Arctic Ocean and Barents Sea Seafloor Substrate Catalogue

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Introduction

This catalogue provides a collection of images depicting the diversity of seafloor substrates in the Arctic Ocean and the Barents Sea. The data was gathered using a range of equipment, including with the MISO TowCam equipped with a still camera Nikon D3300, DSPL HD Flexlink (CAGE 15-2, CAGE 17-2 cruises), ROV Ægir 6000 (IMENCO Spinner II (HD) camera) (CAGE 18-4, CAGE 18-5, CAGE 20-7, CAGE 21-1 (AKMA1); CAGE 22-2 (AKMA2/Ocean Senses)) and ROV Aurora (Orca HD (IP) camera) during AKMA3 cruises (Panieri et al., 2023; Panieri et al., 2017; Bünz, 2022; Bünz et al., 2018; Ferré et al., 2020; Bünz & Panieri, 2022; Panieri et al., 2022; Panieri et al., 2024).

The catalogue is not exhaustive, and future modifications are anticipated following additional cruises.

Study sites

The sites investigated that allowed the development of this catalogue were visited during several cruises that specifically targeted 13 methane seepage systems across various depths and environments, from shallow shelf regions to the deep sea, along the Svalbard continental margin and in the Barents Sea (Figure 1; Table 1):

- Offshore Prins Karls Foreland (120m)
- Vestnesa Ridge (880-1400m)
- Svyatogor Ridge (1800-2000m)
- Leirdjupet Fault Complex (290-350m)
- Håkon Mosby Mud Volcano (1270m)
- Hinlopen Trough (350m)
- Storfjordrenna (350-380m)
- Storbanken (150-200m)
- Olga Basin (150-200)
- Outer Bjørnøyrenna (400m)
- North Knipovich Ridge (870-900m)

- Adventfjorden (110m)
- Norskebanken (150m)

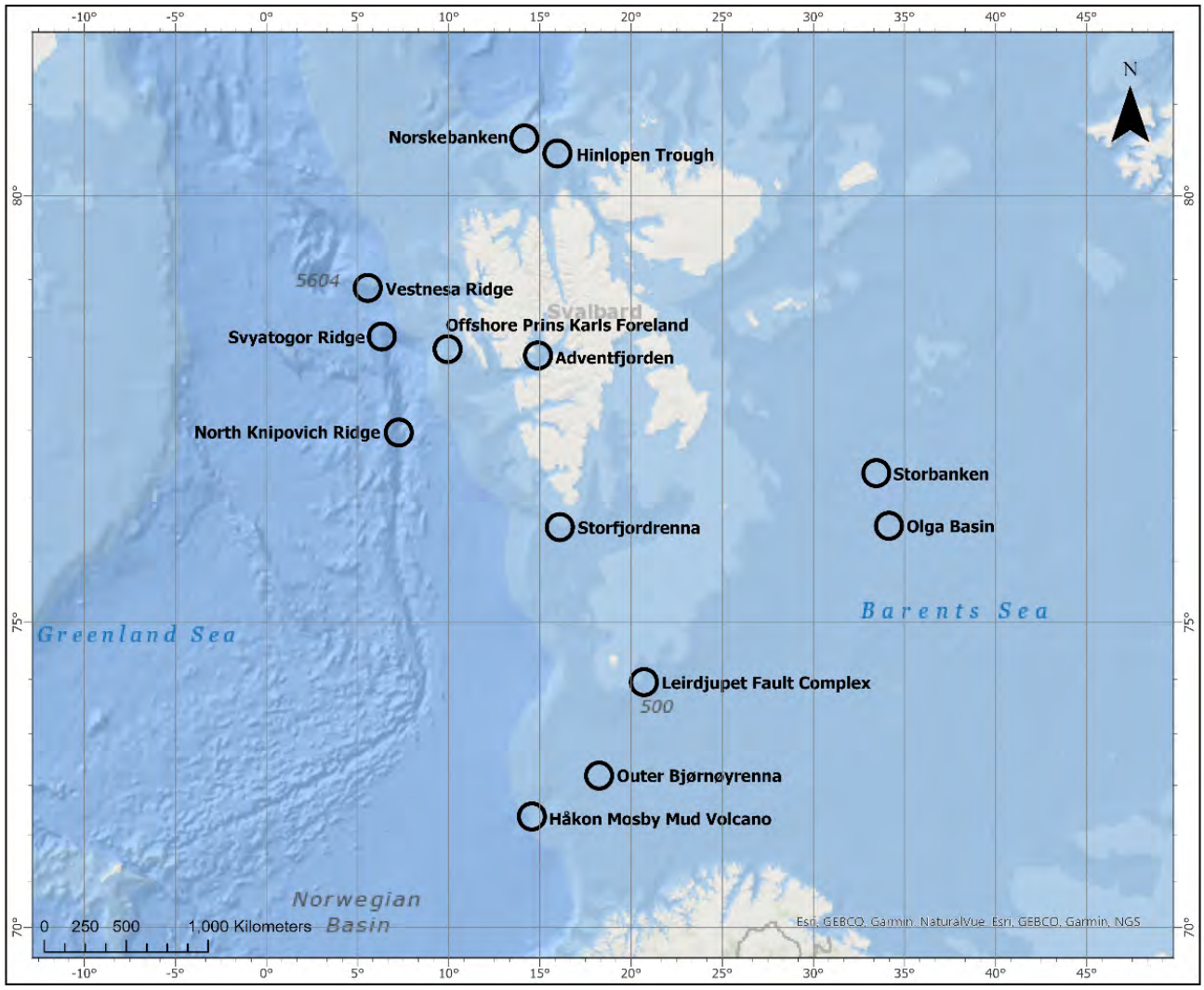


Figure 1. An overview map showing the cold seep sites object of this catalogue.

Methodology

The following methodology was employed to develop the substrate catalogue, designed to ensure a systematic and accurate representation of substrate variability across the Arctic seafloor:

1. Categorization: The catalogue presents a collection of images showcasing different substrate types, systematically grouped into six main categories. These categories were designed to capture the seafloor variability in terms of dominant sediment grain size and visible biophysical properties. The work was developed through a detailed analysis of seafloor imagery datasets including underwater videos and high-resolution still images. This method ensured a consistent framework for organizing and interpreting the diversity of substrates depicted in the catalogue.
2. Annotation process: To ensure precision in observations, all video annotations were conducted at reduced playback speeds (minimum half speed) allowing for meticulous scrutiny of the footage. Additionally, extracted still images were reviewed with at least 50% zoom to enhance clarity and detail.
3. Scaling and Measurements: Accurate scaling of imagery was achieved using laser point references captured by the ROV. The specific scaling factors applied to each dataset were as follows: AKMA3: 16cm; CAGE22-2: 14cm; CAGE21-1: 14cm; CAGE20-7: 14cm; CAGE18-5: 14cm; CAGE17-2: 20cm; CAGE15-2: 20cm. For datasets where laser points were unavailable, scaling was estimated based on reference measurements.
4. Terminology and Definitions: To ensure consistency in describing substrate features, a dedicated glossary (Appendix I) was compiled. This glossary provides precise definitions of the terms used to describe substrate variability, facilitating uniformity and clarity across all annotations.
5. The categorization distinguished six main substrate categories which are:
    - Muddy substrate
    - Fine substrate
    - Gravelly substrate
    - Heterogeneous substrate
    - Hard substrate

6. Additional Features: To provide a more comprehensive understanding of seafloor variability, additional pictures have been included in the catalogue. These images illustrate specific processes taking place on the seafloor including geochemical, biological, bio-geochemical, oceanographic, and anthropogenic processes.

Catalogue scheme

To effectively represent each substrate category, a carefully curated selection of images has been included. Each image highlights the distinctive characteristics and features of its corresponding substrate category. Detailed annotations accompany each image providing essential context and further enhancing clarity. These annotations include descriptions of key features, conditions, and any other relevant information that enhances understanding. This systematic approach ensures that the catalogue offers a comprehensive and informative representation of each substrate category, as outlined in the scheme provided below:

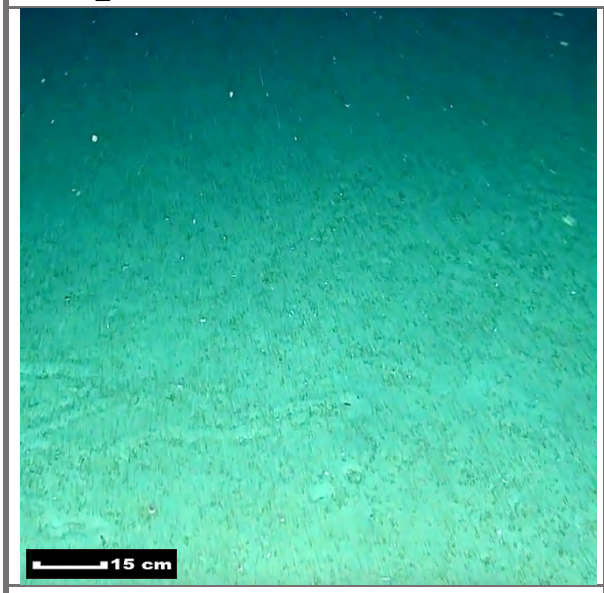
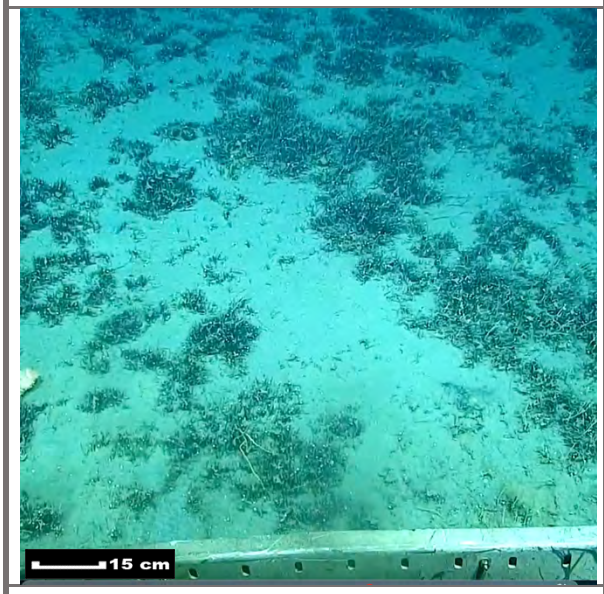
Name
Catalogue Code
Photo
Cruise name - Location - Photo/Video ID code – Timestamp

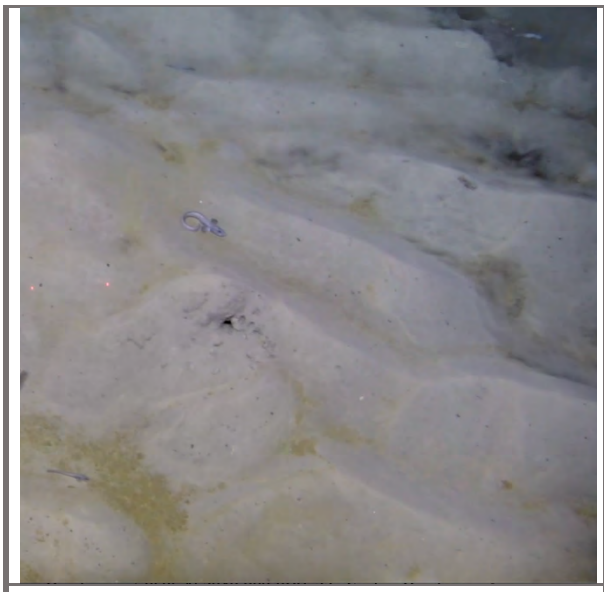
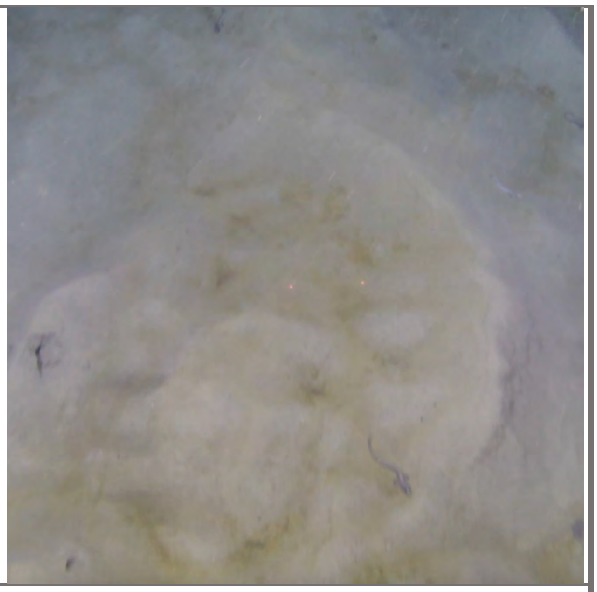
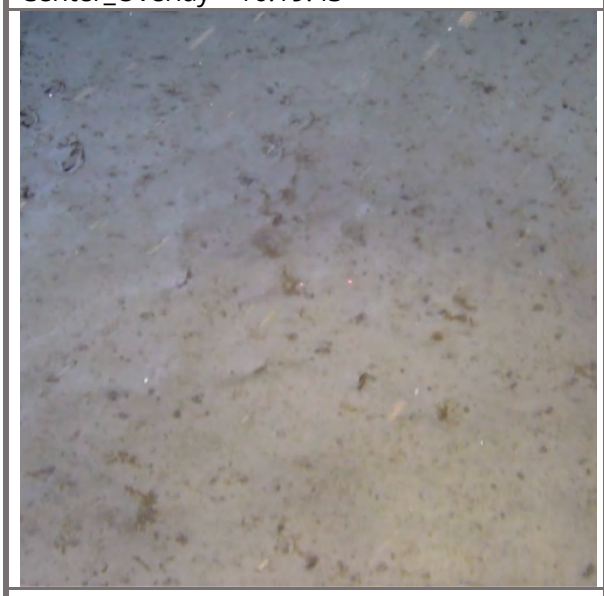
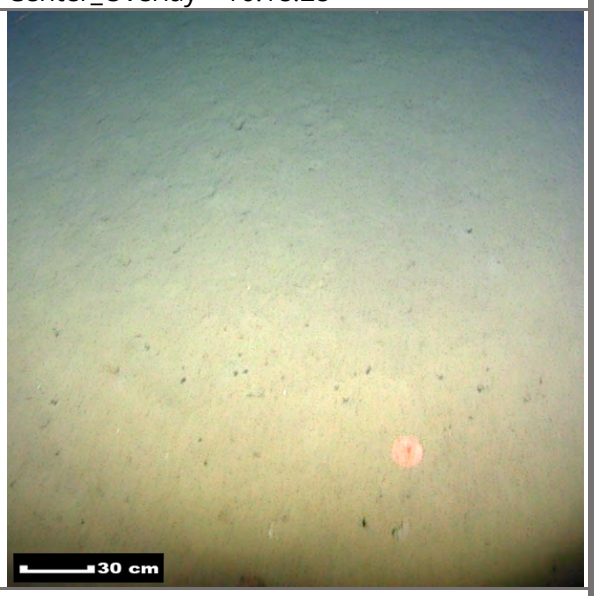
Table I. List of publications resulting from data collected from the cold seep sites of the objective of this catalogue. Data from the AKMA project have been utilized for the results accessible at https://app.cristin.no/projects/show.jsf?id=2528466.

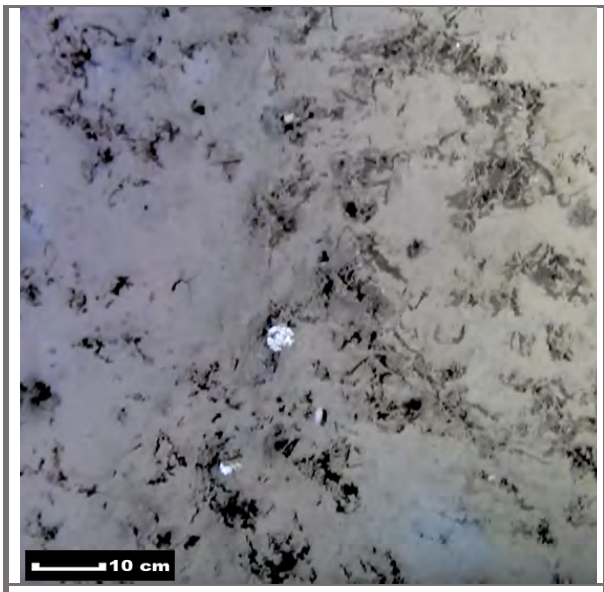
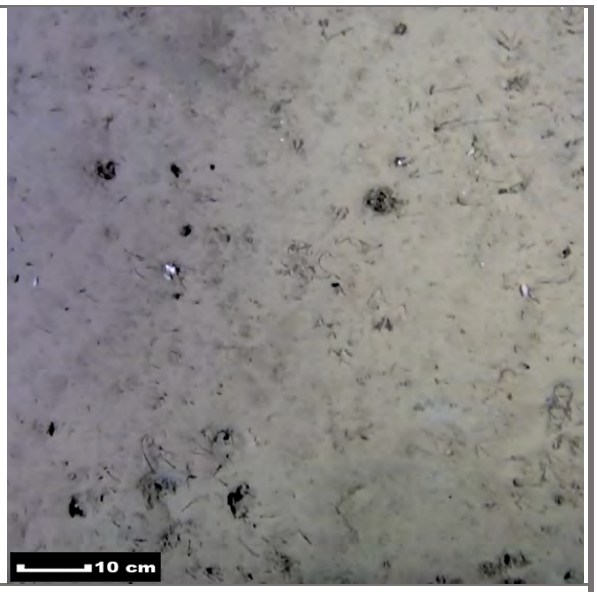
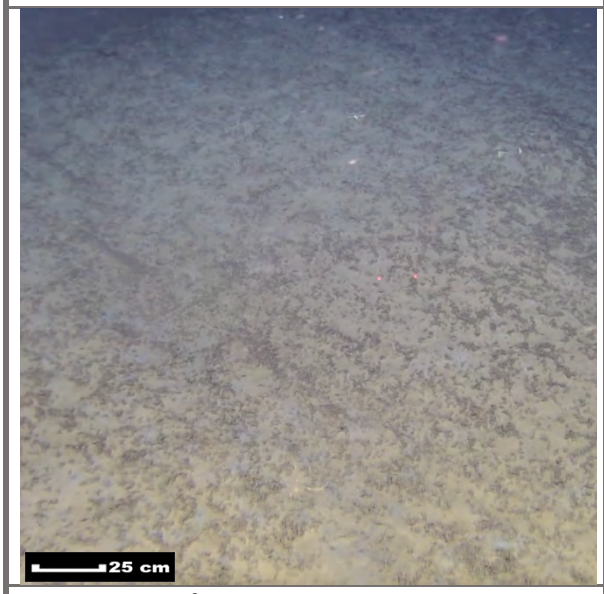
Cruise	**Publications**
CAGE15-2	Åström et al., 2016; Åström et al., 2017; Hong et al., 2017; Panieri, Bünz, et al., 2017; Serov et al., 2017; Åström et al., 2018; Bernhard & Panieri, 2018; Borrelli et al., 2018; Hong et al., 2018; Köseoğlu et al., 2018; Sen et al., 2018; Åström et al., 2019; Hong et al., 2019; Yao et al., 2019; Hong et al., 2020; Blättler et al., 2021; El bani Altuna et al., 2021; Melaniuk, 2021; Åström et al., 2022; Melaniuk et al., 2022
CAGE17-2	Carrier et al., 2020; Dessandier et al., 2020; Sert et al., 2020; Melaniuk, 2021; Heyl et al. 2023; Shackleton et al., 2023
CAGE18-4	Waghorn et al., 2020; Argentino et al., 2021; Argentino et al., 2022a; Argentino et al., 2022b; Cooke et al., 2023; Ferré et al., 2024
CAGE18-5	LeKieffre et al., 2022; Schmidt et al., 2022; Himmler et al., 2024
CAGE20-7	Argentino et al., 2023a; Sert et al., 2023; Hemmateenejad et al., 2024
CAGE21-1 (AKMA1)	Argentino et al., 2022b; Argentino et al., 2023a; Argentino et al., 2023b; Barrenechea Angeles et al., 2024; Fallati et al., 2023; Stiller-Reeve et al., 2023; Argentino et al., 2024; Panieri et al., 2024a, Wittig et al., 2024
CAGE22-2 (AKMA2/Ocean Senses)	Argentino et al., 2023a; Barrenechea Angeles et al., 2024; Holzmann et al., 2024; Panieri et al., 2024a; Panieri et al., 2024b; Panieri et al., 2024c
AKMA3	Panieri et al., 2025

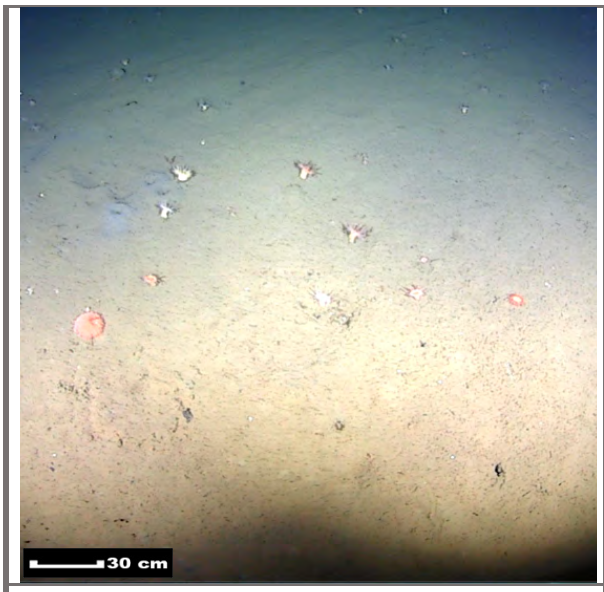
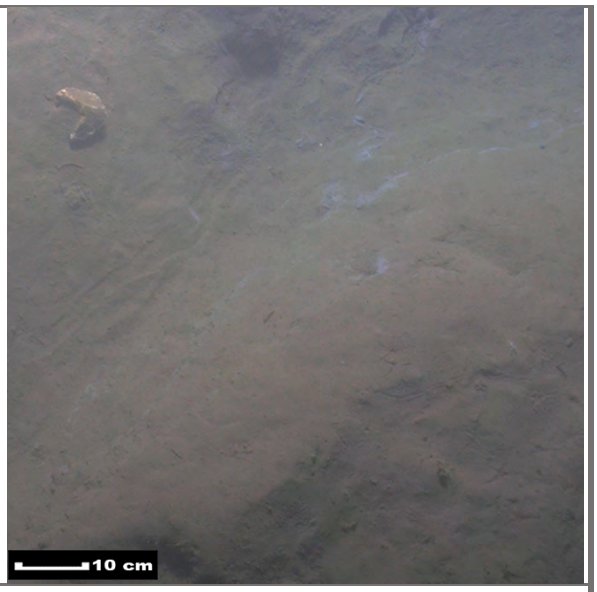
Substrates category

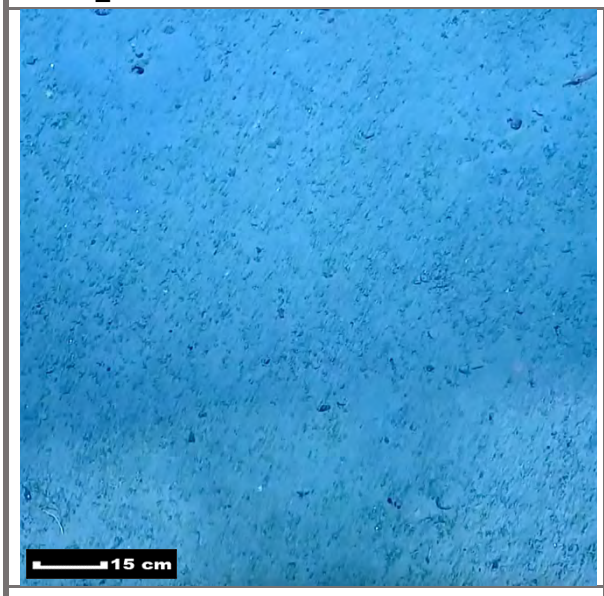
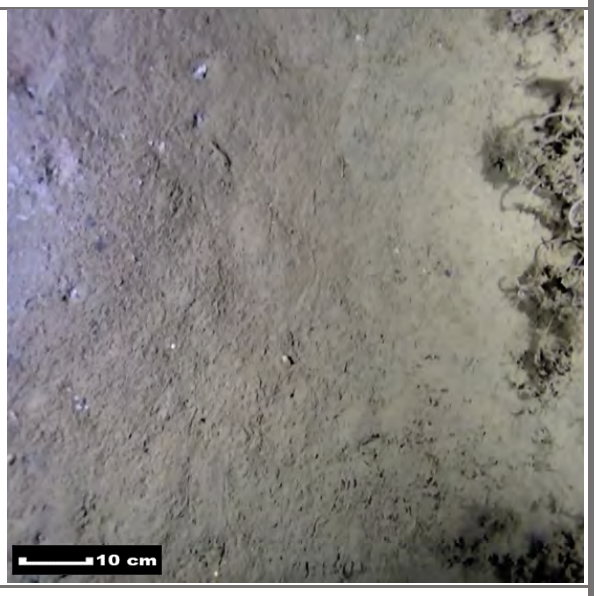
- ### Muddy Substrate

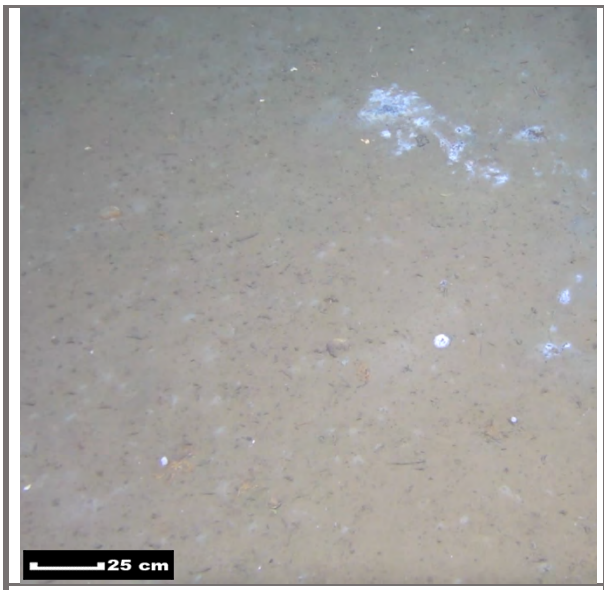
Muddy seafloor	
MUD_001	
	
AKMA3 - Outer Byørnøyrenna - 20230508-075921-CH1 – 08:21:06	**AKMA3 - Outer Byørnøyrenna** - 20230507-132551-CH1 – 13:39:52
	
AKMA3 - Outer Byørnøyrenna - 20230508-154529-CH1 – 15:54:30	**CAGE21-1 - Svyatogor Ridge** - 2021-0526-075344-000-ROV_04 - Center_Overlay – 8:11:28

	
CAGE21-1 - Håkon Mosby Mud Volcano - 2021-0606-152940-000-ROV_23 - Center_Overlay – 16:19:43	**CAGE21-1 - Håkon Mosby Mud Volcano** - 2021-0606-152940-000-ROV_23 - Center_Overlay – 16:18:28
	
CAGE21-1 - North Knipovich Ridge - 2021-0525-092051-000-ROV_03 - Center_Overlay – 10:20:39	**CAGE18-4 - Leirdjupet Fault Complex** - CAHE18_4_HH1136_TC4_V1_p1_Blackmagic HyperDeck Studio Mini[0006] – 00:08:36:29

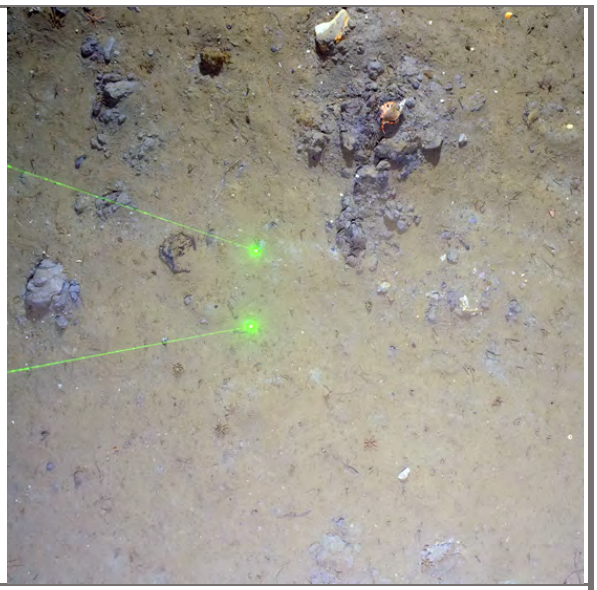
	
CAGE22-2 - Vestnesa Ridge - 20220515-094209-CH3 C – 17:17	**CAGE22-2 - Vestnesa Ridge** - 20220515-094209-CH3 C – 12:58
	
CAGE21-1 - Håkon Mosby Mud Volcano - 2021-0606-112937-000-ROV_23 - Center_Overlay – 11:34:39	**CAGE20-7 - Hinlopen Trough -** 2020-1109-094715-000-ROV_20 - Center_Overlay - 10:09:28

	
CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 01:55:05:18	**CAGE15-2 - Storfjordrenna** - CAGE15-2-HH924_2015-05-24_10-45-29

Cohesive muddy seafloor	
MUD_002	
	
AKMA3 - Outer Byørnøyrenna - 20230507-135551-CH1 – 14:08:50	**CAGE22-2 - Vestnesa Ridge** - 20220515-094209-CH3 C – 23:40

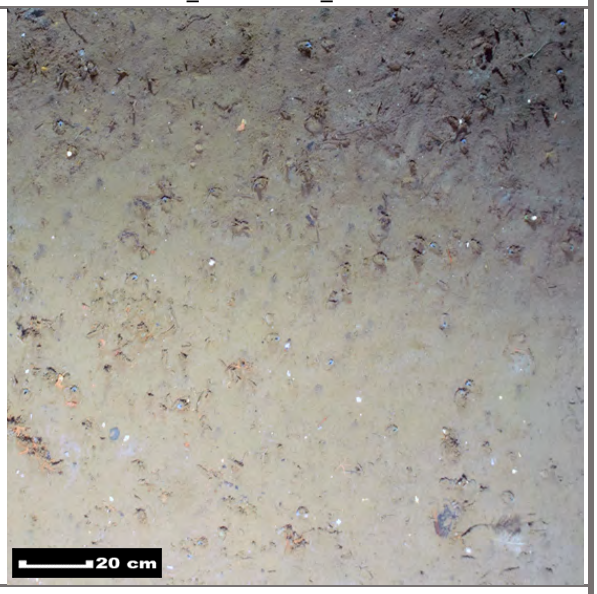


CAGE18-5 - Storbanken - 2018-1030-091645-000--CenterOverlay_ROV_08_MPG4 – 09:22:03

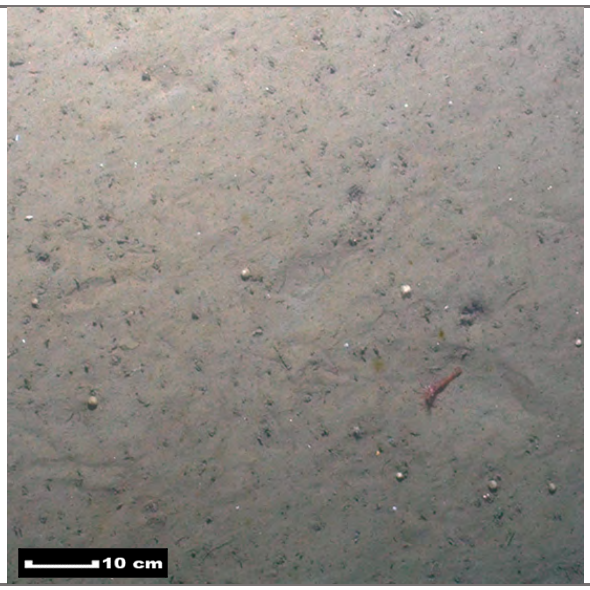


CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH916-TC04_20170623_073608

CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH917-TC05_20170623_090259



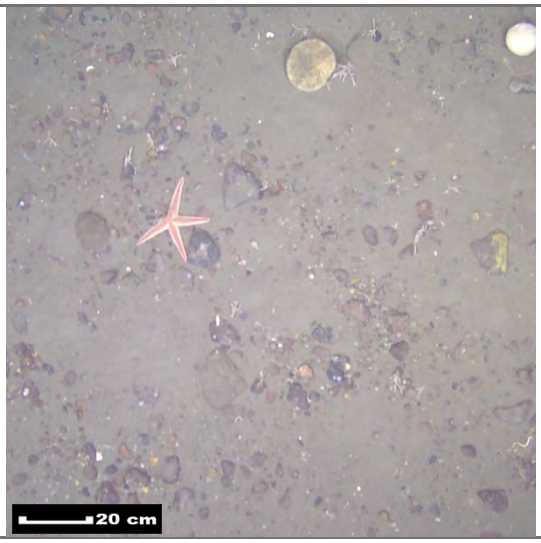
CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH898-TC01_20170622_113320



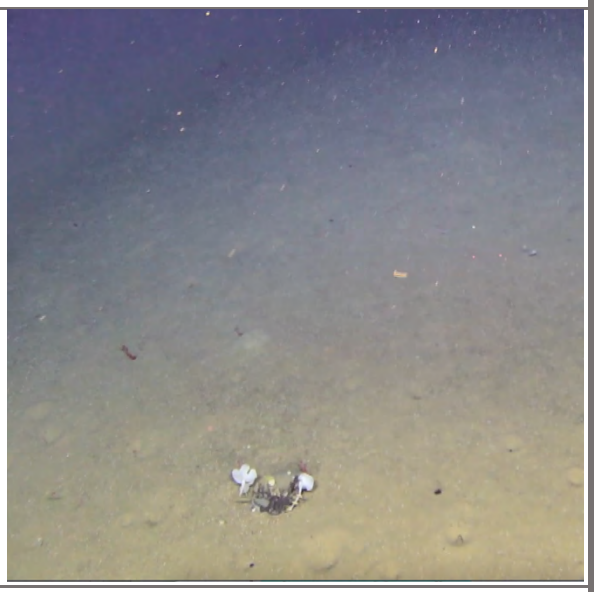
CAGE15-2 - Storfjordrenna Pingos - CAGE15-2-HH932_2015-05-24_16-46-28

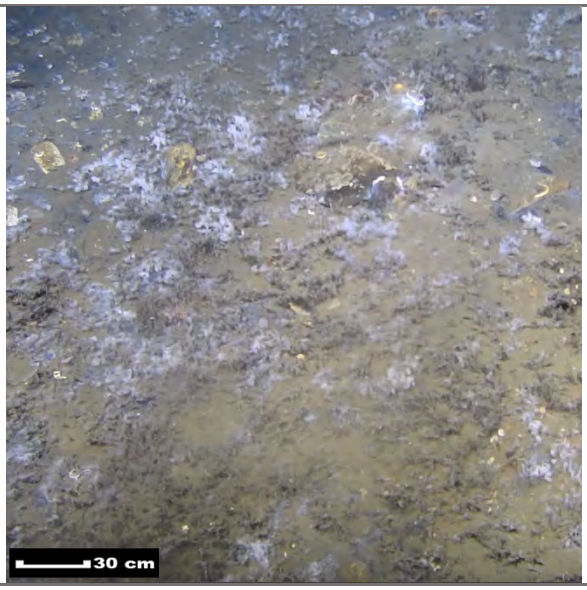
Cohesive muddy seafloor with gravels and pebbles

MUD_003



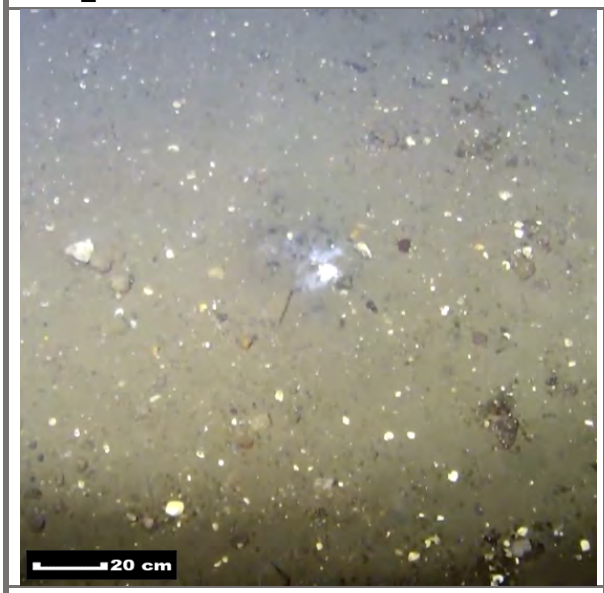
CAGE20-7 – Norskebanken - 2020-1105-104522-000—Mosaik – 11:02:19

Muddy seafloor with scattered cobbles	
MUD_004	
	
CAGE22-2 - Svyatogor Ridge - 20220519-143551-CH3 CENTER – 27:34	**CAGE21-1 - Svyatogor Ridge** - 2021-0527-161321-000-ROV_07 - Center_Overlay – 16:21:24

Cohesive muddy seafloor with scattered cobbles
MUD_005

CAGE20-7 - MASOX - 2020-1113-124607-000-ROV_25 - Center_Overlay - 12:47:32

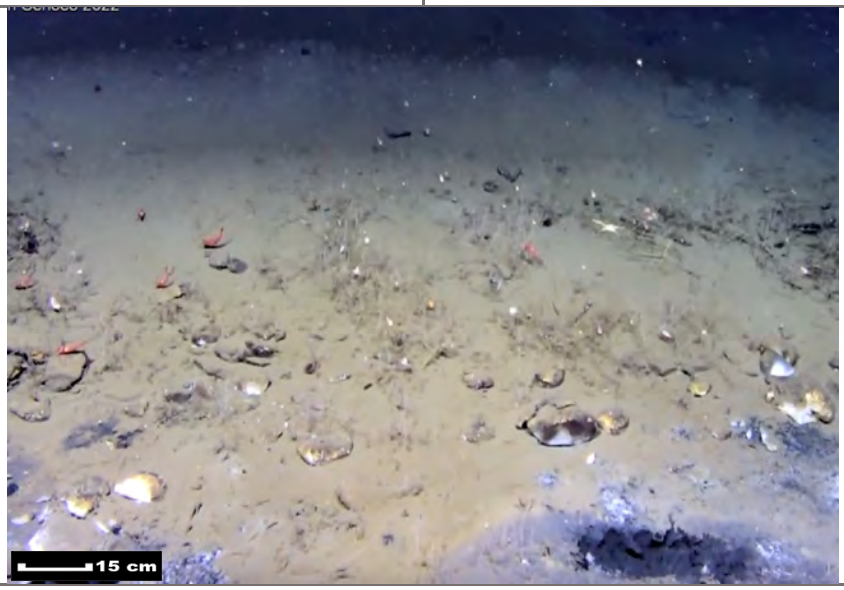
Cohesive muddy seafloor with pebbles and cobbles

GAS_006



CAGE22-2 - Prins Karls Forland - 20220522-083006-CH1 TOP – 58:20

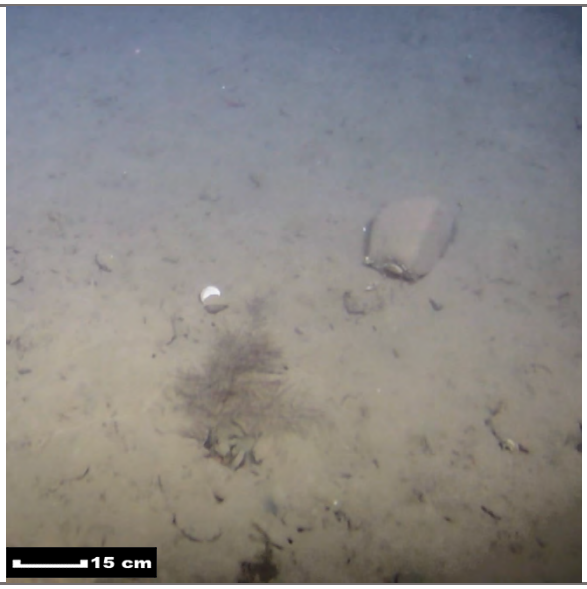
CAGE20-7 - Hinlopen Trough - 2020-1107-122039-000-ROV_13 - Center_Overlay - 12:44:52



CAGE22-2 - Svyatogor Ridge - 20220519-133551-CH3 CENTER – 06:40

Muddy seafloor with pebbles and cobbles

MUD_007



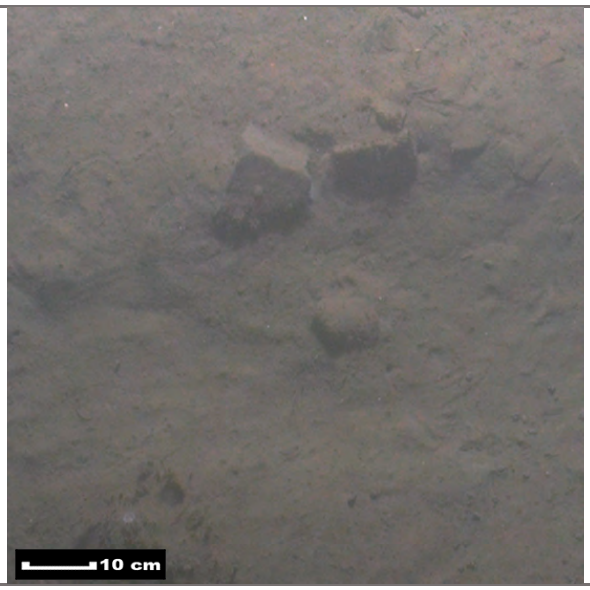
CAGE20-7 - Adventfjorden - 2020-1115-084350-000-ROV_30 - Center_Overlay - 08:52:56

Muddy seafloor with cobbles

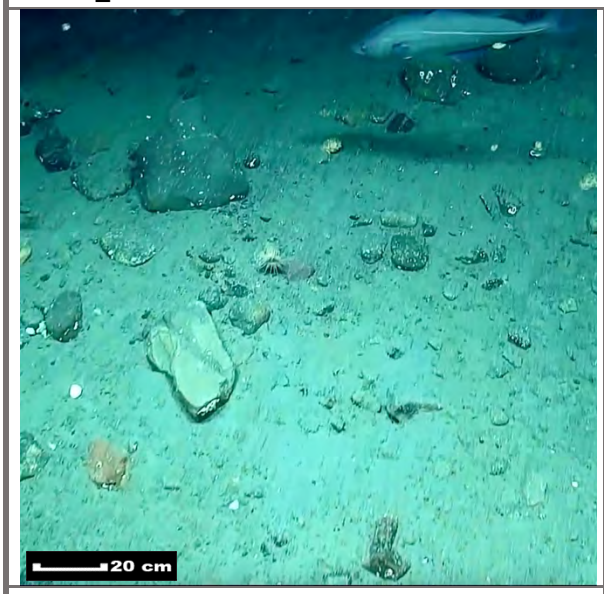
MUD_008

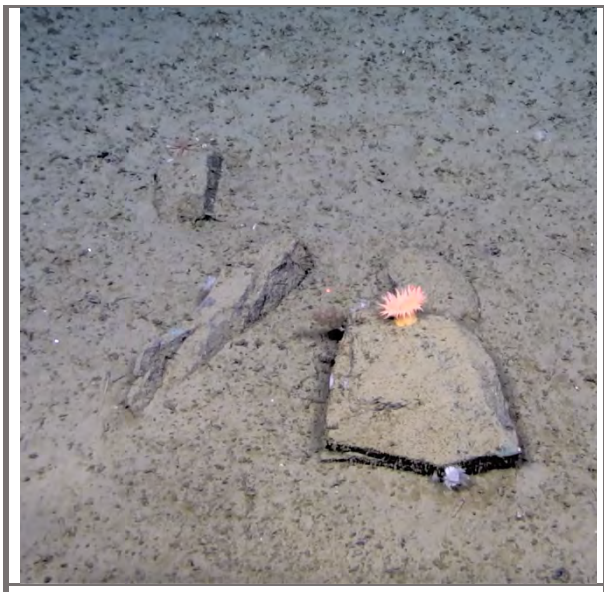
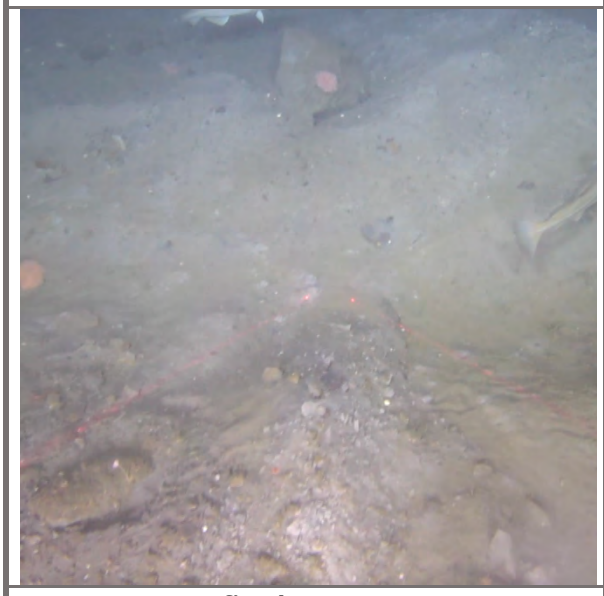
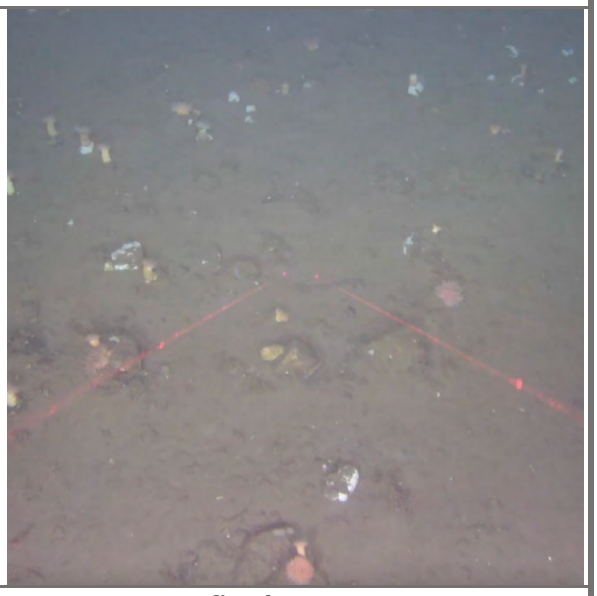
CAGE21-1 - North Knipovich Ridge - 2021-0525-112048-000-ROV_03 - Center_Overlay – 11:45:00

