# SURVEY

OF

# TIDES AND CURRENTS

IN

# CANADIAN WATERS

BY

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*In charge of Tidal Survey.*

OTTAWA
GOVERNMENT PRINTING BUREAU
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OTTAWA, November 14, 1902.

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

I have the honour to submit the following Report on the progress of this Survey. The principal tidal stations have been maintained in operation, and some progress has been made in the reduction of the results, as far means have permitted. The two principal tidal stations which command the two entrances to the Gulf of St. Lawrence have been put in thorough repair this season. The station at St. Paul Island in Cabot Strait, commands the main entrance by which the tides enter the Gulf from the ocean; and its advantage as a port of reference for an important part of the Gulf area, has come out in a clearer light than ever, from the comparative observations secured in 1901.

An important step in advance is being made, in the information supplied to aid navigation on the St. Lawrence route. A part of the tidal record from Father Point is being submitted to harmonic analysis, which will enable tide tables to be calculated directly for that locality. The advantage of this step has become apparent from the tidal observations of 1900 on the Lower St. Lawrence; as they showed that both tide and current in the open estuary below the Traverse, could better be referred to Father Point than to Quebec. So far, the Father Point tide tables have been calculated indirectly from Quebec, by means of the double series of variable differences described in last Report. This elaborate method was devised to save the expense of analysis at an additional station. But it has now been ascertained that the complicated relation between the two places, is chiefly due to the river influence at the upper end of the run of the tide near Quebec; while the tide in the open estuary itself is very regular. Hence the tide tables calculated from the analysis, in conjunction with the other data which have been secured, will enable the turn of the strong tidal currents of the estuary to be readily and accurately known from the tide tables.

On the Pacific coast, good progress has been made, both in the improvement of the tide tables through the analysis of further tidal record from the principal stations, and also in the establishment of additional tidal stations, to extend the information available.

In the present Report, all the information yet obtained is summarized, with regard to the tide and current in Northumberland Strait; and its relation to Cabot Strait where the Gulf of St. Lawrence opens to the ocean. The levels of datum planes, heights of extreme tides, and the effects of wind disturbance, have also been carefully and fully worked out. These are of primary importance with relation to works of construction in the harbours of the strait, as well as for uniform reference levels in any future observations.

Repeated endeavors have been made to ascertain the relation between the various datum planes in use in our cities and towns. There are often two or three of these, out of accord with each other; and further, there is usually uncertainty or actual discrepancy between the various marks by which these planes are defined. In these circumstances, the method which this Survey has adopted from the outset is to refer all the tide levels obtained, to some one satisfactory bench-mark in each port. Eventually, as the observations are continued, the value of Mean Sea Level, extreme tide levels, and other factors of importance, are determined with reference to this bench-mark. Such factors are of the highest value in city drainage works and harbour improvements. In certain rare instances, bench-marks have been established by the Admiralty, which define the low-water datum of the charts. These are always taken advantage of, where they exist. When the height of the tide is referred to this datum level, it shows the depth available in addition to the chart soundings. In the present Report, the result is given of the endeavour to correlate the various datum planes in use at Halifax; and to redetermine the low-water datum at Victoria, B.C. The relation between the tide levels and the Yarmouth town datum, is also given.

Five summer tidal stations were erected this season with the object of obtaining tidal data as a basis for the investigation of the current at the entrance to the Bay of Fundy, and in the bays on the south coast of Newfoundland.

A considerable amount of tabulation from the tidal record already secured, has been done during the year, and submitted to analysis as the means to do so have permitted. This will extend the basis from which the tide tables are calculated, which will be of permanent benefit in improving their accuracy in all future years. 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, 1901, to June 30, 1902, was $8,951.08 in which a supplementary estimate of $1,500 is included, which was expended upon material for the heavy repairs at the permanent tidal stations.

## REDUCTION AND TABULATION OF TIDAL RECORD.

In order to utilize the tidal record for the calculation of tide tables by the modern method of harmonic analysis, it is necessary that it should be tabulated in hourly ordinates, which give the height of the tide at each hour throughout the year. With this object in view, it is of primary importance to secure an uninterrupted record, day and night, during the course of the year. Every endeavour in the way of foresight and vigilance, is made to ensure this. The number of hourly ordinates throughout the course of a year is 8,760; and these must be reduced to a uniform datum and freed from time errors. The tabulation of this character which has been submitted to analysis during the twelve-months since last report, is as follows:

*Halifax*.—Three years, from December 14, 1896, to January 15, 1900, extending the basis from which these tides tables are calculated from one to four years of recent observations. This, together with four years of old observations, obtained between 1851 and 1861, now gives a total of eight years of observations for these tide tables; and this benefits all the ports on the Atlantic coast of Nova Scotia, that depend upon them.

*St. Paul Island*.—Two years, from May 20, 1899, to May 31, 1901; which benefits the tide tables for the ports in Northumberland Strait, and the south-west side of the Gulf of St. Lawrence, which depend directly or indirectly on St. Paul Island.

*Father Point*.—Three years from January 25, 1897, to February 25, 1900. This will be of great benefit to the St. Lawrence route; as it has now been ascertained that the best results are secured by referring to this station, the tides and currents throughout the open estuary.

In addition to the above, the following tidal record from the Pacific coast has been tabulated ready for analysis; which will be made as soon as the finances of the Survey will admit of it.

*Sand Heads, Strait of Georgia.*—Three additional years, from November 1, 1898, to November 24, 1900; and from January 16, 1901, to January 27, 1902. This will serve to improve the accuracy of the tide tables at Vancouver and other ports throughout the Strait of Georgia, which are dependent upon this as a principal station.

## PUBLICATION OF TIDE TABLES, AND IMPROVEMENTS IN THEIR ACCURACY.

The publications of this Survey during the past year, continue to be reviewed in British and foreign periodicals as in former years, which is of service in making them widely known. The requests received for tide tables, and for other information, is continually on the increase.

*Tide Tables for British Columbia.*—These comprise complete tide tables for Victoria, B.C., and for Sand Heads in the Strait of Georgia, a locality centrally situated in that strait, and well suited as a reference station for the ports around it. Tidal differences for Vancouver, New Westminster, Nanaimo and Baynes Sound are given with these tables; as well as the turn of the current in First Narrows, Burrard Inlet. They have met with so much appreciation that the edition printed has been increased from 500 to 800 copies, to meet the demand for them.

It is a real service to mariners that accurate tide tables are available since these were first published in 1901; as the information for British Columbian waters given in the United States tide tables, was far from reliable. This was unavoidable in the circumstances; the tide itself being of a different type, as explained in a former report. Regarding the accuracy of the present tables, Mr. F. N. Denison, who is continuing the tidal observations at Victoria, writes: "Your Victoria tidal predictions are almost perfect, as proved by plotting them upon the actual records, and are greatly admired and appreciated by those who have seen the comparison." The captain of the steamer *Otter*, of the Canadian Pacific Navigation Co., also writes at the end of January, 1902: "During 1901, I often used the tables for that year, and am greatly pleased to say that I found the times of high and low water given in the tables, wonderfully correct. I see the tables for 1902 are a distinct advance on the tables for 1901, as constants are given for Nanaimo, Vancouver and Baynes Sound, ports that I frequently visit; and I find that in the short time I have used this year's tables, they are as exact for the above ports as the tables for 1901 were for Victoria and the Sand Heads."

The tide tables have been reprinted one month at a time, by the *Times* and the *Colonist* of Victoria. The new information now issued with them, is mentioned further on in this report, where the further results now secured are explained.

*Quebec, Father Point, Halifax and St. John, N.B.*—In this set, the accuracy of the tide tables for Quebec has been further improved by extending the basis from which they are calculated for 1903, from four to six years of observation. This improvement is an important one, in view of the full information now issued with these, for the whole of the tidal portion of the St. Lawrence, from Three Rivers to Gaspé. The tide tables for Father Point, were published for the first time in 1902; and those for 1903 are also deduced from the Quebec tide tables by the method described in last report. Hereafter these tables will be calculated directly from the astronomical elements determined by analysis, as already explained.

In this set of tables, tidal differences are also given for the whole of the Bay of Fundy; and for the Atlantic coast of Nova Scotia.

These tide tables were again supplied to the leading Canadian and British almanacs, willing to publish them in whole or in part. An addition of 800 copies, reprinted from Greenwood's Almanac, was found insufficient to meet the increased demand for them; and accordingly for 1903, the quantity has been increased to 1,000. The various newspapers have also done something in the way of re-publishing these tables, or in giving the time of high water daily, much in the same way as in former years.

*St. Croix Bar.*—Tide tables were again computed for this locality, which has been the shallowest point in the St. Lawrence above Quebec. These 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. The new information regarding the tides and currents of the Lower St. Lawrence was also supplied in a condensed form for this publication. The deepening of the ship channel through this bar being now completed, the next shallowest point is at St. Augustin bar, for which tidal data are also computed.

*Charlottetown, Pictou and St. Paul Island.*—These tide tables have the same character as last year, and they again include the whole twelve months. A distinct improvement in the accuracy of these tables was obtained from the observations taken in Northumberland Strait during the season of 1901. The tidal relations of Charlottetown to Pictou, and of Pictou to St. Paul Island, have thus been better determined; and also the tabulation of the tidal record from St. Paul Island itself, which was submitted to analysis, is of direct benefit to this set of tables, as they are dependent upon it as a principal station.

