3.4 Physical Oceanography

Water properties and characteristics of the SEA Area are directly linked to the exchange of sea water between these two regions. The Gulf waters have their own characteristics and makeup while the water mass of the South Coast and west of St. Pierre has its origins from the Labrador Current. The exchange of water masses (and properties) is an exchange between the water of the Gulf and this Labrador Branch. In this section, temperature and salinity seasonal profiles are analyzed from measured and modeled data.

3.4.1 Temperature and Salinity

Annual hydrographic profiles and detailed information are available from the Ocean Science hydrographic database (ODI) at the Bedford Institute of Oceanography (BIO) (Gregory 2004) and some of the profile results are presented here (Figures 3.11 to 3.13). White rectangular regions in the figures indicate no data for the particular month and depth.

All three areas show the same kind of pattern, confirming they belong to the same water masses and respond to the same mechanisms.

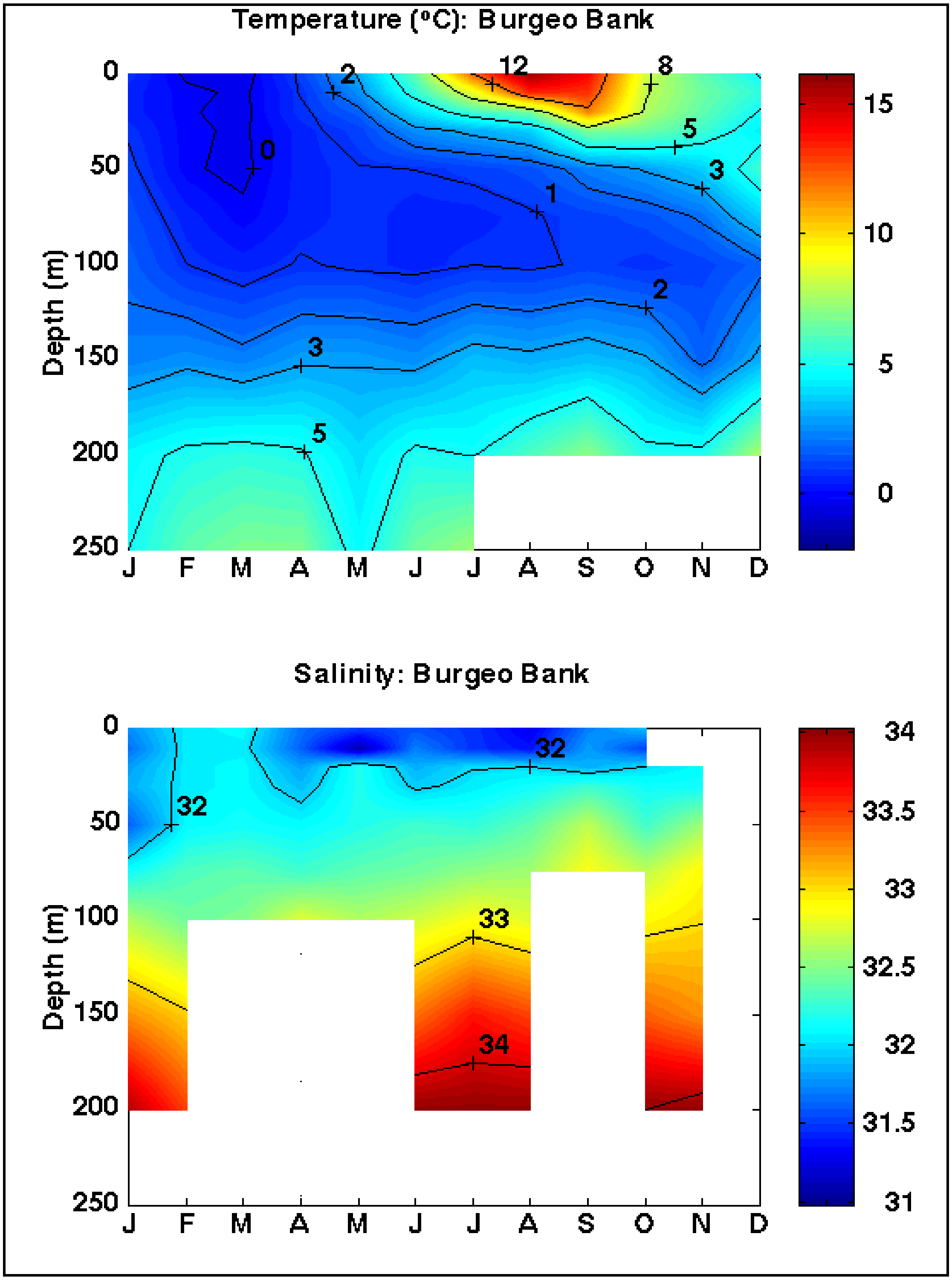
One of the strongest characteristic of this area is that the surface temperature presents a large seasonal change (approximately 12°C magnitude) between summer and winter. In contrast, the bottom temperature remains quite constant, representing the on-shelf water penetration associated with the Scotian shelf slope-derived lower layer (Loder et al. 1997).

During the winter (January to March), cool (approximately 0°C to 1°C) and more salty (32.5 psu) surface water cover the entire area, contrasting with coolest subzero water flowing out of the east Cabot Strait (Han et al. 1999).

During the summer (July to August), the area shows a strong stratification of the water column; warm and relatively fresh water spreading over the two precedent winter waters.

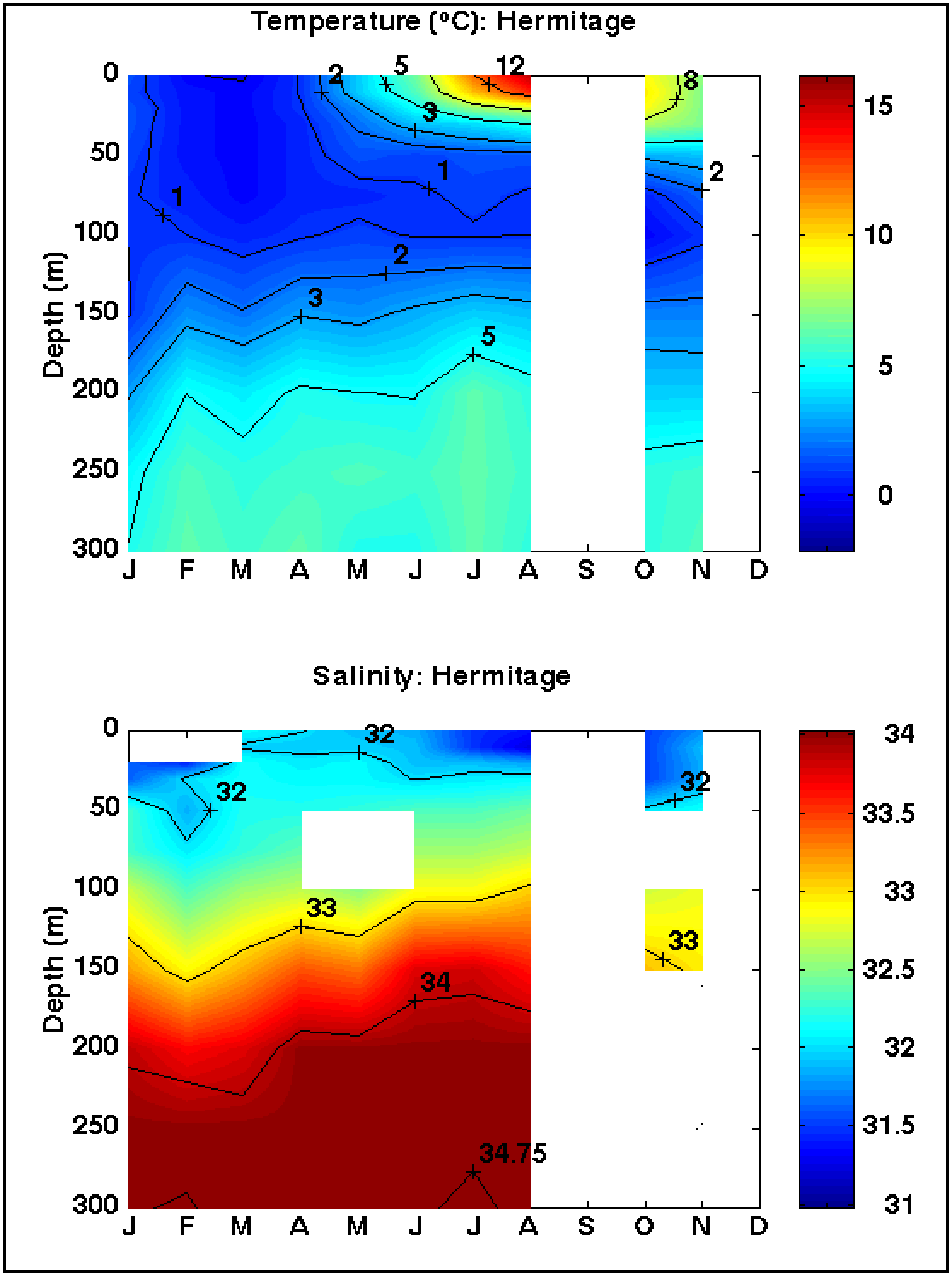
Finally, the change in salinity between winter and summer (drop of approximately 1 psu) clearly shows the influence of annual cycle of rivers discharge.

