The Attenuation of Light in Lake Winnipeg Waters

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Lake Winnipeg water is usually turbid, and little light penetrates into the lake. Secchi disc visibility varied from 0.1 to 1.0 m in the south basin, and 0.5 to 2.6 m in the north basin. Horizontal extinction coefficients calculated from transmissometer (beam transmittance) data were high (12-46 m^{-1}) in the south basin, and lower (0.6-3 m^{-1}) in the central part of the north basin. Vertical extinction coefficients were calculated from percentages of surface light reaching the sensor of the submersible photometer cell, and these values were in the range 1-5 m^{-1} in the south basin and narrows, and 0.5-1 m^{-1} in the center of the north basin. All of these estimates of light transmission through lake water were highly correlated amongst themselves, and with concentrations of suspended sediments. Concentrations of algal biomass, chlorophyll α, and pheophytin were less strongly correlated with light transmission parameters. An attempt was made to estimate the relative proportion of the extinction of light due to scattering by suspended sediments. This was done by subtracting the vertical extinction coefficient from the horizontal (beam transmittance) extinction coefficient.

A sixteen channel spectroradiometer allowed computation of extinction coefficients for individual wavebands. High extinction coefficients were found for blue and green light in turbid waters, with maximum transmission of yellow and red light. Clearer waters of the central north basin had relatively uniform extinction coefficients over the 4,100 to 10,000 Å spectrum.

Key words: beam transmittance; vertical extinction coefficients; limnology; suspended sediments.

RESUME

Brunskill, G. J., D. W. Schindler, S. E. M. Elliott, and P. Campbell. 1979. The attenuation of light in Lake Winnipeg waters. Can. Fish. Mar. Serv. MS Rep. 1522: v + 79 p.

Les eaux du lac Winnipeg sont habituellement troubles, et peu de lumière y pénètre. La visibilité mesurée avec un disque de Secchi varie de 0.1 à 1 m dans le bassin du sud, et de 0.5 à 2.6 m dans le bassin du nord. Les coefficients d'extinction horizontale calculés à partir des données fournies par un transmissomètre à faisceaux dirigés étaient élevés (12-46 m^{-1}) dans le bassin du sud et plus bas (0.6-3 m^{-1}) dans la partie centrale du bassin du nord. On a calculé les coefficients d'extinction verticale à partir des pourcentages de la lumière superficielle qui atteignent le capteur de la cellule photométrique submersible et obtenu des chiffres de 1-5 m^{-1} dans le bassin et les chenaux du sud, et 0.5-1 m^{-1} dans le centre du bassin du nord. Toutes ces estimations de la transmission de la lumière à travers l'eau du lac montraient une très forte corrélation entre elles et avec les concentrations de sédiments en suspension. Les concentrations de la biomasse des algues, de la chlorophylle α et de la phaeophytine montraient une corrélation moins forte avec les paramètres de la transmission de la lumière. On a tenté d'estimer la proportion relative de l'extinction de la lumière qui est due à la dispersion par les sédiments en suspension, en soustrayant le coefficient d'extinction verticale du coefficient d'extinction horizontale (faisceaux dirigés).

Un spectroradiomètre à 16 canaux a permis de calculer les coefficients d'extinction pour des gammes d'ondes précises. Les coefficients se sont révélés hauts pour la lumière bleue et verte dans les eaux troubles, la transmission étant maximale pour les gammes du jaune et de rouge. Les eaux plus claires du bassin central du nord présentaient des coefficients d'extinction relativement uniformes situés au-dessus du spectre 4,000-10,000 Å.

Mots-clés: faisceaux dirigés; absorptivité, verticale; limnologie; sédiments en suspension.

INTRODUCTION

Franklin (1823) and Back (1936) noted the great turbidity of Lake Winnipeg waters while trying to avoid running their canoes onto rocks in the shallow water. Bajkov (1930) found that less turbid parts of Lake Winnipeg had larger abundances of zoobenthos, fish, and plankton. Brunskill (1973) and Brunskill, Schindler et al. (1979) showed that Lake Winnipeg phytoplankton had nutrient supplies in excess of their requirements for growth, and that extreme light attenuation by these turbid waters likely limits the growth of photosynthetic organisms, especially in the south basin of the lake. In this paper, we give an analysis of Lake Winnipeg light attenuation data collected in 1969.

Three factors (suspended inorganic sediments, phytoplankton, and dissolved organic matter in the water) likely control the depth of penetration of light into the lake water. The lake is shallow ($\bar{Z}$ = 12 m) and large in surface area (A_0 = 23,750 km^2). Strong winds over such a large and shallow water body frequently cause seiches, storm surges and large waves (Einarsson and Lowe 1968) which cause considerable resuspension of sediments. The Red River supplies 3-11 x 10^6 tonnes of sediments per year to the south basin of the lake (Brunskill 1973; Brunskill and Graham 1979). During calm weather in summer, dense algal blooms of *Alphanizomenon flos-aquae* and *Anabaena spp.* occur in the upper 0.5-1.0 m of the water column (Bajkov 1934: Brunskill, Schindler et al. 1979). In many bays and river mouths along the east shore of the lake, darkly-stained, humic acid-rich waters from Precambrian Shield watersheds are found. Watershed characteristics, sediment supply, hydrology, morphometry, nutrient chemistry and phytoplankton biology of Lake Winnipeg are given elsewhere (Brunskill, Elliott et al. 1979; Brunskill and Graham 1979; Brunskill, Schindler et al. 1979).

METHODS

Secchi disc visibility was measured *in situ* or in deck tanks (Fig. 1) with a 25 cm diameter secchi disc which was painted in black and white quadrants. The estimated precision for visibility was ±5 cm in most cases. Visual colour of the disc was also recorded at half secchi depth. Percentage light transmittance of lake water at selected stations was also estimated with a Whitney submersible photometer Model 8A by setting the meter to 100% with the sensor cell above water, and then lowering the cell to 10 to 300 cm water depth *in situ* or in deck tank water (Fig. 1). Vertical extinction coefficients (K_ω) were estimated from the slope of the regression line between (Ln % surface light) and water depth, ignoring the depth interval 0-10 cm, or were calculated from the attenuation of irradiation measured by this unit according to the equation of Vollenweider (1969):

$$K_\omega = \bar{\varepsilon}_V^\lambda = \frac{1}{Z_2 - Z_1} \quad (\text{Ln } i_1 - \text{Ln } i_2) \quad \text{(Eq. 1)}$$

where $K_\omega = \bar{\varepsilon}_V^\lambda$ = light extinction coefficient,

Z_1, Z_2 = depth intervals, below 10 cm meter depth

i_1, i_2 = light intensities at depths Z_1 and Z_2, respectively

An estimate of horizontal extinction of light (beam transmittance) was obtained from the use of a Hydroproducts Model 412 Transmissometer. This instrument was calibrated to read 86% transmittance in air at 1 meter light path and 98-100% transmittance in a laboratory tank of distilled water. The distance between the light source and photocell was varied according to the turbidity of the water: in the north basin this distance was usually 50 cm, and in the south basin, 10 to 25 cm. The percentage transmission of light from the light source to the photocell (%T) was used to calculate a horizontal extinction coefficient (K_ω) from the equation:

$$K_\omega = \text{Ln } \frac{100}{\%T} \, d^{-1} \qquad \text{(Eq. 2)}$$

where d = path length in meters.

Vertical extinction coefficients for light of wavelength (λ) from 4000 Å to 10,000 Å, and for specific wavebands, were obtained from an Agroproducts Spectroradiometer. The sensor head of this apparatus was firmly fixed 10 cm below water level in a large tank (1.2 m deep, 0.7 m diameter). The residence time of water in this tank was approximately 20 minutes. This tank was mounted in a deck table over which a tight fitting lid closed (Fig. 1). The lid had a bank of eight fluorescent 80-watt tubes, approximately 1 m long, backed with aluminum foil, which was used as a constant light source for the Spectroradiometer sensor. This light source spectrum is compared to solar radiation on a cloudy day in Fig. 2. The plastic tank was painted black to exclude light from entering from the side walls of the tank. Extinction coefficients for 400 to 1,000 mμ, and for individual wavebands were calculated according to Eq. 1. Calibration of this spectroradiometer against a known light source in a dark room gave 87-116% of the true value.

Suspended sediments were separated from water samples by vacuum filtration through preweighed membrane or glass fibre filters (0.45-1.2 μm nominal pore diameter) on the ship. These filters were desiccated, frozen for storage, and in the laboratory they were dried to 100° C and weighed. Chlorophyll methods are reported in Brunskill, Schindler et al. (1979).

As discussed in Brunskill, Elliott et al. (1979) and Brunskill and Graham (1979) stations were located by radar, gyrocompass, and sonar on Canadian Hydrographic Service Charts 6241 and 6240. Station locations erferred to in the following tables are shown in Fig. 3.

RESULTS

Table 1 gives the results of our measurements of Secchi disc visibility and water color against the white disc at half the depth of Secchi visibility. Minimal values of 0.1-0.2 m were recorded in the plume of the Red River throughout the open water season, and maximal values of 2-3.5 m were observed in the central part of the north basin. The variation of Secchi disc visibility over the open-water season of 1969 is shown in Figs. 4-9. Although the secchi rope was marked in 0.1 m segments, the measurement of secchi visibility in the very turbid waters of the southern part of the south basin, and along the north and west lake shores of the north basin, will have greater relative error than in less turbid parts of the lake. Secchi visibility in the Red River was often <0.1 m, whereas in the Winnipeg and Saskatchewan Rivers, Secchi visibility was in the range 1-3 m. Visual color at half secchi depth was usually yellow-brown in turbid water areas of the south basin. Orange-brown colored water occurred near tributaries draining Precambrian Shield to the east of the lake. With the exception of the nearshore or near-island regions, north basin water was green or blue-green.

Table 2 shows results of our beam transmittance measurements, given as percent transmission per path length (%T_α) and a horizontal extinction coefficient (K_α). High K_α's (ranging from 12-46 m^{-1}) were found in the Red River plume, near shores and islands. Lower values of K_α occurred in the central part of the north basin, and occasionally in the central and northern part of the south basin. These lower values ranged from 0.6 to 3 m^{-1}. The variation of K_α is also shown in Figs. 10-13. Replicate measurements, varying light path length and water depth at Station 35, gave similar results (Table 2). From these measurements, we concluded that light transmittance should be relatively uniform with depth at stations away from shores and river plumes.

Table 3 gives estimates of vertical extinction coefficients (K_ω) obtained from measurements of the percentage of surface radiation reaching several water depths. Some of these measurements were done *in situ* from the unshaded side of the ship (K_ω(IS)), and other measurements were made in lake water-flushed deck tanks (K_ω(DT)) (see Fig. 1) open to sunlight. K_ω(DT) values were always greater than K_ω(IS), probably because of the exclusion of laterally scattered radiation by the black-painted walls of the deck tank. Throughout this paper, K_ω(IS) will be used as our best estimate of the vertical extinction coefficients. Higher values of K_ω(IS) occurred in the Red River plume and near shores and islands, ranging from 1.5-4.5 m^{-1}. Lower values occurred in the center of the north basin, where values of K_ω(IS) were from 0.5 to 1 m^{-1}. K_ω(DT) varied in a similar manner but was usually 2 to 3 fold greater than the value of K_ω(IS).

Table 4 gives results of the measurement of percentage transmission of fluorescent light (Fig. 1, 2) through 10 cm of Lake Winnipeg waters at selected wavelength (%T_λ), and an extinction coefficient for each wave band ($K_{SR\lambda}$) over λ_i = 405 to 1,000 mμ. It is difficult to generally discuss this data, as considerable variation occurs in spectra for similar water masses. Highest $K_{SR\lambda}$ were usually in the region λ = 405-600 mμ, and lower values were often in the region λ = 640-900 mμ. During the season when this data was collected (September-October), the discharge of the Red River was greatly reduced (Brunskill, Elliott et al. 1979), and the difference between the turbidity of the south and north basin is not as great as in June, July and August (see Figs. 4-6, and compare Figs. 7-9). Nevertheless, $K_{SR\lambda}$ for most λ were much lower in open water north basin stations compared to south basin stations (Figs. 14, 15). Humic acid colored water from Precambrian Shield drainage exhibited high $K_{SR\lambda}$ at λ = 430-440 mμ (Fig. 16) and decreased to lower values of $K_{SR\lambda}$ above 700 m . Data for K_λ(IS) (Table 3) and $K_{SR\lambda}$ data were not collected simultaneously, unfortunately.

As we shall see in the discussion, most of our light transmission data are closely correlated with suspended sediment concentrations. We therefore give suspended sediment data in Table 5 and Figs. 17-21. Suspended sediment concentrations were highest (5-80 g m^{-3}) near the mouth of the Red River and near the west and southwest shores of the south basin. Lower values (1-20 g m^{-3}) are found throughout most of the narrows and north basin. The Red River (Station 0 in Table 5) is obviously a major source of sediments for the south basin of Lake Winnipeg, whereas the Saskatchewan (Station 29) and Winnipeg Rivers (Station 7) contribute much less, despite their larger annual discharges (Brunskill, Elliott et al. 1979). The Red River drains a sedimentary watershed with agricultural activities and relatively large populations of humans and livestock, whereas the Winnipeg River drains a Precambrian Shield watershed which has little agriculture and smaller human populations. The Saskatchewan River drains a sedimentary watershed, but most of its sediment load is deposited in its delta (Cedar and Moose Lake area) and recently in reservoirs along its course (Brunskill, Elliott et al. 1979).

Hourly, daily, and monthly solar radiation data is given in Tables 6 and 7, and Fig. 22a-h, for the Winnipeg airport and The Pas, the closest weather stations.

DISCUSSION

For purposes of estimating the attenuation of photosynthetically useful radiation in Lake Winnipeg water, the vertical extinction coefficients measured *in situ* with the Whitney submersible photometer (K_ω(IS)) will be considered the best value. The other measurements of light attenuation will now be related to these data (Table 3).

Secchi disc visibility (Table 1) was closely related to K_ω(IS), as shown in Fig. 23. This is a commonly-found relationship in diverse waters (Jones and Wills 1956; Tyler 1968; Holmes 1970; Schindler 1971). Measurements of vertical extinction coefficients with the Whitney submersible photometer in the deck tank (K_ω(DT), Table 3) was also highly correlated with K_ω(IS) (Fig. 24), but with more variation about the regression line. As previously mentioned, this larger variation and larger absolute value of K_ω(DT) is likely due to the interaction of the black-painted walls of the deck tank and the varying angle of the sun, limiting the amount of lateral and downward scattered radiation. There was an excellent relationship between horizontal extinction (beam transmittance from the transmissometer, K_α, Table 2), and K_ω (IS) (Fig. 25). A different slope and intercept was found for the correlation between K_ω(IS) and K_ω(A) measured on the attenuated circuit of the transmissometer (Fig. 26) in extremely turbid waters. Statistically significant correlations were found between K_ω(IS) and chlorophyll *a*, pheophytin, and algal biomass (Table 8), but the confidence limits of the regression lines are too great for practical use. The algal biomass, chlorophyll *a*, and the pheophytin data used here are taken from Brunskill, Schindler et al. (1970). $K_\omega(IS)$ was highly correlated with suspended sediment concentration (Fig. 27).

The equations (Table 8) from the above correlations (Figs. 23-27) were used to estimate a vertical extinction coefficient ($\hat{K}_\omega$) where $K_\omega(IS)$ was not measured. This allowed the estimation of K_ω for stations done at night and during rough weather. These data are given in Table 9, along with a code to indicate the origin of the estimate. The equations in Table 8 are listed in their order of reliability, such that K_ω predicted from algal biomass, chlorophyll α, and pheophytin are to be least trusted. $\hat{K}_\omega$ is shown also in Figs. 28-32.

Ideally $K_\omega(IS)$ and $\hat{K}_\omega$ should estimate the attenuation of radiation due to absorption and <u>back</u>scattering by water, dissolved organic matter, and particulate matter. K_α and $K_\alpha(A)$ should estimate the attenuation of radiation due to absorption and <u>total</u> scattering by water, dissolved organic matter, and particulate matter. The transmissometer data (K_α) should then be more sensitive to particulate matter (scattering) in the water column. This appears to be true for the values of K_α and K_ω in our data, as K_α varied from 2 to 35 m^{-1} in the south basin of Lake Winnipeg in mid July (Fig. 10), whereas $\hat{K}_\omega$ or K_ω (IS) was in the range 1 to 4.6 m^{-1} (Fig. 29). In both cases, however, the variation of K_ω and K_α was 4-16 fold across this gradient of suspended sediments (Fig. 17). K_α responded to a largely inorganic suspended sediment gradient in the northern part of the north basin (Fig. 10 and Table 2, Stations 23C to 33) by a 25 fold change (0.8 to 25 m^{-1}), whereas K_ω responded with a 15 fold change (0.4 to 6.7 m^{-1}, see Fig. 29 and Table 9). We attempted to partition the components contributing to the measured extinction by approaches similar to those of Tyler (1975), but the heterogeneous suspended sediment parameter completely overwhelmed any derived relationships. A crude and relative estimate of the proportion of K_α that is due to scattering by suspended sediments is obtained by subtracting $K_\omega(IS)$ from K_α. That (K_α - $K_\omega(IS)$) is well correlated with suspended sediment concentration is no surprise (Fig. 33), but this computation indicates that a large fraction of K_α (≈50-80%) is related to light scattering by the water column.

Another way to illustrate the role of suspended sediments (SS) in controlling extinction coefficients of Lake Winnipeg waters is given in Fig. 34. This relationship is derived from equation D in Table 8 where:

$$K_\omega(IS) = 0.5809 + 0.1227SS,$$

and:

$$\%\ \text{attenuation due to SS} = \frac{0.1227}{K_\omega(IS)} \times 100$$

This manipulation indicates that scattering and absorbance explained by SS accounts for 50-90% of $K_\omega(IS)$ over the upper range of SS common in Lake Winnipeg (Table 5). The composition of SS varied considerably. Most samples of SS appeared under the microscope to be largely inorganic matter, whereas some samples contained dense phytoplankton blooms. A similar manipulation on equation G in Table 8 allowed the construction of Fig. 35, which indicates that 10-60% of $K_\omega(IS)$ can be controlled by the range of chlorophyll α concentrations observed (1 to 20 mg Chl α m^{-3}, see Brunskill, Schindler et al. 1979). Figures 34 and 35 indicate that at the concentrations of chlorophyll α, phytoplankton biomass, and suspended sediments considered here, phytoplankton are more effective in attenuating light than are suspended sediments, on a per unit weight basis. Ganf (1974) used a variation of this approach in his studies on Lake George (Uganda).

The data on attenuation of light by wavelength in Table 4 and Figs. 14-16 indicate the extreme effect of scattering of light by high suspended sediment concentrations. Attenuation maxima usually occurred in the violet, blue and green wavebands (405-546 mμ), and lower extinction coefficients were usually found in the red and infrared (640-900 mμ). These spectra are greatly different from the "standard distribution" curves of Vollenweider (1961). According to Hutchinson (1957) and Strickland (1958), particulate matter is very important in scattering and attenuating light below 500 mμ, and less effective for wavelengths >600 mμ. Since there is less energy in solar radiation at the lake surface above 700 mμ (see Fig. 2), and most of the violet, blue and green light is strongly attenuated (Figs. 15 and 16), the yellow, orange, and red wavelengths (546-700 mμ) will have maximum penetration in the turbid areas of Lake Winnipeg. As indicated in Table 1, lake water color in most of the south basin, narrows, and near shore north basin was observed as yellow-brown (or orange-brown in humic acid-rich waters). Clearer waters of the central north basin had relatively flat and lower extinction spectra over 405-1,000 mμ (Fig. 14), and were observed as being green or blue-green in visual color over the secchi disc. Even the lower values for vertical extinction coefficients given here are quite high compared to other lake data (Hutchinson 1957; James and Birge 1938; Whitney 1938; Thomson and Jerome 1975; Thomson et al. 1974). In some cases in Lake Winnipeg (extreme turbidity in the Red River plume or near shore, or in the midst of dense algal blooms), water color is more likely due to the color of suspended matter ("seston color" of Hutchinson (1957, p. 417)). We observed large (≈200 x 400 m) patches of dark water in both the north and south basin of the lake, which proved to be near surface (0-50 cm) accumulations of insect exuviae. During dense algal blooms in calm weather in July and August in the north and south basins, the surface of the water appeared to be covered with opaque, light green or yellow-green paint. The algal bloom was in the upper 30 cm of the water column, and often large clumps of cells and filaments floated on the surface.

The spectroradiometer data for waters of the Red River plume (Stations 05, 59, 59-60, 61, 62 in Table 4) appear to corroborate the Cree name for the Red River (<u>Mikwakumew sepe</u> = Bloody River) according to La Verendrye in <u>1735</u> (see Crouse 1972, p. 42; Hamilton, no date, p. 235), who was told the river had the color of vermillion. Wavelengths of maximum transmission for these waters are in the red. Seasonal variation in winds, river discharge, shore erosion, and algal biomass are likely factors controlling the seasonal variation in extinction coefficients in Lake Winnipeg.

Future work on the optical characteristics of this turbid lake should investigate many of the curious extinction spectra in Table 4. It seems possible that more precise relationships between suspended inorganic matter, detrital organic matter, dissolved organic matter, and algal cells could be obtained if these parameters could be partitioned and sized (Haffner and Evans 1974; Burt 1955), including determinations of particle surface areas, volume, and indices of refraction.

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Table 1. Secchi disc visibility and visual estimates of color at half the depth of Secchi visibility, for stations on Lake Winnipeg in 1969. See Fig. 3 for station locations. TU = Turbid.

STATION NO.	DATE	SECCHI DISC VISIBILITY (METERS)	COLOUR AT HALF SECCHI DEPTH (BA=BLACK;BL=BLUE;BR=BRWN;G,GR=GREEN; GA=GRAY;HU=HUMIC;NITE=NIGHT;OR=ORANGE; RU=RUST;Y,YE=YELLOW)
0	27OCT68	0.70	YE TUR
0	3JUN69	0.28	GYBRTU
0A	5NOV68	******	YBRGTU
0B	5NOV68	******	YBRTU
1	4JUN69	0.30	YEBRTU
1	9JUL69	0.35	YEBR
1	3OCT69	0.50	YEBR
2	28OCT68	0.05	
2	23APR69	******	BRTU
2	4JUN69	0.25	YEBRTU
2	9JUL69	0.30	
2	24JUL69	0.30	
2	2SEP69	0.50	YEBR
2	3OCT69	0.20	YEBR
2	17MAR70	******	TU
3	9JUL69	0.25	
3	24JUL69	0.35	YEBR
3	10SEP69	0.20	BR
3	3OCT69	0.10	YEBR
3C	9JUL69	0.25	YEBR
3C	24JUL69	0.20	
3C	10SEP69	0.70	GRYEBR
3C	3OCT69	0.40	YEBRGA
4	9JUL69	0.30	YEBR
4	10SEP69	0.25	BR
4	3OCT69	0.45	YEBR
4	31OCT69	0.30	YEBR
5	4JUN69	0.20	YEBRTU
5	9JUL69	0.60	
5	25JUL69	0.60	YEBR
5	9SEP69	0.50	YEBR
5	4OCT69	0.65	GRYEBR
6	4JUN69	0.32	YEBRTU
6	10JUL69	0.60	BR
6	26JUL69	0.80	YEBR
6	9SEP69	0.80	BROR
6	4OCT69	0.45	YEBR
7	28OCT68	0.80	YELBRG
7	5JUN69	1.00	
7	10JUL69	0.80	YEBR
7	26JUL69	0.75	GRBR
7	9SEP69	0.50	BR
7	4OCT69	0.80	
7	31OCT69	1.00	BR
8	28OCT68	0.15	
8	5JUN69	0.50	YEBRTU
8	10JUL69	0.80	GRBRHU
8	26JUL69	0.85	YEBR
8	9SEP69	0.75	YEORBR
8	4OCT69	0.40	YEBR
8	31OCT69	0.90	BR
9	10JUL69	0.70	YEBR
9	26JUL69	0.75	YEBR
9	4OCT69	0.20	YEBR
10	5JUN69	0.60	YEBRTU
10	10JUL69	0.90	YEBR
10	26JUL69	1.30	YEBR
10	8SEP69	0.50	ORBR
10A	28OCT68	0.30	BROTUR
11	5JUN69	0.90	YEBRTU
11	10JUL69	1.30	
11	27OCT69	0.50	YEBRTU
12	5JUN69	1.50	YE GR
12	10JUL69	1.10	
12	26JUL69	1.00	GRYEBR
12	8SEP69	0.50	ORBR

STATION NO.	DATE	SECCHI DISC VISIBILITY (METERS)	COLOUR AT HALF SECCHI DEPTH (BA=BLACK;BL=BLUE;BR=BRWN;G,GR=GREEN; GA=GRAY;HU=HUMIC;NITE=NIGHT;OR=ORANGE; RU=RUST;Y,YE=YELLOW)
12	30OCT69	0.40	YEBRTU
13B	10JUL69	1.15	YEBRHU
13C	29OCT68	1.00	YEBRTU
14	5JUN69	1.50	YE GR
14	10JUL69	1.00	YEBR
14	26JUL69	0.70	YEBR
14	8SEP69	0.50	BR
14	5OCT69	0.35	
14	30OCT69	0.30	BRTU
16	6JUN69	1.20	GRYEBR
16	11JUL69	0.60	YEBRHU
16	27JUL69	******	YEBR
16	3SEP69	0.05	BR
16	5OCT69	0.40	YEBRTU
16	28OCT69	0.35	YEBRTU
17	6JUN69	0.70	GYBRTU
17	12JUL69	0.75	
17	27JUL69	1.30	GR
18	6JUN69	0.70	YEBRTU
18	11JUL69	0.60	YEBR
18	27JUL69	1.10	GRYE
18	3SEP69	0.80	GR
19	7JUN69	0.85	
19	13JUL69	1.00	GRYE
19	28JUL69	1.20	GR
19	3SEP69	1.00	
20	7JUN69	0.90	YEBRGR
20	13JUL69	1.10	GR
20	28JUL69	1.35	GRYE
21	7JUN69	0.95	GYBRTU
21	13JUL69	0.90	GR
21	28JUL69	1.80	GR
21	4SEP69	0.60	GR
21	11OCT69	1.00	GR
22	7JUN69	1.20	GR TU
22	13JUL69	1.30	GR
22	28JUL69	1.40	GREEN
22	4SEP69	1.50	
22	11OCT69	0.90	GR
23B	7JUN69	******	GR
23C	7JUN69	******	GR
23C	13JUL69	2.50	GR
23C	28JUL69	1.80	GRTU
23C	6SEP69	2.00	GRBR
23C	11OCT69	1.40	GR
23D	7JUN69	1.10	
23E	7JUN69	1.30	GR
23E	15JUL69	2.00	GR
23E	30JUL69	1.80	GREEN
23E	6SEP69	1.60	GRBR
23E	11OCT69	1.00	GR
24	7JUN69	1.90	
25	7JUN69	1.90	GREEN
25	13JUL69	2.50	GR
25	28JUL69	3.00	GRTU
25	4SEP69	1.50	BLGR
25	29OCT69	1.00	GR
26	14JUL69	2.50	GR
26	29JUL69	3.00	BLYEGR
26	4SEP69	1.50	BLGR
26	9OCT69	0.40	YEBRTU
27	14JUL69	1.10	GR
27	29JUL69	1.20	YEGRTU
27	9OCT69	0.25	YEBRTU
28	13JUL69	2.50	BLGR
28	28JUL69	2.20	BLGR

STATION NO.	DATE	SECCHI DISC VISIBILITY (METERS)	COLOUR AT HALF SECCHI DEPTH (BA=BLACK;BL=BLUE;BR=BRWN;G,GR=GREEN; GA=GRAY;HU=HUMIC;NITE=NIGHT;OR=ORANGE; RU=RUST;Y,YE=YELLOW)
28	4SEP69	1.00	GR
28	29OCT69	1.30	
29	20MAR69	******	BL
29	7OCT69	1.50	BLGR
30	18MAR69	******	YEGRBR
31	9JUN69	1.50	
31	14JUL69	1.50	GR
31	29JUL69	1.90	GRTU
31	6SEP69	0.90	GRBR
31	8OCT69	******	TU
33	9JUN69	0.50	GRTU
33	14JUL69	0.30	YEBR
33	29JUL69	0.60	GRTU
35	18MAR69	******	GR
35	9JUN69	2.20	GRTU
35	14JUL69	2.00	GR
35	29JUL69	2.10	GR
35	6SEP69	1.80	GR
35	8OCT69	1.30	GRTU
39	1APR69	******	GRTU
39	15JUL69	2.40	GR
39	30JUL69	2.60	GREEN
39	6OCT69	1.00	
39	29OCT69	0.85	GR
41	10JUN69	0.90	GRYETU
41	15JUL69	2.00	GR
41	30JUL69	2.40	GREEN
41	7SEP69	1.90	GRYE
41	6OCT69	0.85	GRTU
43	10JUN69	0.40	GRYETU
43	15JUL69	1.80	GR
43	30JUL69	1.40	GRTU
43	6OCT69	0.45	GR
45	15JUL69	2.30	
45	30JUL69	2.50	GR
45	7SEP69	1.20	GRYE
45	6OCT69	1.10	GR
48	2APR69	******	GRTU
48	15JUL69	0.90	GRYE
48	30JUL69	1.00	YEGRTU
48	7SEP69	1.00	YEBR
48	12OCT69	0.85	GRTU
50B	11JUL69	0.50	YEBR
50B	27JUL69	0.50	YEBR
50C	11JUL69	0.50	YEBR
50C	27JUL69	0.60	YEBR
50C	3SEP69	0.50	GRYEBR
51	30OCT68	1.00	BR ORA
51	11JUN69	0.60	RED-BR
51	11JUL69	0.90	HUBR
51	27JUL69	0.85	BRHU
51	3SEP69	0.25	BRBA
51	5OCT69	0.80	BROR
52	11JUN69	0.60	RUBRTU
52	11JUL69	0.60	HUYEBR
52	3SEP69	0.25	
52	5OCT69	0.30	YEBRTU
54	11JUN69	0.80	YEBRGR
54	11JUL69	0.70	YEBR
54	8SEP69	0.45	
54	5OCT69	0.30	YEBRTU
54	30OCT69	0.30	YEBRTU
54B	29OCT68	0.30	YEBRTU
54B	28OCT69	0.25	YEBRTU
55	11JUN69	0.50	
56	29OCT68	0.60	YEBRTU

STATION NO.	DATE	SECCHI DISC VISIBILITY (METERS)	COLOUR AT HALF SECCHI DEPTH (BA=BLACK;BL=BLUE;BR=BRWN;G,GR=GREEN; GA=GRAY;HU=HUMIC;NITE=NIGHT;OR=ORANGE; RU=RUST;Y,YE=YELLOW)
57	31OCT68	0.70	
57	12JUN69	0.60	GYBRTU
57	10JUL69	0.90	YEBR
57	25JUL69	0.90	YEGRBR
57	8SEP69	0.50	GRBR
58	12JUN69	0.30	GYBRTU
58	10JUL69	0.40	YEBR
58	25JUL69	0.40	YEGRBR
58	9SEP69	0.15	YEBR
59	31OCT68	0.50	
59	12JUN69	0.50	
59	9JUL69	0.70	
59	25JUL69	0.95	GRYEBR
59	9SEP69	1.00	GRYEBR
59	4OCT69	1.00	GRYE
59	31OCT69	0.45	YEBR
60	23APR69	3.50	GR TUR
60	12JUN69	0.30	YBRGTU
60	9JUL69	0.40	
60	24JUL69	0.90	YEGRBR
60	2SEP69	1.00	
60	9SEP69	0.70	GRBR
60	31OCT69	0.55	YEBR
60B	9JUL69	0.25	
60B	24JUL69	0.35	YEGRBR
60B	9SEP69	0.45	GRBR
60B	4OCT69	0.40	YEBR
60C	28OCT68	0.15	
60C	24JUL69	0.25	YEBR
60C	9SEP69	0.35	BR
60C	18MAR70	******	TU
61	12JUN69	0.20	YEBRTU
61	9JUL69	0.40	
61	24JUL69	0.75	GRYEBR
61	2SEP69	0.90	YEBR
61	10SEP69	0.90	YEBR
61	3OCT69	0.45	YEBR
61	31OCT69	0.45	GR
62	31OCT68	0.12	
62	12JUN69	0.20	
62	9JUL69	0.25	
62	24JUL69	0.50	GRYEBR
62	10SEP69	0.50	YEBR
62	3OCT69	0.20	YEBR
63	12JUN69	0.10	
63	17JUL69	0.40	YEBR
63	1AUG69	0.20	YEBRTU
63	10SEP69	0.20	BR
63	13OCT69	0.20	YEBRTU
63	31OCT69	0.35	YEBR
64	30OCT68	0.50	YEBRTU
64	15JUL69	0.90	GR
64	31JUL69	0.50	YEGRTU
64	7SEP69	0.50	YEBR
64	12OCT69	0.30	YEBRTU
64B	12OCT69	******	BRTU
65	16JUL69	0.50	GRYETU
65	31JUL69	0.55	YEGRTU
66B	31JUL69	0.70	GRTU
67	2APR69	******	GR
68	16JUL69	0.50	GRYETU
68	31JUL69	0.40	YGTURR
68	8SEP69	0.40	YEBR
68	12OCT69	0.35	YEBRTU
68	30OCT69	0.30	YEBRTU
68B	12OCT69	******	YEBRTU

STATION NO.	DATE	SECCHI DISC VISIBILITY (METERS)	COLOUR AT HALF SECCHI DEPTH (BA=BLACK;BL=BLUE;BR=BRWN;G,GR=GREEN; GA=GRAY;HU=HUMIC;NITE=NIGHT;OR=ORANGE; RU=RUST;Y,YE=YELLOW)
69	16JUL69	0.40	GRYE
69	31JUL69	0.50	YGBRTU
69	8SEP69	0.50	YEBR
69	12OCT69	0.25	YEBRTU
69B	28OCT69	0.20	YEBRTU
70	20MAR69	******	GR

Table 2. Measurements of the percentage of light (% T_α) transmitted from a battery-powered light source to a photosensitive cell over a variable, horizontal path length in the lake water, and computed horizontal extinction coefficients (K_α) based on this %T_α data. All measurements were made in situ at 1 meter water depth, unless otherwise indicated. The notation (A) indicates the use of an alternate, amplified circuit of the transmissometer, which was specified for use in extremely turbid waters.

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE (%T_α, path length^{-1})	K_α (m^{-1})
1	9 Jul. 69	0.25	2	15.65
	30 Oct. 69	0.10	22	15.14
2	24 Jul. 69	0.10	24 (A)	14.27
	2 Sept. 69	0.10	32	11.39
	2 Sept. 69	0.10	30 (A)	12.04
	3 Oct. 69	0.10	2.5	36.89
3	9 Jul. 69	0.10	5	29.96
	24 Jul. 69	0.10	9.5 (A)	23.54
	10 Sept. 69	0.10	14	19.66
	3 Oct. 69	0.10	1	46.05
3 C	24 Jul. 69	0.10	16 (A)	18.33
	10 Sept. 69	0.10	44	8.21
	3 Oct. 69	0.10	34	10.79
4	9 Jul. 69	0.10	22 (A)	15.14
	24 Jul. 69	0.10	26 (A)	13.47
	2 Sept. 69	0.10	48	7.34
	10 Sept. 69	0.10	25	13.86
	3 Oct. 69	0.10	25	13.86
	31 Oct. 69	0.10	23	14.70
5	9 Jul. 69	0.10	42 (A)	8.68
	25 Jul. 69	0.10	48	7.34
	25 Jul. 69	0.10	46 (A)	7.77
	9 Sept. 69	0.10	48	7.34
	4 Oct. 69	0.10	49	7.13
6	10 Jul. 69	0.10	48.5 (A)	7.24
	26 Jul. 69	0.10	61	4.94
	26 Jul. 69	0.10	58 (A)	5.45
	9 Sept. 69	0.10	52	6.54
	4 Oct. 69	0.10	35	10.50
	30 Oct. 69	0.10	33	11.09
7	10 Jul. 69	0.10	42 (A)	8.68
	26 Jul. 69	0.10	55	5.98
	26 Jul. 69	0.10	50 (A)	6.93
	9 Sept. 69	0.10	47	7.55
	4 Oct. 69	0.10	61	4.94
	31 Oct. 69	0.10	73	3.15
8	10 Jul. 69	0.10	60 (A)	5.11
	9 Sept. 69	0.10	61	4.94
	4 Oct. 69	0.10	35	10.50
	31 Oct. 69	0.10	64	4.46
9	10 Jul. 69	0.10	55	5.98
	10 Jul. 69	0.10	67 (A)	4.00
	26 Jul. 69	0.10	48	7.34
	26 Jul. 69	0.10	46 (A)	7.77
	4 Oct. 69	0.10	3	35.07

Table 2. (cont'd)

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE ($\%T_{\alpha}$, path length^{-1})	K_{α} (m^{-1})
10	10 Jul. 69	0.10	62	4.78
	10 Jul. 69	0.10	72 (A)	3.29
	26 Jul. 69	0.10	81	2.11
	26 Jul. 69	0.10	81 (A)	2.11
	8 Sept. 69	0.10	36	10.22
	4 Oct. 69	0.10	27	13.09
	30 Oct. 69	0.10	21	15.61
11	10 Jul. 69	0.10	55	5.98
	10 Jul. 69	0.10	73 (A)	3.15
	27 Oct. 69	0.10	33	11.09
12	10 Jul. 69	0.10	64	4.46
	10 Jul. 69	0.10	76 (A)	2.74
	26 Jul. 69	0.10	76	2.74
	26 Jul. 69	0.10	77 (A)	2.61
	8 Sept. 69	0.10	31	11.71
	4 Oct. 69	0.10	15	18.97
	30 Oct. 69	0.10	14	19.66
13 B	10 Jul. 69	0.10	66	4.16
	10 Jul. 69	0.10	76 (A)	2.74
14	10 Jul. 69	0.10	54	6.16
	10 Jul. 69	0.10	85 (A)	1.63
	26 Jul. 69	0.10	58	5.45
	26 Jul. 69	0.10	58 (A)	5.45
	8 Sept. 69	0.10	38	9.68
	5 Oct. 69	0.10	24	14.30
	30 Oct. 69	0.10	10	23.03
16	11 Jul. 69	0.10	35	10.50
	11 Jul. 69	0.10	42 (A)	8.68
	27 Jul. 69	0.10	32	11.39
	27 Jul. 69	0.10	28 (A)	12.73
	3 Sept. 69	0.10	3	35.07
	5 Oct. 69	0.10	21	15.61
	28 Oct. 69	0.10	13	24.40
17	27 Jul. 69	0.10	73	3.15
	27 Jul. 69	0.10	72 (A)	3.29
	27 Jul. 69	0.50	20	3.22
	27 Jul. 69	0.50	18 (A)	3.43
	5 Oct. 69	0.10	62	4.78
18	11 Jul. 69	0.10	50	6.93
	11 Jul. 69	0.10	50 (A)	6.93
	27 Jul. 69	0.10	73	3.15
	27 Jul. 69	0.10	73 (A)	3.15
	3 Sept. 69	0.10	72	3.29
	5 Oct. 69	0.10	32	11.39
19	13 Jul. 69	0.10	61	4.94
	13 Jul. 69	0.10	58 (A)	5.45
	28 Jul. 69	0.50	19	3.32
	28 Jul. 69	0.50	17 (A)	3.54
	3 Sept. 69	0.10	40	9.16
	11 Oct. 69	0.10	67	4.00
20	13 Jul. 69	0.10	72	3.29
	13 Jul. 69	0.10	72 (A)	3.29

Table 2. (cont'd)

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE (%T_α, path length^{-1})	K_α (m^{-1})
	28 Jul. 69	0.50	25	2.77
	28 Jul. 69	0.50	23 (A)	2.94
	3 Sept. 69	0.10	78	2.49
	11 Oct. 69	0.10	50	6.93
	28 Oct. 69	0.10	55	5.98
21	13 Jul. 69	0.10	70	3.57
	13 Jul. 69	0.10	72 (A)	3.29
	13 Jul. 69	0.10	68	3.86
	13 Jul. 69	0.10	70.5 (A)	3.50
	13 Jul. 69	0.10	70	3.57
	13 Jul. 69	0.10	72 (A)	3.29
	28 Jul. 69	0.50	34	2.16
	28 Jul. 69	0.50	31 (A)	2.34
	4 Sept. 69	0.10	68	3.86
	11 Oct. 69	0.10	71	3.42
	28 Oct. 69	0.10	72	3.29
22	13 Jul. 69	0.10	82	1.98
	13 Jul. 69	0.10	82 (A)	1.98
	28 Jul. 69	0.50	32	2.28
	28 Jul. 69	0.50	30 (A)	2.41
	4 Sept. 69	0.10	31	11.71
	11 Oct. 69	0.10	78	2.48
	29 Oct. 69	0.10	72	3.29
23 C	13 Jul. 69	0.10	93	0.73
	13 Jul. 69	0.50	60	1.02
	28 Jul. 69	0.50	50	1.39
	28 Jul. 69	0.50	51	1.35
	6 Sept. 69	0.50	36	2.04
	11 Oct. 69	0.10	83	1.86
	29 Oct. 69	0.10	72	3.29
23 E	15 Jul. 69	0.50	32	2.28
	30 Jul. 69	0.50	40	1.83
	30 Jul. 69	0.50	38 (A)	1.94
	6 Sept. 69	0.50	33	2.22
	11 Oct. 69	0.10	79	2.36
25	13 Jul. 69	0.50	48	1.47
	28 Jul. 69	0.50	66	0.83
	28 Jul. 69	0.50	66 (A)	0.83
	4 Sept. 69	0.10	50	6.93
	6 Oct. 69	0.50	1	9.21
	29 Oct. 69	0.10	72	3.29
26	14 Jul. 69	0.50	53	1.27
	29 Jul. 69	0.50	62	0.96
	29 Jul. 69	0.50	62 (A)	0.96
	4 Sept. 69	0.10	77	2.61
	9 Oct. 69	0.10	14	19.66
27	14 Jul. 69	0.50	9	4.82
	29 Jul. 69	0.50	30	2.41
	29 Jul. 69	0.50	28 (A)	2.55
	9 Oct. 69	0.10	13	20.40
28	28 Jul. 69	0.50	66	0.83
	28 Jul. 69	0.50	66 (A)	0.83
	4 Sept. 69	0.10	55	5.98
	6 Oct. 69	0.10	54	6.16
	29 Oct. 69	0.10	79	2.36

Table 2 . (cont'd)

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE ($\%T_\alpha$, path length^{-1})	K_α (m^{-1})
29	7 Oct. 69	0.10	82	1.98
31	14 Jul. 69	0.10	39	9.42
	14 Jul. 69	0.50	3	7.01
	29 Jul. 69	0.50	58	1.09
	29 Jul. 69	0.50	56 (A)	1.16
	6 Sept. 69	0.50	13	4.08
	8 Oct. 69	0.10	22	15.14
33	14 Jul. 69	0.10	8	25.26
	29 Jul. 69	0.50	8	5.05
	29 Jul. 69	0.50	6 (A)	5.63
	8 Oct. 69	0.10	6	28.13
35	14 Jul. 69	0.50	34	2.16
	29 Jul. 69	0.50	46	1.55
	29 Jul. 69	0.50	46 (A)	1.55
	6 Sept. 69	0.10	95	0.51
	6 Sept. 69	0.50	36	2.04
	8 Oct. 69 (1m)	0.10	73	3.15
	8 Oct. 69 (1m)	0.10	80	2.23
	8 Oct. 69 (1m)	0.10	73	3.15
	8 Oct. 69 (1m)	0.10	83	1.86
	8 Oct. 69 (1m)	0.10	82	1.98
	8 Oct. 69 (1m)	0.50	22	3.03
	8 Oct. 69 (1m)	0.50	22	3.03
	8 Oct. 69 (2m)	0.10	78	2.49
	8 Oct. 69 (2m)	0.10	73	3.15
	8 Oct. 69 (3m)	0.10	78	2.48
	8 Oct. 69 (3m)	0.10	73	3.15
	8 Oct. 69 (3m)	0.50	19	3.32
	8 Oct. 69 (3m)	0.50	20	3.22
	8 Oct. 69 (5m)	0.10	74	3.01
	8 Oct. 69 (5m)	0.10	72	3.29
	8 Oct. 69 (5m)	0.10	78	2.48
	8 Oct. 69 (5m)	0.10	80	2.23
	8 Oct. 69 (5m)	0.50	18	3.43
	8 Oct. 69 (5m)	0.50	19	3.32
	8 Oct. 69 (7m)	0.10	73	3.15
	8 Oct. 69 (7m)	0.10	71	3.42
	8 Oct. 69 (7m)	0.50	18	3.43
	8 Oct. 69 (7m)	0.50	18	3.43
	8 Oct. 69 (10m)	0.10	70	3.57
	8 Oct. 69 (10m)	0.10	73	3.15
	8 Oct. 69 (10m)	0.10	78	2.48
	8 Oct. 69 (10m)	0.10	77	2.61
	8 Oct. 69 (10m)	0.50	18	3.43
	8 Oct. 69 (10m)	0.50	18	3.43
	8 Oct. 69 (15m)	0.10	55	5.98
	8 Oct. 69 (15m)	0.10	76	2.74
	8 Oct. 69 (15m)	0.50	17	3.54
39	15 Jul. 69	0.50	53	1.27
	30 Jul. 69	0.50	64	0.89
	30 Jul. 69	0.50	63 (A)	0.92
	6 Sept. 69	0.50	15	3.79
	6 Oct. 69	0.50	9	4.82
	29 Oct. 69	0.10	60	5.11
41	15 Jul. 69	0.50	48	1.47
	30 Jul. 69	0.50	64	0.89
	30 Jul. 69	0.50	64 (A)	0.89

Table 2. (cont'd)

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE (%T_α, path length^{-1})	K_α (m^{-1})
	7 Sept. 69	0.50	39	1.88
	6 Oct. 69	0.50	8	5.05
43	15 Jul. 69	0.50	33	2.22
	30 Jul. 69	0.50	16	3.67
	30 Jul. 69	0.50	14 (A)	3.93
	6 Oct. 69	0.50	1	9.21
45	15 Jul. 69	0.50	52	1.31
	30 Jul. 69	0.50	72	0.66
	30 Jul. 69	0.50	72 (A)	0.66
	7 Sept. 69	0.50	18	3.43
	6 Oct. 69	0.10	80	2.23
	6 Oct. 69	0.50	14	3.93
48	15 Jul. 69	0.50	8	5.05
	30 Jul. 69	0.50	27	2.62
	30 Jul. 69	0.50	27 (A)	2.62
	7 Sept. 69	0.50	12	4.24
	12 Oct. 69	0.10	67	4.00
	29 Oct. 69	0.10	18	17.15
50 B	11 Jul. 69	0.10	27 (A)	13.09
	27 Jul. 69	0.10	42	8.68
	27 Jul. 69	0.10	40 (A)	9.16
50 C	11 Jul. 69	0.10	32	11.39
	11 Jul. 69	0.10	38 (A)	9.68
	27 Jul. 69	0.10	50	6.93
	27 Jul. 69	0.10	49 (A)	7.13
	3 Sept. 69	0.10	55	5.98
	5 Oct. 69	0.10	18	17.15
51	11 Jul. 69	0.10	77	2.61
	11 Jul. 69	0.10	72 (A)	3.29
	27 Jul. 69	0.10	64	4.46
	27 Jul. 69	0.10	65 (A)	4.31
	3 Sept. 69	0.10	49	7.13
	5 Oct. 69	0.10	65	4.31
52	11 Jul. 69	0.10	42	8.68
	11 Jul. 69	0.10	49 (A)	7.13
	27 Jul. 69	0.10	42	8.68
	27 Jul. 69	0.10	40 (A)	9.16
	3 Sept. 69	0.10	19	16.61
	5 Oct. 69	0.10	18	17.15
54	11 Jul. 69	0.10	30	12.04
	11 Jul. 69	0.10	62 (A)	4.78
	27 Jul. 69	0.10	61	4.94
	27 Jul. 69	0.10	58 (A)	5.45
	8 Sept. 69	0.10	30	12.04
	5 Oct. 69	0.10	22	15.14
	30 Oct. 69	0.10	12	21.20
54 B	28 Oct. 69	0.10	10	23.03
57	10 Jul. 69	0.10	58	5.45
	10 Jul. 69	0.10	80 (A)	2.23
	25 Jul. 69	0.10	69 (A)	3.71

Table 2. (cont'd)

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE (%T_α,path length^{-1})	K_α (m^{-1})
	8 Sept. 69	0.10	42	8.68
	4 Oct. 69	0.10	34	10.79
58	10 Jul. 69	0.10	22	15.14
	10 Jul. 69	0.10	22 (A)	15.14
	25 Jul. 69	0.10	25 (A)	13.86
	9 Sept. 69	0.10	8	25.26
	4 Oct. 69	0.10	1	46.05
59	9 Jul. 69	0.10	55	5.98
	25 Jul. 69	0.10	80	2.23
	25 Jul. 69	0.10	73 (A)	3.15
	9 Sept. 69	0.10	73	3.15
	4 Oct. 69	0.10	70	3.57
	31 Oct. 69	0.10	29	12.38
60	9 Jul. 69	0.10	30.5	11.87
	24 Jul. 69	0.10	69 (A)	3.71
	2 Sept. 69	0.10	72	3.29
	9 Sept. 69	0.10	69	3.71
	3 Oct. 69	0.10	38	9.68
	31 Oct. 69	0.10	50	6.93
60 B	9 Jul. 69	0.10	3 (A)	35.07
	24 Jul. 69	0.10	28 (A)	12.73
	9 Sept. 69	0.10	45	7.89
	4 Oct. 69	0.10	20	16.09
60 C	24 Jul. 69	0.10	6.5 (A)	27.97
	9 Sept. 69	0.10	28	12.73
	3 Oct. 69	0.10	44	8.21
61	9 Jul. 69	0.10	15.5 (A)	18.64
	24 Jul. 69	0.10	64 (A)	4.46
	2 Sept. 69	0.10	63	4.62
	10 Sept. 69	0.10	58	5.47
	3 Oct. 69	0.10	38	9.68
	31 Oct. 69	0.10	32	11.39
62	9 Jul. 69	0.10	4 (A)	32.19
	24 Jul. 69	0.10	25 (A)	13.86
	10 Sept. 69	0.10	32	11.39
	3 Oct. 69	0.10	3	35.07
63	17 Jul. 69	0.10	41	8.92
	1 Aug. 69	0.10	1	46.05
	1 Aug. 69	0.10	1 (A)	46.05
	10 Sept. 69	0.10	16	18.33
	13 Oct. 69	0.10	2	39.12
	31 Oct. 69	0.10	31	11.71
64	15 Jul. 69	0.10	50	6.93
	15 Jul. 69	0.50	7	5.32
	31 Jul. 69	0.10	45	7.99
	31 Jul. 69	0.10	44 (A)	8.21
	31 Jul. 69	0.50	2	7.82
	31 Jul. 69	0.50	2 (A)	7.82
	7 Sept. 69	0.10	44	8.21
	12 Oct. 69	0.10	18	17.15
	29 Oct. 69	0.10	24	14.27

Table 2. (cont'd)

STATION	DATE	PATH LENGTH (meters)	% TRANSMITTANCE ($\%T_{\alpha}$, path length^{-1})	K_{α} (m^{-1})
65	16 Jul 69	0.10	50	6.93
	31 Jul. 69	0.10	50	6.93
	31 Jul. 69	0.10	49 (A)	7.13
66 B	31 Jul. 69	0.10	70	3.57
	31 Jul. 69	0.10	68 (A)	3.86
68	16 Jul. 69	0.10	62	4.78
	31 Jul. 69	0.10	40	9.16
	31 Jul. 69	0.10	39 (A)	9.42
	8 Sept. 69	0.10	30	12.04
	12 Oct. 69	0.10	14	19.66
	30 Oct. 69	0.10	12	21.20
69	16 Jul. 69	0.10	49	7.13
	31 Jul. 69	0.10	40	9.16
	31 Jul. 69	0.10	38 (A)	9.68
	8 Sept. 69	0.10	34	10.79
	12 Oct. 69	0.10	10	23.03
69 B	28 Oct. 69	0.10	8	25.26

Table 3. Computed values for vertical extinction coefficients, based on measurements of the percentage of surface light reaching several depths in the water column. These measurements were made with a Whitney submersible photometer (Montedoro Corp. model LMT-8A) with no filters over the sensor. Vertical extinction coefficients were obtained as the slope of regressions between (ln % surface light) and water depth, ignoring the depth interval 0-10 cm. These estimates of extinction coefficients were computed from depth profiles of light in lake water-flushed deck tanks [K_w(DT)] on the ship, and from depth profiles of light in the lake [K_w(IS)]. r^2 is the correlation coefficient of the regression.

STATION	DATE	TIME	K_w(DT) m^{-1}	r^2	K_w(IS) m^{-1}	r^2
00	03Jun69	-	4.06	0.966		
00	17Jul69	1335	6.69	0.998		
01	09Jul69	-	7.24	0.996	4.55	0.965
	17Jul69	1145	6.14	0.999		
02	04Jun69	1730	3.42	0.897		
	04Jun69	1730	3.14	0.827		
	09Jul69	1510	5.99	0.992		
04	09Jul69	1710	5.78	0.989		
06	26Jul69	0600	-	-		
07	05Jun69	0830	1.83	0.971		
	10Jul69	1002	3.36	0.989		
	26Jul69	0800	4.08	0.992	2.00	0.956
08	26Jul69	0910	4.69	0.997	2.06	0.973
10	05Jun69	1145	2.44	0.873		
	10Jul69	1235	3.53	0.976	1.88	0.996
	26Jul69	1220	3.25	0.996	1.40	0.956
13	05Jun69	1545	2.06	0.938		
13B	05Oct69	1015	6.56	0.997		
14	05Jun69	1930	1.57	0.917		
	26Jul69	1653	3.52	0.997		
15	06Jun69	1005	2.26	0.965		
16	06Jun69	1115	1.66	0.971		
	11Jul69	1015	3.40	0.988		
	27Jul69	1100	3.80	0.996	2.98	0.994
16B	05Oct69	1515	6.14	0.992		
17	12Jul69	0930	9.33	0.883	1.71	0.985
	12Jul69	1317	5.62	0.998		
	12Jul69	1400			1.44	0.946
	12Jul69	1500	5.88	0.999		
18	06Jun69	1420	2.26	0.988		
	27Jul69	1900			1.47	0.996
20	07Jun69	0815	1.16	0.697	1.64	0.899
	07Jun69	0815			1.79	0.921
	13Jul69	0830			1.46	0.982
	13Jul69	1010	2.76	0.971		
	28Jul69	0900			1.23	0.998

Table 3. (cont'd)

STATION	DATE	TIME	K_w(DT) m^{-1}	r^2	K_w(IS) m^{-1}	r^2
21	07Jun69	1015	1.50	0.953		
	13Jul69	1100			1.31	0.999
	28Jul69	1127			0.822	0.998
	28Jul69	1140	1.48	0.931		
22	13Jul69	1130	2.72	0.959		
23A	13Jul69	1415	1.43	0.977		
23C	28Jul69	1630			0.835	0.999
	28Jul69	1655	2.36	0.992		
23D	07Jun69	1430	2.16	0.971		
23E	07Jun69	1530	2.39	0.980	0.827	0.996
	30Jul69	0825			0.631	0.898
25	07Jun69	2000	0.595	0.890		
	13Jul69	1825	1.79	0.960	0.656	0.991
	28Jul69	1836			0.591	0.996
28	08Jun69	1045	1.35	0.982		
29	08Jun69	1500	1.92	0.901		
	07Oct69	1045	2.37	0.997		
	07Oct69	1600	2.98	0.983		
33	09Jun69	1305	1.69	0.987		
35	14Jul69	0905			0.935	0.995
	14Jul69	0905			0.959	0.993
	14Jul69	0905			0.924	0.994
	14Jul69	0930	2.84	0.779		
	14Jul69	1245	2.50	0.971		
	14Jul69	1420	2.60	0.933	0.834	0.999
	26Jul69	0930	2.72	0.919	0.709	0.943
	29Jul69	1540			0.802	0.998
	29Jul69	1550	2.17	0.992		
	08Oct69	1305	4.35	0.999		
	08Oct69	1305	1.92	0.997		
	08Oct69	1405	1.17	0.996		
	08Oct69	1600			0.938	0.960
	08Oct69	1815	3.44	0.991		
39	15Jul69	0950	3.94	0.952		
	30Jul69	1039			0.509	0.937
41	15Jul69	1140	2.68	0.918	0.640	0.998
	30Jul69	1255			0.534	0.986
	30Jul69	1259	1.72	0.998		
	06Oct69	1700	3.37	0.993		
43	15Jul69	1420	2.20	0.992		
45	15Jul69	1545	1.90	0.997		
	06Oct69	1245	2.92	0.970		

Table 4. Percentage transmission ($\%T_\lambda$) of light (from a bank of fluorescent tubes) at various wavelengths (λ_i) through a 0.1 meter water column, vertical extinction coefficients ($K_{SR\lambda}$) for each wave length over the 0.1 meter water column, and computed vertical extinction coefficients ($\bar{K}_{SR}$) and percent transmission ($\%\bar{T}$) for λ = 400 to 1000 mμ through a 1.0 meter water column. These data were determined with a 16 channel submersible spectroradiometer, with the sensor held just above, and 10 cm below the water surface in a large deck tank flushed with lake water. A relatively constant light source was provided by fluorescent tubes affixed to a lid over the deck tank. See Fig. 1 , and methods.

Station	05		12		13B		16	
Date	02Sep69		02Sep69		05Oct69		03Sep69	
Time	1300		1740		1030		1145	
Wave Length (λ_i) (mμ)	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})
405	24.7	14.0	54.2	6.12	63.4	4.56	49.4	7.05
436	18.0	17.1	6.59	27.2	36.1	10.2	9.76	23.3
460	39.8	9.20	38.2	9.62	51.2	6.70	30.1	12.0
480	32.4	11.3	30.6	11.9	50.6	6.82	44.4	8.11
500	31.7	11.5	33.3	11.0	50.4	6.86	30.8	11.8
520	47.2	7.51	46.4	7.68	53.1	6.33	36.0	10.2
546	60.3	5.06	61.0	4.95	53.9	6.17	45.4	7.90
577	52.5	6.44	52.0	6.54	57.1	5.60	45.8	7.82
600	49.8	6.97	46.3	7.70	55.6	5.88	37.9	9.70
640	50.0	6.93	50.0	6.93	59.7	5.16	46.4	7.69
660	53.3	6.29	53.3	6.29	60.5	5.02	53.3	6.29
691	56.8	5.65	56.8	5.65	67.4	3.95	50.0	6.93
730	55.0	5.98	58.0	5.45	66.4	4.09	50.0	6.93
800	50.0	6.93	50.0	6.93	75.0	2.88	42.9	8.47
900	50.0	6.93	-	-	82.7	1.90	-	-
1000	0.0	-	0.0	-	82.0	1.99	0.0	-
$\%\bar{T}$	0.043 m^{-1}		0.034 m^{-1}		0.188 m^{-1}		0.008 m^{-1}	
$\bar{K}_{SR}$		7.74		7.99		6.27		9.43

Station	48		50C-51		51		58	
Date	07Sep69		03Sep69		05Oct69		09Sep69	
Time	1530		1700		1845		0845	
Wave Length (λ_i) (mμ)	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})
405	38.6	9.53	34.9	10.5	59.2	5.24	45.3	7.92
436	42.4	8.57	4.39	31.3	30.7	11.8	11.6	21.5
460	89.4	1.12	23.6	14.4	46.9	7.58	47.5	7.44
480	85.2	1.60	41.7	8.76	46.4	7.68	44.7	8.05
500	55.8	5.83	25.8	13.5	46.3	7.70	43.1	8.41
520	61.6	4.85	32.8	11.1	51.5	6.63	39.1	9.39
546	74.0	3.02	46.0	7.76	52.9	6.36	48.0	7.34
577	68.8	3.75	43.8	8.27	56.3	5.75	50.5	6.82
600	48.1	7.33	36.8	9.99	58.9	5.29	41.9	8.69
640	60.0	5.11	43.6	8.29	64.8	4.34	55.0	5.98
660	68.3	3.81	51.7	6.60	67.7	3.90	58.9	5.29
691	86.4	1.47	47.7	7.40	75.0	2.88	70.8	3.45
730	0.0	-	47.0	7.55	71.5	3.35	-	-
800	-	-	39.3	9.34	84.0	1.75	84.8	1.65
900	-	-	-	-	90.0	1.05	-	-
1000	28.6	12.5	0.0	-	88.0	1.28	-	-
$\%\bar{T}$	1.64 m^{-1}		0.004 m^{-1}		0.182 m^{-1}		0.032 m^{-1}	
$\bar{K}_{SR}$		4.11		10.1		6.31		8.06

Table 4. (cont'd)

Station	35		35		35		45	
Date	06Sep69		08Oct69		08Oct69		06Oct69	
Time	1200		1300		1825		1315	
Wave Length (λ_i) (mμ)	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})
405	26.5	13.3	78.3	2.45	84.9	1.63	73.5	3.08
436	65.9	4.18	69.5	3.63	71.2	3.40	61.9	4.79
460	66.7	4.06	80.4	2.19	80.6	2.15	74.1	3.00
480	78.7	2.40	79.1	2.34	82.0	1.99	73.5	3.08
500	54.2	6.13	77.3	2.57	80.5	2.17	73.0	3.15
520	62.4	4.72	77.1	2.60	83.6	1.80	75.9	2.75
546	57.1	5.60	81.3	2.08	82.4	1.94	75.7	2.79
577	57.0	5.62	78.9	2.36	83.3	1.82	76.8	2.63
600	39.6	9.25	78.1	2.48	80.0	2.23	74.4	2.96
640	45.5	7.89	82.0	1.99	84.1	1.74	76.9	2.62
660	48.3	7.27	80.2	2.21	83.5	1.81	75.7	2.79
691	59.1	5.26	83.0	1.87	86.0	1.51	78.3	2.45
730	27.0	13.1	75.5	2.81	83.5	1.80	75.0	2.88
800	-	-	86.6	1.44	86.4	1.47	81.5	2.05
900	75.0	2.88	87.9	1.29	85.0	1.63	80.9	2.12
1000	7.62	25.7	86.9	1.41	87.2	1.37	88.6	1.21
$\%\bar{T}$	0.278 m^{-1}		8.73 m^{-1}		12.1 m^{-1}		4.76 m^{-1}	
$\bar{K}_{SR}$		5.89		2.44		2.11		3.04

Station	16		17		23C		25	
Date	05Oct69		03Sep69		06Sep69		04Sep69	
Time	1530		1230		1750		1600	
Wage Length (λ_i) (mμ)	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})
405	63.8	4.50	38.6	9.53	37.3	9.85	54.2	6.12
436	40.0	9.16	4.39	31.3	54.6	6.05	34.1	10.7
460	52.9	6.37	27.6	12.9	69.9	3.58	52.0	6.53
480	53.3	6.29	41.7	8.76	76.9	2.63	63.0	4.63
500	50.0	6.93	28.3	12.6	51.7	6.60	43.3	8.36
520	54.3	6.11	36.0	10.2	62.4	4.72	45.6	7.85
546	54.2	6.13	46.0	7.76	73.7	3.06	63.5	4.54
577	55.2	5.95	43.8	8.27	66.3	4.12	56.3	5.75
600	55.7	5.85	38.6	9.52	43.2	8.40	50.9	6.76
640	58.5	5.37	46.4	7.69	56.4	5.73	54.5	6.06
660	61.2	4.91	55.8	5.83	61.7	4.83	60.0	5.11
691	66.5	4.07	51.4	6.66	72.7	3.19	59.1	5.26
730	71.4	3.37	52.0	6.54	17.0	17.7	55.0	5.98
800	80.9	2.13	45.7	7.83	53.6	6.24	57.1	5.60
900	87.5	1.34	-	-	83.3	1.82	-	-
1000	87.1	1.38	0.0	-	14.3	19.5	0.0	-
$\%\bar{T}$	0.217 m^{-1}		0.006 m^{-1}		0.608 m^{-1}		0.179 m^{-1}	
$\bar{K}_{SR}$		6.14		9.76		5.10		6.32

Table 4. (cont'd)

Station	59		59-60		59		59	
Date	09Sep69		02Sep69		04Oct69		04Oct69	
Time	0945		1340		0940		1850	
Wave Length (λ_i) (mμ)	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})
405	37.7	9.75	34.9	10.5	55.4	5.91	64.9	4.32
436	22.7	14.8	17.6	17.4	37.3	9.85	40.0	9.16
460	55.3	5.92	42.3	8.61	49.7	7.00	53.4	6.28
480	54.5	6.06	35.2	10.4	48.6	7.22	51.4	6.65
500	53.9	6.18	34.2	10.7	49.2	7.10	58.2	5.41
520	52.7	6.40	50.8	6.77	51.4	6.65	54.8	6.01
546	63.3	4.57	63.7	4.52	52.2	6.50	54.2	6.13
577	63.0	4.63	56.3	5.75	54.8	6.02	57.8	5.48
600	53.9	6.18	51.9	6.55	53.3	6.29	56.9	5.64
640	65.0	4.31	53.6	6.23	58.5	5.36	59.8	5.14
660	67.9	3.88	55.0	5.98	59.4	5.21	63.0	4.62
691	75.8	2.77	58.2	5.42	65.8	4.18	70.0	3.57
730	-	-	56.0	5.80	64.0	4.46	40.2	9.12
800	71.7	3.32	48.2	7.30	79.1	2.35	81.8	2.01
900	40.0	9.16	55.0	5.98	83.2	1.84	91.7	0.866
1000	60.0	5.11	0.0	-	82.8	1.89	80.0	2.23
$\%\bar{T}$	0.292 m^{-1}		0.078 m^{-1}		0.146 m^{-1}		0.254m^{-1}	
$\bar{K}_{SR}$		5.84		7.16		6.53		5.98

Station	61		62		68		68	
Date	10Sep69		04Sep69		08Sep69		12Oct69	
Time	0920		1007		0700		1440	
Wave Length (λ_i) (mμ)	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})	$\%T_\lambda$ (0.1 m^{-1})	$K_{SR\lambda}$ (m^{-1})
405	40.6	9.01	60.2	5.07	80.7	2.14	68.7	3.75
436	0.0	-	73.2	3.12	31.2	11.6	44.9	8.01
460	61.8	4.81	81.3	2.07	87.0	1.39	60.0	5.11
480	60.2	5.08	-	-	80.6	2.16	58.0	5.45
500	60.6	5.01	75.0	2.88	56.7	5.68	56.7	5.68
520	63.1	4.60	80.0	2.23	51.2	6.69	56.2	5.77
546	67.7	3.90	88.9	1.18	62.5	4.69	59.4	5.21
577	70.3	3.53	87.5	1.34	59.5	5.19	60.0	5.11
600	64.5	4.38	84.2	1.72	44.2	8.16	56.6	5.69
640	74.5	2.94	81.8	2.01	61.8	4.81	65.5	4.24
660	75.9	2.76	90.0	1.05	70.0	3.57	65.6	4.21
691	81.6	2.03	81.8	2.01	82.7	1.90	70.9	3.43
730	-	-	80.0	2.23	0.0	-	70.6	3.49
800	70.0	3.57	64.3	4.42	60.7	4.99	78.9	2.37
900	76.7	2.66	-	-	83.3	1.82	87.2	1.37
1000	55.5	5.88	0.0	-	19.0	16.6	80.0	2.23
$\%\bar{T}$	0.894 m^{-1}		17.1 m^{-1}		0.344 m^{-1}		0.452 m^{-1}	
$\bar{K}_{SR}$		4.72		1.77		5.67		5.40

Table 5. Suspended sediment (SS) total dissolved solids (TDS), and total solids (TS) for Lake Winnipeg and Red River stations. Station locations can be found in Fig. 3.

STATION NO.	DATE	SAMPLING DEPTH (METERS)	(GRAMS PER CUBIC METER) TDS	SS	TS
0	27OCT68	1.0	145.00	********	********
0	3MAR69	1.0	440.00	110.00	550.00
0	18MAR69	1.0	425.00	90.00	515.00
0	31MAR69	1.0	400.00	11.00	411.00
0	15APR69	1.0	240.00	1900.00	2140.00
0	28APR69	1.0	250.00	285.00	535.00
0	12MAY69	1.0	320.00	159.00	479.00
0	26MAY69	1.0	530.00	200.00	730.00
0	9JUN69	1.0	490.00	201.00	691.00
0	23JUN69	1.0	530.00	50.00	580.00
0	7JUL69	1.0	615.00	75.00	690.00
0	21JUL69	1.0	605.00	54.00	659.00
0	5AUG69	1.0	470.00	38.00	508.00
0	18AUG69	1.0	450.00	43.00	493.00
0	2SEP69	1.0	530.00	25.00	555.00
0	15SEP69	1.0	455.00	15.00	470.00
0	29SEP69	1.0	450.00	42.00	492.00
0	14OCT69	1.0	470.00	23.00	493.00
0	27OCT69	1.0	480.00	9.00	489.00
0	10NOV69	1.0	470.00	20.00	490.00
0	24NOV69	1.0	540.00	20.00	560.00
0	8DEC69	1.0	620.00	10.00	630.00
0	29DEC69	1.0	560.00	10.00	570.00
0	19JAN70	1.0	550.00	< 10.00	********
0	3FEB70	1.0	560.00	10.00	570.00
0	16FEB70	1.0	540.00	********	********
0	2MAR70	1.0	480.00	< 10.00	********
0	30MAR70	1.0	540.00	10.00	550.00
0	13APR70	1.0	480.00	44.00	524.00
0	21APR70	1.0	280.00	780.00	1060.00
0	27APR70	1.0	280.00	251.00	531.00
0	11MAY70	1.0	400.00	23.00	423.00
0	25MAY70	1.0	420.00	174.00	594.00
0	9JUN70	1.0	340.00	218.00	558.00
0	23JUN70	1.0	420.00	132.00	552.00
0	6JUL70	1.0	600.00	195.00	795.00
0	20JUL70	1.0	500.00	134.00	634.00
0	5AUG70	1.0	600.00	33.00	633.00
0	17AUG70	1.0	630.00	30.00	660.00
0	3SEP70	1.0	670.00	20.00	690.00
0	14SEP70	1.0	570.00	10.00	580.00
0	28SEP70	1.0	492.00	16.00	508.00
0	13OCT70	1.0	550.00	27.00	577.00
0	26OCT70	1.0	507.00	11.00	518.00
0	9NOV70	1.0	528.00	86.00	614.00
0	24NOV70	1.0	580.00	23.00	603.00
0	7DEC70	1.0	708.00	17.00	725.00
0	1FEB71	1.0	1524.00	5.00	1529.00
0	15FEB71	1.0	573.00	8.00	581.00
0	1MAR71	1.0	943.00	21.00	964.00
0	15MAR71	1.0	564.00	31.00	595.00
0A	3MAR69	1.0	355.00	205.00	560.00
0A	18MAR69	1.0	360.00	105.00	465.00
0A	31MAR69	1.0	375.00	13.00	388.00
0A	15APR69	1.0	235.00	1380.00	1615.00
0A	28APR69	1.0	395.00	150.00	545.00
0A	12MAY69	1.0	425.00	110.00	535.00
0A	26MAY69	1.0	490.00	195.00	685.00
0A	9JUN69	1.0	450.00	134.00	584.00
0A	23JUN69	1.0	450.00	110.00	560.00
0A	7JUL69	1.0	575.00	195.00	770.00
0A	21JUL69	1.0	490.00	78.00	568.00
0A	5AUG69	1.0	350.00	225.00	575.00
0A	18AUG69	1.0	380.00	48.00	428.00
0A	2SEP69	1.0	415.00	18.00	433.00
0A	15SEP69	1.0	335.00	27.00	362.00
0A	29SEP69	1.0	395.00	28.00	423.00
0A	14OCT69	1.0	415.00	25.00	440.00
0A	27OCT69	1.0	570.00	16.00	586.00
0A	10NOV69	1.0	400.00	20.00	420.00

STATION NO.	DATE	SAMPLING DEPTH (METERS)	(GRAMS PER CUBIC METER) TDS	SS	TS
0A	24NOV69	1.0	420.00	20.00	440.00
0A	8DEC69	1.0	470.00	10.00	480.00
0A	29DEC69	1.0	440.00	< 10.00	********
0A	19JAN70	1.0	400.00	10.00	410.00
0A	3FEB70	1.0	380.00	10.00	390.00
0A	16FEB70	1.0	350.00	********	********
0A	2MAR70	1.0	350.00	20.00	370.00
0A	30MAR70	1.0	390.00	10.00	400.00
0A	13APR70	1.0	400.00	67.00	467.00
0A	27APR70	1.0	280.00	298.00	578.00
0A	11MAY70	1.0	390.00	12.00	402.00
0A	25MAY70	1.0	410.00	135.00	545.00
0A	9JUN70	1.0	290.00	196.00	486.00
0A	23JUN70	1.0	330.00	129.00	459.00
0A	6JUL70	1.0	480.00	188.00	668.00
0A	20JUL70	1.0	380.00	283.00	663.00
0A	5AUG70	1.0	470.00	50.00	520.00
0A	17AUG70	1.0	470.00	30.00	500.00
0A	3SEP70	1.0	470.00	20.00	490.00
0A	14SEP70	1.0	400.00	20.00	420.00
0A	28SEP70	1.0	469.00	29.00	498.00
0A	13OCT70	1.0	440.00	29.00	469.00
0A	26OCT70	1.0	389.00	16.00	405.00
0A	9NOV70	1.0	433.00	32.00	465.00
0A	24NOV70	1.0	500.00	26.00	526.00
0A	7DEC70	1.0	492.00	15.00	507.00
0A	1FEB71	1.0	444.00	6.00	450.00
0A	15FEB71	1.0	355.00	9.00	364.00
0A	1MAR71	1.0	583.00	7.00	590.00
0A	15MAR71	1.0	460.00	97.00	557.00
0B	3MAR69	1.0	820.00	40.00	860.00
0B	18MAR69	1.0	765.00	70.00	835.00
0B	31MAR69	1.0	730.00	2.00	732.00
0B	15APR69	1.0	320.00	450.00	770.00
0B	28APR69	1.0	260.00	250.00	510.00
0B	12MAY69	1.0	310.00	226.00	536.00
0B	26MAY69	1.0	580.00	205.00	785.00
0B	9JUN69	1.0	570.00	145.00	715.00
0B	23JUN69	1.0	615.00	130.00	745.00
0B	7JUL69	1.0	730.00	170.00	900.00
0B	21JUL69	1.0	705.00	223.00	928.00
0B	5AUG69	1.0	710.00	360.00	1070.00
0B	18AUG69	1.0	565.00	360.00	925.00
0B	2SEP69	1.0	595.00	145.00	740.00
0B	15SEP69	1.0	630.00	58.00	688.00
0B	29SEP69	1.0	630.00	58.00	688.00
0B	14OCT69	1.0	710.00	25.00	735.00
0B	27OCT69	1.0	740.00	14.00	754.00
0B	10NOV69	1.0	790.00	20.00	810.00
0B	24NOV69	1.0	440.00	20.00	460.00
0B	8DEC69	1.0	920.00	20.00	940.00
0B	29DEC69	1.0	930.00	10.00	940.00
0B	19JAN70	1.0	880.00	10.00	890.00
0B	3FEB70	1.0	890.00	10.00	900.00
0B	16FEB70	1.0	900.00	********	********
0B	2MAR70	1.0	830.00	10.00	840.00
0B	30MAR70	1.0	3650.00	20.00	3670.00
0B	13APR70	1.0	920.00	33.00	953.00
0B	27APR70	1.0	360.00	343.00	703.00
0B	11MAY70	1.0	450.00	61.00	511.00
0B	25MAY70	1.0	440.00	189.00	629.00
0B	9JUN70	1.0	510.00	113.00	623.00
0B	23JUN70	1.0	630.00	96.00	726.00
0B	6JUL70	1.0	740.00	163.00	903.00
0B	20JUL70	1.0	670.00	305.00	975.00
0B	5AUG70	1.0	710.00	269.00	979.00
0B	17AUG70	1.0	790.00	200.00	990.00
0B	3SEP70	1.0	820.00	220.00	1040.00
0B	14SEP70	1.0	790.00	70.00	860.00
0B	28SEP70	1.0	750.00	59.00	809.00

STATION NO.	DATE	SAMPLING DEPTH (METERS)	(GRAMS PER CUBIC METER) TDS	SS	TS
0B	13OCT70	1.0	650.00	39.00	689.00
0B	26OCT70	1.0	553.00	79.00	632.00
0B	9NOV70	1.0	766.00	56.00	822.00
0B	24NOV70	1.0	865.00	49.00	914.00
0B	7DEC70	1.0	980.00	41.00	1021.00
0B	1FEB71	1.0	935.00	12.00	947.00
0B	15FEB71	1.0	913.00	24.00	937.00
0B	1MAR71	1.0	402.00	7.00	409.00
0B	15MAR71	1.0	214.00	30.00	244.00
1	27OCT68	1.0	95.00	********	********
1	9JUL69	1.0	422.00	30.64	452.64
1	2SEP69	1.0	********	27.90	********
1	27OCT69	1.0	********	74.20	********
2	28OCT68	1.0	205.00	********	********
2	23APR69	3.0	235.00	153.00	388.00
2	9JUL69	1.0	250.00	27.41	277.41
2	24JUL69	1.0	********	21.50	********
2	2SEP69	1.0	********	22.30	********
2	3OCT69	1.0	260.00	44.04	304.04
2	27OCT69	1.0	********	30.50	********
2	17MAR70	1.0	296.00	2.29	298.29
2	17MAR70	5.0	256.00	1.68	257.68
3	9JUL69	1.0	394.00	91.44	485.44
3	3OCT69	1.0	280.00	138.73	418.73
3C	9JUL69	1.0	********	29.87	********
3C	3OCT69	1.0	140.00	19.88	159.88
3C	17MAR70	1.0	299.00	1.97	300.97
3C	17MAR70	4.0	285.00	0.87	285.87
4	9JUL69	1.0	281.00	16.72	297.72
4	24JUL69	1.0	********	13.98	********
4	2SEP69	1.0	********	21.19	********
4	3OCT69	1.0	180.00	25.83	205.83
4	31OCT69	1.0	********	22.07	********
4	18MAR70	1.0	235.00	1.38	236.38
4	18MAR70	6.0	265.00	1.35	266.35
5	9JUL69	1.0	********	10.40	********
6	10JUL69	1.0	95.00	8.00	103.00
6	10JUL69	10.0	********	12.64	********
6	30OCT69	1.0	********	16.30	********
7	10JUL69	1.0	77.00	11.22	88.22
7	9SEP69	1.0	********	14.42	********
7	4OCT69	1.0	65.00	11.85	76.85
7	31OCT69	1.0	********	6.67	********
8	10JUL69	1.0	83.00	7.42	90.42
8	26JUL69	1.0	********	9.33	********
8	9SEP69	1.0	********	8.36	********
8	4OCT69	1.0	45.00	17.38	62.38
8	31OCT69	1.0	********	6.68	********
9	10JUL69	1.0	********	9.98	********
10	10JUL69	1.0	106.00	6.39	112.39
10	10JUL69	11.0	********	5.23	********
10	8SEP69	1.0	********	10.14	********
10	4OCT69	1.0	140.00	20.13	160.13
10	30OCT69	1.0	********	23.62	********
11	10JUL69	1.0	********	5.41	********
11	27OCT69	1.0	********	15.23	********
12	10JUL69	1.0	********	5.39	********
12	8SEP69	1.0	********	11.32	********
12	4OCT69	1.0	********	25.56	********
12	30OCT69	1.0	********	28.40	********
13C	29OCT68	1.0	135.00	********	********
14	10JUL69	1.0	85.00	7.66	92.66
14	26JUL69	1.0	********	11.62	********
14	8SEP69	1.0	********	14.90	********
14	5OCT69	1.0	135.00	21.08	156.08
14	30OCT69	1.0	********	26.73	********
15	31JUL69	0.0	********	42.13	********
15	31JUL69	1.0	********	6.32	********
16	11JUL69	1.0	71.00	8.76	79.76
16	27JUL69	1.0	********	12.58	********

STATION NO.	DATE	SAMPLING DEPTH (METERS)	(GRAMS PER CUBIC METER) TDS	SS	TS
16	3SEP69	1.0	********	49.15	********
16	5OCT69	1.0	80.00	22.63	102.63
16	28OCT69	1.0	********	18.60	********
17	5OCT69	1.0	135.00	********	********
18	11JUL69	1.0	107.00	9.17	116.17
18	27JUL69	1.0	********	4.70	********
18	27JUL69	15.0	********	4.65	********
18	3SEP69	1.0	********	7.54	********
18	5OCT69	1.0	85.00	13.54	98.54
18	28OCT69	1.0	********	32.07	********
19	28JUL69	1.0	********	4.07	********
19	28JUL69	15.0	********	11.98	********
19	3SEP69	1.0	********	8.64	********
19	3SEP69	16.0	********	4.94	********
19	11OCT69	1.0	155.00	8.92	163.92
19	28OCT69	1.0	********	18.60	********
20	13JUL69	1.0	139.00	6.33	145.33
20	3SEP69	1.0	********	6.93	********
20	11OCT69	1.0	180.00	13.02	193.02
20	28OCT69	1.0	********	10.15	********
20	28OCT69	1.0	********	11.25	********
20	28OCT69	14.0	********	14.21	********
21	28JUL69	1.0	********	3.11	********
21	4SEP69	1.0	********	5.97	********
21	11OCT69	1.0	165.00	7.10	172.10
21	28OCT69	1.0	********	6.78	********
22	4SEP69	1.0	********	4.30	********
22	11OCT69	1.0	175.00	4.63	179.63
22	29OCT69	1.0	********	7.75	********
23A	28JUL69	0.0	********	4.70	********
23C	13JUL69	1.0	188.00	2.17	190.17
23C	28JUL69	1.0	********	3.22	********
23C	6SEP69	1.0	********	2.87	********
23C	11OCT69	1.0	170.00	10.52	180.52
23C	29OCT69	1.0	********	7.60	********
23C	29OCT69	16.0	********	9.63	********
23E	15JUL69	1.0	148.00	3.85	151.85
23E	30JUL69	1.0	********	2.18	********
23E	11OCT69	1.0	170.00	10.20	180.20
25	28JUL69	1.0	********	2.40	********
25	4SEP69	1.0	********	6.64	********
25	6OCT69	1.0	190.00	10.20	200.20
25	29OCT69	1.0	********	6.40	********
28	13JUL69	1.0	199.00	4.15	203.15
28	6OCT69	1.0	230.00	********	********
28	29OCT69	1.0	********	5.95	********
29	20MAR69	0.0	305.00	2.00	307.00
29	28JUL69	1.0	********	3.55	********
29	4SEP69	1.0	********	4.06	********
29	7OCT69	1.0	230.00	7.67	237.67
29	29OCT69	1.0	********	3.11	********
30	18MAR69	2.0	200.00	5.00	205.00
30	18MAR69	5.0	200.00	4.00	204.00
30	18MAR69	11.0	200.00	4.00	204.00
35	18MAR69	2.0	200.00	3.00	203.00
35	18MAR69	15.0	190.00	3.00	193.00
35	14JUL69	1.0	148.00	2.75	150.75
35	29JUL69	1.0	********	4.75	********
35	6SEP69	1.0	********	3.50	********
35	6SEP69	15.0	********	3.07	********
35	8OCT69	1.0	185.00	6.93	191.93
35	8OCT69	16.0	190.00	15.54	205.54
39	1APR69	2.0	195.00	2.00	197.00
39	1APR69	8.0	195.00	2.00	197.00
39	1APR69	17.0	195.00	2.00	197.00
39	30JUL69	1.0	********	6.05	********
39	6SEP69	1.0	********	7.90	********
39	6OCT69	1.0	170.00	9.00	179.00
39	6OCT69	15.0	175.00	10.85	185.85
39	29OCT69	1.0	********	8.98	********

STATION NO.	DATE	SAMPLING DEPTH (METERS)	(GRAMS TDS	PER CUBIC SS	METER) TS
39	29OCT69	15.0	********	21.70	********
41	15JUL69	1.0	148.00	2.61	150.61
41	30JUL69	1.0	********	1.24	********
41	30JUL69	14.0	********	4.46	********
41	6OCT69	1.0	190.00	10.57	200.57
45	15JUL69	1.0	167.00	2.58	169.58
45	6OCT69	1.0	195.00	8.69	203.69
48	2APR69	2.0	210.00	7.00	217.00
48	2APR69	10.0	220.00	6.00	226.00
48	2APR69	16.0	210.00	7.00	217.00
48	15JUL69	1.0	120.00	5.83	125.83
48	30JUL69	1.0	********	2.48	********
48	7SEP69	1.0	********	5.33	********
48	7SEP69	15.0	********	3.90	********
48	12OCT69	1.0	155.00	9.16	164.16
48	12OCT69	16.0	135.00	9.30	144.30
48	29OCT69	1.0	********	22.33	********
48	29OCT69	15.0	********	22.33	********
50C	5OCT69	1.0	60.00	********	********
51	11JUL69	1.0	39.00	4.76	43.76
51	3SEP69	1.0	********	4.38	********
51	5OCT69	1.0	70.00	5.87	75.87
52	5OCT69	1.0	60.00	20.23	80.23
54	11JUL69	1.0	56.00	8.10	64.10
54	27JUL69	1.0	********	8.79	********
54	8SEP69	1.0	********	11.64	********
54	5OCT69	1.0	105.00	23.25	128.25
54	30OCT69	1.0	********	26.28	********
54B	28OCT69	1.0	********	28.10	********
55	30OCT68	0.0	135.00	********	********
55B	31JUL69	1.0	********	6.44	********
56	29OCT68	1.0	130.00	********	********
57	31OCT68	1.0	165.00	********	********
57	23APR69	2.0	90.00	1.00	91.00
57	23APR69	6.0	150.00	2.00	152.00
57	23APR69	10.0	330.00	1.00	331.00
57	10JUL69	1.0	********	7.41	********
57	25JUL69	1.0	********	6.26	********
57	4OCT69	1.0	355.00	17.30	372.30
57	27OCT69	1.0	********	13.00	********
58	10JUL69	1.0	********	19.10	********
59	31OCT68	1.0	135.00	********	********
59	9JUL69	1.0	145.00	7.84	152.84
59	9JUL69	10.0	********	8.32	********
59	25JUL69	1.0	********	4.17	********
59	2SEP69	1.0	********	34.33	********
59	9SEP69	1.0	********	5.74	********
59	9SEP69	10.0	********	5.24	********
59	4OCT69	1.0	170.00	7.60	177.60
59	4OCT69	10.0	160.00	9.00	169.00
59	31OCT69	1.0	********	13.24	********
59	31OCT69	10.0	********	17.40	********
60	23APR69	1.0	145.00	32.00	177.00
60	23APR69	4.0	155.00	4.00	159.00
60	23APR69	9.0	160.00	7.00	167.00
60	9JUL69	1.0	224.00	13.56	237.56
60	24JUL69	1.0	********	6.20	********
60	9SEP69	1.0	********	5.58	********
60	3OCT69	1.0	260.00	19.25	279.25
60	3OCT69	9.0	280.00	19.38	299.38
60	31OCT69	1.0	********	10.10	********
60B	9JUL69	1.0	********	33.64	********
60B	4OCT69	1.0	280.00	29.85	309.85
60C	18MAR70	1.0	286.00	3.46	289.46
61	9JUL69	1.0	209.00	21.60	230.60
61	9JUL69	8.0	********	19.65	********
61	24JUL69	1.0	********	6.34	********
61	10SEP69	1.0	********	6.88	********
61	10SEP69	8.0	********	4.75	********
61	3OCT69	1.0	235.00	20.42	255.42

STATION NO.	DATE	SAMPLING DEPTH (METERS)	(GRAMS TDS	PER CUBIC SS	METER) TS
61	31OCT69	1.0	********	16.40	********
61	18MAR70	1.0	253.00	4.72	257.72
61	18MAR70	7.0	387.00	16.06	403.06
62	31OCT68	1.0	150.00	********	********
62	9JUL69	1.0	********	27.70	********
62	30CT69	1.0	310.00	85.90	395.90
63	17JUL69	1.0	257.00	17.76	274.76
63	1AUG69	1.0	********	84.47	********
63	10SEP69	1.0	********	46.60	********
63	13OCT69	1.0	********	69.67	********
63	31OCT69	1.0	********	23.17	********
64	30OCT68	0.0	115.00	********	********
64	15JUL69	1.0	153.00	********	********
64	31JUL69	1.0	********	11.86	********
64	7SEP69	1.0	********	9.82	********
64	12OCT69	1.0	135.00	14.74	149.74
64	29OCT69	1.0	********	18.34	********
65	16JUL69	1.0	207.00	9.83	216.83
65	31JUL69	1.0	********	8.59	********
65	31JUL69	7.0	********	10.05	********
66B	31JUL69	1.0	********	7.78	********
66C	31JUL69	1.0	********	15.05	********
67	2APR69	1.0	1440.00	6.00	1446.00
68	31JUL69	1.0	********	10.92	********
68	12OCT69	1.0	********	27.88	********
68	30OCT69	1.0	********	26.85	********
69	16JUL69	1.0	70.00	6.04	76.04
69	31JUL69	1.0	********	12.00	********
69	12OCT69	1.0	********	38.20	********
69B	28OCT69	1.0	********	30.55	********
70	20MAR69	1.0	210.00	2.00	212.00

Table 6. Daily solar radiation at Winnipeg and The Pas for days of our research on Lake Winnipeg. The weather station at The Pas began recording radiation data in 1973, and we include this data, compared to 1973 Winnipeg data, to illustrate differences in solar radiation over the north and south basin of Lake Winnipeg. This data is derived from Canada Dept. of Transport, Met. Branch, Monthly Radiation Summary, 1969, 1970, 1973, and 1974.

Date	Winnipeg g cal cm^{-2} day^{-1}	The Pas g cal cm^{-2} day^{-1} (1973-74)	Winnipeg g cal cm^{-2} day^{-1} (1973-74)
18 Mar 69	361	155	191
19 Mar 69	325	212	175
20 Mar 69	457	346	263
1 Apr 69	452	260	466
2 Apr 69	408	436	501
23 Apr 69	596	299	509
24 Apr 69	596	-	378
4 Jun 69	630	358	-
5 Jun 69	622	462	492
6 Jun 69	287	338	653
7 Jun 69	693	212	485
8 Jun 69	742	-	465
9 Jun 69	-	110	528
10 Jun 69	-	399	527
11 Jun 69	580	615	705
12 Jun 69	514	603	745
9 Jul 69	608	20	724
10 Jul 69	471	663	639
11 Jul 69	671	590	443
12 Jul 69	660	309	676
13 Jul 69	597	384	520
14 Jul 69	326	623	642
15 Jul 69	383	439	673
16 Jul 69	664	590	626
17 Jul 69	645	403	421

Table 6. (cont')

Date	Winnipeg g cal $cm^{-2}day^{-1}$	The Pas g cal $cm^{-2}day^{-1}$ (1973-74)	Winnipeg g cal $cm^{-2}day^{-1}$ (1973-74)
24 Jul 69	645	211	382
25 Jul 69	644	287	350
26 Jul 69	107	285	290
27 Jul 69	483	573	437
28 Jul 69	637	355	560
29 Jul 69	607	355	498
30 Jul 69	268	620	317
31 Jul 69	661	581	606
1 Aug 69	628	476	626
2 Sep 69	302	468	163
3 Sep 69	369	164	81
4 Sep 69	282	305	258
5 Sep 69	346	209	357
6 Sep 69	465	472	405
7 Sep 69	291	461	482
8 Sep 69	212	311	407
9 Sep 69	445	225	321
10 Sep 69	365	441	499
3 Oct 69	41	198	110
4 Oct 69	172	226	337
5 Oct 69	111	209	323
6 Oct 69	113	273	336
7 Oct 69	158	120	108
8 Oct 69	333	237	111
9 Oct 69	155	274	63
10 Oct 69	-	195	224
11 Oct 69	-	266	165
12 Oct 69	-	144	99
13 Oct 69	-	113	293

Table 6. (cont')

Date	Winnipeg g cal $cm^{-2}day^{-1}$	The Pas g cal $cm^{-2}day^{-1}$ (1973-74)	Winnipeg g cal $cm^{-2}day^{-1}$ (1973-74)
26 Oct 69	152	66	33
27 Oct 69	177	60	95
28 Oct 69	232	155	211
29 Oct 69	66	44	105
30 ct 69	79	86	110
31 Oct 69	81	32	185
17 Mar 70	428	174	282
18 Mar 70	430	-	444

Table 7. Total monthly solar radiation expressed as g cal cm^{-2} at Winnipeg and The Pas for 1969 to 1975.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						WINNIPEG						
1969	3565	5656	11377	14010	16399	14760	15314	14136	9060	4619	3030	2635
1970	3689	5992	11873	11070	13113	15990	16213	15624	9150	5952	2790	2976
1971	4278	5600	9176	12000	16771	14820	-	14477	9570	5084	3540	2728
1972	4030	6583	9672	12390	15996	18870	16461	14322	8850	6851	3300	3286
1973	4061	5684	8680	12570	16399	15810	16895	14477	9870	5890	3210	2697
1974	3999	6328	10757	13080	12462	19080	18166	13330	9150	6355	2970	2635
1975	3348	6132	10137	10500	16213	14850	17701	13020	9450	5952	3840	2790
						THE PAS						
1973	2511	4676	8866	12090	16895	12510	14973	13609	9090	4309	2040	2449
1974	2759	4816	9331	14340	13020	15750	15283	12090	7620	5146	2400	1581
1975	2170	4788	10261	12630	13733	13920	15748	11470	7410	5084	2610	2821

Table 8. Regression equations relating turbidity related parameters to *in situ* vertical extinction coefficients [K_ω(IS)] for solar radiation in Lake Winnipeg waters. K_α is a horizontal extinction coefficient derived from transmissometer measurements, and K_α(A) is from the same transmissometer on the attenuated scale, in units of m^{-1}. SS is concentration of suspended sediments, in g m^{-3}. K_ω(DT) is a measurement of vertical extinction coefficient in a deck tank of Lake Winnipeg water, utilizing the Whitney submersible photometer, in units of m^{-1}. Chl-a is a fluorometric measurement of chlorophyll *a* from extracts of seston on a filter paper. F, degrees of freedom, and correlation coefficients are given for each relationship. The letter codes refer to estimated vertical extinction coefficients given in Table 9.

Code	Predicted $\hat{K}_\omega$		Predictors	Significance
(A)	K_ω(IS)	=	0.3970 + 0.9632 ln K_α(A)	$F_{1,30}$ = 303 r = 0.95
(B)	K_ω(IS)	=	0.4576 + 0.2472 K_α	$F_{1,45}$ = 435 r = 0.95
(C)	ln K_ω(IS)	=	0.3412 - 0.8549 ln Secchi (m)	$F_{1,38}$ = 307 r = 0.94
(D)	K_ω(IS)	=	0.5809 + 0.1227 SS (g/m^3)	$F_{1,28}$ = 108 r = 0.89
(E)	K_ω(IS)	=	- 0.2228+ 0.5158 K_ω(DT)	$F_{1,29}$ = 58.5 r = 0.82
(F)	K_ω(IS)	=	0.9820 + 2.2497x10^{-4} Algal Biomass (mg/m^3)	$F_{1,19}$ = 12.2 r = 0.62
(G)	K_ω(IS)	=	1.2239 + 0.5950 ln Chl-a (mg/m^3)	$F_{1,24}$ = 8.05 r = 0.50
(H)	K_ω(IS)	=	1.3631 + 0.5608 ln Phaeophyton (mg/m^3)	$F_{1,30}$ = 5.45 r = 0.39

Table 9. Measured and estimated values for vertical extinction coefficients ($\hat{K}_{\omega}$) of the transmission of incident light into Lake Winnipeg waters at selected stations. The measured values (without code notation) are derived from in situ % of incident light measurements in lake water, using a Whitney submersible photometer [K_{ω}(IS) in previous tables]. The estimated values (with code notation suffix) are derived from regression equations given in Table , utilizing the parameters Secchi visibility, suspended sediments, algal biomass, chlorophyll a, phaeophyton, horizontal extinction coefficients (K_{α}), and vertical extinction coefficients measured in deck tanks of lake water [K_{ω}(DT)].

