

Seasonal Summary

Great Lakes
Winter 2016-2017



By the North American Ice Service

Summary for the Great Lakes

An examination of the Great Lakes ice season for the 2016-2017 winter reveals a degree of intra-seasonal variability that is not evident by solely considering the overall ice coverage for the period. For this past winter, the total accumulated ice coverage (TAC) registered as the 6th lowest since 1972-1973 at 5.15%. At first glance one would be led to believe that this season was one of limited interest with respect to lake ice, but in fact due to significant climatic variability during the winter, noteworthy periods of ice expansion were observed. The timing of these events was of the utmost importance, as the ice development in these cold episodes was restricted to thinner ice types due to a lack of sustained cold air temperatures over the Great Lakes region.

A near normal start to the ice season was experienced in the basin, with new lake ice developing in mid-December 2016 over the northern bays of Lake Superior. Ice quickly developed in isolated and shallow sections of the Great Lakes including Green Bay, Whitefish Bay, Saginaw Bay, the Bay of Quinte and the Western Basin of Lake Erie. Early TAC values in December quickly exceeded the median values due to this prolific ice growth. Climatologically near-normal air temperatures continued into mid-January 2017 and sustained a near normal ice coverage with respect to the 30 year climatological median. Surface air temperature anomalies ranged from -1.0°C to +1.5°C across the Great Lakes for December to mid-January.

The second notable phase of the ice season became established during the second half of January. An anomalously warm period led to a significant reduction in ice coverage in late January and limited the TAC to less than 50% of the historical median values. A mid-season low TAC of 5.0% was reached in the final week of February 2017, well below the median of 34.16%. Anomalously warm surface air temperatures were observed from mid-January to the end of February and varied from +3.5°C to 7.0°C above normal.

Following this above normal warmth, ice thickness and extent was observed to be well below the median values for the Great Lakes. In early March 2017 a cold episode overtook the region and promoted a rebound in the lake ice. This growth phase led to nearly a four-fold increase in ice coverage by mid-March from the late February low previously observed. The March peak in TAC coincided with the expected climatological peak, with an observed value of 19.4%, but was still well below the median peak value of 39.81%. Analyzed ice thicknesses across the lakes were up to two

thickness categories below the expected predominant ice type at the peak of the season. During the first three weeks of March the surface air temperatures were noted to be up to 4.0°C below normal.

The onset of near normal to above normal temperatures starting in late March ushered in the end of the ice season for winter 2016-2017. Temperatures anomalies were up to 4.0°C over the Great Lakes from the final week of March and through April. Ice cover steadily diminished week over week, with the last remaining ice in Nipigon Bay melting in the final week of April. This conclusion of the ice season was approximately two weeks earlier than the climate normal for the basin, due in large part to the lack of ice cover and the limited thickness of the ice that developed during the season.

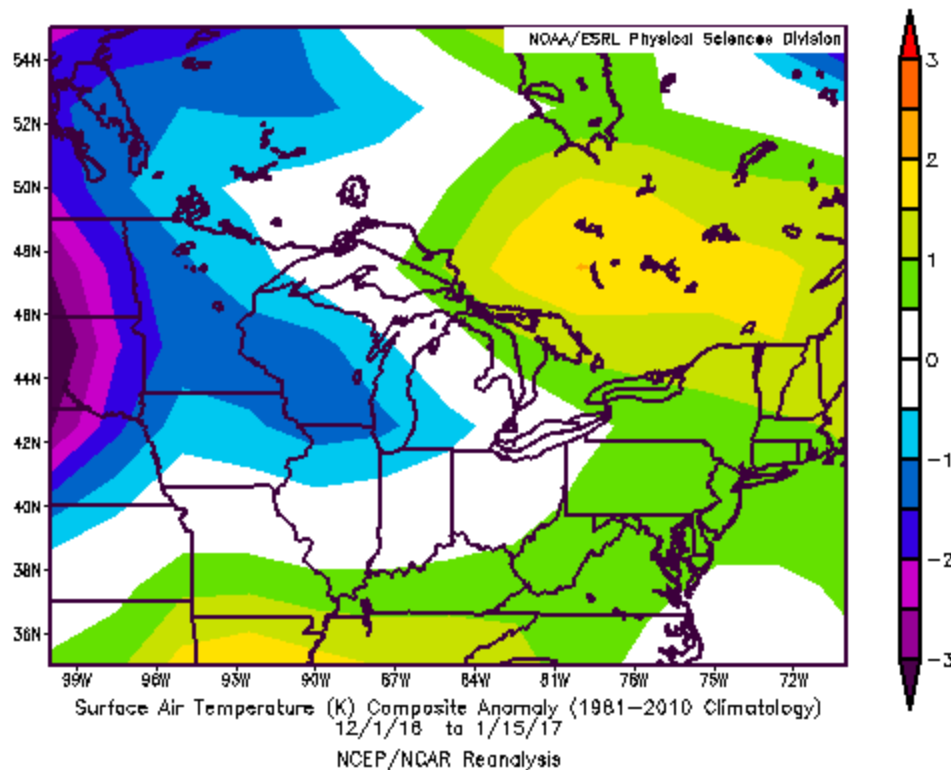


Figure 1: Surface Air Temperature Anomaly for the Great Lakes, 1 December to 15 January 2017.

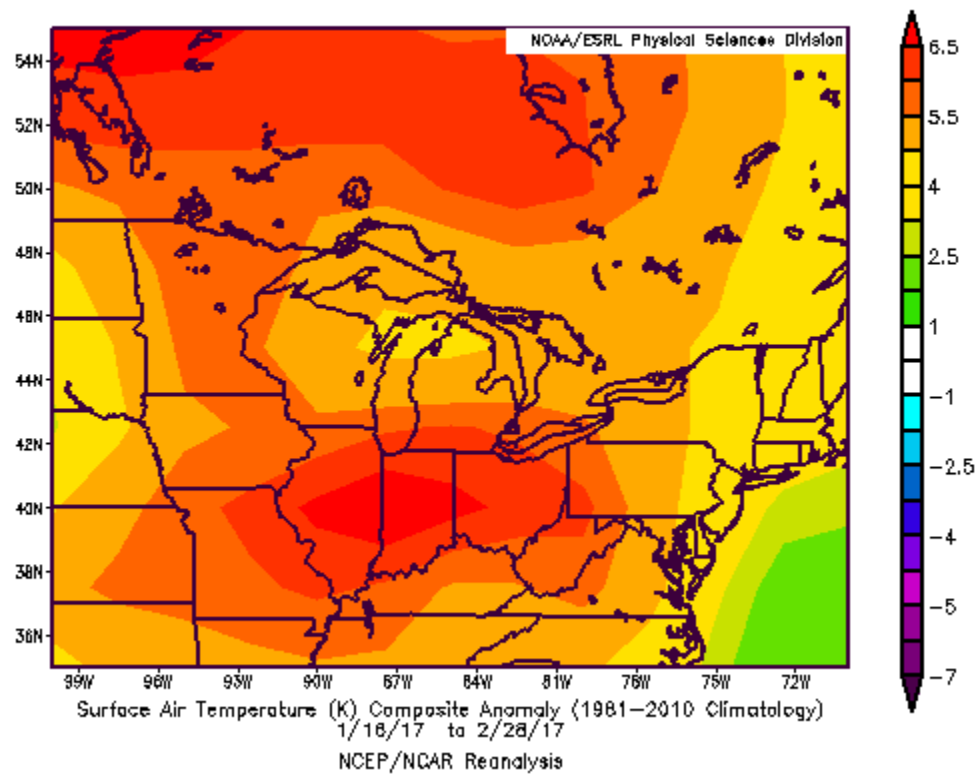


Figure 2: Surface Air Temperature Anomaly for the Great Lakes, 16 January to 28 February 2017.

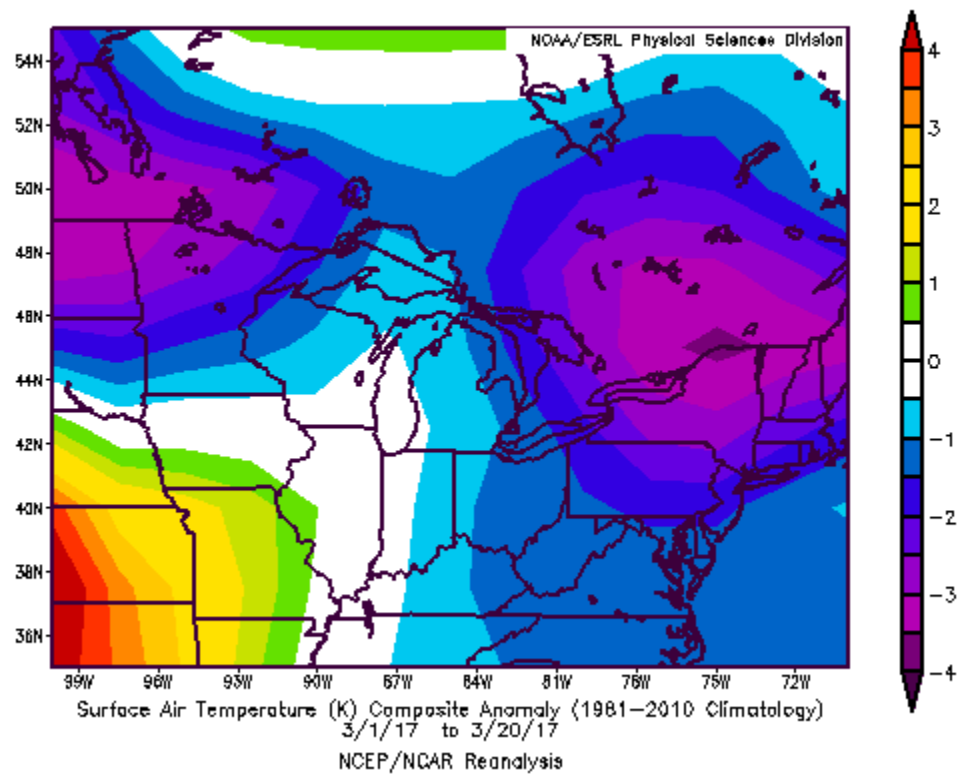


Figure 3: Surface Air Temperature Anomaly for the Great Lakes, 1 to 20 March 2017.

