SURVEY

OF

TIDES AND CURRENTS

IN

CANADIAN WATERS

REPORT OF PROGRESS

BY

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

OTTAWA
GOVERNMENT PRINTING BUREAU
1898

W. P. A
Ch

Sir
Survey,
carried
currents
have be
pass thr
found at
main en
Strait of
Island o
ined and
men and
winter a
the gene
Ocean, a
annual re
the curre
Progress
partment
The
obtained
the curre
for the m

SURVEY OF TIDES AND CURRENTS

IN

CANADIAN WATERS

OTTAWA, 6th November, 1897.

W. P. ANDERSON, Esq., C.E.,
Chief Engineer,
Department of Marine and Fisheries.

SIR,—I have the honour to submit the following Report on the progress of this Survey. A general examination of the currents in the Gulf of St. Lawrence has been carried on by this Survey in the three seasons of 1894, 1895 and 1896, by which the currents in the interior of the Gulf, and in the straits connecting it with the Ocean, have been examined with special reference to the leading steamship routes which pass through it in various directions. The investigation has included the currents found at the three angles of the Gulf, namely, (1) in Cabot Strait which forms the main entrance to the Gulf, between Cape Breton and Newfoundland; (2) in the Strait of Belle Isle; and (3) at the entrance to the St. Lawrence and around the Island of Anticosti. The currents met with in the open Gulf have also been examined and their direction traced; and much information has been collected from seamen and fishermen as to the currents, and with reference to the drift of the ice in winter and spring. The character of these currents as ascertained, and the nature of the general circulation in the Gulf in relation to the St. Lawrence River and to the Ocean, are described in my last Report of Progress dated 26th January, 1897. (See annual report, Department of Marine for 1896; pages 70 to 105.) The behaviour of the current in the Strait of Belle Isle is more fully given in the previous Reports of Progress dated 31st October, 1895, and 13th April, 1896. (See annual report, Department of Marine for 1895; pages 80 to 87, and Plate I.)

The United States Hydrographic Office have drawn attention to the results obtained by this survey, by re-publishing a diagram and explanation of the nature of the current in the Strait of Belle Isle, in their "Pilot Chart for the North Atlantic" for the month of March, 1897; and also a summary on the "Current circulation

within the Gulf of St. Lawrence" in the "Pilot Chart" for July, 1897. A "Notice to Mariners" based upon the information obtained, was also issued by the United States Hydrographic Office in January, 1896. Two extended summaries of the Reports of Progress have now been given in the "Annals of Hydrography and Maritime Meteorology" by Dr. Schott, of Hamburg. The reports have also been reviewed in the "Scottish Geographical Magazine;" the "Annales de Géographie," Paris; and Dr. Petermann's "Mittheilungen," Germany; and the work has been favourably noticed in the "Journal of Commerce," of Liverpool. A short review of the work from its inception, and of the results arrived at, appeared in "Nature," London, 22nd April, 1897.

Little attention has yet been given to the currents in Northumberland Strait and around Prince Edward Island; or to the tidal currents of the Lower St. Lawrence from Anticosti to Quebec, as some knowledge had first to be obtained of the Gulf currents and their relation to the ocean. A further examination of the currents in the Strait of Belle Isle is also desirable, to obtain more complete data for its tidal character. The work has been carried on with the assistance of one of the supply steamers of the lighthouse and buoy service, which has been placed at the disposal of this survey for the three months of July, August and September, in each season, which was as long as it could be spared from its other duties; but it has proved unsuitable for the purpose, as it is so slow and unwieldy as to add materially to the difficulty of carrying out the work to advantage, and the time allowed cuts the season too short, even with the best endeavour to take advantage of every available day, and to make the observations continuous day and night. The further survey of the currents was discontinued this season to save expense to the department; and when it is resumed, a steamer of suitable character and properly equipped for the purpose should be made available for the work; and in some regions one or two schooners, if properly fitted out, could be used with advantage as auxiliaries.

The regions in which the currents most require investigation at present, are on the south coast of Newfoundland and in the Bay of Fundy. On the south coast of Newfoundland it is reported that there is a strong indraught into the larger bays, and to this several wrecks are attributed. The distance from shore that this is felt, and the conditions of wind and tide which give it the greatest strength, should be ascertained; as two of our leading steamship routes follow this coast. I had the opportunity this season of obtaining some preliminary information which will serve as a guide in carrying out this investigation. In the offing of Cape Race, the variation in the Arctic current should be better understood, for information of inward-bound vessels; and no detailed examination has yet been made of this current further north, off the outer end of the Strait of Belle Isle, for the assistance of vessels in making that strait. The currents on the south-western coast of Nova Scotia and at the mouth of the Bay of Fundy have also much importance, and to obtain the necessary tidal data for comparison, a tide gauge should be established at Yarmouth without further delay. In the upper part of the Bay of Fundy, and its arms, the currents are probably more nearly parallel with the coast line, as on the Lower St. Lawrence; but on the other hand, the navigation being entirely dependent on the tide, it comes to be of the first importance to determine the time and height of the tide itself correctly. An examination of these currents should be made while the principal tidal stations now established continue in good working order; as the currents are chiefly tidal, and their behaviour can only be ascertained by direct comparison with a tidal record.

TIDE TABLES FOR 1897.

A marked advance has been made in the amount of tidal information issued during the present year; and this is largely the result of the additional data obtained by the summer observations of 1896. During that season, tidal observations were obtained under the supervision of Mr. H. M. Mackay, at twelve points throughout the south-western portion of the Gulf, extending from Chaleurs Bay along the New

Brunswick coast and around Prince Edward Island, to Cape Breton Island; as detailed in the last Report of Progress. A large amount of work was involved in the reduction of these observations; as comparisons had to be made between the tides at these points and several of the principal tidal stations; notably the stations at Halifax, St. Paul Island and Anticosti, in order to ascertain to which of these stations the tides in the south-western half of the Gulf of St. Lawrence could best be referred. The observations also covered a sufficient extent to enable the general progress of the tide to be traced throughout this region. It was found that the general course of the tidal undulation which passes across the Gulf from Cabot Strait to the entrance of the St. Lawrence, is complicated by a return undulation; and that this makes the time of the tide nearly simultaneous along the north coast of Prince Edward Island; and this appears also to explain an irregularity known as diurnal inequality which occurs in Northumberland Strait.

The outcome of the investigation was to show that the time of the tide in this region cannot be correctly obtained by a constant difference from a port on the Atlantic coast such as Halifax; but that these tides can best be referred to the station at St. Paul Island, where the tidal undulation enters the Gulf from the Atlantic. The comparison of the observations with that station have furnished a valuable set of tidal differences for the harbours of this region, which will become available when the tidal data for St. Paul Island itself are worked out.

The ports which can be referred to that station include Miramichi Bay, Cape Tormentine, Charlottetown, Pictou, and Souris; and also St. Peters, Rustico, and Alberton, on the north coast of Prince Edward Island. All of these ports have railway communication, and several of them have the importance of a railway terminus. It was also found that Pictou was the best port of reference for Northumberland Strait; as the tides at Charlottetown are more irregular, either because of wind disturbance, or because of interference from the tide entering the western end of the strait. This is important with reference to the tidal currents in the strait. In the Shediac region, from Richibucto towards Cape Tormentine, the tides are confused, and have at times so small a range as to be scarcely appreciable. In Chaleurs Bay, the tides can be referred to the station at South-west Point, Anticosti, and thus to Quebec. The range of the tide at Carleton, Que., at the head of the bay, is nearly 10 feet; and at Charlottetown, where the highest tide in Northumberland Strait occurs, the extreme range is nearly 9 feet.

The importance of St. Paul Island in commanding this region thus became evident. As the interruptions there have been serious, owing to the difficulty of maintaining a tide gauge in so exposed a situation, the best continuous record yet available was found to extend from October, 1895, to November, 1896, or one complete year. Any breaks in the tide curves were filled by interpolation, the record was carefully reduced to a uniform datum, and forwarded to the Nautical Almanac office for analysis, and the determination of the constants necessary for the calculation of tide tables for that station; and from these, tide tables for the ports above referred to, can be deduced by direct differences.

In order to make the tidal observations of 1896 immediately available for the present season of navigation (1897), a provisional series of tidal differences was worked out, between Pictou and Halifax. From the simultaneous record obtained from the self-registering tide gauges at the two ports, it appeared that the actual difference in the time of high water between these two places was far from constant; as the time of high water at Pictou was found to range from 0h. 53m. to 3h. 23m. later than at Halifax. This range in the difference is largely due to the diurnal inequality which occurs at Pictou; and it serves to show that such tide tables as have been prepared in the past for ports within the Gulf must necessarily be far from correct, when they are based upon a *constant* difference from a port on the open Atlantic. This difference varies regularly, however, between the above limits, in accordance with the declination of the moon; and, without entering into technicalities, it will be sufficient to mention that it was thus found possible to use a *variable* difference as a sliding scale by which to calculate the Pictou tides from the tide tables already prepared for Halifax. The Charlottetown tides were in turn calcul-

ated by means of a constant difference from Pictou, which was the average difference in the time of high water, as found from four months' simultaneous observations from the self-registering gauges of 1896.

In the St. Lawrence River, above Quebec, tide tables were computed for Ste. Croix bar, which is at present the shallowest point in the ship channel, until the dredging operations now in progress are completed. These tables are derived from the tide tables for Quebec, by means of a series of differences in the time of high water and low water, in which allowance is made for the change of level of the water in the St. Lawrence with the progress of the season. Tide tables were also prepared for Father Point, the St. Lawrence pilot station, by means of a constant difference in the time of the tide from Quebec, derived from the simultaneous records of the tide gauges during the two complete years, 1895 and 1896.

The reduction of the observations of the previous season, and the preparation of the above tide tables for the present season of navigation, was completed before the services of my two assistants were dispensed with in March last. This is the first time that reasonably reliable tide tables have been available for any ports within the Gulf of St. Lawrence, with the exception of Quebec itself; and these tables also enable masters of vessels and pilots to infer with some certainty the direction of the tidal currents which they may expect to meet with, when they know the relation of the current to the tide in Northumberland Strait and in the Lower St. Lawrence. As Pictou has proved to be the best port of reference for Northumberland Strait, the tidal observations have been continued there this season; as this could be done at little more than a nominal expense, as the appliances required were all on hand from the previous season.

The tide tables issued for 1897, and the records on which they are based are as follows:—

Halifax.—The further tidal record found to exist for the years 1851 and 1852, was incorporated with the record of 1860 and 1861 previously analyzed, and the tables for 1897 were calculated from the revised tidal constants derived from the four years' observations.

Quebec.—The tide tables up to this year, are still based upon the record of one full year; namely November, 1893, to January, 1895.

The tide tables for Halifax and Quebec, accompanied with tidal differences for other places, were furnished to the leading British and Canadian almanacs for publication. These tables for a month at a time, have also appeared daily in the Quebec *Chronicle*, with due acknowledgment to this department. The earlier tidal constants for Halifax have also been communicated to the United States Coast and Geodetic Survey, as the basis of calculation for their tide tables for Halifax. Tide tables for Quebec have not yet been published in the United States tables; but the tides of the St. Lawrence are there referred to other ports of reference, some of which are far distant.

Ste. Croix Bar.—These have been issued in company with the tide tables for Quebec, by the Montreal Harbour Commissioners, in their publication entitled "Tide Tables and other information connected with the Ship Channel between Montreal and Quebec;" prepared for the use of the St. Lawrence pilots.

Father Point, the Pilot Station.—Tide tables were prepared in manuscript, and posted at the lighthouse at Father Point, where they are accessible to all the pilots. The secretary of the Pilots' association of Quebec was notified of this; and the tables themselves have been much appreciated by the pilots.

