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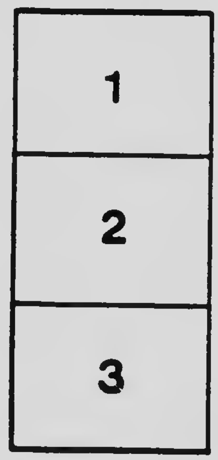

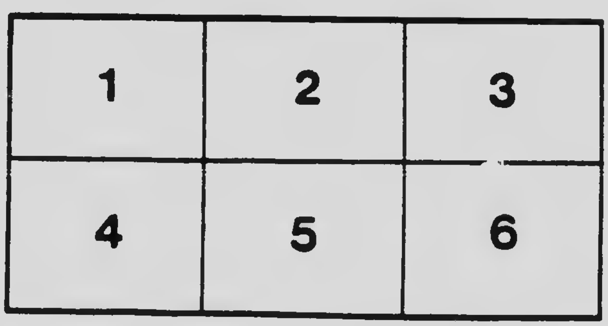

THE CURRENTS

IN THE

ENTRANCE TO THE ST. LAWRENCE

FROM INVESTIGATIONS OF THE TIDAL AND CURRENT SURVEY IN THE SEASONS OF 1895, 1911 AND 1912

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NOTE.

DIRECTIONS. The bearings are from true north throughout, as well as the directions of the wind and current. Bearings in degrees read from 0 to 360, measured clockwise.

TIME. The Time is Atlantic Standard for the 60th Meridian throughout this region; except the time of the tide at the reference station at Father Point, which is Eastern Standard as in the Tide Tables.

THE CURRENTS

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ENTRANCE TO THE ST. LAWRENCE

FROM INVESTIGATIONS OF THE TIDAL AND CURRENT SURVEY IN THE SEASONS OF 1895, 1911 AND 1912

—

OTTAWA, 17 January, 1913.

The importance of the entrance to the St. Lawrence to Canadian commerce can hardly be exaggerated, as it is the gateway to a connected series of waterways which lead further into the heart of the continent than any other in North America. The routes of Atlantic steamers pass through this region, whether they use Belle Isle strait or go south of Newfoundland; and on these routes, the two main entrances to the Gulf of St. Lawrence from the ocean, have already been investigated by this Survey.

As early as 1895 and 1896 a general examination of the entrance to the St. Lawrence was made, as a part of the entire Gulf area; and now the whole season of 1911 has been given to a more systematic investigation of the region lying between the Gaspé coast and Anticosti, as far as its eastern end. One of the main objects of this investigation is to bring the variations of the Gaspé current into relation with the Tide Tables now published annually by this Survey.

Observations obtained.— During the early investigations, this region was examined in 1895, in July and September; and in 1896 the region examined extended from the east end of Anticosti, where two stations were occupied. The results have proved valuable; as a general knowledge of the behaviour the Gaspé current and its displacement in position was obtained, which has been useful in planning the more detailed investigations of later seasons; and a careful examination of the waters off the east end of Anticosti was also made. This last has been supplemented at the Lightship, now stationed off Heath Point, by continuous observations of the set of the current throughout the seasons of 1910 and 1911.

The further time given to this region, extended from June 5 to October 7 in 1911, and July 22 to October 19, 1912. The waters around Anticosti were

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examined in the earlier part of the season of 1911, when the weather is usually quieter; as the currents are there weak, and the exposure severe. Time was taken however during the strongest springs, which in this season occurred early, for the measurement of the greatest velocity of the Gaspé current, as this was important to obtain. Although the first part of the season was exceptionally foggy, this did not interfere with the observations. The latter part of the season, when the weather was more broken, was given almost entirely to the Gaspé current, as well as the whole time in the season of 1912.

In carrying out the investigations, the Surveying steamer *Gulnare* was employed, which was anchored at carefully selected positions in all depths up to 180 fathoms. The steamer thus served as a fixed point from which to measure the strength and direction of the current. The observations were continuous, day and night, both on the steamer and on the Lightship. The more important positions or stations were on two lines; one line lying along the steamship route from Cape Magdalen to the east end of Anticosti, with stations at approximately equal intervals of 30 miles; and the other line being in the strength of the Gaspé current, with stations at a fixed offing from the coast. A few additional stations were occupied, to determine the width of the Gaspé current, or for other special purposes. A list of the stations, with their positions and the time spent at each, is given in Table I. in the Appendix; and they are also shown on the accompanying map.

The most modern methods were employed in the investigation of the currents; the velocity being measured continuously, day and night, by means of a current meter registering electrically on board. The measurement was made at the standard depth of 18 feet; and the direction of the current was observed by means of a float attached to the stern, which was illuminated at night. These observations were taken every half hour, or if necessary every 15 minutes when the current was veering or when a maximum velocity was required. Observations of the under-current were also taken, which were adapted to the special purpose in view; and which are invaluable in detecting wind disturbance in the surface current. The temperature and density of the water were taken, as a help in tracing its movements. There were also complete meteorological observations; the direction of the wind and its velocity measured by an anemometer on board, barometer readings, a barograph record and air temperatures.

To obtain a simultaneous record of the tide for comparison, a registering tide guage was erected at South-west Point, Anticosti; but unfortunately it was carried away during heavy weather which occurred soon afterwards. The tidal comparisons are therefore made with the principal station at Father Point, for which tide tables are published. This has proved entirely satisfactory, as the features of the tide become emphasized and more distinct in the St. Lawrence estuary.

The observations were made under the personal direction of the Superintendent with the assistance of Mr. S. C. Hayden, who was in charge during the season of 1912; and with the assistance of Mr. H. W. Jones in the reduction of the results. The night observations were taken with the help of Messrs. F. Nash and R. Hogg in 1911, and W. A. Murphy in 1912. Captain C. T. Knowlton also gave valuable co-operation in addition to his regular duties. The observations on the Lightship were taken by Captain E. Ménard, with the assistance of the mate at night.

The amount of work done on a Survey of this character may be appreciated by what was accomplished in the first six weeks of 1911, while the weather was moderate, although there was much fog and some rain. From June 7 when the first anchorage was made, to July 22, the number of hours observation of direction and velocity of the current while at anchor, was 701. This, with the omission of Sundays, and four days for coaling twice, and for some special calls, amounts to 81 per cent of the total time, reckoning 24 hours to the day.

In the time not counted in the above, which was chiefly occupied in making runs from one position to another, the temperature and density of the water were obtained, with other observations of value. This may be considered as a satisfactory result with so limited a staff.

Other information. Opportunities were taken during the season to obtain information from the light-keepers, at Cape Gaspé and Cape Rosier, chiefly regarding the movement of the ice in winter and the effect of the wind upon it, which they have an excellent opportunity of observing. Information of value was also obtained from fishermen at Point Peter and Grand Grêve, who have a life-long knowledge of the waters in their vicinity. Their descriptions of the behaviour of the currents was found useful for comparison with the results obtained on the Surveying vessel.

General Characteristics of the Currents.

It has long been known that there is a constant downward current in the middle of the St. Lawrence estuary, which continues along the south shore for the whole length of the Gaspé coast. This constant outward tendency, as distinguished from the usual tidal behaviour of the Lower St. Lawrence, is first felt below Red islet, near the mouth of the Saguenay. It is met by a cross current from Point des Monts, setting towards Cape Chat. Below this, the outward current is still more pronounced, and is known as the "Gaspé current." It follows the curve of the Gaspé coast as far as Cape Gaspé, from which it sets across the Gulf of St. Lawrence toward the Magdalen islands.

There are times when a flood stream is found to occupy a width of one or two miles between the Gaspé current and the shore. Valuable information regarding this has been obtained from the captains of coasting steamers, engaged in the coal trade, who have experience in this region.

In the middle of the passage between the Gaspé coast and Anticosti, and on the Anticosti side, the currents show as their leading characteristic a continuous veer, which in general is completely around the compass in a right-handed direction. There is also good evidence that the water makes westward on the whole, to compensate for the outflow of the Gaspé current.

In the region under consideration, it is thus evident that the currents present a complete contrast in their behaviour. On the one shore, there is a current flowing always in the same direction, while on the other the set is weak and continually veering. Yet in both cases the fluctuation in speed, or the period in which the veer takes place, is distinctly related to the rise and fall of the tide; and although neither type of current can properly be given the usual designation of a "Tidal Stream," yet both types are primarily tidal in their behaviour.

If it were possible to determine definitely the relation of these features to the tide, the problem would be solved for practical purposes; for the strength of the current as it fluctuates, or the direction of the set as it veers, would be known at any given moment by reference to the Tide Tables. One of the chief endeavours in these investigations is thus to reduce these currents to law; and in the case of the Gaspé current it has been largely successful. But the veering currents are weak at the best, as the range of the tide is only three to five feet; and they become irregular and uncertain when the tidal influence falls to its lowest amount at the neaps. It is at least possible to prove that the tide has a dominating influence upon them, and that their directions during flood and ebb are fairly definite as a rule.

The effect of the wind undoubtedly holds a secondary place as compared with tidal influence. Nothing was more striking than the apparent indifference to the wind which these currents generally showed. The weakest currents would set directly into a moderate wind, just as usual, as they veered around. It was not evident during the course of the investigations, that strong winds and gales have any marked effect on the flow of the Gaspé current, although some influence can be detected when the observations are subjected to a searching analysis, with allowance for tidal fluctuation.

These remarks on the wind apply chiefly to the usual winds, up or down the coast; for there is some evidence that during off-shore winds from the south-west the Gaspé current may be displaced in position, and lie farther out. In winter also, the winds across the direction of the passage from the south-west or north-east, are not so infrequent as in the summer season; and they have a distinct influence upon the floating ice. These various effects will be described in their place.

The Relation of the Current to the Tide Tables.

For the entrance to the St. Lawrence, a principal tide station was originally established at South-west Point, Anticosti; where tidal record was obtained for two complete years, summer and winter, simultaneously with Father Point, the reference station for the St. Lawrence estuary. The difference in the time of the tide between the two places proved to be nearly constant, which enabled the Anticosti station to be discontinued; and eventually the region referred to Father Point was extended to include Gaspé and Chaleur bay.

The difference in the time of the tide from South-west Point to Father Point found from the above series of observations is as follows: For high water, 1h. 04m. and for low water 1h. 02m. If these differences are taken approximately as an even hour, the tide tables for Father Point in Eastern Standard time may be considered, as they stand, to be tables for South-west Point in Atlantic Standard time.

The comparison of the turn of the current in this region, where Atlantic time is the standard, with the tide at Father Point will therefore give the same difference of time as if the comparison were made with South-west Point in the standard time of the region. This method of making comparison with the tide at Father Point has therefore two advantages: (1) The difference of time when applied to the tide tables for Father Point, gives as a result the corresponding feature of the current in Atlantic Standard time; and (2) the difference with the tide at South-west Point, as found in the former seasons of 1895 and 1896, can be applied correctly to the Father Point tide tables, with the same result.

THE ANTICOSTI REGION.

It may be appropriate to begin with this region, as this is practically the entrance to the St. Lawrence for vessels inward bound through Belle Isle strait. It is also here that the most continuous observations have been obtained, at the new Lightship off Heath Point. This continuity makes these the most [illegible] as a basis from which to deduce the usual behaviour of the currents in the [illegible] where they veer continually; and these observations also give a good indication of the disturbance of such currents by the wind, as the Lightship is moored [illegible] in all weathers which a surveying vessel is unable to do. It is also in a p[illegible] where the wind can blow from 28 points out of the 32, without being off s[illegible]

The principal deficiency in such observations is the want of investig[illegible] of the under-current, which is invaluable as an indication of wind disturbance when compared with the surface behaviour. This is made up to a fair exten[t] by the excellent under-current observations obtained at two stations in [the] vicinity of Heath Point in 1896.

At the Lightship off Heath Point. This Lightship is moored at 8 miles bearing 105° from Heath Point lighthouse, in 22 fathoms. A line bearing W.N.W. from the Lightship thus strikes the east end of the island, and if continued, it would run along the axis or centre line of Anticosti for its whole length. The set of the current was noted every hour, day and night, by observing the direction of a float attached by a line to the stern of the vessel. The observations thus obtained were as follows:—

In 1910, from July 13 to October 9; for 2,160 hours continuously.

In 1911, from June 11 to October 14; for 3,024 hours continuously.

The current as a rule veers continually in a right-handed direction making a complete revolution in the tidal period. The speed, as found from measurements in this vicinity, seldom exceeds one knot per hour in any direction. This behaviour is maintained while the tidal influence is pronounced, and even at the neaps the veer continues regular in quiet weather, although the strength is weaker and may fall at times to nothing. The wind has also a marked effect on the surface direction, as might be expected with such weak currents as these. The nature of this disturbance will be explained.

The rate of veer is not uniform; but it is more rapid through the N.W. and S.E. quarters, and it holds longer north-eastward and south-westward. This more definite and stronger set continues for two hours before and after high water and low water; and its direction is across the end of the island. The more rapid veer occurs at about half tide, rising or falling; and the speed is then least, falling often to nothing for an hour or two. This rapid veer and slack time corresponds with the directions towards and from the end of the island.

To ascertain as definitely as possible the tidal relations of this current, the direction of the set, reduced to its bearing in degrees, was tabulated for each hour before and after high water. In this tabulation some irregular periods were omitted, and also a few days of heavy wind which caused disturbance. The time included comprises 35 complete days out of the 90 days in 1910, and 71 days out of the 115 days of observation in 1911. The averages thus obtained in each season are shown below; the degrees running from 0° to 360° from true N. in a right-handed direction to N. again. The character of the veer, as above described, is clearly seen in this table.

Season	3 hours before.	2 hours before.	1 hour before.	At High Water.	1 hour after	2 hours after.	3 hours after
1910	162°	179	195	206°	227	264	300
1911	152	178°	192	201°	217	253°	295°
Mean	155°	178	193°	204°	222°	257	299°
Direction	SSE	S	SbW	SSW	SW½S	WbS	NWbW

Season	4 hours after	5 hours after.	At Low Water.	5 hours before.	4 hours before.
1910	3°	28°	54	97°	134°
1911	2°	25°	52°	83°	118°
Mean.	2°	26°	53°	88	124°
Direction	N	NNE	NE½E	E	SEbE

Under-current. —The dominance of the tide in the behaviour of the current , as shown by the observations at the Lightship, is still more marked in the under-current. At two stations in this vicinity, good observations of the under-current were obtained in 1896, at Station N, 25 miles E.S.E. of Heath Point, depth 52 fathoms, occupied for seven days in July; and at Station M, 13 miles E.S.E. of that point, depth 37 fathoms, occupied on seven days in September.

In July of that year, the weather was quiet and the observations continuous day and night; but being at the neaps, the veer of the surface current was very irregular. In September, the weather was often rough, causing several interruptions; but the period of the observations included the spring tides. Observations of the direction and strength of the under-current were made at fifty-seven times, from a depth of three fathoms to 30 or 40 fathoms. (See details in Report of Progress, 26 Jan., 1897, Table II, pages 14 and 15.)

The observations of the direction at 20 and 30 fathoms were all classified in relation to the time of high and low water with the following result. A slack time in the under-current was found on seven occasions, which occurred at half tide, either rising or falling. For three hours before and after low water, the under-current makes on the whole into the north-east quarter, its direction ranging from N.N.W. to E.; and for three hours before and after high water, it makes on the whole to the south-westward, its direction ranging from S.S.E. to W.N.W. In the fifty observations in which the current had a definite direction, there were only four exceptions to the above rule, and these occurred near to the time of half tide, rising or falling, which is also the slack time in the surface current.

It thus appears that the under-current has a definite set in two directions in accordance with the tide; and these dominant directions, just as in the surface current, are nearly across the end of Anticosti island. The under-current, however, maintains the normal behaviour, even when the surface current veers as irregularly as it sometimes does at the neaps; whereas in the surface current this behaviour, though distinct at the springs, is not always evident at other times in the month.

A further reduction of these observations was made to determine in which direction the greater amount of flow occurs. The result throws light on the general movement of the water in this region, which will be explained in its place.

Wind disturbance.—To arrive at the effect of the wind upon the behaviour of the current at the Lightship off Heath Point, the direction of the set at each hour before and after high water throughout the season was first laid out in a tabular form. The periods of strong winds were then dealt with, and the set compared with its average or normal direction as shown by the table already given, to estimate the disturbance which the wind occasioned. A special synopsis was made, to ascertain how soon the effect of a wind became apparent after it began, in view of the strength of the tides at the time. A further summary was made of all times of slack, or cessation of current, to see how far this might be due to a checking of the usual tidal directions by the wind, or merely to a deficiency because of want of tidal influence at the neaps.

In the undisturbed behaviour of these currents, there are not only the tidal influences and their variation, but also a dominant tendency towards the south-west quarter; which is apt to be more persistent during the neaps when the tidal influence is at its least. This tendency should not be overlooked in estimating the influence attributable to the wind itself. It is also to be noted that these observations at the Lightship were obtained from a surface float, unaccompanied by the direction of the under-crurent, and the apparent effect of the wind may thus be exaggerated; as quite possibly the disturbance may be so superficial as not to extend to the draught of an ordinary vessel. On the other hand, the observations are long-continued, as already mentioned; and they include heavier weather than a surveying vessel could work in, as the Lightship is adequately moored for holding.

There were occasionally periods of as much as 14 to 54 hours when the surface current ran continuously south-westward, and it once held for even longer in the south-west quarter. This may be partly due to the dominant set in that direction, as it occurred sometimes during light and variable winds at the neap tides. It is quite evident however, that strong winds and gales from the N. and N.W. give assistance to this tendency. On the other hand, the current as it veers around, is less strong in north-westward directions at any time; so that the set in that quarter is easily checked by contrary winds. N.E. winds were so rare in both seasons, that their effect was not ascertained.

During strong south-westerly winds, the results are just the contrary. The effect of these winds is slight, because they are unable to overcome the strong south-westward tendency of the set. It thus frequently happens that the current when S.S.W. or W.S.W. will set directly into the wind; and it is only occasionally when the tides are weak, that the wind is able to check this, or to reverse its direction. In one instance, at spring tides, during a steady S.S.W. wind, which was strong for two days and moderate for two and a half days more, the behaviour of the current was quite normal, and in veering it set directly into the wind for the usual length of time.

The south winds are to some extent intermediate in their effect between S.W. and S.E. winds, but most usually they have the same influence as the S.E. wind; just as N. and N.W. winds go together in the effect they produce.

South-east wind has an appreciable effect in checking the set against it; as the set has this direction when it is weakest. It may thus hold the set longer in the eastward, or make it veer more quickly into south. The most noticeable effect of S.E. wind however, is to check the south-westward set which is so frequent, and to occasion a larger amount of set into the N.E. quarter. Several flood tides were thus reversed and made to set into the N.E. This wind has little effect upon the ebb which is normally north-eastward.

The reason of this influence is not apparent, unless it may be that the effect is modified by difference of barometric pressure. In some instances also, strong S.E. wind of as much as 22 hours duration, had no influence at all on the usual directions of the current as it veered.

A curious effect is often noticeable when a strong wind begins. If the direction of the set is compared with the direction which it should normally have as it veers with the tide, the current appears drawn towards the wind so as to set more directly against it. This behaviour is quite in accord with the fact, often noted elsewhere, that the current will set towards a coming wind; and will thus set into the wind for a time after it has begun to blow, and until it strengthens.

Off the South Coast of Anticosti.

On the steamship route along the south coast of Anticosti and as far as the middle of the passage between Anticosti and the Gaspé coast, the current shows a very variable behaviour. As a rule, the set veers continuously around the compass in the right-hand direction; but there are times when the veer may be to the left through more than one quadrant, or when the set may hold in one direction for several hours. The speed, however, is never great; as the maximum velocity observed at an offing of five miles or more from shore, was less than 1½ knots; and the strength in any on-shore direction as the current veers, was much less than this, seldom exceeding half a knot.

To dismiss the currents in this region with the general remark that the set may be in any direction with a velocity not greater than the above, would be a poor result to offer as the outcome of several weeks of continuous observations, day and night, during rain and fog, and other varieties of weather. We are also unwilling to believe that the captains of vessels take no interest in the behaviour and other features of the waters they traverse, and only desire to know which way to steer to get through them. Yet even for this, an intelligent grasp of the nature of these currents will give much help.

After rounding the east end of Anticosti, the steamship route lies close along its south shore; and it may therefore be allowable to explain somewhat fully the behaviour of the current from observations off Bagot Point and Pavillon river. To make it unnecessary to describe in detail all the variations which these complex currents exhibit, every method was tried to establish a relation between the current and the tide, and to arrive at any laws governing their behaviour.

We may therefore sum up under a few leading headings, the characteristics at each point which can be relied upon. Special attention will be given to the on-shore directions, which were carefully investigated on the spot because of their importance where the steamship route is so near the coast.

Off Bagot Point and Pavillon river.—Three stations were occupied in this vicinity for nearly three weeks in all, in July and the early part of August; Station J, 8¼ miles bearing 128° from Bagot Point light, and 5½ miles off shore; Station K, 6¼ miles bearing 181° from this light; and Station H, 8½ miles bearing 210° from the mouth of Pavillon river. The weather was exceptionally quiet at these times, which afforded an unusually good opportunity for the observations.

These offings were adopted to avoid the in-shore tidal streams of a local character, and to place the stations as nearly as possible on the steamship route.

General behaviour, and relation to the tide.—At the stations off Bagot Point, the current veers continually in direction. The veer is usually right handed, but backing in the opposite direction sometimes occurs. The rate of veer is not uniform, but is more rapid in passing the on-shore and off-shore directions. The current thus sets for a longer time and more strongly in directions which are along shore; and this tendency is more marked in the under-current, which turns by reversing its direction instead of veering as widely as the surface current does. These directions are in correspondence with the tide, being in a general way to the westward during the flood and eastward during the ebb. The greatest velocities in any direction, as observed at these two stations, were 1.35 and 1.14 knots.

Although the relation to the tide cannot be very definite with such weak currents and a tidal range of only five feet at the most, yet after making trial of a number of different methods, a satisfactory correspondence was found with the time of maximum velocity.

As a general rule, the maximum velocity at all three stations occurs from 2 hours to 3½ hours before high water and low water at Father Point; and the values for this interval, obtained during one week at each of these stations, were reduced to an average. These averages are remarkably good in the circumstances, and show clearly that the currents are truly tidal. They are as follows:

Station J. (from 15 tides). At 1 h. 38 m. before H. W. or L. W.
Station K. (from 15 tides). At 1 h. 48 m. before H. W. or L. W.
Station H. (at 11 High Waters). At 1 h. 47 m. before H. W. or L. W.

The inequalities in the tide itself are also apparent in the current. For example, at the spring tides when Station J was occupied, there was a strong diurnal inequality; the greatest range being once a day on the ebb. In the current a pronounced maximum occurred once a day about the end of this strong ebb, in an eastward direction; the velocity attaining 1.35 knots, which was the greatest here observed. During the week that Station K was occupied, the westward set was at first the stronger of the two, and later in the week the eastward was the stronger; this change corresponding correctly with the greater rise or fall of the tide due to diurnal inequality.

As the tides fall off towards the neaps, the direction becomes more indefinite, and last of all the time of the maximum velocity becomes uncertain. There can be no doubt, however, that the behaviour of the current is primarily due to tidal influence.

During the two weeks, the maximum velocities as observed off Bagot Point were as follows; the greater strength in one direction or the other being due to diurnal inequality:—

Week, July 11 to 15—
July 13. On the flood, 0.74 knot, W. by N.
July 12. On the ebb, 1.30 knots, S.S.E.
Week, July 31 to August 5—
Aug. 1. On the flood, 1.18 knots, N.W. by N.
Aug. 4. On the ebb, 0.80 knot, S.E.

A synopsis of maximum velocity and direction for the two weeks is given in Table II. in the Appendix.

At Station II, 8½ miles from shore, off the mouth of Pavillon river, the general behaviour is much the same as the above. Being farther from shore than the stations off Bagot Point, the veer around the compass is more regular in its period, as it always is in such circumstances. The period of the veer and the relation of the current to the tide, are given in Table III. in the Appendix.

The ebb direction is less definite than the flood, which is almost always between W.N.W. and N.N.E. The flood thus sets obliquely towards the shore, as the on-shore direction is just N.N.E. The strength, however, is never more than one full knot when northward or east of north. The current is strong and deep when setting north-westward or westward, which indicates this as the dominant direction towards which the water makes on the whole. This inward direction becomes more marked in the middle of the passage, as we shall see later

On-shore directions.—At the stations nearer shore, it was soon found that the under-current, at the usually observed depths of 15 and 30 fathoms, became slack when the surface current had on-shore or off-shore directions; and that it turned by reversing its direction up and down the shore, instead of veering widely, as on the surface. It was thus evident that the current in any on-shore direction was quite superficial; and accordingly special observations were taken to ascertain definitely the depth to which the current then extended. Great care was required, as it is in turning that these directions occur, when the current is weak and variable. The results may be thus summarized for both off and on-shore directions, which are the same in their behaviour.

The thickness may be as much as 5 to 7 fathoms; but usually it is only from 10 to 25 feet. Below this, the water was still, or was setting along shore. The velocity, as measured at the standard depth of 18 feet, was only from 0.25 to 0.45 of a knot. These conditions lasted for perhaps one or two hours as the current veered at the turn; and on one occasion only, a weak and variable set on shore continued during three hours at 0.17 of a knot.

As the movement is so superficial, further observations were made to ascertain the true velocity on the surface, by using a second meter at a less depth, or by means of floating objects in quiet weather. The surface velocity was thus found to be 30 per cent more, on the average, than at the standard depth. This represents actually only a small increase however, as the average velocity of 0.35 knot when increased in this proportion would only become 0.46 on the surface.

At Station II, at $8\frac{1}{2}$ miles from shore, where the current veers more uniformly, the strength in the on-shore direction was from half to three-quarters of a knot. The on-shore direction usually extended to a depth of 3 to 5 fathoms, but with a lower speed. On one occasion only, this set amounted to a full knot for two hours, but at a depth of 6 fathoms it fell to less than half a knot; and below this the direction of the under-current was only obliquely towards the shore. There is little doubt however, that the direction would change or the speed decrease as the shore was approached.

It may thus be stated that there is no on-shore set on this coast that an ocean-going vessel need be concerned about. Such a set is not only weak, but is usually less in thickness than their draught. The conditions as found, serve also to explain the repeated reports of fishermen that the current often sets obliquely on shore; as this may very well be true of their fishing boats when becalmed, although the depth of the movement might not be sufficient to affect appreciably a steamer of ordinary draught.

Under-current. The under-current was investigated with special care at these stations, to understand the nature of the movement of the water on the whole; and some of the results have already been referred to.

The tidal features of the current are as well marked below as on the surface; for in general, the under-current sets along the shore in the two directions with the flood and ebb. At the turn, while the surface current veers through off and on-shore directions, the under-current is slack. It may then begin to set along shore, before the surface current has veered to that direction, leaving a layer of still water between the two at a depth of about 10 fathoms; but more frequently, when the surface current has come to be nearly along shore, it gradually deepens; the result being that when the direction is parallel with the shore, the current is deepest as well as strongest.

This is as fair a general account as can be given, while there are many variations in detail. These movements are complicated by occasional backing in the surface current, and irregularities at the weaker neap tides; and even more markedly by diurnal inequality, which may reduce the under-current to almost nothing on one flood or one ebb in the day, as the case may be.

It is evident however, that the under-current corroborates the tidal character of the currents on this coast.

Wind effects.—The quietest part of the season was purposely chosen for the examination of these weak currents. There were some rough days however; and a good deal of fog, which did not interfere with the work. The winds were usually light and variable, and seldom over 10 or 12 miles an hour. Even this would hold the surveying vessel, with a draught of 13 feet, at a high angle to the direction of the current; thus confirming its superficial character at times, as already explained.

It would seem probable that currents of this character must be liable to disturbance by the wind, as they are in other regions. But with such winds as were met with, the current as it veered around, would set directly into the wind for a time, or against the sea, without any change whatever from its ordinary behaviour.

THE MIDDLE OF THE PASSAGE BETWEEN ANTICOSTI AND THE GASPÉ COAST.

Two stations were occupied in the middle of the passage between the Gaspé coast and Anticosti, where the depth is about 180 fathoms. One of these is on the direct line of the steamship route, and the other on the line indicated as a constant current on the chart of the Entrance to the St. Lawrence. The currents are too weak to be of much importance to navigation, so far from shore; but their behaviour is important with relation to the movements of the water on the two sides of the passage.

Station G was almost midway between English Point on the Gaspé coast and South-west Point, Anticosti. It was occupied during 5¼ days in the week from July 3 to 8. Station D was in the middle of the passage farther west, on a line from Fame Point to Ellis bay and rather more than half way across. It was occupied for nearly two full days from July 15 to 17. Both these periods began just after the springs, so that the tides were of medium strength. At Station D there was much rain and fog, but the observations of the current were continuous.

Character of the current.—In general, the current at Station G veers continuously in a right-handed direction, making a complete revolution in the tidal period. The velocity rises regularly to a maximum which occurs near the time of high water, when the direction is almost always between W.S.W. and W.N.W. This behaviour continued until the neap tides, when it became less distinct; there being then as much backing to the left as veering to the right.

At Station D the general behaviour is much the same. The greater strength is in the north-west quarter during the flood, and during the ebb it is weak and irregular in direction.

At both stations, the greater strength is in the north-westward direction, and the least south-eastward; the cross directions being intermediate between the two. The variation in the velocity when at its maximum in the opposite directions is as follows:—

North-westward—Station G; during 10 tides; 0.87 to 1.41 knots.
" —Station D; during 3 tides; 0.84 knots.
South-eastward —Station G; during 10 tides; 0.56 to 0.94 knots
" —Station D; during 2 tides; 0.55 knots.

It thus appears that in the middle of the passage the current is tidal in character, with the same general features as on the south shore of Anticosti. This is further confirmed by the period in which the direction veers completely around the compass. This period during the more definite tides, omitting the neaps, is on the average 12 h. 24 m. or 12 h. 33 m. as found by two different methods; which is just the tidal period. An abstract of the observations on which this is based, is given in Table IV. in the Appendix.

Under-current. In general, the set of the under-current at 15 and 30 fathoms, was north-westward during the flood and south-eastward during the ebb: in correspondence with the general direction of the passage itself. It held these directions more steadily and with less veer than the surface current: and in these directions also the depth was great, the current being still strong at 50 and 90 fathoms, especially when north-westward.

While the surface current, in veering, set transversely to the direction of the passage, the under-current was slack. In these cross directions the current is thus usually thin. There were times when it was still appreciable to a depth of 15 or 20 fathoms; but as a rule it was not more than 3 to 6 fathoms in thickness. These directions at stations nearer the coast, would be off and on shore; but so far out as this, they have less importance, and it is not therefore necessary to describe them in greater detail.

It throws an interesting light on the nature of the on-shore set, to find that even here in the middle of the passage, the current in the transverse directions is relatively thin and superficial; as this helps to explain its character nearer shore.

Wind disturbance.—These stations in the middle of the passage and so far from shore should best show the effect of the wind on a current which veers continuously around; and special attention was therefore given to detect any influence of the wind. It may therefore be allowable to describe somewhat fully the wind conditions and the amount of disturbance which could be attributed to them.

During the week spent at Station G, July 3 to 8, the weather was as follows: The Sunday was calm. From midnight on Sunday to Wednesday at 4 a.m., the wind was nearly all south-easterly, sometimes strong, with fog and rain; amounting to a total of 572 miles from that quarter in 52 hours. Again at noon on Wednesday, light southerly wind began, strengthening and veering to E.S.E. with rough weather, fog and rain, till Thursday at 19 o'clock when it changed suddenly to N.W. and cleared. The total south-easterly wind was 620 miles in the 31 hours, with a gradual increase to 32 miles an hour. From the above hour to Saturday morning the wind held in the N.W. with a rough sea, amounting to a total of 895 miles in 36 hours, and for 12 hours averaging 31 miles an hour. These wind measurementswere made with an anemometer on the vessel while at anchor in the open.

The behaviour of these veering currents in relation to the wind, which is the most noticeable and impressive, is the way that they set at times directly into the wind. On Tuesday, after strong S.E. wind during the day, the current at the end of the afternoon veered just as usual from E.N.E. into the S.E. and S.; the wind being 25 miles an hour at the time. The velocity against this wind was 0.90 knot, which was distinctly stronger than on the previous and following days at the same time of the tide. Also in the other direction, on Friday at midday after N.W. wind for 17 hours which had gradually strengthened to 32 miles an hour with waves 6 to 8 feet in height, the current on the flood set directly into the wind for 2½ hours and during this time the usual maximum velocity occurred. This maximum was 1.26 knots, which was quite up to the average of the previous and following tides. On the following flood, 12 hours later, with the wind still in the N.W. though moderating somewhat, the current again veered through the windward direction, attaining as it did so the highest maximum observed, namely 1.41 knots. The greatest velocity recorded throughout a week's observations was thus directly into a wind which had held in that quarter for 28 hours.

The disturbing effect of the wind appears chiefly in modifying the veer of the current. This is the principal effect observed in currents of similar behaviour off the south coast of Newfoundland; where they usually veer more quickly in passing the windward directions, and hold longer when the set is with the wind.

For four days before Station D was occupied, and throughout the three days there from Thursday to Saturday, June 15 to 17, the wind held steadily in the S.E. and E.S.E. It was mostly light and moderate, though it twice exceeded 30 miles an hour. It is not probable that the more usual set towards the northwest quarter was due to the wind; as the under-current showed this to be the dominant direction. Up to Friday morning, after 97 hours of S.E. wind amounting to a total of 1,335 miles, the current on the ebb still set directly into the wind for over an hour with quite the usual strength. On the following ebb tides however, the current was held longer in transverse directions and passed over the windward directions. On Saturday forenoon, when the wind had increased to 32 miles an hour, the ebb again set transversely, to the north-eastward; and for four hours it did not veer beyond E.N.E. up to the time that the station was left. Meanwhile, the under-current set in the true ebb direction, between E.S.E. and S.S.E., from 10 fathoms to 50 fathoms in depth. This cross direction of the surface current which was thus prevented from veering to S.E. at the time it should, must have been due to wind disturbance. This effect occurred after five days of continuous south-easterly wind, which had a strength at the time referred to, of 33 miles an hour.

Similar examples of disturbance of the usual veer, which may have been due in part at least to the effect of the wind, occurred at Station G. On Thursday July 6 at midday, after 17 hours of strong S.S.E. wind which increased from 20 to 32 miles an hour, the set held in an eastward direction for some hours without veering into the south; but on reaching E.S.E. it changed suddenly to

S.S.W. Again, when this S.S.E. wind ceased after blowing for 25 hours, the current set northward for longer than usual and possibly with greater strength than it would otherwise have had; as it attained 1.08 knots. On the other hand, in the following night, after strong wind from the W.N.W. and N.N.W. for 7 hours, the current as it veered through south was certainly not over its average strength in that direction. It is to be noted regarding these observations, that from Wednesday midnight the veer was no longer regular, as alternate backing and veering then began which continued till Saturday. This was during the weakest of the neaps; and whether the irregularities described were due to decreasing tidal influence or to the wind, is not very clear.

To sum up, it may therefore be stated that even in so open a situation as this, it is quite difficult to prove conclusively that fairly strong winds disturb the current appreciably; whereas the way in which the current will maintain its tidal behaviour with entire disregard of wind and sea, is often evident and obvious.

Return Flow, Compensating for the Gaspé Current.

As the outflow of the Gaspé current may be estimated at something over twelve *cubic miles* per day, it is very evident that there must be a return flow somewhere in this region to compensate for it; and one object of these investigations was to ascertain where this takes place. It is also of some practical value to know in what area there is a westward tendency or dominant flow inwards. We may now summarize with advantage all that has been ascertained on the subject, in several different seasons.

The discharge of the river St. Lawrence, including its principal tributaries, amounts to 240,000 cubic feet per second. This is only one ninety-fifth part of the volume of the Gaspé current. It is thus quite erroneous to speak of this current as St. Lawrence water; as the most that the river can do is to reduce the density by an appreciable amount below the density of standard sea water. To put it in another way, if the St. Lawrence water were shut off for a time, the velocity of the Gaspé current would be decreased by 0.015 of a knot, or one per cent of its present average speed.

Mingan strait.— In this channel north of Anticosti, observations were taken in July of 1895 to ascertain whether any return current of a constant character could be found there. Two stations were occupied in the narrowest part of the channel; and the period of the neap tides was chosen, when the influence of the tide would be less marked. The weather although foggy and wet, was quiet and fairly normal, the wind not exceeding 16 miles an hour.

The current is tidal in character, and runs to the north-west and south-east alternately, though often veering considerably from these directions. Observations were taken continuously day and night, and two periods of 24 and 49 hours were selected for reduction, as it was necessary to have complete tidal periods to make the comparison a fair one. An exhaustive reduction was so made as to give the total mileage of water passing in each direction through the channel. The final result showed 24 per cent of excess in favour of the inward direction to the north-west; although the actual difference in favour of that direction was only 0·13 of a knot per hour. The under-current proved to be nearly as strong as the surface current; but its variation was so great that it could not safely be said in which direction it would in general be strongest relatively to the surface current.

Although these observations only comprised six tidal periods, it is at least clear that there is no constant inward current north of Anticosti, at all comparable with the Gaspé current.

Off the east end of Anticosti. From long-continued observations in various seasons off the east end of Anticosti, it is now well established that the water makes on the whole towards the south-west quarter around the east end of the island.

Observations at the east end of Anticosti were taken for over a month in July and August of 1896, by means of a pair of flag buoys attached to each other, and moored at $1\frac{1}{2}$ miles off East Cape in 30 fathoms. These were observed from the shore, which here runs north and south. The current is nearly parallel to the shore; but in direction it is irregular, as it might set in the same direction all day or turn twice a day. The prevailing set was found to be southward however. Out of 231 observations of the direction, taken every two hours during daylight on clear days, the direction was northward 78 times, and southward 153 times. This may be taken as a fair comparison; for, during the course of a little more than a full month, the observations are distributed pretty evenly over all states of the tide. These observations showed that the set is southward for two-thirds of the time.

Two stations off the east end of Anticosti were occupied in 1896, Station N at 24 miles E.S.E. of Heath Point for seven days in July, and Station M at 13 miles E.S.E. of that point on seven days in September. The surface current veered around the compass as already described, but often quite irregularly; as the more continuous observations in July included the period of the neap tides. The behaviour of the under-current was much more regular; and it is also more important in better indicating the general movement of the water.

From numerous observations of the under-current at 20 and 30 fathoms in both July and September it appears that it has a definite set in two directions in accordance with the tide, while the surface current continues to veer around. The two dominant directions of this set are, to the S.W. while the tide is high and to the N.N.E. while the tide is low, with a slack time which occurs at half tide, either rising or falling. These directions are nearly across the end of Anticosti island. To determine the true relative amounts of the set in these two opposite directions, a computation was made by a special method. When finally reduced to a percentage for convenience in comparison, it was found that the amount by which the under-current makes south-westward is 16 per cent greater than north-eastward.

The water thus makes southward and westward on the whole, around the east end of Anticosti; which is very significant in showing the direction from which the water comes, that forms the return flow to make up for the Gaspé current. This is further confirmed by the continuous observations on the new Lightship off Heath Point, during the seasons of 1910 and 1911. Although they give the direction on the surface only, they were so continuous as to afford a good average indication; and they show that the set south-westward is more frequent and stronger than in other directions.

The main passage south of Anticosti.— From the observations of the season of 1911 at the stations off the south coast of Anticosti and those in the middle of the passage, all the evidence indicates a preponderance of inward flow to the northwest. The stronger and more persistent set on the surface is in that direction. Also, the under-current gives the same indication; although the observations being intended more directly for other purposes, were not taken specially with this object. It also appears from the investigations of 1895 that the deep water, below 100 fathoms, is practically quiescent.

We may therefore conclude that the water after passing around the east end of Anticosti, continues to make inwards on the whole, over the greater part of the width of the passage on the Anticosti side. This movement appears to take place from the surface to a moderate depth, and does not extend to the deep water below a third or half of the total depth of 200 fathoms. We may assume this inward flow to be sufficient in amount to compensate for the outflow of the Gaspé current, with possibly a small contribution also from Mingan strait.

This westward movement of the water to the south of Anticosti, is also in harmony with the general circulation of the Gulf of St. Lawrence. In accordance with this circulation, the water makes westward on the whole along the north shore of the Gulf; and the dominant inward direction around the east end of Anticosti and along its southern coast, must be considered as a continuation of this general movement.

THE GASPÉ CURRENT.

This current flows constantly along the Gaspé coast, in continuation of the outward current on the south side of the St. Lawrence estuary. From Cape Magdalen to Cape Gaspé, it has a width of about twelve miles; and it is usually found to lie between two miles and fourteen miles off shore. Its usual strength is about two knots on the average.

Within one or two miles of the shore, along the greater part of this stretch of coast, a tidal stream is found, which runs westward on the flood; while on the ebb the direction is with the main current. This in-shore flood is little felt except at the springs, and it does not exceed one knot at any time.

It is possible under exceptional conditions for the Gaspé current to lie farther off shore, near the middle of the passage between the Gaspé coast and Anticosti. When the current is in this position, the area between it and the Gaspé coast may be occupied by weak and fluctuating currents, or even by a reverse current setting inwards. This position in the middle of the passage may therefore be regarded as a displacement of the current, or an alternative route which it may take. One of the most experienced captains of the coasting steamers in this region has more than once met with an absence of current below Cape Magdalen at an offing of 2 or 3 miles, during south-west winds which are here unusual. He believes that the main current then lies farther out, but cannot say definitely. In our observations, this change was only met with once in three seasons, when it was carefully investigated; and as it is thus of rare occurrence, the conditions which occasioned it will be fully described further on.

Methods of investigation and observations obtained.— A systematic examination of the Gaspé current was made at different times in the seasons of 1895 and 1911, at three stations, [illegible] the line of the current, where anchorages were made for as much as a w[illegible] at a time, affording continuous measurements of the velocity day and night. These three stations were A [illegible] C, off Cape Magdalen, Fame Point and English Point respectively, at a [illegible] offing of 4½ miles; as the greatest strength of the current is usually found a[illegible]our or five miles from shore. In 1912, this series of sta[illegible]ons was extended by the addition of two more, P and Q, at the same distance from shore; one of them farther west, off Martin river, and the other off Cape Gaspé. Additional observations were also obtained in that season at the former stations.

To determine the decrease in strength with the offing, and the width of the current, other stations were chosen on cross lines from these; where anchorages were made as nearly simultaneously as possible, or comparisons [illegible]ere based on observations obtained under similar conditions. There were th[illegible]e cross lines for this purpose, two of them extending beyond the width of the c[illegible]rent, namely, Stations A and R; Stations B, E and D; and Stations C, F and G. (See Map at end of Report).

