Canadian Research Icebreaker CCGS *Amundsen*

Health & Safety Manual for Scientific Expeditions

AMUNDSEN
SCIENCE

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1 INTRODUCTION

1.1 Objectives and outline

The purpose of this document is to provide the necessary information to ensure all personnel participating in CCGS *Amundsen* Expeditions is familiar with Health, Safety and Environment (HSE) procedures and protocols aboard the *Amundsen* and with Amundsen Science's Health & Safety Manual for Scientific Expeditions. This Health & Safety Manual is an essential part of the field program and is designed to assist science staff and students in performing their tasks safely and reliably, and to support the training and orientation of new staff and students.

Amundsen Science's Health & Safety Manual for Scientific Expeditions follow Canadian Coast Guard (CCG) HSE management and procedures which are required to comply with the International Safety Management (ISM) Code. These codes and regulations cover the management and safe operations of the CCG fleet, including the icebreaker CCGS *Amundsen*, as well as its helicopters and all small crafts launched from the *Amundsen*. When collaborating with industry partners on joint research projects, a bridging Safe Operations Plan is produced that integrates all HSE protocols and procedures specific to the planned field program, including the contents of this Health & Safety Manual.

The main objective of this document is to describe the various science operations conducted during CCGS *Amundsen* Expeditions and to outline the recommended safe method of undertaking each activity and task.

The specific objectives of Amundsen Science's Health & Safety Manual are:

- To document and describe all science operations conducted as part of Amundsen Science's Expedition.
- To identify any potential hazards and risks to personnel or to equipment associated with these operations.
- To apply safeguards and mitigation measures to eliminate or minimize these risks and hazards.
- To establish clear roles and responsibilities for all involved parties during each phase of an operation.
- To describe the execution of science operations through a sequence of clear step-by-step instructions.
- To make this Health & Safety Manual available to all involved personnel.
- To act as a foundation and create a reference to guide the development and improvement of safe work procedures as scientific program evolves.

This document is divided into three sections:

Section 1 introduces and describes the various elements of Health & Safety Manual:

- A list of relevant documents and resources
- The components of the Safe Work Procedures
- The management structure and roles and responsibilities of involved parties
- The review and update process

Section 2 outlines general HSE practices onboard the *Amundsen* and refers to the relevant supporting documents and resources.

Section 3 gives Safe Working Instructions (SWI) for science operations including:

- Deck operations: CTD-Rosette and MVP, nets and trawls to sample plankton, fish and benthos, oceanographic moorings, and sediment coring.
- Moonpool operations
- Multibeam and sonar soundings

- On-Ice operations: Sea-ice strength and dynamics, helicopter ice surveys, melt pond sampling and deployment of beacons for icebergs drift.
- *Amundsen* infrastructures and equipment: Auxiliary vessels (Zodiacs, barge and air-ice boat), helicopter, accommodation ladder and ice-cage.

1.2 Supporting documentation

The Health & Safety Manual presented here is based on various HSE documents from the Canadian Coast Guard (CCG) and Amundsen Science, SWI Meetings presentations prepared by team leaders and experienced professionals for every science operation, as well as references from official websites and videos. Here is a list of the essential documents for Science personnel to read or review prior to boarding the ship:

Familiarization Guide for Supernumerary Personnel Carried Aboard CCG ships

CCGS Amundsen Hazardous Materials User Guide

CCGS Amundsen Cryogenic Safety Manual

CCGS Amundsen Radioisotopes User Guide

Immersion suit donning procedures

Transport Canada and Canadian Coast Guard helicopter pre-flight familiarization and safety briefing video:

https://asd-sda.ca/pdf/elearning/CCG/bell_429_en.html

1.3 Description of health & safety manual elements

HSE Committee meetings

The HSE Committee consists of the Chief Officer, the Chief Scientist and industry HSE advisor (if present) and reports to the Commanding Officer. Meetings of the HSE Committee take place at the beginning of each Leg (transition meeting) and at least once a week during the Leg. The meetings are an opportunity for the people responsible for the day-to-day safety of operations and of their teams to review any incident report or safety issues that arose and ensure the appropriate corrective actions or mitigation measures were put in place.

General Science Meeting

When boarding the vessel for each Leg of the Expedition, all supernumerary personnel are required to attend
the General Science Meeting. The purpose of this meeting is to ensure that personnel are fully familiar with:

• The scope and objectives of the scientific program and of the Leg.
• The roles and tasks of other science teams and the objectives of their projects.
• The health, safety and environment (HSE) procedures and protocols, including an outline of the health & safety manual and their roles and responsibilities within it

Job Safety Analysis (JSA) for all operations

A JSA is a written procedure that summarizes and integrates accepted H&S principles and practices into a particular task or job operation. Amundsen Science management in collaboration with its employees and senior ArcticNet scientists has created a JSA for each existing scientific operation, in addition of developing a detailed Powerpoint presentation for specific operations. Each JSA identifies the required safety equipment and describes the operation job sequence, the hazards associated to it, and how to prevent them. The JSA's information is continually updated to reflect upgrades and corrective actions identified and reviewed during the task by the workers or their supervisors. They are collated into a binder that is made available to scientists and crew members prior to the beginning of the annual Arctic Expedition.

SWI Meetings (presentations to scientists and crew)

The team leader or experienced professional for each component or type of science operations will present the Safe Work Instructions (SWI) for a particular task to all science staff and crew members who will be involved in the task. These meetings will be held at the start of every Leg when changes in personnel, tools or procedures occur, when a new hazard is identified or a new control measure is introduced, and at any time the safety of personnel or the integrity of the equipment is compromised during the execution of the operations.

Daily Operational Meetings

All scheduled science operations for a given day are usually reviewed every morning by the Commanding Officer, the Chief Officer and the Chief Scientist. Operational Meetings are then planned prior to each operation that is conducted for the first time – or as needed during the Leg. These meetings represent a shortened version of the SWI meetings and are intended to assess current environmental conditions and any change to the procedure presented at the beginning of the Leg. Roles and responsibilities are also reviewed, with a particular attention to any new personnel involved in the operation.

Toolbox Meetings

A Toolbox Meeting is held prior to every operation, usually 5 minutes before performing the task. It allows to review the safe working instructions, the roles of all participants, the hazards identified for each step or task, and ensures that the control measures and safeguards to minimize the risks are in place, including the verification that all participants are wearing the appropriate personal protective equipment (PPE).

STOP and Think

Stop and Think is a brief individual mental hazard assessment of the environment, of the task and of oneself. It is done by the workers before and during the work. It serves to:

- Focus the worker's attention on the task.
- Self-assess the task and oneself.
- Identify and eliminate unsafe behaviors and hazardous conditions.
- Promote an environment where workers are constantly assessing their own actions and work areas for hazards.
- Support the JSA with real-time hazard identification as the operations take place.

Cards as shown in Figure 1 can be supplied to workers to facilitate the Stop and Think hazard identification process and act as a reminder to be continually alert.

Figure 1 Stop and Think cards provided to workers and posted in work areas as reminders to assess safety and identify hazards during operations.

Safe Working Instructions (SWI)

Safe Working Instructions are created for every science operation conducted during *Amundsen* Expedition. They must be written by a person with sound, hands on experience and knowledge of the science operations being described. They involve the persons who will be using the Instructions as well as involve consultation with a Health and Safety representative. When complete, the Safe Working Instructions should be reviewed by the supervisor and personnel involved in the activity for which the SWI were intended. The SWI should then be signed and dated by the supervisor. In the case the task is carried from a CCG ship, the Safe Working Instructions should be also reviewed, signed and dated by the Commanding Officer in charge. The revised Safe Working Instructions should be displayed prominently and available to all staff, students and crew that may need them.

Safe Working Instructions include the following information:

- Step-by-step instructions for each scientific activity in plain language
- Precautions to be undertaken before commencing the task
- Specific information regarding the hazards and associated risks of the task
- Who is authorized or allowed to carry out the work

- Tools or equipment used in the activity
- Personal protective equipment (PPE) to be worn while undertaking the task
- Description of the environment where the task must be undertaken and associated environmental risks
- Clear instructions for undertaking the task described in a safe manner
- Specific instructions regarding ways of minimizing the risks of the task

Daily reporting

The Chief Scientist can keep a log of all health and safety related issues in the daily reports, which will be directly used to update Amundsen Science's health & safety manual for scientific expeditions.

1.4 Management and organization of HSE

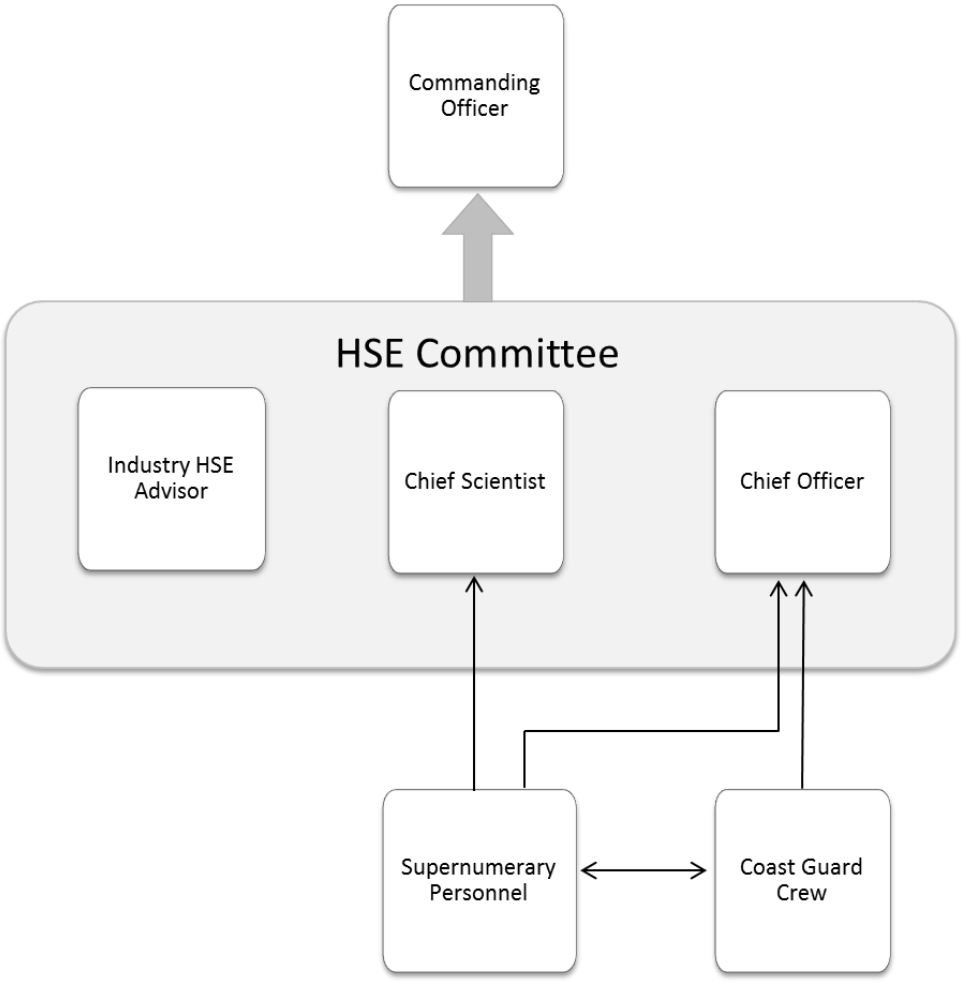

Figure 2 Organisation Chart for the planning, implementation and review of the Health and Safety Management Plan for science operations onboard the CCGS Amundsen.

Commanding Officer of the CCGS *Amundsen*: most senior officer of the vessel responsible for overall safe operation of the ship and her crew.

Chief Officer: Second in Command of the vessel responsible for day-to-day overview of safe operations, and of the crew and supernumerary personnel onboard.

Chief Scientist: most senior scientist on the vessel responsible for overall safety and planning of science operations, and of the supernumerary personnel onboard.

Industry HSE Advisor: representative of industry partners responsible for integrating their organization's HSE Management Plan and the vessel health & safety manual.

Coast Guard Crew: all members of the Canadian Coast Guard Service.

Supernumerary Personnel: all personnel that are not members of the Canadian Coast Guard Service, including industry partnerships and outreach programs (e.g., Schools on Board, Inuit capacity building programs, VIP guests, media, etc.).

1.5 Roles and responsibilities

The role of each individual involved must be made clear prior to the beginning of science operations. All participants must be familiar with the Safe Work Procedures and with the roles and responsibilities associated with the tasks they undertake. All participants in science operations:

- Must refuse work that they consider unsafe; if they have a safety concern, they must report it and it must be resolved before work may proceed.
- Have the right to refuse work where they feel their ability to function may be impaired by fatigue or illness. The task must then be reassigned to another trained and qualified person, and if necessary, the shift schedule and duties must be adjusted by the supervisor(s).

Commanding Officer:

- Has the ultimate authority and responsibility for taking all necessary actions for the safety of the ship, the safety of personnel aboard, and for the protection of the environment.
- Ensures that all HSE procedures and protocols are followed.
- Receives reviews and recommendations from the HSE Committee after each meeting.

The HSE Committee:

- Consists of the Chief Officer, the Chief Scientist and industry HSE advisor (if present).
- Reports to the Commanding Officer.
- Meets at the beginning of each Leg of the Expedition (transition meetings at crew and science personnel changes), and weekly during each Leg.
- Identifies priorities and goals of the HSE and Safe Work Procedures.
- Reviews audits and inspections conducted onboard and submits recommendations.
- Reviews all incident reports (near-misses, hazards, injuries, etc.) and submits recommendations.
- Reviews crew and supernumerary personnel's inputs or concerns and addresses them.
- Makes public the reviews and recommendations issued from these meetings for all personnel to consult and review.

Chief Officer:

- Works with the Chief Scientist and industry HSE advisor(s) to achieve high safety standards within the framework of the operations and science objectives of the expedition.
- Contributes to the vessel's HSE Committee and reports to the Commanding Officer.
- Ensures that all participants onboard are informed of the safety procedures and of their roles and responsibilities.
- Ensures that all participants onboard are qualified and trained according to the requirements outlined in the Safe Work Procedures.
- Ensures that safety procedures are followed by crew and supernumerary personnel on a day-to-day basis.
- Ensures that crew members are fit and ready for work by planning the crew shift schedules and duties.
- Participates in the investigation of all incidents and the implementation of corrective actions.
- Tracks and monitors observations and recommendations from the crew and supernumerary personnel.
- Identifies and removes potential risks to personnel or equipment.
- Participates in the review and update process of the Safe Work Procedures.

Chief Scientist:

- Works with the vessel's Chief Officer and industry HSE advisor(s) to achieve high safety standards within the framework of the operations and science objectives of the expedition.
- Contributes to the vessel's HSE Committee and reports to the Commanding Officer.
- Ensures that all supernumerary personnel onboard are informed of the safety procedures and of their roles and responsibilities.
- Ensures that all supernumerary personnel onboard are qualified and trained according to the requirements outlined in the Safe Work Procedures.
- Schedules the time and sequence of science operations with the Commanding Officer and Chief Officer.
- Ensures that safety procedures are followed by supernumerary personnel on a day-to-day basis.
- Fills in daily reports that include a summary of any health and safety issues that arose.
- Participates in the investigation of all incidents and the implementation of corrective actions.
- Tracks and monitors observations and recommendations from the supernumerary personnel.
- Identifies and removes potential risks to personnel or equipment.
- Participates in the review and update process of the Safe Work Procedures.

Industry HSE advisor:

- Works with the CCG and Amundsen Science personnel to achieve high safety standards within the framework of the operations and science objectives of the expedition.
- Contributes to the vessel's HSE Committee (with the Chief Officer and the Chief Scientist) which reports to the Commanding Officer.
- Ensures that their organization's participants are informed of the safety procedures and their roles and responsibilities.
- Ensures that their organization's participants are qualified and trained according to the requirements outlined in the Safe Work Procedures.
- Verifies that the procedures documented in this Safe Work Procedures are followed.
- Tracks and monitors observations and recommendations from their organization's personnel.
- Identifies and removes potential risks to personnel or equipment.
- Participates in the review and update process of the Safe Work Procedures.

Coast Guard Crew and Supernumerary Personnel:

- Know the Safe Work Procedures and their roles and responsibilities within it.
- Ensure they are trained and qualified for the operations they undertake, as outlined in the Safe Work Procedures.
- Attend the mandatory familiarization and safety orientation tours, emergency drills, General Science Meeting, and relevant SWI and Toolbox Meetings.
- Assess each work space or task for possible hazards before proceeding and apply the appropriate safeguards and mitigation measures to eliminate or minimize them.
- Call a STOP and THINK moment if any circumstance compromises safety, health or the environment.
- Report all hazards, incidents and near-misses promptly to their immediate supervisor, and to the Chief Officer and the Chief Scientist.
- Follow Safe Operations procedures and the direction of supervisors, and practice common sense.
- Propose ideas to further improve safety during operations, including hazard identification and near-miss reporting.
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The Amundsen Science Project Coordinator:

- Plans the Expedition (timetable, equipment, etc.) in accordance with the objectives of the different scientific program and collaborations with partners on joint research projects.
- Provides the Expedition Plan and Safe Work Procedures for all science operations onboard the *Amundsen*.
- Directs users towards the relevant information for access and use of hazardous materials on board the CCGS *Amundsen*.
- Provides the Commanding Officer and Chief Officer of the CCGS *Amundsen* a complete list of all hazardous materials that will be used on board during a scientific expedition, as well as provides to Université Laval the estimated amount of hazardous waste that will be produced during the expedition.
- Overviews the use of radioisotopes onboard the ship and ensures the management of radioactive waste produced during the Expedition along with the Radiation Safety Officer (RSO) of Université Laval.

1.6 Review and update process

The Amundsen Science Safe Work Procedures is a living document that will be reviewed and updated based on:

- HSE Committee reports and recommendations during each Leg of the Expedition, as new hazards are identified during operations or if incidents occur, and procedures are modified by corrective actions or improved to ensure higher safety standards.
- Inputs and suggestions of science staff and CCG crew members that propose improvements.
- New operations being added or operations being modified or removed.

2 GENERAL HSE PRACTICES ABOARD THE CCGS *AMUNDSEN*

This section outlines the key HSE procedures and protocols aboard the CCGS *Amundsen* that are relevant to science operations. It also describes the main stages of planning the field expeditions in terms of safety during science operations and the tasks required of all participants at each stage. A detailed definition of the roles and responsibilities of all parties involved can be found in Sections 1.4 and 1.5.

2.1 General considerations

A *Familiarization Guide for Supernumerary Personnel Carried Aboard CCG ships* is sent to all participants involved in *Amundsen* Expeditions and should be read or reviewed before embarking. This document gives information on the preparation before boarding and about life onboard, including many aspects of health and safety, as well as emergency situation procedures. This section summarizes the main points regarding safety onboard, and participants are required to read the Familiarization Guide as well as Sections 2.2 and 2.3 below for more details.

Before the ship sails

All personnel involved in science operations should review the following points with their supervisor or team leader and be familiar with them before boarding the *Amundsen*:

- The location of the major work areas and laboratories.
- Their tasks and responsibilities onboard the ship.
- The plans concerning gear and safety equipment needed for their team's project.

Each science team must provide a complete list of hazardous materials brought on board to the Amundsen Science Project Coordinator (PC) in accordance with the guidelines in the *CCGS Amundsen Hazardous Materials User Guide* (see Section 3.7 for a summary) and all dangerous goods loaded aboard must be wrapped in compliance with Transport Canada *Transportation of Dangerous Goods Regulations*.

Onboard the ship

All supernumerary personnel are required to:

- Read the Commanding Officer's Standing Orders, which are posted on bulletin boards. They include many instructions relative to safety, including procedures in the event of an emergency and the sections or rooms of the ship reserved for certain designated personnel, i.e. access to the bridge, the engine room and the galley.
- Know the locations of the designated muster station, of their lifejacket, and of fire extinguishers near living and working areas.
- Learn their way around the ship as early as possible. In particular, the area around their cabin and work spaces, and the best paths to go to designated emergency or muster station.
- Take part in the Boat and Fire drills, and follow the established orders in an emergency situation or when a drill is held. This information will be communicated during the initial safety and orientation tour of the ship upon arrival.
- Know the Emergency Warning signal and Lifeboat Station Muster signal.
- Know the meaning of the safety signals posted aboard the ship.
- Be very familiar with the Workplace Hazardous Materials Information System (WHMIS) as well as the location of the Material Safety Data Sheets (MSDS) for the hazardous materials they work with.

- Wear the safety equipment (PPE, lab coat, flotation devices, etc.) called for to carry out their specific tasks and always wear appropriate safety clothing (safety hat and steel toe shoes) when working on deck.
- Know when outside decks are off limits to unauthorized personnel, for example during deck operations or in bad weather.
- Stay clear of all ropes, cables and blocks under strain and not touch any rope or cable that is moving.
- Advise the First Aid Attendant or onboard Medic if they have any medical problem.
- Notify their supervisor and the Chief Scientist if they sense a danger or if any circumstance threatens safety.

Drug/alcohol consumption and smoking

CCG ships and aircrafts are multi-taskable resources that can be assigned, with minimal notice, to conduct an escort, enforce fisheries regulations, limit damages or assist in Search and Rescue (SAR) activities. In view of the importance of these roles and responsibilities, persons are prohibited from carrying out their duties on board a CCG ship or aircraft when under the influence of psychoactive substances. This policy applies to supernumerary personnel as well as to the ship's crew.

- All persons aboard are required to be aware of the rules of conduct and behaviour expected of them. No person shall be impaired by a psychoactive substance at any time while onboard a CCG ship or aircraft.
- No person shall perform, or attempt to perform, any duties while impaired by a psychoactive substance. A person may consume a legal prescription or non-prescription drug, provided it does not cause the person to become impaired.
- Any person found to be in contravention of this policy is subject to disciplinary action up to, and including, discharge.
- The Commanding Officer has the absolute authority to remove any person who is in violation of this policy from the vessel or aircraft.

Alcohol consumption onboard the ship is prohibited.

A detailed policy on smoking on board the ship is set down in the Commanding Officer's Standing Orders. Smoking in bed is strictly prohibited and smoking may also be banned on open decks during certain operations. As well, smoking may be banned in certain areas where flammable hazardous materials are stored or used. Check with the ship's authorities for the various bans.

Emergency situations

The following information summarizes the procedures with three types of emergency situations. Specific characteristics and procedures to follow can be found in the *Familiarization Guide for Supernumerary Personnel Carried Aboard CCG ships* and will also be presented during the safety and orientation tour of the ship upon arrival.

Fire

A fire onboard a ship is one of the most dangerous situations. Most fires are caused by negligence, so it is essential to remain vigilant and continually observe the environment. The following are general instructions that must be followed when a fire is spotted or when there is reason to believe that there is a fire aboard:

- Do not open the door if a fire is suspected somewhere.
- Sound the alarm, alert the deck officers and indicate where the fire is located.
- Where possible, close the doors and hatches in order to isolate the fire.
- When the alarm signal is sounded, report to the designated muster station.
- If surrounded by smoke, cover the nose and mouth with a damp cloth and crawl on the deck, where the smoke is less dense.

Person Overboard (Man Overboard - MOB)

If a person falls into the water:

- Throw a lifebuoy over the side of the ship.
- Notify the deck officers or supervisor that there is a "MAN OVERBOARD / UN HOMME À LA MER" while indicating on which side of the ship the person has fallen.
- Keep eyes constantly fixed on the person overboard.
- Point to the person to help locate and keep the person in sight.

Accidents and injuries

All accidents and injuries, as well as equipment loss or damage, must be reported to the deck officers or supervisor, and ultimately to the Chief Officer and Chief Scientist responsible for resolving any safety issue and incident that arise onboard the ship. The watch officer will inform the Commanding Officer, when appropriate, and will have an emergency action taken if necessary.

2.2 Planning the Expedition in terms of Health and Safety

<u>Prior to departure of the *Amundsen* for its annual voyage</u>

In the weeks prior to the departure of the ship for its annual voyage, the Amundsen Science Project Coordinator (PC) will provide the Canadian Coast Guard, the Commanding Officers, the Chief Scientists and all partners with:

- The Expedition Plan
  - a timeline of the Expedition and an overview of each Leg
  - a description of the scientific objectives of each Leg
  - a list of stations with geographic coordinates
  - a description of operations at stations
- The Safe Work Procedures (reviewed and updated)

This is also the period in which all science participants must ensure that they and their team (if they hold a supervisory position) fulfill the requirements for the tasks and operations they will perform, as outlined in the Safe Work Procedures. They must:

- Read the Safe Work Procedures and understand their role and responsibilities.
- Have the required training, certifications and permits.

Prior to each Leg of the Expedition

In the weeks prior to the start of each Leg of the expedition, the Chief Scientist and the Project Coordinator will meet to review the Expedition Plan and discuss any logistical issues. The Project Coordinator will also provide to the Chief Scientist the following documents:

- Summary of the Expedition Plan
- Expedition timeline
- List of all stations, including geographic coordinates
- Description of operations at stations
- The Safe Work Procedures relevant for the planned operations
- Copy of all the required scientific licenses
- List of hazardous materials
- Amundsen Science reporting guidelines (Chief Scientist Daily Report template and guidelines for individual team reports)
- Any other relevant document to carry out the Expedition plan

Day of embarkation

Transition Meeting

Crew changes will include at least one hour of overlap between key personnel (science staff or CCG crew) on board the vessel or on land. This meeting constitutes an occasion to transfer knowledge to the incoming CCG Officers and Chief Scientist regarding equipment performance, science operations, personnel, etc. This is also the occasion to hold the HSE Committee transition meeting to discuss any health and safety issues that arose during the previous Leg. More specifically, the HSE Committee will review incident reports (near-misses, hazards, injuries, etc.), submit recommendations and ensure that corrective actions are in place.

General Science Meeting

At the beginning of each Leg, a meeting will be held with all Supernumerary Personnel once everyone is on board the vessel. This meeting includes the following:

- Welcome from the Commanding Officer and Chief Scientist
- Introduction of science participants
    - Presentation by the Chief Scientist including safety onboard
        - Familiarization and Safety Orientation Tours
        - Emergency Drill
        - Safe Work Procedures for scientific operations
        - Safe Working Instructions (SWI) Meetings to review science operations procedures and safety protocols
        - Use and disposal of chemicals, and location of MSDS
        - Helicopter familiarization for those conducting dedicated helicopter operations
- Briefing by Commanding Officer and signing of security clearance certificate for new participants
- Briefing by ship nurse/onboard Medic regarding medical evaluation

Safety orientation, emergency drills and SWI meetings

The *Familiarization and Safety Orientation* tour is mandatory for all new participants and for personnel who have not been onboard the *Amundsen* in the past 6 months.