	CRUISE				
Station	4-12 June 1969	9-17 July	24 July - 1 Aug.	2-10 Sept.	3-13 Oct.
1	-	4.55	3.45(C)	4.00(D)	2.54(C)
2	4.60(C)	3.94(C)	2.96(A)	2.79(A)	9.58(B)
3	-	7.86(B)	3.44(A)	5.32(B)	11.84(B)
3B	-	1.61(G)	-	-	-
3C	-	4.60(C)	3.20(A)	2.49(B)	3.12(B)
4	-	3.01(A)	2.90(A)	3.08(B)	3.88(B)
5	5.57(C)	2.48(A)	2.37(A)	2.27(B)	2.22(B)
5B	-	2.47(G)	-	-	-
6	3.73(C)	2.30(A)	2.03(A)	2.07(B)	3.05 (B)
7	1.41(C)	2.48(A)	2.00	2.32(B)	1.62 (B)
8	2.54(C)	1.97(A)	2.06	1.68(B)	3.05(B)
9	-	1.73(A)	2.37(A)	-	9.13(B)
10	2.18(C)	1.88	1.40	2.98(B)	3.69(B)
11	1.54(C)	1.50(A)	-	-	-
12	0.995(C)	1.37(A)	1.32(A)	3.35(B)	5.15(B)
13	0.840(E)	-	-	1.59(H)	1.69(H)
13B	-	1.37(A)	1.28(G)	1.81(G)	3.16(E)
14	0.995(C)	0.868(A)	2.03(A)	2.85(B)	3.99(B)
15	0.943(E)	1.42(G)	5.75(D)	1.38(G)	-
15B	-	-	-	-	1.50(G)
16	1.20(C)	2.48(A)	2.98	9.13(B)	4.32(B)
17	1.91(C)	1.58	1.56(A)	1.42(G)	-
18	1.91(C)	2.26(A)	1.47	1.27(B)	3.27(B)
19	1.62(C)	1.68(B)	1.28(B)	2.72(B)	1.45(B)
20	1.72	1.46	1.23	1.07(B)	2.17(B)

Table 9. (cont'd)

	CRUISE				
Station	4-12 June 1969	9-17 July	24 July-1 Aug.	2-10 Sept.	3-13 Oct.
20B	-	-	-	-	1.50(G)
21	1.47(C)	1.31	0.822	1.41(B)	1.30(B)
22	1.20(C)	1.05(A)	1.24(A)	3.35(B)	1.07(B)
23A	-	0.515(E)	1.16(D)	-	-
23B	-	-	-	2.12(G)	-
23C	-	0.416(A)	0.835	0.962(B)	0.917(B)
23D	1.30(C)	-	1.54(G)	-	-
23E	0.827	1.02(B)	0.631	1.01(B)	1.04(B)
24	0.813(C)	-	-	-	-
25	0.813(C)	0.656	0.591	2.17(B)	2.73(B)
26	-	0.643(C)	0.550(C)	0.995(C)	3.08(C)
27	-	1.65(B)	1.30(A)	-	5.50(B)
28	0.474(E)	0.643(C)	0.218(A)	1.94(B)	1.98(B)
29	0.768(E)	-	1.02(D)	1.08(D)	0.947(B)
31	0.995(C)	2.49(B)	0.540(A)	1.47(B)	4.20(B)
33	2.54(C)	6.70(B)	2.06(A)	-	7.41(B)
34	-	-	-	-	2.05(G)
35	0.717(C)	0.913	0.736	0.774(B)	0.938
39	1.65(F)	0.772(B)	0.509	1.39(B)	1.65(B)
41	1.54(C)	0.640	0.534	0.922(B)	1.71(B)
43	3.08(C)	1.01(B)	1.36(B)	-	2.73(B)
45	-	0.781(B)	-	1.31(B)	1.22(B)
47	-	-	-	2.61(G)	2.25(G)
48	1.45(F)	1.71(B)	1.32(A)	1.51(B)	1.45(B)
50	-	1.93(E)	-	2.33(H)	-
50B	-	2.99	2.53(A)	-	-
50C	-	2.58(A)	2.29(A)	1.94(B)	4.70(B)
50D	-	-	-	2.30(H)	-
51	-	1.54(A)	1.80(A)	2.22(B)	1.52(B)
52	2.18(C)	2.29(A)	2.53(A)	4.56(B)	4.70(B)

Table 9. (cont'd)

Station	CRUISE 4-12 June 1969	9-17 July	24 July-1 Aug.	2-10 Sept.	3-13 Oct.
53	-	1.42(G)	-	-	-
54	1.70(C)	1.90(A)	1.72	3.43(B)	4.20(B)
54B	-	-	-	-	1.38(G)
55	2.54(C)	1.38(G)	1.64(G)	1.28(G)	-
55B	-	-	1.37(D)	-	-
56	-	1.69(G)	1.54(G)	1.54(G)	-
57	2.18(C)	1.17(A)	1.66(A)	2.60(B)	3.12(B)
57B	-	-	-	1.67(G)	-
58	3.94(C)	3.01(A)	2.93(A)	6.70(B)	11.8(B)
59	2.54(C)	1.94(B)	1.82	1.24(B)	1.55
60	3.94(C)	3.39(B)	1.66(A)	1.32(B)	2.85(B)
60B	-	3.82(A)	2.85(A)	2.41(B)	4.44(B)
60C	-	-	3.61(A)	3.60(B)	2.49(B)
61	5.57(C)	3.49	1.84(A)	1.71(B)	2.85(B)
62	5.57(C)	3.74(A)	2.93(A)	3.27(B)	9.13(B)
62B	-	1.72(G)	-	-	-
63	10.1(C)	2.27	4.09(A)	4.99(B)	10.1(B)
64	-	1.97(B)	2.36	2.49(B)	4.70(B)
64B	-	1.52(E)	1.47(G)	-	1.54(G)
65	-	1.73	2.15	-	-
65B	-	-	1.36(H)	-	-
65C	-	-	1.63(H)	-	-
66A	-	-	1.42(G)	-	-
66B	-	-	1.40	-	-
66C	-	-	2.43(D)	-	-
68	-	1.64(B)	2.81	3.43(B)	5.32(B)
68B	-	-	1.54(E)	1.61(G)	1.81(H)
69	-	2.22(B)	2.96	3.12(B)	6.15(B)
69B	-	-	1.61(G)	-	-

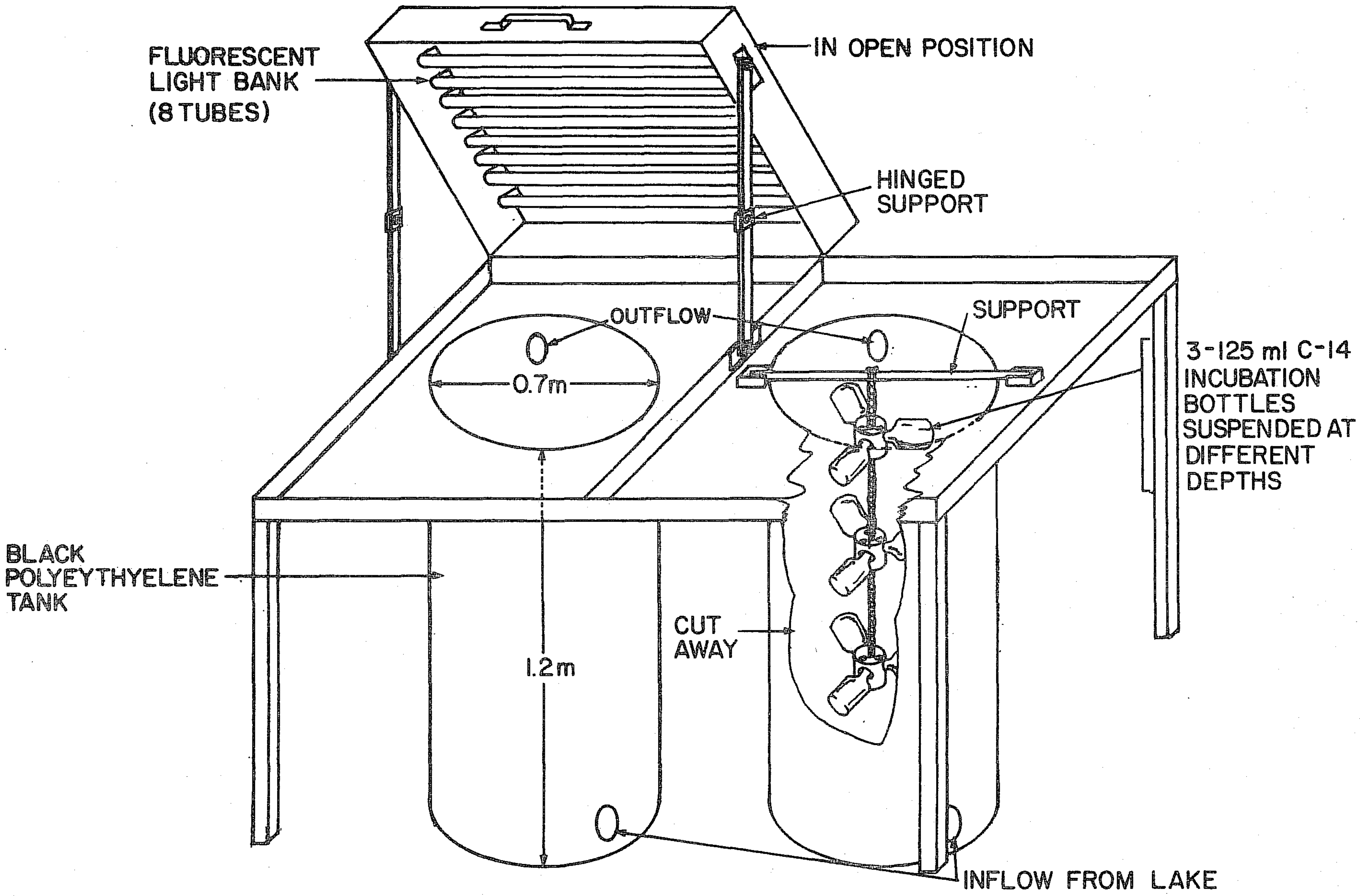

Fig. 1. The deck tank used on the wheel-house deck of the Bradbury for light measurements and primary production work.

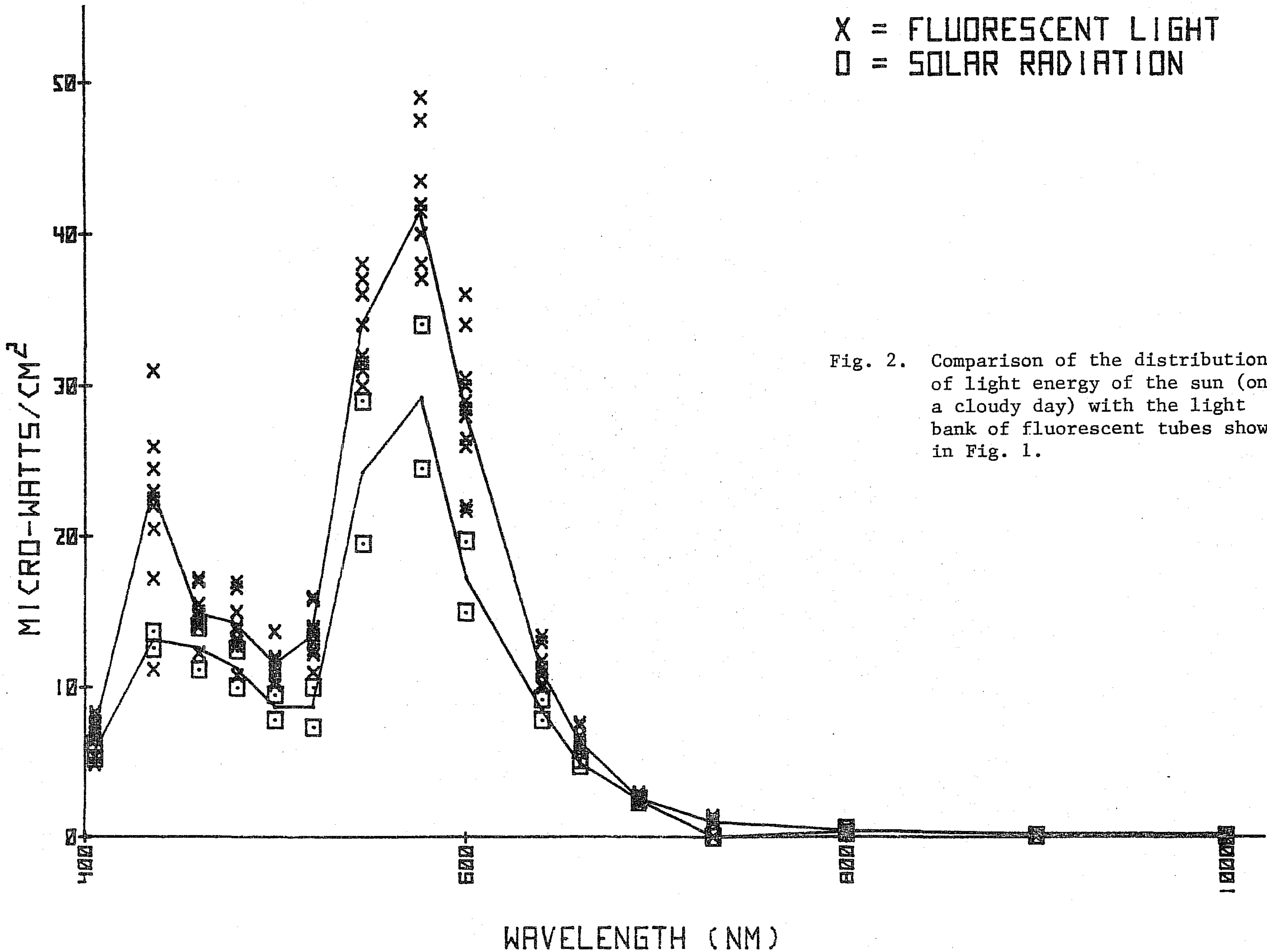

Fig. 2. Comparison of the distribution of light energy of the sun (on a cloudy day) with the light bank of fluorescent tubes shown in Fig. 1.

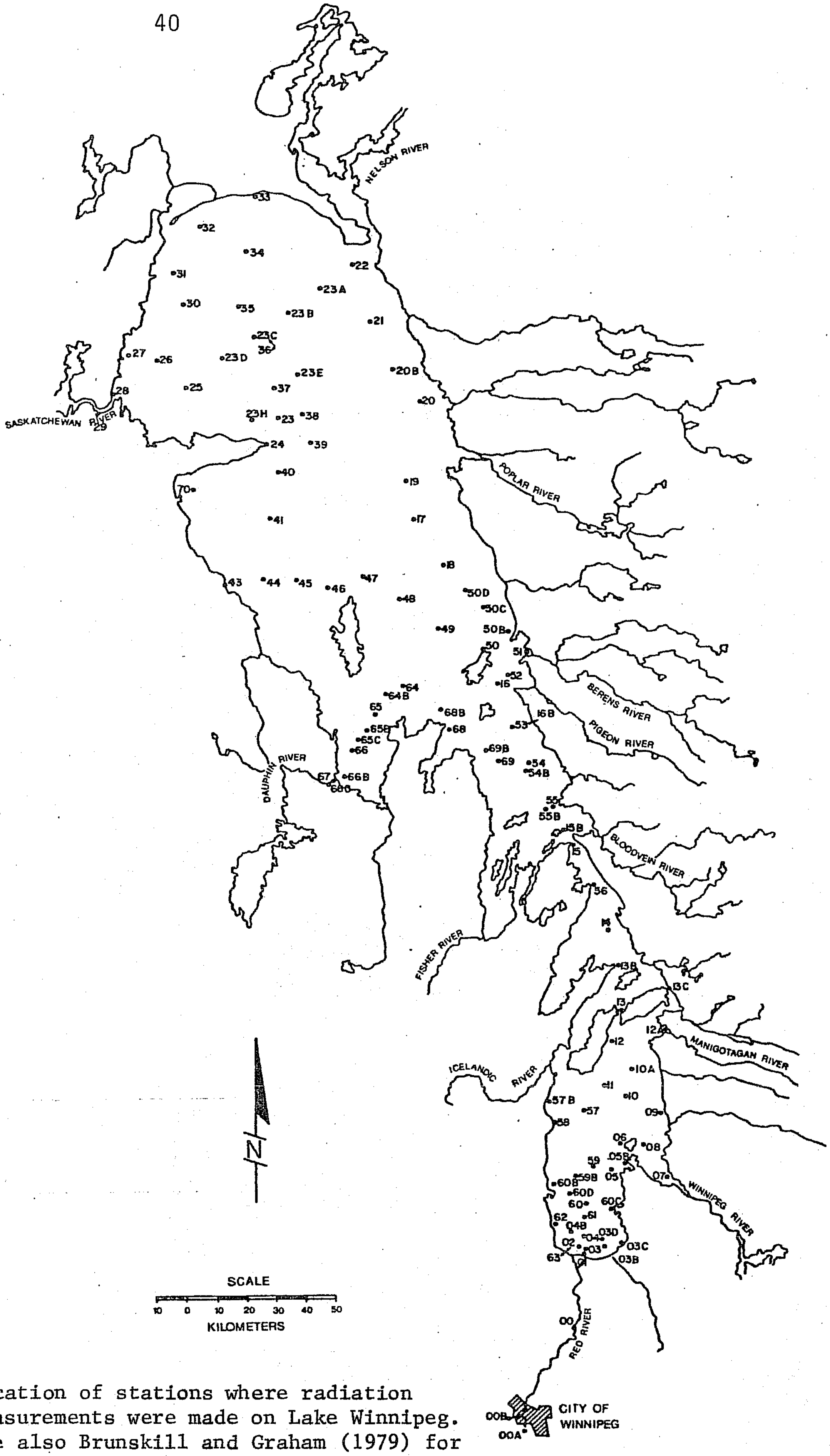

Fig. 3. Location of stations where radiation measurements were made on Lake Winnipeg. See also Brunskill and Graham (1979) for longitude and latitude of these stations.

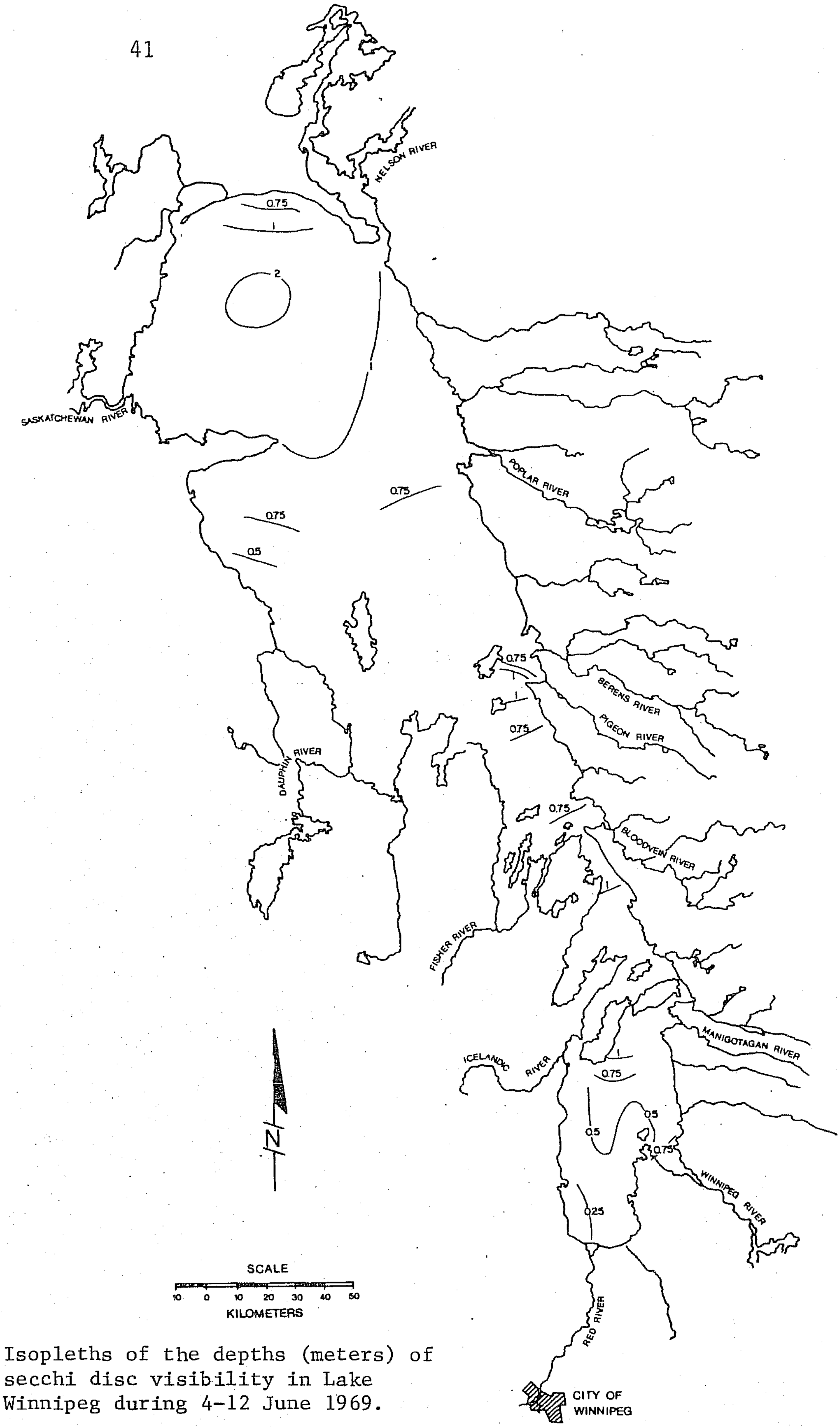

Fig. 4. Isopleths of the depths (meters) of secchi disc visibility in Lake Winnipeg during 4-12 June 1969.

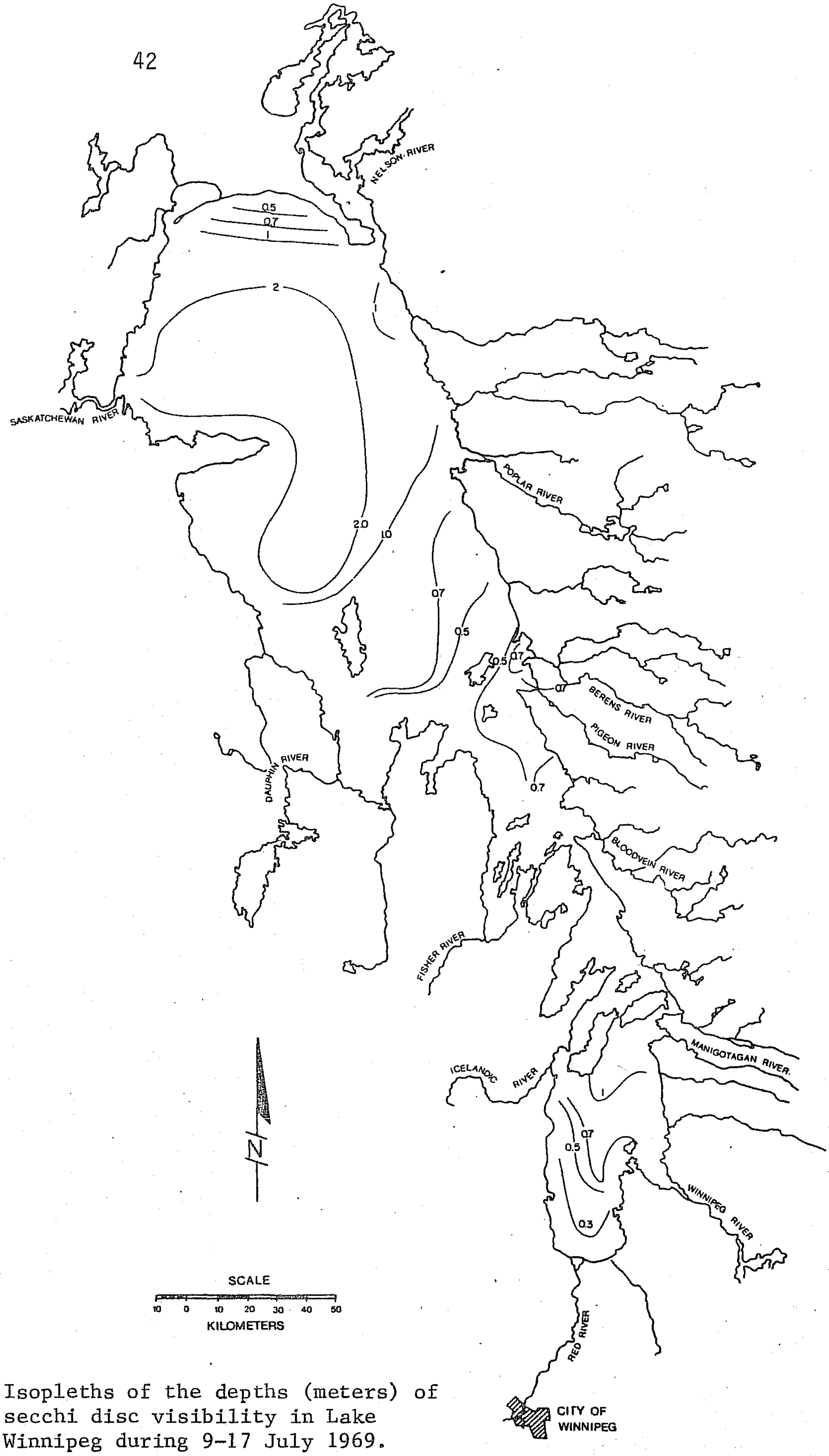

Fig. 5. Isopleths of the depths (meters) of secchi disc visibility in Lake Winnipeg during 9-17 July 1969.

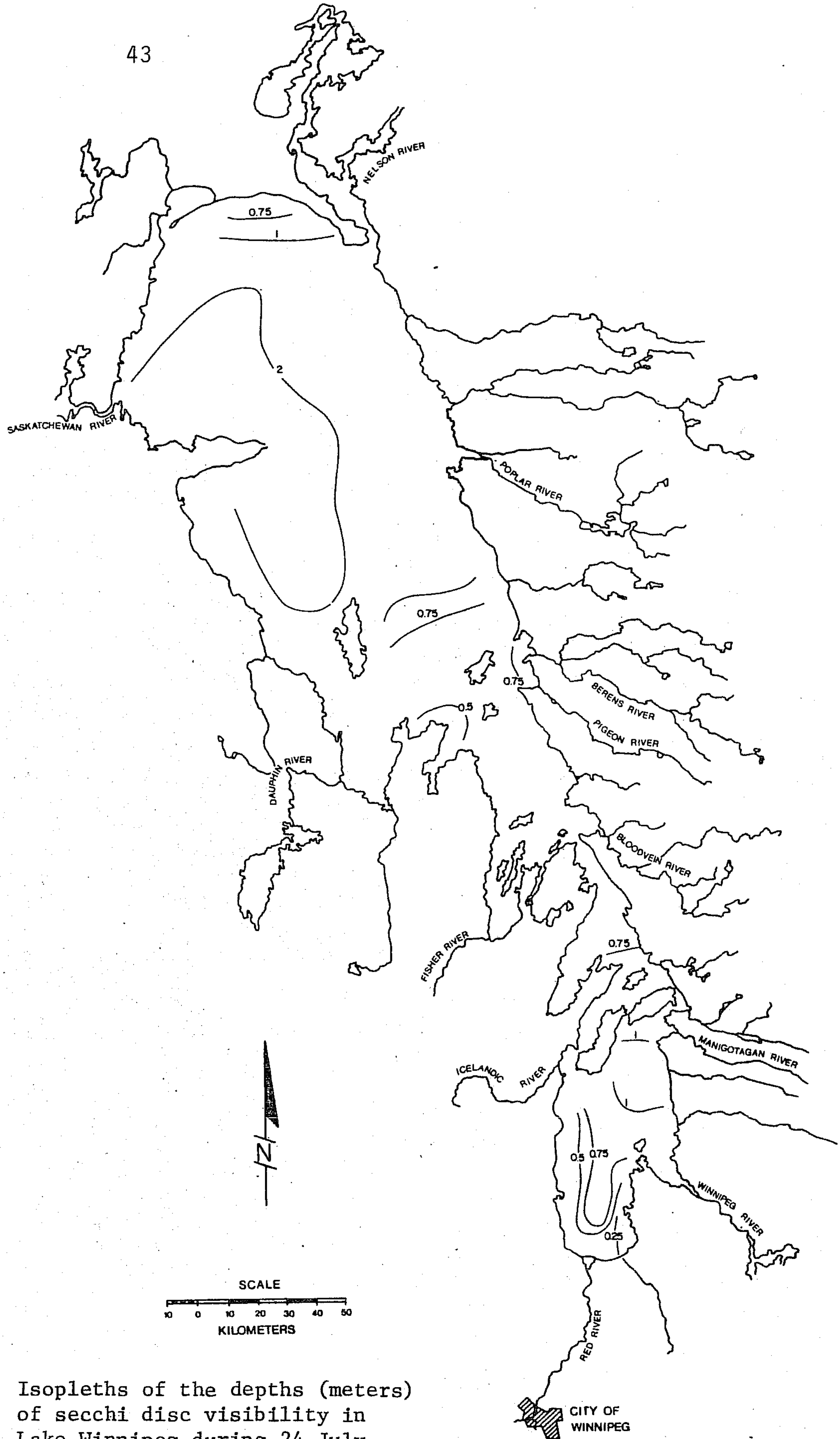

Fig. 6. Isopleths of the depths (meters) of secchi disc visibility in Lake Winnipeg during 24 July - 1 August 1969.

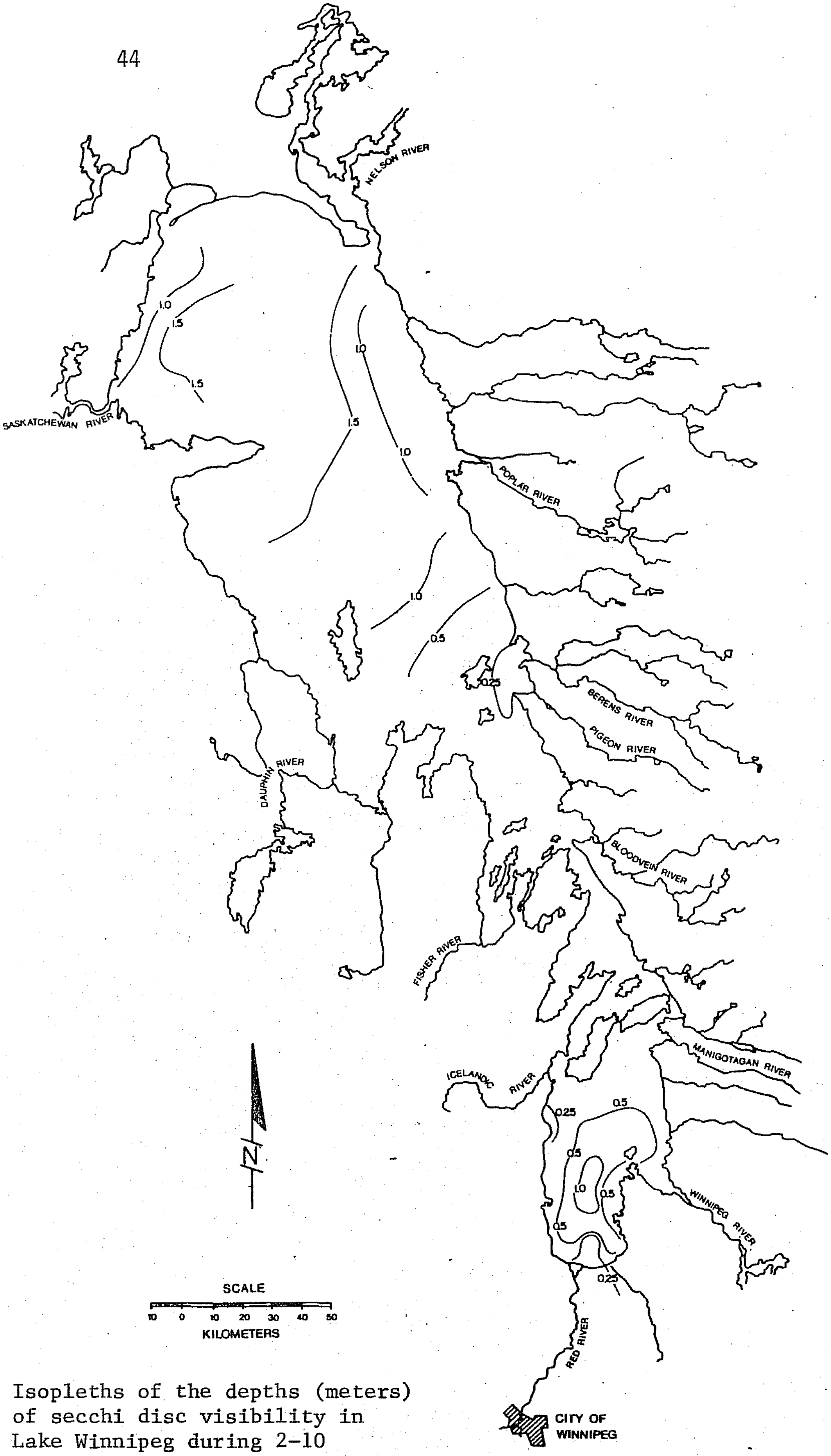

Fig. 7. Isopleths of the depths (meters) of secchi disc visibility in Lake Winnipeg during 2-10 September 1969.

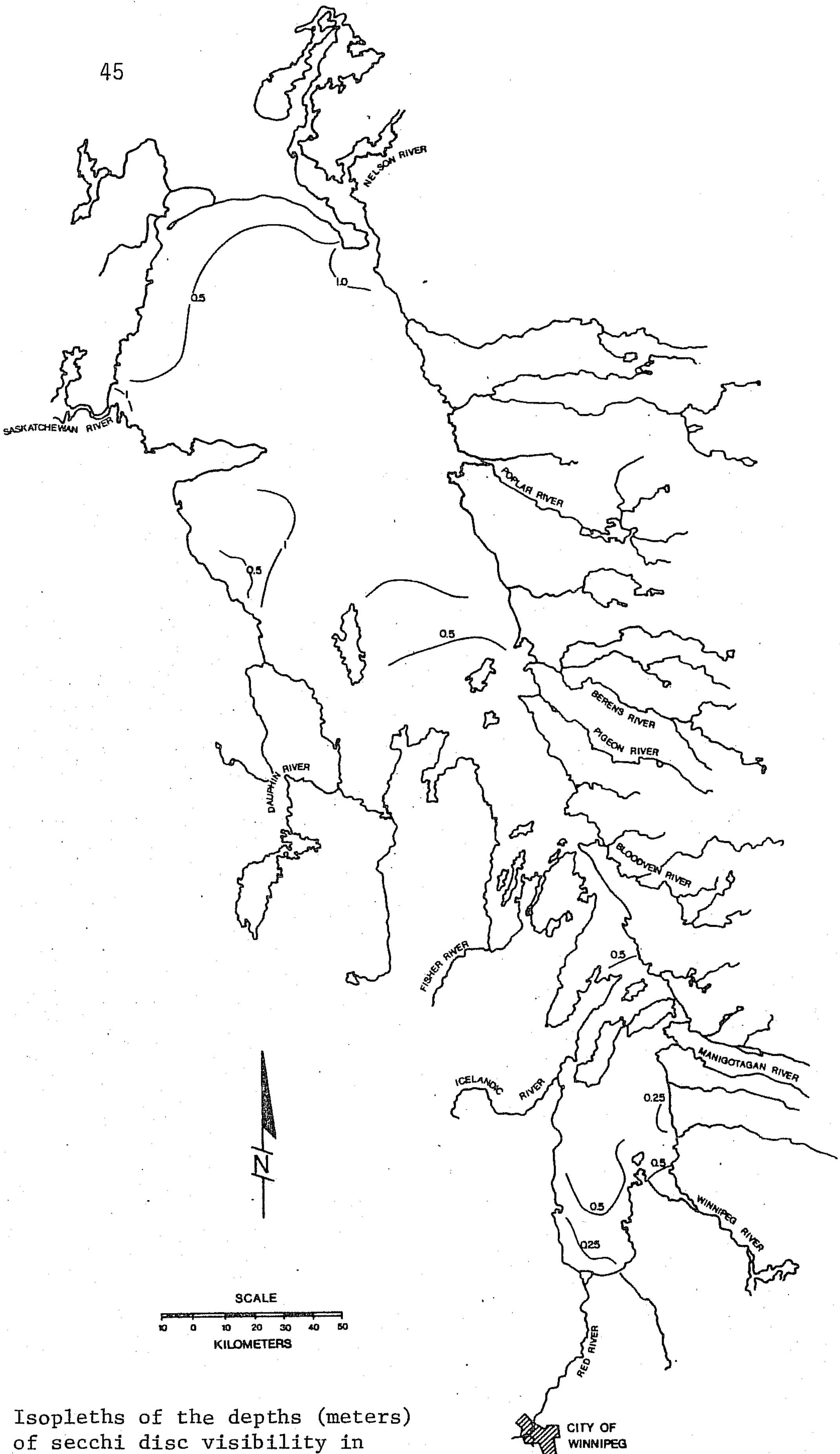

Fig. 8. Isopleths of the depths (meters) of secchi disc visibility in Lake Winnipeg during 3-13 October 1969.

