

**STUDY OF
GEOGRAPHICAL REGIONS AS
POTENTIAL SITES FOR AN
ICE KEEL STRESS EXPERIMENT**



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by
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1. INTRODUCTION

As part of a continuing effort to increase the understanding of sea ice dynamics, the Frozen Sea Research Group has begun the planning and design phases of an experimental study of the drag forces exerted by the water column on the underwater portions (ice keels) of sea ice ridges.

The present report describes the results of a systematic preliminary investigation and selection of sites suitable for the field portion of this study. It assumes that the experimental work will require measurements of water velocities on a three-dimensional grid adjacent to either:

- 1) a keel of depth 6 to 10 m located in an otherwise level ice sheet. Adjacent ridges/keels should be at a separation of 5 km or more and the length to width ratio of the keel should be at least 10:1; or
- 2) individual keels with depths of 1 m to 10 m, distributed with various directional orientations in a roughly 2 km diameter area.

The second alternative is to be considered only if an isolated keel (alternative 1) is not available.

Several additional criteria for a suitable site can be specified as:

- a) Uni- or bi-directional water flows with speeds (within a few metres of the ice undersurface) exceeding 10 cm/s during a significant portion (arbitrarily set at one-third) of the time.
- b) Water depths greater than 50 m and sea bottom roughness <5 m. over a region a few hundred meters in diameter centred on the measurement array.
- c) The availability of data on the upper water level structure in terms of the depths of the mixed layer and the pycnocline.
- d) The ice at the study site can be either first year or multi-year but should be essentially immobile (fast ice) during the spring period (April & May) considered for the study.

- e) The site should be within 2 hours flying time of one of the established Arctic bases (Resolute Bay, Mould Bay, Rae Point, Pond Inlet, Cambridge Bay and Tuktoyaktuk). Assuming a 120 knot ground speed for a loaded Twin Otter, this requirement confines consideration to sites within 445 km. (240 nautical miles) of these bases.

It is also desirable that some means be identified to obtain more detailed data on specific sites during the winter months immediately preceding the planned experiment.

Due to the possibly large number of sites, in the Canadian Arctic, potentially suitable for such an experiment the evaluation process was divided into two distinct phases, beginning with an initial consideration of the extent to which specific identifiable regions within the 445 km (240 nautical mile) circles (criterion e) meet the other project requirements. Charts, data compilations and review articles were consulted to obtain the logistical, hydrographic, oceanographic and ice information necessary to categorize each region into one of three classifications:

- 1) Unsuitable. (U). Sites in the region are unlikely to meet the experimental requirements, or there are major deficiencies in the available data to adequately evaluate the region.
- 2) Marginally Potential. (MP). Although sites in the region are suspected to exist which have suitable characteristics for the proposed experiment, a dearth of data would necessitate significant additional efforts in order to locate and confirm the suitability of these sites.
- 3) Potential. (P). Significant portions of the region can be identified which nominally meet the requirements for a good experimental site.

Classification into these categories is carried out in Section 2.

A more detailed evaluation and description of the potential (P) regions follows in Section 3 prior to the offering of recommendations for an optimum site selection strategy for any given year (Section 4).

2. INITIAL CONSIDERATIONS: REGIONAL REVIEWS

Thirty-eight more or less distinct water bodies were identified (see Table 1 and Figure 1) which satisfied the distance requirement (criterion e) relative to the six considered logistical bases of Cambridge Bay (CB), Mould Bay (MB), Rae Point (RP), Resolute Bay (RB) Tuktoyaktuk (Tuk) and Pond Inlet (PI). The particular division into regions used here is somewhat arbitrary since the identified properties of larger water bodies (i.e. Viscount Melville Sound) cannot be assumed to apply to their smaller sub-units (i.e. Bridport Inlet). In each case, we have tried to choose our designations so that the derived conclusions may be applied to a considerable, recognizable fraction of the study area. The identification of these areas of applicability requires, of course, specific detailed review of the available data for a reduced subset of regions which preliminary analyses suggest to be most likely to contain suitable experimental sites. The initial appraisal and elimination process has been carried out and compactly documented in Table 1. Individual entries for each region are summarized relevant to satisfaction of each of the above-stated (Section 1) site criteria (note: to avoid repetitious entries unless otherwise noted, each of the regions may be assumed to meet the requirement for immobile fast ice conditions during the spring period of interest). Designation of regions according to the Unsuitable (U), Marginally Potential (MP) and Potential (P) categories of Section 1 was determined by the presence or absence in the given row of one or more solid and/or open circles (see below).

In general the demonstrated failure of a region to satisfy minimum water depth, minimum current speed/directionality and thickness/stability criteria was denoted by a solid circle in the appropriate column of Table 1, and an automatic Unsuitable (U) categorization. In most instances, the total absence of the critical current and/or temperature and salinity (TS) data was similarly denoted and the site again given a (U) categorization.

On the other hand, open circles were used to denote those entries which represented inadequate or completely absent verification of the current and TS criteria in regions where inference or other evidence suggests a likelihood for satisfaction of the critical minimum current and directional requirements. In the absence of a pre-eminent solid circle entry in one of the other columns, an open circle entry resulted in a marginally potential (MP) designation for the region in question. In the absence of other alternatives, sites might be reasonably

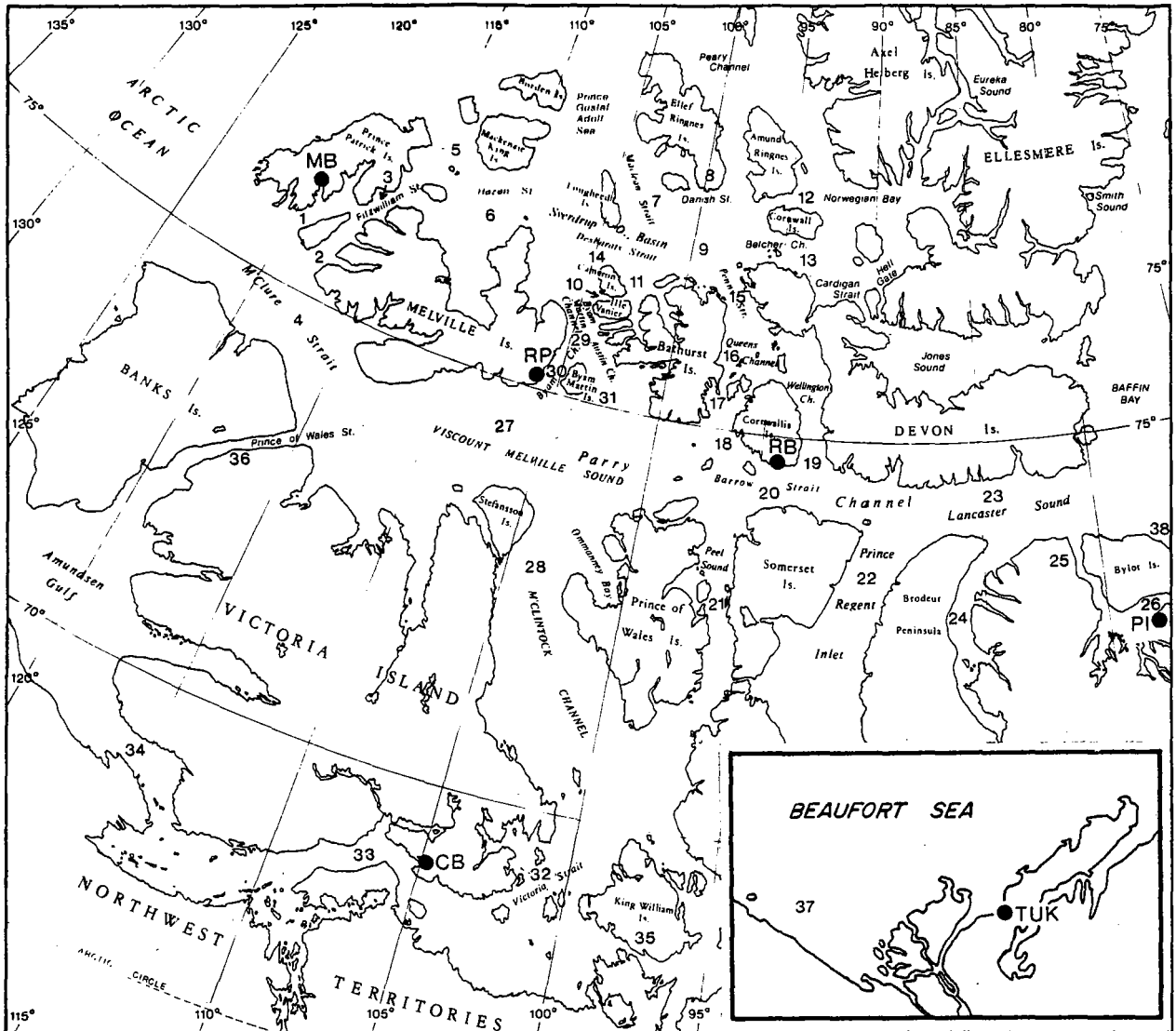


Figure 1: Locations of logistical bases (Mould Bay (MB), Rae Point (RP), Resolute Bay (RB), Cambridge Bay (CB) and Pond Inlet (PI)) and regions evaluated in Table 1.

be expected to be found in such areas using educated guesswork and a sampling of currents and water profiles at one or more area sites.

Finally, those regions without solid or open circle entries were designated as potential (P) sites for the keel experiment.

Seven regions of the desired potential (P) type were found: Danish Strait, Crozier Strait, Wellington Channel, Barrow Strait, Peel Sound, Austin Channel and Prince of Wales Strait.

More detailed evaluations and descriptions of these (P) regions are presented in Section 3. Regions of intermediate or "marginal potential" will receive further consideration only to the extent that they can be incorporated in a site selection strategy which allows for investigations of such areas in cases where, for some reason, sites are not available in the prime potential regions (Section 4).

3. ENVIRONMENTAL DESCRIPTION AND EVALUATION IN POTENTIAL STUDY REGIONS

3.1 INTRODUCTION

The regional descriptions presented below, (3.2), were derived from the cited (Table 1) data sets, reports, reviews and personal observations relevant to the oceanographic, ice, and other properties of interest. In general, because of the emphasis given to the minimum flow and directionality criterion "potential" regions are reasonably well characterized in terms of the basic magnitudes and directions of the currents, and in the vertical structure of the water column. Larger uncertainties are apparent in the description of the regional ice packs. Although each region can be assumed, except where specifically noted (e.g. Barrow Strait) to contain complete or nearly complete coverage (in April-May) by immobile, fast ice, there are few sources of data from which one can identify areas particularly likely to contain ridges of the size, length and degrees of isolation required for the proposed experiment.

The usual sources of ice data for operational planning, namely the ice charts prepared by AES Ice Central and satellite imagery were consulted during the regional evaluations. These charts were particularly useful in characterizing the relative frequencies of occurrence for coverage by first-year, multi-year, or mixed ice. Data on the surface coverage by ridged ice (in terms of the fraction of surface occupied by ridges and/or the number of ridges encountered per unit length of track) were included directly in these charts in the years 1961-1976 and could be used to give some measure of the local ice topography. Comparable ridge data for the post-1976 period are available by special request to AES Ice Central. However, these numbers whether in units of "tenths of ridged surface" or ridges/km are difficult to translate into meaningful terms useful for locating the isolated linear ridge required for the experiment. Nevertheless for general reference in the descriptions given below, chart data have been presented in Table 2 appropriate to the earliest annual surveys carried out (usually in June) in each of the years 1961-1970 (Lindsay, 1974, 1977) and in the results obtained from an independent, 1977 survey by NORCOR Ltd. (NORCOR, 1978) (Figure 2a,b). Because of the immobile nature of the spring ice in these regions, the ice-type and -topographic data are approximately representative of the corresponding April-May periods relevant to experiment planners.

