NOAA Technical Report ERL 370-GLERL 11

Great Lakes Ice Cover, Winter 1974-75

George A. Leshkevich

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U.S. DEPARTMENT OF COMMERCE
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U. S. DEPARTMENT OF COMMERCE
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GREAT LAKES ICE COVER, WINTER 1974-75

George A. Leshkevich

From ice-cover data received at the Great Lakes Environmental Research Laboratory during the past winter, twenty composite ice charts were produced to illustrate estimated ice distributions and concentrations on the Great Lakes at weekly intervals from mid-December, 1974, through the end of April, 1975.

According to the definitions of mild, normal, and severe winters set forth by Rondy (1971), freezing degree-day accumulations indicate that the 1974-75 winter was near normal for Lakes Superior, Michigan, and Huron, but between mild and normal for Lakes Erie and Ontario. Accumulations were near their seasonal maximum near mid-April on northern portions of the Great Lakes and at mid-March on southern portions, except for Cleveland, where maximum accumulation occurred in mid-February.

Skim ice was reported in late November and early December at various sites around the Great Lakes. By mid-December ice had formed on bays and protected areas of northern Lake Superior, the lower St. Marys River, Green Bay, and Saginaw Bay, as well as along the southern shore of Lake St. Clair. Ice growth continued on these and other protected shore areas until the week ending December 29, when substantial melting occurred on the southern portion of the lakes. It wasn't until near mid-January that rapid and extensive ice growth took place, especially on the northern lakes. Ice growth continued through mid-February, when ice covers reached their maximum extent on all the lakes with the exception of Lakes Superior and Ontario, where they occurred near mid-March. Maximum ice extent was estimated to be 30 percent on Lake Superior, 25 percent on Lake Michigan, 45 percent on Lake Huron, 80 percent on Lake Erie, and 16 percent on Lake Ontario. Warmer temperatures during the latter part of February caused significant loss of ice on all of the Great Lakes. Increases and decreases in ice cover resulted in little net change in ice extent through mid-March. The latter part of March brought a week of warm temperatures and the end of significant ice growth on the lakes. Last reports of ice on the northern lakes came during the latter part of April.

1. INTRODUCTION

As part of the Great Lakes Environmental Research Laboratory's ongoing lake ice project, each annual ice cycle on the Great Lakes is documented. This report describes the 1974-75 Great Lakes ice cycle. Reports describing the progression of ice cover on the Great Lakes for past winters, beginning with the 1962-63 winter season, are available from the Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan. As in more recent reports in this series, this report contains information on ice-cover formation, growth, and decay on the Great Lakes on a weekly basis. A summary of freezing degree-day (FDD) accumulations is also included as an indicator of winter severity.

2. DATA COLLECTION AND ANALYSIS

2.1 Data Sources

Ice-cover data collected and utilized in preparing this report includes ice charts, satellite imagery, side-looking airborn radar (SLAR), and surface ice reports. Ice charts depicting ice distribution and ice concentration, as well as size and age of floes, were received from the Ice Navigation Center, Cleveland, Ohio, and Ice Forecasting Central, Ottawa, Canada, throughout the winter. NOAA-3 and -4 VHRR and LANDSAT-1 and -2 satellite imagery was received from the National Environmental Satellite Service in Washington, D.C. SLAR imagery was received from the Ice Navigation Center, Cleveland, Ohio. Weekly and daily surface reports of ice thickness and ice conditions were received from observers of the Great Lakes Environmental Research Laboratory and the United States Coast Guard.

2.2 Data Analysis

United States Coast Guard and Canadian ice charts are graphic representations of visual observations made by ice observers periodically throughout the winter season. Ninety-one Coast Guard ice charts, covering Lake Superior, Whitefish Bay, the St. Marys River, the Straits of Mackinac, Lake Michigan, Green Bay, Lake Huron, Saginaw Bay, Lake St. Clair, and Lakes Erie and Ontario (see map, fig. 1) and forty-four Canadian visual ice charts, covering Canadian portions of the Great Lakes, were received. Little, if any, interpretation of these charts is necessary as they depict actual observed ice conditions through the use of symbols and codes. Weekly and daily surface reports of ice thickness and ice conditions received from GLERL and Coast Guard observers were in written form and similarly needed little or no interpretation.

NOAA-3 and -4 VHRR visible and thermal infrared imagery and LANDSAT-1 and -2 (ERTS) bands 4,5,6, and 7 (visible and near infrared) satellite imagery was received for the ice season in the form of positive transparencies. SLAR imagery was received in the form of paper prints. The satellites' spectral scanners recorded reflected and emitted radiation in the visible and infrared wavelengths. Flown at approximately 11,000 ft (3400 m), SLAR recorded its own reflected radar pulse. By using density, tone, and texture, supplemented by visual ice charts and reinforced by other imagery, if available at or near the time in question, the imagery was visually interpreted and information about ice cover and concentration abstracted and transferred to the composite ice charts.

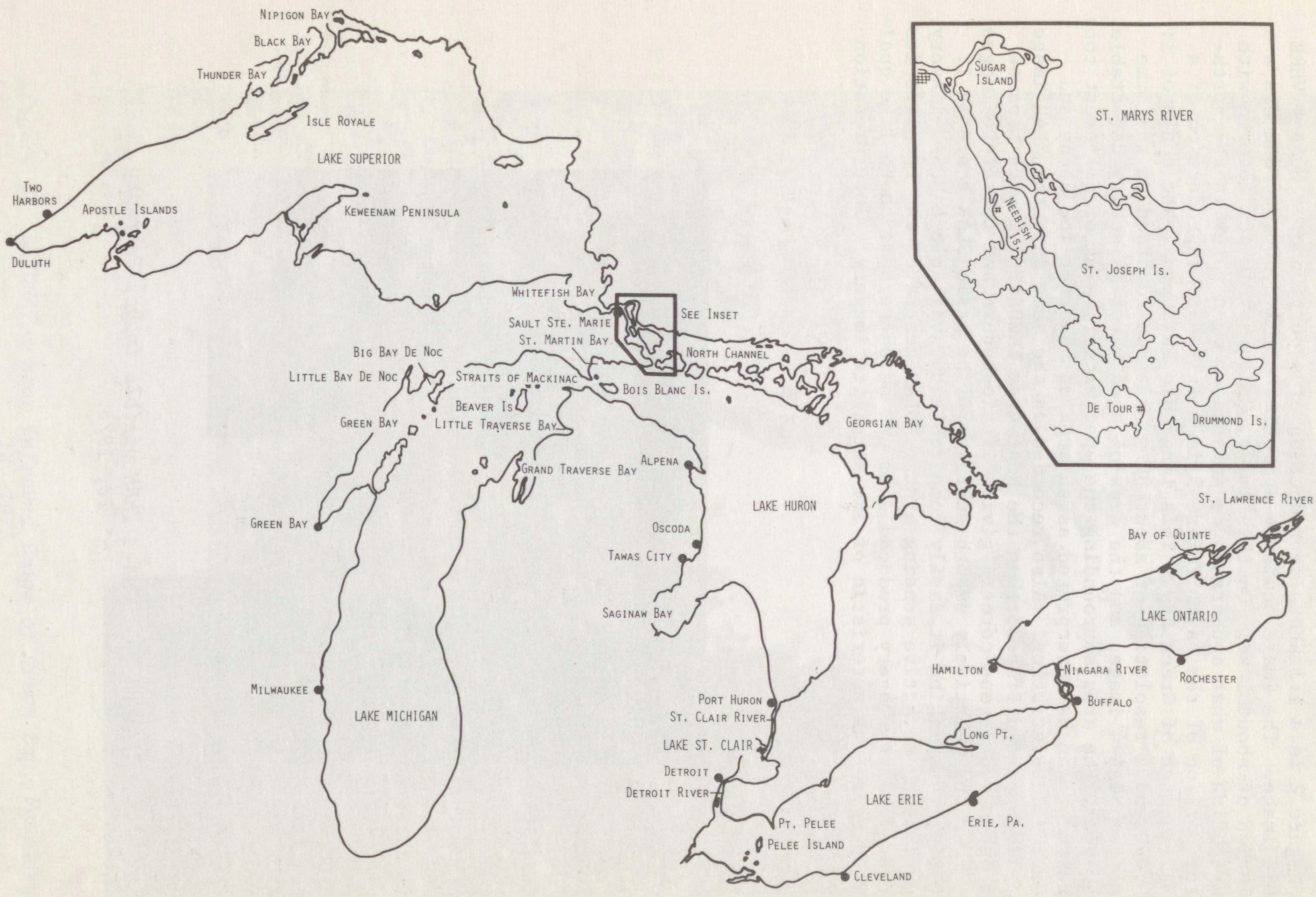

Figure 1. The Great Lakes.

Figure 2 is a 1:1 photo reproduction of a portion of a NOAA-4 VHRR visible image. The image scale is approximately 1:8,500,000 and has a resolution of about 1 km. On this image, Green Bay is ice covered with the exception of what appears to be an area of open water in the north-central portion of the bay. Figure 3 is a 1:1 photo reproduction of a LANDSAT-1 image of Green Bay. This image has an approximate scale of 1:1,000,000 and a resolution of about 80 m. It was recorded on the same day as the NOAA-4 image, and the area of open water is easily detectable. In addition, the area surrounding the open water, being of different tone and texture, can be interpreted as an area of apparent ice decay and decreasing concentration. Also recorded on the same day, the SLAR image (fig. 4) appears different than the NOAA-4 or LANDSAT-1 images because radar "sees" edges and corners giving little return and therefore images dark areas for relatively smooth surfaces. The basic SLAR scale is 1:1,000,000, thus making it easily comparable to available LANDSAT imagery. However, being an active sensing system, SLAR generates and receives its own energy. The imagery produced does not have the same photo-like qualities that are characteristic of the satellite imagery. Interpretation

Figure 2. NOAA-4 VHRR visible image, February 13, 1975.

Figure 3. LANDSAT-1 near infrared image of Green Bay, February 13, 1975.

of the SLAR is made more complex due to the fact that the microwave wavelength used for the SLAR can penetrate freshwater ice. The signal received, therefore, can represent reflectance off the surface and internal structure of the ice. The use of previous SLAR imagery in addition to satellite and other visual data is important in the interpretation of SLAR imagery.

As methods and techniques for the interpretation of ice cover and concentration from satellite and SLAR imagery become more refined, greater use will be made of these remotely sensed data sources.

3. DATA PRESENTATION

3.1 Freezing Degree-Days

Based on average weekly temperatures given in the *Weekly Weather and Crop Bulletin*, a joint publication of the U.S. Departments of Agriculture

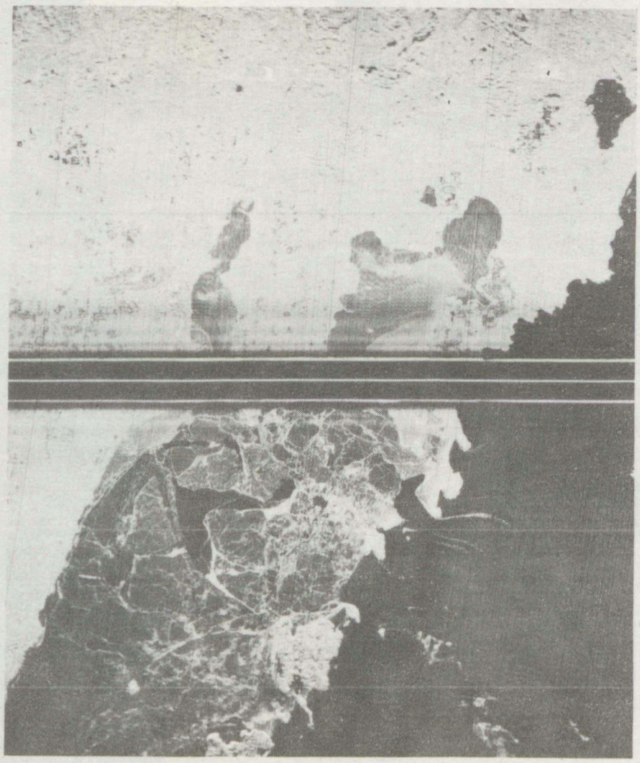

Figure 4. SLAR image of northern Green Bay, February 13, 1975.

and Commerce, FDD accumulations were maintained for selected National Weather Service meteorological stations on the perimeter of the Great Lakes. These stations include: Duluth, Minn.; Sault Ste. Marie, Mich.; Alpena, Mich.; Green Bay, Wis.; Milwaukee, Wis.; Detroit, Mich.; Cleveland, Ohio; and Rochester, N.Y. FDD's measure the cumulative temperature departure from 32°F. Based on the mean of the daily maximum and minimum air temperatures (defined as the mean daily air temperature), 1 FDD is accumulated for each degree of negative departure from 32°F. Thus, for a mean daily air temperature of 28°F, 4 FDD's are accumulated. Graphs depicting the 1974-75 FDD accumulations compared to a 10-yr mean are given for each of the Great Lakes (fig. A.1. through A.5.).

3.2 Composite Ice Charts

The seasonal pattern of ice formation, growth, and decay on the Great Lakes from December 15, 1974, to April 27, 1975, is illustrated on 20 composite ice charts (fig. A.6 through A.25). Based on a subjective evaluation of available ice-cover information, these charts portray estimated ice conditions at weekly intervals as abstracted from data noted in Section 2 of this report.

FDD accumulations at the eight representative stations noted above are also given on each composite ice chart. Weekly, seasonal, and normal seasonal accumulations are presented as an indication of the weekly variation in winter severity and the seasonal variation in severity relative to a 10-yr mean (1961-70).

4. DISCUSSION

4.1 Winter Characteristics

Winter seasons can be reasonably characterized by using maximum FDD accumulations as a measure of winter severity. Applying the FDD winter classification set forth by Rondy (1971), the 1974-75 winter season can be characterized as near normal for Lakes Superior, Michigan, and Huron, and between mild and normal for Lakes Erie and Ontario. The date of maximum accumulation separates a period of potential ice formation from a period of potential ice decay. FDD accumulations were near their seasonal maximum near mid-April on northern portions of the Great Lakes and at mid-March on southern portions of the lakes, with the exception of Cleveland, Ohio, where maximum accumulation occurred in mid-February.

Compared to the average dates of maximum FDD accumulations given by Rondy (1971), the 1974-75 maximum accumulations occurred later on the northern portion of the Great Lakes (Duluth, Minn., Sault Ste. Marie, Mich., Green Bay, Wis., and Alpena, Mich.) and at near average time on the southern portion, with the exception of Cleveland, Ohio, where it occurred 2 weeks earlier. Compared to the 1973-74 season, 1974-75 maximum FDD accumulations were less for each of the representative stations mentioned above and the average dates of occurrence were from 1 to 5 weeks later.

Although somewhat superficial, another indicator of the relative severity of a winter season during the past few years has been the dates of the closing of the locks at Sault Ste. Marie, Mich., to navigation. Assisted in some areas by artificial means under the Extension to the Navigation Season Demonstration Program, navigation on the Great Lakes has progressively been extended further into the winter season. Severe ice conditions have heretofore brought shipping to a halt, ending the 1973-74 navigation season on the northern lakes on February 7, 1974; however, for the first time in history, the locks at Sault Ste. Marie, Mich., were kept operating throughout the 1974-75 winter season, marking the first year-round shipping season. Undoubtedly, the relatively mild ice season facilitated the year-round shipping effort.

It should also be noted that the St. Lawrence Seaway was closed to shipping on December 19, 1974, and reopened on March 25, 1975. Originally scheduled to reopen on April 1, 1975, the March 25 date marked the earliest opening of the St. Lawrence Seaway.