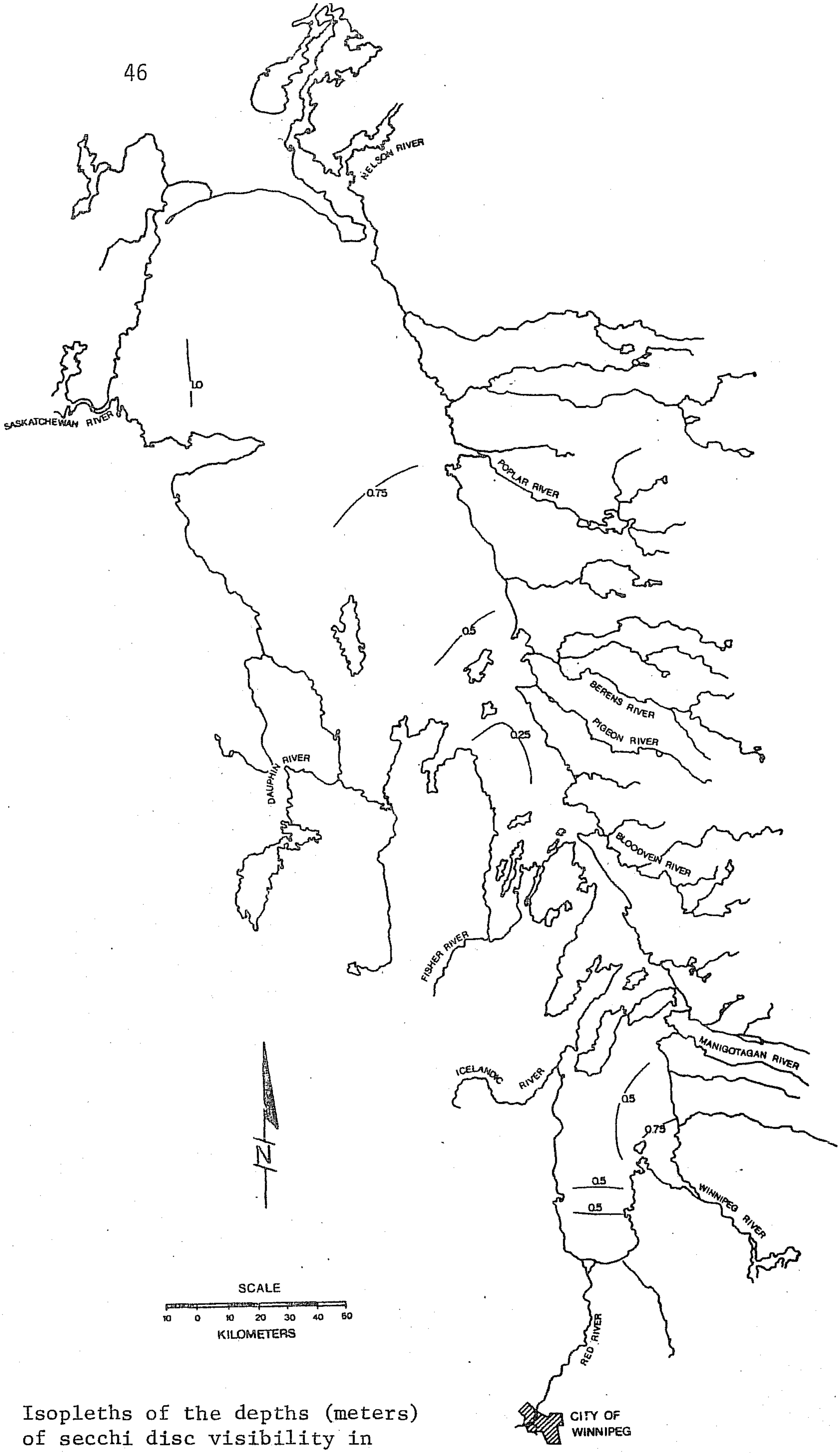

Fig. 9. Isopleths of the depths (meters) of secchi disc visibility in Lake Winnipeg during 26-31 October 1969.

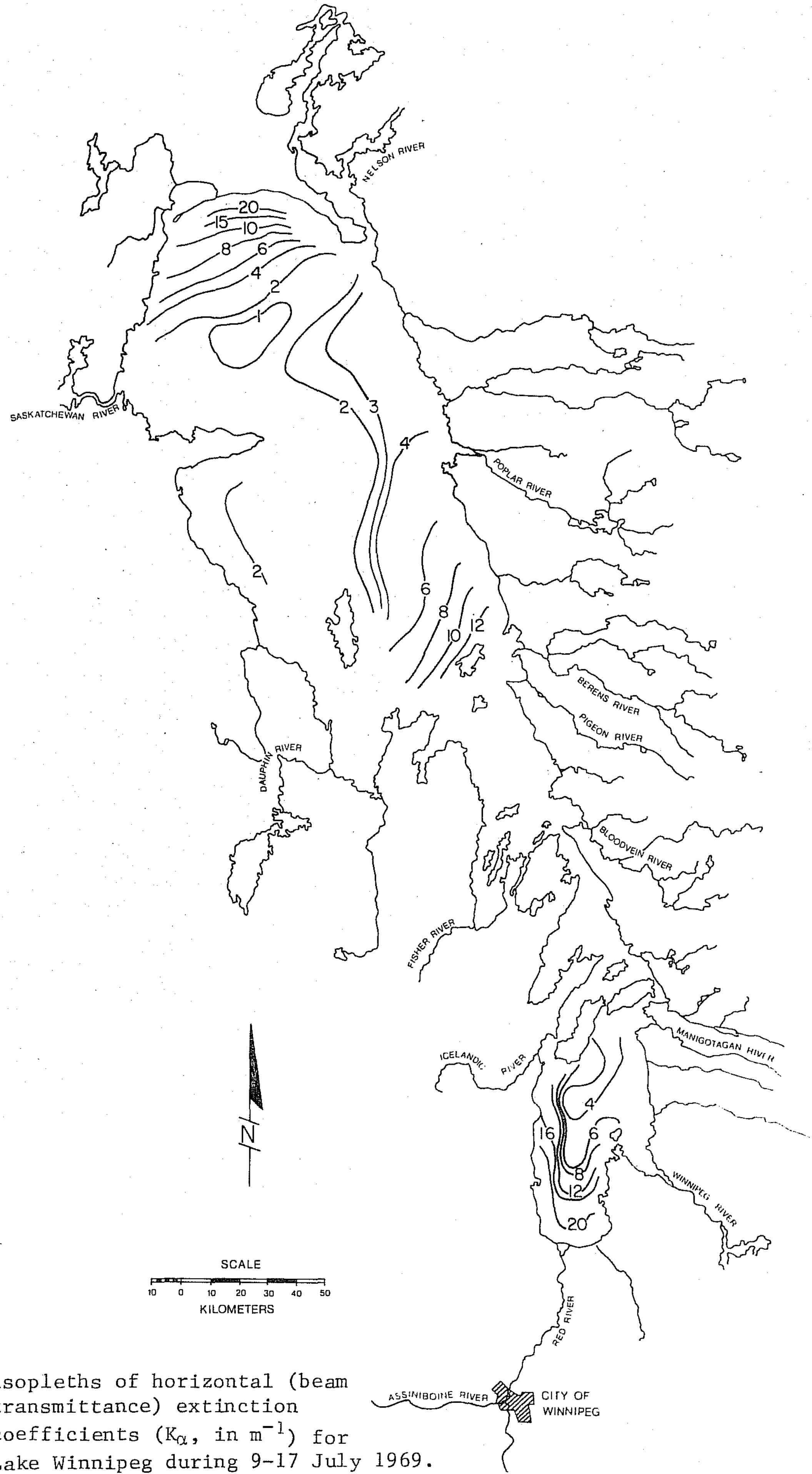

Fig. 10. Isopleths of horizontal (beam transmittance) extinction coefficients (K_{α}, in m^{-1}) for Lake Winnipeg during 9-17 July 1969.

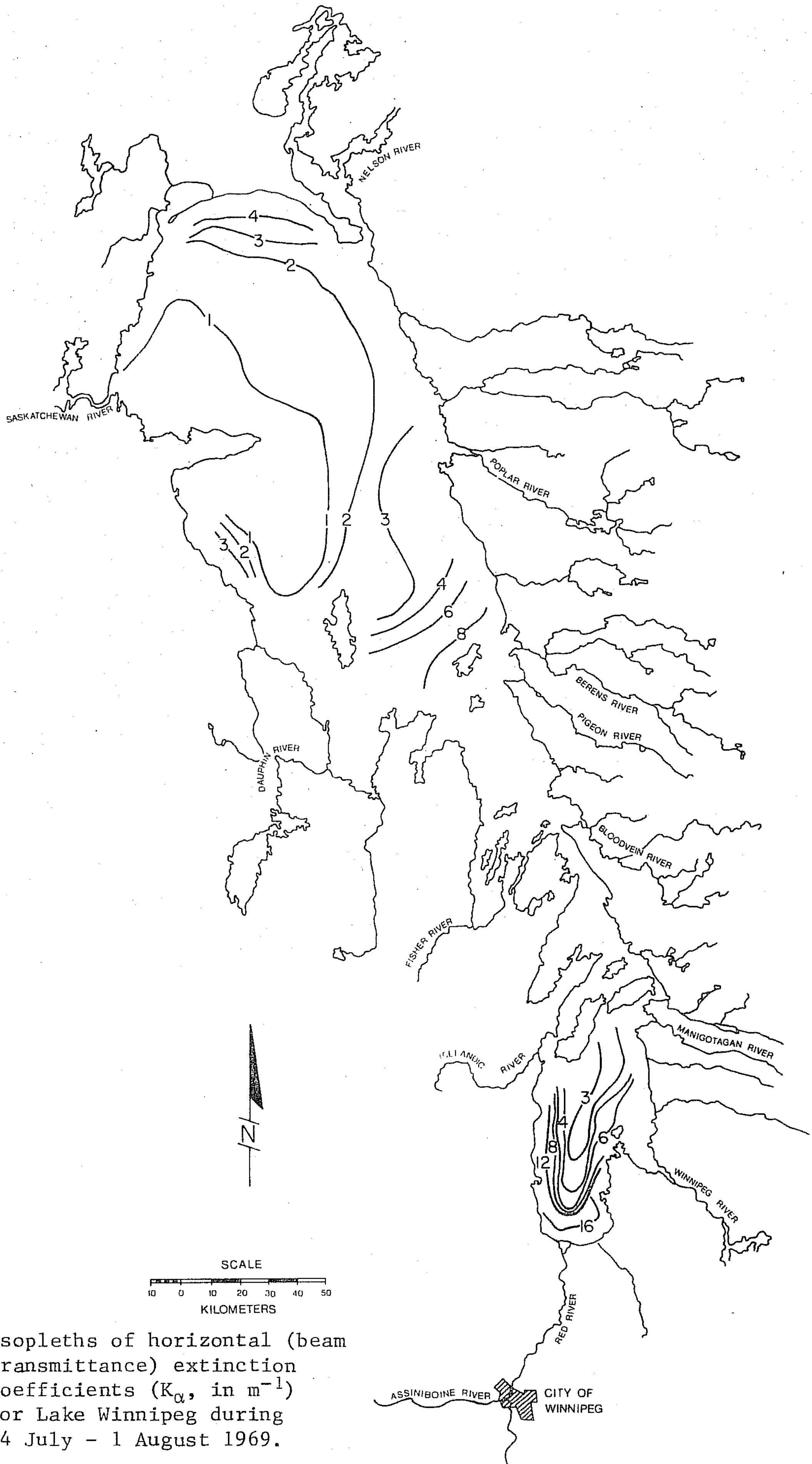

Fig. 11. Isopleths of horizontal (beam transmittance) extinction coefficients (K_{α}, in m^{-1}) for Lake Winnipeg during 24 July - 1 August 1969.

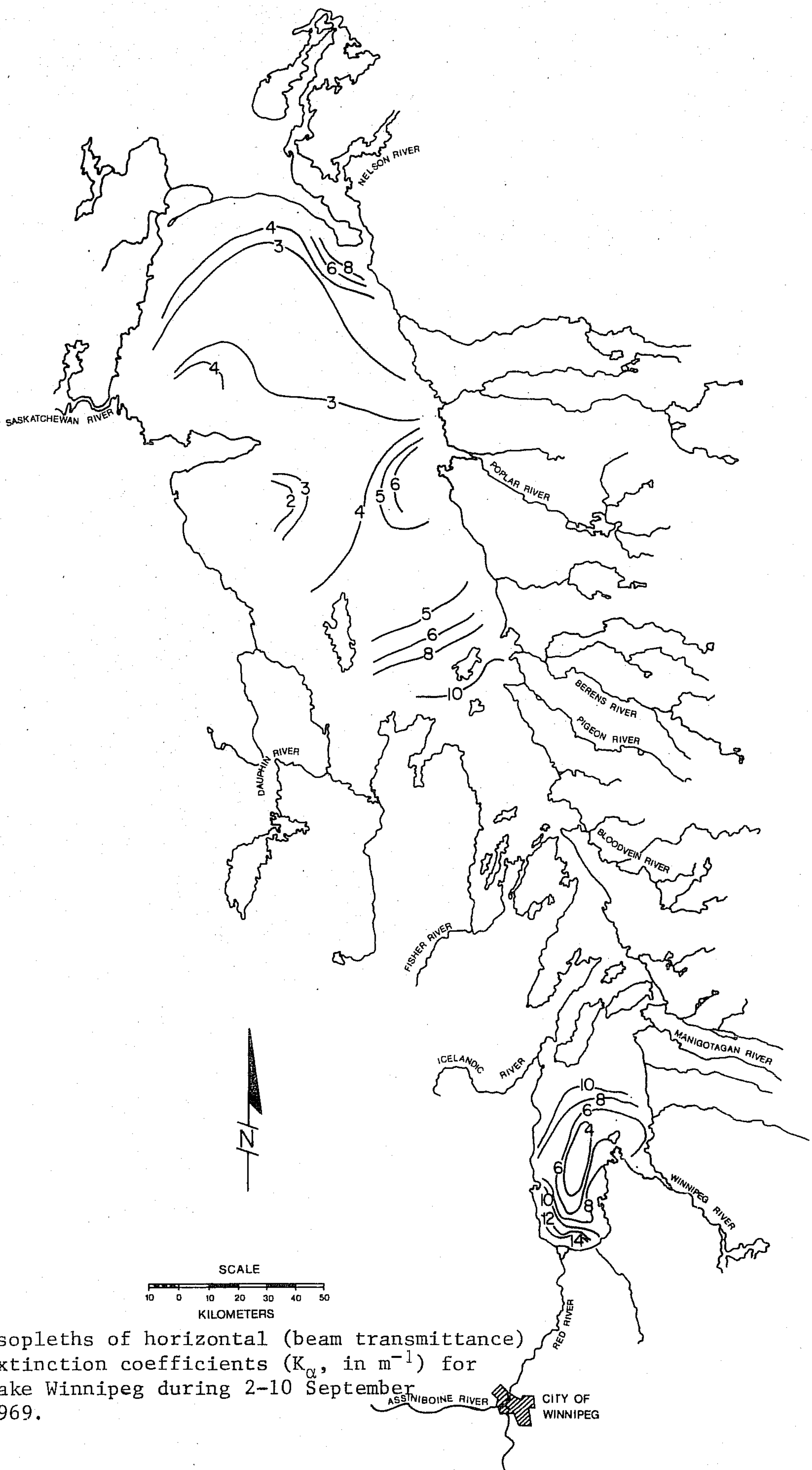

Fig. 12. Isopleths of horizontal (beam transmittance) extinction coefficients (K_{α}, in m^{-1}) for Lake Winnipeg during 2-10 September 1969.

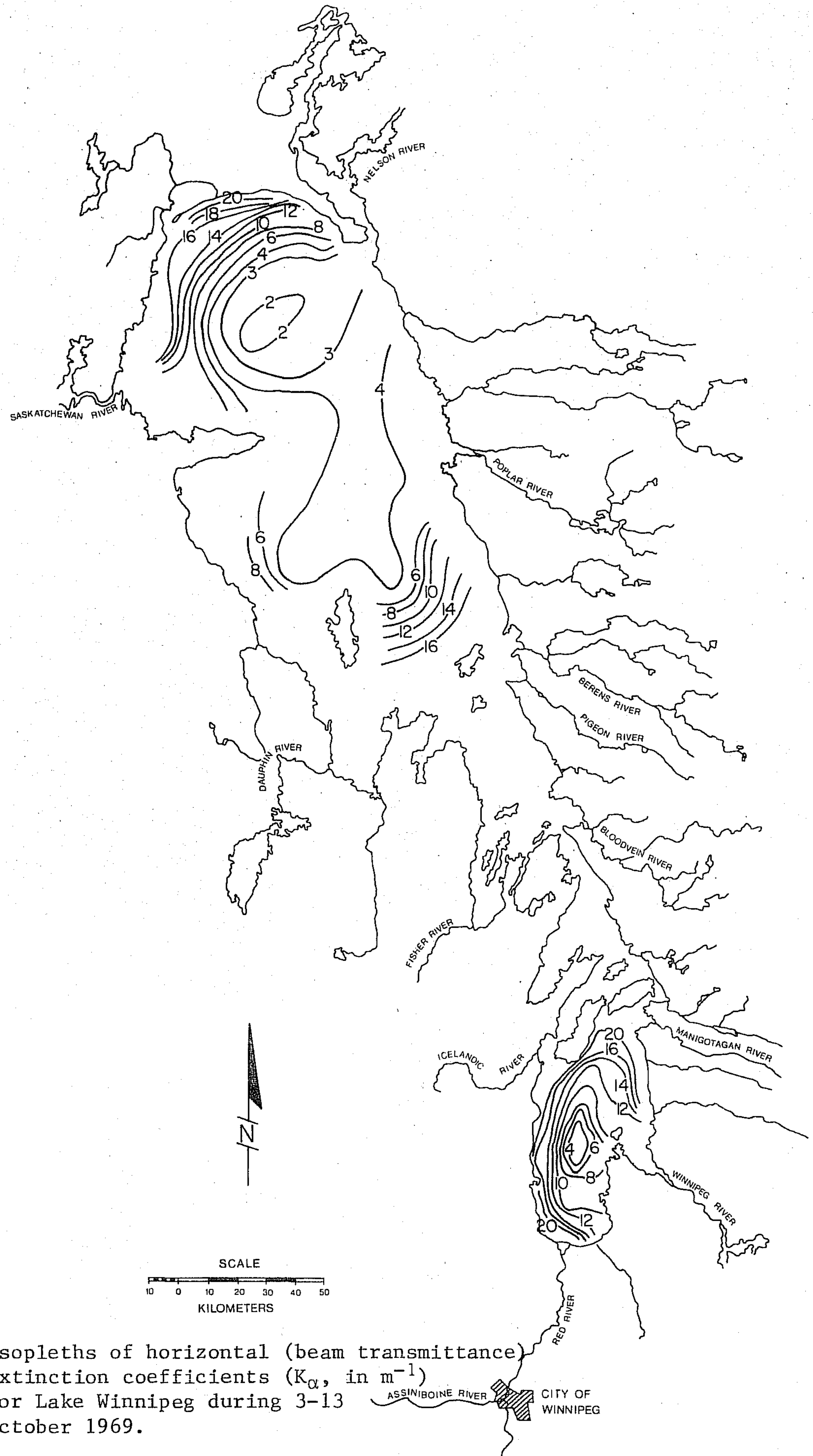

Fig. 13. Isopleths of horizontal (beam transmittance) extinction coefficients (K_{α}, in m^{-1}) for Lake Winnipeg during 3-13 October 1969.

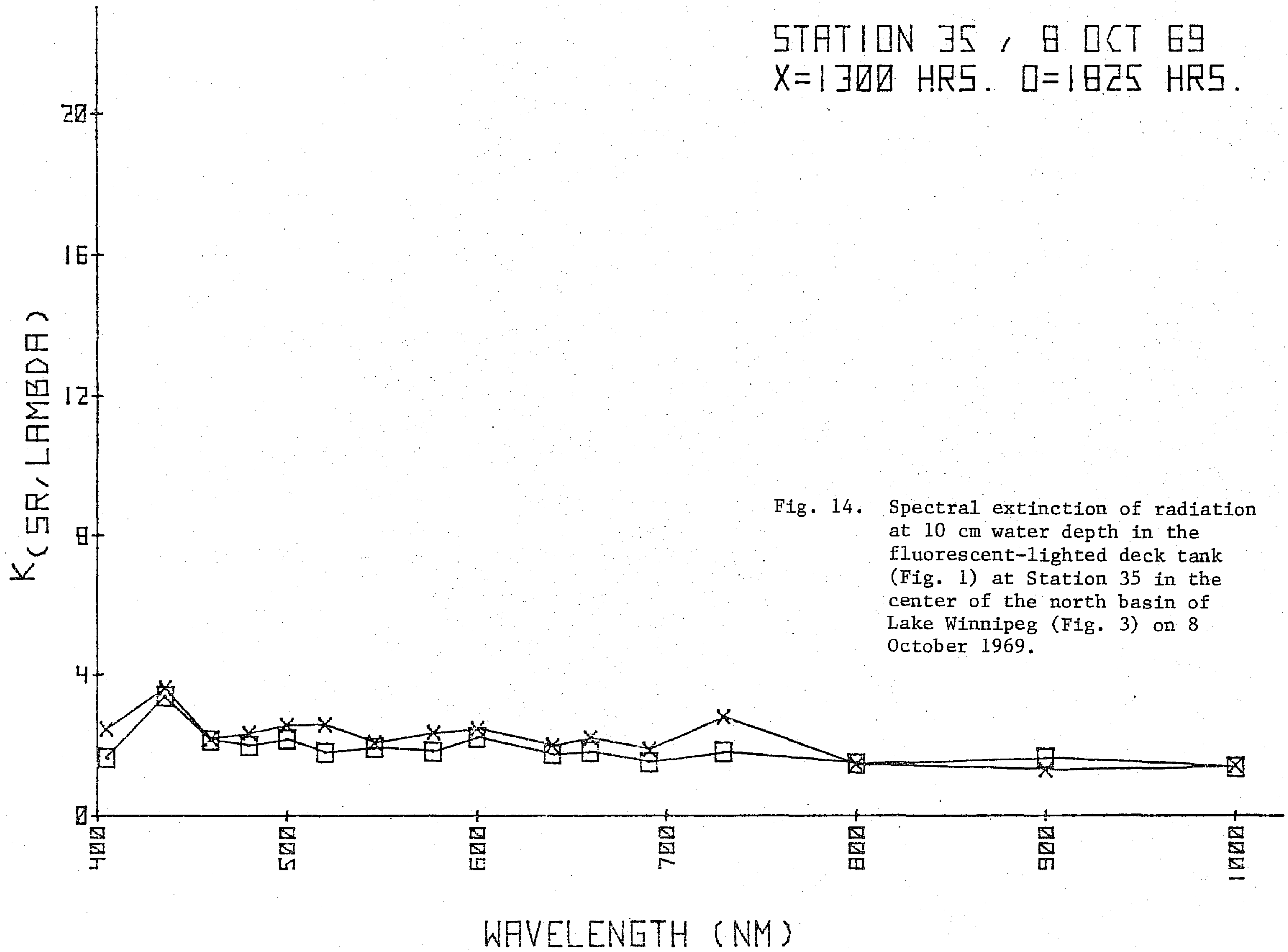

Fig. 14. Spectral extinction of radiation at 10 cm water depth in the fluorescent-lighted deck tank (Fig. 1) at Station 35 in the center of the north basin of Lake Winnipeg (Fig. 3) on 8 October 1969.

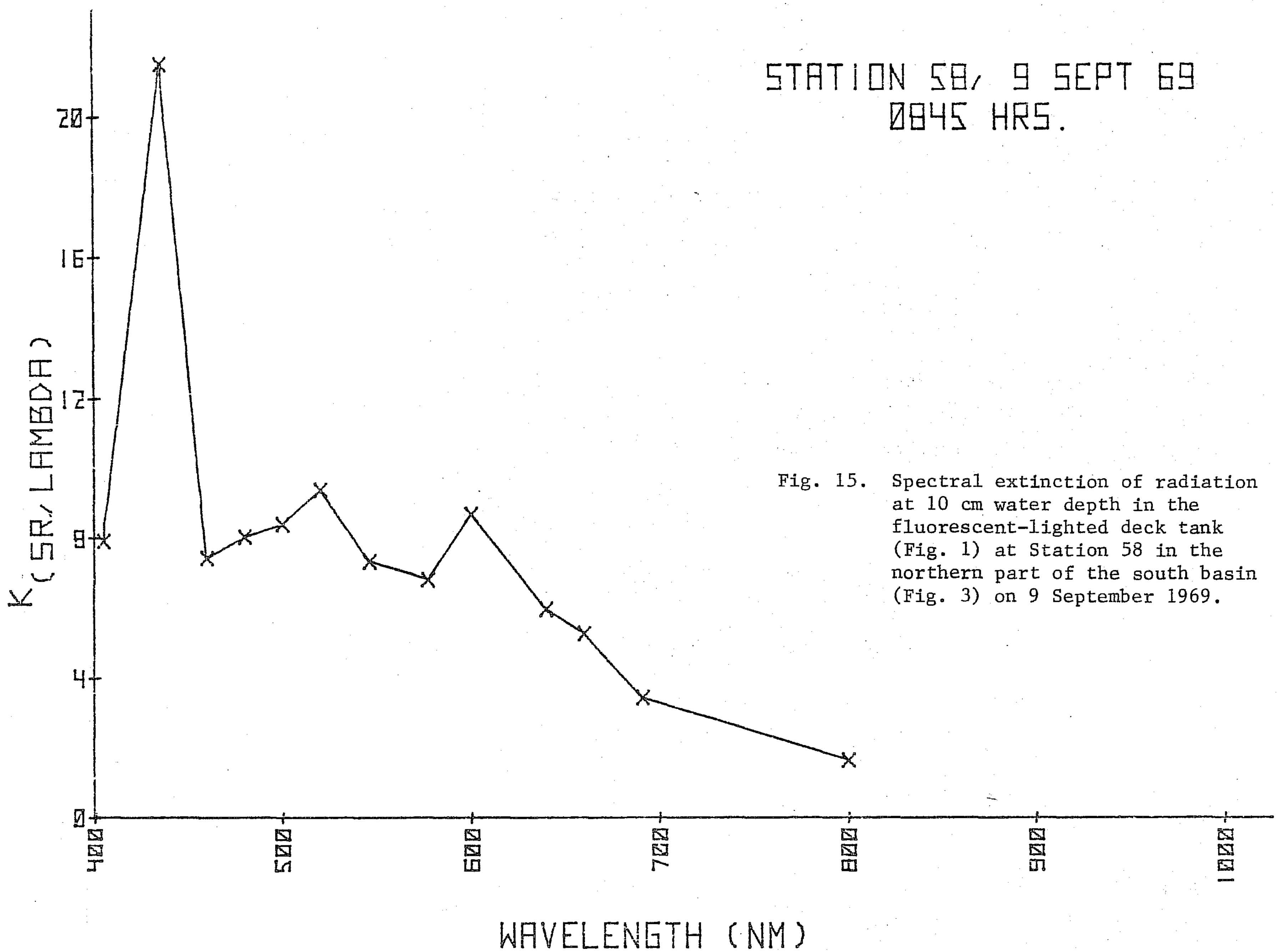

Fig. 15. Spectral extinction of radiation at 10 cm water depth in the fluorescent-lighted deck tank (Fig. 1) at Station 58 in the northern part of the south basin (Fig. 3) on 9 September 1969.

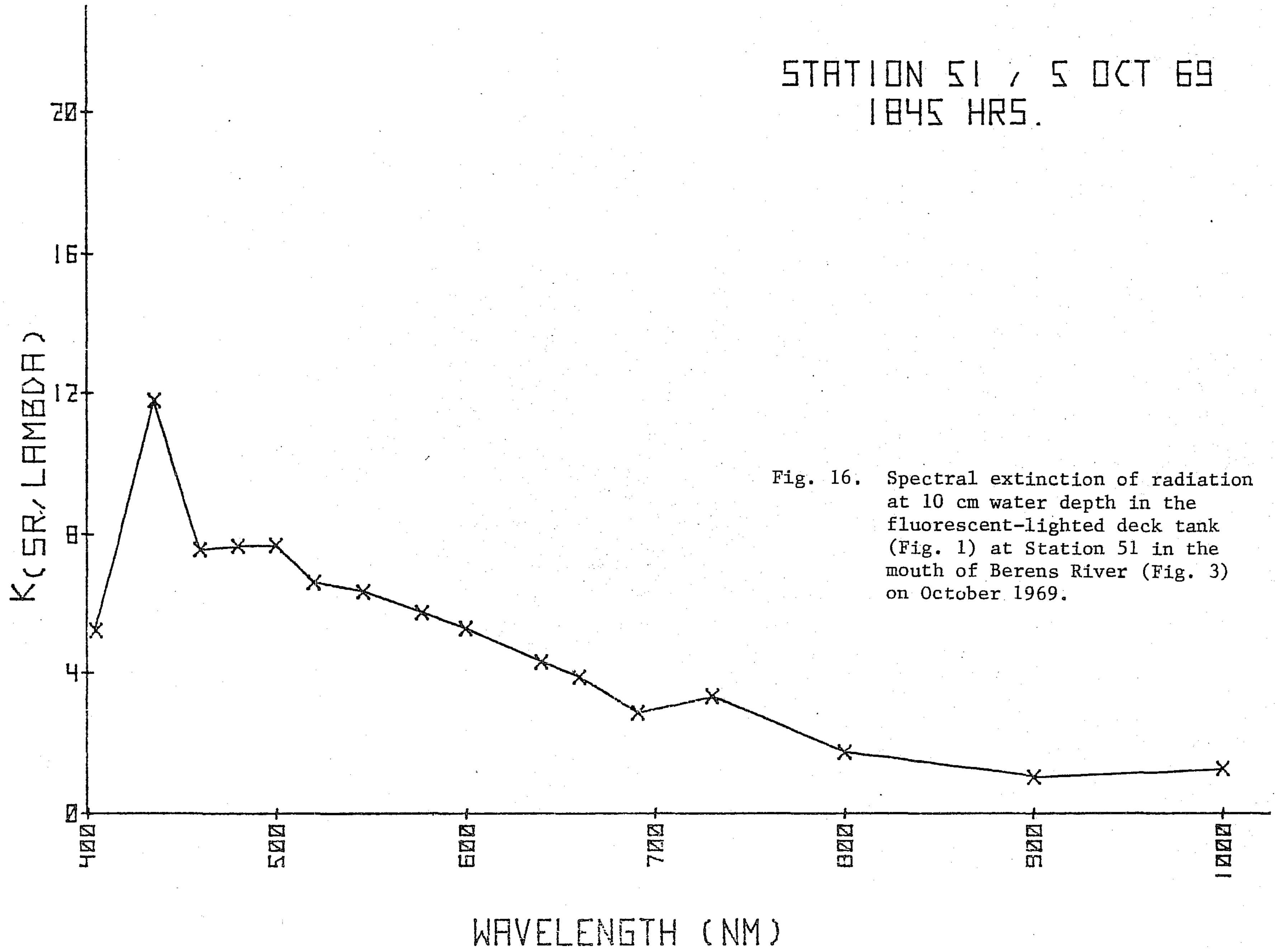

Fig. 16. Spectral extinction of radiation at 10 cm water depth in the fluorescent-lighted deck tank (Fig. 1) at Station 51 in the mouth of Berens River (Fig. 3) on October 1969.