Table 1: Initial compilation of regional data relevant to criteria of Section 1. Classification of individual entry in adequacies in terms of solid (●) and open (○) circles is described in the text as well as the accompanying regional classifications (U), (MP) and (P).

Site	Distance to Base	Water Depth	Currents	TS Profiles	Ice	Other	Regional Classification
1. Crozier Channel	17 n.m. (MB)	300 m	No data. ●	No data. ●			U
2. Kellet Strait	20 n.m. (MB)	250 m	No data. ●	No data. ●			U
3. Fitzwilliam Strait	35 n.m. (MB)	300-400 m	2 June-July OM records at 5 m depth (Queen Elizabeth Islands compilation data set 75-0016), rated "1". Questionable validity, unappraised. ●	3 CID stations 0-8 m depth, data set 75-0016, rated "1". ○			U
4. M'Clure Strait	70 n.m. (MB)	to 500 m	Tidally dominated currents with speeds <6 cm/s except near Peel Point (Melling, pers. comm.). Polar Gas Pipeline data (Northwest Passage compilation data set 79-0013) rated "1". ●	Many CID and bottle cast stations.	High concentration of thick, multi-year ice, suspect difficulty in finding isolated ridges. ○		U
5. Ballantyne Strait	100 n.m. (MB)	40-100 m	No data. ○	No data. ●			U
6. Hazen Strait	100 n.m. (MB) (RP)	100-500 m	OM data (Queen Elizabeth Islands compilation, data sets 75-0016, 75-0018, 75-0022, 77-0023, 77-0024, 77-0025, 77-0033, 78-0013, 79-0017, 79-0019, 79-0020, 79-0021). All indicate (see Peck, 1980b, Van Ieperen, 1981) speeds exceed 10 cm/s less than 2% of time. ●	10-15 stations. ○			U
7. Maclean Strait	200 n.m. (RP) (MB)	400 m	Data (Peck, 1980b, Van Ieperen, 1981) found speeds >10 cm/s 9% and 0% of time. ●	6 CID stations. 3 CID stations, 1982, 2 CID stations, 1983 (Fissel et al., 1984a,b).			U
8. Danish Strait	150 n.m. (RB)	40-250 m	Measurements by Peck (1980b) (Queen Elizabeth Islands compilation data set 79-0019) found 40% of speeds >10 cm/s. ●	3 CID stations (Peck, 1980a). 1 CID station, 1982 (Fissel et al., 1984a).			P

Table 1 (Cont'd)

Site	Distance to Base	Water Depth	Currents	TS Profiles	Ice	Other	Regional Classification
9. Edingburgh Sea	150 n.m. (RB)	40-250 m	Very questionable data (Van Ieperen, 1981, Fissel 1982) (Queen Elizabeth Islands compilation data set 79-0017). Suggest between 0 and 5% of speeds >10 cm/s. Data confined to northern sections. ●	One good north-south line of CTD stations (Queen Elizabeth Islands compilation data set 79-0019).			U
10. Amott Strait	75 n.m. (RP)	25-65 m	One 30-day time series (rated "1") (Queen Elizabeth Islands compilation data set 76-0015) in 40 m of water (instrument depth = 40 m?) found 66% of speeds >10 cm/s. ●	One CTD station (Queen Elizabeth Islands compilation data set 79-0019). ○		Extremely confined area in which to satisfy current, ice and logistical requirements. ●	U
11. Erskine Inlet	75 n.m. (RP)	100-400 m	Data at 1 site (Queen Elizabeth Islands compilation data set 76-0015) (see Van Ieperen, 1981) at 105 m depth (150 m water depth) found 50% of speeds > 10 cm/s. Data rated "1". ○	○			MP
12. Hendriksen Strait	155 n.m. (RB)	15-100 m	No data. ●	No data. ●			U
13. Belcher Channel	150 n.m. (RB)	20-125 m	Undocumented reports of strong tidal currents (NOROP, 1978). No other data. ○	North-south line of 6 CTD stations (Peck, 1977) (Queen Elizabeth Islands compilation data set 76-0016). ○			MP
14. Desbarats Strait	75 n.m. (RP) (RB)	60-500 m	Data reported by Van Ieperen (1981) and Peck (1986) (Queen Elizabeth Islands compilation data set 79-0019) indicated 15% of speeds >10 cm/s. Tidal ellipses are clockwise rotary. ○	North-south line of 5 CTD stations (Queen Elizabeth Islands compilation data set 79-0019).			MP
15. Penny Strait	150 n.m. (RB)	40-230 m	Two 3-week time series measurements indicated strong southerly flow with K_1 , M_2 semi-axes = 10 cm/s, O_1 semi-axes = 8 cm/s (Queen Elizabeth Island compilation data set 76-0016).	Cross-channel line of 6 CTD stations (76-0016).	Spring ice thickness in 1982 and 1983 (Fissel et al., 1984a,b) between 0.5 and 1 m, may not be sufficient for aircraft landings. ●		U
16. Queen's Channel	100 n.m. (RB)	50-350 m	No data except for 1 CM record immediately adjacent to Dundas Island polynya. ○	7 CTD stations taken in Sept. 1957 (Queen Elizabeth Islands compilation data set 57-0003).			MP

Table 1 (Cont'd)

Site	Distance to Base	Water Depth	Currents	TS Profiles	Ice	Other	Regional Classification
17. Pullen and Crozier Straits	50 n.m. (RB)	20-100 m	1 OM record in Pullen, 6 in Crozier (4 in east channel, 2 in west) (Queen Elizabeth Islands compilation data set 77-0026) (see Greisman and Lake, 1978). At Pullen largest (25 m) speeds approximately 8 cm/s. In east Crozier speeds >10 cm/s range from 41 to 69% according to location.	CID profiles taken at all OM stations of Greisman and Lake (1978).			(Pullen)U
		100-300 m					(Crozier)P
18. McDougall Sound	20 n.m. (RB)	80-300 m	No data. ○	Well surveyed in Queen Elizabeth Islands compilation data sets 78-0003 and 81-0007.			MP
19. Wellington Channel	30 n.m. (RB)	100-270 m	Lines of OM across north and south portions of channel (Queen Elizabeth Islands compilation data sets 78-0012 and 73-0008, respectively) (see R.Lake draft report and Herlinveaux et al., 1978). 37-60% of speeds >10 cm/s southerly flow trend, elongated ellipses.	CID stations obtained in data sets 78-0008 and 78-0012. Bottle data available from earlier icebreaker cruises.			P
20. Barrow Straits	20-30 n.m. (RB)	50-150 m	Numerous, modern OM measurements (Queen Elizabeth Islands compilation 78-0007, 81-0007) during 1982 and 1983. Data show strong easterly flow with elongated tidal ellipses and more than 60% of speeds >10 cm/s.	Numerous surveys (Queen Elizabeth Islands compilation data sets 81-0007, 80-0007, 78-0007, 77-0014, 77-0011).	Ice mobile in most of region in 2.5 out of 10 years.		P
21. Peel Sound	60 n.m. (RB)	200-400 m	A line of 5 OM stations at north end of channel (Northwest Passage compilation data set 81-0007).	Data along OM line in 3 years (Northwest Passage compilation data sets 78-0007, 79-0011A, 81-0007).			P
22. Prince Regent Inlet	100 n.m. (RB)	150-400 m	No data (except for summer drifter study). ○	Several CID stations in northern section in spring of 1982 and 1983 (Fissel et al., 1984a,b) as well as summer data (Northwest Passage compilation data sets 79-0011A, 80-0008). Earlier bottle data obtained from icebreaker cruises.	Ice occasionally remains mobile in various portions of inlet (Marko, 1978).		MP

Table 1 (Cont'd)

Site	Distance to Base	Water Depth	Currents	TS Profiles	Ice	Other	Regional Classification
23. Lancaster Sound	100-200 n.m. (RB) (PI)	100-800 m	Data limited to summer only, mostly in eastern Lancaster Sound. For western and central Lancaster Sound, drifting buoy results indicate highly variable speeds and directions, except for southern side where strong easterly currents often occur. ○	Much data, mostly in summer. 2 spring CID transects occupied in western Lancaster Sound in 1982 and 1983 (Fissel et al., 1984a,b).	Ice mobile in 8 out of 10 years. ●		U
24. Admiralty Inlet	180 n.m. (RB) 130 n.m. (PI)	300-750 m	No data. ●	1 CID station adjacent to shoreline. ○			U
25. Navy Board Inlet	60 n.m. (PI)	70-200 m	No winter or spring data. ●	No winter or spring data. ●			U
26. Pond Inlet	10 n.m. (PI)	100-1000 m	No winter or spring data. ●	Steltner (1977) (Baffin Bay compilation data set 77-0029). ○			U
27. Viscount Melville Sound	60 n.m. (RP)	40-500 m	CM data in western portion (Northwest Passage compilation data set 77-0012) indicated current speeds <5 cm/s. Consistent with summertime drifter data (data set 80-0010). ●	1977 and 1978 CID stations (Northwest Passage compilation data sets 77-0012, 78-0007 and earlier icebreaker bottle cast data).			U
28. M'Clintock Channel	150-200 n.m. (RP)	100-350 m	No data. ●	Spring data from 1982 and 1983 (Fissel et al., 1984a, b).			U
29. Byam Martin Channel	35 n.m. (RP)	60-200 m	No data but might anticipate rapid southerly flow from region 31 data (Greisman and Lake, 1978; Fissel et al., 1984a). ○	4 CID stations (Queen Elizabeth Islands compilation data set 79-0019) (Peck, 1980a) and 5 CID stations in spring 1982 (Fissel et al., 1984a).	High variable ice conditions typically contains 7/10 multi-year floes.		MP
30. Byam Channel	5 n.m. (RP)	50-200 m	Near-surface and near-bottom CM data at 4 stations (Queen Elizabeth Island compilation data set 76-0017). Almost all recorded speeds <9 cm/s. ●	One CID station (data set 76-0017) and line of 3 stations (data set 78-0007).			U

Table 1 (Cont'd)