4.2 General Seasonal Trends in Ice-Cover Distribution

Skim ice was reported in late November and early December at various sites around the Great Lakes, and ice formation was confined primarily to bays, harbors, and protected shore areas (fig. A.6). Ice continued to form during the week ending December 22, with notable increases occurring in western Lake Erie and Saginaw Bay (fig. A.7). Mild temperatures during the last week of December contributed to reductions in ice cover on the southern portion of the lakes (fig. A.8). In January ice formation was restricted to portions of the perimeters of all lakes with Green Bay, the Straits of Mackinac, North Channel, Whitefish Bay, and other protected areas gradually forming extensive ice covers (fig. A.9 through A.12). During February, ice extended lakeward from most of the perimeters of Lakes Superior, Michigan, Huron, St. Clair, and Erie (fig. A.13 through A.15). Relatively low average weekly temperatures increased ice covers on most of the lakes until the latter part of February, when higher temperatures caused significant loss of ice (fig. A.16). Lower air temperatures during the first part of March caused temporary reversals of the late February trend (fig. A.17 and A.18). But mild temperatures during the latter part of March again caused deterioration of the ice cover, most noticably on Lake Erie and southern Lake Huron (fig. A.19 and A.20). The decay of the remaining ice cover continued through the end of April without notable events (fig. A.21 through A.25).

4.3 Lake Superior and the St. Marys River

Skim ice was reported at shore sites on western Lake Superior and along the St. Marys River during the last week of November and the first week of December. By December 15, Black Bay and Nipigon Bay along the north-central shore of Lake Superior had partial ice covers and shore ice was reported in Whitefish Bay at the eastern end of the lake. Ice was confined to bays, harbors, and nearshore areas until the week ending January 12, when ice had encompassed the Apostle Islands and covered most of the lower St. Marys River (fig. A.6 through A.10). During the next 5 weeks, low average weekly temperatures contributed to ice formation and growth. By January 19, ice had formed to about 10 miles out along the south-central and southwestern shores of Lake Superior, the lower half of the St. Marys River (below Sugar Island) was completely ice covered, and Whitefish Bay remained primarily ice free (fig. A.11). Ice remained confined mainly to bays and shore areas until early February. During the week ending February 9, ice formed outward from nearly the total perimeter of the lake, but especially from the southeast and northwest shores. The extent of ice cover increased during the next week with Whitefish Bay forming a ten-tenths ice cover (fig. A.12 through A.15). The week ending February 16, marked the end of the period of relatively cold average weekly temperatures and a warming trend started the next week as evidenced by a decline in weekly FDD accumulations at Duluth, Minn., and Sault Ste. Marie, Mich., (fig. A.15 and A.16). As a result, significant lake-wide decreases in ice cover occurred between the weeks ending February 16 and 23, and an area of open water developed to the east of the Keweenaw Peninsula during the week ending February 23 (fig. A.16). Further decreases took place during the next week (fig. A.17). This trend was reversed the week of March 9 and Lake Superior ice cover was estimated to be at its maximum extent, covering 30 percent of the lake during that week (fig. A.18). Slightly warmer air temperatures and probable upwelling along the northern shore of the lake caused some melting and redistribution of ice during the following week (fig. A.19); however, by March 23 a warming trend that produced relatively high average weekly temperatures throughout the Great Lakes region caused significant loss of ice to take place, leaving only bay, harbor, and shore ice over most of the lake. Whitefish Bay and the St. Marys River as yet remained primarily ice covered (fig. A.20). Briefly interrupting the period of ice decay, unseasonably cold air temperatures during the latter part of March and early April caused some new ice formation to take place on the lake and created difficulties in navigation on the lower St. Marys River (personal communication). The period of ice decay then continued through the end of April. At that time areas of ice cover included the three bays along the north-central shore of Lake Superior (Thunder Bay, Black Bay, Nipigon Bay), some sheltered harbors on the south shore, Whitefish Bay, and the lower St. Marys River (fig. A.21 through A.25).

4.4 Lake Michigan

Big and Little Bays de Noc and the southern end of Green Bay were the first areas to report ice formation on Lake Michigan. Skim ice was reported by the first week of December and continued to form in these areas, but was confined to Green Bay until the week ending January 5 (fig. A.6 through A.8), when ice was reported in Grand Traverse Bay, the eastern shore of Beaver Island, and a few sheltered embayments in the northern part of Lake Michigan (fig. A.9). By the end of the following week, the ice had melted from Grand Traverse Bay, not to return until the week ending February 9, while ice continued to grow in Green Bay and along the northern shore of the lake and formed along the southwest shore for the first time during the season (fig. A.10). During the week ending January 19, Green Bay became completely ice covered, the Straits of Mackinac west of the bridge gained a seven- to nine-tenths ice cover and ice continued to grow in the southern end of the lake, subsequently separating from the southeast shore and forming a shore moat (fig. A.11). Ice continued forming in the northern part of the lake, extending to Beaver Island from the north and east shores and southward along the western shore to Green Bay. In the southern portion of the lake, ice changed somewhat in concentration, but little in extent (fig. A.12); however, by February 2, most of the ice cover in the southern portion of the lake had disappeared. But with a substantially lower average weekly temperature during the following week, ice reformed in the southern end of the lake and extended northward along the eastern shoreline. Ice cover remained about the same during the week ending February 16, reaching its maximum extent during this period (fig. A.14 and A.15). At this time, the lake was estimated to be approximately 25 percent ice covered. A sharp increase in the average weekly temperature during the next week caused significant loss of ice cover on Lake Michigan. Most of the ice in the southern end of the lake, as well as the ice that had formed along the eastern and western shorelines, had disappeared. Except for bays and sheltered areas, the ice cover on the northern portion of the lake had retreated to Beaver Island and eastward (fig. A.16). Ice cover fluctuated during the next 3 weeks, expanding in the north and along the southern shore, then retreating and disappearing, respectively. Green Bay remained primarily ten-tenths ice covered, except for an area of decreasing ice concentration in the northern part of the bay (fig. A.17 through A.19). Low pressure cells moving northeastward brought mild temperatures to the Great Lakes region during the week ending March 23. This period of relatively warm temperatures is reflected by a decrease in the accumulation of FDD's and subsequently of ice cover (fig. A.2 and A.20). Although some new ice formed in the northeastern portion of the lake during the following week (fig. A.21), the lake was into the ice decay period. Ice deterioration continued throughout April, and by April 27 the only remaining ice on Lake Michigan was found on Big and Little Bays de Noc, southern Green Bay, and Little Traverse Bay (fig. A.22 through A.25).

4.5 Lake Huron

The first reports of skim ice came from the Alpena, Mich., and Saginaw Bay areas during the first week in December. By December 15, Saginaw Bay had a four- to five-tenths ice cover. The bay ice extended northeast to a point between Tawas City and Oscoda, Mich., by December 22, and new ice formation on Lake Huron was also to be found in the North Channel and the southeastern end of Georgian Bay (fig. A.6 and A.7). By the week ending December 29, most of the ice on Saginaw Bay had melted or been blown out of the bay by southwesterly winds. Shore and harbor ice still remained in the North Channel and Georgian Bay areas. The ice cover remained relatively unchanged until the week ending January 12, at which time the southern part of Saginaw Bay had a ten-tenths ice cover, St. Martins Bay had a seven- to nine-tenths ice cover, and additional ice formation had occurred in the North Channel and Georgian Bay (fig. A.8 through A.10). During the next week, Saginaw Bay was covered by ice of various concentrations, most of the North Channel had a four- to six-tenths ice cover, and shore ice formed in the Straits of Mackinac east of the bridge (fig. A.11). Accompanying the period of low average weekly temperatures which started during the week ending January 19 and continued through the week of February 16, ice continued to form in extent and concentration in all areas of the lake. By February 9, ice encompassed the Lake Huron shoreline and was estimated to cover 45 percent of the lake's surface area during the following week (fig. A.11 through A.15). As on other of the Great Lakes, ice cover decreased during the week ending February 23 in response to mild air temperatures during the latter part of that week. The extent of ice coverage remained fairly constant during the next week, changing only in distribution (fig. A.16 and A.17). Subsequent ice formation again encompassed most of the perimeter of the lake during the week ending March 9. In addition, ice increased in extent on Georgian Bay.

Much of the shore ice melted by the week ending March 16, and north of Bois Blanc Island in the Straits of Mackinac open water extended westward to the bridge. Saginaw Bay and the southern and southeastern portion of the lake, as well as the greater part of Georgian Bay, remained ice covered. By the week ending March 23, however, the ice cover was into the decay period as low pressure systems with their associated winds and warm temperatures retarded FDD accumulations in the Lake Huron area and left Saginaw Bay, Georgian Bay, and the southern end of the lake with diminished ice covers (fig. A.3 and A.20). With the resumption of lower average weekly temperatures during the next 2 weeks, the ice cover fluctuated, with new ice formation in the Straits of Mackinac east of the bridge, Georgian Bay, and the southern portion of the lake with the exception of Saginaw Bay, where concentrations decreased (fig. A.21 and A.22). By April 13, only shore ice remained in most areas, except for the North Channel area, which was still ten-tenths ice covered. Two weeks later, diminished in extent and concentration, ice was confined to the North Channel and the extreme southern end of Georgian Bay (fig. A.23 through A.25).

4.6 Lakes St. Clair and Erie

December 10 marked the first report of skim ice on Lake St. Clair. By December 15, ice had formed along the southern shore of the lake, subsequently decreasing in extent by the end of the following week. Concurrently, in Lake Erie, ice had formed from the western shore eastward to the vicinity of Point Pelee, encompassing Pelee Island (fig. A.6 and A.7). By December 29, melting had returned these areas to open water. During the following 2 weeks, ice covers in western Lake Erie and Lake St. Clair fluctuated with little net change (fig. A.9 and A.10). The week ending January 19 saw a significant increase in ice cover on Lake St. Clair and western Lake Erie, as well as along the north-central and northeastern shore of that lake (fig. A.11). The extent of ice cover remained about the same until the week ending February 2. At that time, ice covered the perimeter of Lake St. Clair, western Lake Erie beyond Point Pelee, and extended lakeward from the northern shore to the eastern end of the lake, skirting the southern shore westward to Erie, Pa. (fig. A.12 and A.13). Continuing to increase in extent and concentration, ice was estimated to cover Lake St. Clair and nearly 80 percent of Lake Erie by February 9, reaching its maximum extent for the season early the following week (fig. A.14 and A.15). As on other of the Great Lakes, extensive ice loss took place on Lakes St.

Clair and Erie during the week ending February 23, resulting in extensive areas of open water. The areas of open water increased and were redistributed on Lake Erie during the following week, extending along the southern shoreline from the western to the eastern end of the lake, while ice cover and concentration increased on Lake St. Clair (fig. A.16 and A.17). March 9 found most of Lake St. Clair and Lake Erie seven- to nine-tenths ice covered, except for a pool of open water in the extreme western end of Lake Erie (fig. A.18). Due to the increased temperatures prevalent over the Great Lakes basin, ice cover diminished in extent and concentration during the following 2 weeks so that by March 23 Lakes St. Clair and Erie, as well as the Detroit River, were essentially ice free (fig. A.4, A.19, and A.20). With the exception of some new ice formation during the week ending April 6, virtual ice-free conditions prevailed for the remainder of the season, with last reports of floating ice on Lake St. Clair on April 12 and on the St. Clair River on April 18.

4.7 Lake Ontario

Skim ice started to form in bays on southeastern Lake Ontario during the latter part of November with a seven- to nine-tenths ice cover forming on the Bay of Quinte in the northern part of the lake by the week ending January 5 (fig. A.9). This ice increased in concentration during the following week and by January 19 ice extended from the Bay of Quinte eastward into the upper St. Lawrence River (fig. A.10 and A.11). Subsequent ice growth southward during the following week encompassed the islands, bays, and harbors in the northeastern portion of the lake. This condition remained relatively stable until the week ending February 9, when the entire northeastern portion of the lake, as well as the upper St. Lawrence River and the extreme western end of the lake, was ice covered (fig. A.12 through A.14). During the following week, the ice in the Rochester, N.Y., area and on the extreme western end of Lake Ontario melted, although the extent of ice cover in the northeast portion of the lake remained approximately the same (fig. A.15). Responding to an increase in temperature, the ice cover retreated during the week ending February 23, corresponding to similar melting on other of the Great Lakes (fig. A.5 and A.16). Little change in the extent of ice cover occurred until March 9, when new ice formation extended lakeward from the northeastern and eastern shores of the lake, as well as from the southern shore between Rochester and the Niagara River. The ice cover on Lake Ontario reached a maximum areal extent of 16 percent at this time (fig. A.17 and A.18), however, maximum ice concentration in the northeast section of the lake occurred near mid-February (fig. A.15). Significant melting took place during the week ending March 16, even though coincident with maximum FDD accumulation at Rochester, N.Y. (fig. A.5). At that time, ice was confined to the Bay of Quinte, the upper St. Lawrence River, and some bays and harbors in the northeastern part of the lake (fig. A.19). Melting continued in these areas until the week ending April 20, when the lake was virtually ice free (fig. A.20 through A.24).

5. ACKNOWLEDGMENTS

This report presents information in the form of composite ice charts abstracted from United States Coast Guard and Canadian visual ice reconnaissance charts, NOAA-3 and -4 and LANDSAT-1 and -2 satellite imagery, and side-looking airborne radar (SLAR) imagery. Climatological data used in this report were taken from the *Weekly Weather and Crop Bulletin,* published jointly by the U.S. Departments of Agriculture and Commerce.

The research and chart compilation was carried out as a part of the activities of the Lake Hydrology Group, Great Lakes Environmental Research Laboratory, under the general direction of Dr. F. H. Quinn, Head of the Lake Hydrology Group, and the supervision of R. A. Assel. Lake Hydrology Group personnel aiding in the preparation of the composite ice charts were J. Gales and B. Hagman.

6. REFERENCES

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U.S. Departments of Agriculture and Commerce. 1974-75. *Wkly. Weather and Crop Bull.*, vol. 61, no. 51-vol. 62, no. 17.

6. APPENDIX

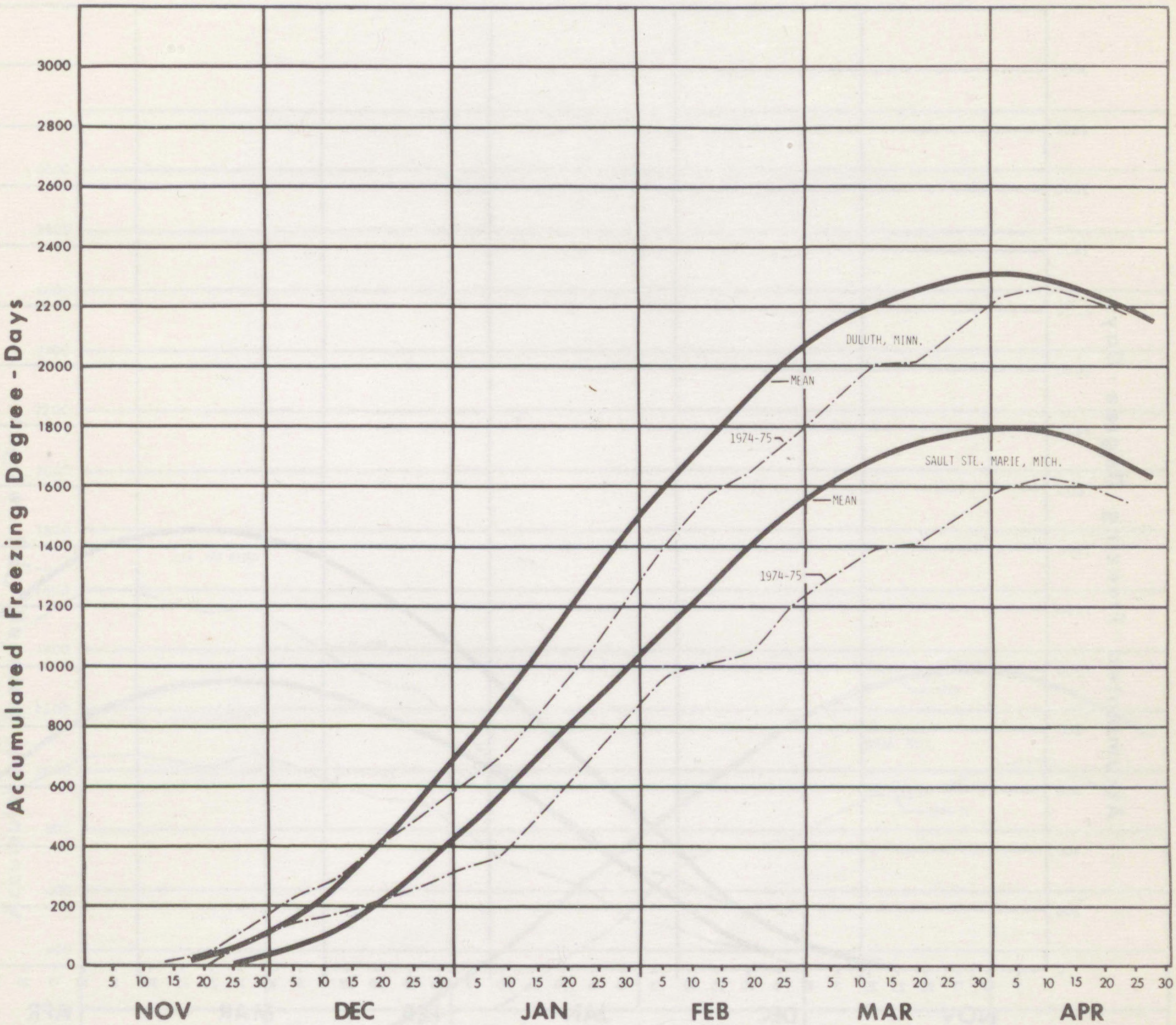

Figure A.1. Accumulated freezing degree-days - Lake Superior at Sault Ste. Marie, Mich., and Duluth, Minn.

