Chlorophyll a and primary production in Georgian Bay, North Channel, and Lake Huron, Apr. to Dec., 1974

by
N.H.F. Watson, L.R. Culp, and
H.F. Nicholson

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Chlorophyll a and Primary Production in Georgian Bay, North Channel and Lake Huron, April to December, 1974.

by N. H. F. Watson, L. R. Culp and H. F. Nicholson

This is the fourteenth Technical Report from the Research and Development Directorate Great Lakes Biolimnology Laboratory Canada Centre for Inland Waters Burlington, Ontario

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1975

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

Chlorophyll a measurements were made during seven cruises between April and December 1974 in Georgian Bay, Lake Huron (north of $45^{o}30'$ latitude), and North Channel. Carbon-14 uptake measurements were also made in Georgian Bay and North Channel between April and October. Carbon uptake values were converted to daily production rates per m^2 of surface area. Annual primary production estimates were computed from chlorophyll a and carbon uptake data.

Georgian Bay cruise means of corrected chlorophyll a ranged from 0.7 µg/l to 1.7 µg/l; individual station values ranged from 0.3 µg/l to 5.6 µg/l. Primary production values varied from 1.0 mg $C/m^3/hr$ to 14.5 mg $C/m^3/hr$, which convert to 0.03 g $C/m^2/day$ to 0.51 g $C/m^2/day$ with a cruise mean range from 0.09 g $C/m^2/day$ to 0.29 g $C/m^2/day$. Annual primary productivity was estimated at 76 g $C/m^2/yr$, using the mean uncorrected chlorophyll a value, and 35 g $C/m^2/yr$, using carbon-14 cruise means extended to zero winter values.

North Channel cruise means of corrected chlorophyll a ranged from 1.3 µg/l to 2.3 µg/l; individual station values ranged from 0.8 µg/l to 3.7 µg/l. Primary production values varied from 1.3 mg $C/m^3/hr$ to 5.5 mg $C/m^3/hr$ which convert to 0.04 g $C/m^2/day$ to 0.44 g $C/m^2/day$ with a cruise mean range from 0.12 g $C/m^2/day$ to 0.32 g $C/m^2/day$. Annual primary productivity was estimated at 92 g $C/m^2/yr$, using the mean uncorrected chlorophyll a value, and 37 g $C/m^2/yr$, using carbon-14 cruise means extended to zero winter values.

Lake Huron cruise means for corrected chlorophyll a ranged from 1.0 µg/l to 2.3 µg/l, with station values ranging from 0.4 µg/l to 4.0 µg/l. Estimated annual primary production from the uncorrected chlorophyll mean was 92 g $C/m^2/yr$.

Résumé

D'avril à decembre 1974, on a mesuré,lors de sept campagnes, la concentration en chlorophylle a de la baie Géorgienne, du chenal du Nord et du lac Huron (au nord de 45^{o} 30' de latitude). D'avril à octobre, on a egalement mesuré la vitesse d'absorption du carbone-14 dans la baie Géorgienne et le chenal du Nord. La consommation de carbone a été convertit en taux de production journalier par mètre carré de surface. Les données sur la chlorophylle a et l'absorption du carbone ont permis d'estimer la production primaire annuelle.

La moyenne des concentrations corrigées de chlorophylle a dans la baie Géorgienne est comprise entre 0.7 et 1.7 µg/l tandis que pour chaque station elle se situe entre 0.3 et 5.6 µg/l. La production primaire varie de 1.0 à 14.5 $mg/m^3/h$ ou de 0.03 à 0.51 $g/m^2/j$, avec une moyenne par croisière de 0.09 à 0.29 $g/m^2/j$.

La production primaire annuelle, estimée à parti de la moyenne des concentrations non corrigées de chlorophylle a ou de l'absorption moyenne de carbone-14 comprenant les valeurs nulles enregistrées en hiver, est de 76 $g/m^2/an$ et 35 $g/m^2/an$, respectivement.

La moyenne des concentrations corrigeés de chlorophylle a dans le chenal du Nord varie de 1.3 à 2.3 µg/l tandis que pour chaque station elle se situe entre 0.8 et 3.7 µg/l. La production primaire varie de 1.3 à 5.5 $mg/m^3/h$ ou de 0.04 à 0.44 $g/m^2/j$, avec un écart des moyennes par croisière allant de 0.12 à 0.32 $g/m^2/j$. La production primaire annuelle, estimée à partir de la moyenne des concentrations non corrigées de chlorophylle a ou de l'absorption moyenne de carbone-14 comprenant les valeurs nulles enregistrées en hiver, est de 92 $g/m^2/an$ et 37 $g/m^2/an$, respectivement.

La moyenne des concentrations corrigées de chlorophylle a dans le lac Huron varie de 1.0 à 2.3 µg/l tandis que pour chaque station elle se situe entre 0.4 et 4.0 µg/l. La production primaire annuelle calculée à partir de la moyenne des concentrations non corigée de chlorophylle a est estimée a 92 $g/m^2/an$.

INTRODUCTION

During 1974, seven cruises were conducted by the Canada Centre for Inland Waters on Lake Huron, North Channel and Georgian Bay as a continuation of the programme of lake-wide coverage of the International and Canadian waters of the Laurentian Great Lakes. During these cruises, observations were carried out by the staff of the Great Lakes Biolimnology Laboratory. Figures 1 and 2 indicate the study area and the station pattern discussed in this report. No previous published records on these parameters are available for Georgian Bay and most of the North Channel. This paper includes unpublished data on chlorophyll a distributions taken in Georgian Bay in 1969 (2 cruises) and 1970 (1 cruise) by the Great Lakes Institute, University of Toronto, at the request of the Freshwater Institute, Winnipeg. Parkos, Olson, and Odlaug (1969) reported on the primary productivity of Lake Huron; and Glooschenko and Moore (1973), and Glooschenko, Moore, and Vollenweider (1973) reported on the chlorophyll a and primary production in Lake Huron and two stations in the North Channel between April and December, 1971.

METHODS

The methods for the determination of chlorophyll a and carbon-14 uptake and the treatment of the data are essentially the same as have been recently described elsewhere (Watson, Nicholson, and Culp, 1975) and need not be repeated here. The mean latitude through Georgian Bay and North Channel is $45^{o}23'$ and the fraction of total daily photosynthesis (mg C/m^3/day) to be expected during a four-hour exposure (1000-1400 hrs) for this latitude has been interpolated for each cruise from Gaechter (1973) and Stadelmann and Moore (1974). Other slight differences from the previously

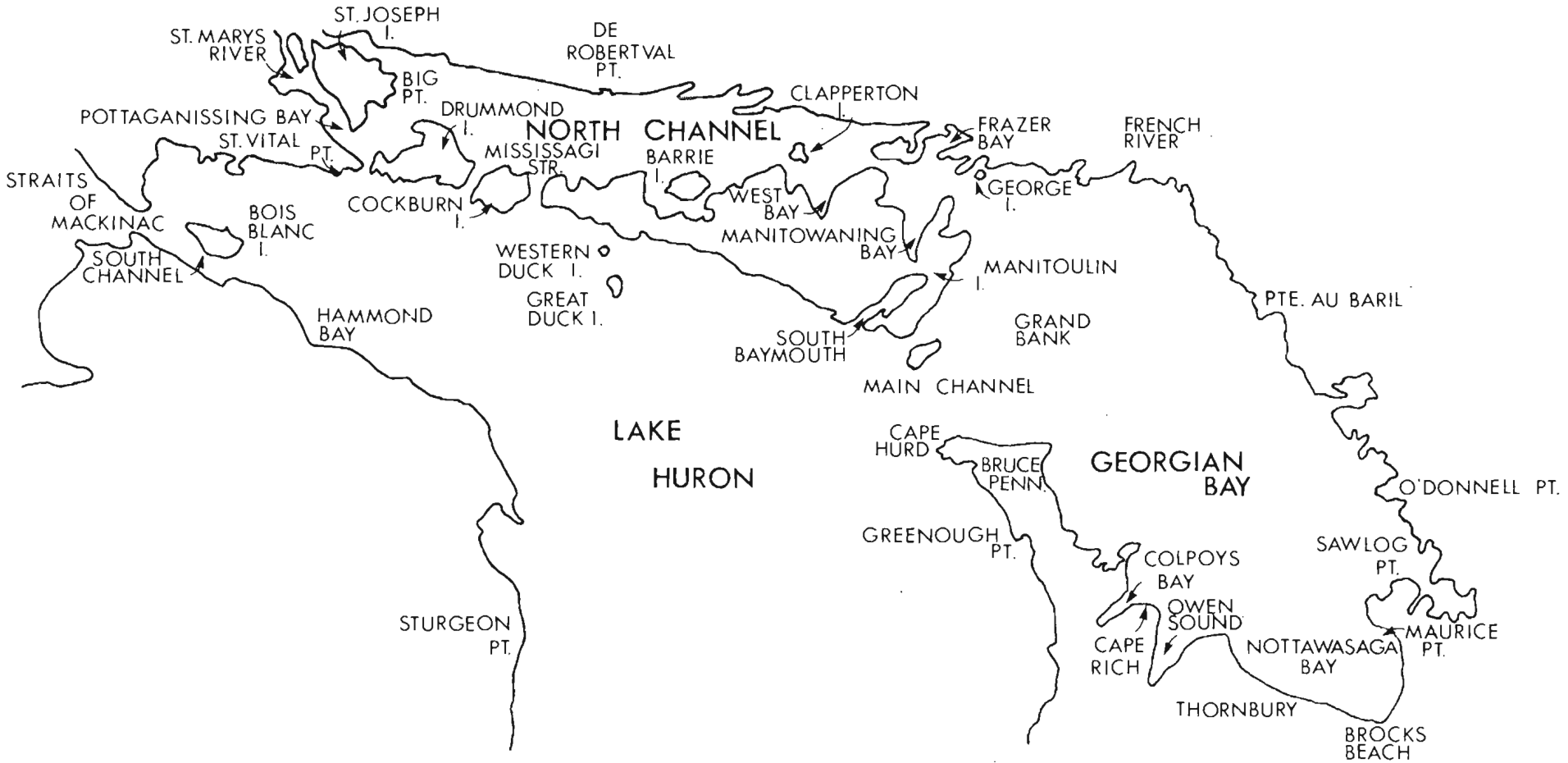

ST. JOSEPH I.
ST. MARYS RIVER
DE ROBERTVAL PT.
BIG PT.
CLAPPERTON I.
POTTAGANISSING BAY
DRUMMOND I.
NORTH CHANNEL
FRAZER BAY
FRENCH RIVER
ST. VITAL PT.
MISSISSAGI STR.
BARRIE I.
STRAITS OF MACKINAC
GEORGE I.
WEST BAY
COCKBURN I.
BOIS BLANC I.
MANITOWANING BAY
WESTERN DUCK I.
MANITOULIN I.
SOUTH CHANNEL
GREAT DUCK I.
PTE. AU BARIL
HAMMOND BAY
GRAND BANK
SOUTH BAYMOUTH
MAIN CHANNEL
LAKE HURON
CAPE HURD
BRUCE PENN.
GEORGIAN BAY
O'DONNELL PT.
GREENOUGH PT.
COLPOYS BAY
SAWLOG PT.
OWEN SOUND
MAURICE PT.
CAPE RICH
NOTTAWASAGA BAY
STURGEON PT.
THORNBURY
BROCKS BEACH

Figure 1

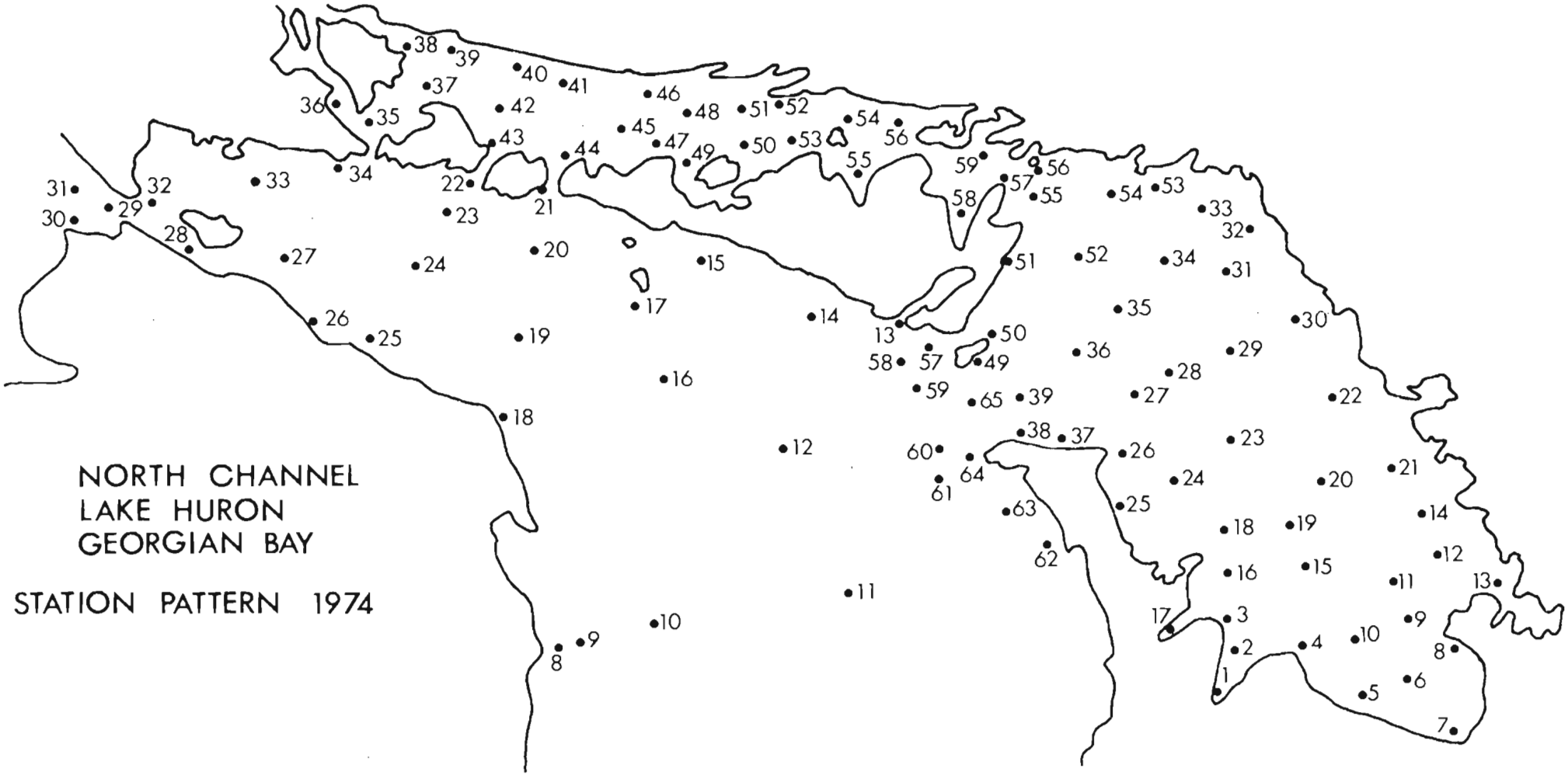

NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
STATION PATTERN 1974

Figure 2

Table 1. Georgian Bay 1974. Corrected chlorophyll *a* concentrations in µg/l from 0-20 m integrated samples.

