Healy Cruise Report

HLY03Td

1 Summary:

Healy cruise HLY-03-Td departed from Thule, Greenland on Tuesday, August 19th, transited through the northern Northwest Passage, through the Prince of Wales Strait and arrived off of Barrow, Alaska on Saturday, August 30, 2003.

The goal of this cruise was to take advantage of the repositioning of the vessel between funded science legs HLY-0301 (St. John's to Thule) and HLY-0302 (Barrow to Barrow) to collect underway data including multibeam swath mapping, subbottom profiler, thermosalinograph (TSG), weather, acoustic doppler current profiler (ADCP), fluorescence marine mammal
observations, and expendable probes (XCTDS.) Additional efforts during this cruise included ship's power system testing, outreach, and development of science metadata standards and procedures.

2 Narrative:

A daily narrative is included in appendices.

2.1 Multibeam

The following observations characterize the performance of the SeaBeam 2112 multiple formed beam swath mapping sonar on the Healy during cruise HLY-03-Td.

2.1.1 System Overview

The multibeam installed on the Healy for this cruise is a SeaBeam model 2112 operating at 12 kiloHertz. It has sixty (60) hydrophones in the receive array and 12 projectors in the transmit array. The arrays are arranged in a Mills Cross at approximately frame 54.

SeaBeam Real-Time Sonar System Software version 1.2.1A was used for the entire cruise.

2.1.2 Multibeam inputs

2.1.3 Sound speed at the keel

Speed of sound was derived from the forward and aft SeaBird Thermosalinographs in real-time, reformatted and provided to the SeaBeam. For some portions of the cruise the sound speed at the keel was forced into manual mode to avoid a bug in the SB2112 software (see section 2.2.3.)

Sound speed was calculated using the Chen and Millero 1977 equation and inputs of conductivity (converted to salinity) and temperature from the active TSG.

2.1.4 Sound speed profiles

Sound speed profiles were derived XCTD profiles. The speed of sound as calculated by the Sippican software was re-sampled with *mbmvelocitytool* and loaded into the SB2112 via ftp..

2.1.5 Navigation and heading

The real-time navigation input for the entire cruise was provided by the ship's integrated bridge system. There is no other reliable source capable of providing the right data in the correct formats available on the ship.

Heading derived from the ship's MK-37 gyrocompasses was provided through the IBS. There was no other continuously available source on board during this leg.

2.1.6 Time synchronization

Time of day synchronization was provided from the IBS for the entire cruise. There was no other source available during this cruise.

2.1.7 Attitude

A Kongsberg Simrad Seatex MRU6 serial number 225 vertical reference was used for the entire cruise. There is no other vertical reference.

2.2 Performance Issues:

2.2.1 Damaged hydrophones

Approximately 17 hydrophones in the receive array exhibit erroneous capacitance and/or electrical shorts. At the recommendation of L3/SeaBeam (see reference) these hydrophones were shorted in the junction boxes.

2.2.2 Thermosalinograph (TSG)

The SB2112 installation on the Healy (in addition to other science systems) depends up real-time measurements of water temperature and conductivity to estimate the speed of sound used in the beam former. Errors in estimating this parameter are very hard if not impossible to accurately remove after the fact. Therefore, problem with water flow that result in poor performance of the TSG and hence inaccurate sound speed are critical.

2.2.2.1 Forward Thermosalinograph

The science seawater intake was out of service for several extended periods during this cruise. Each initial failure was due to the intake becoming clogged with ice while operating in the marginal ice zone or while actively breaking ice. On each occasion, there was a substantial delay after entering open water during which the intake system remained frozen. The un-freezing process could be materially improved by addition of (steam?) heating around the outside of the plumbing. This heat would only be applied to un-freeze the intake, not during normal operation.

2.2.2.2 Aft Thermosalinograph

The aft TSG was the primary source of data for estimating speed of sound at the keel during this cruise. There were a few instances where the flow rate was low but these were resolved relatively quickly once reported.

An automatic method of reporting low flow should be implemented. This will require installation of flow rate sensors. The sensors do not need to be

2.2.3 Sound speed at the keel

An old bug in accepting sound speed at the keel has re-surfaced in the SeaBeam 2112. This bug is encountered when sound speeds less than 1440 m/s are provided via the real-time interface. When presented with such a low sound speed it appears that the

SB2112 (version 1.2.1A) software forwards a zero speed to the beam former and no formed beam data is provided for the subsequent ping.

During several periods during this cruise, we encountered cold, relatively fresh water that results in sound speeds well below 1440 m/s. During these periods, we worked around this bug by switching to manual sound speed at the keel and using a fixed value of 1440.5 m/s.

2.2.4 Navigation heading and time

A few times during this cruise, the integrated bridge system (IBS) had trouble and stopped sending navigation data to the SB2112. This results in a number of errors in the data.

Most if not all of these problems can be resolved in post processing.

2.2.4.1 Loss of time synchronization

At least once during this cruise the IBS sent erroneous time and date synchronization data to the SB2112. The date of the erroneous data was at least two days in the future.

In response to this event, at least some if not all of the computer nodes in the IBS were rebooted to clear the error.

2.2.4.2 Navigation resolution

The format for navigation input to the SB2112 on the Healy only allows for two places for decimal minutes of latitude and longitude. The resulting truncation in precision results in some jitter in the real-time display.

The navigation accuracy in the multibeam data can be improved in post processing by merging data from either of the existing P-Code receivers.

