Seasonal Summary

Great Lakes

Winter 2020-2021

By the North American Ice Service

Summary for the Great Lakes

The 2020-2021 Great Lakes ice season can be summarized by well below normal ice coverage and below normal ice thickness, much like the 2019-2020 ice season. The well below normal ice coverage was driven by warmer than normal surface air temperatures across the Great Lakes basin for most of the winter season. As a result, ice thicknesses were also below normal across all of the lakes; there was no very thick lake ice recorded this season, the first time since 2017. The total accumulated (TAC) ice coverage for this season was just 6.2% compared to the 30-year median of 13.9%, making this season the 8th lowest on record in terms of ice coverage.

The Great Lakes ice season did start two weeks earlier than normal, measuring the first ice in the last week of November. Ice coverage growth initially followed the climatological trend until mid-December when growth slowed significantly due to well above normal temperatures in late-December and the first half of January. Towards the end of the third week in January, ice coverage was near record lows across the Great Lakes at just 2% ice covered.

Ice coverage then sharply increased through the end of January and the first half of February. Ice coverage surpassed the climatological normal in the second week of February, peaking at 39.6% ice covered, compared to a median of 33% for that same week. The ice extent achieved during the second week of February also represented the maximum ice extent for the 2020-2021 Great Lakes ice season. Typically, the peak would occur in mid-March. The spike in ice coverage was driven by a cold air outbreak, especially over Lake Michigan and western Lake Superior.

Following the ice extent peak, ice conditions fell steadily through March and April, with the last of the ice melting by April 30th, just one week ahead of the normal. The initial rapid decline was sparked by above average temperatures through the end of February to mid-March and the rest of the melt was drawn out by normal air temperatures through the end of March, April and May.

Below are subdivided temperature anomaly regimes for the winter of 2020-2021 (Figures 1-6).

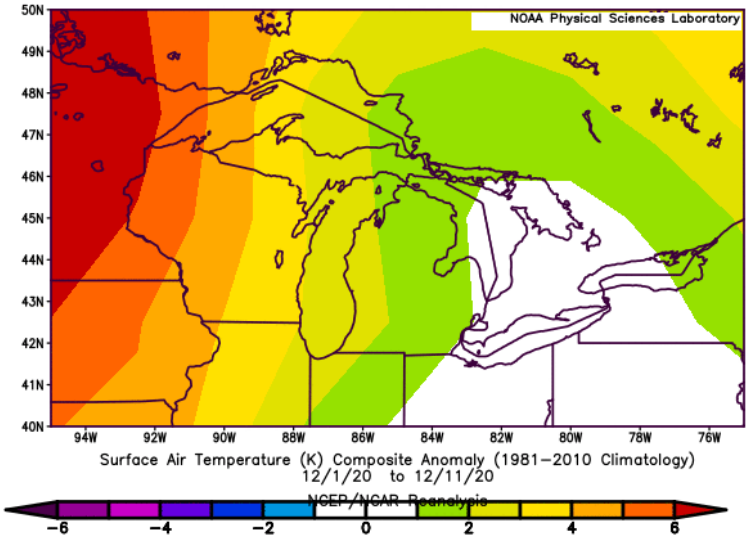

Figure 1: Surface Air Temperature Anomaly for the Great Lakes, 1 December 2020 to 11 December 2020

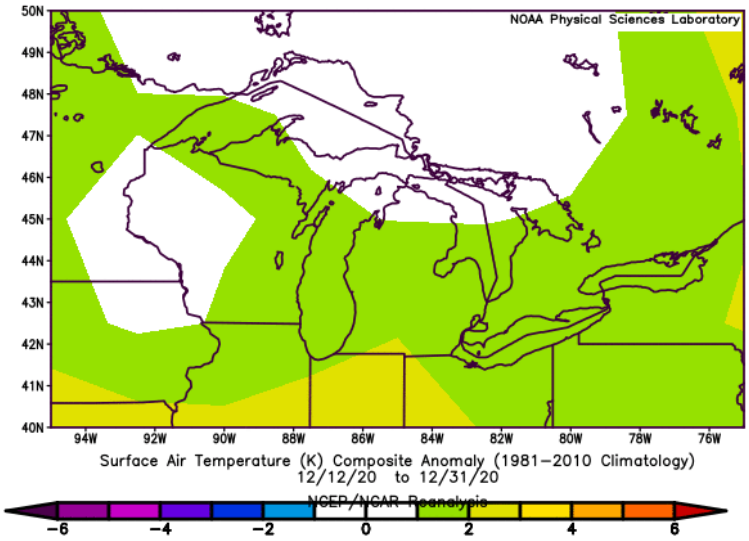

Figure 2: Surface Air Temperature Anomaly for the Great Lakes, 12 December 2020 to 31 December 2020

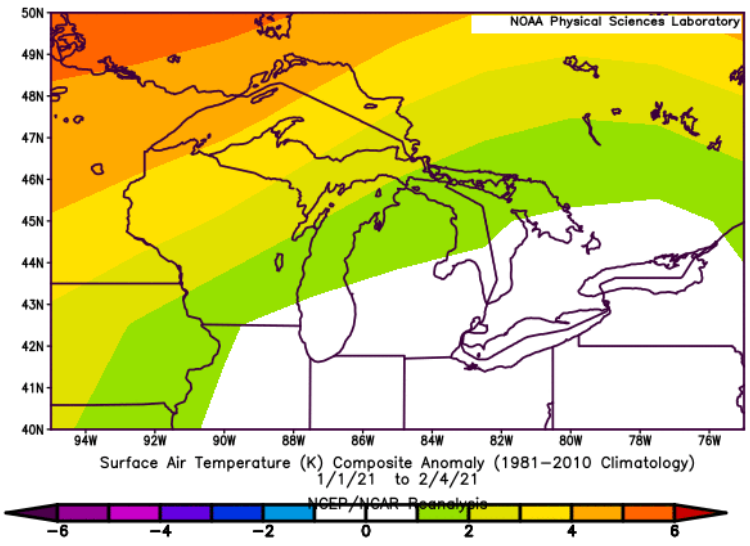

Figure 3: Surface Air Temperature Anomaly for the Great Lakes, 1 January 2021 to 4 February 2021

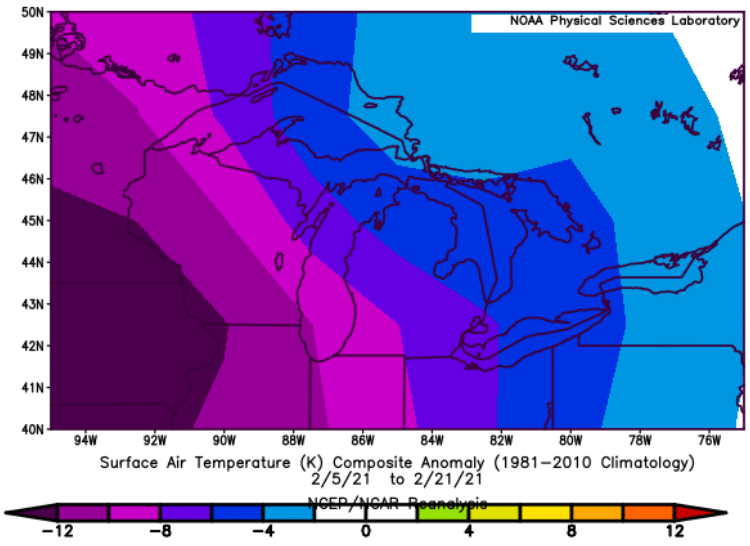

Figure 4: Surface Air Temperature Anomaly for the Great Lakes, 5 February 2021 to 21 February 2021. Note that the scale is double the temperature range of the other anomalies.

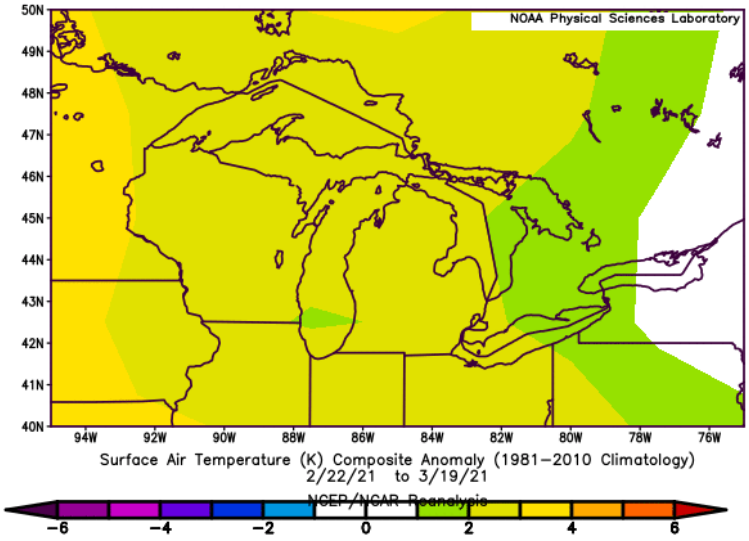

Figure 5: Surface Air Temperature Anomaly for the Great Lakes, 22 February 2021 to 19 March 2021

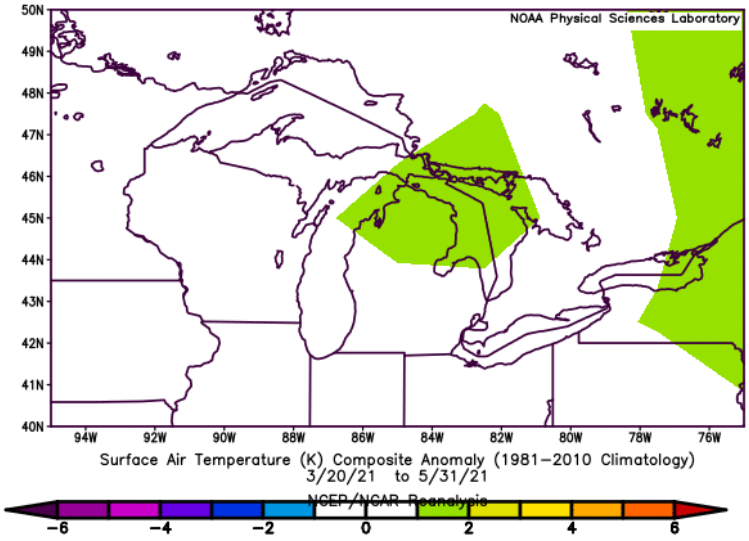

Figure 6: Surface Air Temperature Anomaly for the Great Lakes, 20 March 2021 to 31 May 2021

