SURVEY

TIDES AND CURRENTS

IN

OF.

CANADIAN WATERS

REPORT OF PROGRESS

BY

W. BELL DAWSON, C.E. Engineer in charge of Tidal Survey.

OTTAWA GOVERNMENT PRINTING BUREAU 1901

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SURVEY OF TIDES AND CURRENTS IN CANADIAN WATERS.

OTTAWA, December 20, 1900.

W. P. ANDERSON, Esq., C.E.,

Chief Engineer, Department of Marine and Fisheries.

Sta,--I have the honour to submit the following Report on the progress of this Survey. The principal tidal stations have been maintained in continuous operation throughout the year, and progress has been made in the reduction of the results, and in the use made of them to improve the tide tables, now regularly issued. During the summer season, a series of tidal stations was established throughout the Lower St. Lawrence, from Quebec to Cape Chatte. For these stations, points were selected which would secure the greatest amount of information regarding the relation between 'the tidal currents on the St. Lawrence, and the tiles themselves. Some direct observations of the currents were also made in the Traverse. Another important step, is the calculation and publication of tide tables for British Columbia.

Progress in these directions has been made possible by the increased amount of the appropriation for this Survey. As soon as the increase was decided upon, the tidal records from British Columbia, which had been reduced to figures in tabular form and had been lying in readiness for some time back, were at once sent forward to London, where the analysis of the record is made. Through this promptitude, it was possible to secure tide tables for 1901 in time for publication before the close of the present year. These will be of much service to navigation our west coast.

In the last report on this Survey, full comparative statements were given, to show the improvement in the accuracy of tide tables which had already been secured by the investigations made. Comparative tables were also given to show the difference still outstanding between the improved tide tables now issued by this Survey, and the tides themselves as observed. From these comparisons, it appeared that the greatest difference between the two, or the greatest outstanding error, occurred at Quebec. It was therefore deemed to be of the most service, to reduce two additional years of the tidal record from that harbour, in order to extend the basis from which the Quebec tide tables are calculated, from two years of observation to four years. This will be of permanent benefit to these tide tables in all future years. The expenditure required for this, amounts to \$450 which the Survey could not afford until now. This again illustrates the way in which any increase in the appropriation for this Survey can at once be applied to practical advantage.

This is as much as could be done in one year in this direction; but for other harbours in their turn, a similar improvement will be secured as means are available. In the office work of this Survey, and in the erection of the summer tidal stations, I have had the assistance of Mr. R. Angus and Mr. S. C. Hayden.

The total expenditure on this Survey during the fiscal year from June 30, 1899, to June 30, 1900, was \$4,343.10. This includes an amount of \$378.08 properly chargeable to the tidal observations on the Lower St. Lawrence during this season.

Applications for Information.—As the Survey becomes more widely known, the requests for information and the correspondence resulting, continue to increase. Without attempting to enumerate all the requests for copies of reports and tide tables, the following applications for information may deserve mention :—

The Superintendent of the United States Coast Survey in acknowledging the report of progress containing tidal constants for three of our harbours, for which request had been made, writes as follows:...- Your valuable report was received too late to benefit our 1900 tables; but use will be made of the data given there, in our Tide Tables for 1901, and acknowledged to your survey.'

The Consul for Sweden and Norway made request for a number of sets of Tidal Survey reports for distribution amongst Norwegian steamers employed in the coal trade between Montreal and the Lower Provinces. A sufficient number of reports were sent in reply; as well as further information asked for, regarding Belle Isle strait and the Bay of Fundy. In acknowledging these the Cousul says :--- I shall make it part of my duty, as far as lies in my power, to distribute these amongst Norwegian steamers to whom they may be of the greatest interest.'

On request of the secretary of the Pilotage Commissioners of St. John N. B., thirty copies of the tide tables in which St. John is included, were sent for the information of the pilots at that port.

The tide-levels, which have always to be carefully worked out for the reduction of the tidal observations, often prove of important service also, in connection with harbour works; as the following requests for correct tidal levels will indicate :— Mr. A. J. Stevens, I. C. R. engineer, in determining the depth required for the

Mr. A. J. Stevens, I. C. R. engineer, in determining the depth required for the Intercolonial railway docks at Richmond, and the Deep Water terminus at Halifax, makes request for: 'A low water datum which can be relied upon for security to ships, by shippers and the railway alike. These docks are used by the largest ships upon the Atlantic. They must never touch bottom.'

Major Roberts, superintermedent of signals at Halifax, required to carry the lowwater datum over to St. George's island; and also desired information from which to make a table of the half hourly height of the tide; which was supplied.

Mr. C. E. W. Dodwell, Resident Engineer of Public Works for Nova Scotia, applied for the elevation of high water at ordinary spring tides, at Windsor, N. S.; for reference in connection with works in progress for the improvement of that port. On application from Mr. E. T. P. Shewen, Resident Engineer of Public Works at

On application from Mr. E. T. P. Shewen, Resident Engineer of Public Works at St. John, N. B., some three hundred readings of the height of the tide have been supplied to him, from the tide gauge at St. John; in addition to the series mentioned in a former report. These were required for the reduction of soundings taken for the survey of that harbour.