At all these stations the depth is great, ranging from 127 to 215 fathoms; and the bottom consists of soft clay sufficiently adhesive to ball around the anchor, making very poor holding ground. The winds, being almost always along shore in one direction or the other, soon raise a sea, and the coast is devoid of any bays affording temporary shelter; but with the appliances at command, satisfactory speed measurements were obtained so long as the waves did not exceed six or eight feet in height.

The total number of hours of observation of the Gaspé current, obtained while actually at anchor at the various stations in the three seasons, are as follows: In 1895, 267 hours; in 1911, 897 hours; in 1912, 1,229 hours. The total length of the observations of velocity and direction, at the various stations in this current, thus amount to just one hundred days of 24 hours each. The details with the dates when each station was occupied, are given in Table I., appended.

The regular measurements of the speed of the current were made at the standard depth of 18 feet; as this well represents the speed as it would affect a vessel, and it is also deep enough to be free from superficial wind influence. The speed at greater depths was ascertained a number of times at different stations, by means of appliances for the purpose. It was thus found that the current extends to a great depth; being quite strong at 30 fathoms and still distinctly felt at 90 fathoms. This is important because of its bearing on wind disturbance; as a body of water of such depth and volume is not easily checked; and if disturbed, it readily recovers its normal conditions.

The continuous meteorological observations taken on board, by means of the anemometer and barograph, afforded complete data for the wind, to enable its effect on the current to be estimated.

In addition to the continuous observations, the temperature of the water was taken during the longer runs of the steamer, on lines lying across the direction of the current. The density of the water was also an indication of value in tracing its route and its extent; and the general results thus obtained in the early investigations of 1895 are given in the Report of Progress, April, 1896, and in the plates and diagrams accompanying it.

General description.—The Gaspé current is constant, in the sense of being always in the same direction, which is outward from the St. Lawrence towards the Gulf. It is subject to wide variations in strength, however; which when examined in detail, are very complex in character. The leading variation which is well marked at all times is a regular fluctuation with the tide; the current being stronger on the ebb and weaker on the flood which reacts against it. Although this is always persistent as a fluctuation, the actual velocity may be widely different owing to the influence of other causes; so much so, that it is quite possible for the maximum velocity on the ebb at one date to be no greater than the minimum on the flood at another date. But whether the average strength of the current is greater or less than usual, the fluctuation is always strongly pronounced; and its correspondence with the tide is so definite, that every change such as diurnal inequality, is accurately reflected in the current.

The other variations of a periodic character, occur during the course of the month. The strength of the current is distinctly greater at the springs and less at the neaps; and the change in strength with the moon's distance from perigee to apogee is quite evident. There is also, twice in the lunar month, a well marked diurnal inequality in the current, at times when the moon is at its maximum declination, north or south of the equator. This emphasises the need for continuous observations of the velocity, day and night, as misleading deductions may easily be made from day observations alone.

There is also a change in the strength of the current, more irregular in character, which appears to be due to its becoming wider and weaker at times and again narrower and stronger. This may result in some measure from winds that are obliquely against the current, or that bear on shore across its direction.

For although it is clear that the direct effect of the wind, with or against this current, has surprisingly little influence upon it, yet the power of the wind to displace a current in position is always much greater proportionately

It is evident that the combination of these various causes acting with or against each other, may occasion great variation in the actual strength of the current; and this goes a long way to account for the complexities which are actually met with, when the behaviour of this current is examined in detail. It is thus possible for the average velocity at th neaps to be as great as at the springs in another month; or to be nearly twice as great in one month as in another.

These various fluctuations and changes have been subjected to stringent investigation, in the endeavour to estimate them separately and to distinguish the effect of the wind from other influences, as definitely as possible. In dealing with the main line of the current, the four stations from Martin river to English Point (Q,A,B and C) at the uniform offing of 4½ miles, will be considered together. The station P off Cape Gaspé, will not be included with them in obtaining general results; for when Cape Gaspé is passed, the strength of the current at any fixed position may vary very widely at different times. The current here enters the open waters of the Gulf, and has no longer the guidance of the even sweep of shore which it has followed; and it may thus spread out so widely as to become very weak, or again it may become narrowed to a stream of great strength. This appears to be the reason why, in the vicinity of Cape Gaspé, the irregular changes are often so great as to obscure all other variations, with the exception of the tidal fluctuation.

The part of the coast above indicated as best adapted for close investigation, is also the locality of most practical importance to navigation; as it is here that vessels make the shore on both routes, either round Anticosti or past the Magdalen islands.

Basis of comparisons. In making the investigation, a basis of comparison must be devised which will give correctly the p oportionate strength of the current at the same station at different times, or the rue relation between the strength at different stations.

For such comparisons, it is necessary to use daily mean velocities. Th se were found for each complete lunar day of 25 hours, comprising two tidal periods; and by basing them on this length of time, both the tidal fluctuation and the diurnal inequality are eliminated. By the use of these daily mean velocities, it becomes possible to distinguish the longer variations and to estimate their amount with some hope of success. They also afford the best basis for determining the true width of the current, from the observations obtained on the cros. lines. They also furnish a means of estimating the relative strength of the current at the four successive stations along the coast; and consequently, all the observations at these stations can be placed on a truly comparative basis, which makes the whole of the observations obtained in the three seasons available for the determination of the v iations sought for.

To explain the method of obtaining these daily mean velocities, it will be sufficient to say, that the half-hourly velocities as measured by the current meter, were laid out on graduated paper at right angles to a base line which represented the time. An undulating curve was drawn through the points thus obtained; and from this curve the velocity at each hour, day and night, was taken. The average velocity was thus found for each complete lunar day during the course of the observations; and a few half days (or complete tidal periods) were admitted as fair mean values at times when there was no diurnal inequality.

The maximum and minimum velocities, on each flood and ebb, were also taken from this curve; as this served to eliminate the minor irregularties in the half-hourly velocities which are brought to light by the sensitive accuracy of the current meter. These maximum and minimum values are used to determine the amount of tidal fluctuation in the velocity at the springs and neaps respectively.

Width of the Gaspé current.—On the three cross lines at right angles to the Gaspé current, represented by the Stations A, R and B, E, D and C, F, G, comparisons were made to determine the width of the current. These comparisons are based on the daily mean velocities, grouped according to their position with repsect to the spring and neap tides, to be as truly comparative as possible.

At the stations within the limits of the Gaspé current the relative speeds, on the average for both springs and neaps, are as follows:—

At Station R, 9½ miles off shore, 51 per cent of the velocity at A which is 4½ miles off.

At Station E, 11½ miles off shore, comparisons at the spring tides give 56 per cent of the velocity at B which is 4½ miles off; and at the neap tides, only 26 per cent.

At Station F, 11 miles off shore, 59 and 64 per cent of the velocity at C which is 4½ miles off.

The decrease in speed at the above stations and a comparison with the more outlying stations D and G, where the set is in the opposite direction, affords a basis for estimating the width of the current. This estimate was made by the use of a graphical method which shows as a final result that the outward current, ceases at approximately 14 miles from shore. The Gaspé current proper has therefore a width of about 12 miles, and lies as a rule between 2 and 14 miles from the shore. At its outer edge however, it is no doubt weak and uncertain.

Proportionate speed at the four Stations Q, A, B and C.—It is important to determine as correctly as possible the proportionate speed at these four consecutive stations along the coast, which lie in the main strength of the current; for if this can be done satisfactorily, it will enable all the observations obtained at them to be made truly comparative; and the most extended basis will thus be secured for the determination of the leading variations in the velocity of the Gaspé current.

To determine these proportionate speeds, Station B was adopted for reference, and the general average velocity at each of the other three stations was obtained as a percentage relatively to it. For this purpose, two methods were made use of. Firstly, groups of days were selected for two stations at a time, which had a corresponding position in the lunar month relatively to the springs and neaps, and with allowance as far as possible for the position of perigee and apogee. From a comparison of these, an indication of the relative strength at the different stations was found. Secondly, a general average of all the daily mean velocities obtained at each station in the three seasons was made; and these averages were used to deduce the proportionate strength of the current at the different stations. It is to be noted with regard to this method of comparison, that the tidal fluctuation and the diurnal inequality had already been eliminated in the daily mean velocities themselves; and in so long a series of observations at different dates, it may be assumed that the variations with the moon's phases and distance would be neutralized in the general averages obtained. For. the total length of the observations which make up the complete days utilized for this comparison are as follows: At Station Q 338 hours, at Station A 450 hours, at Station B 275 hours, and at Station C 450 hours.

The result as finally adopted is as follows:—

Station Q—4½ miles off Martin river. 10 per cent less than at B.
Station A—4½ miles off C. Magdalen. 11 per cent greater than at B.
Station B—4½ miles off Fame Point. (Taken for reference).
Station C—4½ miles off English Point. 5 per cent. less than at B.

It thus appears that the greatest speed of the Gaspé current is in the vicinity of Cape Magdalen, and this seems to accord well with the conditions. For this current undoubtedly gathers strength as it passes down the St. Lawrence estuary from the point at which it first becomes constantly outward; and at the other extreme, after leaving Cape Gaspé it expands widely in the open Gulf.

The percentages as thus found, were next applied to the daily mean velocities, to bring them all to the same standard; and thus to make the whole of them available for the determination of the variations in the strength of the current during the course of the month.

Variation in speed from springs to neaps.—To ascertain the amount of this variation, the daily mean velocities as found at the series of stations Q, A, B and C, were first increased or diminished by the small percentages above stated, to make them truly comparative. All the values found in the three seasons were then assigned to their correct positions in the lunar month, from new to full moon, and full to new moon.

When thus tabulated, it was clearly seen that in a general way the velocities were higher about the time of spring tides, and lower about the neaps; but there was considerable irregularity in detail. For example, on six consecutive days after the neaps, the values decreased towards the springs; and once at the springs, the values continued to increase until the fourth day after the new moon. On the other hand, the unusually low values at the springs or high values at the neaps, are nearly all accounted for by the influence of the moon's distance at perigee or at apogee.

To equalize such irregularities, a somewhat extended average was taken as the best basis for the variation sought for. The average of all the daily mean velocities, falling on the 1st, 2nd and 3rd days after the new and full moon, was taken as the velocity at spring tides; and the average of those falling on the 8th, 9th and 10th days after, was taken as the velocity at neap tides. The result thus obtained for these four stations, was as follows:—

Average velocity at the Spring tides....	1.87 knots.
Average velocity at the Neap tides........	1.23 knots.
Ratio of Neap to Spring velocity.......	66 per cent.

These are the best values obtainable for the average velocity throughout the course of the day, at the springs and the neaps, when the tidal fluctuation and other variations are eliminated.

Variation with the moon's distance.—A similar method was used to determine this variation. The daily mean velocities were all assigned to their correct positions between perigee and apogee; and in this tabulation it was again evident that in general the velocities were higher near perigee and lower in the vicinity of apogee. Because of the slower nature of the variation, which occurs only once a month instead of twice a month as in the case of the springs and neaps, longer averages were taken. These averages included the daily mean velocities for four days before and after perigee, and four days before and after apogee.

On further examining the values included in these periods, it was found that too great a proportion of the days in the vicinity of perigee happened to be near the spring tides; and in this way the average for perigee was unduly increased. To correct this, a small allowance was carefully made, based upon the amount of variation from springs to neaps as already found. The best relation between the strength at perigee and apogee is therefore as follows:

Average velocity at Apogee, 82 per cent of velocity at Perigee.

In actual velocity, there is thus nearly half as much variation with the moon's distance from perigee to apogee as the difference in velocity between the springs and neaps.

General average velocity at the three Stations A, B and C.—It may be well to give, for comparative purposes, the average velocity of the Gaspé current as found from all the daily mean velocities obtained at these stations during the three seasons. This average, at the uniform offing of 4½ miles, is 1.65 knots per hour. It is based on observations in the months of June to September; and there does not seem to be any good evidence that the average differs from this in the earlier and later months during the season of navigation.

This value is useful as a term of comparison with respect to the variations already discussed.

Depth of the Gaspé current.—In a current which is constantly in one direction the information of importance regarding the under-current can best be obtained when it is not too strong; and the appliances for the purpose can then be used to better advantage also. The investigations were usually made therefore, when the surface velocity did not exceed two knots; and it may well be assumed that the thickness of the current will not be less, or the proportionate speed of the under-current lower, when the surface velocity is greater.

In the main strength of the current, along the line of the stations A, B and C, the movement in the surface direction was found to extend to a great depth. A comparison of all the observations at 30 fathoms shows that the strength at that depth is never less than 60 to 65 per cent of the surface velocity; and usually it is still strong at 50 fathoms and quite appreciable as far down as 90 fathoms. When the minimum on the flood had a relatively low velocity, there were times when the under-current as far down as 30 or even 50 fathoms was as strong as at the surface.

The special observations taken to determine the time of the minimum velocity, show that this is practically simultaneous in the under-current and at the surface.

A few sets of observations at the outer stations R and E, 9½ and 11½ miles from shore, show that the current there is also deep. When there was even a moderate velocity at the surface, the strength at 30 fathoms was as great proportionately as at the stations nearer shore. When the current was weak and variable at the surface, as it sometimes is at this offing, the under-current was similar in character; and only once an under-current was found setting in the reverse direction below the depth of 40 fathoms.

The chief practical importance of these results is their bearing on wind disturbance. The great depth and volume of this current, explain in large measure its apparent indifference to the wind. Such a current, if disturbed, will also regain its normal velocity very quickly. It is also necessary to know the rate at which the velocity decreases with the depth, in order to make any estimate of the total volume of the current.

Wind Effects, compared with other Variations.

In describing the winds, they will be termed south-east and north-west, when they follow the shore as they usually do; as this may be taken as the general direction of the coast. They are thus directly with or against the current. The south-east wind is not usually as strong as the clearing wind which follows from the north-west, as this is in the direction of the prevailing winds.

All the measurements of the current velocity were made at the standard depth of 18 feet. Any wind effects found are therefore such as would affect a vessel of ordinary draught, and not a mere surface drift. The velocity observations were taken every 15 or 30 minutes continuously day and night; and from these the daily mean velocity was determined for each lunar day, or double tidal period, as already explained; as this keeps out of account the ordinary tidal fluctuation. The comparisons made to detect the effect of the wind are based upon these daily mean values; and in making comparisons, the position of the day with relation to springs and neaps is taken carefully into account.

