# FIGURES

## LIST OF FIGURES

Figure 1.1 General location plan ..... F1

Figure 1.2 Location of sites under consideration along the Estuary of the St. Lawrence River, from Quebec to Tadoussac ..... F2

Figure 3.1 Sample of a Regional Ice Chart for Eastern Canada (January 19, 1973) ... F3

Figure 3.2 St. Lawrence River Ice Chart WIS 91, dated February 2, 2003 ..... F4

Figure 3.3 St. Lawrence River Ice Chart WIS 92, dated February 25, 2003 ..... F5

Figure 3.4 St. Lawrence River Ice Chart WIS 93, dated March 13,1993 ..... F6

Figure 3.5 St. Lawrence River Ice Chart WIS 94, dated January 18, 1993..... F7

Figure 3.6 Identification of ice using the “egg” code..... F8

Figure 3.7 Frequencies of total ice concentrations by month Average for 6 sites ..... F9

Figure 3.8 Frequencies of total ice concentrations by month - Ultramar ..... F9

Figure 3.9 Frequencies of total ice concentrations by month – Pointe-de-la-Martinière..... F10

Figure 3.10 Frequencies of total ice concentrations by month – Pointe- Saint-Vallier ..... F10

Figure 3.11 Frequencies of total ice concentrations by month - Kamouraska ..... F11

Figure 3.12 Frequencies of total ice concentrations by month - Cacouna ..... F11

Figure 3.13 Frequencies of total ice concentrations by month – Ile Verte ..... F12

Figure 3.14 Frequencies of total average ice concentrations by site ..... F12

Figure 3.15 Frequencies of maximum ice thickness by month – Ultramar ..... F13

Figure 3.16 Frequencies of maximum ice thickness by month – Pointe-de-la-Martinière..... F13

Figure 3.17 Frequencies of maximum ice thickness by month – Pointe Saint-Vallier F14

Figure 3.18 Frequencies of maximum ice thickness by month - Kamouraska ..... F14

Figure 3.19 Frequencies of maximum ice thickness by month - Cacouna ..... F15

## LIST OF FIGURES

Figure 3.20 Frequencies of maximum ice thickness by month – Ile Verte..... F15

Figure 3.21 Frequencies of maximum ice thickness by month – 6 sites ..... F16

Figure 3.22 Frequencies of maximum average ice thickness by site ..... F16

Figure 3.23 Frequencies of maximum floe size by month – Ultramar ..... F17

Figure 3.24 Frequencies of maximum floe size by month – Pointe-de-la-Martinière . F17

Figure 3.25 Frequencies of maximum floe size by month – Pointe Saint-Vallier ..... F18

Figure 3.26 Frequencies of maximum floe size by month - Kamouraska..... F18

Figure 3.27 Frequencies of maximum floe size by month - Cacouna ..... F19

Figure 3.28 Frequencies of maximum floe size by month – Ile Verte ..... F19

Figure 3.29 Frequencies of maximum floe size by month– 6 sites..... F20

Figure 3.30 Frequencies of maximum average floe size by site ..... F20

Figure 3.33 Average ice thickness from ice charts, by year..... F21

Figure 3.34 Average floe size from ice charts, by year..... F21

Figure 3.35 Average size and average thickness from ice charts, by year – 3 "north" sites..... F22

Figure 3.36 Relationship between average size and average thickness from ice charts 3 "north" sites – 1983 to 2003..... F22

Figure 5.1 Delimitation of wave climate zones in Estuary and Gulf of St. Lawrence F23

Figure 5.2 Wind roses at Île Rouge for winter months (Jan, Feb and March) ..... F24

Figure 5.3 Wind roses at a site in wave zone V for winter months (Jan, Feb and March)..... F24

Figure 5.4 Legend for climatological charts (for figures 5.5, 5.6 and 5.7) ..... F25

Figure 5.5 Climatological chart of the Estuary of the St. Lawrence for January ..... F26

Figure 5.6 Climatological chart of the Estuary of the St. Lawrence for February ..... F26

Figure 5.7 Climatological chart of the Estuary of the St. Lawrence for March..... F27

## LIST OF FIGURES

Figure 5.8 Accumulated freezing-degree-days (FDDs) at selected meteorological stations, 1955 to 2003 ..... F28

Figure 6.1 Typical tidal curves - Estuary of the St. Lawrence River ..... F29

Figure 6.2 Bathymetry of St. Lawrence Estuary from Quebec to Tadoussac..... F30

Figure 6.3 Tidal current patterns at « South » sites of Pointe-de-la-Martinière and Pointe-Saint-Vallier, 3 to 4 hours after high water at Québec..... F31

Figure 6.4 Tidal current patterns at Kamouraska, 0 to 1 hour after low water at Pointe-au-Père ..... F31

Figure 6.5 Tidal current patterns at Cacouna and Île Verte, 0 to 1 hour after low water at Pointe-au-Père ..... F32

Figure 6.6 Tidal current patterns at Gros Cacouna and Île Verte, 3 to 2 hours before high water at Pointe-au-Père ..... F32

Figure 6.7 Tidal current patterns at Cacouna and Île Verte, 1 to 0 hour before high water at Pointe-au-Père ..... F33

Figure 8.1 Escort and De-icing – Canadian Coast Guard, Laurentian Zone Statistics of operational program (1990-2002) ..... F34

Figure 8.2a Ranking of winters from weather data at Mont-Joli ..... F35

Figure 8.2b Ranking of winters from weather data at Québec..... F35

Figure 8.3 Ranking of winters from ice thickness on ice charts ..... F36

Figure 8.4 Ranking of winters from floe size on ice charts..... F36

Figure 8.5 Zones for ice conditions statistics in Estuary and Gulf of St. Lawrence .. F37

Figure 8.6 Total Accumulated Seasonal Ice Coverage – Gulf of St Lawrence ..... F38

Figure 8.7 Ranking of winters from volume of ice produced – Gulf of St. Lawrence F38

Figure 9.1 Cumulated freezing degree-days (FDDs) – selected seasons and locations ..... F39

Figure 9.2 Daily average wind speed at Mont Joli during winter 2003 ..... F40

Figure 9.3 Daily average wind direction at Mont Joli during winter 2003 ..... F41

Figure 9.3 Daily wind direction – Winter 2003..... F41

## LIST OF FIGURES

Figure 9.4 Ice chart dated February 22 2003 – Ultramar and Pointe-de-la-Martinière..... F42

Figure 9.5 Ice chart dated March 22 2003 – Ultramar and Pointe-de-la-Martinière .. F43

Figurere 9.6 Ice chart dated January 13 2003 – Kamouraska..... F44

Figure 9.7 Ice chart dated January 21 2003 – Kamouraska ..... F45

Figure 9.8 Ice chart dated January 27 2003 - Kamouraska ..... F45

Figure 9.8 Ice chart dated January 27 2003 - Kamouraska ..... F46

Figure 9.9 Ice chart dated January 17 2003 - Cacouna ..... F47

Figure 9.10 Ice chart dated January 30 2003 - Cacouna..... F48

Figure 9.11 Ice chart dated February 1 2003 - Cacouna ..... F49

Figure 9.12 Ice chart dated February 10 2003 – Cacouna and Île Verte ..... F50

Figure 10.1 Regional map of the Ice Severity Index in the Gulf of St. Lawrence for March 20 2003 ..... F51

Figure 10.2 Regional map of the Total Ice Concentration in the Gulf of St. Lawrence for March 20 2003..... F51

Figure 10.3 Regional map of the Ice Thickness in the Gulf of St. Lawrence for March 20 2003 ..... F52

Figure 11.1 Aerial picture of Ultramar wharf taken on March 6, 2003 ..... F53

Figure 11.2 Big floes, approximately 60 cm thick, approaching the Quebec bridges, view from upstream, March 22, 2003 (courtesy Roger Provost, Canadian Ice Service). ..... F53

**Figure 1.1**
**General location plan**

**Figure 1.2**
**Location of sites under consideration along the Estuary of the St. Lawrence River, from Quebec to Tadoussac**