The time of high water for Charlottetown, taken from these tables, has been published a month at a time by the *Patriot* and the *Examiner*. The tide tables for Pictou have also been published in full by the *Advocate* one month at a time, accompanied by the tidal differences for the dependent places in Northumberland strait.

*Summerside, P.E.I., and Yarmouth, N.S.*—Tide tables for Summerside were calculated for the eight months from April to November and supplied to the Summerside *Journal*, in which they were published one month at a time, with due acknowledgement to this Survey. These tables are based upon the observations which were secured at that port itself in 1901. The tide tables for Yarmouth are computed from St. John, N.B., by means of the difference in time already determined by this Survey. They are published in the Yarmouth *Times*.

*Tadoussac, Cacouna and Little Métis.*—Tide tables for the months of July, August, and September were again computed for these seaside resorts to meet the demand of the summer residents and tourists. These tide tables were prepared in manuscript only and posted at the leading hotels.

The tide tables for the five places last mentioned were all prepared by some extra work, without incurring expense or the cost of printing.

## CABOT STRAIT.—TIDAL COMPARISONS.

*Summary of Results for Cabot Strait, between Cape Breton and Newfoundland.*—One of the principal tidal stations is at St. Paul Island in the middle of this strait; and the endeavour was first made to obtain comparisons with Sydney harbour and Port aux Basques on the two sides. The tide at Sydney has so unusual a character, with large secondary undulations, which are often one-third of the height of the main tide, that it was quite unsuitable for comparison with St. Paul Island. After one complete month was secured at Sydney, the gauge was removed to Neil Harbour, a point on the Atlantic side of Cape Breton Island, as near to its northern extremity as practicable. It was distant 30 miles from St. Paul Island to the westward; while Port aux Basques, which is close to Cape Ray, at the south-west angle of Newfoundland, was distant 52 miles to the eastward. The clear width of the strait is 66 miles.

St. Paul Island is the principal station to which the tides on the south-west side of the Gulf of St. Lawrence and in the region of Northumberland strait are referred; and the immediate object of the comparative observations on the two sides of Cabot strait, was to see whether a sufficiently constant relation could be established with St. Paul Island to enable either of these localities to be used to replace it as a reference station for the regions above referred to. The extreme exposure of St. Paul Island makes the gauge unusually liable to accident; and once already it has been carried away, and twice afterwards it was partially wrecked by winter storms.

The total length of tidal record obtained in 1901 from the self-registering gauges at these three localities, was as follows:

Neil Harbour, east side of Cape Breton.....From Aug. 9, to Oct. 31.
St. Paul Island; permanent station, Cabot Strait,.....Continuous record.
Port aux Basques, S. W. angle of Newfoundland,.....From July 9, to Oct. 31.

The differences in the time of the tide in relation to St. Paul Island were fully worked out for these localities. The result, after excluding a few exceptional irregularities, is given below; and it is at once evident that the variation in the difference of time is too great to enable either locality to be taken to replace St. Paul Island. It is remarkable to find so wide a variation in time on such short distances. The comparison with Pictou is also included for the same period, July 15 to October 31; and it is noteworthy that the range in the difference is little greater than for Port aux Basques. The difference with Pictou has also the advantage of being more nearly equal for high and low water, and consequently more amenable to reduction to law, by which the variation in the difference can be allowed for. The variation and the range are in absolute time throughout.

COMPARISONS WITH ST. PAUL ISLAND.—Difference in the Time of the Tide.

| Localities. | Number of Differences obtained. | Variation in the Difference of Time. | Range in the Difference. |
|---|---|---|---|
| | | | M |
| Neil Harbour, H. W..... | 130 | 0 m. to 39 m earlier..... | 39 |
| " " L. W..... | 116 | 7 " 40 " ..... | 33 |
| Port aux Basques, H. W.. . ..... | 158 | 6 m. earlier to 38 m. later..... | 44 |
| " " L. W.. ... ..... | 150 | 15 " 49 " ..... | 64 |
| Pictou, H. W..... | 190 | 1 h. 04 m. to 2 h. 00 m. later.... | 56 |
| " L. W..... | 184 | 0 h. 44 m. to 1 h. 45 m. " ... | 61 |

Throughout the region which extends from Cabot Strait to Northumberland Strait, the leading variation in the difference of the time of the tide follows the moon's declination; and it is greatest in amount when the declination is at its maximum. This is well illustrated by the following comparisons. The first of these shows the unusual result that the two tides of the day at Port aux Basques are alternately earlier and later than at St. Paul Island when the moon's declination is high In the second table, a direct comparison is made at a time of high declination for each of the three localities in Cabot Strait with Pictou itself; which is the local port of reference for Northumberland Strait.

## Tides in Cabot Strait.—Comparison when the Moon's Declination is High.

| Date. | Time of High Water. | | | Time of Low Water. | | | Moon's Declination and Phase. |
|---|---|---|---|---|---|---|---|
| | St. Paul Island. | Port aux Basques. | Difference. | St. Paul Island. | Port aux Basques. | Difference. | |
| 1901. | H M | H M | | H M | H M | | |
| July 11.... | 3 41 | 4 00 | 19 m. later. | 10 30 | 10 23 | 7 m. earlier. | |
| " 11.... | 16 58 | 16 53 | 5 m. earlier. | 22 42 | 23 08 | 26 m. later. | |
| " 12.... | 4 52 | 5 03 | 11 m. later. | 11 39 | 11 20 | 19 m. earlier. | |
| " 12.... | 18 00 | 18 02 | 2 " | ..... | ..... | .... | |
| " 13.... | 5 51 | 6 05 | 14 " | 0 04 | 0 30 | 26 m. later. | |
| " 13.... | 19 16 | 19 10 | 6 m. earlier. | 12 42 | 12 25 | 17 m. earlier. | Maximum north. |
| " 14.... | 6 52 | 7 05 | 13 m. later. | 0 53 | 1 20 | 27 m. later. | |
| " 14.... | 20 22 | 20 07 | 15 m. earlier. | 13 40 | 13 27 | 13 m. earlier. | |
| " 15.... | 7 33 | 8 03 | 30 m. later. | 1 36 | 2 12 | 36 m. later. | |
| " 15.... | 20 52 | 20 50 | 2 m. earlier. | 14 32 | 14 07 | 25 m. earlier. | New moon. |

## Tide at Pictou in Relation to the Three Tidal Stations in Cabot Strait.

| Date. | H. W. at Port aux Basques. | H. W. at Pictou. | Difference in Time. | Alternation in Difference. | Moon's Declination. |
|---|---|---|---|---|---|
| 1901. | H M | H M | H M | | |
| August 23 | — — | 3 25 | — — | | |
| " 23 | 15 50 | 17 37 | 1 47 | | |
| | | | | — 63 minutes. | |
| " 24 | 3 28 | 4 12 | 0 44 | | Maximum south. |
| | | | | + 81 " | |
| " 24 | 16 48 | 18 53 | 2 05 | | |
| | | | | — 95 " | |
| " 25 | 4 40 | 5 10 | 0 30 | | |
| | | | | + 63 " | |
| " 25 | 17 57 | 19 30 | 1 33 | | |
| | | | | — 58 " | |
| " 26 | 5 45 | 6 20 | 0 35 | | |
| | | | | + 57 " | |
| " 26 | 18 40 | 20 12 | 1 32 | | |
| | | | | — 37 " | |
| " 27 | 6 40 | 7 35 | 0 55 | | |
| | | | | + 32 " | |
| " 27 | 19 28 | 20 55 | 1 27 | | |
| | St. Paul Island. | Pictou. | | | |
| August 23 | 1 45 | 3 25 | 1 40 | | |
| | | | | + 01 minutes. | |
| " 23 | 15 56 | 17 37 | 1 41 | | |
| | | | | — 24 " | |
| " 24 | 2 55 | 4 12 | 1 17 | | Maximum south. |
| | | | | + 26 " | |
| " 24 | 17 10 | 18 53 | 1 43 | | |
| | | | | — 48 " | |
| " 25 | 4 15 | 5 10 | 0 55 | | |
| | | | | + 28 " | |
| " 25 | 18 07 | 19 30 | 1 23 | | |
| | | | | — 24 " | |
| " 26 | 5 21 | 6 20 | 0 59 | | |
| | | | | + 33 " | |
| " 26 | 18 40 | 20 12 | 1 32 | | |
| | | | | — 08 " | |
| " 27 | 6 11 | 7 35 | 1 24 | | |
| | | | | + 10 " | |
| " 27 | 19 21 | 20 55 | 1 34 | | |
| | Neil Harbour. | Pictou. | | | |
| August 23 | 1 47 | 3 25 | 1 38 | | |
| | | | | + 41 minutes. | |
| " 23 | 15 18 | 17 37 | 2 19 | | |
| | | | | — 57 " | |
| " 24 | 2 50 | 4 12 | 1 22 | | Maximum south. |
| | | | | + 61 " | |
| " 24 | 16 30 | 18 53 | 2 23 | | |
| | | | | — 78 " | |
| " 25 | 4 05 | 5 10 | 1 05 | | |
| | | | | + 60 " | |
| " 25 | 17 25 | 19 30 | 2 05 | | |
| | | | | — 50 " | |
| " 26 | 5 05 | 6 20 | 1 15 | | |
| | | | | + 44 " | |
| " 26 | 18 13 | 20 12 | 1 59 | | |
| | | | | — 29 " | |
| " 27 | 6 05 | 7 35 | 1 30 | | |
| | | | | + 28 " | |
| " 27 | 18 57 | 20 55 | 1 58 | | |

The last table brings out in the clearest light the pre-eminent advantage of St. Paul Island over the other localities in Cabot Strait, as a station to command the whole region under consideration. This advantage must depend largely upon its being situated in deep water; the 100-fathom line being within three miles of the eastern shore of the island, on which the tide gauge is situated. It emphasises also the importance of chosing strategic points as principal stations, whatever the exposure and the difficulties in maintenance may be, in preference to sheltered harbours where the tide itself is more irregular, owing to shallower water or greater local interference.

### NORTHUMBERLAND STRAIT.—TIME OF THE TIDE.

In the season of 1896 a series of simultaneous observations in Northumberland Strait was obtained at the following localities, in the order of the progress of the tide: Souris, Pictou, Charlottetown, and Cape Tormentine. Some comparative observations were also obtained on the open Gulf coast on the north shore of Prince Edward Island and in Miramichi Bay. These observations when compared with the 'Establishments' for intermediate localities in Northumberland Strait, were sufficient to enable a table of 'Tidal Differences' to be prepared, to accompany the tide tables for this region. The remaining localities on the open Gulf coast were referred directly to St. Paul Island. The results are given, together with the general method used in the calculation of the tide tables for Northumberland Strait, in the Tidal Survey Report of December 15 1898, pages 7 to 10.

In the season of 1901 further observations at Pictou, Charlottetown and Summerside were obtained, to secure more extended data for the calculation of tide tables for these ports. This year was an appropriate one for the purpose in view, as the moon's declination has now its minimum range, whereas in 1896 the range was at its maximum. The tides throughout this region vary chiefly in accordance with the moon's declination; and diurnal inequality is thus a ruling feature of the tide. The observations at Pictou, the port of reference for this strait, extended from May 20th to November 15th without any interruption of consequence. These will enable a revised table to be prepared for the calculation of the tides at Pictou from the principal tidal station at St. Paul Island, for years when the moon's declination is low. The table in use up to the present time is given in the Tidal Survey Report for 1898, page 9. All the observations are taken in Atlantic standard time and the differences are thus in absolute time throughout.

*Charlottetown.*—The observations obtained here in 1896, were much interrupted by the chokage of the inlet to the gauge. At the ends of the wharfs which extend to the channel, the water is deep; but these are constantly occupied by shipping. At their sides, the water shallows at once, and there is great difficulty in securing low-water observations with a recording gauge. In 1901, the gauge was placed at Connolly's wharf, where sufficient depth was secured; but there is more exposure and much interference from the bridge operations now in progress. The object aimed at, is to obtain the difference of time with Pictou for the calculation of the Charlottetown tide tables; and the results secured in the two seasons are as follows:—

1896. Observations from June 20th to November 24th.

From 104 reliable differences, H. W. 51 m. later than at Pictou.
" 99 " " L. W. 58 m. " "

1901. Observations from June 1st to November 15th.

From 255 differences, High Water 31 m. later than at Pictou.
" 259 " Low Water 47 m. " "

The divergence in the values is considerable; and on so long an average, it is difficult to account for. The individual differences also show a wide range in their varia-

tion. In the case of high water for which the divergence is greatest, a further distinction was accordingly made between spring and neap tides, by dividing the month into four quarters. The result is as follows; the observations of both years being combined, and the value given for low water being the general average.

Tide at Charlottetown later than at Pictou:—

For High Water.—About the time of Spring Tides, 42 m. later.
About the time of Neap Tides, 30m. later.
For Low Water.—Throughout the month, 50m. later.

*Summerside.*—The tide-curves here show the effect of tidal interference to a more marked extent than at Charlottetown. The curve at low water is frequently much flattened; or in other words, the tide stands at nearly the same level for an hour or two before rising.

A trial comparison of the difference in the time of the tide for a period of one month was made with both Pictou and St. Paul Island, the two reference stations in this region. It was thus ascertained that the variation with St. Paul Island is 40 per cent greater than with Pictou in the case of high water, and 14 per cent greater in the case of low water.

Accordingly, the difference in the time of the tide between Summerside and Pictou was worked out for the whole period of the observations, from June 12 to November 15, the average results being as follows:—

From 236 differences, time of High Water 50m. later than at Pictou.
From 231 " time of Low Water 1h. 15m. " " "

The extreme variation in the individual differences of time, amounts to 42 minutes more or less than these averages; which illustrates the large irregularity that results from tidal interference in this strait, especially towards its west end; as the dominant tide advances along the strait from the eastern end.

The following table gives the resulting tidal differences for the strait, when revised to accord with the latest information obtained. The values for the intermediate places were found from the differences of "Establishment" taken in both directions from the localities at which the new observations have been secured.

Tidal Differences for Northumberland Strait, to be Applied to the Time of the Tide at Pictou, to give the Time of High and Low Water in Atlantic Standard Time (for the 60th Meridian).

| Locality. | For High Water. | For Low Water. |
|---|---|---|
| | H. M. | H. M. |
| Souris | Sub. 1 17 | Sub. 1 15 |
| Port Hood | " 1 02 | ..... |
| Cape Bear | " 0 57 | ..... |
| Cape George | " 0 45 | ..... |
| Pictou | Add 0 00 | Add 0 00 |
| Tatamagouche | " 0 04 | ..... |
| Pugwash | " 0 36 | ..... |
| Charlottetown | " 0 37 | Add 0 50 |
| Cape Tormentine | " 0 23 | " 0 43 |
| Baie Verte | " 0 27 | ..... |
| Summerside | " 0 50 | Add 1 15 |

*Observations secured to date.*—The amount of tidal record secured so far at the summer stations in these regions, is shown in the following table. At all the localities mentioned, the observations have been secured with self-registering tides gauges. The use of such gauges which give a continuous record day and night, is specially advantageous where the two tides of the day are so unequal.

These observations have furnished simultaneous comparisons with St. Paul Island and Pictou; which afford the basis for the calculation of the tide tables published for Pictou and Charlottetown; and also for the tidal differences above given, which are published in the tide tables.

| Locality. | Year. | Period of Tidal Record. | No. of Tides compared. H. W. | No. of Tides compared. L. W. | Port of Reference. |
|---|---|---|---|---|---|
| Lower Neguac | 1896 | 3 months | 102 | ..... | St. Paul Island. |
| Alberton | 1896 | 11 days | 13 | ..... | " " |
| St. Peters | 1896 | 29 " | 31 | ..... | " " |
| Neil Harbour | 1901 | 2¾ months | 130 | 116 | " " |
| Port aux Basques | 1901 | 3½ " | 158 | 150 | " " |
| Souris | 1896 | 5½ " | 165 | 156 | Pictou. |
| Pictou | 1896 | 6½ " | 716 | 711 | St. Paul Island. |
| " | 1897 | 3½ " | | | |
| " | 1901 | 6 " | | | |
| Charlottetown | 1896 | 3 " | 104 | 99 | Pictou. |
| " | 1901 | 5½ " | 255 | 259 | " |
| Cape Tormentine | 1896 | 1½ " | 58 | 67 | " |
| Summerside | 1901 | 5 " | 236 | 231 | " |

NORTHUMBERLAND STRAIT.—TIDE LEVELS, AND LOW WATER DATUM.

*Pictou, N.S.*—The Bench-mark to which the levels are referred, is the surface of the stone door sill at its south end, in the door way of the Custom House building which faces the Harbour.

| | Feet. |
|---|---|
| Elevation adopted for the Bench mark as above | 100·00 |
| Extreme High Water, which occurred during the 'August gale,' on August 9, 1873. The highest tide known, but not definitely recorded | |
| Exceptional High Water; a night tide in December, 1889, as marked by the Harbour Master at the time. It occurred during a gale from the north and north-west | 90·86 |
| Exceptional High Water of December 5, 1900; as marked at the time by Mr. Peter Fraser | 89·72 |
| Highest tide recorded by the tide-gauge during the season of 1896, from June 3, to November 27. Occurred during a storm on November 6 | 88·35 |
| Highest tide recorded by the gauge during the season of 1897, from June 21 to November 30. Occurred during a storm on November 27 | 88·40 |
| Several tides in these seasons reached elevation | 87·65 |
| Highest tide recorded by the gauge during the season of 1901, from May 20 to November 15. Occurred on October 1 (A storm tide on November 10, was 0·05 foot higher.) | 87·85 |
| LOW WATER DATUM, based upon the average elevation of the lower of the two Low Waters in the day, at spring tides, during the three seasons of 1896, 1897 and 1901 (This should be the same as the low water datum of the Charts, as nearly as can be ascertained by the observations of these three seasons.) | 81·40 |
| Lowest Low Waters recorded by the gauge in each of the three seasons, between the dates already given :— | |
| Season of 1896, on June 26 | 80·25 |
| Season of 1897, on November 27 | 80·15 |
| Season of 1901, on May 20 | 80·02 |
| Zero of the scale of the tide gauge in 1896 | 80·16 |
| " " " in 1901, set six inches lower than in 1896 | 79·66 |

*Charlottetown.*—There is no City datum ; although an approximate level for Low Water was obtained from a short series of tidal observations when the drainage system was put in ; and more recently, the tide levels established by this Survey in 1896 have been made use of. There is no Bench-mark to record and fix the Low-water datum of the charts. The Bench-marks established by this Survey have enabled a uniform datum to be used for the tidal observations of 1896 and 1901. By the instrumental levels taken last season, all the information extant with regard to extreme high and low tides, has been referred to these Bench-marks, which thus serve to fix permanently all the important tide levels ; and the datum adopted in 1901 for the Hillsborough bridge now under construction, has also been connected with them. They are as follows :—

Original Bench-mark of 1896. On Peake's building at the south-west corner of Queen and Water streets. The northern end of the sandstone window sill, next to the corner, on the front of the building facing on Queen street. Elevation, 100·00.

