ARC 400

Canadian

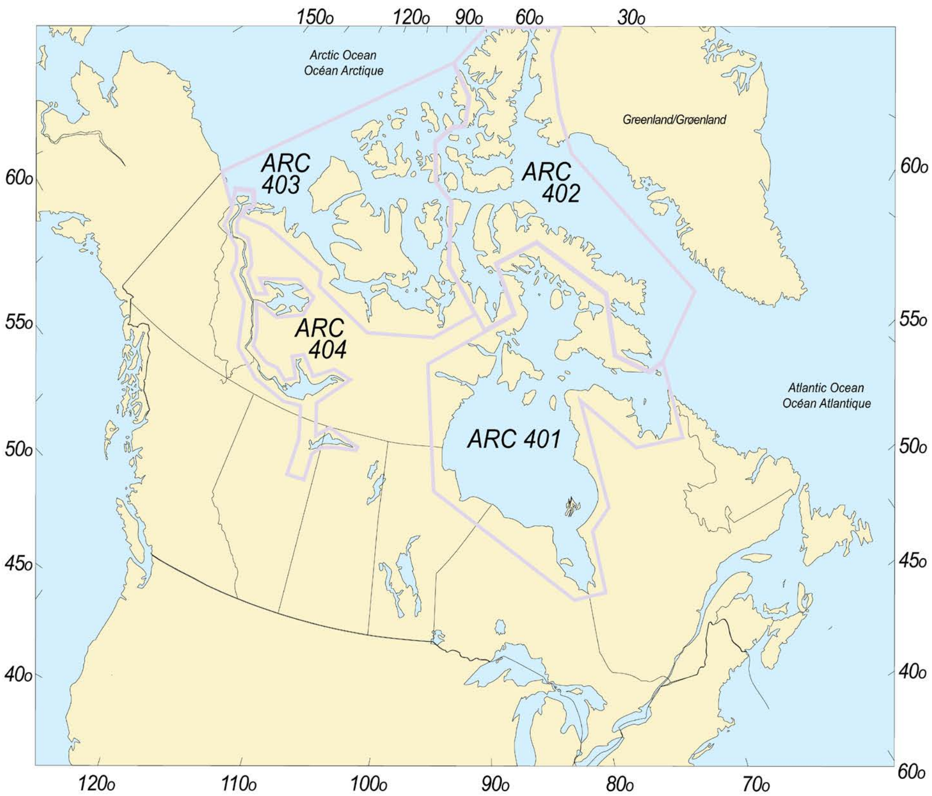
Sailing Directions

General Information, Northern Canada

2025/01

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada



Sailing Directions

ARC 400
General Information,
Northern Canada

ARC 401
Hudson Strait, Hudson Bay
and Adjoining Waters

ARC 402
Eastern Arctic

ARC 403
Western Arctic

ARC 404
Great Slave Lake
and Mackenzie River

Pictogram Legend

Anchorage	**Current**	**Radio calling-in point**
Wharf	**Caution**	**Lifesaving Station**
Marina	**Light**	**Pilotage**

Report discrepancies between real-world observations and descriptions in the publication

Users of this publication are requested to forward information regarding newly discovered dangers, changes in aids to navigation, the existence of new shoals or channels, or other information that would be useful for the correction of nautical charts and publications affecting Canadian waters to: chsinfo@dfo-mpo.gc.ca

IMPORTANT NOTICE

The Canadian Hydrographic Service no longer produces hard copies of its publications.
Updates are published in Notices to Mariners at notmar.gc.ca
and on the Canadian Hydrographic Service website at charts.gc.ca

For more information, contact:

Canadian Hydrographic Service
Fisheries and Oceans Canada
200 Kent Street, Ottawa, Ontario, Canada, K1A 0E6
charts.gc.ca
chsinfo@dfo-mpo.gc.ca

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Record of Changes

As the CHS acquires new information, relevant changes are applied to Sailing Directions volumes in order to maintain safety of navigation. It is the responsibility of the mariner to maintain their digital Sailing Directions file by ensuring that the latest version is always downloaded. Visit charts.gc.ca to download the most recent version of this volume, with all current changes already incorporated.

The table below lists the changes that have been applied to this volume of Sailing Directions. This record of changes will be maintained for the current calendar year only.

Date	Chapter / Paragraph	Description of Change
2025/01	Entire Booklet	ARC 400 has been reformatted and now meets Web Content Accessibility Guidelines (WCAG) 2.0. Other changes include updated imagery, hyper-links, and indexing.

Contents

Preface

The First Edition of *Sailing Directions, ARC 400 — General Information, Northern Canada*, 2009, has been fully updated from Canadian Government and other information sources. In general, all hydrographic terms used in this booklet are in accordance with the meanings given in the *Hydrographic Dictionary (Special Publication No. 32)*, published by the International Hydrographic Bureau.

This booklet contains navigational information and a brief description of the main port facilities as well as geographic, oceanographic and atmospheric characteristics.

Detailed descriptions of geographical areas of Northern Canada are given in *ARC 401*, *Arctic Canada Vol. II (ARC 402)*, *Arctic Canada Vol. 3 (ARC 403)*, and *Great Slave Lake and Mackenzie River (ARC 404)*. Their limits are printed on the back cover. **The appropriate descriptive booklet(s) of *Sailing Directions* should be consulted in conjunction with *ARC 400 — General Information, Northern Canada*, which provides additional information**.

Tide, water level and current information has been revised by the Canadian Hydrographic Service.

Photographs are supplied by the Canadian Hydrographic Service and the Canadian Coast Guard, Fisheries and Oceans Canada. Photographs by individuals are acknowledged where they occur in the booklets.

Users' comments concerning the format, content or any other matter relating to *Sailing Directions* would be appreciated and should be forwarded to the Director General, Canadian Hydrographic Service, Fisheries and Oceans Canada, Ottawa, Ontario, Canada, K1A 0E6.

References to Other Publications

Canadian Hydrographic Service

- *Catalogue of Nautical Charts and Publications*
- *Canadian Tide and Current Tables*

Canadian Coast Guard

- *List of Lights, Buoys and Fog Signals*
- *Radio Aids to Marine Navigation (Atlantic, St. Lawrence, Great Lakes, Lake Winnipeg, Arctic and Pacific)*
- *Annual Edition of Notices to Mariners*

Explanatory Notes

Canadian Sailing Directions expand charted details and provide important information of interest to navigation which may not necessarily be found on charts or in other marine publications. They are intended to be read in conjunction with the charts quoted in the text.

Remarks

Buoys are generally described in detail only where they have special navigational significance, or where the scale of the chart is too small to clearly show all the details.

Chart references, in italics in the text, normally refer to the largest scale Canadian chart but occasionally a smaller scale chart may be quoted where its use is more appropriate.

Tidal information relating to the vertical movements of the water is not given and the *Canadian Tide and Current Tables* should be consulted. However, abnormal changes in water level are mentioned.

Names have been taken from the official source. Where an obsolete name still appears on the chart or is of local usage, it is given in brackets following the official name.

Wreck information is included where drying or submerged wrecks are relatively permanent features having significance for navigation or anchoring.

Units and terminology used in this booklet

Latitudes and Longitudes given in brackets are approximate and are intended to facilitate reference to the general area on the chart quoted.

Bearings and **directions** refer to True North (geographic) and are given in degrees from 000° clockwise to 359°. Bearings of conspicuous objects, lights, ranges and light sectors are given from seaward. Courses always refer to course to be "made good".

Tidal streams and **currents** are described by the direction toward which they flow. The **ebb** stream is caused by a falling tide and the **flood** stream is caused by a rising tide. **Winds** are described by the direction from which they blow.

Distances, unless otherwise stated, are expressed in nautical miles. For practical purposes, a nautical mile is considered to be the length of one minute of arc, measured along the meridian, in the latitude of the position. The international nautical mile, which has now been adopted by most maritime nations, is equal to 1,852 m (6,076 ft).

Speeds are expressed in knots; a knot is 1 nautical mile per hour.

Depths, unless otherwise stated, are referred to chart datum. As depths are liable to change, particularly those in dredged channels and alongside wharves, it is strongly recommended that these be confirmed by enquiry to the appropriate local authority.

Elevations and **vertical clearances** are given above Higher High Water, Large Tides; in non-tidal waters they are referred to chart datum.

Heights of objects, as distinct from the elevations, refer to the heights of structures above the ground.

The *List of Lights, Buoys and Fog Signals* number is shown **in brackets** following the navigational aid (light, leading lights, buoy). The expression "seasonal" indicates that the navigational aid is operational for a certain period during the year; mariners should consult the *List of Lights, Buoys and Fog Signals* to determine the period of operation. The expresion "private" means that the aid is privately maintained; it will not necessarily be mentioned in the *List of Lights* and its characteristics may change without issuance of a *Notice to Shipping*.

Time, unless otherwise stated, is expressed in local standard or daylight time. Details of local time kept will be found in Chapter 2 of *Sailing Directions* booklet *ARC 400 — General Information, Northern Canada*.

Deadweight tonnage and **mass** are expressed in metric tonnes of 1,000 kilograms. The kilogram is used for expressing relatively small masses.

Public wharf, owned by a government authority, is a public port facility governed by various acts and regulations. Local authorities may charge harbour, berthing and wharfage fees for use of the facility. Contact must be made with the wharfinger before using the facility.

Conspicuous objects, natural or artificial, are those which stand out clearly from the background and are easily identifiable from a few miles offshore in normal visibility.

Small craft is the term used to designate pleasure craft and in general, small vessels with shallow draught.

Diagrams are large scale cartographic representations of anchorages, wharves or marinas. The horizontal chart datum used is the North American Datum 1983 (NAD 83). **Depths** are in **metres** and are reduced to the chart datum to which the diagram refers. **Elevations** are in **metres** above Higher High Water, Large Tides and in non-tidal waters, above chart datum.

Pictographs are the symbols placed at the beginning of certain paragraphs. Their main purpose is to allow quick reference to information or to emphasize details. Consult the Pictograph Legend shown on the inside covers of this booklet.

Abbreviations

Units

°C	degree Celsius
cm	centimetre
fm	fathom
ft	foot
h	hour
ha	hectare
HP	horsepower
kHz	kilohertz
km	kilometre
kn	knot
kPa	kilopascal
m	metre
mb	millibar
MHz	megahertz
min	minute
mm	millimetre
NM	nautical mile
t	metric tonne
°	degree (plane angle)
‘	minute (plane angle)

Directions

N	north
NNE	north northeast
NE	northeast
ENE	east northeast
E	east
ESE	east southeast
SE	southeast
SSE	south southeast
S	south
SSW	south southwest
SW	southwest
WSW	west southwest
W	west
WNW	west northwest
NW	northwest
NNW	north northwest

Various

A.P.A.	Atlantic Pilotage Authority
CCG	Canadian Coast Guard
CHS	Canadian Hydrographic Service
DFO	Department of Fisheries and Oceans, Canada
DWT	deadweight tonnage
ETA	estimated time of arrival
ETD	estimated time of departure
HF	high frequency
HW	high water
LW	low water
M	million, mega
MCTS	Marine Communications and Traffic Services
NAD	North American Datum
No.	number
SAR	Search and Rescue
U.S.A.	United States of America
VHF	very high frequency
VTS	Vessel Traffic Services

Chapter 1

Navigational Information

Photo by: Martin Fortier – ArcticNet

General

1 **Limits of Arctic booklets**. — This publication contains information that is pertinent to northern Canada as a whole or is of too general a character to be appropriately included in the geographical booklets *ARC 401* to *ARC 404*. *Sailing Directions* booklet *ARC 401* describes Hudson Strait, Hudson Bay and Adjoining Waters, *Sailing Directions* booklet *ARC 402 (ARCTIC CANADA VOL. II)* covers the east part of the Canadian Arctic north of Hudson Strait and Foxe Basin, *Sailing Directions* booklet *ARC 403 (ARCTIC CANADA VOL. 3)* describes the west part of the Canadian Arctic and *Sailing Directions* booklet *ARC 404 (GREAT SLAVE LAKE AND MACKENZIE RIVER)* covers that inland waterway system. Somerset Island and Boothia Peninsula are considered to separate the eastern from the western Arctic. The limits of the areas covered by *ARC 401* to *ARC 404* are shown on the back cover diagram.

Routes

Chart 7000

Hudson Strait

2 **Hudson Strait** is the entrance to Hudson Bay and James Bay and to Foxe Channel and Foxe Basin. Roes Welcome Sound leads to Foxe Basin from NW Hudson Bay. The passage through Hudson Strait presents no navigational hazards in the form of shoals; there is deep water throughout with few alterations of course necessary. Except for isolated 18.3 m shoals between Coats and Mansel Islands, there are no dangers in the crossing of Hudson Bay to the port of Churchill.

3 Experience has shown that ice conditions make any passage by way of Fury and Hecla Strait, at the NW end of Foxe Basin, too difficult to be seriously considered.

Northwest Passage

4 The **Northwest Passage** spans the Canadian Arctic from Davis Strait and Baffin Bay in the east to Bering Strait in the west. The east entrance to the Northwest Passage, Lancaster Sound, is best approached through Baffin Bay

from the west coast of Greenland because of the more favourable ice conditions. The west entrance to the passage can sometimes be approached direct through the Beaufort Sea but more often is affected by ice and a route closer to the mainland must be used.

5 The Northwest Passage has four possible routes. The first route leads through Lancaster Sound, Prince Regent Inlet and Bellot, Franklin, James Ross and Rae Straits, then through the gulfs and straits bordering the mainland coast to the Beaufort Sea and then to Bering Strait. Sergeant Henry Larsen of the *Royal Canadian Mounted Police* travelled this route from west to east on his first voyage through the Northwest Passage in 1940–42.

6 The second route leads through Lancaster Sound, Barrow Strait and Peel Sound to the entrance of Franklin Strait. From here it continues south and west through the coastal waterways to the Beaufort Sea and Bering Strait. This was Amundsen's route in 1903–06.

7 The third route follows Parry Channel westward to the entrance of Prince of Wales Strait, continues SW through the strait, across Amundsen Gulf, and along the mainland coast to Bering Strait. This was the route chosen by Staff Sergeant Henry Larsen in 1944.

8 The fourth route follows Parry Channel from Lancaster Sound to the western entrance of M'Clure Strait, turns SW along the western coast of Banks Island, crosses Amundsen Gulf, and then continues west to Bering Strait. The first ship to traverse the entire length of M'Clure Strait was the *United States Coast Guard Ship Northwind* in 1954.

9 The entire Northwest Passage has seldom been undertaken by a single vessel because of the short navigation season and the unpredictability of ice conditions which can be encountered.

10 The discovery of oil, natural gas and minerals in the Canadian Arctic has increased the importance of these routes.

Arctic Ocean

11 There are considered to be two practicable routes for surface vessels proceeding from the Atlantic Ocean, between Canada and Greenland, to the **Arctic Ocean**. Both routes are navigable by icebreakers for short periods, normally in the latter part of August.

12 The first route leads through Nares Strait, which is the northern continuation of Baffin Bay between Greenland and Ellesmere Island.

13 The second route leads through Jones Sound, off the NW side of Baffin Bay, then through Norwegian Bay, Eureka Sound and Nansen Sound; the two latter sounds form the channel between Ellesmere and Axel Heiberg Islands.

14 Another route through M'Clure Strait at the west end of Parry Channel is normally hampered by heavy ice conditions. As previously mentioned, M'Clure Strait was navigated by the *Northwind* in 1954, however, in 1969 the specially strengthened deep-draught tanker SS *Manhattan*, escorted by a *Canadian Coast Guard* icebreaker, had to abandon an attempt to pass through the strait after meeting heavy ice.

15 The choice of route depends on the size and strength of the vessels employed, on the nature and purpose of the voyage together with general and local ice conditions in any given year. The *Canadian Coast Guard* publication *Ice Navigation in Canadian Waters, 1999 edition (TP 5064)* must be consulted before any attempt is made of any of these routes.

Shipping routes

16 Freight and fuel for the Hudson Bay area may be shipped by tug and barge from railheads at Churchill, Manitoba and Moosonee, Ontario or routed from the east through Hudson Strait. Traffic for the eastern Arctic is normally routed from the east through Lancaster Sound. The principal means of moving bulk cargo along the Mackenzie River is by shallow-draught tugs pushing long arrays of barges. Freight for the western Arctic is brought to Hay River, on Great Slave Lake, by truck or rail, and fuel brought by rail, for shipment by barge down the Mackenzie River to Tuktoyaktuk where these supplies are trans-shipped. Freight may also be shipped from the west through Bering Strait to Amundsen Gulf.

Distances

17 Table 1 gives distances between Montréal and points in Hudson Strait, Hudson Bay and James Bay and between points in that area. Tables 2 and 3 on the following pages give distances in the western Arctic. Table 4 gives distances from Québec City to selected locations and between places in the eastern Arctic.

Arctic Canada Traffic System (NORDREG)

18 The **Arctic Canada Traffic System**, known as **NORDREG Canada**, is in effect in Canadian Arctic waters to which the *Arctic Waters Pollution Prevention Act* applies, and includes Ungava Bay, Hudson Bay and James Bay south of 60°N.

19 *NORDREG* excludes Mackenzie Bay and Kugmallit Bay south of 70°N and east of 139°W.

Table 1: Table of Distances from Monreal to James Bay

Departing (Location)	Destination (Location)	Distance (Nautical Miles)
Montréal	Québec	138
Montréal	Button Islands (5 miles north of)	1,496
Montréal	Kuujjuaq	1,697
Montréal	Cap Wolstenholme (10 miles north of)	1,887
Montréal	Churchill	2,416
Montréal	Moosonee	2,637
Ungava Bay Button Islands (5 miles north of)	Port Burwell	28
Ungava Bay Button Islands (5 miles north of)	Rivière George	130
Ungava Bay Button Islands (5 miles north of)	Kangiqsualujjuaq	147
Ungava Bay Button Islands (5 miles north of)	Rivière Koksoak	172
Ungava Bay Button Islands (5 miles north of)	Kuujjuaq	201
Ungava Bay Button Islands (5 miles north of)	Leaf Bay	167
Ungava Bay Button Islands (5 miles north of)	Tasiujaq	206
Ungava Bay Button Islands (5 miles north of)	Aupaluk	176
Ungava Bay Button Islands (5 miles north of)	Payne Bay	158
Ungava Bay Button Islands (5 miles north of)	Kangirsuk	171
Ungava Bay	Rivière George to Rivière Koksoak	75
Ungava Bay	Rivière Koksoak to Leaf Bay	63
Ungava Bay	Leaf Bay to Aupaluk	50
Ungava Bay	Aupaluk to Payne Bay	66
Hudson Strait Button Islands (5 miles north of)	Quaqtaq	150
Hudson Strait Button Islands (5 miles north of)	Kimmirut (Lake Harbour)	202
Hudson Strait Button Islands (5 miles north of)	Kangiqsujuaq	225
Hudson Strait Button Islands (5 miles north of)	Deception Bay	322

Departing (Location)	Destination (Location)	Distance (Nautical Miles)
Hudson Strait Button Islands (5 miles north of)	Sugluk Inlet	338
Hudson Strait Button Islands (5 miles north of)	Cap Wolstenholme (10 miles north of)	391
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Ivujivik	24
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Akulivik	152
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Povungnituk Bay (outer anchorage)	206
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Inukjuak	300
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Sanikiluaq	428
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Kuujjuarapik	556
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Chisasibi (via west of Ottawa Islands)	600
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Moose River (outer light buoy)	734
Hudson Bay (East Side) and James Bay Cap Wolstenholme (10 miles north of)	Moosonee	750
Hudson Bay (East Side) and James Bay Moosonee	Waskaganish	81
Hudson Bay (East Side) and James Bay Moosonee	Eastmain	101
Hudson Bay (East Side) and James Bay Moosonee	Wemindji	127
Hudson Bay (East Side) and James Bay Moosonee	Chisasibi	183
Hudson Bay (East Side) and James Bay Moosonee	Albany River	85
Hudson Bay (East Side) and James Bay Moosonee	Attawapiskat River	140
Hudson Bay (East Side) and James Bay Moosonee	Fort Severn	448
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Coral Harbour	204
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Chesterfield Inlet	365

Departing (Location)	Destination (Location)	Distance (Nautical Miles)
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Baker Lake (hamlet)	535
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Rankin Inlet (hamlet)	408
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Whale Cove	439
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Arviat (Eskimo Point)	482
Hudson Bay (North and West Sides) Cap Wolstenholme (10 miles north of)	Churchill	529
Hudson Bay (North and West Sides) Churchill	Arviat (Eskimo Point)	156
Hudson Bay (North and West Sides) Churchill	Whale Cove	220
Hudson Bay (North and West Sides) Churchill	Rankin Inlet (hamlet)	278
Hudson Bay (North and West Sides) Churchill	Chesterfield Inlet	302

Note: 1. Distances are given to the nearest whole nautical mile.
Note: 2. A distance given for a bay, river or inlet is measured to its entrance.

DISTANCES BETWEEN POINTS IN THE WESTERN ARCTIC, WEST OF TUKTOYAKTUK

	Demarcation Point, Alaska	Clarence Lagoon	Komakuk Beach	Herschel Island (north side)	Pauline Cove	Stokes Point	Tent Island	Moose Channel	Blow River	Shingle Point	Adgo C-15 (abandoned)	Adgo F-28 (abandoned)	Sarpik B-35 (abandoned)	Garry Island	Netserk B-44 (abandoned)	Netserk F-40 (abandoned)	Pelly Island (north side)	Kendall Island	Rae Island	Immerk B-48 (abandoned)	Hooper Island	Isserk E-27 (abandoned)	Pullen Island	Tuktoyaktuk
Tuktoyaktuk	192	180	169	144	145	147	148	149	141	140	92	88	95	86	82	79	72	77	70	66	60	46	48	0
Pullen Island	146	135	124	99	97	100	102	103	95	94	45	41	48	39	35	32	25	31	24	20	14	9	0	
Isserk E-27 (abandoned)	145	135	123	103	100	102	107	108	100	99	50	46	53	44	40	35	29	36	28	24	18	0		
Hooper Island	134	123	112	87	85	88	89	90	82	81	32	28	35	26	22	20	12	18	11	6	0			
Immerk B-48 (abandoned)	132	121	110	85	83	86	85	86	78	77	28	24	31	22	18	18	11	7	5	0				
Rae Island	140	129	118	93	91	94	86	87	79	78	29	25	32	23	19	26	19	8	0					
Kendall Island	147	136	125	100	98	101	79	80	72	71	22	18	25	16	12	33	19	0						
Pelly Island (north side)	122	111	100	75	73	77	78	79	71	70	21	17	24	13	11	6	0							
Netserk F-40 (abandoned)	114	103	92	67	65	68	69	70	62	61	16	12	18	10	6	0								
Netserk B-44 (abandoned)	114	103	92	67	65	67	67	68	60	59	10	6	13	4	0									
Garry Island	118	107	96	71	66	68	69	70	62	61	7	2	13	0										
Sarpik B-35 (abandoned)	106	95	84	59	56	56	54	55	47	46	12	12	0											
Adgo F-28 (abandoned)	117	106	95	70	66	67	66	67	59	56	3	0												
Adgo C-15 (abandoned)	119	108	97	72	67	68	66	67	59	58	0													
Shingle Point	108	97	86	61	54	55	17	16	5	0														
Blow River	110	99	88	63	56	57	13	12	0															
Moose Channel	118	107	96	71	64	65	12	0																
Tent Island	117	108	95	70	63	64	0																	
Stokes Point	72	61	50	25	15	0																		
Pauline Cove	63	52	41	16	0																			
Herschel Island (north side)	47	36	25	0																				
Komakuk Beach	27	18	0																					
Clarence Lagoon	15	0																						
Demarcation Point, Alaska	0																							

Table 2

Distances between points in the Western Arctic, west of Tuktoyaktuk

Distances are in nautical miles by the shortest safe courses. The maximum draught for most places mentioned in this table is 3.7 m; for several, the the draught is 2 m or less - see the charts for details on depths.

Features marked "(abandoned)" were artificial islands constructed to serve as oil-drilling platforms. The present condition of these islands is unknown; some may be submerged (2008).

DISTANCES BETWEEN POINTS IN THE WESTERN ARCTIC, EAST OF TUKTOYAKTUK

	Spence Bay	Shepherd Bay	Gjoa Haven	(0.5 mile south of) Eta Island	Gladman Point (McClintock Bay)	Jenny Lind Island	(6 miles west of) Cape Colborne	Cambridge Bay	Sinclair Creek (Byron Bay)	Bathurst Inlet (settlement)	Umingmaktok (Baychimo Harbour)	Port Epworth	Kugluktuk	Lady Franklin Point	Bernard Harbour	(8 miles north of) Cape Bexley	Cape Young	Holman	Johnson Point	Jesse Harbour	De Salis Bay	Sachs Harbour	Tysoe Point	Pearce Point Harbour	Paulatuk	(3 miles north of) Cape Parry	Police Point	Langton Bay	Hans Bay	(entrance to) Eskimo Lakes	Nicholson Point	(3 miles north of) Observation Point	McKinley Bay	Tuft Point	Tuktoyaktuk
Tuktoyaktuk	981	947	898	856	846	750	656	673	581	675	620	529	528	477	440	403	387	340	381	343	275	221	301	258	275	210	209	227	269	183	139	131	65	28	0
Tuft Point	957	923	874	832	822	726	632	649	557	651	596	505	504	453	416	379	363	316	357	319	251	198	277	234	251	186	185	203	235	149	115	107	41	0	
McKinley Bay	927	893	844	802	792	696	602	619	527	621	566	475	474	423	386	349	333	286	327	289	221	178	247	204	221	156	155	173	204	118	84	77	0		
(3 miles north of) Observation Point	850	816	767	725	715	619	525	542	450	544	489	398	397	346	309	272	256	209	250	212	144	98	170	127	144	79	78	96	179	93	47	0			
Nicholson Point	897	863	814	772	762	666	572	589	497	591	536	445	444	393	356	319	303	256	297	259	191	143	217	174	191	126	125	143	124	38	0				
(entrance to) Eskimo Lakes	943	909	860	818	808	712	618	635	543	637	582	491	490	439	402	365	349	307	343	305	237	189	263	220	237	172	171	189	86	0					
Hans Bay	1029	995	946	904	894	798	704	721	629	723	668	577	576	525	488	451	435	388	429	391	323	275	349	306	323	258	257	275	0						
Langton Bay	836	802	753	711	701	605	511	528	436	530	475	384	383	332	295	258	242	205	261	223	158	157	156	113	130	65	58	0							
Police Point	779	745	696	654	644	548	454	471	379	473	418	327	326	275	238	201	185	148	203	165	101	118	99	56	73	8	0								
(3 miles north of) Cape Parry	771	737	688	646	636	540	446	463	371	465	410	319	318	267	230	193	177	140	195	157	94	105	91	48	65	0									
Paulatuk	782	748	699	657	647	551	457	474	382	476	421	330	329	278	241	204	187	160	240	202	137	166	98	52	0										
Pearce Point Harbour	731	697	648	606	596	500	406	423	331	425	370	279	278	227	190	153	139	115	196	158	98	140	54	0											
Tysoe Point	685	651	602	560	550	454	360	337	285	379	324	233	232	181	144	107	91	92	199	161	112	172	0												
Sachs Harbour	641	607	758	716	706	610	516	533	441	535	480	389	388	337	300	263	250	184	222	184	116	0													
De Salis Bay	762	728	679	637	627	531	437	454	362	456	401	310	309	258	221	184	178	89	117	79	0														
Jesse Harbour	792	758	709	667	657	561	467	484	392	486	431	340	339	288	251	214	211	108	52	0															
Johnson Point	819	785	736	694	684	588	494	511	419	513	458	367	366	315	278	241	239	139	0																
Holman	694	660	611	569	559	463	369	386	294	388	333	242	241	190	153	116	112	0																	
Cape Young	603	569	520	478	468	372	278	295	203	297	242	151	150	99	62	25	0																		
(8 miles north of) Cape Bexley	578	544	495	453	443	347	253	270	178	272	217	126	125	74	37	0																			
Bernard Harbour	547	513	464	422	412	316	222	239	147	241	186	96	95	43	0																				
Lady Franklin Point	504	470	421	379	369	273	179	196	104	198	143	52	57	0																					
Kugluktuk	560	526	477	435	425	329	235	252	167	238	183	76	0																						
Port Epworth	480	446	397	355	345	259	165	182	95	188	111	0																							
Umingmaktok (Baychimo Harbour)	468	434	385	343	333	237	143	160	74	55	0																								
Bathurst Inlet (settlement)	523	489	440	398	388	292	198	215	129	0																									
Sinclair Creek (Byron Bay)	406	372	323	281	271	175	81	97	0																										
Cambridge Bay	343	309	260	218	208	112	18	0																											
(6 miles west of) Cape Colborne	325	291	242	200	190	94	0																												
Jenny Lind Island	243	209	160	118	108	0																													
Gladman Point (McClintock Bay)	137	103	54	12	0																														
(0.5 mile south of) Eta Island	125	91	42	0																															
Gjoa Haven	88	55	0																																
Shepherd Bay	93	0																																	
Spence Bay	0																																		

Table 3
Distances between points in the Western Arctic, east of Tuktoyaktuk

Distances are in nautical miles by the shortest safe courses. All distances through Dolphin and Union Strait are via Cache Point Channel.

Table 2: Table of Distances to Points in Eastern Northern Canada

Departing (Location)	Destination (Location)	Distance (Nautical Miles)
Québec	Alert, via west coast of Greenland	2,748
Québec	Alexandra Fiord, via west coast of Greenland	2,505
Québec	Arctic Bay, via Cape Liverpool	2,343
Québec	Arctic Bay, via Pond Inlet	2,363
Québec	Belle Isle	714
Québec	(10 miles east of) Cape Dyer	1,621
Québec	Dundas Harbour	2,261
Québec	Eureka, via Jones Sound	2,677
Québec	Frederikshaab, Greenland	1,762
Québec	Grise Fiord	2,340
Québec	Hall Beach, via Seahorse Point	2,131
Québec	Iqaluit	1,562
Québec	Ivigtut, Greenland, via Strait of Belle Isle	1,333
Québec	Julianehaab, Greenland, via Strait of Belle Isle	1,331
Québec	Nanisivik, via Cape Liverpool	2,336
Québec	Nanisivik, via Pond Inlet	2,356
Québec	Pangnirtung	1,648
Québec	(5 miles north of) Pond Inlet hamlet, via east coast of Baffin Island	2,180
Québec	Repulse Bay, via Foxe Channel	2,062
Québec	Repulse Bay, via Roes Welcome Sound	2,248
Québec	Resolute, via east coast of Baffin Island and Lancaster Sound	2,466
Québec	Resolute, via Fury and Helcla Strait	2,705
Québec	Resolute, via west coast of Greenland	2,641
Québec	St. John’s, Newfoundland and Labrador	905
Québec	Thule, Greenland, via west coast of Greenland	2,306
Hall Beach	Cape Lilly, Fury and Hecla Strait	100
Hall Beach	Igloolik	47
Hall Beach	Longstaff Bluff	143
Cape Lilly	Bellot Strait	289

Departing (Location)	Destination (Location)	Distance (Nautical Miles)
Cape Lilly	Resolute	474
(10 miles east of) Cape Dyer	(5 miles east of) Broughton Island	86
(5 miles east of) Broughton Island	(11 miles east of) Cape Hooper	81
(11 miles east of) Cape Hooper	(10 miles SE of) Cape Christian	143
(10 miles SE of) Cape Christian	5 miles north of) Pond Inlet hamlet	249

Note: 1. All distances are in nautical miles, by the most direct route or as indicated.
Note: 2. For distances from Montréal, add 139 miles to distances from Québec.

20 The primary objective of the *NORDREG* system is to assist the Master in the safe and expeditious conduct of the vessel by promulgating information on ice conditions, giving advice on routes and providing icebreaker support. Traffic clearance requests and reports required by this system shall be addressed to *NORDREG CANADA*. Requests and reports may be passed through any *Canadian Coast Guard Marine Communications and Traffic Services (MCTS)* centre free of charge.

21 For further information concerning this system consult the current editions of *Radio Aids to Marine Navigation*, the *Annual Edition of Canadian Notices to Mariners*, and *Ice Navigation in Canadian Waters, 1999 edition (TP 5064) (for sources, see later in this chapter)*.

Pilotage

22 **Pilotage** is provided by most communities in the north for safe navigation into their harbours. Contact the nearest *MCTS* centre for details.

23 **Ice Navigators** are required on all tankers in Arctic waters and on other ships in certain Arctic Waters. For details, see *Arctic Shipping Pollution Prevention Regulations* at: https://tc.canada.ca/en/marine-transportation/arctic-shipping/arctic-shipping-pollution-prevention-regulations-asppr.

Hazards

Climate induced

24 **Ice** and **fog**, produced by the severe climate, are the major factors affecting sea operations in northern Canada. Fog ranks next to ice as a navigational hazard, although radar and modern navigational fixing aids have reduced the problems in recent years. For detailed information regarding weather and ice conditions in a particular area, see "Ice/Weather Service" at the *Canadian Ice Service* website http://www.ice.ec.gc.ca.

25 **Caution**. — **Growlers** are small pieces of glacial ice that have been adrift for some time and are well-weathered. The growler is a serious menace to shipping; it is sometimes translucent to transparent, very hard and dense, smooth-surfaced and low in the water. Growlers make poor visual and radar targets. For a general terminology of different forms of ice, see *MANICE* under Ice Services, Publications, at the *Canadian Ice Service* website http://www.ice.ec.gc.ca or the *Canadian Coast Guard* publication *Ice Navigation in Canadian Waters, 1999 edition (TP 5064)*.

26 **Caution**. — **Strong winds** combined with **cold temperatures** may cause spray to freeze on contact with ship superstructures. Accumulated ice can affect the stability of a vessel and can cause capsize. For detailed information concerning ship operations in ice and navigation in ice-covered waters, see the *Canadian Coast Guard* publication *Ice Navigation in Canadian Waters, 1999 edition (TP 5064)*.

27 **Caution**. — **Pingos**, on shore, are mounds formed by the upheaval of subterranean ice in an area where the subsoil remains permanently frozen. Pingos are also found in western Arctic waters, rising about 30 m from an otherwise even seabed, with bases about 40 m in diameter and surrounded by a shallow depression; they are then termed submarine pingos. Numerous submarine pingos pose a major hazard to shipping in the east portion of the Beaufort Sea. Each pingo is a small, steep-sided isolated shoal with a depth about ⅓ of that nearby. The use of

echo-sounding may provide no warning when approaching these dangers. The areas dangerous due to pingos are shown on *Charts 7650* and *7651*. For more information concerning submarine pingos, see Chapter 4.

Magnetics

28 **Caution**. — The **magnetic compass** depends for its directive force upon the horizontal component of the magnetic field of the earth. As the north magnetic pole is approached in the Arctic, the horizontal component becomes progressively weaker until at some point the magnetic compass becomes useless as a direction-measuring device. The areas where the ordinary magnetic compass becomes erratic and useless in the Canadian Arctic are shown on *Sheet No. 10* of the *Geophysical Atlas Series*, published by *Geological Survey of Canada*.

29 In the erratic area it is good practice to keep the magnetic compass under constant scrutiny as its errors may change rapidly. Frequent compass checks by celestial observation or any other method available are wise precautions. A log of compass comparisons and observations should be kept for use in predicting future reliability.

30 In almost all parts of the Canadian Arctic, there is a rapid change in magnetic variation with change of geographical position, particularly, of course, as the north magnetic pole is approached. Secular change (the continuous alteration) is also considerable.

31 Measurements of the earth's magnetic field in the Canadian Arctic are not numerous. The isogonic lines in the Arctic are close together, resulting in rapid change in short distances in some directions, and their locations are imperfectly known. As a result, charted variation in the Arctic is not of the same order of accuracy as elsewhere.

32 At any place in the Arctic the magnetic variation is not constant but fluctuates from hour to hour. Diurnal changes in variations as large as 10° have been reported. This is another important source of error.

33 The decrease in the directive force acting on the compass creates a greater influence of frictional errors. The results to the compass are a greatly increased sluggishness in its return to the correct reading after being disturbed. For this reason the compass performs better in a smooth sea free from ice than in a rough sea or an ice-infested area where its equilibrium is frequently upset by impact of the vessel against waves or ice.

34 Magnetic storms, often accompanied by displays of the Aurora Borealis, or Northern Lights, cause fleeting disturbances. Magnetic storms affect the magnetism of a ship as well as that of the earth. Changes in deviation as much as 45° have been reported during severe magnetic storms, although it is possible that such large changes may be a combination of deviation and variation changes.

35 Local magnetic disturbances occur when a mass of magnetic ore, or possibly a wreck, lies sufficiently close to cause an error of the compass. This error is seldom caused by visible land, but more often by the ship passing over such masses lying in shallow water. It occurs in certain known localities, usually noted on the charts and in the geographical chapters of Sailing Directions. Whenever a ship passes over an area of local magnetic disturbance, the position should be fixed, and the facts reported as far as they can be ascertained.

36 A magnetic compass in an exposed position performs better than one in a steel pilot house. The performance of the compass varies considerably with the type of compass, sensitiveness and period, thoroughness of adjustment, location on the vessel, and magnetic properties of the vessel. It also varies with local conditions.

37 Despite its various limitations, the magnetic compass is a valuable instrument in part of the Canadian Arctic where the gyrocompass is also of reduced reliability. With careful adjustment, frequent checks, and a record of previous behaviour, the Arctic navigator can get much useful service from this instrument.

Refraction

38 **Abnormal refraction** at sea is produced by an inversion of temperature in a layer of air, which in turn creates variations in density of the air. Light rays passing through this layer are bent or deflected in excess of normal conditions.

39 Excess refraction occurs most noticeably, when a layer of warm air is in contact with cooler water. The air in direct contact with the water is cooled, while the air above it is warmer, thus there is an increase in temperature with height. Most refraction phenomena are incurred at the junction of this cooler air in contact with the sea and the less dense warm air above. This situation is identical with that which is responsible for the formation of most sea fog and the presence of fog is an indication that excessive refraction may be anticipated.

40 Similar inversions can be expected with the presence of cold air over warmer water. A marked difference between the air and sea temperatures is another guide to the possibility of excessive refraction.

41 Abnormal refraction is not confined to particular geographical areas; however, meteorological conditions in the Arctic are such that this phenomenon may be expected more frequently. Arctic regions are most conducive to this

condition due to the marked difference between sea and air temperatures, and as a result, there are frequent occurrences of extra long range visibility or some form of mirage when comparatively warm light winds pass over cold ice surfaces, or when cold winds blow over open water. This refraction is also caused when temperatures over open water are higher than those over an adjacent ice-covered coast.

42 Looming, which is the apparent rising of an object over the horizon, is one form of abnormal refraction. This occurs quite frequently at sea in high and middle latitudes and is manifest by the appearance of distant objects, which may actually be below the normal horizon at the moment of observation.

43 Looming can appear in two forms, one in which the observed object is apparently increased in height but not in size, or in which the object is increased in size and appears much nearer the observer.

44 The atmospheric condition responsible for looming is an abnormal decrease in the density of the air from the surface upward, with the resultant downward curvature of the light rays. As the density decreases with height, the more marked are the visual aberrations. When the rate of decrease in density is variable at low heights, the shape of the looming object becomes bulged and distorted. There may also be a thinning, flattening or pointing of the reflected image, in such a case a distant rounded peak may loom in its natural shape, appear with a distant flat summit, or with a distorted summit and appearing in closer proximity than its base. The appearance may also differ when viewed from the height of the mast-head as opposed to the deck level.

45 Another form of abnormal refraction, known as superior mirage, is manifested by the apparent reflection from a mirror-like atmospheric condition where a pronounced inversion exists at a distance of several metres above the surface. An abnormal change in density results from this inversion producing very marked refraction. To the eye, it appears as an inverted image above the object and under certain conditions, a second image appears erect, close above the inverted image. In some instances the actual object may not be seen, but the inverted image or the erect image can only be seen.

46 The common factor with both looming and superior mirage is the condition of inversion of temperature where a warm layer of air is present over the sea at a suitable height. However, in the case of superior mirage, there is a more abrupt change from cooler to warmer air at certain heights.

47 Mirage effects near land, appear from the ship, as an unnatural image of the coastline, perhaps appearing singly, double or even triple. The mirage may also convey the impression that the coast is either more distant or closer than in actuality.

48 At sea, beyond range of land, ships and icebergs are the commonest forms of mirage. Ocean fog also contributes to mirage effects as the same factors such as temperature and humidity variations are present. Mirage is not visible in dense fog, but the erroneous reporting of fog itself, may result from these suitable atmospheric conditions.

49 As temperature inversions may cause an abnormal dip of the horizon, which in turn can seriously affect the accuracy of sextant observations, the navigator should be on guard against this possibility.

Cables and pipelines

50 **Caution**. — Canadian charts no longer differentiate between high voltage power lines and other less lethal types of **overhead or submerged cables**; all overhead lines and submarine cables must be treated with the same degree of caution.

51 **Overhead clearances** of bridges and cables, in tidal waters, are given above Higher High Water, Large Tide (HHWLT).

52 In non-tidal waters, chart datum is used as the plane of reference; water levels above chart datum will reduce the overhead clearance.

53 Certain conditions may reduce the overhead clearance. A load of wet snow or ice is obvious. The actual clearance of a power transmission line also depends on the temperature. When the temperature of the cable rises, it expands and its clearance decreases; when the temperature of the cable falls, it contracts and its clearance increases. Under certain exceptional conditions, the decrease of clearance of the cable caused by extremely high operating temperatures is greater than that due to a load of snow or ice.

54 Mariners are further cautioned to allow extra clearance when passing under transmission lines carrying high voltages; a safe clearance depends on the line voltage and possible over voltages. To avoid the dangers of possible electrical discharge when passing under such cables, it is necessary to allow a safe margin of at least 7 m.

55 Overhead cables are subject to frequent change as new cables are installed and existing cables are removed or modified. Current editions of charts may not indicate all overhead cables in an area.

56 **Submarine cables** are laid along or across channels and between islands in many areas. Where known, cable areas and the individual tracks of submerged cables

are shown on the charts but submarine cables are subject to frequent change as new cables are laid and existing cables recovered or modified. For this reason charts may not show all cables.

57 **Caution**. — It is a punishable offence to break or injure a submarine cable. Even though there may be no specific prohibition against anchoring or trawling in submarine cable areas, mariners should avoid doing so in such areas because of the serious interference with communications or power supplies which result from damage to such cables.

58 In the event of any vessel fouling a submarine cable, every effort should be made to clear the anchor or gear by normal methods, taking care to avoid any risk of damaging the cable; should these efforts fail, the anchor or gear should be slipped and abandoned without attempting to cut the cable. High voltages are fed into certain submarine cables other than power transmission cables; serious risk exists of loss of life due to electric shock, or at least of severe burns, if any attempt to cut the cable is made. No claim in respect of injury or damage sustained through such interference with a submarine cable will be entertained.

59 Owners of ships or vessels who can prove that they have sacrificed an anchor, a net, or other fishing gear in order to avoid injuring a submarine cable, shall receive compensation from the owner of the cable. In order to establish a claim to such compensation, a statement supported by the evidence of the crew, should, whenever possible, be drawn up immediately after the occurrence; and the master must, within twenty-four hours after his return to or next putting into port, make a declaration to the *Canada Border Services Agency*, the *Canadian Coast Guard*, or a Fisheries Officer of *Fisheries and Oceans Canada*.

60 The **International Cable Protection Committee (ICPC)** wishes to give wide dissemination to the notice, reprinted below, regarding prevention of damage to international cables.

61 “Modern high capacity repeatered type submarine cables now cross the oceans and major seas of the world. Cables of increasing capacity are being designed and will continue to be laid for many years to come. Activity on the sea bed could very easily damage a cable, put it out of service and cause considerable disruption and interruption to international and world communications. Disruption of world telecommunications could be prolonged if repair is delayed due to disposition of cable ships at the time, and weather hazards.

62 One of the main objectives of the *ICPC* and one on which they are continually working, is to make known the existence of and the location of submarine cables. Charts showing cable positions are available from many Hydrographic Offices and the universal charting of cables has been endorsed by the *International Hydrographic Organization*.

63 The *ICPC* has been asked to remind those whose interests are on or below the sea bed to be sure that they are aware of submarine cable positions in their area of operation. Most of the leading companies and administrations in the telecommunications world are members of *ICPC* and are ready and willing to furnish details of cable positions on request. If there is any difficulty in obtaining cable information, requests addressed to the Secretary, *International Cable Protection Committee*, at: secretary@iscpc.org, will receive immediate attention.”

64 **Submarine pipelines** in the area covered by this publication are generally buried. They may, however, be laid on the seabed. Every care should be taken to avoid anchoring or trawling near such pipelines.

65 **Caution**. — In the event of any vessel fouling a pipeline the anchor or gear should be slipped or abandoned without attempting to clear it. Any excessive force applied to a pipeline could result in a rupture; in the case of a gas pipeline the resultant release of gas at high pressure would be followed by an immediate **fire hazard**.

Oil and gas exploration

66 Oil drilling platforms may be encountered in Canadian Arctic waters, particularly in the Beaufort Sea. The latest information on the positions of offshore exploration and exploitation vessels in Arctic waters can be obtained from *NORDREG CANADA* through any *Canadian Coast Guard Marine Communications and Traffic Services* centre. An exploration or exploitation vessel is required to be lighted and marked and to make sound signals as prescribed by the *Collision Regulations*. For further details concerning the lighting and marking of exploration and exploitation vessels and platforms, see the *Annual Edition of Canadian Notices to Mariners.*

67 Numerous **artificial islands** were constructed in the Beaufort Sea for use as drilling sites for oil exploration purposes. These islands were made of sand-bag dykes filled with gravel, sand or silt dredged from the seafloor. Upon termination of drilling operations the islands were abandoned and left to dissipate through erosion. By 1980 most of the early islands had been abandoned and new construction commenced. For further details see *Sailing Directions* booklet *ARC 403 — Western Arctic (ARCTIC CANADA VOL. 3)*.

Mandatory nautical publications

68 The official guides to navigation in Canadian coastal and inland waters are published by the Canadian Government. The appropriate charts and publications must be carried, as specified by the *Charts and Nautical Publications Regulations, 1995* (see https://laws-lois.justice.gc.ca/eng/regulations/SOR-95-149/index.html). The United States *National Ocean Service* publishes charts and publications for United States waters.

69 **Caution**. — These charts and publications are all affected by the **continual changes** and alterations that take place in navigational information and aids. Mariners and owners are cautioned to use only the latest and corrected editions of these charts and publications.

International Maritime Organization (IMO) publications

70 **IMO publications** are available from:

International Maritime Organization
4 Albert Embankment
London
SE1 7SR
United Kingdom
email: publications-sales@imo.org
Tel.: +44 (0)20 7735 7611
Fax: +44 (0)20 7587 3241

71 On-line orders for the following mandatory publications may be placed at the address shown:

International Code of Signals
https://www.imo.org/en/publications/Pages/English.aspx,
IMO Standard Marine Communication Phrases
https://www.imo.org/en/OurWork/Safety/Pages/StandardMarineCommunicationPhrases.aspx,
International Aeronautical and Marine Search and Rescue Manual Vol. III, (IAMSAR III)
https://www.imo.org/en/OurWork/Safety/Pages/IAMSARManual.aspx.

72 See "Publications" at http://www.imo.org/ for other IMO documents.

73 The *Transport Canada* poster **Illustrated table of life-saving signals T31-59/2003**, if required, is available at https://www.publications.gc.ca/site/eng/241316/publication.html.

