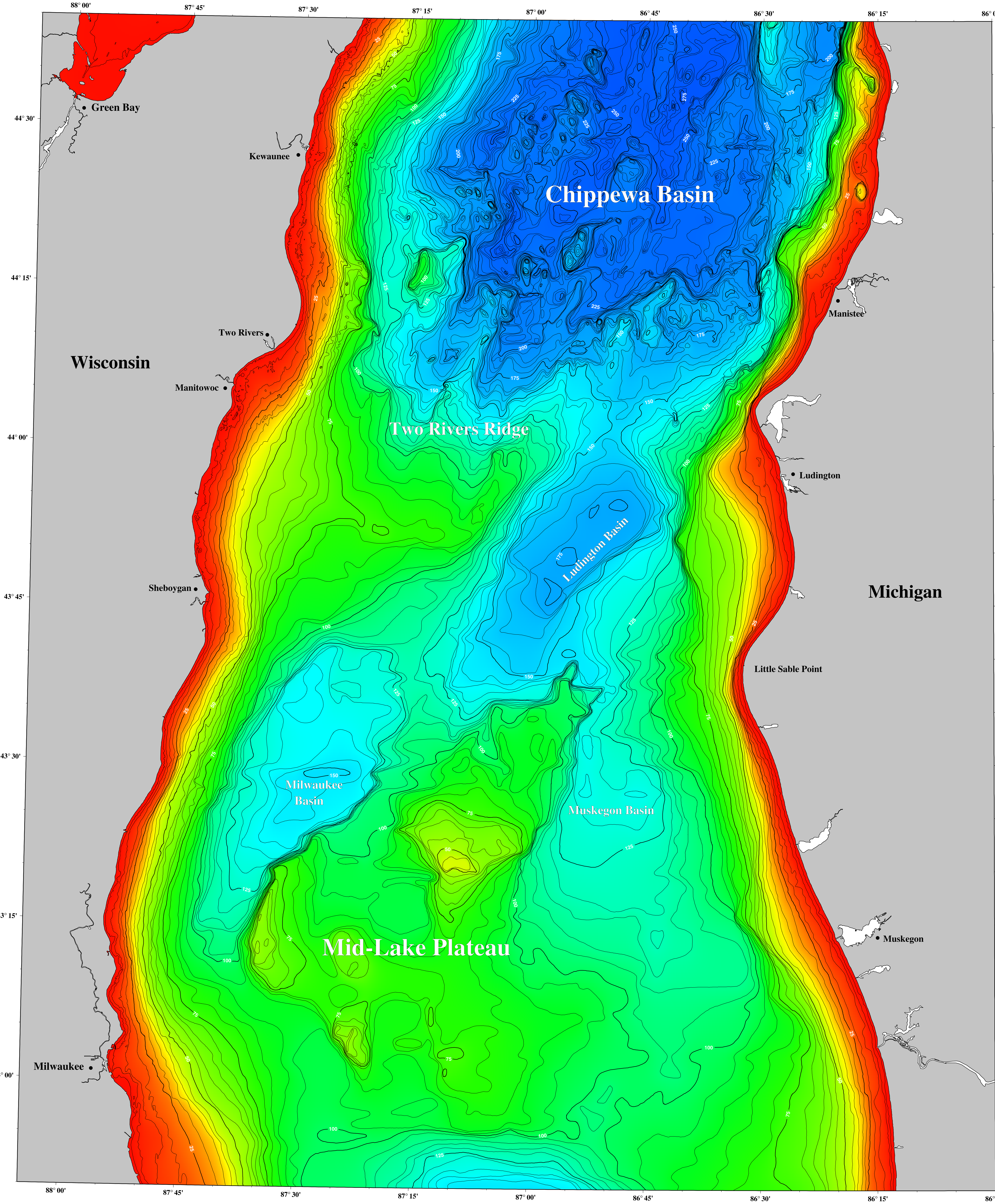

0 (176.8) | 50 (126.8) | 100 (76.8) | 150 (26.8) | 200 (-23.2) | 250 (-73.2)

Depth in Meters (Altitude)

Bathymetry of Lake Michigan

T.L. Holcombe[1], D.F. Reid[2], W.T. Virden[3], T.C. Niemeyer[3,4], R. De la Sierra[5], and D.L. Divins[3]

