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Monitoring Coastal Change along the Canadian Beaufort Sea: Report on the field activities, August, 1994

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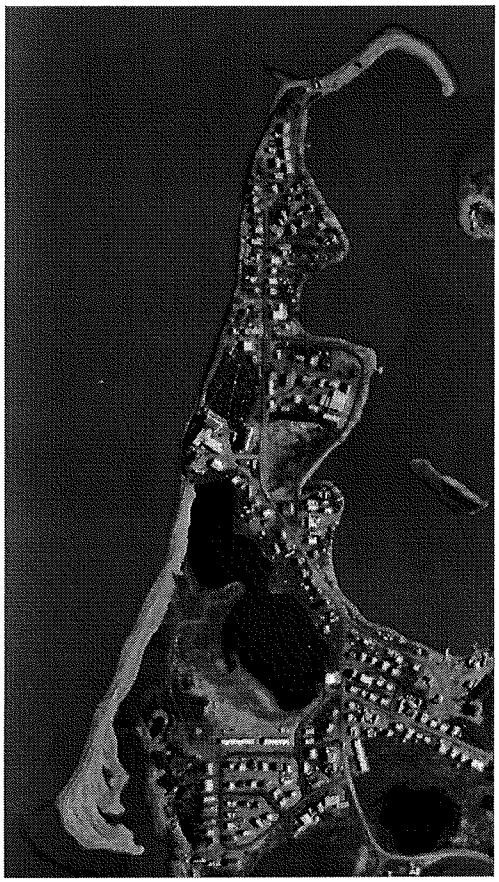

A Contribution to the Canadian Green Plan

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Introduction

Much of the Beaufort Sea coast is undergoing relatively rapid retreat caused by a combination of storm-generated waves, permafrost degradation and global and/or local relative sea-level rise. Historical accounts and measurement of cliff retreat from air photos have identified open water storms and associated storm surges as contributing to much of the year-to-year variability in rates of coastal change (Solomon et al, 1993). A severe storm struck the area in September 1993 with water levels reaching near record highs of 2.27 m above chart datum (E. Sargeant, Canadian Hydrographic Service, pers. comm.). Eyewitness accounts and video tapes attest to the vigour of the wave attack at the Hamlet of Tuktoyaktuk. One eyewitness from the Government of the Northwest Territories estimated that more than half of the sandbag shore protection at Tuktoyaktuk was destroyed (B. Popoff, pers. comm.).

In order to measure the effects of the storm of September,1993, to gain a better understanding of the processes governing arctic coastal retreat and to acquire data for calibration of numerical models, a field program was undertaken in August 1994. The primary effort was directed at the re-measurement of nearshore and beach profiles at selected locations along the southern Beaufort Sea. Cliff retreat measurements were made at existing monitoring sites and CTD profiles were obtained at one location. Active layer thickness was probed at most of the beach profile and cliff retreat sites. As part of the same field program, an air photography mission was mounted through the auspices of the Canadian Interdepartmental Committee on Air Surveys.

Data Collection Locations (refer to Figures 1 and 2)

The field work was performed in the Kugmallit Bay and Mackenzie Delta regions of the southern Beaufort Sea. Echosounding data were collected at Tuktoyaktuk and Tibjak Point. Beach profiling was performed at Tuktoyaktuk, MR2 and Reindeer Islands. Cliff retreat measurements were made at North Head, Taglu Island, Ellice Island and Tent Island. CTD casts were performed in a small breached lake in the Reindeer Islands. Air photography was flown at Tuktoyaktuk, Tibjak, North Head, Tent Island, Ellice Island, and Kay Point.

Methods

Beach profiles, cliff retreat and active layer thickness measurements

Profiles were measured using a Wild T2 Theodolite and survey rod or differential levelling with a pair of graduated staffs. The profiles were measured at sites of previous surveys; the water line at the time of the survey provided a vertical datum. Cliff retreat measurements were made at existing monitoring sites using a tape measure where a sighting pin was located and tape and compass where there was no sighting pin. Active layer thickness was measured with a 1.2 m long stainless steel rod.

Nearshore profiles

A Knudsen digital echosounder was mounted on a 16 foot aluminum boat. The echosounder transducer was mounted on the transom on the boat. The data were logged to a portable computer at one second intervals with the sounder clock set to Mountain Daylight Time (MDT). Positioning was accomplished using two Magnavox Global Positioning System receivers; one mounted in the boat and one mounted at a base station. The base station logged GPS information throughout the day in order to provide data for performing differential corrections on the mobile data.

Conductivity/Temperature/Depth (CTD)

CDT measurements were made with a Seacat conductivity, temperature depth recorder (Seabird Electronics, Inc.). Positioning was done in same manner as for the echosounding.

Observations

Cliff retreat - North Head (GSC sites 5046 and 5047) and the modern Mackenzie Delta (GSC sites 5360, 5340 and 5395) - a summary of results for cliff retreat is given in tables 1 and 2.

Cliff retreat measurements were made along the northern cliff line at North Head along lines (GSC sites 5046 and 5047) which were established by Gillie (1987) and S. Dallimore (Geological Survey of Canada, pers. comm.) (**figure** 2). The last measurements made at these lines were in June, 1993 by S. Dallimore (pers. comm.). Cliff retreat varies from zero to at least 18m in one year, with the highest values concentrated at the west end of North Head.

Cliff retreat was also measured at GSC sites 5395 (Taglu), 5340 (Tent Island), and 5360 (Ellice Island) along the modern Mackenzie Delta front (**figures** 3, 4,and 5). Previous measurement dates vary; annual retreat rates over a period of 2 to 8 years range from less than 2m/a to more than 14m/a. It should be noted that cliff heights along the modern delta are generally < 2m, whereas the cliffs at North Head exceed 15m. Thus, much higher volumes of sediment are released per metre of eroded cliff at North Head, than along the delta.

Beach profiles

A listing of the beach profiles and GPS positions is presented in Appendix A.

*Tibjak Point - GSC site 5202 (**figure** 6)*

The four profiles at Tibjak were located along 2 lines which were established in 1992 by the Geological Survey of Canada (GSC) and two lines established by P. Hill (Universite du Québec à Rimouski, pers. comm.) in 1993. The GSC lines were marked with benchmark (BM) numbers 492 and 493 located along a baseline oriented 175° M. A third benchmark (BM494) was not found; its location was covered in driftwood. BM492 still sported the remains of a cloth airphoto target. The GSC Tibjak location is characterized by low tundra cliffs (BM492 line) and marsh (BM493 line) fronted by a variable-width beach. Driftwood is abundant on the beach crests and in the back-beach areas. The BM493 line originates in a waterlogged, probable drained-lake basin characterized by ponds and ice-wedge polygons. Peat outcrops at the waterline at the BM493 line, but is not present at the more northerly line (BM492). This latter line enters the sea between two shore-attached bars. The sand below the waterline is too soft to support a person. Active layer thickness is less than 100cm across the beach and below the waterline along the BM492 line. The active layer thickness varies from 80 cm to 100 cm along the tundra cliffs. It is greater than 120 cm on the unvegetated beach at BM493. The probe only penetrates about 50 cm in the peats at the waterline, but it may be stopped by wood rather than ice-bonded permafrost.

Hill93-6 was marked by a piece of driftwood driven into the tundra; Hill93-7 uses the front leg of the Racon tower as the front marker and a piece of driftwood as a rear marker. The lines straddle a small pond on the beach shoreward of the beach crest and immediately in front of the low tundra bluffs. This area is close to the southern end of the tundra and at the proximal end of the

southward building spit. The active layer is about 70 cm thick on the tundra and greater than 120 cm across the beach.The beach at the waterline is characterized by metre-scale cusps; higher water levels are marked by storm and swash lines of fine organic debris and driftwood. Small waves (<0.5m) were seen breaking on a nearshore bar within about 100m of the waterline. Southward from the Hill lines, the beach widens and separates from the tundra shore to become a spit. The dominant sediment transport direction is southward from the eroding tundra cliffs which extend northwards from the GSC lines.

The beach profiles at Tibjak depict differences between the southern (Hill lines) and the northern (GSC lines) ends of the beach. The south end of the study area has a wide beach backed by upland tundra surfaces rising to nearly 5m. At the north end, the beach is narrow and backed by drained lakes or low tundra cliffs less than 3 m high (**figure** 7). A comparison between surveys performed in 1992 and 1994 at BM492 and BM493 reveals considerable differences in behaviour between the two sites. At BM493 (**figure** 8), the subaerial portion of the profile has changed little with a suggestion of landward migration of dunes probably as a result of washover during the 1993 storm event. Below mean sea level, the 1994 profile is more than 0.5 m shallower than the 1992 profile for a distance of about 40 m. This is probably the result of alongshore bar migration and attachment of a shoreface bar. BM492 is located updrift of BM493 at the end of a tundra cliff. There appears to have been several metres of retreat at the base of the subaerial cliff with little change at the top of the cliff (**figure** 9). As mentioned above, the sand below the waterline was too soft to support the survey rod-man in 1994, whereas, the surveyors continued without noting a problem in 1992.