New Bench-mark, 1901. On a brick block at the south-west corner of Queen and King streets. The top of the sand tone plinth at the cornar, on the side facing King street ; the level being the same as the joint between the sandstone foundation and the brickwork on the King street side of the block. Marked by an inverted broad arrow on the stone above the plinth, and the letters B. M. Elevation, 103·18.

(The elevation of this Bench-mark above the Hillsborough bridge datum is 108·49.)

| | Feet. |
|---|---|
| Exceptional High Waters during gales ; being night tides on October 11-12 and on December 5, 1900, the latter being the higher of the two. Average level of three points marked at the time by the Harbour Master and by Mr. G. Handrahan | 95·30 |
| Top of cap of wharf beside the tide gauge, at the south-west corner of Connolly's wharf | 94·09 |
| Highest High Water recorded by the gauge in the season of 1896. Occurred November 6 ; level raised by a storm | 93·90 |
| Highest High Water recorded by the gauge during the season of 1901, from May 30 to November 15. Occured on October 1 | 93·95 |
| Low Water Datum, based upon the average elevation of the lower of the two low waters in the day, at spring tides, during the two seasons of 1896 and 1901 | 84·80 |
| Lowest Low Water recorded by the gauge in the season of 1896 ; a number of those in the early part of the season being lost on account of chokage when the tide was low. Occurred October 9 | 84·35 |
| Lowest Low Water recorded by the gauge during the season of 1901, between the dates already given. Occurred October 29 | 84·00 |
| Exceptional Low Water, as observed by the Engineers of the Hillsborough bridge ; 1901 May 20 | 83·03 |
| Zero of the scale of the gauge in 1896 | 81·80 |
| " " " in 1901, set one foot higher than in 1896 | 82·80 |
| Level of the inlet of the tide column in 1901 | 78·03 |

*Summerside, P.E.I.*—A Bench-mark has lately been established here by Commander Tooker, R.N., to define a Low-water datum for the recent surveys made under his direction. As it is only attached to a pile wharf, however, it was deemed advisable to carry instrumental levels to one of the few masonry buildings in the town, for greater permanence.

The point chosen as a Bench-mark was at the north-east corner of Holman's block; the joint between the stone foundation and the brick-work, at the top of the course which forms the door-step level all along the street front of the building.

| | Feet. |
|---|---|
| Elevation adopted for the Bench-mark as above | 100·00 |
| Exceptional High Water. Night tide on October 11, 1900. Six points marked at different places in the harbour as the level reached by the water, were found to range in elevation from 90·07 to 90·31. Mean value | 90·21 |
| Highest High Water recorded by the gauge during the season of 1901, from July 12 to November 15. Level raised by a storm on November 14 | 87·60 |

| | |
|---|---|
| Highest High Water undisturbed by storms. Occurred on June 17 | 87·30 |
| Bench-mark established by Commander Tooker. A broad arrow of sheet copper, placed on a pile on the east side of the Government wharf, nearly abreast of the lighthouse | 87·30 |
| Admiralty Low Water datum, defined as 7·60 feet below this Bench-mark | 79·70 |
| Lowest Low Water recorded by the gauge during the season of 1901, between the above dates. Occurred on October 30 | 80·10 |
| Zero of the scale of the tide-gauge | 79·30 |

*Sydney, C.B.*—The city datum was utilized for the tidal observations. To do this, it was necessary to carry the city levels half a mile further to the site of the gauge, which was placed at the Intercolonial Railway wharf at Battery Point. A Bench-mark was cut on the court house, on the corner of Charlotte and Desbarres streets, which is the nearest masonry building to the sight of the gauge. It is cut on the stone-work on the south side of the basement doorway, under the main entrance; on the west side of the building.

| | Feet. |
|---|---|
| New Bench-mark cut on the court house, as above described. Elevation above the Sydney city datum | 57·20 |
| Cap of the wharf at the tide-gauge, Battery Point | 10·43 |
| Highest High Water recorded by the gauge during the observations from July 4 to August 6, 1901; occurred on July 17 | 5·35 |
| Lowest Low Water recorded, in the same period; occurred on July 16 | 0·10 |
| The Sydney city datum. (Intended for Low Water) | 0·00 |
| Zero of the scale of the tide-gauge; below datum | −1·51 |

*Port aux Basques, Newfoundland.*—The point made use of as a Bench-mark, is the top of an iron eye-bolt let into the rock, six feet west of the north-west corner of E. Pike's fish store: at the head of the Government wharf.

| | Feet. |
|---|---|
| Bench-mark as above; elevation adopted | 100·00 |
| Highest High Water recorded during the season of 1901, from July 9 to November 1 | 93·95 |
| Low Water datum; based upon the average elevation of low water at spring tides, as observed during the season | 88·60 |
| Lowest Low Water recorded during the season of 1901; occurred October 29 | 88·25 |
| Zero of the scale of the gauge | 86·13 |

*Comparison of Spring Tides in Northumberland Strait.*—In the season of 1901, the moon's perigee nearly coincided with the new moon in May and June; and in June the maximum declination also occurred at new moon. In this region the moon's declination is the ruling astronomical factor; as it gives rise to the diurnal inequality which is here so pronounced. In consequence, one of the two tides in the day had an unusual range in June. Conditions favourable to extreme tides did not recur till the autumn, the perigee falling near the full moon in October and November, with high declination. At St. Paul Island the diurnal inequality is less pronounced; and in consequence the spring tides are more nearly equal throughout the season. But only those at the corresponding dates are given for comparison with the tides in Northumberland strait.

The elevations given for comparison are not referred to the same datum throughout; there being as yet no continuous datum established in Canada. Each set of levels is therefore referred to its own local datum.

| St. Paul Island, N. S. | | | | Pictou, N.S. | | | |
|---|---|---|---|---|---|---|---|
| Date. | High Water. | Date. | Low Water. | Date. | High Water. | Date. | Low Water. |
| Sat. June 15.... | 6.30 | Mon. May 20.... | 2.15 | Sat. June 15.... | 87.50 | Mon. May 20.... | 80.02 |
| Mon. June 17.... | 6.45 | Tue. June 18... | 2.50 | Mon. " 17.... | ... | Tue. June 18.... | 81.20 |
| Wed. July 17.... | 6.65 | Sat. July 13.. | 2.80 | Wed. July 17... | 87.40 | Sat. July 13.... | 81.25 |
| Mon. Sept. 30*... | 7.10 | Tue. " 16.... | 3.00 | Tue. Oct. 1.... | 87.85 | Sun. Sept. 29 .... | 81.40 |
| Fri. Oct. 25.... | 6.75 | Sun. Sept. 29.... | 3.05 | Mon. Oct. 28.... | 87.25 | Tue. Oct. 29.... | 80.60 |
| Mon. Oct. 28.... | 6.50 | Tue. Oct. 1.... | 3.05 | Sun. Nov. 10*... | 87.90 | Wed. Oct. 30.. . | 80.65 |
| Sun. Nov. 10.. | 6.55 | Tue. Oct. 29.... | 2.60 | ..... | ..... | ..... | |

| Charlottetown, P.E.I. | | | | Summerside, P.E.I. | | | |
|---|---|---|---|---|---|---|---|
| Date. | High Water. | Date. | Low Water. | Date. | High Water. | Date. | Low Water. |
| ..... | .... | Mon. May 20.... | 83.03 | Sat. June 15.... | 87.25 | ..... | |
| Mon. June 17... | 93.80 | Tue. June 18.... | 84.45 | Mon. " 17.... | 87.30 | Tue. June 18.... | 80.50 |
| Wed. July 17.... | 93.55 | Wed. July 17.... | 84.90 | Wed. July 17.... | 87.20 | Sat. July 13.. . | 80.40 |
| Tue. Oct. 1.... | 93.95 | Wed. Oct. 2.... | 84.75 | Thur. Oct. 3 .... | 87.20 | Wed. Oct. 30.... | 80.10 |
| Mon. Oct. 28.... | 93.75 | Tue. Oct. 29 .. | 84.00 | Thur. Nov. 14*... | 87.60 | ..... | |

* Tides marked thus, are raised above their true level by storms.

*Effect of the Wind on the Height of the Tide in Northumberland Strait.*—As a rule, the tide is highest with north-east wind, and lowest with south-west wind. This is in accordance with the general course of the tidal undulation in its progress along the north-west side of Cape Breton island, in approaching the eastern end of the strait; as these winds are in its favour or contrary to its direction.

*Weather Conditions at the time of the Exceptional High Waters in Northumberland Strait, above given.*—At Pictou, Charlottetown and Summerside, meteorological observations are taken regularly at 9, 14 and 21 o'clock. The wind record is thus for the day time only; and the barometer readings may not give the actual maxima and minima which occur.

The exceptional high water on the night of October 11-12, 1900, is the highest on record at Charlottetown and Summerside, P.E.I. At Charlottetown there was a gale before and after; but it calmed down at about midnight and the tide rose suddenly, flooding the wharves. At Summerside the conditions were precisely similar. The weather conditions on the two sides of the strait at the time were as follows:—

At Pictou; barometer on October 9 at 14 o'clock Standard time, 30.15; falling steadily till the 11th at 21 o'clock when it reached its lowest, 29.15.

| | | | | | |
|---|---|---|---|---|---|
| October | 9 | Wind | north-east all day. | Force III to IV, | Beaufort scale. |
| " | 10 | " | north-east to east. | " IV to III, | " " |
| " | 11 | " | east to north-east | " IV to VIII, | " " |
| " | 12 | " | south-west & north-west | " IV to III, | " " |

At Charlottetown, the barometer fell steadily from 30·270 on October 9 at 21 o'clock; the lowest observed being 28·893 on the 11th at 21 o'clock, Standard time. On the 11th there was a violent rain storm from 18 to 20:30 o'clock.

October 9. Wind north-east and east all day. Rainy.
" 10. Wind east, falling to calm. Raining.
" 11. Wind south-east, east, and south-west. Rain heavy at times.
" 12. Wind north-east or calm. Weather clearing.

At Summerside, the weather observations were as follows:—

October 9. Wind north-east, with rain; all day.
" 10. Wind " "
" 11. Wind east and north-east all day. Rainy.
" 12. Wind north, changing to north west in the afternoon.

At the time of the exceptional high water on December 5, 1900, the wind was also north-east, amounting to a moderate gale. At Pictou the barometer reached its lowest, 29·23, on the 5th at 14 o'clock. The wind record was as follows:—

December 4. Wind west to north-west. Force II to VI, Beaufort scale.
" 5. " north-east all day. " VII to VI, "
" 6. " north-west all day. " III to I, "

## CURRENT IN NORTHUMBERLAND STRAIT.

Observations of the turn of the current were taken in 1901 on the north side of Pictou island, from June 20 till September 15; a total of 164 observations being secured. These were compared with the simultaneous tidal records at Pictou, which has proved the best port of reference for Northumberland strait; and with the tide at St. Paul island, the principal tidal station for this region.

In these comparisons between the time of the turn of the current in the strait and the time of the tide, it was found that the variation in the difference of time was somewhat greater with Pictou than with St. Paul island. It will therefore be better eventually to refer the current directly to the tide at St. Paul island; as the tide tables for Pictou are deduced from that station, and the ultimate reference is to St. Paul island in either case. This will be the best mode of procedure when sufficiently extended observations have been secured to enable a current table to be computed for this strait; but for our present purpose, to indicate the laws which govern the current, we may make the reference to Pictou, the nearer station.

The variation in the difference of time between the turn of the current and the tide is large; as the turn may take place as much as two hours before high water or after low water. The greater part of the variation follows the change in the moon's declination; as this has been found from the first to be the ruling element in this region. This is very confusing to the mariner, as the turn of the current in relation to the tide is out of accord with the moon's phases, and has thus no fixed relation to the spring and neap tides. The greatest apparent irregularity is when the moon's declination is at its maximum; and this occurs sometimes at the spring tides and sometimes at the neaps. The ordinary navigator takes refuge in the conclusion that the currents are chiefly influenced by the wind.

In the case of a tide which is ruled by declination, the chief variation is of the nature of a diurnal inequality. To arrive at correct conclusions, it is therefore important to have observations both day and night. The shore observations which were the only ones that could be taken in the circumstances, could only be obtained in the day time; but to make up for this, a careful analysis of the results was made, on which we will endeavour to base, as concisely as possible, a statement of the laws governing the current in this strait. These laws are well established by the observations; but the amounts of the time-intervals between current and tide are subject to revision, as the length of these observations was not sufficient to eliminate irregularities due to weather conditions.

RELATIONS BETWEEN THE TURN OF THE CURRENT IN NORTHUMBERLAND STRAIT, AND THE TIME OF HIGH AND LOW WATER.

(1.) The time-interval between the turn of the current and the time of the tide, is found to vary with the moon's declination; and the leading variations in this time-interval may be classified as follows:—

For the turn of the current when the tide is high: After an upper transit of the moon at its maximum north declination, or after a lower transit at maximum south declination, the turn occurs at $1^h\ 44^m$ *before* high water at Pictou. For the turn of the current when the tide is low: After a lower transit at maximum north declination or an upper transit at maximum south declination, the current turns at $1^h\ 52^m$ *after* low water at Pictou.

For the turn of the current at a time of maximum declination which comes after the opposite transits of the moon to those above indicated, the interval is as follows:—

For the turn when the tide is high, $14^m$ *before* H. W. at Pictou.
" " " " " low $18^m$ *before* L. W. at Pictou.

Hence for consecutive tides, there is an alternation in the time-interval, which is of the same character as the diurnal inequality in the tide itself. From the amounts above given, this alternation in the time-interval between the turn of the current and the time of the tide, has the following maximum values:—

At consecutive high waters, $1^h\ 30^m$. At consecutive low waters, $2^h\ 10^m$.

(2.) When the moon is near the equator, the turn of the current on the average, is nearly simultaneous with high and low water at Pictou. This average includes both the spring and neap tides.

(3.) Again, when the spring tides only are considered, and an average is taken which is long enough to eliminate the variation due to declination, the turn of the current is within 20 minutes of the time of high or low water at Pictou. The variation with the moon's phases thus appears to be small in comparison with the declination variation, and such irregularities in the turn of the current as may be due to wind disturbance.

The results, at the time of the moon's maximum declination, may be put in a tabular form as shown below. The low tide is the first to occur after the moon's transit.

MOON AT MAXIMUM DECLINATION NORTH.

| After Moon's Upper Transit. | | After Moon's Lower Transit. | |
|---|---|---|---|
| Tide Low : | Tide High : | Tide Low : | Tide High : |
| 18m. before L. W. | 1h. 44m. before H. W. | 1h. 52m. after L. W. | 14m. before H. W. |

MOON AT MAXIMUM DECLINATION SOUTH.

| After Moon's Upper Transit. | | After Moon's Lower Transit. | |
|---|---|---|---|
| Tide Low : | Tide High : | Tide Low : | Tide High : |
| 1h. 52m. after L. W. | 14m. before H. W. | 18m. before L. W. | 1h. 44m. before H. W. |

*Further observations this year.*—The observations of the current in Northumberland strait this year, were taken at its narrowest part, between Cape Tormentine and Cape

Traverse. They were obtained last winter and again in the summer season, as described further on in this report. These observations have not yet been worked out fully; but the turn of the current here also, can best be referred to St. Paul Island.

PACIFIC COAST TIDES.—SUMMARY OF RESULTS TO DATE.

The new information which has now been reduced to practical shape may be summarized as follows:—

(1.) A comparison between the tide at Victoria and Esquimalt during six months in 1900, from simultaneous records obtained at the two places. (2.) A similar comparison between New Westminster and Sand Heads during four months at the four quarters of the year. (3.) Six months simultaneous comparison of the tide at Vancouver and Sand Heads in 1901, by which the time and the range of the tide at Vancouver becomes known from the tide tables for Sand Heads. (4.) Six months observations at Baynes Sound near the north-east end of the Strait of Georgia, compared with the simultaneous record at Sand Heads. (5.) An endeavour to recover the original datum at Victoria, or the low water level to which the soundings are referred on the chart of that harbour. (6.) The turn of the current in First Narrows, Burrard inlet, from six months observations taken in 1901 and compared with simultaneous tidal record. (7.) The current in Seymour narrows from observations taken by the U. S. Coast Survey in 1897, compared with the tide at Sand Heads.

All the tidal observations above indicated, were obtained by means of self-registering tide gauges. It may be noted that on the Pacific coast, there is not only a large diurnal inequality but also an annual variation. Hence to make satisfactory comparisons, it is necessary either to have six months of continuous observation at the two localities, or to take four months at the four quarters of the year. The stations for which tide tables are calculated are Victoria, in Fuca strait, and Sand Heads in the Strait of Georgia; and these are better situated for purposes of comparison and give much better results, than can be obtained from comparisons with the United States tidal station at Port Townsend, on which the information for British Columbia given in their tide tables, is based. The reason for this is the different character or type of the tide at these tidal stations, as already explained in the Report of December, 1900, page 7.

The results of the above observations and investigations have now been embodied in the annual tide tables for British Columbia, which were first published for the year 1901. All the results are in Pacific Standard time, and the differences are thus in absolute time.

*Esquimalt.*—Although this port is only 4 miles distant from Victoria, there is a considerable variation in the time of the tide between the two places. The observations extend over six months from May to October in 1900, and the resulting averages are given below. It will be noted also that the time of the tide is in reality later at Esquimalt than at Victoria, while in the United States tide tables both high and low water were given as earlier up to 1900; and the time of low water is still given as earlier.

From 223 differences, H. W. at Esquimalt is 14m. later than at Victoria.
" 246 " L. W. " 17m. " "

*New Westminster.*—A comparison with Sand Heads has been made during four months at the four quarters of the year; namely, December, 1899, and March, June and September, 1900. The time of high water at New Westminster is 40 minutes later than at Sand Heads, on the average. During the freshets in the early summer, when the water in the river is high, the time of high water is about half an hour later still.

The variation in the time of low water is very great. A general average value, based upon the lower low waters, shows that low water usually occurs at New Westminster 2 h. 30 m. after low water at Sand Heads. The higher low waters occur only half an hour to one and a-half hours after low water at Sand Heads. This uncertainty is of less importance, however, as these low waters are little felt at New Westminster.

*Baynes Sound.*—The observations were taken at the Union wharf by the officers of H.M.S. *Egeria*, and they kindly handed over the original records to the Resident Engineer of Public Works at New Westminster, from whom they were obtained for this Survey. This record extends in all from May, 1898, to June, 1899, and from November, 1899, to June, 1900. Parts of this record were complicated by troublesome time errors or were too much broken by interruptions to be serviceable. A continuous period of six months was selected as the most reliable for comparison with the simultaneous record at Sand Heads. This period extended from December 1, 1898, to May 31, 1899, with an interruption in January, which was supplied from a corresponding period in the following year. This afforded a time comparison between 325 corresponding tides at the two places.

The result is important, as it affords definite information as to the run of the tide throughout the length of the Strait of Georgia almost as far north as the southern tide runs, before meeting the contrary tide from the other direction. The difference in the time of the tide is very little; which may be accounted for by the great depth of the water, about 100 fathoms continuously, which accelerates the tidal undulation. There is also an evident variation with the season of the year, which shows the need of taking a period of a half-year to obtain a correct general average.

TIME OF TIDE IN BAYNES SOUND, COMPARED WITH SAND HEADS. (Monthly averages.)

| — | Dec. | Jan. | Feb. | Mar. | Apr. | May. |
|---|---|---|---|---|---|---|
| | mins. | mins. | mins. | mins. | mins. | mins. |
| Difference for H. W. | +3 | −1 | 0 | +6 | +8 | +13 |
| Difference for L. W | −2 | −2 | −1 | 0 | 0 | + 6 |

General average.—H. W. in Baynes Sound, 5 m. later than at Sand Heads.
L. W. " 0 m. (simultaneous with Sand Heads.)

*Time of the Tide at Vancouver.*—The comparisons between corresponding tides at Vancouver and Sand Heads have now been extended to a period of nearly six months from observations secured in 1901; and the result was worked out promptly for publication this year in the tide tables. The actual periods of the simultaneous comparisons are, June 14 to August 14, and October 12 to December 31. The difference in the time of the tide when reduced to monthly averages, is as follows:—

TIME OF TIDE AT VANCOUVER, COMPARED WITH SAND HEADS. (Monthly averages.)

| — | July. | Aug. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|
| | mins. | mins. | mins. | mins. | mins. |
| Difference for H. W | 31 | 33 | 26 | 24 | 27 |
| Difference for L. W | 28 | 32 | 22 | 31 | 27 |

General average.—H. W. at Vancouver, 28 m. later than at Sand Heads.
L. W. " 29 m. " "

*Range of the Tide at Vancouver.*—To find the relation of the ranges at Vancouver and Sand Heads, a comparison was made for two months, June 14 to August 14, 1901.

It was found that the range at Vancouver was greater in proportion when the range itself was less, and vice versa. The point of equality corresponds to a range of 8½ feet at Sand Heads. The rule given below is based upon average values.

To find the range of the tide at Vancouver, from the range at Sand Heads which is shown in the tide tables:—

(1.) When the range at Sand Heads is large (more than 8½ feet), deduct 5 per cent.
(2.) When the range at Sand Heads is small (less than 8½ feet), add 5 per cent.

*Current in First Narrows, Burrard Inlet.*—Observations at the Narrows were obtained during six months from April to September, in 1901; and instead of comparing these with Vancouver, a direct comparison was made with the tide as observed simultaneously at Sand Heads. In this way a difference is obtained by which the time of slack water in the Narrows may be found at once from the tide tables published for Sand Heads. There is remarkably little variation in the monthly averages, considering that the time of slack water is necessarily much less definite than the time of high water. The chief irregularity in the difference, is in the case of the small tides of little range when the movement of the current is slow, and the true moment of slack water is itself uncertain. The average of 181 observations at high water and 205 at low water gives the following result:—

Slack at High Water occurs 54m. after H. W. at Sand Heads.
Slack at Low Water occurs 50m. after L.W. at Sand Heads.

*Current in Seymour Narrows.*—The observations obtained by the U. S. Coast Survey in 1897, were compared with the simultaneous observations of the tide at Sand Heads, in the hope of establishing a reasonably constant difference in time between them. The variation in time proved to be very wide, however, amounting occasionally to one and half hours, earlier or later than the average value. Also, this variation appears chiefly to follow the change in the moon's declination, which throws it out of accord with the spring and neap tides. The most marked feature when the tide is governed by declination, is the diurnal inequality; and as these observations were taken in the day time only, they were not sufficiently continuous or extended to establish a law by which this large variation could be taken into account.

*Victoria. Datum plane of reference.*—It is highly desirable in tidal observations, that the height of the tide should be referred to the original Low-water datum used for the soundings on the chart. When this is the case, the navigator has only to add the height of the tide to the soundings, to know the available depth of water. The primary importance of establishing a Bench-mark to indicate the Low-water datum of the soundings is rarely recognized, however.

The records of such a Bench-mark at Victoria, were lost in the fire at New Westminister, when the Public Works office was destroyed. It is always a matter of great difficulty to re-establish the low-water datum when it is lost; and it is quite evident that all questions of depth, alteration of shoals, grounding of vessels, &c., depend upon the true elevation of the plane of reference for the soundings being known and fixed permanently by reference to a Bench-mark.

Last season, Captain Walbran, of the D. G. S. *Quadra*, endeavoured to pick up the plane of reference at Victoria, from soundings on the shallows bordering the channel, taken during calm weather.

In this he was assisted by Mr. F. N. Denison, who recorded the height of the tide simultaneously. In the tide tables, the height of the tide is referred to the plane of reference used during the period of the observations themselves. A harmonic analysis has now been made from the two years of observation; and the levels resulting make it possible to draw some conclusion as to the level of the water known as "Low water ordinary spring tides," to which soundings are usually referred. The large diurnal inequality makes this less definite however, than in regions where the tides are more regular. The levels referred to the plane of reference of the tidal observations are as follows:—

| | Feet. |
|---|---|
| Mean Sea Level. From two year's observation, from April 1895 to April 1897... | 5·75 |
| Harmonic Tide Plane; at a distance below Mean Sea Level given by the sum of the harmonic constants $M_2 + S_2 + K_1 + O$..... | 0·89 |
| Lower Low Water; including in addition to the above, the remaining harmonic constants which represent the diurnal inequality..... | 0·06 |

The last elevation given, corresponds closely with the datum of the tide tables. The only elements in the tide which carry it below this level, are the influence of the moon's perigee when it coincides with the above extremes, and the annual variation in the tide.

This shows that the datum plane of the tide tables is as low as it can be put with any reason, and the probability seems to be that this is fully as low as the low-water datum of the chart soundings. This is also corroborated by the results deducible from the special soundings above referred to. It is the practice of the Admiralty also, where there is a pronounced diurnal inequality, to take the lower low water as the reference level. It therefore appears probable that the plane of reference for the height of the tide as used in the tide tables, corresponds with the original low-water datum of the charts, as nearly as can now be ascertained.

*Further observations.*—The observations at Vancouver, B.C., were resumed on March 1, to secure better tidal data for that port. Also, on the occasion of the visit of the Chief Engineer to that coast in July, he made arrangement with the officers of the Meteorological Service for the erection of two gauges to obtain records of the tide of the open Pacific. One of these was placed at Bamfield creek, in Barkley Sound, on the west side of Vancouver Island; at a sufficient distance from the entrance to Fuca Strait to be out of the influence of its currents. The other gauge was placed at Port Simpson, B.C., which is open to the Pacific in both directions through Hecate Strait and Dixon Entrance. The recording instruments used at these stations are of the Richard type; a scale adapted to the range of the tide being obtained by a suitable alteration in the wheel-work.

The principal tidal station in the Strait of Georgia, situated at Sand Heads, has failed to record low water since June; on account of an alteration in the sand bars which now bank in the water at low tide. The neighboring tidal station at Garry Point will meantime be utilized by means of a double reference, in making comparisons with other harbours in the strait. Mr. G. A. Keefer, Resident Engineer of the Public Works department, will have the gauge at Sand Heads moved further out, where the water will have unimpeded access to it. Previous to the time of the above interruption, the length of tidal record which has been submitted to harmonic analysis, or tabulated in readiness for this analysis, amounts in all to five complete years.

## THE PRINCIPAL TIDAL STATIONS.

The seven principal tidal stations in Eastern Canada have been maintained in operation throughout the year. At Quebec, Father Point, Belle Isle strait, and St. John, N.B., the tidal record secured has been continuous. At two of the stations only, serious interruption occurred. At Halifax there was a loss of several months on account of change of observers, before a satisfactory arrangement could be made. Also, at St. Paul island the trouble continued from the threatened choking of the inlet to the tide pipes, referred to in the last report; and finally in an exceptionally severe gale on November 25, 1901, the tide gauge was partially wrecked; the crib-work being carried away, and the iron cylinder displaced. It was braced up temporarily, however, and further record was secured until January 20 following, when the gauge ceased to work. At Yarmouth, N.S., the loss of record last winter extended from January 30 till February 26. There is a similar loss there each year, as this gauge is not heated.

The tidal observations secured last year at Sydney, Neil Harbour and Port aux Basques, on the two sides of Cabot strait, showed that St. Paul island itself was much the most satisfactory station from which to deduce the tides in Northumberland strait

and the south-west side of the Gulf of St. Lawrence. On this account it was deemed advisable to make sufficient expenditure upon it, to put it in thorough condition for the future. The crib-work was rebuilt of hardwood and the irregular angles between it and the rock were filled with cement to hold it in position. The iron cylinder was partially renewed. The difficulty with the chokage of the tide pipes had been largely due to material falling from the cliff above; a friable micaceous rock which is ground up rapidly into sand. The trouble was ultimately overcome by carrying the inlet of the tide pipes in the opposite direction, by brass piping, into a narrow gully which is always kept clean by the scour of the waves. Careful instructions were drawn up, and all the necessary fittings were designed or procured for these repairs; which were carried out during July by Captain Douglas, R. N. R., with the co-operation of Mr. S. C. Campbell, the superintendent of the island. The dipleidoscope which furnishes correct time, was carefully adjusted to the meridian; and the plane of reference for the height of the tide was re-established by instrumental levels from the Bench-marks already placed for the purpose. The work was inspected by myself at the beginning of August, when the final adjustments were made.

