This little book, which sets out to be the story of the massive, eternal tides, is really the story of four men. Authored by one man, Capt. Charles Cates, it was, in the truest sense of the word, inspired also by his father Charles Henry Cates, and his brothers John and James.

You will draw much knowledge and pleasure from this book. The information is authentic. Let me tell you why. The three brothers grew up with the tides of British Columbia. The Cates family is part of the waterfront here. Old Charles Henry, a beloved figure, was towboating round here before the boys were born-in I886. His first "tug" was a twin-screw scow, named Spratt's Ark. What an unbelievable story was her career! He went on from strength to strength, and so the boys as they came along grew up with the tugboating drama. John, Charles, James Cates . . . shipmasters the world over know them, have turned to them for advice and help. You might well do the same by studying this book, which contains the knowledge not of one man alone, but of four.

The information is authentic also because all three brothers are certified master mariners, with a lifelong experience of the movements of the great waters around this coast.
But the little book also contains good stories of life on this coast.

It is the first time in my long experience of the sea that I have seen the tides made clear and real to the layman. I commend it to you, whether you are professional or amateur seaman.

PAT TERRY,
Marine Editor, Vancouver Sun

TIDAL ACTION IN BRITISH COLUMBIA WATERS

With all the wonderful man-made forces being produced today, it is doubtful if many people observe the huge natural phenomenon that is going on day in and day out the year round, in all the oceans of the world.

This is the tide, one of the greatest forces in the world, involving the movement of countless millions of tons of water, but it moves so silently and regularly, that I imagine most people never give it a thought.

It has been known, I believe, as long as man has lived by the sea, because it was from the beaches exposed by the tide that much of his food was obtained. All along our coast in British Columbia are huge mounds or middens, acres in extent, composed of clamshell and the remains of other marine creatures that the people had collected for food.

This can be seen by the charcoal and ashes of their campfires, still to be found among the heaps of shells.

The people of this coast had quite a culture of their own. They knew the movements of the principal stars and of the sun and moon. I don't know whether they connected their positions in the heavens with the tides, but they did have names for all the tidal movements, and set their seasons by the moon.

In other parts of the world it was doubtless the same. Julius Caesar when first coming to Britain from the practically tideless Mediterranean, recorded that the rise and fall of the sea seemed to be governed by the moon. In fact at the present time the names of Spring Tide, which means a tide that is springing up, and a Neap Tide, which means decreased or inactive, have both come down through the ages from ancient Saxon words.

As the marine commerce of the world increased, it was natural that more knowledge would be sought about the movements of the oceans, as it is very important to a shipmaster to know what the tides are doing in any particular locality, at any given time.

The first systematic and thorough investigation of the tides astronomically and mathematically was carried out by Laplace, and the French seem to have assumed that the influence of the run and moon being general, the pattern would be the same everywhere, and that, accordingly, any one harbour would answer as a "Port of Reference" for all tides. In their early tide tables the whole world was therefore referred to Brest.

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TIME DIFFERENCE

It was, however, soon found that a constant difference in time from Brest gave entirely erroneous results in many regions. This led to a scientific check by means of tide gauges, positioned all over the world. In Canada tidal investigation was begun in 1894, both on the Atlantic and Pacific coasts, and the results are the wonderfully accurate tide books that we have today.

They are results of astronomical calculations, and carefully kept records of actual tidal conditions; but with all this technical data, the scientists still admit that some tidal actions are not thoroughly understood.

As I understand it, the rise and fall of the sea is governed in the following manner:

As both the sun and moon are relative to the earth, all three bodies have a gravitational attraction. In other words if the earth were suddenly taken away, and some small earthly object left behind, that object would fall to the moon, as it has the next greatest gravitational attraction. In a similar manner if the moon were not there, then the object would fall or travel toward the sun.

It can be readily understood then that as the moon and sun form various combinations in the heavens, so is the attraction on the earth strengthened or weakened.

As the oceans are fluid and able to move, they naturally flow towards the point of greatest attraction. This causes a rise of water at the point of greatest attraction. Also as the earth itself is attracted it can also move away from the body of water on the opposite side, that is to say the side farthest away from the gravitational pull. This then means that there are two bulges of water on opposite sides of the world, and, as the world rotates once in twenty-four hours, produces two tides per day.

This, of course, would only be possible if the moon and sun were in fixed positions, relative both to themselves and the earth. If the sun and moon were to stay in fixed positions over the equator, then the two tides per 24 hours would be equal.

However, this is far from the case.

Most people are familiar with the movements of the sun, and how it travels across the equator to the Tropic of Cancer, which is 23' North in summer, and back to Capricorn, which is 23' South, being its maximum travel. Also, how the earth rotates once a day so as to expose its complete circumference to the sun once in 24 hours.

TIDAL EFFECT

The moon has many more movements in relation to the earth, which cause the gravitational pull to vary 33% from maximum to minimum, and as it has more than twice the gravitational attraction of the sun, its changes in position have a great effect on the tides.

The moon's orbit is, properly speaking, an ellipse, but the ancient Greeks described it as a circle with the earth a little out of the middle.

The point where the moon is nearest to the earth is Perigee, and the point where it is farthest away is Apogee. The period of rotation from Perigee to Perigee is called the anomalistic month. Its length is slightly over 27-1/2 days.

The motion of the moon in its orbit is not uniform, however, but it travels faster through Perigee and more slowly when near Apogee. This causes the moon to be nearly one hour later each day relative to the sun's position. This cycle is what causes the time of high water to become later each day.

It can be readily understood then, that while the sun and moon are in a favourable position, relative to each other, the attraction will be great, but as they swing so as to pull on the quarter to each other, the pull of one will be opposed to the other. As the movement of tide is a wave action, and the true or mean level of the sea is midway between the level of high and low water, or in other words, the tide falls as much below the mean or undisturbed level as it rises above it, then a slight change in attraction will be quite noticeable in its effect on the tide.

As I have said, the moon has many movements, ore of which the movement north and south across the equator has great effect on the tide. This action is similar to the sun, with the exception, that while the sun makes the journey once a year; the moon crosses the equator twice in less than one month. Also, whereas the sun has a reasonably uniform travel from solstice to solstice, the moon varies in its number of degrees travel with the years.

If we begin with its most restricted movement in declination which in even degrees is from 18’ north to 18’ south, increasing for nine or ten years, until it reaches a maximum range of 28' north, when it again decreases gradually, eventually completing the cycle in 19 years.

RELATION TO POLES

This, of coarse, means that when the sun in midsummer is maximum north, and the moon also comes maximum north, the attraction will run diagonally in relation to the poles. This causes a great variation between the two tides per day.

When we consider such a condition, with the moon at a high angle of declination, the heights of the two tides of the day will be quite unequal, as the opposite big tidal swell will occur south of the equator and will not be felt in this northern latitude.

This change in height is called Diurnal inequality, and when it occurs there is also a pronounced inequality in the interval of time between two successive high waters.

Where the tide is of the declination type the change in the declination of the sun during the course of the year also has a marked effect. The solar inequality is precisely similar to the Lunar, as it is greatest at the solstices and falls to nothing at the Equinoxes, when the sun is on the equator.

In consequence the extreme tides of the year occur when these effects are combined, that is, at the date of the moon's maximum declination, which falls nearest to the solstice. The extremes thus occur about June and December.

STORM INFLUENCE

Around December we often get heavy rains on the B.C. coast and with this tidal condition where the tides remain extremely high for as long as ten hours the waters of the rivers are forced back far inland from their normal mouth. This causes an un-natural condition and very often the rain-swollen river will overflow its banks and cause great damage in its attempt to find a new outlet.

Storms also have a great influence on the tide. The highest tides, which cause damage by flooding, are usually due to the coincidence of a storm with the maximum astronomical tide.

Such extremes are therefore rare, because it is not often that a storm happens to coincide with the highest astronomical tide. These storm tides are also difficult to predict. For example, as regards to the Bay of Fundy, if the centre of a storm which is known to be coming up the Atlantic Coast, should swerve northward, and pass over southern New Brunswick, there will be a heavy wind up the bay, but if it passes on the other side of the bay, the wind will be outward, and will not raise the tide.

When I was a small boy, my father used to tell me, how he and my grandfather assisted in rescuing farmers of Cumberland Basin, Nova Scotia, who were flooded out of their farms by the great Saxby tide, which broke over the dyked lands and flooded the country during a severe gale on October 5th, 1869

The gale occurred at extreme high water, and raised the tide in Cumberland Basin 6.20 feet above the height it should normally have risen. This condition occurred because the storm forced the tide to flow at such speed up the Bay of Fundy that it dashed higher than normal when it reached the land.

I have tried to explain as briefly and simply as possible the main causes of the tide, and will next tell you about the tidal' conditions on our own British Columbia coast.

As I have explained, the tidal wave as it nears the shore gathers momentum, and dashes up on the land. This is a somewhat similar action to the way water can be dashed back and forth in a bathtub. In the centre section of the tub there is a lateral movement and not much rise and fall, while at the ends the rise and fall is greater with not much lateral movement. The tidal wave is, of course, governed by the character of the coast- line. In our B.C. coastline we have an ideal condition for these tidal surges.

