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UPDATE ON EUTROPHICATION SECTION OF HAMILTON HARBOUR RAP STAGE 1

by

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NWRI Contribution No. 92-69

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MANAGEMENT PERSPECTIVE

Studies have been done at NWRI on the response of Hamilton Harbour to nutrient loading abatement since 1988. The stage 1 Remedial Action Plan report contains data which can now be updated with new observations. This report contains summaries of recent data on ammonia, oxygen, phosphorus, chorophyll, Secchi depth. In addition, sediment pore water data are included to indicate a potential link between eutrophication problems and sediment toxicity. There has been a quick concentration response to large reductions in ammonia loads but large reductions in both phosphorus and nitrogen loads are needed to effect satisfactory water quality. A larger detailed report is in preparation.

SOMMAIRE

Des études ont été effectuées à l'INRE, portant sur les résultats de la réduction des charges de substances nutritives dans le port d'Hamilton depuis 1988. Le rapport de l'étape 1 du Plan de mesures correctives contient des données qui peuvent maintenant être mises à jour par des nouvelles observations. Ce rapport contient les résumés des données récentes sur l'ammoniac, l'oxygène, le phosphore, la chlorophylle et la profondeur Secchi. De plus, on y trouve également des données sur l'eau interstitielle des sédiments pour mettre en évidence un lien possible entre les problèmes d'eutrophication et la toxicité des sédiments. On a noté une réponse rapide des concentrations aux importantes réductions des charges d'ammoniac, mais il faudrait d'importantes réductions des charges de phosphores et d'azote pour obtenir une qualité d'eau satisfaisante. Un rapport plus important est en préparation.

ABSTRACT

Measurements of eutrophication indicators dissolved oxygen, phosphorus, chlorophyll, ammonia, Secchi depth were made in Hamilton Harbour 1988-1991. The data indicate beneficial responses to prelininary control of combined sewer overflows and operational improvements at sewage plants. Dissolved oxygen is resistant to change. Most water quality aspects have not improved sufficiently to restore uses to the Harbour. Pore water ammonia linked to discharges at STPs may have the potential to cause apparent toxicity in sediment assessments.

RÉSUMÉ

Des mesures des indicateurs de l'eutrophication comme l'oxygène, le phosphore, la chlorophylle, l'ammoniac et la profondeur Secchi ont été effectuées dans le port d'Hamilton de 1988 à 1991. Les données indiquent des réactions bénéfiques aux mesures préliminaires de traitement des trop-pleins d'égouts et aux améliorations apportées au fonctionnement des usines d'épuration des eaux usées. L'oxygène dissous change très peu. La plupart des aspects de la qualité de l'eau ne présentait pas d'améliorations suffisantes pour le rétablissement d'utilisations dans le port. On a relié l'ammoniac de l'eau interstitielle aux déversements à TPN, et celui-ci pourrait être responsable de la toxicité apparente dans les évaluations portant sur les sédiments.

1 INTRODUCTION

Since publication in 1988, The stage 1 RAP report has been a source of information on the state of the harbour. Several NWRI studies of water quality in the Harbour were undertaken at that time to determine the response of the Harbour to various control measures. These controls were initiation of containement facilities for combined sewer discharges, improved operations for phosphorus treatment at sewage treatment plants (STPs) and improved ammonia nitrification at the Hamilton STP. This report summarizes some of the observations in order to update the eutrophication section of the Stage 1 report.

2 METHODS

Water samples were collected by NWRI at 23 sites in the Harbour and adjacent Lake Ontario at depths of 1M and Bottom-2M. Data from representative stations were chosen to avoid strong bias due to proximity to sewage plants. Water samples were analyzed at the National Water Quality Laboratory, oxygen measurements were obtained with an electronic profiling apparatus, pore water samples were obtained by centrifugation and filtration.

3 RESULTS

In general there has been improvement in the Harbour's water quality. The improvements have not, however, been sufficient to restore ascetic qualities to the water nor to restore full use of the water by fish.