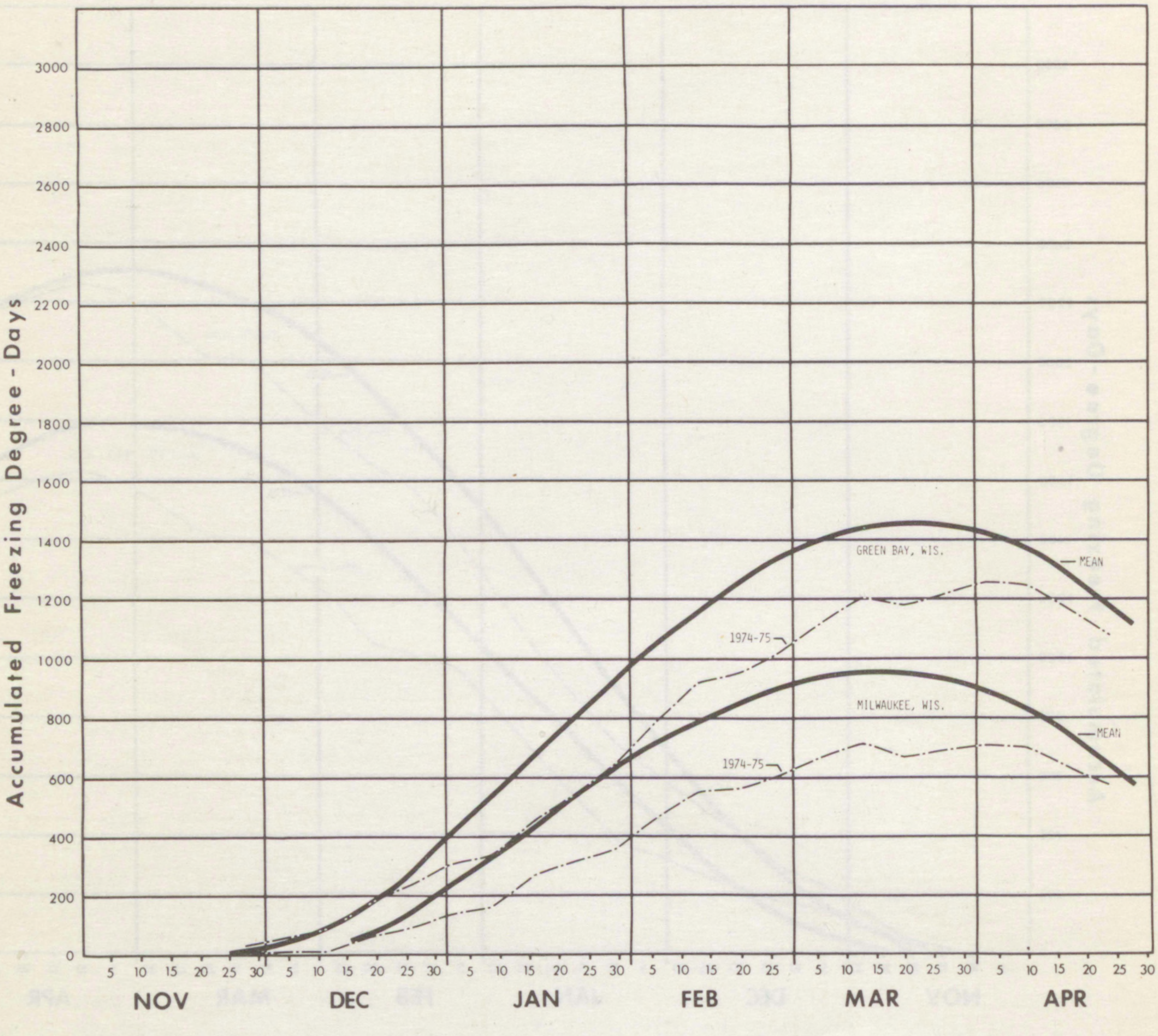

Figure A.2. Accumulated freezing degree-days - Lake Michigan at Green Bay and Milwaukee, Wis.

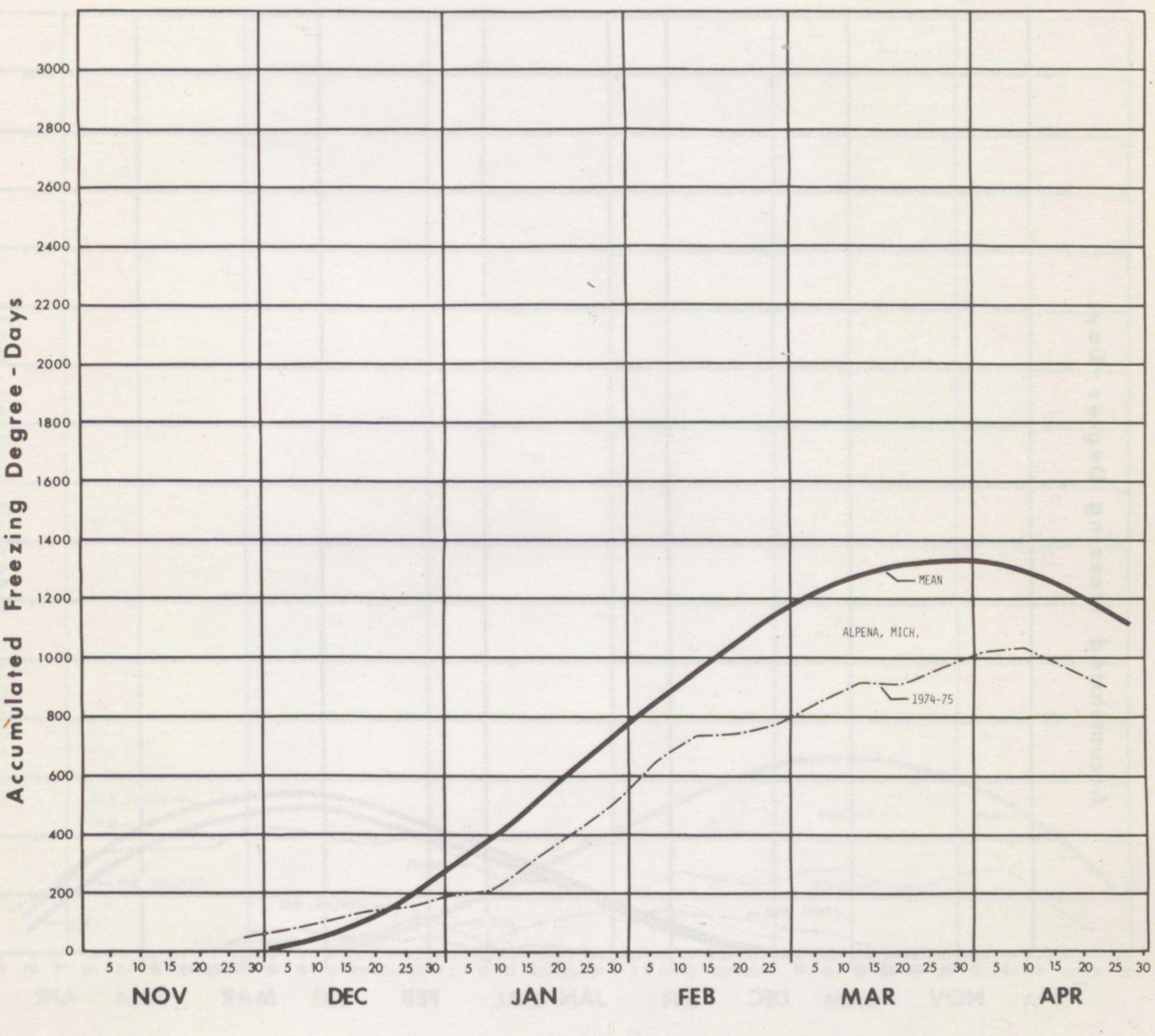

Figure A.3. Accumulated freezing degree-days - Lake Huron at Alpena, Mich.

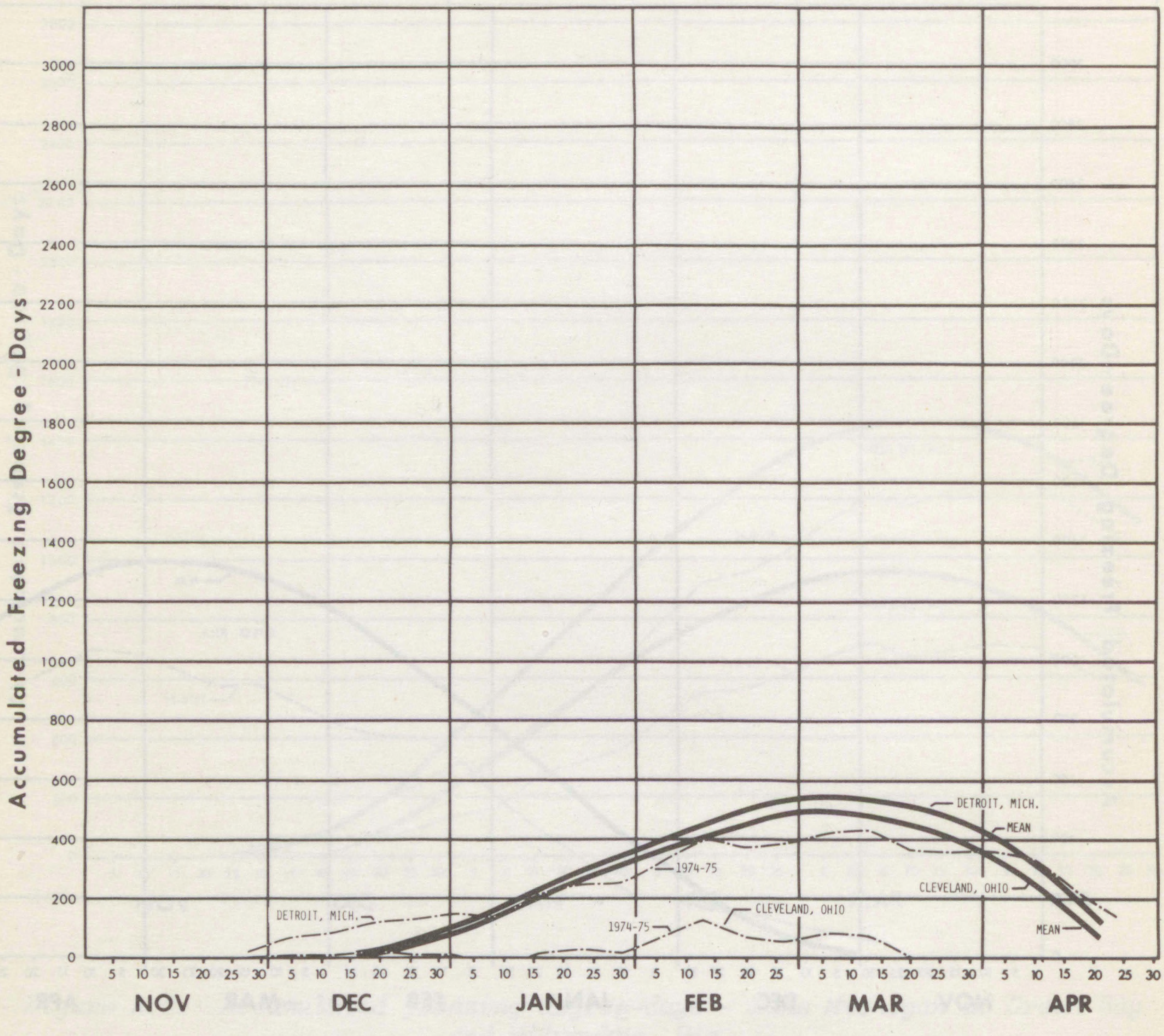

Figure A.4. Accumulated freezing degree-days - Lakes St. Clair and Erie at Detroit, Mich., and Cleveland, Ohio.

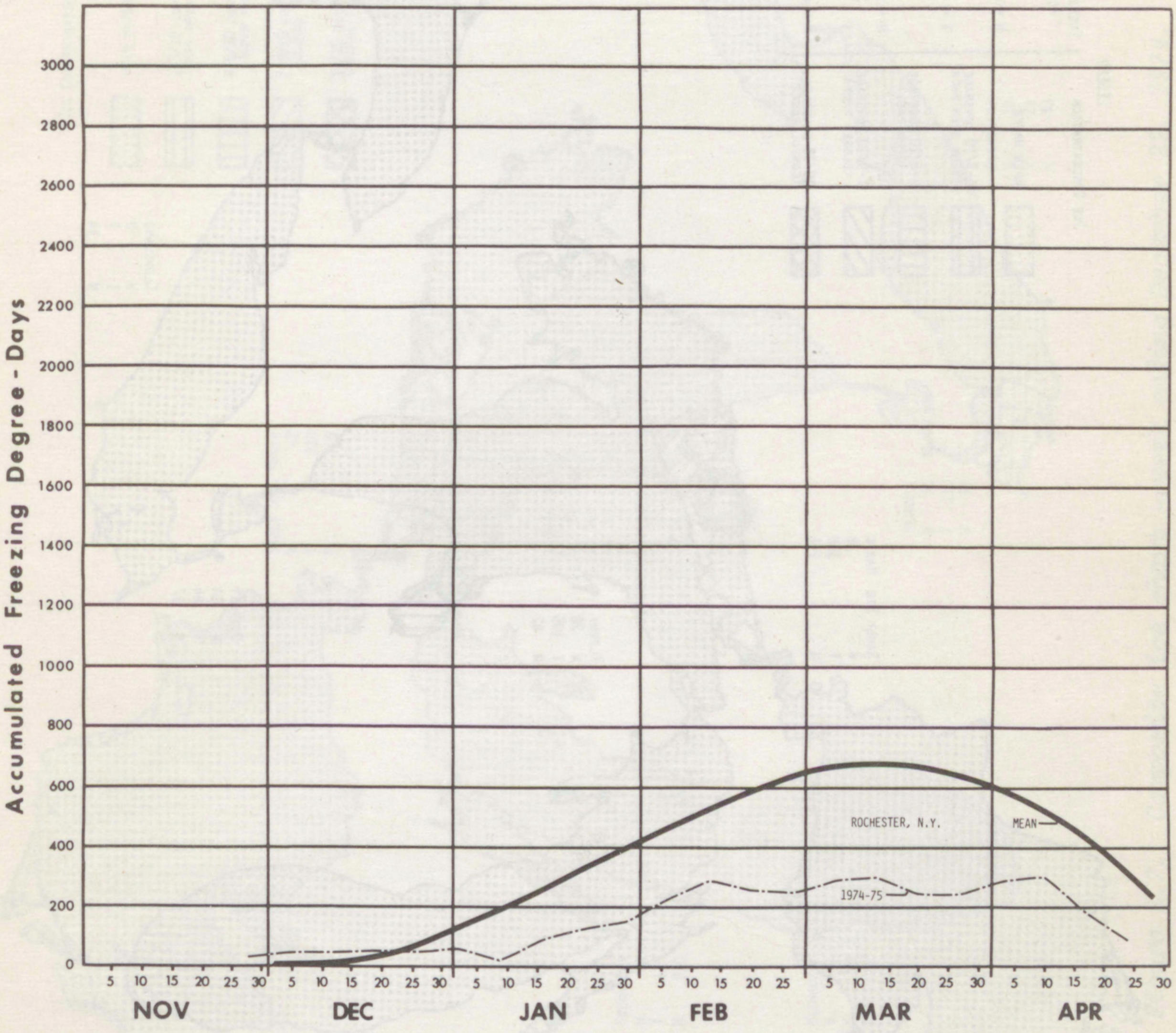

Figure A.5. Accumulated freezing degree-days - Lake Ontario at Rochester, N.Y.

