TECHNICAL DESCRIPTION OF ICENAV 2026

DESCRIPTION

1. This scientific project is aimed at testing the effectiveness of sensor systems that can enhance safe navigation in ice by detecting, tracking, characterizing and communicating through sea ice and floating glacial ice. This study will take place onboard CCGS Henry Larsen during the period 20-30 August. The ICENAV project will study the capabilities of six systems with respect to ice sensing:

   a. DRDC Valcartier's (DRDC-VRC) portable electro-optical module combined with a weather station specialized to characterize the properties of ambient light.

   b. DRDC Atlantic's (DRC-ARC) will evaluate standalone radar systems and georeferenced radio frequency (RF) tags. ARC will also deploy short vertical line acoustic arrays for the study of under-ice acoustics.

   c. NRC's Optical ice data system and image processing techniques for sea-ice mapping and segmentation via ship-borne and Remotely Piloted Aircraft System (RPAS)-borne sensors.

   d. ECCC's Ka-band synthetic aperture radar (SAR) measurements from the Surface Water and Ocean Topography (SWOT) satellite program;

   e. CMRE'S under-ice acoustic propagation system for the marginal ice zone and remotely operated vehicle (ROV) for under-ice morphology characterisation and above se-ice imagery by an RPAS; and

   f. Qillaq Innovations Qillaq Innovations will validate long range unmanned aerial vehicle (UAV) flights for Sea-Ice reconnaissance to assist ship's navigation.

2. DRDC-VRC aims to enhance the capabilities of its integrated naval laser warfare capability, to enable detection and classification of the Arctic environmental layers to automatically find the path of least resistance through the icepack.

3. DRDC-ARC aims to formally evaluate the capability of Radar to produce a picture of the ice regime in the region of the ship. Objectives are to detect and track icebergs and smaller pieces of glacial ice, as well as to identify features of pack ice, such as the ice edge, leads, etc. DRDC-ARC expects to record under-ice acoustic soundscape and noise as well as comparing forecast models to in-situ measurements

4. The NRC aims to evaluate a suite of visible (VIS) and thermal-infrared (TIR) cameras as well as a laser ranging sensor that was specifically developed for ice sensing. NRC's system generates

concurrent data from various sensors and perspectives (including ship-borne and RPAS-borne) and is capable of real-time data processing to provide near-instantaneous information on the local ice conditions.

5. ECCC aims to comprehensively assess the influence of ice on the SWOT mission data in critical regions with a significant ice presence. ECCC also aims to assess the effect of snow on the radar's penetration capability to refine their estimations of ice freeboard. Furthermore, the capabilities of the SWOT mission for sea ice characterization in polar oceans using Ka-band SAR imagery will be explored.

6. The Canadian Ice Service will provide expertise in the form of remote sensing products related to the climatology and the ice conditions of the regions relevant to the planification of the scientific activities as well as to formulate the best practices of utilisation of the systems.

7. NATO's CMRE aims to measure the under-ice acoustic channel properties of the marginal ice zone through active propagation experiments involving the deployment of acoustic sources as well as the characterisation of the under-ice morphology (bottom roughness) using a tethered remotely operated vehicle (ROV, model BlueROV2) deployable by zodiac or RHIB.

8. Qillaq Innovation is an Inuit-owned company based in Cambridge Bay. They provide full UAV services such as piloting, mission planning and maintenance as well as full-service base operations and key facilities near YCB. They are the recipient of the 2025 DRDC IDEas Arctic Mobility prize for navigation through sea-ice for their UAV capabilities. During ICENAV, their goal is to provide ISR electro-optical data to the ship to enhance navigation.
https://www.qillaq.ca/uav-services/

9. The scientific tasks will be:

a. to collect core samples of the sea ice and glacial ice for in-situ testing and validation of measurements.
b. to take images of sea ice and glacial ice using electro-optical active and passive systems and compare to in-situ ice samples
c. to qualitatively assess the capability of radar to characterize pack ice features that are important for navigation by operating near and in the pack and to quantitatively assess the iceberg, bergy bit, and growler detection and tracking range of the radar, by tagging pieces of glacial ice with RF tags and observing the signal loss as the ship moves away from the target; and
d. to evaluate the performance of the NRC system to estimate the local ice conditions in various weather conditions and to collect ice images (ship-based and RPAS-based) to develop post-processing workflows and improve the system's ice characterization algorithms and workflows to optimize ice navigation.
e. to evaluate ice thickness products from the SWOT satellite mission.

f. to explore novel applications for SWOT; specifically, to unlock the capabilities of SWOT Ka-band backscatter products for characterizing sea and glacial ice.
g. to characterize ice roughness/keels: measurements using one or more multi-beam sonar, side-scan sonar, or synthetic aperture sonar, to measure under-ice multi-scale roughness.
h. to measure ice acoustic forward and back scattering (reflection coefficient and reverberation characteristics).
i. To evaluate the performance of Qillaq Innovations' long range UAV endurance for during a 10 hour mission.
j. A CCG helicopter will be used for ice reconnaissance flights along the route.