Site	Distance to Base	Water Depth	Currents	TS Profiles	Ice	Other	Regional Classification
31. Austin Channel	35 n.m. (RP)	50-200 m	5 measurement stations in northern sections (Queen Elizabeth Islands compilation data set 76-0017), 1 northern and 1 southern station in 1978 (data set 78-0007). Northern data indicated elongated tidal ellipses with approx. 40% speeds >10 cm/s.	CID stations in data sets 76-0017 and 78-0007.			P
32. Victoria Strait	100 n.m. (CB)	0-40 m ●	No data. ○	No data. ○			U
33. Dease Strait	100 n.m. (CB)	20-120 m	No data. ●	1 coastal TS station.			U
34. Dolphin and Union Strait	250 n.m. (CB)	40-150 m	Only one set of data obtained in July-August (Northwest Passage compilation data set 79-0012) at near-bottom and mid-water depth. ●	Very early (<1959) bathythermograph data. ●			U
35. Simpson Strait	200 n.m. (CB)	-10 m ●	No data. ●	No spring data. ●			U
36. Prince of Wales Strait	200 n.m. (CB)	50-100 m	1977 spring data (Northwest Passage compilation data set 77-0012 showed M_2 tidal component semi-axes approx. 10 cm/s. More recent FSRC data (Melling pers. comm.) indicates springtime speeds as large as 30 cm/s.	Station data in 77-0012 and in 1982 FSRC CM program.	Typically contains 50% multi-year ice in northern section. First year ice in south. Cross channel leads and ridges observed (Melling) at approx. 10 km intervals.	Reported difficulty in finding suitable landing areas because of small scale roughness of snow surface (Fissel, pers. comm.).	P
37. Western Mackenzie Bay	100 n.m. (Tuk)	50-100 m	No springtime, under-ice data in considered study region which overlies Herschel Canyon (see "Other"). The moderately strong near-bottom currents observed on adjoining southwestern slope of Canyon (Huggett et al., 1977) cannot be assumed to be present in water deeper than 20 m without detailed confirmation. ●	Data limited to measurements obtained at nearshore locations in fisheries studies (Kendel, et al., 1975)		Due to requirement for fast ice, the only suitable portion of the S.E. Beaufort Sea meeting criteria 1 and 2 would have to overlie Herschel Canyon where fast ice is usually stable for some distance beyond the usual 20 m bottom contour.	U

Table 1 (Cont'd)

Site	Distance to Base	Water Depth	Currents	TS Profiles	Ice	Other	Regional Classification
38. N.W. Baffin Bay	45-240 n.m. (PI)	50-100 m	No data in fast ice zone.	No spring-winter data in fast ice zone.	Fast ice found only along eastern coastline of Devon, Bylot and Baffin Islands in local zones extending out to 100 m or deeper water. These zones highly unpredictable in topography and commonly contain grounded icebergs.		MP

Table 2

Ice conditions in potential study regions (1969-1970) (extracted from Lindsay, 1974, 1977). (Notation: F/n, S/n, M/n denotes n tenths coverage by first-year, second-year and multi-year ice respectively; ^/n denotes coverage in tenths by ridged ice).

Year	Austin Channel	Barrow Strait	Peel Sea	Wellington Channel	Crozier Strait	Danish Strait	Prince of Wales Strait
1961	F/10 ^/1	F/10 ^/2		F/10 ^/>1	F/10	In North: F/10 In South: M/7 F/3 ^/2	F/10
1962	F/10 ^/0	Cleared east of Griffith-Lowther-Somerset Island line	Either F/10 or F/9 ^/1	F/10 ^/1 In Southwest: F/10 ^/4	F/9 M/1 ^/>1	M/8 F/2 ^/2	F/9 M/1
1963	In North: M/9 F/1 ^/3 In South: F/10 ^/4	F/10 ^/5	F/9 M/1	F/10 ^/<1	F/10 ^/0	F/10 ^/0	F/9 M/1 14
1964	F/10	Clear to Griffith-Lowther-Somerset Island line	F/10	M/5 F/5	M/10	M/10 ^/1	F/10
1965	M/7 F/3	F/10	F/10 ^/1	F/10	Mixture M, F	M/10 ^/3	F/10
1966	F/10 and M/6 F/4	F/10 ^/5	F/10 ^/0	F/10 ^/2-3	F/10	F/10	F/10
1967	F/10 ^/1	F/10	F/10	F/10	F/2 M/2 ^/3	In North: M/8 F/2 ^/5	F/10 and S/7 F/3

Table 2 (Cont'd)

Year	Austin Channel	Barrow Strait	Peel Sea	Wellington Channel	Crozier Strait	Danish Strait	Wales Strait
1968	F/10	F,S/9 M/1	In North: F/10 In South: S/10 ^/1	S/4 F/4 M/2 In Northwest: M/6 S/3 F/1 ^/1	S/7 F/3	S/10	M/10 ^/0
1969	F/9 M/1 ^/1	Clearing to Griffith-Lowther-Somerset Island line. To West: F/10 ^/1	F/10	F/10	F/10 ^/0-1	M/8 S/1 F/1 ^/1	M/3 S/6 F/1 ^/1-2
1970	In West: F/8 M/2 ^/1 In East: F/10 ^/1-2	F/10 ^/1 with large multi-year field in East-Central Portion	F/9 M/1	In North: M/3 F/7 ^/1 In South: F/10 ^/1	F/10	M/10	F/10 ^/0.1 U

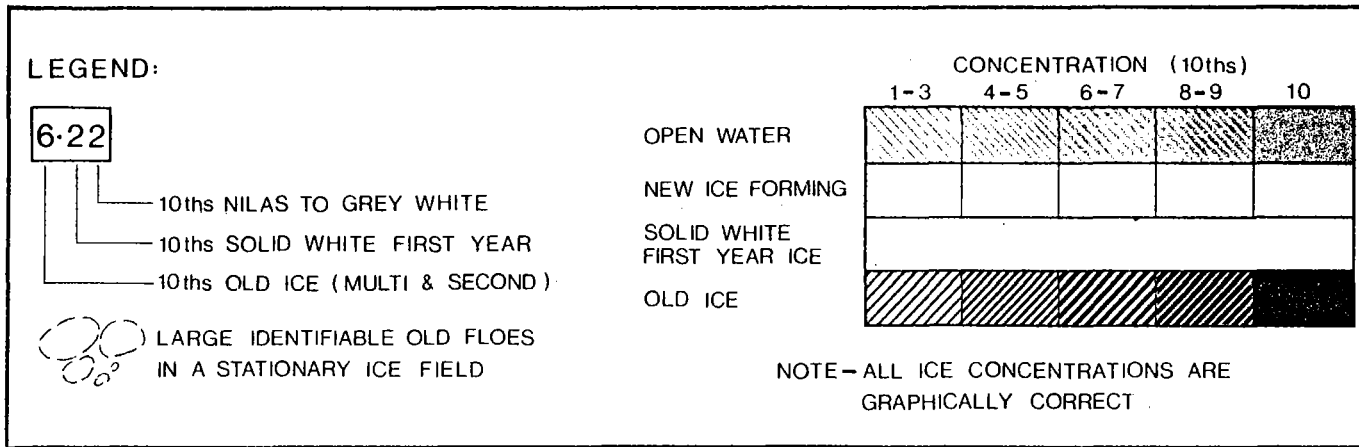


Figure 2a: Legend and mapping of ice conditions in the northern Canadian Arctic Archipelago, June 19-29, 1977 (NORCOR, 1978).

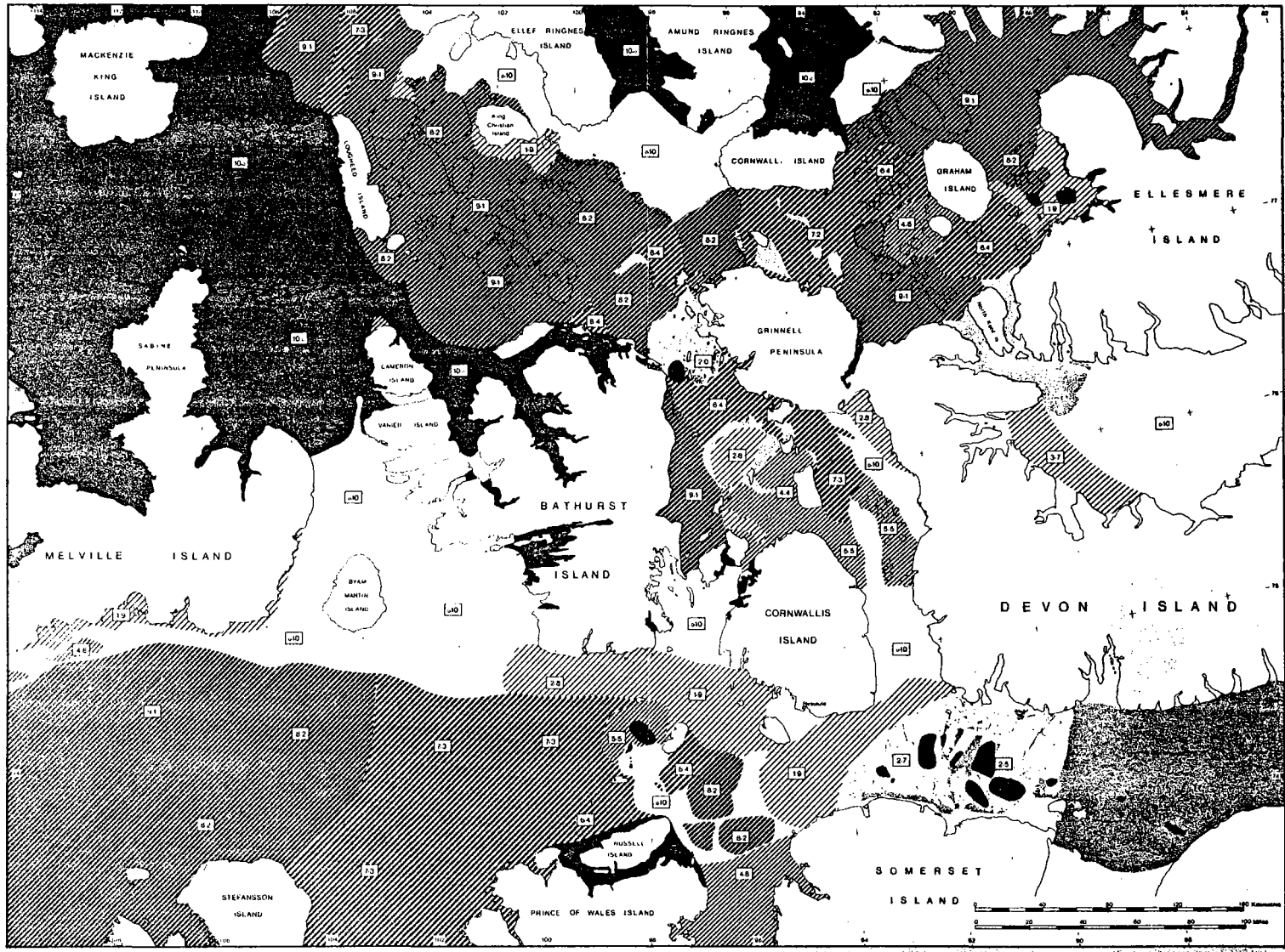


Figure 2a: Legend and mapping of ice conditions in the northern Canadian Arctic Archipelago, June 19-29, 1977 (NORCOR, 1978).

