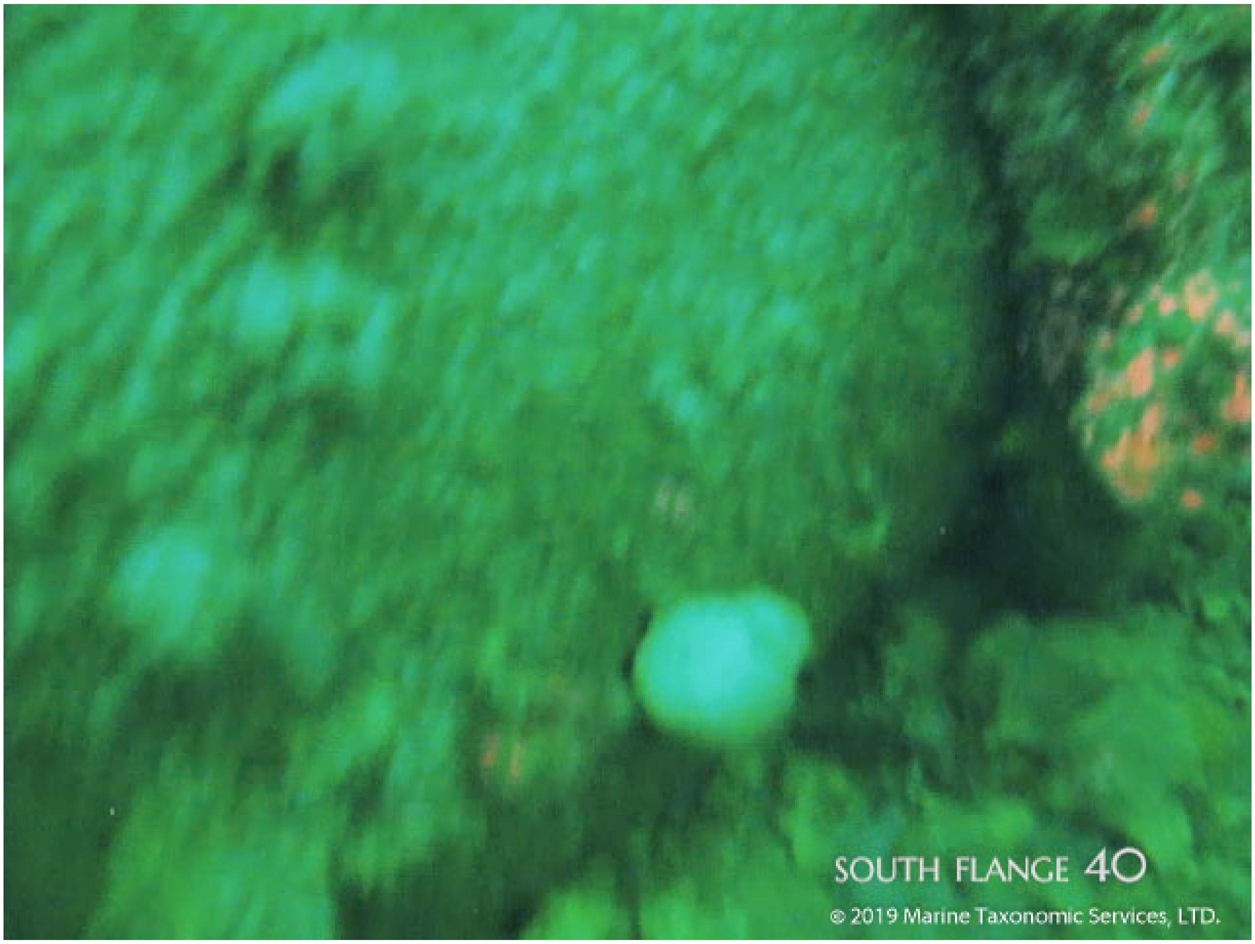
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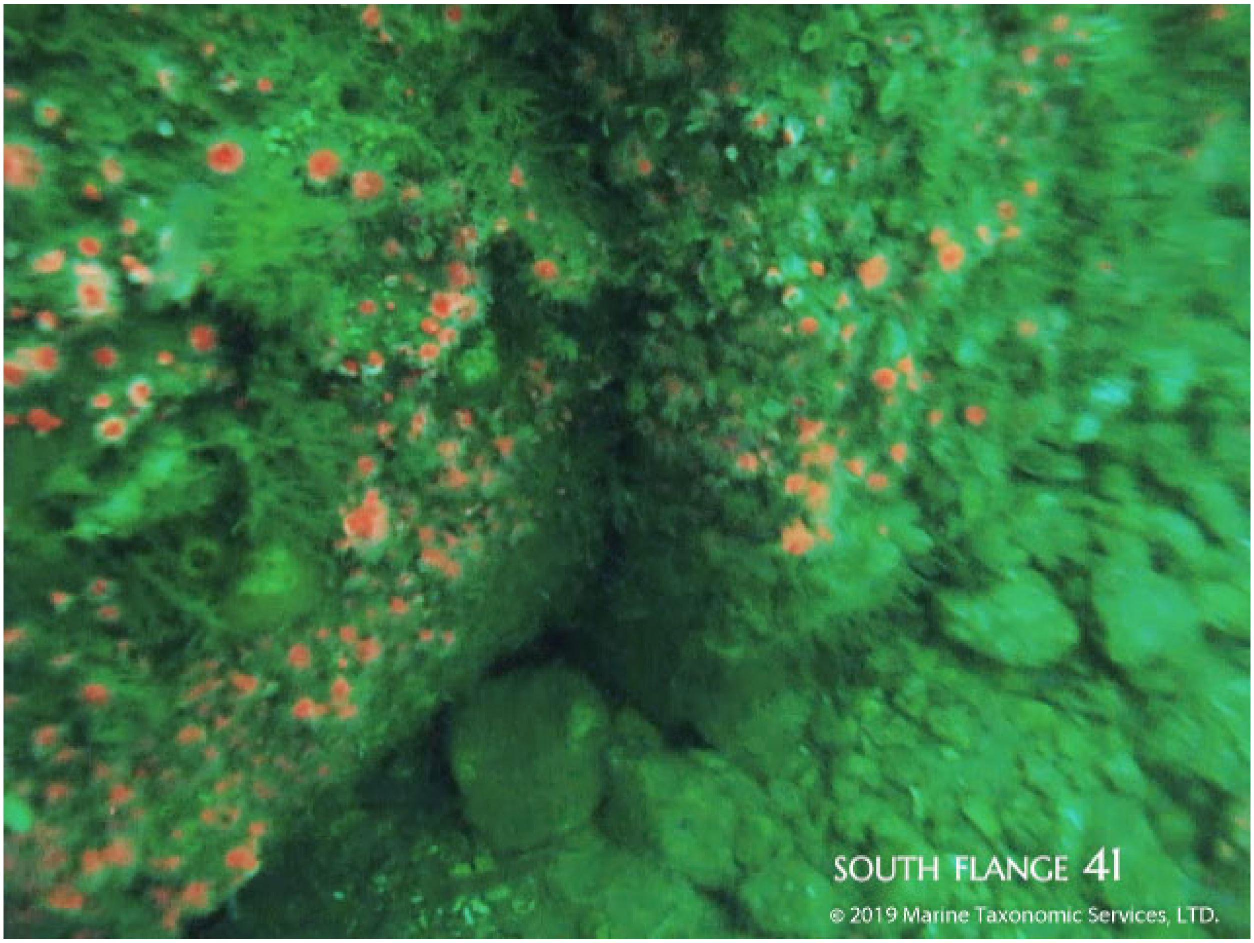
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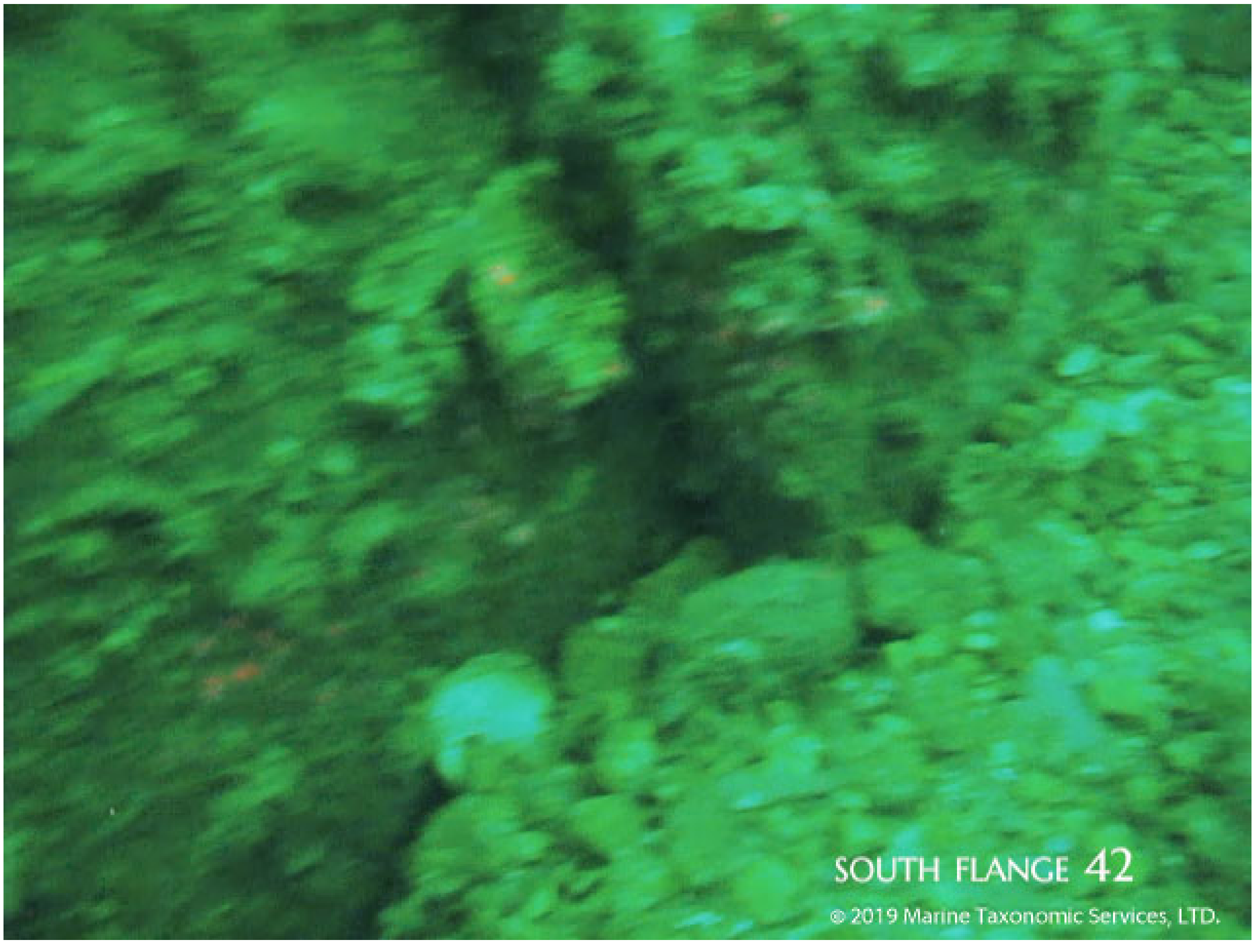
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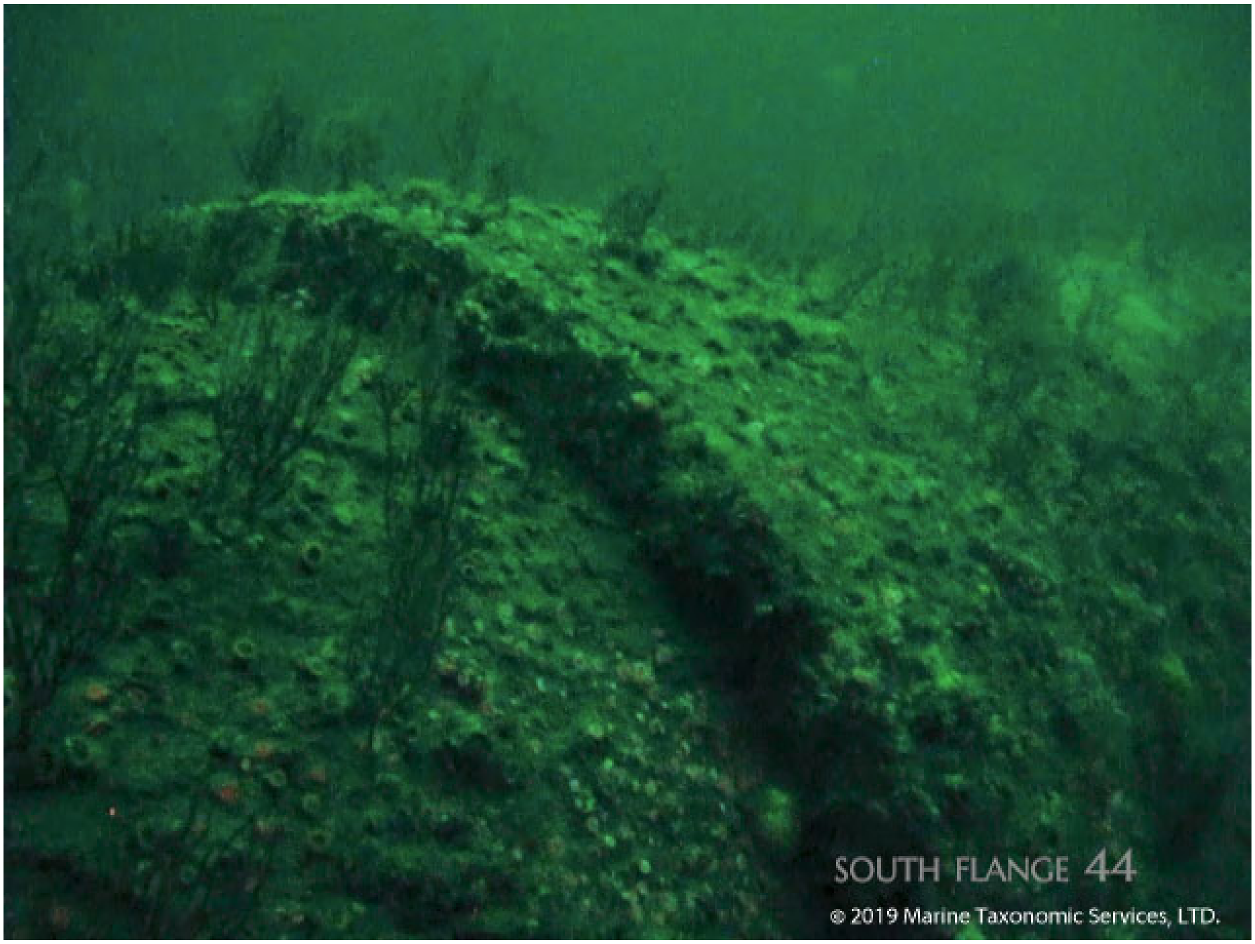
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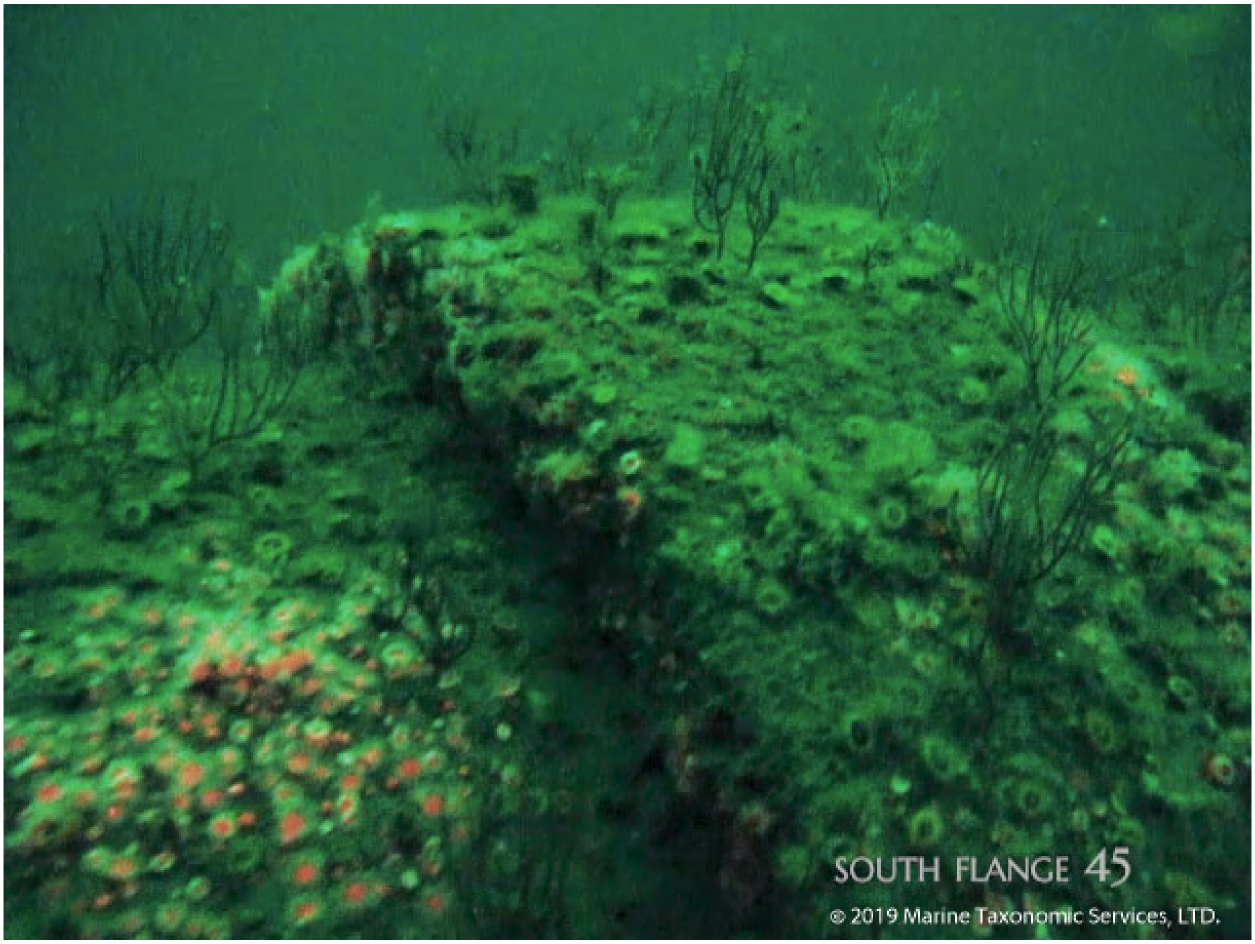
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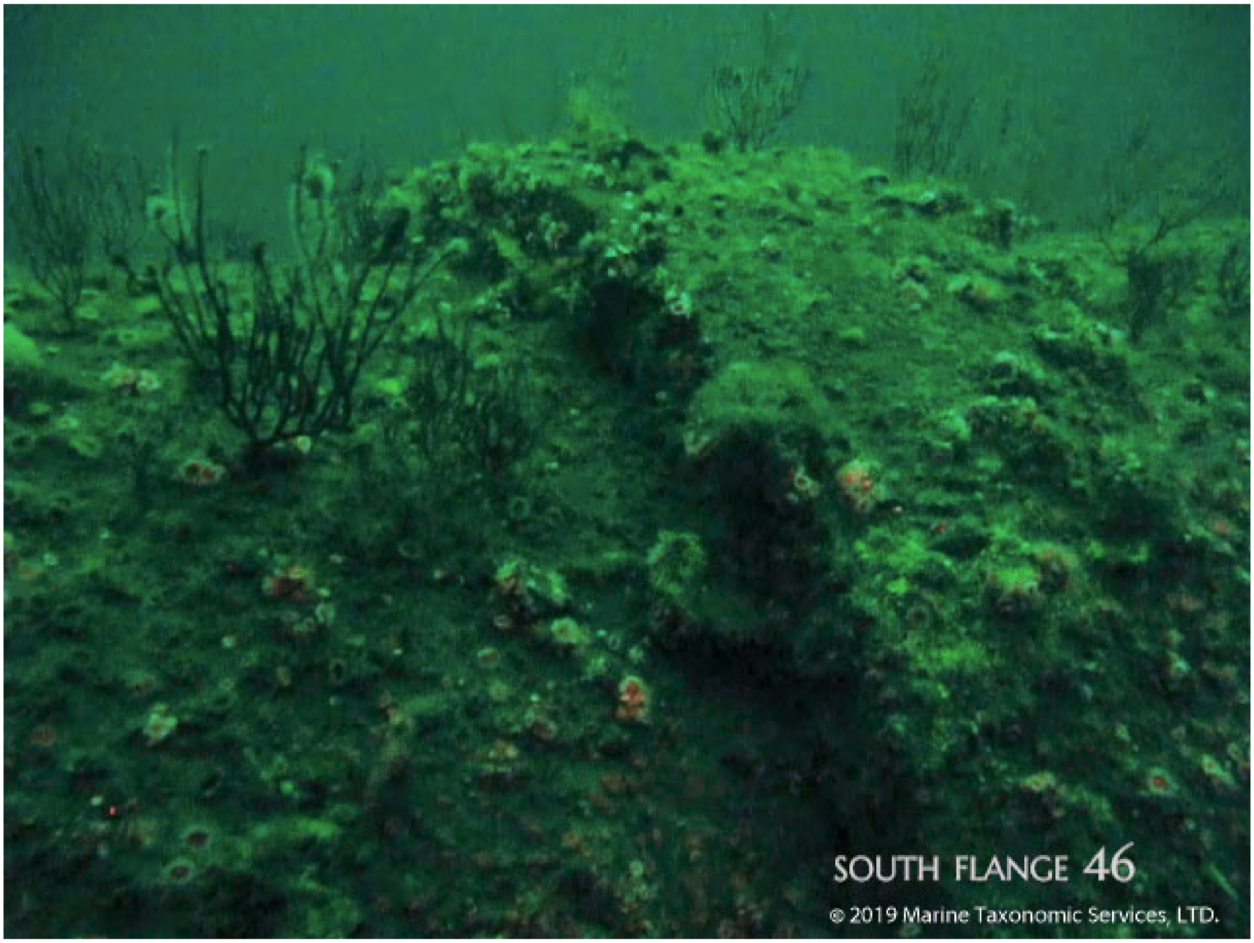
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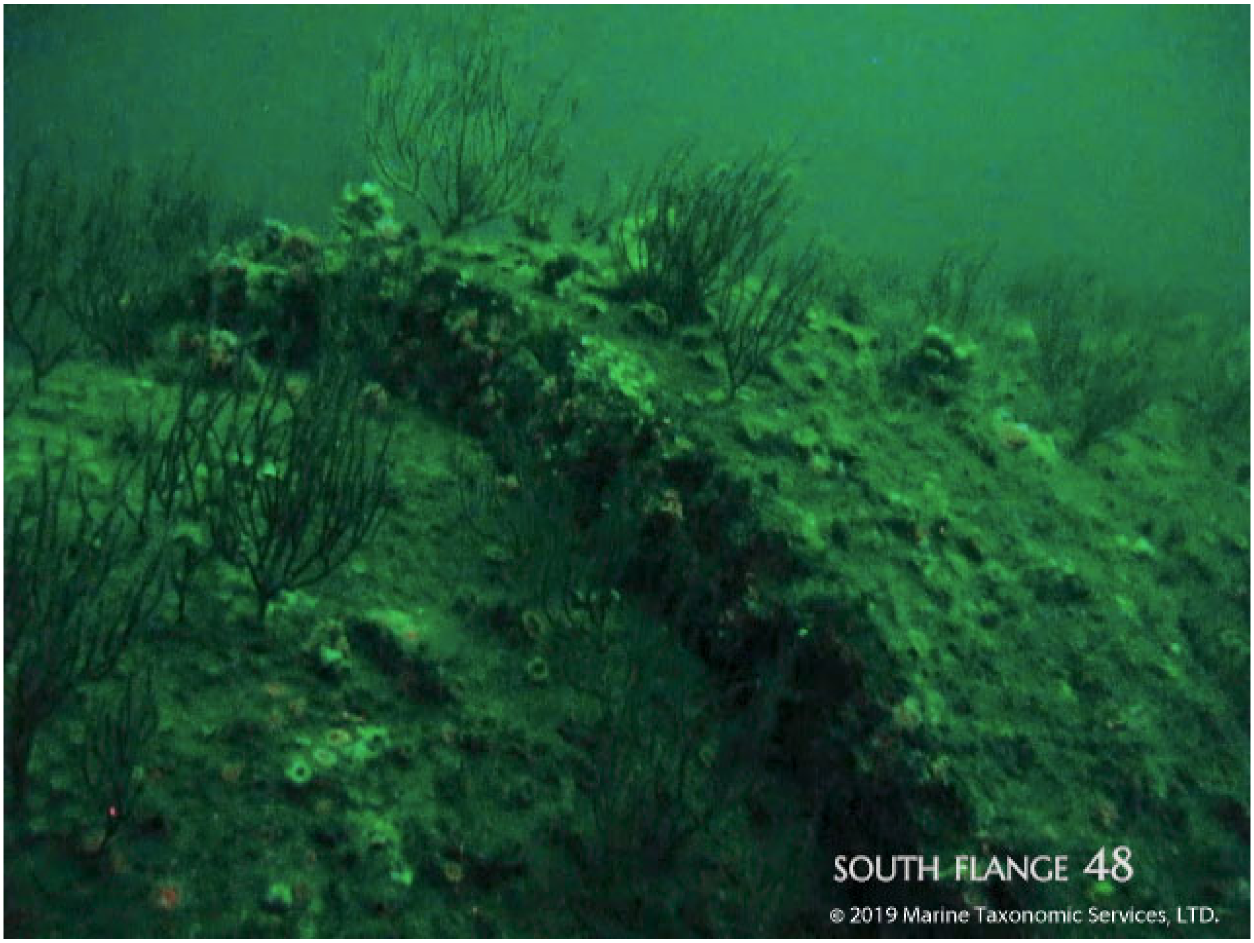
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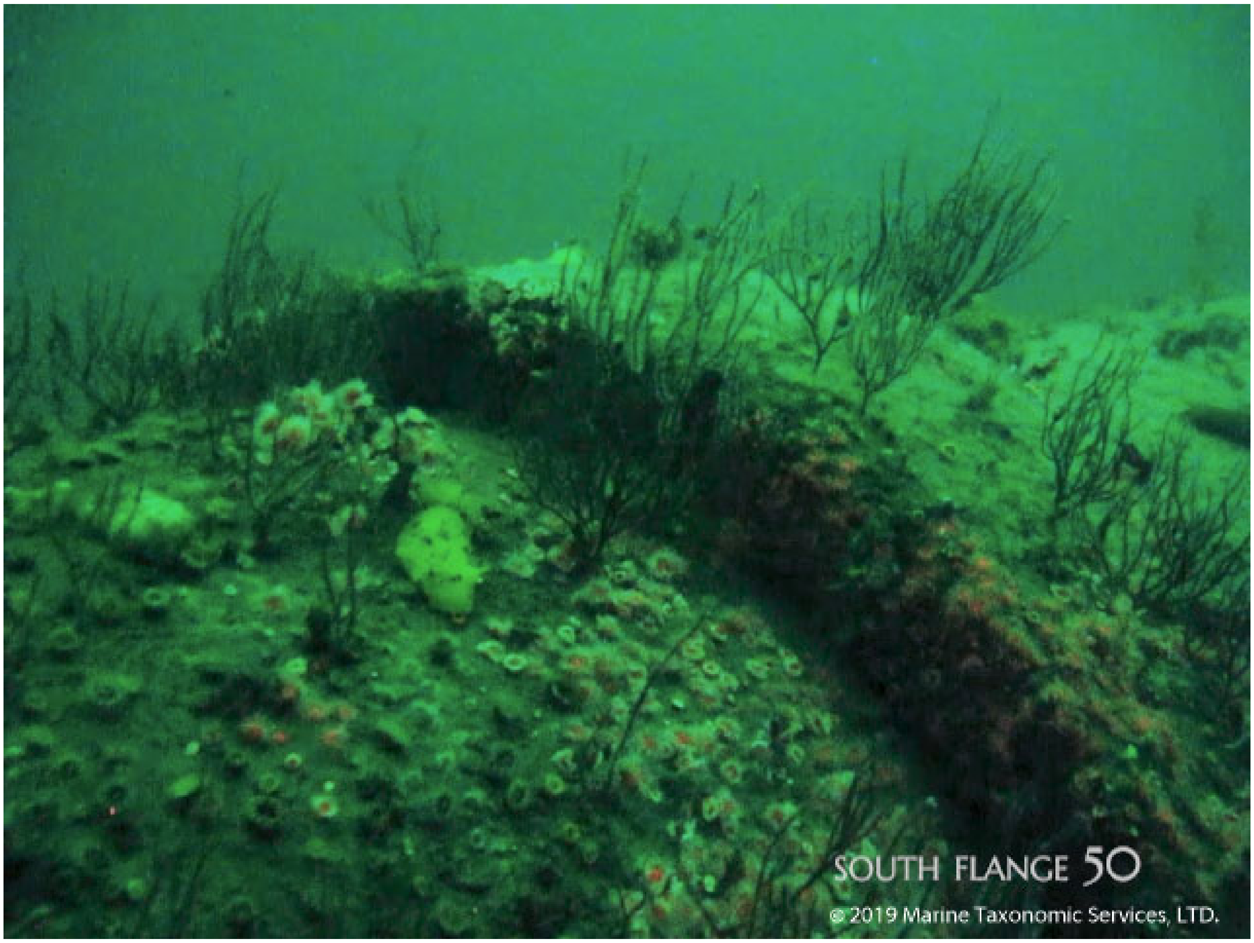
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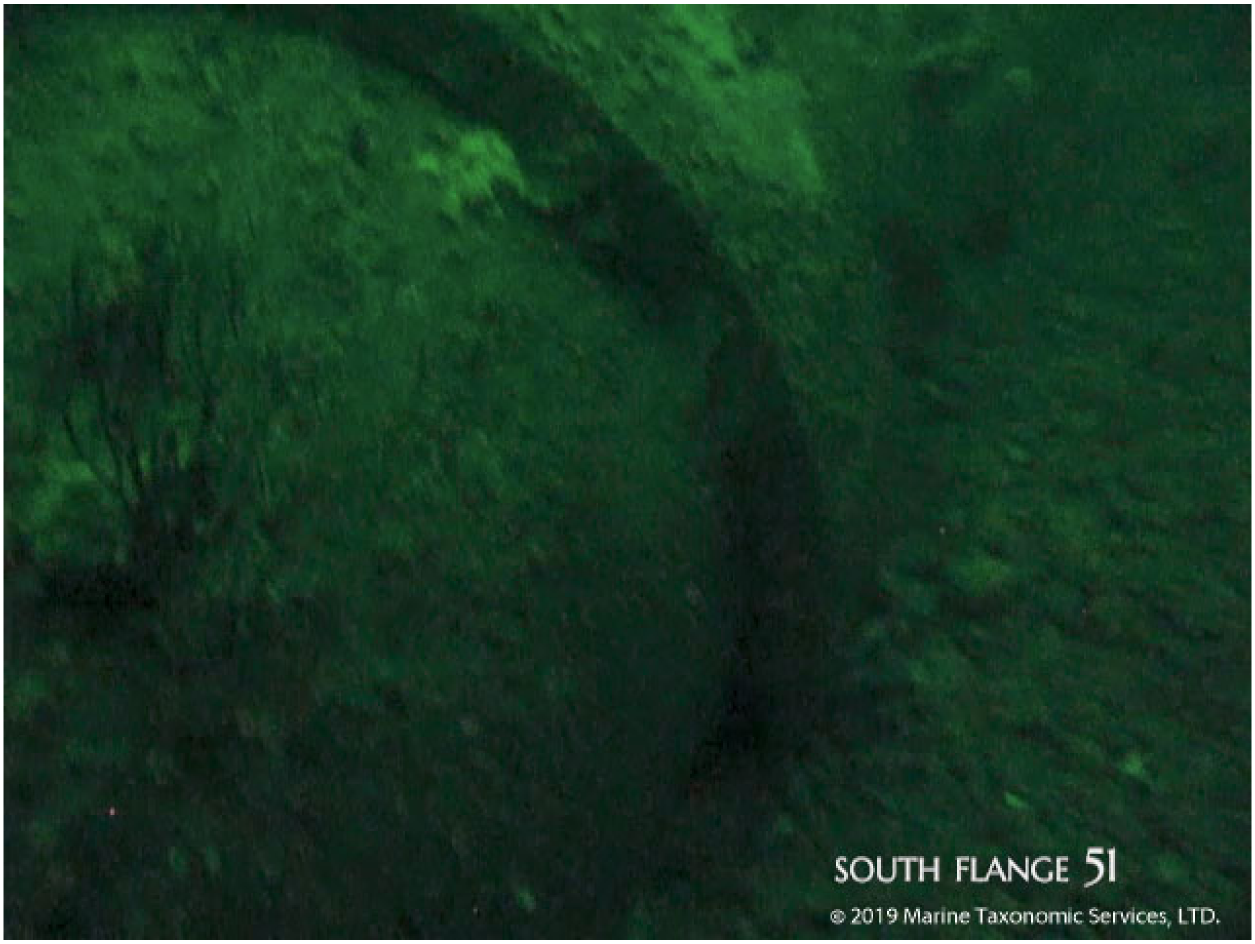
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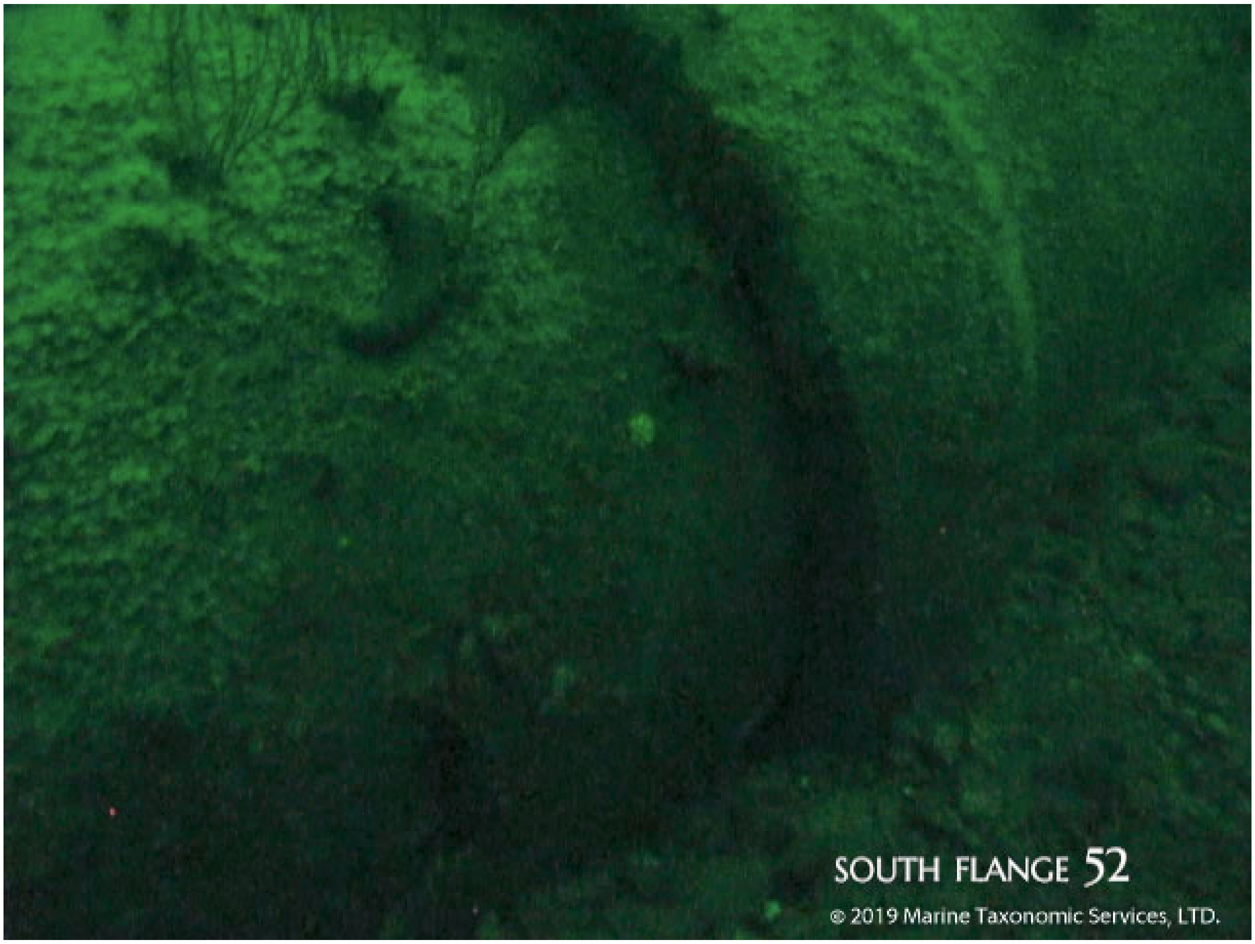
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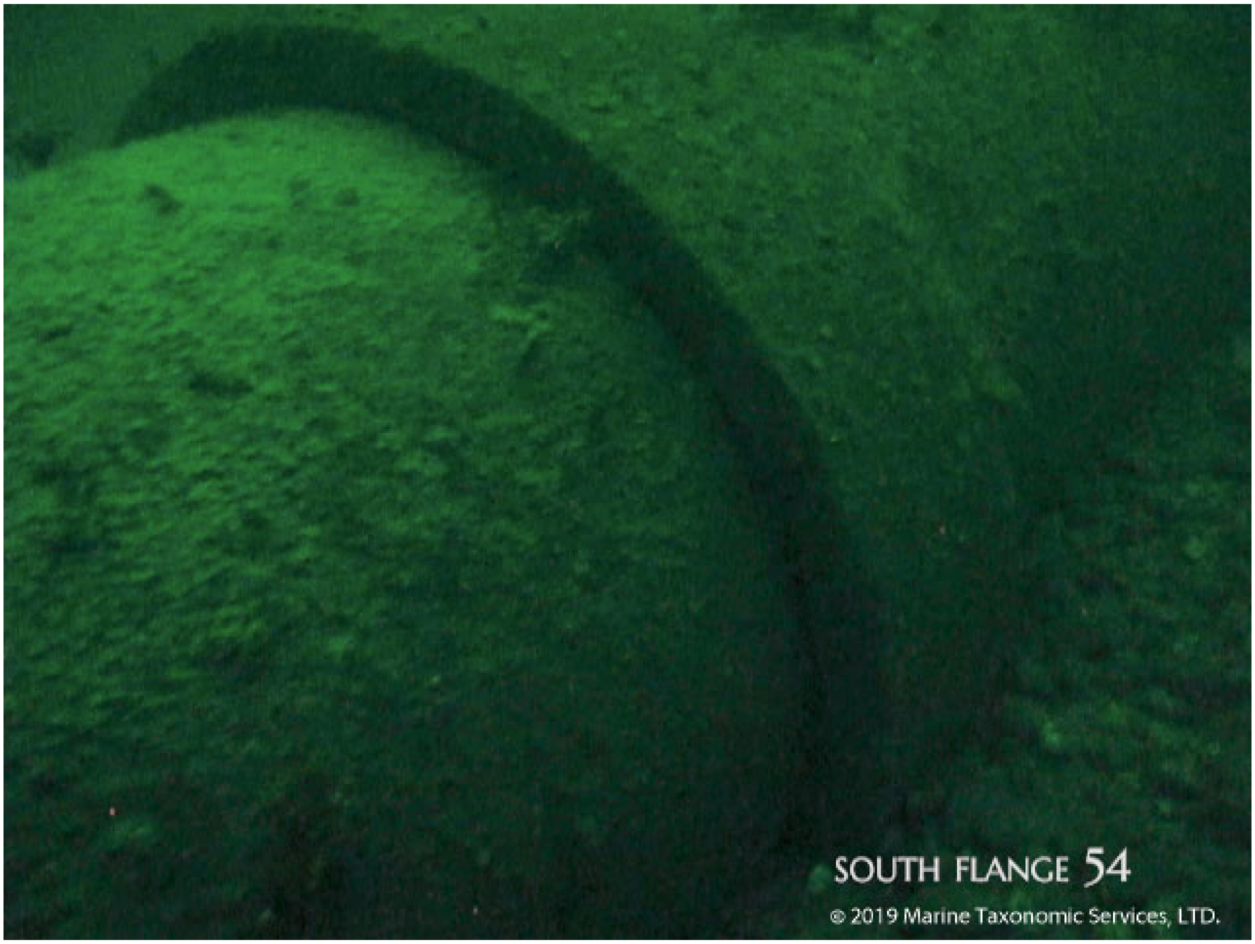
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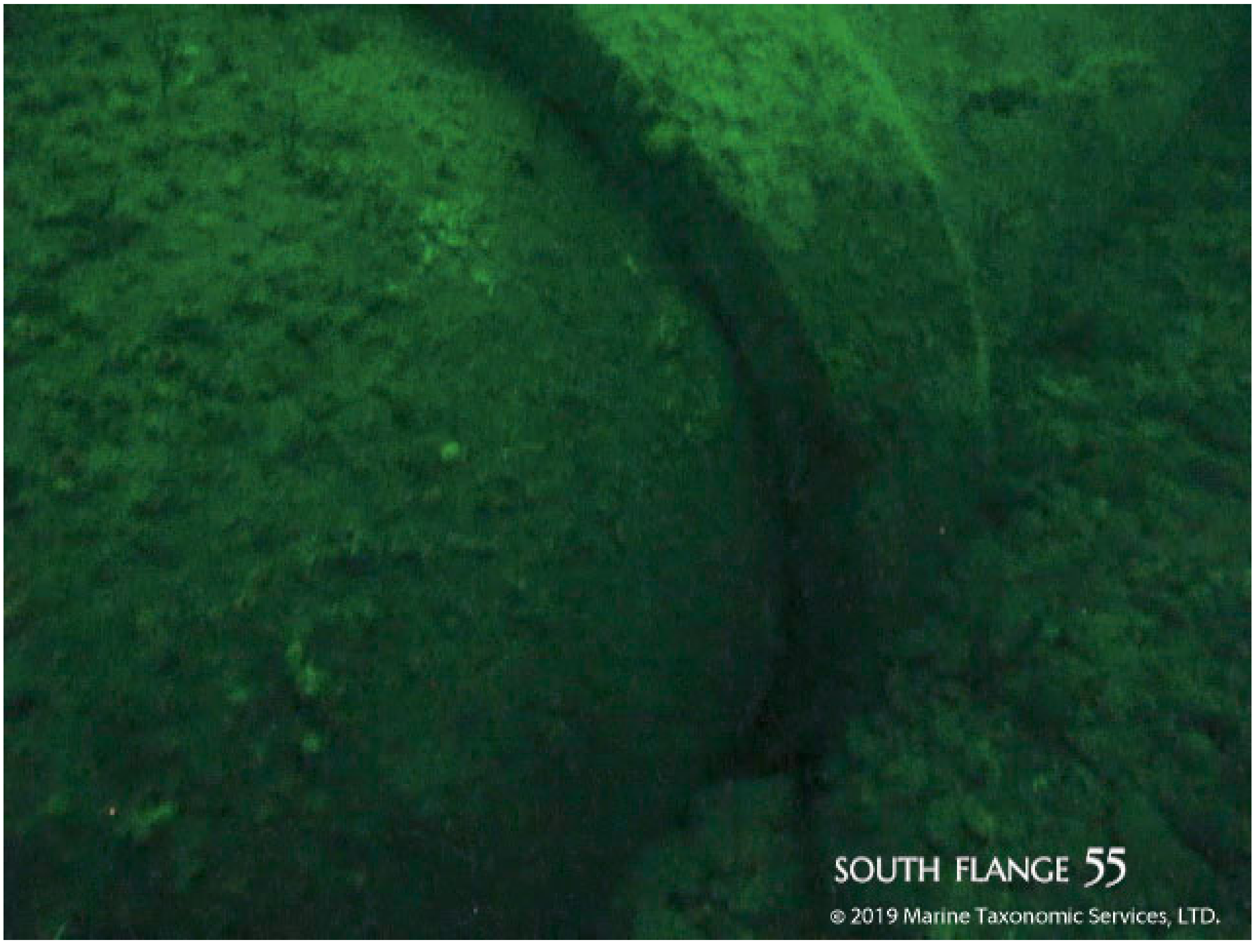
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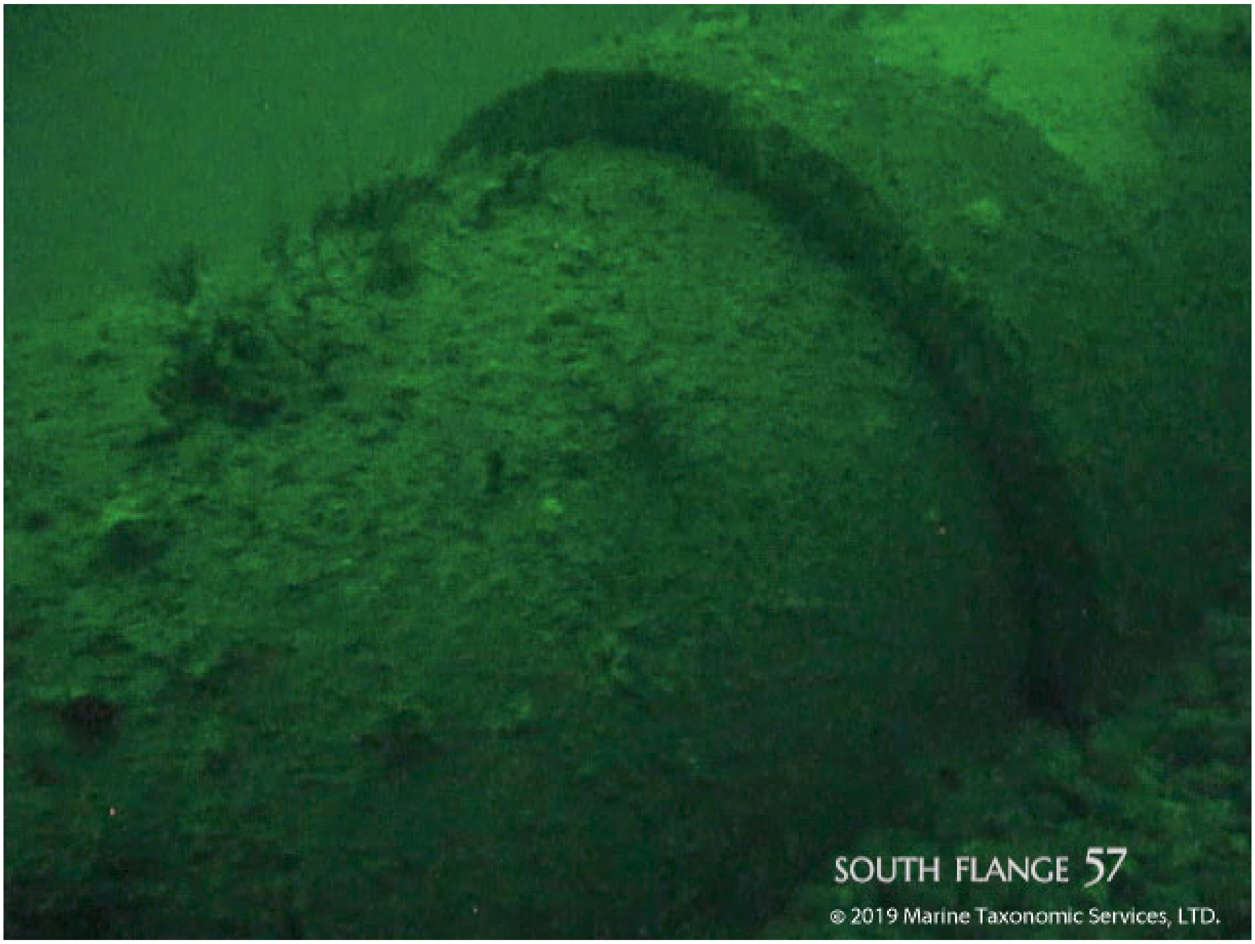
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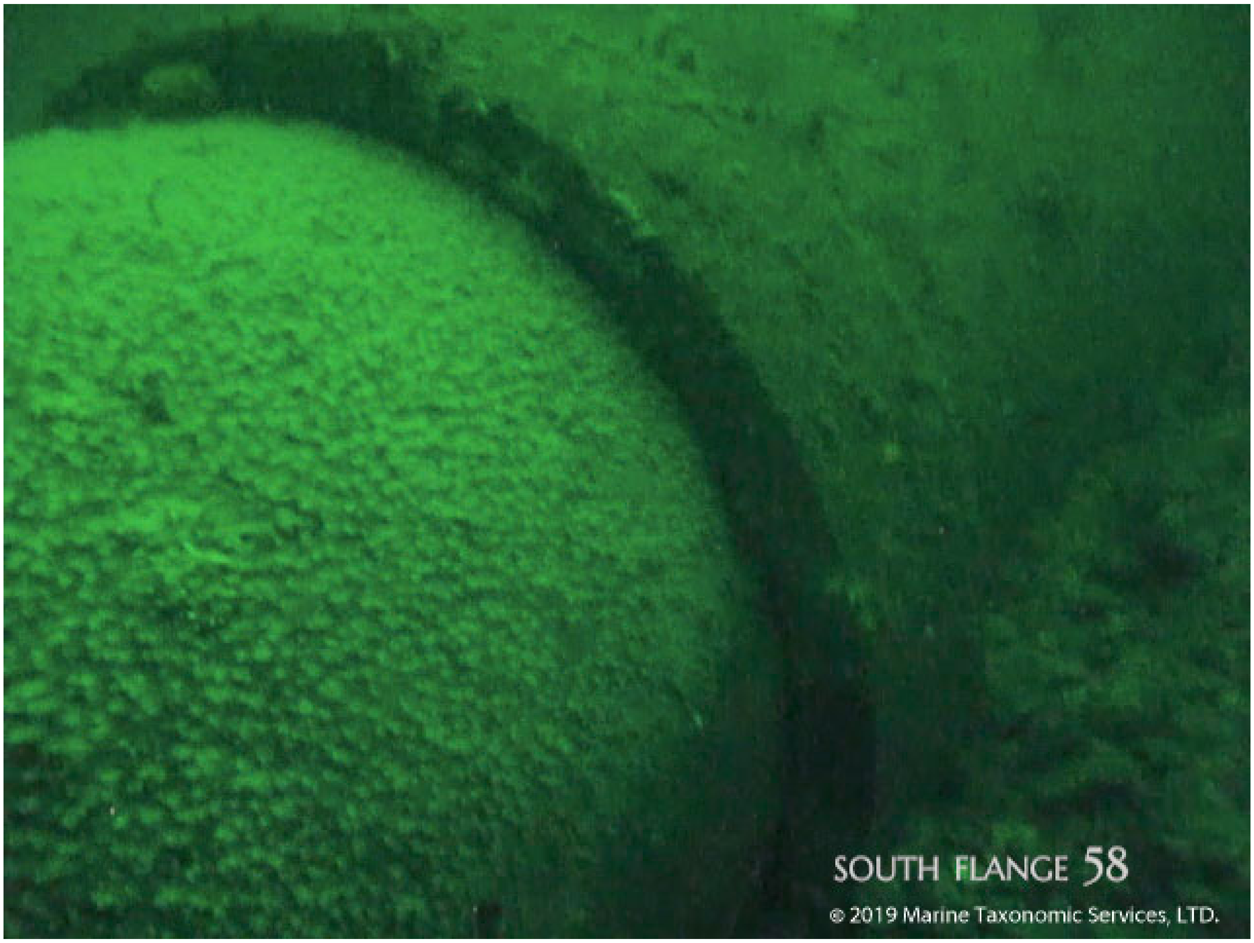
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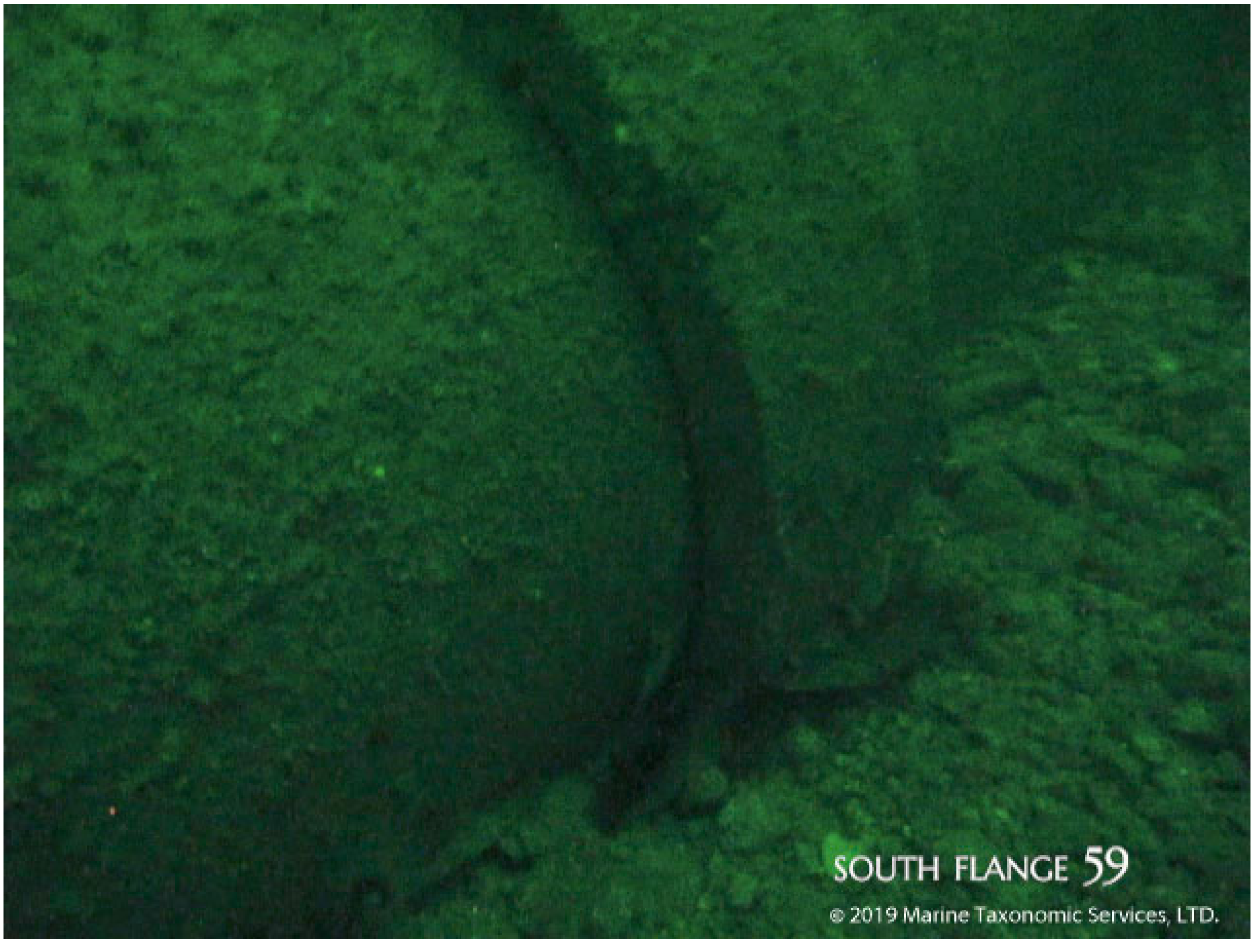
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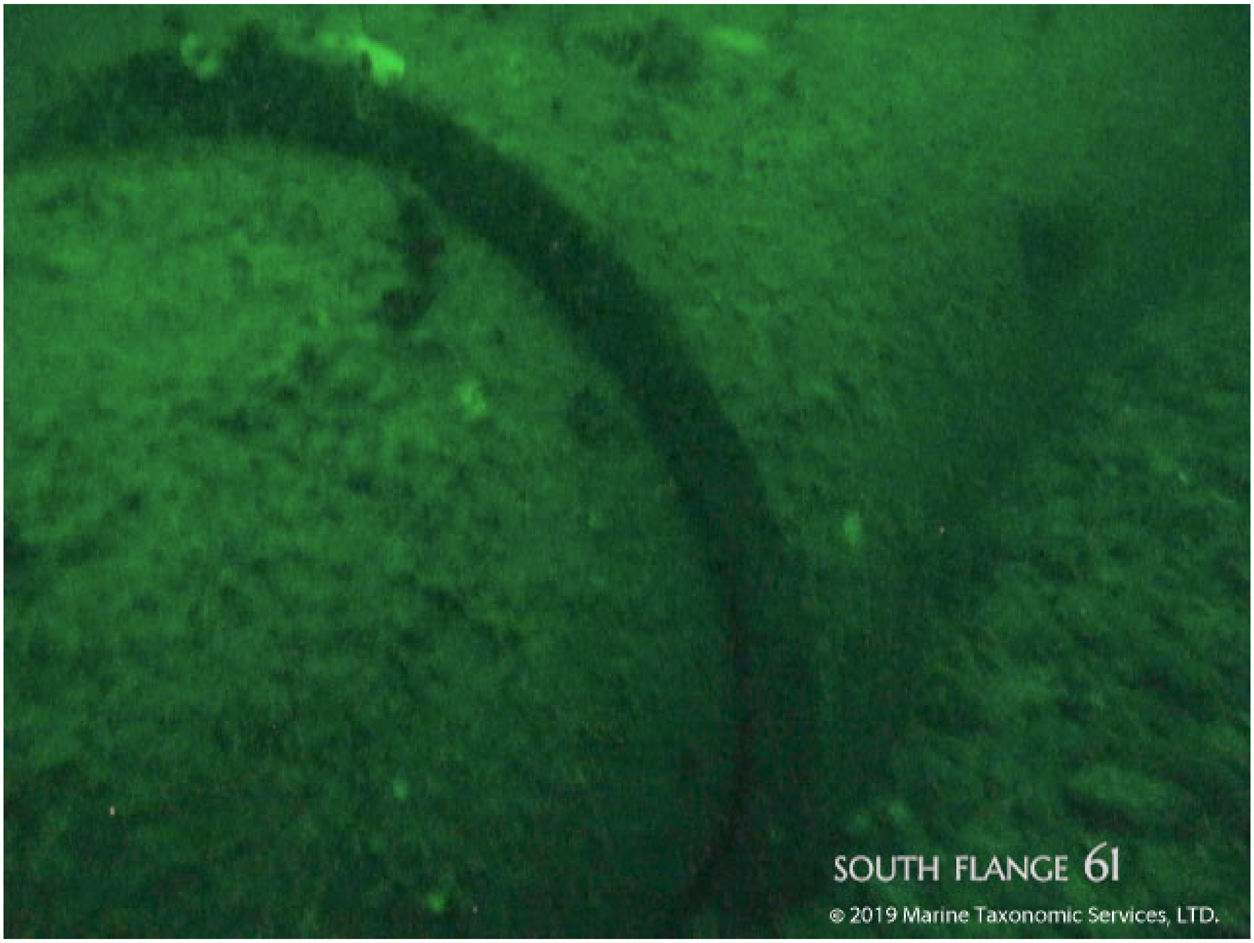
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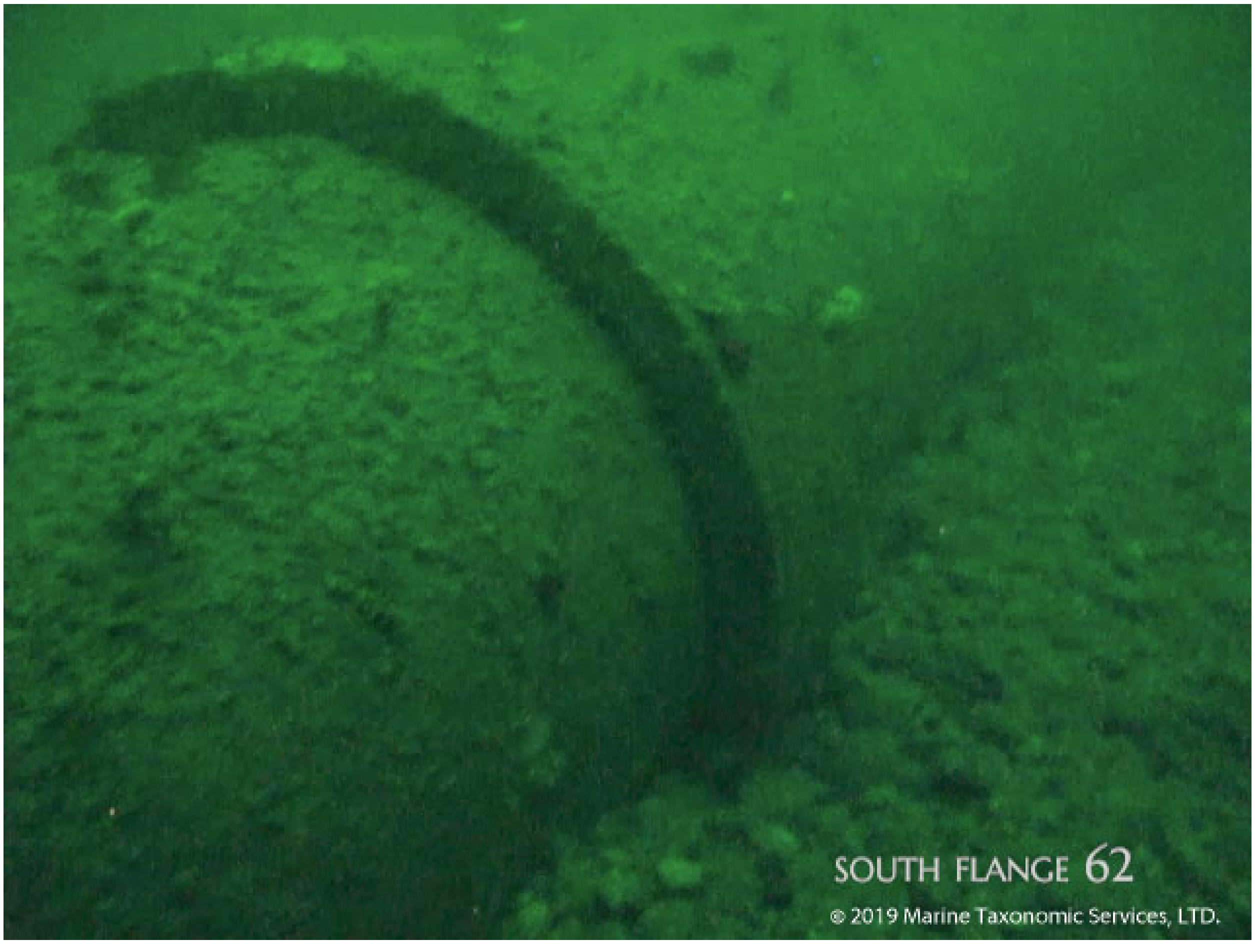
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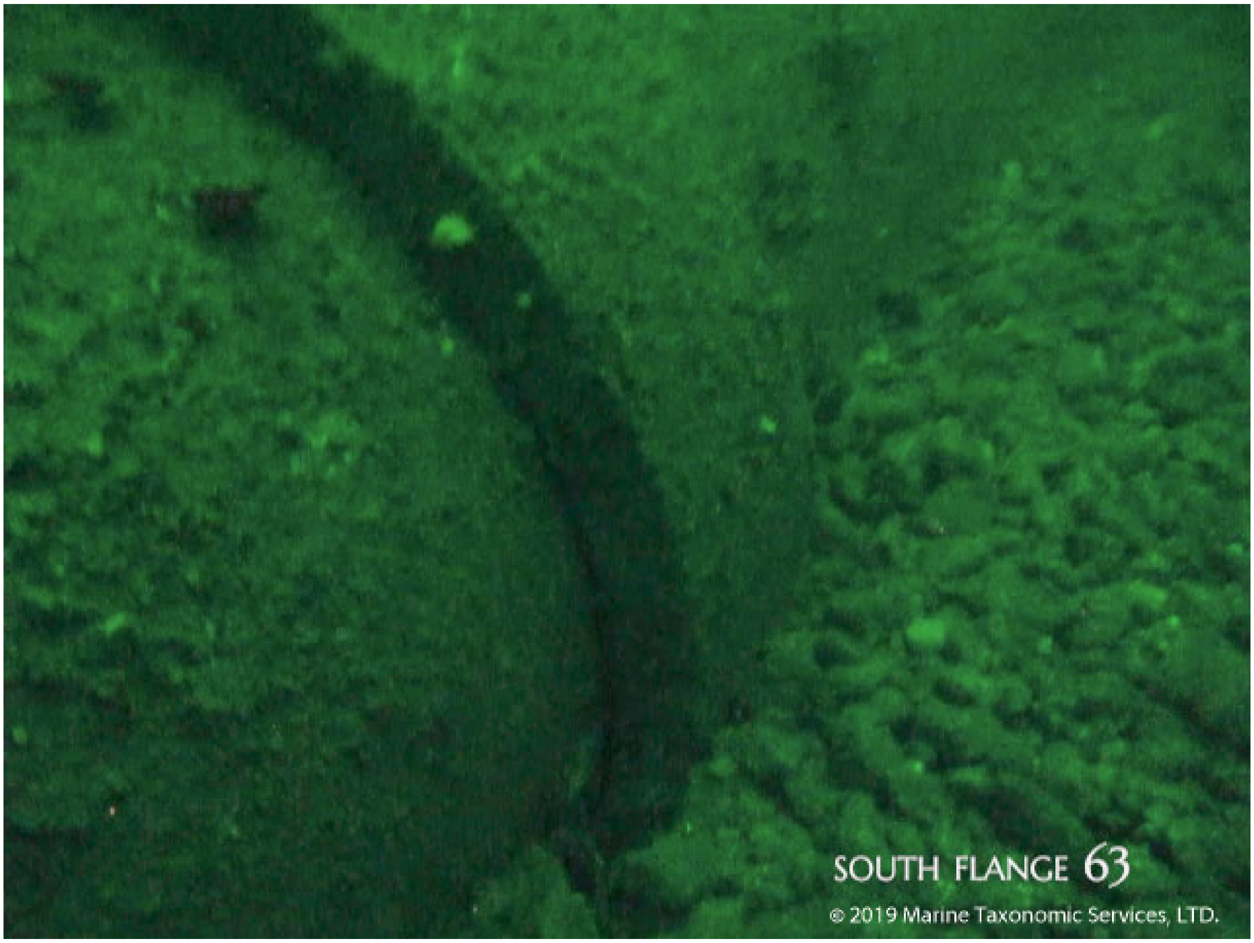
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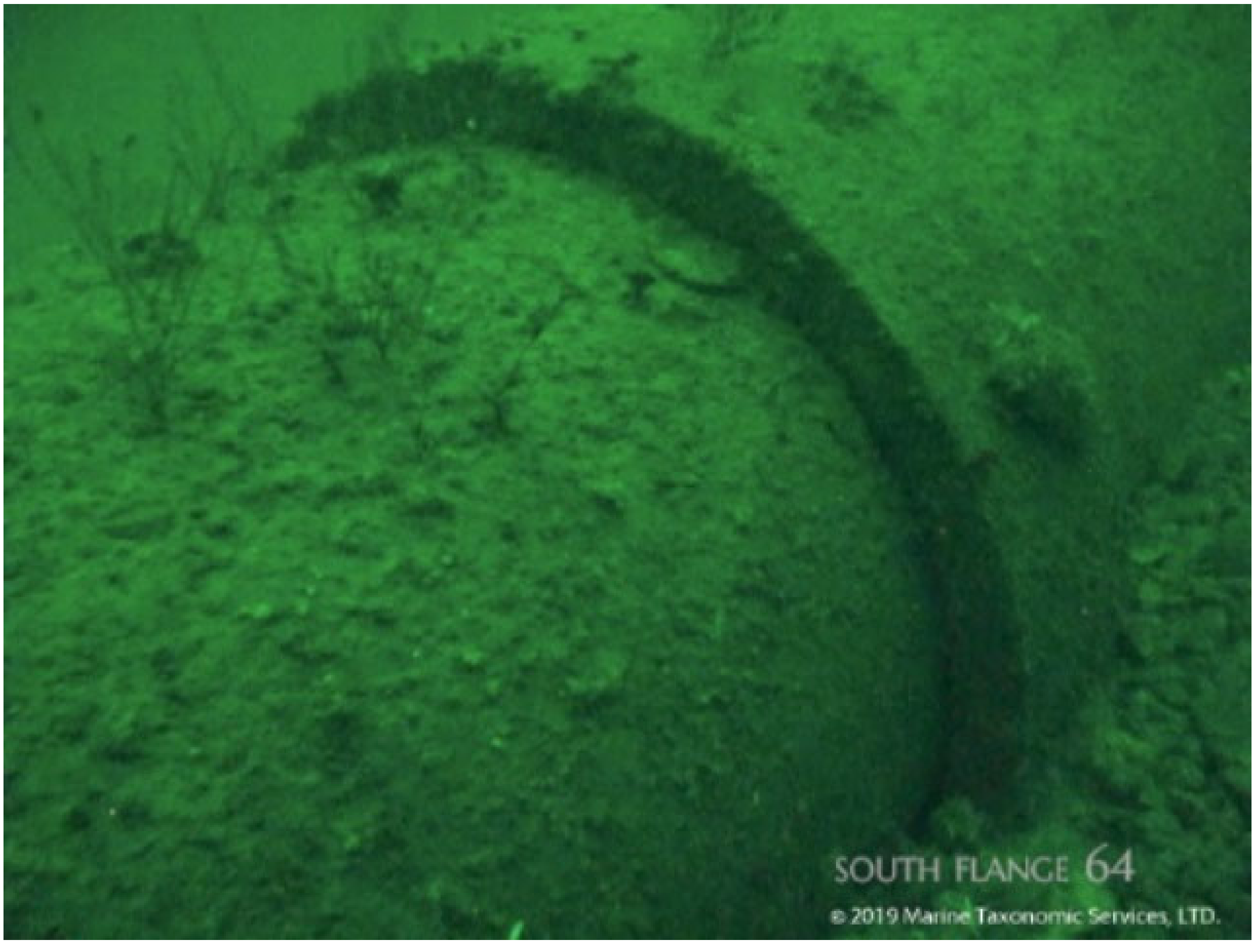
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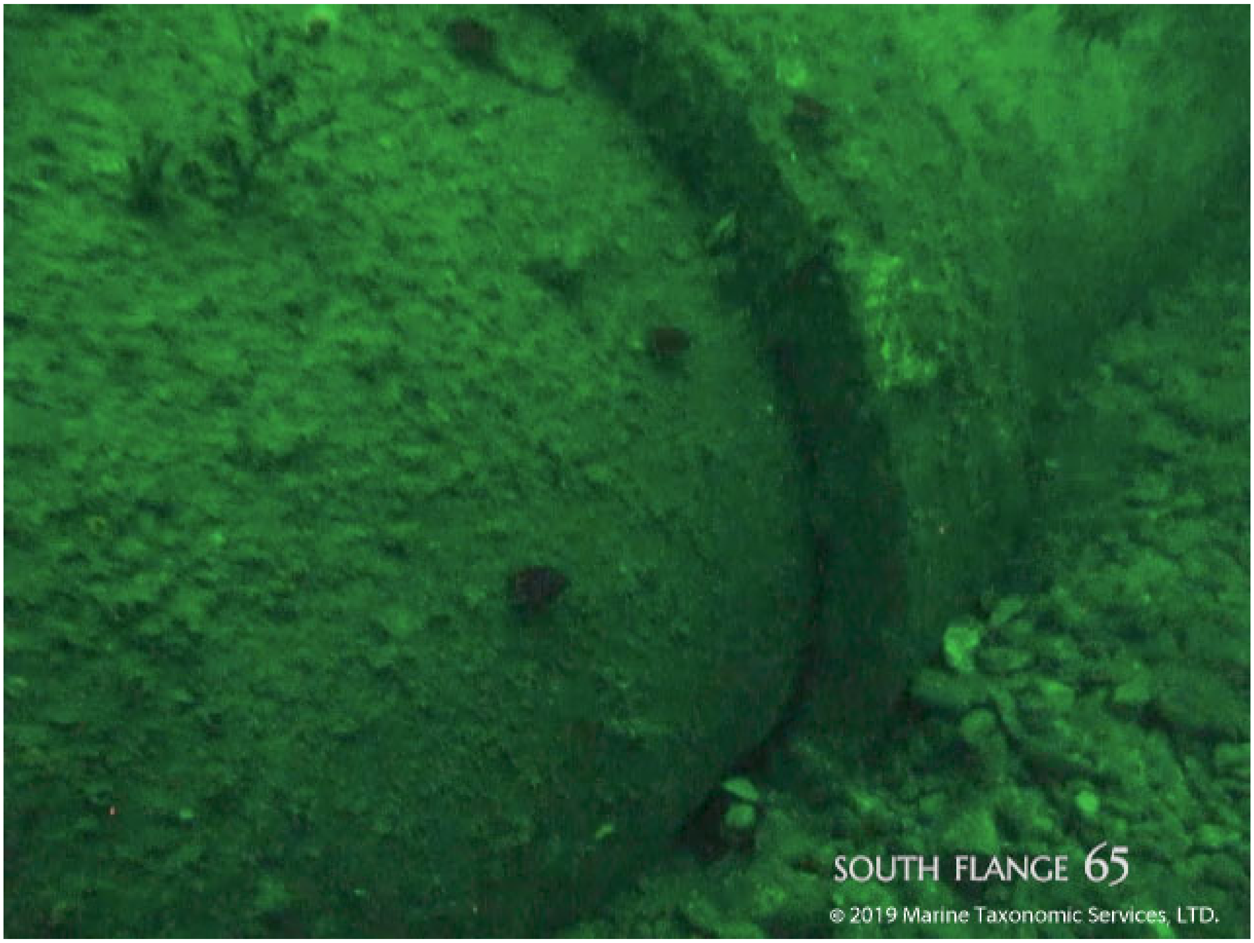
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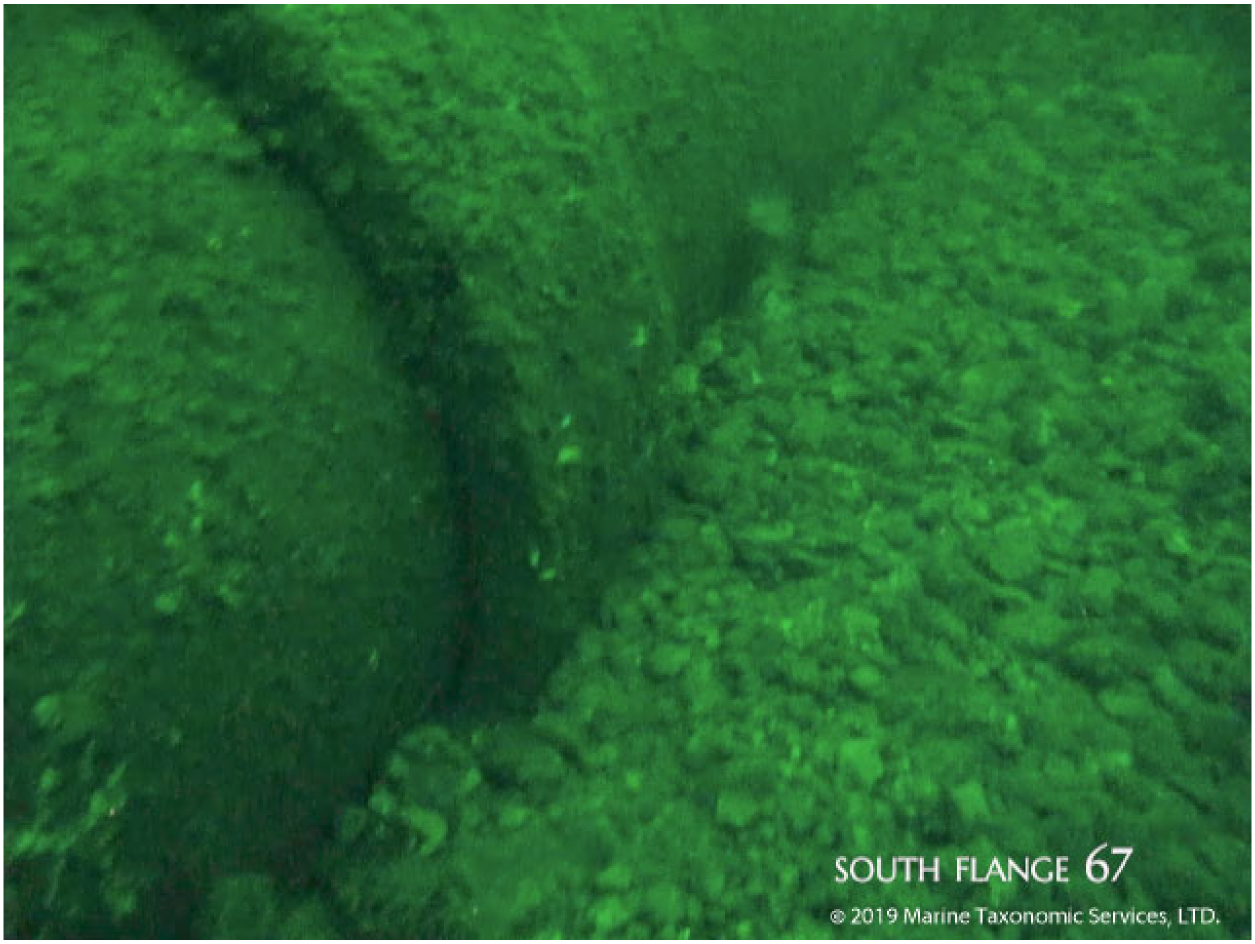
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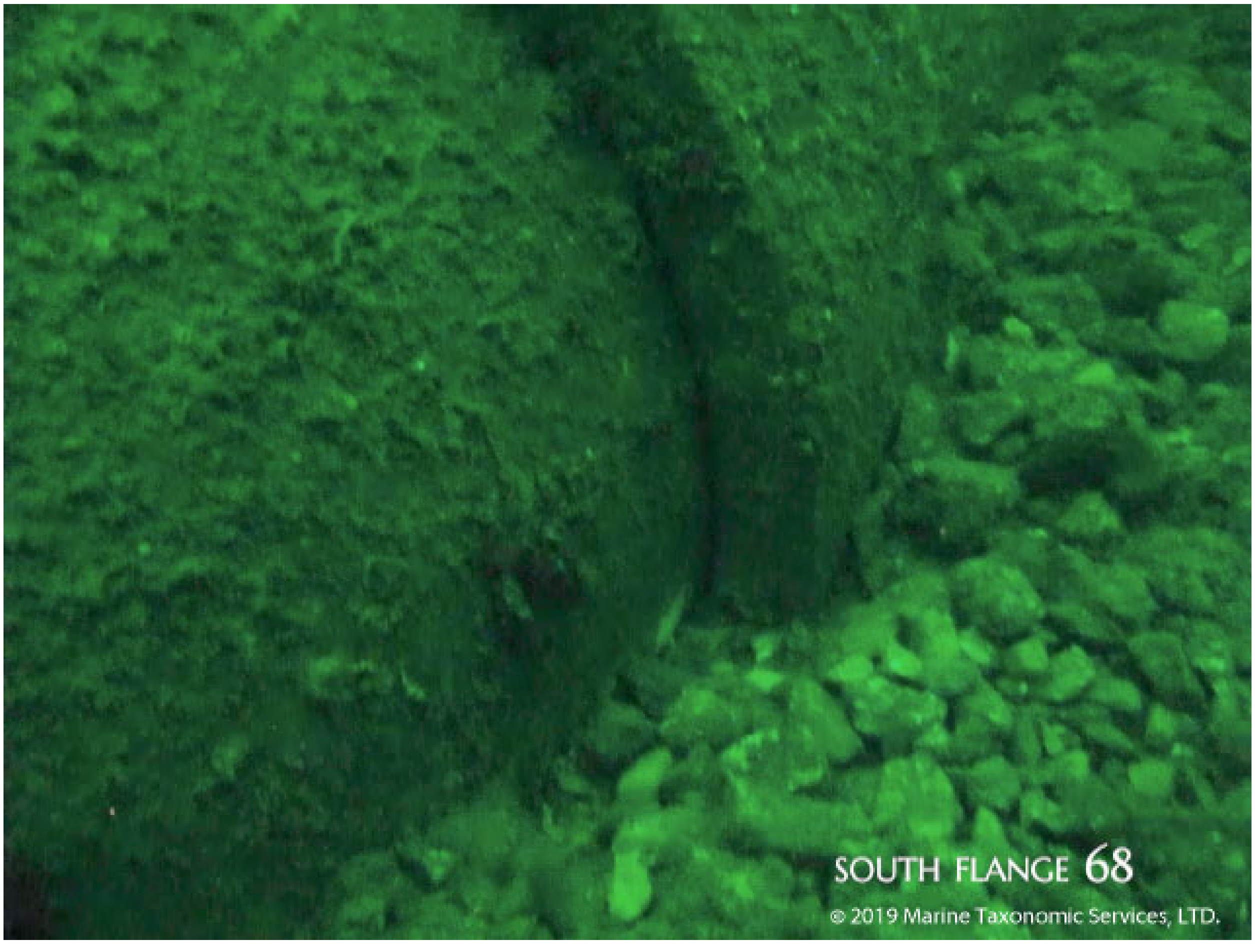
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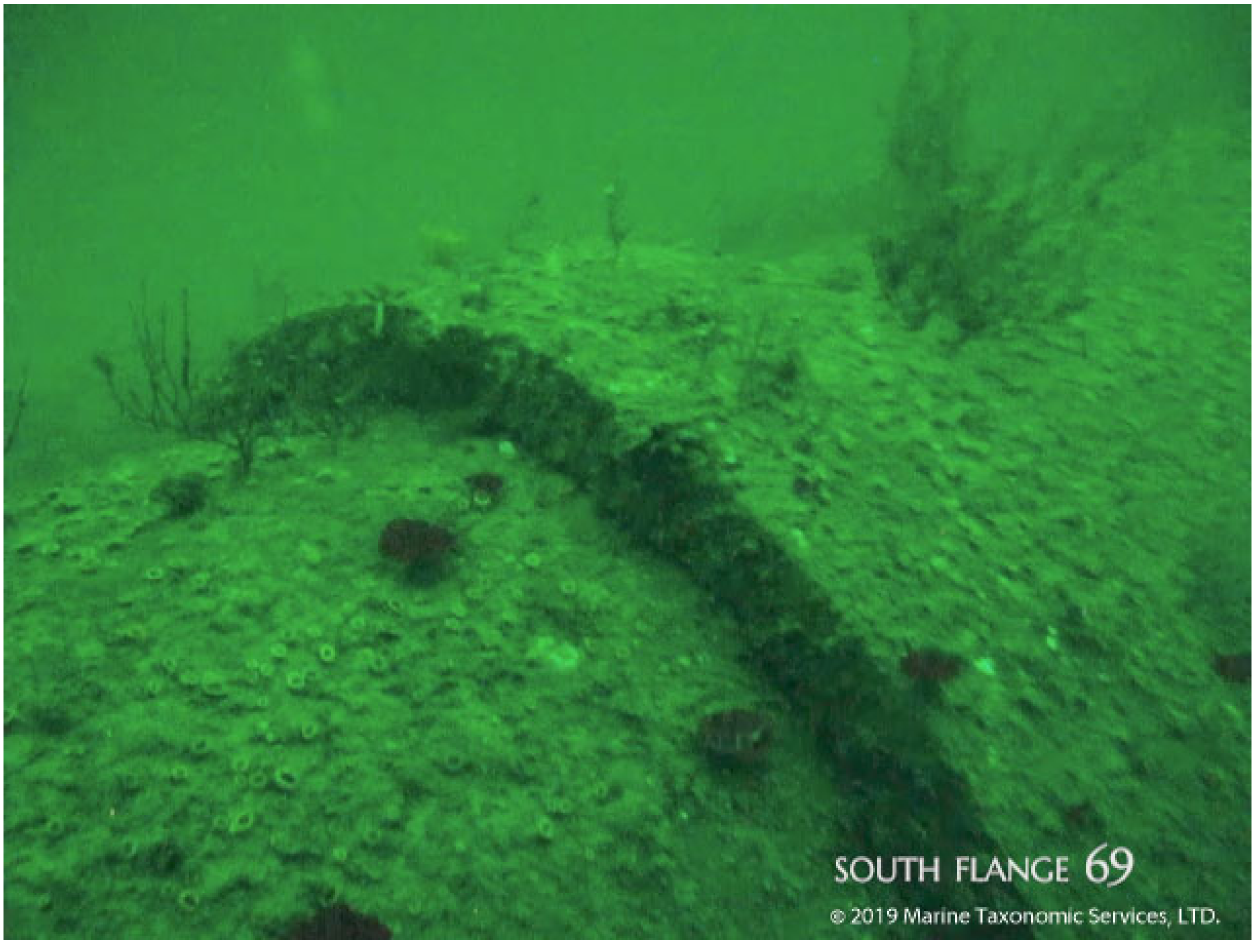
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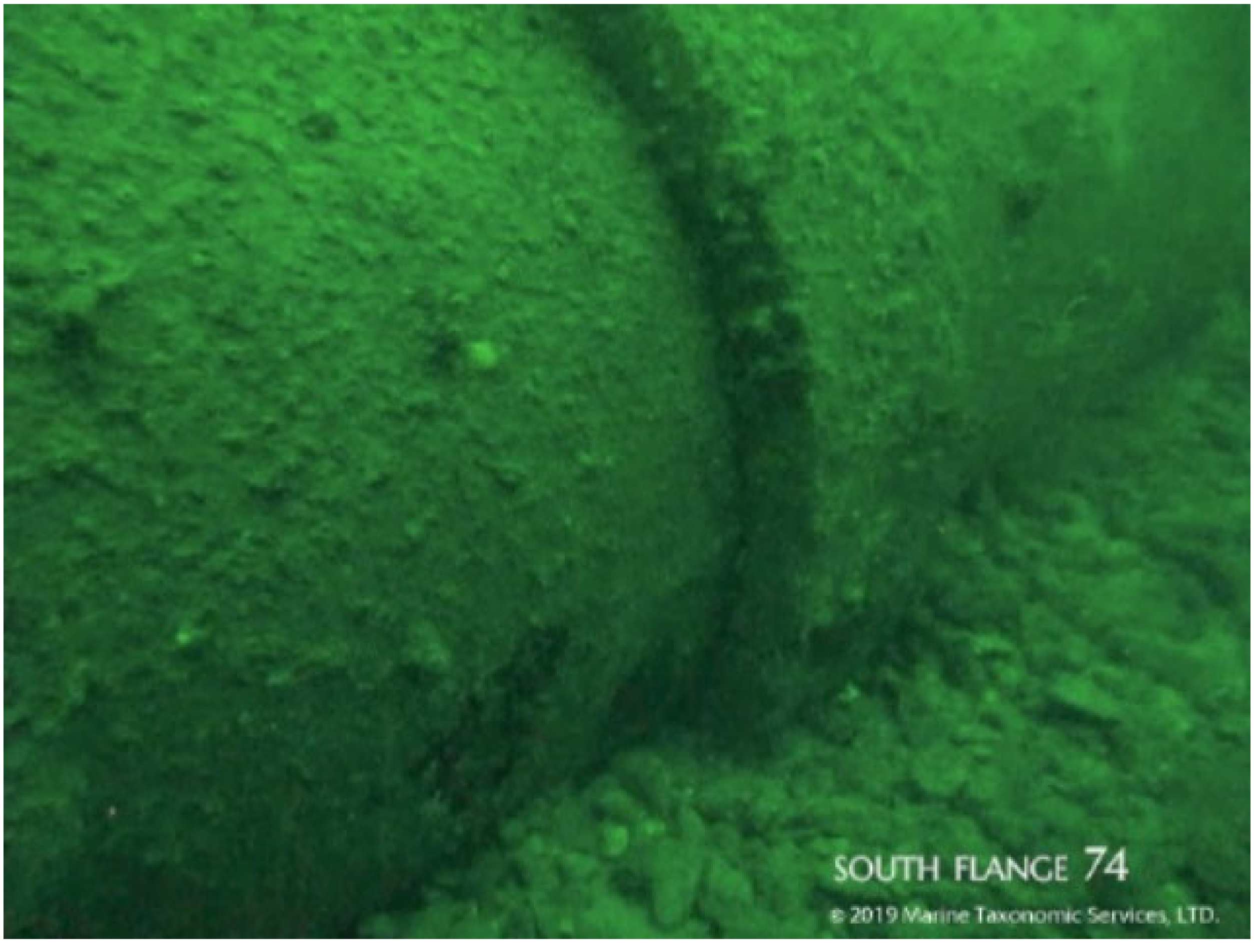
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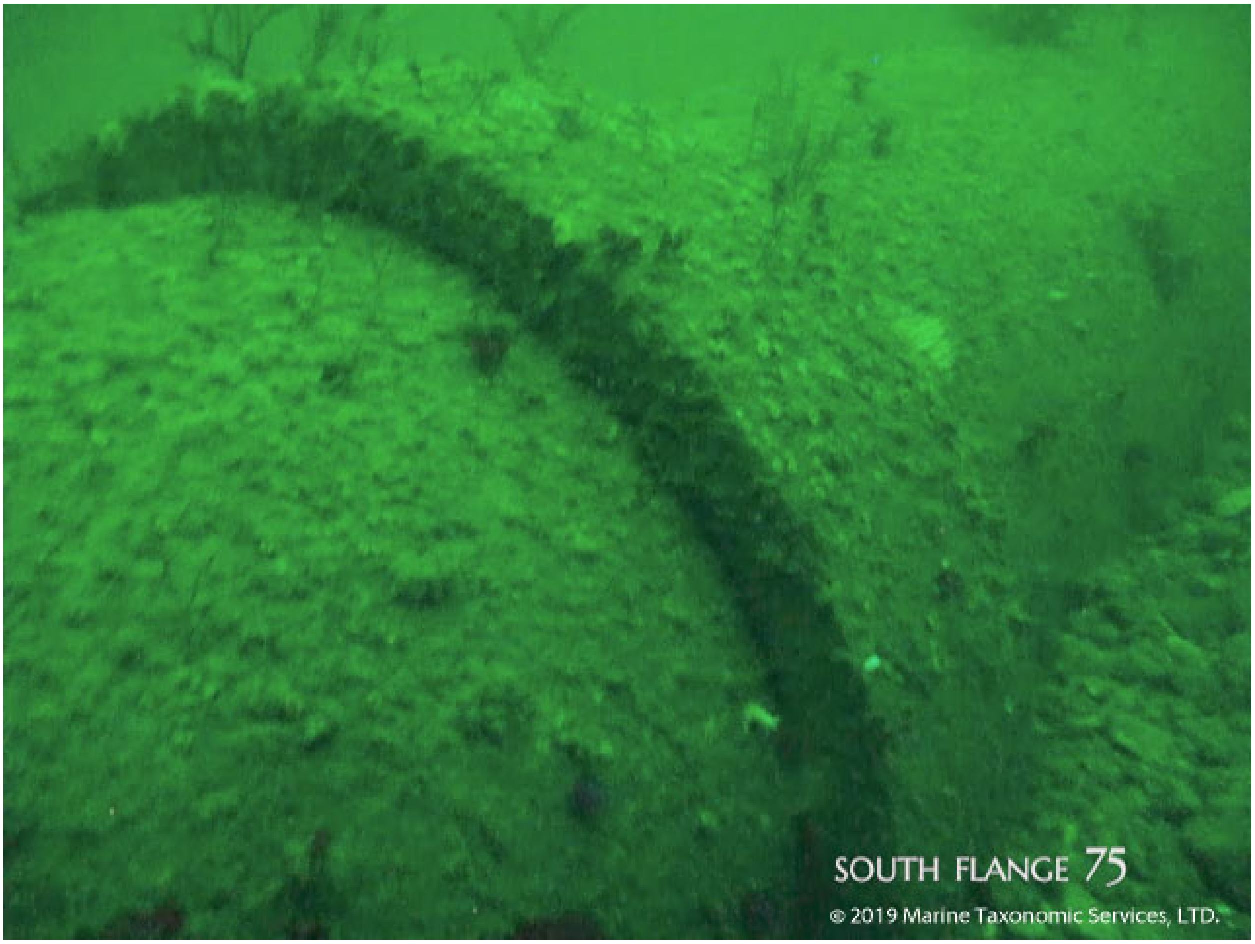
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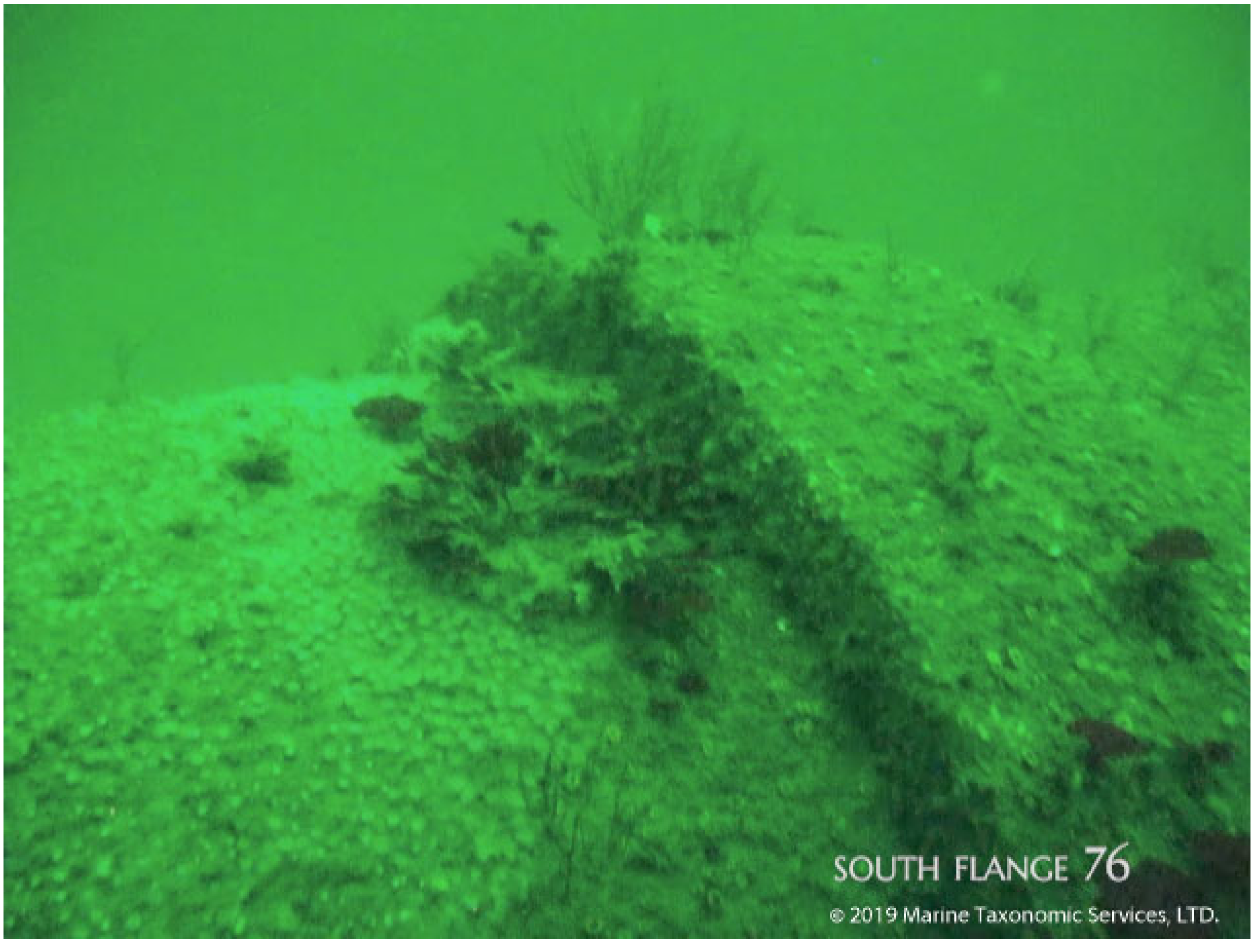
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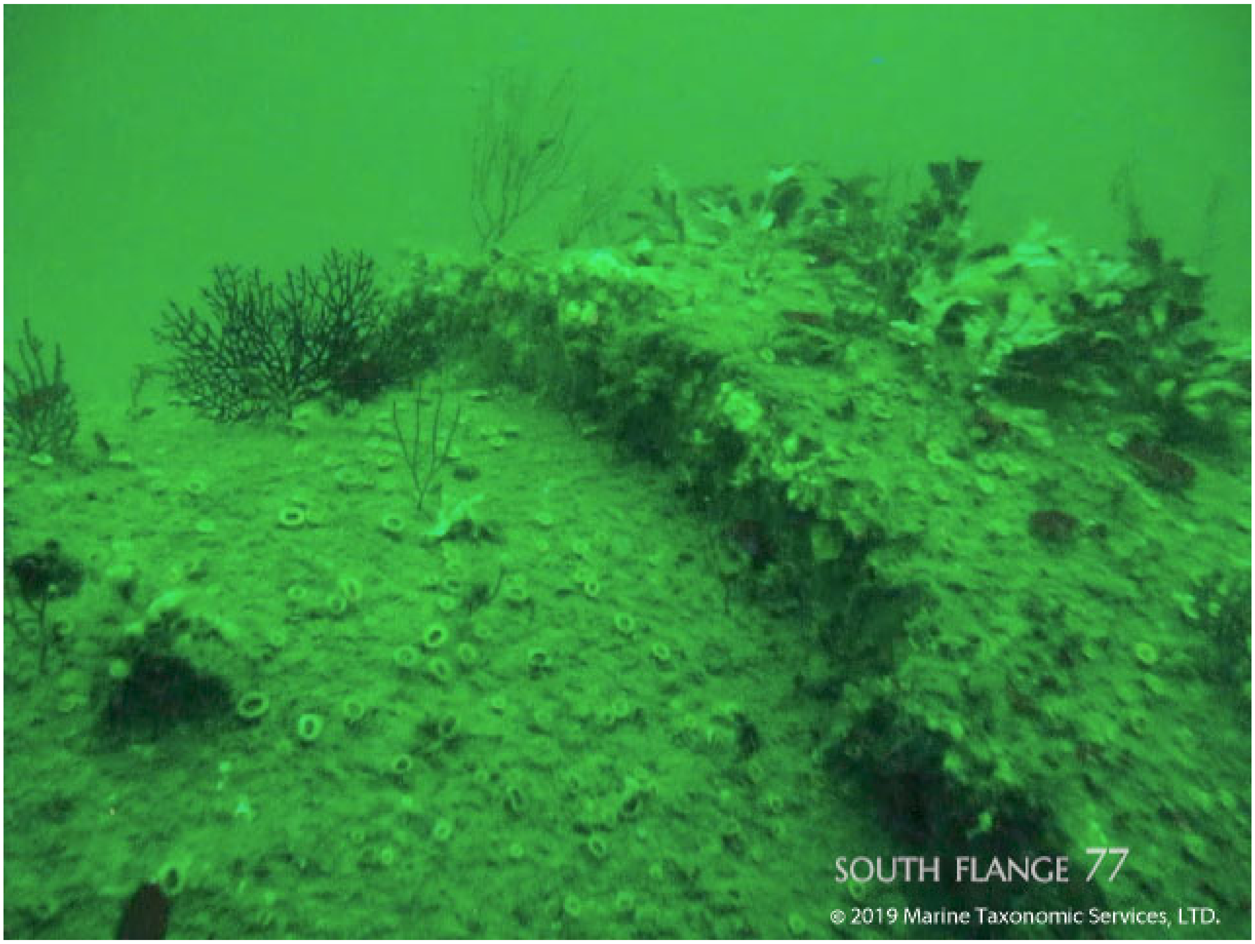
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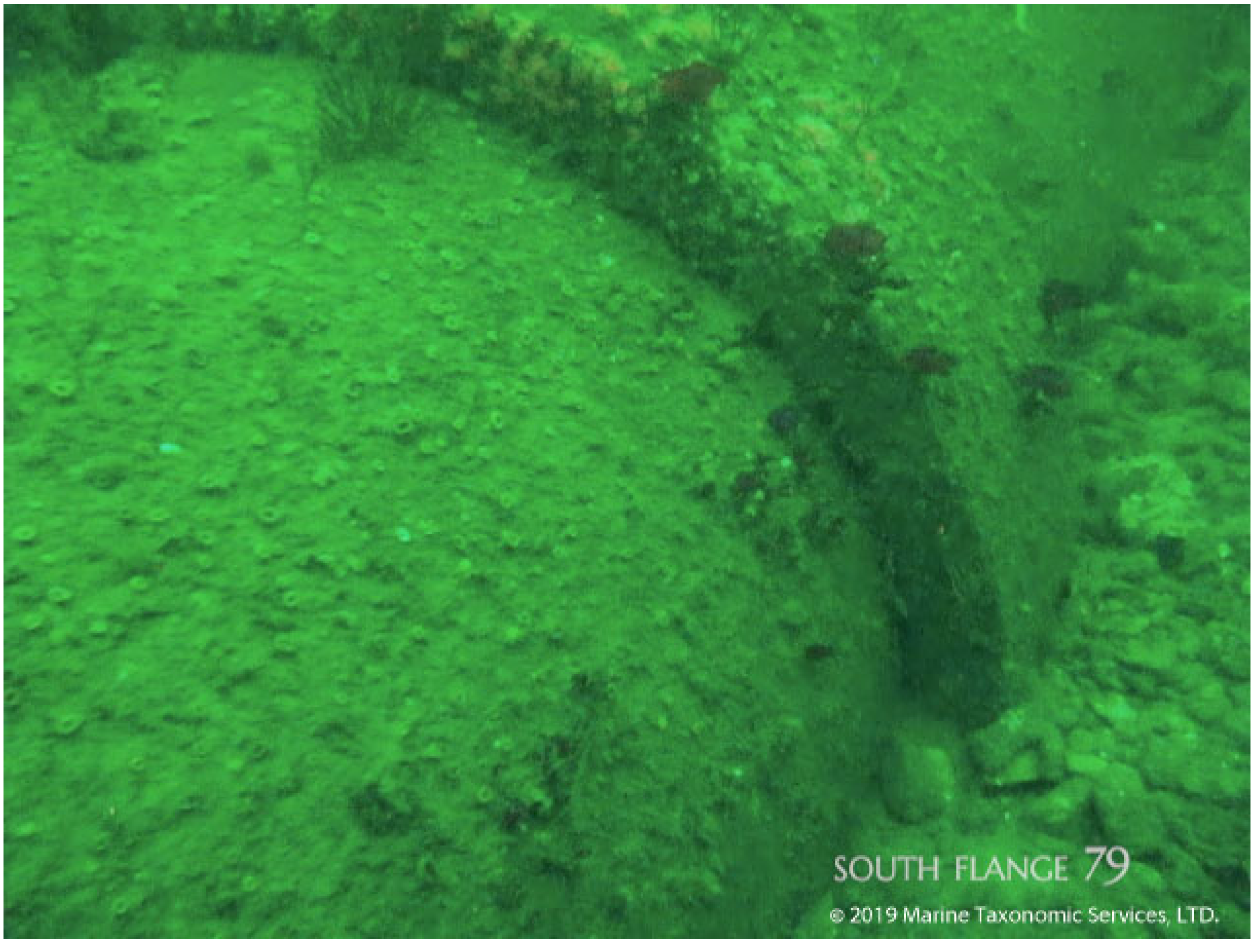
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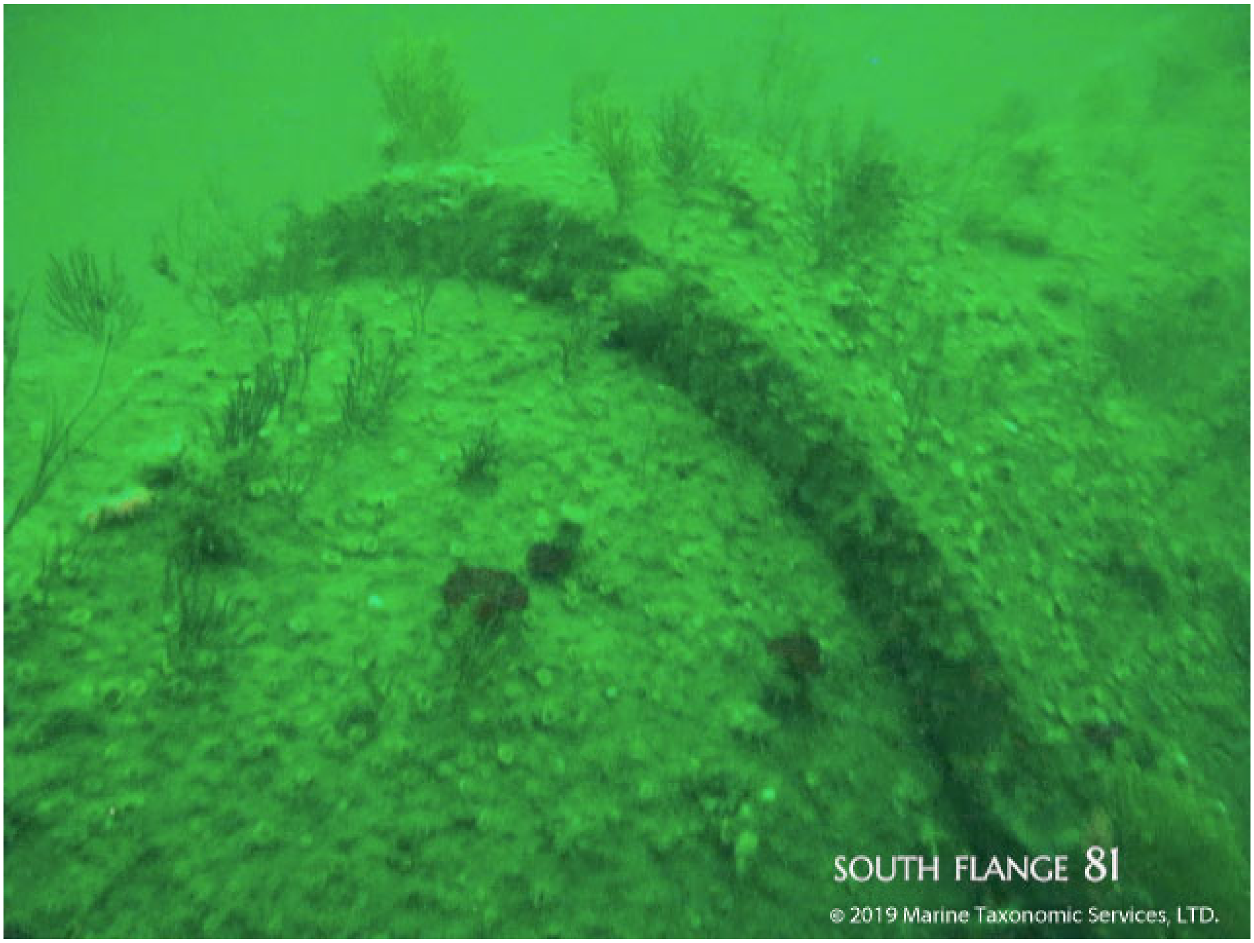
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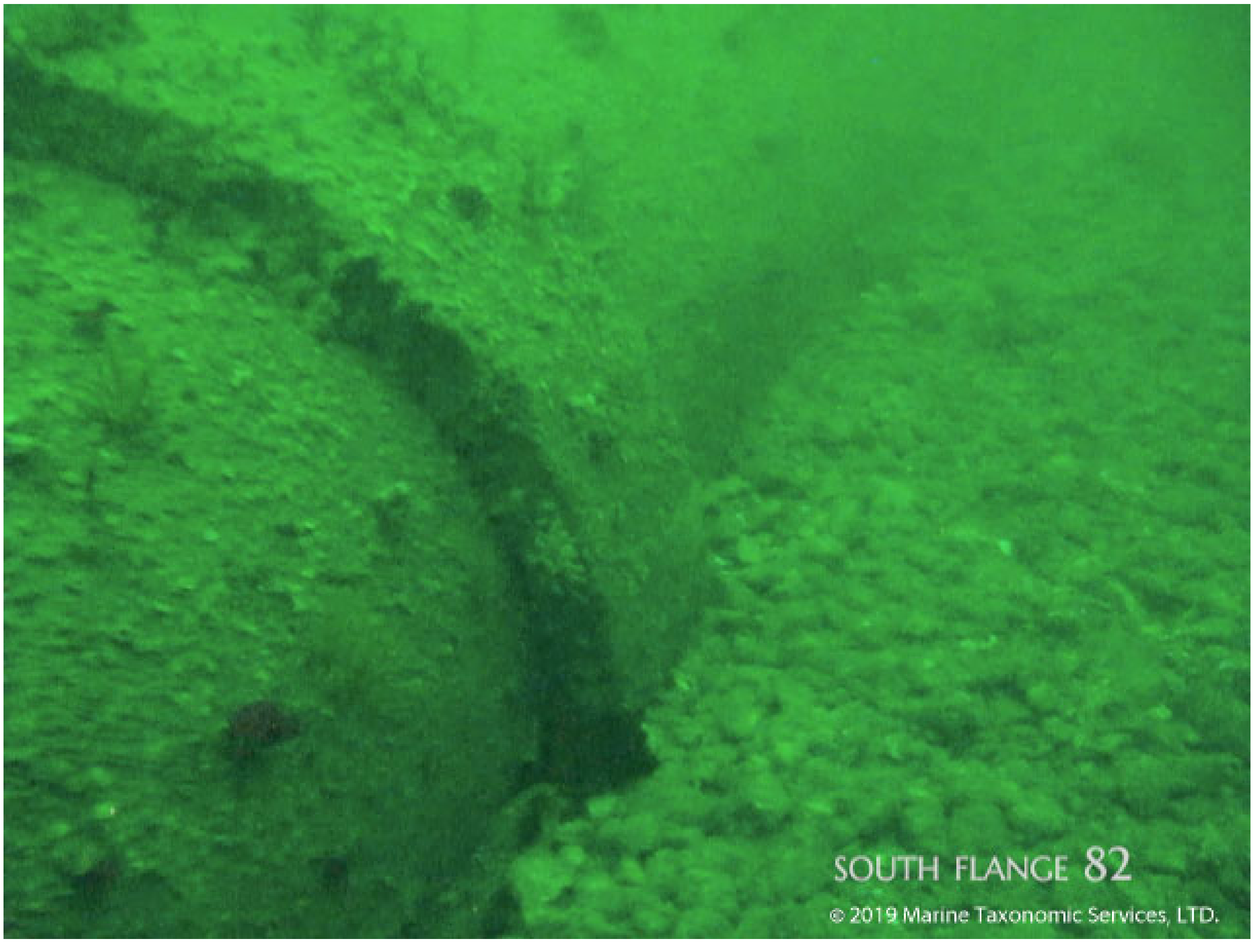
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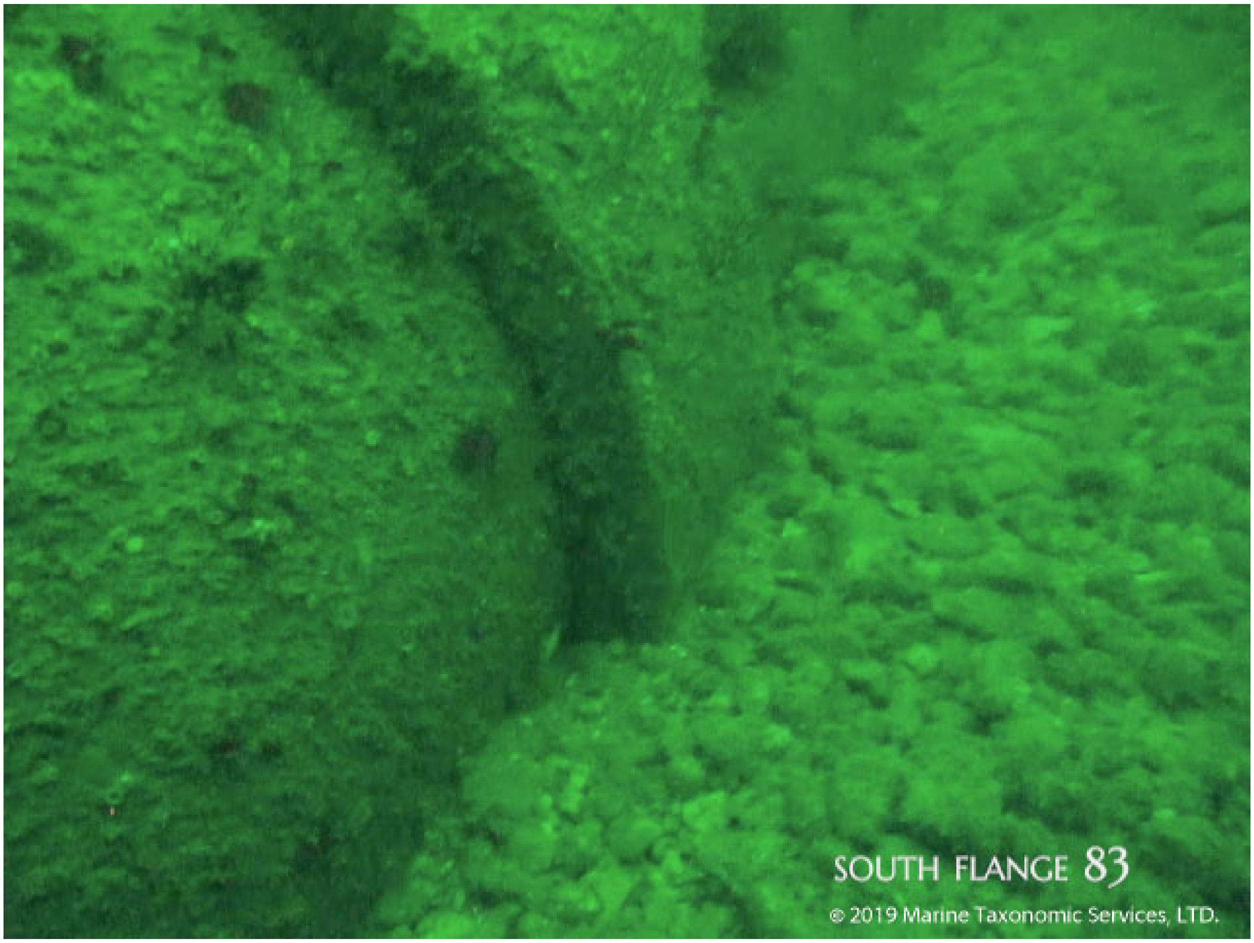
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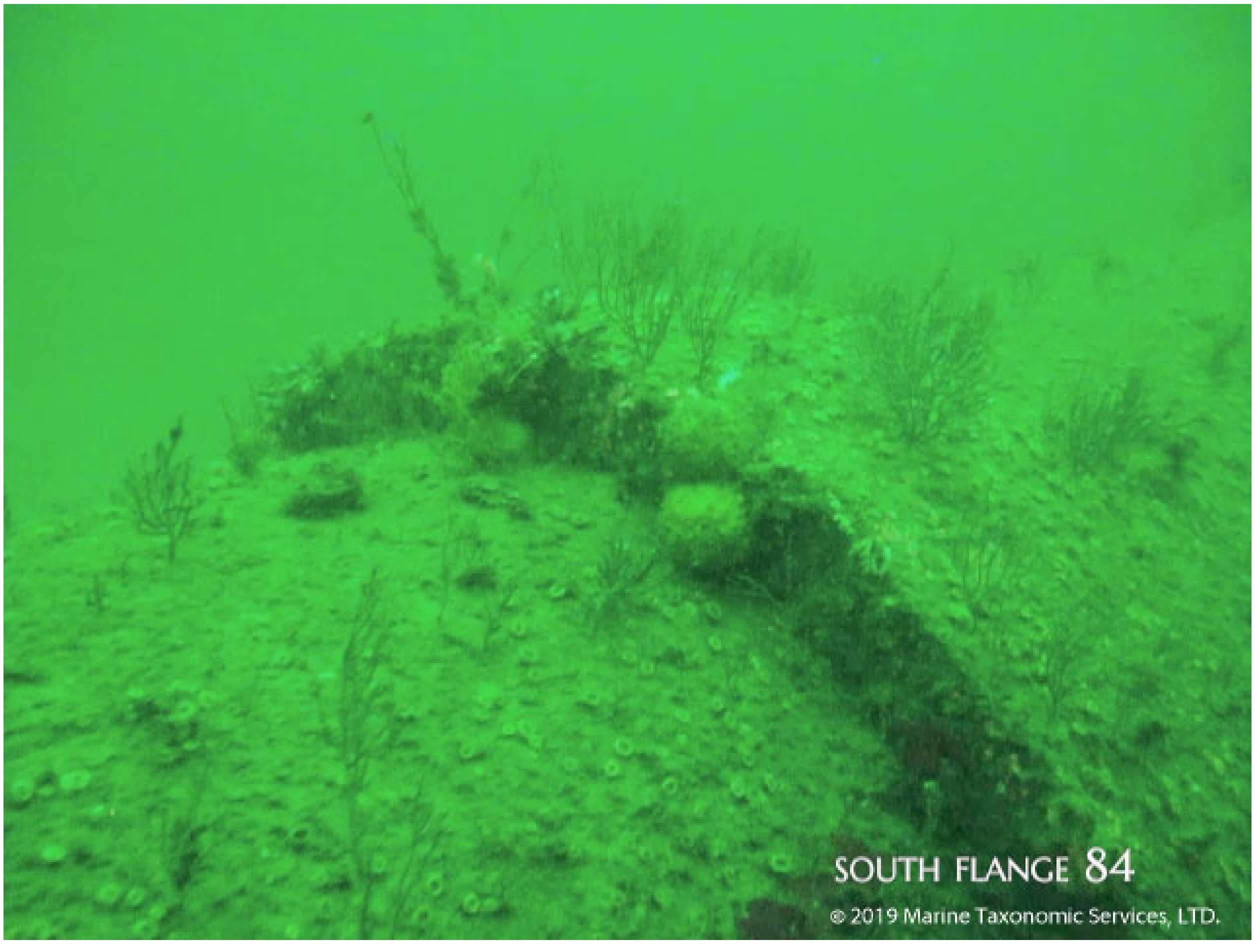
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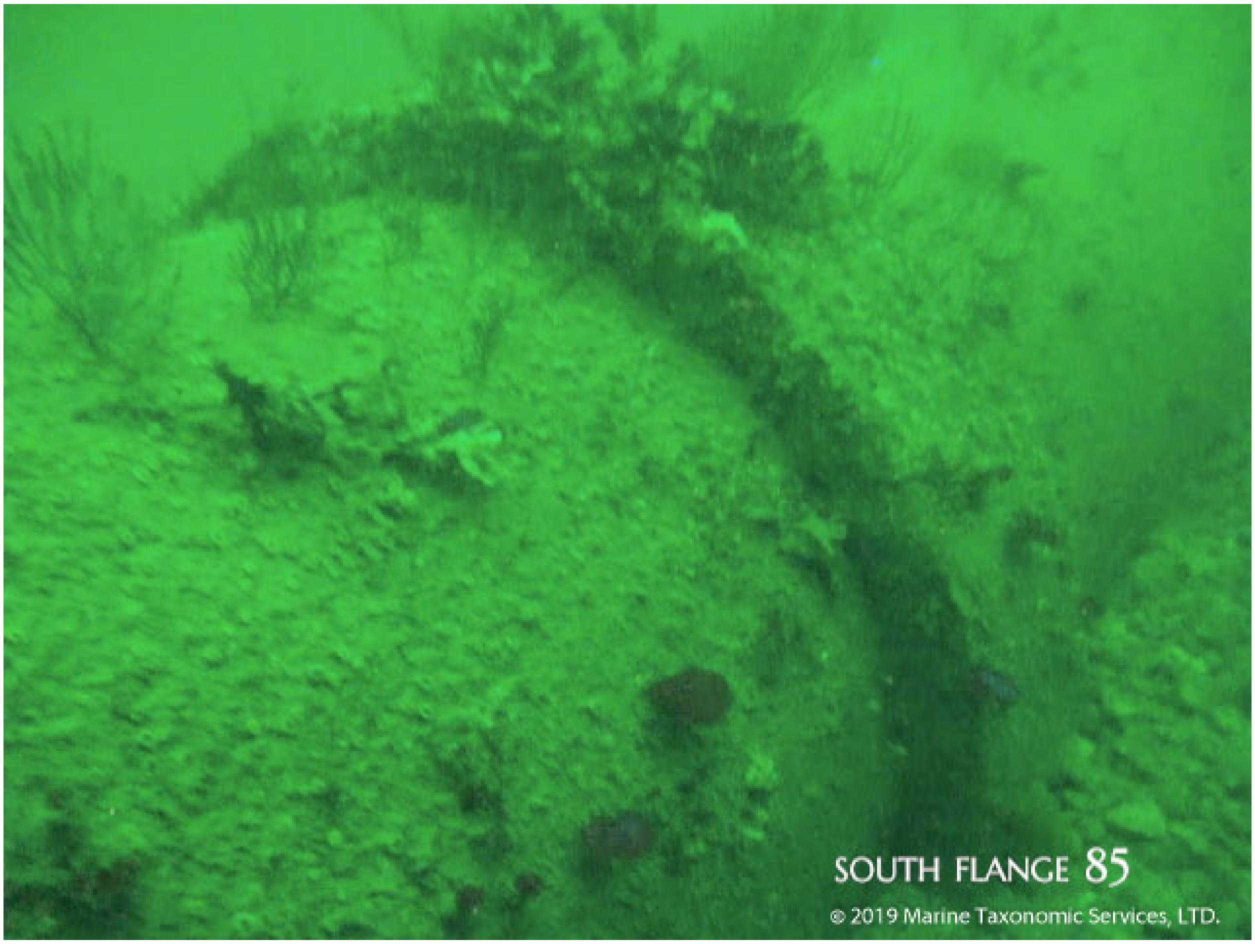
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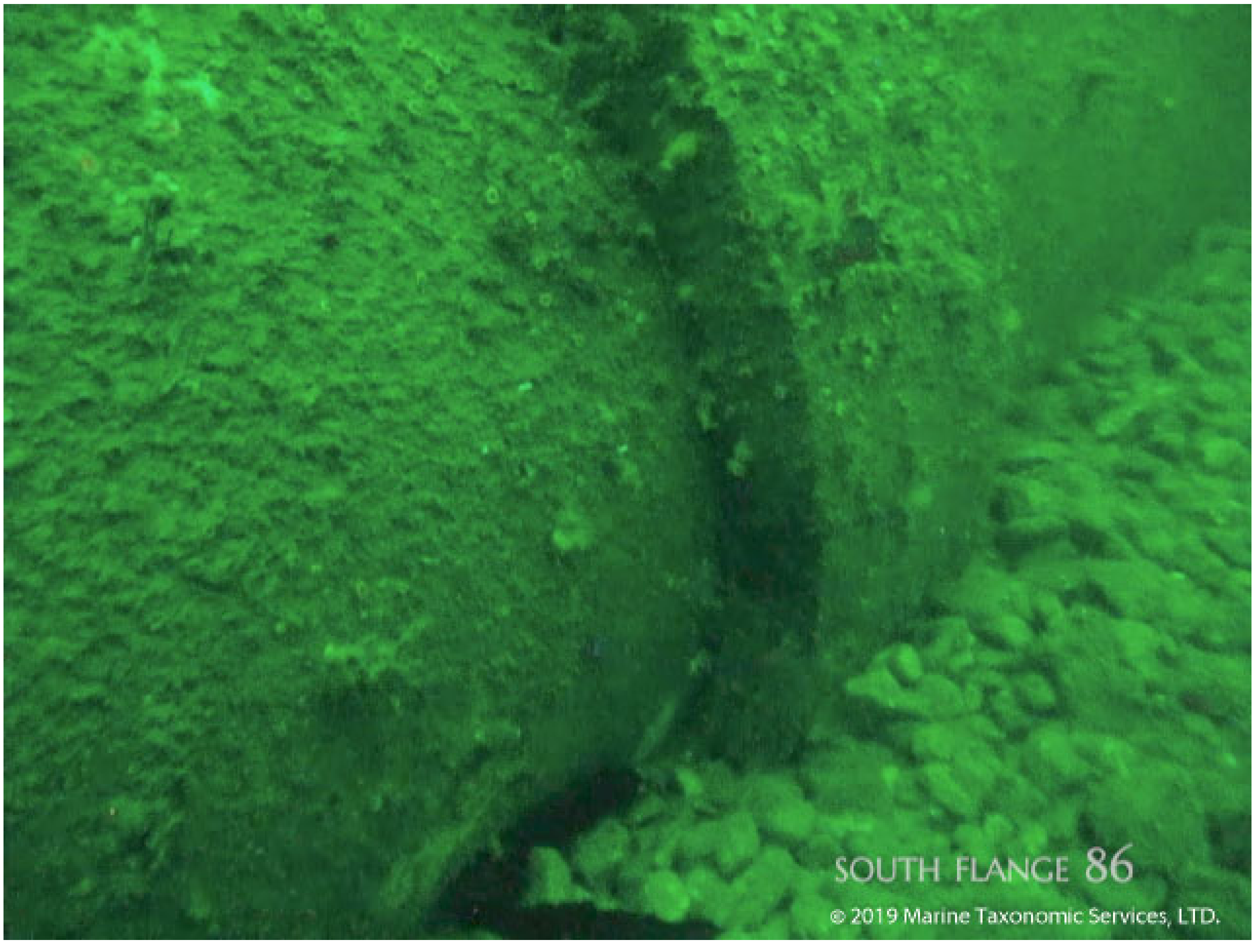
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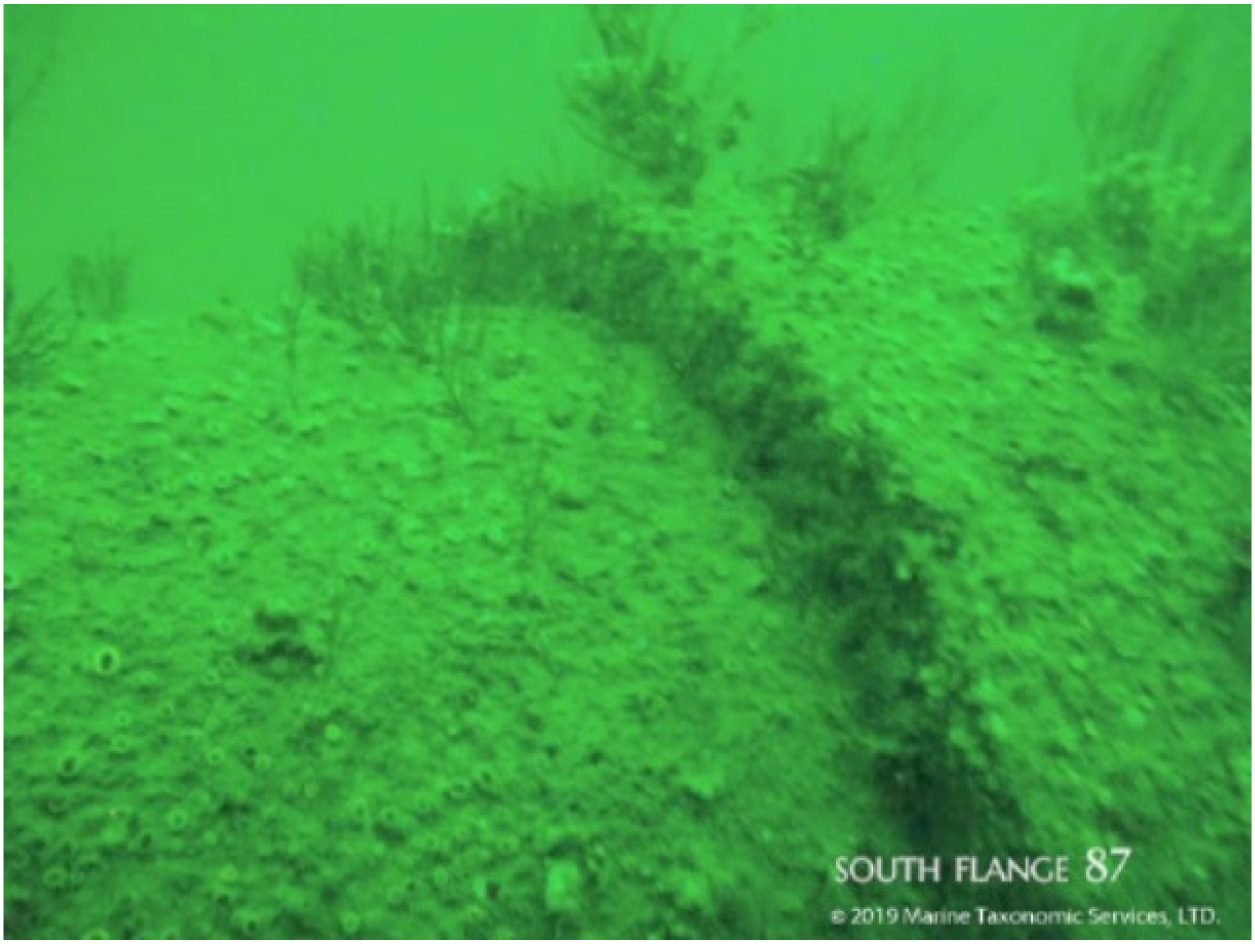
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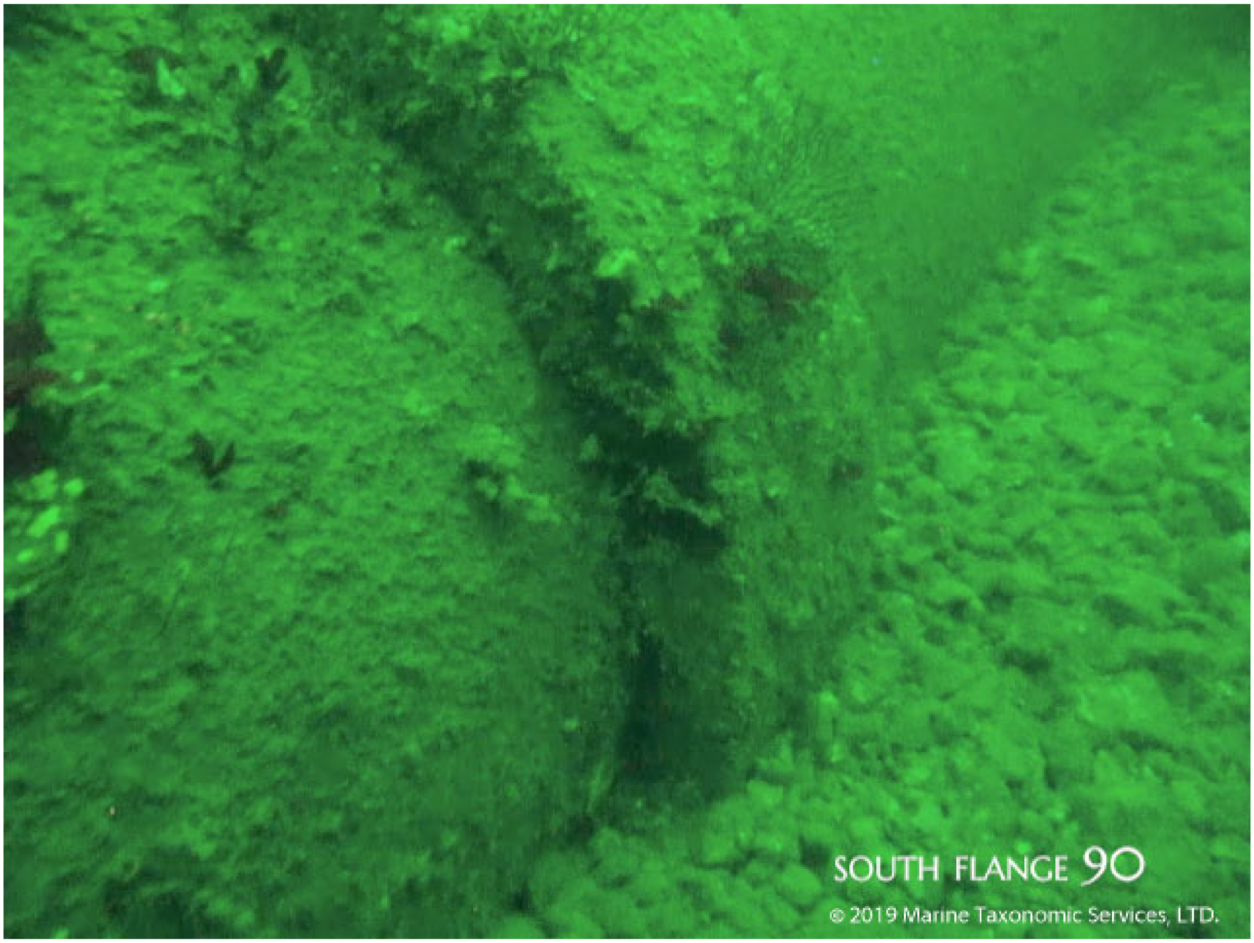
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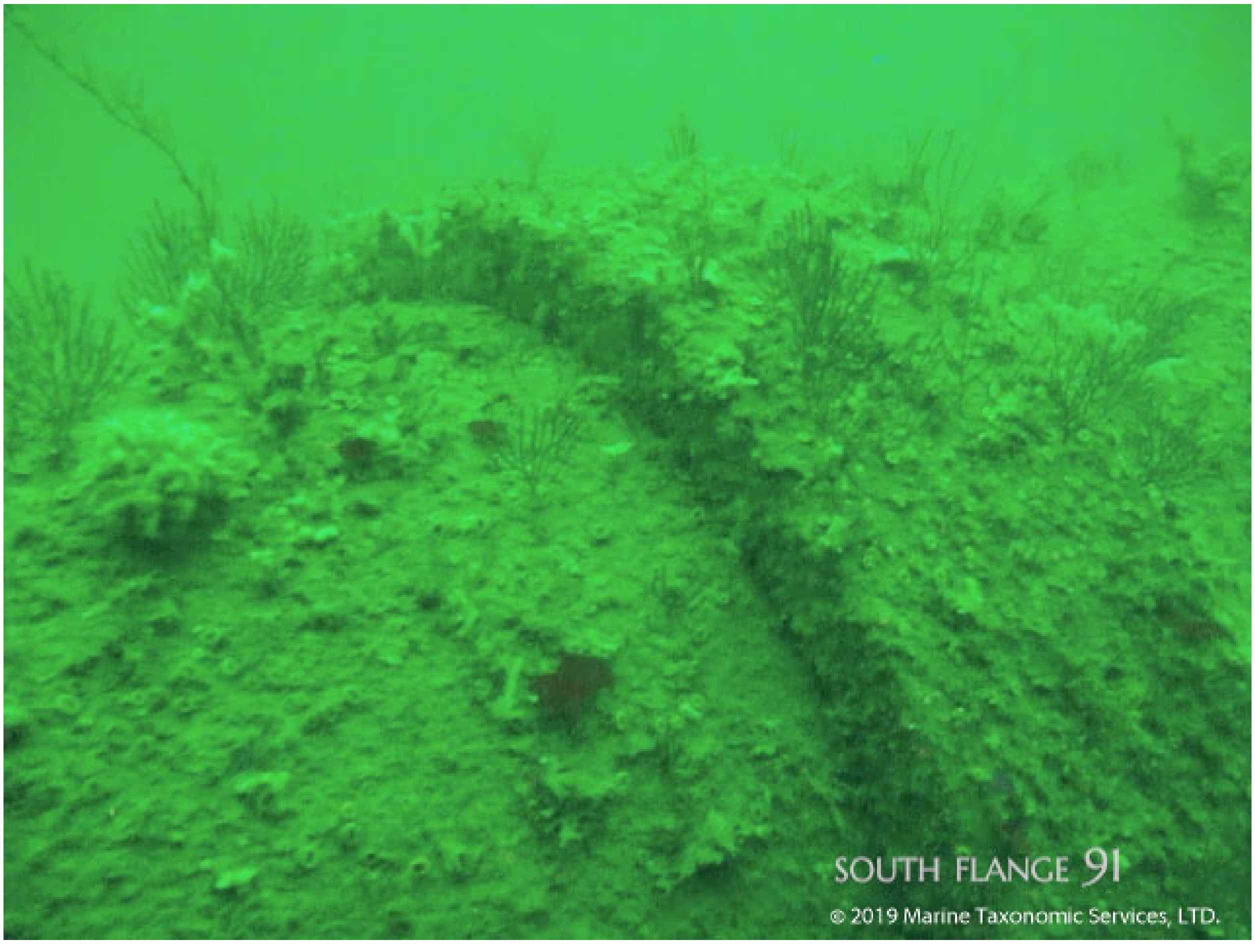
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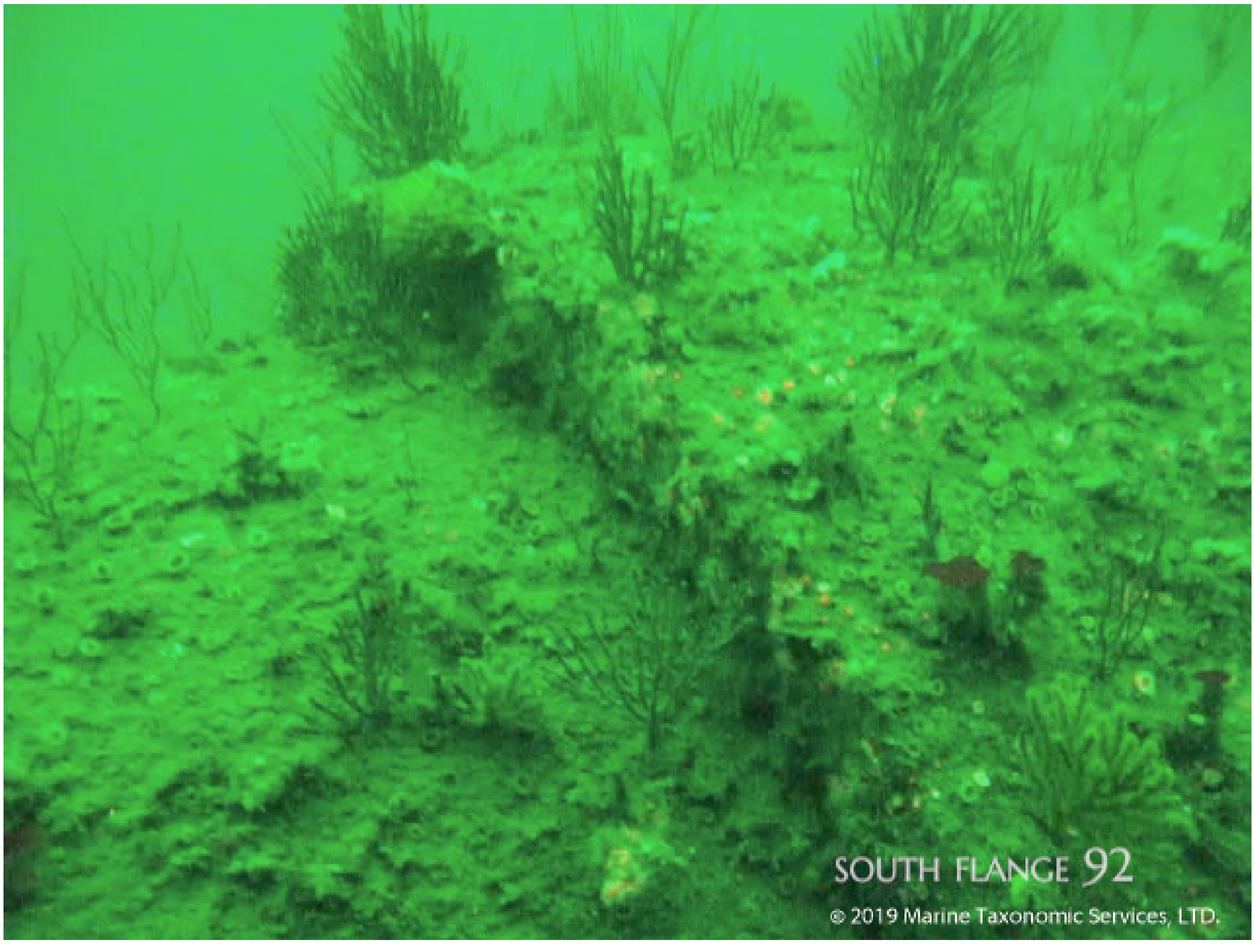
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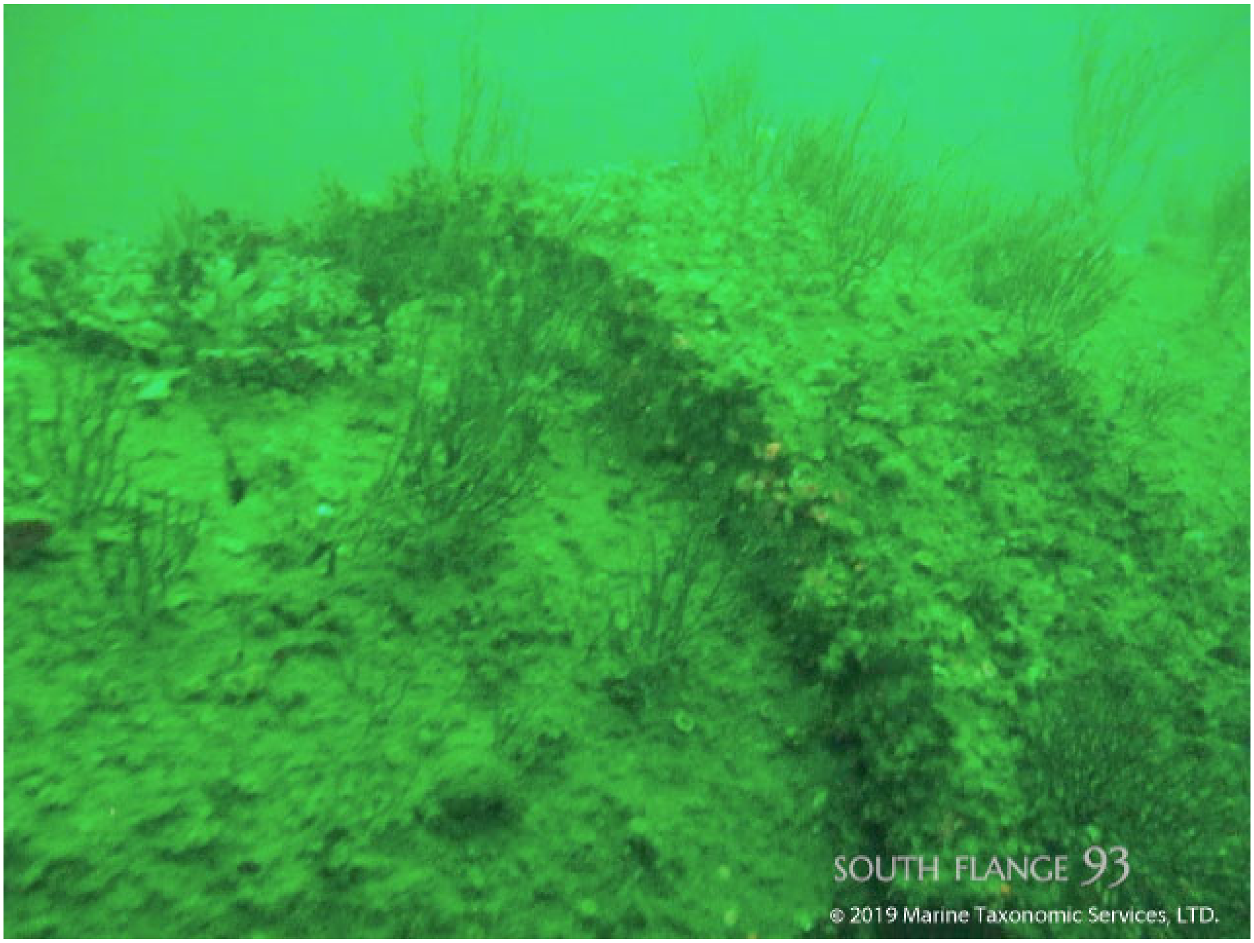
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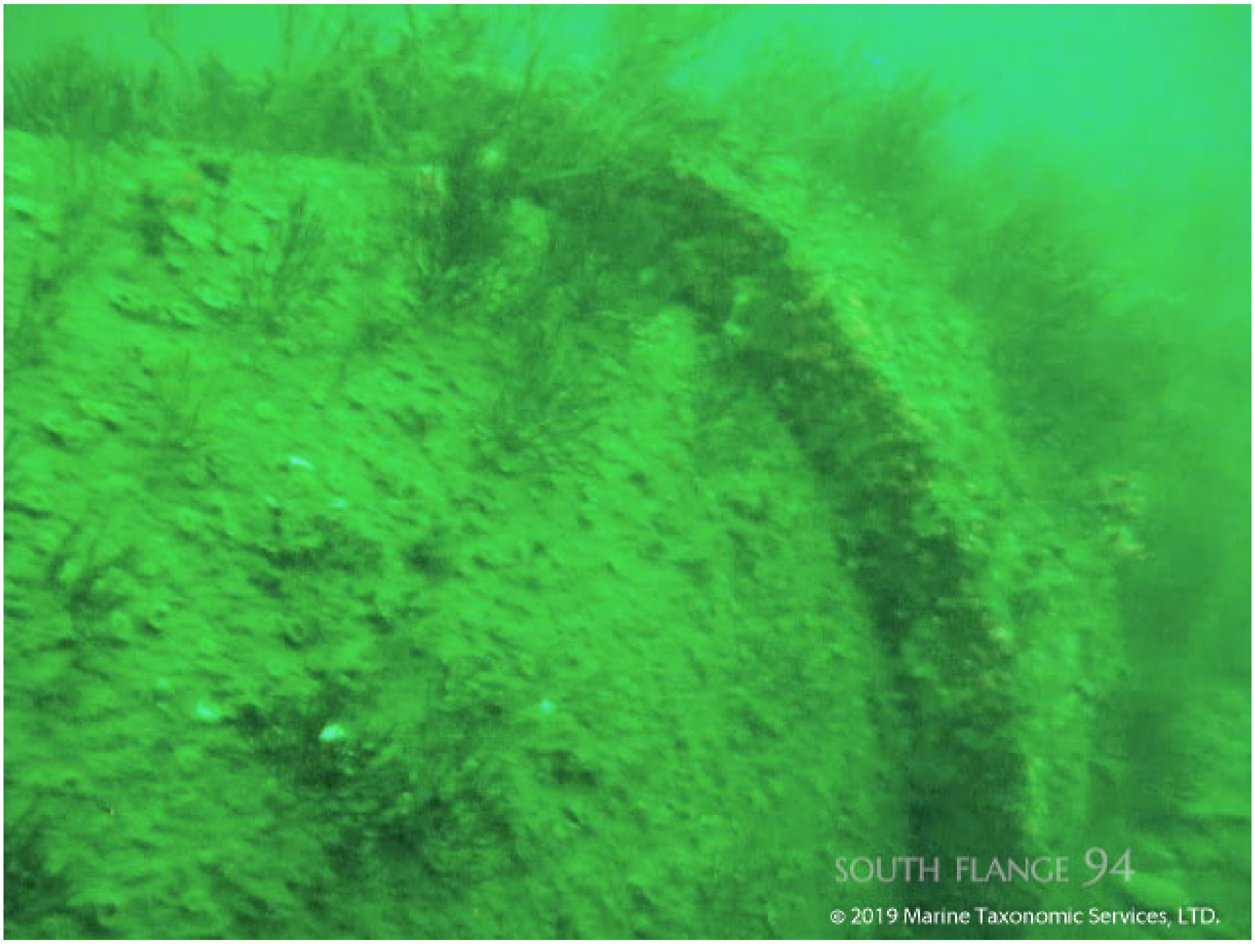
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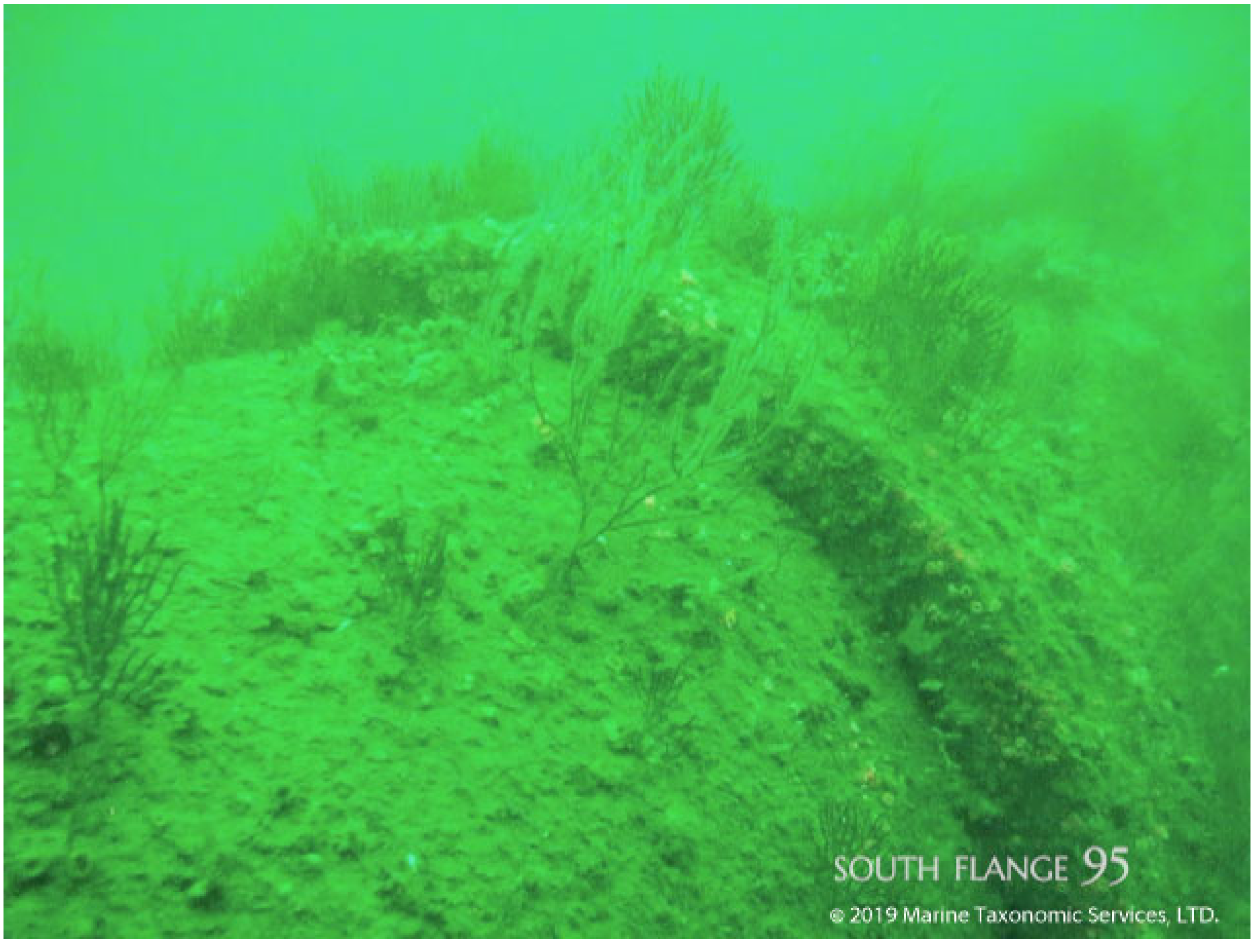
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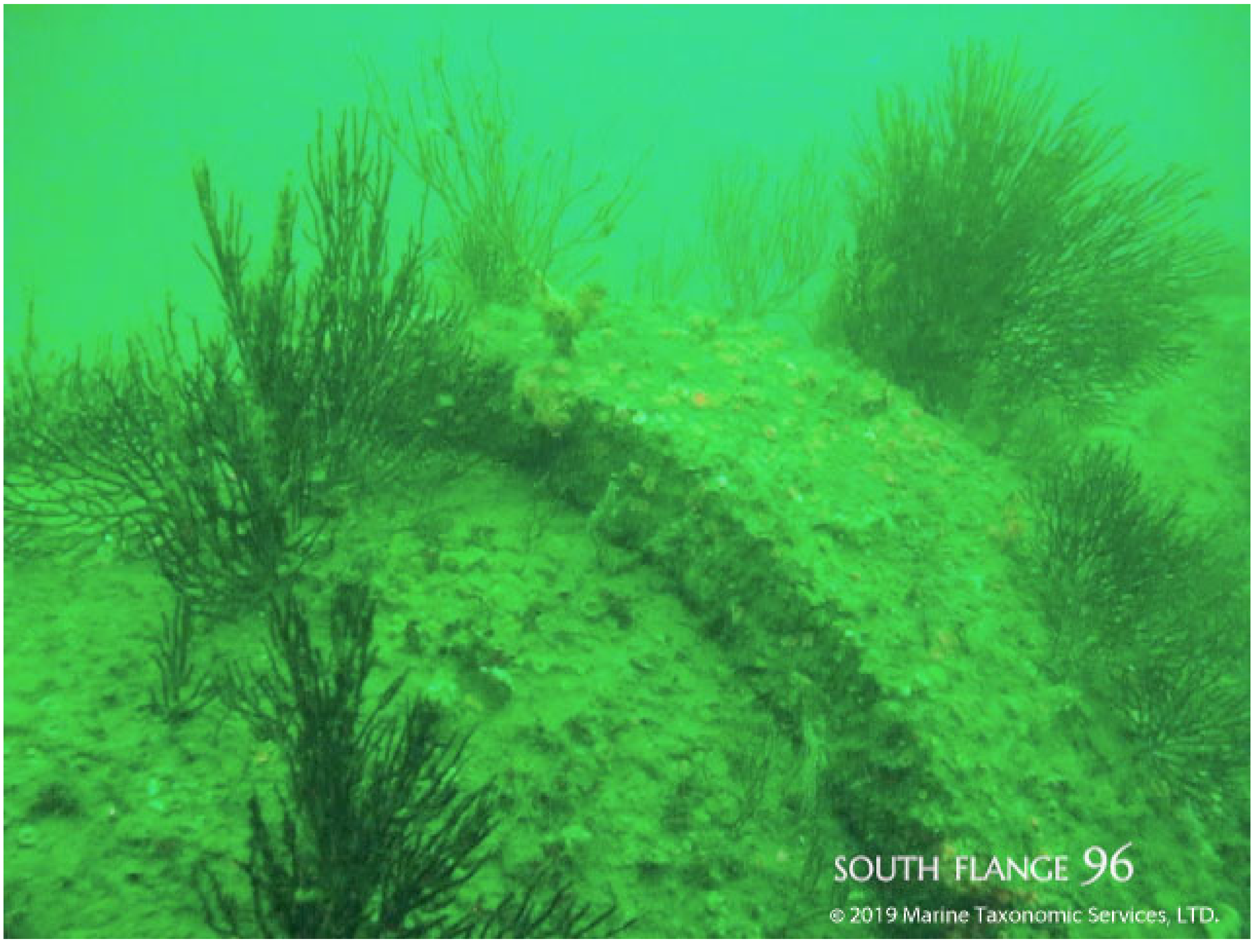
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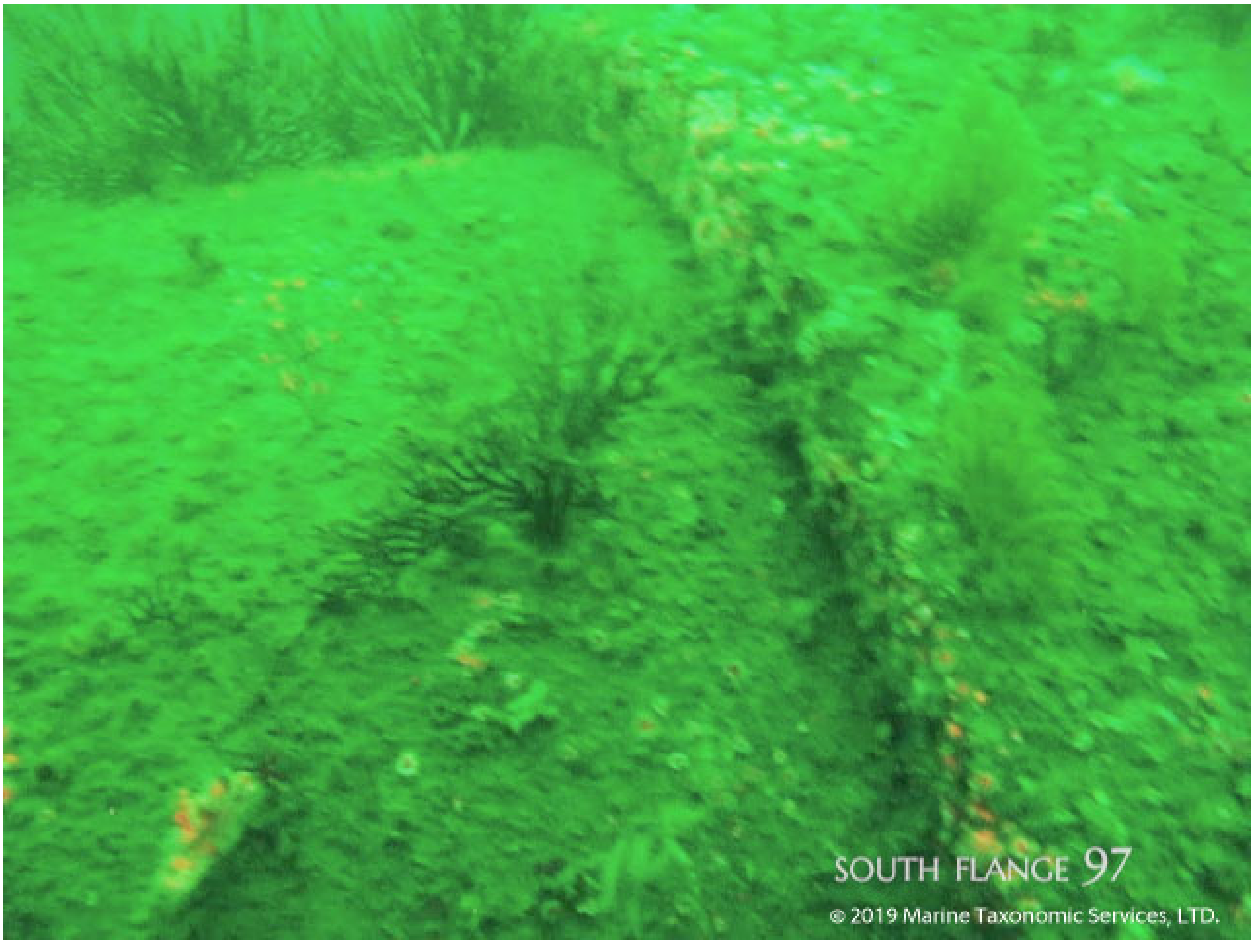
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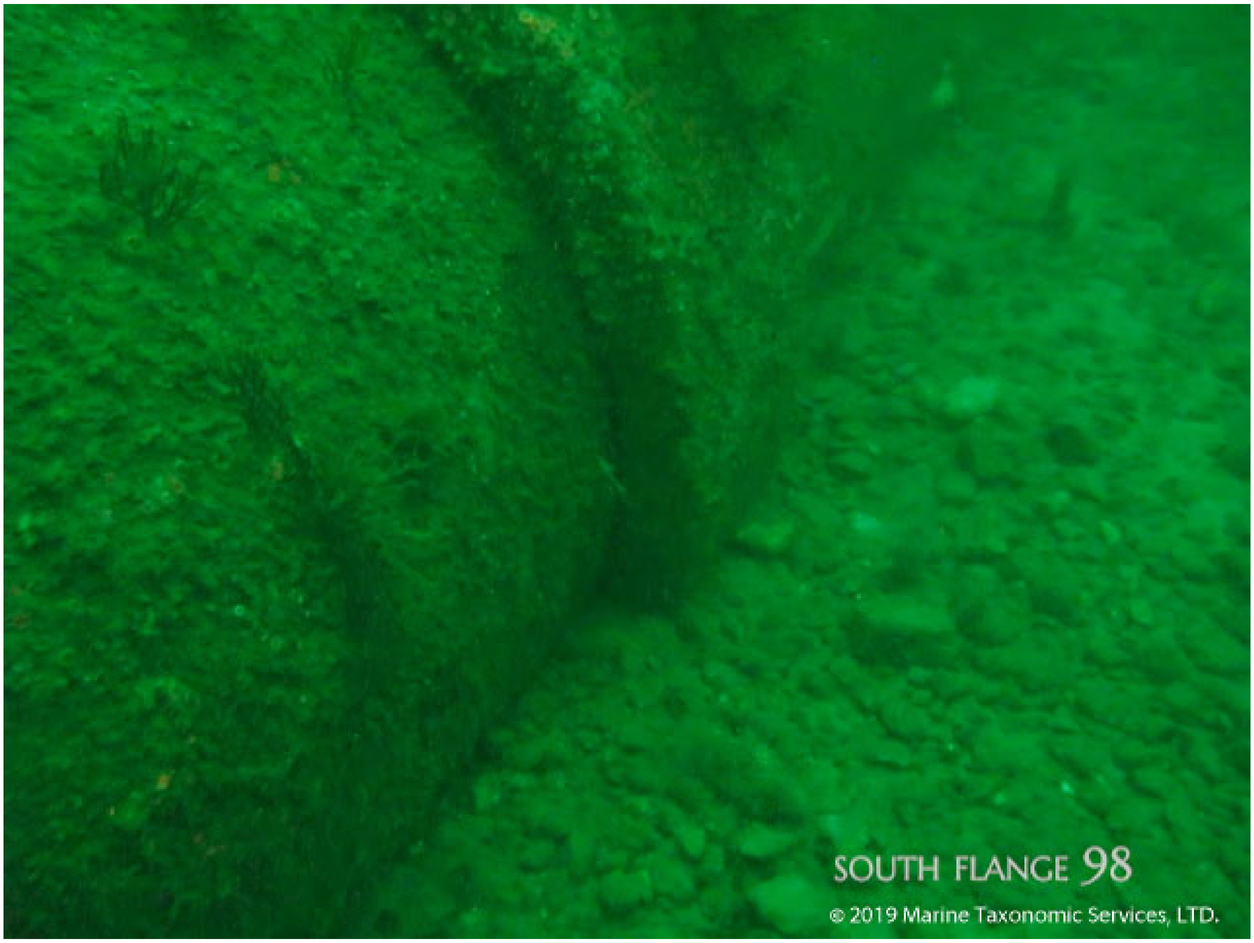
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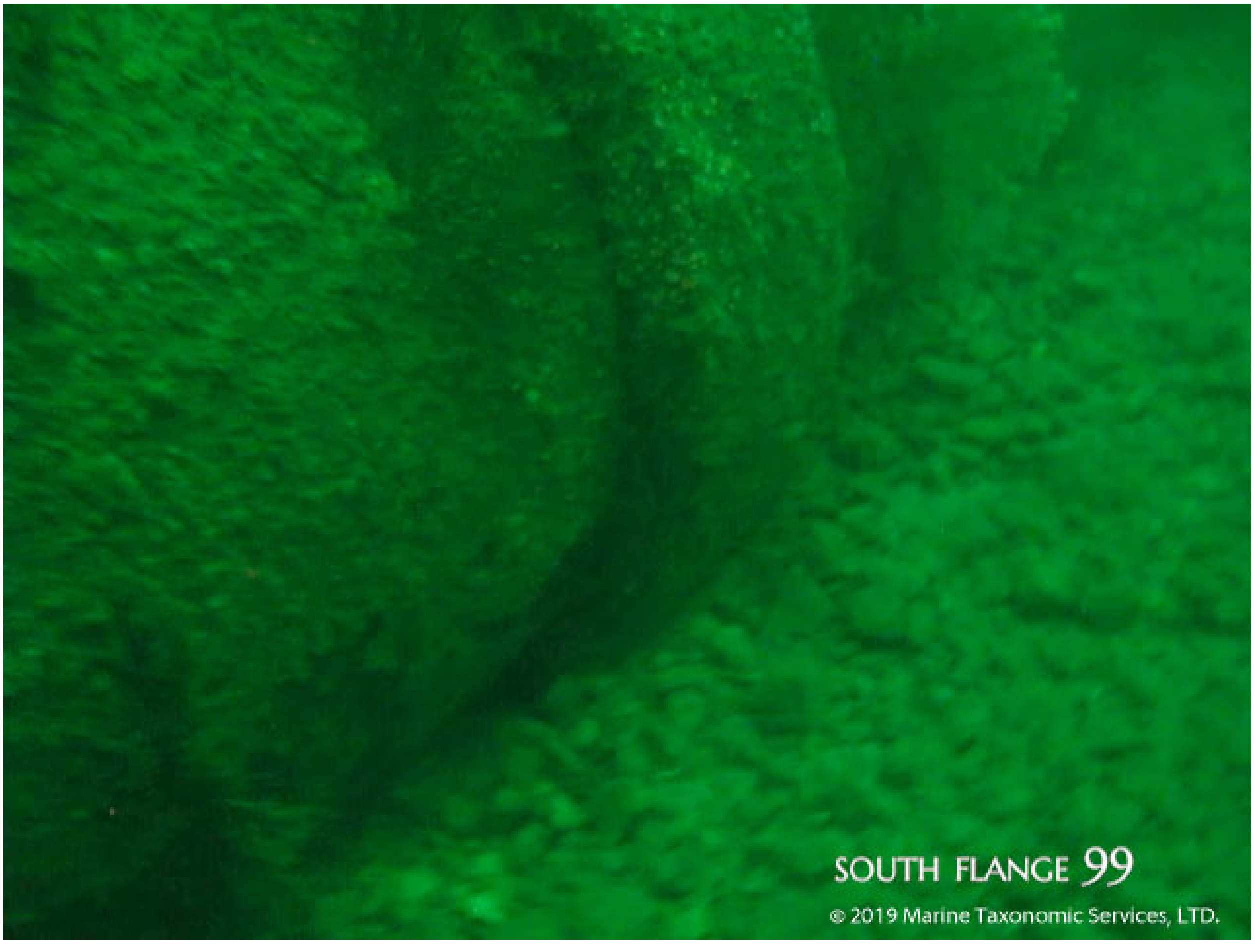
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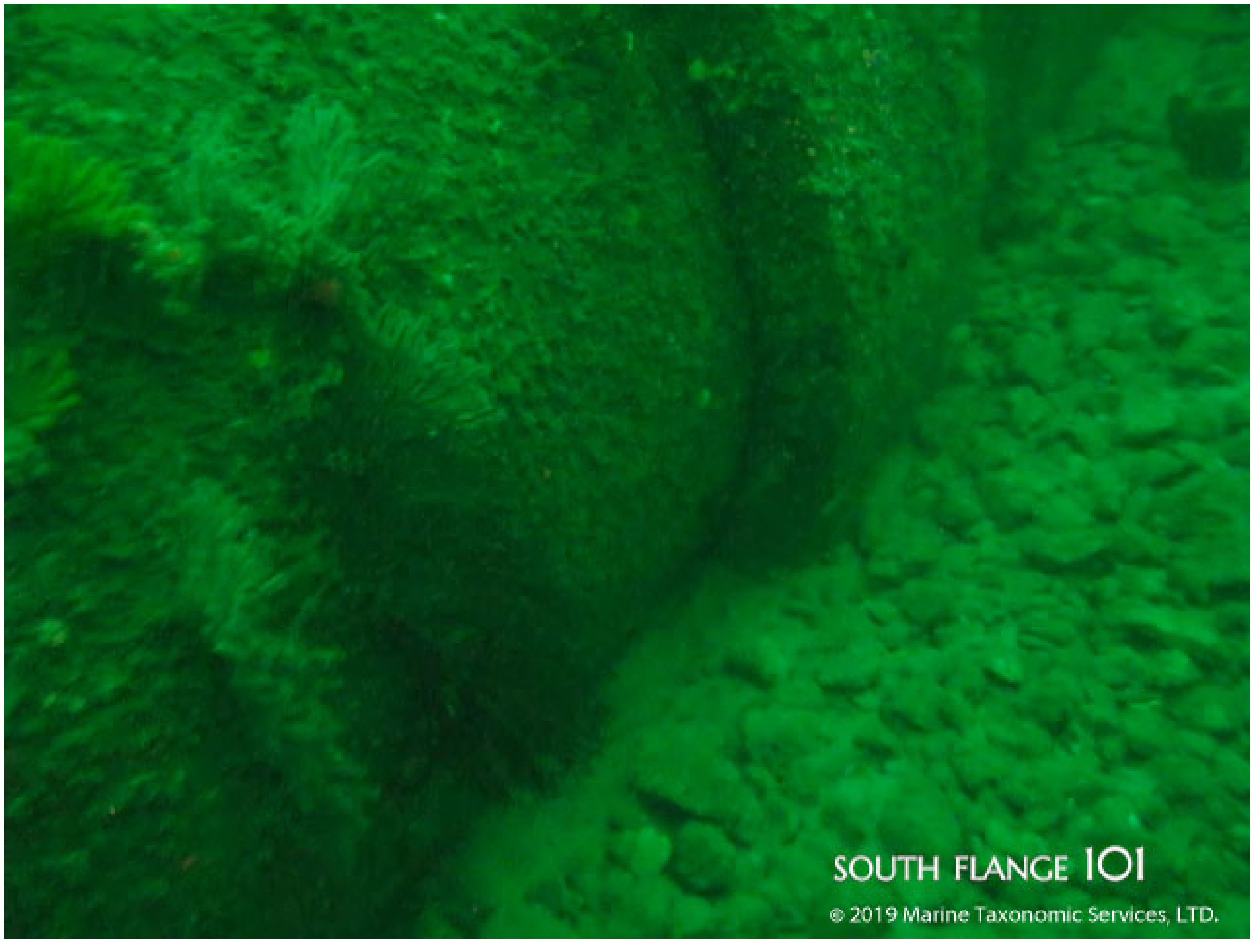
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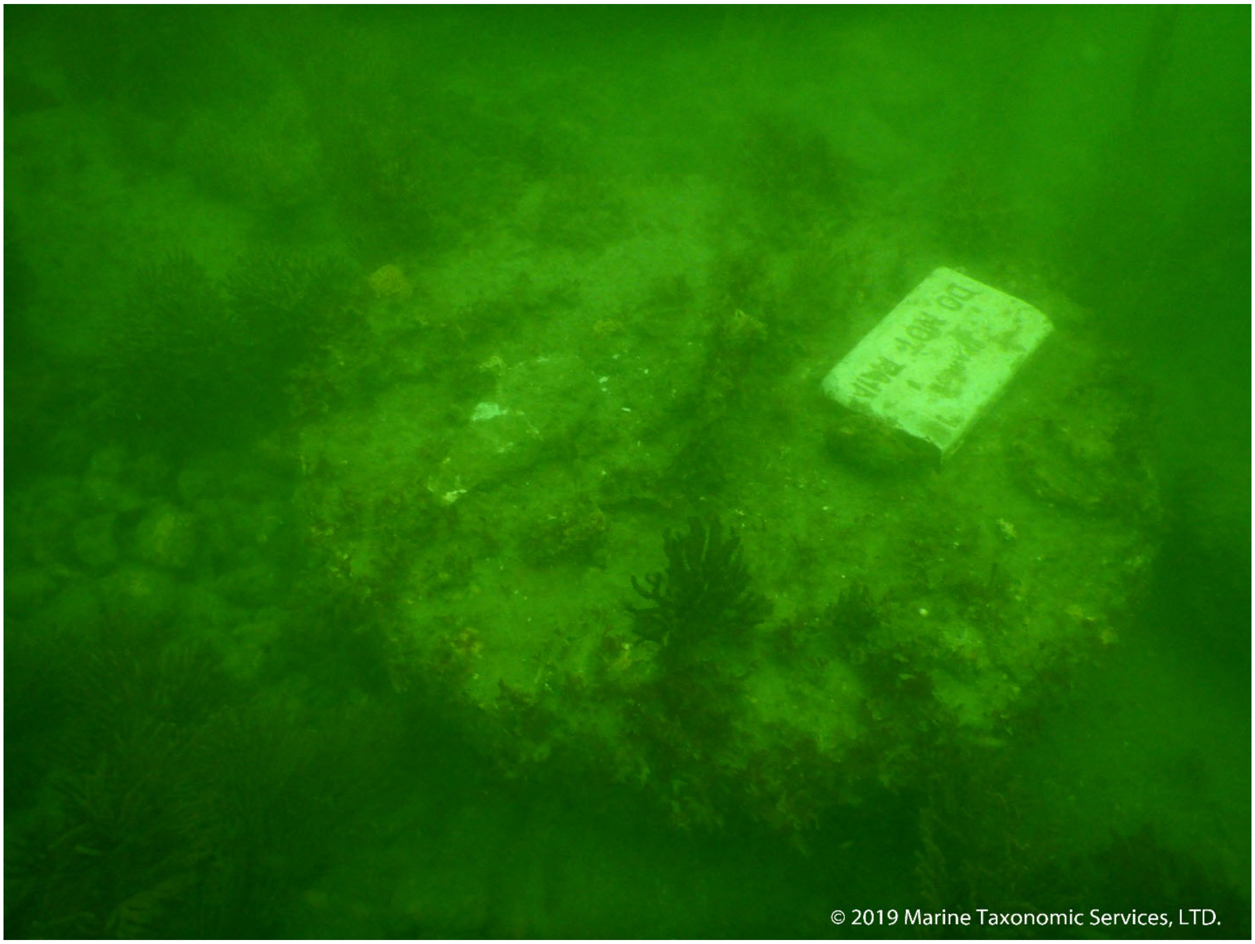
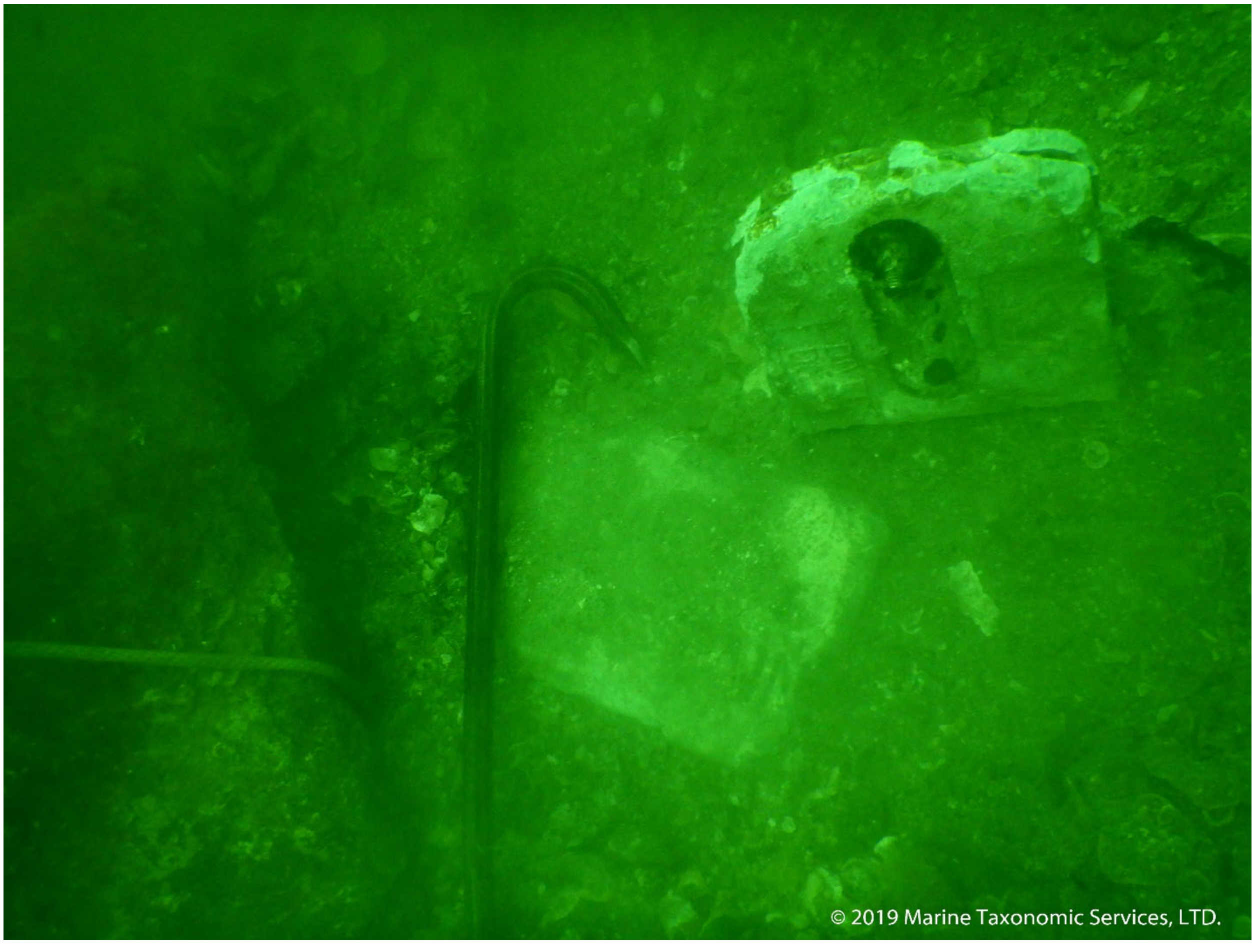
Manhole 1