For those who are not familiar with the B.C. coast I will give a short description of it. Directly from the southern boundary of British Columbia, the bulk of Vancouver Island extends 240 miles north. About one hundred miles farther north lie the Queen Charlotte Islands; these islands, one hundred and fifty miles in length, reach almost to the Alaskan border. The range of tide increases from the outside coastline as it proceeds in through the island passages. The, tidal range also increases as it moves northward. It reaches its extreme range, twenty-four feet, in the area around Prince Rupert, but dies away as it gets to Northern Alaska. There is very little tide above the Aleutian chain of islands.

At the southern end of Vancouver Island lie the straits of Juan de Fuca. These straits are about twenty miles wide and sixty miles long. Directly out from the city of Victoria the channel widens and extends one hundred miles to the south to form Puget Sound, to the north lies the Gulf of Georgia one hundred and thirty miles long by fifteen miles wide with several large inlets as well. The movement of the water into the Gulf of Georgia is heavily restricted by San Juan and Orcas Islands at the southern entrance and the Gulf Islands of Gabriola, Galliano, Mayne and Saturna further north. There are also numerous small islands in this area.

At the northern end of Vancouver Island is Johnstone Straits, a channel which averages less than two miles in width and extends about one hundred miles to the south. Here also are numerous channels and huge inlets like the fiords of Norway, which have to be filled with each tide.

At the southern end of Johnstone Straits lie Quadra and Sonora Islands, which practically seal off the passage of the southward flow of water into the Gulf of Georgia.

RIPPLE ROCK

Between Vancouver Island and Quadra Island is the channel known as Seymour Narrows; this is the passage used by the big steamers. The dangerous reef called Ripple Rock lies in the centre of this channel at the most narrow point. To the north, between Sonora and Stuart Islands and the mainland, lie the Yuculta Rapids. A crooked channel dotted with islands but sheltered from gales, it is much used by log towers and other small craft. Okosollo Rapids, Surge Narrows, Hole in the Wall and Arran Rapids, are also in this area. These last mentioned are used to a certain extent by small craft, but the Seymour and Yucultas are the main channels.

Let me try to describe to you the wonderful sight of the Seymours in full force. It is possible to get into Menzies Bay on the Vancouver Island shore with a small boat, work out behind the point near Ripple Rock and watch the tide pour in on its way southward to the Gulf of Georgia. The channel is one-third of a mile wide with Ripple Rock one hundred yards across, fourteen feet below the surface. As the tide sweeps in it fairly shakes the surrounding shores. Huge eddies wheel and boil, with flocks of seagulls, ducks and eagles, flying around watching for fish that have been injured in this terrific upheaval of nature. The water seems to flicker as it tears in through this narrow passage. Every few seconds the stream will erupt like a depth charge, and raise a mushroom of water, as big as a city lot, fully two feet above the surrounding surface. This only lasts a few seconds and the surface is quite smooth again. The tide rushes on to Race Point a mile away, where it piles up in white foam. The current there is deflected, some swirling in to Menzies Bay on the right hand shore, the rest rushing swiftly up past Campbell River and Quathiaska Cove, to finally reach the Gulf of Georgia at Cape Mudge, seven miles south of the narrows.

When a southeast gale is blowing the tide rips in this area are some of the worst on the coast. These rips are extremely treacherous as it is in this area that the north and south tidal streams collide causing not only extremely heavy seas in stormy weather but they also cause great masses of drifting logs and other flotsam to collect thus creating a severe hazard for any vessel running at night in this locality.

Let me quote a few excerpts from the sailing directions in our British Columbia "Tide Tables". *"North Bound Against the Flood Stream."* "After passing Gowlland Harbour keep to the Eastward of mid-channel to avoid the heavy swirls off Race Point. Round this point at a distance of about four cables and head for Stephenson Point, Menzies Bay bearing 285'. As Seymour Narrows opens, course should be altered gradually to starboard until the vessel is heading up mid channel between Maud Island and Ripple Rock, care being taken to avoid being set over toward the island. When Maud Island light Beacon is abaft the beam, the eastern shore may be favored, as the tidal stream here sets fairly through this part of the channel. When Canoe Pass, northern side of Maud Island, opens work into mid-channel to avoid eddying and broken water off the point, seven cables southward of Puget Bluff.

MAUD ISLAND

The tidal stream is strongest off the western extreme of Maud Island. The overfall here is quite distinct. A thirteen-knot vessel may work up as far as Ripple Rock on any tide, but a speed of at least seventeen knots is required to drive through at full strength of spring tides. It is advisable to make the turn so as to be stemming the tidal stream when the vessel is not less than two cables southward of Maud Island light-beacon where the stream has least width. The line of straight stream during the south going tidal stream can be clearly distinguished on a calm night.

Warning: Strangers are advised to wait for slack water rather than attempt passage against the ebb or north-going stream. At night extreme caution is necessary even by those of intimate local knowledge.

It is interesting to read Captain Vancouver's remarks on his tidal observations at Seymour Narrows when he made his historic voyage through that passage in 1792. His remarks are as follows: "The irregularity of the tides was such that no correct inference could well be drawn. They appeared to be principally influenced by local or incidental causes, possibly by the operation of both. They were greatly affected by the direction or force of the winds, which seemed as equally to act on the rise and fall, as on the current when there was any. This, however, was not always the case; as in the course of some days, there would not be the least perceptible stream; and in others a very rapid one, that generally continued in the same direction twenty-four hours and sometimes longer. The time of high water was equally vague and indefinable; this I attributed to its insular situation, nearly at the extremity of the influence of two tides flowing from directly opposite points, causing their divided streams to act, according to the incidental circumstances that might operate upon them."

Fortunately the navigators of today can travel these channels with complete confidence due to the extreme accuracy of our British Columbia tide tables. My good friend Capt. Charles Moody, now deceased, who spent a life-time navigating these channels, once told me that he used to, when he was captain of the Cowichan, keep a close log of any conspicuous root or snag which was washed out of the Fraser River. He said it would always work northward, sometimes going out into Queen Charlotte Sound within six weeks time. The tidal flow therefore is to some extent anti-clockwise in its rotation past the east side Of Vancouver Island.

The Yuculta Rapids have a somewhat different action. The Channel has a double bend in it, one being a right angle. There are two places where the passage is choked, one at Gillard Island, at the southern entrance; the other is the Dent Islands at the Northern end.

My father told me that when he first came to the coast, he decided to go prospecting. He and “Navvy Jack” Thomas,(one of Vancouver's pioneers, who lived where Hollyburn is now, and from whose beach the first "Navvy Jack" gravel came, bought a large rowboat from Andy Linton, and started up the coast. There were no tide books in those days, and I presume father and “Navvy Jack” didn't have charts. One evening they camped on a little island in a narrow channel. Father said that in the middle of the night "Navvy Jack" woke him up. In great excitement he said the island had come alive and was, steaming away with them. Father said it was quite eerie to see the island with a huge bow wave on it. Of course it was just that they were on upper Dent Island, during a big tide.

Owing to the crooked channel there is an entirely different action to the Seymours. The tide swirls and boils in all directions, in some parts forming huge whirlpools, which locally are called “The devils dishpans.” These are big enough to suck down a launch and have a very weird feeling when they grip a small boat, even when the tide is nearing slack water.

This description would sound as if these passages were un-navigable; such is not the case. The tide book is the answer; if these tables are followed carefully, the smallest boat is quite safe. Southbound log towers, however, often take two tides to pass the four miles of rapids. As these tugs are usually going south, they buck up to Henry Point, two miles from Dent Island, then as the current eases, they go through the narrow portion at Dent Island. As it is about four miles from Dent Island to Calm Channel, at the south end of the narrows, and as there is also a great variation of time of change (thirty-forty minutes at the opposite ends of the narrows) the tide will be running far too strong to make the second passage past Stuart Island.

MERMAID BAY

Of course there are rare occasions with very small tides, when the passage can be made in one tide. However, when the tide is of any size, the boom is taken in to Mermaid Bay (a small bay on lower Dent Island) and the tugs wait as the tide races past, just clear of their booms, On the next tide they pass Gillard and Stuart Islands and in four miles they are in to Calm Channel.

It would seem that if the tide were with the tow, the tug could keep going, but the huge eddies are the danger. If one portion of the boom is in the tide, and the other in the eddy, the boom will be torn apart. Also if the boom comes racing out with the tide streak and hits the still water of Calm Channel, it is telescoped and smashed. However, the crews who operate the log towing tugs are highly experienced, and usually keep out of trouble.

A good story was told to me about the Yucultas, by an old log-towing skipper. He said, “You know, I made a mistake in reading the tide book and hit her in the middle of a big flood. When I passed Dent Island a whirlpool formed in the middle of the boom and eight logs were sucked right out under the side sticks. I couldn't stop, so I went right on through and after I had passed Gillard Island light those eight logs were back in the boom again.” Then after a short pause, “But all the rest of my logs were gone,” he said, with a chuckle.

There are many more channels with similar tidal currents, such as Green Point and Wellbore Rapids. These are to the north of the Seymours and Yucultas. As there are many islands in this area to form many channels, the time of slack water differs with each location. It is remarkable how accurately the time of slack water is recorded in the tide tables. Most of the main channels are individually listed, while others are referred to some of the larger channels as a Port of Reference.
It would be impossible to transport the enormous amount of goods up and down our coast if it were not for the extreme accuracy of our tide tables.

TIDAL ACTION IN COASTAL INLETS

There are very interesting bodies of water on this coast which I would like to describe. These are the salt lakes or lagoons as they are called. They range from almost a lake to an inlet with a very narrow opening. Years ago I was engineer on a forestry cruiser and we called in at a place called Von Donop's Creek on Cortez Island.