CAGE15-2 - Storfjordrenna Craters - CAGE15-2-HH944_2015-05-26_12-23-23



CAGE15-2 - Storfjordrenna - CAGE15-2-HH924_2015-05-24_11-04-39

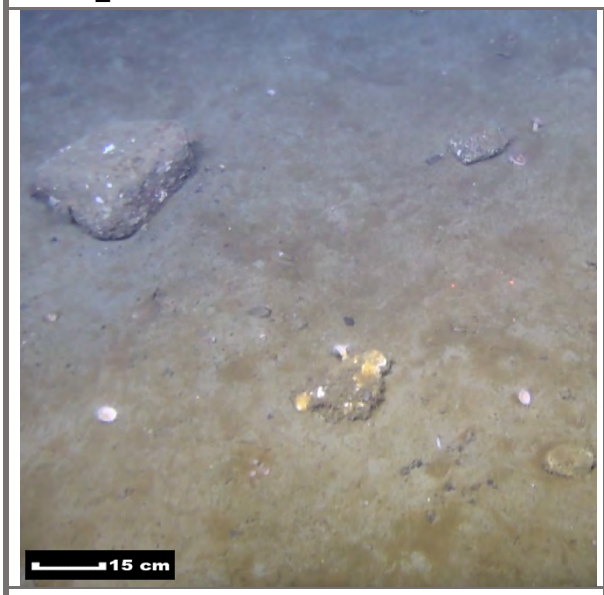
Muddy seafloor with cobbles and boulders	
MUD_009	
	
AKMA3 - Outer Byørnøyrenna - 20230508-151529-CH1 – 15:37:13	**AKMA3 - Outer Byørnøyrenna** - 20230507-122549-CH1 – 12:55:33

	
CAGE21-1 - North Knipovich Ridge - 2021-0525-082048-000-ROV_03 - Center_Overlay – 8:48:55	**CAGE21-1 - North Knipovich Ridge** - 2021-0525-092051-000-ROV_03 - Center_Overlay – 9:43:47
	
CAGE18-5 - Storfjorden - 2018-1025-002744-000--TopOverlay_ROV_01_MPG4 – 00:33:18	**CAGE18-5 - Storfjorden** - 2018-1024-232743-000--TopOverlay_ROV_01_MPG4 – 23:31:19

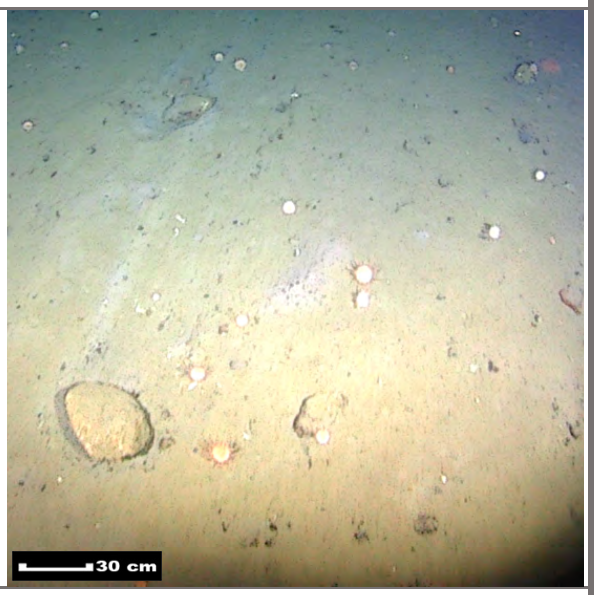
CAGE18-5 - Storfjorden - 2018-1024-232743-000--TopOverlay_ROV_01_MPG4 – 23:29:13

Cohesive muddy seafloor with cobbles and boulders

MUD_010

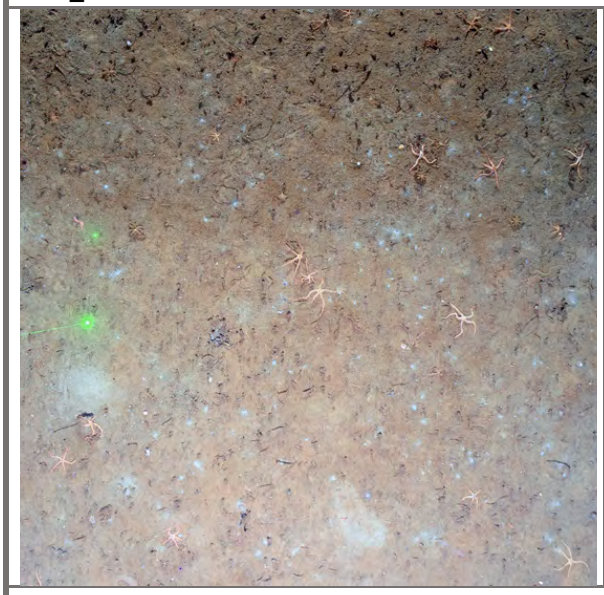
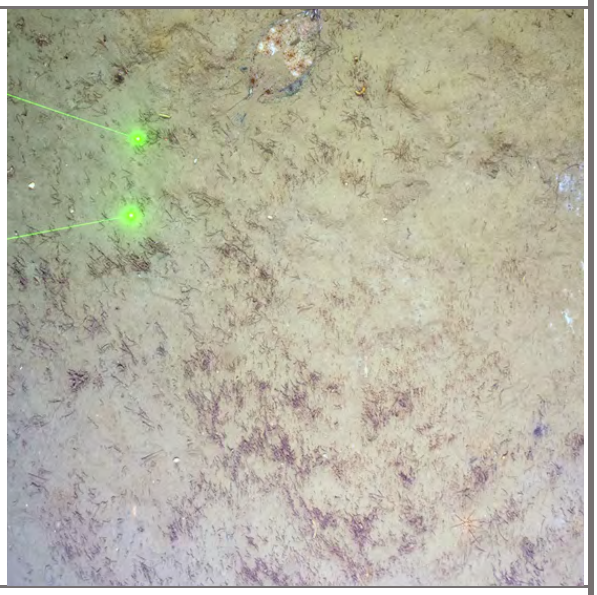
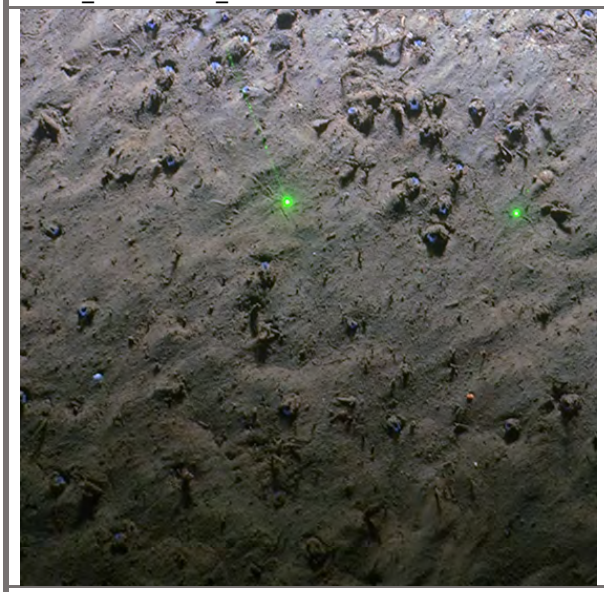


CAGE21-1 - Leirdjupet Fault Complex - 2021-0603-095831-000-ROV_15 - Center_Overlay – 10:40:35



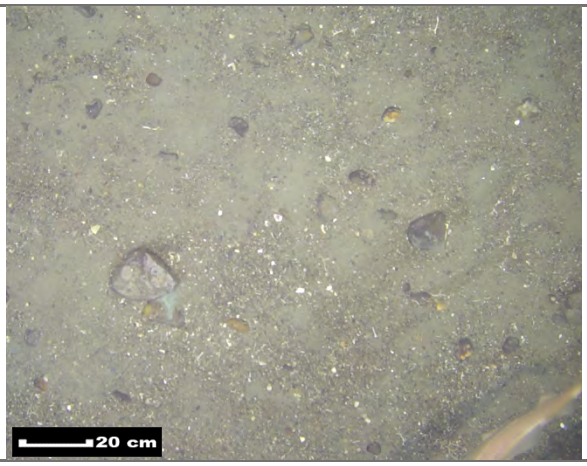
CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 00:07:55:07

- **Fine Substrate**

Fine sediment	
FIN_001	
	
CAGE17-2 - Olga Basin - CAGE17-2-HH939-TC15_20170627_084339	**CAGE17-2 - Storfjordrenna Pingo** - CAGE17-2-HH919-TC07_20170623_112959
	
CAGE15-2 - Storfjordrenna Pingos - CAGE15-2-HH937_2015-05-24_20-23-34	**CAGE15-2 - Storfjordrenna Pingos** - CAGE15-2-HH932_2015-05-24_17-09-28

Fine sediment with gravels and pebbles

FIN_002

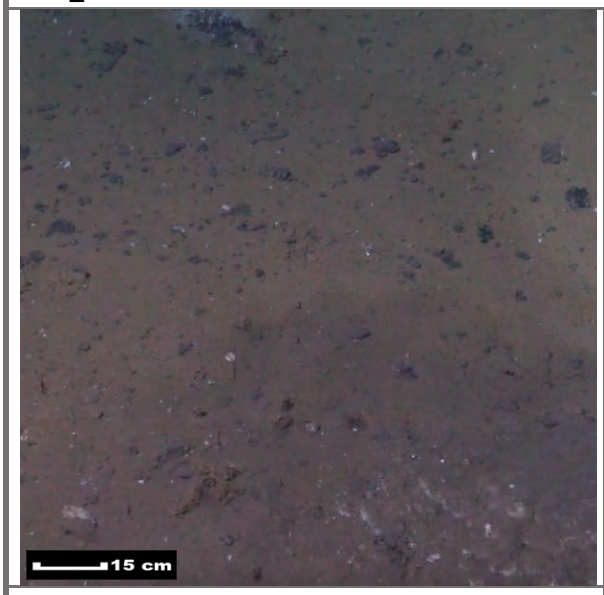
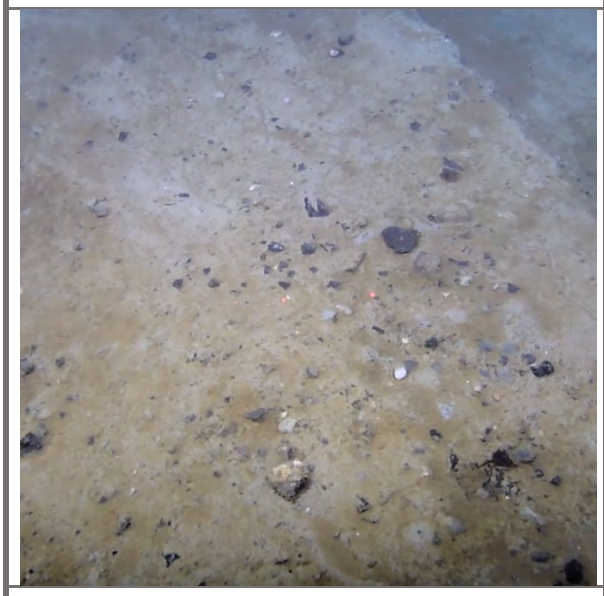
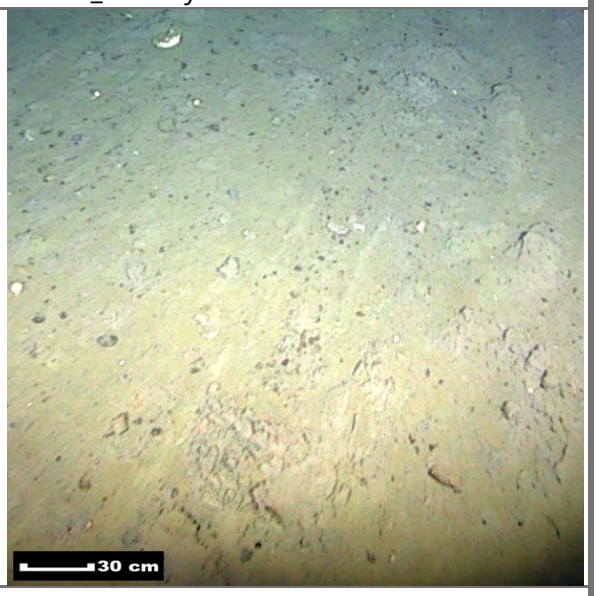


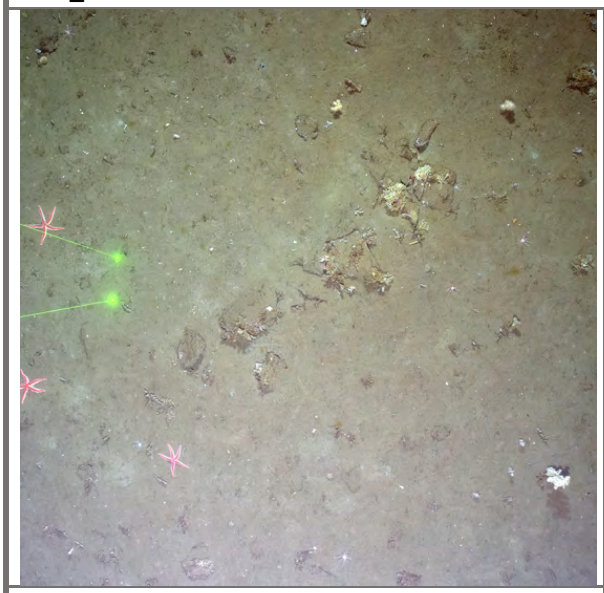
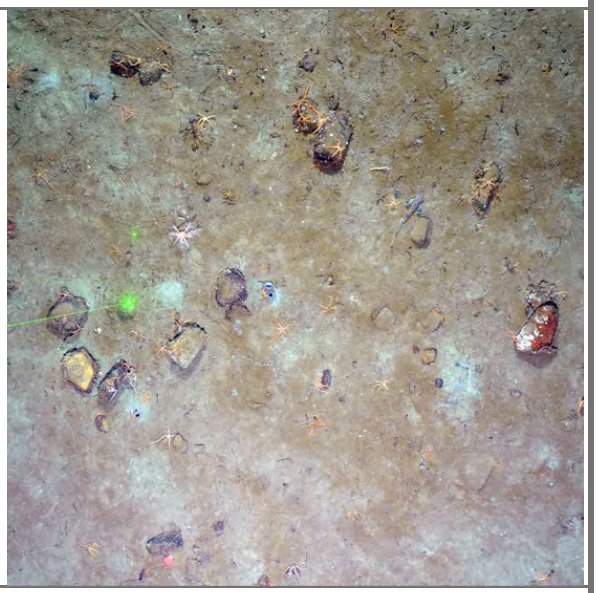
CAGE20-7 - Norskebanken - CAGE17-2-HH970-TC26_20170630_110941

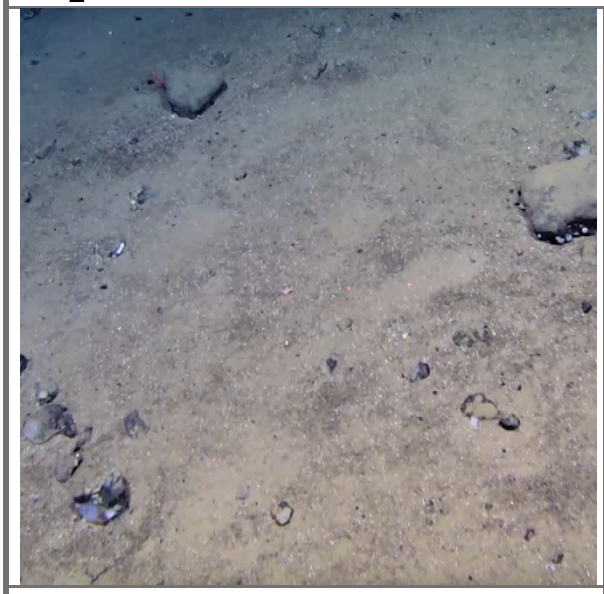
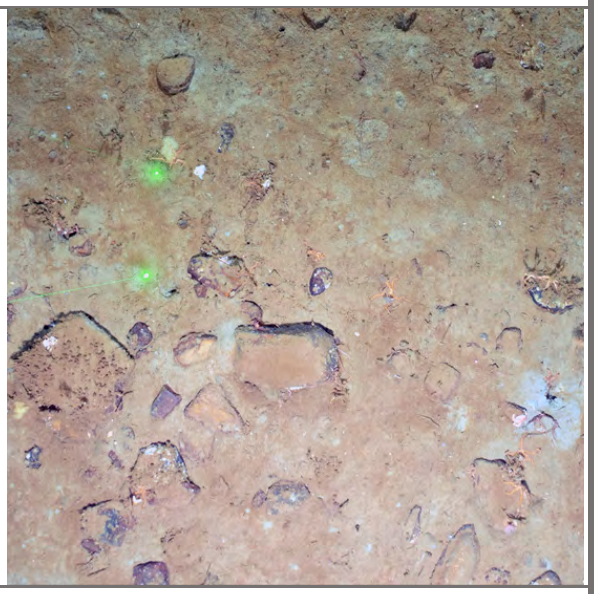
Fine sediment with pebbles

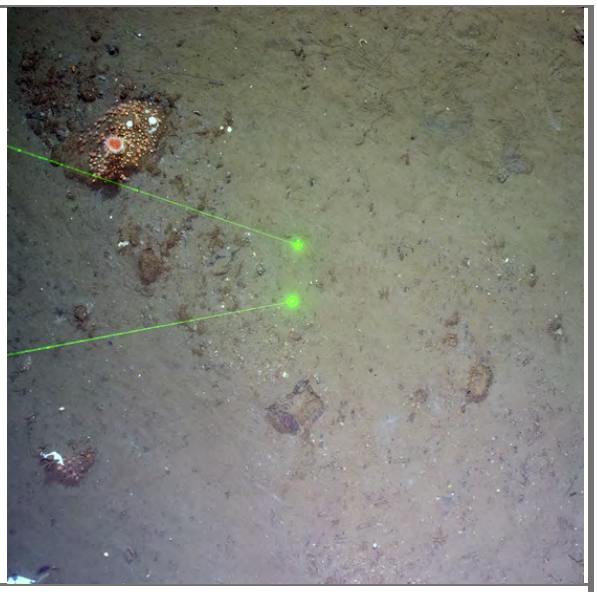
FIN_002

CAGE17-2 - Olga Basin - CAGE17-2-HH970-TC26_20170630_110941

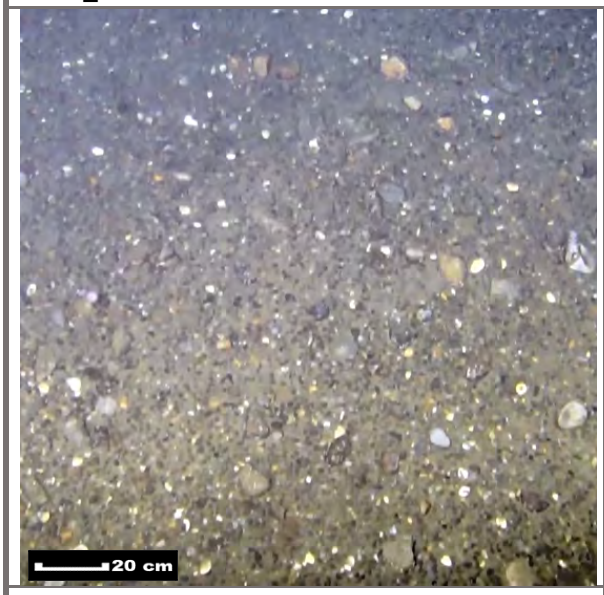
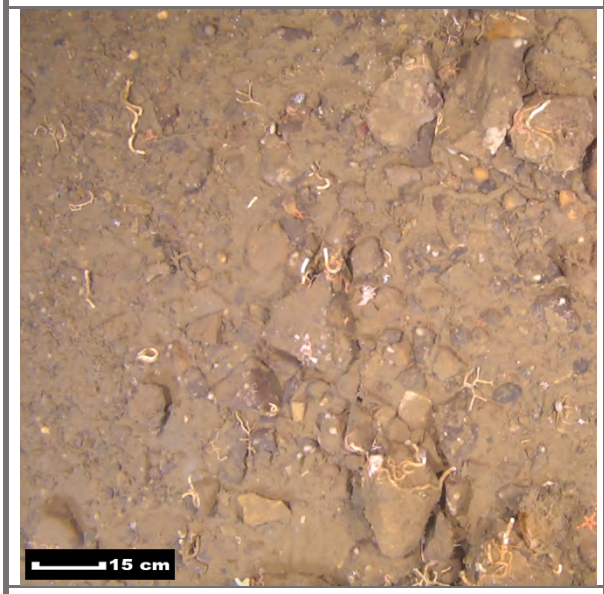
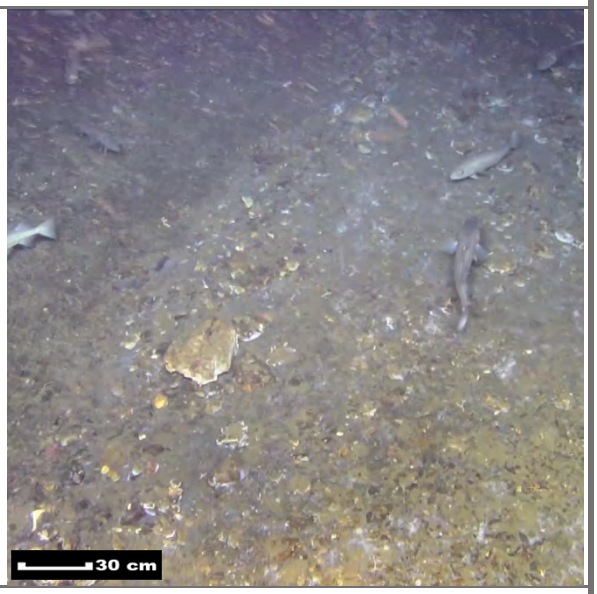
Fine sediment with pebbles and cobbles	
FIN_003	
	