These may serve as examples of the accessory ways in which this Survey often proves of value, in addition to its direct service to the shipping interest.

THE PRINCIPAL TIDAL STATIONS.

These stations have been in continuous operation throughout the past year, with some minor exceptions. The stations at Forteau bay in Belle Isle strait, and at St. Paul island, Yarmouth, Father Point and Quebe, were in-pected this season by myself or Captain Douglas; and some important work done, which will better insure the continuity of the tidal record, and enhance its value.

At Forteau bay in Belle Isle strait, the tide-hou-e had settled when the gauge was damaged by a gale in November, 1897; and it was afterwards levelled up, when the new crib-work was built in September, 1898. The levels being thus disturbed, there was no longer the means of reducing the observations to a uniform datum. Even the wharf-gauge scale itself had been altered in elevation, in making the necessary repairs. The distance from Ottawa to Forteau bay has now been reduced from 2,100 miles to 1,600 miles, by the new route via North Sydney and the west coast of Newfoundland; but owing to the steamer connections being out of order this šeason, through an accident to one of the vessels in the service, a full month was taken up, after reaching North Sydney, to secure ten days at Forteau bay. It is thus something of an undertaking to visit this station, as it breaks into the time in the most important part of the year.

Owing to uncertainty in the levels, because of the changes above noted, the tidal record at Forteau bay for a period of two years, was deprived of nearly half its value. The special object in visiting the station was, therefore, to re-determine the levels as far back as 1898, and thus to restore the continuity of the datum. It was a problem

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ed, the tidal alf its value. the levels as s a problem complicated by the inter-relations of the various changes that had taken place; but technical difficulties need not be explained here, though it may be in place to remark that trouble of this character is always likely to arise when the tide gauges have to be placed on crib-work or other timber-work, which is liable to displacement or settlement. When they have to be so built, towing to the want of masonry on which to set them, the closest watchfulness is necessary; and instrumental levels have to be repeated at frequent intervals, with check calculations, cannot be maintained.

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As a precautionary measure, to enable any settlement to be detected more readily, a bronze bolt was let into a vertical face of rock at about half tide. This rock forms a reef in the vicinity of the gauge, which is covered at high water. The reading on the wharf scale when the water is at the level of this bolt, is posted up in the tide-house for reference. An improvement in the sight-gauge has also been made by using wooden rods for the connection between its scale and the float which rises and falls with the tide. This is to avoid the possibility of alteration in its length ; and it has now been carefully adjusted to standard length. Several other minor improvements were also made.

At St. Paul island similar difficulty has been met with, in maintaining a uniform datum level. A scale of feet was originally cut on the face of the rock for reference; but this has been effaced by the heavy ice of winter. It is seldom in any case that there is not too heavy a swell to obtain satisfactory readings on such a scale. Entire dependance has therefore to be placed on the sight-gauge, to furnish the datum level. The tide-house had to be raised twenty-four feet above high water, to prevent it from being carlied away in winter storms; and this makes the length of the sight-gauge too great to use wooden rods for the connection between its scale and the tide-float. For this connection, heavy nickel wire, made up into chain of 6-inch links, has now been adopted. This gives every promise of success; as it had already proved satisfactory throughout the previous winter at the Halifax gauge.

The rock of which the cliffs are composed and against which the tide gauge is set, is so crumbling that reference marks for the levels are soon lost. A bronze bolt has therefore been drilled into the rock for this purpose; and by these improvements it is hoped that a uniform datum will be more certainly and conveniently maintained; and that the amount of office work required for the reduction of the observations to datum, will be appreciably decreased.

The dipleidoscopes, which give the correct time from the sun, were adjusted by astronomical observations at both Forteau bay and St. Paul island. The barographs, which give a continuous record of the height of the barometer, were also adjusted at both stations.

At Father Point, extended observations were taken in August to compare the actual rise and fall of the tide on the open beach, with the record given by the instrument; as this gauge works by siphoning through an inlet pipe nearly 400 feet long. Simultaneous comparisons were made every two or three minutes for several hours at a time, on fine days during the time of the spring tides. The results need not here be detailed. When compiled with the similar observations obtained the year before, they afford a table of correction to be applied to the height of the tide, to allow for the siphoning action of the gauge. This is essential in the reduction of the observations.

At Quebec, a favourable opportunity was taken to secure a further series of comparisons, to determine the relation between the zero of the tide gauge and the scale of feet cut on the masonry of the dry dock on which the gauge stands.

TIDAL RECORD OBTAINED AT THE PRINCIPAL STATIONS.