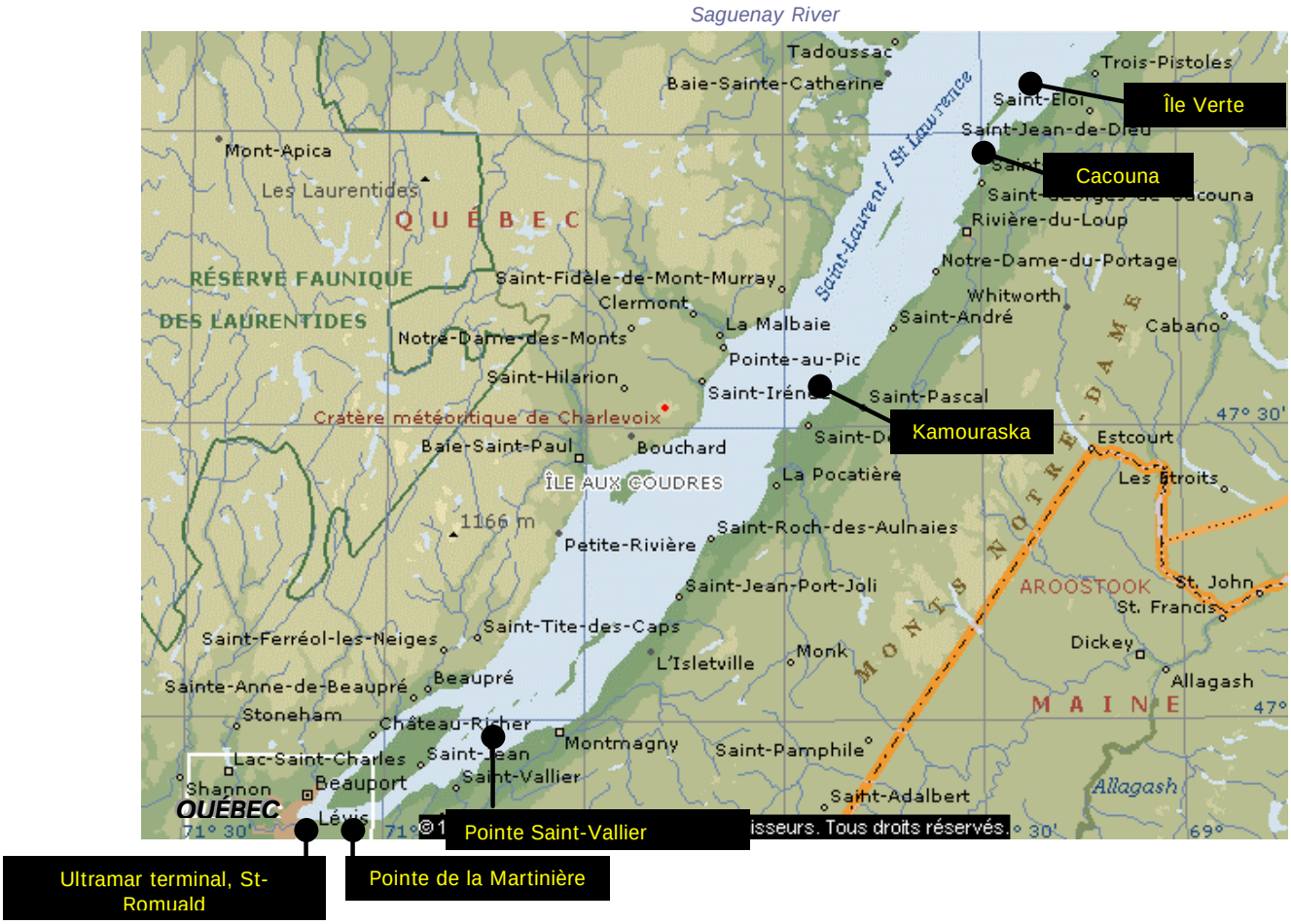

**Figure 3.1**
**Sample of a Regional Ice Chart for Eastern Canada (January 19, 1973)**

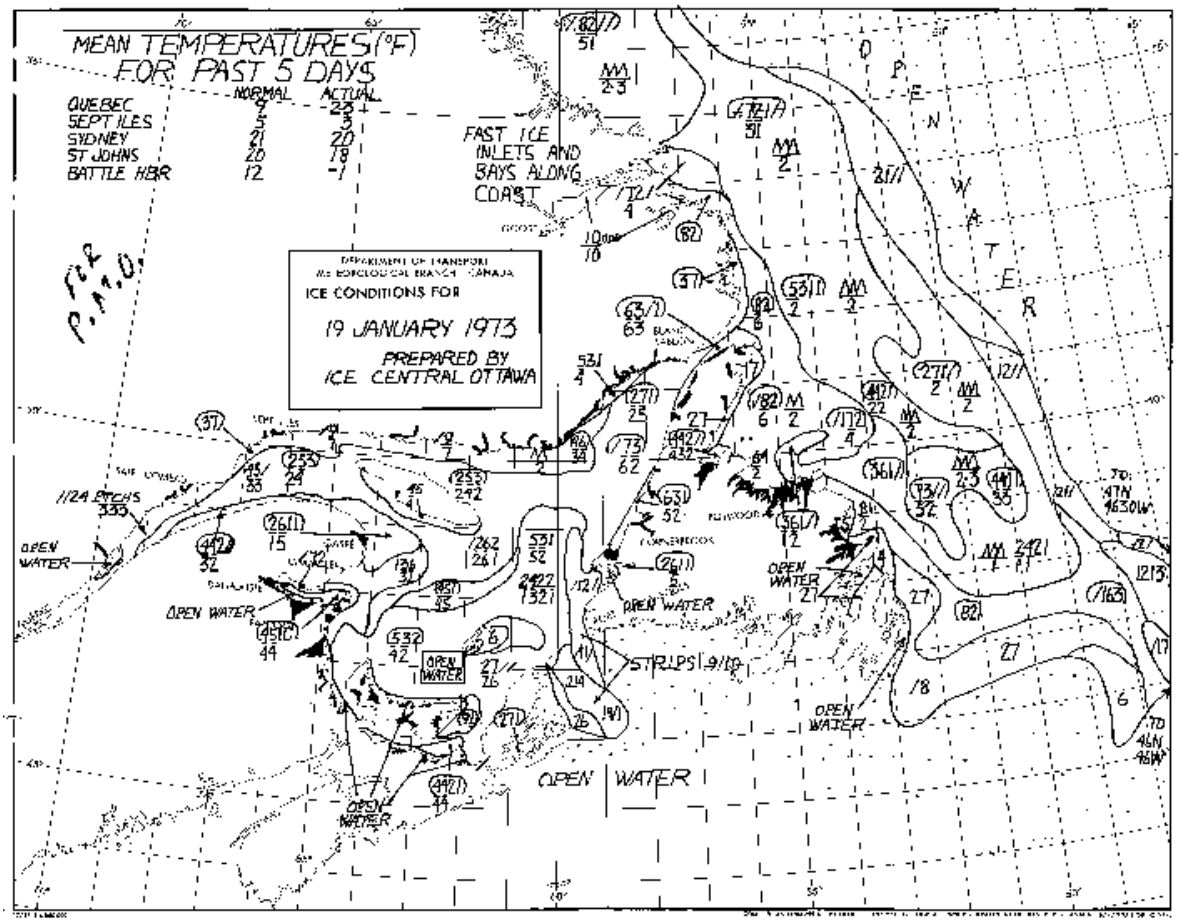

**Figure 3.2**
**St. Lawrence River Ice Chart WIS 91, dated February 2, 2003**

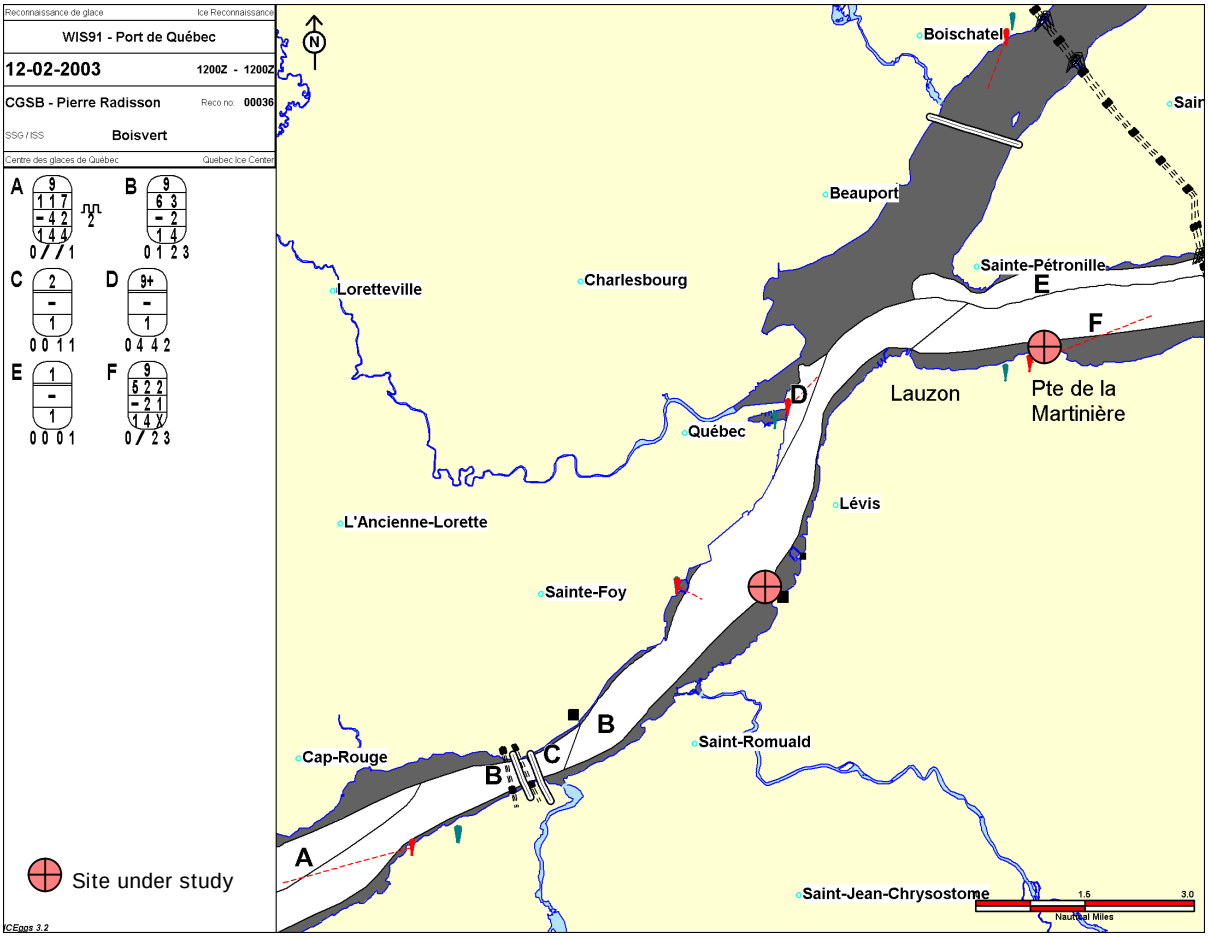

**Figure 3.3**
**St. Lawrence River Ice Chart WIS 92, dated February 25, 2003**

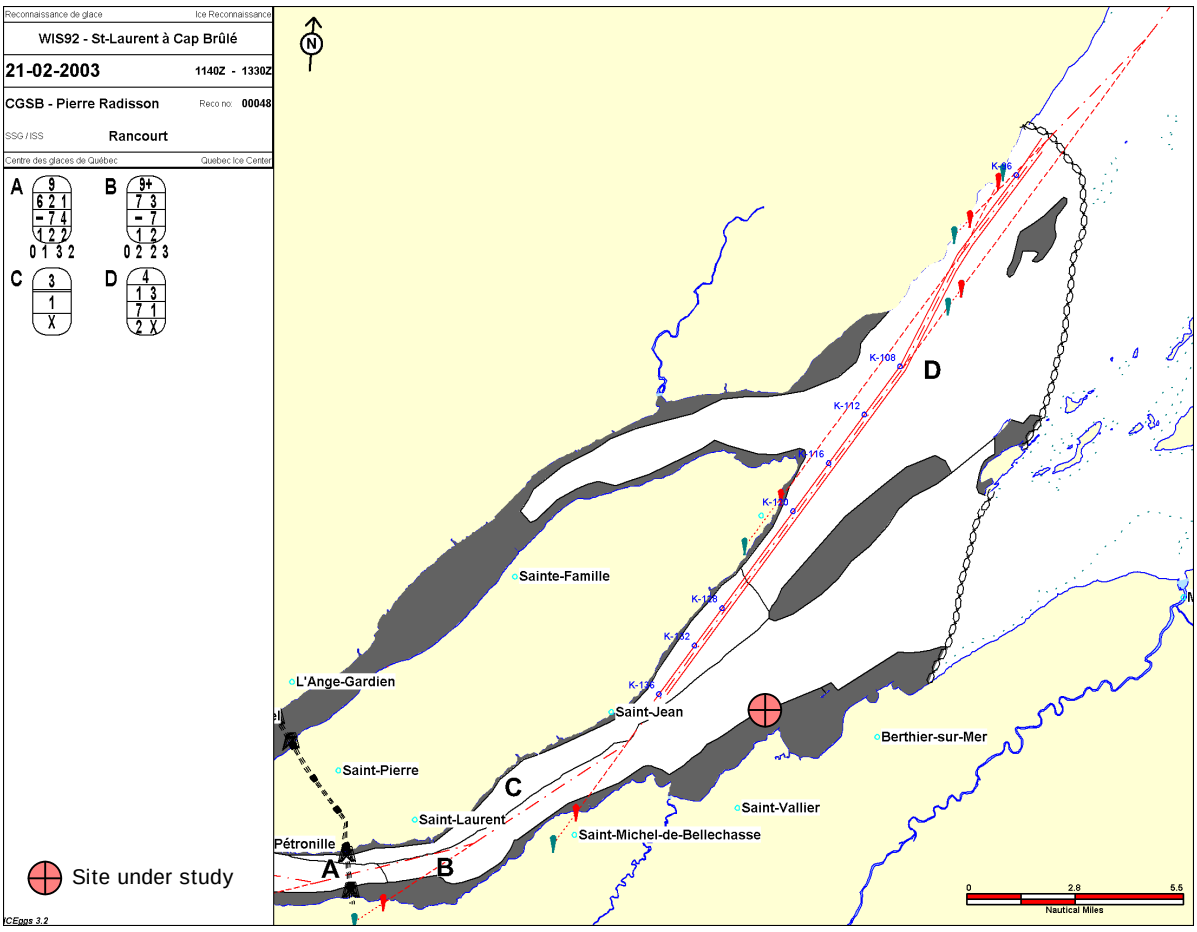

**Figure 3.4**
**St. Lawrence River Ice Chart WIS 93, dated March 13,1993**

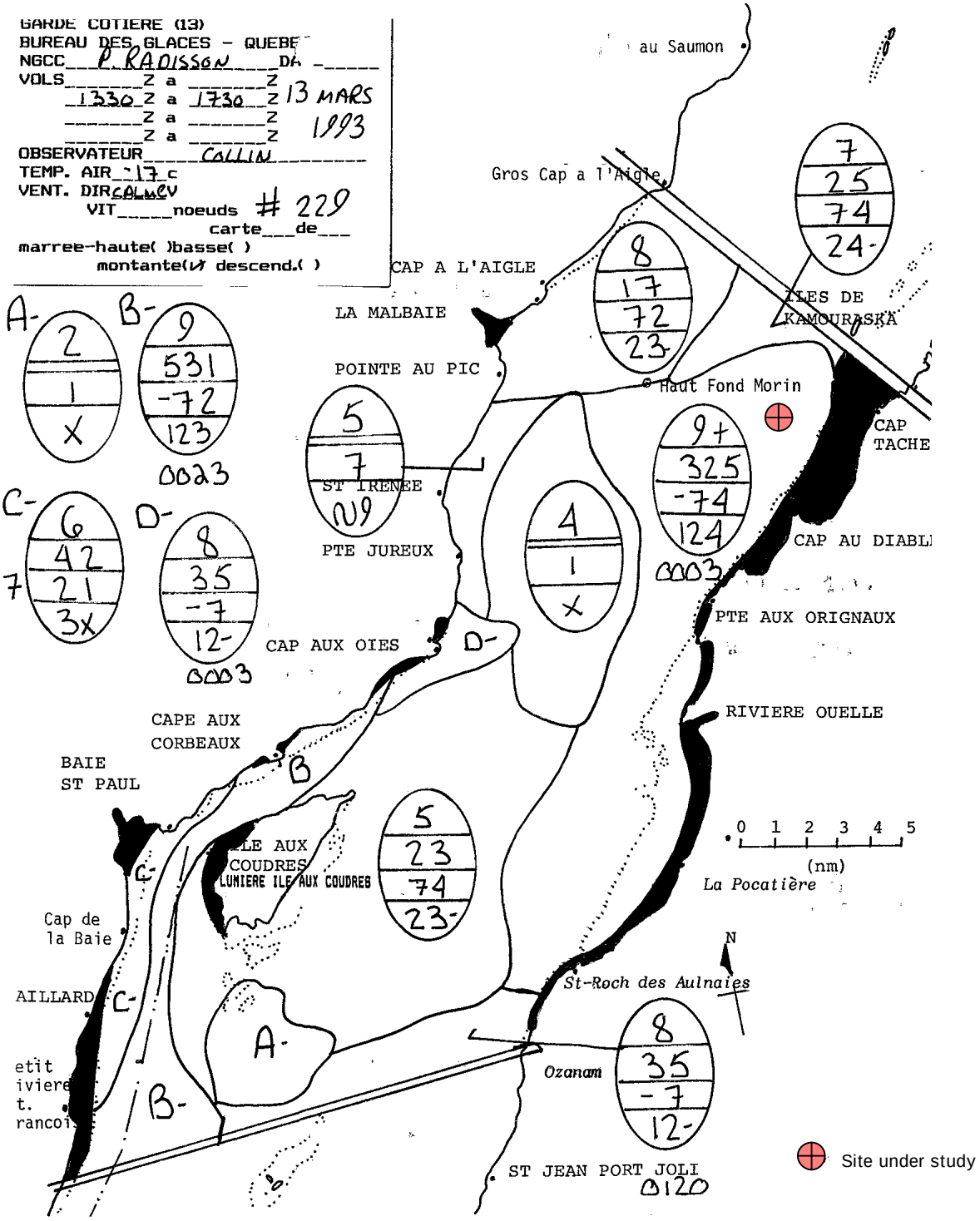

