Tides and tidal currents in Hudson Bay

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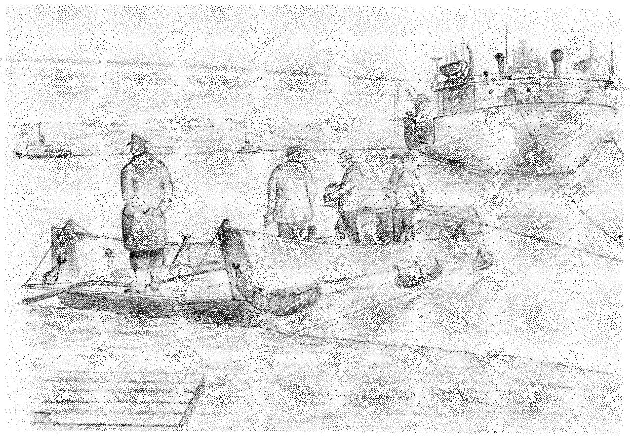
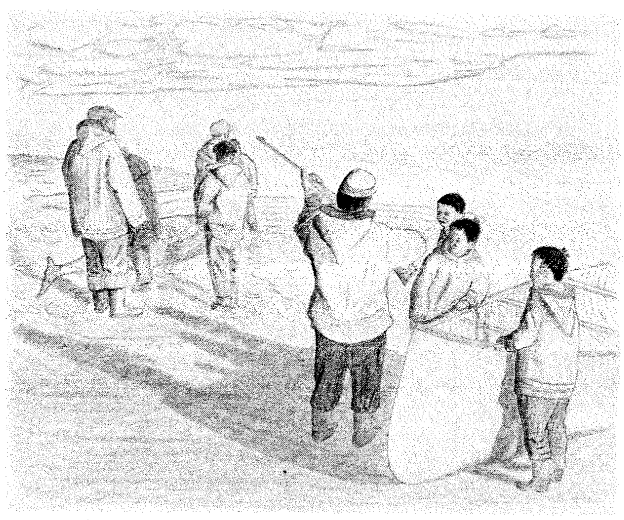
The rhythm of the tides can be felt in varying degree along the entire shoreline of Hudson Bay and in every one of its harbours. To those who are responsible for navigation in these waters or whose livelihood depends upon the harvest of the sea, it would be idle to emphasize the importance of a knowledge of tides and tidal streams. For those of us who do not make our living from the sea, it is perhaps worthwhile to remember that, to take his vessel safely from one port to another, a ship's captain must have an intimate knowledge of tidal patterns and the direction and force of tidal currents. So also with the Eskimo whose success in providing food for his family depends upon his knowledge of the tides. In the open Bay, the vertical tidal movements are of minor importance and it is not until water meets land that the tide is a factor in regulating the movement of ships into harbours and tidal rivers or, where there are no harbours, in the success of beaching operations.

The world-wide phenomena of the tides and the manner in which they are related to the rotation of the earth and the gravitational attraction of the sun and moon have been made the subject of scientific investigation for many years and are well summarized in the Encyclopaedia Brittanica and by A.T. Doodson and H.D. Warburg in the Admiralty Manual of Tides.

To understand the tidal phenomena of Hudson Bay it is necessary to have clearly in mind two concepts. The first is the existence of a tidal undulation in the open ocean which moves forward in a westerly direction, opposite to the direction of the earth's rotation. This undulation is accompanied by tidal streams. The second concept concerns the modifications which occur when the tide encounters irregular distributions of land associated with continents and islands. The best known examples of these modifications are found where the tide enters a bay which grows shallower and narrower towards its head or where the conditions are even more



accentuated when the tide enters the estuary of a river. In the Bay of Fundy, for example, very high tides of the order of 20 to 50 feet are found in the headwaters. Seymour Narrows in British Columbia experiences strong currents of over 10 knots and in Ungava Bay near the

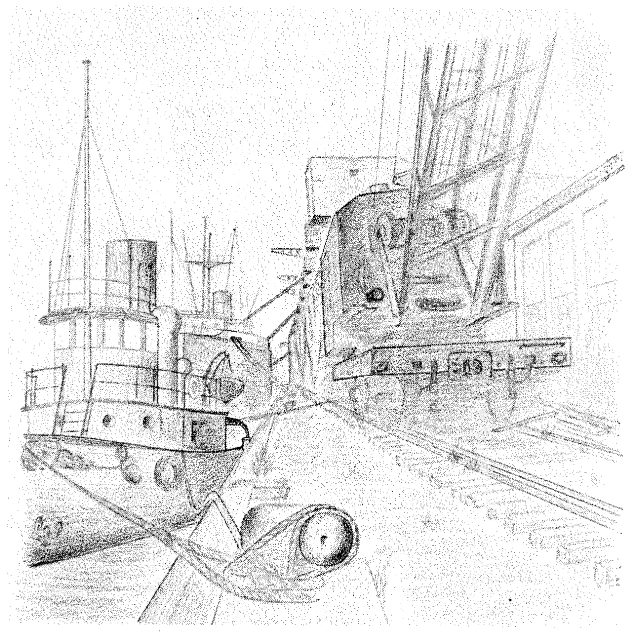


entrance to Hudson Strait, currents of considerable magnitude have been observed. Under these circumstances, the tide can often be a hindrance or even a danger to shipping and can cause erosional effects of considerable magnitude.

Tidal movements are periodic vertical oscillations above and below mean sea level while *tidal streams* are periodic horizontal oscillations over a fixed point on the earth's surface, or, in open waters, an elliptical movement around a fixed point. The periods of these oscillations are identical to those of the forces to which they respond, i.e. the rotation of the earth on its axis, the revolution of the moon around the earth and the revolution of the earth around the sun.

The non-periodical horizontal movements of the sea come under the general heading of *currents*. Solely under the influence of currents, a particle of water will change its position over the earth's surface either progressively or seasonally or with non-periodical fluctuations.