Contour Interval: 5 meters   Transverse Mercator Projection   Scale 1:250,000

km: 0 10 20 30   miles: 0 10 20 30

ABSTRACT

Bathymetry of Lake Michigan has been compiled utilizing the entire historic sounding data base. Bathymetric contours were scanned and vectorized to geographic coordinates from scale 1:250000 compilation sheets. This bathymetry resolves physiography of the lake floor to the extent that known features are revealed more accurately, and features never before seen are revealed for the first time. The Mackinac Channel, a subaerial river channel which drained Lake Chippewa, has a sill depth of about 30m and extends from north of Garden Island eastward through the Straits of Mackinac. A drowned fan lying at depths of 50 to 60m dominates the lake floor east of Washington Island. A large drowned river channel leads upstream from this fan, across the floor of Green Bay and into Little Bay De Noc. This fan and channel are evidence of overflow, possibly catastrophic, of Lake Superior into Lake Michigan via the Au Train-Whitefish Channel during the Lake Chippewa low stand. Morphology of the Mid-Lake Plateau, a cuesta defended by eastward-dipping, presumed Devonian limestones, is more accurately revealed. The Two Rivers end moraine, marking the outer limits of a significant readvance of retreating Wisconsin ice, extends across the lake between Manitowoc and Ludington. Apparently shallow lakes connected by well-defined channels occupied the floor of Green Bay during Holocene times of lower lake level.

PREPARATION OF LAKE MICHIGAN BATHYMETRY

Bathymetry has been compiled using the entire array of good-quality historical hydrographic soundings collected in support of nautical charting over a 120-year period by the NOAA National Ocean Service and its predecessor agency for Great Lakes surveying, the Army Corps of Engineers. An estimated 540,000 bathymetric soundings were employed, of which approximately 60 per cent were already in digital form, 25 per cent were digitized in conjunction with this effort, and the remaining 15 per cent were available only on paper survey sheets.

Density of tracklines is generally about 2000m for the open lake and ranges from 200m to 600m for nearshore areas (see figure below).

Soundings collected since 1903 were already reduced to the Lake Michigan mean low water datum; these were used for bathymetric contouring without further calibration or adjustments. Soundings collected prior to 1903 were reduced to the mean low water datum.

In preparation for bathymetric contouring, digital soundings were converted to metric units and plotted in color; separate colors were assigned to the various depth ranges. From the paper sheets, contours in metric units were generated directly on overlays; these contours were then reduced to the compilation scale of 1:250,000 and patched in.

Compilation sheets were scanned and vectorized; and the resulting digital vector bathymetric contour data were used to generate the imagery shown on the large color plate. Images were constructed using the publicly-available software "Generic Mapping Tools" (GMT).

MACKINAC CHANNEL

The now-submerged Mackinac Channel was first described by University of Michigan Professor George M. Stanley (1938) using U. S. Army Corps of Engineers Lake Survey sounding sheets and some early bathymetric contours. Stanley was among the first to recognize that significant post-Wisconsin lowering of water levels in both Lake Michigan and Lake Huron occurred, with drainage to the sea occurring through an isostatically-depressed valley in the North Bay area; and that the lowstand in Lake Michigan (Lake Chippewa) was at a slightly higher water level than that in Lake Huron (Lake Stanley), with drainage of Lake Michigan occurring through the Mackinac Channel. The name given to the lowstand in Lake Huron honors Professor Stanley.

Hough (1955) referred to this channel in the Straits of Mackinac as the Mackinac River, but in keeping with accepted principles of applying terminology to water-covered topographic features, we refer to it as the Mackinac Channel.

Sediment cores from Lake Michigan provided compelling evidence for an early post-Wisconsin low lake level (Hough, 1955). Further confirmation was obtained that the Mackinac Channel was a subaerial river channel when spruce stumps, rooted and in the growth position, were discovered at 35-40m depth in the Straits of Mackinac. Radiocarbon dates from these stumps range from 9780 +/- 330 ybp to 8150 +/- 300 ybp; stumps at a depth of 9m dated 6788 +/- 250 ybp and 6500 +/- 70 ybp have also been recovered from nearby localities (Somers, 1969; Crane and Griffin, 1972; Lowdon and Blake, 1978).

This new bathymetry provides an integrated view of the Mackinac Channel and the adjoining lakefloor topography. Least channel depths of about 35m occur NW of Waugoshance Point, and at a point north of Garden Island, where the main channel crosses what may be fall lines formed by resistant bedrock. A line of ridges, probably bedrock ridges, extends through this area striking mostly E-W and flanking the main channel. To the east, this presumed resistant bedrock lineation is on strike with remnants of the resistant Mackinac Breccia of lower Devonian age, which crop out on Saint Helena Island and on the peninsula just north of the Straits of Mackinac. Less resistant shales of the Late Silurian Salina Group underlie the Mackinac Breccia.