The *Emergency Drills* are mandatory for all personnel aboard. The *Helicopter familiarization* and a copy of their Helicopter Ditching training certificate is required for science personnel involved in dedicated science operations using the helicopter and must be provided to the Chief Scientist.

The *SWI Meetings* are prepared by team leaders or experienced professionals and present operational procedures and safety protocols for every science operation. These SWI Meetings are required for science staff and CCG crew prior to carrying out operations for the first time of a Leg.

During the Leg

A S*teering Committee Meeting* is held every evening to discuss the day's operations, the plan for the following day and any operational or safety concerns. After the nightly steering meeting, the next day's schedule is printed and posted on the Bridge (3 copies), the Science billboard (1 copy) and the Rosette control room (1 copy).

The Chief Scientist fills out a daily report, in which any health and safety issue that occurred in the last 24 hours is stated, with any corrective action put in place or recommended. The Chief Scientist is also responsible ensuring on a day-to-day basis that all work involving hazardous materials is carried out safely on board the CCGS *Amundsen*. Safety guidelines and work procedures are provided in the CCGS *Amundsen* Hazardous Materials User Guide and in the CCGS Amundsen Radioisotopes User Guide.

Week prior to disembarkation

A meeting is held with all supernumerary personnel in the week before disembarkation to inform them of the following:

- Due date for their team's Leg reports, which should include their comments and recommendations on any health and safety issues.
- Clean up of lab spaces, including the safe storage or disposal of hazardous materials.
- Schedule for the crew change (list of personnel and helicopter boarding times).
- Procedures for immersion suits for helicopter transport during the crew change.

2.3 Training, certifications and permits

The following training and certifications may be required for supernumerary personnel depending on the tasks and operations they will perform. Supernumerary personnel are responsible of ensuring they fulfill the requirements and certifications for their tasks before they board the ship.

- Helicopter ditching course (see Section 3.6.4 Helicopter).
- WHMIS training certificate in the use, storage and disposal of hazardous materials (see Section 3.7).
- Radioactive work permit (see Section 3.7).
- Firearm operation training and license (see Section 3.5 On-Ice operations).
- First Aid training.
- Fall prevention for scientific personnel (given onboard by a competent person).
- Safe Working Instructions (SWI) Meetings relevant to each science operation.

2.4 Psychological and sexual harassment prevention

Context

The purpose of this section is to provide the necessary information to ensure all personnel participating in CCGS *Amundsen* Expeditions are treated with respect and dignity and participate in creating a safe environment and a good atmosphere on board the ship. The working and living environment on the ship shall be characterized by respect for differences and respectful open communication and shall prevent hostile or offensive environment.

Amundsen Science is committed to eliminate any type of harassment and will not tolerate it from any person including chief scientists, scientists, students, scientific staff, artists and media, CCG commanding officer, CCG officers and CCG crew.

Definition

Under the Canadian *Policy on Harassment Prevention and Resolution*, harassment is defined as:

> *Improper conduct by an individual, that is directed at and offensive to another individual in the workplace, including at any event or any location related to work, and that the individual knew or ought reasonably to have known would cause offense or harm. It comprises objectionable act(s), comment(s) or display(s) that demean, belittle, or cause personal humiliation or embarrassment, and any act of intimidation or threat. It also includes harassment within the meaning of the Canadian Human Rights Act (i.e. based on race, national or ethnic origin, colour, religion, age, sex, sexual orientation, marital status, family status, disability and pardoned convictions).*
>
> *Harassment is normally a series of incidents but can be one severe incident which has a lasting impact on the individual.*

The definition of harassment means that more than one act or event is needed in order to constitute harassment. Taken individually, this act or event need not constitute harassment: it is the repetition that generates the harassment. In other words, harassment consists of repeated and persistent behaviors towards an individual to torment, undermine, frustrate or provoke a reaction from that person. It is a behavior that pressures, frightens, intimidates or incapacitates another person with persistence. Each behavior viewed individually may seem inoffensive but the synergy and repetitive characteristic of the behaviors produce harmful effects.

However, one single incident can constitute harassment when it is demonstrated that it is severe and has a significant and lasting impact on the complainant.

Note 1: The legitimate and proper exercise of management's authority or responsibility does not constitute harassment.

Note 2: Sexual and physical assaults are defined by the Criminal Code and will be dealt with according to that legislation. If you have been assaulted, you should seek assistance immediately and contact the police.

Amundsen Science Code of Practice regarding harassment

1. Reporting harassment

    a. How to report harassment

CCGS *Amundsen* expedition participants can report incidents or complaints of harassment verbally or in writing. When reporting verbally, the reporting contact, along with the worker complaining of harassment, will redact a report of the incident together.

The report of incident must include the following information:

- Name(s) of the complainant(s) and contact information
- Name of the alleged harasser(s), position and contact information (if known)
- Names of the witness(es) (if any) or other person(s) with relevant information to provide about the incident (if any) and contact information (if known)
- Details of what happened including date(s), frequency and location(s) of the alleged incident(s)
    - Any supporting documents the worker who complains of harassment may have in his/her possession that are relevant to the complaint
    - List any documents a witness, another person or the alleged harasser may have in their possession that are relevant to the complaint.

We can offer different options to the victim going from moral support, berth reallocation and consult with the medical officer to the use of the helicopter to evacuate the victim from the ship and support in finding the most effective way to fly the person back home.

    b. Who to report workplace harassment to

Report a harassment incident or complaint to the **chief scientist or to any of the two designated senior scientists** should the incident be reported while onboard the ship or to **Amundsen Science management** (info@as.ulaval.ca), should the incident be reported after the end of the expedition.

All incidents or complaints of harassment shall be kept confidential except to the extent necessary to protect expedition participants, to investigate the complaint or incident, to take corrective action or otherwise as required by law.

2. Investigation and handling of a complaint

Amundsen Science will ensure that an investigation appropriate in the circumstances is conducted when a report of incident harassment is received.

Management will investigate and deal with all complaints or incidents of harassment in a fair, respectful and timely manner. Information provided about an incident or about a complaint will not be disclosed except as necessary to protect participants, to investigate the complaint or incident, to take corrective action or as otherwise required by law.

    a. Timing of the investigation

Actions will be taken as soon as reasonably possible.

If the incident is reported during the expedition, a response within the next half-day is expected.

If the incident is reported after the end of the expedition action should be undertaken within 10 working days of receipt of the incident report.

b. Handling complaints

Should the respondent of the complaint be from the Canadian Coast Guard, the person in charge of the complaint reports it to the commanding officer and refers to Fisheries and Oceans Canada Policy on Harassment Prevention and Resolution for the next phases of the investigation.

Should the respondent of the complaint be from outside the Canadian Coast Guard, the person in charge of the complaint reports it to Amundsen Science management and initiate the investigation.

Interim measures for the time of the investigation as well as discipline measure (should harassment is found funded) will be determined by the person in charge of the complaint together with Amundsen Science management. These measures can go from berth reallocation and task reorganization to banishment from the ship.

Figure 3 describes Amundsen Science harassment complaint resolution process.

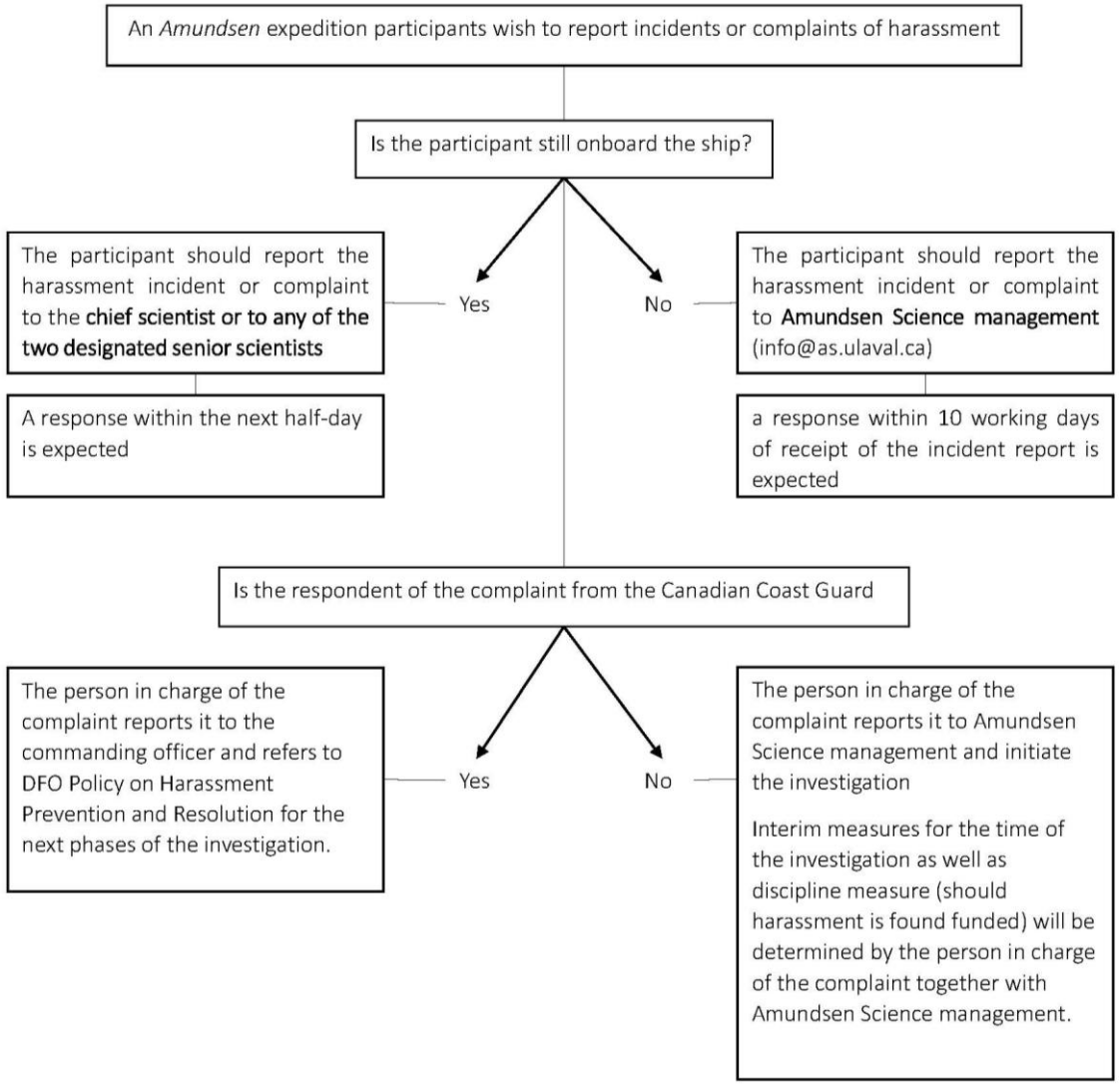


Figure 3 Amundsen Science Harassment Complaint Resolution Flow Chart

3. Record keeping

The employer (human resources or designated person) will keep records of the investigation including:

- a copy of the complaint or details about the incident;
- a record of the investigation including notes;
- a copy of the investigation report (if any);
- a summary of the results of the investigation that was provided to the worker who allegedly experienced the workplace harassment and the alleged harasser, if a worker of the employer;
- a copy of any corrective action taken to address the complaint or incident of workplace harassment.

All records of the investigation will be kept confidential. The investigation documents, including this report should not be disclosed unless necessary to investigate an incident or complaint of workplace harassment, take corrective action or otherwise as required by law.

Records will be kept forever.

Addendum

All employees are expected to act towards other individuals professionally and respectfully and to speak out against unacceptable behaviors in a skillful and sensitive manner. As the improper conduct is not directed at anyone in particular, as per the definition of harassment, a witness may not file a harassment complaint. Witnessing offensive behavior towards others does not constitute harassment for that witness. However, the situation should be reported to the supervisor or to the manager at the next level and prompt action is expected to be taken. All managers are expected to intervene promptly when they become aware of improper or offensive conduct even when no complaint has been made.

3 SAFE WORKING INSTRUCTIONS (SWI) FOR SCIENCE OPERATIONS

3.1 General considerations

Safe Working Instructions (SWI) are required and created for any routine or repeated activity that is associated with a medium to high risk. Medium to high risk in the context of science operations onboard a ship means any activity where an injury or emergency situation may occur, or where equipment may be damaged or lost if not carried out with care or attention.

This Section gives Safe Working Instructions for science operations that are divided into 5 groups:

- **Deck operations**: CTD-Rosette and MVP, nets and trawls to sample plankton, fish and benthos, oceanographic moorings, sediment coring.
- **Moonpool operations**: ROV and CTD-Rosette.
- **Multibeam echosounder and sonar surveys**.
- **On-Ice operations**: Sea-ice strength and dynamics, helicopter ice surveys, melt pond sampling and deployment of beacons for icebergs drift.
- ***Amundsen* infrastructures and equipment**: Auxiliary vessels (Zodiacs, barge and air-ice boat), helicopter, accommodation ladder and ice cage.

3.1.1 Environmental considerations

Safe go/no-go guidelines are established to guide decision to proceed or not with an operation and may differ depending on the operation, i.e. deck vs. on-ice operations will have different guidelines. They also depend on the prevailing ice, sea-state and weather conditions before and during the operations, which are assessed by the Commanding Officer and the Chief Scientist, with the counsel of the Helicopter pilot and Responsible scientist when necessary. If there are any potential risk or danger, or if conditions appear to change, the Commanding Officer and/or the Chief Scientist can cancel or postpone the operation.

3.1.2 Daily shift schedule and duties

An important component of health and safety onboard is that all personnel involved in science operations are fit and ready for work. The Chief Officer is responsible for organizing CCG crew shift schedule and duties, generally dividing the crew into a day shift and night shift. This allows that the minimum number of qualified people required for a planned operation is always available and that rest periods are included and adhered to. Workers are thus fit for work and fatigue does not compromise the safety of operations. The Chief Scientist is responsible for planning the timing and sequence of science operations so that science personnel's time is optimized and overwork is avoided as much as possible. When long hours are involved to carry a particular task, the team lead or supervisor is responsible for putting in place a shift change schedule and ensure personnel are not overworked. This situation may occur whenever an operation is conducted during transit, for example multibeam echosounder mapping of the seafloor as the *Amundsen* travels from one site or station to another.

3.1.3 Emergency response and medical evacuation (Medevac)

An outline of the procedures to follow in case of an emergency can be found in Section 2.1 and is presented in the Familiarization Guide as well as during the Safety Orientation Tour upon arrival on the ship. The

following sections describe the procedures to be followed in case of an emergency requiring medical evacuation (Medevac).

3.1.3.1 Vessel Bridging Procedure

All Amundsen Science supernumerary personnel and partners must report all work-related incident, injuries and illnesses immediately, regardless of severity, to the on-board medical staff, and to the Chief Scientist or on board safety representative. For pre-existing non-work-related conditions, personnel are required to inform the medic or nurse only, as soon as possible after embarkation.

All medical information will be treated as confidential. To ensure that Amundsen Science supernumerary personnel will not suffer undue risk to their health by being on board, all personnel need to complete a statement of medical fitness before embarkation. This requires full disclosure of any prescription or non-prescription drugs that are being taken to treat health issues.

Medevac procedures have been developed to respond to anyone onboard the *Amundsen* who requires medical attention ashore, as a result of illness or injury. Only in cases of life-threatening emergencies will the helicopter be used to transfer an individual to a medical facility onshore.

3.1.3.2 Medevac procedures

Procedures for medical evacuation are covered in the Coast Guard ISM code and *Amundsen*-specific emergency procedure manuals, and meet Amundsen Science's HSE best practices and requirements. Figure 3 shows the decision and action flowchart of Medevac procedures for the CCGS *Amundsen*.

When an injury or accident occurs:

The onboard medical staff:

1. Assesses the patient's condition, and might consult with onshore medical advisors or doctors, if required.

If the injury or illness is non-urgent or non-emergent:

2. The Amundsen's medical staff treats the condition with the vessel medical resources.

If the injury or illness is urgent or emergent:

The onboard medical staff:

3. Consults with the Commanding Officer about the need for a medical evacuation.
4. Contacts an Emergency Medicine Physicians EXtended Services (EMPEX) physician.
5. Advises the program manager, who in turn informs program collaborators, if necessary.
6. Provides the following information to the Chief Scientist and program manager, and to onboard safety representative:
    - Brief description, type, severity of injury
    - Name and location of vessel involved
    - Date and time of incident
    - Name of injured, and third party, if any
    - Job title of injured person
    - Initial injury and treatment given
    - Status of the injured person at the time of the report
    - Brief description of asset, environmental of information loss

The Commanding Officer:

7. Determines what Medevac resources are available, by:
   - Contacting the nearest Joint Rescue Coordination Centre (JRCC) for operational support.
   - Mobilizing the onboard helicopter, if necessary.
8. Contacts the emergency response team leader and the local marine superintendent, to assess the need for a ship-to-ship transfer, in extreme cases.

The Commanding Officer, EMPEX physician and onboard medical staff:

9. Initiate the Medevac procedure in accordance with the Coast Guard ISM code and emergency procedures.
10. If medical assistance is required for the transfer, inform the patient transfer crew (vessel's helicopter crew or Mediflight crew).

The JRCC assumes operational command of the evacuation:

11. Overviews vessel or helicopter transport to the closest medical facility.
12. Informs the appropriate shore-based medical reception facility.
13. Sends the Patient Medevac Report Form to the onshore medical advisor or intended medical reception facility, by e-mail or fax, including information about:
    - The number of patients and their condition
    - The position of the vessel and its intended course
    - Weather conditions

When the patient arrives onshore:

The onshore representative:

14. Meets the aircraft
15. Coordinates, with the hospital staff, the patient's transfer to the medical facility.
16. Arranges for a suitable individual to accompany the patient.

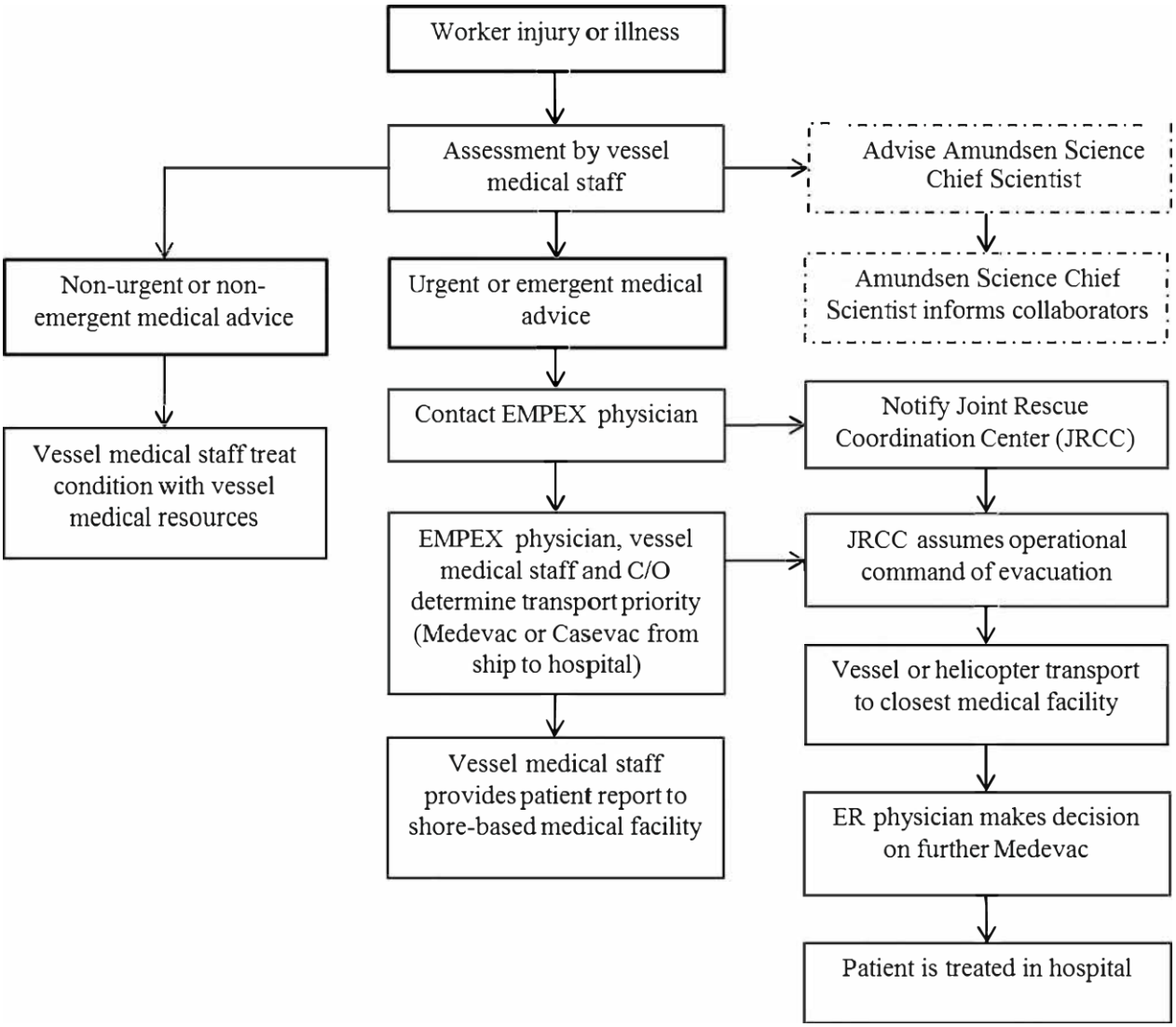


Figure 4 Flowchart of Medevac procedures onboard the CCGS Amundsen

3.1.4 Planning the Safe Work Procedures for science operations

Planning the activities, identifying potential hazards associated with the task and putting in place control measures are essential tasks that need to be defined before operations take place on the ship. Two important tools are used in the preparation and planning phase of scientific operations:

1. A Job Safety Analysis (JSA) is completed for each science operation before the ship's departure to outline the sequence of steps or tasks, assess the risks and hazards associated with each step and establish control measures that will be put in place to eliminate or reduce the risks.
2. SWI Meeting presentations are prepared, which describe the work procedures and explain the risks associated with the task and the safeguards and mitigation measures put in place. This meeting is mandatory for all participants involved in an operation and is usually held at the beginning of each Leg and whenever new personnel, tools or procedures are introduced.

The JSA and SWI Meeting presentations are reviewed and updated regularly and are essential in allowing all participants to understand the procedures, the risks involved and their role and responsibilities when performing the activities.

Risks associated with the planning phase and precautions and control measures to be undertaken before commencing any science operation.

Risks	Control measures
Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.)	Risk analysis and Job Safety Analyses (JSA) in place Review and update Safe Work Procedures Establish operational guidelines and limitations Establish safe go/no go decision guidelines MOB procedures in place Safe lifting plan in place Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task to: • Outline step-by-step operation • Identify potential dangers: injuries, equipment damage or loss, sea or meteorological conditions, etc. • Identify preventive and mitigation measures: PPE, safety equipment, procedures, training, communications, etc. • Present a visual plan of the position of personnel on deck • Present roles and responsibilities of all involved personnel and ascertain their comprehension Mandatory training and certifications for crew members and scientific staff

3.2 Deck operations

Deck operations are conducted in various areas of the *Amundsen* but most deployments of scientific instruments occur on the foredeck, either on the port side when operations require the A-frame, or on starboard, when the crane is used. The CTD-Rosette and MVP have their own launching areas. Two deck operations can never be conducted at the same time, and it is the responsibility of the Chief Scientist to schedule the sequence of activities so that operations take place in an efficient manner. The officer on watch on the bridge must be notified before the start of any deployment and when operations conclude, and the officer on watch is responsible for ensuring that no simultaneous or overlapping operations occur.

3.2.1 CTD-Rosette

General description of the activity

The CTD-Rosette consists of electronic instruments and a series of bottles mounted on a frame and attached to an electronic cable connected to computers in the Rosette operation room. It allows to measure physical and chemical properties of the water column (salinity, temperature, oxygen, fluorescence, and current) and to collect water samples at specific depths by closing the bottles in sequence at the desired depths.

The CTD-Rosette can also be deployed through the moonpool when open deck conditions are inadequate for deployment due to bad weather, rough sea conditions or when ice surrounds the ship. Safe Work Instructions for moonpool deployment of the CTD-Rosette can be found in Section 3.3.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work spaces prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
    a) Launch the Rosette instruments (LADCP, UVP) in the Rosette operation room.
    b) Unplug the instruments (LADCP, UVP) and remove the syringe from the CTD pump.
    c) Double check that instruments are unplugged and that the syringe is removed and wait for Rosette operator to confirm deployment.
    d) Open the garage door and move the Rosette system out of its hangar and onto the deployment area under the A-frame.
    e) Attach fall restraint harnesses and remove the safety net.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the CTD-Rosette.
    a) Lift the Rosette to deployment readiness.
    b) Lower the Rosette just below the water line and wait for the operator to zero the depth (pressure) display. In rough sea conditions, the Rosette must not hit the hull of the ship.
    c) Slowly bring the Rosette to 10 m depth at a rate of 20 m per minute.
    d) Allow for a rinse period of 1 minute and bring it back to the surface for the downcast.
    e) During upcast and downcast, verify that the cable is vertical and notify the bridge if it departs from vertical.
    f) Lower the Rosette to maximal sampling depth (generally bottom – 10 m) at a speed of descent 60 meters per minute (1 m per second).

g) Wait 1 minute.
h) Start the upcast at a rate of 60 m per minute and stop at each predetermined depths. Wait 1 minute at each depth before closing the bottles.
i) Notify the bridge when the Rosette is at the surface and wait for confirmation before proceeding with the recovery.
j) Retrieve the Rosette and place it on its platform.
k) Put the safety net back in place.

6. Bring the Rosette back into the hangar, close the garage door and secure it before collecting the samples. Give enough cable to bring the Rosette into the hangar.
7. Collect the water samples from the Rosette and transport the samples to the laboratory.