Dates	N	MAX	MIN	MEAN	S.E.
Apr. 27 - May 1	46	5.6	1.1	1.6	0.661
May 18 - 22	50	2.7	0.7	1.7	0.461
Jun. 17 - 22	47	3.5	0.9	1.7	0.506
July 31 - Aug. 7	51	1.3	0.3	0.7	0.249
Aug. 31 - Sept. 6	51	2.3	0.7	1.2	0.314
Oct. 6 - 11	51	4.7	0.7	1.5	0.682
Dec. 4 - 12	41	1.8	0.7	1.0	0.229

described methods were (a) three light and one dark bottle were used in the C^{14} uptake studies, (b) for in situ production studies, water samples were taken from 1, 5, 10, 15, 20, 25, 30, 40 and 50 m where sufficient depth was available and to the nearest 5 m from the bottom in the shallow waters of the North Channel, and (c) during the first 6 cruises, station 23 in the middle of Georgian Bay was occupied for a 24 hour period, during which chlorophyll a samples were collected at selected time intervals, depth intervals, and positions relative to the station.

1. Results - Chlorophyll a

1a. Georgian Bay

Individual station values of corrected chlorophyll a ranged from 0.3 µg/l to 5.6 µg/l. Concentrations, however, only exceeded 2 µg/l along the eastern shoreline south of O'Donnell Point to Maurice Point, east of Thornbury, off Pte. au Baril, in Colpoys Bay, near the French River, and in the North Channel. Large offshore water masses low in chlorophyll a are dominant, as indicated by the low cruise means, ranging from 0.7 to 1.7 µg/l (Table 1), and the relatively uniform chlorophyll a values observed over 24 hours at station 23 in the middle of the Bay.

Vertical profiles of chlorophyll a were determined at 4 to 7 stations, on six cruises, from depths of 1, 5, 10, 15, 20, 30, 50, 2 metres from the bottom and also at 25 and 40 metres at in situ production stations (Figs. 3a and 3b). Chlorophyll was unstratified in April and May. In June, concentrations increased to a maximum at or below 10 metres except at station 23 which remained unstratified, and station 6 in the south end of the Bay, which was uniform to 30 metres and subsequently decreasing with depth. The depth of the 1% surface light level, determined from

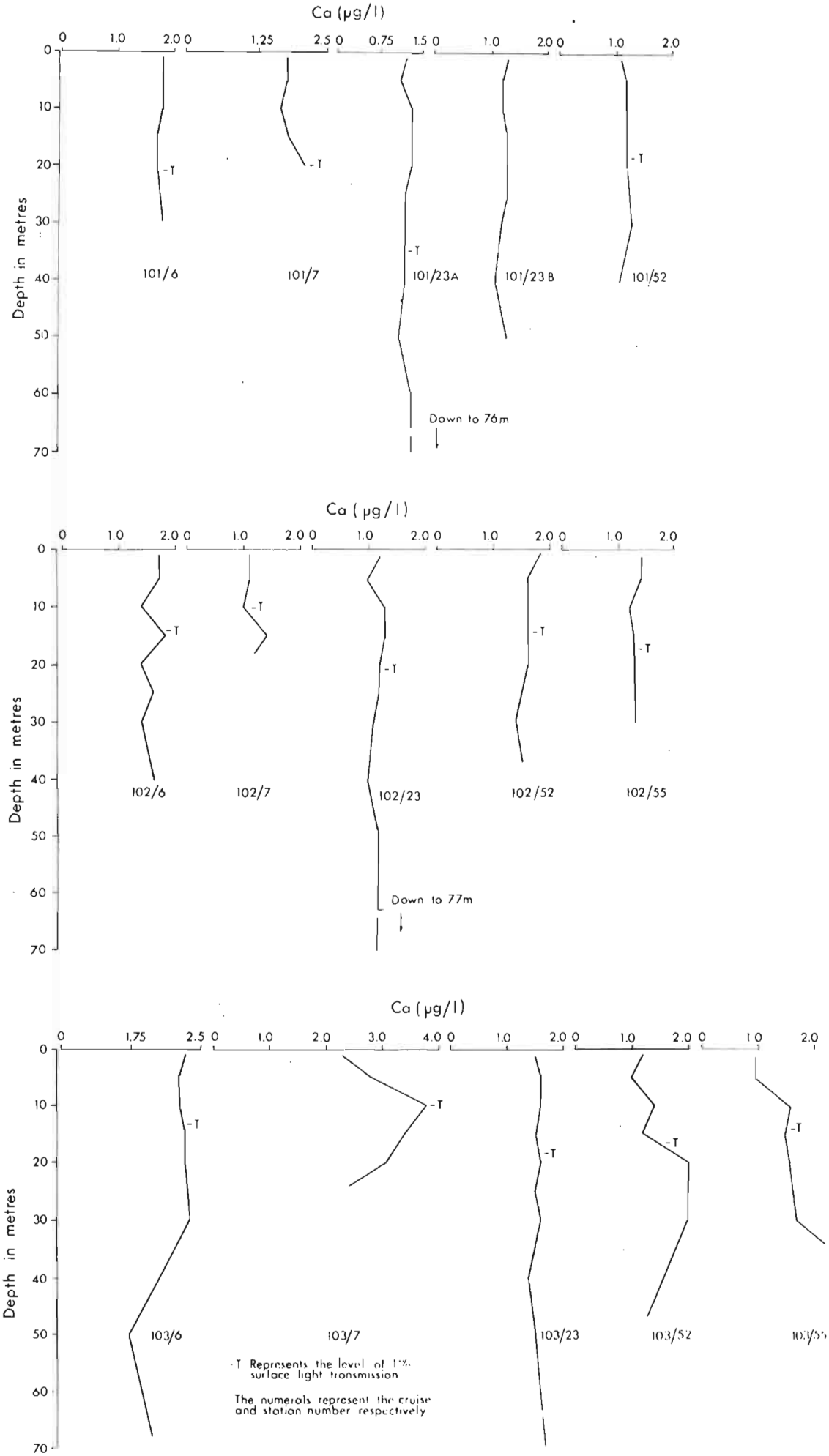


Fig. 3a Georgian Bay 1974 Vertical Profiles of Corrected Chlorophyll a

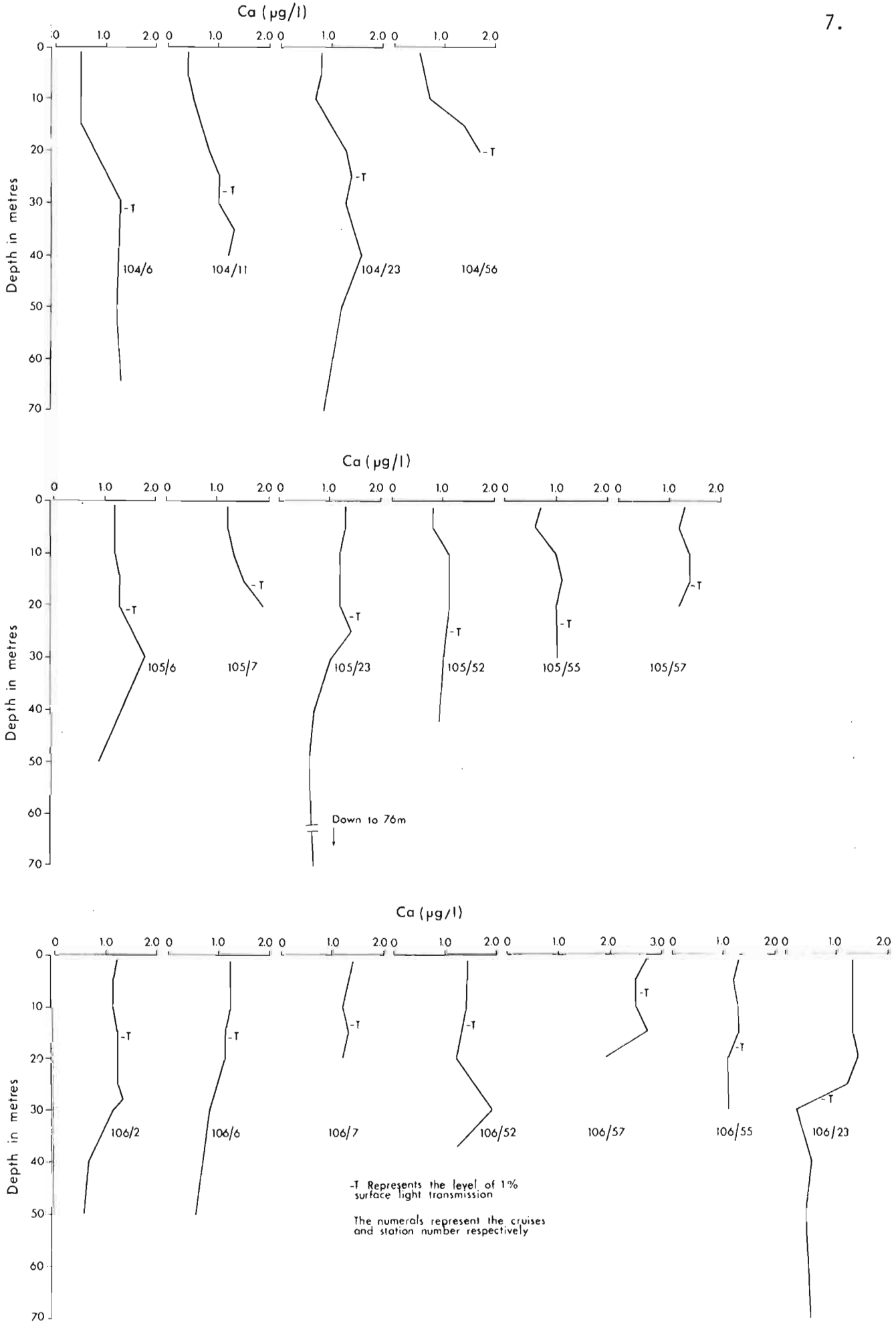


Fig. 3b. Georgian Bay 1974 Vertical Profiles of Corrected Chlorophyll a


ICE
4
3
2
2
2
2
5
NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-101; 74-05-101
Apr. 23 - May 1, 1974
Corrected Chlorophyll a µg/l


2
2
2
3
3
3
2
2
2
2
3
2
1
2
2
1
2
NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-102; 74-05-102
May 13-22, 1974
Corrected Chlorophyll a µg/l

Figure 4a


NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-103; 74-05-103
June 17-28, 1974
Corrected Chlorophyll a µg/l
<2>1