Manhole 2



Manhole 3

Manhole 4



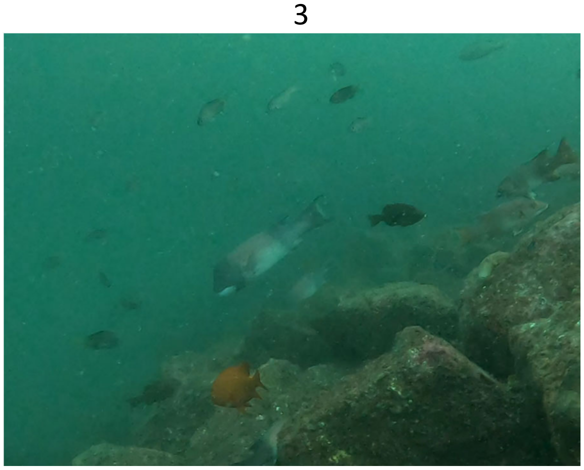
Manhole 5

1

2

3

4



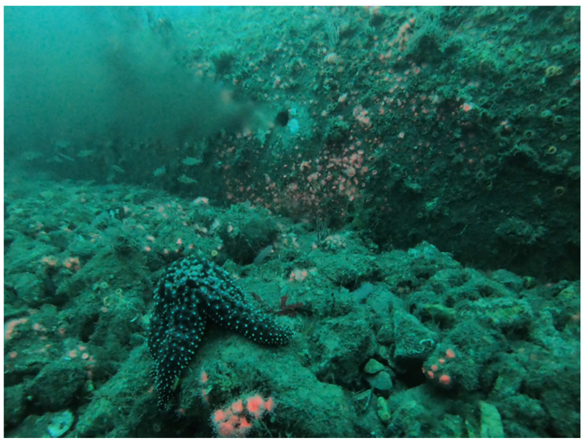
5

6

Black Sea Bass (1), California Halibut (2), Moray (3), Gopher Rock Fish (4), Garibaldi and Male Sheepshead (5), Black Sea Bass and Kelp Bass (6)

1

2



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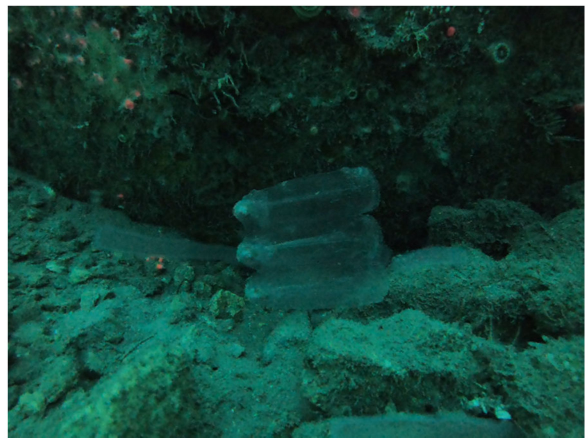

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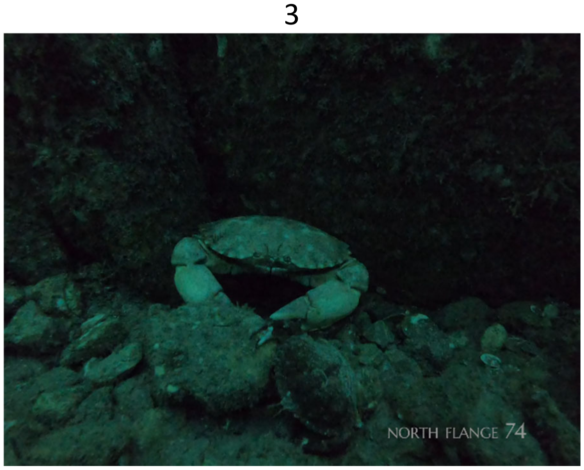

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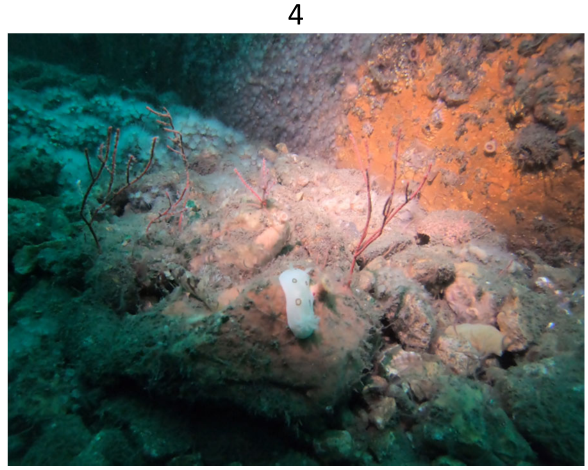
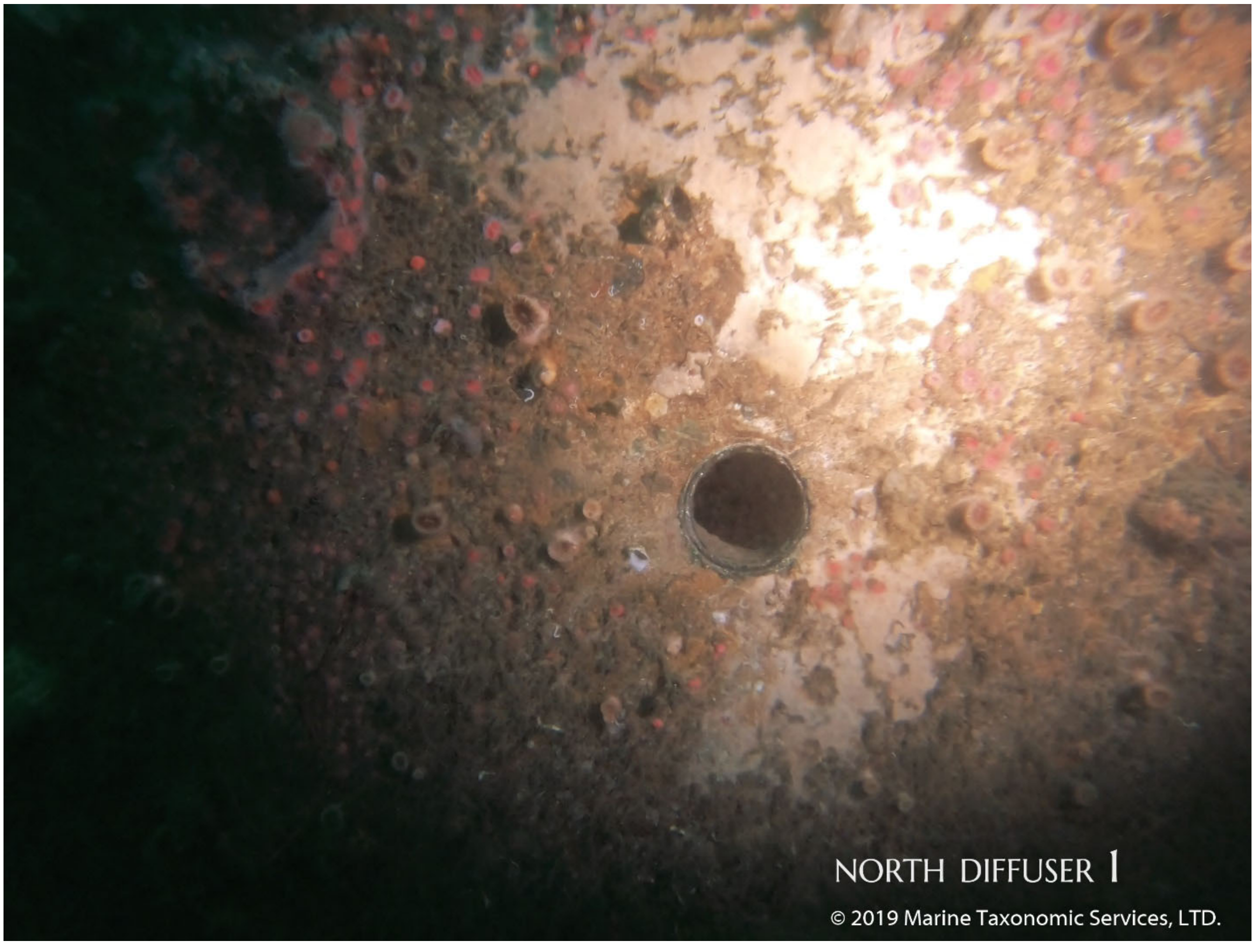


6

California Spiny Lobster and Crowned Urchin (1), Tube Dwelling Anemone and Giant Keyhole Limpet (2), Giant Spined Star (3), Pyrosome (4), Rock Crabs (5), San Diego Dorid (6)