It was a nice evening and I was rowing around the mouth of a small creek, which ran out through the trees on the shore.

I thought I would go back next morning and do some fishing and was astonished to see the creek running the other way. I rowed on and found I was in the salt lagoon that stretches from Squirrel Cove to Von Donop's Creek. There is a similar entrance at Squirrel Cove.

I understand that there is another lagoon in Desolation Sound. These lagoons have channels so shallow and small that they fill only at high water and the height of the water in the lagoon is practically stationary.

There are other inlets such as Sechelt and Seymour Inlet where there are much wider openings but are still so small that the rise and fall in the inlet are greatly reduced. The tidal rapids are usually called Skookum Chuck, meaning Strong Water in the Chinook jargon.

Seymour Inlet rung into the mainland opposite the northern end of Vancouver Island. It is 35 miles long, together with five other inlets and sounds, which open off it. There is one narrow entrance into the inlet at the end of Slingsby Channel.

The total area of Seymour Inlet is so large that the rise of the tide with in it is inconsiderable, while in the open the rise is from twelve to fifteen feet, such a difference of level causes the tide to pour through the one narrow entrance in a torrent as it rises and falls. The district around this group of inlets is an important lumbering region; and the need for some method of determining the time of slack water is very evident; as any attempt to tow logs or lumber out at any other stage of the tide naturally results in wreckage. The narrows is called Nakwakto Rapids and the ports of reference are Clayoquot, Prince Rupert and Sandheads.

A friend of mine once told me that during a heavy storm he set up a surveyor's transit on the shore and measured the huge tidal swells that formed with the outgoing torrent of water.

He said that there were three huge waves standing stationary which were seventy feet from base to crest. Even the whales know the danger of these rapids and stay in the bays and wait for slack water. Nearer Vancouver is the Skookum Chuck**,** at the mouth of Sechelt Inlet near Pender Harbour. This inlet also includes Salmon and Narrows Arm and has a very large area. The water pours through in a wild, utterly un-navigable torrent, but even so, it never manages to fill the inlet.

It therefore means that the tide has been falling for some time on the outside before a level with the inside is reached, and as the rate of fall is greatest in the middle of the tide it means that the time of slack water is negligible. The current reverses almost immediately. This same action, of course, occurs with the flood.

If we divide the elapsed time of a flood or ebb tide into six parts or hours, we find that l/16 of the total rise or fall as the case may be occurs in the first hour, 3/16 in the 2nd hour, 4/16 in the 3rd, 4/16 in the 4th, 3/16 in the 5th and 1/16 in the 6th hour. This is the, reason that the strongest currents occur in the middle hours of a tide. Of course often as a channel becomes shallow at low water the current will be very strong when the tide is low and the passage therefore restricted.

There is a huge source of power in these rapids if some system could be devised to compensate for the slack water periods. Nitinat Lake on the west coast of Vancouver Island is a salt lagoon with the same characteristics.

To get back to the main action of the tide from Victoria in through the gulf islands there is a very peculiar action to be seen at Beacon Hill. The earthquake seismograph stationed there, records the slightest movement of the earth and each day it shows that the shore moves out as the tide falls and is pressed back as the tide rises.

As a big flood tide sweeps past Victoria and up through the gulf islands and into the Gulf of Georgia it naturally swirls, and eddies around the various islands, this means a constantly changing condition for the navigator. There are many narrows in this region but they are not so fierce as the Seymour group.

They have a maximum speed of about eight knots. There is a great deal of traffic through them, however, and a great deal of local knowledge is required to navigate them safely in all weathers. Active Pass, Porlier Pass, Gabriola Pass, Sausum Narrows, Dodds Narrows are some of the principal ones. They not only run strong but also create heavy tidal currents in the channels in this part of the coast.

It is very easy for a stranger to be set far off his course by these currents. Each narrows also has, its own times of slack water but the main narrows are used as ports of reference and the tide book will give accurate information as to time of slack water in any of the smaller passages.

It is interesting to note the increase in the wave range as the tidal swell rolls in from the ocean. If we take the tide of June I of the year 1949 we notice that at 12:20 p.m. the tide is down 1.2 feet at Victoria while at 14:18 p.m., or two hours later, the gauge reads 1.9 at Point Atkinson. Then at high water of the same day the time of 22.28 and height of 1.5 feet is predicted for Point Atkinson. While at 22.27 the tide had only a maximum height of 9 feet at Victoria.

Where there is great depth of water this condition does not seem to occur. The long inlets on the coast of British Columbia, which are similar to the fjords of Norway, afford a noticeable example. These are often 50 or 60 miles long and very deep. Most of them exceed 100 fathoms. The results of timing three inlets are given here.

From Whaletown on Cortez Island to the head of Bute Inlet, distance 52 miles, high water 3 min. later, low water 9 min. later. Namu to Bella Coola, distance 69 miles, high water 2 min. later, low water 7 min. later. Hartley Bay in Wright Sound to Kitimat, distance 49 miles, high water 4 min. later, low water 4 min. later.

The range of the tide at the head of these inlets is only from 2 to 12 per cent greater than at their mouth. It thus appears that the whole surface of the inlet rises and falls simultaneously in correspondence with the impulse at its mouth given by the rise and fall of the tide in the open. It is also observed that there is little current except in the mouth of the inlet where the pulsation takes place.

FRASER RIVER TIDES

When we consider the huge volume of water rushing in to the Gulf of Georgia with the flood tide we must not forget the Fraser River and the Port of New Westminster about 20 miles inland from the Gulf. This estuary is like many others, which form an avenue of approach to important harbours, and the characteristics of the tide in them bring out principles, which apply to the behaviour of the tide in general.

When the estuary of a river opens into the ocean or in the case of the Fraser, the Gulf of Georgia, the rise and fall of the tide causes tidal streams to develop, which run in with the flood, and out for a longer time during the ebb; especially so if, as in the case of the Fraser, the river running into the estuary is of large volume. These tidal streams become more and more unequal in the two directions, up to a point where they can no longer reverse the river current. Above this point, although the flow is always one way, it is stronger during the period of the ebb. The tidal undulation, which is manifested by a rise and fall in level, may still be appreciable as far up the river as this inequality in flow is noticeable.

These conditions characterize the usual estuary where a river widens near its mouth and is not extremely deep. The conditions are very different in the case of deep inlets, as we have seen. But in estuaries they are due to some extent to the quantities of sand and gravel, brought out by the river in the course of centuries and forming huge bars which in the case of the Fraser are known as the sandheads and which have many channels running through them. These channels are continually changing and it is a continual job to build long breakwaters or jetties to keep the river in one deep channel. If we first examine the laws, which govern the flow of water, we will be better able to follow the behaviour of the tidal stream in an estuary or strait. It is by no means a simple matter, because works on hydraulics give attention chiefly to continuous flow in one direction, through channels or pipes; and we have here to deal with flow which not only changes its direction, but which runs in a channel of constantly varying depth and width. Yet in most localities, it has proved possible to bring the practical results to a simple form, for the purpose of navigation, I will here endeavour to give the laws of friction and momentum as they apply to flowing water, in as brief an outline as possible to enable the tidal streams to be understood.

It is well known that the friction of water on itself is lower than the friction between water and any solid substance. This is evident from the flow of water in pipes; for the coefficient of friction is the same whatever the material of the pipe may be; whether iron, wood or other substance; so long as there is no mechanical roughness. This is explained by the theory that a film of water adheres to the surface of the pipe, and that the water really flows against this water film.

There is thus less friction on a wet surface than a dry one. The conclusion is that water prefers to slip on itself one layer on another, rather than to move bodily over a solid surface.

When water is flowing uniformly in a channel, the greatest speed is therefore found on the surface and in the middle. It decreases gradually toward the bottom and also from the middle toward the sides. This is true in all canals and is much accentuated in an ordinary river, which becomes shallower toward the banks.

If the water of an estuary is running out towards the sea during the fall of the tide, when the tide begins to rise again it will not immediately stop. Its momentum carries it forward against the rising water. Perhaps we are more accustomed to think of momentum in connection with solid matter.

Let us suppose then that instead of moving water we have square blocks of ice with just enough water to float them, moving forward like a train of barges down the river. As the outside water begins to rise, these blocks will not stop at once; they will go forward against it and even slide up the rising surface for some distance before they come to rest, and begin to move inward again with the rising tide.

Now, these blocks are no heavier than the same bulk of water; a block of water a yard square and four feet deep weighs a full ton, so we can readily realize the enormous momentum of the ebb stream in an estuary, even when moving comparatively slowly; and the great force from the rising tide that is required to stop its movement and push it back landwards.

It is this momentum of the water that explains the continued flow of a tidal stream for some considerable time after the turn of the tide at high or low water. When the ebb stream is flowing out of an estuary, which usually widens toward the sea, let us consider what will happen when the tide begins to rise in view of these laws of motion.

The rising water of the sea may act in one of two ways to commence with: (1) It may begin to flow up the middle of the estuary as a tongue of water, while the ebb stream still continues to flow toward the sea at the sides. It does this because the water in the middle is deepest, and the first inward flow has thus the advantage of keeping as far as possible from bottom and side friction.

It cannot oppose the ebb stream squarely, and stop it, unless the channel is quite restricted in width and the rise of the tide rapid. But in most estuaries it is best able to make its way, in the first place, up the middle. This central tongue of inflowing water gradually widens till it occupies the whole width from shore to shore.

