Prepared by the North American Ice Service

A collaboration of the Canadian Ice Service and the National/Naval Ice Center

02 June 2011

Seasonal Outlook

For North American Arctic Waters

Summer 2011

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Introduction

This outlook is produced by the North American Ice Service, which is a joint co-operation of the Canadian Ice Service and the U.S. National Ice Center.

It will give an indication of the expected pattern of breakup and clearing of ice in the North American Arctic waters. It will identify areas and timings when breakup and clearing will likely occur with emphasis on those areas where there is ship navigation and other marine activities.

The outlook has been developed through the analysis of the meteorological and ice growth regimes. Thorough analyses have been done of extensive Radarsat 1 and 2 imagery collected during the past winter and spring. NOAA and MODIS satellite imagery were also used for the evaluation of the ice cover. All of this ice information was used in the preparation of regional ice analyses for the Arctic and Hudson Bay.

The results of the meteorological and ice analyses are then compared with previous years' ice conditions and, in conjunction with wind and temperatures forecasts for June, are applied to estimate the timing of breakup and the clearing of ice in the areas of interest. The Canadian Meteorological Centre forecasts the temperature regime for the period from June through August. Any variations from these forecast parameters will have an impact on the forecast breakup pattern and timing.

Tables are included showing the forecast breakup or clearing dates along with median dates and last year's dates for each region. During the summer, these events will be updated twice monthly via the issue of a 30-day forecast to enable planning of shipping or other activities according to changing trends. These 30-day forecasts will also include a prediction of the beginning of the freeze-up process throughout the regions.

Daily radio broadcasts of ice charts and forecasts will be made to support ongoing operations in the various areas where ice affects marine activities. Appendix A provides a link to the key to ice symbols showing the principle features of the International Ice symbols used on the ice charts. Appendix B contains links to these broadcast schedules as well as Aerial Reconnaissance Radio Facsimile Broadcast and NOAA Alaskan Marine Radio frequencies.

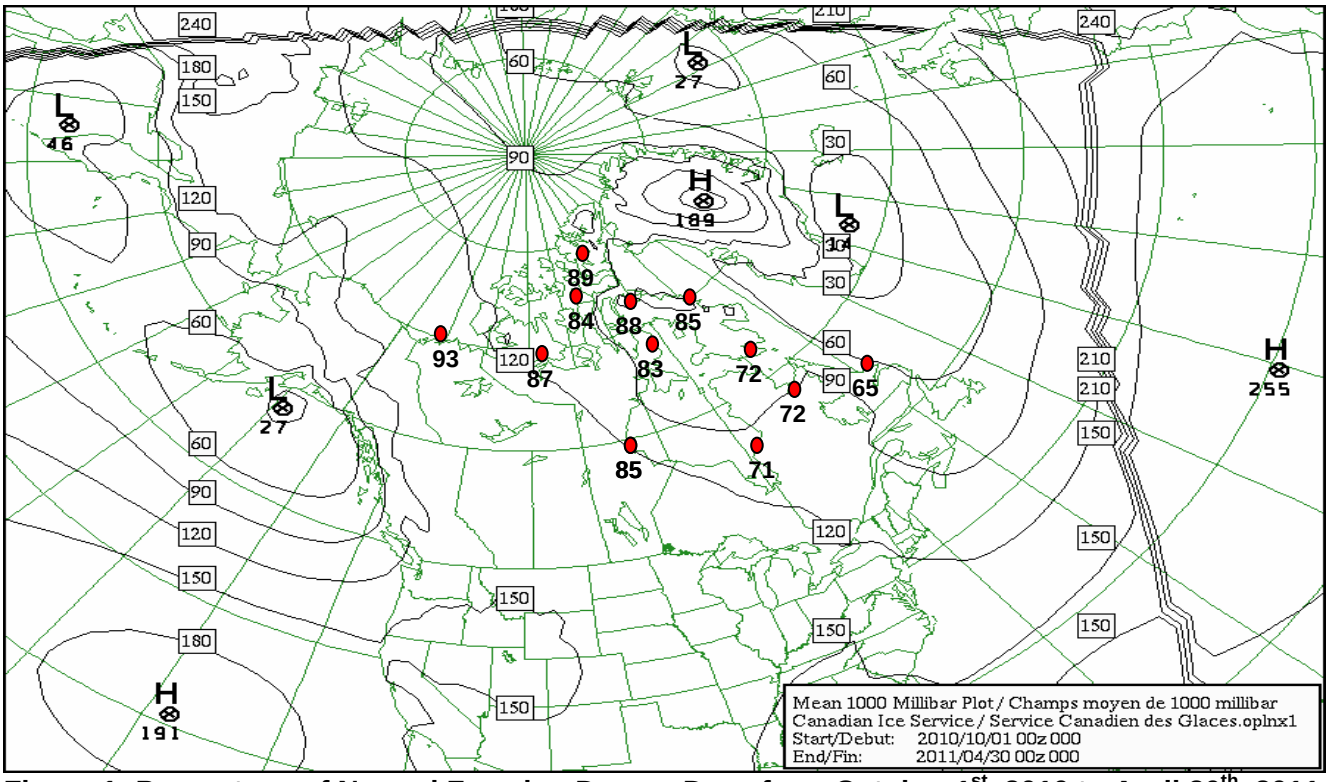

Figure 1: Percentage of Normal Freezing Degree Days from October 1st, 2010 to April 30th, 2011

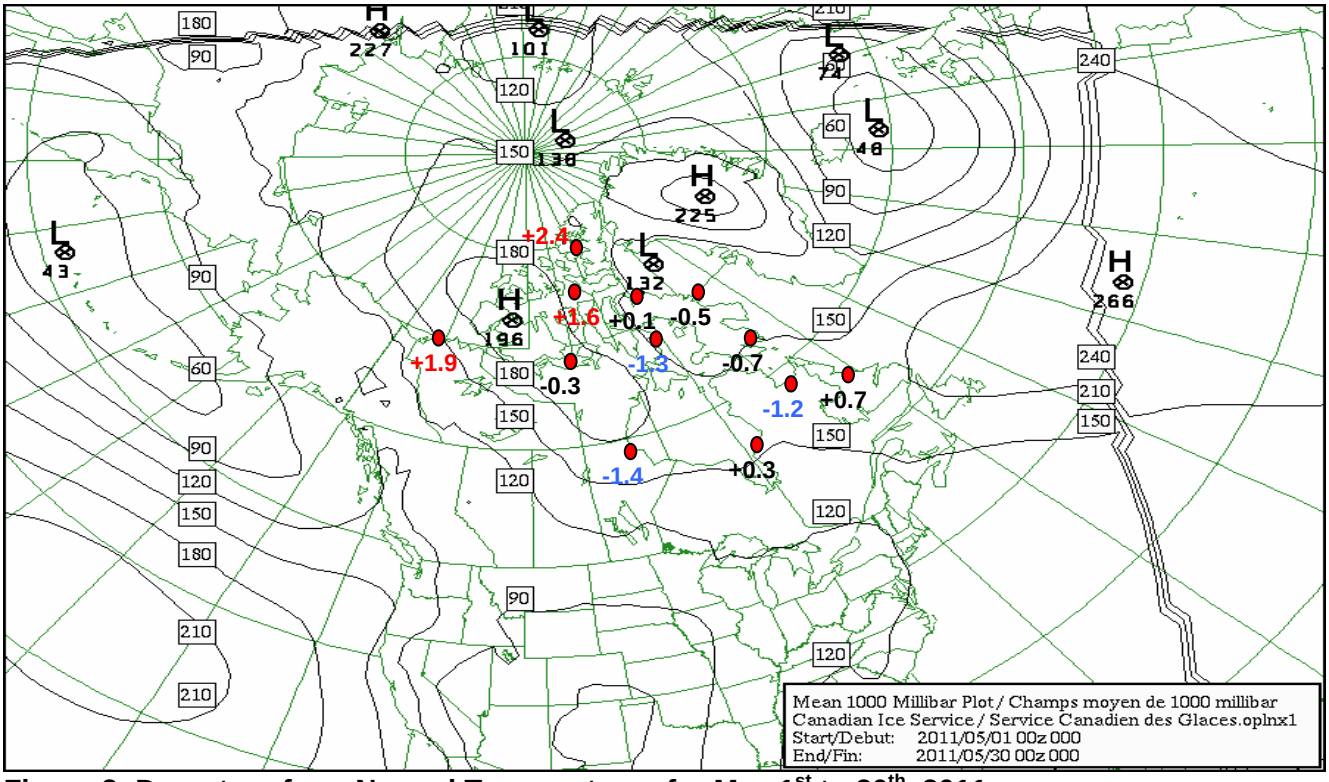

Figure 2: Departure from Normal Temperatures for May 1st to 30th, 2011

General Winter Conditions and Brief Outlook

The mean 1000 mb pressure pattern from October 01st, 2010 to April 30th, 2011 is represented in Figure 1. A weak trough of low pressure extending from southwestern Greenland to the Arctic Ocean prevailed from October to April. A broad area of high pressure dominated over central Greenland. As a result, a light to moderate northwesterly flow persisted over the Eastern Arctic, Hudson Bay and Strait and along the Labrador Coast, while light and variable winds dominated over the Western Arctic.