The record obtained has been practically continuous during the year, at the seven east coast stations, as well as at the two tidal stations in British Columbia. The causes of interruption may be cited briefly, as examples of the nature of the difficulties to be met, against which foresight is required. The gauge at Yarmouth, N.S. was fitted up originally in 1898 as a summer station without any provision for heating in winter, as the climate is milder there than at any of the other principal stations. (See comparative temperatures given in last year's report.) Some special precautions were taken to prevent the formation of ice in winter, as explained in last report; but notwithstanding these, more than a month of record was lost during the first winter, in February of 1899. During the past winter however, the only loss on account of frost was from February 5 to 7, and from February 28 to March 5, 1900; a total of nine days.

At St. John, N.B., there was repeated trouble between January and April, on account of the breakage of the fine platinum wire which connects the tid-doat with the mechanism of the recording instrument. The trouble was finally remedied; but there remains much office work to be done, in filling in the parts of the tide-curves which are thus missing. The gaps can better be made up in this way, than by calculation.

At Halifax, the hair spring of the driving clock of the gauge broke twice, in the months of June and July. Some spare hair springs had been obtained from the makers of the gauge in Glasgow, and placed in charge of a leading watch maker in Halifax; and because of this precaution, the interruption from these accidents was limited to one or two days on each occasion.

At Father Point, at the end of July, choakage occurred in the intake pipe that admits the water to the gauge, by which five days record was lost. To remedy this, the outer end of the pipes had to be disconnected; and it was not until the low spring tides of the middle of August, that they could be re-laid. During the interval, the record of some low waters was lost, as the pipes did not then reach to the lowest tides.

At the other principal tidal stations, namely, Quebec, St. Paul island, and Forteau bay, there was no interruption in the record obtained.

The total amount of tidal record obtained at the principal stations up to the end of 1898, was given in a summary form in Table D, appended to last year's Report of Progress.

TIDE TABLES FOR 1900 AND 1901. IMPROVEMENTS, PUBLICATION, &c.

Several improvements on previous years have been made in the preparation and publication of the tide tables issued by this Survey. A considerable part of the advantage of the work which has now been done, will appear when the tide tables for 1901 are issued; whereas the reduction of additional record and its analysis to extend the basis from which the tide tables are calculated, will first benefit the tables for 1902. The progress made may be best explained, therefore, under the heading of the years in which the tide tables will be improved by the work now done.

Tidal differences in the Bay of Fundy.—In the tide tables of 1900 for the harbours of Quebec, Halifax and St. John, N. B., a slip was inserted giving the preliminary results of the tidal observations, in the Bay of Fundy. A complete set of tidal differences for the whole of this bay has now been prepared, which will appear in the tide tables for 1901. They are based upon a comparison of the tidal observations obtained at the stations of 1898, with the 'Establishments' as already determined by the Admiralty for intermediate points. This comparison affords a valuable check upon the Establishments themselves; and places the time of the tidd the upon the tidal basis. The importance to mavigation of a correct knowledge of the tide in this bay is evident, when the range of the tide is so great. In addition to the tidal differences which enable is given, for points in the upper part of the bay. Navigation may there be said to be entirely dependent on the tide, as the wharfs do not extend beyond half-tide mark, and vessels can therefore only reach, their berths at high water.

New Tide Tables for British Columbia — These are based upon the record obtained from registering tide gauges erected in 1895 by the Department of Public Works. One of these is at Sand Heads at the outlet of the Fraser river, on the coast of the Strait of Georgia. It is thus centrally situated in that strait for comparison with the time of the tide at the harbours around it. Another tide gauge was originally placed at Victoria, in 1895; where two full years of tidal record have been secured. This gauge was afte

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ord obtained forks. One the Strait of the time of ced at Vics gauge was afterwards removed to the Dry Dock at Esquimalt, in May, 1897; where it has been in continuous operation to date.

Duplicate copies of these records where furnished to this Survey in the form of blue prints ; but the whole set was lost in the fire in the departmental buildings in February, 1897. A second set from the Department of Public Works was fortunately obtained before the whole of the original record was destroyed in the extensive fire at New Westminster, in August, 1898. This emphasises the risk run, in allowing a record of such value to stand over for so long, before it is submitted to analysis. It is therefore reassuring to report that there are now three years of this record from which tidal constants have been determined ; which thus places the results from this portion of it, in a position of equal security with the movements of the sun and moon themselves.

The length of record on which these tide tables are now based, is as follows :--

Victoria, on one full year, from April 1, 1895, to April 30, 1896.

Sand Heads, Fraser river, on two years, from May 1, 1895, to May 31, 1896; and from October 1, 1896, to October 28, 1897.

These tables will be of much service to our west coast, because of the complication, of the tides there, which results from the large diurnal inequality. Heretofore, the best approximations available were those given in the tide tables of the United States Coast Survey; where the tides in the Strait of Georgia are referred to Port Townsend at the mouth of Puget Sound, and the tides at Victoria are deduced from Galveston on the Gulf of Mexico.