**Figure 3.5**
**St. Lawrence River Ice Chart WIS 94, dated January 18, 1993**

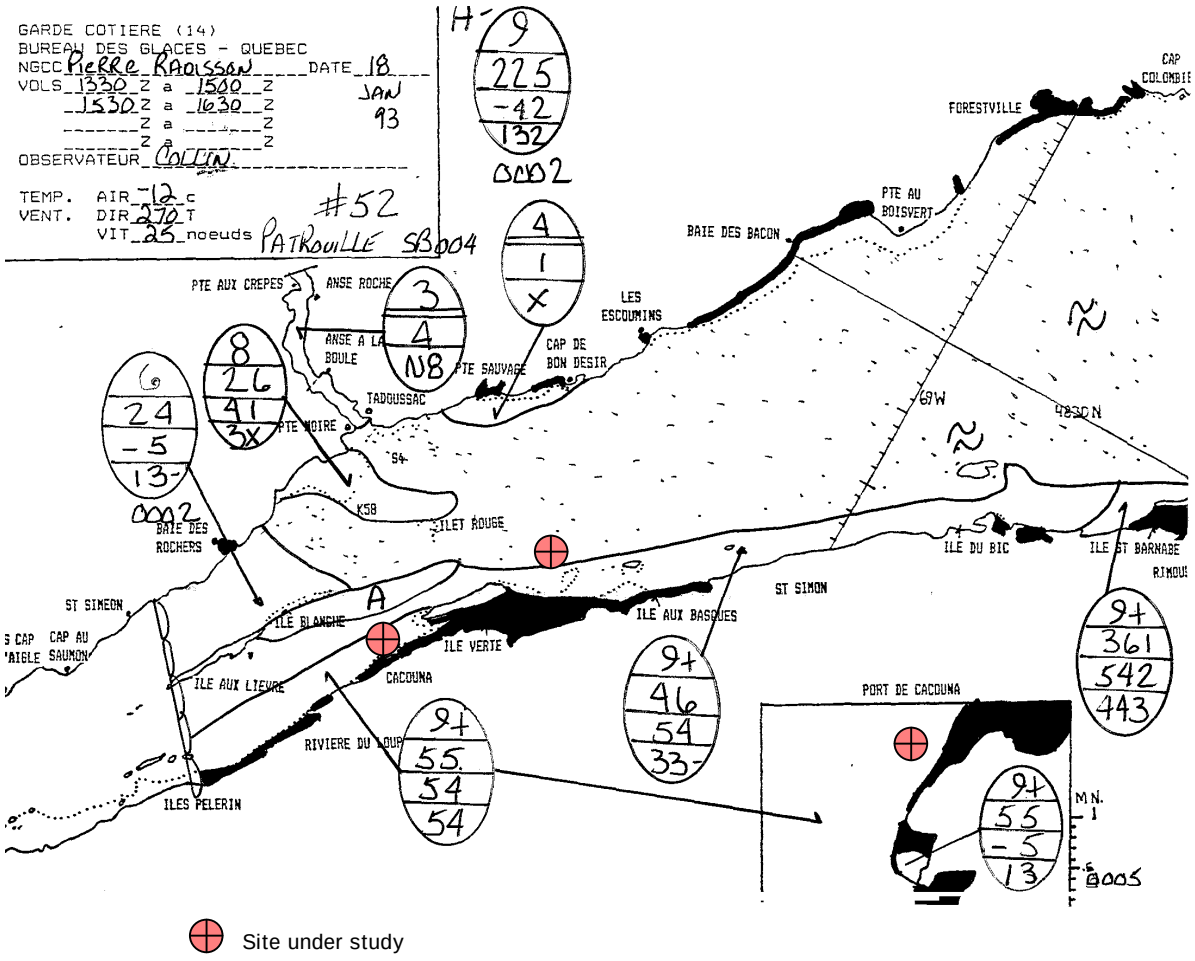

**Figure 3.6**
**Identification of ice using the "egg" code**

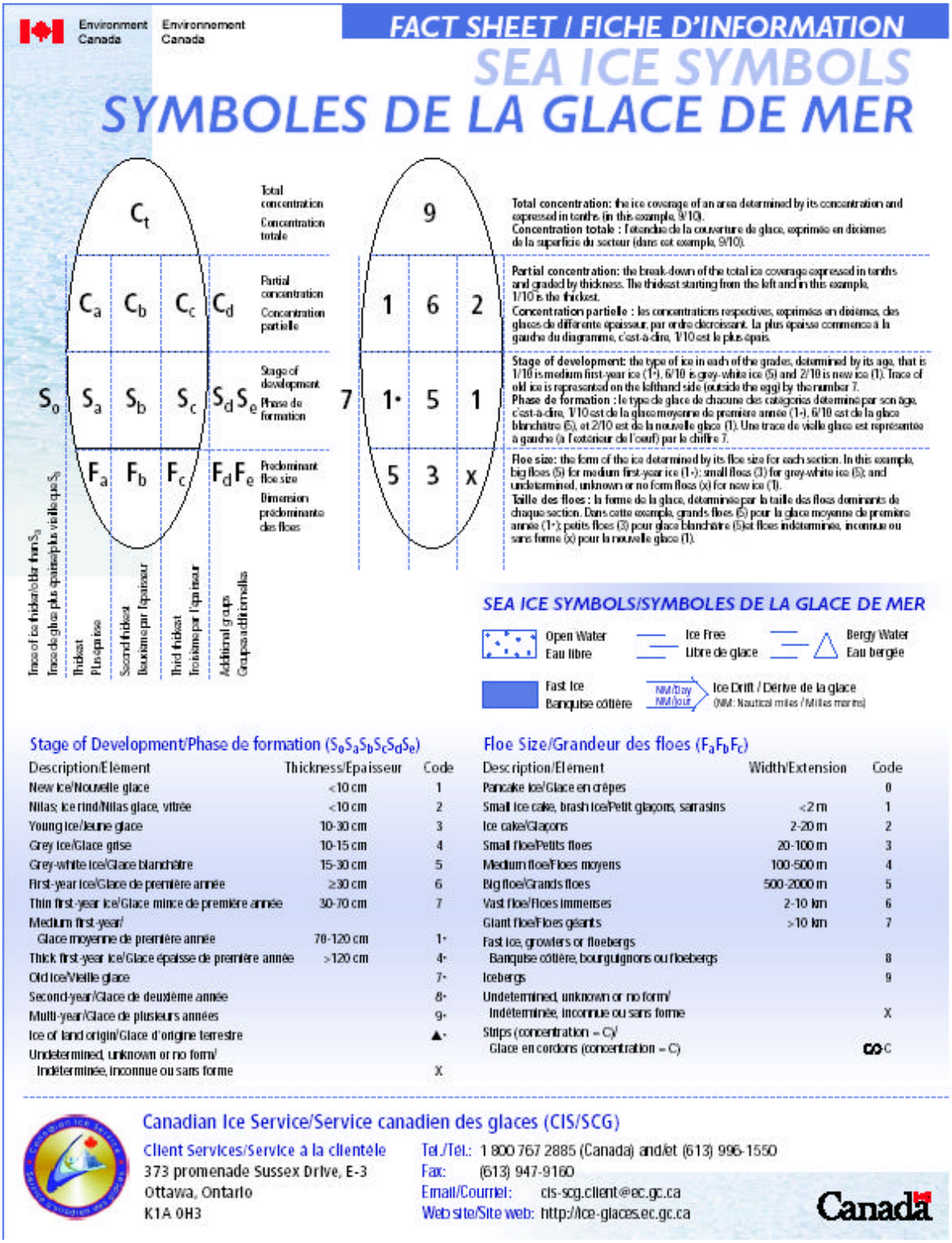

**Figure 3.7**
**Frequencies of total ice concentrations by month**
**Average for 6 sites**

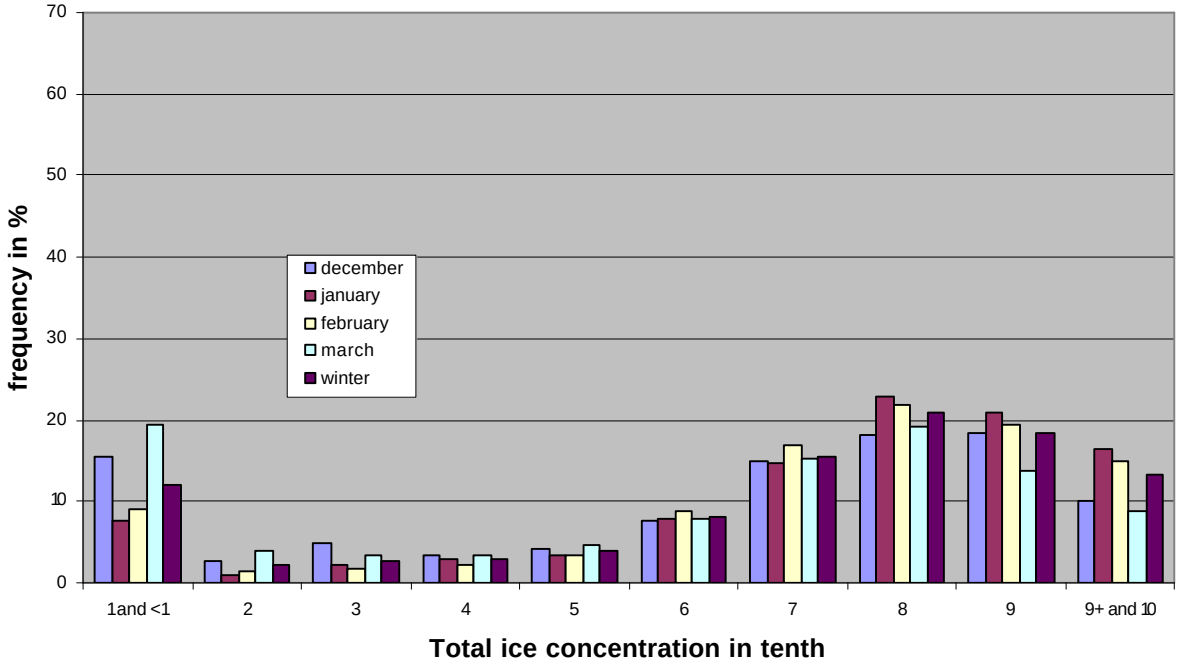


**Figure 3.8**
**Frequencies of total ice concentrations by month - Ultramar**

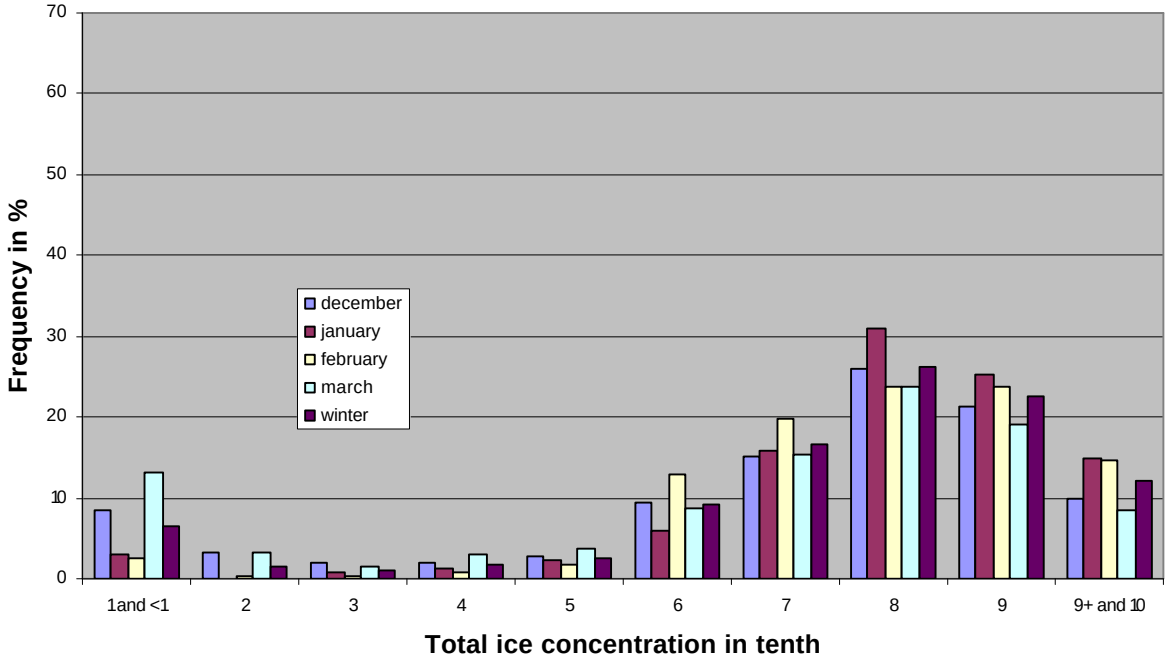