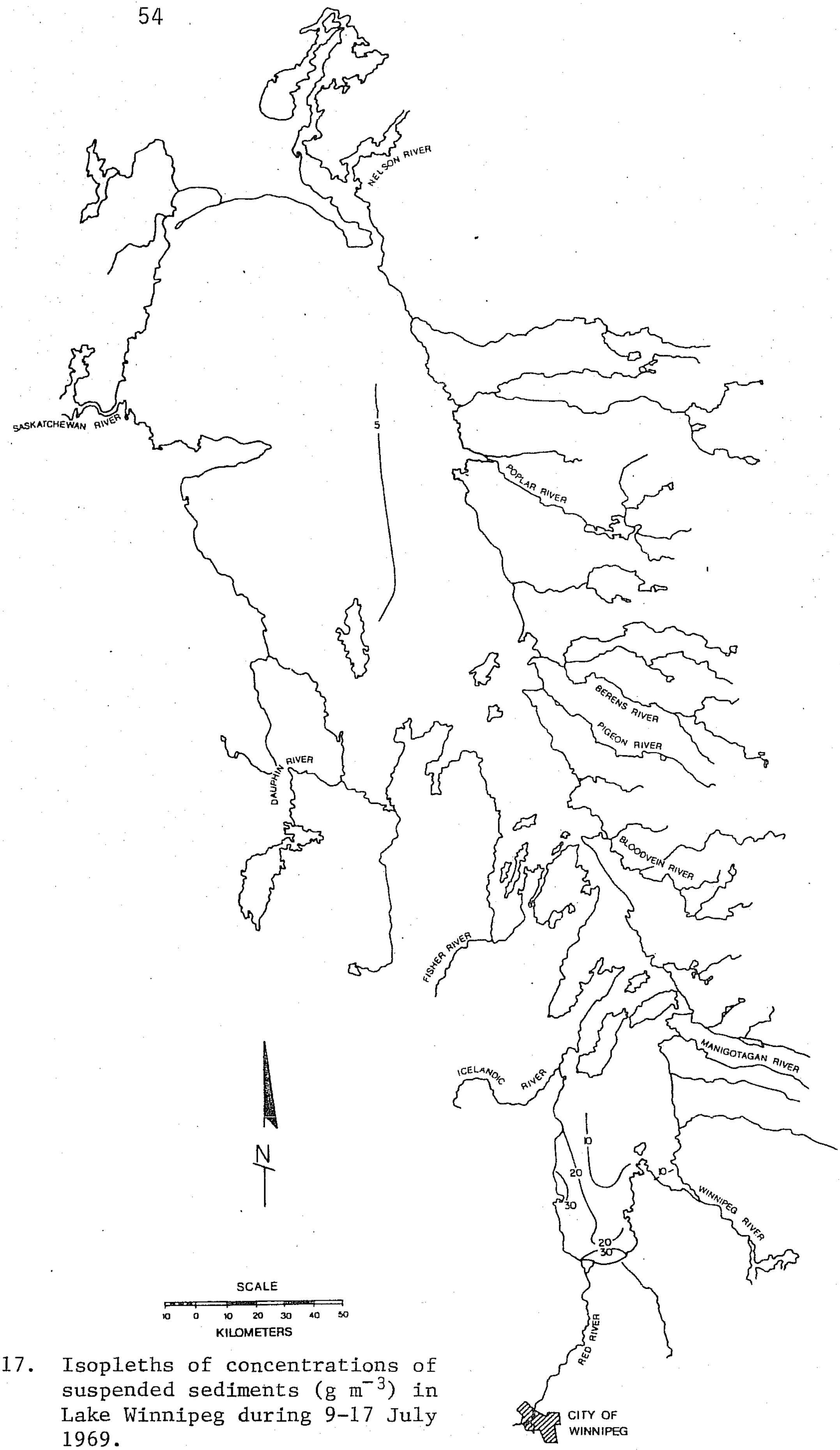

Fig. 17. Isopleths of concentrations of suspended sediments (g m^{-3}) in Lake Winnipeg during 9-17 July 1969.

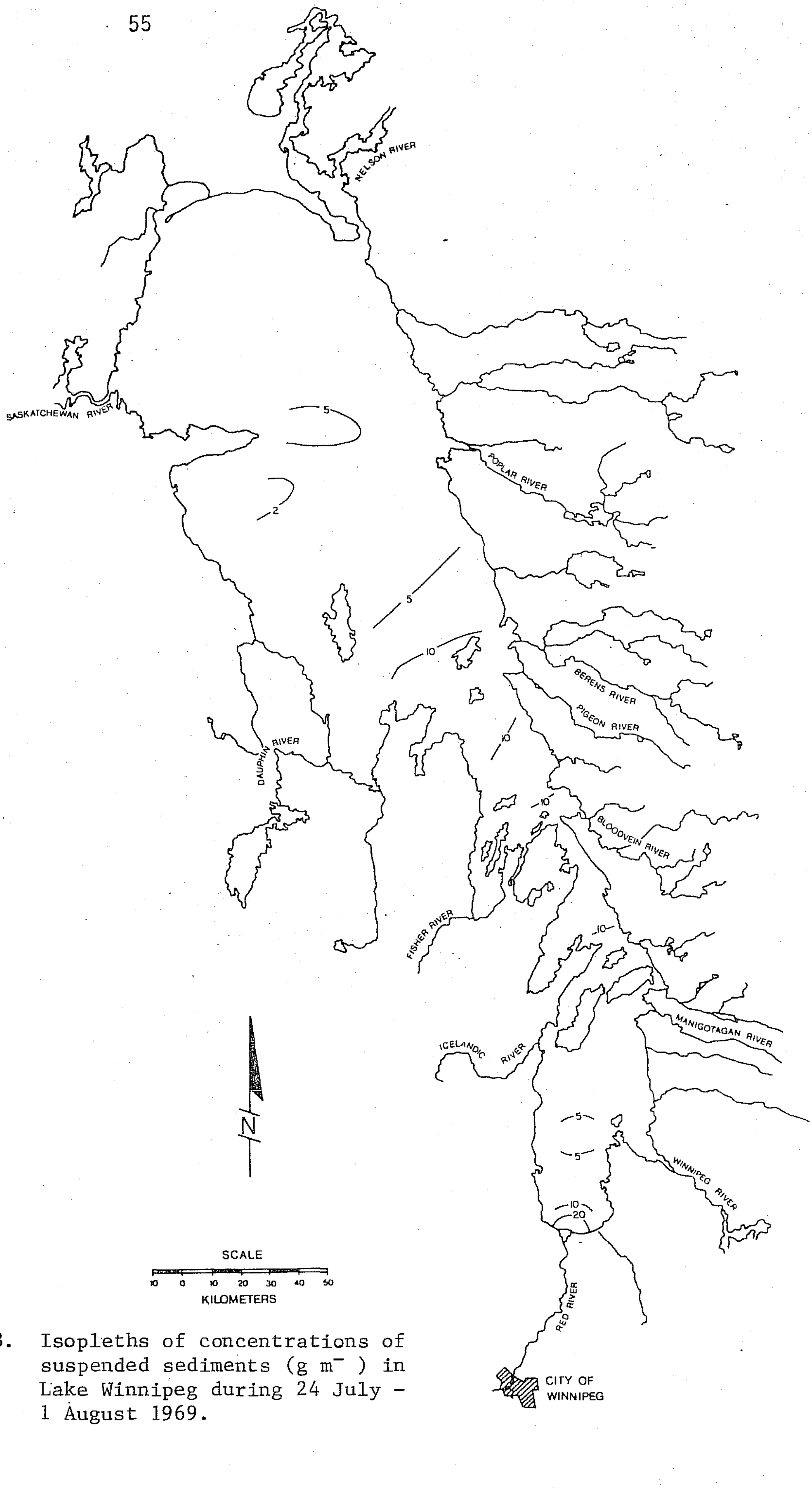

Fig. 18. Isopleths of concentrations of suspended sediments (g m^{-}) in Lake Winnipeg during 24 July - 1 August 1969.

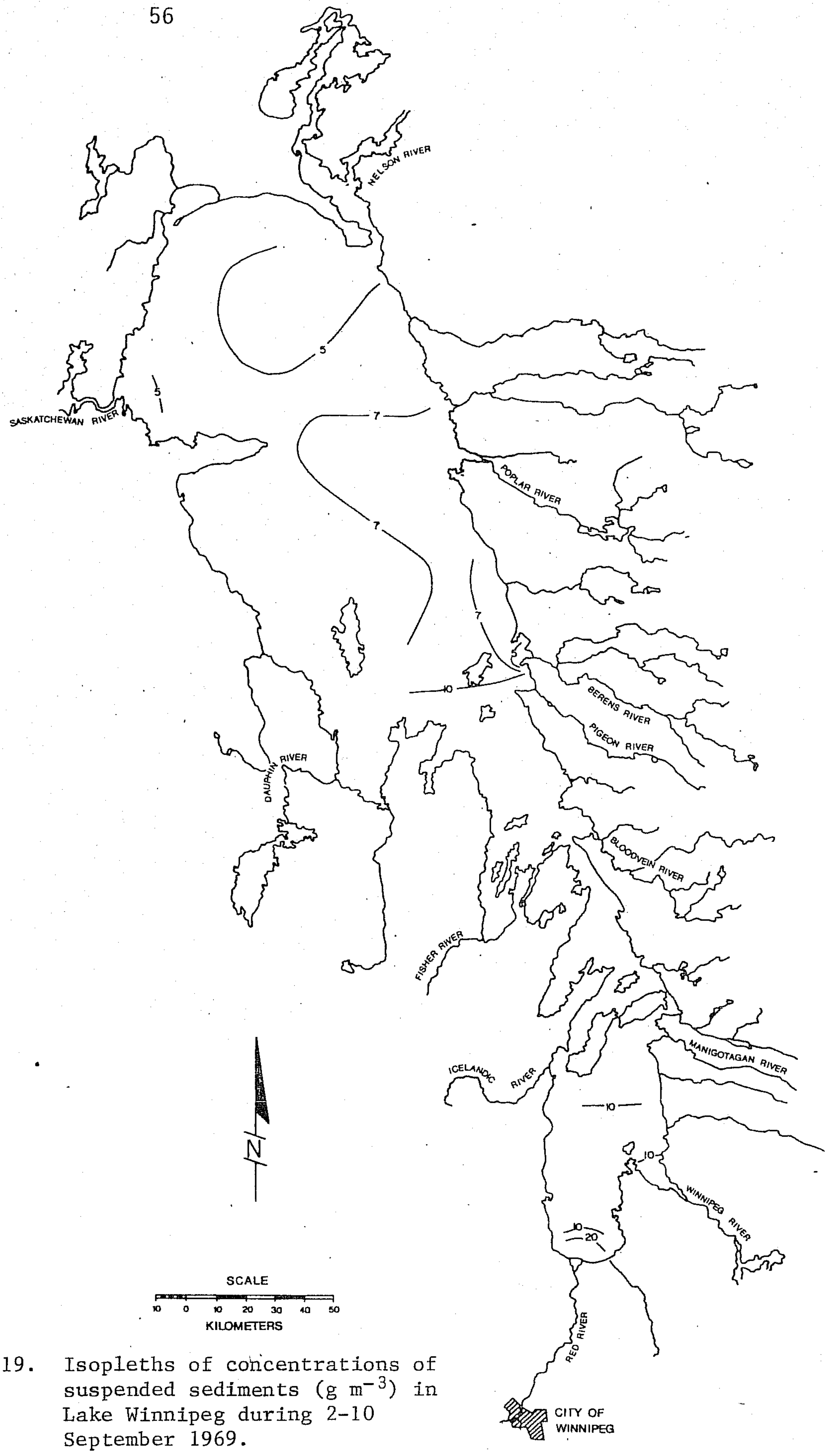

Fig. 19. Isopleths of concentrations of suspended sediments (g m^{-3}) in Lake Winnipeg during 2-10 September 1969.

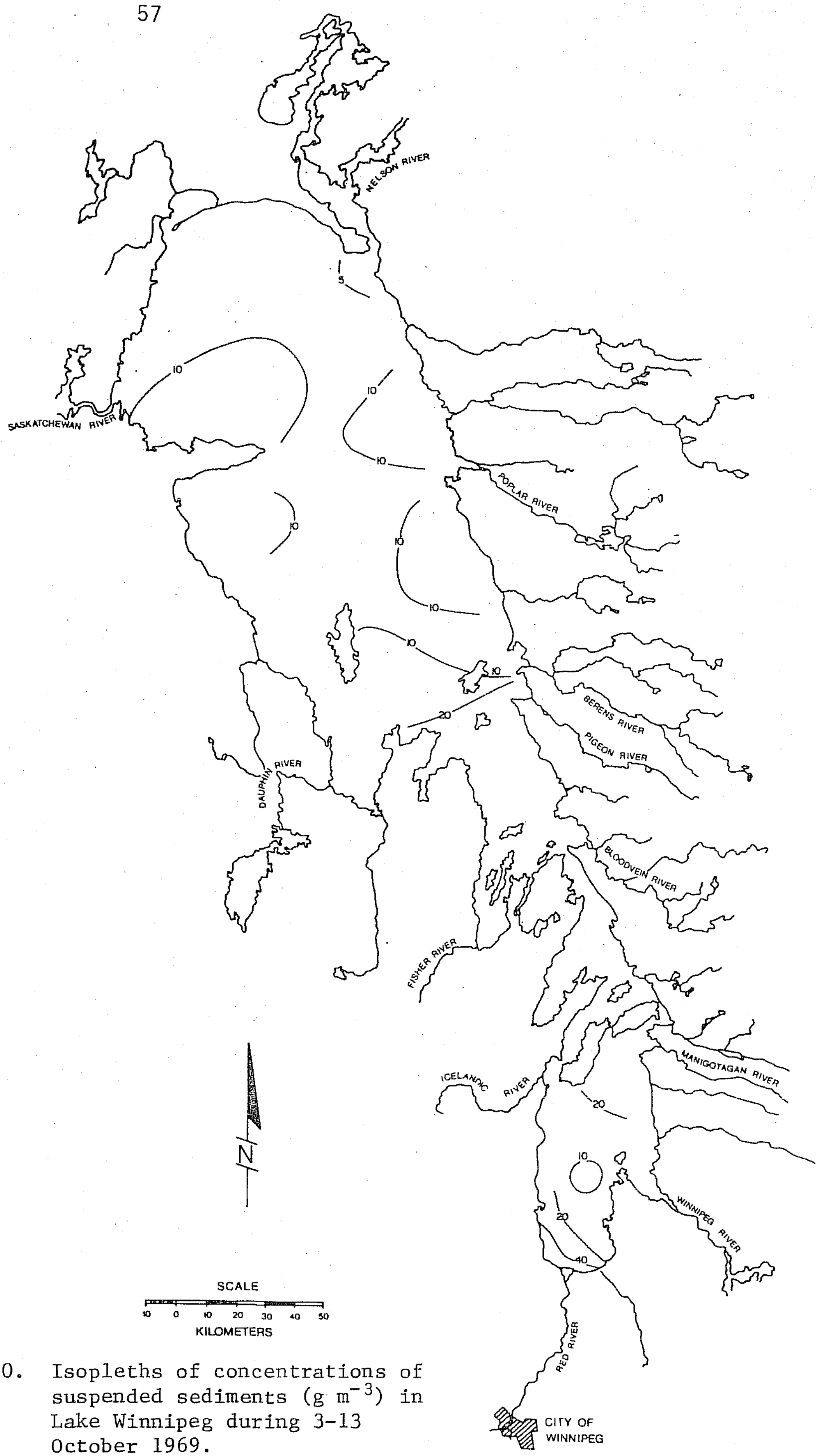

Fig. 20. Isopleths of concentrations of suspended sediments (g m^{-3}) in Lake Winnipeg during 3-13 October 1969.

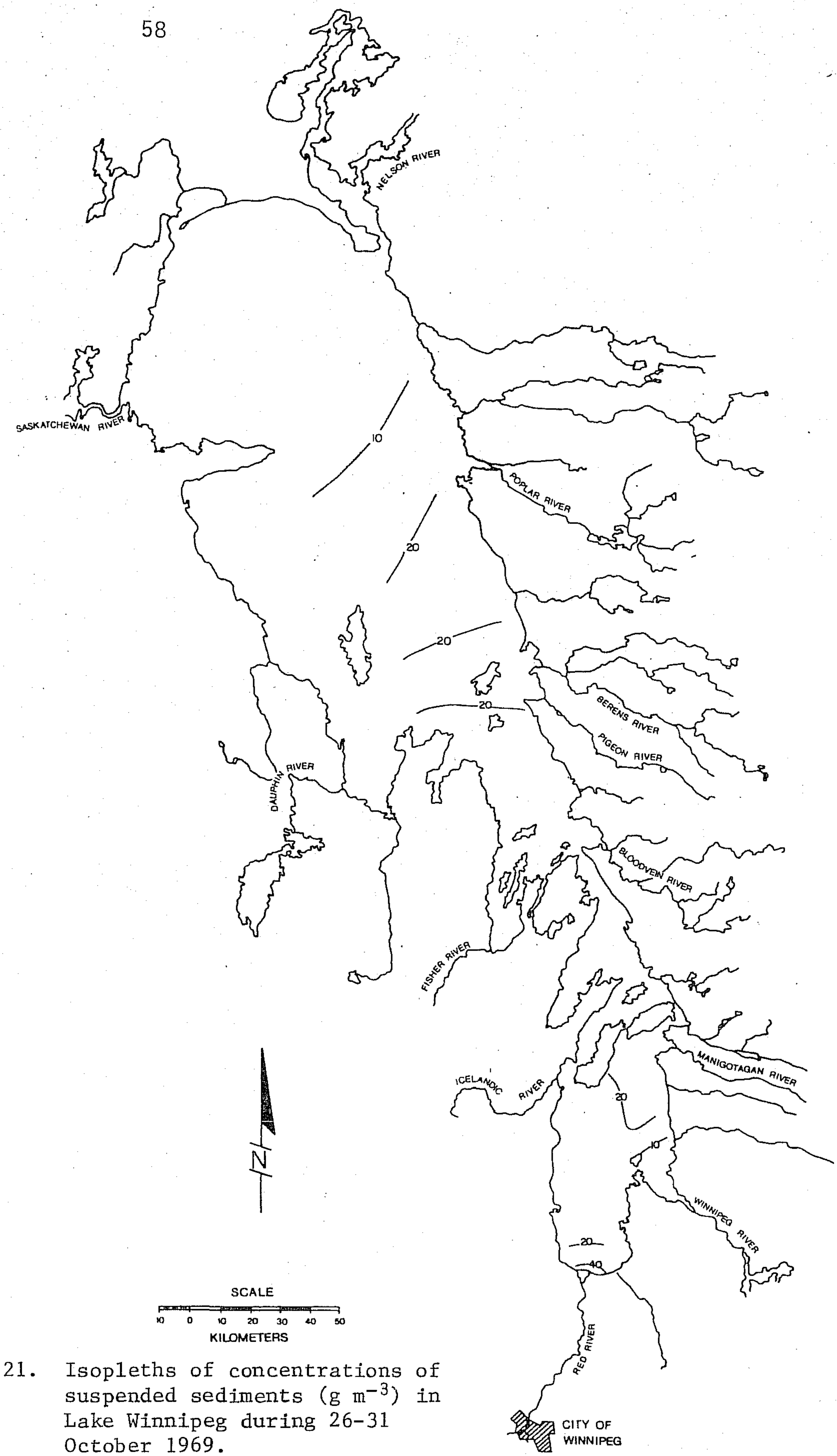

Fig. 21. Isopleths of concentrations of suspended sediments (g m^{-3}) in Lake Winnipeg during 26-31 October 1969.