The term *flow* has the same meaning as horizontal water movement, as it is the combina-



tion, at any instant, of the tidal stream and current.

Tides are normally semi-diurnal in character, with two high and two low waters a day. The heights of the two tides are usually similar but not necessarily identical. There are exceptions to the normal pattern, however, and as far as any particular coast is concerned the following basic questions present themselves:

(a) How great is the range of the tides, i.e., what is the difference between high and low water and what are the rates of the tidal streams in the ebb and flood direction?

(b) Is the tide or tidal stream diurnal or semi-diurnal, i.e., are there one or two cycles per day?

(c) What is the time of high and low water and when do the strongest and weakest tidal streams appear?

When we look for answers to these questions insofar as Hudson Bay and Hudson Strait are concerned, we find that for most regions the tides are semi-diurnal as indicated by the tidal pattern for Churchill in Figure 1a. Here are shown the rise and fall of the tides over a period of a month and it is seen that the semi-diurnal character is well maintained. It is also clear that the height of the two semi-diurnal components is slightly different and that the height of the tides in general is connected by a complicated relationship with the relative positions of the sun, the moon and earth.

The general character of the tides as indicated in Figure 1a, however, does not hold for the Bay as a whole. The tidal rhythm for a considerable stretch of the shoreline between Povungnituk and Port Harrison, is represented in Figure 1b. This figure shows that, while there are still two tides a day, the differences between the two are considerably more marked and these differences, as well as the average height of the tides, are again strongly dependent on the relative position of the sun and moon.

Theories governing these phenomena are abstruse and for a complicated locality like Hudson Bay have not been worked out in detail. We deal therefore in this article not with the theoretical calculations but with the tides that are actually observed in Hudson Bay and Hudson Strait.

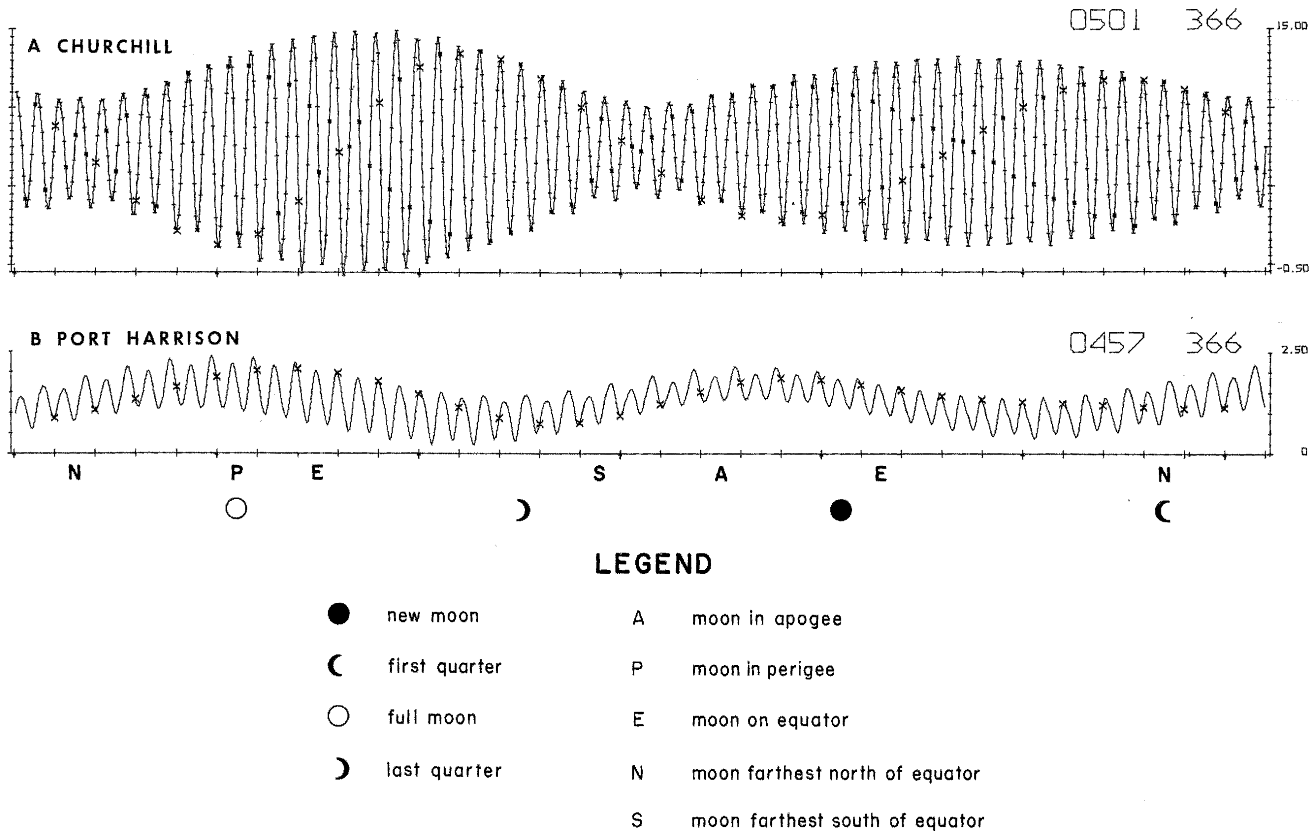


Figure 1. Tidal patterns for Churchill and Port Harrison.

TIDES AND CURRENTS IN HUDSON STRAIT

The tides and currents in Hudson Strait were noted by the earliest navigators to enter these waters, e.g., John Davis, ship's log 1587, "---- where to our great admiration we saw the sea falling down into the Gulf with a mighty overfall and roaring and with divers circular motions like whirlpools in such sort as forceable streams pass through the arches of bridges." Currents of this magnitude presented severe hazards to the small sailing ships of those days and it is to be inferred that the ship captains found it necessary to study the tides carefully and to take advantage of favourable directions of the currents and of periods of slack water to get through the straits.