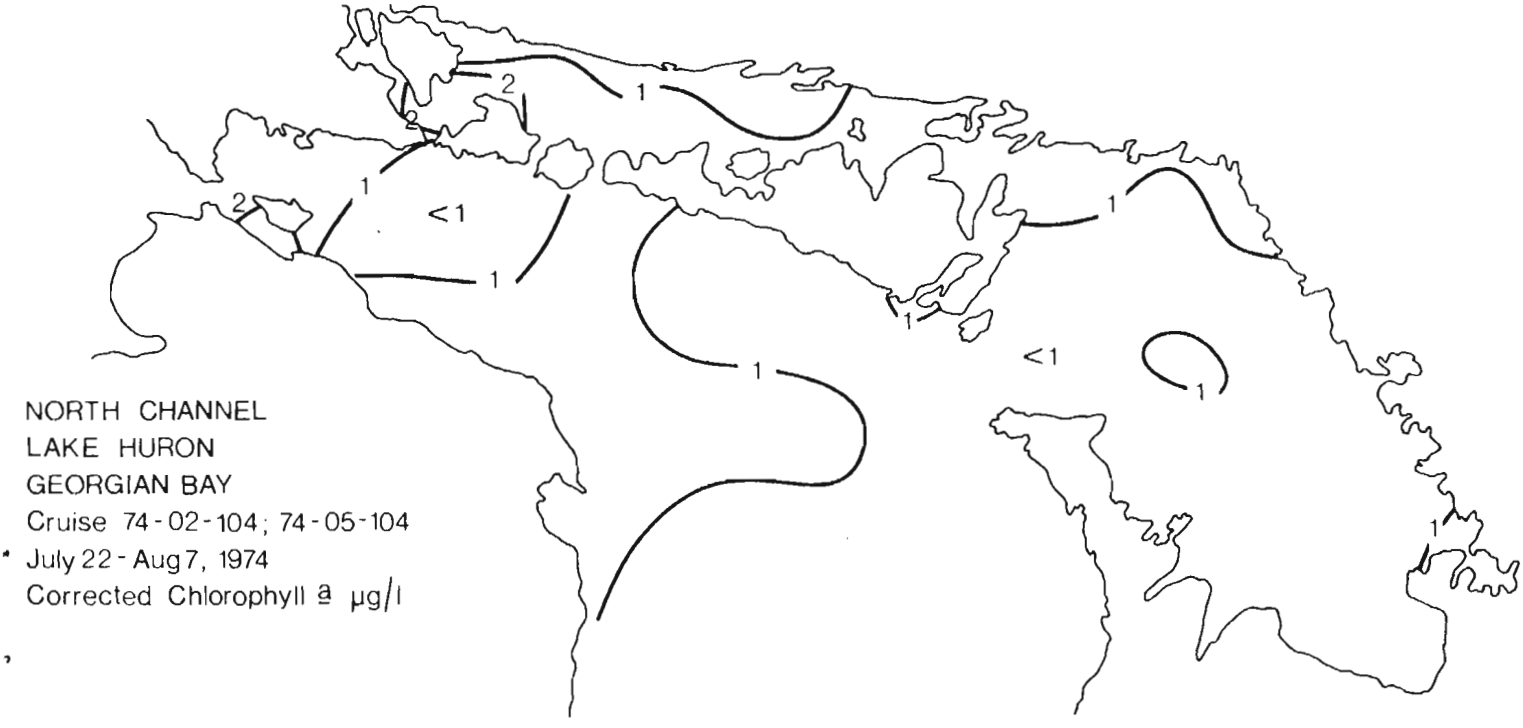

NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-104; 74-05-104
July 22-Aug 7, 1974
Corrected Chlorophyll a µg/l
<1
<1

Figure 4b


NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-105; 74-05-105
Aug 26 - Sept 6, 1974
Corrected Chlorophyll a µg/l
<1


NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-106; 74-05-106
Sept 30 - Oct 11, 1974
Corrected Chlorophyll a µg/l
>1<2

Figure 4c


2
2
2
2
1
1
1
1
<1
1
NORTH CHANNEL
LAKE HURON
GEORGIAN BAY
Cruise 74-02-107; 74-05-107
Dec 4-12, 1974
Corrected Chlorophyll a µg/l

Figure 4d

the transmissometer readings (J. Jerome, personal communication), places part of the layer of maximum chlorophyll concentration within the net productivity range. In July-August, the compensation level and chlorophyll layer increased to a minimum depth of 20 metres and the chlorophyll concentration remained uniform from this depth to the bottom. A similar pattern appeared at several stations during the August-September cruise; other stations were unstratified. In October, concentrations were fairly uniform to 20 metres. From 20 metres to the bottom, chlorophyll concentrations generally decreased.

The surface distribution of corrected chlorophyll a values are plotted in Figs. 4a, 4b, 4c, and 4d. Chlorophyll distribution in the Bay in April-May was fairly uniform, near 1.4 µg/l. A spring maximum of 5.6 µg/l was observed in the warmer water off Sawlog Point; Maurice Point area was also high (2.3 µg/l). In May, the French River and North Channel regions were at a maximum; the concentration east of Thornbury had increased, while the rest of the Bay was essentially unchanged. In June, the chlorophyll a in the Bay had increased. There was a gradient of increasing chlorophyll in the southern end of the Bay to a high of 3.3 µg/l off Brocks Beach. The Main Channel, Colpoys Bay, and off Pte. au Baril were at 2.2 µg/l. The summer minimum was observed in July-August. Only Sawlog Point, the north shore of the Bay, and one station, (35) south of Grand Bank, had values equal to or exceeding 1.0 µg/l. In August-September, east of Manitoulin Island, Main Channel, and Colpoys Bay were still less than 1.0 µg/l. The rest of the Bay increased to between 1.0 µg/l and 1.5 µg/l. Sawlog Point and Frazer Bay were at 2.3 µg/l and 2.0 µg/l respectively. October values in the central Bay were slightly higher than during the previous cruise, and they increased toward the

north shore. High concentrations were encountered off Sawlog Point (4.7 µg/l), in Manitowaning Bay (3.7 µg/l) and in Frazer Bay (2.6 µg/l). In December, the chlorophyll concentration was lower. The central Bay dropped to less than 1.0 µg/l; the northwest and southeast ends of the Bay and the Main Channel were only slightly higher.

The chlorophyll a concentration in Georgian Bay for 1974 appears to have been bimodal. Most of the Bay increased to a spring maximum in June, dropped to its summer minimum in July-August, and increased again to a fall peak in October. The seasonal variation in the small bays, the eastern shoreline in the southern half of the Bay, the French River outflow area, and north of the Bruce Peninsula was more pronounced with the spring maximum occurring earlier than in the rest of the Bay. Colpoys Bay had maxima in April and June, with low values during the other cruises.

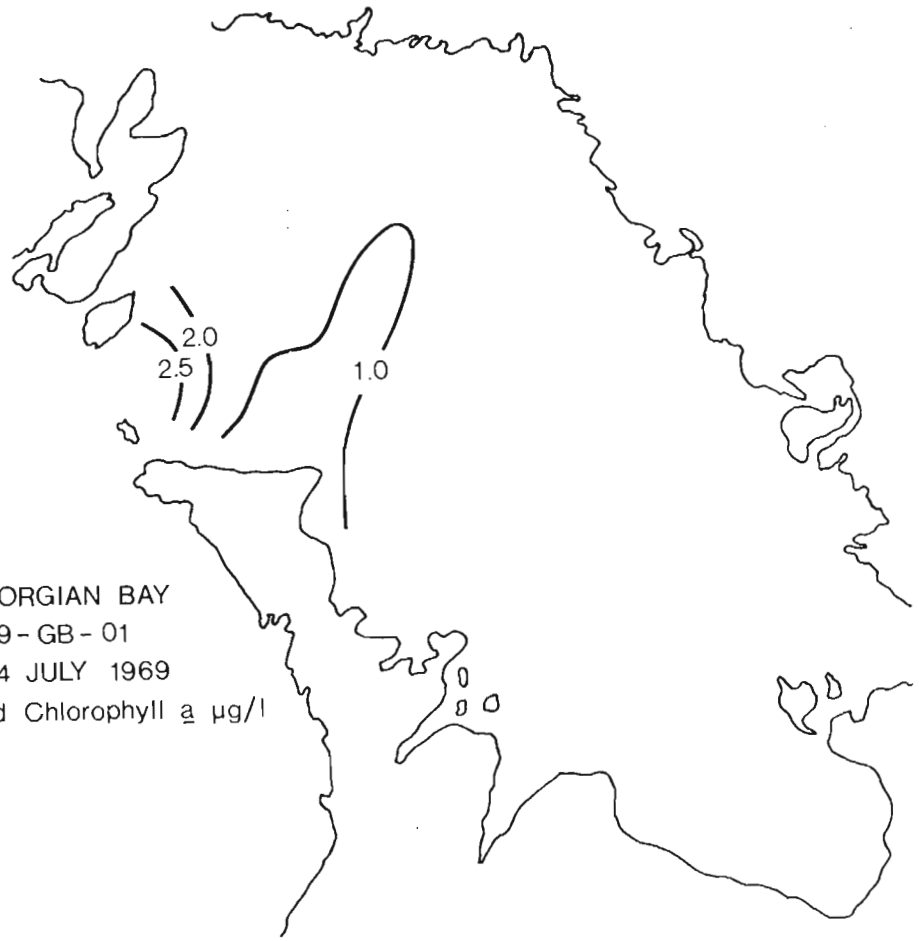
Chlorophyll a samples were collected on Georgian Bay during two cruises, in July and September 1969, and during one cruise, in April-May 1970, by the Great Lakes Institute, University of Toronto. Cruise data are listed in Table 2 and plotted in Figures 5a and 5b. Data are too few to make detailed comparisons, as no statistically significant differences can be detected.

1b. North Channel

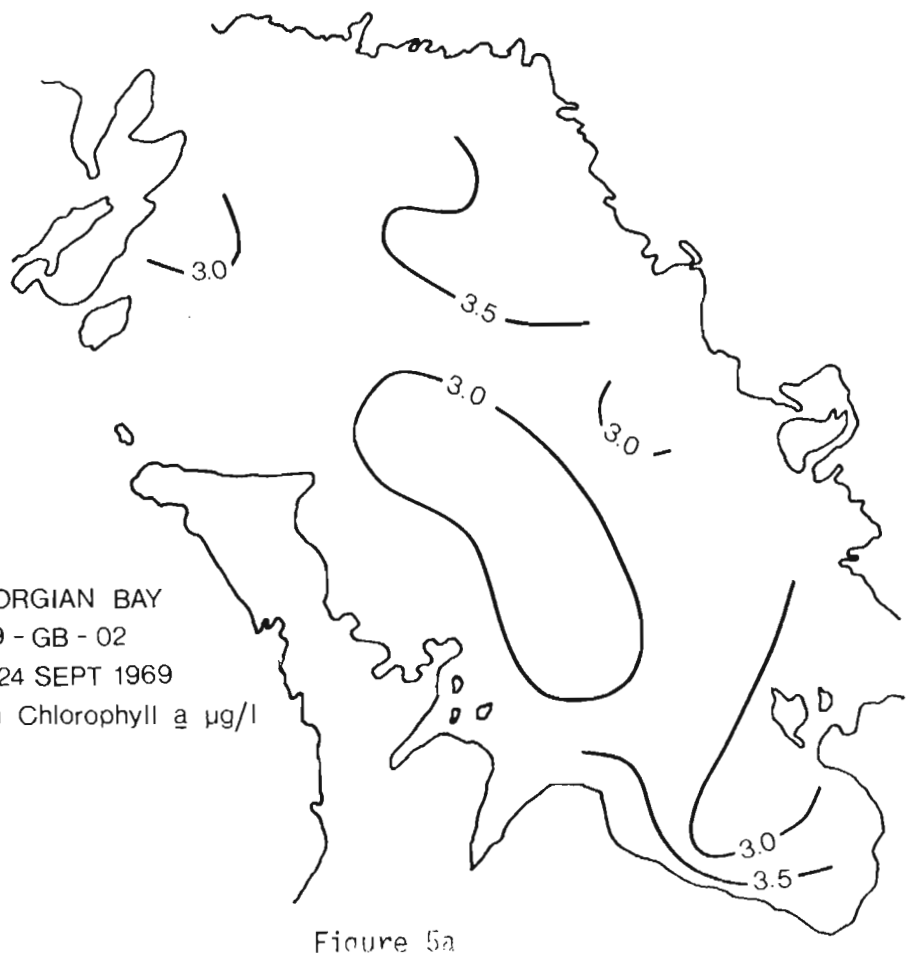
Surface chlorophyll a for the North Channel for 7 cruises in 1974 ranged from 0.8 µg/l to 3.7 µg/l, (Table 3). Only the St. Marys River and station 54 off Clapperton Island, however, had values equal to or exceeding 3.0 µg/l. Most station values were less than 2.5 µg/l.

Table 2. Georgian Bay 1969, 1970. Uncorrected chlorophyll *a* concentrations in µg/l from surface samples.