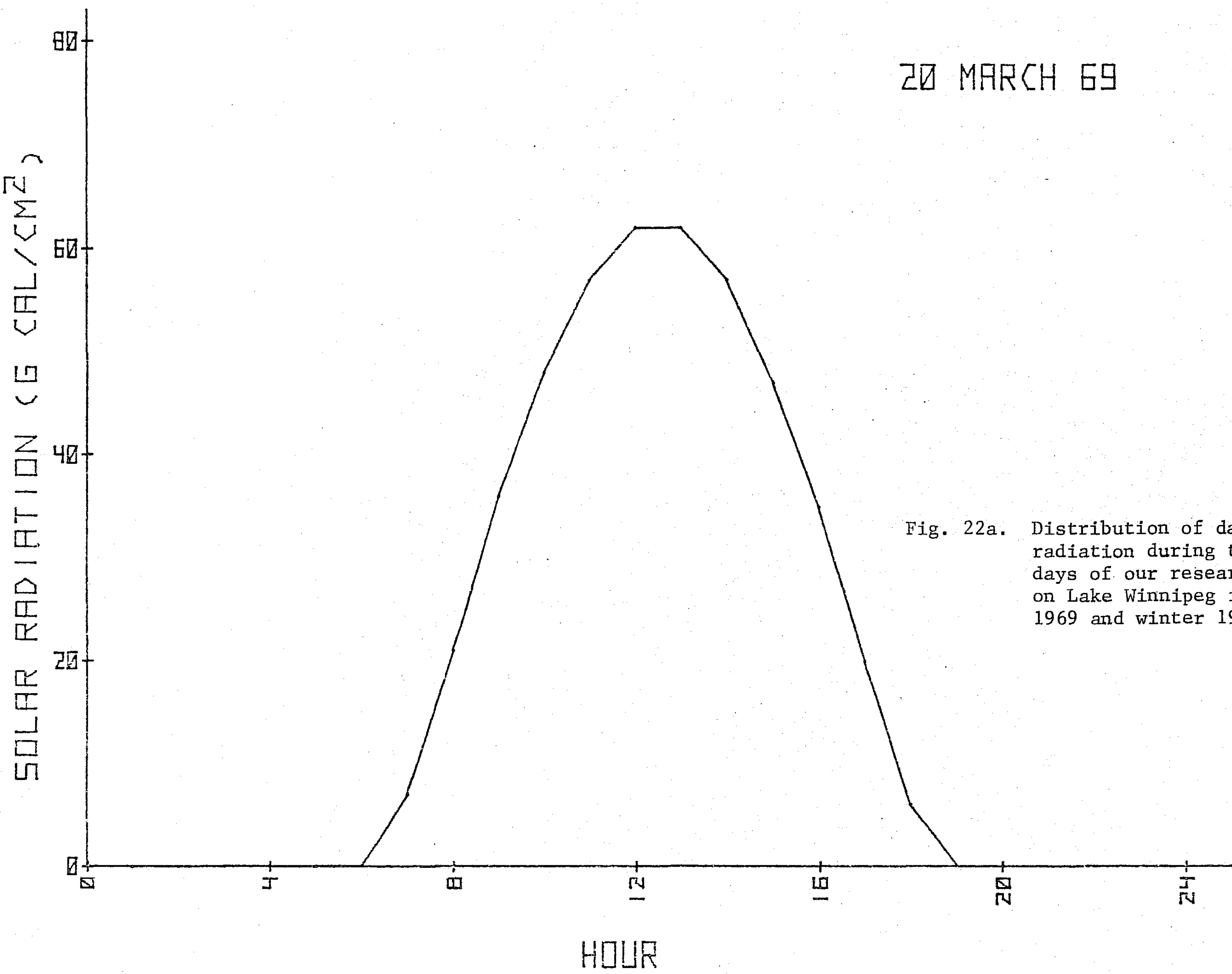

Fig. 22a. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

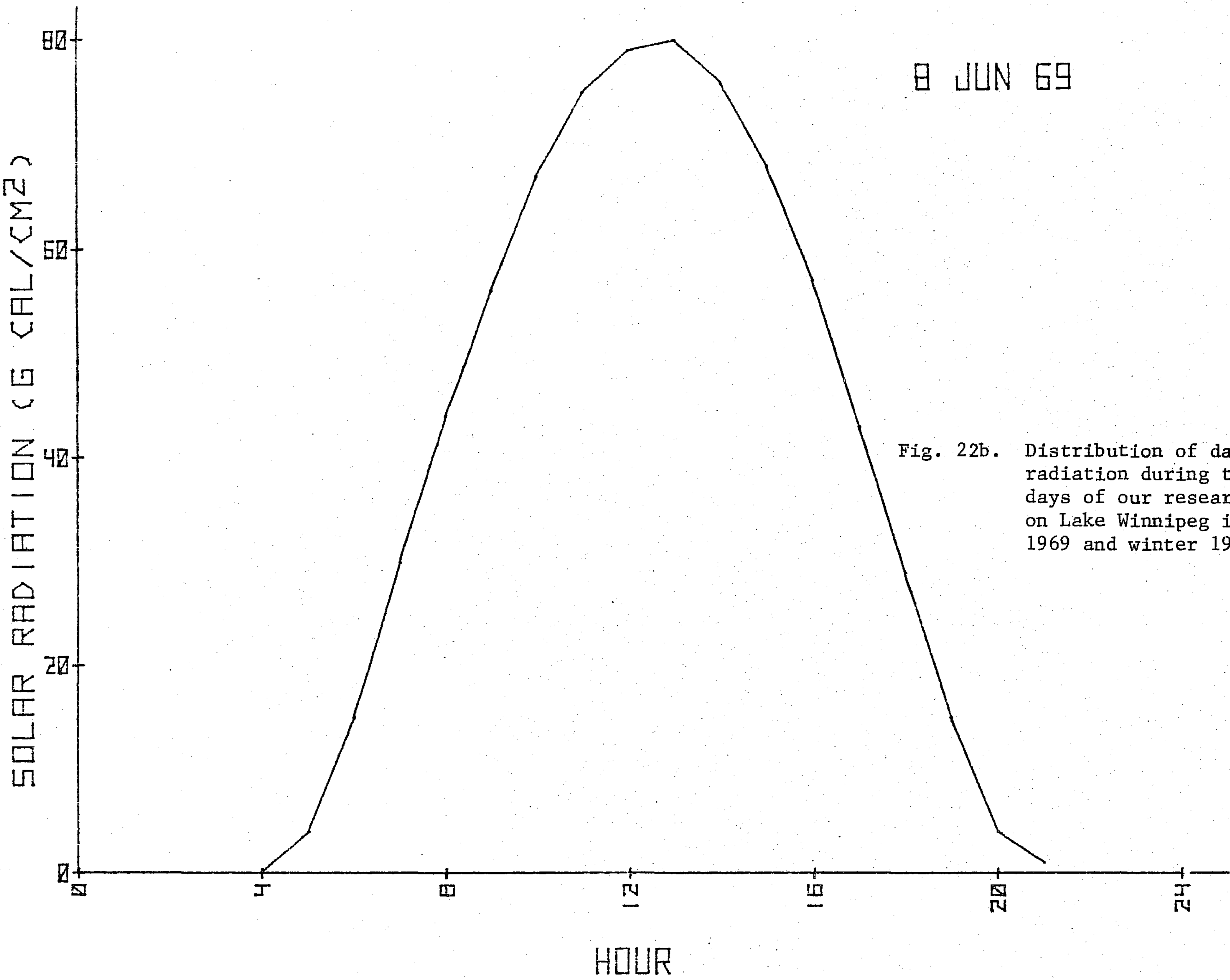

Fig. 22b. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

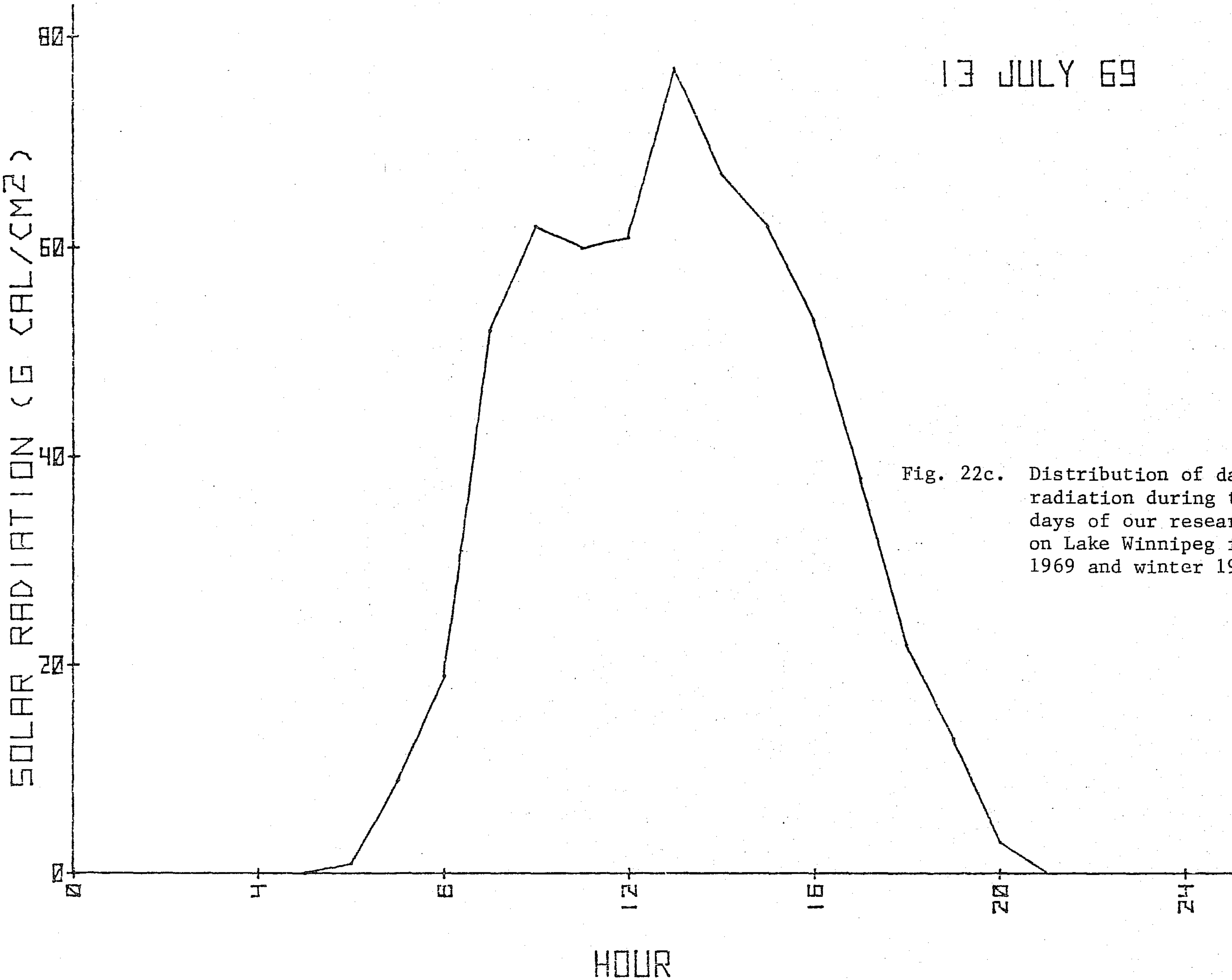

Fig. 22c. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

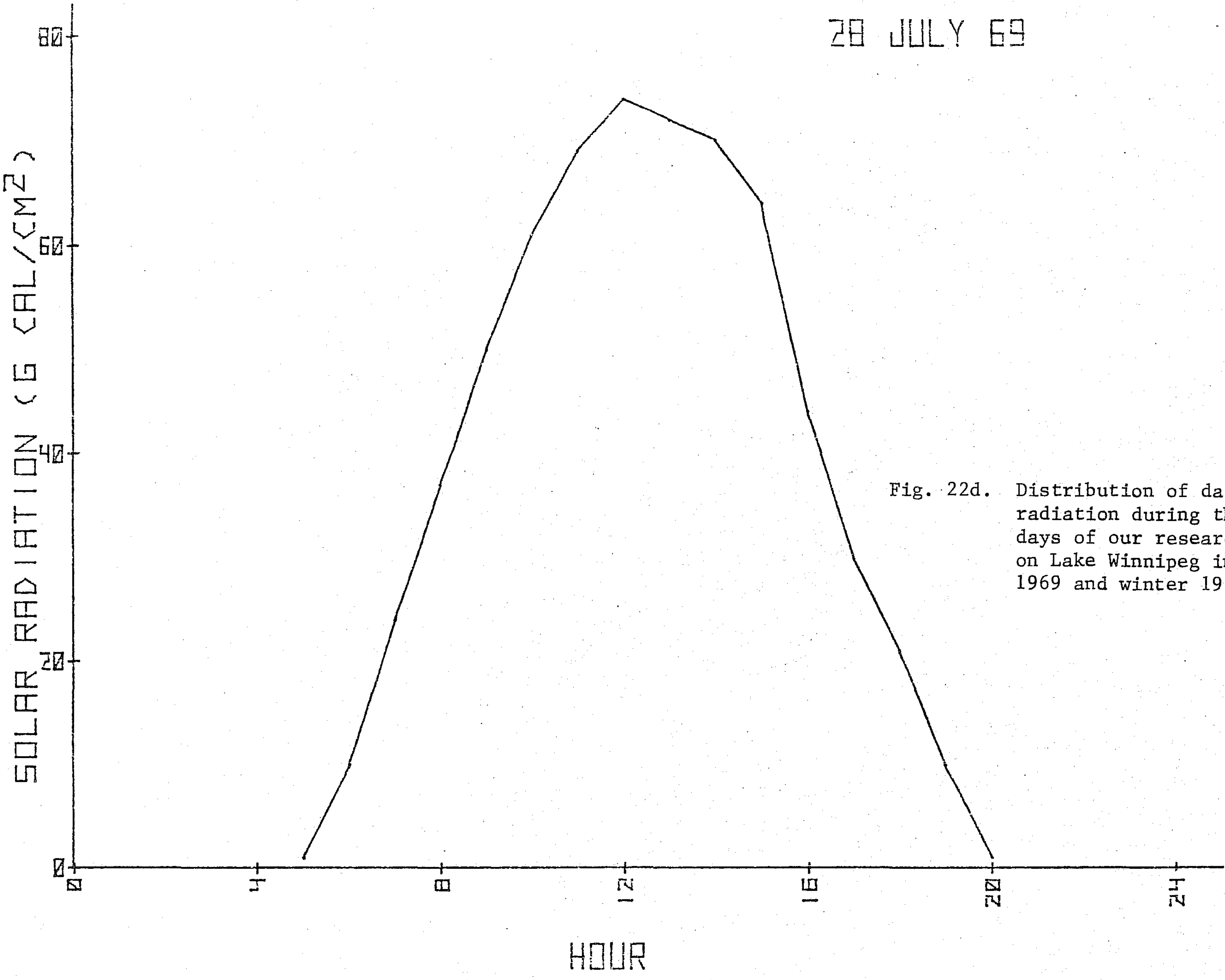

Fig. 22d. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

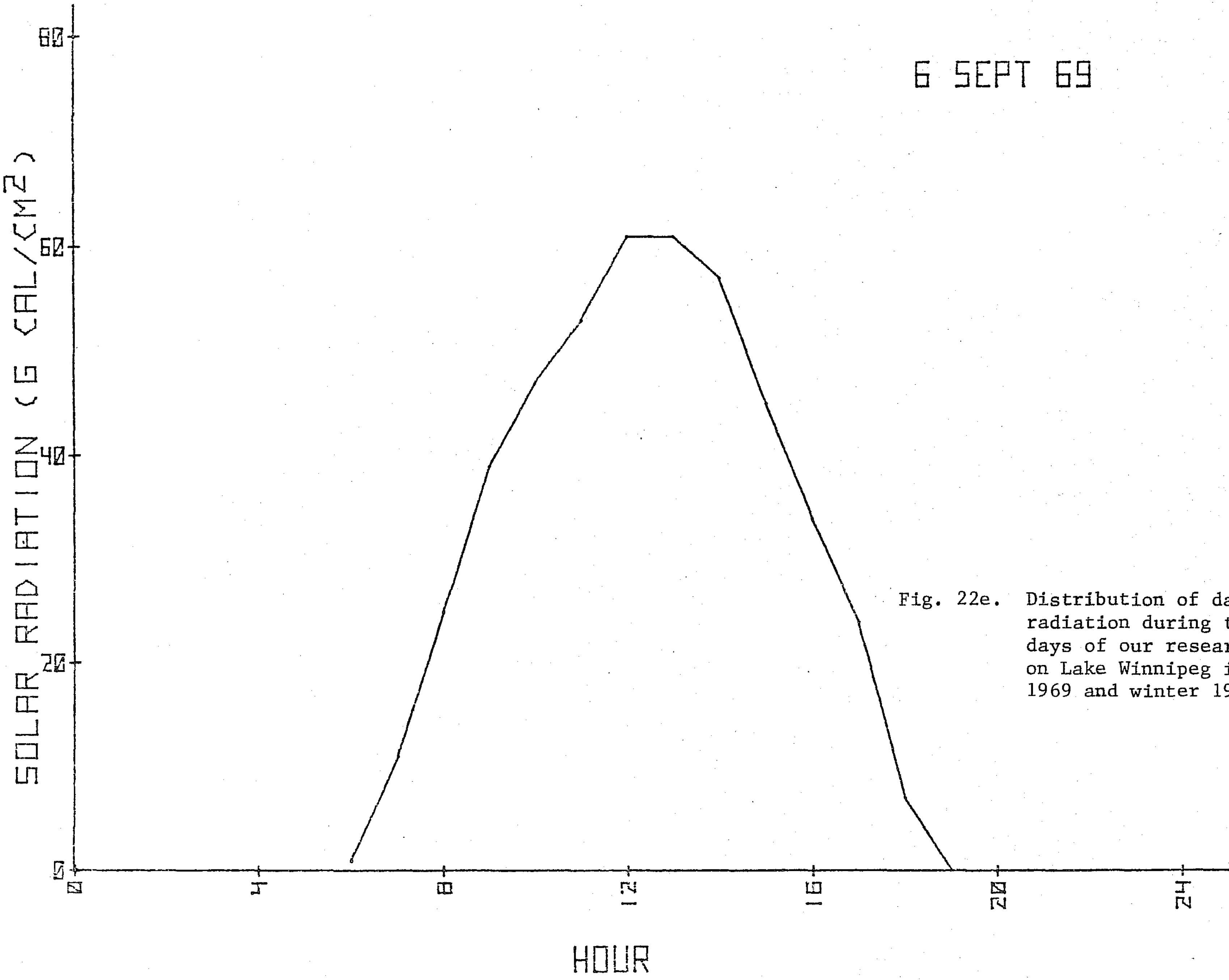

Fig. 22e. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

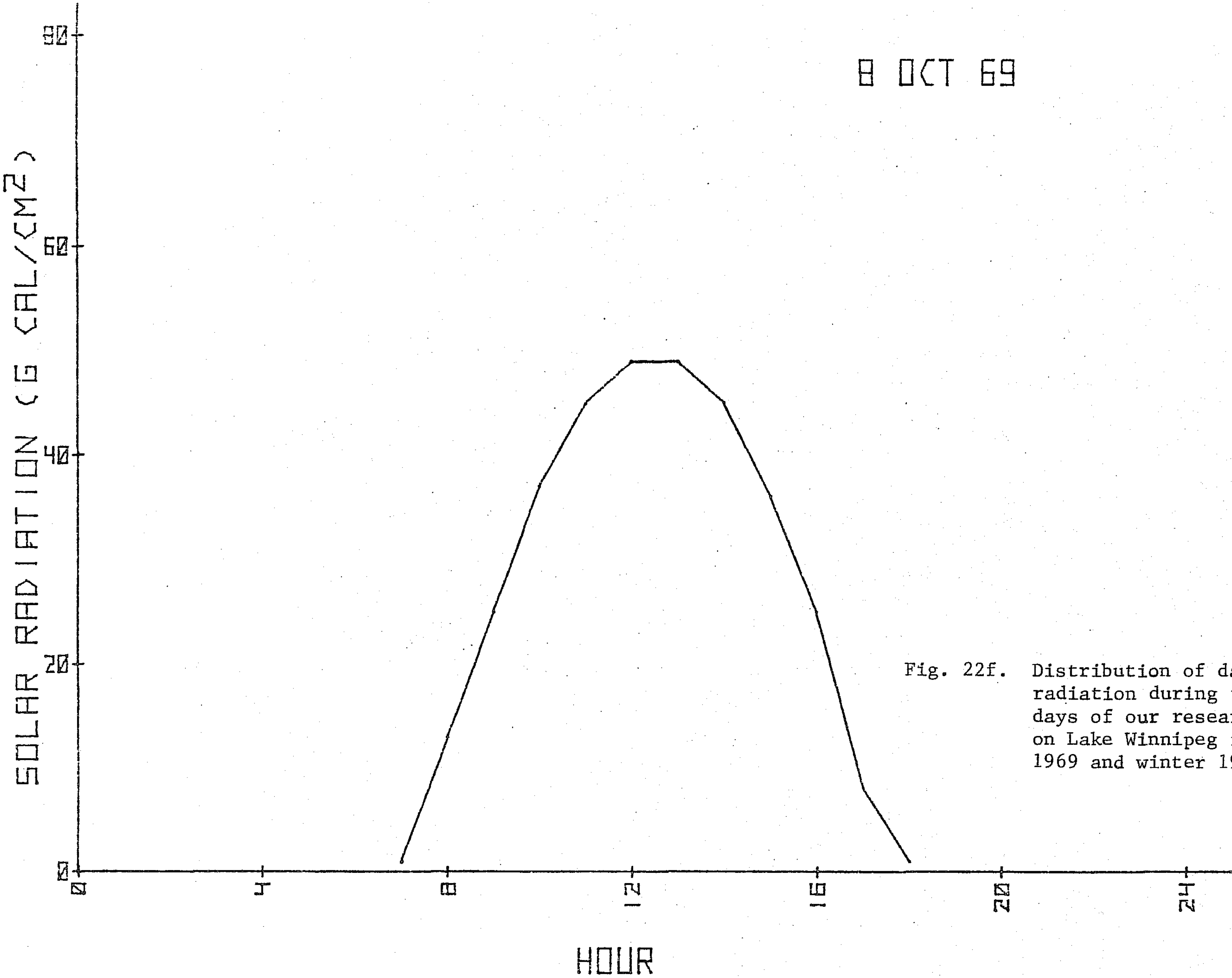

Fig. 22f. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

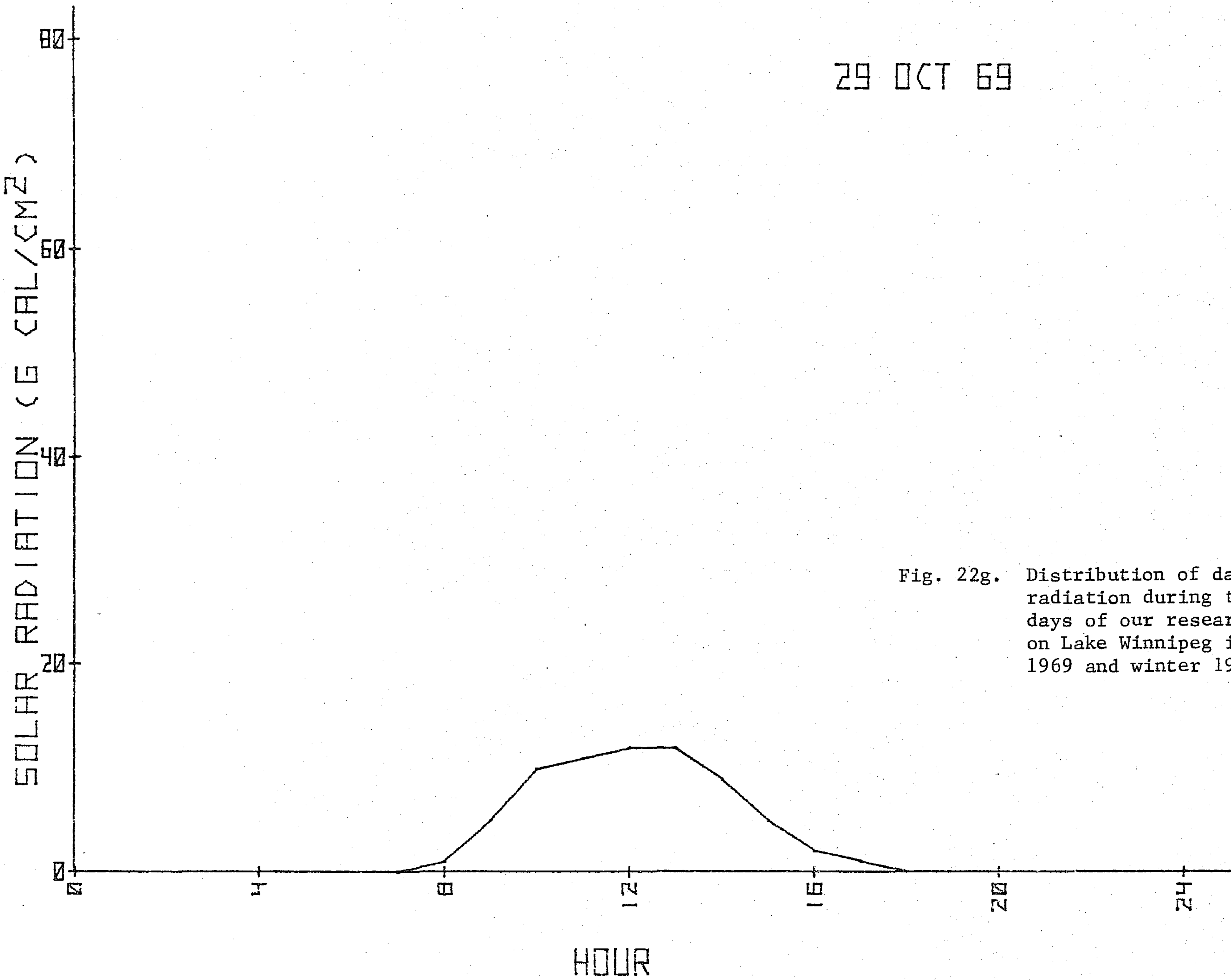

Fig. 22g. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

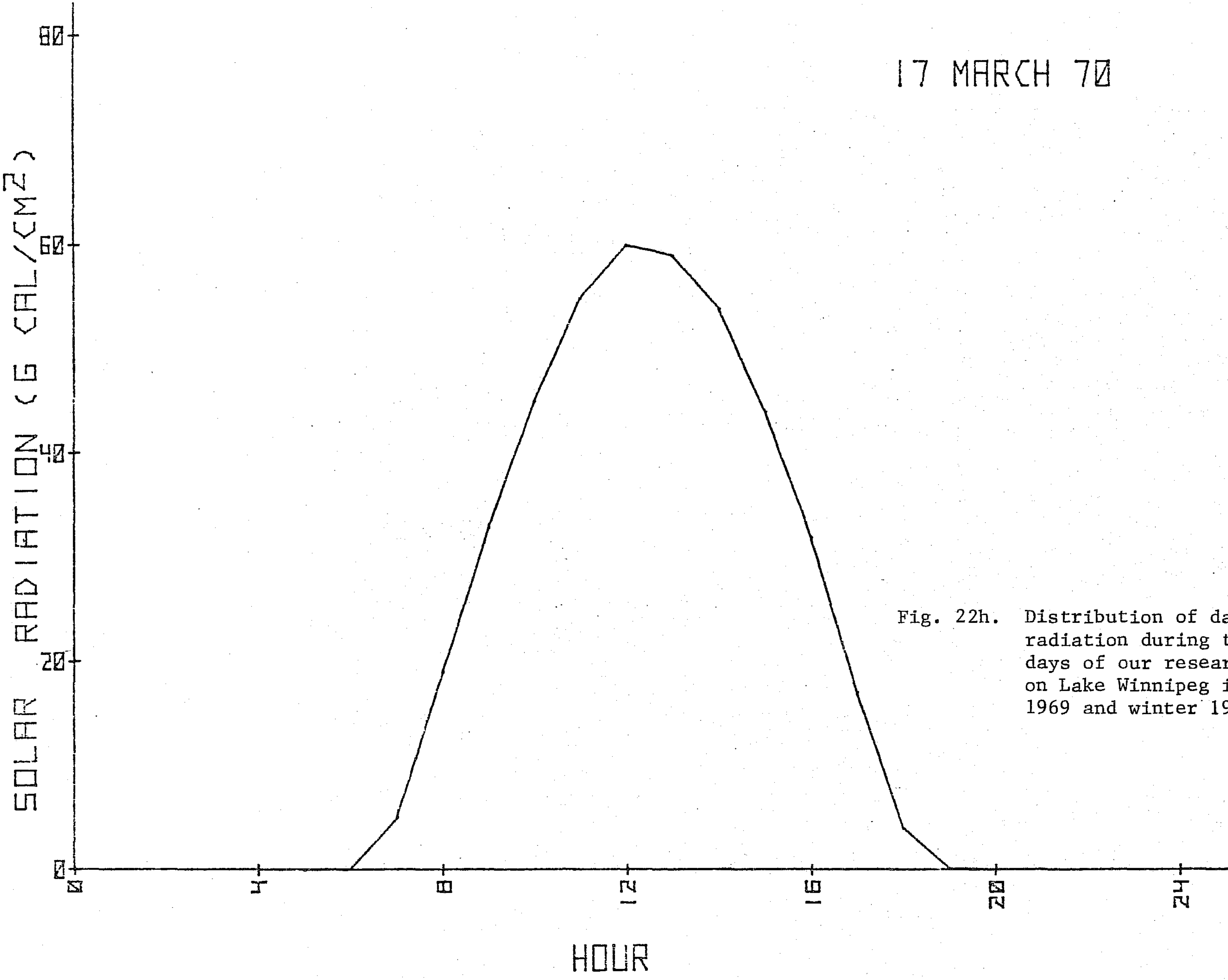

Fig. 22h. Distribution of daily radiation during the days of our research on Lake Winnipeg in 1969 and winter 1970.

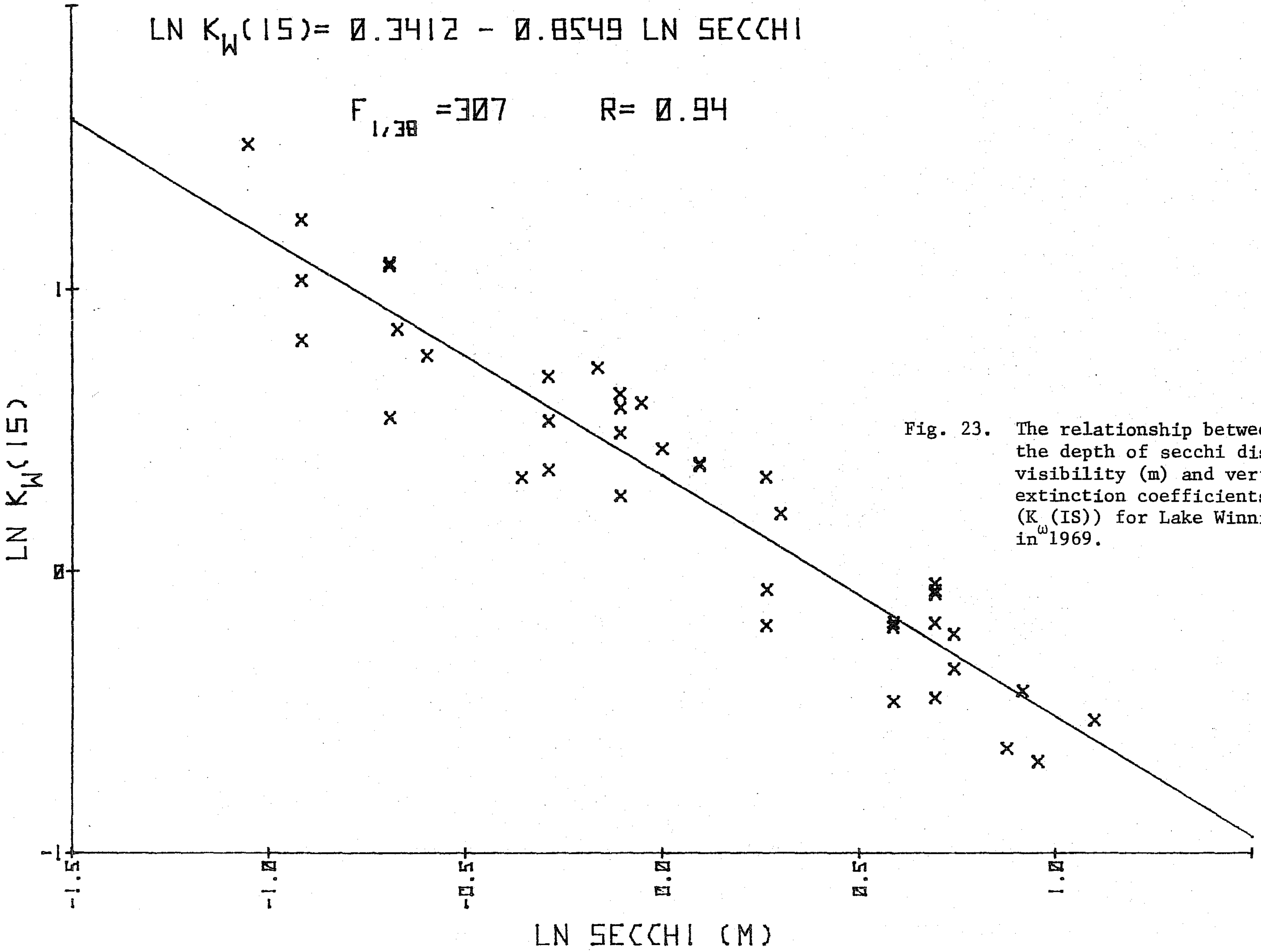

Fig. 23. The relationship between the depth of secchi disc visibility (m) and vertical extinction coefficients (K_ω(IS)) for Lake Winnipeg in 1969.

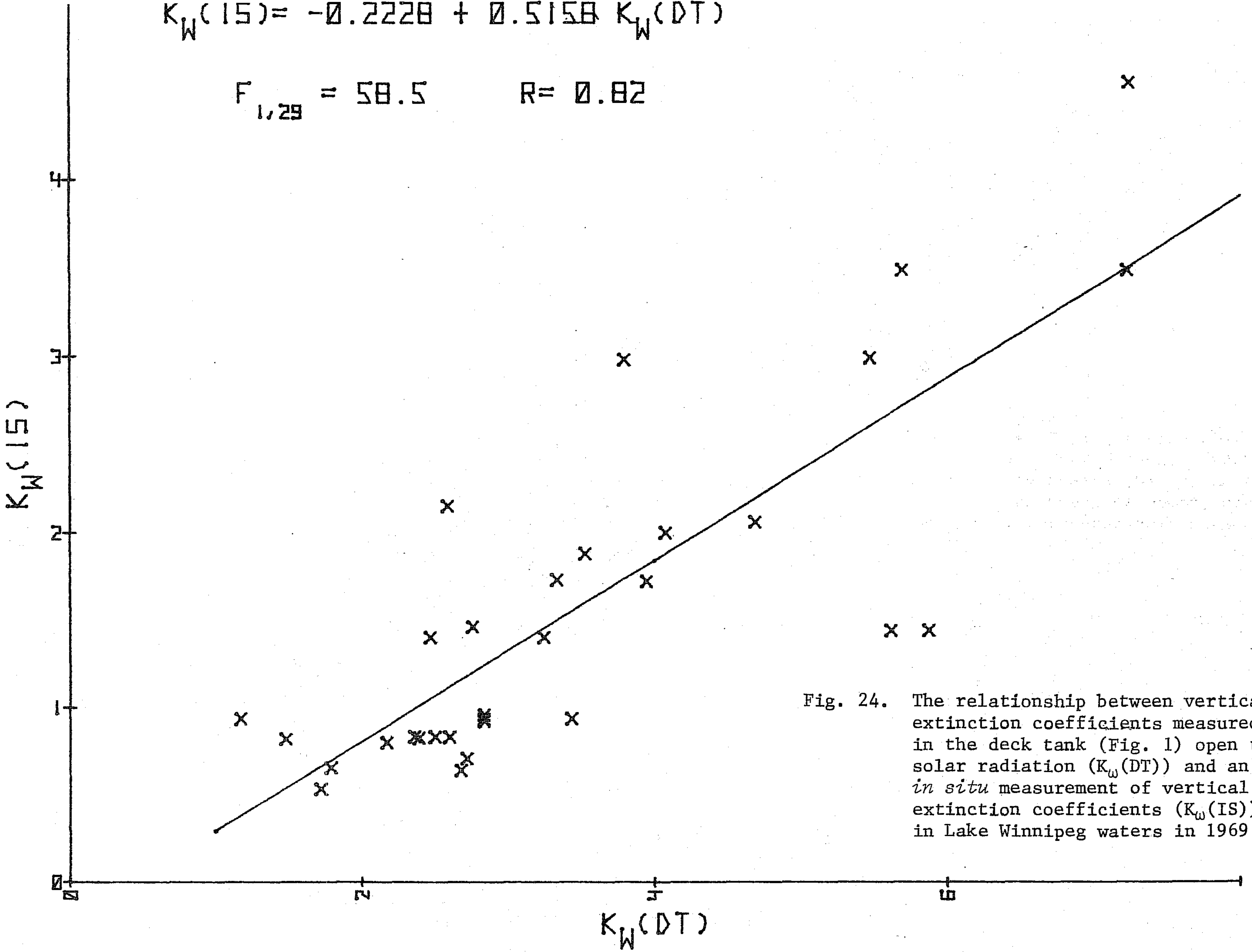

Fig. 24. The relationship between vertical extinction coefficients measured in the deck tank (Fig. 1) open to solar radiation ($K_\omega(DT)$) and an *in situ* measurement of vertical extinction coefficients ($K_\omega(IS)$) in Lake Winnipeg waters in 1969.

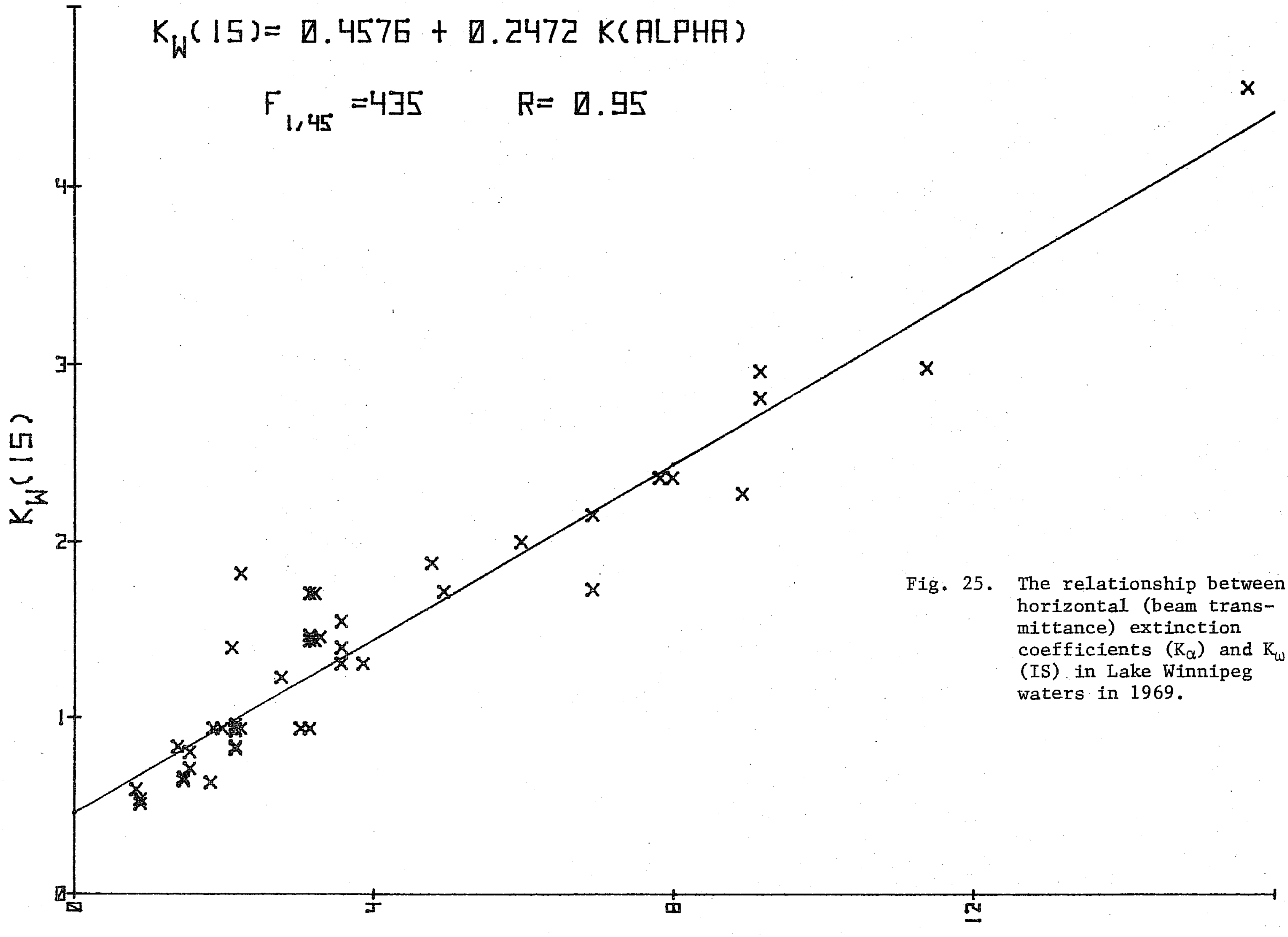

Fig. 25. The relationship between horizontal (beam transmittance) extinction coefficients (K_{α}) and K_{ω} (IS) in Lake Winnipeg waters in 1969.

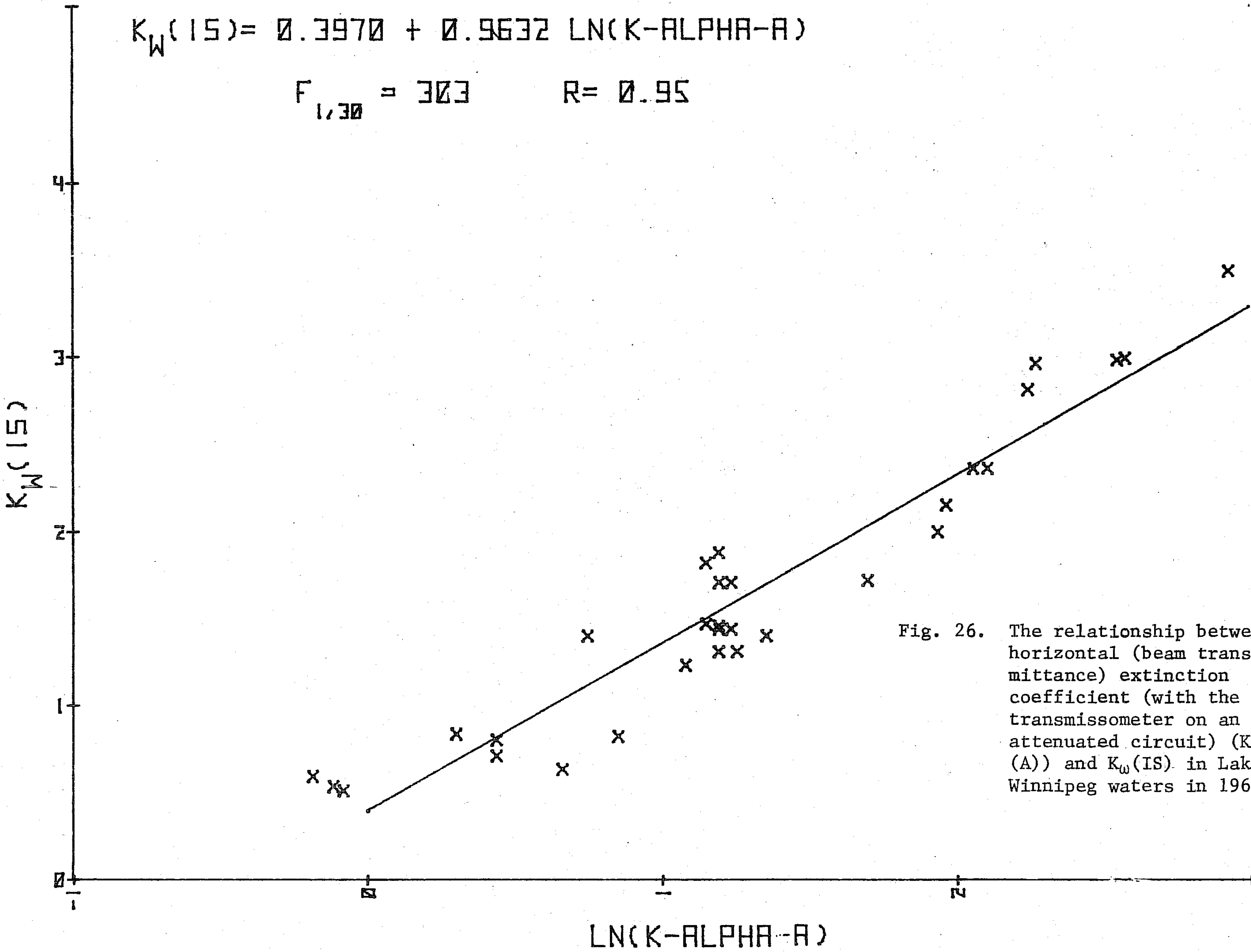

Fig. 26. The relationship between horizontal (beam transmittance) extinction coefficient (with the transmissometer on an attenuated circuit) (K_{α} (A)) and K_{ω}(IS) in Lake Winnipeg waters in 1969.

