Science Plan: CCGS Henry Larsen, Canadian High Arctic, August 2007

International Polar Year – Canada

Chief Scientist

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Dates of Operation

9 August to 1 September 2007 (nominal)

Areas of Operation

1. Nares Strait, from Smith Sound to Hall Basin with focus on a section across Kennedy Channel at 80.5°N.
2. Cardigan Strait, Hell Gate, Fram Sound (see the map on the following page).

Elements of the Scientific Programme

CAT Mooring Project – Nares Strait

Recover internally recording instruments on 12 oceanographic moorings; 8 are in deep water & 4 in shallow bays; dragging will be necessary at 3 sites.

Service recovered instruments and mooring components.

Re-deploy internally recording instruments on oceanographic moorings at 18 sites (perhaps more); 14 are in deep water & 4 in shallow bays.

Measure seawater properties via profiling CTD on cross-sections at 5 locations along the strait.

This activity is the responsibility of Fisheries and Oceans Canada and the University of Delaware, with funding from the Canadian Programme for the International Polar Year (IPY 2006-SR1-CC-135).

CAT Mooring Project – Cardigan Strait

Recover internally recording instruments on 2 oceanographic moorings in deep water.

Service recovered instruments and mooring components.

Re-deploy internally recording instruments on oceanographic moorings at 2 sites (perhaps 3); all are in deep water.

Measure seawater properties via profiling CTD on cross-sections in Cardigan Strait, Hell Gate, Fram Sound.

This activity is the responsibility of Fisheries and Oceans Canada, with funding from the Canadian Programme for the International Polar Year (IPY 2006-SR1-CC-135).

Multi-year Ice Properties – Arctic straits

Measure profiles of thickness across selected multi-year ice floes using surface-based electromagnetic induction radar and drill holes, coincident with imaging by Radarsat.

Measure ice compressional strength in holes drilled into some of these multi-year ice floes.

Deploy satellite tracking beacons one or two floes to facilitate re-measurement at a later time.

Observations are to be carried out in Nares Strait, Norwegian Bay and western Jones Sound.

This activity is the responsibility of the Canadian National Research Council with project funding from industrial partners.

Arctic Transportation Project – Arctic straits

Measure the acceleration components of (viz. total force on) CCGS Henry Larsen when breaking ice, using an autonomous measurement and logging system (MOTAN).

Record scenes from a forward-looking video camera mounted at the bow. The images will be used to identify the ice features whose impacts are associated with high forces.

Photograph ice blocks from floes broken by the ship using a down-looking camera. The images will be used to determines the thickness of ice broken during the ship-ice interaction.

This work involves no requirement for dedicated ship's activity.

This activity is a collaborative effort of the Canadian National Research Council, the Canadian Ice Service and Fisheries and Oceans Canada. The work is supported via funding from the Climate Change Technology & Innovation Initiative (CCTII) of the federal programme on energy research and development (PERD) and the Canadian Programme for the International Polar Year (IPY 2006-SR1-CC-135)

Shoreline Pick-ups

Equipment needed for measurement of the thickness and strength of multi-year floes from CCGS Henry Larsen is presently cached at Alexandra Fjord (78° 53' N, 075° 48'W). The total weight is approximately 1228 lb in 19 boxes. This equipment is needed on board as early as practical during the expedition.

We have received a number of requests from colleagues to retrieve ocean instruments now stranded within our working area in the Canadian Archipelago. All objects are small and readily carried by helicopter. There are three beached objects: one in St Patrick Bay off Robeson Channel, one in Muskox Fjord off Jones Sound and one on the south-western Ellesmere coast in Norwegian Bay. We have made no firm commitments to address these salvage requests. They will be addressed opportunistically.

There are also two satellite tracked beacons still adrift which mark floes to which return visits would be advantageous to the ice-properties activity on this cruise. Both are presently (July 25) on fast ice, one in northeastern Baffin Bay and one in western Jones Sound. Possible visits will again be addressed opportunistically.

Meteorological Project

Two automatic weather stations were deployed in September 2006 near the eastern shore of Ellesmere Island, one on Pim Island and the other at Cape Isabella. Professor Kent Moore of the University of Toronto has asked that we visit these sites to retrieve data recorded during the last year, to assess the continued viability of the installations, and depending on that assessment, to refurbish or retrieve the installations.

CBC Coverage

CBC's Sasa Petricic will be joining the CAT expedition for the last few days of work in the vicinity of Cardigan Strait. He will be working on TV coverage of this element of Canada's programme for the International Polar Year.

We plan to start work in Cardigan Strait no later than the morning of August 28 and to leave for Pond Inlet (a 30-hour transit) late on the 30th. With this schedule, the ship would enter Jones Sound via Glacier Strait on the 27th and pass within 15 miles of Grise Fjord that evening.

Sasa Petricic will travel to Grise Fjord by scheduled flight on Saturday August 25. He will settle in at the Coop and join the ship via helicopter as she passes. Sasa will be the only CBC person joining the ship.

Sasa will film the scientific work in Hell Gate and Cardigan Strait and stay with the ship as it skirts Devon Island and Bylot Island on the way to Pond Inlet (lots of great scenery and wildlife in addition to the scientific activity). Sasa will stay on board until disembarkation on September 1at Pond Inlet (72° 42'N, 077° 59'W).

Sasa Petricic: 613-302-4865   Sasa@cbc.ca

Grise Fjord Coop: 867-980-9913   RCMP: 867-980-1111

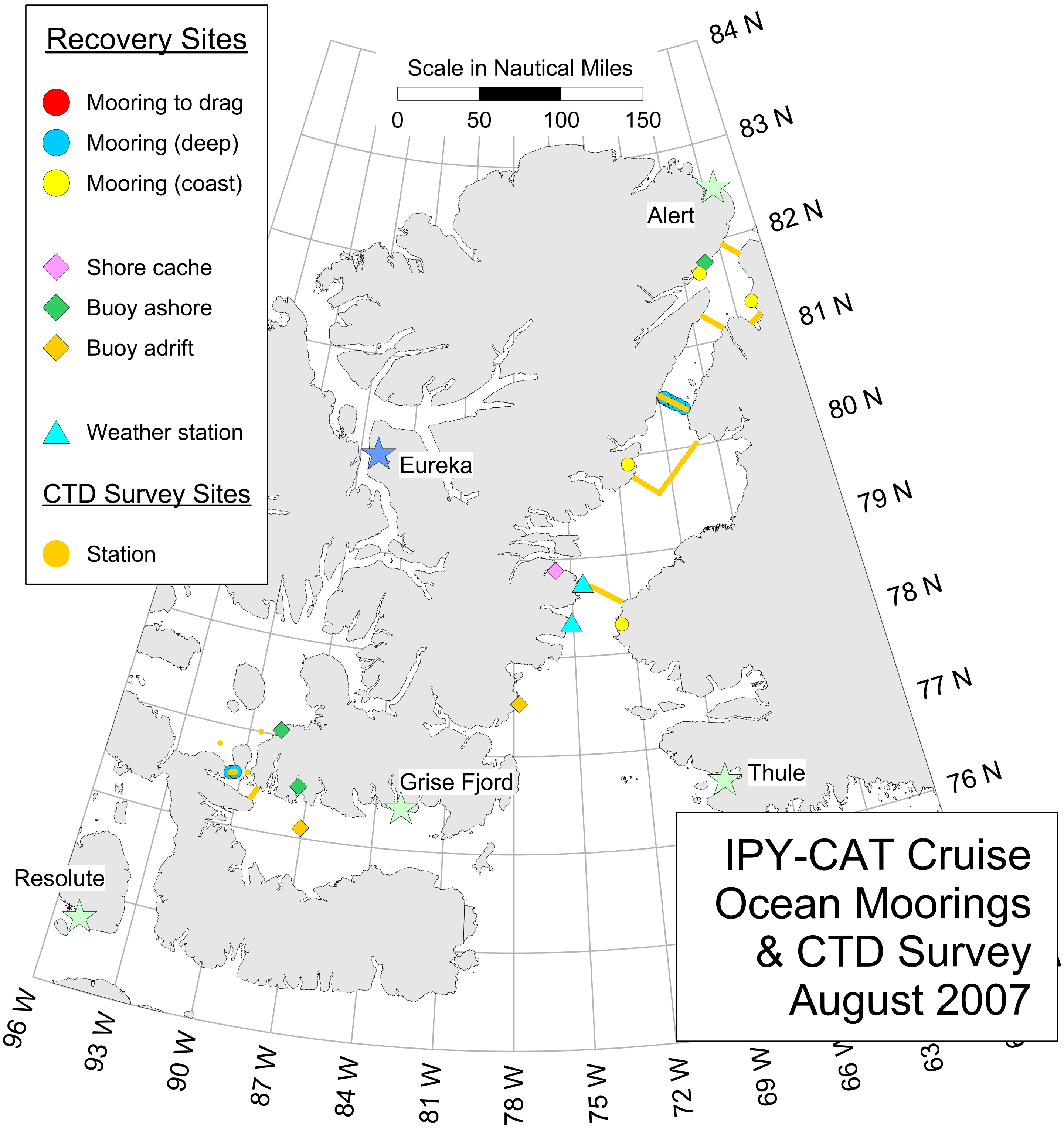


Figure 1. Sites of scientific activity to be conducted from CCGS Henry Larsen during August 2007. The principal centres of activity are in southern Kennedy Channel between Greenland and Ellesmere Island at 80.5°N and in Cardigan Strait between Ellesmere and Devon Islands at 091°W.Activities are listed in the preceding section and described in greater detail below.

Ship's Equipment & Special Installations

CCGS Henry Larsen is not equipped for oceanographic work. The Institute of Ocean Sciences (DFO Science Branch) has supplied several items of deck equipment which were shipped by truck from Victoria and St John's in June:

- Swann 320 Work Winch (s/n 1304), 50 hp, with 1835 m of 3/8" 3x19 wire rope. Weight 6650 lb
- Hydraulic Power Pack, 50 hp: 230/460 volts, 112/56 amps, 60Hz complete with switchbox for 50 hp. Dimensions approximately 36" x 65" x 48". Weight 3000 lb
- Workshop built within a 20-foot steel-clad cargo container, for installation on the foredeck (port side last year). Weight 6000 lb
- Instrument laboratory within a 20-foot aluminum-clad cargo container, for installation on the boat deck (port side last year). Weight 5000 lb
- Light-weight CTD winch (110-volt electric) & block, with 2000 m of 1/8" single-conductor wire. Weight 400 lb

This items were installed by the engineering and deck departments prior to ship's departure on July 4.