2.2.5 Shallow water performance

The SB2112 on the Healy is not capable of shortening it's transmit array when operating in shallow water. As a result, the data in less than about 250m of water is taken with the sonar operating in the near field. The resulting data quality is substantially worse than data collected in deeper water.

2.2.6 VRU error messages

As in previous cruises, there were intermittent bursts of "FATAL" error messages reported in the Status window by the SB2112. Unfortunately, these errors are not recorded which makes documenting correlation with external events difficult.

There is no direct evidence that the bathymetry data is significantly degraded in association with these errors but it is possible. Perhaps more importantly, these errors are very alarming to watch standers.

The long cable run between the SB2112 (in the Computer Lab) and the VRU (in the IC/Gyro Space) provides power down to the VRU and data communications between the VRU and the SB2112 receiver processor.

It is possible that EMI is causing interference with the communications between the two devices. Options for addressing this issue include moving the VRU to the Computer Lab, adding EMI filters, installing filtered line drivers and re-routing the cable. Careful thought should be given prior to future effort.

2.2.7 VRU alignment

No accurate alignment and offsets exist for this installation.

2.2.8 Ping rate

This SB2112 has a minimum ping interval of about 1.5 seconds. As a result, along track sampling in less than about 500m of water is significantly less that desirable.

3 ADCP-HLY-03-Td

Preliminary report on HLY-03-Td ADCP data collectio

David Huntley, Graduate College of Marine Studies, University of Delaware
Aug. 28, 2003

3.1 Introduction

The USCGC Healy contains two separate and independent hull-mounted acoustic Doppler current profiler systems. The systems are a 75 kHz phased array (Ocean Surveyor) and a regular 4-beam 153 kHz transducer (BroadBand). Each system is mounted in its own well that is filled with anti-freeze solution and is separated from the water by an acoustic window. Both systems collected data continuously, but only the 75 kHz system was fully operational. As stated in the HLY-03-01 cruise report by Dr. Andreas Muenchow, the BB153 data is suspect due to excessive mechanical and/or electromagnetic noise that has reduced both water tracking range and data quality below acceptable levels for the BB153 system. While the BB153 system did have its moments of clarity, it did not perform at acceptable levels during this transit.

3.2 Data streams

Both the 75 kHz Ocean Surveyor (OS75) and the 153 kHz Broadband (BB150) were run via VMDAS under Windows-2000 Professional and controls input and output data streams. VMDAS receives

OS75 or BB150 single ping data via serial port COM7 (.ENR file on output), Gyro heading data via serial port COM7 (.ENR file on output), P-code (aft) GPS data via serial port COM8 (.N1R file on output), and Ashtech navigational and attitude data via serial port COM9 (.N2R file on output)

The aft P-code GPS system is distinct from the bridge P-code GPS system. VMDAS generates 10 different output files that merge and average data from the three input streams in varying ways. A .LOG file contains both direct commands sent to the OS75 or BB150 on start-up as well as all subsequent error messages. The most common error message recorded was:

NMEA [RPH] communication timeout

The main ADCP problems appear to be software rather than hardware related. The most common issue with both systems was the operating system freezing, thus disrupting data collection. Microsoft Windows and its network provide an unstable platform environment for data collection. However, RD Instruments does not currently support any other operating system other than Microsoft Windows. A single, stripped down, stand-alone CPU with dedicated serial inputs may remedy many ADCP data collection. The ADCP data collection CPU should NOT be used for ANY other processes besides data collection.

3.3 Performance

OS75

The OS75 performed well during the cruise when run NarrowBand mode using 15-m vertical bins and 10-m blanking. All data were collected with this setup. The water profiling range varied from more than 600-m to less than 200-m depending on the presence of scatters in the water column. The OS75 tracked the bottom without any problems down to 900-1100-m. Ship speeds below 15 knots had little effect on the systems performance and an optimum ship speed in waters may be 12-14 knots. Once

the third engine operates (irrespectively of speed), however, the additional vibrations degrade the OS75 substantially. The same applies to active ice-breaking when little useful data are returned at any ship speed.

BB150

The BB150 did not perform well for most of this transit. There are installation issues which have been noted in the previous cruise report (HLY-03-01) and the data from this instrument should be viewed as suspect. The BB150 was run using 4-m vertical bins and 4-m blanking. All data were collected with this setup. The water profiling range varied from less than 20-m to just over 150-m. Bottom tracking was good below 350-m. Ship speeds of greater than 6 knots affected the data quality, as did ice-breaking and running the third engine.

5. Watchstanders

A dedicated team of watchstanders monitored both ADCPs and SeaBeam data collection at all times. These were

0000-0600 Local David Huntley

0600-0000 Local (6hr rotating) David Monahan & Kevin Wood Diane Bentley & Al Hayashida

Bob Arko

Their tireless efforts ensured an almost gap-free, high-quality ADCP record.

4 XCTD-HLY-03-Td

The Healy MSTs ably handled the deployment of the XCTDs during the Healy Northwest Passage transit, generally with the assistance of one of the science watchstanders in the computer lab.

Twentynine (29) XCTDs were successfully deployed on the transit (see track plot for positions) with the main purpose of characterizing differences in water masses in basins and across sills during the passage, and with a view toward understanding freshwater flux through the Canadian Archipelago.

As to operational details. Due to the potential for occasional transient computer problems the science watchstander was employed to monitor the Mk21 computer as the probe was loaded and tested. When the ready to launch message was displayed the MST on deck was notified (usually by phone) and the probe was launched. In shallow water the cast was teminated when the probe reached the bottom. The MSTs then exported the data file and logged the drop.