APPENDIX C

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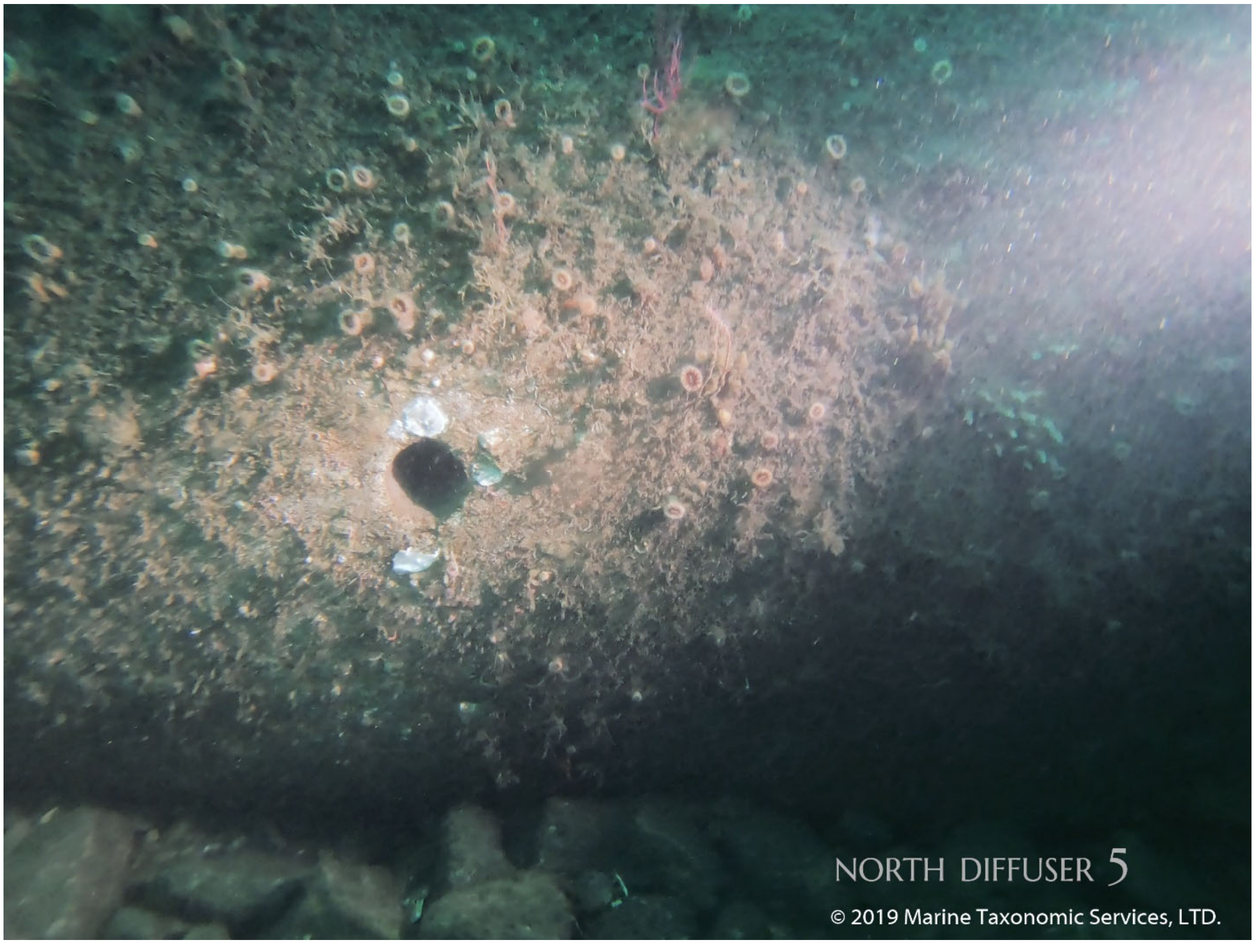
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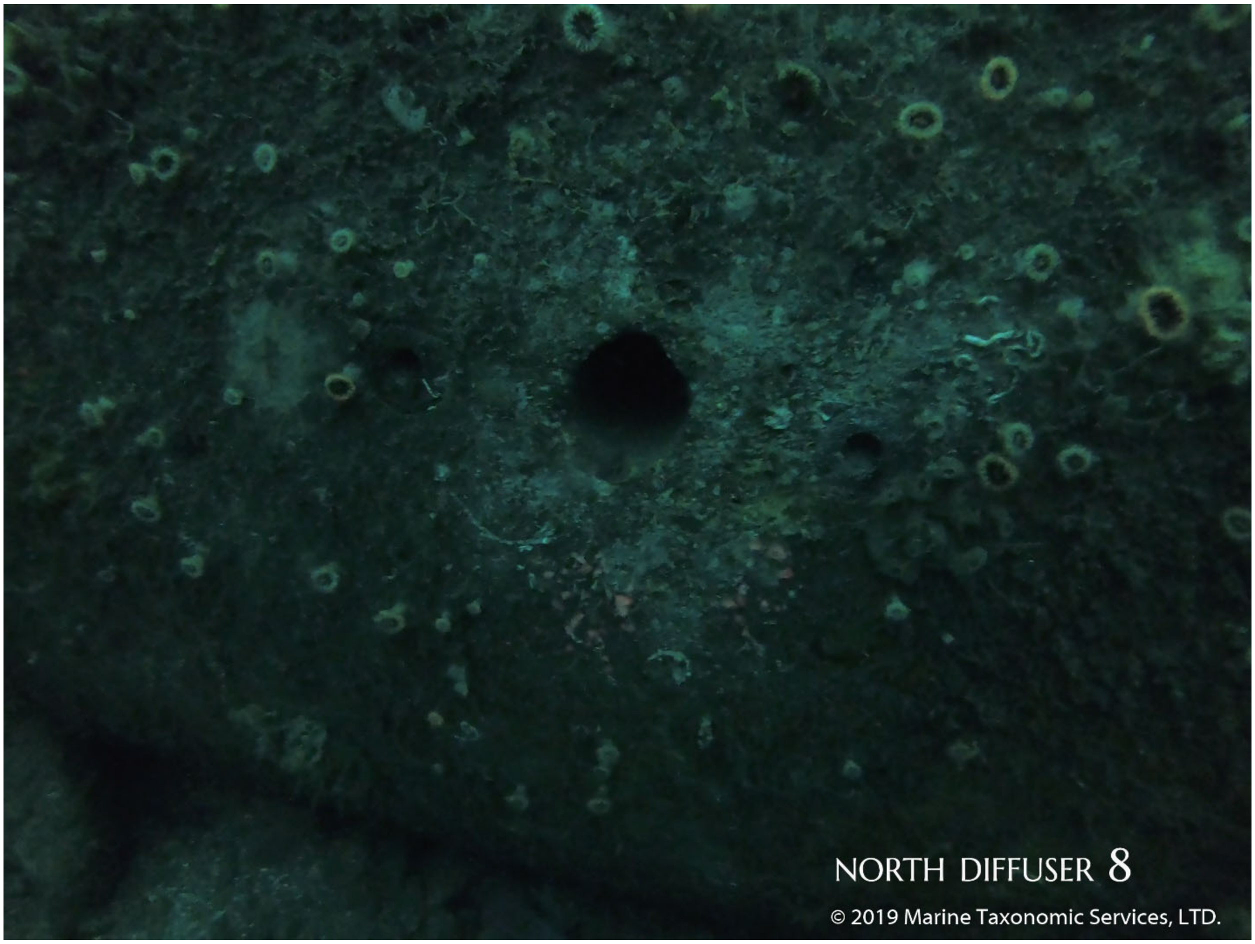
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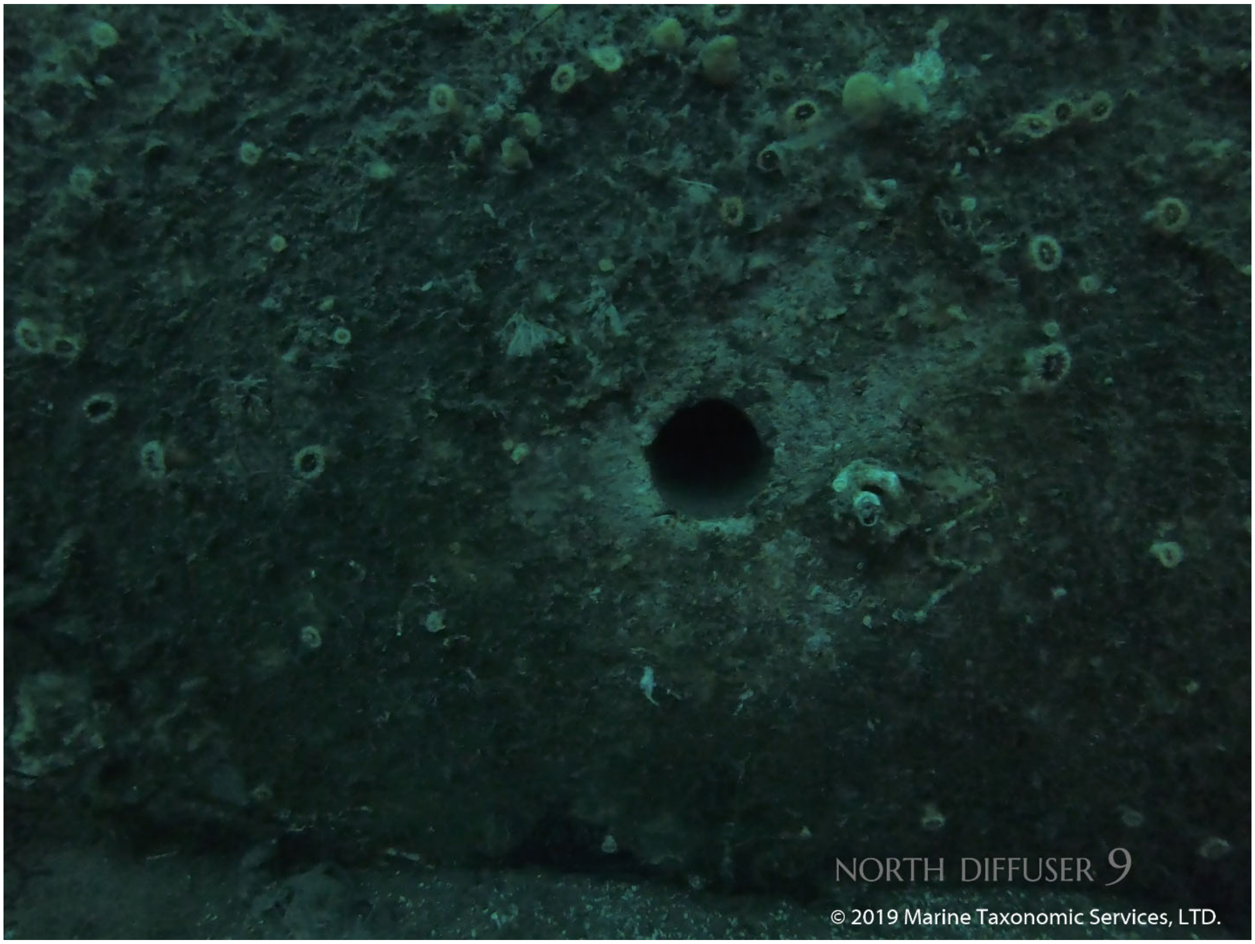
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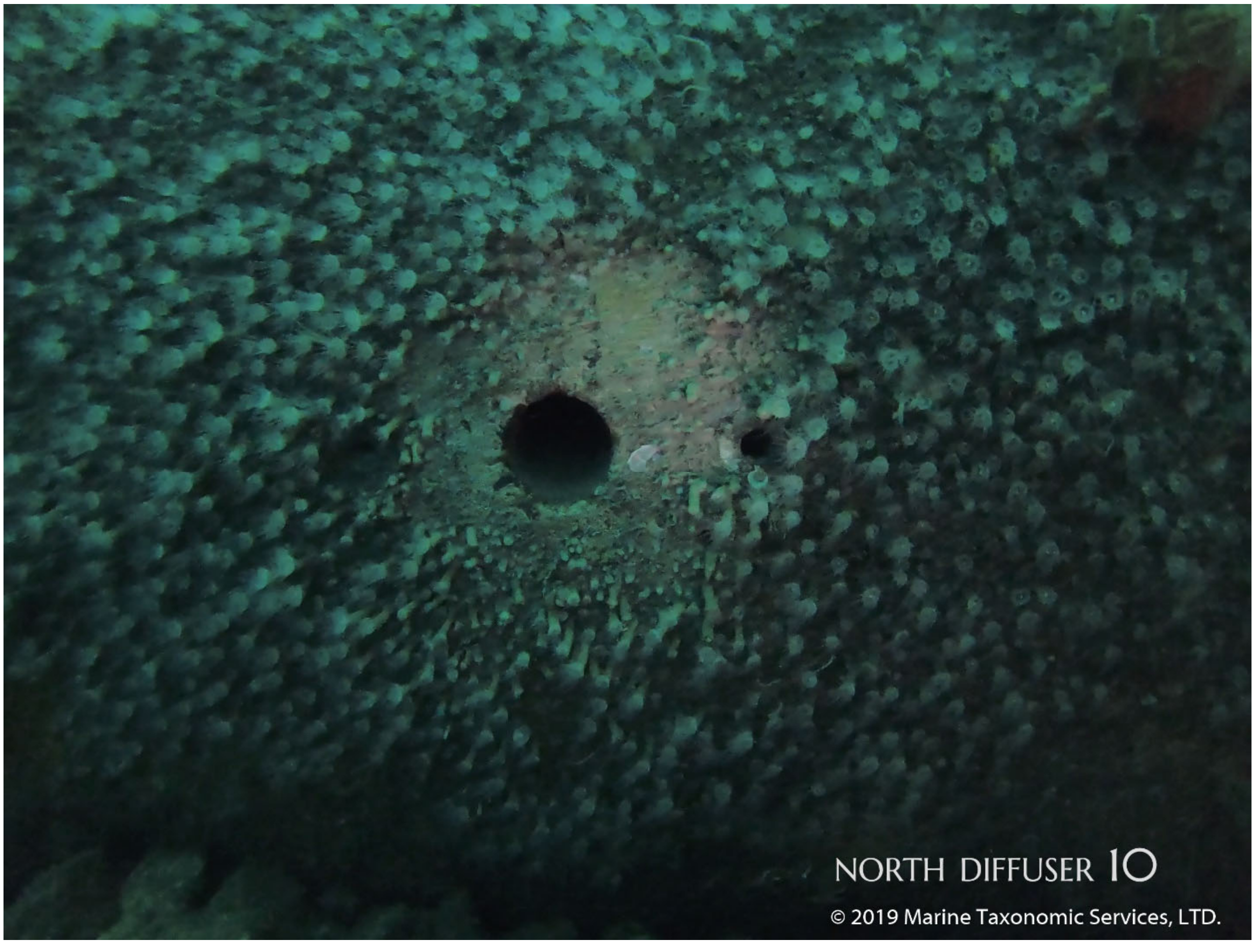
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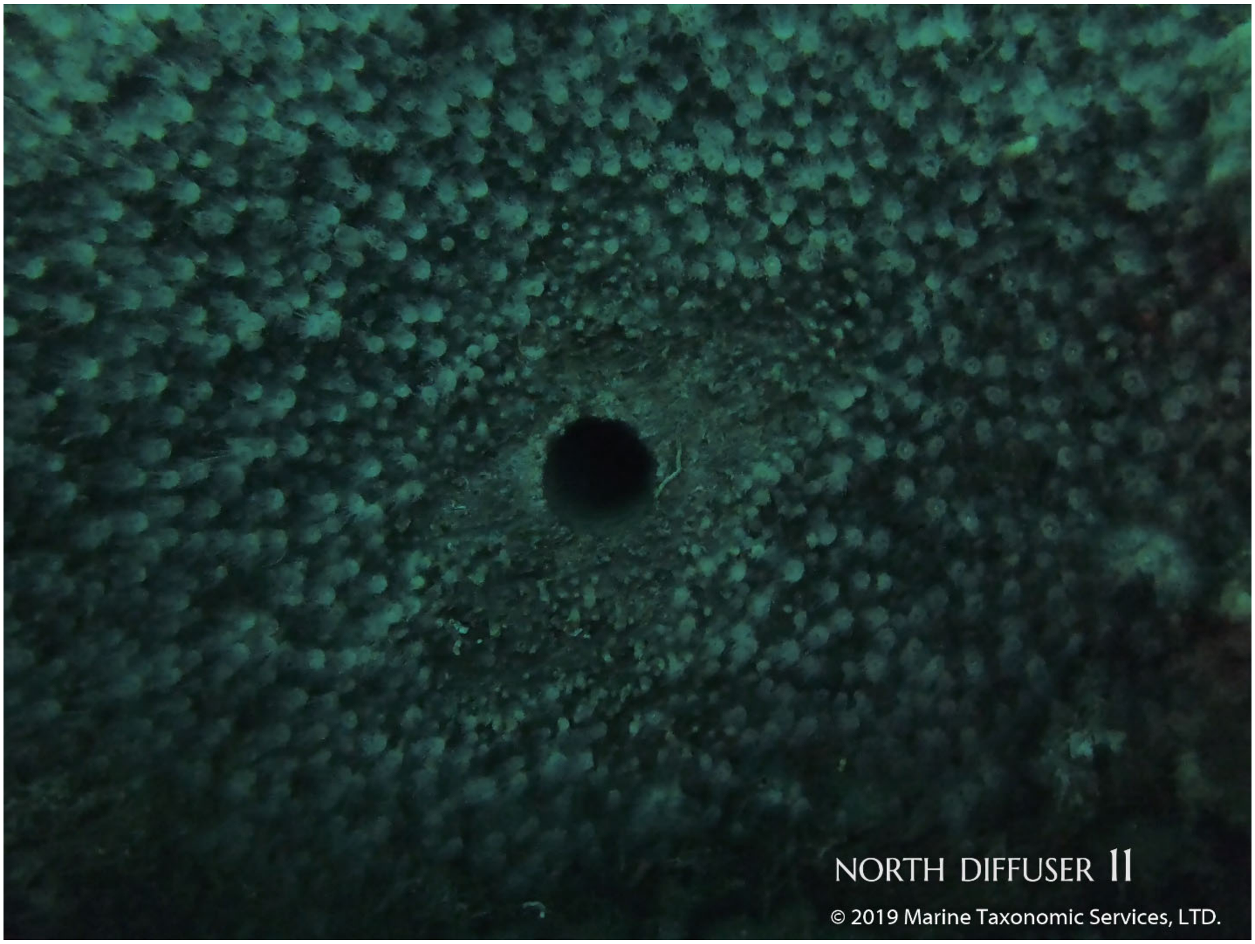
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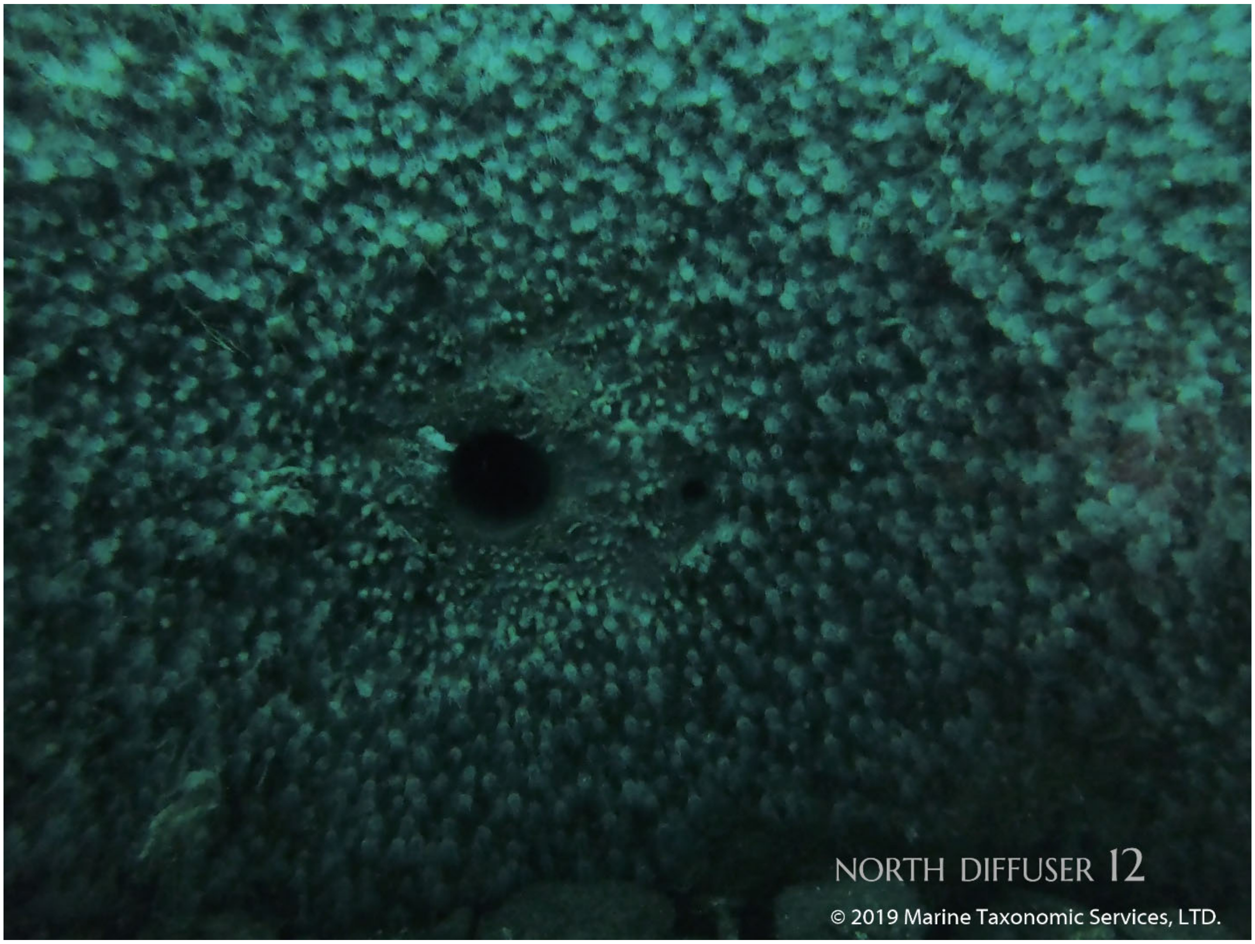
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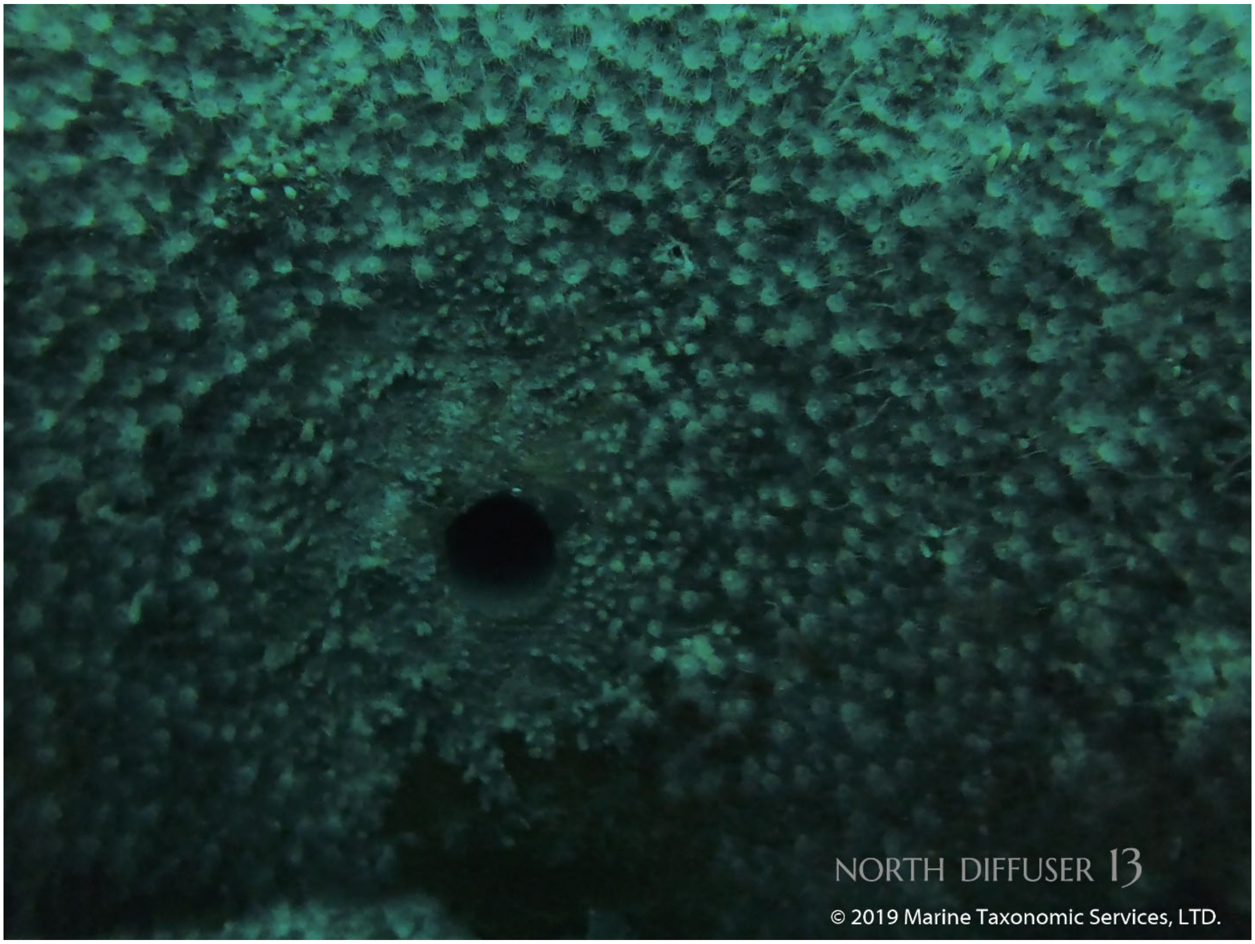
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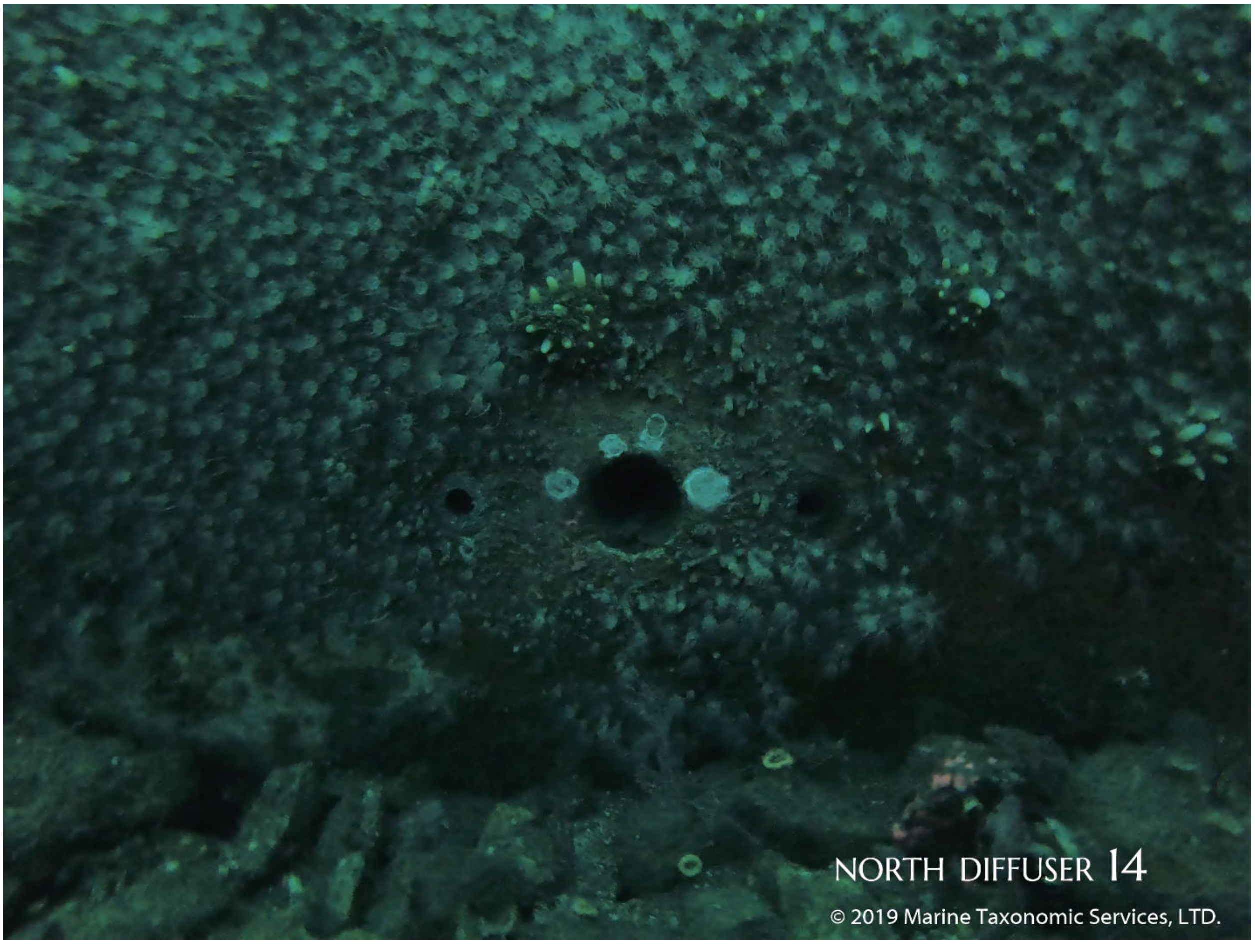
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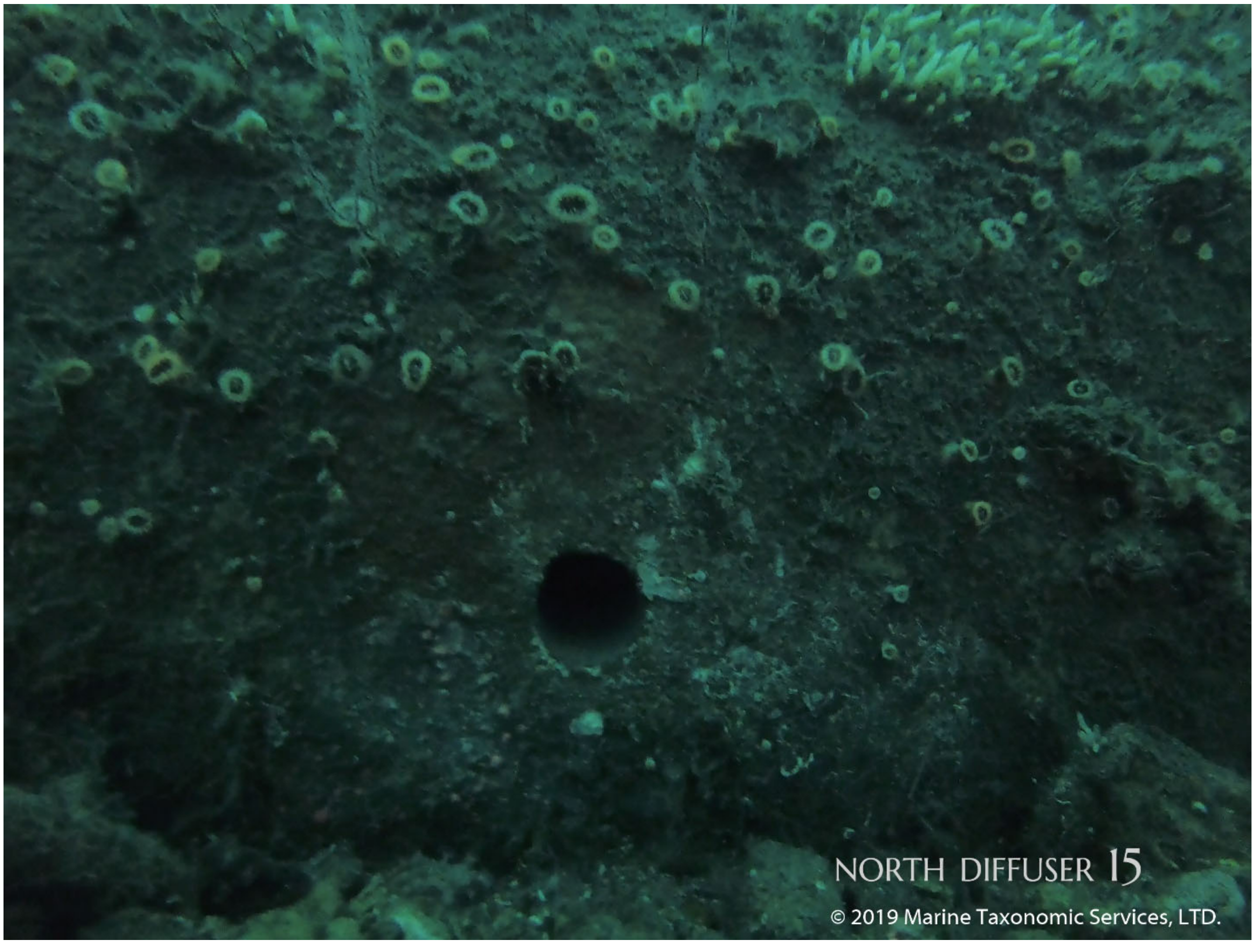
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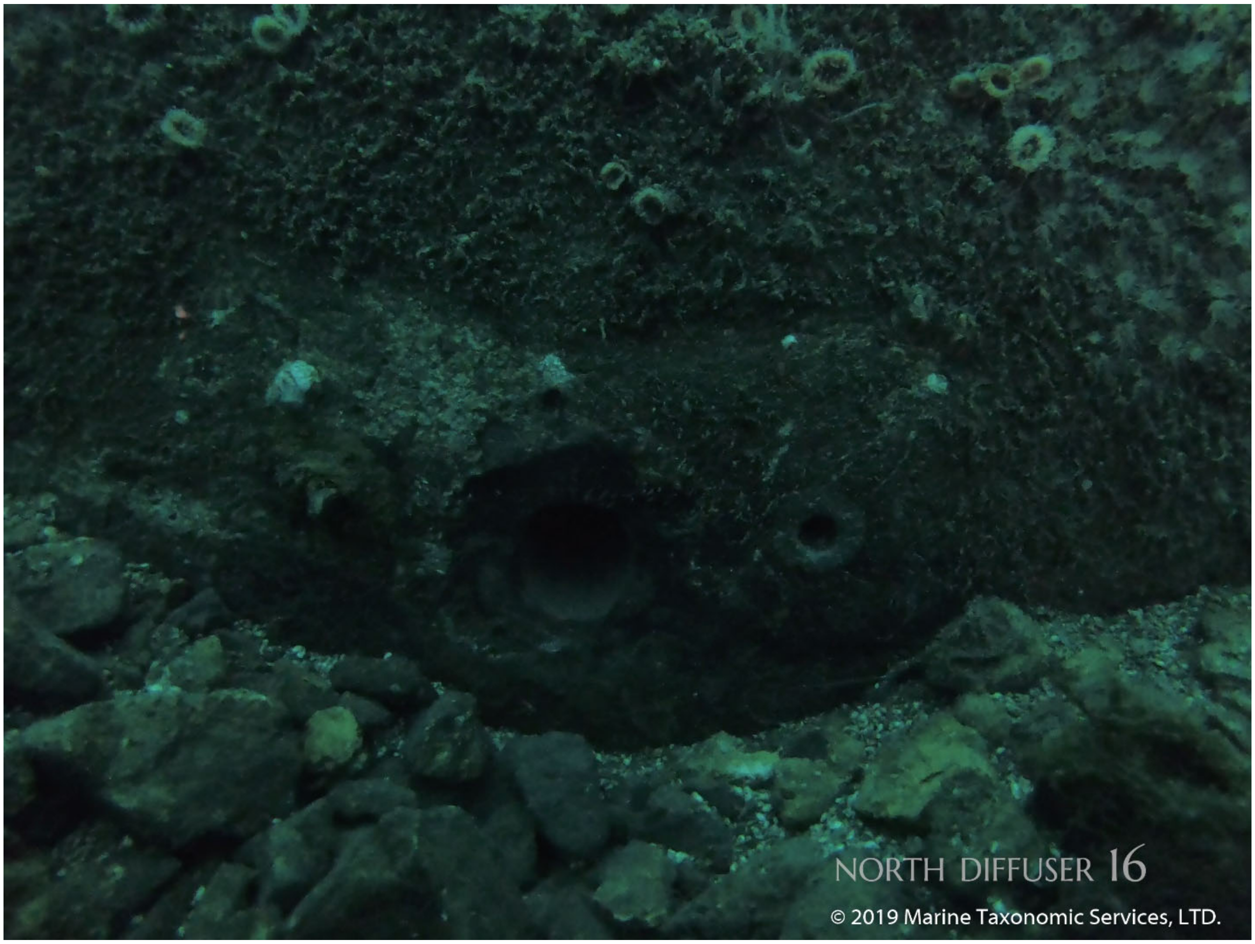
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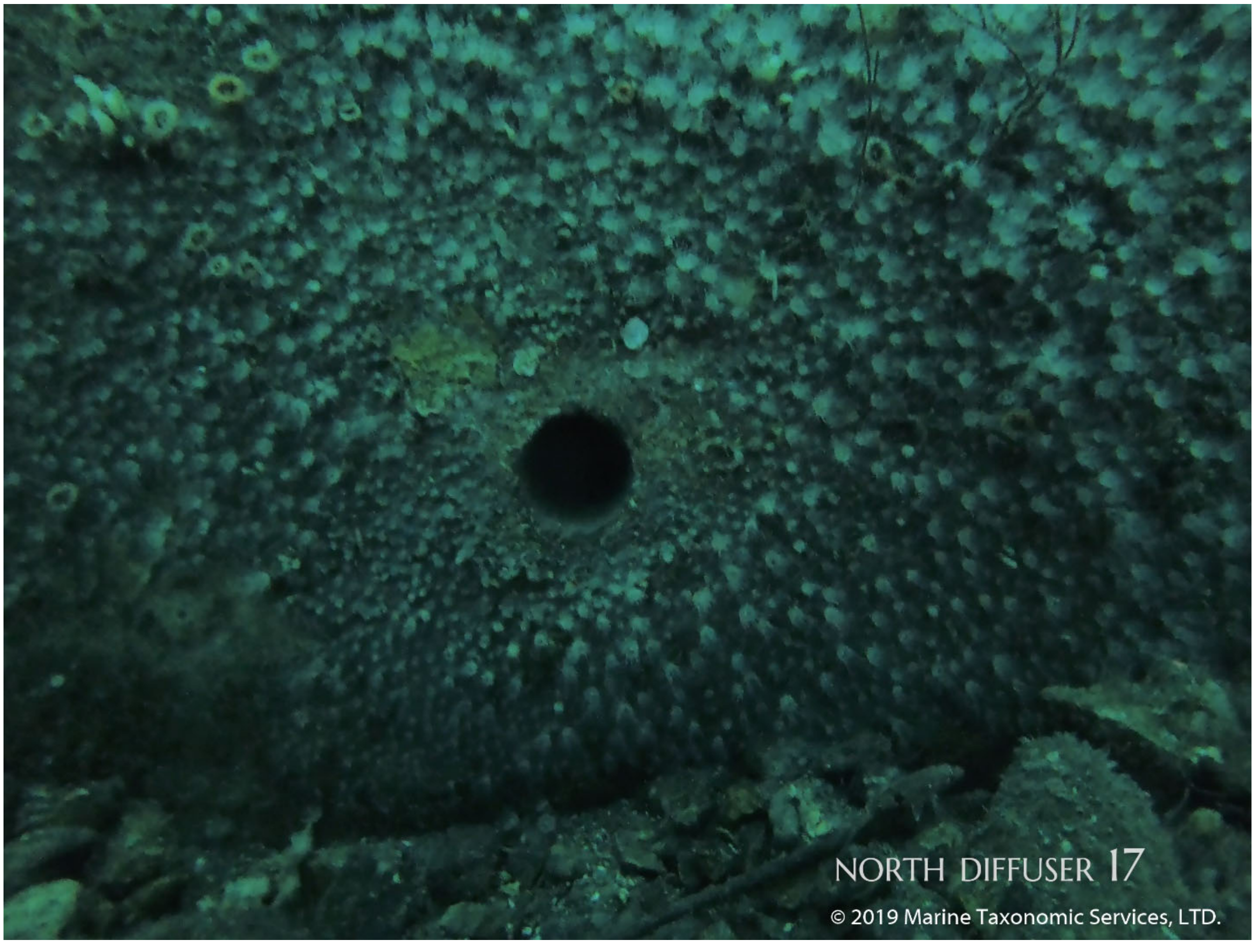
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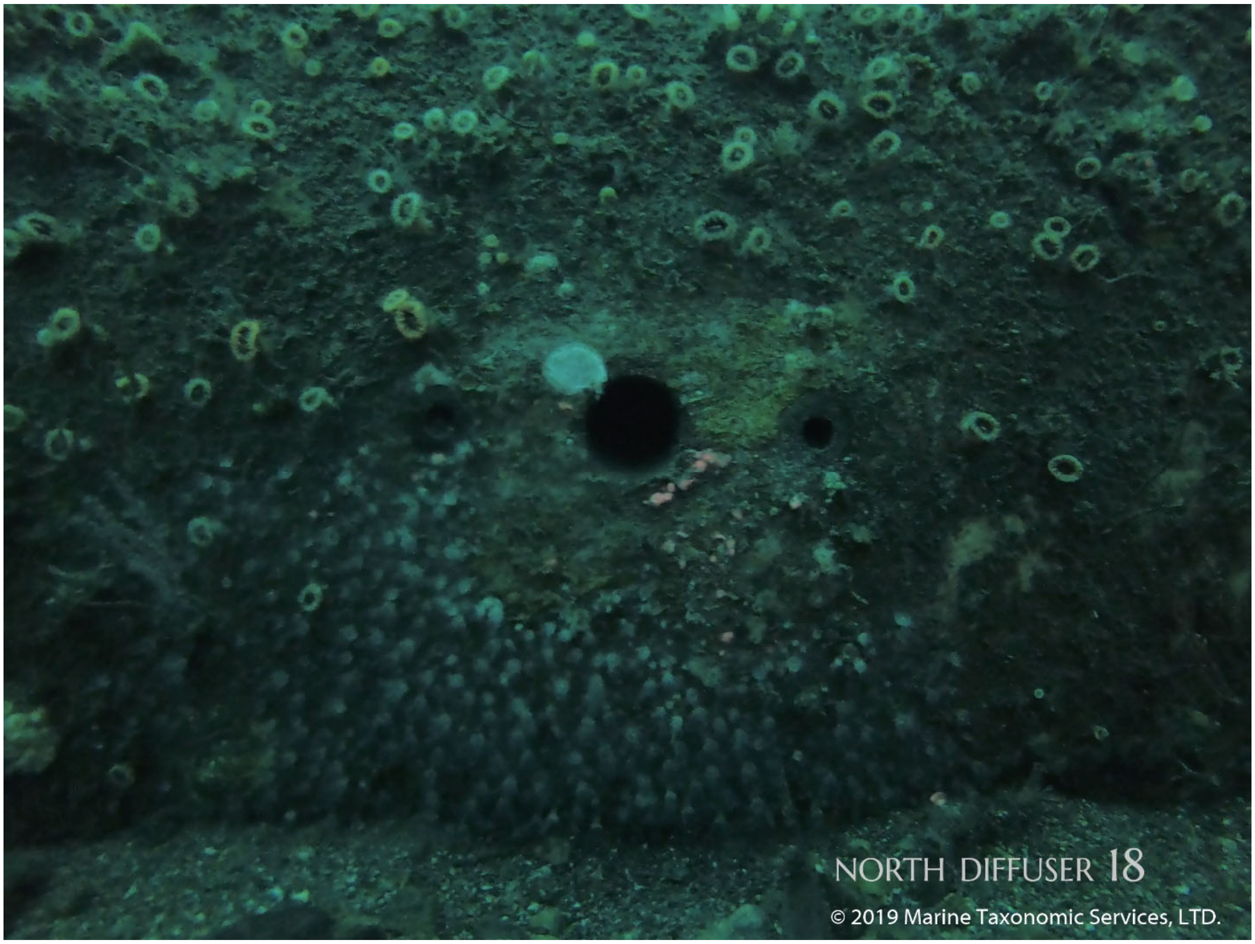
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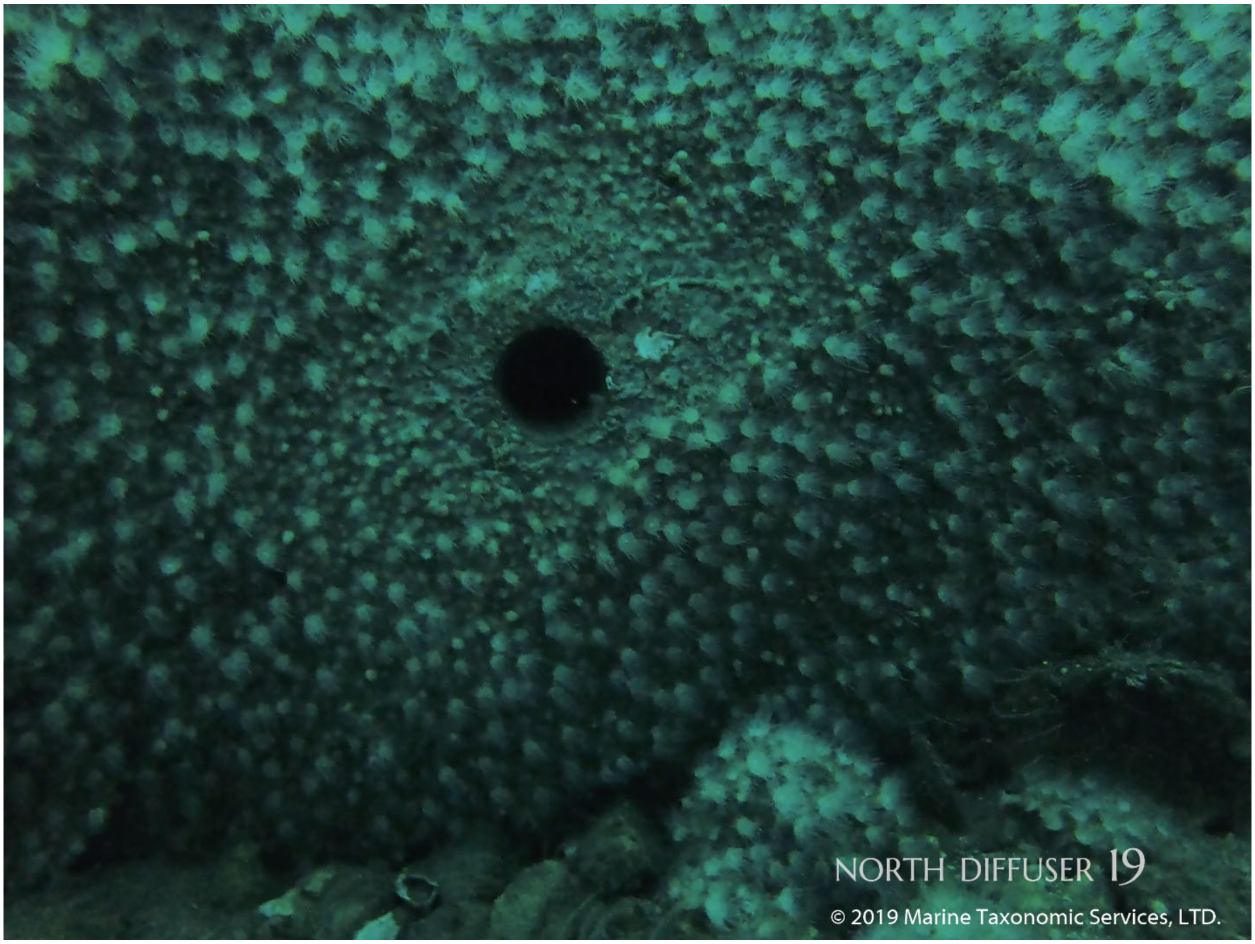
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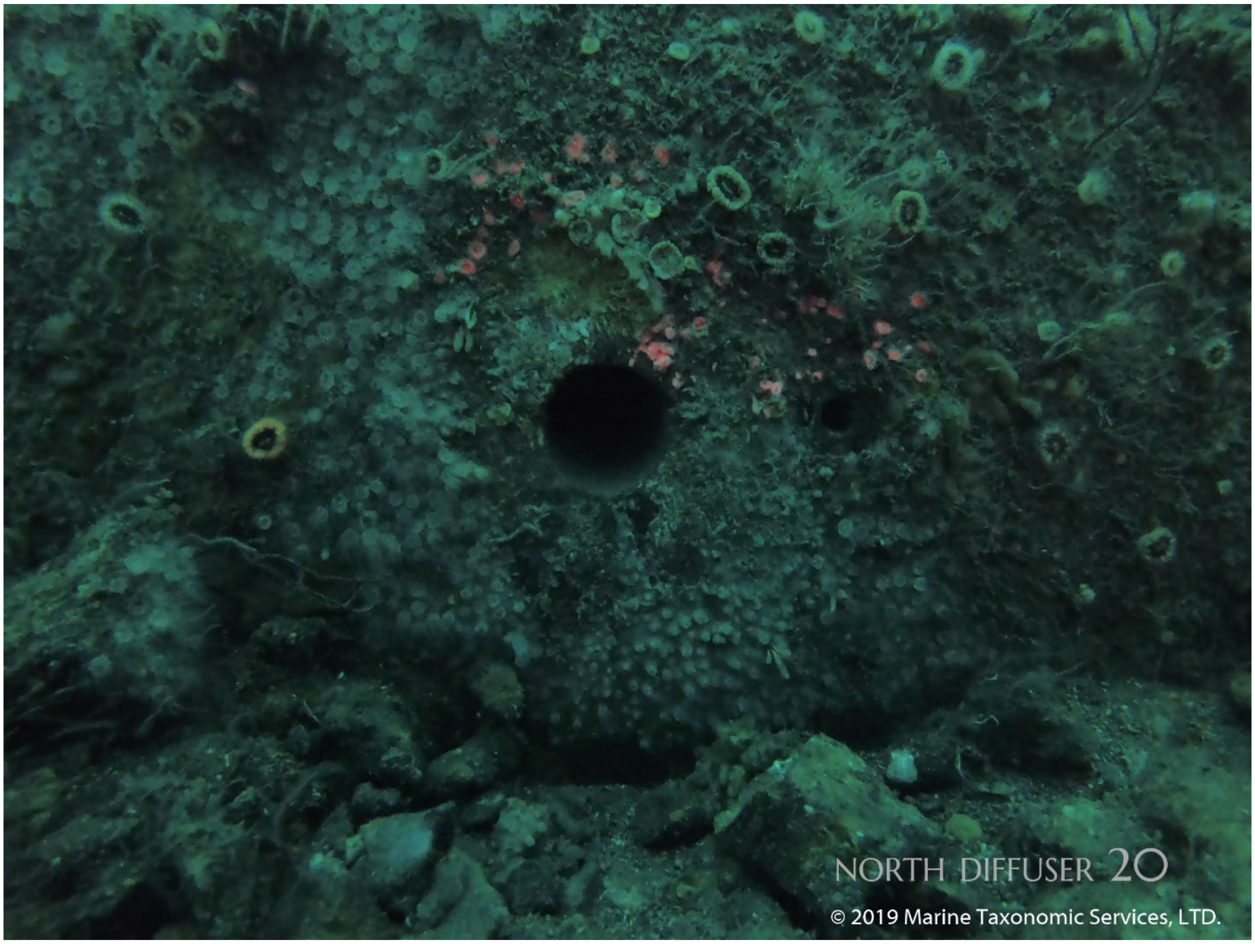
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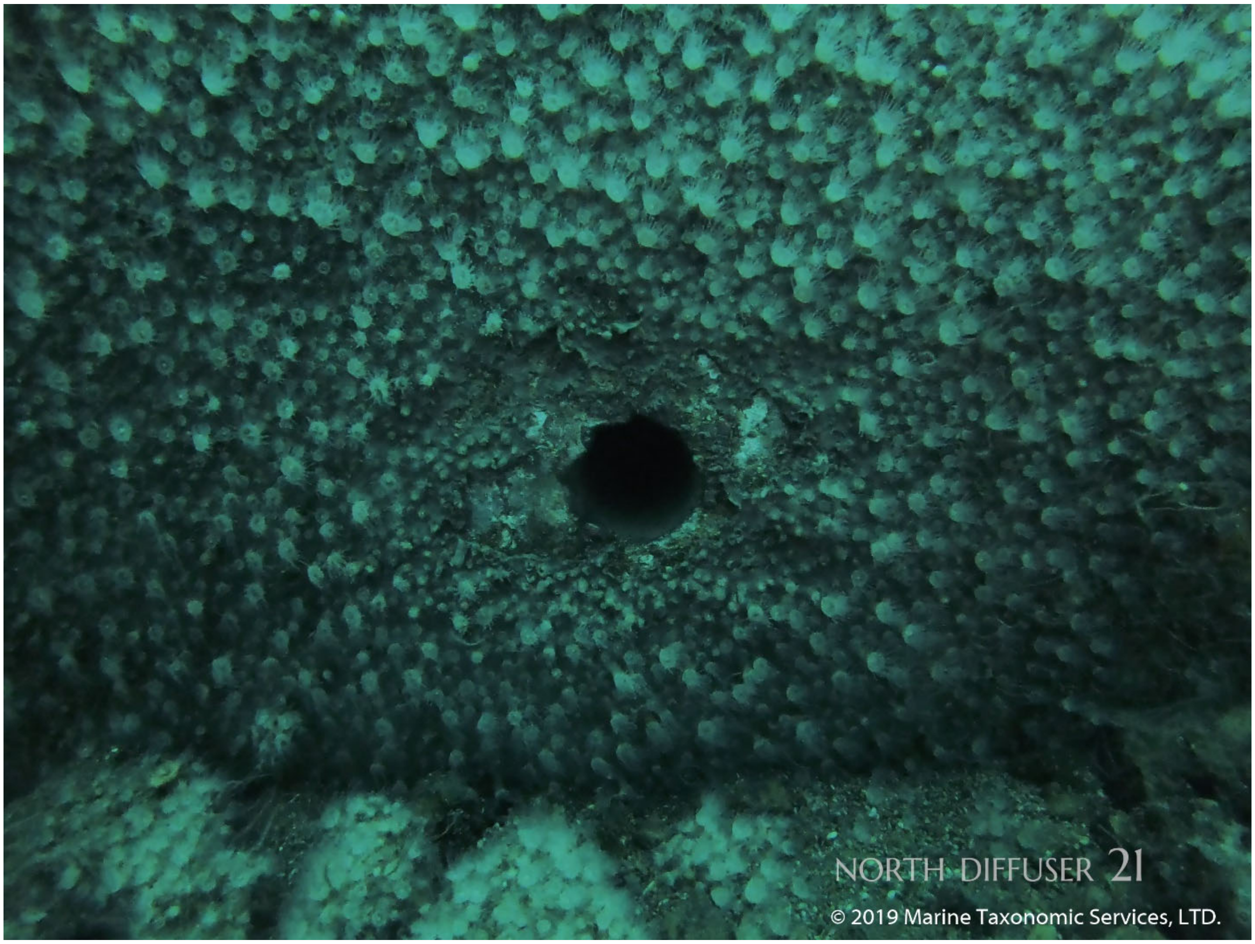
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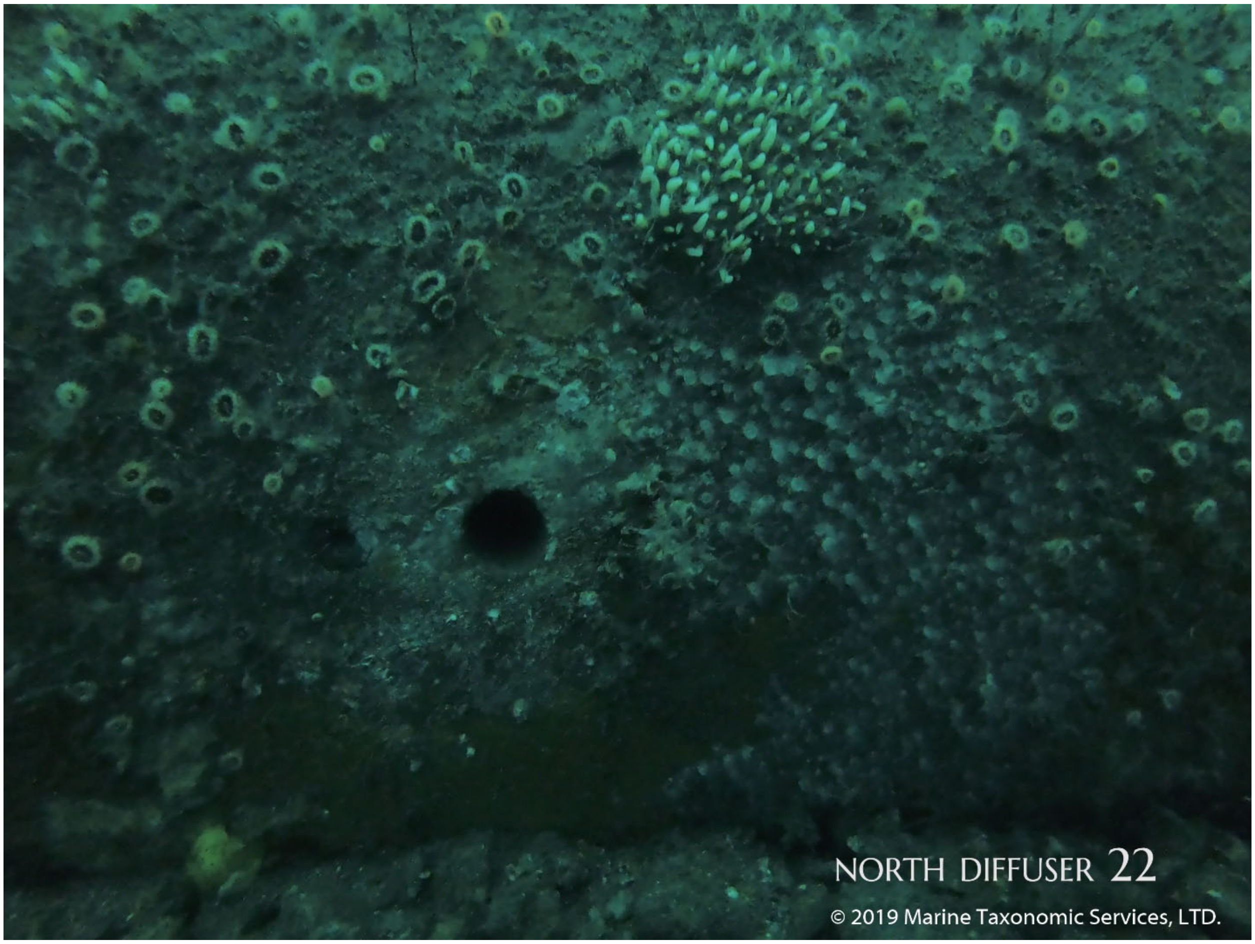
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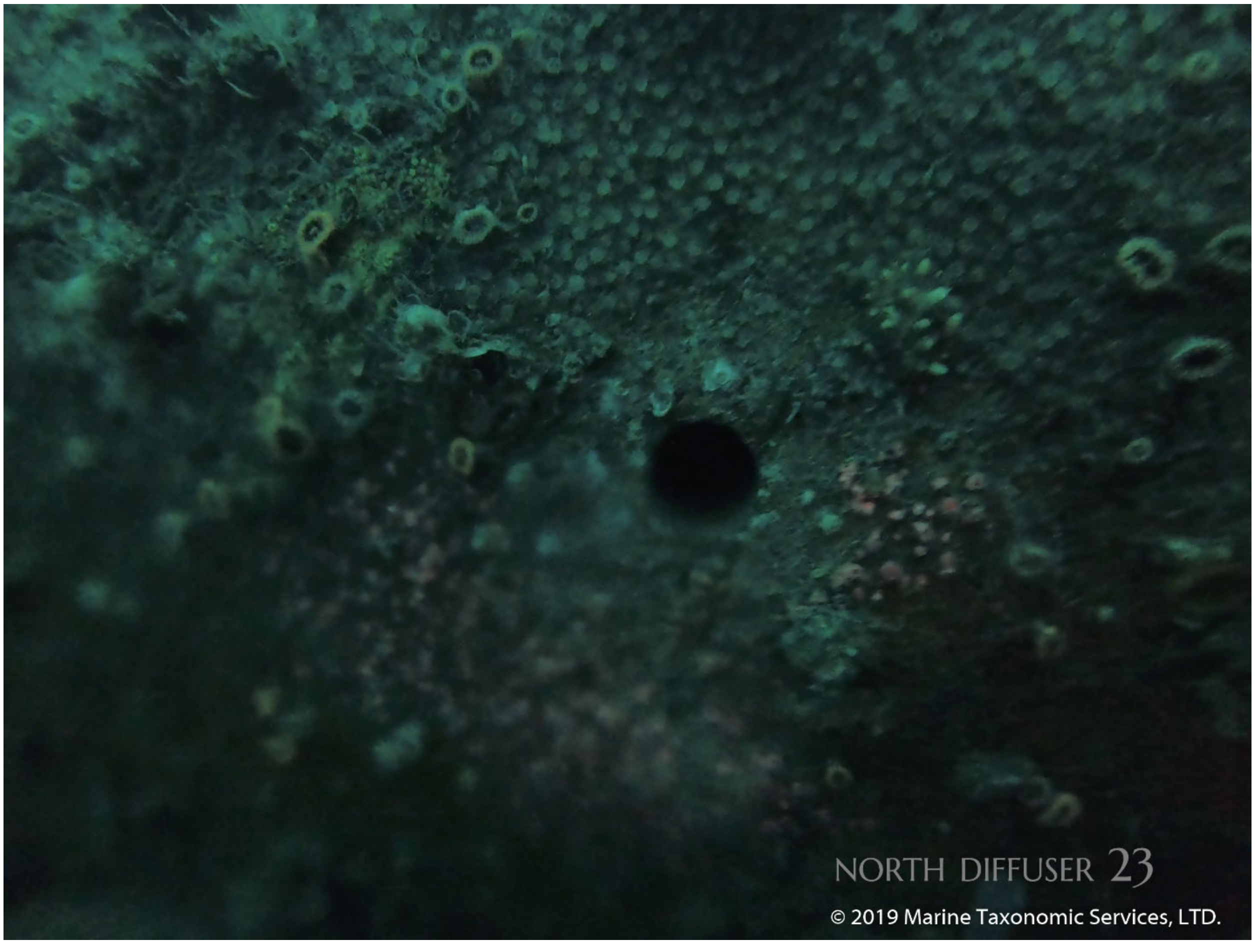
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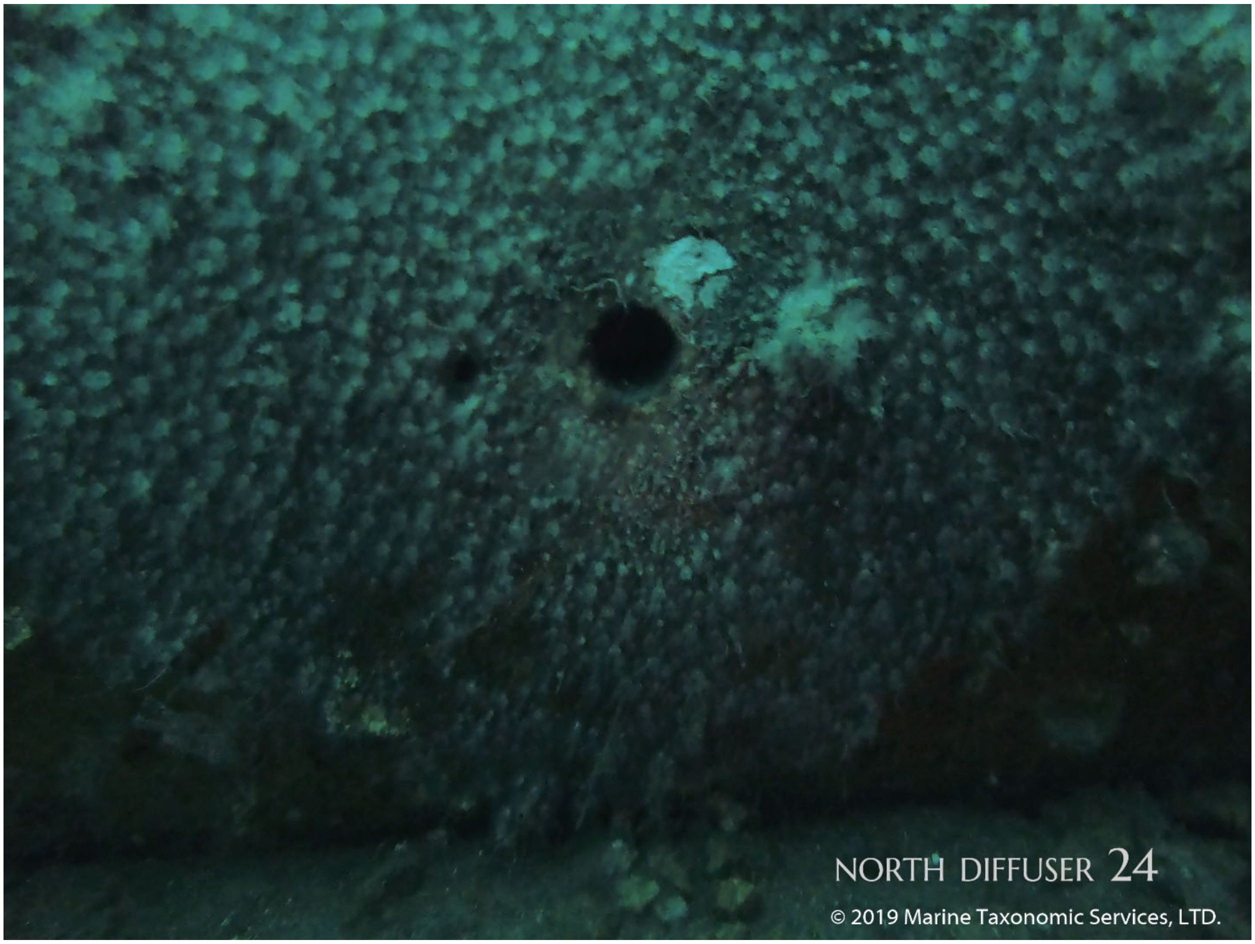
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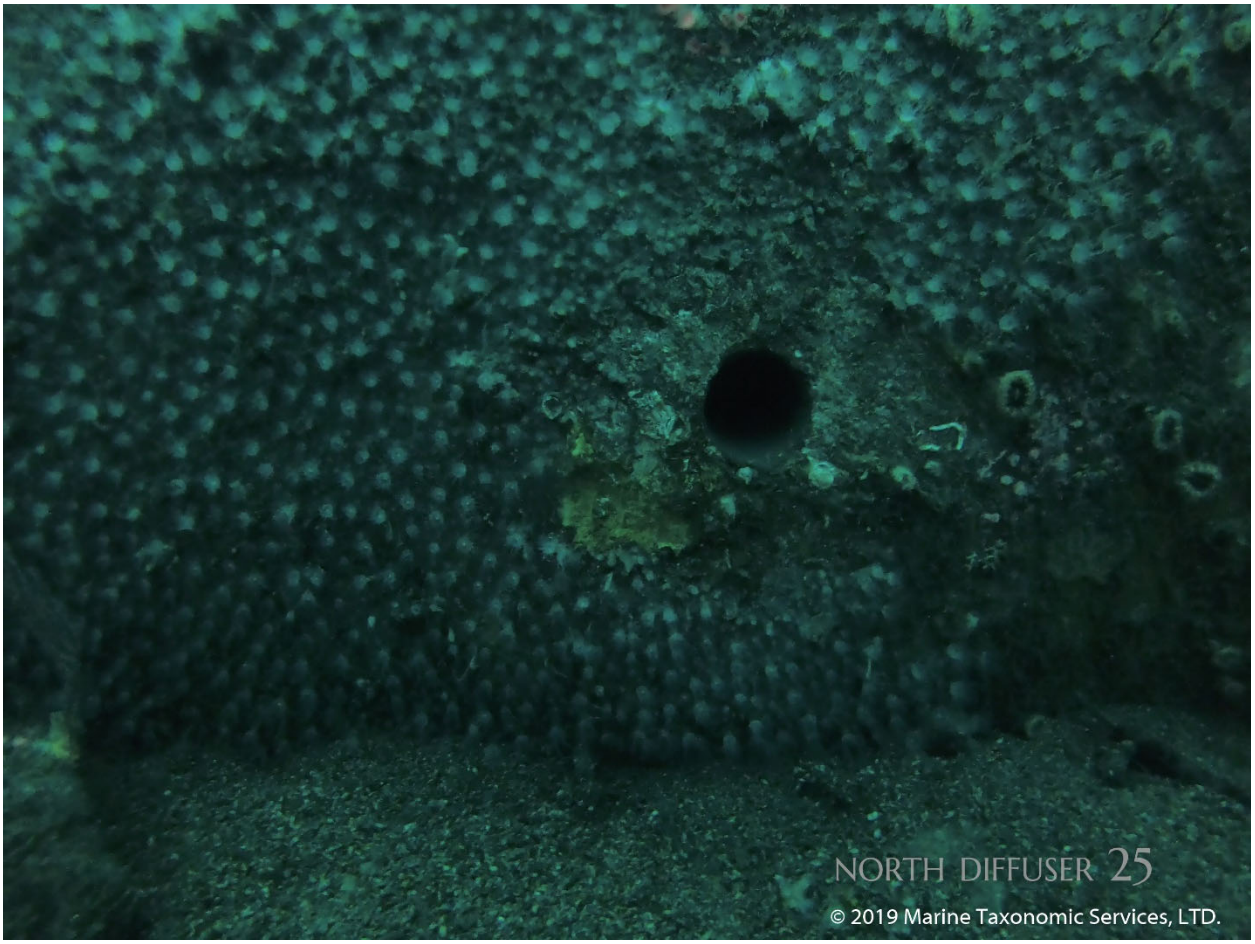
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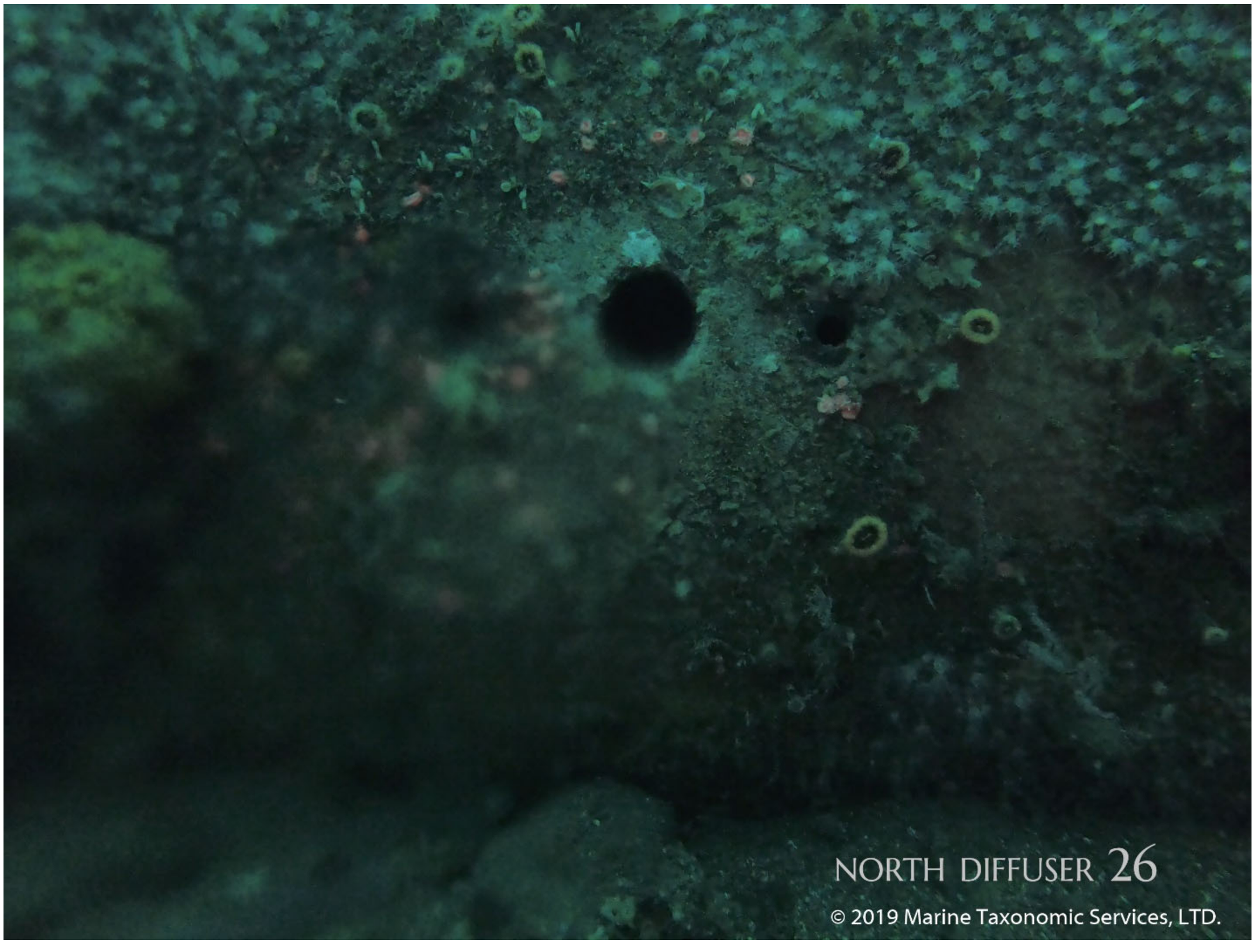
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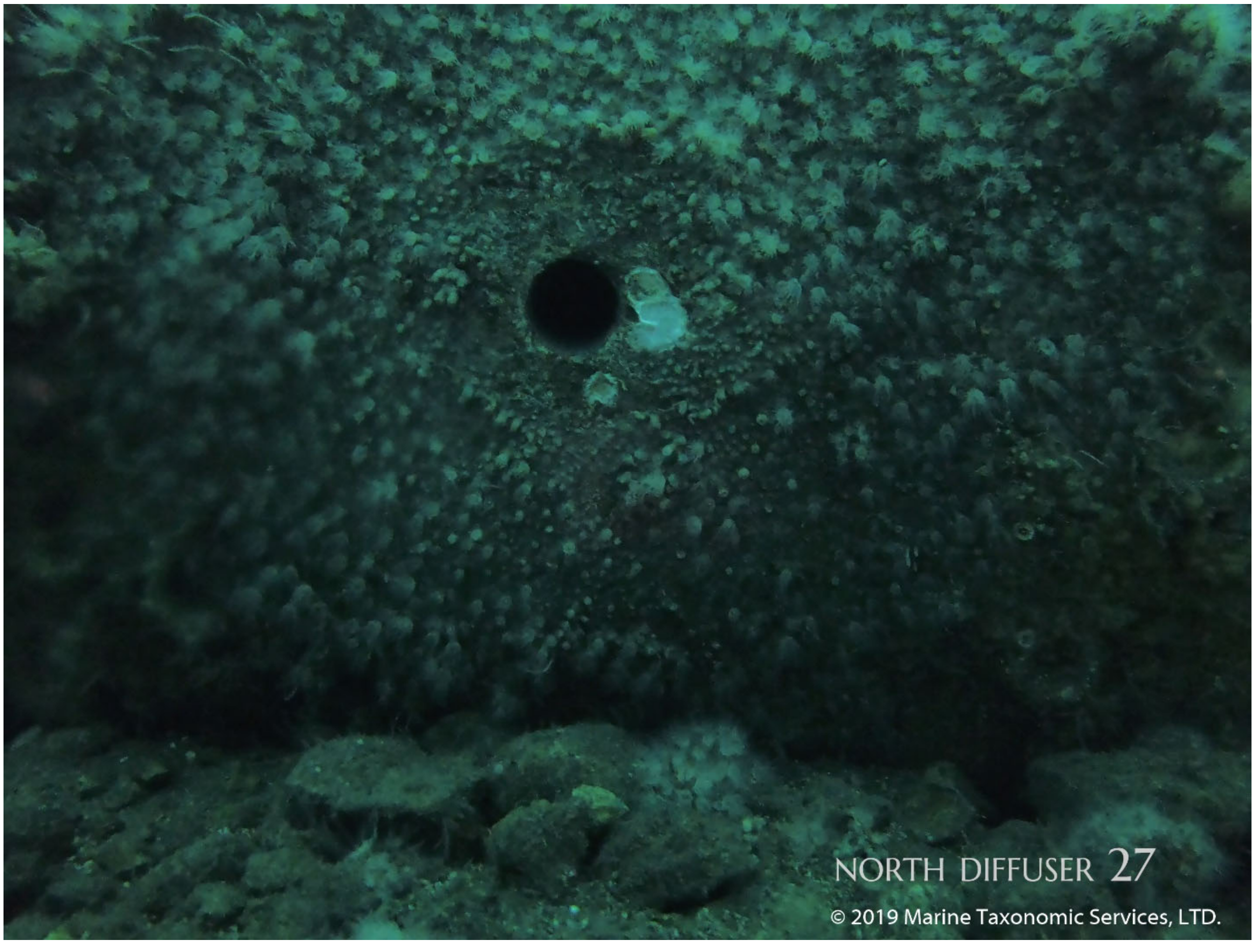
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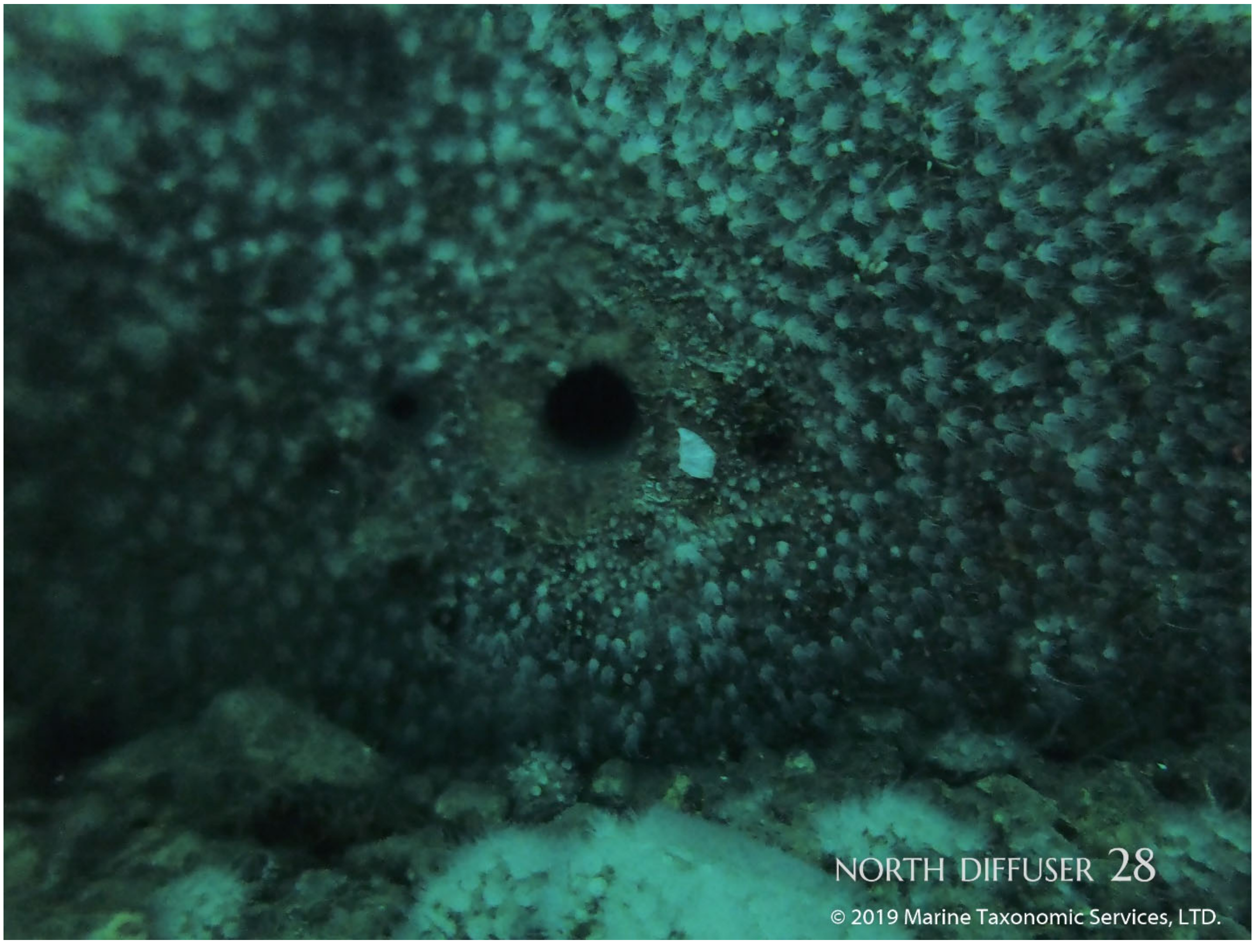
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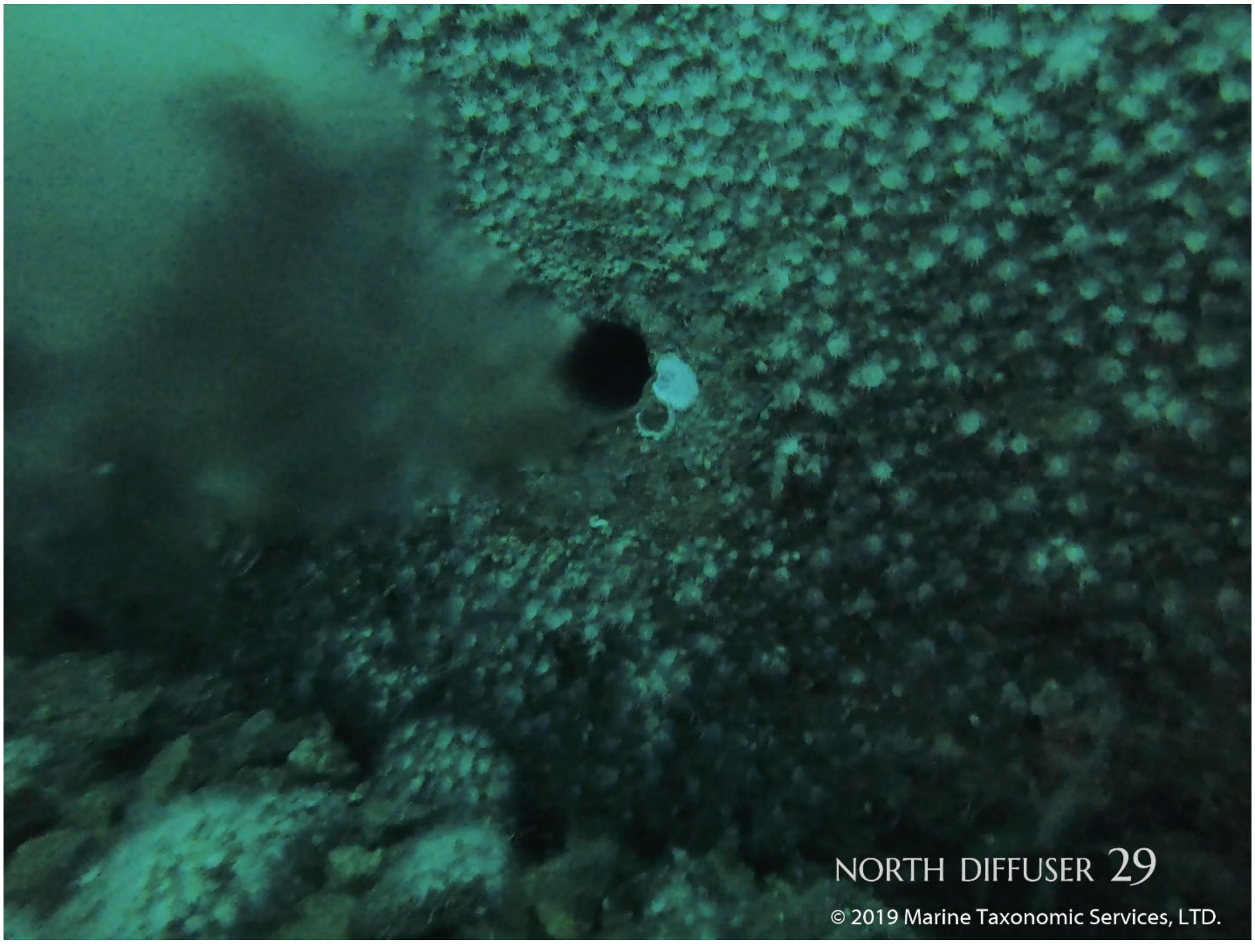
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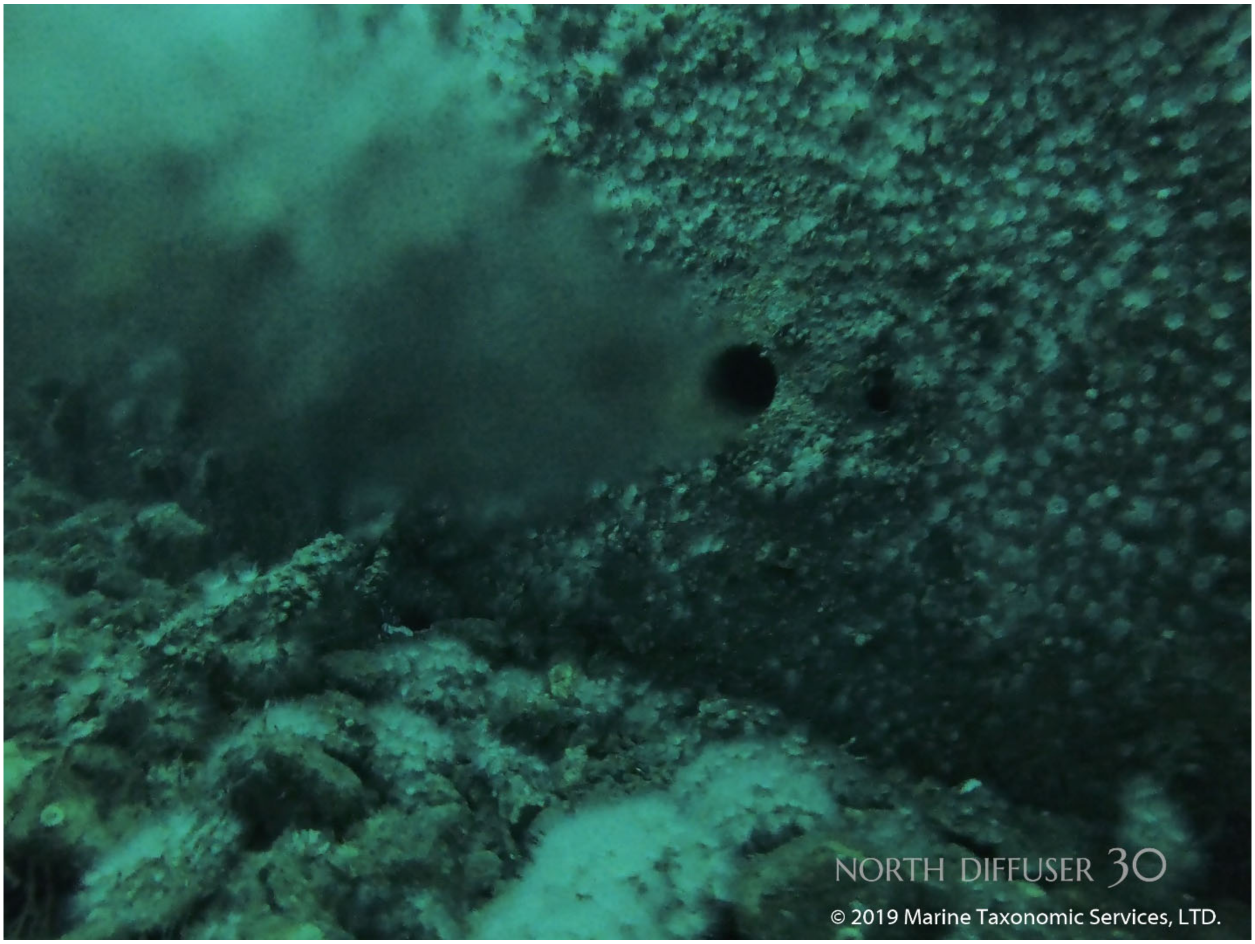
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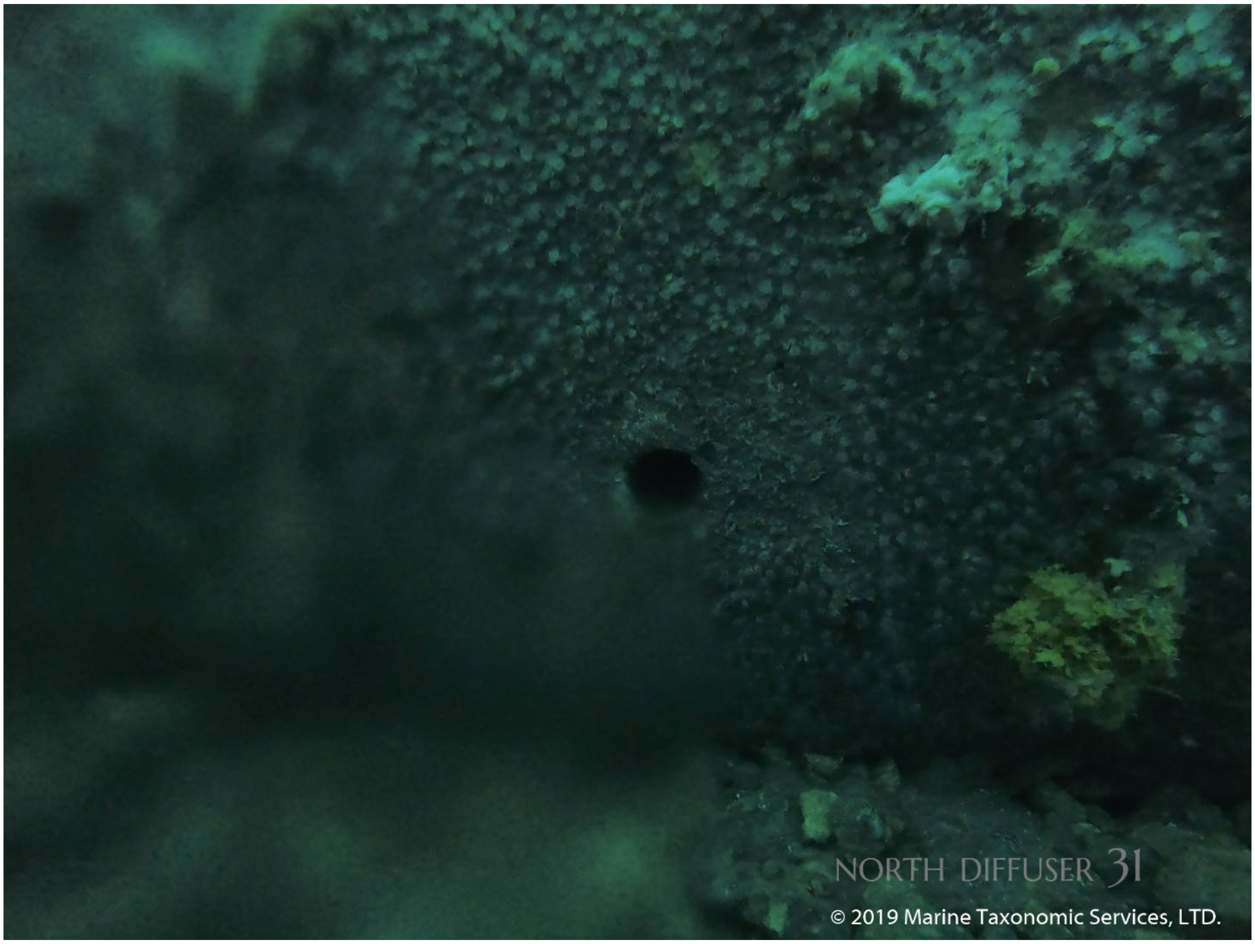
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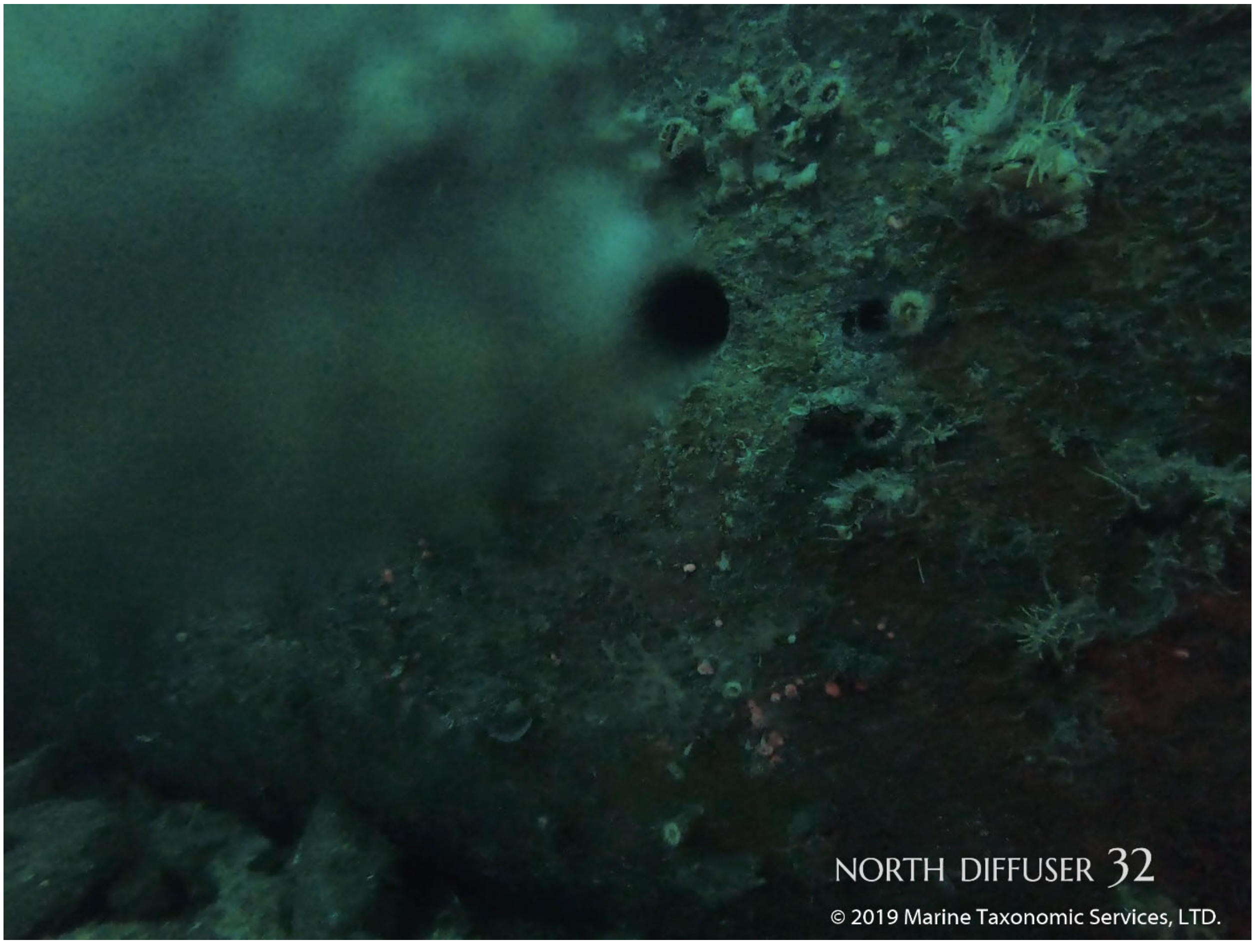
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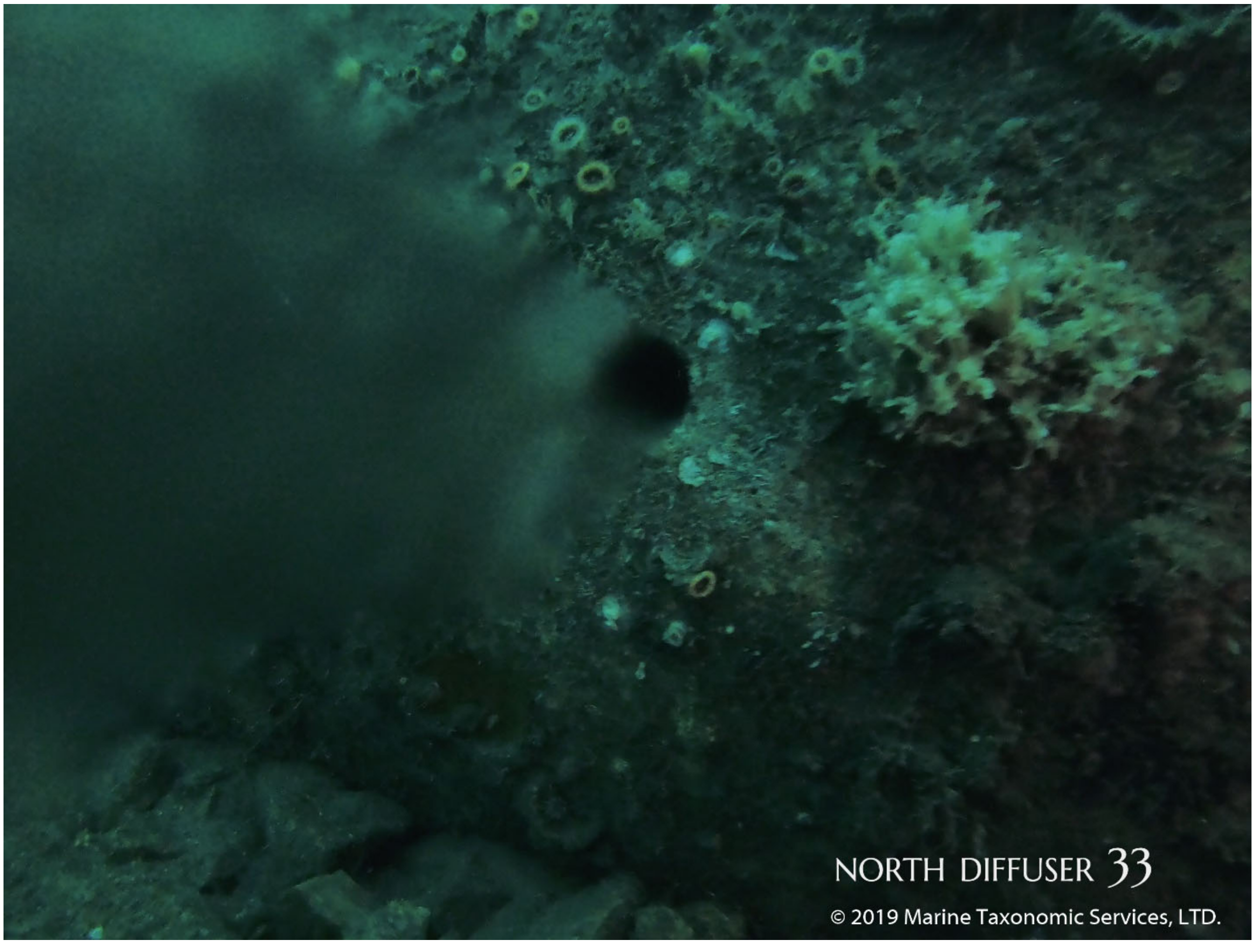
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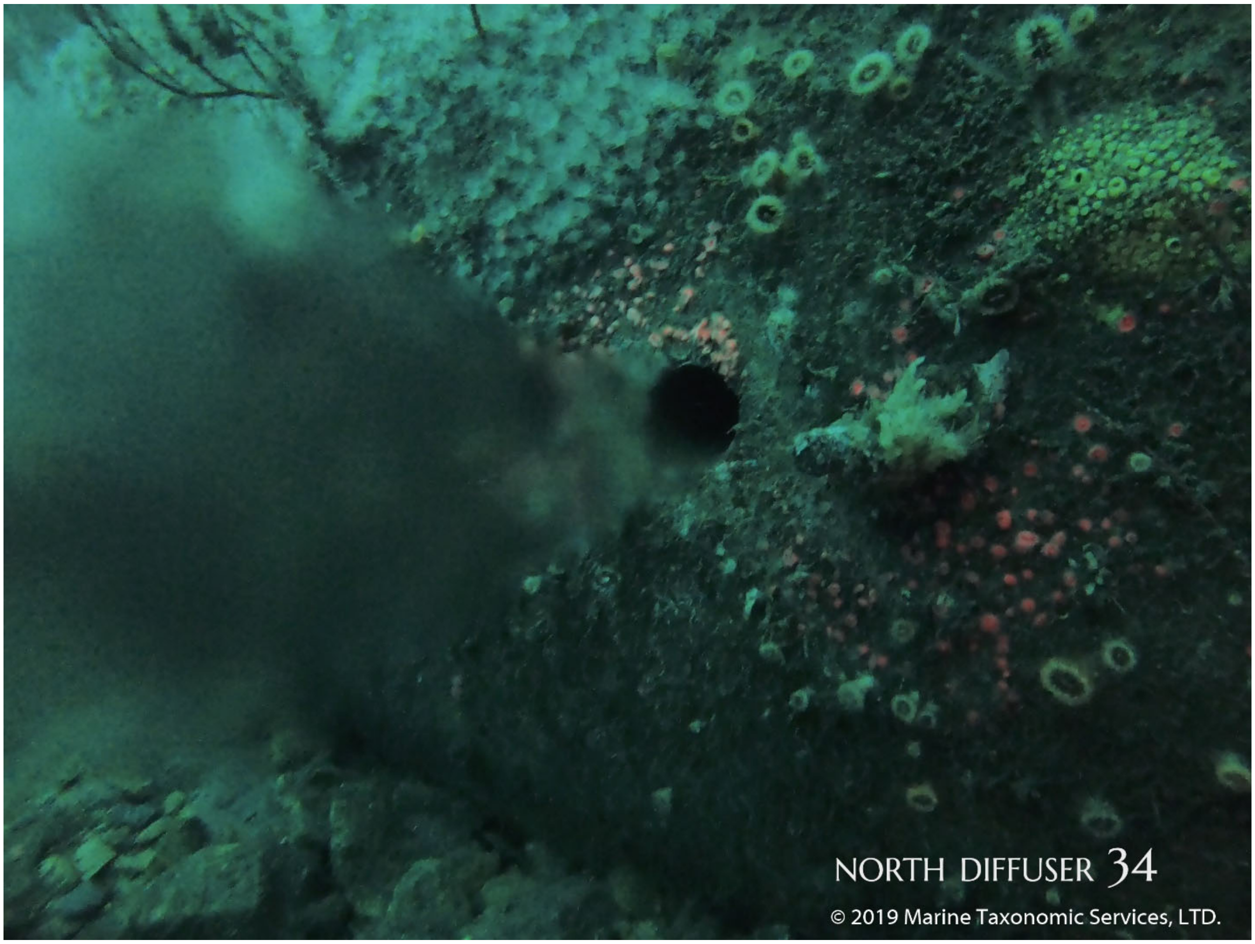
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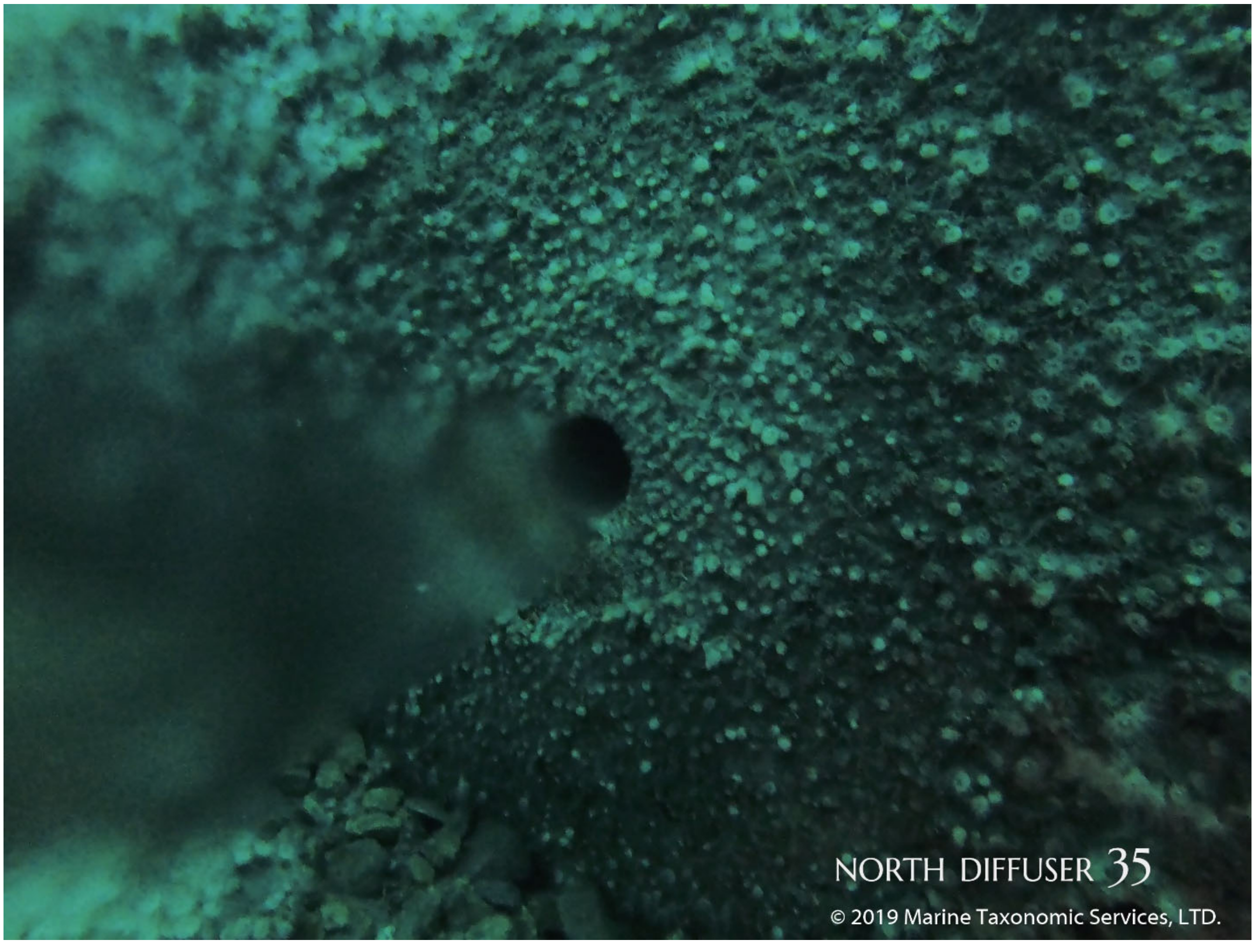
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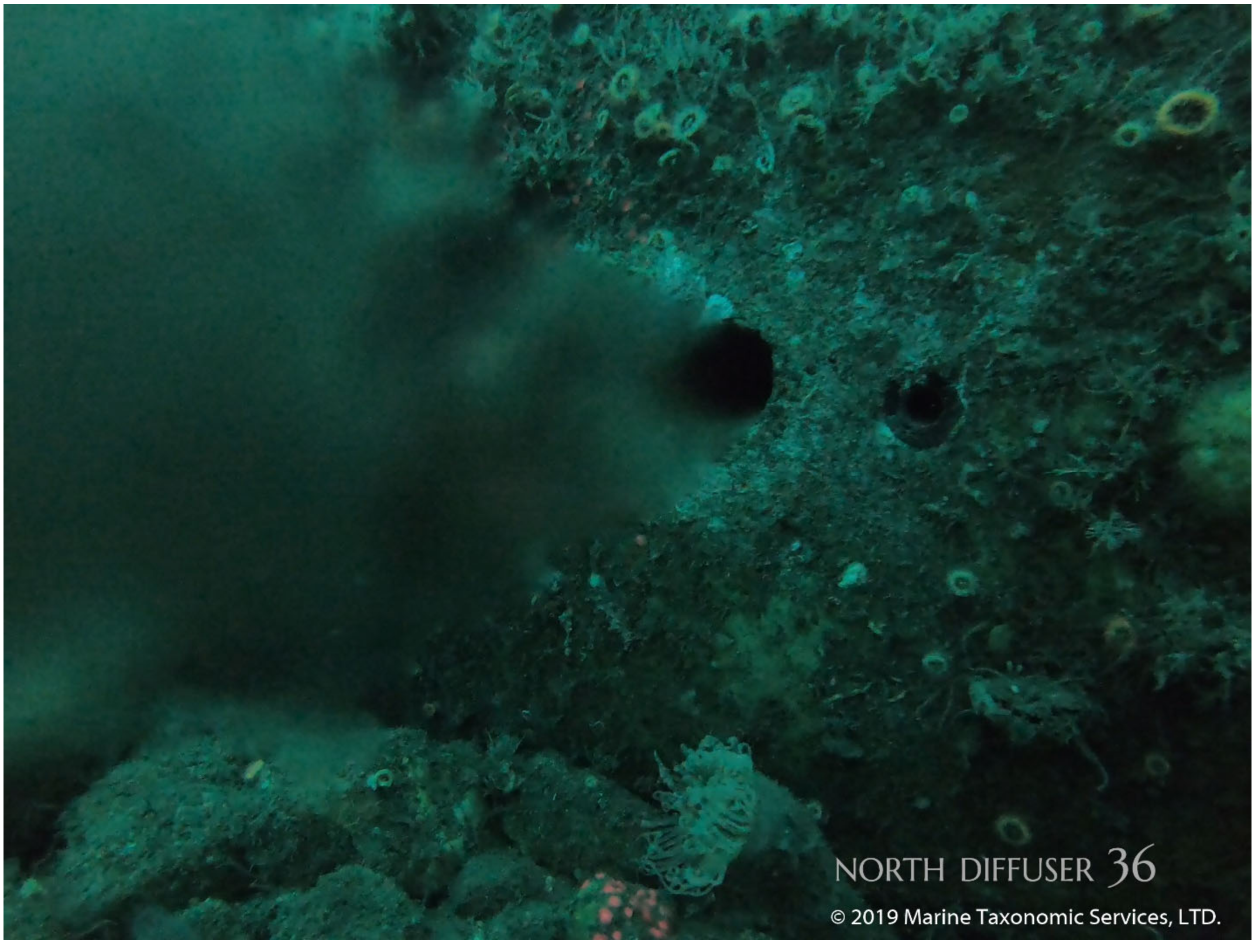
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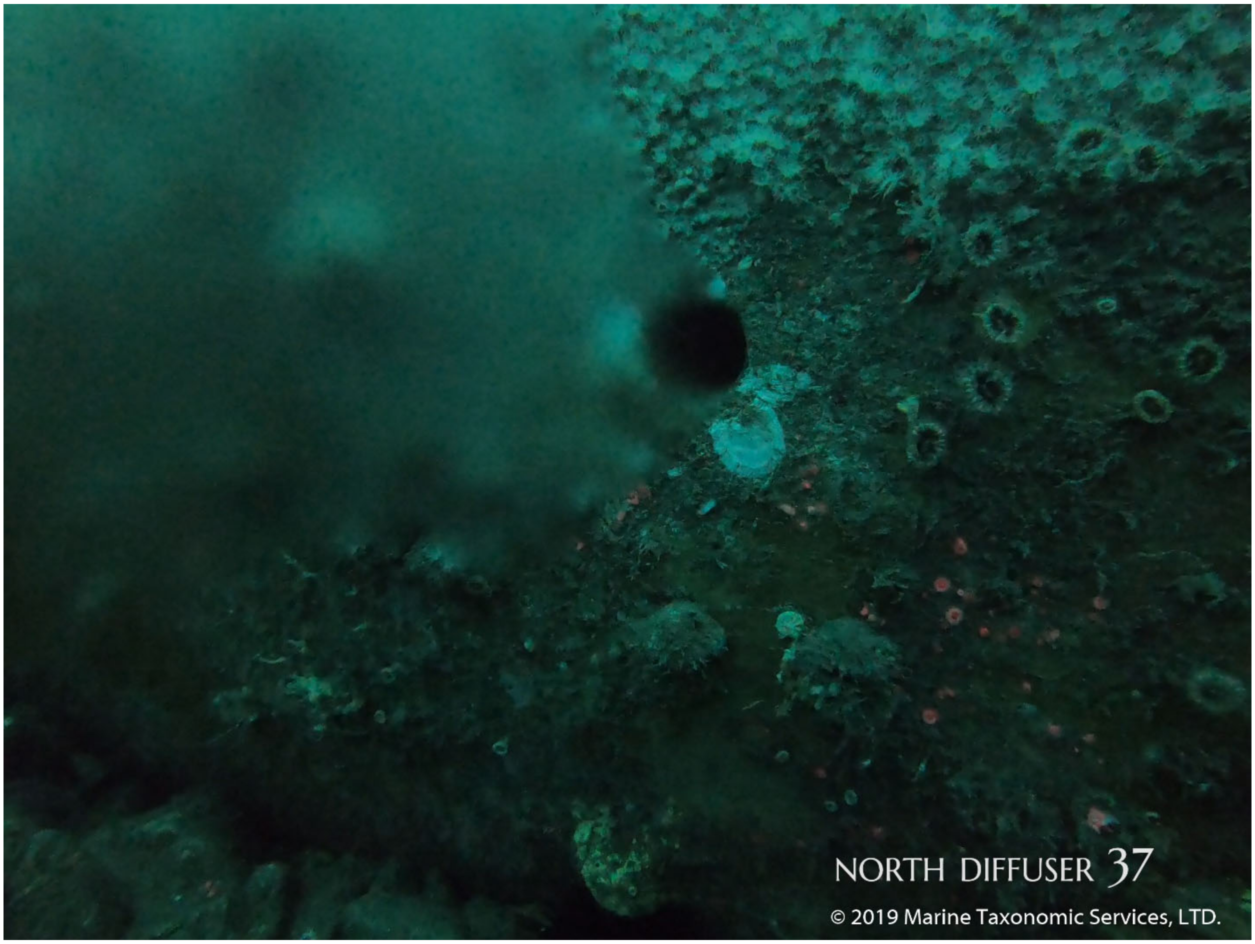