Ammonia

Figure 1 shows B-2M ammonia data for 1988, 89, 90, and 91. Ammonia in the bottom water is thought to contribute to the oxygen depletion problem. During the winter of 1991, the nitrification process at the Woodward STP in Hamilton was successful. Usually, ammonia accumulates to levels of 1-2 mg/L during the winter because nitrifying bacteria cease activity in the Harbour water in cold temperatures. The results were immediately apparent in ammonia concentrations about one half of usual values in April. This is important new evidence that the Harbour responds rapidly to major loading changes.

By mid June, ammonia concentrations were similar to those of other years.

Dissolved Oxygen

Figure 2 shows a comparison of dissolved oxygen concentrations near the bottom for 1990 and 1991. Despite the large decrease in initial concentrations of ammonia, the rate of change of O_2 in the early part of the summer was similar to that of 1990 and the concentrations near the bottom for most of the stratified period were similar to other years. Thus, the relationship between ammonia and oxygen is not clear. Since only static quantities of ammonia are measured the actual daily load to the hypolimnion and hence, the relationship between total load and oxygen, is unknown.

Total Phosphorus

Data are shown for the years 1988-1991 in Fig. 3. The most recent data for 1991 are mostly in the range 40-50 ug/L which is somewhat lower than the mean of 64 ug/L reported in 1985. At any given time the 1991 means can be either higher or lower than the values as far back as 1988. The mean concentrations observed in 1991 are 4-5 times higher than desirable levels now present in Lake Ontario.

Chlorophyll

Surface water data for the years 1989-1991 are shown in Fig. 4. In 1989, typical concentrations were around 12 ug/L. Concentrations in 1990 and 1991 were lower for much of the season but in July of both years a massive bloom began to develop. This is a good illustration of the well known observation that peak concentrations of algae can be three times or more the seasonal mean. In 1991 and 1990 floating scums of Blue-Green algae gave the water in some areas the appearance of spilled paint. Thus, even though the frequency of low algal populations is increasing the occurence of obnoxious blooms must be addressed by even lower nutrient loads.

Sediment Pore Water Ammonia

Ammonia occurs due to the decomposition of organic matter. Ideally, the oxygen demand of converting ammonia to nitrate would occur in STPs. Ammonia is however released both directly and indirectly in the form of un-decomposed organic matter. Typical concentrations in pore water are an order of magnitude higher than in open water. Figure 5 (Réal Roy, McGill/NWRI GLURF partnership) shows high concentrations associated with sewage discharges at Hamilton and particularly at Burlington. The values at most of the stations are in the upper end of those found for lake sediments in the literature, but the values near the Burlington STP are enormous. It is surmised that, since these data come from sediments, the elevated ammonia is due to particles discharged from the STP. It is unknown to what extent these particles are moved around the Harbour and may contribute to the oxygen problem as they decompose. The unionized fraction of 20 mg/L total ammonia in typical pore water samples is 2-8 times the provincial guideline for toxicity at temperatures of 10-15°C and pH 7-7.5. It has been recommended that, in sediment toxicity tests, the toxicity due to ammonia must be considered before toxicity due to organics or metals can be assessed (van de Guchte and Mass-Diepeveen, 1988). Up to date treatment technology which removes the organic particles from STPs is available.

Water Clarity, Secchi Depth

Although water clarity has been improving, there is still much room for improvement. Figure 6 shows Secchi depths in mid-July 1991. Obviously, ideal depths of 3M are not being achieved and therefore more improvement of STPs is needed.

REFERENCES

van de Guche, C. and Mass-Diepeveen, 1988. Screening sediments for toxicity: a water-concentration related problem. In: Proceedings of the Fourteenth Annual Toxicity Workshop: November, 1987, Canadian Technical Report of Fisheries and Aquatic Sciences No. 1607. Department of Fisheries and Oceans, 1988. eds. A. J. Niimi and K. R. Solomon.