Most navigators are aware of these estuary conditions and local vessels take advantage of them by keeping to the middle of the estuary, or making out along the sides, according as they are inbound or outbound, as the tide may favour them. (2) In some estuaries, especially where that river discharge is large, the river water may be warmer as well as fresher even in the estuary, than the incoming sea water.

The rising tide has then a more difficult task, as it can only make its way in along the bottom, because it is heavier owing both to its coldness and its greater saltiness. The sea water is thus obliged to make in with bottom friction below it and the friction of the outflowing fresh water above it. It is thus greatly retarded**;** and the surface water continues to flow outward for a long time after the tide begins to rise.

Here, this upper flow has the double advantage of its momentum and of the very low frictional resistance over a water surface below it. At length, however, the rising tide will gain the mastery and reverse the flow to the inward direction.

This action of sea water in under-running the river outflow during the rise of the tide can be made quite evident with adequate appliances. It appears indeed to be quite usual in some stretches of any ordinary estuary; it is more likely that the first of the flood will make in at the middle of the width; but further up, where the estuary narrows to a width not much greater than the width of the river itself this under-running will probably be found.

It also occurs commonly in channelways, which extend seaward through the shallow waters beyond the river mouth; a good example is our Fraser River, which extends its channels for five miles through the sandheads before reaching deep water. The main Fraser channel has a depth of eighteen feet below low water and the rise of the higher tides is over twelve feet.

The resistance which sea water has overcome in flowing inward under fresh water need not be exaggerated. Below low water, the outflow is swift and it extends to the bottom, as there is not only the river volume to be discharged but also the additional water, which has accumulated while the tide was high. But after low water, as the surface level rises and the depth increases, there comes a time when a thickness of a few feet at the surface affords sufficient area for the whole discharge of the river.

Below this, therefore, there is little to prevent the inflow of the colder and heavier sea water except bottom friction, which it must overcome if it is to flow in at all; for the friction between the two layers of water is extremely slight, as I have already pointed out.

These conditions of flow may not be so disadvantageous to an incoming vessel as they might appear, and a vessel of any considerable draught may have the body of the flow in its favor in spite of surface appearances. The reverse directions of the flow of the upper and under waters may thus be made curiously evident. I

For example, at the mouth of the Fraser River, a deep draught vessel which was being towed in, at a certain stage of the tide, was carried forward by the undercurrent faster than the tug with half the draught could make against the swifter running surface water. The tug had thus difficulty to avoid being overrun by the vessel it was towing.

It can thus be seen what an immense amount of research and observation has had to be done by our tidal survey scientists, for conditions in a river like the Fraser are constantly changing.

I might say at this time that the most of the B.C. Coast Rivers have these conditions at the mouth.

The sea channels are usually very deep and as the rivers pour their gravel and sand out they can only carry it as far as the low water tide-line. This means that the long shallow flats extend far out, as in the case of the sandheads, and then go off at a steep angle to deep water. Nearly all the rivers at the heads of our inlets have this same characteristic. It is either too shallow to anchor or there is no bottom.

TIDAL ACTION IN LOCAL WATERS

As we approach the entrance to Vancouver Harbour we, of course, enter English Bay and the whole of the west shore to Point Atkinson. It is very interesting to note how the tide flows in this area.

At practically all stages of the tide, flood or ebb, the flow is to the westward at Point Atkinson, while the reverse is the case along the Point Grey shore.

I presume that this flow is what brings the enormous quantities of sand out of the North Arm of the Fraser, to form Spanish Banks along the northwest shore of Point Grey.

The action of this current can be very clearly seen on a fresh westerly day with a big ebb tide. A rough streak of water, which may be seen well from the Lions Gate Bridge, extends along the Hollyburn shore as far as Newcastle Point. This point causes the current to veer from west by north to west south west, and this stream, like a broad river, flows out past Point Atkinson, and then swings down the gulf.

This current can be used to great advantage by seafarers, as a good ebb will run at a speed of at least two knots as far as Point Atkinson.

It must be remembered, however, that with this speed of current an extremely short dangerous sea will develop if the wind is westerly. There is also a condition to be considered in the fact that although a small boat may hold to the south toward Siwash Rock, and get out of the rips off Hollyburn, the same rips of extreme strength will have to be crossed before the mouth of Howe Sound can be reached.

I usually like to try and work the rips as far as Newcastle Point and then get in close along the shore at Dundarave. This area is usually quite moderate, and outside of a short distance at Point Atkinson, it is usually quite safe.

The reverse, of course, applies to a boat coming towards the harbour in these conditions. It is always better even on a flood to work over towards Jericho after leaving Point Atkinson. As soon as the tide streak is crossed there is a back eddy or flood, as the case may be. Current running with instead of against the wind makes the swell much more moderate. Of course, if the wind is from the eastward the tidal ebb stream is quite safe even for a rowboat and an outward going vessel should follow it as far as possible. Even when the tide is flooding not much easterly current will be met if the Dundarave shore is followed on the way to Point Atkinson.

A few years ago the West Vancouver Ferry No. 5 was sunk in the narrows in a collision in the fog, and one of her lifeboats was carried away. A few days later this boat was picked up near Active Pass, about 35 miles away. This gives some idea how fast the water travels.

There is a condition near Prospect Point, which I think I should call attention to. This is the meeting of the back eddy with the ebb stream. As a big ebb pours out under the Lions Gate Bridge and flows toward Hollyburn, a strong back eddy is formed which runs along the shore from Siwash Rock towards Prospect Point.

It is customary to take advantage of the eddy and get as close to Prospect Point as possible before entering the ebb stream.

The danger lies in the fact that the vessel is approaching the point with about a two-knot current in her favour, when suddenly she is struck on the starboard bow by a stream of about six knots going in the opposite direction. This means that an eight- knot vessel with two knots additional current meets a six-knot current running in the opposite direction. This for a few seconds gives the vessel a speed of 16 knots in the ebb stream. It means that a vessel of any weight may be thrown halfway across the narrows to the north side of the channel in a few seconds, placing her directly in the path of the outgoing traffic.

There have been many serious accidents from this condition and many vessels have been lost. It is extremely hazardous at night in the wintertime, when the big ebb is near midnight.

The correct thing to do then with a vessel of any size is to enter the ebb stream well west of the Capilano light, and buck up to the narrows, but many times I have been loathe to do this when a favourable current is right alongside.

When a tug has scows or a car barge, this ebb stream is doubly dangerous, as the tug enters the stream first and is swept westward while the tow continues to the east. The towline will come slack at first and then tighten with a snap. Several tugs have been capsized by this happening. I might say though that even if the vessel is fully in the ebb stream and bucking up to the bridge, there is a condition abreast the Capilano light, which I do not understand. Twice to my knowledge big freighters, in charge of highly capable men, have suddenly taken a sheer to starboard and gone ashore in exactly the same place, about 100 yards south of Prospect Point. I cannot see why this condition should occur, but there it is.

I might say that in the summer when the weather is fine and fresh westerlies are blowing, it is quite common for small launches to break down in the tiderips, owing to the dirt in fuel tanks being violently stirred up.

When another boat is attempting to get a towline aboard, it is unsafe to get either to leeward or windward of the broken down vessel. If either the current or, the wind is the stronger, the two vessels may come together and seriously damage each other. I usually keep off to the side where the drift will be past my vessel.

When going to False Creek or Kitsilano, especially with a tow, such as a boom or some other slow-moving vessel, it is good to buck out against the last of the flood. The first of the ebb then sweeps close along the shore to Siwash Rock, and in no time you are at Ferguson Point, where the guns were placed during the war. This condition, unless the ebb is very small, only lasts a short while, and is much more pronounced when it is raining hard and the Capilano River is high. As soon as the ebb stream reaches any strength, the eddy, which I have been describing, forms and then it would be practically impossible to tow a boom to the southwest from Prospect Point. The thing to do then is to follow the ebb stream to Newcastle Point before swinging south, by doing this the eddy can be crossed without effort, and there is soon a favourable current in to English Bay.

My father used to tell me how the steamer *"Beaver*," the first steamer on this coast, was wrecked just south of Prospect bluff. She was a side-wheeler, with the rudder placed in the same position as an ordinary vessel. With her speed of 4 knots it meant that the rudder had very little effect. My father also said that on that trip the crew was sober and therefore not normal. However, she came slowly out of the narrows, and to dodge the tiderip the captain swung her bow to the south. As soon as the eddy struck her starboard bow she was swung to port and ran ashore just west of Prospect Point. I don't think any attempt was made to salvage her.

It is always a good thing, when in doubt, to ring PA. 1271, the National Harbour Board office, and ask for the First Narrows Bridge signal station, before going out through the First Narrows with any small craft in the summer. The signalmen are all highly skilled and efficient, conscientious seamen, and can always give good information as to rip conditions. The trouble is otherwise that a swell may be coming up and running against the tide, creating a heavy sea, and a small vessel coming out with a big ebb is into it almost without warning, and after that there is no turning back.

TIDES ABOVE SECOND NARROWS BRIDGE

As I have stated previously the two tides, which occur each day, are more nearly equal near the equinoxes and become very unequal at the solstices. Being in the tugboat business as I am, in Vancouver I have observed a condition which I don't believe is noticed so much in other lines of marine business.