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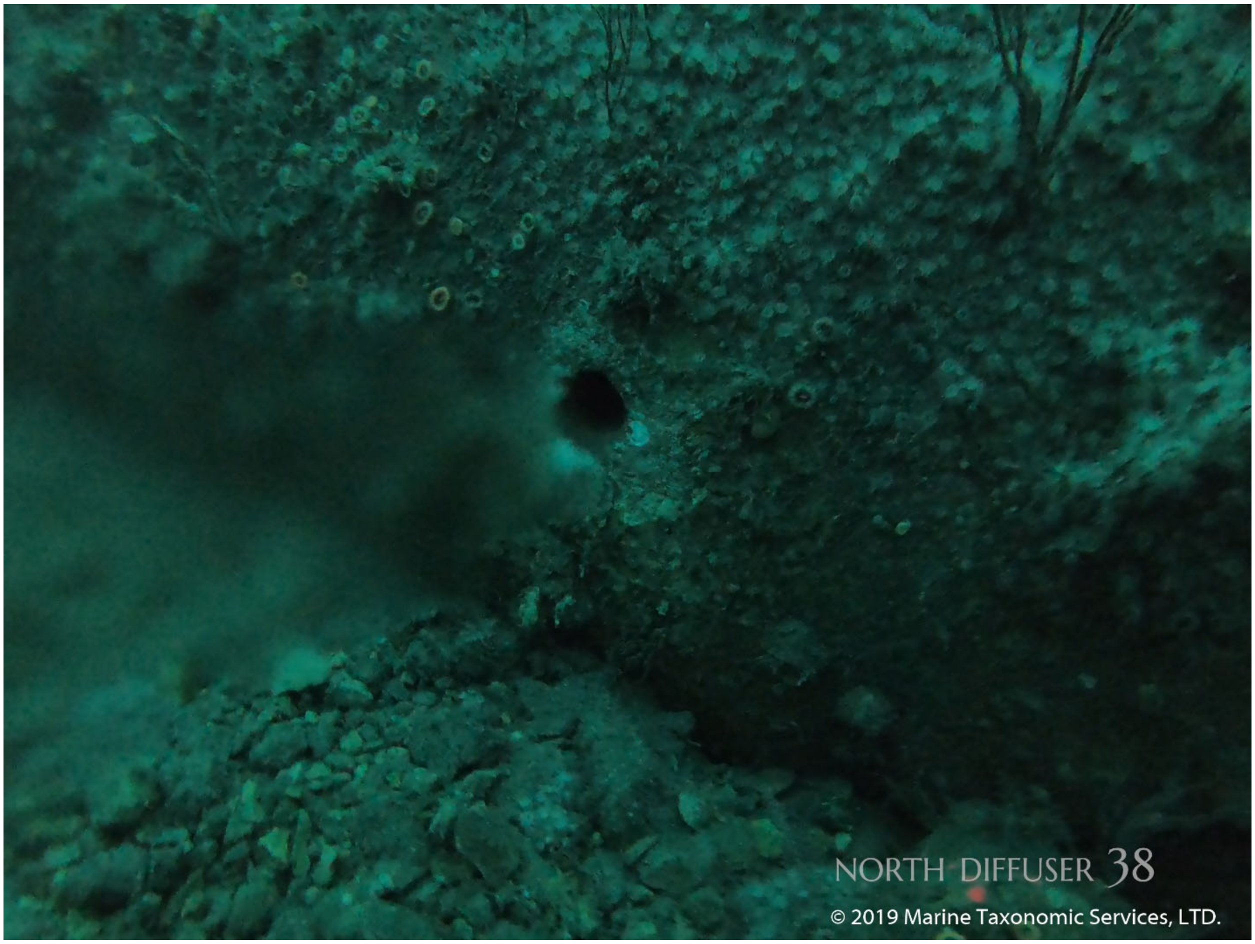
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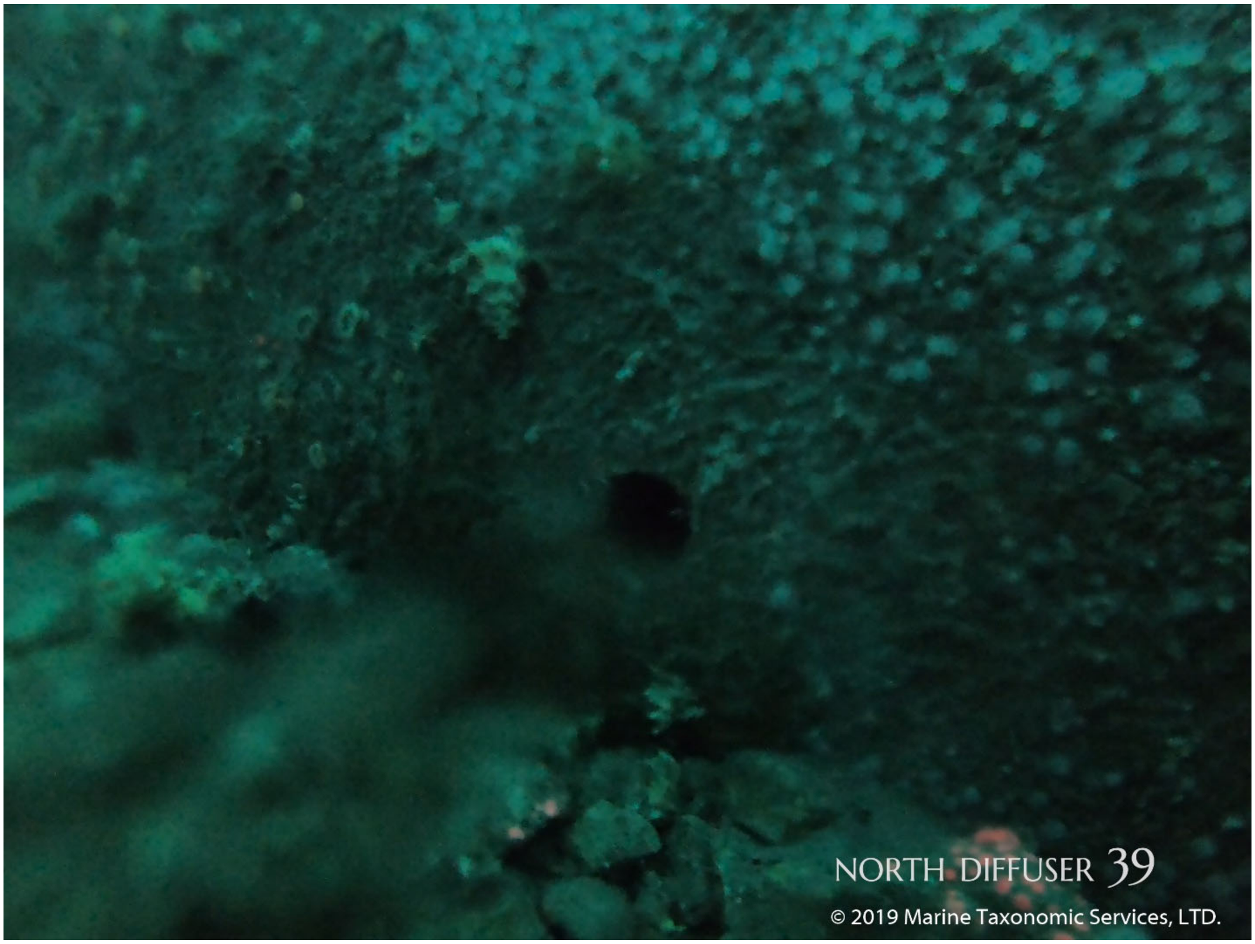
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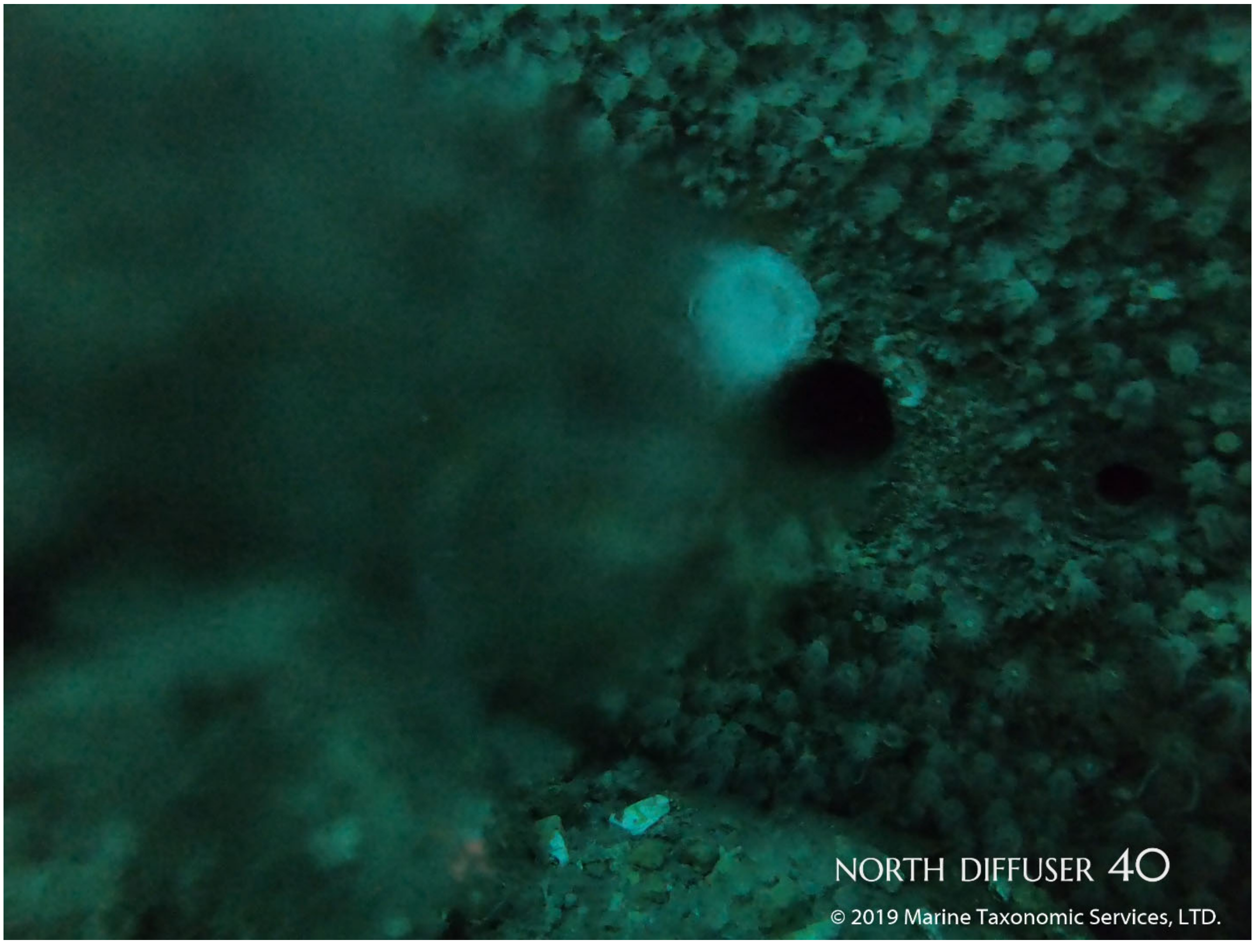
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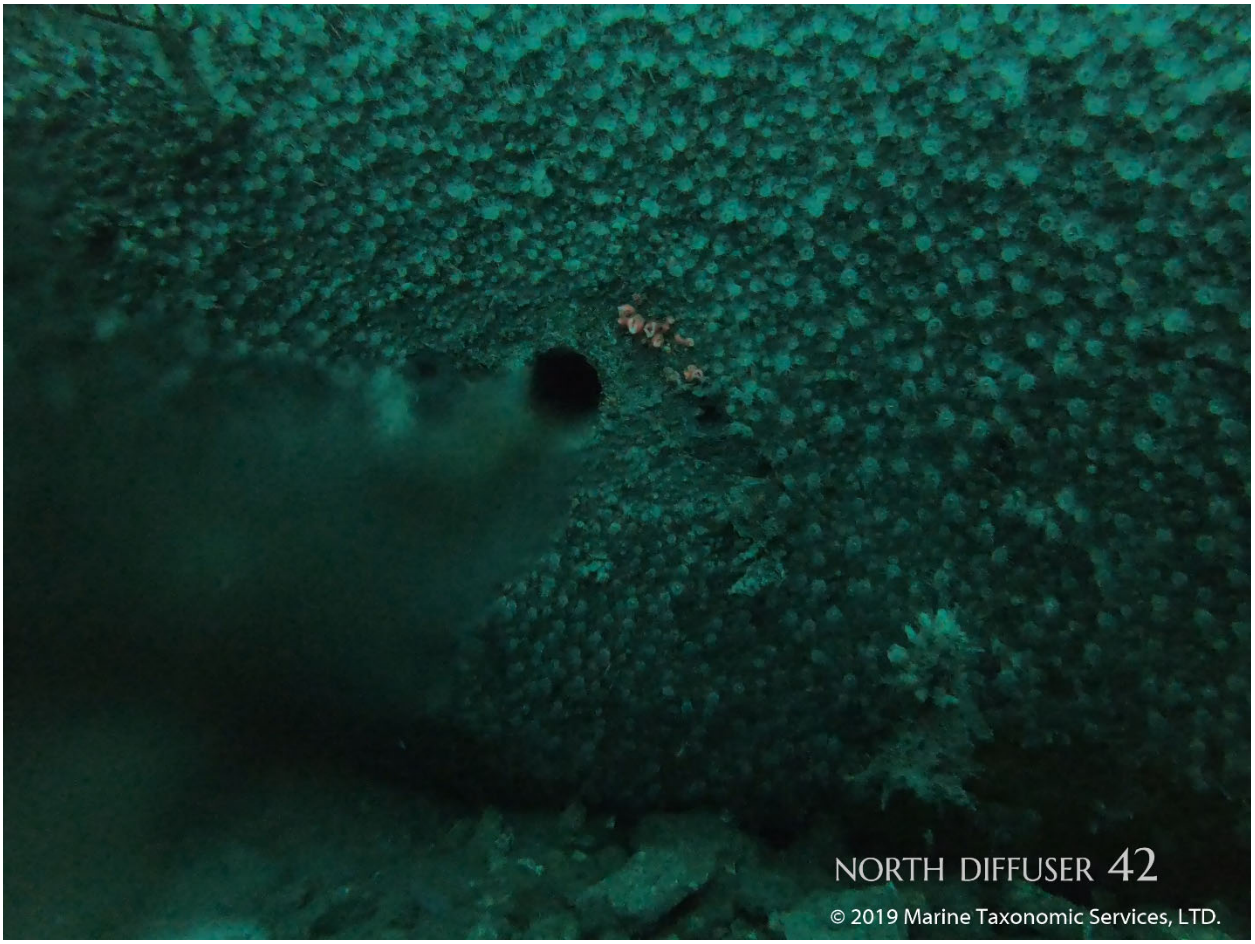
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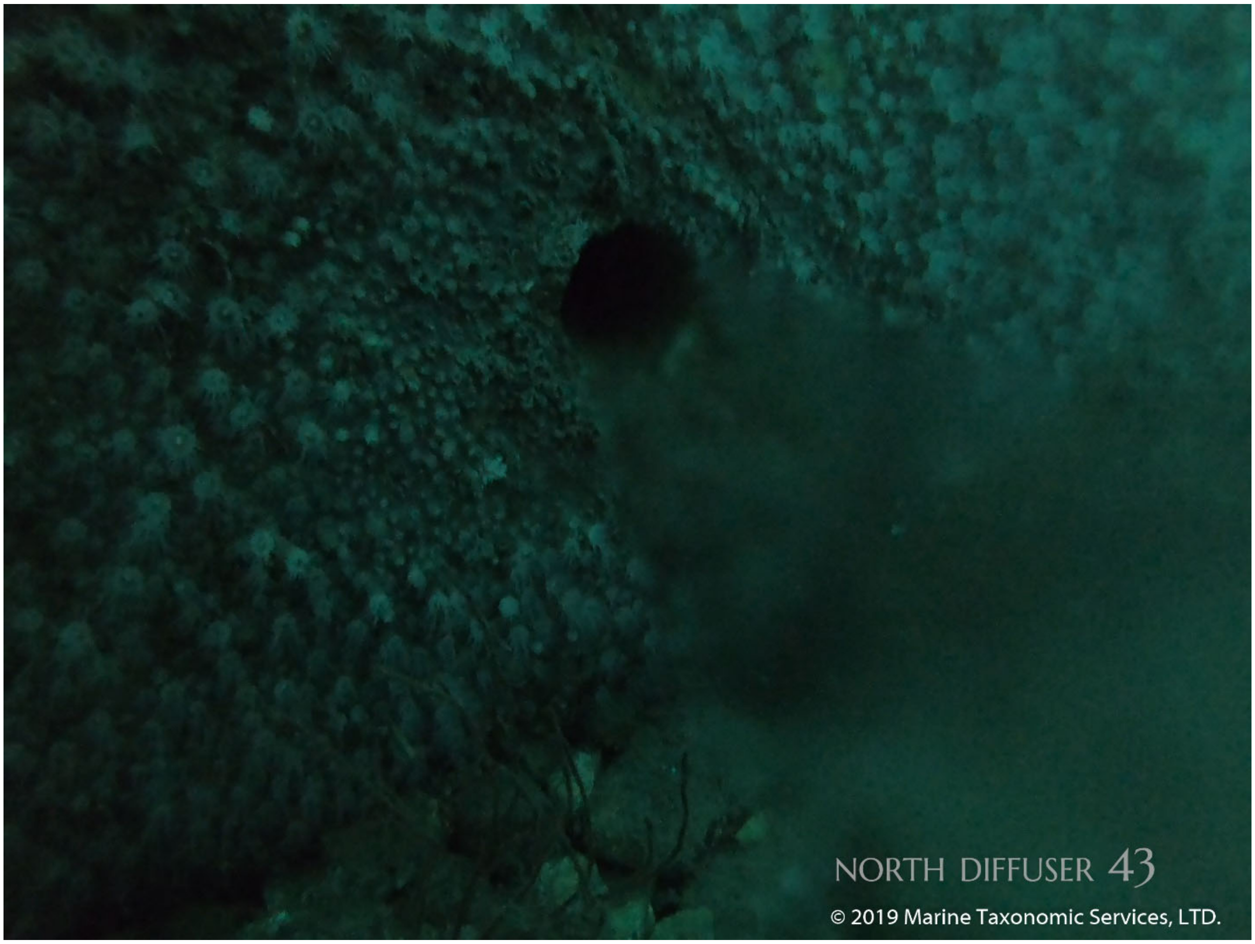
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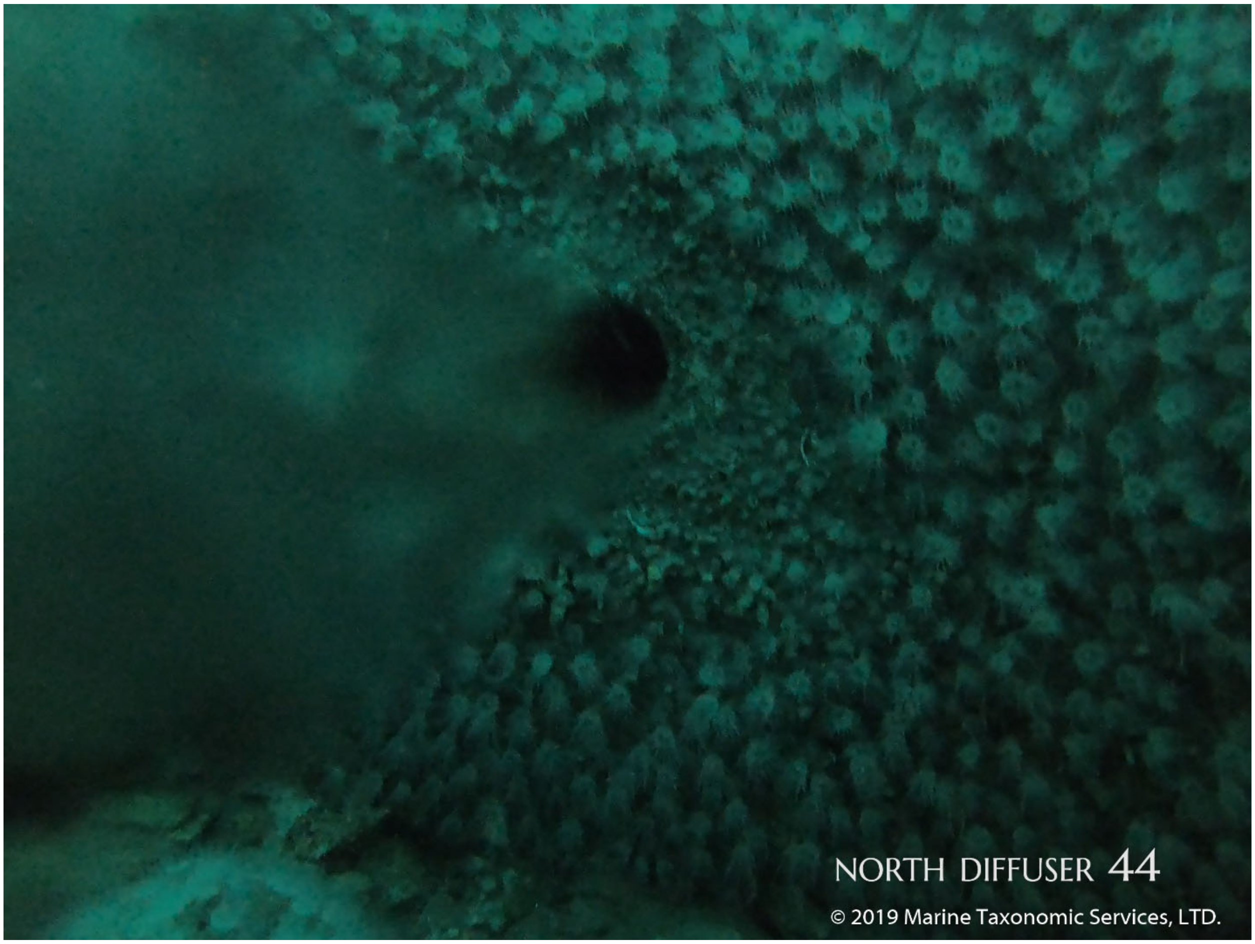
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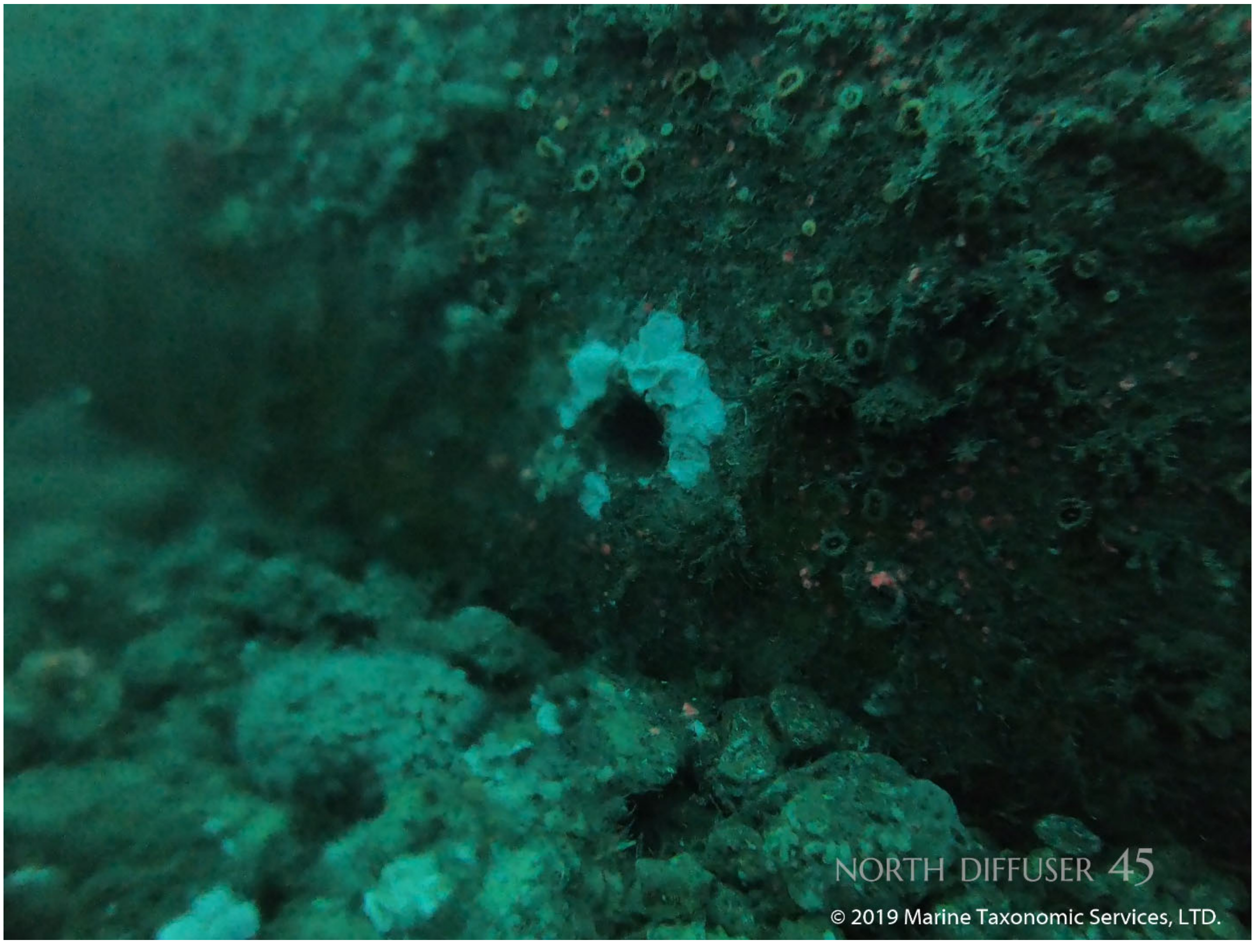
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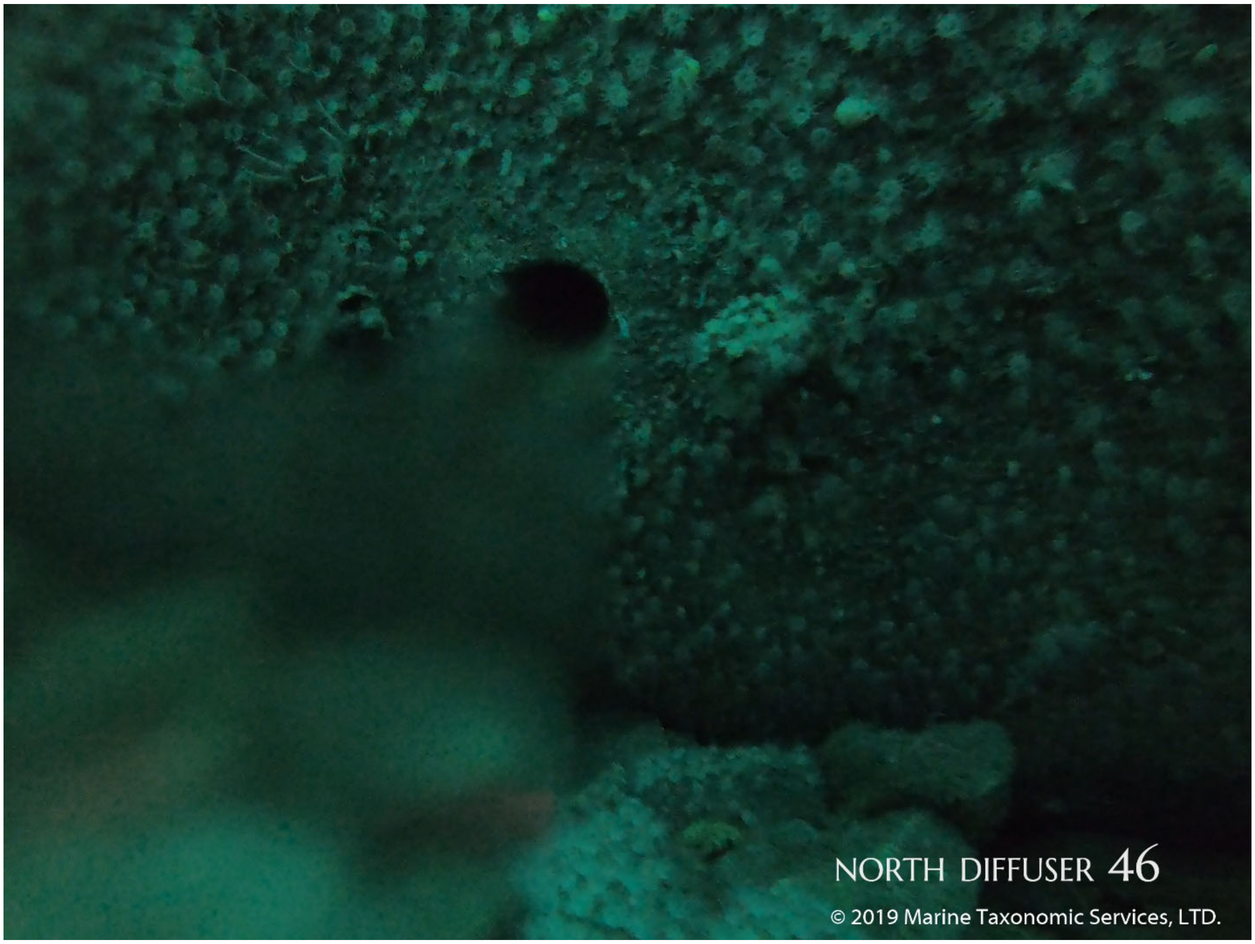
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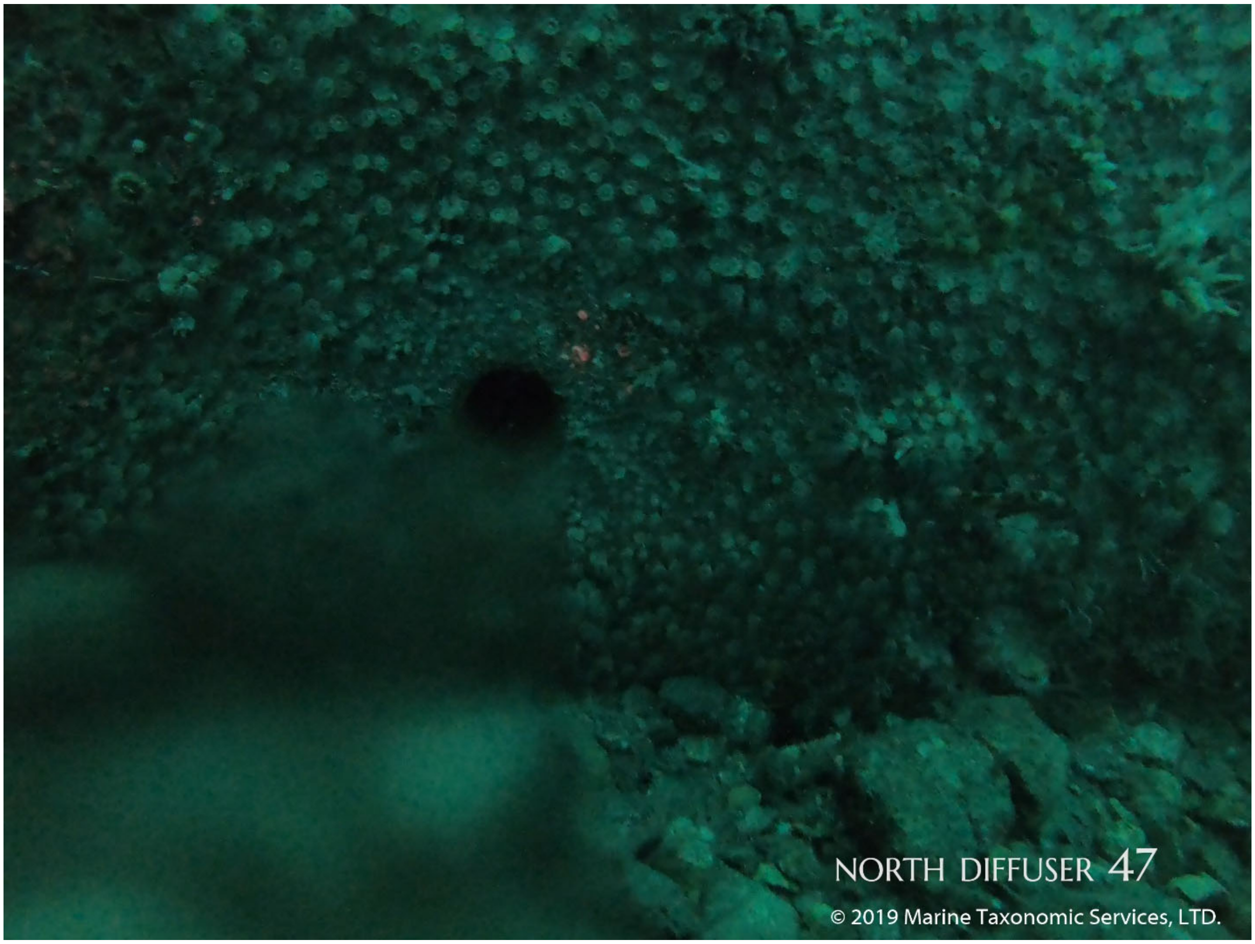
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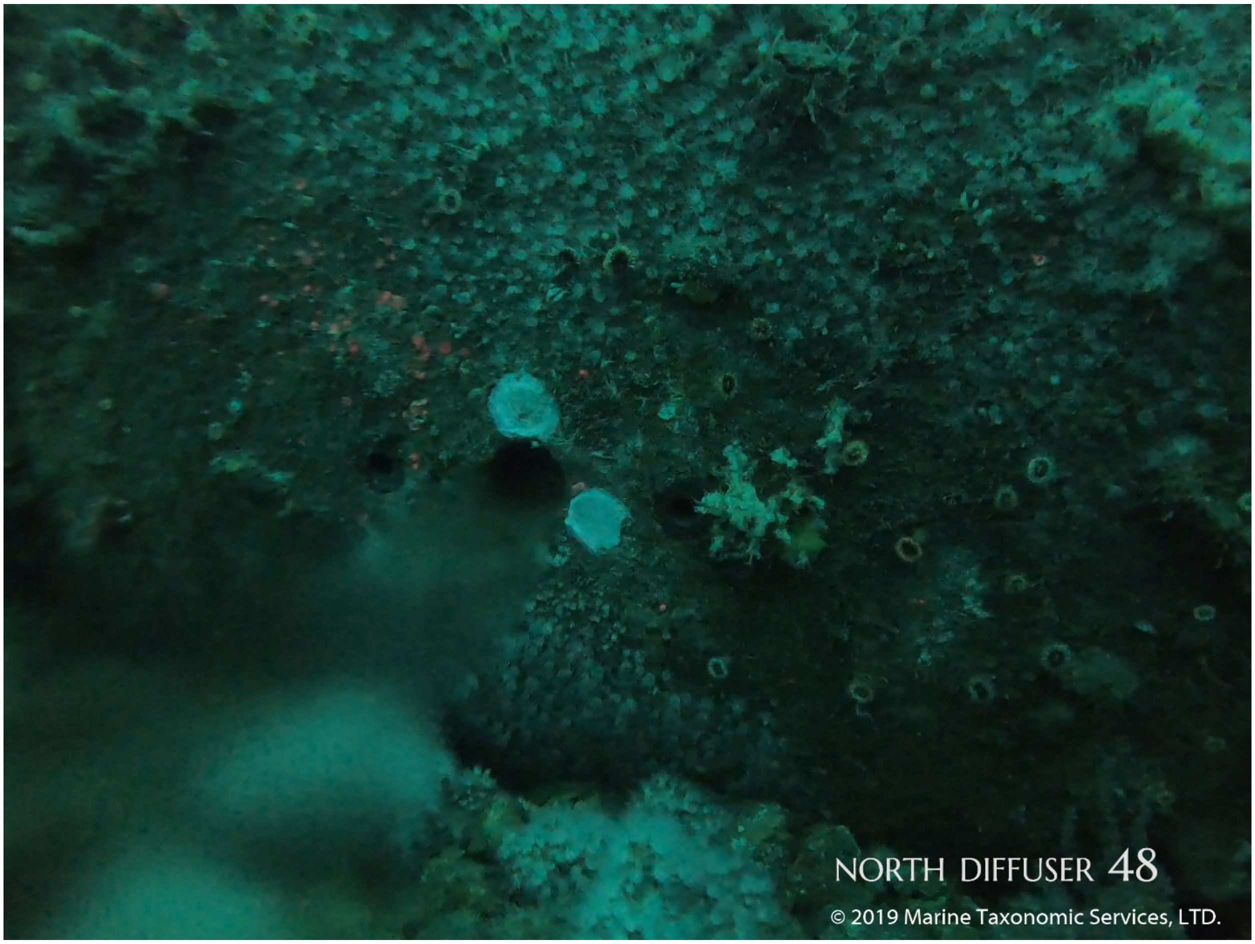
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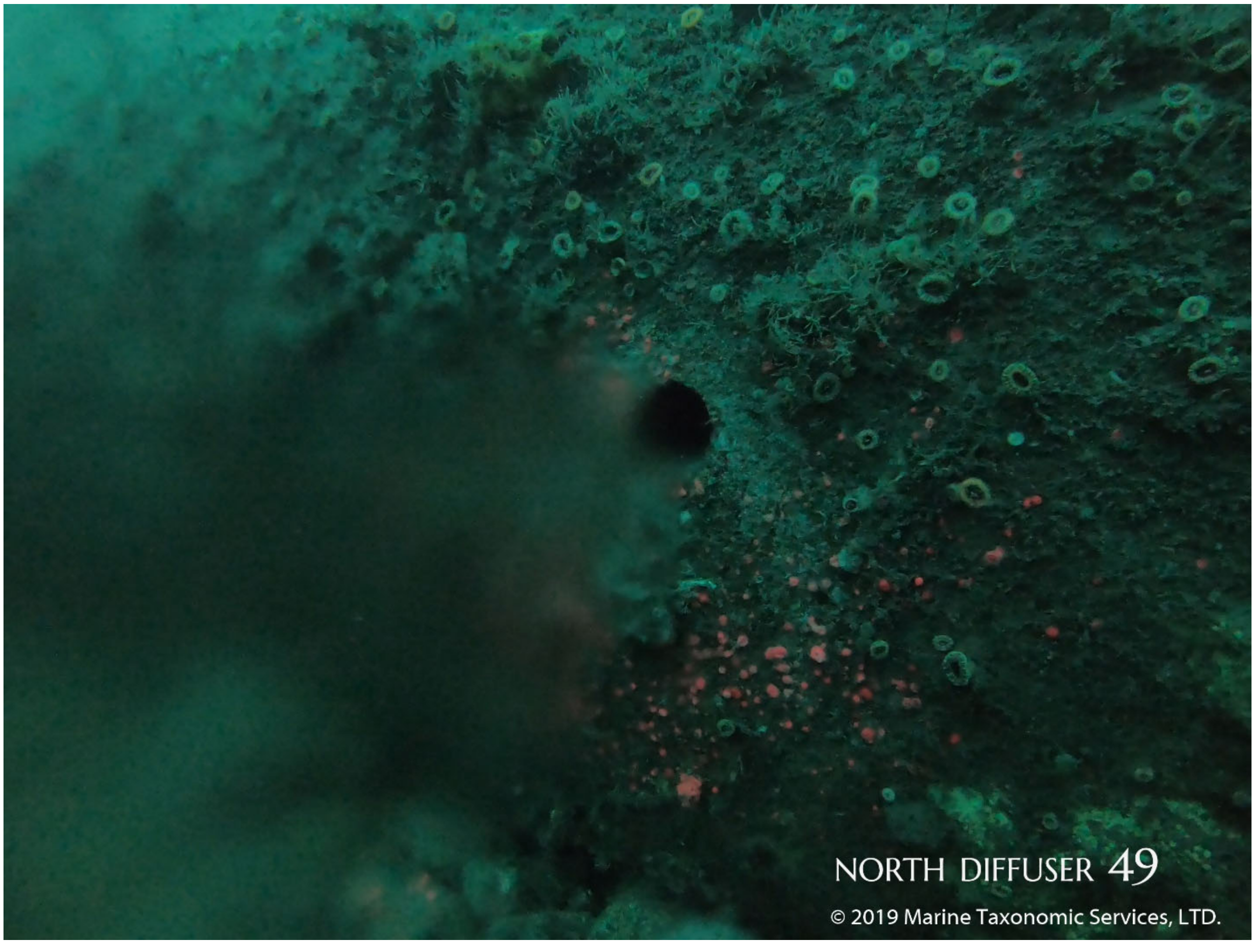
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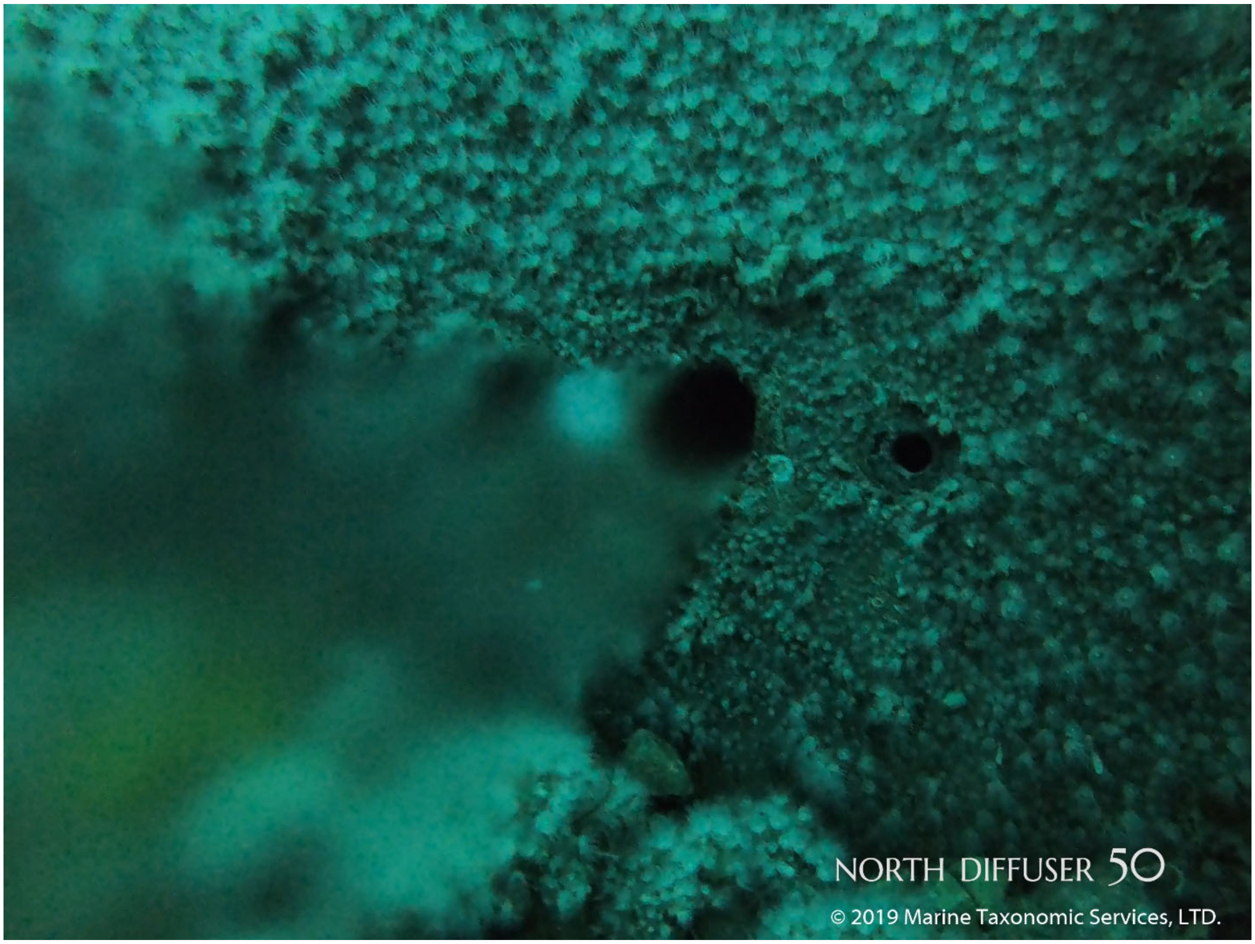
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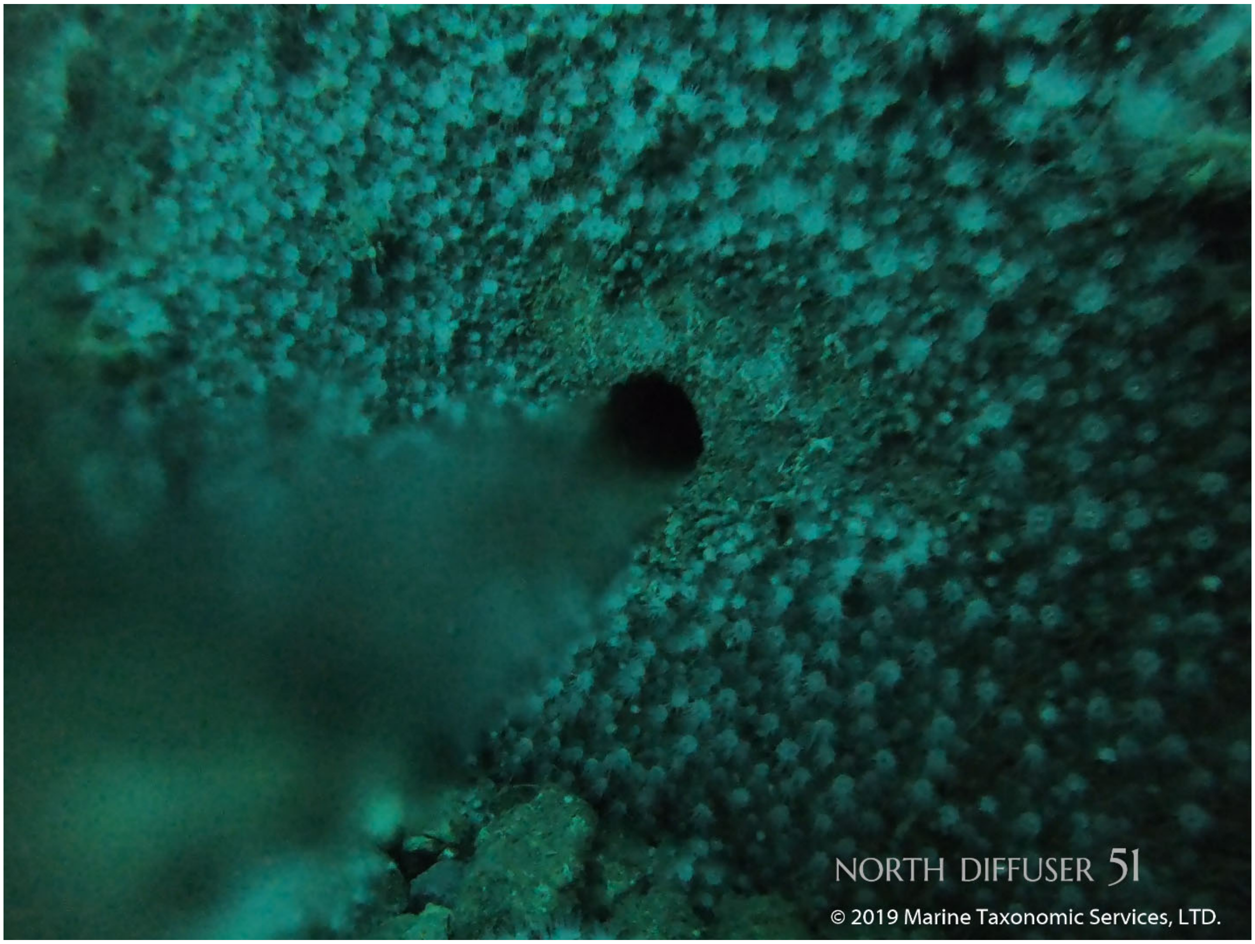
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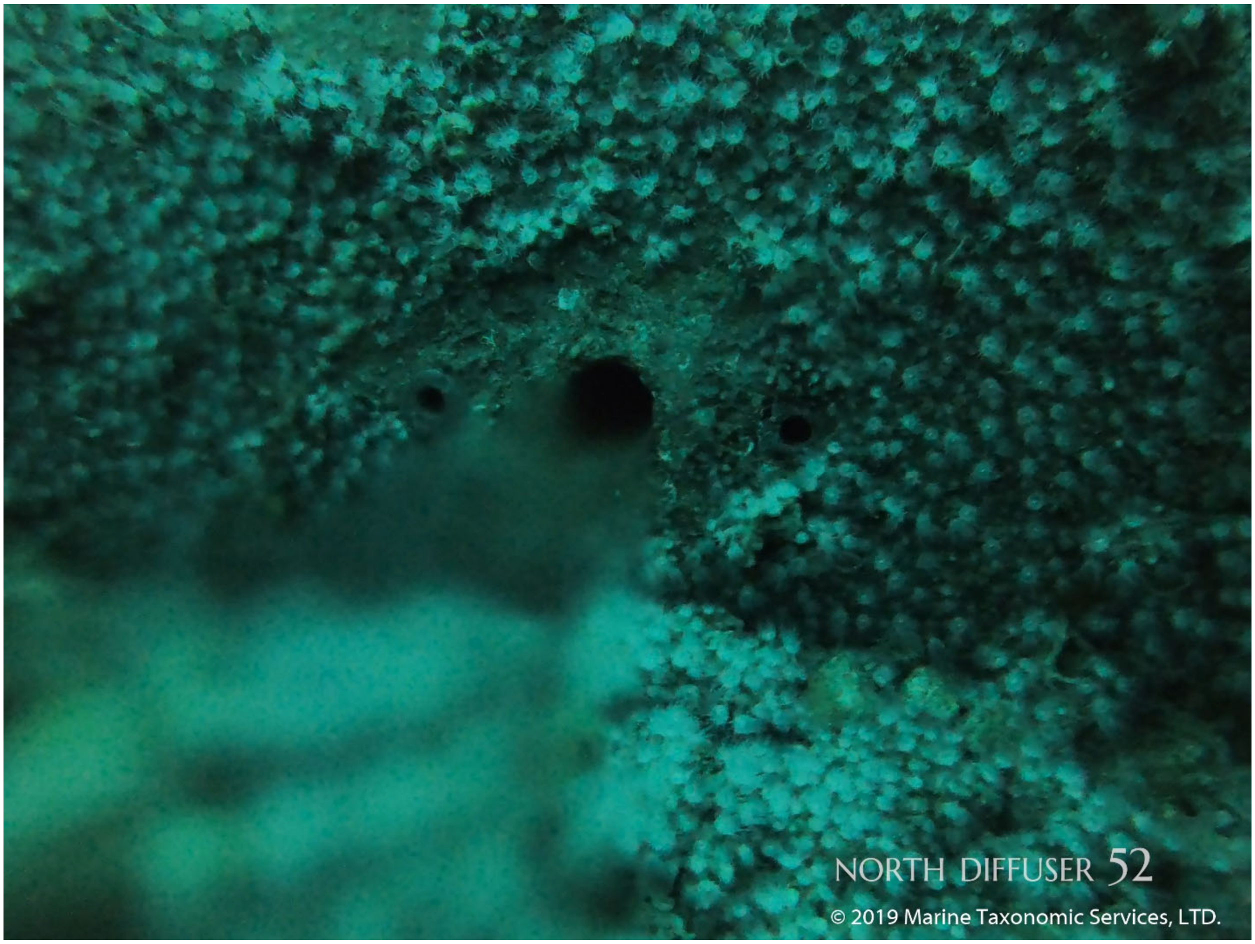
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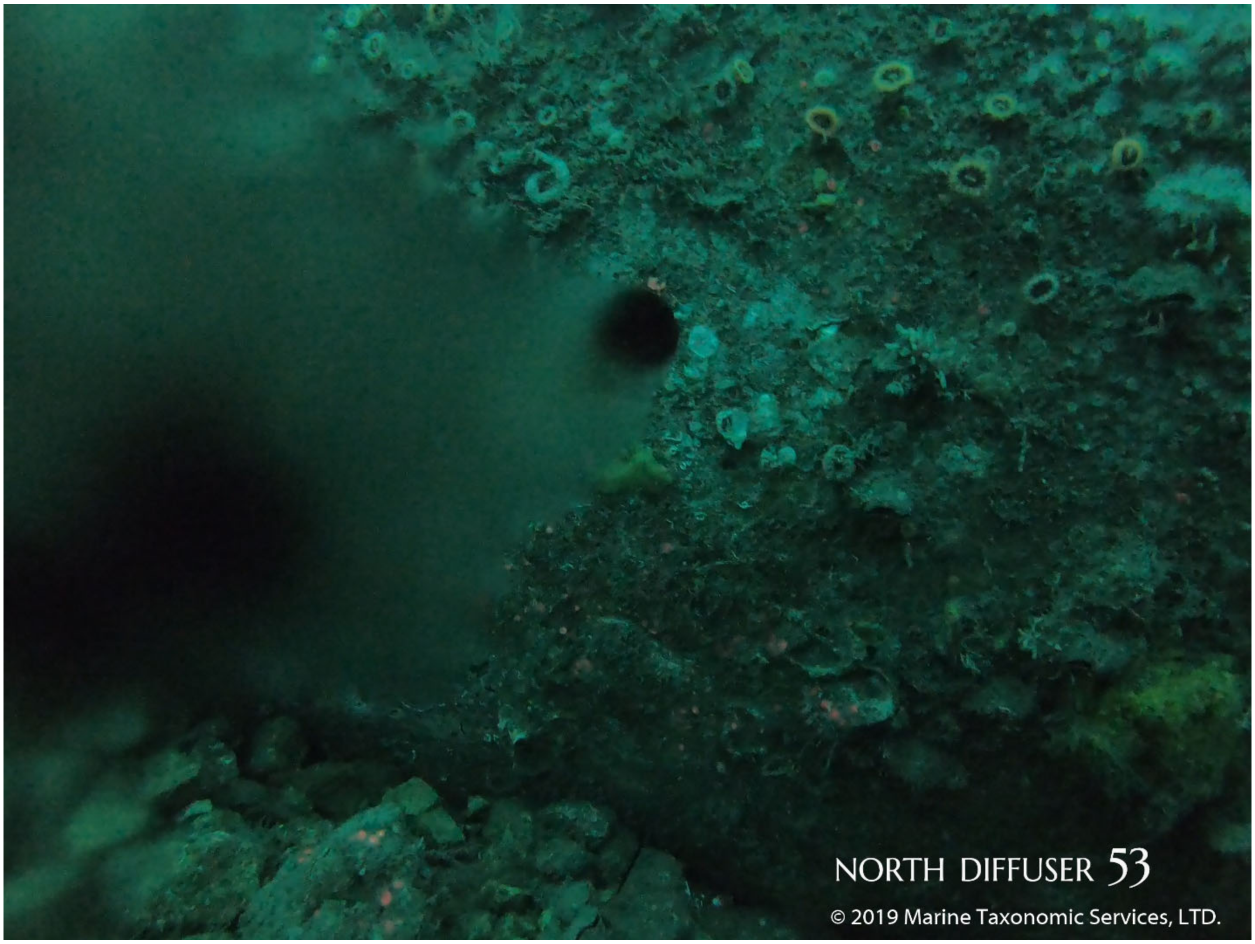
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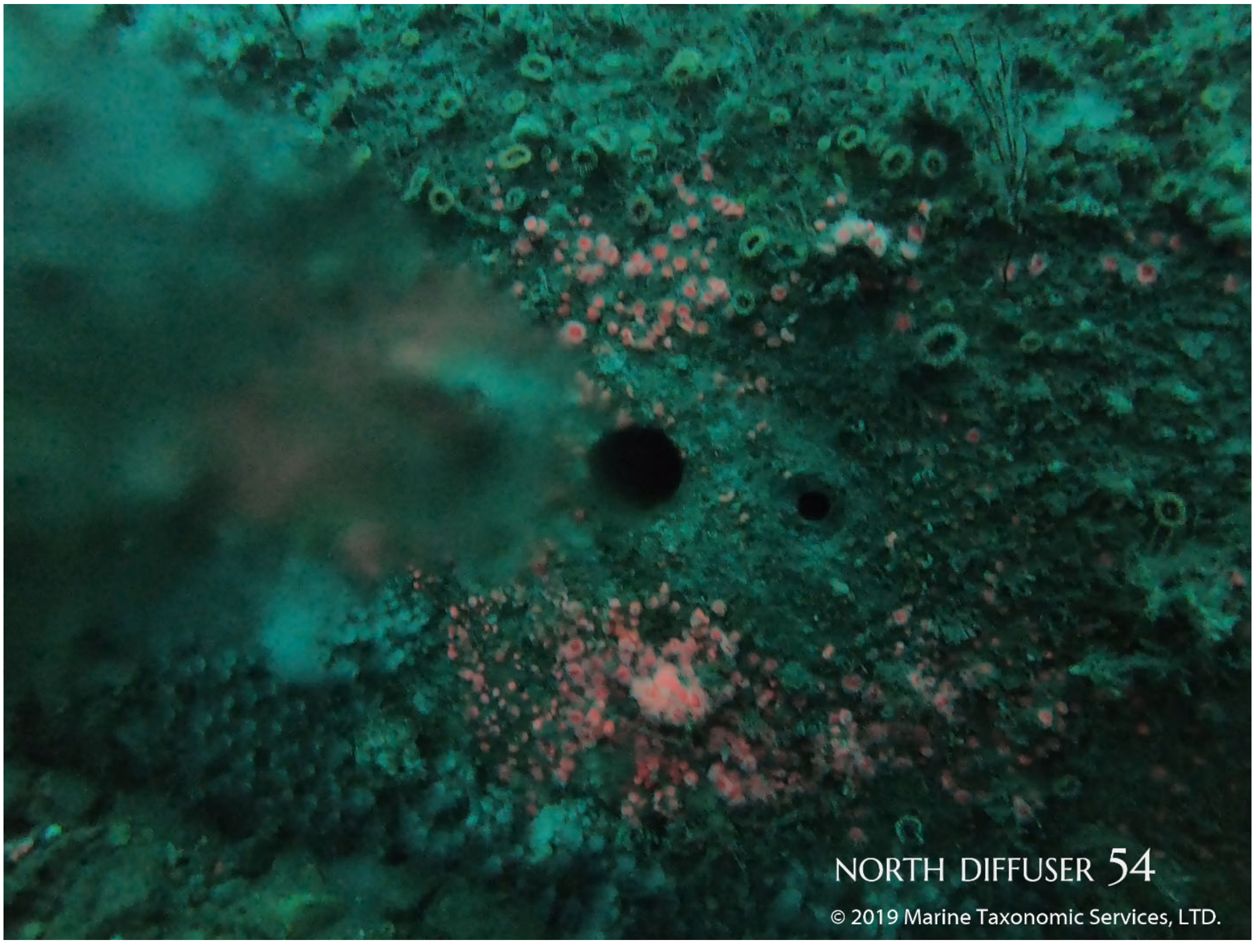
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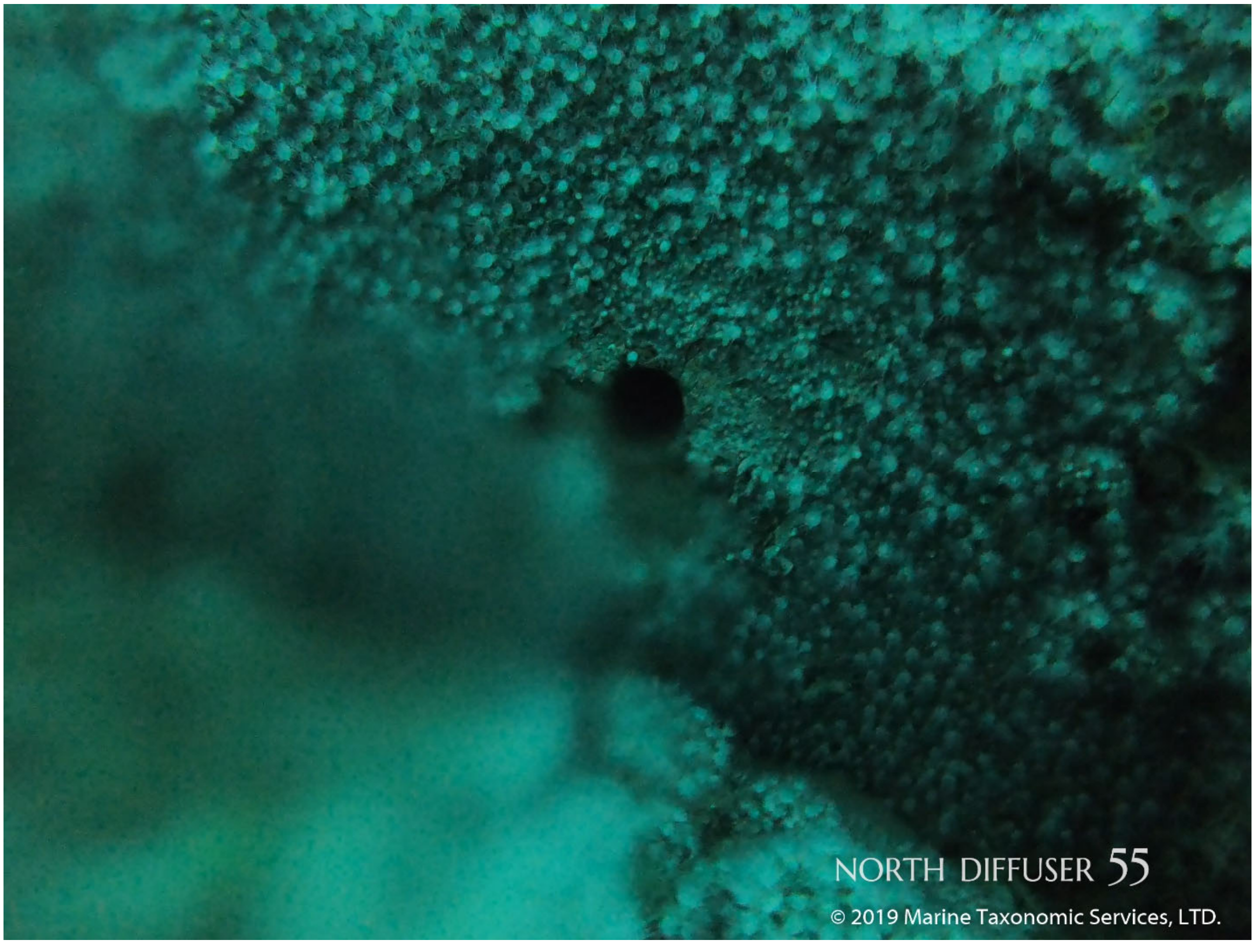
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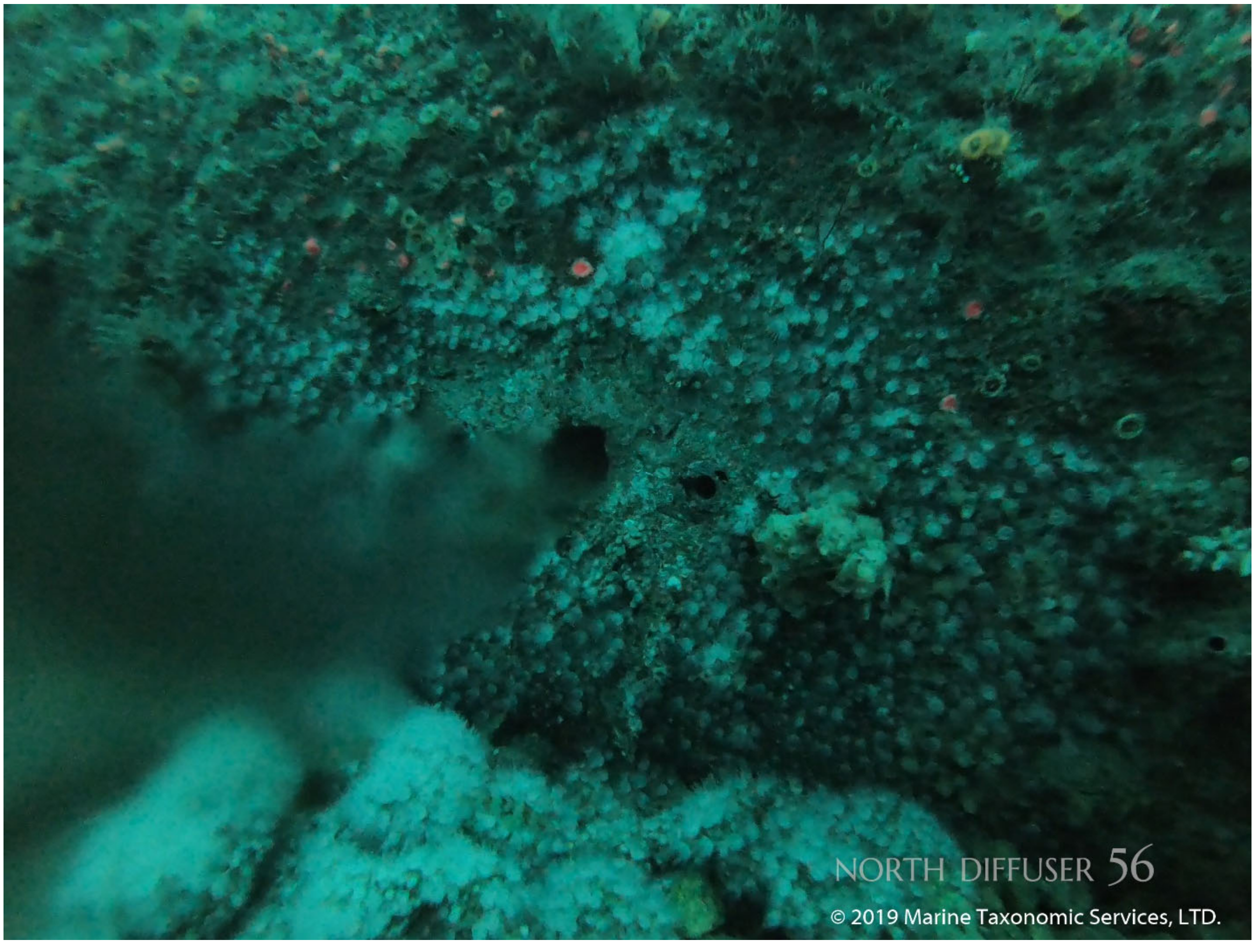
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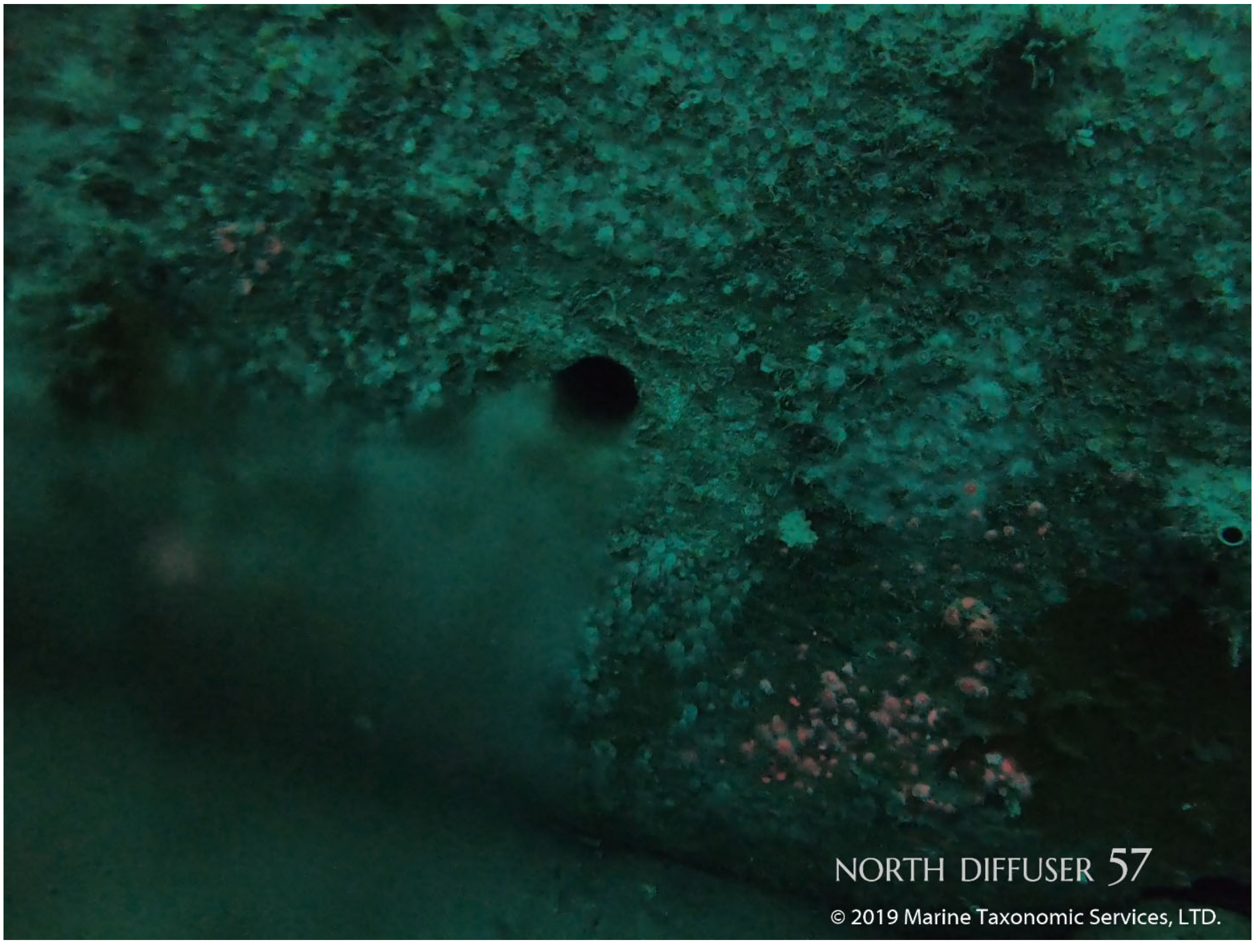
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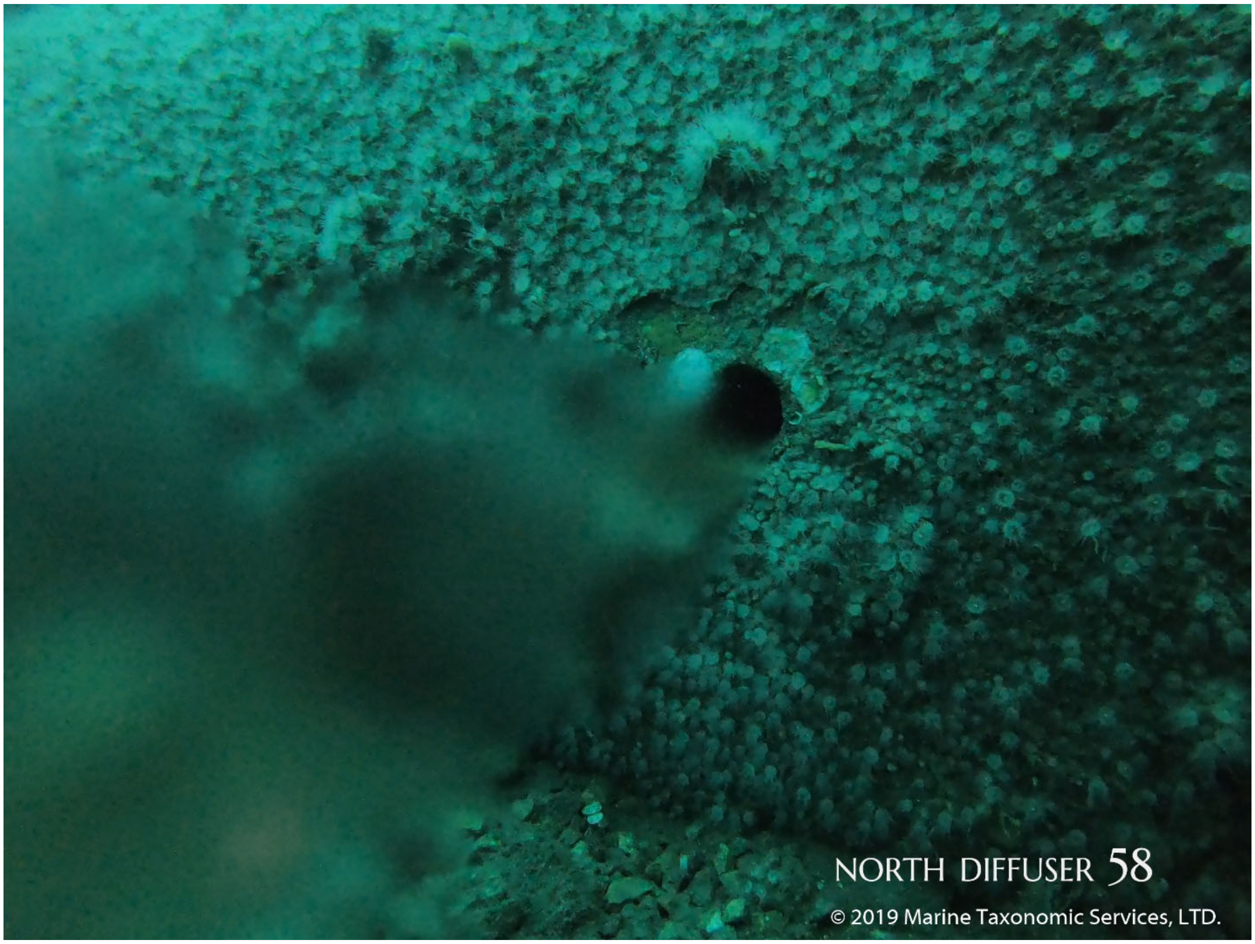
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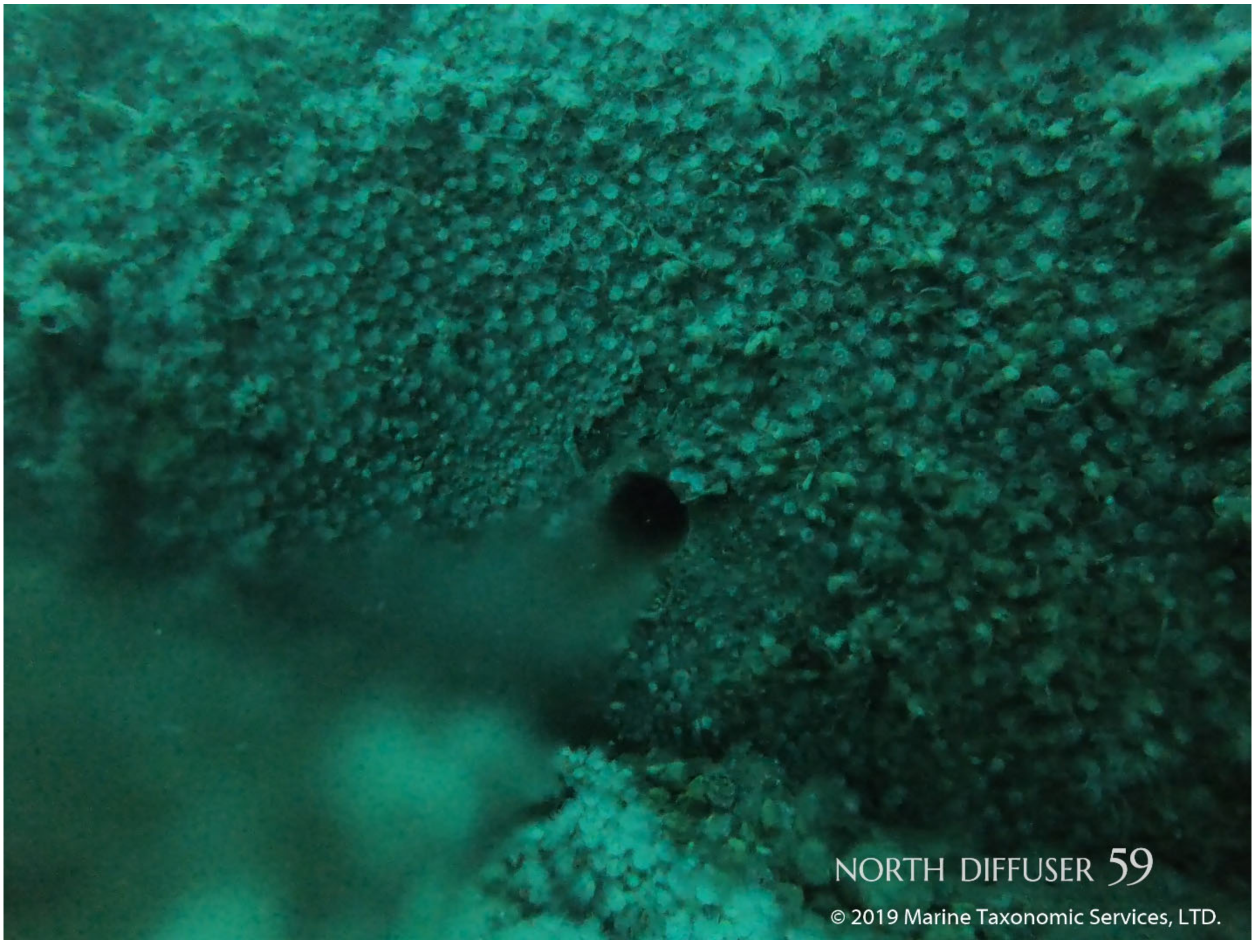
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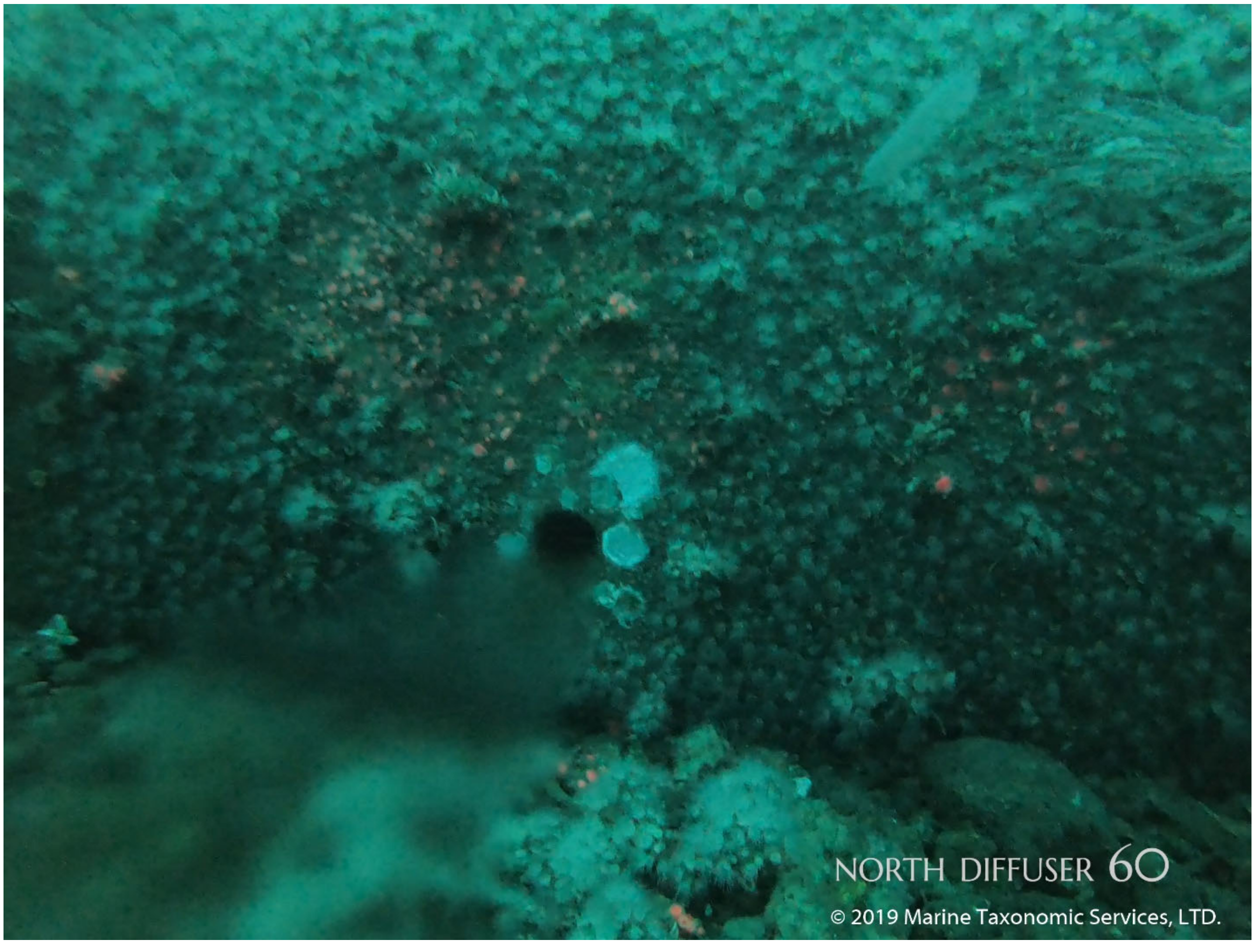
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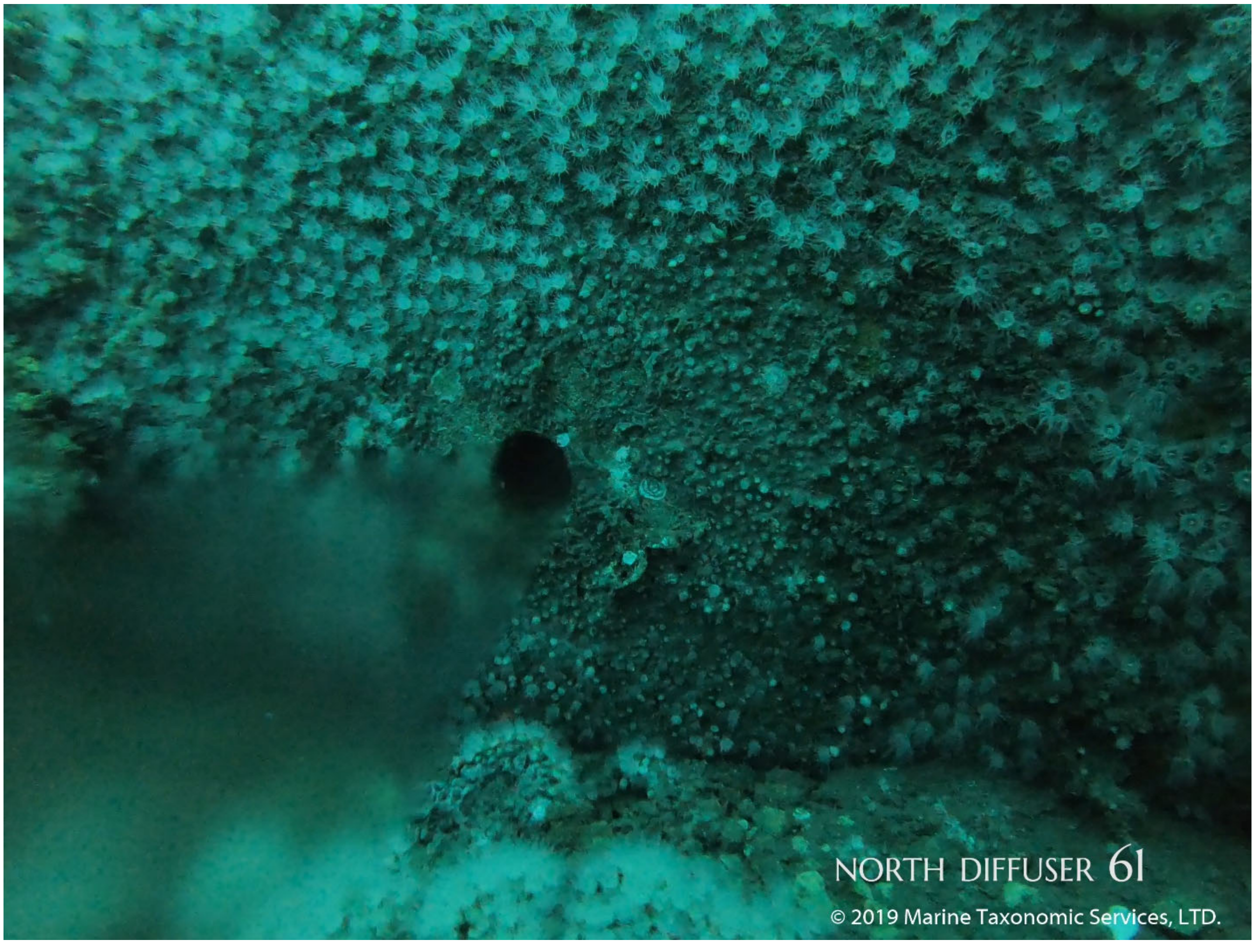
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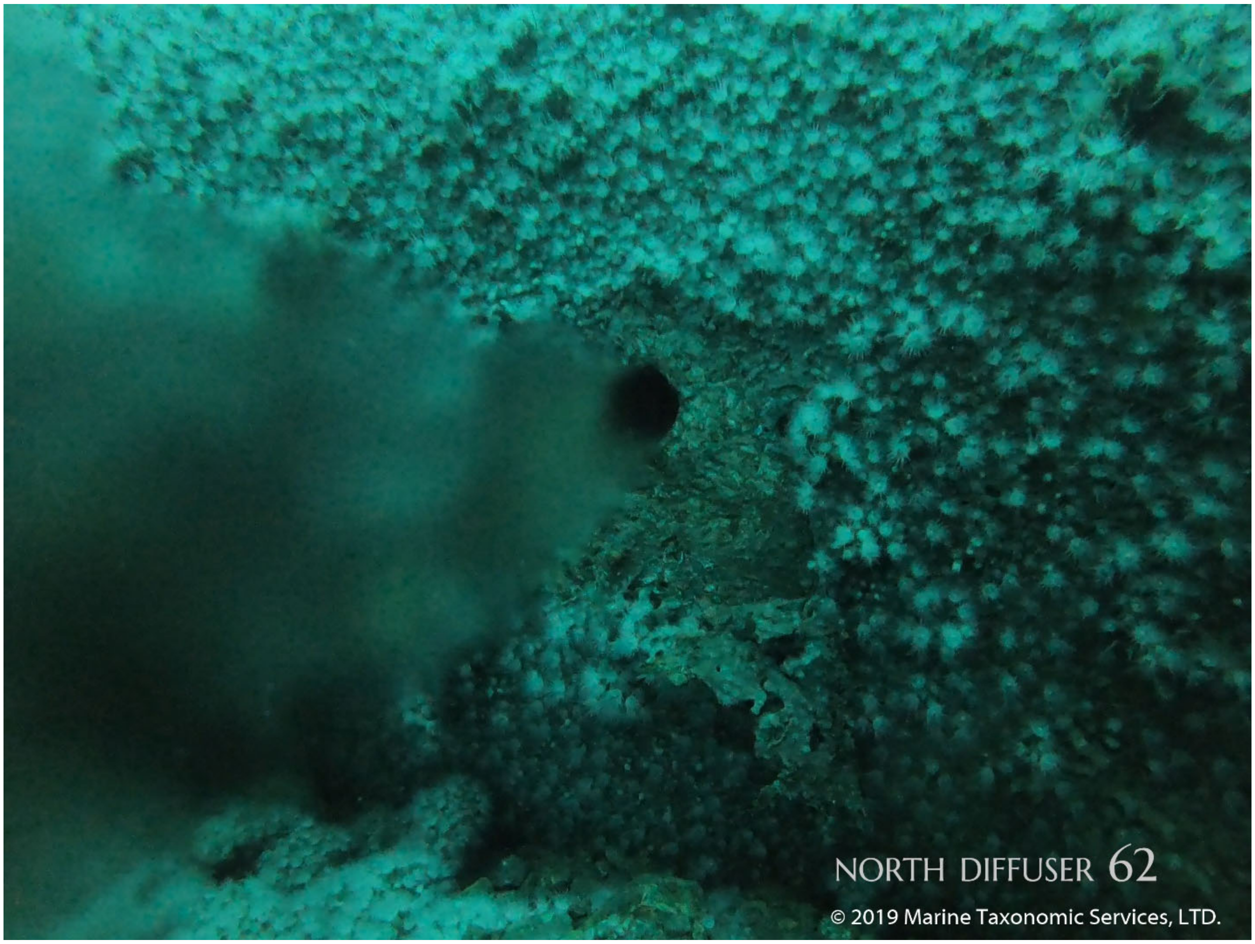
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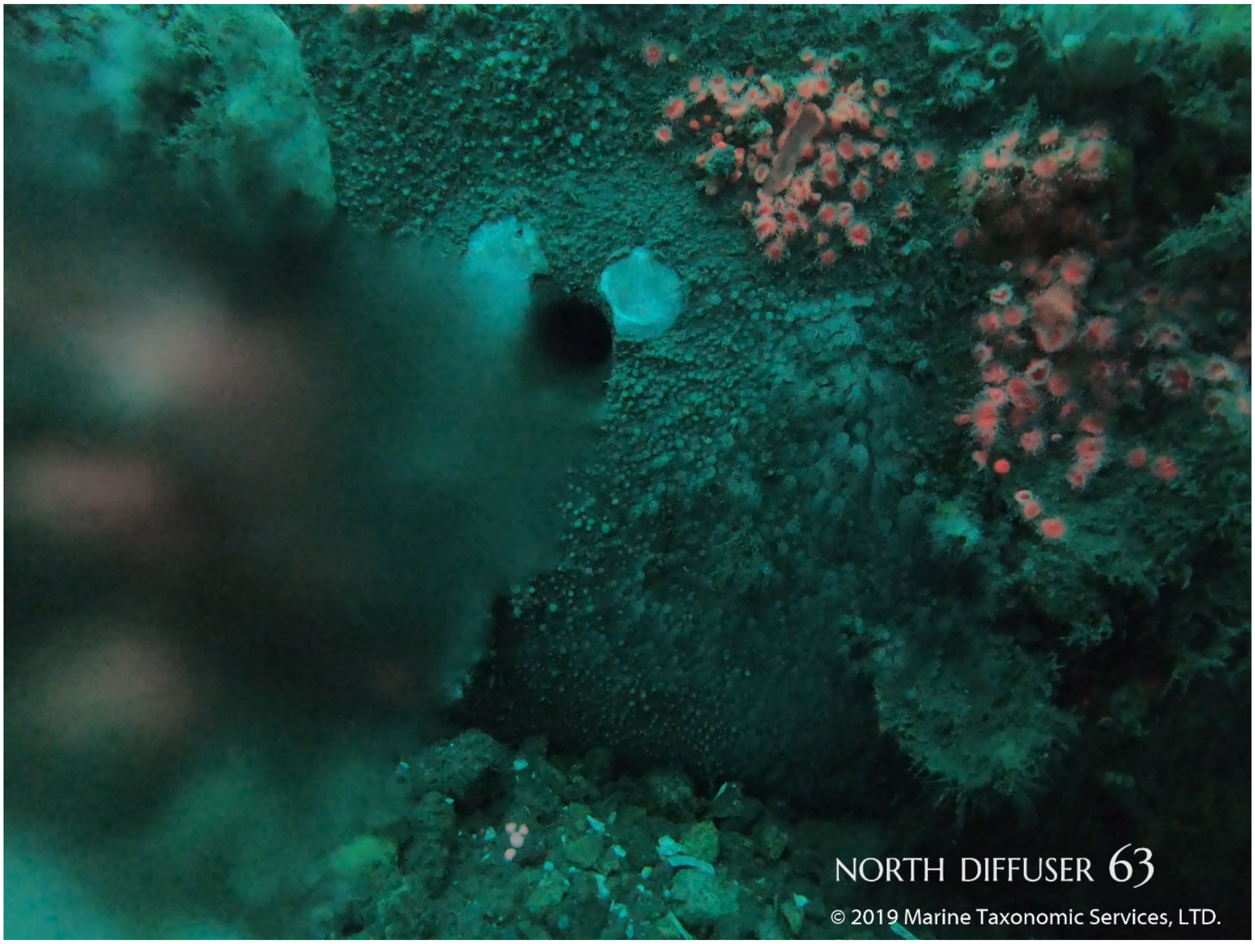
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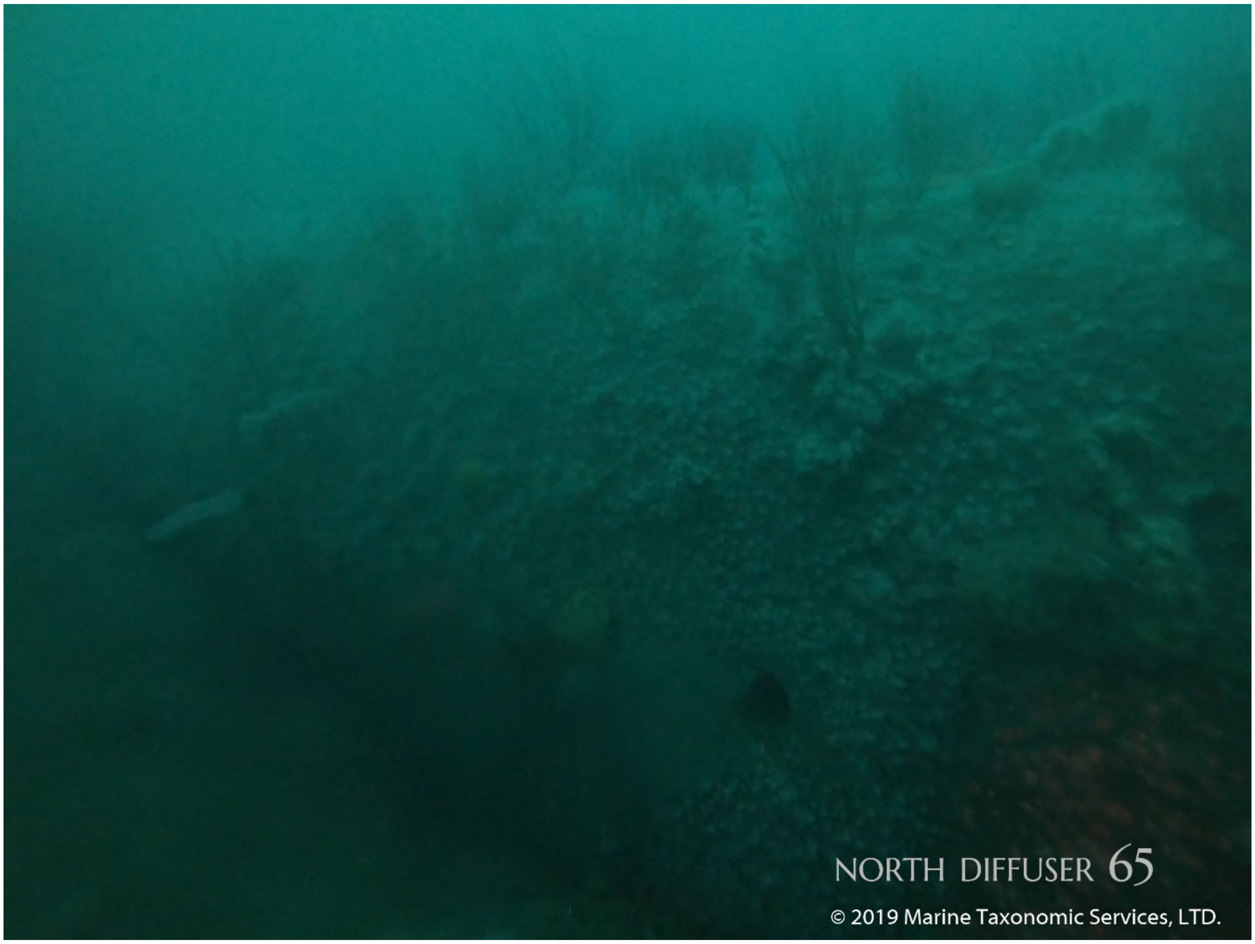
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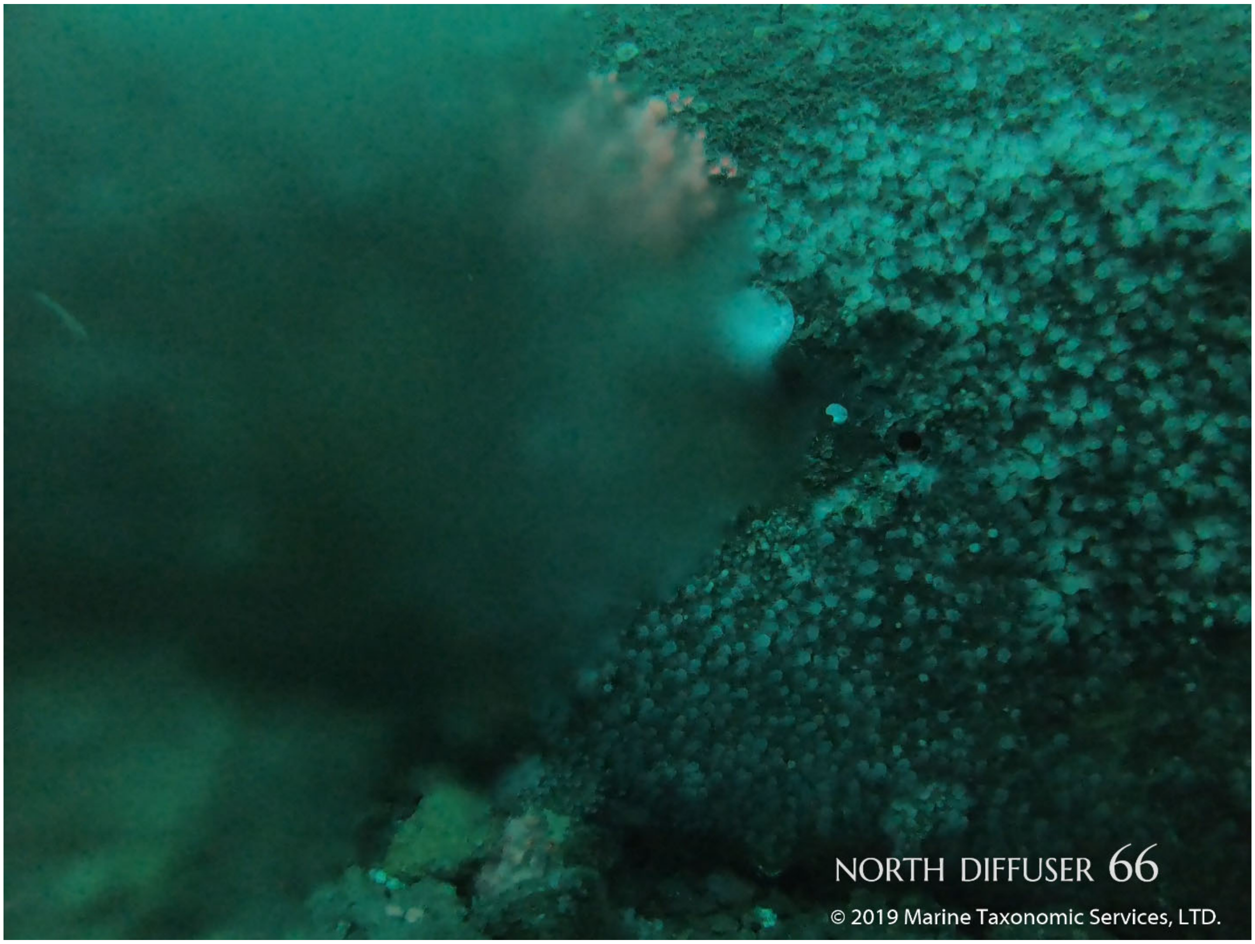
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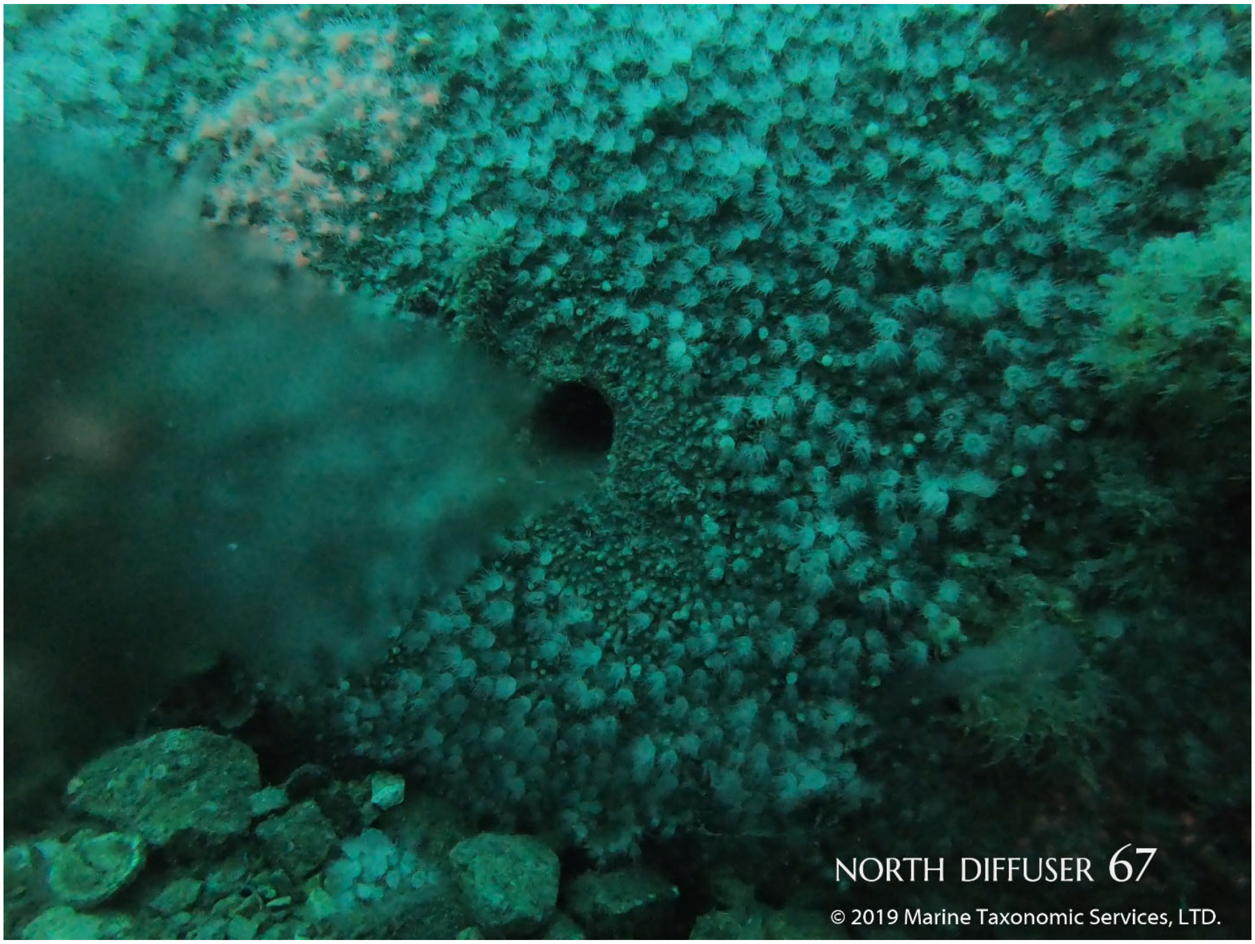
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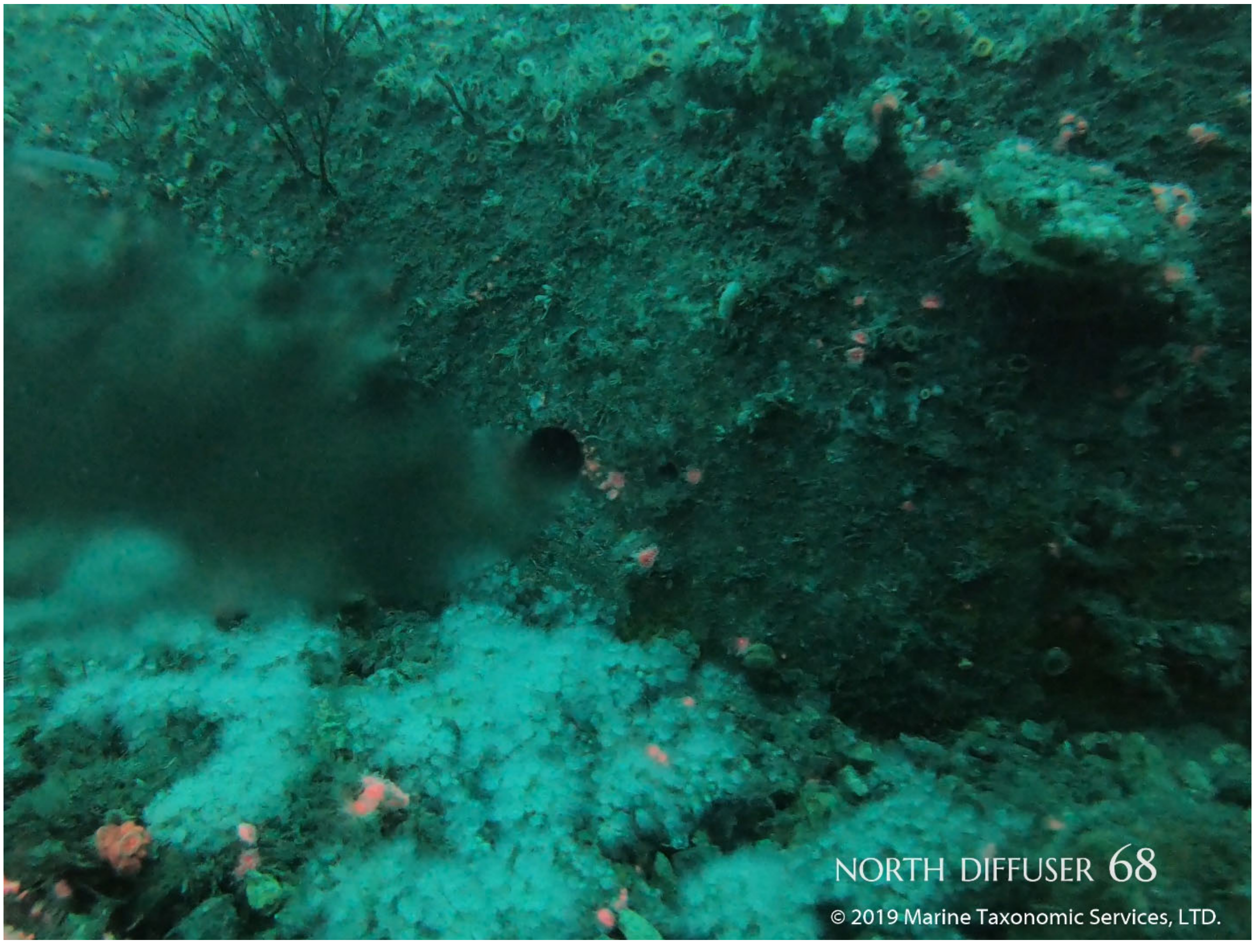
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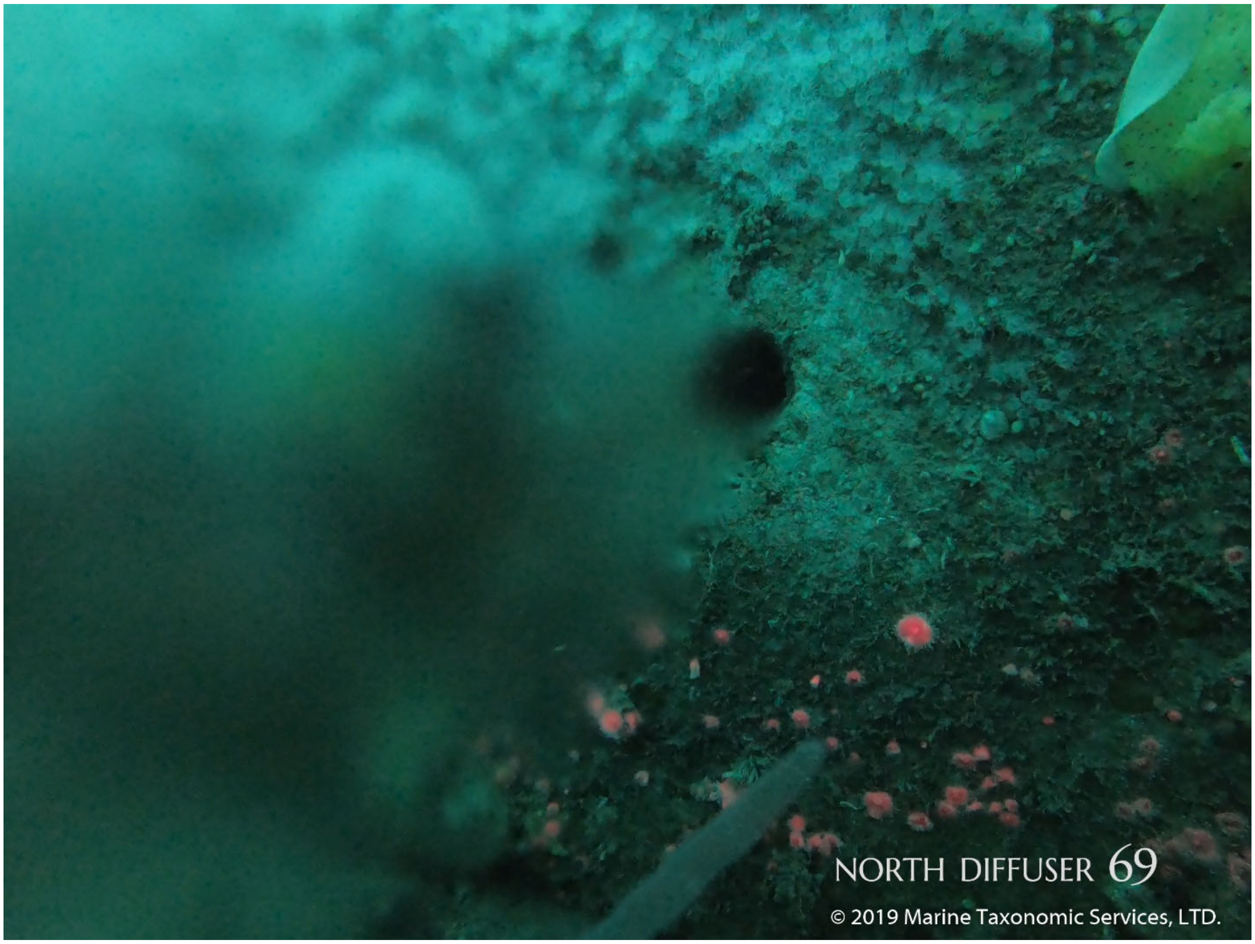
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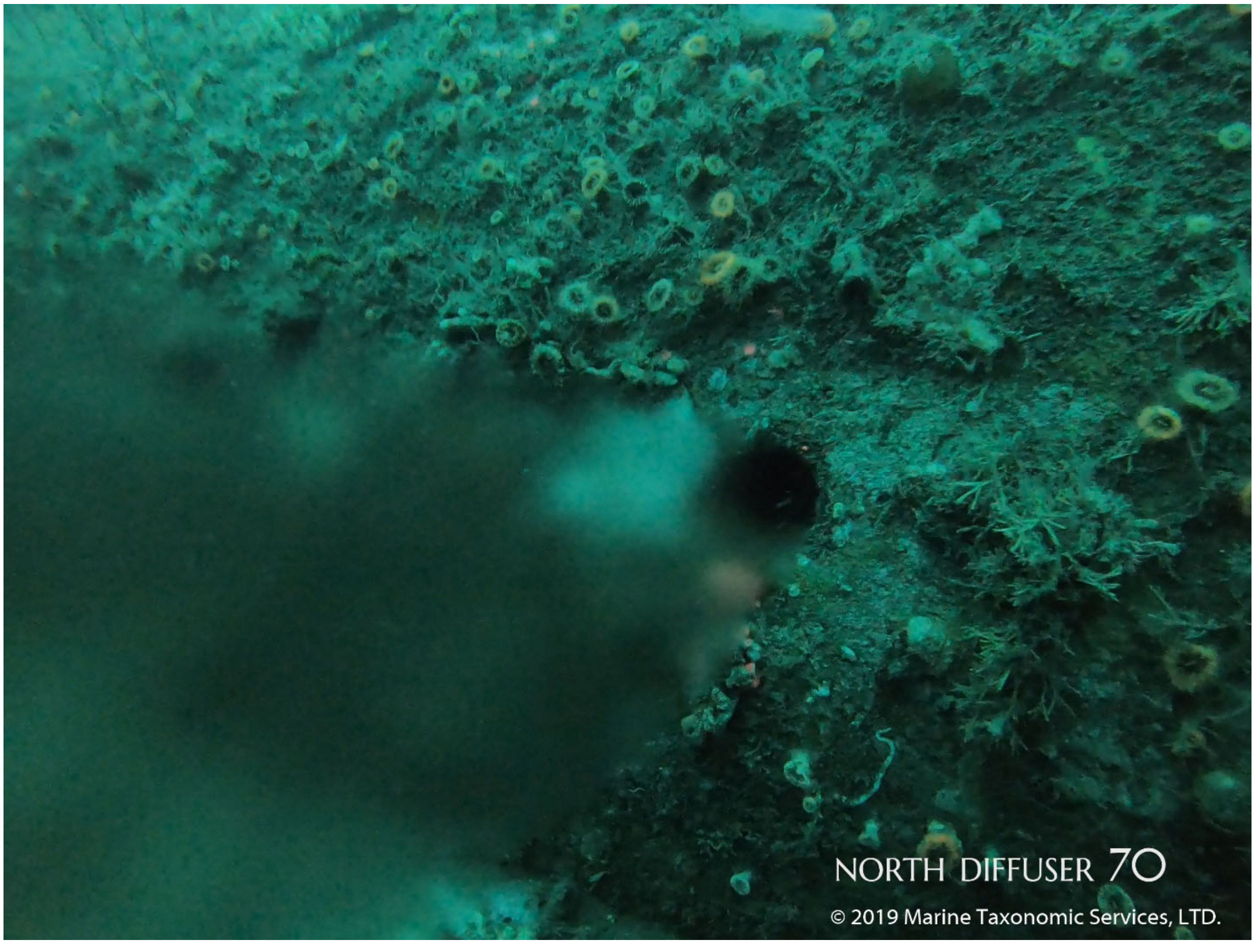