*Hamlet of Tuktoyaktuk - GSC site 5012 (**figure** 10)*

Beach profiles (**figure** 11) were measured along four lines oriented approximately east-west and orthogonal to the peninsula forming the most densely populated portion of the Hamlet (**figure** 10). The lines are known (from North to South) as the RCMP line, the Cemetery Line, the proximal spit line and the distal spit line. The RCMP line is located at the northwest corner of the turquoise RCMP garage at the north end of the townsite. Its orientation is parallel to the north wall of the garage along a bearing of approximately 290°M. The beach consists of gravel and cobbles with little sand, backed by a 2.5-3 m cliff protected by sand bags. This location is noted for its vulnerability to erosion by westerly and northwesterly storms and the accompanying surges (e.g.Rampton and Bouchard, 1975). The most recent storm (September 22-23, 1994) overtopped and removed most of the shore protection (sand bags) and eroded at least 3 to 5 m of reclaimed land including some of the roadway in front of the garage (pers. comm.: B. Popoff, Oct. 27, 1993; P. Hill, May, 1994). By August 6, 1994, the road had been repaired and the sand bags replaced at this site. Further southward along the peninsula, I estimate at least 60% removal of sand bag shore protection.

The Cemetery line is marked by GSC BM290 on a bearing of 255°M. This BM was located immediately adjacent to the cemetery fence. In 1992 it was located inside the fence indicating that either the fence or the benchmark was moved. A Dominion Land Survey BM dated 1949 was not found during this survey, but was present in May 1994 (P. Hill pers. comm.) and was probably hidden by vegetation in August. The shore protection along this line has been mostly removed and a nearly vertical 1.5m scarp is present at the shoreward edge of the beach. The beach is narrow and sandy with some gravel.

The Proximal spit line is at the northern end of the spit building southward from the eroding coastal bluffs. It is marked by benchmarks 287 and 288 located in the tundra behind the spit . The BM's lie on a bearing of 265°M. The spit has a distinct gravel and sand crest. It is primarily gravel with

some sand above the waterline and predominantly sand below. The landward edge of the spit terminates in a washover lobe overlying tundra vegetation. Storm surge lines are marked by logs driven up onto the tundra.

The distal spit line is located about 100m south of the proximal spit line and is marked by 2 poles on the beach which lie along a bearing of 263°M. The spit at this point is backed by a tidal lagoon; there are distinct washover lobes overlying the lagoon which were not present in a 1993 air photograph. The sediments below the waterline are mostly sand which give way to gravel and cobbles above sea level.

The RCMP, Cemetery and Proximal spit lines have been monitored since 1984, however, undocumented changes in the horizontal positions of the benchmarks at the RCMP and Proximal spit lines make comparisons difficult prior to 1991. **Figures** 12, 13, and 14 illustrate the dramatic changes between 1992 and 1994 which we attribute to an intense storm and storm surge which occurred in September, 1993. Along the Cemetery line (**figure** 12), the 1994 and 1984 cliff-lines are coincident , whereas the 1991 and 1992 cliff-lines are about 10 m seaward. Land reclamation and shoreline protection commencing in 1987 built the coastline seawards to approximately the 1981 position (Solomon et al, 1993). As a result of the 1993 storm, the cliff-line has retreated once again to that approximate position. At the RCMP line (**figure** 13) more than 5m of erosion has occurred at the top of the profile. By the time the 1994 survey was performed, the shore protection had been partially rebuilt; actual erosion was greater than depicted. At the BM287 line (**figure** 14) The profile remained virtually unchanged from 1991 to 1992 followed by approximately 10m of landward movement at the crest of the spit.

*Reindeer Spit - GSC site 5038 (**figure** 2)*

The Reindeer Spit profile is located close to profile 90-7 (Hill and Frobel, 1991) and along a line of shallow boreholes drilled in 1993 (Solomon, 1994). The bearing of the profile is 010°M. It consists of a barrier beach backed by a broad gravel washover flat characterized by a gravel deflation surface (**figure** 15). The beach is comprised of gravelly sands with a ridge and runnel morphology at the seaward water line. The landward side of the washover flats slopes gently down to Hansen Harbour. The water level measured at Tuktoyaktuk at the time of the survey was 75 cm above chart datum (45 cm above mean water level). The plotted profile (**figure** 15) uses mean water level as the datum. This is based on the water level at the time of the survey corrected using the tide gauge at Tuktoyaktuk. Active layer thickness is greater than 120cm across the entire spit/barrier complex. Peat outcrops at the waterline several hundred metres north of the spit and is nearly continuous along the length of the shoreline.

*MR2 Island - GSC site 5040 (**figure** 12)*

The MR2 Island profile is located on the east-facing side of the island at the base of a low tundra cliff and at the proximal (updrift) end of a barrier fronting a small lagoon. The profile is at the landward end of a line of shallow boreholes drilled in 1993 (Solomon, 1994) on a bearing of 350°M. The landward end of the profile starts at the waterline of a small lagoon (the remains of a breached lake) continues up over a low tundra cliff and onto the beach (**figure** 15). The beach is more than 25 m wide with small ripples parallel to the shoreline and scattered peat blocks littering the surface. Log debris is concentrated on the lagoon side of the spit. At the time of the survey, the winds were blowing directly from the north, but waves were refracted arounf Pullen Island (located about 7 km to the north) so they approached the beach virtually orthogonally (i.e. along the same bearing as the surveyed profile. The water level measured at Tuktoyaktuk at the time of the survey was 86 cm above chart datum (56 cm above mean water level). The plotted profile

(**figure** 15) uses mean water level as the datum. This is based on the water level at the time of the survey corrected using the tide gauge at Tuktoyaktuk. The active layer thickness increases from 80cm at the lagoon waterline and across the tundra to 90 cm at the base of the tundra cliff and to more than 120 cm close to the waterline.

CTD

CTD measurements were made in a breached lake on the southern side of Reindeer Island. Six casts were made as the boat drifted with the wind in a southwesterly direction across the lake. The time of each cast was recorded and will be tied to positions recorded on the GPS. All six casts showed a similar pattern. **Figure** 16 illustrates the presence of a distinct thermo- and halocline between 3-4m. Water temperatures decline from about 10°C to <0°C and salinity increases from fresh at the surface to more than 25-35 ppt. The lake is roughly circular and approximately 500 m in diameter. It is at least 12 m deep with a well defined apron of shoals less than 2 m deep. Data collected during a 1993 borehole program (Solomon, 1994) found laminated marine clays at the bottom of the lake (Forbes et al. 1994).

Echosounding

Thirty two nearshore profiles each between ~500 and ~1000 m long were measured at 19 locations using echosounding techniques (see **figures** 6 and 10 for location of echosounding surveys). In some cases the profiles were extensions of onshore beach profiles. The tie-in to the beach surveys was hampered somewhat by low water levels, which limited our ability to survey within the barred nearshore areas. In general, nearshore profiles were concave upwards until the barred portion was encountered. Multiple bar systems were found at Tibjak and Tuktoyaktuk, but did not appear to be present at Tuktoyaktuk Island. Profiles at Tibjak tended to be fairly consistent along the shoreline, whereas the Tuktoyaktuk profiles were more variable.

References

Forbes, D.L., Solomon, S.M. and Hamilton, T.S. 1994. Morphology and sedimentary processes of microtidal embayments, Beaufort Sea coast, western Arctic Canada. In Proceedings, International Coastal Symposium, Hofn, Hornafjörõur, Iceland, June 1994.

Gillie, R.D. 1987. Beaufort Sea coastal morphology study; Geological Survey of Canada Open File Report #1826.

Hill, P.R. and Frobel, D. 1991. Documentation of Summer NOGAP Activities July 22 to August 25, 1990. Geological Survey of Canada Open File Report #2451, 84 p.

Rampton, V.N. and Bouchard, M. 1975. Surficial geology of Tuktoyaktuk, District of Mackenzie. Geological Survey of Canada, Paper 74-53, 18 p.

Solomon, S.M. 1994. Report on field activities and preliminary data interpretations, Beaufort Sea: Spring, 1993. Geological Survey of Canada Open File Report #

Solomon, S.M. and Forbes, D.L., and Kierstead, B. 1993. Coastal impacts of climate change: Beaufort Sea erosion study. Geological Survey of Canada Open File Report #2890.