LIST OF FIGURES

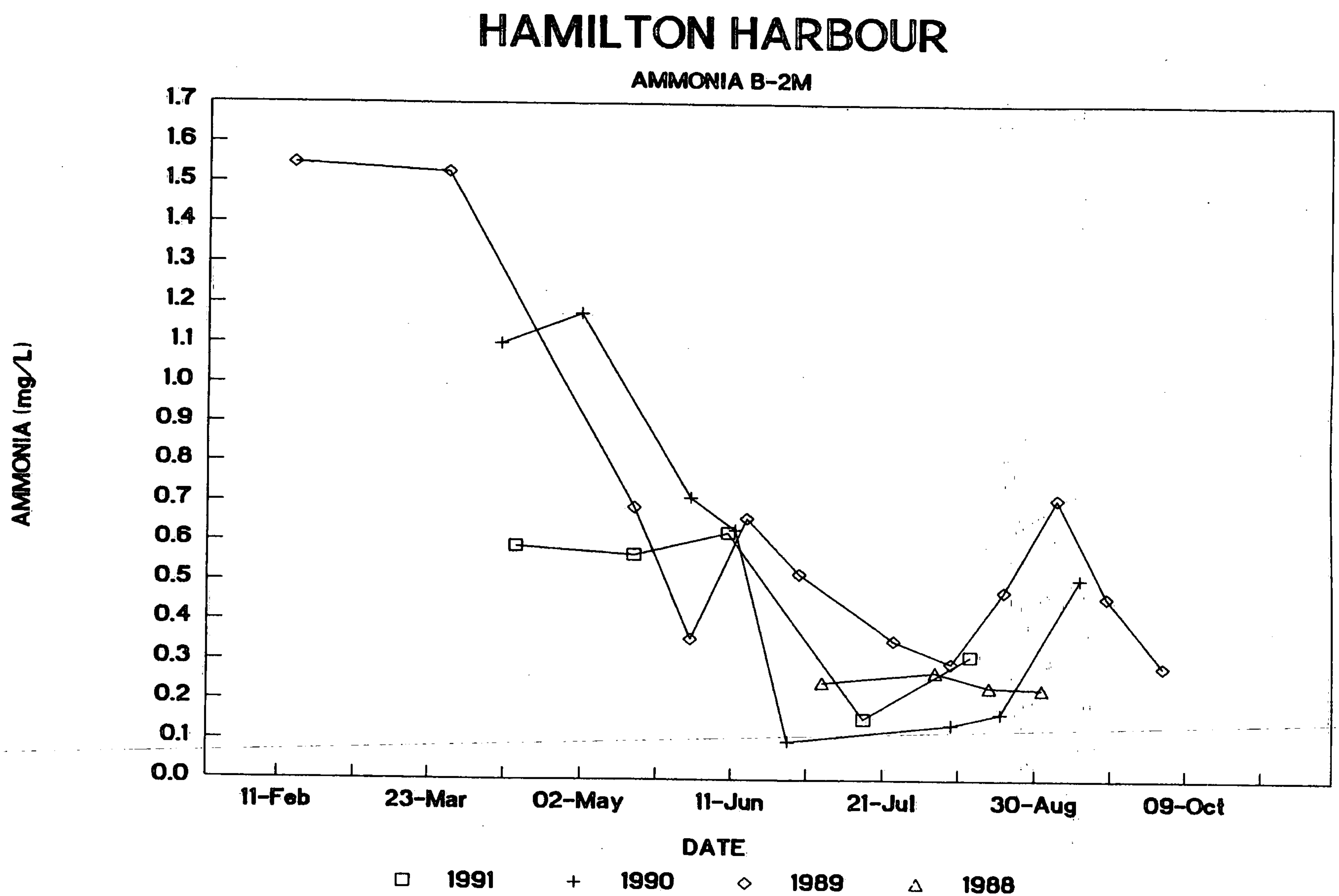
HAMILTON HARBOUR
AMMONIA B-2M
AMMONIA (mg/L)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11-Feb
23-Mar
02-May
11-Jun
21-Jul
30-Aug
09-Oct
DATE
□ 1991
+ 1990
◇ 1989
△ 1988