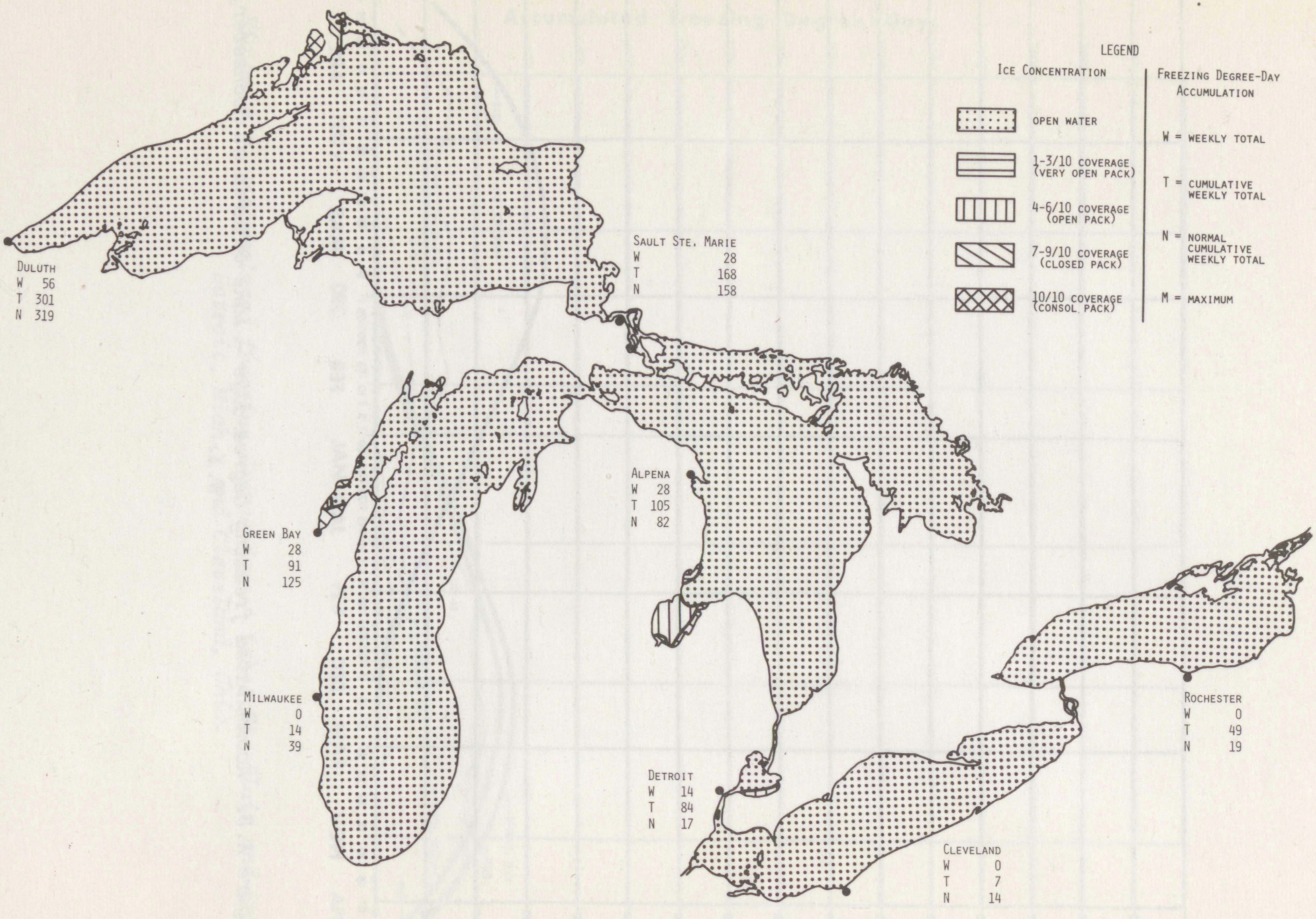

Figure A.6. Composite ice chart - week ending December 15, 1974.

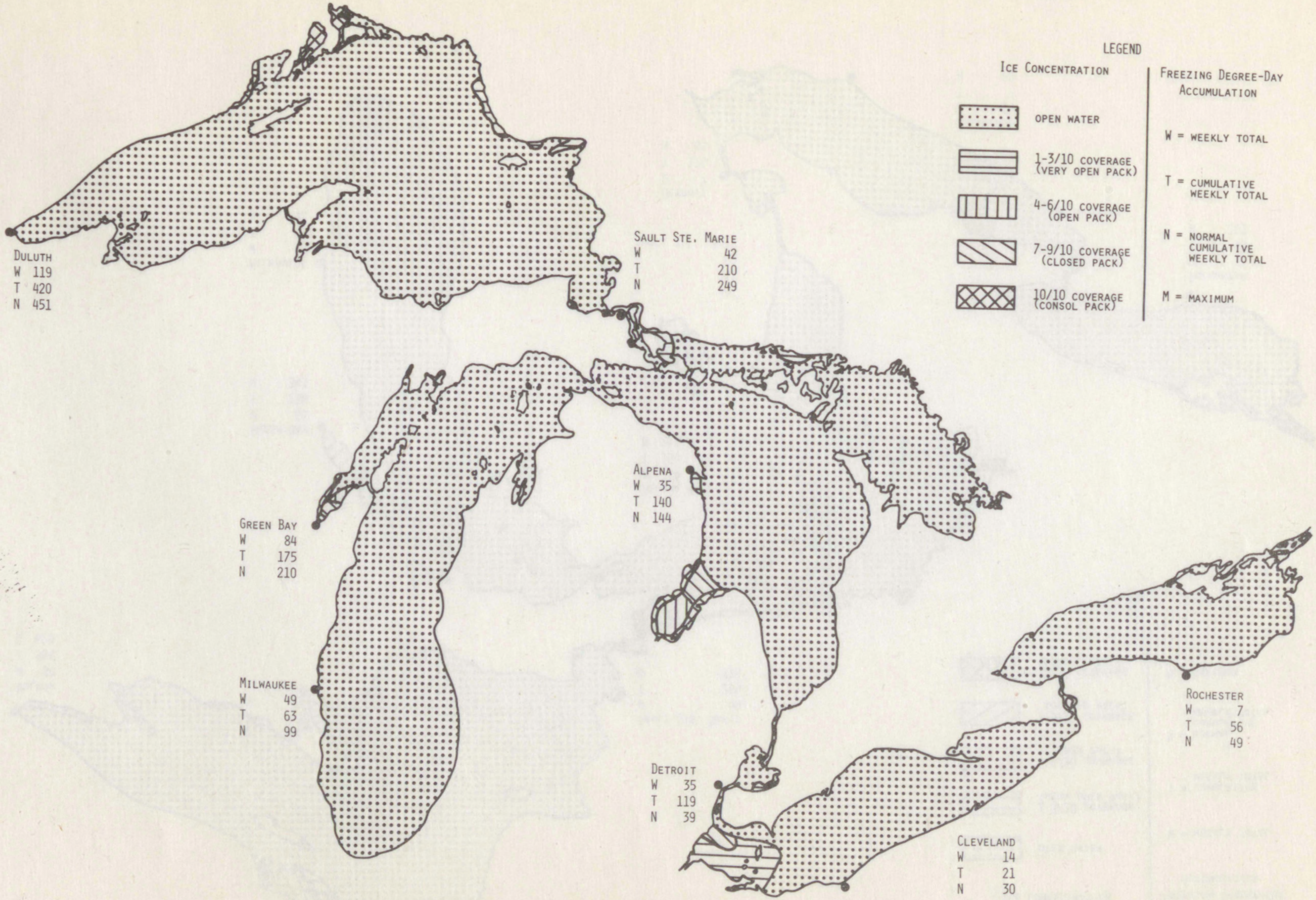

Figure A.7. Composite ice chart - week ending December 22, 1974.

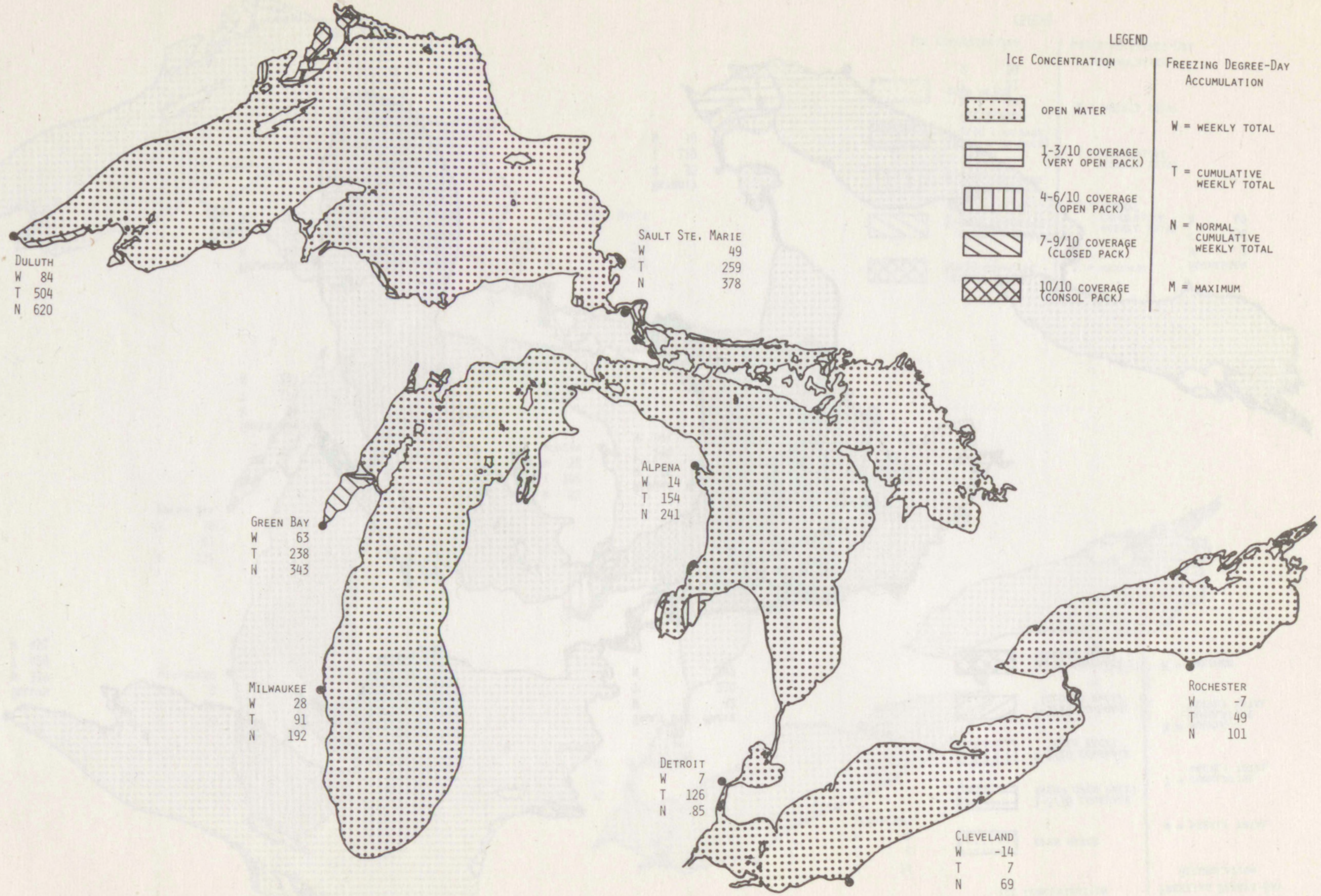

Figure A.8. Composite ice chart - week ending December 29, 1974.

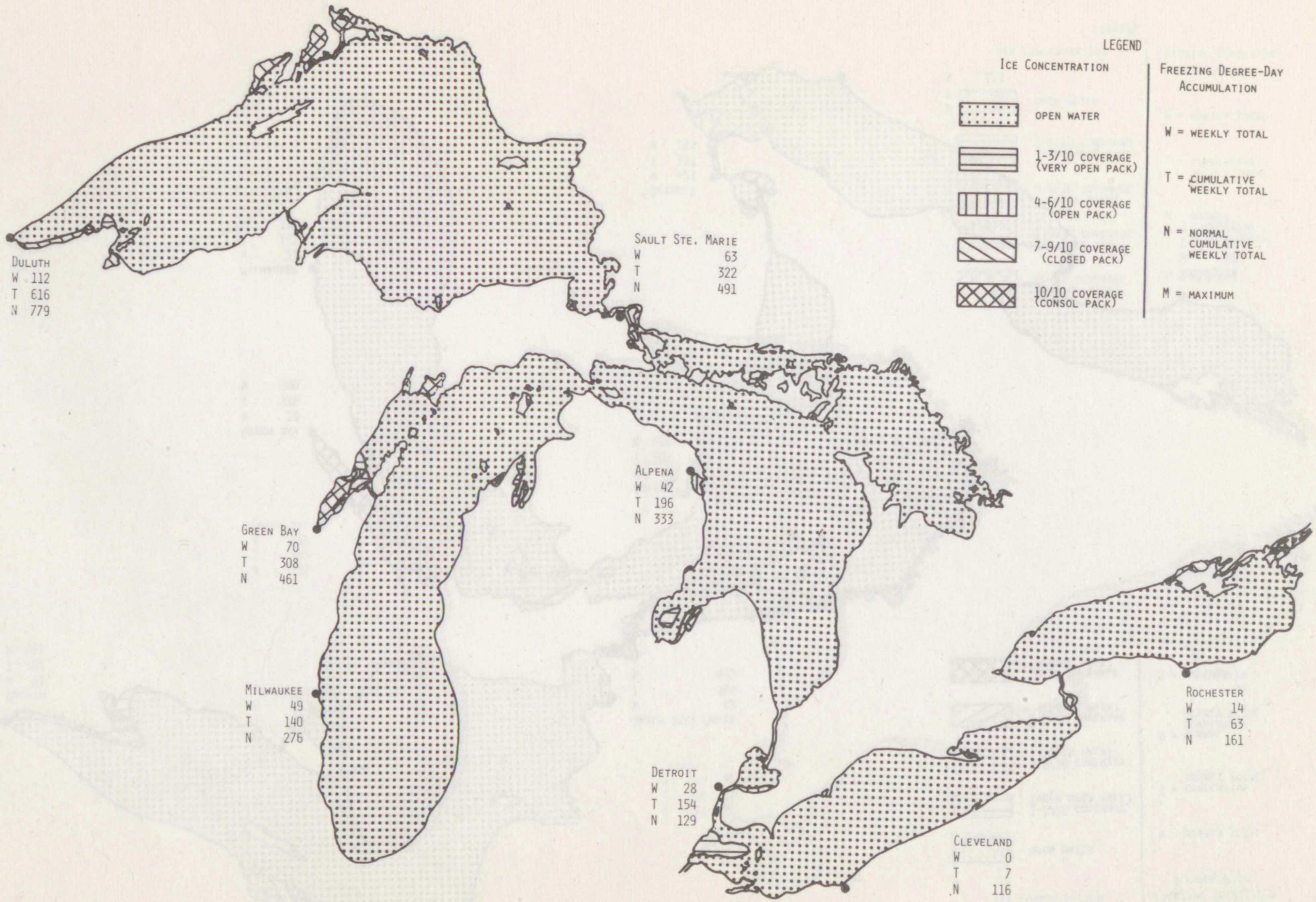

Figure A.9. Composite ice chart - week ending January 5, 1975.