The main tidal streams in Hudson Strait are strong and definite with no cross currents setting to either shore. Flood waters entering the strait, however, are curved somewhat to southward by the indraught to Ungava Bay; consequently the progress of the tidal undulations is more rapid along the south side of the strait than on the north shore. The time of high water at Wakeham Bay, therefore, is only a little later than at Port Burwell, while at Ashe Inlet, immediately opposite Wakeham Bay, high water occurs considerably later. The same relation holds for the time of low water at those points, but it is likely that the main ebb holds farther north across Ungava Bay than the flood.

In addition to the ordinary tidal pulsations in Hudson Strait, there are general progressive movements or circulations of water. Icebergs which enter the strait can do so only around Resolution Island and through Gabriel Strait. In their southward journey from Davis Strait, they are drawn in by the flood and some fail to go out with the ebb. These work westward, indicating a general movement of the water in the northern part of the strait in that direction. They are found westward as far as Charles Island and one was reported even further west in the vicinity of Nottingham Island by the officers of the Hudson Strait Expedition of 1927-28. If they are carried to the south side of the strait, they will be borne to the eastward.

Observations of the ice movement south of Resolution Island over a period of several months show the duration of the flood and ebb currents to be about equal. This however, is not proof that an excess inward movement of water on the north side of the strait does not exist, for the necessary indraught is more than likely supplied through Gabriel Strait, or it might be a deep undercurrent.

The outward flow from Hudson Bay is evident as a dominant easterly set along the northern side of Digges Islands and off Cape Wolstenholme where it becomes locally, and perhaps for some distance, a constantly outward current. Doubtless the movement continues along the southerly side of the strait.

The strength of the tidal streams between Resolution Island and Cape Chidley is given as 5 knots on the charts, but no determinations have been made elsewhere in the straits.

The currents in Digges Sound and its approaches are not considered dangerous to navigation. There is an ebb and flood rate of 2-3 knots between Capes Digges and Wolstenholme. The flood approaches Digges Sound from the northeast as an undercurrent and turns to the southward on entering the strait. The ebb, flowing northeastward past Cape Wolstenholme, turns eastward into a constantly outward current starting at the west end of the Digges Islands and continuing past Erik Cove. At Erik Cove, there is a 3-knot current which slackens to a low rate with flood effect.

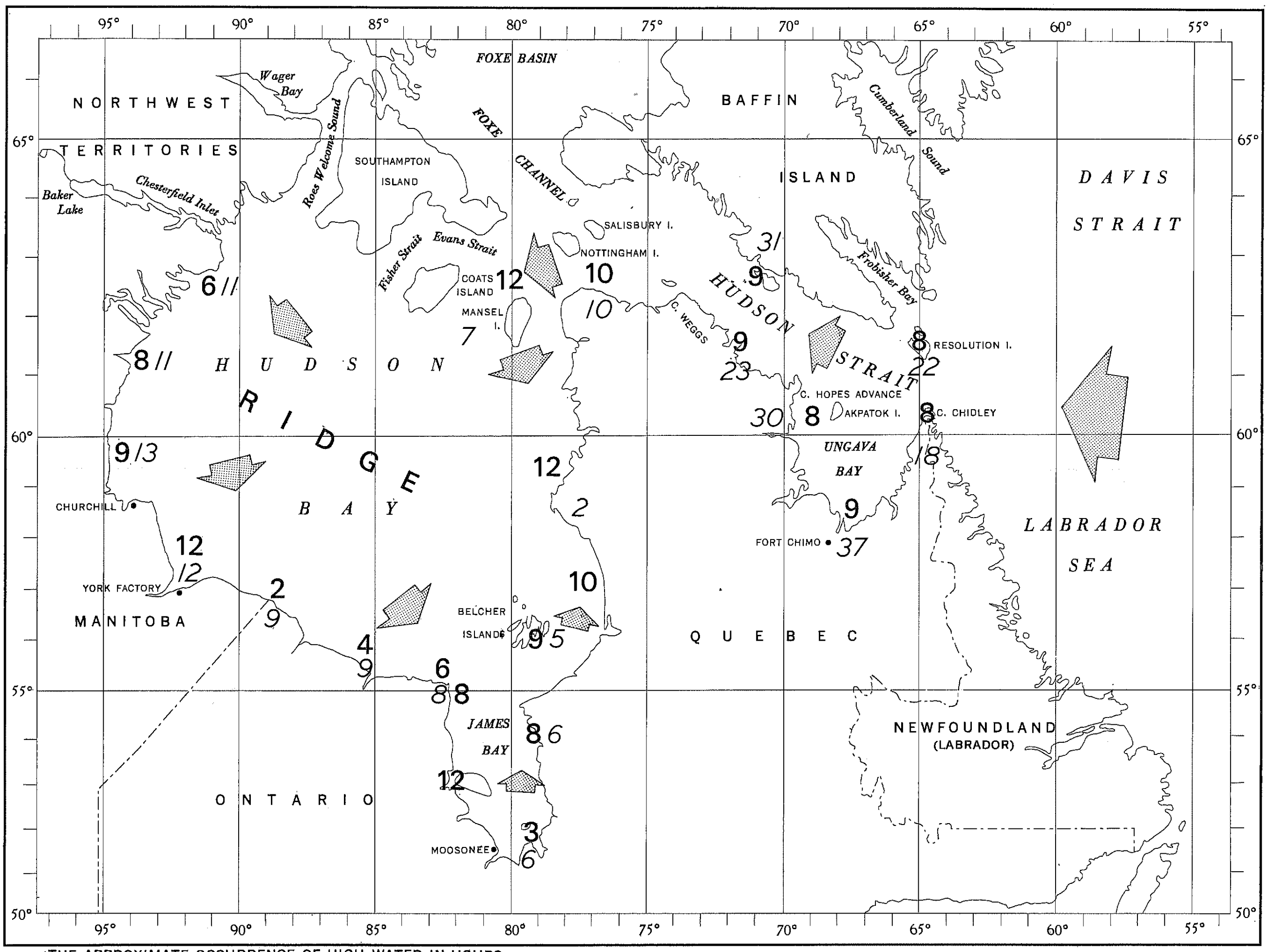
Off Erik Cove and extending westward to Cape Wolstenholme, there is a shelf with moderate depths of 50 to 70 fathoms extending a half mile or more from the shore. Beyond this shelf, soundings indicate a sharp drop to depths approaching 250 fathoms. This deep body of water, moving in one direction, causes heavy rips, swirls, and eddies over the shelf which, during strong winds, create a danger to small craft.