There were 7 probe failures out of 36 deployments (a 19% failure rate), and 8 cases where the .rdf datafile could not be exported to .edf format. In one case the data was written to the Sippican proprietary format (.sip) and did not write to .rdf. In most cases these problems seemed to be related to computer software. We found that it was best to reboot the computer each time, and to always follow the same procedure for loading and launching the probe. This way extraneous failure modes might be avoided. However, the Mk21 system is not perfectly reliable (particularly on the software side), and should receive some attention, although it is noted that some percentage of failures is probably to be expected with expendable probes.

Finally, there were 3 instances where designated stations were sailed past a short distance without a deployment. This did not cause significant problems for the XCTD program, but the importance of monitoring communications between the bridge, aloft con, and the computer lab is highlighted. Undoubtedly the changeable nature of the ship's track throught the ice and the flexibility of station locations during the latter phase of the transit contributed to this tendency. A CCTV monitor in the computer lab would vastly improve the MSTs and science watchstanders ability to determine distance to station and approximate ETA.

5 Suggestions:

The following suggestions were accumulated by the science party during the cruise.

5.1 Expendables:

The HP 710? scanner/printer in the main lab was out of ink and turned off. This device (and it's partner in the 02 Science Conference Room) are the only scanners on board. The alternative is a long way from the science spaces.

5.2 Computer Projector:

Evening talks and discussion are an important part of all cruises and these days, a high resolution computer project is a key ingredient. The high resolution projector in the science conference room has a color balance problem and there appears to be no spare high resolution projector on board. A spare should be provided.

5.3 Video Display in the lab spaces:

There is no video display in the Computer Lab or the Future Lab. These displays are an important key to keeping the science watchstanders up to speed on what the ship is doing and the outside environment. Installing displays in these labs would provide a huge improvement

5.4 Wired Telephone:

There is no wired telephone in the forward end of the computer lab for underway watchstanders. Sharing the cordless phone is awkward as it's charger is far from the watchstanders location and the handset often gets left laying around. A phone with a separate extension and a pickup-group should be added..

5.5 Bathy 2000 Display:

The existing Bathy 2000 display in the lab is not scaled correctly and does not allow one to see the depth display. A correct display should be provided.

5.6 Potentially Icy Decks:

We noticed that the 01 deck starboard side (outside the Computer Lab) does not drain well. In cold weather, this lack of drainage is likely to result in icy decks.

5.7 Access to general purpose computers:

Most shipboard science is a 24x7 operation. Having computing resources down for significant periods of time is a hindrance. The hardware, software and procedures should be revised to insure full time access while retaining effective backup capability. For unknown reasons some parts of the system are routinely un-available due to backups and virus scans..

5.8 Hydrographic Launch

There would be some value in having Healy carry a hydrographic launch (HSL is the USN designation). This is a small 25-35 ft survey boat with positioning system and multibeam sounder, and a normal crew of one seaman and one tech or scientist. These boats can be used when Healy is moored or on station as a subsidiary survey vessel, particularly useful to survey small bays and areas of shoal water which the Healy’s draft would make risky or impassible. Could increase the data return on each cruise leg without a great increase in resource use.

6 Appendices

6.1 Narrative for HLY-03-Td

Friday, August 15, 2003

- C-130 flight from Schnectaday, NY to Thule, Greenland for most of us. A few were already onboard for the previous leg.
- Overnight at the Northstar Inn

Saturday, August 16, 2003

- Small boat transfer out to the Healy in the morning

Sunday, August 17, 2003

- At anchor off of Thule
- Roll (attitude) calibration for the vertical reference unit (VRU), a Kongsberg Seatex MRU6 that supports the SeaBeam

Monday, August 18, 2003

- At anchor off of Thule
- High winds and seas prevent small boat transfers
- Evening lecture: Arctic History

Tuesday, August 19, 2003

- Underway shortly after 1000
- Zigzag across Baffin Bay, filling in blanks in the navigation charts

Wednesday, August 20

- Spotted and recorded uncharted rock off Coberg Island
- Helicopter transfer to Griese Fjord
- Evening lecure: Marine Mammal Identification

Thursday, August 21, 2003

- Helicopter flights for luck crew members this morning
- Drills in the afternoon
- Saw our first polar bear
- Begin to see iceberg furrows on sea floor
- Close pass by Bechy Island this afternoon
- Good turnout for "Field Guide to Healy Science Systems"

Friday, August 22, 2003

- Breaking ~9+/10s ice most of the morning
- Many seals, mostly unknown
- Plan to fly a helo for ice recon
- Flew a helo recon in the afternoon

- Got into open water
- Saw a mother polar bear and cubs swiming and on the ice

Saturday, August 23, 2003

- Open water sailing in relatively shallow water in the morning.
- Saw a bow head whale.
- Scattered (1/10 to 2/10) ice w/ snow showers at mid-day
- Hump day for the crew so a few celebrations

Sunday, August 24, 2003:

- Got through the "heavy" ice into the mouth of the Prince of Wales Strait without much trouble in the early morning.
- Then into mostly open water.
- Propulsion tests of main engines while against selected ice mass
- Evening talk on submarines under ice
- Four hour time change at 2000 local. We are now on Alaska time.