Charlottetown.—Prepared as above described. To save expense of printing, the tables were type-written only; and copies posted at the agency of the department, and the custom house. Supplied also for publication to the following papers:—*The Patriot, The Guardian, The Examiner, The Herald.*

Pictou.—Prepared and type-written as above; and posted at the agency and the custom house. Supplied also to the following papers:—In Pictou, *The Advocate* and *The Standard;* in New Glasgow, *The Chronicle* and *The Enterprise.*

TIDE TABLES FOR 1898.

The tide tables issued for 1898 will include tables for St. John, N.B., as well as Halifax and Quebec. The tables for Halifax are based upon the four years of the old record above mentioned; and one complete year of the new record has been prepared for analysis. The new record is reduced to the original Admiralty low water datum, used for the chart of Halifax harbour; and this analysis, and the determination of Mean Sea Level, enables the same datum to be carried back to the old observations formerly obtained, and thus to bring them all to a uniform basis. A further year of the Quebec record has also been prepared and analysed, and the basis of the tables extended to include the two years from November, 1893, to January, 1896. The tables for St. John, N.B., are based upon the record extending from April, 1894, to May, 1896, or two full years. The time used in these tables is Standard time in all cases; and the tidal differences give the time of the tide for other places in Standard time also. Eastern standard time is used for Quebec and the Lower St. Lawrence as far as Point de Monts; as this is the best position for the dividing line between the River and the Gulf of St. Lawrence. This line is midway between the 75th and 60th standard meridians, and includes the whole of New Brunswick with the other Lower Provinces, in the region of Standard time for the 60th meridian. The tables for St. John, N.B., are therefore given in 60th meridian time, as well as Halifax; and also Charlottetown and Pictou.

These tide tables have been offered as usual to all the leading British and Canadian almanacs willing to publish them. We have unfortunately no Canadian almanac of sufficient breadth, either in Ontario or the Lower Provinces, to be willing to publish tide tables for all three of the principal tidal harbours of eastern Canada. It would therefore be much more satisfactory if the tide tables were published by this department; but to do so, it would be necessary to have a special assistant to attend to their preparation during the summer, and have them in print for the coming year not later than September, in time to furnish them to the almanacs for re-publication before the end of the year. This would enable all the tables to be issued in a uniform way, and accompanied by proper explanations; and in sufficient quantity to distribute to the agents, collectors of customs, pilots and others who should have copies. At present the expense of the printing itself cannot be met; as the appropriation for this survey is reduced for this year to two thousand five hundred dollars; and this has to cover the salaries of the tidal observers, maintenance of stations, inspection and travelling expenses, as well as the cost of calculation and preparation of the tide tables themselves. The present method of publication will therefore have to be continued in the meantime; and it will not likely be possible to prepare again for the coming season of navigation the tide tables for Father Point, Charlottetown and Pictou, so long as the work of the survey devolves upon myself alone without assistance, as there is already a large accumulation of arrears. This is to be regretted, as these tables could now be put upon a better basis with direct reference to St. Paul Island, as already explained.

The tide tables for Halifax, Quebec and St. John, N.B., will appear in *Greenwood's Almanac*, published by Mr. W. N. Greenwood, of Lancaster, England; and the tables for Halifax and Quebec in the *Canadian Almanac*, published by the Copp, Clark Co., of Toronto. The tables for Halifax alone will appear in *Belcher's Almanac*, published by the McAlpine Co.; in *Cogswell's Almanac*, published by Mr. R. H. Cogswell, of Halifax; and in *Brown's Almanac*, published by Messrs. J. Brown & Son, Glasgow. In the *Tide Tables* published by the U. S. Coast and Geodetic Survey, the Halifax tables are calculated from the tidal constants furnished by this survey. The tide tables for Quebec will be given in the publication prepared by the Montreal Harbour Commissioners for the use of the Pilot service. The tide

tables for St. John, N.B., now available for the first time, will appear in *McMillan's Almanac*, published by Messrs. J. and A. McMillan of St. John. In all the above, due acknowledgment is made to the Tidal Survey branch of this department for the tables supplied; and some of the newspapers in the above ports may also issue the tables daily.

These tide tables give the height as well as the time of the tide; which is very important in such harbours as St. John and Quebec, where the rise is so great. The depth of water on the sill of the dry docks at Quebec and Halifax, is also given with relation to the tide, so that vessels may know the depth of water available for entrance to those docks at any high tide.

TIDE TABLES FOR 1899.

As the preparation of tide tables always requires much time, the calculation of the tide tables for Quebec, Halifax and St. John, for 1899, by Mr. E. Roberts, of the Nautical Almanac Office, London, was arranged for in May last. They should thus be ready in good time next year. On account of the present want of means, it was not possible to extend the basis of these tables by the analysis of further record obtained from the self-registering tide gauges; but they will depend for their accuracy upon the same lengths of tidal record, as the tide tables for 1898, as above mentioned.

SUMMER SEASON OF 1897.

During this season the seven principal tide gauges were visited by myself, and a number of improvements made in them. In reaching them the ordinary routes of travel were followed, as the steamers of the department were unable to furnish assistance in the matter. By these routes the furthest of the stations, in the Strait of Belle Isle, is 2,100 miles from Ottawa; and the total amount of travel in visiting the stations was over 6,000 miles, in all conveyances from ocean steamers to schooners. The time occupied was from June 17th to October 18th.

There are three of the tidal stations which are less accessible than the others, and are also without any means of communication during the winter months. These have given much anxiety in the past, as any interruption from failure of the driving clock of the recording instrument, or other cause, was often impossible to remedy for months, and thus involved a serious break in the tidal record. To place such stations in a more satisfactory position, a new form of recording instrument was devised by me, in which the driving clock is made removable, instead of being a fixed part of the instrument; and a duplicate clock is placed at the station for security. (See description in annual report of the Department of Marine for 1896, pages 70-71.) Instruments of this new type have now been manufactured by Messrs. A. Légé & Co., of London; and this season these have been placed at two of the stations, namely, at Forteau Bay, in the Strait of Belle Isle, and at St. Paul Island. The gauge removed from St. Paul Island was taken to South-west Point, Anticosti, and left there as a duplicate instrument in case of accident; as the two were identical in scale and otherwise, and their driving clocks had already been fitted with an improved and stronger form of escapement for greater security against interruption. By the replacement of these gauges, it also became possible to send two of the old type of instrument to the makers, in Glasgow, to have them fitted with the new escapement. In this way, better security will be obtained for the other stations at which that type of instrument is still in use, as driving clocks with this improvement will be on hand to replace any that may require to be removed for cleaning or repair.

Next to this, the chief difficulty has arisen from the accumulation of gravel and debris, around the inlet which admits the water to the tide gauge. This would be avoided if there were any wharfs at the exposed stations, at which sufficient

depth of water could be obtained to keep the inlet well off the bottom. As it is, the inlets have to be protected by crib-work; and to put these in thorough repair, it would have been necessary to take men as well as materials to these distant places, as it is not usually possible to hire labour there during the fishing season. As this expense could not be incurred this year, some minor repairs were made, and some expedients adopted which may answer in the meantime.

The heating lamps used in winter to prevent the water from freezing in the tide pipes, have sometimes given trouble by smoking, which is rather a serious matter if it should happen to occur in the night; as the recording instrument may become so clogged with the soot as to be much impeded in its working. The instrument is inclosed in a glass case for protection against this contingency and against dampness; but this oily soot is very penetrating. A better grade of coal oil has been used to avoid this trouble; and this season more thorough arrangements were made for the ventilation of the deep tide wells inclosing the tide pipes, in which the heating lamps have to burn.

At these isolated stations, meridian instruments, named dipleidoscopes, are used to obtain the time for the observations. These were inspected and adjusted, by comparisons with the chronometer of a man-of-war, kindly furnished by the navigating officer, or by telegraphic exchange of time with an observatory provided with a transit instrument, as the case might be.

In the sight gauges, on which the datum plane of the observations depends, the connecting line between the tide float and the graduated staff must be of some material which will neither stretch nor rust; and it should also be very light, as it has to be balanced by a counterweight. Copper wire is too soft; and brass wire or chain becomes brittle after a time, apparently because of sulphurous fumes from the heating lamps. This connection has now been made by aluminium chain, which promises to prove satisfactory. It is important that the connection should be permanent and unaltered in length, as the re-determination of the length gives rise to much trouble and possibly also to uncertainty in the result. Several improvements in detail were also made this season at the different stations, and some fittings renewed.

At several of the stations careful levels were again taken this season with a surveying instrument, to check the elevation of the low water datum plane, to which the tidal observations are referred. The result of these, and of the levels previously taken for the better determination of low water datum planes, are given below.

As the vote for this survey for the current fiscal year has been reduced to one-fourth of its former amount, it was not possible to continue the tidal observations this season for the determination of tidal differences in any further region. The saving effected by discontinuing this branch of the work has amounted to nine hundred dollars. This was the cost of equipping the seven temporary stations of last season with recording instruments, and of obtaining short records for comparison at five other points, including travelling expenses and salaries paid to local observers during three to six months; but without counting the salary of the assistant in charge of the work. Observations of this character are much required in the Lower St. Lawrence, the Bay of Fundy, and along the Atlantic coast of Cape Breton Island and Nova Scotia. The time of the tide in these regions, with reference to the principal stations, would thus be known; which would not only be of direct importance locally, but would also be of service to navigation, by helping to bring the time at which the strong tidal currents turn, into relation with the rise and fall of the tide itself.

LEVELS AND DATUM PLANES.

On the charts of rivers and harbours, as on all other charts, the soundings show the depth of the water below the level of the water surface at low water at ordinary spring tides, which is known as the Low Water datum. The determination of this datum can only be made by means of tidal observations; and on the correct

level of this datum the whole question of the depth of water on shoals and bars and the grounding of vessels, must necessarily depend. If this datum has been recorded by a bench mark, at the time the survey for the chart was made, or if it can be correctly determined, the height of the tide can be measured upward from it. The height of the tide at low water or at high water, as given in the tide tables, will then show what increase of depth is available for a vessel in addition to the depth shown on the chart. In the same way, the depth of water on the sill of a dry dock can also be found from the height of the tide, when once the level of the sill with reference to the datum has been determined by means of levels taken for the purpose.

The height of the tide may thus be of quite as much importance to shipping, as the time of high and low water itself. It is also of much consequence in our sea ports to have a reliable datum plane for the construction of harbour improvements; and also for city works; because the discharge of sewers for example, may be affected by the tide. In some cases also, the extent of the fore-shore and the position of low-water mark is important, as it may define the boundary of marine properties. In most of our cities, the question of a good datum plane for reference is in a very unsatisfactory position. Careful attention has therefore been given to this matter in connection with the tidal observations taken by this survey. For this purpose it is necessary to have accurate levels at the tide stations, and to reduce the tidal observations themselves to one uniform plane of reference. The direct measurement of water level during the rise and fall of the tide is obtained from the sight gauge, which is actuated by a float in the same way as the recording instrument itself. The actual level which this shows, has to be determined ultimately from a bench mark in the vicinity of the tide gauge. By referring the tide levels to this bench mark, the low water datum, mean sea level, etc., become definitely fixed. In this way also it even becomes possible to determine after a term of years, whether or not the coast itself is changing its elevation with reference to the mean level of the sea.

The results of the determinations of level and datum planes as obtained from the tidal observations themselves, and special instrumental levels taken for the purpose, will now be given.

St. John, N.B.—Owing to the great fire of 1877 the bench marks and other points of reference were destroyed; and when the tidal observations were begun in 1893, there was no means of ascertaining the datum plane used in the original Admiralty survey of the harbour, or in the later survey of the entrance to the harbour, made in 1887 by the Public Works Department; nor had any permanent marks been established to show the levels of high and low water at spring tides, as determined at the time that the Government wharf and the breakwater at Negro Point were constructed. There was also no City datum in use; as the steep slope of the streets was taken advantage of, to lay out city works by difference of level without reference to any one datum plane.

In these circumstances it was necessary to re-determine the low water datum; and its level was not easy to arrive at, where the tide has so great a range, the extreme range being nearly twenty-nine feet, and the level of low water at spring tides varying so much in consequence. This determination has now been made with great care; by means of the tidal observations themselves; and also from the level of the breakwater at Negro Point.

The levels which will be given, are all referred to a new bench mark which was cut on the granite foundation of the custom house. The lower part of the tide gauge consists of a timber column, fifty-six feet in height, heavily ballasted at its lower end so as to rest firmly on the bottom, and to be unaffected by any movement in the timber wharf against which it stands. The level of the gnomon or zero point of the sight gauge was determined with reference to the bench mark; and the level checked from time to time, to detect and allow for any settlement which might occur. The level of the tide at any moment is then observed by means of a steel tape attached to the tide float of the sight gauge; and from it a constant level is also derived which furnishes a reference plane for the continuous tidal record of the

recording instrument. The rusting and breaking of the steel tape, and the frequent re-determination of its length, the removal and replacement of the gauge in March, 1894, and an error of scale in the construction of the recording instrument, have involved much revision in the reduction of the levels; but to avoid any technical details, the methods adopted in dealing with these difficulties and the means taken to overcome them, will not be here described; as all outstanding causes of error have been eliminated from the results. To meet the immediate need for some determination of low water level, preliminary values were computed from the early part of the record, which were communicated to the department of Public Works, and also to the City Engineer of St. John.

The original plans of the breakwater at Negro Point, show the levels of low water and high water at spring tides as adopted during its construction. This low water level is presumably the same as that used in the latest survey of St. John harbour, which was also made by the Engineers of the department of Public Works at about the same date. This breakwater is of crib-work; and the outer end may have settled to some extent. The original plans show the tide levels then adopted to be as follows:—High water at 5 feet 0 inches, and low water at 30 feet 6 inches below planking on top of crib-work. With the co-operation of Mr. E. T. P. Shewen of the department of Public Works, and Mr. D. L. Hutchinson, the tidal observer, levels taken near the inner end of the breakwater were carried across to the tide gauge, a distance of 8,000 feet, by means of simultaneous observations of the level of the surface of the water at high tide on a calm day. This method should give quite as close a result as the levels do; as the top of the breakwater itself is uneven to the extent of about two inches; as the following levels show. The elevation of the planking of the breakwater at 150 and 250 feet from the shore end, was found to be as follows, the bench mark on the custom house being 100·00:—

			Feet.
At 150 feet.	Planking,	north side	76·89
do	do	south side	76·79
At 250 feet.	do	north side	76·70
do	do	south side	76·64
Mean elevation at 150 feet, where the settlement is presumably the least			76·84
Low water, as above defined			30·50
Hence, original low water datum as adopted when the breakwater was built			46·34

A similar determination was made from the level of the Government wharf on the St. John side; the low water datum being shown on the original plans as 31 feet 6 inches below the level of the timber cap of that wharf. The resulting level of the low water datum was 43·57; and this was further checked by comparison with the zero of a tide-board spiked to one of the wharfs, and said to be at the same level as the one used while the survey of the harbour was being made. The level of the zero of this tide-board is 43·78 which agrees nearly with the above; but the indications make it more probable that settlement has occurred here, rather than in the case of the breakwater at Negro Point. The datum as obtained from that breakwater, probably gives the level of low water at spring tides as then adopted, as nearly as it can now be arrived at from existing structures, for purposes of comparison with the new determinations. The tidal observations themselves show that the actual level of low water at spring tides is below this. The uncertainties attached to determinations of this character are obviated for the future by the establishment of a bench mark to which the series of levels now obtained are referred.

The comparison of the various old and new datum planes is given in the following list, together with the levels resulting from the analysis of two complete years of tidal record; namely, from April, 1894, to May, 1896. This record was carefully reduced to one uniform plane of reference by the method above referred to; and the analysis itself was made by Mr. E. Roberts, F.R.A.S., of the Nautical Almanac Office, London. The levels are given in the order of their height; the elevations are all referred to a plane of reference 100·00 feet *below* the Tidal Survey bench mark

cut on the granite foundation at the south-east corner of the custom house; and the heights in feet, above the Tidal Survey datum itself, are also given.

St. John, N.B.—Tidal Levels and Datum Planes.	Elevation referred to Bench Mark.	Height above Tidal Survey Datum.
	Feet.	Feet.
Bench Mark on custom house, as above described	100·00	55·60
Gnomon or zero-point of sight gauge, since June, 1896	79·94	35·54
Highest high water, at the spring tides of October and November, 1896. Probably about the level of the highest astronomical tide possible, apart from storm disturbance	73·10	28·70
Mean Sea Level, from the harmonic analysis of the continuous record during two years. Result for the year 1894-1895 = 58·355; result for the year 1895-1896 = 58·347. Mean value	58·35	13·95
Level of low water at spring tides, as determined from the breakwater at Negro Point, as above explained. (This is presumably the low water level to which the soundings at the entrance of the harbour were reduced in the survey of 1887, as shown on the chart.)	46·34	1·94
Level of low water at spring tides, as adopted in the original survey of the harbour by the Admiralty. Surveyed under the orders of Captain W. F. W. Owen, R. N., in 1844	Unknown.	——
Harmonic Tide Plane, or low water mark at a distance below Mean Sea Level given by the sum of the harmonic constants $M_2+S_2+K_1+O$. Sum of these constants for the year 1894-1895=12·569; for the year 1895-1896=12·497. Mean value=12·529. Resulting level of tide plane	45·82	1·42
Public Works datum, adopted by that department in 1896 for construction purposes. Based upon the harmonic analysis of the one month of October, 1895	45·66	1·26
Tidal Survey datum, at 55·60 feet below the bench mark. From this datum the heights of the tide in the tide tables for St. John are measured	44·40	0·00

The plane of reference from which the height of the tide in the tide tables is measured, should if possible be placed sufficiently low that few tides in the course of the year may fall below it; as this gives rise to negative values in the tide tables. Where the range of the tide is so great as it is at St. John, and there is consequently so much variation in the level of low water at spring tides, it is difficult to adopt a low water datum which on the one hand will exclude these negative values, without on the other hand placing it too far below the probable level of low water to which the soundings on the chart of the harbour were originally reduced. If the low water datum is thus placed too low, it makes it appear that the height of the tide gives a *greater* depth on shoals and bars, than will in reality be found upon them. The tidal survey datum for low water as above defined, is still appreciably above extreme low water. During the course of the year 1895, six tides touched or fell below this datum. Also in the calculated tide tables for 1898 there are six out of the twenty-five spring tides which occur during the course of the year, at which some of the low waters touch or fall below this datum; the lowest tides falling to four-tenths or five-tenths of a foot below it. This datum has therefore as good a position on the whole for a plane of reference for tidal purposes as can be chosen, to avoid the two difficulties above referred to, in a port where the tide has so great a range.

Halifax, N.S.—The low water datum to which the soundings on the Admiralty chart of this harbour were reduced, was recorded by a bench mark in the Dock-

yard; and the low water datum itself is thus defined on the chart:—"The soundings are reduced to the level of Low Water at Ordinary Spring Tides, viz. 16·08 feet below a Bench Mark cut near the South-east angle of the Sail loft at the Dockyard." This level was carried over to the tide gauge at the Marine and Fisheries wharf when the observations were begun in September, 1895; and the tidal observations from that date have all been reduced to this datum.

The tide tables so far issued, however, are based upon the old records of 1860-1861, and 1851-1852, for which a different plane of reference was adopted. The plane of reference then used has been re-determined by means of comparisons with mean sea level as now ascertained by the analysis of the present series of observations. The results are given below; and also the elevation of the sill of the dry dock, which enables the depth of water available for entrance at any tide, to be found from the height of the tide as given in the tide tables.

The height of mean sea level above the Admiralty datum was first obtained by making a summation of the hourly tidal ordinates during periods of 29 days, or lunar months, out of four months in the opposite quarters of the year. The result was as follows:—

		Feet.
1895.	Nov. 2-30—Mean Sea Level above Admiralty datum	3·134
1896.	Feb. 1-29 do do do	3·604
1896.	May 3-31 do do do	3·270
1896.	Aug. 3-31 do do do	3·472
	Average of the four months	3·370

It is to be noted that the Royal Engineers' datum for the Ordnance Survey, and also the City datum for Halifax, are both of them different from the Admiralty datum as above defined.

Halifax, N.S.—Tidal Levels and Datum Planes.	Above or below Admiralty Datum.
	Feet.
Bench Mark in the Dockyard, as above described, which records the Admiralty datum	16·08
Coping of the Dry Dock	10·97
Mean Sea Level, from the analysis of one complete year, from October, 1895, to November, 1896; 3·371 above Admiralty datum	3·37
Harmonic Tide Plane or low water mark at a distance below Mean Sea Level given by the sum of the harmonic constants $M_2+S_2+K_1+O$. Sum of these constants from the analysis of one complete year as above = 2·96. Resulting level of tide plane above Admiralty datum	0·41
Admiralty Datum, or low water at ordinary spring tides. Used as the plane of reference for the new tidal observations, begun in September, 1895.	0·00
Level of low water used as the plane of reference for the tidal observations of 1860-1861. For the two years, the levels used were at 3·829 and 4·391 feet, respectively, below Mean Sea Level. Average = 4·110; or below Admiralty datum. (The tide tables for 1896 and previous years, are referred to this plane of reference.)	0·74
Level of low water used as the plane of reference for the tidal observations of 1851-1852. For the two years, the levels used were at 4·658 and 4·628 feet, respectively, below Mean Sea Level. Average for all four years as above = 4·377; or below Admiralty datum. (The tide tables for 1897 and 1898 are referrred to this plane of reference.)	1·01
Sill of Dry Dock at Halifax. Level of the granite sill of the dock, below Admiralty datum	23·49

Hence to find the depth of water on the sill of the dry dock at any tide, add 22·4 feet to the height of high water as given in the tide tables for 1898.

Quebec.—The low water datum to which the soundings on the Admiralty chart are reduced, has been recorded by a bench mark which still exists; and the low water datum itself is thus defined by a note on the chart of Quebec harbour:—"The soundings are reduced to the mean level of Low Water ordinary Spring tides; or 28 feet below a Bench Mark cut in the stonework on the East side of the principal gateway to the Marine and Fisheries department." The tide gauge for Quebec was erected in October, 1893, at the masonry dry dock on the Lévis side; and instrumental levels have been carried over from this Admiralty bench mark to the dock by Mr. R. Steckel, of the Department of Public Works. The levels were carried across the river from the Quebec to the Lévis side at Cap Rouge; and a bench mark was cut on the dry dock itself on the face of the masonry of the second altar step, on the west side, near the inner end. This bench mark is numbered LXXIV. in Mr. Steckel's series. The elevations of the two bench marks, referred to his datum, are as follows:—Admiralty bench mark = 27·039; bench mark No. LXXIV. = 21·617. The elevation of the bench mark at the dock, above the Admiralty low water datum, is therefore 22·58 feet; and this affords a direct means at the dry dock itself of reducing the tide levels to the Admiralty datum. The actual height of the water level during the rise and fall of the tide is obtained from the steel tape of the sight gauge, which is attached to a tide float; and the true level of the gnomon, or zero-point of this gauge is determined with reference to the bench mark. The comparison of the sight gauge readings with those of the recording instrument, enables the datum line to be ruled in on the sheets on which the continuous tide curves are traced.

There are two scales of feet cut on the masonry of the dry dock, one outside and the other inside of the dock gate, which are intended to show the heights above the masonry sill of the dock. When tested by accurate levels, these prove, unfortunately, to be incorrect in the heights they show; and on the average both scales are low; that is to say, the level of the zeros from which the scales count, are from half an inch to three-quarters of an inch below the level of the dock sill itself.