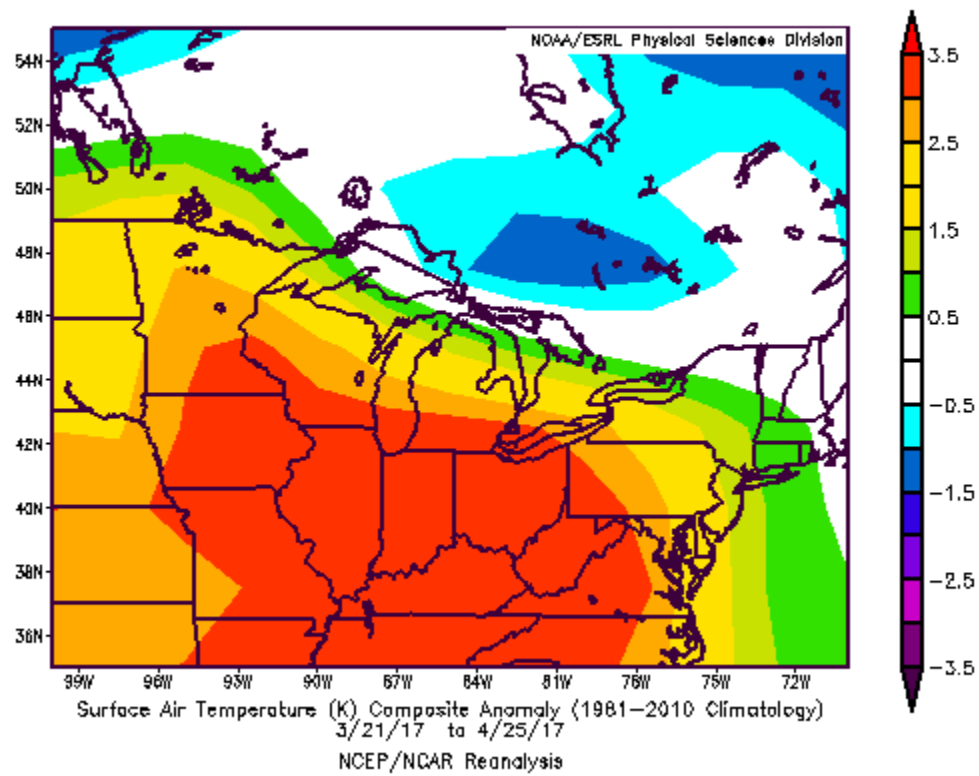


Figure 4: Surface Air Temperature Anomaly for the Great Lakes, 21 March to 25 April 2017.

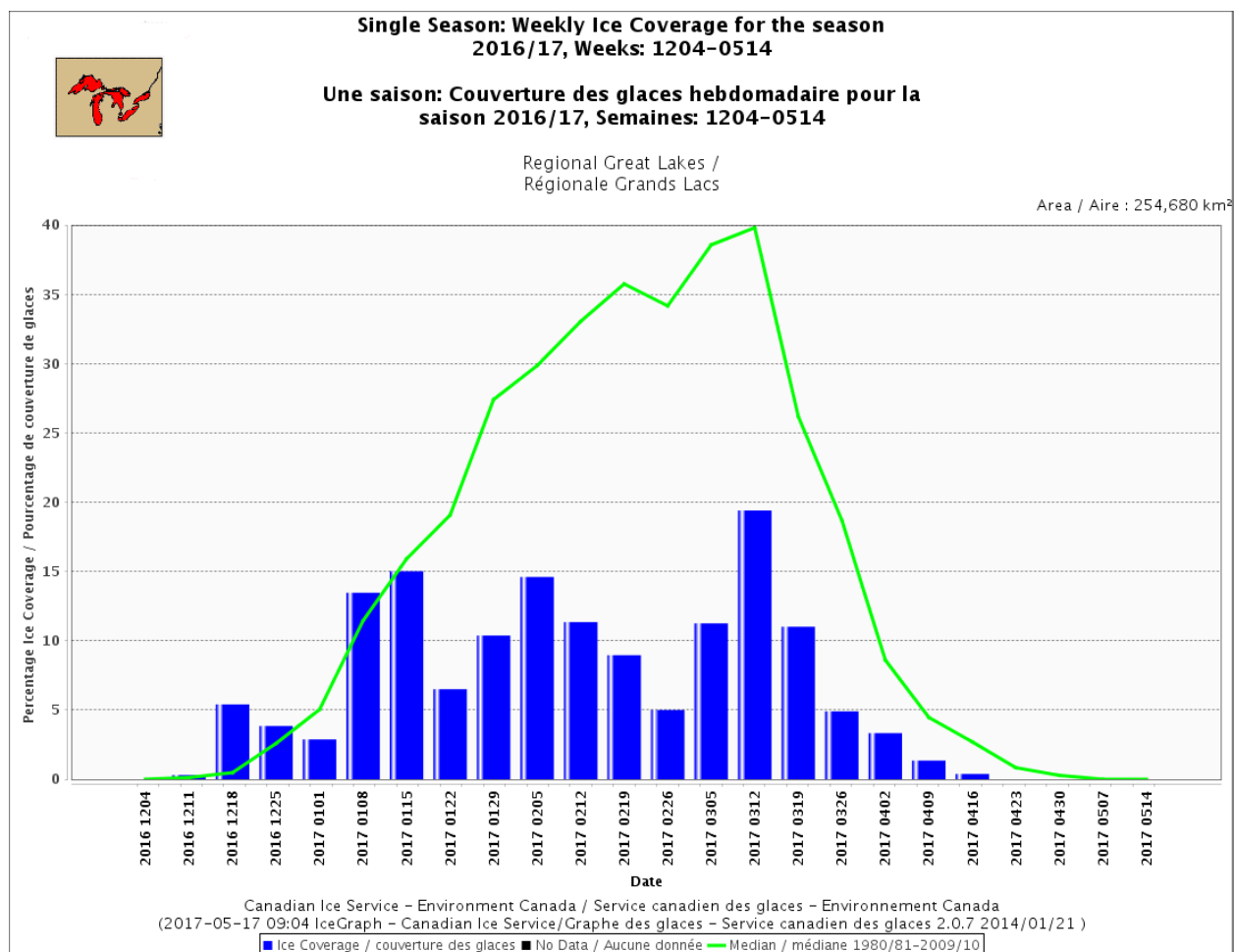


Figure 5: Weekly ice coverage for the Great Lakes, winter 2016-2017.

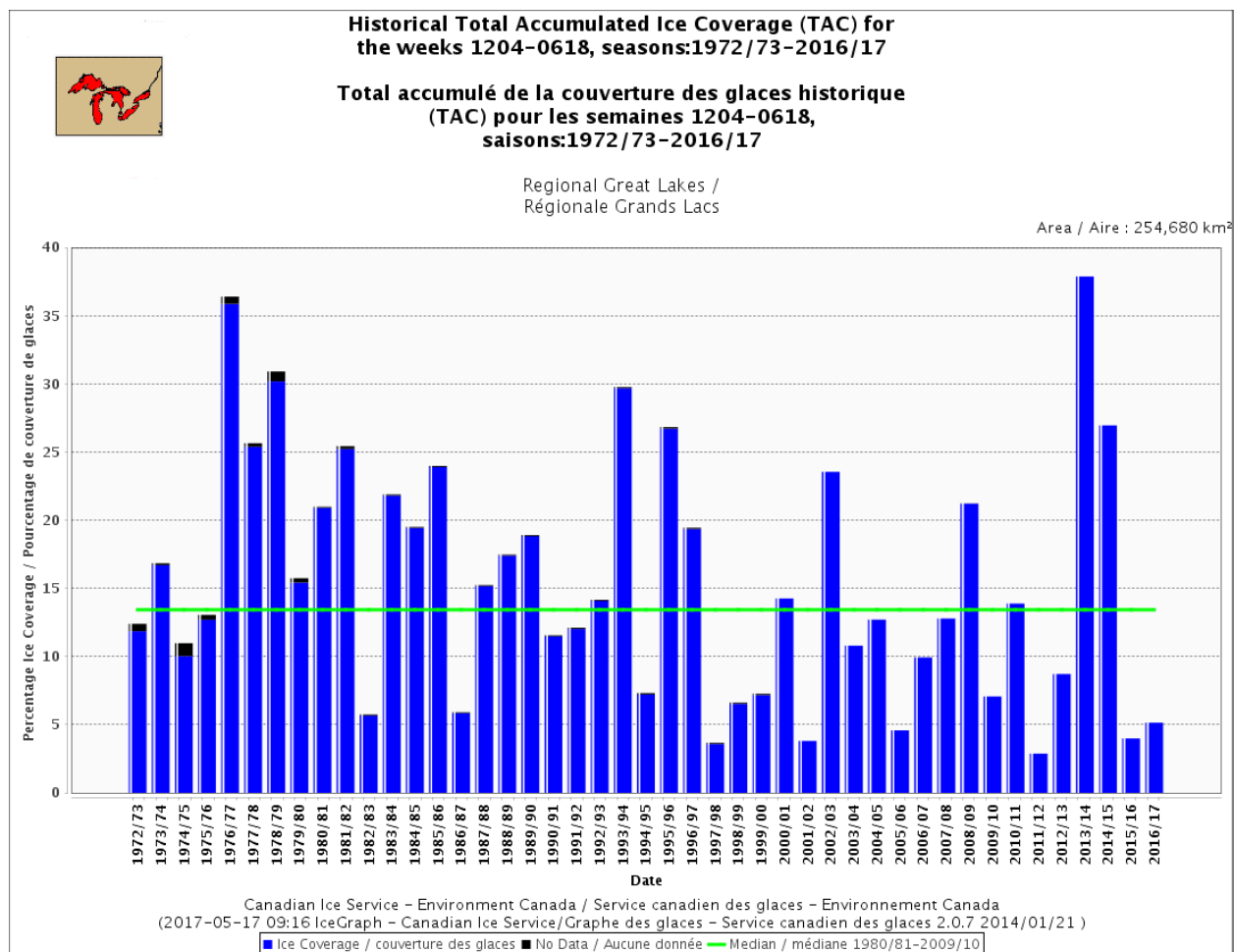


Figure 6: Historical Total Accumulated Ice Coverage on the Great Lakes, 1972-1973 to 2016-2017.

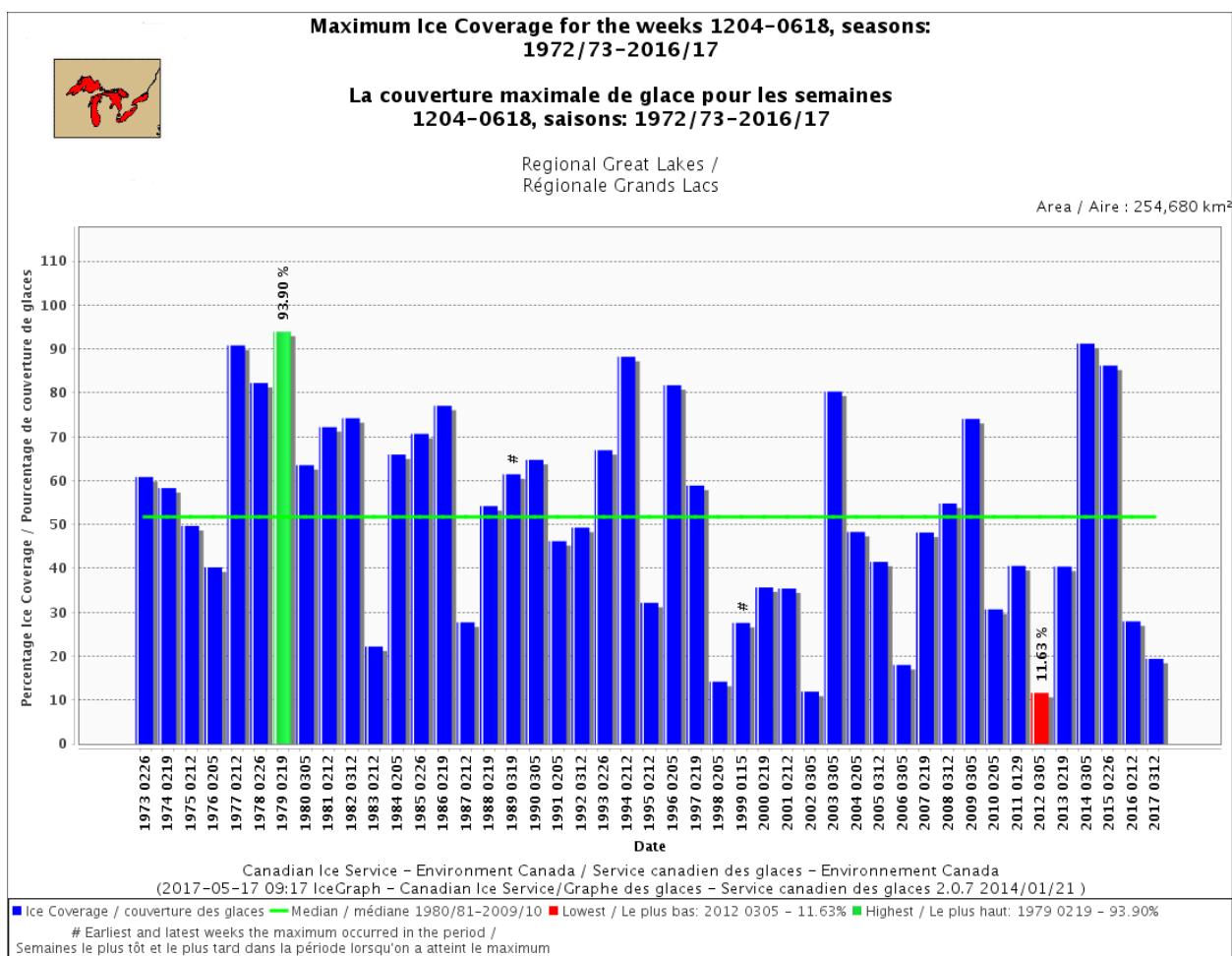


Figure 7: Maximum weekly ice coverage for the Great Lakes, 1973 to 2017.

Lake Superior

2016-2017 Season temperatures:

A near normal surface air temperature regime was established over Lake Superior at the beginning of the ice season, with temperatures within 1°C of the 1981-2010 climate mean. A pronounced warming spread across the lake beginning in mid-January with anomalies ranging from 3.0°C to 6.0°C above normal. This warm period persisted until early March when a cold phase overtook Lake Superior. Colder than normal temperatures were observed the first three weeks of March with a maximum anomaly value approaching -2°C over the extreme western section of the lake. After this cold episode, the anomaly pattern shifted such that the eastern portion of the lake remained near normal seasonal temperature values and the

western section was nearly 2.5°C above normal from late March through April 2017.

2016-2017 Ice conditions:

The first ice formed in Black and Nipigon bays shortly before mid-December. New lake ice development occurred in Thunder, Chequamegon, and Whitefish bays in the following days. Intermittently, new lake ice appeared along the southern shore of Lake Superior through December. Gradual thickening continued in the isolated bays of the lake, with ice becoming predominantly thin lake ice in Black, Nipigon and Chequamegon. In general, ice development was progressing at a near normal pace with respect to climatology.

Consolidated thin and medium lake ice was established in Chequamegon, Black and Nipigon bays in early January. Significant expansion was noted in the first week of the month, with ice appearing along the southern shore and in Thunder Bay. Quickly, this ice reached the thin lake ice stage by the second week of January. After mid-month, ice in Black, Nipigon and Chequamegon Bay became predominantly thick lake ice. But the growth phase of lake ice came to an abrupt halt in the third week of the month as anomalously warm temperatures encompassed the region. Widespread destruction of lake ice along the southern shores was observed and the remaining ice was limited to isolated bays and inlets. Also notable was the lack of extensive fast ice development in the Apostle Islands and Thunder Bay during January. Lake ice coverage for Lake Superior was now climatologically delayed approximately one week, with particularly notable absences of ice in Whitefish Bay and along the southern shore.

The pattern observed in the second half of January continued through February. Lake ice growth in early February was limited to the near shore environment for the southern section of the lake, and low concentrations of new and thin lake ice spread to cover Whitefish Bay. The departure from normal ice concentrations was now readily identifiable as lake ice coverage at the end of February was well below the median climatological conditions. Ice was confined to the presence of predominantly thick consolidated lake ice in Nipigon, Black and Chequamegon Bay, and modest amounts of new and thin lake ice in Whitefish and Thunder Bay. Climatologically the conditions observed were more reflective of those expected in early January, indicating a delay in ice formation of nearly two months.

The first three weeks of March 2017 commenced with a much colder temperature anomaly signature, leading to a rapid return of ice. Ice expansion along the southern shore and the eastern shore from Michipicoten Bay and southward peaked at mid-month, with thin and new lake ice composing the majority of this ice. This would mark the peak of the ice season for Lake Superior, with a TAC of 17.63%, falling well short of the historical median of 49.65% for this week. Following this peak, a quick decay of the existing ice commenced and by the end of March ice was again limited to the major bays of the lake.

Given the lack of ice lake ice growth during the winter, a quick breakup and clear out of the remaining ice proceeded in April. Open water conditions prevailed in Chequamegon Bay and Thunder Bay in the second week, and breakup of the fast ice in Black and Nipigon bays was underway. The fourth week of April saw the last ice clear from Whitefish Bay and the northern bays of Lake Superior to conclude the ice season.