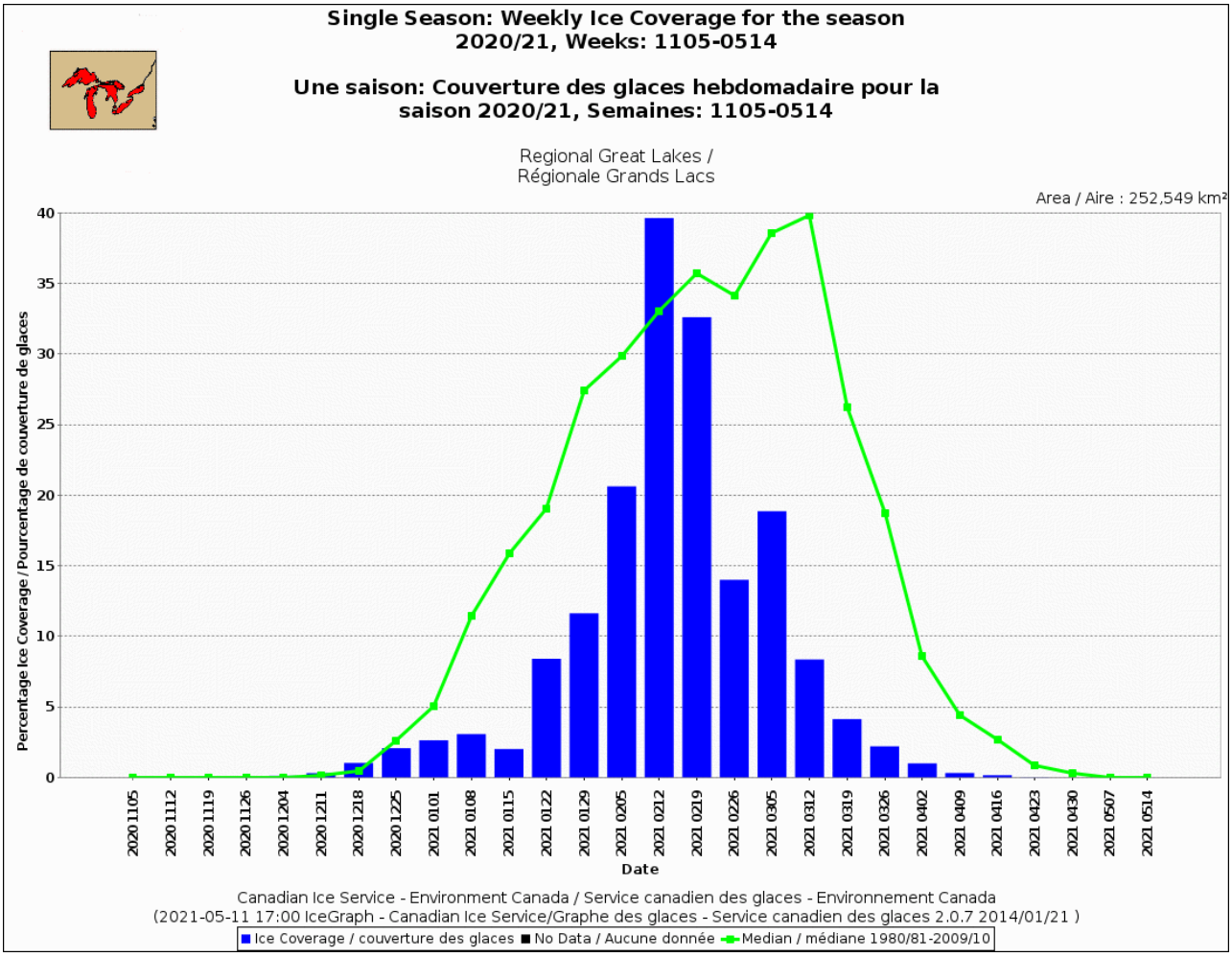

Figure 7: Weekly Ice Coverage for the Great Lakes, winter 2020-2021

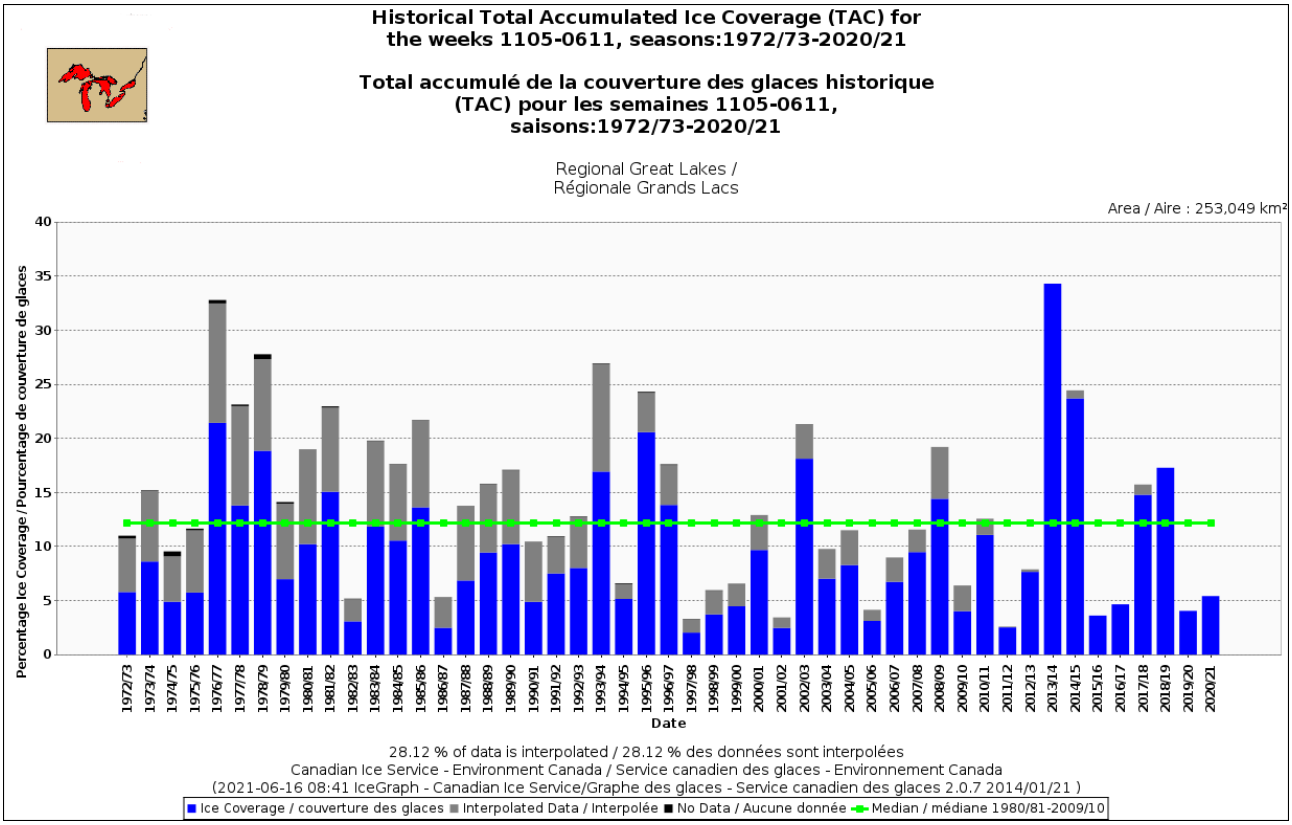

Figure 8: Historical Total Accumulated Ice Coverage on the Great Lakes, 1972-1973 to 2020-2021

Lake Superior

2020-2021 Season Temperatures:

The 2020-2021 ice season started with near normal temperatures for Lake Superior for the second half of November. These near normal temperatures allowed the first traces of ice to form in the northern most bays in the last week of November.

The beginning of December ushered in anomalously warm temperatures, with the eastern portions of the lake seeing average air temperatures of 1-2 degrees Celsius above normal, while the western portions were experiencing temperatures on average of 5-6 degrees Celsius above normal. This lead to very little ice growth in the first 2 weeks of December.

Following the above normal temperatures in the beginning of December, near normal temperatures return to Lake Superior for the second half of December.

The beginning of January saw the return of above normal average air temperatures, however, to a much high degree than what occurred in early December. In northern and western Lake Superior, average air temperatures were 7-9 degrees Celsius above normal, while the southern and eastern parts of the lake were 5-7 degrees Celsius above normal. These very warm temperatures actually caused a decrease in ice coverage during the first two and a half weeks of January to a near record low.

The substantial warm period came to an end in the third week of January and more normal average air temperatures settled into the region until early February. A significant cold air outbreak began in early February with average air temperatures falling to 2-4 degrees Celsius below normal in the eastern end of the lake to 8-10 degrees Celsius below normal in the western end of the lake. This caused ice to grow rapidly and ice coverage even surpassed the climatological normal, just 4 weeks after reaching near record lows.

Average air temperatures warmed in the end of February and early-March with average temperatures of 2-3 degrees Celsius above normal across Lake Superior. This lead to a sharp decrease in the ice coverage of the mobile ice.

Through the end of March to the end of May, average air temperatures remained near normal as the ice season came to a close in late-April and early-May.