Centrally in the sound, off eastern Digges Islands and off Staffe Island, the direction of the ebb is with the channel; information on the direction of the flood current, however, is not available. Off Ivugivik Point and Nuvuk Harbour, the ebb runs with the channel; the flood is variable and turns at times toward the Nuvuk Islands. These conditions are also found, to a lesser extent, south of Fairway Island. One mile south of North Skerries, flood and ebb run west and east.

From the information available, it seems that the ebb current has a much longer duration than the flood. Between Nuvuk and Fairway Island, the flood period seems to be $4\frac{3}{4}$ hours and the ebb nearly 8 hours. No definite times can be given for the turn of the tidal currents but, from Ivugivik Point eastward, high-water slack in Eastern Standard Time may occur 3 to 4 hours after the time of high water, and the low-water slack 4 to 5 hours after the time of low water, as given in the tide tables for Diana Bay. Similarly, in the western approach to the sound to Fairway Island, the high-water slack may be 5 to 6 hours after the times of high water, and the low-water slack at approximately the times of low water, as given in the tide tables for Diana Bay.

Chesterfield Inlet

The tidal streams at Chesterfield Narrows are strongly influenced by the fresh water outflow from Baker Lake. Slack water occurs before and after a prolonged high-water period. The flood is characterized by a maximum westward flow of about 4.5 knots for about 4 hours. The ebb flow, which reaches a maximum velocity of about 7 knots at low water, lasts some 8 hours. The current, therefore, is reversing, with maximum velocities at high water and low



4 THE APPROXIMATE OCCURRENCE OF HIGH WATER IN HOURS AFTER THE MOON'S MERIDIAN PASSAGE AT 60° WEST

7 MEAN HIGH WATER. HEIGHT IN FEET ABOVE CHART DATUM

Figure 2. Map of Hudson Bay and Hudson Strait showing height of mean high water above chart datum and times of occurrence of high water.

water respectively.

LOCAL TIDES IN HUDSON BAY

In a body of water the size of Hudson Bay, the tide-raising forces due to the gravitational attraction of the sun and moon would certainly result in a small tide of the order of a few inches even in the absence of any connection with the ocean. In addition, the connection with the Arctic Ocean by way of Foxe Channel and Fury and Hecla Strait would also have some effect, however small, on the tide and tidal stream regime of Hudson Bay. In fact, these minor effects are completely overshadowed by the powerful tides which surge twice daily into the Bay through Hudson Strait.

VERTICAL WATER MOVEMENT

Owing to the shape, size and depth of water in Hudson Bay and the gyroscopic and gravitational forces acting upon the water masses, there is what may be referred to as a ridge on the surface of the water in the middle of the Bay where any changes which occur in the water level during the semi-diurnal tide cycle are small. This ridge extends from 60.5° N, 87° W southeasterly toward Port Harrison as shown in Figure 2.

Within the boundaries of this ridge, the rise and fall of the tide is close to zero while around the coast of the Bay the range in height between high and low water may be as great as 13 feet at Churchill Harbour and as little as 1.6 feet at Port Harrison.

The tide progresses in a roughly circular movement, following the contour of the shoreline starting from the northwestern part of the Bay, moving southward along the western shore and almost petering out along the eastern shore. At the entrance to the Bay, the average height

TABLE 1

SECONDARY PORTS

PORTS SECONDAIRES

INFORMATION AND TIDAL DIFFERENCES
RENSEIGNEMENTS ET DIFFÉRENCES DES MARÉES

INDEX NO. / NO. D'INDEX	SECONDARY PORT / PORT SECONDAIRE	TIME ZONE / FUSEAU HORAIRE	POSITION: LAT. N. / LAT. N.	POSITION: LONG. W. / LONG. O.	DIFFERENCES: HIGHER HIGH WATER / HAUTE MER SUPÉRIEURE: TIME / HEURES	HIGHER HIGH WATER: MEAN TIDE / MARÉE MOYENNE	HIGHER HIGH WATER: LARGE TIDE / GRANDE MARÉE	LOWER LOW WATER / BASSE MER INFÉRIEURE: TIME / HEURES	LOWER LOW WATER: MEAN TIDE / MARÉE MOYENNE	LOWER LOW WATER: LARGE TIDE / GRANDE MARÉE	RANGE / AMPLITUDE: MEAN TIDE / MARÉE MOYENNE	RANGE: LARGE TIDE / GRANDE MARÉE	MEAN WATER LEVEL / NIVEAU MOYEN DE L'EAU
			° ′	° ′	h. m.	ft./pi.	ft./pi.	h. m.	ft./pi.	ft./pi.	ft./pi.	ft./pi.	ft./pi.
	AREA / RÉGION 4 — HUDSON STRAIT												
							on/sur DIANA BAY						
	RESOLUTION ISLAND												
4160	SORRY HARBOUR	+4	61 37	64 44	- 0 22	- 8.8	-11.2	-0 15	-1.2	+1.3	13.3	21.0	12.4
4170	ACADIA COVE	+4	61 21	64 54	+ 0 35	- 5.9	- 6.8	+0 36	-0.8	+0.3	15.8	26.4	14.1
	HUDSON STRAIT NORTH SHORE												
4205	LAKE HARBOUR	+5	62 51	69 53	+ 0 05	+ 6.0	+ 7.8	+0 03	+1.8	+0.1	25.1	41.2	21.5
4215	ASHE INLET	+5	62 33	70 35	+ 0 12	+ 3.3	+ 4.5	+0 12	+0.4	-0.8	23.8	38.8	19.0
	FOXE CHANNEL												
4255	SCHOONER HARBOUR	+5	64 24	77 52	+ 3 12	-11.5	-13.3	+3 11	-5.3	-3.5	14.7	23.7	9.2
	UNGAVA BAY												
4265	PORT BURWELL	+4	60 25	64 51	+ 0 51	-10.5	-12.5	+0 51	-4.8	-2.8	15.2	23.8	10.0
4295	KOKSOAK R. (entrance)	+5	58 32	68 12	+ 0 11	+ 8.4	+10.6	+0 0[illegible]	+0.7	-1.5	28.6	45.6	22.2
4315	LEAF BASIN	+5	58 44	69 50	+ 0 57	+11.7	+14.5	+0 56	+2.2	-0.5	30.4	48.5	24.5
4325	HOPES ADVANCE BAY	+5	59 21	69 38	+ 0 02	+ 8.0	+10.0	+0 02	+1.4	-0.5	27.5	44.0	22.3
4335	AGVIK ISLAND	+5	60 01	69 42	+ 0 02	+ 5.4	+ 6.5	+0 02	+1.8	+0.7	24.5	39.3	21.2
4340	PIKIYULIK ISLAND	+5	60 00	69 55	+ 0 55	+ 0.5	-	+0 55	-0.1	-	21.5	33.5	17.8
4345	BASKING ISLAND	+5	59 59	70 05	+ 0 59	+ 1.6	-	+0 59	0.0	-	22.5	35.3	18.4
	HUDSON STRAIT SOUTH SHORE												
4400	STUPART BAY	+5	61 35	71 32	+ 0 01	- 2.3	-	+0 03	-1.0	-	19.6	31.4	16.0
4415	DOCTOR ISLAND	+5	61 41	71 34	+ 0 14	- 2.3	-	+0 14	-1.9	-	20.5	33.1	15.5
4435	DOUGLAS HARBOUR	+5	61 55	72 37	+ 0 14	- 4.7	- 5.4	+0 13	-2.2	-1.6	18.4	29.7	14.3
4460	DECEPTION BAY	+5	62 09	74 45	+ 0 57	-11.9	-14.5	+0 57	-2.9	-0.3	11.9	19.3	10.3
4470	SUGLUK	+5	62 13	75 39	+ 1 02	-13.3	-16.0	+1 04	-3.5	-0.8	11.1	18.3	9.2
	DIGGES ISLANDS												
4480	DIGGES HARBOUR	+5	62 34	77 52	+ 1 54	-18.5	-22.4	+1 54	-4.8	-0.9	7.2	12.0	6.0
4490	PORT DE LAPERRIERE	+5	62 34	78 04	+ 1 31	-20.6	-25.2	+1 31	-6.3	-1.7	6.6	10.0	4.2
	NOTTINGHAM ISLAND												
4500	PORT DE BOUCHERVILLE	+5	63 10	77 35	+ 1 35	-16.6	-19.6	+1 35	-5.9	-2.9	10.2	16.8	6.5
	AREA / RÉGION 5 — HUDSON BAY												
							on/sur CHURCHILL						
	HUDSON BAY EAST												
4550	POVUNGNITUK	+5	60 02	77 16	+ 5 23	-10.7	-13.1	+4 56	-1.4	+1.1	1.7	2.9	1.9
4575	PORT HARRISON	+5	58 27	78 06	+ 3 23	-11.5	-14.3	+3 05	-1.6	+1.2	1.1	1.6	1.3
4600	TUKARAK ISLAND	+5	56 19	78 50	+ 0 52	- 8.8	-11.0	+0 44	-1.1	+1.1	3.3	5.0	3.0
4610	INNETALLING I.	+5	55 54	79 04	+ 0 45	- 8.4	-10.3	+0 41	-1.2	+0.8	3.8	6.0	3.1
4620	FLAHERTY ISLAND	+5	55 53	79 37	+ 0 14	- 8.2	-	+1 03	-1.2	-	-	-	-
							on/sur SAND HEAD						
4645	GREAT WHALE R.	+5	55 16	77 46	- 6 01	- 4.8	- 5.5	-5 54	-2.3	-1.6	4.4	6.3	3.0
4655	CAPE JONES	+5	54 46	79 44	- 6 22	- 3.9	-	-6 15	-1.5	-	4.5	7.6	3.9
	JAMES BAY EAST												
4680	FORT GEORGE RIVER	+5	53 50	79 02	- 5 39	- 3.7	- 4.2	-5 36	-1.6	-0.9	4.8	6.9	3.9
4710	EASTMAIN RIVER	+5	52 15	78 33	+ 0 08	- 6.7	- 7.8	+0 20	-2.3	-1.1	2.5	3.5	2.1
4720	STRUTTON ISLANDS	+5	52 05	78 57	- 0 57	- 4.9	- 6.0	-1 11	-2.0	-0.8	4.0	5.0	2.9
4730	CHARLTON ISLAND	+5	51 58	79 18	+ 0 15	- 3.6	- 4.1	+0 11	-1.6	-1.0	4.9	7.1	4.0
4740	STAG ISLAND	+5	51 38	79 02	+ 1 18	- 1.4	-	+1 15	-1.2	-	6.7	9.5	5.4
	MOOSE RIVER												
4790	SHIP SANDS ISLAND	+5	51 20	80 26	+ 0 35	- 1.5	-	+1 15	-0.2	-	5.6	8.7	5.8
4800	NICHOLSON CREEK	+5	51 18	80 34	+ 1 25	- 2.3	-	+2 10	-0.7	-	5.3	8.6	5.0
4810	MOOSONEE	+5	51 17	80 38	+ 1 45	- 2.6	-	+2 45	-0.7	-	5.0	8.4	5.1
	JAMES BAY WEST												
4840	FORT ALBANY	+5	52 07	81 22	- 0 07	- 2.4	-	-0 03	-2.1	-	6.6	9.8	4.4
4880	BEAR ISLAND	+5	54 21	81 05	- 6 11	- 2.3	-	-6 27	-2.8	-2.2	7.0	9.9	4.2
							on/sur CHURCHILL						
	HUDSON BAY WEST												
4920	WINISK	+5	55 17	85 06	- 4 18	- 4.7	- 5.8	-4 23	-1.3	+0.2	7.6	11.1	4.9
4980	PORT NELSON	+5	57 00	92 30	+ 3 31	- 0.1	-	+4 45	-1.6	+0.7	12.5	15.9	6.3
5040	ESKIMO POINT	+6	61 07	94 04	- 1 23	- 2.3	-	-1 28	-0.1	-	8.8	14.3	6.8
5070	MARBLE ISLAND	+6	62 41	91 12	- 3 24	- 2.0	-	-3 22	+0.2	-	8.8	14.0	7.1
5100	RANKIN INLET	+6	62 49	92 04	- 3 03	- 0.9	-	-3 02	+0.5	-	9.6	15.3	7.8
5140	CHESTERFIELD INLET	+6	63 20	90 42	- 3 47	- 0.9	- 1.6	-3 48	+0.6	+1.6	9.5	13.9	7.8
	SOUTHAMPTON ISLAND												
5180	CORAL HARBOUR	+5	64 08	83 10	- 8 02	- 2.7	- 3.4	-7 59	+0.2	+1.0	8.1	12.7	6.7
	ROES WELCOME SOUND												
5200	REPULSE BAY	+6	66 32	86 15	- 6 35	+ 3.7	+ 5.0	-6 42	+0.9	-0.3	13.8	22.4	10.2