We request use of the foredeck crane for lifting oceanographic equipment over the side, and when rigged with stays, for deploying dragging wire at the three sites where moorings must be grappled from the seabed. In the latter instance we request a suitable block from the ship's equipment store.

We request use of the rigid-hull inflatable boat & perhaps of the ship's barge for retrieving equipment at the surface or from shallow coastal locations.

We request the rigging of a boom from the forward corner of the house-works to support the lightweight block (our equipment) used to deploy the CTD (port side, same as last year).

We request permission to install a lightweight boom in the breezeway to support a down-looking camera for photogrammetric measurements of over-turned ice blocks.

As the mooring work progresses, we will use of a significant fraction of the foredeck for storing floats, anchor weight and other mooring components. All remaining free space on the starboard side will be used for staging moorings at times of recovery and deployment.

We need a location on the bridge top to install a GPS antenna for logging the ship's track. We would like to complete the installation before leaving Thuke so that the full cruise track can be recorded.

The MOTAN logging system will be secured in the ship's engineering office on the upper deck, which is close to the amidships location needed for these measurements.

We request use of space on the towing deck and in the adjacent Salvage Diving Locker for staging gear used for on-ice measurements. We request additional sheltered workshop space for technical work, repairs, etc.

We request use of the Special Navigation Chart Room behind the bridge for computer work and for the servicing and preparation of scientific instruments that can be carried conveniently to this level in the ship.

We request storage space in freezer for small number of sea-ice cores (non-toxic)

Helicopter Support Required

Support to small-boat operations near shore, depending on ice (slinging & personnel transfer): 0-5 hours

Access to multi-year floes for thickness surveys and strength testing: Maximum 10 days x 3 flying hours per day: 6 for thickness surveys and 4 for strength testing (on-ice activity fills a working day).

Retrieval of stranded equipment as opportunities arise: 0-5 hours.

Servicing of automatic weather stations: 0-5 hours.

Research Permits

Fisheries and Oceans Canada: Institute of Ocean Sciences Cruise No. 2007-52

Denmark Ministry of Foreign Affairs

Permission to work in Greenland waters was granted on 1 August 2007. JTF, File no.55.Dan.9-11.

Danish Polar Centre

Kirsten F. Eriksen, kfe@dpc.dk, +45 32 88 01 08

We were informed in 2006 that a science permit is not required for marine research near Greenland. However, we have provided the Danish Polar Centre with the work plan for CCGS Henry Larsen in 2007.

Nunavut Research Institute

Andrew Dunford, ADunford@nac.nu.ca

Variation & forcing of fluxes through Nares Strait and Jones Sound – Nunavut Scientific Research Licence No. 0203207R-M received May 7, 2007 (replaces No. 0204406R-M valid until December 31, 2006)

Measurements of second-year and multi-year ice – Nunavut Scientific Research Licence No. 0202607R-M (amendment to No. 0203706R-M valid until December 31, 2006)

Automatic weather stations. Information pending.

Northern Consultation

Drs Humfrey Melling and Michelle Johnston completed a tour of the North Baffin Region in June 2007. The tour was coordinated by DFO's National Centre for Arctic Aquatic Research Excellence (N-CAARE) and visited Resolute Bay, Grise Fjord, Pond Inlet and Arctic Bay. Participants met with members of the local HTAs and discussed proposed and completed work at public meetings.

Canadian Environmental Assessment Act

Screening document completed and signed by Robin Brown, Head Ocean Science Division, Pacific DFO.

Ice Conditions in Nares Strait

Ice is land-locked in Nares Strait for several months in most winters. Beginning in June or July, the tide loosens ice in Kennedy Channel and it begins to move back and forth with the current. Typically in late July the ice bridge across Smith Sound collapses and prevailing winds and currents begin to flush ice southward into Baffin Bay. This initiates a wave of ice clearing that progresses from south to north.

Lighter ice conditions are relatively short lived. As ice bridges progressively collapse up the strait, they release ice to clog the waters further south. When the northernmost bridge across Robeson Channel breaks, multi-year pack ice is free to invade from the Lincoln Sea, so that by early September navigation is difficult even as far south as Smith Sound.

Long-lived ice bridges did not form in Nares Strait during the winter of 2006-07. The southward drift of multi-year floes from the Lincoln Sea has been unobstructed since July 2006. In consequence, a continuous steam of old ice stretched from the Lincoln Sea to Newfoundland by springtime. Floes in Kane Basin tagged with satellite tracking beacons from the CCGS Henry Larsen in August 2006 were south of the Strait of Belle Isle in April.

Normally, the freeze-up of Nares Strait progresses from north to south; the entry of heavy ice from the north is blocked before its exit from the south. Since this sequence permits flushing of old ice into Baffin Bay before winter, multi-year ice concentration south of Hall Basin is lowest during winter and early summer. The abnormal 2006-07 winter replenished the stock of old floes in the Strait, making conditions in July 2007 similar to those normally encountered in this area in mid September. The charts on the following page compare present (23 July) conditions with 30-year (1970-1999) median conditions for ice concentration and old-ice concentration. The previous occurrence of such events was during the winter of 1992-93.

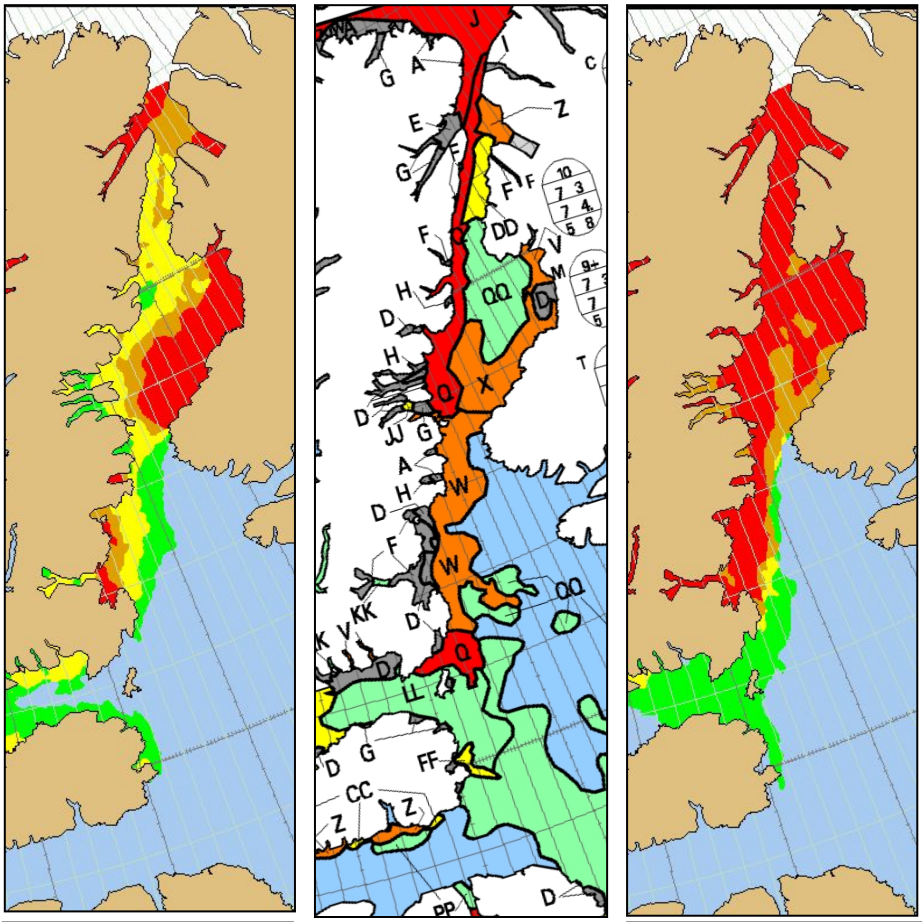


Figure 2. Median concentration of sea ice in Nares Strait on August 13 (left) and September 17 (right). Red denotes 9-9+ tenths ice, orange 7-8 tenths and yellow 4-6 tenths. The centre panel shows ice concentration on 23 July 2007, where area ‘J’ has 9/10 old ice and ‘Q’ & ‘W’ each have 6 tenths.

Charts from the Canadian Ice Service.

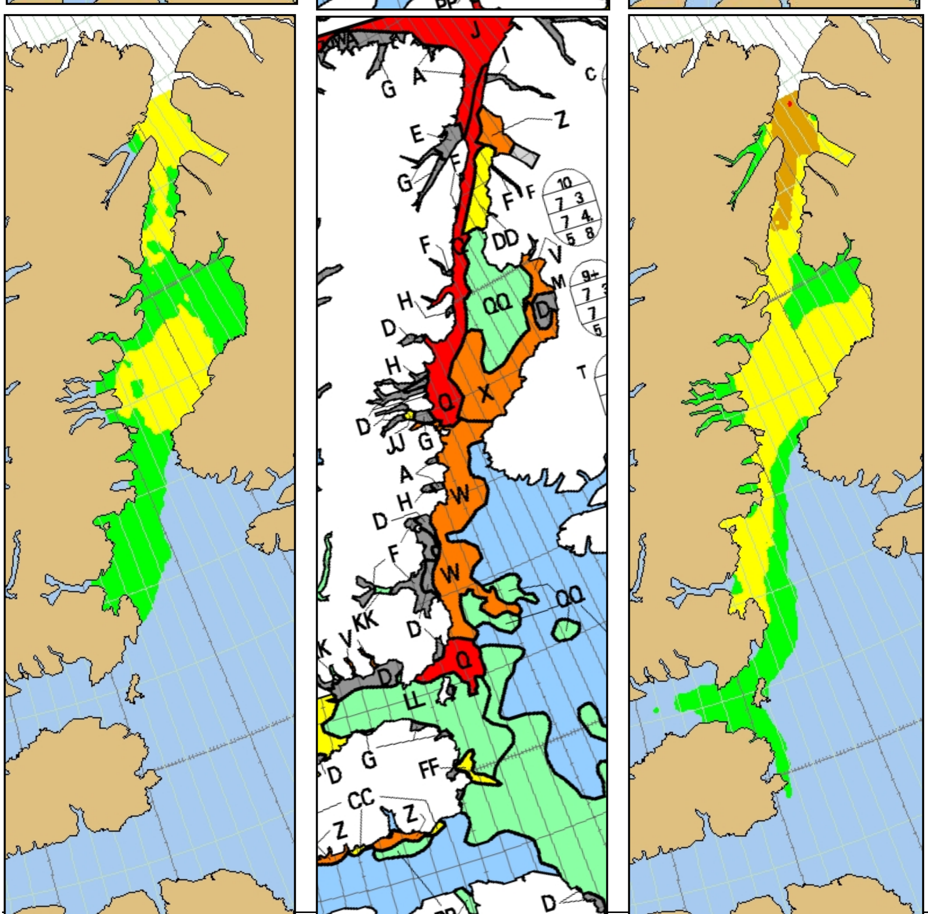


Figure 3. Median concentration of multi-year sea ice in Nares Strait on August 13 (left) and September 17 (right). Orange denotes 7-8 tenths, yellow 4-6 tenths and green 1-3 tenths. The centre panel for July 23 2007 is duplicated from Figure 2, where area ‘J’ has 9/10 old ice and ‘Q’ & ‘W’ each have 6 tenths. Note that multi-year ice presence in mid July 2007 is comparable to that reached only three months later in a typical year.