**Figure 3.9**
**Frequencies of total ice concentrations by month – Pointe-de-la-Martinière**

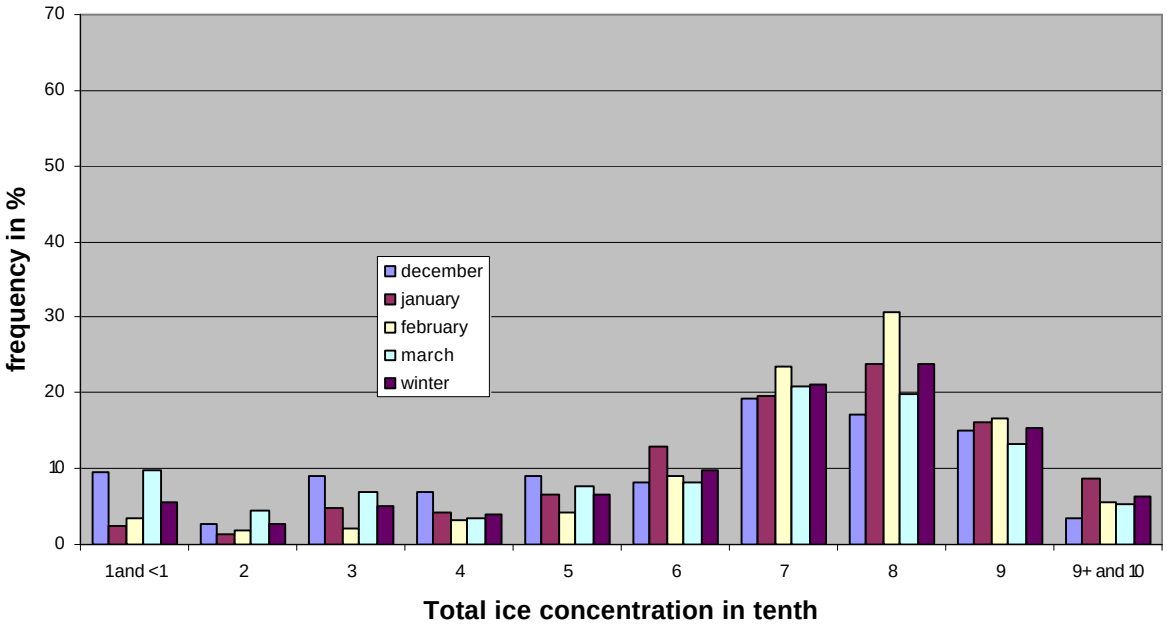


**Figure 3.10**
**Frequencies of total ice concentrations by month – Pointe- Saint-Vallier**

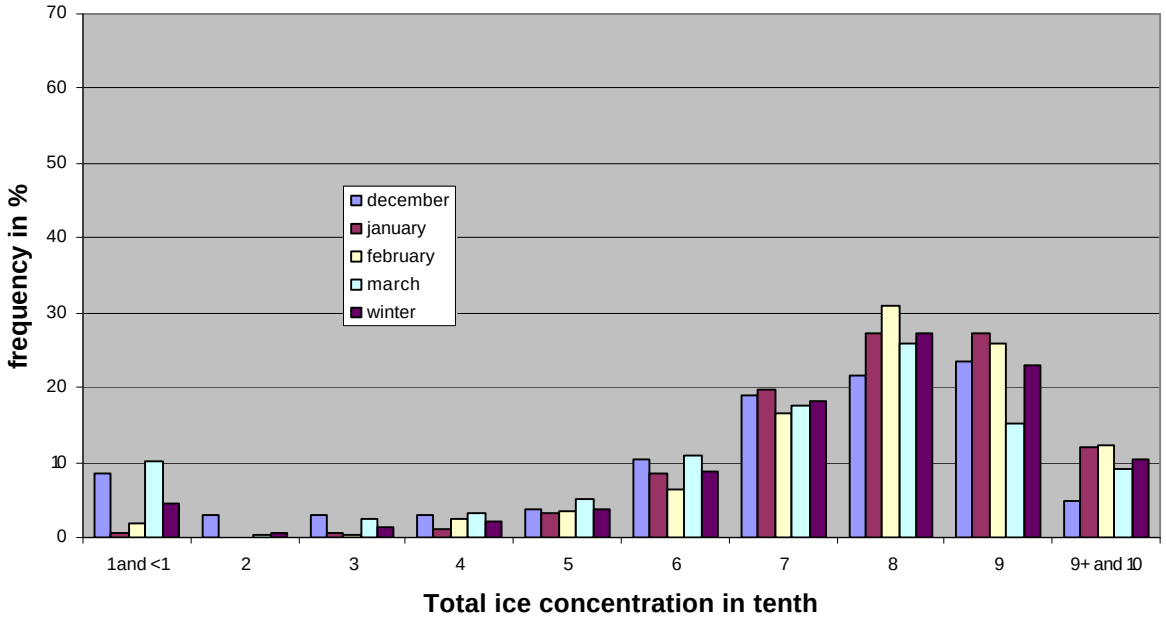

**Figure 3.11**
**Frequencies of total ice concentrations by month - Kamouraska**

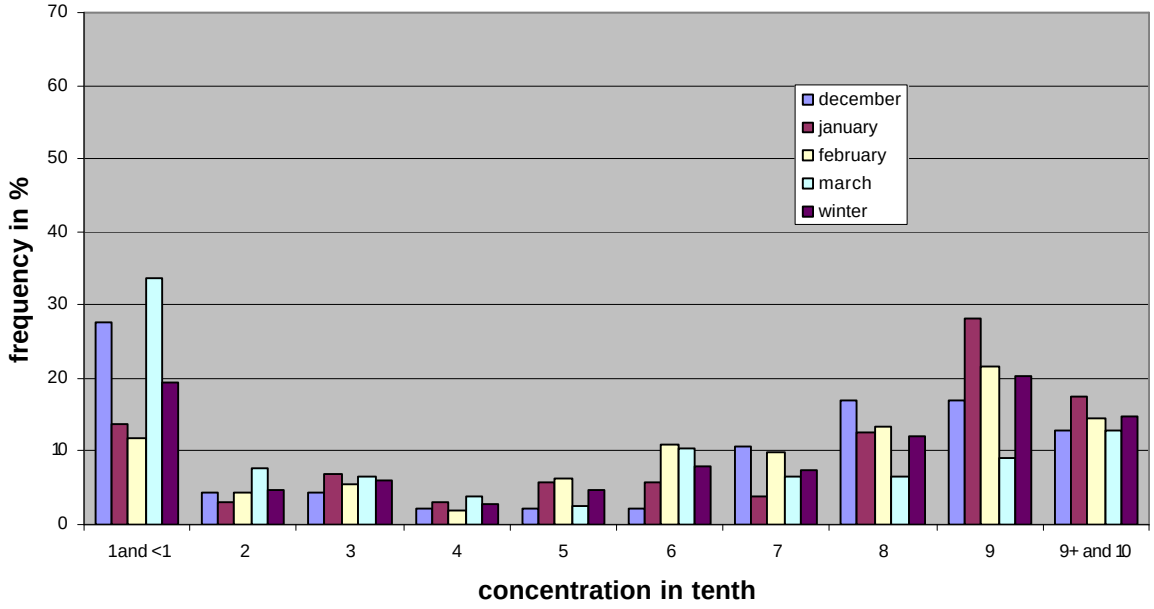


**Figure 3.12**
**Frequencies of total ice concentrations by month - Cacouna**

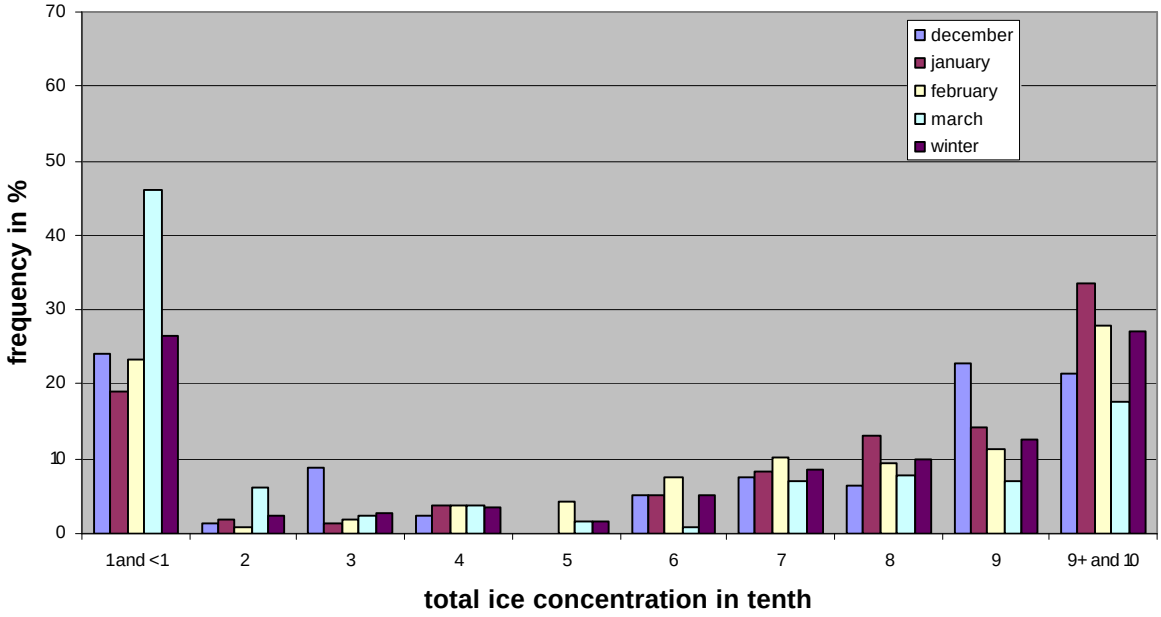