FIGURE 1

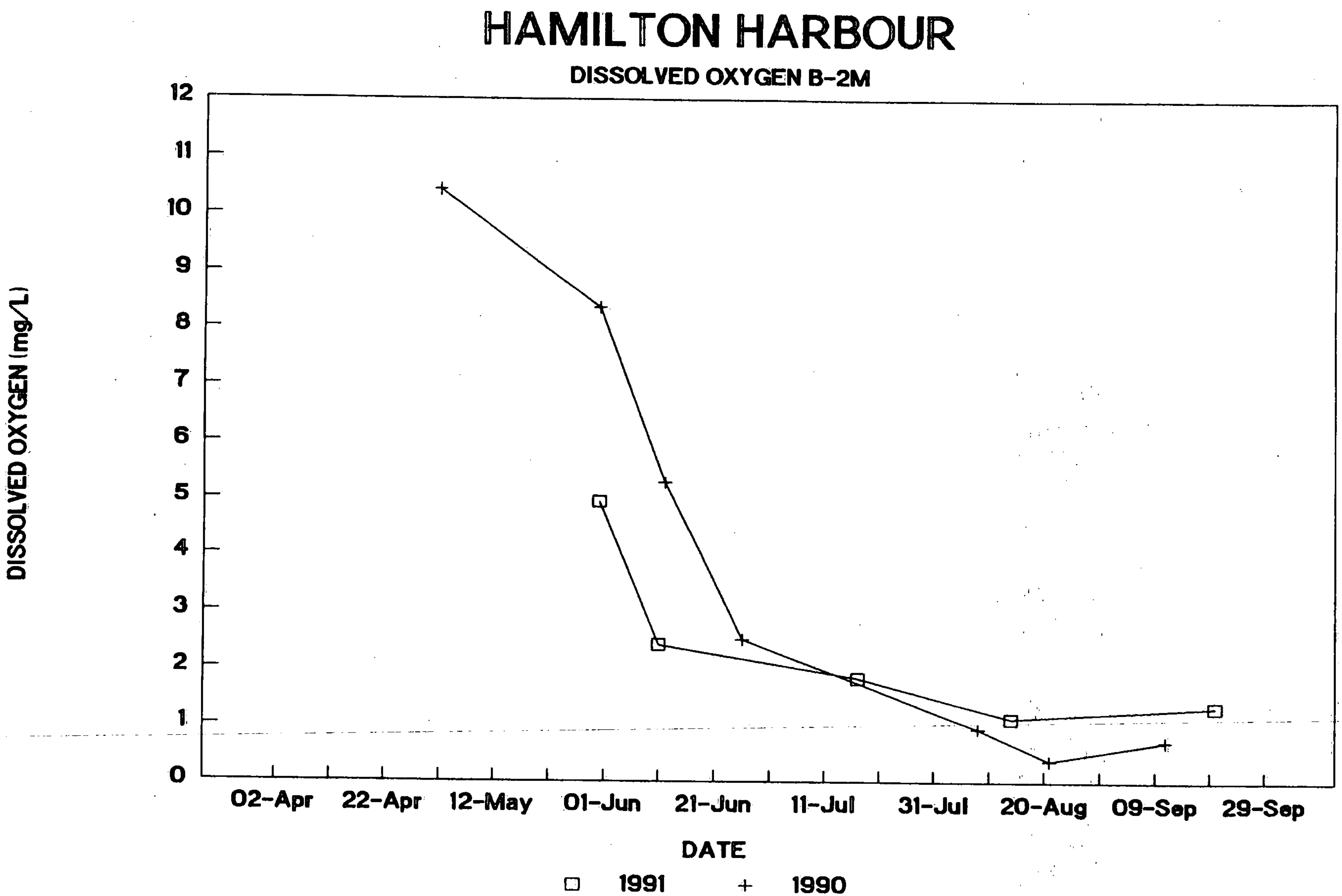
HAMILTON HARBOUR
DISSOLVED OXYGEN B-2M
DISSOLVED OXYGEN (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
02-Apr
22-Apr
12-May
01-Jun
21-Jun
11-Jul
31-Jul
20-Aug
09-Sep
29-Sep
DATE
1991
1990