2020-2021 Ice Conditions:

The near normal temperatures in the second half of November allowed the first ice to form in the last week of the month in the Black Bay. Transient amounts of ice did also form in Thunder Bay and Nipigon Bay, however, it wasn't until the second week of December that the ice persisted in those two bays. This was also around the time when ice started to form in sheltered bays along the southern shore and the ice in Black Bay began to fast. By the last week in December, both Black Bay and Nipigon Bay were covered with

thin and medium lake fast ice while low concentrations of new lake ice started to line the southern shore of the lake and in Whitefish Bay. Ice formation started generally on time compared with climatology and progressed according to climatology until the beginning for January.

In the beginning of January, with well above normal average air temperatures, ice growth halted and ice coverage remained near 2% ice covered, which the lake had reached in mid-December. In the third week of January, the ice extent actually receded slightly to just 1.62% ice covered, nearly breaking the record low ice coverage for that week of 1.58% which was set in 2008. At the low point, ice was restrained to the fast ice in Black Bay and Nipigon Bay as well as a few sheltered bays along the southern Lake Superior coast.

The anomalously warm air over the region finally ended as a near normal air temperature invaded the area in the third week of January. This regime change finally allowed ice to start accumulating in Lake Superior, filling in Thunder Bay, Black Bay, Nipigon Bay and the Apostle Islands as well as lining the southern shore once again. Ice coverage climbed to 7.4% by the end of January, however, this was still far below the median of 18.7% ice covered. At the end of the month, Black Bay, Nipigon Bay and Chequamegon Bay were all filled with thick lake ice. Meanwhile, Thunder Bay was filled with thin lake ice and most of the southern and eastern shores were lined with new and thin lake ice.

Average air temperatures plunged in early February, especially in western Lake Superior. As a result, ice coverage more than tripled in the second week of February, rising from 10.4% to 34.7% and exceeding the climatological median of 22.8%. New and thin lake ice quickly covered the waters in western and southern Lake Superior as well as in Whitefish Bay and between Thunder Bay and Isle Royale. As temperatures remained cold in the third week of February, ice coverage increased again to 38.2%, just above the median of 36.3%. This also represented the maximum ice coverage for Lake Superior for the 2020-2021 ice season. At this point, ice filled up most of the western half of the lake and continued to thicken to be predominantly thin and medium lake ice. The ice around the Apostle Islands also thickened to medium lake ice and became fast while Whitefish Bay transitioned to medium lake ice.

In the last week in February, the cold air outbreak came to an end and above normal average air temperatures returned to the area, this also coincided with a series of low-pressure systems brining strong winds. This lead to a significant destruction of ice in Lake Superior, ice coverage dropped by over 75%, from the maximum of 38.2% down to just 8.63% ice covered in just one week, far below the median of 32.1%. The last week in February saw the destruction of the majority of new and thin lake ice that built up through the month, leaving the mobile ice as mainly medium lake ice, while the larger bays contained thick lake ice.

Ice coverage rebounded slightly in the first week of March due to near normal average air temperatures, rising to 15.4% ice covered as new and thin lake ice formed once again along the southern shore and up to Michipicoten Bay and between Thunder Bay and Isle Royale. This didn't last long however, as average air temperatures rose to be above normal and daily high temperatures often above zero in the second week of March. Typically, the second week of March represents the peak ice extent on Lake Superior, with a long-term median ice coverage of 49.7%. However, ice coverage fell from the previous week down to 7.5% ice covered. The fast ice in Thunder Bay, around the Apostle Islands and in Whitefish Bay also began to break up. Ice had receded to be contained mostly in the major bays and as a thin band of ice along the southern shore as well as up to Michipicoten Bay.

Ice coverage continued to decline through the second half of March as the above normal average air temperatures remained in place. In fact, the daily high temperatures reached above zero degrees Celsius and into the double digits for a few days. By the end of March, very little mobile ice remained and was mainly concentrated in Thunder Bay and Whitefish Bay. All of the fast ice had melted from the Apostle Islands, the fast ice broke up in Chequamegon Bay and the remaining fast ice in Thunder Bay, Black Bay, Nipigon Bay and Whitefish Bay had become rotten. By the end of March, ice coverage fell to 2.5%, well below the median of 24.6%.

Typically, in April, the ice melt slows as the most of the mobile ice has already melted and all that is left is the thicker and more protected fast ice. With near normal average air temperatures over the region, the ice melt through April followed the same trend. Ice coverage started out the month at 1.6%. This extent was predominantly made up of the fast ice in the three northern bays

and Whitefish Bay. By the end of the second week in April, the fast ice in Whitefish Bay had broken up and melted out, leaving the fast ice in Thunder Bay, Black Bay and Nipigon Bay as the only ice left in Lake Superior. Over the course of the last two weeks in April, this fast ice continued to fracture and melt and by April 30th, the last strips of ice finally melted from Black Bay and Nipigon Bay. Lake Superior was free of ice roughly 1 month ahead of the normal full melt of ice.

The TAC for Lake Superior for the 2020-2021 ice season was 4.6%, which is well below the long-term median of 12.7%. This puts the 2020-2021 ice season as the 12th least severe ice season since the 1972/73 season.

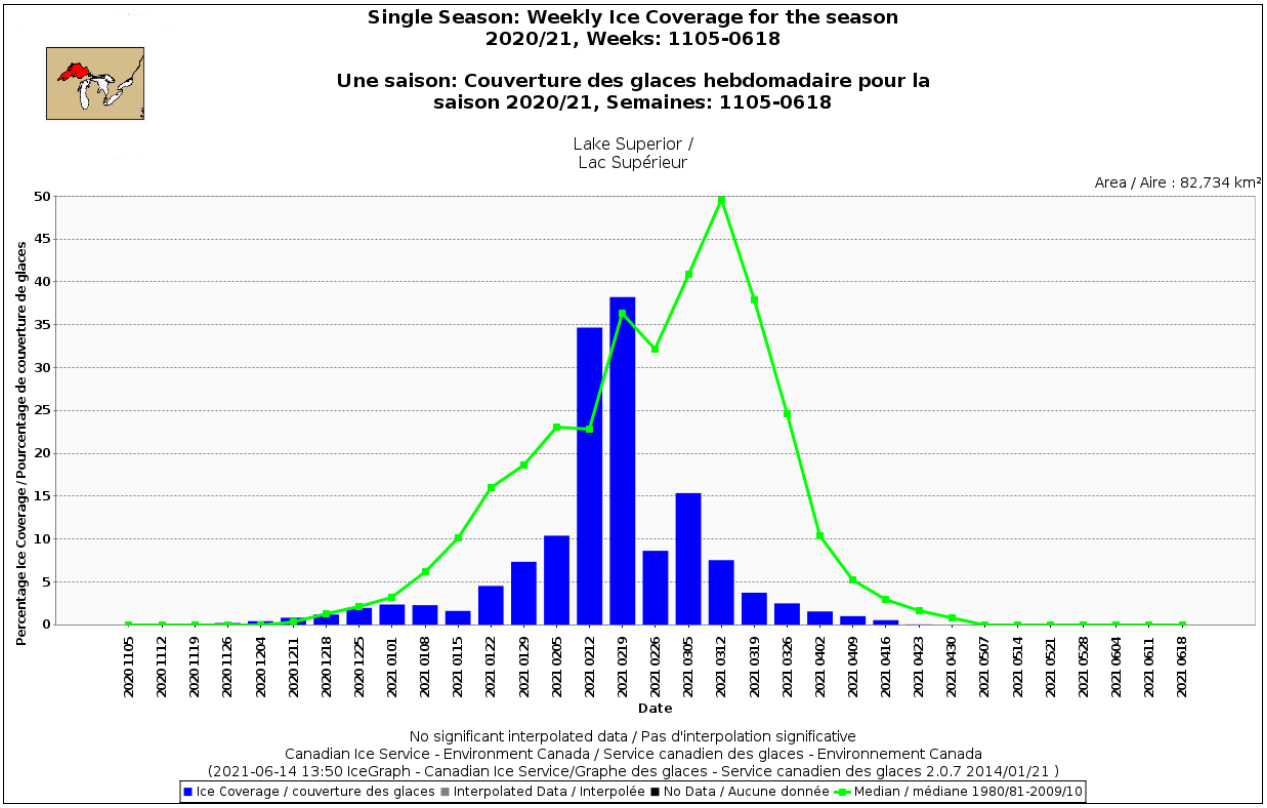

Figure 9: Weekly Ice Coverage in Lake Superior for winter 2020-21.

