AMUNDSEN SCIENCE

2021 | Expedition Summary

CCGS *Amundsen*

4 July – 3 November 2021

LEG 1 – 5

Baffin Bay

Beaufort Sea

Canadian Arctic Archipelago

Labrador Sea

Introduction

The 2021 Expedition Summary is an overview of the science activities undertaken onboard the CCGS *Amundsen* during the 2021 field season. This document is available in English, French and Inuktitut and targets anyone who wishes to get a general idea of expeditions' objectives and activities, including partners and local communities. A detailed description of the sampling methods and preliminary results is presented in the more exhaustive 2021 Expedition Report, freely available in English on our website.

Amundsen Science manages the scientific mandate of the research icebreaker CCGS *Amundsen*. We are looking forward to improving the way we share the results of the annual expeditions and support local involvement. Comments, suggestions and research initiatives are welcome and can be sent to media@as.ulaval.ca.

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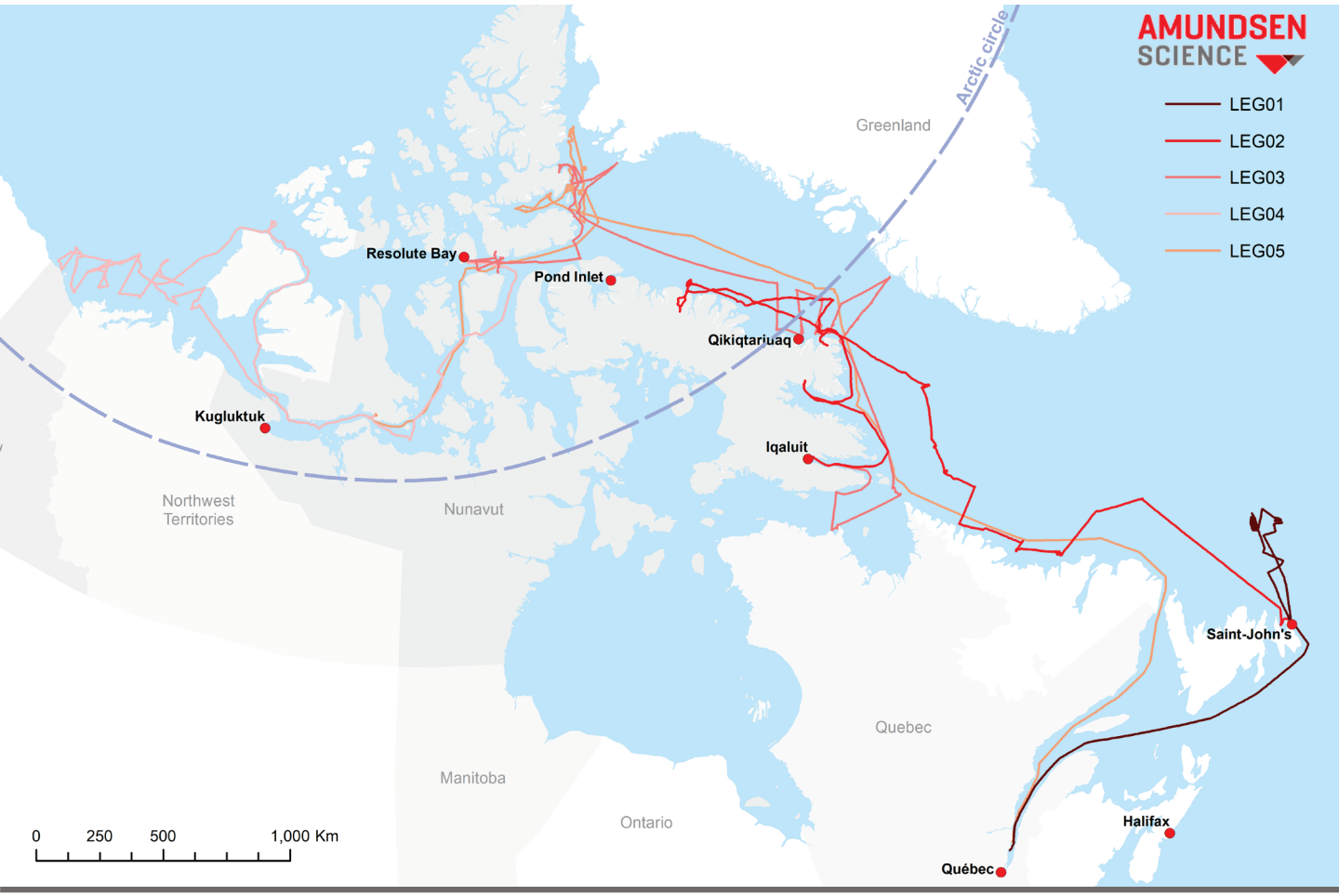
Overview

The 2021 Expedition began on 4 July, when the Canadian research icebreaker CCGS *Amundsen* left Quebec City for its 18th annual mission to the Arctic. The multidisciplinary expedition ran until 3 November and allowed more than 140 scientists from national and international research teams to study the marine and coastal environments of the Labrador Sea, the Baffin Bay, the Canadian Arctic Archipelago and the Beaufort Sea. Overall, the ship travelled over 17 968 nautical miles (33 277 km, or six times Canada's width) during 122 days to support 8 major research programs, and additional ancillary collaborations.