With the very late freeze-up experienced during the winter season and colder than normal temperatures observed in April, mean air temperatures were still 2 to 5°C above normal values for the period from October to April. As a result, freezing degree day accumulations were 83 to 93 percent of normal values over most of the Arctic. However these numbers were much lower over eastern Hudson Bay, Hudson Strait, Davis Strait and along the Labrador Coast where freezing degree days were 65 to 72 percent of normal values. As a result, this was also reflected in the ice thickness measurements across the Arctic where it was 10 to 25 cm less than normal. Percentages of normal freezing degree day accumulations are indicated in Figure 1.

The mean 1000 mb pressure pattern for May is shown in Figure 2. A trough of low pressure dominated along the western shore of Greenland, while a broad area of high pressure extended from Victoria Island to western Hudson Bay to the southern Labrador Coast. Light to moderate west to northwesterly winds prevailed over most of the Arctic except for moderate easterly winds over the Beaufort Sea and along the Alaskan Coast. During the month of May, temperatures were near normal values over most of the Eastern Arctic, southern Hudson Bay, along the Labrador Coast and along the southern section of the Northwest Passage. Temperatures were from 1.2 to 1.4°C below normal over northern Hudson Bay, Foxe Basin and in Hudson Strait. For the rest of the Arctic, temperatures remained above normal values and ranged from 1.6 to 2.4°C.

For the summer period of June through August, above normal temperatures are forecast for most Arctic regions except for near normal temperatures from the central Arctic, to western Hudson Bay and in Baffin Bay. As a result, all breakup events are expected to occur near to earlier than normal dates.

Hudson Bay and Approaches

Freeze-up and Winter Ice Regime

Air temperatures averaged 2 to 4°C above normal throughout September and October, 6 to 8°C above normal in November and 12 to 16°C above normal from early December through to the third week of January. All ice cleared out of Foxe Basin in the first week of September, 2 to 3 weeks earlier than normal, and the entire region was ice-free by mid-September breaking the record for the lowest seasonal average ice coverage. Freeze-up was delayed in all areas with initial ice formation taking place during the first week of November along the shore of Foxe Basin, Southampton Island and along the western shore of Hudson Bay. Ice development was confined to these areas until mid-December due to the mild temperatures and strong winds associated with a continuous stream of low pressure systems moving through Hudson Bay, Foxe Basin and / or moving northward along the Labrador Coast into Baffin Bay. Therefore, the ice extent into all areas was slow to develop and was delayed by 6 weeks in Hudson Bay such that it was mid-January before it was ice covered. The ice migration and development eastward through Hudson Strait was delayed by as much as 8 weeks and only became ice covered during the last week of January. Ice formation in Frobisher Bay and along the Labrador Coast was also delayed by 8 weeks with new ice developing in the inner bays during the first week of January while new ice still predominated over the Labrador Coast by the end of January. Low ice coverage records were broken for all areas especially in Hudson Strait, Davis Strait, and the northern Labrador Sea where only 36% of normal ice coverage had developed by early January, becoming near normal coverage with new ice development for most areas by the end of January. The northern Labrador Sea, however, maintained record low amounts of ice coverage. The calculated theoretical ice thicknesses were much less than normal in all areas by the end of January.

By the third week of November new and grey ice with fast ice in sheltered bays had become established along the southwestern shore of Southampton Island and the western shore of Hudson Bay with new ice extending along Hudson Bay and James Bay western shores. In early December, grey ice covered much of Roes Welcome Sound and extended southward along the western shore of Hudson Bay to Churchill with mostly new ice further south along Hudson Bay southwestern shore and James Bay shores. Grey ice was also forming along the eastern Foxe Basin shore and in sheltered bays along the northeastern shore of Southampton Island at this time. Ice continued to spread south and eastward at a slower than normal pace through December with grey and grey-white ice forming southward through Foxe Basin and western Hudson Bay. New ice started to form in southern Ungava Bay and along the northwestern shore of Hudson Strait by the third week in December. By the end of December, most of Foxe Basin and western Hudson Bay was covered with grey and grey-white ice. New and grey ice was becoming established over much of central Hudson Bay as well as western and southern James Bay. A large area of open water, at the end of December was still evident from southern Foxe Channel to central James Bay. The total ice coverage for Hudson Bay and approaches was 15% less than normal at this time setting a new 30 year minimum record.

In early January, grey-white with thin first-year ice pushed southward into Foxe Channel with grey-white ice extending further east into central Hudson Bay and western James Bay. Ice growth was still well behind normal at this time with a large area of open water still remaining in southeastern Hudson Bay. Patchy new with some grey ice started forming in Hudson Strait at this time while Frobisher Bay remained opened with patchy new ice forming in the inner bay near Iqaluit and with a mix of new and grey ice drifting southward into the entrance of Frobisher Bay to Resolution Island. Hudson Bay did not completely freeze over until mid-January with ice thicknesses much less than normal with thin first-year ice predominating along with grey-white ice. Hudson Strait became ice covered during the last week of January with predominantly grey-white ice with thin first-year ice in the western portion and mainly grey and grey-white ice in the eastern entrance and into Ungava Bay. Low ice coverage records were broken for all areas and only 36% of normal ice coverage had developed by early January in Hudson Strait, Davis Strait and the northern Labrador Sea. The ice slowly formed and thickened to grey ice for the majority of Frobisher Bay during the last week of January with a tongue of thin first year ice drifting southward into the entrance of the Bay. Patchy new and grey ice started to form along the northern Labrador coast during the last week of January and thickened to mostly grey and grey-white ice and reached the approaches to Groswater Bay by mid February. The calculated theoretical ice thicknesses were less than normal in all areas with theoretical thicknesses varying from 15 cm thinner than normal in southern Hudson Bay to 30 cm thinner than normal in Foxe Basin, northern Hudson Bay, Hudson Strait, Ungava Bay and along the Labrador Coast. Theoretical ice thicknesses were as much as 44 cm thinner than normal in Frobisher Bay.

Slower than normal ice growth was observed for the second half of February and into the month of March. At the end of February, a mix of thin and medium first-year ice covered most of the central section of Hudson Bay and southern Davis Strait, while mostly thin first-year ice covered the rest of Hudson Bay, Hudson Strait, Frobisher Bay and Cumberland Sound. However a narrow band of grey ice with patchy grey-white ice was predominant along the western shore of Hudson Bay. A trace of multi-year ice was observed in the pack ice over Davis Strait. Along the Labrador Coast, ice concentrations remained slightly less than normal with mostly grey-white ice. As well, the eastern extent of the ice edge was located farther west than normal for the end of February. The ice continued to thicken during the month of March with medium first-year ice covering the eastern section of Hudson Bay, while a mixture of medium and thin first-year ice prevailed over western Hudson Bay, in James Bay, in Hudson Strait and Cumberland Sound. The ice was generally thicker in southern Davis Strait, while the ice was compressed along the Labrador Coast during the month of March with a trace of old ice embedded in the pack ice. A series of deep storms moving across the area during the last two weeks of March has loosened up the pack ice north and east of Belcher Islands, in most of Hudson Strait and along the ice edge over the Labrador Sea. Similar ice conditions continued to prevail during the month of April with medium first-year ice over most of Hudson Bay and Hudson Strait, while thick first-year ice dominated over southern Davis Strait and along the Labrador Coast. However, embedded areas of very open drift multi-year ice drifted southward to reach the extreme northern portion of the Labrador Coast by the end of April. During the second half of April, a large area of grey-white and grey ice developed along the western shore of Hudson Bay and the southern shore of Southampton Island.

During the first half of May, ice conditions persisted in most areas except for the eastern regions. However, the ice started to decay quite significantly over the eastern section of Hudson Strait and along the Labrador Coast where large areas of bergy water were observed resulting in lower than normal ice concentrations. Meanwhile, areas of very open drift multi-year ice were embedded in the pack ice over southern Davis Strait, while a trace of multi-year ice persisted along the Labrador Coast. During the last two weeks of May, large areas of bergy water developed over Frobisher Bay and the northern section of Hudson Strait. Clearing was already underway along the eastern and northwestern shores of Hudson Bay. At the end of May, loose ice conditions were present over southern Davis Strait and along the Labrador Coast.

Observed Ice Conditions

The regional ice chart in figure 3 was based on the analysis of Radarsat 1 and 2 and NOAA/MODIS imagery from around May 23rd, 2011. This chart revealed some of the following features:

a) Lower than normal ice concentrations and bergy water areas are present along the Labrador Coast, Frobisher Bay, in northern Hudson Strait and in eastern Ungava Bay. This is indicating that the ice breakup is 2 to 3 weeks ahead of normal.

b) A trace amount of multi-year ice is embedded in the pack ice along the Labrador Coast and in the eastern entrance to Hudson Strait, while isolated areas of 2 tenths of multi-year ice are present over western Davis Strait.

c) Areas of open water along the northwestern and eastern shores of Hudson Bay are 1 to 2 weeks ahead of normal.

d) Ice thicknesses over all areas are 15 to 25 cm less than normal for this time of year.

