

rents. Had this water been discharged at the bow of the ship, she would have been freed much sooner. An ice-breaker equipped with steam or hot water in the bow, would never be delayed by either frazil or lolly ice.

This year, the keeping of the channel open at Cap Rouge has had the effect of keeping the river clear all the way up to Three Rivers.

Battures have formed, but these have come away early, not being held in place by the ice pack, and on March 20th, during the trip of the "Montcalm" from Quebec to Three Rivers, no ice was met with, the whole river being practically as clear as in summer. The effect of keeping an open channel has been to produce less ice than was expected. Open water allows the free entrance of the sun's heat, and during the month of March the water flowing past Quebec steadily rose. Fig. 7 shows the rise of water temperatures during a period of several bright clear days, with the temperature at or a little below the freezing point. The effect of surface ice would have been to prevent the rise of water temperature. Thus, the action of ice already formed is to refrigerate the water and really delay the disintegration of the river ice.

During the passage of the "Lady Grey" up the river from Quebec to Three Rivers to commence operations on the ice of Lake St. Peter, on March 16th, temperature measurements were made in the water at intervals. This was found to drop slowly at first and more rapidly up to the edge of the border ice on Lake St. Peter, where the temperature was found to be almost exactly at the freezing point. A most remarkable example of the effect of the sun in warming the water was observed on March 21st, during the time of the opening of a part of the channel in Lake St. Peter. See Figs. 8 and 9. A channel several hundred feet wide was made through fifteen and eighteen inches of clear lake ice for a distance of nearly five miles. Every measurement showed the temperature at the fresh cut into the surface ice, out of which the water flowed, to be about one one-hundredth of a degree above freezing. During the day, the sun was shining, and by the time the ship returned over the lower part of the cut, the water temperature had risen by two or three hundredths of a degree.

Small as this rise seems, measured by ordinary standards, it is very large when taken in connection with the formation or disintegration of ice. Only a few hundredths of a degree will prevent ice formation altogether in water, even in a very cold atmosphere. No freezing or sticking of the ice is possible on the river, warmed to this amount, and the existing ice is rotted and honeycombed to a large extent. How great a reservoir of heat the whole of Lake St. Peter would become if kept free of ice, cannot be adequately estimated. At first sight, it appears that a surface layer of ice acts as a protective coat. But the effect of the sun during the day is much greater than the effect of a cold atmosphere, and yet all this is effectually shut off by the layer of surface ice.

It is hoped that attempts will be made some time to keep Lake St. Peter free of surface ice. Through it there runs a current of about one mile per hour, which is quite sufficient to clear it of ice if broken up. Small tugs creating a powerful wash would be sufficient to do this. During an easterly blizzard, the tugs could not work, but if set at the ice directly after much could be accomplished. It seems wrong to allow the ice time to grow to its present thickness, and then spend time and money breaking it up. The channel, at least, should be kept open during the winter, to allow of a free runaway for the ice. It is very likely that the open lake would to a large extent react on the lower parts of the river, and make the problem at Cap Rouge much easier.

Results of the Work of the Flood Commission

As early as 1886, the Royal Commission appointed to study the St. Lawrence River, with a view of finding some remedy for the winter and spring floods, issued a very elaborate and valuable report, giving a careful survey of the river above and below Montreal. The result of their study showed that the floods were occasioned by the winter packing of the ice, and that all this could be avoided by keeping the channel open to tide water. The St. Lawrence is not subject to floods such as affect many of the American rivers; its flow is more uniform. The winter and spring floods are entirely due to ice jams. Floods may last for a few hours, or a week or more. The one of 1858 lasted two weeks. There are certain critical spots in the river, where the ice forms first, which starts the pack. Thus, at Lake St. Peter the ice-bridge causes the water to rise behind it. The winter level of Lake St. Peter itself is four or five feet higher than the summer level while the river is open, but when that is closed it rises seven or eight feet.

Mr. T. C. Keefer, C.M.G., one of the greatest authorities on the ice conditions of the St. Lawrence, describes, in his address already referred to the taking of the ice over the St. Lawrence in 1886, when he studied the question as a member of the Flood Commission. In that year, the ice-bridge took at Nicolet, the lower end of Lake St. Peter, on December 4th, and the lake was covered to Stone Island, twenty miles above, in thirty hours. The ice then reached Sorel, seven miles further on, in fourteen hours after. It reached Vercheres, twenty-three miles above, in seventy-eight hours. After five days' thaw, it reached Verennes, going nine miles in seven days. The upward march to Longue Point (seven miles) was made in two days of cold weather. The whole of the river channel for fifty-five miles above Lake St. Peter to Lachine Rapids was covered in about three weeks. At the St. Mary's Current, ice shoves are most frequent. Sometimes, the water rises as rapidly as a foot in less than two minutes. During the great flood of 1886, the water in Montreal Harbor rose twenty-seven feet above the summer level, by an ice jam below Hochelaga. This gave way suddenly, before the pressure caused by this head, and the ice-laden wave (starting at twenty-seven feet) was precipitated down the river. It dropped in amplitude only three feet in the first mile and was twenty feet high at Longue Point, which elevation it maintained for a distance of thirty miles. It finally reached Sorel, with a height of sixteen feet above summer level, in ten hours going at the rate of four and one-half miles per hour.

Flood Commissioners on Winter Navigation

The Flood Commissioners, after very careful deliberation came to the conclusion that there would be a great deal to be gained by keeping the St. Lawrence clear of ice, from Montreal to tide water, in order to avoid the winter and spring floods. They recommended a boom to be thrown across the base of Lake St. Louis, to keep back the lake ice. This was estimated to cost about \$70,000.00, but was never carried out. Ice-breakers for the harbor of Montreal were authorized in 1885, but were likewise never put in operation. Experiments on explosives to break up the ice jams were tried, but were found to be of little use in the masses of packed ice. Moreover, they were very expensive, quite apart from any value in moving the jams.

They stated that the prevention of the ice-bridge at Lake St. Peter would result in an open channel up to the Lachine Rapids. The current, under a head of one-fifth of an inch per mile, was found to be effective in other parts of the river in keeping the surface clear of ice. As it is now, the ice-bridge at the lake stops the floating ice, which would otherwise pass out to tide water.