Table 1: North Head Cliff Retreat

Line designator	Cliff Retreat 1993-1994 (m)
TSD lines at 1987 borehole site	
10W	marker not found
15W	11.7
30W	18.1
50W	15.6
70W	10.5
90W	10.3
110W	11.44
130W	10.9
150W	6.1
170W	18.53
0E	6.4
20E	9.9
40E	4.8
70E	no change
100E	9.4
130E	marker not found
190E	marker not found
220E	marker not found
250E	marker not found
Gillie BM IV - Site NP6	
50W	
40W	13.5
20W	12.3
0 - BM IV	11
20E	11.4
40E	15.2
Gillie BM V - Site NP5	
S1	7.63
S2	8.35
S3	1.4
S4	0.6
S5	0.5
Gillie BM III - Site NP3	
S1	6
S2	11.17
S3 - BM III	marker not found
S4	0.7
S5	-1.5
Gillie BM II - Site NP2	
S1	5.5
S2	0.1
S3 - BM II	marker not found
S4	2.9
S5	0.7

Table 1: North Head Cliff Retreat (continued)

Line designator	Cliff Retreat 1993-1994 (m)
Gillie BM I - Site NP1	
S1	0.5
S2	1.7
S3 - BM II	0.85
S4	0.14
S5	no change

Table 2: Mackenzie Delta Cliff Retreat

Line Designator	Cliff Retreat (m)					
	86-91	86-92	86-94	91-92	91-94	92-94
Taglu						
Rebar1						6.10
Rebar2						4.32
Rebar3						1.53
Ellice Island						
BM II	3.98	3.78	4.34	2.80	4.93	6.00
Rbar400	6.54	6.00	5.94	3.30	4.93	5.75
Rbar300	6.19	6.32	6.30	6.95	6.48	6.25
Tent Island						
BM I			8.21			
100	14.06		14.21		14.45	
200	2.36		3.70		5.93	
200	8.16		7.33		5.93	

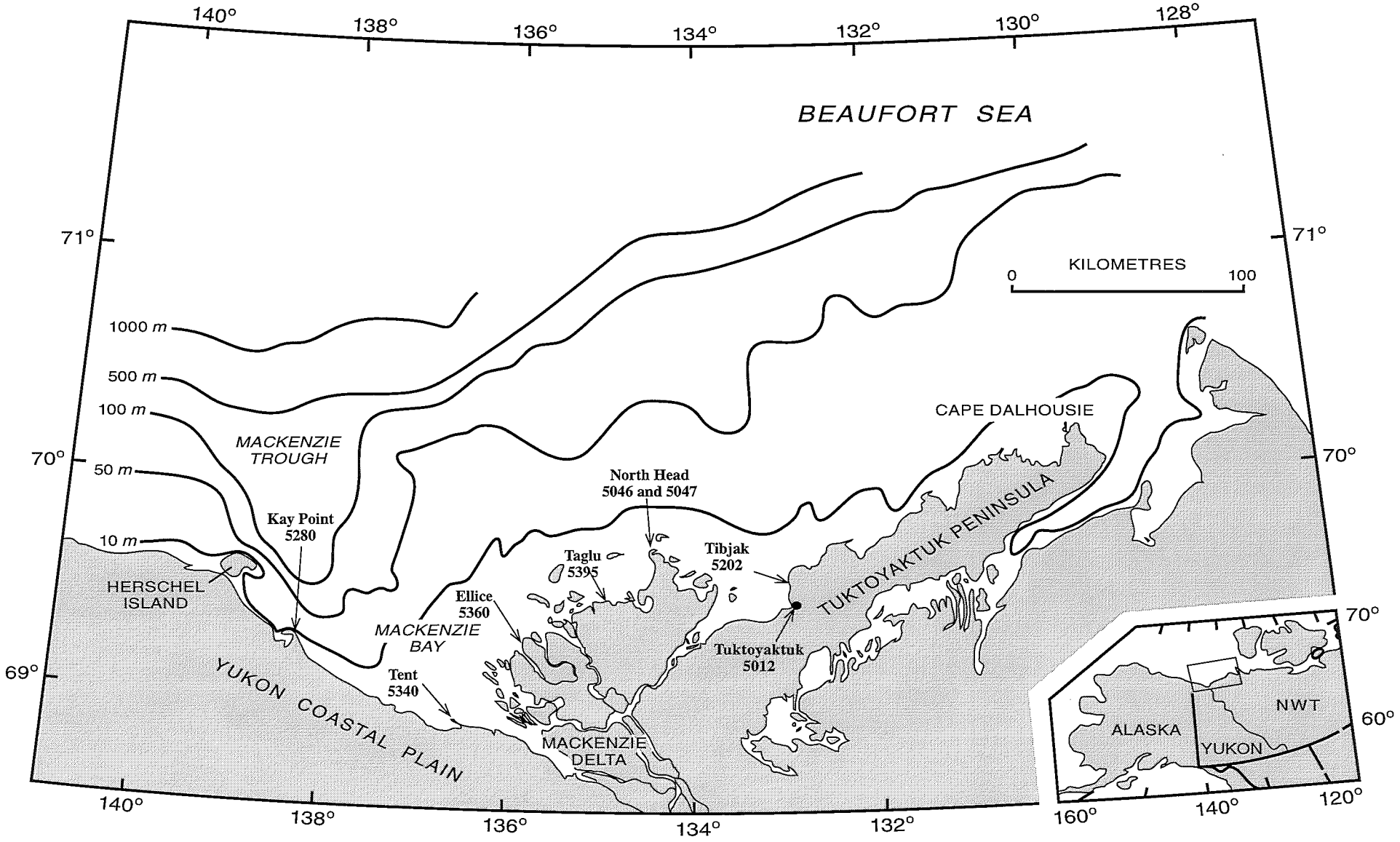

Figure 1 Index map showing the locations of the study sites.

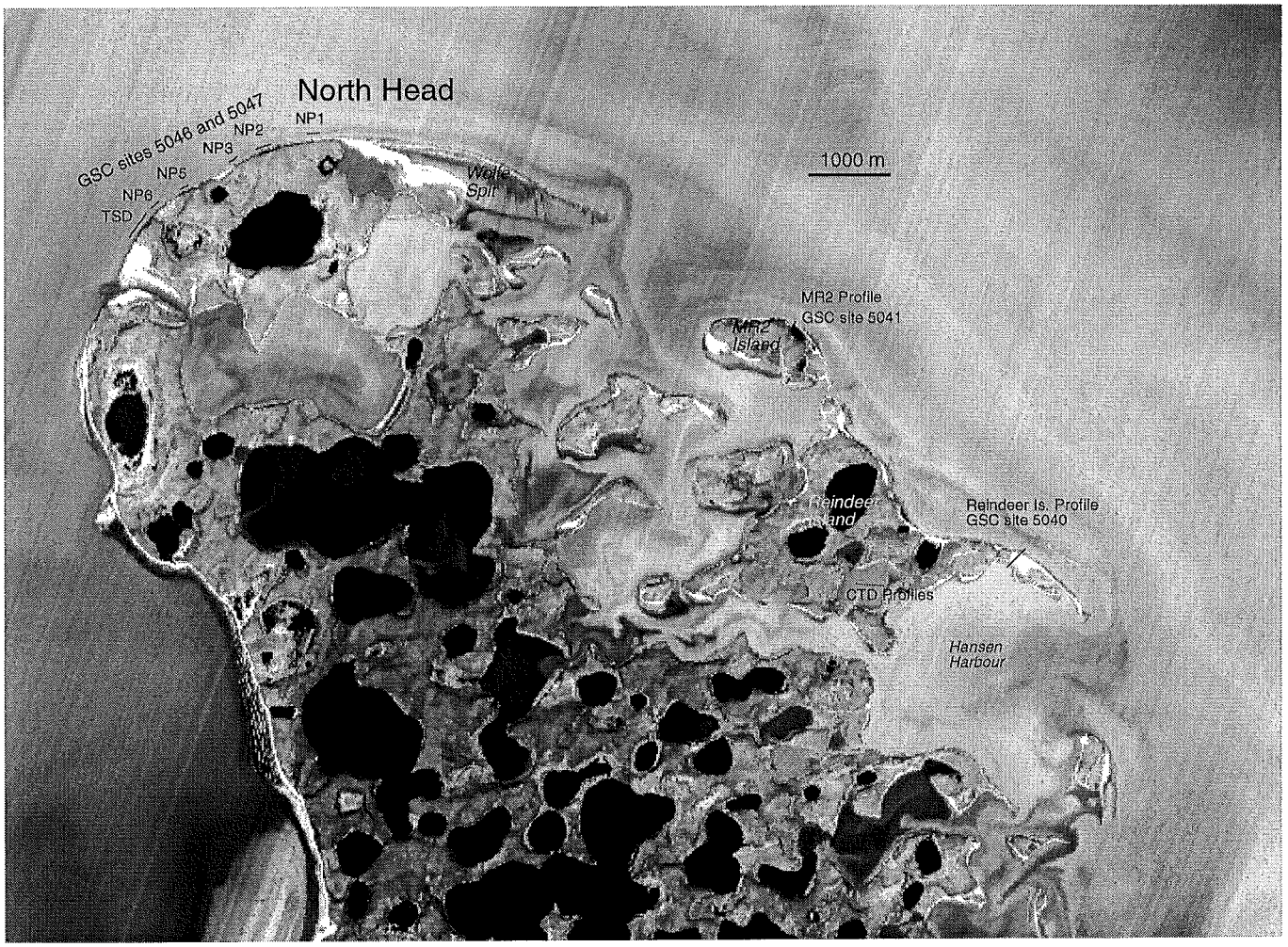

Figure 2 The North Head study area consists of several profile and cliff retreat monitoring sites. Reindeer Island and MR2 are beach profile sites, the remainder are cliff retreat sites.