Charts from the Canadian Ice Service.

Information on the Oceanographic Project

Context

The Institute of Ocean Sciences (DFO) is engaged in a long-term collaborative project to determine flows of seawater and ice through the Canadian Arctic Archipelago. During the period 2007-2010, the project is a component of the Canadian programme for the International Polar Year. There are two expeditions in the summer of 2007: one on CCGS Henry Larsen to Nares Strait, Hell Gate and Cardigan Strait; one on CCGS des Groseilliers to Barrow Strait, Wellington Channel and Lancaster Sound.

Each expedition is focussed on two primary activities: 1) Recovering, servicing and redeploying arrays of autonomous instruments for continuous long-term observation from sub-sea moorings 2) Completion of surveys of seawater properties along the flow paths of seawater passing these arrays.

Moorings in Nares Strait were installed from the USCG Healy in August 2003. A team was to recover and redeploy these moorings during April 2005, supported by helicopter from a field camp on the Greenland shore. This activity was terminated when extreme winds destroyed the camp. A renewed effort was supported by CCGS Henry Larsen in August 2006, when 15 of 23 moorings were retrieved and 6 were re-deployed. Moorings in Cardigan Strait were installed from CCGS des Groseilliers in September 2005 and those in Barrow Strait from the same ship in August 2006.

Description of Activities

Operating Area

There are two widely separated operating areas for CCGS Henry Larsen in August 2007, Nares Strait, and Cardigan Strait / Hell Gate at the opposite corner of Ellesmere Island. The emphasis in Nares Strait is Kennedy Channel where most of the moorings are placed. A few moorings are distributed along the strait, at Foulke Fjord and Alexandra Fjord in the south, Scoresby Bay on Kane Basin and Discovery Harbour and Offley Island on Hall Basin. CTD surveys will span the length of the strait. There are only two moorings in the second operating area, in Cardigan Strait. Here all CTD surveys are within 30 miles of the moorings.

Recovery and Deployment of Moorings

In the absence of pack ice, the recovery of an oceanographic mooring can be completed in less than an hour. However in seaways such as Kennedy Channel and Cardigan Strait, where pack ice is plentiful, access to work sites may frequently be blocked. We have budgeted time for standby in the vicinity of moorings, on the lookout for drifting openings in the pack wherein moorings may be released to the surface, with sufficiently dispersed floes on route to permit ship’s access. This wait-wait-go scenario is derived from past experience with CCG icebreakers in these areas: in Smith Sound in early August 1998, 1999 and 2001, in Hell Gate / Cardigan Strait in September 2000, 2002 and 2005 and in Kennedy Channel in August 2006.

Obviously, our need to access particular locations and to wait for suitable ice conditions for mooring recovery will require patience, tactical flexibility and luck. We are obliged to adopt an opportunistic approach to the ice environment.

Seawater Surveys by CTD

We will use a small CTD (conductivity, temperature, depth) probe repeatedly during the cruise to measure basic physical properties of seawater within cross-sections of the straits. Approximately 100 CTD stations are planned. The surveys will provide a detailed map of the water in the Strait at the time of the expedition in August. They will also provide data for the calibration of similar sensors that have been (and will be) recording data from moorings over several years.

The winch and rigging used for lowering the CTD from CCGS Henry Larsen in 2006 is shown on the following page. Here a light-weight winch with 2000 m of 0.125” wire was mounted on its (reinforced) packing box just ahead of the house-works. The winch is electrically powered (110 V). The total load on the winch with 1000 m of wire out (deepest cast planned) is about 180 lb. The boom to support the block (our supply, not shown) was ship’s equipment originally supplied for landing personnel at canal locks

Figure 4. Setup for operating the CTD probe on board CCGS Henry Larsen. CTD deck electronics and the computer for logging data were installed in the 20-foot workshop container seen at the edge of the picture.

Detailed Sub-Area Maps

Figure 5. Locations in Smith Sound & Kane Basin. Shallow mooring (yellow), CTD station (orange), weather station (cyan), pick-up (magenta).

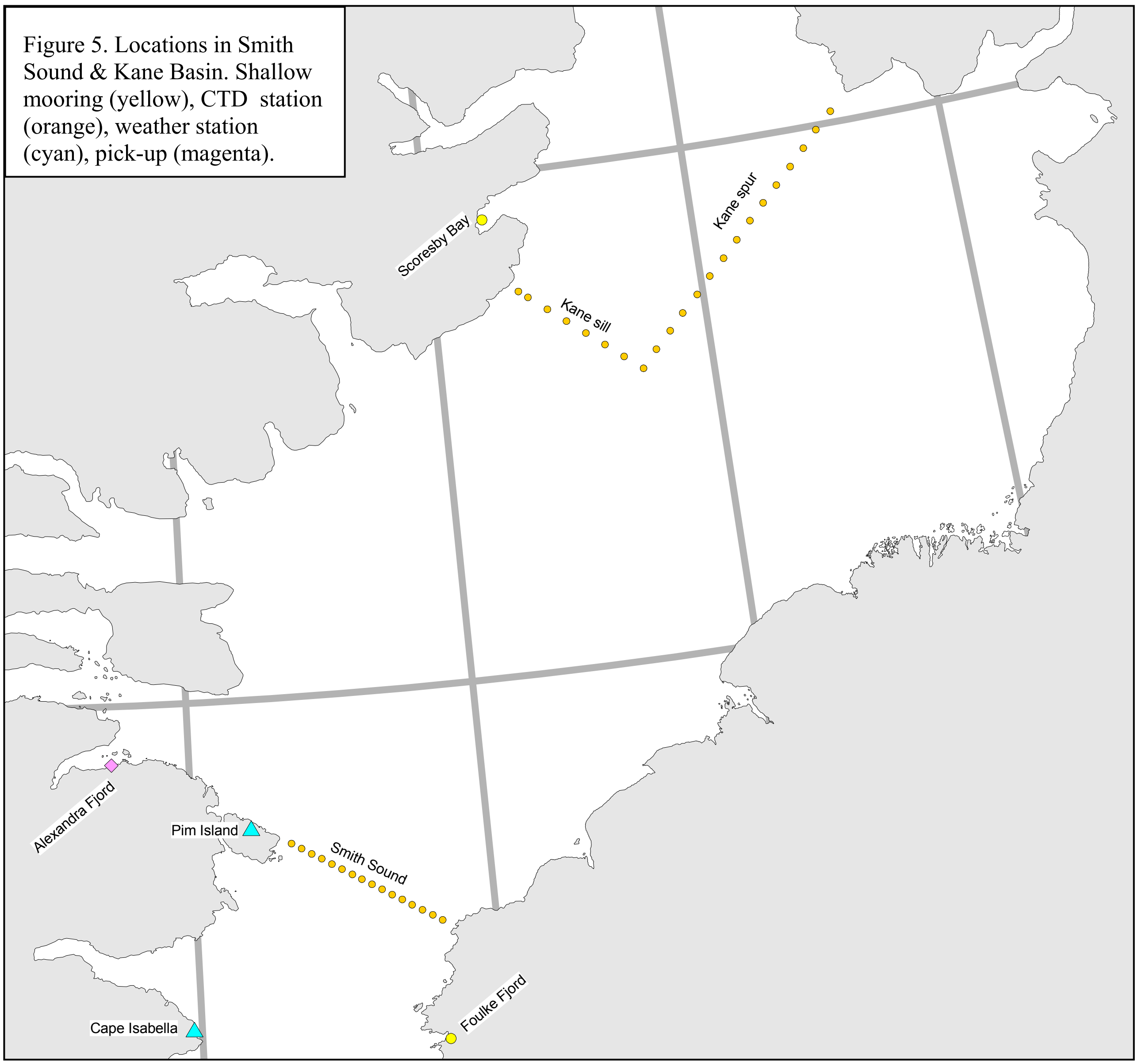


Figure 6. Locations in Kennedy Channel, Hall Basin and Robeson Channel. Shallow mooring (yellow), CTD station (orange), deep mooring (blue), deep mooring for dragging (red), pick-up (green).