Canadian Hydrographic Service (CHS) publications

74 **Catalogues of Nautical Charts and Publications** are published regularly; they inform mariners of the charts and related publications available and required for safe navigation in Canadian waters. The catalogues offer useful information and list *CHS* dealers in Canada and foreign countries. *Catalogue 1* covers the Atlantic coast and the St. Lawrence River to Montréal, *Catalogue 2* covers the Pacific coast, *Catalogue 3* covers the upper St. Lawrence River, the Great Lakes area and Lake Winnipeg and *Catalogue 4* covers northern Canada and the Canadian Arctic.

75 **Nautical Charts**, in paper or electronic format, are designed specifically to meet the needs of marine navigation. They show depths of water, emphasize dangers to navigation, portray maritime cultural features and show topographic detail considered useful to navigation. Charts also show various aids to navigation and information on tides and currents, as well as information in the form of diagrams and notes.

76 **Chart 1** is a booklet listing the symbols and abbreviations used on charts.

77 **Sailing Directions** are volumes or booklets which cover various geographic areas. They offer general information important for navigation as well as coastal descriptions, geographic information, and detailed descriptions of port facilities.

78 **Canadian Tide and Current Tables** are published annually and offer tide predictions for various ports as well as times of slack water and times and velocities of maximum current at specified locations. See chart catalogues 1, 2 and 4 for more details.

79 The above publications and other documents are available from:

Hydrographic Distribution Office,
Fisheries and Oceans Canada,
Client Services
615 Booth
Ottawa, ON
K1A 0E6
Ph: 613-998-4931
Fax: 613-998-1217
E-mail: chs_sales@dfo-mpo.gc.ca
Internet: https://charts.gc.ca/charts-cartes/purchase-achat/index-eng.html.

Canadian Coast Guard (CCG) publications

80 **List of Lights, Buoys and Fog Signals** is in four volumes; it gives the names and details of the characteristic of lights, lighted buoys, and fog signals in Canadian waters (see http://www.notmar.gc.ca/).

81 **Radio Aids to Marine Navigation** is in two volumes; it gives information on *CCG MCTS* centres,

Vessel Traffic Services zones and procedures, and services and systems. Also given is information on marine weather services provided by *Environment Canada* and delivered by *CCG* (see http://www.ccg-gcc.gc.ca/eng/CCG/MCTS_Radio_Aids).

82 **Annual Edition of Notices to Mariners** carries *Notices to Mariners 1 to 46* of each year. These Notices include information of a general nature on aids to navigation and marine safety such as radiotelephone communications, pollution, military exercise areas, search and rescue, pilotage, and vessel traffic services (see https://www.notmar.gc.ca/annual).

83 **Ice Navigation in Canadian Waters, 1999 Edition (TP 5064)** gives information on ice conditions in Canadian waters, navigation in ice, and ice advisory and shipping support services (see https://www.ccg-gcc.gc.ca/publications/icebreaking-deglacage/ice-navigation-glaces/page01-eng.html).

84 The **Monthly Edition of Notices to Mariners**, in 5 Sections, gives important up-to-date navigational information affecting nautical charts and publications. The release of new charts and new editions of existing charts and publications is also announced through this publication (see http://www.notmar.gc.ca/).

85 **Notices to Shipping** are radio navigational warnings broadcast by *CCG MCTS* centres. Printed versions are available by contacting any *CCG* office.

Optional nautical publications

86 **Canadian Aids to Navigation System (TP 968)** is a booklet which describes the Canadian system and the aids in use (fixed, floating, lighted, radio). It is issued free of charge by the *Canadian Coast Guard* in pdf format (See http://www.ccg-gcc.gc.ca/Aids_To_Navigation_System_2011.).

87 **Safe Boating Guide, TP511**, is issued free of charge by *Transport Canada*. It contains information valuable to the small-craft operator concerning laws, safety equipment, rules of the road and safe practices related to small craft (see https://tc.canada.ca/sites/default/files/2024-03/tp_511e.pdf).

88 **Recommended Code of Nautical Procedures and Practices, TP 1018**, is issued free of charge by *Transport Canada*. Once a required document, it contains invaluable information for all mariners on maintaining a safe watch, both at sea and in port (see http://www.tc.gc.ca/MarineSafety/TP/TP1018/menu.htm).

89 *Ice Navigation in Canadian Waters, 1999 Edition (TP 5064)* and *Annual Edition of Notices to Mariners 1 to 46*, among others, are available in print from the *Canadian Hydrographic Service* Client Services office (see https://www.notmar.gc.ca/annual).

Use of charts

CHS Charts

90 Under the *Charts and Publications Regulations*, 1995, of the *Arctic Waters Pollution Prevention Act*, the mariner must have the appropriate *Canadian Hydrographic Service (CHS)* charts and publications on board and in use when navigating in Canadian waters.

91 The use of symbols and abbreviations on charts is necessary in order to show as much information as possible. **Chart 1, Symbols and Abbreviations**, a booklet published by the *CHS*, gives examples and explanations to help with chart interpretation (see https://www.charts.gc.ca/publications/chart1-carte1/index-eng.html).

92 **Natural Scale** means the relationship between the size of the chart and the size of the earth. For example, 1:15,000 means that one unit on the chart equals 15,000 units on the earth. Here are the different types of charts issued by the *CHS* and their uses; the scales shown are approximate:

- **Harbour Charts** are large scale, 1:5,000 to 1:15,000, and are used for navigation in harbours or intricate, hazardous, shoal-infested waters.
- **Approach Charts**, 1:15,000 to 1:50,000 are used for approaching coasts where a lot of detail is required.
- **Coastal Charts**, 1:50,000 to 1:150,000 give continuous extensive coverage with sufficient inshore detail to make landfall sightings easy.
- **General Charts**, 1:150,000 to 1:500,000 give extensive offshore coverage with enough inshore detail to make landfall.
- **Sailing Charts**, 1:500,000 and smaller, are used for offshore navigation out of sight of land.
- **Small Craft Charts** describe some areas not covered by other charts. They are specially designed for recreational boaters and are generally published in strip format (accordion folded).

Corrections to charts

93 Standard navigational charts published by the *CHS* are up-to-date at the time of publication, and they are then hand corrected from *Canadian Coast Guard Notices*

to Mariners, Section 2, to the date stamped on each chart before it is sold. Most chart dealers do not hand correct charts and thus charts obtained from dealers will generally be corrected only to the date stamped on the chart before it is shipped to the dealer.

94 Small craft charts and certain other charts published by the *CHS* are not hand corrected after publication. Such charts must be corrected by reference to Section 2 *Notices to Mariners* issued since the publication date of the charts.

95 **Caution**. — It is the responsibility of the chart user to apply subsequent corrections promulgated in the monthly editions of *Notices to Mariners* before using the chart for navigation. A list of such corrections for any particular chart can be obtained from the *CHS* Client Services Office or by visiting http://www.notmar.gc.ca/.

96 Chart users are reminded that charts are not to be permanently corrected from Section 1 or Section 2 **Temporary (T) or Preliminary (P) Notices to Mariners**. Such notices affecting a chart should be noted on the chart in pencil. The *Canadian Coast Guard* publishes an annual summary of all *(T)* and *(P)* notices in effect at the beginning of each year, and a list of all *(T)* and *(P)* notices in effect is also published every six months in the regular monthly editions of *Notices to Mariners*.

97 The release of new charts and publications, and of new editions and reprints of existing editions, is announced in Section 1 of *Notices to Mariners*. Only the latest edition of a chart or publication may legally be used for navigation.

Reliance on a chart

98 The value of a chart depends largely on the accuracy and detail of the surveys on which it is based. The date of survey, or a statement of the authorities on which a chart is based, is given under the title of the chart. Mariners are cautioned, however, that when a chart is compiled from several sources the dates and areas of the surveys may be difficult to define. For this reason new charts and some new editions will have a source classification diagram to show the type of survey data used in the construction of the chart.

99 The appearance of a chart may show the thoroughness of the surveys on which it is based but it should be borne in mind that a chart drawn from an old survey with few soundings may have had further soundings added to it later from ships' tracks on passage, thus masking the inadequacy of the original survey. On the other hand, the quality of a chart is not shown only by the number of soundings; new metric charts based on recent surveys show more depth contours and fewer soundings, and some metric charts show information from old charts converted to metres. It is important to use the source classification diagram to assess a chart's reliability.

100 A chart represents general conditions at the time of the original survey and also includes any changes reported to the *Canadian Hydrographic Service* before the edition date shown on the chart. Areas with sand or mud, especially in the entrances and approaches to rivers and bays, are subject to change; extra caution is necessary in such areas.

101 In areas with reefs and rocks it is always possible that surveys may have failed to find every obstruction. When navigating in such waters, customary routes and channels should be followed; avoid waters where irregular and sudden changes in depth indicate conditions associated with reefs and pinnacle rocks.

102 **Caution**. — For today's ships of normal draught in much-frequented waters, the reliability of most charts based on early surveys has been confirmed by the safe passage of ships over the years. Vessels with draughts approaching 30 m should exercise care inside the 200 m line in less adequately surveyed areas, even in recognized shipping lanes. In many instances, ships with draughts approaching 30 m may be **testing the chart** despite the fact that many shallower-draught ships may have passed previously. A ship venturing into unfrequented waters may also be testing the chart for the first time and should exercise due caution.

103 **Caution**. — The **largest-scale** chart of an area should always be used for navigation because dangers cannot be shown with the same amount of detail on small-scale charts. In addition, it sometimes happens that because of production priorities only the largest scale charts incorporate information from a new survey.

104 **International charts** covering the world at scales of 1:3½ million and 1:10 million are being compiled by some member states of the International Hydrographic Organization. These charts can be reprinted by any member state in its own national series. Each chart carries its International number as well as any national number allocated to it.

105 International charts of waters surrounding Canada are being reprinted in the Canadian chart series as they become available. Being part of the Canadian series, these charts will appear in the Canadian Chart Catalogues and will be corrected by *Notices to Mariners* in the usual way.

106 The Canadian chart coverage for the whole of northern Canada is shown in the *Catalogue of Nautical Charts and Related Publications, No. 4, Arctic*, published by the *Canadian Hydrographic Service*.

107 Parts of Canada's Arctic waters have not been surveyed to modern standards. In some areas, spot soundings through the ice or reconnaissance track soundings are the only survey data available. Shipping routes, and areas in the Beaufort Sea with a large number of pingos, have been surveyed in greater detail.

108 **Caution**. — In the areas covered by spot soundings, the density is variable and in most cases, shoal examinations have not been undertaken.

109 **Caution**. — A number of Arctic charts are now in metric units. Mariners should pay particular attention to whether the soundings on a chart are in fathoms, feet or metres.

North American Datum 1983 (NAD83)

110 Mariners are advised that the *Canadian Hydrographic Service (CHS)* has begun a conversion of the horizontal reference system used to define the latitudes and longitudes used on nautical charts. For many years, *CHS* charts were based on the *North American Datum 1927 (NAD27)*. With the advent of the *Global Positioning System (GPS)*, it has become necessary to facilitate the use of the geographic co-ordinate system – *World Geodetic System 1984 (WGS 84)* – used by these navigation instruments. This co-ordinate system is identical to a non-military co-ordinate system known as *North American Datum 1983 (NAD83)*. New charts are being published, and older charts are being converted to *NAD83*. The difference between the *NAD27* co-ordinate value and *NAD83* co-ordinate value of the same feature is about 110 m (361 ft) on the Pacific coast, 60 m (197 ft) on the Atlantic coast and near zero in the Great Lakes. These differences are discernible to the mariner with the advent of *GPS* and become more significant the larger the scale of the chart.

111 Mariners that have the *Global Positioning System (GPS)* have, in many situations, the capability of positioning the ship to a better accuracy than the hydrographer had when surveying for the chart. This means that the accuracy of the mariner's location relative to the charted feature will be limited, not by the ship's positioning equipment, but by the charted information.

112 **Caution**. — Some *Canadian Hydrographic Service (CHS)* charts are from surveys that cannot be related to *NAD27*, *NAD83* or *WGS84*; therefore, there are no available corrections for those charts. In some cases, *CHS* has been able to estimate a possible upper limit to the discrepancy between the chart's and *WGS84 (or NAD83)* positions and this information has been provided on the chart. One to 4 mile discrepancies have been observed. See *Horizontal Datum* note on charts.

113 Most *Canadian Hydrographic Service* charts printed after 1986 have a note indicating whether the chart is based on *NAD27* or *NAD83* and will contain sufficient information to allow conversion to and from the two datums.

114 There are two methods of incorporating the change in horizontal datum.

115 *Canadian Hydrographic Service* charts published on *NAD83* are capable of being used to plot directly the positions derived from satellite navigation systems *(GPS)*. However, when transferring a position from a chart or other document based on *NAD27* to the chart based on *NAD83*, the *NAD27* position must be converted to *NAD83*.

116 *Canadian Hydrographic Service* charts published on *NAD27*, if medium or large scale, require a conversion correction before plotting *NAD83* positions obtained by *Global Positioning System (GPS)*.

Chart datum

117 **Chart datum**, or reduction level, is the low water plane to which are referred the depths of water over features permanently covered by the sea and the heights of those which are periodically covered and uncovered. By international agreement chart datum should be a plane so low that the tide will seldom fall below it. The *Canadian Hydrographic Service* has adopted the plane of lowest normal tides as *Chart Datum*. It should be remembered that the tide may occasionally fall below the datum to which the soundings on the charts have been reduced. In some cases this only occurs with the greatest spring tides, but where the range of tide is small, meteorological conditions may cause even average tides to fall below chart datum.

Tides and tidal streams

118 Where the tidal range is considerable, caution is always necessary in coastal navigation. There are nearly always indraughts to all bays and bights, although the general set of the tidal stream may be parallel to shore.

119 The turn of the tidal stream offshore seldom coincides with the time of high and low water onshore. Off the coast, the tidal stream may turn two or three hours after the occurrences of high or low water and in consequence, the terms "flood" and "ebb" are usually replaced by "in-going stream" or "north-going stream".

120 **Caution**. — Arrows on charts only show the usual or the mean direction of a tidal stream or current. It must never be assumed that the direction of a stream will not vary from that indicated by the arrow. In the same manner, the rate of a tidal stream constantly varies with circumstances, and the rate given on the chart is

merely the mean of those found during a survey, possibly from very few observations.

Sailing Directions

121 **Sailing Directions** amplify the information given on charts and give other information of general interest to the mariner. This publication is complementary to the geographic booklets of the Sailing Directions for northern Canada (*ARC 401* to *ARC 404*) and gives notes on subjects of general interest to mariners and general information on Arctic Canada.

122 Corrections between new editions of Sailing Directions are promulgated in Section 4 of the monthly editions of *Canadian Notices to Mariners*. When using Sailing Directions, mariners should ensure that all amendments since publication have been entered.

123 Sailing Directions are stored in digital format. Because it takes many years before a new edition of a Sailing Directions booklet can be brought out in lithographic print form, Sailing Directions are now becoming available as a "print on demand" product. In the near future, mariners may purchase or download a fully updated copy of the current edition of any booklet at any time.

124 The publication of new editions of Sailing Directions booklets is announced in the monthly editions of *Notices to Mariners*.

Aids to Navigation

125 This section refers to the following *Canadian Coast Guard* publications: *The Canadian Aids to Navigation System (TP 968)*, the *Inland Waters List of Lights, Buoys and Fog Signals*, and *Radio Aids to Marine Navigation (both volumes)*. *(These publications were described earlier in this chapter.)*

126 **Daymarks**, unless otherwise stated, for leading lights described in Sailing Directions are of the shape for typical range daymarks as described in *The Canadian Aids to Navigation System (TP 968)*. An unlighted "daymark range" is interchangeable with "leading beacons" as described in *Chart 1, Q102.2* and *Q120*.

127 The **Inland Waters List of Lights, Buoys and Fog Signals** is published by the *Canadian Coast Guard* and is available at: http://www.notmar.gc.ca/. Corrections to the *Lists of Lights* are contained in Section 5 of the monthly editions of *Notices to Mariners*. These corrections should be inserted in the parent publications. The *Lists of Lights* should be consulted for the full details of the characteristics and positions of lights, light buoys and fog signals.

Buoys

128 **Caution**. — s**Buoys** serve only as warning markers. Mariners are cautioned not to rely solely on buoys for navigation purposes. The position of any buoy may not be as charted, and the characteristics of any buoy may not be as advertised, due to the effects of weather or circumstance. Mariners should always navigate their vessels by bearings or angles on fixed shore objects and by soundings or through use of satellite or radio-navigation systems whenever possible.

129 Buoys laid in Arctic waters must be regarded merely as temporary and very unreliable aids to navigation. It may be impossible to fix the buoys accurately in relation to the shore or the dangers which they may be intended to mark. The movement of ice and the operation of icebreakers can move buoys from their charted positions.

130 In cases where it is necessary to establish a buoy near an existing aid to navigation or a navigational hazard such as a shoal, sounding, reef or ledge, the buoy symbol may be offset slightly on the chart so that the existing symbol or hazard is not overprinted.

Buoyage

131 The Canadian system of buoyage is based on *Region B* of the *Maritime Buoyage System* developed by the *International Association of Lighthouse Authorities* and adopted by all major maritime nations. In *Region B*, which includes all of North and South America, Japan, the Republic of Korea, and the Philippines, a vessel navigating in the upstream direction keeps green buoys to port and red buoys to starboard. The shape and/or colour of the buoy and the flash characteristic of the light on the buoy indicate the function of the buoy. It is essential that mariners use up-to-date charts with this system. *Chart 1*, *Symbols and Abbreviations*, explains the buoyage symbols used on Canadian charts. The Canadian system includes Lateral, Isolated danger, Cardinal and Special buoys.

132 The **Lateral System of buoyage** indicates the course of a navigable waterway; the sides of the navigable waterway are indicated by buoys of a defined shape, colour or light characteristic in relation to the upstream direction. This upstream direction is the direction from seaward, toward the head waters, into a harbour, up a river, or with the flood tidal stream. In general, the upstream direction is in a southerly direction along the Atlantic coast, in a northerly direction along the Pacific coast, and in an easterly direction along the Arctic coast. In some waters

the upstream direction is indicated on charts by lines and arrows.

133 **Lateral buoys** indicate the side on which they may be safely passed. There are five types of lateral buoys: *port-hand*, *starboard-hand*, *port bifurcation*, *starboard bifurcation* and *fairway*.

134 **Isolated danger buoys** mark hazards that have navigable water all around them, such as a rock or a wreck, and should be kept to port when passing. Consult the chart for details of the obstruction.

135 **Cardinal buoys** indicate the location of the safest or deepest water by reference to the cardinal points of the compass. There are four cardinal buoys: north, east, south and west.

136 **Special purpose buoys** convey information which, while important, is not primarily intended to assist in navigation. They may include a variety of shapes of lighted and unlighted buoys, and they may have yellow reflective material. Except for the *Ocean Data Acquisition System (ODAS)* buoy, which is an anchored oceanographic buoy, special purpose buoys may have a flashing yellow light; an *ODAS* buoy may have a group flashing yellow light.

137 Many special buoys are privately owned. As required by the *Private Buoy Regulations*, such buoys must be marked with the letters "PRIV" and the owner's name, address and telephone number. They will not display numbers or letters conforming to the Coast Guard identification system.

138 **Control buoys** and **Keepout buoys** mark areas where boating is restricted. Mandatory speed limits are also in effect in certain small-craft waters. Refer to the *Vessel Operation Restriction Regulations* for more details.

139 **Hazard buoys**, introduced in January 1992, mark random hazards such as rocks and shoals. Hazard buoys differ from isolated danger buoys, which mark isolated dangers such as rocks and shipwrecks along specific routes and have navigable water around them. Hazard buoys mark random rocks and shoals, may or may not have navigable water around them, and would not normally be on routes marked by Coast Guard buoys. It is anticipated that the most common use of a Hazard buoy will be that of a private buoy, placed by individuals and organizations in areas where Coast Guard policy does not provide for Aids to Navigation service at public expense.

140 **Buoy numbering** applies only to starboard and port hand buoys; starboard hand buoys have even numbers and port hand buoys have odd numbers. Buoy numbers increase in the upstream direction and are kept in sequence on both sides of a channel by omitting numbers where required. Buoy numbers are usually preceded by one or two letters to help with channel identification. Other types of buoys do not have numbers but are identified only by letters. All buoy numbers and letters are white or reflective silver.

141 **Sound signals**, such as a bell or a whistle activated by the motion of the buoy in the water, may be fitted to any of the buoys in the Canadian buoyage system. Such buoys are generally used only in coastal waters where there is enough buoy movement to activate the sound device, and where a sound signal is needed to help locate the buoy in poor visibility.

Fixed aids

142 **Daybeacons** are sometimes used to mark channel entrances, approaches and bridges; they indicate the channel or the preferred channel. The "hand" of daybeacons, starboard or port hand, is determined in the same way as that of buoys.

143 **Emergency lights** are fitted at certain light stations in the interest of safety; these are noted in *List of Lights, Buoys and Fog Signals*. The emergency light is of lesser intensity than the main light and is normally visible for 5 miles on a dark night with clear atmosphere. The standard characteristic of an emergency light is group flashing (6) 15 seconds, i.e. 6 flashes, followed by a period of darkness, repeated four times a minute. An emergency light is automatically activated by failure of the main light and may be operating without a covering *Notice to Shipping*.

144 More information on aids to navigation is given in the booklet *The Canadian Aids to Navigation System (TP 968)*, published by the *Canadian Coast Guard* and available from *CHS*, most chart dealers and from all *Canadian Coast Guard* offices.

Radio

145 The *Canadian Coast Guard* operates two *Marine Communications and Traffic Services (MCTS)* centres, with a system of peripheral repeater sites, for vessels navigating in Canadian waters covered by *ARC 401* to *ARC 404*.

146 *MCTS* ***Iqaluit*** *(63°44'N, 68°33'W)*, call sign VFF, with repeater sites at Killenek *(60°25'N, 64°50'W)*, Coral Harbour *(64°09'N, 83°22'W)*, Resolute *(74°45'N, 94°58'W)*, Inuvik *(68°19'N, 133°35'W)*, Parson's Lake *(68°54'N, 133°56'W)*, Cambridge Bay *(69°07'N, 105°01'W)*, Hay River *(60°50'N, 115°47'W)*, Enterprise *(60°36'N, 116°13'W)* and Yellowknife *(62°26'N,*

114°24'W), handles communications in northern Hudson Bay, Foxe Basin, the Arctic and in the Great Slave Lake and Mackenzie River system.

147 *MCTS* ***Thunder Bay*** *(48°26'N, 89°14'W)*, with a repeater site at Churchill *(58°42'N, 94°15'W)*, covers southern Hudson Bay and James Bay.

148 For full details of these and other stations consult the latest edition of *Radio Aids to Marine Navigation (Atlantic, St. Lawrence, Great Lakes, Lake Winnipeg and Eastern Arctic)* and *Radio Aids to Marine Navigation (Pacific and Western Arctic)*. A Master who does not hold an applicable copy of *Radio Aids to Marine Navigation* should call the nearest *Canadian Coast Guard MCTS* centre on a calling frequency to request a working frequency for further information.

Radio medical advice

149 Mariners may obtain medical advice by calling any *Marine Communications and Traffic Services (MCTS)* centre and requesting to be connected to a medical professional. The *MCTS* centre will connect the vessel to an appropriate medical professional via the *Marine Telephone System*. Medical advice may also be obtained by addressing a message addressed to "RADIOMEDICAL" and routing it via the nearest *MCTS* centre which will refer the message to the nearest medical authority and transmit the reply to the ship.

Radio distress communications

150 All *Canadian Coast Guard Marine Communications and Traffic Services* centres keep a continuous watch on the international distress and calling frequency 2182 kHz, and all port radio stations maintain continuous watch on the safety and calling frequency of 156.8 MHz (channel 16).

151 Masters should conform to international procedures and the use of designated frequencies. However, should transmission on international emergency frequencies be impossible, any other available frequency on which attention might be attracted should be utilised.

152 Information on digital selective calling, the alarm signal and voice procedures for distress, urgency and safety communications are found in Chapter 4 of *Radio Aids to Marine Navigation*.

153 **Ship Station (Radio) Regulations (1999)** state: "The main operating position of a ship station shall have a card of instructions, visibly displayed, setting out a clear summary of the radio distress procedures."

Ionospheric disturbances

154 Radio communications in the Arctic, beyond "line of sight" limits, suffer problems that occur only rarely in lower latitudes. **Ionospheric disturbances** are the main factors which affect the behaviour of radio waves in the low frequency (LF), medium frequency (MF) and high frequency (HF) bands. Knowledge of the behaviour of different types of ionospheric disturbances can assist those individuals responsible for communications, to maintain communication during these disturbances. Those which affect radio communication belong to three main types:

- Sudden ionospheric disturbances (SID), the "flare blackouts"
- Polar cap absorption (PCA), caused by "solar cosmic rays"
- Ionospheric storms, and mixed PCA and storm events.

155 The number and strength of these ionospheric disturbances is determined by disturbances on the sun. As is well known, solar activity rises and falls in an eleven year cycle, called the "sunspot cycle". Ionospheric disturbances follow a similar eleven year cycle with maxima being observed near the years of sunspot maximum (1979/80, 1990/91, 2001/02, etc.).

156 Sudden ionospheric disturbances may occur anywhere in a sunlit hemisphere. Polar cap absorption occurrences are, however, definitely high latitude phenomena, and they are rarely seen at middle and low latitudes. Ionospheric storms seriously affect radio communication circuits in mid and high latitudes.

157 During a sudden ionospheric disturbance, radio waves are absorbed in the lower ionosphere, with the resultant attenuation of frequencies between 2 and 50 MHz. Within this frequency range the attenuation during a given SID is very much stronger at the lower frequencies. Representative values for a one-hop communication system during a moderate sudden ionospheric disturbance, would be the attenuation of several hundred decibels at 2 MHz and 30 decibels at 10 MHz. Above 50 MHz, however, SIDs can sometimes produce enhanced propagation.

158 A sudden ionospheric disturbance is caused by abnormal X-ray emissions from a solar optical flare. The flare radiation enters the earth's ionosphere, where it increases the ionization in the "D" region at heights of 40 to 55 km. The resultant radio wave attenuation is strongest directly under the sun, and gradually weakens as the sun's zenith angle decreases. The SID is therefore relatively weak at high latitudes. The radio wave attenuation reaches its maximum value within a few minutes after the start of the SID. The return to normal depends on the duration of

the solar flare, and may take from several minutes up to as much as three to four hours.

159 In a polar cap absorption occurrence, as is the case in a sudden ionospheric disturbance, radio waves are absorbed in the lower ionosphere, and low frequencies are attenuated much more strongly than high frequencies. A PCA occurrence differs from a SID in several important respects; it occurs only in the polar regions, above the 50^{th} to 60^{th} parallel of north or south latitude; it lasts much longer than a SID and it affects a wider range of frequencies (about 0.2 to 100 MHz). During the 1949–59 sunspot cycle, about forty moderate to strong PCA occurrences took place, each with an average duration of two days. Nearly half of these PCA's occurred in 1957–59, near the peak of the sunspot cycle, but none during the sunspot minimum years 1952 through 1955. High frequency radio links with transmitting and receiving terminals within the Arctic Circle, may become inoperative during the daylight hours of a PCA occurrence; communication may however, be re-established several hours after sunset, but a second blackout may occur the next day after sunrise. However, such re-establishment of communication would not be possible for links located in the high Arctic where the sun does not set during midsummer months.

160 A polar cap absorption event is caused by sporadic emission of highly energetic charged particles from the sun, called "solar cosmic rays". As a result of their electrical charge, the earth's magnetic field deflects the solar cosmic rays from the equator toward the polar regions, where most of them are absorbed at heights of 50 to 100 km. The PCA events usually start within a few minutes or hours of a large solar flare, but they continue long after the initiating flare has died out, in some instances for five or six days. The radio wave attenuation depends not only on the flux of solar cosmic rays, but also on the intensity of sunlight in the lower ionosphere. The attenuation is maximum near noon, and often becomes quite weak at night.

161 Ionospheric storms are more complex and somewhat less well understood than either sudden ionospheric disturbances or polar cap absorption events. During such a storm, radio waves may be absorbed, scattered, ducted or undergo unusual reflections. All of these effects vary with frequency, time and latitude. Some of these storms last a few hours, others last as long as a week. Some storms tend to recur at twenty-seven day intervals (corresponding to the solar rotation period), while others appear to be isolated events.

162 In the course of an ionospheric storm not preceded by a polar cap absorption event, the severest radio transmission losses occur at auroral zone latitudes, and the attenuation at the low end of the high frequency band is often sufficient to disrupt communication. Within the polar cap, communication can actually improve during such disturbances, because noise and interference propagating through the auroral zone may be reduced by auroral absorption. Such auroral zone disturbances occur much more frequently than PCA events.

163 When a PCA event is followed by an ionospheric storm, solar cosmic rays are found at latitudes appreciably lower than the normal polar region, resulting in severe radio transmission losses for communication circuits operating at these latitudes. Other storm effects, such as rapid signal fading and changes in the maximum usable frequency, are much more widespread and may occur anywhere from low latitudes to the poles.

164 The maximum usable frequency in the Arctic is usually reduced on long distance circuits, but at times may be increased on circuits up to about 2,500 km in length due to one-hop propagation via the sporadic "E" layer. Thus attempts should be made to use the higher frequency assignments during storms. Alternative routeing, or relaying procedures, may also be required to maintain communication during an ionospheric storm.

Communications procedures

165 During ionospheric disturbances, there are procedures that can be taken to overcome radio communication blackouts, or periods of extremely poor propagation. It may be possible to establish communication by operating the circuit on alternate frequencies and by relaying messages via mobile or fixed stations. As a result, the location of all search and rescue communication facilities, and of all fixed radio stations in the operational area, should be posted in radio rooms and communication offices, together with their power output, call signs and operating frequencies. Mobile stations operating in the area must be listed in a similar manner, and changes must be amended immediately.

166 It may be necessary, because of a falling off of the received signal, for a ship to operate two separate circuits, each on a different frequency and with an operator for each circuit, whereas ordinarily in other regions, a single circuit would suffice. When setting up requirements for personnel and equipment, allowance should be made for such a situation. On long distance circuits, the practice of keying two or more transmitters simultaneously on widely divergent frequencies, has been found to facilitate communication.

167 Communication facilities for high latitude operation should include transmitting and receiving equipment with a maximum operating frequency of at least 26 MHz. Several frequency assignments, based on high

frequency prediction information, should also be available for operation in the Arctic. When normal communication is disrupted on one channel, the alternative frequencies may be tried on a pre-arranged schedule, and often a higher frequency can be used. If communication is still poor, attempts can be made to use relay stations. Operators can best be trained in these procedures during undisturbed ionospheric conditions. This training should include rapid tuning of transmitters and receivers, and the anticipation of frequency shift by means of standby equipment.

168 During ionospheric disturbances, frequencies below 200 kHz may be used for communication, even though radio waves between 0.25 and 50 MHz are absorbed in the lower ionosphere. The additional ionization formed in the ionosphere during a disturbance provides a very good reflector for these low frequencies, and so the lack of penetration also results in less absorption. Also, the ground wave is very effective at all frequencies below 1 MHz and can provide reliable communication during disturbances.

169 Very high frequency communication is sometimes impossible due to the shielding effect of mountains, fiords and enclosed harbours. When operations are carried out in mountainous regions, VHF circuits with aircraft should be paralleled with HF circuits. VHF coverage can be increased significantly through the use of transponders on a nearby mountain.

Radio Aids to Navigation

Radiobeacons

170 The *Canadian Coast Guard* no longer operates a radiobeacon service; however, all northern communities have an airstrip and most have an operating aeromarine radiobeacon.

171 The dual-purpose marine/air radiobeacons operate in the 200 to 405 kHz band. They transmit a continuous carrier which is modulated by a 1020 or 400 Hertz tone. This tone is interrupted six times a minute for the transmission of a one, two or three letter identifier. For detailed descriptions of Arctic radiobeacons see *Sailing Directions* booklets *ARC 401* to *ARC 404*.

172 **Caution**. — Mariners are cautioned with regard to the limitations of radiobeacons and the receiving equipment, and the possible erroneous bearings that may result.

173 The attention of mariners is drawn to the serious dangers which may arise from the misuse of radiobeacons in fog. No attempt should be made to home on such a radiobeacon station while at the same time relying on hearing a sound fog signal from the same station in time to alter course to avoid danger.

Radar

174 **Radar** is a particularly valuable aid to navigation in the Arctic, but it is not infallible, due to instrument as well as human error, coupled with the possibility of inaccurate charting of the land masses relative to one another.

175 The possible errors in the measurement of bearing and range must be taken into account when using radar for position fixing. In general the ranges obtained from navigational radar sets are appreciably more accurate than the bearings. It therefore follows that if radar information alone is available, the best fixes will be obtained from the use of three or more radar ranges as position arcs.

176 A visual bearing should always be used in preference to a radar bearing. The best fixing accuracy may sometimes be obtained by a combination of a visual bearing and radar range of an isolated object such as a rocky islet. A radar range of the nearest land can also sometimes serve as a useful check.

177 The precision of radar range fixing is dependent upon the correct selection of radar conspicuous targets and their proper interpretation from an accurately calibrated radar display.

178 Certain difficulties will, however, be encountered with the use of radar fixing in the Arctic. When extensive drift ice extends from shore, the accurate location of the shoreline is extremely difficult. Identification is even more of a problem when the shoreline is beyond the radar horizon and accurate contours of the land are not shown on the chart. Where there is a lack of topography on the chart, the use of topographic maps may assist mariners in identifying the radar returns.

179 A situation may arise where there is a disagreement between radar ranges. This can be caused by ranging errors or it may be the result of chart inaccuracies. To rectify this situation, it is recommended that fixing should be directed to the nearest land, but not on both sides of a channel, strait or inlet.

180 Good training and extensive experience are needed to interpret accurately the radar response in the Arctic where ice can cover both land and sea. A number of icebergs close to a shore may be too close together to be resolved, giving an altered appearance to a shoreline, or they may be mistaken for off-lying islands. The shadow of an iceberg or pressure ridge and the lack of return from an

open lead in the ice can easily be confused. Smooth ice can look like open water.

181 However, the advantages of radar ranging for fixing in the Arctic more than offset the above-described limitations. This method of fixing can be employed in the hours of darkness and under all conditions of reduced visibility, and does not depend on other aids to navigation such as lights and buoys.

182 **Radar reflectors** are fitted to many buoys and some light structures to provide a more effective reflecting surface in order to increase the strength of the returned radar signal. In the Arctic a number of beacons with radar reflectors are established as independent aids to navigation.

183 **Radar reflectors** are available from most ship chandlers. Operators of small craft are encouraged to have a radar reflector as high as possible in their craft, particularly in low visibility, as this will greatly increase the likelihood of being detected by a ship's radar.

184 **Radar transponder beacons (Racons)** may be fitted to more important aids to navigation. The beacon consists of a radar-frequency transmitter that responds to a received radar transmission and is known as a Racon. Most Racons used by the *Canadian Coast Guard* are of the frequency-agile type and consist of a transmitter that transmits in the X or S band radar frequencies.The Racon signal appears on the radar display as a line from the position of the Racon towards the outer edge of the display, along the line of its bearing from the ship. The line on the display is broken into a code consisting of a series of dots and dashes, as published in *Radio Aids to Marine Navigation*. Racons are shown on Canadian charts.

185 Should a Racon fail to give a response on a ship's radar, report this fact immediately to the nearest *MCTS* centre so that the information can be broadcast as a *Notice to Shipping*.

NAVSTAR Global Positioning System (GPS)

186 The NAVSTAR **Global Positioning System (GPS)** uses a constellation of at least twenty-four satellites to provide the necessary data so that the receiver can continuously compute its latitude, longitude and ellipsoid height. The satellites are located in space at sufficient height and separation that a minimum of four will always be visible from ground locations (barring any local shielding by mountains, buildings or parts of the ship). GPS was declared operational by the U.S. Department of Defence in July 1995 and navigation signals are available to everyone. As with many navigation positioning systems, the obtainable accuracy is a function of the equipment that is installed and the method in which it is used.

187 **Differential GPS (DGPS)** uses real time corrections transmitted from a monitor that is within several hundred kilometres of the ship to improve the accuracy. Several countries, including Canada, are using this method and accuracies within a few metres are achieved.

Automatic Identification Systems

188 A ship-to-ship and ship-to-shore identification system, similar to aircraft identification transponders, has been developed with guidelines from the International Maritime Organization (IMO), International Telecommunication Union (ITU) and the International Electro-technical Commission (IEC). *Automatic Identification System (AIS)* transponders use *GPS* technology and can transmit ship identification, voyage information, position and present course and speed to other similarly equipped vessels and shore stations for safety and security purposes. Aids to navigation are also being equipped with *AIS* transponders to enhance navigation safety in inclement weather. For details on carriage requirements, see Chapter V, Regulation 19 of the *International Convention for the Safety of Life at Sea (SOLAS), 1974*. In the United States and on the Great Lakes, *AIS* is mandatory for most vessels. *AIS*, as with other electronic aids to navigation, must be properly set up and maintained, and used with caution.

189 Certain Canadian vessels operating on international voyages must be equipped with *Long-Range Identification and Tracking of Vessels (LRIT)* equipment approved by IMO. The *LRIT* system, used world-wide in *GMDSS* Sea Area A3, transmits the ship's name, latitude and longitude, date and time in a secure radio message via *Inmarsat* geostationary satellites to intended recipients. The *Canadian Coast Guard* is responsible for receiving *LRIT* transmissions and notifying intended recipients in Canada. The main purpose of the *LRIT* system is to enhance security; however *LRIT* has been incorporated in *SOLAS* Chapter V, *Safety of Navigation*, for the purposes of safety and environmental protection.

Canadian Coast Guard

190 The **Canadian Coast Guard** is the fleet of ships and aircraft and the associated shore services with which the *Fisheries and Oceans Canada* fulfils its responsibilities to marine navigation. They operate in Canadian waters from the Great Lakes to the northernmost channels of the Arctic Islands and from the Queen Charlotte Islands in the Pacific to the Grand Banks of Newfoundland in the Atlantic.

191 *Canadian Coast Guard* ships supply and maintain shore-based and floating aids to navigation in Canadian waters, without which commercial shipping could not operate. The *CCG* is also responsible for ice management in all Canadian waters. The *CCG* manages a research fleet for *DFO* science, and supplies vessels for *SAR* response.

192 The service consists of heavy, light and medium icebreakers, including icebreaking buoy tenders; aids-to-navigation service vessels and survey ships for marine research. Many other purpose-built vessels are provided for specialized duties such as search and rescue and shallow-draught operations on the Mackenzie River system and in the Arctic.

193 In winter, icebreakers assist shipping in the Gulf of St. Lawrence and in east coast waters and provide flood control icebreaking service on the St. Lawrence River.

194 In summer, the greater part of the fleet is concentrated on its task of keeping shipping channels safe for marine traffic. The icebreakers are sent to northern Canada to resupply government installations throughout the Arctic and then are stationed to provide escort, if required, to merchant shipping that carries the next year's supplies to civilian communities. Many of the *CCG* ships also serve as floating bases for scientific parties from other government departments engaged in oceanographic, hydrographic and related studies.

195 At the same time, the fleet provides icebreaker assistance when needed for commercial shipping using the summer sea route from the Atlantic Ocean through Hudson Bay to Churchill, Manitoba, and to shipping to the new drilling and mining developments in the Arctic.

196 The *Canadian Coast Guard* also carries out duties as the marine element of the search and rescue organization for which the *Canadian Forces* have the overall responsibility.

197 Principal bases for the ships are the department's district offices, at St. John's, Newfoundland and Labrador; Dartmouth, Nova Scotia; Saint John, New Brunswick; Charlottetown, Prince Edward Island; Québec and Sorel, Province of Quebec; Prescott and Parry Sound, Ontario; Victoria and Prince Rupert, British Columbia, and Hay River on Great Slave Lake in the Northwest Territories.

Search and Rescue

198 The *Canadian Forces* are responsible for co-ordinating all **Search and Rescue (SAR)** activities in Canada, including Canadian waters and the high seas off the coasts of Canada. **Joint Rescue Co-ordination Centres (JRCCs)** are located in the *Canadian Forces* bases at Halifax, N.S., Trenton, Ont. and Victoria, B.C. to co-ordinate activities in their regions. Each *JRCC* is the headquarters of a co-ordinated network of agencies trained and responsible to search for and aid vessels, aircraft or persons in distress. There are *Canadian Coast Guard* officers at each *JRCC*, who are on continuous watch to arrange the response to marine *SAR* incidents.

199 A **Marine Rescue Sub-Centre** (MRSC) will be maintained at Québec City until 2013. The *MRSC* is a sub-centre of the *JRCCs* and will coordinate response measures to *SAR* incidents in waters adjacent to the province of Quebec.

200 All distress situations and requests for assistance should be directed to the appropriate *MRSC* or *JRCC* via the nearest *Canadian Coast Guard Marine Communications and Traffic Services* centre, *Vessel Traffic Services* centre or by any other available means.

201 All *Government of Canada* ships and aircraft are available for search and rescue duties when required, as are all Canadian-registered ships in accordance with the *Canada Shipping Act, 2001*. In addition the *Canadian Coast Guard* operates a number of specialized vessels whose prime mission is search and rescue.

202 The *JRCC*s have current information on the location of all Government ships which can render assistance. Information regarding the disposition of participating commercial vessels which is held by the *Vessel Traffic Services* systems, Traffic Systems in Eastern and Arctic Waters of Canada and the *Automated Mutual-Assistance Vessel Rescue System (AMVER)* is available to the *JRCC*s. The *JRCC,* on being made aware of distress, will direct immediate action to ensure safety of life, and if possible the prevention of damage to or loss of any ship or its cargo, until such time as private or commercial salvage is available for this service.

203 The **Global Maritime Distress and Safety System (GMDSS)** is an international system using improved terrestrial and satellite technology and ship-board radio systems. It ensures rapid alerting of shore-based rescue and communications authorities in the event of an emergency. In addition, the system alerts vessels in the immediate vicinity and provides improved means of locating survivors. All ships subject to the *International Convention for the Safety of Life at Sea (SOLAS), 1974* are required to comply with *GMDSS*; all other vessels equipped with radio are also affected.

204 See *Canadian Coast Guard* publication *Radio Aids to Marine Navigation* for more information, including areas of coverage (sea areas). Mariners are also advised to contact

Transport Canada, Marine Safety Directorate Offices for communications equipment carriage requirements relating to the *GMDSS*.

205 **Helicopter evacuation** can be hazardous to both patient and helicopter crew and should only be used as a last resort to prevent death or permanent injury.

206 If helicopter evacuation is necessary you must be prepared to proceed within range of a helicopter. Most rescue helicopters cannot proceed more than 150 miles offshore, and then only if weather conditions permit. If you are beyond helicopter range advise the *Canadian Coast Guard* of your intentions so that a rendezvous can be selected. In order that the *Canadian Coast Guard* can evaluate the need for helicopter evacuation the following information should be ready:

- name of vessel, call sign, position, course and speed;
- patient's name, age and sex;
- state of consciousness;
- respiration rate and difficulty or pain associated with breathing;
- pulse rate, strength and regularity;
- temperature of patient;
- nature and specific location of pain; is pain dull, sharp, continuous, intermittent, confined to a small area or widespread;
- when injury occurred and cause, nature of wound, cuts or bruises; state if patient has been moved;
- determine amount of bleeding;
- any deformity or abnormal functioning on the part of the patient;
- what treatment has been given and how has patient responded;
- ETA destination and intentions;
- agent's or owner's name, address;
- radio frequency vessel standing by on and other back-up frequencies available.

207 When evacuation of personnel by helicopter is planned, prepare a suitable hoisting area, preferably aft, with a minimum radius of clear deck, 15 m if possible. The foredeck should be prepared only when the stern and amidships area cannot possibly be used. If the bow area is the only area available, change course to place the wind 15°–30° off the starboard quarter. Be sure to advise the helicopter before it arrives, so the pilot can approach to aft, amidships or forward, as required. Point search lights vertically to aid the helicopter in locating the ship; turn them off when the helicopter is on the scene.

208 In preparing the hoist area booms, flagstaffs, stays, running gear, antenna wires, etc., must be cleared away. Secure loose gear, the headgear worn by crew at the hoist area, awnings and trice up running gear. At night, light the pick-up area but shade the lights so as not to blind the pilot. Put lights on any obstructions in the vicinity so that the pilot will be aware of their position. Arrange a set of hand signals to be used among crew members who will assist because there will be a high noise level under the helicopter and voice communication on deck will be virtually impossible.

209 Do not secure any line from a helicopter to the vessel; merely tend it by keeping a moderate tension on it by hand. Allow the *SAR* Technician, basket or stretcher from the helicopter to touch the deck before assisting to avoid static electrical shock.

210 Leave the patient in a warm dry area. The *SAR* Technician that will be lowered to the vessel will evaluate the patient's condition and organize the hoisting of the patient to the helicopter. Make sure the patient's documentation is available, passport, visa, hospital insurance card, etc., as well as the patient's medical record and have them packaged ready for transfer with the patient. Have a life jacket available but do not put it on the patient until the *SAR* Technician has made an examination.

211 **Airborne liferafts** and survival equipment can be dropped by *Canadian Forces* fixed wing aircraft and helicopters. The complete drop consists of a line 305 m long with a 10-person inflatable dinghy at each end and a number of survival packages in between. This is dropped upwind to a distressed mariner; the dinghies inflate upon contact with the water.

212 **Rescue locator systems** such as the Emergency Locator Transmitter (ELT) for aircraft, the Submarine Distress Indicator Buoy or the Distress Radio Transmitting Buoy for submarines, and the **Emergency Position Indicator Radio Beacon (EPIRB)** for surface vessels, which transmit a homing signal on distress frequencies; and the **Search And Rescue (Radar) Transponder (SART)** which allows radar-equipped vessels to home-in on its signal, greatly enhance the probability of locating vessels in distress or survivors in the minimum amount of time.

213 Requirements concerning the carriage of *EPIRBs* may be found in the *Ship Station (Radio) Regulations, 1999*.

214 Requirements concerning the carriage of *SARTs* may be found in the *Ship Station (Radio) Regulations, 1999*; the *Life Saving Equipment Regulations*; the *Large Fishing Vessel Inspection Regulations* and the *Small Fishing Vessel Inspection Regulations*.

215 The 406 MHz *EPIRBs* which are designed to operate with the COSPAS/SARSAT satellite system provide a high location accuracy in addition to the automatic alerting of shore based facilities via polar-orbiting satellites. Other advantages of the system are global coverage including all areas of the Canadian Arctic and the ability to operate equally well on inland and coastal waters as well as ocean areas.

216 Satellite-compatible *EPIRBs*, operating on 406 MHz, are required under the *International Convention for the Safety of Life at Sea (SOLAS), 1974*.

Aircraft signals

217 The following manoeuvres performed in sequence by an aircraft mean the aircraft wishes to direct a surface craft toward an aircraft or a surface craft in distress. First, the aircraft circles the surface craft at least once. Second, the aircraft crosses the projected course of the surface craft close ahead at low altitude and rocks its wings, or opens and closes the throttle, or changes the propeller pitch. Due to high noise levels onboard surface craft, the rocking of wings is the primary means of attracting attention. The above-mentioned sound signals may be less effective and are regarded as alternative methods. Third, the aircraft heads in the direction in which the surface craft is to be directed. A repetition of such manoeuvres has the same meaning.

218 The following manoeuvre by an aircraft means the assistance of the surface craft to which the signal is directed is no longer required. The aircraft crosses the wake of the surface craft close astern at a low altitude and rocks its wings, or opens and closes the throttle, or changes the propeller pitch.