The velocity of the wind was measured by an anemometer on board, which was read every four hours, day and night. A continuous record of the variation of the barometer was obtained from the barograph.

General features of the current in relation to wind.—It is noticeable to begin with, that the greatest strength of the current did not occur during heavy winds or gales, so long at least as it was possible to hold at anchor; although observations were sometimes continued in winds of 40 and 50 miles an hour and with waves eight feet in height. Nor did the weakest current occur during a period of south-east wind against its direction. On the other hand, one of the most impressive occurrences, in watching the behaviour of the current while anchored in it, was to see it setting with its full strength directly into a south-east wind, as it usually did

In examining the matter, we will therefore first state the conditions under which the highest velocity of the current occured, and then describe in detail its behaviour during heavy winds, in the endeavour to estimate as closely as possible the true amount of the change in velocity caused by the wind, when differentiated from other variations.

Greatest strength, and accompanying weather conditions.—The highest of the daily mean velocities in the season of 1911, was on June 28, at Station A; when it amounted to 2.40 knots. The weather was perfectly calm and smooth, and it was at spring tides with the moon near perigee. In 1912, an extremely strong current was observed from August 28 to 30, at Station C, which was quite exceptional, and will be described in detail. The wind on these days was north-westerly and fairly strong at times; but as it did not exceed 20 miles an hour, the strong current cannot well be attributed to the influence of the local wind. The highest daily mean velocity in 1912 next to this, was on August 16, at Station A, when it amounted to 2.36 knots. This was after the spring tides, with a smooth sea and light to moderate westerly wind, not exceeding 17 miles an hour.

The highest of the maximum velocities on the ebb tide, as measured during any half-hour period, occurred at the same dates as the above high averages for the day, and were as follows: In 1911 on June 27, 3.46 knots; and in 1912, the highest during the exceptional strength at the end of August was 4.21 knots on the 29th. On August 16, the maximum was 3.92 knots. The conditions at these times were as above stated.

It thus appears that with the one exception above noted, the greatest strength observed in either 1911 or 1912 at any of the stations, was during calm weather or with the usual moderate westerly winds of summer.

Wind in 1895.—As the time given to the Gaspé current in this season was only the month of July and part of September, there was not much opportunity to investigate wind disturbance. The best example in that season occurred in July at the two stations B and C. On July 2 and 3 for a full day, the wind was W.N.W. and N.W. amounting to a total of 549 miles in 24 hours, or 23 miles an hour. The mean velocity of the current for this day was 1.49 knots; this being at the neap tides. Again on July 8 to 9 during a full day, the wind was E.S.E. and S. E. and S.S.E. amounting to a total of 447 miles in 24 hours, and rising to 24 miles an hour for 12 hours. The mean velocity of the current for this day was 1·43 knots; this being two days after the spring tides.

As these daily mean velocities are so nearly the same, the difference in the effect of the winds in the two directions is nearly equal to the difference between the spring and neap velocities, which from the values already found, we may take as 0·75 of a knot.

Wind in 1911.—The heaviest north-west wind of the season occured while the vessel was at Station A, off Cape Magdalen. It rose suddenly on the forenoon of Tuesday, August 29. For 16 hours, from noon on Tuesday to 4 o'clock on Wednesday norning, there was a total of 579 miles, or an average of 36 miles an hour. During that time, the maximum was 60 miles an hour for 2 hours and for 8 hours the average was 55 miles an hour. On Wednesday forenoon it fell off as quickly as it had risen. During Tuesday night the vessel was anchored closer to shore in the hope of obtaining some shelter. The best method of judging of the effect of the wind is therefore a comparison of the succesive maximum velocities of the current, with careful allowance for the diurnal inequality and the falling off towards neaps.

It thus appears that the current was weaker by fully one knot during Monday night before the gale began, reducing it to two-thirds of what it should have been at the time. This accords with the tendency of a current to set towards a coming wind, so often met with. The maximum velocities on the corresponding tides, Tuesday morning and Wednesday morning before and after the gale, were the same within 0.07 of a knot. During the gale, the observations were continued but some dragging occurred. The nearest estimate of the increase in strength is 0.25 knot; and although this was at a position nearer shore, it probably represents fairly the increase due to the wind.

There is usually a decrease in the velocity of the current during south-east winds, but it is not always that any change occurs. During all the periods of south-east wind in the season, the accompanying changes in the current were as follows:—

On June 7 to 10, at Station B, the weather was calm, followed by moderate north-west wind. The total mileage from noon on the 9th to noon on Saturday the 10th was 708 miles. On these days the current was very strong, the daily mean velocities increasing from 2.07 to 2.15 knots, towards the spring tides. The weather was fine on Sunday with little wind. On Monday the 12th at 8 o'clock, south-east wind began, and continued for 31 hours, averaging 23 miles an hour, and amounting to a total of 685 miles. The mean velocity for a complete day during this wind, was 1·08 knots, although this was just at the springs, but with the moon in apogee.

It may be that the current was unusually strong before the south-east wind began, as it often sets strongly towards a coming wind; and it may thus have been above the normal for apogee springs. at allowing for this, there was a decrease of at least three-quarters of a knot, after the south-east wind had been blowing for some time.

At the same station in August, with the same strength of south-east wind, there was no change in the velocity. This was on August 8 to 9, when during 20 hours there was a total of 443 miles of south-east wind, averaging 22 miles an hour. Before this wind, it had been perfectly calm, and afterwards, such wind as there was, was light and variable. There was thus the best opportunity to detect any effect produced.

The daily mean velocities of the current on three lunar days, or successive periods of 25 hours, were as follows: First period, while calm, 0·99 knot; second period, including all the south-east wind, 1·19 knots; third period, with only light and variable winds, 1·22 knots. These days were just before the spring tides when a gradual increase was to be expected.

The direct action of the wind while south-east, thus occasioned no change in the current as compared with the previous and following days. But one day later, after 24 hours of strong N.W. and W. wind, the mean velocity rose to 2·16 knots, which is above the normal for the apogee springs. This large increase in the daily mean, estimated at 0·75 knot, must represent the difference due to south-easterly and north-westerly weather conditions; the change in velocity probably resulting from difference of barometric pressure in the two directions, rather than from the direct effect of the wind.

A result which is more definitely due to direct wind effect, is a change in the relative lengths of the period of increase and decrease in speed, during flood and ebb. On the day of south-east wind above mentioned, the decrease of speed during the flood continued longer than usual, making the minimum at high water about one hour late, which such a wind might well occasion.

Another instance of this occurred at Station C in the middle of August. After 18 hours of calm, a light easterly wind began at noon on the 15th. This continued to strengthen, and during the forenoon of the 16th it was N.E. amounting to 17 miles per hour, with heavy south-east swell. After the minimum at high water at 4 o'clock on the morning of the 16th, the ebb current did not strengthen as it should have done, but remained constant for 10 hours at an average of half a knot, when it became so rough that the station was left. During those hours, the total of easterly wind was 194 miles.

Wind in 1912.—At Station F which is at an olling of 11 miles, a noteworthy example occurred of the effect of south-east wind. The current is less strong at this olling, and it was during the neap tides. On August 20 and 21 there was light to fresh north-west wind, falling off to calm; and the successive maximum velocities of the current were 1·31, 1·51, 1·50, 1·71 and 1·53 knots. On the 22nd, south-east wind and swell set in, and continued to increase throughout the 23rd. The maximum in the current, early on the 23rd, increased to 2·70 knots, after the south-east wind had been blowing for 18 hours. There was pronounced diurnal inequality at the time; but allowing for this, the increase in strength directly against this wind for some hours after it began, amounted to 0·85 of a knot.

A similar example was met with at Station C in September. The station was occupied from the 23rd to the 27th; and from the beginning until the afternoon of the 26th, the current was unusually weak with long periods of slack; the daily mean velocity being only from 0·47 to 0·66 of a knot. At 17 o'clock on the 26th, strong S.E. wind set in; and on the day that this wind began, the current increased a full quarter of a knot. This south-east wind continued until the station was left at noon on the 27th, and during this time the current maintained its increased strength. The barometer in the earlier days was unusually high, registering 30·60; but began to fall rapidly when the south-east wind commenced.

Exceptional strength in relation to weather conditions.—The strongest current ever encountered was at Station C, during a period of three days from Wednesday morning to Saturday noon, August 28 to 31, 1912. The spring tides occurred on Thursday, but with the moon at its mean distance. The daily mean velocities on these days were 2·71, 3 09 and 2·95 knots successively; and the maximum velocities on the consecutive ebb tides were 3·58, 3·88, 4·21, 3·64, 3·58 and 3·75 knots. These are the more noteworthy, as there was little diurnal inequality at the time, to give a specially high value once in the day.

On the Monday previous, the wind changed from N.W. to S.E. late in the evening. It held in the S.E. for a full day throughout Tuesday, and although sometimes squally with a rough sea, it was moderate on the average. From Wednesday morning to Saturday noon, the wind was between W.N.W. and N.N.W and varied from a strong wind to nearly calm; the average velocities for the three days from noon to noon being 13, 16 and 14 miles an hour. This amount of wind cannot be taken as an explanation of the great strength of the current, especially as it decreased in the usual way after the spring tides, although the wind continued.

The only explanation that can be found is in the general meteorological conditions at the time, which were very unusual. The low pressure area which passed over the Gaspé region on Tuesday, when the S.E. wind occurred, did not continue its onward course to the Atlantic, but remained in the vicinity of Newfoundland for three whole days, from Wednesday to Friday; and by Saturday it dispersed. There was thus a pronounced barometric gradient from Quebec to the Gulf area which persisted during the three days under consideration. The pressure at Quebec during these days was 29·80 to 29·90 while the average over the Gulf area remained at 29·50. In the Gaspé region, the barometer necessarily remained steady, so that it gave no indication locally to account for the current.

If such conditions are a sufficient explanation because of their long continuance, this affords a noteworthy example of the effect upon the current of difference of barometric pressure over wide areas. It is also an explanation which accords with the conditions observed in Belle Isle strait, where the strongest and most persistent currents show no relation to the local wind in the strait at the time; but appear to be due in the same way to widely extended differences of barometric pressure.

Next to this exceptional velocity, the highest maximum ever observed was also in the season of 1912. It amounted to 3·92 knots at Station A, with moderate to light winds, and a smooth sea, as already explained.

Summary of results regarding wind disturbance.—The results which we may now sum up, are based not only on the leading examples already given in detail, but also on close observation while at anchor with all the factors under consideration at the time, including special examination of the under-current to obtain an additional term of comparison. After a careful analysis of all the facts and figures obtained, the results are largely negative. It has been possible however, to make an estimate of the actual influence of the wind, which we will give.

(1) The general result to begin with, is that the Gaspé current cannot be checked, much less reversed in direction, by a wind blowing directly against it. This is also true in winter, when the presence of ice gives the wind a greater influence than it would have on open water.

(2) The greatest variation in strength, as indicated by the daily mean velocities, is not caused by the wind; as the variation from springs to neaps is greater in amount than any winds met with during the summer season appear able to effect.

(3) The highest measured velocities of the current did not occur during the storms met with, up to such time at least as it was no longer possible to hold at anchor in the open. This is corroborated by both the daily mean velocities and the maximum values.

(4) The weakest current observed did not occur during a period of contrary wind from the south-east. In September 1912, the daily mean velocity fell below half a knot, at a time when the wind was light and variable; and for two days afterwards, it was still below three-quarters of a knot.

(5) There is some indication that the current strengthens during the quiet time, with south-east swell running, before a S.E. wind begins. Whether this is always the case or not, one of the most striking features of the behaviour of the current is the marked increase in strength during the early part of a south-easterly blow. The current on several occasions set directly into the wind with a velocity quite above the normal, up to the time that the station was left because it was no longer possible to hold at anchor.

(6) The strongest current ever encountered occurred at a time when the local wind was moderate. It was apparently due to a pronounced difference of pressure, or barometric gradient, from Quebec to the Gulf area, which held for three successive days, as fully explained.

(7) The effect of the winds in the opposite directions up and down the coast, from a careful analysis of the observations in 1895 and 1911, is found to amount only to 0·75 knot, as closely as can be estimated. This result is based on winds having a strength of 20 to 30 miles an hour, under such conditions as have been described; and the amount found is nearly the same in each instance. If half this change in velocity is attributed to the wind in each direction, the increase or decrease in velocity due to such winds, is three-eighths of a knot. It is by no means certain that this change in velocity is occasioned by the direct action of the wind. The wind itself is caused by difference of barometric pressure in the two directions; and it is quite possible that the current is affected by this difference of pressure rather than by the direct influence of the wind. The exceptional instance described in 1912, may corroborate this view. It is also possible that strengthening during the clearing winds, is due to their making the current narrower and stronger by pressing it against the shore, as they often veer from north-west into north.

Displacement of the current.—During exceptional weather conditions, it is possible for the main south-eastward current which consists of water of the least density, to lie in the middle of the passage between the Gaspé coast and Anticosti. When the current is in position, the area between it and the Gaspé coast may be occupied by weak and fluctuating currents, or even by a reverse current setting inwards to the north-west. This position in the middle of the passage may therefore be regarded as a displacement of the current, or an alternative route which it may take.

The most definite instance of disturbance of this character was observed in September of 1895, in the vicinity of Fame Point. The wind conditions at the time were as follows: On the 31st of August there was strong S.S.E. wind, followed on the 1st and 2nd of September by heavy wind from the N.W. This was accompanied on the Lower St. Lawrence by heavy W.S.W. wind, with a mileage during the three days of 1,950 miles, as recorded at Father Point.

It is to be noted that winds which are south of west at Father Point and S.S.E. at Anticosti, are off shore along the Gaspé coast, and tend to carry the current away from the shore. There were strong southerly winds on the

4th and 5th, and again on the 7th and 8th; which were also accompanied by moderate south-westerly winds on the lower St. Lawrence. This was followed on the 10th by strong northerly wind, which averaged 25 miles per hour for 24 hours. On the following days the wind fell off. On the 8th and 9th a storm centre was passing in the offing of the Nova Scotia coast.

The barometer as recorded at South-west Point during the period of the observation of the currents, was as follows: From September 6th to 13th the barometer fell gradually from 30·23 on the 7th to 29·58 on the 13th, and afterwards rose rapidly to 30·43 on the 15th. The average height for the month of September 1895, was 29·84.

At Station B off Fame Point, the current on September 9th and 10th was found to be weak and variable. During a period of 16 hours the set for 6 hours at different times was W.N.W. and N.N.W., or in the reverse direction; and for only 10 hours it was in the usual direction between S.E. and E. veering once as far as N.E. Its velocity throughout the time was considerably below one knot per hour. While the current was slack, during a change from N.W. to S., the under-current also fell off to nothing as far down as 50 fathoms; which shows that there was no deep under-current in any constant direction.

As the heavy weather of the 10th had made it necessary to take shelter under Cape Rosier, a course across the direction of the current was run from there on the morning of the 11th. It was N. by E., and on this course a series of points were carefully fixed. It was thus found that within 6 miles of the shore the current ran S.E. by S. with a velocity of 2·20 knots; and from 6 to 12 miles it ran S.E. with a velocity of 1·55 knots per hour.

On anchoring at Station D in the middle of the passage the current was found to be setting north-eastward, or across the direction of the passage. During a period of 24 hours on the 11th and 12th, it there set steadily in directions between N.E. and N. with a velocity which varied from 0·86 to 1·70 knots per hour. The least of these velocities occurred at high water and the greatest at low water; which would indicate that although the current was there setting across the passage it may have formed a bend in a line of current which if traced would be found to make outwards and not inwards. On account of this transverse direction of the current, the under-current was carefully examined at three different times. It was found to set in the same direction as the surface current, or within one or two points of it. It also extended to a depth of more than 50 fathoms, and was thus remarkable for its strength and thickness in this transverse direction.

To ascertain more definitely where this current came from, another anchorage was made 13 miles to the south-west against its direction at Station E, 11½ miles off Fame Point. The current there on September 12th and 13th, during a period of 20 hours, was found to veer continuously from N.W. through north, east and south to S.S.W. and back to south. The velocity varied from 0·41 to 1·55 knots per hour. From observations of the under-current it appeared that the body of the movement was north-eastward, while the veering on the surface was relatively superficial and weak. This station therefore lay at the outer edge of the veering current found nearer shore; and below this there was the same deep under-current as found at the middle of the passage, flowing north-eastward.

To follow up this transverse direction of the under-current further, an anchorage was made at Station T off Ellis bay, during the night of the 13th. The surface and under-current were found to run parallel to the shore but in opposite directions. This was probably due to the transverse direction of the deep under-current in the middle of the passage, which would tend to make it bear against this shore.

It is clear from the above description that the direction of the current must have been very disturbed and circuitous during the above period. Under such conditions the difficulty is felt of tracing the course of the current by means of observations taken on a single vessel, especially when it is so difficult to hold at anchor in these open situations and great depths.

The density of the water however, gave valuable help in supplementing the current measurements themselves. The density was determined throughout the region immediately before and after these observations; and the contours of equal density which resulted, corroborate the view that the water in the transverse current finds its way outwards past Cape Gaspé eventually, as already inferred from the nature of its tidal behaviour. The water of least density between Fame Point and Ellis bay, occupied a width of eleven miles at the middle of the passage. Also, off Cape Gaspé, the water of least density was found immediately off the cape, which corresponds with the position of the outflowing water in that vicinity. From all the indications obtained, there can therefore be little doubt that the current off Cape Rosier and Cape Gaspé set south-eastward continuously throughout these days.

Wind and ice. In judging of the effect of the wind on a current by the behaviour of the ice it carries, there are two points that require to be considered: (1) The effect when ice is present is much greater than the same wind would have upon open water; as the broken and up-turned edges of the ice give the wind a greater hold upon it than it would otherwise have. (2) Even when the ice is set off the coast, the current itself may not be displaced to the same extent. For, the open water between the stream of ice and the shore may be setting in the same direction, as usual. This has been noted by careful observers, as actually occurring.

The movement of the ice in winter, off Cape Rosier, is thus described by Mr. Eugène Costin, who has been lightkeeper there for 21 years: Close inshore, the ice runs westward during the flood; but this run is not more than 400 feet wide, beyond the bordage or shore ice. The main body of the ice, going south-eastward, sets rather off shore in this vicinity; leaving a strip of open water from English Point to Cape Gaspé, which it passes about ¼ mile off. To the westward of English Point, the ice is always close in shore.

There is ice from the middle of January to the middle of April; and the main body of ice always moves outward to the south-east. No wind can stop it or reverse its direction. It may be driven from the land by the wind, and after a week of off-shore winds, there may be no ice visible at all, even in mid-winter. A south-east wind against the current, and also a northerly wind which bears on shore, will bring the ice close in; cutting off the strip of open water.

The movement of the ice as seen from the high view-point of the light-house on Cape Gaspé, 355 feet above the sea, is thus described by the lightkeeper, Mr. F. W. LeHuquet, who has been in charge for 15 years: The ice runs steadily southward during the winter and this direction is never reversed under any conditions. The movement usually extends from the shore line as far out as can be seen. The ice is mostly broken and packed; but there are fields amongst it, of as much as a mile in size.

The usual winds in winter are N.W. and N.E. With north-west winds, the ice is opened out and moves more freely on; and with north-east winds, which bear on shore, it is more closely packed and somewhat retarded. At other times there is open water for as much as a mile from the coast. This occurs with S.W. winds which are off shore.

These descriptions confirm the results of the observations, in showing that the wind cannot check this current by blowing directly against it, even when the effect of the wind is augmented by the presence of ice in the water. They also show that the wind is more capable of displacing the current in position; although it may be quite possible for the ice to be driven off shore by the wind, while the current itself continues to flow along shore as usual.

Another example of this want of accord between the movement of the ice and the current itself, is afforded by its behaviour farther on, in the offing of Point Peter south of Gaspé bay. The residents of that point observe the ice carefully, as they go out hunting upon it; taking a boat with them for safety. The ice in this offing always sets southward, as it does off Cape Gaspé, except during east winds which pack it in, and make it stand; but even then, the water still runs southward underneath it. On the other hand, northwest winds, owing to their direction relatively to the coast here, send the ice off shore, but in the open water left in shore, there is the usual tidal stream in the two directions which is here found near the land.

The current off Cape Gaspé, and Southward.

Although the currents in the neighbourhood of Cape Gaspé are not on the route of ocean steamships or on the leading coastal routes, yet they are of importance to some steamers and to smaller vessels in the region.

At Cape Gaspé, where the current leaves the guiding line of the shore, the wind has more scope and its effect is more marked. The current as observed at any fixed point, shows a wide variation in velocity; apparently due to a change in the position of the line of strongest current, which is in all probability due to wind influence. The edge of the line of strong current is sometimes visible as a tide rip.

The observations in this locality were obtained at Station P, at 5 miles east of Cape Gaspé and 1½ miles outside a 30-fathom bank known locally as Norway bank. The depth at the station was 50 fathoms; and it was thus quite beyond any local disturbance from shallows. It was occupied chiefly in broken time because of its nearness to the only good shelter on the coast.

Nearly all the observations at this station were obtained in 1912 towards the end of the season. They were thus largely in unsettled weather, after storms or when they were threatening, except the earlier of them, in September, when the conditions were quite normal; and these may serve as a term of comparison with the other stations as well as with the disturbed conditions later. During these observations, on September 12 to 14, the weather was fine with variable winds which only once exceeded 15 miles an hour. The daily mean velocity amounted to 2·00 and 2·30 knots, which is much the same as elsewhere in the line of the Gaspé current at the spring tides. The successive maximum velocities were 2·71, 3·18, 2·93, and 2·18 knots; there being no diurnal inequality at the time. The highest of these values accords well with the greatest velocity found at the other stations under similiar conditions.

During the windy weather of October however, some marked changes of velocity were observed. On October 7, midway between neaps and springs, with a strong S. S. W. wind all day, the velocity did not exceed a maximum of 0·84 knot; but the next day the maximum on the corresponding ebb rose to 3·61 knots. This was after 19 hours of N. W. wind, which was not less than 20 to 30 miles an hour in the open; as the vessel was in shelter during the night. On the two following days, the 9th and 10th, during light and variable winds not exceeding 10 miles an hour, the successive maximum velocities were 2·31 and 2·37 knots. If these are considered to be normal, the above wide difference on the 7th and 8th must be due to disturbance, probably because of a change in position of the strong run of current.

At noon on the 10th a strong N. N. W. wind began, which in 1½ hours rose to 34 miles an hour, with a heavy sea, when the station was left. Up to the time of leaving, the velocity had risen to 2·50 knots, at the hour when the maximum should occur. The total of 106 miles of wind since noon, had thus increased the velocity by only 0·16 of a knot, above the previous maximum values already mentioned.

It is thus possible in the offing of Cape Gaspé, for a very strong current to be met with, especially during north-west winds. Vessels making Gaspé should be aware of this; but the main steamship routes do not pass the cape so closely as to encounter it.

Information from Fishermen. Some valuable information regarding the behaviour of the current after leaving Cape Gaspé, was obtained from fishermen at Point Peter on the south side of Gaspé bay. They are acquainted with a series of banks which extend in a line south-eastward from Cape Gaspé to American bank, which is 12 miles from the cape. In speaking of American bank, they refer to the 5-fathom patch near its north end. Without entering upon the complex topography and nomenclature of the bottom, which it was necessary to master to understand their explanations, it will be sufficient to mention one bank, named the Big Hill, which is just half way between Cape Gaspé and this 5-fathom patch on American bank. Their descriptions when summarized, are as follows:—

After leaving Cape Gaspé, the general direction of the current is southward; and its greatest strength lies over the Big Hill, which is practically the centre of the current; the American bank being near its outer edge. This makes the usual width of the current about ten miles, which is the distance between Point Peter and American bank. After S. E. winds, the current lies closer in shore and is narrower and very strong; and there may then be a northward set over American bank. This northward set however, is never strong and only lasts a few hours at a time, and with change of wind the set is again southward.

During N. and N.E. winds, the strength of the current is increased; and on the other hand, there are times when no current is found in the width from Point Peter to American bank. This they cannot assign to any cause; although some of them consider that northerly winds 'run the current out', and thus occasion a slack time afterwards.

The greatest strength of the current which is met with, is not during heavy winds, however. It occurs during hot and squally weather, or when calm and showery. Weather of this character 'creates tide' as they express it.

These are the leading points in which the fishermen agree, with the omission of much that is discordant, apparently because it is unusual or too local. It is interesting to note the slight emphasis laid on the direct effect of the wind by close observers who have spent a life-time in this region; and their recognition of the displacement of the current, as well as its great strength at times when barometric conditions afford the only explanation of the increase.

Tidal features of the Gaspé Current.

The most distinct feature in the behaviour of the current is a marked fluctuation in velocity with the flood and ebb. Whether the average speed of the current is greater or less than usual, because of other variations such as those already explained, this tidal fluctuation is always pronounced and persistent. The two elements in this fluctuation which require determination, are the amount of the variation, and the time of greatest and least velocity in relation to the time of high and low water. These elements will enable a vessel to know whether it is encountering the current during the flood or ebb period and whether there will be a gain in avoiding or taking advantage of the current.

Tidal fluctuation in velocity.—The following summary is based upon observations in the vicinity of the spring tides as obtained in the seasons of 1911 and 1912, at the three stations which lie in the strength of the current at the uniform offing of $4\frac{1}{2}$ miles. The values given are the mean of the three lowest and the three highest that were observed, in each case. These are the best comparative values that can be given to show the usual fluctuation in velocity from flood to ebb, and also to indicate the extent by which these values may vary from time to time. It is to be noted that it is quite possible for the minimum on the flood at one date to be quite as high as the maximum on the ebb at another date, because of variations from other causes.

Station A.—Minimum on the flood from 0·88 to 1·85 knots.
" B.— " " " from 0·65 to 1·77 "
" C.— " " " from 0·49 to 1·88 "

Station A.—Maximum on the ebb from 1·85 to 3·64 knots.
" B.— " " " from 1·39 to 2·91 "
" C.— " " " from 1·25 to 3·51 "

A final result for the usual fluctuation from flood to ebb in the vicinity of the spring tides, is given by the average of 59 maximum and 59 minimum velocities as observed at these three stations, as follows:—

Minimum on the flood. General average 1·10 knots.
Maximum on the ebb. " " 2·35 "

Fluctuation, flood to ebb. . . . . 1·25 "

The fluctuation at the neap tides is somewhat less than this. The general average, including both springs and neaps, is about 14 per cent less; but the observations in the vicinity of the springs have been preferred, as giving a more definite result.

Extreme velocities.—The following list gives the greatest velocities ever observed, under combinations of the various conditions as they actually occur. All the stations at the uniform offing of $4\frac{1}{2}$ miles are here included; and also the greatest velocities found in any of the three seasons, those of 1895 not being as great as in the other two seasons when the observations were more extended.

The values given are the velocities as measured in any half-hour period. They are all necessarily on the ebb tide; but it is to be noted that some of them occur at times of diurnal inequality when one ebb in the day is much stronger than the other. It is also striking to see how high these velocities may be in calm or quiet weather, as compared with any effects which the wind can produce.

Sta. Q.	2·16	knots	1912, July 29. At spring tides, at apogee. Some diurnal inequality. Calm and smooth.
Sta. A.	3·46	"	1911, June 27. At spring tides, at perigee. Large diurnal inequality. Calm and smooth.
"	3·92	"	1912, Aug. 16. Between springs and neaps, moon at mean distance. Light to moderate west wind.
"	3·63	"	1912, Aug. 17. (Same conditions as above).
Sta. B.	3·28	"	1911, June 21. At neap tides, moon at mean distance. Wind light and variable.
"	3·42	"	1911, Aug. 12. Near spring tides, moon at mean distance. Some diurnal inequality. Strong W.N.W. wind.
Sta. C.	3·35	"	1911, July 28. At spring tides, near perigee. Large diurnal inequality. Calm.
"	3·21	"	1911, Sept. 14. Between springs and neaps, near perigee. Large diurnal inequality. Strong N.W. wind.
"	4·21	"	1912, Aug. 29. (Exceptional). At spring tides, moon at mean distance. Moderate N.W. wind.
Sta. P.	3·18	"	1912, Sept. 13. At spring tides, near perigee. Wind light.
"	3·61	"	1912, Oct. 8. Between neaps and springs, at perigee. Little diurnal inequality. Strong N.W. wind.
"	2·50	"	1912, Oct. 10. At spring tides, near perigee. Wind N.N.W. becoming heavy.

Time of greatest and least strength of the current in relation to the tide.—To arrive at this relation, the graphical method already referred to, was made use of. The velocity of the current, for every half hour day and night, was laid off at right-angle to a base line which represented the time. The variation in velocity was thus represented by an undulating curve. The time of the maximum and minimum velocities were then carefully determined for comparison with the time of high and low water at Father Point, as recorded simultaneously by the registering tide gauge established there.

The time of maximum and minimum velocity appeared at first sight to correspond definitely with low water and high water respectively; but the difference in time, between the two, was not found to be as constant as might be expected. It is not unusual for the difference to vary as much as 1h. 10m. from its average value. Also, when the moon is in high declination, north or south of the equator, causing diurnal inequality in the tide, the time of maximum and minimum may be alternately earlier and later by 40 to 55 minutes relatively to the tide.

The observations do not show any progressive change in the difference at the successive stations along the Gaspé coast. As far as can be judged, in view of the variations which occur, the maximum and minimum in the current is practically simultaneous all along the coast. The best result was therefore obtained by taking a general average for the four stations in the line of the current, at the uniform offing.

At these four stations Q, A, B and C at $4\frac{1}{2}$ miles from shore, the observations in the three seasons of 1895, 1911 and 1912 afforded 118 times of maximum and 116 of minimum in the current, for comparison with the tide. The general average which results, is as follows:—

The minimum velocity on the flood occurs on the average at 1h. 50m. before High Water at Father Point; and the maximum on the ebb at 2h. 05m. before Low Water at Father Point.

These values include one hour of difference in absolute time. Hence by subtracting them from the time as given in the tide tables for Father Point, the time of greatest or least velocity in the current is found in Atlantic Standard time. The result as thus found may differ from the actual time by the amount of the variations above indicated.

A vessel when off the coast may thus know whether it is on the flood or the ebb at the time, and it may thus take advantage of the explanations following, in deciding upon the most advantageous offing for its course.

Routes for best time. Inward course.—The coasting steamers engaged in the coal trade when inward bound, are tempted to take a route close in shore, to avoid the Gaspé current and obtain help from the upward flood. Apart from the risk of keeping within a mile or two of the shore, this in-shore flood is in most places only strong enough to be of service about the time of spring tides, and then only for the flood period. After the six hours of flood, in which some 60 miles along the coast are made, these steamers must sheer out to a greater offing; as for the next six hours the in-shore ebb stream adds to the strength of the main current.

The captains with longest experience therefore maintain that better time can be made by keeping out to an offing of 8 or 10 miles near the outer edge of the Gaspé current where it is usually weak enough to be inappreciable. Record time has been made at this offing, and one captain claims that at an offing of 12 miles he only lost a quarter of an hour from current as far in as Point des Monts.

The best inward route from Bird Rocks is to make the Gaspé coast at an offing of 14 miles at Cape Rosier, and to maintain an offing of 10 miles from Fame Point to Cape Chat. Sailing vessels should tack when ten miles off. From there, the choice is open to make Manikuagan and follow the north shore, which may be advisable for better shelter in the autumn or at any other time when northerly winds are prevalent, which keep the weather clear.

The investigations of this current also show that Atlantic steamers, inward bound, will gain time by making a straight course from Bagot Point, Anticosti, to a point 10 miles off Cape Magdalen, and thence maintaining the same offing till within the mouth of the estuary opposite Point des Monts.

Outward course.—A distinct advantage will be gained by all vessels by keeping in the strength of the Gaspé current, at an offing of 4 to 5 miles, from Cape Chat outward. Even steamers on the Belle Isle route may obtain an advantage by following the rounding of the coast at this offing as far as Fame Point at least, before turning off towards Anticosti. The distance that the coast should thus be followed will be greater if it is ebb tide at the time; as they may then obtain as much as 3 knots in their favour which will more than compensate for the slight extra distance by the chart. All coasting steamers, and Atlantic steamers on the route south of Newfoundland, will gain by keeping this offing till they leave the Gaspé coast.

TABLE I.

STATIONS at which anchorages were made; their positions, and length of observations at each. The bearings are from true north, and the magnetic bearings are given in brackets.

Locality.	Year.	Date.	Time in hours.	Total time.	Position.
Station Q	1912	July 23–Aug. 2	232		From Martin River Light; 4½ miles 345° (N 12° E mag.)
	1912	Sept. 2 to 7	118	350	
Station A	1911	June 26 to 30	102		From Cape Magdalen; 4½ miles 7° (N 34° E mag.)
	1911	Aug. 28 to 29	21		
	1911	Aug. 30–Sep. 1	53		
	1912	Aug. 5 to 7	43		
	1912	Aug. 7 to 17	235	454	
Station R	1911	June 30–July 2	33	33	From Cape Magdalen; 9½ miles 7° (N 34° E mag.)
Station B	1895	July 2 to 5	64		From Fame Point; 4½ miles 15° (N 42° E mag.)
	1895	" 30 to 31	23		
	1895	Sept. 9 to 10	16		
	1911	June 7 to 13	101		
	1911	" 21 to 22	18		
	1911	Aug. 7 to 12	92		
	1911	" 21 to 23	46	360	
Station E	1895	July 5 to 6	23		From Fame Point; 11½ miles 12° (N 39° E mag.)
	1895	Aug. 1 to 2	24		
	1895	Sept. 12 to 13	20		
	1911	June 19 to 21	52		
	1911	Sept. 4 to 6	51	170	

TABLE I.—*Continued.*

Locality.	Year.	Date.	Time in hours	Total time.	Position.
Station D	1895	July 25 to 26	34		From Cape Henry, Anticosti: 17¼ miles 192° (S 39° W mag.)
	1895	Aug. 2	9		
	1895	Sept. 11 to 12	24		
	1911	June 15 to 17	42	109	
Station C	1895	July 8 to 10	48		From English Point, Griffin cove: 1½ miles 46° (N 73° E mag.)
	1895	Sept. 17	7		
	1895	Sept. 20 to 21	17		
	1911	July 24 to 28	98		
	1911	Aug. 14 to 16	54		
	1911	Sept. 14 to 16	44		
	1912	Aug. 26 to 31	95		
	1912	Sept. 18 to 21	75		
	1912	" 23 to 27	93	531	
Station I	1895	July 11 to 12	25		From English Point: 11 miles 46° (N 73° E mag.)
	1911	Sept. 7	7		
	1911	Sept. 25 to 30	80		
	1911	Oct. 2	3		
	1912	Aug. 20 to 23	67	182	
Station G	1895	July 11 to 13	22		From South-west Point, Anticosti: 16 miles 220° (S 76° W mag.)
	1911	July 3 to 8	127	149	
Station P	1911	Aug. 19	9		From Cape Gaspé Light: 5 miles 69° (S 84° E mag.)
	1911	Aug. 25 to 26	25		
	1911	Oct. 7	8		
	1912	Sept. 10 to 14	73		
	1912	*Oct. 1 to 12	163		
	1912	*Oct. 15 to 19	35	313	
Station H	1911	July 17 to 22	129	129	From mouth of Pavillon river, Anticosti: 8½ miles 210° (S 57° W mag.)
Station J	1895	Sept. 4	10		From Bagot Point: 8¼ miles 128° (S 25° E mag.)
	1911	July 11 to 15	97	107	
Station K	1911	July 31–Aug. 5	126	126	From Bagot Point: 6¼ miles 181° (S 28° W mag.)

TABLE I.—*Concluded.*

Locality.	Year.	Date.	Time in hours.	Total time.	Position.
Station L	1910	July to Oct		2,160	Lightship. From Heath Point; 8 miles 103° (S 50° E mag.)
	1911	June to Oct.........		3,024	
Station M	1895	Aug. 7	4	...	From Heath Point; 13 miles 111° (S 42° E mag.)
	1896	Sept. 16 to 17	19		
	1896	" 21 to 26	47	70	
Station N...........	1896	July 15 to 16	7	......	From Heath Point; 25 miles 112° (S 41° E mag.)
	1896	" 17 to 23	107	114	
Station S	1895	July 24 to 25	26	.....	From South-west Point, Anticosti; 15½ miles 305° (N 28° W mag.)
				26	
Station T	1895	July 22 to 23	42	......	From Cape Henry, Anticosti; 6½ miles 171° (S 18° W mag.)
	1895	Sept. 13	12	54	

*With several interruptions between these dates.

TABLE II.

Stations J and K.—*Time of maximum strength in relation to the tide.*

Locality and Date. 1911.	Maximum on the Flood. Time.	Direction of Current.	Velocity.	Maximum on the Ebb. Time.	Direction of Current.	Velocity.	Tide at Father Point. H. W.	L. W.	Maximum in relation to time of tide
	H. M.		Knots.	H. M.		Knots.	H. M.	H. M.	H. M.
STATION J.									
Tuesday, July 11				9:30	EbS	1·26		8:35	55
" "	13:10	SEbS*	(0·75)				14:25		1:15
" "				18:10	NNW*	(0·26)		19:50	1:40
" "	23:10	NNW	0·69				2:30		3:20
Wednes'y, July 12				6:10	SE	1:30		9:05	2:55
" "	13:15	NEbN	0·77				15:00		1:45
" "				18:50	SE	0·49		20:25	1:35
Thursday, July 13	1:35	WbS	0·74				3:00		1:25
" "				8:05	EbS	1·15		9:35	1:30
" "	14:00	WSW	0·57				15:30		1:30
" "				21:50	NEbE	0·58		21:10	30
Friday, July 14	0:50	SSW	0·73				3:35		2:45
" "				8:55	E	0·47		10:10	1:15
" "	14:15	SE†	(Irreg.)				16:05		1:50
" "				19:35	SE	0·27		21:45	2:10
Saturday, July 15	2:00	WNW	0·57				4:15		2:15
STATION K.									
Monday, July 31	16:20	NWbW	1·18				18:15		1:55
" "				23:45	(SE'd)	0·37		24:25	0:40
Tuesday, Aug. 1	5:20	WNW	1·15				6:40		1:20
" "				11:45	W*	(0·18)		12:45	1:00
" "	16:35	NW	0·61				19:05		2:30
" "				23:15	E	0·28		1:30	2:15
Wednesday, Aug. 2	4:20	NNW	0·52				7:30		3:10
" "				11:00	EbS	0·43		13:25	2:25
" "	18:20	NWbN	0·61				20:05		1:45
Thursday, Aug. 3				(Uncert)	EbS	0·54		2:45	. .
" "	7:15	NNE‡	0·48				8:30		1:15
" "				12:10	ESE	0·61		14:25	2:15
" "	18:50	NWbN	0·59				21:05		2:15

TABLE II.—*Concluded.*

Locality and Date, 1911.	Maximum on the Flood.			Maximum on the Ebb.			Tide at Father Point.		Maximum relation to time of tide
	Time.	Direction of Current.	Velocity.	Time.	Direction of Current.	Velocity.	H. W.	L. W.	
	H. M.		Knots.	H. M.		Knots.	H. M.	H. M.	H. M.
STATION K.— Friday, Aug. 4				1.50	ESE	0·80		4 00	2.10
" "	7 40	(W'd)	0·38				9:45		2.05
" "				11:30	SE*b*E	0 43		15:20	0:50
" "	21 00	W*b*N	0·57	...	...	...	22:20		1:20
Saturday, Aug. 5				(Unc'n)	ESE	0·32	.	5:15	
	(Unc'n)	W*b*N	0·38	.	.	.	11:00		
Average time of maximum before H. W. and L. W. at Father Point								...	1.43

* The maximum is represented by a minimum in the opposite direction.
† Current reversed in direction and velocity irregular.
‡ Current backing to the left but time of maximum distinct.

TABLE III.

STATION II.—*Period of veer, completely around: and relation of current to tide.*[1]

Based on time of Maximum velocity and direction North-north-westward.

Date 1911.	Time of Maximum	Direction of Current.	Velocity at Maximum.	Period of Veer.	Time of H. W.	Maximum in NNW'ward direction, before High Water.
	H. M.		Knots.	H. M.	H. M.	H. M.
Monday, July 17	3:40	NNW	0·93		5:30	1·50
				12·40		
" "	16:20	NW by N	0·86		18:00	1·40
				12·15		
Tuesday, July 18	4:35	N by W	0·80		6:20	1·45
				12·45		
" "	17:20	NW	1·08		18:50	1·30
				12:00		
Wednesday, July 19	5:20	N	0·83		7.10	1·50
" "	(Uncert.)	NNW	1·09	12·12	19:45	
Thursday, July 20	6:45	NNW*	(0·91)		8:10	1·25
				11·55		
" "	18:40	N by W ½ W ‡	0·87		20:45	2·05
				12:30		
Friday, July 21 ...	7:10	N by W	0·84		9:15	2·05
				12:55		
" "	20:05	NNW	1·03		21:45	1:40
Average period ..				12:29	Mean .	1·46

* Time when direction was NNW. Maximum some hours later.
‡ The direction held in NE quarter for 20 hours; but two distinct maxima occurred during this period

TABLE III.—*Concluded.*

STATION II.—*Flood and Ebb directions.*

Limiting directions during flood, from 1h. after L.W. to 1h. after H.W.; being 3 hours before or after the maximum, which is taken as the half-tide point.

Date. 1911.	Flood Direction			Ebb Direction.
Monday, July 17	NW*b*W	N	NNE	The ebb direction is more variable; for after veering as far as east, it may back to NW or WNW; or if the veer goes much beyond the eastward direction, there may be a sudden change to the westward quarter. The time of this change is very definite, as it occurs on the average at 20 minutes before L. W. in one or other of these ways.
" "	NW*b*W	N	NE	
Tuesday, July 18.	NW	N	NNE	
" "	NW*b*W	N	N*b*W*	
Wednesday, July 19.	NW*b*N	N	NE*	
" "	W	N	NE*b*N	
Thursday, July 20	W	N	NNE	
" "	E*b*N	N	NNE*	
Friday, July 21	N*b*W		NE*b*N	
" "	NW*b*N	N	NNE	
Saturday, July 22	WNW			

Average central direction during flood .... N*b*W.

*Part of the time, backing; the limiting directions being as stated.

TABLE IV.

STATION G. – *Tidal period in the current, and time-relation to the tide.*

Based on time of Maximum velocity in westward direction, near high water.