Figure 3.11 Annual Temperature and Salinity Profile at Burgeo Bank



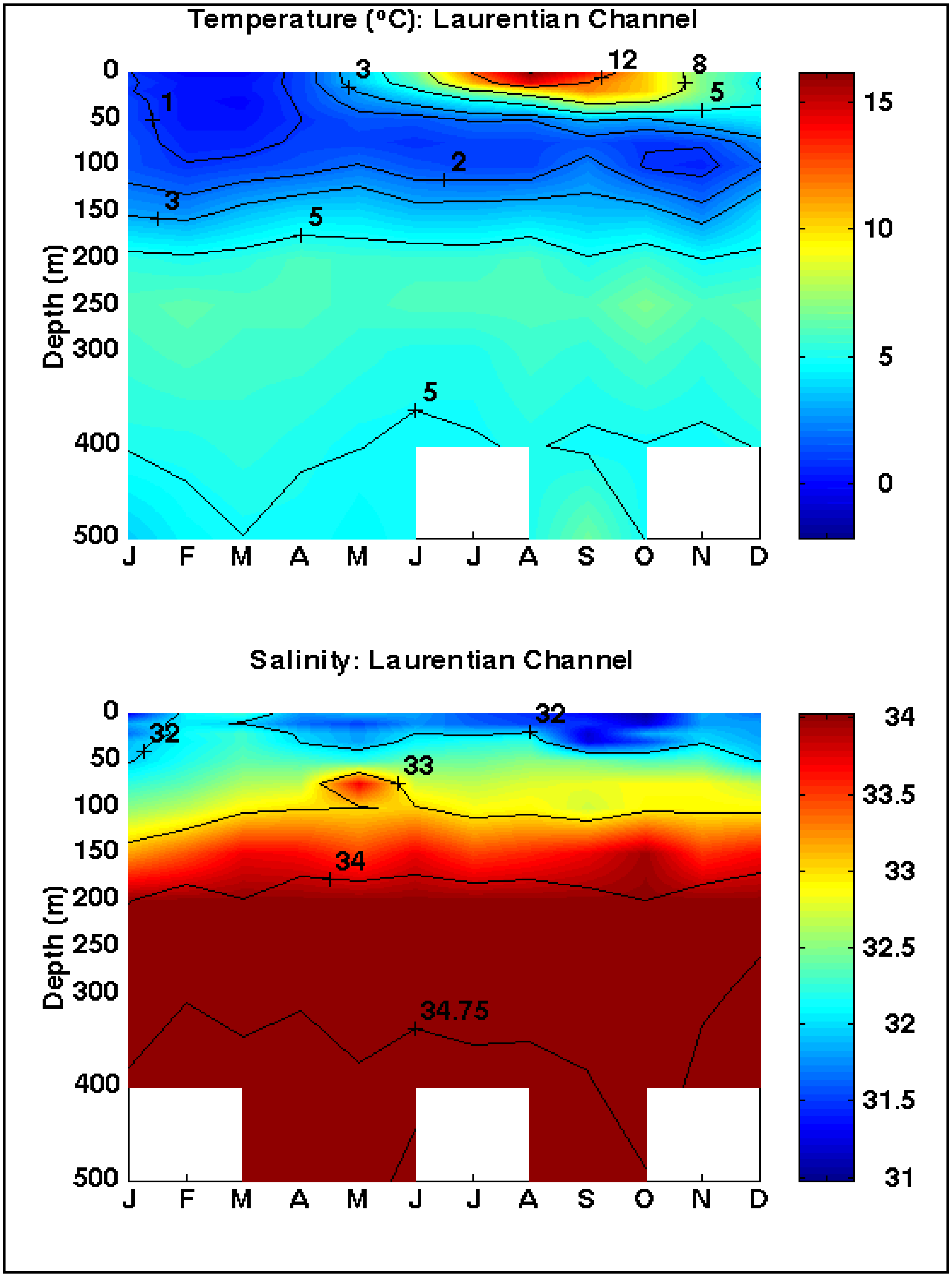
Source: BIO 2006.

Figure 3.12 Annual Temperature and Salinity Profile at Hermitage Channel



Source: BIO 2006.

Figure 3.13 Annual Temperature and Salinity Profile at Laurentian Channel



Source: BIO 2006.

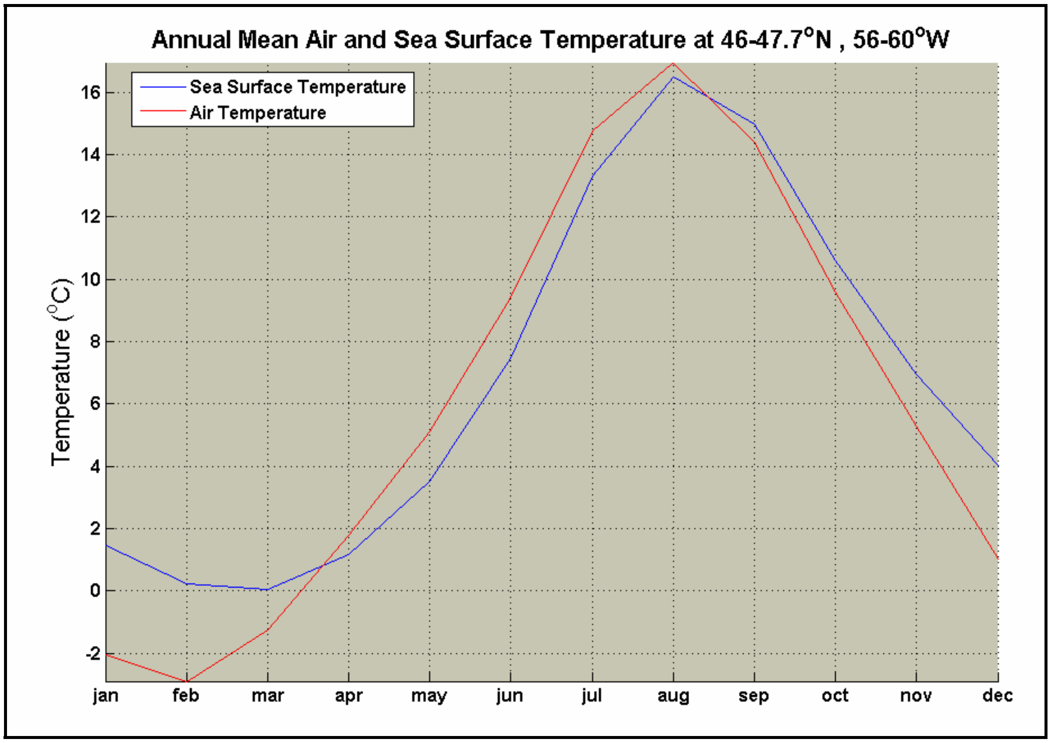
3.4.2 Weather

Monthly averaged annual air and sea surface temperature, and visibility frequency were extracted from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). ICOADS consist of marine weather and sea state observations from vessels and other platforms types. Data measured from 1961 to 2004 were extracted and averaged by month.

3.4.2.1 Air-Sea Temperature

Large seasonal variation is noticeable with sea surface temperature varying from 0°C to 16°C and air temperature from approximately -3°C to more than 16°C, respectively, from February to August (Figure 3.14). Also noticeable is that the difference between air and sea surface temperature gets much larger during the winter, being relatively similar during the summer.