Roles and responsibilities

A minimum of 4 science and crew members is required to deploy/recover the CTD-Rosette:

1 winch operator
2 crew members to deploy and recover the Rosette
1 Rosette operator

Tools or equipment used in the activity

CTD-Rosette
Deck equipment: winch, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the Rosette.

A certified fall restraint safety harness must be worn at all times by science/technical staff and crew members when deploying and retrieving the Rosette.

Description of the environment where the task must be undertaken

Rosette deployment area on starboard side of the helicopter deck (level 400).

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Potential hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for winch wire cables and anchor points Pre-heat oil in winch prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on deployment area and work spaces during operations Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance
5. Deploy and recover the CTD-Rosette	Hoist/crane lifting overhead Moving loads and equipment Working over water	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications

Step	Potential hazards	Control measures
	Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on deployment area during operations Use of tag and hold back lines Strict adherence to deployment procedures
6. Secure the Rosette in its hangar	Slippery or obstructed deck	Remain on station until Rosette is secured and deployment area is safe Notify the bridge at the end of operations
7. Collect and transport samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between Rosette hangar and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.2 Moving Vessel Profiler (MVP)

General description of the activity

The Moving Vessel Profiler (MVP) consists of a 'towed vehicle' equipped with a Seabird CTD measuring depth, temperature, salinity and oxygen. The MVP is towed by the vessel and records multiple vertical profiles of the water column by free falling to the maximum depth and then coming up near the surface.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work spaces (aft deck) prior to the start of operations and ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
    a) MVP is stowed in the aft between-deck area near the MVP winch or in the lab under the helicopter deck.
    b) Verify communication between MVP and computer.
    c) The ship is stationary during initial deployment.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the MVP.
    a) Bring the arm of the MVP winch above the fish (winch swift must be in HAND position.
    b) Lift the fish with the fish using the small winch on the arm.
    c) Open the aft bulwark.
    d) Pivot the arm to bring the fish through the door and over the water, careful not to hit and damage the fragile head of the fish.
    e) Lower the fish until tension goes to the winch cable and unhook the fish from the small winch.
    f) Lower the fish in the water.
    g) Continue to unwind the cable while pushing the Reset button.
    h) Two messengers on the cable will stop the winch. Stop when the second messenger is reached.
    i) The ship starts moving at predetermined speed, generally 4 to 6 knots.
    j) When ship's target speed is reached, the winch operator puts the winch in AUTO mode to transfer control of operations to the MVP technician.
    k) Retrieve the MVP by doing the deployment steps in reverse order.
    l) Close the bulwark.
6. Stow and secure the equipment and make sure the work space (aft deck) is clean and safe.

Roles and responsibilities

A minimum of 3 people is required to deploy/recover the MVP:

1 winch operator
1 crew members assisting with deployment and recovery
1 MVP operator (in acquisition room located behind the bridge)

Tools or equipment used in the activity

MVP profiler
Deck equipment: MVP, winch

Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the MVP.

Fall restraint safety harness must be worn at all times by science/technical staff and crew member when when working over water during deployment and retrieval of the MVP.

Description of the environment where the task must be undertaken

Aft between-deck area near the MVP winch.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Potential hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space prior to start of operations 2. Ensure crew members are positioned and ready 2. Ensure crew wear appropriate safety equipment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for winch wire cables Pre-heat oil in winch prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition

Step	Potential hazards	Control measures
3. Prepare material and work space (aft deck) 4. Notify bridge and wait for confirmation to proceed with deployment		Sufficient light or lighting on deployment area and work spaces during operations Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance
5. Deploy and recover the MVP	Moving loads and equipment Working over water Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on deployment area during operations Strict adherence to deployment procedures
6. Secure the MVP	Slippery or obstructed deck	Remain on station until MVP is secured and deployment area is safe Notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.3 Nets and trawls for plankton, fish and benthos

3.2.3.1 Hydrobios

General description of the activity

The Hydrobios is used to sample plankton in multiple layers of the water column and consists of 9 nets of 200 µm mesh attached to a metal frame with an opening of 0.5 m^2. The Hydrobios is operated vertically while the ship is stationary and each net is opened and closed electronically at predetermined depth intervals. Closing of the nets is controlled by a computer located in the foredeck starboard container. The device is deployed over the starboard side, using the crane. The hydraulic winch on the starboard of the forward hold is used to lower the Hydrobios to the sea bottom and to raise it to the surface. The vessel must remain in a stationary position.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
    a) Position the Hydrobios on the foredeck.
    b) Attach the pulley to the crane cable.
    c) Ensure the electronic cable is positioned and lashed to the metal frame. Make sure the cable is plugged to the Hydrobios before turning on the computer.
    d) Arm the net closing mechanism on the Hydrobios. This is done by slightly lifting the frame for a better access, then putting the Hydrobios back on deck to wait for deployment.
    e) Determine the stop depths and intervals of sampling layers based on bottom depth and scientific objectives.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the Hydrobios.
    a) Crane lift the Hydrobios to deployment readiness using a tag line to maintain the Hydrobios well positioned until it is in the water.
    b) Lower the Hydrobios just below the water line and wait for operator to zero the depth (pressure) display.
    c) Lower the Hydrobios to maximal sampling depth at a speed of descent specified by the science personnel in charge, usually 40 meters per minute. The winch operator notifies the technical staff every 100 m on the downcast (and later, on the upcast) and slows down before reaching target depth.
    d) Wait 1 minute. Double check that the first net is open.
    e) Start the upcast at a rate of 30 meters per minute.
    f) Close each net at the specified depth without stopping.
    g) Retrieve the Hydrobios once it is at the surface and the last net is closed.
    h) Rinse the nets over the side of the ship (starboard).
    i) Bring the Hydrobios on deck and secure it before collecting the samples.
6. Stow and secure the equipment and make sure the work space (foredeck) is clean and safe.
7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the Hydrobios requires a minimum of 5 people positioned on the foredeck as in the diagram in Appendix 3:

1 boatswain signaling and coordinating the various steps.
1 deckhand operating the winch
1 deckhand operating the crane
2 science/technical personnel preparing, deploying and recovering the instrument, and collecting the samples. One of them has to operate the computer opening and closing of the nets.

Tools or equipment used in the activity

Hydrobios
Deck equipment: crane, winch, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the Hydrobios.

Description of the environment where the task must be undertaken

Foredeck on starboard side and control room in the starboard container (see diagram in Appendix 3).

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Steps	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.

Steps	Hazards	Control measures
with the task and control measures		
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Regular inspections and scheduled maintenance for A-frame, cranes, winches, wire cables, davits and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Non-skid material on metal decking is in good condition Sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the Hydrobios	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and tools Working over water MOB Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.)	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck Use of tag and hold back lines Strict adherence to deployment procedures

Steps	Hazards	Control measures
	Reduced visibility	
6. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until Hydrobios is secured and deck is cleaned Notify the bridge at the end of operations
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between deck and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.3.2 Bioness

General description of the activity

The Bioness (Zooplankton Multiple Net Sampling System) is used to sample zooplankton in multiple layers of the water column and consists of 9 nets of 333 µm mesh attached to a metal frame with an opening of 1 m^2. The Bioness is operated horizontally and is towed while the ship moving. Each net is opened and closed electronically at predetermined depth intervals to sample zooplankton in a stratified manner. Closing of the nets is controlled by a computer that is in the starboard container. This device is deployed over the starboard side, using the crane. The hydraulic winch on the starboard of the forward hold is used to lower the Bioness to the sea bottom and to raise it to the surface. The vessel steams at a speed of 1.8-2 knots. Since the device is very heavy, it quickly sinks to the bottom with little angle on the cable. There is thus little risk for the starboard propeller. The recommended maneuver for taking a sampling with the Bioness is to make a slow, controlled turn toward starboard or, if the wind speed permits, to put the vessel's starboard into the wind and steer on a constant heading.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
   a) Position the Bioness on the foredeck.
   b) Attach the pulley to the crane cable.
   c) Ensure the electronic cable is positioned and lashed to the metal frame. Make sure the cable is plugged to the Bioness before turning on the computer.
   d) Arm the net closing mechanism on the Bioness and put the safety on while waiting for deployment.
   e) Determine the stop depths and intervals of sampling layers based on bottom depth and scientific objectives.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the Bioness.
   a) Crane lift the Bioness to deployment readiness using a tag line to maintain the instrument well positioned until it is in the water.
   b) Lower the Bioness just below the water line and wait for the winch operator to zero the depth (pressure) display.
   c) Lower the Bioness to maximal sampling depth at a speed of descent specified by the science personnel in charge, usually 30 meters per minute. The winch operator notifies the technical staff every 100 m on the downcast (and later, on the upcast) and slows down before reaching target depth.
   d) Double check the first net is open.
   e) Start the upcast at a rate of 20 meters per minute.
   f) Close each net at specified depths without stopping.
   g) Retrieve the Bioness once it is at the surface and the last net is closed.
   h) Rinse the nets over the side of the ship (starboard).
   i) Bring the Bioness on deck and secure it before collecting the samples.
6. Stow and secure the equipment and make sure the work space (foredeck) is clean and safe.
7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the Bioness requires a minimum of 5 people positioned as in the diagram in Appendix 3:

1 boatswain signaling and coordinating the various steps.
1 deckhand operating the winch
1 deckhand operating the crane
2 science/technical personnel preparing, deploying and recovering the instrument, and collecting the samples. One of them has to operate the computer opening and closing of the nets.

Tools or equipment used in the activity

Bioness
Deck equipment: crane, winch, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the Bioness.

Description of the environment where the task must be undertaken

Foredeck on starboard side and control room in the starboard container (see diagram in Appendix 3).

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.

Step	Hazards	Control measures
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the Bioness	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and tools Working over water MOB Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck Use of tag and hold back lines Strict adherence to deployment procedures (i.e. winch's speed of descent, etc.)

Step	Hazards	Control measures
	Damage to scientific equipment	
6. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until Bioness is secured and deck is cleaned Notify the bridge at the end of operations
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between deck and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.3.3 5 Net Vertical Sampler (5NVS) or Monster

General description of the activity

The 5 Net Vertical Sampler (5NVS) or Monster Net is used to sample plankton vertically in the water column and consists of 4 square nets (2 of 200 µm mesh and 2 of 500 µm mesh size) with openings of 1 m^2 and an additional 10 cm diameter net (50 µm mesh) attached to the upper part of the frame. It is also equipped with rigid, semi-closed cod ends for capturing live specimens and with flowmeters of types TSK (2) and GO (2). The 5NVS is operated vertically in the water column, generally from the sea bottom to the surface, while the ship is stationary. The net is put in the water using the A-frame and the 500-HP hydraulic winch is then used to lower it to the bottom and raise it to the surface. The vessel remains in a stationary position by following the water mass. When the winds are strong, because of the size of the net, the Wheelhouse will position the vessel to provide protection from the wind, in order to avoid injuries to the personnel on the foredeck.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
   a) Position the 5NVS on the foredeck under the A-frame (manually).
   b) Prepare nets by fastening the cod ends and installing the flowmeters (science) and prepare the cross (crew).
   c) Attach the 5NVS to the winch cable.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the 5NVS.
   a) Lift and position over the safety barricade (keep the safety net in place) using the A-frame and a tag line to maintain the nets well positioned until they are in the water.
   b) Lower the 5NVS just below the water line and wait for the winch operator to reset the depth display to zero.
   c) Lower the 5NVS to maximal sampling depth, generally the bottom, at a speed of descent of 30 or 40 meters per minute.
   d) Wait 1 minute.
   e) Start the upcast at a rate of 30 meters per minute.
   f) Bring the nets above the water and rinse them over the side of the ship.
   g) Bring the 5NVS over the deck, rinse again and collect the cod ends with the samples.
   h) Lower the 5NVS to the deck and unfastened it from the winch cable.
6. Stow and secure the equipment and make sure the work space (foredeck) is clean and safe.
7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the 5NVS requires a minimum of 5 people positioned on the foredeck as in the diagram in the Appendix 3:

1 chief officer supervising the operations

1 boatswain signaling and coordinating the various steps
1 deckhand operating the winch
2 science/technical personnel preparing, deploying and recovering the instrument, and collecting the samples

Tools or equipment used in the activity

5NVS
Deck equipment: A-frame, winch, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the 5NVS.

A certified fall restraint safety harness must be worn at all times by science/technical staff and crew member when deploying and retrieving the 5NVS.

Description of the environment where the task must be undertaken

Foredeck on port side (see diagram in Appendix 3).

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.

Step	Hazards	Control measures
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the 5NVS	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and tools Working over water Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Damage to scientific equipment	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck Use of tag and hold back lines Strict adherence to deployment procedures (i.e. winch's speed of descent, etc.)

Step	Hazards	Control measures
6. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until 5NVS is secured and deck is cleaned Notify the bridge at the end of operations
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between deck and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.3.4 Double Square Net (DSN) or Tucker

General description of the activity

The Double Square Net (DSN) or Tucker is used to sample plankton obliquely or horizontally in the water column and consists of 2 square nets (500 µm mesh and 750 µm mesh size) with openings of 1 m^2. It is equipped with rigid, semi-closed cod ends for capturing live specimens and with flowmeters and depressors. The DSN is operated horizontally in the water column, generally at 50 m depth, while the ship is slowing moving, generally a speed of 2 knots or adjusted to maintain the net at an angle of 60°.

The net is put in the water using the A-frame and is then lowered to the sea bottom and raised to the water surface using the 500-HP hydraulic winch. Given the fact that it is lowered slowly to the bottom when the vessel is moving, there is a risk for the port propeller. The Wheelhouse must steer according to the pre-existing conditions and ensure that the net remains a safe distance from the hull to eliminate this risk. To do this, the Wheelhouse can make a controlled turn toward the port, maneuver with the starboard propeller only and/or put the port side to the wind if the wind speed so permits.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
   a) Position the DSN on the foredeck.
   b) Prepare the nets by fastening the cod ends and installing the flowmeters and depressors (science).
   c) Attach the DSN to the winch cable.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the DSN.
   a) Ship starts moving at a speed of 1.5 knots.
   b) Lift and position the DSN over the safety barricade (keep the safety net in place) using the A-frame and a tag line to maintain the nets well positioned until they are in the water.
   c) Lower the DSN just below the water line and wait for the winch operator to reset the depth display to zero.
   d) Lower the DSN to the specified sampling depth at a speed of descent of 20 meters per minute and increase vessel speed to 2 knots.
   e) Doublecheck the angle of the cable and modify speed to attain 60° angle.
   f) Wait 1 minute at requested depth.
   g) Start the upcast at a rate of 20 meters per minute.
   h) Bring the nets above the water and rinse them over the side of the ship. Vessel speed is dropped to 1 knot.
   i) Bring the DSN over the deck, rinse again and collect the cod ends with the samples.
   j) Lower the DSN to the deck and unfastened from the winch cable.
6. Stow and secure the equipment and make sure the work space (foredeck) is clean and safe.
7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the DSN requires a minimum of 5 people positioned on the foredeck as in the diagram in the Appendix 3:

1 chief officer supervising the operations
1 boatswain signaling and coordinating the various steps
1 deckhand operating the winch
1 or 2 science/technical personnel preparing, deploying and recovering the instrument, and collecting the samples

Tools or equipment used in the activity

DSN
Deck equipment: A-frame, winch, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the DSN.

A certified fall restraint safety harness must be worn at all times by science/technical staff and crew member when deploying and retrieving the DSN.

Description of the environment where the task must be undertaken

Foredeck on port side.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.

Step	Hazards	Control measures
with the task and control measures		
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the DSN	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and tools Working over water MOB Inadequate communication Cable entanglement in the port propeller Unexpected vessel movement Meteorological conditions (wind, sea	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Steer ship to ensure net remains a safe distance from the hull to eliminate this risk to propeller Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations

Step	Hazards	Control measures
	state, ice, temperature, etc.) Reduced visibility Damage to scientific equipment	Good visibility from bridge to foredeck Use of tag and hold back lines Strict adherence to deployment procedures (i.e. winch's speed of descent, etc.)
6. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until DSN is secured and deck is cleaned Notify the bridge at the end of operations
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between deck and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.3.5 RMT and Benthic Beam Trawl

General description of the activity

The Rectangular Mid-water Trawl (RMT) is used to sample fish and large zooplankton horizontally at one depth in the water column and consists of a large rectangular net (1 cm mesh size) with an opening of 9 m^2. The Benthic Beam Trawl is similar to the RMT but consists of one large net of varying mesh size along its length (1 5/8"x1.2 mm in the first section, 1 ¼" in the last section and a liner with 3/8" mesh size) with an opening of 3 m^2. Both the RMT and the Beam Trawl are operated horizontally in the water column at a constant depth while the ship is slowing moving.

The net is put in the water using the A-frame and is then lowered to the bottom and brought up to the water surface using the 500-HP hydraulic winch. Since it is lowered to the bottom while the vessel is moving, there is a risk for the port propeller and the Wheelhouse must maneuver the vessel according to the pre-existing conditions and ensure that the net remains a safe distance from the hull in order to eliminate this risk. To do this, the Wheelhouse can make a controlled turn to the port, maneuver with the starboard propeller only and/or put the port side into the wind if the wind speed so permits. When the winds are strong, because of the size of the net, the Wheelhouse will position the vessel to provide protection from the wind, in order to avoid injuries to the personnel on the foredeck.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
   a) Position the trawl under the A-frame using the crane.
   b) Attach the top beam to the 2.5 tons winch cable.
   c) Attach the main sling of the frame to the 500-HP winch cable and tie the green rope.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the RMT/Beam Trawl.
   a) Ship starts moving at a speed of 1-1.5 knots.
   b) Lift and position the trawl over the safety barricade (keep the safety net in place) using the 2.5-ton winch and a tag line to maintain the frame and net well positioned.
   c) Once overboard, transfer the tension to the 500-HP winch cable and release the 2.5-ton winch cable.
   d) Lower the trawl until the frame is just below the water line and wait for the winch operator to reset the depth display to zero.
   e) Lower the trawl to the specified sampling depth at a speed of descent of 20 meters per minute and increase vessel speed to 2-2.5 knots (30 m/minute at speed of 2 knots for Beam Trawl).
   f) Double-check the angle of the cable and modify speed to attain 60° angle.
   g) Trawl for a maximum of 20 minutes (twice 10 minutes for Beam Trawl).
   h) Drop vessel speed to 1 knot. Start the recovery at a rate of 20 meters per minute (30 meters per minute for Beam Trawl).
   i) Bring the frame of the trawl above the water and transfer the top beam to the 2.5-ton winch cable.
   j) Haul the net onboard. If the net is too heavy to be brought by hand, attach the green line to the drum cable or to the crane.

k) Bring the frame of the trawl onboard using the 2.5-ton winch.
l) Redeploy the Beam Trawl for another 10 minutes. This is to prevent "mud bombs".
m) Lower the trawl to the deck and unfastened from the winch cable.

6. Stow and secure the equipment and make sure the work space (foredeck) is clean and safe.
7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the RMT or Beam Trawl requires a minimum of 5 people positioned on the foredeck as in the diagram in the Appendix 3:

1 boatswain signaling and coordinating the various steps
1 deckhand operating the winch.
1 deckhand operating the crane
2 science/technical personnel preparing, deploying and recovering the instrument, and collecting the samples

Tools or equipment used in the activity

Trawl (RMT or Beam Trawl)
Deck equipment: A-frame, crane, winches (2), tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the trawls.

A certified fall restraint safety harness must be worn at all times by science/technical staff and crew member when deploying and retrieving the trawls.

Description of the environment where the task must be undertaken

Foredeck on port side.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Steps	Hazards	Control measures
1. Prepare sequence of operations	Insufficient or incomplete planning Insufficient training	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines

Steps	Hazards	Control measures
1. Assess risks and hazards associated with the task	Insufficient understanding of the procedure	Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task
1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Heavy workload (limited staff, schedule, etc.) Fatigue	Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Ensure sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Ensure good visibility from bridge to foredeck
5. Deploy and retrieve the trawl	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and tools Working over water MOB Cable entanglement in the port propeller	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place

Steps	Hazards	Control measures
	Inadequate communication	Inspect and wear appropriate PPE, fall arrest safety harness, etc.
	Unexpected vessel movement	Steer ship to ensure net remains a safe distance from the hull to eliminate this risk to propeller
	Meteorological conditions (wind, sea state, ice, temperature, etc.)	Meteorological conditions within working tolerance
		Adequate lighting on foredeck and work spaces during operations
	Reduced visibility	Good visibility from bridge to foredeck
		Use of tag and hold back lines
		Strict adherence to deployment procedures (i.e. winch's speed of descent, ship's speed, etc.)
6. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until trawl is secured and deck is cleaned
		Notify the bridge at the end of operations
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads	Safe lifting plan in place
	Slippery or obstructed deck	Establish safe route between deck and lab
	Stairs	Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.3.6 Agassiz trawl for benthos sampling

General description of the activity

The Agassiz trawl is a sledge made of a rectangular metal frame with a net attached behind and it is towed along the bottom to collect benthic organisms from the seafloor.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
   a) Assemble the trawl on the foredeck and tie off the cod-end.
   b) Position the trawl under the A-frame (manually).
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the Agassiz trawl.
   a) Attach the trawl to the winch cable; lift and position the trawl over the safety barricade (keep the safety net in place) using a tag line to maintain the trawl well positioned until it is in the water.
   b) Lower the trawl to the water line and wait for the winch operator to zero the depth (pressure) display.
   c) Lower the trawl to the sea floor at a speed of descent specified by the science personnel in charge, usually 50 meters per minute (0.83 m/second).
   d) While giving cable, the ship starts moving at a speed of 1.5-2 knots. Adjust the cable length according to bottom depth and the speed of the ship.
   e) Trawl for 3 to 10 minutes as required by science personnel.
   f) Retrieve the trawl.
   g) Rinse the trawl over the side of the ship.
   h) Bring the trawl on deck using a second winch.
   i) Open the net while it is still suspended and empty its contents into the sample containers.
   j) Clean the deck.
6. Stow and secure the equipment and make sure the work space (deck) is clean and safe.
7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the Agassiz Trawl requires a minimum of 5 people on the foredeck positioned as in the diagram in the Appendix 3:

1 chief officer supervising the operations.
1 boatswain signaling and coordinating the various steps.
1 deckhand operating the winch
2 science/technical personnel preparing, deploying and recovering the trawl, and collecting the samples.

Tools or equipment used in the activity

Agassiz Trawl

Deck equipment: A-frame, winch (2), barricades, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the Agassiz trawl.

A certified fall restraint safety harness must be worn at all times by science/technical staff and crew members when deploying and retrieving the Agassiz trawl.

Description of the environment where the task must be undertaken

Foredeck on port side near A-frame.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting for work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.)	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition

Step	Hazards	Control measures
3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Reduced visibility	Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Sufficient light or lighting on foredeck and work spaces during operations Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the Agassiz trawl	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and tools Working over water Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck Use of tag and hold back lines Strict adherence to deployment procedures (i.e. winch's speed of descent, ship's speed, etc.)
6. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until all objects on deck are secured and deck is cleaned Notify the bridge at the end of operations
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between deck and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.4 Oceanographic moorings

General description of the activity

An oceanographic mooring is a line of instruments anchored to the bottom and maintained vertically in the water column by flotation devices. Instruments on the mooring gather continuous records of currents, temperature, conductivity, turbidity, dissolved oxygen and the vertical flux of carbon and contaminants. A hydrostatic release and transmitter are attached to the base of the mooring to help locate it. The equipment is deployed and recovered over the port side using the A-frame and the warping end of the 500-HP hydraulic winch.

The Zodiac is sometimes used to assist in deploying the mooring: it takes the upper end of the mooring which consists of floaters and pulls the line perpendicular to the vessel to gradually let out the mooring. When the depth for the mooring is confirmed, the Zodiac releases the mooring. A triangulation is then made to confirm its exact position.

The mooring is retrieved using the GPS position recorded when the mooring was put in the water and a transducer that communicates with the transmitter attached to it, which indicates the distance of the transmitter from the vessel. The ship must be positioned to ensure that the mooring is not beneath it (i.e. that the distance of the mooring is greater than the water depth). When the vessel is positioned so that the mooring is off the bow and that the mooring will not rise beneath or near the vessel, the hydrostatic release is activated and the mooring line rises to the water surface. For greater safety, it is possible to put the Zodiac in the water for the recovery.

Step-by-step instructions for deployment

1. Meet for planning and overview of operations (day before).
   a) Review the deployment plan and the components of this specific mooring.
   b) Review roles and responsibilities.
   c) Review general safe work practices and safe work instructions for oceanographic moorings.
2. Program oceanographic instruments (by mooring professionals).
   a) Lift equipment onto aluminum ‘Hold’ cover plates for programming and maintenance.
3. Transfer equipment from the aft container and from the ship’s hold to the foredeck.
4. Prepare all mooring equipment on the foredeck.
   a) Assemble the anchor
   b) Place the instruments in order of deployment, respecting the space available on the foredeck and allowing for safe working conditions
   c) Connect all of the items as identified in the mooring deployment sheet.
   d) Secure the equipment keeping all loads close to the deck and on non-skid mats. Ensure that all equipment is stationary.
5. Inspect all equipment and the work space (foredeck) prior to the start of operations.
6. Hold a pre-deployment Toolbox Meeting on the foredeck to review procedures and roles (5 minutes before).
7. Launch Zodiac (if necessary).
8. Ensure science and crew personnel are positioned and ready and that they wear appropriate safety equipment.
   a) Two mooring professionals with harnesses are attached to two different points on the same side of the A-frame.
   b) One deckhand (with harness) is attached to the A-frame, opposite of the mooring professionals, to assist with the anchor deployment.
9. Notify the bridge and wait for confirmation before proceeding with the deployment.

10. Deploy mooring from top to bottom with the anchor last
    a) Bring in the A-frame and give slack on the 500-hp winch cable
    b) Attach the tag line (SeaCatch) to the frame or lifting ring (pear link)
    c) Lift the instrument and extend the A-frame
    d) Lower instrument to foredeck level and remove the safety pin of the SeaCatch
    e) Lower instrument to water surface
    f) Release the instrument by releasing the SeaCatch
    g) The Zodiac keeps the mooring line taut (slowly backing up) and perpendicular to the vessel
    h) Repeat until mooring anchor is released
11. Recover Zodiac
12. Triangulate mooring releases
    a) Perform a triangulation around the anchor release coordinates (3 locations ~ 100m perpendicular to anchor release coordinates).
    b) The chief officer relays the distance to releases from the mooring professional in the Mooring Container to the mooring professional in the wheelhouse (observer)
13. Collect a water column profile at last triangulation point using the CTD-Rosette.
14. Verify mooring orientation and depth with the multibeam sonar.
    a) Pass over the mooring line with the multibeam sonar, identifying the orientation and depths of the mooring instruments (Multibeam Team to Process Data / Imagery)
15. Stow and secure the equipment and make sure the work space (foredeck) is clean and safe.

Step-by-step instructions for recovery

1. Meet for planning and overview of operations (day before).
    a) Review the recovery plan and the components of this specific mooring.
    b) Review roles and responsibilities of participants.
    c) Review general safe work practices and safe work instructions for oceanographic moorings.
2. Determine mooring presence and orientation
    a) Pass over the mooring line with the multibeam and identify the orientation and depths of the mooring instruments (Multibeam Team to process data/imagery)
3. Interrogate the acoustic releases
    a) Verify acoustic release presence and get ranges to releases
4. Collect a water column profile with the CTD-Rosette.
5. Prepare equipment on the foredeck.
6. Inspect all equipment and the work space (foredeck) prior to the start of operations.
7. Hold a Toolbox Meeting to review procedures and roles (5 minutes before operation)
8. Launch Zodiac (if necessary).
9. Ensure science and crew personnel are positioned and ready and that they wear appropriate safety equipment.
    a) Two mooring professionals under the A-frame (harnessed to each side of the A-frame)
10. Notify the bridge and wait for confirmation before proceeding with the operation.
11. Verify that the ship is well positioned, approximately 500 m away from mooring.
12. Activate the release of the mooring to the surface.
13. Approach the ship to mooring's top float (or use the Zodiac to bring it close to the ship).
14. Recover the mooring from top to bottom.
    a) Extend the A-Frame
    b) Grapple the mooring line
        i. OR Zodiac attaches a heaving line to the top float of the mooring and drags it to the vessel in front of the A-frame

c) Connect the cabestan heaving line (via separate pulley on A-frame) to the equipment via a carabeener (crazy hook)
   ii. OR Throw cabestan heaving line to Zodiac and attach via carabeener
   iii. OR Throw the heaving line to the foredeck, from the zodiac, and lift equipment with cabestan via carabeener
d) Initially lift the mooring line/equipment with the cabestan
e) Bring in the A-frame and attach the 2.5T winch hook at a connection point on the lee side of the mooring line
f) Lift enough to release tension on cabestan line. Slacken and unhook the cabestan rope from the equipment
g) Secure the 2.5T winch line to the deck horn, to prevent flailing equipment and personnel injury
h) Detach the equipment and secure it on the foredeck away from recovery area
i) Reconnect the cabestan heaving line to the mooring line and lift to a point where the deck horn tack and/ or 2.5T hook can be removed (transferring all tension to cabestan heaving line).
j) Repeat steps a) to h) until all equipment is onboard

15. Secure the equipment and make sure the work space (foredeck) is clean and safe. Keep all loads close to the deck and on non-skid mats.

Roles and responsibilities

Mooring deployment or recovery requires 7 to 9 persons positioned as in the diagram in the Appendix 3:

1 chief officer supervising the operations.
1 boatswain signaling and coordinating the various steps.
1 winch (500-HP) operator
2 deckhand(s) deploying or recovering the various components of the mooring
2 mooring professionals
1 officer on the Zodiac (if launched)
1 deckhand on the Zodiac (if launched)

Tools or equipment used in the activity

Oceanographic mooring instruments and deck equipment: A-frame, crane, winch, tag lines. Radio.

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the mooring equipment.

Fall restraint safety harness must be worn at all times by science/technical staff and crew member when deploying and retrieving the mooring equipment.

Description of the environment where the task must be undertaken

Foredeck on port side.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
DEPLOYMENT		
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Lift equipment onto aluminum 'Hold' cover plates for programming and maintenance	Failure of deck equipment Manual lifting and handling of heavy loads Hoist/crane lifting overhead Swinging or moving loads and equipment	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Pre-heat oil in winches and cranes prior to work Inspect and wear appropriate PPE, fall arrest safety harness, etc. Good communications with appropriate hand and visual signals and radio communications Secure equipment from rolling or sliding Keep equipment close to computer set-up area
3. Transfer equipment from the aft container and from hold to the foredeck	Swinging or moving loads and equipment Failure of deck equipment Hoist/crane lifting overhead	Go / no-go decision depending on sea state, weather Good communication between personnel, bridge, crane operator Trained operator, proper equipment maintenance, regular survey of gear, belaying lines, sea state limits

Step	Hazards	Control measures
5. Prepare mooring equipment on the foredeck	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Swinging or moving loads and equipment	Safe lifting plan in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Coordinate with other activities on foredeck Secure equipment from rolling or sliding
6. Inspect equipment and work space prior to start of operations 7. Hold a Toolbox Meeting to review procedures and roles 8. Ensure personnel and crew are positioned and ready 8. Ensure personnel and crew wear appropriate safety equipment 9. Notify bridge and wait for confirmation to proceed with deployment	Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition and rubber mat is in place Ensure sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Ensure good visibility from bridge to foredeck
10. Deploy the mooring	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Swinging or moving loads and equipment Working over water MOB Inadequate communication Unexpected vessel movement Zodiac capsize Meteorological conditions (wind, sea	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications, including with the Zodiac Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck

Step	Hazards	Control measures
	state, ice, temperature, etc.) Reduced visibility Equipment and mooring line entanglement Equipment damage	Use of tag and hold back lines and belay points Strict adherence to deployment procedures
13. CTD-Rosette	See Section 3.2.1	
14. Multibeam echosounder	See Section 3.4.2	
15. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until trawl is secured and deck is cleaned Notify the bridge at the end of operations
RECOVERY		
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
4. Prepare equipment on the foredeck	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Swinging or moving loads and equipment	Safe lifting plan in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Secure equipment from rolling or sliding
5. Inspect equipment and work space prior to start of operations 6. Hold a Toolbox Meeting to review procedures and roles 9. Ensure personnel and crew	Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition and rubber mat is in place Ensure sufficient light or lighting on foredeck and work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc.

Step	Hazards	Control measures
are positioned and ready 9. Ensure personnel and crew wear appropriate safety equipment 10. Notify bridge and wait for confirmation to proceed with deployment	Inadequate communication	Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Ensure good visibility from bridge to foredeck
14. Recover the mooring	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Swinging or moving loads and equipment Working over water MOB Inadequate communication Unexpected vessel movement Zodiac capsize Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Equipment and mooring line entanglement Equipment damage	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications, including with the Zodiac Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck Use of tag and hold back lines and belay points Strict adherence to deployment procedures
15. Stow/secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until trawl is secured and deck is cleaned Notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.5 Sediment coring

3.2.5.1 Box coring

General description of the activity

The box corer is used to sample surface sediments on the sea floor. It is lowered to the sea bottom where the box penetrates the sediments. A cutting arm is then closed under the box and seals in the sediment sample. The corer is pulled back up to the vessel with the sample inside the box.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
    a) Assemble the box corer on the foredeck. Attach sample box to the coring device. Attach spade to the coring device by connecting the cam closures to both sides of the spade.
    b) Position the box corer under the A-frame.
    c) Attach the winch cable to the box corer (certified 8.5 tons shackle) and apply slight tension on the lifting cable to align cable head with triggering lever at the top of the central column. Slide the triggering lever into locking position by fitting it through the keyhole in the cable head.
    d) Attach the trigger arm. While holding lever into position, flip trigger at base of central column into the lock position.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the box core.
    a) Attach harnesses and remove the safety barricade.
    b) Lift the box corer over overboard using a tag line to maintain the box corer well positioned until it is in the water.
    c) Remove the safety pins from the central column, which will allow the column to pass through gimbals as the frame touches the seafloor.
    d) Lower the box corer to the water line, zero on the winch.
    e) Lower box corer to the sea floor at a rate of descent specified by the science personnel in charge, usually 50 meters per minute (0.83 m/second).
    f) Slow the speed of descent to 15-25 m per minute when reaching 100 m above the bottom. *The slower the box makes its contact with the bottom, the smaller the resultant bow-wave effect will be. Alternatively, should contact be made too slowly and if the ship is drifting, the corer will be dragged over on its side before it has a chance to penetrate. Also, as a result of ship's surge, it might touch bottom, lift off again, and re-contact in a slightly different position, thus having disturbed the surface of its own sample.*
    g) Validation of the box corer reaching the seafloor will be determined by a distinct drop in tension on the in-line tension meter OR by watching tension drop in the winching cable.
    h) On contact, wait for a moment to allow a little extra wire out for box penetration then stop the winch.
    i) A few seconds thereafter, winch back in at a slow rate, approximately 10 m/min or less. *It is during this period that the spade is levered into the mud and the apparatus is pulled out.*

j) Increase wire speed to 50 m/min and bring the corer to the surface.
k) Bring the box core on deck by lifting and rotating the A-frame inboard.
l) Inserting the safety pins through the central column to secure the box corer for transit.
m) Lower the box corer slowly until it is placed on a secure surface on the foredeck.
n) Re-install the safety barrier across the transom or over-side deployment area.

6. Disassemble the box corer, secure the equipment and make sure the work space (deck) is clean and safe.
7. Transport the sample to the laboratory.

Roles and responsibilities

Operation of the Box corer requires a minimum of 5 people positioned as in the diagram in the Appendix 3:

1 chief officer supervising the operations
1 boatswain signaling and coordinating the various steps
1 deckhand operating the winch and crane
2 science/technical personnel assembling and disassembling the corer, deploying and recovering, and collecting the samples

Tools or equipment used in the activity

Box corer
Deck equipment: A-frame, winch, barricades, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the box core.

Fall restraint safety harness must be worn at all times by science/technical staff and crew members when deploying and retrieving the box core.

Description of the environment where the task must be undertaken

Foredeck on port side near A-frame.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Sufficient light or lighting on foredeck and work spaces during operations Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the box corer	Manual lifting and handling of heavy loads Hoist/crane lifting overhead	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads

Step	Hazards	Control measures
	Moving loads and equipment	Good communications with appropriate hand and visual signals and radio communications
	Working over water	Vessel heading adjusted to minimize heave and spray during operations
	Inadequate communication	MOB procedures in place
	Unexpected vessel movement	Inspect and wear appropriate PPE, fall arrest safety harness, etc.
	Meteorological conditions (wind, sea state, ice, temperature, etc.)	Meteorological conditions within working tolerance
		Adequate lighting on foredeck and work spaces during operations
	Reduced visibility	Good visibility from bridge to foredeck
		Use of tag and hold back lines
	Damage to scientific equipment	Strict adherence to deployment procedures (i.e. winch's speed of descent, etc.)
6. Disassemble and secure the equipment and make sure deck is safe	Slippery or obstructed deck	Remain on station until all objects on deck are secured and deck is cleaned
	Hazardous gas emission	Notify the bridge at the end of operations
		Gas detection meter on hand
7. Transport the samples to the laboratory	Manual lifting and handling of heavy loads	Safe lifting plan in place
		Establish safe route between deck and lab
	Slippery or obstructed deck	Use handrails
	Stairs	

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.5.2 Piston coring

General description of the activity

The piston corer is used to sample sediments on the sea floor. It consists of a piston head, a core barrel with a piston at its tip, and a trigger arm and weight that release the piston core into the sediment. It is lowered to the sea bottom where the corer penetrates the sediments. The barrel of the core is then closed and the sediments sealed in. The corer is pulled back up to the vessel with the sample inside the core barrel which is then opened and disassembled on deck.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (foredeck) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task.
    a) Assemble the piston corer in the sediment sampling area under the A-frame and along the port side on the foredeck.
        i. Secure the core head onto the wooden chucks under the A-frame.
        ii. Line up and level the 10-foot long core barrels using jacks.
        iii. Attach and join the core barrels using the piston couplings.
        iv. Insert the plastic core liners and join with tape.
        v. Insert piston cable through the core head to the end of the last barrel.
        vi. Attach the piston to the piston cable.
        vii. Insert the catcher into the liner, which will keep the core in the liner.
        viii. Attach cutter barrel.
    b) Lift and position the piston corer for deployment
        i. Attach slings in 2 places.
        ii. Lift slightly to remove the jacks.
        iii. Attach 2 tags lines to the core head
        iv. Attach a rope at the base of the core
        v. Lift the piston so that the core head is elevated.
        vi. Position under the A-frame with the tip over the side
    c) Attach the trigger arm.
    d) Bring the corer to upright position over the water.
    e) Attach the trigger weight.
4. Notify the bridge and wait for confirmation before proceeding with the deployment.
5. Deploy and retrieve the piston corer.
    a) Lower the piston corer to the sea floor at a rate of descent specified by the science personnel in charge.
    b) The trigger weight core hits the seabed first, the trigger arm moves up and the piston core is released. The piston core hits the seabed and sinks into it.
    c) Lift the corer from seabed and bring it up to the surface and stop when at sight.
    d) Bring the corer on board
    e) Disassemble the core barrels from the head.
    f) Lift and position the core barrel to the sediment sampling area on the foredeck.
6. Disassemble the corer and secure the equipment and make sure the work space (deck) is clean and safe.

7. Transport the samples to the laboratory.

Roles and responsibilities

Operation of the piston corer requires 7 to 9 people positioned as in the diagram in the Appendix 3:

1 chief officer supervising the operations.
1 boatswain signaling and coordinating the various steps.
1 deckhand operating the winch
1 deckhand operating the crane
2 deckhands deploying and recovering the corer
2 science/technical personnel assembling and disassembling the corer, deploying and recovering, and collecting the samples.

Tools or equipment used in the activity

Piston corer
Deck equipment: A-frame, crane, winch, barricades, slings, jacks and wooden chucks, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (thermal flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working on the foredeck to prepare, deploy, recover and secure the piston corer.

Fall restraint safety harness must be worn at all times by science/technical staff and crew members when deploying and retrieving the piston corer.

Description of the environment where the task must be undertaken

Foredeck on port side in sediment sampling area and under the A-frame.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task

Step	Hazards	Control measures
1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Heavy workload (limited staff, schedule, etc.) Fatigue	Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE, fall arrest safety harness, etc. Sufficient light or lighting on foredeck and work spaces during operations Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to foredeck
5. Deploy and retrieve the piston corer	Manual lifting and handling of heavy loads Hoist/crane lifting overhead Moving loads and equipment Working over water Inadequate communication Unexpected vessel movement	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Inspect and wear appropriate PPE, fall arrest safety harness, etc. Meteorological conditions within working tolerance

Step	Hazards	Control measures
	Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Damage to scientific equipment	Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to foredeck Use of tag and hold back lines Strict adherence to deployment procedures (i.e. winch's speed of descent, etc.)
6. Disassemble and secure equipment and make sure deck is safe	Slippery or obstructed deck Hazardous gas emission	Remain on station until all objects on deck are secured and deck is cleaned Notify the bridge at the end of operations Gas detection meter on hand
7. Transport samples to the laboratory	Manual lifting and handling of heavy loads Slippery or obstructed deck Stairs	Safe lifting plan in place Establish safe route between deck and lab Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.2.6 Drone Flights

General description of the activity

This activity consists of taking aerial photographs or videos using an Unmanned Aerial Vehicle (UAV), often a drone piloted by remote control.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the site (*Amundsen*'s deck or on the ice) prior to the start of operations. Hold a Toolbox Meeting to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare and calibrate the material required for the task and perform pre-flight system checks.
4. Notify the bridge and wait for confirmation before proceeding with the flight.
5. Perform the flight plan previously approved by the CCG.
6. When the battery level is around 25%, land the UAV and conduct post-flight checks.

Roles and Responsibilities

Drone flights requires a minimum of 3 people.

1 UAV Pilot-in-Command (PIC): has decision of go/no-go based on conditions, communicates with flight authorities, CCG crew and officer, chief scientist and science team, and with spotters, ensures compliance with CARs Air Defence Identification Zone in consultation with Amundsen helicopter pilot (if necessary).
2 observers: assists with collision avoidance and orientation of vehicle.

Tools or equipment used in the activity

Drone

Drone remote controller (RC)

Cellphone (to connect to the RC)

Personal protective equipment (PPE) to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)
Waterproof insulated footwear
Sunglasses are recommended for both the pilot and the observer.

Description of the environment where the task must be undertaken

While onboard the CCGS Amundsen, operations are performed from the helideck. You can also conduct drone operations from the barge, the zodiac, on land or on ice.

Required training

- Pilot Certificate – Advanced Operations, which you obtain via the following steps:
    - Formal Ground School (Passing grade and certificate)
    - Flight training (Passing grade and certificate)
    - Restricted Operators Certificate – Aeronautical (ROC-A)
    - Register your Drone with Transport Canada and mark it with its Registration Number
    - Small Advanced Exam (Pass)
    - Flight review with a TC approved individual
- SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and site 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and perform pre-flight tests 4. Notify bridge and wait for confirmation to proceed with flight	Fault in UAV software or hardware Damage or fault in UAV systems Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Evaluation of weather, icing, ceiling and visibility conditions Hold a Toolbox Meeting prior to UAV flight If flight from the ice, review on-ice safety and communication procedures Comply with Transport Canada *Guidance for Operating an Unmanned Aerial Vehicle under an Exemption (AC No. 600-004)* Comply with exemption of the *Canadian Aviation Regulations* (CARs 602.41 and 603.66) Define exclusion zone (on the ice or on deck) and restrict access to personnel directly involved in flight Maintenance and assessment of flight readiness of vehicles

Step	Hazards	Control measures
5. Fly the UAV and conduct planned drone flight 6. Land the UAV and conduct post-flight checks	Loss of orientation of the UAV Loss of contact with the drone. Interference with the ship Meteorological conditions (wind, sea state, ice, temperature, etc.) Controlled or uncontrolled collision of UAV Falling through ice Presence of bear	Trained PIC operator Safe UAV operations Maintain constant visual contact with the UAV or awareness of its position Record position, altitude and direction of the drone. Monitor flight telemetry and use binoculars to accomplish this if needed Modify the loss of contact behavior of the drone to hover in a still position and not to RTH as you will have most likely drifted from the recorded home location Ensure the calibration of the drone compass as high as you can while being on the helideck and do not fly above the wheelhouse because of the presence of high energy antennas. Immediately inform PIC of any suspected hazards to safe operation of UAV Direct or indirect communication with *Amundsen* bridge Flights limited in time and distance as absolutely necessary Ensure minimum buffer distances to personnel and vessel during flight Ensure the UAV does not enter a trajectory leading to collision with *Amundsen*, on ice equipment, or on ice personnel Awareness of hazards associated with lithium polymer batteries If flight from the ice, follow on-ice safety and communications procedures Polar bear watch, on ice and shipboard Work near spotter with shotgun (with firearms permit and experience) Constant radio communication to ship to send or receive warnings of potential hazards. Personal awareness about cold, overheating, hunger, etc. Work in groups of minimum 2 Maintain alertness and use common sense

Emergency procedures specific to activity and reference personnel

- Risk of collision with equipment or personnel: PIC will be notified by Spotter #1 if any risk of collision is present. PIC will determine if ditching craft is necessary by immediate shutoff of engines, causing the vehicle to fall to the surface. Risk is reduced by never flying UAV over people, equipment, or ship
- Lithium polymer battery fire: batteries will be charged in a safe manner to reduce the risk of fire. Batteries will be observed at all time during charge/discharge cycles and stored safely. A suitable fire extinguisher will be on hand to action any issues.
- Hardware or software issue causing loss of power: aircraft will not be flow over personnel, equipment, or ship to strongly reduce risks associated with sudden loss of power. Damage limited to UAV and payload. Battery involved in an incident will be safely disposed of and not reused
- Risk of polar bear or on ice emergency: communication with bridge via radio contact, loudspeaker, or fog horn signal can indicate an immediate cease of operations and return to the ship. Evacuation may be controlled (i.e. landing of UAV, returning equipment to ship) or rapid (i.e. immediate safe controlled flight of UAV into surface and disarming and immediate return of all personnel to the ship)

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, emergency situations, and to equipment failure, damage or loss.

3.2.7 Other types of sampling

3.2.7.1 Drifting sediment traps

The drifting sediment traps are made up of a series of small traps attached to a 150-metre cable. These traps are put into the water and imprison sediments as they drift with the currents during a period usually varying from 12 to 36 hours. They are connected to a VHF beacon, a radar reflector and an Argo beacon, in order to help with the positioning of the equipment once the sampling is completed. Despite the presence of these beacons, it is difficult to locate the traps after the sampling. The ship must, insofar as possible, follow the traps during the period they are deployed and evaluate their drift, which will make it easier to locate them when sampling is completed. Before the drifting traps are deployed, science personnel verify the available water depth in the sector and ensure that it is sufficient to enable the traps to drift safely. The traps are deployed and recovered from the port side using the A-frame and the 500-HP winch. The vessel remains stationary but drifts to follow the water mass (and the traps). The recovery operation is a delicate procedure, during which it is important to avoid any abrupt maneuvers that would project residue into the traps and thereby contaminate the sampling.

3.2.7.2 Profiling Natural Fluorometer (PNF)

The PNF (profiling natural fluorometer) is a small device connected to a computer in the starboard container that makes a profile of the water's fluorescence. It is deployed from the foredeck, usually over the port side but, as required, can be lowered over the starboard side (depending on sunlight and shadows). Being manually deployed, the instrument does not require the assistance of a crew member. The vessel must remain as stationary as possible by following the water mass.

3.2.7.3 PhytoFlash

The phytoFlash is a small very expensive camera. It is deployed over the port side using the small blue electric winch. Use of this winch does not require the assistance of a crew member. When the phytoflash is being lowered into the water and recovered, the ***Wheelhouse*** must pay particular attention so as to ensure that the instrument not strike against the hull.

3.2.7.4 Thorium in situ pumps

Thorium pumping consists in a series of pumps attached to a Kevlar cable. The A-frame is used to put these pumps over the port side, after which they are lowered into the water using the 500-HP winch. Deployment, sampling and recovery take approximately two hours; the vessel must remain as stationary as possible during that time.

3.3 Moonpool operations

General description of the activity

The moonpool is a vertical opening in the forward part of the bow of the ship. Located in the forward hold compartment, it is made of a 2.4 m² by 9-meter-high vertical well. The lower part is closed by a hydraulic pivoting shell door. This door is not watertight but prevents ice and other floating objects from entering the well. The upper part is protected by a sliding hydraulic door. This door is watertight and ensures the integrity of the hull of the ship.

In general, the moonpool is used when ice conditions or outside weather conditions do not allow deployment of scientific instruments from the open decks.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work spaces (forward hold, moonpool well and launching area, Control Room) prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the scientific equipment required for the task.
4. Notify the bridge and wait for confirmation before proceeding with the opening of the moonpool doors and the deployment of equipment.
5. Deploy and retrieve the scientific instrument.
   a) Open the moonpool doors.
   b) Remove safety net to allow passage of the instrument.
   c) Lift the instrument above then into the launching well.
   d) Test the instrument at the surface of the well.
   e) Lower the instrument in the water column and conduct planned scientific operations.
   f) Bring back the instrument to the surface of the well then up in the launching area.
   g) Put the safety net back in place.
6. Secure and lash down the equipment.
7. Close the moon pool doors and make sure the work space is clean and safe.
8. Notify the bridge at the end of the operations.

Roles and responsibilities

Deployment of scientific instruments through the moonpool requires a minimum of 3 people:

1 deckhand operating the winch
2 science/technical personnel operating the equipment or instrument. One of the scientists will be designated at all times as the Responsible Scientist for the operation.
For some instruments, one extra scientist will be required in the CTD / ROV control room.

Tools or equipment used in the activity

Scientific equipment: CTD-Rosette or other scientific instrument to be deployed.
Winch
Radio

Personal protective equipment to be worn while undertaking the task

PPE (flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working in the moopool launching area and near the well to prepare, deploy, recover and secure the scientific equipment.

Life rings with floating line as well as an emergency ladder must be close at hand and ready for immediate response.

Description of the environment where the task must be undertaken

Moonpool well and launching area
ROV or CTD Control Room

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Perform regular inspections and scheduled maintenance for the winch, wire cables and other deck equipment Updated stress test certification for winch wire cables Pre-heat oil in winch prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on decking is in good condition

Step	Hazards	Control measures
2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment		Sufficient lighting in work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE Notify the bridge and wait for confirmation before beginning operations Establish safe go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance
5. Deploy and retrieve the instrument	Manual lifting and handling of heavy loads Hoist lifting overhead Moving loads and equipment Working near well Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Damage to scientific equipment	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize ship's movement during operations Use of gaff and tag lines Emergency response procedures in place in case someone falls in the moonpool well Inspect and wear appropriate PPE Meteorological conditions within working tolerance Adequate lighting in work spaces during operations Strict adherence to deployment procedures
6. Secure and lash down equipment 7. Close moonpool doors and make sure work space is clean and safe 8. Notify bridge at the end of operations	Slippery or obstructed deck	Remain on station until all equipment is secured and launching area is cleaned Always notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.3.1 Remotely Operated Vehicle (ROV)

General description of the activity

A Remotely Operated Vehicle (ROV) is a highly maneuverable unmanned underwater robot, which is controlled from the vessel and connected by one or more cables. The term ROV refers to all equipment including the robot, series of cables and deployment cage or TMS (Tether Management System). The ROV used on the *Amundsen* is a sub-Atlantic Super Mohawk equipped with a video camera, various sensors and two manipulator arms. It can go down to a maximal depth of 2 000 m (6 500 feet) and carry up to 60 kg (132 lbs) of samples. It can perform light work such as observation, exploration and surveys. The deployment cage (TMS) is connected to the vessel by a 1-inch (25.5 mm) thick cable referred to as the umbilical and the underwater robot is connected to the cage by a smaller cable known as a tether. This series of cables allows for the transfer of electricity, data from various sensors, as well as video images. On the *Amundsen*, the ROV is always launched from the moonpool well.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work spaces prior to the start of operations. Hold a pre-dive Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
3. Prepare the material required for the task and conduct the pre-dive check of functioning systems.
4. Notify the bridge and wait for confirmation before proceeding with the opening of the moonpool doors and the deployment of the ROV.
5. Deploy and retrieve the ROV.
   a) Open the moonpool doors.
   b) Remove the safety net to allow passage of the ROV.
   c) Lift the ROV above and into the launching well.
   d) Test the ROV at the surface of the well.
   e) Lower the ROV in the water column and conduct the planned dive.
   f) Bring back the instrument to the surface of the well then up in the launching area.
   g) Put the safety net back in place.
6. Secure and lash down the equipment and perform the post-dive check of all ROV systems.
7. Close the moon pool doors and make sure the work space is clean and safe.
8. Notify the bridge at the end of the operations.