219 A **ship-to-air distress signal** for use in Canadian waters has been designed in conjunction with the *Canadian Forces* and the *National Search and Rescue Secretariat*. The signal consists of a cloth painted or impregnated with fluorescent paint showing a disc and square to represent the ball and flag of the international visual distress signal. Evaluation tests by *Canadian Forces* aircraft indicate the most suitable colour combination is black symbols on a background of fluorescent orange-red. The smallest useful size is a cloth 1.8 m by 1.1 m showing symbols which have dimensions of 46 cm and are 46 cm apart. Grommets or loops should be fitted at each corner to take securing lines.

220 As the purpose of the signal is to attract the attention of aircraft it should be secured across a hatch or cabin top. In the event of foundering it should be displayed by survival craft.

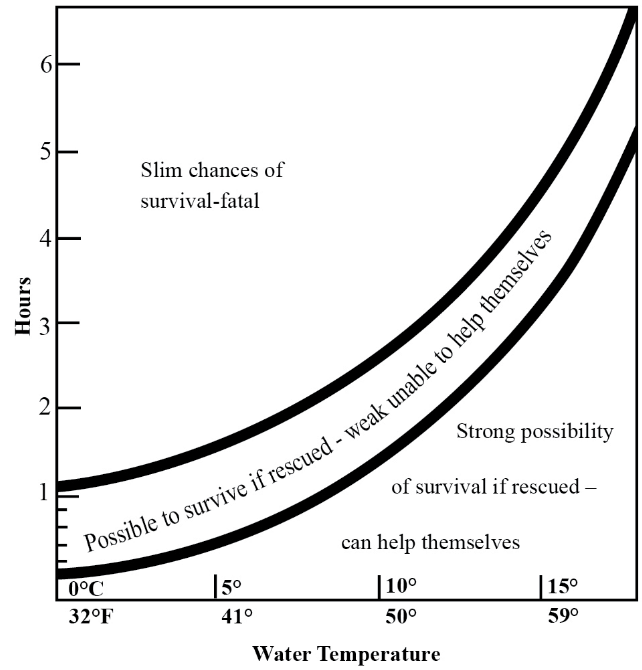
221 Search and rescue aircraft recognize this signal as a distress signal and look for it in the course of a search. Other aircraft on seeing this signal are requested to make a sighting report to the *Joint Rescue Co-ordination Centre (JRCC)* or *Marine Rescue Sub-Centre (MRCC)*.

222 The signals are commercially available but can be made aboard ship without difficulty.

Cold water survival

223 Although water temperatures may warm-up towards the end of summer, Canadian waters are cold.

COLD WATER SURVIVAL



Without appropriate protective clothing, even a short period of immersion in cold water causes **hypothermia**, a lowered deep-body temperature which can be fatal. Protective clothing such as an immersion suit or a Personal Flotation Device (PFD) with good thermal protection helps prevent hypothermia.

224 Skin and external tissues cool very rapidly in cold water, and in 10 to 15 minutes the temperature of the heart, brain and other internal organs begins to drop. Intense shivering is an attempt to increase the body's heat production and counteract the large heat loss.

225 Once cooling of the deep body begins body temperature falls steadily; unconsciousness can occur when it drops from the normal 37˚C to about 32˚C. When the body core cools to below 30˚C, death from cardiac arrest usually results.

226 Persons without thermal protection become too weak to help themselves after about 30 minutes in water temperature of 5°C, and after an hour the chances of survival are slim even if rescued.

227 Predicted survival times in a water temperature of 10°C are shown in the table.

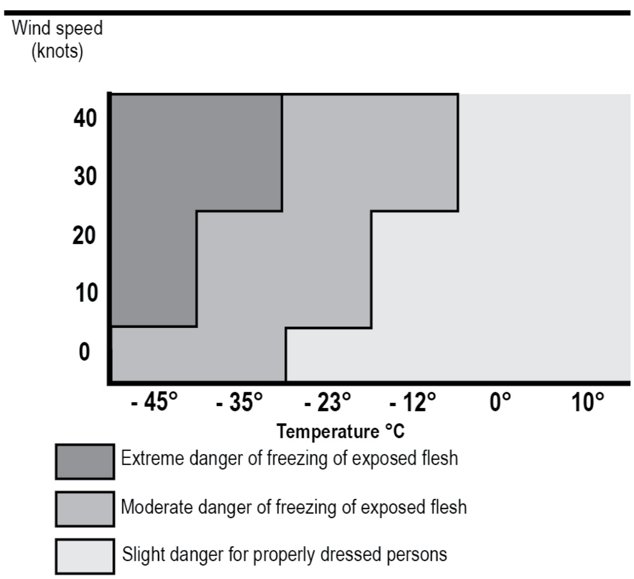
- In 10°C water
- Clothing worn was cotton shirt, pants and socks plus running shoes.

Table 3: Predicted Survival Time*

Situation	Time (Hours)
No flotation	—
Drownproofing	1.5
Treading water	2.0
With flotation	—
Swimming slowly	2.0
Holding still	2.7
HELP	4.0
Huddle	4.0
Flotation jacket	7.0

*In 10°C water
Clothing worn was cotton shirt, pants and socks plus running shoes.

EFFECT OF WIND ON EXPOSED PERSONS



228 In almost all weather conditions the body cools much faster in water than in air, so the less body surface submerged the better. The parts of the body with the fastest heat loss are the head and neck, the sides of the chest, and the groin. To reduce body heat loss, protect these areas.

229 Two ways of reducing heat loss are:

- HELP (Heat Escape Lessening Position): arms held tight against the sides, ankles crossed, thighs close together and raised;
- Huddle: two or more persons in a huddle with chests held close together.

To use these methods successfully, a person must be wearing a PFD. As shown in the table, survival time is greatly increased by wearing clothing that gives thermal protection, including a hood to prevent heat loss from the head.

230 Do not swim to keep warm as this causes extra heat to be lost to the cold water due to the extra circulation to the arms, legs and skin. If you have no PFD, remain as still as you can, moving your arms and legs just enough to keep your head out of water.

231 **Rewarming after mild hypothermia**. — If the casualty is conscious, talking clearly and sensibly and shivering vigorously, then:

- get the casualty out of the water to a dry sheltered area;
- remove wet clothing and if possible put on layers of dry clothing; cover head and neck;
- apply hot, wet towels and water bottles to the groin, head, neck and sides of the chest;
- use electric blankets, heating pads, hot baths or showers;
- use hot drinks but **never alcohol**.

232 **Rewarming after severe hypothermia**. — If the casualty is getting stiff and is either unconscious or showing sign of clouded consciousness such as slurred speech, or any apparent signs of deterioration, immediately (if possible) transport the casualty to medical assistance where aggressive rewarming can be initiated.

233 **Caution**. — Once shivering has stopped, there is no use wrapping casualties in blankets if there is no source of heat as this merely keeps them cold. A way of warming must be found quickly. Some methods are:

- put the casualtyin a sleeping bag or blankets with one or two warm persons, all with outer clothing removed;
- use hot, wet towels and water bottles as described above;
- warm the casualty’s lungs by mouth-to-mouth breathing;
- warm the chest, groin, head and neck but not the extremities of the body as this can draw heat from the area of the heart, sometimes with fatal results. For this reason, do not rub the surface of the body. Handle the casualty gently and keep in a prone position if possible, to avoid damaging the heart.

234 **Caution**. — The risk of frostbite on exposed body parts increases considerably with wind speed; appropriate measures for protection should be taken.

235 **Arctic survival**. — See Chapter 4.

Regulations

236 List of Statutes, Regulations, Guidelines and Conventions:

Arctic Waters Pollution Prevention Act

- *Arctic Shipping Pollution Prevention Regulations*
- *Arctic Waters Pollution Prevention Regulations*
- *Charts and Nautical Publications Regulations, 1995*
- *Navigation Safety Regulations*
- *Ship Station (Radio) Regulations, 1999*
- *Shipping Safety Control Zones Order*

Canada Customs Act

Canada Shipping Act, 2001

- *Collision Regulations*
- *Pollutant Discharge Reporting Regulations, 1995*
- *Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals*
- *Shipping Casualties Reporting Regulations (SOR/85-514)*
- *Vessel Operation Restriction Regulations*
- *Canadian Environmental Protection Act, 1999*
- *Disposal at Sea Regulations*

Criminal Code

Health Canada

- *Ship Sanitation Certificate Program*

Marine Transportation Security Act

- *Marine Transportation Security Regulations*

Marine Liability Act

Migratory Birds Convention Act, 1994

Quarantine Act

Transport Canada

- *Arctic Ice Regime Shipping System (TP12259)*

237 Through the **Arctic Waters Pollution Prevention Act** of 1970, the *Government of Canada* seeks to ensure that businesses that operate near Arctic waters, and ships that navigate in Arctic waters, do so in a manner that preserves and protects the northern aquatic ecosystems.

238 The Arctic has been divided into 16 zones, by the **Shipping Safety Control Zones Order**, with Zone 1 having the most severe ice conditions and Zone 16 having the least severe.

239 Ships are divided into catagories according to their ice capabilities by the **Arctic Shipping Pollution Prevention Regulations**.

240 The *Arctic Shipping Pollution Prevention Regulations* also list equipment standards, manning standards, requirements for Ice Navigators, reporting requirements and exemptions.

241 Each Shipping Safety Control Zone has been assigned a series of dates indicating safe operating conditions for each category of ship. This is known as the **Zone-Date System**.

242 The *Zone-Date System*, however, does not allow ships to adapt to natural fluctuations in ice conditions. *Transport Canada* has instituted, on a trial basis, the **Arctic Ice Regime Shipping System (AIRSS)** to answer this need. The Ice Navigator aboard a ship uses current ice forecasts and planned routes to determine which ice regimes will be encountered. Under *AIRSS*, each ice regime is assigned an "ice numeral" value for each category of ship. If the numeral is zero or greater for each ice regime to be encountered, a vessel can submit an "Ice Regime Routing Message" to *NORDREG* and proceed. An "After Action" report is required. If any ice numeral is negative, the ship can select an alternate route, request ice-breaker support or wait for improved conditions. See *Ice Navigation in Canadian Waters, 1999 Edition (TP 5064)* (at https://www.publications.gc.ca/collections/collection_2010/mpo-dfo/T31-73-1999-eng.pdf) and *Arctic Ice Regime Shipping System Standards (TP 12259)* (at https://tc.canada.ca/en/marine-transportation/marine-safety/tp-12259e-arctic-ice-regime-shipping-system-airss-standard for more information.

243 Radio equipment, including *Emergency Position-Indicating Radio Beacons (EPIRBs)* and *Search and Rescue Transponders (SARTs)*, carriage standards, required documents, required spare parts and required electrical supply are detailed by the **Ship Station (Radio) Regulations (1999)** of the *Arctic Waters Pollution Prevention Act*.

244 No ship of any class shall navigate in any shipping safety control zone prescribed by the *Arctic Waters Pollution Prevention Act* unless the ship complies with **Collision Regulations**. Note that there are certain modifications to the Collision Regulations in waters under Canadian jurisdiction.

245 **Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals** expressly forbids the discharge of oil, oily mixtures, noxious liquids, pollutant substances listed in Schedule 1 of the regulations, sewage or sewage sludge, organotin compounds or garbage in Canadian waters by any ship, and by Canadian ships in any waters. Smoke pollution caused by ships is also covered by the regulations. Penalties for contravention of the regulations include fines of up to $1,000,000.00, imprisonment for up to eighteen months, or both.

246 The **Pollutant Discharge Reporting Regulations, 1995** requires the master or owner of any ship in Canadian waters or a Canadian ship in any waters, to immediately report discharge or probable discharge of a pollutant substance to a pollution control officer, if in Canadian waters; or if not in Canadian waters, to an appropriate official of the nearest coastal state. To make

a report pursuant to the *Pollutant Discharge Reporting Regulations, 1995*, in Northern Canada, contact the nearest *MCTS* centre or telephone 1-800-265-0237 or, if necessary the appropriate telephone number below:

a. If in waters adjacent to Quebec, contact the *Environmental Protection Operations Directorate – Quebec*, and *Environment Canada*, at 514-283-2333, or if within Quebec, 1-866-283-2333;
b. If in waters adjacent to Ontario, contact the *Spills Action Centre*, *Ontario Ministry of the Environment*, at 416-325-3000, or if within Ontario, 1-800-268-6060;
c. If in waters adjacent to or in Manitoba, contact the *Manitoba Department of Conservation*, at 204-944-4888;
d. If in Saskatchewan, contact the *Saskatchewan Ministry of Environment*, at 1-800-667-7525;
e. If in Alberta, contact the *Alberta Ministry of Environment*, at 780-422-4505 or 1-800-222-6514;
f. If in waters adjacent to or in Nunavut or Northwest Territories, contact the *Department of Environment and Natural Resources*, *Government of the Northwest Territories*, at 867-920-8130, or
g. If in waters adjacent to or in Yukon, contact the *Yukon Department of Environment*, at 867-667-7244.

247 The **Shipping Casualties Reporting Regulations (SOR/85-514)** require the Master of any ship in Canadian waters, or of a Canadian ship in any waters, to report a shipping casualty, accident or dangerous occurrence. Masters are reminded that penalties can be incurred for failing to report a shipping casualty.

248 The **Vessel Operation Restriction Regulations** include restrictions on the speed of vessels or prohibitions on the operation of power-driven vessels in a number of waterways in Canada for safety reasons. The Regulations provide for signs and/or buoys marking controlled, keepout or restricted areas.

249 The **Canadian Environmental Protection Act, 1999** prohibits unauthorized dumping of substances at sea; however, the Act allows emergency disposal of substances where it is necessary to avert a danger to human life or to a ship, an aircraft, a platform or another structure at sea, provided that a report is made as set out in the **Disposal at Sea Regulations**.

250 The **Criminal Code** contains prohibitions against certain acts by vessel operators. Offences include, among others, of operating a vessel in a manner that is dangerous to the public, dangerous operation causing bodily harm, dangerous operation causing death, operation while impaired, operation while impaired causing bodily harm and operation while impaired causing death. Penalties range up to life imprisonment.

251 The **Canada Customs Act** requires that every person in charge of a conveyance arriving in Canada shall, except in such circumstances and subject to such conditions as may be prescribed, ensure that the passengers and crew are forthwith on arrival in Canada transported to a *Canada Border Services Agency (CBSA)* office or the nearest office of the *Royal Canadian Mounted Police*. In the case of merchant ships not carrying passengers, where the person in charge intends to make a customs report by telephone, the person in charge must notify the *CBSA* not less than 2 hours and not more than 48 hours before arrival in Canada.

252 Health Canada, through its **Ship Sanitation Certificate** Program, protects public health by ensuring that international vessels stopping in Canada are free of contamination and infection, which could introduce communicable diseases. Under *International Health Regulations* (2005), vessels engaged in international trade are required to obtain either a Ship Sanitation Control Certificate, or a Ship Sanitation Control Exemption Certificate, every six (6) months. The Ship Sanitation Certificates replace the Deratification Certificate required by the *International Health Regulations* (1969). For more information on the issuance of Ship Sanitation Certificates, visit phb_bsp@hc-sc.gc.ca to request a free copy of the *Ship Sanitation Certificate Program Inspection Policy and Procedures Manual*. To request an inspection, visit gilles.chartrand@hc-sc.gc.ca or fax request to (514) 283-4317.

253 The **Marine Liability Act** defines liabilities and the limits of liability for shipowners regarding property damage, passengers, freight, and pollution. Civil liabilities regarding oil pollution are quite clear, and severe, and special funds have been established to help pay for cleanup costs if necessary. Evidence of financial responsibility to the limits of liability must be carried.

254 The **Marine Transportation Security Regulations** require that all ships in Canadian waters and all Canadian ships in any waters, with certain exceptions, have an International Ship Security Certificate or a Canadian Vessel Security Certificate and other documents as required; a duly approved Vessel Security Plan and a Ship Security Officer on board. Non-compliance with these regulations can incur fines of up to $25,000.00.

255 The **Migratory Birds Convention Act, 1994** provides for fines up to $1,000,000.00 and/or three years imprisonment for unlawfully being in possession of a migratory bird, egg or nest, among other offences, or

dumping without lawful excuse, in waters frequented by migratory birds, of any substance that is or could be harmful to migratory birds. *Migratory Bird Sanctuaries*, including maritime limits, are established in Regulations to the Act. Permits are required to enter a Migratory Bird Sanctuary except in cases of emergency.

256 The **Quarantine Act** requires the master of a vessel to inform a quarantine officer or cause a quarantine officer to be informed, as soon as possible before arriving in Canada, of any reasonable grounds to suspect that any person, cargo or other thing on board the conveyance could cause the spreading of a communicable disease. The Minister of Health may order the diversion of a conveyance, to any place in Canada specified by the Minister, if the Minister has reasonable grounds to believe that doing so is necessary to prevent the introduction and spread of a communicable disease.

257 **Caution**. — Mariners are cautioned that these synopses of regulations and acts are printed for determining **general impressions only** and that no liability is accepted for failure to publish complete details of any particular regulation. Mariners are also cautioned that changes or amendments may be made to regulations subsequent to the printing of this publication. Mariners are advised to make the necessary arrangements to be provided with the complete and latest regulations governing subjects of interest. Contact the nearest *Transport Canada Marine Safety* office. For further information, including mandatory documents, record keeping, inspections and exceptions, consult the "Regulations by Title" section of https://laws-lois.justice.gc.ca/eng/regulations/.

Chapter 2

Geographical Information

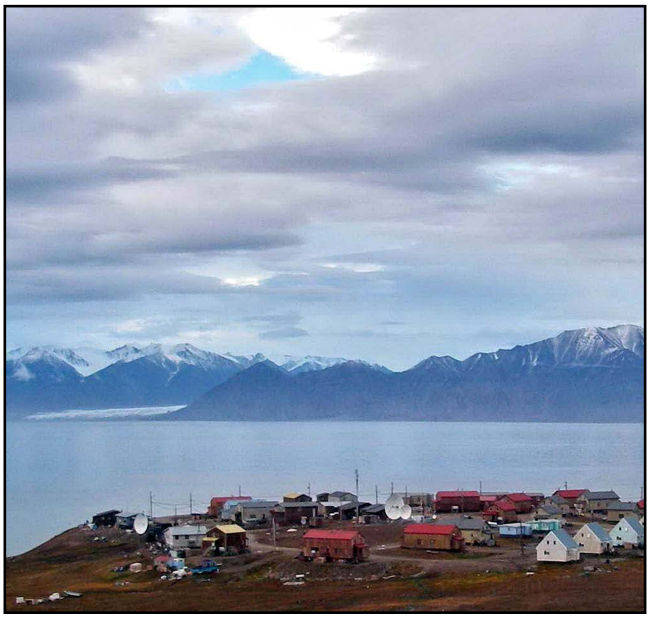


Photo by: Martin Fortier – ArcticNet

General

1 **Canada** is the largest country in the Western Hemisphere and second largest in the world. Its territory of 9,970,610 square kilometres of land and fresh water includes the almost semitropical Great Lakes peninsula and southwest Pacific coast, wide fertile prairies and great areas of mountains, rocks and lakes and northern wilderness and Arctic tundra. The farthest point south is Middle Island in Lake Erie *(41°41'N)*; 4,634 km north in the Arctic is Cape Columbia on Ellesmere Island, Canada's northernmost point *(83°07'N)*. From east to west the greatest distance is 5,514 km — from Cape Spear, Newfoundland and Labrador *(52°37'N)* to the Yukon/Alaska border. The offshore areas of the Canadian continental margin, including Hudson Bay, cover over 6.5 million square kilometres, an area equivalent to over 60% of Canada's total onshore area.

2 Most of Canada's 31.6 million people *(2006)* live within 300 km of the southern border that is shared with the United States for 6,415 km. Here, where the climate is generally moderate, the resources of the land, forest, mines and water have long been developed and utilized.

3 Politically, Canada is divided into ten provinces and three territories (the Yukon, Northwest Territories and Nunavut). Each province administers its own natural resources. Nunavut became the newest territory of Canada on April 1, 1999, when the Northwest Territories was divided into two parts. The part to the east of the dividing line became Nunavut, whereas the part to the west became a new territory which retained the name Northwest Territories. For political maps of Canada, see https://geo.ca/map-gallery/.

4 **Government of Canada**. — In Canada there is a fusion of executive and legislative powers. Formal executive power is vested in the Queen, whose authority is delegated to the Governor General, her representative. Legislative power is vested in the Parliament of Canada which consists of the Queen, an appointed upper house (the Senate) and a lower house (the House of Commons) elected by universal adult suffrage. The independence of the judiciary is safeguarded through the constitutional provision that superior court judges are appointed by the Governor-in-Council, that is, by the Governor General on advice of the Cabinet, and that they hold office during good behaviour

and cannot be removed unless both houses of Parliament, the Cabinet and the Governor General agree.

5 **Provincial and Territorial Governments**. — In each of the provinces, the Queen is represented by a Lieutenant-Governor appointed by the Governor General-in-Council. The Lieutenant-Governor acts on the advice and with the assistance of the Premier of the province who is responsible to the legislature and resigns office under circumstances similar to those concerning the Government of Canada.

6 The legislature of each province is unicameral, consisting of the Lieutenant-Governor and a legislative assembly. The assembly is elected by the people for a statutory term of five years but may be dissolved within that period by the Lieutenant-Governor on the advice of the Premier of the province.

7 The Yukon and the Northwest Territories are each governed by a Commissioner, appointed by the Government of Canada, and a legislative assembly elected by the people. Since April 1, 1999, the Government of Nunavut has been gradually assuming the responsibilities formerly exercised by the Government of the Northwest Territories, with the transfer of administration for programs in areas such as culture, public housing and health care to be complete by 2009.

8 The Canadian federal state of ten provinces and three territories had its foundation in an act of the British Parliament, the *British North America (BNA) Act, 1867*. This act was fashioned for the most part from Seventy-two Resolutions draughted by the Fathers of Confederation at Québec in 1864. The BNA Act provided for the federal union of three British North American provinces, Canada (Ontario and Québec), Nova Scotia and New Brunswick, into one dominion under the name Canada. The act made provision for possible future entry into Confederation of the colonies or provinces of Newfoundland, Prince Edward Island and British Columbia, and of Rupert's Land and the North-Western Territory, a vast expanse then held by the Hudson's Bay Company. In 1870, the company surrendered its territories to the British Crown which transferred them to Canada. From this new territory was carved Manitoba in 1870, much smaller at its inception than now, and later, in 1905, Saskatchewan and Alberta. British Columbia entered the union in 1871, followed by Prince Edward Island in 1873. It was not until 1949 that Newfoundland joined.

9 The *BNA Act, 1867*, which remains the country's basic constitutional document, and the amendments passed between 1871 and 1975, have been renamed and are now known as the *Constitution Acts 1867 to 1975*. The written constitution consists of the *Constitution Acts 1867 to 1982*, proclaimed by the Queen in Canada in 1982. The *Constitution Act, 1982* includes a *Charter of Rights and Freedoms* and a formula for amending the constitution.

10 The *Charter of Rights and Freedoms* guarantees fundamental rights and freedoms to individuals; freedom of speech, freedom of assembly, freedom of religion, freedom of the press, mobility rights, legal rights and similar liberties are recorded in the charter. The charter also provides specific constitutional protection to the use of the English and French languages.

11 As well as the written constitution, there are unwritten parts which are of equal importance such as common law, convention and usage which were transplanted from Great Britain over two hundred years ago and which are fundamental to the Canadian style of democratic government. Among these are the principles governing the Cabinet system of responsible government with its close identification and functioning of executive and legislative branches.

12 The constitution, in its broadest sense, also includes statutes of the Parliament of Canada pertaining to such matters as succession to the throne, the royal style and title, the Governor General, the Senate, the House of Commons, the creation of courts, the franchise and elections, as well as judicial decisions that interpret the written constitution and other statutes of a constitutional nature. The constitutions of the provinces of Canada form part of the overall Canadian constitution, and provincial acts which are of a fundamental constitutional nature similar to those listed above are also part of the constitution. The same can be said of both federal and provincial orders-in-council that are of a similar fundamental nature.

13 Apart from the creation of the federal union, the dominant feature of the *Constitution Act, 1867* and indeed of the Canadian federation, was the distribution of powers between the central or Government of Canada on the one hand and the component provincial governments on the other. In brief, the primary purpose was to grant to the Parliament of Canada legislative jurisdiction over all subjects of general or common interest, while giving to the provincial legislatures jurisdiction over all matters of local or particular interest. These powers cover the whole area of government and each level of government is sovereign with respect to the powers it exercises. Hence, provincial governments, when acting within their jurisdiction as set out in the *Constitution Acts, 1867 to 1982*, are as sovereign as the Government of Canada when acting within its spheres of power.

Northwest Territories

14 The *Temporary Government Act, 1869* was the first legislation by the Government of Canada to establish government in the newly acquired Rupert's Land and North-Western Territory. However, functional territorial government really dates from the *Northwest Territories Act, 1875*. The creation of the Provinces of Saskatchewan and Alberta in 1905 and the adjustment of the northern boundaries of the Provinces of Manitoba, Ontario and Québec by 1912 pushed the Territories north of the 60th parallel. The 1905 legislation provided for a federally appointed Commissioner with wide executive and legislative powers and a Council of four but no Councillors were appointed for sixteen years. In 1921 the Council was expanded to six members and, until 1946 when the first territorial resident was appointed, it was comprised entirely of senior federal officials.

15 Defence early warning systems, radio and greatly improved air transportation after World War II ended the extreme isolation of the North and pressures for improved territorial government soon followed. The main advances came with legislative changes in 1951 and 1952 when the Council membership was increased to eight, with three of these elected from the Mackenzie District. A fourth was added in 1954. At least two Council sessions were required to be held each year; one in the Territories and all others at the seat of government in Ottawa. The subjects on which the Commissioner in Council could legislate were increased to approximate those of the provincial legislatures except that natural resources (other than game) were reserved to the Government of Canada. A Territorial Court was established.

16 Since federal interest in the North intensified in the 1950's, there have been concern and effort to arrange for a resident territorial government and to chart the course of its future development. An amendment to the *Northwest Territories Act*, in 1966, created three new electoral districts in the Eastern Arctic and, for the first time, gave elected representation to all residents of the Territories. Also, at the ensuing election the first Inuit was elected to the Territorial Council. A separate consolidated revenue fund was set up for the territorial government and wider powers in other areas of financial administration were introduced.

17 Meanwhile, in 1965, the Government of Canada had appointed an Advisory Commission on the Development of Government in the Northwest Territories which travelled widely in the North to examine local needs for change. Following receipt of its recommendations in 1966, the Government of Canada acted quickly to provide for a territorial administration resident in the Territories. Yellowknife was designated as the seat of territorial government and arrangements were begun to accommodate the Commissioner and staff in the new capital.

18 The **Northwest Territories Act, 1970**, provides for an executive, legislative and judicial structure. The Commissioner is the chief executive officer, appointed by the Government of Canada and is responsible for the administration of the Northwest Territories under the direction of the Minister of *Indian and Northern Affairs Canada*. The Commissioner spends funds voted by the legislative assembly and all new revenue measures are subject to assembly approval. Normally the Commissioner obtains federal approval of proposed legislation and budgetary measures before submitting them to the assembly.

19 The legislative assembly of the Northwest Territories has legislative powers similar to those of a provincial legislature. The *Northwest Territories Act* gives the assembly authority to legislate in most areas of government activity except for natural resources other than game, forestry and fire suppression; these are reserved to the Government of Canada. Legislation must receive three readings and have the assent of the Commissioner. The Government of Canada may disallow any act within one year.

20 The legislative assembly consists of nineteen members elected for four years. It meets twice a year, usually for six weeks at a winter session and for a shorter fall session. A third short spring or summer session may also be held. The assembly does not, at present, operate on a party system. Its members attempt to make decisions and provide advice to the executive council by consensus. The legislative assembly selects its speaker from among its members. A majority of the members of the legislative assembly are of aboriginal descent.

21 The executive council is the senior decision-making body of the government of the Northwest Territories. The Commissioner continues to be the formal head of government. The legislative assembly nominates up to eight of its members to the executive council and chooses one as government leader and chairman of the executive council. Each elected executive council member is responsible for one or more departments of the Territorial government. Executive members are collectively responsible for decisions on policy and programs, for relations with federal and provincial governments and for the general conduct of the government of the Northwest Territories.

22 The federal *Department of Justice* Minister is the Attorney General of Northwest Territories under the

Criminal Code of Canada, with responsibility for criminal but not for civil matters or the constitution or organization of the courts. Law enforcement is provided by the *Royal Canadian Mounted Police*.

23 Yellowknife, on the north arm of Great Slave Lake, was named the capital in 1967.

24 The population of the Northwest Territories is 41,464 *(2006)*.

25 The **Government Organization Act** charges the Minister of *Indian and Northern Affairs Canada* with responsibility for the development of the North and for the general co-ordination of federal activities in the area. Other Government of Canada agencies, such as the northern region health service of *Health Canada* and the *Royal Canadian Mounted Police*, are responsible for health and police services with the territorial government sharing their costs. *Transport Canada* operates main line airports throughout the north; the *Canadian Broadcasting Corporation* provides live radio and television service via Anik, a communications satellite, and special high-frequency northern broadcasts, and maintains local stations in the territories. Federal cost-shared national assistance programs, appropriate to territorial needs, are available on the same conditions as they are to the provinces.

26 Extensive financial assistance is given to the territorial government under special federal-territorial agreements. These agreements allocate the financial responsibility of each government for the provision of services in the territories.

Yukon

27 The Yukon was established as a separate territory in 1898 to meet a need for local government created by the influx of miners during the gold rush period. The *Yukon Act* provided for a Commissioner and a Council of not more than six, all appointed by the Governor-in-Council. The Commissioner-in-Council was given legislative powers comparable to those held by the Lieutenant-Governor and the Legislative Assembly of the provinces. By 1902, five elected councillors had been added and in 1908 a fully elected Council of ten members was introduced. A population decline following the end of the gold rush was accelerated by enlistment during World War I and in 1919 the Council was reduced to three elected members. This remained the level of government until after World War II when population and economic activity again showed an increase, beginning with the building of the *Alaska Highway*. In 1960, the Council was increased to seven elected members and provision was made for the appointment of an Advisory Committee on Finance.

28 A principal feature of territorial government is its very close constitutional and working relationship with the Government of Canada. Although the provinces and the Government of Canada each have jurisdiction and powers originally allocated by the *British North America Act*, the authority of the Territorial government is allocated only by federal legislation. The *Yukon Act* prescribes the structure of the executive, legislative and judicial branches of the territorial government and the scope of their authority; all residual matters remain under federal control. The Territory has fully representative but not responsible government. The Act has been amended to give increased authority to the territorial government and it provides that the number of subjects on which the Legislative Assembly can legislate may be increased by the Governor-in-Council. The *Yukon Act* also provides for the designation of the seat of government; Whitehorse, the single large community in the territory, was so designated in 1953.

29 The constitution for the government of the Yukon is based on two federal statutes: the ***Yukon Act*, *2002***, and the *Government Organization Act*, 1966. The *Yukon Act* provides for a Commissioner as head of government and for a legislative body called the Legislative Assembly of Yukon. Under the *Government Organization Act*, the Minister of *Indian and Northern Affairs Canada* is responsible (with the Governor-in-Council) for directing the Commissioner in the administration of the Yukon.

30 'Devolution' refers to the transfer of authority from Canada to Yukon. This has been a gradual process, largely over the past 30 years. In the 1970s the Yukon gained control over the administration of justice, highway maintenance personnel and resources, and the administration of fresh water sports fishing. In the 1980s came control over land titles and the assets of the *Northern Canada Power Commission*. The 1990s saw the transfer of control over oil and gas, health care and airports.

31 On April 1, 2003 Yukon gained control over its natural resources, a power the provinces have but Nunavut and the Northwest Territories do not. Crown Land (land belonging to the government) is still owned by the federal government, though the territory manages it and has the right to get resources royalties from it. In the provinces the provincial government owns Crown Land.

32 With this transfer the Yukon Legislative Assembly now has the power to make laws in more areas than before. However, this transfer of power will not change the Yukon's constitutional status. Territorial jurisdiction will continue to be enshrined in a federal law, the *Yukon Act*, not the *Constitution of Canada*.

33 Yukon includes two cities, one town, four villages, one hamlet and eight unorganized communities. The cities, towns and villages have full municipal status and are responsible for their own taxation and administration. The Yukon government provides municipal services to the unorganized communities. The seat of government was moved from Dawson City to Whitehorse in 1953.

34 The population of the Yukon is 30,372 *(2006)*.

Nunavut

35 Nunavut has a population of approximately 29,500 *(2006)*, of whom more than 80% speak Inuktitut as their first language. All of the population lives in one of 28 communities. The largest community is the capital, Iqaluit.

36 Nunavut makes up one-fifth of Canada, and is the largest component part of the country. Nunavut's area (land plus freshwater) is 2,093,190 square kilometres.

37 On the official Government of Nunavut Web site, www.gov.nu.ca, users can find out details about the origin of Nunavut, its government and its people. This site also provides links to other sites in Nunavut.

38 The Atlas of Canada site, atlas.nrcan.gc.ca, has a substantial set of maps and other information pertaining to Nunavut. Two sections specifically referring to the territory are:

- "People & Society" for the "Nunavut" topic;
- "Reference Maps" then to sections on Provinces and Territories for a map of Nunavut.

39 A good source of information is the Community Profiles site in Statistics Canada, http://www.statcan.ca/.

40 Another site of interest is the map visualization site prepared by the Centre for Topographic Information, *Natural Resources Canada* at https://natural-resources.canada.ca/science-and-data/science-and-research/geomatics/geospatial-data-tools-and-services/10785. This site has several interesting maps of Nunavut.

41 When it became a territory in 1999, Nunavut had already held an election to its legislature. Nineteen members were elected, one for each constituency. The members elected retained the tradition of the Northwest Territories in not having party affiliation.

42 The **Nunavut Planning Commission (NPC)** was established under the *Nunavut Land Claims Agreement* and is responsible for land use planning and various aspects of environmental reporting and management in the new Territory.

43 NPC's main function is to develop land use plans, policies and objectives that guide resource use and development throughout Nunavut, with an emphasis on protecting and promoting the existing and future well-being of the residents and communities of the Nunavut Settlement Area. It should be noted that the term "land use" also includes water, wildlife and offshore areas.

44 For the past few years, the NPC has been actively mapping wildlife populations, human use, and areas of archaeological significance while examining land use issues. This mapping work combines the invaluable knowledge of the Inuit with the latest computer mapping technology.

45 Members of the NPC are nominated by Inuit organizations and the governments of Canada and Nunavut.

46 The Nunavut Implementation Commission *(1993-1999)* consisted of nine members named by the Government of Canada, six of whom had to be residents of Nunavut. The Commission advised all parties on the funding and design of training plans, the timetable for transferring services, and the process for holding the first election for the Government of Nunavut, in February 1999. This initial transition phase ended with the election.

47 Nunavut is made up of three distinct cultural regions: Qikiqtaaluk includes Melville Peninsula, Baffin Island and the Queen Elizabeth Islands; Kivalliq includes NW Hudson Bay, with most of its watershed, and Southampton Island; and Kitikmeot includes the mainland shores and islands west of the Gulf of Boothia and south of Parry Channel. There are twenty-eight communities in all. The Nunavut Government is decentralized, with government departments and agencies set up in communities throughout the territory, thereby sharing the economic benefits and responding to the particular needs of each region. For more information on the Government of Nunavut, see http://www.gov.nu.ca/.

48 Elders play a crucial advisory role in all aspects of Inuit society and political structure.

49 **Legal system**. — With one exception, in all provinces as well as in the three territories, the legal system derives from the common law system of England. The exception is the province of Québec where the system has been influenced by the legal developments of France. Québec has its own Civil Code and Code of Civil Procedure. Over the years, both Canadian common law and Québec civil law have developed unique characteristics.

50 The criminal law of Canada has as its foundation the criminal common law of England built up through the ages and consisting first of customs and usages and later expanded by principles enunciated by generations of judges.

51 **Currency**, **weights and measures**. — The legal currency in Canada is the Canadian dollar with coinage in 1, 5, 10, 25, 50 cents, and one dollar and two dollar denominations. Bank of Canada notes in denominations of 5, 10, 20, 50, 100 and 1,000 dollars are legal tender.

52 In the past the Imperial system of weights and measures has been followed, an exception being the ton, where unless otherwise stated, the short ton of 2,000 pounds was used. Canada has converted to the metric system of weights and measures.

53 **Holidays**. — In addition to Sundays the following holidays are observed

- *New Year's Day
- Good Friday
- Easter Monday
- Queen's Birthday (by proclamation)
- *Canada Day (1 July)
- Civic Holiday (1st Monday in August)
- Labour Day (1st Monday in September)
- Thanksgiving Day (by proclamation)
- *Remembrance Day (11 November)
- *Christmas Day
- *Boxing Day (1st weekday after Christmas)

*When these days fall on a Saturday or Sunday government offices observe them on the following Monday.

54 The Yukon has a General Holiday on "Discovery Day," usually the third Monday in August, to celebrate the discovery of gold in the Klondike.

55 **Post offices** are located at all settlements in the Canadian Arctic.

56 **Customs**. — The **Canadian Border Services Agency (CBSA)** maintains customs offices at the Iqaluit airport in Nunavut and the Inuvik airport in the Northwest Territories. Service is provided at both locations from 0900 to 1700 hours Monday to Friday, exclusive of statutory holidays. Should service be required outside authorized hours or if further information is required, call 1-800-461-9999. No immigration services are provided.

57 The CBSA also offers seasonal vessel customs reporting services, as required, at Tuktoyaktuk and Churchill. No immigration services are provided.

58 Customs service at other northern ports is provided by local *Royal Canadian Mounted Police* detachments.

59 **Time zones**. — Canada has six standard time zones referenced to Coordinated Universal Time (UTC), which is the modern implementation of Greenwich Mean Time. From east to west, these zones are called Newfoundland and Labrador, Atlantic, Eastern, Central, Mountain and Pacific Standard Time. Four of these zones are used in Canada's north.

60 *Eastern Standard Time*, five hours slow on UTC, is kept in that part of Nunavut that is east of the 85th meridian of west longitude, and in Southampton Island and the islands adjacent to Southampton Island.

61 *Central Standard Time*, six hours slow on UTC, is kept in that part of Nunavut that is between the 85th meridian of west longitude and the 102nd meridian of west longitude, except Southampton Island and the islands adjacent to Southampton Island and all areas lying within the Kitikmeot Region.

62 *Mountain Standard Time*, seven hours slow on UTC, is kept in that part of Nunavut that is west of the 102nd meridian of west longitude, and all areas lying within the Kitikmeot Region.

63 *Mountain Standard Time* is also kept in the Northwest Territories.

64 *Pacific Standard Time*, eight hours slow on UTC, is kept in the Yukon.

65 *Daylight Saving Time* is observed in Nunavut (except Southampton Island and the islands adjacent to Southampton Island), in the Northwest Territories, and in the Yukon from the **second Sunday of March to the first Sunday of November**. Daylight saving time is one hour ahead of standard time; *Central Daylight Time*, for example, is five hours slow on UTC.

Inuit

66 For many centuries, outsiders called Inuit "Eskimos". Inuit no longer find this term acceptable. They prefer the name by which they have always known themselves: Inuit, which means "the people" in their own language, Inuktitut.

67 Inuit inhabit vast areas of Nunavut, the Northwest Territories, the coast of northern Labrador and about 25 percent of Northern Quebec. Traditionally, they have lived above the treeline in the area bordered by Alaska in the west, the Labrador coast in the east, the southern tip of Hudson Bay in the south and the High Arctic Islands in the north.

68 About 55,700 Inuit live in 53 communities across the North. The Inuit population has grown rapidly over the past few decades. According to Statistics Canada, if present trends continue, there will be about 84,600 Inuit in the North by 2016.

69 Inuit are one of the three Aboriginal peoples in Canada, as defined by the Canadian Constitution. The other two Aboriginal peoples are First Nations and Métis people.

A culture rooted in the land

70 Inuit origins in Canada date back at least 4,000 years. Their culture is deeply rooted in the vast land they inhabit. For thousands of years, Inuit closely observed the climate, landscapes, seascapes and ecological systems of their vast homeland. Through this intimate knowledge of the land and its life forms, Inuit developed skills and technology uniquely adapted to one of the harshest and most demanding environments on earth.

71 Inuit treated human beings, the land, animals and plants with equal respect. Today, they continue to try to maintain this harmonious relationship. They try to use the resources of land and sea wisely to preserve them for future generations.

72 Strict hunting traditions and rules help maintain this balance. Inuit in Labrador, for example, forbid the killing of any animal in its mating season.

73 Before the creation of permanent settlements in the 1940s and ’50s, Inuit moved with the seasons. They established summer and winter camps to which they returned each year. These seasonal camps enabled Inuit to use the resources of land and sea at the times of the year they were most abundant.

74 Traditional knowledge about Inuit history, and the land, plants and wildlife, has been passed down through the generations. The family is the centre of Inuit culture, and co-operation and sharing are basic principles in Inuit society. Inuit share the food they have hunted, and everyone does his or her part to help those in need.

75 Inuit culture has been exposed to many outside influences over the past century. Nevertheless, Inuit have managed to hold on to their values and culture. Inuktitut is still spoken in all Inuit communities. It is also the principal language used in radio and television productions originating in the North, and it is in the school curriculum.

76 Many Inuit communities continue to practise traditional Inuit dance and song, including the drum dance and throat singing. Oral tradition and storytelling are still very much alive in Inuit culture, with tales passed down over the centuries. These stories are often about powerful spirits that inhabit the land and sea. They have been a continuing source of inspiration for Inuit artists whose prints and sculptures are prized by collectors and art galleries around the world.

The contact period

77 The first regular contact between Inuit and Europeans began in the mid-1700s when European whalers arrived in the Arctic. By the late 1800s the whaling industry had started to decline and it was replaced by the fur trade. In the decades that followed, an economic relationship based on fur trading developed between Inuit and Europeans.

78 Apart from encounters with fur traders and some explorers, Inuit had very little contact with the rest of Canada until the 1940s. By then, the Canadian government had begun to establish its presence in the Arctic.

79 The government encouraged Inuit to live in permanent settlements, instead of their seasonal camps. These settlements were soon supported by *Royal Canadian Mounted Police (RCMP)* detachments, health and social services, and a housing program.

80 In the 1960s, Inuit began to form marketing co-operatives to help sell local products, including art prints and carvings that were to become world-famous. By the 1970s, the new centralized settlements had become a permanent feature of Inuit life, with new schools and improved medical facilities. Regular air travel and telecommunications helped link the settlements to each other and the rest of the world.

81 Inuit communities are governed by elected municipal councils. Supporting these councils are committees that deal with hunting, fishing and trapping, and health and education. Inuit schools today offer a modern educational system that incorporates cultural teachings, including Inuktitut language teaching.

The Inuit economy today

82 Today, Inuit work in all sectors of the economy, including mining, oil and gas, construction, government and administrative services. Many Inuit still supplement their income through hunting.

83 Tourism is a growing industry in the Inuit economy. Inuit guides take tourists on dogsled and hunting expeditions, and work with outfitting organizations. About 30 percent of Inuit derive part-time income from their sculpture, carving and print making.

84 The settlement of land claims in the Northwest Territories, resulting in the creation of Nunavut, and of land claims in Northern Quebec, known by its Inuit inhabitants as Nunavik, has given the Inuit money and a framework to develop and expand economic development activities. New emerging businesses include real estate, tourism, airlines and offshore fisheries.

Plant and Animal Life

Vegetation

85 There are three main vegetation regions, or ecotones, in northern Canada: the Arctic tundra, including the High Arctic subregion of the Arctic coast and islands and the Low Arctic subregion of the mainland barren lands and Péninsule d'Ungava; the Subarctic forest-tundra, a wide transition zone between tundra and taiga south of the treeline; and the taiga, or boreal coniferous forest, to the south of the forest-tundra, stretching from the Slave, upper Mackenzie and Liard Rivers systems in the Northwest Territories to Quebec.

86 The Arctic tundra is a land without trees. Tundra soils are churned by frost actions, subject to low temperatures which hinder the decay of organic matter, and soil fauna are scanty. Continuous permafrost retards plant growth and prevents deep root penetration. Even in areas which contain excess moisture owing to poor drainage, the soil is physiologically dry for plants because low temperatures and low pH retard absorption by the roots. Finally, the summer growing season is very short and winter, long and harsh.

87 Despite such formidable obstacles, varieties of plant species survive and thrive in the Arctic tundra. Many display special adaptations to their Arctic environment. They tend to be low and compact to trap radiant energy. Some have thick, waxy cuticles or protective fuzz. Tundra plants sometimes start growth under the snow, and can often withstand freezing. Most are perennials capable of storing food over the winter. They reproduce quickly and disperse readily.

88 In the High Arctic, a large proportion of the ground is bare of plant life. High wasteland fields composed of wind-eroded, frost-heaved rock fragments, can feature crustose lichens, black lichen mats and colonies of avens. Flat bush berries stunted by high winds grow in protected nooks and crannies. Arctic oases of complete and colourful plant cover, can, however, be found along water courses or seepage areas.

89 High wasteland fields and rock deserts composed of grasses and lichens supplied with moisture from melting snowdrifts are also characteristic of the Low Arctic. Here, however, fields are mainly confined to the dry, windswept ridges. Somewhat wetter areas are clothed with cotton sedge tussocks, interspersed with dwarf birch, willows, lichens and mosses important as food to the tundra animals. Wetland areas are dominated by grasses, sedges and rushes, with occasional pockets of lush vegetation. Shrubs grow taller and may form minature functional canopies.

90 Some common species of the Arctic tundra include small ferns, crowberry, cotton-grass and brightly coloured flowering plants such as moss-pink, Arctic poppy, saxifrages, locoweeds and alpine milk vetch, in the rock deserts; various grasses and sedges, Arctic lupine, coltsfoot and various members of the heath family such as Labrador tea, Lapland rosebay, bear-berry, white heather and alpine cranberry in the tundra areas. Bushes or shrubs are mainly dwarf willow and dwarf birch, with some green alder in southern areas.

91 The Subarctic forest-tundra is a transition zone of scattered, often stunted coniferous trees and shrubs mixed with tundra vegetation. A boreal 'tree', as opposed to a shrub, is defined as having a minimum height of 2 m above the snowline and a single central trunk. As a region with both forest and permafrost, it varies in appearance from isolated clumps of forest surrounded by tundra, to scattered trees interspersed with tall shrubs, to extensive stands of willow and birch shrubs.

92 The type of bed-rock and resultant soil dictates to a large degree which species will occur and what their pattern of distribution will be. Peat accumulations also limit tree growth.

93 Low temperatures and soils that are waterlogged because of poor drainage caused by permafrost, and acidic, because of conifers and sphagnum moss, result in few species of soil invertebrates and micro-organisms. Dead vegetation remains intact and non-decomposed for long periods of time. The resulting mass of waterlogged, acidic, compressed by only slightly decomposed vegetation is peat. Peat bogs tend to expand at the expense of initial forest.

94 The depth of permafrost in this region is also a determinant of species distribution. Tall willows and isolated stands of balsam poplar indicate the presence of unfrozen ground. Where the active layer is somewhat less thick and the permafrost closer to the surface, willows, aspens and white spruce follow. White spruce grows mainly on rich clay and alluvial soils, while hardy black spruce will grow on acid soil in waterlogged peaty valleys and where permafrost is quite close to the surface. Tamarack and bog cranberries also inhabit this environment.

95 In the forest-tundra, there is more vegetation and more snow accumulation than in the tundra itself. Permafrost temperatures are not too far below freezing. Disturbance to the insulating vegetation is critical, and thermokarst is a constant problem. Frost heave, slumping and other types of earth movement associated either with annual freezing or permafrost is important in governing the growth of tree species, and result in the area's characteristic 'drunken forest' appearance.

96 Most of the taiga, or boreal forest, lies in the zone of discontinuous permafrost. Taiga soils are formed under the influence of an acidic conifer needle litter, resulting in a strongly acid soil with reduced levels of plant nutrients in the upper layer, consequently, a few species of tree dominate the ecotone.

97 The ground cover of well developed taiga has a high percentage of lichens. In closed taiga, however, the ground cover may be primarily feather mosses. Berry bearing shrubs are present in abundant variety, including blueberries, high and low-bush cranberries, crowberries, strawberries, cloudberries and rowan, all of which are important to animal life in the area. A variety of flowering shrubs and herbs are also found.

98 Since coniferous trees are highly resinous, the taiga is extremely susceptible to fire. Although wildfire was common in pre-contact times, its frequency has increased greatly with the advent of Euro-Canadian settlement. This ecotone characteristically regenerates through stages of fireweed, birch and aspen, but on the Canadian Shield, jackpine stages may persist for many years.

Fish

99 As with other forms of plant and animal life there are fewer varieties of fish in northern waters than in the south. Northern fish, compared to their southern counterparts, also grow more slowly; the thick ice cover which forms in winter and the longer Arctic winter nights cut down on life sustaining sunlight. A ten year old lake trout would weigh about 1 kg in northern waters, compared to 5 kg in southern waters. This, plus the emphasis in sport fishing on larger trophy fish, makes the replacement rate of fish in northern waters extremely slow.

100 Nevertheless, a number of freshwater species are fished commercially, domestically or for sport. A few species, such as char and grayling, are specific to northern waters. Relatively few species of fish inhabit the Arctic Ocean, and of these, only the anadromous char is of commercial importance. Species such a Polar Cod are, however, important as a source of food for marine mammals. The following are some of the principal species and their distribution in northern Canada.

101 *Cod Family*. — Apart from the Polar Cod of the Arctic Ocean, a predacious freshwater species known variously as burbot, ling, maria, loche or methy inhabit the Hudson Bay and Mackenzie River drainage systems. Its body is rounded in front and elongated at the rear, with a rounded tail and a barbel under the chin. It varies from dark brown through to yellow, depending on location, and weighs in at an average of less than 2 kg. While not an important food or sports fish, it is prized among the Dene of the Mackenzie Delta for its sweet-tasting liver and eggs.

102 *Grayling Family*. — The Arctic Grayling is the only member of this family found in Canada. It is a true northern fish, found particularly in the Mackenzie, Coppermine, Anderson, Thelon and Back Rivers drainages, where it feeds mainly on insects and their larvae. The Arctic Grayling is considered to be one of the worlds most beautiful freshwater fishes, with its dark blue back, violet spotted purple-grey sides and large, sail-like dorsal fin. It is a spirited game fish with excellent table qualities. Average weight is under 1 kg.

103 *Lamprey Family*. — One parasitic, anadromous species, the Japanese Lamprey, has been recorded in the Mackenzie River drainage and Beaufort Sea. Lampreys are not, in fact, true fish. These eel-like animals have no jaws, paired fins, ribs or scales.

104 *Minnow Family*. — Species of minnow include Lake Chub and Spottail Shiner. Both of these small fishes live mainly on aquatic insects and plankton. They are important chiefly as forage fish for other species and as live bait for anglers. The Trout-Perch, while not a true minnow, has characteristics of both trout and perch.

105 *Mooneye Family*. — Goldeye, or Goldeneye, were once plentiful as far north as *Wood Buffalo National Park of Canada* and Great Slave Lake, where they were commercially fished. This fish resembles whitefish, with the distinguishing characteristic of gold or yellow coloured eyes. They are surface-feeding, eating large quantities of insects, and make good sports fish, although they average less than half a kilogram in weight. They are delicious when smoked.

106 *Perch Family*. — Perch species include the Yellow Perch, a recent immigrant to the Great Slave Lake area which is also common in waters of the Hudson Bay watershed. The Yellow Walleye, also known as dore, pickerel and pikeperch, is plentiful in smaller lakes both north and south of Great Slave Lake and to a lesser extent further north. It is a schooling fish reaching up to 5 kg in weight. Both species are rated as good food fish which are relatively easy to catch.

107 *Pike Family*. — The Great Northern Pike is a long, slender fish with a large flat head and broad jaws containing many teeth. It is generally dark green on the back and a lighter green on the sides, with a white belly and rows of light spots. Pike are abundant in the drainage system of the Mackenzie River and in the Great Slave Lake area. They are voracious feeders on other fish, frogs, crayfish, small animals and birds. Although it is a tasty fish and a spectacular fighter, this species tends to be neglected as a

food fish. Pike generally run between 2 and 5 kg, but fish as large as 18 kg are not uncommon.

108 *Salmon and Trout Family*. — Three species of the *genus Salvelinus* represent this family. All are important food, sports and commercial fish.

109 Arctic Char is almost exclusively a far northern fish, it can be found from Baffin Island west to the Yukon border. Char are anadromous, spending the summer in the ocean but spawning and wintering in fresh waters flowing into the Arctic Ocean or Hudson Bay. There is also a land-locked variety which inhabits deep, cold northern lakes. In appearance, they are very streamlined, with dark green backs shading to silvery sides and belly, and pinkish spots on the side. The male develops a bright orange colour and a protruding jaw at spawning time. Char are a good game fish, averaging 2 to 3 kg in weight, and are similar to salmon in flavour.

110 Dolly Varden is a close relative of Arctic Char. It is a delicately flavoured predator with both anadromous and land-locked varieties, encountered only in the western Arctic and sub-Arctic. Its long, rounded body is an overall greenish brown with numerous red and orange spots on the sides.

111 Lake Trout is an excellent game fish, particularly in northern waters, and an important commercial fish. It has a long, slender body with well developed teeth and a dark colour with light grey or white spots. Lake Trout are found throughout the Mackenzie, Thelon, Back and Coppermine Rivers drainage systems, and trophy specimens have been caught in Great Bear and Great Slave Lakes. It is carnivorous and averages about 5 kg in weight.

112 *Sculpin Family*. — Sculpins are grotesque looking fish with large bony heads and large pectoral fins. Larger marine varieties are present in the Arctic Ocean, and smaller freshwater types inhabit coastal areas. None are food fish, but they are important as food for other fish and marine mammals.

113 *Stickleback Family*. — Two species are found in Arctic waters, the Threespine Stickleback and the Ninespine Stickleback. These fish inhabit both fresh and salt water and grow to a length of about 7.5 cm. They are a forage fish for other species, noted biologically for their nest building habits.

114 *Sucker Family*. — The White Sucker, commercially marketed as mullet, is common in lakes and rivers throughout the northern mainland of Canada. The Longnose Sucker is found right up to the Arctic Ocean. They are an important food for larger fish.

115 *Whitefish Family*. — The three species representing this family are valuable food fish, taken both domestically and commercially.

116 Lake Whitefish is a large, oval-bodied fish, with silver sides shading to dark or olive brown. It is mainly a bottom feeder, eating molluscs, insects and invertebrates. It ranges throughout the continental sub-Arctic and Arctic, with the exception of the Northern Keewatin and Melville Peninsula. Whitefish is the most common and commercially sold lake fish, but is seldom taken by sports fishermen.

117 Inconnu resembles a large herring, with dark back, silvery sides and large scales. It is mainly a northern fish, distributed throughout the Subarctic, but particularly common in the Hay, Big Buffalo, Taltson and Anderson Rivers, and the Mackenzie Delta. ‘Coneys’ average 4 to 9 kg in weight.

118 Northern Cisco, also known as Lake Herring or tullibee, is dark blue to gray-green on the back and silvery on the sides. It is long and slender, with a lower jaw longer than the upper jaw. This feature distinguishes it from whitefish. It is occasionally taken commercially along with Lake Whitefish in Great Slave Lake.

Marine mammals

119 Canada’s Arctic is one of the few areas of the world with an abundance of marine mammals. A variety of seals, walrus and whales have their breeding grounds off the coast of Baffin Island and in Hudson Bay, and they frequent the Arctic coast and High Arctic areas as well. They were traditionally the staff of life of the Inuit people of these far northern regions.

120 All these mammals are adapted to an aquatic existence and spend most or all of their lives in the water. Their limbs are adapted to serve as paddles or rudders. All have a thick layer of fat under the skin to protect them against cold and serve as a food reservoir in times of scarcity, common species are as follows.

121 *Harbour seal.* — The Western Atlantic Harbour Seal, or Common Seal, is found as far north as Ellesmere Island and in the coastal waters of Hudson Strait, Hudson Bay and Foxe Basin. Harbour seals are brown, tan, or gray, with distinctive V-shaped nostrils. An adult can attain a length of 1.85 meters and a mass of 132 kilograms.

122 *Ringed Seal*. — The Ringed Seal, a true Arctic species which does not migrate to southern waters, is a small, brownish animal with darker rings or spots on the back. Its single pup is born in the spring in snow dens on the ice of calm bays and inlets. The Ringed Seal feeds on small invertebrates and fish. In winter, it makes holes in the ice in order to come up to the surface and breathe. These

seals are found from Ellesmere Island south to Labrador and Hudson Bay and along the Arctic coast to Alaska. They are also known as jar seal.

123 *Harp Seal*. — This medium sized, pale grey seal with its distinctive harp-shaped markings winters on the Gulf of St. Lawrence. Its pups, born there in spring, are covered with a coat of long, white hair for their first few weeks. Harp Seals, which can weigh up to 350 kg, feed on small fish and crustaceans. They are distributed from the west coast of Greenland and Ellesmere Island south to Hudson Bay and Baffin Island in summer. A few have also been recorded in the Western Arctic.

124 *Bearded Seal*. — The Bearded Seal is distinguished by its conspicuous whiskers, plain brown colour and large size. Males can be up to 3 m long and weigh up to 430 kg. It is a solitary species, gathering in groups only at breeding time. Pups are born in early May and spend a long time with their mothers before taking to the water. The hide of the Bearded Seal is prized by the Inuit because of its toughness and suitability for harpoon lines. This seal ranges from Ellesmere Island south to Hudson Bay and west along the Arctic coast to Alaska.

125 *Hooded Seal*. — This is a large dark grey or black seal with white or brown spots on the flanks. The male has a bag-like swelling on the end of its snout which is inflated when it is angered. The male in fact has a reputation for ferocity, especially in defence of the female and its pup. Hooded Seals live on ice floes, feeding mainly on fish, and migrate south in winter. They do not use breathing holes but instead keep to stretches of open water among the ice pans. The species ranges from southern Ellesmere Island down to Labrador and is occasionally found in the Western Arctic.

126 *Walrus* are actually an exceptionally large seal. They use their characteristic tusks to dig clams and other shellfish on which they mainly feed. Males can be as long as 3.4 m and weigh up to 1,360 kg. Pups are born on ice pans in shallow bays and inlets and nurse for nearly two years, until their tusks have grown. Walrus are found from Ellesmere Island and Greenland south to Hudson Bay and Hudson Strait and west to Somerset Island and Barrow Strait. They are extremely vulnerable to over harvesting and are protected in Canada.

127 *Bowhead Whale*, also known as the Greenland Right Whale, was a staple of the old-time whaling trade. It is a large, black animal up to 18 m in length, with black baleen and a large, highly arched mouth. The Bowhead Whale was formerly common from Greenland south to Baffin and Southampton Islands, and in Hudson Bay and Hudson Strait. It was also found in Alaskan waters and east to Banks Island. The Bowhead Whale is a threatened species.

128 The Fin Whale, or Common Finback, is a large, slender whale, up to 24 m in length, grey above and white below, with a small dorsal fin. On the right side, its lower jaw and baleen are white, while on the left they are grey. It occurs in Davis and Hudson Straits and south along the Greenland coast. The Fin Whale is a threatened species.

129 *Lesser Rorqual*. — This small, slender whale is found from the coast of Greenland south through Davis Strait and down to the coasts of Newfoundland and Labrador. It is black above and white below, with a white patch on the upper surface of the front flippers.

130 *Blue Whale*. — This is the largest of all mammals, sometimes reaching over 30 m in length. It is dark bluish-grey above and speckled with white spots below. The baleen is jet black, and the tip and underside of the front flippers are white. It has been seen along the coast of Greenland and south through Davis Strait. The Blue Whale is an endangered species.

131 *Humpback Whale*. — The Humpback Whale has long flippers almost one third its total length. Both flippers and head are covered with tubercles which are usually infested with barnacles. The body is black above and white below, and the baleen is black. It occurs on the Greenland coast and in small numbers in Cumberland Sound, Baffin Island.

132 *Killer Whale*. — The Killer Whale is a large porpoise with a large back fin. It is black above and white below with a white patch back of the eye and on the flanks. It is a toothed species that subsists on seals and other whales. Killer whales are found on the Greenland coast south to Baffin Island, but are rare in the Western Arctic.

133 *Harbour Porpoise*. — This small porpoise is grey above and white below, with black flippers and flukes and has a rounded snout. It occurs on the Greenland coast and in Cumberland Sound and south. The Harbour Porpoise species is at risk.

134 *Beluga Whale*. — Also known as the White Whale, the Beluga is a prized source of the Inuit delicacy ‘muktuk’. It is a pure white whale with no back fin, usually between 3 and 4 m in length. It occurs from Greenland and Ellesmere Island south to Lancaster Sound, Baffin Bay, Foxe Basin, Hudson Strait and Hudson Bay. Belugas also occur in small numbers in Coronation Gulf west to the Mackenzie Delta. The Beluga Whale species is at risk.

135 *Narwhal*. — The Narwhal is distinguished by the male’s long, spiral ivory tusk. This small grey-mottled porpoise, which grow to about 4.5 m in length, was hunted both for its ivory and as food. It occurs from Ellesmere Island and Greenland south through Davis Strait to Hudson Strait and Labrador and west to Somerset Island. Although

it is also seen around Point Barrow, Alaska, it has not been recorded in the Canadian Western Arctic.

Small land mammals

136 Shrews, small, active insectivores with long pointed snouts and short legs are found throughout the mainland of northern Canada. Species include the Masked Shrew, found both in the boreal forest and on the tundra; the Water Shrew of the southern Mackenzie River and Great Slave Lake area; the Dusky Shrew, with a similar distribution; the Arctic Shrew, one distinctive subspecies of which inhabits the Mackenzie Delta, and another the Mackenzie Valley; and the Pygmy Shrew, found through the boreal forest region and the transition zone.

137 Two species of bat inhabit the Northwest Territories. The Little Brown Bat is found in the south Mackenzie River area and south of Great Slave Lake, as is the rare Hoary Bat, a solitary tree-dwelling species. Bats are not prevalent farther north — although a stray Red Bat once turned up at Coral Harbour, Southampton Island. They originated in the tropics and require warm temperatures for their activities. The Little Brown Bat hibernates in caves with above-freezing temperatures.

138 The Pika is a small, stocky tailless mammal that looks similar to a guinea pig. It is a characteristic mountain animal and is highly specialized for that environment. Collared Pikas can be found in the mountains on the Northwest Territories/Yukon border, typically inhabiting rocky talus above the treeline. They are active in winter, tunnelling under the snow, and cache the vegetation that forms the bulk of their diet.

139 Hares are an important food source for both people and other animals. The common Snowshoe Hare, which turns white in winter, is found in the forested areas up to the treeline. The Arctic Hare is a large, heavy-bodied hare found only beyond the treeline, its habitat includes the Arctic Archipelago, and it has even been seen on the ice at 83°10'N, several kilometres from the most northerly point of land. It is evidently well adapted to northern living, with padded feet, claws for digging in the snow, long, warm hair and long incisors to extract dwarf tundra plants from under the snow. Meat and seaweed also form part of its diet.

140 A small, slender chipmunk, the Least Chipmunk, is characteristically found in open stands of jackpine and fire growth on the edge of boreal forest. This active food gatherer enters a state of torpor in winter, but does not actually hibernate. Seeds, nuts, berries, insects and birds eggs are its food.

141 Northern marmots include the Woodchuck, a grizzled thickset, ground dwelling squirrel found in the southern Mackenzie area. The Woodchuck puts on a thick layer of fat before it hibernates, usually in burrows at the roots of trees. It's burrowing activity helps increase soil fertility. The Hoary Marmot is larger than the Woodchuck, and hibernates up to eight months of the year. It is a mountain dweller found in alpine tundra beyond the treeline in the Northern Cordillera.

142 The Arctic Ground Squirrel, or 'Siksik', is a true northern species, inhabiting the continental tundra. A subspecies is also found in transition zone clearings in the lower Mackenzie River area. The Siksik has a shortened breeding period and grows quickly, subsisting on tundra vegetation and scavenged meat. It caches vegetation for spring, when it burrows up through the snow from its hibernation den at the permafrost line.

143 Both species of northern Canada squirrel are active in winter. The Red Squirrel, a solitary arboreal animal, inhabits dense coniferous taiga. Its diet includes conifer cones and buds, insects, bird eggs and mice, so it is considered helpful in reforestation and pest control. The less frequently encountered Northern Flying Squirrel is found along the Mackenzie River and south of Great Slave Lake. This hardy, sociable animal eats lichens and scavenges trap bait, in addition to the usual squirrel diet.

144 Mice and Voles are cosmopolitan species, found virtually everywhere. Species include Deer Mice, found in the vicinity of the treeline; the Northern Red-backed Vole, characteristic of shrub vegetation and in the transition zone and tundra; Gapper's Red-backed Vole, their taiga cousins; the Brown Lemming, a tundra native found as far north as the southerly Arctic Archipelago; the Northern Bog Lemming, which frequents sphagnum, Labrador tea, black spruce bogs and mossy woods in the transition zone and taiga; the Heather Vole, which prefers dry coniferous forest and the forest edge; Singing Voles of the alpine tundra west of the Mackenzie River, Meadow Voles, Tundra Voles, Long-tailed Voles in the South Nahanni River valley, Jumping Mice in the southern Mackenzie, Chestnut-Cheeked Voles in the Mackenzie River watershed, House Mice, and finally the Collared Lemming. The Collared Lemming is a native tundra species which shows greater adaptation to the Arctic than any other rodent. It turns white in winter, has furred feet and long claws with which to burrow in snowbanks. The Collared Lemming is found only on the Arctic tundra, as far north as the Queen Elizabeth Islands.

145 The Bushy-tailed Wood Rat, or 'pack rat', is found in the Northwest Territories. It is a transition zone animal that prefers rocky habitat and subsists on twigs and foliage. There are no domestic rats in the north. Porcupines are found south of the treeline.

146 All of these small mammals have an important place in the food chain in their respective habitats. They are the main source of food for most fur bearing animals and predatory birds.

Fur bearers

147 Large cinnamon-coloured Coyotes are found as far north as the Mackenzie Delta in forested areas. There is evidence to suggest that these eaters of small game and carrion are relatively recent immigrants which reached the Mackenzie only in the 19th century.

148 Wolves are native to the North. They are similar to a German Shepherd or sled-dog in appearance, with lankier bodies, longer legs, larger feet and narrower chests. The Wolf is a meat-eating animal and travels in packs preying on large game such as moose and caribou. Wolves range in color from pure white in Arctic populations, to mixed colors of gray, brown, cinnamon, and black. Usual color in North America is white with shades of black, gray, and brown on the upper parts of the animal.

149 The Arctic Fox, an Arctic native, eats mostly lemmings and voles, but will tail polar bears, wolves and man to scavenge carrion. It is the size of a terrier, and turns white or more rarely 'blue' in winter. It is found north of the treeline to the Queen Elizabeth Islands. Red Foxes show colour variations including Cross Fox and the rare Silver Fox. They prefer open country, including Baffin and Southampton Islands.

150 The Muskrat is the largest of the North American rats, mice and lemmings. This important fur bearer is modified for an aquatic life. It lives in ponds and marshes south of the treeline to the Mackenzie Delta.

151 Martens are mink-sized aboreal weasels, dark brown to bluff in colour and solitary in habits. They eat smaller mammals, fruit and insects. Martens are a relatively rare species and occur only in pockets of suitable habitat in dense coniferous forest.

152 Fishers, another species of Marten, resemble a large black cat and are one of the few animals that prey on porcupine. They have a more southerly distribution than Martens, which reach the treeline in the North Mackenzie.

153 Northern weasels include the circumpolar Ermine or Stoat, a ferocious little carnivore that not only eats mice and voles but stores them for the winter. Its black tipped white winter coat is traditionally considered royal wear. Ermines inhabit most of the northern taiga and tundra, including the Arctic Archipelago. Mink are larger than Ermine, and their diet includes hare and muskrat. Subspecies of Mink are found in both the north and south Mackenzie areas to the treeline. The Least Weasel is a rarer species, similar to the Ermine but often without the black tip on its tail and smaller. At 20 cm long, it is one of the smallest of North American carnivores.

154 Wolverines are large weasels the size of a bear cub, dark brown, strong and solitary. They are known through the north as omnivorous camp robbers. Wolverine fur is prized as parka trim because the hair resists frosting. This scavenger inhabits both the taiga and the tundra, including the Arctic Archipelago to Ellesmere Island. The Wolverine is a species of special concern.

155 Beaver are found as far as the treeline and in the Mackenzie Delta. They rarely venture onto the tundra, although stragglers have been found at the Coppermine River. Beaver eat bark and aquatic plants, and prefer slow-flowing streams in forest or muskeg areas.

156 The common Striped Skunk is found south of Great Slave Lake and in the southern Mackenzie area as far as Fort Simpson.

157 River Otters sometimes occur in tundra lakes and river, but stay generally in the Mackenzie River valley south of the treeline.

158 Lynx are medium sized cats with big feet and a distinctive ruff. They are nocturnal, solitary and silent hunters of the deep forest, preying mainly on hare, lemmings and ptarmigan. They sometimes roam out onto the tundra in pursuit of food.

Large mammals

159 Bears are common in the Canadian north. Black Bears are found in forests, swamps and berry patches south of the treeline. They can be a nuisance around dumps and camps. Large yellow-to-brown Grizzly Bears spend less time hibernating than Black Bears. These omnivorous and much feared animals prefer open spaces in the mountains west of the Mackenzie River and on the tundra in the northeastern Mackenzie and central Keewatin areas. Polar Bears are large, slender white bears up to 700 kg in weight. They frequent the Arctic ice pack in search of seals, walrus, fish, carrion and birds, and have been seen as far as 88°N. Grizzly Bears and Polar Bears are both species of special concern.

160 Caribou are members of the deer family, well adapted to their Arctic and Subarctic environment. They have large, blunt, furry muzzles, with valvular nostrils, short furry ears, long thick fur and big feet with hooves that act as snow-shoes in winter. They are a herd animal, and some migrate extensively between summer tundra ranges and winter forested ranges. Both sexes can have antlers. Lichen is their main food. Subspecies include the Woodland Caribou, a threatened species, of the boreal

forest; Barren-ground Caribou, a species of special concern, of Baffin Island and the continental tundra which migrate south in winter; Peary Caribou, an endangered species, of the Queen Elizabeth Islands; and domesticated Reindeer of the Mackenzie Delta and Greenland.

161 Mule Deer, with their characteristic big ears, are found in open coniferous forest in the southern Mackenzie to Fort Simpson and south of Great Slave Lake.

162 Moose, the largest of the deer family, are the size of a horse. They are solitary browsers and like shrubby growth south of the treeline but range widely over the tundra reaching the shores of the Arctic Ocean in midsummer.

163 Some of the world's few remaining Wood Bison, a threatened species, are to be seen near Fort Providence in the southern Mackenzie. They are larger, darker and woollier than the Plains subspecies. Bison found in *Wood Buffalo National Park of Canada* on the Alberta border are a hybrid between Plains and Wood Bison.

164 Musk-ox are large, shaggy relics of the last Ice Age that are making an encouraging come-back in the Arctic. They form a ring facing outward when threatened. Musk-ox browse the tundra, preferring wet seepage meadows in summer. They are found across the continental tundra to the Arctic coast and in the Arctic Islands.

165 The Mountain Goat is a white bearded antelope that inhabits rugged mountainous terrain with deep snow in the Northern Cordillera; it is often confused with Mountain Sheep. Mountain sheep in North America are classified as either bighorn sheep *(Ovis canadensis)* which occur mainly in the Rocky Mountains or thinhorn sheep *(Ovis dalli)* which occur farther north. Among thinhorn sheep there are two subspecies: Dall's sheep *(Ovis dalli dalli)*; and Stone's sheep *(Ovis dalli stonei)*. Dall's sheep are found in Alaska, the Yukon, the western NWT and extreme north-western British Columbia. They are pure white with amber-coloured horns. Stone's sheep are found in the southern Yukon and northern British Columbia. They are silver grey to black with white patches on the rump, forehead, muzzle, and hind legs. Grey sheep have been seen occasionally in the NWT near the Yukon border and these may be intergrades between Dall's sheep and Stone's sheep.

Birds

166 Most birds found in Northern Canada are migratory summer residents or transients. Birds of forty-one families and over two hundred species breed and stage in the north, ranging from the American White Pelican of the Alberta-Northwest Territories border to the tundra Peregrine Falcon of the Arctic Islands.

167 River deltas, such as the Mackenzie, Slave and Anderson Rivers deltas, are important habitat for waterfowl and water birds. Northern Canada hosts 20% of the continental populations of ducks, geese and swans. Half of the geese on the North American continent, including world populations of Greater Snow Geese, Atlantic Brant and Ross's Geese, nest in the Northwest Territories and Nunavut. This area also supports 90% of the entire population of Inuit or Lesser Snow Geese, common Eiders and King Eiders and 80% of Oldsquaw.

168 Far northern birds, including the few resident species such as the Snowy Owl, Rock Ptarmigan, Gyrfalcon and common Raven, show a number of cold weather adaptations. In the Arctic, bird species as big as or bigger than the pigeon make up 60% of all species, as compared to 30% for more temperate areas. Large birds stay warmer by presenting less body surface for their mass. Northern birds also tend to have more feathers and more fat than comparable southern species.

169 Slower night time metabolism, block huddling, fluffing and tucking are other cold weather physiological and behavioural adaptations common to birds which winter in continental northern Canada as well as those of the Arctic. Migration south avoids the worst of the Arctic winter, but birds that remain through all or part of the colder weather also seek warmer 'micro-climates', such as holes in vegetation, snow cliffs or open water.

170 As with other northern life forms, bird distribution tends to follow the pattern of vegetation. Hawks, grouse, woodpeckers, thrushes, kinglets, warblers, crossbills, sapsuckers, sparrows and others inhabit the taiga. The boreal owl, gray jay and boreal chickadee are specific to the forest environment.

171 Beach areas are inhabited by large numbers of migratory shore birds and waterfowl in spring and fall. Fish-eating water birds such as mergansers inhabit the lakes and river, while puddle ducks, geese, snipe and swamp sparrows prefer ponds and marshes. Alder flycatchers, sandpipers such as Lesser Yellowlegs and the Northern Waterthrush also enjoy boggy habitat.

172 Somewhat fewer species inhabit the tundra, even in summer, but they are often abundant. Typical species include longspurs, snow buntings, plovers, snowy owls, rough-legged hawks, golden eagles and gyrfalcons. Wetland areas are inhabited by ducks, tundra swans, geese, loons, phalaropes, sandpipers and turnstones.

173 The Arctic coast and the straits and coasts of the Arctic Islands are frequently by a variety of sea birds. They include the Arctic tern, fulmar, herring gull, thick-billed

murre, common and king eider duck, Thayer's gull, glaucous gull, Atlantic brant, snow geese and jaegers.

174 A number of northern nesting species are particularly rare. All species are protected to some degree. North America's only colony of river nesting white pelicans is found at the Slave River Rapids near Fort Smith. The breeding grounds of the whooping crane lie within *Wood Buffalo National Park of Canada*. The Peregrine Falcon, Whooping Crane, Ross's Gull and Eskimo Curlew are all threatened or endangered species.

175 Edible varieties of bird life are an important seasonal food resource for residents of northern Canada.

Insects

176 The insect life in northern Canada is recently derived, in biological terms, from that of more temperate areas. Many species common in southern Canada, representing the full range of insect activity, are found in the taiga. Beyond the treeline, some insects belong to technically distinct species which are, however, closely related to boreal and temperate forms.

177 Insect life follows the pattern of northern vegetation. More than 10,000 species inhabit the taiga or the Northwest Territories. The transitional forest-tundra contains only about half as many species. True Arctic species number about 1,000, with the order of two-winged flies accounting for half of these. Sheltered, sunny spots in the High Arctic can harbour 250 species. Finally, the number of species decreases to perhaps half a dozen around the edges of the permanent ice fields.

178 Northern insects share some adaptations to the long, cold winters with their temperate zone counterparts. Some resist freezing by the development of glycerol 'antifreeze' in their blood. In others, ice can actually form in the body fluids without harm to the animal. Metabolism comes almost to a standstill at very cold temperatures, and an insect can exist in this dormant state for years before returning to life.

179 Fewer insects have, however, adapted to the short cool summers, which restrict growth and breeding, particular in the tundra areas. One such adaptation shown by some northern insects is a change in metabolic rate, such that the animal grows as fast at a lower temperature. A single generation per season may be produced, rather than several, or the life cycle can be extended over two or more periods of winter hibernation.

180 Nearly all the main north temperate insect groups are present in the taiga areas. These include species of butterflies and moths; bees, wasps, ants and sawflies; caddis, mayflies, dragon flies, stoneflies; many species of true flies; lice, grasshoppers, aphids, thrips and others. A relative abundance of aquatic insects is a characteristic feature of both the boreal and tundra ecosystems. These are important food sources for fish, migratory birds and even foxes.

181 Butterflies, bumblebees, blackflies, mosquitoes and midges are among the species found north of the treeline. Tundra insects often show special adaptations to windy conditions which make normal flight difficult. Butterflies fly close to the ground, and spread their wings to increase the heat-absorbing surface; some insects bask on the ground to achieve a take-off temperature. Dark colours aid in the efficiency of basking. Mosquitoes and blackflies shift their active periods to midday to take advantage of maximum temperatures, bumblebees warm themselves by shivering before flying out of their nests in below-freezing temperatures.

182 Other species are wingless or maintain themselves without flight. A walking bumblebee pollinates Arctic saxifrage on Ellesmere Island. Up to the treeline, blackflies fly in search of a blood meal, which is necessary for egg development in the female. All but one species of tundra blackfly, however, are non-biting forms that depend on food stored during the larval stage for egg development. Some species have also abandoned the mating flight for the ground.

183 The most notorious insect pests are the various biting flies: mosquitoes, blackflies, deerflies and biting midges or 'no-see-ums'. Biting species are far more prevalent in forested areas than on the tundra, and are almost non-existent in the High Arctic. Further, the greater part of the zone of maximum blackfly biting occurs south of 60°N. Nonetheless, these species can constitute a moderate to severe nuisance in the southern areas of the Northwest Territories and Nunavut.

184 Other pest species include warble and botflies, which infest caribou, sometimes to a harmful extent, spruce budworm in the Liard and Mackenzie Rivers valleys; larch sawfly; a variety of defoliating caterpillars and wood-boring beetles; household pests, including the small German cockroach reported as far north as Ellesmere Island; and human and animal parasites, such as lice. Poisonous spiders are absent, and, with the exception of lice and possibly deerflies and midges, no northern insect species carries human disease.

185 Most northern insects, however, are a vital part of the forest or tundra ecosystem to which they belong. They play an essential role in the food chain, and assist in the decomposition of organic material in soil and the pollination of vegetation.

Reptiles and amphibians

186 Only one species of reptile and five amphibians are known to inhabit northern Canada. They are the garter snake, common south of Great Slave Lake; the wood frog, found throughout the taiga and adjacent tundra as far north as the Mackenzie Delta; the chorus frog, found from the Alberta border north to Great Bear Lake; the leopard frog, a species of special concern, and the Canadian toad, both found in the Northwest Territories/Alberta border area. Islands of James Bay, which are part of Nunavut, are inhabited by the Hudson Bay toad. No reptiles or amphibians are found in the Arctic Islands.

187 Because their body temperature is dependent on external conditions, these animals are not generally good northern colonizers. There are no uniquely Arctic or Subarctic species. Reptiles and amphibians found in the north of Canada belong to groups centred in tropical and temperate areas, and, except for relatively minor adaptations, differ little from southern species. Northern temperatures, availability of suitable hibernation habitat and especially the short length of summer are significant in limiting their northern distribution.

188 Garter snakes, the only reptile to reach the Subarctic, are northern adapted in that they are viviparous rather than egg-laying. The young require two years for full development inside the mother's body. These snakes hibernate in winter, congregating in deep fissures in rock outcrops below the frost line.

189 Amphibians which are nocturnal in more temperate regions concentrate activity instead during the warmest and brightest part of the day. The wood frog in particular can tolerate lower minimum temperatures than other species at all stages of its development. Northern amphibians tend to lay submerged egg masses, which increases the chance of survival in case of surface freezing. The eggs are also larger and darker to increase absorption of radiant energy.

190 Amphibians also tend to be smaller and more vividly coloured. This permits rapid exchange of heat between the ectothermic animal and its environment, and greater heat absorption as well as camouflage from daytime predators. They have a higher weight to length ratio for metabolism and insulation during long periods of hibernation, and shorter legs, which reduce loss of heat and moisture.

191 Despite the limited number of species, reptiles and amphibians are often found locally abundant. They form part of the diet of many animals in the areas they inhabit. In turn, they prey upon insects, and in the case of garter snakes, on worms and amphibians.

Chapter 3

Physiography

Photo by: Martin Fortier – ArcticNet

General

Chart 7000

1 The areas of Northern Canada accessible by sea includes the sub-Arctic regions of Hudson Bay and Great Slave Lake — Mackenzie River valley, the Arctic mainland coast from Point Barrow, Alaska, eastward to Melville Peninsula and the NW shores of Hudson Bay, and all the islands north of the mainland, generally referred to as the **Canadian Arctic Archipelago**. The archipelago is roughly triangular in shape, covering approximately ⅓ of the total area of Canada.

2 The land masses within this vast territory can be divided for convenience into five main groups:

- the Hudson Bay area, accessible by sea through Hudson Strait;
- the Arctic eastern block, with sea approaches usually through Davis Strait and Lancaster Sound;
- the Arctic western block, with sea approaches usually through Bering Strait and Beaufort Sea;
- the Arctic northern block, where penetration by sea is possible in the east by Smith Sound and in the south through, Lancaster Sound, Parry Channel or Jones Sound and some of their tributary channels;
- the Great Slave Lake and Mackenzie River basin, accessible only by shallow-draft vessels.

3 The Hudson Bay area includes the shores of Hudson Strait, Hudson Bay, James Bay, Foxe Channel, Roes Welcome Sound, Foxe Basin and Fury and Hecla Strait.

4 The Eastern block comprises the NW shores of Melville and Boothia Peninsulas and Baffin, Bylot, Southampton and Somerset Islands.

5 The Western block includes the mainland coast from the vicinity of Point Barrow, Alaska to the eastern shores of Peel Sound, Franklin, James Ross and Rae Straits; as well as Banks, Victoria, Prince of Wales and King William Islands.

6 The Northern block consists of the triangle of island groups north of Parry Channel and known collectively as the Queen Elizabeth Islands.

7 The Great Slave Lake and Mackenzie River area includes Great Bear Lake, Great Bear River, Lake Athabaska, and Athabaska and Slave Rivers.

8 For a detailed map of the physiographic regions of Canada, see https://atlas.gc.ca/phys/en/.

9 The physical characteristics of the Canadian Arctic are greatly influenced by the underlying rock type and structure, each specific combination producing its own distinctive landscape.

- The ancient crystalline rocks of the Precambrian or Canadian Shield give an extremely rugged and barren landscape regardless of whether they rise high and mountainous, as along the western shores of Davis Strait and Baffin Bay, or lie at low elevations as along the southern shore of Queen Maud Gulf.
- The sedimentary strata of the later geological ages form a variety of landscapes, depending on elevation and on whether the strata remained horizontal or were folded. When high and horizontal, they produce prominent plateaux; where high and folded they result in spectacular mountains; and where low and flat-lying, they give monotonous plains such as those bordering the Foxe Basin coast of Baffin Island. Over large areas, particularly in the western islands, the beds of horizontal limestone have been subjected to the fracturing action of frost and their surface is covered by a mantle of sharp-edged, frost-riven fragments.

10 The effects of glaciation during the last Ice Age are very marked over much of this area. The extreme west and NW parts were not covered by ice but the eastern islands and much of the mainland were inundated. Because of the great weight of this ice cover, the land beneath it was depressed and as a result, when the ice melted, much of it was below sea level. Its gradual rise is marked in many areas of the Arctic by a series of strandlines or raised beaches which indicate the high water level at various stages of the land's emergence. Some of these emergent beach lines now lie at about 100 m above the present high water level. The non-glaciated areas in the west do not appear to have been depressed during the Ice Age but at the present time, while the eastern areas are rising relative to sea level, the western coasts of Banks and Prince Patrick Islands appear to be sinking.

11 The landscape modifications resulting from this glaciation are varied. In mountainous areas the glaciers have etched peaks and ridges into sharp relief and have deepened and rounded the ancient V-shaped river valleys. The eroding power of the ice in more level areas is difficult to determine but the effects of the heavy load of rock and sediment left behind as the ice retreated are evident over vast expanses and in a variety of forms. In some areas this glacial debris has simply been deposited as great hills or fields of unsorted moraine. In others it may form vast fields of boulders from which all the finer sediments have been washed away by the glacial melt waters, and re-deposited at some lower elevation as outwash plains, great river deltas or the bottom sediments of post glacial lakes. Over wide stretches of the mainland and the more southerly islands, the ice cap's load was frequently deposited in smooth elongated hills known as drumlins, whose orientation indicated the direction of ice movement at the time they were formed. Winding, sometimes for miles, across the country are eskers, ridges of sorted sediments which formed the beds of melt-water streams which flowed in or beneath the ice cap and which, with the disappearance of the enveloping ice, now rise above the surrounding terrain like wandering railway embankments.

12 Throughout the region the rigourous climatic conditions have resulted in the development of permanently frozen ground close below the surface, and this prevents surface waters from percolating downward. Deposits of glacial debris form additional obstacles to the drainage pattern, impounding the surface waters to form shallow lakes, blocking and altering the courses of existing rivers and, in areas of gentle gradient, creating waterlogged surfaces such as the mainland bordering the western shore of Hudson Bay.

13 At the present time, glaciation in the Canadian Arctic is relatively limited in extent. Only on the larger eastern islands can permanent ice fields of any size be found. Elsewhere the land is too low or the precipitation too slight to produce such ice cover, and except for scattered permanent snow patches or small relic ice masses, the land becomes bare in the course of the short summer.

14 Although the snow begins to melt in May in the southern parts of the Canadian Arctic and not until some time in June in the northern parts, it is nevertheless in the north that it disappears first because of the longer daily period of sunlight and the relatively lighter snow cover. With the onset of the thaw the northern streams tend suddenly to become wide raging torrents, but once the snow has melted, streams which are not fed by glacial run-off usually either shrink to mere trickles or dry up completely. As a result, throughout much of the summer, many of these northern streams occupy beds much larger and more impressive than their small volume of water might seem at first glance to justify.

Hudson Bay area

15 **Hudson Bay** could be considered as a large inland sea which penetrates deeply into the NE portion of the North American continent. The bay has a maximum length of about 720 miles and a width, at latitude 60°N, of approximately 540 miles; it is landlocked. It has an exit to the Atlantic Ocean via Hudson Strait and a connection with the Arctic Ocean through Foxe Channel and Fury and Hecla Strait.

16 The Provinces of Quebec, Ontario and Manitoba, and The Territory of Nunavut all border on Hudson Bay.

17 James Bay itself is approximately 200 miles long, with a width of 80 to 100 miles.

18 Hudson Bay lies in the vast horseshoe-shaped plateau, known as the Precambrian Shield, that occupies nearly all of Canada east of a line joining Great Bear Lake and Lake Winnipeg, except for the extreme southern parts of Ontario and Québec, the Maritime Provinces, and an area adjacent to the SW shores of Hudson Bay often called the Hudson Bay Lowlands. The distinguishing features of this shield are the predominating exposure of rocks and the rugged and uneven surface.

19 The average height of hills in the coastal areas of Hudson Bay is from 30 to 61 m above sea level. The appearance of the terrain is rough, rocky and hilly, broken by innumerable streams, rivers and lakes and lacking any soil cover.

20 As a result of this lack of soil, the major part of the terrain bordering Hudson Bay is devoid of tree growth, however, the tree line extends as far north as the Rivière Nastapoka on the east side of the bay and a similar zone extends northward on the west side as far as Churchill.

21 Many rivers of varying sizes discharge their waters into Hudson Bay, the largest of which is Nelson River. Rivière Nastapoka and Rivière de la Baleine flow into the east side of Hudson Bay; La Grande Rivière, Rivière Eastmain, Rivière Broadback, Rivière Nottaway, and Moose, Abitibi, Albany and Attawapiskat Rivers empty into James Bay; Winisk and Severn Rivers discharge into the SW part of Hudson Bay; Hayes, Nelson and Churchill Rivers flow into the western side of the bay; Thelon, Quoich and Dubawnt Rivers empty into Baker Lake, then, via Chesterfield Inlet, into Hudson Bay.

22 The shores of **Hudson Strait** are generally high, rocky and barren, and devoid of trees. The north shore is irregular, with numerous inlets, bays and innumerable islands, while the south shore, with the exception of Ungava Bay, has a smooth appearance and few inlets. Heights along the north side of the strait range from 122 to 183 m at the coastline, gradually rising inland, from 610 to 914 m, except in the area of Foxe Peninsula where the heights are rarely more than 244 m.

23 The southern shore west of Ungava Bay is generally higher than the north shore, rising from 305 to 457 m abruptly from the water.

24 Numerous rivers and streams drain into the bays and inlets on both sides of the strait. Some of these bays provide excellent anchorages though there is a tendency for winds of high velocity to funnel down through these high-sided bays at times and caution should be exercised accordingly.

Arctic Eastern block

25 The mainland section of the Arctic Eastern block extends from the vicinity of Chesterfield Inlet north to Bellot Strait and NE to Fury and Hecla Strait. It is, in the main, an area of rugged Precambrian rocks, vast stretches of which have been heavily glaciated during the last Ice Age. In many places the tortured folds of the original bedrock lie at the surface, their joints and fractures often forming the beds of lakes and rivers. Where these structural depressions reach the coast as, for example, at the head of Committee Bay, they produce intricately indented shorelines along which the offshore ridges form a fringe of rocky islands and treacherous reefs. In other places a heavy mantle of glacial deposits covers the landscape and softens the contours of the rock beneath. Along the low shores of Roes Welcome Sound, between Cape Fullerton and Repulse Bay, this heavy cover of glacial drift has resulted in a smooth and regular coast and has impounded the drainage into a waterlogged pattern of shallow lakes and meandering rivers. Muddy underwater flats extend a considerable distance offshore.

26 **Boothia Isthmus** and **Rae Isthmus** are low, lake-strewn, and dotted by knobby granitic hills. Both isthmuses have been glaciated and Boothia Isthmus in particular is heavily covered with glacial drift. North and south of these two narrow necks of land, the terrain rises to a rugged featureless plain between 300 and 600 m above sea level, crossed in varying directions by rounded ridges, all so alike as to afford few distinctive features in the monotonous landscape.

27 The east coast of **Melville Peninsula** in the vicinity of Cape Wilson, and the greater part of the west coast are bold, and although often not more than 120 to 180 m high, are backed a short distance inland by higher ridges, rising as high as 450 m. Between Parry Bay and Hooper Inlet, the rough Precambrian landscape gives way to low-lying beds of later sedimentary strata, characterized

by gentle gradients, shallow offshore waters and smooth featureless coastlines whose former high water levels are marked by a series of emergent strandlines. **Wales Island** and the adjacent shores of Committee Bay, as well as the greater part of **Simpson Peninsula**, are also composed of similar stretches of the same smooth, low-lying sedimentaries.

28 **Boothia Peninsula**, roughly 30,000 km^2 in area, is formed by a broad tongue of Precambrian rock which extends NNW from the mainland and continues through the coastal areas of Somerset and Prince of Wales Islands to form the shores of Peel Sound as far north as Cape Granite and Browne Bay. In the Boothia Peninsula this feature stretches as a rolling, monotonous plateau, some 600 m high along its central axis and falls off NE and SW through an extremely rugged upland to disappear beneath coastal lowlands of more recent sedimentary strata. This Precambrian zone is highest and most rugged in the SE, and most spectacular in the area of Murchison Promontory where it rises in sheer cliffs about 200 m high and is characterized by long, narrow steep-walled depressions which follow a NE/SW line of fracture. Bellot Strait forms the largest of these depressions, and several others just fail to extend from coast to coast and either form long, finger inlets or are partially filled by narrow elongated lakes.

29 In the NE, the sedimentary lowland areas of Boothia Peninsula extend roughly from the vicinity of Cape Palmerston to the southern shores of Brentford Bay, and in the SW from the head of Josephine Bay to Weld Harbour. They are, on the whole, smooth and featureless and their relatively even coasts are marked, for a considerable distance inland, by a broad series of raised beaches. For the most part the gradient is gentle and offshore waters shallow, but the land slopes up gradually toward the north to form low, flat-topped hills along the southern side of Brentford Bay.

30 **Baffin Island**, the largest island in the Canadian Arctic Archipelago, ranks as the second largest island in the northern hemisphere and the fifth largest island in the world. Its area is 507,451 km^2, roughly 2½ times the size of the British Isles. Its topography shows marked contrast ranging from the 2,000 m peaks of Cumberland Peninsula to the level, muddy Great Plain of the Koukdjuak lying barely above sea level along the shores of Foxe Basin. **Bylot Island**, 11,067 km^2 in area, lies within the large bay at Baffin Island's NE corner.

31 These islands are composed of Precambrian rocks which are overlain in NW Baffin Island and along stretches of the Foxe Basin coast by thick beds of later sedimentaries. The islands are part of the edge of a vast, ancient peneplain which, over a long period of geologic time, has been tilted by earth movements so that it rises east and NE from the near-sea level elevations bordering Foxe Basin to end abruptly in the precipitous cliffs and high mountains fronting Davis Strait and Baffin Bay. The eastern edge of this high land has been dissected by steep-walled, branching fiords, and eroded by wind, water and ice until, from the seaward side, the level character of its former surface has been lost in the alpine aspect of its present mountains. Only in the symmetry of its summits is there any reminder of the ancient plain. Westward, however, the relatively level areas increase in number and extent, elevations become lower, and, except in the plateaux and uplands of the NW peninsulas, the island becomes rough, rolling lowland of relatively low relief.

32 The highland zone along the east coast of Baffin Island extends inland only to about the heads of the major fiords, and, south of Cumberland Sound, the terrain is upland in character rather than truly mountainous. In Hall and Meta Incognita Peninsulas the land rises toward the east and NE but the greatest elevations seldom exceed 900 m. The rugged south and SW coasts of both peninsulas are generally below 300 m in height, and are fringed by a maze of reefs, rocks and islands. The north and NE coasts are, by contrast, bold and precipitous, forming the impressive SW shore of Frobisher Bay and the Davis Strait shore of Hall Peninsula.

33 The truly mountainous zone extends NW from Cumberland Sound and, with the exception of Barnes Ice Cap, contains all the major ice fields and glaciers on Baffin and Bylot Islands. The largest and highest of these fields is Penny Ice Cap on Cumberland Peninsula, rising to elevations of about 2,000 m in the central area and with heights estimated at just over 2,100 m in its SE section. Numerous glaciers flow down from it on all sides. The second largest ice field occupies the greater part of Bylot Island and is only slightly lower than Penny Ice Cap. Mountain peaks rising through it attain elevations over 1,800 m.

34 Between these ice fields, the entire east coast is distinguished by precipitous peaks from 900 to 1,500 m high. Some of these rise almost sheer from the sea, and are surrounded by ice fields and glaciers which, although less extensive than those of Bylot Island and Cumberland Peninsula, are nonetheless considerable and impressive. There are also small ice fields in the NE parts of Hall and Meta Incognita Peninsulas.