FIGURE 2

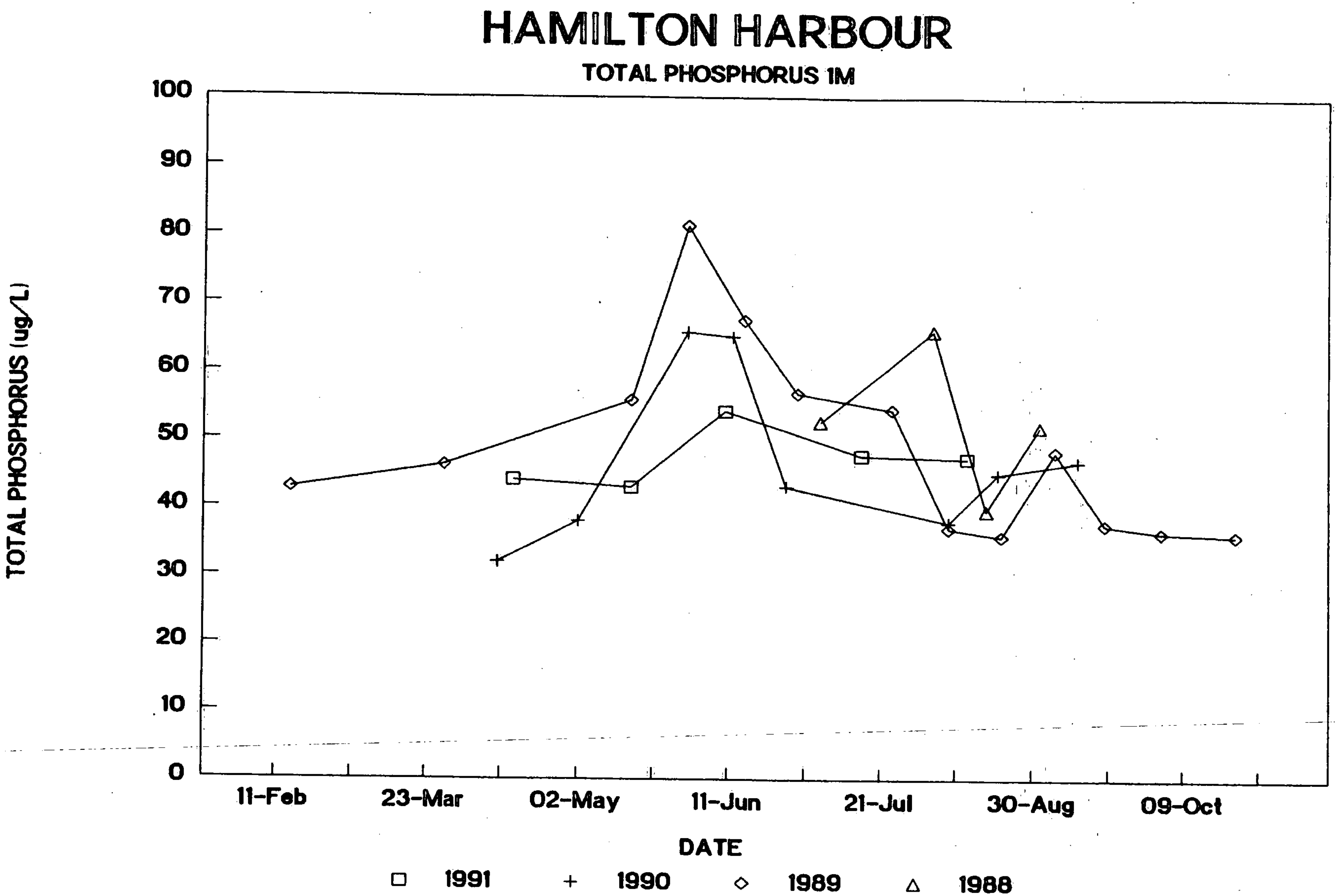
HAMILTON HARBOUR
TOTAL PHOSPHORUS 1M
TOTAL PHOSPHORUS (ug/L)
100
90
80
70
60
50
40
30
20
10
0
11-Feb
23-Mar
02-May
11-Jun
21-Jul
30-Aug
09-Oct
DATE
1991
1990
1989
1988