Monday, August 25, 2003:

- Foggy through Amundsen Gulf this morning
- Forward sea chest is still frozen up. The external temperature probe now says 8 degrees.
- Evening talk on 19th century exploration

Tuesday,August 26, 2003:

- Evening talk on Arctic and Law of the Sea

Wednesday, August 27, 2003:

- Started zig-zag survey along the Alaska slope after wending our way out tot he 2,500m contour
- Loose, weak multi-year pack ice
- Evening talk on the ships propulsion system

Thursday, August 28, 2003:

- Continue slope survey. Crossing and paralleleing lines from SCICEX '99 where we have swath data and need navigation ties.
- Sunny and clear in the afternoon
- Fog in the early evening

Friday, August 29, 2003:

- Finish survey along the slope, head for Barrow
- Fog

Saturday, August 30, 2003:

- Arrive Barrow
- Personnel, mail and material transfers via helicopter

7 Science Watchkeepers

HLY-03-TD

PEOPLE

Team A	Arko (Bob, 819)	
Team B	Monahan (Dave, 820)	Wood (Kevin, 818)
Team C	Bentley (Diane, Dede, 823)	Hayashida (Al, 828)
Team D	Huntley (Dave, 811)	
El Supremo	Chayes (Dale, 827)	

TIMES

		T	W	T	F	S	S	M	T	W	T	F	S
		19	20	21	22	23	24	25	26	27	28	29	30
0000-0600			D	A	B	D	D	D	D	D	D	D	D
0600-1130			A	B	C	A	B	C	A	B	C	A	B
1130-1730		A	B	C	D	B	C	A	B	C	A	B	C
1730-2400		B	C	D	A	C	A	B	C	A	B	C	

8 Ice condition encountered during USCGC Healy transit of Northwest Passage

Christopher Szorc

National Ice Center

Naval Ice Center
Aug. 298, 2003

Departed Thule 19 Aug, sea ice free, bergy bits throughout northern Baffin Bay and Glacier Inlet. Sea ice first encountered on the 21st in vicinity of 90.2W. As Healy continued westward thru Lancaster Sound ice gradually increase in concentration until we entered 9 tenths of thick first year ice just west of Resolute on the 22nd.

On the 23rd Healy entered an area of 9/10 multi-year/first year thick ice, transited thru this ice for about 4 hours when we entered a lead from Bathurst Island to the Dundus Peninsula of Mellville Island. Healy transited the lead south until we encountered 9/10 multi-year/first year ice extending 30 miles north of the Prince of Wales Strait. Healy entered the Prince of Wales Strait on the 24th where the ice began to decrease in concentration to 3-5 tenths. At 72.5N, Healy again entered ice free waters into the Amundsen Gulf. Entered eastern Beaufort Sea on the 25th where Healy again encountered multi year ice. Healy in and out of areas of multi year ice with concentrations ranging from 1/10 to 9/10 as ship transited southern Beaufort Sea until the 29th, when Healy entered ice free waters west of 149W.

The latest ice information was received on a daily basis via Inmarsat and Iridium. Imagery consisted of Radarsat from the Canadian Ice Service and National Ice Center, NOAA and OLS received on the ship's Terascan system. As well as 2 ice recon flights aboard HH-65a helicopter.

Attached are examples of Ice charts from both NIC & CIS as well is Radarsat imagery.

9 Marine Mammal and Seabird Observations Cruise Report

By: Stephanie Burkhart, USCG, and Marc Webber, USFWS

Sightings of marine mammals and seabirds were recorded from the United States Coast Guard Cutter Healy during its transit from Thule, Greenland to Barrow, Alaska from August 19-30, 2003. During this period, 147 hours of single observer watches were stood from the fully enclosed bridge of the Healy, approximately 60 feet above water level. Visual scans for animals were conducted by both the naked eye and with 7x and 10x binoculars from beam to beam as the vessel moved through a variety of ice and open water habitats. Sightings of marine mammals were recorded on NOAA, NMFS Platforms of Opportunity forms, and seabird sightings were recorded by species and grouped by two hours time blocks.

A list of sightings is provided in Table 1. One cetacean and four pinniped species, the polar bear, and 14 seabird and waterfowl species were recorded. The most frequently sighted marine mammal species was the bearded seal (31 sightings), followed by the polar bear (19 sightings) and the ringed seal (18 sightings). The most frequently sighted bird species was the thick-billed murre (989 birds), followed by the northern fulmar (769 birds), and the black-legged kittiwake (486). The largest number of marine mammal sightings occurred within the Parry Channel, whereas the largest number of birds was seen in Baffin Bay. Sightings of bowhead whale, harp seal and hooded seal all made well into the Parry Channel may represent additions to the knowledge of the range of these species in this area, and will be shared with interested colleagues.

The marine mammal sighting forms will be added to the NOAA National Marine Mammal Laboratory's database in Seattle, WA, which has data dating back to 1958. This data helps biologists to determine the distribution and range of marine mammals all over the world. Polar bear sightings, photographs and video will also be archived with the U. S. Fish and Wildlife Service, Office of Marine Mammals Management in Anchorage, AK. Data of seabirds will be sent to the U. S. Fish and Wildlife Service, Office of Migratory Bird Management in Anchorage, AK.

10 A brief outline of some historic sites along the Northwest Passage

Kevin R. Wood

NOAA Arctic Research Office

Most everyone who has been involved in polar research develops a fascination with the history of polar exploration, and the history of the search for the Northwest Passage during the 19th century is particularly evocative. This is partly because of the tint of Victorian tragedy caused by the loss of Sir John Franklin's expedition (1845-48) and the long search that followed, but also because recent scientific work has suggested that adverse climate conditions contributed to the heroic futility of the entire enterprise. Some ice core proxy records show that the first half of the 19th century may have been the coldest period of the Little Ice Age, though more recent interpretations suggest a more complicated scenario in the context of global climate change.