Figure 3.14 Air and Sea Surface Temperature

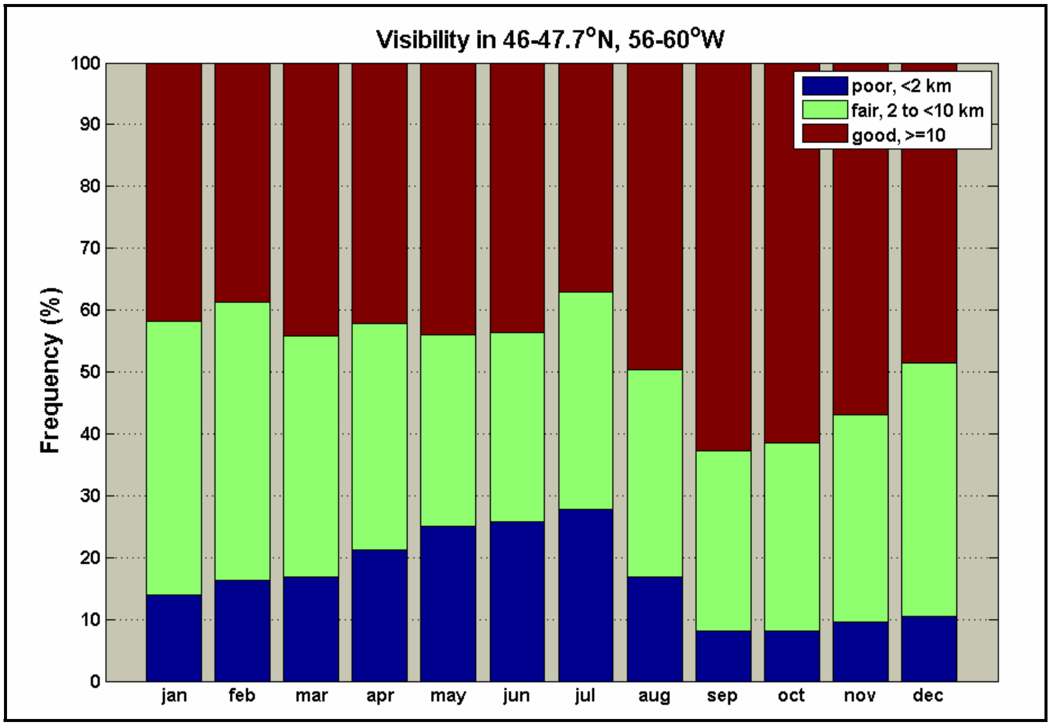


Source: ICOADS 2006a.

3.4.2.2 Visibility

Visibility varies considerably during the year, having a peak of rather bad conditions in the summer time (May to July), when there is poor visibility up to 30 percent of the time, to rather good during the winter (November to February), when up to 50 to 60 percent of the time there is good visibility conditions (the peak of best visibility being actually in September) (Figure 3.15).

Figure 3.15 Percent Frequency of Occurrence of Visibility Range



Source: ICOADS 2006b.

3.4.3 Wave Conditions

For the same reasons as those presented for the wind climatology, the six AES40 nodes (Figure 3.16) were reviewed to take account or the possible range and variation in sea state over the SEA Area.

A sea state is commonly described in terms of significant wave height (Hsig), maximum wave height and spectral peak period (Tp). The significant wave height is the average height of the one-third highest waves, whereas the maximum wave height is the greatest vertical distance between a wave crest and adjacent trough and finally, the spectral peak period is the period of the waves with the largest energy levels (which approximate the period of the one-third highest waves).

Yearly Hsig wave roses for the six nodes are presented in Figure 3.16, and monthly mean (over the 48 years of data) and maximum Hsig are presented in Figure 3.17.

The Hsig directional frequency roses are also generally similar for the six different nodes, but show slightly more differences than for the wind. Specifically, the nodes situated farther west and offshore show a generally stronger sea state (on average approximately 1 m larger, and as large a difference as 3 m). In addition, there is a greater occurrence of waves from the southwest for these offshore locations.

Figure 3.16 Yearly Directional Distribution of Wave Heights for Six AES Grid Points in the Strategic Environmental Assessment Area

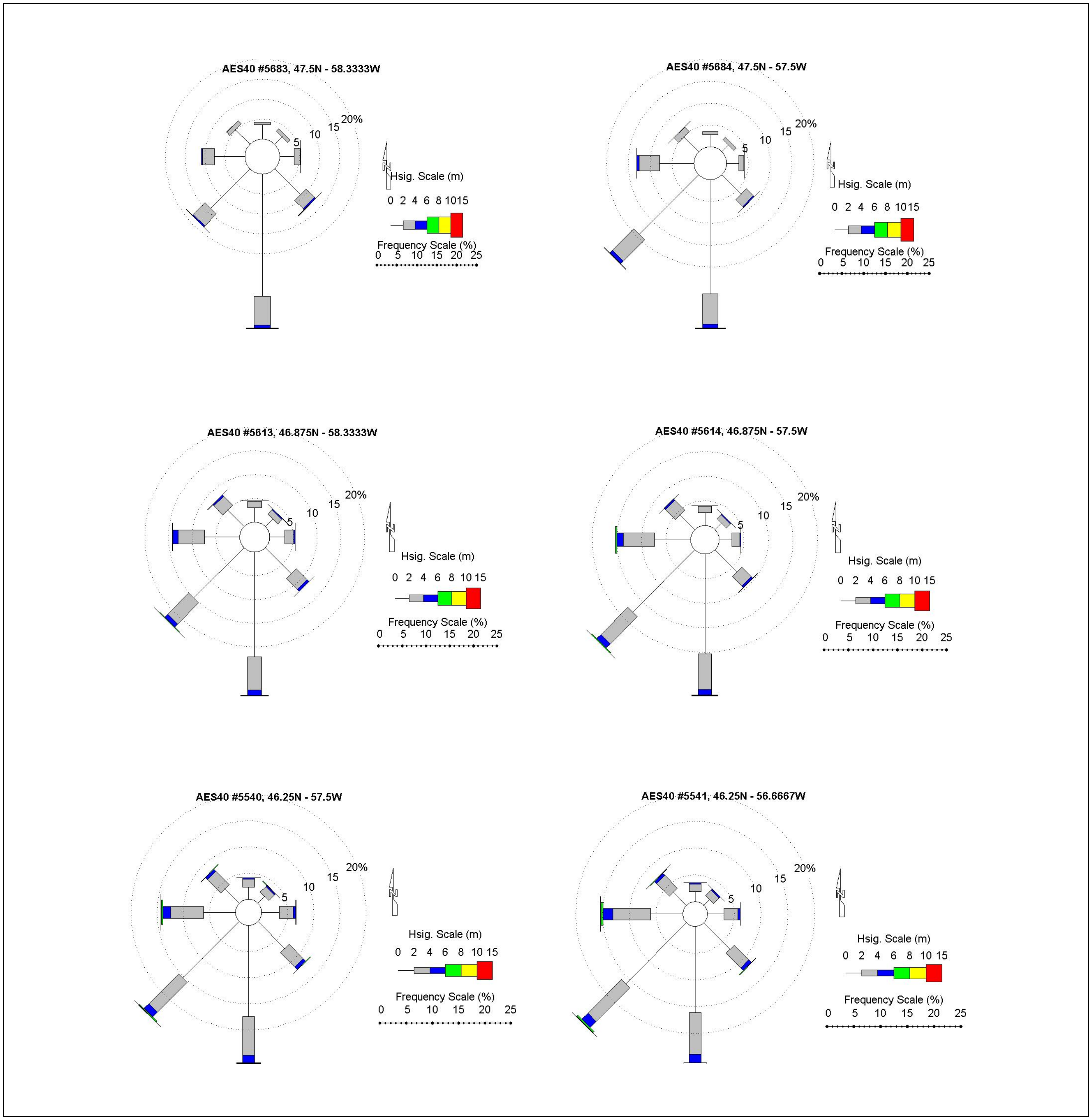
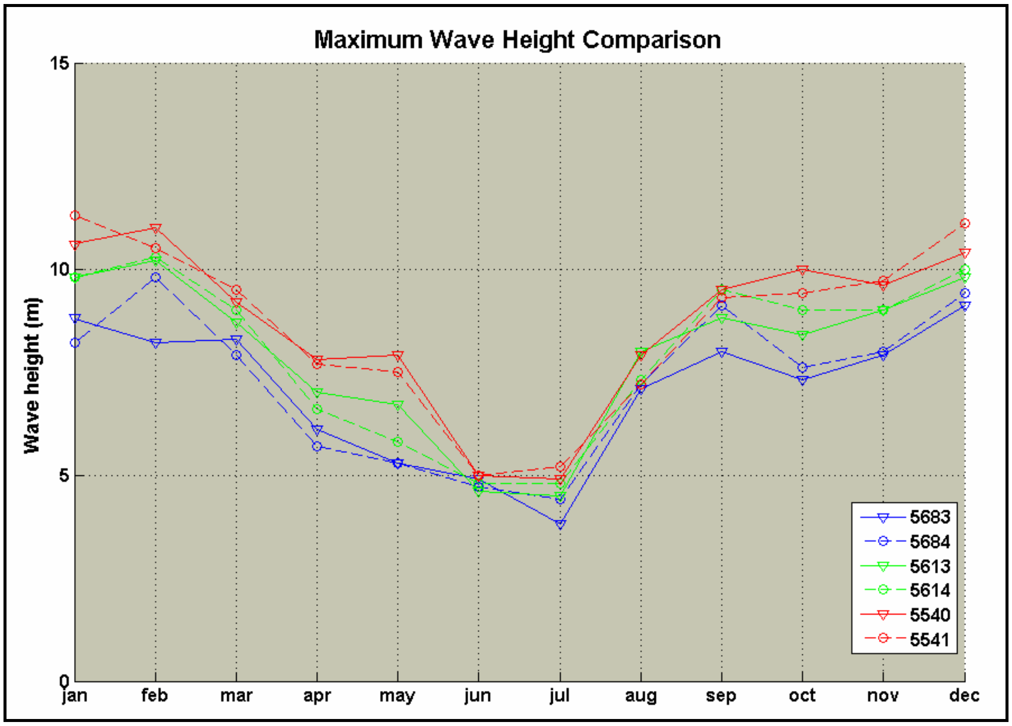
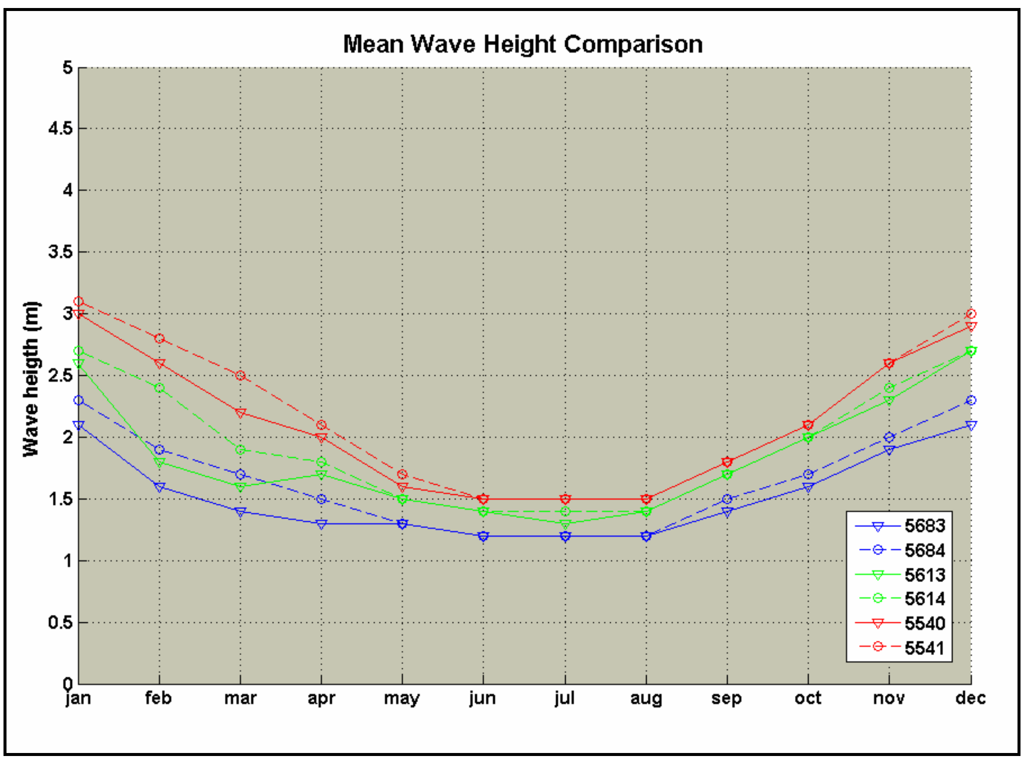