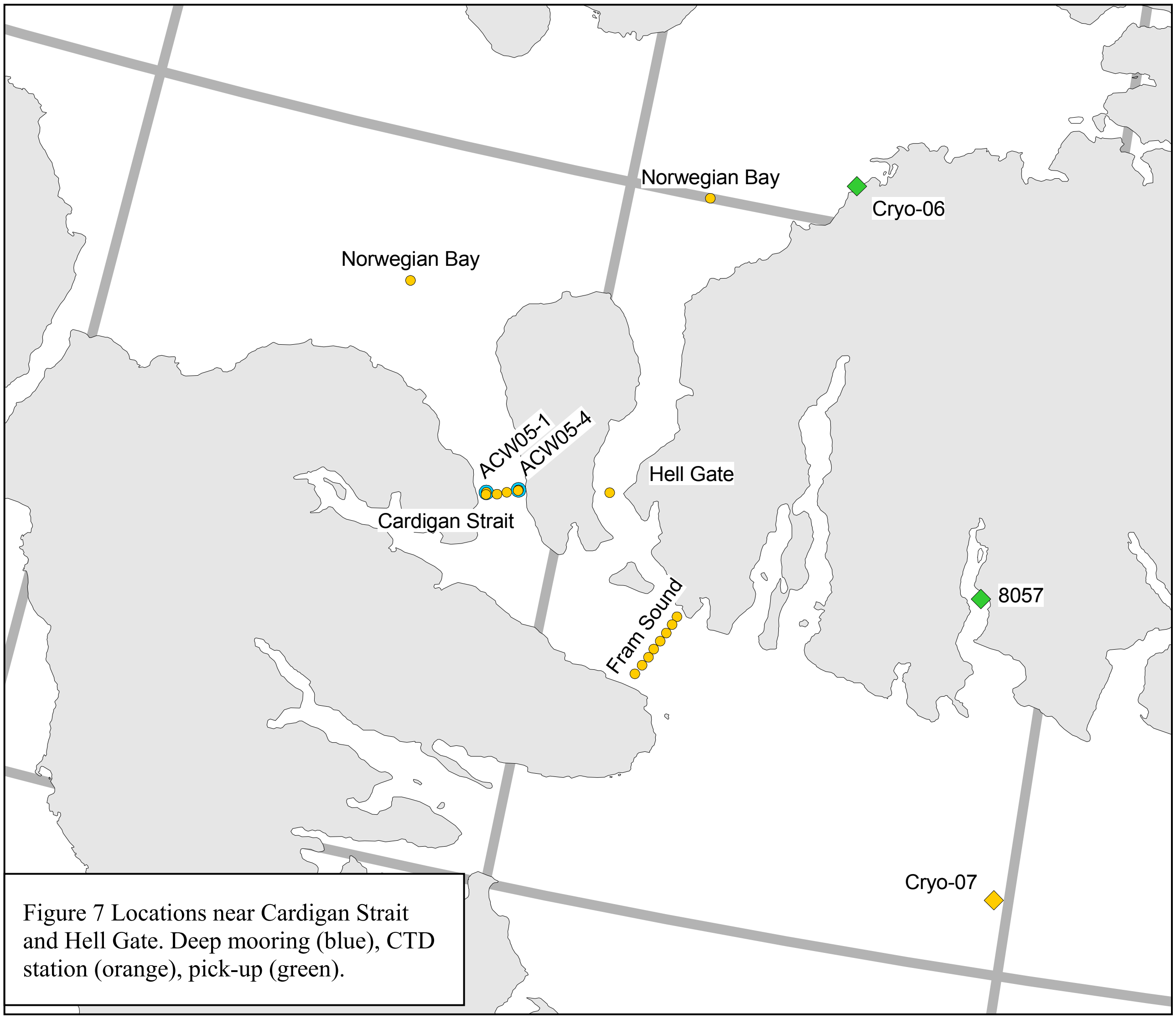


Figure 7 Locations near Cardigan Strait and Hell Gate. Deep mooring (blue), CTD station (orange), pick-up (green).

Mooring Designs

Pressure Mooring (4 sites)

The mooring is an unconventional design intended to provide a stable foundation for the pressure gauge (vertical movement limited to millimetres) during a 2-3 year deployment. The instrument is positioned as shallow as practical to avoid ice (18-20 m) and in a location chosen to minimize the risk from icebergs.

Vulnerability was reduced by deploying in shallow bays that are covered by fast (non-drifting) ice for much of the year and relatively sheltered from in-drifting ice in summer. Discovery Harbour and Foulke Fjord were probably the best sites in this respect. The three other sites were exposed to incursion of pack ice in some directions.

In 2003, the moorings were positioned by divers from Healy upon metal stakes hammered into the seafloor. Pressure recorders to be deployed in 2007 will be secured on moorings of simpler design; divers are not required. Unlike conventional oceanographic moorings that float to the surface when a release is activated acoustically to disconnect the mooring from its anchor, the release of this mooring permits the surfacing of a tethered float. Recovery is achieved by pulling up on the tether to lift the non-buoyant mooring off the seabed.

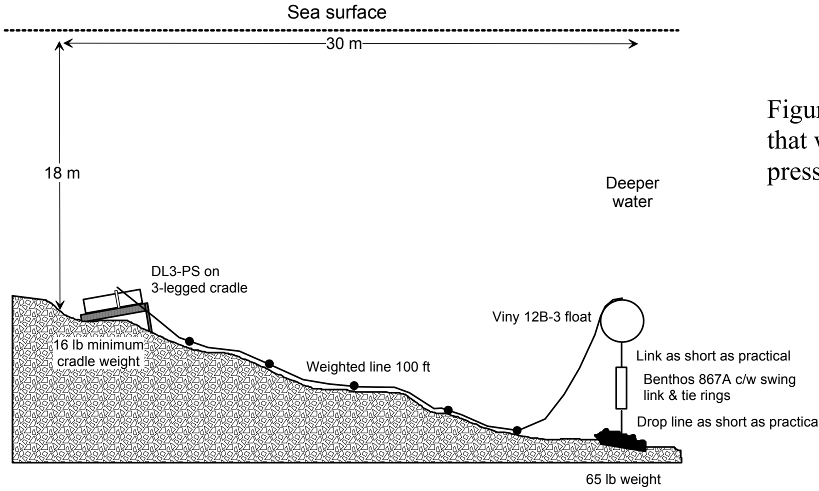


Figure 8. Schematic diagram of the mooring that will be used in 2007 to deploy recording pressure gauges in shallow sheltered waters.

Ocean Current Mooring (8-10 sites)

This is a torsionally rigid mooring used to support an Acoustic Doppler Current Profiler (ADCP) and a temperature-salinity recorder, The mooring holds the sonar at fixed heading and pointing upward within a few degrees, even in strong current. There are two acoustic transponder-releases to provide redundancy in case of failure. The mooring used in Nares Strait is a lighter version of that used in Hell Gate and Cardigan Strait, where currents are 2-3 times stronger, reaching 3 m/s (6 kt) at times.

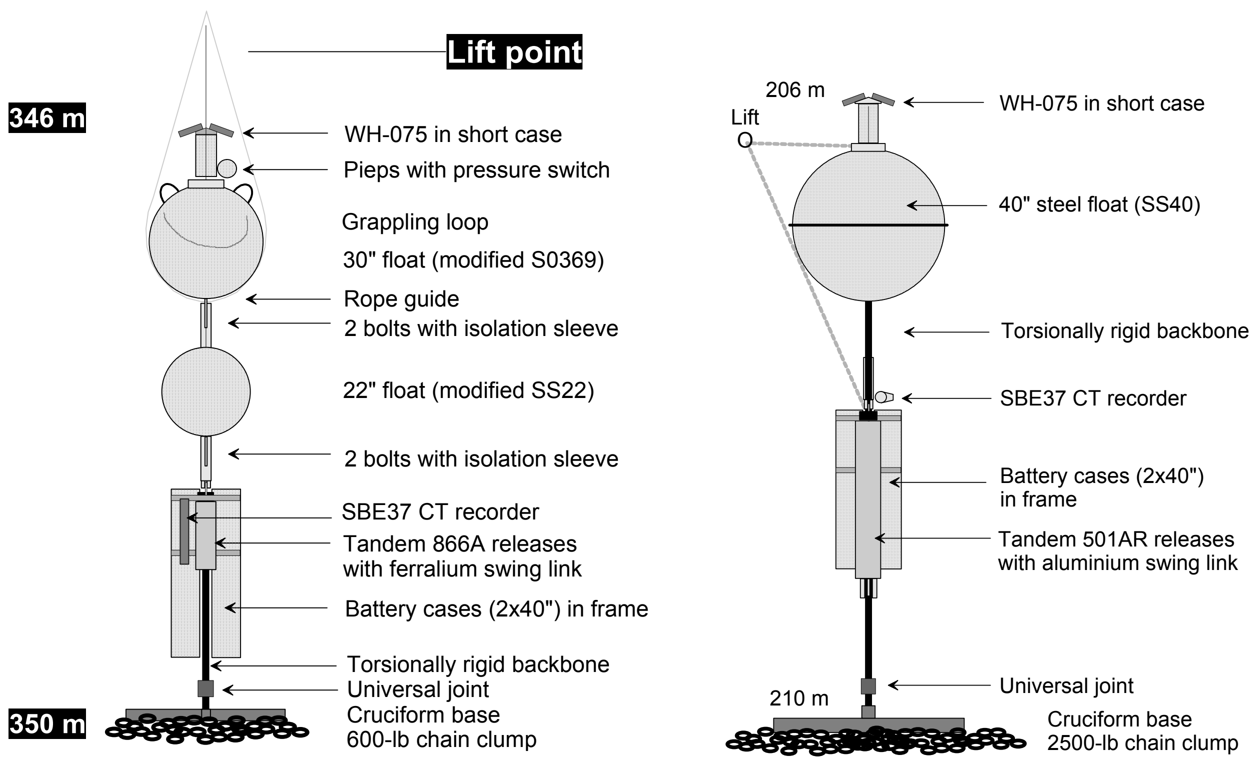
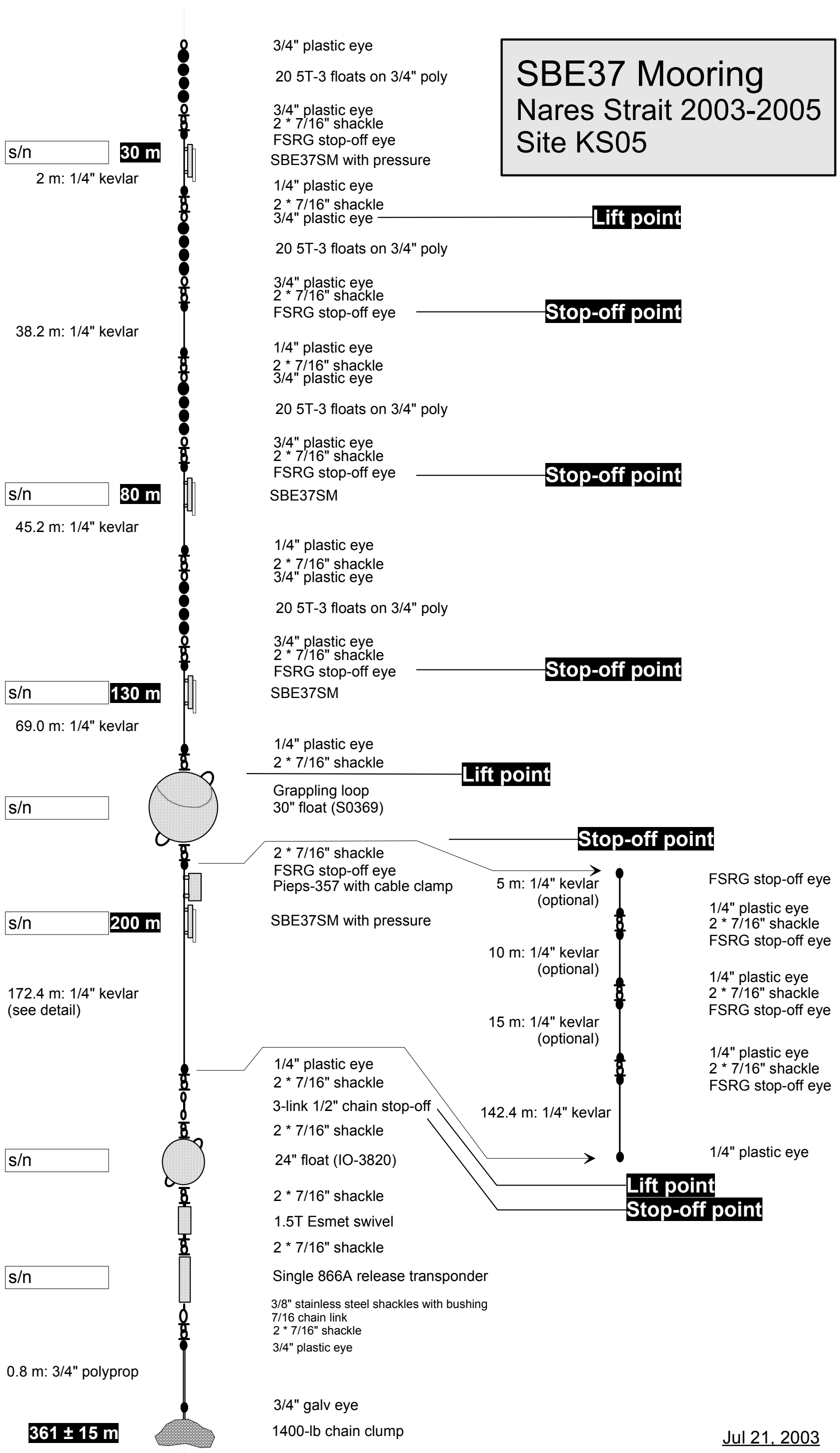