FIGURE 3

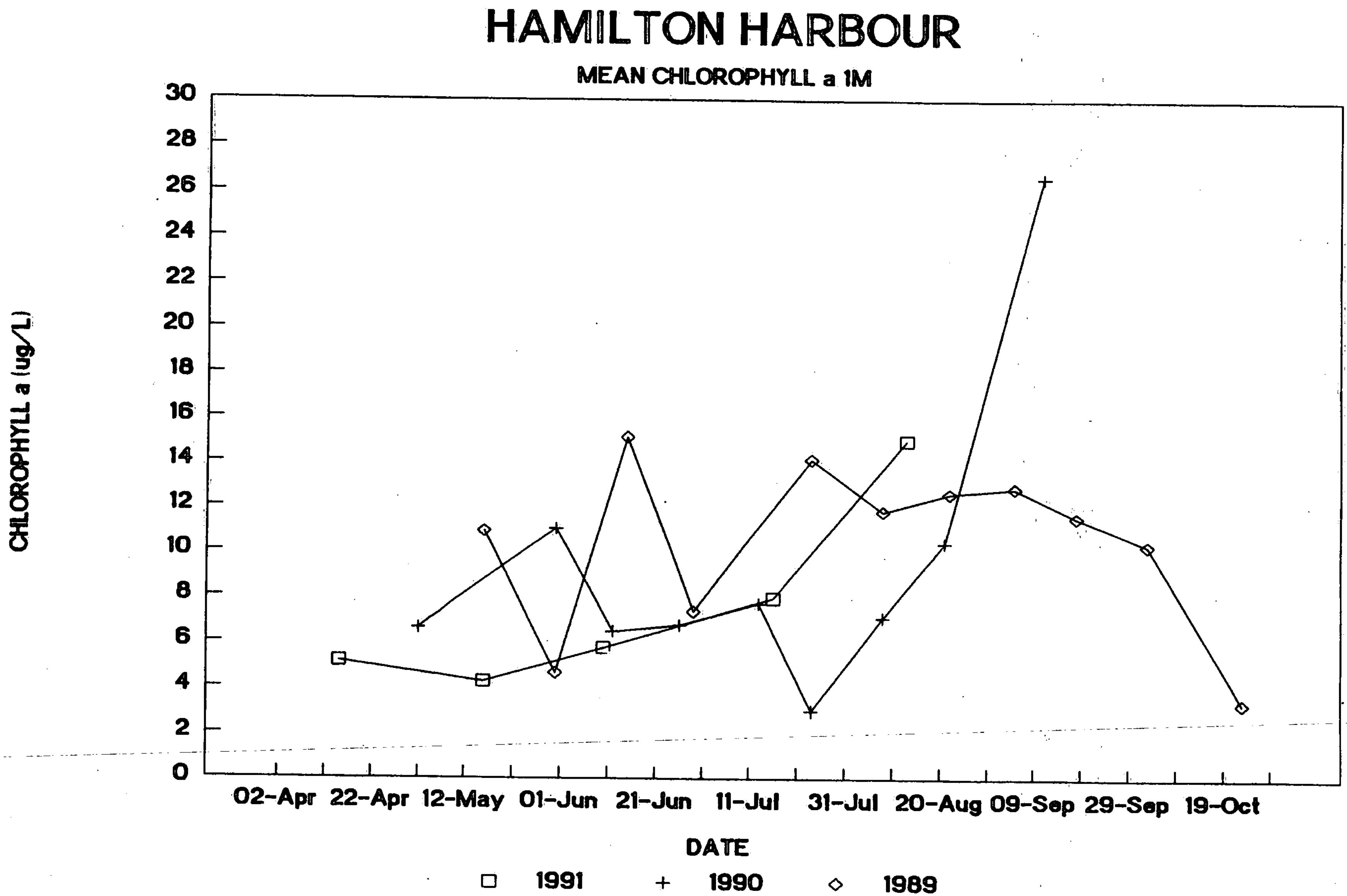
HAMILTON HARBOUR
MEAN CHLOROPHYLL a 1M
CHLOROPHYLL a (ug/L)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
02-Apr
22-Apr
12-May
01-Jun
21-Jun
11-Jul
31-Jul
20-Aug
09-Sep
29-Sep
19-Oct
DATE
1991
1990
1989