At Forteau bay in Belle Isle strait the tide gauge required considerable improvement. A sheathing of hardwood, four inches thick, was placed on the two most exposed sides of the crib-work and secured by heavy angle-irons at the corners. The iron cylinder had settled over to an inclination of one in twelve from the vertical; and in straightening it up, it was necessary to alter the positions of both gauges inside the tide house, and to refit the sight-gauge. Every thing was put in thorough repair and the various instruments were also adjusted, as at St. Paul island.

*Types of Sight Gauge.*—In the sight-gauge at Forteau bay, wooden rods are used for the connection between the graduated staff and the float. These rods are an inch in diameter, and are made of basswood for lightness. Their length is seven feet, and they are varnished to prevent them from absorbing moisture, as this would increase their weight and depress the float. The total length of the sight-gauge was carefully set at 16.00 feet in September, 1900; and in August, 1902, its length was found by accurate measurement to be 15.99 which proves this type of sight-gauge to be perfectly reliable. It is the most satisfactory arrangement when the distance between the staff and float is not too great to preclude its use. Where this distance is greater, as at St. Paul island, where it amounts to twenty-four feet, nickel wire made into long links has proved to be the most satisfactory connection. These results are mentioned because of the great difficulty in finding any material for this connection, which would withstand sea-water and maintain its length unaffected by the heating lamps in winter.

## FIELD WORK IN THE SEASON OF 1902.

In arranging the work of the season the first consideration had to be given to the principal stations; as St. Paul island was partially wrecked and required reconstruction; the gauge in Belle Isle strait was not in a satisfactory condition; and there were difficulties at Halifax and St. John which demanded attention. Careful preparation was needed for this work, especially for the isolated places; as most of the fittings and iron-work had to be specially made. Also, with a view to the reconstruction of the tide-gauge at Father Point when the new wharf there is completed, two lengths of old boiler were secured for the tide column and stored there in readiness.

The gauges at St. John and Halifax were visited in May, and the difficulties adjusted or noted for further investigation. From June 20 to July 23 the four summer tidal stations at the southern end of Nova Scotia, between Shelburne and Yarmouth, were erected and the observations commenced. My assistant Mr. S. C. Hayden, was then left in charge of these, with headquarters at Clarke harbour; and in August and September the tidal stations at St. Paul island, Trepassey bay at the eastern end of Newfoundland, and in Belle Isle strait, were visited and put in order as explained above; and on the way, the instrumental levels required were taken at Yarmouth, Digby and Halifax. Clarke harbour was again reached on September 27 after

making a round of 2,750 miles. Notes and sketches were made of the wharfs in the harbours around the Newfoundland coast, which will be of value for future reference.

SECONDARY TIDAL STATIONS IN SOUTHERN NOVA SCOTIA.

The object of the stations established this year on the Nova Scotia coast was to secure a better connection between the Atlantic tides and the Bay of Fundy. On a length of 60 miles of coast at the southern end of Nova Scotia, the tide increases from its oceanic range of 7 feet at Shelburne or Negro harbour, to 16 feet at Yarmouth at the entrance to the Bay of Fundy. It has already been ascertained by the observations of 1898, that the tides from Yarmouth upward throughout this bay, can best be referred to St. John, N.B.; and a further object of the present observations was to ascertain the dividing line between places referable to the principal tidal stations in the two directions, St. John, N.B., and Halifax. The tidal undulation in the North Atlantic strikes squarely upon the Atlantic coast of Nova Scotia, there being little difference in the time of its arrival at any of the harbours between Cape Sable and Scatari, except where delayed locally in running up deep bays. The height of the tide also, is nearly the same throughout this distance, and this whole coast can therefore be correctly referred to Halifax.

The points selected after careful consideration were Shelburne, Clarke harbour, Barrington passage and Pubnico bay. Shelburne is sufficiently far to the eastward of Cape Sable to be beyond the reach of any influence of the Bay of Fundy and thus to give the unaffected Atlantic tide. The observations there will also furnish a check on the time at the intermediate ports from there to Halifax. Clarke harbour is practically the same as Cape Sable and the nearest point to that cape at which shelter can be secured. It thus gives the tide at the extreme outlying angle at the southern end of Nova Scotia. At Pubnico bay, which is only 18 miles north-westward, the tide already has the same characteristics as in the Bay of Fundy. Lastly, Barrington passage was selected to afford an intermediate point in the progress of the tide, at about the middle of the time-interval between Shelburne and Clarke harbour.

Another tide gauge was placed at Trepassey Bay, within 16 miles of Cape Race, the extreme south-eastern angle of Newfoundland. It is a locality difficult to reach, as with nine days travel it was only possible to obtain two days at the locality itself. The object of this station is to secure tidal data with reference to the currents in the bays on the south coast of Newfoundland.

A list of the stations established, with the length of record obtained, is given below:—

*Shelburne, N.S.*—Gauge placed on the north side of the steamboat wharf. The wharf is built of piles, to which the gauge column is braced. Tidal record from July 7 till October 10. Observer, J. C. Morrison, harbour master.

*Barrington Passage.*—Gauge placed at Robertson's wharf, at which the local steamers call. Tidal record from July 12 till October 22. Observer, E. Nickerson, captain of the ferry steamer.

*Clarke Harbour.*—Gauge placed at the Government wharf, Swim's point, at the inner end of the harbour. Tidal record from July 2 till October 22. Mr Hayden here acted as observer.

*Pubnico Bay.*—Gauge situated at Lower East Pubnico, at D'Entremont's wharf; about half a mile above the lighthouse. Tidal record from June 27 till October 20, Observer, W. H. Amiro, customs officer.

*Trepassey Bay, Newfoundland.*—Instruments and fittings shipped from Ottawa, with full instructions, on June 19th. After much correspondence and enquiry, delivered at Trepassey August 1. Gauge placed at the steamboat wharf, and observations begun on August 6, but unavoidably interrupted from August 8 till the 21, the date of my arrival there. Satisfactory observations secured from August 21 till late in November. Observer, J. L. Murphy, customs officer.

These stations were all equipped with self-registering instruments of the Richard type. The tide columns were built of timber, with a clear area of 13 by 10 inches in-

side. The total length of the columns varied from 18 to 25 feet. The installation of the gauges was similar to that described in the Report of December 1898, page 16, to which reference may be made.

*Data for time and height.*—It was not anticipated that there would be any difficulty in obtaining correct time at these localities; as they are all telegraph or telephone stations. But at Lower East Pubnico the telegraph office was closed; and the long-distance telephone elsewhere was not found satisfactory for the purpose. The only point where the time could be obtained correctly was at Barrington Passage, which is in reality the best centre of communication in the whole of this region. At the three other localities, chronometers were used, which were obtained from St. John, N.B., as soon as the necessity for them became evident. The observers were supplied with tables of correction for these chronometers, based upon their rates. The rate was also checked during the season, and at its close, by time comparisons. The time was thus kept correct to the nearest minute, which is as close as tidal observations can be made.

It was not deemed necessary to establish Bench-marks at any of these localities except Clarke harbour. At Shelburne and Pubnico, the wharves are of piling and are not liable to settlement; and the zero of the tide scale is fixed with reference to the cap of these wharves, so that it can be placed at the same elevation again should observations be resumed. The tide column at Trepassey, Newfoundland, stands on solid rock, and can be replaced without alteration in level if required again. At Clarke harbour the Bench-mark is an iron bolt drilled into the rock at 14½ feet from the north-east corner of Swim's warehouse, which is the most northerly of a set of buildings extending to the Government wharf. The level of the zero of the tide scales at the various localities is defined as follows:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Shelburne, N.S..... | Zero of tide scale | 14.12 | feet | below | cap of wharf. |
| Barrington Passage... | " " | 14.42 | " | " | " |
| Clarke Harbour..... | " " | 21.98 | " | " | the Bench-mark. |
| Pubnico Bay..... | " " | 17.58 | " | " | cap of wharf. |
| Trepassey, N'fld..... | " " | at rock surface, foot of tide-column. | | | |

## FURTHER TIDE LEVELS AND BENCH-MARKS.

Repeated endeavours have been made to ascertain the relation at Halifax between the Admiralty datum, the Royal Engineers' datum, and the City datum, none of which accord with each other. In explaining these relations care will be taken to distinguish what is reliable from what is uncertain.

The most important of these from a marine point of view, is the Admiralty Low Water datum, to which the soundings on the chart of Halifax harbour are referred. This datum is fixed by reference to a Bench-mark in the Dockyard; and it is defined as follows in a note on the chart of Halifax harbour: "The soundings are reduced to the level of Low Water Ordinary Spring Tides, viz.: 16.08 feet below a Bench-mark cut near the South-east angle of the Sail loft at the Dockyard." It is further to be noted that the tidal observations themselves show that the datum as thus defined, accords correctly with mean low water at spring tides.

The levels were carried over from this Bench-mark to the tide gauge, which is situated at the Marine and Fisheries' wharf; and the Admiralty datum as thus defined has been used throughout the series of observations as the plane of reference to which all tide levels have been referred by this Survey. The observations at Halifax were begun in 1895; and the levels have been repeatedly checked from the same Bench-Mark in subsequent years; and any changes in elevation at the gauge, due to settlement or other causes, have been carefully allowed for, to maintain the same elevation for reference throughout.