CAGE22-2 - Vestnesa Ridge - 20220516-154220-CH3 CENTER – 16:05	**CAGE21-1 - Leirdjupet Fault Complex** - 2021-0603-065830-000-ROV_15 - Center_Overlay – 7:35:36
	
CAGE21-1 - Leirdjupet Fault Complex - 2021-0603-095831-000-ROV_15 - Center_Overlay – 10:47:06	**CAGE18-4 - Leirdjupet Fault Complex** - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 00:03:52:20

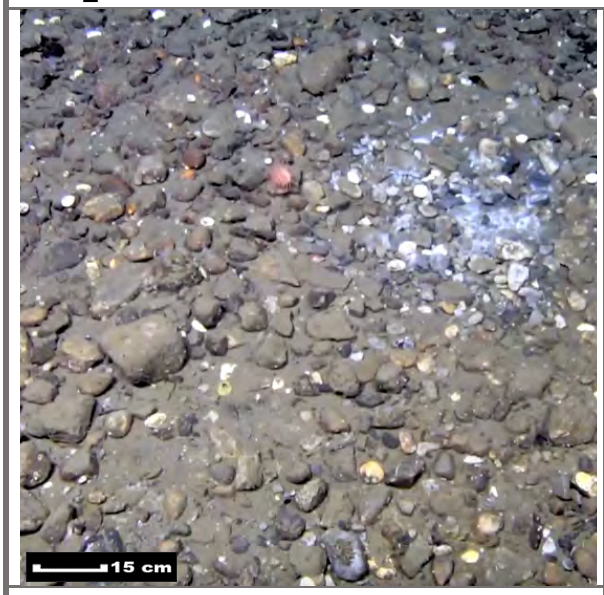
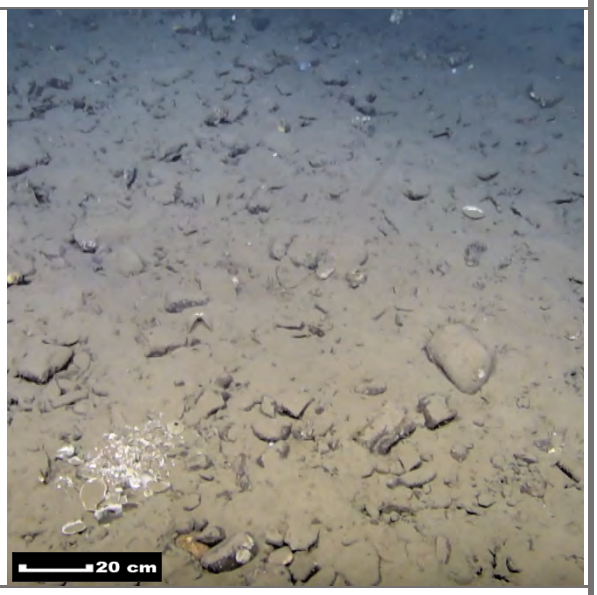
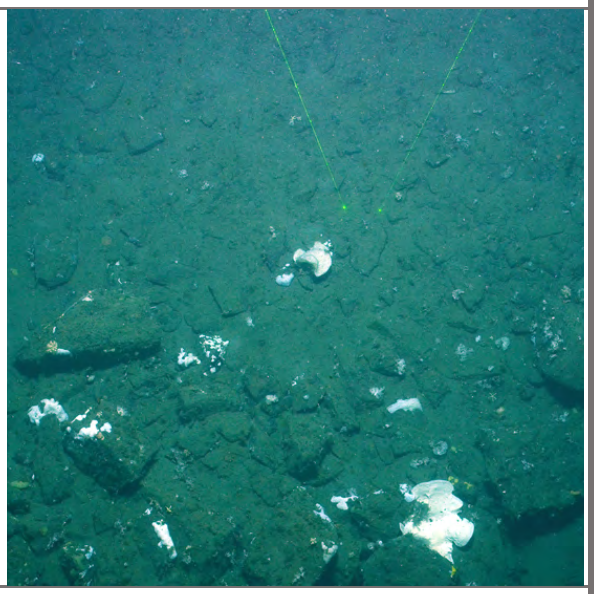
Fine sediment with cobbles	
FIN_004	
	
CAGE17-2 - Olga Basin - CAGE17-2-HH933-TC14_20170626_161128	**CAGE17-2 - Olga Basin** - CAGE17-2-HH957-TC22_20170629_084955

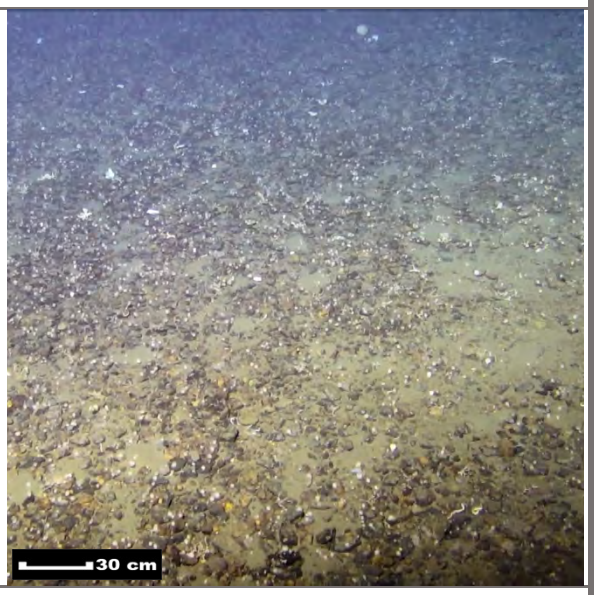
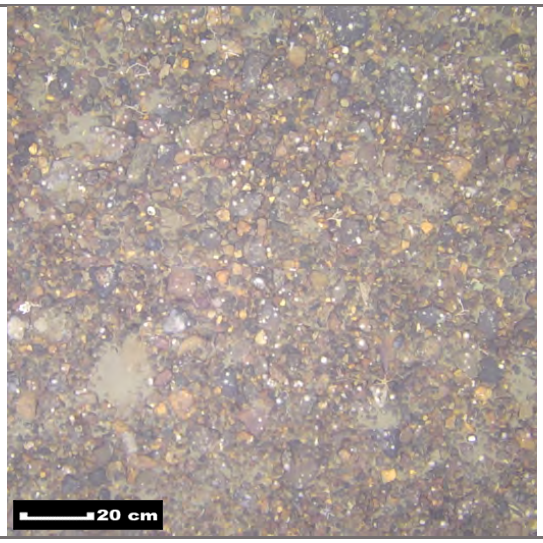
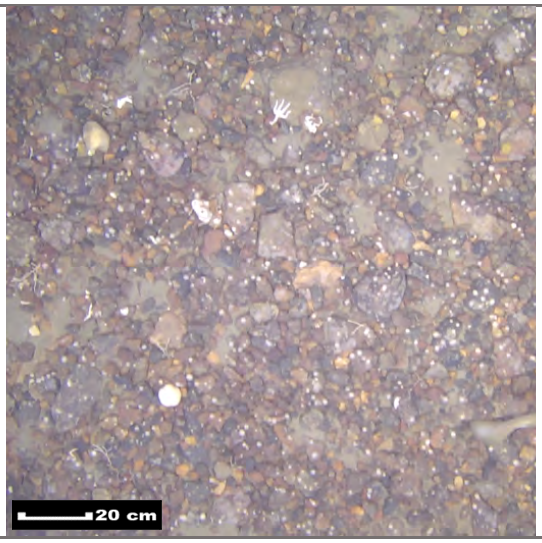
Fine sediment with cobbles and boulders	
FIN_005	
	
CAGE21-1 - Svyatogor Ridge - 2021-0526-152134-000-ROV_05 - Center_Overlay – 15:48:15	**CAGE17-2 - Olga Basin** - CAGE17-2-HH957-TC22_20170629_092425

	
CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH900-TC02_20170622_151953	**CAGE17-2 - Storfjordrenna Pingo** - CAGE17-2-HH919-TC07_20170623_114059

- **Gravelly Substrate**

Gravelly seafloor	
GRA_001	
	
CAGE22-2 - Prins Karls Forland - 20220522-083006-CH1 TOP – 41:40	**CAGE22-2 - Prins Karls Forland** - 20220522-125103-CH3 CENTER – 00:23:47
	
CAGE20-7 - MASOX - 2020-1114-154909-000-ROV_29 - Mosaik - 15:53:38	**CAGE20-7 - MASOX** - 2020-1114-153043-000-ROV_29 - Center_Overlay - 16:20:06

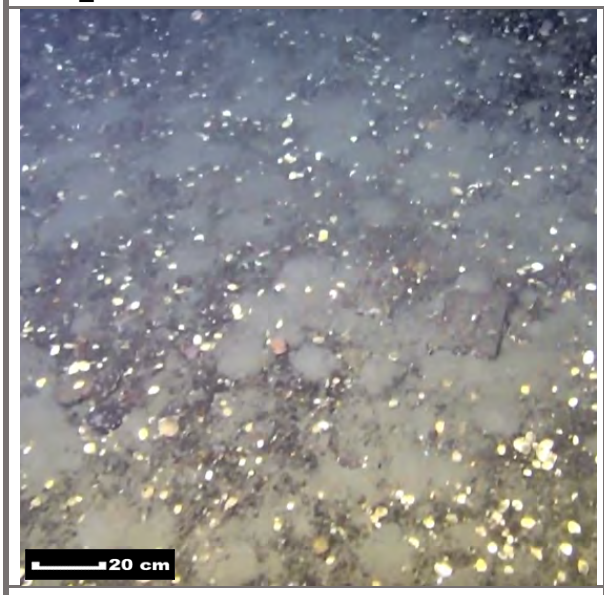
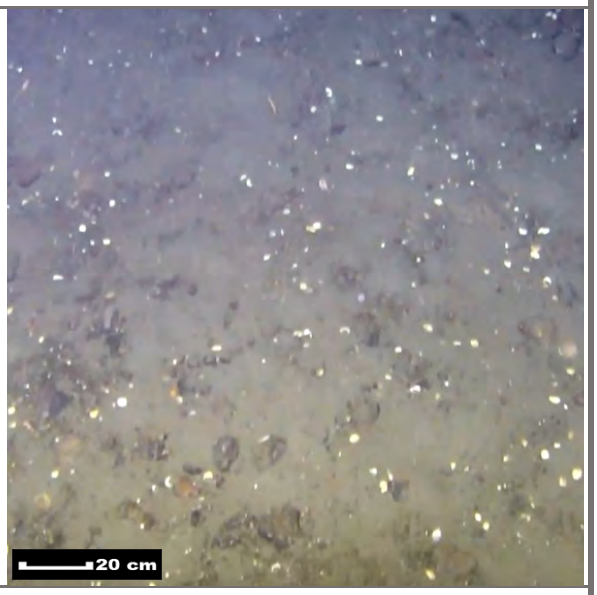
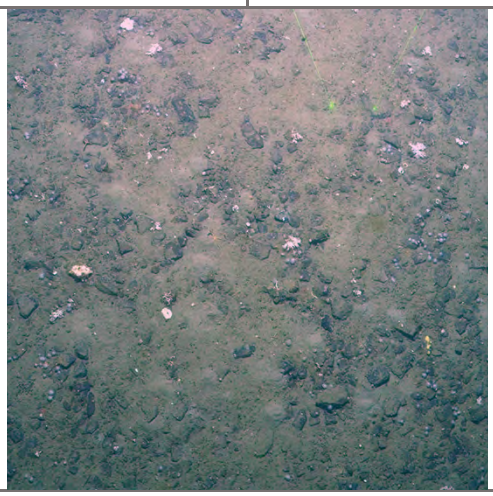
Gravelly seafloor covered by mud	
GRA_002	
	
CAGE22-2 - Prins Karls Forland - 20220522-063047-CH3 CENTER – 07:15	**CAGE20-7 - Adventfjorden** - 2020-1115-112514-000-ROV_31 - Center_Overlay - 11:34:22
	
CAGE20-7 - MASOX - 2020-1114-153043-000-ROV_29 - Center_Overlay - 16:01:54	**CAGE15-2 - Storfjordrenna Craters** - CAGE15-2-HH944_2015-05-26_12-51-53

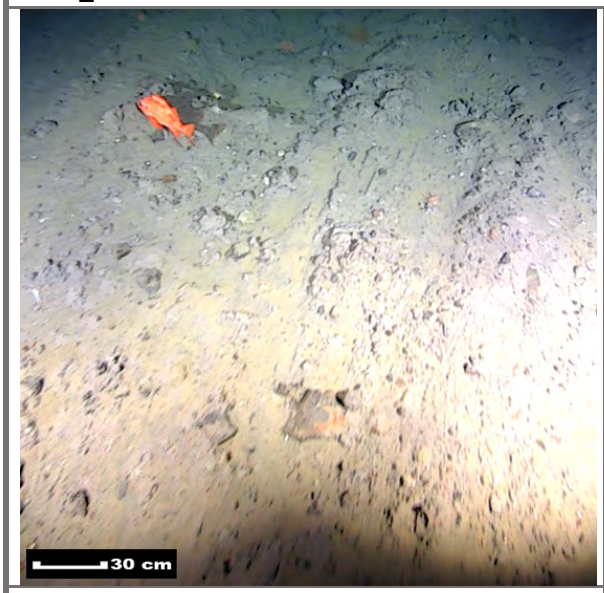
Gravelly seafloor dominated by pebbles	
GRA_003	
	
CAGE20-7 - Hinlopen Trough - 2020-1107-155748-000-ROV_14 - Center_Overlay - 16:16:44	**CAGE20-7 - Hinlopen Trough** - 2020-1107-093231-000-ROV_11 - Center_Overlay - 09:51:18
	
CAGE20-7 - Norskebanken - 2020-1105-114522-000—Mosaik – 12:17:29	**CAGE20-7 - Norskebanken** - 2020-1105-114522-000—Mosaik – 11:51:43

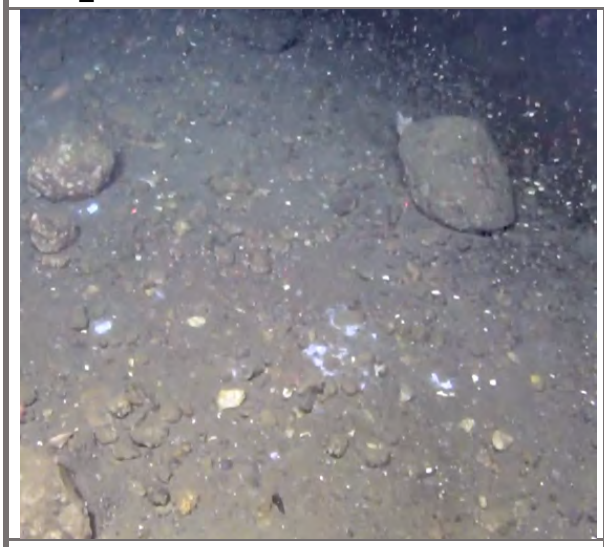
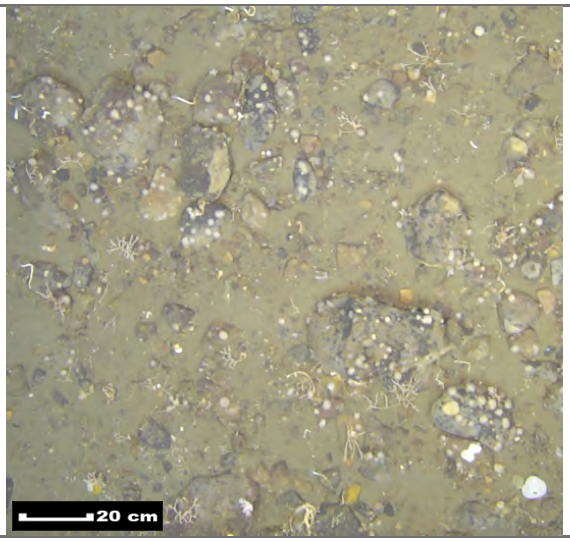
Gravelly seafloor with scattered boulders
GRA_004

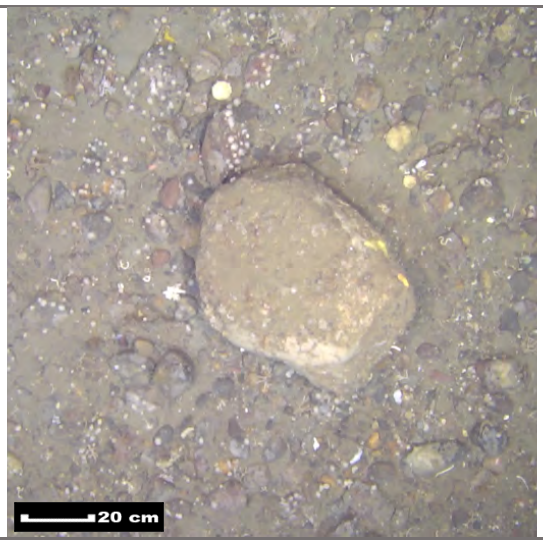
CAGE21-1 - Prins Karls Forland - 2021-0524-124843-000-ROV_01 - Center_Overlay – 11:50:46

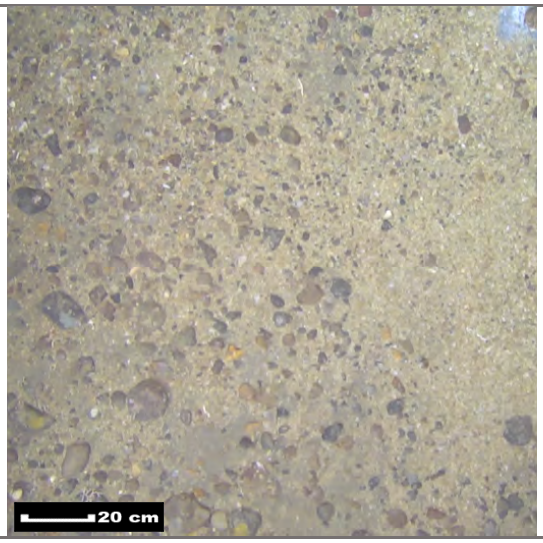
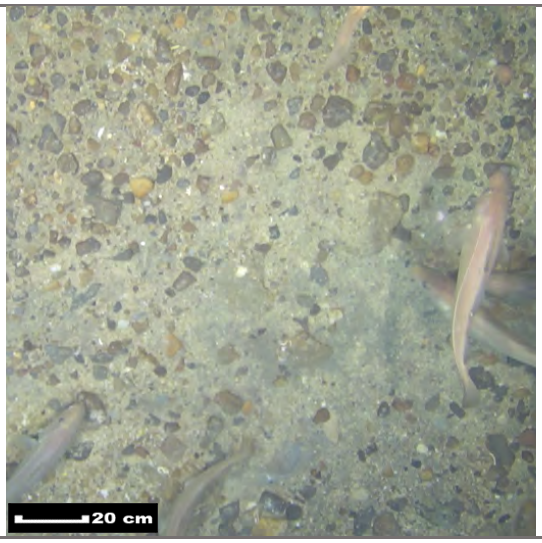
- **Heterogeneous Substrate**

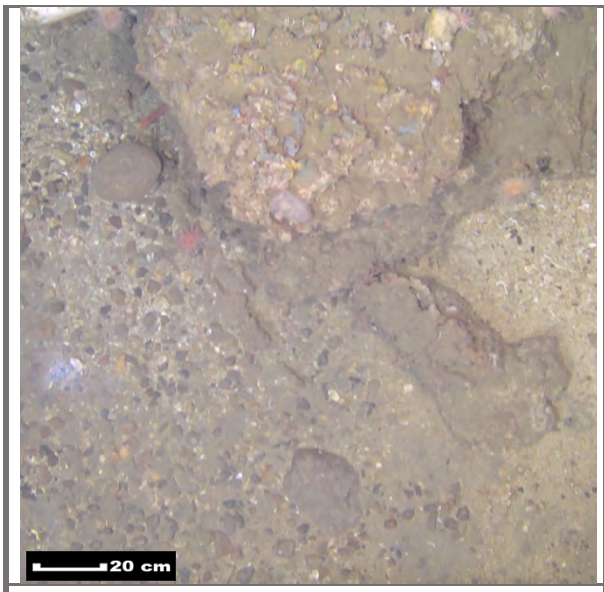
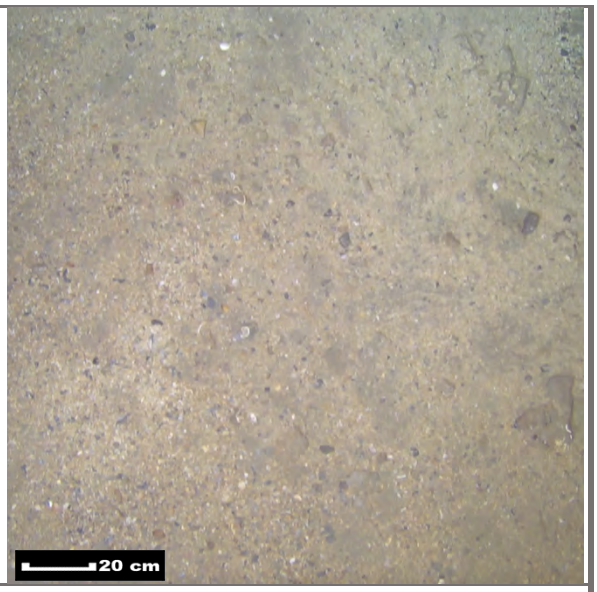
Heterogeneous sediment	
HET_001	
	