The levels of the various marks above referred to, are given in the following list, in which they are all reduced to the original Admiralty low water datum; and the results of the analysis of the tidal record as regards level, are included also.

QUEBEC.—TIDAL LEVELS AND DATUM PLANES.	Above or below Admiralty Datum.
	Feet.
Bench Mark at the Marine and Fisheries building in Quebec, which records the Admiralty datum	28·00
Gnomon of the sight gauge at the Dry Dock at Lévis	29·53
Coping of the Dry Dock; average level taken near the dock gate	24·78
Bench Mark No. LXXIV, on the masonry of the Dry Dock, as above described	22·58
Mean Sea Level, from the analysis of the continuous record during the two years from November, 1893, to January, 1896. Result for the year 1894 = 8·677; for the year 1895 = 8·529; mean value, above Admiralty datum	8·60
Admiralty Datum, or low water at ordinary spring tides. Used as the plane of reference for the tidal observations; and from it also the heights of the tide in the tide tables for Quebec are measured	0·00
Harmonic Tide Plane, or low water mark at a distance below Mean Sea Level, given by the sum of the harmonic constants $M_2+S_2+K_1+O$. Mean value of the sum of these constants for 1894 and 1895 = 8·65; resulting level of tide plane below Admiralty datum	0·05
Sill of Dry Dock at Lévis—The zeros of the scales of feet cut on the masonry inside and outside of the dock gate do not quite correspond with the level of the sill itself. Average level of the zeros of the two scales, and of the dock sill, below Admiralty datum	7·75

Hence to find the depth of water on the sill of the dry dock at any tide, add 7·7 feet to the height of high water as given in the tide tables.

The levels at Father Point and at South-west Point, Anticosti, are referred to bench marks cut on the surface of the solid rock, above high water mark, in the vicinity of the tide gauges. At St. Paul Island, and Forteau Bay in the Strait of Belle Isle, the iron plate at the top of the iron column of the dipleidoscope is used as a bench mark. In all cases the elevation of the bench mark itself is taken as 100·00, and all the levels in connection with the tide and the zero of the gauges are referred to this elevation. The true height of the low water datum and mean sea level will thus be determined eventually from the tidal observations themselves. It is also important to ascertain the range of the tide at these stations, so that in using them as reference stations for other ports, the range of the tide may be found in comparison by means of a ratio. In this way the height of the tide, as well as the time, will be brought into relation with the principal stations.

For the summer observations of 1896 the following points were made use of as bench marks:—

Carleton, Que.—Top of pile in the angle between south side of wharf and front of freight shed. Zero of gauge 15·01 feet below top of this pile.

Neguac, N.B.—Bench mark cut on the south-east corner of the lighthouse at Lower Neguac. Zero of gauge 9·37 feet below this bench mark.

Cape Tormentine.—Bolt in rock at head of the railway wharf, about 200 feet south of the track. Zero of gauge at 12·80 feet, and zero of wharf gauge board at 10·80 feet, below this bench mark.

Charlottetown.—On Peake Bros.' building, corner of Water and Queen streets. North end of sandstone window-sill of the most northerly window of the east front. Zero of the gauge at 18·18 feet, and zero of the wharf gauge board at 16·18 feet, below this bench mark.

Pictou.—On the Custom house; west end of the sandstone door-sill at the south side of the building. Zero of the gauge at 19·84 feet, and zero of the wharf gauge board at 18·84 feet, below this bench mark.

Souris, P.E.I.—Circular hole cut in red sandstone and marked B.M., about 90 yards west of shore end of Knight's wharf. Zero of the gauge below this mark 8·00 feet before July 16th, and 6·00 feet after that date.

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

W. BELL DAWSON,
In charge of Tidal Survey.

NOTE.—*On the Progress of the Tides in the Gulf of St. Lawrence, as ascertained by the Summer Observations of 1896; and the Tidal Differences derived from them. Explanation of Plates illustrating these tides.*

On account of the great variety in the range of the tide on our eastern coasts and in the Gulf of St. Lawrence, it has been found necessary to establish seven principal tidal stations at which continuous observations are obtained throughout the year. In addition to affording the tidal data necessary for the investigation of the currents, these stations are so located as to serve for ports of reference, to which the tides in the intermediate regions may be referred. The aim of this Survey is to obtain this tidal information by means of secondary stations which are kept in operation during the summer season only; without the substantial construction required to withstand winter ice, and the special arrangements needed at the principal stations for heating in winter. By this method, the undue multiplication of principal stations is avoided.

In the season of 1896, a beginning in this direction was made in the region extending along the south-western side of the Gulf of St. Lawrence, as explained in the last Report of Progress and mentioned in the present report. A valuable series of simultaneous observations was thus obtained. So far, the results worked out from them, have only comprised the differences in the time of the tide; in order to obtain a general knowledge of the progress of the tide throughout the Gulf, and to secure tidal differences with reference to the principal stations. A paper based upon this work was prepared by me in June last, for the Halifax meeting of the Royal Society of Canada, entitled "Character and Progress of the Tides in the Gulf and River St. Lawrence; as ascertained by Simultaneous Observations with self-registering Tide Gauges." In it, an explanation is given of the complicated nature of these tides; the series of comparisons with the various principal stations are detailed; and the methods are described by which the most satisfactory tidal differences were finally arrived at. The paper is accompanied by the plates illustrating the character of these tides, which are now appended to this report.

The positions of the principal tidal stations themselves, are shown on the outline map, Plate I. They are as follows:—St. John, N.B.; Halifax, N.S.; Strait of Belle Isle; St. Paul Island, in Cabot Strait; South-west Point, Anticosti; Father Point, and Quebec.

The last four stations as above given, form a series extending from the main Gulf entrance to Quebec, a distance of 690 miles; and the character of the tide in its progress on this main route is shown in Plate II; and in the first half of Plate III, the simultaneous Atlantic tides at Halifax and in the Strait of Belle Isle, are given for comparison. The tide curves given in these plates, are fac-simile reductions from the actual traces obtained from the self-recording tide gauges. The vertical scale of the gauge at each station, is adapted to the local range of the tide. The time used throughout is Standard time for the 60th meridian; four hours slower than Greenwich Mean Time. Each series of tides is thus a simultaneous set, in absolute time.

The tide in Cabot Strait is affected by an irregularity known as diurnal inequality. When the moon's declination is high, the two tides of the same day have there a long interval and a short interval of time between them; and their ranges are also very different in amount. It was already known that the tides at Pictou and Charlottetown, in Northumberland Strait were affected by diurnal inequality; but the reason of this was not understood. The nature of this inequality is shown in the tide curves obtained at Pictou and Charlottetown, as given in Plate IV, where it is strongly marked. It is remarkable that this irregularity in the tide is much less noticeable after it enters the mouth of the St. Lawrence, and at Father Point and Quebec it is scarcely appreciable.

The series of tidal stations established in the season of 1896 had for their object to trace the progress of the tide in the Gulf of St. Lawrence, in order to ascertain how far these irregularities are felt; and also to determine the extent of the region which can be referred to each of the principal stations as to a port of reference, as already stated. The positions of the secondary stations on the

south-western side of the Gulf, at which observations were taken for these purposes, are shown on the map, Plate I.

From a digest of the simultaneous observations obtained, and an exhaustive series of comparisons with the principal stations, the following description of the general course of the tides in the Gulf can now be given. The main tide of the Gulf enters by Cabot Strait; whereas the tide from the Strait of Belle Isle appears to be relatively slight, as its influence on the south-western side of the Gulf was not apparent. When the tidal undulation enters Cabot Strait, a branch passes to the southward, off the west coast of Cape Breton Island, and into Northumberland Strait. The large diurnal inequality observed at St. Paul Island, affects this region; and is very marked at Pictou and Charlottetown, though somewhat altered in amount. The latest tide in this region is at Charlottetown. The main tidal undulation from Cabot Strait undoubtedly follows the line of the deep channel which runs directly across the Gulf towards the entrance to the St. Lawrence. (A part of the tidal undulation no doubt turns into the north-eastern arm of the Gulf, and runs between Newfoundland and the North Shore, towards the Strait of Belle Isle; but the tides in this region have not yet been examined.) On reaching the Anticosti side of the Gulf, there is reason to believe that a portion of the main tidal undulation turns off towards Chaleurs Bay and Miramichi, and returns along the north coast of Prince Edward Island to its extreme eastern end. In the western end of Northumberland Strait, there is interference between this return undulation and the direct tide which enters the strait by its eastern end. The result of this is, that in the western end of the strait, from Shediac to Richibucto, the tide is almost effaced; and the time of the tide is usually difficult if not impossible to determine with any certainty.

The character of the tides on these two lines of progress through the Gulf of St. Lawrence, are shown in Plates III, IV, and V; which give as before a reproduction of the tide curves from the recording instruments, in Standard time for the 60th meridian. In the latter half of Plate III, and in Plate IV, a set of spring tides in July is followed from the Atlantic through Cabot Strait, and along Northumberland Strait; by means of the simultaneous records obtained at Halifax, St. Paul Island, Souris, Pictou and Charlottetown. The tides at Carleton are also given for comparison. Plate V shows a set of unusually high spring tides in November, extending from Cabot Strait along the north coast of Prince Edward Island to Miramichi and Charleurs Bay; obtained from the stations at St. Paul Island, St. Peters, P.E.I., Neguac, N.B., and Carleton, Que. On the greater part of these coasts, it is only at the springs that the tides are well marked, as they become very flat during the neaps.

Tidal Differences in the Gulf.—The irregularities in time and height which are found in the Gulf tides, appear to be due to the effect of the return undulation above referred to, which follows the open Gulf coast south-eastward from Chaleurs Bay towards Prince Edward Island. On those coasts the tidal differences, or the differences in the time of high water, if taken for the same tide followed on its course from Cabot Strait, are so irregular as to be entirely valueless for practical purposes. The only tidal differences which approach to constancy, are those between the time of high water at any point and the *next following* high water at St. Paul Island. The extended comparisons made in arriving at the best values for these differences, and the methods employed, are described in the paper prepared for the Royal Society, above mentioned; and they need not be repeated here. It will be sufficient to give the practical outcome of the observations of 1896, in so far as the determination of tidal differences is concerned, in the regions examined; as the results finally obtained must serve as a basis for the tides in the south-western half of the Gulf of St. Lawrence, in which all the more important Canadian harbours in the Gulf are found.

The observations show that the region of the Lower St. Lawrence, already referred to Quebec, can be extended to include Chaleurs Bay. The open shore of the Gulf, from Miramichi Bay along the north coast of Prince Edward Island, can be referred to St. Paul Island by giving the time of the tide as *earlier* than at that station. Northumberland Strait forms a third region in which the tides must also be referred directly or indirectly to St. Paul Island.

The following summary gives the results for the stations at which the observations were taken; and from these, the time of the tide for intermediate places may be found by the comparison of their Establishments or other methods of interpolation. In the observations, the time of the tide is in Standard time for the 60th meridian throughout; and the differences themselves are all therefore in absolute time.

It is to be noted that Carleton, in Chaleurs Bay, was chosen as a station which would be as near the head of the bay as possible, while avoiding the local disturbance of the tide which may occur at the mouth of the Restigouche River. Also, the tide stations at Alberton, Rustico, and St. Peters, were placed at the mouth of the bays or in the entrances to them; in order to obtain the tide on the open coast, unimpeded by the bars which shut in the greater part of the bays on that coast.