10. The data collected during this Evaluation will be used by DRDC, DRC, NRC, ECCC, CMRE and Qillaq:

a. to enhance the performance of the systems for ice detection and safe navigation in the regions of the High and Low Arctic throughout all seasons.
b. to integrate with other systems aimed at ensuring the safe navigation of vessels in Arctic regions.
c. to develop autonomous and stand-alone techniques, algorithms and technologies that will aid in the identification of the path of least resistance through sea-ice and to provide reliable detection of ice bergs, bergy bits, and growlers.
d. to compare, assess, and make recommendations to the CAF and CCG concerning the capabilities of new and existing sensors related to ice navigation and arctic operations.
e. To validate ship-launches autonomous vehicles and long range AUVs flights the systems for ice detection and safe navigation in the regions of the High and Low Arctic throughout all seasons.

AREA OF OPERATIONS

11. The ICENAV program will be executed in 10 days. Table 1 shows a notional trial schedule for the number of days that will be dedicated to testing the multiple sensor systems by different types of ice.

Table 1: Notional trial schedule ICENAV

	Summer trial (days)
Land fast ice	2
Pack ice	2-3
Marginal Ice Zone (MIZ)	2-3
Glacial ice	2

13. The targeted region is the Northwest Passage of the Canadian Archipelago. The Northern Route (Parry Channel, M'Clintock Channel, Prince of Wales strait, and V. Melville Sound, see Fig. 1) is privileged so far due to larger possibilities of finding multi-year ice, although according to ice conditions in 2023 and 2024 during the same period, the southern route (Peel Sound, Larsen Sound and Queen Gulf, see Fig. 2) shows less ice density and better possibilities of navigation. Figure 1 shows the route with 18 possible stations, the scientific team will embark in Resolute on Augst the 19th and will partially debark in Cambridge Bay (Or Resolute Bay) on August 20th. The CCGS Henry Larsen will transit back to St. Johns after partial disembarking of the scientific team.