CAGE22-2 - Prins Karls Forland - 20220522-083006-CH1 TOP – 10:43	**CAGE22-2 - Prins Karls Forland** - 20220522-083006-CH1 TOP – 43:20
	
CAGE15-2 - Storfjordrenna Craters - CAGE15-2-HH944_2015-05-26_13-15-13	

(Altered) heterogeneous muddy sediments with pebbles, cobbles and boulders	
HET_002	
	
CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 00:34:24:06	**CAGE18-4 - Leirdjupet Fault Complex** - CAGE18_4_HH1136_V1_TC4_p2_Blackmagic HyperDeck Studio Mini[0007] – 00:16:25:13

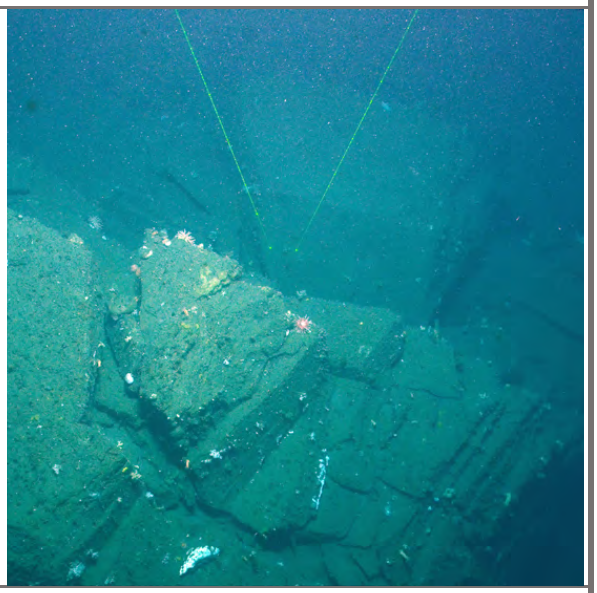
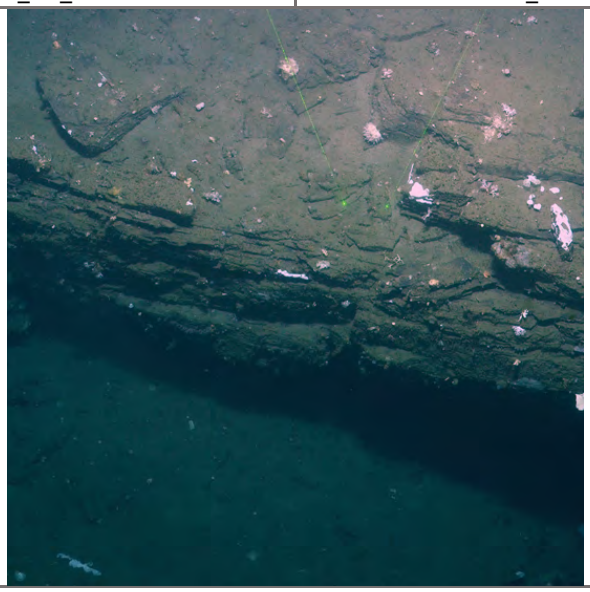
Heterogeneous sediment with pebbles, cobbles and boulders	
HET_003	
	
CAGE22-2 - Prins Karls Forland - 20220522-063047-CH3 CENTER – 14:58	**CAGE20-7 - Norskebanken** - 2020-1105-124522-000—Mosaik – 12:53:41

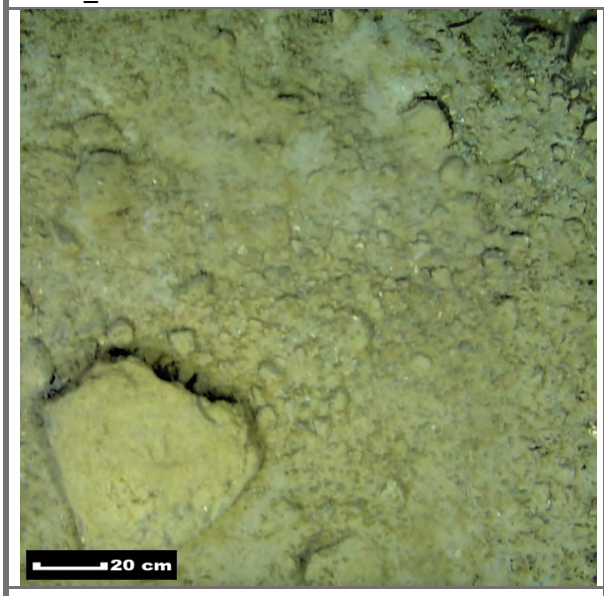
	
CAGE20-7 - Norskebanken - 2020-1105-114522-000—Mosaik – 12:03:54	**CAGE18-4 - Leirdjupet Fault Complex** - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 00:34:10:23

Heterogeneous coarse sediment	
HET_004	
	
CAGE20-7 – Norskebanken - 2020-1105-114522-000—Mosaik – 11:49:15	**CAGE20-7 – Norskebanken** - 2020-1105-134522-000—Mosaik – 14:07:29

	
CAGE20-7 – Norskebanken - 2020-1105-170850-000-ROV_05 – Mosaik -17:26:07	**CAGE20-7 – Norskebanken** - 2020-1105-170850-000-ROV_05 – Mosaik -17:59:11

o Hard Substrate

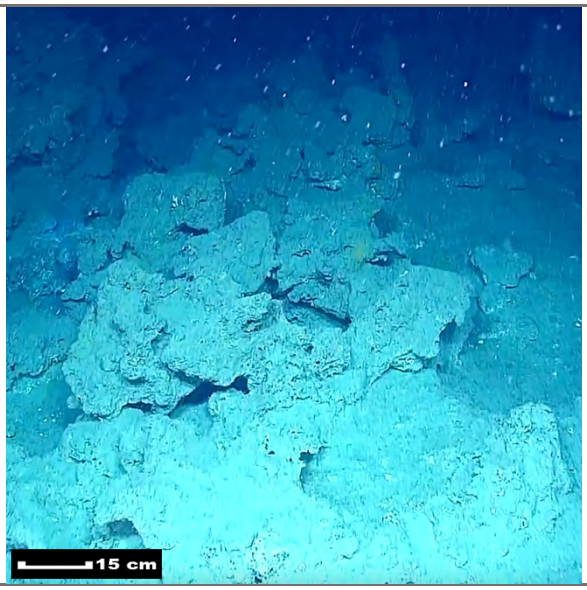
Rocky outcrop	
HAR_001	
	
CAGE18-5 - Storbanken - 2018-1030-153123-000--CenterOverlay_ROV_09_MPG4 – 15:33:48	**CAGE15-2 - Storfjordrenna Craters** - CAGE15-2-HH944_2015-05-26_13-00-13
	
CAGE15-2 - Storfjordrenna Craters - CAGE15-2-HH944_2015-05-26_13-01-43	

Conglomerate	
HAR_002	
	
CAGE21-1 - North Knipovich Ridge - 2021-0529-074950-000-ROV_09 - MOSAIC – 07:57:20	**CAGE21-1 - North Knipovich Ridge** - 2021-0529-084950-000-ROV_09 - MOSAIC – 08:56:50

Firm- or hardground	
HAR_003	
	
CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH916-TC04_20170623_073738	**CAGE17-2 - Storfjordrenna Pingo** - CAGE17-2-HH919-TC07_20170623_114209

Authigenic carbonate crust

HAR_004



AKMA3 - Outer Byørnøyrenna - 20230508-072922-CH1 – 07:51:57

Authigenic carbonate pavement covered by muddy sediment with pebbles and cobles

HAR_005

AKMA3 - Outer Byørnøyrenna - 20230508-144529-CH1 – 15:01:53

Example of additional substrate descriptors

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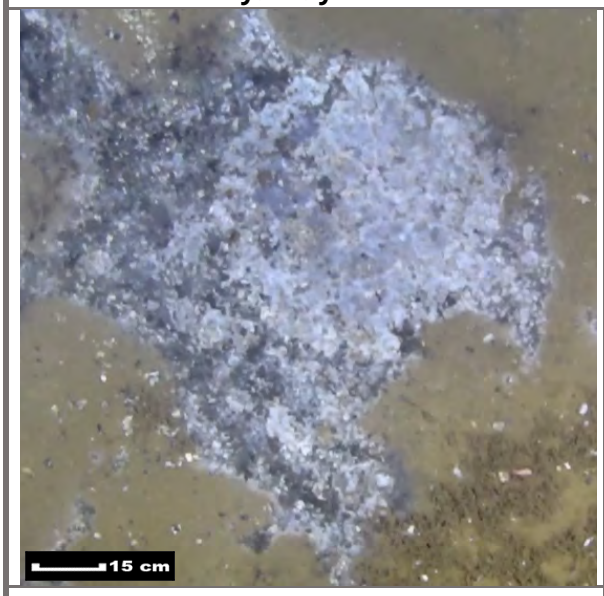
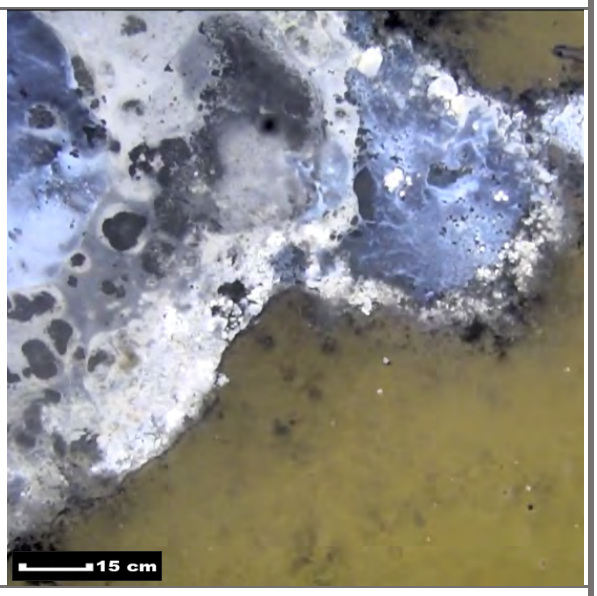
<tr><td> 
</td><td> 
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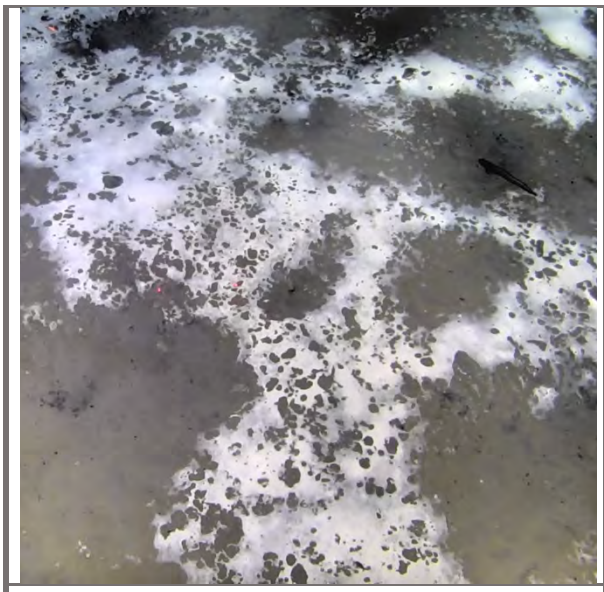
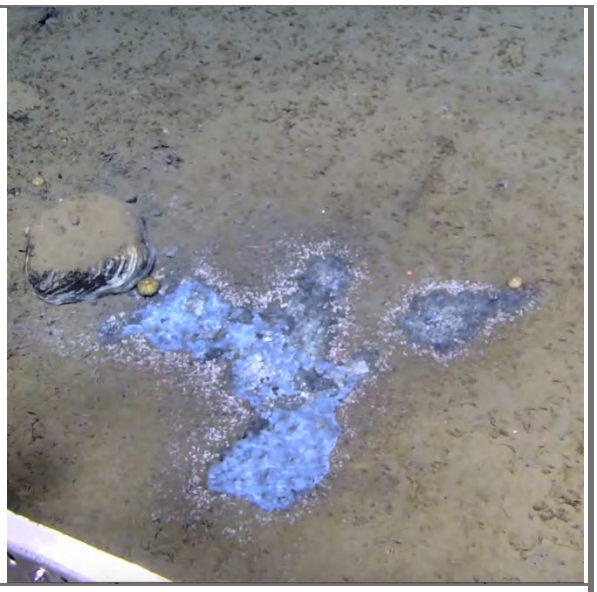
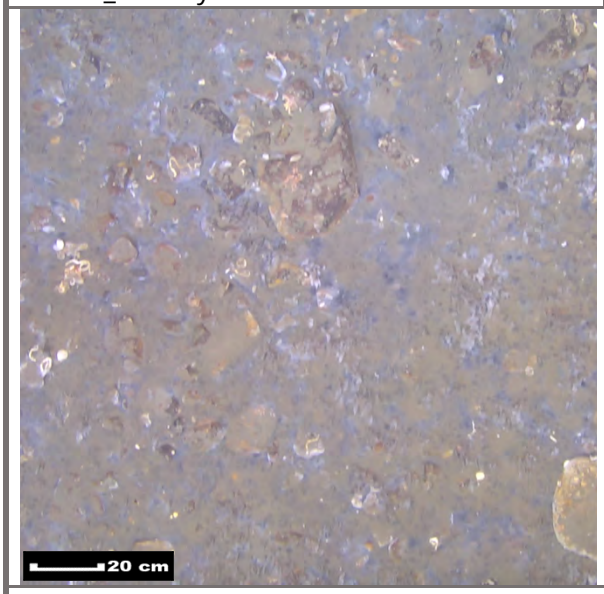
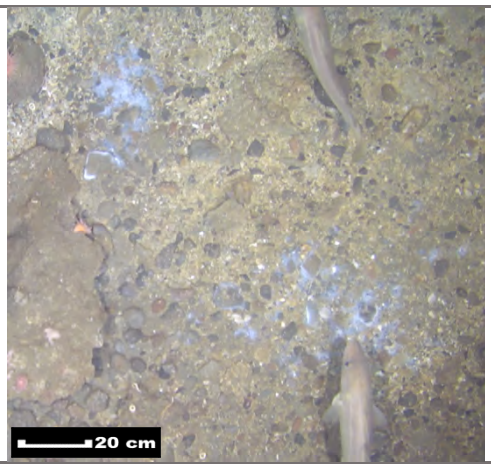
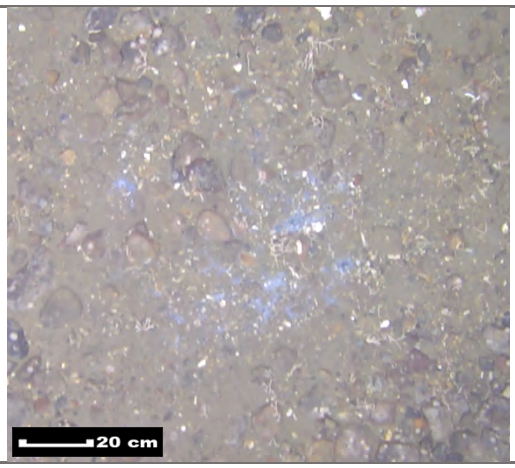
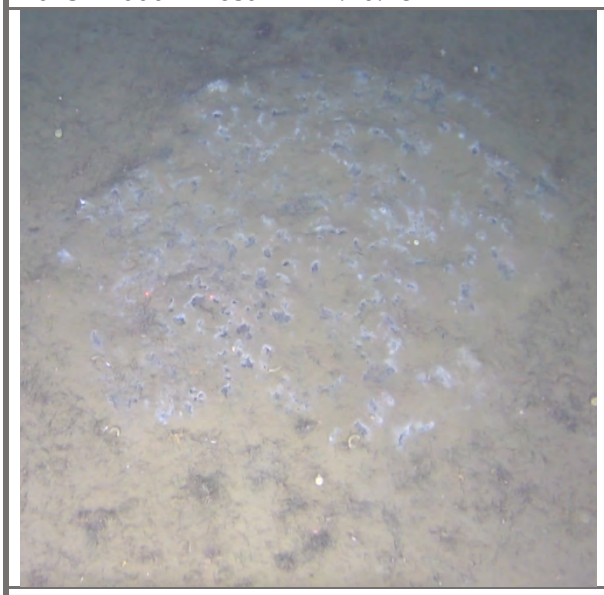
	
CAGE21-1 - Håkon Mosby Mud Volcano - 2021-0606-132939-000-ROV_23 - Center_Overlay – 14:02:51	**CAGE21-1 - North Knipovich Ridge** - 2021-0525-092051-000-ROV_03 - Center_Overlay – 9:55:17
	
CAGE20-7 - MASOX - 2020-1114-154909-000-ROV_29 - Mosaik - 16:32:01	**CAGE20-7 - Hinlopen Trough** - 2020-1107-122039-000-ROV_13 - Center_Overlay - 12:59:40



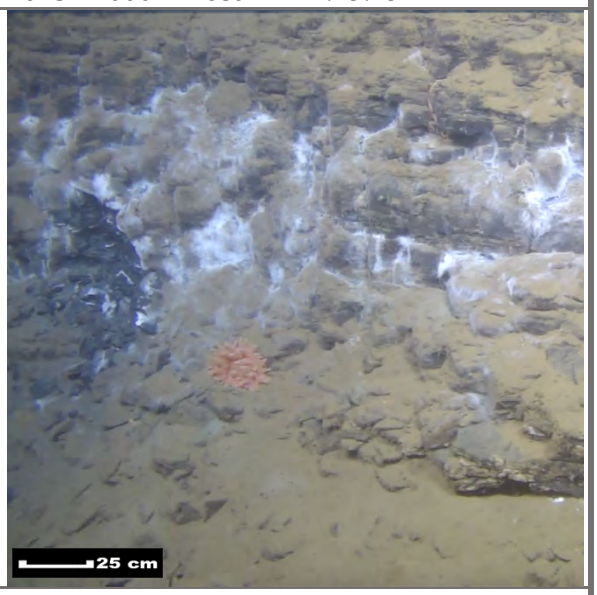
CAGE20-7 - Norskebanken - 2020-1105-104522-000—Mosaik – 11:40:48



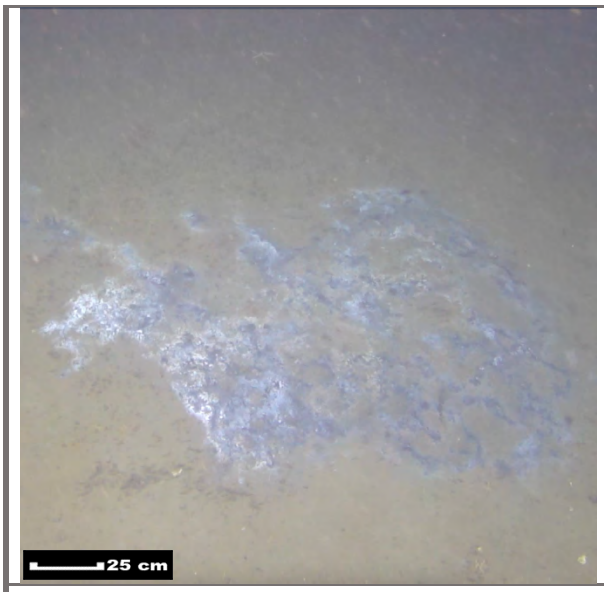
CAGE20-7 - Norskebanken - 2020-1105-104522-000—Mosaik – 11:19:29



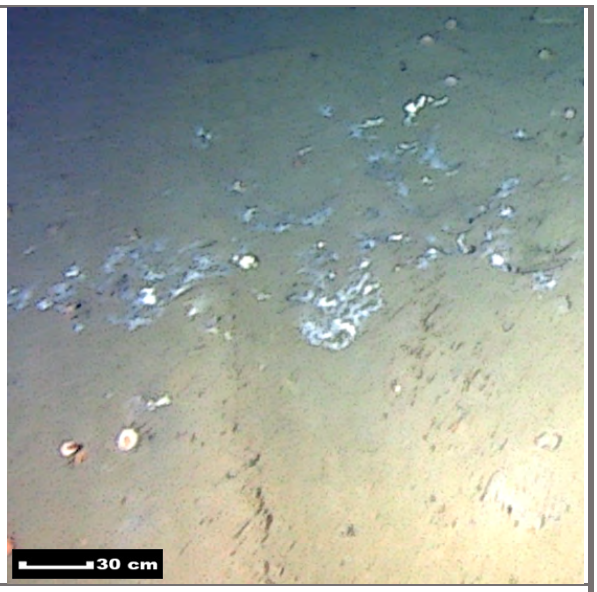
CAGE18-5 - Storfjorden - 2018-1025-044137-000--CenterOverlay_ROV_01_MPG4 – 05:01:13



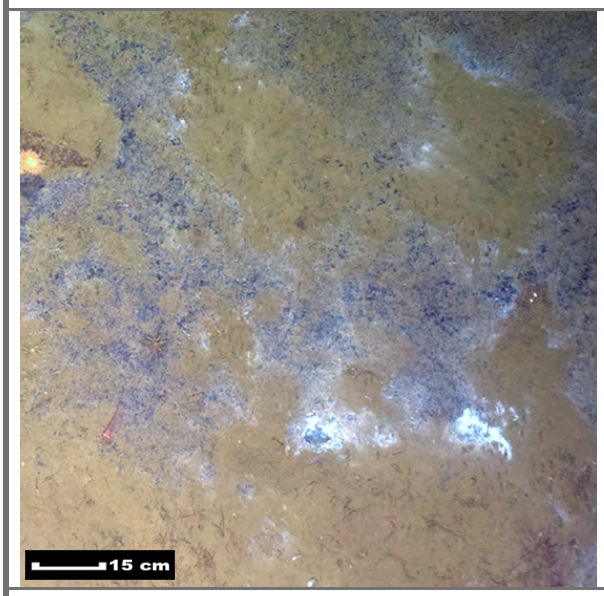
CAGE18-5 - Storbanken - 2018-1030-212209-000--CenterOverlay_ROV_10_MPG4 – 21:59:56



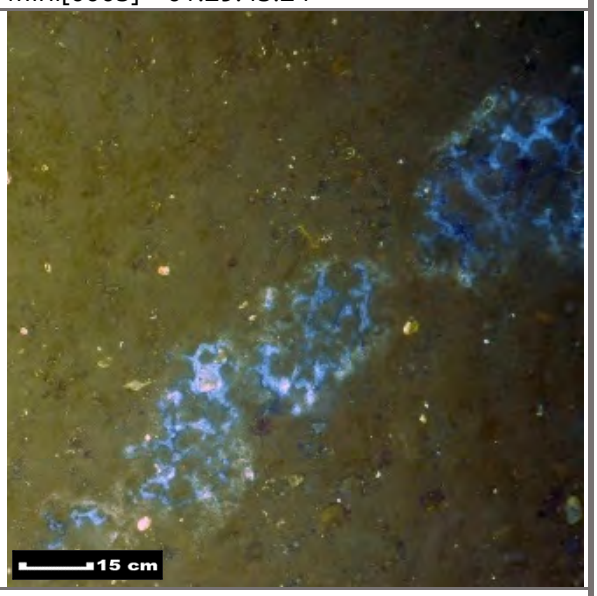
CAGE18-5 - Storbanken - 2018-1030-081642-000--CenterOverlay_ROV_08_MPG4 – 08:42:47



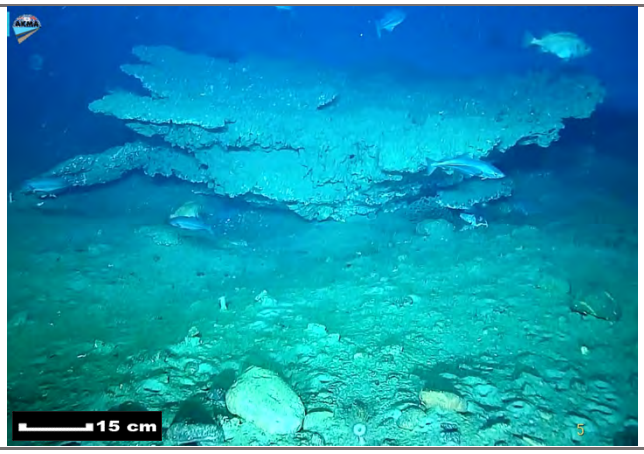
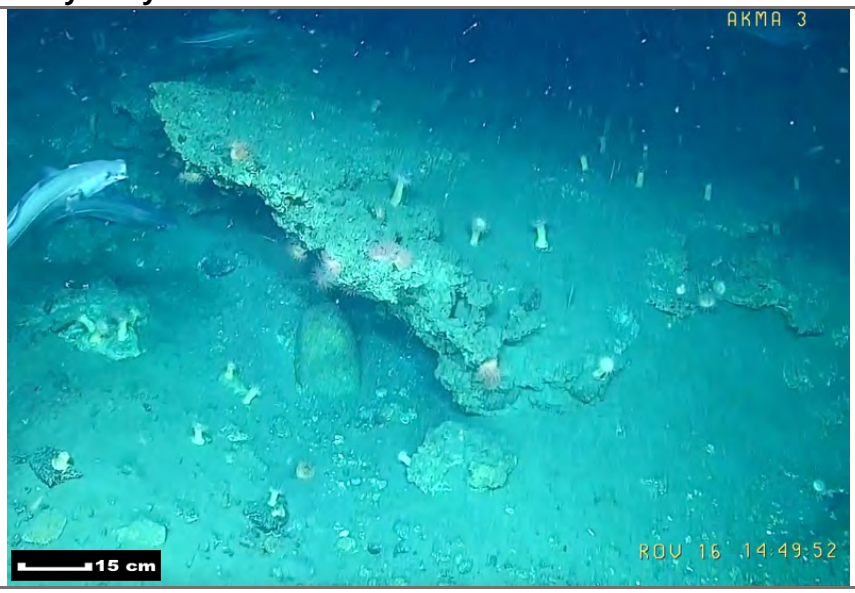
CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 01:29:45:24

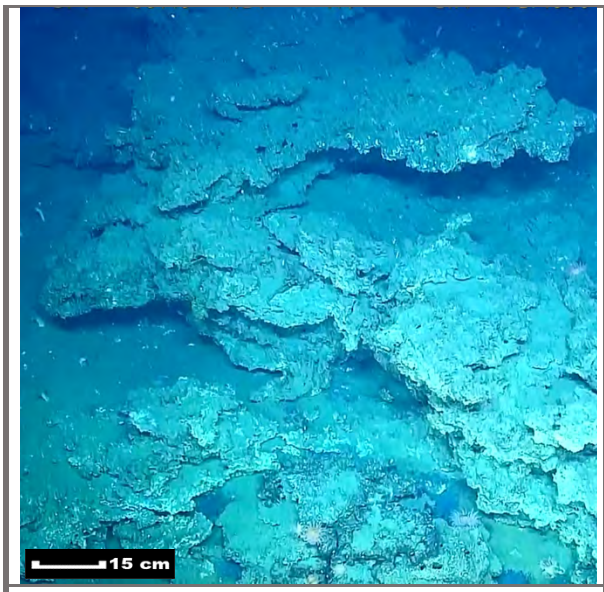
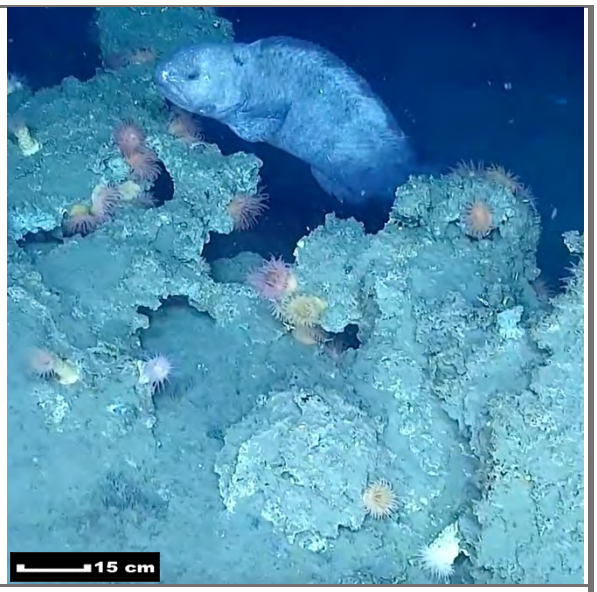
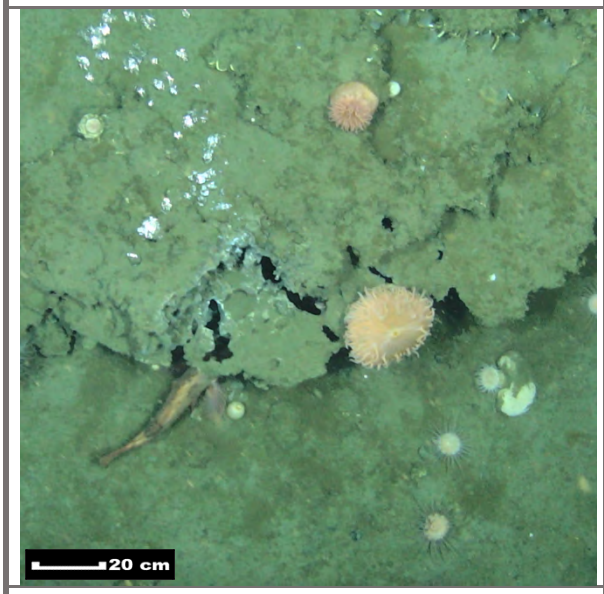
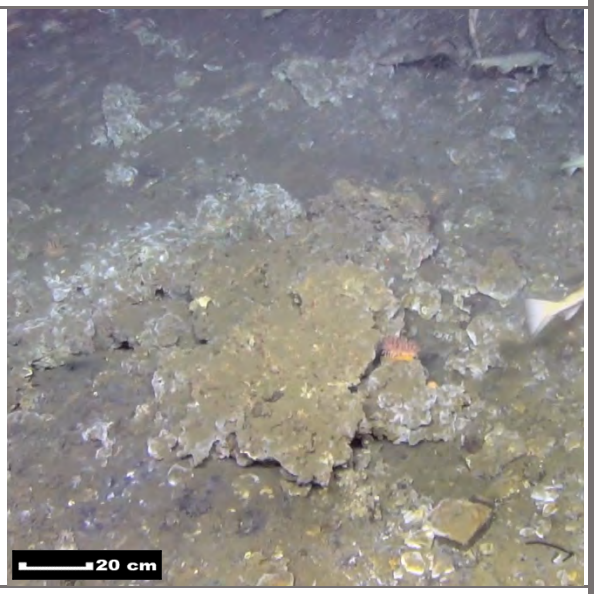


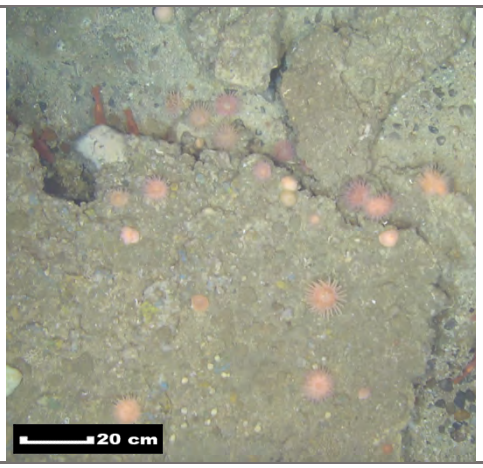
CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH919-TC07_20170623_113109



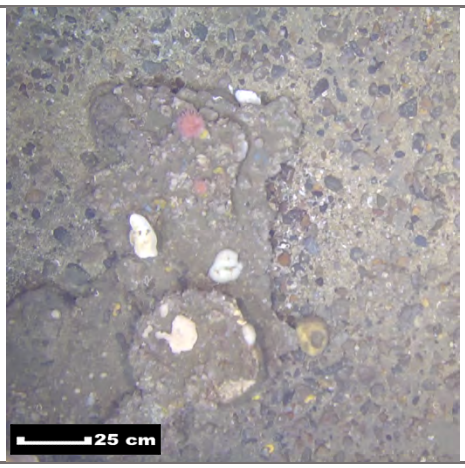
CAGE15-2 - Prins Karls Forland - CAGE15-2-HH850_2015-05-17_01-40-06

Methane derived authigenic carbonate crust
ADD_002

AKMA3 - Outer Byørnøyrenna- 20230507-080550-CH1 – 08:22:29

AKMA3 - Outer Byørnøyrenna - 20230508-144529-CH1 – 14:49:52

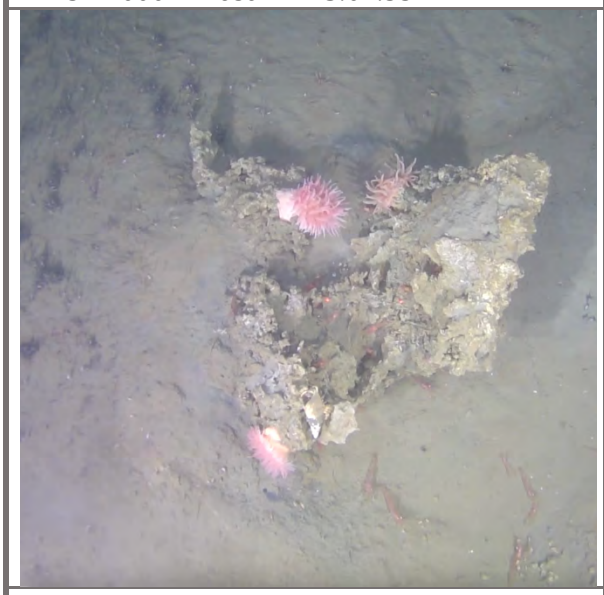
	
AKMA3 - Outer Byørnøyrenna - 20230507-125551-CH1 – 13:13:31	**AKMA3 - Outer Byørnøyrenna** - 20230508-072922-CH1 – 07:39:33
	
CAGE21-1 - Leirdjupet Fault Complex - 2021-0604-065311-000-ROV_18 - MOSAIC – 6:59:37	**CAGE20-7 - MASOX** - 2020-1114-153043-000-ROV_29 - Center_Overlay - 16:30:51



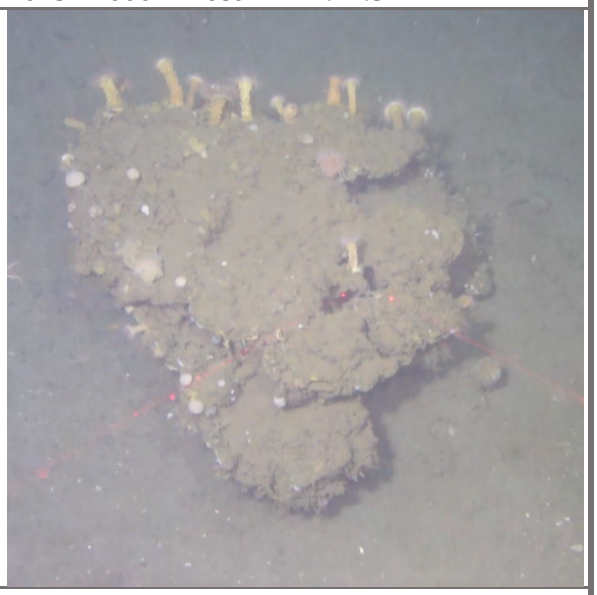
CAGE20-7 - Norskebanken - 2020-1105-124522-000—Mosaik – 13:07:55



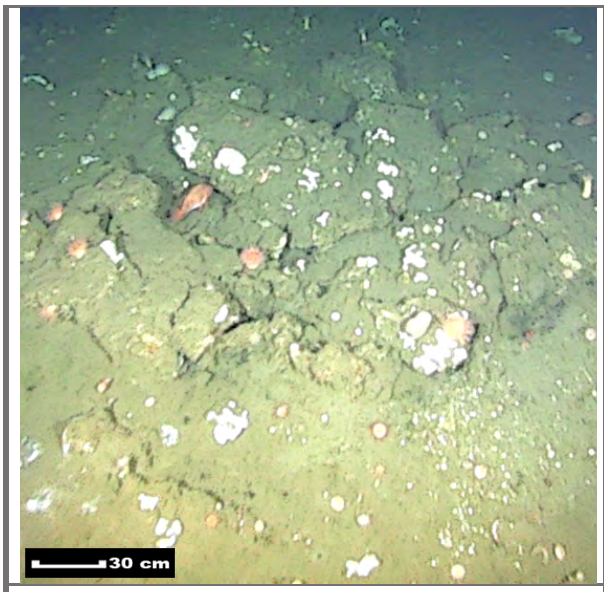
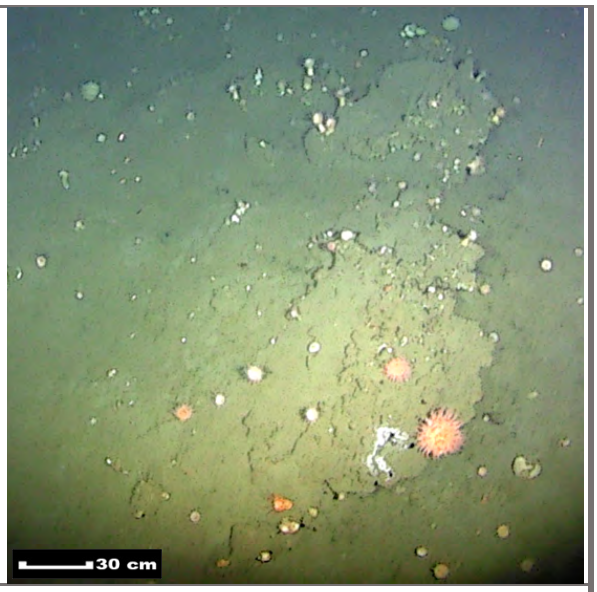
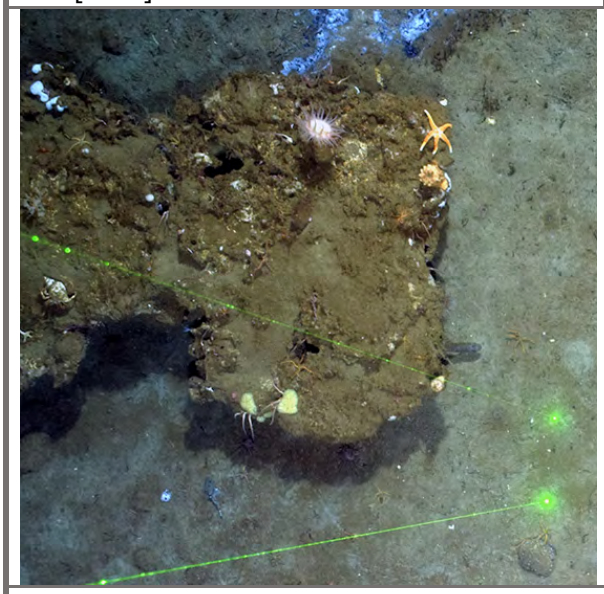
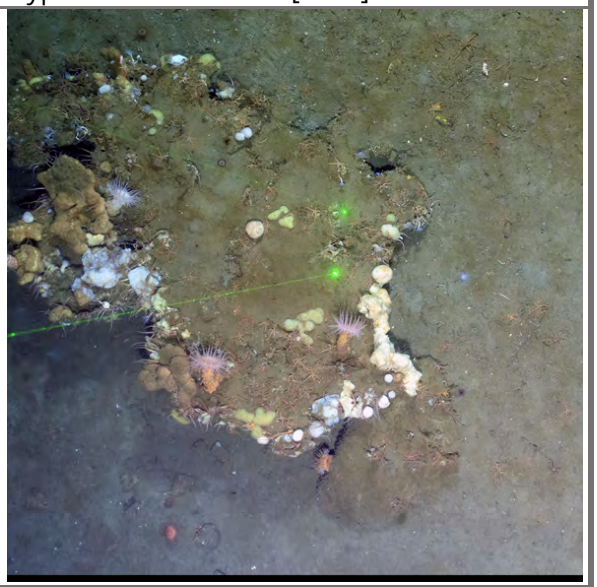
CAGE20-7 - Norskebanken - 2020-1105-104522-000—Mosaik – 11:27:51

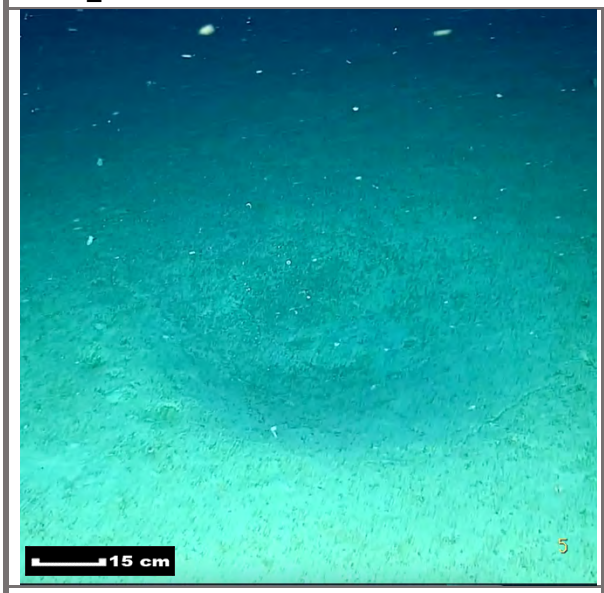
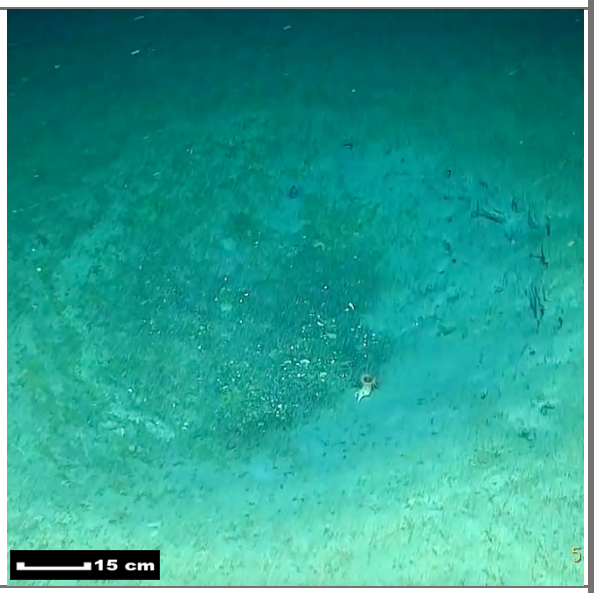


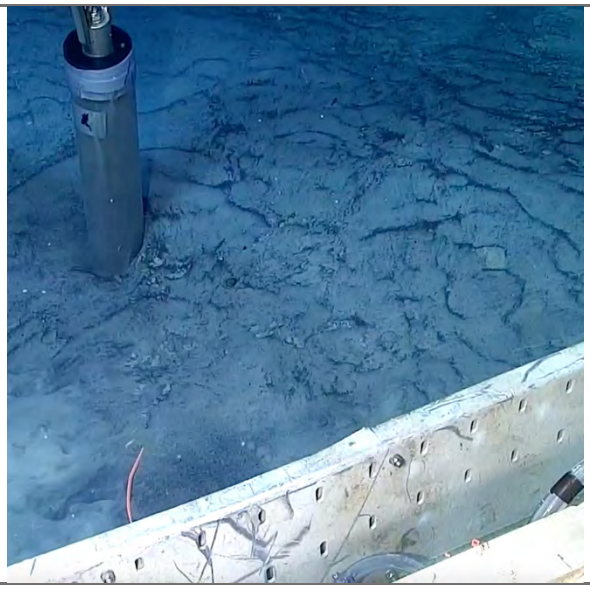
CAGE18-5 - Storfjorden - 2018-1025-064138-000--CenterOverlay_ROV_01_MPG4 – 07:36:58