Along the cruise track that the USCGC *Healy* followed through the Northwest Passage in August, 2003, there are a number of locations where significant events in the history of Arctic exploration took place and where some historical relics still exist. These are for the most part found in the places where naval expeditions had their winter quarters. Nine of the more important locations are listed below; the first five in the order that they were encountered on the cruise track:

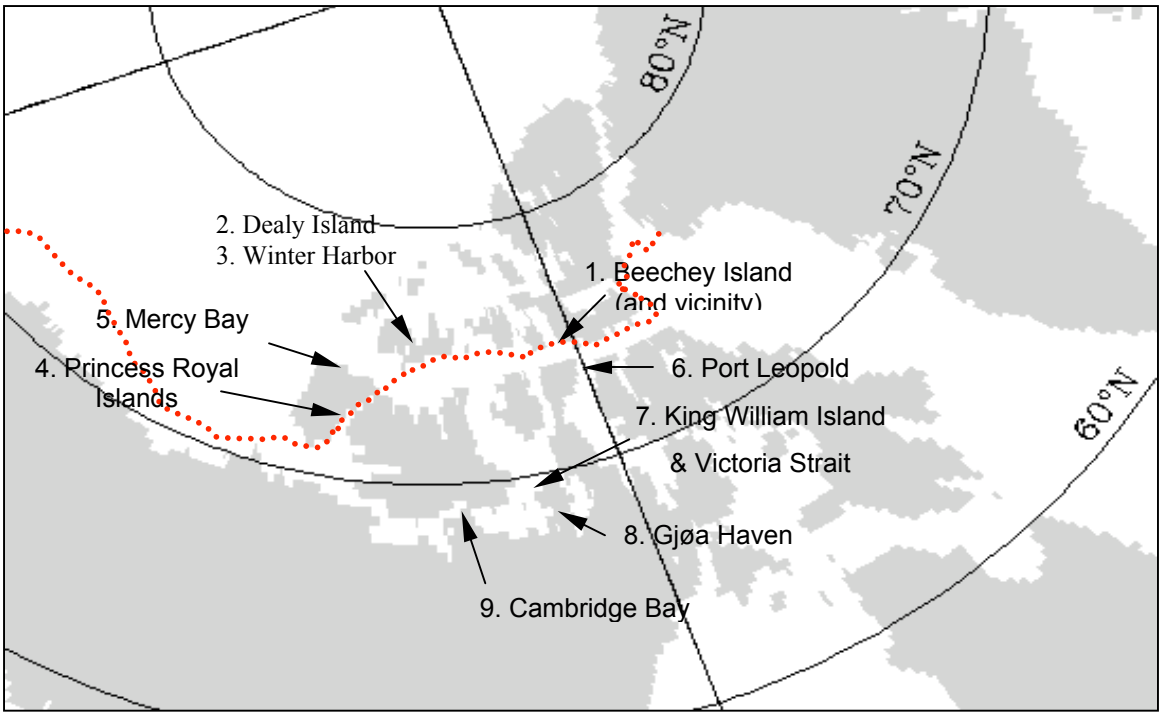
On the route that the *Healy* followed through the Parry Channel and the Prince of Wales Strait:

	Location	Position	Commander	Year
1.	Beechey Island	74.7 093.0	John Franklin	1845-46
	(and vicinity)		Search Expeditions	1850-51 1852-54
2.	Dealy Island	74.9 110.0	Henry Kellet	1852-53
3.	Winter Harbor	74.8 111.0	Edward Parry	1819-20
4.	Princess Royal Islands	72.8 118.5	Robert M'Clure	1850-51
5.	Mercy Bay	74.1 119.0	Robert M'Clure	1851-53

Sites on other routes through the Passage:

6.	Port Leopold	73.9 090.0	James Clark Ross	1848-49
7.	King William Island	69.6 098.7	John Franklin	1846-48
	& Victoria Strait			
8.	Gjøa Haven	68.6 095.9	Roald Amundsen	1903-05
9.	Cambridge Bay	69.5 105.0	Richard Collinson	1852-53

A map of these locations is shown below (Fig. 1).



In the following section a brief history of the events that took place in each of these locations is provided along with a description of some of the historical relics that can still be seen today.

HISTORIC SITES ENCOUNTERED ALONG THE TRACK OF THE *HEALY*

1. Beechey Island (and vicinity)

The Franklin expedition wintered over at Beechey Island, on the western extremity of Devon Island, in 1845-46. Traces of the lost Franklin expedition were first found here by Austin's squadron in August 1850 (Fig. 2), among them the graves of three of Franklin's crewmembers (Fig. 3). One of the enduring mysteries surrounding the Franklin expedition is the absence of any documentation found at Beechey Island or any other place where the expedition passed. It was customary at the time for expeditions to leave an account of their plans and proceedings in stone cairns for those following to find. Only one written record of this type from the Franklin expedition was ever found, and this was at Victory Point, King William Island.

Figure 2. TOP Austin's squadron along with ships under the command of Penny and Ross in Union Bay, Beechey Island, September 1850. Drawn by G.F. M'Dougal and published in *Facsimile of the Illustrated Arctic News* (image courtesy of Univ. of Alaska, Elmer F. Rasmussen Library). **BOTTOM** Union Bay as it appeared during the *Healy* transit, August 22, 2003.