Dates	N	MAX	MIN	MEAN	S.E.
Jul. 2-4, 1969	49	2.5	0.9	1.2	0.037
Sep. 22-24, 1969	49	3.9	2.4	3.1	0.042
Apr. 20-May 7, 1970	48	2.7	1.0	1.9	0.070



GEORGIAN BAY
69 - GB - 01
2 - 4 JULY 1969
Uncorrected Chlorophyll a µg/l



GEORGIAN BAY
69 - GB - 02
22-24 SEPT 1969
Uncorrected Chlorophyll a µg/l

Figure 5a


GEORGIAN BAY
70 - GB - 01
APRIL 20 - MAY 7
UNCORRECTED CHLOROPHYLL a
µg/l
<2
2
2
2
2
2
3
2

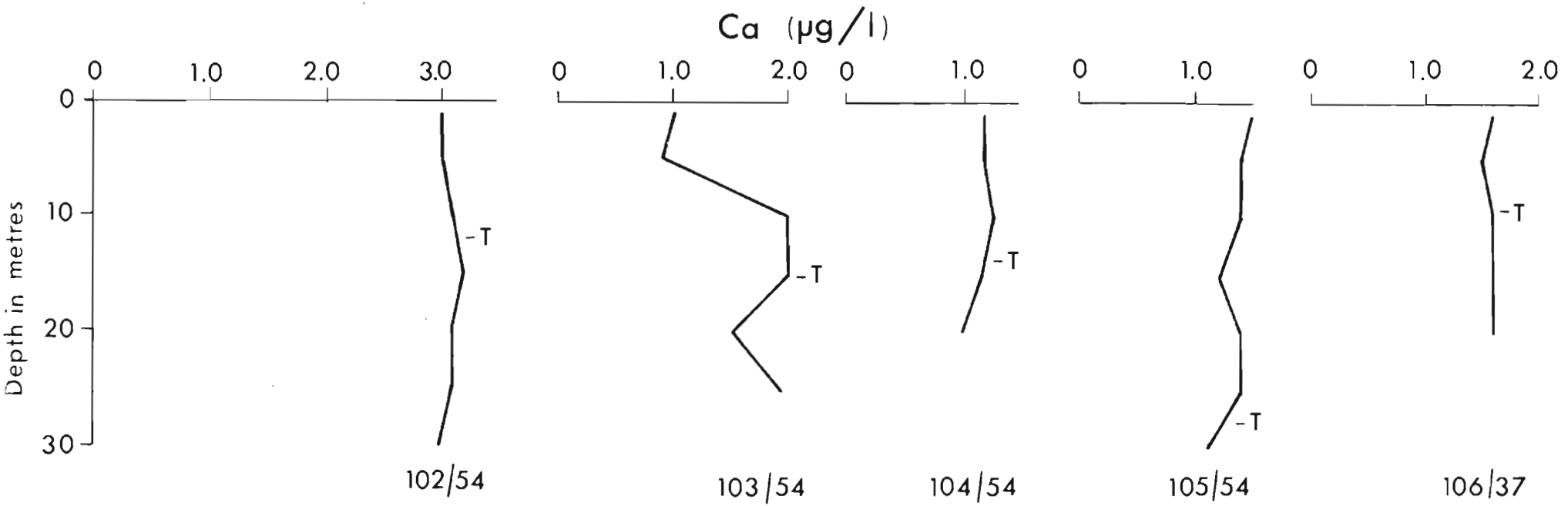
Figure 5b

Table 3. North Channel 1974. Corrected chlorophyll a concentrations in µg/l from 0-20 m integrated samples.

DATES	N	MAX	MIN	MEAN	S.E.
Apr. 27	3	1.7	1.2	1.4	0.187
May 16-18	22	3.7	1.4	2.3	0.132
June 26-27	22	2.3	1.1	1.7	0.058
July 26-27	22	2.9	0.8	1.3	0.111
Aug. 29-31	22	1.6	1.1	1.3	0.031
Oct. 4-5	22	2.6	1.2	1.5	0.080
Dec. 8	8	2.0	0.8	1.9	0.083

Vertical profiles of chlorophyll a were determined, in conjunction with in situ production moorings, at station 54 off Clapperton Island, on four cruises, and at station 37 off Chippewa Point, on one cruise. Samples were collected from 1, 5, 10, 15, 20, 25, and 30 metre intervals (Fig. 6). A pronounced peak between 10 and 15 metres, and a smaller peak at 25 metres was evident in June; the 1% light transmission level for this station was at 15 metres. Chlorophyll appeared unstratified during the other cruises.

The surface distribution of chlorophyll a values are plotted in Fig.4a-4d. Ice cover in April prevented access to all but 3 North Channel stations. In May, chlorophyll a was high in the west (2.5 µg/l to 3.7 µg/l), in the east (2.9 µg/l to 3.0 µg/l) and in the north, off De Roberval Point, (2.5 µg/l), decreasing centrally to 1.4 µg/l to 1.6 µg/l. The central region increased to near 2.0 µg/l in June, while the remainder of the Channel decreased. North of Drummond Island the concentration was highest at 2.3 µg/l. Chlorophyll continued to decline in July, with most of the north shore at less than 1.0 µg/l. The central and eastern regions were at 1.3 µg/l; North of Drummond Island and Potaganissing Bay had values of 2.9 µg/l and 2.3 µg/l respectively. Distribution was uniform near 1.4 µg/l in August. Values increased, to greater than 2.0 µg/l, east of Clapperton Island and off the northeast shore of St. Joseph Island, in October. The western half of the north shore increased slightly, while the central region was similar to the August distribution. In December, only the region east of Cockburn Island and west of Barrie Island was sampled. The station of Mississagi Strait decreased slightly; the other stations increased from October.



-T represents the level of 1% surface light transmission

The numerals represent the cruise number and station number respectively

Fig. 6 North Channel 1974 Vertical Profiles of Corrected Chlorophyll a

Chlorophyll a in the North Channel in 1974 was bimodal with a spring peak occurring in May, decreasing to a minimum in July, and subsequently increasing to a second peak in October to December. The station in the St. Marys River had the highest recorded chlorophyll value for the North Channel (3.7 µg/l) during a single maximum occurring in May.

1c. Lake Huron

The chlorophyll a concentrations in Lake Huron, north of $45^{o}30'$ latitude, in 1974, ranged from 0.8 to 4.0 µg/l (Table 4). The highest values were restricted to the Straits of Mackinac, South Channel, South Baymouth, and Sturgeon Point. The rest of the lake rarely had values exceeding 2.5 µg/l.

The surface distribution of chlorophyll a values are plotted in Figs. 4a - 4d. The concentration in April was near 1.7 µg/l increasing in the western end to 4.0 µg/l in the Straits of Mackinac. Values exceeded 2.0 µg/l south of Manitoulin Island and west of the Bruce Peninsula. Chlorophyll increased in May. Concentrations in the central lake were greater than 2.0 µg/l, South Baymouth was at 3.0 µg/l, and the Straits of Mackinac was near 4.0 µg/l. Values less than 2.0 µg/l were observed between Bois Blanc Island and Western Duck Island, and southwest of Cape Hurd. Chlorophyll decreased in June, except in the Main Channel, which was unchanged from May, and off Greenough Point, which increased slightly. July-August values were at a minimum. Values of less than 1.0 µg/l of chlorophyll were found in the eastern half of the lake and south of Drummond Island. South of Mississagi Strait and in the Straits of Mackinac, concentrations were higher; South Channel was the highest at 2.0 µg/l.

Table 4. Lake Huron 1974. Corrected chlorophyll *a* concentrations in µg/l from 0-20 m integrated samples.

Dates	N	MAX	MIN	MEAN	S.E.
Apr. 25-28	35	4.0	1.2	2.0	0.102
May 15-18	35	3.9	1.6	2.3	0.096
Jun. 22-26	35	2.4	0.9	1.6	0.061
Jul. 25-28	35	2.0	0.4	1.0	0.057
Aug. 28-31	35	4.0	0.7	1.1	0.113
Oct. 2-6	33	3.2	1.1	1.5	0.066
Dec. 4-12	18	2.4	0.8	1.5	0.132

In August-September the central region remained low. Concentrations greater than 1.0 µg/l were found in the Great Duck Island area and west, increasing to 1.5 µg/l in the Straits of Mackinac, off South Baymouth, and west of Cape Hurd. The highest value was observed off Sturgeon Point, at 4.0 µg/l. This area fell to 1.9 µg/l in September-October, while the rest of the lake increased to 1.5 µg/l. South Baymouth at 3.2 µg/l was the highest value recorded during this cruise. The only areas sampled in December were west of Great Duck Island and the channels between Georgian Bay and Lake Huron. The chlorophyll in South Channel, the Straits of Mackinac, off St. Vital Point, and in Hammond Bay exceeded 2.0 µg/l. South of Cape Hurd, and at two central stations, values were less than 1.0 µg/l. The remaining stations had values similar to those in October.

The Northern Lake Huron chlorophyll a distribution for 1974 was bimodal. Chlorophyll increased to a spring maximum in May, started declining in June to a summer minimum in July-August, and increased from August to a second maximum, in the central region, in October; concentrations in the western area of the lake were highest in December. The chlorophyll a concentrations and seasonal distribution in Northern Lake Huron for 1974 are similar to the 1971 observations reported by Glooschenko and Moore (1973).

2. Results - Primary Production

2a. In situ studies

Nineteen in situ carbon-14 moorings were completed on the first 6 cruises on Georgian Bay and the North Channel (Figs. 7a, 7b and 8). Production in April was low with small peaks occurring at 5 to 10 metres.

In May and June, production increased to maximum values at 10 to 20 metres, where the station depth exceeded 30 metres, and at 5 to 10 metres at the shallower stations. Surface production increased significantly during the July-August and August-September cruises. At the North Channel station 54 in July, production was highest at one metre below the surface; the remaining moorings during both cruises, had peaks at 5 metres. The vertical distribution was similar in October, although production was generally lower.

Production estimates from the profiles were converted to an areal basis, using the maximum carbon uptake in mg $C/m^3/hr$ as P opt. These in situ values were compared to the light box incubated samples, from the 0-20 metre integrator, in Fig. 9. The close agreement obtained will allow lake-wide production estimates to be made from the light box incubated samples. The production values from the integrator-light box analyses are charted in Figs. 10a-10c and 11a-11b. Mean, maximum and minimum values appear in Tables 5 and 6 for Georgian Bay and North Channel respectively.

2b. Georgian Bay

April production in Georgian Bay was low (0.09 g $C/m^2/day$). The highest areas were off the north shore of the Bruce Peninsula (0.23 g $C/m^2/day$) north to George Island (0.20 g $C/m^2/day$), and off Sawlog Point (0.20 g $C/m^2/day$). Production decreased to less than 0.10 g $C/m^2/day$ in the central part of the Bay; Main Channel was also low (0.09 g $C/m^2/day$). In May, Sawlog Point decreased to a minimum (0.09 g $C/m^2/day$), while other areas generally increased (mean value 0.15 g $C/m^2/day$). The highest values were located in Frazer Bay (0.23 g $C/m^2/day$), off the north shore of the Bruce Peninsula (0.20 g $C/m^2/day$), and in the southeast end of the Bay

