Continued Evaluation of Controlled Fertilization of Acidified Wetlands for Enhancement of Waterfowl Production

Final Report
March 1994

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Supported by:
Canadian Wildlife Service
Ducks Unlimited Canada
Eastern Habitat Joint Venture
Nova Scotia Department of Natural Resources

Acadia Centre for Estuarine Research Publication No. 34

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SUMMARY

During 1993 a limited monitoring programme was conducted at a number of wetland sites located within the Tobeatic Wildlife Management Area in southwestern Nova Scotia to further evaluate the potential of artificial fertilization for enhancement of waterfowl production. Levels of total phosphorous and total nitrogen at sites fertilized in the spring of 1991 were very close to levels measured prior to fertilization. This was also true of phytoplankton chlorophyll *a* levels. Periphyton growth rates at the fertilized sites, however, were among the highest recorded during the study. Zooplankton abundance remained at about the same level as in 1992 but underwent considerable changes in species composition.

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1. BACKGROUND

During the period 1990-1993, the Acadia Centre for Estuarine Research carried out an intensive field study at a number of sites in the Tobeatic Wildlife Management Area of southwestern Nova Scotia to determine the feasibility of using artificial fertilization for enhancement of waterfowl production in acidified and oligotrophic wetlands. The primary objectives of the study were to determine the effectiveness of controlled artificial fertilization in stimulating production processes and to evaluate the overall environmental impact, particularly on adjacent systems, of fertilizer addition. The results of that study (Brylinsky 1993) indicated that, although these systems respond well to the addition of artificial fertilizers in terms of increased primary and secondary production, the length of time production was enhanced varied considerably among sites. Within one or two weeks after fertilization, phytoplankton levels at the fertilized sites rose to more than an order of magnitude above pre-fertilization levels. Phytoplankton levels in the early spring of the second year, however, had decreased substantially, particularly in those sites characterized by high flushing rates and a thermally unstratified water column. Zooplankton biomass showed little change during the year of fertilization, but increased during the second year after fertilization. Those organisms having longer generation times, such as emergent insects and benthic invertebrates, showed little response to fertilization during the two years after fertilization.

These results suggest that the effect of artificial fertilization is relatively short-lived, particularly with respect to phytoplankton productivity. In order for artificial fertilization to be considered a cost effective management technique for enhancing waterfowl productivity, management agencies maintain that fertilizer addition should not be required more than once every four or five years. Thus the increase in productivity brought about by one-time fertilization should last a minimum of three to four years. It was therefore considered desirable to continue monitoring productivity levels for at least one more year in order to provide a more complete evaluation of artificial fertilization as a management technique.

2. APPROACH

Because of funding limitations the monitoring programme for the 1993 field season was considerably reduced from that of the initial three year study. The number of sites monitored was reduced to five; two control sites (Round and Menchon) and three fertilized sites (Stump, Jib and Perfect). Each site was sampled monthly (as opposed to biweekly) and sampling was restricted to the period between 1 May and 15 September. In addition, sampling was limited to the following parameters: water temperature and conductivity depth profiles, chemical parameters (analyzed by the Inland Waters Directorate of Environment Canada), dissolved oxygen, phytoplankton chlorophyll *a*, periphyton growth and zooplankton numbers. Emergent insect and benthic invertebrate abundance were not monitored. Sampling methodology and analyses were consistent with the procedures employed during 1990-1992 and are described in Brylinsky (1993).

3. RESULTS

3.1. Chemistry

Total phosphorous levels of surface waters at the fertilized sites during 1993 remained at about the same levels as in 1992 and were only slightly greater than levels measured prior to fertilization (Table 1 and Figures 1 and 2). This was true of both the thermally unstratified site (Stump) as well as of the thermally stratified sites (Jib and Perfect). Total phosphorous levels within the hypolimnion of the stratified sites also continued to decrease. Perfect had the highest levels of total phosphorous within the hypolimnion during 1992 and this was attributed to the fact that, unlike Jib, it has no surface outlet which would tend to reduce the chance of flushing from the system. The decrease during 1993, however, was dramatic and indicates that over a longer time period the loss of phosphorous by settling may be as important as the more immediate loss resulting from flushing.

Total nitrogen also continued to decrease at all of the fertilized sites and during 1993 was about equal to pre-fertilization levels (Table 1 and Figures 3 and 4).

Following fertilization, depletion of dissolved oxygen within the hypolimnion of the stratified experimental sites tended to occur earlier in the year. This no longer appears to be occurring (Figure 5), particularly at Perfect which did not become anaerobic until early July in 1993 as opposed to early June in 1991 and 1992. However, Round, a stratified control site, showed a similar behavior suggesting that factors other than fertilization may have an influence on the timing and extent of the development of anaerobic conditions.