35 From about Cape Henry Kater to the vicinity of Cape Adair the mountainous zone is bordered on the east by a low coastal plain. Inland, elevations generally decrease rapidly westward and the mountains are soon replaced

by a narrow upland zone which in turn, merges almost imperceptibly into the rugged lowlands.

36 The great peninsulas which occupy the NW part of Baffin Island from the vicinity of Navy Board Inlet to the shores of Prince Regent Inlet are underlain by Precambrian rocks which dip gently toward the west and are covered by horizontal beds of later sedimentary rocks. These sedimentary strata increase in thickness westward until, on Brodeur Peninsula, they form a high, level plateau which fronts the sea in precipitous cliffs. The major relief features of this plateau are the narrow deeply-entrenched ravines of the great river valleys. Elevations decrease from east to west, from approximately 900 to 1,200 m in the vicinity of Oliver Sound, between 600 to 1,200 m on Borden Peninsula and about 550 m on Brodeur Peninsula. Although around Oliver Sound and Milne Inlet the terrain is high and extremely rough, it is on Borden Peninsula, where both Precambrian and sedimentary rocks occur, that the topography is most complex. In the east the boundary between upland and plateau is difficult to establish as one tends to merge into the other. Equally indistinct is the southern boundary of the plateau area, although it appears to follow roughly along an east/west line lying some miles north of the vicinity of Bernier Bay and Berlinguet Inlet.

37 The horizontal sedimentary rocks of Brodeur Peninsula have resulted in a steep and fairly even coastline with only a few relatively minor indentations on the west coast. By contrast, the western coast of the more complex Borden Peninsula is broken by a number of inlets of considerable size. A few relic ice fields and small glaciers are found in the NE parts of both peninsulas.

38 The lowland is a vast area of rolling, monotonous terrain marked here and there by knobby hills or by undistinguished granitic outcrops. In the central area of Foxe Peninsula, the land is barely 30 m above sea level in the vicinity of its watershed, although it rises again to a little over 300 m in the SW. Elsewhere throughout the lowland area heights tend to drop off toward the west and south. Much of the surface of the underlying Precambrian rocks is heavily lake-strewn, and almost all of it covered by a mantle of glacial drift. The rugged lines of its worn folds continue off the north shore of Hudson Strait in the maze of coastal islands extending from Markham Bay to Andrew Gordon Bay.

39 The area contains two outstanding major features. One is the Barnes Ice Cap, located west of the mountain zone, with streams draining east to the fiords between Clyde and Scott Inlets and west to Foxe Basin north and south of Eqe Bay. The cap rises to about 1,100 m and is a relic of the vast ice sheet which formerly covered the entire area. For miles around it is encircled by high moraines and fields of glacial outwash.

40 The other major feature is the Great Plain of the Koukdjuak which stretches from Hantzsch Bay to Cory Bay and extends inland along the western shores of Nettilling and Amadjuak Lakes. Here the Precambrian rocks have been overlain by more recent sedimentary strata and covered by glacial and marine deposits, and the whole area appears to have emerged only recently from beneath the waters of Foxe Basin. The gentle gradient continues offshore for considerable distances giving shallow coastal waters and low featureless coasts. For 10 to 30 miles inland these coasts are bordered by a distinctive belt of waterlogged, marshy country, dotted with numberless shallow circular lakes and drained by a striking pattern of straight parallel streams flowing at right-angles to the coast. The eastern boundary of this marshy zone is marked south of the Koukdjuak River by a series of raised beaches, and east of Cape Dominion by a distinctive area of light-coloured surface deposits worked either by ice or water, or both, into a remarkable pattern of parallel ridges.

41 **Baird Peninsula** and the islands lying in Foxe Basin off the Baffin Island coast have much in common with the coastal belt of the Koukdjuak plain. They are of the same sedimentary rock formation, have the same low elevations, and are so difficult to detect from the sea that several of them were not discovered until aerial reconnaissance for mapping purposes was undertaken by the Royal Canadian Air Force after World War II. They are distinguished by a series of old beach lines, by clusters of shallow circular lakes and by smooth, featureless shores. Even in this area of limited tidal range, the shallow offshore waters, combined with the gentle gradient of the coasts, can produce such extensive areas of drying flats that at low water it has sometimes been difficult to distinguish accurately the boundaries between such adjacent land masses as Bray Island and Baird Peninsula.

42 **Southampton Island**, lying SW of Baffin Island at the north limit of Hudson Bay, has an area of 41,214 km^2. It is divided into two strongly contrasting regions along an escarpment which runs SE from the head of Duke of York Bay to the head of South Bay and eastward from there to reach the coast at about the northern limit of East Bay. To the east of this boundary lies a rolling monotonous plateau of Precambrian rocks which forms the bold rocky coastline along Foxe Channel. Elevations average about 300 to 450 m with the occasional knob or cluster of rounded hills reaching possibly to 550 or 600 m. The greatest heights lie in the NE section between the drainage basins of Mathiassen Brook and Canyon River. The relatively few lakes in this zone are for the most part near the east coast,

and drainage of the area as a whole is mainly into South Bay through the many branching tributaries of Kirchoffer and Ford Rivers. An outlier of this rugged Precambrian plateau forms the east coast of Bell Peninsula. Its altitude is in general about 150 m above sea level with the one distinctive elevation of Mount Minto rising to about 210 m at the head of Nalojoaq Bay.

43 To the west and south of the escarpment stretches a low, gently sloping limestone plain whose greatest heights seldom reach and rarely exceed 150 m. Its offshore extension gives shoal water and broad mud flats for a considerable distance, especially along the shores of the larger bays. From the low featureless coasts the land rises inland toward the escarpment, its surface marked by old beach lines and dotted by the innumerable shallow ponds which form the larger part of its drainage. There are only two rivers of any size in this area, the Boas and the Sutton, which drain south toward the Bay of Gods Mercy and Fisher Strait, respectively. Between their head-waters in the plain is mantled by glacial drift but elsewhere frost action has fractured the surface limestone into small, sharp-edged fragments which cover the country as if with fields of coarse gravel.

44 **Somerset Island** is 24,786 km^2 in area and divided into two contrasting regions along a line which runs SE from Cape Granite, follows the eastern shore of Stanwell-Fletcher Lake and continues past the head of Creswell Bay to the head of Hazard Inlet. To the east lies a vast plateau of level sedimentary strata similar to those on Brodeur Peninsula but at a lower general elevation of between 335 and 400 m. It slopes down from the NE corner of the island only to rise again along the extreme western edge to its highest recorded elevation of 488 m a little north of the latitude of Howe Harbour. It is almost entirely devoid of lakes and its most outstanding surface feature is the dissecting network of deeply-incised river valleys. Bordering Prince Regent Inlet as far south as Creswell Bay, the cliffs rise sheer to about 300 m and the edge of the plateau forms a steep smooth coastline similar to the coast opposite on Brodeur Peninsula and broken by two major inlets, Elwin and Batty Bays. Along Barrow Strait and along the north shore of Creswell Bay the land slopes less steeply to the sea, with isolated bluffs or groups of rounded hills still maintaining the level of the summit of the plateau from which they have been carved by the erosion of wind and water. South of Creswell Bay elevations are lower and the land slopes gently toward Prince Regent Inlet, its surface ridged for a considerable distance inland by emergent strandlines.

45 West of this sedimentary plateau lies a rugged upland of Precambrian rock generally over 300 m high, a continuation of the Precambrian belt which extends NW from the mainland to form the greater part of Boothia Peninsula. Between this upland zone and the plateau to the east lies a trough whose southern end is occupied by the island's major lakes but whose northern limits are poorly defined because the rising ground gradually merges with the higher land to the east and west.

46 The highest elevations in the Precambrian zone lie in the south and west where they rise to about 300 m along the north shore of Bellot Strait and terminate in sheer cliffs comparable to those of Murchison Promontory across the channel. Long, narrow, structural depressions running NE/SW mark the southern limits of Somerset Island. The most important contains Bellot Strait while the two main depressions to the north are occupied by Fitz Roy Inlet and by False Strait with Macgregor Laird Lake.

47 The west coast of Somerset Island, although fairly regular in general outline, is extremely rugged in detail, being indented by numerous tiny bays and fringed in many places by islands, including those lying offshore between Four Rivers Bay and Howe Harbour, as well as the De la Roquette Islands NW of the entrance to Fitz Roy Inlet. A short distance inland, heights exceed 300 m, but the actual coastal elevations along this rugged shore are generally about 150 m or less.

Arctic Western block

48 The mainland coast of the Western Arctic falls into two main divisions, each of which contains a number of small sub-divisions. A low waterlogged coastal plain underlain by sedimentary strata of recent geological age extends along the NE coast of Alaska and continues eastward to the vicinity of Darnley Bay. Eastward from Pearce Point stretch the ancient rocks of the Precambrian Shield. Between the head of Darnley Bay and Pearce Point, the Precambrian rocks are so low and so heavily covered by glacial drift that the area differs very little topographically from the lowland to the west.

49 The coastal plain is widest in the vicinity of Point Barrow where it is roughly triangular in shape, extending approximately 150 miles from its apex at Point Barrow to its base along the northern slopes of the Brooks Range. West of the Mackenzie Delta it is characterized by stretches of low coastal cliffs 6 to 12 m high and bordered by shallow water for a considerable distance offshore. It is covered by a thick mantle of unconsolidated deposits and underlain at no great depth by permanently frozen ground which blocks the downward drainage of surface waters and results in a wide scattering of shallow lakes and meandering streams. The

plain narrows considerably toward the east so that along the Arctic coast of the Yukon it stretches inland only about 10 to 20 miles, ending abruptly against the northern slopes of the British and Richardson Mountains. Its most distinctive landmarks are the wide beds of broad, braided streams such as the Malcolm and Firth Rivers which flow from the mountains across its nearly level expanse. Along the coast the sediments brought down by these rivers are building up deltas, sand spits, lagoons and low alluvial islands.

50 The waterlogged delta of the Mackenzie River interrupts the continuity of the coastal plain and extends roughly from the longitude of the eastern limits of the Richardson Mountains eastward to Richards Island. It is an incredible maze of alluvial banks and islands, innumerable shallow lakes and fantastically meandering channels, all of which may considerably alter their shape or orientation over a period of years as a result of spring floods and the consequent redisposition of river sediments. The delta is tree-covered almost to the coast and is so extremely low-lying that in some places along its western edge the southern limits of the coastal plain rise above it in sheer cliffs 30 to 60 m high. The amount of sediment brought down by the Mackenzie River results in very shallow offshore waters in Mackenzie Bay.

51 Eastward from the Mackenzie Delta the low coastal plain extends toward Baillie Islands and Cape Bathurst, and is bordered by extensive shoals, spits and sand bars. The coastline is extremely complex as a result of the gradual sinking of this densely lake-strewn, almost-level area. Stretches of the old shorelines of former lakes still protrude in many places as low, rounded fingers, encircling the coastal inlets which, due to the lowering of the land, now occupy the former lake beds. Low conical hills rising inland to 30 or 60 m form the only distinctive elevations in the area.

52 From the eastern limits of this lake-strewn coastal plain the monotonous lowland stretches SE, heavily mantled by unconsolidated deposits through which meandering rivers have incised deep valleys. Lakes are few and the great meanders of the major rivers such as the Anderson and the Horton are the area's most outstanding features. Elevations increase gently north and NE, reaching 150 to 240 m in the Smoking Hills, which do not actually form a range, but are the seaward edge of the low interior plateau.

53 Southward from Cape Bathurst the bold western shore of Franklin Bay is formed of mud and unconsolidated materials which, over long stretches, fall to the sea in sheer cliffs, sometimes not more than 15 m high. In the vicinity of Fitton Point elevations rise to approximately 60 m; southward from this the coast is higher and formed by the line of the Smoking Hills where beds of bituminous shale in the nearly-horizontal strata have been smouldering since before the discovery of these coasts by Sir John Richardson in 1826. Toward the head of the bay these hills trend inland, merging with the western limits of the Melville Hills with heights over 300 m. The melting of layers of ice in the mud and unconsolidated materials, and the removal of the bituminous strata in the Smoking Hills by combustion, have caused the steep cliffs to crumble in many places, but even where the high banks have retreated inland and the land now slopes to the sea instead of falling sheer, the western coastline of Franklin Bay nevertheless remains well defined.

54 Parry Peninsula which separates Franklin and Darnley Bays rises from a low drift-strewn isthmus, dotted by innumerable shallow lakes, to attain a height of about 60 m near its northern limit where outcrops of limestone form steep cliffs 24 to 30 m high, both on the tip of the peninsula and on the offshore islands. These cliffs have been eroded by sea action into an intricate confusion of arches, caves, inlets and islands, with underwater reefs giving treacherous waters in many areas. Southward from this, the offshore waters again become shallower and spits, shoals and mud banks fringe the coast.

55 The eastern shore of Darnley Bay is formed by the low, drift-strewn western edge of the Precambrian Shield which, except for its underlying structure, its occasional outcrops of bedrock and its gradual increase in height to the eastward, it does not differ too greatly in surface appearance from the sedimentary lowland to the west.

56 From Pearce Point to Deas Thompson Point the Precambrian rocks present a different aspect from the usual rugged, worn topography of the Shield. They are very ancient sedimentary rocks, tilted to form steep-facing escarpments backed by gentle slopes. These cuestas are most pronounced inland in the area of Coppermine and September Mountains where they reach 520 m, and around the head of Bathurst Inlet where they rise in coastal crags 300 m high; along the Arctic coast they show only as intermittent cliffs rising 60 to 90 m. These stratified rocks form a wide belt which curves southward from the south shores of Amundsen Gulf to reappear along the coast again at Cape Kendall. From here they continue eastward in a narrowing band along the south shore of Coronation Gulf and the eastern side of Bathurst Inlet. They reappear offshore in the island chains crossing Coronation Gulf from SW to NE, include the Richardson Islands off the south coast of Victoria Island and form the almost-detached mass of Kent Peninsula. Over much of the area the escarpments face south and their gentle northern slopes form the rocky, shelving, south shore of Coronation Gulf and the low north shores of Kent Peninsula and the offshore islands. The

waters bordering these shores are shallow but along the bolder south coasts of the islands the cliffs fall sheer to deep water. Toward the SE, the trend of the terrain appears to alter direction so that on the SW side of Bathurst Inlet many of the high scarps face SE or ESE forming high coastal cliffs.

57 West of Bathurst Inlet much of the country inland is overlain by a heavy mantel of glacial drift, some of it conspicuously orientated into parallel ridges. The Melville Hills which rise roughly 760 m throughout much of their length and which reach heights over 850 m east of the Croker River, appear to be composed mainly if not entirely of elongated mounds of this glacial debris. These hills are visible from the coast in the vicinity of Keats Point, the head of Darnley Bay and at more easterly points along Dolphin and Union Strait.

58 Between Deas Thompson Point and Cape Kendall the ancient Precambrian strata are overlain by later sedimentary rocks. Although there are few coastal cliffs in this stretch, the coastline as far as the vicinity of Clifton Point is bold and regular. Eastward from here elevations become lower, the shoreline becomes more complicated, and the cover of glacial drift grows less.

59 Although lying to the east of Bathurst Inlet, Kent Peninsula is part of the zone of tilted Precambrian strata. Its western and northern coasts are low and regular, with shallow offshore waters. In the east the coast is marked by emergent strandlines and the land rises with a gentle gradient from the shallow waters of Queen Maud Gulf to a series of south-facing escarpments, 165 to 225 m in elevation. From elevations of about 120 m at Elu Inlet, heights along the complicated south coast fall off westward to about 30 m toward the outer limits of Melville Sound. The isthmus joining Kent Peninsula to the mainland is a low neck of hilly land about 60 m in height, whose offshore ridges form the fringe of coastal islands.

60 Eastward from Bathurst Inlet and Kent Peninsula, the mainland coast marks the northern limits of that broad expanse of the Precambrian Shield which extends westward from the shores of Hudson Bay and Roes Welcome Sound. It is formed of the more characteristic ancient crystalline rocks and its rolling, monotonous terrain is crossed by low ridges and scatterings of knobby hills about 150 or 180 m high. Along the south shore of Queen Maud Gulf the coast is low and rocky, and much of it is overlain by recent marine sediments. The shallow offshore waters are dotted by rocks, shoals and islands. The west coast of Chantrey Inlet is low with rock outcrops occurring amid the glacial deposits and with the hills of the interior plateau rising to 60 m not far inland. The rocky east shore of the inlet is comparatively regular throughout much of its length and between the Hayes River and Cape Barclay, rises to between 90 and 150 m.

61 The Precambrian rocks of Adelaide Peninsula, and a considerable stretch of the coast between Chantrey Inlet and Spence Bay, are overlain by relatively smooth, flat-lying sedimentary rocks of more recent date which have been covered in their turn by a heavy mantle of glacial drift. This drift cover has impounded the drainage and given a waterlogged character to the area, and has produced along the coast low rounded capes, shallow offshore waters, and many low islands in Simpson Strait. On Adelaide Peninsula these glacial deposits are conspicuously orientated SE/NW while on the east shore of Rae Strait they are aligned SW/NE.

62 **Banks Island**, the most westerly island of the Canadian Arctic Archipelago, has an area of 70,028 km^2. It is formed of sedimentary strata of various geological ages, spectacularly banded in colours of pink, white, buff and black. The whole surface has been tilted downward toward the middle of the island leaving a high north-dipping plateau in the south, a slightly lower south-dipping plateau in the north and NE, and an intervening narrow belt of hilly upland along the east coast. Elevations fall off toward the west and the belt of hilly upland soon merges into a low featureless plain. Coasts are bold in the north, east and south, but along the Beaufort Sea the shoreline is low and irregular, marked by coastal bars, spits and islets, and with shallow water for a considerable distance offshore. The land in this area appears to be sinking and the drowned shoreline is similar to the Arctic mainland coast east of the Mackenzie Delta.

63 The highest elevations are found in the southern tableland where the various coloured strata reach elevations of 670 m in Durham Heights and form the dramatic promontory of Nelson Head which rises sheer about 365 m from the water's edge. The northern boundary of this tableland lies roughly along the valley of the Masik River.

64 The NE plateau attains its greatest heights of 300 to 450 m in the vicinity of Mercy Bay. Between Cape Vesey Hamilton and Rodd Head the nearly vertical coastal cliffs rise 240 to 300 m and continue bold but at ever-lowering altitudes eastward toward Parker Point. Westward from Castel Bay, coastal elevations decrease to less than 150 m at Cape M'Clure and 90 m at Cape Prince Alfred. Inland the plateau becomes dissected SE of Mercy Bay into an area of flat-topped hills, and further west it passes through a region of low, rounded, rocky hills to merge into the lowland.

65 In the central area lies a crescent-shaped belt of hilly upland with elevations reaching at times approximately 380 m along the east coast. The island's main watershed lies roughly 10 to 12 miles inland from Prince of

Wales Strait, and west of this the upland disappears into the rolling prairie lowland. For the most part this lowland zone is featureless except for the long, straight rivers which flow across it from the eastern watershed and reach the western coast as broad, braided streams. Much of the lowland surface is covered by a mantle of unconsolidated material and the whole region is underlain by permanently frozen ground so that along the western coast where the land is sinking and the drainage is sluggish the country presents a waterlogged surface dotted with numerous small lakes and shallow ponds.

66 **Victoria Island**, with an area of 217,290 km^2, is the second largest island in the Canadian Arctic Archipelago, being slightly larger than Ellesmere Island and roughly half the size of Baffin Island. It is divided into three main physiographic areas: a sedimentary plateau in the NW similar to the NE plateau of Banks Island, a vast lowland of drift-strewn sedimentary rocks occupying the eastern ⅔ of the island, and, in between, an upland zone of ancient, tilted Precambrian sedimentary rocks similar to those of the scarp-land zone on the south shore of Coronation Gulf.

67 The boundary of the northwestern plateau follows roughly along a line from the north side of Walker Bay to the western shores of Glenelg Bay. The flat-to-rolling terrain is between 300 and 450 m high and much of the surface is covered by unconsolidated materials. The two main rivers of the area rise a short distance north of Walker Bay and flow north and NE to the head of Richard Collison Inlet while the majority of the other shorter, smaller rivers flow NW into Prince of Wales Strait or into the SE side of Richard Collison Inlet. The lakes in this plateau zone are fairly small and for the most part lie in a belt about 10 to 15 miles wide, parallel to the coast of Prince of Wales Strait but at a distance inland. There is also another small scattering of lakes near the eastern boundary of the area. The coasts are fairly smooth in outline, generally of low elevations but rising to higher ground a short distance inland.

68 The western limits of the eastern lowland zone extend from the vicinity of Investigator Island in Prince Albert Sound to the west shore of Hadley Bay, a short distance south of the entrance. The land rises very gradually from the extremely low coasts in the east and SE to reach general elevations of about 300 m in Wollaston Peninsula and in the hilly, broken belt bordering the Precambrian zone north of Prince Albert Sound. Raised gravel beaches mark former high water levels along the low coasts, and the whole area is heavily mantled by glacial deposits which are, for the most part, strewn randomly over the nearly-level surface. The low, rounded ridges of glacial drift, combined with the permanently frozen ground beneath, have impounded the surface drainage into innumerable shallow lakes and sluggish, meandering streams. The most distinctive elevations in this monotonous landscape are Mount Pelly, rising 210 m a short distance to the NE of Cambridge Bay, and a rocky hill 224 m high on the NW side of Stefansson Island.

69 In Wollaston Peninsula, one height of 518 m has been recorded, and several probably approach 450 m. The higher terrain here resembles the mainland area between Deas Thompson Point and Cape Kendall and has the same fairly even coastline and gently rolling surface. Along the south shore of Prince Albert Sound the smooth coastline slopes quickly up to bold cliffs while north of the sound, in the hilly belt of broken terrain bordering the Precambrian zone, elevations may reach 300 m. In this higher western part of the lowland, glacial deposits have formed scattered groups of low, rounded hills, such as Colville Range which bears marked similarities to the Melville Hills on the mainland.

70 Although the lowland is composed mainly of unfolded nearly-level sedimentary strata, Precambrian rocks outcrop at a number of places, the most notable being on the south coast where the Richardson Islands and the adjacent shores are a continuation of the sedimentary Precambrian strata along the south shore of Coronation Gulf. Elsewhere on the lowland, Precambrian outcrops are more difficult to recognize because of the heavy drift cover. This cover, however, thins out toward the north and west, although the area around Goldsmith Channel and the southern part of Stefansson Island is covered with orientated deposits. The bedrock lies at the surface, from the northern shore of Stefansson Island west to Hadley Bay, forming low, bold cliffs along Viscount Melville Sound and giving a relatively distinct, regular shoreline, quite in contrast to the shelving, intricate coasts in the east and SE.

71 The Precambrian upland zone extends NE from Prince Albert Sound to the peninsula separating Wynniatt and Hadley Bays. Like the Precambrian sedimentary zone south of Coronation Gulf, it is composed of ancient stratified rocks which have been tilted and weathered to form bold escarpments. Around Minto Inlet in the south, this scarpland terrain only attains heights of about 300 m, but in the vicinity of Wynniatt and Glenelg Bays elevations rise to approximately 550 m. In contrast to the mainland zone, the greater number of escarpments on Victoria Island appear to face north, but the orientation is by no means consistent and in some areas they face NW, south or, occasionally, east. Lakes are few and are, for the most part, either in the NE in the vicinity of Glenelg Bay or in the SW near the head of Minto Inlet. The coasts are steep and rugged rising to 300 m where the escarpments

reach the water's edge, as along the bold eastern shore of Glenelg Bay and the SE shore of Minto Inlet, where some of the cliffs rise to over 300 m. The NW shore of Minto Inlet, formed by the low, gentle, lee slope of the next line of scarps, gives a gently-shelving, rugged coastline similar to the south shore of Coronation Gulf. The non-submerged tops of offshore ridges form groups of rocky coastal islets.

72 **Prince of Wales Island** has an area of 33,338 km^2 and lies midway between the east and west limits of the Canadian Arctic Archipelago. It is probably the most inaccessible and least visited of the large islands south of Parry Channel. As a rule the north shore can be reached during the summer, at least by icebreaker, and the east coast can usually be approached through Peel Sound. In some years, however, an ice barrier may form at the northern entrance of Peel Sound and approach to the east coast can then be made only by way of Prince Regent Inlet and Bellot Strait. The forbidding ice conditions in M'Clintock Channel and Victoria Strait prevent any approach from the west by sea, except by powerful icebreakers.

73 The island is divided into two main zones. In the north and east it forms part of the great level sedimentary plateau which includes Brodeur Peninsula and much of Somerset Island. In the west and SW it is a continuation of the drift-strewn, waterlogged sedimentary lowland which stretches from the mainland through King William Island and eastern Victoria Island. The winding boundary between these two zones runs roughly SW from the western end of Baring Channel across the isthmus connecting Cape Dundas and Cape Berkeley to the main part of the island, and from there along a line of low hills SW to Drake Bay. It then follows the edge of the escarpment north of Drake and Smith Bays, runs east from the head of Smith Bay to the head of Browne Bay and thence SE to the vicinity of Coningham Bay.

74 The highest part of the plateau lies in the NE. Along the shore at Cape Walker on Russell Island and at Bellot Cliff the coast rises steeply to more than 240 m, and a short distance inland, elevations rise to over 300 m. The river valleys of the plateau are broader than the deeply incised streams of Somerset Island and Brodeur Peninsula; in fact, in the dissected area south of Browne Bay they become so broad and gentle that the widely separated remnants of the flat-topped plateau surface rise above them as mesas.

75 South and west of the plateau, the lowland extends flat to gently rolling, with broad stretches covered by glacial drift which in many places is orientated in the same directions as the neighbouring deposits on King William Island and the adjacent parts of the mainland. On Prince of Wales Island, however, this cover is not so thick, and stretches of exposed bedrock are not uncommon. Such a stretch runs NW for about 30 miles from the head of Guillemard Bay, and appears to be composed of smooth, elongated mounds of glacial debris about 120 m high. The coasts of the lowland zone are, on the whole, gently shelving, marked in many places by emergent strandlines and shallow offshore waters.

76 On the east coast of the island, from Prescott Island to the vicinity of Transition Bay just south of Strzelecki Harbour, a narrow rugged strip of ancient crystalline rocks forms the western shore of Peel Sound. It is the NW edge of the broad tongue of Precambrian rocks which extends NW from the mainland to form the greater part of Boothia Peninsula and the SW part of Somerset Island. On the western side of Peel Sound, it reaches its highest elevation of 350 m on Prescott Island.

77 **King William Island** has an area of 13,111 km^2. Like the SE section of Victoria Island, it is formed of low level, monotonous, limestone plain, heavily overlain by glacial deposits and underlain by permanently frozen ground which prevents drainage and gives a waterlogged landscape of rounded hills and numberless shallow lakes. In some places the glacial drift is orientated, usually in the same direction as the deposits on the neighbouring sections of the mainland. Along Humboldt Channel and James Ross Strait, and for a distance southward from Cape Felix, the coast is formed by a series of low cliffs which slope up gently from the sea and are marked by parallel bands of emergent strandlines. Elsewhere, the low, island-fringed coasts are shelving and featureless, often difficult to distinguish in winter from the ice-covered straits surrounding them. Near its centre, the island reaches its highest elevation of 120 m. Its most outstanding landmark is Mount Matheson in the extreme SE, rising to 73 m.

Arctic Northern block

78 **Queen Elizabeth Islands** have a variety of landscapes and geological formations, and can be divided roughly into five main areas.

79 The most easterly section is part of the Precambrian Shield and extends as a tapering zone through eastern Devon Island and through eastern Ellesmere Island as far north as the vicinity of Bache Peninsula. On Devon Island it forms high, ice-covered upland with relatively bold, regular coasts; but on Ellesmere Island it produces a deeply-fiorded, spectacular coastline similar to the Baffin Island coast in the vicinity of Cape Eglinton.

80 West of this Precambrian zone lies a plateau of gently dipping, later sedimentary rock, which extends

across western Devon Island and the western half of southern Ellesmere Island.

81 An area of folded sedimentary rocks, to which has been given the name of the "Innuitian" zone, extends east from Kellett Strait through the islands on the north side of Parry Channel as far as Wellington Channel and from there it curves through Grinnell Peninsula, the greater part of Axel Heiberg Island, and all of Ellesmere Island north of a line drawn roughly from Blue Fiord to Bache Peninsula. It is highest and most rugged in north and NE Ellesmere Island and on Axel Heiberg Island, and although in the south and west elevations decrease and the folds appear more worn and weathered, the terrain remains, on the whole, rolling and difficult.

82 North of the Innuitian zone, the Arctic Coastal Plain extends from the coast of the western mainland, through western Banks Island, Prince Patrick and Eglinton Islands, and the northern peninsulas of Melville and Bathurst Islands. It also includes several islands in the Sverdrup Islands group and all the islands discovered during 1913–18 by the Canadian Arctic Expedition under Stefansson. The coasts are low, flat and usually featureless, especially those which face toward the Arctic Ocean. Elevations increase somewhat east and south toward the central part of the Queen Elizabeth Islands, with the greatest extent of higher, more rugged terrain being located on Ellef Ringnes Island.

83 A northern extension of the sedimentary zone which forms the plateaux of NE Banks Island and NW Victoria Island, appears north of Parry Channel in Dundas Peninsula on Melville Island and along a considerable stretch of the north shore of Liddon Gulf.

84 Glaciation in Queen Elizabeth Islands appears to have been extensive only in the east and NE. At the present time major ice fields exist only on Devon, Ellesmere and Axel Heiberg Islands, although there is a small ice cap on Meighen Island and some small permanent snow fields on Melville Island.

85 **Devon Island**, with an area of 55,247 km^2, is the fifth largest island in the Canadian Arctic Archipelago. It falls physiographically into three distinct areas. In the east, almost entirely enveloped in ice, is a high, irregular upland of Precambrian crystalline rocks similar to those along the east coast of Baffin Island. The coasts, although bold, are not as a rule high, but a short distance inland elevations increase quickly to between 1,200 and 1,500 m, with a recorded maximum of 1,920 m on the ice cap. In the SE, between Croker Bay and Hyde Inlet, the peaks of Cunningham Mountains and the barely submerged lower ridges break the level surface of the ice cover, but elsewhere, the gently-domed cap extends smooth and even across the whole surface of the upland, with glaciers flowing down to tidewater. Coburg Island off the NE corner of Devon Island is also a part of this Precambrian upland and is so heavily mantled by ice that its west and north coasts are mainly composed of the outer edges of the tongues of numerous glaciers.

86 West of a line running NNW from the vicinity of Dundas Harbour roughly to Cape Skogn on the north coast, the rugged Precambrian rocks are overlain by smoother sedimentary strata which, like those on Borden and Brodeur Peninsulas, increase in thickness toward the west. In the east where the Precambrian rocks are but thinly overlain, the terrain is rugged and hilly but westward the surface becomes level and the thicker layers of sedimentary rocks are deeply incised by rivers. Elevations reach approximately 1,200 m in the east where a tongue of the ice cap extends SW across the plateau, but fall to about 600 m in the hilly zone just west of the ice, and to between 150 and 240 m along the west coast. For the most part the land is flat and featureless except for the dissecting rivers and for the tongue of ice which reaches the western side of Blanley Bay. Ice-free areas and isolated ice fields alternate along the southern coast as far west as the vicinity of Maxwell Bay. Along Lancaster Sound, the plateau forms an impressive coastline, its steep flat-topped cliffs dramatically banded by the diversely coloured level strata, and fringed at their base by high scree slopes or narrow stretches of emergent strandlines. Its straight regular line is pierced by numerous spectacular high-cliffed inlets. Off the SW corner of the island, and connected to it at low water by a long gravel bar, lies tiny Beechey Island where Franklin wintered 1845–46 and which has since been visited by practically every expedition entering Lancaster Sound.

87 North of a line running roughly from Dragleybeck Inlet to Viks Fiord, the level sedimentary strata have been disturbed and slightly tilted, and the terrain assumes the more broken and hilly aspect typical of the folded Innuitian zone. A prominent escarpment, bordered by a low coastal plain, extends from Dragleybeck Inlet to Point Hogarth but, except for this stretch, the coasts of this NW zone are generally rather low at the actual shoreline and rise steeply a short distance inland. On the north side of Colin Archer Peninsula they stand more than 300 m high in places, while on the south side an escarpment extending eastward from Arthur Fiord also provides a bold coastal outline. There are four small ice fields on Colin Archer Peninsula; from the most easterly a large glacier reaches tidewater on the north coast. Maximum heights on Grinnell Peninsula are in the neighbourhood of 450 m, while those in the more rugged Colin Archer Peninsula generally rise between 360 and 550 m with a few probably exceeding 600 m. The two

peninsulas are joined by a low isthmus extending from the head of Arthur Fiord to Prince Alfred Bay. This was originally charted as a strait, with Grinnell Peninsula shown as an island.

88 **Ellesmere Island** is the third largest island of the Canadian Arctic Archipelago, having an area of 196,236 km^2. In the south its geological structure resembles that of Devon Island with a highland zone of ancient Precambrian rocks extending in a broad belt northward from Jones Sound to Buchanan Bay. West of this, the westward-dripping Precambrian rocks are overlain by increasingly thick later sedimentary strata which extends inland from Jones Sound for a short distance beyond the heads of the fiords. This southern plateau is considerably more dissected than the similar zone on Devon Island, and its strata, instead of lying flat, dip slightly northward. Its elevations fall from about 1,500 m in the east to about 300 m in the vicinity of Hell Gate.

89 The remainder of the island belongs to the Innuitian zone of folded sedimentary strata, and is subdivided into two distinct sections by a high plateau which extends in a broad belt from the heads of Greely and Tanquary Fiords NE to Archer Fiord and the vicinity of Alert. In the section lying SE of the plateau the line of folding runs generally NE/SW with the greatest heights in the neatly aligned ridges of the ice-covered Victoria and Albert Mountains. The northern section with heights over 2,000 m, contains the highest elevations in North America east of the Pacific Cordillera, and its coasts are deeply indented by magnificent fiords.

90 Ellesmere Island is the most heavily glaciated part of the Canadian Arctic Archipelago at the present time. In the SE, the Precambrian zone is almost entirely ice-covered, with impressive glaciers flowing down to the east coast and contributing many bergs to the southerly drift into Baffin Bay. This ice cap is divided into two distinct parts by Makinson Inlet. Highest elevations in the southern cap are less than 1,500 m and the ice here does not form a featureless dome as on Devon Island but is pierced by numerous nunataks, and in many places indicates by its uneven undulating surface, the contours of the underlying ridges. North of Makinson Inlet it is higher, reaching nearly 2,100 m a short distance east of the head of Bay Fiord. The southern plateau zone also contains an ice cap, which lies at about 1,000 m and extends roughly from the head of Harbour Fiord west to the head of Baad Fiord. Smaller caps at elevations of about 760 m lie near the base of all the western peninsulas and on North Kent Island.

91 In the rolling uplands of Raanes and Fosheim Peninsulas where elevations reach approximately 1,200 m, the few tiny ice fields are located well inland. A small, compact ice field, with elevations up to about 1,700 m, lies between the head of Cañon Fiord and the Bache Peninsula area of the east coast. It is probably a detached segment of the larger and higher field which extends NE from Cañon Fiord to Archer Fiord and which, except for the immediate coastal area, stretches across the entire width of the island from Greely Fiord to the east coast. Elevations reach about 2,000 m in places and peaks of the parallel ridges of the Victoria and Albert Mountains pierce the surface, forming rows of nunataks. Huge glaciers flow down to the heads of practically all the major fiords along the heavily indented east coast south of Rawlings Bay and to the shore of Cañon and Greely Fiords. Ice cover is limited to the western side of Judge Daly Promontory and does not extend farther north than about half way along the east shore of Archer Fiord. Although structurally a part of this mountainous zone of sedimentary rocks, the strata on Bache and Knud Peninsulas and in the vicinity of Cape Field have been tilted but not folded. In contrast to the surrounding areas they form relatively level ice-free plateaux, with elevations falling off from about 900 m inland to roughly 450 m at their eastern limits.

92 The folded zone north of the plateau belt, which extends between the head of Greely Fiord and Alert, is covered by an enormous ice cap, divided into three distinct segments by two large through valleys. One valley runs SE from the head of Clements Markham Inlet, the other connects the heads of Yelverton Bay and Tanquary Fiord. The smallest segment of this ice cap lies east of the first valley, and its highest elevations reach about 2,000 m. The central and largest segment lies between the two valleys and its greatest elevations are about 2,600 m. Many of its impressive glaciers flow down to the Arctic coast, while a number of smaller ones flow eastward over the plateau zone toward Lake Hazen. The SW segment of the ice cap also reaches elevations of approximately 2,600 m and many of its glaciers flow down to the Arctic coast and to the heads of the great inlets which indent the shores of Nansen Sound and Greely Fiord. Small outliers of this ice field are found on many of the north coast headlands. The segments of the northern cap do not form smooth domes but are pierced by peaks of the underlying ridges or undulated by their buried contours. Highest elevations appear to lie along a broad belt extending NE from the heads of Hare and Otto Fiords. West and NW of this belt the land slopes down to Nansen Sound and to the low NW headlands of the Arctic coast. Between Yelverton Bay and Cape Joseph Henry the coast is extremely bold and high, and much of it is bordered by the heavy-ridged shelf ice from which large fragments break off from time to time to become the long-enduring, distinctive "ice islands" of the Polar Basin. Most of the inlets also contain areas of multi-year ice which can remain in position

for decades, attaining thicknesses of more than 5 m in places.

93 Except for limited areas south of Baumann and Slidre Fiords and for a stretch in the extreme NW, the coasts of Ellesmere Island are generally high, steep-cliffed and impressive. In some areas the land slopes up steeply to considerable heights a very short distance inland, in others it falls almost sheer to the sea. The greatest coastal heights appear to be those near the base of Judge Daly Promontory where the deeply dissected folded ridges form a series of V-shaped cliffs 1,500 m high.

94 **Axel Heiberg Island**, with an area of 43,178 km^2, belongs mainly to the zone of flooded sedimentary strata which forms the greater part of Ellesmere Island. The axis of folding, however, runs north/south in contrast to the general NE/SW orientation of the Ellesmere Island ridges. Except in the SE the coasts are generally fairly low, broken here and there by cliffs of rocky bluffs which, though not of any great height themselves, are nonetheless outstanding because of their contrast with the surrounding low terrain. Inland the elevations rise to ice-covered heights between 1,200 and 1,500 m, and in the SE, between Wolf Fiord and Whitsunday Bay, even the coastal cliffs rise almost sheer in places to 600 m, with greater heights almost immediately inland. In this SE section the north/south alignment of the folded ridges is very evident in the hilly uplands and in the orientation of the major fiords.

95 The west coast and the NW tip of the island belong to the Arctic Coastal Plain and are somewhat higher and more rugged than most parts of that zone. In many places the stretches of level mud flats and gravel beaches give way a short distance inland to a scattering of conical hills and a number of prominent ridges and rocky outcrops. The best known of these ridges is the dark line of cliffs at the NE tip of the island, which rises sharply on both seaward and landward sides and which Sverdrup named Svartevaeg Cliffs. There is also some indication of piercement domes on both the east and west coasts, which with their rugged, eroded centres surrounded by concentric rings of escarpments, suggest possible oil deposits in the underlying strata.

96 The ice cap on Axel Heiberg Island is divided into two main sections. The more rugged southerly one lies south of Strand Fiord and its highest estimated elevation of approximately 1,800 m is located slightly NW of the head of Glacier Fiord. Many glaciers flow down from the cap but none reach tidewater. The northern section occupies most of the central area of the island and rises dome-like to about 1,800 m with a long, finger extending SE along the watershed ridge between Skaare and Wolf Fiords. One of its many glaciers reaches tidewater and calves flat-topped bergs into the unnamed west coast bay north of South Fiord.

97 **Cornwallis Island**, although geologically part of the Innuitian zone of folded sedimentary rocks, the 6,996 km^2 present a relatively even surface and a gently domed shape. The terrain rises to nearly 360 m in the SE section, with cliffs between 240 and 300 m high in places along the coast. The east and south coasts are relatively regular and the few inlets are widely spaced and clearly defined. The north and west coasts are much lower, marked in places by shingle beaches and having, like low-lying Little Cornwallis Island to the NW, deeply-indented, complex outlines. Much of the area is heavily mantled by unconsolidated surface materials, probably frost-riven fragments of the underlying bedrock. The rivers are well incised in the nearly-level surface, especially in the SE.

98 **Bathurst Island and Byam Martin Island**. — The Bathurst Island Group is about 21,000 km^2 in area and belongs for the most part to the sedimentary Innuitian zone. South of a line running east from the vicinity of Hooker Bay, the strata have remained relatively unfolded and form a plateau rising between 240 and 300 m in the easterly section. Elevations in this relatively unfolded zone fall off south and west to such an extent that a 120 m hill in the SW corner of the island forms a distinctive landmark. This SW section also has a few flat-topped hills, some of which are estimated to be about 300 m high, although the majority are considerably lower. The coasts in the eastern part of this area are bold, being intricately indented along McDougall Sound but more regular along the south coast as far west as Allison Inlet. From Allison Inlet to De la Beche Bay the coast continues low and regular, and from there to Bracebridge Inlet it resembles the McDougall Sound area in outline but is lower in elevation.

99 In the northern half of Bathurst Island the sedimentary strata have been folded, and the ridges are orientated ENE/WSW. The trend of the relief is clearly evident in the alignment of the straits and inlets on the west coast and along the shores of Erskine and May Inlets. These coastal indentations are, for the most part, the drowned seaward ends of the valleys lying between the folded ridges, or the drowned mouths of rivers which flow through these valleys. Erskine and May Inlets which cross the area at right angles to the alignment of the terrain are possibly the drowned estuaries of rivers which flowed down from the highest and most southerly ridge and which maintained their north/south valleys in spite of the foldings. Most of the ridges have been so greatly worn down that the surface of the island, though hilly, forms a peneplain rather than a mountainous zone. Heights average about 300 m, being somewhat lower in the north and west and rising gradually

toward the east and south. One height of 410 m lies east of the entrance to Erskine Inlet and another of 305 m is located on the south shore of Stuart Bay. In a narrow strip bordering the east coast of this area, the line of folding changes abruptly to a north/south direction and one ridge continues southward from Goodsir Inlet and forms Truro Island. This folding results in a bold, regular coast whereas elsewhere in the upland zone the coasts show the alternate variations of cliff and vale resulting from the ridge and valley topography of the parallel folds.

100 The lower general elevations in the western section of Bathurst Island have resulted in a complete flooding of the major valleys of the NW peninsula, transforming them into straits while the intervening ridges persist as islands of which Cameron Island in the extreme NW is the largest. The southern section of Cameron Island belongs to the zone of folded sedimentary strata and the island's highest elevation of 193 m is in the extreme SE. The northern section of the islands has been overlain by more recent sedimentary deposits and forms part of the Arctic Coastal Plain. Elevations do not exceed 60 m, and the coasts of this low and featureless country shelve with gentle gradient into shoal waters. Byam Martin Island is slightly domed in outline and its low coasts rise gently from shallow waters to inland elevations of about 120 and 135 m. Except from the air, where the parallel east/west orientation of the folded strata shows up clearly, the island has no outstanding features.

101 **Melville Island** is 42,149 km^2 in area and can be divided topographically into three main regions. The largest comprises the whole island with the exception of the two northern and the two most SW peninsulas. This region is part of the folded Innuitian zone which, through weathering, has developed an extremely rugged worn landscape of ridge and valley topography. The trend of the relief is for the most part either east/west or SE/NW. The rivers have carved deep beds in the valley troughs and in many places have excavated their ravines along the crests of the ridges. Elevations rise generally toward the west and north, reaching a maximum of about 700 m in the area between the heads of Murray Inlet and Ibbett Bay, where three small snow fields remain throughout the summer. Along the southern limits of the tightly-folded Canrobert Hills north of Ibbett Bay, heights reach approximately 600 m. The north and east coasts of this area are low but generally well defined, with fairly prominent cliffs occurring at intervals. This is also true of the south coast, but here, the crests of the folds which continue offshore as barrier ridges into Skene Bay and Bridport Inlet and which form the rocky finger of Wakeham Point near Winter Harbour, provide additional distinctive landmarks.

102 North of a line running roughly SE from the head of Marie Bay to the southern limits of Eldridge and Sherard Bays, the folded strata are overlain by later sediments and the area forms part of the Arctic Coastal Plain. Elevations are generally low but the region is not entirely featureless, for the even, seaward slopes are broken by the occasional low ridge or isolated hill, and by the elongated deltas which the broad, braided streams build for considerable distances in the shallow offshore waters.

103 In the SW, Dundas Peninsula and the peninsula separating Liddon Gulf and Purchase Bay form a plateau region of flat or gently tilted sedimentary rocks similar to those more southerly plateaux which flank the northern section of Prince of Wales Strait. The area is characterized by deeply incised river valleys and bold coasts which either rise in sheer cliffs from the sea or slope steeply up to the plateau level. Coastal elevations are approximately 600 m near the head of Murray Inlet but decrease westward and along the north coast of Dundas Peninsula, becoming bold cliffs between 150 to 180 m high. Between Cape Ross and Cape Providence on the south and SW coast, the cliffs maintain an average elevation of about 300 m.

104 **Islands of the Arctic Coastal Plain** are, in general, low and featureless. The smaller ones are usually dome-shaped, rising gradually from shallow coastal waters to central elevations of 90 to 200 m. The large ones rise gently from the shelving coasts to their watershed which usually runs along their longest axis, NE/SW on Prince Patrick Island, east/west on Borden Island. Except for lagoons or occasional areas of coastal ponds, lakes are either few in number or completely absent. The rivers drain in straight courses from the watershed to the nearest coast, sometimes being deeply incised near their heads, but becoming shallow in their lower reaches and frequently reaching the coast as flat, broad-mouthed, braided streams. The outer coasts of the Archipelago are in some cases so low as to become broad mud flats at sea level, with shoals, islets and offshore bars producing a confusing intricate shoreline. Much of the surface of the islands is covered by unconsolidated materials, probably frost-riven fragments of the underlying bedrock.

105 Elevations and ruggedness throughout the region tend to increase south and east toward the centre of the Archipelago. The northern part of Ellef Ringnes Island is typical of the coastal plain, and in fact its low featureless terrain forms one of the most extensive mud flat coasts of the whole Archipelago. About ⅓ of the way from its NW tip, however, the island is crossed by a band of level strata, dissected by broad rivers into flat-topped blocks, which form a plateau about 240 m high. South of this, the general elevation falls again although individual outcrops may

reach 300 m or more. In this southern part of Ellef Ringnes Island and on most of Amund Ringnes and Cornwall Islands the structural grain of the country is evident in spite of the overburden. Except in the plateau belt of Ellef Ringnes Island where coastal cliffs may in places rise nearly 180 m high, the coasts even in the SE part of the Arctic Coastal Plain are low and shelving.

106 The small ice cap, which lies at an elevation of 240 m and occupies the central part of dome-shaped Meighen Island, is the only ice field on the Arctic Coastal Plain.

Great Slave Lake — Mackenzie River area

107 **Great Slave Lake** is the fifth largest lake in North America and the tenth largest in the world, counting the Caspian and Aral Seas as lakes. It has an area of about 28,500 km^2 of which 27,000 are water, the remainder islands. Soundings over 610 m have been recorded, which establishes Great Slave Lake as the deepest lake in North America. The water from 985,000 km^2 drain into Great Slave Lake, and it in turn is the source of the Mackenzie River.