Prediction

CHURCHILL (Z+6)

1968

TIDE TABLES

JUNE-JUIN

Day	Time	Ht./ft.	Jour	Heure	H./pi.
1	0410	3.1	16	0515	2.1
	1030	12.3		1145	13.1
	1630	2.3		1740	1.6
	2305	12.4			
2	0450	3.3	17	0020	13.2
	1115	12.1		0610	2.6
	1715	2.6		1240	12.5
	2345	12.2		1840	2.3
3	0545	3.5	18	0110	12.7
	1205	11.8		0715	3.0
	1805	2.9		1330	12.0
				1935	2.9
4	0040	12.1	19	0210	12.3
	0640	3.7		0810	3.3
	1300	11.6		1430	11.6
	1910	3.2		2035	3.3
5	0135	12.0	20	0300	11.9
	0745	3.7		0910	3.5
	1405	11.6		1535	11.4
	2015	3.3		2130	3.6
6	0245	12.1	21	0355	11.8
	0850	3.4		1010	3.4
	1510	11.8		1635	11.5
	2115	3.1		2230	3.7
7	0345	12.4	22	0455	11.8
	0955	2.8		1100	3.2
	1620	12.2		1725	11.7
	2220	2.8		2325	3.7
8	0445	12.9	23	0540	11.9
	1055	2.1		1150	2.9
	1715	12.8		1815	12.0
	2320	2.3			
9	0540	13.4	24	0015	3.5
	1150	1.4		0625	12.1
	1810	13.4		1235	2.6
				1855	12.2
10	0010	1.8	25	0055	3.3
	0630	13.9		0705	12.3
	1240	.8		1320	2.3
	1905	13.8		1945	12.5
11	0105	1.4	26	0135	3.2
	0720	14.1		0750	12.5
	1330	.3		1400	2.0
	2000	14.1		2025	12.7
12	0155	1.1	27	0215	3.0
	0810	14.2		0830	12.7
	1420	.1		1430	1.9
	2050	14.3		2100	12.9
13	0245	1.1	28	0250	2.8
	0905	14.2		0910	12.9
	1505	.2		1510	1.8
	2145	14.2		2140	13.1
14	0335	1.3	29	0325	2.7
	1000	14.0		0945	12.9
	1555	.5		1545	1.7
	2235	14.0		2215	13.2
15	0425	1.6	30	0405	2.5
	1055	13.6		1025	13.0
	1650	1.0		1625	1.7
	2330	13.7		2255	13.3

JULY-JUILLET

Day	Time	Ht./ft.	Jour	Heure	H./pi.
1	0455	2.5	16	0000	14.0
	1120	13.0		0545	1.8
	1705	1.8		1215	13.3
	2340	13.3		1805	1.8
2	0535	2.5	17	0040	13.4
	1200	12.9		0640	2.3
	1755	2.0		1300	12.7
				1855	2.5
3	0025	13.2	18	0125	12.8
	0620	2.5		0730	2.9
	1250	12.7		1350	12.0
	1845	2.3		1945	3.3
4	0115	13.1	19	0215	12.2
	0715	2.6		0825	3.4
	1345	12.5		1445	11.5
	1940	2.6		2045	3.9
5	0210	12.9	20	0310	11.7
	0815	2.6		0920	3.7
	1440	12.4		1545	11.3
	2040	2.8		2145	4.3
6	0310	12.8	21	0405	11.4
	0925	2.5		1030	3.7
	1550	12.4		1650	11.3
	2150	2.9		2300	4.4
7	0415	12.9	22	0510	11.5
	1025	2.2		1130	3.5
	1655	12.7		1750	11.6
	2300	2.8			
8	0520	13.2	23	0000	4.2
	1130	1.8		0605	11.8
	1800	13.2		1225	3.1
				1845	12.1
9	0005	2.4	24	0045	3.9
	0620	13.5		0655	12.2
	1230	1.2		1310	2.6
	1900	13.6		1935	12.6
10	0100	2.0	25	0130	3.4
	0720	13.8		0750	12.7
	1325	.8		1350	2.2
	2000	14.1		2020	13.1
11	0155	1.6	26	0210	3.0
	0815	14.1		0825	13.1
	1420	.4		1425	1.8
	2055	14.4		2100	13.5
12	0240	1.3	27	0245	2.5
	0910	14.3		0910	13.5
	1505	.3		1505	1.5
	2145	14.6		2135	13.9
13	0330	1.1	28	0320	2.1
	1000	14.4		0945	13.7
	1550	.3		1535	1.3
	2230	14.6		2210	14.1
14	0415	1.2	29	0355	1.8
	1045	14.2		1020	13.9
	1635	.6		1610	1.2
	2315	14.4		2250	14.2
15	0500	1.4	30	0435	1.6
	1130	13.8		1100	13.9
	1725	1.1		1645	1.2
				2320	14.2
			31	0510	1.6
				1135	13.7
				1725	1.5