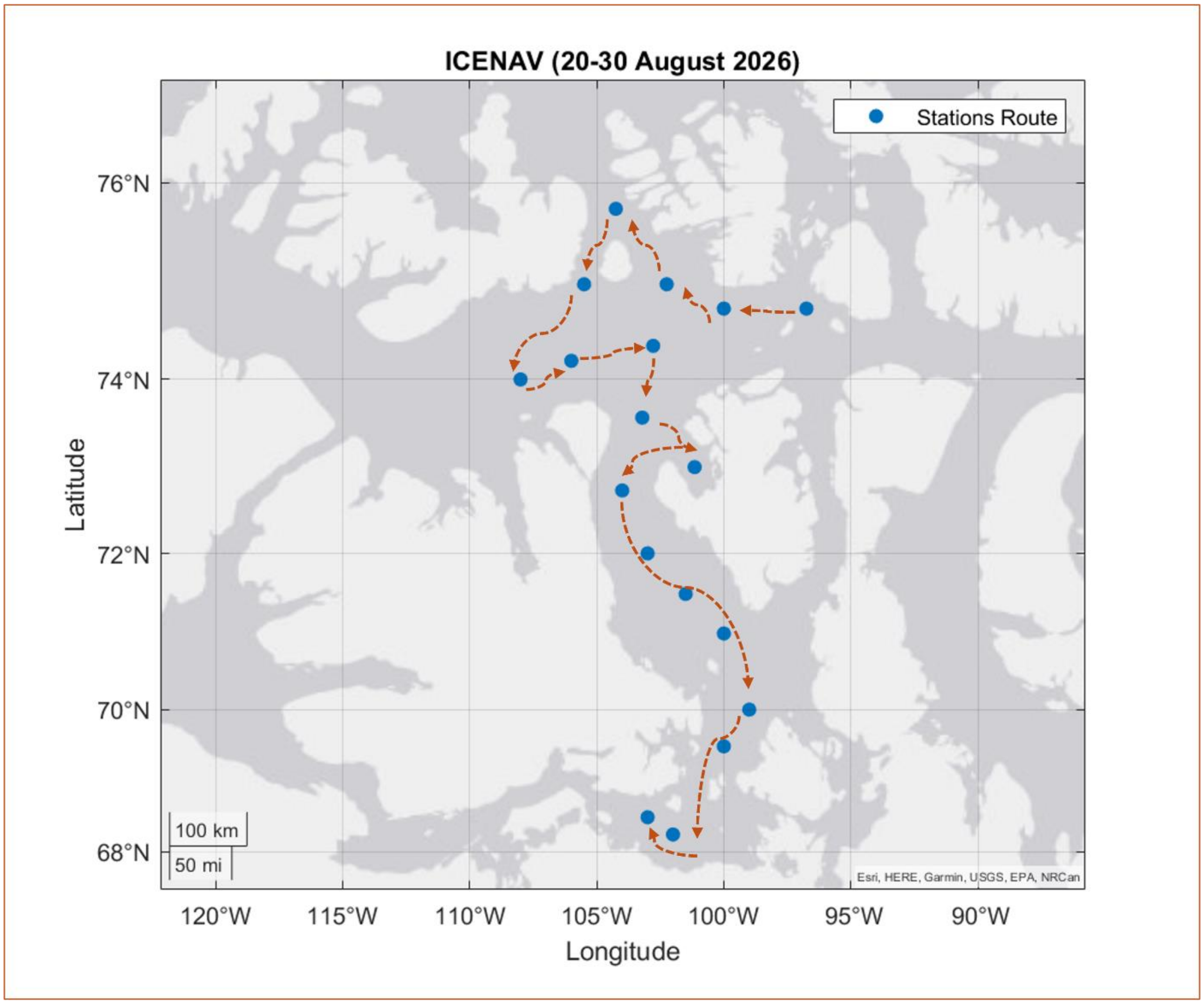

Fig. 1, ICENAV's Route. The routes start in Resolute Bay continuing south to Cambridge Bay.

14. Furthermore, this area does not include designated environmental areas, parks, heritage sites, nor sensitive marine habitat areas. Both the municipalities of Cambridge Bay and Resolute Bay have been contacted as well as their hunters and Trappers associations We have signaled to the community that there is still some flexibility regarding route planning of the

ICENAV mission. The scientific team has invited the community members or the HTO to address questions, concerns, and observations to ICENAV's Scientific team as well as local knowledge that they may wish to share. The have been informed that such input could help identify opportunities to adjust activities or routing in a manner that better respects local priorities and ongoing land use. The scientific team has also offered to provide additional information or arrange a discussion with members of the scientific team.

Table 2: Notional trial schedule for dedicated deployment for the summer leg

Day	Location	Activity
0	Resolute	Embarkinf of trial staff, transit to North of Lancaster sound
1-2	Resolute and Parry Channel	**Trials**: Glacial ice
3-4	North M'Clintock into QEI	**Trials**: MIZ and landfast ice
5-6	Viscount Melville Sound	**Trials**: MIZ and landfast ice
7-8	South M'clintock and Ommaney Bay	**Trials**: MIZ and pack ice
9	Resolute	In transit from trials area to Cambridge Bay, debarking trial staff.

15. A notional trial schedule onboard CCGS Henry Larsen has been developed based on the proposed trial areas selected above. This estimate includes transit and trials time. Lastly, the trial areas and schedule will be updated according to weather and sea-ice conditions.
16. To characterize the under-ice acoustic channel properties of the marginal ice zone through active propagation experiments a minimum depth of 50m is needed. Fig 3 shows the bathymetry index in the region of interest.

Physical environment

17. The study area encompasses the eastern portion of Bathurst Island, Central Parry Channel, and M'Clintock Channel within the Canadian Arctic Archipelago. This region forms part of the northern route of the Northwest Passage and is characterized by a polar desert climate, extensive seasonal sea ice, deep marine channels, and relatively low levels of human activity. Parry Channel serves as one of the principal east-west marine corridors in the Canadian Arctic and is used seasonally by Canadian Coast Guard vessels, research ships, government vessels, expedition cruise ships, and occasional commercial transits. Late August coincides with the annual sea-ice minimum, when ice concentrations are typically at their lowest. Conditions generally include areas of open water interspersed with first-year ice, remnant multi-year ice floes, pressure ridges, and mobile ice features. While navigation conditions are generally most favorable during this period, sea ice remains highly variable and can present operational challenges due to the presence and movement of multi-year ice throughout the region.
18. The marine environment supports a diverse array of Arctic wildlife and includes important migration corridors and feeding habitats for narwhal, beluga, bowhead whale, ringed seal, bearded seal, walrus, and polar bear. M'Clintock Channel supports a recognized polar bear

subpopulation, while recurrent polynyas, leads, and ice-edge habitats serve as biologically productive areas that attract marine mammals, seabirds, and fish. Migratory birds, including eiders, Arctic terns, fulmars, murres, and gulls, use the region extensively during the summer and early autumn.

19. Bathymetry within the study area is characterized by deep channels and basins separated by shallower coastal shelves and submarine ridges. These features influence ocean circulation, sea-ice movement, and habitat distribution. Oceanographic conditions are driven by semidiurnal tides, localized tidal currents, wind forcing, and seasonal freshwater inputs from melting snow and ice. The interaction of these processes with sea ice contributes to a dynamic marine environment.
20. Ambient underwater noise levels are generally low compared to southern marine environments and are dominated by natural sources such as sea-ice movement, ice fracturing, wind, waves, and marine mammal vocalizations. Anthropogenic noise is primarily associated with seasonal vessel traffic, including icebreaking operations. When present, icebreakers are typically the dominant source of underwater noise, generating broadband low-frequency sound capable of propagating over considerable distances under Arctic conditions. Overall, the region remains one of the least acoustically disturbed marine environments in Canada due to its remoteness and relatively low vessel traffic.

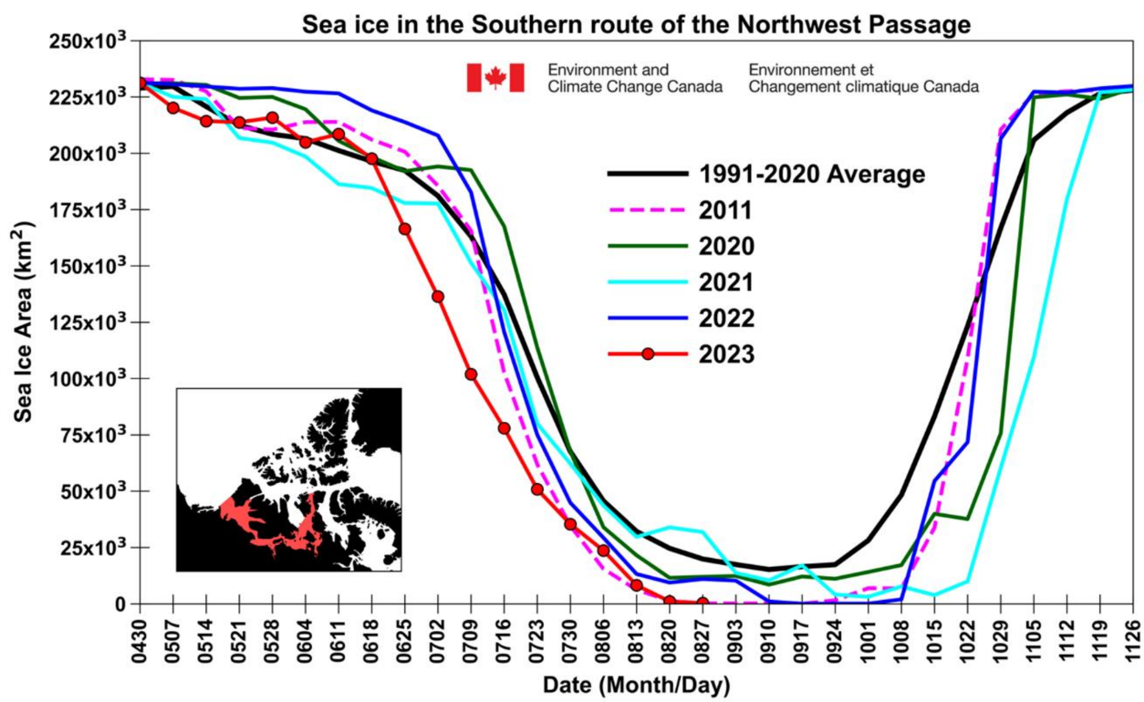

Figure 2: Sea ice coverage in the Southern route of the Northwest Passage.