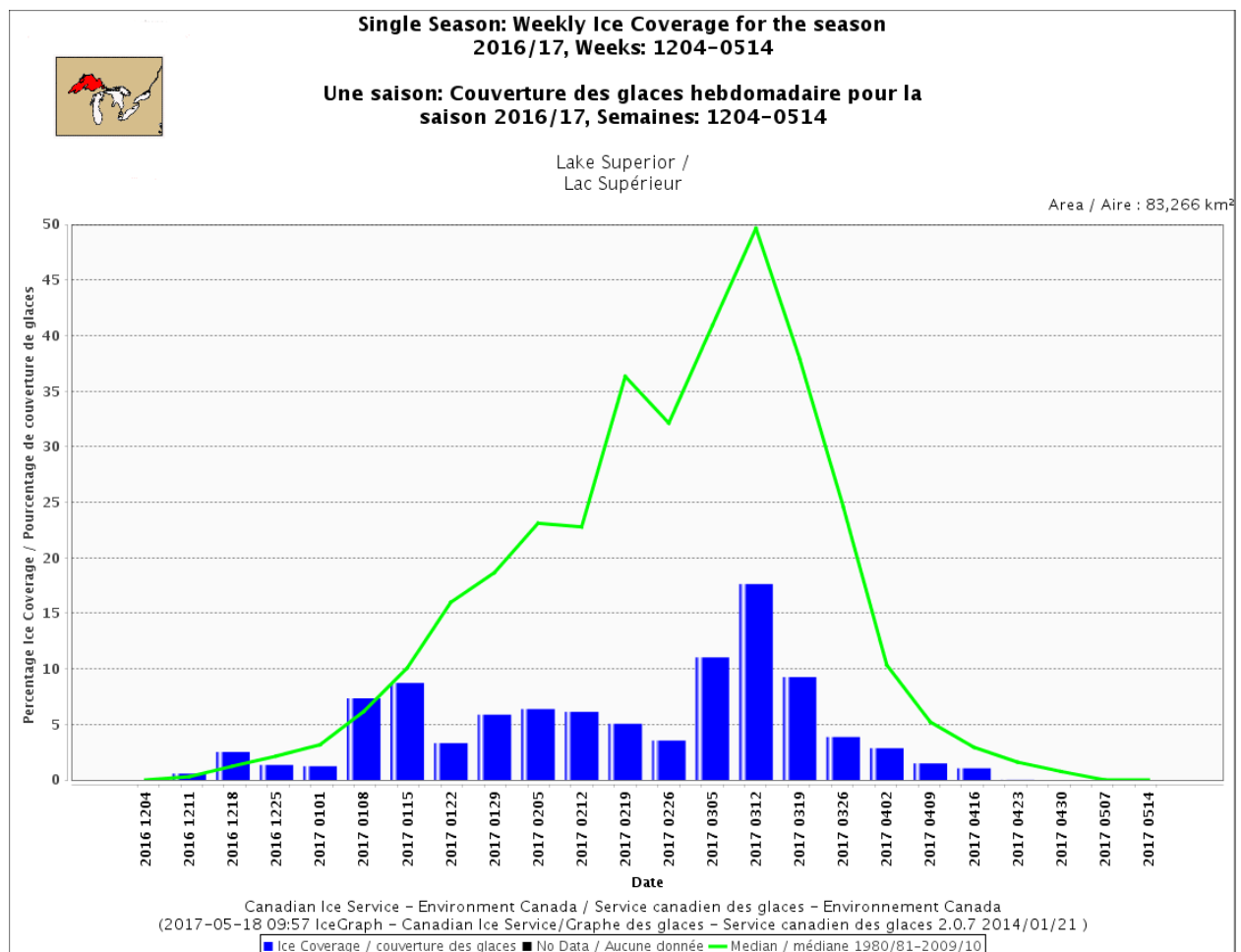


Figure 8: Weekly Ice Coverage in Lake Superior for winter 2016-17.

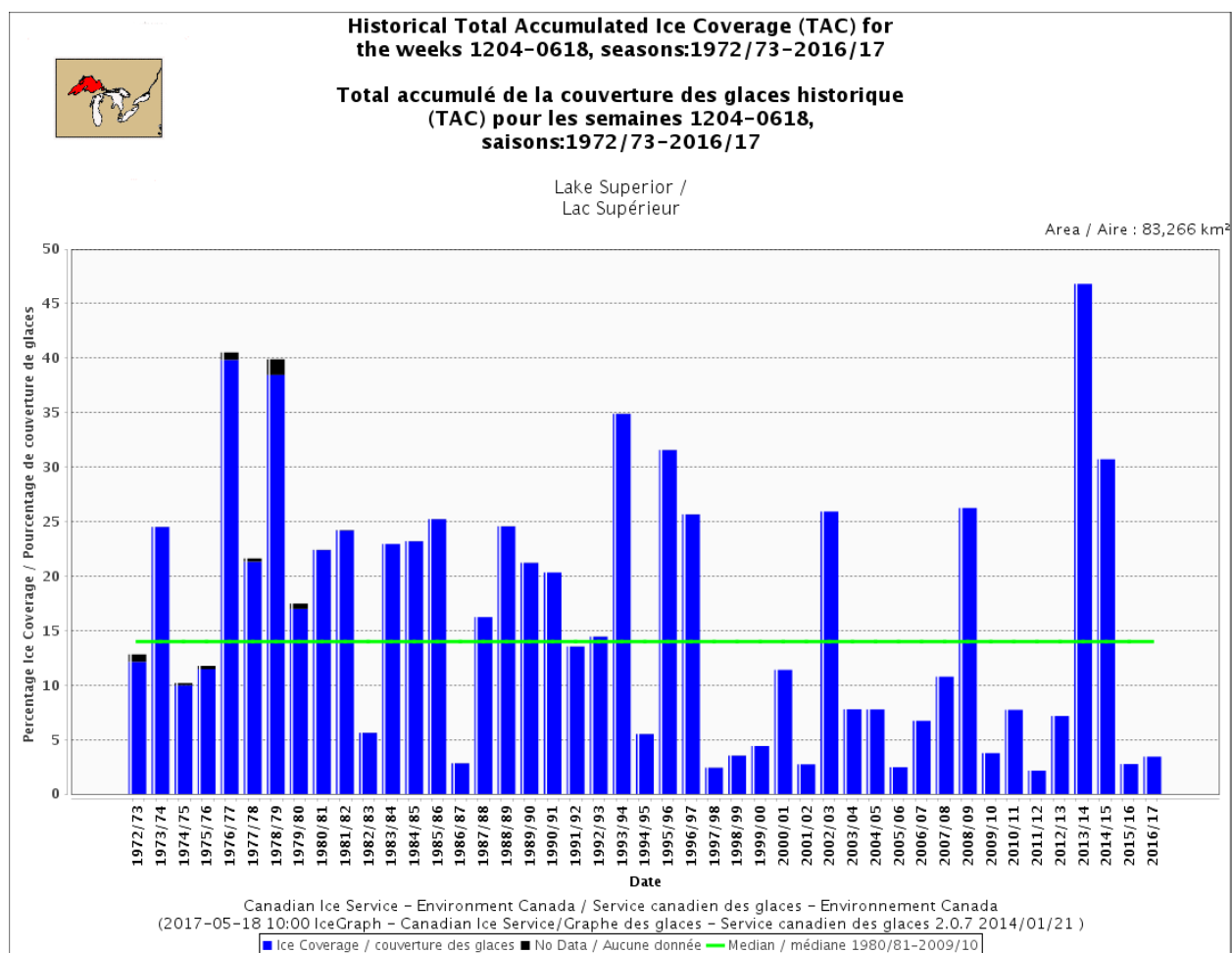


Figure 9: Historical Total Accumulated Ice Coverage in Lake Superior by season, 1972-2017.

Lake Michigan

2016-2017 Season temperatures:

The air temperature anomaly regime at the start of the season for Lake Michigan was notably different from the other Great Lakes in that the region experienced near normal to below normal temperatures into mid-January 2017. The negative anomaly was near -1°C over the southwestern section of the lake at its maximum. The reversal of this pattern manifested in mid-January and persisted through February, with a positive surface air temperature anomaly of up to 7°C at the southern extreme of Lake Michigan. The cooling trend observed over the Great Lakes during the first three weeks of March was less evident over Lake Michigan, as the air temperature was near normal during this period. The final identifiable phase during the spring break-up commenced in late March with warmer

than normal temperature values from 0.5°C to 4.0°C continuing through the majority of April.

2016-2017 Ice conditions:

A near normal start to the ice season for Lake Michigan saw the first new lake ice form in the second week of December in the extreme southern and northern sections of Green Bay. Episodic appearances of new lake ice were frequent along the northern shore of Lake Michigan as well in the second half of December from the entrance of Green Bay to the Straits of Mackinac.

The first significant expansion of ice in January 2017 happened in the first week of the month. New and thin lake ice developed across all of Green Bay, along the southern and western shores from Grand Haven, MI to the Door Peninsula, and northeast of Beaver Island to the Straits of Mackinac. Consolidated medium lake ice was established in the Bays de Noc and southern Green Bay near mid-month. The second half of January experienced a stagnation in ice growth and some destruction, particularly along the southern and western shores of the lake. Ice was predominantly at the medium stage over central Green Bay by month end, but overall conditions were nearly two weeks behind the climatological ice growth expected for the region.

The second half of January's abnormal warmth was continued through February and led to significant delays in ice development. The central portion of Green Bay west of the Door Peninsula and northeast Lake Michigan near the Straits of Mackinac remained unconsolidated throughout the month, whereas consolidation is usually exhibited in these areas according to the climatological median. Appreciable concentrations of thick lake ice were not detected in the mobile ice while thick lake ice would be the expected predominant thickness in late February in the aforementioned regions. Breakup of fast ice in southern Green Bay occurred by the end of the month as well, a full month ahead of the climate normal.

The overall colder than normal trend for the Great Lakes in the first three weeks of March was not as appreciable for Lake Michigan. New and thin lake ice returned to cover all of Green Bay, and the northeast portion of the lake southward to Grand Traverse Bay briefly near mid-March. This peak ice coverage period was well below the median peak of 22.98%, registering a TAC of only 16.47% and observed approximately a month after the climatological peak. The last week of March introduced a clearing

and breakup phase that reduced the remaining ice to southern and northern Green Bay and an area of low ice concentrations from Beaver Island to the Straits of Mackinac.

In the first week of April, fast ice in the Bays de Noc broke up and all remaining ice in Green Bay cleared. A small isolated area of ice in Little Traverse Bay remained until clearing in the second week. The timing of the spring melt constituted a climatologically early event by approximately one to two weeks across the basin.