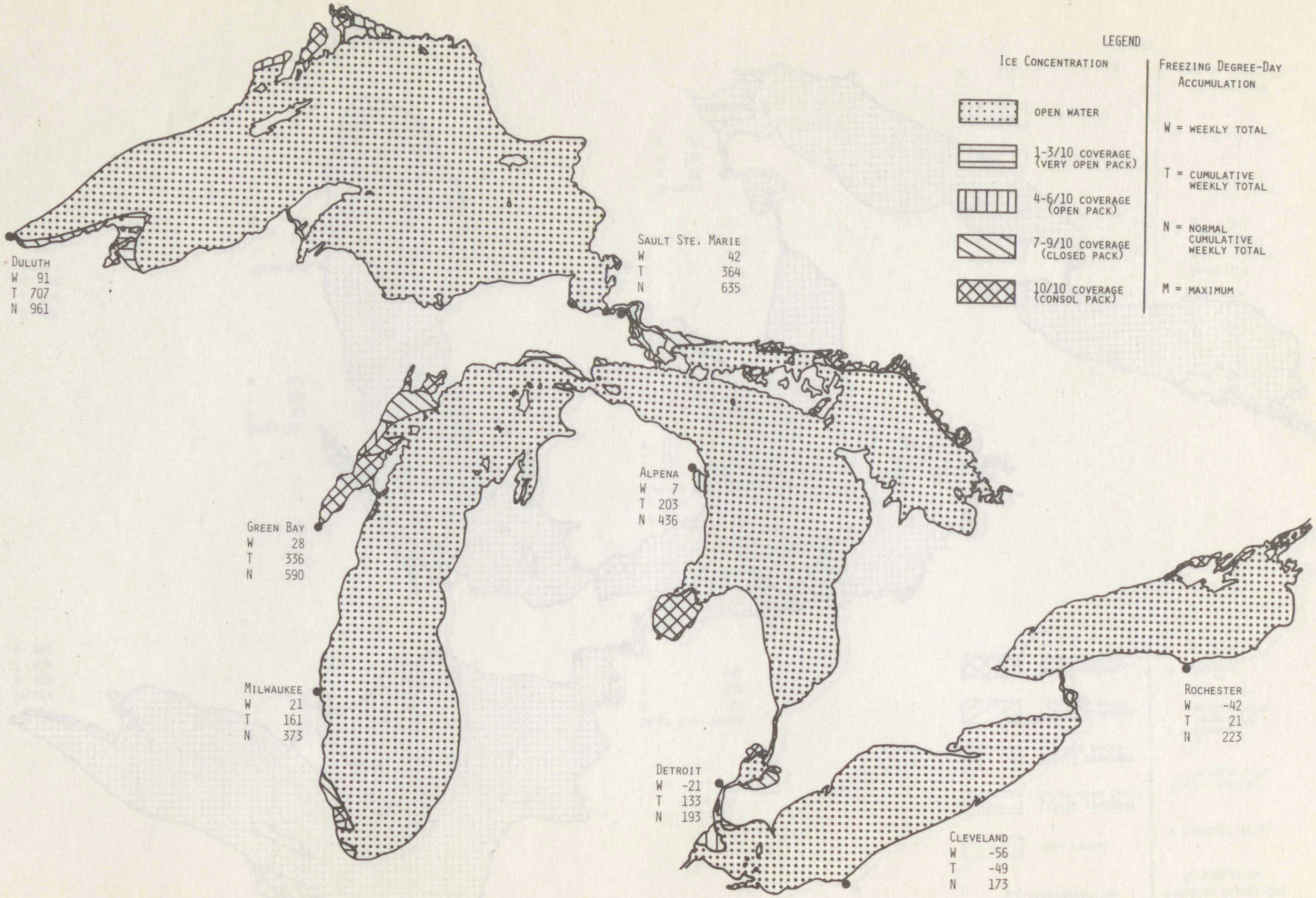

Figure A.10. Composite ice chart - week ending January 12, 1975.

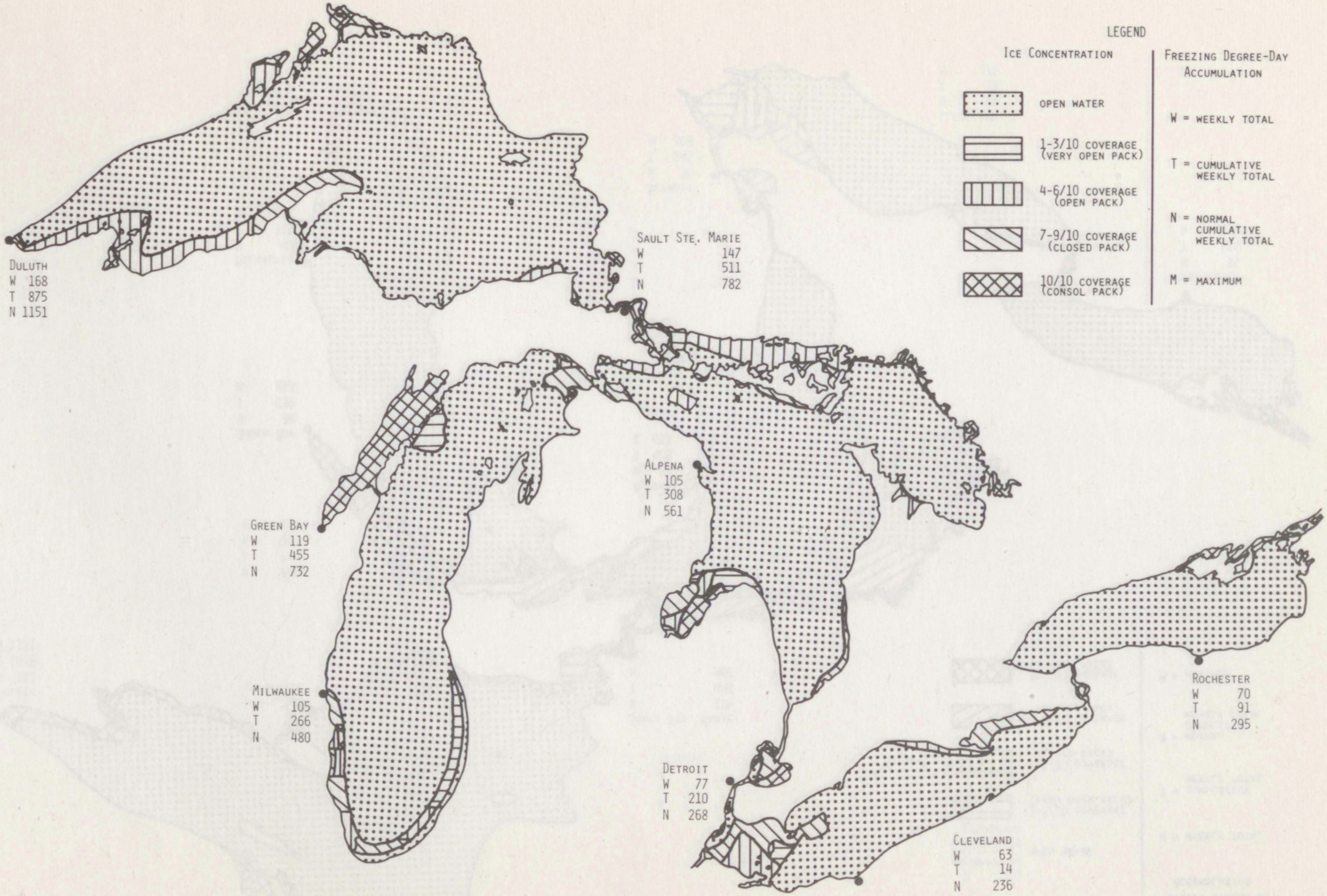

Figure A.11. Composite ice chart - week ending January 19, 1975.

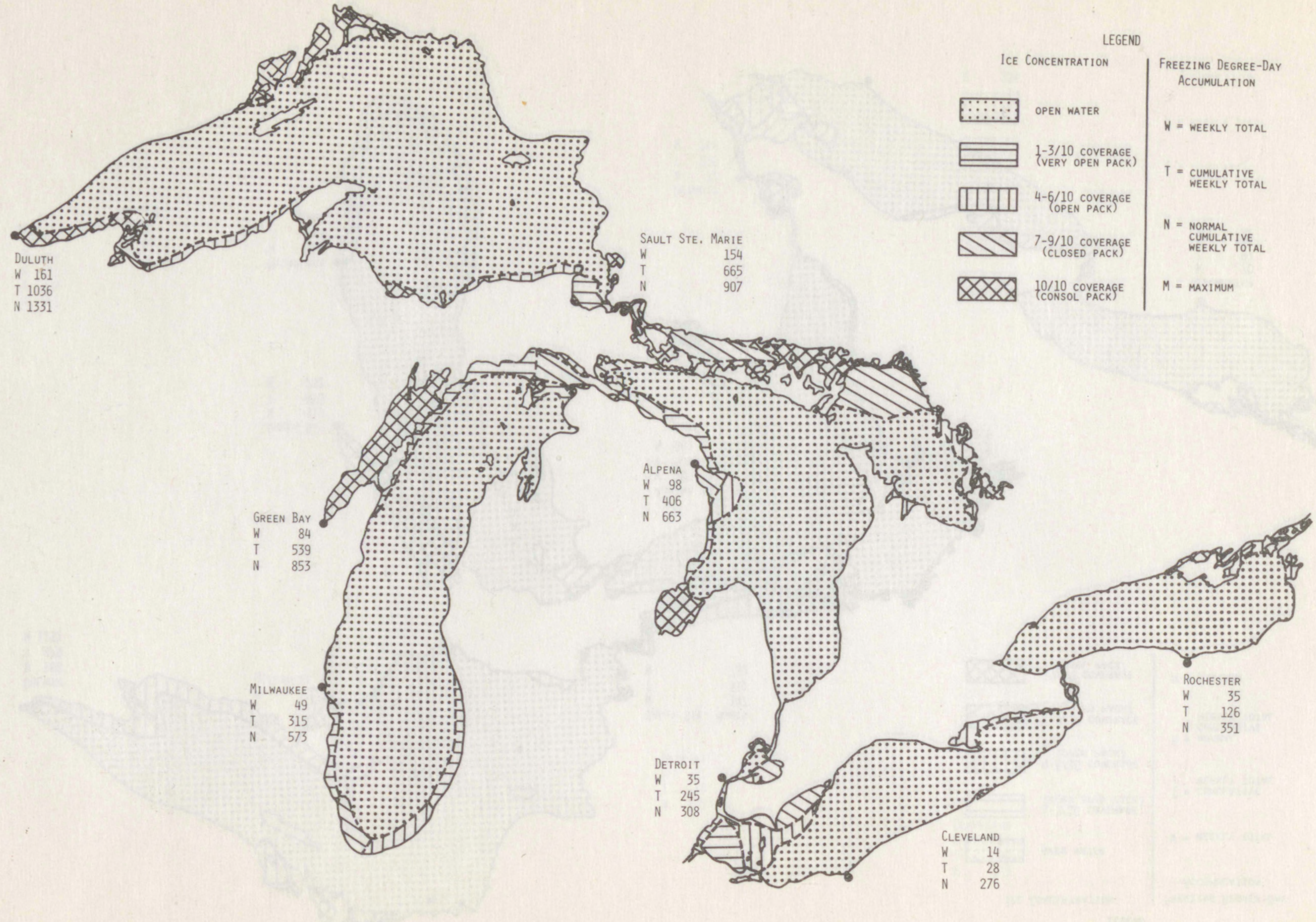

Figure A.12. Composite ice chart - week ending January 26, 1975.

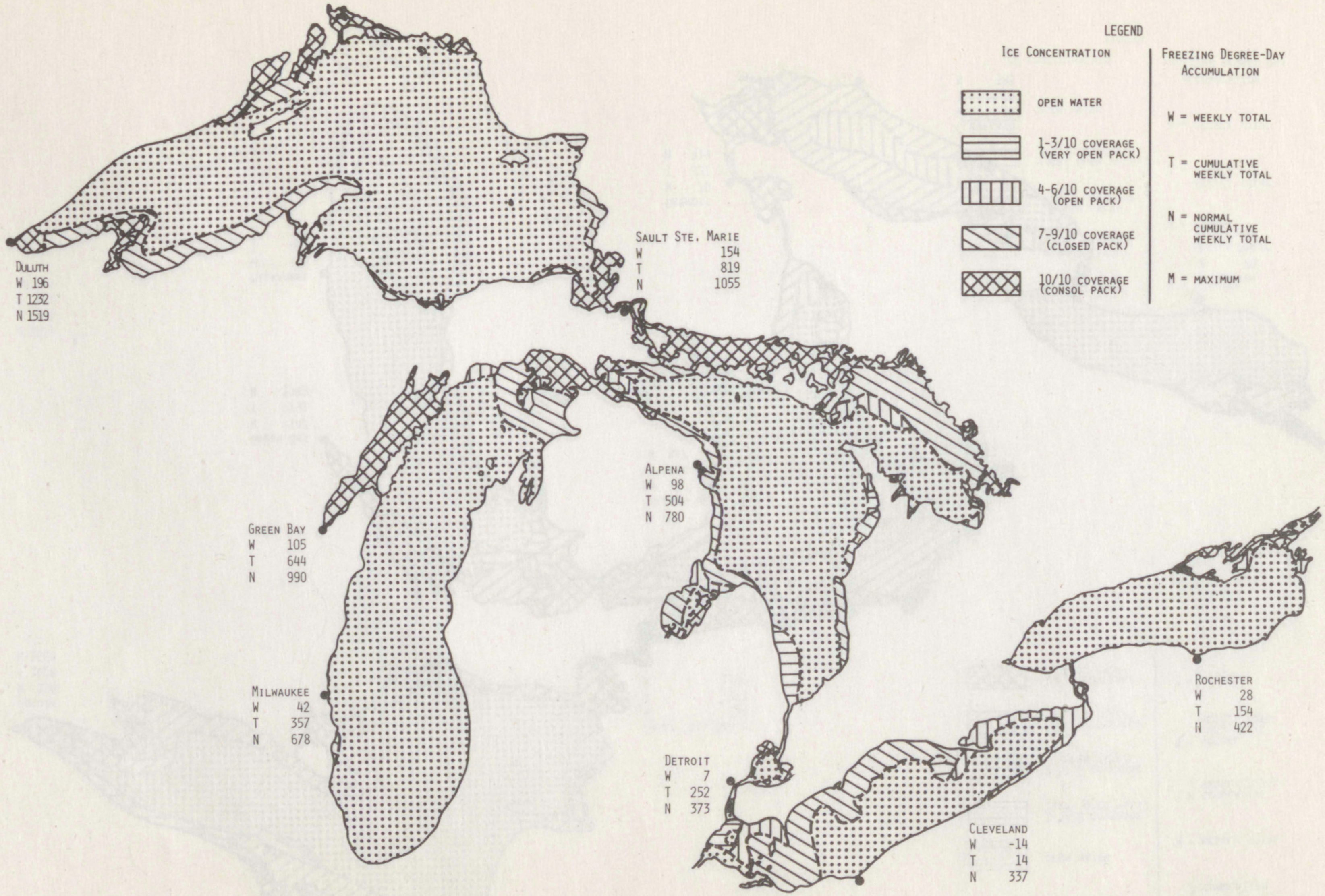

Figure A.13. Composite ice chart - week ending February 2, 1975.

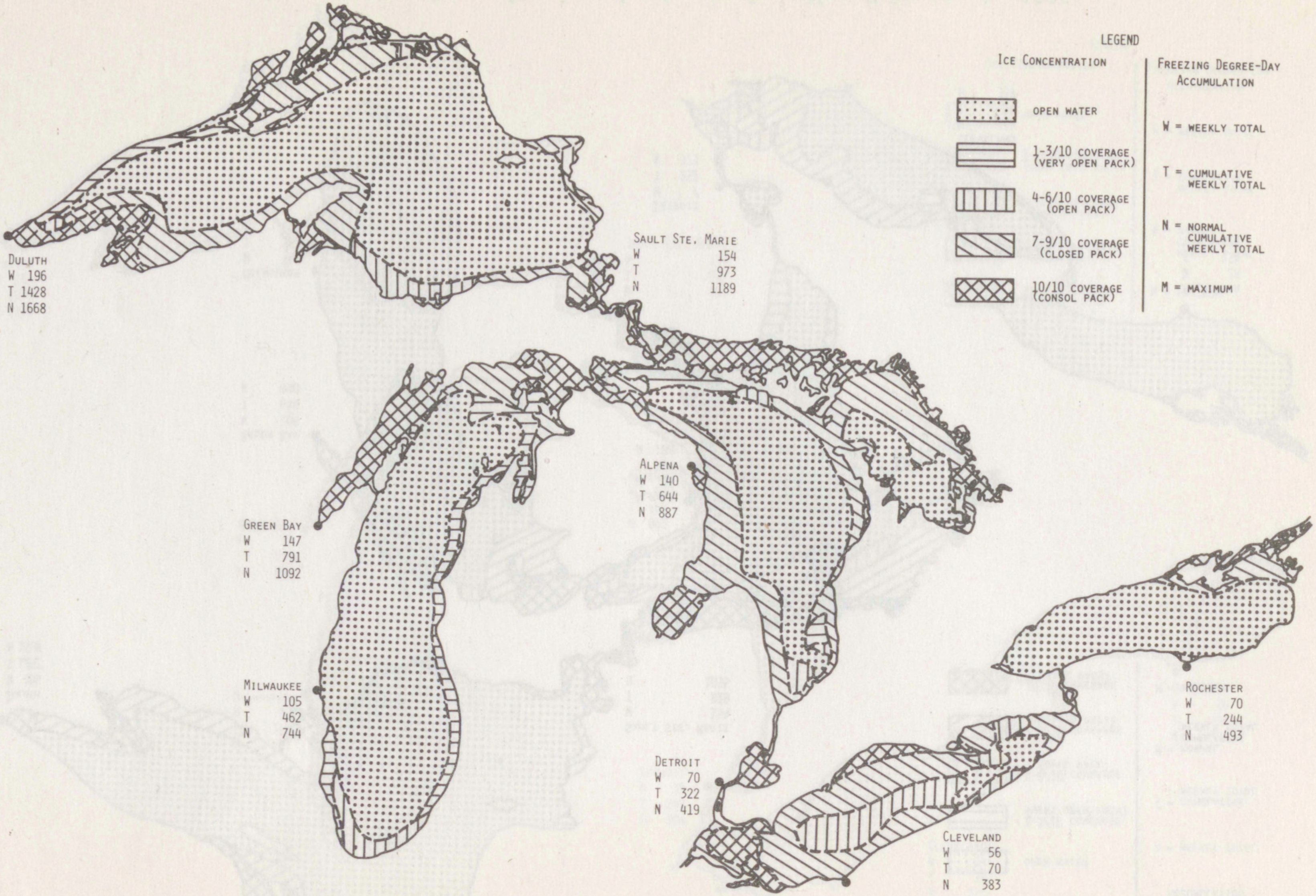

Figure A.14. Composite ice chart - week ending February 9, 1975.

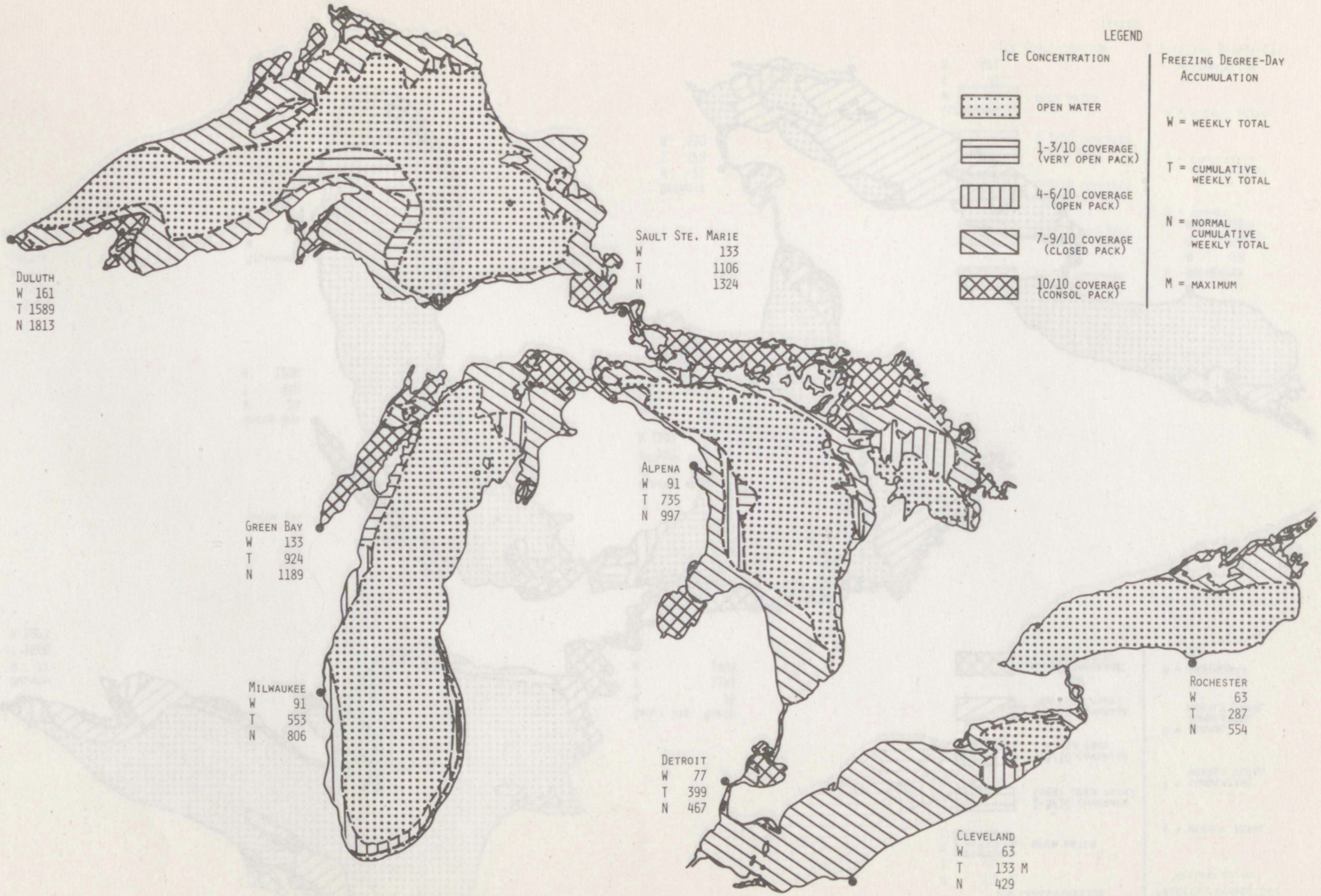

Figure A.15. Composite ice chart - week ending February 16, 1975.

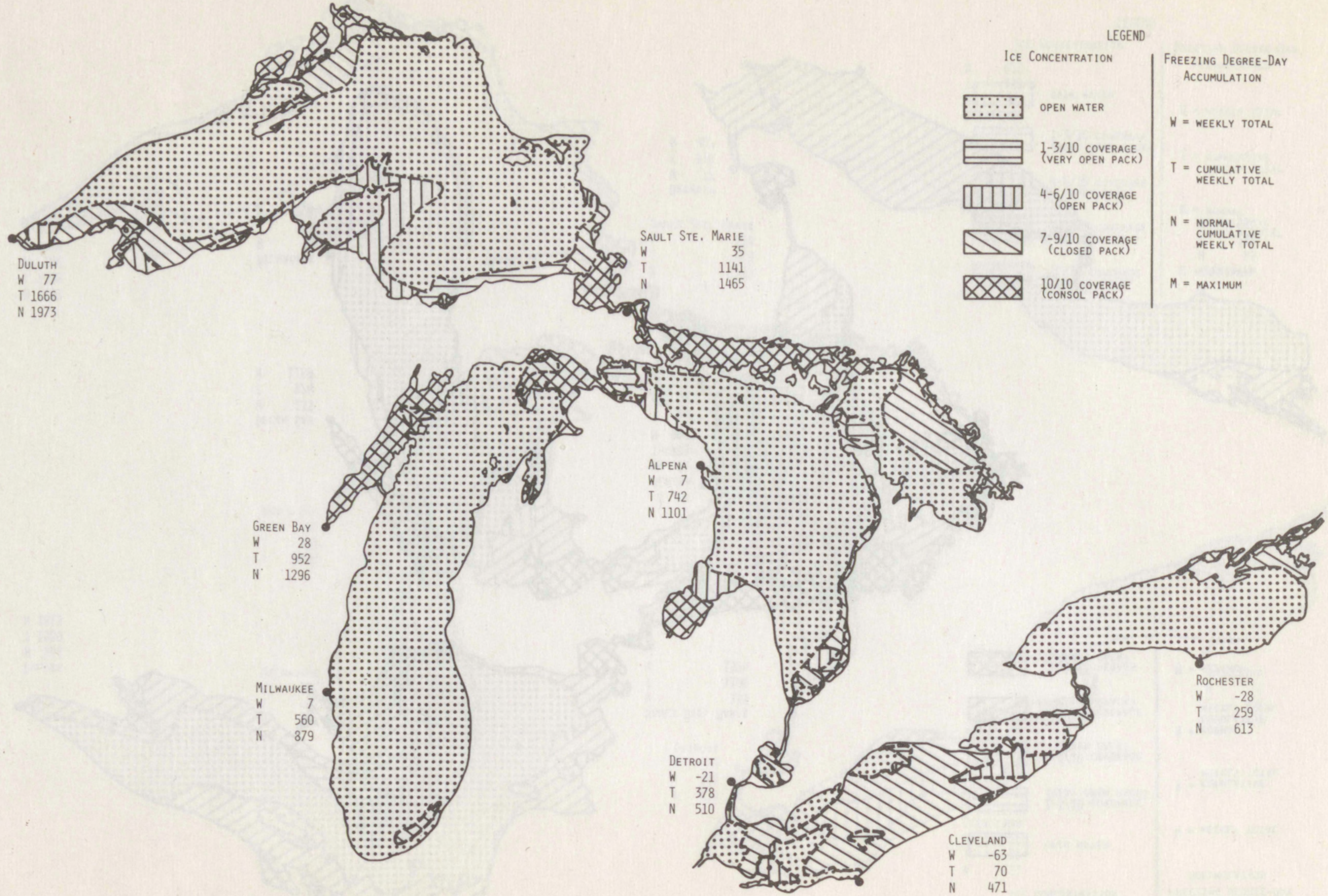

Figure A.16. Composite ice chart - week ending February 23, 1975.

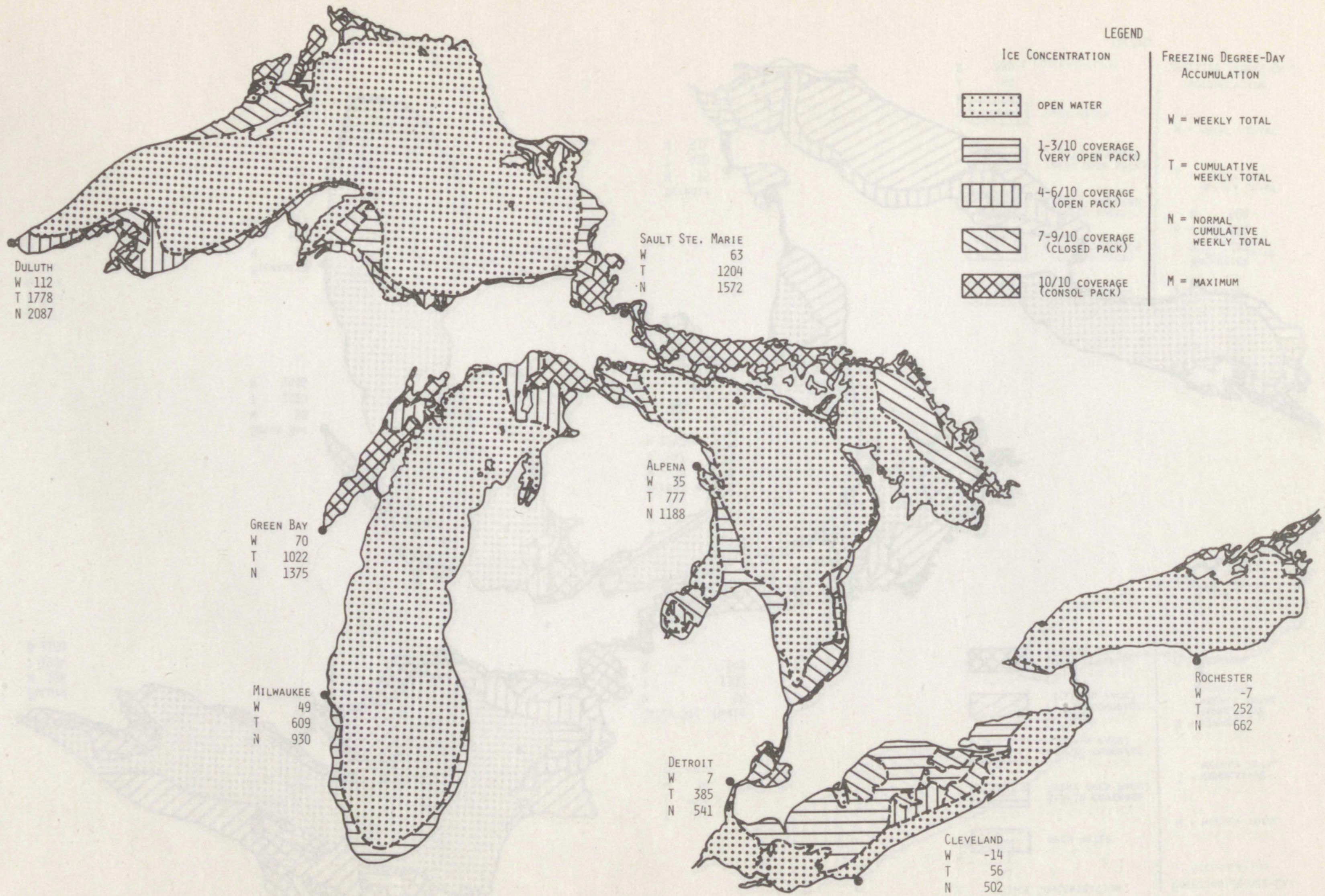

Figure A.17. Composite ice chart - week ending March 2, 1975.

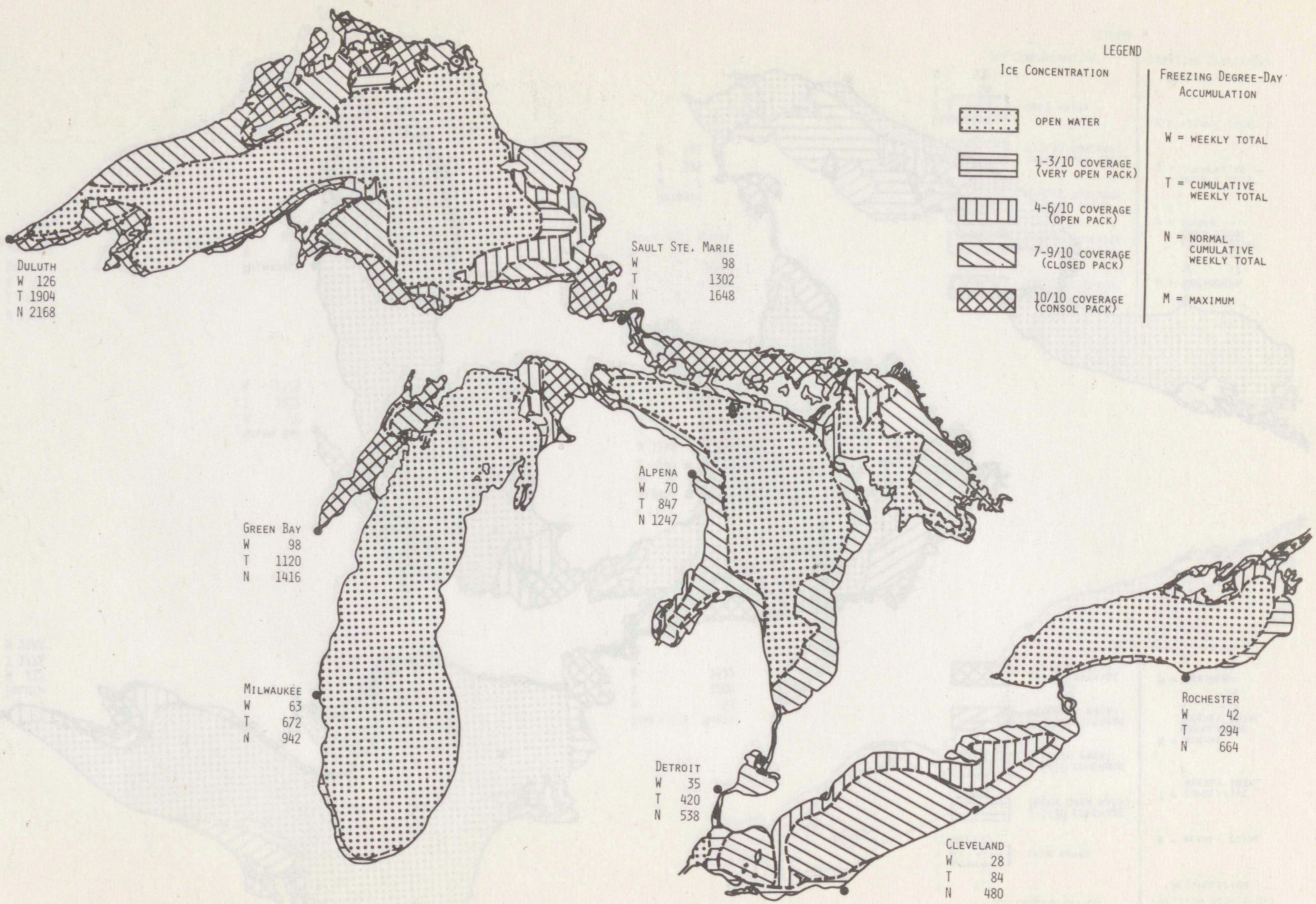

Figure A.18. Composite ice chart - week ending March 9, 1975.