As tugs are often called upon to shift large heavy objects, it is always preferable to move them when the tides are not strong. In the winter when the big tides are at night, it is not so bad, as usually really difficult work is done in daylight. In the summer, however, the lowest tides are around noon and the highest in the evening. The tugboat companies usually breathe a sigh of relief as a big tide passes its peak, but then this condition occurs. For example, if we take June 1, 1949, we find that at 14:56 the low tide which while past its maximum is still a big tide and is rising from 1.7 feet above zero. In the early morning the small tide is commencing to get lower in its range of fall.

As it does so, its time of low water advances very rapidly. For example, June 1, low 3:21 a.m. with a low of 11.3 feet, June 2-4:25 a.m., June 3-5:35 a.m., and so on, so that by June 8 at 10 a.m. a new long run out has developed, down to 2.3 feet above zero. From then on we notice a different time range. For example, June 8--low water at 10 a.m., June 9-at 10:43 a.m., June 10-at 11:27 a.m. This means that almost all summer there is either a long run cut near noon or a small tide that will develop into a long run out advancing toward noon at more than an hour advance per day. Also, although a tide is small, if in a few days it has become a big tide it will develop very strong currents. It is a strange fact after a tide has started to decline although it still has a large range, it will not develop the same fierce currents as a tide that is making. My father showed me this when I was a small boy, as he used to be very careful to check the tide book and see what the week's tides were doing. It is certainly good that the tides answer this way, however, as the long days in the summer usually allow sufficient daylight to do a heavy job after high water slack in the evening. After the big rise of tide in the evening in the summer the tide has no great range until early morning when the big fall commences.

This changing of tide from low at midday in summer to midnight in winter is, of course, caused by the sun’s declination but one of my old Indian friends told me that the white man is all wrong. He told me this story, which he said left no doubt as to why the tides perform in this manner.

The Bella Coola Indians believe that in the beginning, the world was created by a supreme being whom they know as Ach-quantam, and who, they say, lived in a space somewhere between Heaven and earth, and all the souls must pass Ach-quantam before coming to this earth, and, likewise, must again pass him before being allowed to go to Heaven after they die. Heaven, incident- ally, is a very much more beautiful place than earth, according to the Bella Coolas.

Now, after Ach-quantam had created the world, he decided he should have someone to look after the various functions and happenings in the world. He, therefore, appointed four brothers, the first one's name being Muttla Mellatsukh, whose duty it was to look after the spiritual welfare of the souls coming into the world, and who had the spiritual ability of being able to perform any deed in one second. Thwa-tla Mellatsukh, the second brother, administered to all things that grew in the world, and had the ability to perform any act in two seconds. Ah-smoov-san Mellatsukh was the third brother and he administered to all movements of planets and Heavenly bodies, the seasons of the year, and so forth, and performed his tasks in three seconds. Moosan Mellatsukh, the fourth brother, looked after all the souls who departed from this world and saw them safely back past Ach-quantam, and safely into Heaven.

These four brothers, to administer properly the affairs of the world came down from Heaven and were stationed on a mountain known as Nuskulst, where they took up positions so that one looked north, one south, one east and one west, and nothing occurred in the world that was not observed by one of these brothers.

Ah-smoov-san. Mellatsukh, the third brother, to me is very interesting. As I have said, he lived in the mountain and controlled the seasons of the year according to the Indians' idea of the scheme of things, and each day he placed the sun in the sky in the position he considered the most advantageous. As the sun moved to midsummer and the summer solstice, Ach-quantam decided that Ah-smoovsan Mellatsukh should get ready to leave the mountain and go for a holiday to his home in Heaven, and my old Indian friend says this must be true because in midsummer the sun remains fixed in the sky until Ah-smoov-san Mellatsukh re- turns. Then day-by-day, the sun moves a little further south in the sky and the Indian knows that Ah-smoovsan Mellatsukh has returned to the mountain and is again on the job. He stays there until December and at the time of the winter solstice leaves the sun in the sky and returns again to Heaven for his winter vacation.

Another interesting factor about the job, which Ah-smoov-san Mellatsukh performed, was in the matter of tides. To me, as a sailor, it has always been one of the first signs of spring to see the way the tides change over from low water at midnight in the winter time to low water at mid-day in the summer time. My old Indian friend says that this is easily understood as in the month of March Ah-smoov-san Mellatsukh turns the world upside down and therefore, whereas formerly, in the winter time, the water had run out of the world in the night time, in the summer time, when the world is upside down, the water runs out in the daylight hours.

These stories of the Mellatsukh brothers, while, of course, appearing very far-fetched, to me show a far above the average imagination and observation of the natural phenomena of the world which occurs all about us.

The North Arm of Vancouver Harbour, like most inlets, has very little flood except near the mouth, but in the ebb the current runs strong. As it sweeps past Dollarton, it is deflected off Roche Point toward

Shelburne. This current meets the outflow from Port Moody and both currents run very strongly past Shelburne with no back eddies. Part of the Port Moody ebb, however, comes close around Burns Point and goes up toward Belcarra. When towing a boom eastward in an ebb, it is advisable to keep in the lee of Roche Point when going past McKenzie Barge and Derrick Shipyard and then cut across toward Burns Point. Once the current from the North Arm is crossed, the Port Moody tide is not usually too excessive.

As the currents out of the inlets sweep westward, they are again deflected, this time by Berry Point. The current sweeps to the northwest across the flats and then straightens for the bridge. This is a bad condition in fog, as a vessel, which gives Berry Point too wide a berth may be put aground on the North Shore. By the fact of Berry Point sheering the tide to the northwest, however, an eddy is formed on the south shore from Stanovan to Berry Point, and this area is moderately quiet regardless of the size of the fall. West of Stanovan there are no more eddies, as the tide sweeps to the bridge. I always line the centre, of the bridge to a course of W.S.W. magnetic. This appears to be quite a bit off square with the bridge but that is the angle that the current runs. Care must be taken, however, in the wintertime at slack water if Seymour Creek is in freshet. The current from the creek when in this condition runs very strong at right angles to the bridge at slack water and it is practically impossible to get through the bridge with any heavy tow without being thrown against the south pier. It is always best to wait until the tide is ebbing at good strength so that all the Seymour Creek water is deflected through the northern spans A and B of the bridge. It is a very dangerous condition, however, and with any difficult tow it is sometimes necessary to wait several days until the freshet subsides. Of course, if the tow can be bucked through against the flood it will be all right because the freshet water then is deflected eastward and is well clear of the bridge.

As soon as the bridge is passed, huge eddies and swirls form on big ebb tides. The back eddy on north is moderate and extends out about flush with the Navy dock. Small boats may use this eddy but as all this area was at one time tide flats, which have been dredged for gravel to build various big piers, it is not safe for a vessel of any draught to get too close in as there are many shoal patches. On the south shore, however, conditions are entirely different. The tide sweeps in toward the shore, just east of the Columbia elevator, where it splits, part going through the Columbia wharf and, deflecting off the shore, rushes out through the east end of the Terminal dock. The other part of the tide swings and heads eastward past Hastings Park at about 3 knots on big tides. As it reaches the west end of the Pool Elevator it pours through the piling almost straight off the dock and makes the landing of a ship at this stage of the tide practically impossible. About half way up the dock, however, the ebb through the south hole of the bridge is met and the east or No. 3 berth will have ebb tide. There is so much fluctuation on big tides, however, that it is not practical to attempt to berth a large ship during a large ebb. I would also like to state that there is a danger of being swept in on the Columbia on big tides and I always favour the north edge of the ebb streak until well west of the Columbia Elevator.

A heavy laden ship which has been lying at the Pool elevator with her head to the eastward could get into trouble very easily while trying to leave during a big ebb. It is hardly possible to swing the ship to starboard owing to the extreme current on the port quarter. The ship will be swept rapidly westward and is apt to crash broadside into the Columbia elevator. The best method is to let the ship drift clear of the dock. Then with a tug on the bow swing her bead to port. In a matter of seconds the strong ebb stream on the starboard bow will have swung the ship 180' and she is in position to steam safely down the harbour.

In the pioneer days of Vancouver, my popular and jolly uncles, Jack and Will Cates, ran the harbour tug, *"Lois."* Jack was captain and Will was engineer. When they would arrive in town after a trip there were much more exciting things to do than sleep, so on one trip to the North Arm they left in a slightly exhausted condition. On the way down the tug was running light, so Will put on a good fire and propped his chair against the bulkhead to have a nap. He said he was fast asleep when suddenly the *"Lois"* fell over and upset him on the floor. He scrambled on deck to find the *"Lois"* up on the beach where the Columbia Elevator is now. Just as he woke up, brother Jack poked a sleepy head out of the pilothouse window and remarked in an exasperated voice "I thought *you* was watchin' out." What had happened was that with no one in charge the heavy tide set had put the *"Lois"* ashore.

Of course, the power of those currents vary with the strength of tide and even on big ebbs it is fairly slack for the first hour after high water. The big trouble is that if any delay occurs in docking, the current increases with speed and from then on there is no slack until after low water.

TIDES IN BURRARD INLET

I think that before I describe the ebb stream west of the Terminal Dock I should mention a condition, which greatly influences the action of the ebb. This is the previous flood. For instance, a large flood of, say, 14 feet will come in with such force that it drives a wall of water into the upper inlet above the Second Narrows to a height greater than its maximum level. Also at the same time the waters between First and Second Narrows are violently agitated and huge eddies formed. These currents I shall describe later on. However, as I have said, the whole harbour area is violently agitated and especially on the north shore west of Midland Elevator a strong eddy sets westerly. Now as soon as the big flood has reached its peak and the ebb commences even though it is only a small one, the pent-up water in the upper inlet rushes down and meets the already fast-running westerly eddies. These extremely strong currents are often considered to be the ebb, but are really nothing but the last kick of a big flood and any attempt to judge slack water by the tide book would be useless. All that may be done is to wait about one and one-half hours after high water by the tide book in Burrard Inlet when the slack will come so quickly as to be completely slack in five minutes. Along near low water there may come a much more moderate current, which is the true small ebb. This is not the case, however, if a strong S.E. is blowing. The speed of the current will be so maintained that a strong set westerly will stay till after low water. One of the worst tides of this nature is when the ebb has a fall of around 5 feet. When this happens the ebb is not strong enough to create the back eddies along the shores. The westerly winds will cause the opposite condition and after the first ebb has died away there will be no more ebb of any strength. On the other hand, if there is a small flood of, say, one foot and an ebb of twelve feet there will be no recoil and no eddies formed. The ebb will start quite slowly at the Second Narrows and after about two hours will gradually reach down in to the lower harbour. By the time the ebb streak has reached down off the West Indies Dock it is running at a speed of about three knots in a narrow streak about 1200 feet wide, the northern edge of, which is just off the West Indies Dock. This narrow streak then heads for the middle of the narrows off Brockton Point and leaves all the rest of the harbour in a gentle back eddy. I always consider that the best time to do any heavy work, especially on the Vancouver shore, is during the middle of a big ebb. I say on the Vancouver shore because during the war the shipyard docks on the north shore were extended far out into the inlet. This now means that sometimes the fast-running narrow ebb streak will swing north and run hard at the docks for a few minutes before it veers out into the harbour again. The Terminal Dock is the one exception on a big ebb on the Vancouver side.

As I said before, when the ebb strikes the point of the Columbia Elevator it splits, with part going eastward in a back eddy. The westerly section glances off the shore and rushes out through the piling for about 300 feet west of the east end of the dock at about two knots speed and joins the main ebb which at the east end of the Terminal Dock is only about 200 feet to the north and is running in a westerly direction. The ebb streak coming through the dock runs off the dock at about W.N.W. At the same time as this is happening the back eddy, as I have said, is flowing eastward along the Vancouver shore. As it reaches the Terminal Dock it is accelerated by the suction of the ebb and so flows east and north at a speed of about one knot through the westerly section of the dock. There as both ebb and eddy meet at a point about 300 feet from the east end of the pier they flow practically straight off the dock to join the ebb which is running to the westward just north of the dock. As the Terminal Dock lies N.E. and S.W. the eddy width is much wider at the, west end of the dock. It is very difficult to berth a big ship even with tugs under these conditions, as regardless of what is done the ship will set off the dock It might be suggested that the ship be berthed with her bead to the westward, but the main ebb is not a ship's length out and before a ship may be swung the ebb hits her counter and washes her westward along the dock. About the only thing that can be done is to get the ship's head in tight to the dock with good lines out and then with the aid of tugs and the ship's winches warp her stern in. This condition only applies when the ebb is running strong. A small ebb or any flood does not cause this condition., I might say that the recoil of a big flood creates a Very bad condition down the south shore as far west as the C.N. Dock. The big danger is that sometimes there is a slack in the tide just at high water, but a close watch should always be kept on the patches of driftwood, which collect along the tide streaks. I always watch them very closely as they are a good indication of what the tide is doing. With experience it is quite easy to see a flood or ebb streak if there is any wind, as the current opposing the wind will always have a rougher appearance. The flood recoil will come very suddenly sometimes, especially near La Pointe, and may cause what looked at first to be very good conditions to become very hazardous. This never occurs in the back eddy formed by the big ebb. When this condition exists there is very little change in speed or direction of flow. When a big ebb is commencing there is a rather bad condition in the First Narrows. This is to a certain extent the flood recoil again. As the tide has been flooding, the main stream is on the south side of the narrows and the flow over the north side tide flats is to the westward. As soon as the flood pressure slackens it is natural that the ebb will occur where the flow is already westward. This means that the water near Brockton Point will be moving eastward even after high water, while the ebb will crowd down the harbour and be deflected over across the north shore flats. This is the reason that there are so many strandings east of Calamity Point. Care must be taken when coming in against an ebb to watch out for a set to the north. Often when a vessel is going to the Creosote Wharf she will be set over very quickly to the north if great care is not taken. It is a strange thing that although the creosote wharf maintains fairly slack water on big ebbs. 200 feet west of the dock the tide conditions are exactly as they are in the narrows. They turn at high slack water and from then on there is no change in the ebb until low slack is reached. For the benefit of junior navigators the international rule of the road is as follows: In narrow channels every steam vessel shall, when it is safe and practicable, keep on that side of the fairway or mid-channel which lies on the starboard side of such vessel. A steam vessel shall be considered to be any vessel propelled by any power other than sail or oars.

This means then that all vessels going out the narrows must keep on the north side of the channel, and when the tide is high it is difficult to know just how far out the shoals extend. I always make it a rule before going west of Brockton Point to have the beacon at Calamity Point bearing at least 100 feet north of the signal station on the Lions Gate bridge. I have checked this at low water when the flats are visible and there is no danger of stranding if a vessel is kept to the south of this bearing. On coming in the harbour the south shore of course is favoured. There is not much eddy until Harris' house is passed. This is the house about 500 yards east of the bridge. After the house is passed an eddy forms in by Lumberman's Arch and extends to Brockton Point, but care must be taken, as there are large boulder reefs in this area. Once past Brockton Point it is best to favour the south shore, as from the ferry wharf west to Coal Harbour is the stillest area of the harbour as regards to tide. Only occasionally with a S.E. wind and small ebb will there be any westerly set along the C.P.R. docks. I have worked a great deal around the first narrows and have always been amazed at the accuracy of our tide tables In fact you can set your watch as to when the streak will form at low water and the flood start in. The second narrows is not so close as to time of change. I think a great deal of this error is caused by the volume of fresh water, which is poured into the upper inlet by the rivers in the wintertime. I have found it safer to be a little late when coming down on the last of a big ebb, as sometimes at low slack by the book the run out will be still quite strong.

The ebb tide always seems to me to have the same characteristics as the fall of the year or the later years of a person's life. When the tide is ebbing all the creatures of the sea and those creatures that live near the sea become listless. The crabs which you may catch in 40 to 50 feet of water and which have been coming constantly to the bait during the flood tide will cease to feed during the ebb. It seems queer that they would know the difference in that depth of water but such is the case. Even although the tide is still high and the flats are well covered, all the crabs and small fish will disappear as soon as the ebb starts.

In the summer the flats come bare near mid-day and children can run on the sand in their bare feet and find the odd sea creatures which have been trapped in the pools.

Along the edge of the receding sea the ducks and gulls feed and the herons wade out quietly on their long legs to catch the unwary small fish with a lightning swift dart of their long pointed beaks. The crows, while not true sea birds, also are around in large numbers. It is amusing to watch these wise birds pick up clams and fly up over a large rock or even take them to nearby concrete pavement where they drop them so that their shells will be smashed.

It always seems to me that all this activity is carried out in a very leisurely manner, without haste, for it is like the autumn and peace is in the air.

Now, as a big ebb reaches near its extreme low, a tension seems to come in the air. I have asked many sailors and they say that they can feel it. Certainly the fish and birds and crustaceans know that the flood is coming. A little before low water all these creatures reappear and become very active. Any fisherman will tell you that at the low slack and as the flood starts is the time to catch salmon as they race around in the little eddies and snap up the little fish to be found there. The crabs reappear and wait just at the tide lines ready to scurry over the flats in countless numbers as soon as there is barely sufficient water for them to travel in. All along the shore the gulls and ducks swoop and dive for there is renewed life in the sea. The flood tide is starting. The old Indians smile and say Kwa-Kwatts, the tide is rising.

FLOOD TIDE AT THE NARROWS

The first and second narrows have a different action at this time. If we take the first narrows, the ebb stream comes to a stop practically from shore to shore at the same time. Farther out, off Hollyburn the set may still be westward but under the Lions Gate bridge the water comes to a definite slack. This slack comes very quickly on a big ebb. In other words, from a strong ebb to completely slack will come in about 20 minutes.

This condition is not quite the same in the second narrows.

There the ebb rushes west down the centre span C, while, near low water, the eddy on the south shore along the Pool Elevator commences to reach eastward along the shore through the south span. By the time low slack by the book has been reached the south side of the channel will have a fair set easterly while in the centre the set may be still quite strong westerly. The two northern spans A and B have moderate flows easterly at this time, but they can not be considered as it is not legal for east bound traffic to use them at any time, and naturally, west bound traffic uses the big centre span C.

FIRST NARROWS

At the first narrows the current, as I have said, will come absolutely slack and then right after low water slack by the tide book a line will form across the channel. There will be a rippling foamy edge appear along this line and all water in this area will start eastward. This is the first of the flood. The water in the harbour will not be affected to any extent for some time, but will continue to flow gently eastward along almost all the docks on both shores. This, of course, applies only to tides big enough to form the eddies I have mentioned previously.