Figure 9. Schematic diagrams of the moorings used to position acoustic Doppler current profilers (ADCPs) near the seabed in areas where the geomagnetic field is not a reliable reference direction. These moorings can lean in strong current but do not twist. The ADCPs measure ice drift and ocean current at all depths in the water column. The heavy duty version at the right is used in Cardigan Strait and Hell Gate, and the less massive version at the left in Nares Strait.

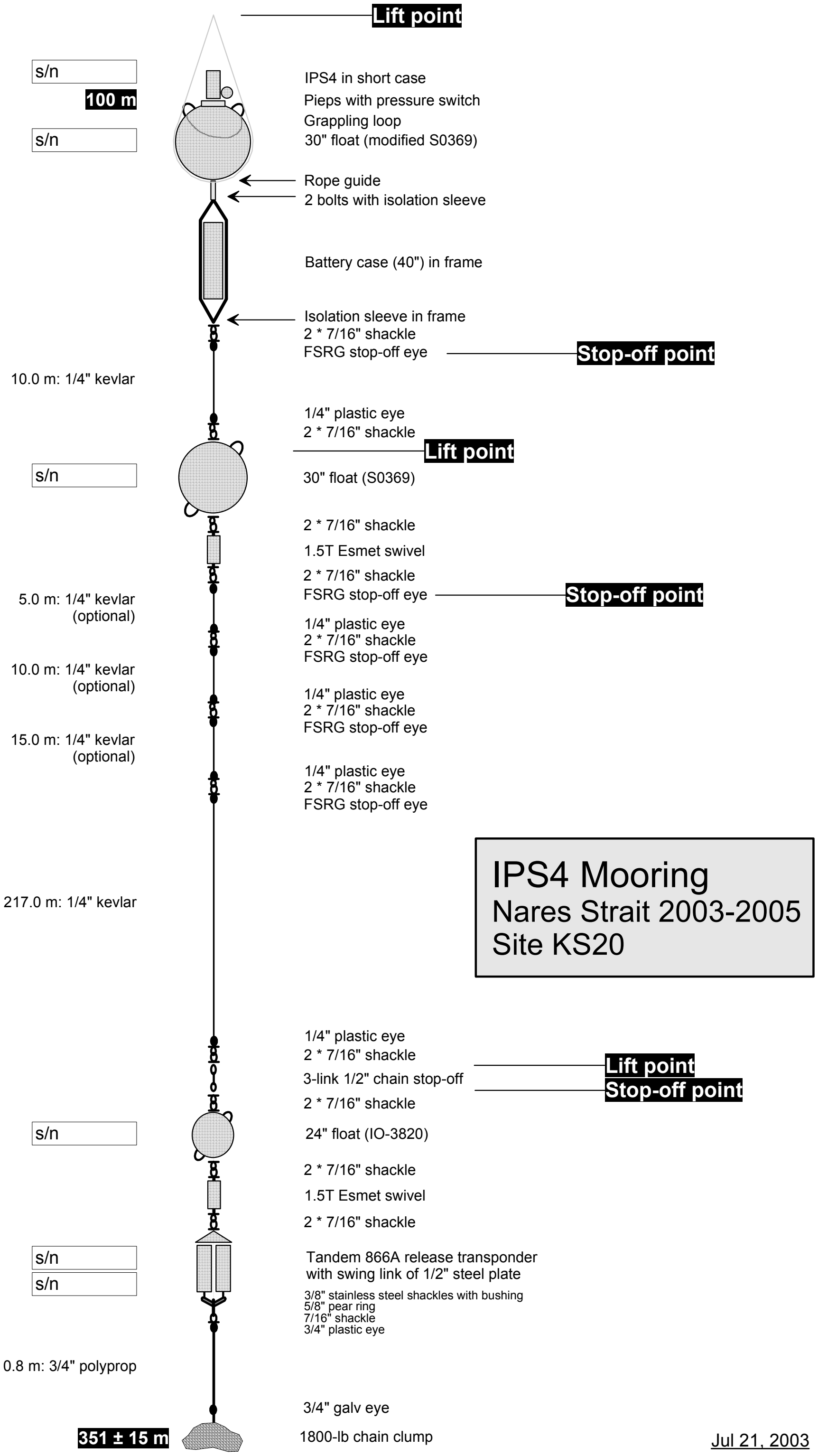
Temperature-Salinity Mooring (8 sites)

This is a taut-line mooring used to support temperature-salinity recorders at four levels between 30-m and 200-m depth. There is one acoustic transponder-release. Above 200-m depth, the buoyancy is small, so that the top of the mooring will pull down appreciably in strong current. This sensitivity is deliberate: since icebergs sweep larger volumes per unit time in strong current, pull-down in such conditions reduces the likelihood of strikes by icebergs. The mooring straightens at slack tide allowing observations closer to the surface. The mooring relies on strings of small plastic floats for buoyancy at upper levels, instead of conventional spherical floats, in order to reduce the likelihood of snagging on contact with drifting ice.



Ice-thickness Mooring (2 sites)

This is a taut-line mooring used to support an ice-profiling sonar (IPS) at 100-m depth. There are two acoustic transponder-releases. Because measurements by the IPS are degraded by pull-down and tilt of the instrument, this mooring has significant buoyancy to make it stiff. A necessary consequence of buoyancy is a heavy anchor; at 1800 lb, this is the heaviest among the four mooring types. The IPS has been placed at the greatest depth consistent with effective operation (100 m) in acknowledgement of risk from icebergs.