TWO RIVERS RIDGE AND DOOR - LEELANAU RIDGE

An arcuate ridge so named because it is partly underlain by glacial till of the same name, the Two Rivers Ridge is presumed to be site of an end moraine marking the outer limits of the last readvance of glacier ice (Two Rivers) extending this far south in the lake. Till deposits associated with the Two Rivers readvance underlie the ridge and also crop out on the Wisconsin shore in the vicinity of the town of Two Rivers, Wisconsin (Lineback and Gross, 1974).

A foundation of bedrock apparently underlies this ridge, probably composed of resistant middle Devonian carbonates (Thwaites, 1949; Wold, 1980; Lineback and Gross, 1974), which have been stripped away by glacial erosion from the deeper basin to the north. The bedrock core of this ridge with its north-facing relief probably stalled the readvance of the Two Rivers ice lobe and ultimately determined the position of the end moraine.

Farther north a smaller ridge extends across the deepest basin of the lake between Door County, Wisconsin and Leelanau County, Michigan. This ridge is also arcuate, convex to the south, favoring the suggestion that it, too, marks the position of an end moraine associated with a minor, even younger, readvance of the retreating Lake Michigan ice lobe.

CHIPPEWA BASIN AND SOUTH CHIPPEWA BASIN

The largest and deepest basin of Lake Michigan, the Chippewa Basin, extends northward from the Two Rivers Ridge almost to the outflow point of the now-submerged Mackinac Channel. It is so named because it is the main site of the former Lake Chippewa. Depths in excess of 275m, deepest of Lake Michigan, are reached near the southern end of this basin, where a large segment of the floor of Lake Michigan extends below sea level.

Bedrock geology of the Chippewa Basin probably consists of a dip slope of resistant Silurian dolomites forming the western boundary, with the deeper eastern two-thirds of the basin having been eroded in less resistant upper Silurian redbeds (see Emery, 1950; Wold, 1980). Evaporites occur within the upper Silurian section (see Landes et al., 1945), and dissolution of these evaporites may have contributed to the collapse and stripping away of the overlying Devonian strata. North-south trending ridges on the floor of the basin may coincide with erosional remnants of moderately resistant strata within the upper Silurian section. Escarpments forming the eastern boundary of the Chippewa Basin probably are underlain by the eroded edges of the resistant Devonian carbonates.

Whereas the main Chippewa Basin may have been eroded in less resistant upper Silurian strata, the smaller South Chippewa Basin was probably eroded mostly in upper Devonian shales, with a dip slope on the west formed partly on more resistant middle Devonian limestones (Thwaites, 1949; Foster, et al., 1991). Depths in this smaller basin do not extend below sea level (maximum depth in excess of 165m), but this basin was deep enough to contain lake water even during the lowest lake levels of the Chippewa lowstand.

WHITEFISH CHANNEL AND FAN

Spot depths on navigation charts have, since the 1920's, shown indistinctly the existence of the large submerged channel beginning in Little Bay de Noc and extending across the floor of Green Bay and around Washington Island. To this feature we give the name Whitefish Channel because of its association with the Whitefish River and the Au Train - Whitefish Valley on land.

Geologists have been speculating for over a century about the history of the large valley extending northward from Little Bay de Noc across the peninsula of northern Michigan to Au Train Bay on Lake Superior. These earlier interpretations presented difficulties because only higher, not lower, late glacial and postglacial lake levels were assumed. Once the likelihood of a postglacial lowstand in Lake Michigan was established, University of Illinois Professor Hough (1955) recognized that the Au Train - Whitefish Valley, together with the submerged channel extending across Green Bay, was probably the site of the main outlet of Lake Superior into Lake Michigan at a time when Lake Michigan level was low.

About 1968, University of Northern Michigan Professor John Hughes obtained the Lake Survey sounding sheets from the immediate area of the Whitefish Channel and described the bottom morphology. He discovered the existence of the large fan, here named the Whitefish Fan, which lies at the downslope end of the Whitefish Channel and has a top depth in the range of 50 to 55m. Hughes (1989) attributed formation of the Whitefish Channel and Fan to drainage, possibly catastrophic at times, of Lake Superior into Lake Michigan when western Lake Superior was open water but eastern Lake Superior was filled with ice and the St. Marys River outlet was blocked. Hughes recognized that the level of the top of the fan constitutes a record of the level of Lake Chippewa at this location.