SECOND NARROWS

In the second narrows there is really no slack under these conditions. What really happens is that the south eddy develops into the flood and the ebb gradually diminishes in the centre span. Complaints are often heard by users of the second narrows bridge of how a tug kept the bridge open for too long a time. The trouble is that the tail end of a long boom is still in a strong westerly current while the tide is flooding at the bridge and the tug, therefore, can make very little headway. I have seen a strong westerly set off the Columbia elevator for at least an hour after slack water by the book. This ebb streak carries down to off the Midland elevator before it disappears.

The rippling line of flood which first formed under the Lions Gate bridge now moves east with increasing speed but the water ahead of it is not affected to any extent until reached by this miniature bore. Immediately, all this area is in a fast flowing river of tide. This flow continues until Brockton Point is reached and the flow is a foaming line from shore to shore. By this time, say half an hour after slack the same condition has occurred east of the second narrows bridge and the big flood is definitely under way.

As the line of flood tide reaches Brockton Point it dashes right on the Point itself and the portion of the stream that is deflected to the south whirls back toward Lumberman's Arch to form a back eddy on the south shore which extends to a narrow point at Prospect Point. This eddy does not help the seafarer, however, as it is illegal to use the south side of the channel when outbound and inbound traffic naturally stays in the main flood stream. This eddy does have some effect on the flood off Calamity Point and better speed will be made in this area if the outgoing vessel keeps nearer mid-channel than if she hugs the north shore.

As I have said, the first of the flood strikes Brockton Point and I have seen many tugs have their booms smashed there. Usually it is the tail end of the boom that strikes and this causes the tug and head end of the tow to be swept in on Burnaby Shoal before the tail end of the boom comes clear. I have seen whole booms completely smashed here and I believe that, years ago, the tug *Superior* was capsized by her tow in the tide near Burnaby Shoal.

It is a very common breach of rules for small boats to come out of Coal Harbour and proceed out between Brockton Point and Burnaby Shoal. This means that the outgoing vessel will come out in the relatively still water behind Brockton Point and suddenly run into a flood stream of about six knots. This causes the outgoing vessel to be suddenly thrown out into the centre of the flood stream and directly into the path of any vessel, which may be inbound, and on her proper side of the channel according to the harbour rules. The proper and safest way to go out the narrows is to keep well east of Burnaby Shoal until the narrows have been opened up and good visibility is obtained. Then a vessel may be worked across the flood stream and can proceed out on her proper side of the channel.

Incoming small craft may turn south at Brockton Point when proceeding to Coal Harbour, but a tug must be careful when towing anything heavy as, before she could get her tow out of the tide she might be swept down on Burnaby Shoal. It is done, however, by tugs as large as those that tow the C.P.R. barges and is another warning to small craft not to use this channel while leaving the harbour.

As the flood tide makes into the harbour it runs in a parallel line from N. to S. up the inlet. As Brockton Point has offered an obstruction the flood does not reach in past the Union Steamship Dock. The main force of the flood rushes up both sides to strike the C.N. Dock on the south and Pacific Drydock on the north side. The flood on the south then splits. Part of it running directly in on the Vancouver ferry dock and Evans Coleman Evans, where it turns west and heads out from where Pier D used to be, to just east of Brockton Point, where it meets the flood stream again. On the north shore the first rush of a big flood runs parallel with the shore, but as it progresses eastward it gradually swings north and when it reaches the Pacific Drydock it is flowing about E.N.E.

Previously I explained the effect of channel friction. If we examine the chart of Vancouver harbour we find a deep channel extending from Burnaby Shoal east along the south shore past the main Piers, up past the Terminal Dock and through the 2nd Narrows. This channel is only about 1/2 mile wide and the rest of the harbour is quite shoal. It would not average 100 feet in depth. This shallowness of the north shore seems to me to create the following condition. As the flood wave progresses easterly tip the harbour, there is less resistance in the deep channel on the south side than there is in the shallow portion on the north. The line of tide therefore runs faster on the south side and slowly the line of flood bends northward. This is very noticeable at the Creosote plant where the tide will slowly swing without much decrease in speed from E.N.E. around to N. then to S.W. x S., or a back eddy. This stream will often run without slacking till 1-½ hours after high water. The eastern end of this tide line curve extends to the W. Indies Dock, where by this time it has ceased to run east, but is running directly in on the shore. This, of course., blocks the flow that has been traveling eastward at the drydocks.

At the North Vancouver Drydocks this is a very dangerous time to shift a heavy vessel, for, as I have said before, the water is comparatively slack until this miniature bore arrives. It is not bad in the daytime, however, as the rippling tideline may be seen for at least ½ mile on a clear day. The only thing to do with a heavy ship is to wait and let the tide wave pass, for within ½ hour the flood will have ceased and the tide will be running from the Ballantyne Pier to off the West Indies Dock, where it splits, part going N.E. toward Moodyville and the other portion running W.S.W. past the drydocks. Near the drydocks it has not the continuous flow, which I have described at the Creosote plant, but often will lull for an hour before the back eddy sets westward in any strength.

On the Vancouver shore the flood line, by the time it has reached the Ballantyne Pier, has started all the waters moving eastward along the docks, and the bore mixes with the stream and all flood east together.

East of the Columbia Elevator, however, there is a bore similar to that of the first narrows. It must be caused from the last of the back eddy but it comes along the Hastings Park shore with great speed about 1½ hour after low water. On a big tide the water will foam along the shore at about 3 knots, but will not last long. As soon as the flood tide stream, which is traveling toward the second narrows up the centre of the channel, reaches the western end of the Pool Elevator, part of the stream swings south and a back eddy forms stopping this flood and causing a slight flow westward past Hastings Park till it swings to the north just east of the Columbia Elevator. After this eddy has formed the flood stream flows to the Columbia and is deflected by this eddy to the northern half of the channel and the south side has only a gentle set westerly, which continues throughout the tide.

In the second narrows the tide flows east in a similar foaming line and causes great difficulty in berthing a ship at Stanovan at this stage of tide. I have seen a tanker come alongside to make a starboard landing and just as the head lines were put out, a rush of flood tide forces itself between the ship and the dock, causing the ship to swing to almost right angles to the dock. As this burst of flood rushes eastward it is deflected by Berry Point and part of it turns west and heads back along the shore to Stanovan where on a big tide it comes out through the dock at about 3 knots speed in a northwesterly direction. There is no slackening of this eddy from then on till near high water.

The main flood stream, which has been deflected by Berry Point, flows in a northeasterly direction in a line from Berry Point to ½ mile west of Roche Point. Flooding strongly along past McKenzie Barge and Derrick Shipyard it is deflected by Roche Point, heads off toward Barnet till about ½ mile to the east of Roche Point it swings in toward Belcarra and then flows up the North Arm past Boulder Island. The waters along the shore on the east side of Roche Point nearly to Dollarton always flow south on a flood tide.

On the south side of the Inlet, Berry Point prevents any flood from striking Shellburn and except on the very first of a flood, the set is practically always westerly. This westerly set starts at the West end of the old Barnet Mill, where the Texaco Oil Co. is now, and is caused by the flood being deflected south by Roche Point. East of Barnet the tides are relatively mild and flow easterly with flood and westerly with ebb with no strong eddies.

By the time the tide has reached the third hour of flood the main streams are fairly well defined. Taken from Prospect Point the flood veers across to the northern side of the narrows so that the main stream is right at the Calamity Point Beacon. Here it veers to the south again as a large back eddy has formed on the north side, east of Calamity Beacon. This eddy is very useful in foggy weather as the edge of the flood tide may be clearly seen and followed without danger of stranding, right out to Calamity Beacon.

On the south shore as I have explained previously the eddy carries right west to Prospect Point. It is this eddy which forces the flood stream over to Calamity Point. I often think, when going out the First Narrows, of the great changes which have been made there in the last forty years. Before the coming of the white man, the Capilano River had been steadily filling in the channel until there really was very little actual channel left. Through the First Narrows the tide used to roar like some of the northern narrows. It was impossible for even a ten-knot freighter to buck out against a big tide. The northern eddy ran very strong to abreast of where the Empress figurehead is today.

One day in the summer of, I think, 1906, I was sitting on our verandah with a good pair of glasses watching the tug *"Chehalis"* which had left Larson's wharf in North Vancouver with a picnic party for Bowen Island. The tug went out in the big north eddy to where it met the flood stream. Just at this point the Princess Victoria was slowly bucking out against the strong flood stream. The *"Chehalis"* came out of the eddy and the flood tide struck her starboard bow. It seemed that in an instant the *"Chehalis"* shot out and came flat against the Princess Victoria, right under the flare of the starboard bow. There was just a crash and the *"Chehalis"* was gone, never to be found.

There is a monument in the park, on the south side of the road just west of Brockton, Point. It was put there in memory of the people who were lost in this accident.

Today, while the tide does not run as strong as in those days, it is still a place which may become Calamity Point for the unwary navigator. About 1912, however, it was decided that the Narrows should be widened, and the dredge *"Mastodon"* was brought out from the Old Country, and the tugs *"Point Grey"*, and *"Point Ellice"* were built in North Vancouver for this work.

For about 5 years the *"Mastodon"*, with her endless chain of buckets, groaned and squealed like thousands of pigs being slaughtered, as she slowly chewed her way out the narrows at the rate of about 120,000 cubic yards of gravel per month. The worst part of the dredging was Parthia Shoal, named because the steamer Parthia struck it, when it extended from the Empress figurehead to the north shore. It was not gravel like the rest of the Narrows but was composed of big boulders and blue clay. Big rock breaking scows were used as well as every other ingenious device, but even today there is a shoal spot across the Narrows, so that an extremely deep vessel, like a battleship, must wait till high water to go over it. Since the days of the Mastodon, however, the currents are much more moderate and the average boat can get out at any stage of flood.