**Figure 3.13**
**Frequencies of total ice concentrations by month – Ile Verte**

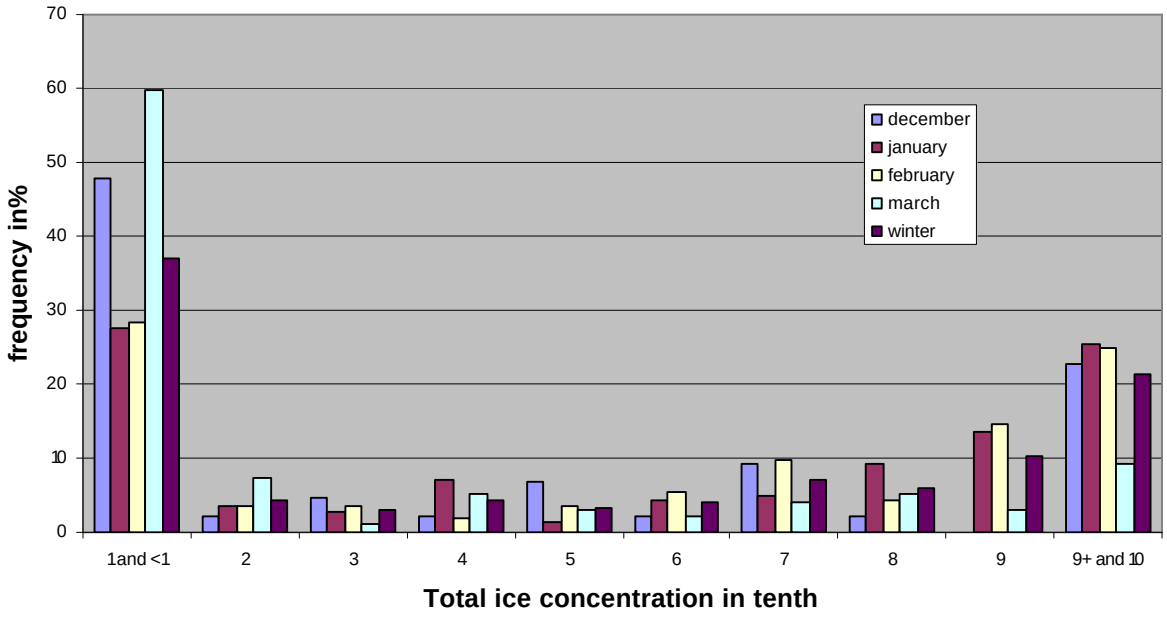


**Figure 3.14**
**Frequencies of total average ice concentrations by site**

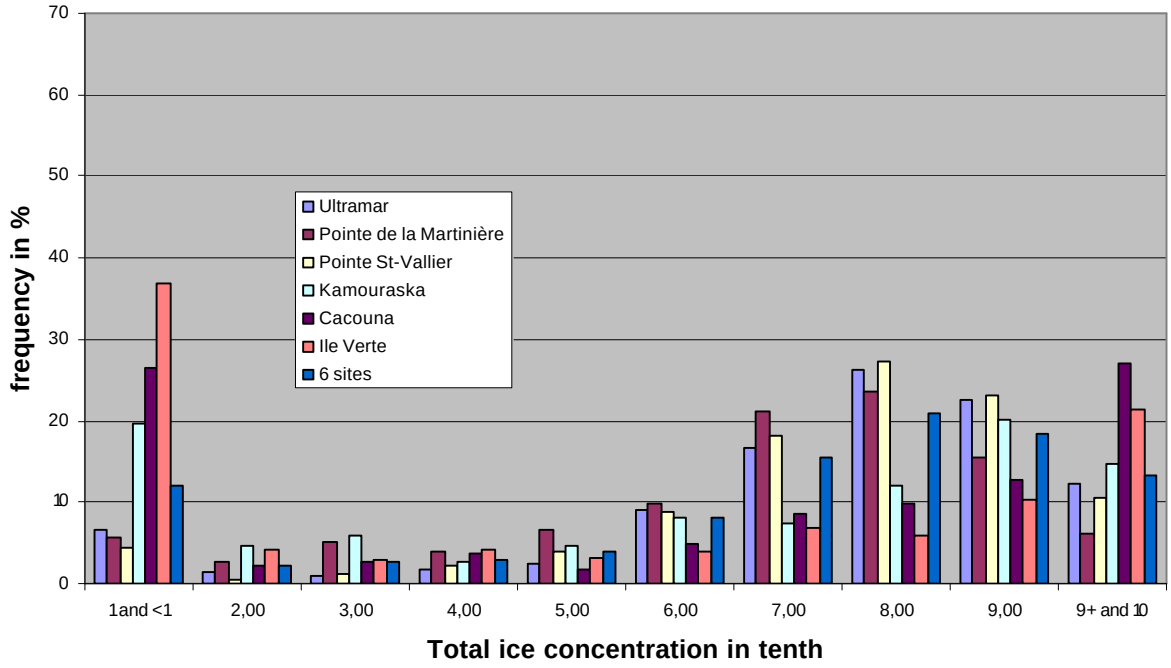

**Figure 3.15**
**Frequencies of maximum ice thickness by month – Ultramar**

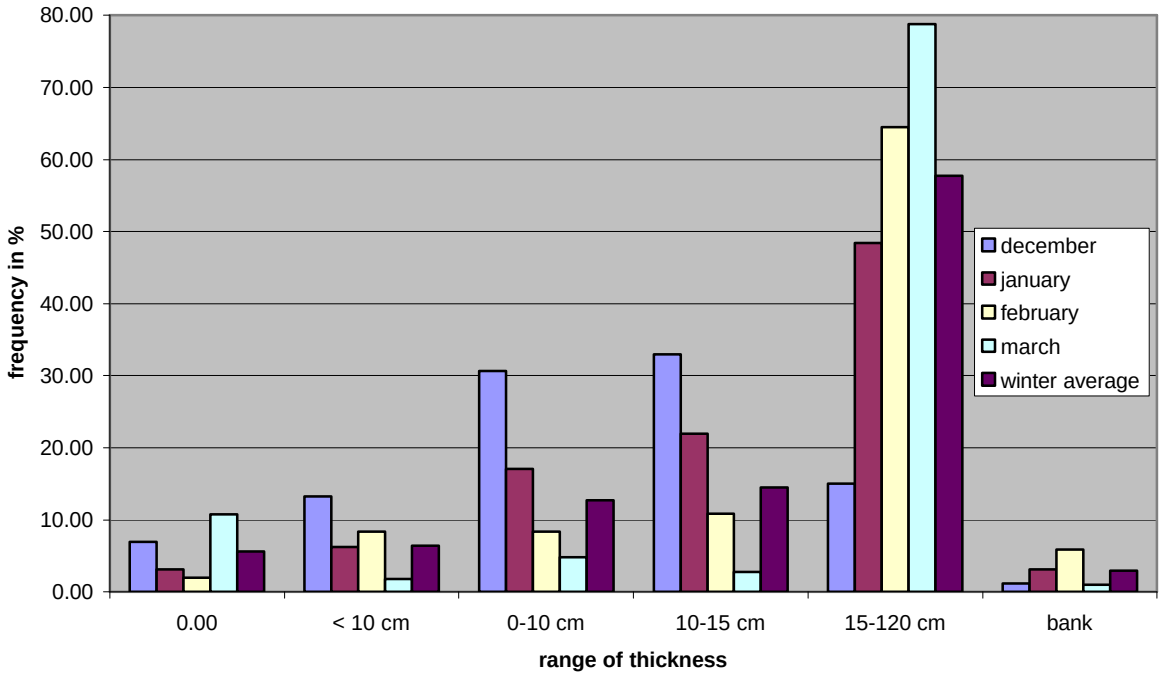


**Figure 3.16**
**Frequencies of maximum ice thickness by month – Pointe-de-la-Martinière**

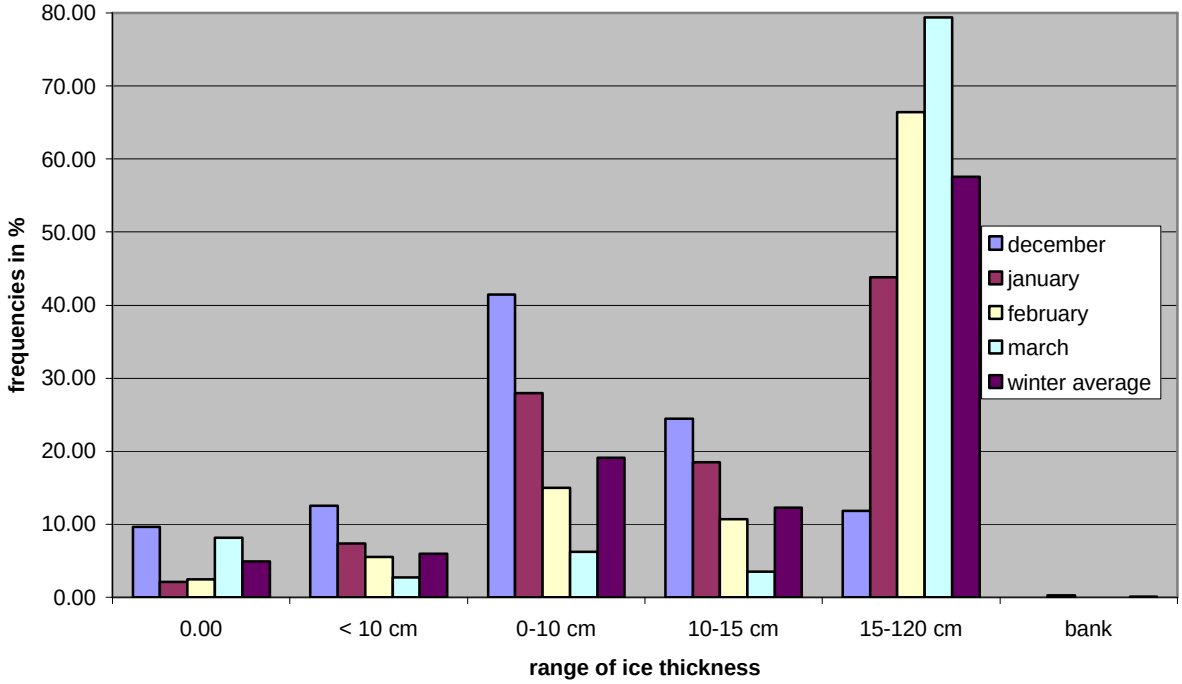