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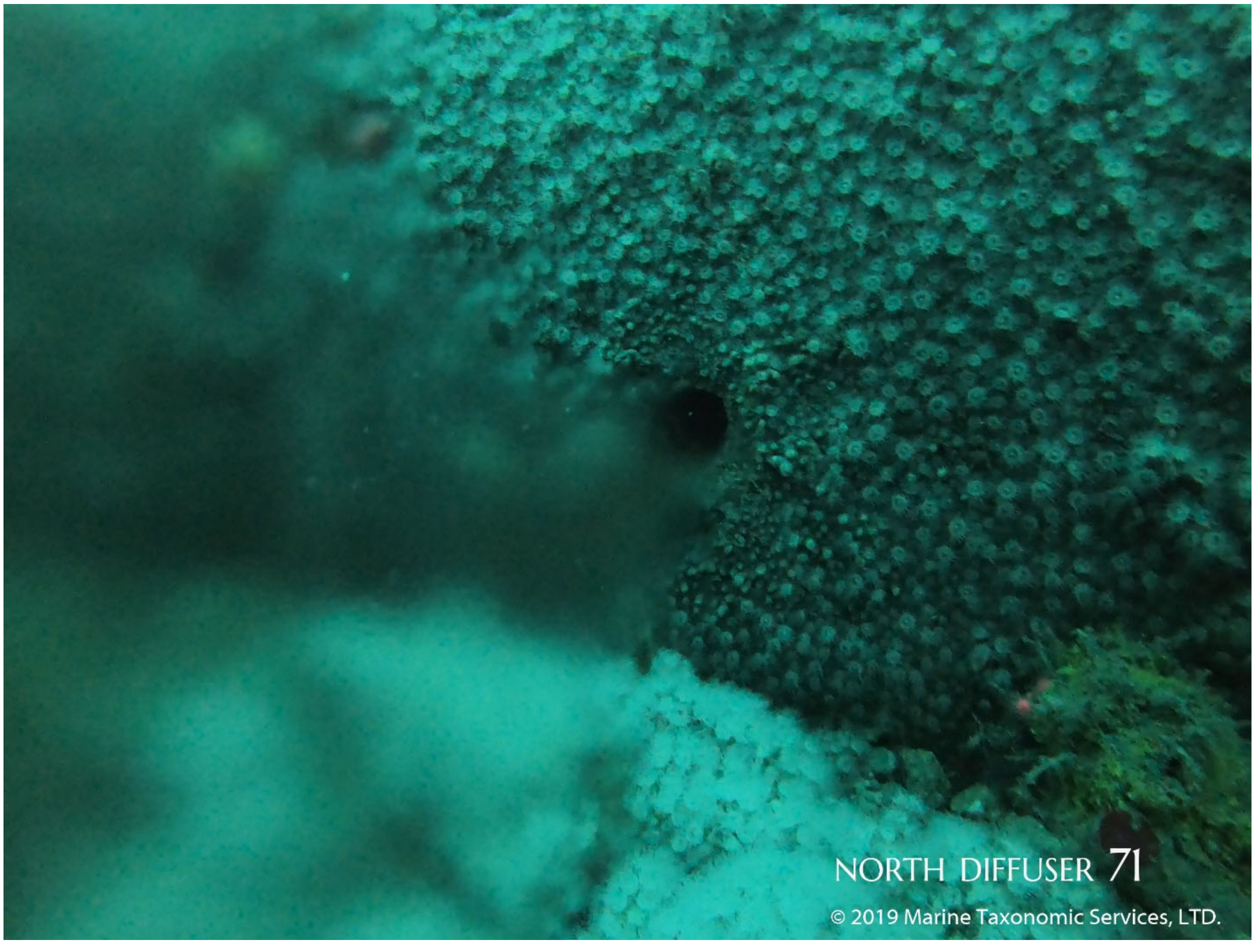
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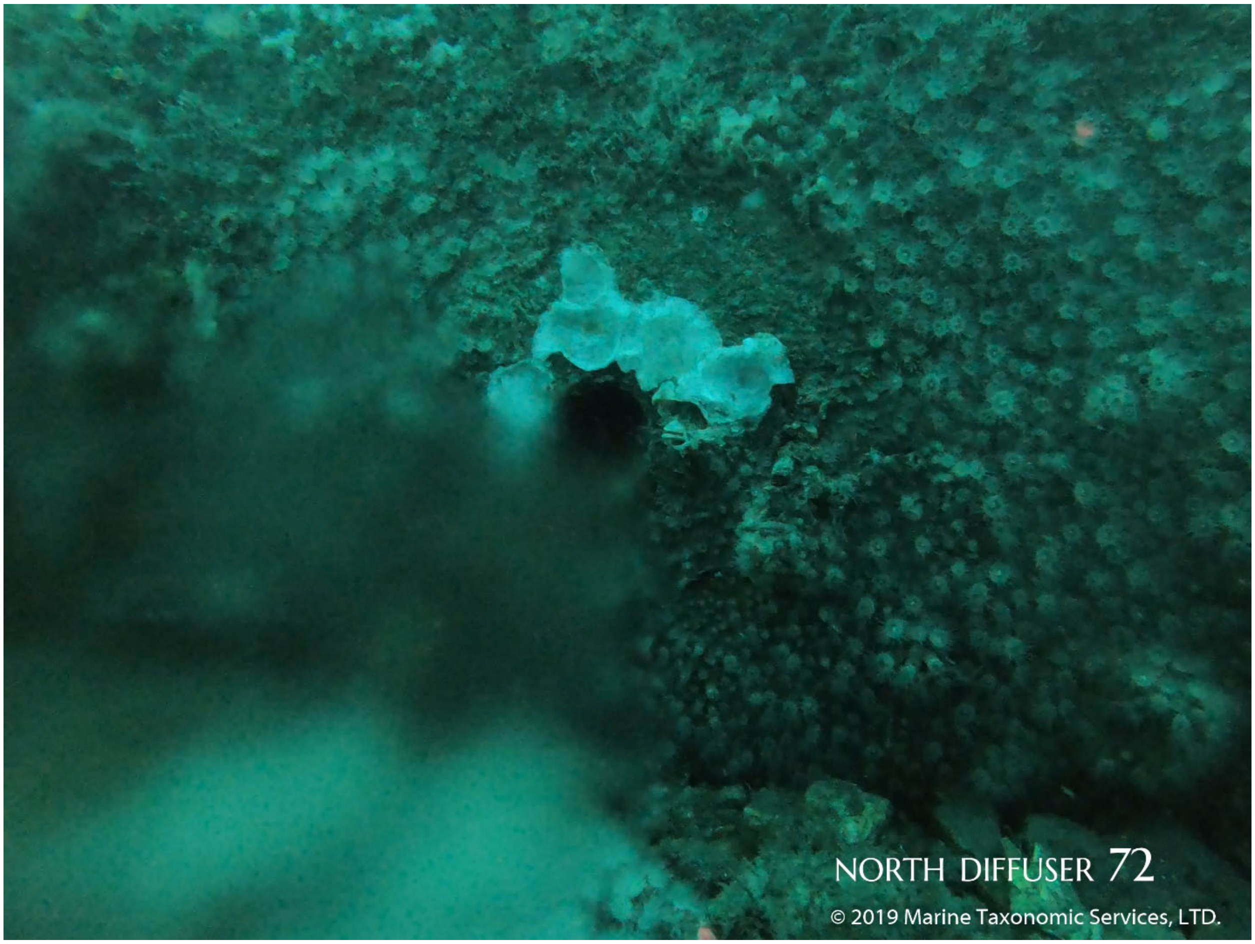
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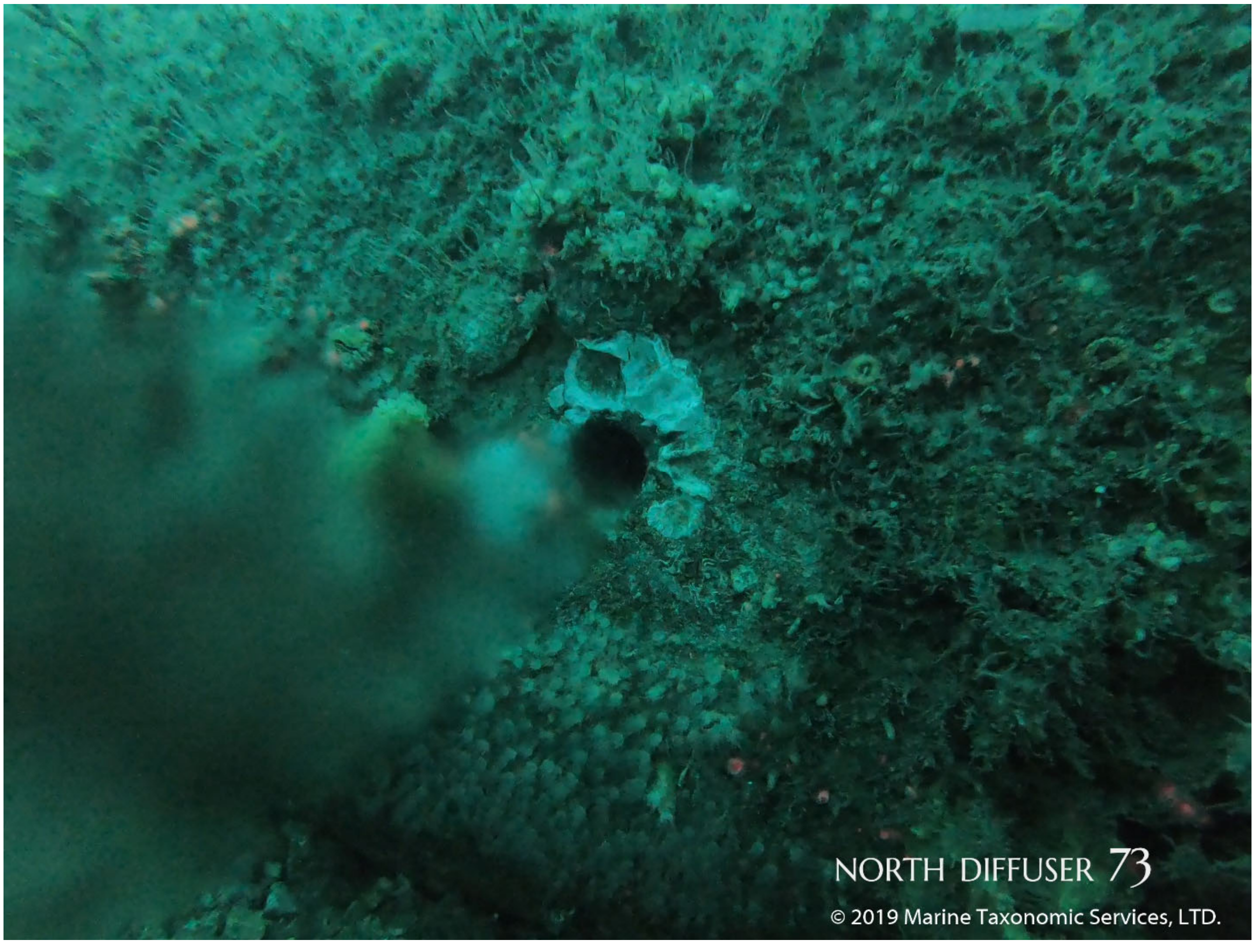
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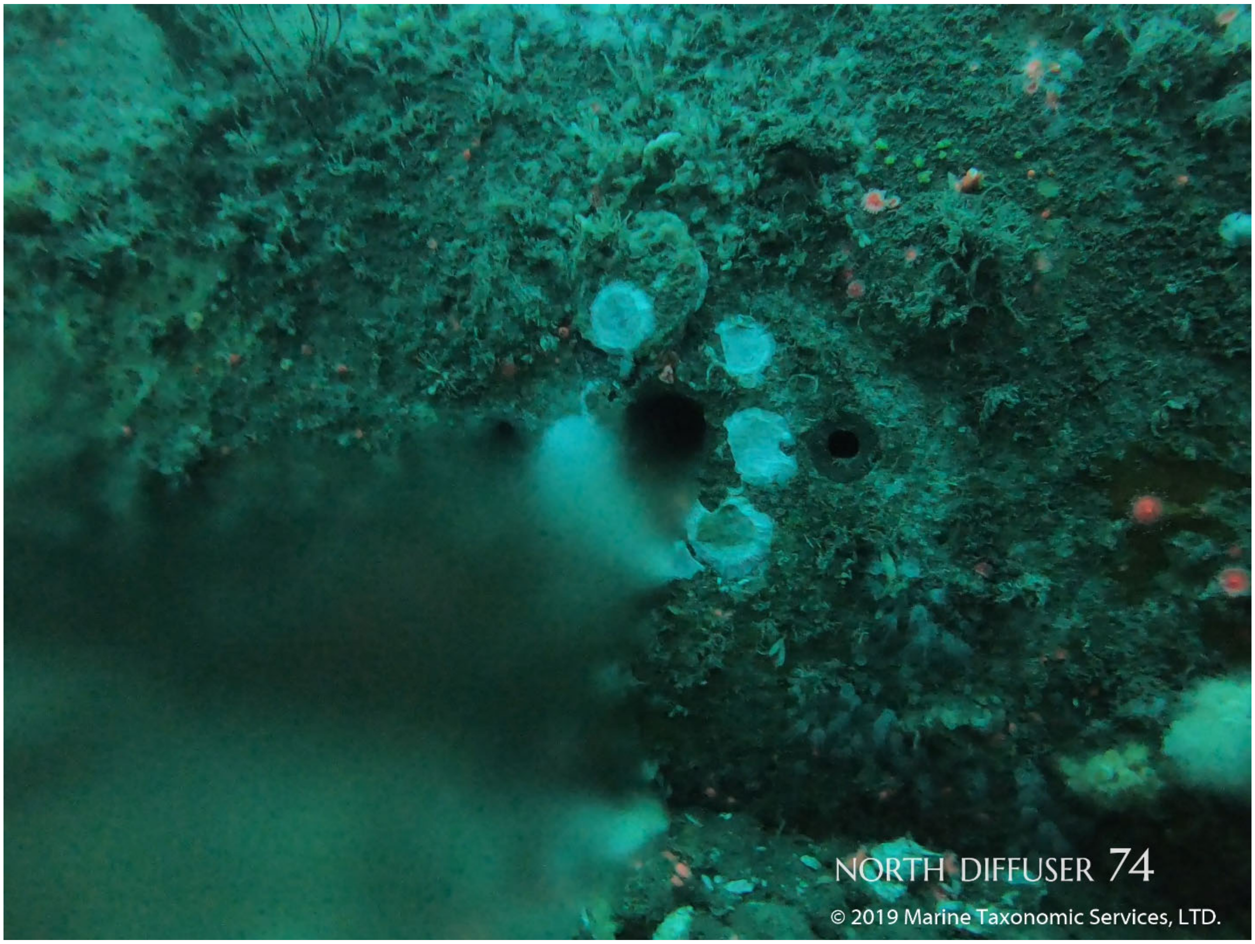
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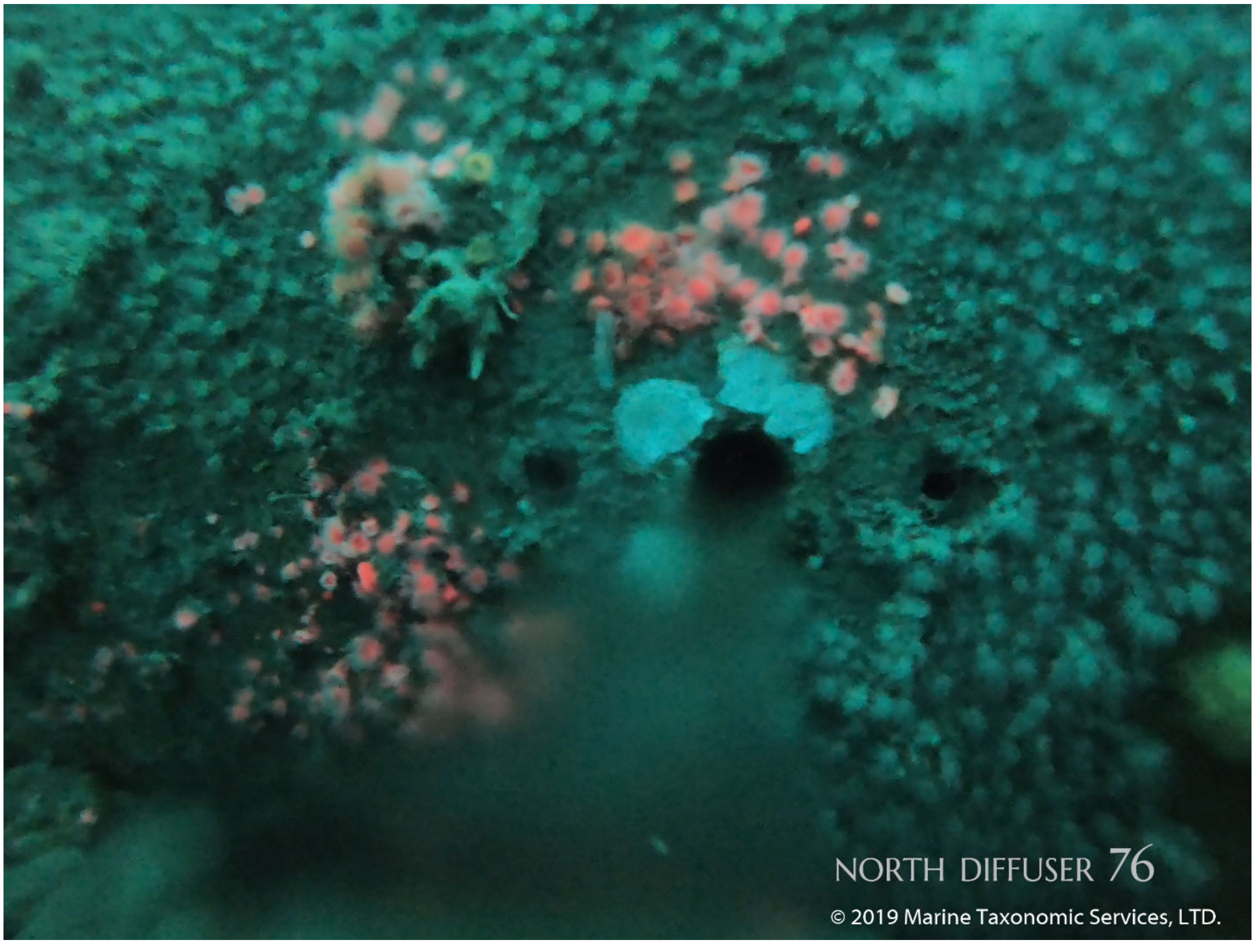
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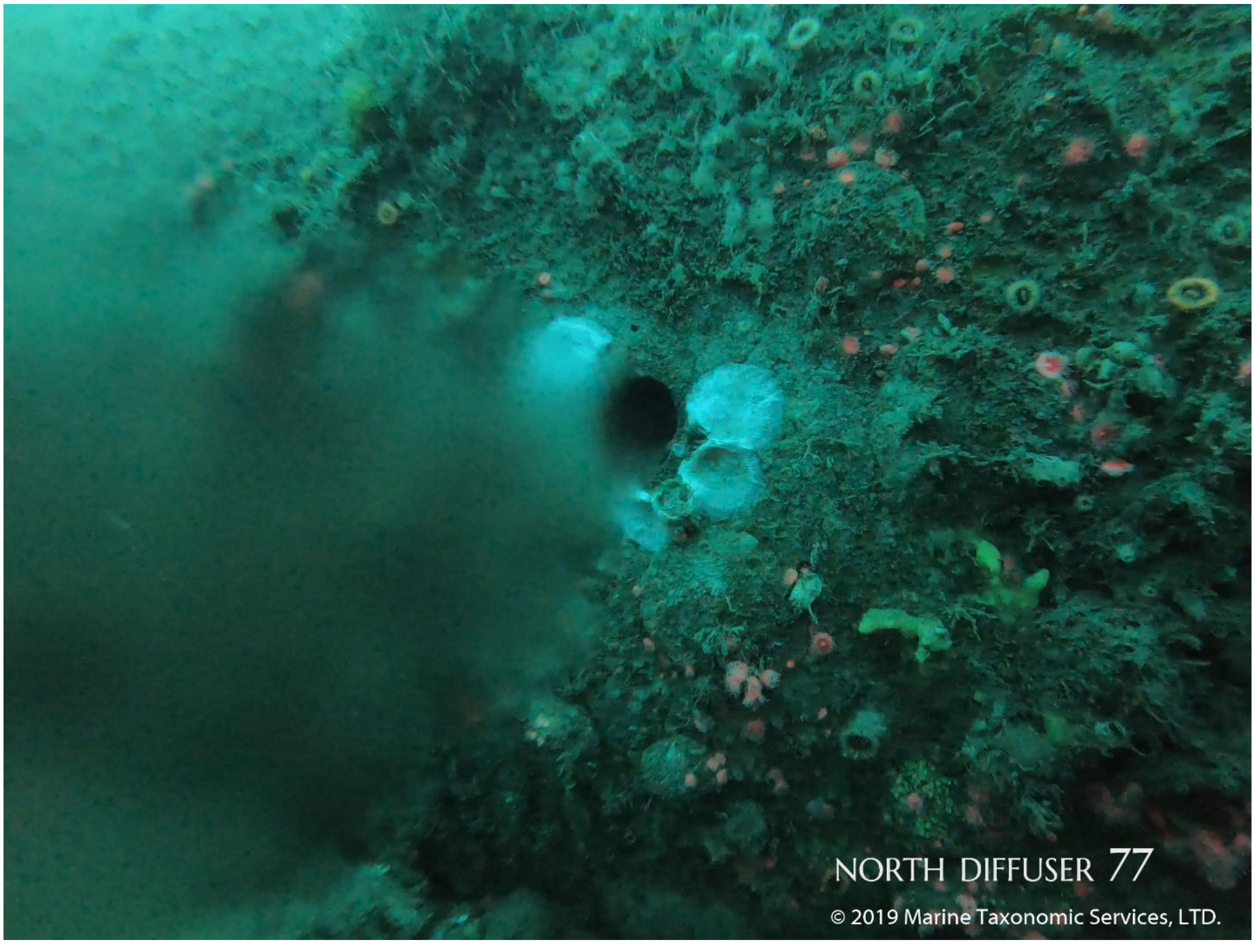
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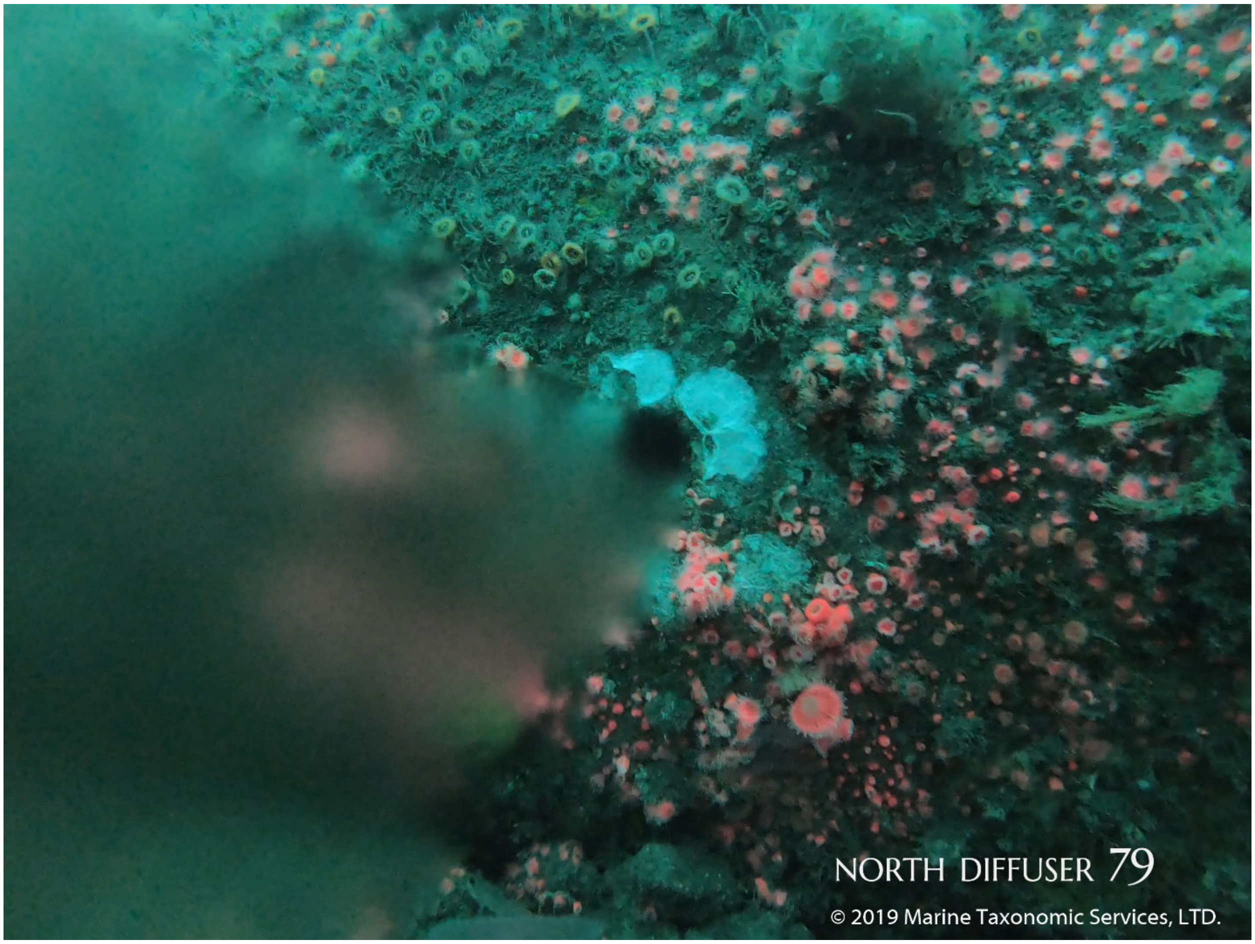
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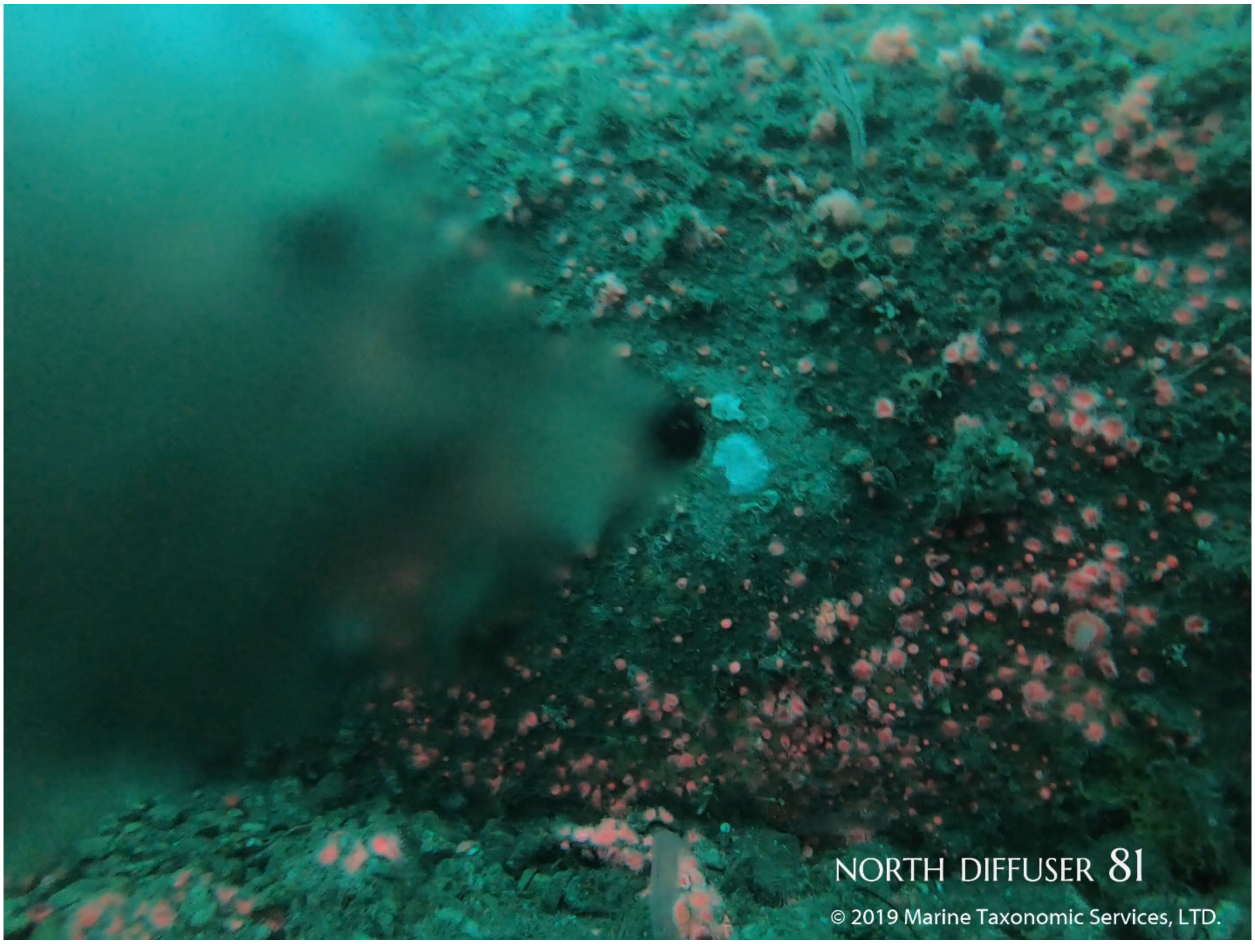
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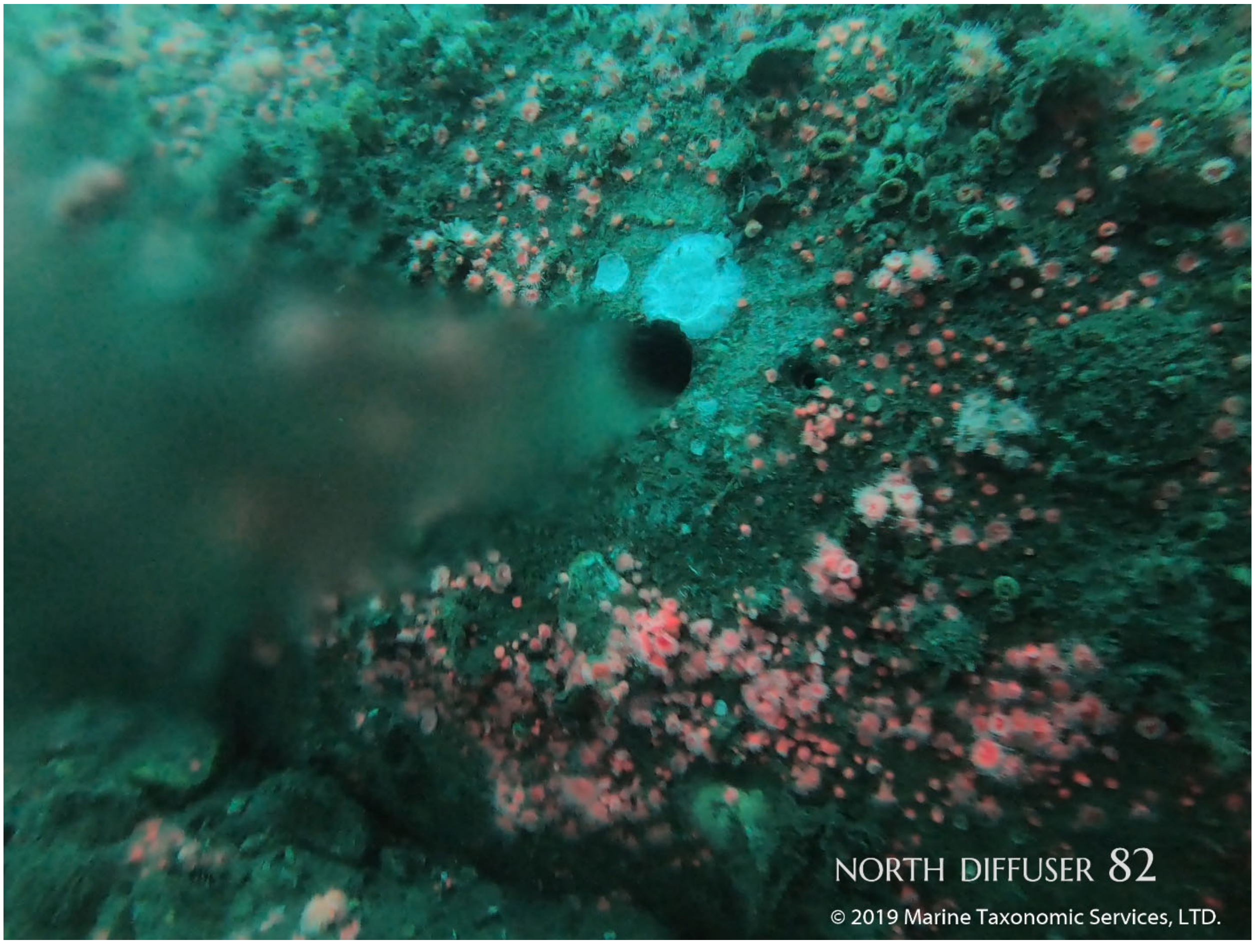
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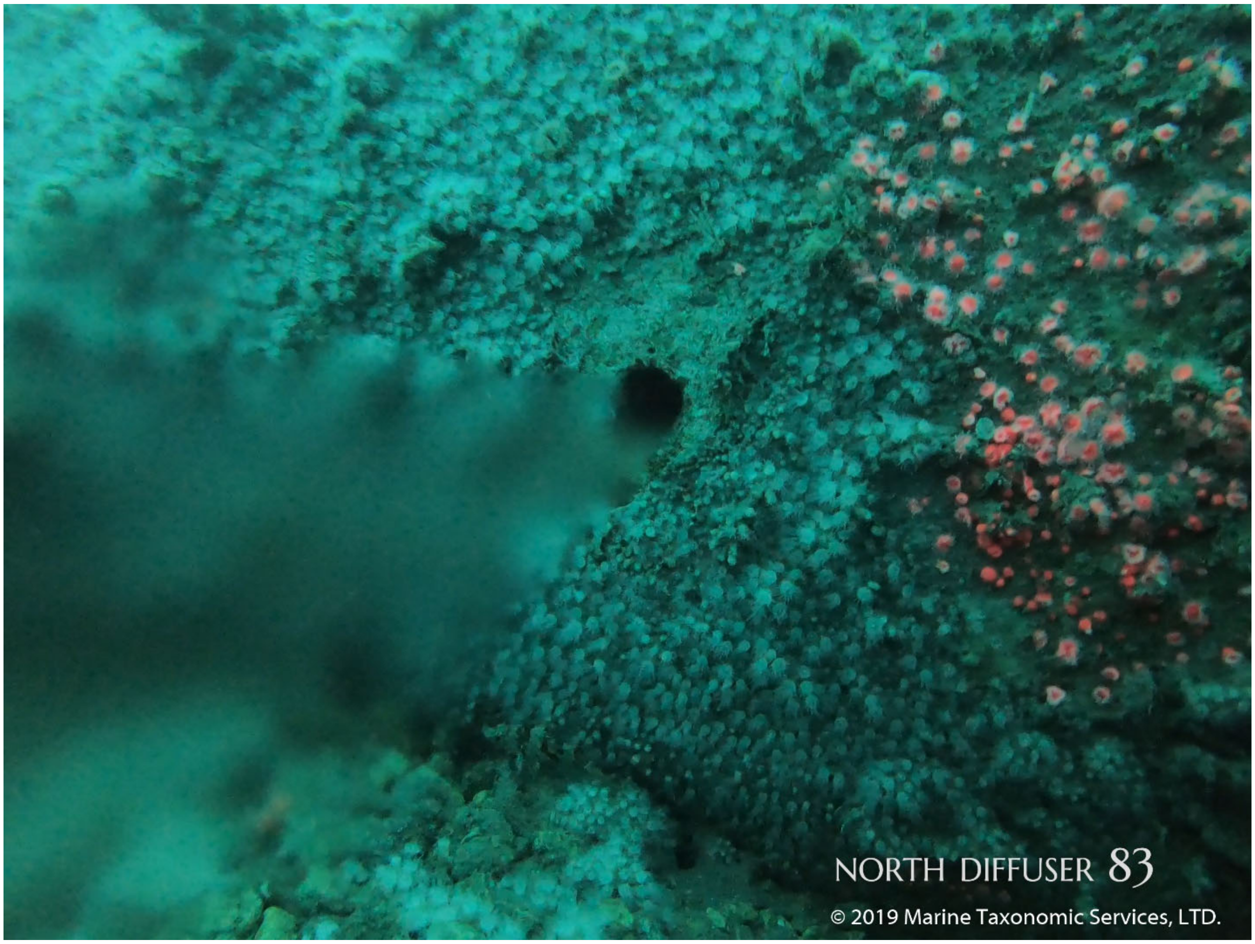
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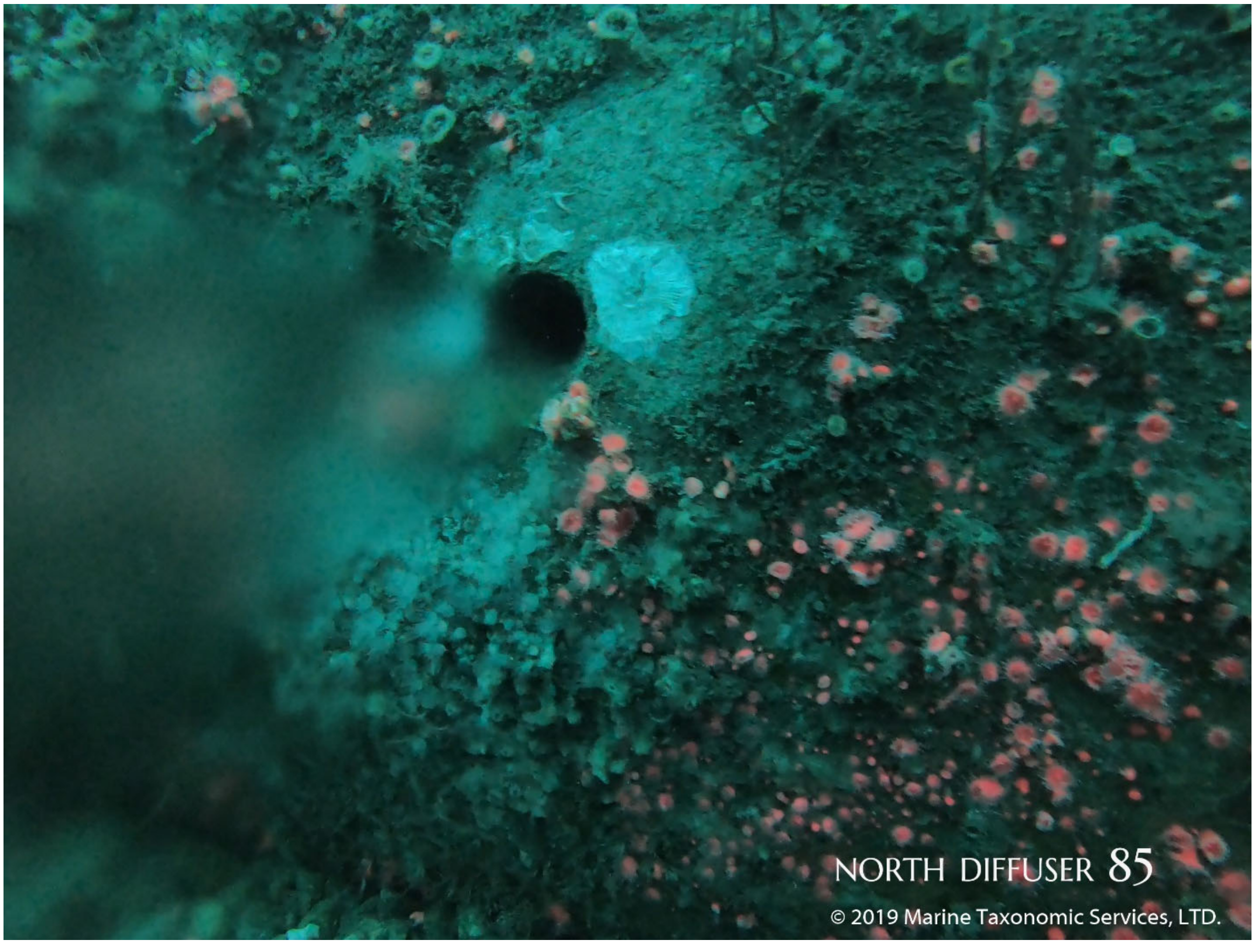
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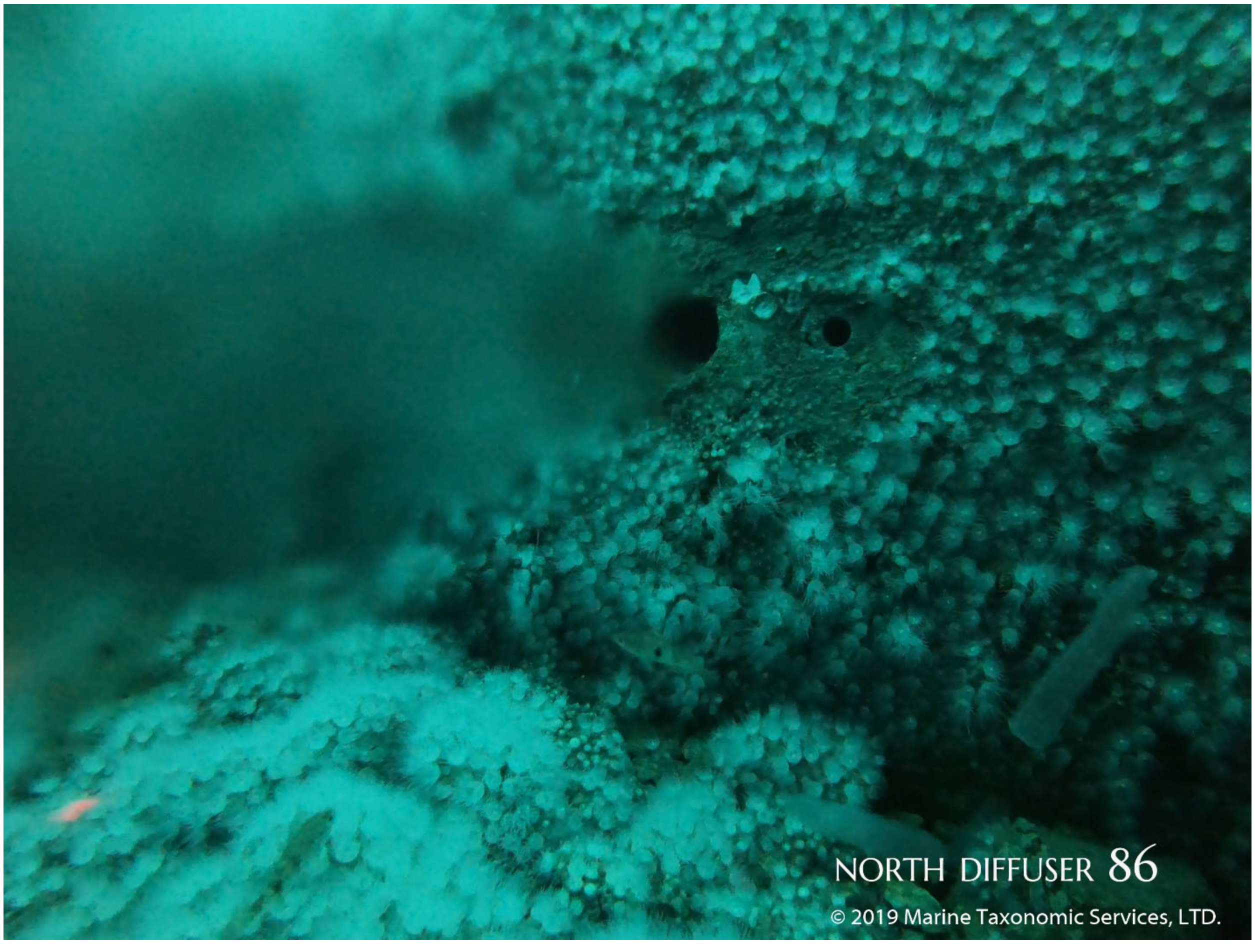
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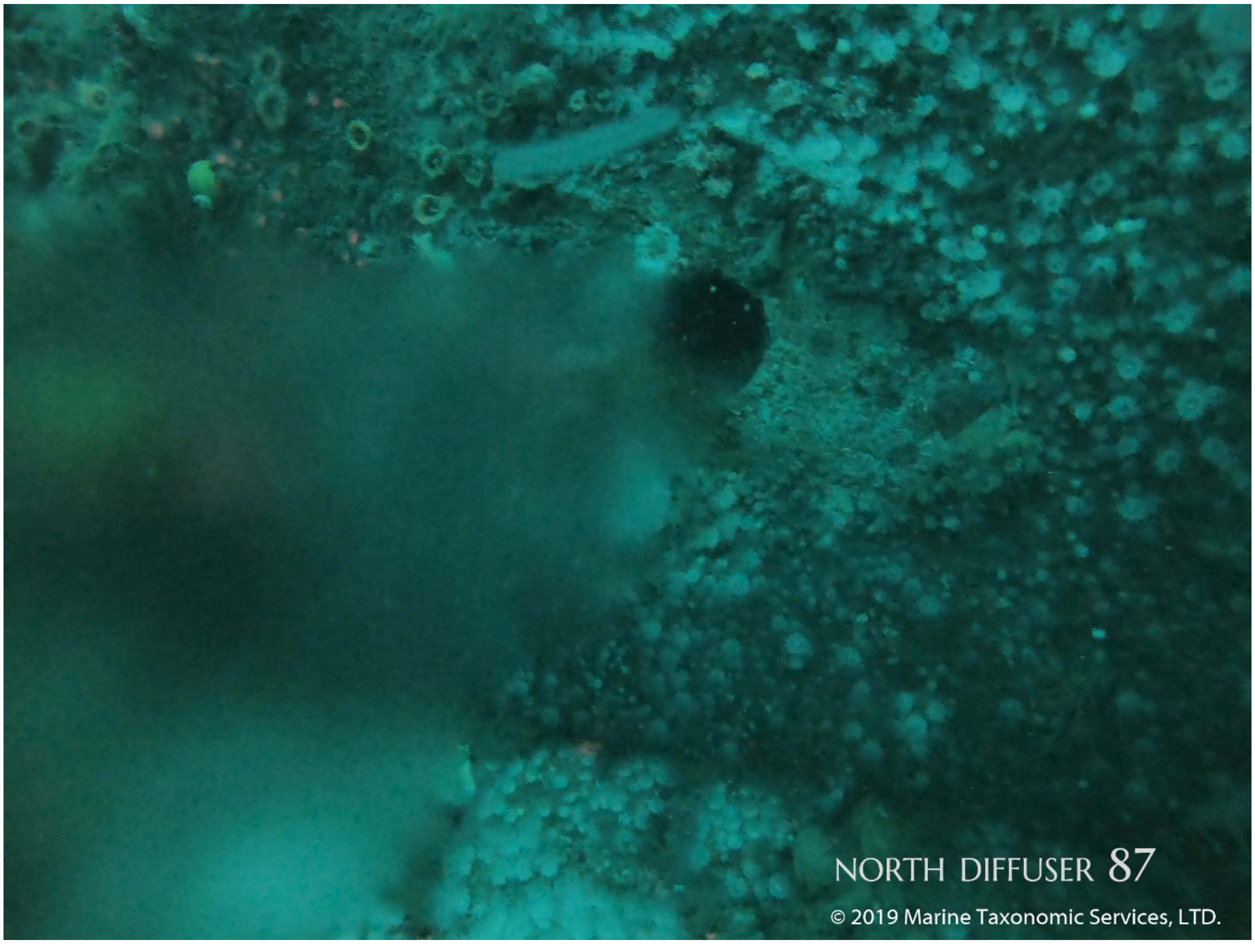
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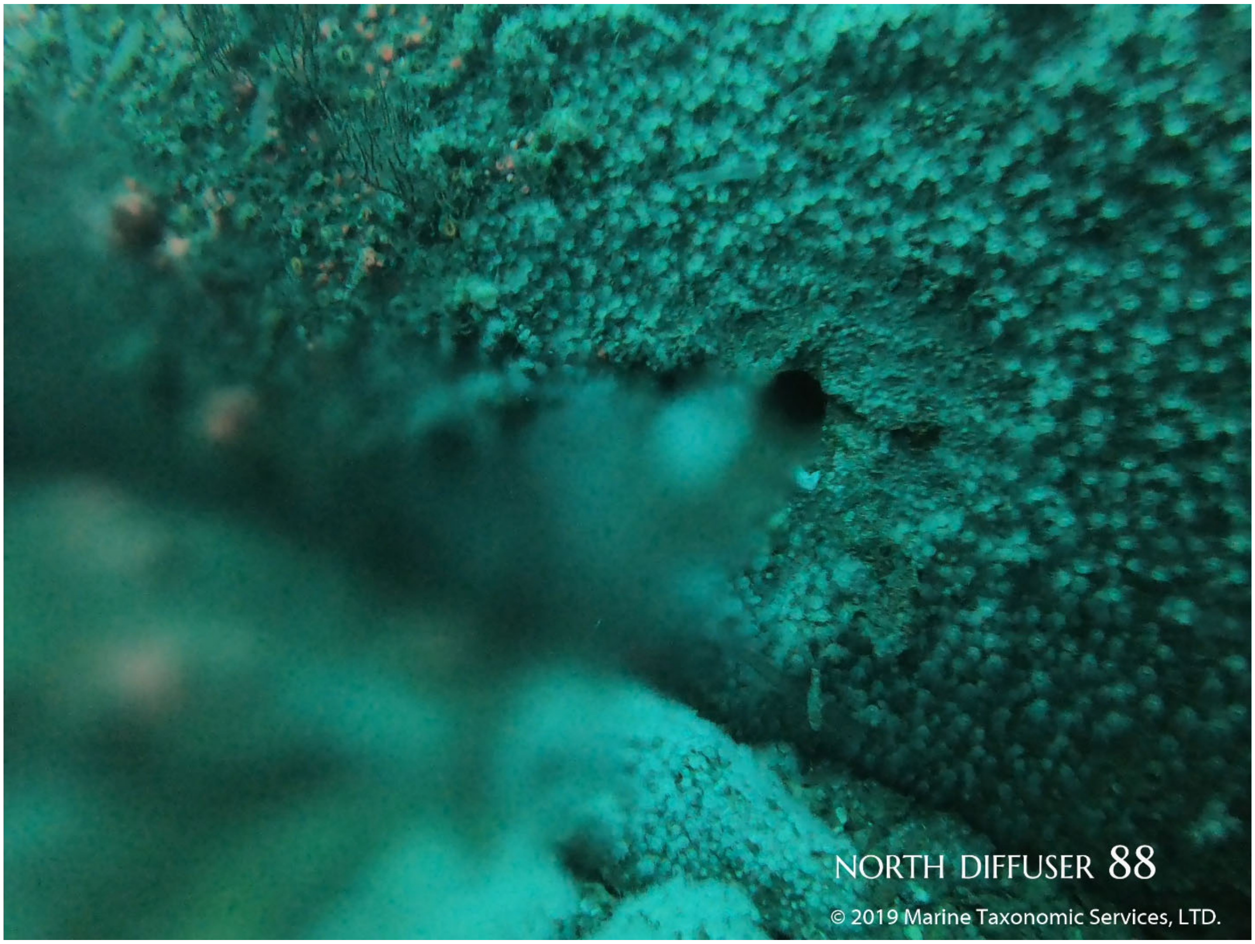
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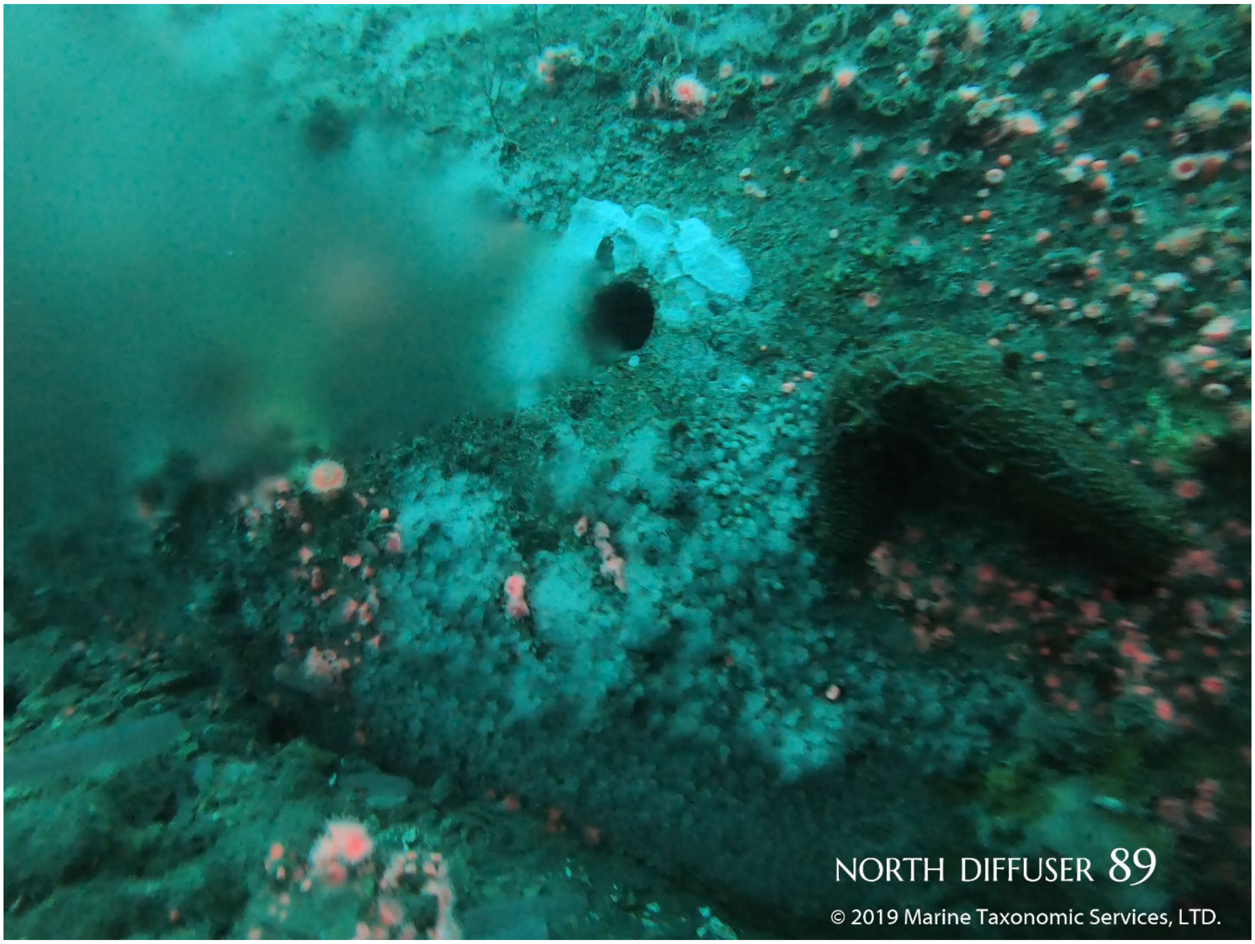
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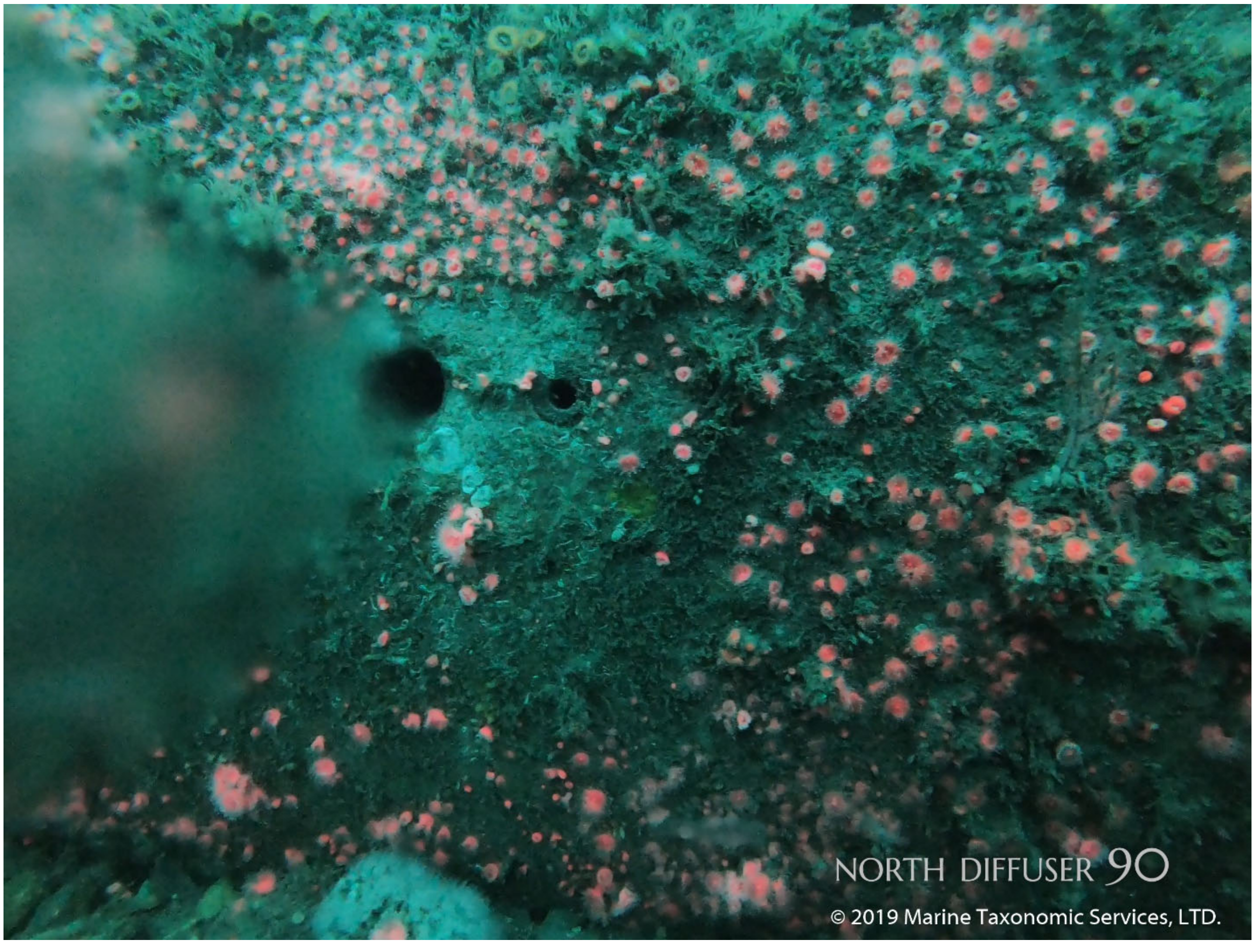
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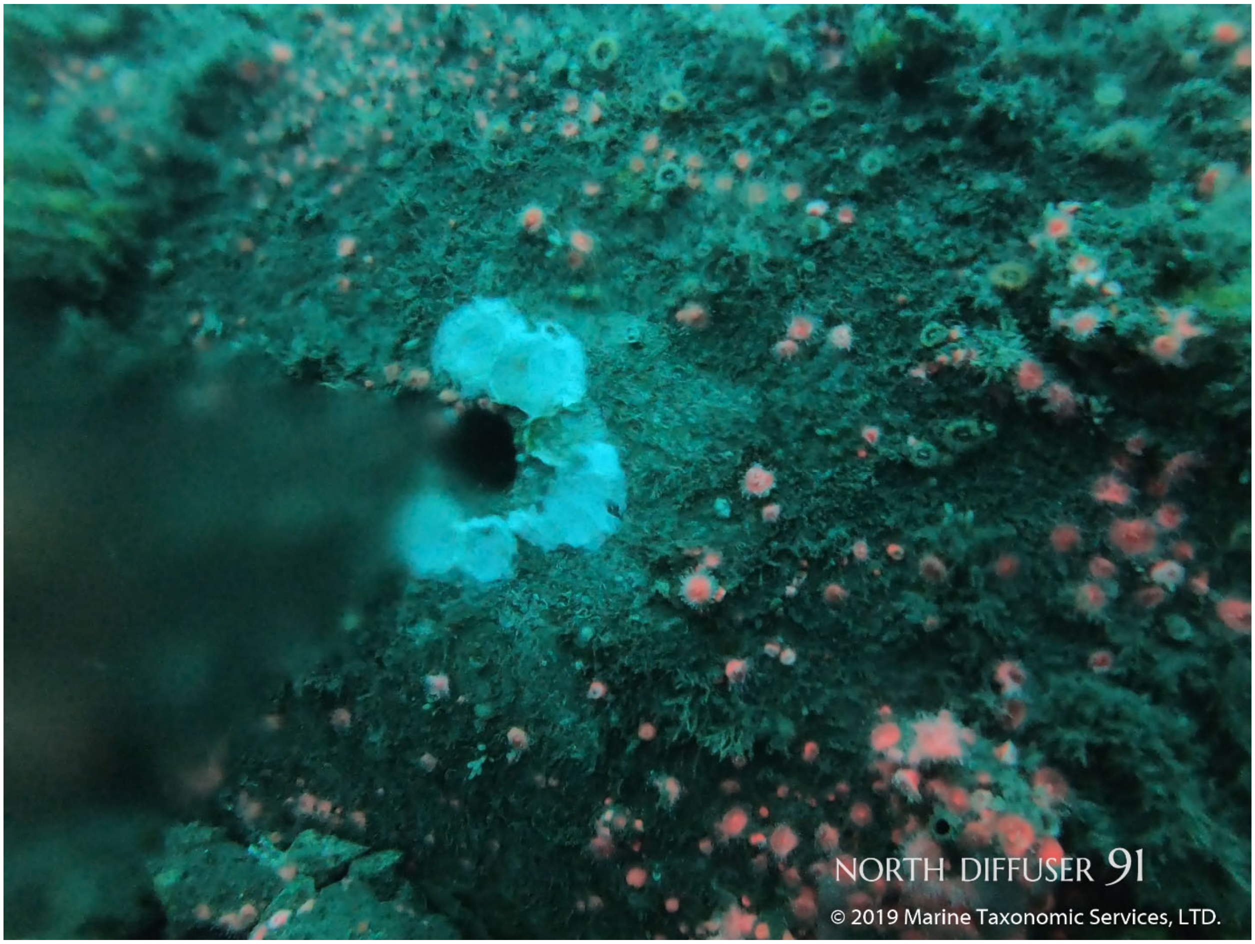
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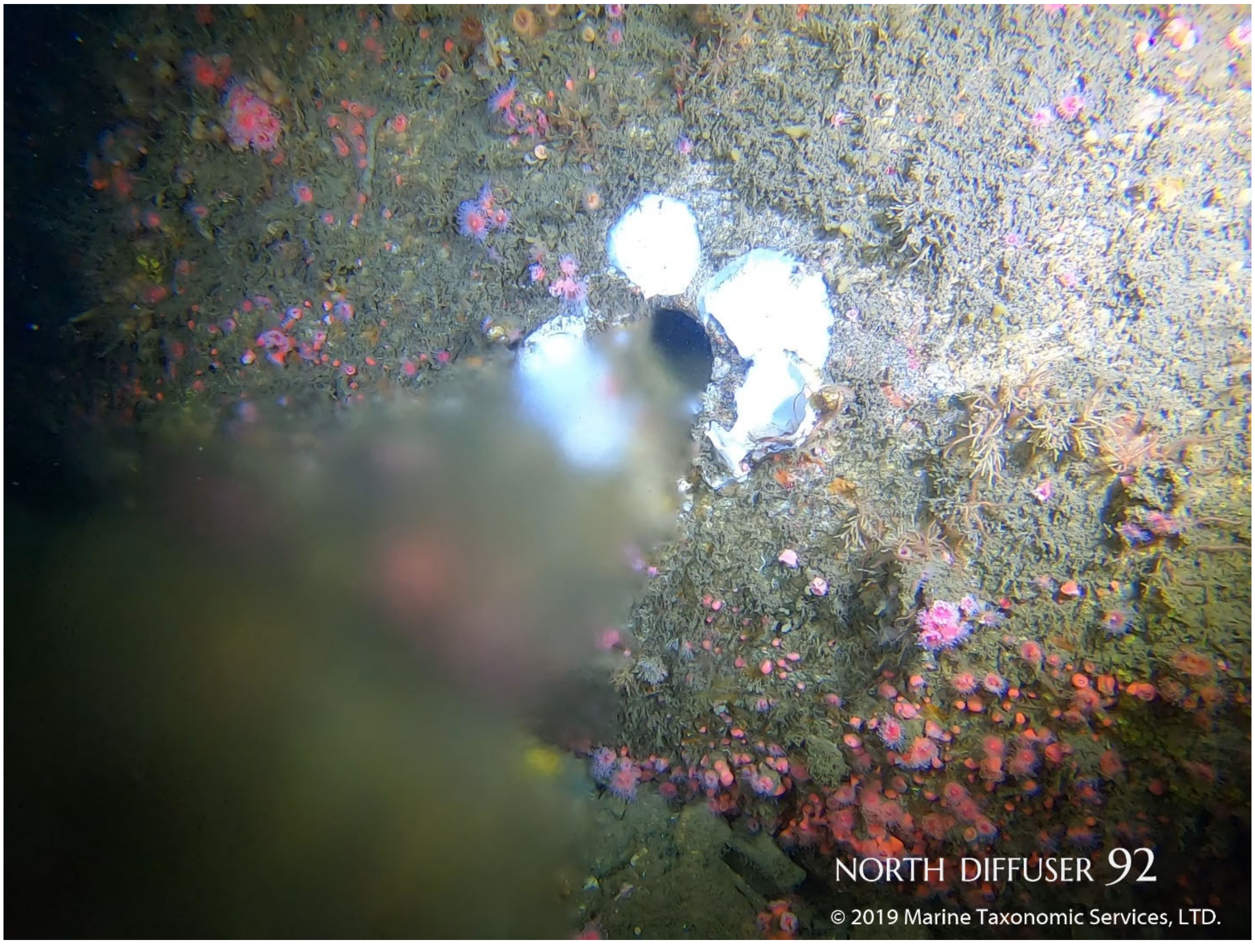
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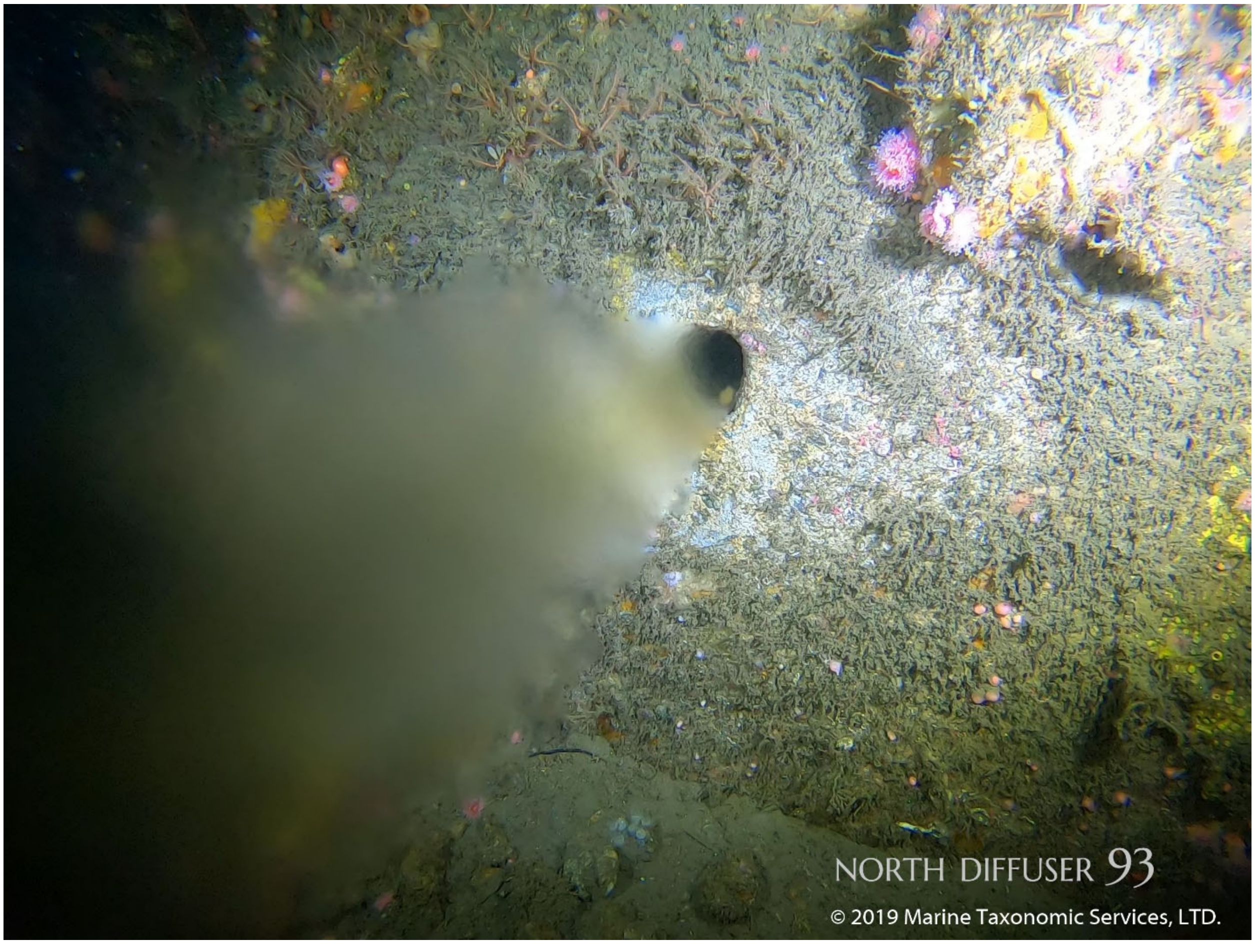
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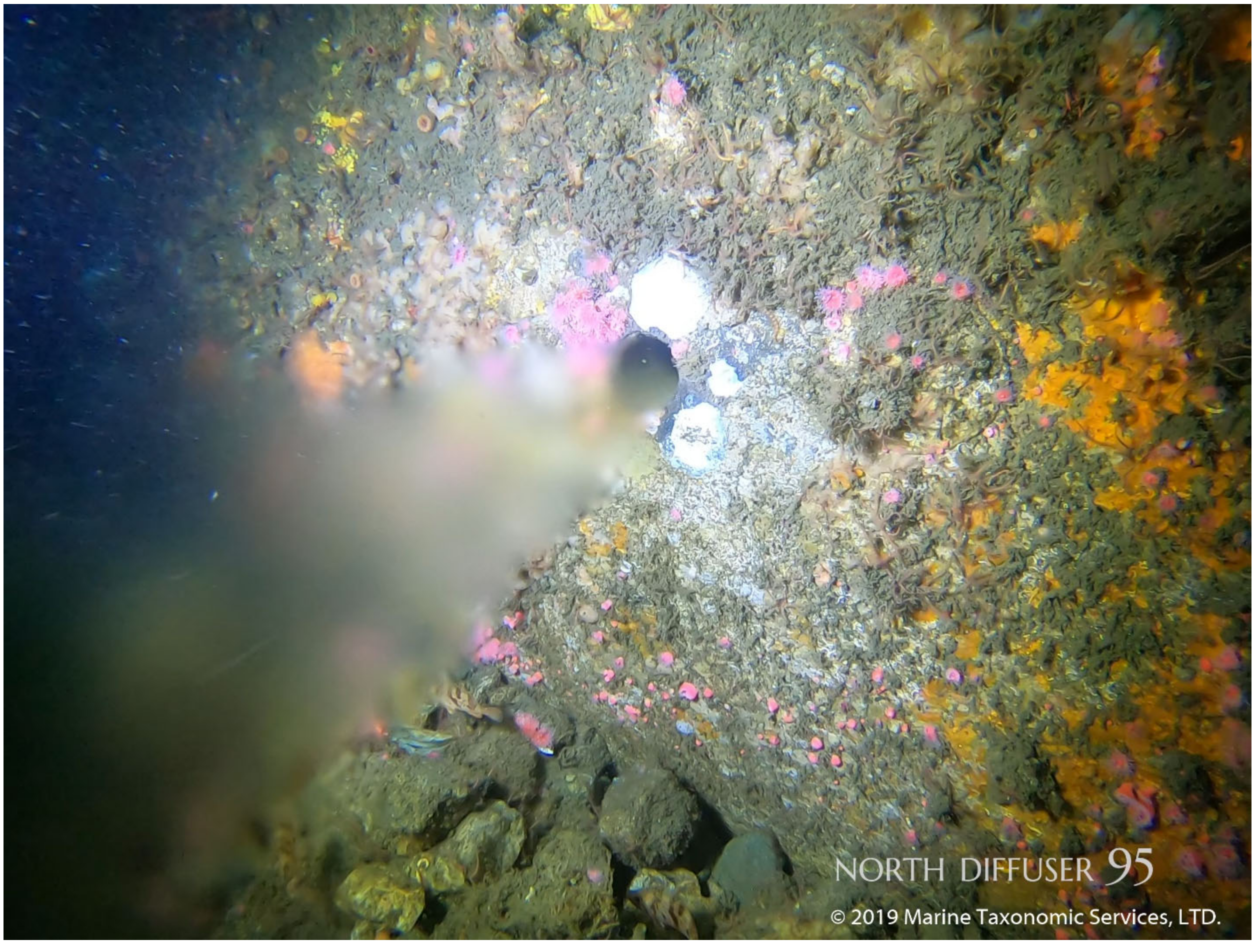
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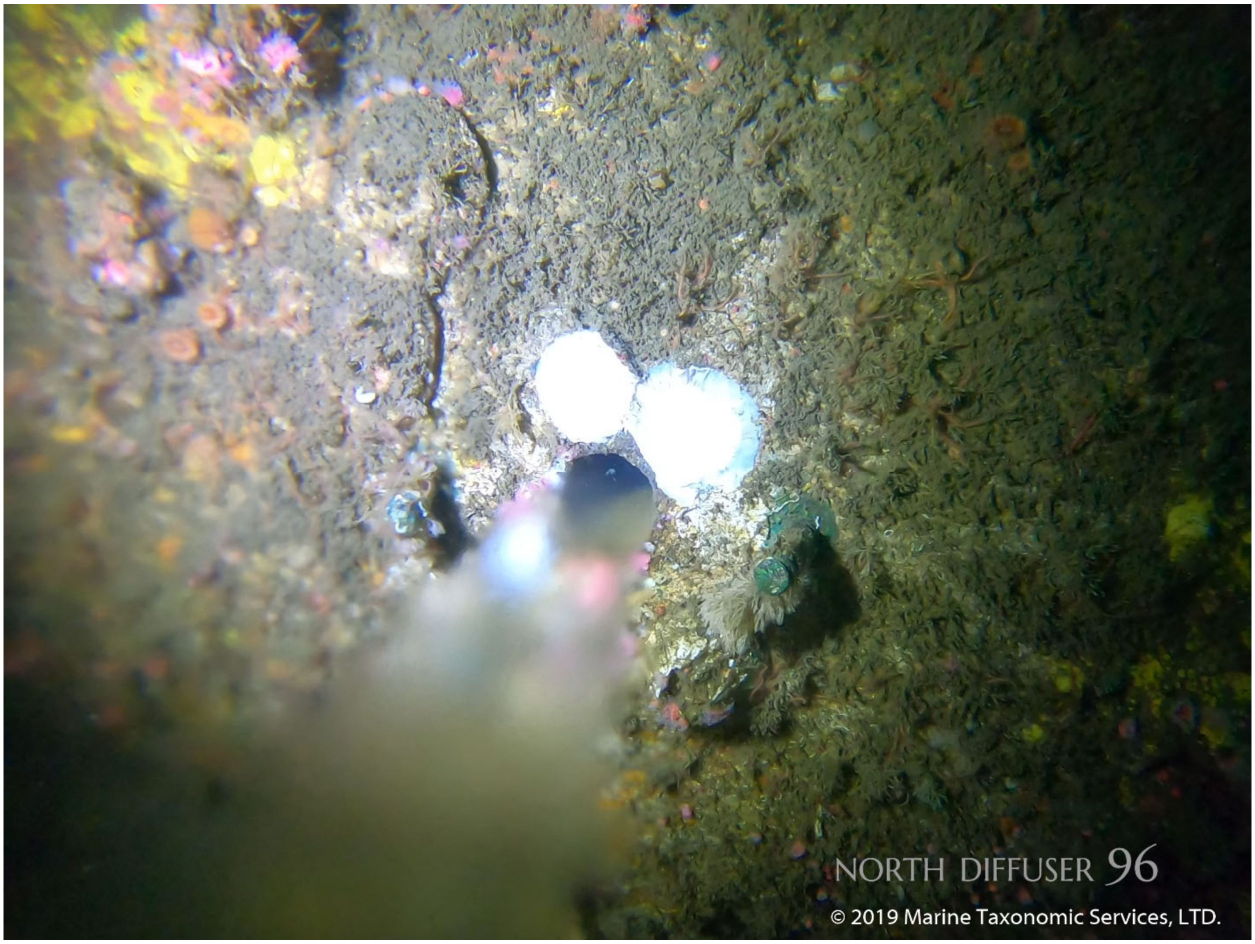
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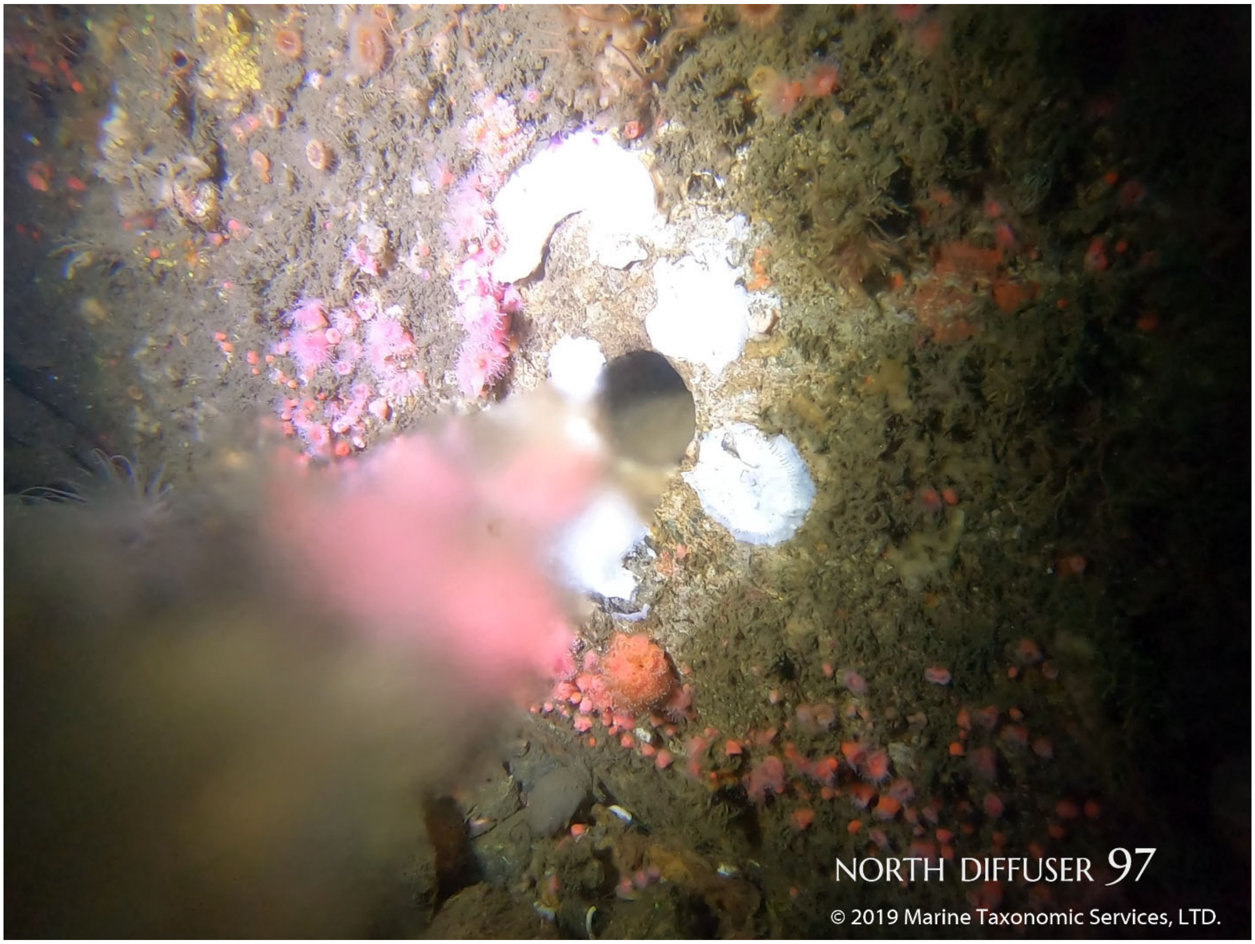
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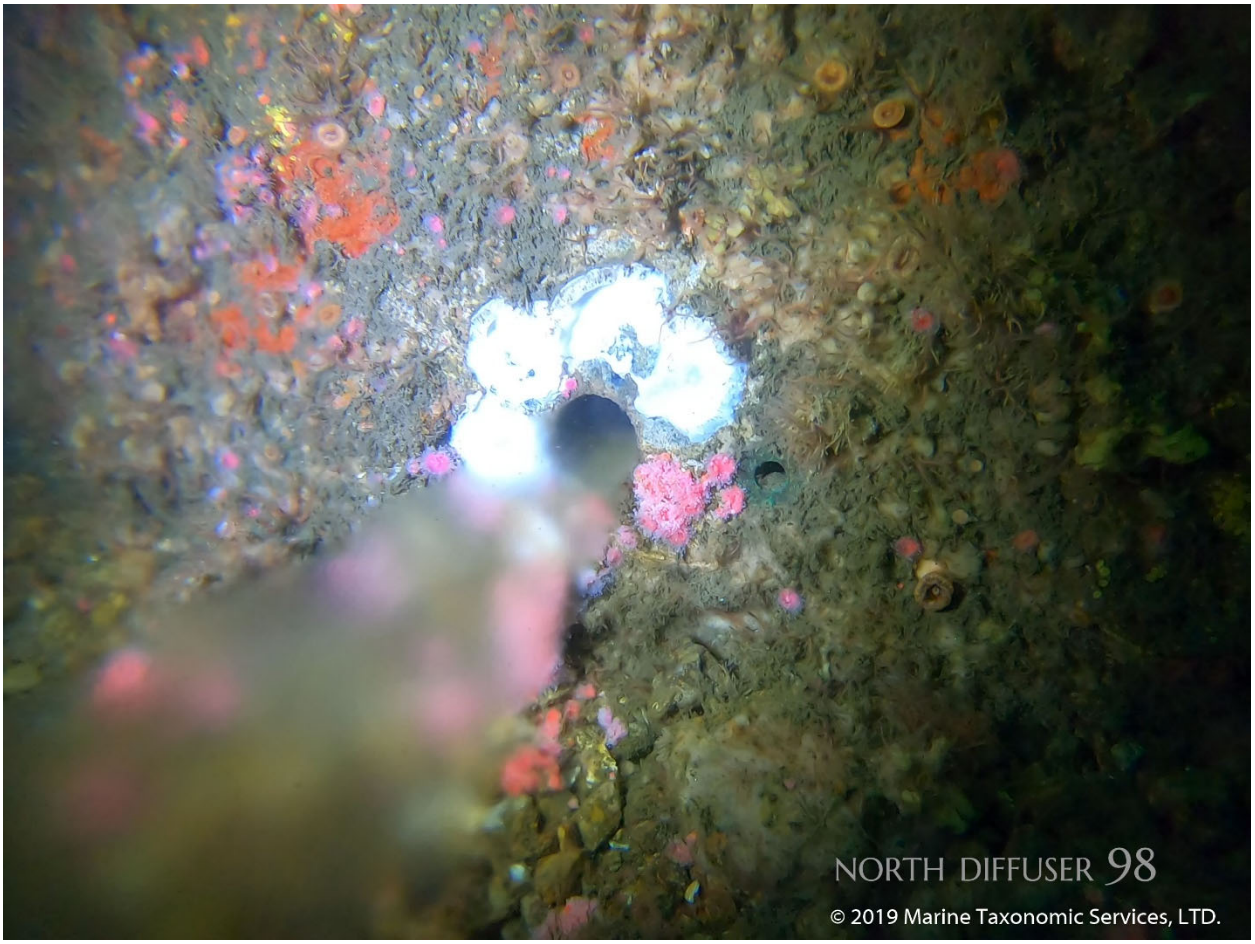
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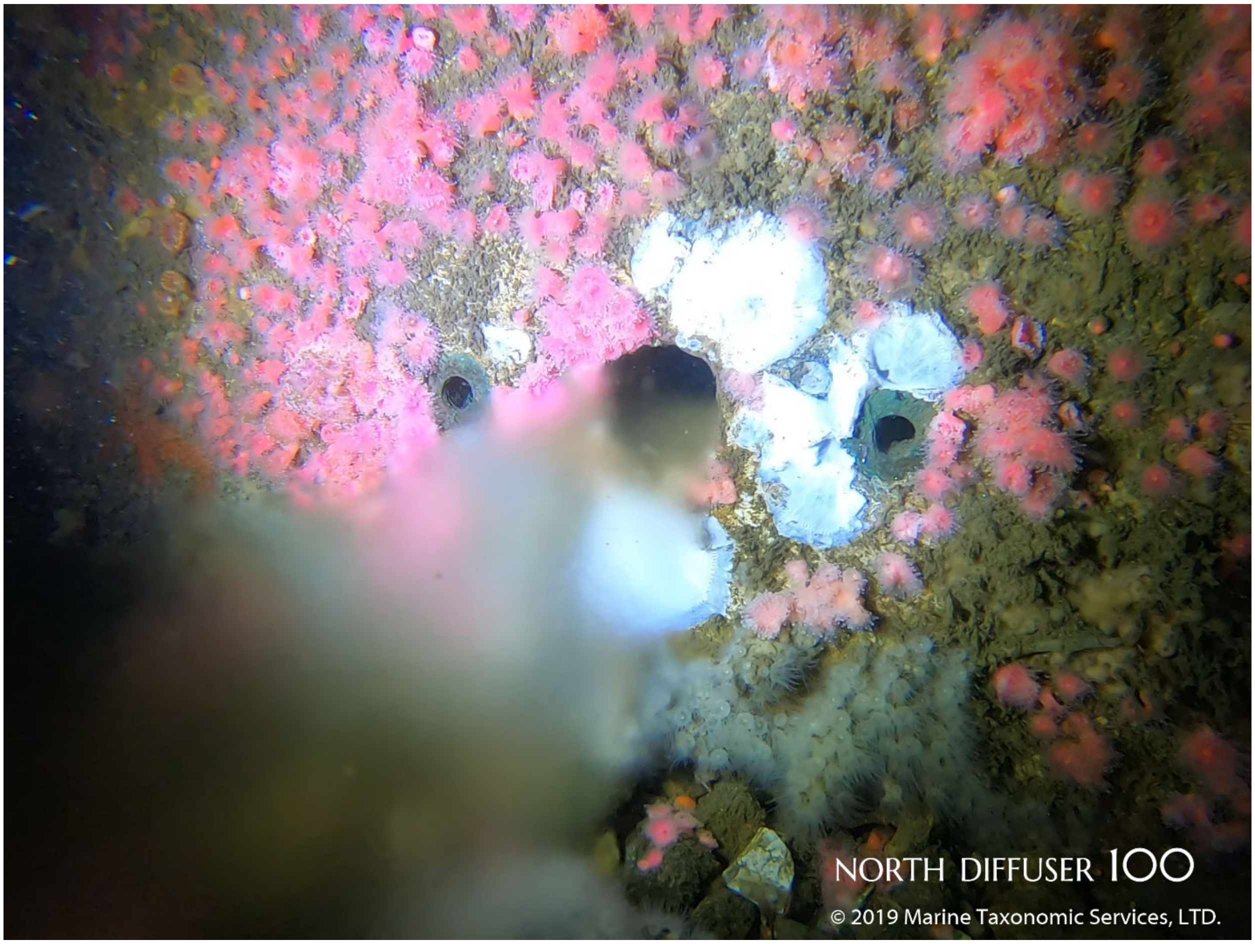
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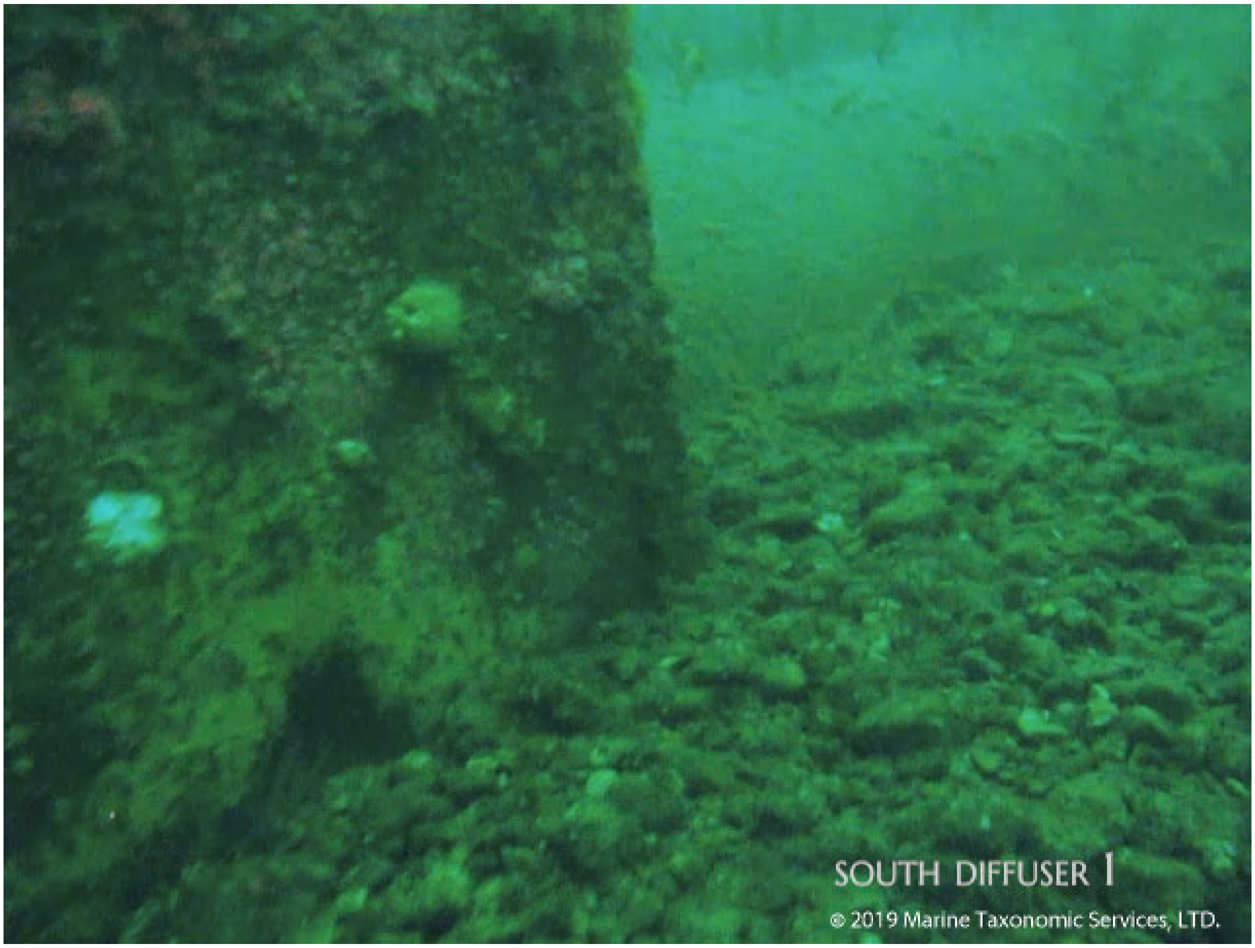
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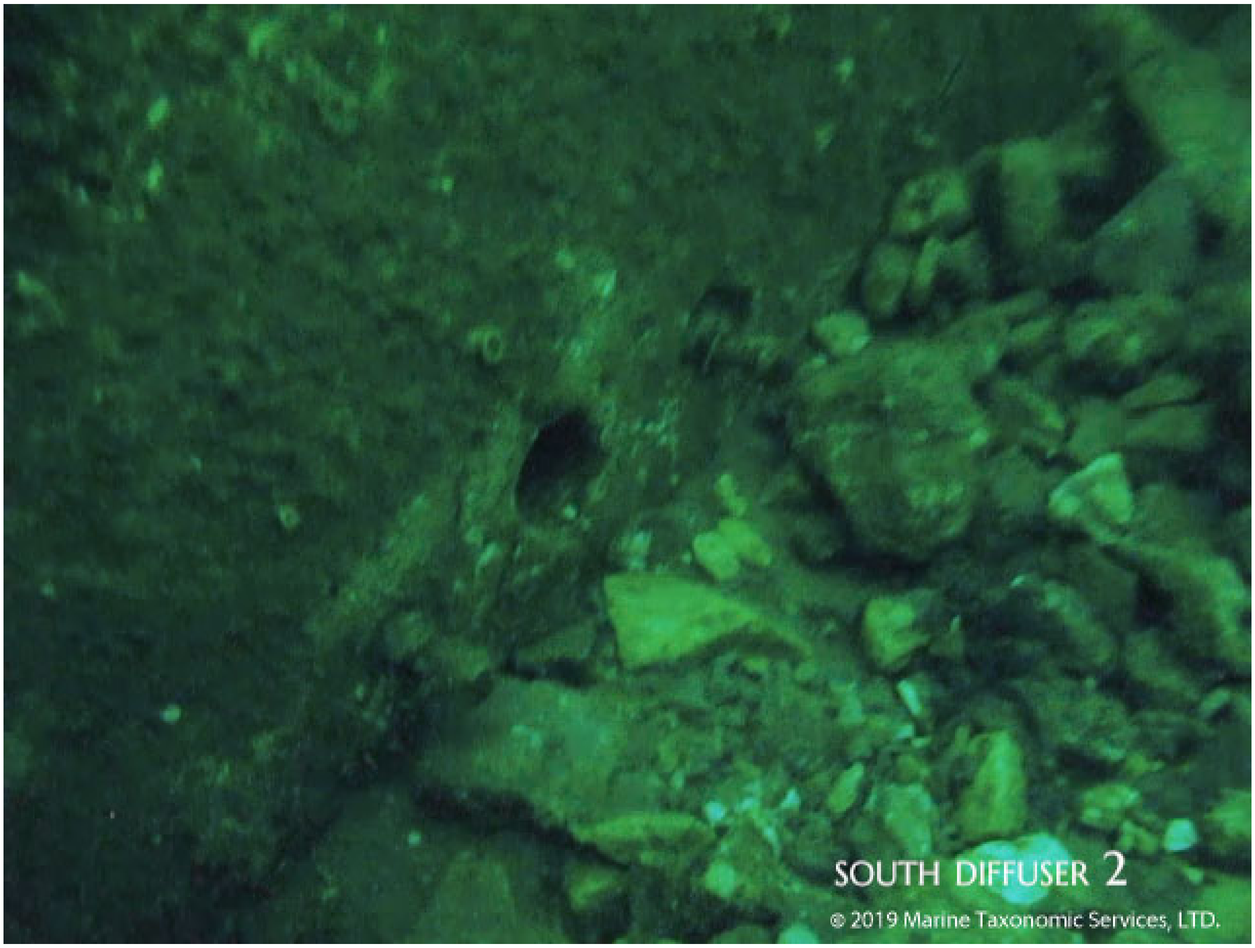
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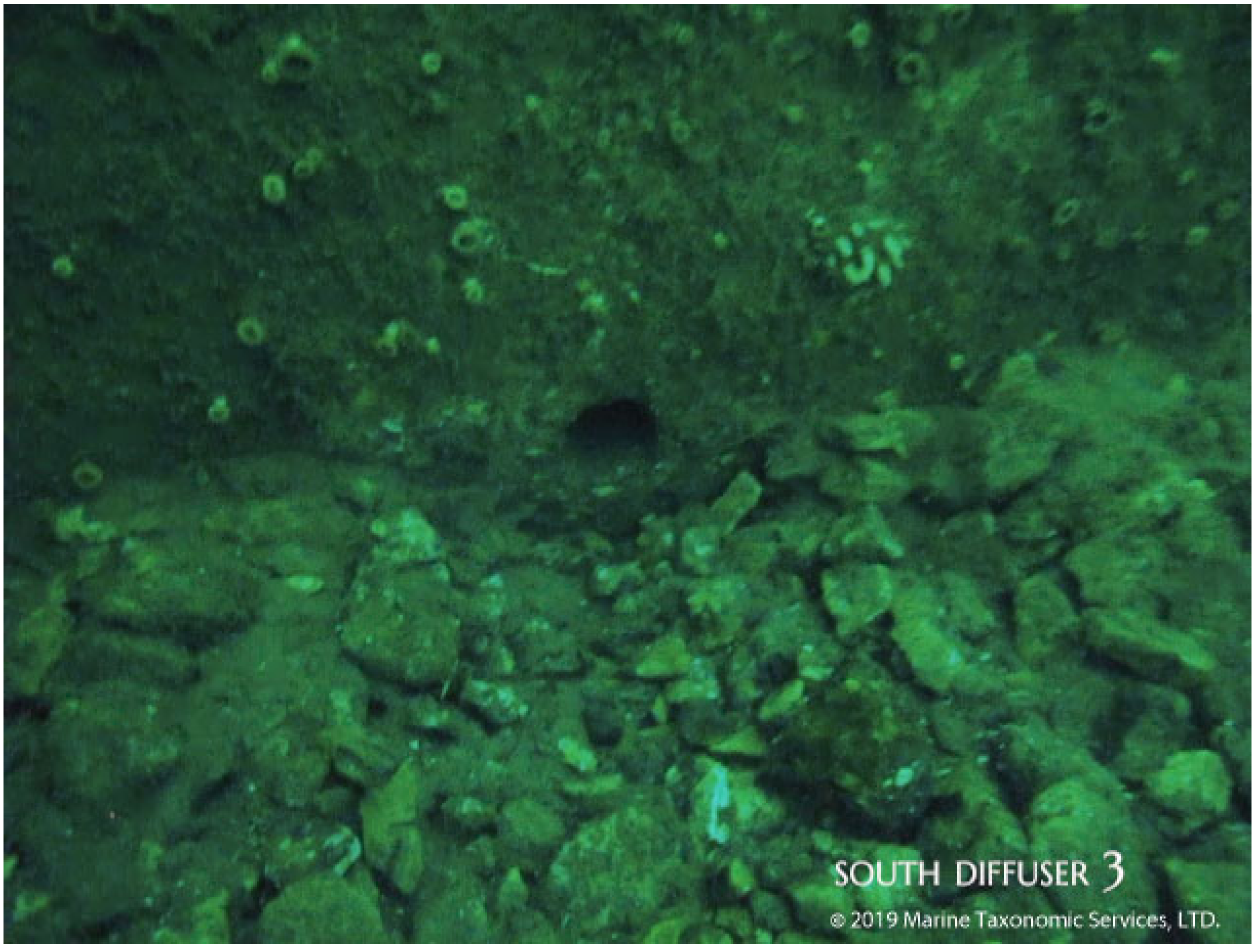
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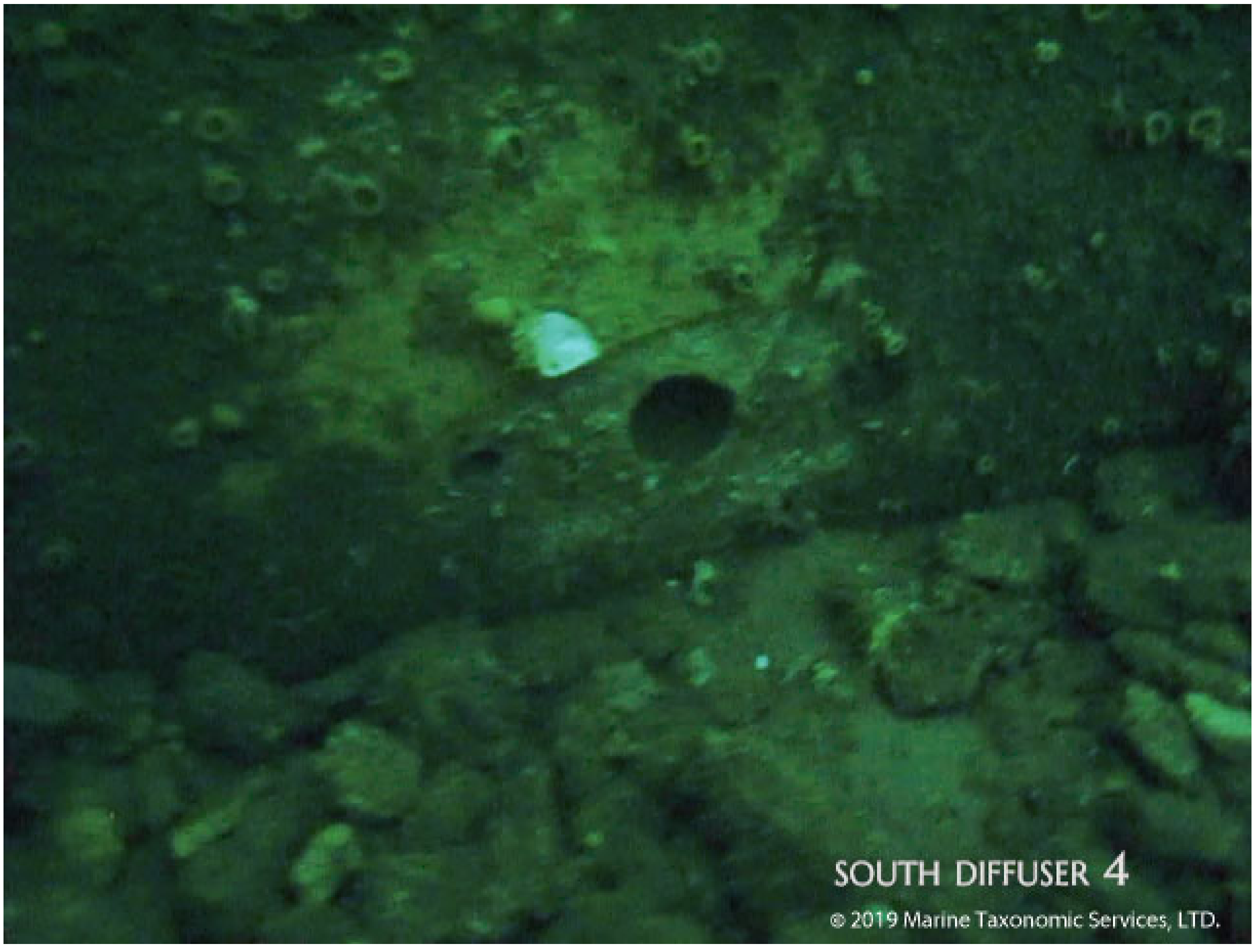
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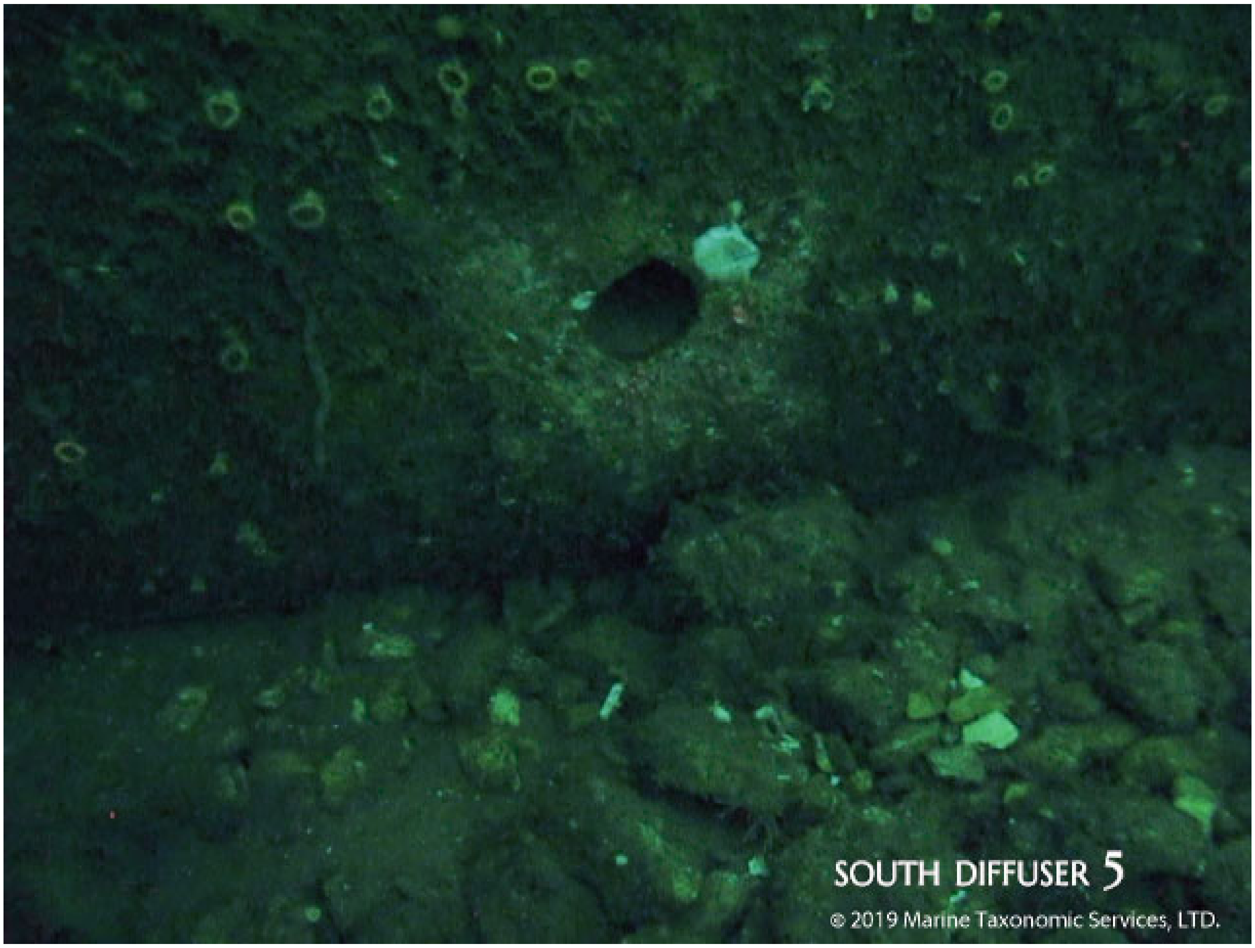
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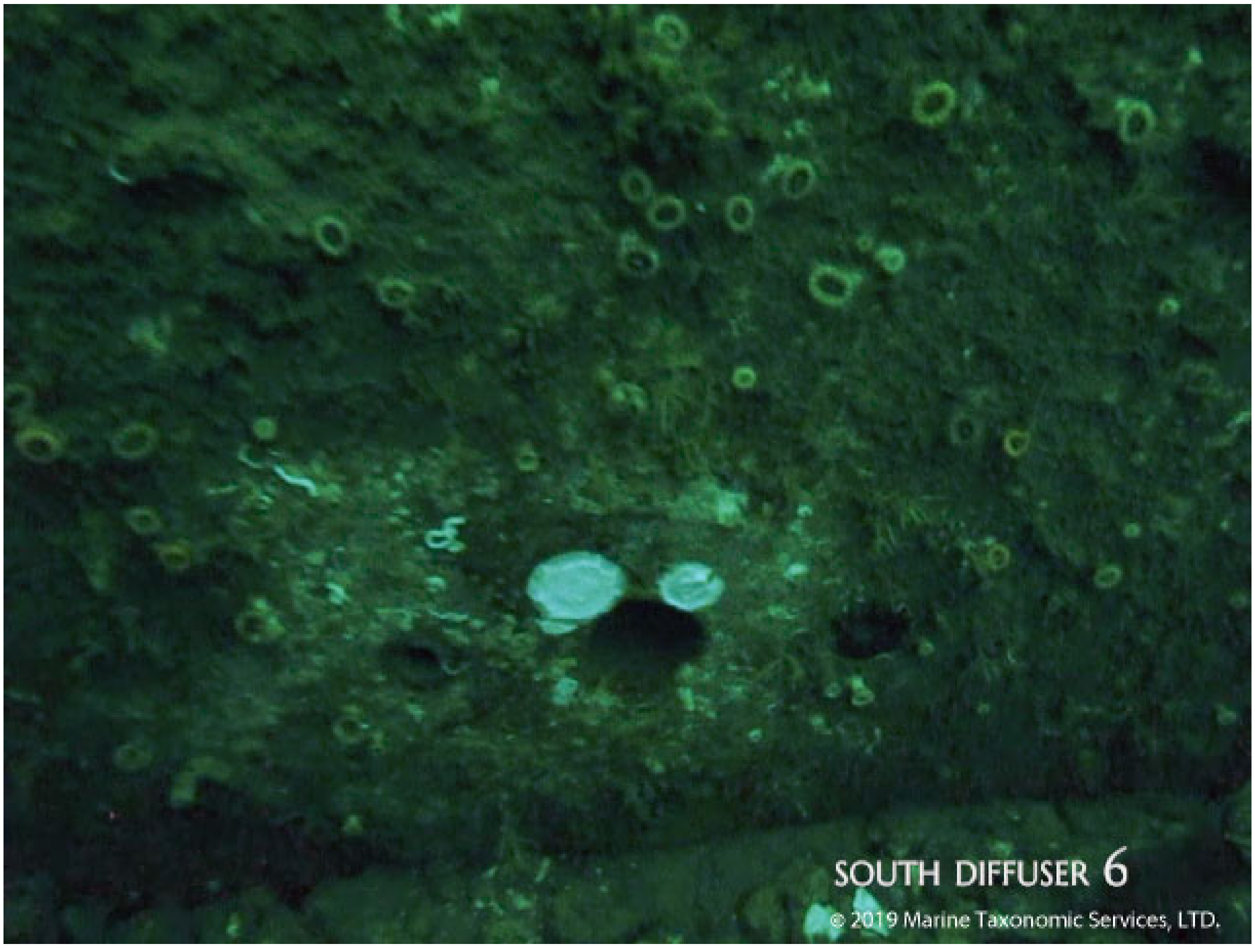
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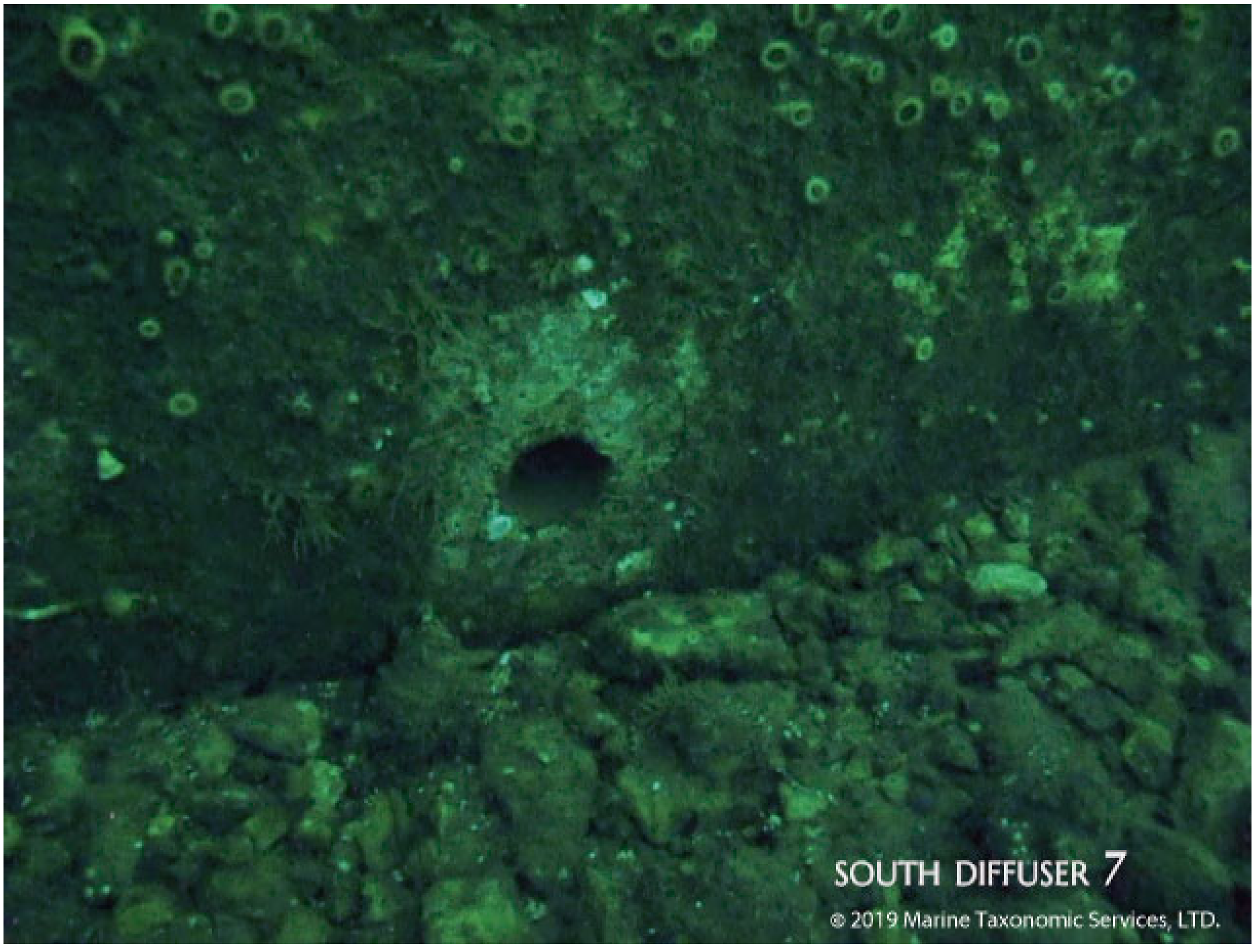
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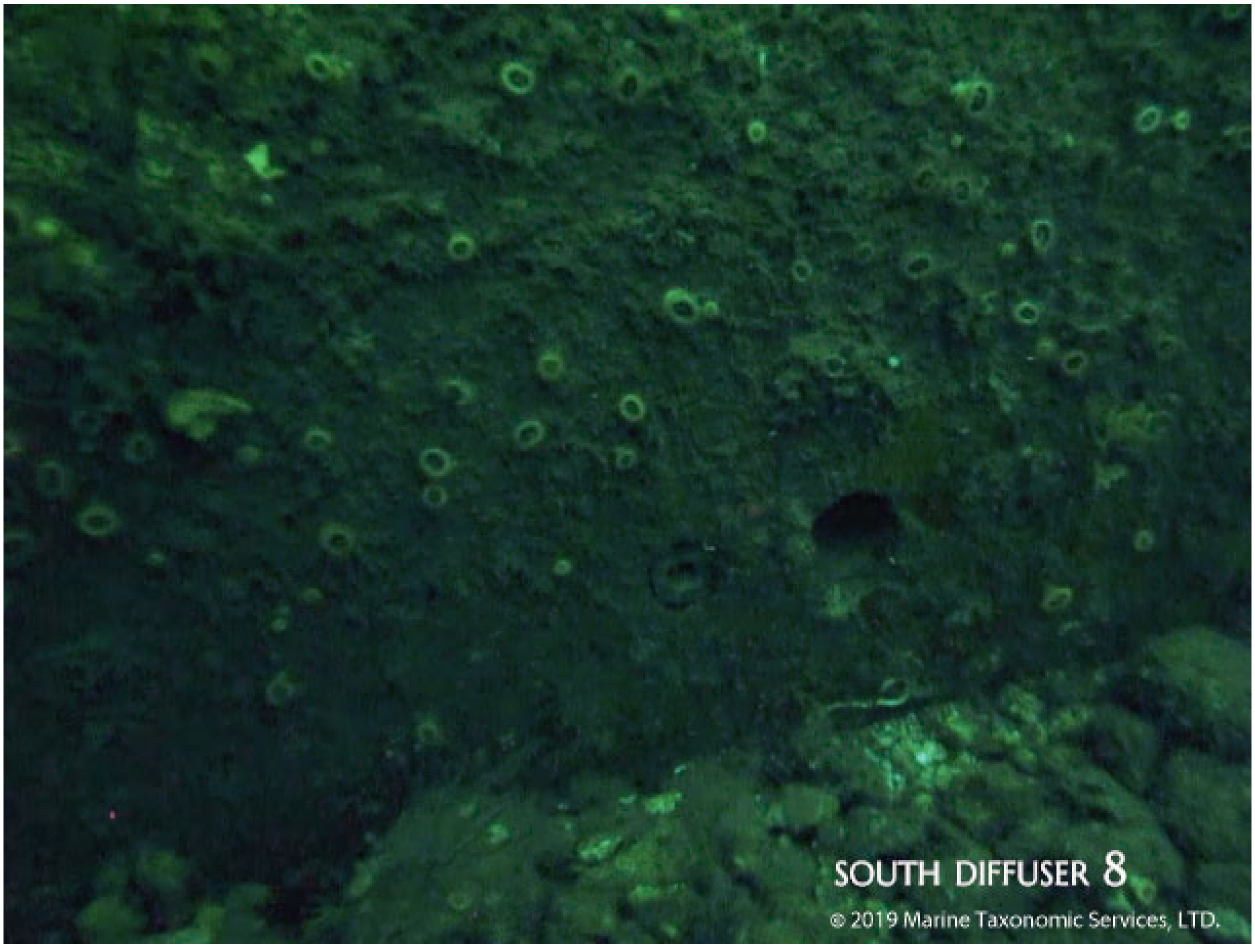
