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Rates of Reflux of Phosphorus from The In-Place Sediments of the Bay of Quinte

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Management Perspective

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EC Priority Issue:	Conserving Canada's Ecosystems, Great Lakes 2000, RAPs
Current Status	Eutrophication in the Bay of Quinte is exacerbated by phosphorus reflux from the sediments. Dissolved phosphorus can build up to several mg/L in sediment porewater. The diffusion of porewater phosphorus into the water column helps drive the algal bloom in summer. The reflux rate corresponds to proximity of the sewage sources. Moreover at one station, the reflux rate has decreased over the years of nutrient load abatement. This means that the important sediment water interaction will slow, but not prevent, recovery of the Bay of Quinte if nutrient sources are reduced enough.
Next Staps:	The lead author has retired. The findings will be communicated to the Bay of Quinte RAP process.

RATES OF REFLUX OF PHOSPHORUS FROM THE IN-PLACE SEDIMENTS OF THE BAY OF QUINTE

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ABSTRACT

The rates of reflux of bioavailable phophorus from in-place sediment in Upper Bay of Quinte are consistent with continuing eutrophic conditions. Rates are significantly greater at a site 6 km west of Belleville than at a site 6 km east of Belleville, in the western end of Big Bay. Rates of reflux in Big Bay may have decreased since the measurements of 1988/89, possibly as a consequence of reductions in inputs from the sewage treatment plants. The recent zebra mussel infestation may cause further decreases in rates of reflux in future years since less organic matter, in the form of algal remains, is deposited to the sediments. The overall outlook is for clearer water.

INTRODUCTION

The impact of colonial settlement on the trophic status of the Bay of Quinte has been severe. Eutrophication has impaired water usage, although sport fishing has remained popular. Nutrient concentrations in the water have been strongly supported in summer by massive releases (reflux) of bioavailable phosphorus from in-place sediments (Minns et al. 1986, Manning 1996). Recent years have seen a significant improvement in water clarity, particularly in nearshore areas. Improved clarity may be due in large measure to the very recent infestation of the Bay by zebra mussels. Nevertheless, the reflux of phosphorus from the offshore sediments remains an important factor in algal productivity in summer. Here, we report rates of reflux of soluble reactive phosphorus at two stations in Upper Bay. These rates are then compared with the initial mesurements made in 1988 and 1989.

EXPERIMENTAL

The preparation, placement, and sampling of "peepers" have been described in Manning (1996). The two stations in Upper Bay are: station PM1 at 44 07' 45"N and 77 28' 12"W, approximately 6 km west of Belleville, and station 878 at 44 08' 46"N and 77 17' 12"W, in Big Bay approximately 7 km east of Belleville. Water depth at both stations is 5 m. "Peepers" were placed, in replicate, on several occasions and retrieved, sampled, and preserved on site two weeks later. Soluble reactive phosphate ion was measured by phosphomolybdate colorimetry (Manning 1996).

Rates of reflux were calculated from the SRP concentration gradient at the sediment-water interface (usually the top 4 "peeper" chambers) and Fick's First Law of random diffusion (see Manning 1996).

RESULTS

Rates of reflux measured in 1994/6 show excellent consistency at both stations. Rates are much higher at station PM1, possibly a consequence of adjacent cottage and agricultural activities. Rates seem to have decreased in Big Bay (station 878) since 1988/89, although the data set is limited (Table 1). The same methods were used then and more recently.

DISCUSSION

The higher rates of reflux at station PM1 (Table 1) are indicative of continued eutrophication, particularly in the western (upstream) end of Upper Bay. The mean depth of water in Upper Bay is 2.5 m, hence the actual summer rise in soluble reactive phosphorus is twice the concentration range listed in Table 1. It is not immediately obvious as to why rates at PM1 should be so significantly greater than at 878. Big Bay is continually rough with considerable wind fetch, sediment resuspension is extensive, and surface porewaters may be skimmed away by physical action, particularly during the spring freshet and autumn storms.

The infestation of Upper Bay by zebra mussels seems too recent to have directly influenced rates of reflux from the offshore sediments. The nearshore areas of Upper Bay became heavily infested by the mussels in 1995. Increased water clarity was observed in the summer of 1996 and is also evident in 1997, particularly downstream of Big Bay. The clarification of water in parts of Lake Erie has been attributed to the filtering action of zebra mussels. The increased rate of sedimentation of phosphorus caused by zebra mussels is accompanied by lower rates of sedimentation of organic matter. The rate of decomposition of the pseudofaeces in the offshore sediments may be reduced. The overall outlook is for clearer water in the Bay of Quinte.

The arrival of the zebra mussel renders near impossible a final assessment of the contribution of phosphorus controls on improved water clarity in the Bay. Two items worthy of future study are: (a) the fate of mussel pseudofaeces and their rate of decomposition, and (b) continuing trends in rates of reflux from offshore sediments.

CAPTIONS FOR FIGURES

Fig. 1. Concentrations of soluble reactive phosphorus in porewater as a function of sediment depth at station PM1.

Fig. 2. Concentrations of soluble reactive phosphorus in porewater as a function of sediment depth at station 878,

REFERENCES

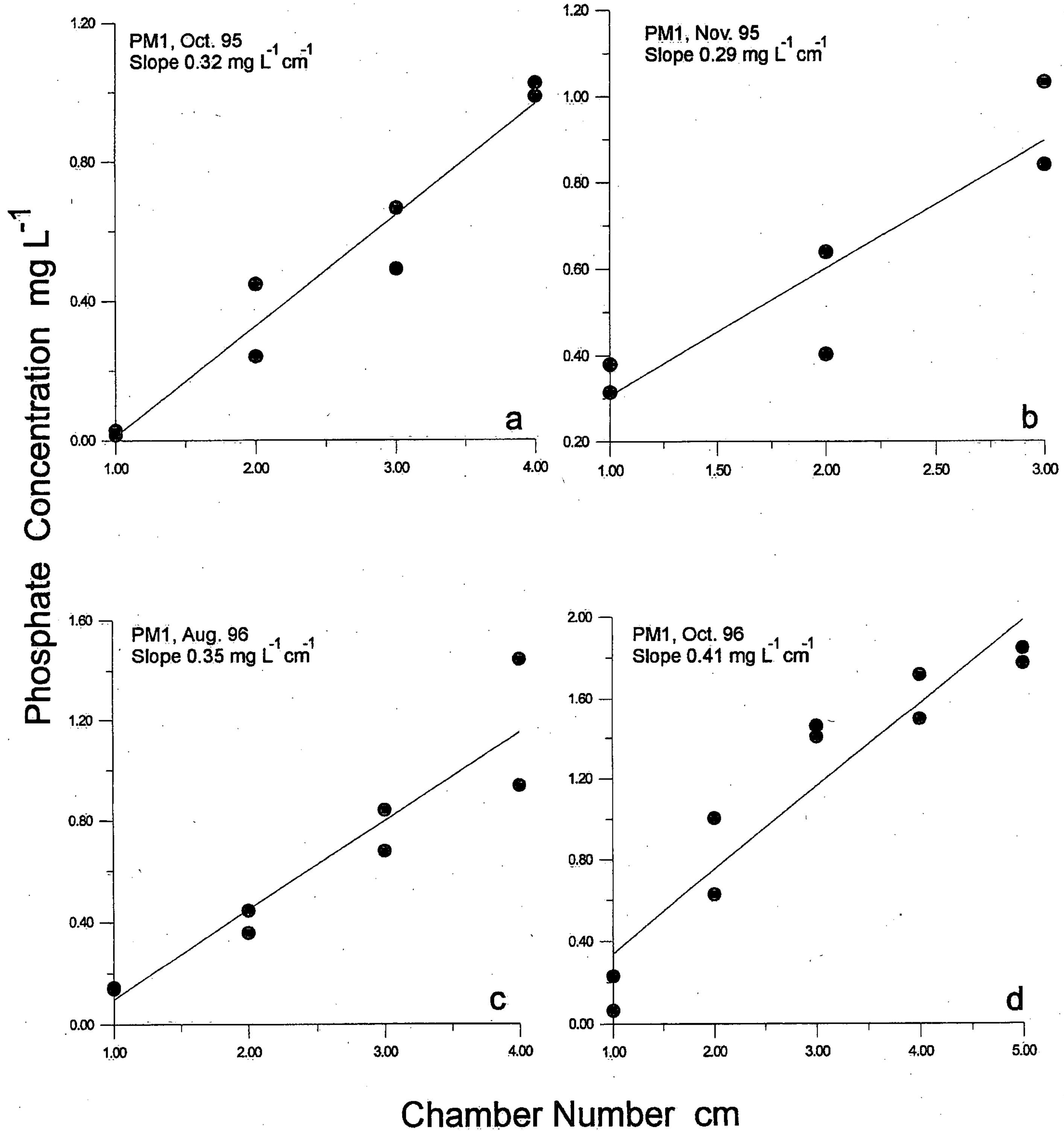
MANNING, P.G. (1996): Bioavailability of riverine, sewage plant, and sediment phosphorus in the Bay of Quinte, Lake Ontario. Can. Mineral. 34, 667-675.

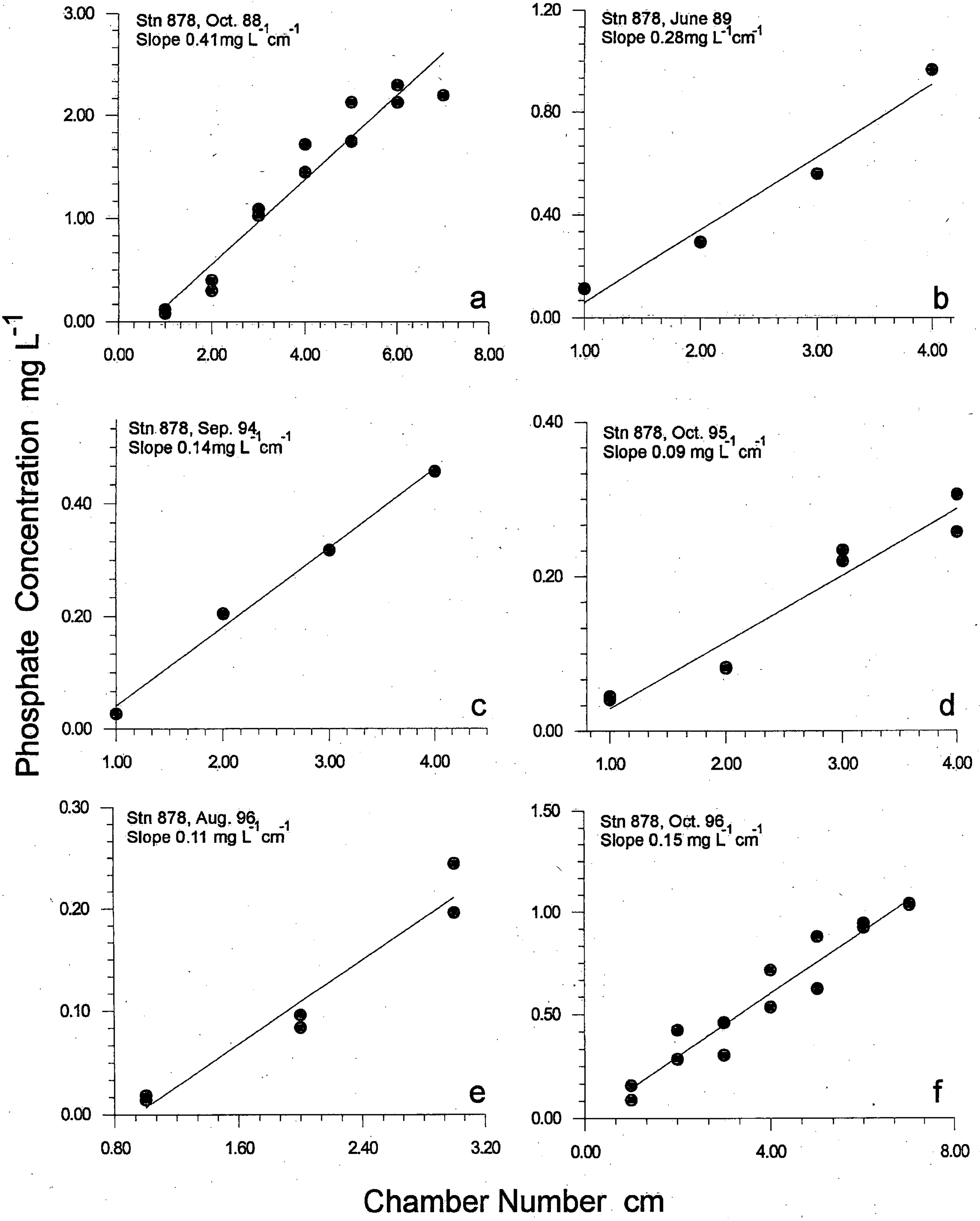
MINNS, C.K., OWEN, G. E. & JOHNSON, M.G. (1986): Nutrient loads and budgets in the Bay of Quinte, Lake Ontario, 1965-1981. Can. Fish. Aquat. Sci. Spec. Publ. 86, 59-76.

TABLE 1. Reflux of Phosphate Ion from Upper Bay of Quinte Sediments

Date	SRP gradient $mg\ L^{-1}\ cm^{-1}$	Rate reflux $mg\ m^{-2}\ d^{-1}$	Incr. water concen. $\mu g\ L^{-1}$ SRP
		Station PM1	
Oct. 95	0.32	0.91	36
Nov. 95	0.29	0.82	32
Aug. 96	0.35	0.99	40
Oct. 96	0.41	1.16	46
		Station 878	
Oct. 88	0.41	1.34	54
June 89	0.28	0.78	32
Sept. 94	0.14	0.40	16
Oct. 95	0.09	0.25	10
Nov. 95	0.13	0.37	14
Aug. 96	0.11	0.31	12
Oct. 96	0.15	0.42	16

SRP gradients measured from plots in Figures 1 and 2. Increased water concentrations refer to 100 days (summer) of cumulative release to a 5m deep water column. Mean depth of water is 2.5m.


PM1, Oct. 95
Slope 0.32 mg L-1 cm-1
a
PM1, Nov. 95
Slope 0.29 mg L-1 cm-1
b
PM1, Aug. 96
Slope 0.35 mg L-1 cm-1
c
PM1, Oct. 96
Slope 0.41 mg L-1 cm-1
d
Phosphate Concentration mg L-1
Chamber Number cm


Stn 878, Oct. 88
Slope 0.41mg L-1cm-1
a
Stn 878, June 89
Slope 0.28mg L-1cm-1
b
Stn 878, Sep. 94
Slope 0.14mg L-1cm-1
c
Stn 878, Oct. 95
Slope 0.09 mg L-1 cm-1
d
Stn 878, Aug. 96
Slope 0.11 mg L-1 cm-1
e
Stn 878, Oct. 96
Slope 0.15 mg L-1 cm-1
f
Phosphate Concentration mg L-1
Chamber Number cm

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