Roles and responsibilities

Deployment of the ROV through the moonpool requires a minimum of 3 people:

1 deckhand operating the winch
2 science/technical personnel operating the ROV. One of the scientists will be designated as the Responsible Scientist for the operation.
For some dives, one extra scientist will be required in the ROV control room.

Tools or equipment used in the activity

ROV

Winch
Radio

Personal protective equipment to be worn while undertaking the task

PPE (flotation device, hard hat, safety glasses, gloves and safety boots) must be worn at all times by all people working in the moopool launching area and near the well to prepare, deploy, recover and secure the scientific equipment.

Life rings with floating line as well as an emergency ladder must be close at hand and ready for immediate response.

Description of the environment where the task must be undertaken

Forward Hold, Moonpool well and launching area
ROV Control Room

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person).
SWI meeting for safe work procedures related to this scientific operation.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space 2. Hold pre-dive Toolbox Meeting 2. Ensure personnel and crew are	Failure of deck equipment Restricted space to work Slippery or obstructed deck Damaged or leaking hydraulic lines Use of high voltage for ROV operations	Perform regular inspections and scheduled maintenance for the winch, wire cables, hydraulic lines and other deck equipment Updated stress test certification for winch wire cables Pre-heat oil in winch prior to work Establish deck exclusion zone and restrict access to authorized personnel only

Step	Hazards	Control measures
positioned and ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Prepare material and work space 4. Notify bridge and wait for confirmation to proceed with deployment	Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Inadequate communication	Ensure non-skid material on decking is in good condition Strict adherence to tag-out procedures (no work on live electrical systems) Sufficient lighting in work spaces during operations Review step-by-step procedures and roles for the task Inspect and wear appropriate PPE Notify the bridge and wait for confirmation before beginning operations Establish safe go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance
5. Deploy and retrieve the ROV	Manual lifting and handling of heavy loads Hoist lifting overhead Moving loads and equipment / side to side motion of ROV Working near well Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility In sea equipment stuck on obstruction on seafloor Cable entangled	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize lateral motion during deployment and recovery Good visibility from ROV control room and winch area Use of gaff and tag lines MOB procedures in place Use of safety nets to prevent personnel of falling into moonpool Inspect and wear appropriate PPE Meteorological conditions within working tolerance Adequate lighting in work spaces during operations Strict adherence to dive plan and deployment procedures Experienced ROV operator (e.g. IMCA)
6. Secure and lash down equipment. Conduct post-dive checks 7. Close moonpool doors and make	Slippery or obstructed deck	Remain on station until all equipment is secured and launching area is cleaned Always notify the bridge at the end of operations

Step	Hazards	Control measures
sure work space is clean and safe		
8. Notify bridge at the end of operations		

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.4 Multibeam echosounder

General description of the activity

The multibeam echosounder, a Simrad EM-300-2, is mounted to the vessel's hull and controlled from the data acquisition room (Room 202), where all the information from the multibeam is sent and processed. It is used to conduct bathymetric surveys and seafloor mapping.

Two types of surveys can be conducted: Planned survey and Opportunity-based surveys. A planned survey is stipulated beforehand in the mission plan, which includes a detailed list of the locations to take soundings with the vessel. Surveys can also be performed on an opportunity basis when site/event-specific survey work is made possible by favourable ice conditions, scientific discoveries or interests during the mission. This type of survey can be conducted while in transit between two scientific data survey stations or conducted between two scientific collection operations at a specific sampling station.

Normally, the multibeam sounder is always operating and gathers bathymetric data, whether the vessel is in transit or during specific operations. During transits at sea, the vessel will follow a route parallel to a former data route in order to broaden, with each pass, the area of coverage. The Survey Technician will indicate to the Wheelhouse the requirements concerning the distance at which the vessel must pass by the former route as well as which side.

During a planned survey, a Survey Technician must be present at all times in the data acquisition room. The Responsible Scientist must establish a shift schedule that provides the Survey Technicians with rest periods that are frequent and long enough to ensure that they are alert during their shift. Generally, in uncharted or poorly charted waters, the Survey Technician continually checks and interprets the data from the sounder and notifies the officer on watch on the bridge if there are concerns about the floor, depth and or any data supplied by the device.

The accuracy of the data supplied by the multibeam sounder depends on many physical properties related to the composition of the water, such as its temperature and salinity, which must be regularly monitored. This is done using the MVP and the CTD-Rosette (Sections 3.2.1 and 3.2.2). The survey operations must then be planned to time them with the periods where the MVP or CTD will be deployed.

The success of the bathymetric surveys is the result of good communication between the survey team and the Wheelhouse, which must agree on: the vessel's speed during the surveys, the length of each survey line, the distances between two leadlines, the effective swath of each pass, the track error allowed and the rate of correction to return to the track.

Multibeam surveys and mapping from an auxiliary vessel

The multibeam echosounder can be deployed on a small vessel such as the barge (see Section 3.6.3 for launch procedures) to conduct surveys or mapping operations in areas inaccessible to the *Amundsen*. The operational limits for the use of the auxiliary vessel are then re-defined for these procedures by the Commanding Officer, the Chief Scientist and Survey Technician, with counsel from the officer acting as coxswain on the small vessel. For example, the barge will keep at least 1.5 lengths away from the shore, ice edge or iceberg’s keel and will operate only in waters deeper than 10 m.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).

2. Inspect all equipment and the work spaces prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready.
3. Notify the bridge and wait for confirmation before proceeding with the multibeam survey.
4. Conduct bathymetric survey and/or seafloor mapping. In poorly charted waters, the survey technician must be in the Acquisition Room and keep in constant communication with the bridge.
5. Notify the bridge at the end of the operations.

Roles and responsibilities

Operation of the Multibeam echosounder requires a minimum of 2 people:

1 officer on the bridge to adjust vessel's speed and route according to survey team specifications and science objectives.
1 science/technical personnel operating the sounder. One scientist will be designated as the Responsible Scientist for the operation, and must always be present in the acquisition room (room 202) during planned surveys.

Tools or equipment used in the activity

Multibeam echosounder
Computer in acquisition room
Radio

Description of the environment where the task must be undertaken

Acquisition Room

Required training

SWI Meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines (i.e. ice and frazil) Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.

Step	Hazards	Control measures
2. Inspect equipment and work spaces 2. Hold Toolbox Meeting 2. Ensure personnel and crew are positioned and ready 3. Notify bridge and wait for confirmation to proceed with survey	Ice and meteorological conditions (wind, sea state, temperature, etc.) Inadequate communication Equipment failure	Review step-by-step procedures and roles for the task Notify the bridge and wait for confirmation before beginning operations Establish safe sea go/no go decision guidelines Evaluate present and future ice meteorological conditions before start of operations and ensure they are within working tolerance Regular maintenance and testing of the sounder and electronic/computer equipment Hot water circulated in hull-through tube before gate valve is opened and sonar is used
4. Conduct survey 5. Notify bridge at the end of operations	Inadequate communication Ice and meteorological conditions (wind, sea state, temperature, etc.)	Good communications between bridge and survey team Strict adherence to operation procedures, i.e. vessel speed and heading, planned route, etc. Ice and meteorological conditions within working tolerance Always notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.5 On-Ice operations

Prior to on-ice sampling, present and forecasted weather and sea-state conditions are assessed by the Commanding Officer and the Chief Scientist, with the counsel from the Helicopter pilot if the helicopter is used. If conditions are deemed safe (good visibility, light wind, no waves, etc.), on- ice operations are authorized. On-ice sampling can be cancelled at any point by both the Commanding Officer and the Chief Scientist if conditions appear to change, or if there are any present dangers to the team and/or to equipment.

Ice conditions are also closely studied prior to sending any teams on the ice. It is the responsibility of the Commanding Officer and Chief Scientist to decide if ice conditions are safe to allow participants to conduct their work on the ice. If they detect any unsafe ice conditions or if there are any potential threats associated with the ice conditions, they may cancel or delay on-ice operations.

Since Arctic weather and ice conditions are so unpredictable and can deteriorate quickly, on-ice participants need to be prepared for many situations, to dress warmly and carry a spare set of warm clothes. When deployed onto the ice, the ice teams must be prepared for science operations to last longer than expected.

Depending on the method of deployment on the ice, different Safe Work Procedures will apply with appropriate safety equipment and relevant training, which are detailed in the following sections:

- Ice cage (Section 3.6.2)
- Zodiac, Air-Ice boat and barge (Auxiliary vessels in Section 3.6.3)
- Helicopter (Section 3.6.4)

There are numerous reasons that the on-ice sampling team would be required to evacuate the field site. These include a change in the weather that affect the visibility and safety of the team, as well as any immediate threats to the personnel, such as the presence of a polar bear or crack appearing in the ice. In the event that an evacuation from the field site must take place, the final decision will be made by the Commanding Officer and/or the Chief Scientist. Typically, the team would be notified by the On-Ice Team Lead, who would be responsible for holding a radio and maintaining communication with the bridge, and/or by the foghorn from the ship. Once the on-ice team has been notified of the evacuation, everyone is to follow the Coast Guard guidelines and return to the ship in a timely manner.

Survival kits

In the very unlikely event that personnel would have to remain on the ice overnight, the on-ice team must have a "Survival Kit" on the ice with them at all times. This survival kit should include food rations, water, a satellite phone, a GPS, extra batteries, a compass, thermal blankets, a standard First Aid kit, hand picks, flashlight, glow sticks, duct tape, knife/pocket tool, as well as extra ammunition for the firearm. The team will also have with them Arctic sleeping bags and a tent/shelter.

Survival kits, as well as a firearm, are also standard equipment onboard the helicopter and auxiliary vessels (barge, air-ice boat and zodiacs).

Immersion suits

All personnel working on the ice must wear a 'dry-type' immersion suit (see Section 3.6.4) and a personal flotation device, whether they are deployed with the helicopter or one of the auxiliary vessels.

Firearms operation

Firearms are an essential piece of equipment for those participating in on-ice operations. The presence of polar bears is a constantly pressing threat, and the primary safety measure is to have at least one firearm per team on the ice. Teams must consist of at least two people and one person on the team is designated as the spotter. The spotter does not participate in the on-ice science operations and must remain vigilant to the surroundings of the field site for bear presence. Often, the spotter will also carry the radio and will be in charge of communications with the ship. The spotter must also have training in firearms operations and a valid license. To ensure readiness in case a polar bear, the firearm's magazines must be kept full, the safety must be in the "on" position, and no cartridge must be in the chamber until a bear is in sight. Finally, every person on the ice must be prepared to evacuate the area. To ensure that, in the case of a polar bear encounter, all on-ice personnel must be prepared to return to the ship in a safe and effective manner.

3.5.1 Ice island survey or near-ice work (with Zodiac or barge)

General description of the activity

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the site and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
3. Zodiac or barge will near an ice feature of interest.
4. At predetermined distance from the feature, air temperature, water temperature and GPS location will occur.
5. Deploy the idronaut to 50 meters.
6. Transport material and samples back to the laboratory.

Roles and Responsibilities

Ice island survey or near-ice work requires a minimum of 2 Coast Guard crew members for the Zodiac and minimum of 3 Coast Guard crew members for the barge:

Zodiac:
- 1 or 2 science/technical personnel doing science operations
- 1 coxswain piloting the small vessel
- 1 deckhand

Barge:
- 1 or 2 science/technical personnel doing science operations
- 1 coxswain piloting the small vessel
- 1 engineer
- 1-2 deckhands

Personal protective equipment to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)
Waterproof insulated footwear
Immersion suit (Survitec Survival-One)
Personal flotation device
Sunglasses/goggles
Whistle
Binoculars
Radio from CCGS *Amundsen*
First Aid kit and firearm (on small vessel)
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

Required training for Supernumerary Personnel

SWI Meeting for safe work procedures related to on-ice operations

Emergency procedures specific to activity

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Notify the bridge and wait for confirmation before beginning launching auxiliary vessel and beginning operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good communication with ship to send or receive warnings of potential hazards
3. Zodiac or barge will near an ice feature of interest	Meteorological conditions (wind, sea state, temperature, etc.)	Maintain alertness and use common sense Personal awareness about cold, overheating, sweating, hunger, etc.

Step	Hazards	Control measures
4. Take air temperature, water temperature and GPS location 5. Deploy the idronaut to 50 m	MOB Frostbite, freezing to death Sunburns	Work within sight and hailing distance of ship and/or one or more other work parties Remain within 20 nm of the ship during operations Radio communication to ship at pre-determined intervals Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications
7. Transport material /samples to the laboratory	Manual lifting and handling of heavy loads Stairs/ladder	Safe lifting plan in place Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.5.2 Under-ice physical sampling - ADCP

General description of the activity

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the site and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
3. Auger an 8" diameter hole through the ice.
4. Install the Aquadopp and make observations.
    a) Select appropriate length of aluminum pipe and mount the Aquadopp.
    b) Lower the aluminum pipe containing the Aquadopp until the transducers are 30 cm below the ice.
    c) Fix in position, connect the laptop and initiate Aquadopp logging.
    d) Leave in place.
    e) Check operation (laptop, 2 persons) at 5 h intervals over next 20 h.
    f) Retrieve pipe & AquaDopp.
5. Auger a second 8" diameter hole through the ice.
6. Make ancillary observations
    a) Measure ice depth
    b) Make CTD casts to 100 m at 5 h intervals beginning immediately after installation of AquaDopp
7. Transport material and samples back to the laboratory.

Roles and Responsibilities

Under-ice physical sampling requires 2 or 3 persons.

1 or 2 persons doing operations (2 are required when augering and installing the Aquadopp).
1 bear watcher and radio communication

Personal protective equipment to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)
Waterproof insulated footwear
Immersion suit (Survitec Survival-One)
Personal flotation device
Gloves for coring/drilling (warm when wet)
Sunglasses/goggles
Whistle
Binoculars
Firearm (and a licensed operator)
Radio from CCGS Amundsen
First aid kit
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

Required training for Supernumerary Personnel

SWI Meeting for safe work procedures related to on-ice operations
First Aid training
Firearms training and license

Emergency procedures specific to activity

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Frostbite, freezing to death Sunburns	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Sufficient light or lighting during operations Notify the bridge and wait for confirmation before beginning on-ice operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to work team on the ice

Step	Hazards	Control measures
		Good communication with ship to send or receive warnings of potential hazards. (i.e. fog horn blasts symbolize evacuate ice)
3. Auger 8" diameter hole through ice 4. Install Aquadopp and make observations 5. Auger second 8" diameter hole 6. Make ancillary observations	Getting lost Falls on ice Injury operating augur or installing pipe Falling into sea, drowning Presence of polar bears Vibration and noise hazards? Sharp auger blades, rotating machinery Inhalation of fumes from auger (if fuel type) Potential for work related upper limb disorder due to prolonged exposure?	Maintain alertness and use common sense Personal awareness about cold, overheating, sweating, hunger, etc. Work within sight and hailing distance of ship and/or one or more other work parties Radio communication to ship at pre-determined intervals, w/ GPS coordinates if needed Open communication at all times concerning dangers, questions, suspicions Work with people with auger training or experience One or more people with first responder training (e.g. CEOS Wilderness First Aid Training) Team of 2-3 people, at least one with experience working on sea ice Polar bear watch, on ice and shipboard Work near spotter with shotgun (with fire arms permit and experience) Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications
7. Transport material and samples to the laboratory	Manual lifting and handling of heavy loads Stairs/ladder	Safe lifting plan in place Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, emergency situations, and to equipment failure, damage or loss.

3.5.3 On-ice sea morphology sampling

General description of the activity

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the site and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
3. Survey grid, mark positions of SEMI lines.
4. Place targets at mid-points of lines a to d.
5. Scan ice surface.
6. Conduct the SEMI surveys upon completion of LIDAR surveys.
7. Collect ground confirmation data (Ice thickness) through scanning period, 2” auger holes.
8. Conduct scans at EM site.
9. Transport material and samples back to the laboratory.

Roles and Responsibilities

On-ice morphology sampling requires 3 people:

2 people doing the operation
1 bear watcher and radio contact

Personal protective equipment to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)
Waterproof insulated footwear
Immersion suit (Survitec Survival-One)
Personal flotation device
Gloves for coring/drilling (warm when wet)
Sunglasses/goggles
Whistle
Binoculars
Firearm (and a licensed operator)
Radio from CCGS Amundsen
First aid kit
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

Required training

SWI Meeting for safe work procedures related to on-ice operations

Emergency procedures specific to activity

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Frostbite, freezing to death Sunburns	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Ensure safe ice conditions Awareness of potential hazardous conditions associated with rubble ice Sufficient light or lighting during operations Notify the bridge and wait for confirmation before beginning on-ice operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to work team on the ice Good communication with ship to send or receive warnings of potential hazards. (i.e. fog horn blasts symbolize evacuate ice)

Step	Hazards	Control measures
3. Survey grid, mark positions of SEMI lines 4. Place targets at mid-points of lines a to d 5. Scan ice surface 6. Conduct SEMI surveys upon completion of LIDAR surveys 7. Collect ground confirmation data (Ice thickness) through scanning period, 2" auger holes. 8. Conduct scans at EM site.	Getting lost Slipping/Falling on ice Injury operating augur or installing pipe Falling into sea, drowning Presence of polar bears Vibration and noise hazards? Sharp auger blades, rotating machinery Inhalation of fumes from auger (if fuel type) Potential for work related upper limb disorder due to prolonged exposure?	Maintain alertness and use common sense Personal awareness about cold, overheating, sweating, hunger, etc. Work within sight and hailing distance of ship and/or one or more other work parties Radio communication to ship at pre-determined intervals, w/ GPS coordinates if needed Open communication at all times concerning dangers, questions, suspicions Work with people with auger training or experience One or more people with first responder training (e.g. CEOS Wilderness First Aid Training) Team of 2-3 people, at least one with experience working on sea ice Polar bear watch, on ice and shipboard Work near spotter with shotgun (with fire arms permit and experience) Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, emergency situations, and to equipment failure, damage or loss.

3.5.4 On-ice Met Tower setup

General description of the activity

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the site and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
3. Survey the site for the installation of the Met Tower
4. Tighten on the 1-meter extension and connect the power supply.
5. Attach the tower to the ice using ice screws through the tripod feet.
6. Drill three 2” auger holes through the ice to attach the additional guy wire.
7. Tighten all guy wires and activate the iridium system.
8. Drill an 8” auger hole about 1-2 feet deep for ice beacon
9. Place ice beacon in whole and activate by removing magnet

Roles and Responsibilities

On-ice Met Tower setup requires 3 people:

2 people doing the operation
1 bear watcher and radio contact

Personal protective equipment to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)
Waterproof insulated footwear
Immersion suit (Survitec Survival-One)
Personal flotation device
Gloves for coring/drilling (warm when wet)
Sunglasses/goggles
Whistle
Binoculars
Firearm (and a licensed operator)
Radio from CCGS Amundsen
First aid kit
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

Required training

SWI Meeting for safe work procedures related to on-ice operations

Emergency procedures specific to activity

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Frostbite, freezing to death Sunburns	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Ensure safe ice conditions Awareness of potential hazardous conditions associated with rubble ice Sufficient light or lighting during operations Notify the bridge and wait for confirmation before beginning on-ice operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good visibility from bridge to work team on the ice Good communication with ship to send or receive warnings of potential hazards. (i.e. fog horn blasts symbolize evacuate ice)
4. Tighten the 1 meter extension	Getting lost	Maintain alertness and use common sense

Step	Hazards	Control measures
and connect power supply 5. Attach tower to the ice using ice screws through the tripod feet 6. Drill three small auger holes to attach additional guy wire 7. Tighten all guy wires and activate iridium system 8. Drill 8" auger hole 1-2 feet deep for ice beacon 9. Place ice beacon in hole and activate by removing magnet	Slipping/Falling on ice Injury operating augur or installing pipe Falling into sea, drowning Presence of polar bears Vibration and noise hazards? Sharp auger blades, rotating machinery Inhalation of fumes from auger (if fuel type) Potential for work related upper limb disorder due to prolonged exposure?	Personal awareness about cold, overheating, sweating, hunger, etc. Work within sight and hailing distance of ship and/or one or more other work parties Radio communication to ship at pre-determined intervals, w/ GPS coordinates if needed Open communication at all times concerning dangers, questions, suspicions Work with people with auger training or experience One or more people with first responder training (e.g. CEOS Wilderness First Aid Training) Team of 2-3 people, at least one with experience working on sea ice Polar bear watch, on ice and shipboard Work near spotter with shotgun (with fire arms permit and experience) Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, emergency situations, and to equipment failure, damage or loss.

3.5.5 Sea-ice dynamics – Ice beacons

General description of the activity

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the site and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
3. Land helicopter on a safe / appropriate ice floe. Test ice thickness as described in the safe working Instructions for operations using the Helicopter (Section 3.6.4).
4. Safely exit helicopter and retrieve beacon and 8" auger system from helicopter cargo.
5. Move away from helicopter blades to perform the next steps.
6. Drill an 8" diameter hole about 2' deep into floe using gas-powered auger.
7. Turn on and drop beacon into drilled hole.
8. Return to helicopter with auger system and stow it away in the helicopter cargo.
9. Return to ship.

Roles and Responsibilities

Sea ice dynamics operations requires 3 persons:

1 Helicopter Pilot: ensures flight safety, has authority to cancel flights based on established CCG flight safety protocols.
2 science/technical staff doing operations: ensure safe ice conditions, survey area, LIDAR scanning, placing of targets, etc.

Personal protective equipment to be worn while undertaking the task

Helicopter-specific immersion suit
Personal flotation device
Gloves for coring/drilling (warm when wet)
Sunglasses/goggles
Whistle
Binoculars
Firearm (and a licensed operator)
Radio from CCGS *Amundsen*
Warm waterproof boots
First aid kit
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

Required training

Coast Guard and Transport Canada Safety briefings for all personnel working in and around helicopters
Helicopter Ditching training
SWI Meeting for safe work procedures related to on-ice operations

Emergency procedures specific to activity and reference personnel

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Frostbite, freezing to death Sunburns Flying conditions	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Ensure safe ice conditions Awareness of potential hazardous conditions associated with rubble ice Sufficient light or lighting during operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good communication with ship to send or receive warnings of potential hazards. (i.e. fog horn blasts symbolize evacuate ice)

Step	Hazards	Control measures
3. Land helicopter on a safe / appropriate ice floe. 3. Test ice thickness 4. Exit helicopter and retrieve beacon and auger from hold 5. Move away from helicopter blades 6. Drill 8" diameter hole about 2' deep into floe using gas-powered auger 7. Turn on and drop beacon into drilled hole 8. Return to helicopter with auger system and stow it away in the helicopter cargo. 9. Return to ship	Flying conditions Ice floe unsafe for landing Slipping/Falling on ice Sharp auger blades, rotating machinery Falling into sea, drowning Presence of polar bears Slippery ice Helicopter blades Vibration and noise hazards Inhalation of fumes from auger (if fuel type)	Experienced and sufficient technical crew to choose appropriate ice floe for landing One person (with harness) checks thickness before team heads out onto the ice Maintain alertness and use common sense Personal awareness about cold, overheating, sweating, hunger, etc. Coast Guard and Transport Canada Safety briefings for all personnel working in and around helicopters Radio communication to ship at pre-determined intervals, w/ GPS coordinates if needed Open communication at all times concerning dangers, questions, suspicions Work with people with auger training or experience One or more people with first responder training (e.g. CEOS Wilderness First Aid Training) Team of 2-3 people, at least one with experience working on sea ice Polar bear watch Work near spotter with shotgun (with fire arms permit and experience) Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications Extreme care when operation requires use of the helicopter

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, helicopter ditching or emergency situations, and to equipment failure, damage or loss.

3.5.6 Physical ice sampling

General description of the activity

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the site and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
3. Land helicopter on a safe / appropriate site. Test ice thickness as described in the Safe Working Instructions for operations using the Helicopter (Section 3.6.4).
4. Conduct physical sampling of snow, sea ice, and melt ponds on ice floes at multiple locations and during multiple times during visits to the ice floe surface.
5. Perform snow pits in order to gain an understanding of the physical characteristics of the snow.
6. Extract ice cores for temperature, salinity, and structural information.
7. Perform a close examination of the salinity core before it is sectioned for salinity measurements.
8. Conduct EMI sled transects to determine the distribution of ice thickness.

Roles and Responsibilities

2 persons doing sampling operations
1 bear watcher/safety observer

Personal protective equipment to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)
Waterproof insulated footwear
Immersion suit (Survitec Survival-One)
Personal flotation device
Hip-waiters when working in melt ponds
Gloves for coring/drilling (warm when wet)
Sunglasses/goggles
Whistle
Binoculars
Firearm (and a licensed operator)
Radio from CCGS *Amundsen*
First aid kit
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

Required training

Transport Canada and CCG Familiarization and Safety briefings for all personnel working in and around helicopters
Helicopter Ditching training
SWI Meeting for safe work procedures related to on-ice operations

Emergency procedures specific to activity and reference personnel

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required. YB will be the primary first-aid provider for M. Johnston's group.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment 3. Land helicopter on a safe / appropriate ice floe. 3. Test ice thickness	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Frostbite, freezing to death Sunburns	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Ensure safe ice conditions Awareness of potential hazardous conditions associated with rubble ice Sufficient light or lighting during operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good communication with ship to send or receive warnings of potential hazards. (i.e. fog horn blasts symbolize evacuate ice) One person (with harness) checks thickness before team heads out onto the ice

2. Conduct physical sampling of snow, sea ice, and melt ponds on ice floes at multiple locations multiple times 3. Perform snow pits for physical characteristics of the snow 4. Extract ice cores for temperature, salinity, and structural information 5. Examine the salinity core before it is sectioned for measurements 6. Conduct EMI sled transects to determine distribution of ice thickness.	Slipping/Falling on ice Falling into sea, drowning Open water and melt ponds Falling through ice Presence of polar bears Sharp auger blades, rotating machinery Vibration and noise hazards Inhalation of fumes from auger (if fuel type) lack of attention due to exhaustion overheating from drilling/coring in floatation gear strain/back injuries resulting from heavy lifting eye strain (snow blindness, glare off ice, etc.) ear injuries caused by noise of gas-powered engines	Maintain alertness and use common sense Personal awareness about cold, overheating, sweating, hunger, etc. Remain within sight of ship (<1 km distant) Radio communication to ship at pre-determined intervals, w/ GPS coordinates if needed Throw ropes (safety bagged throwing rope, or standard safety line) One worker in melt pond while other worker monitors their activity Open communication at all times concerning dangers, questions, suspicions One or more people with first responder training (e.g. CEOS Wilderness First Aid Training) Team of 2-3 people, at least one with experience working on sea ice Polar bear watch, on ice and shipboard Work near spotter with shotgun (with fire arms permit and experience) Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications Safe lifting plan Extreme care when operating the snow machine or requiring use of the helicopter

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, emergency situations, and to equipment failure, damage or loss.