**Figure 3.17**
**Frequencies of maximum ice thickness by month – Pointe Saint-Vallier**

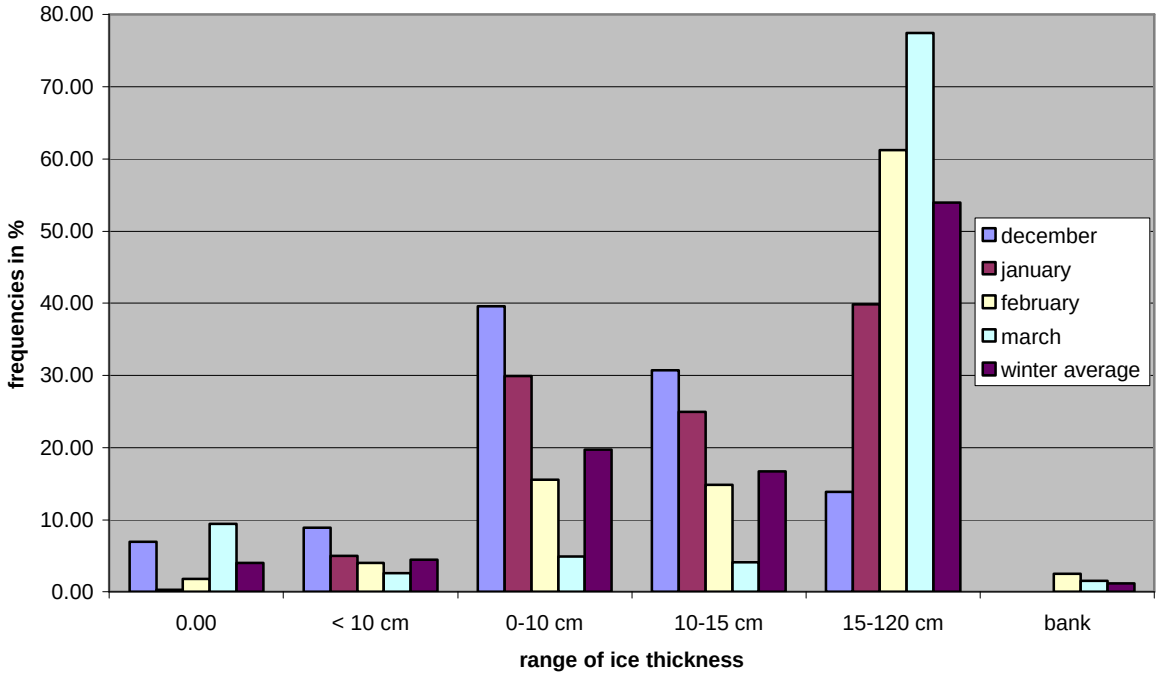


**Figure 3.18**
**Frequencies of maximum ice thickness by month - Kamouraska**

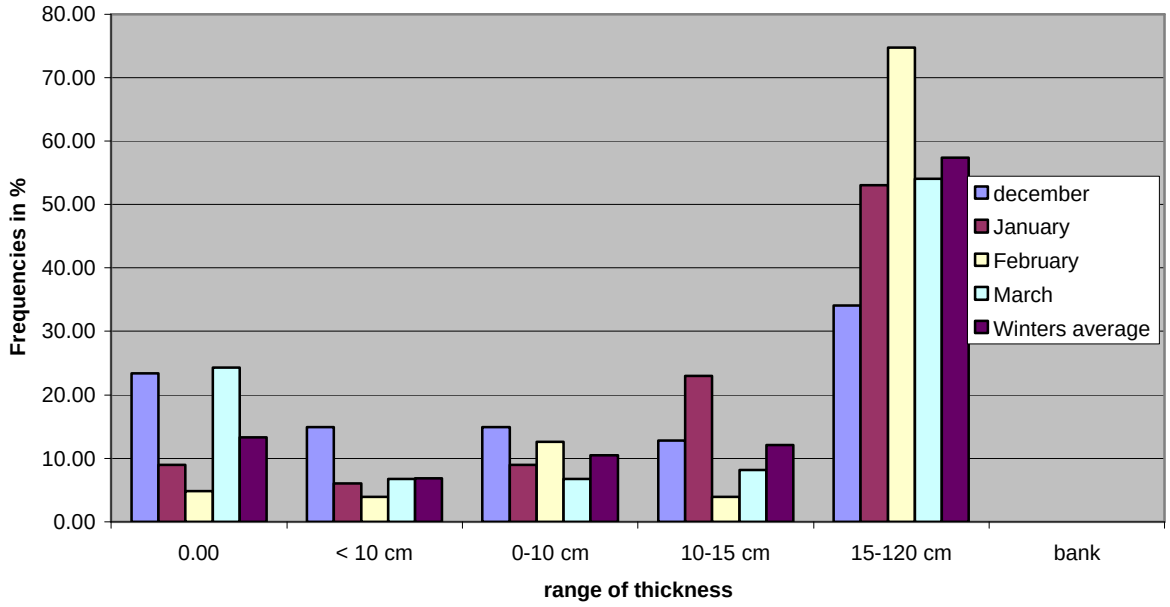

**Figure 3.19**
**Frequencies of maximum ice thickness by month - Cacouna**

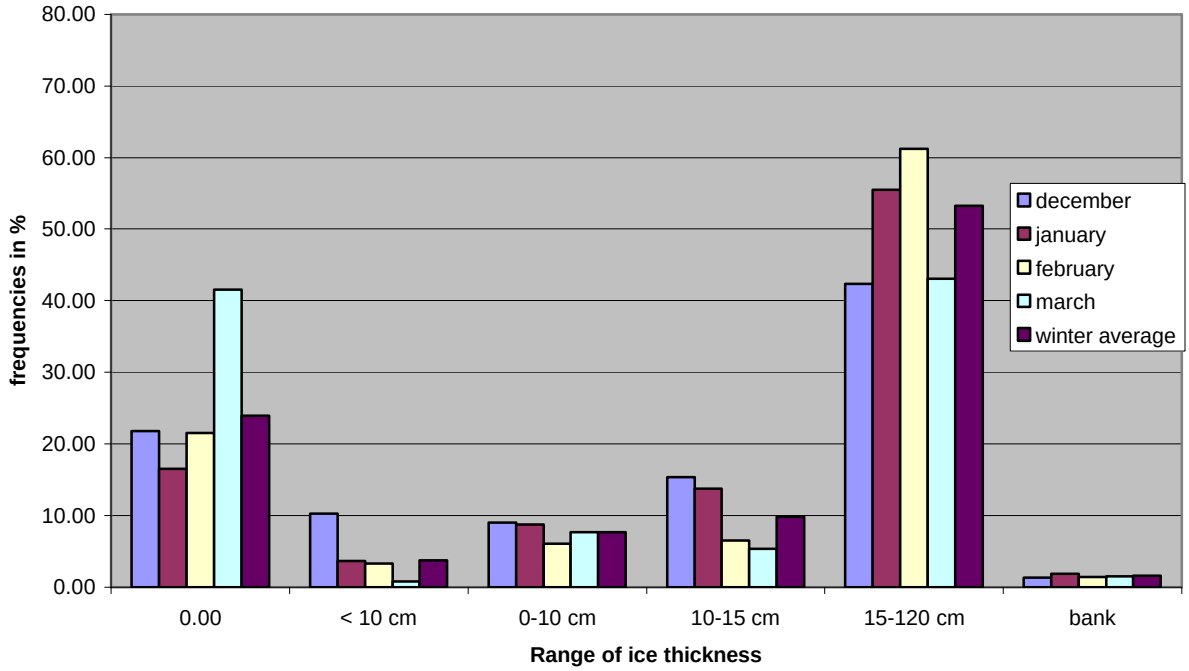


**Figure 3.20**
**Frequencies of maximum ice thickness by month – Ile Verte**

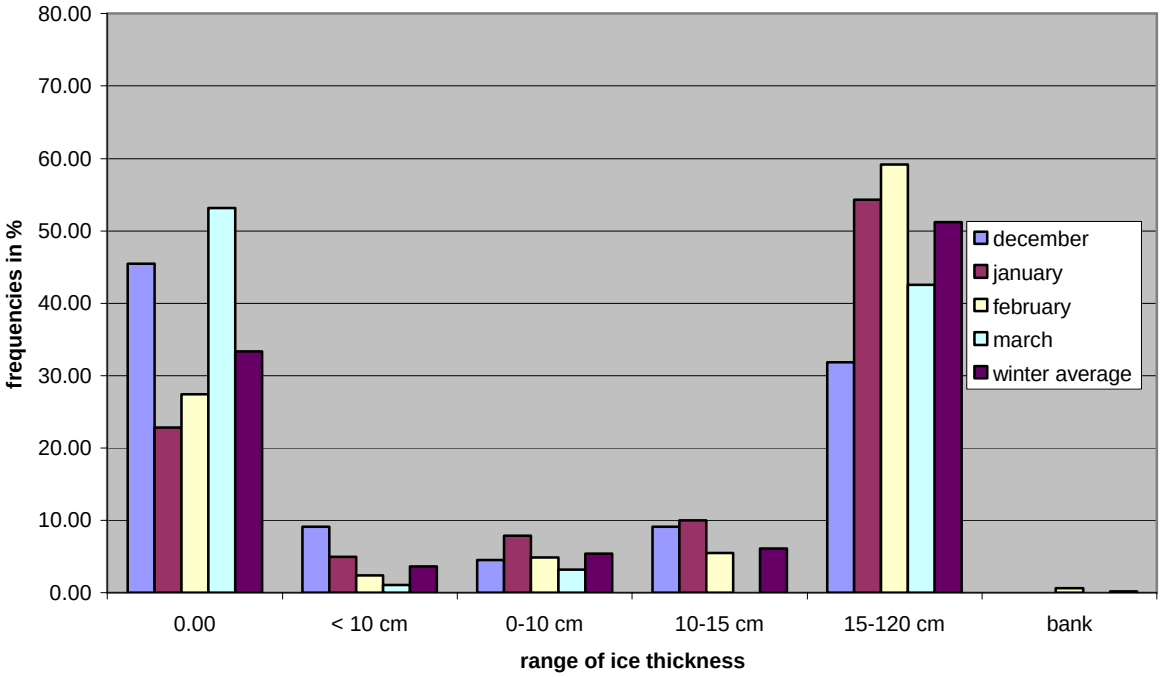

**Figure 3.21**
**Frequencies of maximum ice thickness by month – 6 sites**

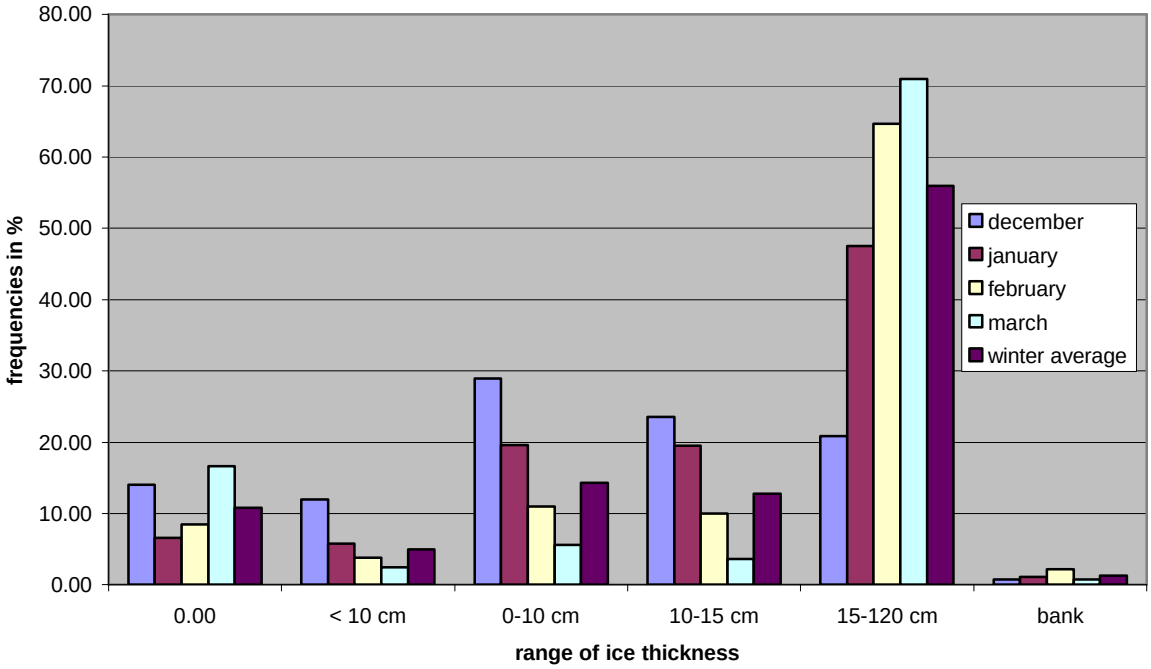