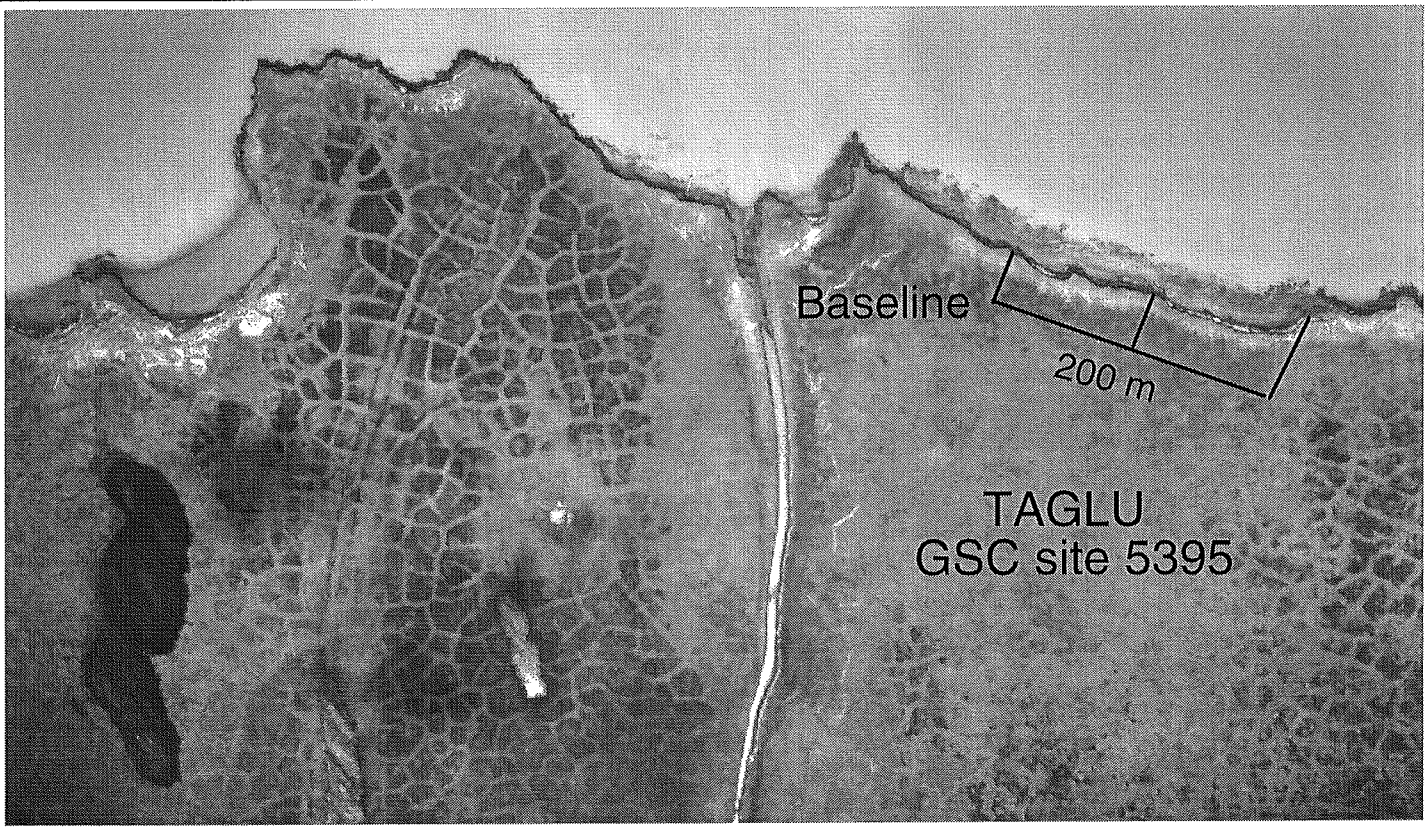

Figure 3 **The Taglu cliff retreat measurement site overlaid on a 1993 air photograph.**

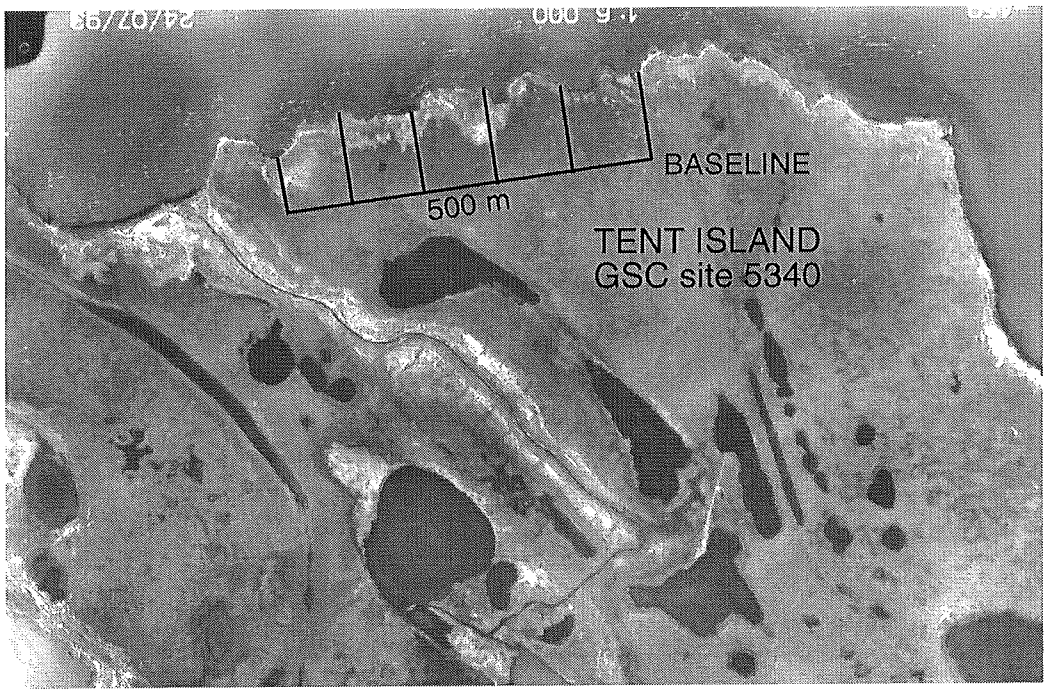

Figure 4 The Tent Island cliff retreat measurement site overlaid on a 1992 air photograph.

Figure 5 The Ellice Island cliff retreat measurement site overlaid on a 1973 air photograph

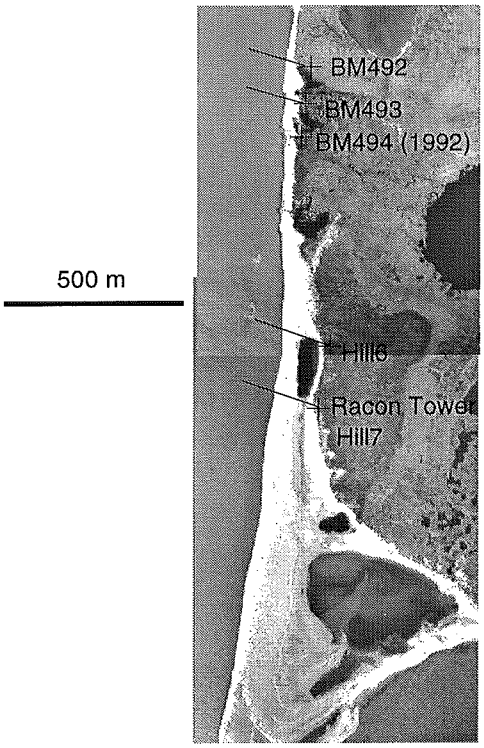

Figure 6 The Tibjak Point beach profile measurement site overlaid on a photograph mosaic of two 1993 air photographs. BM494 was put in 1992, but not found in 1994.