3.2. Biology

Phytoplankton chlorophyll *a* levels at Jib and Stump remained about the same in 1993 as in 1992 and were only slightly greater than pre-fertilization levels (Table 2 and Figures 6 and 7). At Perfect, which exhibited the highest phytoplankton chlorophyll *a* levels during 1992, they decreased substantially but were still about twice as high as pre-fertilization levels. These changes closely follow those of surface water total phosphorous concentrations. Periphyton growth during 1993 (Table 2 and Figure 8), however, was considerably greater at Jib and Stump and only slightly lower at Perfect than in 1992. It is difficult to understand why periphyton growth remains high while phytoplankton levels are

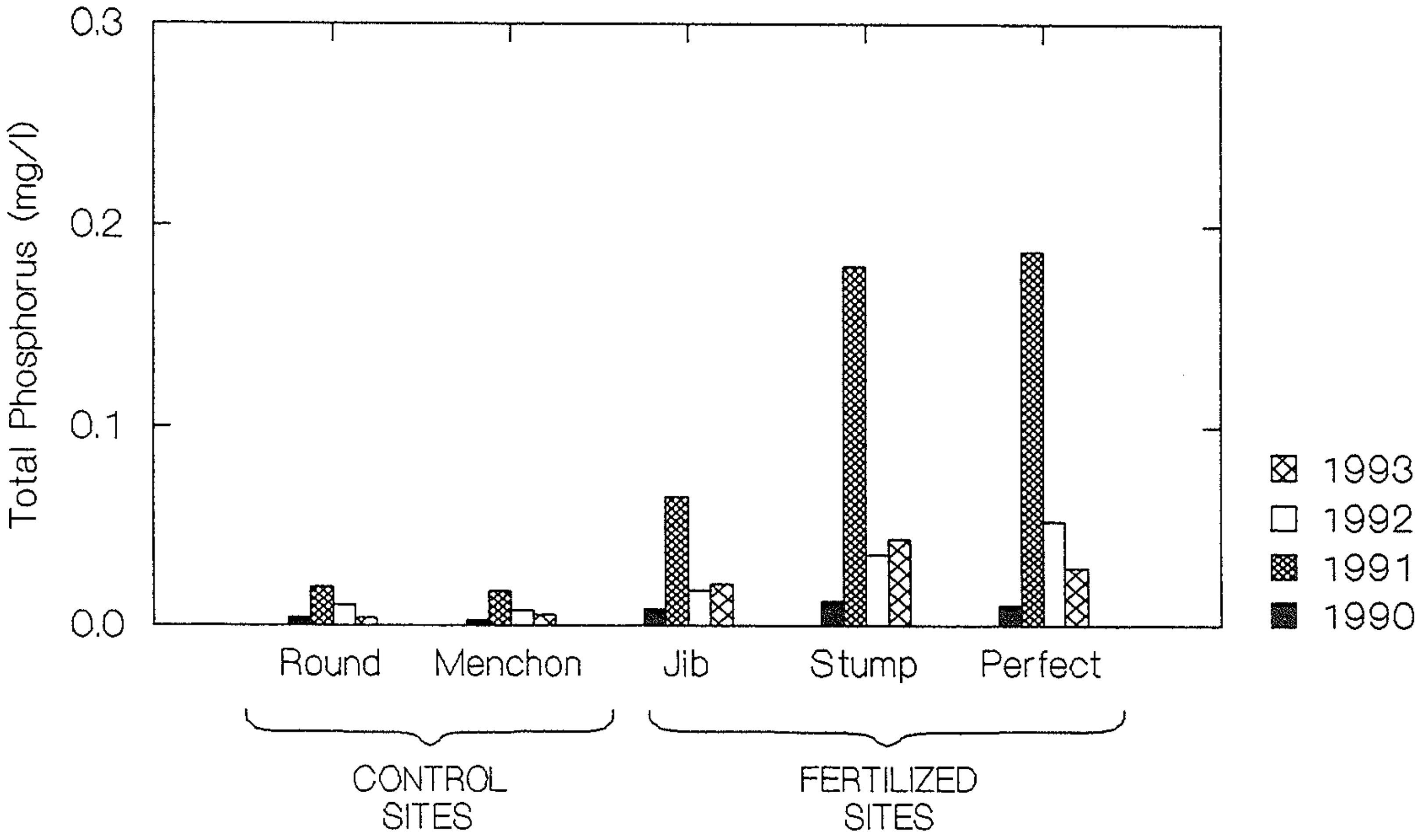

Figure 1. Mean total phosphorous concentrations at control and fertilized sites for the period between 1 May and 15 September of each year.