The tides at Victoria apparently, cannot be 'referred to the United States tidal station at Port Townsend, and the results obtained for the Strait of Georgia have been far from satisfactory ; which in all probability is due to an alteration in the character or type of the tide after it enters the Strait of Fuca. This change is made clear now that the tidal constants have been obtained, as a comparison of the leading harmonic components given below will show. The progress of the tide is in the order of the columns. While there is a general increase in the' values, in correspondence with the increase in the range of the tide itself, the proportions between the diurnal and semi-diurnal components are profoundly modified.

Symbol.	Tidal Component.	VICTORIA. (Strait of Fuca.)	Port Townsend.	SAND HEADS. (Strait of Georgia,)
M 2	Lunar semi-diurnal	1 23 feet.	2 · 22 feet.	2.81 feet. ~
\mathbf{S}_2	Solar semi-diurnal	0.33	0.22 "	0.68
. K.	Luni-solar semi-diurnal	0.08 "	0.16	.0.22
K,"	Luni-solar diurnal	2.05 "	2.51 "	2.70
0	Lunar diurnal.	.1.24	1.45	1.48
Р	Solar diurnal	0.62 "	0.80	0.80 "

In following the onward progress of the tide, it is thus necessary to take the Victoria tide as the type for the Strait of Fuca, while Port Townsend is probably typical of the Puget Sound region. The tide is then further modified in its passage through a network of narrow channels, in reaching the Strait of Georgia. In these circumstances, constant differences in time do not hold, as they usually do when a tide progresses evenly along a channel or strait. The only way to meet the difficulty is to secure tidal data for the Strait of Georgia itself, as has now been done.

for the Strait of Georgia itself, as has now been done. With the tide tables now traved, tidal differences are given which enable the time of the tide to be found approximately for Esquimalt, Vancouver, New Westminster and Nanaimo. An explanation is given in the tide tables themselves, of the data on which these differences are based. Quebec, Halifax and St. John, N.B.—The tide tables for these principal harbours remain, up to 1901, without further improvement in their accuracy; being still based upon the same length of tidal record as before. These tables give the time and height of the tide, the depth of the water on dock sills, &c.; and they are accompanied by tidal differences, by which the time of the tide at a large number of other ports becomes known. The chief improvement in this set of tables, is the addition of the tidal differences for the Bay of Fundy, as above explained.

These tide tables were again supplied to the leading British and Canadjan Almanacs, for 1900, as far as they were willing to publish them. Some improvements in this respect may be noted. In McMillan's Almanac, the St. John tables for 1900 are printed in full, the height of the tide as well as the time being given, which 'is important in a harbour where the range of the tide is over thirty feet. The newspapers have also done a little better on the whole, in making the tide tables known. The St. John papers have not published them as fully as in former years; but on the other hand, in Quebec, the *Cheronicle* and the Solei' have published the tide tables for that harbour pretty regularly throughout the season, giving two or three days at a time; and have made acknowledgement to this Department for them. The Quebec *Telegraph* also gave occasionally the the tides for the following day.

The almanaes in which the tide tables appear in whole or in part are as follows :--Canadian Almanae. --All the above, in full. --The Copp, Clark Co., Toronto. Greenwood's Almanae. " " --Capt. W. N. Greenwood, Lancaster, Eng.

Greenwood's Almanac.— ""——Capt. W. N. Greenwood, Lancaster, Eng. Brown's Almanac.—Halifax tide tables.—Messrs. J. Brown & Son, Glasgow and L'pool. Belcher's Almanac.—Halifax tide tables.—The McAlpine Publishing Co., Halifax. McMillan's Almanac.—St. John tide tables in full.—Mrs. J. & A. McMillan, St. John. Cogswell's Almanac.—(Discontinued.—Did not appear for 1900.)

Moore's Tide Tables.-Quebec; time only.-Messrs. T. J. Moore & Co., Quebec.

These tide tables were again reprinted from Greenwood's Almanac; the reprints including the tables for St. Paul island also, with tidal differences for the south-west coast of the Gulf of St. Lawrence. Of these, nearly 500 copies were widely distributed. In this way all applications for the tables have been met; forty-nine copies having been sent inbreply to requests for them. The number of these reprinted copies ordered for 1901 has been increased to 600.

Charlottetown, Pictou and St. Paul Island.—These tide tables are computed by this Survey and printed by the Department. A step in advance has been made, in preparing them earlier in the year, and also in extending them to include the whole year, instead of only eight months as formerly. To do this, it was of course necessary to compute two sets of tables during the one year; and to facilitate the extra work, a tidal-difference machine was devised by me, by which variable differences in the time of the tide can be run off with the same facility as a constant difference. The series of differences used in the successive computation of this set of tables, from the principal tidal station at St. Paul island, was also revised and slightly modified. (For explanation of the method used, see Report of Tidal Survey, December, 1898, pages 8 and 9.)