108 The demarcation line between the Canadian Shield and more recent geological formations bisects the lake in a NW/SE direction between the mouth of the Slave River and the settlement of Behchok at the head of the North Arm. To the SW of the demarcation line, the shoreline is low and regular and there are very few islands, so that the whole area is an unbroken expanse of open water. To the NE of the line, the coastline is very irregular, with long peninsulas and bays and thousands of islands of all sizes.

109 The source of the **Mackenzie River** is at the SW extremity of Great Slave Lake. The river extends about 1,080 miles from Pointe Desmarais *(61°01'N*, *116°28'W)* in a general NW direction to discharge into Mackenzie and Kugmallit Bays on the Beaufort Sea at 69°40'N. From its source to its mouth Mackenzie River drops about 156 m. Numerous rivers and streams which drain the Mackenzie basin flow into the Mackenzie River.

Chapter 4

Natural Condition

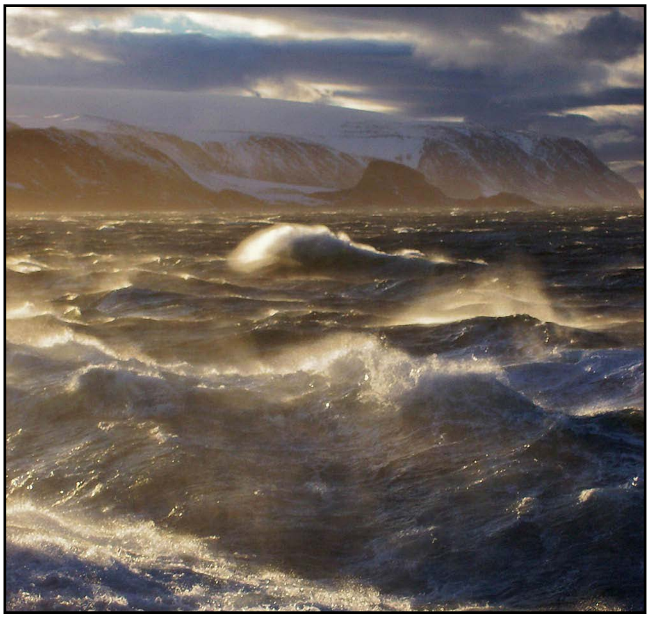


Photo by: Martin Fortier – ArcticNet

General

1 Northern Canada has an extreme climate, covers a vast area and is very sparsely populated. For these reasons, among others, resource exploitation, scientific exploration and hydrographic charting are difficult and very costly. These activities, however, are ongoing.

Submarine Topography

2 It should be emphasized that knowledge of submarine topography in the Arctic is not as complete as it is in more frequented Canadian waters. Most shipping routes have been surveyed to modern standards with a closely spaced pattern of sounding lines and in them our understanding of submarine topography is high. Extensive areas have been surveyed to the extent of a grid of spot soundings through the ice; although each spot sounding is highly precise, the distance between soundings, usually 6 to 12 km, prevents detailed depiction of the sea floor. The third class of knowledge occurs in those areas that have been surveyed neither to modern standards nor as a grid of spot depths, and have only been traversed by ships in passage who have recorded depths along their track. These depths are usually distributed in irregular patterns and their quality is highly variable. In such areas the sea floor may be quite well revealed, but often it is impossible to determine the quality of the knowledge. Finally, there are still some areas of the Arctic where no soundings have ever been taken and the general shape of the seabed can only be estimated.

Hudson Bay area

3 Hudson Strait presents no navigational hazards in the form of shoals; there is deep water throughout. Except for isolated 18.3 m shoals between Coats and Mansel Islands, and shallow waters near the island chains along the eastern shore, there are no known hazards in Hudson Bay. James Bay is quite shallow, with shoals in the NW and along the eastern shore.

Arctic Archipelago

4 The Canadian Arctic Islands and their adjoining ocean basins present a seemingly chaotic maze of

intersecting channels strewn through a series of islands of many shapes and sizes. Relief ranges from deeper than 800 m to greater than 2,000 m above sea level while surface configuration varies from almost flat to extremely rugged. The area seems to be geomorphologically unique on the earth and is the result of a complex interaction of geological processes acting over a considerable portion of the Earth's history. The following paragraphs provide a very general description of this complicated area; a complete graphical depiction is provided on the *General Bathymetric Chart of the Oceans (GEBCO)* 5.17, published by the *Canadian Hydrographic Service*.

5 In the east, the Arctic is bounded by the Labrador Sea and Baffin Bay, two small deep oceans separated from one another by an extensive sill across Davis Strait. The northern end of the Labrador Basin terminates at this sill with four major waterways, Hudson Strait, Frobisher Bay, Cumberland Sound and Davis Strait continuing westward and northward. Hudson Strait, a rather deep channel, continues NW as Foxe Channel which forms the southern boundary of Foxe Basin; this basin is largely unexplored but appears to have a flat bottom less than 50 m deep, except for some somewhat deeper water along its western edge. Frobisher Bay and Cumberland Sound are large deep fiords cutting northwestward into Baffin Island while Davis Strait leads north into Baffin Bay. The Continental Shelf adjacent to Baffin Island is narrow and heavily dissected by both marginal and transverse troughs, whose origin is usually attributed to glacial action.

6 Baffin Bay's northern edge is an extensive bank cut by a channel which leads into Nares Strait, a long trough of uncertain origin, which connects it with the Arctic Ocean via the Lincoln Sea. Lancaster Sound, a deep, steep-sided, flat-bottomed trough which comprises the eastern end of Parry Channel, leads westward from Baffin Bay. Parry Channel shallows considerably in Barrow Strait where it crosses the Boothia Uplift, and deepens again in Viscount Melville Sound and M'Clure Strait. North of Parry Channel most waterways have been sounded over a grid pattern and appear to comprise fairly smooth, deep troughs broken occasionally by sills connecting islands.

7 All channels leading south from Parry Channel are quite deep, but M'Clintock Channel is only poorly explored. Victoria Strait, Queen Maud Gulf, Coronation Gulf and Dolphin and Union Strait which form a waterway between Victoria Island and the mainland have extremely rugged floors with numerous shoals. They lead westward into Amundsen Gulf, a deep, wide bay forming the eastern edge of the Beaufort Shelf.

Beaufort Sea — Pingos

8 The Beaufort Shelf is about 70 miles wide, shallow, and slopes very gently to the shelf edge which occurs at a depth of about 70 m.

9 **Caution**. — An abrupt shoaling of the ocean floor on the Beaufort Shelf was first noticed in 1969 by hydrographers onboard the *CCGS John A. Macdonald*, a Canadian icebreaker escorting the tanker SS *Manhattan* through the Canadian Arctic. The pingo-like shoal manifested itself as a rapid rise of the sea bottom from 49 to 23 m below sea level, over a horizontal distance of 200 m. This rapid rise was followed immediately by an equally rapid drop to 49 m. This shoal is named "Admirals Finger".

10 A later survey conducted by the *Canadian Hydrographic Service* of Admirals Finger and the surrounding area revealed a large number of pingo-like features interrupting an otherwise smooth seabed. Each mound bore, in size and shape, a superficial resemblance to Admirals Finger. As far as could be inferred from detailed topographic examinations by means of launches, the mounds were generally irregular and asymmetric in form, with one side steeper than the other. The diameters of the bases averaged 400 m, and the heights, from base to peak, 30 m. In most cases, a shallow moat or depression of up to 10 m surrounded the base of the feature.

11 During the above-mentioned survey, seventy-eight mounds were located in the survey area with minimum depths over their summits ranging from 15.4 m to more than 45 m. Their distribution appeared to be random. Several were grouped in clusters, others were paired, and the remainder were scattered singly within the 70 m contour.

12 Other hydrographic surveys, at about the same time, discovered similar mounds outside the above-mentioned survey area. These discoveries indicate that more shoals may exist on the uncharted portions of the Beaufort Shelf, particularly since seven mounds located by means of side-scan sonar were not detected by echo sounder.

13 The similarity in the morphology of these submarine mounds with pingos (hills that have a central core of ice) on the Tuktoyaktuk Peninsula to the south, suggests that they are probably of the same origin as the pingos on the land.

14 As the implications of the foregoing, with respect to deep-draught shipping in the western Arctic, are serious, the *Canadian Hydrographic Service* initiated a special survey with line spacing of 100 m to provide a corridor through areas of potential pingo-like features. This corridor is shown on *Chart 7620* and is recommended for vessels

transiting the area. It should be noted that several pingo-like features, with less than 20 m over them, lie in the corridor.

Athabasca — Mackenzie waterway

15 The Athabasca — Mackenzie waterway between Fort McMurray and Tuktoyaktuk is 2,763 km long and for the most part lies within the land mass of the Northwest Territories. The southern 512 km section of the waterway, from Fort McMurray to Fort Smith, is in Alberta and Saskatchewan. The system is also connected to British Columbia and the Yukon by navigable rivers which are tributaries of the Mackenzie River. The farthest through navigation route on the waterway, from Fort Smith to Tuktoyaktuk is 2,216 km.

16 Mackenzie River is navigable along its entire length; however, several sections of fast, shallow water which may present navigation problems, especially at low water stages, are encountered on this waterway.

Tides

Hudson Bay area

17 The greatest tidal range in the Canadian Arctic is found in the eastern part of Hudson Strait. At Leaf Basin in Ungava Bay, a maximum spring range of 14.8 m has been recorded. At Acadia Cove in Resolution Island at the eastern entrance to Hudson Strait, the spring range is 8 m. Along the north shore of Hudson Strait near its central part, there is a maximum range of 12.6 m at Lake Harbour. The range then decreases toward the western end of the strait, till at Nottingham Island it is 5.1 m.

18 In the southeast part of Foxe Basin in the vicinity of Bowman Bay the maximum tidal range is approximately 9 m. The tidal range decreases progressively to the north and west and is only 1.4 m at Hall Beach.

Arctic Archipelago

19 The tidal range in the upper part of Frobisher Bay at Resor Island reaches 13.1 m, while northward of Resolution Island along the eastern coast of Baffin Island, there is a progressive decrease of the range to 6.5 m at Brevoort Harbour, 7.3 m near the head of Cumberland Sound and 2.8 m at Cape Dyer. Further northward, still along the eastern coast of Baffin Island, the range further diminishes to 1.6 m at Broughton Island and 1.1 m at Cape Hooper. Northwestward of this point along the western sides of Baffin Bay and Davis Strait there is little further alteration in tidal range. In Smith Sound, however, a range of 4.8 m has been recorded at Pim Island, further northward, Hall Basin shows a decrease in range to about 2.2 m and near the entrance to the Lincoln Sea, at Cape Sheridan, a range of 1 m.

20 In Lancaster Sound and Barrow Strait the maximum tidal range is 2.9 m and further west, at Cape Capel on Bathurst Island, the range decreases to 1.6 m. At Winter Harbour, in Viscount Melville Sound, the range is 1.5 m.

21 At the head of Milne Inlet, and in Admiralty Inlet, there is a maximum tidal range of 2.7 m. In Committee Bay, at the south end of the Gulf of Boothia, the maximum tidal range is 4.1 m.

22 Along the mainland coast of the western Arctic the tidal range is very small, being almost everywhere less than 0.6 m. The influence of meteorological conditions, however, is a large factor in the determination of water levels. This is particularly true of the shallow waters of the Beaufort Sea where strong onshore winds produce water levels as high as 2.3 m above chart datum, while strong offshore winds produce water levels up to 0.8 m below chart datum.

23 In general throughout the Arctic, where observations have been made, the tides are semi-diurnal, with two high waters and two low waters each day. In the central part of the Archipelago, there is considerable inequality in the heights of successive high and low waters.

Tidal streams and currents

Hudson Strait

24 The tides and currents in Hudson Strait were noted by the earliest navigators to enter these waters. John Davis, in 1587, wrote in his ship's log, "...where to our great admiration we saw the sea falling down into the Gulf with a might overfall and roaring and with divers circular motions like whirlpools in such sort as forceable streams pass through the arches of bridges". Currents of this magnitude presented severe hazards to the small sailing ships of those days and it is to be inferred that the ship captains found it necessary to study the tides carefully and to take advantage of favourable directions of the currents and of periods of slack water to get through the straits.

25 The main tidal streams in Hudson Strait are strong and definite with no cross currents setting to either shore. Flood waters entering the strait, however, are curved somewhat to southward by the indraught to Ungava Bay; consequently the progress of the tidal undulations is more rapid along the south side of the strait than on the north shore. The time of high water at Wakeham Bay, therefore, is

only a little later than at Port Burwell, while at Ashe Inlet, immediately opposite Wakeham Bay, high water occurs considerably later. The same relation holds for the time of low water at those points, but it is likely that the main ebb holds farther north across Ungava Bay than the flood.

26 In addition to the ordinary tidal pulsations in Hudson Strait, there are general progressive movements or circulations of water. Icebergs which enter the strait can do so only around Resolution Island and through Gabriel Strait. In their southward journey from Davis Strait, they are drawn in by the flood and some fail to go out with the ebb. These work westward, indicating a general movement of the water in the northern part of the strait in that direction. They are found westward as far as Charles Island and one was reported even farther west in the vicinity of Nottingham Island by the officers of the Hudson Strait Expedition of 1927-28. If they are carried to the south side of the strait, they will be borne to the eastward.

27 Observations of the ice movement south of Resolution Island over a period of several months show the duration of the flood and ebb currents to be about equal. This, however, is not proof that an excess inward movement of water on the north side of the strait does not exist, for the necessary indraught is more than likely supplied through Gabriel Strait, or it might be a deep undercurrent.

28 The outward flow from Hudson Bay is evident as a dominant easterly set along the northern side of Digges Islands and off Cap Wolstenholme where it becomes locally and perhaps for some distance, a constantly outward current. Doubtless the movement continues along the southerly side of the strait.

29 The strength of the tidal streams between Resolution Island and Cape Chidley is given as 5 knots on the charts, but no determinations have been made elsewhere in the straits.

30 The currents in Passe Digges (Sound) and its approaches are not considered dangerous to navigation. There is an ebb and flood rate of 2 to 3 knots between Cape Digges and Cap Wolstenholme. The flood approaches Passe Digges (Sound) from the NE as an undercurrent and turns to the southward on entering the sound. The ebb, flowing NE’ward past Cap Wolstenholme, turns eastward into a constantly outward current starting at the west end of the Digges Islands and continuing past Erik Cove. At Erik Cove, there is a 3-knot current which slackens to a low rate with flood effect.

31 Off Erik Cove and extending westward to Cap Wolstenholme, there is a shelf with moderate depths of 91 to 128 m (50 to 70 fathoms) extending 0.5 mile or more from the shore. Beyond this shelf, soundings indicate a sharp drop to depths approaching 457 m (250 fathoms). This deep body of water, moving in one direction, causes heavy rips, swirls, and eddies over the shelf which, during strong winds, creates a danger to small craft.

32 Centrally in the sound, off eastern Digges Islands and off Staffe Islet, the direction of the ebb is with the channel; information on the direction of the flood current, however, is not available. Off Pointe d’Ivujivik and Nuvuk Harbour, the ebb runs with the channel; the flood is variable and turns at times toward the Nuvuk Islands. These conditions are also found, to a lesser extent, south of Fairway Island. One mile south of North Skerries, flood and ebb run west and east.

33 From the information available, it seems that the ebb current has a much longer duration than the flood. Between Nuvuk Harbour and Fairway Island, the flood period seems to be 4¾ hours and the ebb nearly 8 hours. No definite times can be given for the turn of the tidal currents but, from Pointe d’Ivujivik eastward, high water slack in Eastern Standard Time may occur 3 to 4 hours after the time of high water, and the low water slack 4 to 5 hours after the time of low water, as given in the tide tables for Diana Bay.

34 Similarly, in the west approach to the sound to Fairway Island, the high water slack may be 5 to 6 hours after the times of high water, and the low water slack at approximately the times of low water, as given in the tide tables for Diana Bay.

35 A very large increase in the range of the oceanic tides occurs along the SE coast of Baffin Island and across the entrance to Hudson Strait. To SW’ward of that entrance, the range is still further increased by the topography of Ungava Bay, at the head of which an extreme range of nearly 15.2 m is reached. In the strait itself, the greatest range occurs on the north side in the vicinity of Big Island, where the extreme range is over 12.2 m, while on the opposite shore, near Wales Island, it is only 10.1 m.

36 The differences in the tidal ranges on the two sides of the strait are due to the gyroscopic effect, known as the Coriolis force, which arises from the earth’s rotation about its axis, and to the fact that the streams are setting at their maximum rates to the westward when the tide is high and to the eastward when the tide is low. The Coriolis force causes particles of water moving over the earth’s surface in the northern hemisphere to be deflected to the right. In a strait, this force creates a gradient, sloping upwards across the strait towards that side which lies to the right of the direction in which the water is flowing; so that, when the tide is high and the stream is setting westward, the water level is raised on the north side and correspondingly depressed on the south side. The reverse occurs when the tide is low and the stream is setting eastward. Thus, on the north side the range is increased by the raising of the high

water level and the lowering of the low water level, while on the south side the range is decreased by the lowering of the high water level and the raising of the low water level. For this reason, the tidal range along the north side of Hudson Strait and along the east side of Foxe Channel is notably larger than that on the opposite shore. The exception is in the east entrance; there the tidal streams are slack near the times of high and low water, and in consequence there is no gradient at these times to affect the ranges of the tide. In this area the range is greatest on the south side owing to the topography of Ungava Bay.

Hudson Bay

37 In a body of water the size of Hudson Bay, the tide-raising forces due to the gravitational attraction of the sun and moon would certainly result in a small tide of the order of a few centimetres even in the absence of any connection with the ocean. In addition, the connection with the Arctic Ocean by way of Foxe Channel and Fury and Hecla Strait would also have some effect, however small, on the tide and tidal stream regime of Hudson Bay. In fact, these minor effects are completely overshadowed by the powerful tides which surge twice daily into the bay through Hudson Strait.

38 Owing to the shape, size and depth of water in Hudson Bay and the gyroscopic effect and gravitational forces acting upon the water masses, there is an area in the middle of the bay where any changes which occur in the water level during the semi-diurnal tide cycle are small. This ridge extends from 60°30’N, 87°W SE towards Inukjuak.

39 Within the boundaries of this area, the rise and fall of the tide is close to zero while around the coast of the bay the range in height between high and low water may be as great as 5.2 m at Churchill and as little as 0.5 m at Inukjuak.

40 The tide progresses in a roughly circular movement, following the contour of the shoreline starting from the NW’ern part of the bay, moving southward along the west shore and almost petering out along the east shore. At the entrance to the bay, the average height of the tide above chart datum (a level below which the tide seldom falls) is 3 m, increasing to 4.1 m along the west shore. It decreases along the south shore and then along the east shore to about 0.5 m at Inukjuak.

41 The tidal wave which progresses along the SW shore of Hudson Bay is refracted around Cape Henrietta Maria and enters James Bay; approximately 7 hours later the tide reaches the south end of the bay. The range of large tides is larger on the west and south coasts of James Bay than it is on the east coast, having values of 3 m at Cape Henrietta Maria and Sand Head, while at Rivère Eastmain it is only 1.1 m and, at Fort George and Chisasibi, 2.1 m.

42 Surveys conducted at the mouth of James Bay have shown that the currents generally flow southward into the bay on the west side and northwards out of the bay on the east side.

43 Meteorological influences such as prolonged winds and abrupt atmospheric pressure changes can have an extreme effect on both the mean water level and on the nature of the tide and tidal streams in James Bay.

44 The rotary progression of the tides around Hudson Bay has corresponding tidal streams associated with it and the flow in Hudson Bay has been observed not only by present-day ship masters but also, as mentioned earlier, by the early explorers of the bay.

45 Unfortunately the tidal streams are as yet insufficiently known. It is possible however to say that they are strongest in the west part of the bay, while in the vicinity of Povungnituk and Inukjuak they are weak and irregular. Both tides and tidal streams are closely related and the shape of the north part of Hudson Bay and its orientation relative to the mouth of Hudson Strait suggests that the flow would in the main be anti-clockwise. This is actually observed to be the case.

46 The actual flow encountered in the bay is not exclusively tidal but is influenced by the numerous rivers which discharge large quantities of fresh water into Hudson Bay. Since the volume of the rivers is subject to large seasonal variations, this will have an influence on the flow which is not precisely predictable. The flow, like the tides, is also influenced by meteorological disturbances, in particular by the strong winds which are often encountered in the bay.

47 The tidal streams at Chesterfield Narrows are about 8 knots with spring tides and about 6 knots with neap tides. Slack water occurs before and after a prolonged high water period. The flood is characterized by a westward flow for about 4 hours. The ebb flow, which reaches a maximum rate at low water, lasts some 8 hours. The current, therefore, is reversing at high water and low water respectively.

48 Meteorological conditions such as strong prolonged winds, abrupt changes in barometric pressure or prolonged periods of very high or very low pressure introduce fluctuations in the mean water level of both Hudson Bay and James Bay. These fluctuations cannot be predicted in advance since they differ from year to year as well as at shorter frequencies.

Arctic Archipelago

49 The currents in the waters of the Canadian Arctic are, directly or indirectly, the result of the outflow of water from the Arctic basin. This outflow results from the fact that the inflow of water to that basin due to the north-going branches of the North Atlantic Current, the influx from large rivers, and the snowfall, largely exceeds the loss of water by evaporation which is slight, owing to the low air temperature. The East Greenland Current constitutes the main outflow for this excess of water, but there is also an outflow through the various channels of the Arctic Archipelago, part of which emerges into Baffin Bay, and part going via Foxe Basin and Hudson Bay and emerging through Hudson Strait into the Labrador Sea.

50 Except in a few areas, existing current data for these waters is very limited, being based largely on casual and discontinuous observations, sometimes of doubtful accuracy. In many of the straits and channels amongst the islands the dominant surface flow may be almost obscured by local tidal streams, having alternating directions, and it is greatly influenced by prevailing meteorological conditions not only at the place of observation but in adjacent waters. Thus, these occasional and random observations can be an indifferent guide to the estimation of the dominant or average flow in any area.

51 The tidal streams are semi-diurnal in Robeson Channel, Barrow Strait, Prince of Wales Strait, M'Clure Strait and Byam Channel. In Lancaster Sound, Crozier Strait, Pullen Strait, Fury and Hecla Strait and Austin Channel the tidal streams are mainly diurnal. The mean flow may move in opposite directions against the shores of the wide channels in the Arctic Archipelago.

52 The pattern of circulation in all the major bodies of water in the eastern Arctic is cyclonic, or anti-clockwise. In the Labrador Sea, the West Greenland Current and the Labrador Current flow respectively NW and SE. A large part of the West Greenland Current turns westward in about latitude 63°N, just southward of the Davis Strait ridge, and then southwestward to join the current, variously known as the Canadian Current or Baffin Current or Baffin Island Current, that flows southward along the coast of Baffin Island, and the Labrador Current flowing southeastward along the coast of Labrador.

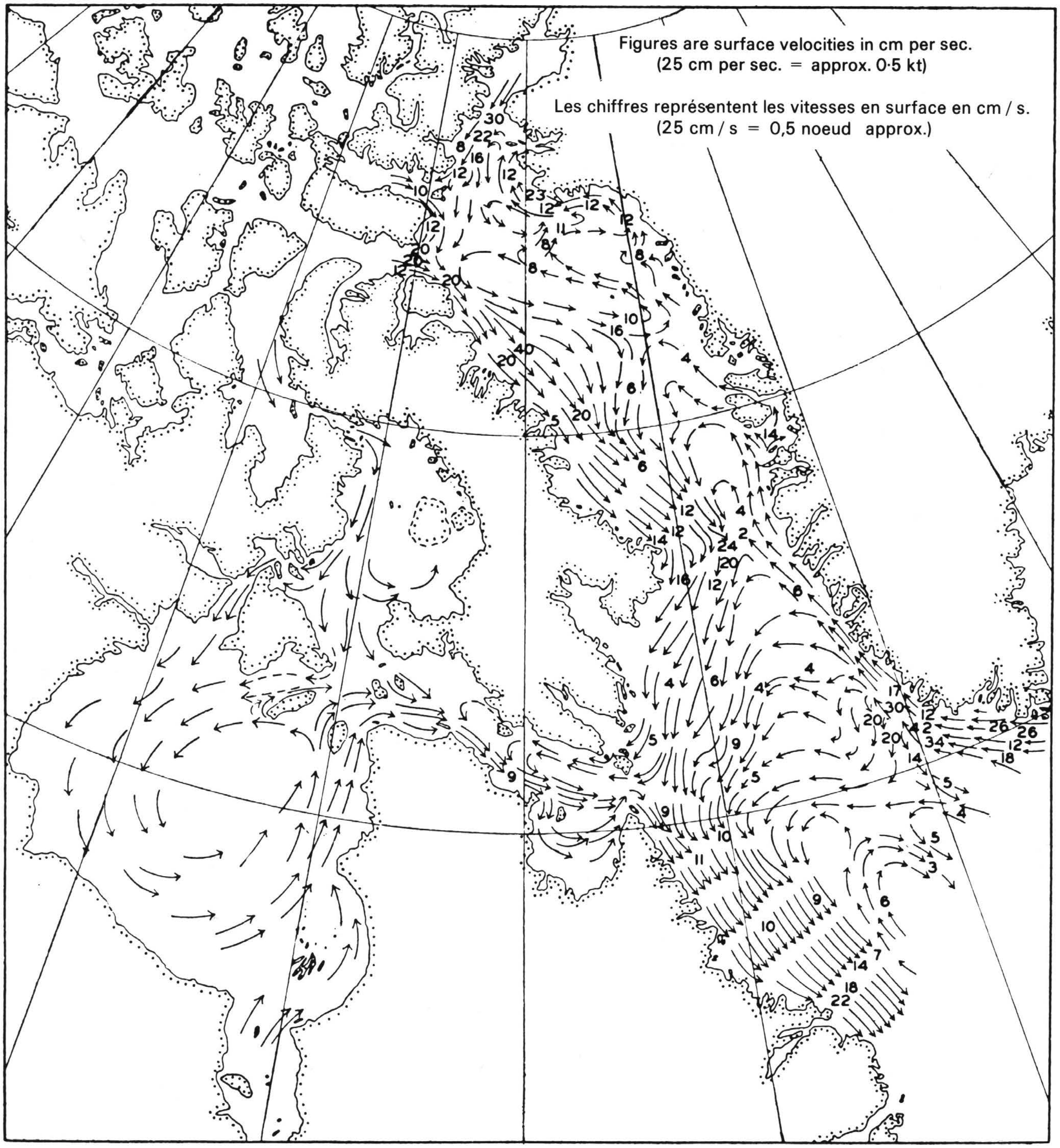
53 In Davis Strait, the general pattern of circulation is simple; a strong southward flow along the west side (Canadian Current) and a weaker northward flow along the east side (West Greenland Current). The Canadian Current flows at rates of 5 to 12 miles per day at the surface. The West Greenland Current in Davis Strait, according to the "Godthaab" results, increases in velocity and transport considerably during the summer, being from two to three times stronger in September than in the early summer (June). Normally, the Canadian Current covers more than half the northern entrance to Davis Strait.

54 In Baffin Bay, the continuation of the warm West Greenland Current flows northward, turning northwestward at the northern extremity of the bay, while the cold Canadian Current, formed of polar water from Lancaster, Jones and Smith Sounds, flows southward and southeastward. The Labrador Current is formed of water from Hudson Strait, from the Canadian Current, and from the West Greenland Current. The rates of the West Greenland and Labrador Currents are shown in the diagram; they represent average rates at the surface in the several areas marked.

55 Baffin Bay receives its water in approximately equal quantities from the SE, from western Greenland and from the NW, from Lancaster, Jones and Smith Sounds. While there is a large net outflow from each of these sounds, there are counter currents, westward along the northern sides of Lancaster and Jones Sounds, and northward along the east side of Smith Sound. The occurrence of large icebergs in Prince Regent Inlet indicates that the counter current in Lancaster Sound penetrates, in some volume, as far west as the entrance to that inlet. These bergs can only have come from the west or NW coasts of Greenland, or possibly from the glaciers of Devon and Ellesmere Islands, and the only reasonable route by which they could have reached Prince Regent Inlet is via Lancaster Sound.

56 In Prince Regent Inlet and the Gulf of Boothia, there is a southward movement along the west side and northward along the east side. In Fury and Hecla Strait, the dominant surface flow is to the eastward, bringing water from the Gulf of Boothia into Foxe Basin where it flows southward along the west side of the basin and turns in a weak anti-clockwise movement toward the coast of Baffin Island. This current also flows out of Foxe Basin through Frozen Strait and Roes Welcome Sound, to circulate anti-clockwise in Hudson Bay, and out through Foxe Channel. The dominant flow of water in Hudson Strait, fed from Hudson Bay and Foxe Channel, is eastward, and this water joins and reinforces the Labrador Current off the entrance to the strait. On the northern side of Hudson Strait, however, there is a counter current, fed from the Canadian Current and setting westward, from the eastern entrance as far west as Big Island where it turns southward and joins the out-going easterly current along the south side of the strait.

SURFACE CURRENTS IN THE EASTERN ARCTIC



57 Along the northwestern coasts of the Queen Elizabeth Islands, the dominant surface flow of the current is to the southwestward. This current continues southwestward and southward as far as Banks Island off which it swings westward along the north coast of Alaska. Stefansson believed that a great eddy exists in the Beaufort Sea as he found an easterly-setting current 300 miles north of the Alaskan coast, which turns south again as it reaches the coast of Prince Patrick Island. A branch of the outflow of current from the Arctic basin appears to turn southeastward in the vicinity of Cape Columbia, the northern point of Ellesmere Island and there is a very marked southward flow through the channels between Ellesmere Island and Greenland and into Baffin Bay. Other branches of this current infiltrate southward and southeastward between the islands of the Queen Elizabeth Islands group, and also eastward through M'Clure Strait and the rest of the Parry Channel, to exit into Baffin Bay by way of Jones and Lancaster Sounds, respectively.

58 For the greater part of the Canadian Western Arctic, only a limited amount of information is available concerning the set and drift of the prevailing currents. In the Beaufort Sea on the shelf the current tends to be easterly though the surface currents are influenced strongly by the wind. When ice is prevalent there is quite a set to the eastward around Baillie Island. In Amundsen Gulf the circulation may be considered anti-clockwise inasmuch as an easterly-setting surface current moves along the coast of the mainland, and, while one branch of this current enters Dolphin and Union Strait, another branch curves northward along the west coast of Victoria Island and northeastward along the eastern side of Prince of Wales Strait. A south-setting coastal current enters Amundsen Gulf from the western side of Prince of Wales Strait, eventually moving westward toward Cape Kellett.

59 A weak easterly drift prevails from Dolphin and Union Strait through Coronation Gulf and Queen Maud Gulf, and a south-setting current moves through M'Clintock Channel and Victoria Strait, entering the northeastern part of Queen Maud Gulf.

60 In Peel Sound there appears to be a general setting of the ice to the south, but this is probably due to wind and is not constant.

61 For further details of currents in the waters of the Canadian Arctic, see the *Sailing Directions* geographic booklets of the Northern Canada series, *ARC 401, ARC 402 (ARCTIC CANADA VOL. II), ARC 403 (ARCTIC CANADA VOL. 3) and ARC 404 (GREAT SLAVE LAKE AND MACKENZIE RIVER)*.

Climate of the Canadian Arctic

62 This section examines significant features of the climate which may, directly or indirectly, affect year-round operations in the waterways of the Canadian Arctic. The area is exposed to extreme and hazardous weather conditions necessitating prudent planning, robust equipment design and operational attention.

63 For information on current marine weather forecasts and tides, in latitudes north of 60°, see https://weather.gc.ca/mainmenu/marine_menu_e.html and https://tides.gc.ca/. For information on climate normals for selected locations in Nunavut and the Northwest Territories, see: https://climate.weather.gc.ca/climate_normals/index_e.html.

Climate controls

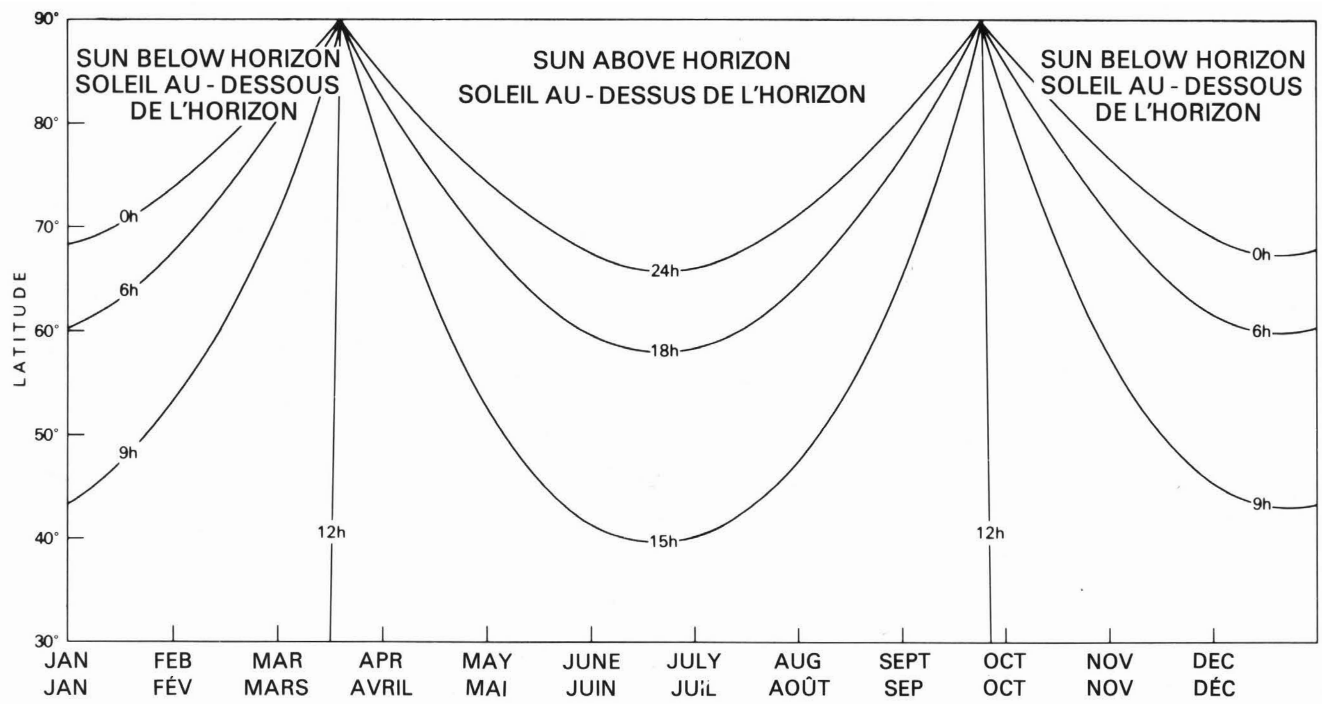
64 The dominant factors which influence climate are the character of the solar energy input, the nature of the immediate surfaces, weather systems and topography.

65 The annual and daily cycling of the energy from the sun received on a unit surface in the Arctic is quite different from that experienced on a similar surface at lower latitudes; see the diagram. The diagram, however, does not give a true indication of the amount of useful light in northern latitudes. Arctic twilight is quite prolonged, and at the Pole complete darkness does not set in until at least a month after the sun sets in late September. The reflection of the moonlight on the snow surface also adds to the brightness of the landscape during the polar night.

66 Since the sun's rays strike the earth at a relatively small angle, even in summer, the energy received on a horizontal unit of area in a unit of time in the Arctic is also small; however, this is compensated for by the increased length of day. Consequently the total heat energy available from the sun in June and July is approximately the same as at temperate latitudes, but due to the high reflectivity of the Arctic surfaces only a small percentage of the available energy remains to heat the earth's surface and the atmosphere. The extensive cloud layers and ice-congested polar seas in summer, for example, reflect more than 50% of the incident radiation.

67 The large scale hemispheric wind patterns are the result of unequal solar heating of the earth and its atmosphere at high and low latitudes. Regionally the course of these winds is altered by the barriers of mountain ranges and by great contrasts in the sun's heating over forest, tundra, snow, ice and sea surfaces. There are also, of course, seasonal patterns to the circulation of the atmosphere as it adjusts to changes in heat from the sun.

DURATION OF DAYLIGHT HOURS



68 In winter, the dominant feature in the western Arctic is the Arctic anti-cyclone which is centred over the Mackenzie Valley and whose influence extends northward into the eastern Beaufort Sea. By summer, however, this feature has been reduced to a large weak high pressure area. Storm activity in the western Arctic is most evident during the autumn when systems, generally originating in the Mackenzie Valley, move eastward and northeastward affecting the Beaufort Sea and the south-central Arctic islands.

69 The rather permanent trough of low pressure over Baffin Bay combines with the Arctic anti-cyclone over the western Arctic in winter to maintain a general NW to SE circulation over the eastern Canadian Arctic. Low pressure areas generally cross Canada at latitudes well south of Hudson Bay during this period and only affect the Arctic as they recurve northward into a region of high cyclonic activity over Baffin Bay. Since most of these storms lack sufficient moisture to cause precipitation over the Arctic, their main effect is to induce strong north winds as they reach Baffin Bay.

70 There is a general weakening of the average pressures in spring, and by summer the paths followed by the low pressure areas are displaced well north of their winter routes. Many of the storms move directly across Hudson Bay, from the west or SW, while there is a second preferred path into Davis Strait. These low pressure areas are similar in behaviour and in the cloud and precipitation patterns they produce to those found in coastal regions of southern Canada in the spring. September brings a fairly rapid transition from summer conditions to the strong gradients and distinct weather patterns of winter.

71 The seas and countless channels which surround all islands north of the Canadian mainland make up more than half of the Arctic area and have a dominant influence on the climate of the coasts and adjoining lands. The melting of the snow and ice requires considerable thermal energy. This process, combined with the high reflective properties of the snow, delays the arrival of spring in the Arctic. The extensive snow and ice fields also affect the character and movement of low and high pressure areas and frontal systems.

72 The character of the underlying surface is of particular importance to the summer and autumn climate when there is considerable open water available for the formation of low clouds and fog in summer and frequent snow squalls in autumn. Greenland and the high, ice-capped mountain ranges along the eastern coastlines of Baffin,

Devon and Ellesmere Islands, present a barrier to the entry of mild, moist air from the north Atlantic. The rugged relief causes considerably increased precipitation, particularly along the SE coast of Baffin Island.

Seasons

73 Throughout the Canadian Arctic the period when the general terrain is free of snow is limited to July and August except in the extreme southern areas where the limits may be mid June to mid September. For convenience this period is referred to as summer in the following text; the first two or three weeks at the start of the period can be termed spring, and at the end of the period, autumn; winter occupies the remainder of the year. The date on which the average air temperature rises above 0°C provides an indication of the onset of spring and the date on which the average air temperature falls below 0°C marks the arrival of winter.

74 In the eastern Arctic, spring does not arrive until after June 1 and in fact, central and northeastern Baffin Island and the territory north of Lancaster Sound do not experience spring until after June 15. Generally, the entire eastern Canadian Arctic, with the possible exception of the Davis Strait area, experiences the end of autumn by October 1, but such locations as Ellesmere and Devon Islands can be so affected by September 1. In the western Arctic, spring does not arrive until after June 1 and the areas north of Parry Channel do not experience spring until after June 15. The entire western Canadian Arctic experiences the end of autumn by September 1.

Winds

75 A north to NW air flow dominates over all but the western sections of the Arctic throughout much of the year. Cyclonic influences are less over the Beaufort Sea, resulting in about equal frequencies of SE and NW winds. While wind speeds over the seas can be explained by the pressure gradients associated with low and high pressure areas and the stability of the air over the sea surface, local effects are especially important as causes of strong winds. There are two significant local influences.

76 Onshore winds along the coastlines are deflected in directions nearly parallel to the shore and increase in speed. Similarly, the prevailing directions in straits and fiords are usually along the channel and the speed increases as the channel narrows.

77 Along precipitous coastlines where there is a snow-covered area in the interior to collect a pool of relatively cold air, strong winds can occur when this dense, cold air drains seaward. Such winds are often of short duration but can extend several miles to sea.

78 Sheltered locations (such as Eureka) experience light winds which are not representative of winds offshore; on the other hand maximum reported hourly wind speeds of greater than 70 knots at such stations as Alert, Cape Dyer, Iqaluit, Isachsen, and Resolute reflect the influence of local topography. Such super-gradient winds are often due to the topography along the coast and can extend more than 20 miles offshore. They are mainly winter-time phenomena.

79 Wind speeds at most stations are highest in the fall, averaging in the 10 to 13 knot range. During other months, average speeds can be up to 3 knots lower.

80 In winter, some stations report calm conditions up to 30% of the time, but in summer, although average wind velocities at most coastal stations are not too different from winter values, there are few calm conditions and consequently there are a lower percentage of winds in the speed ranges above 16 knots. Usually, winds reach gale force on only one or two days each month in summer. Surface winds are also more variable in direction than in winter since their patterns are complicated by the low pressure areas which affect the region. The complete daily reversal of direction in the ordinary land and sea breeze effect, so common along the coasts in southern latitudes, does not always occur in the Arctic, although when the pressure gradient is weak and skies are clear in late summer an onshore component can develop during the afternoon.

Air temperature

81 Arctic temperatures average well below -15°C for all months, December through March and, over the Queen Elizabeth Islands group, during April also. The year's coldest weather can occur at any time during this period although on the average February is the coldest month.

82 On a monthly or yearly basis the Arctic regions are the coldest in Canada. In the southern Arctic average temperatures in March are about 6°C higher than in February. The important feature of the winter pattern over the Arctic is the cold mean monthly temperature (-35°C) of the central area extending from Isachsen and Mould Bay in the north to the mainland south of Gladman Point. In the eastern Arctic, northern Ellesmere Island and adjacent smaller islands experience similar temperatures.

83 The presence of ice and snow cover over the seas and channels practically cuts off the exchange of heat between the water and the atmosphere. Where open water is present, air temperatures are considerably higher than those indicated above. Davis Strait and southern Baffin Bay are examples.

84 The frequencies of occurrence of low temperatures at stations in the Arctic provide further evidence of the

persistent coldness of the area. During the coldest months December, January, February and March, temperatures can be expected to drop as low as -23°C on 85–100% of the days, -29°C on 60–85% of the days, and -34°C on 30–70% of the days (the lower frequencies apply to the Mackenzie Bay area and the higher values to the Resolute area). Several stations in the Arctic have failed to record temperatures higher than -34°C for periods up to twenty consecutive days. Conversely, although temperatures rarely rise above the freezing point during the winter, mild air from the north Atlantic occasionally reaches the eastern islands of the Archipelago.

85 If only extremes of minimum temperature are considered, several areas of Canada well south of the limits of the Arctic islands are colder. Only one Arctic station in two has a record low temperature colder than -51°C while several have never recorded temperatures as low as -46°C. (At inland locations on the larger islands, lower temperatures would be expected.)

86 Low temperatures are, of course, more easily tolerated when winds are light. The term “wind chill” is often used to indicate the human discomfort caused by the combined effects of wind and low temperature. On the basis of wind chill factor the most extreme areas are not in the high Arctic, but actually over the barrens to the NW of Hudson Bay.

87 With lengthening days, temperatures rise slowly in March and early April, finally reaching above-freezing values by late May or early June. Even at these late dates, however, sharp falls in temperature to near -20°C are possible. During April the familiar “maximum during the day, minimum at night” temperature pattern of southern latitudes occurs in the Arctic as well.

88 Air temperatures in the Arctic during July and August conform closely to the nature of the underlying surface. Over continental interiors the long hours of sunshine produce relatively high temperatures, but where the partially ice-covered channels and seas act as stabilizing influences the temperature never deviates far from 1°C to 4°C. At coastal locations, temperature can be expected to drop close to the freezing point whenever onshore winds occur, but when winds are off the large land surfaces, 7°C to 13°C readings are more likely.

89 The summer uniformity of temperature breaks down abruptly in late August and early September with the onset of cold weather and by mid October readings below -18°C prevail in all northern sections.

90 During the winter a strong temperature inversion persists over the uniform snow and ice surface, generally to a depth of 900 to 1,200 m. In summer, the inversion disappears over the land areas but is still present, to a lesser extent than in winter, over the cold seas and channels.

Clouds and precipitation

91 September and October are the stormiest months over most of the Arctic. With the shortening autumn days and the annual southward displacement of the paths followed by the storm centres, progressively colder outbreaks of air from the polar seas affect the Canadian Arctic. During these months the waters of the bays and channels are largely unfrozen and the relative warmth and moisture they provide lead to instability and frequent snowfalls. The greater proportion of the average annual snowfall occurs during these months. These values increase from 50 cm in the western Arctic to 300 cm in the eastern Arctic, except for some exposed higher locations where the mean annual snowfall can reach as much as 600 cm (such as Cape Dyer). By September 15, the lands of the Arctic are mainly snow-covered.

92 As winter deepens and the land and sea surfaces become uniformly snow-and-ice-covered the Arctic is relatively free of clouds and snowfall is light. Even so, light snow may be reported 10–15% of the time. Although snowfall can be fairly uniform over a region, it is quickly redistributed by the wind. Freshly fallen snow rapidly increases in density and the snow cover soon becomes compact and capable of supporting a human. In general the winter average snow depth increases from about 25 cm in the west to over 70 cm in the east, with locally deeper amounts along the eastern coasts of Baffin Island. May marks an abrupt change in the cloud pattern, although precipitation is still in the form of snow. Two basically different systems, frontal and maritime, which cause clouds to form and influence their distribution, combine to produce a large percentage of overcast skies in summer. The former also accounts for practically all the measurable precipitation.

93 With the exception of southeastern Baffin Island, where small amounts of rain or freezing rain can occur in almost any month, rainfall over the Canadian Arctic is generally confined to June to early September. July and August are usually the wettest months, with monthly rainfall totals of about 25 to 35 mm in southern sections of the western Arctic and about 50 mm in the southern sections of the eastern Arctic, decreasing northward to less than 20 mm over the Queen Elizabeth Islands. Days with precipitation are more frequent than one would expect from the low monthly rainfall totals. During July and August periods of light rain or drizzle occur on an average of one day in three. Rainfall is extremely variable from year to year and despite the fact that average amounts are low,

heavy rains have been reported on occasion in the Arctic. In August 1960, for example, several stations including Mould Bay in the western Arctic reported a one-day rainfall of more than 25 mm and during July 1973, a one-day rainfall of 49 mm was recorded at Vendom Fiord on south-central Ellesmere Island.

94 Over the Queen Elizabeth Islands, rainfall occurring during the short summer season amounts to about the same as the total water equivalent of snowfall during the nine months of winter. Together they total about 100 mm on the average. Annual precipitation increases southward to about 150 to 200 mm over the mainland in the west and to more than 600 mm along the SE coast of Baffin Island (Cape Dyer).

Visibility and fog

95 The range of visibility varies greatly in the Arctic. Air masses are free of pollutants and in the absence of falling precipitation, blowing snow, suspended ice crystals or fog, visibilities are high. Distant objects stand out with great clarity in shape and detail.

96 Ice, which is itself a manifestation of the severe climate of the area, has a major influence on sea operations in the Arctic. Fog ranks next to ice as a marine hazard, although radar and modern navigational aids, as well as electronic navigation systems, have reduced the problems. During the period June to September advection (sea) fog is a common obstruction to vision over the Arctic waterways and the Polar Basin. Throughout the region, even the warm air masses which penetrate the region from southern Canada are subject to the cooling effects of large areas of ice-cold water. Evaporation from the exposed water areas and saturated ground surfaces produces a further cooling in the lower levels of the air mass. The resulting temperature inversion inhibits turbulent mixing with the drier air aloft. Beneath the inversion the air is moist and when it moves over colder water or drifting sea ice the excess moisture condenses to form fog or mist. Fog is widespread over the seas during the period when the ice is melting. As the season advances the fog becomes more patchy, tending to be frequent and dense at the edges of the drifting ice and less frequent over ice-free seas and over land.

97 As a rule, under conditions which produce offshore winds, fogs do not usually form immediately adjacent to the large land areas. Similarly, narrow channels can remain relatively free of fog when the wind flow is across the water, but with light winds along the channel fog would be more likely. Advection fogs are quite dependent on the strength of the surface winds. Fog is more frequent over the seas when winds are light, than with strong winds. As winds strengthen the fog lifts, but only to form low-lying clouds.

98 At coastal stations along the Arctic navigation route, fog is generally recorded in 15–20% of all observations in July. Averages are closer to 25% in August while some improvement is evident in September. Since the fog is typically maritime in character, it would probably be somewhat more frequent and dense in the proximity of drifting ice floes in the seas and channels. Actually, statistics from drifting ice island stations show that the values given above for the coastal stations are fairly typical of fog frequencies over the drift ice in summer.

99 From the climatological tables for the individual reporting stations, it appears that the coastal areas along Hudson Strait experience the highest frequencies of sea fog in summer. At Resolution Island, the eastern entrance to the strait, for example, fog occurs on an average of one out of two days. In the vicinity of the islands in the NW, adjacent to the Arctic Ocean, fog frequencies are also quite high.

100 Steam fog (Arctic sea smoke) forms when very cold air passes over areas of open water in winter. The rate of evaporation from the water surface remains relatively high in this situation while the capacity of air to hold moisture is restricted by its low temperature. The excess moisture in the air quickly condenses into fog. Steam fog is often observed in the Arctic from October to April, but it is relatively localized and usually does not persist more than a few miles downwind from the open leads or tide cracks. This fog can inform the navigator of the presence of open water at a distance.

101 Ice fog is another, typically winter, cause of reduced visibility. Fogs of this type occur rather infrequently in the Canadian Arctic due to the lack of moisture in the very cold air. As settlements become larger, however, and industrial and transportation activity increases, sufficient moisture may be added to the air through fuel consumption, to cause local pockets of ice fog. Terrain is important to the formation of ice fog although the extent of the fog usually bears a close relationship to the size of the area of human activity.

102 At most Arctic locations, during the November-April period, blowing snow is the most frequent cause of low visibility. Winter snowfall at these latitudes is powder-fine and, depending upon whether the snow is wind-packed or new, even relatively light winds can cause drifting or blowing snow.

103 Although drifting conditions can be initiated by winds of 8 to 17 knots, investigation has shown that at exposed sites less than 5% of the winds in this speed group cause blowing snow. One half of the 18 to 25 knot winds can be expected to cause blowing snow while nearly 90% of strong winds (26 knots or greater) are associated with blowing snow. In the case of strong winds more than

half of the reported visibilities are under 0.5 mile. When winds exceed 35 knots the visibility is almost invariably reduced to a few metres in blowing snow. Two- or three-day windstorms, and attendant blowing snow, are not uncommon during the winter in the eastern Arctic.

104 Mention should also be made of the Arctic whiteout. During the spring and fall, when the sun is near the horizon and the snow surface and clouds are of uniform whiteness, it is often difficult to distinguish either the horizon or objects close at hand. Under these conditions navigation by sight becomes difficult.

105 **Caution**. — Strong winds combined with cold temperatures may cause spray to freeze on contact with ship superstructures. Accumulated ice can affect the stability of a vessel and can cause capsize. For detailed information concerning ship operations in ice and navigation in ice-covered waters, see the *Canadian Coast Guard* publication *Ice Navigation in Canadian Waters, 1999 edition (TP 5064)*.

Ice Regime, Hudson Bay area

Hudson Strait and Ungava Bay

106 The ice of Hudson Strait and Ungava Bay is mostly formed locally but winds and currents can carry floes from Foxe Basin or Davis Strait into these areas. Freeze-up usually begins in late October in the western end of Hudson Strait and ice formation progresses eastward to cover the entire area by early December.

107 Through the winter, shore-fast ice becomes extensive among the islands from Lake Harbour to Cape Dorset and in the bays and inlets of Ungava Bay.

108 1In May, open water leads become more persistent as temperatures rise and the rate of re-freezing is reduced. Ice melt is slow until July but then progresses rapidly. By the second half of July the ice pack is usually confined to Ungava Bay and the south side of Hudson Strait.

109 Complete clearing of sea ice usually occurs during the second week of August; for the remainder of the shipping season, icebergs from Davis Strait and occasional intrusions of sea ice from Foxe Basin are the only ice hazards.

Hudson Bay

110 Freeze-up is a lengthy process because of the great size of Hudson Bay. The first ice formation in the bay is usually in late October in the coastal inlets in the northwestern sector. As the weather grows progressively colder, the ice spreads southward along the shore more rapidly than it extends seaward. Hudson Bay is normally ice covered by mid-December.

111 During the winter, a 5 to 10 mile wide belt of fast ice develops along most of the coastline. Beyond the shore-fast ice, Hudson Bay is covered with pack ice which moves in response to the wind.

112 As temperatures rise in May and June, flaw leads in the northwest portion of the bay become persistent. Normal clearing of the pack ice progresses southward from the Chesterfield Inlet - Southampton Island area and westward from the Quebec side of the bay. Associated ice melt is a slow process which accelerates in July with an open water shipping route to Churchill forming by the end of the month. The pack will often separate into a few large patches before melting completely by the middle of August.

James Bay

113 James Bay ice is noted for its discoloration. This feature is related to the freezing of muddy water in the fall, a condition caused by the shallowness of the bay and wind conditions in November. Another contributing factor is the spring melting and river run-off which concentrate sediments on the surface of the ice.

114 Freeze-up in James Bay usually develops during the second half of November; because the bay is shallow, ice spreads quickly to completely cover it by early December.

115 Melting begins in late April, but it is not until the second half of May that the bay begins to clear. Clearing progresses generally from south to north. Complete clearing normally occurs during the last week of July, but it is not unusual for some ice to persist until early August.

Foxe Basin

116 Ice in Foxe Basin is characterized by its extreme roughness and muddy appearance, large areas of land-fast ice and the fact that the pack ice appears to be in constant motion. The roughness of the ice is due to motion and stress produced by currents, winds, thermal expansion, and particularly to the large tidal ranges. Its muddy appearance is due to the freezing of muddy water, large tidal ranges, and winds; which keep a large amount of bottom deposits suspended.

117 New ice forms in northern Foxe Basin normally during the second week of October. It spreads southward more rapidly along the coasts than seaward to completely cover Foxe Basin and Foxe Channel early in November.

118 The typical ice regime in early March portrays fast ice along most shorelines. It is particularly extensive among

the islands to the northeast because of the shallowness of the water.

119 Melting starts in late May or early June, resulting in puddling and the beginning of the ice weakening. The ice then becomes predominantly composed of small floes but it is August before rapid disintegration occurs. Small patches of loose ice persist during September; they either melt by the end of the month or remain until freeze-up (in October) thus lasting until the following year.

Ice regime, Davis Strait and Baffin Bay

120 There are major factors controlling the ice regime in this region:

- A relatively warm north-flowing current along the Greenland Coast. This current retards the time of ice formation in eastern Davis Strait, results in earlier spring break-up along the Greenland Coast to Cape York, and provides an early access route into "North Water".
- A cold south-flowing current along the Baffin Island Coast. This current results in early ice formation along the Baffin Island Coast, delayed spring break-up in the same area and in a southward extension of ice-covered waters far beyond the limits of Davis Strait.
- A major polynya in Smith Sound at the north end of Baffin Bay known as the "North Water". This polynya is maintained by northerly winds, water currents, and an ice bridge in the northern part of Smith Sound. Vertical mixing of the water column may also contribute to the formation of the "North Water". Throughout the winter months ice covers most of Baffin Bay. The "North Water" polynya which develops every year is always evident even during calm periods when it may be briefly covered with new or young ice. Because it occurs every year, it is called a recurring polynya.

121 During the winter months, fast ice becomes well established along the Baffin Island and Greenland Coasts partly due to the frequency of winds having an on-shore component. The offshore pack remains mobile throughout the winter and the floes which range from small to vast in size are repeatedly frozen together and broken apart.

122 Clearing in the spring starts as soon as temperatures begin to rise and melt the thin ice in the "North Water" polynya. This area then expands southward across the approach to Jones Sound about the end of the second week of June, across the approach to Lancaster Sound by the end of June and southeastward to near Cape York around the middle of July.

Ice Regime, Arctic Archipelago

123 With some exceptions, the waterways of the Arctic Archipelago are dominated by a consolidated ice sheet during the winter months.

124 As temperatures rise in May, the open water areas start to expand slowly. During the month of June, clearing of Lancaster Sound progresses from the west. Although the sound itself usually clears of sea ice by early July, subsequent break-up in adjoining waterways can result in ice floes drifting into the area during July and early August.

125 The consolidated ice cover on many of the waterways is completely broken by the last week of July. The last ice areas to break-up are those in the waterways between the Queen Elizabeth Islands; this usually occurs about the end of August.

126 During the first week of September, new ice usually begins to form among the old floes in the Queen Elizabeth Islands area. By the middle of September, it begins to spread from the northern and western sections, covering many of the waterways by the end of the month. Lancaster Sound is the last area to become ice covered and this usually occurs by the middle of October. By the end of October, ice in many of the waterways has already consolidated.

Ice Regime, Western Arctic

127 During winter, ice coverage is nearly 100%, with ice motion confined to the Beaufort Sea and Arctic Ocean. An extensive belt of shore-fast ice lies along the mainland coast from Point Barrow, Alaska, to Amundsen Gulf.

128 The first clearing of sea ice occurs in late June in the Mackenzie River-Mackenzie Delta area. A week or two later, the fast ice along the Tuktoyaktuk Peninsula becomes completely fractured and during the fourth week of July an open water route develops from Mackenzie Bay into western Amundsen Gulf. The Arctic Ocean circulation is a delaying factor for break-up of ice along the coast between Point Barrow, Alaska, and Herschel Island. Even though the fast ice becomes completely mobile by early July, open ice conditions do not develop until the first week of August and an open water route not until the first week of September.

129 The last ice areas to break-up are those from Queen Maud Gulf to St. Roch Basin. Fracturing of the consolidated ice cover usually occurs during the second half of July with much of the area becoming mostly open water around the middle of August.

130 September is normally when the Western Arctic has the most open water. The timing of freeze-up in the Beaufort Sea depends to a very great extent upon the location of the southern limit of the polar pack because initial ice formation occurs among the older floes and spreads southward from there.

131 In the St. Roch Basin - Rasmussen Basin area new ice begins to form during the first week of October and spreads rapidly. The last area to achieve new ice growth is the central portion of Amundsen Gulf, normally during the fourth week of October.

Ice Regime, Athabasca — Mackenzie River system

Athabasca and Slave Rivers

132 Break-up on these rivers progresses from south to north in the second half of April, and in eight to twelve days these two rivers are clear of drifting ice although much may remain on the banks to melt. Seasonal variations are one to two weeks at Fort McMurray but only seven to ten days at Embarras and Fort Smith. Thus, the mean open water date at Fort McMurray is May 2 but it can be as early as April 18 or as late as May 20. At Fort Smith the mean date is May 14 with a variation to May 3 and May 21.

133 Freeze-up is similarly spread over a two week period on the average but the north to south variation is small. At Fort Smith and Fort McMurray the average date for first ice is November 2 and freeze-over of the river November 18. Because it is a very weather-dependent event there is a large variation in freeze-over date at any particular location. At Fort Smith freeze-over has occurred as early as October 18 and as late as December 6, a range of seven weeks. At Fort McMurray the variation is from October 27 to December 31.

134 Initial ice is usually observed at the end of October, but this is even more subject to minimum temperatures on clear autumn mornings and is of little significance. During winter, the ice usually attains 60 cm in thickness by January 1 and a maximum of about 100 to 115 cm in March.

Great Slave Lake

135 From a complete ice cover at the end of April with ice thickness (at Yellowknife) averaging 135 to 140 cm, the lake changes in six weeks time to nearly open water conditions by mid June.

136 Signs of melting in the form of open water areas at river mouths are common by the middle of May and the ice in the main body of the lake breaks up and begins to move in response to the wind by the first few days of June. Complete disappearance of ice is usually accomplished by June 15 in the main lake and the North Arm, but in Hearne Channel and in the NE part of the lake, it averages June 24 in Charlton Bay (Fort Reliance) and July 3 in McLeod Bay.

137 Variations in these dates are indicated in the records as one to two weeks but early clearing in one area does not necessarily mean that the whole lake clears early. Aerial reconnaissance has shown that the broken floes drift about in response to the wind, and that the last ice can be found in many different sections of the lake in different years. These surveys have clearly shown that drift of ice from Great Slave Lake down the Mackenzie River is far from a normal occurrence and only arises when east winds develop. By far the greatest proportion (probably over 95 per cent) of the ice melts within the lake itself.

138 The lake is open to navigation for 4½ to 5 months each year with ice formation beginning to occur on cold autumn mornings in mid October. Freeze-over is a fairly lengthy process, because fall storms can easily break up the newly formed ice and some motion in the main part of the lake probably continues through December. At Yellowknife (in Back Bay) the average freeze-over is October 31, but it can occur as early as October 17 or as late as November 18. At Fort Reliance, the mean date is November 11 to 15, but in exposed locations like Fort Resolution and Hay River, mean dates, of November 18 and December 13 are reported. This difference reflects the time needed to freeze the main body of the lake as opposed to the early growth that can develop in the smaller bays and inlets. Despite this, navigation is usually terminated in late October or early November.

139 During winter, the ice grows from 60 to 75 cm by January 1 and to 1.2 m by March 1. Pressure ridges formed by ice motion or by ice expansion as the temperature changes can reach 3 m in height during the winter and can be many miles in length.

Mackenzie River

140 Break-up on the Mackenzie River differs radically from the same process on Great Slave Lake; it is a gradual procedure on the lake, but a sudden and spectacular event on the river. As might be expected, the first open water develops in the south, but usually at the mouth of the Liard River rather than where the Mackenzie River begins. The ice in the Liard River begins to move, on the average, as early as May 5 and the river is open after May 18. On the Mackenzie River, movement begins in the upper sector

from Wrigley to Fort Providence between May 10 and May 15 and open water develops in the last week of May. At Fort Providence, however, because of the lingering ice in Great Slave Lake which may be driven into the river flow, the last ice averages June 13. From this date it is evident that much melting goes on in the river after break-up for this late ice never reaches Fort Simpson, about 100 miles downstream.

141 The seaward progression of the first ice movement is not exactly regular but it usually develops between May 10 and May 20. The motion may begin at Norman Wells for instance before it develops at Tulita (Fort Norman). Once this movement has occurred, the development to open water conditions progresses steadily with average dates being Wrigley on May 27, Fort Good Hope by June 1 and Inuvik by June 6. Again the melting of ice as it moves downstream is evident for this represents an average of a 2 knot rate for all ice, including that delayed in shallows and backwaters.

142 Year to year variations are moderate as far as first movement is concerned, varying from advances of 2-3 weeks to delays of 1-2 weeks. In clearing of the ice, however, the difference is considerably smaller. The range at Wrigley is from May 18 to May 31 with a mean of May 27, thirteen days over-all, while at Fort Good Hope it is from May 19 to June 9 with a mean of June 1, only three weeks over-all.

143 On the Arctic coast, conditions in the sea become an important factor for navigation because the ice there is much later in breaking up. Although the channel at Inuvik clears on average by June 6 and in the extreme case during the last week of the month, at Tuktoyaktuk the mean clearing is July 1 and coastal navigation rarely begins until mid July.

144 The navigation season on the Mackenzie River lasts from mid June until late October when ice begins to form in shallows and areas of minimum current. This first ice is very unstable and its occurrence progresses southward from the Arctic coast in mid October to the Fort Simpson area by the end of the month. A similar but slower upstream progression is evident in freeze-over dates which average October 12 at Aklavik and October 22 at Inuvik. On the Arctic coast in Kugmallit Bay at Tuktoyaktuk, the average date is October 15, very much in agreement with the other freeze-over occurrences in the area, river current apparently balancing the effect of salinity. The upstream progression is steady, on the average, reaching Fort Good Hope on November 8, Tulita (Fort Norman) by November 14 and Fort Simpson by November 27.

145 Yearly variations in these dates are approximately two weeks earlier or later than the mean and there is little difference from one location to another. Since most navigation on the river is from Great Slave Lake to the sea, the end of the shipping season is closely related to freeze-over at the mouth of the river and as a result the navigation season ends in late October.

146 Beginning in June, the ice-free season ranges from 180 days in the south to 100 days near Tuktoyaktuk. The break-up of rivers precedes small lakes by one to two weeks but there is a further delay in central Great Bear and Great Slave Lakes due to the greater a real extent and thickness of their ice. The freeze-up begins in small lakes followed by rivers about two weeks later; the central parts of the two largest lakes of the region are the last to freeze.

147 The severity of the Canadian Arctic winter is such that even unusual year to year variations in weather produce little change in the total ice cover. Thus the yearly variations are measured by means of the thickness of the ice rather than by its extent or nature. But even here, the differences from season to season are of minor importance. It is generally not significantly easier for a vessel to penetrate 180 cm of ice than 200 cm. Yet in order to reduce ice thicknesses from 200 to 180 cm, daily temperatures would have to range about 9°C above normal for three entire months; an appreciable variation.

148 The *Sea Ice Climatic Atlas - Northern Canadian Waters 1971-2000* is published by the *Canadian Ice Service*, *Environment Canada*, at https://publications.gc.ca/site/eng/441147/publication.html. The atlas should be consulted for additional information on ice conditions in the Canadian Arctic.

Arctic Survival

149 The following notes and recommendations have been compiled from *Canadian Forces* sources by *Defence Research and Development Canada* and from other sources.

150 Vast areas of the Canadian Arctic consist of water and tundra. Much of this area is inhospitable to humanity and large regions are not habitable. Mariners who find it necessary to abandon ship may be presented with the need to maintain life in a hostile environment until rescued.

151 Despite the high standards which have been achieved in Canadian search and rescue services, situations can arise during which prompt rescue does not, or cannot occur. The following paragraphs discuss the equipment, actions and attitudes which will help an individual to survive, and increase the probability of prompt rescue.

152 A lot of research on survival in cold, wet conditions has been completed in the last few years and

new techniques have become available. New materials for clothing and shelter are now available which make the saving of the lives of survivors in extreme conditions more certain, and in some cases easier. However, the most important developments during the last few years in the Canadian Arctic have been the expanded and improved radio communication facilities, and the increase in the number and capabilities of aircraft and ships operating in the Arctic. The ability to make contact in the event of a disaster, and the availability of rescue aircraft, has, under normal circumstances, reduced the time taken for a completed rescue from days or weeks to hours. Apart from the radio watch maintained at the *Canadian Coast Guard Marine Communications and Traffic Services* centres, airfields and industrial centres, there are, particularly in the spring and summer months, several dozen small field parties, all of whom are in radio contact with their bases and each other at scheduled times each day, while aircraft fly over large areas each day. For example, the *Polar Continental Shelf Project* of *Natural Resources Canada* have many small parties scattered over the Arctic. Consequently the most important single piece of survival equipment is a radio, whether it be the main transmitter in the ship, or a portable VHF transceiver on the ice, in a boat or taken ashore.

153 The first endeavour from a ship in distress must be to make and maintain radio contact, and the activities of a party of survivors must depend on whether such contact is held or not. If radio contact is not immediately made, or if the weather is bad enough to delay flying, the survivors must be prepared to get from the ship to the beach or to a safe area of sea ice and survive there until the arrival of rescuers. Their ability to do this, particularly in the winter, is a function of the knowledge that they may have of survival techniques and of the equipment and clothing which they have with them. Lifesaving equipment specified by regulations for normal ship service and the usual standard of shipboard heavy clothing will not be sufficient to prevent extreme hardship and possible death to some of the party. The scale of equipment which is now becoming standard for ships working in the Arctic, such as the oil company drill ships, includes immersion suits, additional parkas, insulated footwear and mitts, and sleeping bags. Liferaft outfits of emergency food should also include small gas or liquid fuel stoves with a supply of fuel in sealed containers. The provision of such an outfit could well make the difference between life and death for a crew forced to abandon ship. Many of the remarks in the following sections apply to survivors who have only the life-saving equipment which is now specified by *Transport Canada* regulations, but Masters and officers of ships sailing in the Arctic should make all possible efforts to improve upon these standards.

Survival attitude

154 If a distress message has been acknowledged before abandoning ship, or subsequently by the use of portable radios from the beach or ice camp, the survivors know that rescue efforts are underway and there should be no serious problem with morale. If such is not the case, or if rescue is likely to be seriously delayed by darkness or weather, the survivors will have to face the possibility of a longer stay before they are located and rescued. The survivor of a shipwreck is inevitably faced with little choice but that of fighting for continued existence, and contention with the physical and mental afflictions of the temperature, hunger and thirst. The utter loneliness of the single survivor adds considerably to mental strain.

155 The survivor of an Arctic shipwreck, previously accustomed to a relatively well-ordered, well-fed and comfortable life onboard ship, will be faced with the need for sharp physical and mental readjustment. Despite the inhospitability of the Arctic, however, the case may not be as hopeless as at first seems apparent. Sources of food, drink and shelter can be found, and both physical and mental problems can be met. Once the survivor understands and is prepared to accept the inconveniences and discomforts of a primitive existence, the body will, with a little assistance, gradually readjust physically.

156 The same cannot, however, be said of the psychological aspect of survival. The shipwrecked mariner, particularly the lone survivor, will have to apply all will power and mental discipline to control overwhelming feelings of depression, concern, confusion, despair and possibly panic. To control these feelings, the survivor should concentrate on the job to be done. Confidence in both equipment and personal abilities is required; above all the survivor should believe that rescue will arrive. Mental readjustment to abnormal physical conditions should be established in the first four or five days of forced association with them. A day-to-day assessment of state of mind should see the survivor through this critical period.

157 It is a matter of record that no two individuals respond to the same situation in exactly the same way. It is also a matter of record that certain individuals when faced with the problem of survival have come back alive from circumstances of almost unbelievable hardship, while others faced with less brutal conditions have succumbed.

158 The following paragraphs contain some guidance on survival for the benefit of mariners whose duty takes them into Arctic waters.

Afloat

159 The immediate threat to life on entry into water is drowning. A good **personal flotation device** should maintain the face of a survivor above the surface of the water with minimum physical activity. The optimum attitude for a survivor wearing a personal flotation device is one of 45° backward from the vertical facing oncoming waves. A desirable device will bring the nose and mouth of an unconscious survivor out of the water and to a position facing the waves.

160 Lifejackets are of minimal use in Northern Canada conditions. If a person goes into the water, a lifejacket will keep the individual afloat but after only a very few minutes this will be a matter of academic interest only, since the person will be dead. Even if the individual is pulled from the water alive, chances of living under Sub-Arctic or Arctic conditions are small, unless the person can immediately be taken into a heated space and provided with dry warm clothing. The first objective then must be to keep everyone out of the water while abandoning ship and reaching land. If no better alternative exists, vest type inflatable lifejackets, inflated by releasing a CO_2 cartridge, are recommended as being less bulky, space consuming and more comfortable for persons embarked in inflatable liferafts. Such lifejackets have an inflation tube permitting them to be deflated and inflated again by mouth, as necessary for subsequent use.

161 **Immersion suits** are designed along the same lines as a diver's dry suit. They are required equipment for most ships operating in Canadian waters. The effectiveness of an immersion suit depends on the knowledge and skill of the person using it. Donning the suit quickly and correctly takes regular practise.

162 The main functions of an immersion suit are to provide protection against the paralysing effects of the near-freezing temperature of Canada's northern waters and to provide flotation properties, for an extended period of time.

163 Protection from the elements and exposure is offered by 15 or 20-person inflatable **liferafts** with built-in canopies. Great care would have to be taken in ice-choked waters to avoid damage to the raft. Tests have shown that such liferafts stowed in plastic containers will, upon firing the CO_2 bottles, break free, even though the container is encased in several centimetres of solid ice. The container may, however, if frozen to the ship, be impossible to throw overboard, and the stowage position therefore should permit the raft to be inflated on deck. Standard emergency packs should be adequate; however, "sea water desalter kits" equal to the fresh water normally in the emergency pack should be carried in addition as fresh water containers would be subject to freezing.

164 While more manageable than inflatable liferafts, open **lifeboats** offer little protection from the elements. They should, if possible, be used as "shepherds" for the liferafts, with small crews only, being relieved as often as necessary by persons from the liferafts. Motorised, fully-covered lifeboats, providing considerable protection to the crew, are now in common use and should be used to provide the same "shepherd" function if liferafts are present.

165 While "hand warmers" provide short term comfort and flexibility to the hands they are best used with insulated mitts, and, of the two items, the mitts are the more important. All crew members should have adequate mitts and spare mitts should be available in the lifeboats and liferafts.

166 **Caution**. — Great care must be exercised to prevent damage to the liferafts and boats from loose ice. In some circumstances, when the raft is not heavily loaded, it may be possible to release some of the inflating gas. This will reduce the likelihood of tearing the fabric on the edges of floating ice.

167 Under Arctic conditions the value of shepherding the rafts and keeping them together for mutual support is much increased. If there is more than one raft, they should be connected with at least 8 m of line. Connect rafts only at the life line around the outer periphery of the rafts. Unless the sea is very rough, shorten the line if an aircraft is seen or heard. Two or more rafts tied close together are easier to spot than scattered rafts.

168 Upon reaching shore or solid ice, the liferafts will make excellent shelters if pulled up on the ice or shore and kept inflated. The build up of moisture within these devices limits their long term use as shelters.

169 Owing to the build-up of CO_2 from the human occupants of an enclosed liferaft, adequate ventilation should be provided at all times, particularly if additional insulation is provided by using snow walls or snow cover on the canopy.

170 As with other activities undertaken in Arctic conditions, preparations for **abandoning ship** will only vary in degree from similar preparations made in more temperate zones. Where possible, an early decision to prepare to abandon ship should be made. Survival chances will be greatly increased where the crew are mentally prepared, and properly clothed, to meet existing conditions. Preparations should include dressing in the warmest possible clothing without overly restricting movement. Should there be time to eat, sugar increases recovery from, and resistance to chill if eaten prior to exposure. Chocolate bars and other candies provide a convenient source of sugar, and all supplies readily available should be taken from

the ship. Alcohol should be avoided before, during and after exposure. In the event of immersion, several layers of clothing will decrease the immediate loss of body heat. Adequate clothing will also be essential for survival on ice or ashore.

171 Immersion in Arctic waters presents the same initial dangers as those experienced in the North Atlantic and elsewhere, accentuated by the lower temperature of the water. It is important to note that some individuals can withstand considerable exposure to cold water and survive. Persons have been picked up alive after being in sea water below 0°C for an hour and others have survived in sea water at 2.8°C for 90 minutes. However, in water at less than 20°C, body heat is lost faster than it is produced. Once the body temperature falls below 35°C, heat production is itself reduced and at lower body temperatures, respiratory and circulatory depression occurs. Even a very short period of immersion in extremely cold water will contribute to hypothermia and can be fatal. In the Arctic, the dangers from immersion in cold water do not end when the individual is pulled out. Unless dry clothing is readily available in the raft or on the beach, the person's chances of surviving in winter or spring conditions are greatly reduced. It is of great importance, therefore, that arrangements to abandon ship include transferring the crew, in their immersion suits, to the lifeboats without their entering the water. This transfer, if possible, should be accomplished either onboard, before lowering the lifeboats, or by scrambling nets.

In the boats

172 Sequence of events after taking to the liferafts and/or lifeboats:

a. stay clear of the ship (out of oil-saturated waters) but in the vicinity until it sinks;
b. search for missing personnel;
c. salvage floating equipment. Stow and secure all items and check rafts for proper inflation, leaks, and points of possible chafing. Bail out your raft, be careful not to snag it with shoes or sharp objects;
d. if not already done, put on immersion suits if available and begin combating exposure, hypothermia or other physical debilitations. For example, rig a wind break, spray shield or canopy. If with others, huddle together and exercise regularly. Check the physical condition of all onboard; give first aid if necessary. Take sea sick pills if available; wash off oil and fuels from the body and clothes;
e. if there is more than one raft, connect rafts or boats with at least 8 m of line;
f. get the emergency radio into operation (if available). Prepare other signalling devices for instant use;
g. items such as compass, matches, watches and lighters should be stowed in waterproof containers such as plastic bags. Make a calm, careful review of the situation and plan a course of action;
h. securely stow water and rations – assign duties to the crew;
i. Keep:
   - a log,
   - an inventory of all equipment,
   - a supply of water and food by saving energy,
   - a ration schedule,
   - calm; and above all,
   - a sense of humour and use it often!
j. remember that rescue is a co-operative project. Increase visibility by using all possible devices for attracting attention.

Ashore or on the ice

173 Sequence of events after reaching shore, or after boarding a substantial ice floe:

a. All available equipment should be carried ashore or onto solid ice and secured. In good weather this may merely mean piling equipment in a convenient place, but in bad weather, with drifting snow, care must be taken that equipment is protected from loss or damage. Extra clothing in the survival packs should be issued to anyone in immediate need.
b. The order in which things are done depends a great deal on circumstances, for example, whether or not a distress message has been acknowledged, and the estimated time before rescue can be expected. In general their order of importance might well be to:
   - provide first aid for the sick and injured and initiate immediate personal care for each individual's protection,
   - provide temporary shelter, even if it consists only of a wind break for the sick and injured,
   - set up the antennae and make a radio contact,
   - select a camp-site and construct a more permanent shelter,
   - provide hot drinks, food and heat,
   - lay out or prepare distress signals,
   - select and mark an emergency airstrip.

174 Most of these activities can be carried on simultaneously and the relative importance and necessity for individual action will depend on the weather and on what kind of rescue effort can be expected. For example,

if the ship has been lost in good summer weather, the crew have reached the shore without injury or immersion, and a distress signal has been acknowledged, the most urgent task might well be to locate and mark a landing strip for the rescue aircraft which may be expected in an hour or so. In the worst case, where the ship has been lost in the winter, where no acknowledgement has been received to distress signals and no radio contact has been made with the portable sets, the survivors must prepare for an extended period under harsh conditions, and shelter and warmth become the first priorities.

175 The need for immediate **first aid** treatment of any injury under survival conditions cannot be over estimated. Since the quantity of medical supplies available will be limited, it is doubly important that minor injuries be treated immediately to avoid both possible complications and further demands on supplies. Minor cuts and skin abrasions render the affected area susceptible to frost-bite.

176 Immediate action should also be taken individually to protect the body and its extremities from the effects of exposure and severe temperature conditions. Headgear should always be worn as the head is the area of greatest heat loss. The hands particularly are of exceptional importance to the survivor. If they are injured, the survivor becomes helpless and an easy prey to the elements. Gloves should be worn constantly, even for delicate jobs. Care should be taken to avoid skin contact with cold metal objects. Contact with steel at temperatures of -20°C and lower will cause instant blistering. Feet should be protected from the effects of blisters, frost-bite and "immersion foot" – a condition of painful swelling with inflammation and open lesions caused by prolonged exposure to low temperatures and moisture. Immersion foot can be avoided by keeping the feet warm and dry, which is also the only treatment possible should the complaint be contracted.

177 Frost-bite appears as a grey or white patch, with a waxy, wooden appearance. It is not necessarily painful but will usually cause numbing and stiffness. Frost-bite is caused by heat loss and can be brought on by the chill of high wind at only moderately cold temperatures as well as by extreme cold. Protection from frost-bite can be achieved by keeping the most susceptible areas, hands, feet, nose, cheeks, forehead and ears covered or shielded. Avoidance is the best treatment for frost-bite. Since the freezing of small areas of the face and hands cannot always be felt, everyone should be alert for the signs of frost-bite in other persons.

178 To treat frost-bite, do not rub the affected area. Seek shelter. If the frozen part is on the face, ears or trunk, cover it with a warm ungloved hand. If a hand is the affected part, insert it within the shirt, up against the body. If a foot is involved, remove the shoe and sock and place the foot within the shirt and against the body of another person. Treat as a burn by wrapping in sterile dressing and cover warmly. If there is any chance of refreezing a thawed body part, do not rewarm it in the first place. Freezing, rewarming and freezing the skin again causes much more tissue damage than being frozen once. As it rethaws, the skin turns red, swelling develops, and the area becomes quite painful.

179 Perspiration should be avoided by the Arctic survivor since it soaks into the clothing and ruins insulation qualities, as will any form of moisture. Before starting arduous work, clothing should be removed or opened up so that work is commenced "cold". As the work progresses, clothing should be replaced or closed up until a comfortable body temperature is reached.

180 Panting, and the intake of large masses of cold air, can lead to internal frost-bite, and should therefore be avoided. Frequent rests between spells of labour and breathing only through the nose will help in this respect. A muffler or scarf worn across the lower part of the face will also be of value. In cold dry conditions when much energy is being expended, the survivor should be alert for symptoms of dehydration. This is due to the higher rate of water loss from the lungs because of the dryness of the air and the rate and depth of breathing.

181 Snow blindness, a condition arising from excess ultra-violet light in low-angle polar sunlight, can cause itching and extreme pain in the eyes and eyelids. The eyelids tend to become inflamed and swollen and sight is considerably reduced or even lost while the condition exists. Snow blindness can be prevented by wearing sun glasses or tinted polaroid eyeshields. If these are not available, some protection can be gained by wearing a mask of cardboard or cloth with narrow eyeslits, or by blackening the face about eyes, nose and cheeks with dirt, charcoal or soot.

182 Above all, personal hygiene is essential. Regardless of the situation, it is most important that one attempts to keep ones body as clean as possible.

Long term

183 Having landed and attended to immediate first aid requirements, the survivor should attempt to orientate oneself and, if able, reconnoitre the immediate area before establishing camp. Clearly the only recourse of the shipwrecked mariner in Arctic regions is to establish some form of shelter, with warmth and sustenance, there to survive while awaiting rescue. This course of action should be undertaken as soon as possible, before strength and stamina deteriorate further. In addition, it will provide immediate physical and mental preoccupation and help to avoid despair or confusion.

184 In selecting a suitable camp-site, thought should be given to natural shelter and wind-breaks provided by terrain and sources of food, water and other necessities.

185 **Fire** is one comfort of civilization which can be taken into a survival situation. Quite apart from the very practical benefits of warmth, discouragement of prowling animals and heat for cooking, a fire provides a great measure of mental comfort and support. The desirability of starting a fire early is therefore obvious.

186 The four fundamentals involved in making and maintaining a fire are spark, tinder, fuel and oxygen.

187 The best way of igniting tinder is with the flame from a match. A damp match can be dried by stroking the tip through the hair several times or by drying in the sun. However, if a cigarette lighter is available, it should be used first, to conserve matches, as it will quickly dry out. If a flame is not available a spark must be produced to ignite the tinder. The easiest way to achieve this is again with a cigarette lighter. Another method of producing a spark is by short circuiting a battery, by touching two pieces of metal or heavy wire, whose other ends are already held or clamped to the battery terminals. Alternatively both terminals can be touched directly by a piece of metal but this method is hazardous. The basic method of producing a spark is by using a hard rock as a flint, and striking this a glancing blow with a knife or steel to knock sparks onto the tinder.

188 Tinder is any dry substance which is readily ignited by a spark. It can comprise cloth or cotton, particularly if soaked with gasoline or oil, or from paper if available. Sparks cause the tinder to smoulder. Blowing increases the supply of oxygen and creates the necessary draught for the smouldering tinder to burst into flame.

189 Fuel may be obtained from wood used in the construction or fitting of lifeboats. On the tundra, wood is scarce. Look for any woody brush or shrub, and burn roots as well as stems. On the coast, look for driftwood. Animal fat and bones can be used as fuel. In the Arctic, the natural fuels are the fats of animals. These are most readily burned in a container such as a shallow metal ration can or pan. Cloth tinder should be placed on the fat as a wick and ignited. The heat from the flame will warm the fat around the wick and melt it into liquid form, which then soaks into the wick to sustain burning as in an oil lamp. Oil can also be used in this fashion although it causes more smoke than animal fat. If it can be spared from a first aid kit, a Vaseline dressing will provide both wick and fuel for a short time. Adequate stocks of fuel should be provided, if possible, before starting a fire.

190 To maintain a fire inside a shelter it is essential that adequate ventilation is provided both to supply the necessary oxygen for combustion and to remove its poisonous by-products.

191 In most circumstances survivors in the High Arctic will find it difficult to build fires, and natural fuels may be hard to come by. Even if seal or whale blubber is available, the production of a clear burning flame is an art without which the lamps are inefficient and produce combustion by-products causing severe soreness of the eyes (tent-eye). Since hot drinks and hot food are essential in very cold weather, it is much more practicable to have at hand one of the many types of commercial portable cooking stoves, which are ready immediately to supply water and heat when they are most needed. These stoves can be very small and compact and, together with sufficient sealed fuel containers to provide 20 to 30 hours burning, add little weight to a survival pack. When used in a closed shelter, ventilation is required with these stoves also.

192 The rate of loss of heat from the body depends on the air temperature and on the square of the wind speed. It is very important to provide some kind of **shelter** from the wind, particularly for those suffering from shock after injury. A liferaft or boat sail may be available but for most of the year packed snow will be the best insulation available. The best snow for building purposes is found in comparatively shallow drifts, 0.5 to 1 m thick. If a person can walk across a drift, without leaving footprints and making either no noise or a ringing tone the snow is good for building. Blocks are most easily cut with a snow knife which has a thin, flat, rectangular blade about 5 cm wide and 40 cm long with a rounded tip, the blade being moderately sharp on both sides and set in a flat wooden handle long enough to be easy to manipulate in heavy mitts. A good substitute for a snow knife is a small carpenter's panel saw. To make a wind break quickly, cut blocks about 50 cm^2 by 20 to 30 cm thick. A wall two blocks high can be rapidly constructed to protect the injured and when curved can be extended later to form a "round-house" as discussed later. Gaps between the blocks are chinked with loose snow. Even if a liferaft is being used as the initial shelter, its value is enhanced by using snow blocks around it to provide additional insulation.

193 The most effective shelter in an Arctic winter is the igloo or snow house. Details of construction can be found in various publications. Basically, a trench is dug in a snow drift to a depth of not less than 50 cm, the blocks for building the igloo being cut from the trench. Blocks should be about 116 cm wide by 50 cm deep. A circle of 4 m diameter will provide an igloo of suitable size for five people. For numbers less than five 0.3 m per person less in diameter is appropriate. The igloo is constructed in beehive shape by fitting blocks in a narrow ascending spiral with

a final key block at the top. The entrance is through a low L-shaped tunnel, usually draped at both ends with cloth or skins. Ventilation is provided by a hole near, but not at, the apex. Inside a sleeping platform of snow is provided, not lower than the top of the entrance tunnel. Banked snow also will provide shelves to hold cooking utensils and food and the fat or oil-fired cooking lamp. The latter should be supported to prevent the snow beneath it melting due to the warmth it generates. The igloo is windproof, soundproof and is easily kept warm by a single oil lamp. The average temperature on the sleeping platform can be maintained without difficulty at 4°C in a well constructed dwelling.

194 Although an igloo is the best form of Arctic shelter and can be erected by one person in a few hours, survivors inexperienced in igloo building may find a simpler variation easier to construct. Such can be achieved by erecting circular vertical walls of snow blocks to about shoulder height and laying canvas or other suitable canopy material across the top, held in place by further snow blocks. If sufficient canopy material is available, two roofs should be provided with an insulating air space between.

195 The simplest form of snow shelter, and one which is quite effective, is to burrow a cave into a suitable snow bank or drift, providing a ventilating hole near the roof and draping the entrance with skins, canvas or other material. The bank or drift should be of sufficient height to permit a cave in which a stooping person can stand.

196 An efficient shelter for one or two persons can most easily be made in a shallow drift by cutting a trench about 4 m long and 1 m wide and using the cut blocks to build a wall along each side of the trench. The ends are then blocked up and blocks laid across the top to form a flat roof. After chinking the shelter, two sleeping bags are placed on the snow floor and the entrance closed by a moveable block fitted in the trench from inside the shelter. Such a covered trench will provide a measure of comfort for days or weeks, body heat alone being sufficient to raise the inside temperature 20° or more above that on the outside.

197 Snow suitable for cutting into blocks may not be found on open ice but usually forms in the lee of pressure ridges or ice hummocks. If snow is not available, it may be possible to make a shelter of thin ice slabs. Make it as small as convenient so that less area will have to be heated. Use the lee side of a pressure ridge if necessary. Arrange equipment inside the shelter so that it can be packed in a hurry. Any ice floe can break up and leads can form at any time. On ice, be prepared to move camp at a moments notice.

198 Even when a radio distress signal from the ship has been acknowledged before abandoning ship, it is very important that the party ashore should be in **radio communication** with the rescue organization. This can usually be accomplished using a small portable HF transceiver, since for much of the navigation season, in addition to the *Canadian Coast Guard Marine Communications and Traffic Services* centres there are several dozen small field parties using HF radio, for example, the *Polar Continental Shelf Project*, *Natural Resources Canada* headquarters in Resolute Bay. Inuit hunting parties also communicate by HF radio.The air charter companies operating in the Arctic maintain watch on VHF frequencies. The ships radio officer should ensure that the correct crystals, if required, for the most commonly used frequencies are available. At least one radio set, complete with crystals, if required, batteries and antenna, should be part of the abandon ship equipment, and if these are kept ready in a waterproof wrapping there should be little difficulty in getting them ashore in working condition. A T-antenna can be strung on temporary poles or, in an emergency, laid out flat on a level snow surface. If no acknowledgement was received to the distress messages before abandoning ship, the establishment of communications with the portable set is obviously of the greatest importance, but even if the distress message was passed successfully there is still an urgent need for continuous communications with the rescue organization. Medical advice may be necessary to save lives, and local weather information is of great importance to rescue aircraft. Information received by radio will affect all of the activities ashore. For example, if rescue aircraft are immediately available the first concern of the shore party will not be to provide shelter but to find and mark an airstrip and to prepare the injured for evacuation. It cannot be over-emphasized that the single most important item of life-saving equipment for a party of survivors in the Arctic is an operating radio. If available, satellite telephones may be used as a second option to contact SAR authorities.

199 **Distress signals** should be provided from all available sources. Flares and pyrotechnics if salvaged from ship, raft or lifeboat should be preserved for use only when an aircraft is in the vicinity and in position to observe them. Permanent distress signals, however, should be laid out as soon as possible. Some standard ground to air signals are shown near the end of this chapter.

200 One of the simplest methods of signalling distress in the Arctic in winter is to mark out the letters SOS in the snow. This can be done by trampling wide paths to form letters at least 3 m square and 3 m apart. If possible, rocks or wreckage or anything available should be laid in the tracks to accentuate the letters.

201 If not already used for construction of a shelter, the sail from a lifeboat or canopy from a liferaft stretched out

on the snow, makes a colourful and conspicuous marker. It should be laid in a clear space adjacent to the camp.

202 Any obviously artificial, unnatural marker such as piles or rocks or wreckage arranged symmetrically will be conspicuous in the Arctic and attract the attention of aircraft crews. On the approach of an aircraft, use should be made of more active signals such as flares, pyrotechnics and signalling mirrors. If possible, bonfires, capable of producing dense quantities of smoke, should be prepared for such occasions.

203 **Water** forms 2/3 of the body's weight. A deficit of 10% will cause severe symptoms of dehydration and loss of effectiveness. The body water volume is kept constant by balancing the water ingested against that lost in sweat, urine, faeces and through the respiratory tract. Even in a cold environment insensible perspiration is constantly secreted at a rate of 500 ml per 24 hours. The exhaled breath is always fully saturated and the amount of water lost in the expired air is on the average of 500 ml per day. An output of urine of at least 250 to 500 ml per day is necessary to rid the body of waste products. Thus even without sweating the minimum water loss amounts to about 1500 ml per day. Metabolism produces 300 to 500 ml of water per day. Therefore, the ingestion of about 1500 ml per 24 hours will more than maintain water balance in Arctic regions.

204 Obtaining good water should present no problem in any Arctic survival situation. Almost any fresh water found away from human habitation is safe, regardless of appearances. If a scum exists, it should be parted and water dipped from below. Likely sources of drinking water in the Arctic include

a. melting fresh water ice or packed snow;
b. old sea ice from which salt has been leached by thawing and refreezing – this is distinguishable by a blue or clear colour – not greyish;
c. pools of snow water found on sea ice in late spring or early summer;
d. pools of water around growths in muskeg areas;
e. icebergs frozen in Arctic sea ice – the thin layer of frozen salt water spray should be chipped off the berg and the ice below used;
f. sea water, provided a desalting kit is available.

It is noteworthy that fresh water ice requires approximately 50% less fuel than snow to obtain a given quantity of water.

205 Snow and snow water pools which have lain on sea ice for long periods of time can contain salt.

206 Hard packed snow is preferable to light and fluffy snow. If fluffy snow is used, it should be packed down into the container. In melting snow, the contents of the container should be worked with a knife or spoon until there is more water on the bottom than can be absorbed by the snow above it. This will prevent the bottom of the container from becoming dry and burning out and will prevent the melted snow from having a burnt taste.

207 Snow should not be eaten directly. If heat is not available, small quantities should be melted in the mouth or hand before swallowing.

208 If there is doubt concerning the condition of water, it should be boiled for about 5 minutes and then shaken to restore oxygen and eliminate the flat taste. If available, patent water purification tablets such as are provided in survival kits can be used, following the directions. If nothing else is available, three drops of iodine per litre will also purify drinking water. Side effects may occur after prolonged use of iodine.

209 At sea, where limited water may be available to survivors, rations must be designed to spare as much body water as possible. The metabolism of proteins and fats produces waste material which must be excreted. This increases the output of urine. Carbohydrates provide a readily assimilated form of energy which does not add to the waste material which the kidneys must excrete. If the water ration is less than the daily fluid loss, then only carbohydrates should be taken.

210 A diet with a protein-fat-carbohydrate ratio of 1:3:7 by weight is very effective for survival. This is usually packaged as an appetizing ration kit of approximately 3000 calories per meal. Acute discomfort is a common feature of survival situations but an acceptable diet can appreciably boost morale, especially if the food can be heated.

211 The main sources of food will be animal, supplemented by rations, if any, brought ashore. Little plant life will be found by the Arctic survivor, depending on the time of year and particular location. In the tundra, however, the leaves of dwarf birch can be used to brew tea.

212 Should plant life be in evidence, the following safety rules should be observed before using it for food:

a. avoid all mushroom-like plants unless they can be positively identified as edible;
b. avoid white berries and all berries growing in clusters. Red berries should be taken with caution;
c. generally plants which do not taste bitter are safe to eat;
d. anything eaten by birds or animals is usually safe;
e. if in doubt, a small quantity should be eaten and the subsequent effects, if any, over the ensuing 24 hours observed before eating more;
f. north of the treeline, there are no known poisonous plants.

213 Animal sources of food include the flesh of most fish, fowl, land animals and amphibians found in Arctic regions. However, again certain safety rules should be observed:

a. Polar bear meat has a high incidence of parasites and must be cooked thoroughly; polar bear and seal liver must be avoided since they contain considerable excess of Vitamin "A", in the form of retinol, which will cause illness or death;
b. fish should be well cooked since many northern species contain parasites which may attack humans when consumed;
c. rabbit should not be eaten exclusively although it is probably the easiest of any game animal to kill. A continuous diet of rabbit meat is almost devoid of fat and will cause severe diarrhoea within ten days, death within a few weeks. Even after a few days of such a diet survivors will experience discomfort and fail to satisfy their hunger despite an increased intake. This paradox has been called 'rabbit starvation'.