Observational 'Picket Fence' in Kennedy Channel

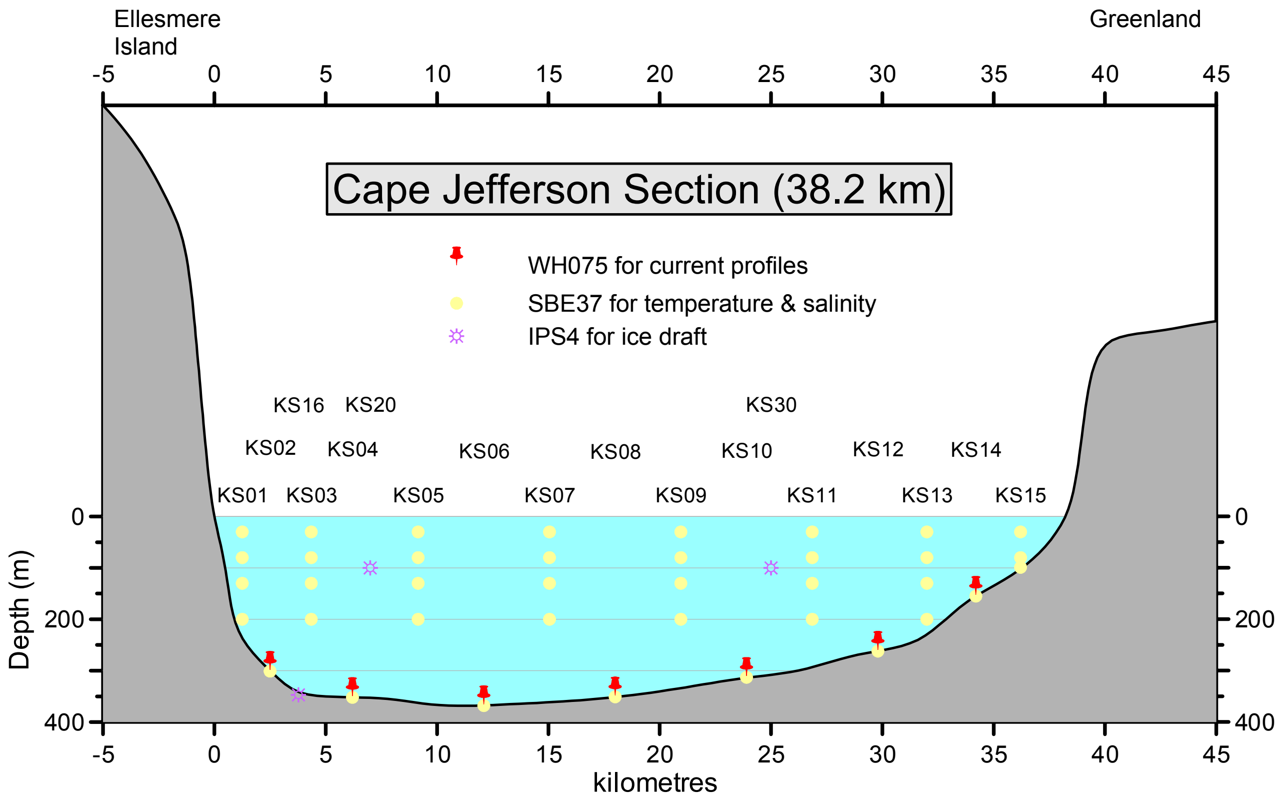


Figure 10. Arrangement of moorings with instruments for measuring and recording ocean current, ocean temperature & salinity and ice thickness in a section across the southern end of Kennedy Channel. The diagram shows the original array in 2003. The array deployed in 2007 will be modified according to how many of the original moorings are recovered.

Recovering Moorings for Current, Temperature-Salinity & Ice Thickness

According to Plan

Our procedure for retrieving instruments moored in the deep water of Arctic channels is oceanographic standard practice, with concessions to the risks and impediments posed by drifting pack ice.

We start with a strategic assessment of ice cover near the site of the mooring. The outcome of the assessment is a decision whether to move the ship to the site at this time. The decision will be guided in part by the usual considerations – daylight, weather, workday, etc. – and in part by information about pack ice at the location and on route to it – concentration, floe size, ice type, rate of drift – derived from ice charts, satellite imagery and perhaps aerial reconnaissance.

Once the ship is positioned by GPS at the location of the mooring and stopped, we place a hydrophone over the side to communicate with the acoustic transponder-release(s). The releases used in Nares Strait have been modified for increased longevity by turning off the main electronics for 2 minutes out of 3. Since the release is only capable of "hearing" and responding when turned on, repeated transmissions over an interval of several minutes are required to catch the transponder in its ON state, and to switch it to an "Enabled" condition when it is fully attentive.

In difficult ice, we may wish to interrogate the acoustic transponder from two or more locations of the ship in order to establish the exact position of the mooring relative to the ship and to any ice floes in the vicinity.

If ice cover at the site is appreciable, surfacing of the mooring following anchor release must be timed to coincide with the presence of ice-free water over the location. The speed and direction of ice drift are useful knowledge in this decision. Ice drift can be measured by tracking ice floes on the ship's radar. Note that rising mooring will drift with the tide, but will not be influenced by wind as is the ice.

Estimates of the time between anchor release and surfacing of the top mooring component differs with the depth and surplus buoyancy of the mooring, as follows:

Ocean current mooring: 4 min from 350 m

Temperature-salinity mooring: 30-60 s from 30 m (nominal)

Ice-thickness mooring: 60-100 s from 100 m

The mooring is released from its anchor via a coded acoustic transmission following a favourable tactical assessment of the ice hazard.

After being sighted at the surface, the mooring must be secured and brought to the ship's crane using the ship's boat. Simple moorings (such as the ADCP) may be hoisted to the deck in a single lift. The long-line moorings can be drawn in manually, with a few crane lifts necessary for heavier components.

Possible Need to Drag

Moorings for recovery were deployed variously in August 2003, 2005 and 2006, with intended recovery after 24 months. Several 2003 moorings that were not recovered in August 2006 will have been at sea for 48 months and at the end of their design lifetime. Batteries powering the transponder-releases may be depleted.

In such circumstance, the means of recovery will be via dragging. We have equipped the ship with a 50-HP winch and hydraulic power pack, 1800 m of 3/8" 3x19 wire rope and a selection of grappling hooks and weights. We propose paying out the drag line through a block suspended from the ship's crane. Stays to the boom may be used to prevent damage to the crane by sideways loading. The winch can pay out heavily weighted line at up to 3 m/s.

The adjacent schematic depicts a dragging plan for a mooring in 350 m of water with a 2-knot drift. Here we lay out at least 1200 m of wire, or three times the water depth. Perhaps one half of this length (depending on ship speed, current, etc.) spans the water column; the remainder is pulled along or close to the seabed. With a 2-kt drift, the ship must be 700 m upstream when starting the lay. We have an Excel worksheet to assist in planning the stages of the operation, based on knowledge of the ship speed, winch speed, surface drift and water depth.

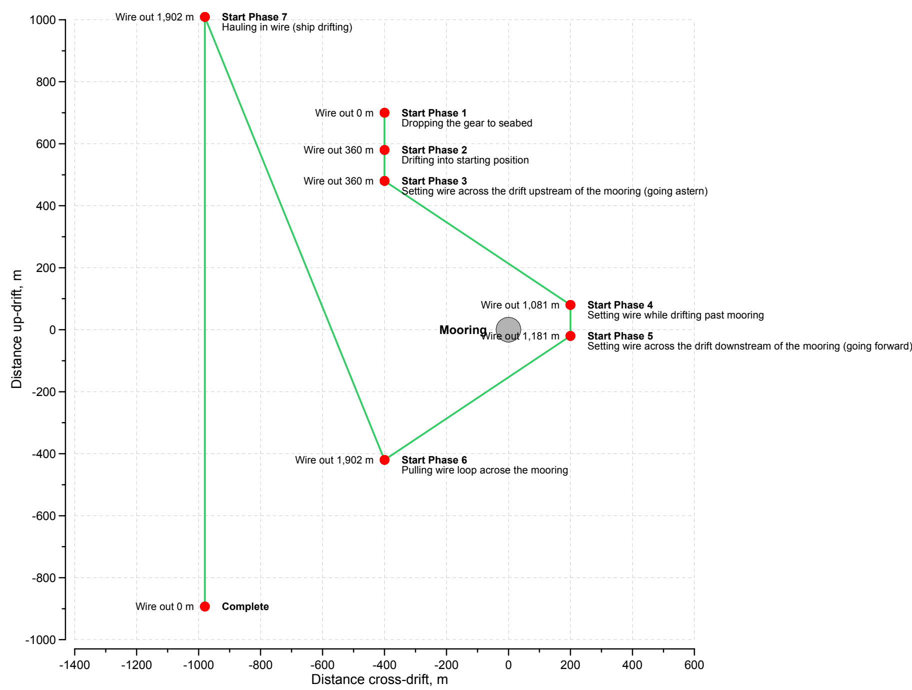


Figure 11. Schematic representation of a plan for dragging up a mooring in 350 m of water. The objective is to foul the mooring so that it is either dislodged to float to the surface or dragged up to the surface.

For taut-line moorings, the objective is to cut the mooring line as close as possible to the seabed, via abrasion with the rough dragging wire; the mooring surfaces under its own buoyancy. For the ADCP moorings, which stand only 3 m above the seabed, the objective is to lodge the trailing hooks into the mooring assembly for a lift to the surface.

Recover Moorings for Pressure

According to Plan

We start with a strategic assessment of ice at the mooring site. Since the pressure moorings are in shallow uncharted waters near shore, the assessment considers presence/absence of ice at the mooring, the feasibility of ship's approach within a few miles and the practicality of reaching the mooring site by rigid hull inflatable (fast, if little ice), by barge (slow, but more ice tolerant) or by small boat slung in by helicopter.

Once at the GPS location of the mooring, we place a hydrophone over the side to communicate with the acoustic transponder-release. Since the transponders have been modified for increased longevity by turning off the main electronics for 2 minutes out of 3, the release is not always capable of "hearing" and responding. Therefore transmissions repeated over an interval of several minutes are required to catch the release in its ON state, and to switch it to an "Enabled" condition when it is fully attentive.

With these moorings, a coded acoustic transmission releases a pick-up buoy on a tether linking it to the instruments 20 m below. The tether may be used to lift the instruments off the vertical mooring stake and raise them to the surface, ensuring that the boat is more or less directly over the installation.

Possible Need to Drag

For various reasons, there is some possibility that we will retrieve the shallow pressure-gauge moorings by grappling from the recovery boat.

The shallow depth of the pressure-mooring sites (18-20 m) allows a better directed approach to recovery by grappling. We carry a small rotary-scan sonar (Imagenex) with an effective range of about 30 m, which may permit "finding" the mooring on the seabed. We also carry an underwater video camera with lights. With this assistance it may be possible to "fish" for the mooring with grappling hook. Otherwise, these imaging devices will be helpful in confirming the presence or absence of the mooring (often a big uncertainty with dead moorings), and in setting the drag line at the correct location. Since there are no components to cut on the pressure mooring, we drag with a polypropylene rope and grappling hook, with the objective of snagging the mooring and lifting it to the surface.

Deploy Moorings for Current

These moorings are completely assembled on deck. For deployment, they are lifted over the side, lowered to the water surface and cut loose to free-fall to the seabed (2 minutes for a depth of 400 m). These moorings can be readily deployed even in heavy ice, requiring only a few square metres of ice-free water adjacent to the hull.

When the mooring has reached the seabed, we interrogate the transponder-release to verify its operability before setting it to sleep and leaving the site.

Figure 12. A long-range ADCP ready for deployment via the A-frame of USCGC Healy in August 2003.

Deploy Moorings for Temperature-Salinity and Ice Thickness

Temperature-salinity recorders and ice-profiling sonar are deployed on taut-line moorings several hundred metres in length. Although it is possible to deploy such moorings anchor first in heavy ice, this requires an A-frame and a capstan winch, with which we will not be equipped on the CCGS Henry Larsen. Thus, all taut-line moorings deployed in 2007 will be deployed anchor last. This method requires an expanse of ice-free water sufficient to stretch out the length of the mooring along the sea surface. In the adjacent picture, the float strings forming the upper sections of a temperature-salinity mooring are paid out from the stern of the Healy.