From Brockton Point, the tide runs east in the deep channel as I have mentioned. However, if the chart of the harbour is examined, it will be seen that between La Pointe pier and the Midland Elevator is a large shoal patch of 9 fathoms. This we call Loch Katrine bank as the captain of the Loch Katrine first noticed it when anchoring. This shoal seems to cause the tide to split. Part of the stream going up past the Terminal dock while the other part heads from Ballantyne to Midland, where it splits again, part going east along the north shore, while the other whirls west down the north shore, past the drydocks and out to meet the flood stream west of Brockton Point.

It used to seem ridiculous to leave with a boom of logs from just west of the North Van ferry wharf, go west to Brockton Point, then up to Ballantyne and across to the mills just west of Midland. But in a big tide this is the quickest and easiest way it can be done. The south shore at this stage of the tide all the way from the C.N. Dock to the La Pointe pier is very dangerous for docking a large vessel, as the tide stream seems to veer in and out along the docks. I think that a condition occurs here at this time that is not generally thought of.

If we take a ship of 500 feet in length and, being loaded, draws 30 feet of water. The tide stream may be out 100 yards and the dock therefore in slack water. The big ship moves in on an angle of about 45 degrees and comes in to the still water at the dock. Immediately the ship becomes a wingdam and diverts the flood stream with her side. In a matter of minutes there is a strong flood and the ship crashes the dock. If the ship backs away, in a few minutes the tide will be gone and the water at the dock will be slack.

At night when the tide streams cannot be watched so easily, this is a dangerous condition and I am sure this is the reason for some of the troubles when docking a large ship at this stage of tide.

The Ballantyne seems to have the worst condition in this respect. The Sugar dock and Burrard elevator are rather unpredictable as the flood stream swings in and out. Sometimes there will be quite slack water At the docks east of Ballantyne while at other times it will foam white in on the Sugar dock and Burrard elevator.

The La Pointe being solid does not allow much flood on its west side and I have seen some very good landings made at berths 7 and 8, by coming in head on from the westward close along the shore until the headlines are out, when the ship may be swung in against the dock without trouble.

The berths 1 to 5 are not nearly so easy as the flood often runs across the end of berth 5 and in toward the B.C. Marine, through berths 1 and 2, which are not solid. This is not a continuous condition, however, and sometimes by watching carefully, a ship may be berthed between surges.

The Terminal dock is not bad in a flood, as the tide runs fairly parallel to the dock and a port landing may be made usually without too much trouble.

The Columbia elevator is very easy at this time, as the flood has been deflected to the north and there is a gentle back eddy at the dock. A port landing is the easiest to make at this stage of tide. The Pool elevator is also not bad except that sometimes there is quite a strong set on the dock at No. 2 and 3 berths. No. 1 usually has a set westerly on a big flood.

To go through the 2nd Narrows at this time I like to have Berry Point bearing fair in the centre of the big span or at night, the operation, tower bearing E x N ¾ N. This is the angle the tide runs and very little set will be felt if this course is followed.

There are no eddies cast of the bridge until the black beacon is reached except on the south shore, where the eddy from Berry Point rushes down the south side and out through the dock at Stanovan. From Stanovan west there is a narrow stretch of slack water west to the water mains but it is dangerous practice to use it when coming west as it is the wrong side of the channel for west bound vessels.

From Berry Point east the flow does not change but carries on up the inlet as I have previously explained.

As the time approaches, high water conditions naturally change in the harbour. The flats are now covered, giving greater area of water in the narrows. Strangely, though, the flood still stays in its usual position in the narrows, but the shallow flats have back eddies. On the south shore east of Brockton Point there is often a complete change, however, for sometimes in the last hour of a big flood the tide will run very strong from Burnaby Shoal right in on pier B. A ship berthing at this stage of tide may be swept heavily on to the docks with this current.

As a rule the flood stays out off the docks as far east as La Pointe and from La Pointe west to Evans, Coleman, Evans there will be a westerly eddy along the docks. There is often a very strong set east of La Pointe, running E.S.E. into B.C. Marine. It is very awkward docking a ship at No 1, 2 and 5 La Pointe when the tide is running under this condition.

I might say that a small flood will produce the same conditions, and I have at times found it almost impossible to dock a ship when there is only about one foot of a tide rise. With the small rise this occurs at nearly all the main docks in the harbour east of the C.N. dock and only occurs in the last hour or so of the flood.

East of La Pointe the flood commences to decrease as high water nears, and the west end of the Terminal will have a westerly set. This is the path of the first of the ebb, i.e. close along the Terminal docks. The Columbia Elevator has no flood, but the Pool is often quite bad with the flood tide setting in on berths 2 and 3 at about 20 degrees angle. With 3 ships in berths it is very easy, even with tugs, for a ship leaving No. 2 berth to be swept in on the ship at No. 3. This also applies to a ship trying to berth in No. 2, with, No. 1 and 3 berths occupied. I have seen many ships swept heavily broadside against the dock at this stage of the tide for the current is sometimes not discernible on the surface.

This southerly set also occurs right in the span of the Second Narrows bridge at this stage of tide, sometimes with such force that it is very difficult to keep a boom off the south pier of span C. East of the bridge the current remains much the same as before on the south shore, except that near high water the big eddy in the bay at Stanovan slackens. In fact the west side of the dock will flood at high water.

The north side of the narrows, however, has a peculiar condition. The flats are of course by this time covered, and a back eddy is sweeping across them to the westward. This eddy extends southward into the channel far enough that a skipper who knows his range marks may get within 500 yards of the bridge before striking a strong flood.

From the new water main west to the bridge there are no eddies. The tide speed does fluctuate, however, and sometimes a tug with a scow will be stopped for several minutes and then move ahead. I always find that on a big tide if I can buck a scow past the Water Board cut on the north shore, there is a good chance of getting past the bridge. Right at the bridge, however, don't be fooled. Open the engine up full, for as the scow gets past the bridge, it will hit a rise and if not enough speed is on the scow it will be stopped and washed back through the bridge.

This sort of lump of water seems to be only about a scow length west of the bridge, and if the scow is bumped past this ridge, the tide speed decreases rapidly and in no time you may work the scow over to the south eddy west of the Pool Elevator.

There is a very dangerous condition just east of the black beacon abreast of Stanovan. Here, for no apparent reason, the tide runs due north. Years ago I was assisting the old *"Malahat"* down through the narrows when we struck this northerly set. She just took a sheer and started for the bush and I don't know yet how we stopped her.

Even with a scow in tow and a skipper who knows of this set, it still means that great care must be used to keep from being put ashore on the north flats.

Speaking of the flats, there is one thing that I have learned to my sorrow. That is, never try to put a scow or any other tow far in on the flats in the last hour of flood. If there is not enough water there one hour before high tide, get out and wait till the next tide. The reason is that the flood tide comes over the flats in waves and often at high water there is less tide height than there was one hour before high.

Years ago there was quite a lot of this kind of work, taking donkey engines on scows up sloughs to unload them on the beach. It sometimes means the ruining of a scow when she hangs up on a gravel bar from lack of water, and as I say, the water will be high enough to get the scow in and then the wave will recede and the scow will not float again on hat tide.

East of Berry Point the tide continues running across toward McKenzie Barge & Derrick, and does not come much to ebb at any time. West of McKenzie's the eddy makes and runs very strong across the flats at Deek's, out to the black beacon.

On the south shore past Shellburn, the eddy still runs westward to increase as the tide turns to ebb.

Returning to the north shore of the harbour: As the flats are covered the big back eddy, which has been running down the north shore, does not reach in on the flats. Instead, another current forms which flows eastward. This is a narrow streak of weak current, which extends as far east as the West Indies Dock. It is not always reliable, but usually appears. It is a rather dangerous time to shift a ship at the drydocks however, as the minute the ebb starts the big back eddy outside may sweep in without warning. Once this eddy has returned along the drydocks I usually figure to wait about 1 ½ hours after high water, when the eddy will cease. This is what seems to happen.

As the time of high water arrives, the eddy from La Pointe west widens. At high water on a big flood, a big patch of driftwood will form about ½ mile north of the Copra Dock. After high water, this patch of driftwood will move rapidly northward. This seems to be the last of the flood, which has been deflected by the gaining westerly eddy from La Pointe. In about 1-½ hours after high water this driftwood will have reached the end of Burrard drydocks, and will have collided with the big eddy, which has been running strongly to the west. When this collision occurs, the current will run strongly right in on the docks. That is a good sign, for within five minutes, unless there is a strong wind blowing, the tide will be absolutely slack with no danger of a return of the back eddy. Thus ends a big tide and all the tension that goes with it. Peace seems to come to the shores of the inlet.

In the summer it is usually evening, and as an old Indian friend of mine said to me once when we were talking about it, “Take all your white man's pleasures, your aeroplanes and motorcars, give me a nice dugout (snaaquaylsh) canoe and let me paddle far up the sloughs where the smell of the sedge grass fills the air, where I can see the flounders scooting away in the clear water ahead of the rippling bow, and hear the birds in the trees along the shore singing their sleepy evening song; then I will be contented as the peace of evening comes with Kwaha-li-us, the full of the tide.”