AUGUST-AOÛT

Day	Time	Ht./ft.	Jour	Heure	H./pi.
1	0000	14.0	16	0040	12.8
	0555	1.7		0640	3.0
	1220	13.4		1300	12.1
	1815	1.9		1850	3.7
2	0045	13.6	17	0120	12.0
	0650	2.1		0725	3.8
	1310	13.0		1355	11.4
	1910	2.5		1950	4.6
3	0140	13.1	18	0215	11.3
	0745	2.5		0830	4.4
	1415	12.5		1500	10.9
	2010	3.2		2100	5.3
4	0240	12.7	19	0315	10.9
	0850	2.9		0940	4.7
	1525	12.2		1615	10.8
	2125	3.6		2220	5.4
5	0355	12.4	20	0430	10.9
	1010	2.9		1100	4.4
	1645	12.3		1730	11.2
	2245	3.6		2340	5.0
6	0505	12.6	21	0540	11.4
	1120	2.6		1200	3.9
	1755	12.8		1825	11.9
7	0000	3.2	22	0030	4.4
	0615	13.0		0635	12.1
	1230	2.0		1255	3.2
	1905	13.4		1920	12.7
8	0100	2.5	23	0115	3.6
	0720	13.6		0730	12.8
	1325	1.3		1335	2.5
	2000	14.1		2000	13.4
9	0150	1.9	24	0155	2.9
	0810	14.1		0810	13.5
	1410	.8		1405	1.9
	2045	14.6		2035	14.0
10	0235	1.4	25	0230	2.2
	0900	14.5		0850	14.0
	1455	.6		1440	1.5
	2130	14.8		2110	14.5
11	0315	1.1	26	0300	1.7
	0945	14.6		0925	14.4
	1535	.6		1510	1.1
	2205	14.8		2150	14.8
12	0355	1.1	27	0330	1.3
	1025	14.5		0955	14.5
	1610	.8		1550	1.0
	2245	14.6		2215	14.9
13	0430	1.3	28	0405	1.0
	1100	14.1		1035	14.5
	1650	1.3		1620	1.0
	2320	14.2		2255	14.8
14	0515	1.7	29	0440	1.1
	1135	13.6		1115	14.3
	1730	1.9		1700	1.4
				2330	14.4
15	0000	13.6	30	0525	1.4
	0550	2.3		1200	13.8
	1215	12.9		1745	2.0
	1810	2.8			
			31	0015	13.8
				0615	2.1
				1250	13.1
				1840	3.0

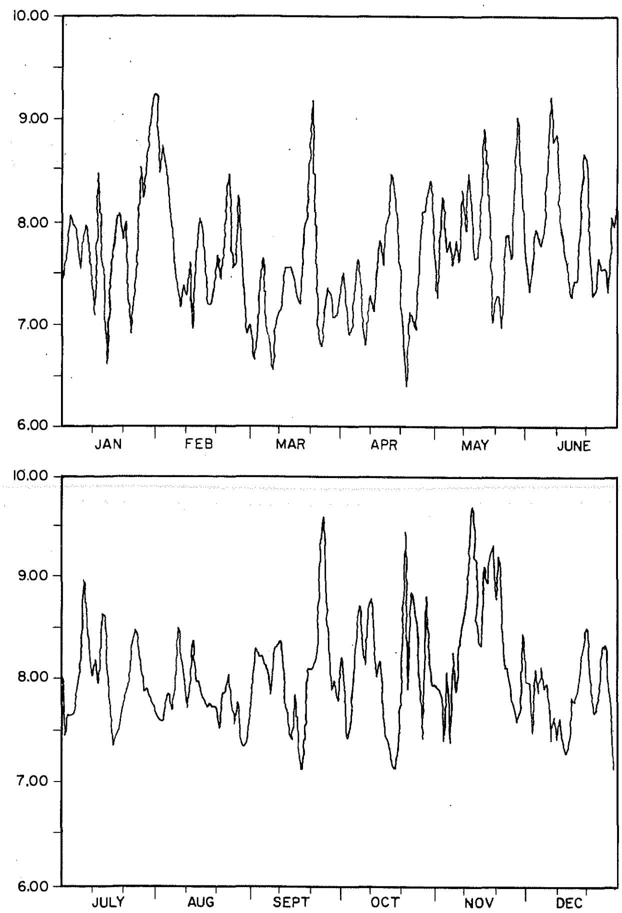


Figure 3. Variations in mean water level at Churchill during 1965.

of the tide above chart datum (a level below which the tide seldom falls) is 10 feet, increasing to 12 feet along the western shore. It decreases gradually along the southern shore and then along the eastern shore to about 1½ feet at Port Harrison.