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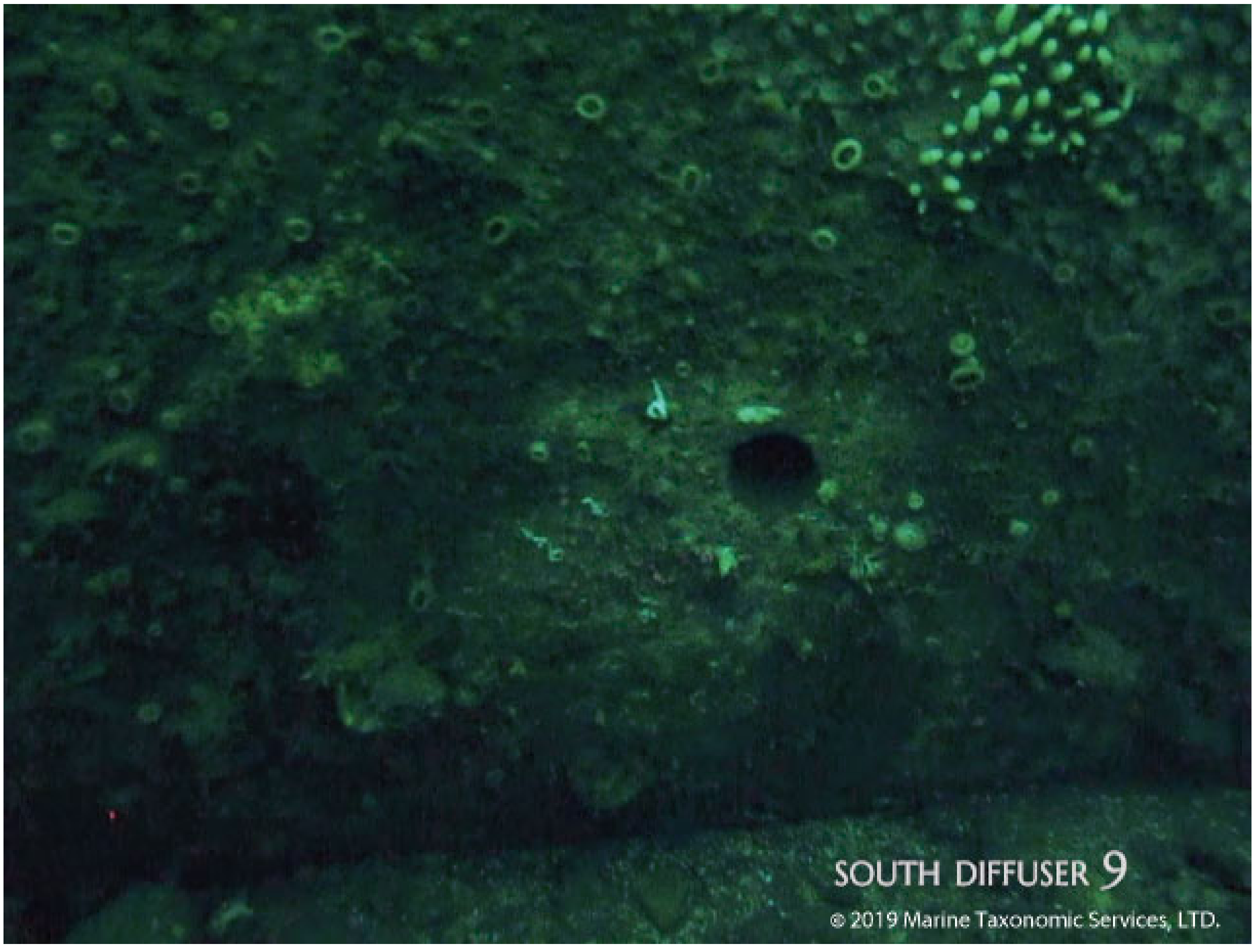
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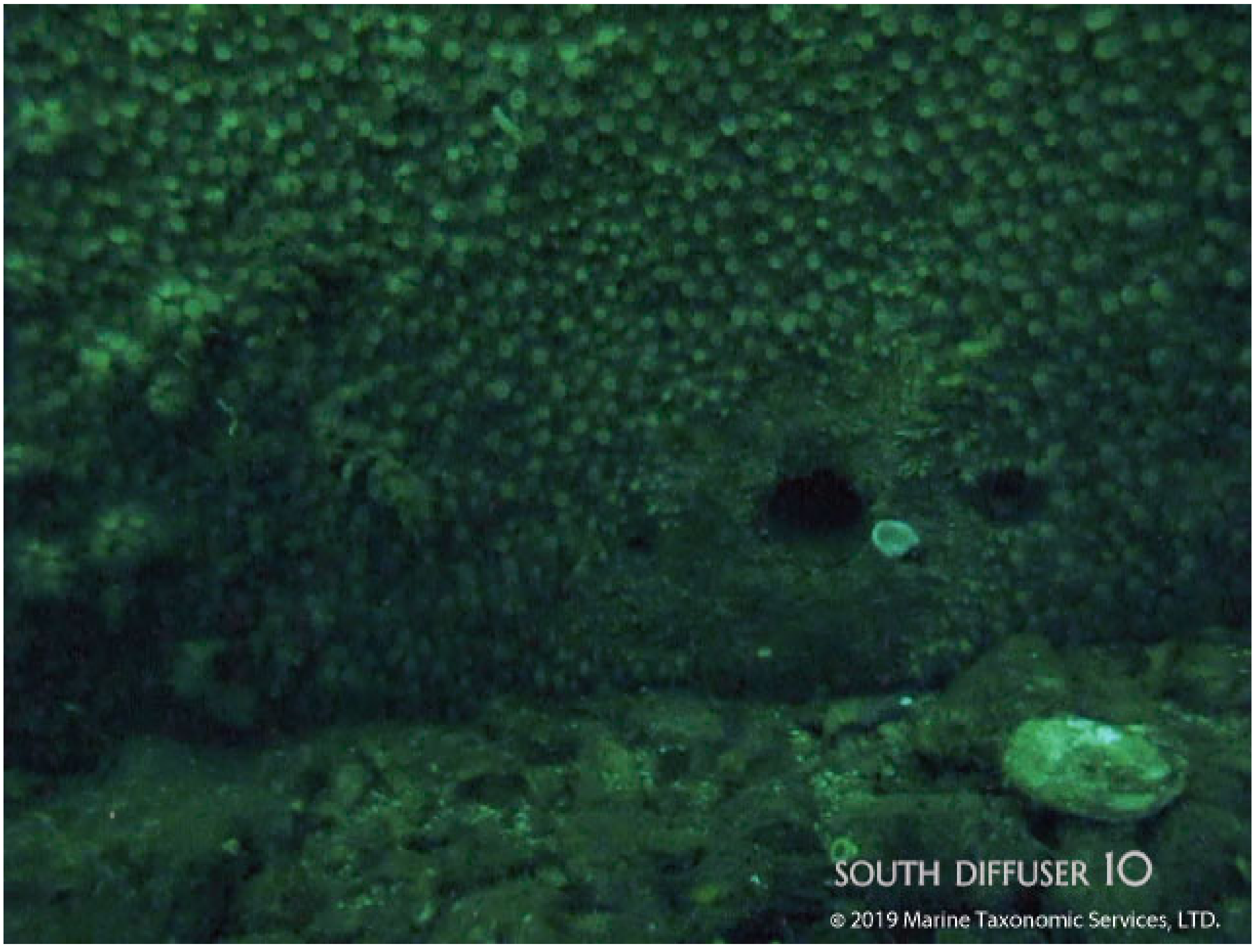
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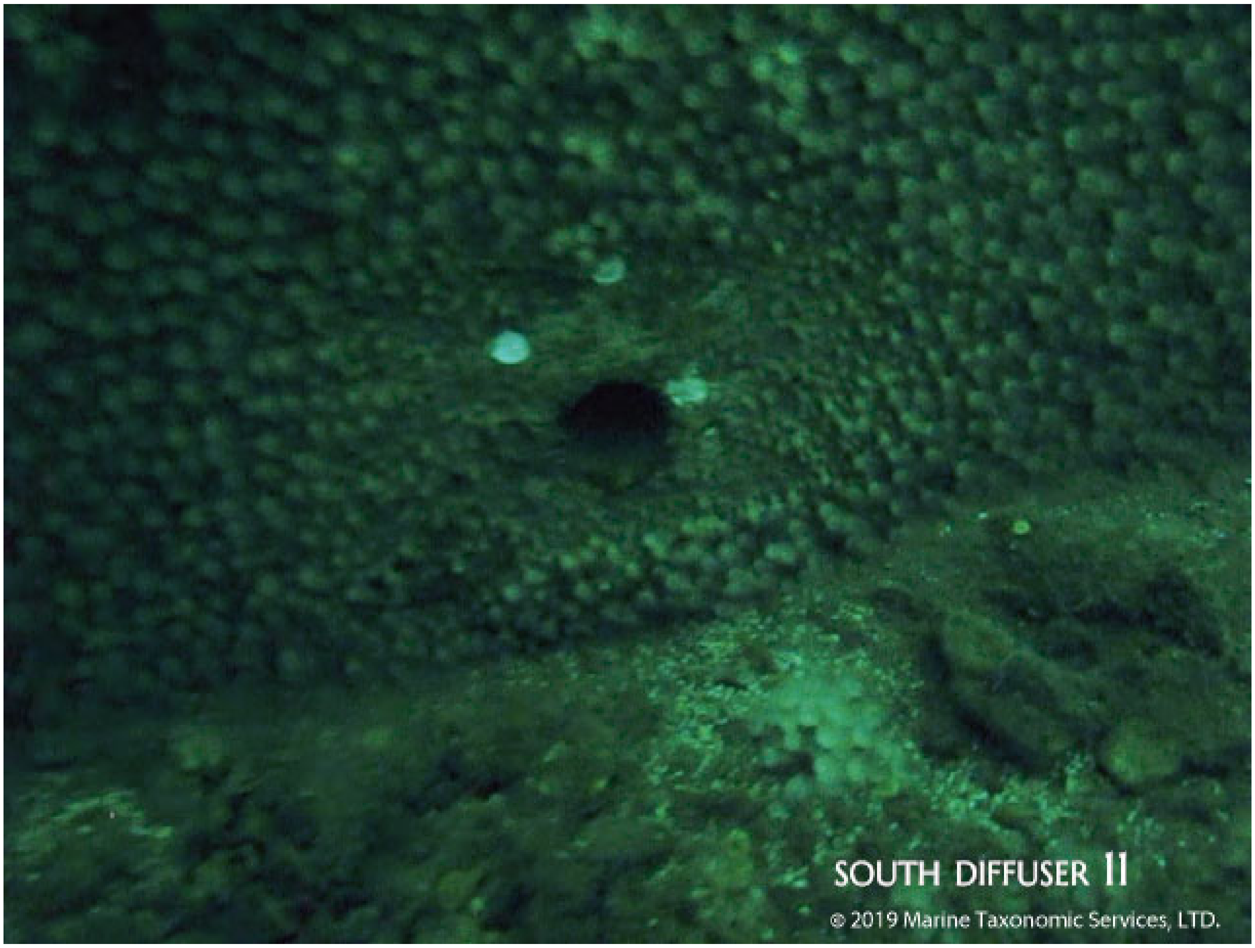
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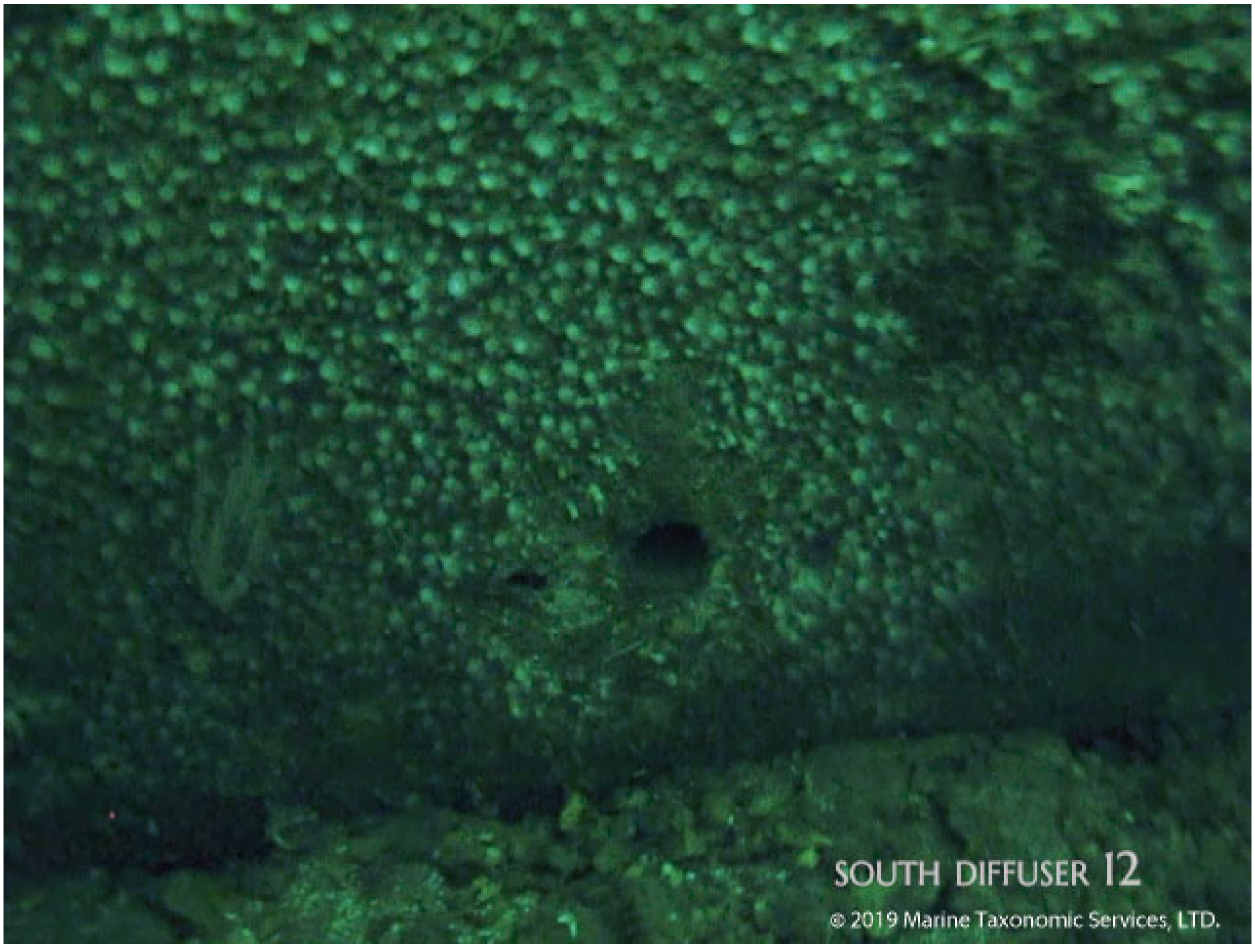
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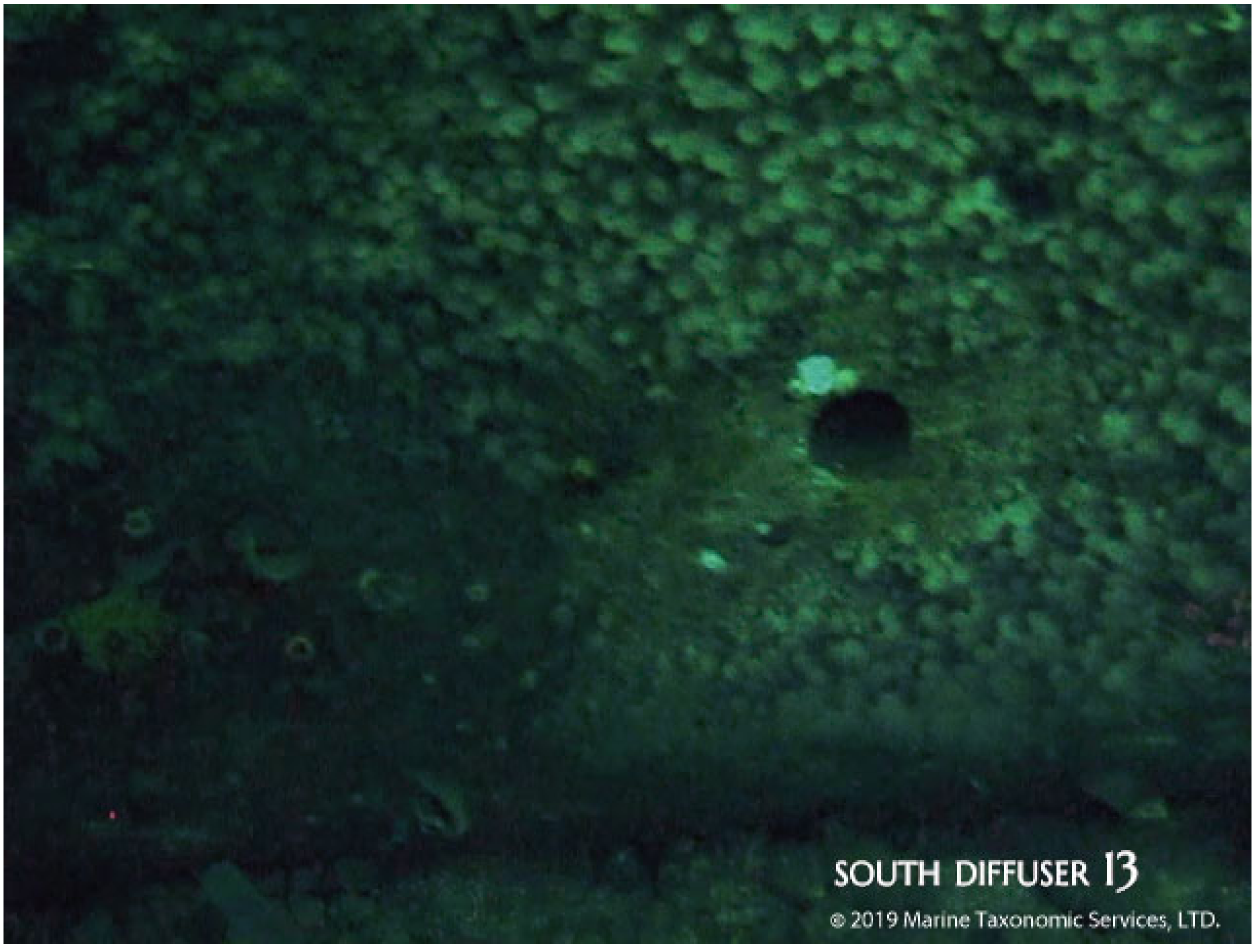
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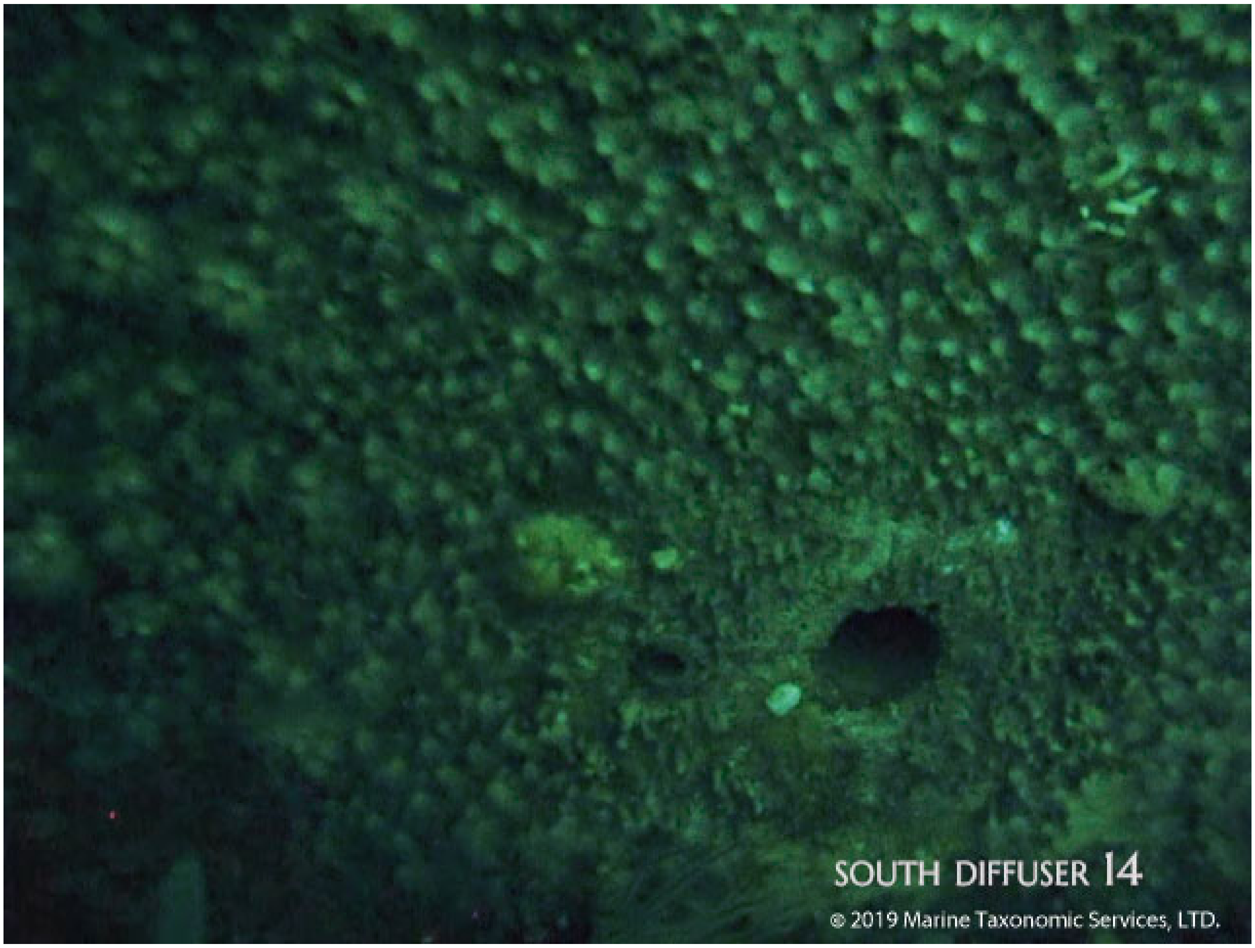
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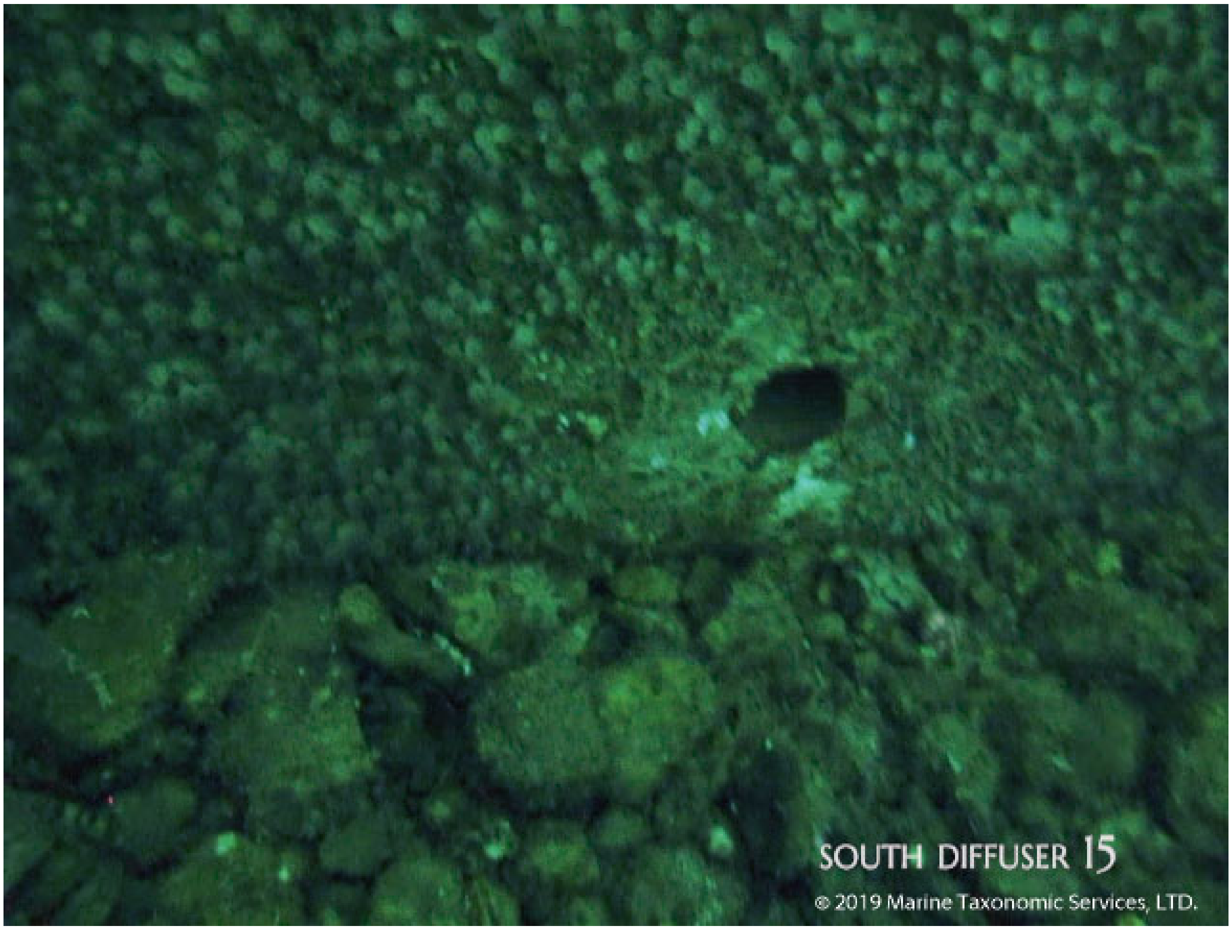
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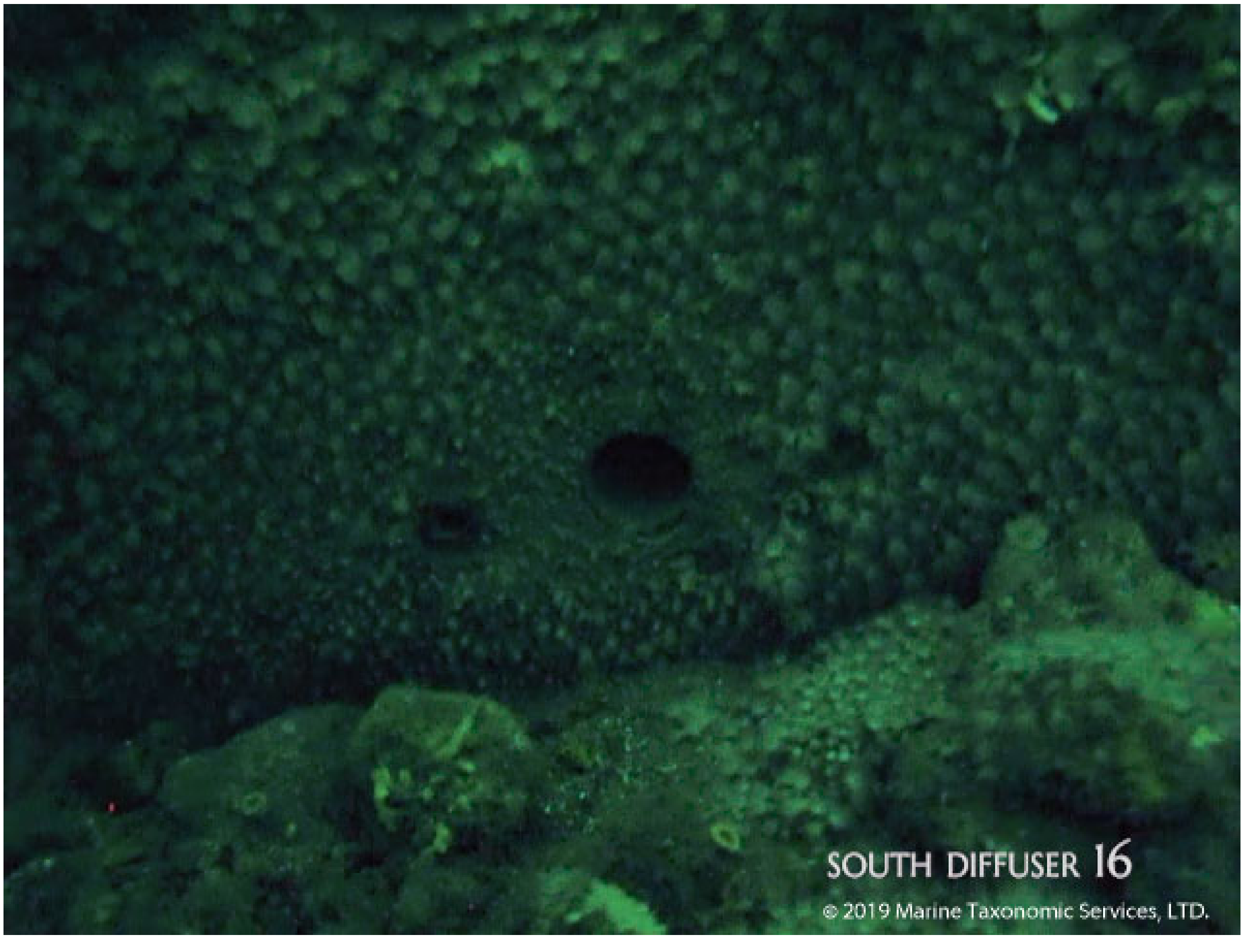
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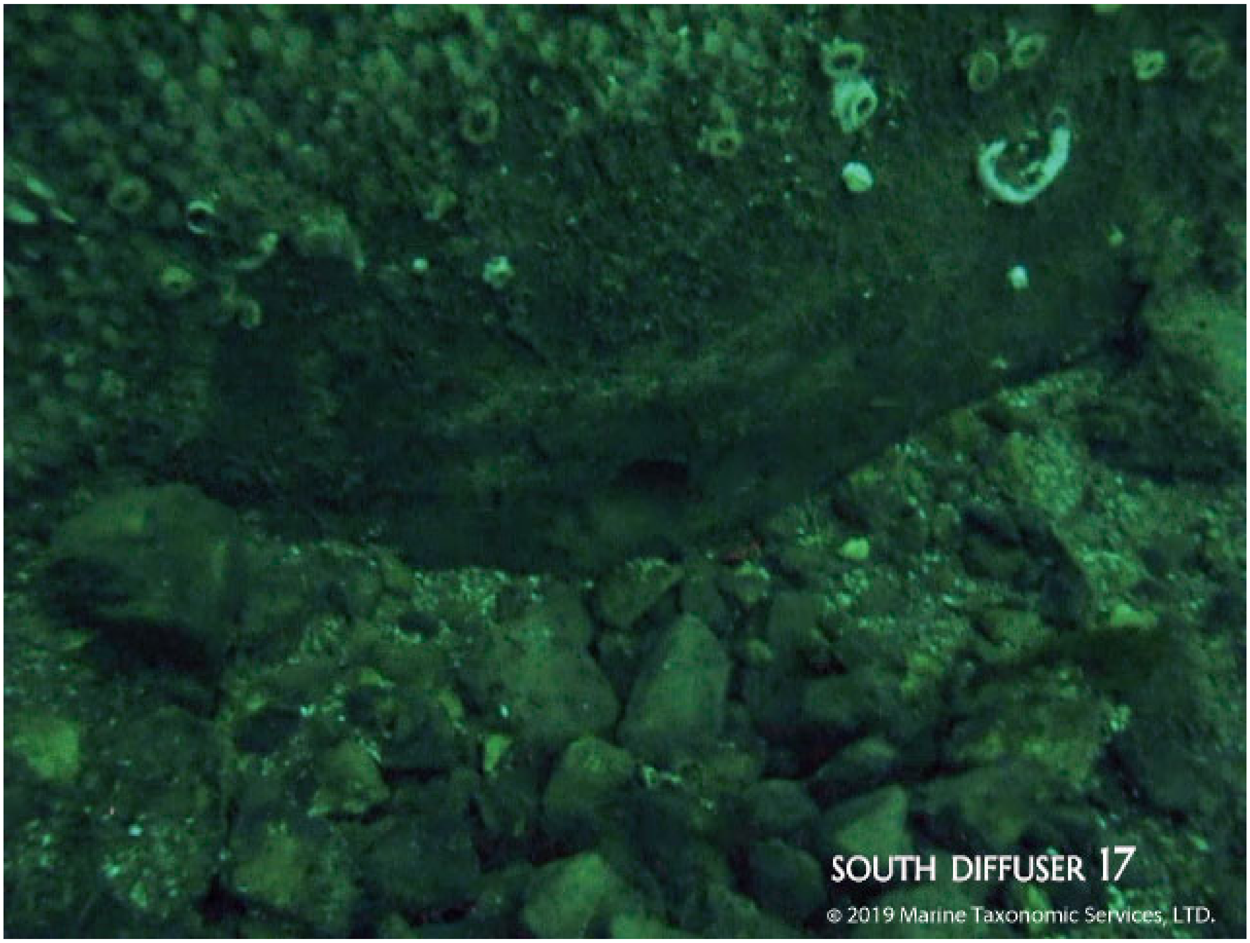
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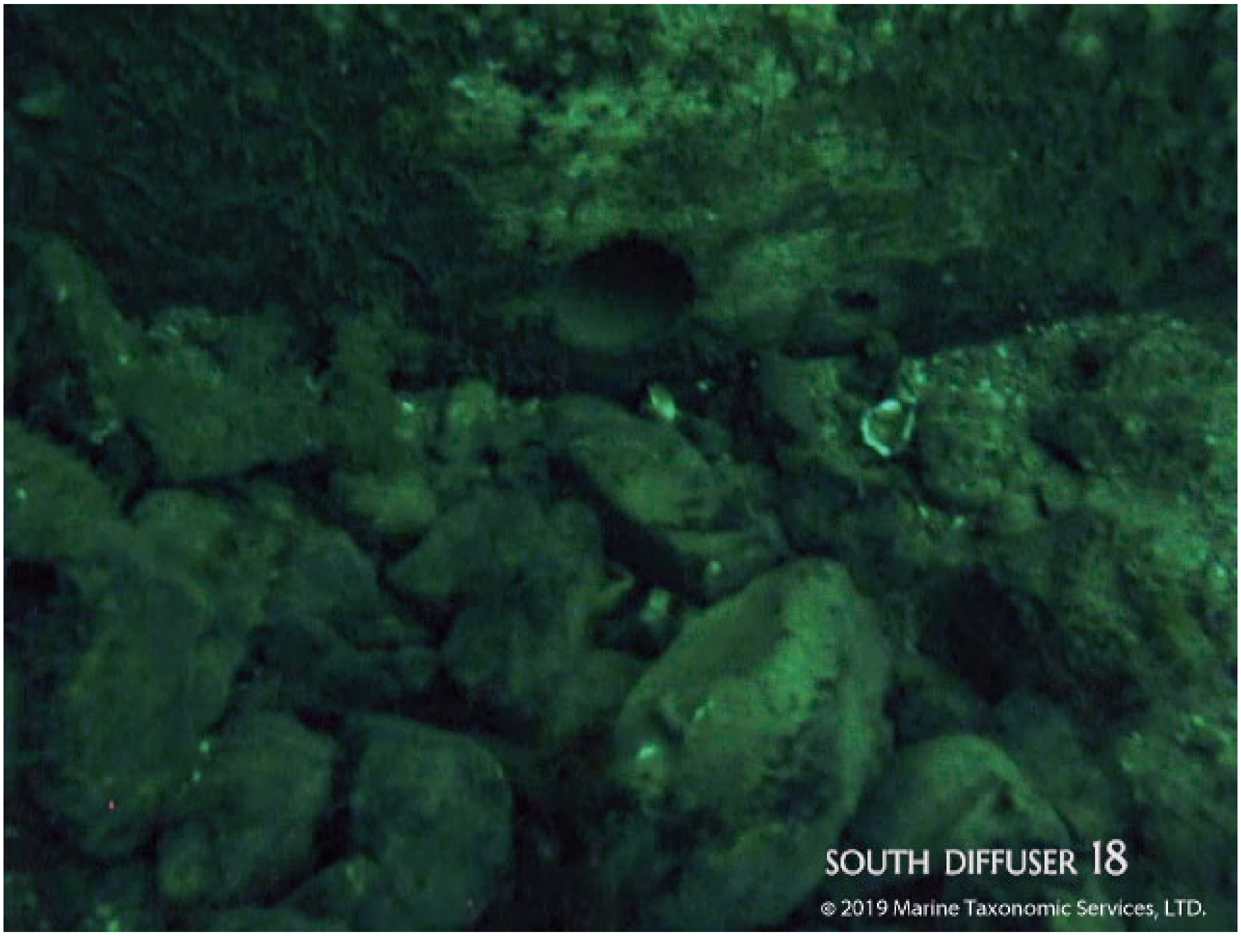
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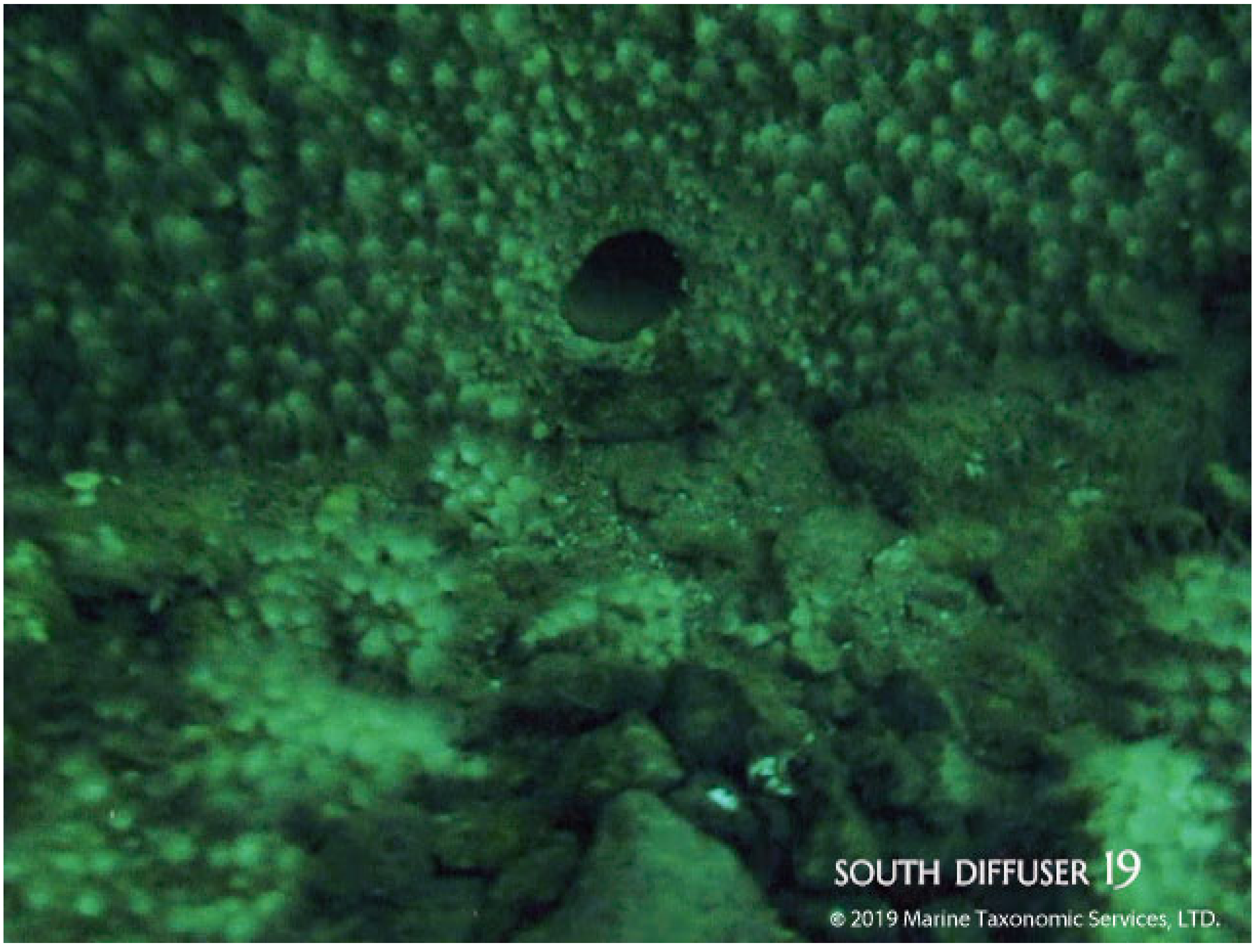
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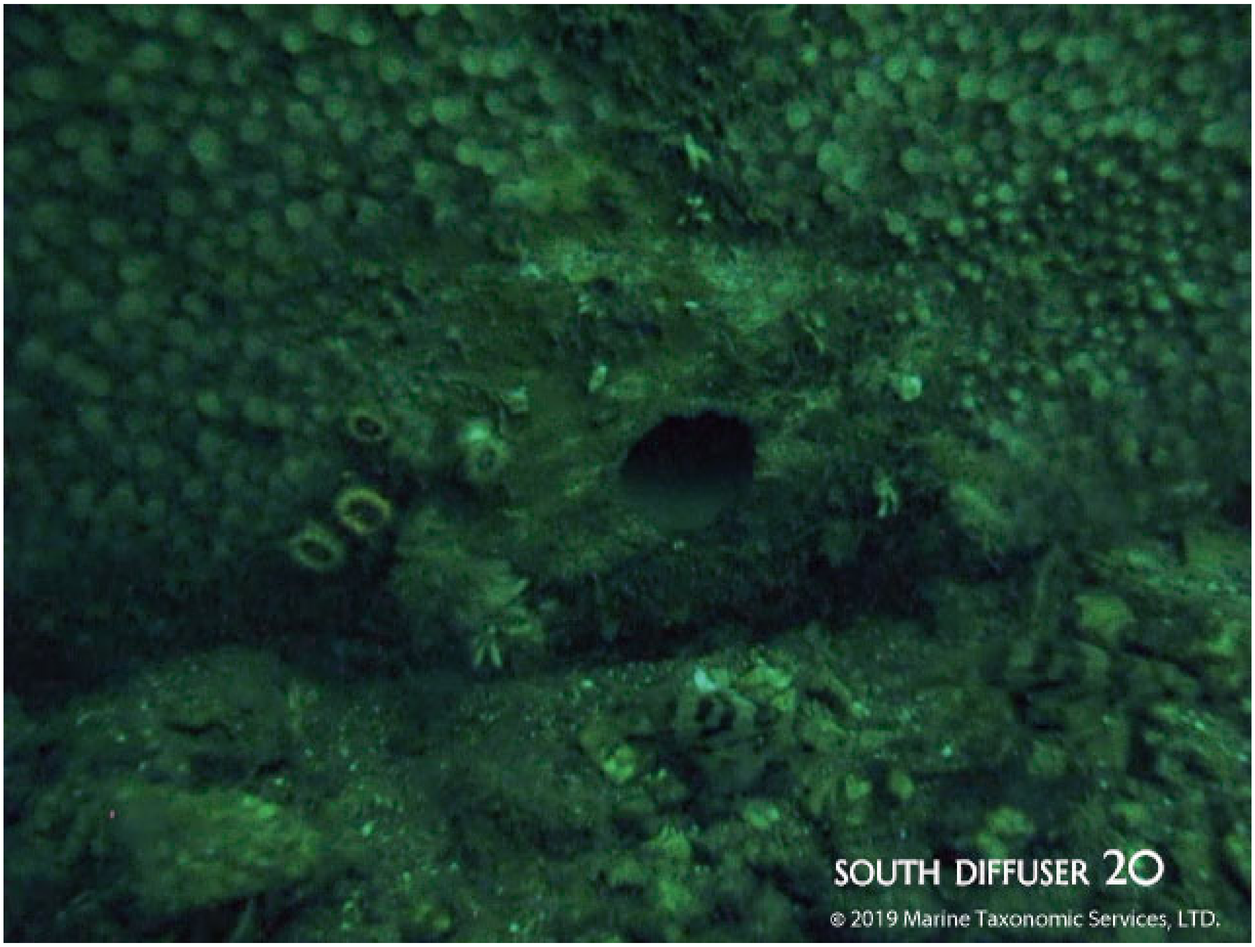
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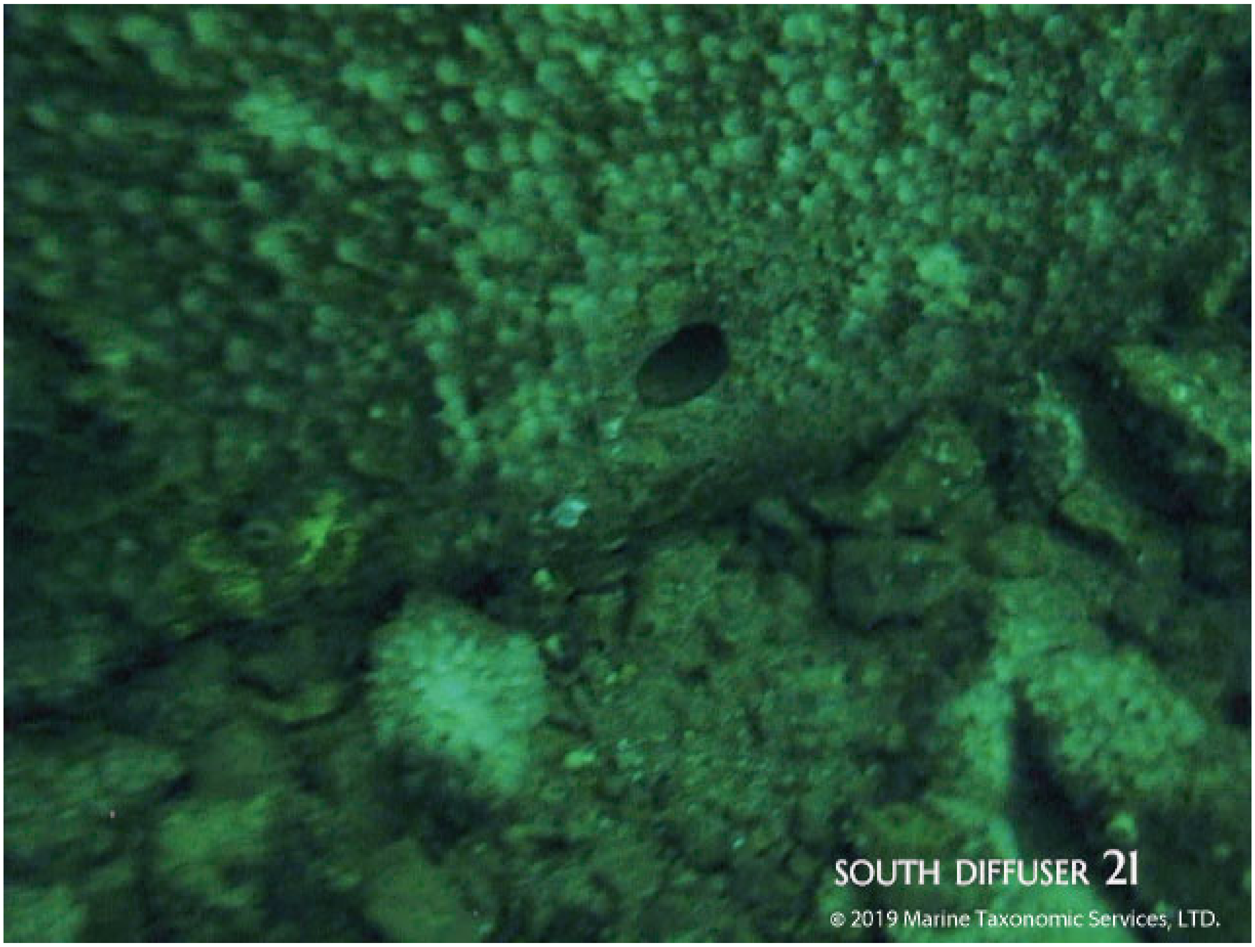
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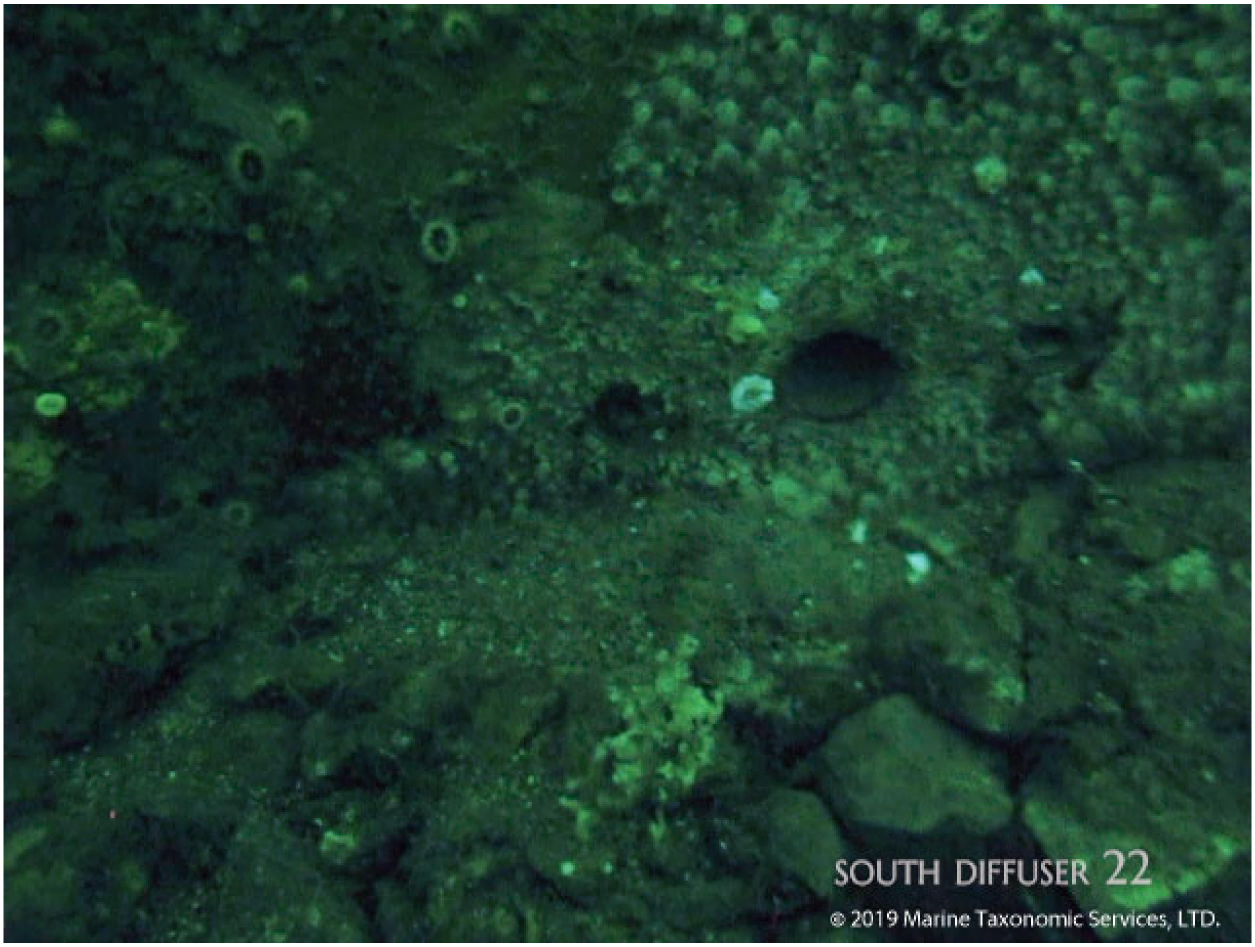
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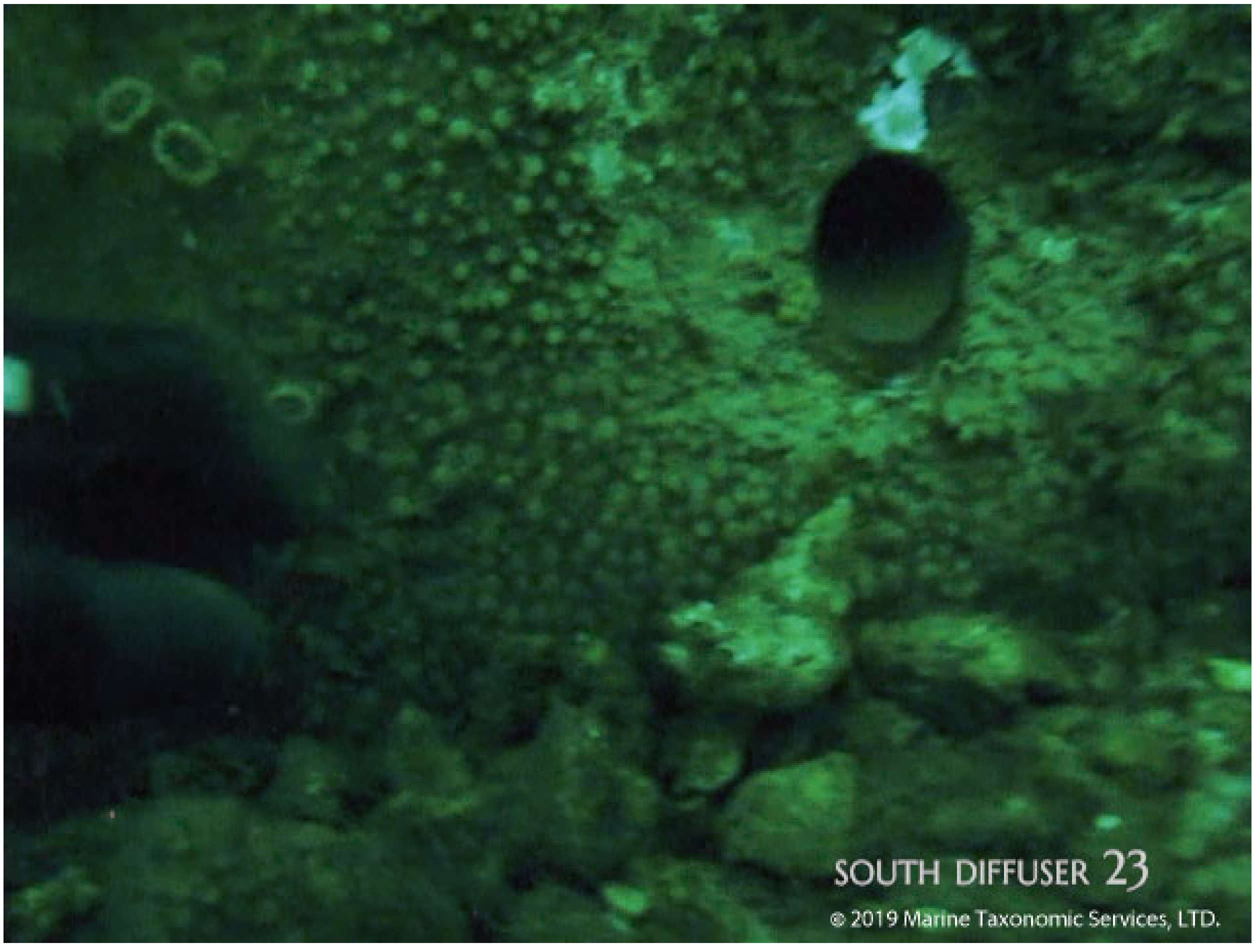
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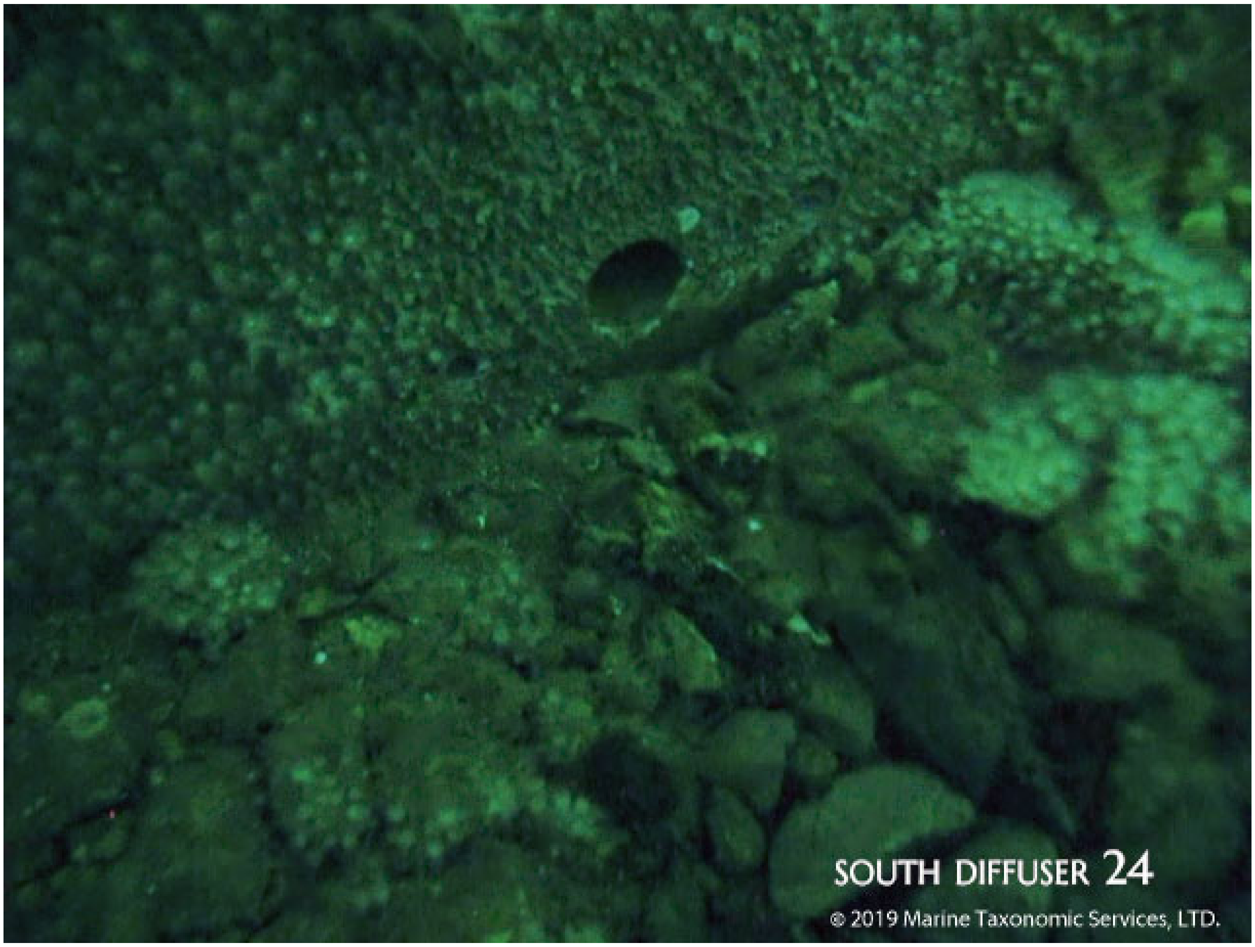
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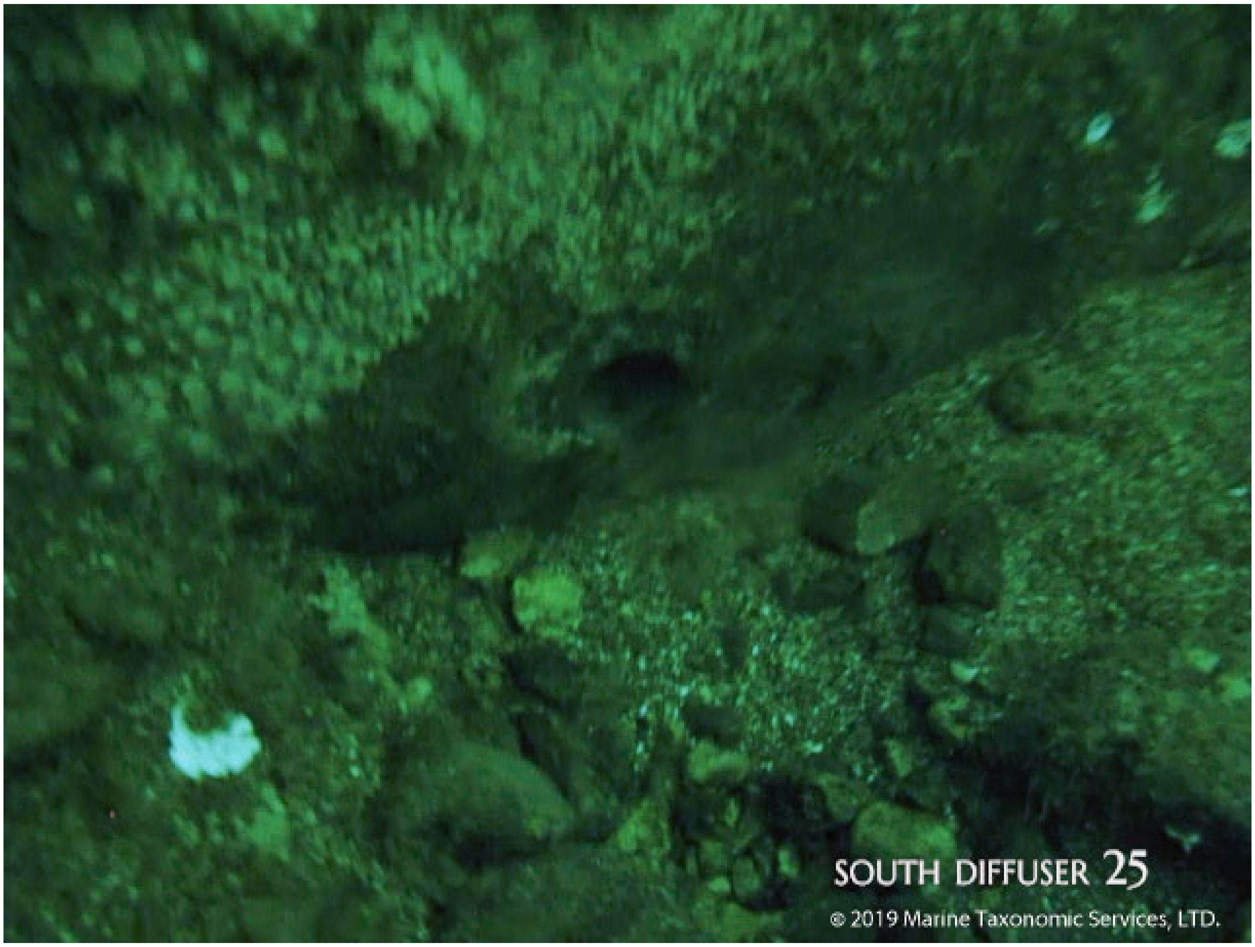
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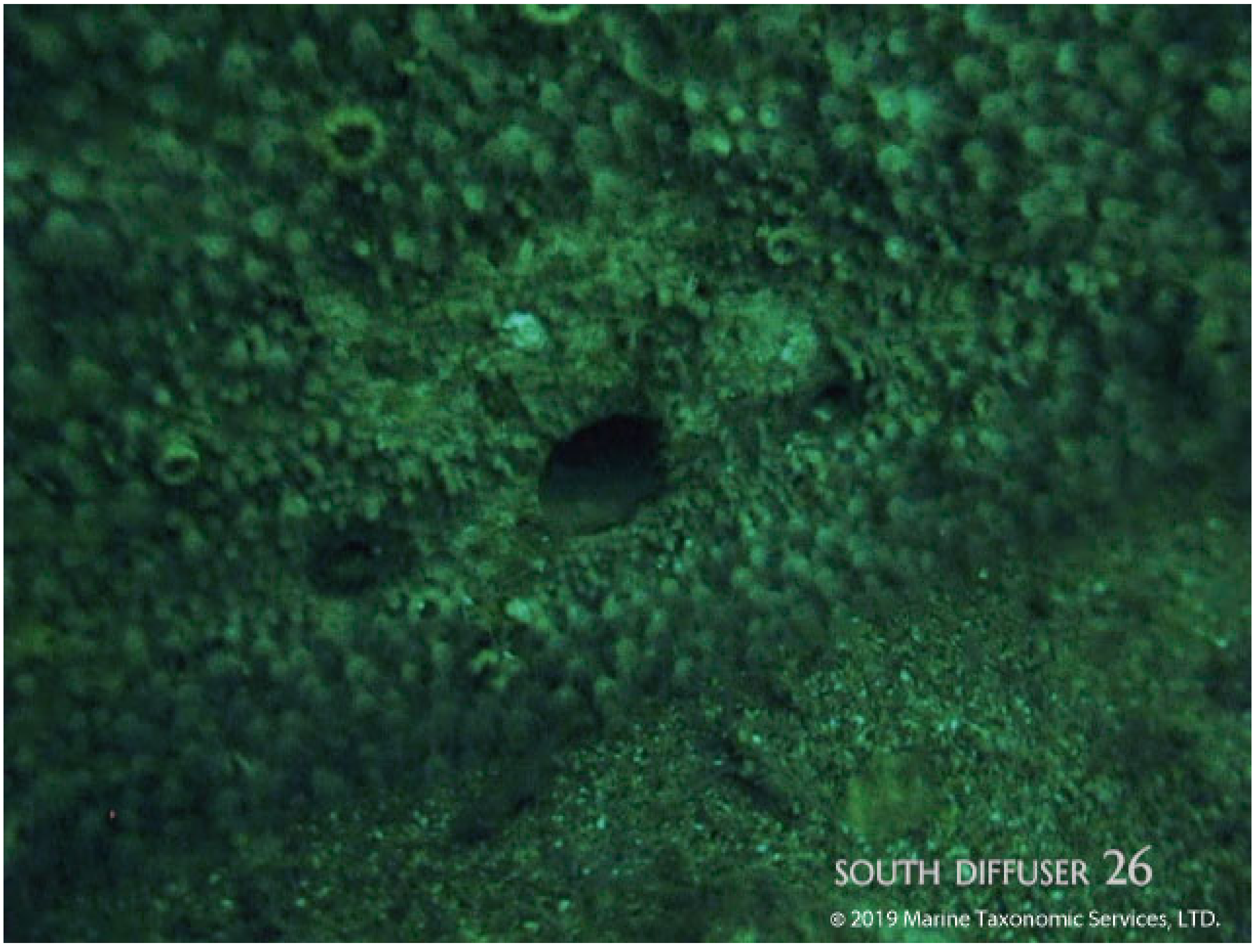
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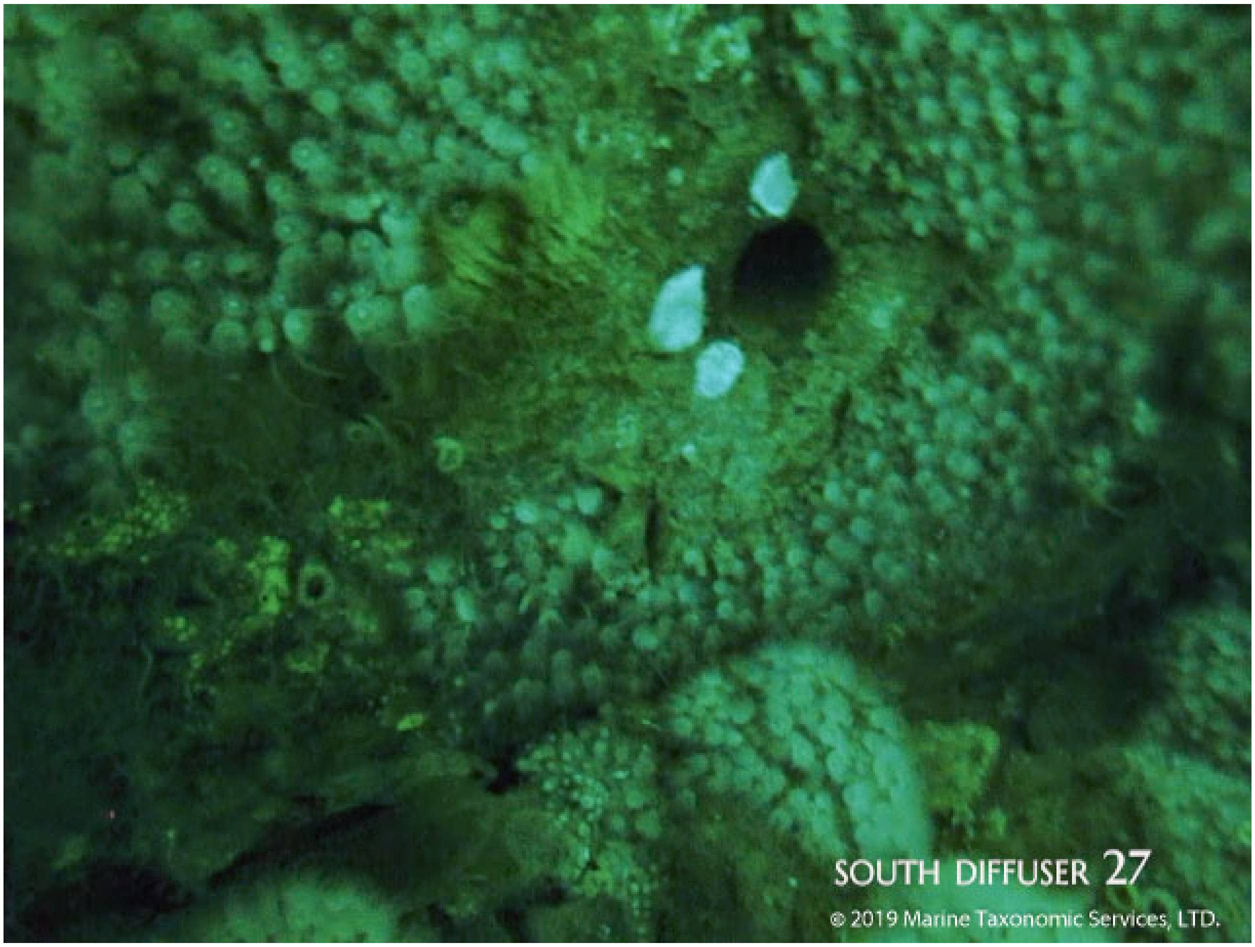
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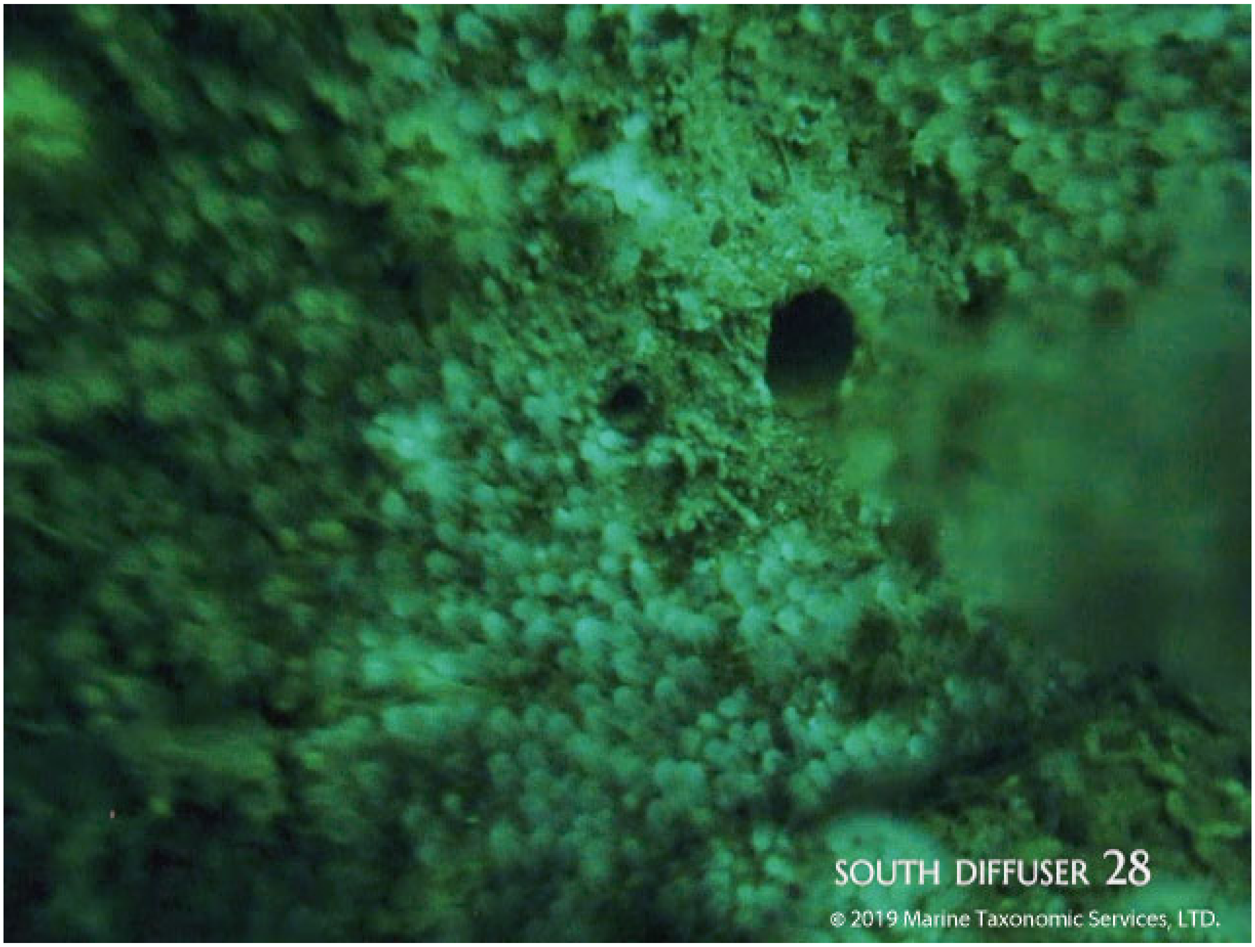
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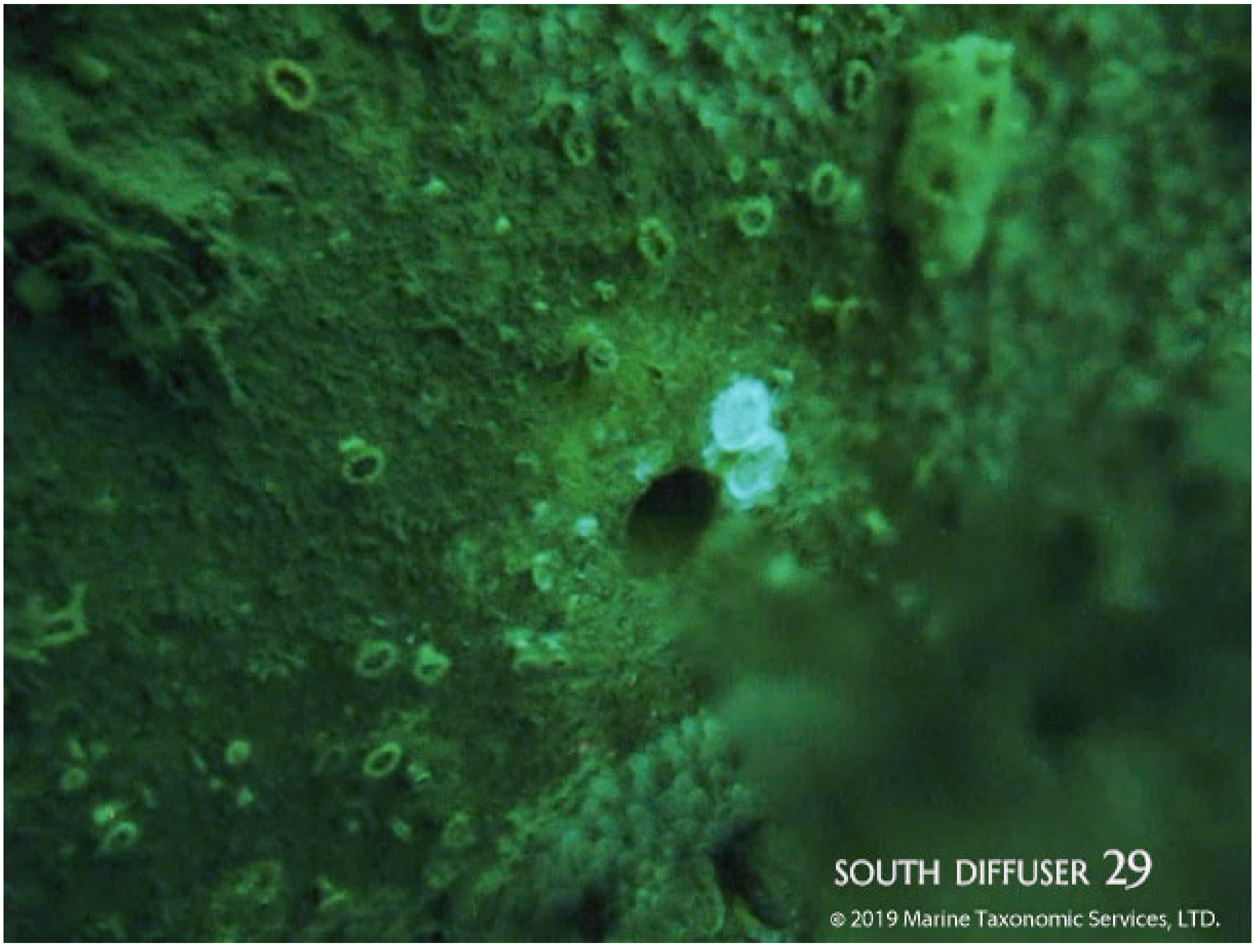
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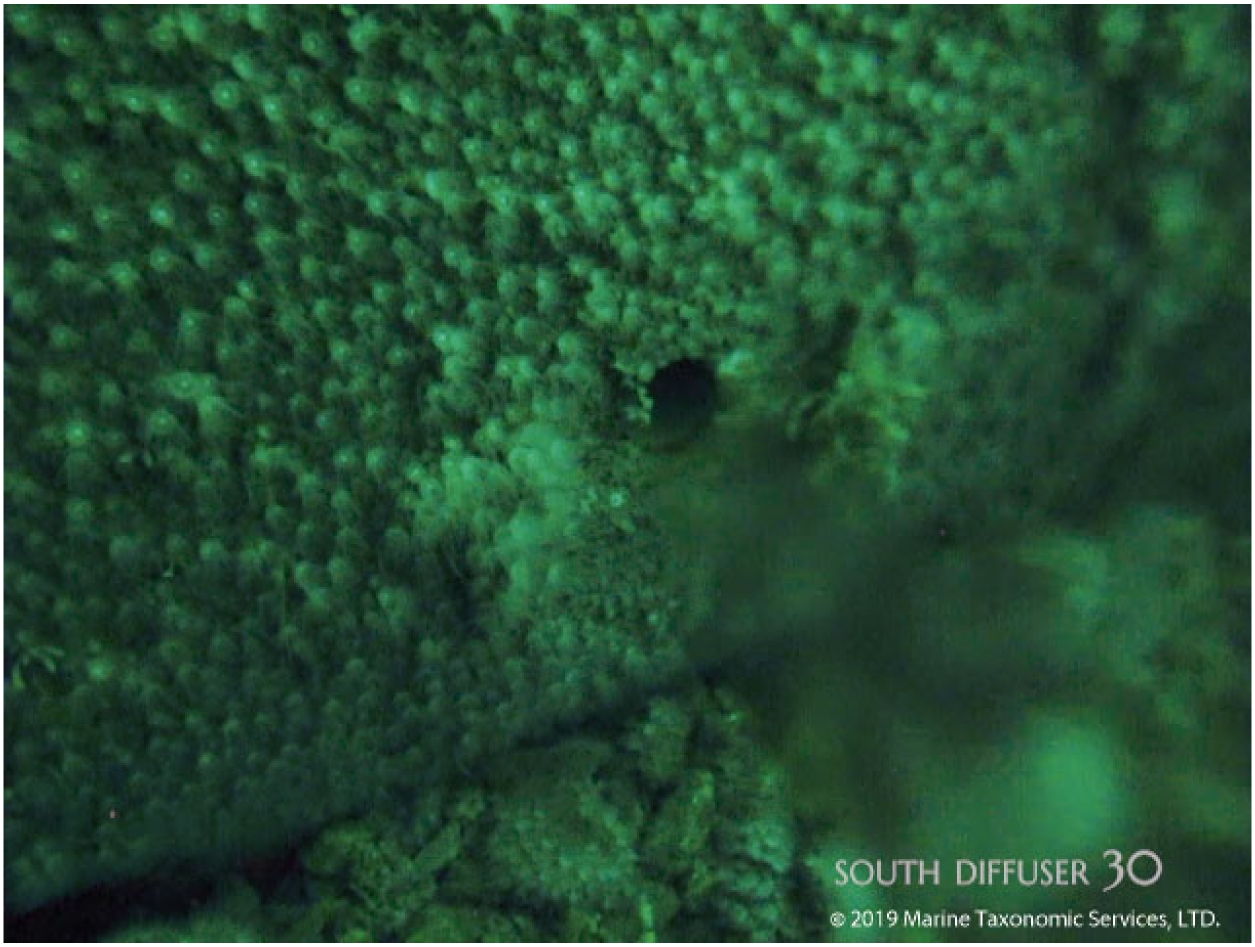
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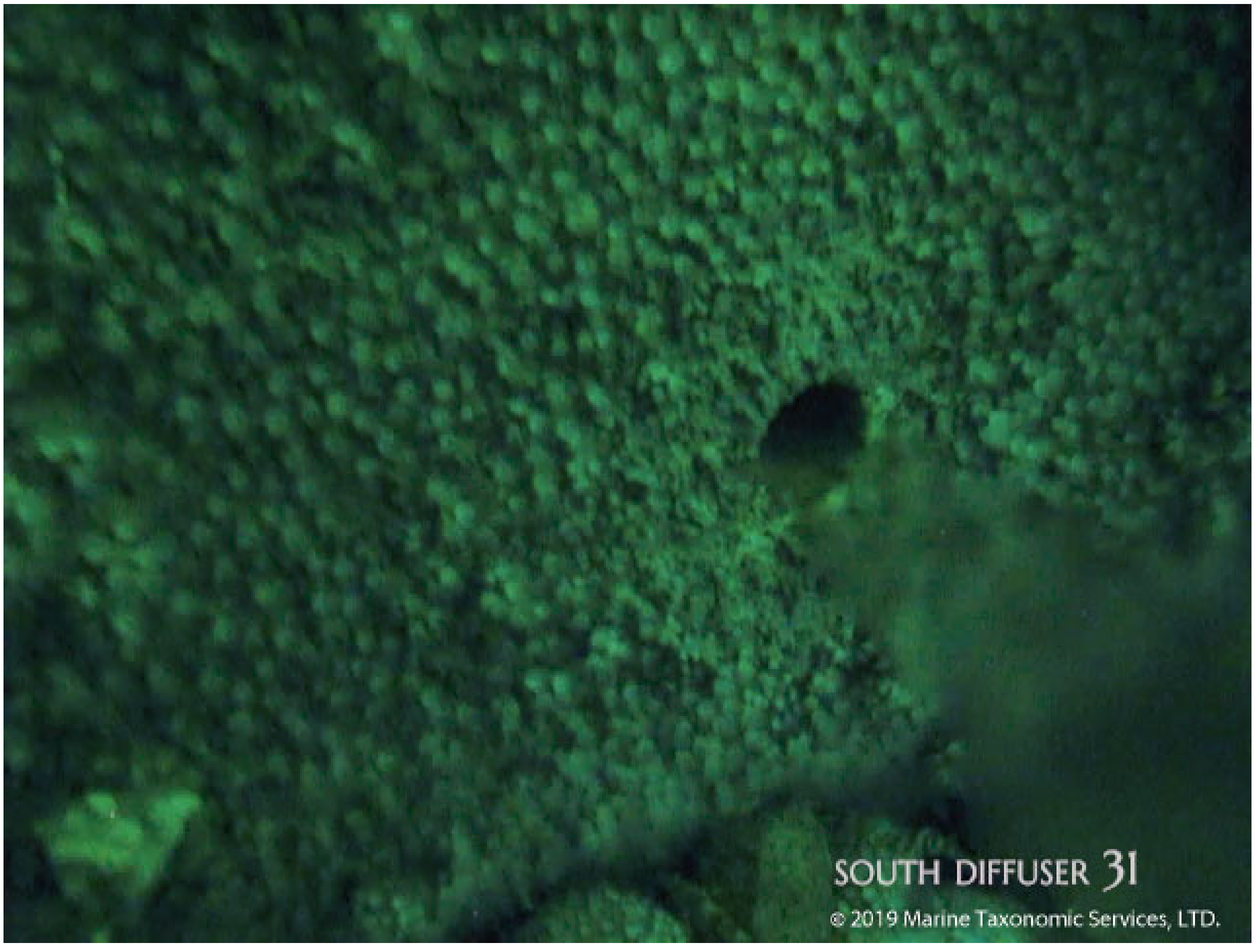
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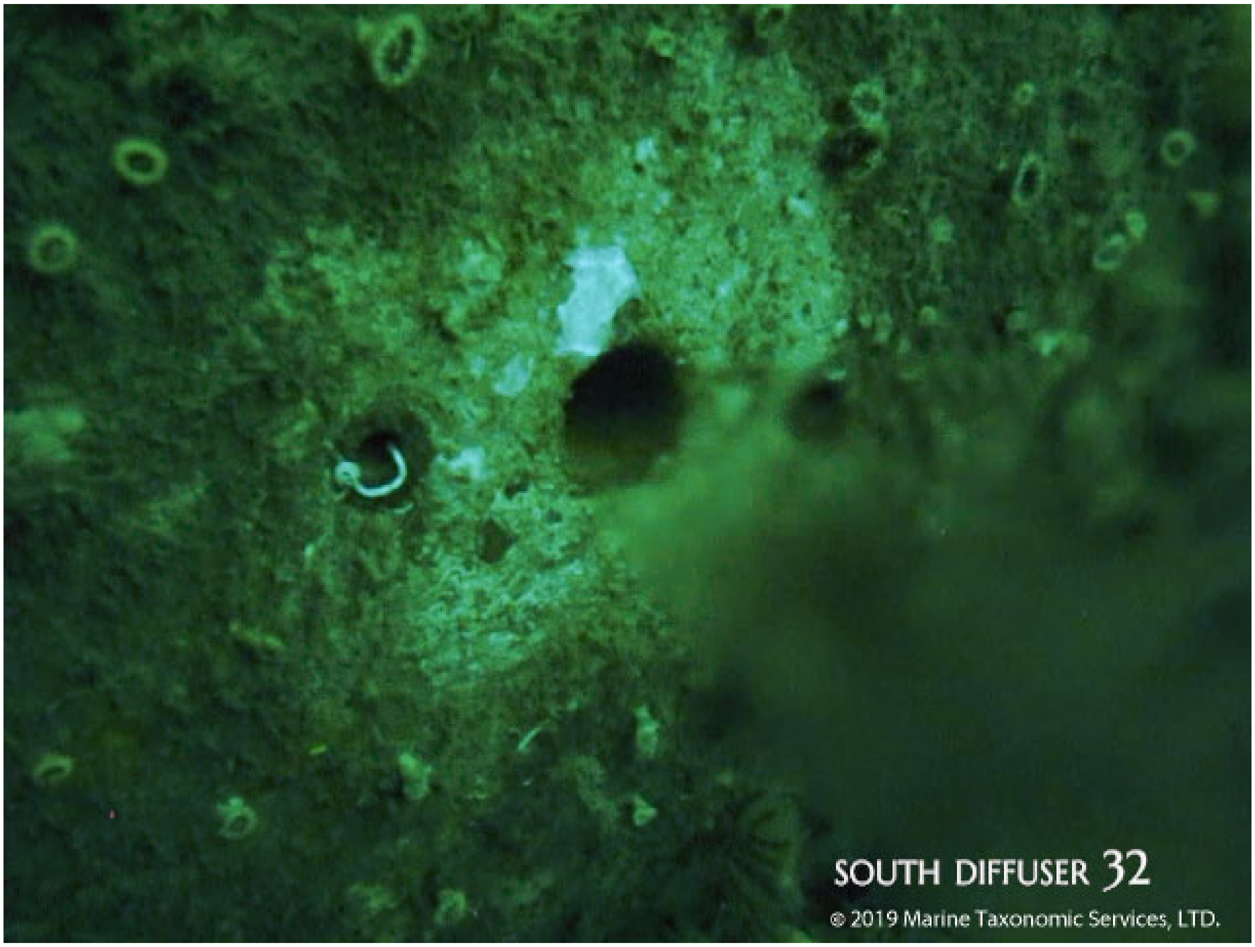
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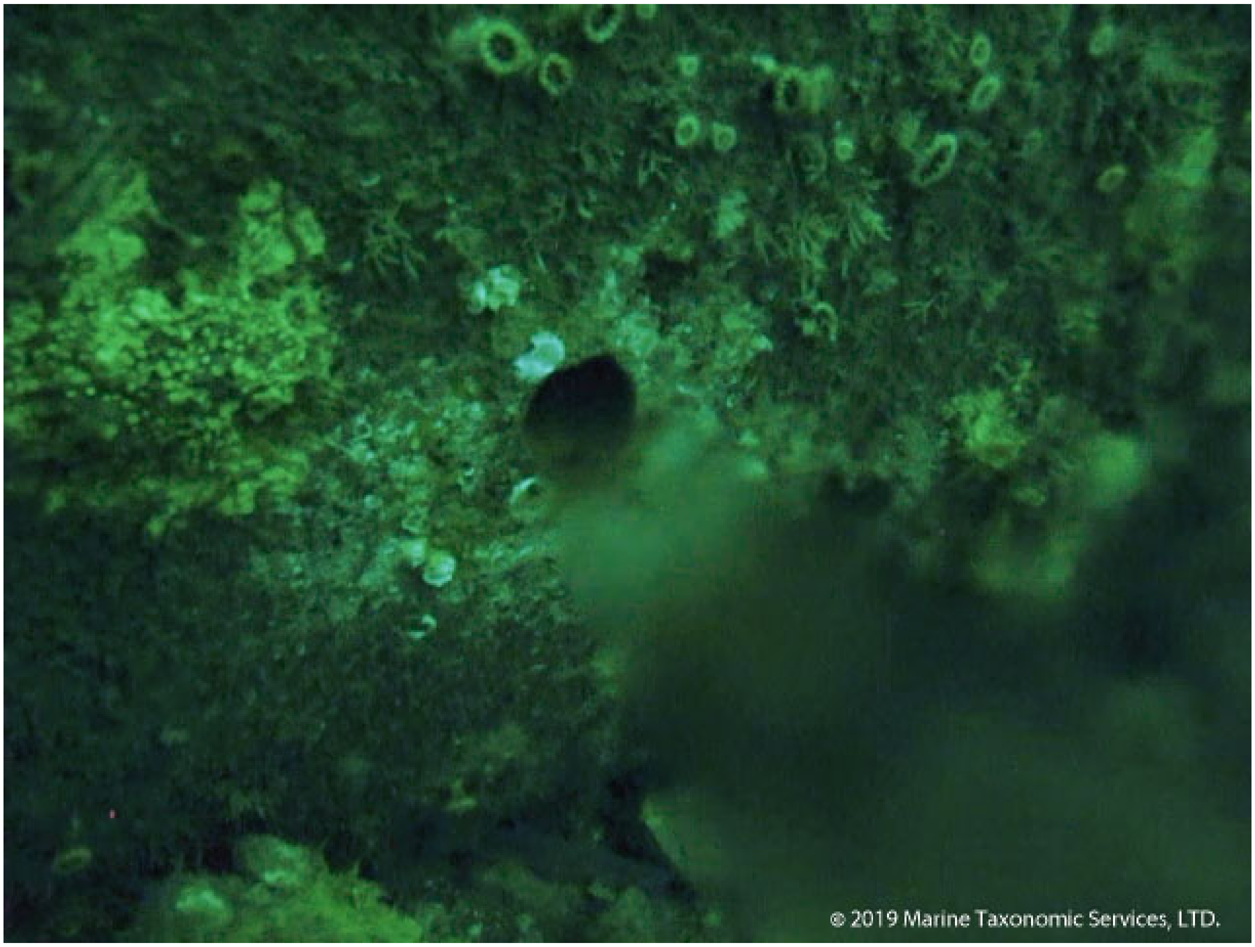
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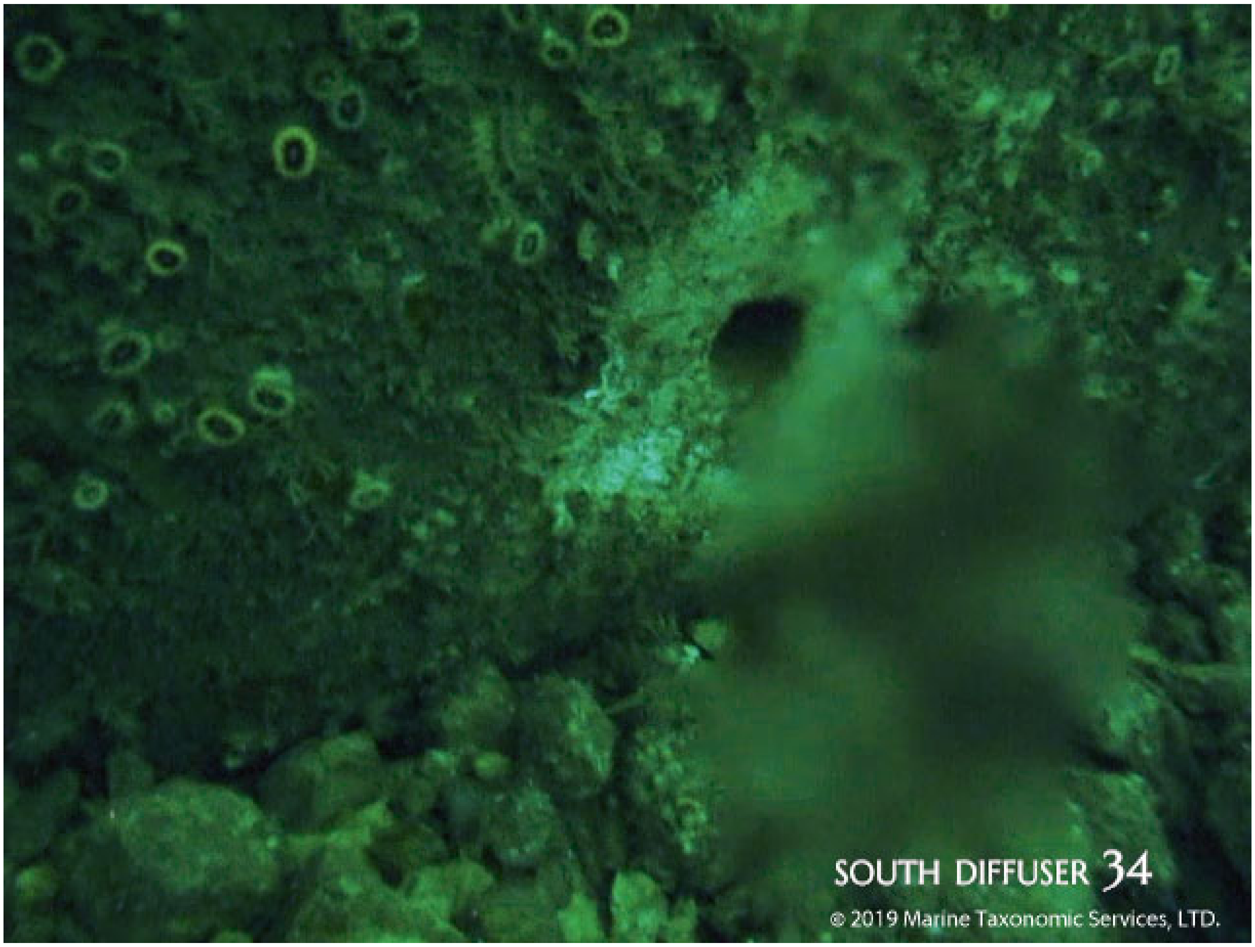
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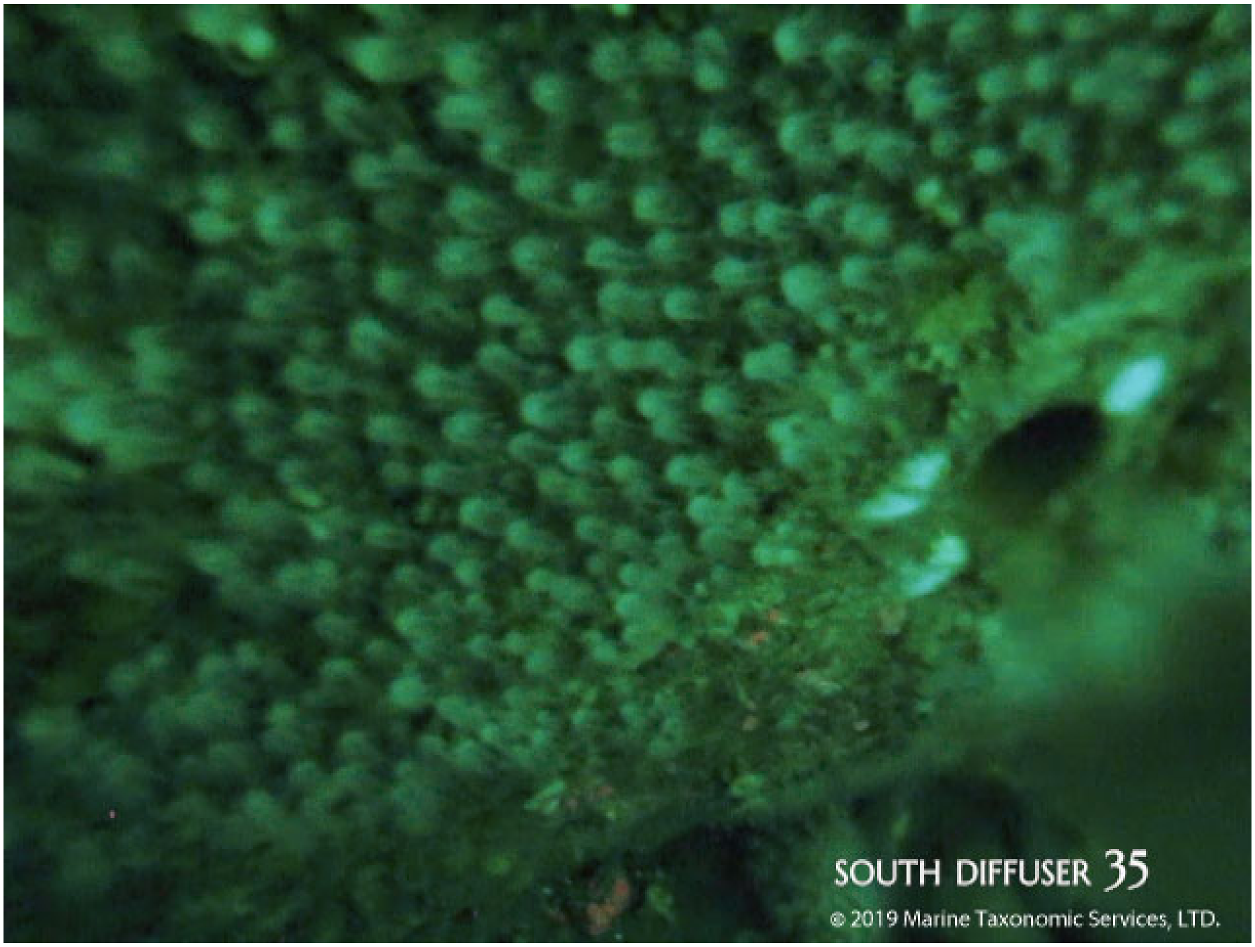
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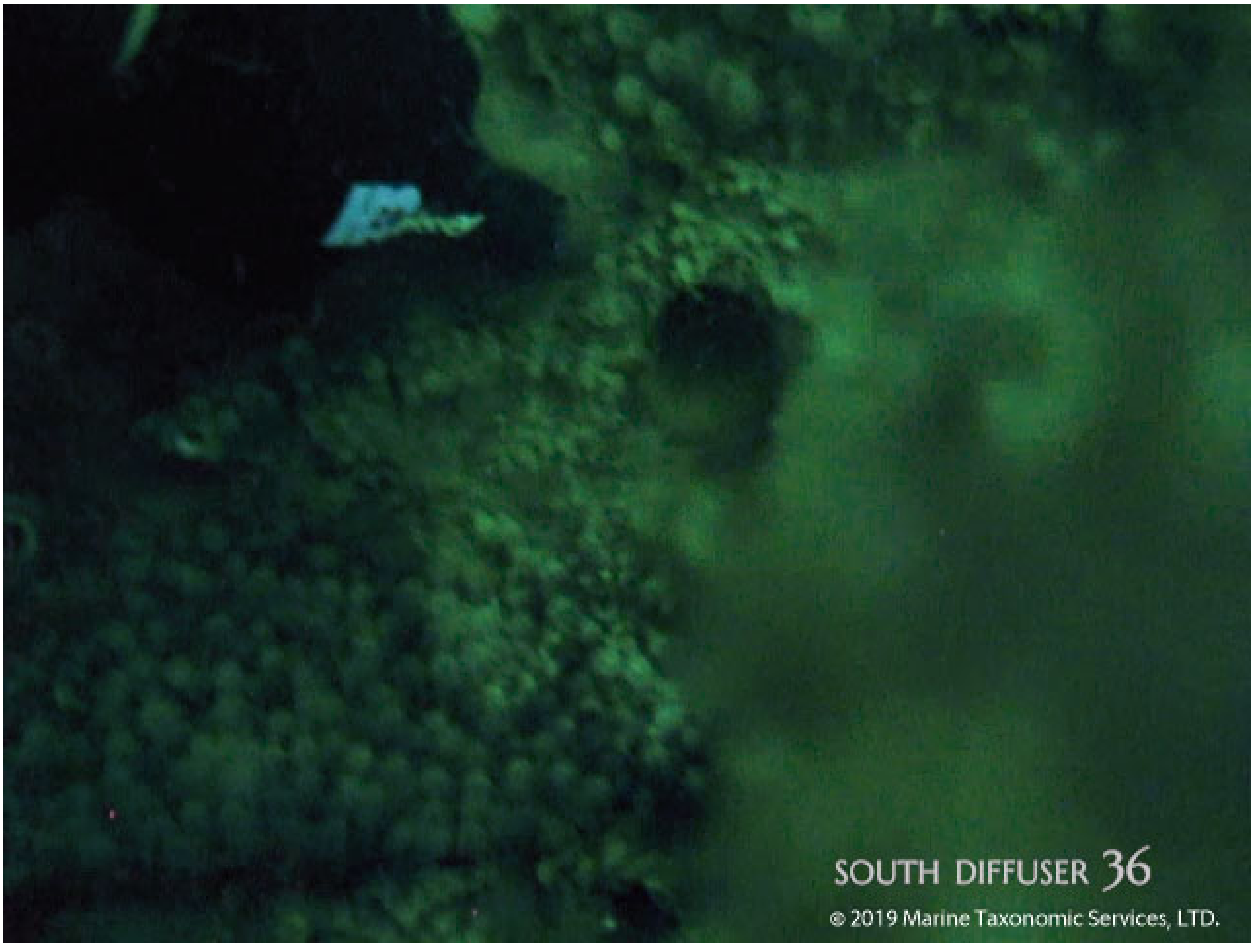
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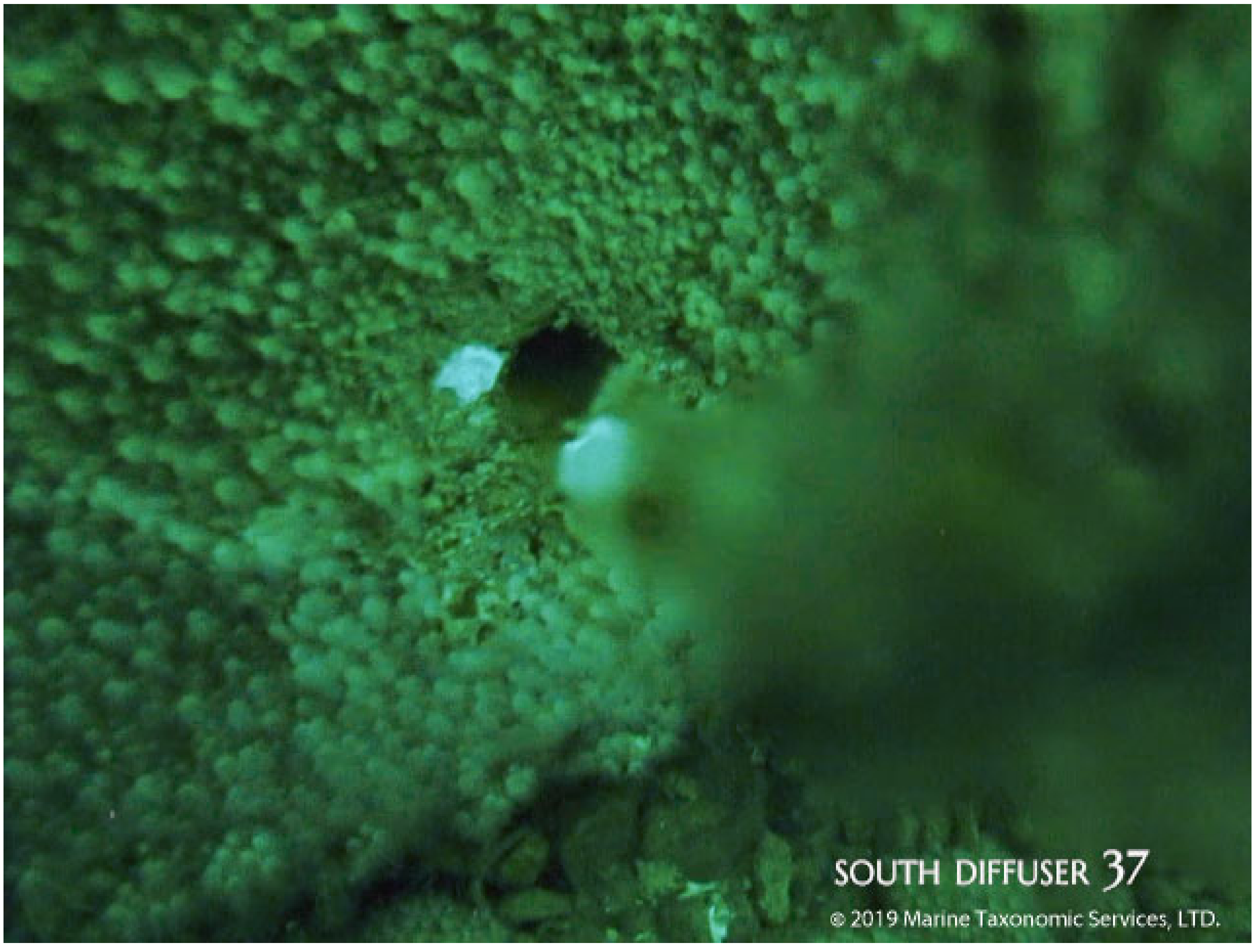
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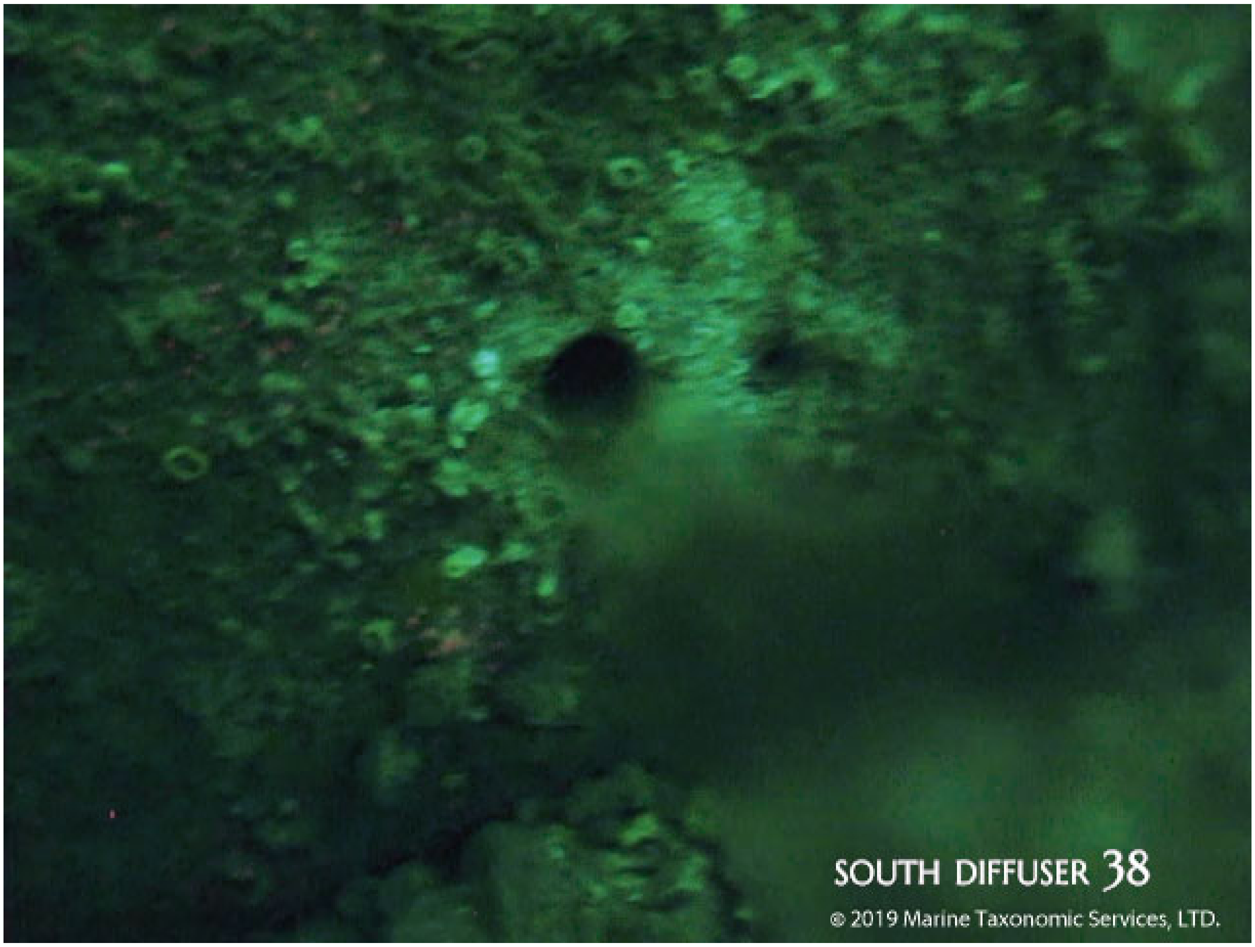
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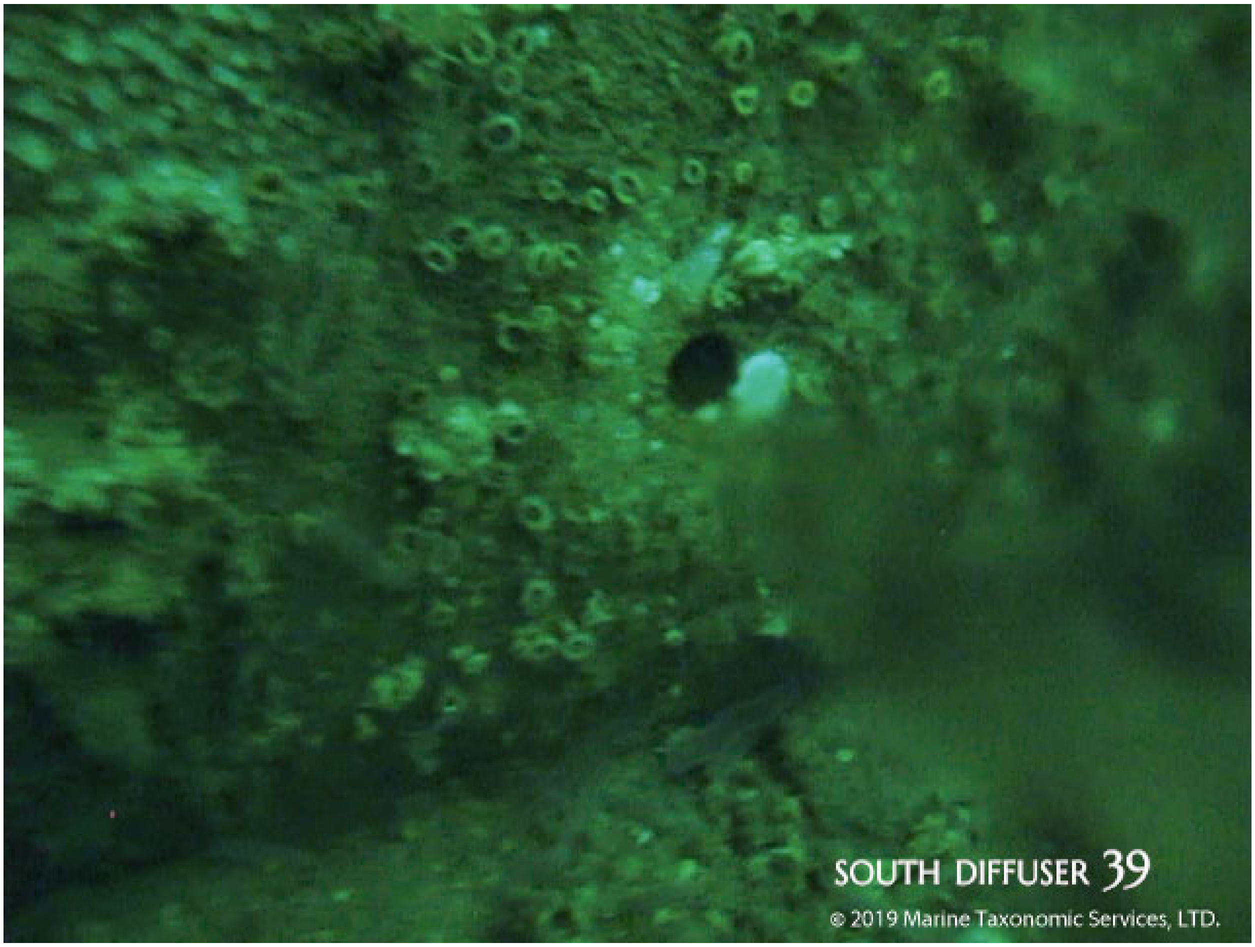