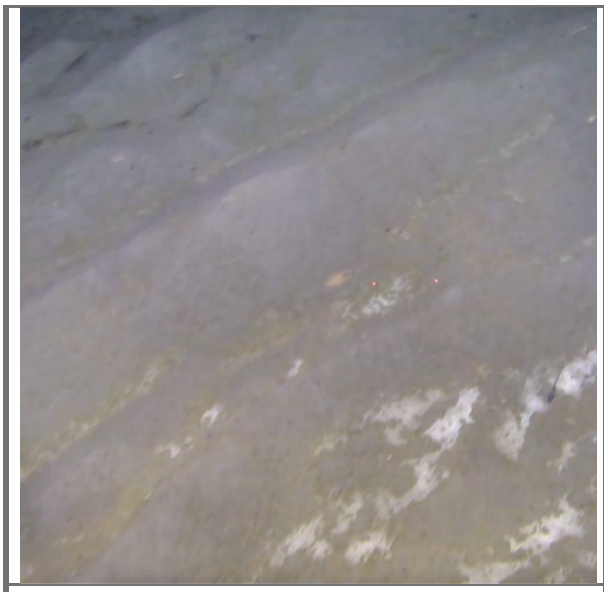
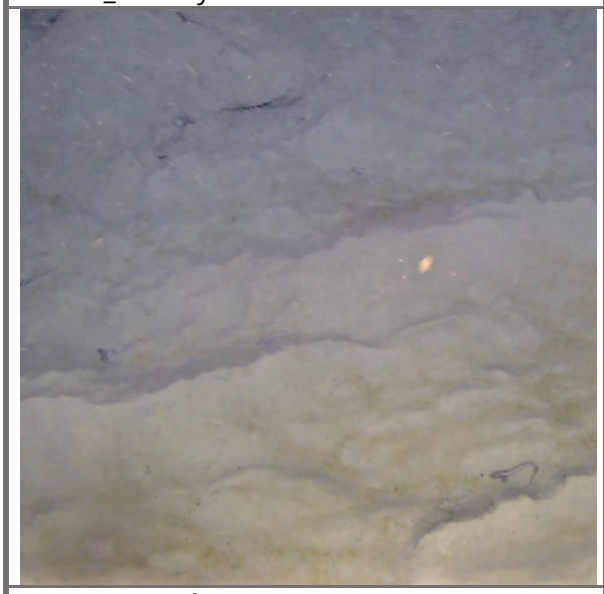
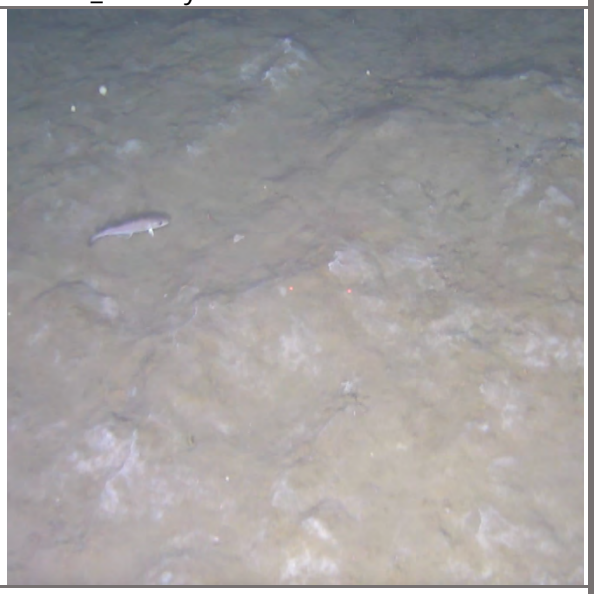


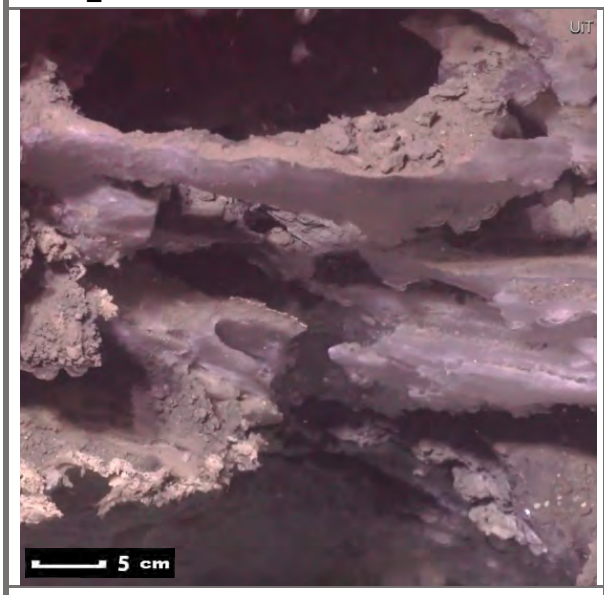
CAGE18-5 - Storbanken - 2018-1029-123931-000--CenterOverlay_ROV_06_MPG4 – 13:32:12

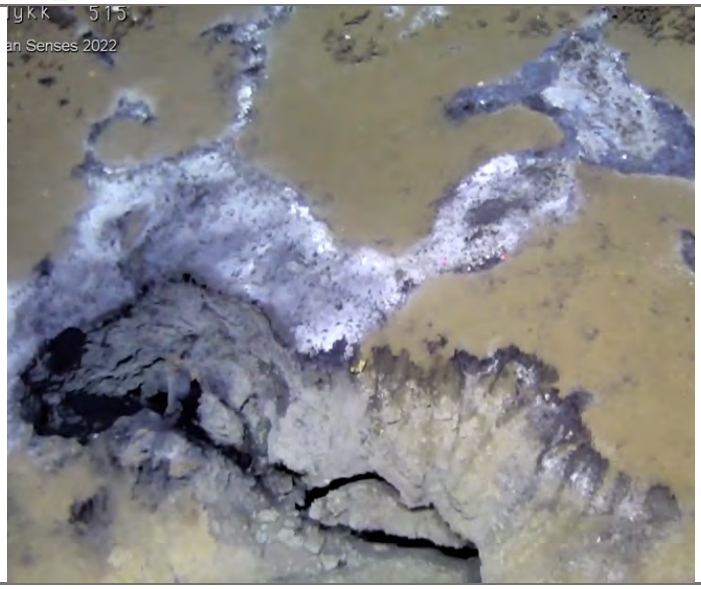
	
CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH_Blackmagic HyperDeck Studio Mini[0000] – 01:18:28:00	**CAGE18-4 - Leirdjupet Fault Complex** - CAGE18_4_HH1141_TC6_V3_Blackmagic HyperDeck Studio Mini[0003] – 00:05:34:15
	
CAGE17-2 - Olga Basin - CAGE17-2-HH939-TC15_20170627_102519	**CAGE17-2 - Olga Basin** - CAGE17-2-HH957-TC22_20170629_100545

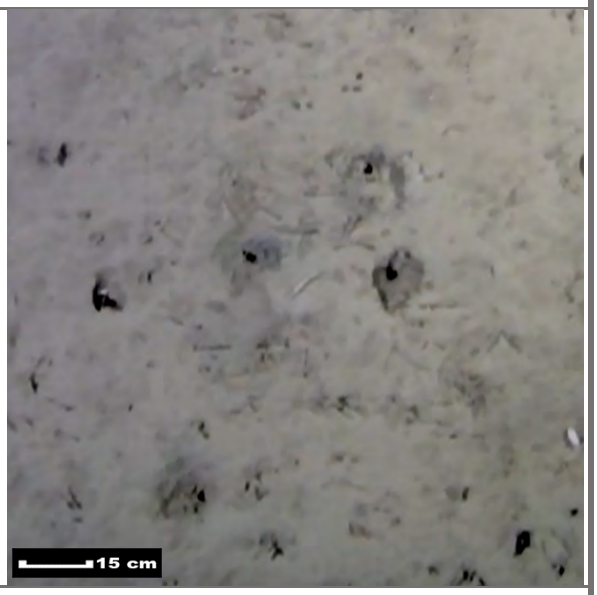
Collapsed seabed feature in gas-charged sediment	
ADD_003	
	
AKMA3 - Outer Byørnøyrenna - 20230508-075921-CH1 – 08:19:13	**AKMA3 - Outer Byørnøyrenna** - 20230508-075921-CH1 – 08:20:48

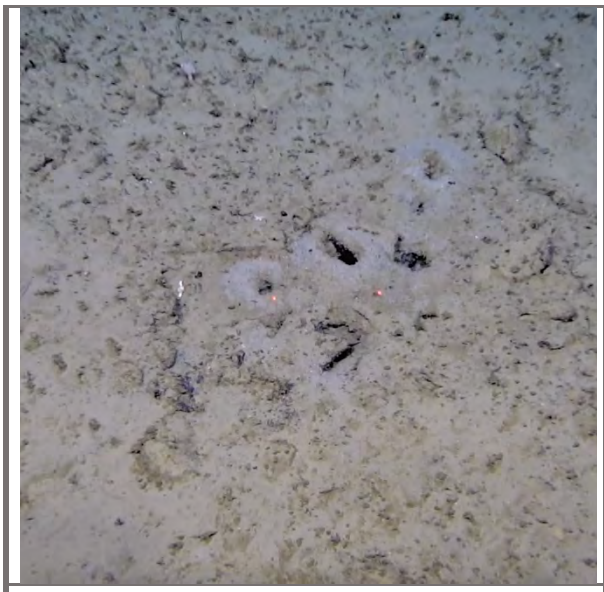
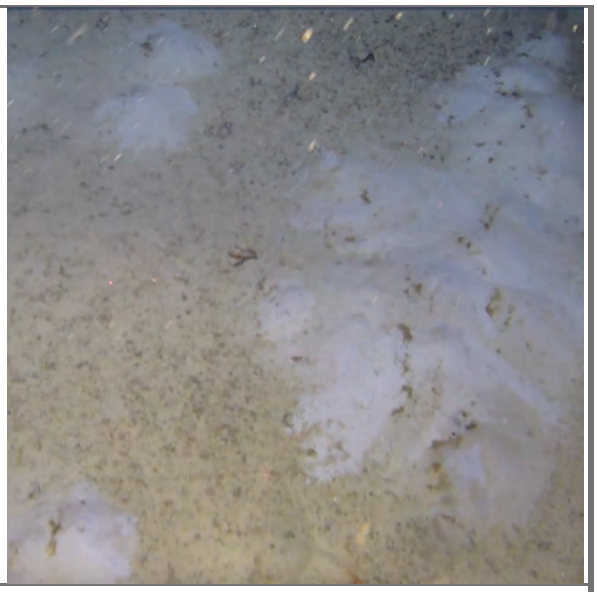
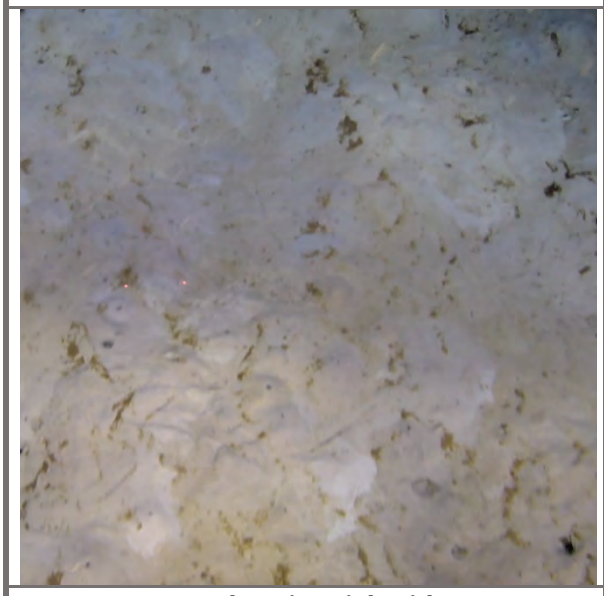
Hummocky-mottled muddy seafloor in gas-charged sediment
ADD_004

AKMA3 - Outer Byørnøyrenna - 20230508-134529-CH1 – 13:56:43

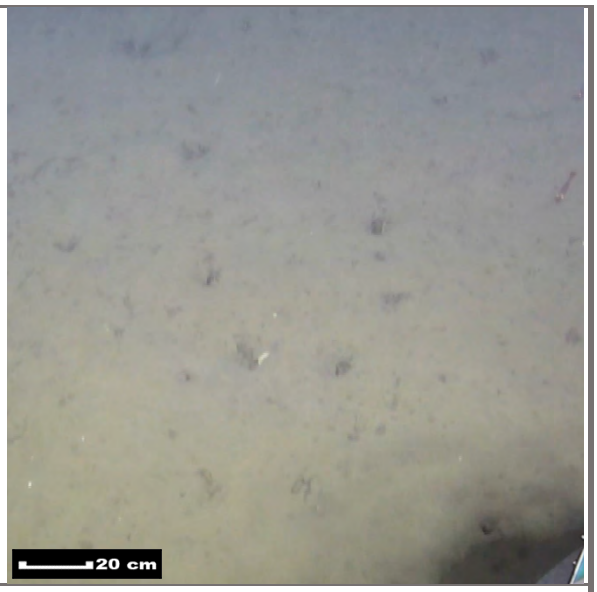
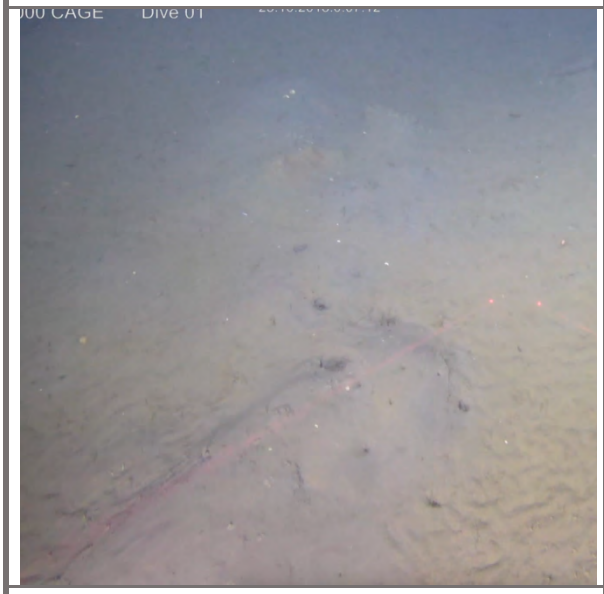
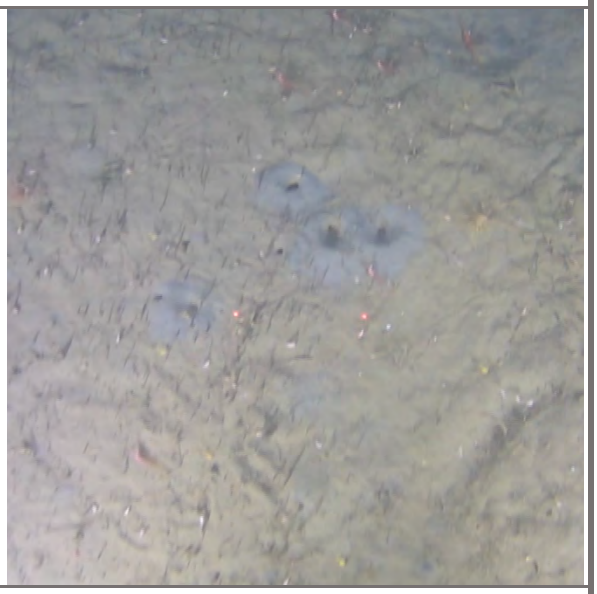
	
CAGE21-1 - Håkon Mosby Mud Volcano - 2021-0606-152940-000-ROV_23 - Center_Overlay – 16:15:25	**CAGE21-1 - Håkon Mosby Mud Volcano** - 2021-0606-152940-000-ROV_23 - Center_Overlay – 16:18:24
	
CAGE21-1 - Håkon Mosby Mud Volcano - 2021-0606-152940-000-ROV_23 - Center_Overlay – 16:10:47	**CAGE18-5 - Storfjorden** - 2018-1025-074138-000--CenterOverlay_ROV_01_MPG4 – 08:16:02

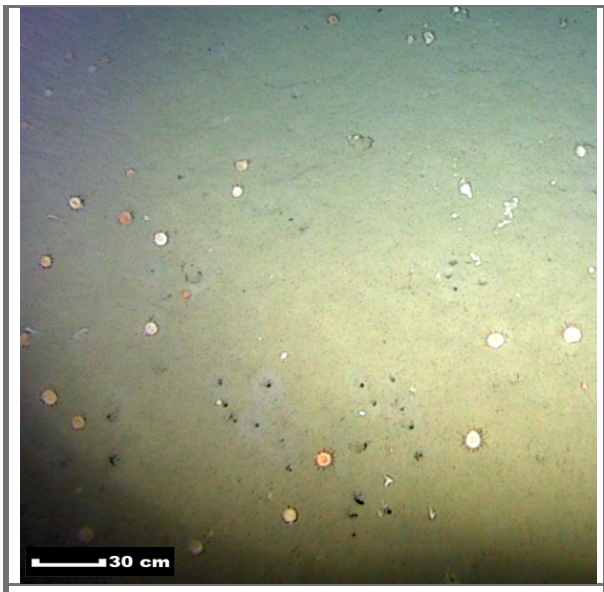
Gas hydrate crater	
ADD_005	
	
CAGE22-2 - Vestnesa Ridge - 20220516-164220-CH3 CENTER – 56:38	**CAGE22-2 - Vestnesa Ridge** - 20220516-164220-CH3 CENTER – 55:25

Muddy crater in gas-charged sediment
ADD_006

CAGE22-2 - Vestnesa Ridge - 20220521-083710-CH3 CENTER – 51:23

Bioturbation	
ADD_007	
	
AKMA3 - Outer Byørnøyrenna - 20230507-132551-CH1 – 13:38:37	**CAGE22-2 - Vestnesa Ridge** - 20220515-094209-CH3 C – 12:56
	
CAGE22-2 - Vestnesa Ridge - 20220521-093710-CH3 CENTER – 56:08	**CAGE22-2 - Svyatogor Ridge** - 20220520-140121-CH3 CENTER – 02:26

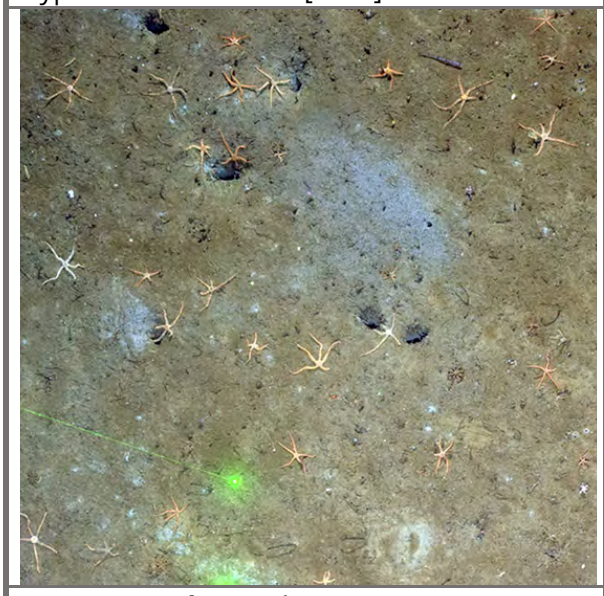
	
CAGE21-1 - North Knipovich Ridge - 2021-0525-082048-000-ROV_03 - Center_Overlay – 8:59:38	**CAGE21-1 - North Knipovich Ridge** - 2021-0525-102048-000-ROV_03 - Center_Overlay – 10:17:22
	
CAGE21-1 - North Knipovich Ridge - 2021-0525-092051-000-ROV_03 - Center_Overlay – 10:17:22	**CAGE21-1 - Svyatogor Ridge** - 2021-0526-075344-000-ROV_04 - Center_Overlay – 8:17:54

	
CAGE21-1 - Svyatogor Ridge - 2021-0526-085345-000-ROV_04 - Center_Overlay – 9:13:18	**CAGE20-7 - Hinlopen Trough** - 2020-1109-150005-000-ROV_21 - Top_Overlay - 15:20:48
	
CAGE18-5 - Storfjorden - 2018-1024-232743-000--TopOverlay_ROV_01_MPG4 – 00:07:12	**CAGE18-5 - Storfjorden** - 2018-1025-074138-000--CenterOverlay_ROV_01_MPG4 – 07:46:49

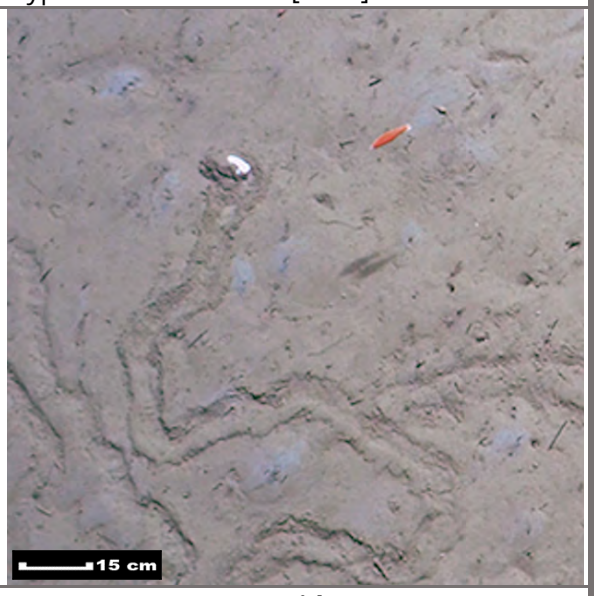


CAGE18-4 - Leirdjupet Fault Complex - CAHE18_4_HH1136_TC4_V1_p1_Blackmagic HyperDeck Studio Mini[0006] – 00:02:41:15

CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH1141_TC6_V3_Blackmagic HyperDeck Studio Mini[0003] – 00:05:58:15