The extension of these tables to include the whole year, will be of service to the winter navigation in Northumberland strait. Also, by preparing them early in the year, the almanacs were supplied with copies for 1901 in good time, and it is thus hoped that they will be induced to publish them. It would be an important improvement if they would publish the tide tables prepared by this Survey; because any other tide tables, as formerly published for Charlottetown and Pictou, have been quite incorrect; or the tidal difference given by which to compute them, has been misleading. The reasons for this, which are attributable to the character of the tides, have been explained in Reports of Tidal Survey, December 1898, page 7; and December, 1899, page 11; where examples are given in illustration. It was chiefly in the hope of replacing this inaccurate information with reliable tide tables that the effort was made to issue them in the spring, amongst the press of other preparations in leaving for the work of the summer season.

Already, during 1900, the Charlottetown *Patriot* has published the tide tables of this Survey, one month at a time, with the full explanation accompanying them. The *Examiner* has also given them correctly for the later months of the year. At SummerTl year. as the observa

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e tables of hem. The t Summerside, P.E.I., the *Journal* was found to be publishing tables for that harbour which were inaccurate; and the tide tables of this Survey, with the correct difference in time from Charlottetown, were therefore sent to it. The Pictou and New Glasgow papers have also been supplied with this set of tide tables; which the Pictou *Advocate* and the New Glasgow *Enterprise* published when they were first issued in 1897 and 1898.

Ste. Croix Bar.—Tide tables were again computed for this locality, as it is still the shallowest point in the Ship channel between Quebec and Montreal; and the difference in time for St. Augustin Bar is also given. An improvement in the accuracy of these tables has been secured, by working up the observations recorded by the semaphore operator at Cap Santé, opposite Ste. Croix Bar. The additional record thus utilized, extended from June 9 to November 26 in 1898.

These tide tables are published in company with the tide tables for Quebec, by the Montreal Harbour Commissioners ; in the publication they prepare annually for the information of the St. Lawrence pilots. f

Father Point.—Prepared in manuscript only; and posted at the lighthouse at Father Point. As this is the Pilot Station for the Lower St. Lawrence, they are three accessible to the pilots.

Tadousac, Cacouna and Little Metis.—Tide tables for the months of July, August and September were computed for these sea-side resorts to meet the demand of the summer residents and tourists. This was done by a little extra work, without expense; as the tide tables were prepared in manuscript only, and posted at the leaving hotels.

TIDE TABLES FOR 1902.

These are now in hand for calculation, and will be ready in the early part of next year. An improvement in the accuracy of the tide tables for Quebec will be secured; as the basis from which they are calculated will be extended from two to four years of observations, by the analysis of two additional years of tidal record; namely, from February 1, 1896, to February 28, 1898.

Similarly, the accuracy of the St. Paul Island tide tables will be improved by extending their basis from one to two years, by the analysis of one year of additional record; namely, from December 12, 1897, to December 31, 1898. On St. Paul Island, the tide tables for Pictou and Charlottetown in Northumberland strait, are dependent; as well as the south-west coast of the Gulf of St. Lawrence and the north shore of Prince Edward Island, for which tidal differences from St. Paul island are given.

The tide tables for St. John and Halifax will remain on the same basis ; and also those for British Columbia for 1902, which will be calculated from the same record that serves as the basis of the tide tables now prepared for 1901.

THE CURRENTS.

Currents in the Gulf of St. Lawrence, including the Anticosti region, and Belle Isle and Cabot Straks.—A pamphlet with this title was prepared, and published by order of the Minister in June last. The information it contains is derived from the investigations in the Gulf of St. Lawrence made by this Survey during the summer months of 1894, 1895 and 1896; supplemented by information collected by myself from captains of vessels, fishermen and others, having a long experience in the Gulf. For greater clearness, no reference is made to the methods and appliances employed in these investigations; although some of them were used for the first time at sea, or were devised to meet the special conditions in the Gulf.

In condensing this information from the Reports of Progress already issued by this Survey, a division of the subject into two parts was made, as follows :--Part I. Description of the currents on the surface, as a mariner may expect to find them in each locality. Part II. The causes, as far as ascertained, which influence the currents in moving as they do; and the general circulation of the water in the Gulf of St. Lawrence.

This second part is also of value to mariners, in showing the usual direction in which the water tends to move, when undisturbed. It is added for the benefit of those who may desire to obtain some intelligent grasp of the conditions in the Gulf area, and the causes which influence the currents in moving as they are found to d_0 ; and who may wish to know something of the general relation of the waters in the Gulf area to the St. Lawrence river and the ocean; on which the work of this Survey has thrown considerable light.