MEAN ICE RIDGE FREQUENCY, SPRING 1977
 QUEEN ELIZABETH ISLANDS AND ADJACENT WATERS

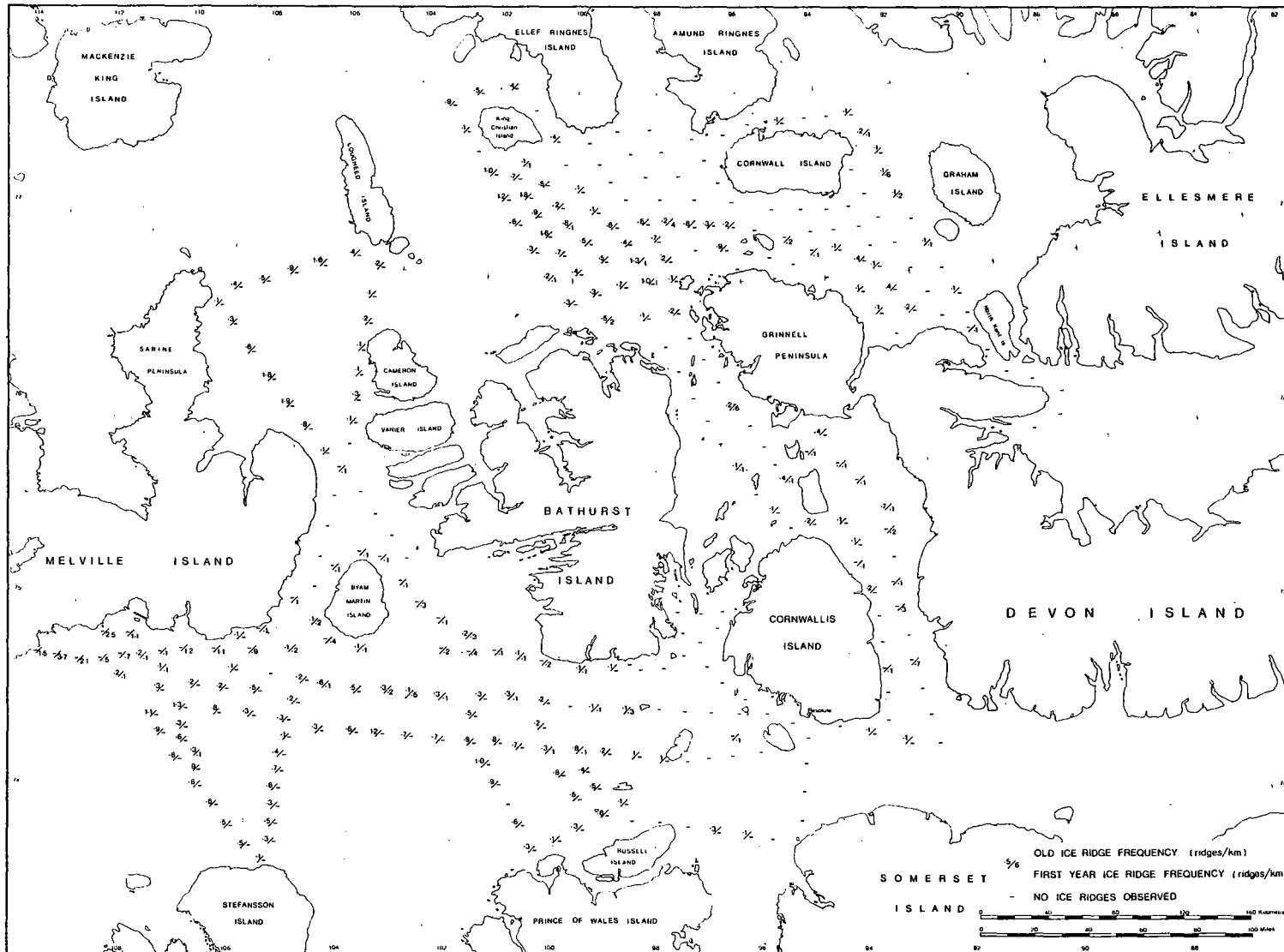


Figure 2b: Ice ridge frequencies in the northern Canadian Arctic Archipelago, June 19-29, 1977 (NORCOR, 1978).

Data on ridging patterns, degrees of repetitiveness and general scales of surface roughness germane to the site selection process are most readily obtained from satellite and SLAR imagery.

Thus for example even standard, precision processed Landsat images (See Figure 3) offer considerable information on the extent of surface roughness and the locations of large linear features and smooth regions where encountered ridges would be likely to satisfy the isolation criterion. Although no provision was made for detailed imagery analysis in the present evaluation, a survey was carried out of both the microfiche imagery collection of the B.C. Dept. of Environment and the more complete Prince Albert, CCRS processed imagery catalogue. Twenty-three specific dates were identified on which detailed ice topography data are readily apparent in the imagery of Wellington Channel, Barrow Strait, Peel Sound and Crozier Strait (Table 3).

Table 3: Historical Landsat frames containing spring ice topography in Wellington Channel, Barrow Strait, Peel Sound and Crozier Strait.

Date	Landsat	Track	Frame
30-5-73	1	49	6,7
1-4-74	1	49	6,7
30-6-74	1	49	6,7
25-6-75	1	49	6,7
29-6-77	1	49	6,7
23-6-77	2	49	7
20-6-81	2	49	6,7
2-4-74	1	50	6,7
26-6-75	1	50	6,7
24-6-77	2	50	6,7
21-6-81	2	50	6,7
14-6-73	1	51	6,7
27-6-75	1	51	6
26-6-77	2	51	6
25-6-77	2	51	6
25-5-82	3	51	7
26-6-73	1	52	6,7
23-6-81	2	52	6
21-6-73	1	53	6,7
29-6-80	2	53	6,7
28-6-82	3	53	6,7
25-6-81	2	54	6,7
29-6-82	3	54	6,7

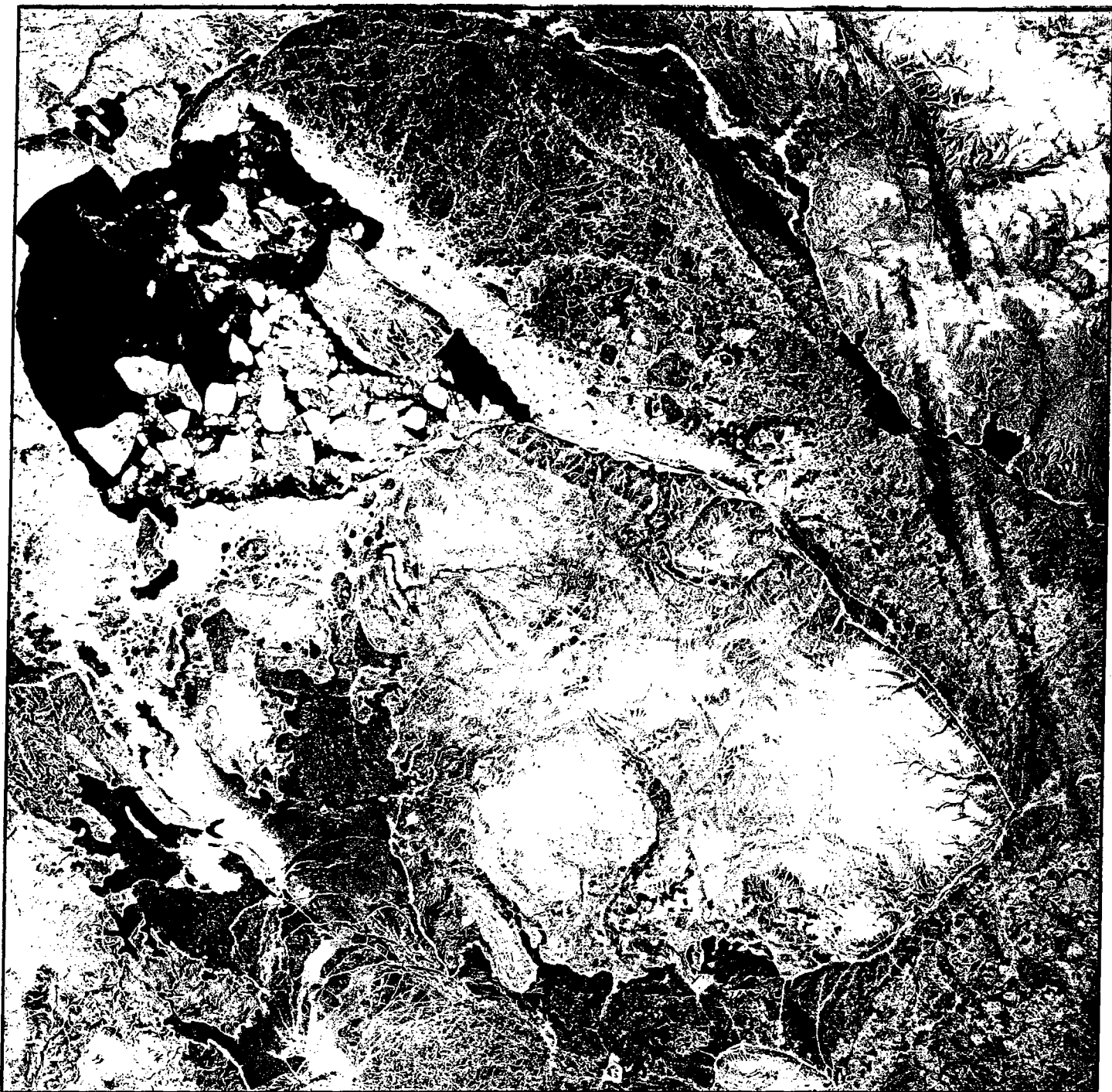


Figure 3: A June 19, 1973 Landsat Band 7 satellite imagery showing marine areas surrounding Cornwallis Island.

Discussion of the possible utilization of these historical images together with the still more detailed and less ambiguous SLAR data available from AES winter overflights will be given in the recommendations of Section 4.

3.2 REGIONAL DESCRIPTION AND EVALUATION

3.2.1. AUSTIN CHANNEL

Ice Conditions

The predominant movement of ice in this region parallels the general southerly trend of the water movements during the normal July to October period of mobile ice conditions (Marko, 1977). Exceptional situations have been noted (Marko, 1977) following summers of large amounts of ice clearance in Viscount Melville Sound when southward ice movement continues during a portion of the winter period (i.e. 1962-1963 and 1963-1964). The age distribution of the ice present in the area during the spring period thus exhibits high year-to-year variability and is a function of both the preceding summer ice conditions in Viscount Melville Sound and the highly variable autumn rate of ice flow out of the Sverdrup Basin through Byam Martin Strait.

The data listed in the first column of Table 2 suggest that in 50% of the years surveyed, the regional cover is nominally 10/10 first year ice. Very large multi-year ice components were noted while 1/10 to 2/10 multi-year averages were indicated in 20% of the observations.

Local generation of ridges would be expected in connection with the merging of the southerly and easterly flow trends which are characteristic of the Channel and Viscount Melville Sound, respectively. The reported data suggest that ridging densities range upward from 0/10 to 3/10. No historical data have been extracted on ridge orientation or degrees of isolation.