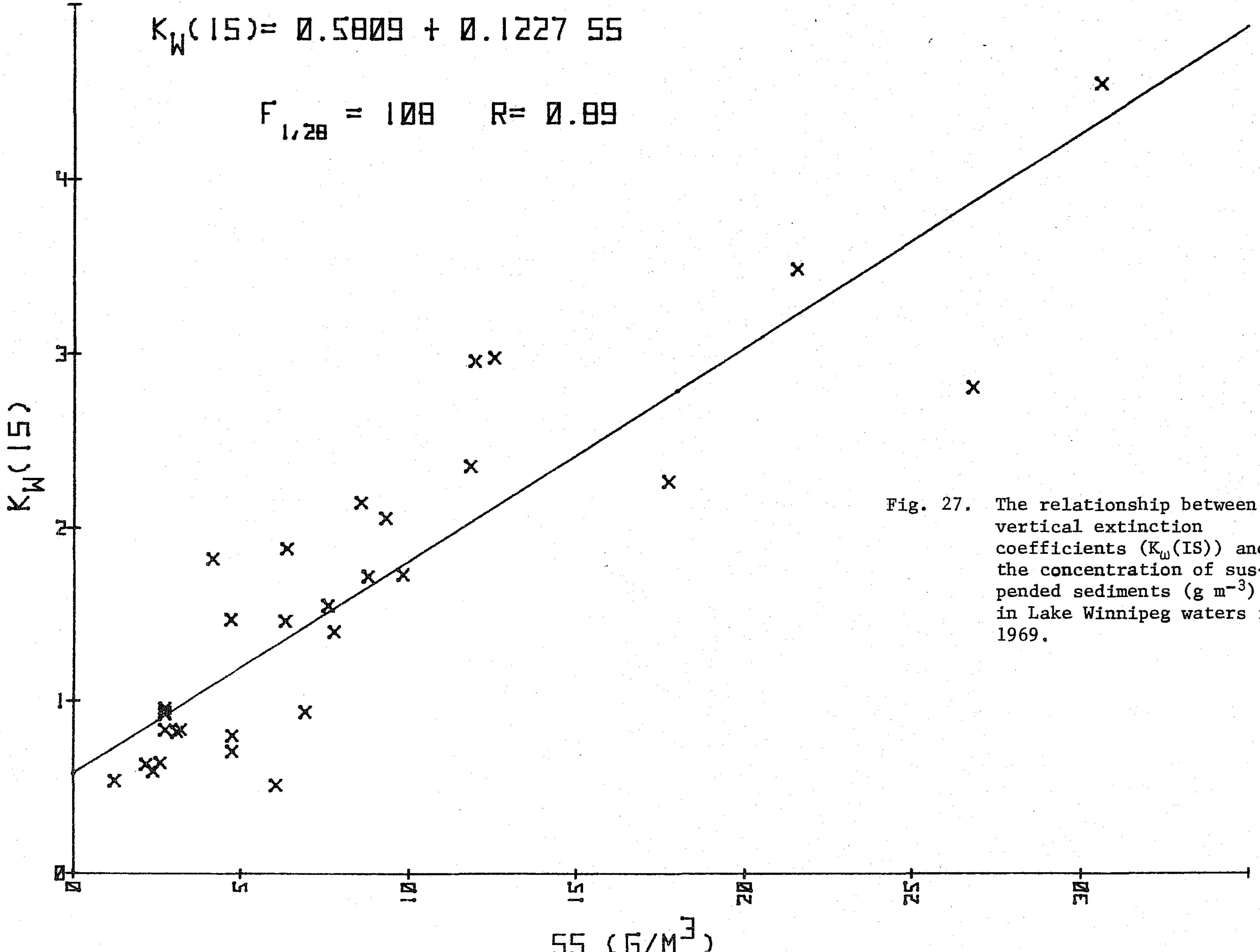

Fig. 27. The relationship between vertical extinction coefficients (K_{ω}(IS)) and the concentration of suspended sediments (g m^{-3}) in Lake Winnipeg waters in 1969.

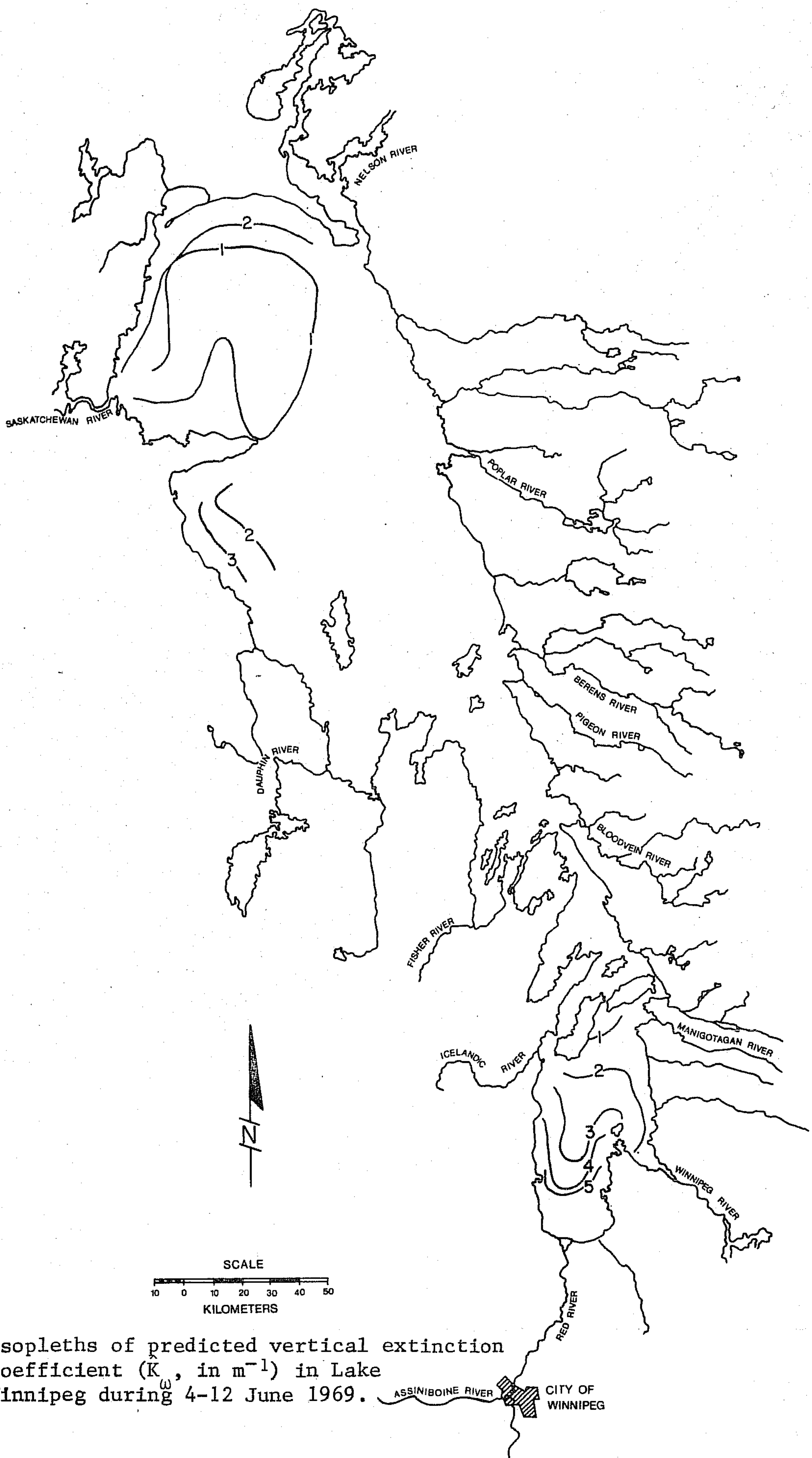

Fig. 28. Isopleths of predicted vertical extinction coefficient ($\hat{K}_{\omega}$, in m^{-1}) in Lake Winnipeg during 4-12 June 1969.

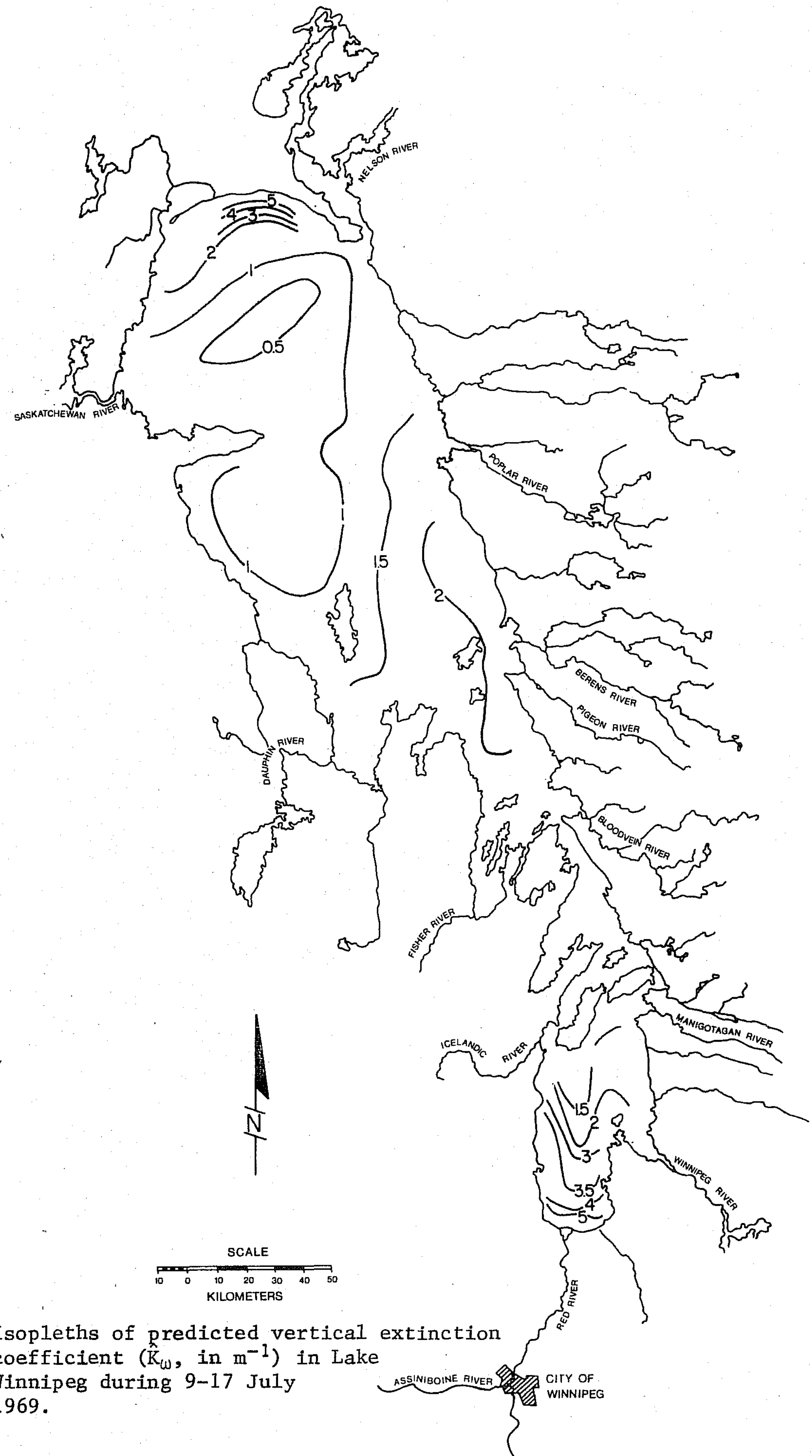

Fig. 29. Isopleths of predicted vertical extinction coefficient ($\bar{K}_{\omega}$, in m^{-1}) in Lake Winnipeg during 9-17 July 1969.

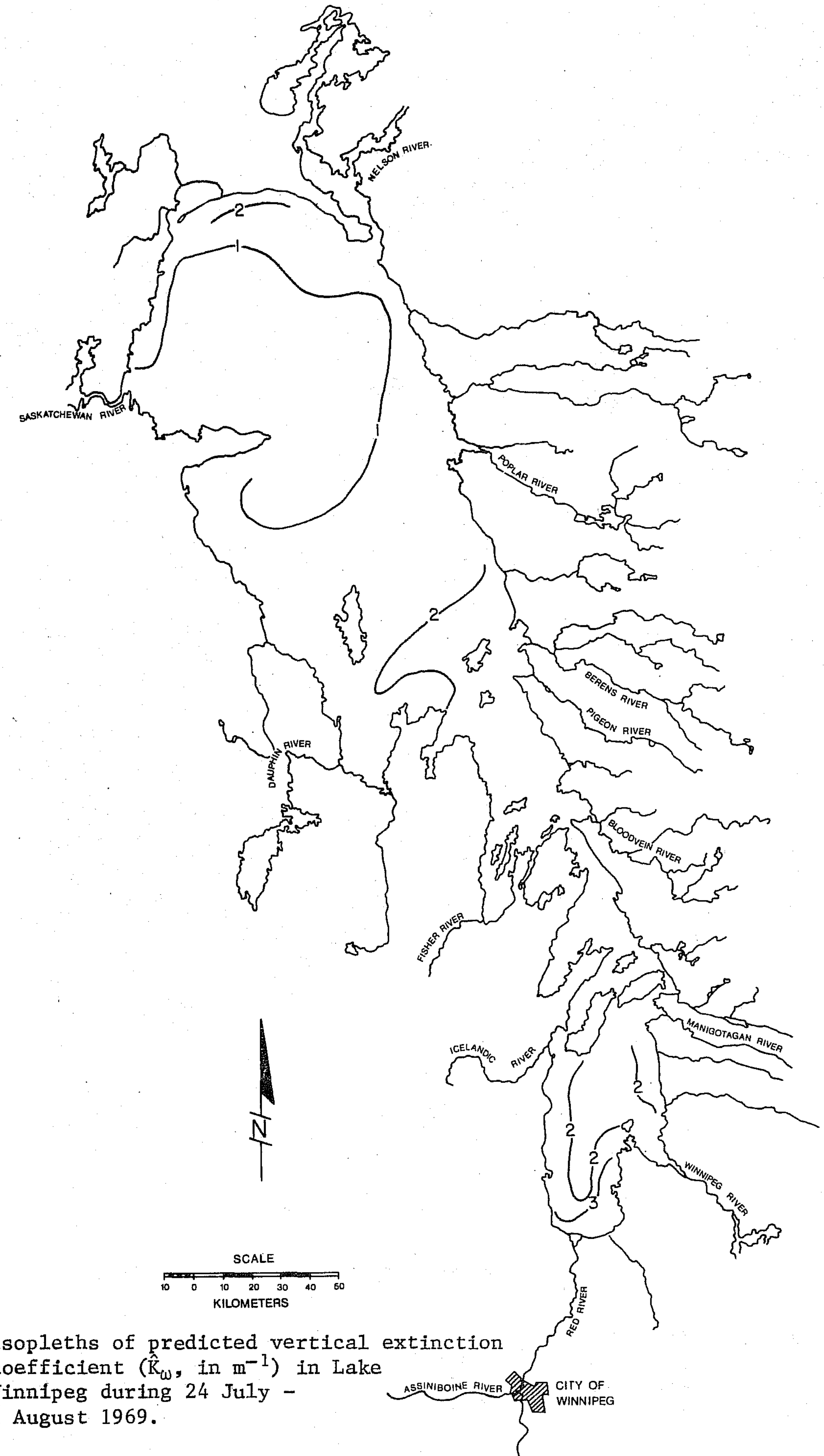

Fig. 30. Isopleths of predicted vertical extinction coefficient ($\hat{K}_\omega$, in m^{-1}) in Lake Winnipeg during 24 July - 1 August 1969.

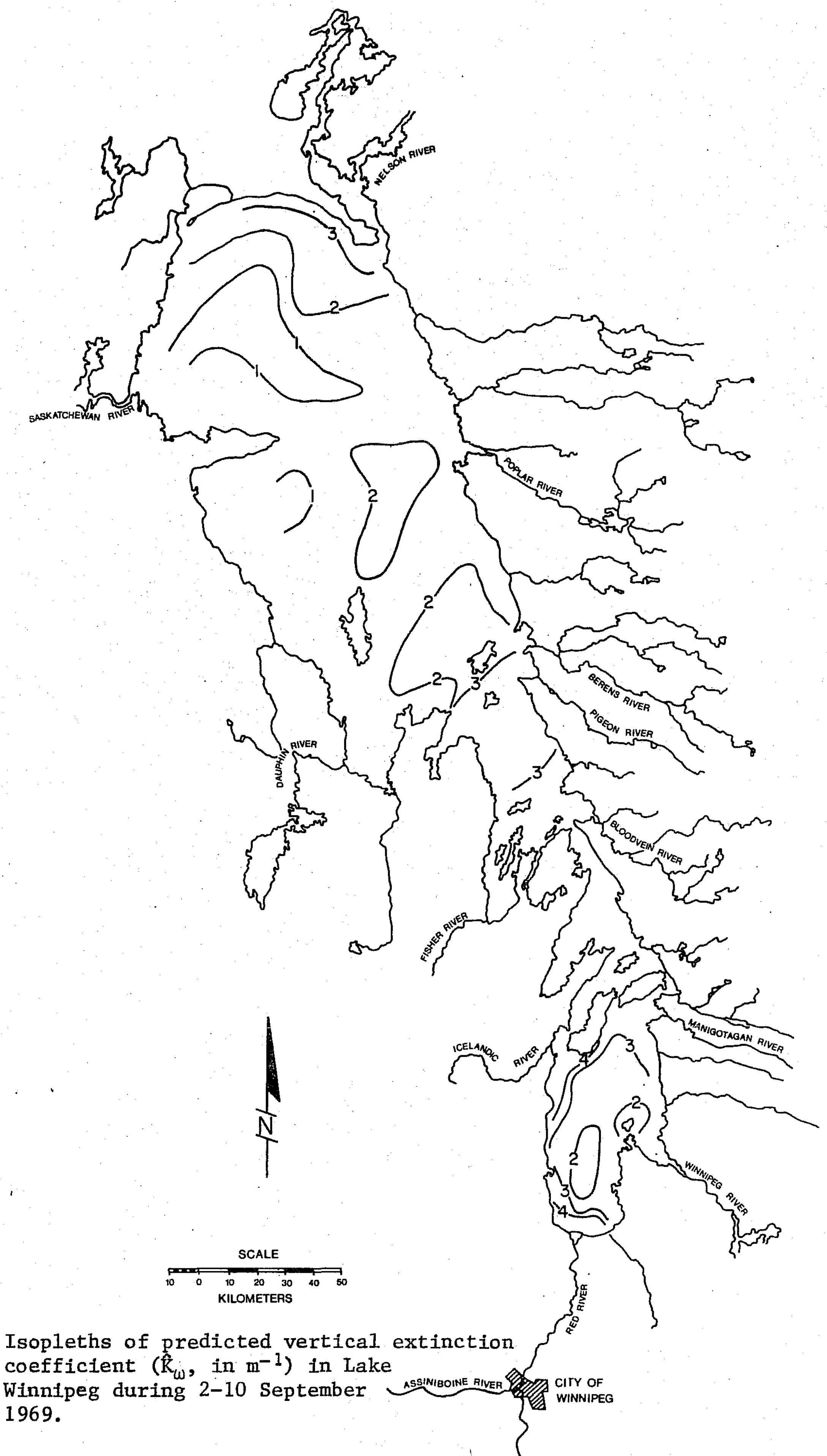

Fig. 31. Isopleths of predicted vertical extinction coefficient ($\hat{K}_{\omega}$, in m^{-1}) in Lake Winnipeg during 2-10 September 1969.

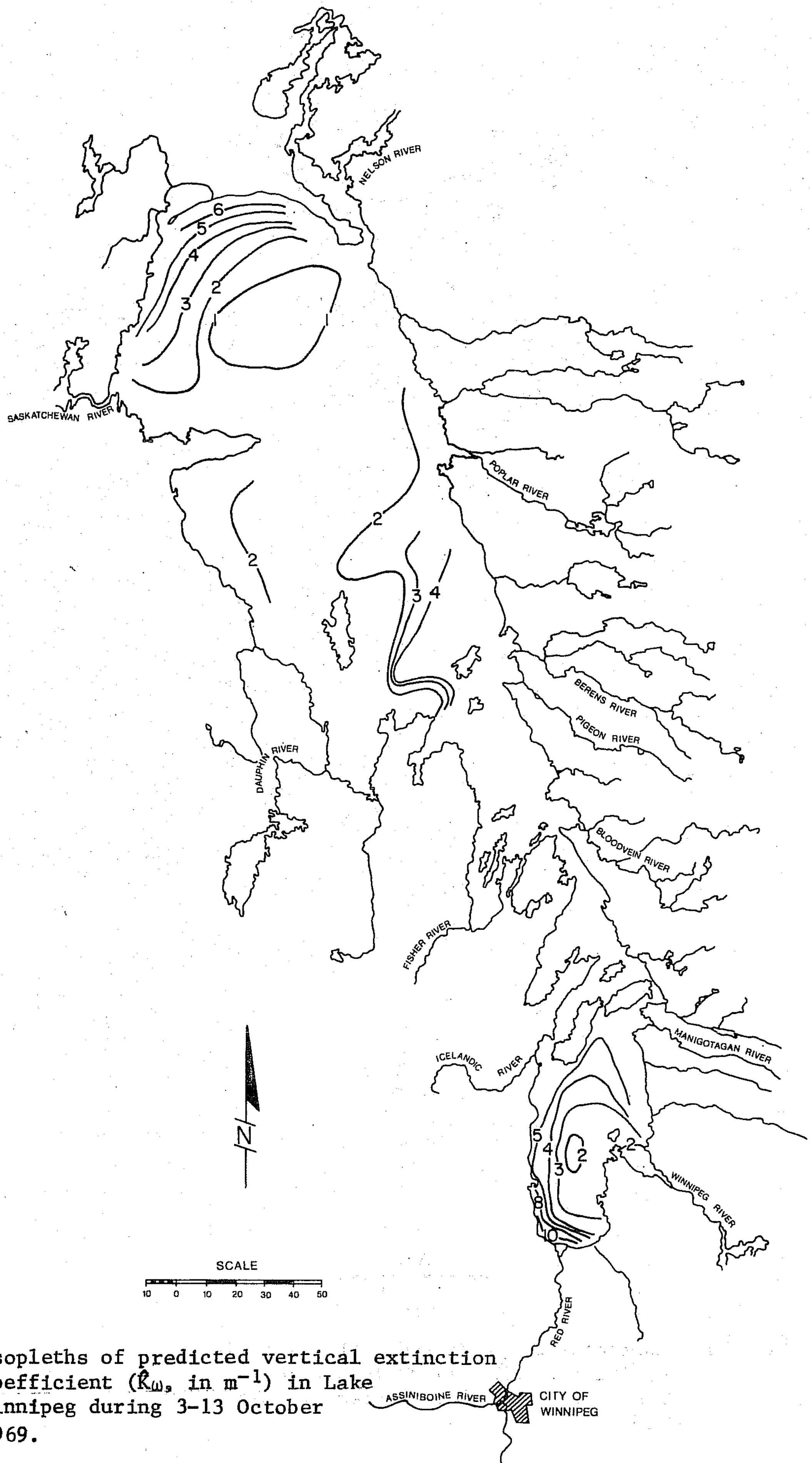

Fig. 32. Isopleths of predicted vertical extinction coefficient ($\hat{K}_{\omega}$, in m^{-1}) in Lake Winnipeg during 3-13 October 1969.

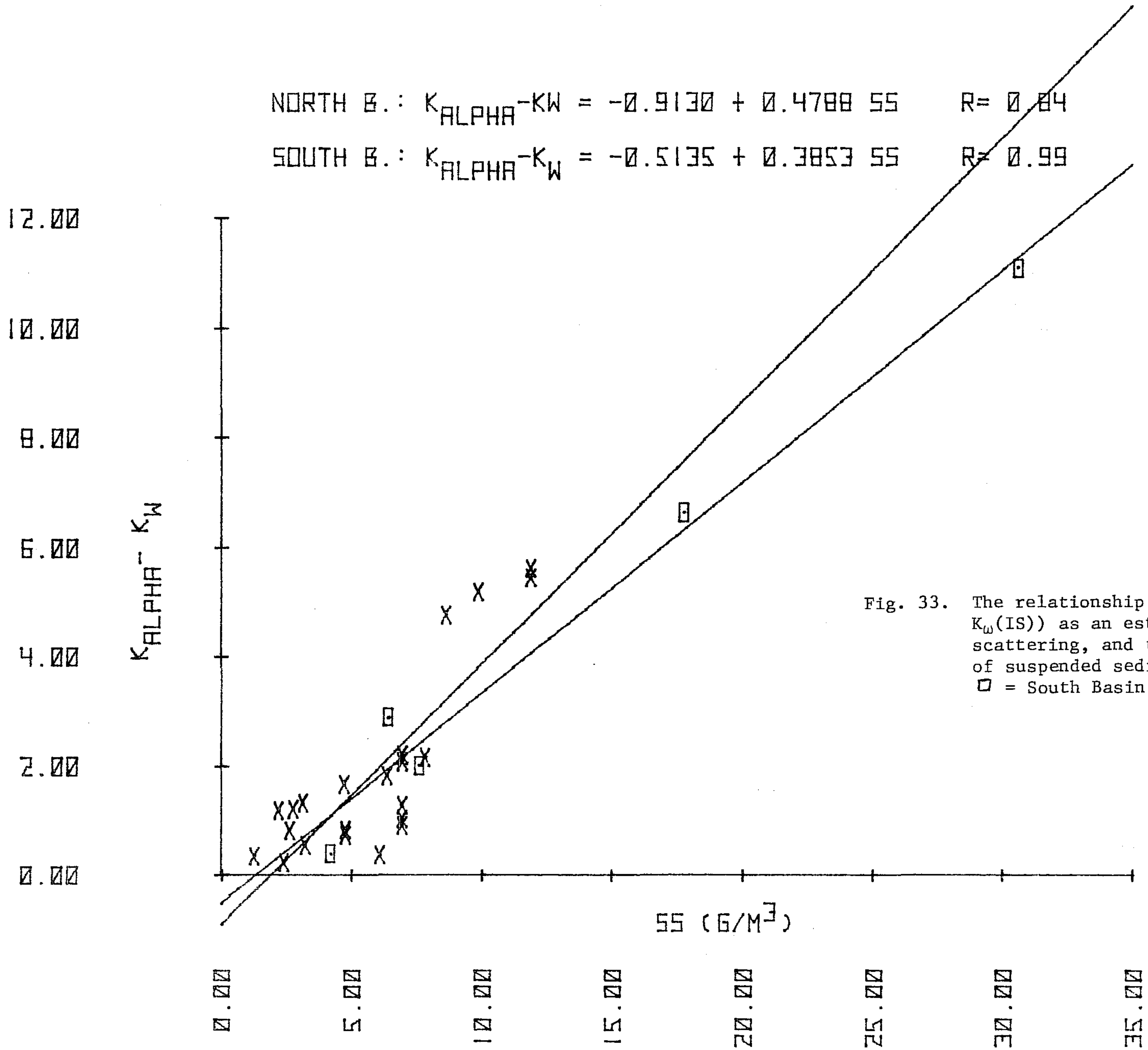

Fig. 33. The relationship between (K_α - K_ω(IS)) as an estimator of scattering, and the concentration of suspended sediments in g m^{-3}. ◻ = South Basin, X = North Basin.

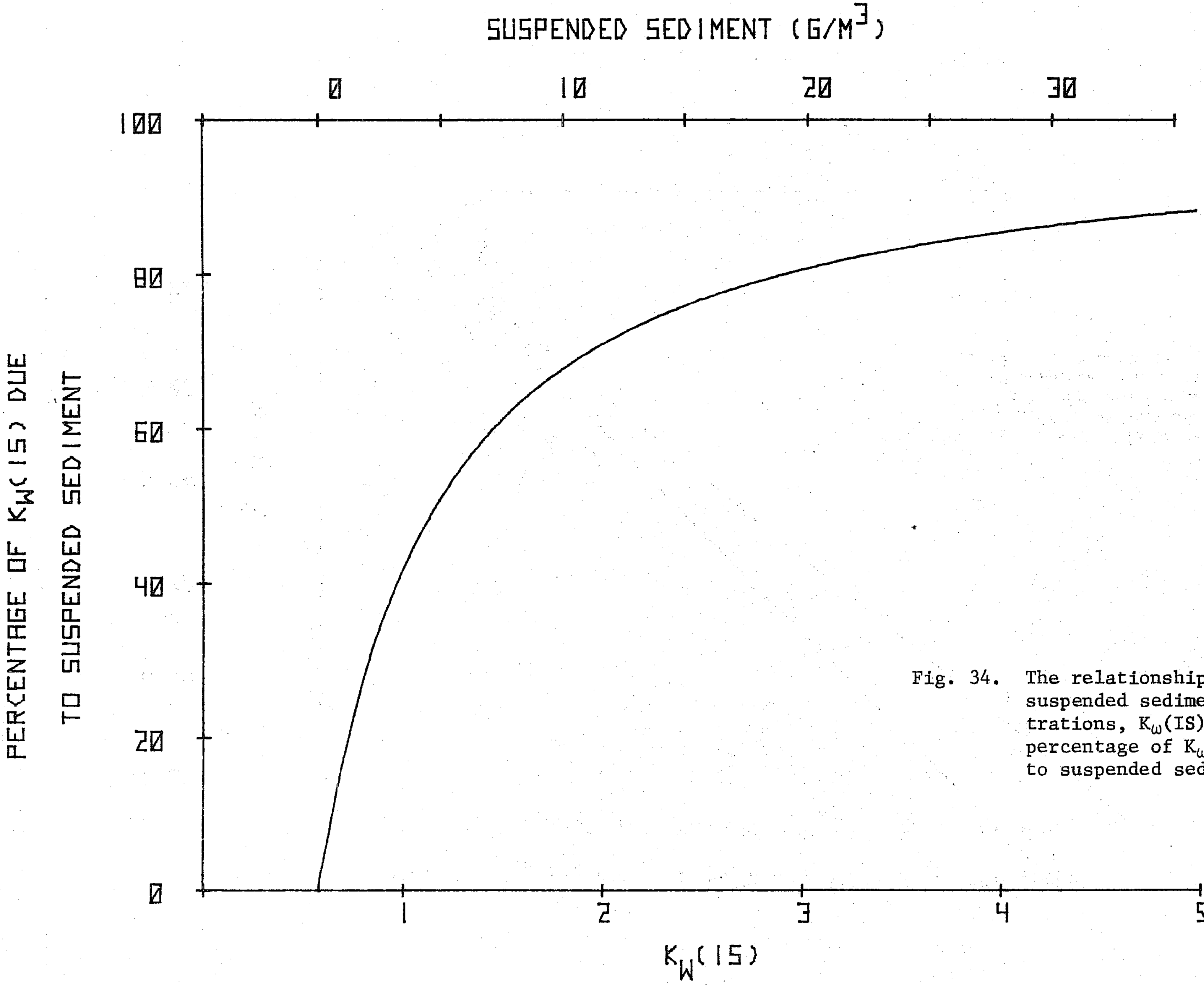

Fig. 34. The relationships between suspended sediment concentrations, $K_{\omega}(IS)$, and the percentage of $K_{\omega}(IS)$ due to suspended sediment.

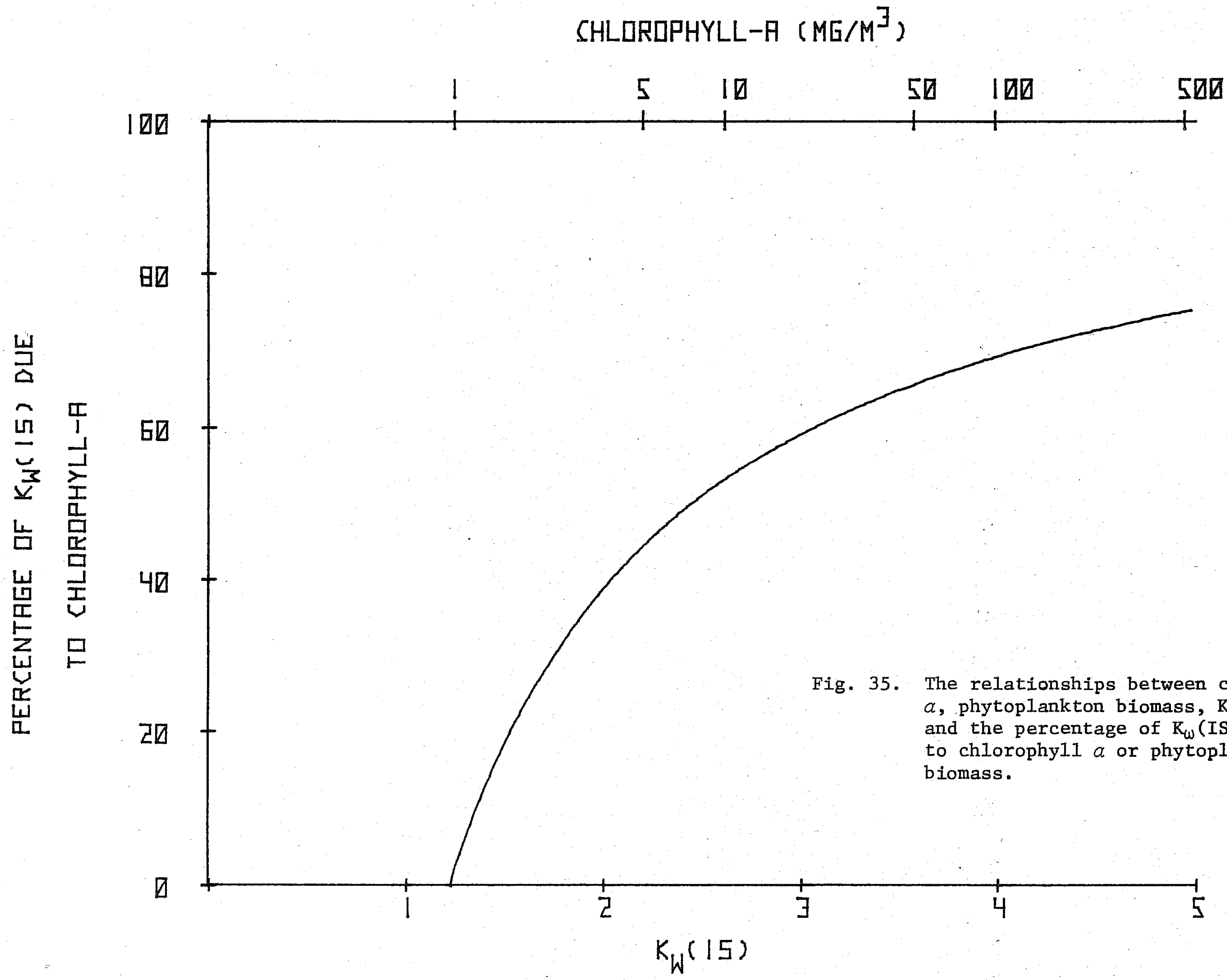

Fig. 35. The relationships between chlorophyll *a*, phytoplankton biomass, K_ω(IS), and the percentage of K_ω(IS) due to chlorophyll *a* or phytoplankton biomass.