Figure 3.17 Mean and Maximum Monthly Wave Height by Grid Point





Furthermore, the duration of strong sea state varies also significantly from one node to another. For example, maximum Hsig are greater than 5 m during most of the year (except in June) for the nodes 5540 and 5541, whereas the nodes 5683 and 5684 show a relatively calm season from April to July.

Taking these differences in consideration, it is still possible to take only one node as representative of the area for more detailed investigations. The same node then from the wind climatology study (5614) has therefore been selected and its results are presented in Figures 3.18 and 3.19 and Table 3.5.

Figure 3.18 Monthly Directional Distribution of Wave Height for AES40 Grid Point 5614

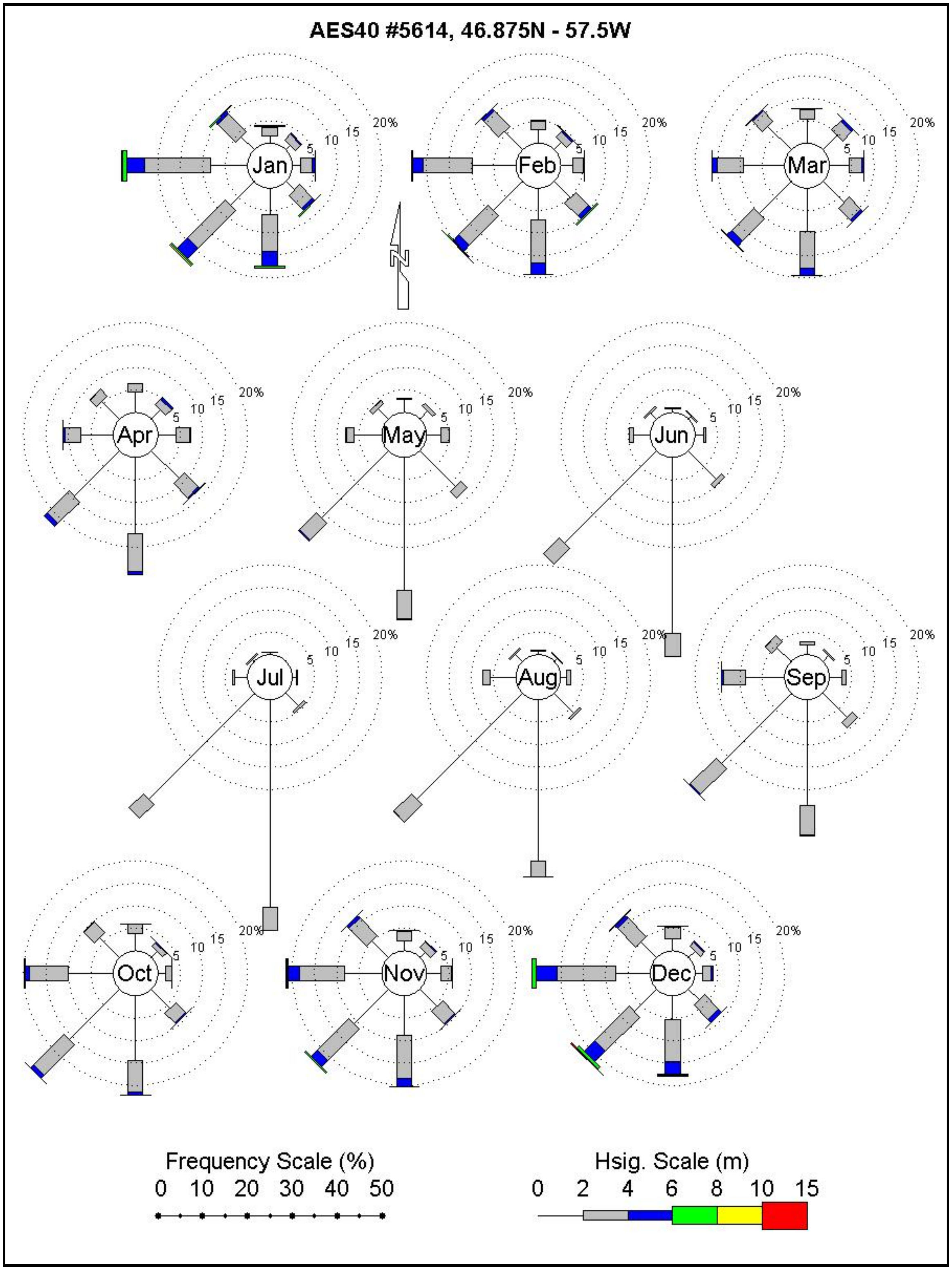


Figure 3.19 Frequency of Occurrence of Peak Period by Significant Wave Height Grouping