214 Small animals such as rabbits can be taken with a simple snare fashioned from a loop of wire or cord with a free-running eye, attached to a stick or a set of gallows made with sticks. The snare should be placed in visible or known "runs" with the loop, opened up to about 11.5 cm diameter, across the trail.

215 Larger animals, birds and amphibians can be taken with club or spear. A carefully selected or whittled club can be a deadly weapon in the hands of a patient stalker. Practice should be gained in throwing the club as well as using it in the hand. A spear, for throwing or hand use, can be fashioned by lashing a knife to a stick or pole. If a knife is not available, a hardwood pole sharpened at one end, the point then hardened over a fire, will serve adequately.

216 A sling for projecting small rocks and pebbles can be fashioned very simply from two cords each attached at one end to a 5 or 7 cm square of leather. One cord should have a sizeable knot in the other end for holding on to when the other is released in operation. Such a weapon, though primitive, can with practice develop tremendous power and accuracy comparable to arm-throwing. It can be most effective against small game and wild fowl.

217 Fish can be taken by net, spear or hook and line. The simplest method for use by the survivor is the hook and line. This requires little tending, and once set can work all day and night without attention, except to remove fish. It can, if necessary, be fashioned entirely from natural materials when these are available. It consists of a length of line anchored ashore at one end and in the water at the other. In the middle are a series of hooks suspended, by short lines of about 60 cm, from the main line. These hooks can be baited with almost anything including fat, grubs, fish or game offal and even coloured cloth smeared with grease.

218 If fish hooks are not available, a substitute called a "gorge" can be fashioned from a 2.5 cm sliver of bone, wood or metal, sharpened at both ends. The line is tied to the middle and both ends are baited. The gorge when taken by a fish will lodge in the gullet or mouth, the points piercing either side.

219 Nets if available can be invaluable for trapping fish and can also be used to catch birds. For the latter purpose, the net should be laid low above the ground with bait beneath it so that birds become entangled as they attempt to reach the bait.

220 Frying, baking and broiling have no place in snow-housekeeping. All cooking should be by boiling or stewing. These will be found easier than the former methods and the cooking results will be more beneficial to the survivor.

221 All water used for boiling or stewing food should be saved and drunk. Beside providing a hot drink, it will contain nourishment derived from the food cooked in it.

222 **Caution**. — Travel should be avoided unless absolutely necessary or unless all hope of rescue has been abandoned. It is probable that the shipwrecked mariner will be ill-prepared, at best, for Arctic travel, since this requires adequate food, clothing and equipment, knowledge of one's starting position and the exact direction of one's objective with relation to it. If travel is embarked upon as a last resort, the trail followed, if possible, should be marked to aid search parties and a record left at each "camp" of experiences to date. Movement should be slow and compass indications, if available, rigidly accepted.

223 The following **ground to air signals** are included for information. All figures should be at least 3 m square and laid out on the ground as conspicuously as possible from whatever materials may be at hand.

- Require doctor, serious injuries |
- Require medical supplies ||
- Unable to proceed X
- Require food and water F
- Am proceeding in this direction →
- Probably safe for you to land here Δ

224 Depending on aircraft availability, weather conditions, communications, etc., the rescue organization may decide to lift out the survivors by helicopter, fixed-wing aircraft or both. A helicopter can usually land much closer to the camp than can a fixed-wing aircraft, and requires little in the way of preparation of a landing area other than to find a reasonably level piece of ground over

a radius of 20 m or so which is not covered in loose snow which is liable to fly up and blind the pilot during landing. Helicopters in the Arctic are normally fitted with inflated pontoons and can land safely on loose rocks up to about 30 cm in diameter. The helicopters in use will usually carry a pilot and three passengers or one stretcher case and one more passenger. A helicopter with the rotors turning should be approached only from the front (i.e. in view of the pilot), on signal from the pilot, and in a crouched position. If the landing area is on a slope, approach from the downhill side.

225 The most likely fixed-wing aircraft to be used for rescue in the Arctic is a De Havilland Twin Otter, a STOL aircraft which, using over-sized wheels can land on comparatively rough ground or on sea ice. In conditions of soft snow they must be fitted with skis, an operation which takes about 3 or 4 hours at their base. In either case a strip 200 to 300 m long is ample. For a summer landing a suitable location can usually be found on a raised beach or delta; it should be level, and free of large scale (5 to 10 m) irregularities more than about 30 cm high, over a width of at least 20 m. This may involve, for example, filling in a shallow stream bed across the strip. The strip should then be cleared as much as possible, of loose rocks more than about 20 cm diameter and marked as well as the party can manage. Ideally there should be at least one flag at each corner and a substitute for a wind-sock, but more or less anything which the pilot can see from the air can be used. For a spring or winter landing on sea ice, a strip must be found which is free of irregularities such as small pressure ridges, the raised edge of a crack, or loose ice blocks. The Twin Otter can land on oversized wheels with up to about 20 cm of snow cover. If there is more snow than that, a ski landing will be necessary and it is important that the whole area of the strip be examined on foot to ensure that the snow is not concealing potential dangers. The Twin Otter will carry about a dozen survivors from a short strip.

226 It is possible that a Douglas DC3 aircraft may be used. This plane can lift about twenty-five people at a time but it requires a longer run than a Twin Otter and, for a landing on skis, minimum distance of 400 m should be checked on foot for hazards. No matter what the conditions, the rescue will be accomplished faster and much more safely if the ground party is in radio contact with the aircraft. Weather in the Arctic is very local, and conditions at the survivors' camp are likely to be different to those at the aircraft base. Considerable help to the pilot can be made if the landing conditions are discussed before coming down; the pilot may well have seen a more promising site from the air than the one the party has chosen. A great deal of confusion can be avoided if the portable radio has the correct crystal for the aircraft frequency.

Chapter 5

Infrastructure

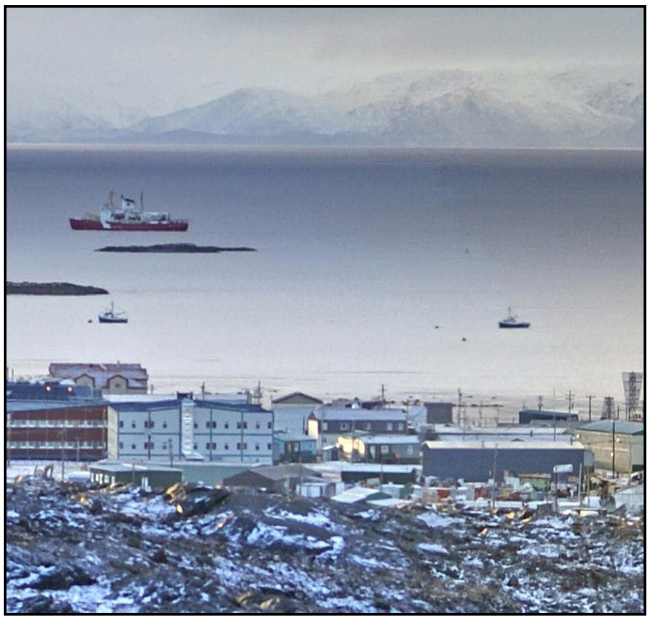


Photo by: Martin Fortier – ArcticNet

General

1 The search for oil, gas and minerals in the Canadian Arctic has greatly increased the demand for transportation in recent years. Air and water routes provide the only means of commercial transportation to much of the Canadian Arctic. There are only three railheads, at Hay River, Northwest Territories, Churchill, Manitoba and Moosonee, Ontario and year-round roads are limited to the Great Slave Lake and Upper Mackenzie River areas. Winter roads in the continental Arctic and sub-Arctic are more extensive.

2 **Water transportation**, although the most economical form of transport in the Canadian Arctic, is severely handicapped by ice conditions. The normal shipping season runs only from late July to early October. The *Canadian Coast Guard* co-ordinates freight to the Eastern Arctic for all Government of Canada departments and agencies and for various other organizations. During the short navigation season each year, *Canadian Coast Guard* icebreakers escort various ships carrying supplies to civilian communities, commercial operations and *Canadian Forces* installations. Chartered supply vessels usually depart from Montréal and Government-owned vessels from Quebec City or ports further east.

3 The *Canadian Coast Guard* transports government cargo as far north as Grise Fiord in Jones Sound, and as far west as Rae Point, Melville Island. *Canadian Coast Guard* icebreakers also transport supplies, when ice conditions are favourable, to meteorological stations on Ellesmere Island.

4 Ports in the Western Arctic, east as far as Spence Bay, are served by several companies via the Mackenzie River. At Tuktoyaktuk, cargoes are trans-shipped from river barges to coastal vessels or barges towed by ocean-going tugs. The 1,100 mile passage from Hay River on Great Slave Lake to Tuktoyaktuk on the Beaufort Sea takes about nine days. Specialized shallow-draught *Canadian Coast Guard* icebreakers are generally in the vicinity for escort purposes as required.

5 Lead-zinc mines at Nanisivik on Strathcona Sound and on Little Cornwallis Island in the Parry Islands, both now closed, used ice-strengthened vessels to bring in supplies and ship out ore.

6 Commercial shipment of Arctic oil from the *Panarctic Oil Company's Bent Horn Project* on Cameron Island, using ice-strengthened tankers, commenced in 1985 and continued until 1996.

7 **Air transportation** is of extreme importance in all northern operations and development. All-weather landing strips at each community permit wheeled aircraft and passenger and cargo jet aircraft to operate year-round. In the summer, pontoon-equipped planes can serve practically all areas. During the cold months, pontoons and wheels are replaced by skis. Short takeoff or landing (STOL) aircraft, such as the Twin Otter, provide passenger and freight service year-round by using interchangeable landing gear. Helicopters are ubiquitous. During winter darkness, flying is generally restricted to stations with permanent landing installations; with the return of daylight the scope of air operations expands, with frozen lakes and other stretches of level ice serving as landing strips. The flexibility and adaptability of air transport makes it especially useful throughout this vast region.

8 Regularly scheduled services into the Canadian north originate from Calgary, Edmonton, Winnipeg, Ottawa and Montréal. Within the Northwest Territories and Nunavut, flights are available on scheduled and chartered basis. Helicopters are also available for charter.

9 *Canadian Coast Guard* vessels use helicopters for ice reconnaissance and ship-to-shore or ship-to-ship transfers.

10 **Road transportation** between settlements in the Northwest Territories is limited, and non-existent in Nunavut. The Dempster Highway connects Inuvik, on the Mackenzie River delta, to the continental highway system at Dawson in Yukon. Winter ice or snow roads are built each year to serve as temporary supply routes between major centres and isolated communities or mine sites. Extreme changes in temperature can open large cracks and gaps and pressure ridges can also form in finished roads. Travel on these roads is therefore at one's own risk.

11 **Unconventional transport** such as snowmobiles, all-terrain motor vehicles and the dogsled are used for cross country travel in areas without roads.

12 Air-cushion vehicles have been tested and performed well in the Arctic. Weather conditions or terrain, whether land or sea ice, do not inhibit their movements, except vertical objects of a prohibitive height.

13 **Radio**. — **Television**. — **Telephone**. — **Internet**. — All communities receive radio and television programs in English and French via satellite. There are also local private and community radio and television operators. Programming is in English or French and Aboriginal languages. Telephone connection via satellite with all parts of the world can be made from all communities. High-speed internet connection via satellite is now available for computer applications.

Economic development

14 Originally, the principal products of the Canadian Arctic with a commercial value were furs, fish, whalebone, ivory and blubber. Only fur and fish, in limited quantity, are now exported. The production of hydroelectric power from rivers emptying into western Hudson Bay and eastern James Bay is important. Tourism, by air or cruise ship, is a growing industry. Exploration for and exploitation of minerals, oil and natural gas are major economic activities, despite the difficulties in transport.

15 **Minerals**. — The Canadian Arctic has a wide variety of minerals. The search for minerals by early explorers such as Hearne and Frobisher, and later by prospectors, played a major role in opening the Arctic to economic development. Mineral discoveries not only attracted more people to the North but formed the basis for a new northern economy, based on minerals rather than on hunting, trapping and fishing.

16 In addition to lead and zinc, gold, silver, copper, tungsten and cadmium are being mined in the Yukon and Northwest Territories. Soapstone is widespread but the mineral rights to the known deposits have been reserved for the Inuit who have long worked this mineral. Diamonds are a recently developed resource in the Northwest Territories.

17 **Oil and natural gas**. — The discovery of major oil and gas fields at Prudhoe Bay on the Alaskan north slope in 1968 spurred the hunt for oil and gas in northern Canada. In the Mackenzie Delta-Beaufort Sea area, oil was discovered in 1970 and gas somewhat later. Another area of development potential is the high Arctic islands. Gas has been discovered on Melville, King Christian and Ellef Ringnes Islands, and oil on Cameron and Ellesmere Islands. The Bent Horn field on Cameron Island was in production from 1985 to 1996.

18 The *Geological Survey of Canada* estimates the potential of the Arctic Islands at 686,000,000 m^3 oil and 2,257,000,000 m^3 gas (average expectation). Both gas and oil potential are highest in the Sverdrup Basin.

19 Transporting gas and oil from the Arctic Islands to markets, safely and economically, is the key problem in developing these finds.

20 **Hunting and trapping** are traditional pursuits in the Canadian north. Hunting for food continues to be

significant as a link to the past and cultural identity. Species hunted for food are caribou, moose, musk-ox, small game and birds. A general hunting license is required.

21 Big game hunting in the north is closely regulated and has specific regulations for residents and non-residents.

22 Trapping for fur harvesting is very important to most communities in the Northwest Territories as other employment opportunities are limited. Trappers harvest beaver, Arctic and red fox, lynx, marten, mink, muskrat, wolf and wolverine.

23 **Marine mammal harvesting** is an important traditional economy in Inuit communities. The harvest is used for food (for both people and dogs), clothing, handicrafts, lashings and lines. The harvest includes beluga, narwhal, walrus and seals. The European ban on the importation of sealskins in 1982-83 resulted in the near-collapse of the Arctic commercial sealskin industry which was virtually the only cash income in some communities.

24 **Fishing** for domestic purposes is an important traditional economy. Arctic char above the treeline and whitefish below are most prized for human consumption. Northern pike is utilized for dogfood.

25 Sport fishing is the foundation of the Northwest Territories tourist industry. Several sports fishing lodges are in operation, usually from June to September. Licences are required.

26 Commercial fishing for Arctic char, with processing plants in Rankin Inlet and Cambridge Bay, is an important part of the economy.

27 A relatively new fishery off Baffin Island harvests scallops, turbot and shrimp.

28 **Tourism** is a growing industry and is becoming increasingly important in the Northwest Territories and Nunavut economies. The north offers varied natural beauty, fishing, wildlife, and frontier lifestyles. Over eighty hotels, sixty lodges, ninety outfitters and two hundred package tours are in operation.

29 **Arts and crafts** is an important business in the Canadian Arctic with over 4,000 artisans. The arts and crafts are recognized for their authenticity because the artists maintain their traditional production techniques. Products available include a wide range of traditional clothing; traditional toys, household goods and souvenirs; and paintings, prints and carvings.

30 **Co-operatives** are private enterprises serving members/owners and the largest economic sector controlled by native people in the North. The co-operatives are often multipurpose operations, active not only in arts and crafts but also in retail marketing, local service contracts, construction, transportation and the hospitality industry.

Principal ports and anchorages

31 Listed below is a summary of the **principal ports and anchorages** in the Canadian Arctic. Detailed information on these ports and anchorages is given in the appropriate geographical chapter in *Sailing Directions ARC 401*, *ARC 402 (ARCTIC CANADA VOL. II)*, *ARC 403 (ARCTIC CANADA VOL. 3) and ARC 404 (GREAT SLAVE LAKE AND MACKENZIE RIVER)*.

32 **Akulivik** *(60°49'N*, *78°10'W)* is on the NE shore of Hudson Bay. Good anchorages are available in nearby Babs Bay and Knight Harbour. *(See Sailing Directions ARC 401.)*

33 **Alert** *(82°30'N*, *62°20'W)*, on the shore of Dumbell Bay on the Lincoln Sea, is the site of a *Canadian Forces* radio station, an *Environment Canada* weather station, an airstrip and a landing beach. It can be reached, in August, by icebreakers. Anchorage is obtainable if ice conditions permit. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

34 **Arctic Bay** hamlet *(73°02'N*, *85°08'W)*, on the north side of Adams Sound in Admiralty Inlet, has an airstrip and landing beach. Anchorage with excellent holding is available and the landing beach is protected by a breakwater. Break-up occurs about mid July, freeze-up early in October. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

35 **Arviat (Eskimo Point)** *(61°07'N*, *94°04'W)*, a community on the west shore of Hudson Bay, can be reached near high water by craft drawing 2.4 m. Anchorage with protection from northerly winds is available 6 miles from the settlement in 13 m. *(See Sailing Directions ARC 401.)*

36 **Attawapiskat** *(52°55'N*, *82°27'W)*, a community 6 miles up Attawapiskat River in west James Bay, can be reached at high water by craft drawing 2.1 m. *(See Sailing Directions ARC 401.)*

37 **Aupaluk** *(59°21'N*, *69°41'W)* is a settlement in Hopes Advance Bay on the west coast of Ungava Bay. Good anchorage is available in 18.3 m. *(See Sailing Directions ARC 401.)*

38 **Baker Lake** *(64°19'N*, *96°02'W)* is a community 170 miles from Hudson Bay on Baker Lake at the inland end of Chesterfield Inlet. The hamlet is supplied annually by a barge train drawing about 2.4 m and has been reached by craft drawing 4.6 m. Anchorage with good holding

may be obtained 0.5 mile off the west shore. *(See Sailing Directions ARC 401.)*

39 **Baychimo Harbour** *(67°42'N, 107°56'W)*, the site of the abandoned settlement *(2006)* of **Umingmaktok**, is a good harbour apparently well sheltered from any weather except from the south. There is an abandoned airstrip and a landing beach. Anchorage is obtainable in the NW part of the harbour. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

40 **Bernard Harbour** *(68°47'N, 114°45'W)*, on the mainland coast of southern Dolphin and Union Strait, is the site of an unmanned *North Warning System* station, abandoned trading post and an abandoned airstrip. Large vessels can obtain anchorage 1 mile north of Chipman Point. An alternative anchorage, with only fair holding, can be obtained 0.8 mile ENE of North Star Point. Small vessels can anchor 0.3 mile east of Bernard Creek or 0.2 mile SE of North Star Point. All anchorages are untenable in NW gales. The former landing beach at North Star Point is soft and suitable only for small landing vessels. Break-up usually occurs early in July and freeze-up in mid October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

41 **Bridport Inlet** *(75°02'N, 108°44'W)*, on the SE coast of Melville Island, was the planned site of a gas liquefaction plant and LNG carrier terminal. Good anchorage for large vessels is obtainable off the south shore of the inlet. The inlet is usually clear of ice after mid August with freeze-up commencing about mid September. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

42 **Broughton Island** *(67°32'N, 64°03'W)*, on the east coast of Baffin Island, is the site of the Inuit settlement of Qikiqtarjuak, an unmanned *North Warning System* station, an airstrip and two landing beaches. Anchorage with very good holding and shelter is obtainable. The navigation season is mid July to mid October. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

43 **Cambridge Bay** hamlet *(69°07'N, 105°03'W)* is one of the principal communication, transportation and supply centres in the Arctic and is also centre of administration for the Kitikmeot region of Nunavut. There is a remotely controlled *Canadian Coast Guard* radio station operated during the shipping season by *Iqaluit MCTS*, a manned *North Warning System* station and logistics support base, a public wharf and an airfield. The hamlet borders the NE arm of the bay. Anchorage with good holding can be found in the central part of the arm. Strong NW winds, usually late in the season, produce waves up to 2 m high. Good anchorage is also found close off the landing beach on the north side of the entrance to the NW arm. The landing beach is suitable for all types of landing vessels. The bay is usually ice-free by late July although an ice barrier often persists outside until early August. Freeze-up starts in late September. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

44 **Cape Dorset** *(64°14'N, 76°33'W)*, a settlement at the NW end of Hudson Strait, affords anchorage with poor shelter in 18.3 m. *(See Sailing Directions ARC 401.)*

45 **Cape Dyer** *(66°36'N, 61°18'W)*, the easternmost tip of Baffin Island, is the site of an unmanned *North Warning System* station, an abandoned *DEW Line* station and an abandoned airstrip. The former beaching area is in Sunneshine Fiord about 9 miles west of the cape. Anchorage with fair holding but poor shelter is obtainable. Break-up usually occurs by mid July. Mid August ice conditions are considered the best but the Baffin pack ice can move in at any time. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

46 **Cape Hooper** *(68°24'N, 66°36'W)*, 43 miles south of Cape Henry Cater on Baffin Island, is the site of an unmanned *North Warning System* station. There are landing beaches for a former *DEW Line* station and an abandoned airstrip. Anchorage with poor holding and open to NE winds is obtainable. Break-up occurs about the first week in August, freeze-up about the third week in October. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

47 **Cape Parry** *(70°12'N, 124°32'W)* is on Parry Peninsula NE of Cape Buchan. There is an abandoned *DEW Line* station and abandoned airstrip, as well as an unmanned *North Warning System* station. Anchorage is available in Cow Cove, with poor holding but good shelter from east winds; west winds cause heavy surf and can fill the bay with drift ice. The beaching area is at the north end of the cove. Alternate beaches in Bath Bay, where the holding is poor, provide little shelter; the east one was used for discharging aviation fuel. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

48 **Cape Young** *(68°57'N, 116°59'W)* is the site of an abandoned *DEW Line* station and abandoned airstrip. Unprotected anchorage can be obtained 0.5 mile off the former landing beach. Barges berthed at the landing beach in calm weather only; otherwise cargoes were lightered ashore. A bay west of Cape Young should provide shelter, except from winds between north and west, but nothing is known of its holding capability. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

49 **Chesterfield Inlet** *(63°20'N, 90°42'W)* is an Inuit settlement on the NW shore of Hudson Bay at the mouth of Chesterfield Inlet. Fair anchorage can be obtained in 15 m. *(See Sailing Directions ARC 401.)*

50 **Chisasibi (Fort George)** *(53°50'N, 79°00'W)* is a Cree settlement near the mouth of La Grande Rivière in

NE James Bay. Water levels and currents in the river are affected by the *James Bay Hydro-electric Project*. Several exposed anchorages with depths between 11 and 36 m are off the entrance of La Grande Rivière. A paved road connects Chisasibi to the *James Bay Highway*. *(See Sailing Directions ARC 401.)*

51 **Churchill** *(58°47'N, 94°12'W)*, a town and major port for the shipment of grain from the Canadian prairies, is at the SW corner of Hudson Bay. Churchill has a well-sheltered harbour; fresh water, limited supplies of fuel and a machine shop are available. Rail transportation is the only surface link to the south. *(See Sailing Directions ARC 401.)*

52 **Clyde River** hamlet *(70°27'N, 68°35'W)*, on the NE shore of Baffin Island, has an airstrip and landing beach. Anchorage with very good holding and protection from all except southerly winds is obtainable. The navigation season is mid August to October. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

53 **Coral Harbour** *(64°08'N, 83°10'W)*, a settlement on the south shore of Southampton Island, can be reached at high water by craft drawing 2.4 m. Larger vessels can obtain fair anchorage off the settlement in 11 to 18.3 m. A pilot is available. *(See Sailing Directions ARC 401.)*

54 **Deception Bay** *(62°09'N, 74°42'W)*, on the south shore near the west end of Hudson Strait, is the site of an ore loading terminal. There are two berthing cells about 76 m apart. *(See Sailing Directions ARC 401.)*

55 **De Salis Bay** *(71°27'N, 121°37'W)* is on the south coast of Banks Island. Sheltered anchorage from all but north to west winds can be obtained on the east side of the bay, north of, and about 1 mile east of the west end of the sand and gravel spit. An alternative anchorage can be found in the NW part of the bay. The ice cover begins to break near the end of June and clears during the first week of August. Freeze-up usually commences by the second week of October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

56 **Dundas Harbour** *(74°32'N, 82°26'W)*, on the SE shore of Devon Island, is the site of an abandoned *RCMP* outpost. Dundas Harbour affords anchorage in two locations. A landing beach is in the SE part of the harbour. The navigation season is early August to late September. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

57 **Eastmain** *(52°15'N, 78°30'W)* is 2 miles up Rivière Eastmain in SE James Bay. Changes in river flow rates have occurred due to the *James Bay Hydro-electric Project*. Eastmain can be reached at high water by craft drawing 2.4 m, Anchorage is available in 12 m with good holding and some shelter about 15 miles from the settlement. *(See Sailing Directions ARC 401.)*

58 **Eureka** *(79°59'N, 85°55'W)*, on the north shore of Slidre Fiord, is the site of a weather station and an airstrip. A gravel pier has been constructed below the weather station. Anchorage is obtainable. Break-up occurs about mid July, freeze-up during the first two weeks of September. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

59 **False Strait** *(71°59'N, 95°11'W)* affords good anchorage for vessels awaiting favourable conditions to make the eastward passage through Bellot Strait. There is shelter from all but westerly winds and good holding about 1 mile within the entrance. Beyond this point the inlet shoals fairly rapidly. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

60 **Fort Albany** *(52°12'N, 81°41'W)* and **Kashechewan** are settlements on SW James Bay 9 miles up South Channel and 5 miles up North Channel, respectively, of Albany River. They can be reached at high water by craft drawing 2.1 m. *(See Sailing Directions ARC 401.)*

61 **Fort Severn** *(56°00'N, 87°38'W)*, a settlement 6 miles up Severn River on the south coast of Hudson Bay, can be reached at high water by craft drawing 2.4 m. *(See Sailing Directions ARC 401.)*

62 **Gjoa Haven** hamlet *(68°37'N, 95°53'W)* is on the west side of Rasmussen Basin. It is an excellent harbour for small and medium-sized vessels and has an airstrip. Anchorage with good holding and shelter from all winds is obtained close off the landing beach. The normal navigation season is from the end of July to early October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

63 **Gladman Point** *(68°39'N, 97°44'W)*, forming the west side of M'Clintock Bay, is the site of an unmanned *North Warning System* station and abandoned airstrip. Anchorage is obtainable south of the entrance to the bay and off the former landing beach, inside the bay at the extremity of Gladman Point. The landing beach was suitable for all types of landing vessels. The area is normally clear of ice by early August with freeze-up following in early October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

64 **Grise Fiord** hamlet *(76°25'N, 82°54'W)*, Canada's most northerly Inuit community, has an airstrip and a landing beach. Good anchorage is available. The normal navigation season is mid August to mid September. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

65 **Hall Beach** *(68°46'N, 81°13'W)*, on the west shore of Foxe Basin, is the site of a manned *North Warning System* station and logistics base, an Inuit hamlet, an airstrip and landing beaches. There is a ruined jetty at Hall Beach. The parabolic antennaes of a former *DEW Line* station are conspicuous. The anchorage is open roadstead

with fair holding. The recommended period for resupply is late August to mid September. *(See Sailing Directions ARC 401.)*

66 **Hat Island** *(68°20'N, 100°03'W)*, in the Queen Maud Gulf, is the site of an unmanned *North Warning System* station. Anchorage with good holding is obtainable. A landing beach is on the east side of the island. Ice normally clears the area by mid August but easterly winds can bring heavy concentrations of ice into the anchorage. Freeze-up commences in early October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

67 **Holman** *(70°44'N, 117°48'W)*, an Inuit hamlet on the west coast of Victoria Island, has an airstrip and landing beach. Its approaches have not been fully sounded and should be navigated with caution. Anchorage, with poor holding and exposed to winds from the south, is obtainable off the west side of Kings Bay. The bay usually clears of ice in mid July with freeze-up following in early October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

68 **Igloolik** hamlet *(69°23'N, 81°48'W)*, on the island of the same name in NW Foxe Basin, has a science resource centre, an airstrip and landing beaches. Anchorage, open to south and SE, is available in the outer part of Turton Bay. Shallow draught vessels can obtain well sheltered anchorage in the inner part of the bay. Break-up usually occurs about mid July, freeze-up mid October. *(See Sailing Directions ARC 401.)*

69 **Inukjuak (Inoucdjouac or Port-Harrison)** *(58°27'N, 78°06'W)*, a settlement on the east shore of Hudson Bay, affords anchorage in 20 m, clay. *(See Sailing Directions ARC 401.)*

70 **Inuvik**, a transportation hub for the Western Arctic, is on the East Channel of the Mackenzie River delta. Depths at the Public Wharf are reported to be less than 3 m. *(See Sailing Directions ARC 404 (GREAT SLAVE LAKE AND MACKENZIE RIVER).)*

71 **Iqaluit (Frobisher or Frobisher Bay)** *(63°44'N, 68°31'W)*, on the north shore of Koojesse Inlet, is the largest community in the Eastern Arctic and the chief administrative, communications and transportation centre for Nunavut. There is a seasonal *Canadian Coast Guard Marine Communications and Traffic Services* centre and an airport. Anchorages are protected except to the SE. Diesel fuel, water and supplies are available in limited quantities. Break-up starts about the end of June, freeze-up about mid October. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

72 **Ivujivik** *(62°25'N, 77°55'W)* is a settlement at the NE corner of Hudson Bay. Anchorage with poor shelter is available in 55 m. *(See Sailing Directions ARC 401.)*

73 **Jenny Lind Bay** *(68°39'N, 101°46'W)* is the site of an unmanned *North Warning System* station, an abandoned *DEW Line* station and abandoned airstrip. Anchorage, with good shelter except from south and SE winds, is obtained in Jenny Lind Bay. Ramps at each end of the landing beach are not maintained. The harbour is usually clear of ice by early August but it can be filled again by southerly winds at anytime during the navigation season. Freeze-up usually commences late September. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

74 **Kangiqsualujjuaq (Port-Nouveau-Québec)** *(58°41'N, 65°56'W)* is a settlement on Rivière George in SE Ungava Bay. Anchorage is in an open roadstead. *(See Sailing Directions ARC 401.)*

75 **Kangiqsujuaq (Maricourt)** *(61°36'N, 71°57'W)* is a settlement in Wakeham Bay on the south coast of Hudson Strait. Fair anchorage is available in 55 m. *(See Sailing Directions ARC 401.)*

76 **Kangirsuk (Bellin) (Payne Bay)** *(60°01'N, 70°01'W)* is a settlement 9 miles up Rivière Arnaud in Bassin Payne, in NW Ungava Bay. Good anchorage is available in 22 m. *(See Sailing Directions ARC 401.)*

77 **Kimmirut (Lake Harbour)** *(62°51'N, 69°52'W)*, on the north shore of Hudson Strait, affords anchorage in 48 m with stern lines to the shore. *(See Sailing Directions ARC 401.)*

78 **Komakuk Beach** *(69°36'N, 140°10'W)* is the site of an unmanned *North Warning System* station and an abandoned airstrip. The landing beach is exposed to onshore winds. Vessels anchor in the open roadstead with good holding. An alternative anchorage can be found in Thetis Bay on Herschel Island, 25 miles east. The ice usually breaks up at the end of June; freeze-up is in the first week of October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

79 **Kugluktuk** hamlet *(67°50'N, 115°05'W)* is a centre for communications and local commerce. There is a public wharf and an airstrip. An anchorage with good holding, which should be approached with caution, is 0.8 mile NNW of the hamlet. It is not sheltered from northerly winds or ice but alternative anchorages are available. Ice usually clears the area late in June and freeze-up commences early in October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

80 **Kuujjuaq (Fort-Chimo)** *(58°06'N, 68°24'W)* is a settlement 31 miles up Rivière Koksoak. It is the administrative centre of Nunavik. An anchorage 2 miles below the settlement must be approached between half tide and high water; the river is navigated regularly by vessels

drawing up to 5.5 m. A pilot is available. *(See Sailing Directions ARC 401.)*

81 **Kuujjuarapik** *(55°17'N*, *77°46'W)* and **Whapmagoostui** are Inuit and Cree settlements sharing a location at the mouth of Grande rivière de la Baleine in SE Hudson Bay. The village was formerly known as **Poste-de-la-Baleine**. Anchorage is in open roadstead in 31 m. *(See Sailing Directions ARC 401.)*

82 **Lady Franklin Point** *(68°31'N*, *113°09'W)* is the site of an unmanned *North Warning System* station and abandoned airstrip. Some buildings from an abandoned *DEW Line* station remain. Anchorage can be obtained 0.4 mile off the landing beach, sand and pebble bottom. Barges anchor with stern lines to shore. Dry cargo is lightered ashore. A channel leads through an offshore sand bar to a ramp, no longer maintained, on the landing beach. Onshore winds can cause surf and ice congestion. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3))*

83 **Longstaff Bluff** *(68°53'N, 75°10'W)* is the site of an unmanned *North Warning System* station, an abandoned *DEW Line* station and an abandoned airstrip. Vessels anchor in open roadstead with good holding. Anchorage with better protection is available near by. Break-up occurs toward the end of July but floes remain close by until late September. Freeze-up usually commences about mid October. *(See Sailing Directions ARC 401.)*

84 **McDougall Sound**, on the SE coast of Bathurst Island, has a large bay on the west side between Lacey Point *(75°19'N*, *97°53'W)* and Bass Point, 4 miles north; this bay provides anchorages sheltered from all directions. There are good beaches for dry ramp landings. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

85 **McKinley Bay** *(69°57'N*, *131°11'W)* is the site of a repair and wintering basin for oil exploration, support and supply ships, approached through a dredged channel. An artificial island protects the basin from ice movement and provides a land base, with an abandoned airstrip, for related maintenance, support and resupply activities. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

86 **Moosonee** *(51°16'N*, *80°38'W)* and **Moose Factory**, settlements 10 miles up Moose River in south James Bay, can be reached at high water by craft drawing 2.4 m. There is a railhead at Moosonee. Anchorage is in open roadstead off the river entrance in 7.3 to 9.1 m. *Moosonee Transportation Company* floating wharf, in Moosonee, is used by barges 52 m long drawing 1.8 m. *(See Sailing Directions ARC 401.)*

87 **Nanisivik** *(73°04'N*, *84°33'W)* is an abandoned settlement in Strathcona Sound that was developed to support a zinc and lead mine. There is an airstrip and a wharf near the former mine site. Anchorage is available 2.5 miles east of the wharf. Good anchorage can be found 2 miles farther east in English Bay. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

88 **Nicholson Island** *(69°55'N*, *128°58'W)* is the site of an umanned *North Warning System* station and abandoned airstrip. Anchorage can be obtained close off the outer side of Hepburn Spit. Great care should be exercised in the vicinity of the spit due to extensive shoaling. There is a landing beach and a gravel ramp, not maintained, for barges to berth bows-to. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

89 **Pangnirtung** *(66°09'N*, *65°44'W)*, an Inuit hamlet on the south shore of Cumberland Sound, has an airstrip and landing beach. The recommended anchorage for dry cargo vessels is about 0.6 mile NW of the landing beach with poor holding and subject to sudden gales. The recommended period for resupply is late August or early September. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

90 **Paulatuk** *(69°21'N*, *124°02'W)*, an Inuit hamlet on the shore of Darnley Bay, has an airstrip and is accessible only to barges with draughts of about 1 m. Anchorage, with good holding, is available 2 miles NW of the hamlet. The harbour is usually ice free from mid July to mid October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

91 **Pearce Point Harbour** *(69°49'N*, *122°44'W)* affords anchorage with good holding and protected from all but north winds. It is the only sheltered anchorage for 200 miles east of Darnley Bay. A landing beach is on the west side of the harbour and an abandoned airstrip on the south side. The harbour is uninhabited. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

92 **Peawanuck** *(55°01'N*, *85°28'W)* is about 20 miles upstream from the entrance to Winisk River *(55°16'N*, *85°14'W)*. The settlement can be reached by canoe. Anchorage is poor at the entrance to Winisk River. *(See Sailing Directions ARC 401.)*

93 **Pelly Bay** hamlet *(68°53'N*, *90°12'W)* has an airstrip. An unmanned *North Warning System* station is 6.5 miles SSE of the hamlet. Resupply missions are conducted by icebreaker or air due to difficult ice conditions. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

94 **Pond Inlet** *(72°42'N*, *78°00'W)* is an Inuit hamlet with an airstrip. Open anchorage is available under constant threat from heavy ice floes. The normal navigation season is mid August to late September. Anchorage with good shelter from winds but not from ice can be found in Albert

Harbour, 10 miles NE of the hamlet. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

95 **Port Burwell** *(60°25'N, 64°51'W)* is the site of the remotely controlled *Canadian Coast Guard* radio station "*Killinek*". Anchorage with good holding is available in 29 m. *(See Sailing Directions ARC 401.)*

96 **Port Epworth** *(67°43'N, 111°56'W)*, the site of an abandoned settlement, has an excellent sheltered harbour and has been used for wintering. The approach routes are charted and anchorages are obtainable in the west and east arms; however, the anchorages here are suitable only for shallow-draught vessels. Many **dangers** exist in the approaches to these anchorages. The harbour is usually clear of ice by late July with freeze-up commencing in early October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

97 **Puvirnituq (Povungnituk)** *(60°02'N, 77°16'W)* is a settlement on Povungnituk Bay in NE Hudson Bay. Unsheltered anchorage is available in 29 m. *(See Sailing Directions ARC 401.)*

98 **Quaqtaq (Koartac)** *(61°03'N, 69°38'W)* is a settlement on the NE shore of Diana Bay. Fair weather anchorage with poor holding can be found in 27.4 m. *(See Sailing Directions ARC 401.)*

99 **Rankin Inlet** *(62°49'N, 92°05'W)* is a community and communications hub on the NW shore of Hudson Bay. It is also the administrative centre for the Nunavut region of Kivalliq. An exposed anchorage is available off the hamlet in 12.8 m. *(See Sailing Directions ARC 401.)*

100 **Repulse Bay** *(66°31'N, 86°15'W)*, an Inuit hamlet in Talun Bay on the SW shore of Foxe Basin, has an airstrip and landing beaches. Dry cargo vessels anchor west of Netchik Point with fair holding but poor protection. Vessels less than 46 m in length can find better shelter in the inner harbour. Break-up normally occurs early in July, freeze-up toward the end of September. *(See Sailing Directions ARC 401.)*

101 **Resolute** *(74°41'N, 94°53'W)*, with an Inuit hamlet on the shore of Resolute Bay, is a centre of transportation, communications and administration for the high Arctic. There is a remotely controlled *Canadian Coast Guard* radio station, landing beaches and an airfield. Anchorage with poor holding is available in the bay for vessels drawing less than 8.5 m; vessels of deeper draught anchor in open roadstead. The harbour is usually opened by an icebreaker by early August, and the last icebreaker leaves late in September. The resupply period is generally mid August to mid September. *(See Sailing Directions ARC 402 (ARCTIC CANADA VOL. II).)*

102 **Sachs Harbour** *(71°58'N, 125°15'W)*, an Inuit hamlet on the SW coast of Banks Island, has a landing beach with a gravel ramp and an airstrip. The bar at the harbour entrance should not be crossed during more than moderate west to SE winds. Anchorage can be obtained in very clear water but should the wind become westerly or NW'ly the ice barrier offshore can quickly close the land. During strong north winds more suitable anchorage is found 6 miles to the west. Vessels drawing 1.8 m are reported able to lie alongside the beach near the point. The harbour clears of ice by mid July and freezes-up in October. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

103 **Salluit (Sugluk)** *(62°13'N, 75°39'W)* is a settlement on the south shore of western Hudson Strait. Anchorage with good holding can be found in 27.4 to 55 m. *(See Sailing Directions ARC 401.)*

104 **Sanikiluaq** *(56°33'N, 79°l4'W)* is a hamlet in Belcher Islands. Anchorage is available in Eskimo Harbour off the settlement. *(See Sailing Directions ARC 401.)*

105 **Shingle Point** *(68°56'N, 137°15'W)*, on Trent Bay, has an unmanned *North Warning System* station and an abandoned *DEW Line* station with an abandoned airstrip nearby. Good anchorage can be obtained on the south side of Escape Reef. A prepared gravel ramp on the landing beach is no longer maintained. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

106 **Sinclair Creek** *(68°44'N, 108°58'W)* is on the north shore of Dease Strait, north of Cape Flinders. There is a landing beach for the abandoned *Byron Bay DEW Line* station. Unsheltered anchorage is available over a rock and shingle bottom. A prepared ramp, for small landing vessels, is no longer maintained. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

107 **Summer's Harbour** *(70°08'N, 125°03'W)*, on the south side of Booth Island, provides anchorage with excellent protection from sea and ice with good holding. Landing beaches are in the NE and NW corners of the harbour. Summer's Harbour is usually clear of ice when other anchorages are blocked by drift ice. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

108 **Taloyoak (Spence Bay)** hamlet *(69°32'N, 93°31'W)* is at the head of Spence Bay. It is a centre for aboriginal activities and has an airstrip. Good anchorage, except in SW winds, can be obtained close off the landing beach at the head of the inlet, with stern lines ashore. Another landing beach is on the south side of a low peninsula on the NW side of the inlet. Ice usually clears the harbour by the end of July with freeze-up following near

the end of September. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

109 **Tasiujaq** *(58°42'N, 69°56'W)*, a small settlement in Lac aux Feuilles at the SW corner of Ungava Bay, affords excellent anchorage in 31 m. *(See Sailing Directions ARC 401.)*

110 **Tuktoyaktuk** *(69°27'N, 133°02'W)* is close to the East Channel of the Mackenzie River delta. Its harbour is relatively deep and sheltered and is a strategic cargo trans-shipment site. An unmanned *North Warning System* station, an airstrip and base camps of northern exploration and exploitation groups are in the area. The approach is buoyed and very shallow. There are public and commercial wharves and mooring buoys. Repair facilities, including a dry dock, are available by prior arrangement. Diesel fuel and supplies are available in limited quantities; water is supplied by tank truck. Break-up usually occurs late in June with freeze-up following late in September. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3) and ARC 404 (GREAT SLAVE LAKE AND MACKENZIE RIVER).)*

111 **Tysoe Point** *(69°36'N, 120°46'W)* is the site of the abandoned *Clinton Point DEW Line* station and an abandoned airstrip. Anchorage can be obtained 0.4 mile offshore but it is exposed to wind and ice. The landing beach is frequently exposed to heavy surf. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

112 **Umiujaq** *(56°33'N, 76°33'W)* is a settlement on the east Hudson Bay mainland coast in Nastapoka Sound. There is an anchorage offshore in 29 m. *(See Sailing Directions ARC 401.)*

113 **Waskaganish (Fort-Rupert)** *(51°12'N, 78°46'W)* can be reached at high water by craft drawing 2.4 m. Waskaganish is joined by gravel road to the *James Bay Highway*. *(See Sailing Directions ARC 401.)*

114 **Wemindji (Nouveau-Comptoir)** *(52°55'N, 78°47'W)*, a Cree Indian settlement on the east shore of James Bay, can be reached by craft drawing 2.4 m. Anchorage can be obtained 6 miles from the settlement in 7.3 to 9.1 m but depths of 6.4 m lie in the approaches to the anchorage. *(See Sailing Directions ARC 401.)*

115 **Whale Cove** *(62°10'N, 92°34'W)* is an Inuit hamlet 58 miles south of Rankin Inlet. Anchorage with poor protection is available off the cove in 38 m. *(See Sailing Directions ARC 401.)*

116 **Wilkins Point** *(68°48'N, 93°38'W)*, on **Shepherd Bay** in Rasmussen Basin, is the site of an unmanned *North Warning System* station, the abandoned *Shepherd Bay DEW Line* station and an abandoned airstrip. Unsheltered anchorage with good holding is obtainable by larger vessels about 0.4 mile off the beach and for shallow-draft vessels 0.15 mile offshore. The landing beach has an earth ramp, no longer maintained. The ice generally clears Shepherd Bay early in July with freeze-up commencing at the end of September but a variation of up to one month can occur. *(See Sailing Directions ARC 403 (ARCTIC CANADA VOL. 3).)*

Sail Plan

Adapted from Transport Canada Publication TP 511E.

Fill out a sail plan for every boating trip you take and file it with a responsible person. Upon arrival at your destination, be sure to close (or deactivate) the sail plan. Forgetting to do so can result in an unwarranted search for you.

Sail Plan

Owner Information

Name: ______________________________

Address: ______________________________

Telephone Number: ______________ Emergency Contact Number: ______________

Boat Information

Boat Name: ______________ Licence or Registration Number: ______________

Sail: __________ Power: __________ Length: __________ Type: __________

Colour __________ Hull: __________ Deck: __________ Cabin: __________

Engine Type: ______________ Distinguishing Features: ______________

Communications

Radio Channels Monitored: HF: VHF: MF:

MMSI (Maritime Mobile Service Identity) Number: ______________

Satellite or Cellular Telephone Number: ______________

Safety Equipment on Board

Lifejackets *(include number)*: ______________

Liferafts: ______________ Dinghy or Small Boat *(include colour)*: ______________

Flares *(include number and type)*: ______________

Other Safety Equipment: ______________

Trip Details — Update These Details Every Trip

Date of Departure: ______________ Time of Departure: ______________

Leaving From: ______________ Heading To: ______________

Proposed Route: ______________ Estimated Date and Time of Arrival: ______________

Stopover Point: ______________ Number of People on Board: ______________

Search and Rescue Telephone Number: ______________

The responsible person should contact the nearest Joint Rescue Coordination Centre (JRCC) or Maritime Rescue Sub-Centre (MRSC) if the vessel becomes overdue.

Act smart and call early in case of emergency. The sooner you call, the sooner help will arrive.

JRCC Victoria (British Columbia and Yukon) 1-800-567-5111
+1-250-413-8933 (Satellite, Local or out of area)
727 (Cellular)
+1-250-413-8932 (fax)
jrccvictoria@sarnet.dnd.ca (Email)

JRCC Trenton (In Canada) 1-800-267-7270
+1-613-965-3870 (Satellite, Local or Out of Area)
+1-613-965-7279 (fax)
jrcctrenton@sarnet.dnd.ca (Email)

MRSC Québec (Quebec Region) 1-800-463-4393
+1-418-648-3599 (Satellite, Local or out of area)
+1-418-648-3614 (fax)
mrscqbc@dfo-mpo.gc.ca (Email)

JRCC Halifax (Maritimes Region) 1-800-565-1582
+1-902-427-8200 (Satellite, Local or out of area)
+1-902-427-2114 (fax)
jrcchalifax@sarnet.dnd.ca (Email)

MRSC St. John's (Région de Terre-Neuve-et-Labrador) 1-800-563-2444
+1-709-772-5151 (Satellite, Local or out of area)
+1-709-772-2224 (fax)
mrscsj@sarnet.dnd.ca (Email)

MCTS Sail Plan Service

Marine Communications and Traffic Services Centres provide a sail plan processing and alerting service. Mariners are encouraged to file Sail Plans with a responsible person. In circumstances where this is not possible, Sail Plans may be filed with any MCTS Centre by telephone or marine radio only. Should a vessel on a Sail Plan fail to arrive at its destination as expected, procedures will be initiated which may escalate to a full search and rescue effort. Participation in this program is voluntary.

See Canadian Radio Aids to Marine Navigation.

Other References

Information for the Protection of Right Whales:
https://www.dfo-mpo.gc.ca/fisheries-peches/commercial-commerciale/atl-arc/narw-bnan/index-eng.html

Atlantic Pilotage Authority Regulations:
https://www.atlanticpilotage.com/acts-regulations/

Meteorological data:
https://www.canada.ca/en/services/environment/weather.html

Marine Forecasts and Warnings for Canada:
https://weather.gc.ca/marine/index_e.html

Current Predictions (Data Viewer by DFO - MSDI Dynamic Current Layer):
https://gisp.dfo-mpo.gc.ca/apps/dataviewer/?locale=en

Customs:
https://www.cbsa-asfc.gc.ca/travel-voyage/pb-pp-eng.html

SAR:
Search and rescue (ccg-gcc.gc.ca)

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