Oceanographic Conditions

Direct measurements of under-ice currents in Austin Channel are limited to observations in April-July, 1976 (Greisman and Lake, 1978) and March-April 1978 (Peck, 1980a) obtained at the locations shown in Figure 4. In the former data set, the current meters were situated only 0.15 m below the ice, well within the boundary layer; the measured currents are reduced by an unknown amount from the free stream values at greater depths (also see discussion for similar measurement depths in Crozier Strait, Section 3.2.5). The 1978 measurements were obtained at 50 m depth at the northernmost location (882) and at 5 m depth at the

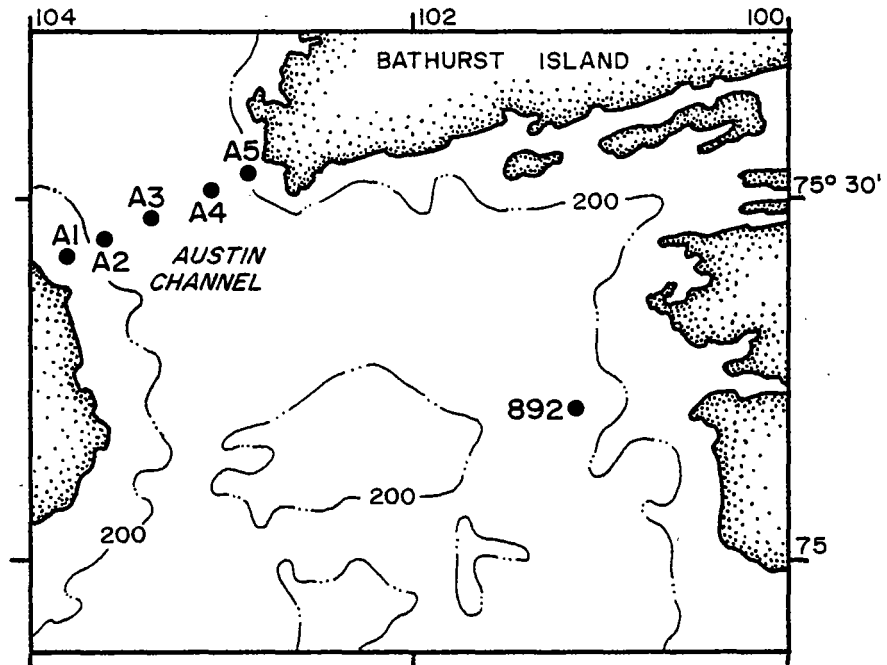


Figure 4: Locations of current measurement stations in Austin Channel.

southern site (895).

The currents of largest magnitude (Table 4) have been measured between the northern tip of Byam Martin Island and the nearest portion of Bathurst Island, a distance of 40 km. Through this transect of Austin Channel, the currents are generally stronger on the eastern side of the Channel by nearly a factor of two. Even at the sites where the strongest currents have been measured (A5 and station 882), the current exceeds 10 cm/s in only 42% of the observations.

The currents in Austin Channel are dominated by tidal activity, accounting for approximately 70% of the total variance. Lower frequency variations and the southeasterly along-channel mean flow make other significant contributions to the current variance. The tidal analysis results for the 1976 and 1978 data are in serious disagreement, with diurnal tidal flows being dominant in the 1976 data while semi-diurnal flows are dominant as computed from the 1978 results. Given the relatively short length of the 1978 records (11 and 17 days), the results based on the 1976 data are likely more reliable. The tidal ellipses have relatively low eccentricity, indicating that the tidal streams are rectilinear in character, with the flows directed along the axis of the Channel.

In late winter and early spring, the water column beneath the sea-ice consists of an upper layer, having near-freezing temperatures and uniform density (or weak stratification) extending to typical depths of 10 to 30 m as estimated from CTD profiles obtained in conjunction with the 1976 and 1978 current meter studies (Frozen Sea Research Group, 1976; Prinsenberg, 1978). Beneath this surface layer is the main Arctic Water pycnocline extending to the bottom.

Because the currents in Austin Channel are often less than the optimum values for the ice keel experiment, the use of tidal predictions based on the 1976 results, or water level data is recommended to determine the time of spring tides when the tidal contribution to the currents will be largest. Based on the available data, preference should be given to locations on the eastern side of Austin Channel, at the narrowest constriction between Bathurst and Byam Martin Islands.

Table 4: Summary statistics and tidal analysis results for current meter records grouped by potential study areas.

Station	Record Length (days)	Msmnt Depth (m)	PCT >5 cm/s	PCT >10 cm/s	PCT >15 cm/s	Mean Speed cm/s	Max. Speed cm/s	Vector-Averaged Velocity cm/s @ °T	M ₂ Maj ² Min cm/s	K ₁ Maj ¹ Min cm/s		
Austin Channel												
Ala	72	0.15	47.1	16.5	0.2		15-18	2.0 119	3.5 2.3	5.9 -0.2		
A2a	54	0.15	43.4	11.3	0.2		15-18	2.3 134	3.0 2.1	5.6 -0.2		
A3a	40	0.15	60.0	23.4	1.7		15-18	5.7 138	2.2 2.0	4.7 -0.4		
A4a	79	0.15	64.0	29.8	1.9		18-21	5.4 126	2.9 2.5	4.8 0.3		
A5a	42	0.15	73.8	41.1	6.9		18-21	4.2 111	5.0 2.7	6.8 1.4		
882	11	50	73.8	42.3	10.8		20-25	1.9 118	7.4 -2.0	1.0 -0.4		
892	42	4	43.5	4.8	0		10-15	- -	- -	- -		
895	17	4	25.6	0.3	0		10-15	1.7 191	3.0 -1.7	2.0 -1.1		

a - for percent exceedance values, 6 was used in place of 5 cm/s and 9 was used in place of 10 cm/s.

The results for station A1 to A5 are from Greisman and Lake (1978) and those of stations 882, 892 and 895 are from Peck (1980).

Barrow Strait												
78-28	33	04	76.0	32.1	8.3		25-30	4.6 110	5.3 3.7	3.9 -0.9		
78-35	42	04	86.9	50.8	18.1		35-40	5.3 94	8.2 5.1	3.4 -0.7		
78-35	42	50	96.0	84.9	67.1		45-50	5.1 21	25.2 -7.1	5.0 -1.6		
78-38	16	04	77.1	40.7	14.2		25-30	3.6 202	9.9 -0.2	4.1 -2.3		
78-42	43	04	86.4	56.3	25.9		30-35	6.8 128	7.5 4.5	4.0 -0.6		
78-45	43	04	84.0	42.3	13.5		25-30	4.7 79	8.0 6.1	4.2 0.5		
78-45	43	50	93.5	75.3	53.0		45-50	1.1 70	19.3 -5.1	5.4 -0.2		
82-42	34.1	10	92.3	67.3	43.0	14.0	39.0	8.4 82				
83-42	28.8	10	92.9	68.6	43.9	14.5	47.2	6.4 103				
83-44	28.9	10	95.2	72.6	42.3	14.2	40.4	8.1 119				
81-46	183	25						18.0 81	17.5 -0.7	14.9 -0.3		
81-46	183	60						13.8 98	17.8 -1.9	14.1 -1.5		
82-46	30.8	10	94.7	73.6	51.9	16.7	41.5	12.0 80				
83-46	28.9	10	96.2	78.1	48.1	15.9	43.0	10.4 77				
83-47	28.9	10	93.9	74.1	53.5	16.8	45.9	9.5 85				

Table 4 (Cont'd)

Station	Record Length (days)	Msmnt Depth (m)	PCT >5 cm/s	PCT >10 cm/s	PCT >15 cm/s	Mean Speed cm/s	Max. Speed cm/s	Vector-Averaged Velocity cm/s @ °T	M2 Maj Min cm/s	K1 Maj Min cm/s
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Peel Sound

81	29.1	10	76.1	24.5	3.5	7.2	22.4	1.2 142		
85	29.0	10	86.3	49.7	22.6	10.0	24.7	7.0 4		

Wellington Channel

WC 1	74	12	74.8	54.6	27.6	11.0	31.9	6.7 168	5.5 2.5	12.3 0.4
WC 2	80	12	71.5	47.2	15.0	9.4	27.5	2.0 139	4.9 2.8	11.7 -0.9
WC 3	94	20	68.7	43.5	20.6	9.7	30.4	4.5 134	6.0 1.8	11.9 -0.3
WC 4	92	12	74.6	53.6	26.0	10.9	31.1	1.7 18	8.8 0.0	12.5 -0.9

Crozier and Pullen Strait

C1	75.9	0.15	85.9	69.1	39.4		30-33	5.7 167	8.1 0.5	12.5 0.3
C1	75.0	25	87.7	77.7	56.1		45-48	5.7 172	11.9 -0.9	17.6 -1.2
C2	73.6	0.15	83.5	62.0	23.7		27-30	0.9 48	9.2 2.1	10.8 -0.7
C2	72.9	25	87.5	74.1	46.5		39-42	1.6 50	13.2 2.5	15.4 -1.1
C4	65.5	0.15	77.9	61.5	30.9		27-30	8.5 170	4.8 1.0	8.1 -0.3
C6	69.7	0.15	82.8	63.4	24.6		27-30	7.0 166	5.3 0.5	8.8 0.0
P3	55.2	0.15	82.9	63.4	21.1		24-27	2.2 250	10.3 -1.1	10.0 -1.5
P3	55.8	25	89.0	79.7	54.3		39-42	4.2 294	15.9 -2.1	15.4 -2.9

Danish Strait

932	22	5	73.8	36.4	15.3		20-25	5.1 138	8.4 2.6	3.8 0.6
932	29	50	75.9	43.6	20.2		20-25	5.1 105	10.5 -0.2	3.7 0.2

Table 4 (Cont'd)

Station	Record Length (days)	Msmnt Depth (m)	PCT >5 cm/s	PCT >10 cm/s	PCT >15 cm/s	Mean Speed cm/s	Max. Speed cm/s	Vector-Averaged Velocity cm/s @ °T	M2 Maj	M2 Min	K1 Maj	K1 Min
Prince of Wales Strait												
CM01	25.3	20	79.4	58.4	41.9		47	8.4 WSW	15.2	0.1	4.2	-0.4
CM02*	90.5	20	79.3	52.0	29.6		35-40	4.5 WSW	13.5	0.1	3.6	-0.4
CM03	25.3	20	74.3	33.9	4.6		15-20	<2	10.0	0.1	2.8	-0.4
CM06	9.15	20	80.9	49.5	16.8		30-35	<2	14.4	0.1	4.0	-0.4
CM08	39.3	20	77.0	46.5	22.0		20-25	<2	13.6	0.1	3.6	-0.4
CM09	79.5	20	80.1	29.8	11.5		20-25	<2	12.0	0.1	1.9	-0.4
PW1	29.0	10						3.2 24	16.4	0.6	3.5	-0.6
42	39	6						1.9 251	9.9	4.1	3.0	-0.2
42	39	34						2.4 253	14.2	-1.2	3.3	0.0

3.2.2 BARROW STRAIT

Ice Conditions

Because of the complex and highly variable patterns characteristic of ice movement in the eastern portion of Parry Channel, Barrow Strait exhibits a range of ice conditions which probably exceeds those associated with any other potential study region. The spring ice is primarily first year in type although small multi-year floes do enter the region from Viscount Melville and McDougall Sounds and Wellington Channel during the fall and early winter months. Some of these floes become incorporated into the regional pack in those years (75%) in which the cross-channel edge of fast ice in Parry Channel forms at west longitudes of 90°W or less. In the remaining years (25% of the total) the Parry Channel fast ice edge forms along a line linking Griffith, Lowther and Somerset Islands, giving rise to a polynya immediately to its east and allowing ice to continue to move irregularly eastward through the Strait during the winter period. In such years, excluding the narrow shorefast ice zones, the fast ice requirement for a study site is met only at the western entrances to the Strait, in the passes between Russell, Lowther and Griffith Islands studied oceanographically by Peck (1980a).

Generally, station data taken predominantly in those years when the fast ice edge was east of 90°W (see Peck, 1980, Prinsenberg and Sosnoski, 1983b,c) are indicative of thicknesses in the range of 1.5 to 2.5 m although thin (0.9 to 1.0 m) conditions have also been recorded during the 1983 spring season when the fast ice edge was located in an extreme eastern position (Fissel et al., 1984b).