3.5.7 Melt pond sampling

General description of the activity

Melt ponds develop on sea ice when snow and ice melt in the spring and water accumulates. Melt ponds exist in different sizes, can be connected or isolated, can be cut off from the surface of the ice and connected by a shaft underneath. In the Canadian Arctic, melt ponds depth rarely exceeds 30 cm in sea ice of variable thickness but generally thicker than 1 meter. Two types of stations can be conducted to sample melt ponds: Basic stations and Full stations. At basic station, the water in the melt pond is sampled, whereas on Full station, melt ponds, ice and the water column underneath are sampled. The Chief scientist and the captain are responsible to determine which type can be performed.

A survey flight by the helicopter is conducted first to locate a site with appropriate melt ponds for sampling and where sampling activities can safely take place (i.e. type of ice, presence of animals, etc.). The helicopter pilot and the captain are responsible to determine personnel (crew and science) required for this survey flight. Radarsat images can also be used to evaluate zones of sea ice.

Before a team exit the helicopter and goes on the ice, two people evaluate ice thickness in multiple locations around and within a safe zone to conduct sampling activities. This safe zone is then delineated and all personnel are informed of the extent of this area.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and assess the sites and the environment (ice, sea state and weather) prior to the start of operations and ensure scientific personnel and crew are ready and that they wear appropriate safety equipment.
   a) Evaluate present sea, ice and wind conditions and weather forecast.
   b) Consult Radarsat images.
   c) Conduct helicopter survey flight to identify potential sites.
3. Take photographs before landing to evaluate spatial cover of melt ponds in the sampling area.
4. Asses ice thickness in multiple locations and delineate the safe zone before landing on the ice.
5. Science personnel (and crew) exit the helicopter and goes on the ice. The helicopter goes back to the ship and will return when team is ready to leave.
6. Sample the melt ponds (basic and full stations).
   a) Select 3 or 4 ponds for sampling: 1 main and 2 or 3 secondary. Measurements are made from the edge of melt ponds. To avoid contamination and for safety reasons, team members will not walk in the melt ponds.
   b) Record GPS locations of the melt ponds and their dimensions (length and width) using a measuring tape of laser tool.
   c) Determine depth in 10 locations in each of the ponds using a 1-m ruler attached to a telescopic arm.
   d) Measure water temperature with a thermometer attached to a telescopic arm.
   e) Sample water in the melt ponds.
      Water is collected with a flexible tube attached to a telescopic arm and connected to a pump installed on the edge of the ponds.
      Water is collected at the surface and at the bottom of each melt ponds (6 samples per pond).
      Samples are collected as they come out the pump for the following measurements: transparency, salinity, DMSP, DMS, DMSO nutrients, algal taxonomy.

Samples are placed in a cooler for transport.

f) Install the chamber to measure sea-air gas fluxes.
   Assemble the chamber.
   Install the floating chamber at the surface of the main melt pond.
   Secure the chamber to the ice edge with a rope.
   After 15 minutes, gas in the chamber is sampled.
   Re-install the chamber in the same position and repeat the gas sampling procedure 3 more times.
   Disassemble the chamber.

g) Take auxiliary measurements.
   Incident light
   Air temperature
   Snow cover thickness
   Collect a snow sample (10 cm^3) near the main melt pond and put the sample in the cooler.

7. Collect ice cores
   Select a sampling zone near the melt pond.
   Assemblage the coring system.
   Collect up to 3 8'' diameter cores.
   Cut the cores into sections of approximately 10 cm, place into separate bags and put in cooler.
   Measure ice thickness.
8. Sample the water column underneath the ice under the melt pond.
   Auger an 8'' diameter hole through the ice near the melt pond
   Insert the telescopic arm equipped with a flexible tube connected to a pump into the hole.
   Collect water directly under the melt pond at 0.5 m depth.
   Store the water samples into containers and put into the cooler.
9. Transport the samples to the helicopter and back to the ship.

Tools or equipment used in the activity

All material will be transported in one trip in the helicopter cargo hold. The total weight of the equipment will be given to the helicopter pilot before each sampling visit.

Pump and flexible tubing
Telescopic arm
Gas flux chamber
Sample containers
Cooler(s) (2 for a full station)
Various basic tools and equipment

Roles and Responsibilities

Three to five people are required for melt pond sampling:

1 team lead: ensures communication with the ship, safe work procedures and sea ice strength, decides working zone and collects samples.
1 to 3 people to collect samples (depending on basic vs. full station)
1 bear watcher / safety observer

Personal protective equipment to be worn while undertaking the task

Weather-appropriate clothing, including gloves (warmth)

Waterproof insulated footwear
Immersion suit (Survitec Survival-One)
Personal flotation device
Micro-spikes
Waterproof gloves to collect samples (warm when wet)
Sunglasses/goggles
Whistle
Binoculars
Firearm (and a licensed operator)
Radio from CCGS *Amundsen*
Ice survival kit
First aid kit
GPS
Ice pic (Pick-of-Life awls)

Description of the environment where the task must be undertaken

On the ice around 3 to 4 melt ponds.

Required training

Coast Guard and Transport Canada Safety briefings for all personnel working in and around helicopters
Heilcopter Ditching training
SWI Meeting for safe work procedures related to on-ice operations (CCG and science personnel).

Emergency procedures specific to activity and reference personnel

In case of injury, frostbite, falling into water: apply first responder training as necessary, advise the ship of the accident and have the onboard nurse and CCG staff deploy to the ship with suitable first-aid equipment (stretcher, frost bite, etc.) as required.

Radio for assistance from the onboard medical officer and Coast Guard Crew to come to the on-ice site.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations	Insufficient or incomplete planning	Risk analysis and Job Safety Analysis in place
1. Assess risks and hazards associated with the task	Insufficient training	Reviewed and updated safe work procedures
1. Hold SWI Meeting presenting work procedures, risks	Insufficient understanding of the procedure	Safe go/no go decision guidelines
	Heavy workload (limited staff, schedule, etc.)	Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task
	Fatigue	Organize crew shift changes, task delegation, staff duties, etc.

Step	Hazards	Control measures
associated with the task and control measures		
2. Inspect equipment and asses the site prior to start of operations 2. Ensure personnel and crew are ready 2. Ensure personnel and crew wear appropriate safety equipment 2. Conduct helicopter survey and select site	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Frostbite, freezing to death Sunburns, snow blindness, glare off ice Flying conditions	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Sufficient light or lighting during operations Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good communication with ship to send or receive warnings of potential hazards. (i.e. fog horn blasts symbolize evacuate ice) Ensure safe ice conditions
3. Take photographs 4. Assess ice thickness and delineate safe zone 5. Exit helicopter 6. Sample the melt ponds 7. Collect ice cores 8. Sample the water column under the melt pond	Slipping/Falling on ice Falling into sea, drowning Open water and melt ponds Falling through ice Presence of polar bears Manual lifting of heavy loads	Maintain alertness and use common sense Personal awareness about cold, overheating, sweating, hunger, etc. Remain within sight of ship (<1 km distant) Radio communication to ship at pre-determined intervals, w/ GPS coordinates if needed Throw ropes (safety bagged throwing rope, or standard safety line) Open communication at all times concerning dangers, questions, suspicions One or more people with first responder or first aid training Team of 2-3 people, at least one with experience working on sea ice Polar bear watch, on ice and shipboard Work near spotter with shotgun (with fire arms permit and experience) Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications Safe lifting plan

Step	Hazards	Control measures
		Coast Guard and Transport Canada Safety briefings for all personnel working in and around helicopters
		Extreme care in or around the helicopter

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.5.8 Iceberg drift beacons

General description of the activity

GPS drift beacons will be deployed on icebergs using the Amundsen's helicopter to access them. The beacons will allow investigating the drift and deterioration of icebergs. Several types of beacons will be used, which are broadly classified as disposable (not recovered) or recoverable. The selection of icebergs on which to conduct the scientific measurements will a joint decision between the Responsible Scientist, Chief Scientist, the Commanding Officer and the helicopter pilot. Identification of icebergs that permit safe deployment of drift beacons will be an important part of the selection process. In general, icebergs will be safer for deployments if they have low freeboard to length ratios, and flat tops (tabular). The availability of locally smooth areas for landing is also important as this will minimize helicopter side-slip. If the helicopter lands, or attempts to land at the selected site and the helicopter pilot is not completely satisfied that the site is safe (slippery, uneven surface, sloping surface, etc.) the pilot will take off and an alternate site must be selected. If, for any reason, the Project Lead or Safety Officer do not think the site is safe, they can signal this to the pilot and the site will be abandoned.

Two of the greatest risks associated with the beacon deployment are iceberg rolling and calving. Rolling is extremely difficult to predict. Icebergs that are actively calving may be more likely to roll, but the absence of calving is not a reliable indication of stability. Tabular icebergs are not necessarily tabular under the water, and all icebergs will role during the deterioration process. Close monitoring of the iceberg during the deployment procedure is critical to project safety and will be performed by personnel on the helicopter and from the bridge of the *Amundsen*.

Iceberg rolling can take several seconds. Iceberg calving is an instantaneous process that provides no opportunity for mitigative action. Even if the helicopter is in a 'power on landing' state, if the ice calves the loss of ground effect may make it impossible maintain lift. Studies of iceberg calving on the east coast of Newfoundland (Crocker, personal communication) have show that calving rates are a function of water temperature with major calving events occurring once every 24 hours in 5°C water and once every 48 hours in 2°C water. Small calving events are more frequent. Because calving is typically limited to the perimeter of icebergs, the best approach to mitigating the risk from calving is to limit landing sites to a *minimum* of 2 freeboard (H) distances from any edge (Fig. 4).

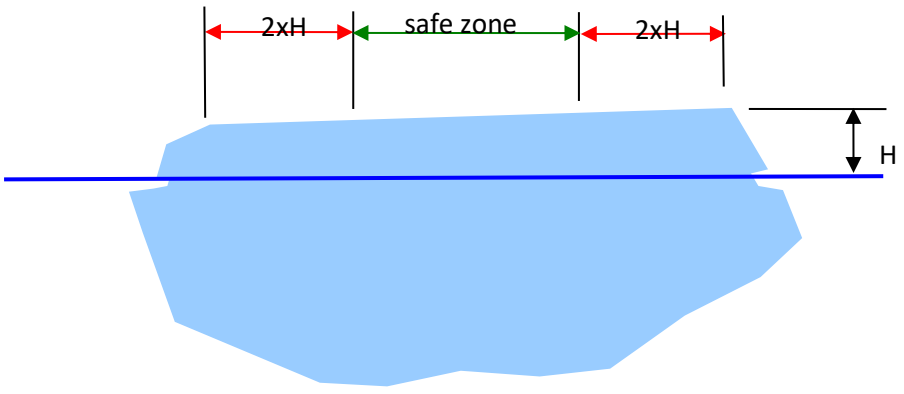


Figure 4. Illustration of safe working zone for helicopter landing on an iceberg.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Select a suitable site icebergs with appropriate landing zone (Fig.3) and assess environmental conditions.
3. Inspect all equipment prior to the start of operations. Hold a Toolbox Meeting to review procedures and roles (usually 5 minutes before). Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment.
4. Land helicopter on a safe / appropriate icebergs. Once the helicopter has touched down the pilot must 'seat' the helicopter on the ice and reduce lift to a 'power on landing' state.
5. Attach a harness, open the helicopter door and exits onto the ice surface with a drill.
6. Drill an 0.5 m hole into the icebergs.
7. Install beacon into drilled hole.
8. Re-enter the helicopter with auger system, remove harness and attach safety belt.
9. Return to ship.

Roles and Responsibilities

Deployment of iceberg drift beacons requires 3 persons:

1 Helicopter Pilot: ensures flight safety, has authority to cancel flights based on established CCG flight safety protocols and has authority to cancel landing if the selected site is unsafe.
2 science/technical staff doing operations and ensuring safe conditions (i.e. no rolling or tilting of the iceberg).

Personal protective equipment to be worn while undertaking the task

Helicopter-specific immersion suit
Personal flotation device
Gloves for coring/drilling (warm when wet)

Description of the environment where the task must be undertaken

Helicopter and icebergs surface.

Required training

Coast Guard and Transport Canada Safety briefings for all personnel working in and around helicopters
Helicopter Ditching training
SWI Meeting for safe work procedures related to on-ice operations

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Select a suitable site icebergs with appropriate landing zone and assess environmental and flight conditions 3. Inspect all equipment 3. Hold a Toolbox Meeting to review procedures and roles (usually 5 minutes before) 3. Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment	Meteorological conditions (wind, sea state, temperature, etc.) Ice conditions Reduced visibility Flying conditions	Inspect and wear appropriate PPE and warm clothing Review step-by-step procedures and roles for the task Ensure safe ice conditions Awareness of potential hazardous conditions associated with iceberg tilting or rolling Establish safe go or no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Good communication with ship to send or receive warnings of potential dangers
4. Land helicopter on a safe / appropriate ice floe. 5. Attach a harness, open the helicopter door and exits onto the ice surface with a drill.	Flying conditions Iceberg unsafe for landing Slipping/Falling on ice Sharp blades, rotating machinery Falling into sea, drowning Slippery ice Helicopter blades	Experienced and sufficient technical crew to choose appropriate iceberg for landing Coast Guard and Transport Canada Safety briefings for all personnel working in and around helicopters Radio communication to ship at all times Proper care and routine maintenance of instruments and equipment to avoid damage/accidents/malfunction Strict adherence to operation procedures, including communications

Step	Hazards	Control measures
6. Drill an 0.5 m hole into the icebergs. 7. Install beacon into drilled hole 8. Re-enter helicopter with auger system 9. Return to ship	Vibration and noise hazards Inhalation of fumes from auger (if fuel type)	Extreme care when operation requires use of the helicopter

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, helicopter ditching or emergency situations, and to equipment failure, damage or loss.

3.6 *Amundsen* infrastructures and equipment used in science operations

3.6.1 Accommodation ladder

General description of the activity

Deployment and recovery of the accommodation ladder located near the bow. The accommodation ladder is often deployed to embark and disembark passengers from/to the barge when science operations or a crew change require its use.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space prior to the start of operations. Hold a Toolbox Meeting prior to start of operations to review procedures and roles (usually 5 minutes before). Ensure crew members are positioned and ready and that they wear appropriate safety equipment.
3. Notify the bridge and wait for confirmation before proceeding with the deployment.
4. Deploy and recover the ladder.
    a) Lower the ladder
    b) Set the ladder railing
    c) Transfer passengers to/from the barge
    d) Recover the ladder
    e) Recline the ladder railing
5. Lock down the ladder and make sure the work space is safe.

Roles and responsibilities

A minimum of 3 crew members is required to deploy and recover the accommodation ladder:

1 winch operator
1 crane operator
1 crew member to secure railing in place
1 crew member as safety observer

Tools or equipment used in the activity

Ladder
Deck equipment: winch, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (life jacket, hard hat, and safety shoes) must be worn at all times by crew members deploying and recovering the ladder. A flotation device must be worn by all persons using the ladder.

Life rings with 90’ floating line must be close at hand and ready for immediate response.

Description of the environment where the task must be undertaken

Foredeck on starboard side.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Steps	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space prior to start of operations 2. Hold a Toolbox Meeting 2. Ensure crew members are positioned and ready 2. Ensure crew wear appropriate safety equipment 3. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on foredeck and work spaces during operations Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance

Steps	Hazards	Control measures
		Good visibility from bridge to foredeck
3. Deploy and recover the ladder	Hoist/crane lifting overhead Moving loads and equipment Working over water Inadequate communication Unexpected vessel movement Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations MOB procedures in place Observer and emergency equipment pre-positioned for immediate response Inspect and wear appropriate PPE Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to ladder Use of tag and hold back lines Strict adherence to deployment procedures
4. Lash down/secure the ladder and make sure deck is safe	Slippery or obstructed deck	Remain on station until ladder is secured Notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.6.2 Ice cage

General description of the activity

Deployment and recovery of the ice cage used to transfer personnel to the ice directly from the vessel.

Step-by-step instructions of the activity

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space prior to the start of operations. Hold a Toolbox Meeting to review procedures and roles (usually 5 minutes before). Ensure crew members and science personnel are positioned and ready and that they wear appropriate safety equipment.
3. Notify the bridge and wait for confirmation before proceeding with the deployment.
4. Deploy and recover the ice cage.
    a) Position the ice cage on the foredeck.
    b) Secure the ice cage to the crane.
    c) Board personnel wearing a certified fall restraint safety harness with a roll-up leash attached to the crane and not to the cage.
    d) Lift the ice cage with the crane and use tag lines to stabilize the ice cage and orient it for landing on the ice.
    e) Passenger exits onto the ice. The first person to be lowered on the ice must check ice thickness by boring a hole with an auger (at least 30 cm deep) while the harness is still fastened to the crane.
    f) Conduct on-ice operations.
    g) Bring back passengers back on board.
5. Secure the ice cage and make sure the work space is safe.

Roles and responsibilities

A minimum of 3 crew members is required to deploy and recover the ice cage:

1 winch operator
1 crane operator
1 crew member as safety observer
1 passenger at a time in the ice-cage

Tools or equipment used in the activity

Ice cage
Deck equipment: winch, crane, tag lines
Radio

Personal protective equipment to be worn while undertaking the task

PPE (life jacket, hard hat, and safety shoes) must be worn at all times by crew members deploying and recovering the ice cage.

Immersion suit and personal flotation device must be worn by all persons using the ice cage.

Description of the environment where the task must be undertaken

Foredeck on port side.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI Meeting on safety and communications during on-ice operations
SWI Meeting on safe work procedures for use of the ice cage.

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Steps	Hazards	Control measures
1. Prepare sequence of operations 1. Assess risks and hazards associated with the task 1. Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
2. Inspect equipment and work space prior to start of operations 2. Hold a Toolbox Meeting 2. Ensure crew members are positioned and ready 2. Ensure crew wear appropriate safety equipment 3. Notify bridge and wait for confirmation to proceed with deployment	Failure of deck equipment Restricted space to work Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Perform regular inspections and scheduled maintenance for the A-frame, cranes, winches, wire cables and other deck equipment Updated stress test certification for overhead travelling crane, wire cables and anchor points Pre-heat oil in winches and cranes prior to work Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on foredeck and work spaces during operations Inspect and wear appropriate PPE, fall arrest safety harness, etc. Notify the bridge and wait for confirmation before beginning deck operations Establish safe sea go/no go decision guidelines

Steps	Hazards	Control measures
		Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance
		Good visibility from bridge to foredeck
3. Deploy and recover the ice cage	Hoist/crane lifting overhead Moving loads and equipment Working over water Inadequate communication Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Ice thickness insufficient	Safe lifting plan in place Mandatory training in safe work procedures for manual and crane lifting and handling of heavy loads Good communications with appropriate hand and visual signals and radio communications MOB procedures in place Observer and emergency equipment pre-positioned for immediate response Inspect and wear appropriate PPE, including certified fall restraint safety harness with roll-up leash Meteorological conditions within working tolerance Adequate lighting on foredeck and work spaces during operations Good visibility from bridge to deck Use of tag and hold back lines Check ice thickness before going onto the ice Strict adherence to deployment procedures
4. Secure the ice cage and make sure deck is safe	Slippery or obstructed deck	Remain on station until ice cage is secured Notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.6.3 Auxiliary vessels

General description of the activity

Auxiliary vessels or workboats, such as the Zodiacs, the barge and the air-ice boat, are regularly used to transport passengers and personnel during crew change and during dedicated science operations. Examples of such operations are:

- Use of the Zodiac to assist the deployment and recovery of oceanographic moorings.
- Use of the barge to transport science personnel to sampling sites, conduct Multibeam surveys, etc.
- Use of the air-ice boat to access the ice during on-ice operations.

The operational parameters specific to the use of auxiliary vessels are established at the beginning of the operation by the Commanding Officer. These parameters include determining the weather, visibility, sea-state and ice conditions under which the workboats can be launched and used. When used in science operations, small vessels must operate within a 20 nautical miles' radius of the *Amundsen.* Auxiliary vessels are equipped with an AIS (Automatic Identification System) transceiver that allows the *Amundsen* to locate and track the small craft on the radar at all times during operations out of visual contact from the ship.

When a workboat is in the water, meteorological conditions will be closely followed by the officer on watch and notes taken in a logbook every hour. This procedure allows for quick action to recover the auxiliary vessel if the weather and/or sea conditions deteriorate.

Often, science operations performed using auxiliary vessels require that the craft be left adrift or kept stationary, which means the boat is subject to the to-and-fro movements of the sea and engine exhaust gases can linger. Also, personnel deploying the scientific gear into the water and retrieving it must often work with their head lowered or in uncomfortable positions. These factors increase the risk of seasickness and this must be taken into account when establishing the list of personnel called on to work aboard the craft. It is also recommended that personnel take the appropriate medication, as required.

A detailed work schedule is established for the auxiliary vessels that take into account prevailing conditions and operational constraints (distance to travel, ice conditions, etc.). Minor changes that have no impact on how the operation is conducted can be decided on the spot but all major changes must be authorized by the Chief Scientist and the Commanding Officer. The Chief Scientist has the responsibility to keep the work schedule up to date and make this schedule be available on the bridge.

Requirements for small vessels not owned by the CCG

Only a Canadian Coast Guard officer with experience, required training (SVOP, RHIOT, etc.) and operation license can operate an auxiliary vessel launched from the *Amundsen*. In the case of a small craft owned by another entity (e.g., U. Manitoba's Air-Ice Boat), the owner (U. Manitoba) has to comply with the following requirements to operate this craft and submit all documents and proofs of compliance to the Commanding officer prior to departure for the annual expedition:

All documents attesting to the good condition of the craft:

- License certificate for the craft (Transport Canada)
- Small Vessel Monitoring and Inspection Program (Transport Canada)
- Self-checked inspection record

The craft has all the required and mandatory equipment on board:

- List of inventory of equipment

The craft is conforming to Small Vessel Regulations (building standards) including the recent modification to the regulation requiring craft stability to safely conduct planned operations:

- Technical datasheet from the manufacturer
- Craft's Stability Booklet (operational stability envelope, load limit, environmental and safety limits, etc.).

Description of each type of vessel and methods of launch and recovery

Zodiacs 733 and 540

The Hurricane 733 Zodiac is a fast rescue craft, and is the craft normally used for conducting scientific work. The Zodiac 733 is perfectly suited to deployment and recovery at sea using the Miranda davit.

The Hurricane 540 Zodiac fast rescue craft, and is the spare craft used for certain scientific work. The Zodiac 540 does not have a specific davit for launching and recovery, since these operations are carried out using the vessel's cranes. Launching and recovery operations can prove to be difficult so a calm sea is required to operate this craft.

Zodiacs general operating conditions:

- The Zodiacs must remain within a 20 nautical mile radius of the *Amundsen*
- Open water and open water with ice present
- Wave height <2m
- Wind speed of ≤20 knots
- Visibility around Zodiac ≥1 nautical mile

Barge

The barge is a workboat with a flat bottom that enables it to be run aground on a shoreline and is adapted to transporting personnel and/or merchandise. The barge has a specific davit located on the port side and requires a fairly calm sea for launching and recovery.

Barge general operating conditions:

- The barge must remain within a 20 nautical mile radius of the *Amundsen*
- Open water and open water with ice present
- Wave height <2m
- Wind speed of ≤20 knots
- Visibility around barge ≥1 nautical mile

Hydroplane or Air-Ice Boat (or Skippy boat)

The hydroplane workboat or Air-Ice Boat has a flat-bottom hull, a shallow draught and is propelled by an aircraft propeller**.** Hydroplanes are rapid craft that are usually designed for interior. The Air-Ice Boat's structure has been altered to enable it to climb on top of ice floes but it is not designed for use in rough seas or swells.

The Air-Ice Boat does not have a specific davit for launching and recovery and these operations are done using the vessel's cranes. Launching and recovery of the boat are both difficult and require a calm sea.

In operations conducted at sea, the Air-Ice Boat must always remain in view of the ship. When it is in the pack ice and the ice cover is stable and safe, the Air-Ice Boat does not have to remain in view of the ship but must remain within radio range. In addition, the boat must inform the ship before it leaves its established

work-position and notify of any changes made to the position where the work is to be conducted. Under no circumstances is the Air-Ice Boat allowed to be more than 20 miles from the main vessel.

Airboat operating conditions:

- In open water, the airboat must remain within view of the *Amundsen*
- In pack ice, the airboat must remain within radio range of the *Amundsen*
- Temperatures can range from -30°C to 32°C (-22°F to 90°F)
- The water can be as shallow as 229 mm (9 in)
- The airboat can operate on frozen bodies of water
- It can travel over dry hard snow and pack ice
- It can go up and down very gentle grades
- The airboat can operate during freeze up-and break-up
- The airboat's ability to operate both in the water and over ice and snow also limits its operation. The operational limitations are:
  - Operations are limited to within 20 nautical miles radius of the CCGS *Amundsen.*
  - Wave height must not exceed 1 m (3 feet).
  - High wind conditions may make it difficult or impossible to operate and maintain control.
  - Impossibility to reverse direction without turning around.
  - Fuel consumption dependent on wind, water and loading conditions. More fuel will be used when operating upwind over a known distance than when operating downwind. Loading and surface conditions will also affect fuel consumption. All conditions will also affect fuel consumption. All conditions must be evaluated when establishing maximum safe operating range.