FIGURE 4

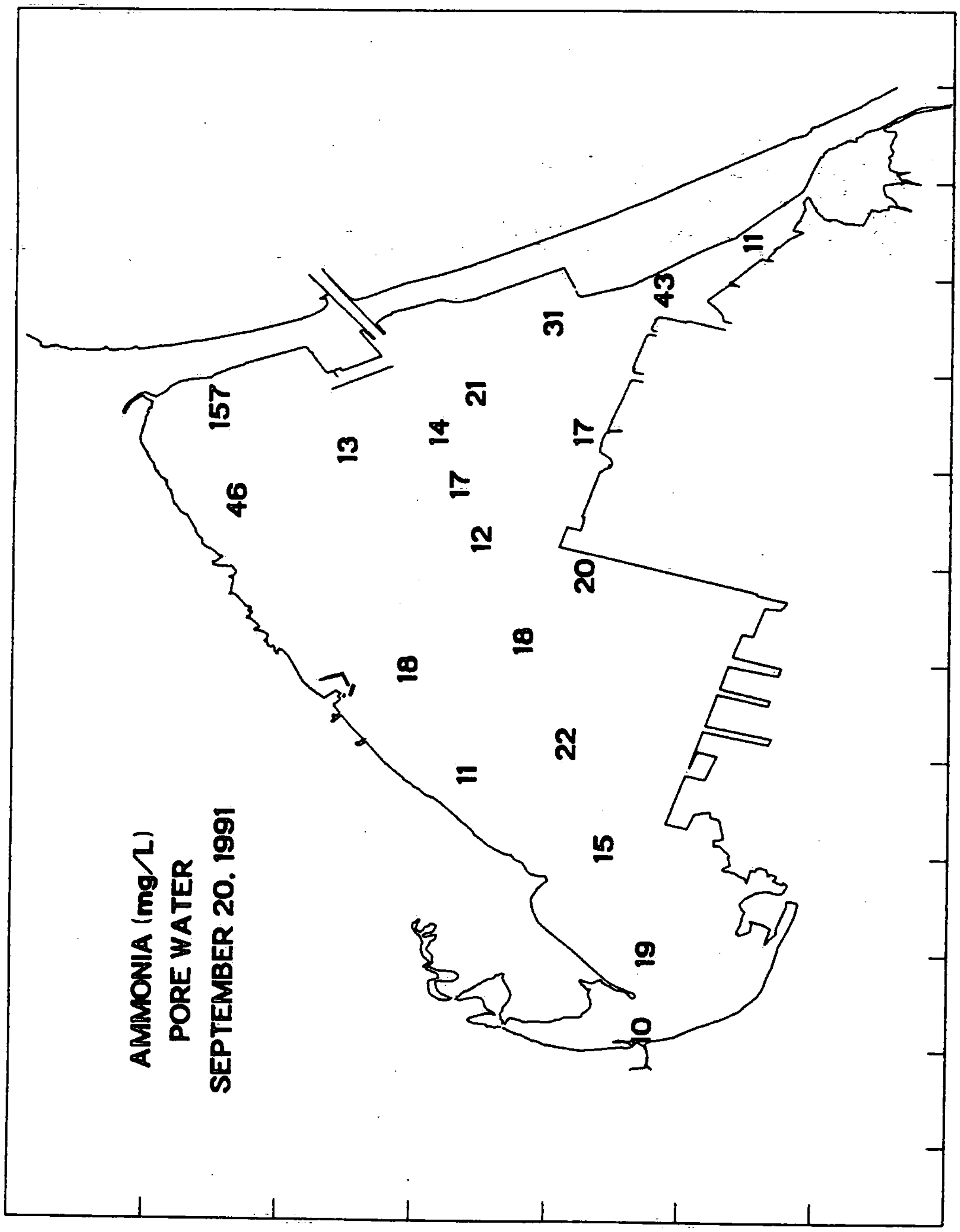
AMMONIA (mg/L)
PORE WATER
SEPTEMBER 20. 1991
157
46
13
14
17
21
12
31
43
11
17
20
18
18
22
11
15
19
10