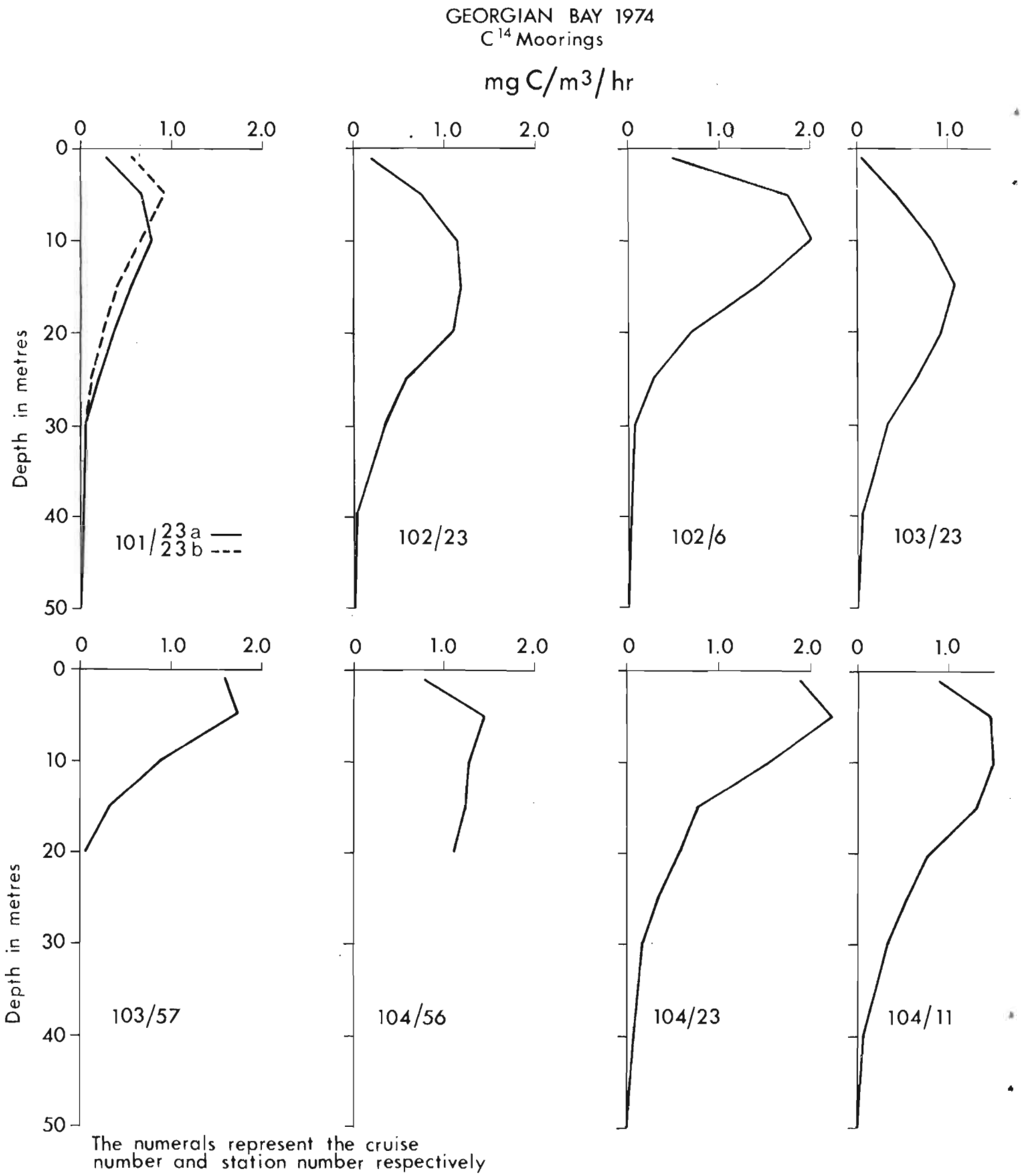


Fig. 7a. Georgian Bay 1974 Vertical Profiles of in situ Carbon-14 Uptake

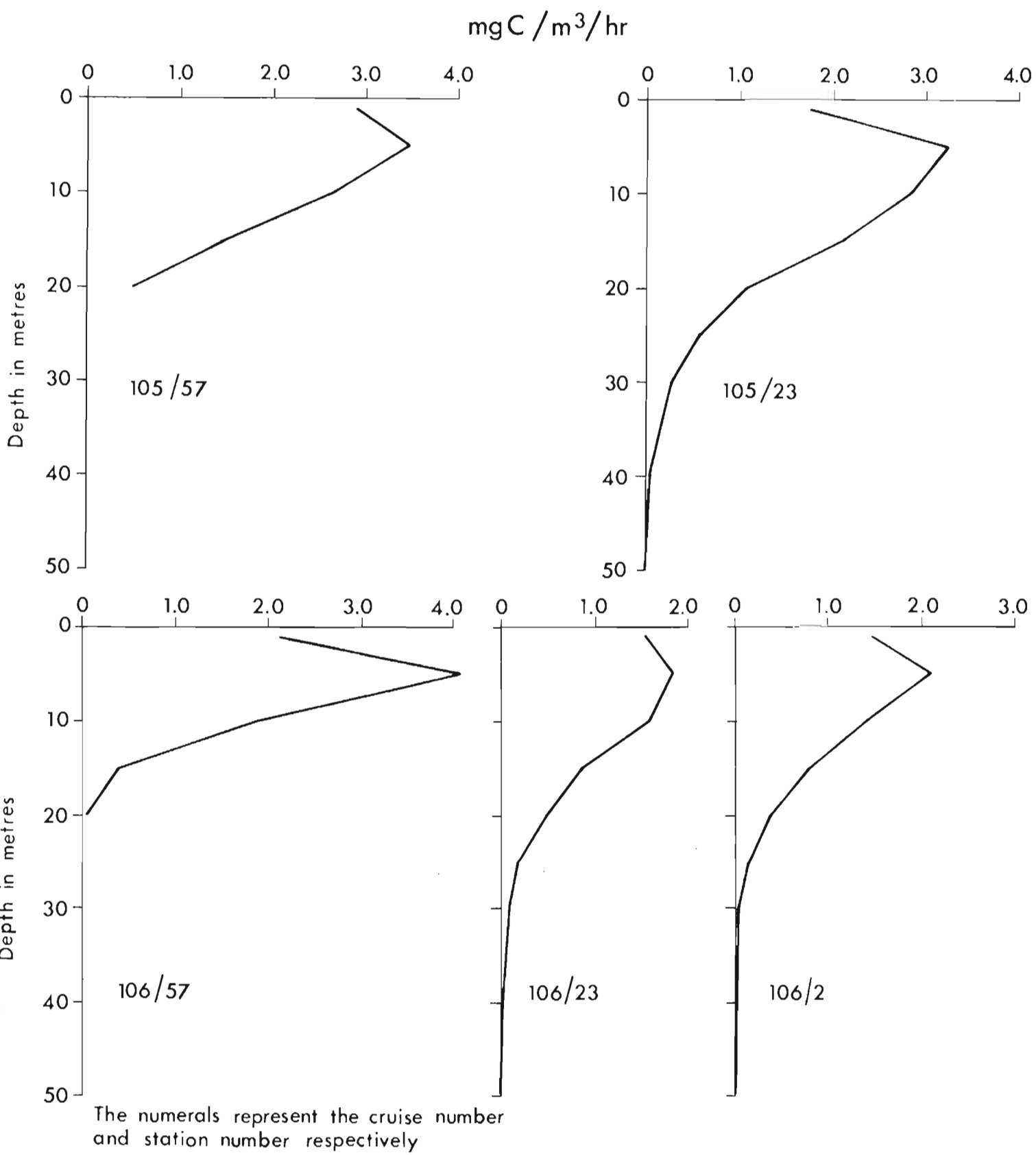


Fig. 7b. Georgian Bay 1974 Verticle Profile of in situ Carbon-14 Uptake

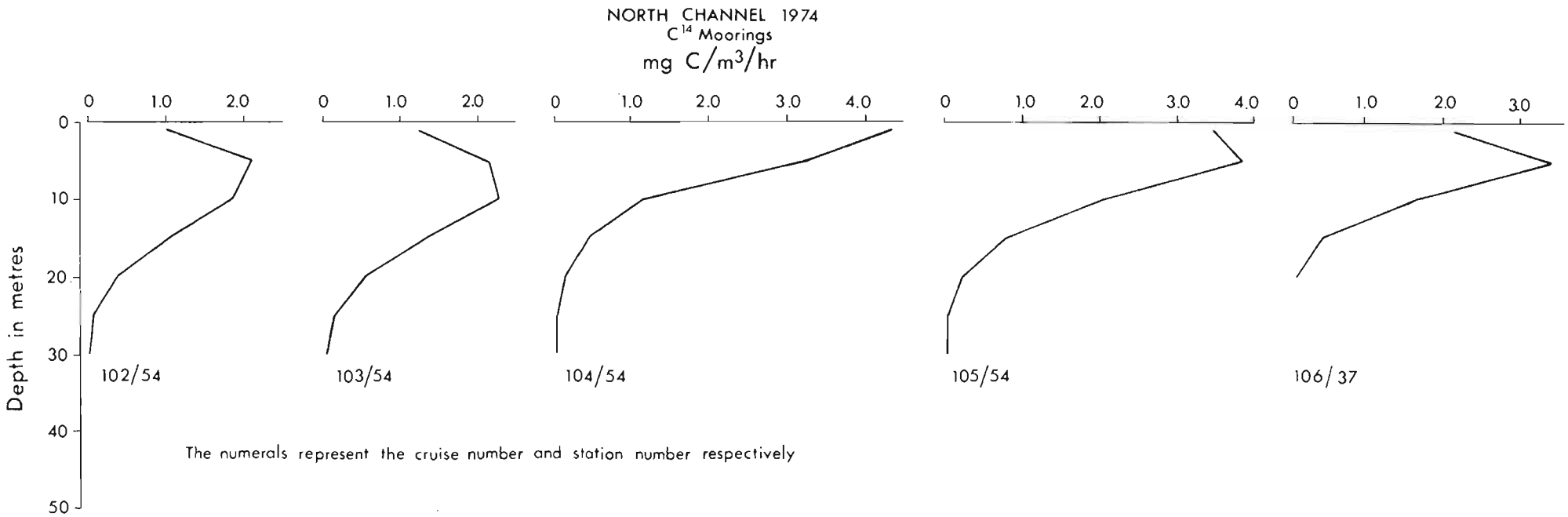


Fig. 8. North Channel 1974 Vertical Profiles of insitu Carbon-14 uptake

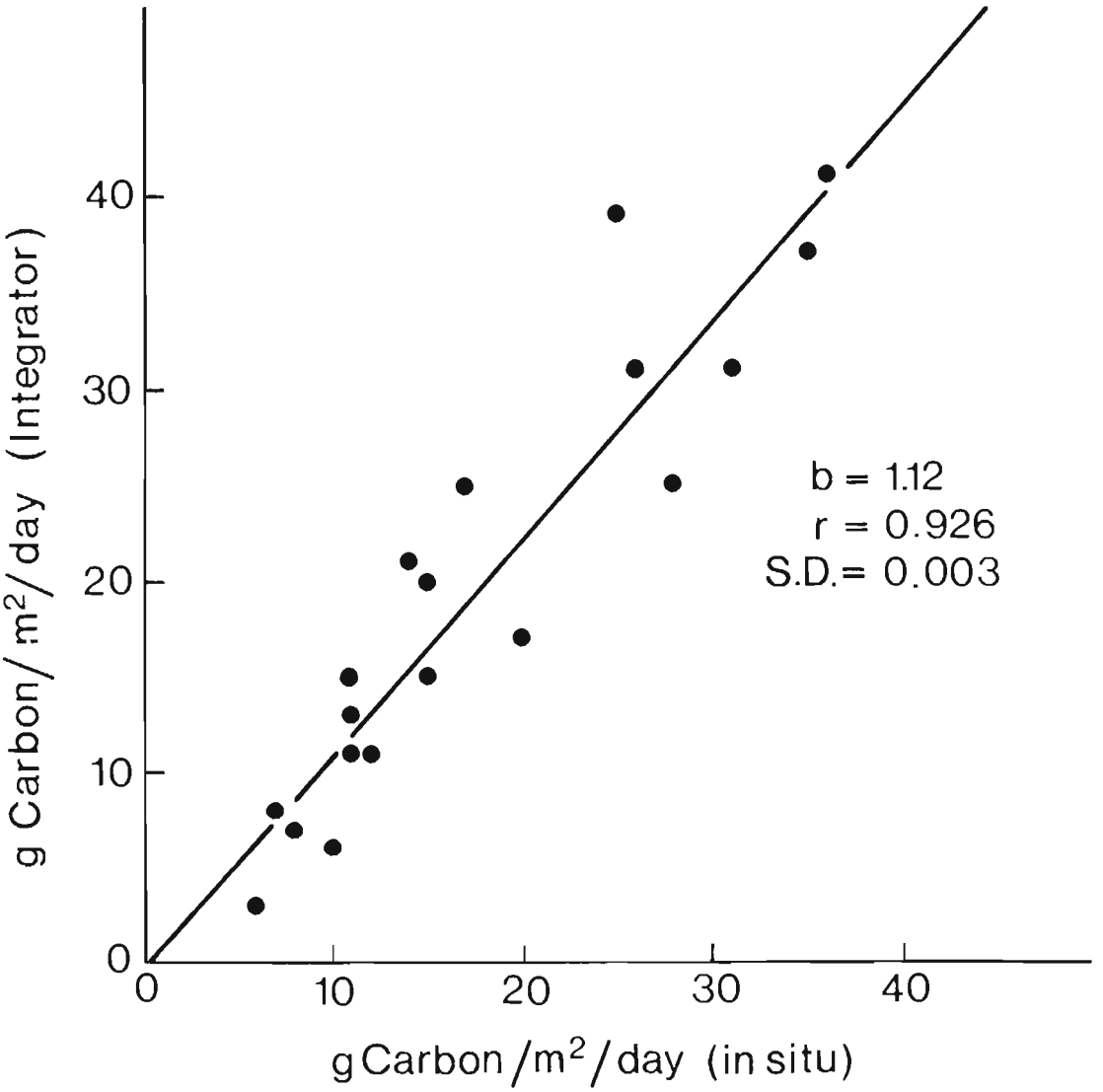
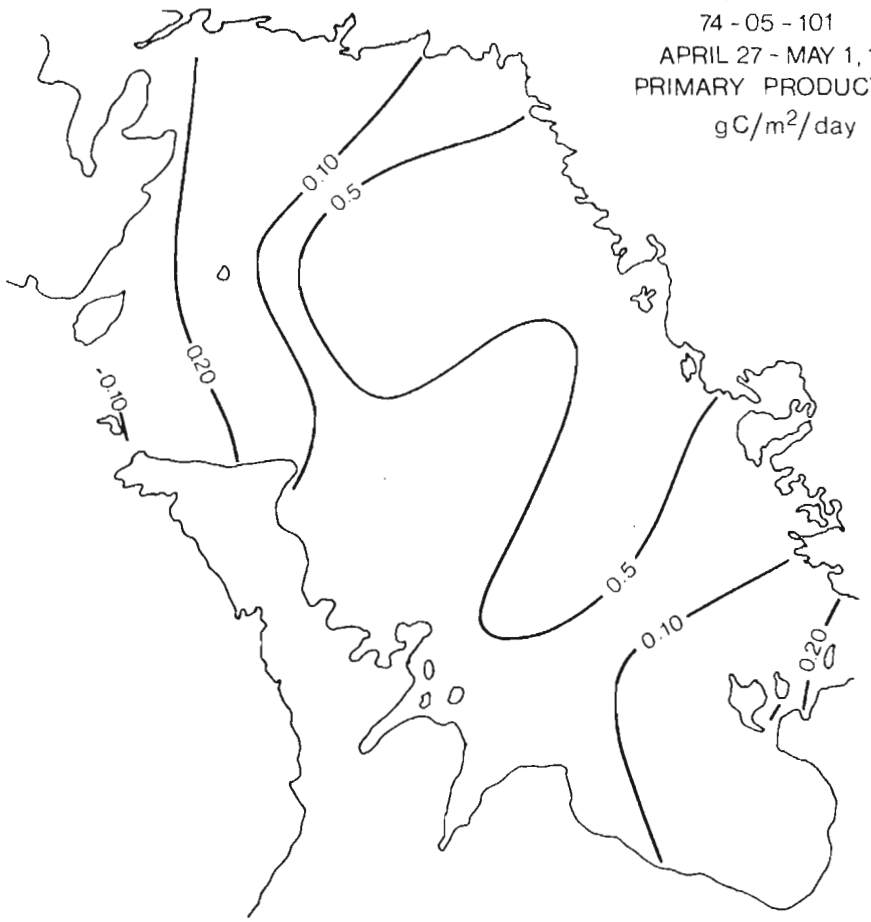


Fig. 9. AREAL CARBON-14 UPTAKE FROM 19 IN SITU MOORINGS Vs. CALCULATED UPTAKE FROM LIGHT BOX INCUBATED 0-20m INTEGRATED SAMPLES AND LIGHT EXTINCTION DATA.