Step-by-step instructions for launches and recovery of vessels with a davit (Zodiac 733 and barge)

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).
2. Inspect all equipment and the work space (boat deck) prior to the start of operations. Ensure the craft's fuel tank is full before it is launched.
3. Board personnel and/or load equipment and cargo. Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment (including Immersion Suit and personal flotation device).
4. Unlock the Zodiac or barge from its berth.
5. Advise the bridge of launch deployment, test the radio and obtain permission from the bridge to detach.
6. Deploy and lower the auxiliary vessel to the water using the davit.
7. Unhook the launch from the davit.
8. Conduct scientific operations or transport of passengers and cargo.
9. Hook the launch to the recovery davit.
10. Recover the craft.
11. Lock and secure the launch to its berth.

Step-by-step instructions for launches and recovery of vessels with the crane (Zodiac 540 and Air-ice Boat)

1. Prepare the sequence of work operations and assess the risks associated with the task (JSA). Hold a SWI Meeting presenting the work procedures and explaining the risks associated with the task and the mitigation measures (see Section 3.1.4 for more details).

2. Inspect all equipment and the work space (boat deck) prior to the start of operations. Load scientific equipment and cargo. Ensure the craft's fuel tank is full before it is launched.
3. Notify the bridge and wait for confirmation before proceeding with the launch.
4. Deploy the craft.
5. Ensure scientific personnel and crew are positioned and ready and that they wear appropriate safety equipment (including Immersion Suit and personal flotation device). Board personnel using the rope ladder.
6. Conduct scientific operations or transport of passengers and cargo.
7. Disembark personnel using the rope ladder.
8. Recover the craft.
   a) Attach the small vessel to the crane
   b) Lift and position the craft in its berth on deck
9. Lock and secure the launch to its berth.

Roles and responsibilities

Two to four crew members are required to launch, operate and recover auxiliary vessels. The number of science personnel onboard depends on the craft and on the science operations to be conducted.

Zodiac 733 (with davit): minimum 2

- 1 coxswain: CG officer trained (SVOP and RHIOT) and experienced with science operations
- 1 deckhand with SVOP and RHIOT training
- Maximum of 6 people on board

Zodiac 540 (with crane): minimum 2

- 1 coxswain: CG officer trained (SVOP and RHIOT) and experienced with science operations
- 1 deckhand with SVOP and RHIOT
- Maximum of 4 people on board

Barge (with davit): minimum 3 or 4

- 1 coxswain: CG officer trained (SVOP) and experienced with science operations
- 1 or 2 deckhands
- 1 engineer
- Maximum of 16 people on board

Hydroplane (with crane): Minimum 2

- 1 coxswain: CG officer trained (SVOP) and experienced with science operations
- 1 deckhand
- Maximum of 4 people on board

Tools or equipment used in the activity

Auxiliary vessel
Deck equipment: davit, crane
Radio

Personal protective equipment to be worn while undertaking the task

During the operations, PPE consisting of a personal flotation device (PFD), gloves, safety boots and hard hat must be worn by everyone aboard a workboat and by all personnel involved in the launching an recovery of the auxiliary vessels.

In addition, during work in the Arctic or during the winter, all personnel aboard a workboat must wear an Immersion Suit and ensure it is donned properly.

Description of the environment where the task must be undertaken

Boat deck.

Required training for Supernumerary Personnel

Fall prevention for scientific personnel (given onboard by competent person)
SWI Meeting for safe work procedures related to this scientific operation

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
Prepare sequence of operations Assess risks and hazards associated with the task Hold SWI Meeting presenting work procedures, risks associated with the task and control measures	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure Heavy workload (limited staff, schedule, etc.) Fatigue	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines Mandatory attendance to the SWI Meeting by all crew members and scientific staff prior to executing the task Mandatory training and certifications for crew members and scientific staff Organize crew shift changes, task delegation, staff duties, etc.
Inspect all equipment and the work space prior to the start of operations Ensure the craft's fuel tank is full before it is launched Board personnel and/or load equipment and cargo Ensure scientific personnel and	Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility Hazardous materials in scientific equipment or cargo Manual lifting and handling of heavy loads Failure of deck equipment	Risk analysis in place Emergency response and contingency plan in place Practice emergency drills in vessel procedures Launch Vessel team ready for immediate response Observers and emergency equipment pre-positioned for immediate response MOB procedures in place Regular coxswain training and crew awareness Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition

Step	Hazards	Control measures
crew are positioned and ready and wear appropriate safety equipment Unlock Zodiac or barge from berth Advise bridge of launch, test radio and obtain permission to detach	Vessel or vessel's equipment not conform	Sufficient light or lighting on helideck during operations Inspect and wear appropriate PPE Regular and correct maintenance and inspections of the craft and its equipment Perform regular inspections and scheduled maintenance for the cranes, davits and other deck equipment MSDS for all hazardous material onboard and spill kit if necessary Safe lifting plan in place Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance Permission imperative from bridge before commencing operations
Deploy and recover auxiliary vessel to the water using davit or crane	Meteorological conditions (wind, sea state, ice, temperature, etc.) Slippery or obstructed deck Unexpected vessel movements (*Amundsen* and small craft) Personnel or cargo falling overboard Limited maneuverability Collision Capsizing Pinch points between davit and hooking mechanisms of launch	Emergency personnel and equipment pre-positioned for immediate response MOB procedures in place Good communication with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and movements during operations Meteorological conditions within working tolerance Adequate light lighting on boat deck and work spaces during operations Good visibility from bridge to launch areas Strict adherence to deployment procedures Coxswain and crew are trained in SVOP and RHIOT, including emergency procedures in case the vessel capsizes
Conduct scientific operations or transport of passengers and cargo	Rapid deterioration of weather Difficulty communicating with the ship	Sea survival equipment onboard Return to the ship if weather conditions deteriorate or communications fail Position small vessel to minimize heave and spray during operations

Step	Hazards	Control measures
	Small vessel's deck slippery or obstructed Manual lifting and handling of heavy loads Hazardous materials onboard Presence of wild animals	MOB procedures in place Safe lifting plan in place MSDS for all hazardous material onboard and spill kit if necessary Main working area free of obstructions Keep watch for animals and have a shotgun onboard (and an operator with firearms permit and experience)
Secure small vessel and make sure deck is safe Transport samples to laboratory	Slippery or obstructed deck Inadequate communication Stairs and ladders Manual lifting and handling of heavy loads	Remain on station until auxiliary vessel is secured Notify the bridge at the end of operations Safe lifting plan in place Use handrails

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.6.4 Helicopter

General description of the activity

The CCGS *Amundsen*'s helicopter is used for transportation of personnel and cargo during crew changes and for dedicated science operations such as sampling of sites on the ice or on shore and conducting ice reconnaissance surveys.

Helicopter flights over open water or sea-ice are limited to a 25 nm radius of the *Amundsen*. When landing on the ice, one (and only one) person must get onto the ice and measure ice thickness by boring a hole at least 30 cm deep with an auger. If the ice is sufficiently thick, personnel can then go on the ice and rotors can be put on idle. Stopping rotors completely will be at the pilot's discretion.

All passengers aboard CCG helicopters and all CCG personnel aboard non-CCG helicopters chartered for CCG operations must wear a "dry-type" immersion suit with appropriate thermal protection underneath that is authorized by CCG (in Appendix 2), where the helicopter is flying over Arctic waters (see CCG Arctic Operations Helicopter Immersion Suit Policy).

Immersion suits for helicopter transport

A "dry-type" immersion suit provides a barrier between the wearer and the water and is suitable for helicopter operations. For a list of Coast Guard approved immersion suits, please refer to Appendix 2. For crew changes using the helicopter, a total of 21 immersion suits in various sizes are divided between the ship, the airport and aboard the helicopter, and a rotation of the suits is put in place so that different sizes are always available and the crew change is done efficiently.

The Survitec Survival-One immersion suit used on the *Amundsen* offers the following features (follow link in the Table for more information):

- Designed specifically for helicopter passengers
- Exceptional in-water performance and survivability
- Waterproof and breathable to improve passenger cabin comfort
- Inherently flame retardant material providing optimum protection against fire
- Enhanced thermal insulation
- Seals with superior performance, delivering greater flexibility and comfort over long wear periods
- Latest waterproof zip technology provides a lightweight, flexible and durable solution

Step-by-step instructions of the activity

1. Prepare the sequence of operations and assess the risks associated with the task (JSA).
2. Hold a safety briefing and view the familiarisation video for personnel working in and around helicopters (made by CCG and TC: http://asd-sda.ca/CCG/CCG_video_page/SFC2_web.html).
3. Make a demonstration or view the video on how to put on the Survitec Survival One immersion suits (https://www.youtube.com/watch?v=WSRZYPEH4YY).
4. Explain the procedures and the risks associated with the flight, and the mitigation measures to eliminate or reduce these risks.
5. During a crew change, personnel to be transported will be divided into groups of three. A total of 21 immersion suits available in various sizes will be divided between the ship and the airport.
6. On the ship, suits will be donned in the Officer's Mess. At the airport, suits will be donned in the waiting room.
7. Don the immersion suit (numbers refer to the steps of the illustrations in Fig. 2). Personnel on the ship and at the airport will be available to help, if necessary.

1) Before donning the suit, check to make sure there is no damage to the waterproof zippers and seals and that it is the correct size. Remove watches, jewellery, glasses and piercings before donning the suit. Avoid wearing hoodie type sweaters under the suit. Remove footwear and feed trousers inside the socks. Wear appropriate footwear (e.g. no flip flops/sandals). Shoes or boots are worn over the waterproof liner socks of the immersion suit.
2) Open the main entry zip slider to its fullest extent.
3) Place the right leg inside the survival suit, then the left leg. Bring the suit up around the torso.
4) Place one arm and shoulder fully into the sleeve. Stretch the wrist seal widthwise to get the hand through. Talk (baby powder) for the wrists will be available to help with this step and avoid damaging the wrist seals.
5) Put on the other arm and shoulder. Do not don both sleeves at once and pull up over the shoulders as this will damage the zipper.
6) Bring the suit over the head and assist the head through the neck seal by pulling the seal widthways.
7) Close the main entry zip (shoulder to hip) and make sure it goes to the end stop. Close the flap over the zipper.
8) Hold neck seal open.
9) Crouch into a small ball to remove excess air from the suit. Once the airflow has stopped, close the neck seal and then stand up.
10) Double check seals and smooth out wrinkles.
11) Put on your shoes/boots.
12) Put on the gloves and hood.

8. Board personnel and/or load baggage and equipment. When embarking, passengers must follow the procedures outlined in the helicopter familiarisation and safety briefing/video. During crew changes, passengers will bring only their coats in the helicopter with them. Carry-ons will be transported in the helicopter cargo hold. All other baggage will be transported at the end with the remainder of the cargo.
9. Notify the bridge of helicopter readiness and wait for confirmation before proceeding with the flight.
10. Warm up the engines.
11. Advise bridge of helicopter departure.
12. Take-off and landing of the helicopter. For flights dedicated to science operations, see specific safe work instructions in Section 3.7.3.
13. Disembark passengers and unload baggage and cargo. When debarking, passengers must follow the procedures outlined in the helicopter familiarisation and safety briefing/video. During crew changes, personnel should rapidly go to the Officer's Mess or the airport's waiting room to remove the immersion suits. The next group of three passengers should be ready to board the helicopter for the flight back to the ship.
14. When operations are completed (crew change or dedicated science operation), move the helicopter from the helideck to the hangar.
15. Secure the helicopter in the hangar.

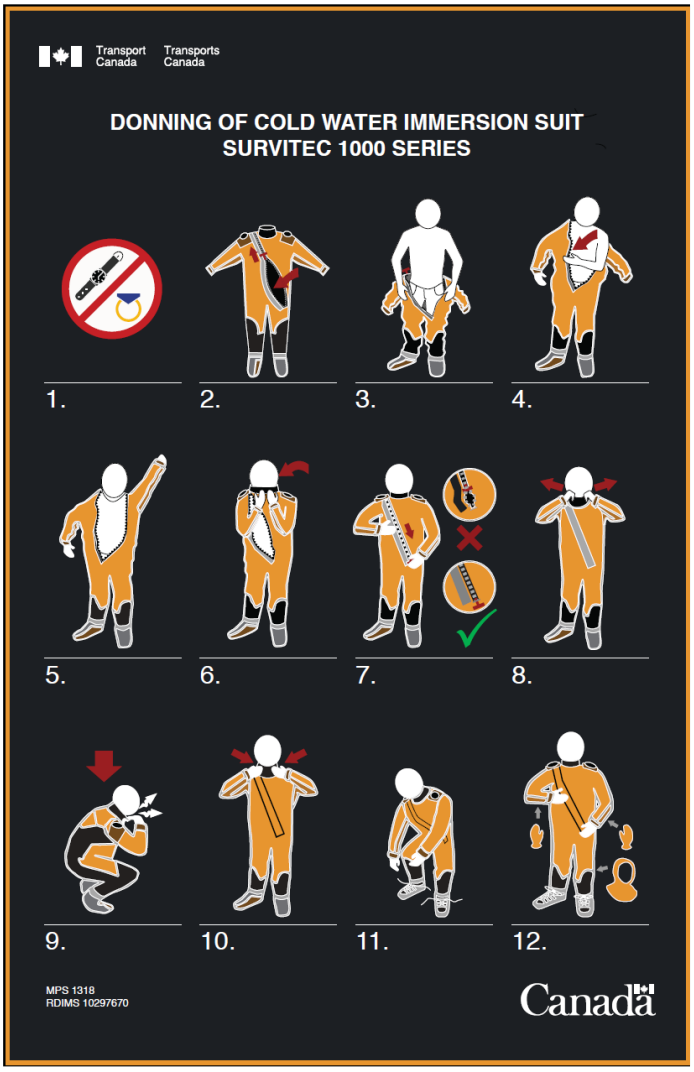


Figure 5 Illustration of how to don the Survitec Survival-One immersion suits used on the CCGS Amundsen's helicopter. Numbers on the illustration refer to steps 7.1) to 7.12) in the instructions above.

Roles and responsibilities

1 helicopter pilot
1 helicopter engineer
3 passengers

A minimum of 4 crew members is required during preparation, pre- and post-flight operations, fire / Emergency response during take-off and landing, helping passengers, and loading/unloading baggage and cargo.

Tools or equipment used in the activity

Helicopter
Immersion suits
Radio

Personal protective equipment to be worn while undertaking the task

Immersion suits (Survitec Survival One) and personal flotation devices must be worn by all helicopter passengers.

PPE (personal flotation device, gloves, safety belt and safety shoes) must be worn at all times by crew members during pre- and post-flight procedures and when assigned to fire crew/emergency response during take-off and landing.

Description of the environment where the task must be undertaken

Helicopter deck and hangar. Officer's Mess and airport waiting room to don the immersion suits.

Required training for Supernumerary Personnel

Helicopter Ditching Course

All science personnel are strongly encouraged to complete a recognized Helicopter Ditching Course prior to joining the *Amundsen* Expedition. The aim of this course is to provide offshore helicopter passengers with the emergency response procedures and skills to effectively react to a helicopter-ditching emergency over water.

The Helicopter Ditching Course is **strongly recommended** for personnel who will only be using the helicopter for ship to shore transfers during crew changes.

The Helicopter Ditching Course is **mandatory** for personnel who will be using the *Amundsen*'s helicopter to conduct dedicated science operations such as sea-ice sampling, melt-pond sampling, ice beacon deployments, accessing land for sampling, etc. All science personnel involved in dedicated science operations will be required to present their course certificate before boarding the *Amundsen*'s helicopter.

Familiarization and Safety briefing for all personnel working in and around helicopters.

Before boarding the helicopter, all participants will receive a pre-flight familiarization and safety briefing. Transport Canada and the Canadian Coast Guard have made available a video (in English and French) presenting the safety features of the helicopter, the operation of onboard equipment, and how to operate while working in and around the aircraft. All participants boarding the Amundsen's helicopter are required to view this video (16 min): http://asd-sda.ca/CCG/CCG_video_page/SFC2_web.html

Potential hazards and risks associated with each of the steps (numbers refer to instructions above) of the task and control measures to minimize or eliminate them

Step	Hazards	Control measures
1. Prepare sequence of operations and assess risks associated with the task (JSA)	Insufficient or incomplete planning Insufficient training Insufficient understanding of the procedure	Risk analysis and Job Safety Analysis in place Reviewed and updated safe work procedures Safe sea go/no go decision guidelines

Step	Hazards	Control measures
2. Hold familiarisation and safety briefing 2. Make demonstration or view video on how to put on immersion suits 2. Explain procedures and risks associated with the flight, and mitigation measures 3. During a crew change, divide personnel into groups of three 5. Don immersion suit		Mandatory attendance to the safety briefing by all personnel working in and around helicopters Training and certifications for crew members and scientific staff (e.g. Helicopter ditching course recommended or mandatory)
6. Board personnel and load cargo/ equipment 7. Notify bridge of helicopter readiness and wait for confirmation before proceeding with flight	Slippery or obstructed deck Meteorological conditions (wind, sea state, ice, temperature, etc.) Reduced visibility	Risk analysis in place Emergency response and contingency plan in place Practice emergency drill in helicopter and vessel procedures Establish deck exclusion zone and restrict access to authorized personnel only Ensure non-skid material on metal decking is in good condition Sufficient light or lighting on helideck during operations Inspect and wear appropriate PPE Recent aviation audits and inspections Permission imperative from bridge before commencing helicopter operations Regular and correct maintenance of helicopter Establish safe sea go/no go decision guidelines Evaluate present and future meteorological conditions before start of operations and ensure they are within working tolerance
11. Take-off and landing of the helicopter 11. Debark personnel and unload cargo/ equipment	Injury to personnel from contact with rotors Inadequate communication Unexpected vessel movement Crash on deck	Emergency personnel and equipment pre-positioned for immediate response (ex: fire fighters) Good communication with appropriate hand and visual signals and radio communications Vessel heading adjusted to minimize heave and spray during operations

Step	Hazards	Control measures
	Ditching Emergency landing Bird strike Rapid deterioration of weather or flight conditions	Inspect and wear appropriate PPE, including helicopter immersion suits and life jackets Survival equipment on board helicopter Meteorological conditions within working tolerance Adequate lighting on helideck and work spaces during operations Strict adherence to deployment procedures
13. Secure helicopter and make sure deck is safe	Slippery or obstructed deck Inadequate communication	Remain on station until helicopter is secured Notify the bridge at the end of operations

Consequences

Failure to follow these safe work instructions and procedures, to take into account the hazards and to apply the control measures listed above can potentially result in injury or fatality to science personnel and/or crew members, MOB or emergency situations, and to equipment failure, damage or loss.

3.7 Hazardous materials

3.7.1 Hazardous material falling under WHMIS guidelines

The Workplace Hazardous Materials Information System (WHMIS) training is a legal requirement for all personnel working with controlled products in Canada. WHMIS is intended to protect the health and safety of workers by promoting access to information on hazardous materials to ensure the safe storage, handling, use and disposal of controlled products in the workplace. Any and all transportation, usage, storage, transfer, and disposal of hazardous materials must be carried out in accordance with the policies and procedures contained in the WHMIS guidelines (www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/index-eng.php. For additional information about the application and structure, and the categories of products, of the WHMIS system, consult the following websites:

Official National WHMIS website

Service du répertoire toxicologique de la Commission de la santé et sécurité du travail du Québec

Participants using chemicals or gases on board the CCGS *Amundsen* must hold a valid Workplace Hazardous Materials Information System (WHMIS) training certificate. It is the employer's responsibility to ensure that their employees receive the proper training for handling of hazardous materials. Universities and federal departments provide WHMIS training on a regular basis. Employers can obtain further information by contacting their workplace environmental health and safety department.

Participants using hazardous materials in a CCGS *Amundsen* expedition are required to read the document CCGS *Amundsen Hazardous Material User Guide* and ensure that the proper procedures described therein are followed and that forms pertaining to the use and disposal of hazardous materials are completed.

Within the first 24 hours of the commencement of a Leg, the Chief Scientist will give a presentation detailing the safety procedures to be followed for work in the laboratories. Additionally, on each Leg of the expedition, all science teams must designate a Hazardous Materials Safety Representative (HMSR) who will be responsible to:

- Make sure that all members of their team, who will be using hazardous materials, have valid WHMIS certification before boarding the ship.
- Ensure the proper storage, handling, use and disposal of their respective science team's hazardous materials.
- Ensure that their respective team acquires the appropriate spill clean-up materials, specific to the hazardous materials they will be using, as well as the appropriate personal protective equipment (PPE) for use when handling the hazardous materials.
- Brief their respective team on the different hazardous materials to be used by the team during the Leg, the location of the MSDS sheets in the laboratory, the location of the spill clean-up material, the PPE to be used when handling the materials, the location of the supplementary emergency equipment provided, and the location of the hazardous waste disposal.
- Post all safety information in the laboratory where the hazardous materials are used.
- Post the inventory list of their team's chemicals in the storage room.
- Provide all safety information to team members and provide all required paperwork to the Chief Scientist and the Amundsen Science Project Coordinator, i.e. MSDS, waste list, etc.
- In the event of an emergency on board, the HMSRs may be asked to communicate with the Commanding Officer and Chief Officer in regards to potential dangers due to hazardous materials in their team's laboratory.

At the end of each Leg, the HMSRs must:

- Ensure the laboratory is left clean and organized and that all hazardous waste has been disposed of in the barrels provided.
- Ensure that chemicals left in the laboratory or Chemical Storage Room are properly labelled, stored, and secured.
- Ensure that information sheets are updated if chemicals are left in the laboratory and removed if all chemicals have been taken out of the laboratory.
- Update the inventory list of hazardous materials posted on the cabinets in the Chemical Storage Room according to what remains from their respective team.
- At the end of an expedition, the HMSRs must ensure that all hazardous materials belonging to their team are removed from the ship. Transportation of these materials must follow the Canadian Transport of Dangerous Goods Act (http://www.tc.gc.ca/eng/tdg/safety-menu.htm).

3.7.2 Cryogens

Detailed guidelines and procedures concerning the safe handling, transport, storage, and use of cryogenic liquids are documented in the *CCGS Amundsen Cryogenic Safety Manual*. Participants using cryogenic liquids during a CCGS *Amundsen* Expedition must read the cryogenic safety manual and ensure that the proper procedures described therein are followed and that forms pertaining to the storage, use and transport of cryogens are completed.

- Do not allow unprotected areas of skin to touch objects cooled by cryogenic liquids and wear the mandatory protective devices (appropriate clothing, gloves and goggles/face shield).
- Use tongs to withdraw objects immersed in the liquid and handle the object carefully.
- Handle slowly to minimize boiling, splashing and spilling.
- Use proper transfer equipment: a phase separator or special filling funnel (the top of the funnel should be partly covered to reduce splashing).
- Store only in well-ventilated areas.
- Do not overfill containers
- Use wooden or solid metal dipsticks.
- DO NOT USE in closed areas, gases can reduce the oxygen concentration and can result in asphyxiation. To avoid asphyxiation, an oxygen monitor is recommended when working with a cryogen in a confined space.
- Use containers specifically designed for low-temperature liquids, such as a Liquid Dewar flask. Do not connect the tank and the Dewar tightly to avoid pressure build up in the Dewar. Do not use any stopper or other device that would interfere with venting of gas.
- Cryogenic containers are designed and made of materials that can withstand rapid changes and extreme temperature differences encountered in working with cryogenics. However, containers should be filled slowly to minimize internal stresses that occur when any material is cooled.
- Use care when filling portable Dewars and do not overfill them. When hand-carrying cryogen-containing Dewars, ensure the Dewar is your only load (don't carry anything else). Watch for people who may run into you. Large Dewars should always be carried by two people.
- Ensure Dewars are properly labelled with the identity of the cryogen. Do not mix different cryogens in the same Dewar.
- Do not cover or plug the entrance opening of any Dewar. Do not use any stopper or other device that would interfere with venting of gas.
- Keep containers upright at all times except when pouring liquids from Dewars specifically designed for that purpose. Handle containers gently; rough handling can cause serious damage to Dewars and refrigerators.

- Keep containers clean and dry. Moisture, chemicals, strong cleaning agents may promote corrosion which should be removed promptly. Use water or mild detergent for cleaning and dry the surface thoroughly. Do not use strong alkaline or acid cleaners that could damage the finish and corrode the metal shell. Follow manufacturer's recommendations.

3.7.3 Radioisotopes

Any and all transportation, usage, storage, transfer, and disposal of radioisotopes must be carried out in accordance with the policies and procedures contained in the Canadian Nuclear Safety and Control Act, the consolidated licence, the DFO Radiation Safety Manual, the Radiation Safety regulations of Université Laval and the licensed institution(s) under which the work will be conducted. Detailed guidelines and procedures concerning the safe handling, transport, storage, and use of radioisotopes are documented in the *CCGS Amundsen Radioisotopes User Guide*.

Participants using radioisotopes during a CCGS *Amundsen* expedition must read this user guide and ensure that the proper procedures described therein are followed and that forms pertaining to the storage, use and transport of radioisotopes are completed. Copies of the DFO radiation safety manual are available for reference from the Designated Mission Radiation Safety Officer (DMRSO). Participants using radioisotopes must also refer to Canadian Coast Guard procedures regarding transport of radioactive material onboard the ship (7.E.3.A27.2a) and complete the checklist (7.E.3.A27.3a).

- Radioisotope users must ensure that their work will be conducted under a Canadian Nuclear Safety Commission licence (CNSC) on which the CCGS *Amundse*n is listed as a facility. The person in charge of the licence and activity requiring the use of radioisotopes must obtain the written approval of the Regional Radiation Safety Officer (RRSO) at least 6 weeks before the ship's departure.
- The Radvan laboratory on board the CCGS *Amundsen* is the property of Université Laval. To use the Radvan, a written request must be submitted to the Radiation Safety Officer (RSO) of Université Laval at least 6 weeks prior to the ship's departure. The person in charge of the licence and activity requiring the use of radioisotopes must provide to Amundsen Science Project Coordinator (PC) a list of all radioisotopes that will be used on board the CCGS *Amundsen* under a same licence and the Radioactive Waste form. The Amundsen Science PC along with the RSO of Université Laval will ensure the management of radioactive waste produced during the expedition.
- A copy of the Nuclear Substances and Radiation Devices licences (CNSC) under which the work will be conducted must be provided to the Amundsen Science PC and posted in any location using or storing radioisotopes (eg. Radvan and room 665 – the scintillation counter room). The internal permits, including the names of the certified users, and emergency contact information should also be provided to the Amundsen Science PC and posted in any location using or storing radioisotopes (eg. Radvan and room 665), including the scintillation counter room.
- Once on board the CCGS *Amundsen*, radioisotope users must complete the Radioisotope Tracking worksheets for all radioactive solution produced and/or stored and the Université Laval RAD waste worksheets to document and a copy of these worksheets must be left inside the logbook in the Radvan laboratory.
- Disposal of radioactive waste must be done in the appropriate containers identified to this effect and must be documented in the RAD waste worksheets. Radioactive waste must be transported according to the Transport of Radioactive Material Check list 7.E.3.A27.3A.
- Contamination tests (wipe tests) must be performed in the Radvan and liquid scintillation counter room (room 665) at least once a week throughout the duration of the expedition, after any radioactive incident, spill, or accident, and at the very beginning and end of each Leg. Measurements are carried out in the liquid scintillation counter and the results must be reported on the appropriate form. Any reading above the predetermined threshold requires decontamination and a new wipe test.