This new bathymetry gives an integrated view of the channel and fan and the topography of the surrounding lake floor which is more detailed than that published by Hughes (1989). It demonstrates that there are no other submerged fans or channels in northern Lake Michigan of anywhere near comparable size. The twenty-meter difference between Lake Chippewa level here and Lake Chippewa level at its outlet is accounted for by the difference in subsequent isostatic rebound which has occurred between the two localities.

RIDGES AND VALLEYS IN THE ISLANDS AREA

In the islands area of northern Lake Michigan, a series of distinct N-S trending ridges and valleys characterize the lake floor. This topography has the highest local relief of any in Lake Michigan and its relief exceeds 180 meters in places. Overall the topography looks something like that of the finger lakes region of New York, and the effect of glacial erosion in sculpting the topography is well known. Grand Traverse Bay and the adjacent land areas in Michigan have the same ridge and valley topography and the on-land features merely represent that portion of the topographic province which is not submerged. The islands are the emergent portions of ridge-tops. Many of the ridges are relatively flat top features bounded by steep escarpments and relatively deep, flat-floored valleys.

Sediment cover of glacial drift and lacustrine sediments is thin over much of this area, and bedrock outcrops are known to occur or may be expected on the ridge-tops, the escarpments, and some shallower areas of the lake floor. This area is underlain by upper Silurian and middle and upper Devonian strata which dip gently southeastward toward the center of the Michigan Basin. Hard limestone horizons occur within the Traverse Group, the Dundee Limestone, and the Bois Blanc Formation. Several islands are underlain by resistant bedrock of one or more of these three rock units (Thwaites, 1949; Milstein, 1987), and we would expect that many of the prominent ridges are also underlain by one or more of the three resistant units.

The valleys apparently are areas where glacial erosion has cut through one or more of the hard Devonian carbonates and exposed underlying upper Silurian or Devonian shales or redbeds which are not as resistant to erosion and which furthermore contain evaporites which may be particularly susceptible to corrosion. The valleys of Grand Traverse Bay apparently are underlain at their entrance by a dip slope formed on Traverse Group and Dundee Limestone. Both valleys deepen southward, excavated into the overlying upper Devonian shales of the Antrim and Ellsworth Formations (Emery, 1950; Milstein, 1987).

Steepness of the escarpments separating ridges from valleys is noticeable and could in part be explained by abrupt differences in resistance to erosion between overlying hard strata and underlying soft shales and redbeds. Erosion of the escarpments may have been enhanced by coastal erosion during the Lake Chippewa lowstand, which would have placed tops of some of the presently submerged escarpments in the shore zone.

MID-LAKE PLATEAU

Referred to as the Mid-Lake High in previous literature, we propose that this feature be termed the Mid-Lake Plateau in keeping with the established principles of use of terminology for water-covered topographic features. This broad, relatively flat-topped cuesta, lying directly east of Milwaukee, lies generally at depths less than 90m and extends upward to minimum depths of 40-60m at three localities. Escarpments which form its northwestern, western, and southwestern boundaries are thought to expose the resistant eastward-dipping middle Devonian limestones of the Traverse Group (Thwaites, 1949; Emery, 1950; Wold, 1980).

Deeper channels on the west and east, and the South Chippewa Basin on the south, bound the Mid-Lake Plateau and isolate it from other shallow water areas. This feature was undoubtedly an island during part of the time of the Lake Chippewa lowstand. Post-glacial lacustrine sediments thin or are missing over the top of this feature, suggesting that it is today swept by strong currents which prevent or inhibit sediment deposition.

Tills associated with the Manitowoc readvance terminate against the northwest escarpment (Lineback and Gross, 1974), suggesting that here, too, occurrence of resistant bedrock has determined the maximum extent of one of the last readvancing ice lobes during the post-Wisconsin ice retreat.

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NGDC wishes to thank the following individuals for reviewing this poster: D. Foster, USGS, C.E. Larsen, USGS, and T. Moore, University of Michigan.

1 National Oceanic and Atmospheric Administration
National Geophysical Data Center
Boulder, Colorado

2 National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory
Ann Arbor, Michigan

3 Cooperative Institute for Research in Environmental Sciences
University of Colorado
Boulder, Colorado

4 Presently with Environmental Consulting, Olancha, CA

5 Cooperative Institute for Limnology and Ecosystems Research
University of Michigan
Ann Arbor, Michigan

World Data Center A for Marine Geology and Geophysics
Report MGG-11
1996

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION