**ICENAV (Summer trials) Environmental Impacts: Risks and mitigation strategy**

1. Loss of deployed drifters

Risks:

1. Ice fracture and deformation
2. Loss of communications
3. Battery failure due to cold
4. Environmental contamination from spills or damaged equipment
5. Wildlife disturbance and interactions
6. Inability to recover deployed equipment

Mitigation Strategy :

- Redundant drifters (The Sc team will deploy more units than the minimum scientific requirement).
- Real time GPS/Iridium tracking of deployed equipment.
- Satellite ice monitoring before and after deployment.
- Robust power systems with 25–50% energy reserve.
- Regular health/status transmissions to detect failures early.
- Spill Prevention and Response Plan.
- Waste Management Plan (pack-in/pack-out).
- Wildlife Interaction Protocol **(refer to Annex A)**
- Equipment Recovery and End-of-Life Strategy.
- Environmental Incident Reporting Procedure.
- Tracking and accountability for all deployed assets.

2. Underwater noise from deployed scientific acoustic sources

Risks:

- Marine mammal disturbance: Underwater acoustic transmissions may cause whales, dolphins, and seals to alter their behavior, including avoidance of feeding, migration, breeding, or resting areas.
- Hearing impacts to marine mammals: Animals close to the source may experience temporary hearing threshold shifts (TTS), while prolonged exposure at very close range could result in permanent hearing impacts (PTS).
- Fish and invertebrate effects: Acoustic energy may alter fish behavior, disrupt schooling, affect predator-prey interactions, or cause avoidance of important habitats. Early life stages (eggs and larvae) may be particularly sensitive.
- Acoustic masking: Scientific sound sources can interfere with the ability of marine animals to detect biologically important sounds used for communication, navigation, mating, and predator avoidance.

- Under-ice sound propagation: In Arctic environments, sound can travel efficiently beneath sea ice, potentially increasing the area in which marine mammals and fish are exposed to acoustic signals.
- Temporary habitat displacement: Marine mammals, fish, and other organisms may avoid areas where acoustic operations are underway, reducing habitat availability for feeding or migration.
- Cumulative effects: Acoustic emissions may add to existing noise from shipping, icebreakers, commercial vessels, and other research activities, increasing overall environmental stress.
- Impacts on community harvesting activities: Noise-induced movement of marine mammals or fish may affect local hunting and harvesting activities and associated cultural practices.
- Vessel-related environmental effects: Ship operations may contribute additional underwater noise, air emissions, waste generation, and fuel-spill risks beyond those associated with the acoustic source itself.

Mitigation Strategy:

- Conduct acoustic propagation modelling and environmental assessments before operations.
- Establish marine mammal exclusion zones around the vessel.
- Use Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM).
- Implement soft-start/ramp-up procedures to allow animals to leave the area before full source power is reached.
- Suspend operations if marine mammals enter designated shutdown zones.
- Engage communities and communicate planned activities in advance.
- Implement vessel spill prevention, waste management, and environmental monitoring programs.
- The scientific acoustic source to be used is a low-power system with a significantly smaller acoustic footprint and shorter propagation range than the CCGS *Henry Larsen* itself. Vessel-generated noise from icebreaking operations can reach source levels of approximately 210–220 dB re 1 µPa @ 1 m and is dominated by low-frequency sound, which propagates over much greater distances than the higher-frequency, low-power scientific acoustic source. As a result, the incremental contribution of the scientific source to the overall acoustic environment is expected to be minor relative to the vessel's routine operating noise.

3. Remotely Piloted Aircraft System (RPAS) Noise Impacts on Birds

   Risks:

   - RPAS noise and presence may disturb birds, causing alarm responses, flushing, or avoidance behavior.

- Repeated disturbance can increase energy expenditure, particularly during periods of limited food availability.
- Birds may perceive drones as predators, resulting in stress, defensive behavior, or temporary displacement.
- Nesting and breeding birds are particularly sensitive, and disturbance may interrupt incubation, reduce parental care, or lead to nest abandonment.
- Repeated overflights may displace birds from important feeding, resting, or staging areas.
- Colonial seabirds may be especially vulnerable, as disturbance can affect large numbers of individuals simultaneously.
- Species at Risk and migratory birds may experience greater sensitivity to disturbance during breeding and migration periods.
- Cumulative impacts may occur if multiple drone flights are conducted repeatedly in the same area over an extended period.

Mitigation Strategy :

- Conduct pre-flight assessments to identify nesting colonies, sensitive habitats, and areas of high bird use.
- Avoid flying over or near nesting colonies, breeding areas, and migratory staging sites whenever possible.
- Schedule drone activities outside sensitive periods such as nesting, incubation, chick-rearing, and peak migration periods.
- Operate at the highest practical altitude consistent with mission objectives.
- Avoid prolonged hovering, rapid approaches, or repeated passes over the same area.
- Minimize the frequency and duration of flights.
- Establish exclusion or buffer zones around nesting colonies
- Assign a wildlife observer during operations in environmentally sensitive areas.
- Suspend or modify operations if birds exhibit signs of disturbance such as repeated flushing, persistent alarm calls, defensive behavior, or nest abandonment.
- Record wildlife observations and adapt flight operations as necessary to reduce disturbance.

4. RPAS Loss or Crash

Risks :

- Loss of an RPAS may result in the introduction of debris (plastics, metals, wiring, and electronic components) into sensitive Arctic terrestrial, freshwater, sea-ice, or marine environments.
- Damaged lithium batteries may leak hazardous substances, causing localized contamination of snow, ice, soil, or seawater.
- Crashed aircraft or detached components may be ingested by wildlife or create entanglement hazards for birds and marine mammals.

- Loss of an RPAS over open water, sea ice leads, or polynyas may result in permanent marine debris if recovery is not possible.
- A crash into a nesting colony, bird aggregation, or marine mammal haul-out area may cause direct wildlife disturbance and habitat disruption.
- Unrecovered debris may persist in the Arctic environment for extended periods due to slow natural degradation processes.
- Damaged batteries can pose a small but potential fire risk during recovery and handling.
- Repeated aircraft losses may result in cumulative environmental impacts over the life of a project.
- Lost equipment may create concerns for Indigenous communities if debris remains within traditional land-use or harvesting areas.

Mitigation Strategy :

- Use Arctic-rated RPAS platforms with proven reliability and redundancy systems.
- Conduct thorough pre-flight inspections and maintenance checks before each mission.
- Apply conservative weather restrictions to avoid operations during high winds, icing conditions, poor visibility, or other adverse conditions.
- Utilize fail-safe functions such as geofencing, return-to-home capabilities, lost-link procedures, and minimum battery reserve requirements.
- Equip RPAS with GPS tracking devices and position-reporting systems to facilitate recovery.
- Develop and implement RPAS recovery procedures prior to field deployment **(refer to Annex B).**
- Avoid flights over environmentally sensitive areas, wildlife concentrations, nesting colonies, and marine mammal haul-outs whenever feasible.
- Minimize operations over open water and unstable sea ice where recovery would be difficult.
- Maintain an inventory and tracking system for all deployed RPAS and associated equipment.
- Recover crashed aircraft, batteries, and debris as soon as safely practicable.
- Document and report all RPAS losses and assess any resulting environmental effects.
- Engage appropriate authorities and stakeholders if significant equipment losses occur in protected or traditional-use areas.
- With appropriate operational controls and recovery procedures, the likelihood of RPAS loss is low.
- Any environmental effects are expected to be localized and minor.
- The primary residual risk is the unrecoverable loss of batteries or electronic components into remote marine or sea-ice environments where retrieval may not be feasible.

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**Annex A – Wildlife Interaction Protocol for ICENAV**

A1. Purpose

The purpose of this Wildlife Interaction Protocol is to provide procedures and mitigation measures to:

- Protect personnel during field operations in wildlife habitat;
- Minimize disturbance to wildlife and sensitive habitat during scientific activities;
- Ensure compliance with applicable environmental regulations, permits, and wildlife protection requirements; and
- Support environmentally responsible scientific operations in the areas of operation.

A2. Scope

This protocol applies to all 13x personnel participating in vessel-based, helicopter-supported, and on-ice field activities associated with the deployment, maintenance, and recovery of scientific equipment of the ICENAV project.

A3. Roles and Responsibilities

Lead Scientist

- Ensure all personnel receive wildlife awareness briefings prior to field activities;
- Suspend operations when wildlife interactions present a safety or environmental risk;
- Ensure wildlife observations and incidents are documented; and
- Coordinate responses to wildlife encounters.

Polar Bear Watch (2x agents)

- Maintain continuous surveillance of the work area during on-ice operations;
- Immediately notify personnel of wildlife sightings;
- Recommend suspension of activities when wildlife approaches exclusion distances; and
- Maintain communication with the Field Team Lead.

All Scientific Personnel

- Remain vigilant for wildlife at all times;
- Follow instructions issued by the Lead Scientist and Polar Bear Watch;
- Avoid actions that could attract or disturb wildlife; and
- Report wildlife sightings and incidents immediately.

A4. General Wildlife Protection Measures

- Wildlife shall not be approached, fed, harassed, or pursued.
- Disturbance to wildlife and habitat shall be minimized wherever practicable.
- Activities should be planned to avoid known sensitive wildlife areas when feasible.
- Operational footprints shall be kept as small as possible.
- Personnel shall maintain appropriate stand-off distances from wildlife.
- All wildlife observations shall be documented.
- Waste and food shall be securely stored to prevent wildlife attraction.

A5. Polar Bear Management

A5.1 Pre-Deployment Requirements

Before commencing on-ice work:

- Conduct a visual inspection of the work area for wildlife activity.
- The Bear Watch will be designated by the CCGS Henry Larsen's command team and it will be composed of at least 2x crew.
- Establish communications between field personnel and the vessel.
- Verify availability of approved wildlife deterrents and emergency equipment.
- Review evacuation procedures.

A5.2 Response Procedures

Where a polar bear is observed:

| Polar Bear Distance | Required Action |
|---|---|
| Greater than 1 km | Continue operations while maintaining enhanced monitoring. |
| 500 m to 1 km | Increase vigilance and prepare for operational suspension if required. |
| Less than 500 m | Suspend operations and prepare for personnel withdrawal. |
| Approaching personnel or displaying interest in operations | Immediately cease work and withdraw personnel to a safe location. |

A5.3 Prohibited Activities

- Feed wildlife;
- Intentionally approach bears;
- Leave food, waste, or attractants unattended;
- Separate from the work party without authorization; or
- Attempt wildlife deterrence unless trained and authorized to do so.

A6. Marine Mammal Protection

Marine mammals potentially encountered during operations may include:

- Ringed seals;
- Bearded seals;
- Walrus;
- Beluga whales;
- Narwhal; and
- Bowhead whales.

To minimize impacts:

- Avoid known haul-out areas and concentrations of marine mammals where practicable.
- Minimize vessel manoeuvring near marine mammal aggregations.
- Reduce non-essential noise-generating activities when wildlife is present.
- Delay or modify operations if animals appear disturbed by activities.
- Record marine mammal observations in the field log.

A7. Bird Protection Measures

Migratory birds and nesting colonies may be present during seasonal operations.

The following measures shall be implemented:

- Avoid known nesting and breeding areas where feasible.
- Minimize disturbance near bird colonies.
- Avoid unnecessary low-altitude aircraft operations over wildlife concentrations.
- Restrict prolonged hovering of helicopters near nesting habitat.
- Suspend activities if significant wildlife disturbance is observed.

A8. Helicopter and Remotely Piloted Aircraft System (RPAS)

Helicopter Operations

Aircraft operators shall:

- Maintain the highest safe operating altitude consistent with mission objectives;
- Avoid repeated overflights of wildlife aggregations;
- Avoid circling wildlife; and
- Minimize time spent in sensitive habitat areas.

Remotely Piloted Aircraft System (RPAS)

- Maintain safe distances from wildlife;
- Avoid direct approach flights toward animals;
- Immediately terminate flights if wildlife exhibits signs of stress or avoidance behaviour
- Operate in accordance with applicable permits and regulations.

A9. Waste and Attractant Management

To prevent wildlife attraction:

- All food shall remain in designated storage areas.
- Waste shall be collected and returned to the vessel for disposal.
- No waste shall be left on sea ice or shorelines.
- A "pack-in/pack-out" policy shall be followed for all field activities.
- Equipment and work areas shall be inspected before departure to ensure no materials remain.

A10. Wildlife Observation and Reporting

The following information shall be recorded for notable wildlife observations:

- Date and time;
- Location;
- Species observed;
- Number of animals;
- Distance from operations;
- Behaviour observed;
- Any operational modifications implemented; and
- Any safety concerns or incidents.

A11. Stop-Work Requirements

Field activities shall be suspended when:

- A polar bear enters the designated exclusion zone;
- Wildlife behaviour indicates significant disturbance from project activities;
- Personnel safety cannot be maintained;
- Regulatory or permit conditions require cessation of activities; or
- Directed by the Lead Scientist, CCGS Henry Larsen's command team.

A12. Emergency Response

In the event of a wildlife-related emergency:

1. Immediately stop work.
2. Notify all personnel and assemble at the designated safe location.
3. Withdraw personnel to the vessel or landing craft (Zodiac)
4. Implement approved wildlife deterrence measures only where necessary and by authorized personnel.
5. Notify the Lead Scientist, CCGS Henry Larsen's command team
6. Document the incident and corrective actions taken.

A13. Expected Outcome

Implementation of this protocol is intended to ensure that scientific activities during the ICENAV project activities are conducted in a manner that:

- Protects personnel from wildlife-related hazards;
- Minimizes disturbance to wildlife and sensitive habitats;
- Supports regulatory compliance and environmental stewardship; and
- Reduces the likelihood of wildlife interactions affecting the success of field operations.

**Annex B – Spill Prevention and Response Plan for Sea-Ice Coring and RPAS Operations for ICENAV**

B1. Purpose

The purpose of this Spill Prevention and Response Plan is to minimize the risk of fuel, lubricant, battery electrolyte, or other hazardous material releases during sea-ice coring and Remotely Piloted Aircraft System (RPAS) operations conducted during the ICENAV project. The plan establishes procedures to prevent spills, protect the environment, and ensure a timely and effective response should a spill occur.

B2. Scope

This plan applies to all personnel involved in:

- Sea-ice coring and ice characterization activities;
- RPAS deployment, operation, and recovery;
- Equipment maintenance and battery charging;
- Transportation, use, and storage of fuels and hazardous materials; and
- Environmental response and reporting activities.

B3. Objectives

The objectives of this plan are to:

- Prevent releases of fuel, lubricants, batteries, and other hazardous materials to snow, sea ice, seawater, and terrestrial environments;
- Minimize the potential for environmental contamination;
- Ensure personnel are trained and prepared to respond to spills;
- Recover spilled materials and contaminated media where practicable; and
- Comply with applicable environmental policies, permits, and regulatory requirements.

B4. Potential Sources of Spills

B4.1 Sea-Ice Coring Activities

Potential sources of contamination include:

- Fuel-powered ice augers or support equipment;
- Small portable generators;
- Lubricants and hydraulic fluids associated with field equipment;
- Fuel transfer and refuelling activities;
- Fuel container leakage or damage.

B4.2 RPAS Operations

Potential sources of contamination include:

- Damaged lithium-ion batteries;
- Battery charging systems;
- Portable generators used for charging equipment;
- RPAS crashes resulting in battery rupture or component loss;
- Damaged electronic equipment.

## B5. Spill Prevention Measures

### B5.1 Equipment Inspection

Prior to mobilization and daily during operations:

- Inspect all equipment for leaks, damage, or deterioration.
- Verify that fuel containers are approved, intact, and properly labelled.
- Inspect batteries for signs of swelling, puncture, corrosion, or damage.
- Remove defective equipment from service immediately.
- Maintain equipment in accordance with manufacturer recommendations.

### B5.2 Fuel Storage and Handling

- No fuel should be be taken onto the ice and equipment should be refueled onboard.
- Fuel shall be stored onboard the CCGS Henry Larsen in approved sealed containers.
- Containers shall remain closed when not in use.
- Fuel shall not be stored near cracks, leads, melt ponds, or areas where spilled material could enter marine waters.
- Fuel inventories shall be maintained and regularly inspected.