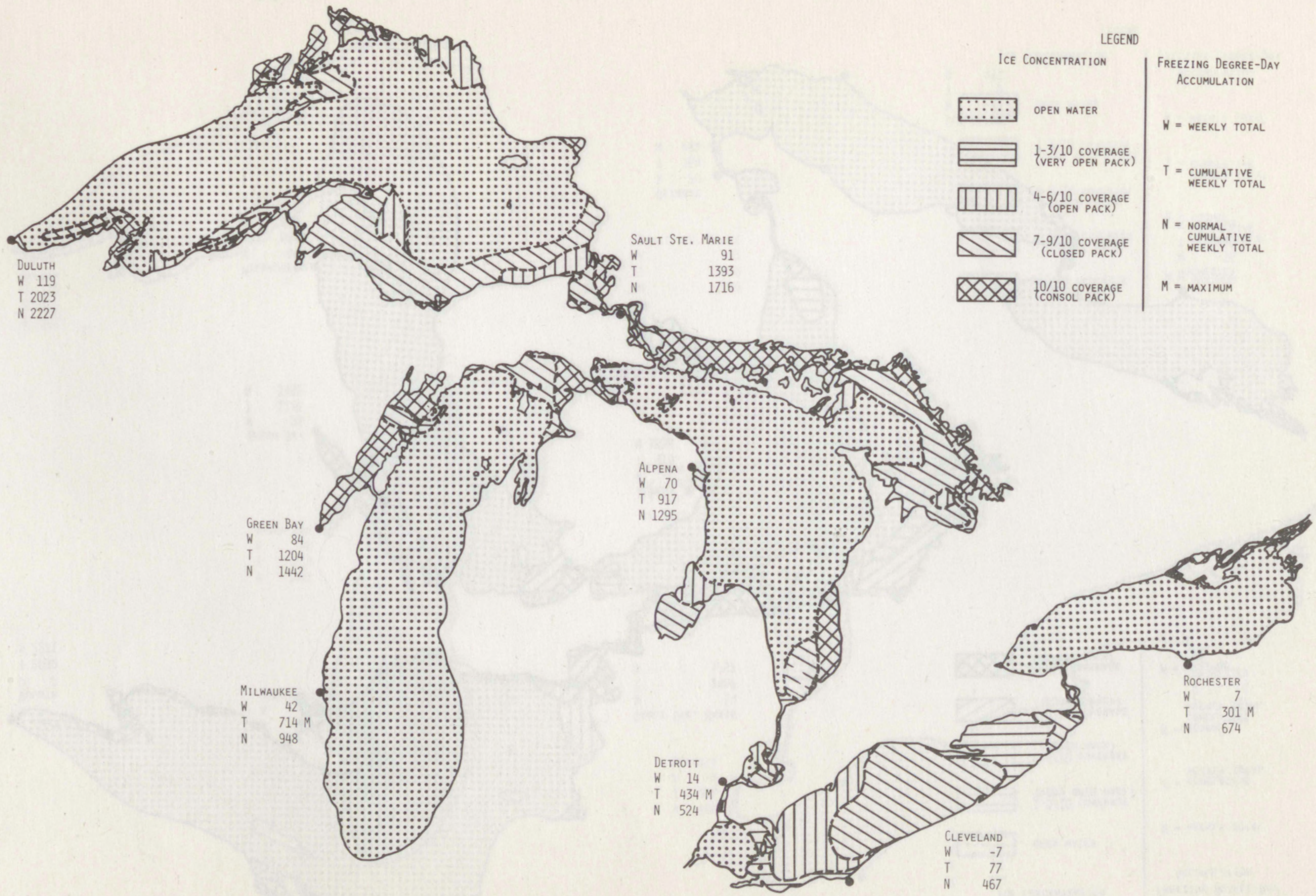

Figure A.19. Composite ice chart - week ending March 16, 1975.

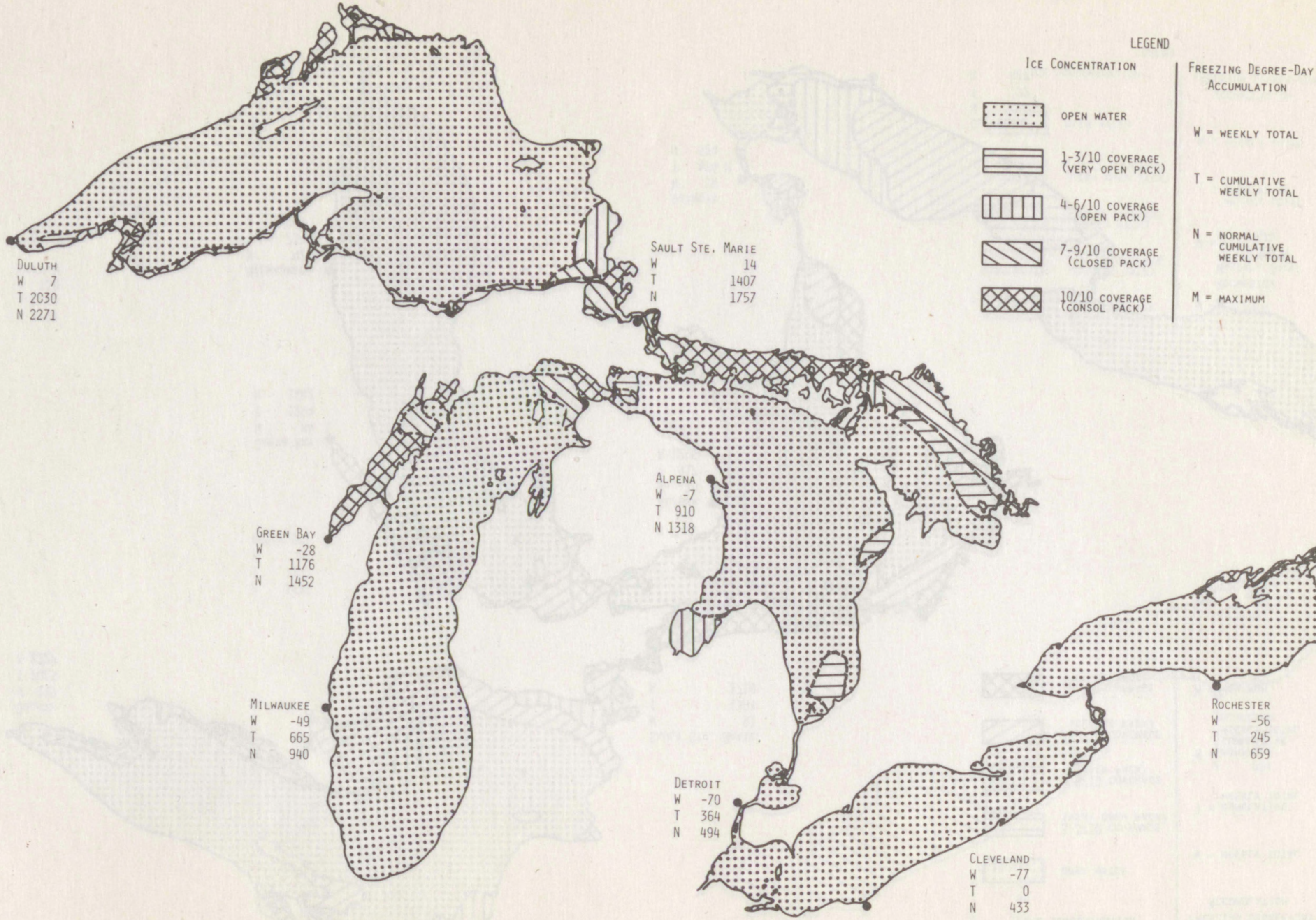

Figure A.20. Composite ice chart - week ending March 23, 1975.

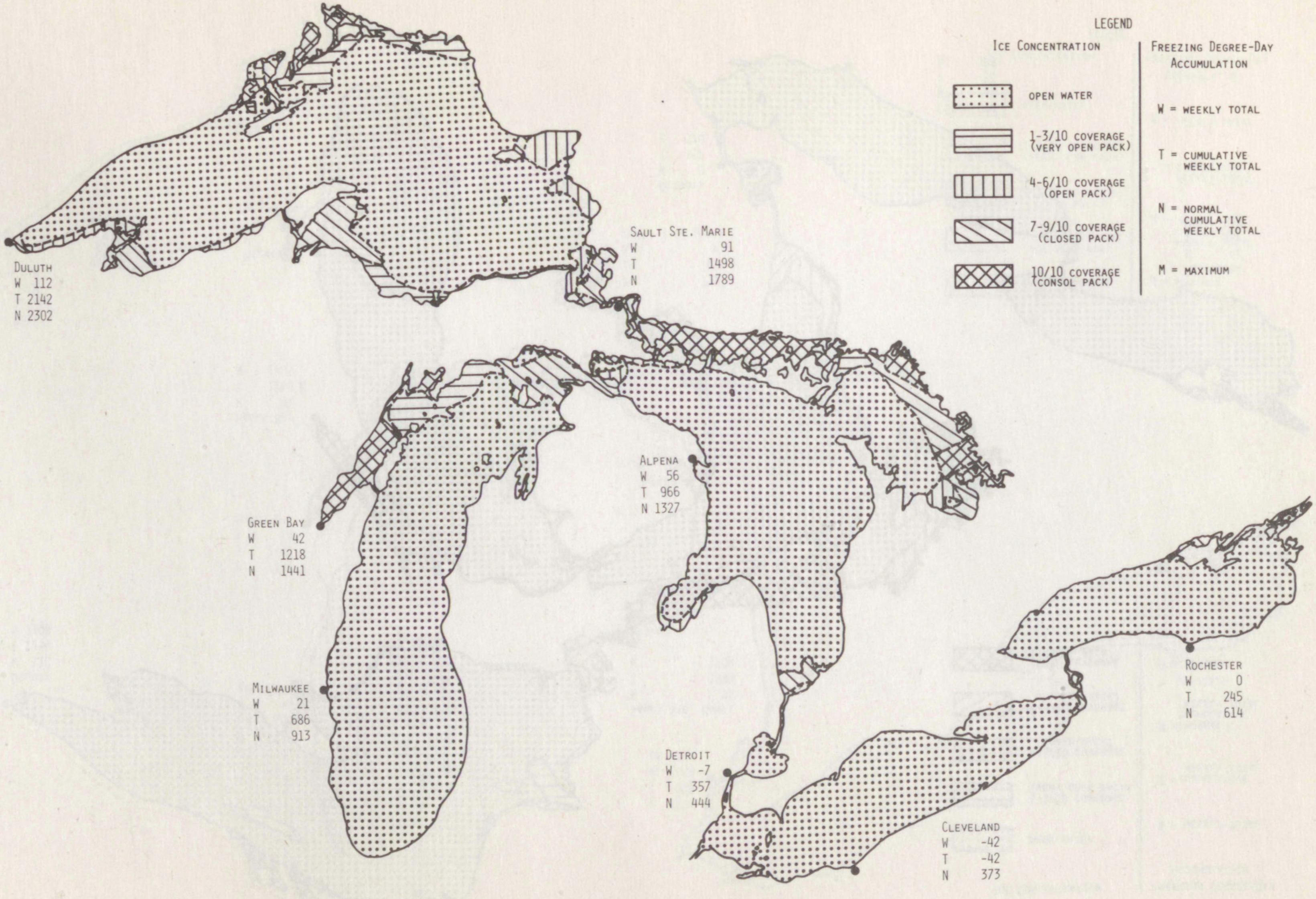

Figure A.21. Composite ice chart - week ending March 30, 1975.

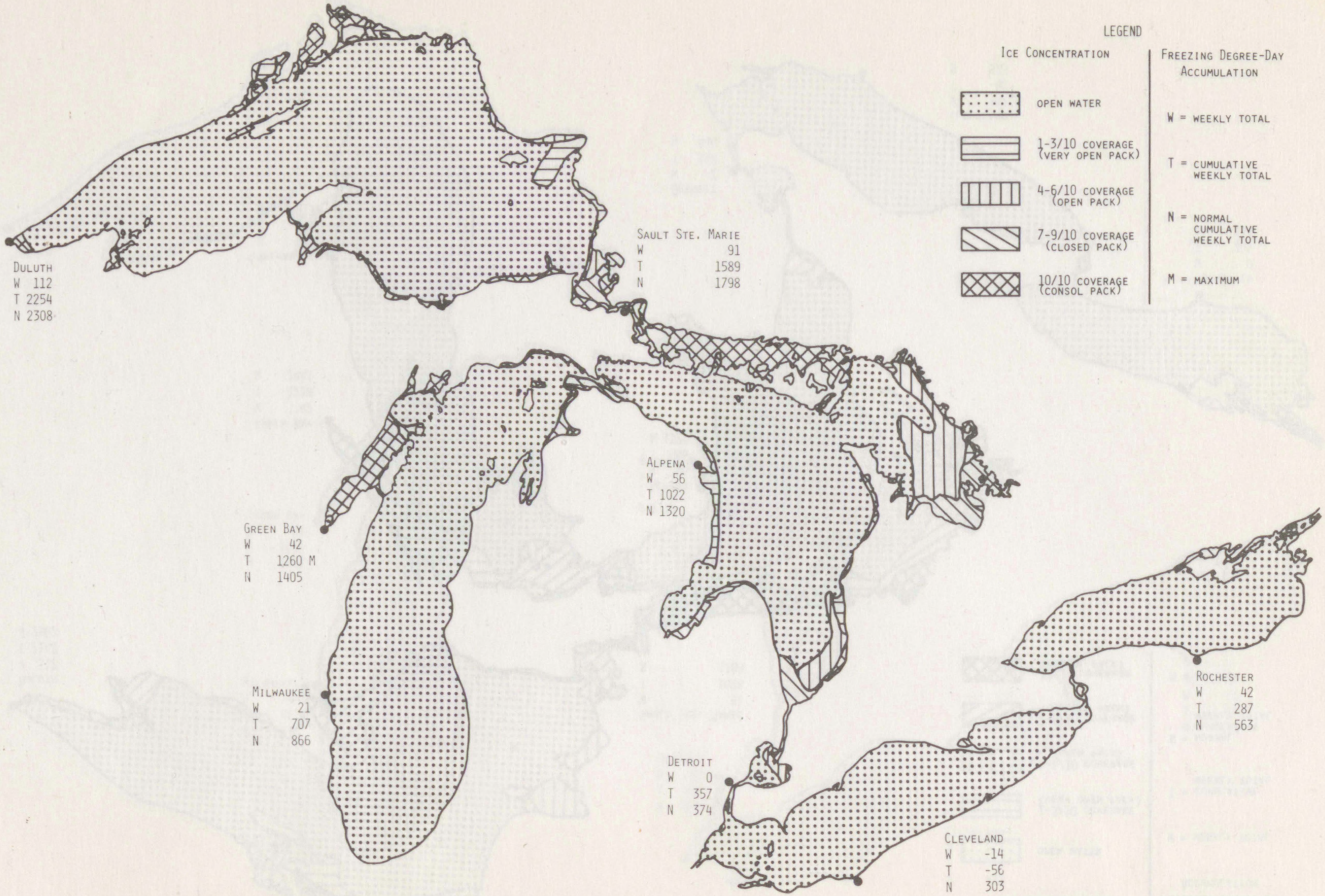

Figure A.22. Composite ice chart - week ending April 6, 1975.

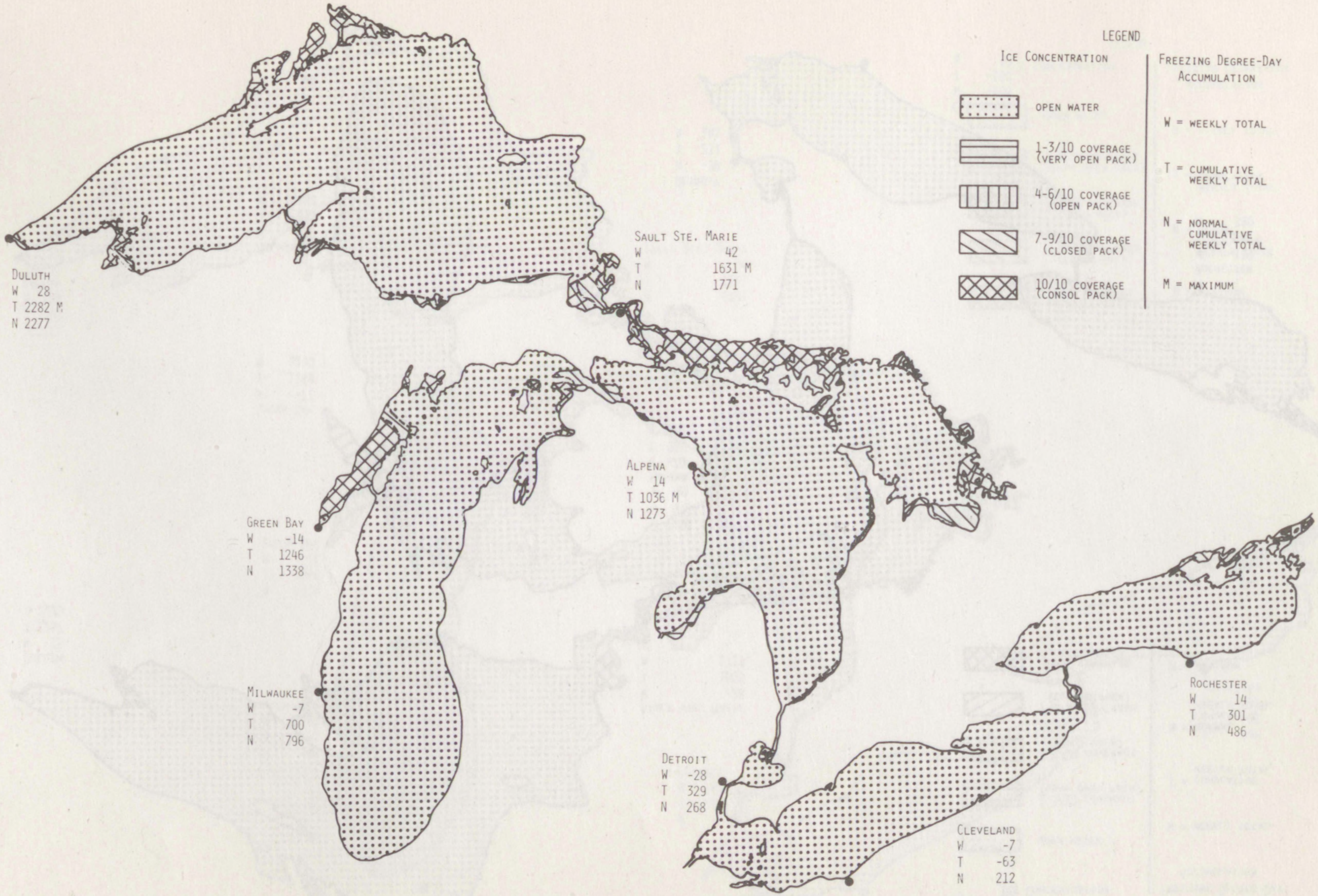

Figure A.23. Composite ice chart - week ending April 13, 1975.

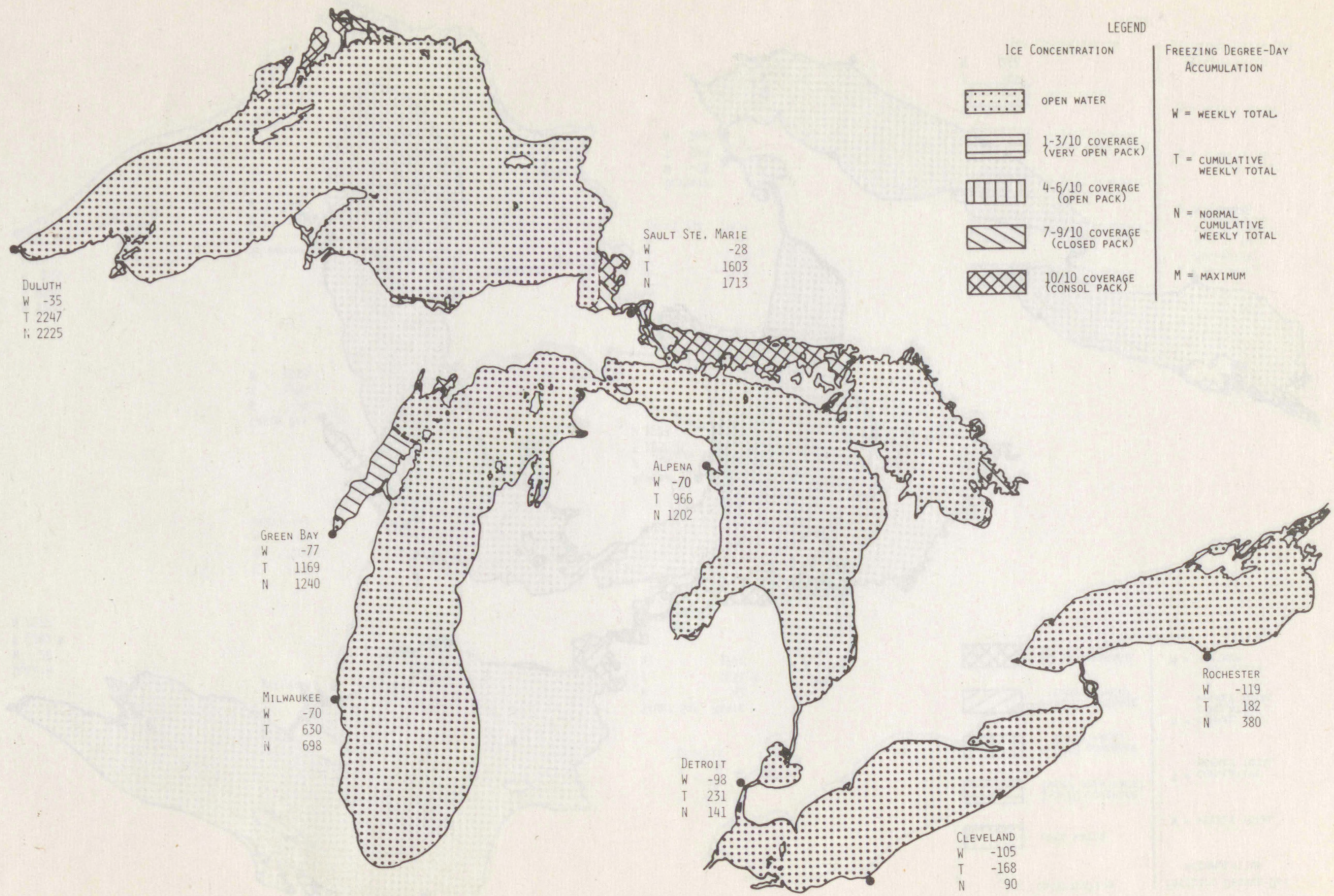

Figure A.24. Composite ice chart - week ending April 20, 1975.

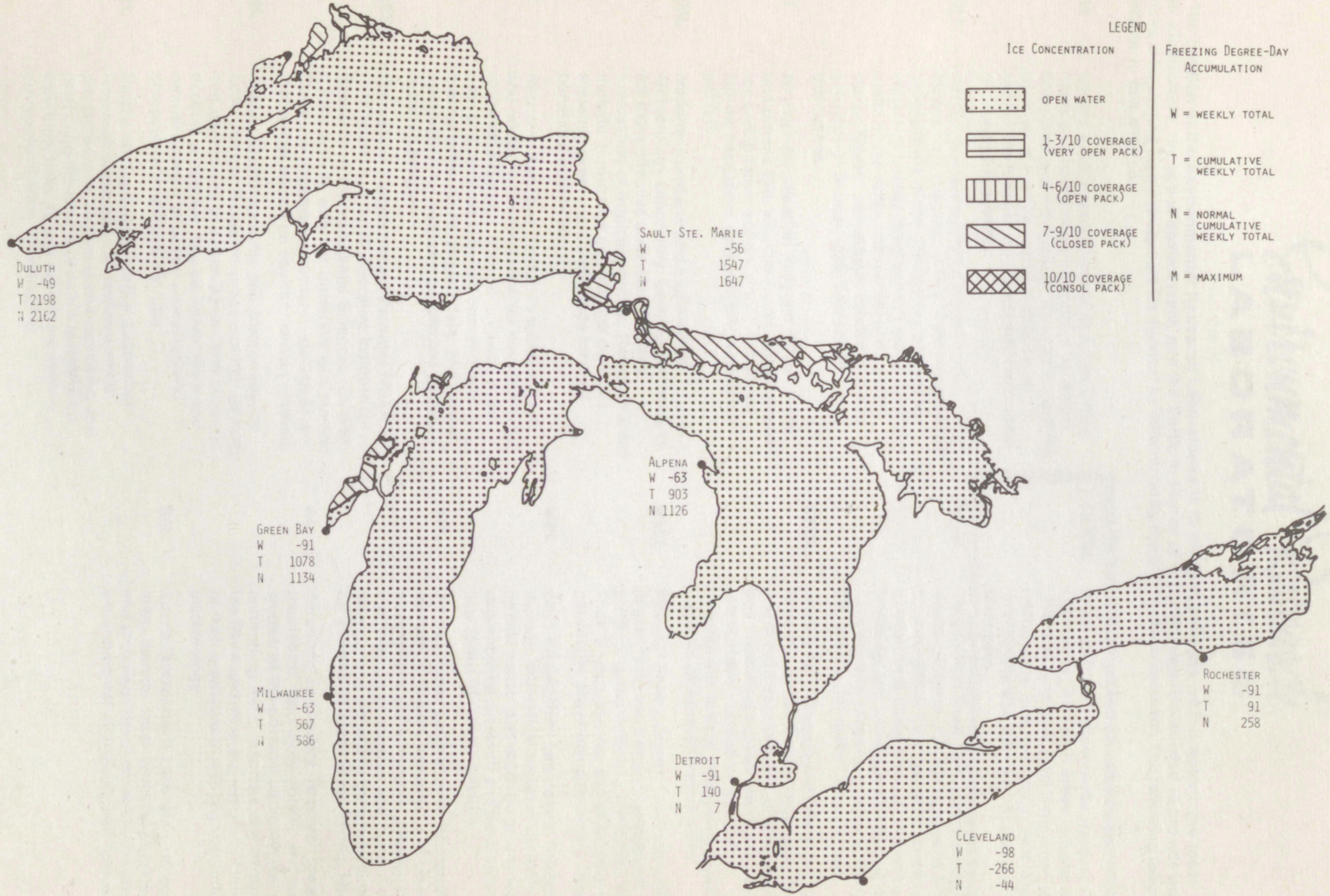

Figure A.25. Composite ice chart - week ending April 27, 1975.

✫ U.S. Government Printing Office: 1976-677-347/1282 Region 8

Environmental Research LABORATORIES

The mission of the Environmental Research Laboratories is to study the oceans, inland waters, the lower and upper atmosphere, the space environment, and the Earth, in search of the understanding needed to provide more useful services in improving man's prospects for survival as influenced by the physical environment. The following laboratories contribute to this mission.

MESA *Marine EcoSystems Analysis Program Office.* Plans and coordinates regional programs of basic and applied research directed toward the solution of environmental problems which involve the functioning, health and restoration of marine ecosystems.

OCSEA *Outer Continental Shelf Environmental Assessment Program Office.* Plans and directs assessments of the primary environmental impact of energy development along broad areas of the outer continental shelf of the United States; coordinates related research activities of federal, state and private institutions.

W/M *Weather Modification Program Office.* Plans and directs ERL weather modification research for precipitation enhancement and severe storms mitigation; operates ERL's research aircraft.

NHEML *National Hurricane and Experimental Meteorology Laboratory.* Develops techniques for more effective understanding and forecasting of tropical weather. Research areas include: hurricanes and tropical cumulus systems; experimental methods for their beneficial modification.

RFC *Research Facilities Center.* Provides aircraft and related instrumentation for environmental research programs. Maintains liaison with user and provides required operations or measurement tools, logged data, and related information for airborne or selected surface research programs.

(CIRES) *Theoretical Studies Group.* Provides NOAA participation in the Cooperative Institute for Research in Environmental Sciences (CIRES), a joint activity with the University of Colorado. Conducts cooperative research studies of a theoretical nature on environmental problems.

AOML *Atlantic Oceanographic and Meteorological Laboratories.* Research areas include: geology and geophysics of ocean basins and borders, oceanic processes, sea-air interactions and remote sensing of ocean processes and characteristics (Miami, Florida).

PMEL *Pacific Marine Environmental Laboratory.* Research areas include: environmental processes with emphasis on monitoring and predicting the effects of man's activities on estuarine, coastal, and near-shore marine processes (Seattle, Washington).

GLERL *Great Lakes Environmental Research Laboratory.* Research areas include: physical, chemical, and biological limnology; lake-air interactions, lake hydrology, lake level forecasting, and lake ice studies (Ann Arbor, Michigan).

GFDL *Geophysical Fluid Dynamics Laboratory.* Research areas include: dynamics and physics of geophysical fluid systems; development of a theoretical basis, through mathematical modeling and computer simulation, for the behavior and properties of the atmosphere and the oceans (Princeton, New Jersey).

APCL *Atmospheric Physics and Chemistry Laboratory.* Research areas include: processes of cloud and precipitation physics; chemical composition and nucleating substances in the lower atmosphere; laboratory and field experiments toward developing feasible methods of weather modification.

NSSL *National Severe Storms Laboratory.* Research is directed toward improved methods of predicting and detecting tornadoes, squall lines, thunderstorms, and other severe local convective phenomena (Norman, Oklahoma).

WPL *Wave Propagation Laboratory.* Research areas include: theoretical research on radio waves, optical waves, and acoustic gravity waves; experimental research and development on new forms of remote sensing.

ARL *Air Resources Laboratories.* Research areas include: diffusion, transport, and dissipation of atmospheric contaminants; development of methods for prediction and control of atmospheric pollution; geophysical monitoring for climatic change (Silver Spring, Maryland).

AL *Aeronomy Laboratory.* Research areas include: theoretical, laboratory, rocket, and satellite studies of the physical and chemical processes controlling the ionosphere and exosphere of the Earth and other planets, and of the dynamics of their interactions with high-altitude meteorology.

SEL *Space Environment Laboratory.* Research areas include: solar-terrestial physics, service and technique development in the areas of environmental monitoring and forecasting.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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