Date 1911	Time of Maximum	Direction of Current.	Velocity at Maximum	Period of Veer	Time of H. W.	Maximum and tide.	Tide
	H. M.		Knots.	H. M.	H. M.	H. M.	
Monday, July 3	7:20	W*b*N½N	0·96		7:25	0:05	Neap tides strengthening towards springs. Diurnal inequality increasing.
" "	20:15	WSW	1·09	12:55	19:55	20	
Tuesday, July 4	8:45	SW*b*W	1·32	12:30	8:25	20	
" "	20:10	W*b*S	1·10	11:55	21:00	0:20	
Wednesday, July 5	9:45	SSW	1·01	13:05	9:25	20	
" "	21:30	(Indef'te)	0·76	11:45	21:50	0:20	
Thursday, July 6	10:40	NE*b*E*	0·92	13:10	10:35	05	
" "	22:40	WNW	0·87	12:00	22:55	0:15	
Friday, July 7	11:50	WNW	1·26	13:10	11:30	20	
" "	22:55	W*b*N	1·41	11:05	23:45	0:50	Current during flood setting directly into the wind.
Average period				12:24	Mean	0:03	

*Direction held for 10 hours in the north-eastward quarter before continuing to veer.

TABLE IV.—*Concluded.*

STATION G.—*Tidal Period in the Current.*

Based on time of Minimum velocity at half ebb.†

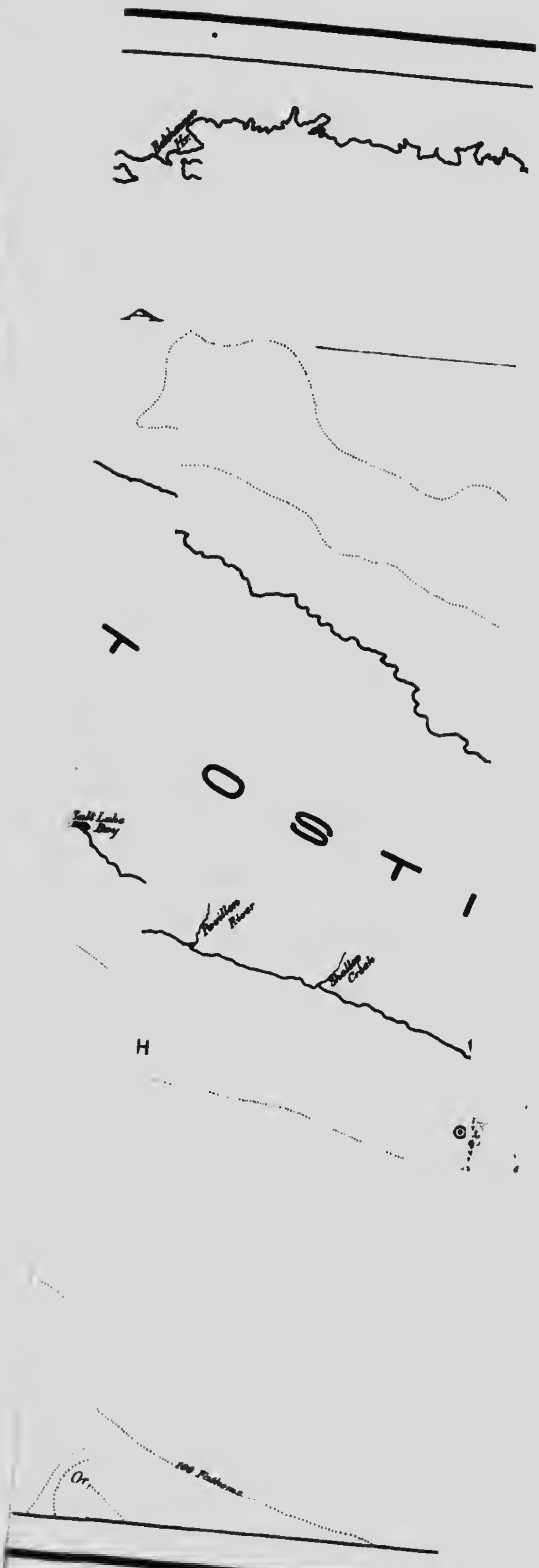
Date—1911.	Time of Minimum	Direction on Surface.	Under-current	Period of Veer.	Wind and Sea.
	H. M.			H. M.	
Monday, July 3	10:35	NbE	NE'ward		Wind ESE, strong. Fog and rain.
				12:55	
" "	22:30	NbW			Wind ESE. Sea moderating. Fog.
				12:10	
Tuesday, July 4	11:40	NbW½W	NNE		Wind ESE, moderate. Fog continues.
				14:10	Wind SE, strong. Sea rough.
Wednesday, July 5	1:50	EbS			
				11:45	Wind ESE till 4:00. Then NNE till noon.
" "	13:35	NWbN	E.		
				10:45	Light south'y airs beginning. Sea smooth.
Thursday, July 6	0:20	NW'ward			
				13:50	Wind SSE, strengthening. Becoming rough.
" "	14:10	WbS	NEbE		
				11:10	Wind ESE, strong. Quite rough. Fog.
Friday, July 7	1:20	SSE			
				12:35	Wind WNW, fresh, from 18:30. Clearing
" "	13:55	SW	WNW		
				13:40	Wind WNW, heavy. Waves 8 to 10 feet high.
Saturday, July 8	3:35	ENE			Wind NNW, moderating. Heavy swell.
Average period				12:33	

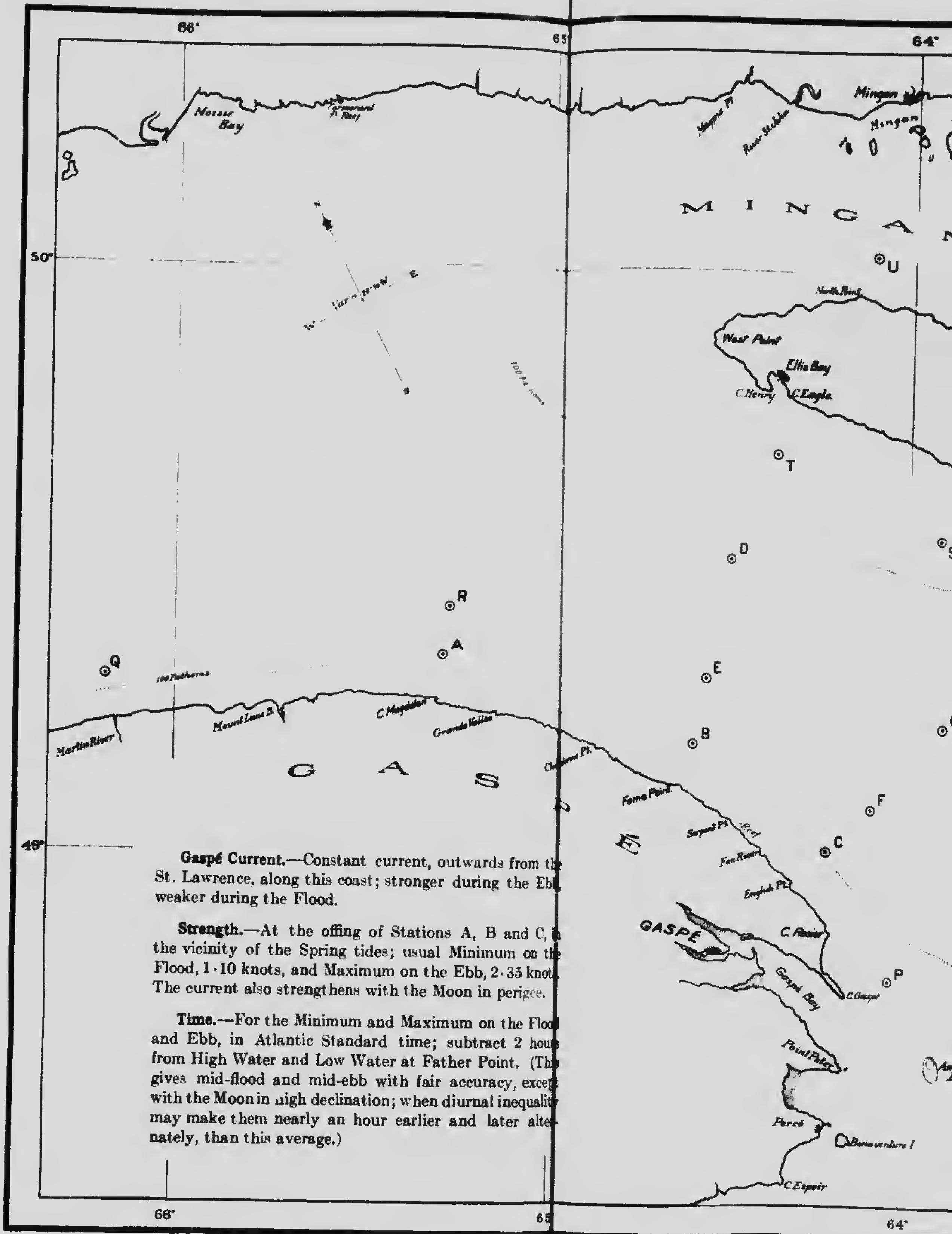
†During the ebb, the surface current veers widely. The direction of the under-current is thus more definite. The under-current was not observed at night.

WIND MILEAGE.—Sunday, light and variable; mostly calm.
Sunday midnight to Tuesday midnight; mileage during 48 hours:—
N 16; E 22; ESE and SE 449; SSE 123; SW'ly 28 miles.
Wednesday 4:00 to 12:00, in 8 hours. NE and N 162 miles.
Wednesday at 12.00 to Thursday at 19:00, in 31 hours. SSE 560; ESE 60 miles.
Thursday at 19:00 to Saturday at 7:00, in 36 hours. WNW and NNW 895 miles.

[illegible]

[illegible]

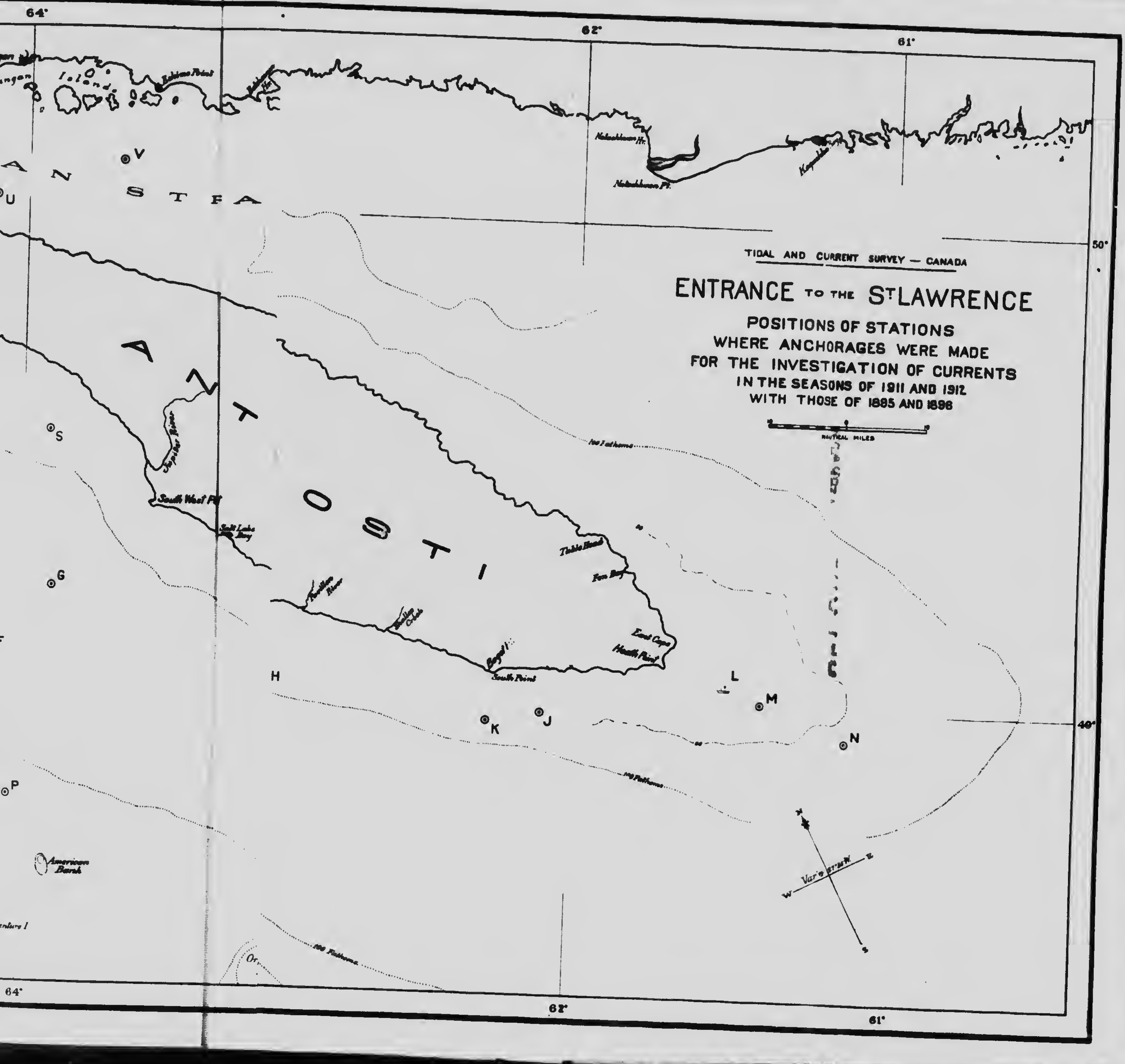

100 Fathoms



Gaspé Current.—Constant current, outwards from the St. Lawrence, along this coast; stronger during the Ebb, weaker during the Flood.

Strength.—At the offing of Stations A, B and C, in the vicinity of the Spring tides; usual Minimum on the Flood, 1·10 knots, and Maximum on the Ebb, 2·35 knots. The current also strengthens with the Moon in perigee.

Time.—For the Minimum and Maximum on the Flood and Ebb, in Atlantic Standard time; subtract 2 hours from High Water and Low Water at Father Point. (This gives mid-flood and mid-ebb with fair accuracy, except with the Moon in high declination; when diurnal inequality may make them nearly an hour earlier and later alternately, than this average.)



TIDAL AND CURRENT SURVEY — CANADA
ENTRANCE TO THE ST LAWRENCE
POSITIONS OF STATIONS
WHERE ANCHORAGES WERE MADE
FOR THE INVESTIGATION OF CURRENTS
IN THE SEASONS OF 1911 AND 1912
WITH THOSE OF 1885 AND 1896
NAUTICAL MILES
64°
62°
61°
50°
49°
V
U
S
G
H
K
J
L
M
N
P
South West Pt
Table Head
Fox Bay
East Cape
Heath Point
South Point
100 fathoms
American Bank
Var'n
N
S
E
W