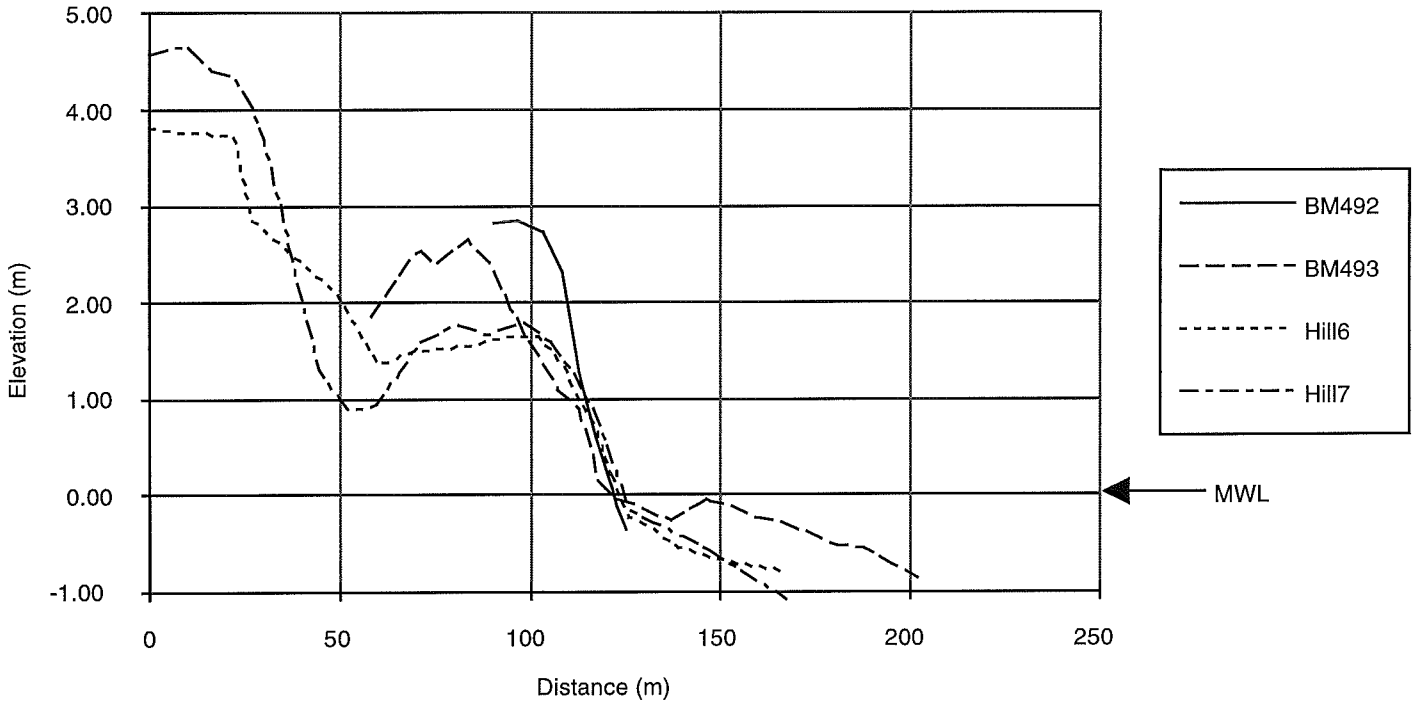

Figure 7 Beach and cliff profiles at Tibjak Point along each of the four lines. The position of the mean water level was chosen as a common horizontal and vertical datum.

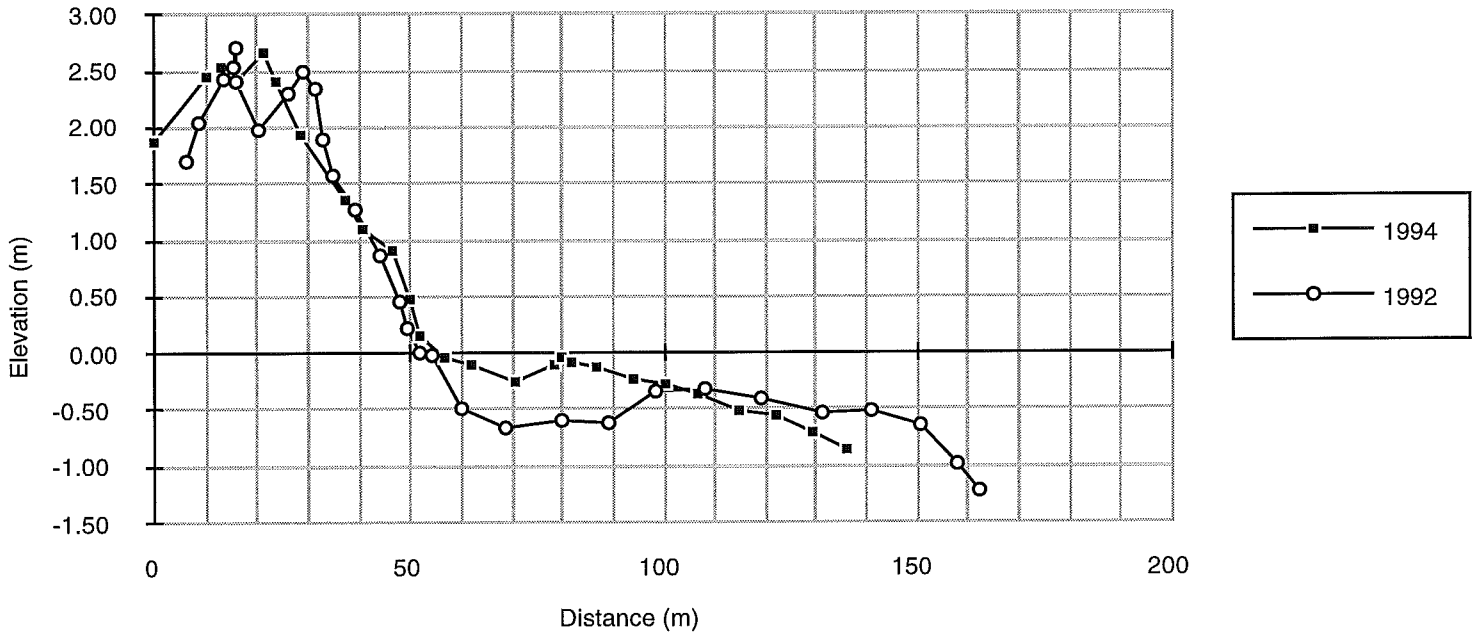

Figure 8 A comparison between beach profiles measured in 1992 and 1994 at BM493. Landward retreat occurs at the dune crest along with shoaling at the toe of the beach as a result of alongshore bar migration.

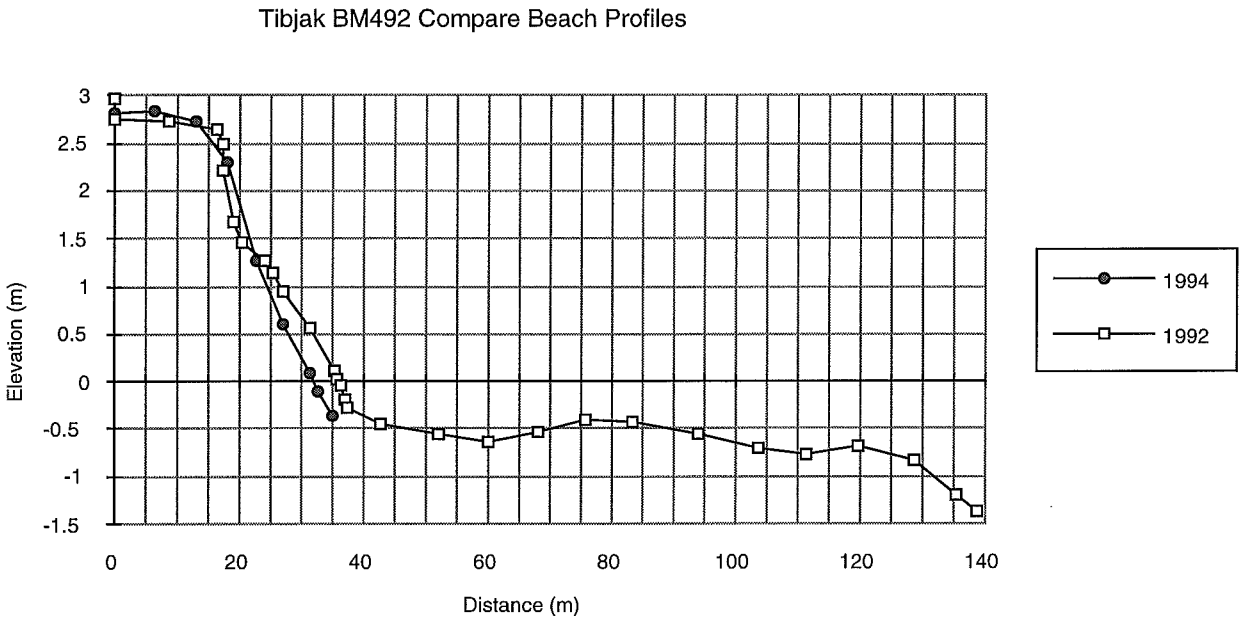

Figure 9 A comparison between beach profiles measured in 1992 and 1994 at BM494. This location is at the edge of a low tundra cliff updrift from BM493. Retreat of several metres is seen at the toe of the cliff. The 1994 survey was discontinued just below the water-line because the sediment was too soft to support the survey assistant.