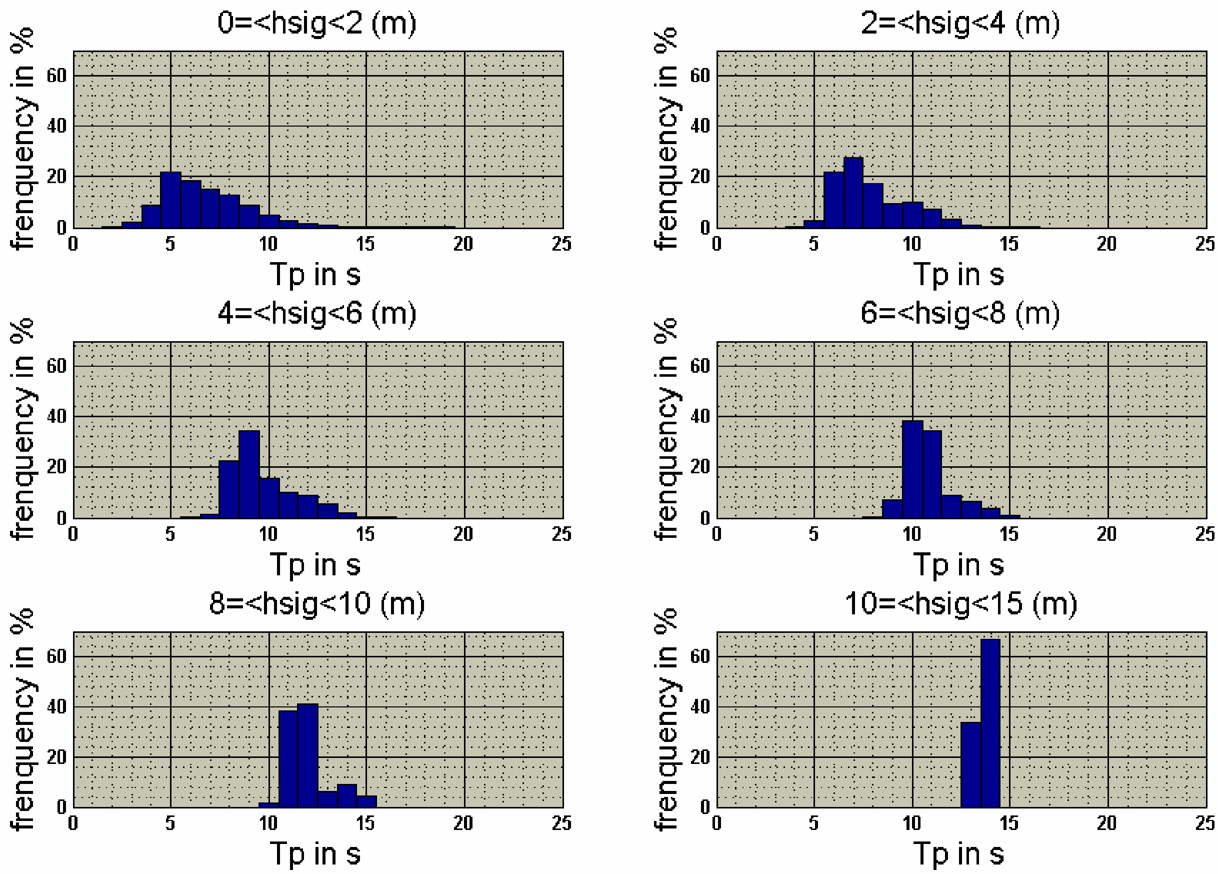


Table 3.5 Monthly Mean and Maximum Wave Parameters

Wave Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Hsig (m)	2.7	2.4	1.9	1.8	1.5	1.4	1.4	1.4	1.7	2.0	2.4	2.7	1.9
Most Frequent Direction (from)	W	W	S	S	S	S	S	S	SW	SW	SW	W	S
Mean Tp (s)	8.4	8.1	7.1	7.6	7.5	7.4	7.4	7.3	7.7	7.5	7.9	8.4	7.7
Maximum Hsig (m)	9.8	10.3	9.0	6.6	5.8	4.8	4.8	7.3	9.5	9.0	9.0	10.0	10.3
Most Frequent Direction (from)	W	SW	W	SE	E	S	SW	S	S	S	S	SW	SW
Tp of Maximum Hsig (s)	12.2	14.1	11.9	11.8	9.8	10.4	10.1	13.0	12.8	12.7	14.1	13.0	14.1
Maximum Tp (s)	15.6	14.7	16.1	16.0	19.3	16.1	17.5	16.2	18.5	17.7	14.5	15.6	19.3
Source: AES40 Grid Point 5614.													

Typically, strong waves coming from the west to south-southwest occur from November through February/March with mean significant waves of approximately 2 to 3 m and maximum Hsig ranging from approximately 9 to 10 m.

From May to August, the sea-state is significantly weaker having mean significant waves of approximately 1.5 m and maximum significant waves ranging from approximately 5 to 7 m coming from the south.

Typical wave period (Tp) ranges from 5 to 14 s for Hsig ranging from approximately 1 to 11 m; the longest period corresponding to the highest waves.

3.5 Ice and Iceberg Conditions

Sea ice extent can be very variable on the Newfoundland coast as both winds and temperatures are effective in changing the location of the edge (Canadian Ice Service 2001).

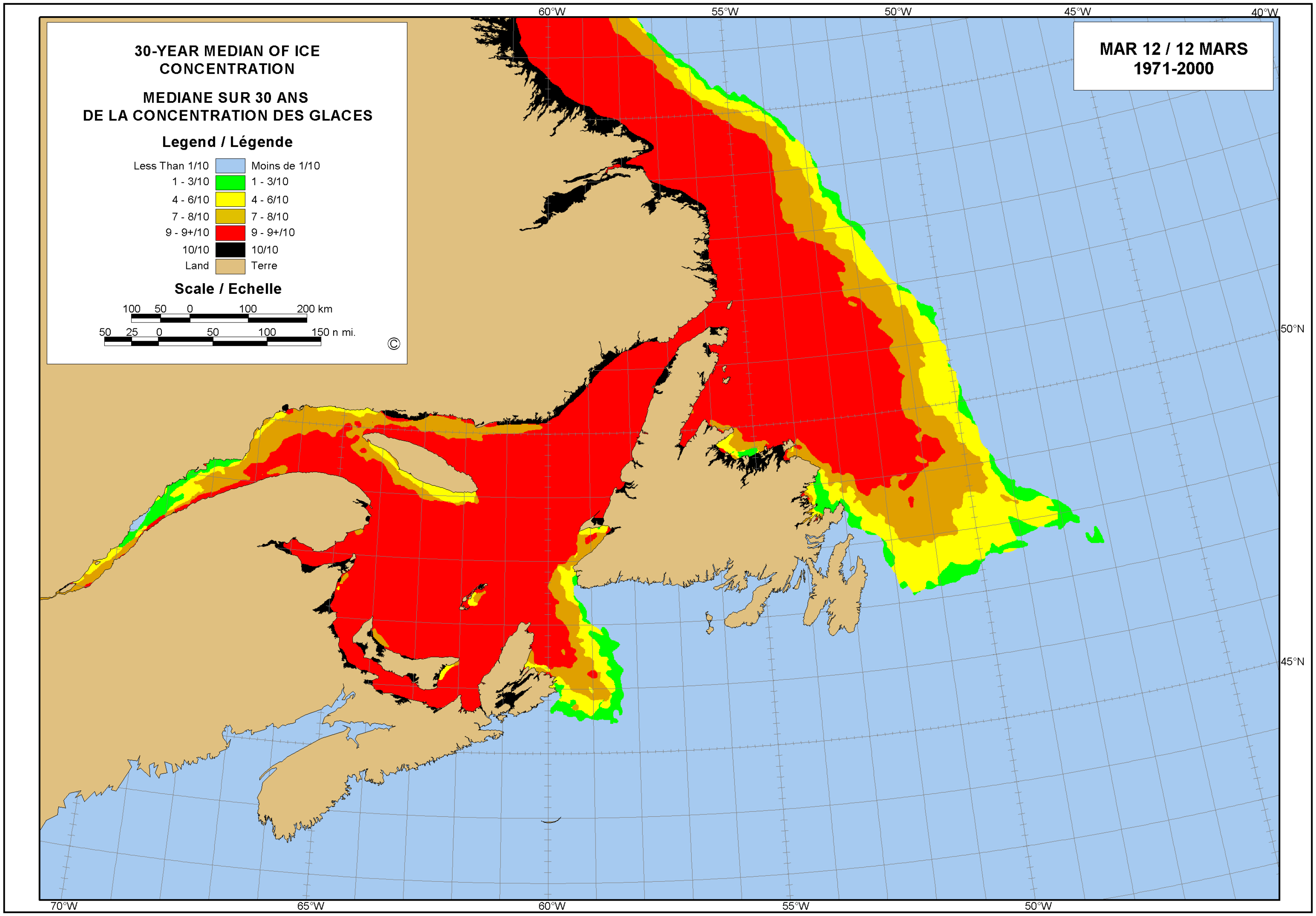
The maximum southern extent of the ice generally occurs from the end of February to the middle of March (Figure 3.20). The 1/10 concentration ice generally extends down to 47°N, but in some years can extend (1 to 15 percent of the years between 1971 and 2000; see Figure 3.20) down to 45°N.

During the second half of March, the rate of melting at the ice edge increases sufficiently to counterbalance the southward ice drift, and the slow retreat of sea ice generally begins. In early May, the rate of melting increases and the southern ice edge retreats by the fourth week in May, typically to north of the Strait of Belle Isle. The melting of the pack ice may also expose any icebergs that may have drifted through the Strait of Belle Isle into the Gulf of St. Lawrence.

For the SEA Area, weather and sea state, and also sea ice in particular will vary by location. As seen in Figures 3.20 and 3.21, sea ice is more frequent in the western region of the SEA Area and close to Cabot Strait (34 to 50 percent of the time) and less frequent for the remainder: generally from 1 to 33 percent of the time. A more recent (since the 1971 to 2000 results presented in Figures 3.20 and 3.21) and specific example of the range of sea ice coverage possible is given in Figure 3.22, which shows the daily sea ice chart from March 10th, 2003. For this year, the eastern and southern extents are clearly greater than the median (Figure 3.20) but do not appear to be inconsistent with the range of conditions possible (Figure 3.21). For this particular year, and day in March, a large extent of sea ice that has drifted out of the Gulf of St. Lawrence extends to the southeast from Cabot Strait (ice conditions in the Gulf of St. Lawrence are not shown on this Cabot Strait chart).

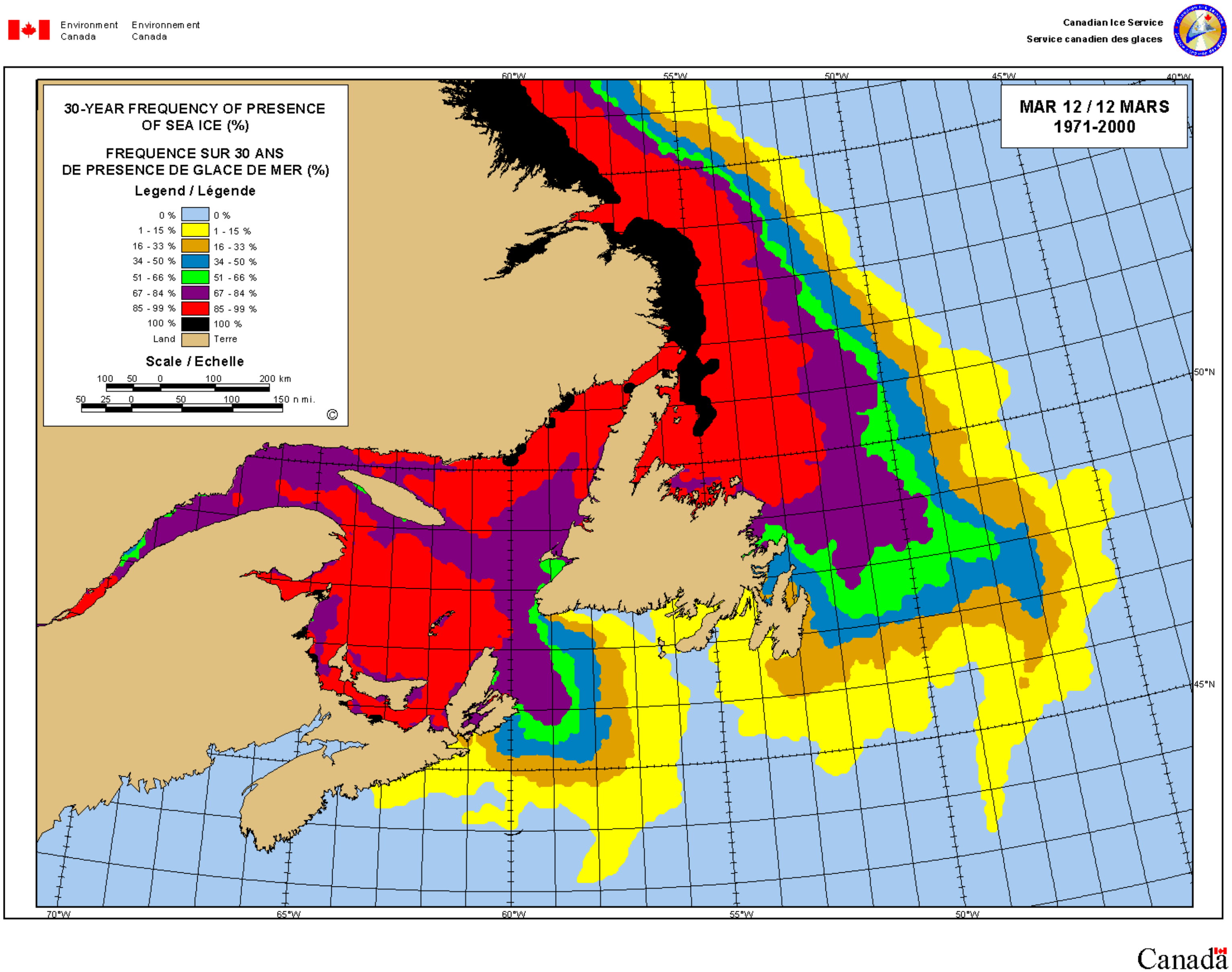
There is ice of 7/10 (to the northeast) to 9/10 concentration in Cabot Strait, which then extends as far as to the southeast of Cape Breton (Figure 3.22). The 7/10 concentration northeastern portion (egg C) is comprised of 1/10 grey ice (approximately 10 to 15 cm thickness), 3/10 medium first year ice (70 to 120 cm), and 3/10 thin first year ice (30 to 70 cm). The 9/10 concentration of ice (egg B) has a similar makeup but with 4/10 concentrations of the medium and thin first year ice. At the eastern and southern limits (egg A) the ice is of 4/10 concentration comprised of 1/10 medium first year ice, 2/10 thin first year, and 1/10 grey white ice (15 to 30 cm). Again, the greatest ice concentrations are located to the west, in this example generally outside the SEA Area. To the east of the ice pack there is open water as indicated by the dotted area east to 56°W with a few strips of very thin ice south of St. Pierre.

Figure 3.20 30-Year Median of Ice Concentration, 1971 and 2000, Week of March 12



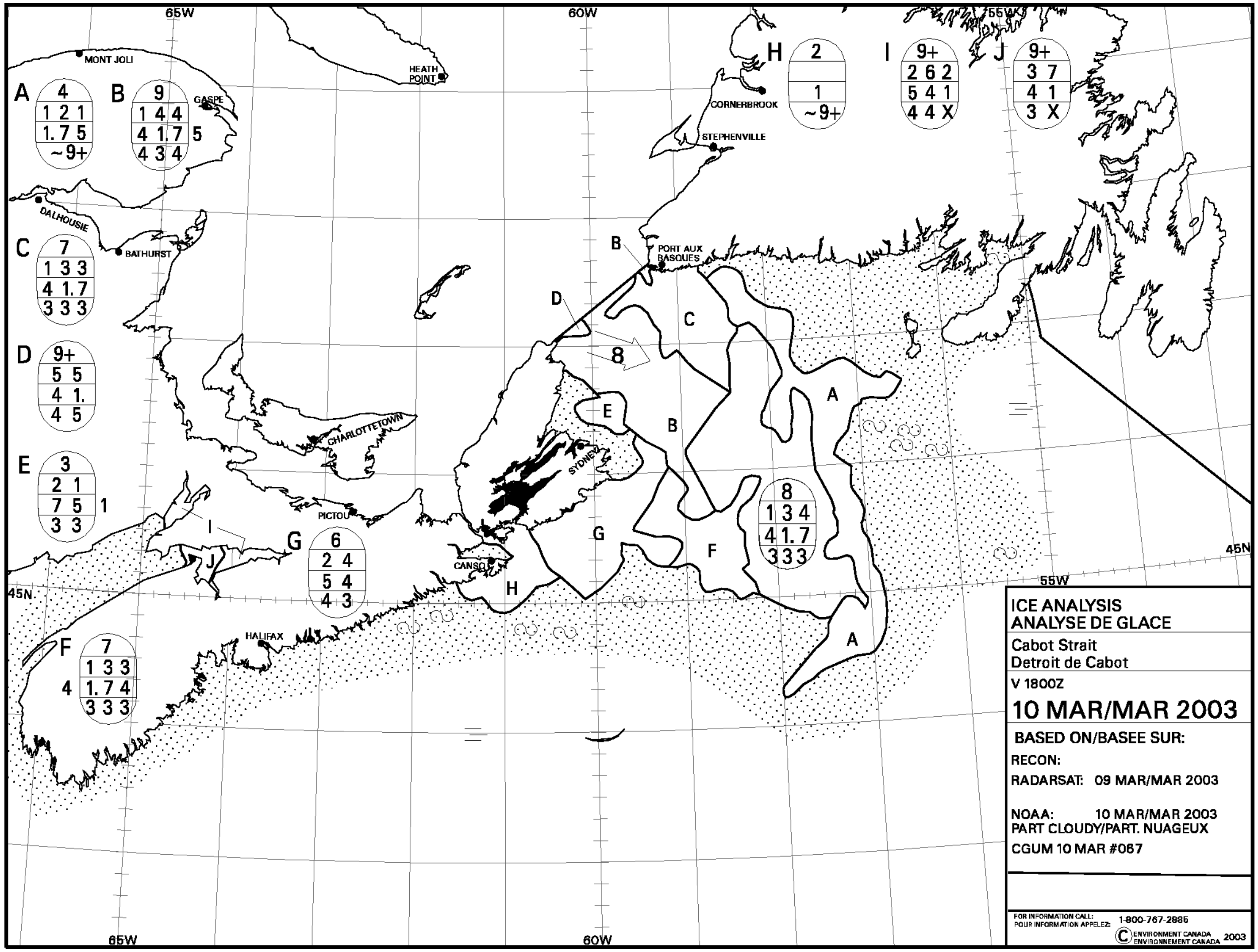
Source: Canadian Ice Service 2001.

Figure 3.21 30-Year Frequency of Occurrence of Sea Ice, 1971 and 2000, Week of March 12



Source: Canadian Ice Service 2001.

Figure 3.22 Sample Daily Ice Chart Illustrating Large Sea Ice Extent in Strategic Environmental Assessment Area, March 10, 2003



Source: Canadian Ice Service 2003.

The annual frequency of occurrence of icebergs for the area 46° to 47°40'N and 56° to 60°W (which contains the SEA Area) is shown in Figure 3.23. Results are presented for small (upper left panel), medium (upper right), large (lower left), and very large (lower right) icebergs where the size groupings are as follows:

- Small icebergs: 5 to15 m height above sea level; 15 to 60 m width or length;
- Medium icebergs: 16 to 45 m height above sea level; 61 to 120 m width or length;
- Large icebergs: 46 to 75 m height above sea level; 121 to 200 m width or length; and
- Very large icebergs: ≥75 m height above sea level; ≥200 m width or length.

The iceberg frequency of occurrence is low and sparse (Figure 3.23), reaching 12 percent for small and large icebergs which are localized to the northwest and southeast respectively. This frequency corresponds to one iceberg every eight years. Medium icebergs are located generally to the east and west (i.e., few icebergs in the middle of the SEA Area, with a frequency of approximately 4 to 5 percent, which corresponds to one iceberg every 20 to 25 years).

3.6 Atmospheric Circulation

3.6.1 General Atmospheric Circulations

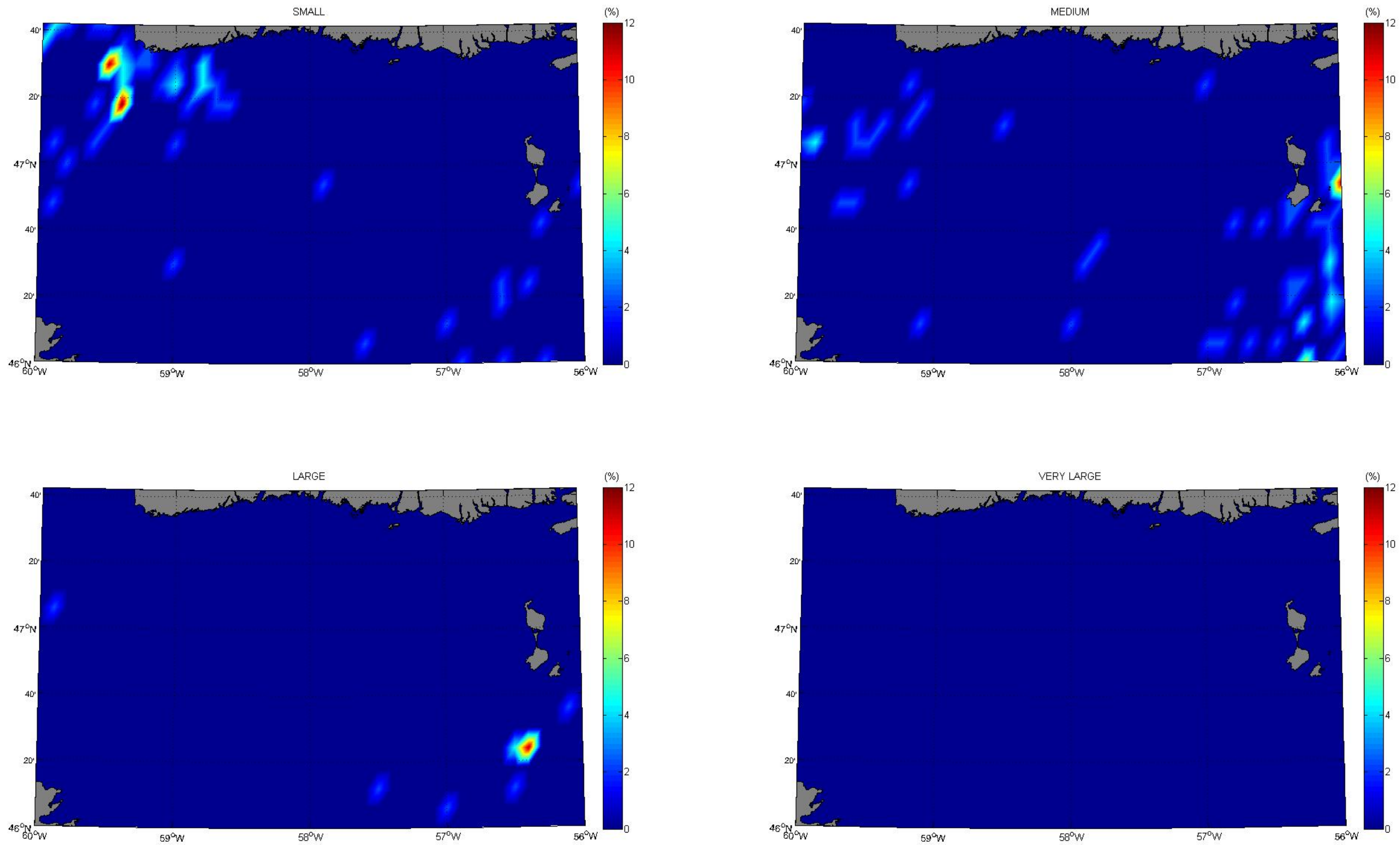
A project-specific environmental assessment should include a description of general atmospheric circulations (see Section 6.4).

3.6.2 Tropical Storms

Hurricanes and tropical storms (tropical cyclones) are among the most dangerous of all storms faced by the mariner. The pattern of tropical cyclones over Atlantic Canada is illustrated in Figure 3.24. The SEA Area lies generally in a region subject more to secondary tracks rather than primary tracks that continue over the northern Grand Banks. While rare occurrences, the frequency of these storms is unpredictable. In some years there are none: five hurricanes and three tropical depressions hit the region in 1969. The average number of tropical cyclones per year reported here (shown in red) is approximately 0.4 to 0.6, compared with the Grand Banks values of 0.75 to 1.0 (Bowyer 1995), although it is believed these numbers may be low compared with the past 10 years or so, consistent with the multi-decadal signal[1]. This should still provide a general picture of the tropical cyclone path characteristics of the region.