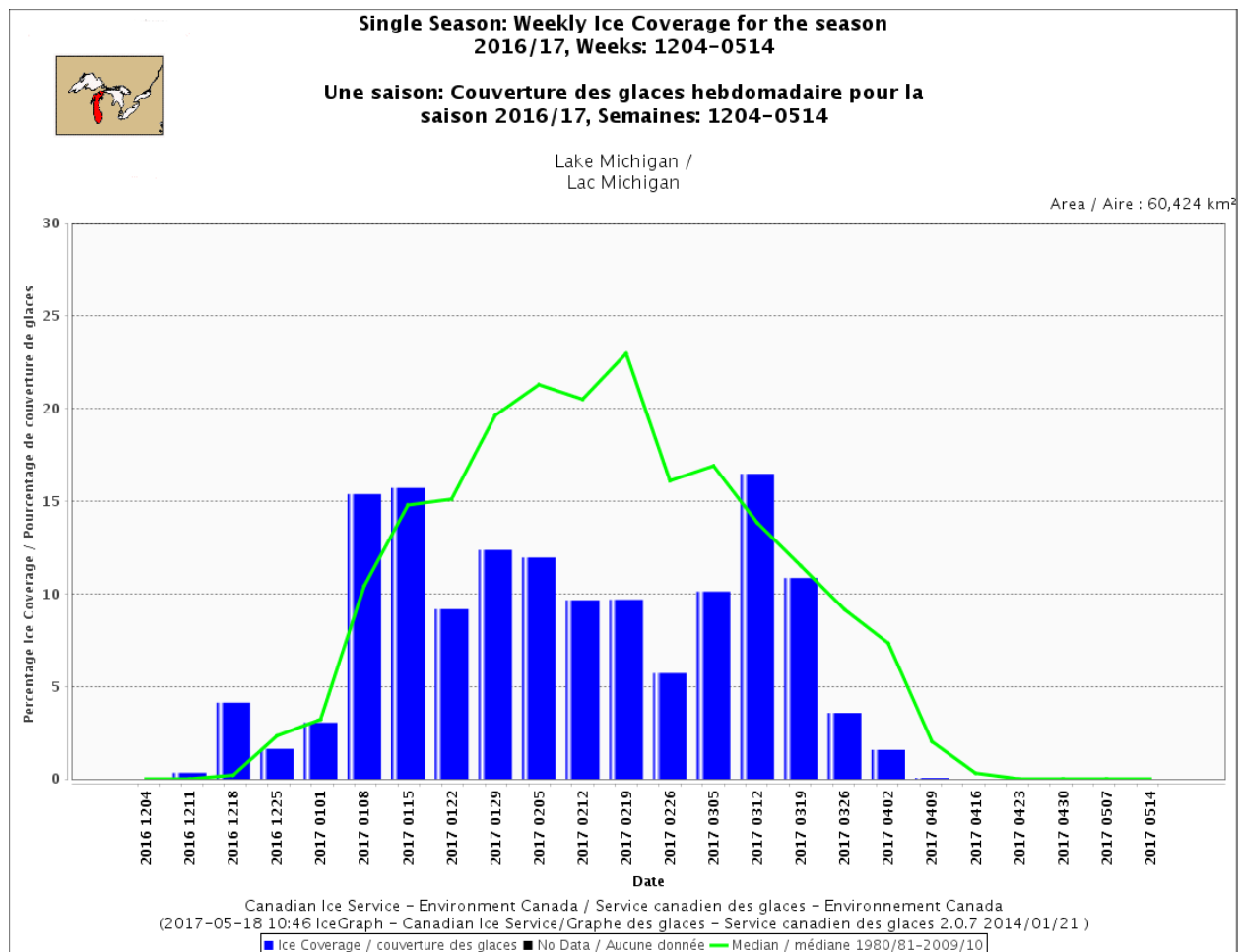


Figure 10: Weekly Ice Coverage in Lake Michigan for winter 2016-17.

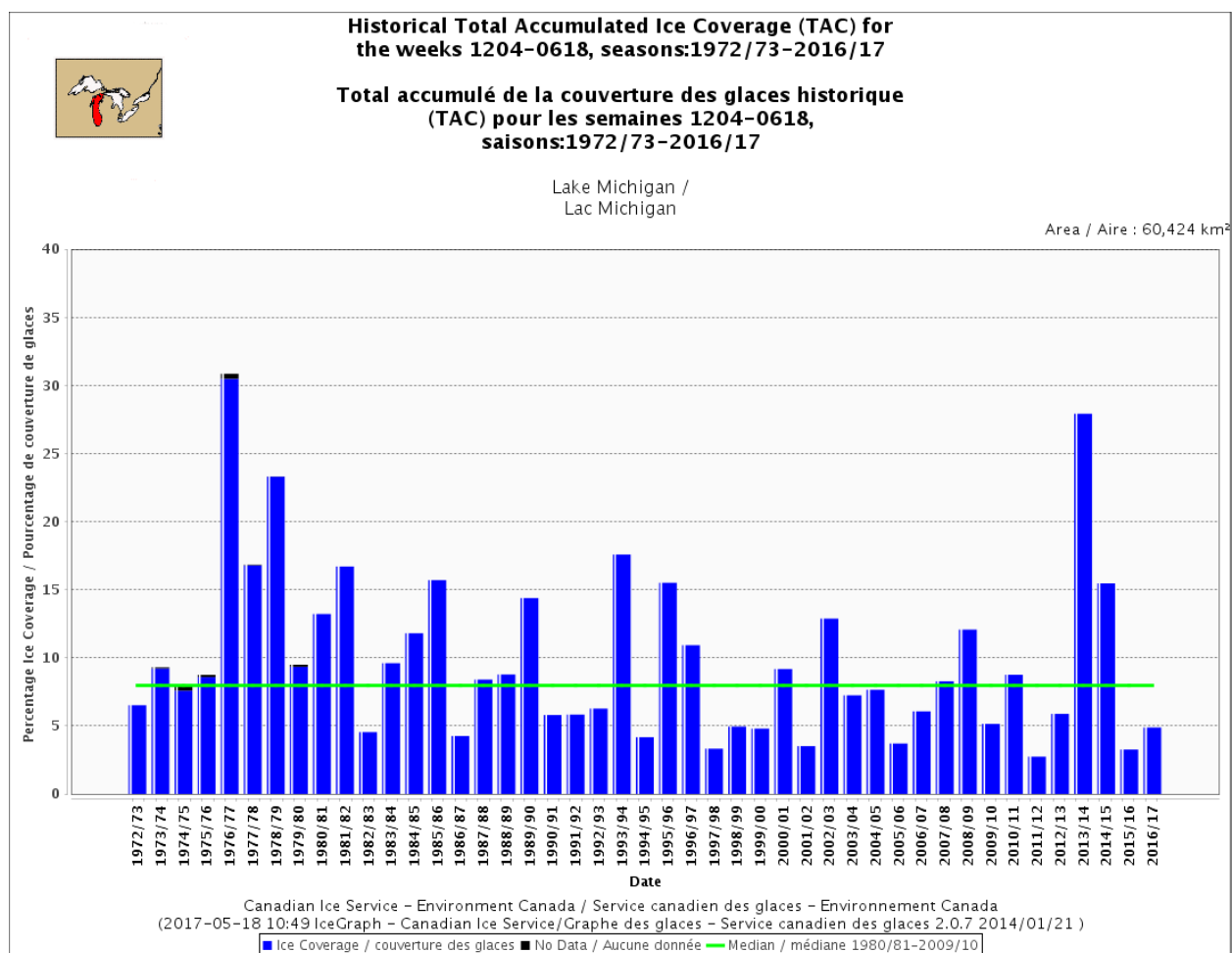


Figure 11: Historical Total Accumulated Ice Coverage in Lake Michigan by season, 1972-2017.

Lake Huron

2016-2017 Season temperatures:

The temperature anomaly pattern across Lake Huron beginning in December and continuing through mid-January was oriented from near normal over southwestern Lake Huron and up to 1.5°C above normal over northern Georgian Bay. The warm anomaly pattern amplified over the lake from mid-January to the end of February, with a maximum value of 5.5°C over the region. The reversal of this temperature regime took place in the first three weeks of March with surface air temperatures -1.0°C to -2.5°C below average. To conclude the winter 2016-2017 ice season, surface air temperatures from late March and through April were near normal over northern Lake Huron and up to 2.5°C over the southern section of the lake.

2016-2017 Ice conditions:

Traces of new ice began to form in the St. Mary's River and Saginaw Bay during the second week of December 2016, relatively normal with respect to the climatology of the region. By mid-December ice had expanded across Saginaw Bay and fringed the shores of the North Channel, Lake Huron, and northeastern Georgian Bay. Predominantly thin lake ice prevailed in Saginaw Bay and the St. Mary's River in the third week of December and ice in general was limited to the isolated bays and inlets of Lake Huron.

Early January exhibited a steady progression of ice growth along the shores of Lake Huron again, as well as a near complete coverage of the North Channel. Fast ice was identified in the majority of Saginaw Bay, the St. Mary's River and in the eastern and western sections of the North Channel by mid-month. Again though, after mid-January the pace of growth slowed and ice concentrations diminished in the exposed areas of the lake. The central section of Saginaw Bay became unconsolidated near the end of January and ice in the North Channel remained mobile as well, an occurrence driven by the warmer than normal temperatures over Lake Huron.

A lower than normal ice coverage persisted through February. Ice normally expected at the start of the month over wide swaths of northeastern Georgian Bay and near the entrance to Saginaw Bay was absent, as were elevated concentrations near the Straits of Mackinac. Lake ice managed to achieve the predominantly medium stage in Saginaw Bay and the North Channel in the second week, but many gains in ice cover during the third week of the month were wiped out after a significant destruction event in the fourth week of February. Ice cover was now approximately one and a half months behind the climatological median.

The preconditioned waters of Lake Huron would permit the most notable rapid ice expansion period in the Great Lakes for the 2016-2017 winter. During the second week of March, anomalously cold temperatures and light wind conditions supported the quick growth of new and thin lake ice across the majority of Georgian Bay within a four day period. Ice formation along the western shores of the lake was also appreciable during this timeframe. Unsurprisingly this growth phase coincided with the seasonal TAC maximum of 36.48%, still short of the climatological median peak of 46.84% for the basin. The fragility of this ice was problematic though, as it was quickly destroyed shortly after mid-month in a significant wind event. By month end, Saginaw Bay was nearly devoid of ice and a

notable portion of the North Channel remained unconsolidated, while southern Lake Huron was free of ice. Highly diminished concentrations of ice in the St. Mary's River and Georgian Bay were also unusual for the time of year.

Lake ice thickness was observed to be below normal across all sections of Lake Huron, from one to two thickness categories below the normal climate values. Over the course of the first week of April 2017, remaining ice cleared from Saginaw Bay, near the Straits of Mackinac and over the exposed sections of Georgian Bay. Fast ice fracture was detected throughout the St. Mary's River and the North Channel by the second week of April, and this ice along with the remaining ice in the isolated bays of Georgian Bay cleared by the third week of April.