The above-mentioned progression of the tides, their heights above chart datum and the relative times at which high water occurs in different parts of the Bay are shown in Table 1 and Figure 2. The times in Figure 2 are given in terms of high water after the moon's transit of Meridan 60° W which occurs three quarters of an hour (on the average) later each day. For example, that high water at the entrance to the Bay will occur at the same time as low water at Rankin Inlet while high water at York Factory will take place at the same time as low water in the vicinity of the Belcher Islands.

HORIZONTAL WATER MOVEMENTS

The rotary progression of the tides around Hudson Bay already described and illustrated in Figure 2 has corresponding tidal streams associated with it and the flow in Hudson Bay has been observed not only by present-day ship captains but also, as mentioned earlier, by the early explorers of the Bay.

Unfortunately the tidal streams are as yet insufficiently known. It is possible however to say that they are strongest in the western part of the Bay, while in the vicinity of Povungnituk and Port Harrison they are weak and irregular. Both tides and tidal streams are closely related and the shape of the northern part of the Bay and its orientation relative to the mouth of the Strait suggests that the flow would in the main be anti-clockwise. This is actually observed to be the case.

The actual flow encountered in the Bay is not exclusively tidal but is influenced by the numerous rivers which discharge large quantities of fresh water into Hudson Bay. Since the volume of the rivers is subject to large seasonal variations, this will have an influence on the flow which is not precisely predictable. The flow, like the tides, is also influenced by meteorological disturbances, in particular by

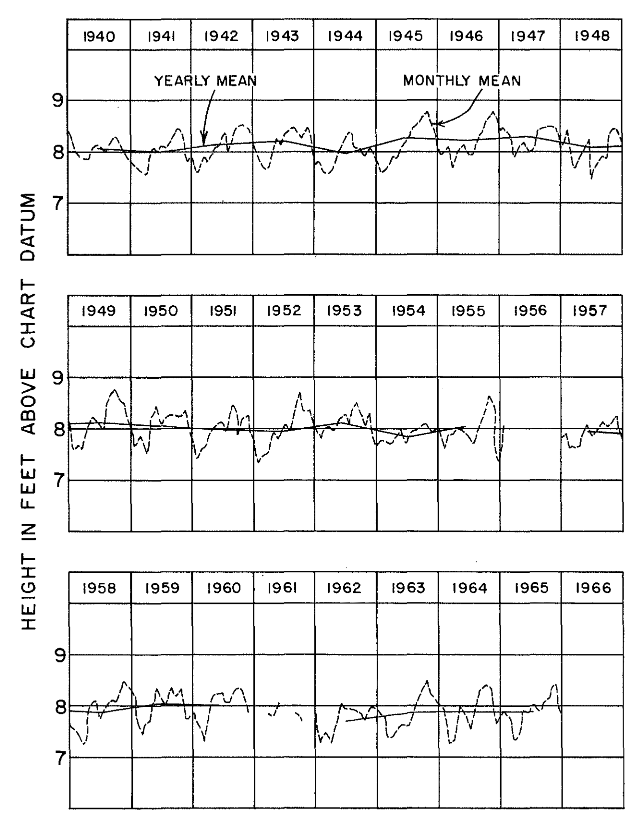


Figure 4. Mean annual and monthly levels at Churchill for the period 1940-1965.

the strong winds which are often encountered in the Bay.

TIDE LEVEL FORECASTS

The Tides and Water Levels Section predicts the rise and fall of the tide for Churchill, Diana Bay and Sand Head, and gives relative heights for 45 other locations around the Bay and Strait. These forecasts take the form indicated in Table 2. The tide tables give the day of the month and the time of high and low water in hours and minutes. Instead of giving the actual water levels for all the ports, these are given in terms of differences from the Churchill, Diana Bay or Sand Head daily predictions. These differences are the amount to be added or subtracted from the predicted tide levels to obtain the height of the tide at any particular port (Table 1). Tide prediction tables are obtainable from the Canadian Hydrographic Service, Ottawa.

Meteorological conditions such as strong prolonged winds, abrupt changes in barometric pressure or prolonged periods of very high or very low pressure introduce fluctuations in the mean water level of the Bay. These fluctuations cannot be predicted in advance since they differ from year to year as well as at shorter frequencies. Figure 3 shows the variations for the year 1965 and Figure 4 the trend for the period 1940-1965.

Knowledge of the tides and tidal currents in Hudson Bay is very scanty and a determined effort is being made by the Department of Energy, Mines and Resources to improve the tidal predictions and to undertake detailed studies of tides and tidal currents in Hudson Bay. In addition to improving the information of interest to navigators, the establishment of new stations will also give a better coverage of the mean sea-level data so urgently needed in connection with gravity measurements, field stress investigations of the earth's interior and other geophysical research.

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OSTRACODES *(continued)*

Of considerable interest to the glacial geologist is the application of fossil ostracodes to determine the past history of a lake or pond. This allows the specialist to determine changes in the ecology of the lake as well as to infer climatic changes that have occurred. The ecology of the past can be determined because the ostracodes which lived during glacial times have not become extinct. Knowing the conditions they live under now enables one to interpret the conditions under which various ostracode assemblages lived in the past.

Ostracodes are not the only organisms which can be used for such studies. Snails and clams can also be used as effectively, as can plant remains. The study of these indicators of paleohydrology can provide important information for the solution of present-day hydrologic problems.

BREAK-THROUGH GUARD *(continued)*

same time not interfering with the clearing of ice cuttings up the flighting.

The simple guard worked well, so well indeed that the project to design a more elaborate break-through shoe was abandoned as no longer necessary. An added bonus was the fact that the operator could see when the pilot cutter was through the ice and was able to avoid damage to the cutters where the under-ice depth was critical.

There are doubtless many other solutions to this problem. The author hopes, however, that the break-through guard described in this article may commend itself to operators who might otherwise deny themselves the advantages of the General auger because of its lethal break-through.