GEORGIAN BAY
74 - 05 - 101
APRIL 27 - MAY 1, 1974
PRIMARY PRODUCTION
gC/m²/day
0.10
0.5
0.20
0.10
0.5
0.10
0.20

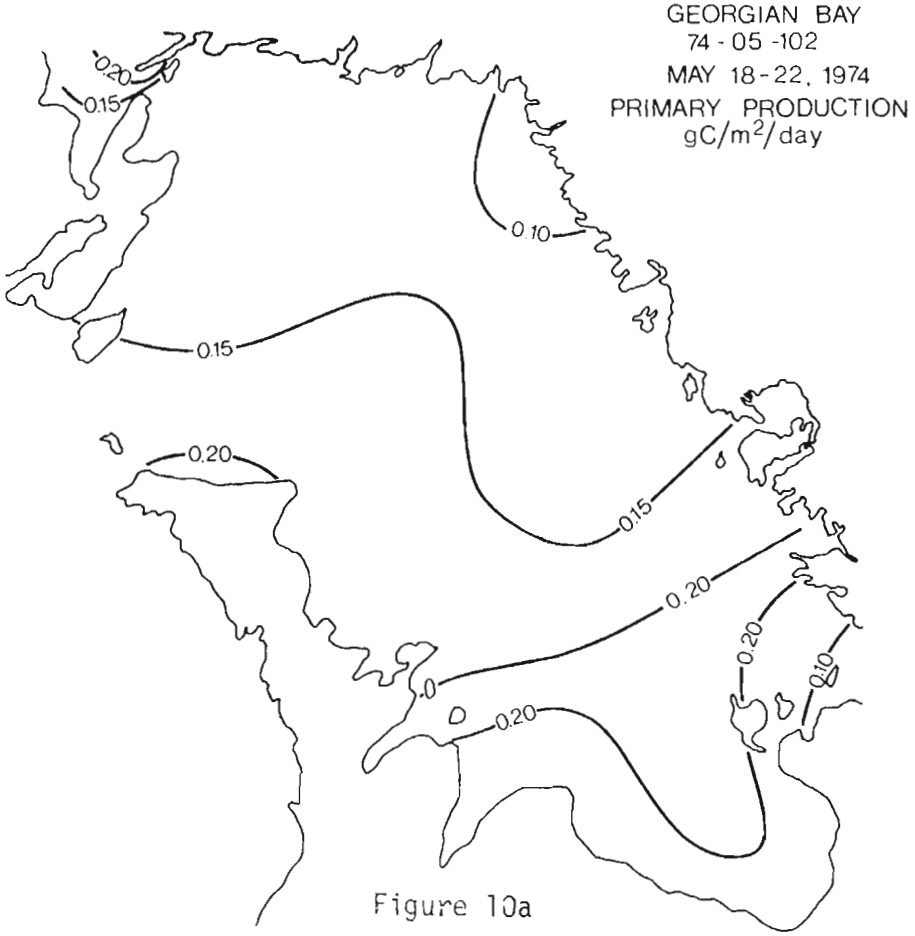
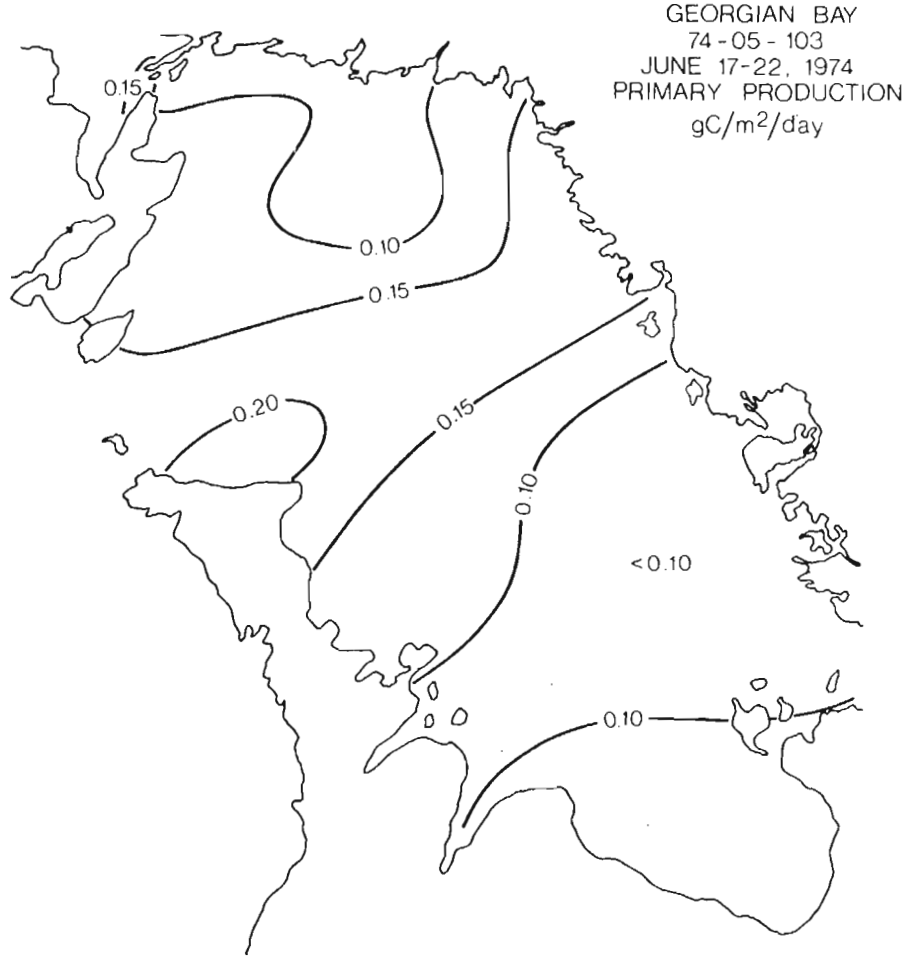

GEORGIAN BAY
74 - 05 -102
MAY 18 - 22, 1974
PRIMARY PRODUCTION
gC/m²/day
0.20
0.15
0.10
0.15
0.20
0.15
0.20
0.20
0.10
0.20

Figure 10a


GEORGIAN BAY
74-05-103
JUNE 17-22, 1974
PRIMARY PRODUCTION
gC/m²/day
0.15
0.10
0.15
0.20
0.15
0.10
<0.10
0.10

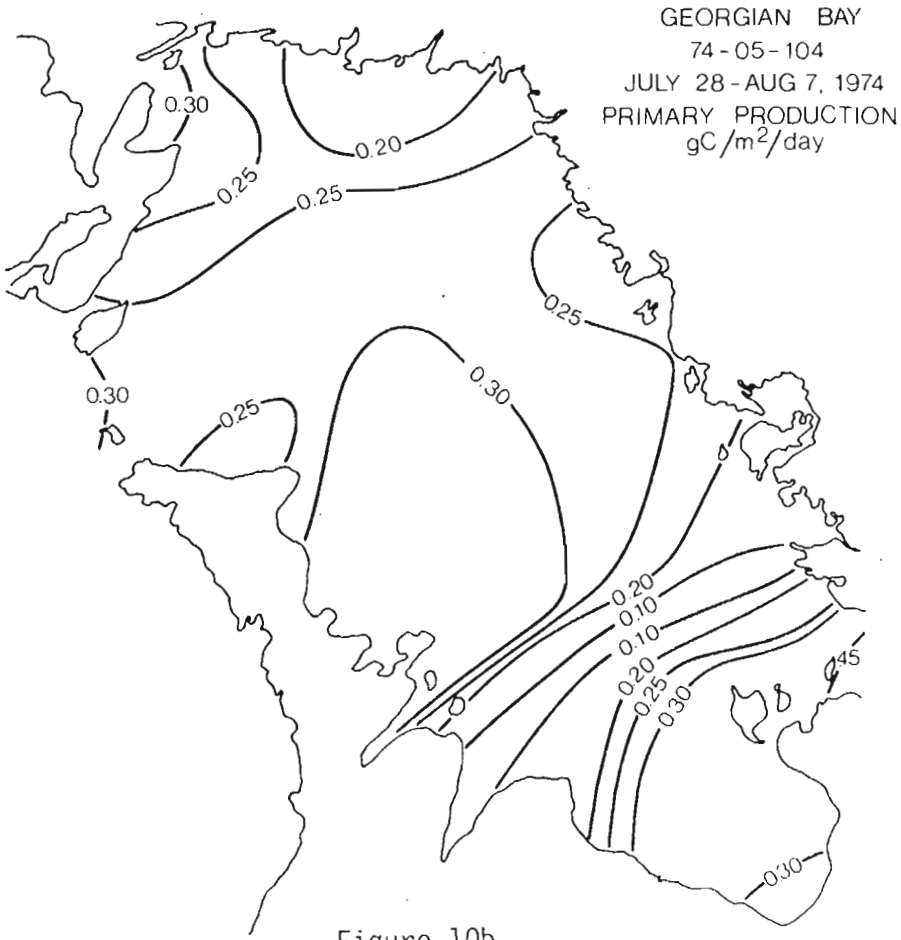
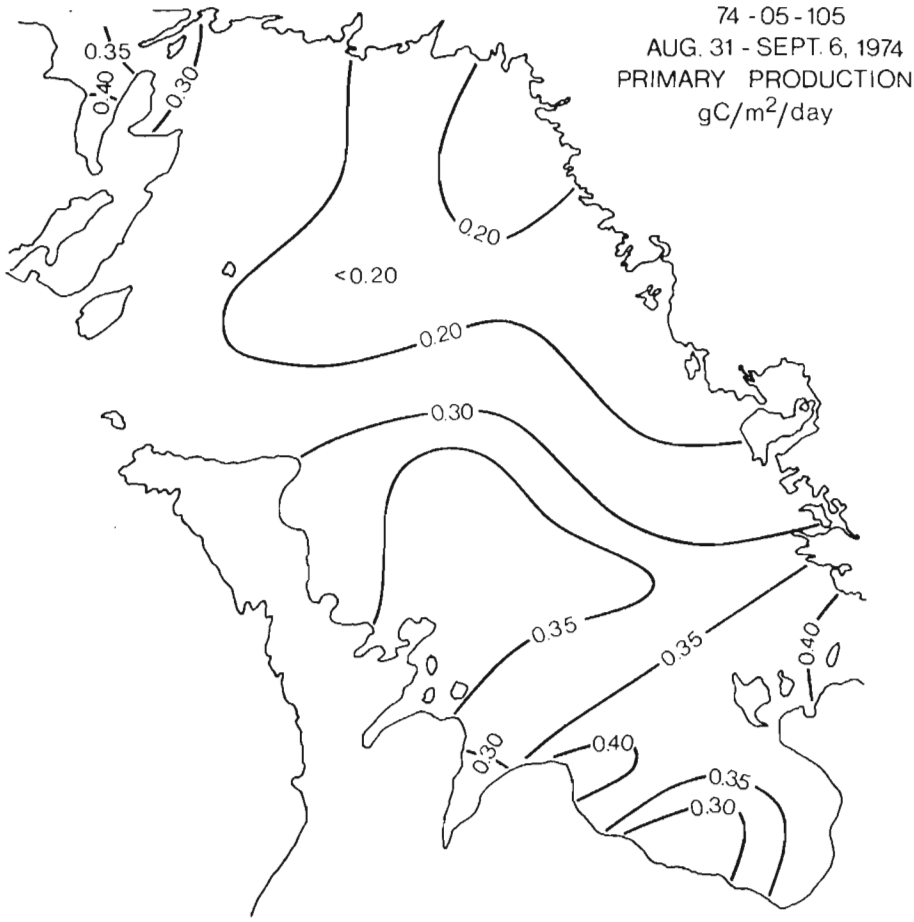

GEORGIAN BAY
74-05-104
JULY 28-AUG 7, 1974
PRIMARY PRODUCTION
gC/m²/day
0.30
0.20
0.25
0.25
0.25
0.30
0.30
0.25
0.20
0.10
0.10
0.20
0.25
0.30
45
0.30

Figure 10b


GEORGIAN BAY
74 - 05 - 105
AUG. 31 - SEPT. 6, 1974
PRIMARY PRODUCTION
gC/m²/day
0.35
0.40
0.30
0.20
<0.20
0.20
0.30
0.35
0.35
0.40
0.30
0.40
0.35
0.30