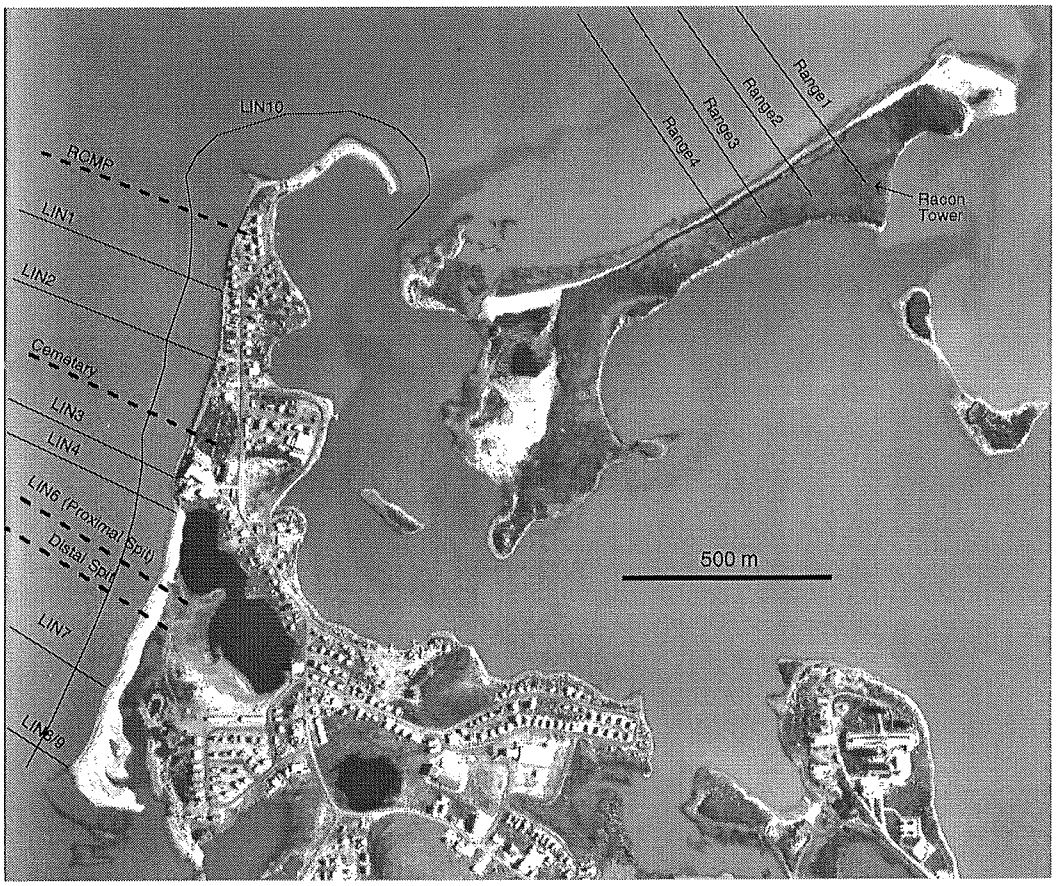

Figure 10 Beach profile and nearshore survey lines at Tuktoyaktuk overlaid on a 1993 air photograph. Both beach profiles and bathymetric surveys were obtained along the heavy dashed lines.

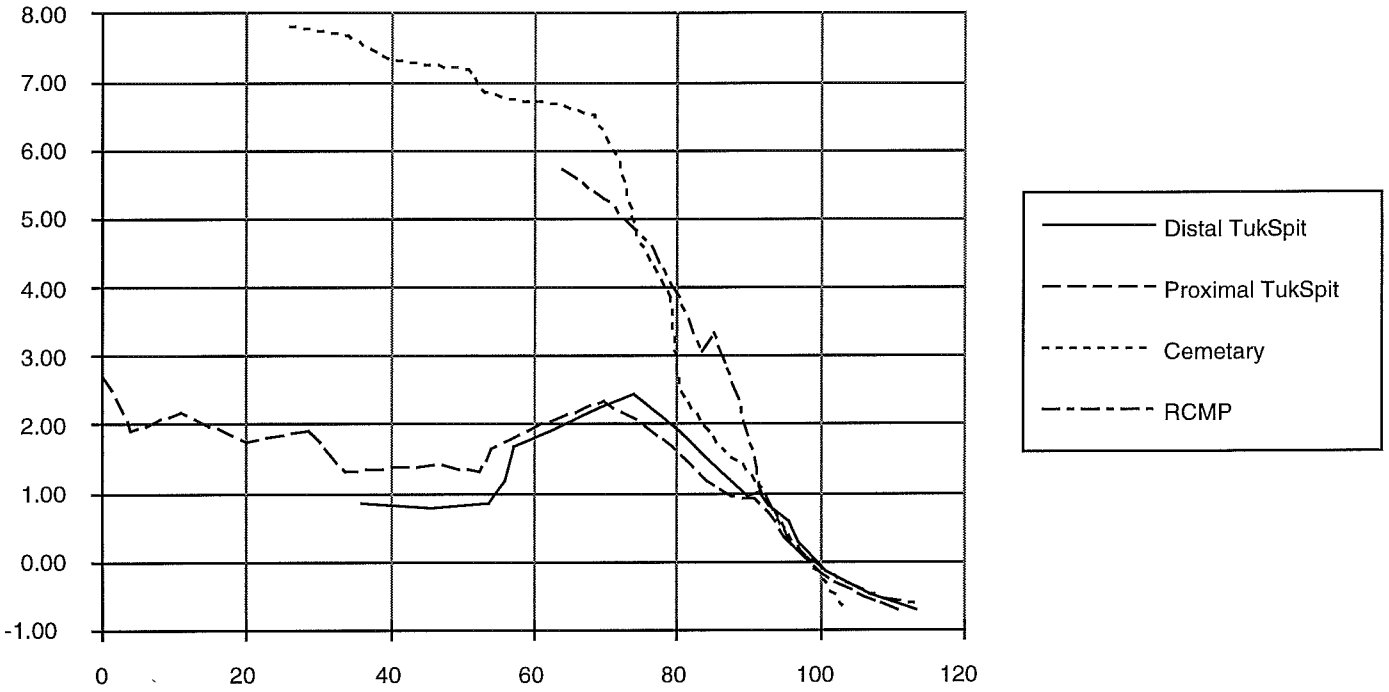

Figure 11 The four Tuktoyaktuk beach profiles measured in 1994 using the water-line at the time of the surveys as a common horizontal and vertical datum.