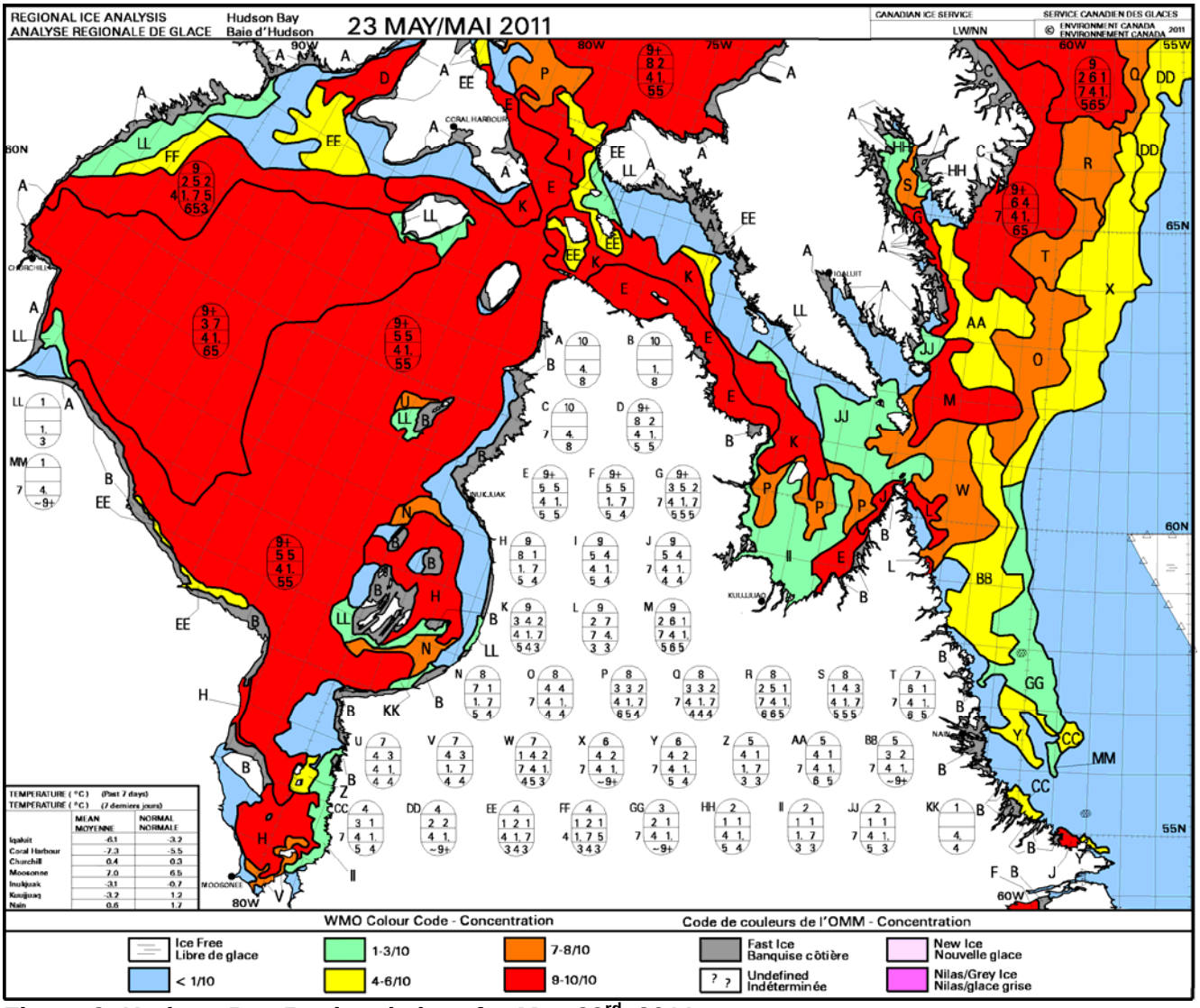

Figure 3: Hudson Bay Regional chart for May 23rd, 2011

Outlook for Hudson Bay

The summer temperature outlook from June to August suggests above normal temperatures along the Labrador Coast and Hudson Strait and near normal temperatures over the eastern section of Hudson Bay. Over western Hudson Bay, temperatures should remain slightly below normal values for the period. However the presence of multi-year ice over the southern section of Davis Strait and along the Labrador Coast will slightly delay the ice decay but not enough to have an impact on the breakup. Accumulated freezing degree days at mid-May are still well below normal values which will result in an earlier than normal breakup. The trend for the clearing for this summer will be from north to south over Hudson Bay and from west to east across Hudson Strait. As for the Labrador Coast, the ice will continue to retreat northward. However areas of fast ice are still present in bays and inlets along the Labrador Coast and in Lake Melville. The first area to open will be the open water route across northern Hudson Bay where it will occur during the first week of July.

At the end of the first week of July, a bergy water route will develop in Hudson Strait, while the ice will melt completely along the Labrador Coast. By that time, an open or bergy water route will be established from the eastern entrance of Hudson Strait into Churchill. With the ice retreating northward east of Hudson Strait, the ice will loosen up in Frobisher Bay resulting in an open drift or less route to develop over the area during the second week of July. With the clearing occurring from west to east, the last ice to remain will be over eastern Hudson Strait and southern Ungava Bay, where clearing will develop during the third week of July. A week later, the ice will melt completely along the shipping route to Frobisher Bay. The last remaining ice to melt will be located over southern Hudson Bay where it should clear during the third week of August. Breakup events for Hudson Bay and James Bay will be normal due to the clearing pattern that is expected this summer.

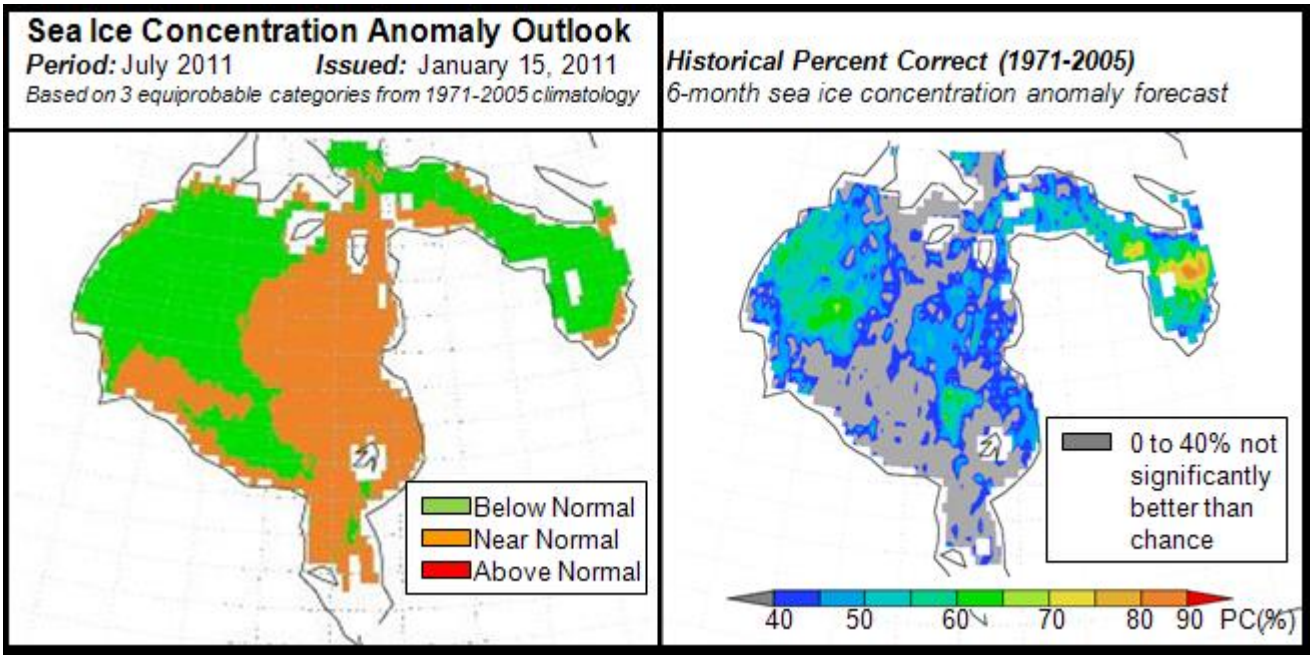

Figure 4: Hudson Bay sea ice concentration anomaly outlook for July 2011

Note: Based on Canonical Correlation Analysis (CCA) techniques similar to those used to produce the Canadian Meteorological Centre seasonal temperature outlooks. For details see: Tivy, A., S.E.L. Howell B. Alt, J. Yackel and T.Carrieres (2011) Origins and levels of seasonal forecast skill for sea ice in Hudson Bay using Canonical Correlation Analysis. Journal of Climate, doi:10.1175/2010JCL13527.1.