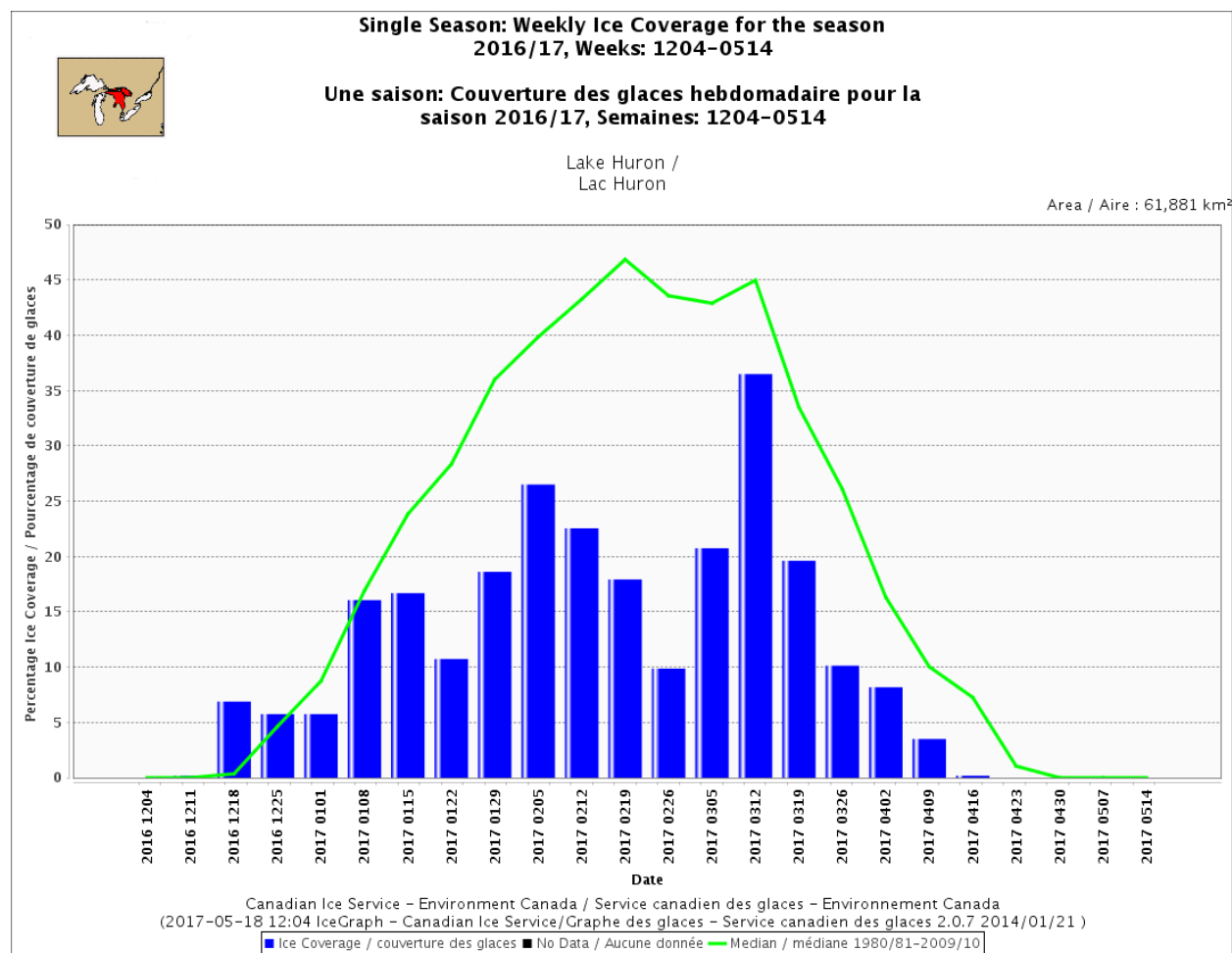


Figure 12: Weekly Ice Coverage in Lake Huron for winter 2016-17.

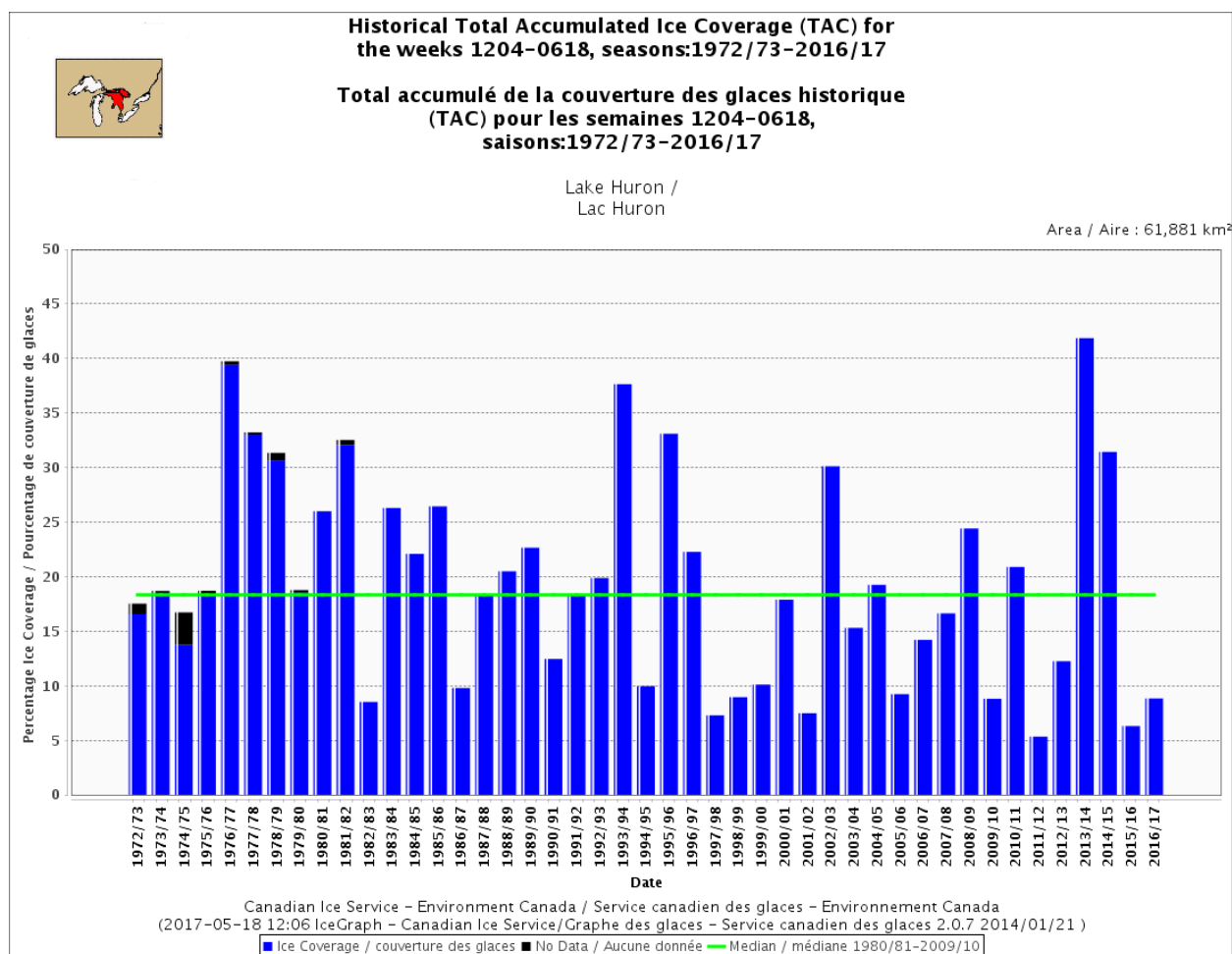


Figure 13: Historical Total Accumulated Ice Coverage in Lake Huron by season, 1972-2017.

Lake Erie

2016-2017 Season temperatures:

A near normal temperature anomaly pattern was exhibited across Lake Erie in December and into mid-January. Anomalously warm temperatures developed in the second half of January and through February, varying from 4.5°C to 6.0°C above the climatological average. A colder than normal trend was established over the course of the first three weeks of March, with temperatures -1.0°C to -2.5°C below normal. Spring then ushered in warmer than average surface air temperatures ranging from 2.0°C to 4.0°C above normal from the final week of March until the end of April 2017.

2016-2017 Ice conditions:

An early start to the ice season took place in the Western Basin of Lake Erie and Lake St. Clair, with new and thin lake ice appearing near mid-December a full two weeks earlier than normal. But before the end of the month this ice was destroyed and only isolated concentrations remained intact.

Progressively over the first two weeks of January ice growth returned to the region, with a major expansion of new and thin lake ice in the Western Basin, Lake St. Clair and along the shores of Lake Erie. The culmination of this period of ice formation was the seasonal maximum in TAC at 36.5%, well below normal and approximately a month early with respect to the climatological median of 87.33% for mid-February. All the gains of the first half of January were again lost during the second half of the month, leaving only low concentrations of ice near Pelee Island, Long Point Bay, and the shores of Lake St. Clair.

The low ice concentrations in Lake Erie and Lake St. Clair at the start of February were well below the climatological median, as a near complete coverage of the region is expected through the month. A brief increase in ice concentration was experienced in the first week, but again confined to predominantly new and thin lake ice in Lake St. Clair, the Western Basin and the north shore of Lake Erie. Clearing of all ice proceeded in the second half of the month, with complete melt observed in the fourth week. The open water conditions across the basin were about one month ahead of normal.