- The Radvan must be decommissioned after completing all radioisotope work conducted under a same licence. The Radvan must be cleaned and emptied and all wipe tests performed. A copy of all worksheets and wipe tests results must be handed to the Commanding Officer, to the Chief Scientist and to the next DMRSO before leaving the ship, and to the Regional Safety Officer and to the Radiation Safety Officer of Université Laval within 7 days of the completion of each Leg in order to make sure the ship's laboratories are free of contamination.

Appendix 1 – List of acronyms

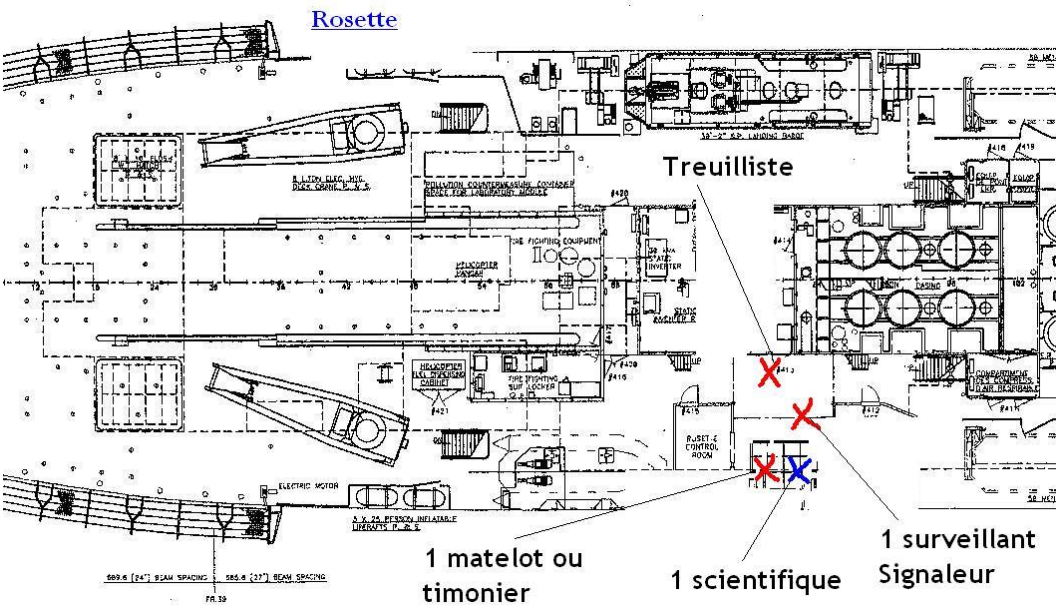
5NVS	5 Net Vertical Sampler or Monster
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CG	Coast Guard
DSN	Double Square Net or Tucker
HSE	Health Safety and Environment
ISM Code	International Safety Management Code
JSA	Job Safety Analysis
MOB	Man Overboard
MSDS	Material Safety Data Sheet
MVP	Moving Vessel Profiler
PC	Project Coordinator
PPE	Personal Protective Equipment
ROV	Remotely Operated Vehicle
RSO	Radiation Safety Officer
SAR	Search and Rescue
SWI	Safe Working Instructions
TC	Transport Canada
UAV	Unmanned Aerial Vehicle
WHMIS	Workplace Hazardous Materials Information System

Appendix 2 – List of authorized Immersion Suits for CCG Helicopter and Arctic operations.

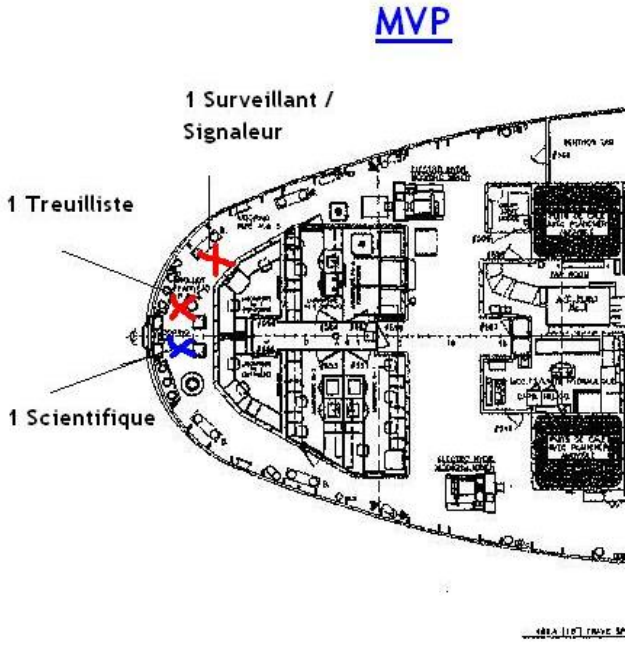
Manufacturer	Type	Link
Mustang	MSD697	https://www.mustangsurvival.com/en_CA/products/government-and-industry/immersion-and-dry-suits/sentinel-series-aviation-dry-suit-MSD697.html
Mustang	MSD644 or MSD634 non-heavy duty	https://www.mustangsurvival.com/en_CA/products/government-and-industry/immersion-and-dry-suits/sentinel-series---lightweight-boat-crew-dry-suit-MSD634.html
Survitec	Survival-One 1000 Series (1000GN000)	https://survitecgroup.com/survitecproducts/14027/1000-series-tri-approved-wind-energy-suit
Viking	SB0846 (AKA PS4089)	http://www.dssaviation.com/products_details.asp?ID=299&DivisionID=4&SubCategoryID=610&CategoryID=53
Switlik	U-zip-it	http://www.switlik.com/aviation/uzipit
Helly-Hansen	352	https://www.hellyhansen.com/fr_ca/aegir-ocean-dry-suit-31706
O.S. SYSTEMS INC.	SARR Surface Water Drysuits SPLB-SROB (Full Featured) or SRBEC (Economy)	http://ossystems.com/rescue/saar-surface-water-drysuit/ http://ossystems.com/rescue/sarr-surface-water-economy-drysuit/
Kokatat	USCG Boat Crew Drysuit LC and NC	USCG BCL_BCN 2.pdf

Appendix 3 – Positioning of personnel during deck operations (Section 3.2).

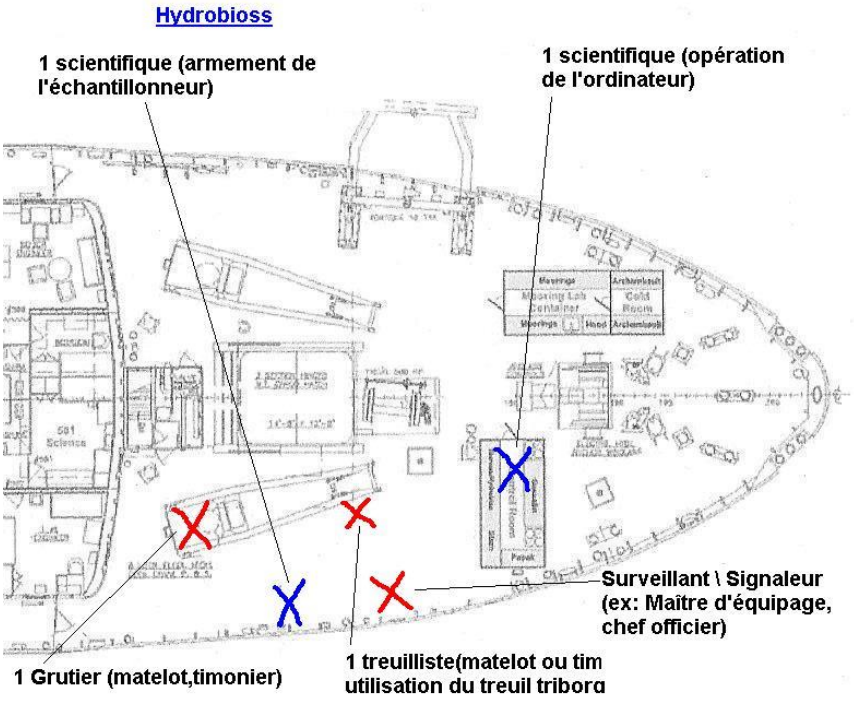
CTD-Rosette (Section 3.2.1)



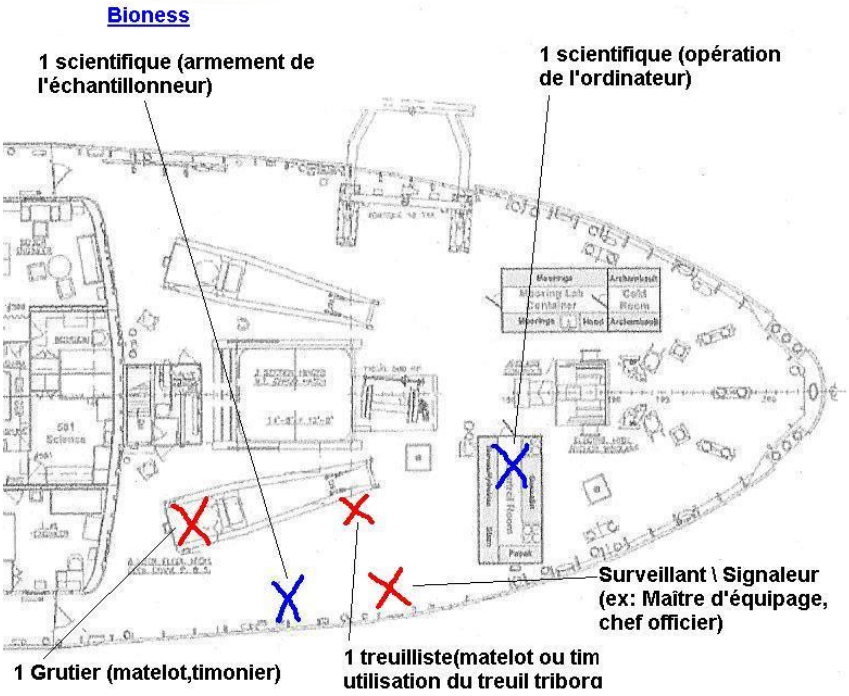
MVP (Section 3.2.2)



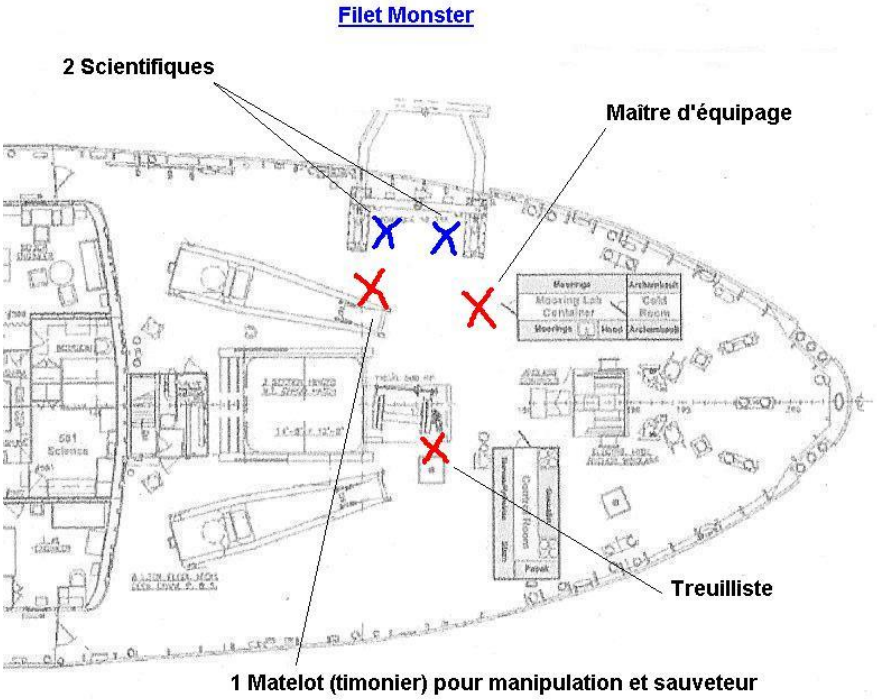
Hydrobios (Section 3.2.3.1)



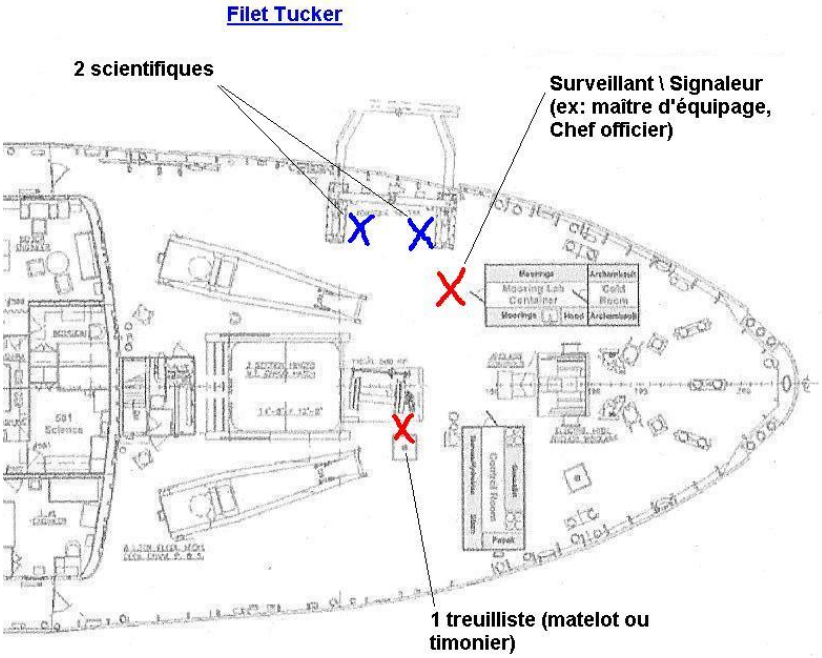
Bioness (Section 3.2.3.2)



5NVS (Monster) (Section 3.2.3.3)

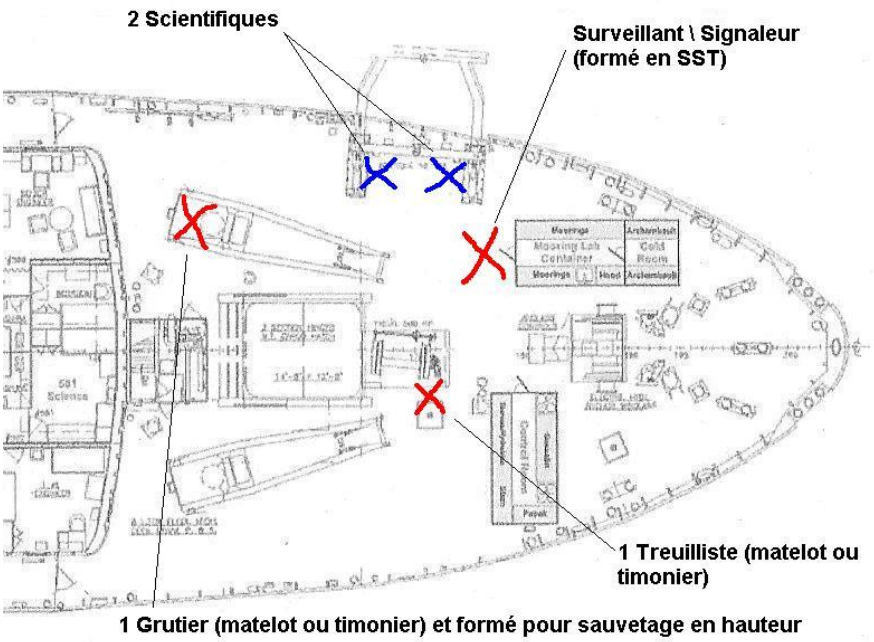


DSN (Tucker) (Section 3.2.3.4)



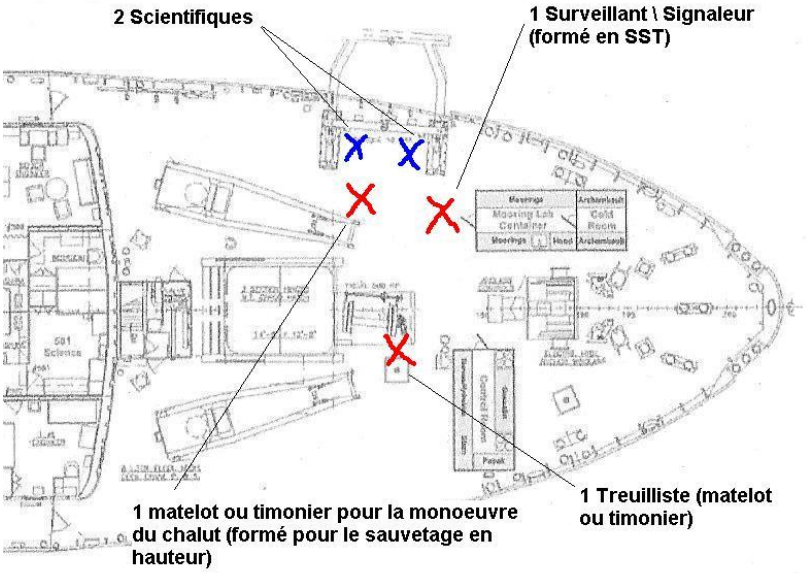
RMT or Beam Trawl (Section 3.2.3.5)

Filet RMT

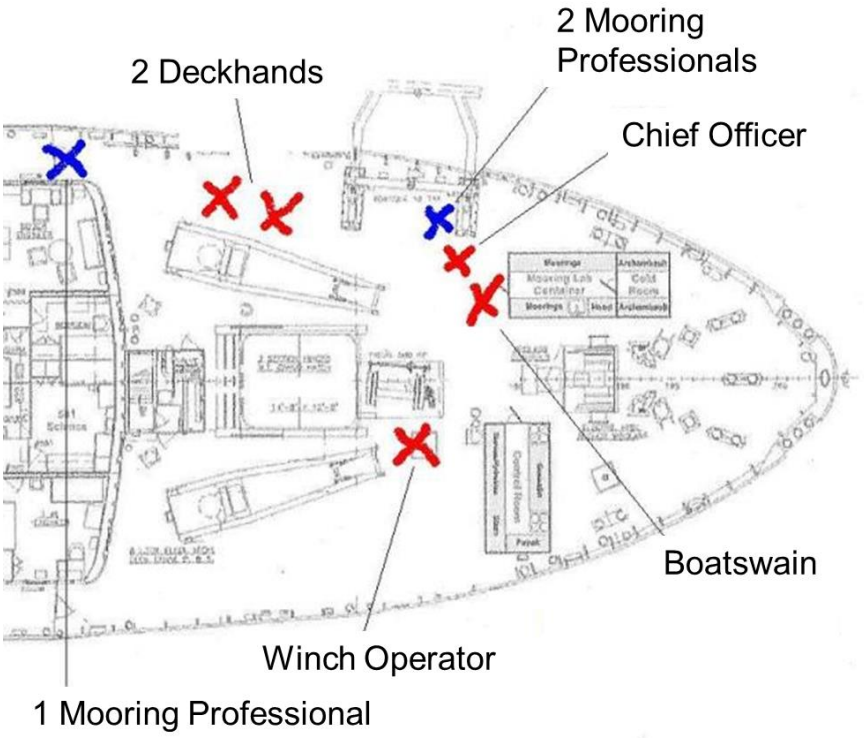


Agassiz Trawl (Section 3.2.3.6)

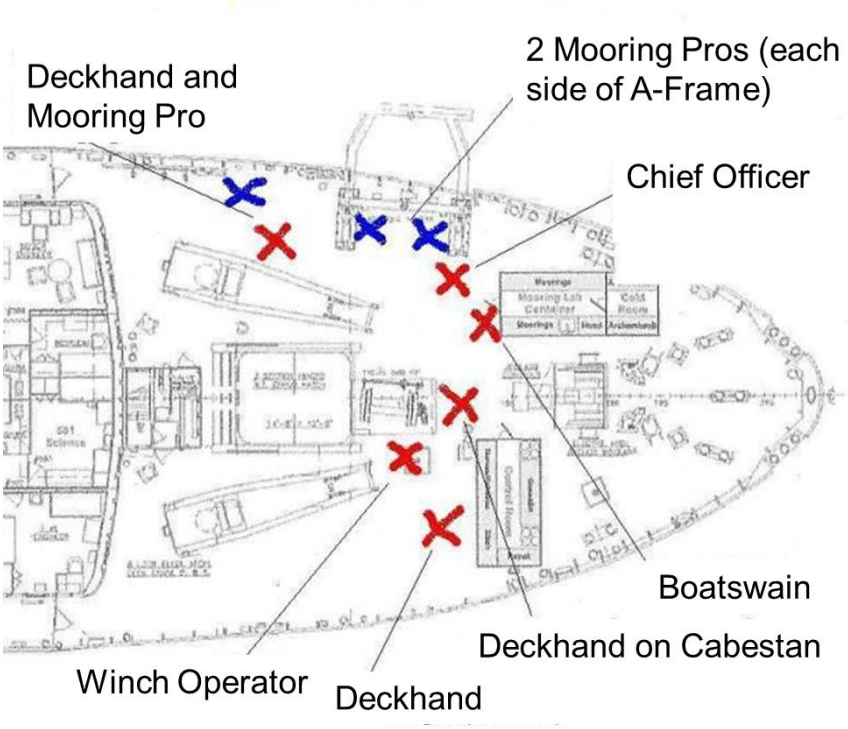
Chalut Agassiz



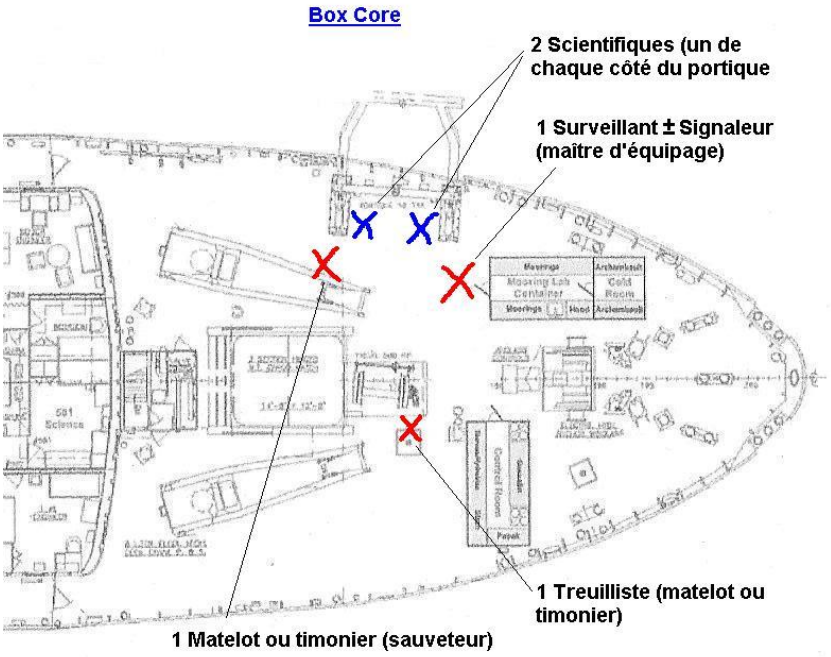
Moorings Deployment (Section 3.2.4)



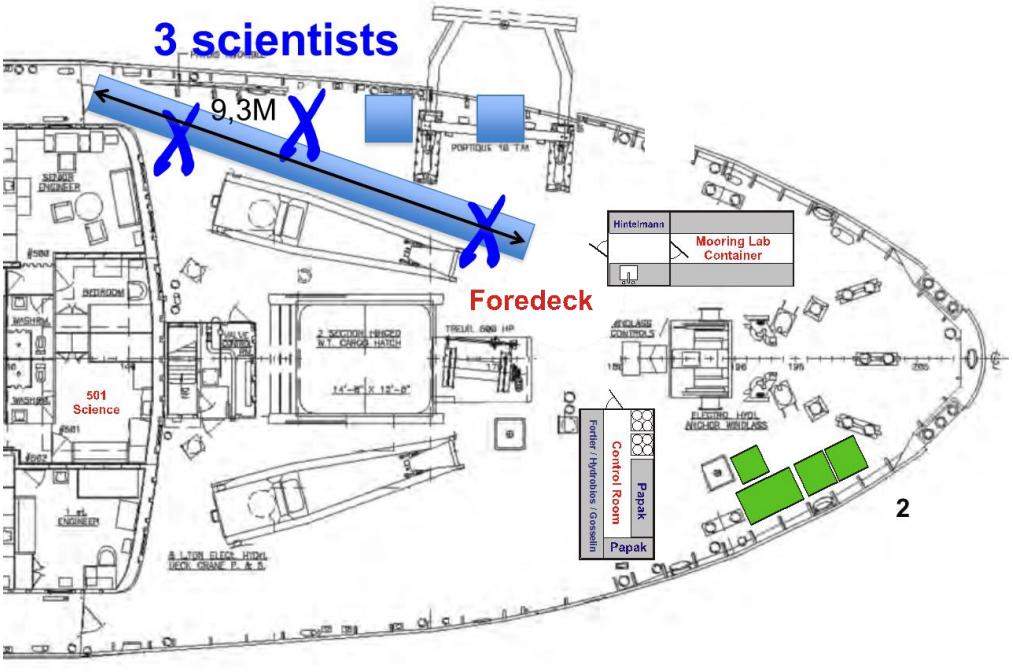
Moorings Recovery (Section 3.2.4)



Box Coring (Section 3.2.5.1)



CASQ coring(Section 3.2.5.2)



Piston coring (Section 3.2.5.3)