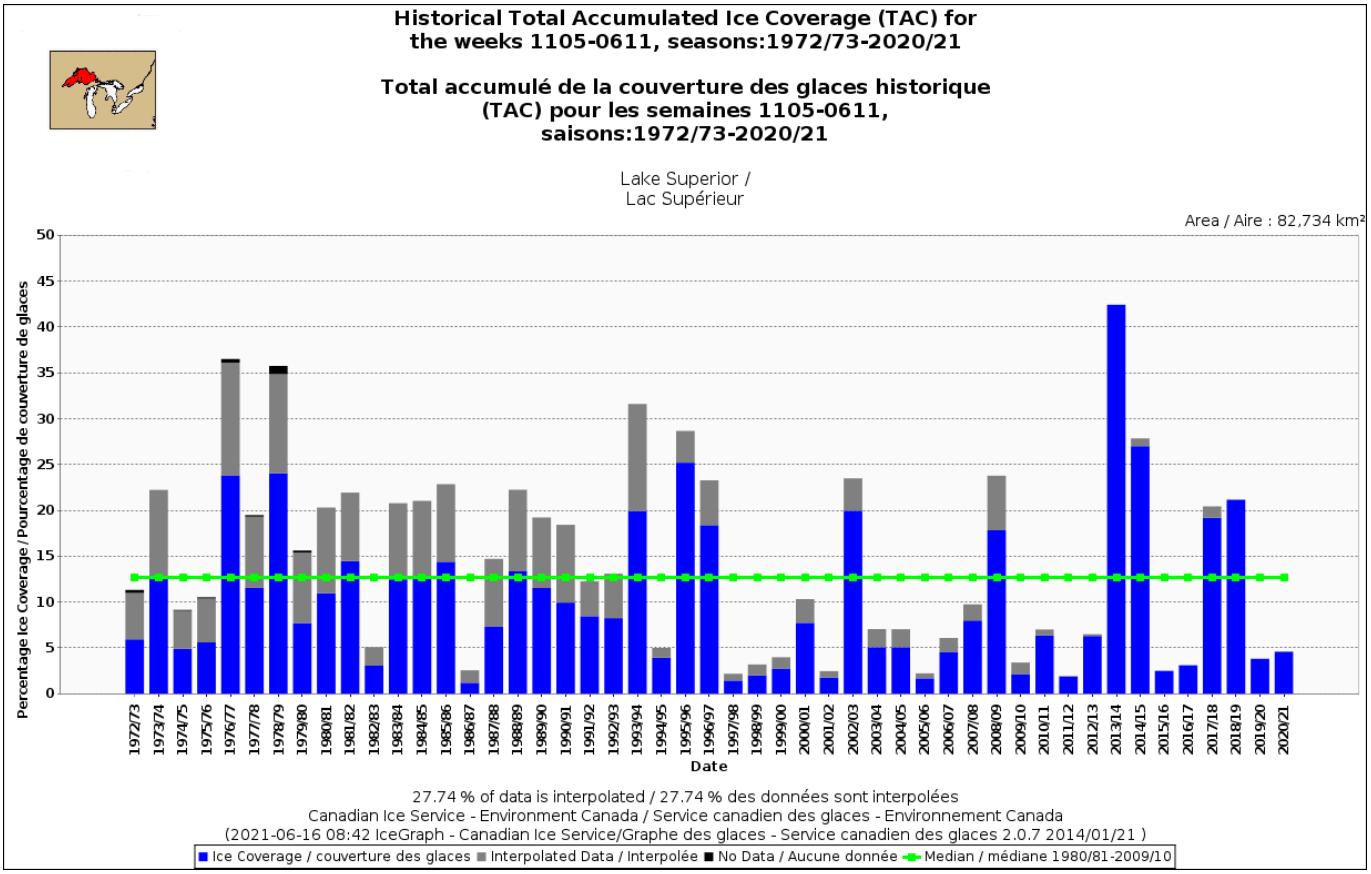

Figure 10: Historical Total Accumulated Ice Coverage in Lake Superior by season, 1972-2021.

Lake Michigan

2020-2021 Season Temperatures:

Average air temperatures were near normal for the second half of November. In the beginning of December, the average air temperature anomaly increase to 2-3 degrees Celsius above normal for the bulk of the lake. By mid-December, near normal average air temperatures return to the region, and with it, the first sustained period of sub-zero average air temperatures. This lead to the first formation of ice in parts of Green Bay and the Bays de Noc.

In early January, average air temperatures were once again above normal. The southern half of the lake saw anomalies of 1-2 degrees Celsius above normal, while the northern half experience average temperatures of 3-5 degrees Celsius above normal. This caused the ice coverage to reduce in mid-January to a near record low ice coverage.

Following the warm spell in the first half of January, average air temperatures returned to near normal in the second half of the month. This allowed ice to grow through the end of January and the first few days of February.

Towards the end of the first week in February, average air temperatures plunged to well below normal until the end of the third week of February. The anomaly was the most severe in the southern half of the lake where average air temperatures dropped to 8-10 degrees Celsius below normal. The northern half of the lake recorded anomalies closer to 4-6 degrees Celsius below normal during that time. Ice coverage grew significantly during this period and the ice extent actually surpassed the long-term median.

In the final week of February, more moderate, slightly above normal temperatures settled over the lake and remained in place until mid March. Average air temperatures of 2-3 degrees Celsius above normal meant that daily high temperatures were frequently above zero degrees Celsius which started the declined in ice coverage.

Following the relative warmth of early March, average air temperatures trended closer to the long-term average through the end of March, April and

May. Despite near normal average air temperatures, by mid-March, average air temperatures are generally above zero and the ice melt is well underway.

2019-2020 Ice Conditions:

Lake Michigan saw its first ice form on December 15th in Green Bay and Bays de Noc, which matched the climatological ice formation of the third week of December. Ice continued to slowly form, nearly following the climatological trend, through mid and late December due to the near normal average air temperatures. By the end of the month, ice covered nearly 1.3% of the lake compared to the typical extent of 2.3%; almost all of this was in Green Bay and the Bays de Noc.

In early January, above normal average air temperatures dominated the region, which caused the ice growth to stagnate and ice coverage remained near 2%. Ice coverage even dropped in the third week in January down to 1.4%, which is more typical of mid-December, and well below the long-term average of 14.8%. Typically, ice growth is at its highest rate in early-January, rather than in the decline that occurred this year. Through this warm period, ice was mainly restrained to southern Green Bay and in the Bays de Noc; however, some transient ice did form along the northern shore of the lake.

In the second half of January, near normal average air temperatures returned and ice growth resumed. New and thin lake ice continued to form in Green Bay and the fast ice in southern Green Bay and the Bays de Noc transitioned to medium lake ice. In addition, smaller concentrations of new lake ice were established along the northern shore of the lake leading into the Straits of Mackinac as well as along the southwestern shore. By the end of January, ice coverage had risen to 10.1%, which was only nearly half of the median coverage of 19.6%.

February started in a similar fashion, with near normal average air temperatures, but temperatures sharply dropped towards the end of the first week, allowing the ice for expand and thicken quickly. Ice coverage doubled by the end of the first week, reaching 20.8%, just below the median of 21.3%. At this point, a mix of thin and medium lake ice completely filled Green Bay and the entrance to the Straits of Mackinac and new and thin lake ice lined most of the shores of the lake. As the cold spell continued, the ice did not

expand much, but it did thicken, as the ice in Green Bay transitioned to medium lake ice and became fast. Also, the ice lining the shore and in the entrance to the Straits of Mackinac became a mix of thin and medium lake ice. By the end of the cold spell, all of Green Bay and the Bays de Noc were fasted with medium and thick lake ice, the entrance to the Straits of Mackinac was full of medium lake ice and partially fast. There was a significant concentration of medium lake ice along the southern shore of the lake including a large area of fast medium lake ice from Chicago to just past Michigan City. This cold spell lead to the peak in ice extent on Lake Michigan in the second week at 27.6% ice covered, reaching above both the median for that week of 20.5% and the median peak ice cover of 23%, which typically happens in the third week of February.

The cold air outbreak ended in the third week of February and ice coverage began its decline. Ice coverage dropped 10%, down to 17% due to ice melting along the shores of the lake. Ice coverage continued to deteriorate, especially in the southern half of the lake as average air temperatures rise above zero degrees Celsius in the last week of February. Most of the ice along the shore and in the southern half of the lake melted out, leaving only the fast ice in Green Bay and the high concentrations of mobile ice leading into the Straits of Mackinac along with a thin band of medium lake ice near the southeastern shore of the lake. This lead to an ice coverage of just 10.4% at the end of February compared to the long-term median of 16.1%.

The above normal average air temperatures persisted into March, this spurred the break up of the fast ice in Green Bay, fracturing the ice between the Bays de Noc and the northern tip of the Door Peninsula. Ice coverage did not change very much between the last week of February and the first week of March with ice coverage only dropping 0.1% to 10.4% compared to the climatological mean where ice coverage typically expands slightly in the first week of March to 16.9%. Ice coverage continued its slow decline in the second and third weeks of March as the land fast medium and thick lake ice in Green Bay fractured and melted, as did the mobile ice near the Straits of Mackinac. Ice coverage dropped to 2.1% by the third week.

Over the course of the last week in March, the few strips of ice in Green Bay completely melted; the fast ice had broken up in the Bays de Noc and nearly melted out, while concentrations near the Straits of Mackinac dwindled to

strips of ice along the northern shore. Ice coverage rounded out the month of March at 0.6%, well below the 9.5% median.

The ice that was left at the end of March did not make it past the first week of April as the remaining strips melted out by April 4th, ending the 2020-2021 ice season on Lake Michigan. This represented an end to the ice season of about 4 weeks earlier than the climatological normal.

The TAC for the 2020-2021 season was 4.5%. This value is nearly half of the historical median of 8.6% and very close to the coverage of last season. This TAC puts the ice season as the 7th least severe ice season since the 1972/73 season.

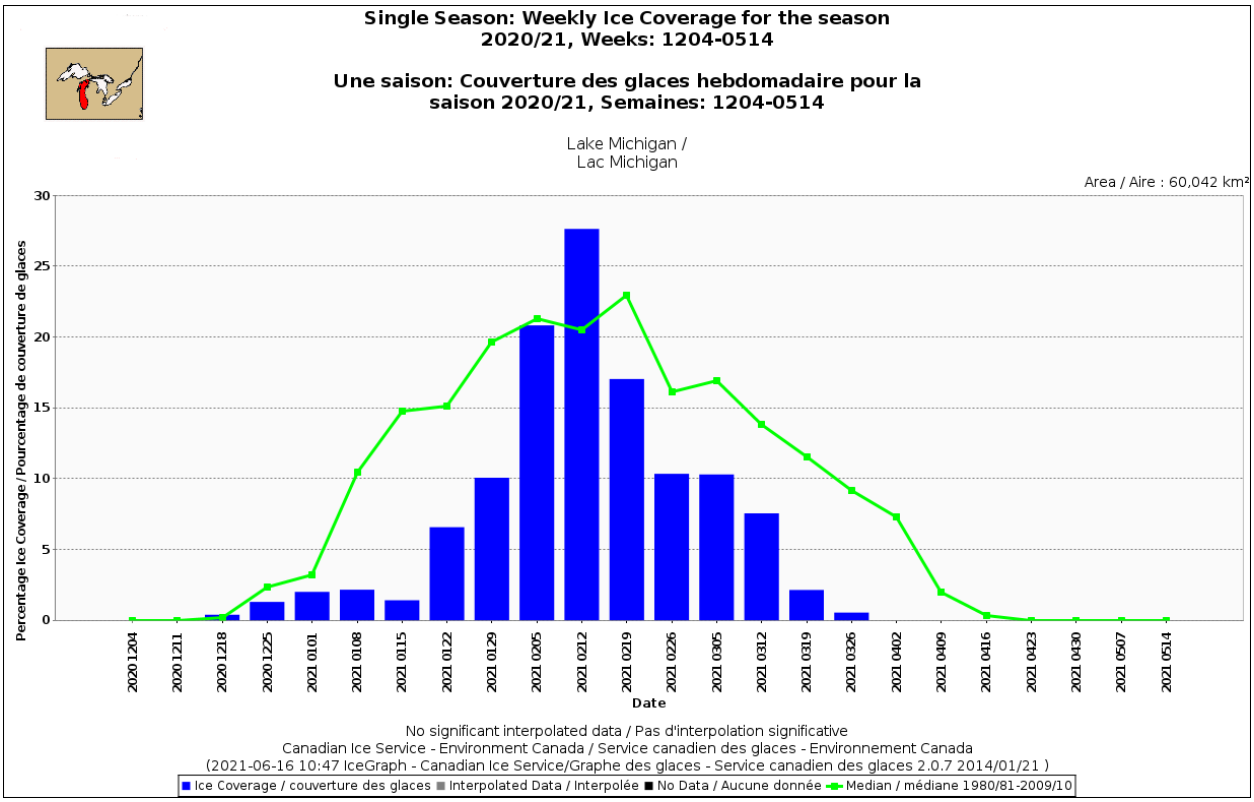

Figure 11: Weekly Ice Coverage in Lake Michigan for winter 2020-21

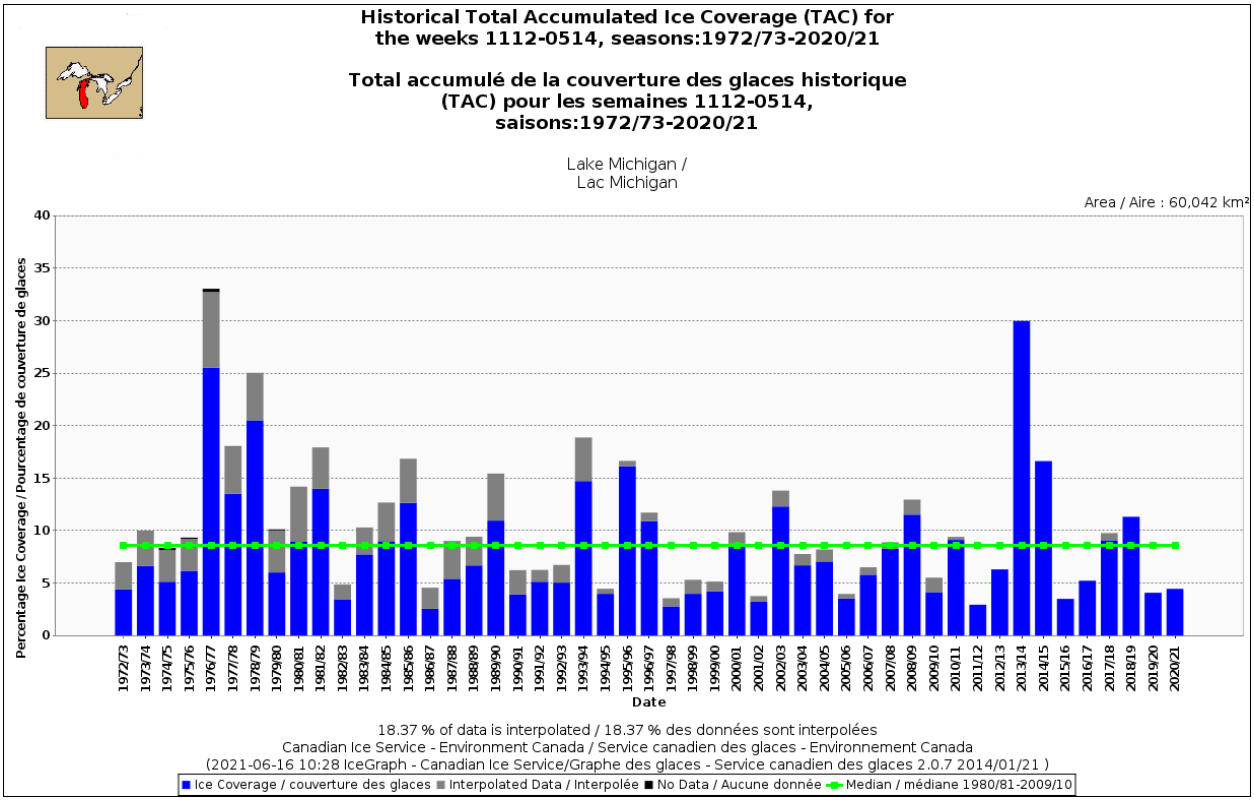

Figure 12: Historical Accumulated Ice Coverage in Lake Michigan by season, 1972-2021

Lake Huron

2020-2021 Season Temperatures:

Lake Huron began the season with near normal to slightly above average air temperatures that began in the second half of November and lasted right through to the end of December.

In the first two weeks of January, above average air temperatures settled over Lake Huron. Average air temperature anomalies were 2-4 degrees Celsius above normal for the central and southern portions of the lake, while the North Channel and the St. Mary's River had temperatures of 4-5 degrees Celsius above normal. This warm spell caused the ice to melt slightly in mid-January.

Following the warm first half of January, temperatures return to near normal for the second half of the month and the first few days of February, promoting a resumption of ice growth.

From the end of the first week of February to the end of the third week, Lake Huron experienced a cold air outbreak that lead to average air temperatures of 4-6 degrees Celsius below normal for most of the lake. The exception being parts of the North Channel and the St. Mary's River where the temperature anomaly was slightly less. These cold temperatures allowed the ice to grow significantly.

Starting in the last week of February, the below normal temperatures ended and were replaced with a warmer air regime where temperatures were 2-3 degrees Celsius above normal. The above average temperatures lasted until mid-March, generating a rapid decline in ice coverage.

Through the end of March and into April, the average air temperatures were about 1-2 degrees Celsius above normal except for parts of northern Georgian Bay and the western portions of the North Channel where average air temperatures were closer to 2-3 degrees Celsius above normal. The above normal average air temperatures coupled with average temperatures being above zero degrees Celsius lead to the end of the ice season on Lake Huron in early April.

2020-2021 Ice Conditions:

The ice season on Lake Huron started three weeks early compared to the long-term median, with the first ice forming in the St. Mary's River on November 26th. However, the ice was transient and melted during the warmer days in the late fall. It wasn't until the second week in December that the ice became more established and started to appear in parts of the North Channel and in some sheltered bays near the Straits of Mackinac.

Ice coverage grew nearly in line with climatology for the first few weeks of the season as new and thin lake ice filled many of the bays in the North Channel and Georgian Bay and began to fill Saginaw Bay. However, the trends quickly diverged by the end of December and early-January. At the beginning of January, Lake Huron remained near 5% ice covered compared to the long-term median of 8.7%.

Ice coverage did increase slightly in the second week of January, reaching 6.7%. However, due to the above average air temperatures, especially in the northern extremes of the lake, ice coverage shrank in the third week, receding to just 4.3%, well below the median of 23.8%. Much of the new and thin mobile lake ice melted leaving mainly fast thin lake ice in many of the bays in the northeastern section.

Following the reduction in ice coverage, average air temperatures returned to near normal values and ice began to grow once again, almost quadrupling the ice coverage to 16.5%. The St. Mary's River, Saginaw Bay and along most of the shore of the North Channel and Georgian Bay filed with new and thin lake ice once again and a large amount of the land fast ice thickened to medium lake ice. By the end of January, both the eastern and western sections of the North Channel and St. Mary's River were fast ice; the middle of the North Channel, northern Georgian Bay and Saginaw Bay held large amounts of lake ice and mobile ice lined much of the shore of the lake. Ice coverage had risen to 19.6%, but this was still well below the median of 36%.

Ice coverage over Lake Huron once again increased significantly due to well below normal average air temperatures through early and mid-February. The ice extent nearly doubled from the first week in February at 24.1%, to the second at 43.8%. It also represented the peak ice coverage on Lake Huron for the 2020-2021 ice season; one week earlier than the long-term median. The cold air outbreak resulted in the North Channel and Saginaw Bay filling

fully and then fasting with thin and medium lake ice, while high concentrations of lake ice lined the shores of Lake Huron and occupied a large portion of Georgian Bay. During this cold spell, some of the fast ice transitioned from medium to thick lake ice.

The temperature regime flipped at the end of February as above normal average air temperatures returned to the lake. A sharp decrease in ice coverage was the result of these warm temperatures coupled with a series of low-pressure systems. The ice coverage dropped to just 17% two weeks after the peak. Much of the mobile ice melted once again leaving mainly medium and thick fast ice through the St. Mary's River, North Channel, Straits of Mackinac, Saginaw Bay and the northeastern shore of Georgian Bay. The only mobile ice spared was the high concentration of medium lake ice along the shore between Sarnia and Goderich and some ice that remained along the northern shore in Georgian Bay.