The ridging data of Table 2 suggest that a rugged surface topography is common in those years in which fast ice conditions prevail throughout the Strait. Repetitive cracks, leads and ridges have been reported to occur along various lines either partially or completely crossing the Channel. Examples of such features are most apparent in Resolute Passage in the image of Figure 3. Again local surveys and/or comparisons with SLAR data are necessary to identify those features which do correspond to ridges of dimensions appropriate to study sites.

Oceanographic Conditions

By comparison with other areas of the Canadian Arctic Archipelago, a considerable quantity of current meter data exist for the winter-spring season. Much of the available data have been collected by the oceanographic unit based at Canada Centre

for Inland Waters (CCIW) in 1978 (Peck, 1980a) and 1981 to 1983. The latter data set consists of current meter measurements at several locations on a north-south transect (94°W) across Barrow Strait in March-April, 1982 and repeated again in 1983, along with year long records at one site (station 46) in Southern Barrow Strait (see Figure 5). The final results of the 1981-1983 field work are not yet available; a few preliminary results were obtained for this study (E.B. Bennett, pers. comm.).

Currents in Barrow Strait result in large part from a combination of strong tidal currents and a mean easterly flow. The amplitude of the tidal currents exhibit considerable differences within the Strait according to depth and location (Table 4). At depths ranging from 25 m to 60 m or greater, the semi-diurnal tidal currents are large, with the amplitude of the M_2 constituent of 15 to 25 cm/s. At these depths, the amplitude of the diurnal constituent is more variable ranging from 5 cm/s over the relatively shallow passages of the Barrow Strait sill (98°W) to 15 cm/s, off the coast of Somerset Island. While the tidal flows are generally strong along the east-west orientation of the Strait, the tidal currents assume rotary, usually clockwise, characteristics at locations away from the coastal boundaries. At shallower depths, the amplitude of the tidal flows decrease; for example the M_2 tidal flows at 1978 stations 35 and 45 are reduced by a factor of 2 to 3 from 50 m depth to 4 m depth.

A persistent easterly flow occurs at most measurement sites in Barrow Strait. Over much of the Strait, the mean flow has an amplitude of approximately 5 to 9 cm/s, but along the coastline of Somerset Island, the mean flow increases to 15 cm/s or more. Considerable low frequency (sub-tidal) fluctuations are superimposed on the mean flow at most locations, having periods of several days or greater. In southern Barrow Strait to the east of Peel Sound, the largest currents exist; at a depth of 10 m, flows exceed 10 cm/s approximately 75% of the time.

The water column in Barrow Strait is characterized by a high degree of variability, with significant changes often occurring over periods of less than one hour (Peck, 1980a; Fissel et al., 1984b). On the northern side of the Strait, the water column has a small degree of stratification, with high surface salinities. Lower surface salinities and a better developed surface mixed layer are found on the southern side of the Strait, reflecting the greater volume of the passage of the lower salinity water of the western Archipelago passing eastward through Barrow Strait. Here the depth of the mixed layer typically ranges from 15 to 50 m, with a considerable degree of interannual variability

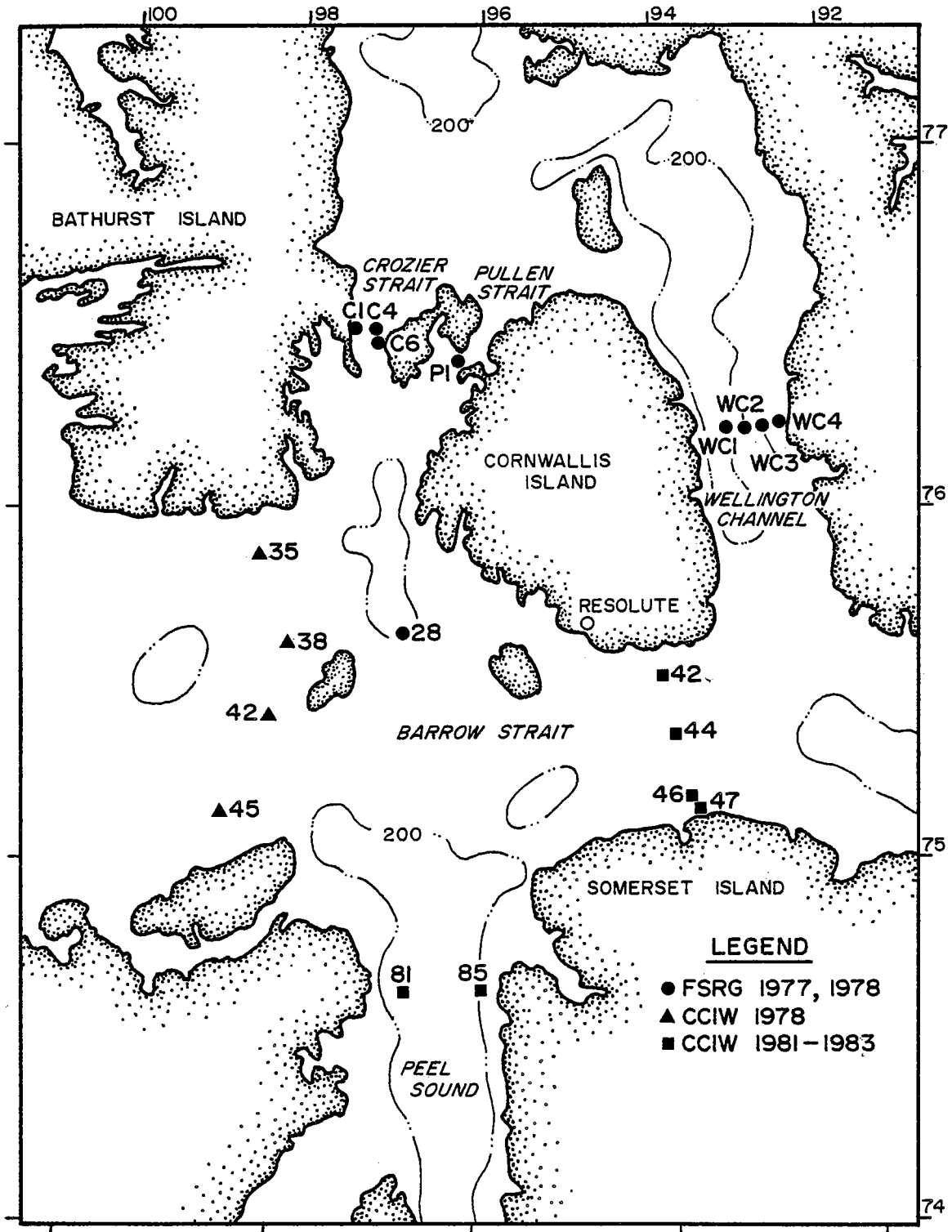


Figure 5: Locations of current measurement stations in Barrow Strait, Crozier Strait, Pullen Strait, Wellington Channel and Peel Sound.

indicated (Prinsenbergs and Sosnoski, 1983a, 1983b, 1983c).

3.2.3 PEEL SOUND

Ice Conditions

The southward trend of the ice flow in this body generally results in its near-clearance by October and hence the nearly completely first-year springtime cover almost uniformly reported over the 1961-1971 period. Occasional instances of non-clearance have occurred (i.e. 1972) leaving a second year ice cover in much of the Channel for the following spring period.

Aerial surveillance of this body has evidently been of relatively low priority resulting in an abnormally low density of data on ridge densities and other ice features. As a result little guidance is available on the probabilities/locations of suitable ridges.

Oceanographic Conditions

Available current meter data for Peel Sound are limited to line of current meters operated over a one month period across northern Peel Sound in March-April, 1981 (see Figure 5). Currents are low on the west side of the northern Sound, and increase along the eastern side, bordering Somerset Island (Table 4). While no tidal analysis results were available for these data, the currents are clearly dominated by tidal flows parallel to the coastline.

The water column in northern Peel Sound is similar to that of the southern Barrow Strait. (Prinsenbergs and Sosnoski, 1983a, 1983b, 1983c), having a surface mixed layer with depths varying from 15 to 50 m.

3.2.4 WELLINGTON CHANNEL

Ice Conditions

The trend of the flow in this Channel is again southerly with the dates and duration of the southern movement influenced by the positions of the landfast ice edge which stabilizes each winter somewhere in Lancaster Sound or Barrow Strait. In roughly 75% of the observed years (Marko, 1982) this latter feature was located at or to the west of the 90° line of west longitude dictating ice blockage of the Channel mouth until early to mid-July. In the remaining 25% of the years stabilization at a line which includes Griffith, Lowther and Russell islands results in a

much earlier (May) clearance of the southern Channel mouth. This difference does not lead to any destabilization of the fast ice relevant to a springtime experiment in areas removed from the immediate southern entrance to the Channel.

Instead these and other variations in Parry Channel and in the Edingburgh Sea and Sverdrup Basin source regions give rise to a range of uncertainty in the distribution of spring ice types. Although 10/10 coverage by first year ice was reported in 50% of the 1961-1970 years, complete or partial coverage by multi-year ice is a common occurrence.

Reported values for the ridged surface fraction (Table 2) and the ridge frequency along a given line (Figure 2b) suggest these features are normally found in the area in considerable numbers. Moreover inspection of the 1973 Landsat image (Figure 3) indicates the presence of numerous cross-channel linear, possibly ridge-like, features. This particular alignment of these structures is apparent at the south end of the Channel and is consistent with reports of repetitive, roughly east-west directed ridging near the Parry Channel junction (R. Herlinveaux, pers. comm.).

Oceanographic Conditions

The only set of extended current meter measurements available for Wellington Channel was obtained in April-June 1978 by the Frozen Research Group (1981) at the locations shown in Figure 5. The currents of largest magnitude were measured in the west side of the Channel (Table 4), due to the presence of a sizeable net flow (6.7 cm/s), setting to the south. At all locations, diurnal tidal currents accounted for most of the total variance. The amplitude of the largest diurnal constituent (K_1) exceeded that of the largest semi-diurnal constituent (M_2) by a factor of two. The next largest diurnal constituent (O_1) had amplitudes comparable in magnitude to the M_2 constituent at stations WC1, WC2 and WC3. At station WC4 on the eastern Channel, the semi-diurnal tidal current amplitudes increase to near 9 cm/s, presumably due to the presence of internal tides. This increase appears to account for the larger speeds measured near the eastern coastline, as compared to mid-Channel measurements. All tidal currents were directed along the orientation of the Channel with negligible cross-channel components.

In late winter and spring, the water column in Wellington Channel generally has low levels of stratification. Surface salinities are often near 33.0, only 0.1 to 0.2 less than the

values of the near-bottom salinities (Prinsenberg and Sosnoski, 1983a, 1983b, 1983c, Fissel et al., 1984b). The elevated surface salinities and absence of a less dense surface mixed layer likely results from vigorous vertical mixing occurring in shallow passages to the north of Wellington Channel (e.g. the Dundas polynya as described by Topham et al., 1983). In some years, a mixed layer of less saline water, has been observed (1978-Frozen Sea Research Group, 1981; 1981-Prinsenberg and Sosnoski, 1983a), with depths ranging from 20 to 50 m. This feature appears to be more common along the eastern and southern portions of the Channel, likely representing less saline water from Lancaster Sound flowing northward along the Devon Island coast.