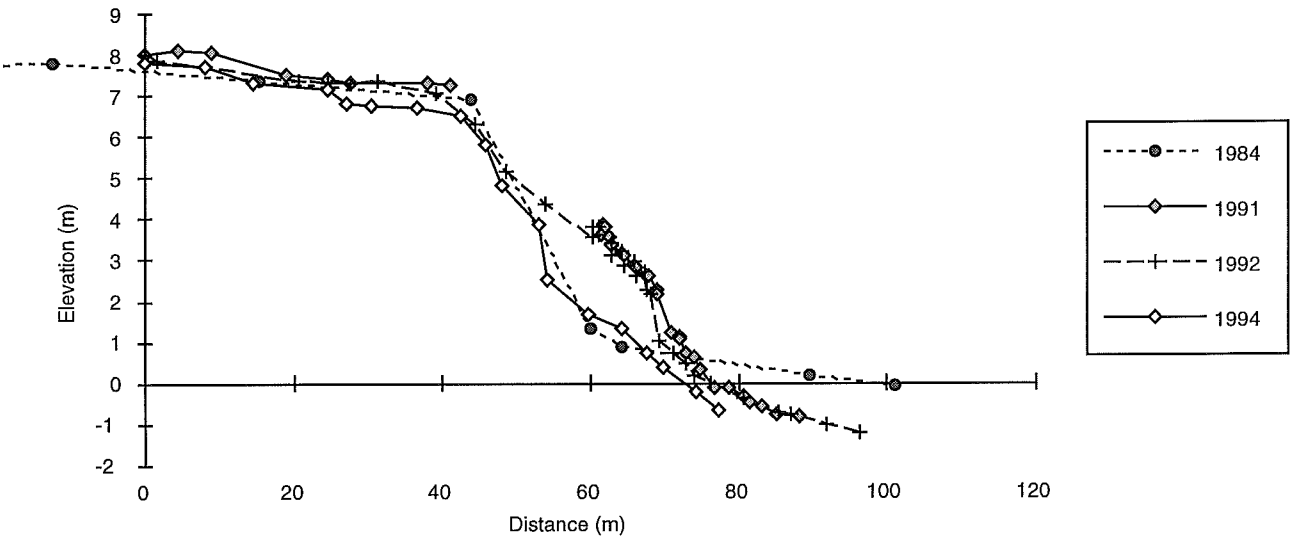

Figure 12 A comparison of the Tuktoyaktuk Cemetery profile as measured in 1984, 1991, 1992 and 1994. The 1991 and 1992 profiles illustrate the results of the shoreline reclamation and protection which was instituted in 1986-87. The 1994 profile depicts the dramatic effects of the 1993 storm which washed away most of the sandbag shore protection. The 1994 and 1984 profiles are very similar above the water line; note the steeper shoreface profile.

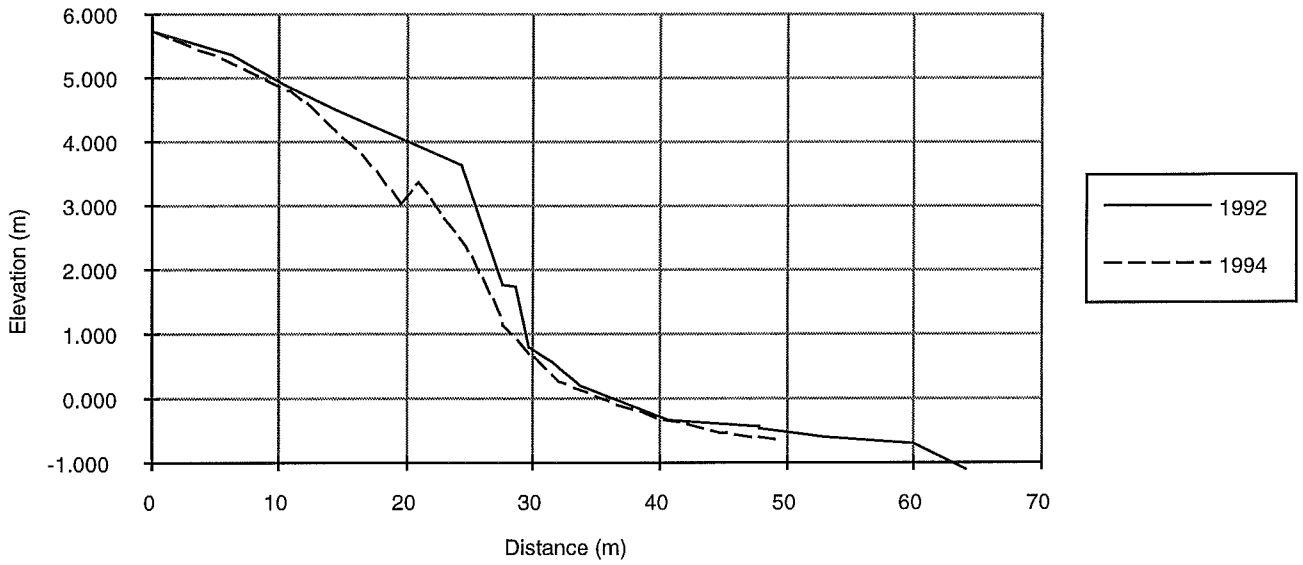

Figure 13 A comparison of beach profiles measured in 1992 and 1994 at the RCMP site at Tuktoyaktuk. The 1994 profile illustrates the effect of the 1993 storm. The shoreline protection along this line was partially rebuilt after the 1993 storm but before the profile was measured, so actual erosion was worse than the graph indicates.

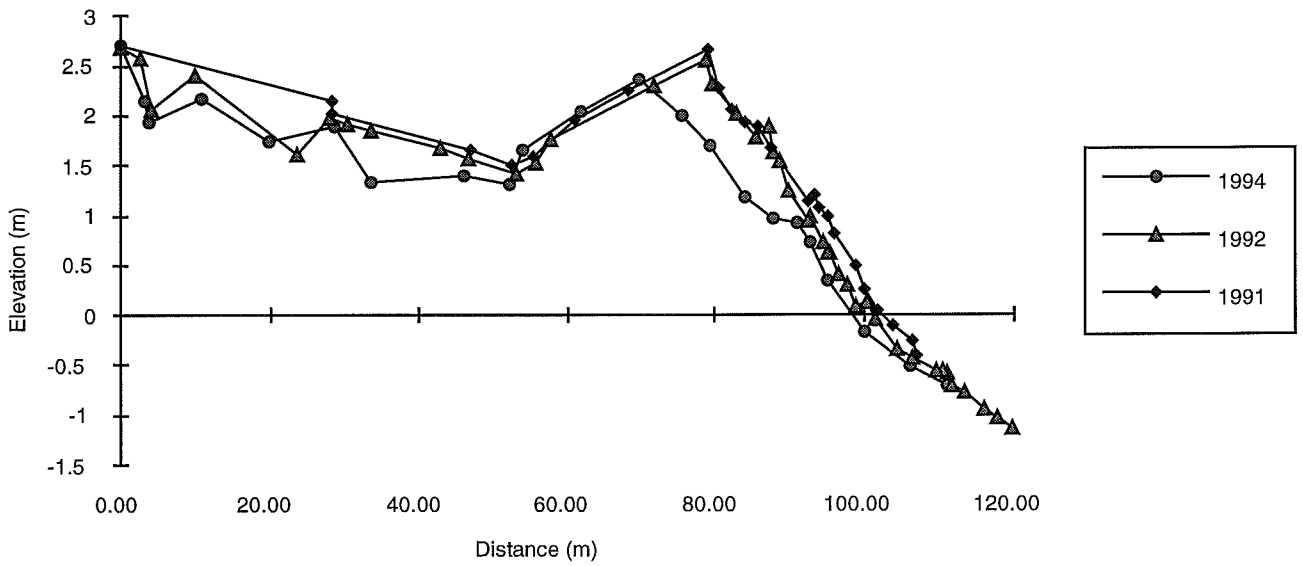

Figure 14 A comparison of beach profiles measured in 1991, 1992 and 1994 along the proximal spit (BM287) line on the Tuktoyaktuk Spit. The 1994 profile depicts nearly 10 m of landward migration of the spit crest and a sharp break in the profile at 1 m above the mean water line. The 1991 and 1992 profiles are virtually identical.

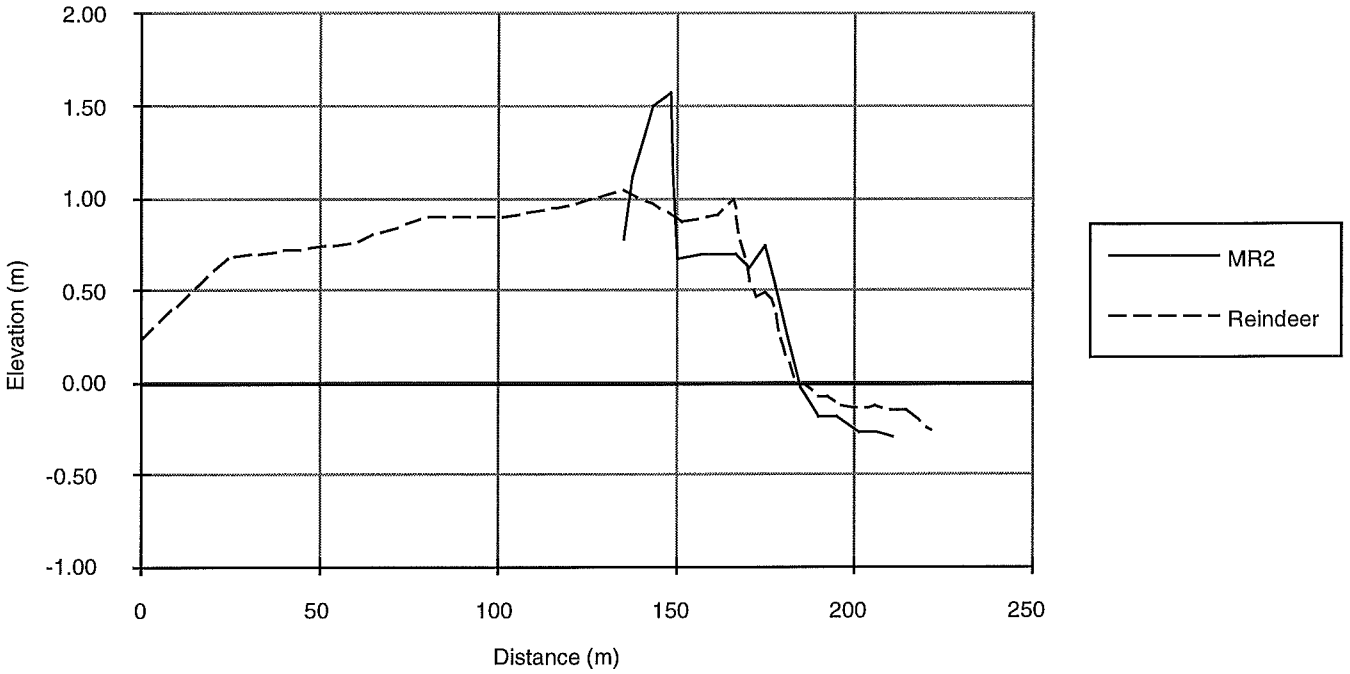

Figure 15 Comparison of the profiles measured at MR2 and Reindeer Islands using the water line at the time of the surveys as a common horizontal and vertical datum.