The tidal difference between Pictou and St. Paul Island, given as $1^h\ 35^m$, is the actual average of the difference in time of high water derived from 285 tides, as observed simultaneously. The comparisons show, however, that the time of the tide at Pictou can be computed from St. Paul Island with greater accuracy than by using a constant difference, by means of the following method: A higher difference than the above, namely, 1 hour 43 minutes is to be used as constant, except for two periods of eight days in each lunar month, during which a special series of differences must be used for the upper and lower transit tides respectively. The tides thus excepted are the 5th to the 13th lower transit tides following the moon's ascending node, and the 5th to the 13th upper transit tides following the moon's descending node. For these tides the differences are less; and they follow a curve which falls to a minimum difference of 55 minutes in each case. If the tides are thus computed first for Pictou, and the constant differences from Pictou as given, are then used throughout the length of Northumberland Strait from Souris to Cape Tormentine the residual error due to change in the diurnal inequality along the Strait will be so distributed as nearly to disappear. It is important to have the Pictou tides correctly, as it is probable that this port will also be found to stand in the best relation to the tidal currents in the Strait, when these come to be examined systematically.

A.—LOWER ST. LAWRENCE AND CHALEURS BAY.

Locality.	Difference in time of High Water.		Period of Observation on which the Difference is based.
	hrs.	min.	
Father Point. From continuous observations during two full years. Tide earlier than at Quebec	4	20	17th Dec., 1894, to 28th Feb., 1897.
South-west Point, Anticosti. Continuous observations during two years. Tide earlier than at Quebec	5	24	12th Nov., 1894, to 26th Oct., 1896.
Carleton, Que. Near the head of Chaleurs Bay. Tide later than at South-west Point, Anticosti	1	30	1st July to 25th Oct., 1896.
Tide earlier than at Quebec	3	54	

B.—OPEN COAST, SOUTH-WEST SIDE OF GULF.

In this region, the differences give the time of High Water as *earlier* than the next following High Water at St. Paul Island.

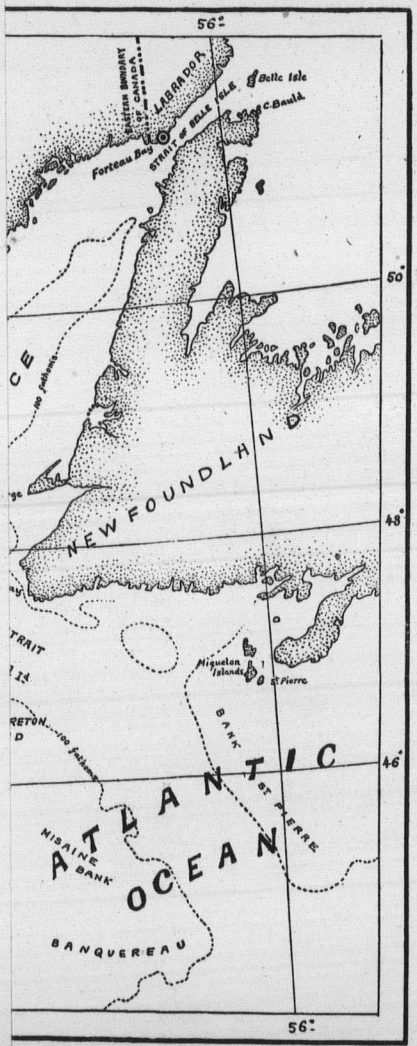
Neguac. At the mouth of Miramichi Bay	3	21	18th Aug. to 6th Nov., 1896.
Alberton. North shore of Prince Edward Island	2	33	Thirteen tides in Oct., 1896.
Rustico. do do	2	31	Seven tides in Oct., 1896.
St. Peters. do do	2	10	29th Oct. to 22nd Nov., 1896.

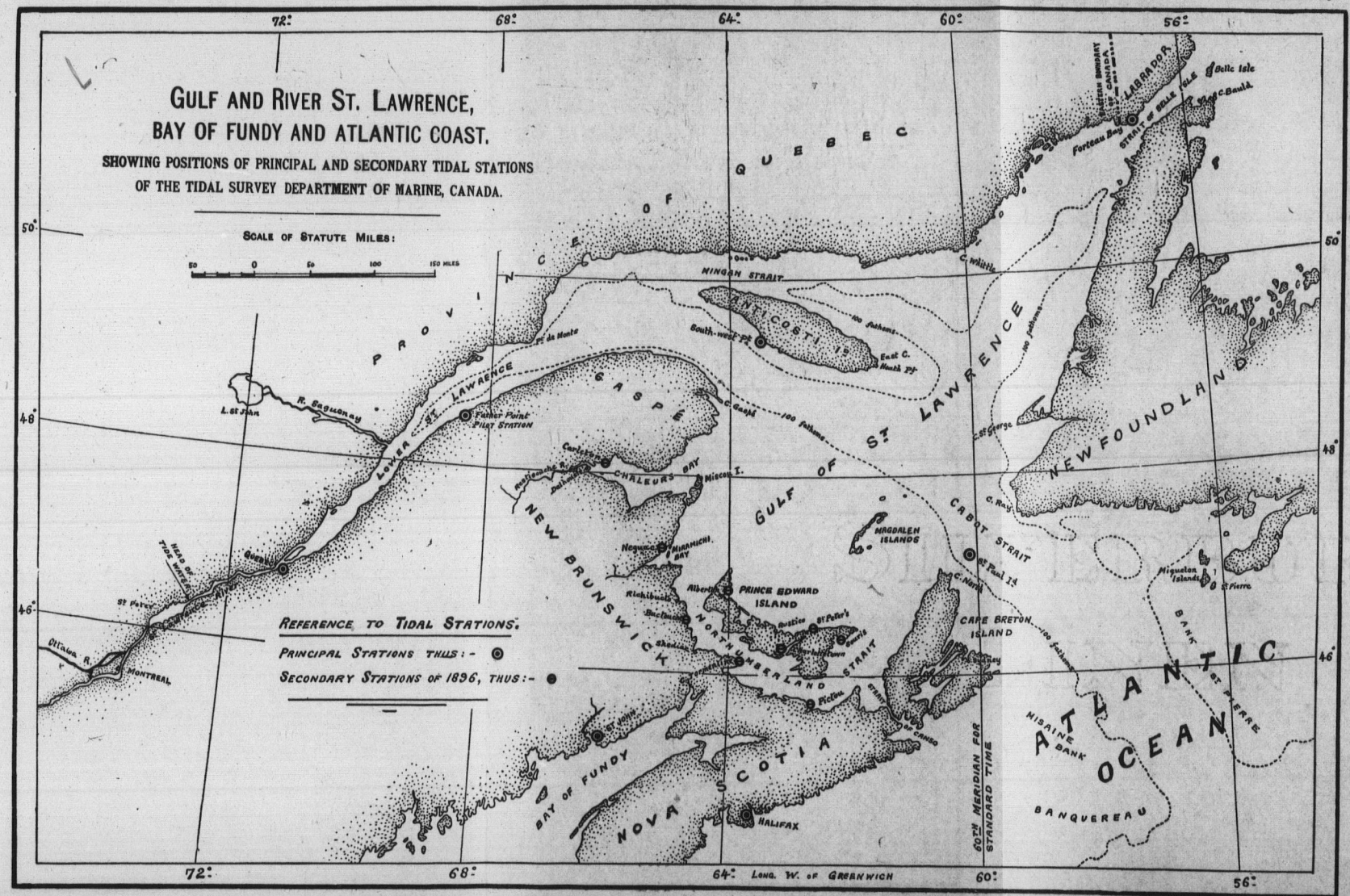
C.—NORTHUMBERLAND STRAIT.

Pictou Harbour. Tide later than at St. Paul Island	1	35	4th June to 1st Nov., 1896.
Souris, P.E.I. Tide earlier than at Pictou	1	14	8th July to 15th Nov., 1896.
Charlottetown. Tide later than at Pictou	0	55	20th to 26th June, and 18th July to 25th Nov., 1896.
do Later than at St. Paul I'd on the average	2	21	
Cape Tormentine. Tide later than at Pictou	0	24	25th July to 10th Aug., and 5th to 30th Sept., 1896.
Region of tidal interference at the west end of Northumberland Strait. *Shediac*	Uncertain.		8th to 11th Sept., 1896.
Buctouche	do		15th Sept., 1896.
Richibucto	do		5th to 8th Aug., 1896.

W. B. D.

PLATE 1.


56°
EASTERN BOUNDARY OF CANADA
LABRADOR
Belle Isle
C. Bauld
Forteau Bay
STRAIT of BELLE ISLE
50°
NEWFOUNDLAND
48°
Miquelon Islands
St Pierre
BANK
ST PIERRE
46°
ATLANTIC
OCEAN
MISAINE BANK
BANQUEREAU
56°


GULF AND RIVER ST. LAWRENCE,
BAY OF FUNDY AND ATLANTIC COAST.
SHOWING POSITIONS OF PRINCIPAL AND SECONDARY TIDAL STATIONS
OF THE TIDAL SURVEY DEPARTMENT OF MARINE, CANADA.
SCALE OF STATUTE MILES:
50 0 50 100 150 MILES
REFERENCE TO TIDAL STATIONS.
PRINCIPAL STATIONS THUS:- ⊙
SECONDARY STATIONS OF 1896, THUS:- ●
QUEBEC
PROVINCE OF
NEW BRUNSWICK
NOVA SCOTIA
NEWFOUNDLAND
LABRADOR
GASPE
ANTICOSTI I.
MAGDALEN ISLANDS
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
GULF OF ST. LAWRENCE
LOWER ST. LAWRENCE
NORTHUMBERLAND STRAIT
CABOT STRAIT
BELLE ISLE STRAIT
BAY OF FUNDY
ATLANTIC OCEAN
BANQUEREAU
MISAINE BANK
BANK OF ST. PIERRE
MINGAN STRAIT
CHALEURS BAY
Father Point Pilot Station
L. St John
R. Saguenay
Quebec
Montreal
Ottawa R.
St John
Halifax
Pictou
Charlottetown
St Peter's
Sydney
Forteau Bay
C. Bauld
C. Norman
St Paul I.
St Pierre
Miquelon Islands
C. Ray
C. St George
C. Gaspé
Pt de Monts
South-west Pt
East C.
North Pt
Miscou I.
Caraquet
Dalhousie
Restigouche R.
Shediac
Richibucto
Escuminac
Head of Tide Water
100 fathoms
60TH MERIDIAN FOR STANDARD TIME
72° 68° 64° 60° 56°
50° 48° 46°
LONG. W. OF GREENWICH

T
tions
be fou
tion.
meri
I
would
ance
tide s
bays
peded
T
the ac
obser
tide a
using
than
period
must
excep
node,
node.
to a n
first
throu
the r
so dis
corre
relati
syste

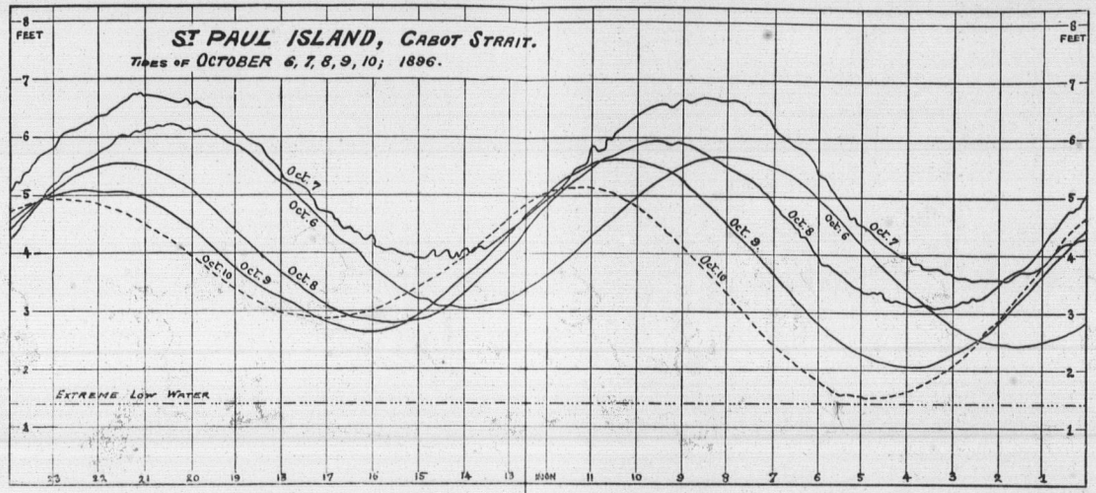
Father
ful
South-w
du
Carleto
Tic
Tic

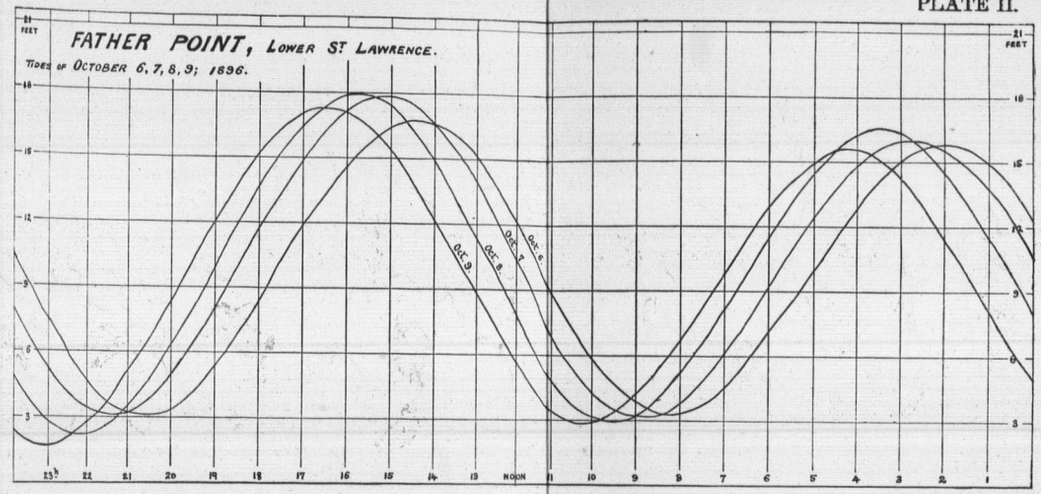
In

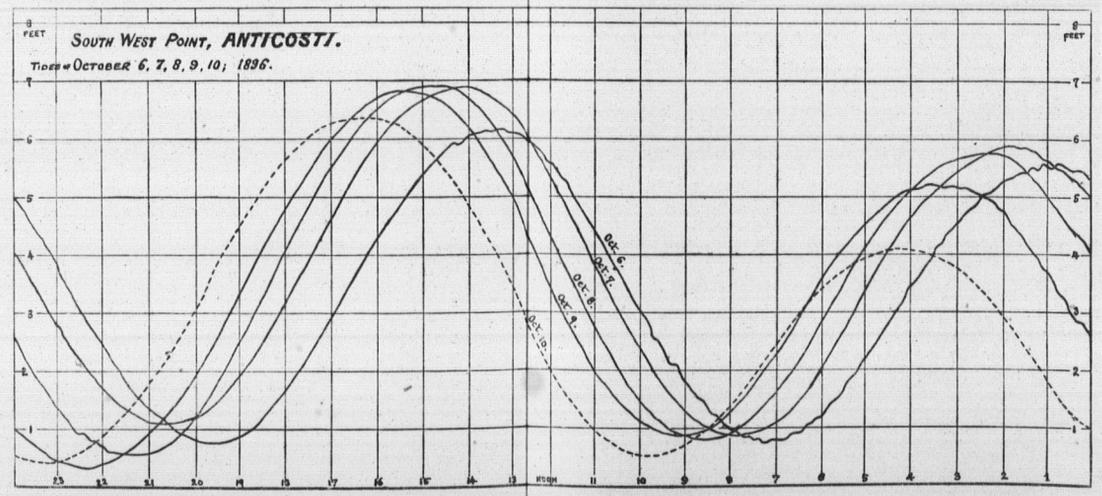
Negua
Alberto
Rustic
St. Pet

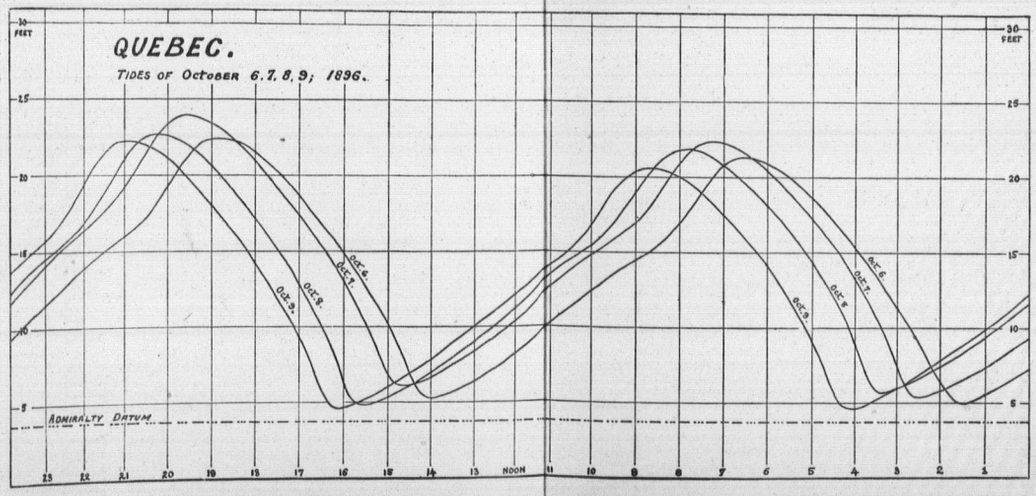
Pictou
Souris
Charlo
Cape P

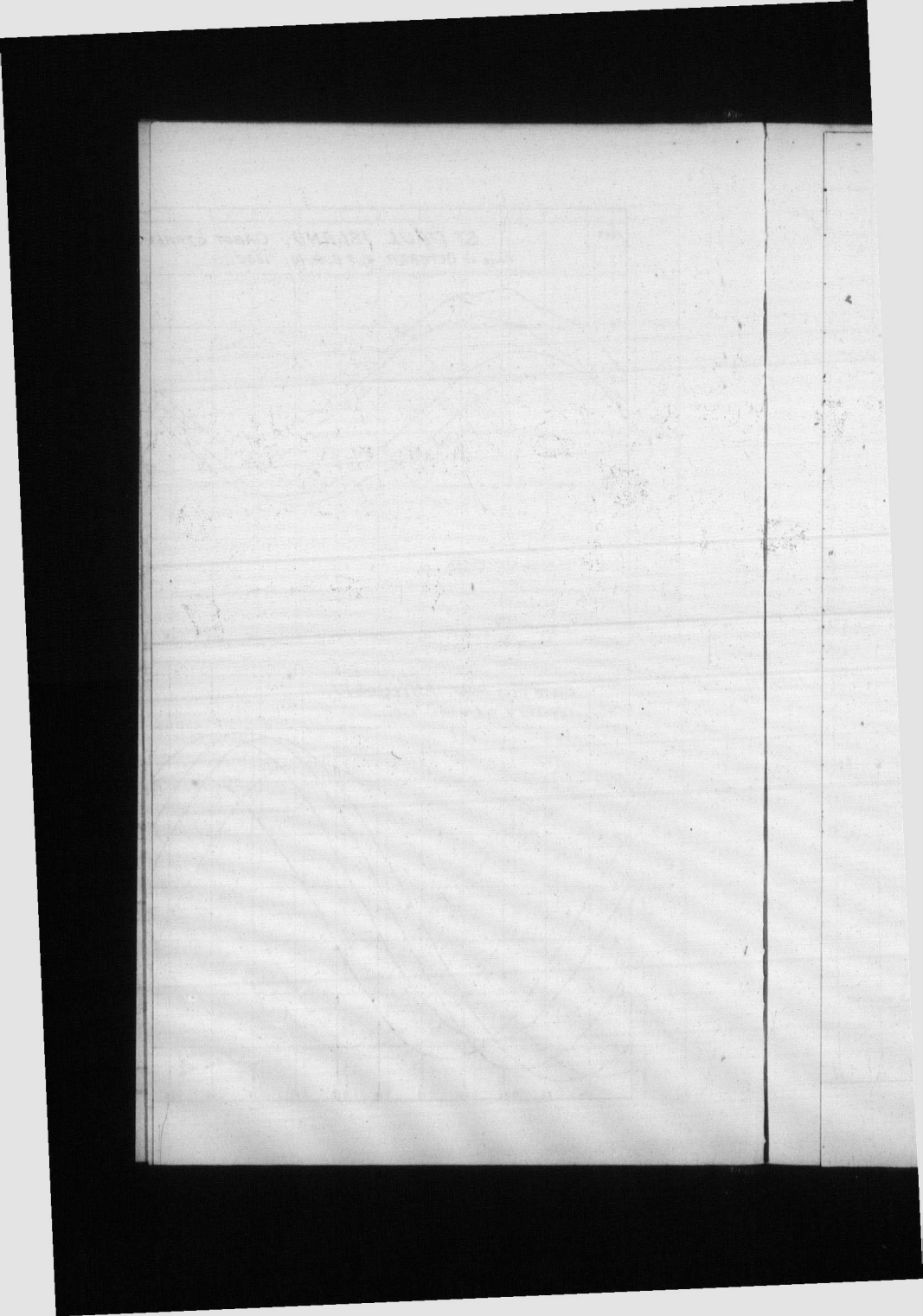
Region
en

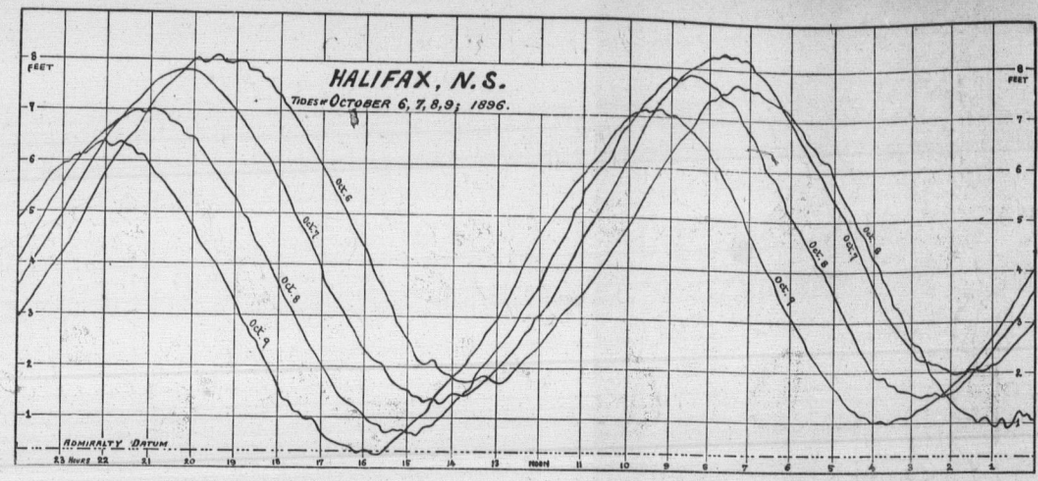

ST PAUL ISLAND, CABOT STRAIT.
TIDES OF OCTOBER 6, 7, 8, 9, 10; 1896.
FEET
Oct. 7
Oct. 6
Oct. 10
Oct. 9
Oct. 8
Oct. 8
Oct. 9
Oct. 6
Oct. 7
Oct. 10
EXTREME LOW WATER
NOON

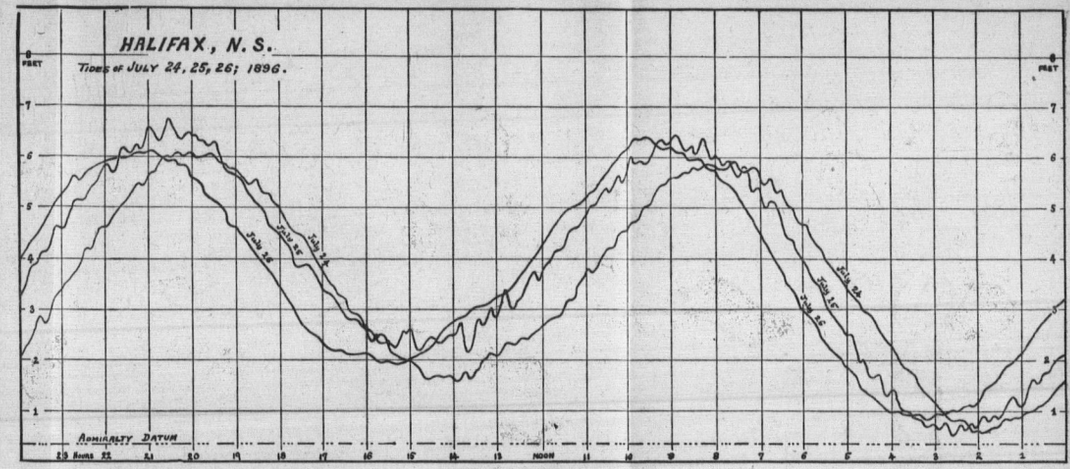

FATHER POINT, LOWER ST LAWRENCE.
TIDES OF OCTOBER 6, 7, 8, 9; 1896.
FEET
Oct. 9
Oct. 8
Oct. 7
Oct. 6
NOON

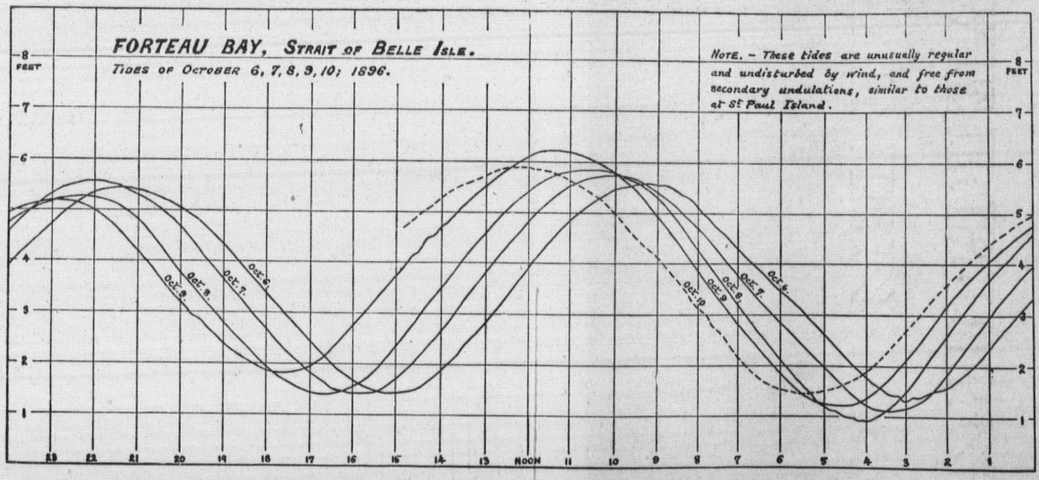

SOUTH WEST POINT, ANTICOSTI.
TIDES OF OCTOBER 6, 7, 8, 9, 10; 1896.
FEET
Oct. 6
Oct. 7
Oct. 8
Oct. 9
Oct. 10
NOON

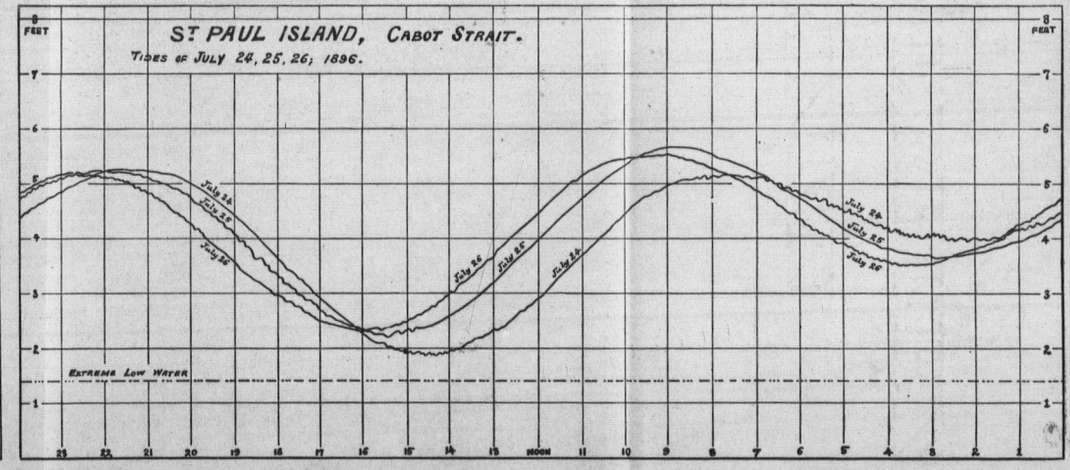

QUEBEC.
TIDES OF OCTOBER 6, 7, 8, 9; 1896.
FEET
Oct. 9
Oct. 8
Oct. 7
Oct. 6
Oct. 9
Oct. 8
Oct. 7
Oct. 6
ADMIRALTY DATUM
NOON

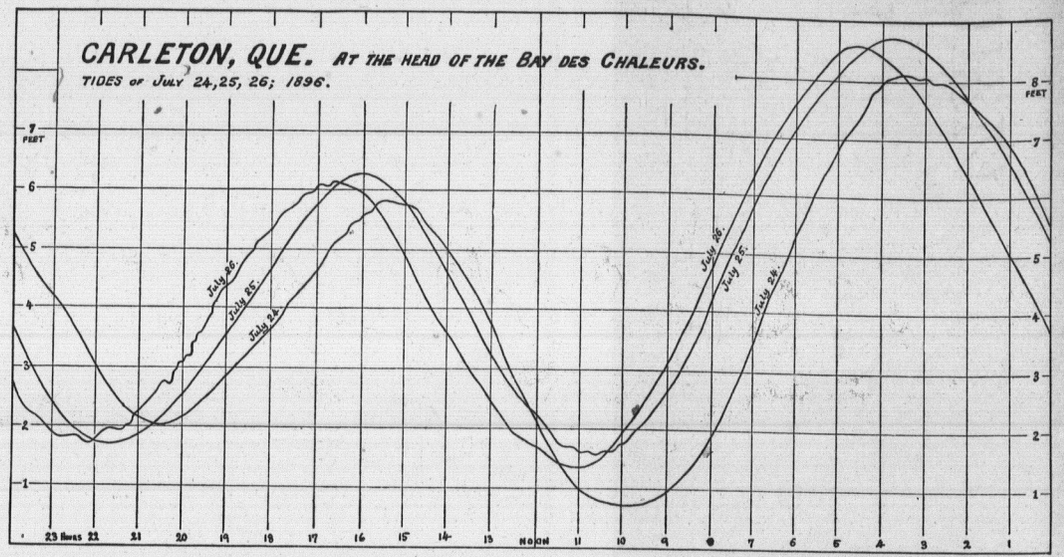


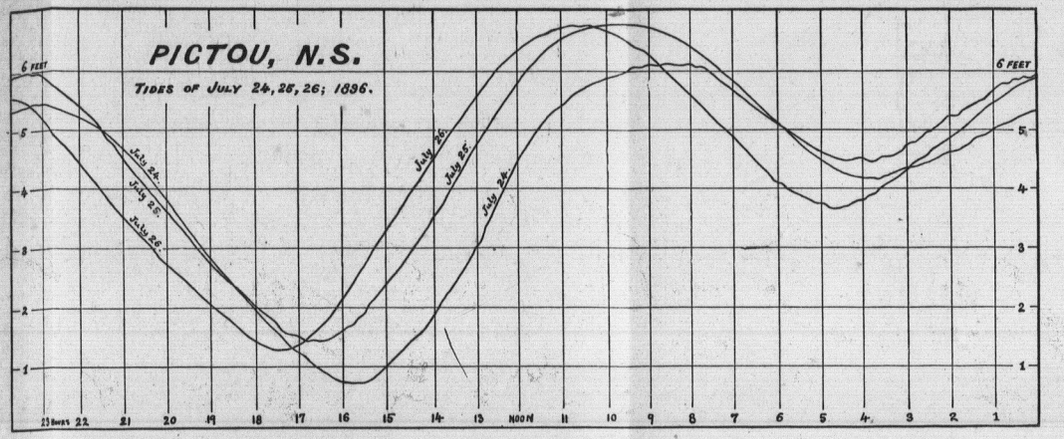

HALIFAX, N.S.
TIDES OF OCTOBER 6, 7, 8, 9; 1896.
FEET
Oct. 6
Oct. 7
Oct. 8
Oct. 9
ADMIRALTY DATUM
HOURS
NOON

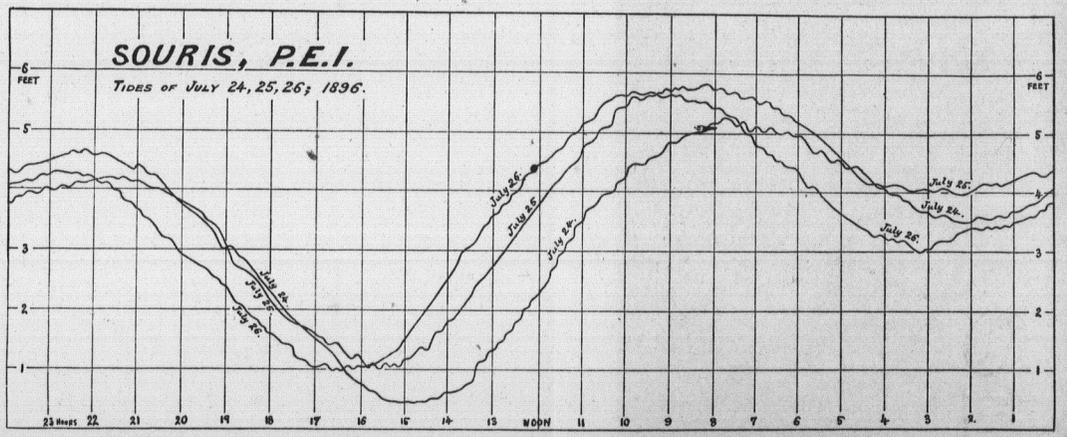

HALIFAX, N.S.
TIDES OF JULY 24, 25, 26; 1896.
FEET
July 24
July 25
July 26
ADMIRALTY DATUM
HOURS
NOON

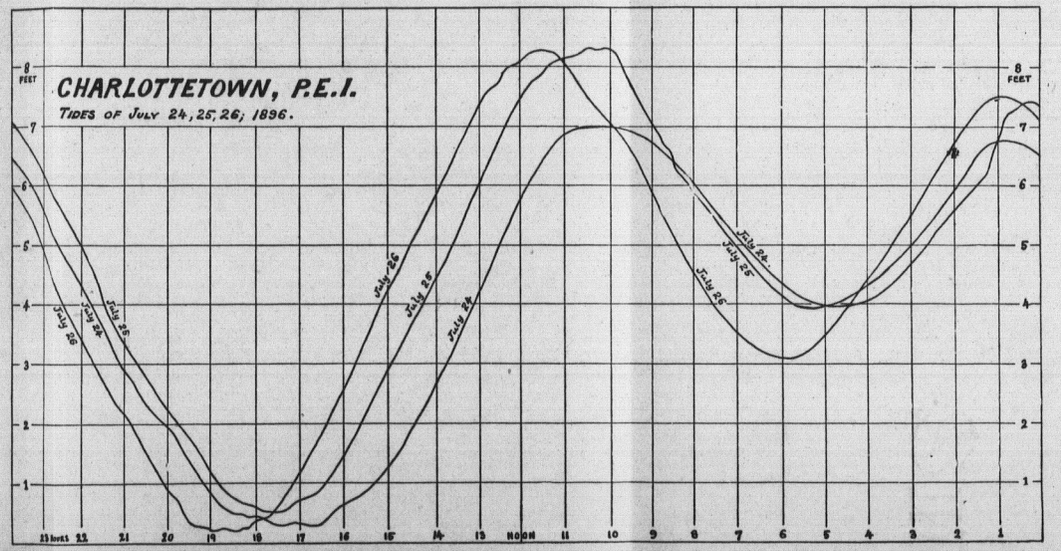

FORTEAU BAY, STRAIT OF BELLE ISLE.
TIDES OF OCTOBER 6, 7, 8, 9, 10; 1896.
NOTE. – These tides are unusually regular and undisturbed by wind, and free from secondary undulations, similar to those at St Paul Island.
FEET
Oct. 6
Oct. 7
Oct. 8
Oct. 9
Oct. 10
HOURS
NOON

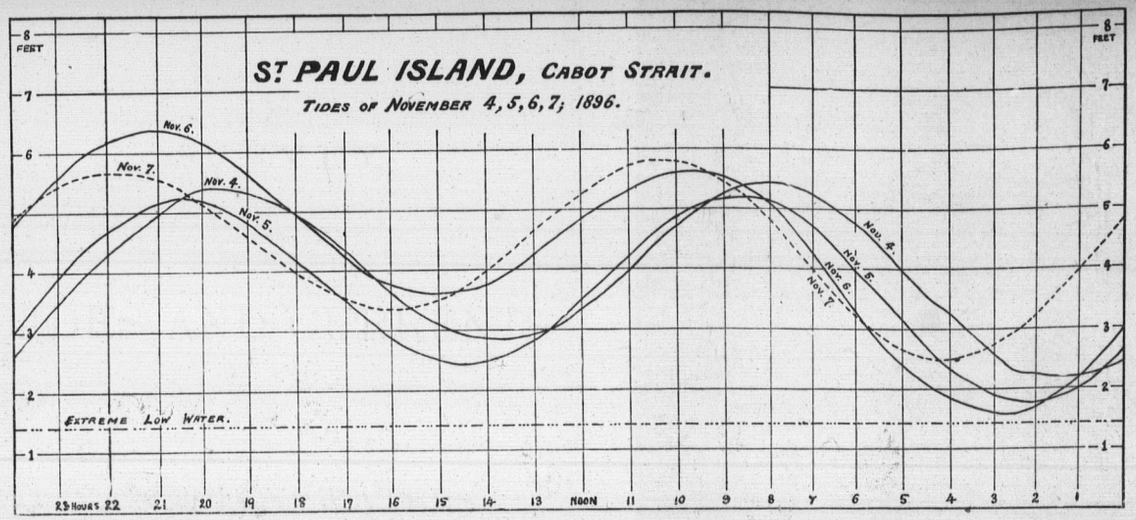

ST PAUL ISLAND, CABOT STRAIT.
TIDES OF JULY 24, 25, 26; 1896.
FEET
July 24
July 25
July 26
EXTREME LOW WATER
HOURS
NOON

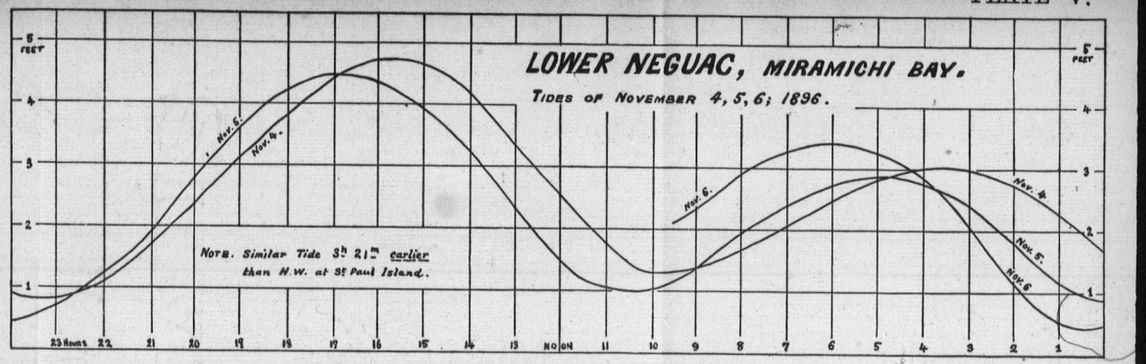

CARLETON, QUE. AT THE HEAD OF THE BAY DES CHALEURS.
TIDES OF JULY 24, 25, 26; 1896.
July 26.
July 25.
July 24.
FEET
23 Hours
NOON

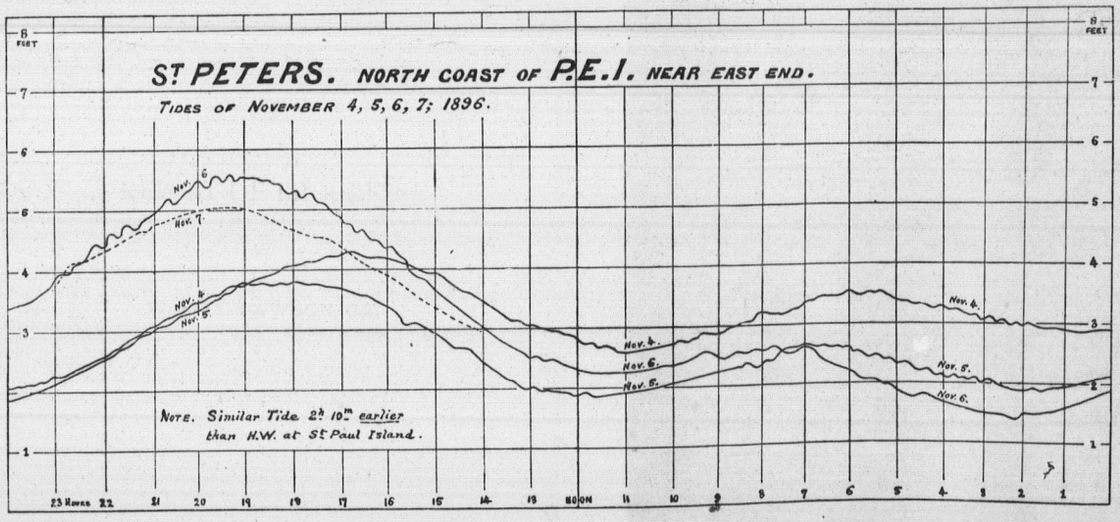

PICTOU, N.S.
TIDES OF JULY 24, 25, 26; 1896.
July 26.
July 25.
July 24.
6 FEET
23 Hours
NOON

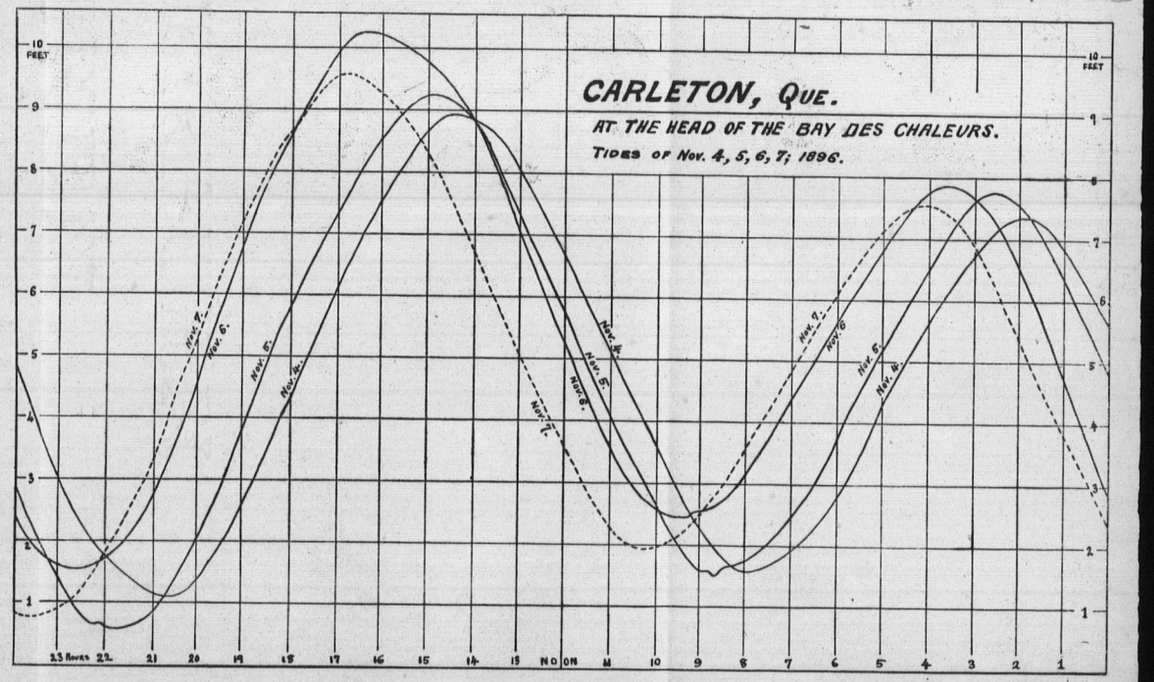

SOURIS, P.E.I.
TIDES OF JULY 24, 25, 26; 1896.
July 26.
July 25.
July 24.
FEET
23 Hours
NOON


CHARLOTTETOWN, P.E.I.
TIDES OF JULY 24, 25, 26; 1896.
July 26.
July 25.
July 24.
FEET
23 Hours
NOON


St PAUL ISLAND, CABOT STRAIT.
TIDES OF NOVEMBER 4, 5, 6, 7; 1896.
Nov. 6.
Nov. 7.
Nov. 4.
Nov. 5.
EXTREME LOW WATER.
23 HOURS 22 21 20 19 18 17 16 15 14 13 NOON 11 10 9 8 7 6 5 4 3 2 1


LOWER NEGUAC, MIRAMICHI BAY.
TIDES OF NOVEMBER 4, 5, 6; 1896.
Nov. 5.
Nov. 4.
Nov. 6.
Nov. 4.
Nov. 5.
Nov. 6.
NOTE. Similar Tide 3h 21m earlier than H.W. at St Paul Island.
23 HOURS 22 21 20 19 18 17 16 15 14 13 NOON 11 10 9 8 7 6 5 4 3 2 1


St PETERS. NORTH COAST OF P.E.I. NEAR EAST END.
TIDES OF NOVEMBER 4, 5, 6, 7; 1896.
Nov. 6
Nov. 7
Nov. 4
Nov. 5
Nov. 4.
Nov. 4.
Nov. 6.
Nov. 5.
Nov. 6.
NOTE. Similar Tide 2h 10m earlier than H.W. at St Paul Island.
23 HOURS 22 21 20 19 18 17 16 15 14 13 NOON 11 10 9 8 7 6 5 4 3 2 1


CARLETON, QUE.
AT THE HEAD OF THE BAY DES CHALEURS.
TIDES OF Nov. 4, 5, 6, 7; 1896.
Nov. 7.
Nov. 6.
Nov. 5.
Nov. 4.
Nov. 4.
Nov. 5.
Nov. 6.
Nov. 7.
Nov. 6
Nov. 5
Nov. 4
23 HOURS 22 21 20 19 18 17 16 15 14 13 NOON 11 10 9 8 7 6 5 4 3 2 1