3.2.5 CROZIER STRAIT

Ice Conditions

The ice data for this body again indicate the preponderance of coverage by 10/10 first year ice with multi-year and second year inclusions generally less than 1-2/10. As elsewhere, years of near total coverage by multi-year ice have also been encountered. Quoted ridging densities (Table 2) are usually given for the southern end of Queen's Channel and have been assumed approximately valid for the region. Both the 1973 Landsat image (Figure 3) and lower resolution 1977 imagery (NORCOR, 1978) suggest the presence of much structure on scales much smaller than the ideal 5 km minimum separation of potential isolated ridges. In the former case linear features are noted immediately to the south of the Strait in McDougall Sound. As in Wellington Channel these features appear to be predominantly oriented perpendicular to the general southerly flow trend.

Oceanographic Conditions

In Crozier and Pullen Straits, only one set of current meter data has been obtained to date. These data were collected by the Frozen Sea Research group (Greisman and Lake, 1978) in March-June 1977 at six locations across the width of Crozier Strait and a single site in Pullen Strait (see Figure 5). For all sites, currents were measured at a depth of 0.15 m beneath the sea-ice, while at three locations only, currents were also measured at 25 m depth. The current data obtained immediately beneath the sea-ice are reduced by an unknown amount from the free stream values appropriate for layer depths in the near-surface layer. A comparison of the tidal analysis results for 0.15 m and 25 m depth suggest that the former measurements are reduced to approximately 65 to 70% of the values at 25 m for tidal frequencies. Greisman and Lake (1978) note that this sizeable

reduction for tidal oscillations does not appear to apply to the mean flow (see also Table 4).

The currents in both Straits are dominated by tidal currents, flowing parallel to axis of the Straits. The strongest tidal currents occur at diurnal frequencies, with the largest constituent (K_1) having amplitudes of 15 to 18 cm/s at 25 m depth. The next largest diurnal constituent (O_1) and largest semi-diurnal constituent (M_2) have comparable amplitudes at most stations in Crozier Strait, with values of 10 to 13.5 cm/s. In Pullen Strait, the M_2 tidal currents are larger (16 cm/s at 25 m depth) comparable in amplitude to the K_1 diurnal constituent (15 cm/s) and considerably larger than the O_1 diurnal constituent (9 cm/s).

Within the near-surface layer, a mean flow to the south is evident at most Crozier Strait locations. This flow is largest (6 cm/s) on the west side of the western channel of the Strait and at all locations through the east channel of the Strait, decreasing from 9 cm/s on the west side to 7 cm/s on the east side. In Pullen Strait, by comparison, the net flows are weak (<2 cm/s). Superimposed on the mean flows are low frequency modulation periods of several days or longer; the amplitude of the low frequency variations are sufficient to reduce the daily averaged currents to near zero over periods of a few days, but reversals in the daily average current are very rare (Greisman and Lake, 1978).

Based on CTD data obtained in March of 1977 and 1978, the water column in Crozier and Pullen Strait is well mixed with a low level of stratification (Frozen Sea Research Group, 1977,1981). Surface salinities range from 32.7 to 32.9, and mixed layers, when present, are separated from the remainder of the water column by a very weak halocline.

3.2.6 DANISH STRAIT

Ice Conditions

The predominant trend in this region is for coverage by multi-year or second year ice. One year (1963) (see Table 2) of complete coverage by first year ice was recorded (see also Figure 2a) as well as several years when such ice was predominant in a significant fraction of the area.

Ridging densities (Table 2 and Figure 2b) appear to be as high or higher than most of the potential study regions.

Oceanographic Conditions

Extended measurements of currents have been collected at only one site, located in mid-channel (Figure 6) in April 1979 by Peck (1980c). These data consist of two relatively short current records of 22 and 29 day durations obtained at depths of 5 and 50 m. In 1974 and 1975 current data were obtained as part of early studies by Panarctic Oils Ltd. in this area, but the data records are even shorter in duration and preliminary in nature (Van Ieperen, 1981).

The currents in Danish Strait are dominated by tidal flows, aligned southeast-northwest along the axis of the Strait (Table 4). The cross Strait component of the tidal flows are small. Tidal flows of semi-diurnal period (8-10 cm/s) are approximately twice the amplitude of the diurnal flows (4 cm/s). A persistent net flow to the southeastward is present, having mean speeds of approximately 5 cm/s. The magnitude of the net southeastward current varies over periods of 3 to 5 days and longer, ranging from near-zero to approximately twice its mean amplitude in the daily averaged current velocity (Peck, 1980c).

Available vertical profile measurements of temperature and salinity are also very sparse, being limited to three CTD casts obtained in April 1979 (Peck, 1980b). The data at two locations (stations 932 and 933) reveal the upper 100 m of the water column to be weakly stratified, with salinity increasing by approximately 0.2 from the surface to 100 m depth; beneath this level a larger halocline occurs. At the third location, a shallow halocline extends from immediately beneath the sea-ice (salinity of 31.0) to approximately 12 m depth (salinity of 32.6).

3.2.7 PRINCE OF WALES STRAIT

Ice Conditions

Ice data listed in Table 2 for the northern section of the region (which is within the 120 n.m. circle centered on a Mould Bay airstrip) are indicative of a predominant first year ice cover (in 8 out of 10 years the first year ice component was at least 9/10). However, very large intrusions of multi-year or second year ice do occur from Viscount Melville Sound and M'Clure Strait.

Reported ridge densities appear to be low. Recent observations (Fissel, pers. comm.) suggest the snow-covered surface contains considerable small scale roughness

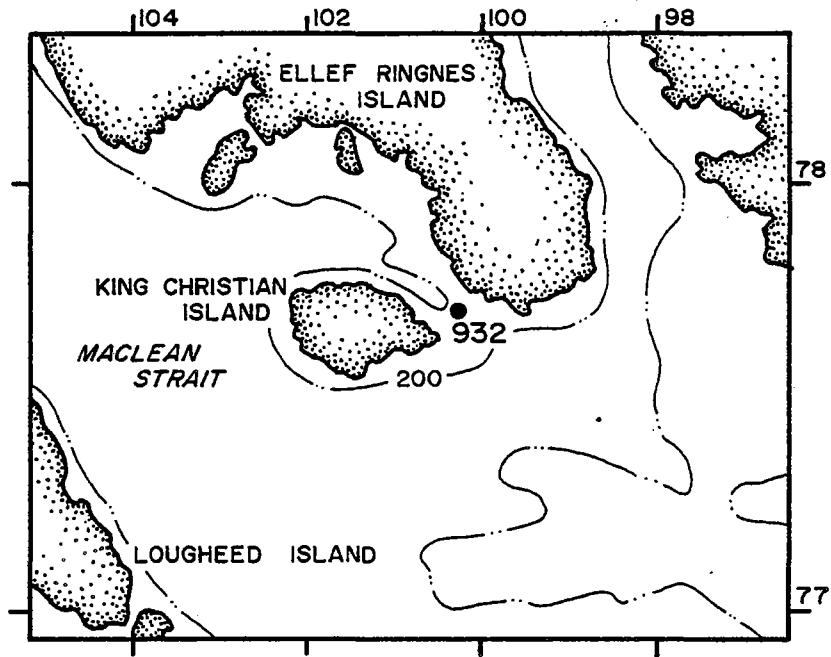


Figure 6: Locations of current measurement stations in Danish Strait.

(corresponding to vertical elevations of 1 m or less) which complicate aircraft-based operations. Cross-channel ridges have been reported to occur at separations on the order of 10 km along the length of the northern Strait (Melling, pers. comm.).

The isolation of these ridges and their orientation perpendicular to the alignment of the tidal ellipse major axes both suggest good prospects for a successful experimental site.

Oceanographic Conditions

The most complete set of under-ice current measurements were obtained by the Frozen Sea Research Group of IOS from late March to June 1982, in the northern half of Prince of Wales Strait at 20 m depth (H. Melling, pers. comm.). In the same year, the Tidal and Current Survey Group of IOS measured currents in the vicinity of the Princess Royal Islands, mid-way along the length of the Strait. In 1977, current meter data were acquired at the northern end of Prince of Wales Strait (Peck, 1978). The locations of data sets used in this study are displayed in Figure 7.

The currents through Prince of Wales Strait are dominated, to a very large extent by semi-diurnal tidal flows. The tidal currents are oriented along the axis of the channel with virtually no cross-channel component. Among the available data sets, the amplitude of the largest semi-diurnal tidal constituent (M_2) ranges from 10 to 15 cm/s (Table 4).

At most locations, currents other than of tidal origin are comparatively small. However, a current setting to southwest is apparent along the Banks Island coastline. This current appears to be small in width, a few kilometres or less, accounting for the significantly increased speed measured at station CM02 and to a lesser degree at station 42.

The water column exhibits a considerable degree of interannual variability in late winter and early spring. For the northern half of Prince of Wales Strait, the surface mixed layer was shallow (approx. 20 m) and had low salinities in 1977 (Peck, 1978) but was much deeper (approx. 40 m) and more saline (32.3) in 1982 (H. Melling, pers. comm.). In 1983, the mixed layer characteristics were intermediate between those of 1977 and 1982, with a mixed layer depth of approx. 28 m and a salinity of 31.8 (Fissel et al., 1984b).

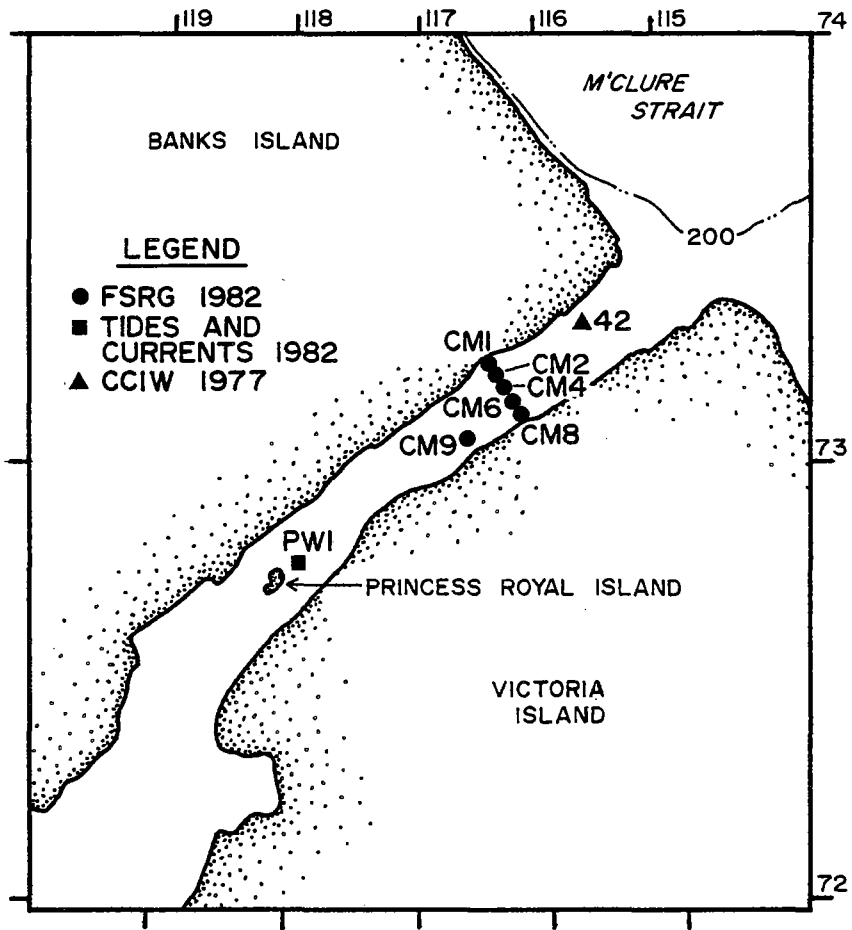


Figure 7: Locations of current measurement stations in Prince of Wales Strait.