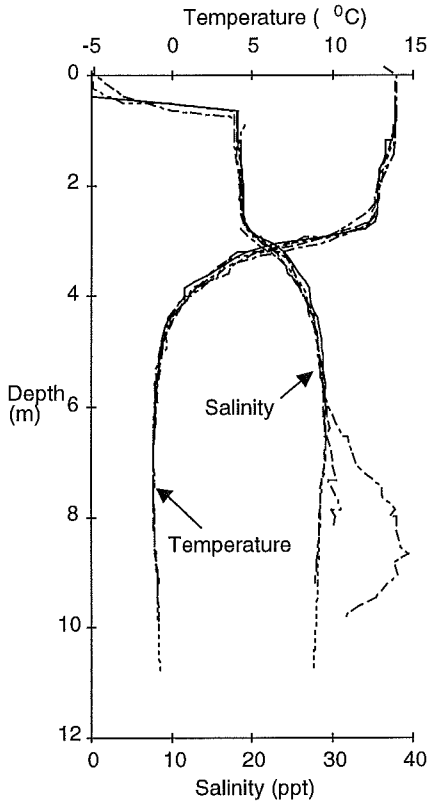

Figure 16 Salinity and temperature profiles measured in a breached lake on the south side of the Reindeer Islands near the entrance to Hansen Harbour. Despite the limited depth, the embayment is highly stratified. The relatively fresh water of the the Mackenzie River plume overlies the denser, very cold Beaufort Sea water with a sharp thermo- and halocline at 3-4 m.

APPENDIX A

Table A1: List of Beach Profiles

Location or Line #	BM	Oreintation	Date	Julian Day	MDT	MST	Water Level (cm)
Tuk - RCMP	na	290°M	94/08/03	215	10:21	09:21	57
Tuk - Cemetary	290	255°M	94/08/03	215	12:15	11:15	70
Tuk - Proximal Spit	287-8	265°M	94/08/03	215	14:47	13:47	65
Tuk - Distal Spit	na	265°M	94/08/03	215	15:38	14:38	60
Reindeer Is		010°M	94/08/08	220	12:30	11:30	75
MR2	na	350°M	94/08/08	220	13:51	12:51	86
Tibjak	492	265°M	94/08/09	221	12:50	11:50	20
Tibjak	493	265°M	94/08/09	221	13:12	12:12	25
Hill6	na	265°M	94/08/09	221	15:12	14:12	51
Hill7	na	265°M	94/08/09	221	15:57	14:57	60
Tuk - RCMP	na	290°M	94/08/11	223	10:30	09:30	37
Tuk - Cemetary	290	255°M	94/08/11	223	11:35	10:35	28
Tuk - Proximal Spit	287-8	265°M	94/08/11	223	12:33	11:33	25
Tuk - Distal Spit	na	265°M	94/08/11	223	13:25	12:25	30

Table A2: List of Nearshore Profiles

Location or Line #	Date	Julian Day	Start Line	End Line	Water Level (cm)
Tuk - Trial line	94/08/05	217	11:21	11:35	20
Tuk Distal Spit BMTS	94/08/05	217	11:42	11:51	22
Tuk BM Line TSPN	94/08/05	217	12:05	12:12	26
Tuk Cemetary	94/08/05	217	12:18	12:28	28
Tuk RCMP	94/08/05	217	12:37	12:47	31
Tuk Line 1	94/08/05	217	13:19	13:40	38
Tuk Line 2	94/08/05	217	13:47	13:54	40
Tuk Line 3	94/08/05	217	14:02	14:09	42
Tuk Line 4 Prox spit	94/08/05	217	14:17	14:25	43
Tuk Line 5 mid spit	94/08/05	217	14:32	14:38	44
Tuk Line 6	94/08/05	217	14:44	14:53	45
Tuk Line 7	94/08/05	217	15:00	15:08	46
Tuk Line 8 Distal spit	94/08/05	217	15:15	15:20	46
Tuk line 9 redo 8	94/08/05	217	15:24	15:30	46
Tuk Line 10	94/08/05	217	15:37	16:02	45
Tuk Is Range1	94/08/06	218	18:06	18:13	59
Tuk Is Range2	94/08/06	218	18:20	18:24	56
Tuk Is Range3	94/08/06	218	18:26	18:29	56
Tuk Is Range4	94/08/06	218	18:32	18:35	55
Tibjak - Hil7	94/08/09	221	10:53	11:04	14
Tibjak - Hil7a	94/08/09	221	11:12	11:17	14
Tibjak - Hil6	94/08/09	221	11:23	11:28	15
Tibjak - Hil6a	94/08/09	221	11:33	11:36	15
Tibjak - 493a	94/08/09	221	11:47	11:52	16
Tibjak - 492a	94/08/09	221	11:58	12:04	17
Tibjak - 492b	94/08/09	221	12:09	12:13	18
Tibjak - Hi6c	94/08/09	221	16:53	16:57	67
Tibjak - Hi7d	94/08/09	221	17:10	17:13	68
Tibjak - Hi7d	94/08/10	222	11:04	11:12	9
Tibjak - Hi6d	94/08/10	222	11:19	11:27	9
Tibjak - 493d	94/08/10	222	11:38	11:45	8
Tibjak - 492d	94/08/10	222	11:52	11:57	8

Table A3: GPS Positions 1994

Description	Date	Time (UT)	PDOP	Latitude	Longitude
RCMP Inst Pos	8/3/94	na	na	69.4550	133.0350
Cemetary Inst Pos	8/3/94	18:24	1.5	69.4507	133.0396
BM287	8/3/94	21:54	1.3	69.4471	133.0384
BM288	8/3/94	21:53	1.3	69.4472	133.0390
Proximal Tuk Spit IP[1]	8/3/94	21:50	1.3	69.4469	133.0407
Landward Pipe (TS)[2]	8/3/94	21:56	1.9	69.4470	133.0406
Seaward Pipe(TS)	8/3/94	21:57	1.4	69.4468	133.0407
Hill7 Tower front leg	8/6/94	14:49	1.4	69.5816	132.9979
Dftwd Mkr	8/6/94	14:51	1.4	69.5816	132.9973
Hill6 Back peg	8/6/94	15:13	1.3	69.5829	132.9953
Hill6 front peg	8/6/94	15:15	2.5	69.5829	132.9953
Tibjak BM492	8/6/94	15:59	2.4	69.5894	132.9882
Tibjak BM 493	8/6/94	16:12	2.7	69.5882	132.9887
Tibjak BM494 [3]	8/6/94	16:26	3.6	69.5877	132.9915
Tuk Is Inst Pos	8/6/94	22:47	1.3	69.4554	133.0015
TukIs 2 front rge mkr	8/6/94	22:43	1.3	69.4560	133.0005
87BH	8/7/94	19:34	1.3	69.7129	134.4857
ReindeerSpit BH	8/8/94	17:42	1.5	69.6699	134.1687
ReindeerSpit Inst Pos	8/8/94	18:43	1.9	69.6704	134.1680
MR2 Inst Pos	8/8/94	20:13	5.6	69.6999	134.2492
MR2 landward rebar	8/8/94	20:14	1.9	69.7000	134.2507
MR2 seaward rebar	8/8/94	20:15	1.9	69.7000	134.2503
Ellice Island	8/8/94	22:23	1.3	69.2897	135.8543

[1]IP=Instrument Position
[2]TS=Tuktoyaktuk Spit
[3]Position approximate - benchmark not found
Datum: NAD27