FIGURE 5

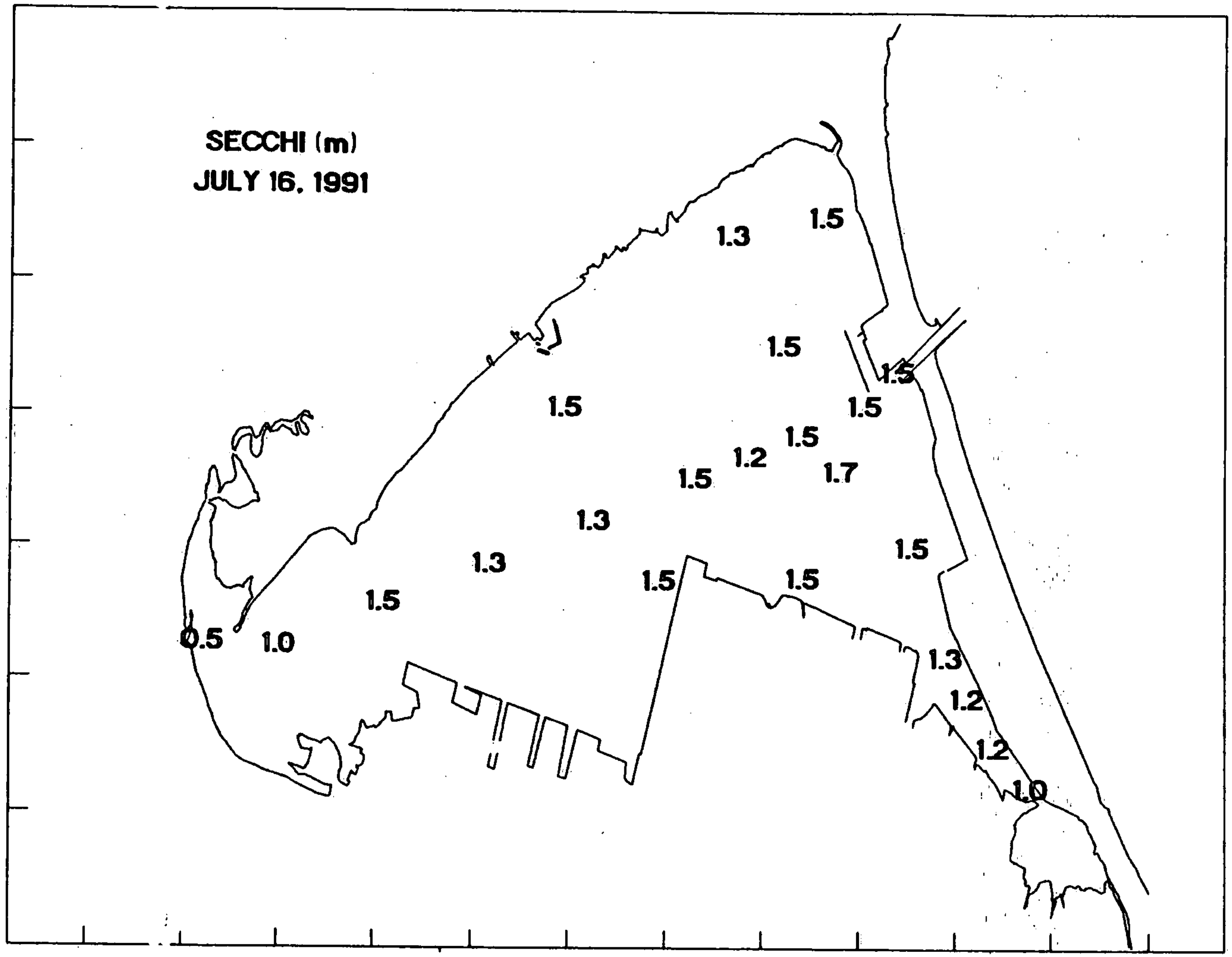
SECCHI (m)
JULY 16, 1991
1.3
1.5
1.5
1.5
1.5
1.5
1.5
1.2
1.5
1.7
1.3
1.5
1.3
1.5
1.5
1.5
0.5
1.0
1.3
1.2
1.2
1.0

FIGURE 6

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