From 1850 to 1854, Beechey Island and vicinity became the center of activity for the Franklin search. In 1850 the island was visited by ships under the command of Austin, Penny, Ross and DeHaven, who later wintered over on the opposite side of Wellington Channel near Griffiths Island and in Assistance Bay. In 1852-54 the HMS *North Star*, a supply ship for Edward Belcher's squadron, was stationed at Beechey Island. During this period a number of structures were built, including Northumberland House and a large monument or cenotaph and a memorial to Lt. Bellot, an officer of the French navy who drowned while carrying dispatches for Belcher.

Figure 3. Two of the graves of Franklin crewmembers on Beechey Island. Photo by Jamie Stewart, 1995.

Today, a number of relics from the Franklin era can be seen on Beechey Island. These include the graves of three of Franklin's crew, the ruins of Northumberland House, several monuments, and the remains of a number of caches.

Also near Beechey Island is the wreck of the HMS *Breadalbane*, which lies in 340 feet of water south of the island (Fig. 4). The *Breadalbane* was transporting supplies for Belcher's squadron when it was nipped by ice and sank in August, 1853. The ship remains in a good state of preservation. Since this wreck was located in 1980 it has become something of a tourist destination for those who want to book a trip on a submersible.

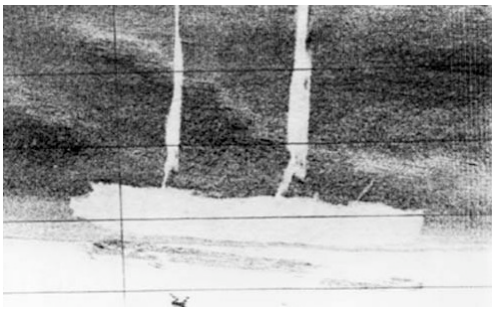


Figure 4. LEFT: The sinking of the HMS *Breadalbane* south of Beechey Island in August, 1853. "The field of ice, easing off from the *Phoenix* passed astern to the *Breadalbane*, and entering her bow, she filled and sank in less than 15 minutes, in 30 fathoms of water." National Archives of Canada, C-000227. RIGHT: Side scan sonar image of the wreck of the *Breadalbane.* Kline and Associates.

2. Dealy Island

In 1852 Edward Belcher was placed in command of a squadron to search for the missing Franklin expedition from the east by way of the Atlantic and Lancaster Sound. In order to cover as much ground as possible he separated his ships into 3 divisions. He retained command of the HMS *Assistance* and the steam tender *Pioneer*, and sailed northward from Beechey Island up Wellington Channel to Northumberland Sound. Henry Kellet, with the HMS *Resolute* and the steam tender *Intrepid,* was sent to the westward through Viscount Melville Sound to Melville Island. The other ships, including the HMS *North Star* remained at Beechey Island.

Kellet went into winter quarters at Dealy Island (Bridport Inlet). From this base sledge crews were dispatched to survey the coast and to search for traces of the Franklin expedition. The remains of Kellet's cache can be found at Dealy Island, along with the graves of three crewmembers that died on the expedition (Fig. 5).

Figure 5. A cache built by Henry Kellet at Dealy Island in 1853, as it appeared in 1910. Photo from Prince of Wales Northern Heritage Center (http://pwnhc.learnnet.nt.ca).

After finding a message left at Parry Rock, in Winter Harbor, Kellet was able to establish contact with Robert M'Clure and the HMS *Investigator* beset at Mercy Bay, on the north coast of Banks Island. In the spring of 1853 the *Investigator* was abandoned and the crew evacuated to Dealy Island. Ironically, the first individual to travel from one end of the Passage to the other was one of M'Clure's officers, who had become mentally affected and was evacuated by sledge all the way to Beechey Island and then on to England by sea.

The *Resolute* and the *Intrepid* were trapped by new-forming ice in Melville Sound, near Cape Cockburn, in the fall of 1853 and were forced to drift with the pack through the winter (Fig. 6). The following spring, Belcher ordered these ships to be abandoned. The *Intrepid* was lost, but the *Resolute* was carried by the pack out into Davis Strait, where she was found adrift by an American whaler. Some years later, when the *Resolute* was broken up, the British government built a desk from wood salvaged from the ship and presented it to the White House, where it is still in use.

Figure 6. LEFT HMS *Resolute* under sail for the last time (M'Dougal, 1854). **RIGHT** Viscount Melville Sound, with Cape Cockburn in the distance, August 23, 2003.

3. Winter Harbor

Winter Harbor, on the south shore of Melville Island, is not far from the most westerly position ever attained by a ship sailing from the Atlantic during the 19th century. Edward Parry, with HMS *Hecla* and *Griper*, was the first to reach this point in 1819, on his first voyage in command of an Arctic expedition. From Melville Island Parry could see the outline of land on the south side of the channel. Only about 60 miles separate Melville Island from the nearest positions attained by HMS *Investigator* and HMS *Enterprise* thirty years later, both sailing from the west by way of Bering Strait. However, the sea between Melville Island and Banks Island is often filled with heavy ice from the polar basin, and this effectively barred the way for the sailing ships that encountered it.

At Winter Harbor there is a remarkable block of sandstone on the beach near Parry's winter quarters (Fig. 7). The names of Parry's ships and the date were inscribed on this rock in 1820. During the Franklin search Parry's Rock functioned as a post office of sorts, and was the site where Kellet and M'Clure made contact in 1853, and thus completed the discovery of two of the possible routes through the Northwest Passage (through M'Clure Channel and west of Banks Island, and south through Prince of Wales Strait).

Kellet sailed close to Winter Harbor in 1852 but encountered of a barrier of shore-fast ice that was too wide to allow him to cut in to the harbor as Parry had done. He found it more expedient to sail back a few miles to the east, where the harbor at Dealy Island was free of ice. In 1908-09 Bernier, in the *Arctic*, found the sea south and west of Melville Island completely free of ice. He wintered over that year at Winter Harbor, and visited again in 1910.

Figure 7. Parry's Rock today. A commemorative plaque and flagpole were added by Bernier, who also repaired a number of caches and constructed huts along the route. Photo from Prince of Wales Northern Heritage Center (http://pwnhc.learnnet.nt.ca).

4. Princess Royal Islands

In 1850 the HMS *Enterprise* and *Investigator* were sent from England to search for the Franklin expedition from the Pacific, under the overall command of Richard Collinson, but the two ships were separated before reaching the Arctic. Robert M'Clure, in the *Investigator,* was able to round Point Barrow with favorable ice conditions in 1850, while Collinson, who arrived two weeks later, encountered heavy ice and was forced to retreat until the following year.

M'Clure followed the coastline to Amundsen Gulf, crossed to Banks Island, and then followed Prince of Wales Strait to within 30 miles of Viscount Melville Sound before being stopped by ice. At this point he recognized that if he could link up with Parry's farthest west only 60 miles away on the opposite side of Viscount Melville Sound, the long sought Northwest Passage would be completed. With the navigation season well advanced M'Clure decided to seek a safe winter haven on the southern shore of Victoria or Banks Island. However, on the return passage down Prince of Wales Strait the *Investigator* became entangled in rapidly consolidating sea ice, and was forced to winter in the pack near the Princess Royal Islands (Fig. 8).

Figure 8. TOP The perilous position of the HMS *Investigator* wintering in the pack near the Princess Royal Islands, October 1850. From a sketch by Samuel G. Creswell. National Archives of Canada. BOTTOM The Princess Royal Islands on August 24, 2003.

5. Mercy Bay

Failing to find an opening through the ice into Viscount Melville Sound from Prince of Wales Strait in 1851, M'Clure attempted to round Banks Island to the west by way of a shore lead along the coast. After a narrow escape from having his ship crushed or forced on shore by heavy polar ice he fortuitously came to a sheltering bay, which he called the 'Bay of God's Mercy,' which is known today as Mercy Bay (Fig. 9). Unfortunately, by locating his winter quarters nine miles inside the bay he was unable to cut the ship out the following summer when the ice did not completely clear—though tantalizingly open water was seen at the mouth of the bay and in the strait. The *Investigator* was trapped in the ice in Mercy Bay until abandoned in April of 1853. The crew of the *Investigator* was forced to endure a fourth winter of hardship when the rescuing ships *Resolute* and *Intrepid* were beset in Viscount Melville Sound. M'Clure and his crew were the first to transit the Northwest Passage, though they were compelled to abandon ship twice along the way. The wreck of the *Investigator* has never been found, though it is not unlikely that it remains in Mercy Bay.

Figure 9. LEFT: *Critical position of HMS Investigator on the North-Coast of Baring* [Banks] *Island, August 20, 1851.* RIGHT: *Sledge crews departing the HMS Investigator in Mercy Bay, April 1853.* Both paintings by Lt. Samuel Creswell of HMS *Investigator*. National Archives of Canada.

HISTORIC SITES ON OTHER ROUTES THROUGH THE NORTHWEST PASSAGE

6. Port Leopold

Port Leopold is located on the northeast shoulder of Somerset Island near Cape Clarence. A Royal Navy expedition under the command of James Clark Ross with HMS *Enterprise*

and HMS *Investigator* wintered over here in 1848-49 (Fig. 10). This was the first naval expedition sent to search for John Franklin and his ships, the HMS *Erebus* and HMS *Terror*, which had not been heard from since they were last seen in Melville Bay in 1845.

Figure 10. LEFT: *Ravine Near Port Leopold,* painted by William H.J. Browne in 1849. National Archives of Canada. RIGHT: HMS *Enterprise* and *Investigator* in winter quarters, Port Leopold 1848-49.

No significant finds relating to the whereabouts of the Franklin expedition were made during this expedition, but sledge journeys were made down both coasts of Somerset Island.

Port Leopold was used occasionally as a depot in the years following the 1848-49 expedition, but no other expeditions wintered over there. A large rock lying on the beach was inscribed with the date and initials of the two ships (Fig. 11). In the 20th century the Hudson's Bay Company erected a small house that can still be found.

Figure 11. This rock, carved with the initials of the HMS *Enterprise* and *Investigator*, lies on the beach at Port Leopold. Photo by Jamie Stewart, 1995.

7. King William Island and Victoria Strait

According to the only record found from John Franklin's expedition (Fig. 12), the HMS *Erebus* and the *Terror* were beset in the ice for two winters within 15 miles of King William Island. The ships were abandoned on April 22nd, 1848, 5 leagues north-northwest of Victory Point (given as 69.62 098.68). The Franklin record was found in a cairn at Victory Point in 1859, nearly 10 years after the disaster, by members of Francis M'Clintock's search expedition in the auxiliary-steam yacht *Fox*.