Figure 13. Float strings forming the upper sections of a temperature-salinity mooring are paid out from the stern of the Healy

The work deck on Healy is at the stern. This setup allowed the mooring to be streamed out behind the ship as it moved slowly forward towards the drop location. On CCGS Henry Larsen, where work is conducted from the foredeck, this approach is not practical. Instead, we use the ship's boat to pull the mooring out from the starboard side of the ship as it is passed over the side. When the final lift is on the crane and over the side and the ship at the desired location for deployment, the ship's boat casts off the top end of the mooring, and the final lift is cut loose.

Figure 14. The final lift (float, tandem release assembly, drop line and anchor clump) of an ice-thickness mooring is shown on the crane, prior to its drop to the sea floor. Mooring floats appear in the background.

Deploy Moorings for Pressure

The pressure recorder mooring for deployment in 2007 consists of two lightweight (less than 100 lb) components separated by a 100-foot weighted ground line. The moorings is designed for 18-m water depth.

The method of deployment is straightforward:

Locate an 18-m water depth in the chosen sheltered location. Determine in which direction the water deepens most rapidly. Since the second element of the mooring stands higher off the seabed, it should be placed in the deepest water within 100 feet of the pressure recorder.

Lift 1 comprises the ballast cradle plus the pressure recorder, weighing a total of 57 lb in air and 20 lb in water. This assembly is lowered to the seabed in the appropriate depth using the weighted ground line.

The boat is moved into deeper water, paying out the weighted ground line on the way.

Lift 2 comprise the deadweight anchor, a Benthos 867A transponding release, a Viny 12B-3 float, weighing a total of 91 lb in air and 20 lb in water. The second lift is dropped from the surface when the ground line is fully deployed and taut to the pressure recorder.

Information on Multi-year Ice Testing

Objective

The objective of this work is measurement of the physical and mechanical properties of decaying second-year and multi-year ice floes, specifically ice strength and floe thickness. We will strive to re-visit towards the close of the expedition one or more floes sampled during the first week, in order to document change during August, the month of most rapid ice warming and ablation.

This work is being conducted as a collaborative effort among DFO, NRC and various industrial partners. It is highly relevant to objectives on the federal Program of Energy Research and Development (PERD) in relation to safe Arctic hydrocarbon development and transportation.

Study Area

The observations will be conducted on old ice floes drifting in two areas of focus, Nares Strait and Cardigan Strait.

Sampling of each multi-year ice floe will require 4-8 hours. The work will be conducted during down time in the mooring programme, or if practical, simultaneously with it.

Sampling Methodology

The multi-year ice work has two components: ice thickness measurements and ice strength measurements.

<u>Ice thickness component:</u> The work involves measuring ice thickness and using the data to validate RADARSAT images acquired specially for this project. The ice thickness will be measured along a number of transects, which will be traversed on foot. The ice thickness will be measured by drilling 2” holes through the ice with a gas-powered auger and again using an electromagnetic induction sensor. We plan to drill at least 50 holes in each floe. If time permits, a representative ice core will also be obtained. The ice-thickness work can be done by Michelle Johnston and technician Richard Lanthier over the course of a day. It requires only about 100 kg of equipment: 15 m of 50 mm stainless steel auger flighting, a gas-powered drill, the EM-31 and EM-34 thickness radars, the ice corer and extension rods. For this work, the floes can either be accessed directly from the ship or via helicopter.

<u>Ice Strength:</u> Once the thickness of a sufficient number of floes (6) has been measured, we will proceed to measuring the strength, temperature and salinity of several more floes. The strength measurements require considerably more equipment (250 kg) and at least 3 field personnel (Michelle, Richard and a member of the crew or science team). An electro-hydraulic borehole jack will be used to measure the compressive strength of the ice, to a depth of 5 m. The borehole jack consists of a stainless steel hydraulic cylinder, with laterally acting plates, each having a maximum stroke of 25 mm. This work requires drilling three 150 mm diameter boreholes, processing the ice cores and measuring the strength of the ice at 30 cm intervals down to a depth

of 5 m. We have loaded a hot-water ice melting system this year in consideration of possible difficulties in retrieving the jack from depths greater than 3 m. A data acquisition system will be used to record the oil pressure and the displacement of the two indentors. Portions of the core will be taken to the ship, where they will be used for measuring the density of the ice (for which kerosene has been requested and shipped). For this work, it is preferred that the floes be accessed via helicopter in order to minimize the possibility of splitting the floe.

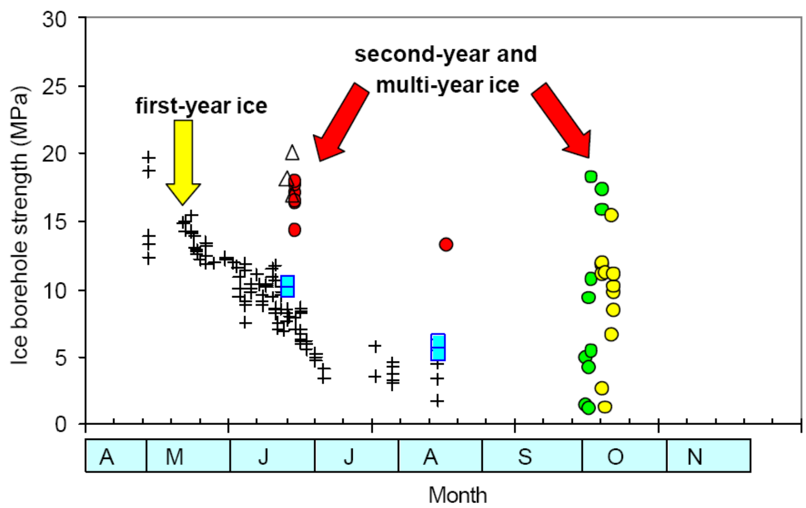


Figure 15. Decrease in strength of sea ice that occurs from May (M) to October (O). Results from different second-year and multi-year ice floes show that the ice was strong in some areas, and weak in others.

To facilitate a follow-up visit to some floes, the Canadian Ice Service (CIS) has provided two compact air launch ice beacons (CALIB) which track the floes' positions via satellite. The floes will also be tagged with VHF beacons and markers.

Refrigeration space may be required for storage of selected ice cores, to be transported to Ottawa at the end of the field programme.

Global Ice Loads, CCGS Henry Larsen

Complementary to the programme of multi-year ice testing is a programme that uses inertial measurement system (MOTAN) of the Canadian Hydraulics Centre to measure the global loads on the CCGS Henry Larsen during the voyage. The MOTAN is an autonomous system that will operate in parallel to and independently of other activities of the ship.

Two other data streams will be acquired to facilitate interpretation of ice-impact data recorded by MOTAN.

A weather-proof video camera mounted at the forepeak of the ship will capture views of the ice floes with which the ship is about to interact. The camera will provide information on ice type, floe size and ice-floe response to impact.

In addition, a down-looking video camera will be mounted on a boom partway down the length of the ship, to photograph ice blocks broken from floes with which the ship has collided. Ice thickness will be measured via photogrammetric analysis of blocks that have rolled on edge by the ship's passage. The same system was usefully operated from CCGS des Groseilliers during the re-supply mission to Eureka in 2002. For this purpose, the camera was mounted on a boom attached to the rail in the breezeway, just forward of midships.

Automatic Weather Stations

Nares Strait, separating Ellesmere Island from Greenland, has unique severe weather. Strong winds that result from air-flow channeling by high surrounding terrain are challenging to forecast and hazardous to operations. For example, hurricane-force winds devastated a CAT field camp in April 2005, resulting in its abandonment. Such wind events may occur as often as 5-10 times per month during the winter and spring. Winds in the strait also play a role in the transport of Arctic Ocean water and ice southward towards Baffin Bay. Data will improve our ability to forecast wind and weather in Nares Strait, with benefits for safety for operations and improved knowledge of the ocean and ice dynamics of the region.

Two automatic weather stations were deployed on the Ellesmere side of Smith Sound in September 2006, at Pim Island and at Cape Isabella. We plan to visit these sites by helicopter from CCGS Henry Larsen and complete tasks from a sequence of graduated difficulty, depending on how well the equipment has fared during 12-months operation in these hostile environments.

1) Take some pictures of the site, in whatever poor condition it may be.
2) Assess the damage to the installation. If the tri-pod is in very bad condition and cannot be used again, we will dismantle the installation and bring all parts all the parts back to the ship.
3) Determine if the sensors are visibly damaged. If the wind sensor is no longer operable, dismantle the installation and bring all parts all the parts back to the ship.
4) If there is no visible damage to sensors and the tripod looks as if it can withstand a second year of operation, leave the sensors on the tower and re-stabilize it for use.
5) Download the data from the on-site logger (if there are any)
6) If it is possible to the recorded data on site, check the record for realistic values and continued operation throughout the deployment.
7) Photograph the renovated weather station and depart.

Figure 16. Automatic weather station of the type now operating on Pim Island and at Cape Isabella. This photograph show the same equipment at at 4000 m elevation on Mount Logan.

Shoreline Pick-ups

Alexandra Fjord

There is a cache here placed via PCSP aircraft from Resolute Bay in mid July 2007. The cache contains much of the equipment needed for the multi-year ice testing activity lead by Michelle Johnston. For this reason, the cache must be retrieved early in the expedition.

There are 19 boxes of equipment, with a total weight of 1230 lb. The heaviest single item is 150 lb. The bulkiest item is 36” x 28” x 8”. The longest item is 120”.