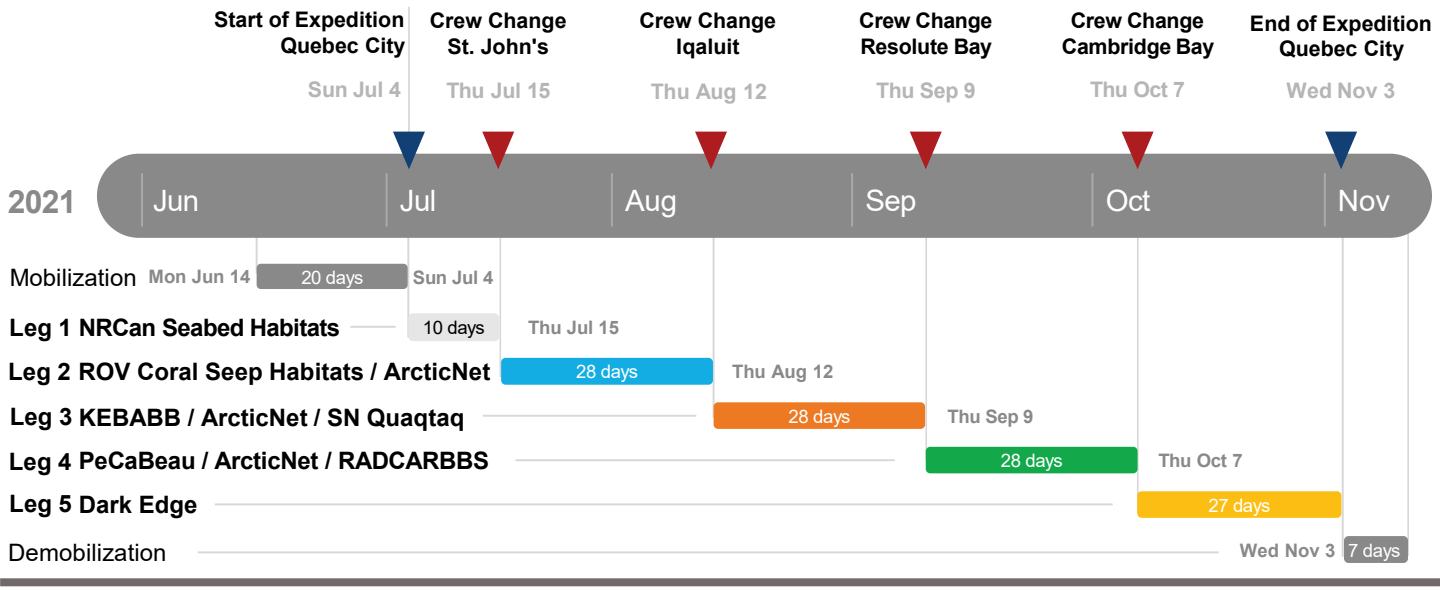
At the beginning of the 2021 Expedition, sanitary measures were implemented to limit the risks associated with the COVID-19 pandemic. Scientific participants were vaccinated, and tested before boarding and throughout their stay aboard. Crew changes were conducted following a strict "no contact" policy with communities. These measures proved to be efficient and the expedition was conducted with a full scientific crew.



The first part of the expedition (Leg 1) took the CCGS *Amundsen* in the Labrador Sea for the Marine Spatial Planning program of Natural Resources Canada (NRCan). Leg 2 took the ship further along the coast of Labrador and in Baffin Bay for a Coral seep habitat study using Amundsen Science's Remotely Operated Vehicle (ROV). The Knowledge and Ecosystem-Based Approach in Baffin Bay (KEBABB) program, led by Fisheries and Oceans Canada in collaboration with Canadian universities, took place in Baffin Bay and Lancaster Sound during Leg 3, in addition to Sentinel North's Survey in Quaqtaq (Nunavik). Leg 4 hosted the international PeCaBeau program, which studied Permafrost Carbon Exchanges in the Beaufort Sea and the RADCARBBS project, which recorded exchanges of radiocarbon isotopes between Baffin Bay and the Beaufort Sea. The ship then headed back to Quebec City while conducting the Dark Edge integrated study in Baffin Bay during Leg 5. Finally, members of the ArcticNet Marine program were onboard to sample seafloor sediments, nutrients, contaminants and ecosystem productivity from plankton to fishes during Legs 2 to 4.

The 2021 Amundsen Expedition was overall very successful, and greatly benefited from the continuous collaboration with the Canadian Coast Guard, research programs and permitting agencies. All data acquired during the expedition is currently in the process of being analyzed and published, either by the Amundsen Science or by individual research teams. Core scientific data acquired by Amundsen Science will be publicly available on the Polar Data Catalog, and scientific publications and their outputs are usually shared on our website once published.

The next sections present a summary of the research activities and programs that took place during each of the 5 Legs of the 2021 Amundsen Scientific Expedition.

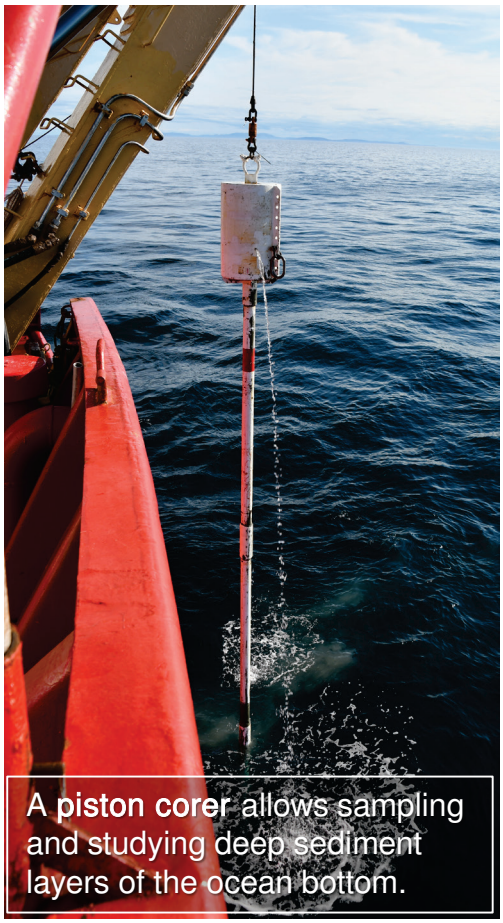


Leg 1

Description of the Program

Led by NRCan, the Marine Spatial Planning program studies the Seabed habitats and marine geohazards in Northeast Newfoundland slope and aims at providing innovative regional geoscience products to support DFO's policies and decision-making. The program was also supported in 2020 in the midst of the COVID-19 pandemic when the icebreaker stayed in the subarctic.

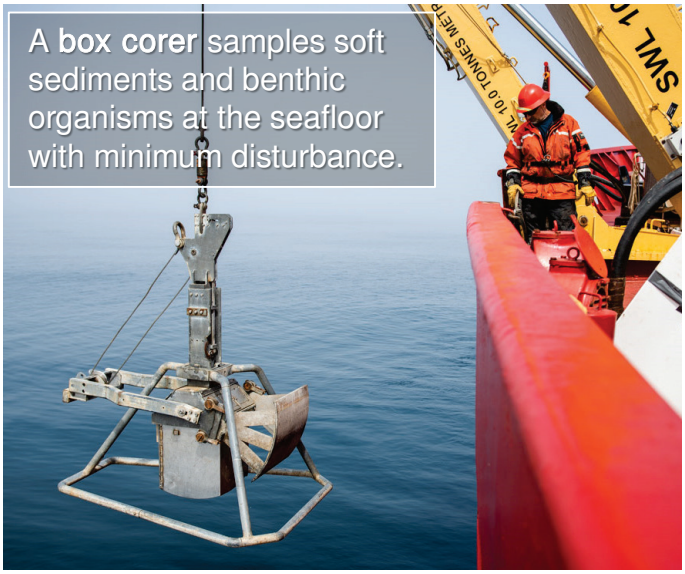
Previous surveys showed that the seafloor in this region is marked by geological hazards, particularly submarine slope failures. Better interpretation of these features are necessary, in particular to identify and date the geological hazards and to understand how the geology can impact the ecological habitats and processes.



A **piston corer** allows sampling and studying deep sediment layers of the ocean bottom.

Research Activities

Storms in the Labrador Sea affected the operations conducted during this short Leg. Overall, the teams recovered sediments from 2 piston cores and one box core, collected seawater with 2 CTD-Rosettes, surveyed the seafloor ecosystem with 3 submarine cameras, and mapped 3495 km^2 of seabed.



A **box corer** samples soft sediments and benthic organisms at the seafloor with minimum disturbance.

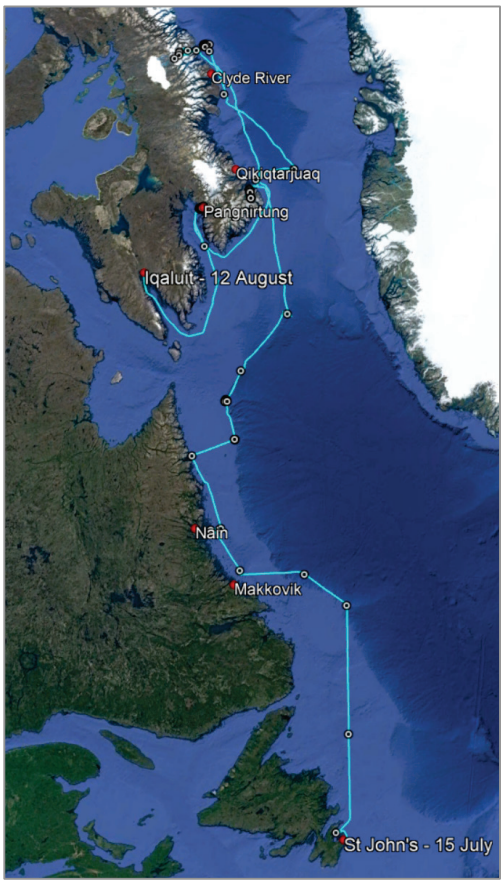
A **CTD-Rosette** is equipped with sensors to measure physical, biological and chemical parameters and collect seawater samples across the water column.

Leg 2

Description of the Programs

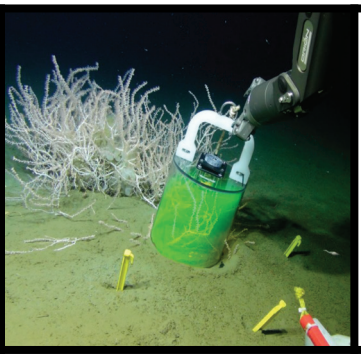
Thirty-five scientists boarded the CCGS *Amundsen* to participate in an integrated study of the Coral habitats and seabed seep features in the Labrador Sea and Baffin Bay. This program, led by Dalhousie University in 2021, was conducted in partnership with other universities, federal departments (DFO, NRCan) and local governments. Scientists from the ArcticNet Marine Program were also onboard to study fish, kelp, and regional geology of the seafloor.

Limited access to deep-sea environments such as Labrador Sea and Baffin Bay lead to historical knowledge gaps. The integrated geological, biological, and oceanographic sampling of these understudied ecosystems will help understand the faunal communities and associated processes. Amundsen Science Technology for Remote Innovation & Discoveries (ASTRID, the new ROV) was essential to access and sample these fragile deep ecosystems.



Research Activities

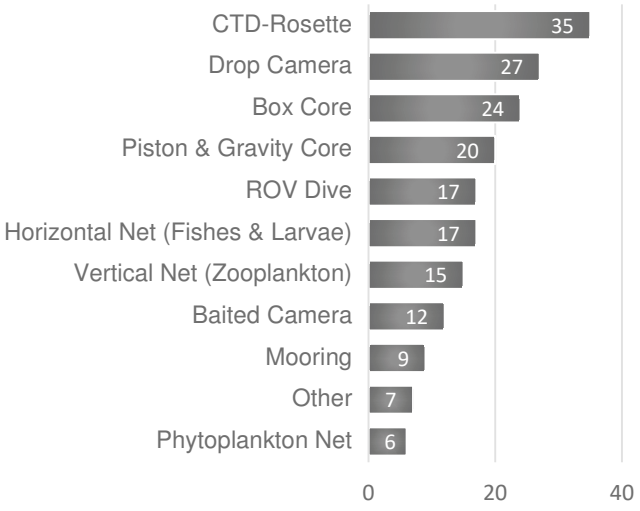
While dives with the ASTRID ROV were central to this scientific study and a high-priority of Leg 2, 17 different operations were conducted at 68 stations spanning from southern Labrador Sea to the fjords of Baffin Island. Amongst other experiments, it is interesting to note that: 1) the site of a submarine landslide caused by the grounding of an iceberg was revisited to study these hazards, 2) a coral was dyed and will be retrieved in a few years to study its growth, 3) two acoustic moorings were deployed close to Clyde River and Scott Inlet to support the development of the community's acoustic monitoring program.



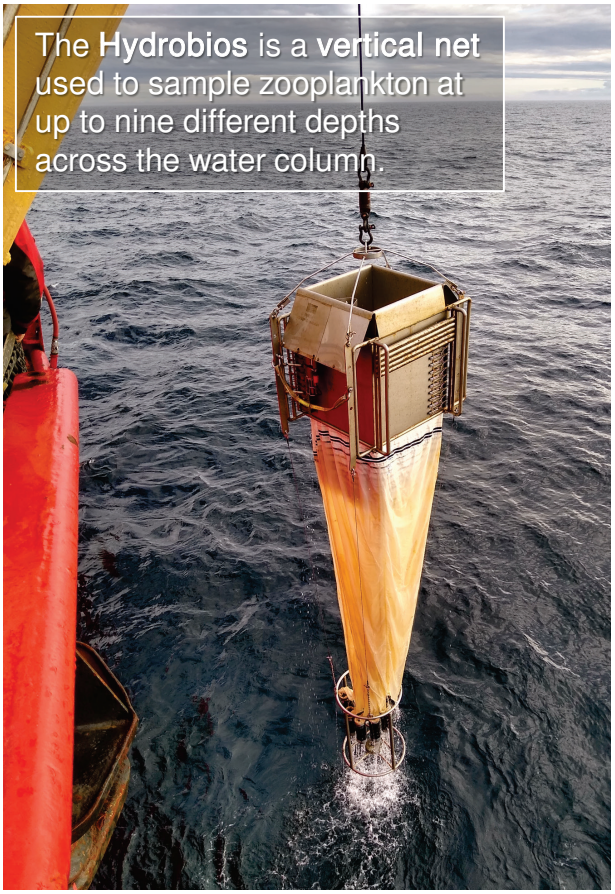
Images taken by the ROV will be analyzed to identify the species of the cold deep-seas and their distributions.

← The dye experiment will determine coral growth rates

Total Leg 2: 189 operations

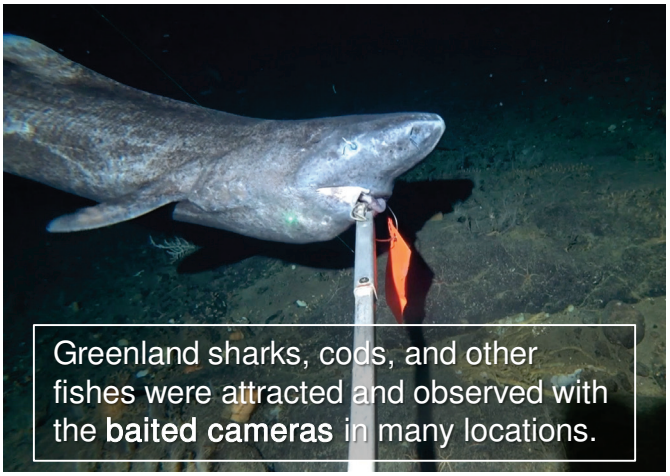


Moorings have multiple sensors and are retrieved after months of data recording at sea.



The **Hydrobios** is a **vertical net** used to sample zooplankton at up to nine different depths across the water column.

The first Arctic dives of **ASTRID** took place during Leg 2. The **ROV** is controlled from the ship while sampling the seafloor.



Greenland sharks, cods, and other fishes were attracted and observed with the **baited cameras** in many locations.

Leg 3

Description of the Programs

Stock assessment surveys are regularly conducted in the Canadian Arctic for major commercial fisheries such as Greenland Halibut and Northern Shrimp. However, fisheries management based on the ecosystem as a whole is needed to understand the changes in oceanographic conditions and evaluate their influence on fisheries resources. The KEBABB program was developed by DFO and Canadian Universities in 2019 and will provide crucial physical, chemical, and biological oceanographic data. The complementary KEBABS survey will do the same in Barrow Strait.

The ArcticNet Marine Program were onboard to help assess all aspects of the Canadian Arctic marine ecosystem, from nutrients and contaminants cycling to glacial history and fish. They also monitored gas exchanges between the Arctic Ocean and the atmosphere to understand the role of the oceans in a globally warming climate. Finally, scientists from the Sentinel North research community in partnership with the Nunavik Marine Region Wildlife Board studied the links between the marine environment and the nutritional properties of bivalves and belugas near Quaqtaq.

Research Activities

Since numerous aspects of the marine environment were studied during Leg 3, a total of 302 operations were conducted over the 28-day Leg at 79 stations across Baffin Bay, Lancaster Sound and close to Quaqtaq (Nunavik). Mapping was also conducted in uncharted areas near the Mittie glacier terminus (Ellesmere Island) and water sampling took place in glacial river mouths, which were accessed with the vessel's helicopter. The helicopter was also used to sample river sediments and to deploy tracking beacons on icebergs and record their movements in Canadian and Greenlandic waters.

The vessel also participated in a joint Search-and-Rescue exercise with the U.S. Coast Guard icebreaker Healy nearby Resolute Bay in early September.

80 **nets** were deployed during Leg 3 to sample:

- Microscopic marine algae (phytoplankton)
- Small aquatic organisms (zooplankton)
- Fishes, larvae and eggs

The content of nets is analyzed in laboratories.

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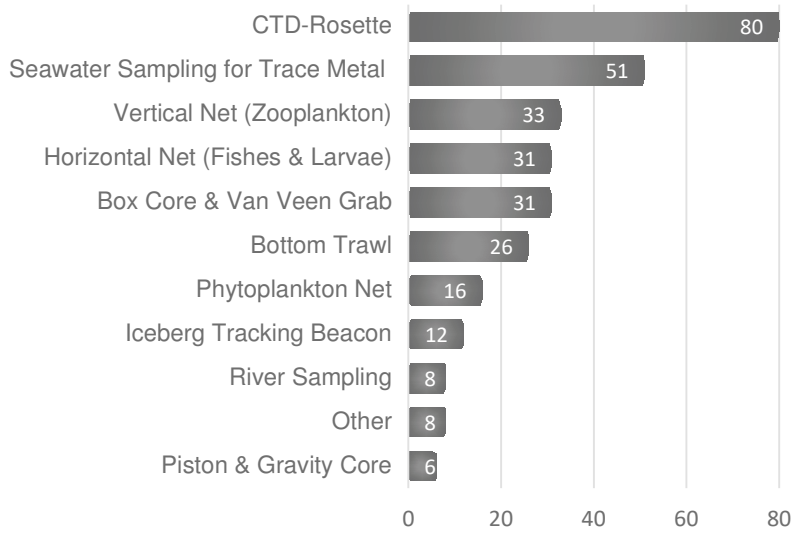
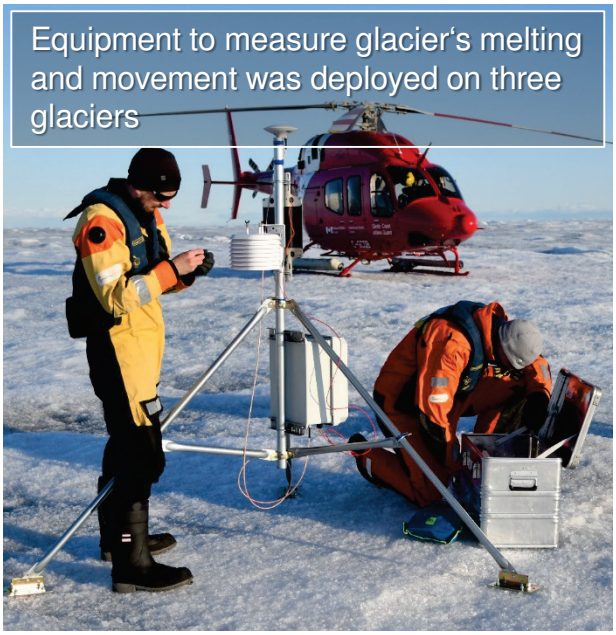
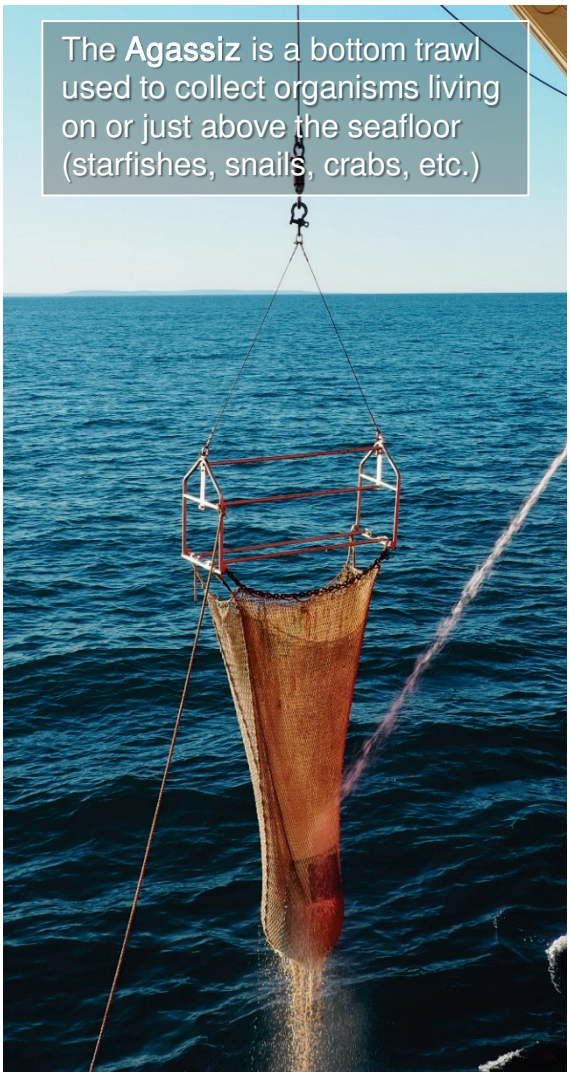
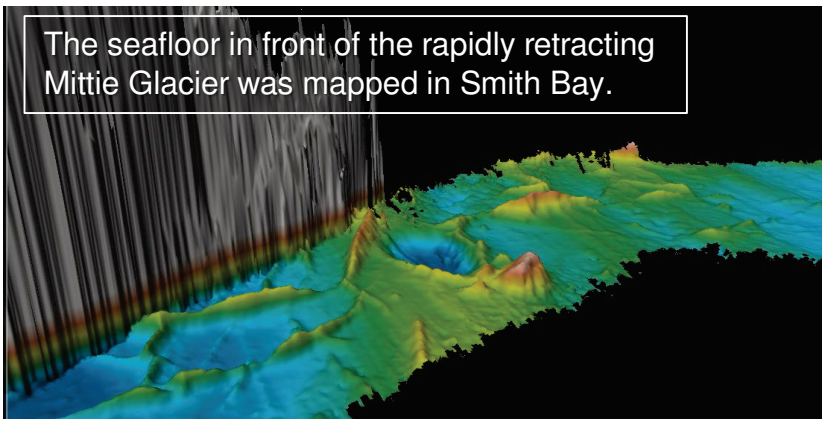
Total Leg 3: 302 Operations