Ice coverage did briefly rebound in the first week of March, bouncing back up to 25.4% during a brief cold spell. Following the uptick in ice extent, the ice coverage fell once again down to 15.4% as the fast ice in Saginaw Bay and the middle of the North Channel broke up an began to melt, prompted by the above normal air temperatures rising above zero degrees Celsius. Ice coverage continued to deteriorate through March, with the last ice melting from Saginaw Bay by March 21st, two weeks earlier than climatology. By the end of March, most of the fast ice in the St. Mary's River and the North Channel had fractured, leaving mainly mobile ice in these areas as well as some thick fast ice along the northern shore of Georgian Bay. Ice coverage had fallen to just 5.2%, just one quarter of the median ice coverage of 26.1%.

As the average air temperatures continued to warm in early-April, the fast ice in the northern extremes of the lake accelerated its break-up and melt. The last of the ice in Lake Huron melted by April 11th, 3 weeks earlier than the climatological median.

The TAC (Total Accumulated ice Coverage) for the 2020-2021 season for Lake Huron was 7.9%. This is well below the long-term median TAC of 18.3%. A TAC of 7.9% puts the season as the 5th lowest since the 1972/73 season and was very similar to the TAC from the previous season.

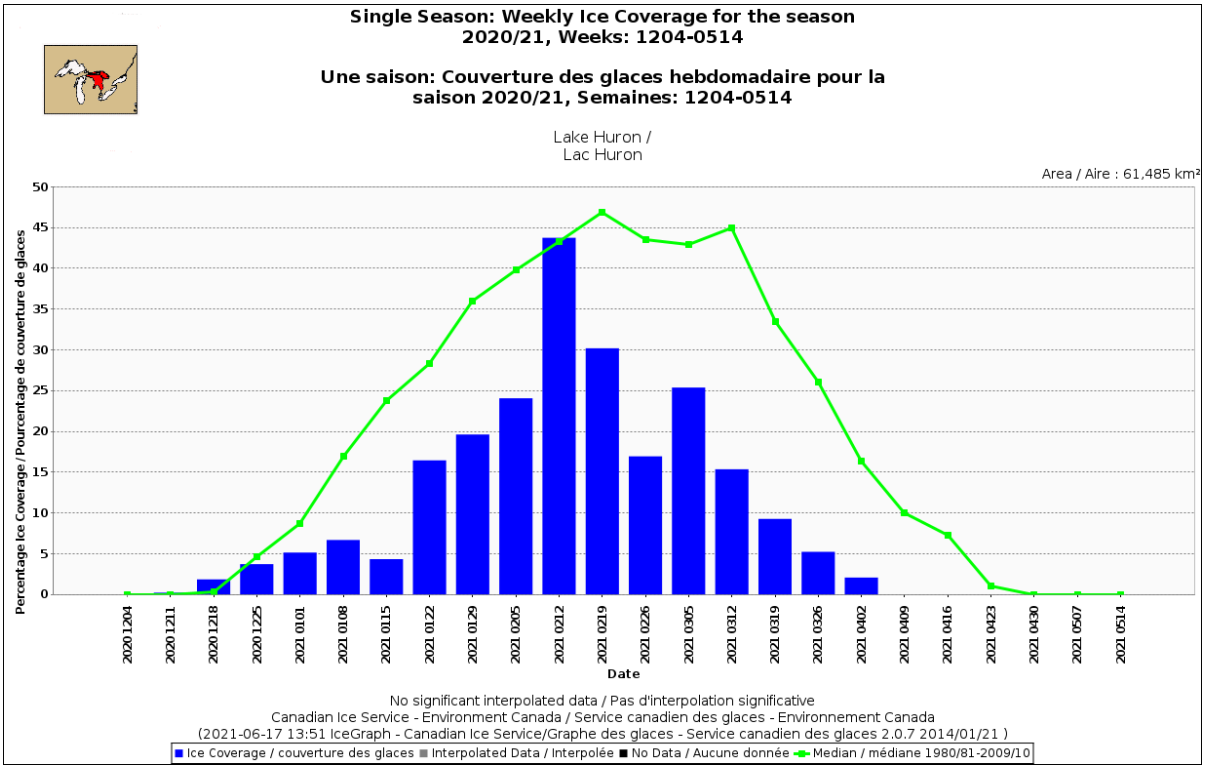

Figure 13: Weekly Ice Coverage in Lake Huron for winter 2020-21

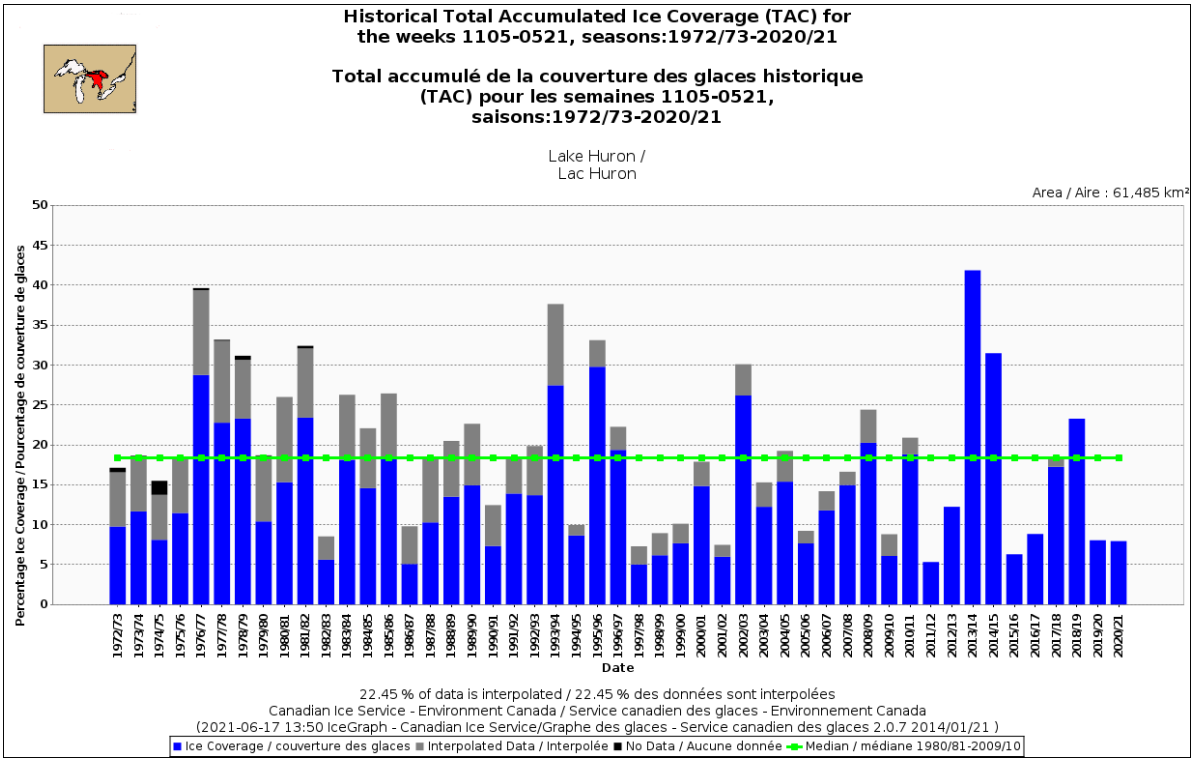

Figure 14: Historical Accumulated Ice Coverage in Lake Huron by season, 1972-2021

Lake Erie

2020-2021 Season Temperatures:

Average air temperatures over Lake Erie started the Great Lakes ice season about 1-2 degrees Celsius above normal in the second half of November. The temperatures continued to remain near to slightly above normal through the month of December. The occasional cold night did allow some transient ice to form in sheltered bays on the lake for the first time in mid-December.

The mild temperatures continued through the first half of January with the mean temperature anomaly of 1-2 degrees Celsius above normal. These warm temperatures caused ice concentrations to reduce around the lake due to average daily temperatures generally at or above freezing during this time frame. In the second half of January and early-February, near normal average air temperatures returned to the lake, meaning that average air temperatures returned to below freezing, allowing ice growth to resume once again.

Towards the end of the first week in February, a cold air outbreak settled over the region. This produced average air temperatures of 4-6 degrees Celsius below normal for central and eastern Lake Erie, while the western basin recorded temperatures closer to 6-7 degrees Celsius below normal. These well below normal temperatures resulted in significant ice formation.

By the end of February, the below normal temperatures were replaced with above normal temperatures with average air temperatures registering near 2-3 degrees Celsius above normal. This temperature regime lasted into late-March, which is generally when daily average air temperatures rise above zero degrees Celsius for the region. These above average air temperatures led to the rapid decline in ice coverage and the end of the ice season.

2020-2021 Ice Conditions:

The first ice of the Lake Erie and Lake St. Clair ice season was recorded on December 19th, which is generally in line with climatology. This ice was only temporary as it only lasted two days before melting. The new lake ice ebbed and flowed in the second half of December as temperatures bounce above

and below the freezing point. At the end of December, ice coverage was near 1%, which generally matched the climatological mean ice coverage for that time of year.

Average air temperatures continued to fluctuate around the freezing point through the first two and half weeks of January. Ice coverage remained below 1% during this time, diverging from the climatological trend. At the end of the above average temperatures, ice coverage was recorded at 0%, where typically the ice coverage should be near 24%.

Once average air temperatures returned to near normal in the second half of January, ice coverage quickly increased, jumping to 10.8% in the fourth week as new and thin lake ice filled Lake St. Clair as well as the western basin of Lake Erie and formed along parts of the shore elsewhere in the lake. At the end of January, ice coverage increased once again to 14.2%, however, this was still far below the long-term median of 58.8%.

As below normal average air temperatures settled over the lake in early and mid-February, Lake Erie and Lake St. Clair experienced a period of significant ice growth. In the first week in February, ice coverage jumped to 50% when thin lake ice completely filled Lake St. Clair, the western basin and lined much of the shore in the rest of Lake Erie. The third week followed with another rise to 83.2% ice covered in the second week of February. This cold air outbreak gave rise to the peak in ice coverage in the second week, which did coincide with the climatological peak, however, the climatological peak is slightly higher at 87.3%. At the peak, Lake St. Clair was fast with thin and medium lake ice, the western basin was full of medium lake ice, the southern half of which was fast, and the rest of Lake Erie was mostly filled with mobile thin and medium lake ice.