### B5.3 Refuelling Procedures

Where refuelling is required:

- Refuelling shall be conducted under direct supervision.
- Absorbent pads or portable drip trays shall be used during fuel transfer.
- Fuel containers shall remain secured during refuelling.
- Refuelling shall not occur during adverse weather conditions where spill containment may be compromised.
- Any minor drips or spills shall be cleaned immediately.

### B5.4 Battery Management

- Lithium batteries shall be transported in protective containers.
- Battery terminals shall be protected against short circuits.
- Batteries shall be inspected before and after each operation.
- Damaged batteries shall be removed from service immediately.
- Batteries shall be stored away from ignition sources and protected from physical damage.

### B5.5 RPAS Risk Reduction

To minimize the likelihood of RPAS loss or crash:

- Conduct pre-flight inspections and functionality checks.
- Operate within established weather limitations.
- Utilize geofencing and return-to-home functions where available.
- Maintain adequate battery reserves.
- Avoid flight paths over open leads, polynyas, sensitive wildlife concentrations, or areas where equipment recovery would be difficult.

B6. Spill Response Equipment

A spill response kit shall be available at all active field sites and include:

- Absorbent pads and rolls;
- Absorbent socks or containment materials;
- Protective gloves;
- Waste collection bags;
- Sealable containers for contaminated materials;
- Shovel or scraping tools for contaminated snow and ice;
- Fire extinguisher suitable for battery incidents.

Spill response equipment shall be inspected regularly and replenished as necessary.

B7. Spill Response Procedures

B7.1 Fuel or Lubricant Spill

In the event of a fuel or lubricant spill:

1. Stop the source of the release immediately.
2. Secure the area and prevent further spread.
3. Deploy absorbent materials to contain the spill.
4. Prevent spilled material from entering leads, cracks, melt ponds, or open water.
5. Collect contaminated snow, ice, absorbents, and debris.
6. Place contaminated materials into suitable sealed containers.
7. Return all contaminated materials to the vessel for appropriate disposal.
8. Notify the Lead Scientist and document the incident.

B7.2 Damaged Battery Incident

Where a battery is damaged, leaking, or overheating:

1. Suspend operations in the immediate area.
2. Isolate the battery and maintain a safe distance.
3. Use appropriate personal protective equipment.
4. Recover all battery fragments and associated debris.
5. Place damaged batteries in approved containment packaging.
6. Remove contaminated materials from the site for disposal.
7. Report the incident to the Field Team Lead.

B7.3 RPAS Crash

Following an RPAS loss or crash:

1. Record the last known position.
2. Assess recovery feasibility and safety.
3. Recover the RPAS, batteries, and associated debris where practicable.
4. Inspect the site for contamination.
5. Collect and remove any contaminated snow, ice, or debris.
6. Document the incident, recovery actions, and environmental observations.

B8. Waste Management

- All waste materials shall be removed from the field.
- A strict "pack-in/pack-out" approach shall be implemented.
- No fuels, batteries, waste, or contaminated materials shall be abandoned on sea ice or shorelines.
- Waste generated during spill response shall be returned to the vessel for appropriate disposal.

B9. Reporting Requirements

The following information shall be recorded for all spill events:

- Date and time;  Location; Material involved;
- Estimated quantity released;
- Cause of the incident;
- Environmental conditions;
- Response actions undertaken;
- Quantity recovered; and
- Corrective actions implemented.

B10. Training and Awareness

All personnel participating in field activities shall:

- Receive a spill prevention and response briefing prior to operations;
- Be familiar with the location and use of spill response equipment;
- Understand reporting requirements and response procedures; and
- Immediately report any spill, leak, or environmental concern to the Lead Scientist.

B11. Residual Risk Assessment

With implementation of the measures outlined in this plan:

- The likelihood of fuel-related spills during sea-ice coring activities is expected to be low.
- The likelihood of battery-related environmental contamination associated with RPAS operations is expected to be low.
- Environmental effects from any spill are expected to be localized, temporary, and reversible through prompt containment and recovery measures.

B12. Expected Outcome

Implementation of this Spill Prevention and Response Plan will minimize the risk of environmental contamination during sea-ice coring and RPAS operations and ensure that any accidental releases are rapidly contained, recovered, documented, and managed in a manner consistent with environmental stewardship and best practices for ICENAV'S field operations.