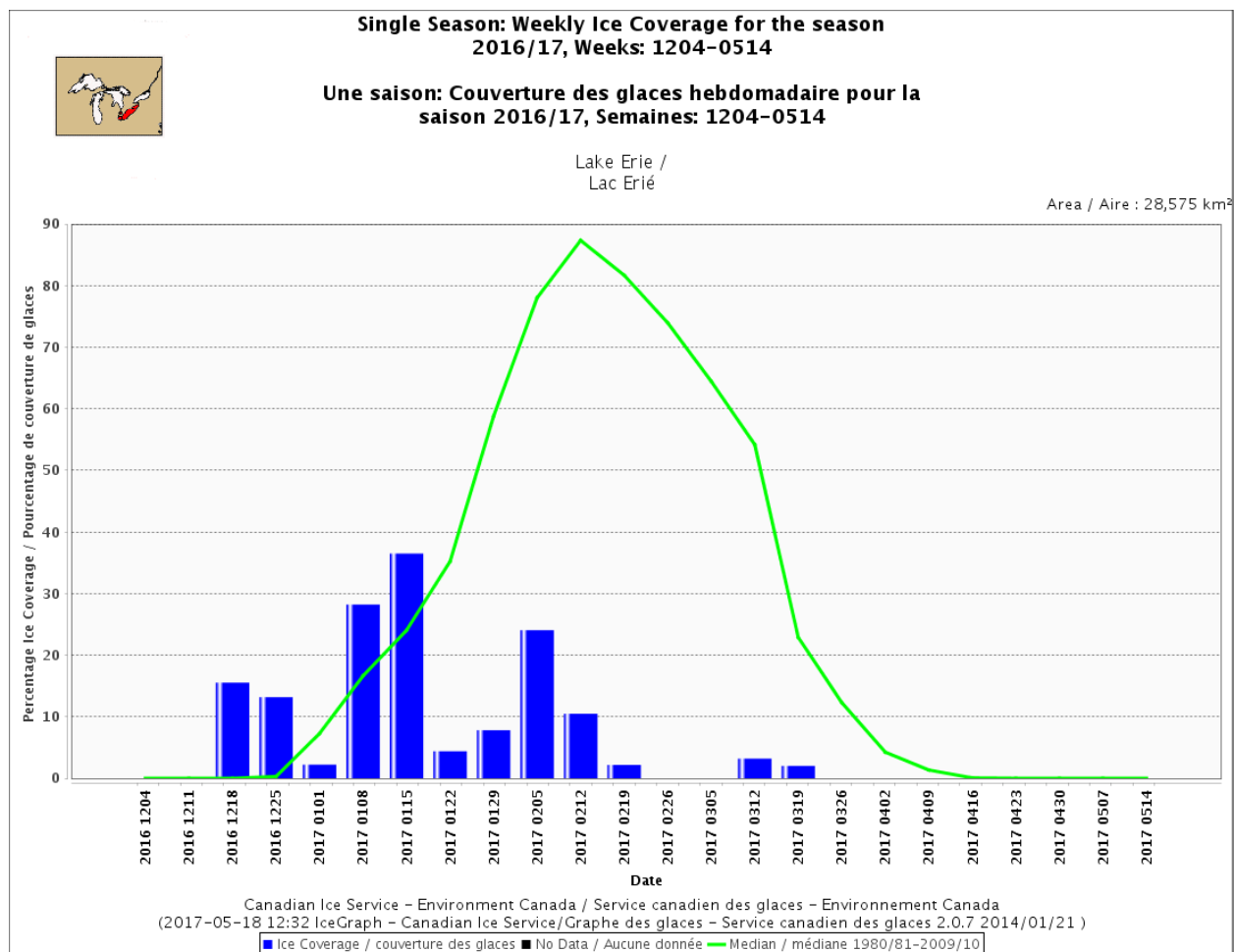


Figure 14: Weekly Ice Coverage in Lake Erie for winter 2016-17.

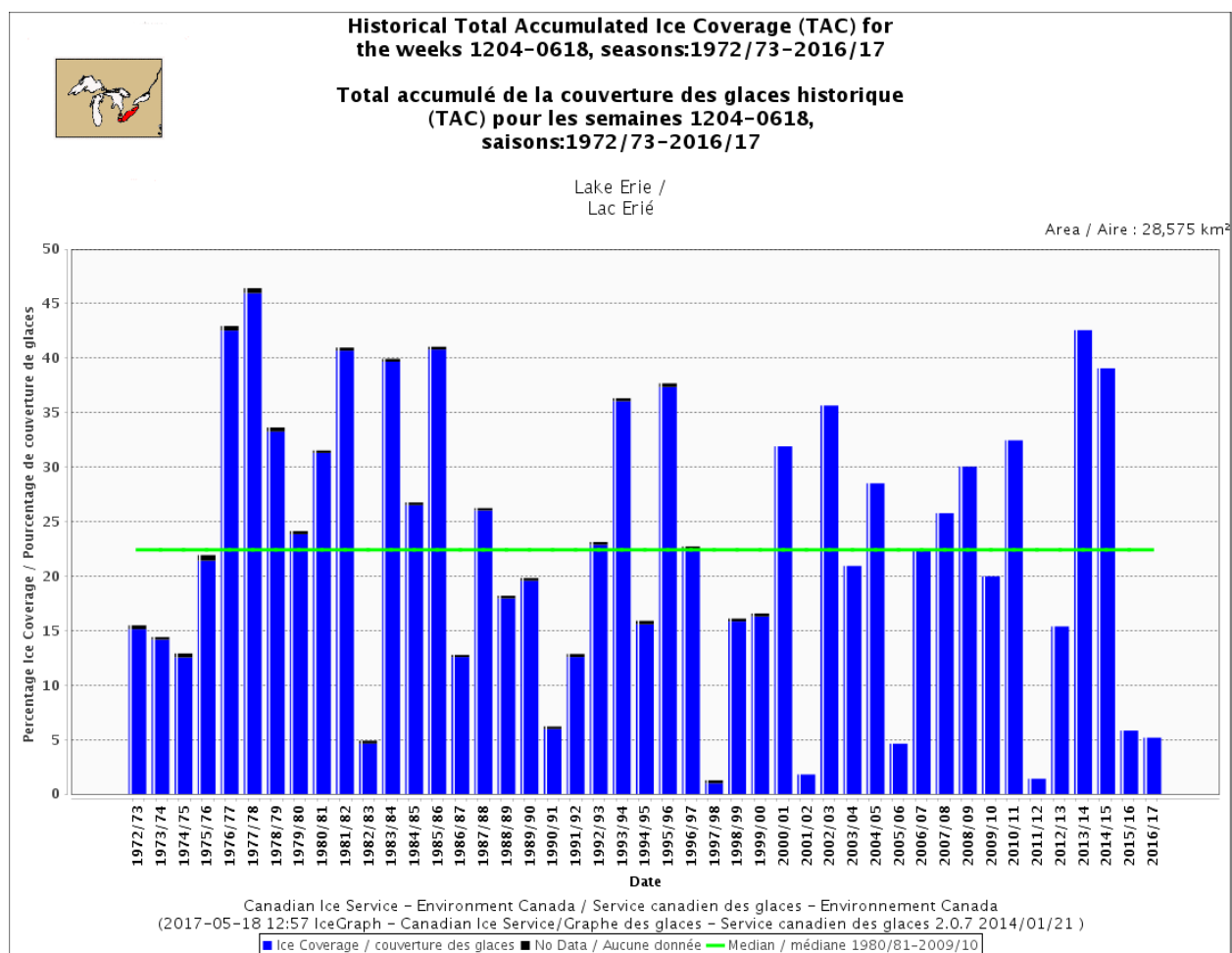


Figure 15: Historical Total Accumulated Ice Coverage in Lake Erie by season, 1972-2017.

Lake Ontario

2016-2017 Season temperatures:

Near normal to slightly above normal surface air temperatures prevailed over Lake Ontario through December and the first half of January. Anomalously warm temperatures from 4.5°C to 5.5°C above the climate average then developed across the region during the second half of January and through February. Early March exhibited a significant change in the temperature anomaly as a negative pattern emerged with values 2.0°C to 4.0°C below the average. This period of anomalous cold was short-lived as a warm anomaly of up to 2.0°C developed in late March and into April.

2016-2017 Ice conditions:

By mid-December the Bay of Quinte and portions of the St. Lawrence River were beginning to freeze-up, a week faster than normal. Thin and medium lake ice consolidated in the Bay of Quinte in the first week of January and narrow bands of new lake ice appeared along the southern shore of the lake and Prince Edward County. The ice along the shoreline was short-lived though as it quickly was destroyed before mid-month. Ice continued to be limited in the second half of the month with only consolidated medium and thin lake ice remaining in the Bay of Quinte and isolated bays in the northeastern section of the lake. Ice development was roughly three weeks behind the climate median for the lake.

Below normal ice concentrations persisted through February 2017 but the seasonal ice cover maximum was attained in the first week. The TAC value was 6.27% in the first week of February, significantly below the usual peak of 15.05% in the third week of the month. Ice concentration and coverage was relatively stable for the February across the region until near the end of the month. At this point, consolidated ice began to deteriorate and fracture in the Bay of Quinte signaling the beginning of the seasonal breakup.

The cold phase during the first three weeks of March reintroduced new and thin lake ice to the northeastern portion of the lake. The Bay of Quinte was again fast by the third week of March as a result of this anomalous cold. The return of warmer than normal temperatures in the final week of March and through April initiated the clearing of the ice in the lake and St. Lawrence River. By the end of the first week of April, Lake Ontario was free of ice.