The levels of the Tidal Survey are thus consistent, and they are in accord with the chart datum. But it is highly desirable that the tide levels as now determined, should be known with reference to the other datum planes, to make them available in the construction of harbour works, city drainage, etc.

The best relation between the other two datum planes, was established by Mr. E. H. Keating when City Engineer at Halifax, from comparisons between twenty-one Bench-marks, which define the City datum and the Royal Engineers' datum respectively. From his original notes, the difference between them, as indicated by these Bench-marks, ranges from 1.61 to 1.96 feet, when two exceptional values are discarded which he has marked. The actual average of the nineteen remaining differences is 1.81 feet; and the mean value which Mr. Keating has finally adopted, places the Halifax city datum at 1.85 feet below the Royal Engineers' datum. This value for the difference has since been generally adopted.

The height reached by the exceptional tide of October 5, 1869 known as the Saxby tide, was also determined by Mr. Keating in April 1876, from the best marks that could then be pointed out to him. From the mean level of these marks, he found the elevation which this tide reached at Halifax to have been 7.90 feet above the Halifax city datum.

A further endeavour was made this season, to connect the Halifax city levels with the Bench-mark in the Dockyard, to establish a relation with the Admiralty datum. But the city Bench-marks in that vicinity were found to have both "original" and "corrected" elevations; besides showing a want of agreement with each other; and no method of working out the comparisons could be devised to give a satisfactory result. Descrepancies ranging from four inches to a foot remained outstanding which could not be accounted for, as there was no means of knowing which of them had the greater balance of probability in their favour.

The elevation of the Bench-mark in the Dockyard is given as 11.05 feet above the Royal Engineers' datum on their own plans; and it is also so noted on the chart of Halifax harbour; but there was some doubt as to this, because the Royal Engineers' datum is presumably intended for Mean Sea Level. The true value of Mean Sea Level however, as now ascertained by this Survey from four complete years of continous observation, is found to differ by 1.55 feet from this value for their datum; an error which is inadmissibly large where the range of the tide is only seven feet. From a comparison which has just been made by the Royal Engineers, the corrected elevation of this Bench-mark is 12·61 above their datum. This determination now serves to define the relations desired.

The tide levels given below, are defined by reference to the one Bench-mark. These levels have been repeatedly checked by myself; and there is no error outstanding in them which exceeds 0.01 of a foot.

| 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 Halifax Dry Dock | | 10·97 |
| Highest High Water during the tidal observations from 1895 to 1902. Occurred during a gale on November 25, 1901. Elevation reached | | 9·35 |
| Mean Sea Level. Deduced from the hourly ordinates of the tide during four complete years of observation, as follows:— | | |
| During one year, October 1895, to October 1896 | 3·391 | |
| " " January to December, 1897 | 3·515 | |
| " " " " 1898 | 3·512 | |
| " " " " 1899 | 3·492 | |
| Mean value for the four years | 3·478 | 3·48 |
| 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 this sum for the four years 1851—1852 and 1860—1861 = 2·955. Value for the year 1895·6 = 3·093 feet below Mean Sea Level which in that year was 3·391. Average elevation resulting | | 0·41 |

| Halifax, N.S.—Tidal Levels and Datum Planes.—*Continued.* | Above or below Admiralty Datum. |
|---|---|
| | Feet. |
| Admiralty Datum, or low water at ordinary spring tides; at 16·08 feet below the Bench Mark. Used as the plane of reference throughout the tidal observations since their commencement in 1895 | 0·00 |
| (The tide tables for 1903 and onwards, are referred to this plane of reference.) | |
| Level of the plane of reference used for the early tidal observations of 1851–1852 and 1860–1861. Average for the four years = 4·377 feet below Mean Sea Level: or 1·421 below the Harmonic Tide Plane. Mean elevation resulting, below Admiralty datum | 0·96 |
| (The tide tables for the years 1897 to 1902 are referred to this plane of reference.) | |
| Sill of the Halifax Dry Dock. Level of the granite sill of the dock, below Admiralty datum | 23·49 |
| (The depth of water on the sill of the dock at any tide, may therefore be found by adding 23·4 feet to the height of high water as given in the tide tables.) | |

* Extreme low water at Halifax; occurred Jan. 13, 1903. Elevation below datum = 1·38.

*Digby.*—A Bench-mark was cut on a flight of granite steps to fix the levels of the tidal observations of 1898; but unfortunately these steps have since been pulled down. Accordingly, this season, a new Bench-mark was set upon the post office building, built since; there being no masonary buildings in the town in 1898. The levels were obtained from known points on the timberwork of the long Digby pier, which were compared with each other and carried to the new Bench-mark. This is on the north side of the tower of the post office building, at the joint between the granite foundation and the brickwork. It is marked by a broad arrow cut at the upper edge of the granite, at two feet west of the basement window in that side of the tower.

| | Feet. |
|---|---|
| New Bench-mark as above described. Elevation | 108·98 |
| Top of cap on north side of pier, where the tide gauge column was placed. Elevation originally taken as 100·00 for convenience in the tide measurements | 100·00 |
| Highest high water observed in 1898; July 3, p.m. | 93·90 |
| Lowest low water observed; July 5, a.m | 64·20 |
| Inlet at foot of tide column | 63·00 |

*Yarmouth.*—As noted in the Report of December 1898, the best point for a permanent Bench-mark which could be found in the vicinity of the tide-gauge, was the brick chimney of the Kemptville Lumber Company, as it stands on a stone base built in cement; and as the foundation is carried down to the rock, it is not liable to settlement. The point used as a Bench-mark is the joint between the stone foundation and the brickwork, at the northwest corner.

Levels have been taken since, on two occasions, to obtain the relation between the Tidal Survey levels and the town datum in Yarmouth; and in this endeavour the Town Engineer, Mr. E. S. Matheson, has given his co-operation. In the best comparisons that can be obtained, there is still an uncertainty of over two inches in the result however; as will be seen from the elevations referred to the Yarmouth town datum, given below. The elevations of some additional points are now given; and the slight variation in the elevation of the tide scale is also indicated. The rail level at the railway crossing at the foot of Forrest street was originally taken as 100·00, but this was found to have changed more than an inch between 1898 and 1901, and was therefore thrown out as unreliable. The levels on hydrants are taken on top of the spindle.

| | Feet. |
|---|---|
| Bench-mark on chimney, as above described | 108·53 |
| On hydrant at the corner of Cliff and Main streets. Elevation above Yarmouth town datum = 141·88. | 137·31 |
| On hydrant at the foot of Horton street, near Water street | 103·87 |
| On hydrant at the foot of Brown street, corner of Water street | 103·32 |
| Top of stone post at south-east corner of L. E. Baker's office; at head of the Yarmouth S.S. company's wharf. Elevation above Yarmouth town datum = 93·54. | 94·81 |
| Highest high water observed in the season of 1898; July 4, p.m. | 90·45 |
| Lowest low water observed in that season; July 5, a.m. | 74·15 |
| Zero of Tide Scale; as originally set in 1898 | 72·36 |
| " " after being replaced more than once by a new scale. Elevation in September, 1901 | 72·37 |

The above levels were taken in 1901 and 1902; and as in the case of all the Tidal Survey levels published, they are reliable within 0·01 of a foot. The zero of the tide scale in 1901 was checked by two series of measurements made by two different methods; and the alteration in elevation since 1898 may be disregarded where the range of tide is sixteen feet.

## OBSERVATIONS OF THE CURRENTS IN THE SEASON OF 1902.

*Northumberland Strait.*—The current at the narrowest part of this strait was observed during last winter by noting the movements of the ice as seen from the two sides at Cape Tormentine and Cape Traverse. There was, however, less ice than usual during the season. Again, in the summer, notes were taken of the time of the turn of the current in mid-strait between these two capes. The notes were taken during the lobster season by fishermen while setting or hauling their traps. Independent notes from two men were secured under the supervision of Mr. E. Crosby, the station agent at Cape Traverse, who already had the experience of observing the drift of the ice in winter. Observations have thus been secured in winter from February 3 to March 29, and in summer from June 2 to August 23, with a comparatively slight expenditure.

*Neighbourhood of Cape Sable, N.S.*—In the offing of the coast from Cape Sable to Pubnico bay, some observations were taken this season by arranging with the fishermen to note the time of the turn of the current. The object in view was to obtain the first indraught of the current into the Bay of Fundy, with relation to the rise and fall of the tide as recorded simultaneously by the gauges on the shore opposite. The inshore fishermen in these parts do not anchor their boats, however, which makes their notes less definite than might be desired. Also, the season was unusually foggy, which occasioned much interruption in the record they were able to make. The result though thus imperfect, may give indications which will be of service until the work can be better done with adequate appliances.

*South Coast of Newfoundland.*—Information regarding the currents was obtained wherever possible while travelling during the season; from the captains of coasting steamers, and schooners accustomed to fish on the outlying banks. With regard to the alleged indraught into the bays on the south coast of Newfoundland, the best information obtained this season goes to corroborate the statements already given out by this Department, which were based upon inquiries previously made by this Survey. (See Notice to Mariners, No. 103 of 1901.) What has now been learned will also be of value as a guide in the further investigation of the currents on that coast.

Respectfully submitted,

W. BELL DAWSON,
*Engineer in charge of Tidal Survey.*