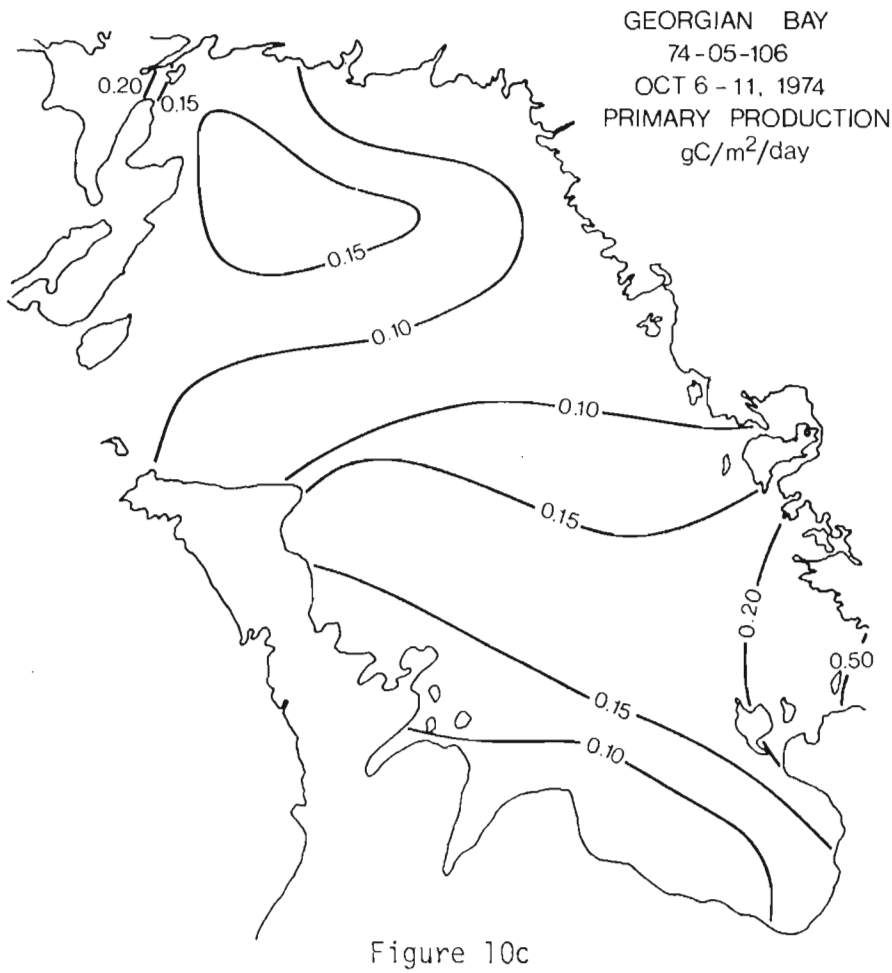
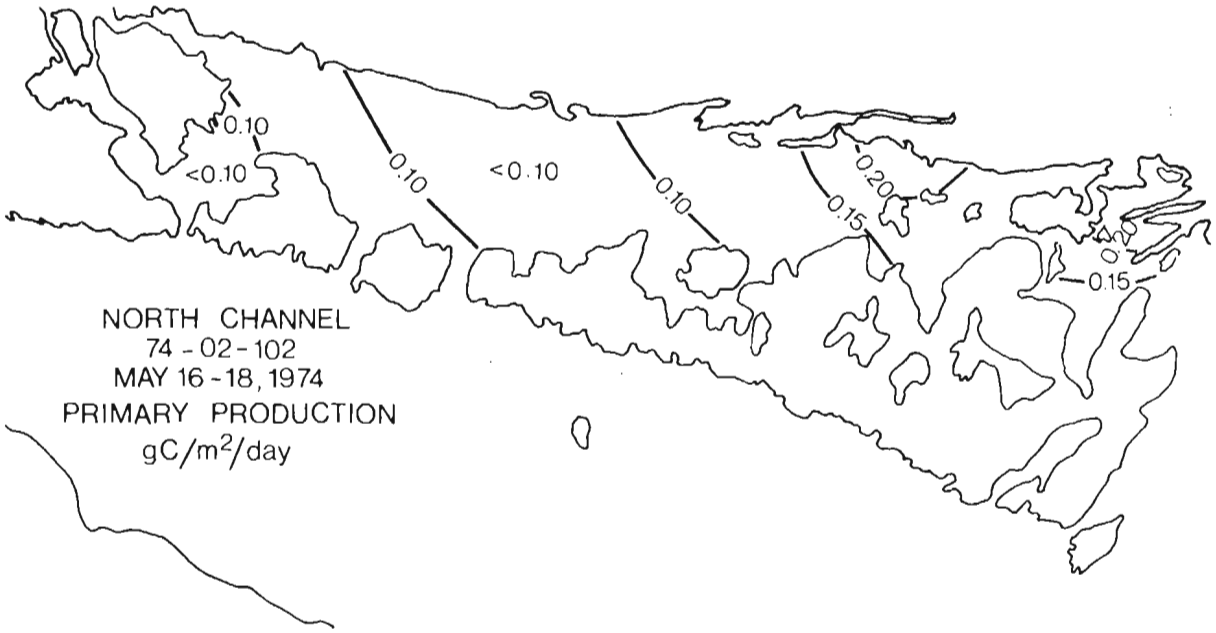
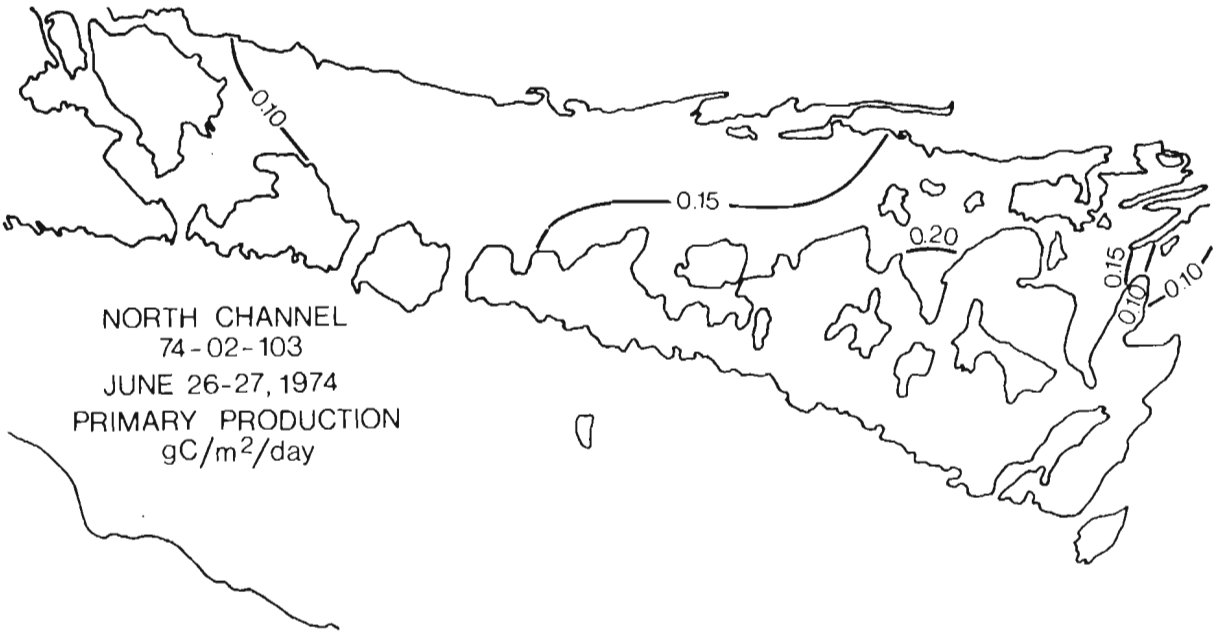

GEORGIAN BAY
74 - 05 - 106
OCT 6 - 11, 1974
PRIMARY PRODUCTION
gC/m²/day
0.20
0.15
0.15
0.10
0.10
0.15
0.20
0.50
0.15
0.10

Figure 10c


0.10
<0.10
0.10
<0.10
0.10
0.20
0.15
0.15
NORTH CHANNEL
74-02-102
MAY 16-18, 1974
PRIMARY PRODUCTION
gC/m²/day


0.10
0.15
0.20
0.15
0.10
0.10
NORTH CHANNEL
74-02-103
JUNE 26-27, 1974
PRIMARY PRODUCTION
gC/m²/day

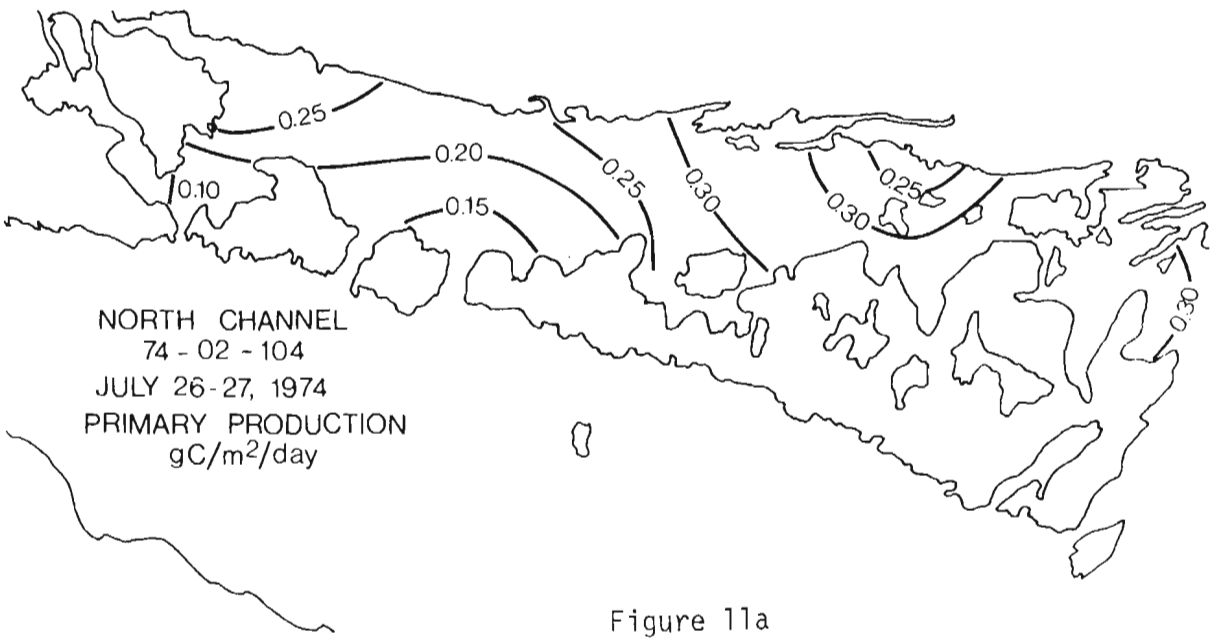

0.25
0.20
0.10
0.15
0.25
0.30
0.25
0.30
0.30
NORTH CHANNEL
74-02-104
JULY 26-27, 1974
PRIMARY PRODUCTION
gC/m²/day

Figure 11a

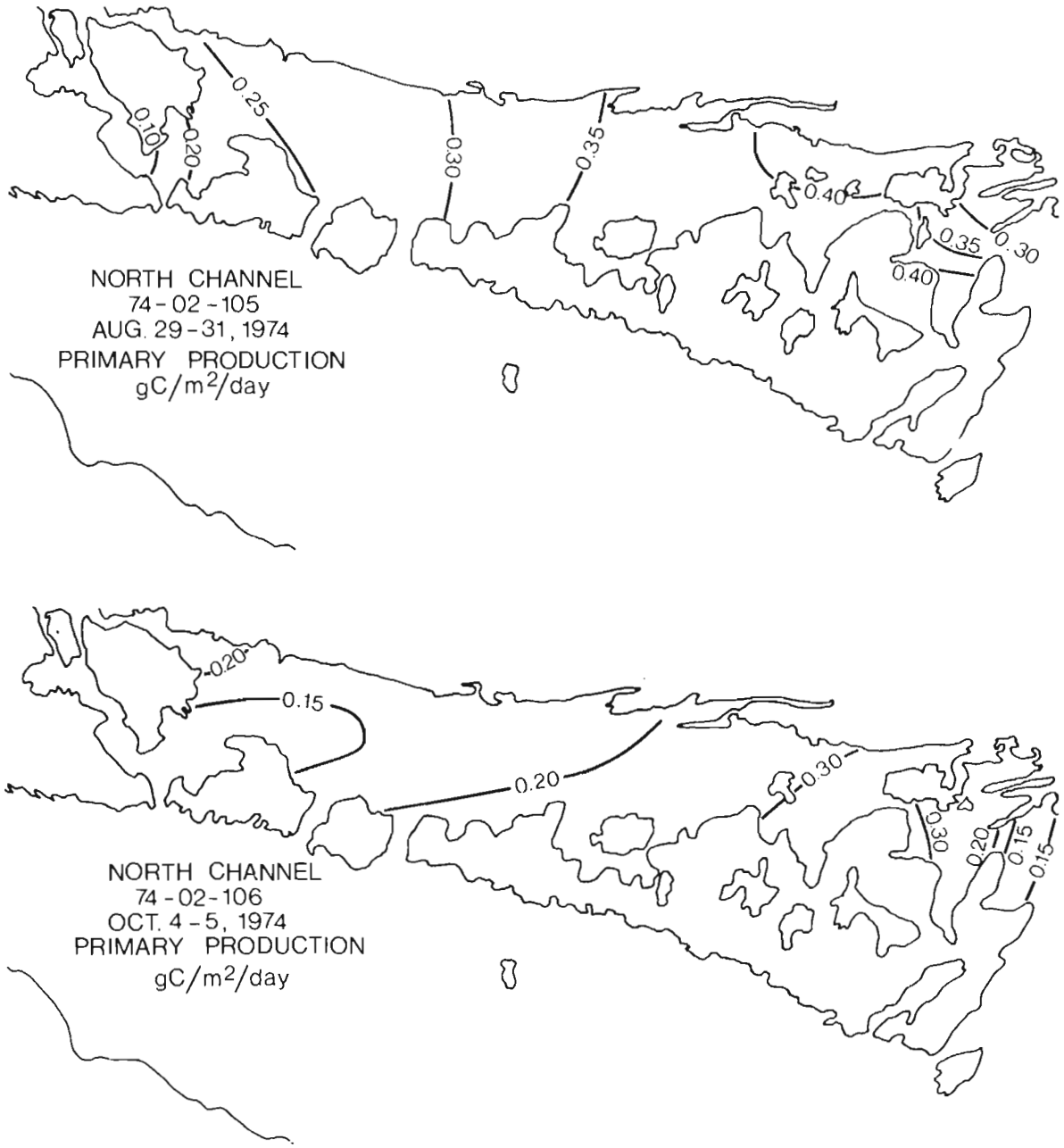

0.10
0.20
0.25
0.30
0.35
0.40
0.35
0.30
0.40
NORTH CHANNEL
74-02-105
AUG. 29-31, 1974
PRIMARY PRODUCTION
gC/m2/day
0.20
0.15
0.20
0.30
0.30
0.20
0.15
0.15
NORTH CHANNEL
74-02-106
OCT. 4-5, 1974
PRIMARY PRODUCTION
gC/m2/day

Figure 11b

Table 5. Georgian Bay 1974. C-14 uptake from 0-20 m integrated samples.