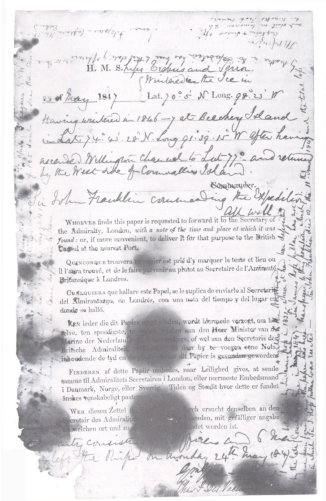


Figure 12. The record found by Lt. Hobson of the *Fox* in 1859. Two messages are written in the margins of a standard Admiralty form:

"H.M. ships *Erebus* and *Terror* wintered in the ice in Lat. 70°5' N Long. 98°23'W. Having wintered in [1845-46] at Beechey Island, in Lat. 74°43'28"N., Long. 91°37'15"W., after having ascended Wellington Channel to Lat. 77° and returned by the West Side of Cornwallis Island. Sir John Franklin commanding the expedition. All well. Party consisting of 2 officers and 6 men left the ships on Monday 24th May, 1847."

"H.M. ships *Terror* and *Erebus* were deserted on the 22nd April, 5 leagues NNW of this, having been beset since the 12th of September, 1846. The officers and Crews, consisting of 105 souls, under the command of Captain F.R.M. Crozier, landed here in Lat. 69°37'42", Long. 98°41'…Sir John Franklin died on the 11th June, 1847, and the total loss by deaths in the expedition has been to this

Over the years remains of the lost expedition have been found scattered along the western shore of King William Island to the coast of the mainland. No trace of the ships has ever been found, though native accounts reported by Roald Amundsen indicate that

one of the ships came ashore on the south side of Cape Crozier. The other probably foundered to the north of the Royal Geographical Society Islands.

8. Gjøa Haven

Roald Amundsen wintered over in Gjøa Haven from 1903 to 1905 (Fig. 13). During this period Amundsen and his small crew engaged in an extensive program of scientific observations, including an investigation of the Earth's magnetic field. Amundsen sailed from Gjøa Haven to King Point (15 miles west of Shingle Beach) in 1905, where he wintered over for a third season. Amundsen became the first to make a complete transit of the Northwest Passage by vessel in 1906.

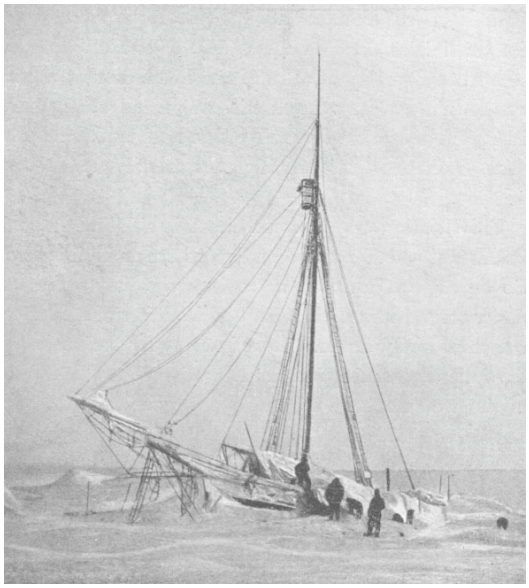


Figure 13. The Gjoa in winter quarters at Gjoa Haven. From *The Northwest Passage* by Roald Amundsen.

Today, the town of Gjoa Haven is located on this site. The Northwest Passage Territorial Historic Park is also located here. According to Nunavut Parks:

> The Northwest Passage Territorial Park is not a park in the conventional sense. Located in and around the hamlet of Gjoa Haven on King William Island, it is part of a larger goal to provide an informative tour about the quest by Europeans to find a Northwest Passage and the search for answers concerning the disappearance of the Franklin Expedition that failed to find the passage. A self-guided Interpretive Trail tells the story of the many failed expeditions and the one successful attempt of Roald Amundsen to find a Northwest Passage. The hamlet also has on display artifacts that describe Amundsen's exploration and time in the community.

See http://www.nunavutparks.com/ for more information about the park and the town of Gjoa Haven.

9. Cambridge Bay

In 1850 the Admiralty dispatched an expedition under the command of Richard Collinson, with the HMS *Enterprise* and the *Investigator*, to search for Franklin and his ships by way of Bering Strait. The *Enterprise* and the *Investigator* were supposed to be sailing in consort but were separated before entering the Arctic. Robert M'Clure, with the HMS *Investigator*, chose not wait at the designated rendezvous point but continued onward to explore Prince of Wales Strait and the north and west coasts of Banks Island in 1850-51. He was trapped by ice in Mercy Bay at the end of the navigation season in 1851, and remained there until forced by impending starvation to abandon his ship in 1853.

Collinson did not enter the Arctic proper until 1851, and during the first season was forced to double M'Clure's tracks south of Banks Island for lack of intelligence as to his progress. Collinson wintered over at Walker Bay, on the west coast of Victoria Land in 1851-52, at Cambridge Bay in 1852-53, and at Camden Bay in 1853-54. Some writers have suggested that had M'Clure and Collinson remained together it is possible that they would have discovered the fate of Franklin (and perhaps the most navigable portion of the Northwest Passage east of King William Island). This conjecture is based on the fact that Collinson did not have the manpower to explore both sides of Victoria Strait from Cambridge Bay in the spring of 1853 and was compelled to limit his search to the east coast of Victoria Island.

Today, Nunavut Park's Arctic Coast Visitor Center is located in the town of Cambridge Bay (http://www.nunavutparks.com/).

Further information:

More detailed descriptions of historical sites from the Franklin era can be found in *The Camps, Cairns and Caches of the Franklin and Franklin Search Expeditions* by Caroline Phillips (Parks Canada, Cornwall Ontario) published in The Franklin era in Canadian arctic history, 1845-1859, Patricia D. Sutherland ed. (Ottawa : National Museums of Canada, 1985), pp 149-173.