This pamphlet was widely distributed, being sent to all those who usually receive 'Notices to Mariners' for the Atlantic coast of Canada; as well as to the foreign consuls, harbour boards, corporations of pilots, port-wardens, &c.; and to thirty-six shipping firms and agents of steamship lines. Several appreciative letters were received in reply from these firms; and the following additional copies were sent on request, which where desired chiefly for distribution to the captains of vessels:----

	Copies
The High Commissioner for Canada, London, England	. 50
The Imperial German Consulate	. 4
The Consul for Sweden and Norway, for the captains of Norway	e.
gian vessels	. 36
Messrs. H. & A. Allan, Allan Line, Montreal	. 25
Messrs. D. Torrance & Co., Dominion Line, Montreal	. 8
Messrs. Elder Dempster & Co	. 20
The Robert Reford Co., Donaldson and Thomson Lines	. 36
Messrs. McLean, Kennedy & Co., Ulster S.S. Co	. 24
The Hamburg American Line	. 20
Messrs. Carbray, Routh & Co., Dene Line	. 12
The Quebec Steamship Co	. 5
Messrs. Furness, Withy & Co., Furness Line, Halifax	. 6
Messrs. Pickford & Black, Halifax and W. India Lines	6
The Newfoundland Railway and Steamship Co., St. John'	s. 12

Note on Chart of the Gulf of St. Lawrence.—On the latest editions of the general chart of the Gulf, Admiralty chart No. 2516, the following note appears with respect to the currents, which embodies an outline of the results arrived at, in the investigations made by this Survey :—

"In the Strait of Belle Isle the currents are principally tidal, the west-going stream predominating; but wind has a great influence both in direction and force. Cross currents here appear to be rare.

"In Cabot strait the currents, although influenced by winds and tides, usually set to the north-westward round Cape Ray on the Newfoundland side, and to the southward on the Cape Breton side, this last current sometimes extending nearly across the whole width of the strait.

"On the main steamship route between the Strait of Belle Isle and Anticosti, and over most of the open area of the Gulf of St. Lawrence, the current is very variable, its rate soldom exceeding one knot per hour; and its direction, apparently, principally governed by winds. Its uncertainty renders it necessary for the mariner to exercise much caution.

"The only currents in the Gulf which run with any constancy, in the season of navigation, are: —A north-easterly set, of less than one knot per hour, off the west coast of Newfoundland, between Bonne Bay and Rich Point, and the easterly current between the entrance of the river St. Lawrence and the west end of Anticosti, turning to the southward round Cape Gaspé: but these currents are retarded, and may even be reversed, by strong contrary winds."

Tidal currents of the Lower St. Lawrence.—Some relations between the turn of the current and the time of high and low water, have been ascertained while the surveys for the Admiralty charts were being made. But unfortunately the time of the tide itself has not been known with sufficient accuracy to make these relations with the current practically available to mariners. The tidal observations of the present season will afford the information required, and will thus enable the turn of the current to be readily computed also.

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turn of the he surveys of the tide th the curseason will cent to be The relations referred to, as noted on the St. Lawrence charts, when put in tabular form, are as follows :---

	Flood Stream begins after L. W.		Ebb Stream begins after H. W.		Duration of Flood Stream.		Duration of Ebb Stream.	
	Н.	М.	н.	М.	н.	М.	H.	М.
after low water and high water by the shore-			1		1			
Quebec	. 1.	10	1	00	Ð	00	· 7	30
Ste. Anne de Beaupré.	0	45	1	00	5	10	7	15
St. Laurent, Orleans Island	. 0	-00	1	10	5	00	1 7	25
Berthier	. 1	10	1	05	ð	05	7	20
Grosse Isle	1	00	1	05	5	10	7	10
L'Islet After low water and high water at Orignaux Point	. 0	30	0	30	5	30	6	50
In Upper Traverse.	. 2	05	1	30	. 5	25	7	00
In Lower Traverse,	. 1	55	1	45	5	45	6	45
Orignaux Point After low water and high water at Rivière du Loup-	0	30	1	10	5 *	55	6	30
In Brandy Pot Channel	. 1	05	0	50	6	05	6	20
reen Island	1				6	00	6	24
Cadousac					6	08	1 6	15
Sic Island				1.1.1.1		50	6	34
Port Neuf (north shore outosite Bio)					6	07	6	18

Current observations on the St. Lawrence in 1900.—With the object of obtaining further simultaneous comparisons where the currents are strongest, arrangements were made this season for observation of the turn of the current at L'Islet, and in the Upper and Lower Traverse. The current there attains a speed of $7\frac{1}{2}$ knots during spring tides. The pier recently placed at the edge of the channel in the Upper Traverse, was made use of for these observations; and in the Lower Traverse, two miles below, the swing of the light-ship enabled the turn of the current to be noted at both day and night tides. The observers were instructed to take the corresponding moment in the turn of the current at both places. They also noted the swing of the buoys on the opposite side of the channel, so that the turn of the current in mid-channel might be correctly deduced from the double observations.