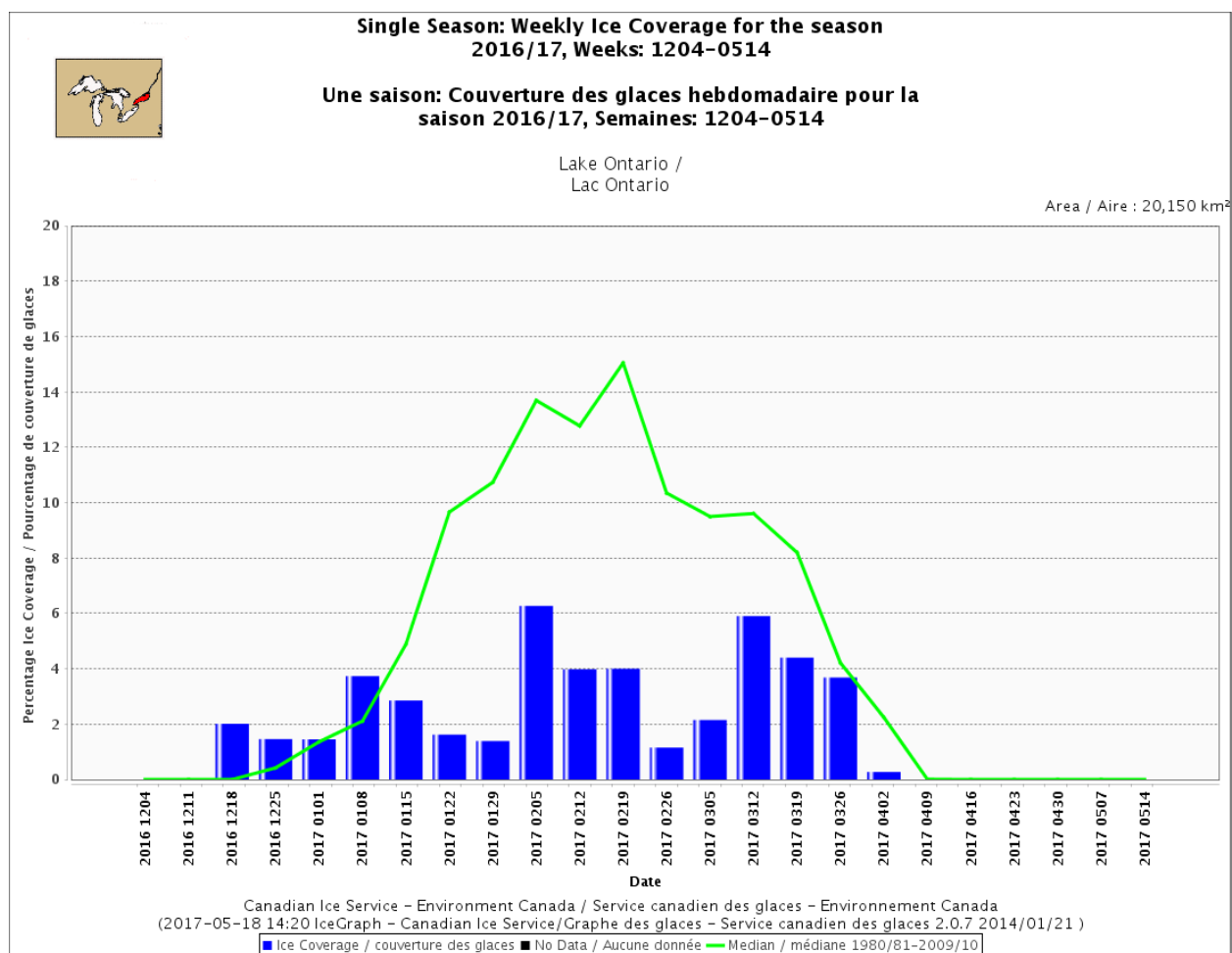


Figure 16: Weekly Ice Coverage in Lake Ontario for winter 2016-17.

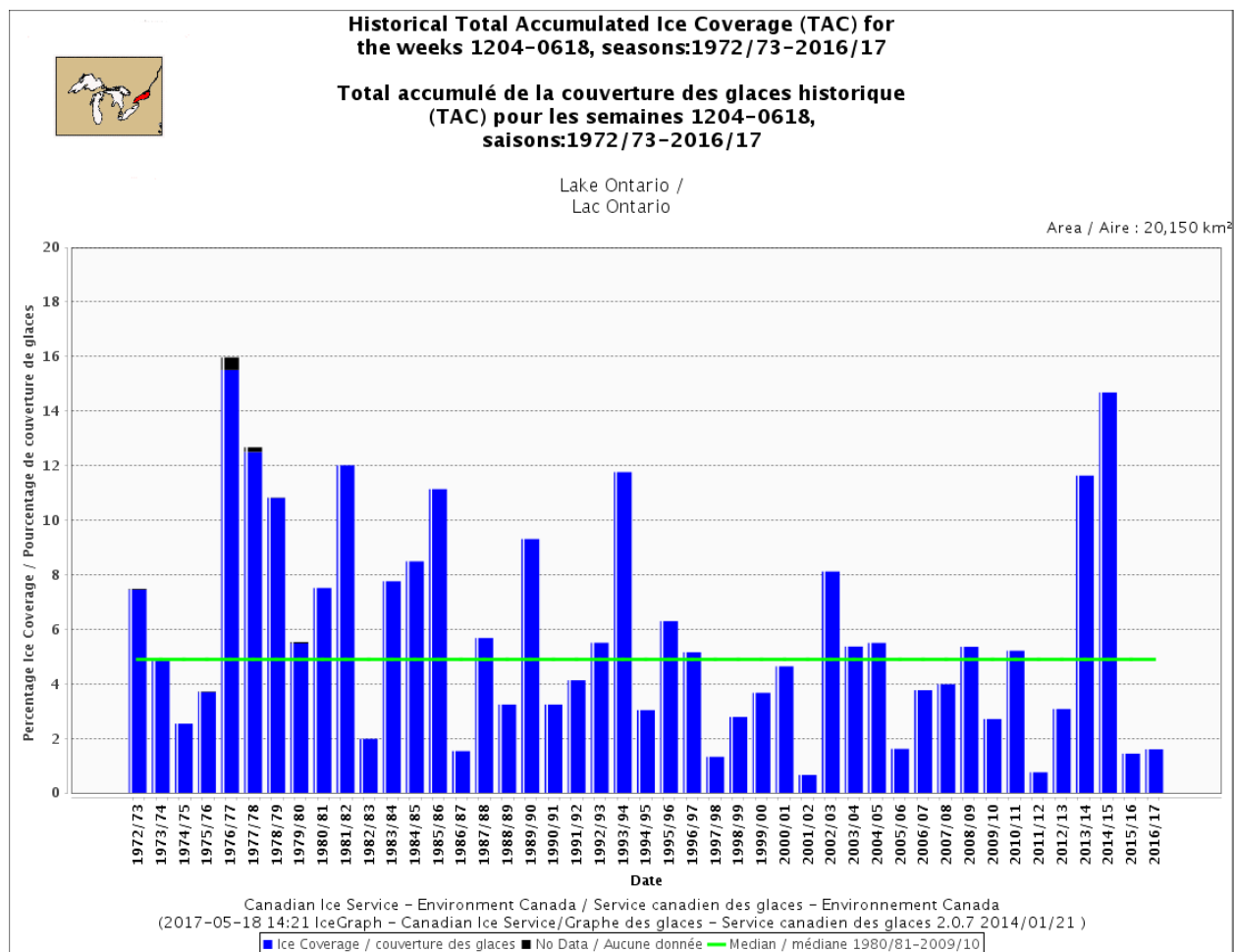


Figure 17: Historical Total Accumulated Ice Coverage in Lake Ontario by season, 1972-2017.

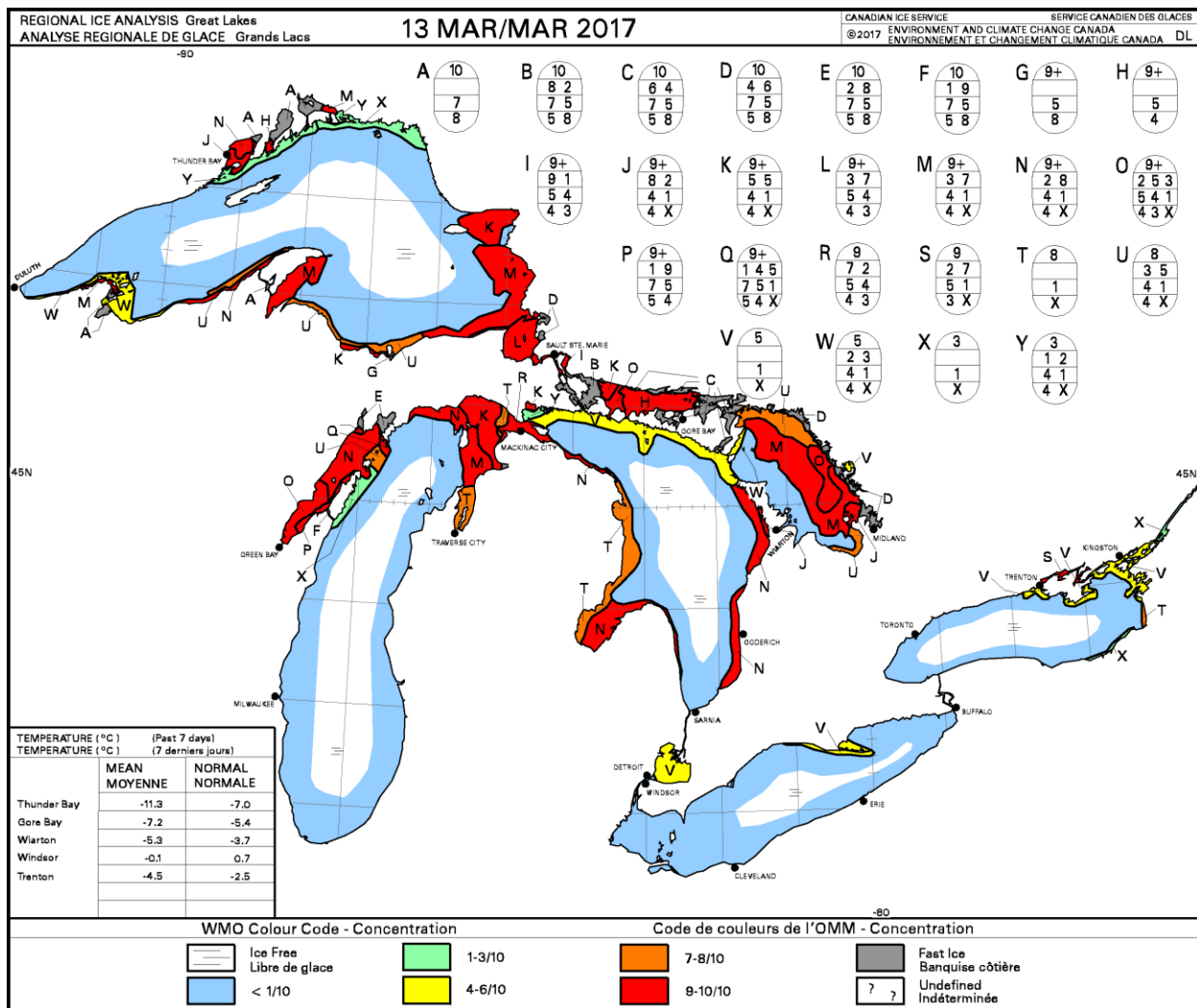


Figure 18: Maximum ice cover for the Great Lakes, 2016-2017 ice season.