Dates	N	mg $C/m^3/hr$				g $C/m^2/day$			
		MAX	MIN	MEAN	S.E.	MAX	MIN	MEAN	S.E.
April 27-May 1	22	5.9	0.5	1.0	0.241	0.23	0.03	0.09	0.014
May 18-22	26	3.2	0.2	1.7	0.123	0.23	0.09	0.15	0.008
June 17-22	26	3.0	0.9	1.8	0.120	0.21	0.05	0.12	0.009
July 28-Aug. 7	28	4.3	0.8	2.1	0.138	0.45	0.08	0.27	0.018
Aug. 31-Sept. 6	28	6.6	2.0	3.2	0.200	0.44	0.12	0.29	0.018
Oct. 6-11	28	14.5	1.3	3.1	0.484	0.51	0.05	0.14	0.018

Table 6. North Channel 1974. C-14 uptake from 0-20 m integrated samples.

Dates	N	mg $C/m^3/hr$				g $C/m^2/day$			
		MAX	MIN	MEAN	S.E.	MAX	MIN	MEAN	S.E.
May 16-18	9	4.5	1.3	2.7	0.382	0.18	0.05	0.12	0.017
June 26-27	9	3.8	1.6	2.4	0.225	0.21	0.04	0.14	0.018
July 26-27	9	5.4	1.4	3.7	0.420	0.34	0.09	0.25	0.032
Aug. 29-31	9	4.9	3.0	4.1	0.222	0.44	0.07	0.32	0.039
Oct. 4-5	8	5.5	2.7	3.8	0.437	0.33	0.11	0.22	0.026

(0.21 g C/m^2/day). Production values were increasing from 0.12 g C/m^2/day in the northwest to 0.21 g C/m^2/day in the south east. Production decreases were observed in June for Frazer Bay (0.17 g C/m^2/day), the north shore (less than 0.10 g C/m^2/day), and the southeast end of the Bay (less than 0.10 g C/m^2/day). In July, production values from Owen Sound northeast to O'Donnell Point were low (0.09 g C/m^2/day). The rest of Georgian Bay had increased to a mean of 0.27 g C/m^2/day; most of the central Bay had values near 0.30 g C/m^2/day. High values were found off Sawlog Point (0.45 g C/m^2/day), in Manitowaning Bay (0.34 g C/m^2/day), in Frazer Bay (0.35 g C/m^2/day) and in Nottawasaga Bay (greater than 0.35 g C/m^2/day). On the August-September cruise, production was at a maximum. The southern half of Georgian Bay exceeded 0.30 g C/m^2/day, with the highest value of 0.44 g C/m^2/day occurring off Sawlog Point and off Cape Rich. Values increased from 0.13 g C/m^2/day in the north to 0.36 g C/m^2/day in the southeast. Frazer and Manitowaning Bays had values of 0.30 g C/m^2/day and 0.41 g C/m^2/day respectively. The highest value measured (0.51 g C/m^2/day) was observed off Sawlog Point in Georgian Bay in October. All other station values had decreased. Sawlog Point at 0.51 g C/m^2/day, Manitowaning Bay at 0.29 g C/m^2/day, and Frazer Bay at 0.27 g C/m^2/day, were the only areas of Georgian Bay exceeding 0.20 g C/m^2/day.

Production in Georgian Bay 1974 was weakly bimodal with a low peak in May (0.15 g C/m^2/day), and a higher peak in August-September (0.29 g C/m^2/day).

2c. North Channel

The mean production in May for the North Channel was 0.12 g C/m^2/day with values generally increasing from west to east. In June, production

increased slightly in the central region raising the mean to 0.15 g C/m^2/ day. Except for Mississagi Strait at 0.12 g C/m^2/day, values generally increased in July. Production reached 0.29 g C/m^2/day in the west off Big Point; the central region was at 0.20 g C/m^2/day increasing easterly to greater than 0.30 g C/m^2/day. The western end decreased in August; the remainder of the Channel was at a maximum, with eastern values exceeding 0.40 g C/m^2/day. In October, production was decreasing. The mean carbon uptake was 0.21 g C/m^2/day. The maximum value for the cruise was observed in West Bay at 0.33 g C/m^2/day.

The North Channel, in 1974, had one seasonal production maximum of 0.32 g C/m^2/day occurring in late August. Generally, a gradient of production, increasing from west to east, was observed on all cruises. Station 36 in the St. Marys River exhibited consistently low production values (0.04 g C/m^2/day to 0.09 g C/m^2/day) due to the high turbidity of the water column, as determined from the transmissometer and secchi disc readings.

3. Annual Production Estimates

Mean primary production for each cruise on Georgian Bay and the North Channel are plotted as a function of time in Figs. 12a-12b. The curves have been extrapolated assuming zero production prior to the last week in March and after mid-November. Annual estimates, determined from the area under the curves, are 35 g C/m^2/yr for Georgian Bay and 37 g C/m^2/yr for the North Channel.

Estimates of annual primary production were also made using uncorrected (total) chlorophyll _a_ data and the formula

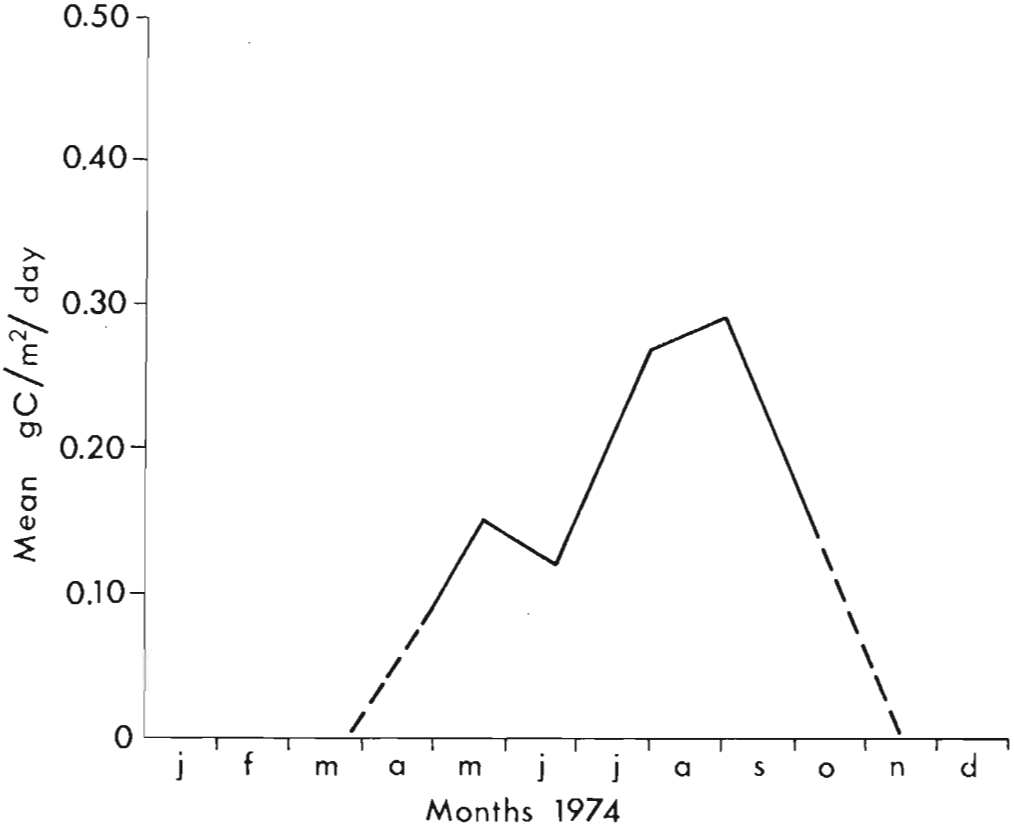


FIG. 12a GEORGIAN BAY 1974. SEASONAL PRODUCTION TREND, EXTENDED TO ZERO WINTER VALUES.

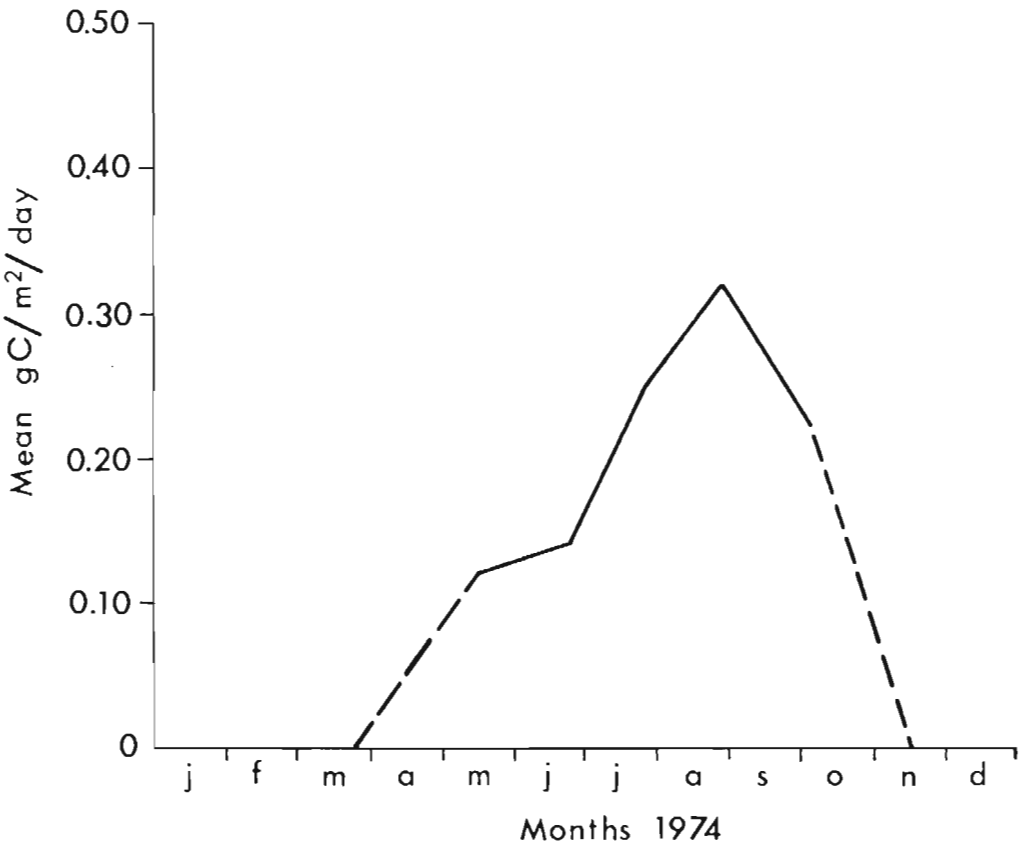


FIG. 12b NORTH CHANNEL 1974. SEASONAL PRODUCTION TREND, EXTENDED TO ZERO WINTER VALUES.

$$g\ C/m^2/yr = 420 \cdot \frac{1.15\ (mg\ Ca/m^3)^{1.33}}{9 + 1.15\ (mg\ Ca/m^3)^{1.33}}$$

from Vollenweider et al (1974). The mean uncorrected chlorophyll a values from April to December for Georgian Bay (1.5 mg Ca/m^3), Lake Huron (1.8 mg Ca/m^3), and the North Channel (1.8 mg Ca/m^3), yield estimates of 76 g $C/m^2/yr$ for Georgian Bay and 92 g $C/m^2/yr$ for Lake Huron and North Channel. The Georgian Bay value is midway between the Lake Huron value and the Lake Superior value (58 g $C/m^2/yr$) calculated by Watson et al (1975); the Lake Huron, North Channel estimate is in agreement with the April to December 1971 estimate of 80-90 g $C/m^2/yr$ given by Vollenweider et al (1974), from the data of Glooschenko and Moore (1973). The lack of data for the winter months, however, has led to annual production estimates which are too high, when using the chlorophyll data, and too low when using the carbon-14 data. Actual carbon uptake probably falls within the above range.

From these estimates, primary productivity of the study area is low; it is oligotrophic based on the ranges of the trophic states given by Dobson et al (1974), and mesotrophic based on the ranges given by Rhode (1969) and Vinberg (1961), as reviewed by Vollenweider et al (1974). In comparative terms, the tropic status of Georgian Bay appears to be somewhere between Lake Superior, on the oligotrophic end of the scale, and Lake Huron and North Channel, approaching the mesotrophic end.

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