The chief essential was to obtain correct time for these observations. The observer on the Traverse Pier was provided with a chronometer, and he gave a time signal to the light-ship by lowering a flag at the moment of nine o'clock; as at that hour the direction of the sunlight is the most favourable for seeing the signal from it. To simplify matters for the observer, the face reading of the chronometer was taken without correction throughout the season; and its error was ascertained by time comparisons made at two different dates when the locality was visited by myself or my assistant. The total accumulated error amounted only to $2\frac{1}{2}$ minutes, at the close of the season, which is hardly appreciable in observations of this character, but has nevertheless been allowed for.

The observations of the turn of the current which were secured at the three localities, extended over the following periods :--

These observations, when brought into relation with the time of high and low water as ascertained by the tidal observations of this season, will evidently afford information of permanent value regarding the turn of the current.

TIDAL OBSERVATIONS IN THE SUMMER SEASON OF 1900.

Summer stations on the Lover St. Lawrence below Quebec.—The two permanent tidal stations in the St. Lawrence region, are at Quebec itself, and at Father Point, 180 miles below ; and the chief object of the observations at other places in this region, is to obtain 'tidal differences' by which the time of the tide may be correctly computed for them. The information which exists with respect to the turn of the strong tidal currents of the Lower St. Lawrence, will become practically available when once the time of the tide itself can be definitely computed. This has been explained above where the currents are referred to.

The difference in the time of high water and low water, between Father Point and Quebec, has now been determined from two complete years of simultaneous record. The average values which result for the whole period $\operatorname{are}(\operatorname{ars}\operatorname{follows})$, in absolute time :—

 $4^{\rm h}~20^{\rm m}$ for the difference of the time of High Water. $5^{\rm h}~29^{\rm m}$ " " Low Water.

The time taken by individual tides in running up the estuary from Father Point to Quebec, varies appreciably from these mean values, during the course of the month. It appears probable that this variation occurs chielly in the upper part of the run of the tide, towards Quebec. Father Point is in the middle of the open estuary, at only seven miles from the 100-fathom line in the offing ; while Quebec is in reality in the river, above the true head of the estuary, which must properly be considered as being below Orleans island. It is there also that the tide has its maximum range ; which corroborates this view.

An effort was accordingly made to erect as early as possible in the season the tide gauges at Grosse Isle and L'Islet, below Orleans island. A better and longer series of comparisons with Quebec was thus obtained, especially as the early months of May and June are less disturbed by storms than the later months of autumn. It is hoped that these comparisons will enable the greater part of the variation between Father Point and Quebec to be accounted for, when the observations are worked out.

Other work then made it necessary for me to return to Ottawa; especially the arrangements required in order to close the financial year. The gauge at Orignaux Point was next established, as soon as the hotel there was opened for the summer season. The manager of the hotel acted as tidal observer; as none of the few residents at the Point was capable of taking the necessary observations. Gauges were next erected at Rivière du Loup Point, and at Tadousae. In the choice of these tidal stations, the first consideration was given to points at which relations to the tidal eurrents had already been obtained, as above mentioned.

The permanent station at Father Point comes next in order; and below that, it was important to establish a tidal station in a position to command the mouth of the estaary at its narrowest part, in the vicinity of Point de Monts. This must properly be considered as the dividing line between the estuary and the Gulf of St. Lawrence, the length of the true estuary from the lower end of Orleans island to Point de Monts being 230 miles.

After considerable inquiry, the best position available in this vicinity, where the advantage of a wharf could be had, was found to be at Cape Chatte River. A steamer calls fortnightly in this offing ; but to save bone it was found best to go overland 80 miles from Little Metis on the Intercolonial railway. This last tidal station was in working order by July 17, when the whole series of eight stations gave simultaneous returns. The observations were continued till the middle of October, with the exception of Tadousac and Orignaux Point, where difficulties arose which made it necessary to close the stations a month earlier.

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The whole series of stations, with the length of tidal record secured at each, and the names of the observers, are as follows :--

Quebec	Permanent tidal station Continuous record.
Grosse Isle	. Captain C. Langlois May 4 to Oct. 15
L'Islet.	Réal Pelletier " 12 to " 15
Orignaux Point	T. Grindrod June 22 to Sept. 11
Rivière du Loup	M. McCarthy
Tadousae	. L. N. CatellierJuly 6 to Sept. 15
Father Point	Permanent tidal station Continuous record.
Cape Chatte	J. S. RussellJuly 17 to Oct. 1

Equipment of the Tidal Stations.—All the stations were provided with selfregistering gauges of the Richard type. The gauges were diffied with a pulley-wheel of special diameter, to adapt the scale to the height of the tide in this region, and bring it within the range of the instrument. The total range thus provided for, was 24 feet; and diagrams with corresponding graduations were specially printed. The accuracy of the scale was checked by a direct test before the intruments were used.