**Figure 3.22**
**Frequencies of maximum average ice thickness by site**

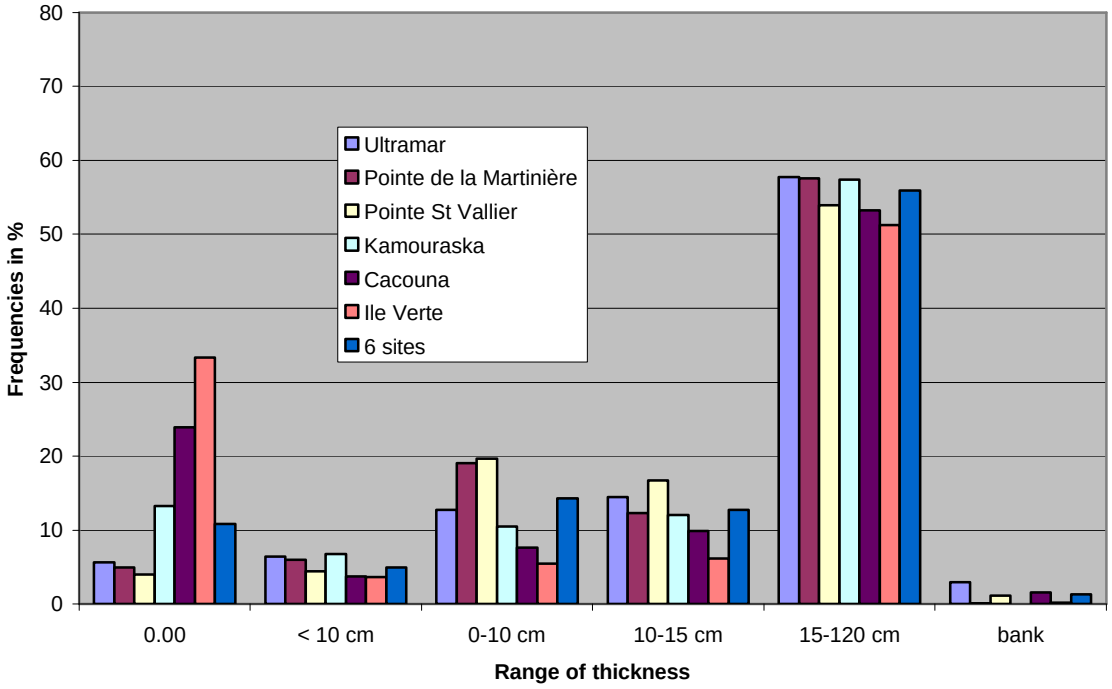

**Figure 3.23**
**Frequencies of maximum floe size by month – Ultramar**

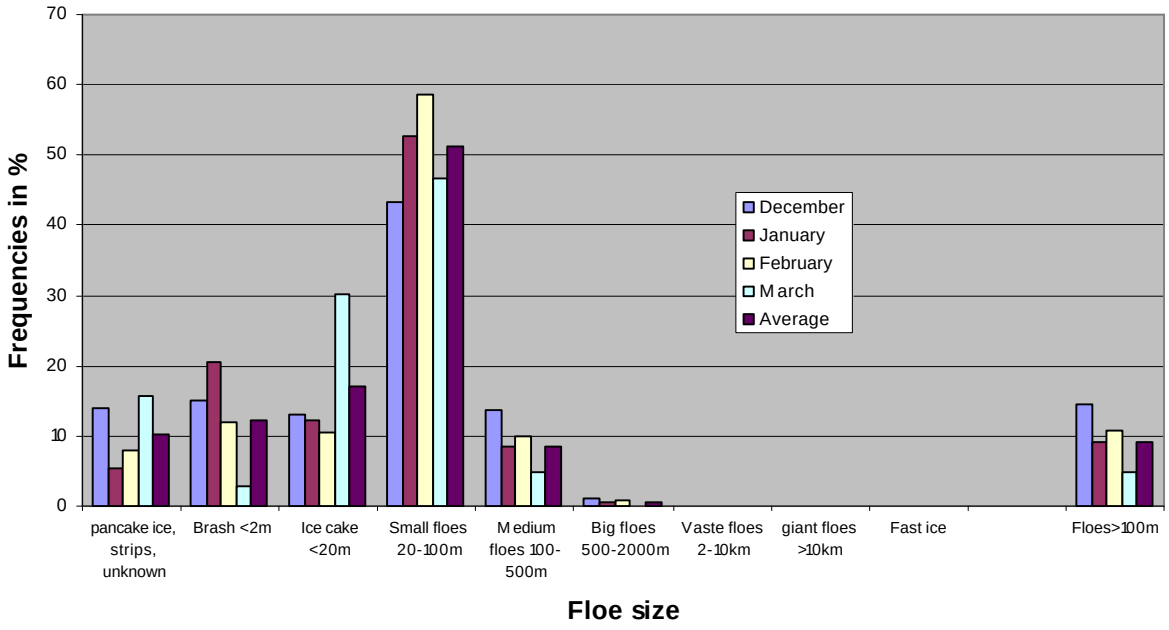


**Figure 3.24**
**Frequencies of maximum floe size by month – Pointe-de-la-Martinière**

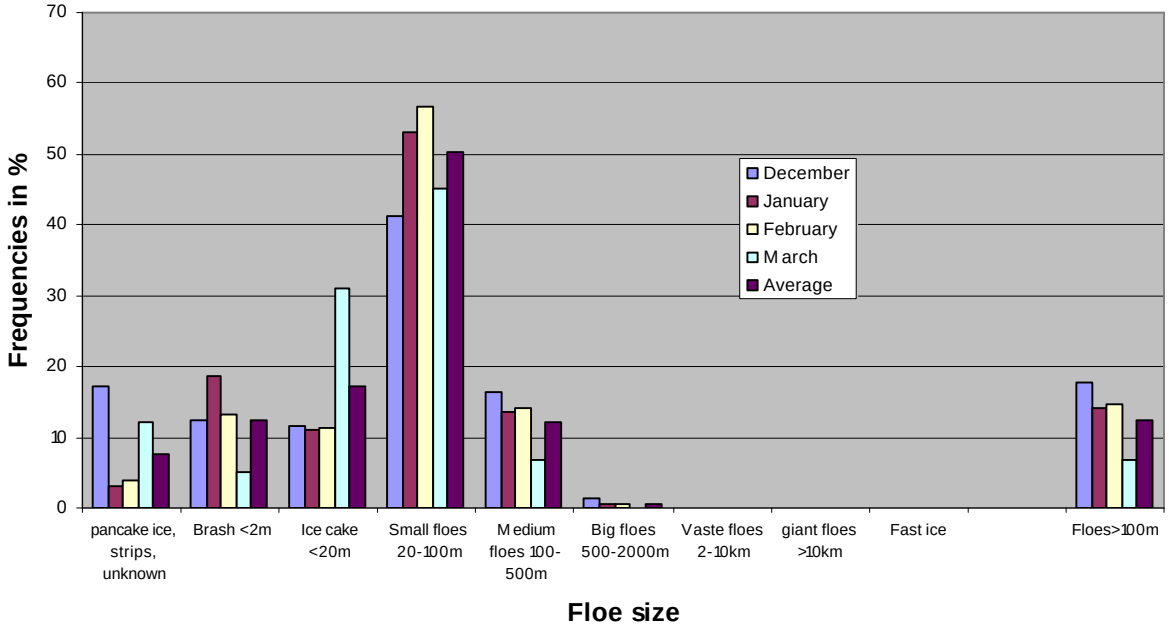

**Figure 3.25**
**Frequencies of maximum floe size by month – Pointe Saint-Vallier**

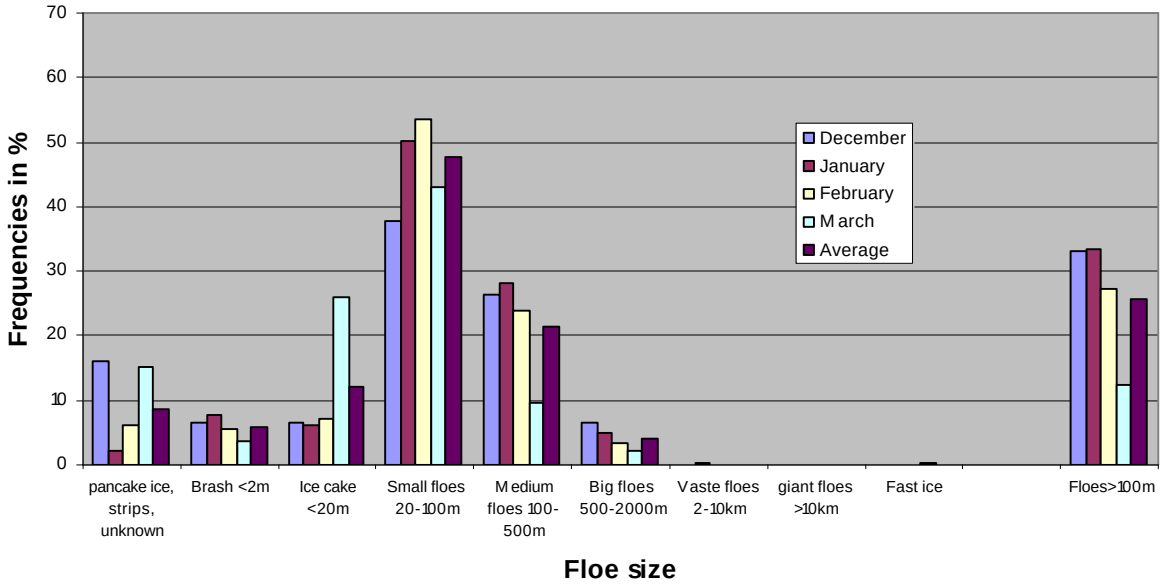