Flotsam in St Patrick Bay

Satellite Tracked Buoy in Musk Ox Fjord

Satellite Tracked Buoy in Norwegian Bay

Locations of Installations

Moorings in deep water

Mooring Site	CATS name	Type	Latdeg	LatMin	LonDeg	LonMin	Actual depth (m)	Datum	Deployed
KS04	Bobcat	ADCP	80	32.124	068	42.840	357	WGS84	Aug-03
KS06	Serval	ADCP	80	30.162	068	27.240	363	WGS84	Aug-03
KS08	Margay	ADCP	80	28.286	068	11.433	350	WGS84	Aug-03
KS07	Panther	CT	80	29.372	068	19.455	377	NAD83	Aug-06
KS09	Leopard	CT	80	27.349	068	03.839	330	NAD83	Aug-06
KS13	Jaguar	CT	80	23.801	067	34.575	219	NAD83	Aug-06
KS20	Sabre Tooth	IPS	80	32.041	068	39.046	344	NAD83	Aug-06
KS30	Snow Leopard	IPS	80	26.416	067	51.113	294	NAD83	Aug-06
ACW05-1		ADCP	76	32.045	090	28.346	130		Sep-05
ACW05-4		ADCP	76	32.823	090	17.205	131		Sep-05

Moorings in shallow water

Mooring Site	CATS name	Type	Latdeg	LatMin	LonDeg	LonMin	Actual depth (m)	Datum	Deployed
Foulke Fjord	Calico	DL3-PS	78	17.830	072	34.080	20	NAD83	Aug-06
Discovery Harbour		DL3-PS	81	42.371	064	47.940	19	WGS84	Aug-03
Offley Island		DL3-PS	81	18.408	061	48.824	20	WGS84	Aug-03
Scoresby Bay		DL3-PS	79	54.654	071	21.388	21	WGS84	Aug-03

Automatic weather stations

Station Name	LatDeg	LatMin	LongDeg	LonMin	Elevation (ft)	Deployed	Type
Cape Isabella	78	21.075	075	04.756	250	11-Sep-06	Weather stn
Pim Island	78	44.704	074	23.906	840	8-Sep-06	Weather stn

Items to pick up

Name	LatDeg	LatMin	LongDeg	LonMin	Type	Owner	Note
St Patrick Bay	81	48.000	064	15.600	Buoy ashore	Unknown	West side, 100 ft above sea level
Alexandra Fjord	78	53.000	075	48.000	Cache ashore	Johnston	Air strip
11248	77	31.920	077	44.760	Buoy adrift	Johnston	Across from Thule
Cryo-06	77	03.302	088	37.102	Buoy ashore	Green Ice	Norwegian Bay
8057	76	31.000	087	26.500	Buoy ashore	Haas	Muskox Fjord, delta, east side
Cryo-07	76	06.244	087	05.150	Buoy adrift	Green Ice	Jones Sound

Cross-sections for Measurement by CTD

Station	Lat (deg)	Lat (min)	Lon (deg)	Lon (min)	Section name	Station	Lat (deg)	Lat (min)	Lon (deg)	Lon (min)	Section name
SS01	78	42.56	073	59.97	Smith Sound	KS01	80	33.53	068	54.56	Kennedy south
SS02	78	41.88	073	54.04	Smith Sound	KS02	80	33.25	068	52.16	Kennedy south
SS03	78	41.16	073	48.14	Smith Sound	KS03	80	32.46	068	45.58	Kennedy south
SS04	78	40.51	073	42.22	Smith Sound	KS04	80	31.69	068	39.00	Kennedy south
SS05	78	39.78	073	36.34	Smith Sound	KS05	80	30.88	068	32.24	Kennedy south
SS06	78	39.08	073	30.46	Smith Sound	KS06	80	30.08	068	25.61	Kennedy south
SS07	78	38.36	073	24.43	Smith Sound	KS07	80	29.27	068	18.99	Kennedy south
SS08	78	37.70	073	18.90	Smith Sound	KS08	80	28.44	068	12.09	Kennedy south
SS09	78	37.00	073	13.06	Smith Sound	KS09	80	27.68	068	05.90	Kennedy south
SS10	78	36.30	073	07.22	Smith Sound	KS10	80	26.85	067	59.15	Kennedy south
SS11	78	35.56	073	01.42	Smith Sound	KS11	80	26.08	067	52.89	Kennedy south
SS12	78	34.89	072	55.59	Smith Sound	KS12	80	25.22	067	45.98	Kennedy south
SS13	78	34.15	072	49.97	Smith Sound	KS13	80	24.46	067	39.97	Kennedy south
SS14	78	33.44	072	44.02	Smith Sound	KS14	80	23.66	067	33.57	Kennedy south
SS15	78	32.73	072	38.08	Smith Sound	KS15	80	22.84	067	26.99	Kennedy south
SS16	78	32.02	072	32.48	Smith Sound	RC01	81	55.85	062	40.36	Robeson south
KB01	79	45.67	071	02.51	Kane sill	RC02	81	55.36	062	36.72	Robeson south
KB02	79	44.83	070	56.62	Kane sill	RC03	81	54.42	062	29.83	Robeson south
KB03	79	43.13	070	44.67	Kane sill	RC04	81	53.51	062	22.91	Robeson south
KB04	79	41.45	070	33.00	Kane sill	RC05	81	52.54	062	16.12	Robeson south
KB05	79	39.74	070	21.18	Kane sill	RC06	81	51.59	062	09.10	Robeson south
KB06	79	38.08	070	09.61	Kane sill	RC07	81	50.68	062	02.47	Robeson south
KB07	79	36.37	069	58.13	Kane sill	RC08	81	49.69	061	55.34	Robeson south
KB08	79	34.64	069	46.49	Kane sill	RC09	81	48.78	061	48.97	Robeson south
KB09	79	36.68	069	36.29	Kane spur	PF01	81	05.55	062	08.12	Petermann Fjord
KB10	79	38.62	069	25.45	Kane spur	PF02	81	06.33	062	00.93	Petermann Fjord
KB11	79	40.50	069	15.47	Kane spur	PF03	81	07.09	061	53.56	Petermann Fjord
KB12	79	42.42	069	04.05	Kane spur	PF04	81	07.81	061	46.25	Petermann Fjord
KB13	79	44.36	068	53.88	Kane spur	PF05	81	08.55	061	39.05	Petermann Fjord
KB14	79	46.21	068	42.83	Kane spur	PF06	81	09.32	061	31.77	Petermann Fjord
KB15	79	48.13	068	32.09	Kane spur	ACW05-1	090	28.346	76	32.045	Cardigan Strait
KB16	79	50.12	068	21.21	Kane spur	ACW05-4	090	17.205	76	32.823	Cardigan Strait
KB17	79	51.96	068	10.41	Kane spur	NB02	77	00.00	089	30.00	Norwegian Bay
KB18	79	53.78	067	59.54	Kane spur	NB01	76	48.00	091	12.00	Norwegian Bay
KB19	79	55.67	067	48.10	Kane spur	CS04	76	32.76	090	17.30	Cardigan Strait
KB20	79	57.56	067	37.01	Kane spur	CS03	76	32.42	090	21.15	Cardigan Strait
KB21	79	59.47	067	26.32	Kane spur	CS02	76	32.09	090	24.45	Cardigan Strait
KB22	80	01.32	067	14.21	Kane spur	CS01	76	31.87	090	28.32	Cardigan Strait
						HG01	76	34.15	089	44.84	Hell Gate
KN01	81	16.21	065	13.60	Kennedy north	FS01	76	25.06	089	12.50	Fram Sound
KN02	81	15.33	065	07.10	Kennedy north	FS02	76	24.34	089	13.66	Fram Sound
KN03	81	14.44	065	00.27	Kennedy north	FS03	76	23.55	089	15.11	Fram Sound
KN04	81	12.66	064	47.20	Kennedy north	FS04	76	22.79	089	16.68	Fram Sound
KN05	81	10.87	064	34.05	Kennedy north	FS05	76	22.03	089	18.41	Fram Sound
KN06	81	09.49	064	24.28	Kennedy north	FS06	76	21.27	089	19.69	Fram Sound
KN07	81	08.53	064	17.51	Kennedy north	FS07	76	20.51	089	21.36	Fram Sound
KN08	81	07.72	064	11.58	Kennedy north	FS08	76	19.69	089	23.28	Fram Sound

Shipments of Scientific Equipment

Fisheries and Oceans Canada

Institute of Ocean Sciences, 9860 West Saanich Road, Sidney BC, V8L 4B2

Ron Lindsay (250-363-6592) LindsayR@dfo-mpo.gc.ca

National Research Council of Canada

Canadian Hydraulics Centre, Bldg M-32, Montreal Road, Ottawa, K1A 0R6

Michelle Johnston, (613-990-5141) Michelle.Johnston@nrc-cnrc.gc.ca

Cargo Description

Fisheries and Oceans Canada

2 x 20-foot cargo container: scientific equipment in boxes, winch & winch hydraulics

- Aluminum-clad container with personnel door is for installation on the boat deck. The 50-HP hydraulic power pack & electrical panel must be removed from this container before it is lifted onto the ship.
- Steel-clad container is for installation on the foredeck. This container houses the 50-HP winch.

6 additional pallets of mooring components

11 steel drums containing scrap chain for deadweight anchors

National Research Council of Canada

28 boxes of equipment for sheltered storage (approximately 19 boxes, 1230 lb, from Alexandra Fjord cache.

Hazardous Materials (in small quantities)

Triton-X cleaning solution

Scotch Kote (for underwater splices)

BR Type lithium cell, model 123

AF24173 Anti-Foulant capsule

Ethanol & WD-40 (NRC)

Supernumeraries on the Science Team

1	Humfrey Melling	M	250-363-6552	MellingH@dfo-mpo.gc.ca	Chief scientist
2	Andreas Münchow	M	302-831-0742	Muenchow@udel.edu	USA Lead scientist
3	Helen Johnson	F	44-118-378-5569	Helen.Johnson@earth.ox.ac.uk	Scientist: oceanography
4	Michelle Johnston	F	613-990-5141	Michelle.Johnston@nrc-cnrc.gc.ca	Scientist: ice properties
5	David Spear	M	250-363-6581	SpearD@dfo-mpo.gc.ca	Technician: mooring
6	David A. Riedel	M	250-363-6570	RiedelD@dfo-mpo.gc.ca	Scientist: support
7	Ron W. Lindsay	M	250-363-6592	LindsayR@dfo-mpo.gc.ca	Technician: electronics
8	Jonathon Poole	M	250-363-6593	PooleJ@dfo-mpo.gc.ca	Technician: equipment
9	Berit Rabe	F	302-345-2679	beritrabe@yahoo.ca	Student: oceanography
10	Richard Lanthier	M			Technician: equipment

Ice in Nares Strait, 25 July 2007 (MODIS)