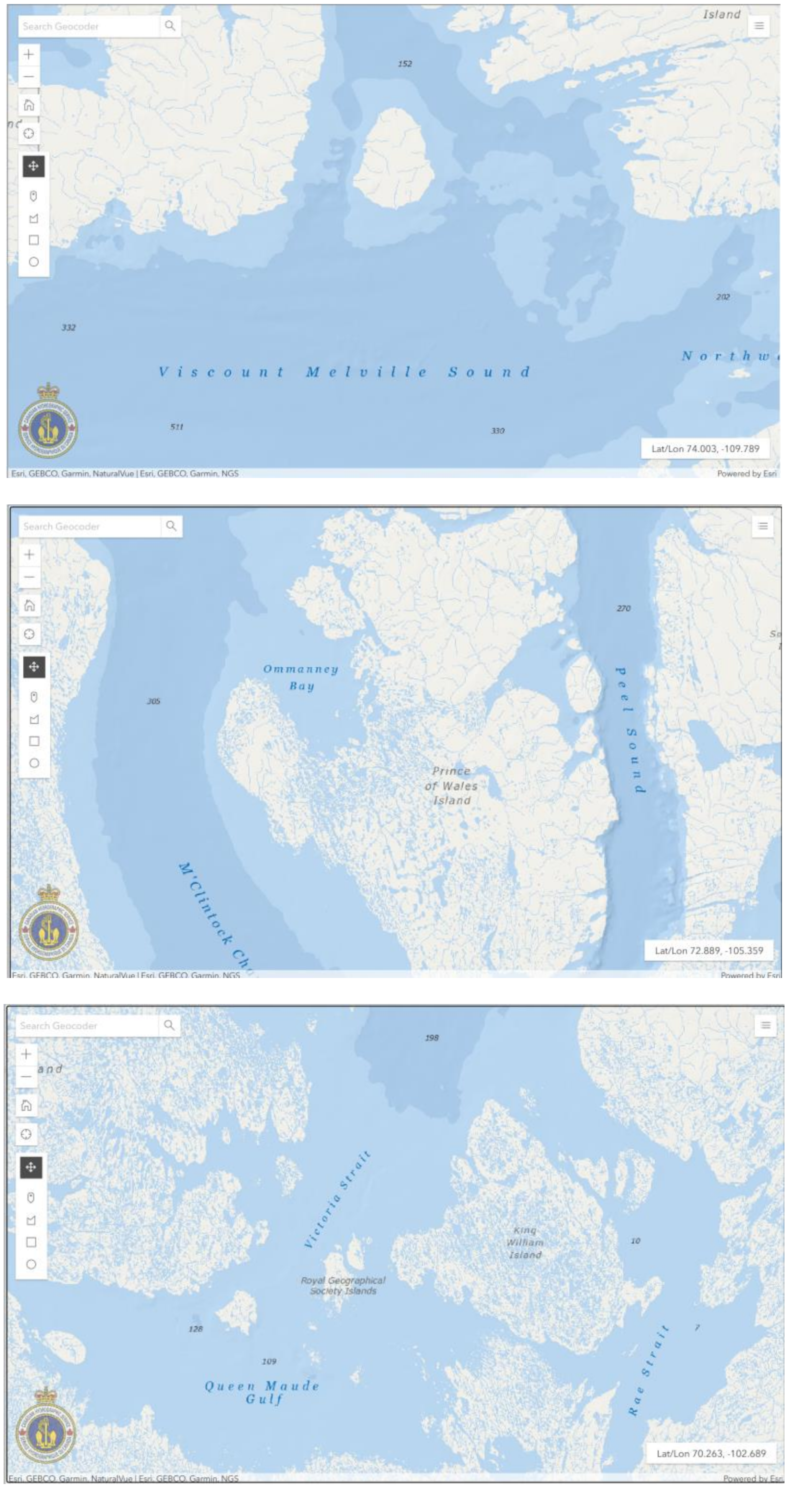

Figure 3: Bathymetry Index of the area of interest. Source: DFO.

Biological environment

15. The biological environment of the Central Parry Channel, M'Clintock Channel, and eastern Bathurst Island region is characteristic of the High Arctic, supporting relatively low biodiversity but highly productive seasonal ecosystems that are closely linked to sea-ice dynamics. Biological activity is concentrated during the short summer open-water period and around recurring polynyas, leads, and ice-edge habitats that provide important feeding and migration areas for marine species.

16. Vegetation is sparse and typical of Arctic tundra and polar desert environments. Plant communities are generally limited to mosses, lichens, sedges, grasses, and low-growing flowering plants that occur in sheltered valleys, moist depressions, and coastal areas. Vegetation cover is patchy and constrained by low temperatures, limited precipitation, and a short growing season.
17. The region supports important populations of migratory birds during the summer months, including northern fulmar, black-legged kittiwake, thick-billed murre, Arctic tern, glaucous gull, snow goose, king eider, and common eider. Coastal areas, islands, cliffs, and wetlands provide nesting, staging, and feeding habitat. Bird abundance peaks during the breeding season and southward migration in late summer and early autumn.
18. Marine ecosystems are dominated by ice-associated species. Key aquatic resources include Arctic cod, a critical forage species linking lower trophic levels to marine mammals and seabirds, as well as Arctic char in nearshore waters and a variety of benthic invertebrates including crustaceans, molluscs, polychaetes, and echinoderms. Marine productivity is enhanced in areas of open water and seasonal ice margins where phytoplankton and zooplankton production is concentrated.
19. The study area forms part of important migration and movement corridors for marine mammals including narwhal, beluga whale, bowhead whale, ringed seal, bearded seal, and walrus. Seasonal movements are strongly influenced by sea-ice conditions, with marine mammals using leads, polynyas, and ice-edge habitats for migration, feeding, breeding, and access to overwintering areas. Polar bears are widely distributed throughout the region and depend on sea ice as a platform for hunting seals and seasonal movements.
20. Several Species at Risk may occur within the area. These include the Bowhead Whale (*Balaena mysticetus*), Narwhal (*Monodon monoceros*), Peary Caribou (*Rangifer tarandus pearyi*), Ivory Gull (*Pagophila eburnea*), and several populations of Polar Bear (*Ursus maritimus*). Critical habitats for these species are associated with sea-ice environments, marine migration corridors, coastal nesting areas, and Arctic tundra habitats. Consequently, biologically sensitive areas within the region include polynyas, recurring leads, seabird nesting sites, marine mammal migration routes, and important polar bear and Peary caribou habitat.
21. Overall, the biological environment is characterized by seasonal productivity, strong dependence on sea-ice processes, and the presence of ecologically and culturally important wildlife species that are adapted to one of the most extreme environments in Canada.

Socioeconomic environment

22. The socioeconomic environment of the Central Parry Channel, M'Clintock Channel, and eastern Bathurst Island region is characterized by a very low permanent human presence, limited

infrastructure, and seasonal use associated with Indigenous harvesting, scientific research, government operations, and Arctic tourism. The study area is remote from permanent communities; the nearest communities include Resolute (Qausuittuq), approximately 250 km east of eastern Bathurst Island, and Gjoa Haven, Taloyoak, and Cambridge Bay farther to the south and southwest. These communities maintain cultural, subsistence, and travel connections to portions of the broader region.

23. The area contains numerous archaeological and culturally significant sites associated with Inuit land use and travel, as well as historic European exploration routes related to the search for the Northwest Passage and the Franklin Expedition. Cultural heritage resources may occur along coastlines, former campsites, travel corridors, and hunting areas, and may not always be formally documented.
24. Land and resource use is primarily associated with Inuit traditional activities, including harvesting of marine mammals, polar bear, caribou, fish, and migratory birds. Seasonal harvesting occurs throughout the broader region, particularly along marine travel routes, sea-ice corridors, coastal areas, and biologically productive polynyas. Commercial resource development is limited, and no major industrial activities occur within the immediate study area.
25. Tourism activity is generally low but has increased in recent years due to expedition cruise vessels, adventure tourism, and visits associated with Arctic wildlife viewing and historical sites. Local guiding and outfitting activities occur periodically and may support hunting, cultural tourism, and wildlife observation.
26. Marine traffic is highly seasonal and concentrated during the late summer open-water period. Vessel movements primarily consist of Canadian Coast Guard operations, government and defence vessels, scientific research vessels, expedition cruise ships, community resupply traffic, and occasional commercial transits through the Northwest Passage. Overall vessel density remains low relative to southern Canadian waters.
27. Human health considerations in the region are largely related to the remote operating environment. Risks include limited access to emergency services, challenging weather and sea-ice conditions, long medical evacuation times, and potential encounters with wildlife such as polar bears. Community health and well-being are closely tied to the continued availability of traditional harvesting resources and the protection of culturally important marine and terrestrial environments.
28. Overall, the socioeconomic environment is defined by its remoteness, cultural importance to Inuit communities, reliance on traditional land and marine resource use, limited seasonal tourism and shipping activity, and strong connections between environmental conditions and community well-being.

Cumulative Effects

29. The area of operations chosen for the ICENAV project is already subject to seasonal vessel traffic, scientific research, marine monitoring programs, and government operations. Existing and reasonably foreseeable activities in the region include Canadian Coast Guard operations, Arctic shipping through portions of the Northwest Passage, scientific surveys, environmental monitoring programs, community resupply voyages, defence-related activities, and expedition tourism.

30. In a regional context, the ice characterization activity would be short in duration, localized in extent, and non-intrusive in nature. The activity would primarily involve the collection of sea-ice observations and measurements to support navigation safety and operational planning. As a result, interactions with other past, present, and foreseeable projects are expected to be limited and primarily cumulative in relation to vessel presence and associated noise. The activity would not result in habitat alteration, resource extraction, long-term infrastructure development, or permanent changes to the physical environment.
31. Potential cumulative effects may include minor and temporary increases in vessel traffic, underwater noise, and wildlife disturbance when combined with other marine operations occurring during the late summer navigation season. However, these effects are expected to be negligible on the regional scale given the low intensity and short duration of the activity, the relatively low level of overall marine traffic in the area, and the large spatial extent of available wildlife habitat.
32. The activity is not expected to adversely affect community land use, harvesting activities, cultural resources, tourism operations, or access to marine resources. By improving situational awareness of sea-ice conditions, the activity may contribute positively to navigational safety and support the safe conduct of scientific, government, and marine transportation activities within the broader region.
33. Overall, considering the limited footprint of the proposed activity and the low level of concurrent development in the High Arctic, interactions with the effects of past, present, and reasonably foreseeable projects are expected to be minor, temporary, and not significant on the regional scale.

DESCRIPTION OF STATIONS

34. Sampling stations are composed of the following experiments:

No.	Title	Description	Lead Organization(s)
0	Daily local sea-ice brief	The CIS officer will provide a daily brief on the local/regional ice conditions and will advise on the feasibility of scientific operations; accordingly, estimated time: 30 min.	CIS
1	Optical sea-ice analysis	The EO system will gather daily sea-ice data at previously chosen locations at a cruise speed of 5 knots; estimated time: 2-3 hr. This activity can be tied to other observations.	DRDC-VRC
2	In-situ sea-ice cores	A team of 2-3 scientists will daily conduct sea-ice coring operations directly on the icepack (ship alongside floe) up to a distance of 100 m from the ship; estimated time: 2 hrs.	DRDC-VRC

No.	Title	Description	Lead Organization(s)
6	Radar sea-ice performance comparison	The system will gather daily sea-ice data at previously chosen locations at a cruise speed of 5 knots; estimated time: 2-3 hr. This activity can be tied to other observations.	DRDC-ARC
7	Radar in-situ evaluation	A team of 2 scientist will reach the icepack or glacial ice by zodiac to place RF tags which will be detected from the ship at various distances; estimated time: 3-4 hrs. This operation is requested at least three times during the trials.	DRDC-ARC
9	Under-ice morphology analysis	An autonomous underwater vehicle (AUV, Iver class) or an under-water tethered vehicle (ROV, BlueROV2) will be deployed and recovered alongside the ship or from a zodiac/RHIB. The vehicle will navigate under the marginal ice zone or under a large glacial ice piece gathering morphological features from under the sea-ice (roughness); estimated time: 4-5 hrs. This operation is requested five times during the trials.	CMRE
10	Vertical under-ice acoustic analysis, active (TBC)	An acoustic source will be deployed near the marginal ice zone to stimulate the vertical acoustic arrays. The source can be towed from the ship, from the RHIB or directly from the icepack (ship alongside floe); estimated time: 4-5 hrs. This operation is requested four times during the trials.	CMRE
11	Sea-ice system evaluation	The cameras and LiDARs from the system will gather daily sea-ice data at previously chosen locations at a cruise speed of 5 knots; estimated time: 2-3 hr. This activity can be tied to other observations. Data will be supplemented with EM thickness measurements from on ice or from the ship.	NRC
12	Airborne sea-ice evaluation	An <25-kg vertical take-off and landing RPAS will be deployed and operated from the ship by trained/licensed operators from NRC and/or supporting NRC. The RPAS will gather aerial sea-ice imagery while the ship is stopped at the pre-selected in-situ stations, with estimated flight times of 2-3 hrs.	NRC
13	SWOT product evaluation	The ECCC scientist will compare the daily products generated by the CIS officer onboard against the data taken by the SWOT-SAR sensor, this analysis	ECCC

No.	Title	Description	Lead Organization(s)
		will be verified by the in-situ sea-ice measurements of the day. Internet access onboard is requested to retrieve remote-sensing products.	
14	Qillaq Innovations' long range UAV flight	Qillaq Innovations will plan and execute the launching, piloting and recovering of a long range AUV in a radius of 500 km from Cambridge Bay. They will relay electro-optical and IR information to the ship.	Qillaq/RDDC

*Passive scientific instruments will record data during transit time.