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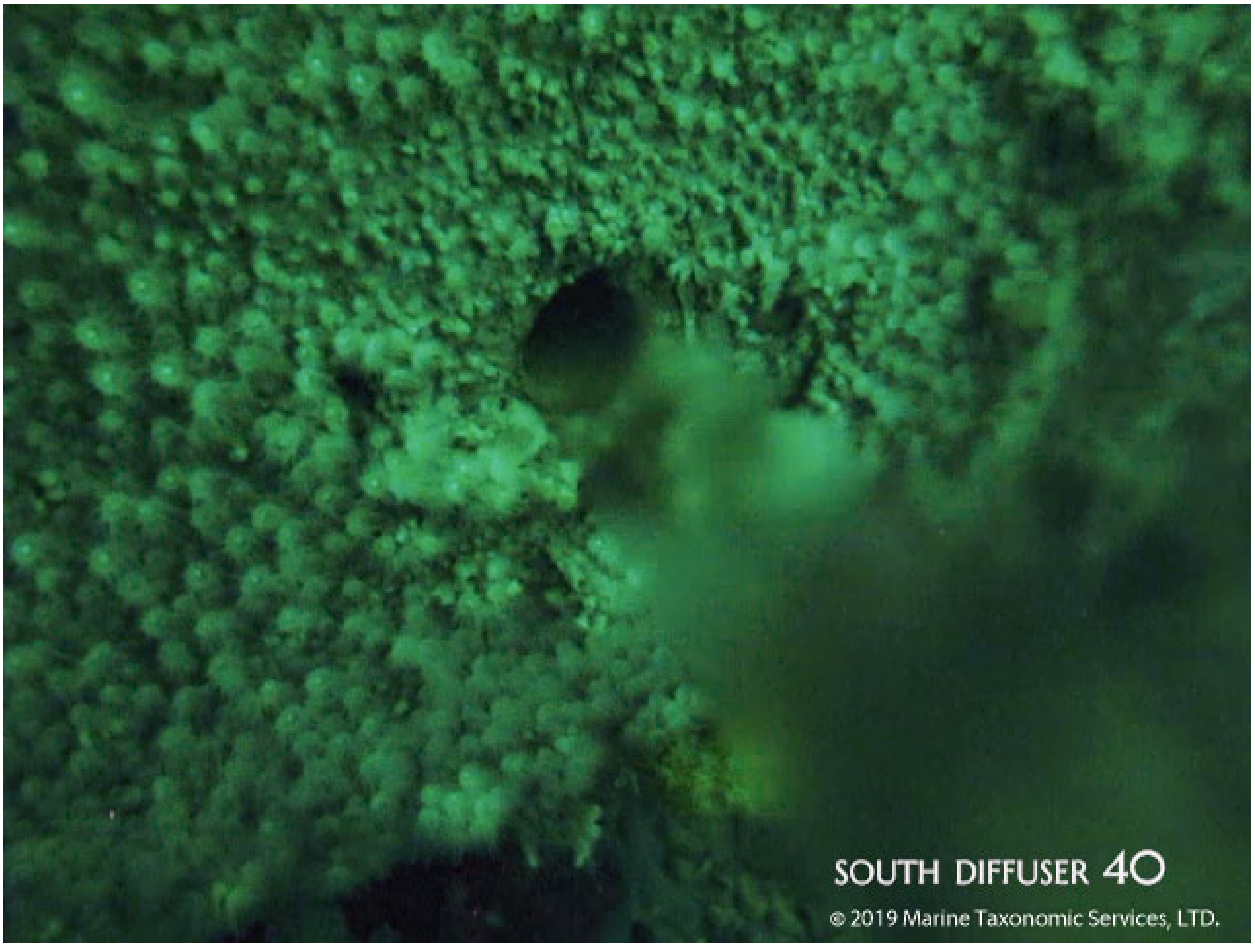
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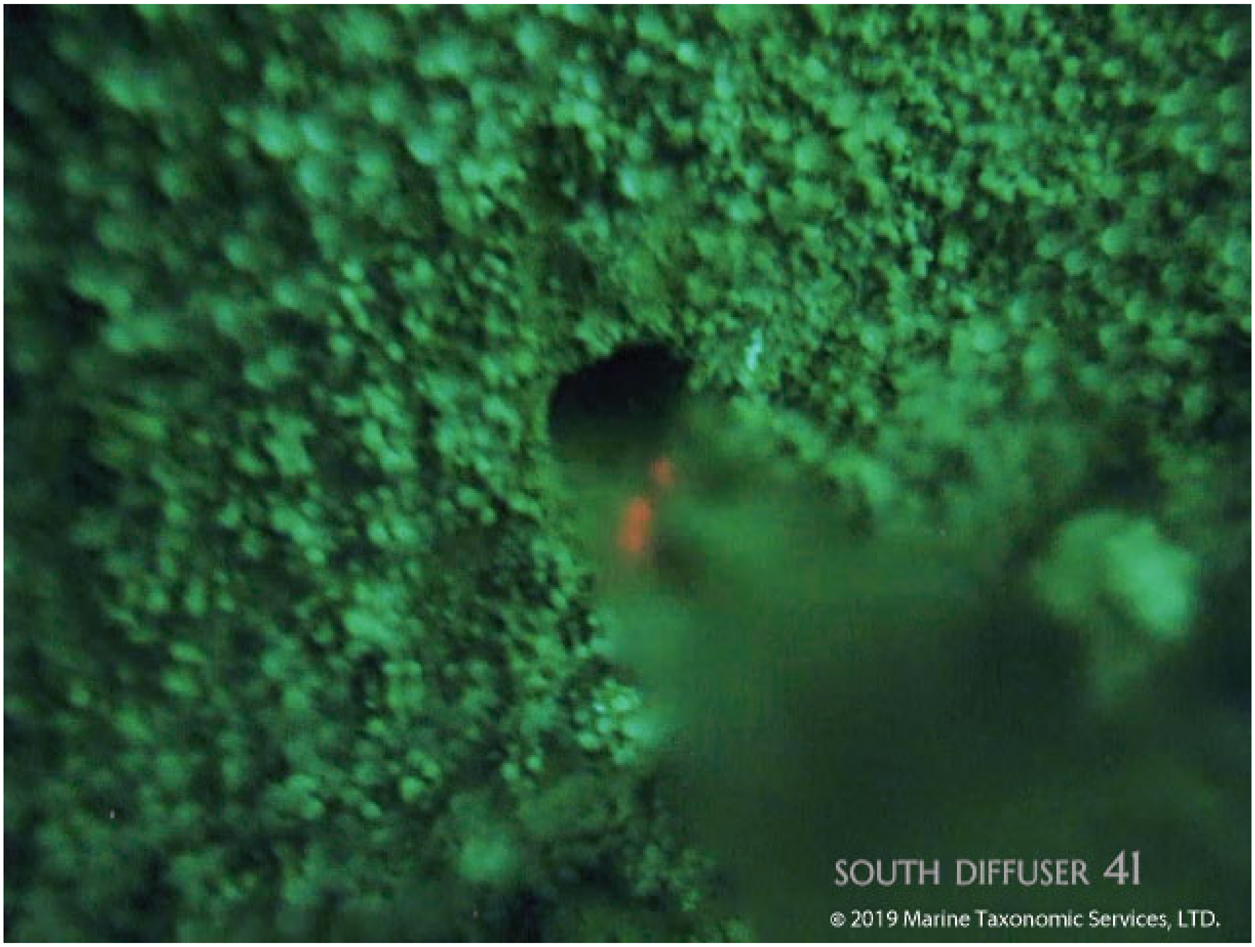
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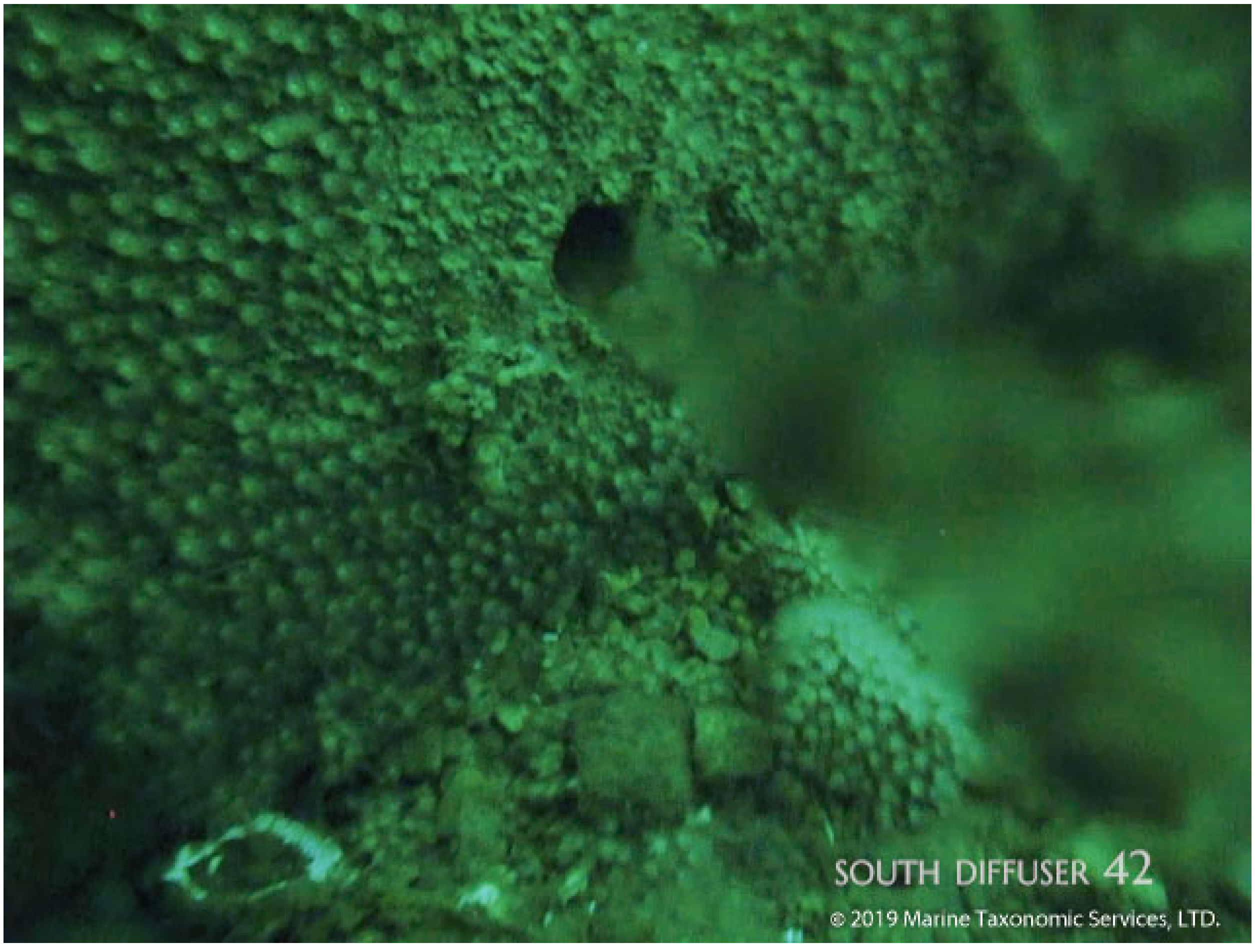
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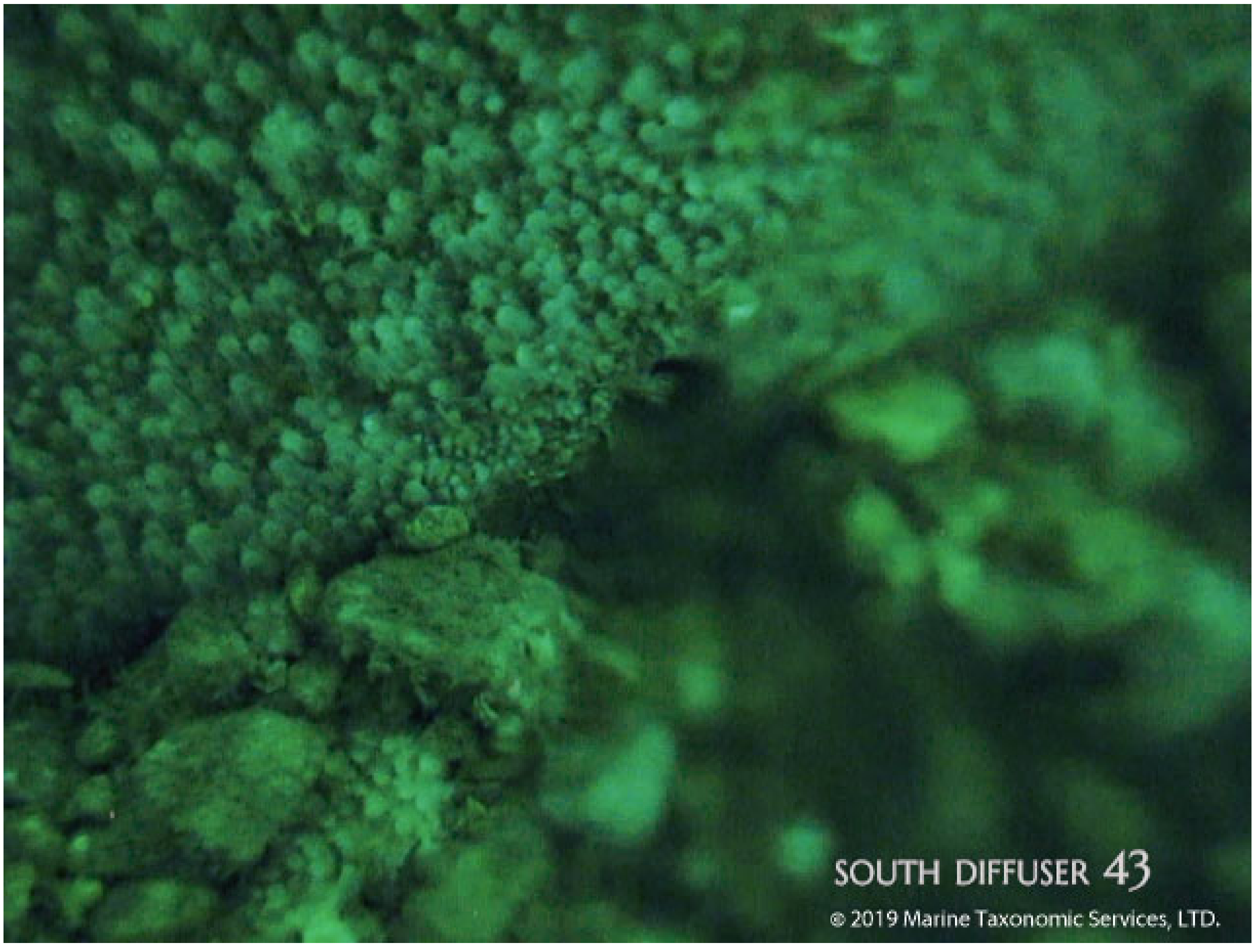
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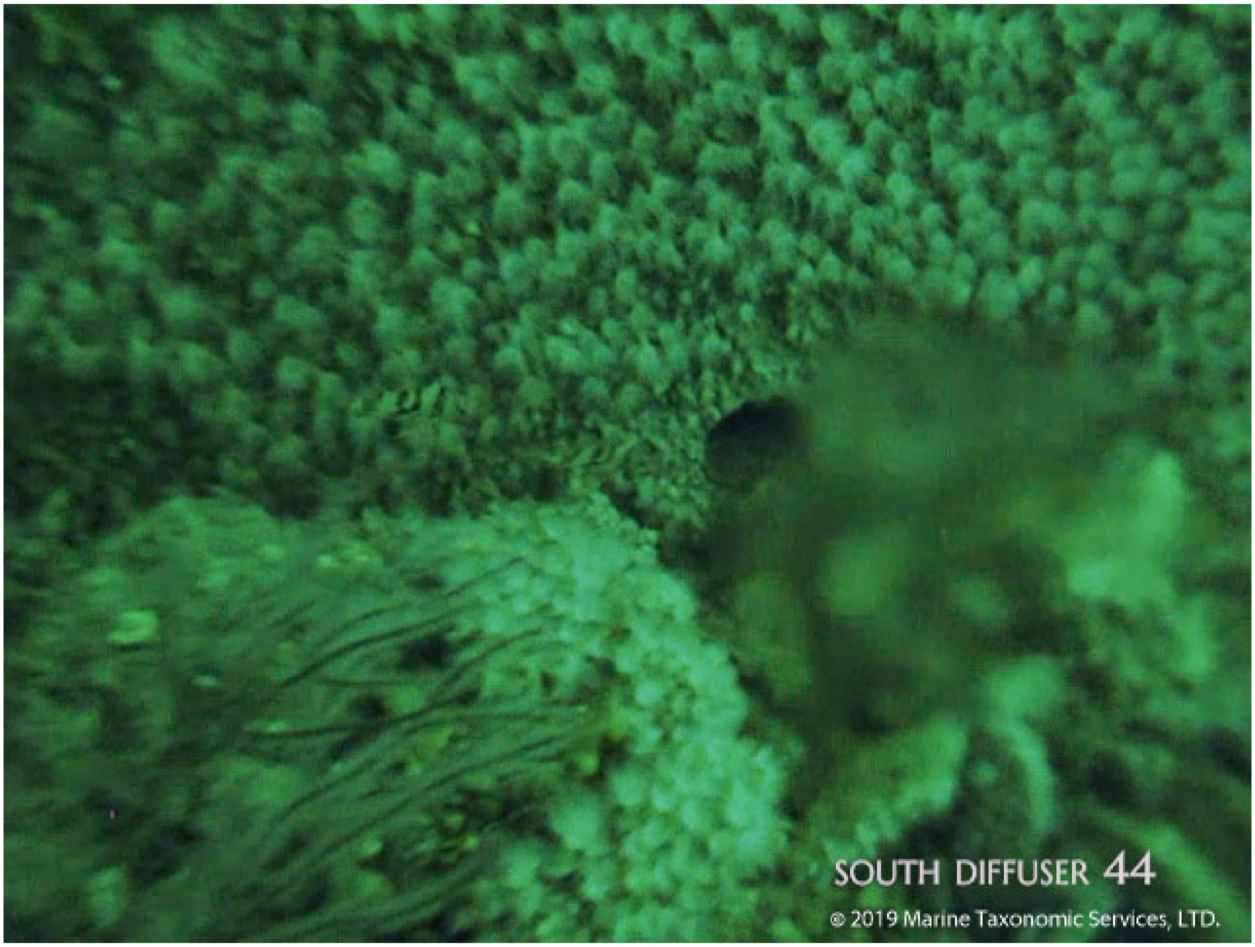
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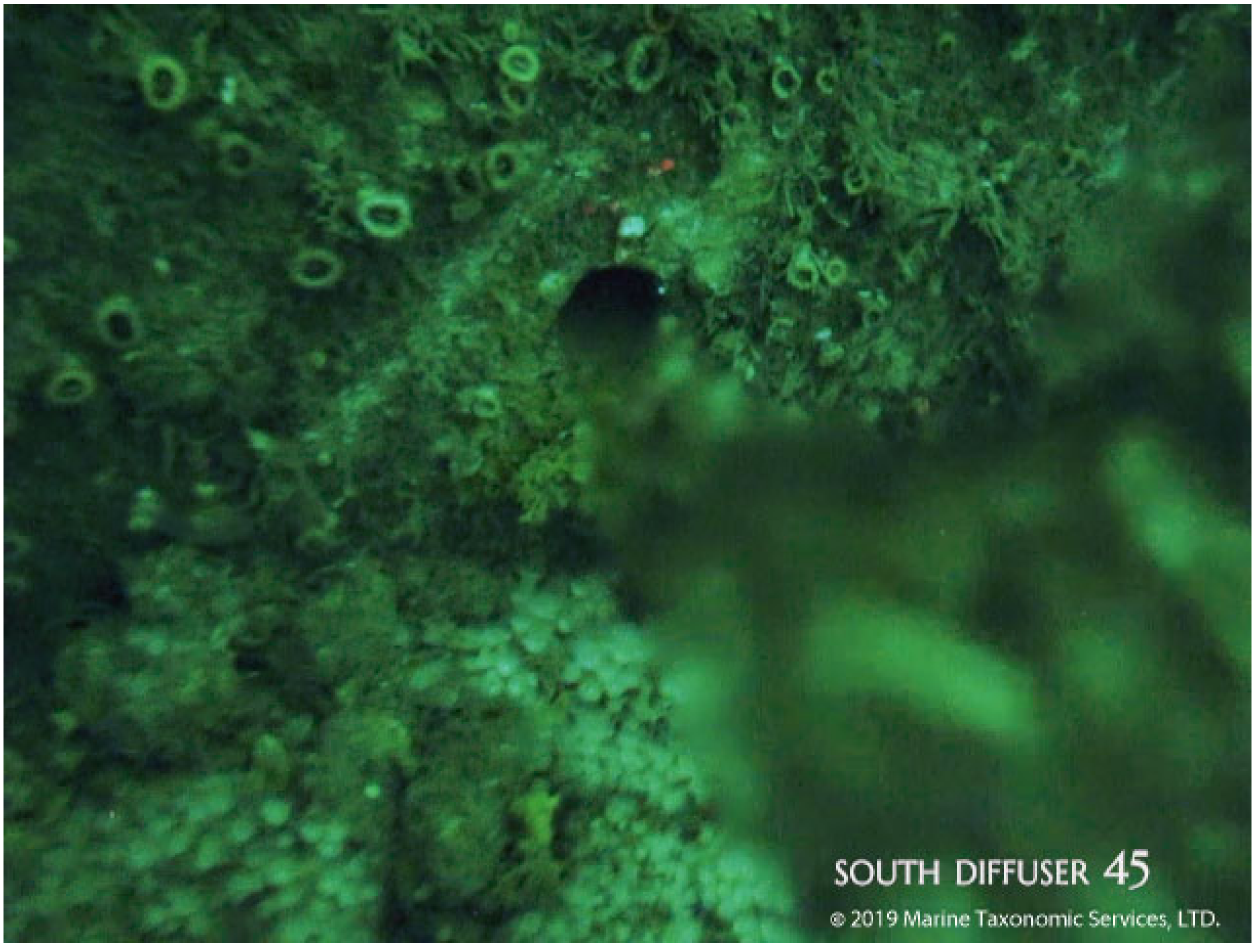
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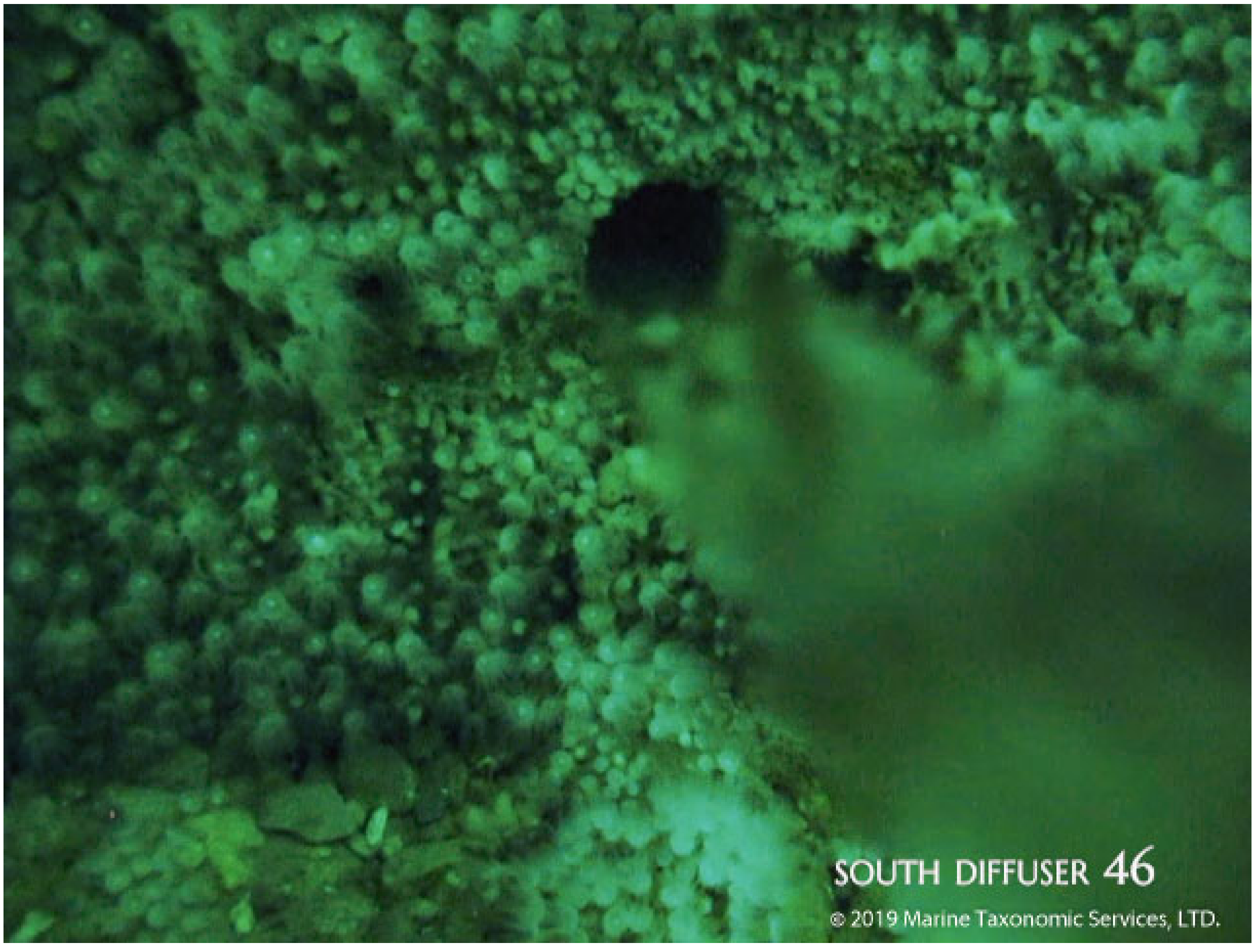
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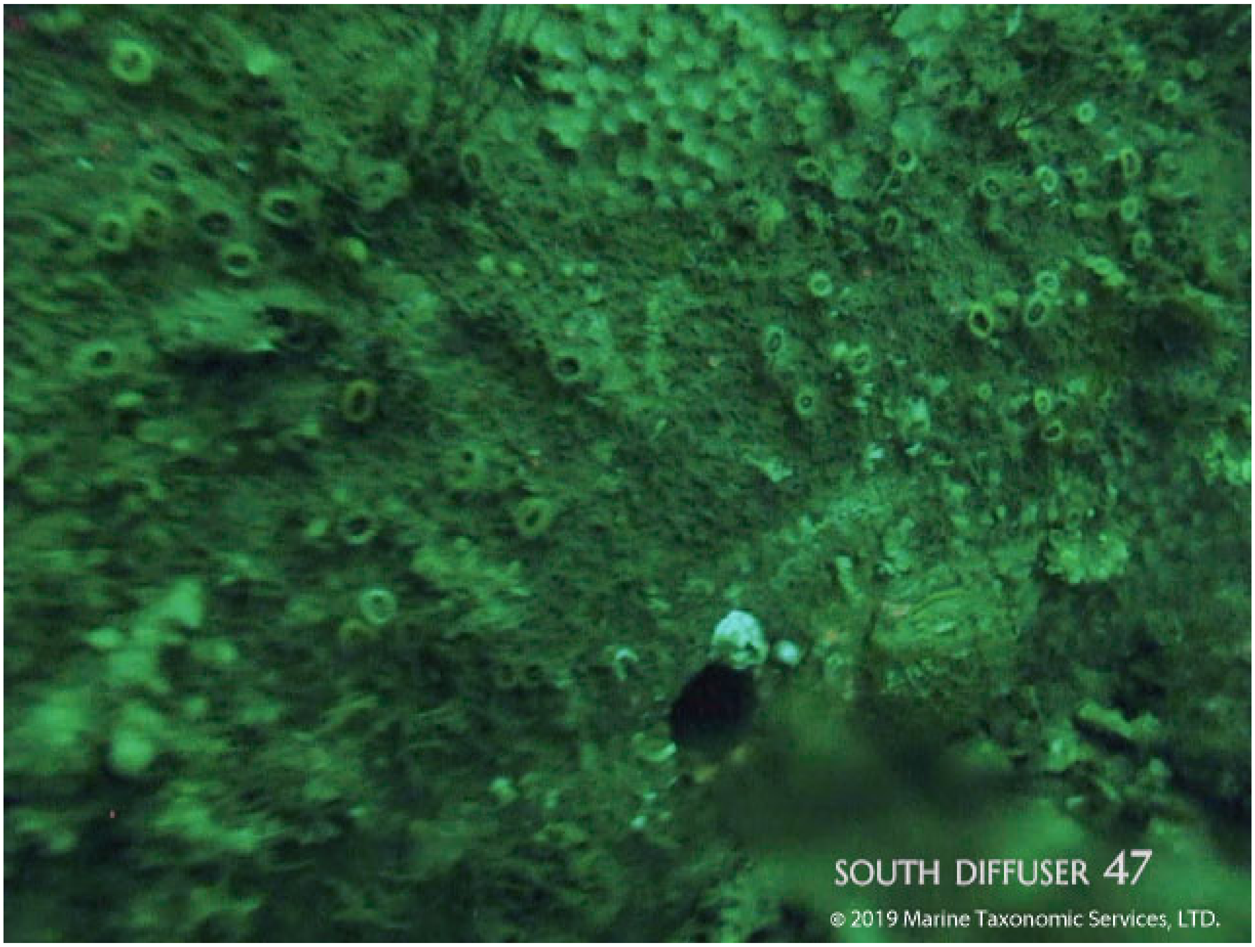
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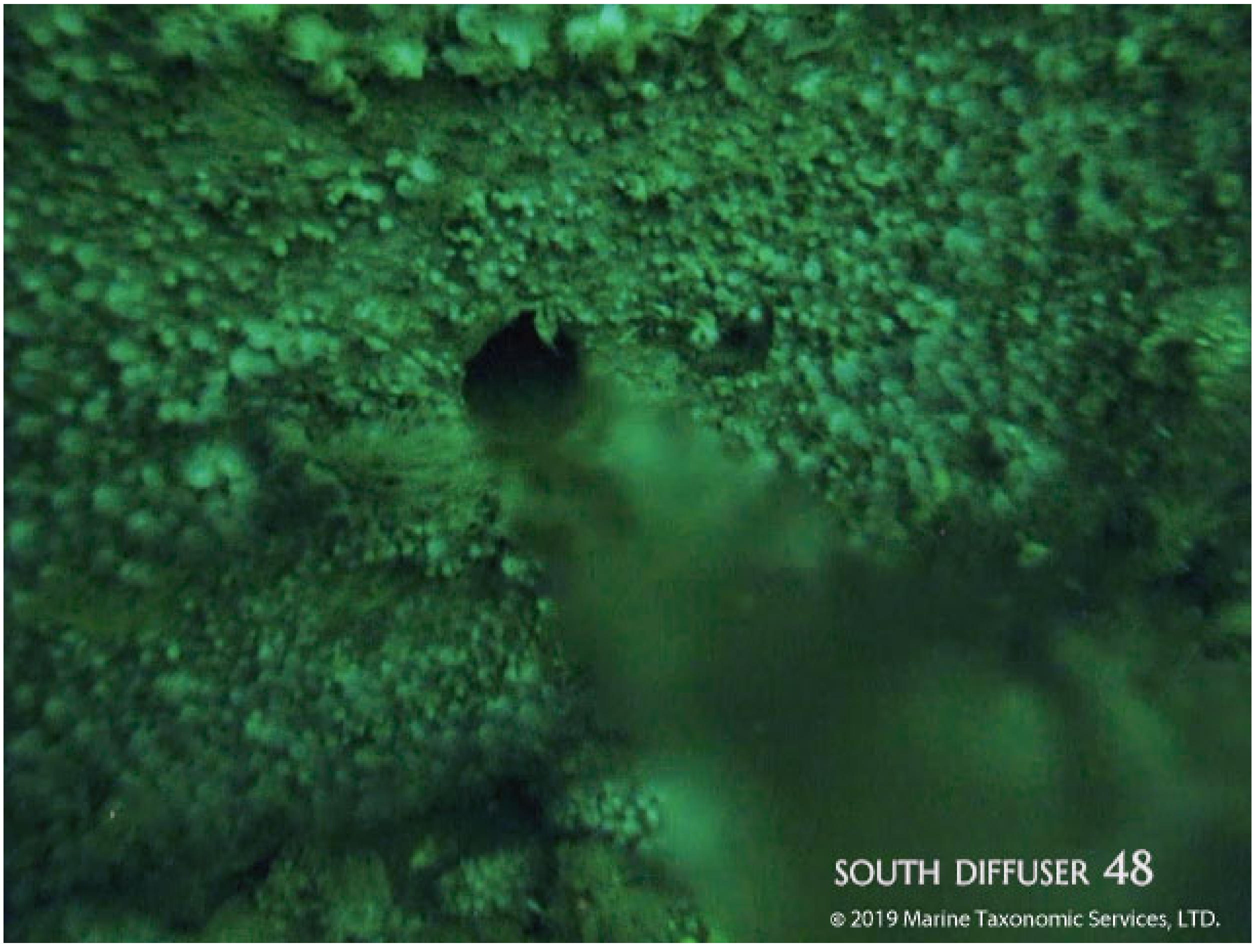
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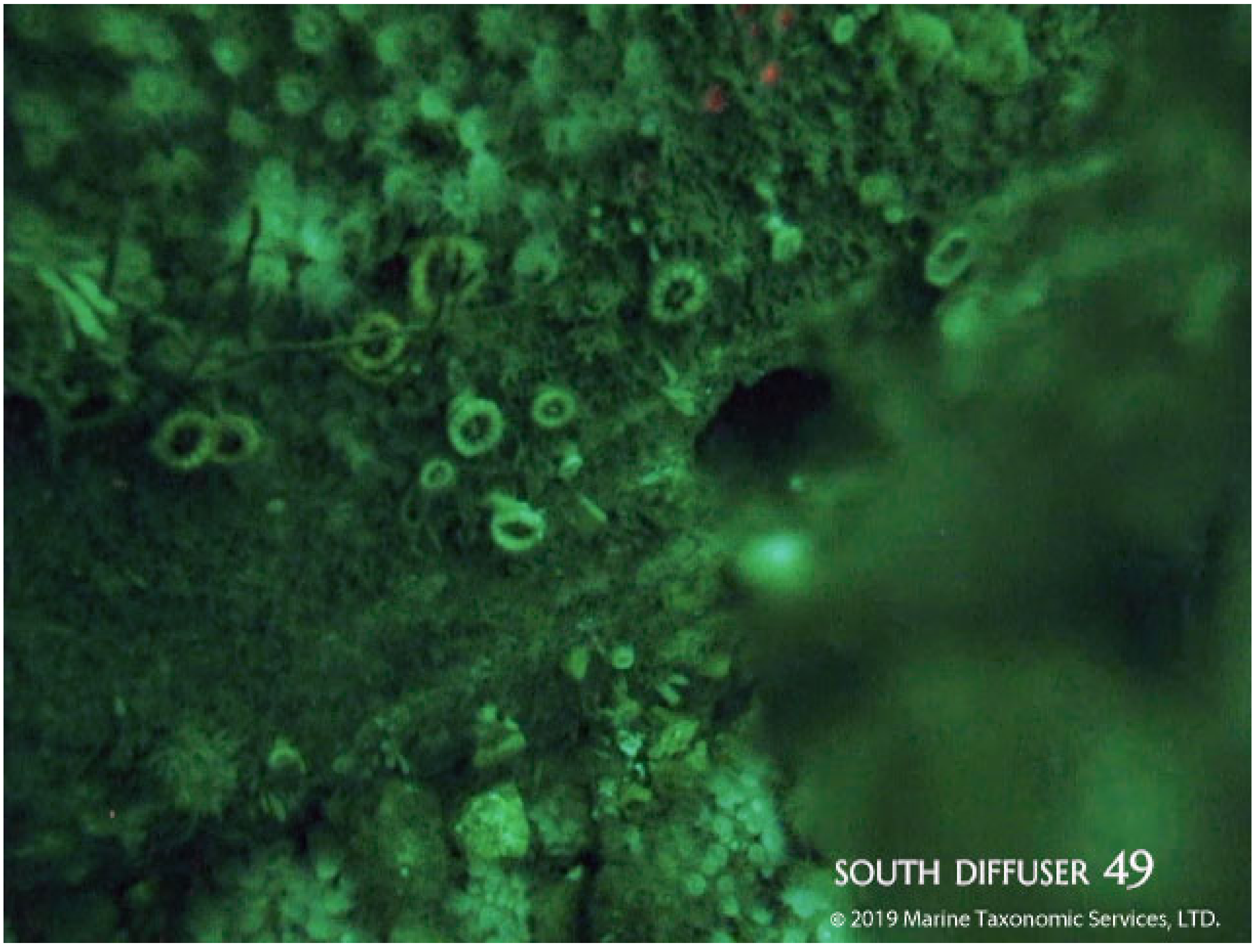
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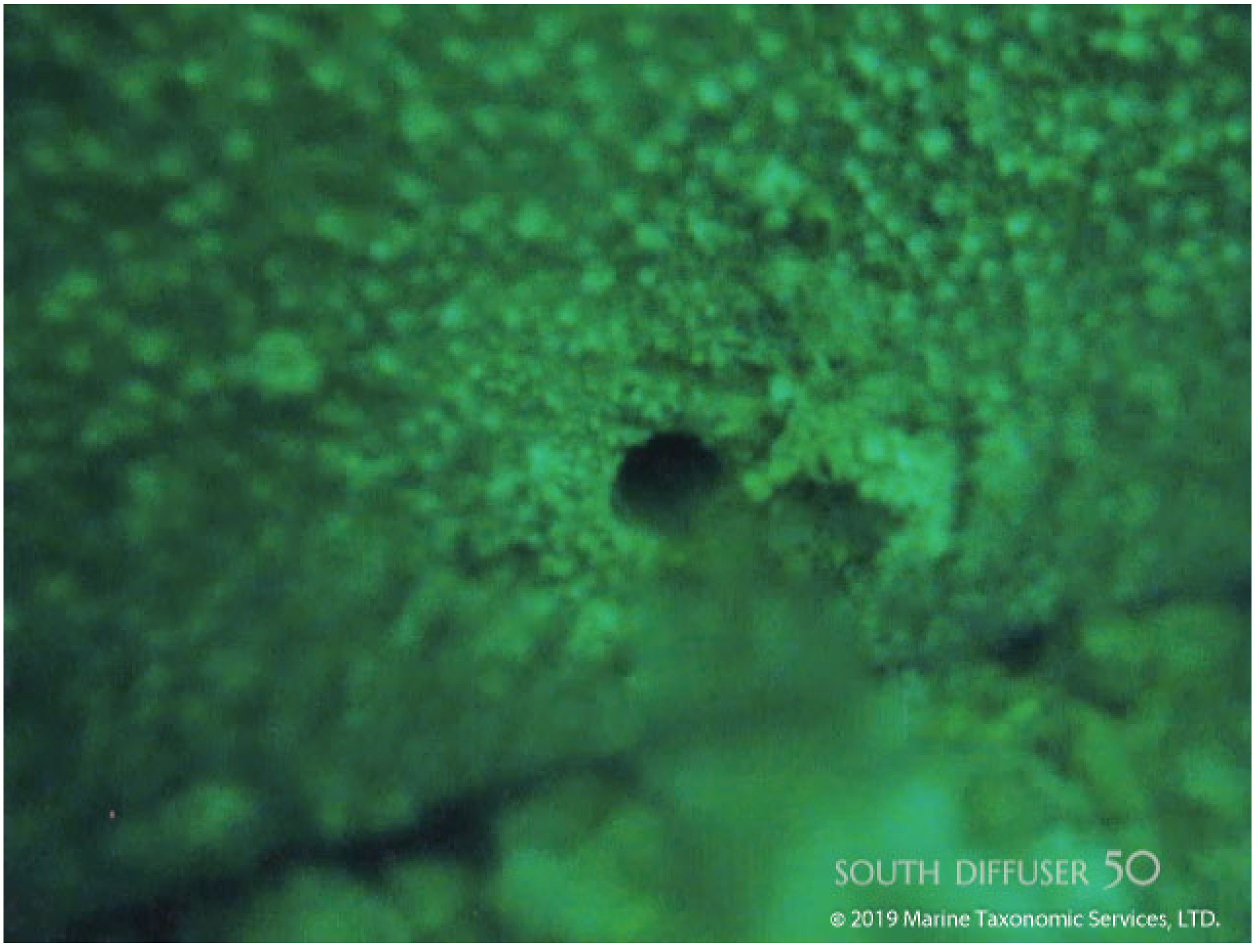
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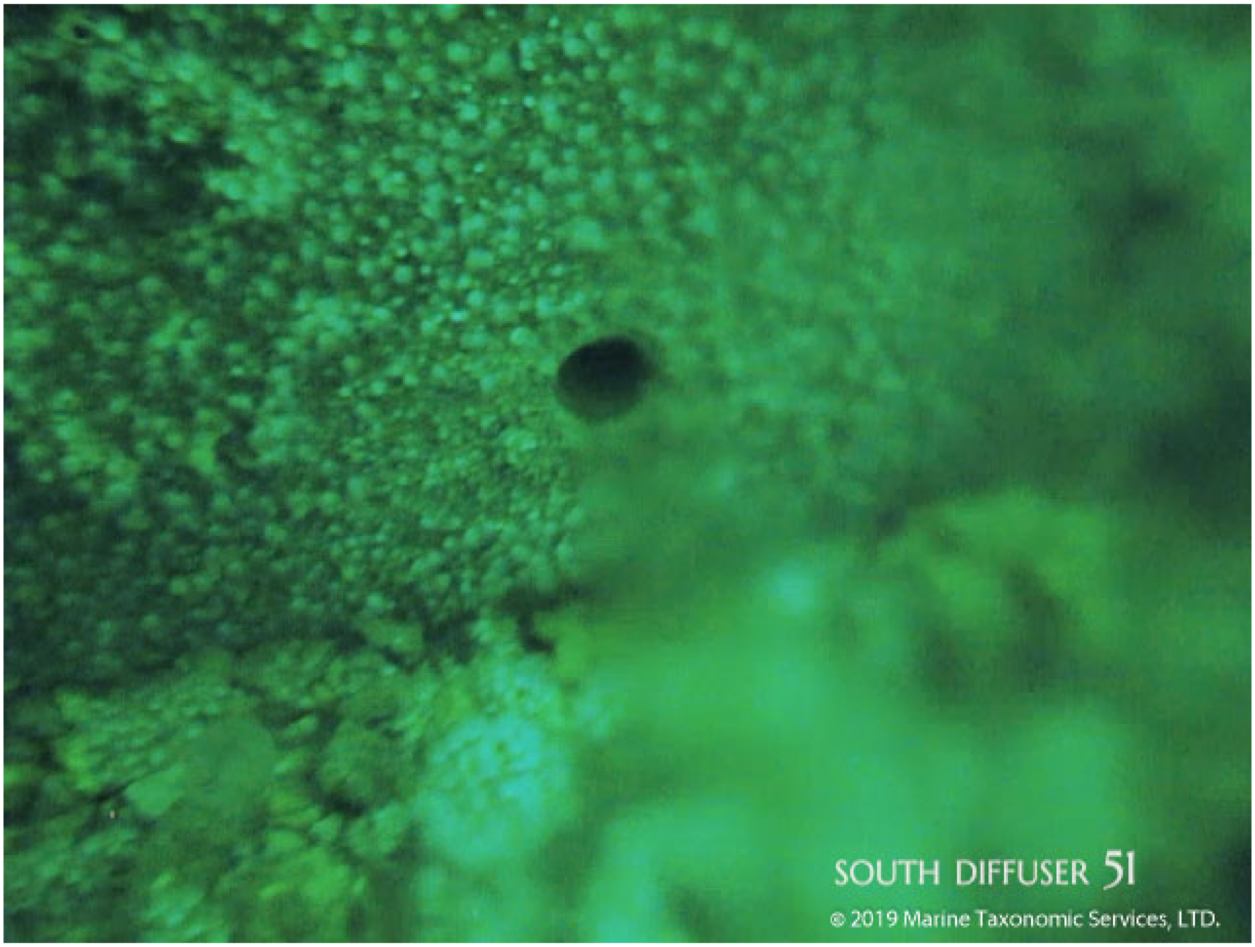
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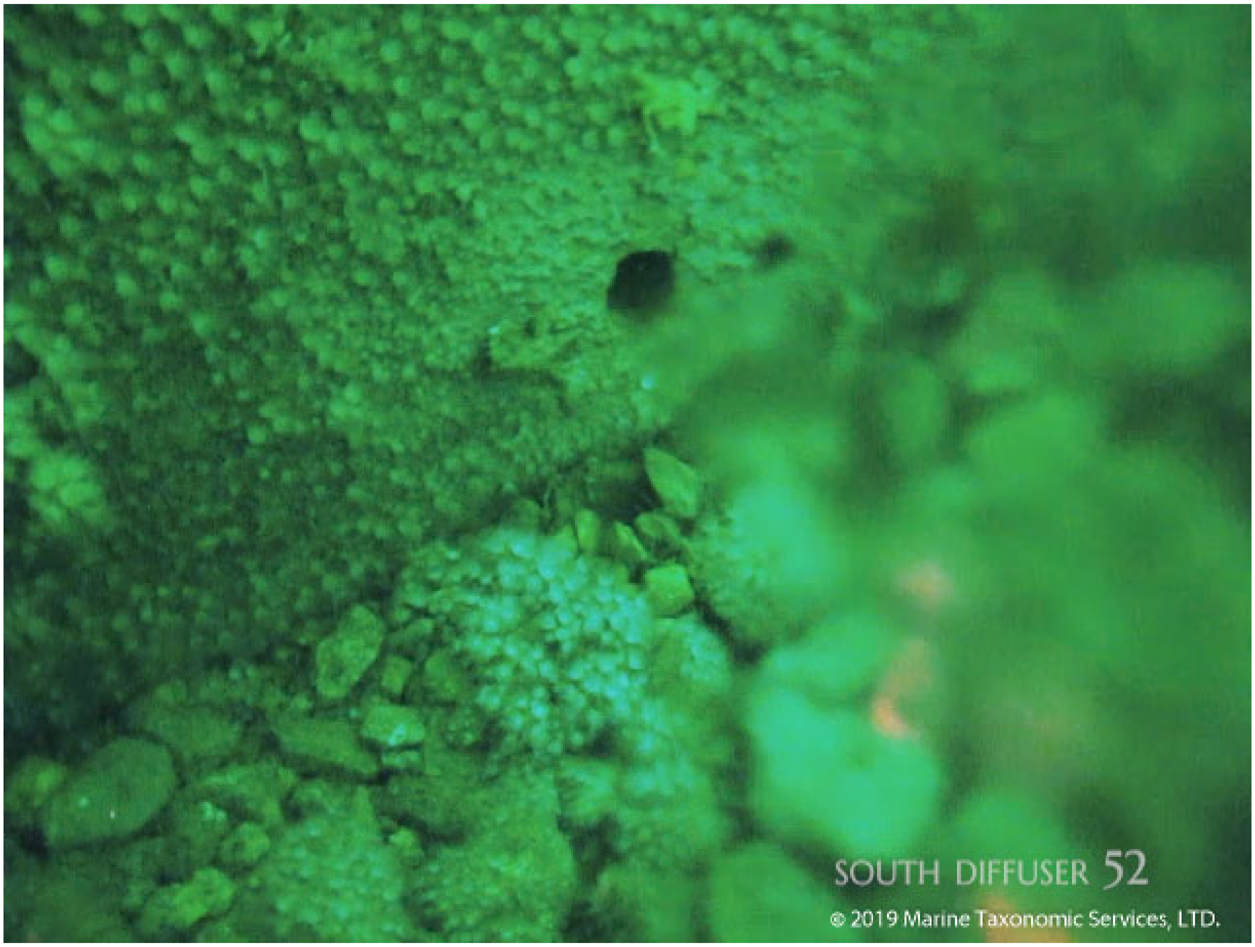
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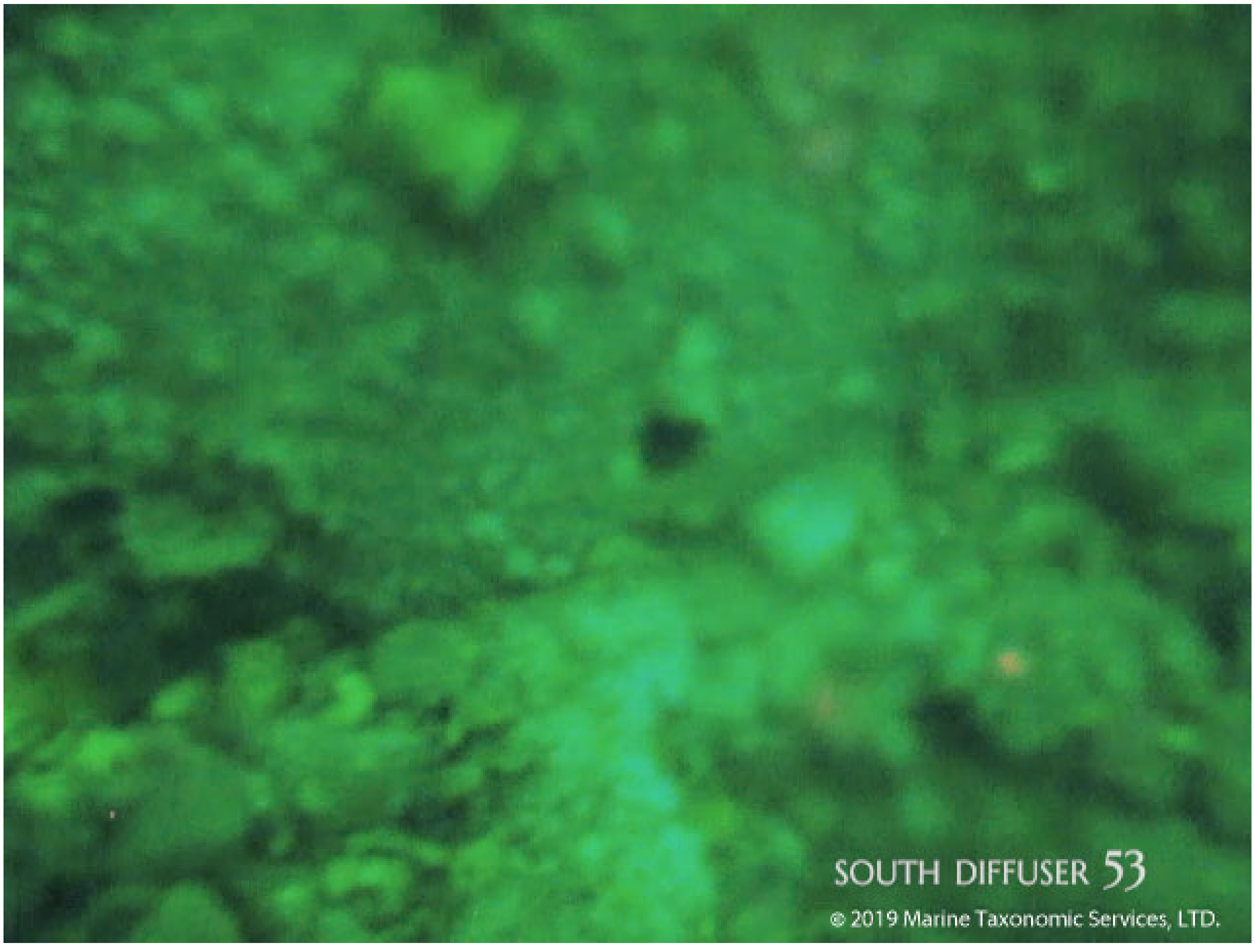
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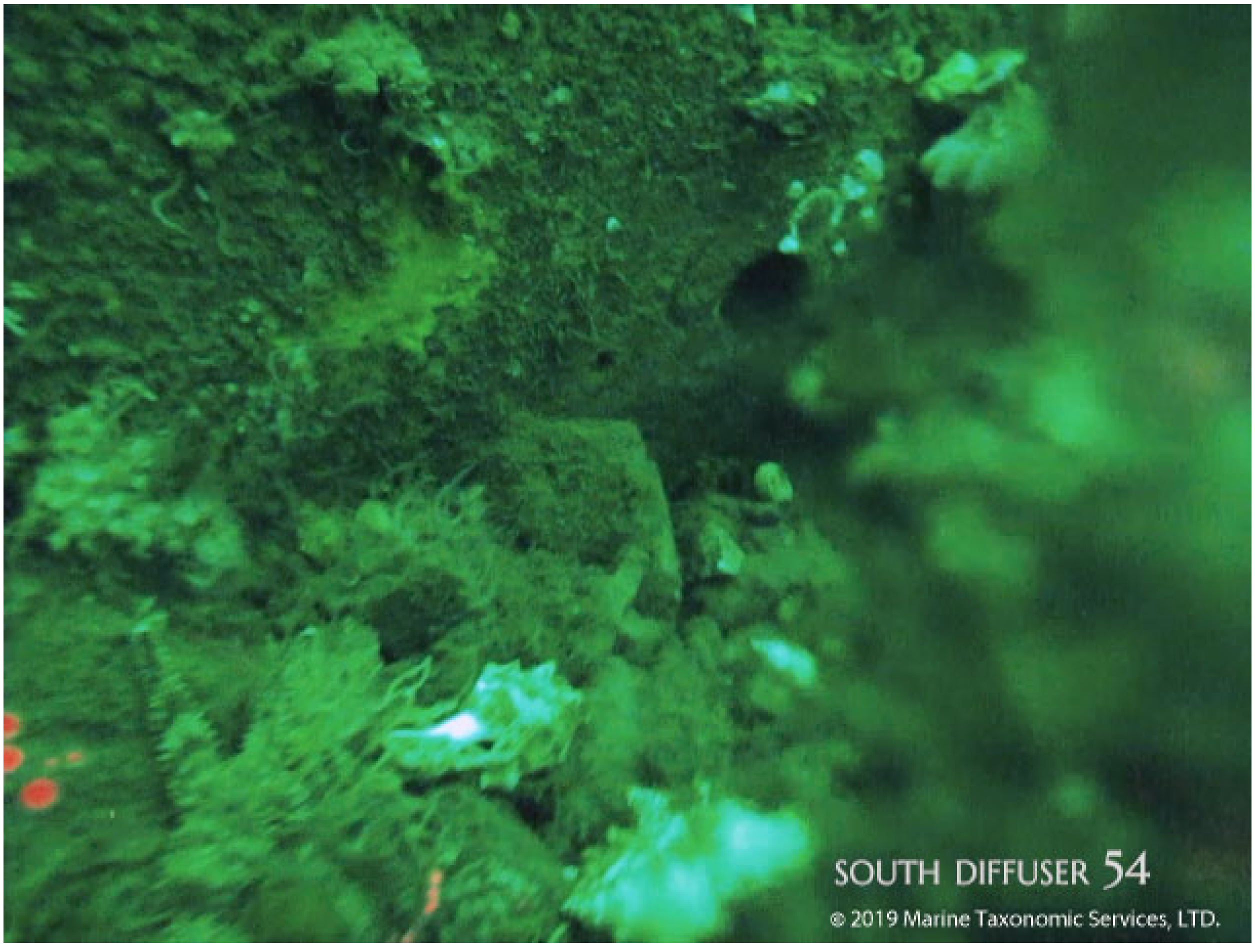
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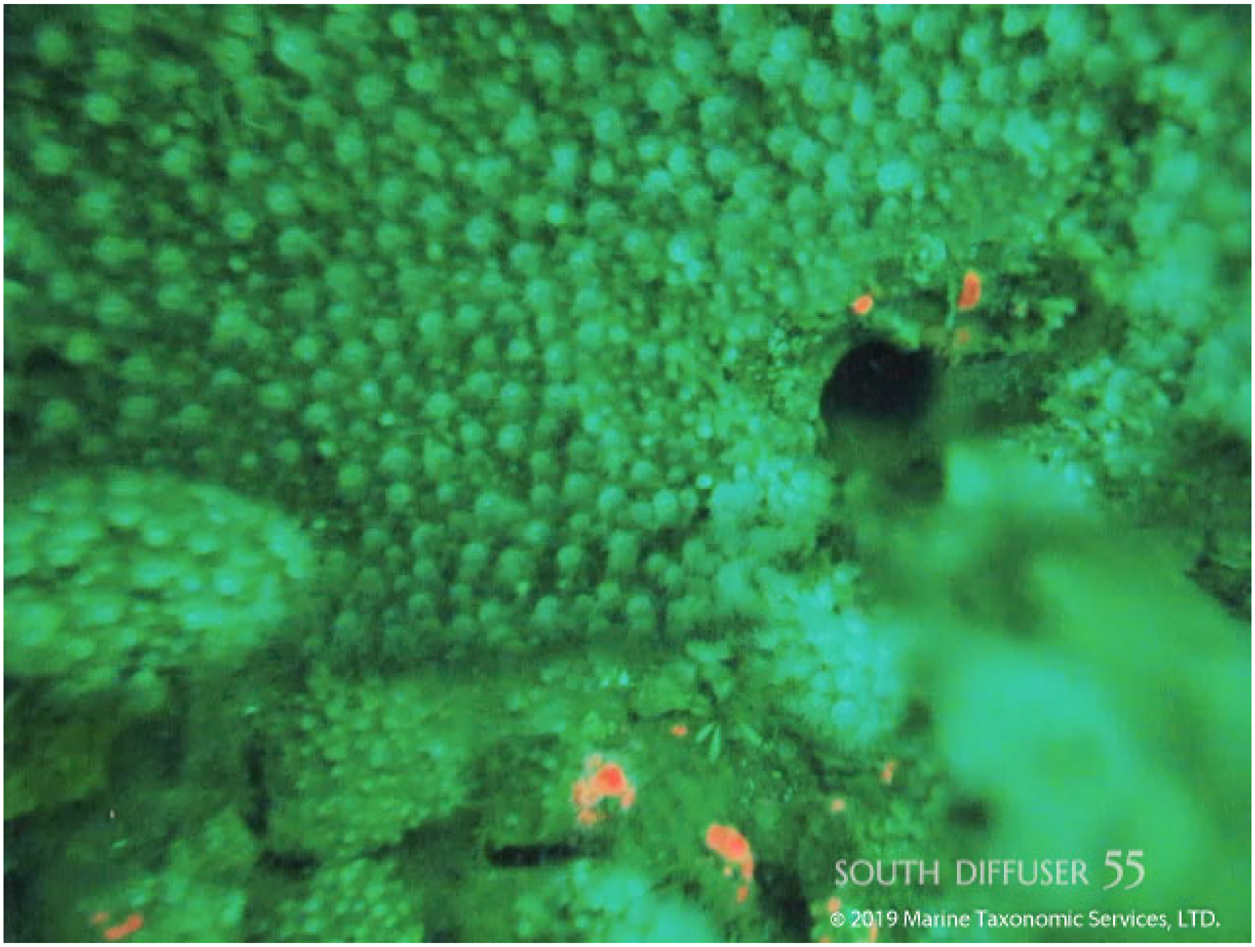
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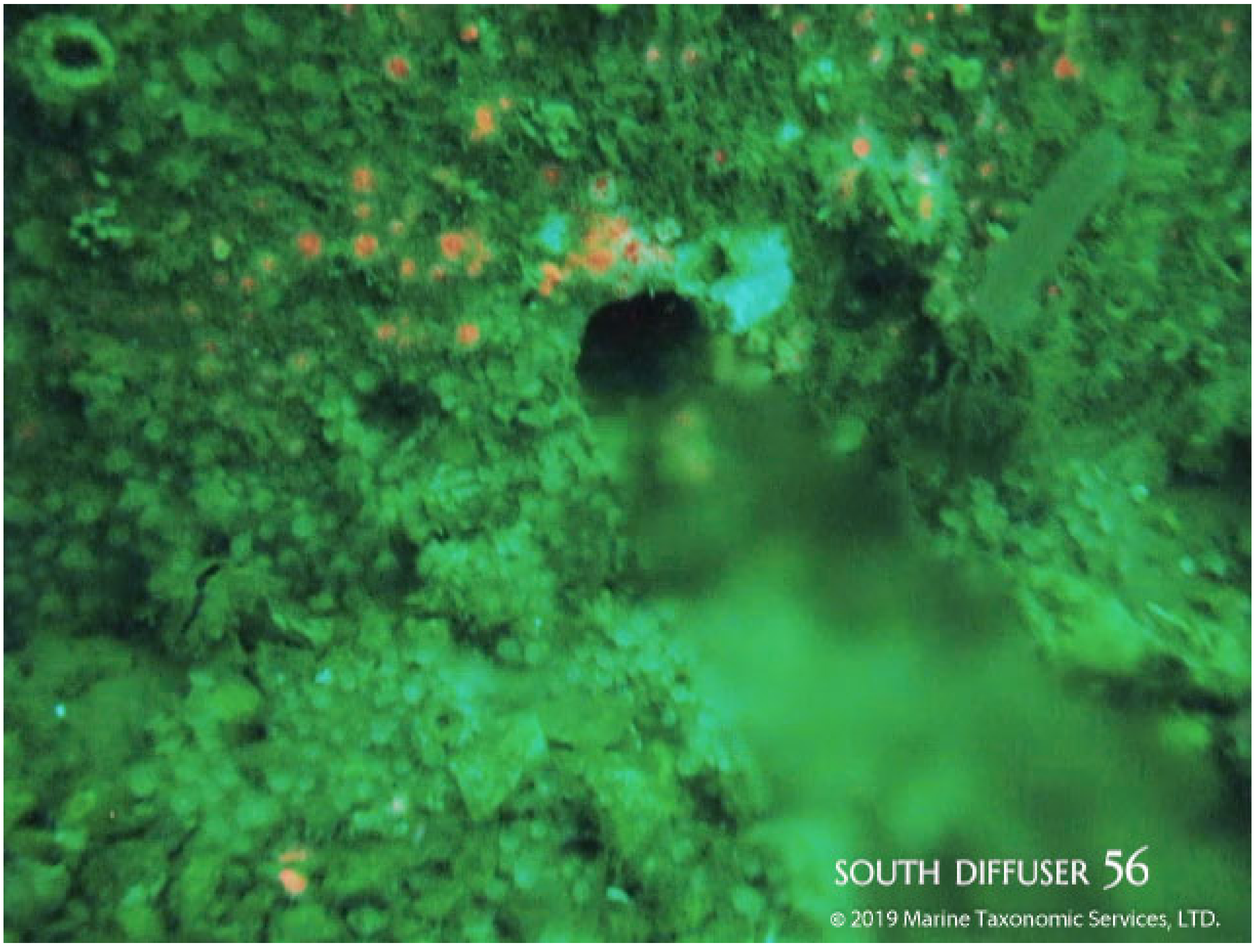
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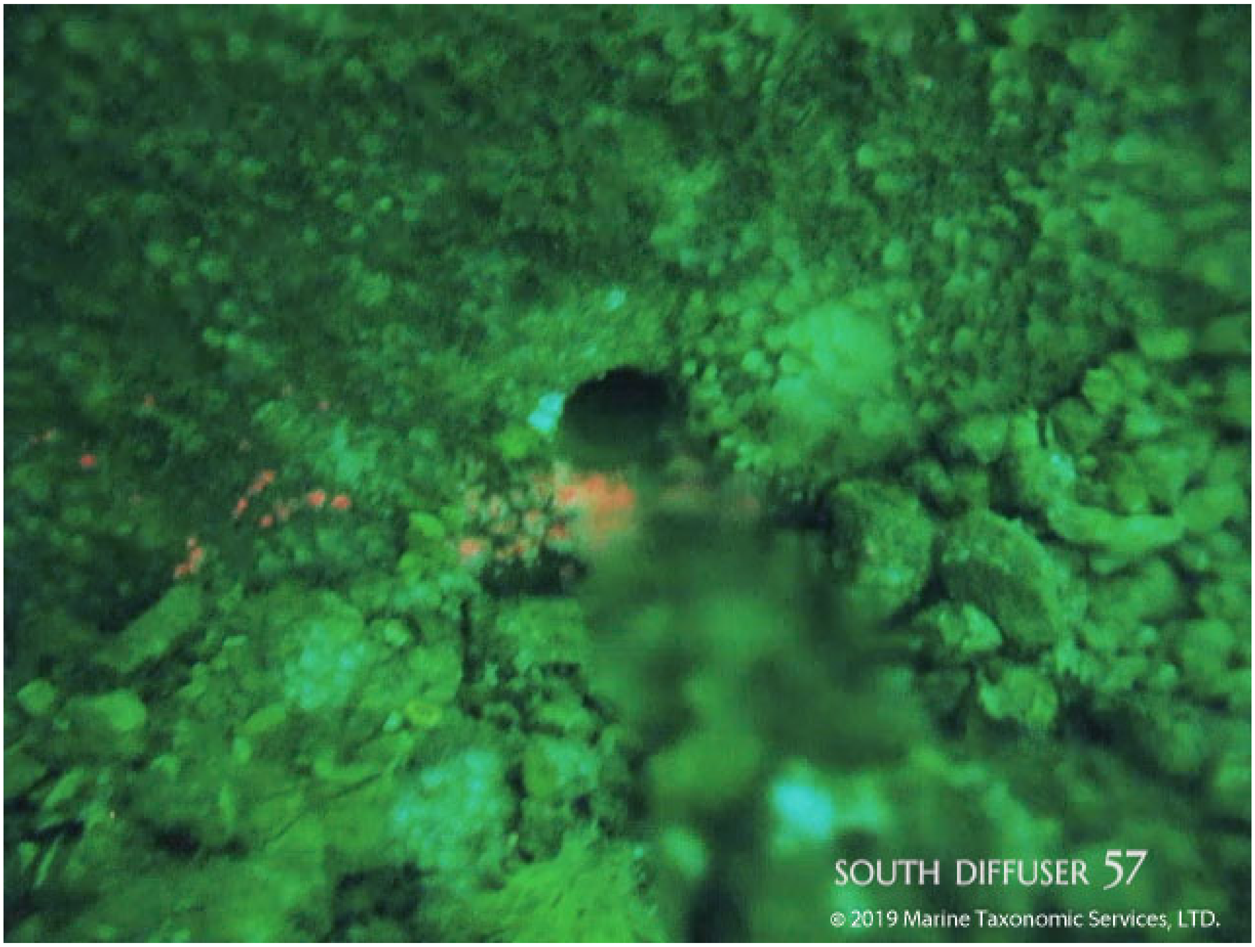
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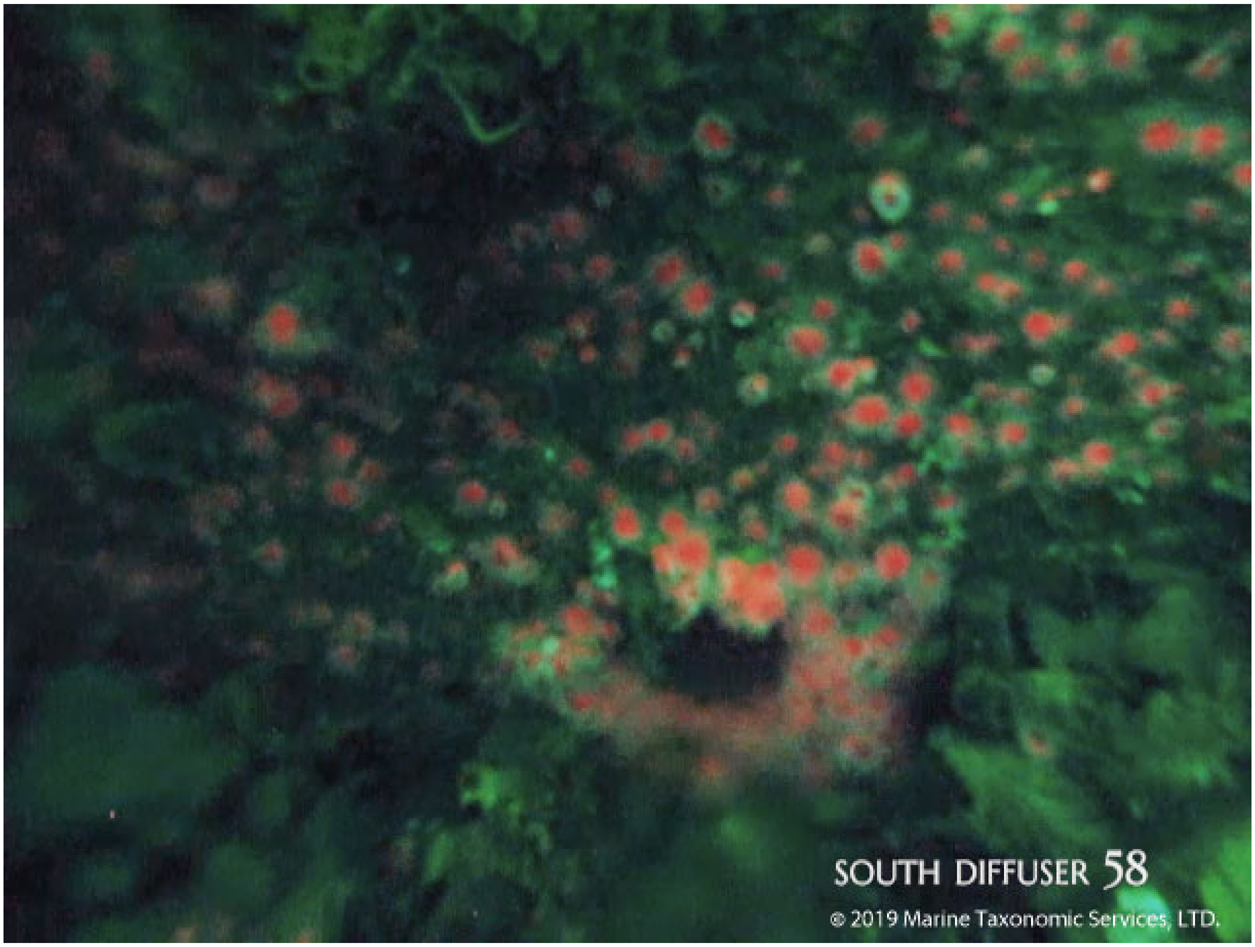
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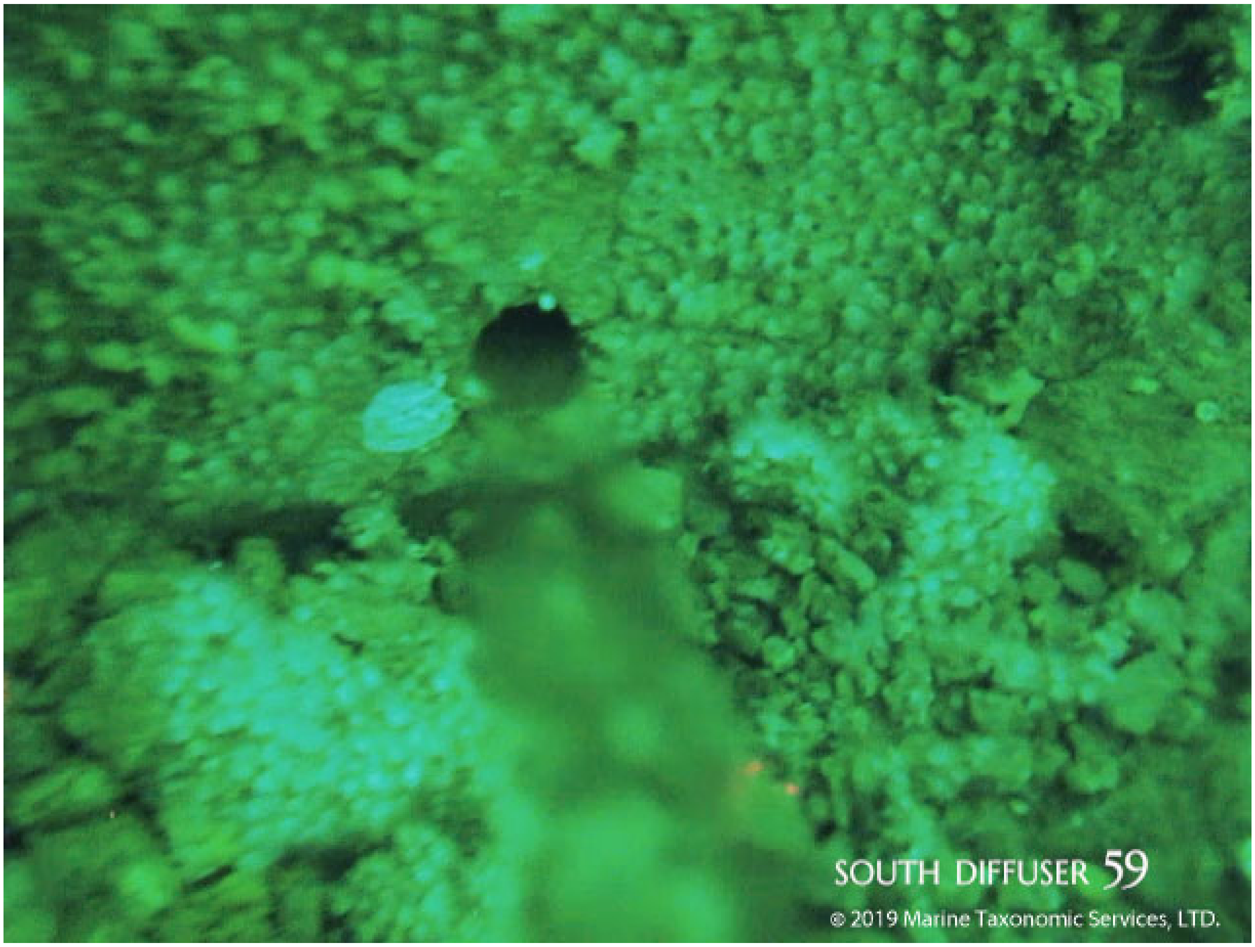
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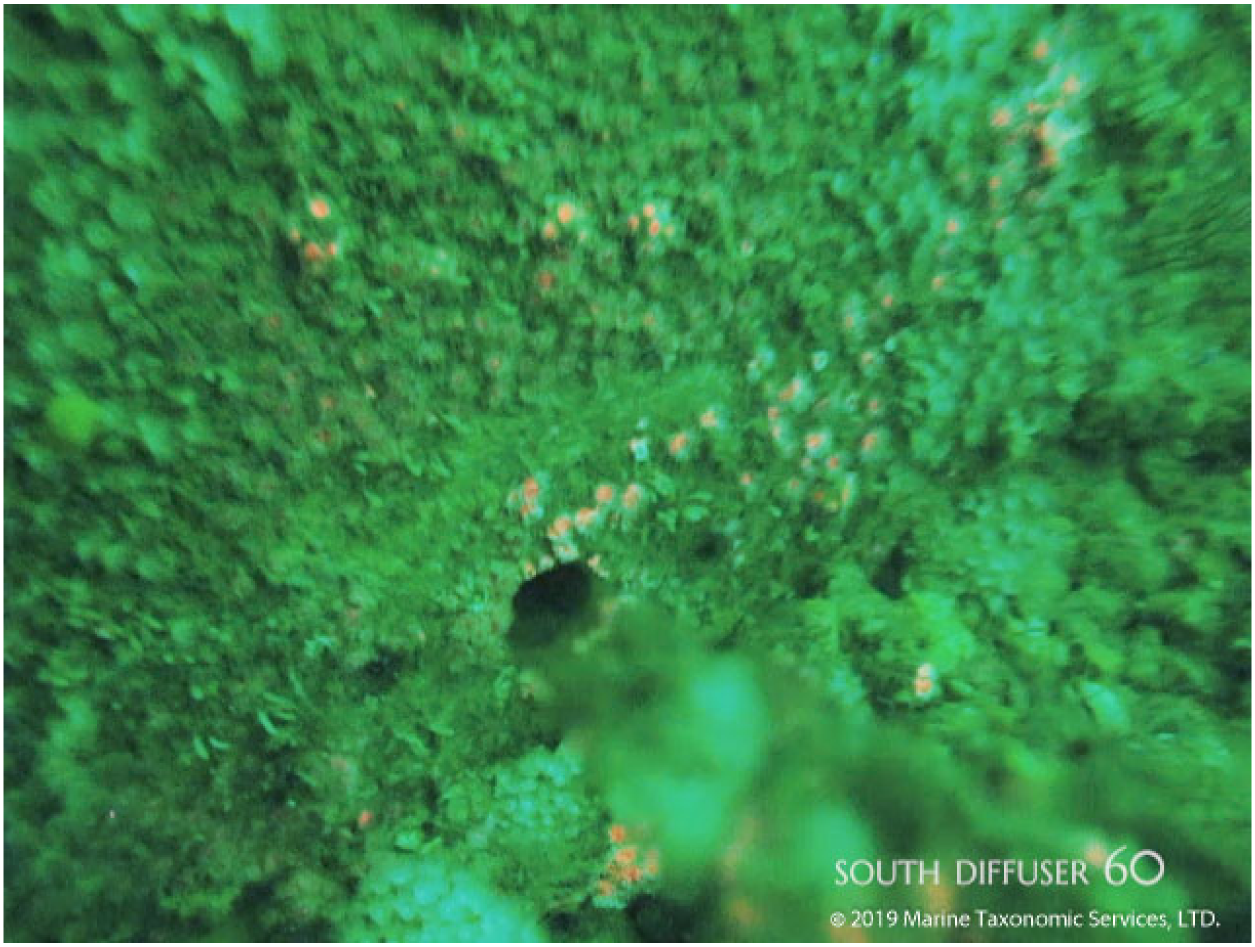
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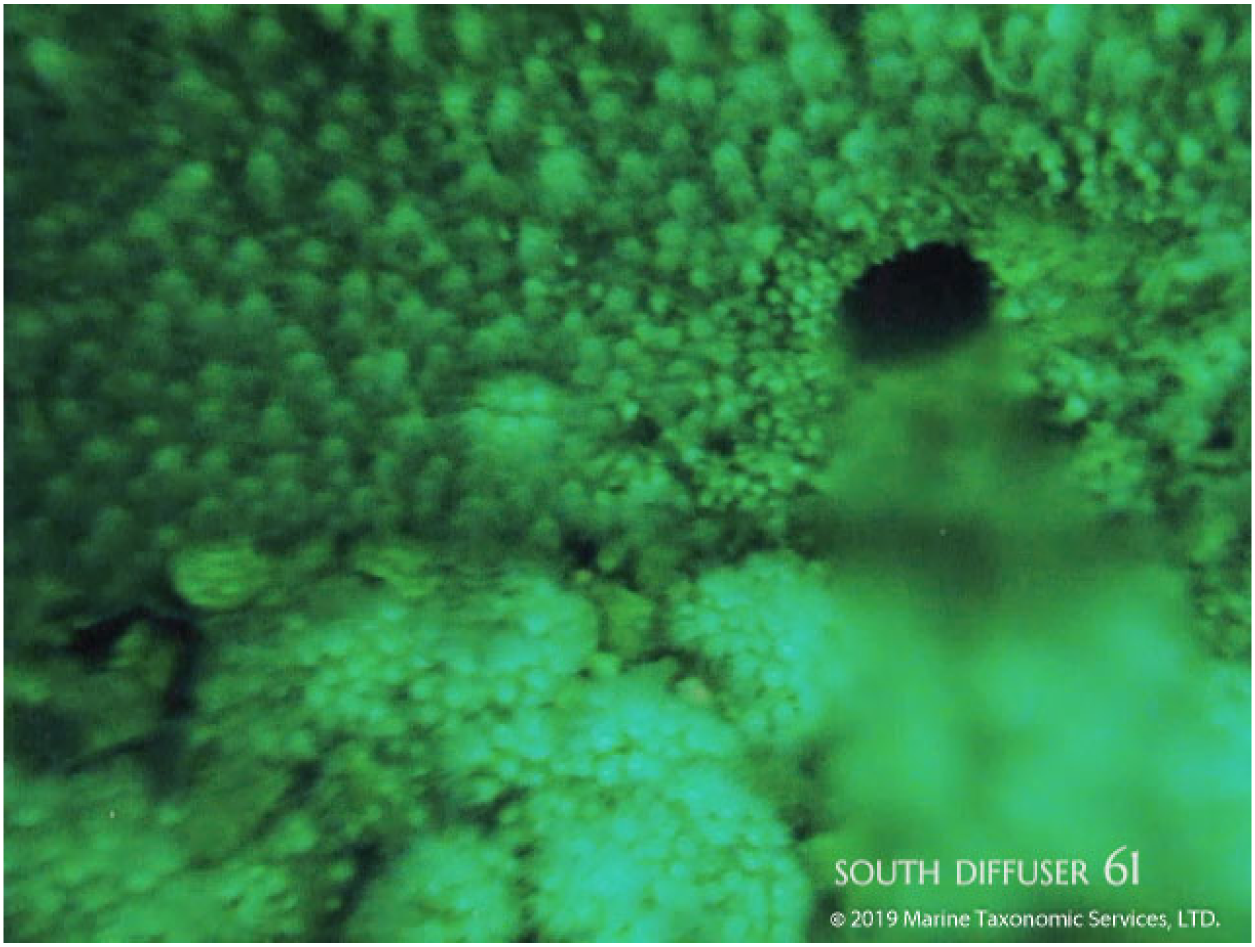
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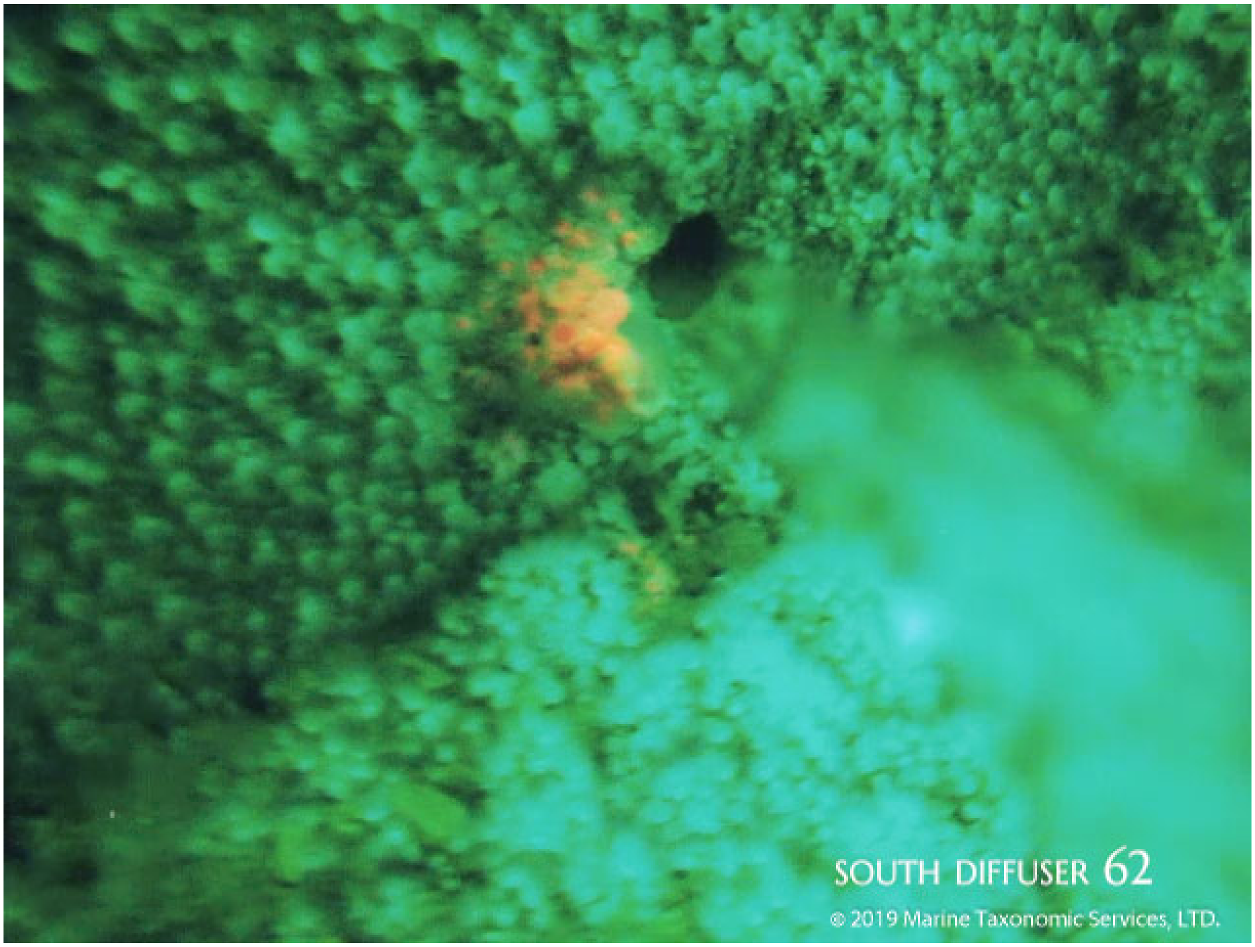
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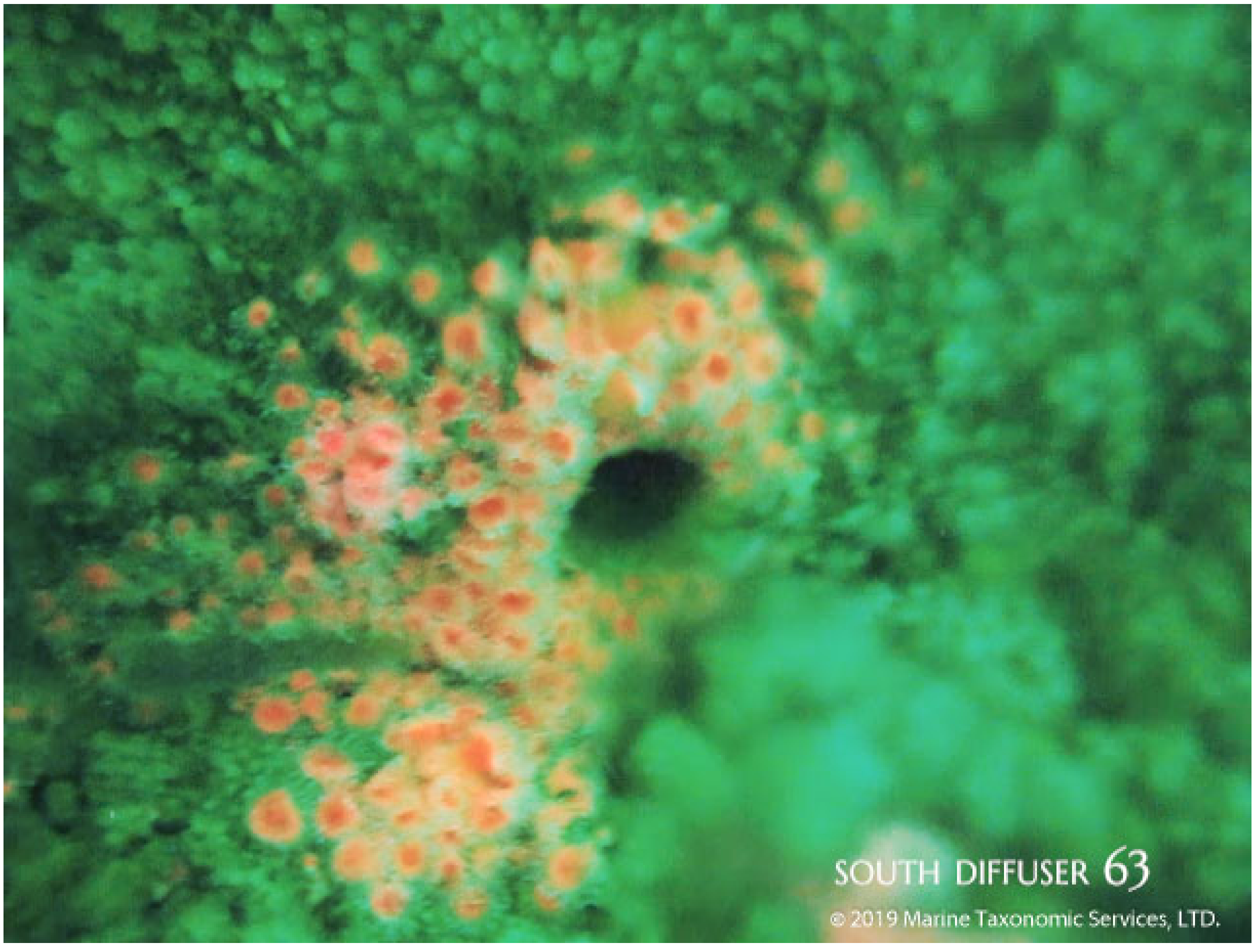
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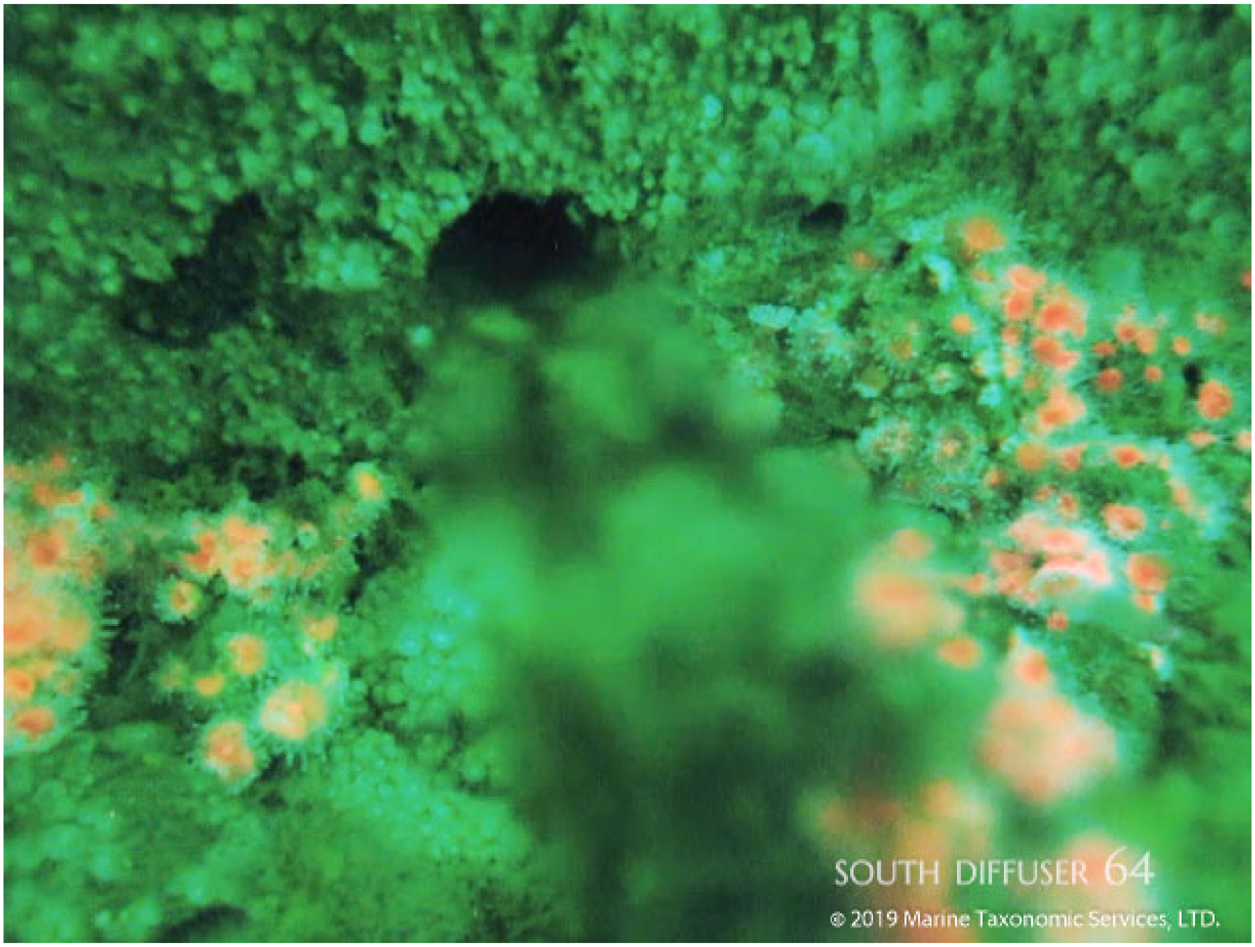
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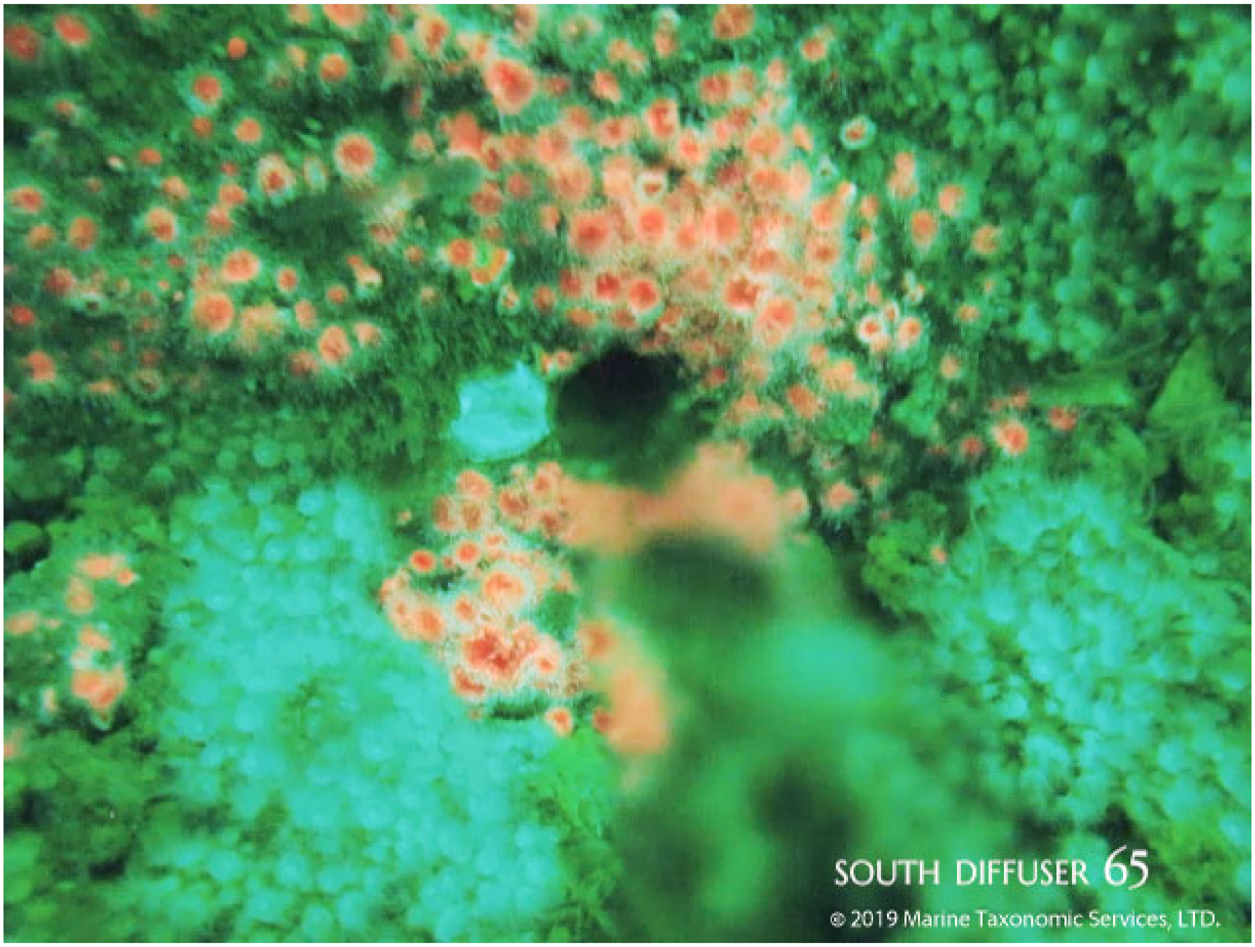
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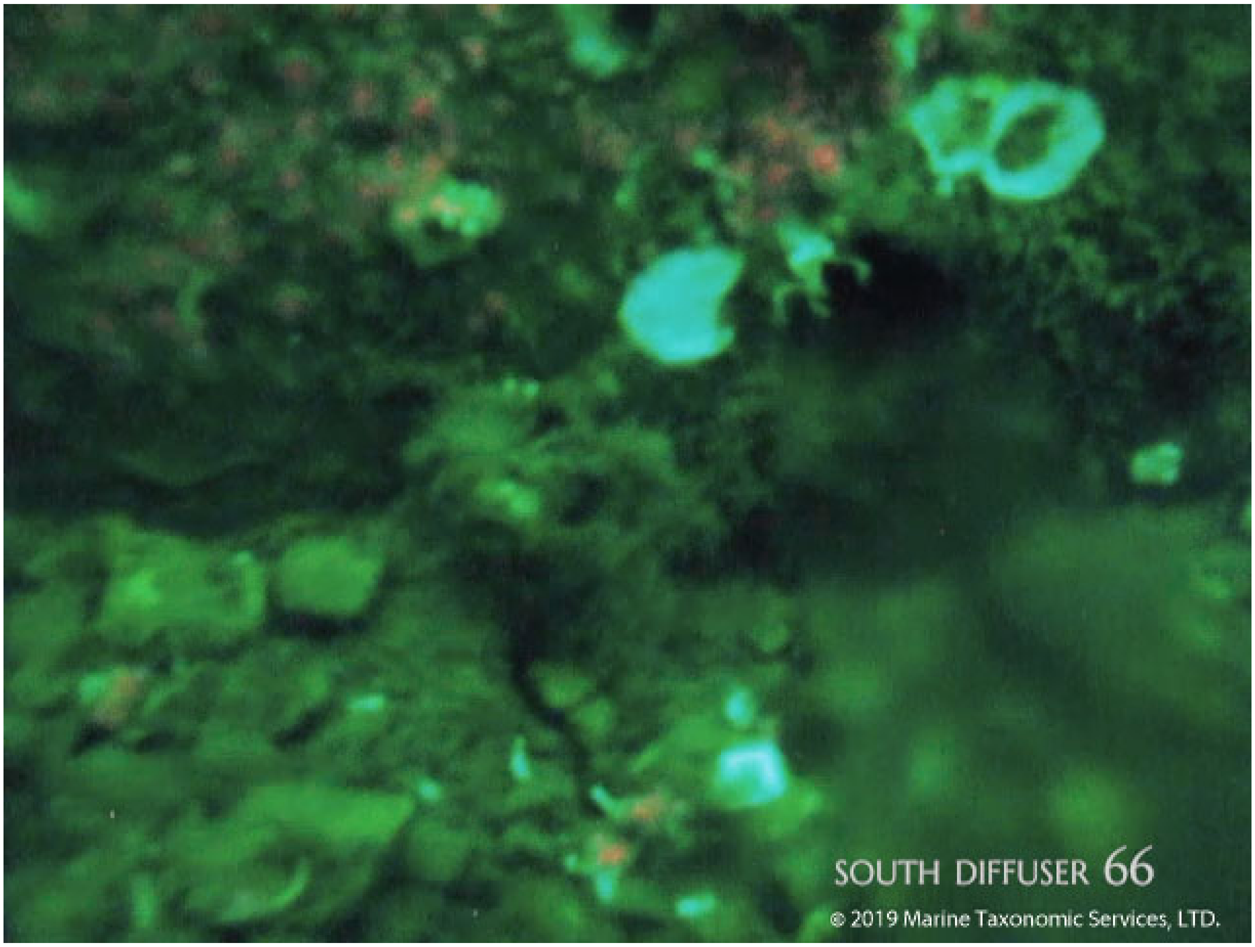
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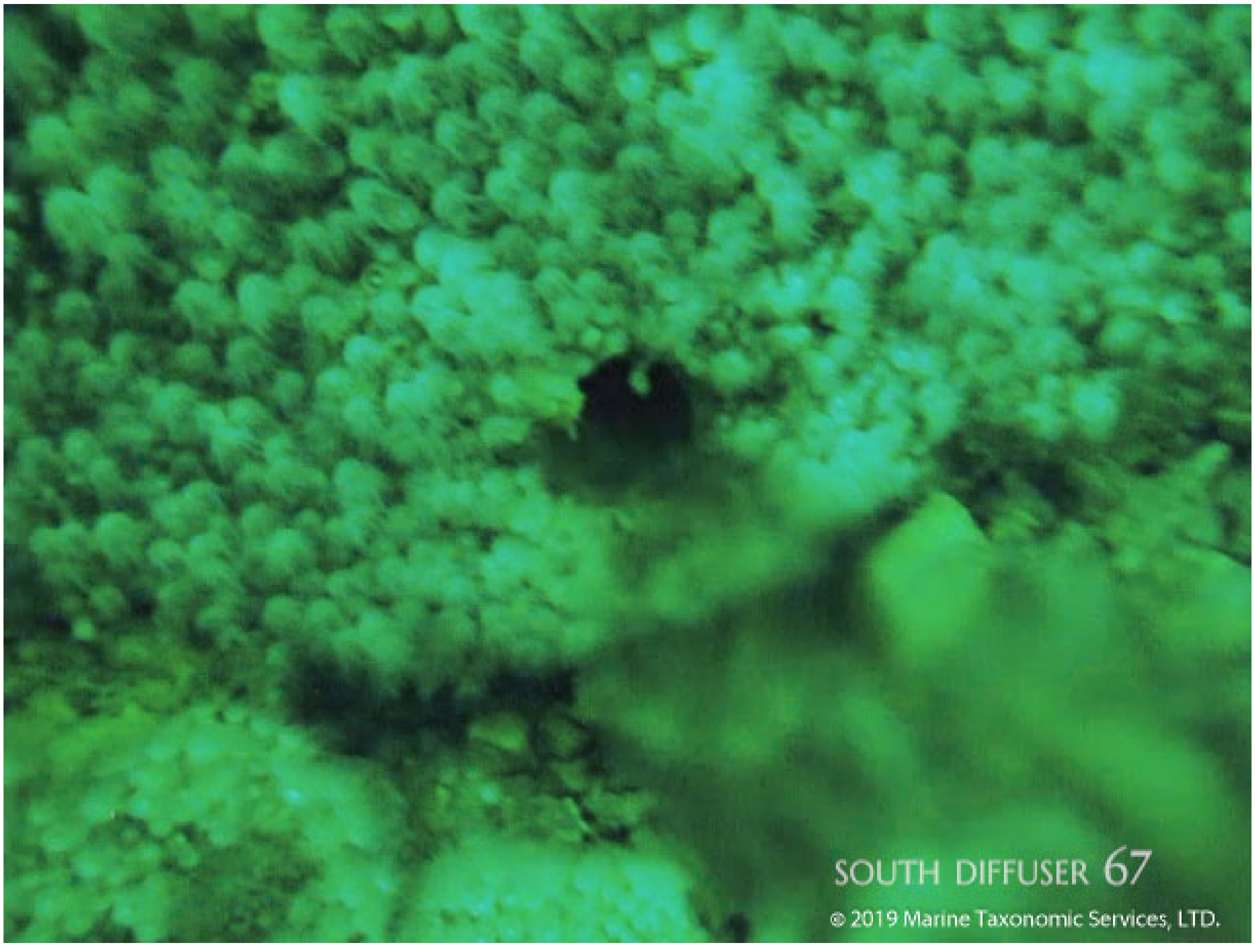
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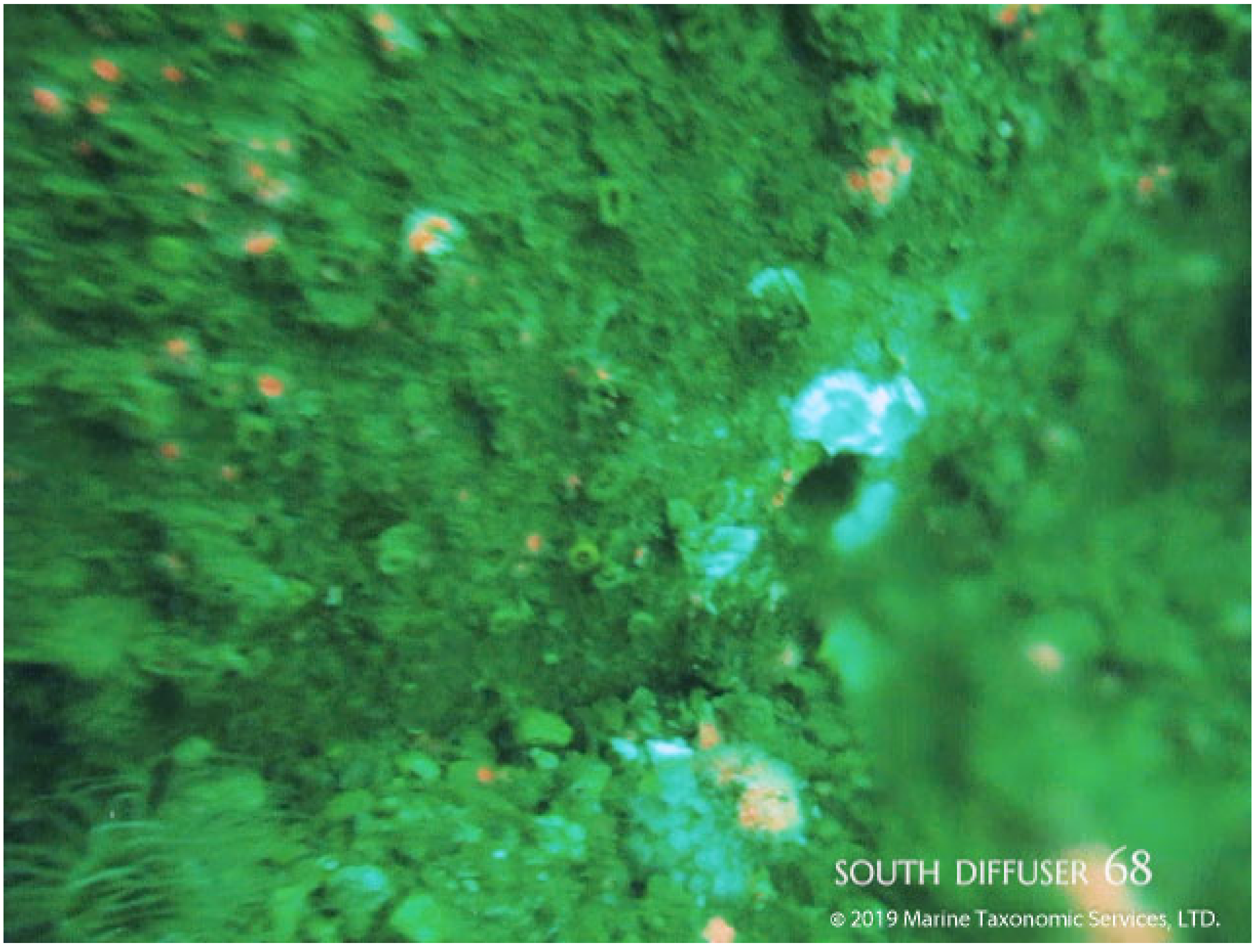
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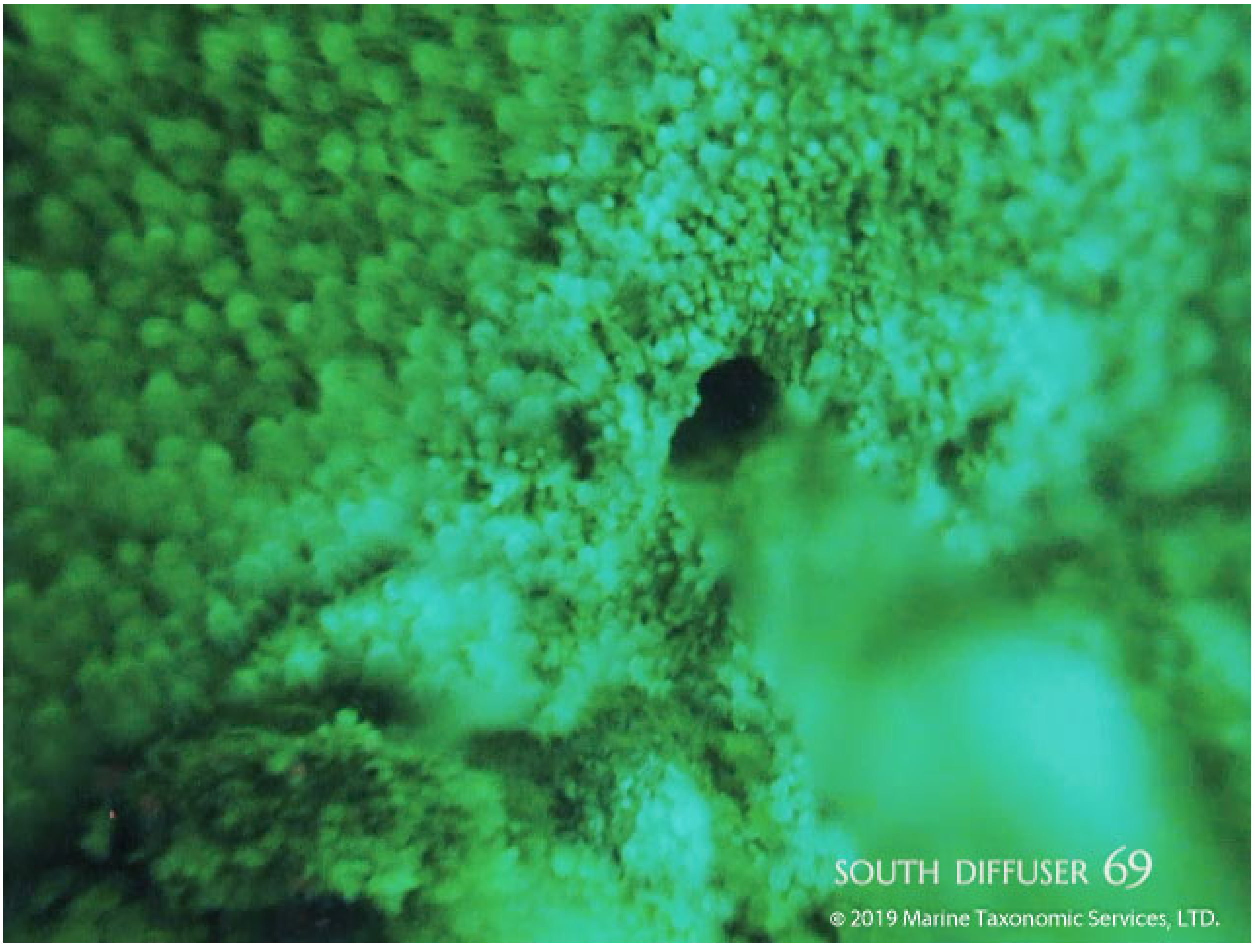
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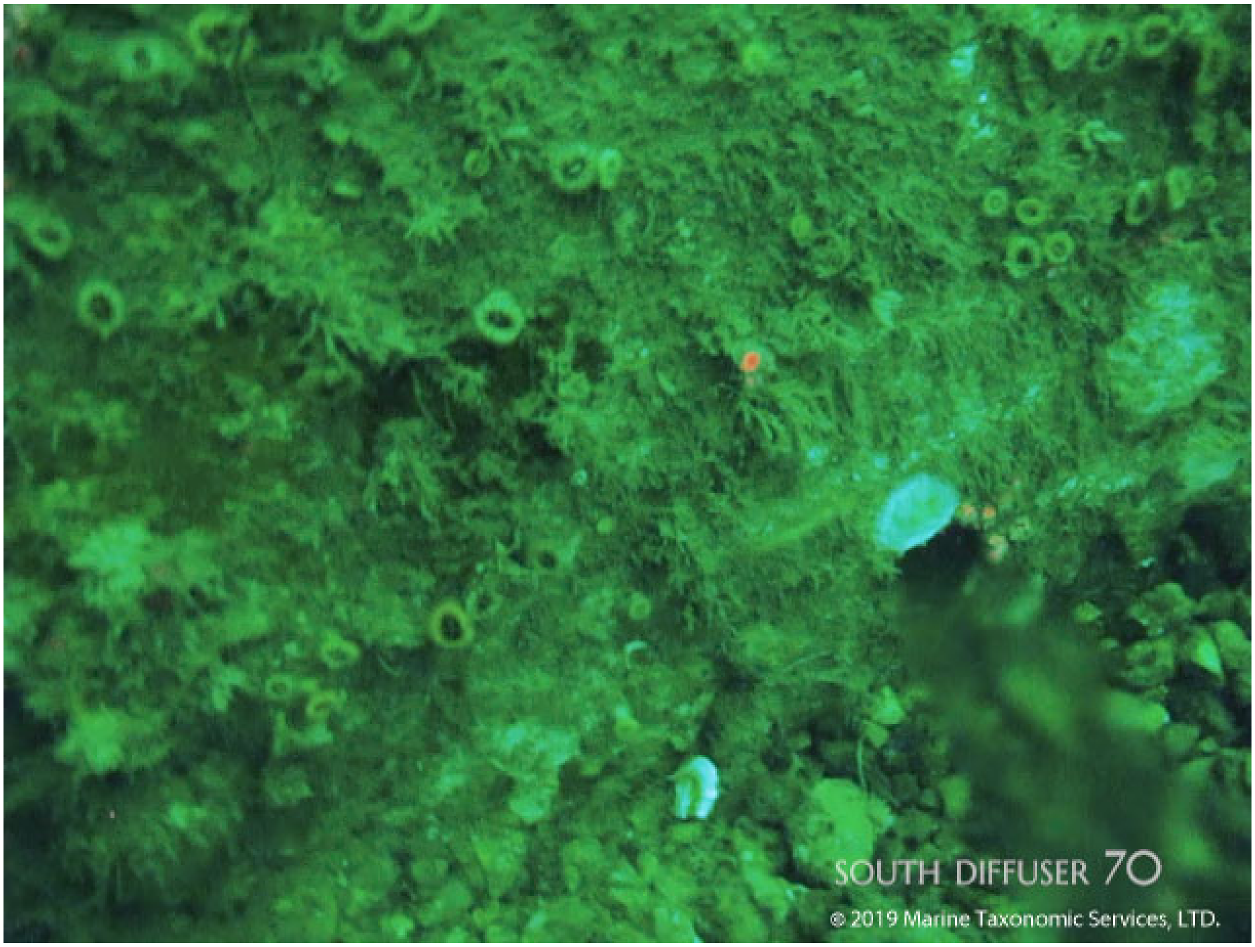