In the fourth week of February, as average air temperature warmed, aided by warm southwesterly winds due to a series of low-pressure systems, the ice in Lake Erie began to melt. By the end of the month, ice coverage dropped by more than half, down to 37.4%. Large amounts of mobile ice melted throughout the lake and the fast ice in the western basin and Lake St. Clair fractured.

Ice coverage remained nearly the same in the first week in March as cold northerly winds briefly dominated the area leading to a large amount of new lake ice to form in the middle of Lake Erie. This new lake ice did not last long

as temperatures warmed quickly. In the second week of March, ice conditions were reduced to just 1% ice covered compared to the median of 54.2% covered. This large reduction was due to a brief 5 day stretch of well above normal average air temperatures with daily highs reaching into the high teens and low twenties in many areas around the lake.

The third week in March saw coverage drop to less than 1%, as the last of the ice melted in Lake St. Clair, leaving a few strips and patches of medium lake ice as well as a significant concentration of medium lake ice remained near Buffalo. As temperatures continued to warm in March and daily highs frequently above 10 degrees Celsius, the last of the ice on Lake Erie melted out on the 28th of March, a whole month earlier than climatological normal.

The TAC for the 2020-2021 season for Lake Erie was 11.8%. This is well below the long-term median TAC of 25%. A TAC of 11.8% puts the season as the 10th lowest TAC since the 1972/73 season.

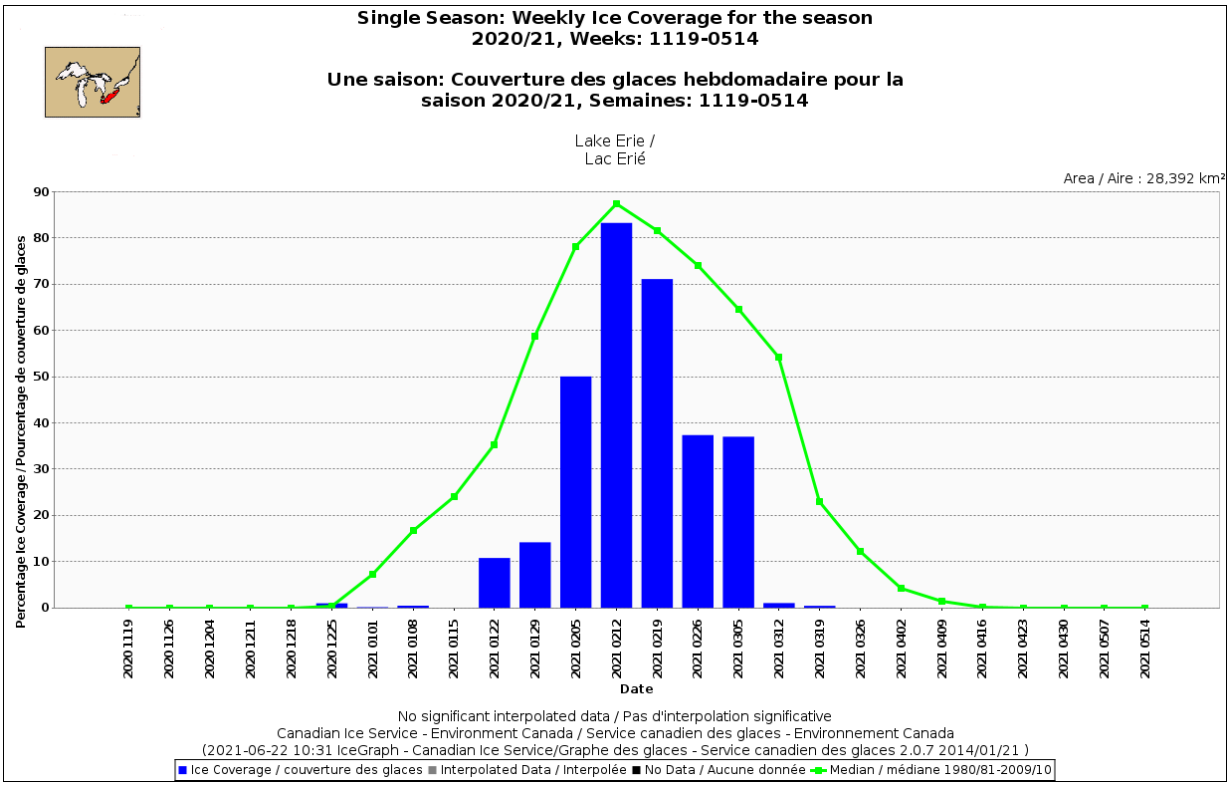

Figure 15: Weekly Ice Coverage in Lake Erie for winter 2020-21

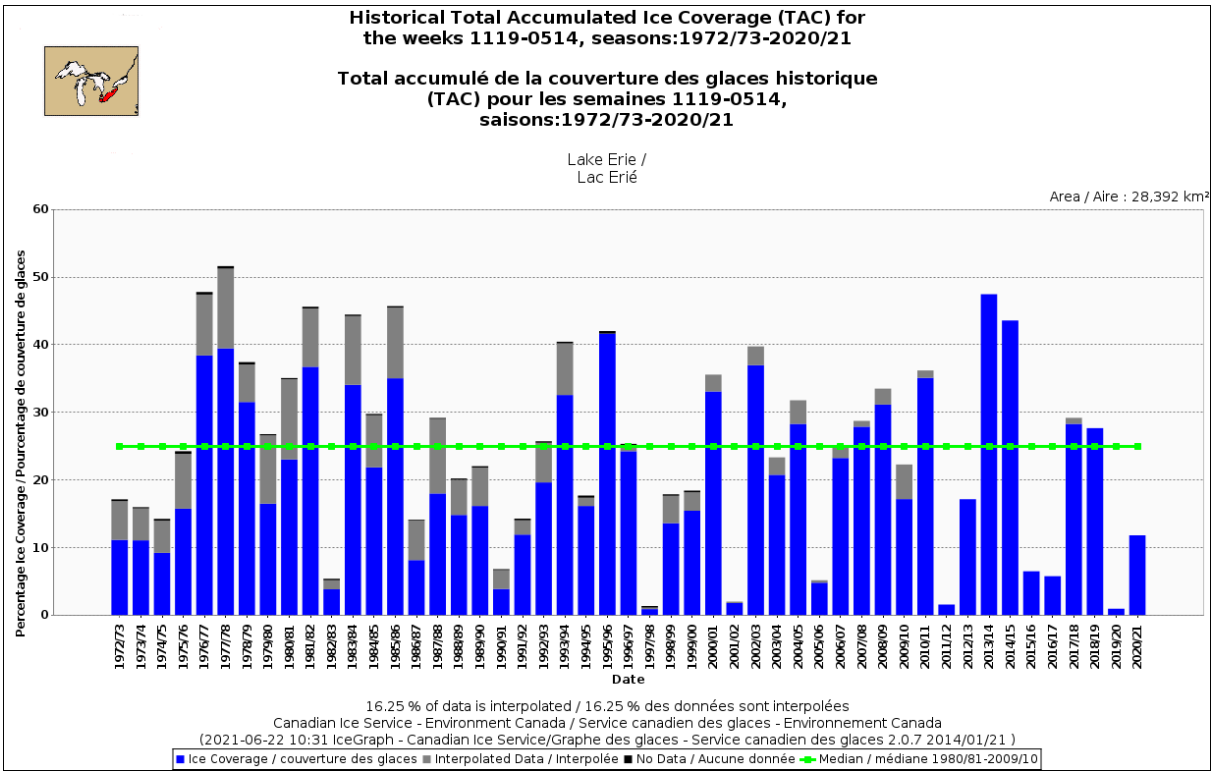

Figure 16: Historical Accumulated Ice Coverage in Lake Erie by season, 1972-2021

Lake Ontario

2020-2021 Season Temperatures:

Lake Ontario experienced near to slightly above normal average air temperatures from the second half of November until the end of December. Mean air temperatures generally hovered around 0.5-1.5 degrees Celsius above normal with occasional brief periods of colder temperatures. It was during one of these brief cold spells that ice first formed in mid-December in the Bay of Quinte.

In early January, above normal average air temperatures settled over Lake Ontario with temperatures of 2-3 degrees Celsius above average, preventing the ice from growing any further than it did in mid-December. In the second half of January and the first few days of February, average air temperatures returned to near normal.

Following the near normal average air temperatures and the slight ice growth that came with it, below normal temperatures moved into the region towards the end of the first week in February. Average air temperatures were near

3-5 degrees Celsius below normal across the lake, with the strongest anomaly occurring in the western section of the lake. This cold air outbreak allowed ice coverage to grow rapidly through early and mid-February.

The below normal temperatures were flushed out of the area near the end of February and replaced with above normal temperatures between 3-4 degrees Celsius above normal as a few low pressure systems swung through the region, bringing warm air with them.

The week of above normal temperatures quickly flipped to below normal temperatures for the first week of March, with anomalies dipped to 2-3 degrees below normal. This cold spell was also short lived as temperatures warmed to 2-3 degrees Celsius above normal by the second week in March, a typical late-winter/early-spring trend.

These 2-3 degrees Celsius above normal temperatures carried through to the end of April and lead to an early end of the Lake Ontario ice season.

2020-2021 Ice Conditions:

The ice season on Lake Ontario began during a brief cold spell during what was a period of generally above normal temperatures, with the first ice forming on the lake on December 16th in the Bay of Quinte and a few small bays in the eastern extremes of the lake. This ice formation came one week earlier than the climatological median. Ice grew slightly through the rest of December to fill the Bay of Quinte and a few of the bays in eastern Lake Ontario. Ice coverage in December remained essentially the same from when ice first form, resting near 1.4%.