The gauge was actuated by a float, six inches in diameter, which rose and fell with the tide within a column of planking, of which the inside dimensions were 10 inches by 14 inches. This gave room enough for the protection of the counterweight, on a line with the off-side of the pulley-wheel of the instrument. The column was built in 12-foot lengths, and set against the side of a wharf, in a truly vertical position. The necessity for its being vertical, usually made substantial braining necessary ; as the batter of the side of the wharf gave the column an off-set of two or three feet at the upper end. It was often difficult to find a position where the column would not be struck by vessels using the wharf, to secure a sufficient depth of water. Special care was given to the design of the inlet which admitted the water at the bottom of the column, and to such other details as would prevent wave-motion within the column, which has always proved so troublesome in rough weather. The means adopted to this end were eminently successful, the details often requiring adaptation to local conditions ; but they need not here be described at length.

Correct time for the observations.—It is very evident that correct time for these observations was essential, when one of the primary objects was to obtain time differences with relation to the tide. Where there is any uncertainty in the accuracy of the time used, the tidal record itself becomes valueless for its chief purpose. In the extensive series of simultaneous observations in the Bay of Fundy, there was practically more loss of record from this cause, than from interruptions through damage by storms or in any other way. This experience emphasised the need of making effective provision to secure correct time.

It might seem at first sight, that no special arrangements to secure correct time would be needed in this region. On the Intercolonial Railway, running parallel to the south shore of the estuary, a time signal is transmitted every day at the moment of noon ; and there is also a telegraph line along each shore. Pratically however, the tidal gauges nearest to the railway, were at four to six miles distant from the railway stations; and some were on islands or in isolated positions. The expense of hiring conveyances to take advantage of the railway signals, would therefore be considerable; as time comparisons would be required at least twice a week during the season. It was therefore found best to supply most of the tidal stations with chronometers. With one already belonging to this Survey, five additional ones were found sufficient. They were carefully rated in advance ; and if the rate was at all large, the observer was given a table of corrections to apply to the face reading during the season. Their rate was also checked during the season, by exchange of time by telegraph with the observatory at Quebec ; which the meteorological observer, M. Arthur Smith, kindly undertook to transmit whenever desired. A watch of high grade, running at a steady rate, was also used to carry the time from place to place, when the stations were visited for inspection during the season. These were the arrangements adopted in general, with modifications adapting them to local circumstances, which need not be detailed.

To this use of chronometers, the success of the season's work is largely due; and no part of the tidal record had to be rejected as unreliable through uncertainty in the time. The time used throughout, was Eastern Standard, for the 75th meridian. All the time-differences between stations are thus in absolute time.

Supervision.—The instructions drawn up for the observers, provided for observations of such a character as to secure an independent check on the working of the recording instrument. The correct setting of the instrument at the time, can thus be verified alterwards in the office. A further advantage as regards supervision, was secured by making Rivière du Loup headquarters for the season. It is situated in the middle of the region; and being a divisional point on the railway, the trains in both directions are convenient; and the river steamers also call at the wharf. The tidal returns were sent there; and any want of accuracy could be detected at the time, or a station could readily be visited if trouble occurred. The full advantage of this arrangement was not obtained however; as it was necessary for me to leave for a month in the middle of the season to visit one of the principal tidal stations at Forteau bay in Belle Isle strait. Mr. Hayden, who had assisted me in the erection of the tidal garges, was left in charge at Rivière du Loup during my absence. We were also both absent for a week in August, while taking the special observations at Father Point, already referred to; which it was convenient to secure while in this region.

Results.—When the observations now secured are fully worked out, there will result in the first place, trustworthy tidal differences by which the time of the tide along the Lower St. Lawrence will be correctly known. This will then enable the time of the turn of the strong tidal currents to be determined also, as already explained; and it is in this that the chief value of the work to navigation, will consist.

The tide-levels, which have to be worked out in the reduction of the observations, will also be of practical service. These levels have been referred to the original Admiralty bench marks; a list of those on the Lower St. Lawrence being kindly furnished by the Hydrographer to the Admiralty. The primary importance of these bench marks is very evident; as the low water datum of the charts is thus permanently recorded. The tide-scales of the gauges erected this season, were connected with the bench marks by means of instrumental levels; and the tidal observations themselves, are thus brought into direct relation with the chart soundings, the depth on shoals, &c. The points at which the bench marks have thus been made use of, are at Quebec, Grosse Isle, L'Islet, Orignaux Point, and Rivière du Loup; as well as the Tidal Survey bench mark

The total cost of the summer observations from May to October, including the salaries of observers, was \$1,241.06. This comprises six tidal stations for periods varying from three to five months, and three stations at which observations of the current were obtained. The average cost of each of the six tidal stations, including its erection, the salary of the observer, the cost of obtaining correct time, and travelling expenses, was \$192.00. This amount does not include the salary of the Engineer-in-charge, or of his assistant, during the time the work was in progress.

I have, sir, the honour to remain, Your obedient servant,

> W. BELL DAWSON, In charge of Tidal Survey.