EQUIPMENT DETAILS

35. VRC Equipment

a. The following scientific equipment will be temporarily secured on the ship
    - EO system
        i. Tripod, power-supply, acquisition board
        ii. In all: 300 W, 50 pounds
b. Sea-ice sampling equipment: Ice core drill with 5 inches blade, extension shaft for ice-core drill, ice drill auger 5 or 8 inches with shaft, 1 ice thickness gauge, isometric ice thickness measurement bar, 2 aluminum Zarge boxes (70 x 65 x 19 cm), 1 1 thermistor, 1 caliper, 2 hand saws, 1 plastic sled, 1 camera, 1 measuring tape, 1 50-cm ruler, 1 1kw power generator, 1 LiDAR system, personal equipment for cold weather for 3-4 scientists.

36. ARC Equipment

a. The trial team will embark or install the following scientific equipment on the ship chosen for the Ice Navigator experiment.

    a) Radar (most recent hardware and software)
        i. New server to replace existing rack-mounted processor
        ii. No net change in weight/power
    b) Two (2) Class B AIS transponder for growler tagging
        i. Portable power supply, transponder, antenna in pelican case or equivalent
        ii. In all: 2 W, 50 pounds
b. Under-ice acoustic instrumentation
    a) APADS – combination source/receiver
    b) 2 vertical line arrays, approx. 10-20 m long
    c) One or more transducer sources (handheld, with batteries)

37. NRC Equipment

a. The trial team will embark or install the following scientific equipment on the ship chosen for the NRC Real-Time Ice Data experiment.

   a) Stereo optical camera system, Infrared camera, Lidar sensor, Optical action camera, Rack with data acquisition and processing system,
   b) EM Induction sensor
   c) RapidCore
      - Is a remotely operated (tethered) ice coring machine which can be deployed to extract sea ice cores quicky without putting personnel on the sea ice. The device is shown in use in Fig 1.
      - For use in ice + snow thicknesses up to 1m.
      - Requires 3-4 operators: One trained rapid core operator, 1-2 deckhands to man taglines, and one crane operator, typically from the ship's crew.
      - Can be disassembled to save space for transportation.
   d) Remotely piloted aircraft system (RPAS)
      - The precise RPAS make/model remains to be determined, but the following can be assumed:
      - The RPAS will consist of (1) an aircraft weighing no more than 25 kg (incl. payload), and (2) a compact 'ground control station' (GCS) comprised of a handheld controller at minimum and/or a laptop-based station at most.
      - The aircraft will take off and land vertically from the ship's flight deck.
      - The aircraft is likely to be gas-powered as opposed to battery-powered, and NRC will make the necessary arrangements to bring the required type of fuel (and sufficient quantity for the entire mission) on board, and handle and store it in accordance with CCG guidelines.
      - The RPAS will be equipped with its own radio telemetry system for communication between the aircraft and GCS, and NRC will make the necessary arrangements to ensure it does not interfere with the ship's RF systems.
      - Powering the GCS and/or recharging its batteries will require access to the ship's electric power system, e.g. a standard 110V AC outlet.

38. ECCC Equipment

- GNSS-IR instrumentation, installed on ship.

39. CMRE Equipment

a. Acoustic source
   - Amplifiers, control PC, transducers (Neptune –HF-, Geospectrum (To Be Procured))
   - Target Source Level 180 dB ref 1uPa@1m
   - Target frequency bands: [500-10000]Hz

b. Oceanographic sensing
   - Rapid CTD cast (hand deployable), thermistor chain

c. Passive acoustic[1]
   - Drifting vertical line arrays compact and hand deployable (tentatively PSLIMs and OCTOPUSS). Equipped with tracking device (GPS, AIS, IRIDIUM)

Figure 1: RapidCore being deployed in level ice from the CCGS Henry Larsen.

40. Qillaq Innovations Equipment

- LDS-150 orLSS-80 AUV

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