Leg 4

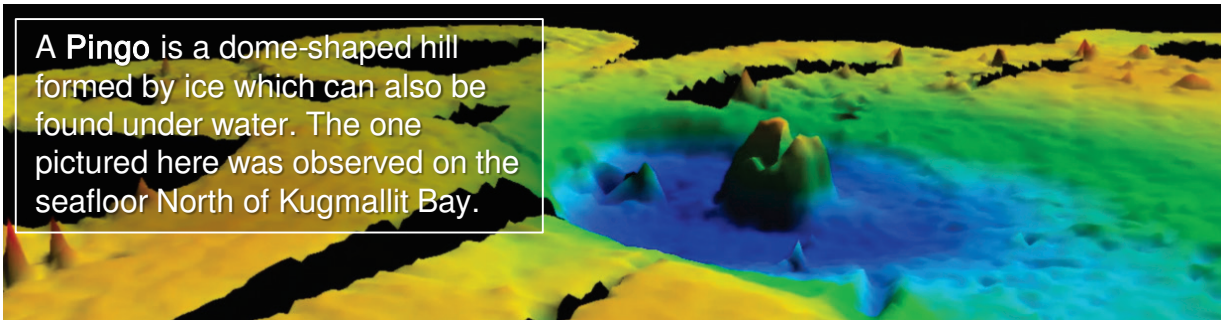
Description of the Programs

The continental shelves of the Arctic Ocean are rapidly responding to global climate change. Rising air temperatures and declining summer sea-ice extent have direct consequences as strong coastal erosion and permafrost (frozen soil) thawing lead to the release of large quantities of sediment, organic carbon and nutrients into nearshore waters. During Leg 4, scientists from the international Permafrost Carbon in the Beaufort Shelf program (PeCaBeau) were studying fluxes, composition and fate of organic matter in Southern Beaufort Sea. Their goals were to identify the provenance of organic matter (from permafrost coastal erosion, Mackenzie River discharge or submarine permafrost degradation), and to investigate how these sources have changed in the last millennia.

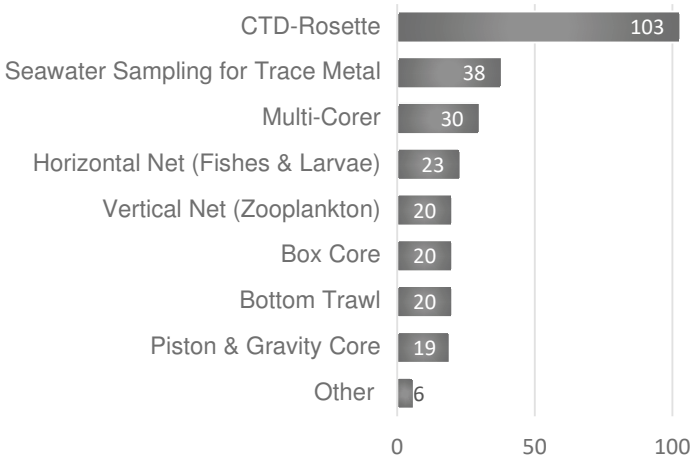
The RADCARBBS program was on the *Amundsen* to study radiocarbon cycling within the Northwest Passage and the southwestern Beaufort Sea. More specifically, their work aimed to tell: 1) how and where most marine carbon is produced in the Northwest Passage (i.e. produced by marine phytoplankton or by riverine input from land), 2) how long it will persist, and 3) how microbes can use this marine carbon, perhaps transforming it into stable forms that can be stored in the deep sea. Once again, scientists from the ArcticNet Marine Program were onboard to study fish, plankton, contaminants, carbon cycle and biogeochemistry along specific historical transects.

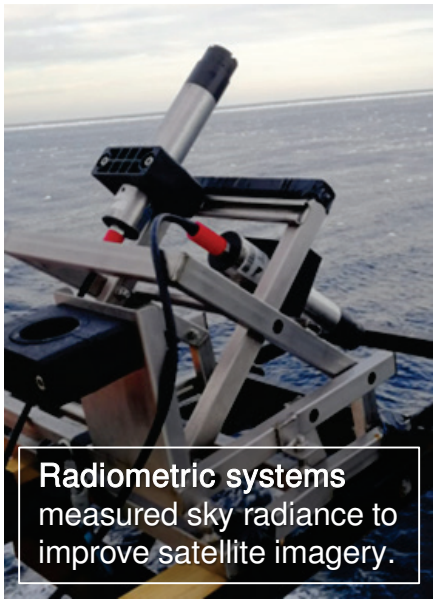
Research Activities

One of the best ways to study the history of marine organic matter is through the use of sediment coring tools such as a piston corer, a box corer, or a multi-corer (see next page). Sediment sampling was a substantial component of the research activities during Leg 4. Amongst other results, it is interesting to note that: 1) a submarine pingo was discovered and mapped North of Kugmallit Bay, 2) upwelling (the process through which rich waters from the ocean's depth resurface) was observed near Cape Bathurst, and 3) more than a hundred CTD-Rosettes were deployed over this 28-day Leg.



A **Pingo** is a dome-shaped hill formed by ice which can also be found under water. The one pictured here was observed on the seafloor North of Kugmallit Bay.





Radiometric systems measured sky radiance to improve satellite imagery.

The **Multi-Corer** allow the retrieval of up to 8 small cores containing sediments and bottom seawater with minimal disturbance.