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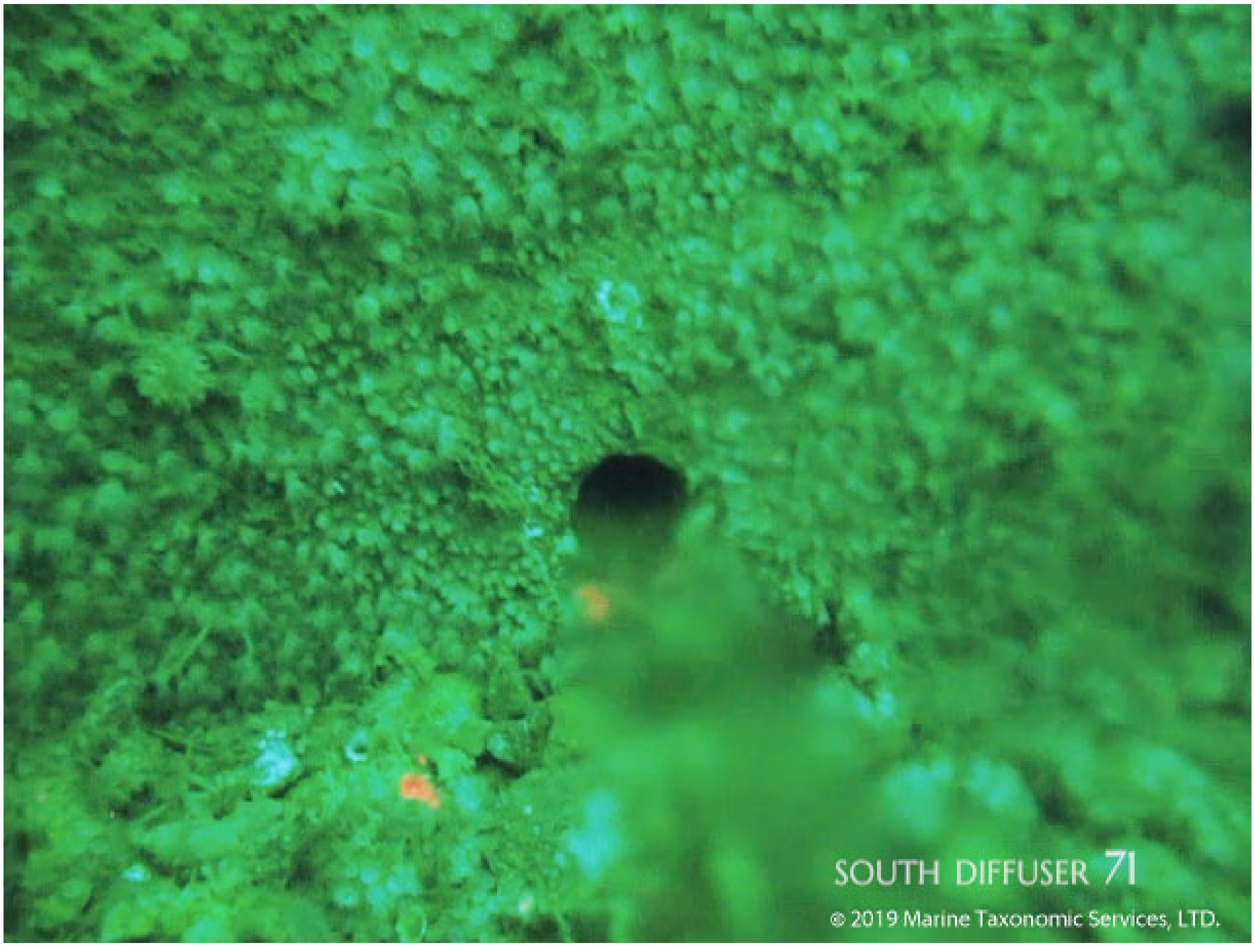
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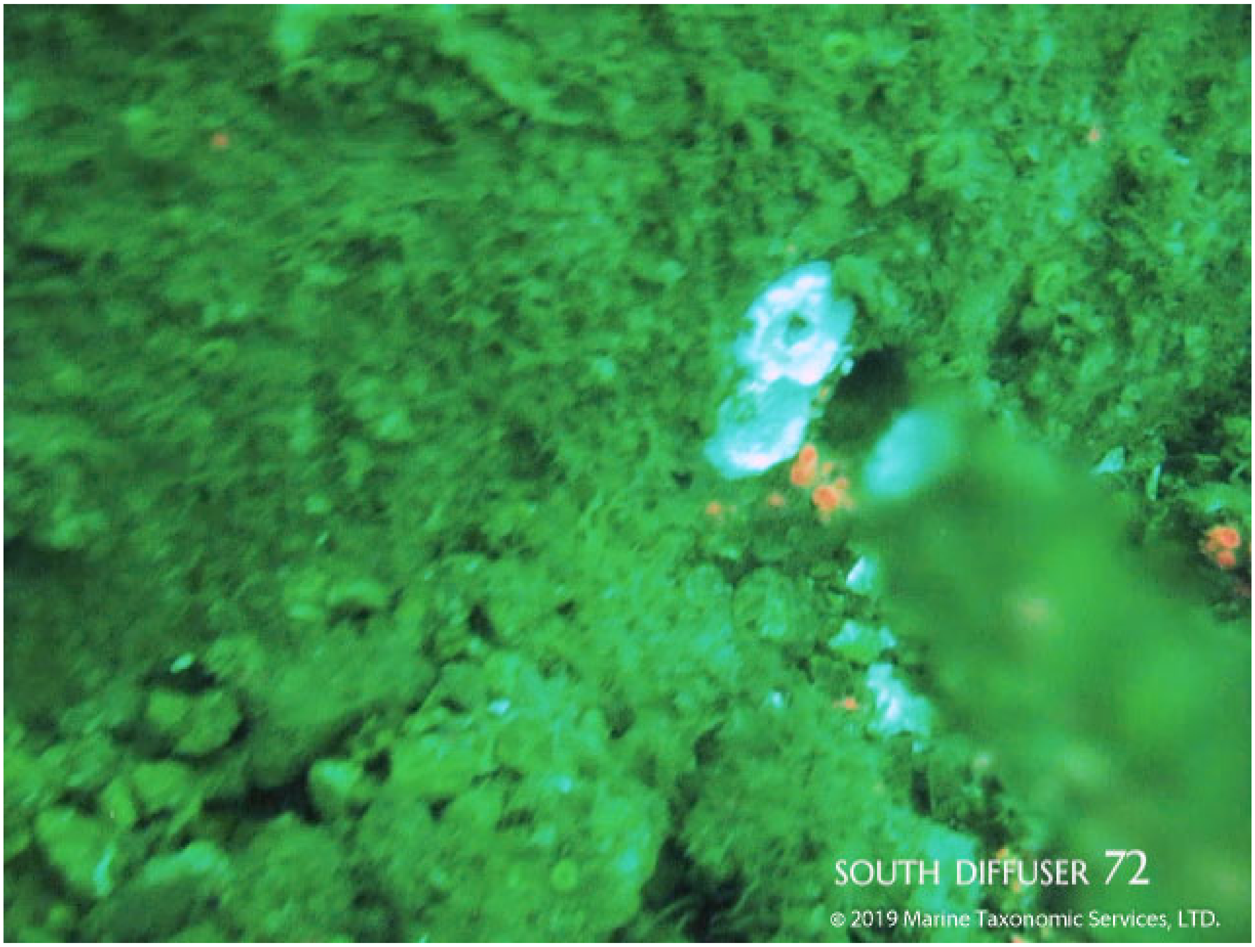
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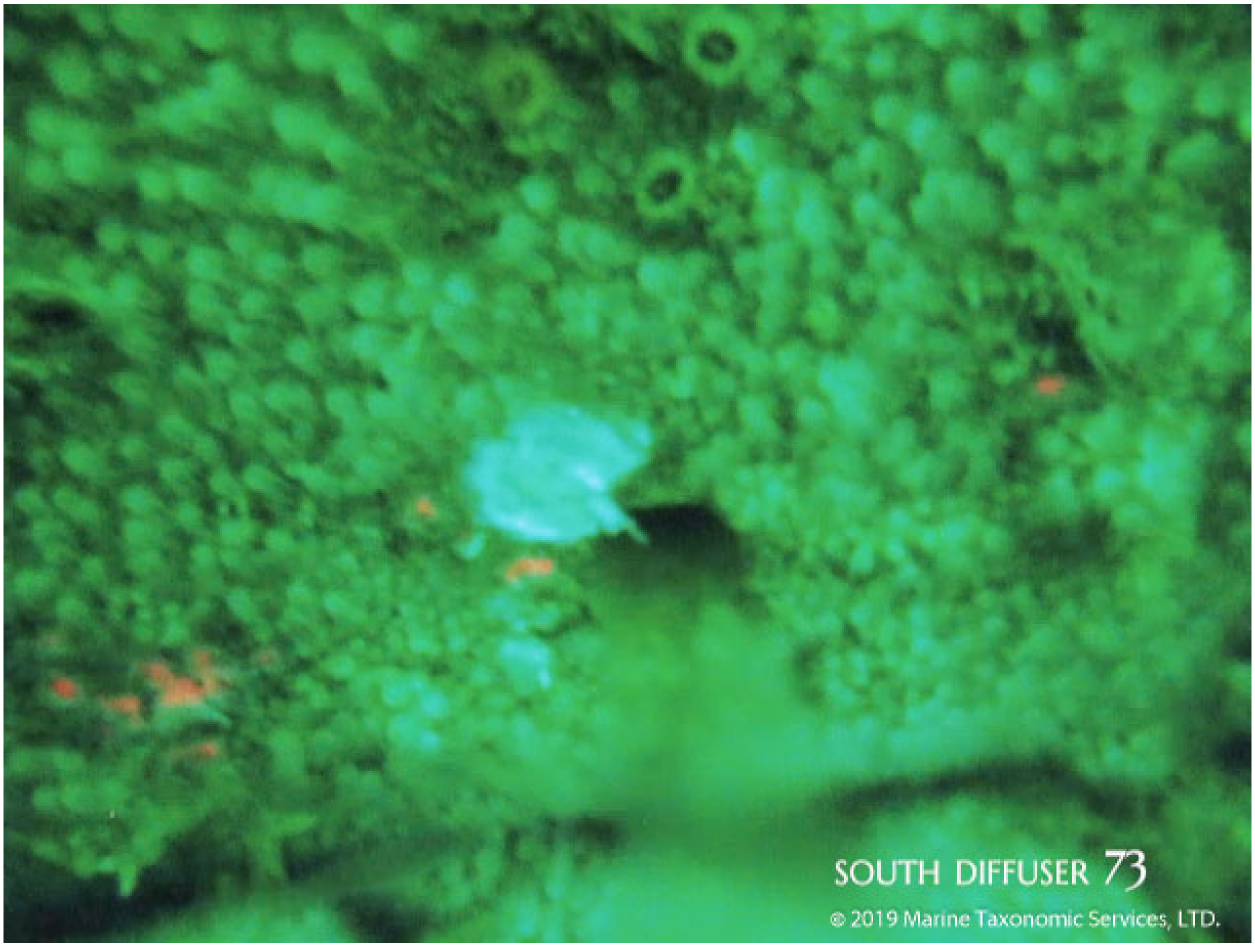
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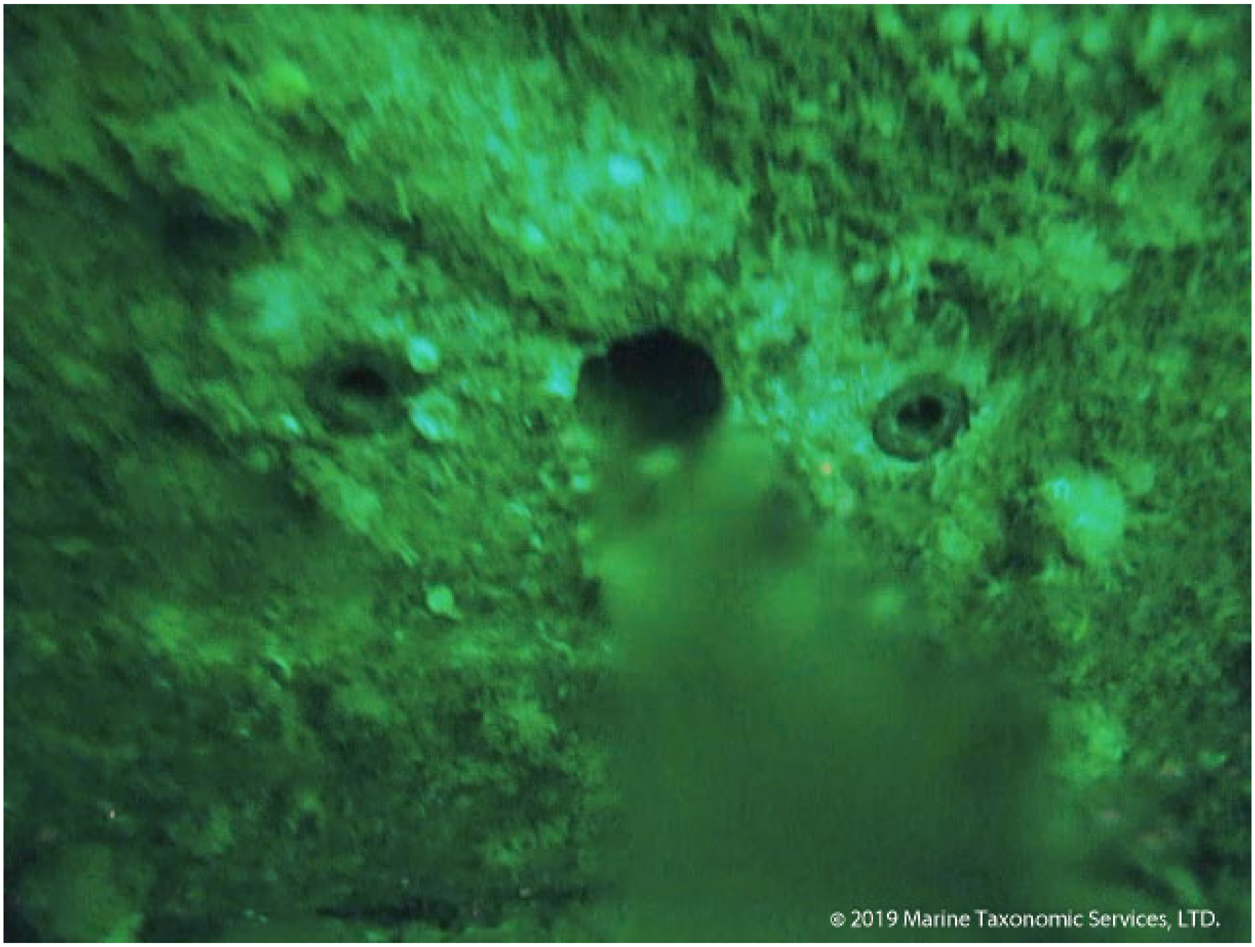
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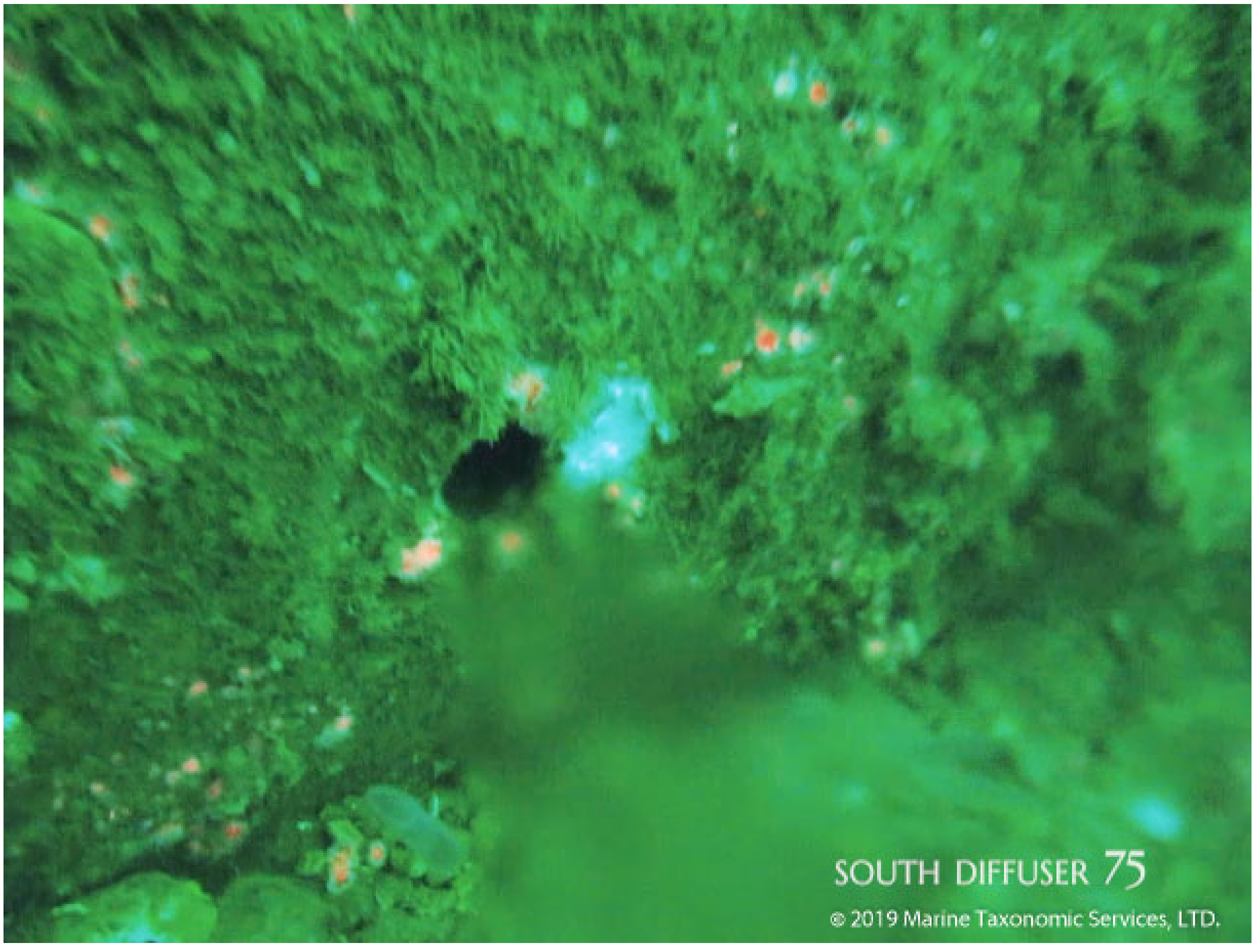
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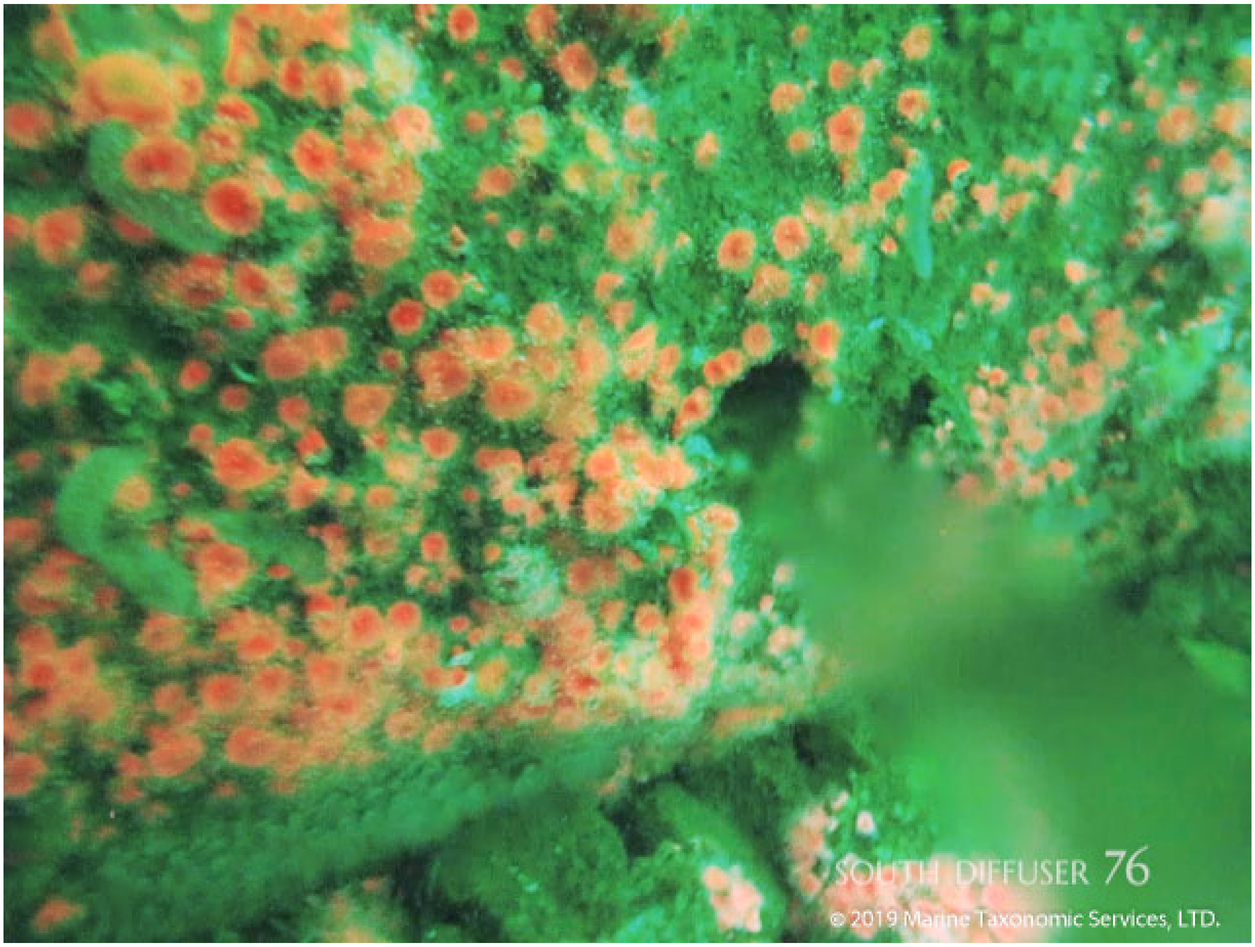
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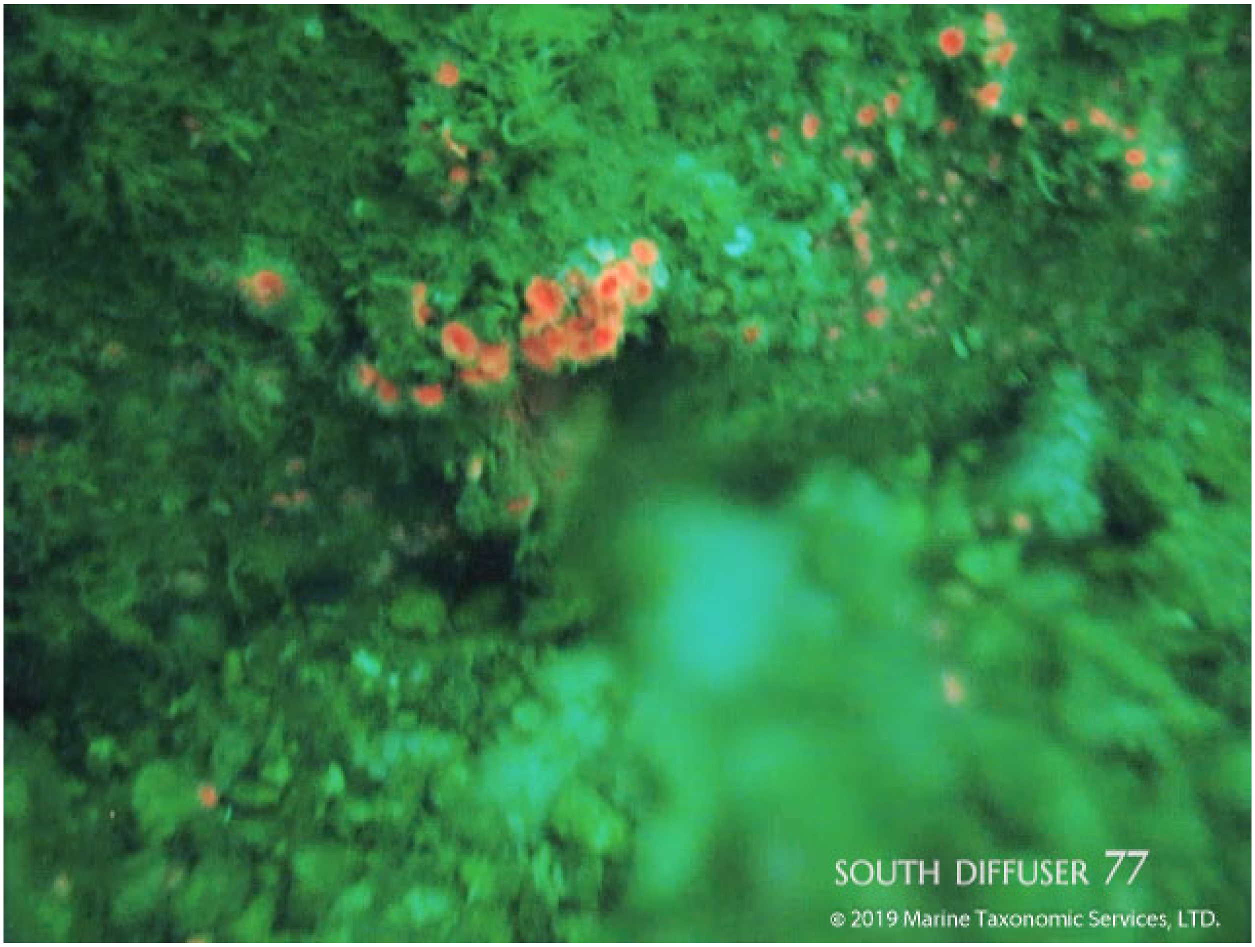
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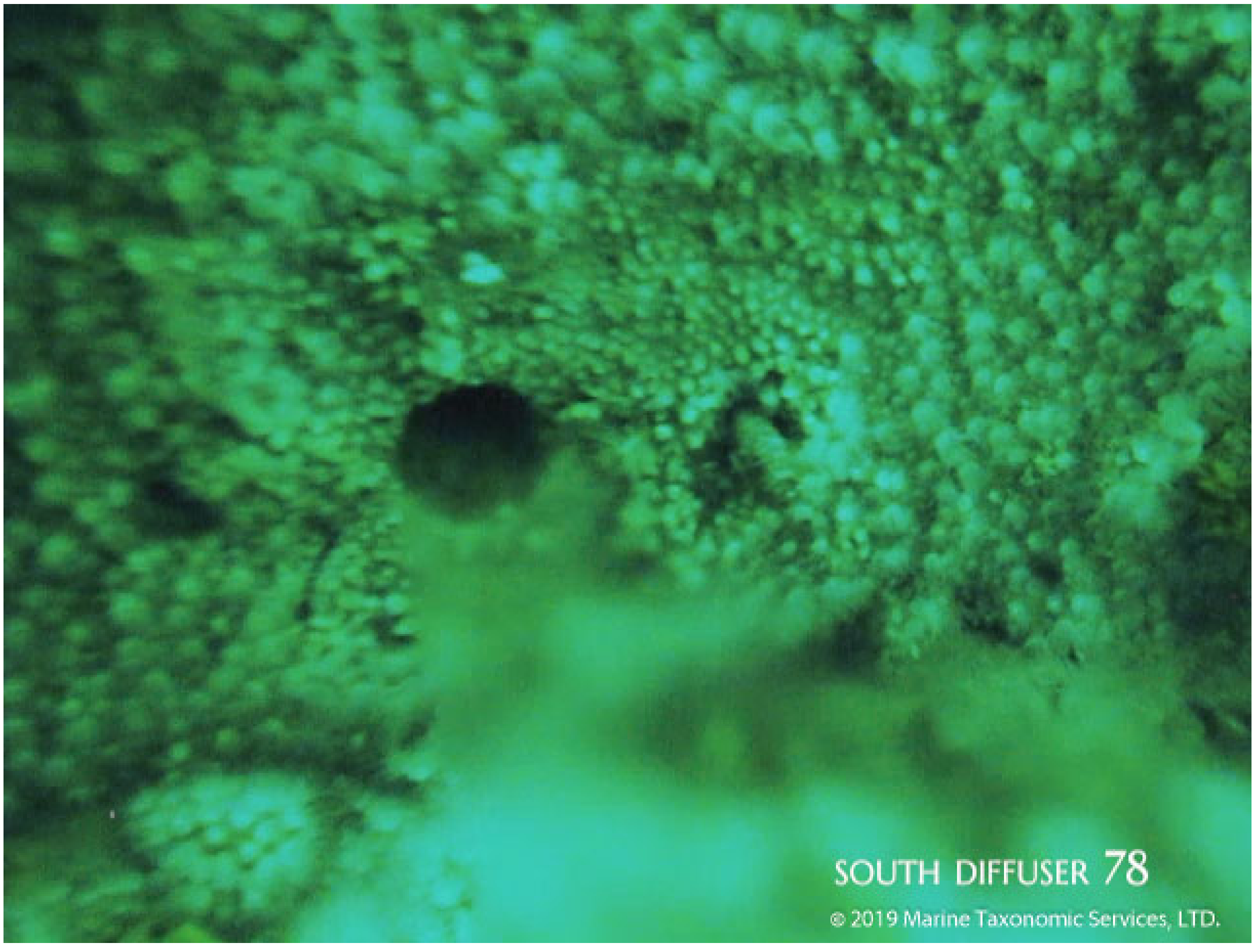
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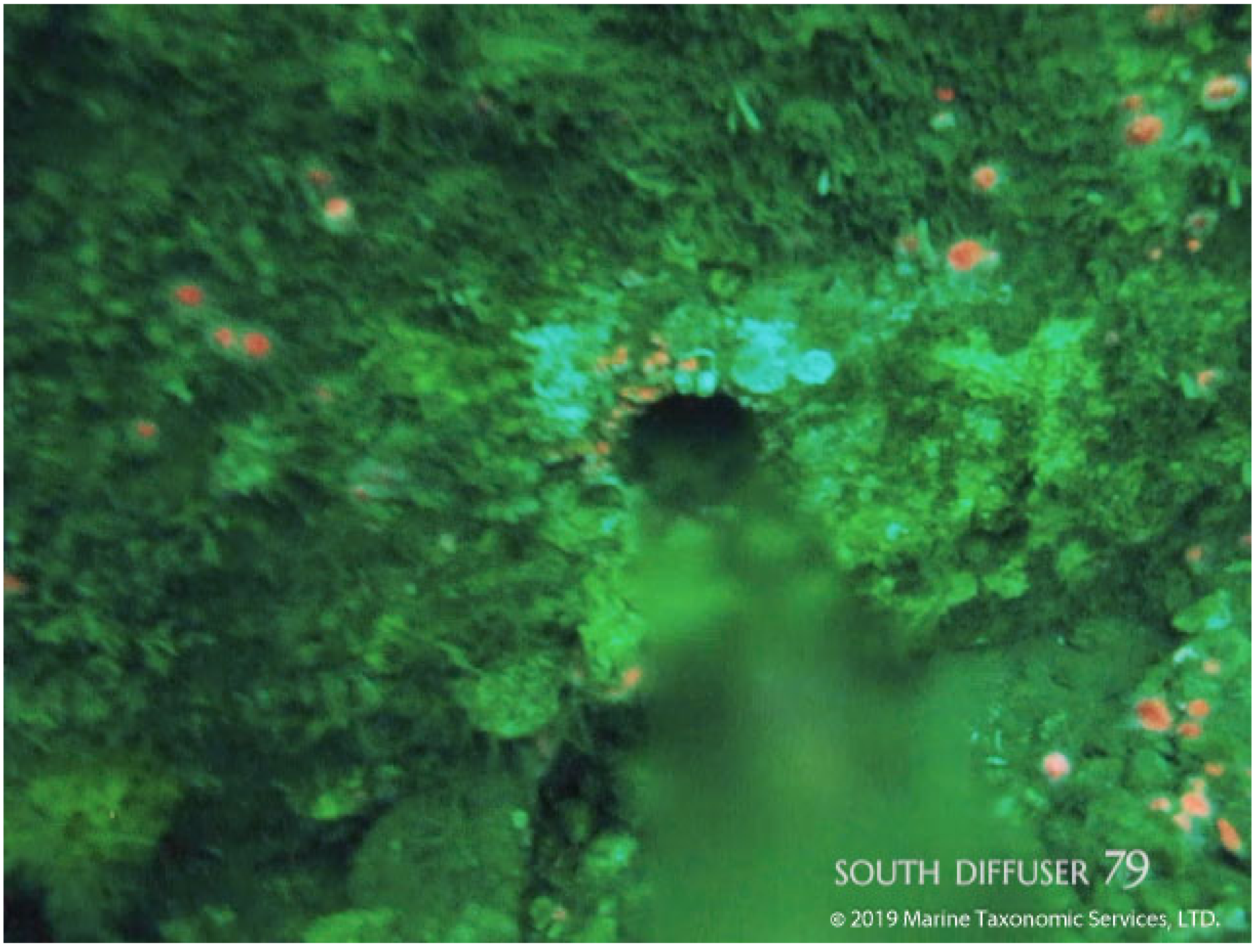
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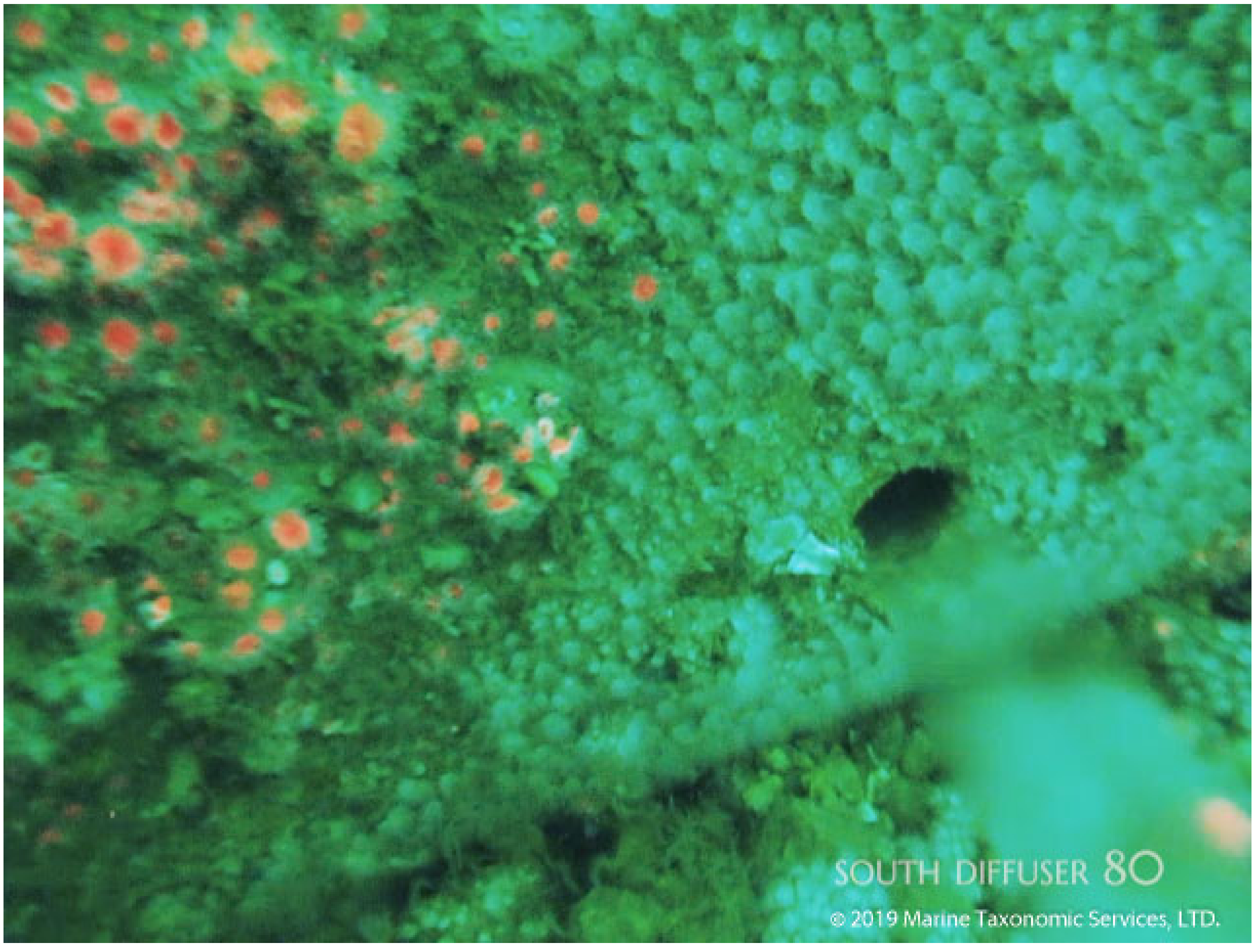
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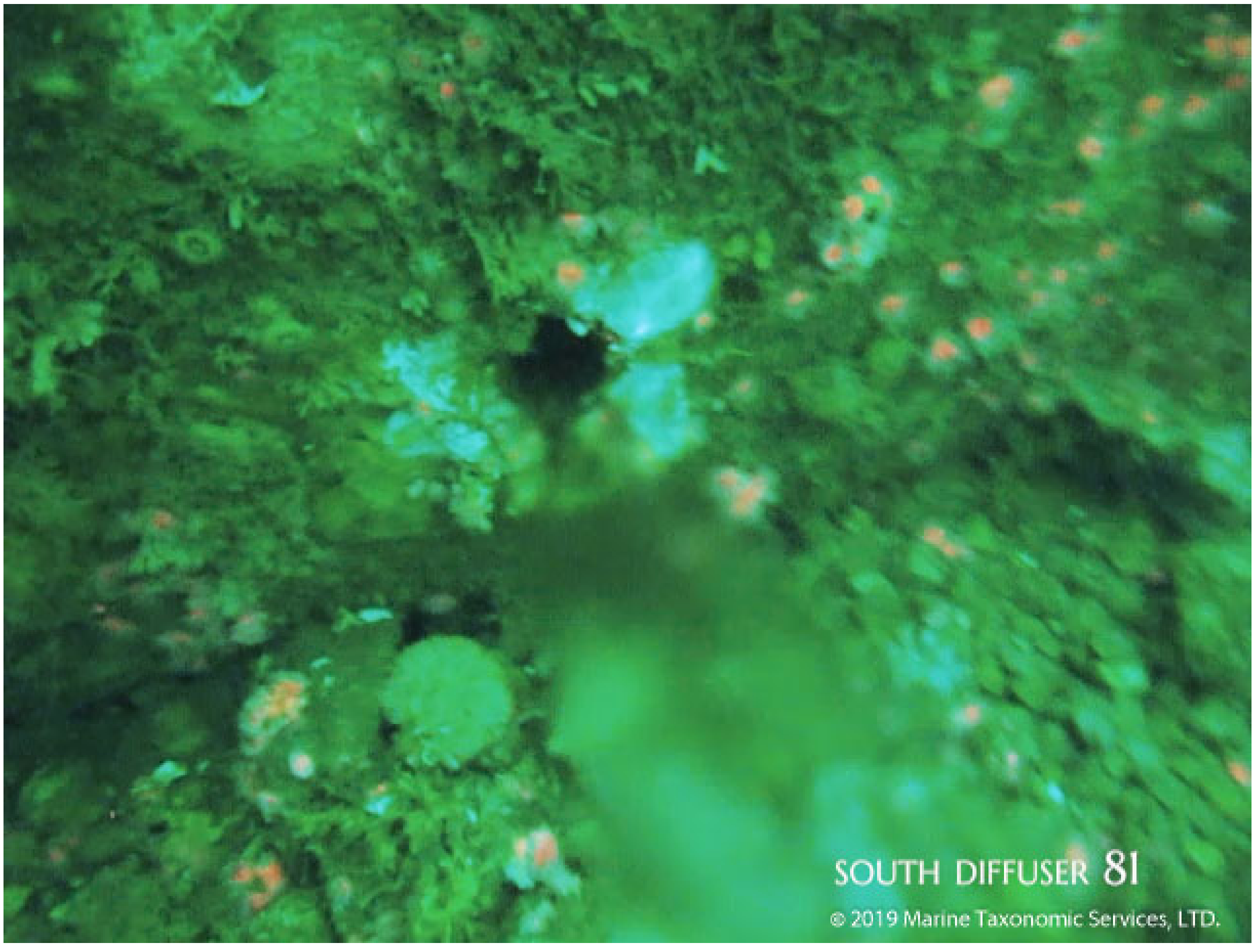
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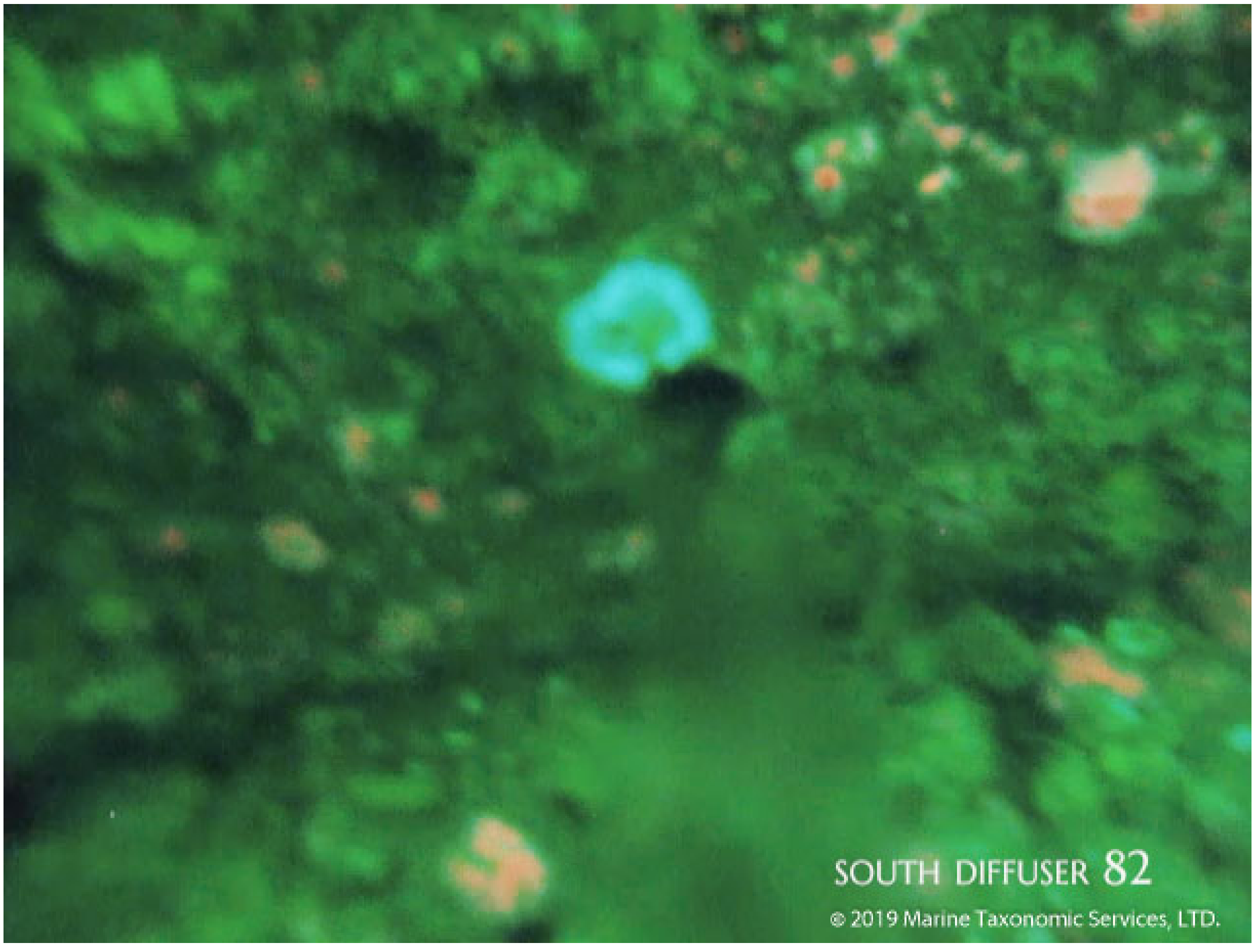
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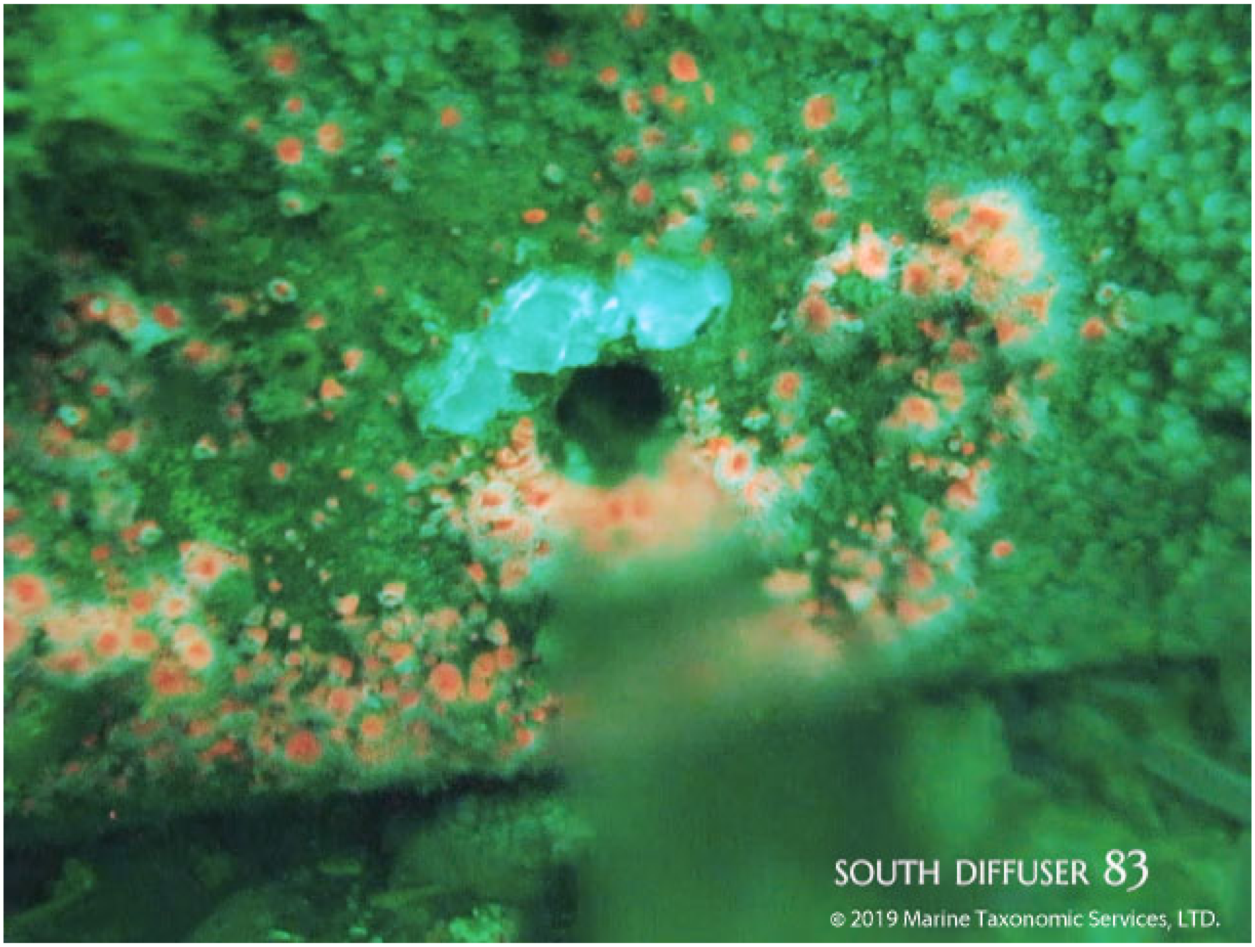
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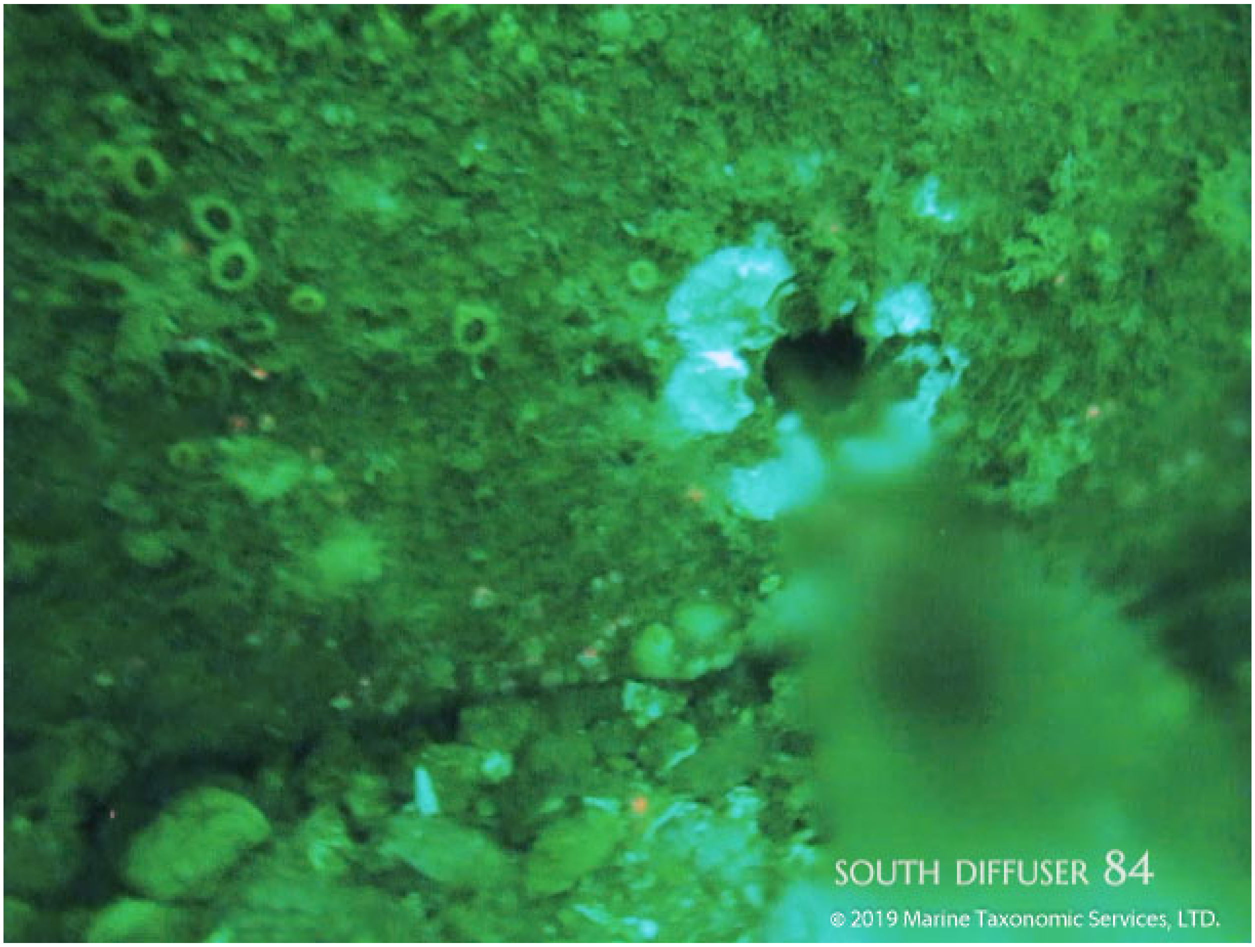
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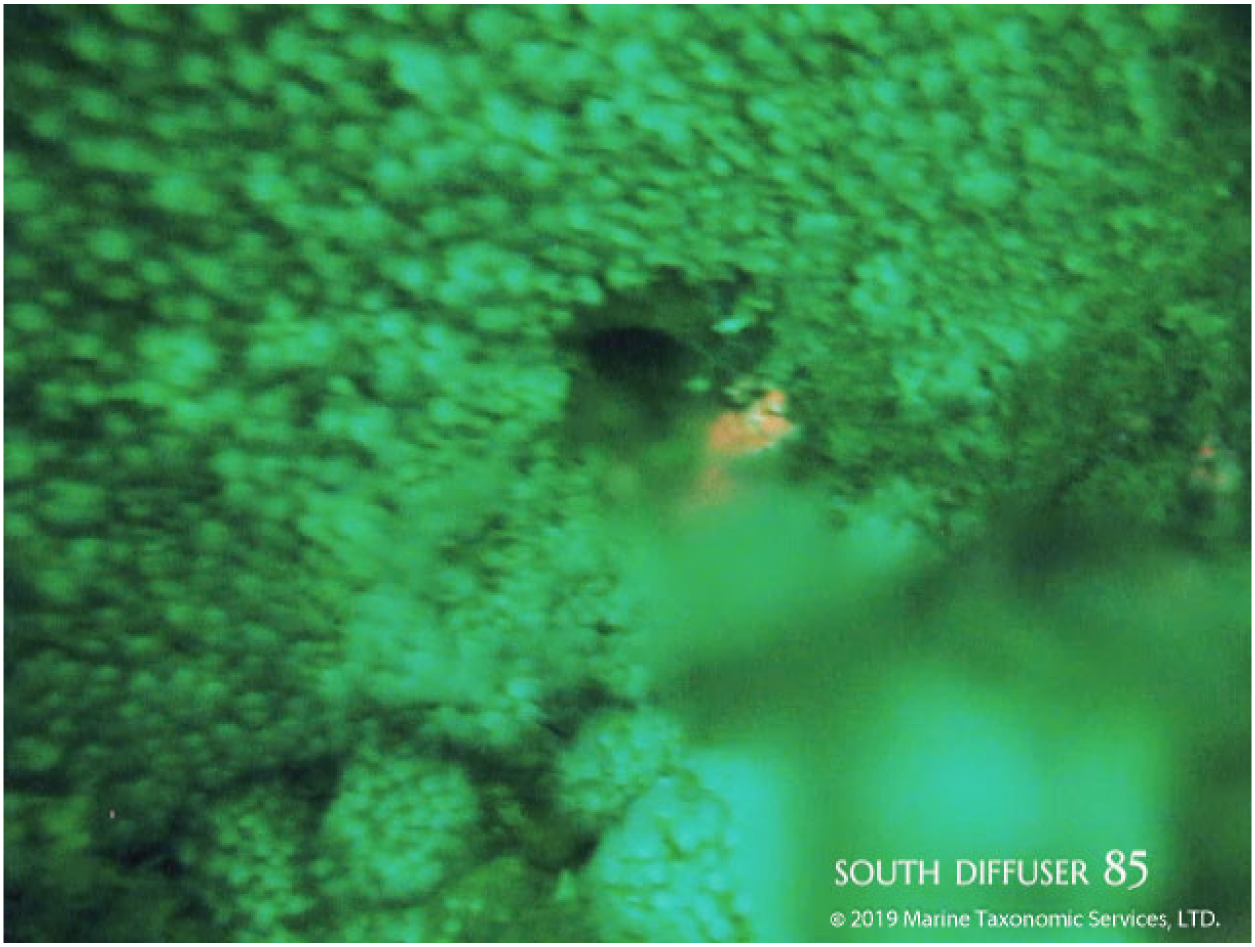
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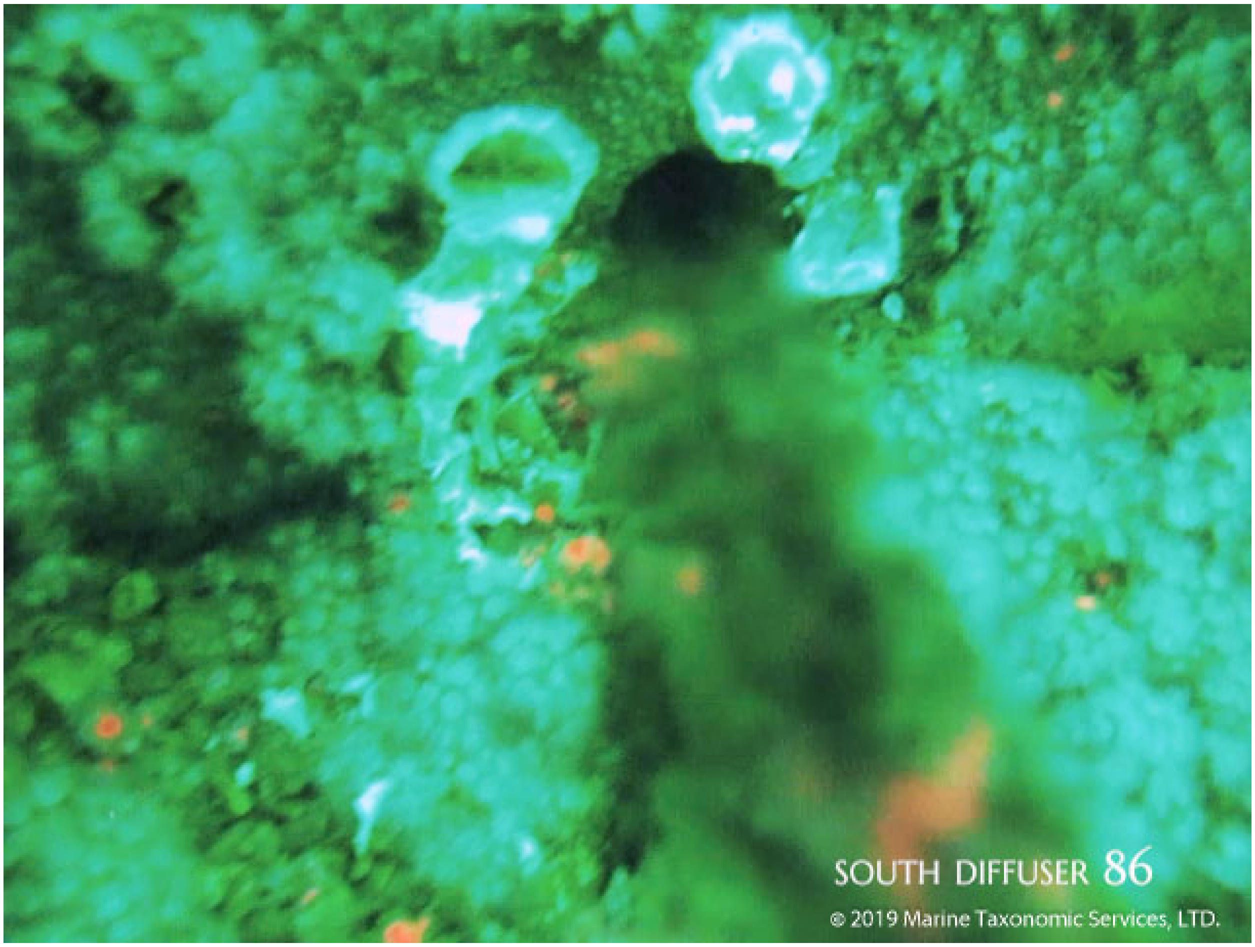
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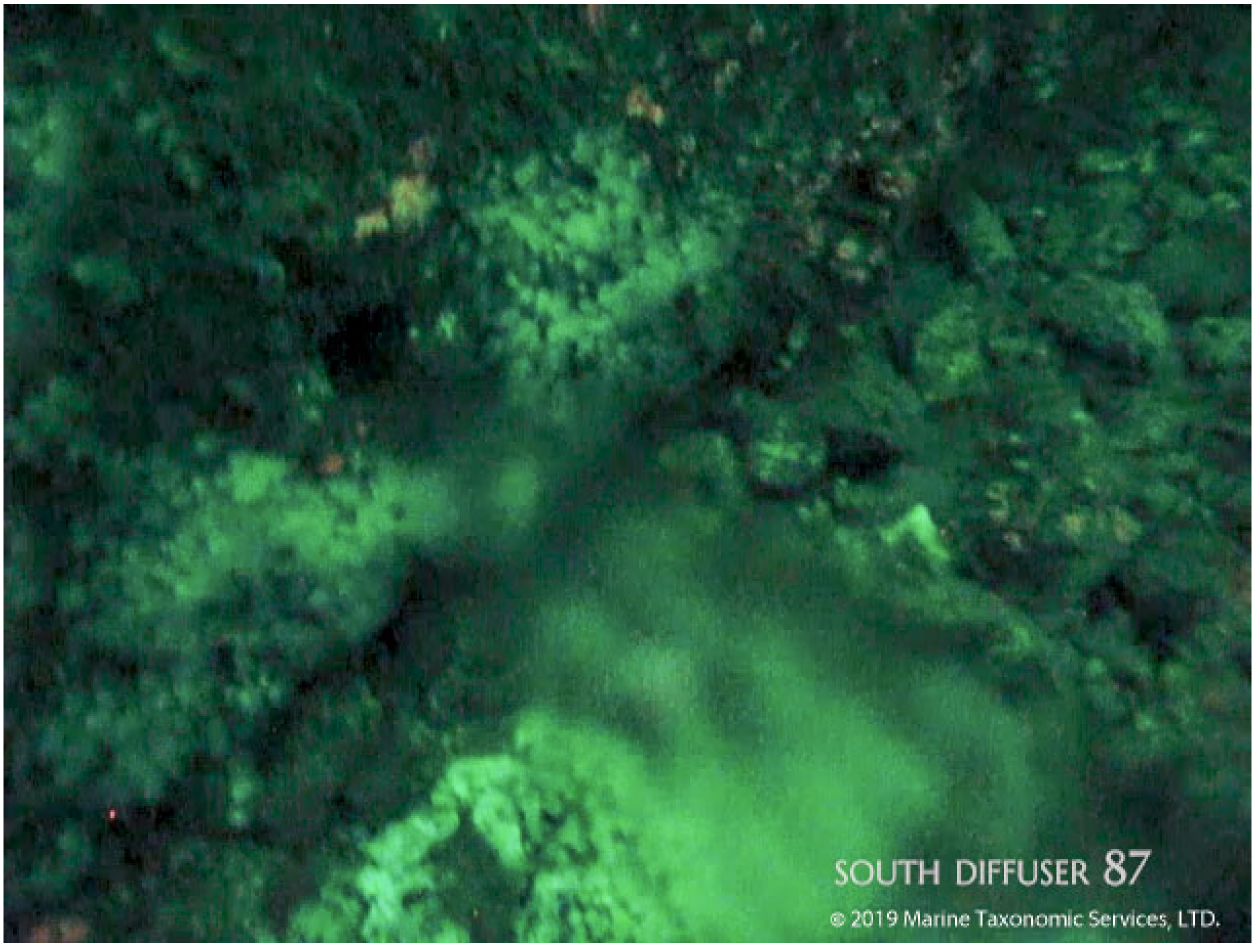
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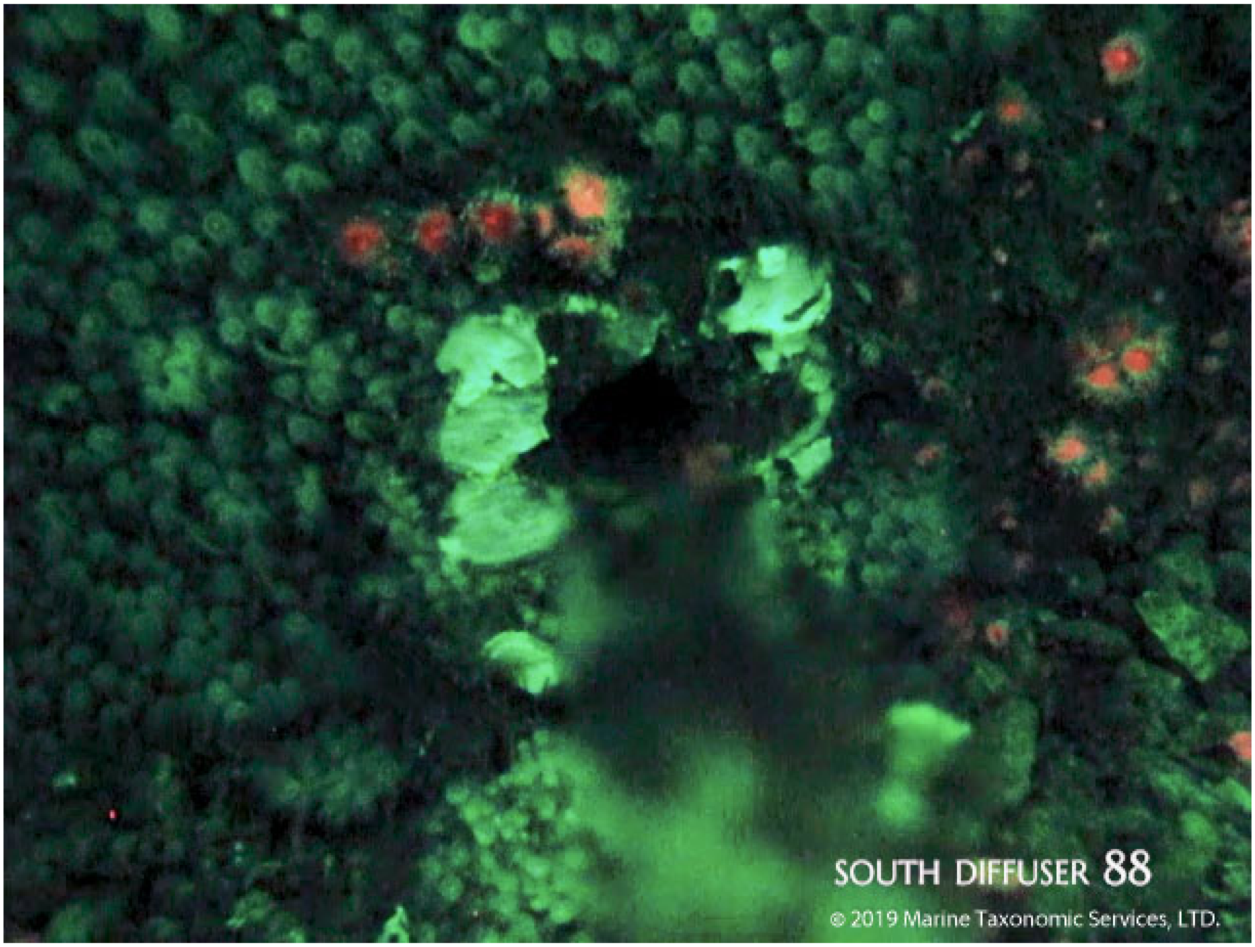
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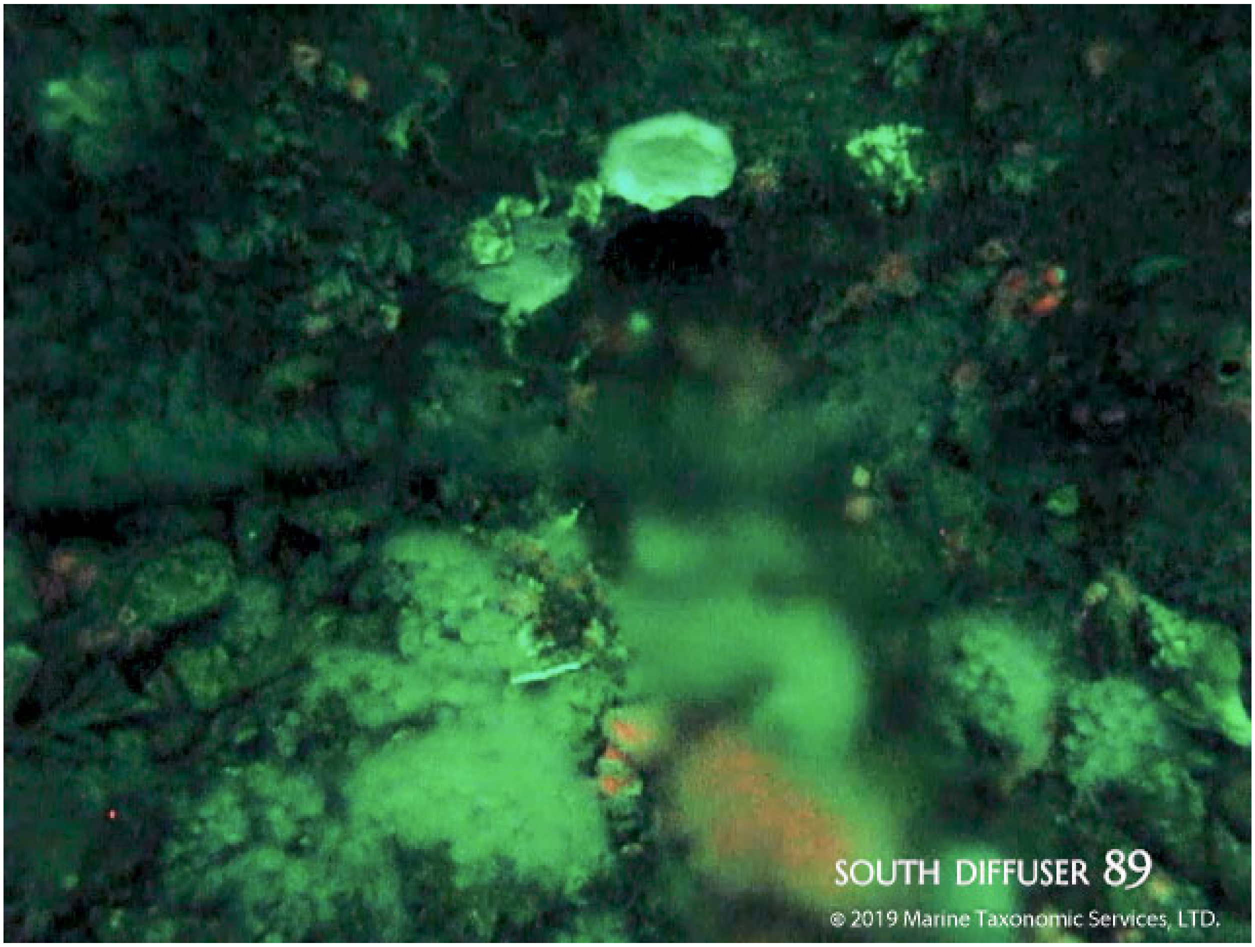
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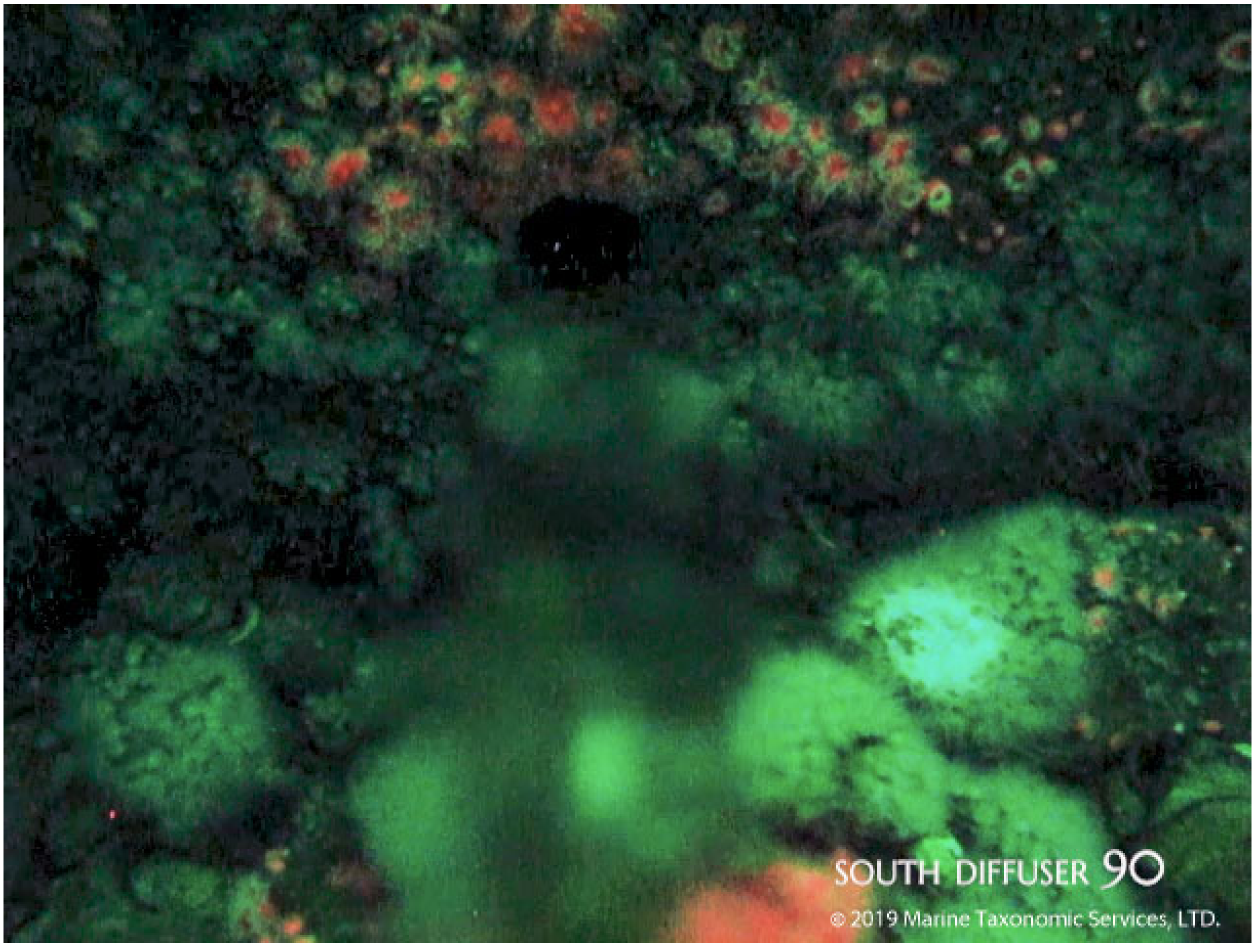
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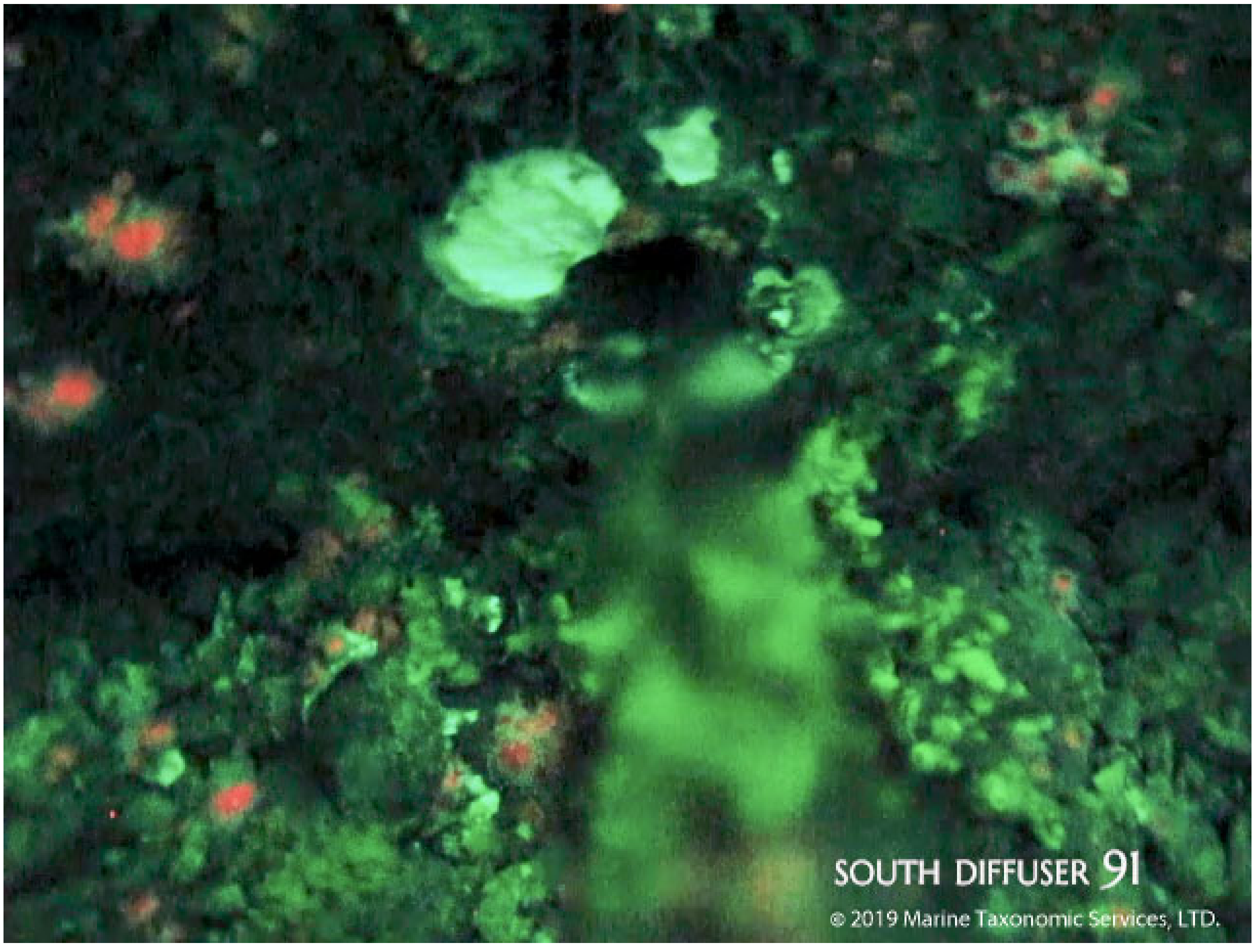
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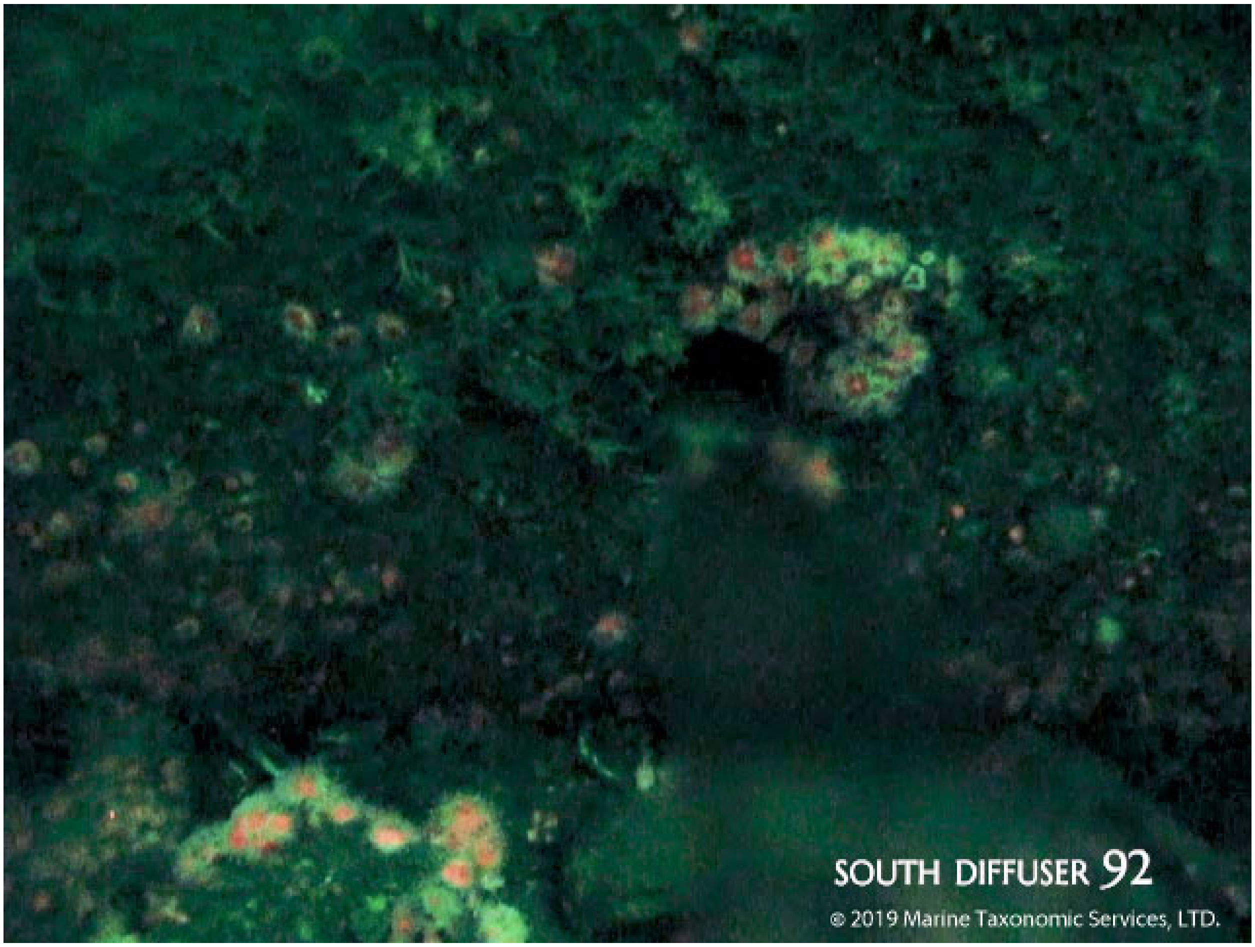
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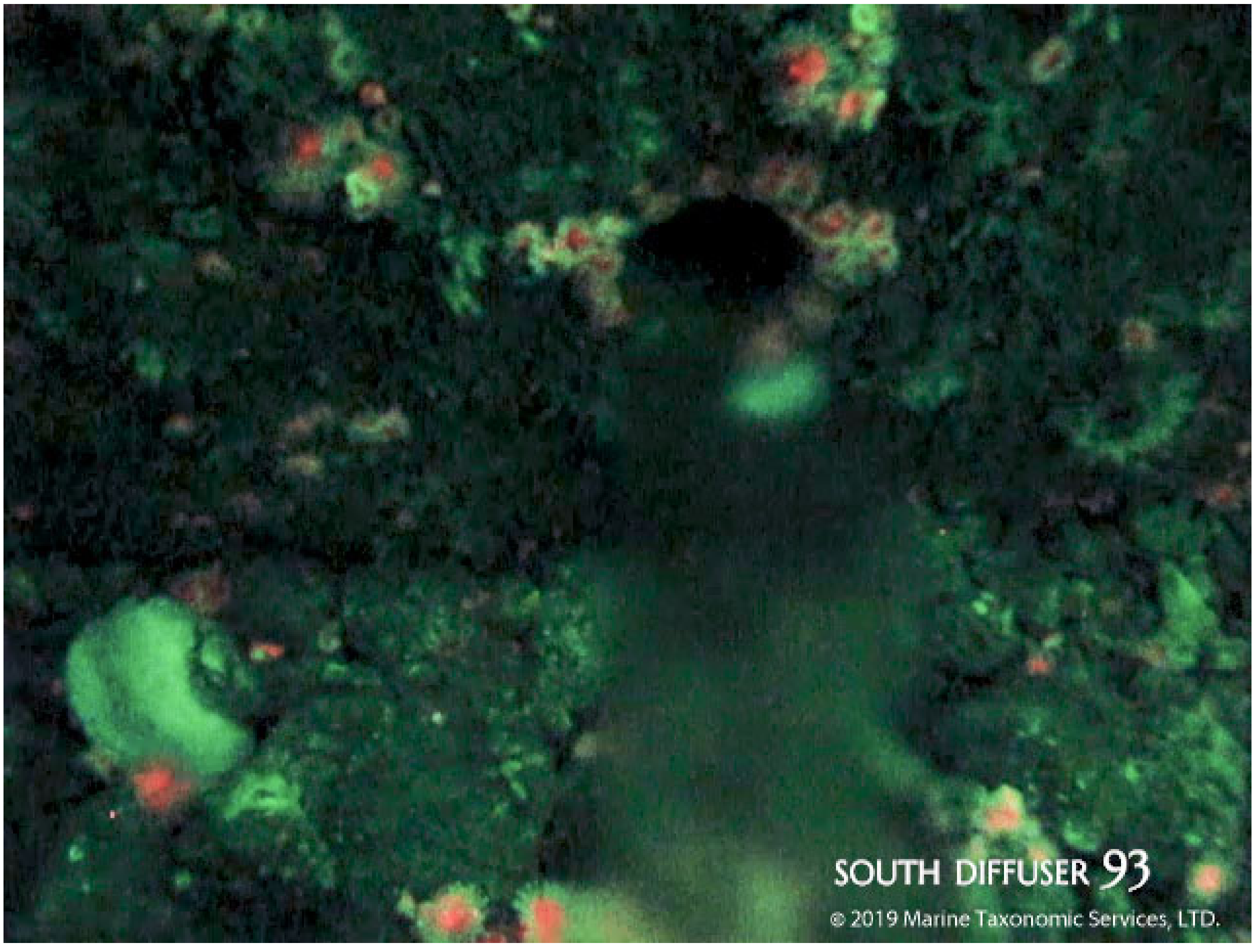
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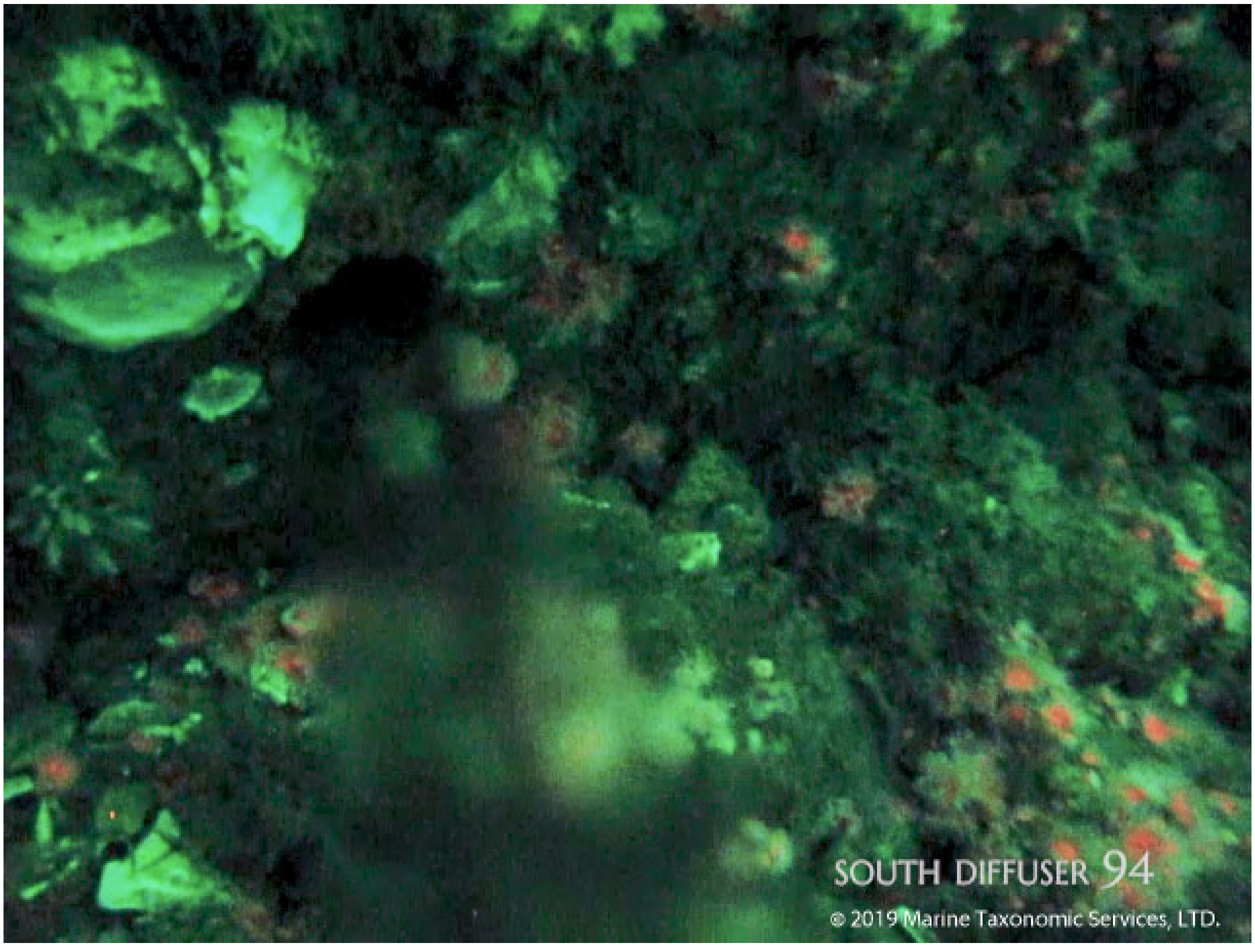
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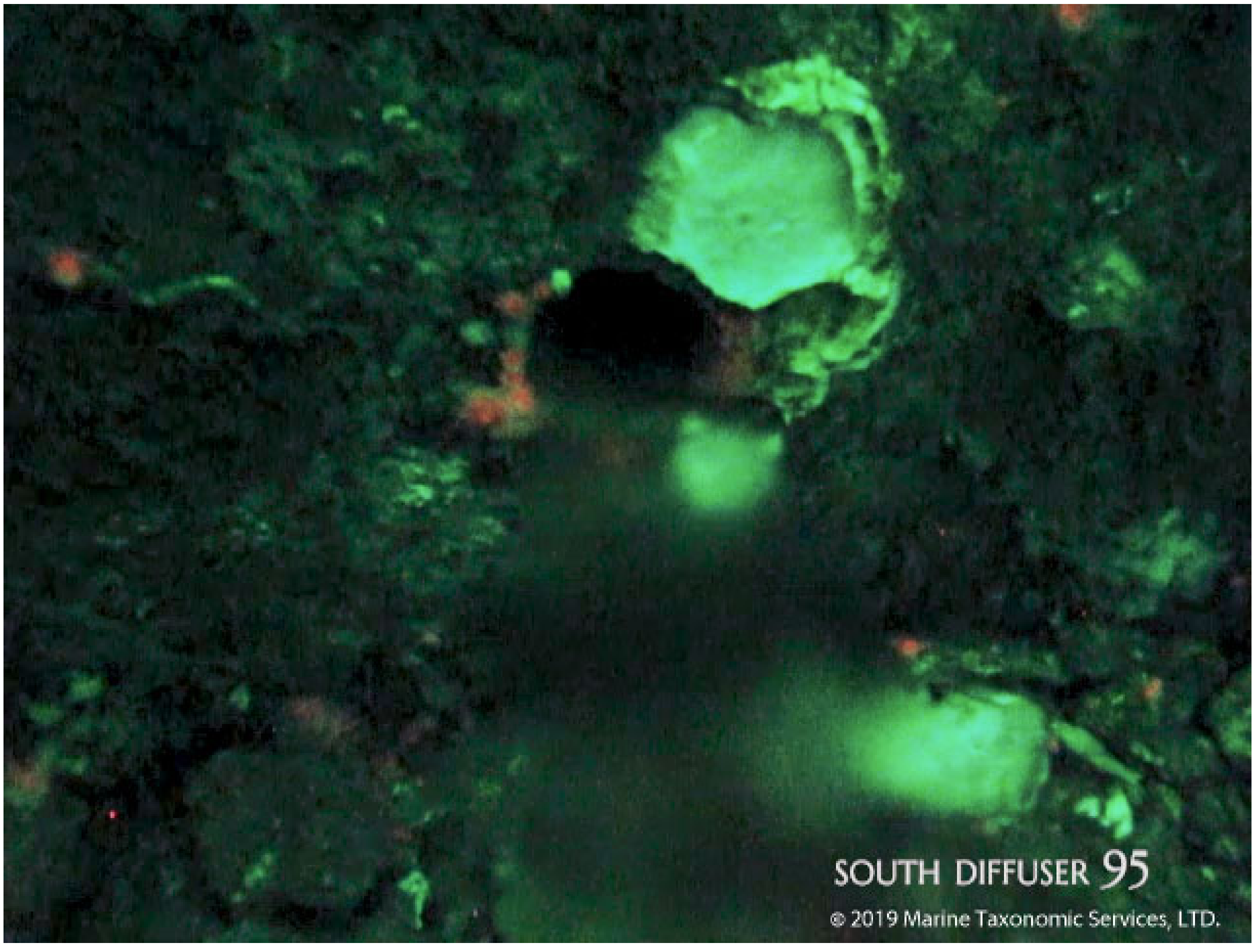
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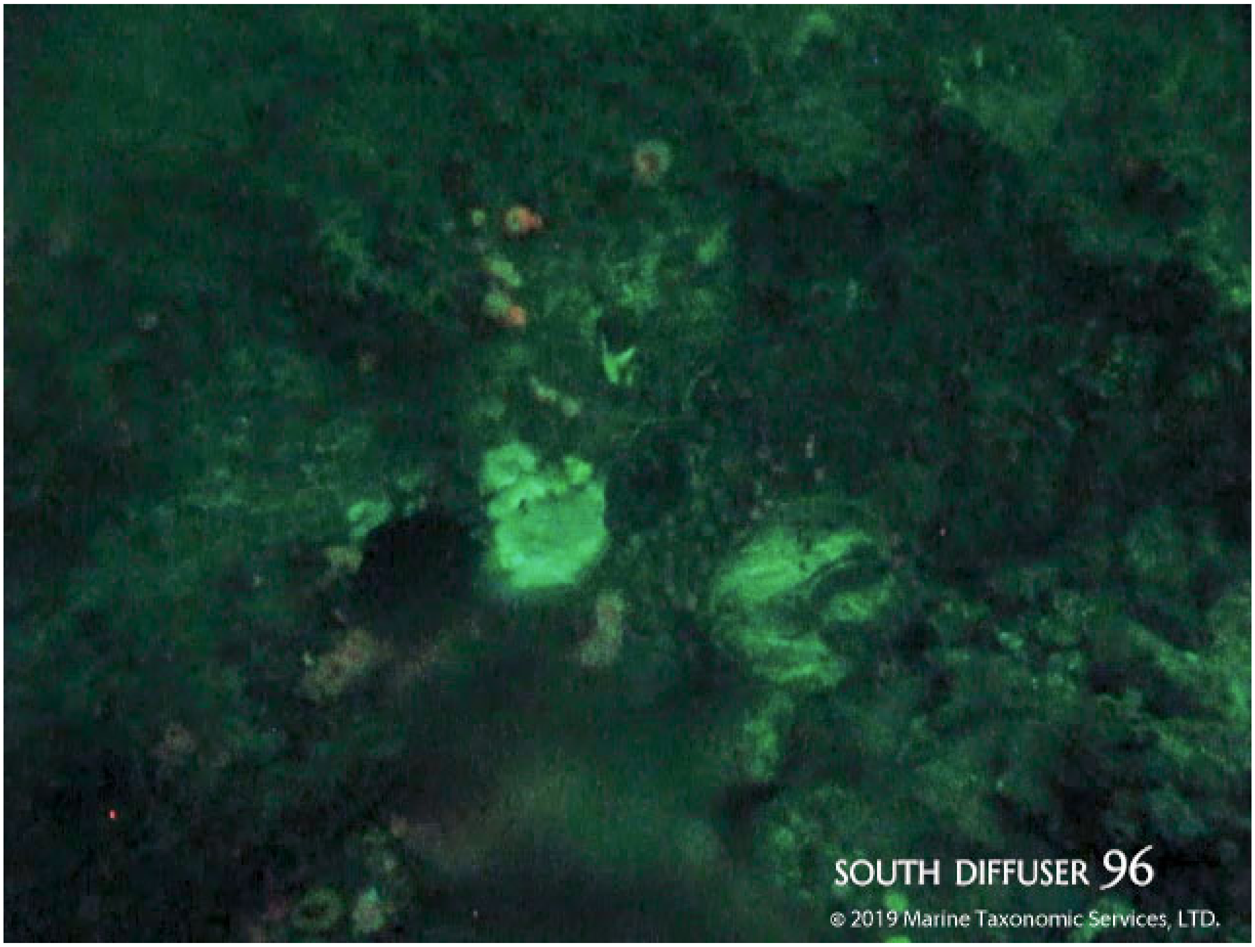
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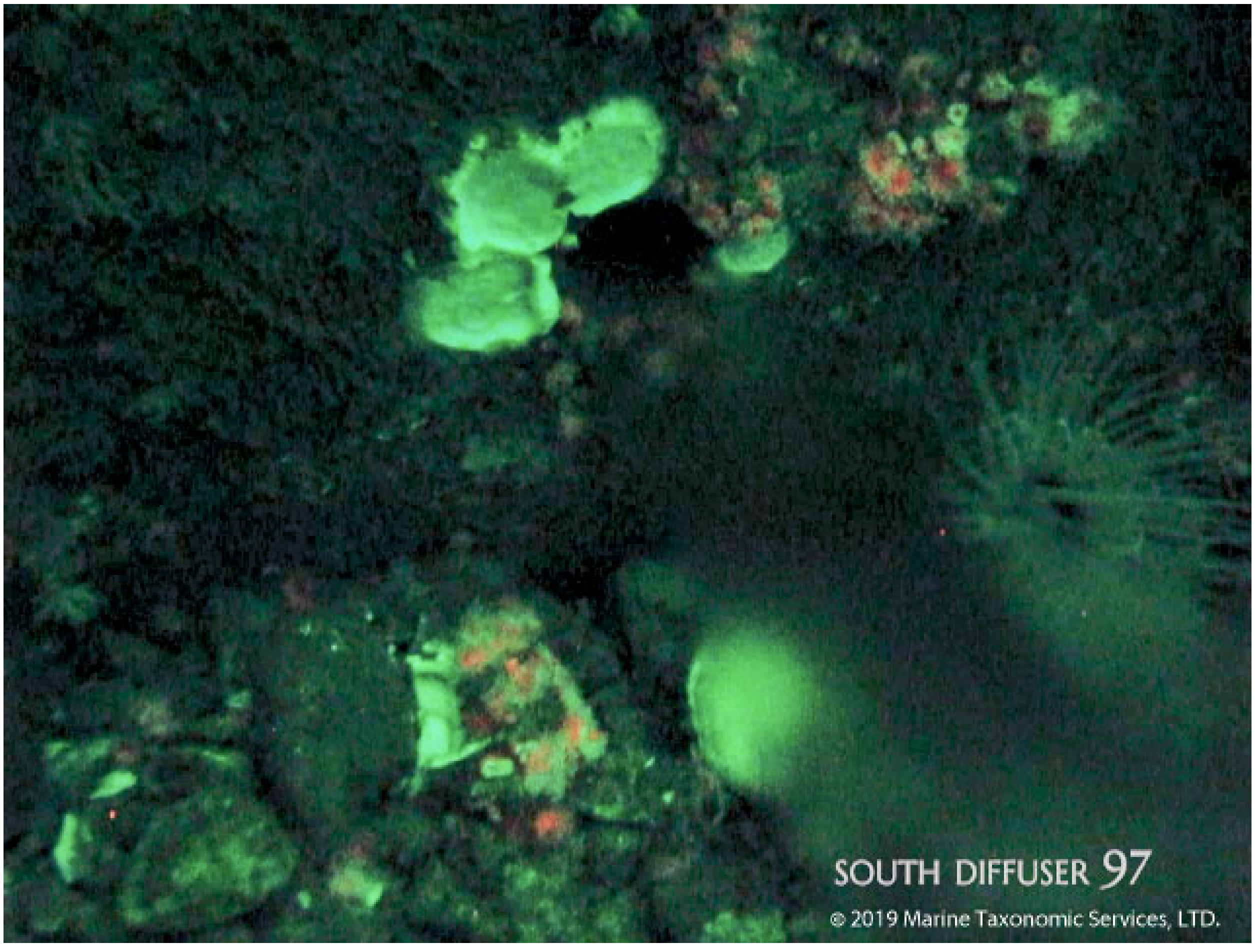
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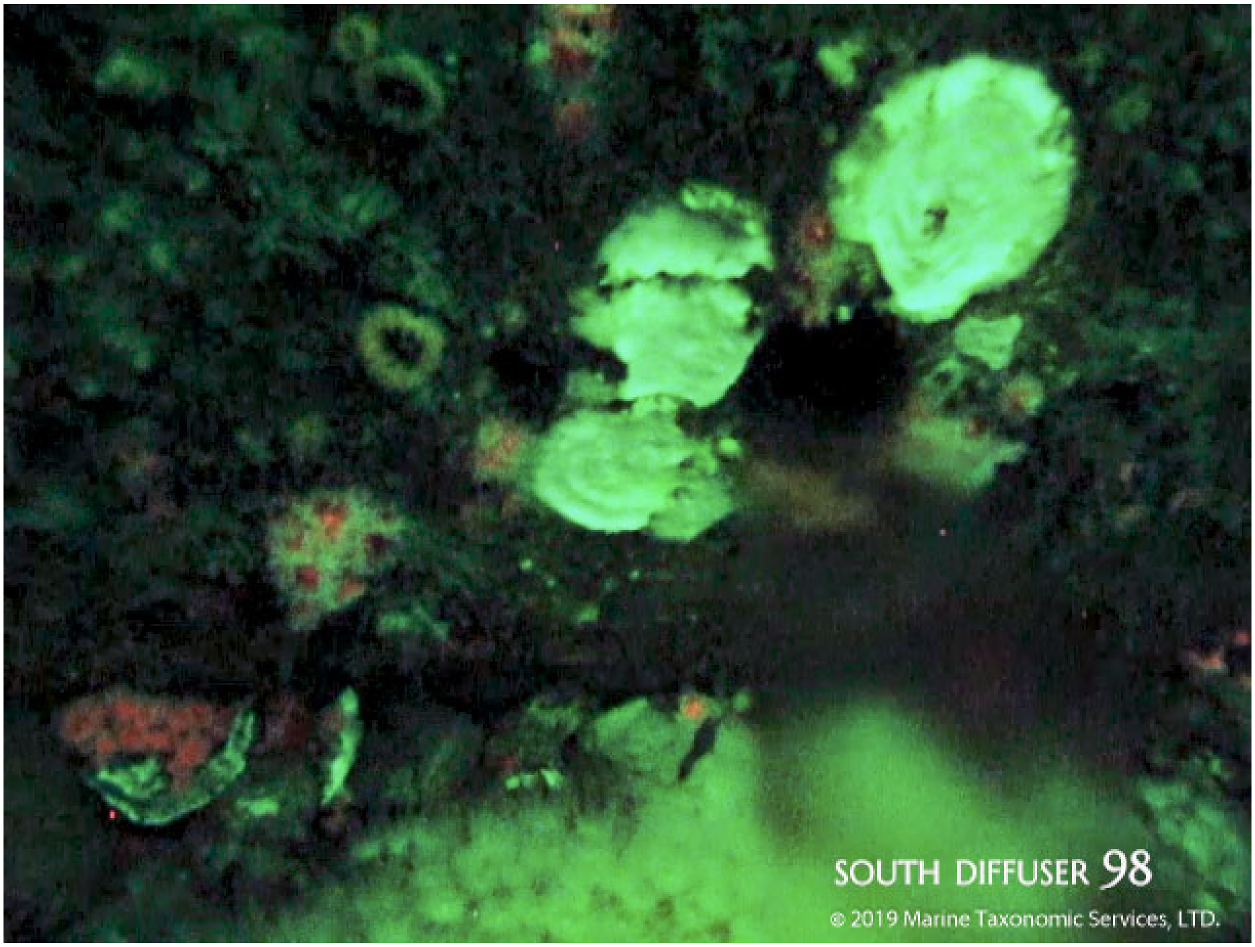
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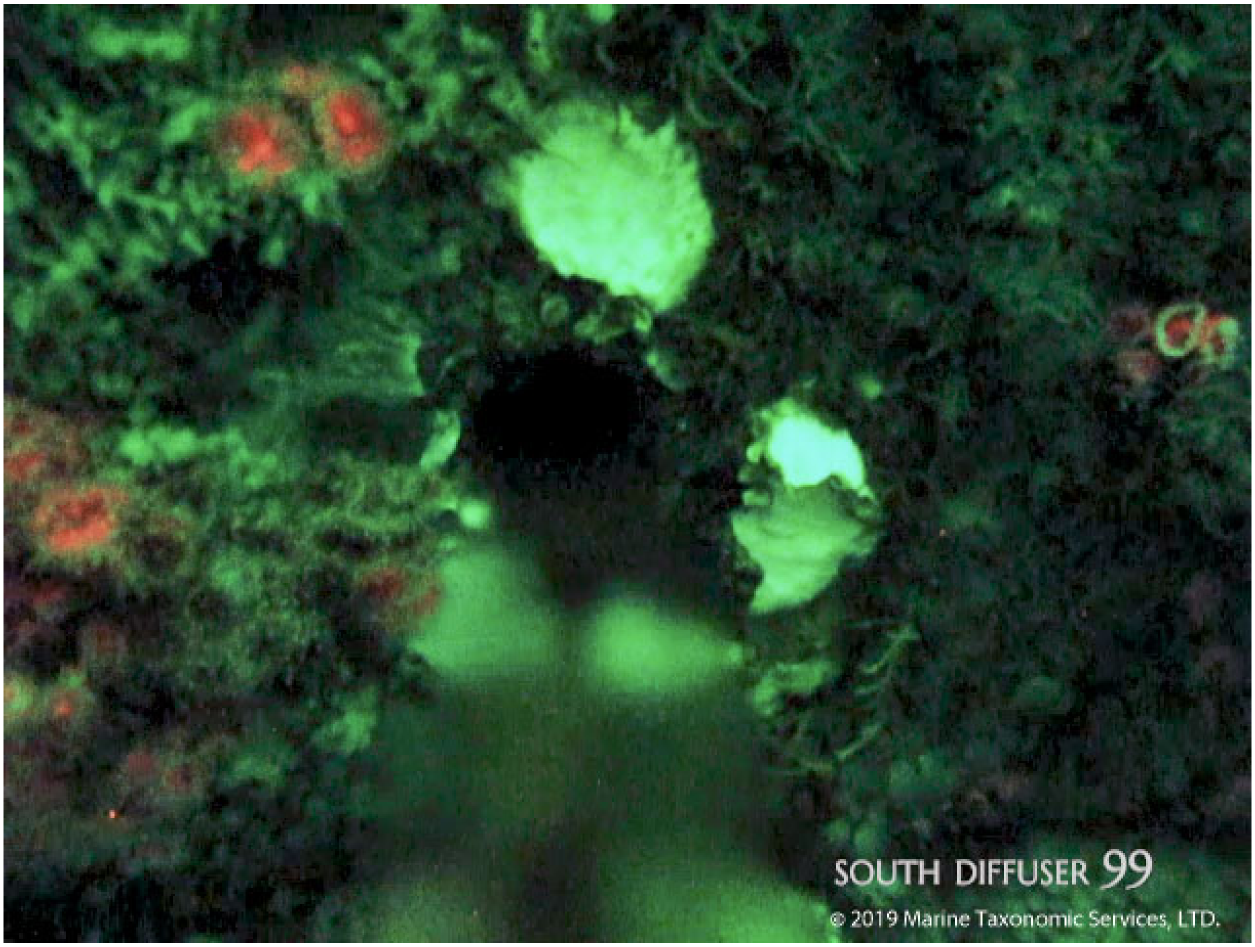
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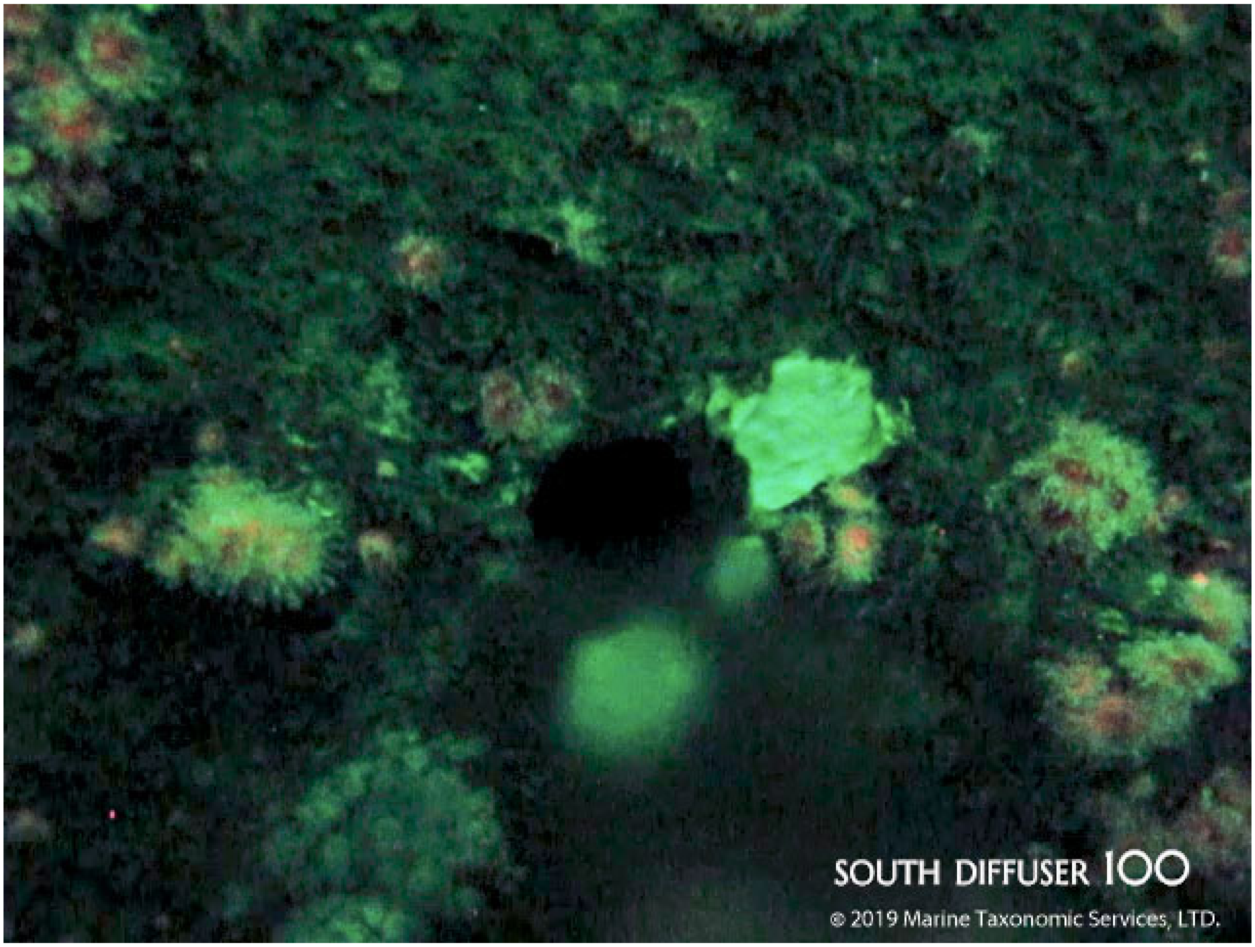
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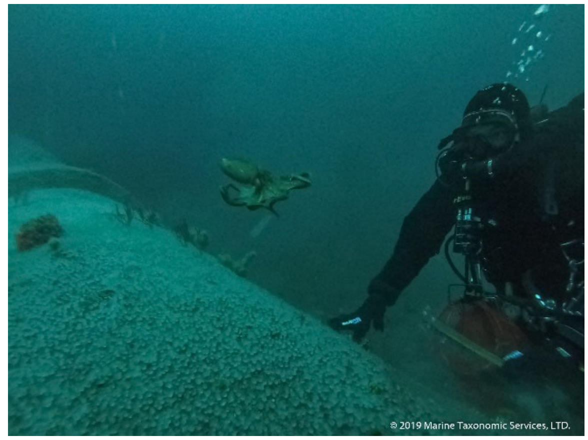

Diver Photos