Table 1: Hudson Bay - Break-up Outlook Dates

	2010	Median (1981-2010)	Outlook for 2011
Labrador Coast to Cape Chidley **- Clearing**	08 Jul	21 Jul	08-10 Jul
Frobisher Bay **- Open drift or less** **- Clearing**	19 Jul 02 Aug	19 Jul 04 Aug	10-12 Jul 26-28 Jul
Ungava Bay **- Clearing**	13 Jul	31 Jul	22-24 Jul
Bergy water route through Hudson Strait (eastern entrance to south of Nottingham Island)	03 Jul	25 Jul	09-11 Jul
Hudson Strait **- Clearing**	15 Jul	04 Aug	18-20 Jul
Bergy/open water route to Churchill (eastern entrance of Hudson Strait to Churchill)	14 Jul	26 Jul	09-11 Jul
Open water route through northern Hudson Bay (south of Nottingham Island to Churchill)	14 Jul	17 Jul	05-07 Jul
Hudson Bay **- Clearing**	27 Jul	19 Aug	18-20 Aug
James Bay **- Clearing**	11 Jul	27 Jul	26-28 Jul

Eastern Arctic

Freeze-up and Winter Ice Regime

Mean air temperatures in all areas of the Eastern Arctic were well above normal during freeze-up. The average temperatures were 2 to 4°C above normal from September through to mid-October then 8 to 10°C above normal through to the end of November. December and January saw average temperatures climb as much as 14 to 18°C above normal. Air temperatures cooled to near normal values only during the last week of January. The ice extent was less than normal at the beginning of the freeze-up season for most areas with very little to no sea ice in central and northern Norwegian Bay, Eureka Sound and Greely Fjord. However, above normal concentrations of multi-year ice flowed southward from the Lincoln Sea into Nares Strait at the beginning of the season and drifted southward into Baffin Bay, Jones Sound and Lancaster Sound during the freeze-up period. By the end of January, the ice extent was near normal for most areas with the exception of the eastern sections of Baffin Bay and Davis Strait where less than normal conditions persisted with little to no sea ice formation along the Greenland Coast. Record breaking low ice coverage was seen throughout eastern Baffin Bay and Davis Strait. The calculated ice thickness was less than normal for all areas. Interestingly, the multi-year ice flowing southward through Nares Strait and into Jones Sound was pushed sufficiently westward by currents and easterly winds during early October to reach and join with the multi year ice drifting southeastward through southern Norwegian Bay at Cardigan Strait and Hell Gate.

At the end of the 2010 summer, less than normal ice concentrations prevailed for most areas with very little to no sea ice in central and northern Norwegian Bay, Eureka Sound and Greely Fjord. However, greater than normal concentrations of multi-year ice flowed southward from the Lincoln Sea into Nares Strait by consistent northerly winds. The prevailing northerly winds also maintained greater than normal ice concentrations in southern and western Norwegian Bay, Penny Strait and Queens Channel. Much warmer than normal air temperatures centered over Committee Bay provided lower than normal ice concentrations of primarily open drift ice in Committee Bay.

Freeze-up began with new ice forming in Eureka Sound, Norwegian Bay, Queens Channel and Nares Strait during the third week of September. New ice started to form in Jones Sound, Barrow Strait and Committee Bay during the first week of October. At this point ice formation was generally two weeks behind normal. By mid-October, new ice was forming in Lancaster Sound, Eclipse Sound, Prince Regent, Navy Board, and southern Admiralty Inlets. New ice was also forming in the Gulf of Boothia. The ice thickened during the third week of October to become grey and grey-white in Barrow Strait, Prince Regent Inlet and Lancaster Sound. The ice thickened to grey-white in Jones Sound, Norwegian Bay and became consolidated grey-white with scattered multi-year ice in Eureka Sound and Greely Fjord. At the same time the multi-year ice flowing southward through Nares Strait into Baffin Bay was pushed westward into Jones and Lancaster Sound by persistent easterly winds. During the first week of November new ice was starting to form in Foxe Basin with the ice edge in Baffin Bay extending southward to Clyde River.

Freeze-up was about 2 weeks later than normal over Baffin Bay and approximately 4 weeks behind in Foxe Basin. Norwegian Bay became consolidated at this time. Ice slowly thickened to become generally thin first-year ice by the end of November from Jones Sound through Lancaster Sound, Prince Regent Inlet, Admiralty Inlet and southward to the Gulf of Boothia. By the third week of December, Foxe Basin became completely ice covered. The ice edge in Baffin Bay finally pushed south of the Cumberland Peninsula in mid-December; four weeks behind normal. The eastward extent of the Baffin Bay sea ice was also much less than normal with an area of bergy water extending northward along the Greenland Coast into Melville Bay. Ice development in Cumberland Sound was even further behind normal with new ice forming in late December and into the first week of January, seven weeks behind normal, resulting in record breaking low ice coverage for Baffin Bay and Davis Strait where only 60% of normal ice coverage had developed by early January.

The Cumberland Sound ice thickened to grey and grey-white in mid-January to become mostly thin first-year by the end of January. Western Jones Sound became consolidated by the end of January while central and eastern Jones Sound remained mobile. By the beginning of February, Kane Basin became consolidated and the first-year ice thickened to thick first-year ice in the high Arctic with medium first-year ice extending south from Kane Basin into Lancaster Sound, Prince Regent Inlet / Gulf of Boothia and along Baffin Bay into Davis Strait. Embedded very open drift multi-year ice could be found just east of Jones Sound into Lancaster Sound and Prince Regent Inlet as well as southward along Baffin Bay to Cape Dyer. By early February, Foxe Basin was covered with thin and medium first-year ice and the ice extent was near normal for most areas with the exception of eastern Baffin Bay and Davis Strait. Very little to no sea ice formation occurred along the Greenland Coast revealing an area of bergy water along the coast up to southern Melville Bay. The calculated theoretical ice thicknesses were less than normal in all areas with theoretical thicknesses varying from 15 cm thinner than normal in Eureka Sound to as much as 44 cm thinner than normal in Cumberland Sound and Frobisher Bay.

The area of bergy water along the Greenland Coast has decreased very slowly during the last two weeks of February with the northern extent lying north of Disko Island. By the end of February, medium first-year ice was covering most of the western section of Davis Strait, the eastern section of Baffin Bay and Foxe Basin. Over these areas, the ice thicknened to a mixture of thick and medium first-year ice at the end of March. The rest of Baffin Bay, Parry Channel and Prince Regent Inlet were covered with thick first-year ice with embedded areas of very open drift multi-year ice during the months of February and March. During the same time, consolidated thick first year dominated over Admiralty Inlet, most of the High Arctic north of Resolute and in Nares Strait. At the end of March, strong northwesterly winds over the eastern sections of Barrow Strait and Jones Sound pushed the ice rapidly eastward creating areas of mostly greywhite ice. Meanwhile, a narrow area of bergy water was present along the Greenland Coast south of Disko Island. The ice consolidated over western Barrow Strait at the end of March. The temperature trend changed during the month of April where below normal temperatures were observed over most of the Arctic. This trend continued over the Central Arctic and Foxe Basin during the first half of May. A return to slightly above normal values was seen over eastern Baffin Bay and western Davis Strait, while near normal temperatures dominated over the High Arctic. This cold temperature event helped to thicken the ice at a faster pace than normal, while the eastern

limit of the pack ice extended farther east than normal at the beginning of May. At mid-May, thick first-year ice dominated over most areas where the ice was mobile, while consolidated thick first-year ice was present over most of the High Arctic west and north of Resolute and in Nares Strait. Embedded areas of very open drift multi-year ice persisted over the western sections of Baffin Bay and Davis Strait, in southern Lancaster Sound and in Prince Regent Inlet. Open drift multi-year ice was embedded in the pack ice over Pelly Bay, along parts of the shipping route to Norwegian and north of Eureka. At mid-May, the ice started to decay over Davis Strait with large areas of bergy water developing in southeastern Cumberland Sound and along the Greenland Coast south of Disko Island. During the last two weeks of May, small areas of bergy water developed north of Disko Island up to 73°N which is near normal. Clearing is already underway from south of Smith Sound to east of Jones Sound, in eastern Barrow Strait and in northwestern Foxe Basin which is 2 to 3 weeks ahead of normal. Loose ice conditions are present along the eastern edge of the pack ice over eastern Davis Strait and in eastern Baffin Bay southwest of Disko Island. Little change was seen over the rest of the Eastern Arctic.

Observed Ice Conditions

The regional ice chart in figure 5 was based on the analysis of Radarsat 1 and 2 and NOAA/MODIS imagery from around May 23rd, 2011. This chart revealed some of the following features:

a) Lower than normal ice concentrations are present over Cumberland Sound, south of Smith Sound, in eastern Barrow Strait and over northwestern and southwestern sections of Foxe Basin.

b) A narrow bergy water lead along the western Greenland coast extended north to Disko Island which is near normal for this time of year.

c) Greater than normal multi-year ice concentrations are present over the western sections of Baffin Bay and Davis Strait, in Pelly Bay, in northern Admiralty Inlet, in northwestern Jones Sound, in southwestern Norwegian Bay and south of Penny Strait.

d) Isolated areas of multi-year ice are present in Eureka Sound and Tanquary Fiord.

e) Ice thicknesses over all areas are 10 to 20 cm less than normal except 35 cm less than normal over Eureka Sound.

f) Ice bridge prevailed over Kane Basin at the end of May.

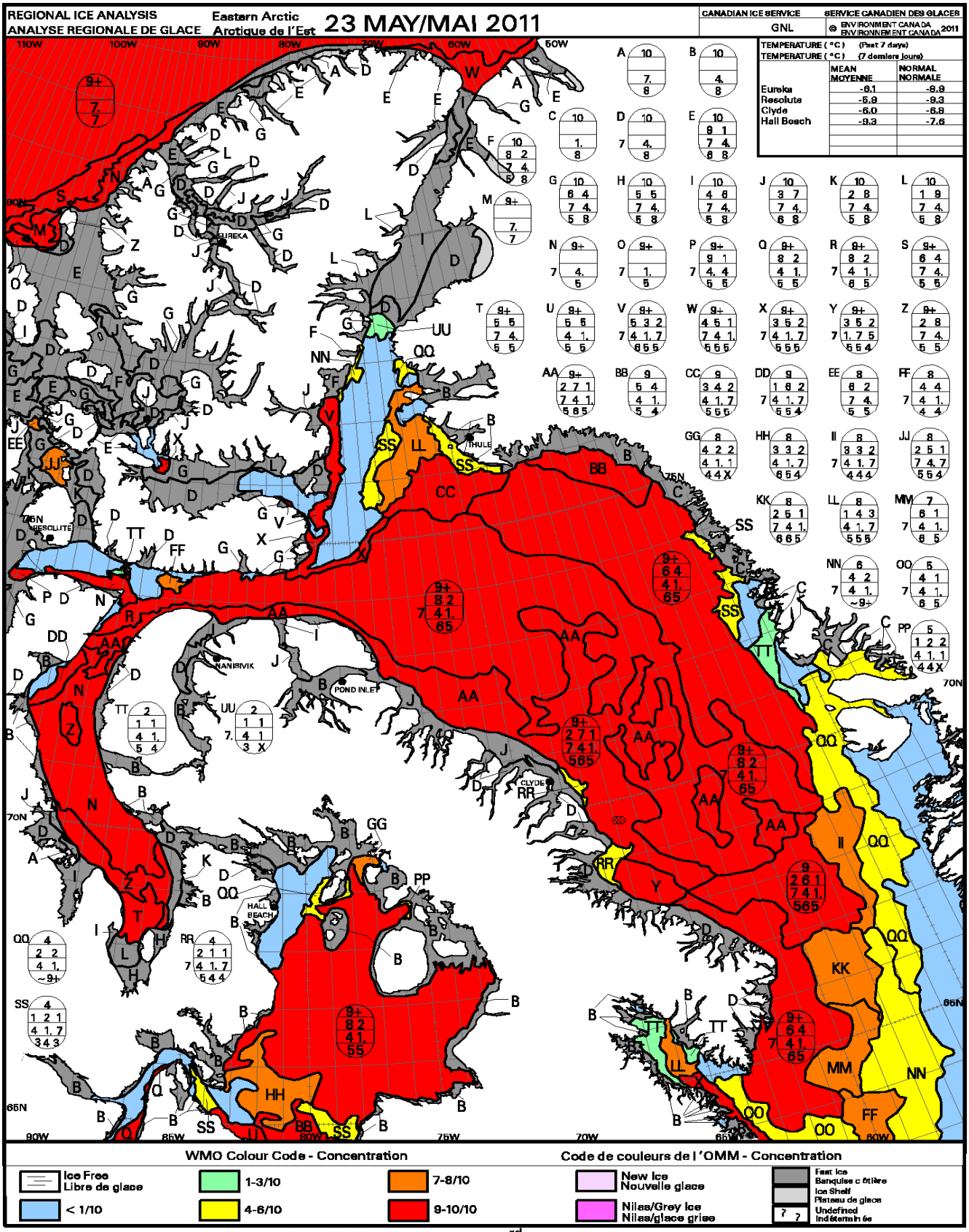

Figure 5: Eastern Arctic Regional chart for May 23rd, 2011

Outlook for the Eastern Arctic

The summer temperature outlook from June to August is expected to be slightly above normal values for most regions except for near normal temperatures for Baffin Bay and the Central Arctic. Breakup events will be earlier than normal over most regions. With the ice decaying over the northern portion of Baffin Bay at the start of the summer season, an open drift or less route will form during the first week of July which will be earlier than normal. Fracture events are expected to occur earlier than normal this summer except for Kane Basin, Jones Sound and Eureka Sound where it will be closer to normal. Ice will start to fracture over the northern portion of Admiralty Inlet just before mid-July and over Pond Inlet and western Barrow Strait near mid-July. A few days later, a fracture event will occur normally over Kane Basin, while an open drift or less route will develop earlier than normal along the shipping route to Cape Dyer. Some of the multi-year ice from the Kane Basin area will drift southward delaying the bergy water route across northern Baffin Bay until the third week of July. During that same week, the ice will fracture in Wellington Channel and southern Norwegian Bay. Fracture events will continue to occur over McDougall Sound, in northern Norwegian Bay and Eureka Sound during the fourth week of July. This will be followed by Jones Sound at the end of July.

The presence of multi-year ice over northern Admiralty Inlet, along the shipping route to Home Bay and near Pond Inlet will have an impact on the breakup over these areas this summer. Ice will melt completely in early August over the northern section of Admiralty Inlet which is a few days earlier than normal. An open drift or less route to Home Bay will develop during the first week of August, while clearing in Pond Inlet will occur a week later. Both of these breakup events will be near normal. Clearing is expected to occur from north to south over Foxe Basin this summer. As a result, an open water route to Hall Beach should form at the end of the third week of August. Clearing in both Davis Strait and Baffin Bay will clear during the fourth week of August due to the presence of old ice which will drift southward during the summer season. With the normal clearing pattern in Foxe Basin, the last remaining ice will be located along the northern shore of Southampton Island and melt during the third week of September which will be near normal. As the ice in Nansen Sound breaks up later this summer, higher than normal concentrations of multi-year ice will drift into Eureka Sound and Slidre Fiord preventing any clearing from occurring. The presence of multi-year ice in Pelly Bay, in northwestern Jones Sound and east of Graham Island will cause some difficulties for shipping activities into these areas. As the ice breaks up during the latter half of the summer over Wellington Channel and McDougall Sound, some of the multi-year ice will drift southward into Barrow Strait affecting shipping activities near the Resolute area.

Table 2: Eastern Arctic - Break-up Outlook Dates

	2010	Median (1981-2010)	Outlook for 2011
Route across Northern Baffin Bay			
- Open drift or less	12 Jul	13 Jul	04-06 Jul
- Bergy water route	10 Aug	27 Jul	18-20 Jul
Baffin Bay			
- Clearing	06 Sep	06 Sep	26-28 Aug
Davis Strait			
- Clearing	08 Aug	02 Sep	22-24 Aug
Home Bay			
- Open drift or less	30 Jul	05 Aug	02-04 Aug
Cape Dyer			
- Open drift or less	19 Jul	25 Jul	16-18 Jul
Open water route			
to Hall Beach	26 Aug	29 Aug	20-22 Aug
Foxe Basin			
- Clearing	05 Sep	20 Sep	19-21 Sep
Pond Inlet			
- Fracture[1]	13 Jul	23 Jul	14-16 Jul
- Clearing	07 Aug	08 Aug	08-10 Aug
Admiralty Inlet northern half			
- Fracture[1]	19 Jul	21 Jul	12-14 Jul
- Bergy water	15 Aug	06 Aug	01-03 Aug
Lancaster Sound			
- Fracture[1]	Not consolidated	06 Jul	Not consolidated
Barrow Strait to Resolute			
- Fracture/eastern[1]	Not consolidated	08 Jul	Not consolidated
- Fracture/western[1]	11 Jul	24 Jul	15-17 Jul
Wellington Channel			
- Fracture[1]	24 Jul	26 Jul	21-23 Jul
McDougall Sound			
- Fracture[1]	26 Jul	31 Jul	27-29 Jul
Kane Basin			
- Fracture[1]	Not consolidated	20 Jul	16-18 Jul
Jones Sound			
- Fracture[1]	15 Jul	29 Jul	30 Jul-01 Aug
Norwegian Bay			
- Fracture/southern[1]	21 Jul	29 Jul	20-22 Jul
- Fracture/northern[1]	21 Jul	04 Aug	25-27 Jul
Eureka Sound			
- Fracture[1]	23 Jul	01 Aug	28-30 Jul
- Bergy water	Never cleared	18 Aug	Never clear
Pacer Goose route to Thule			
-Open drift or less	22 Jun	13 Jul	06-08 Jul
-Bergy water route	25 Jun	27 Jul	16-18 Jul

[1] Fracture indicates complete breakage of consolidated ice.

Western Arctic

Freeze-up and Winter Ice Regime

Mean average air temperatures in all areas were generally 3ºC above normal in early September and became near normal by late September and into the first week of October. The air temperature was generally 6ºC above normal for the remainder of October and November, including a period of up to 10ºC above normal during the last week of October. The months of December and January saw temperatures returning to 3ºC above normal in general intermixed with periods of below normal temperatures during the second week of December and the last week of January.

At the beginning of freeze-up the ice concentration in the Arctic Ocean ice pack was much less than normal, the third lowest on record after 1998 and 2008. Only a trace to very open drift multi-year ice was evident south of 78ºN and west of 142ºW and then open drift multi-year ice south of 82ºN and west of 140ºW. Moreover, an unusual band of very open drift thick first-year ice with a trace of multi-year ice persisted through the summer months and remained along the Alaskan Coast from Prudhoe Bay to Cape Halkett. Meanwhile, mostly open water prevailed in western Parry Channel by mid-September, setting a new record for lowest ice coverage in that area. South of Parry Channel, an area of primarily multi-year ice remained in southern M'Clintock Channel with a tongue of multi-year ice extending north and south. Ice concentrations into southwestern Larsen Sound, Victoria Strait and northern Queen Maud Gulf were greater than normal at the end of the melt season due to ice drifting from M'Clintock Channel.

Freeze-up started in mid-September with new ice forming between the predominantly multi-year ice floes in Sverdrup Channel, Maclean Strait and Queens Channel. New ice began forming in Parry Channel, Prince of Wales Strait and along the Arctic Ocean ice pack by the first week of October. There was slow and steady ice growth and expansion in October. The new ice thickened to grey and grey-white ice by mid-October throughout M'Clure Strait, Viscount Melville Sound, Barrow Strait, M'Clintock Channel, Peel Sound, and along the Arctic Ocean ice pack. At the same time, new ice started to form in the Mackenzie Delta as well as the Alaskan Coast and along the southern edge of the Arctic Ocean ice pack. By early November, the new ice thickened to predominantly thin first-year in Parry and M'Clintock Channels but remained mostly grey-white in Prince of Wales Strait and Peel Sound. New ice started to form in Larsen Sound and along the shores of Queen Maud Gulf. New ice also formed in early November along the western shore and the southern tip of Banks Island. The ice west of the Tuktoyaktuk Peninsula and along the Alaskan Coast thickened to grey ice at this time and new ice continued to migrate southward along the southern edge of the Arctic Ocean pack. During the second week of November, new ice formed along the shores of southern Victoria Island into Amundsen Gulf and Coronation Gulf. The ice also continued to form and thicken and completely cover Queen Maud Gulf. However; large open water areas were still evident throughout much of Coronation Gulf, Amundsen Gulf, and in the Beaufort Sea between the Alaskan Coast ice and the Arctic pack.

Freeze-up progressed quickly and by the third week of November the Western Arctic became completely ice covered, three weeks behind normal. Open drift multi-year ice continued its southwesterly motion from the Arctic Ocean toward the Alaskan Coast and a combination of grey-white and thin first-year ice predominated in Amundsen Gulf, Coronation Gulf, and Queen Maud Gulf as well as the Alaskan Coast at this time. The developing ice continued to slowly thicken in December to become medium first-year ice north of Parry Channel and thin first-year south of the channel. By mid-December the ice consolidated in Prince of Wales Strait, Minto Inlet, Prince Albert Sound, Coronation Gulf and Rasmussen Basin. The ice was slow to consolidate in the High Arctic especially in Prince Gustaf Adolf Sea and Byam Martin Channel where moderate to strong northerly winds prevented the ice from becoming consolidated until the third week of December.

By the beginning of January, most waterways of the Queen Elizabeth Islands became consolidated with the exception of Queens Channel north of Cornwallis Island where it remained mobile until the last week of January. Queen Maud Gulf became consolidated by mid-January; however, most of Viscount Melville Sound, M'Clintock Channel and Larsen Sound remained mobile until the end of January, only to become completely consolidated by mid-February. The ice also continued to thicken reaching medium first-year ice south of Parry Channel and thick first-year north of the channel by the end of January. At that time, the main multi-year Arctic Ocean pack ice was located about 40 kilometres west of Banks Island to 175 kilometres north of the Tuktoyaktuk Peninsula and 175 kilometres northeast of Point Barrow. A trace of multi-year ice lay west of Point Barrow due to the westward migration of the remnant Alaskan Coast summer ice band and from the advancement of the Arctic Ocean pack ice. The calculated ice thicknesses were slightly below normal varying from 12 to 16 cm less than normal for most areas and up to 22 cm less than normal in the Queens Channel and Barrow Strait area near Cornwallis Island.

During the second half of February and in March, consolidated thick first year dominated over most of the Central Arctic and the Queen Elizabeth Islands. A trace of multi-year ice was present along the southern section of the Northwest Passage. However embedded areas of very open drift multi-year ice was observed over the northwestern section of Amundsen Gulf and in Prince of Wales Strait, while a large area of open drift multi-year ice was present over western Viscount Melville Sound. The main multi-year Arctic Ocean pack ice was located about 40 kilometres west of Banks Island to 175 kilometres north of Tuktoyaktuk Peninsula and 220 kilometres northeast of Point Barrow. Thick first-year ice dominated between the Arctic Ocean pack ice and the coast. Most of the ice in Amundsen Gulf remained mobile during the second half of February until it became consolidated during the second week of March. Much lower than normal multi-year ice concentrations were still present north of 72ºN and west of 141ºW at the end of March. With the colder than normal temperatures experienced during the month of April and the first half of May, the consolidated thick first-year ice grew along the Alaskan Coast and north of Tuktoyaktuk Peninsula. Meanwhile, similar ice conditions persisted over the rest of the Beaufort Sea and over the Central Arctic. With the westward progression of the pack ice over the Arctic Ocean during the first half of May, the southern edge of the multi-year pack ice remained in its current position north of Tuktoyaktuk Peninsula but was located about 175 kilometres northeast of Point Barrow.

At mid-May, ice concentrations of multi-year ice remained much lower than normal north of 72ºN and west of 141ºW. During the last two weeks of May, the southern edge of the multi-year ice pack was located near its normal position north of Tuktoyaktuk Peninsula and farther north than normal northeast of Point Barrow. At the end of May, large areas of open water developed over the southeastern section of the Beaufort Sea, in western Amundsen Gulf and off the consolidated first-year ice west of Banks Island. Clearing is already under progress west of Point Barrow. Breakup is 3 to 4 weeks ahead of normal at this time of year. Little change was seen over the rest of the Western Arctic.

Observed Ice Conditions

The regional ice charts in figures 6 and 7 were based on the analysis of Radarsat 1 and 2 and NOAA/MODIS imageries from around May 23rd, 2011. These charts revealed some of the following features:

a) A trace amount of multi-year ice is present along the shipping route from Peel Sound to southeastern Amundsen Gulf.

b) Isolated areas of up to 3 tenths of multi-year in the pack ice dominates from west of Resolute to M'Clure Strait with less than normal multi-year ice concentrations except for a large of 8 tenths of multi-year over western Viscount Melville Sound.

c) Less multi-year ice than normal prevailed over most of M'Clintock Channel except for an area of 9 tenths of multi-year ice over the southwestern section.

d) Isolated areas of up to 2 tenths of multi-year ice are present in Prince of Wales Strait and northeastern Amundsen Gulf with slightly greater than normal multi-year ice concentrations.

e) Large areas of open water developed over western Amundsen Gulf, in southeastern Beaufort Sea and west of Point Barrow which is 3 to 4 weeks earlier than normal for this time of year.

f) A southern edge of the multi-year ice pack over the Beaufort Sea is 220 kilometres north of Tuktoyaktuk Peninsula which is near normal and about 200 kilometres northeast of Point Barrow which is farther north than normal.

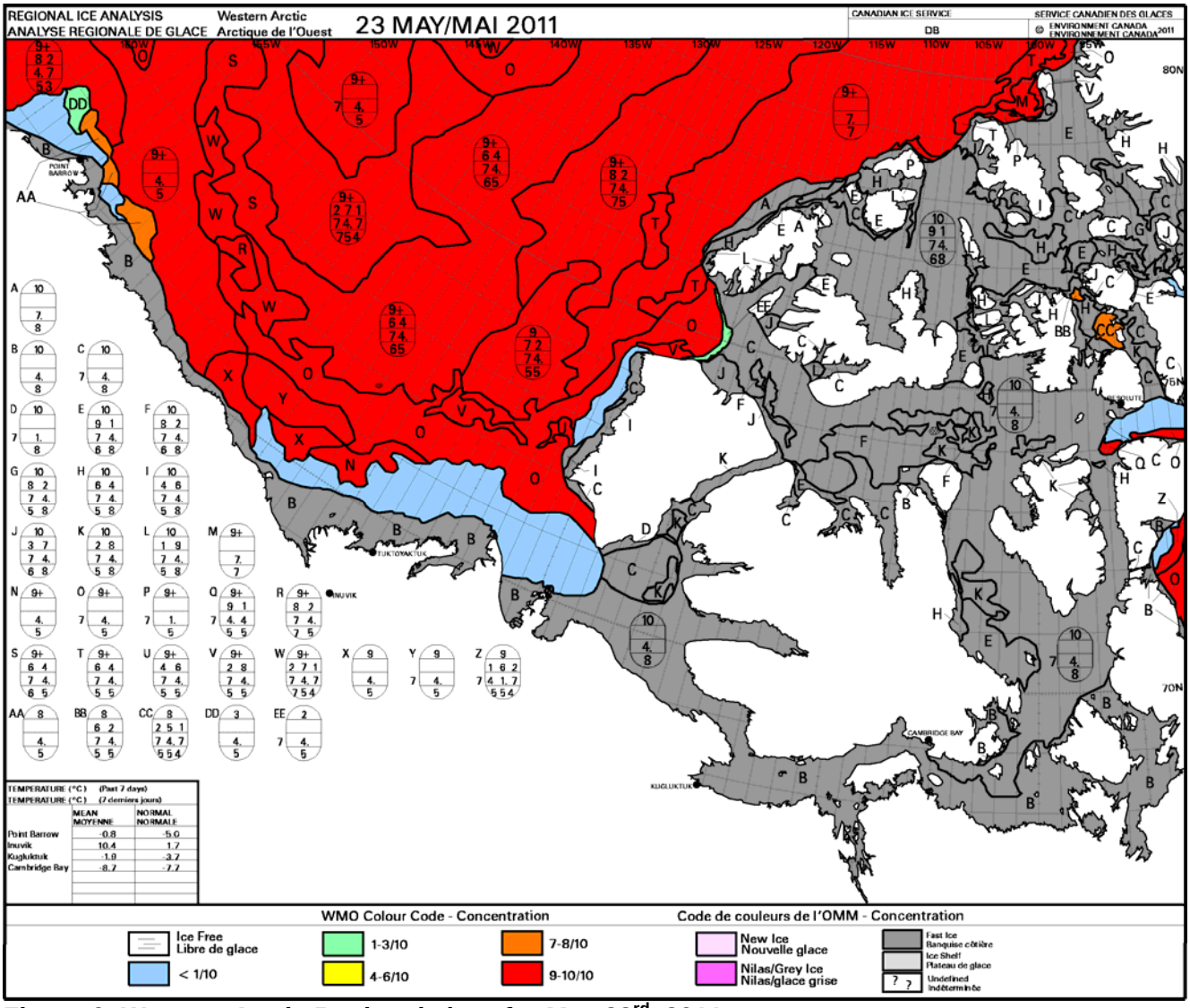

Figure 6: Western Arctic Regional chart for May 23rd, 2011

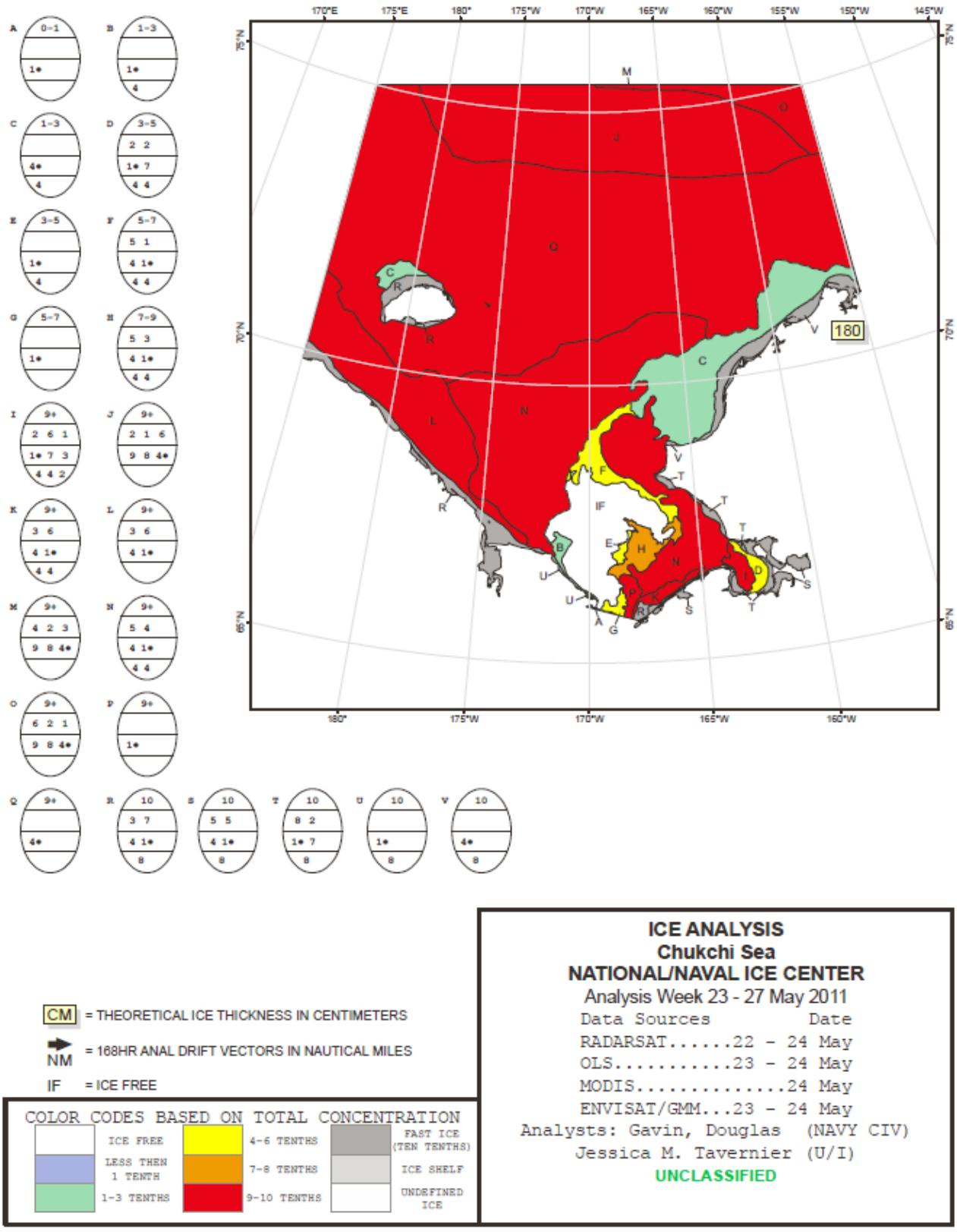

Figure 7: Chukchi Sea Regional chart for May 25th, 2011

Outlook for the Western Arctic

The summer temperature outlook from June to August is forecasting above normal temperatures over most regions except for near normal values along the shipping route from Peel Sound to Queen Maud Gulf. With colder than normal temperatures experienced over April and the first half of May, this will delay most of the breakup events this summer to near normal dates. However, clearing will be earlier than normal over the southeastern section of the Beaufort Sea and along the Northwest Passage west of Queen Maud Gulf. Clearing is expected to occur over Mackenzie Bay during the third week of June and over Kugmallit Bay early in the fourth week of June. At the end of June or early July, the ice will fracture along the Tuktoyaktuk Peninsula and in Amundsen Gulf. Near mid-July, a fracture will occur over Coronation Gulf, while an open water route will develop from Mackenzie Bay to Cape Bathurst. With the ice moving offshore west of Point Barrow, an open drift or less route from Cape Lisburne to Point Barrow will form after mid-July. The ice is expected to melt completely in Coronation Gulf during the fourth week of July. Fracture events will occur along the shipping route from Queen Maud Gulf to Peel Sound at the end of July. The ice will melt completely over Amundsen Gulf during the first week of August, while an open water route will develop from Amundsen Gulf to Taloyoak and from Cape Lisburne to Point Barrow a week later. With the ice drifting westward along the Alaskan Coast, an open drift or less route will form from Mackenzie Bay to Prudhoe Bay in early August and from Prudhoe Bay to Point Barrow during the second week of August.

Some of the multi-year ice in the southwestern section of M'Clintock Channel will drift into Victoria Strait but in low concentrations during the latter half of the summer. For most of the southern section of the Northwest Passage, the lack of old ice in the area will not create any major difficulties this summer. The area of high concentrations of multi-year ice present over the western section of Viscount Melville Sound and Byam Martin Channel will create difficulties for ships transiting into the area when the ice starts to breakup in August. Some scattered areas of low concentrations of multi-year ice will be present along the shipping route from Prince of Wales Strait to northern Amundsen Gulf but should not affect the clearing events during the summer season. The southern edge of multi-year pack ice which is located 175 kilometres north of Tuktoyaktuk Peninsula and 220 kilometres northeast of Point Barrow will move away from the shore during the summer but will move closer to the shore north of Point Barrow as the ice moves northwestward. With above normal temperatures forecast for this summer, this will slowly melt some of the multi-year ice over the Beaufort Sea and the Arctic Ocean maintaining areas of very open to open drift ice when the first-year ice melts completely.

Table 3: Western Arctic - Break-up Outlook Dates

	2010	Median (1981-2010)	Outlook for 2011
Mackenzie Bay			
- Clearing	23 Jun	20 Jun	19-21 Jun
Kugmallit Bay			
- Clearing	24 Jun	24 Jun	21-23 Jun
Tuktoyaktuk Peninsula			
- Fracture[1]	29 Jun	01 Jul	30 Jun-02 Jul
Mackenzie Bay to Cape Bathurst			
- Open water route	12 Jul	26 Jul	13-15 Jul
Coastal waterway Mackenzie Bay to Prudhoe Bay			
- Open drift or less	18 Jul	13 Aug	01-03 Aug
Coastal waterway Prudhoe Bay to Point Barrow			
- Open drift or less	23 Jul	13 Aug	08-10 Aug
- Close pack (refreeze)	08 Oct	08 Oct	09-11 Oct
Cape Lisburne to Point Barrow			
- Open drift or less	10 Jul	06 Aug	15-17 Jul
- Open water route	13 Jul	14 Aug	07-09 Aug
Wainwright			
- Open drift or less	10 Jul	29 Jun	26-28 Jun
Coastal waterway Prudhoe Bay to Barter Island			
- Open drift or less	14 Jul	13 Aug	13-15 Jul
Open water route to Taloyoak	04 Aug	12 Aug	07-09 Aug
Amundsen Gulf			
- Fracture[1]	Not consolidated	05 Jul	02-04 Jul
- Clearing	23 Jul	15 Aug	03-05 Aug
Coronation Gulf			
- Fracture[1]	05 Jul	15 Jul	14-16 Jul
- Clearing	27 Jul	30 Jul	24-26 Jul
Queen Maud Gulf			
- Fracture[1]	16 Jul	20 Jul	29-31 Jul
Larsen Sound			
- Fracture[1]	19 Jul	28 Jul	30 Jul-01 Aug
Peel Sound			
- Fracture[1]	27 Jul	29 Jul	31 Jul-02 Aug

[1] Fracture indicates complete breakage of consolidated ice.

Table 4: Selected Sea Ice Data and Severity Index for the north coast of Alaska (1953-2010)

		1	2	3	4	5	6	7	8	9		
RANK	YEAR	10 Aug	15 Sep	10 Aug	15 Sep	date	date	# days	# days	# days	Obs Index	Fcst Index
1	2007	150	397	183	515	16 Jul	08 Oct	63	84	77	1136	221
2	2009	161	425	161	445	10 Jul	19 Oct	60	100	83	1103	148
3	2008	0	318	213	318	07 Jul	03 Oct	66	91	86	879	170
4	2010	33	219	214	258	27 Jul	08 Oct	56	72	66	671	144
5	2004	13	238	70	260	16 Jul	08 Oct	71	68	77	637	602
6	1958	50	150	50	210	19 Jul	25 Oct	92	99	74	624	446
7	1968	25	165	30	200	19 Jul	18 Oct	86	91	74	615	495
8	1998	15	105	20	240	15 Jul	21 Oct	72	100	78	584	486
9	2005	70	130	85	250	23 Jul	03 Oct	63	70	70	580	381
10	2003	18	167	27	185	21 Jul	20 Oct	52	92	72	568	481
11	1993	0	130	5	185	18 Jul	07 Nov	64	112	75	565	388
12	2002	0	135	18	225	13 Aug	14 Oct	32	64	49	504	293
13	1962	25	150	30	150	19 Jul	30 Sep	49	68	74	490	406
14	1973	5	80	5	190	31 Jul	20 Oct	73	82	62	486	344
15	1954	20	115	20	210	01 Aug	30 Sep	38	61	61	484	552
16	1997	28	150	40	150	08 Aug	10 Oct	47	63	54	463	297
17	1963	5	130	5	130	13 Aug	18 Oct	67	67	49	442	351
18	1990	0	90	40	90	23 Jul	12 Oct	75	105	70	429	173
19	1961	15	105	15	135	25 Jul	24 Sep	49	62	68	418	414
20	1996	10	65	70	155	16 Jul	25 Sep	37	71	77	405	446
21	1979	0	125	0	125	04 Aug	08 Oct	31	56	58	394	178
22	1989	10	70	55	110	19 Jul	22 Oct	34	95	74	383	284
23	1974	10	100	10	100	06 Aug	05 Oct	35	61	56	351	372
24	1978	5	70	30	95	25 Jul	09 Oct	35	76	68	343	492
25	1986	10	80	10	110	29 Jul	21 Oct	30	58	64	342	517
26	1999	15	45	45	105	30 Jul	08 Oct	56	70	63	338	98
27	1977	5	55	25	85	02 Aug	15 Oct	63	74	60	336	381
28	1959	20	65	20	65	19 Jul	06 Oct	42	86	74	331	271
29	1995	30	30	50	50	15 Jul	17 Oct	70	94	78	329	477
30	1972	0	60	30	90	31 Jul	01 Oct	45	63	62	320	251
31	1982	0	85	0	95	03 Aug	10 Oct	21	69	59	318	271
32	2006	17	18	17	69	04 Aug	13 Oct	60	70	58	275	-462
33	1994	10	35	10	60	05 Aug	24 Sep	44	55	57	251	334
34	1957	5	45	70	60	01 Aug	06 Oct	18	67	61	250	300
35	1987	0	10	0	85	05 Aug	30 Oct	35	59	57	250	299
36	1981	0	0	35	100	26 Jul	01 Oct	0	66	67	232	521
37	2000	10	70	10	75	31 Jul	02 Oct	19	33	62	228	274
38	1985	0	35	0	55	01 Aug	15 Oct	22	52	61	224	245
39	1967	15	0	30	50	25 Jul	12 Oct		68	68	213	212
40	1984	0	25	0	50	11 Aug	15 Oct	21	42	51	209	219
41	1966	5	0	5	45	01 Aug	22 Oct	24	65	61	194	296
42	1992	15	0	15	75	09 Aug	19 Sep	24	37	53	188	560

		1	2	3	4	5	6	7	8	9		
RANK	YEAR	10 Aug	15 Sep	10 Aug	15 Sep	date	date	# days	# days	# days	Obs Index	Fcst Index
43	1965	0	10	0	70	25 Aug	25 Sep	25	32	37	173	182
44	2001	0	25	15	25	17 Aug	08 Oct	26	52	45	172	262
45	1980	15	25	15	25	05 Aug	30 Sep	11	42	57	159	426
46	1953	0	0	5	35	27 Jul	16 Sep	5	52	66	157	213
47	1976	0	15	0	15	15 Aug	07 Oct	21	53	47	150	106
48	1971	0	0	0	30	23 Aug	01 Nov	8	71	39	147	166
49	1991	0	0	0	20	16 Aug	02 Oct	0	46	46	111	199
50	1960	0	0	20	20	05 Aug	07 Sep	0	34	57	110	231
51	1988	0	0	0	25	09 Aug	20 Sep	0	32	53	110	354
52	1964	0	0	0	5	13 Aug	20 Sep	0	39	49	95	536
53	1983	0	10	0	10	08 Aug	16 Sep	0	21	54	92	41
54	1970	0	0	5	0	06 Aug	14 Sep	0	32	56	87	251
55	1956	0	0	0	40	07 Sep	30 Sep	0	24	24	87	93
56	1969	0	0	0	30	07 Sep	18 Sep	5	12	24	70	157
57	1955	0	0	5	15	13 Sep	24 Sep	0	12	18	44	44
58	1975	5	0	5	0	NEVER	NEVER	0	0	0	0	8

1. Distance from Point Barrow northward to ice edge (10 Aug)
2. Distance from Point Barrow northward to ice edge (15 Sept)
3. Distance from Point Barrow northward to boundary of five tenths ice concentration (10 Aug)
4. Distance from Point Barrow northward to boundary of five tenths ice concentration (15 Sep)
5. Initial date the entire sea route to Prudhoe Bay is less than or equal to five tenths ice concentration.
6. Date that combined ice concentration and thickness dictate end of prudent navigation.
7. Number of days the entire sea route to Prudhoe Bay is ice free.
8. Number of days entire sea route to Prudhoe Bay less than/equal to five tenths ice concentration.
9. Number of days between initial opening date and 01 Oct.

Appendix A : Key To Canadian Ice Service Sea Ice Symbols

For more information on this section, please refer to the following web link on the Canadian Ice Service web site:

http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?Lang=eng&lnid=76&ScndLvl=no&ID=11030

or on the National Ice Center web site:

http://www.natice.noaa.gov/products/egg_code.html

Appendix B : Broadcast Schedules For Arctic Ice and Marine Conditions

For more information on this section, please refer to the following web links:

Canadian Coast Guard (Radio Aids to Marine Navigation):

http://www.ccg-gcc.gc.ca/eng/CCG/MCTS_Radio_Aids

Alaska Marine VHF Voice:

http://www.nws.noaa.gov/om/marine/akvhfv.htm

NOAA MF/HF Voice – 4125 kHz:

http://www.nws.noaa.gov/om/marine/noaahfv.htm

NOAA Weather Radio at U.S. Coast Guard Sites in Alaska:

http://www.nws.noaa.gov/om/marine/aknwr.htm

For further information, please contact Canadian Ice Service by:

Phone: 1-877-789-7733
Fax: 1-613-947-9160
E-mail: ECWeather-Meteo@ec.gc.ca

Or National Ice Center by:

Phone: 1-301-817-3911
E-Mail: liaison_web@natice.noaa.gov