CAGE17-2 - Olga Basin - CAGE17-2-HH942-TC17_20170627_145012



CAGE15-2 - Vestnesa Ridge - CAGE15-2-HH897_2015-05-21_00-07-32

Skeletal remains

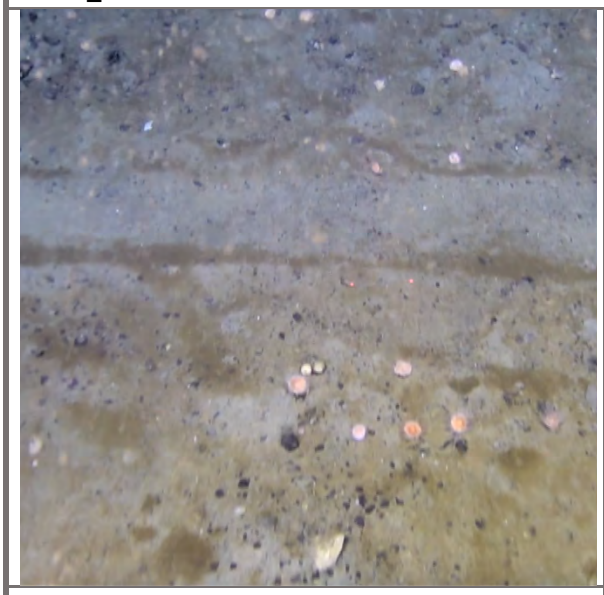
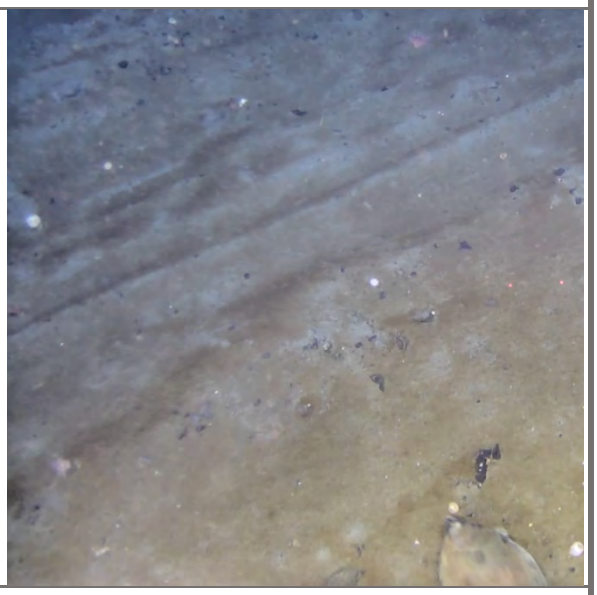
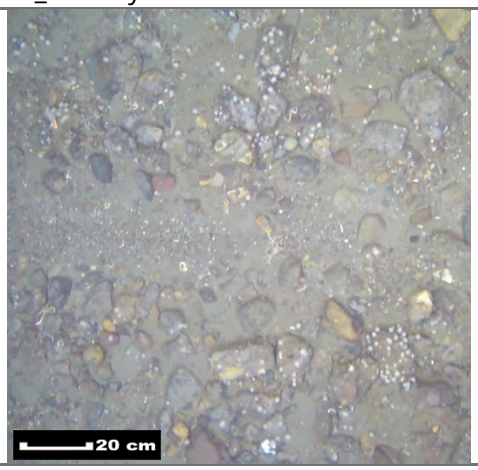
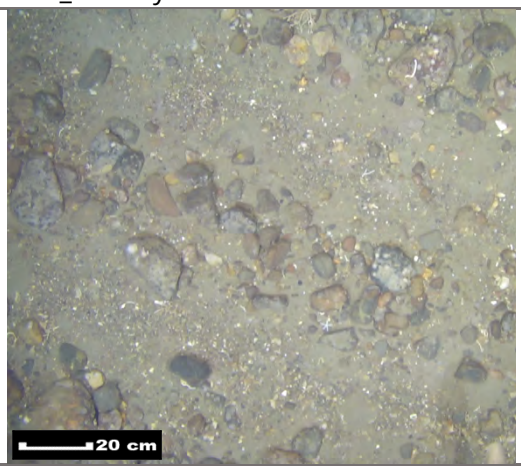
ADD_008

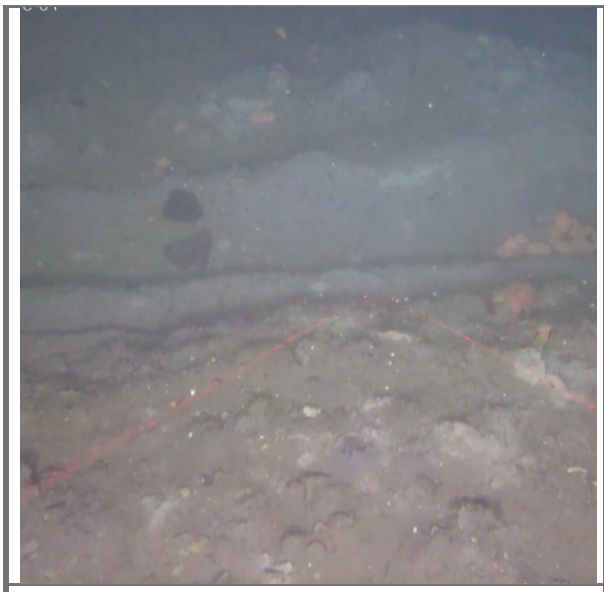
CAGE17-2 - Olga Basin - CAGE17-2-HH939-TC15_20170627_090509

Bedforms – lineation and small-scale crag and tails

ADD_009

CAGE15-2 - Storfjordrenna Pingos - CAGE15-2-HH937_2015-05-24_20-23-34

Fishing tracks	
ADD_010	
	
CAGE21-1 - Leirdjupet Fault Complex - 2021-0605-104331-000-ROV_21 - Center_Overlay – 11:03:27	**CAGE21-1 - Leirdjupet Fault Complex** - 2021-0605-104331-000-ROV_21 - Center_Overlay – 11:03:27
	
CAGE20-7 - Norskebanken - 2020-1105-124522-000—Mosaik – 13:17:07	**CAGE20-7 - Norskebanken** - 2020-1105-124522-000—Mosaik – 13:41:40



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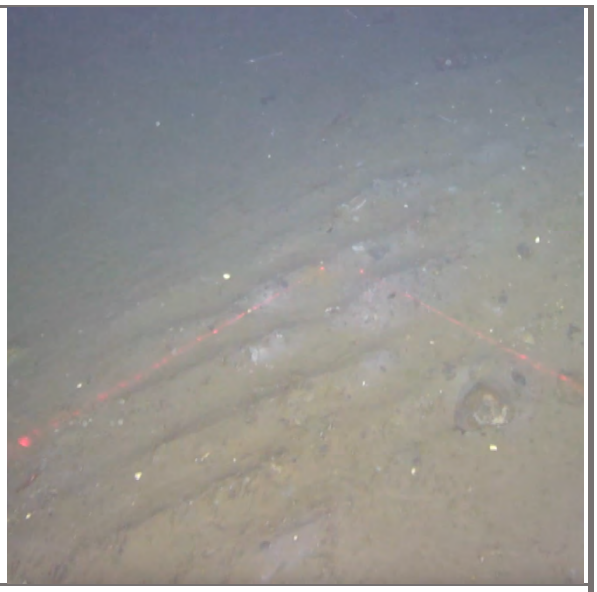

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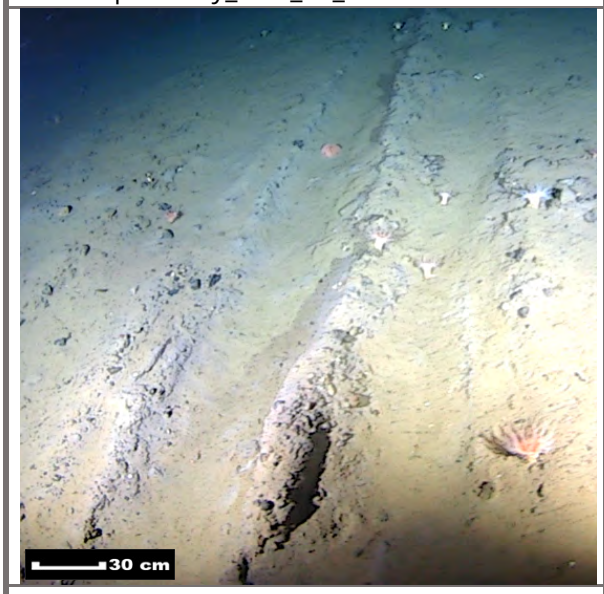

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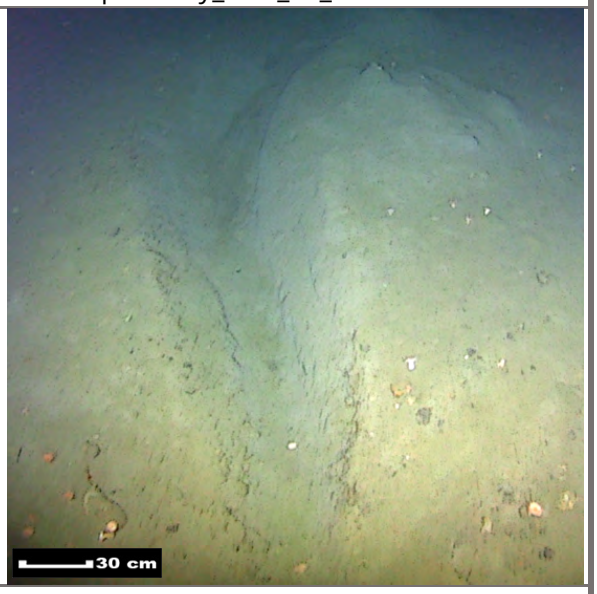

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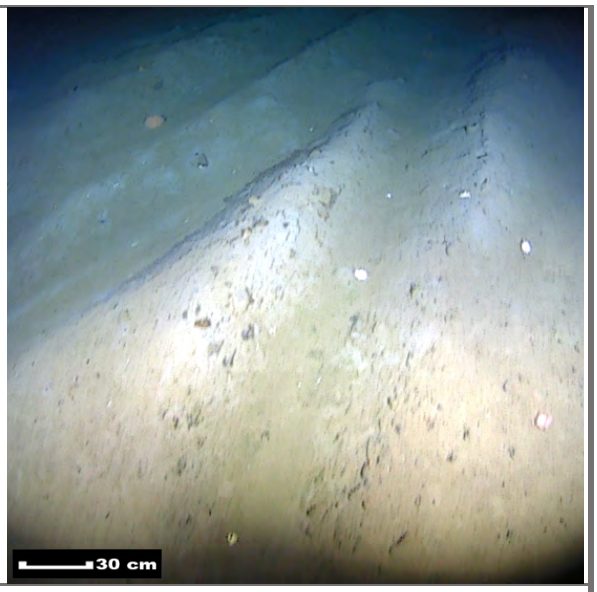
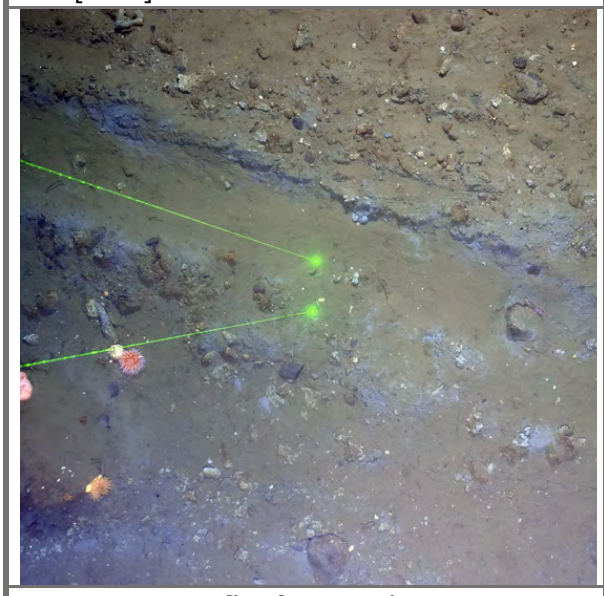
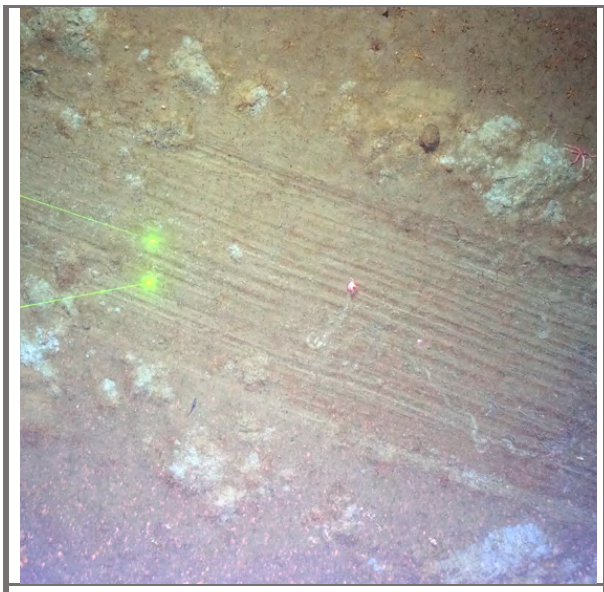
	
CAGE18-4 - Leirdjupet Fault Complex - CAGE18_4_HH1135_TC3_V1_bacterial mats_Blackmagic HyperDeck Studio Mini[0005] – 00:03:26:22	**CAGE18-4 - Leirdjupet Fault Complex** - CAHE18_4_HH1136_TC4_V1_p1_Blackmagic HyperDeck Studio Mini[0006] – 00:09:31:29
	
CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH922-TC10_20170623_170131	**CAGE17-2 - Olga Basin** - CAGE17-2-HH958-TC23_20170629_114803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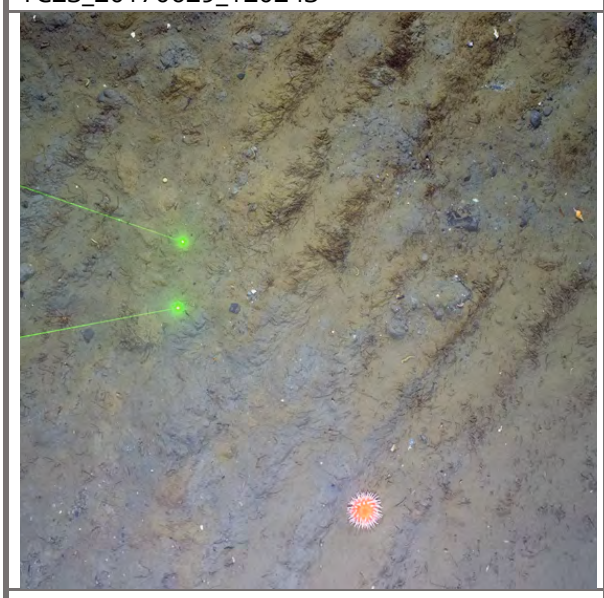	
CAGE17-2 - Storfjordrenna Pingo - CAGE17-2-HH902-TC03_20170622_173921	**CAGE17-2 - Storfjordrenna Pingo** - CAGE17-2-HH917-TC05_20170623_090019

Appendix I

Glossary of sedimentological terms

Purpose

This glossary has been compiled to clarify the terminology used in the catalogue for describing substrate types. To ensure consistency and avoid misunderstandings, concise definitions are provided for all terms as they are applied in this catalogue. This resource aims to support a shared understanding of the substrate descriptors for the Arctic Ocean and Barents Sea Seafloor Substrate Catalogue.

Glossary terms

Altered - Altered sediment refers here to sedimentary material that has undergone modifications from its original state, primarily due to human activities. These alterations may include changes in composition, structure, or distribution resulting from interventions such as fishing, dredging, pollution, construction, or other anthropogenic influences as described in Budillon et al., 2022.

Fishing tracks - “Depressions, incisions, or disturbances on the seafloor caused by the dragging of trawl nets across the ocean bottom during commercial fishing activities” (Zhao et al., 2019) often reported in literature as “trawl marks” (Friedlander et al., 1999; Hiddink et al., 2006; Eigaard et al., 2016).

Authigenic carbonate - Authigenic carbonates are defined as carbonate minerals that form *in situ*, rather than being transported and deposited from elsewhere (unless they are reworked by bottom trawling, for example), either at the sediment-water interface or within the sediments. They are commonly found in association

with methane seeps and other hydrocarbon-rich environments. The formation of authigenic carbonates is in fact primarily driven by the anaerobic oxidation of methane (AOM), a process facilitated by consortia of microbes (Boetius et al., 2000; Schrag et al. (2013). In this process, methane is consumed in the absence of oxygen, often in conjunction with sulfate reduction, and leads to the formation of Methane-Derived Authigenic Carbonates (MDAC). MDAC can take various forms, including carbonate cement, nodules, crusts, and pavements (Bohrmann et al., 1998; Stakes et al., 1999; Aloisi et al., 2002; Han et al., 2004; Sellanes et al., 2004; Gieskes et al., 2005; Pancost et al., 2005; Crémière et al., 2013; Levin et al., 2017; Çağatay et al., 2018; Isson & Planavsky, 2018; Wang et al., 2019; Argentino et al., 2022b; Pereira et al., 2022).

Microbial mats - Microbial Mats are multi-layered sheets of microorganisms, predominantly bacteria and archaea, that can colonize the seafloor in various seafloor environments. In cold seep environments (MacDonald et al., 2003; Joye et al., 2004; Lloyd et al., 2010) they typically exhibit whitish to bluish hues and thrive in conditions rich in methane and sulfide. They also play a crucial role in biogeochemical processes, particularly in the transformation of carbon and sulphur compounds, and support diverse marine life through symbiotic relationships (Dessandier et al., 2019). Microbial mats can vary in cohesiveness. Some form cohesive, carpet-like layers firmly attached to the substrate, while others may be more filamentous or loosely associated with the seafloor (Prieto-Barajas et al., 2018).

Bedform - Depositional submarine landforms formed by the interaction between water flow (including waves, tides, various types of bottom currents, and, in some cases, density flows) and sediment on the seafloor. These submarine landforms can

vary widely in size, shape, and orientation, depending on the strength, dynamic and persistence of the water flow, as well as sediment grain size. The classification of bedforms has evolved over time, with early studies often relying on examples from outcrops. A notable early contribution is Ashley's classification (1990). More recently, advancements in direct seafloor exploration and mapping technologies have enabled classification approaches based primarily on acoustic remote sensing datasets and ROV imagery (Stow et al. 2009; Hernendez Molina et al., 2011).

Bioturbation - "Bioturbation" refers to how organisms modify and disturb sediments through their activities. These activities can include burrowing, feeding, and other forms of movement that alter the physical and chemical characteristics of the substrate (Aller, 1982; Kristensen et al., 2012; Wiesebron et al., 2021).

Boulder - A boulder is a very large sediment particle, much larger than a cobble or pebble. Boulders are typically rounded or angular and, according to Wentworth (1922), can range in size from several centimetres to several meters in diameter (i.e.: larger than 256 mm).

Coarse - Refers to unconsolidated granular material composed of all sediment particles larger than fine sand and smaller than boulder (grain size range 0.25 mm – 256 mm), as classified by the Wentworth (1922) scale.

Cobble - In the context of sedimentology and the Wentworth (1922) scale, a "cobble" refers to a sediment particle larger than a pebble but smaller than a boulder (Size Range: 64 - 256 mm). It typically has a rounded shape, and its size makes it visible and easily distinguishable.

Cohesive mud - Cohesive mud refers to mud or sediment composed of fine particles, particularly clay-sized particles, that tend to stick together (Baas et al., 2011).

Conglomerate - A clastic sedimentary rock composed of rounded to sub-rounded rock fragments (clasts) that are typically larger than 2 mm in diameter, embedded within a finer-grained matrix of sand, silt, or clay. According to the Wentworth grain size scale, the clasts in a conglomerate can range from granule-sized (2–4 mm) to cobble-sized (64–256 mm) or even boulder-sized (>256 mm) (Wentworth 1922, Folk 1980).

Crater - sub-circular, negative seafloor feature of variable dimensions and shapes. Different seafloor processes are able to generate the formation of crater-like submarine landforms, including the release of methane from the subseafloor (Andreassen et al., 2017).

Dominated (sediment grain) - The term "dominated" is used to describe a specific sediment parcel or particle size fraction that is more abundant in a given area (Milliken, 2014).

Fine sediment - "Fine sediment" in this context refers to small particles of mixed material that have settled in the size range of smaller than medium sand (<0.25 mm) (Wentworth, 1922).

Firmground - Refers to a sedimentary rock surface that is compact and resistant to erosion but may still show some evidence of burrowing or bioturbation. It is harder

than the surrounding sediments but less resistant than the hardground (García-Hidalgo & Gil-Gil, 2024).

Gas-charged substrate/sediment - Sediment on the seafloor that is visibly influenced by the presence of gas, typically methane or other hydrocarbons, as observed through ROV imagery. Indicators of gas charging include softness of the sediment, occurrence of greyish mud, visible bubbles emanating from the substrate, presence of free gas or gas hydrates, as well as microbial mats, and/or tubeworms. These features are often associated with active gas seepage environments on the seafloor.

Gas hydrate - Gas hydrates are ice-like formations that consist of gas molecules, such as methane, enclosed within a lattice structure of water molecules. They are formed in specific pressure and temperature conditions, commonly found in deep-sea sediments and permafrost regions (Mienert et al., 2022).

Gravelly - The term "gravelly" describes a surface or area covered with, or composed of, gravel. Gravel consists of individual particles with a size range of 2 - 64 mm (Wentworth, 1922), larger than sand but smaller than a cobble. Gravel particles can vary in shape, including rounded and angular, and may be composed of various minerals, rocks, or organic materials.

Hardground - Is a resistant and indurated sedimentary rock surface cemented or lithified to a greater degree than the surrounding sediments. Hardgrounds often form through the cementation or precipitation of minerals, making them more resistant to erosion (García-Hidalgo & Gil-Gil, 2024).

Hard substrate - Indicate a solid and resistant surface or material that provides a foundation or support for living organisms in aquatic environments that are not easily eroded or modified by physical processes (Taylor & Wilson, 2003).

Heterogeneous substrate/sediment - Refers to substrate or surface sediment composed of different, non-uniform materials or exhibits variations in its properties, especially in grain size. According to Holland & Elmore, 2008, the term "heterogeneous" denotes a lack of uniformity or the presence of diversity within the substrate.

Hummocky - Refers to topographic irregularities on the seafloor that exhibit an undulating appearance or are characterised by small, rounded, and often irregular mounds or hills. These features are usually associated with specific geological processes (Wu et al., 2024).

Mottled - seafloor sediment exhibiting a variegated and/or spotty appearance, characterized by irregular patches of varying colours, textures, or compositions. This mottling can result from different processes (often by bioturbation) and indicates areas of active biological activity or zones where different sediment types intermingle due to environmental factors.

Muddy - Term used to describe seafloor substrate composed by mud. In geological terms, "mud" is typically a soft, moist sediment made up of a blend of water and minerals, including clay with a variable contribution of silt and organic matter, and with a diameter generally smaller than 0.0625 mm (Wentworth, 1922).

Pebble - Is a sediment particle with a size range of 4 - 64 mm, bigger than sand but smaller than a cobble. It typically has a rounded or sub-angular shape. Pebbles are easily visible and distinguishable from finer-grained particles (Wentworth, 1922).

Rocky outcrop - An exposed section of consolidated rock on the seafloor that stands out from the surrounding unconsolidated sediments. Rocky outcrops often provide stable hard substrates for benthic organisms.

Seafloor substrate - In oceanography and marine geology, "seafloor substrate" refers to the composition and characteristics of the materials that make up the bottom of the ocean or sea. Substrates can include various materials such as sediments (like mud, sand, or gravel), rocks, and even features like coral reefs or hydrothermal vent deposits. The type of substrate influences marine ecosystems, affecting the distribution of marine life and the physical and chemical processes occurring on the ocean floor (Levin, 2005).

Skeletal remains - The remaining bones of a dead marine creature.

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