In the beginning of January, ice coverage did not progress due to above normal average air temperatures. Ice coverage remained near 1.5-2% through the first three weeks of January. In contrast, ice coverage normally sees its largest growth during this very same period, with the ice extent usually growing to 9.7% by the end of the third week. Early-January did see the first ice formation in the St. Lawrence River, however, this ice formed and melted as the air temperatures bounced between above and below the freezing point.

It wasn't until the end of January that ice coverage on Lake Ontario saw its first significant increase when it jumped to 5.2%, still less than half of the long term median of 10.7%. In the last week of January, the thin lake ice in the

Bay of Quinte became fast. New and thin lake ice also formed along the southern shore of the lake stretching from the Welland Canal to the St. Lawrence River.

February saw increase ice growth as below normal temperatures affected the region. In the first week in February, ice coverage increased to 9.5% and as the cold temperatures persisted, this was follow by a large increase to 20.8% in the second week. The ice extent in the second week of February was recorded as the peak ice coverage for the season, occurring one week earlier than the climatological peak. The peak surpassed both the median ice coverage for that week, 12.8%, and the climatological peak of 15.1%. The cold temperatures in early and mid-February resulted in much of the fast ice around the lake to thicken to medium lake ice and filled most of the northeastern section of the lake and the St. Lawrence River with thin and medium lake ice. Lesser concentrations also remained along the southern shore of the lake.

Following the cold spell, an early spring-like low pressure system brought above normal and above freezing temperatures to the lake at the end of the third week of February, destroying and melting much of the mobile ice that had formed earlier in February. Ice coverage sharply dropped to 8.1% in the same week that coverage should have been peaking. The warm temperatures continued in the last week of the month and ice coverage dropped further to just 4.7%, less than half of the long-term median of 10.4%. This left only the medium and thick fast ice in the Bay of Quinte and in parts of the St. Lawrence River as well ice a thin band of mobile thin and medium lake ice packed into the northeastern section of the lake.

The turbulent weather continued in the first week of March with the return of below normal temperatures and an associated increase in ice coverage. For the second time this season, ice coverage exceeded the long term median, jumping to 13%, compared to the median at just 9.5%. This increase came from the formation of new lake ice in the northeastern end of the lake and along parts of the southern shore. During this cold spell, the fast ice in the Bay of Quinte thickened to be completely thick lake ice.

The springtime ice melt resumed in the second week of March; the above normal air temperatures meant that the daily highs were frequently above the freezing point. This lead to the melting of most of the mobile ice in the

northeastern extent of the lake along with the fracturing of some of the fast ice in the St. Lawrence River. Ice coverage dropped to just 2.9% in this time.

Ice break-up continued in the third week of March, seeing the fast ice in the Bay of Quinte fracture and a slight reduction in ice extent in the St. Lawrence River. Ice coverage dropped only slightly from the week before, reducing to 1.4%. In the fourth week, with daily high temperatures reaching above 10 degrees Celsius and the fast ice fractured, the ice season on Lake Ontario quickly came to an end. The last ice melted from the Bay of Quinte and the St. Lawrence River by March 27th, ending the ice season 3 weeks early.

TAC for the 2020-2021 season was 2.6%, well below the long term median TAC of 5.5%, and just above last seasons TAC of 1.8%. The TAC of 2.6% puts the season as the 11th lowest year since the 1972/73 season.

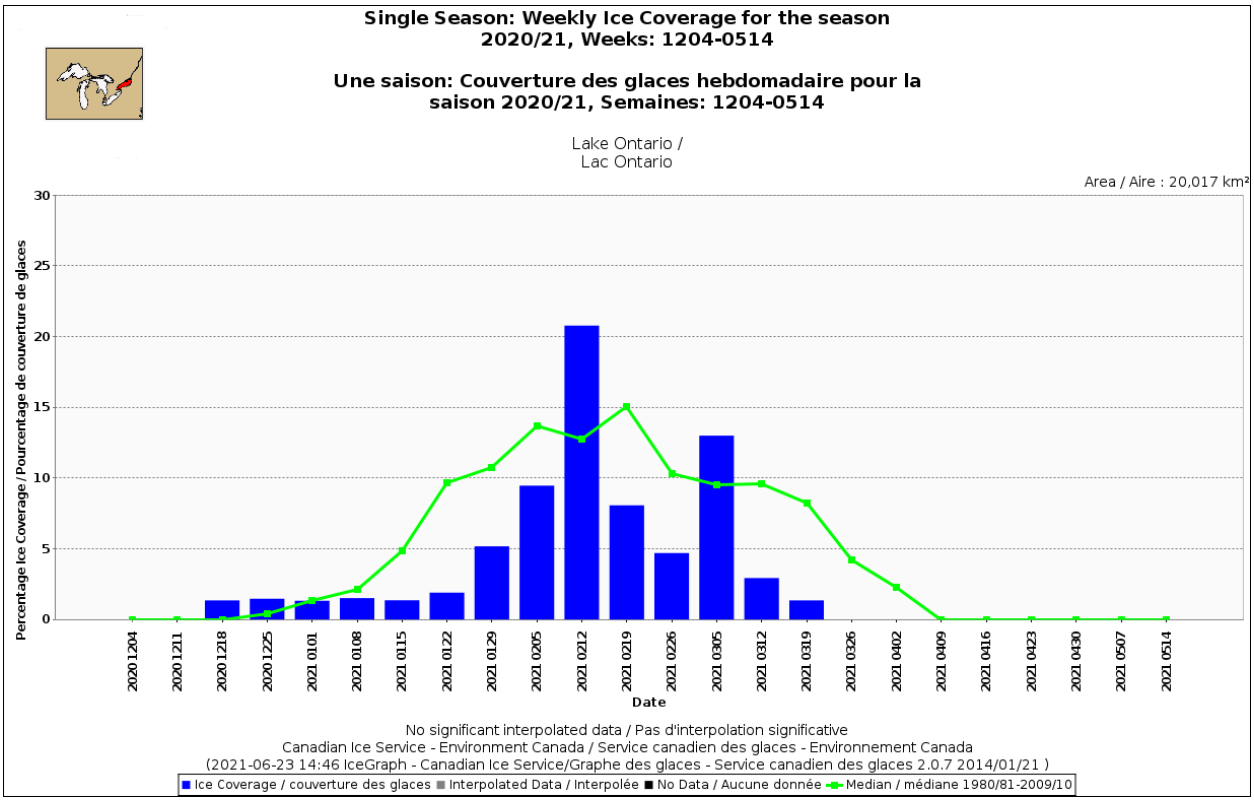

Figure 17: Weekly Ice Coverage in Lake Ontario for winter 2020-2021

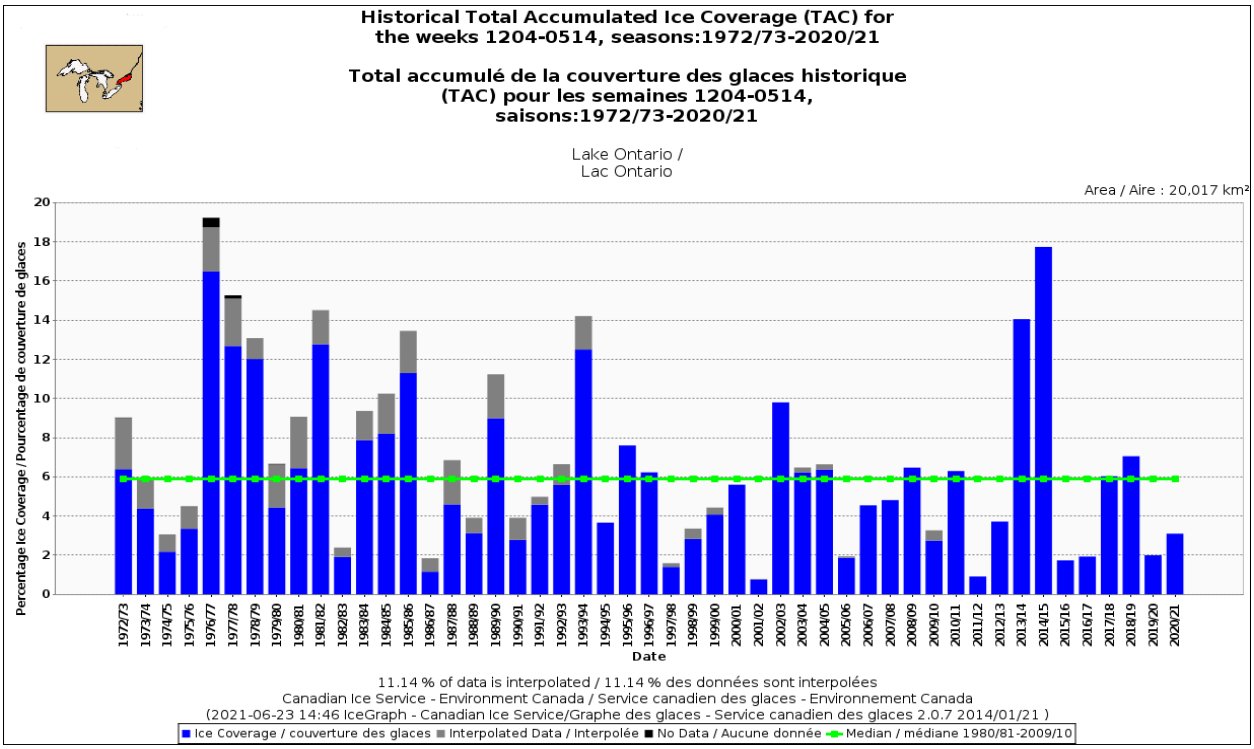

Figure 18: Historical Total Accumulate Ice Coverage in Lake Ontario by season, 1972-2021.