4. SUMMARY AND RECOMMENDATIONS

Following an initial selection of regions with regard to distance to logistical bases and nominal ice conditions (fast ice with thicknesses >2 m) available sets of winter-spring current meter measurement data [as identified in the Arctic Data Compilation and Appraisal Reports (Cornford et al., 1982; Birch et al., 1983a, 1983b; Fissel et al., 1982) and from personal knowledge of more recent data] were used to select seven "potential" areas having water flows of sufficient strength for the ice keel experiment. Several areas, particularly in the northwestern and eastern portions of the Canadian Archipelago were excluded from consideration due to the complete absence of winter-spring current measurements.

The oceanographic conditions in each of the seven potential regions have been listed in Table 4. It should be recognized that in almost all areas, the data were very limited in their temporal extent, typically corresponding to measurements in one or two seasonal programs. Further since the number of measurement locations were generally few in number, no data were available in large portions of each region.

A particular difficulty encountered in assembling near-surface current information was associated with a very apparent lack of consistency in the measurement depths. Current measurements closest to the water surface were obtained at 0.15, 4, 5, 10, 12, 20, 25 and 50 m in the various measurement programs. Where simultaneous measurements were available at the same location (Greisman and Lake (1978) in Crozier Strait at 0.15 and 25 m; Peck (1980a) in Barrow Strait at 4 and 50 m), large differences were apparent, with a marked reduction (by factors of 1.5 to 3) in the tidal streams from the deeper levels (25 to 50 m) to levels within a few metres of the ice. Because of these current shears, comparisons between data sets must be made with considerable caution.

For the seven areas considered in more detail, comparative speed statistics are presented in Figure 8. In some of these areas, currents of the necessary magnitude were limited to subareas: the northwestern portion of Austin Channel, the eastern half of Peel Sound and the western half of Prince of Wales Strait. The speed values of Figure 8 were chosen to be representative of these sub areas of stronger flows. On the bases of the percent of measurements exceeding 10 cm/s, the areas can be subdivided into three categories:

- 1) Barrow Strait and Crozier Strait, with 60-80% occurrence of speeds >10 cm/s.
- 2) Western side of Prince of Wales Strait, Wellington Channel and eastern Peel Sound, with 40-60% occurrence of speeds >10 cm/s.
- 3) Danish Strait and northwestern Austin Channel, with 30-40% occurrence of speeds >10 cm/s.

In all areas, tidal flows accounted for much of the measured current speeds, although the period of the dominant tidal streams varied considerably being diurnal in Crozier Strait, Wellington Channel, semi-diurnal in Prince of Wales and Danish Straits and mixed semi-diurnal in Barrow Strait and Peel Sound. Intense mean or low frequency currents also occur in some areas. These were of smaller horizontal scale than the tidal flows. A feature of the currents evident in several of the areas, was the presence of narrow but intense (5-15 cm/s) coastal current, moving in such a way that the coastline was to the right of the flow direction. These coastal currents, observed on the western sides of Prince of Wales Strait and Wellington Channel, on the eastern side of Peel Sound and the southern side of Barrow Strait, can result in a significant increase in current speeds.

The directionality requirement (a) of Section 1 is readily satisfied in the identified portions of these regions due to the generally strong alignment of both the low frequency- and tidal-current components parallel to the channel axes.

On the other hand, with perhaps two exceptions, the apparently large year-to-year and spatial variabilities in ice conditions (Table 2 and Figures 2 and 3) precludes extensive use of these data in further narrowing of regional preferences. The first cited exception is the Crozier Strait region where satellite imagery (Figure 3 and NORCOR, 1978) and personal observations (Topham, pers. correspondence) suggest the frequent presence of smaller and intermediate scale roughness (<1 km) in the ice cover which would complicate both logistics and the interpretation of experimental data. The second exception is the restriction of operations in Barrow Strait proper to those seasons (75% overall probability) when the Parry Channel ice edge forms at a longitude $\leq 90^\circ$ W. However, experiments can be carried out in all years in the passes between Griffith, Lowther and Russell Islands at the eastern entrance to Barrow Strait (assuming the presence of suitable ridges).

Requirements for minimum keel dimensions, degrees of isolation and flatness in the seabottom and the surrounding ice cover can only be established from further reviews of historical SLAR and Landsat imagery and/or by SLAR and aerial survey flights and on-ice soundings prior to the experiment.

The regional data support a site selection strategy which takes advantage of the fact that 6 of the 7 (5 of 6 if, as recommended, Crozier Strait is eliminated from consideration) potential study regions lie within the 2-hour flying time circles of the Resolute Bay logistic base. The remaining seventh (sixth) region, Prince of Wales Strait, is in many respects ideal for the study with relatively minor disadvantages associated with the reported very small-scale roughness of its snow-covered surface and the necessity of working out of smaller, more remote logistics bases (Rae Point or Mould Bay). On the other hand, however, the accessible Prince of Wales study region is relatively small in spatial extent and surrounded by areas unsuitable for the experiment. As a result, failure, for some reason, to find a suitable site in the Strait would leave the program with few options short of a major shift in its logistical base.

The obvious alternative, a program centred on Resolute Bay, would allow access to Barrow Strait, Wellington channel, Peel Sound, Austin Channel and Danish Strait. On the basis of their size and the current speed data of Figure 8, the first three of these regions must be regarded as the most probable locations for experimental sites. Should sites not be available in these regions, a Resolute Bay-based program could then still operate in the more distant and less desirable (because of generally lower current speeds and, in the case of Danish Strait, large concentrations of heavily ridged multi-year ice) Austin Channel and Danish Strait regions. Additional options inherent to a Resolute Bay-based operation include the possibilities of mounting programs in marginally potentially regions such as Queen's Channel, McDougall Sound, Erskine Inlet, Desbarats Strait and Byam Martin Strait.

Actual selection of sites would have to be made on the basis of interpretation of SLAR imagery obtained from flights made during the winter and spring periods immediately preceding the experiment and knowledge of the current magnitudes and patterns in each area. SLAR coverage of the areas in questions can be arranged by contacting Mr. Alec Beaton (613-995-6818) two to three weeks in advance of the approximately monthly survey flights carried out by AES in the Arctic Archipelago. Some initial surveys of historical surface topography data using

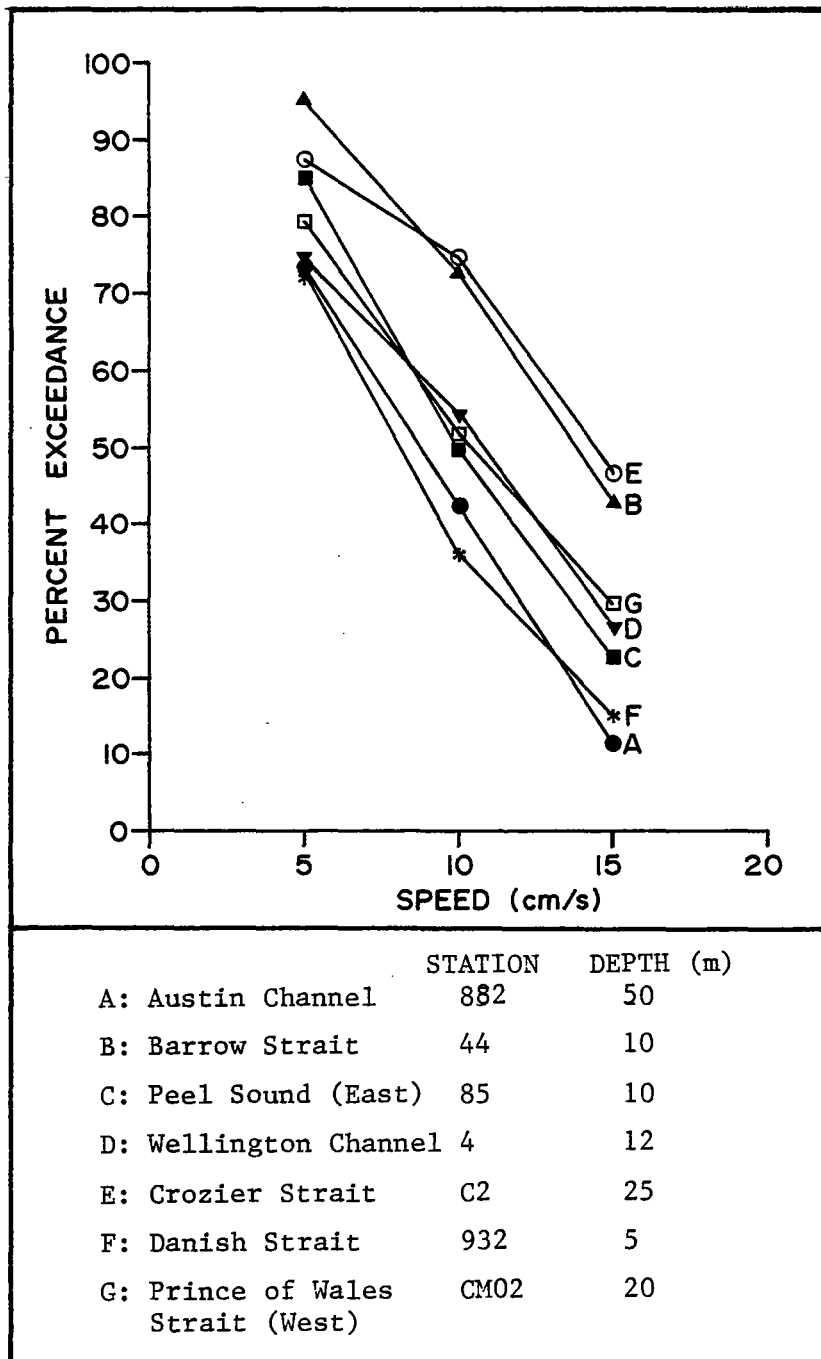


Figure 8: Plots of percentages of current observations exceeding 5, 10 and 15 cm/s in seven potential study regions.

either the Landsat imagery listed in Table 3 or a previous year's SLAR imagery (available from AES at \$75 to \$100), might be useful in this respect by pinpointing the most likely locations for suitable ridges which can then be observed in the highest spatial resolution (25 to 50 km ground swath widths as opposed to 100 km) modes of the AES imaging systems. Current meter data relevant to the site selection process are most abundant in Barrow Strait and Wellington Channel although in the former area these data have, as yet, been subjected only to preliminary processing and analysis. Nevertheless, the data would seem to imply suitable current conditions are prevalent in very large fractions of both regions. On the other hand, the minimum current criterion (a) has been demonstrated to be satisfied at a much more restricted set of geographical locations in Austin Channel, Peel Sound and Danish Strait. Choices of sites in areas well-removed from previous measurement stations would appear to require a current sampling program prior to full commitment of resources to the experimental program.

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