**Figure 3.26**
**Frequencies of maximum floe size by month - Kamouraska**

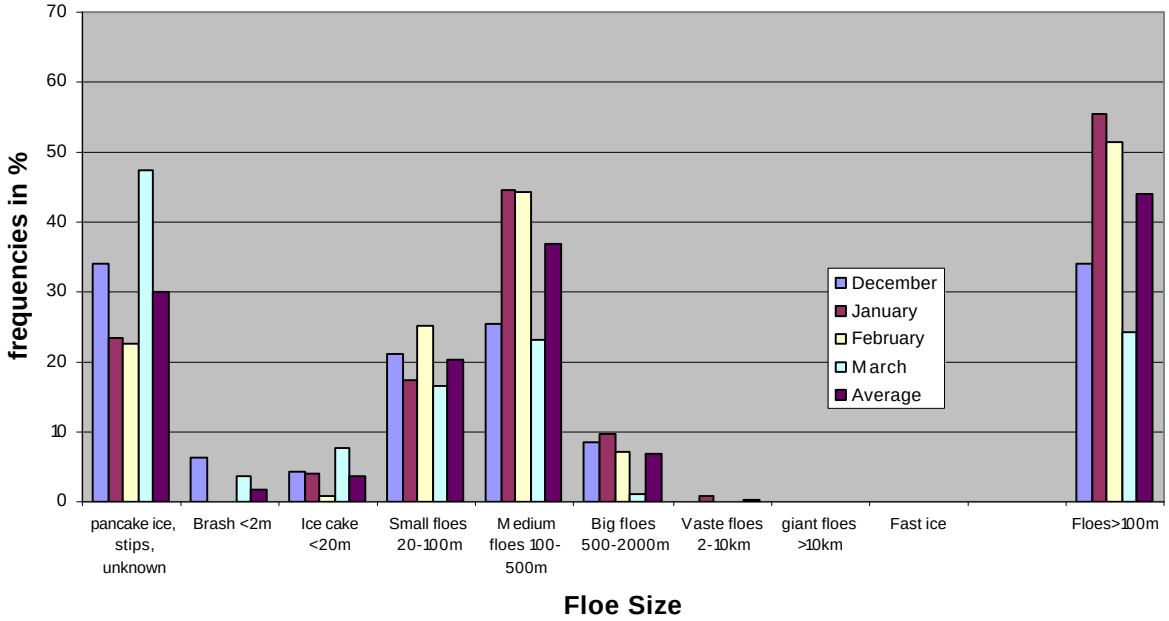

**Figure 3.27**
**Frequencies of maximum floe size by month - Cacouna**

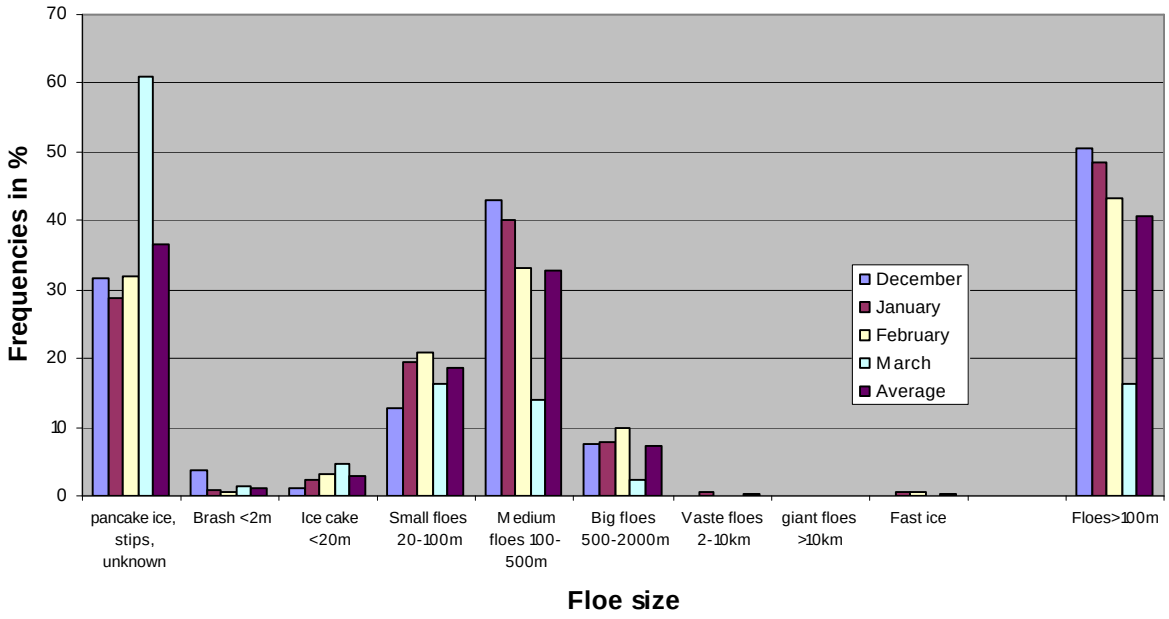


**Figure 3.28**
**Frequencies of maximum floe size by month – Ile Verte**

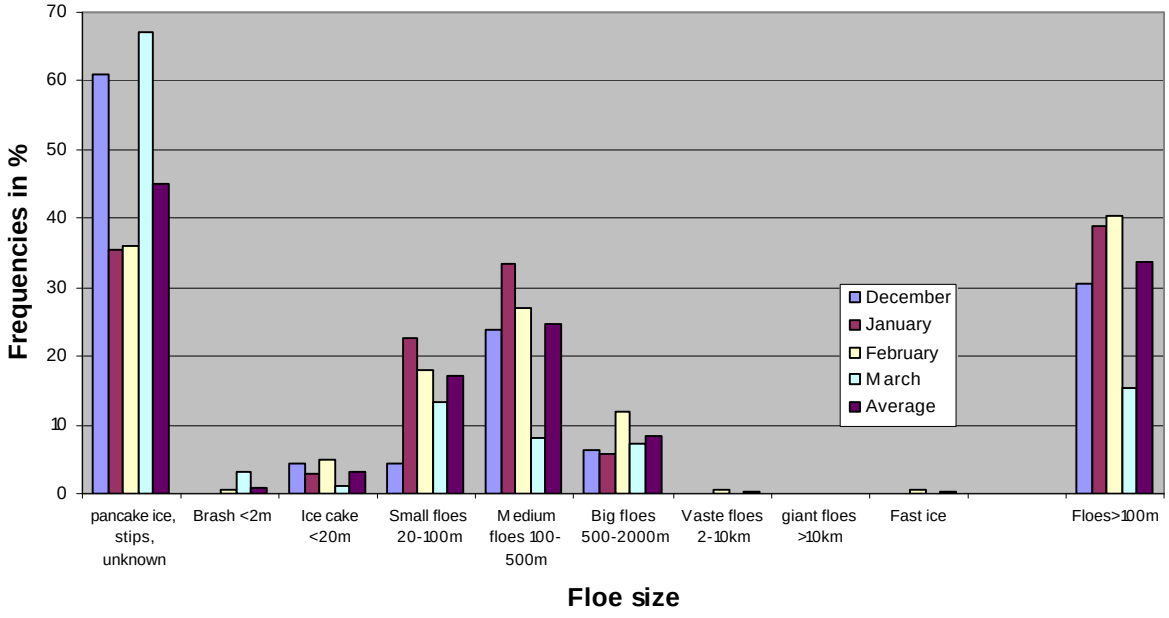

**Figure 3.29**
**Frequencies of maximum floe size by month– 6 sites**

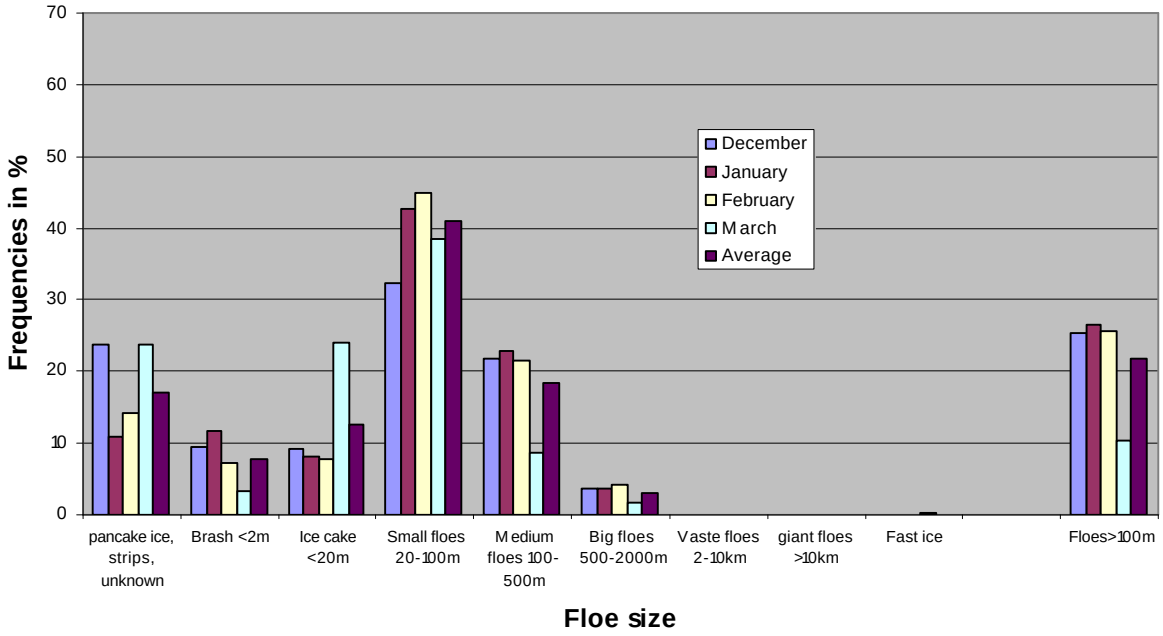


**Figure 3.30**
**Frequencies of maximum average floe size by site**