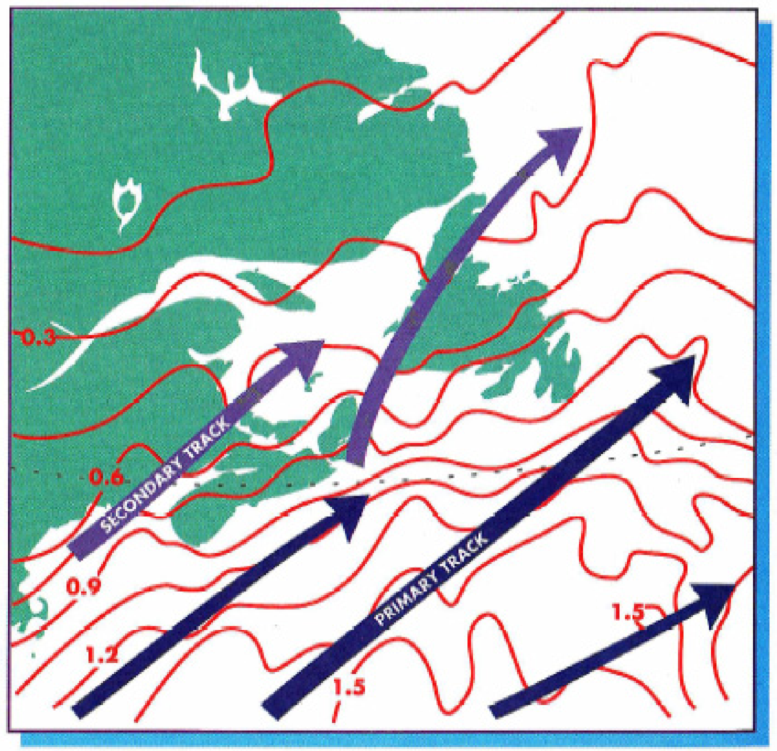
[1] In NOAA's recent update to the Atlantic Hurricane Season Outlook (NOAA 2006), it is noted that the Expected Climate Conditions include an active multi-decadal signal and above-average Atlantic Ocean temperatures, and of note here is that "All of the Atlantic hurricane seasons since 1995 have been above normal, with the exception of two moderate to strong El Niño years (1997 and 2002). This contrasts sharply with the 1971 to1994 period of generally below-normal activity."

Figure 3.23 Annual Iceberg Frequency of Occurrence and Geographic Extent between 1980 and 2005



Source: International Ice Patrol 2006.

Figure 3.24 Primary and Secondary Tropical Cyclone Tracks Through Atlantic Canada



Source: Bowyer 1995.
Note: The average number of tropical cyclones per year that brought gale-force (63 to 74 kmh (34 to 40 knots)) winds to some part of the region are shown in red.

3.7 Planning Implications (Effects of the Environment on the Project)

3.7.1 Geology

The Laurentian Channel region (including the SEA Area) is generally regarded as the most seismically active portion of the Newfoundland Continental Shelf. Over the past 100 years, there have been a number of significant earthquakes in the region (although not in the SEA Area specifically). Specific faults and earthquake areas in the SEA Area are reasonably well known, so the probability of a significant geological event over the short (40 to 60 days to drill a well) duration of the exploration activities is relatively low. However, seismicity should remain an important planning and design consideration for any future offshore petroleum activity in the SEA Area.

3.7.2 Climatology, Winds, Waves, Temperature, and Salinity

The wind and wave climates for the SEA Area, although for example not as potentially severe as other East Coast regions such as the Grand Banks, should be considerations for drilling rig selection and for operations. Time of year will be a factor. For example, in January there is a 20 to 30 percent chance of gales, compared with 1 to 2 percent in June. Extreme waves occur in all of Atlantic Canada's waters and for most of the SEA Area in February, with wave heights greater than 2 m for 50 percent of the time. The highest instrumentally measured deep-water wave of 30.7 m was, reported by a Nomad Weather Buoy on the East Scotian Shelf during the Halloween Storm of 1991 (Bowyer 1995).

The North Atlantic is well-known for the sudden development of frontal lows. Gale-force storms are 10 times more likely to accompany these systems in the winter than summer. Storm-force storms which are rare in summer occur from one to four percent of the time in winter. Tropical storms which can produce extreme wind and sea conditions are further mentioned in Section 3.6.2.

The effect of forecasted high winds and seas is generally to limit operations or activities offshore. Depending on the rig or vessel, nature of activities or operations and of course the weather itself, the effect may be significant or not. Clearly, having appropriate forecasting and monitoring programs in place goes a long way to mitigating this type of risk. A careful review of expected normal and extreme conditions is a prerequisite for any vessel operating offshore. Extended periods of reduced visibility may be such that helicopter or other logistics activities are disrupted. Any activities sensitive to large currents may need to be supported by in situ current monitoring and current or tide prediction.

3.7.2.1 Vessel Icing and Fog

Vessel icing due to freezing spray accompanied by strong winds, low temperatures and high seas is a winter hazard, with the potential for moderate icing or worse 15 to 20 percent of the time in January and February, 5 to 10 percent in March, and 5 percent in December. For freezing spray to occur air temperatures must be 2°C or colder and sea temperatures less than 5°C. Ice accretion is also directly proportional to the wind speed and sea state. A nomogram depending on these factors can be used to predict icing potential. Ice accretion due to freezing precipitation and ice fog is also possible but generally these are less of a contributor than freezing spray.

Freezing rain occurs when rain from warmer air aloft falls through a cold surface layer and hits the sub-zero temperatures of a vessel’s superstructure, forming a clear glaze of ice over decks, railings, stairways, windows, and equipment. Due to the moderating influence of the sea on air temperatures, the occurrence of freezing precipitation offshore is low (higher for coastal locations). From January through April, moderate to heavy freezing rain might be expected for one percent of all precipitation events. By comparison, St. John’s shows the highest frequencies of freezing precipitation, approximately 3.6 percent of precipitation observations in February.

The presence of snow (icing events are frequently accompanied by flurries or snowsqualls) can add to the ice loading although it does not affect the spray itself.

Ice fog or arctic sea smoke occurs when cold air is blown over relatively warmer waters. This fog is composed of tiny super-cooled water droplets which freeze on contact with a structure. Ice fog poses a serious icing risk only when atmospheric conditions are just right.

Factors such as the size, weight, hull design, and amount of equipment and superstructure exposed to the elements, and the vessel’s speed and heading into the wind will also determine the amount of icing experienced. Vessel icing potential is less as one moves to the South nearer warmer Scotian Slope waters and greater as one moves closer to the cooler waters of the Gulf of St. Lawrence.

Conversely, fog is less of an occurrence for the SEA Area, where in July visibility is reduced to 0.9 km (0.5 nautical miles) or less 20 to 30 percent of the time, compared to a 40 to 50 percent of the time on the Grand Banks (Bowyer 1995).

3.7.2.2 Precipitation and Temperatures

Precipitation is likely 30 to 40 percent of the time in January over the SEA Area, perhaps slightly more frequent than for the Grand Banks and 5 to 10 percent of the time in July, comparable to the Grand Banks. Air temperatures are slightly colder over the SEA Area in February compared with the Grand Banks, where the February mean is -2.5°C, compared with approximately 0°C near Hibernia, Terra Nova and White Rose. Conversely, summer temperatures are approximately 2.5°C warmer, where the August mean is approximately 17.5°C. Sea surface temperatures are similarly slightly cooler in the winter and warmer in the summer compared with the Grand Banks. The mean sea surface temperature is approximately 0°C for most of the SEA Area in February and 16°C in August (Bowyer 1995).

3.7.3 Ice Management

Operators are typically required to submit an ice management plan as per the *Guidelines Respecting Physical Environmental Programs during Petroleum Drilling and Production Activities on Frontier Lands* (which are currently being revised) (NEB et al. 1994). The guidelines clearly indicate all reporting requirements associated with the plan.

3.8 Unexploded Ordinance

There is one potential site within the SEA Area for which there may be the possibility of unexploded ordinances (UXO). The potential UXO site is the wreck of the *HMCS Shawinigan*. The exact position for this site is unknown, as historical review and site survey to date have not yet located the wreck of *HMCS Shawinigan*. This ship was a flower class corvette used to escort convoys in the Atlantic Ocean during the Second World War. After safely completing a routine escort of the Newfoundland Ferry, the *Burgeo*, from Nova Scotia to Port Aux Basques on November 24, 1944, *HMCS Shawinigan* returned to regular patrol duties and was torpedoed by U-1228. The position where the ship sank is thought to be in the Cabot Strait, near Port Aux Basques, at approximately 47°34"N 59°11"W as illustrated on Figure 3.25.

In addition, the SEA Area corresponds primarily with MARLANT OP Area Quebec 1, where Canadian Naval Vessels conduct various exercises on a year-round basis.

Figure 3.25 Potential Unexploded Ordinances within the Strategic Environmental Assessment Area