Leg 5

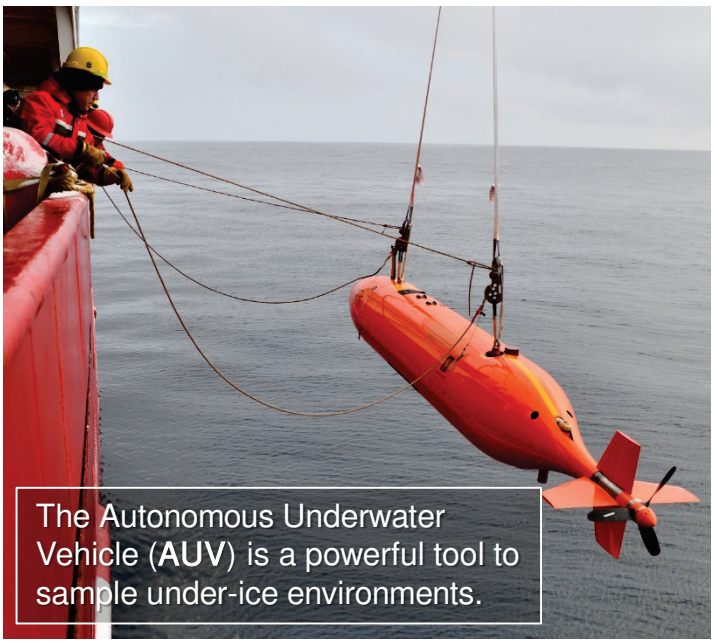
Description of the Program

Leg 5 supported the international multidisciplinary DarkEdge study. The scientific objectives of DarkEdge were to study the fall-to-winter transition of the Arctic Ocean and its ecosystem as the ice is forming and light availability is reducing. To address this important process, researchers aimed to:

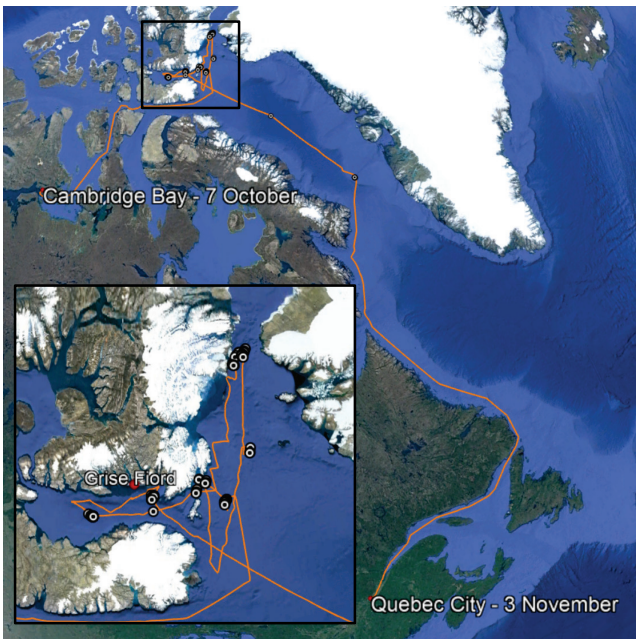
1) identify the key processes that control ocean mixing and sea ice cover by measuring physical parameters with buoys, an ice canoe, and other instruments,
2) survey the underwater and under-ice environments (light, nutrients, etc.) using an autonomous underwater vehicle (AUV) and a small ROV,
3) identify phytoplankton species and quantify how they adapt and grow under low-light conditions,
4) cartography and qualify zooplankton and fish stocks using various nets and acoustic instruments.

Research Activities

The sampling strategy during Leg 5 was to occupy stations at the transition between ice-covered and ice-free zones over the course of 3 days. Overall, the campaign was a success, with operations conducted at 6 stations across Northern Baffin Bay, the deployment of 38 CTD-Rosettes, 34 nets, and the first Arctic deployments of the AUV, the ice-canoe and an automated catamaran measuring air-ocean energy fluxes.



The Autonomous Underwater Vehicle (**AUV**) is a powerful tool to sample under-ice environments.



Conclusion

Despite the persisting context of the COVID-19 pandemic and acute logistical and technical constraints, the 2021 Amundsen expedition spanning 122 days at sea across the entire Canadian Arctic represents the most extensive and scientifically productive campaign of the last five years. We can't emphasize enough how important and crucial the good collaboration between the Canadian Coast Guard, the scientific programs, the local communities and Amundsen Science has been. Thank you!

The research activities undertaken onboard the CCGS *Amundsen* in 2021 will allow a better understanding of coastal and marine ecosystems of the Canadian Arctic, help understand how climate change affects fragile marine ecosystems and human health, and facilitate locally-supported objectives targeting the offshore Arctic environment. Mapping conducted along the expedition will also increase the safety of shipping activities. The total seafloor area mapped by the ship in 2021 covers over 38 000 km^2, which corresponds to a region larger than the Prince of Wales Island (NU) or the whole country of the Netherlands! Researchers and technicians are still working on further analysis on the data collected during the expedition.

The planning and licensing processes are ongoing for the 2022 Expedition which will be reduced in length due to major repairs on the CCGS *Amundsen* taking place during Winter-Spring 2022. Do not hesitate to reach out to media@as.ulaval.ca for any questions or comments about this document or the Amundsen Expeditions.