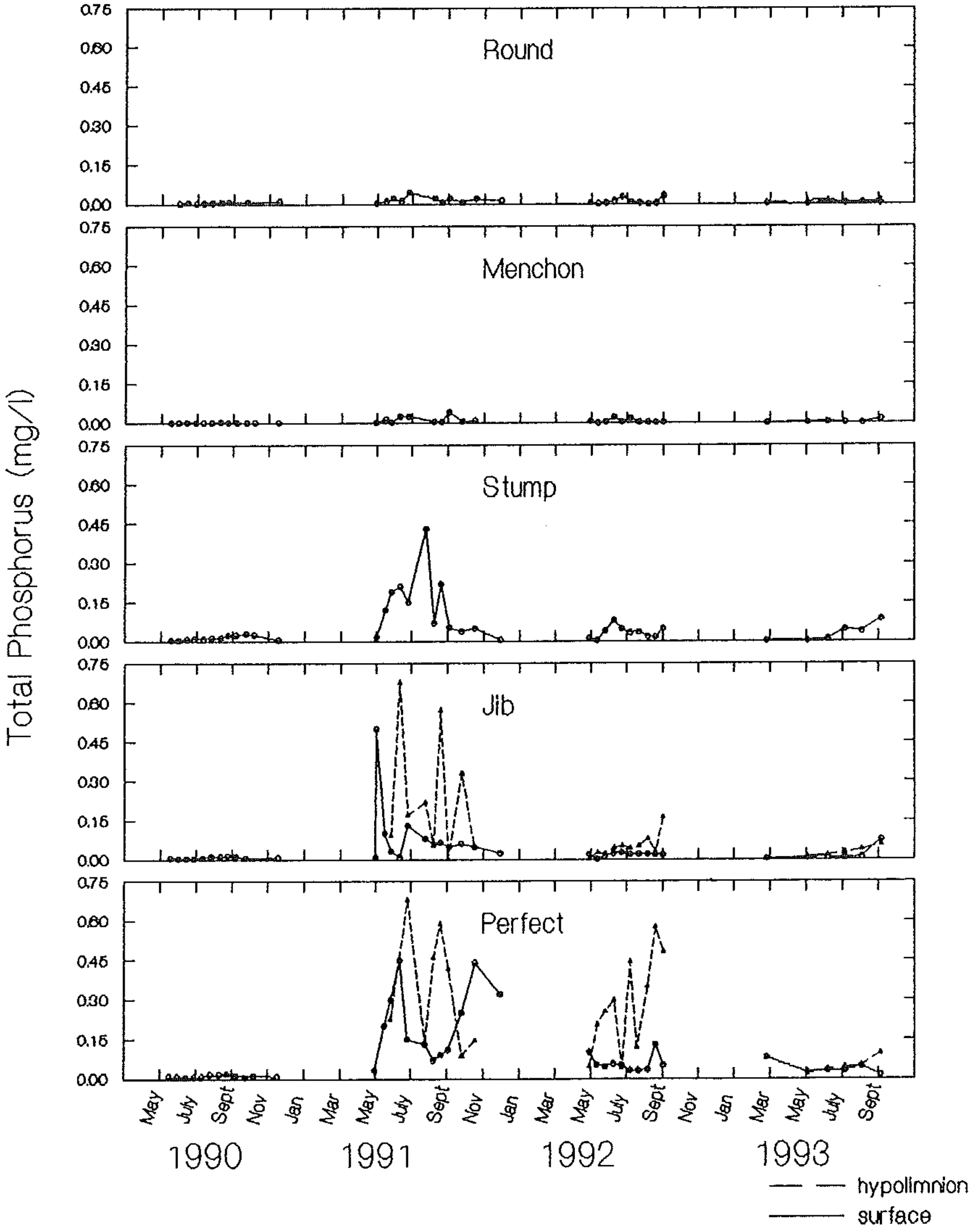

Figure 2. Seasonal variation in total phosphorous concentration at control and fertilized sites.

Table 1. Summary of mean values (sd) of total phosphorous and total nitrogen for the period 1 May to 15 September of each year.

Site	Year	Total P Surface (mg/l)	Total P Outlet (mg/l)	Total P Hypolimnion (mg/l)	Total N Surface (mg/l)	Total N Outlet (mg/l)
Round	1990	0.004(0.002)			0.140(0.055)	
	1991	0.020(0.012)			0.176(0.073)	
	1992	0.010(0.012)			0.130(0.040)	
	1993	0.004(0.002)		0.010(0.004)	0.126(0.019)	
Menchon	1990	0.003(0.001)			0.123(0.022)	
	1991	0.018(0.014)			0.136(0.041)	
	1992	0.007(0.008)			0.122(0.039)	
	1993	0.005(0.006)			0.104(0.018)	
Stump	1990	0.013(0.007)	0.036(0.048)		0.403(0.148)	0.394(0.237)
	1991	0.180(0.118)	0.167(0.115)		2.148(1.127)	3.400(1.386)
	1992	0.036(0.023)	0.045(0.032)		0.542(0.142)	0.890(0.471)
	1993	0.045(0.040)	0.031(0.043)		0.462(0.240)	0.330(0.246)
Jib	1990	0.008(0.004)	0.008(0.004)		0.182(0.050)	0.189(0.045)
	1991	0.065(0.038)	0.082(0.050)	0.254(0.264)	0.849(0.675)	0.834(0.820)
	1992	0.018(0.007)	0.019(0.009)	0.056(0.043)	0.210(0.058)	0.287(0.102)
	1993	0.021(0.030)	0.013(0.007)	0.029(0.018)	0.178(0.031)	0.175(0.021)
Perfect	1990	0.011(0.005)			0.221(0.056)	
	1991	0.188(0.129)		0.471(0.235)	4.000(2.420)	
	1992	0.053(0.031)		0.307(0.173)	0.438(0.128)	
	1993	0.028(0.012)		0.048(0.029)	0.296(0.081)	

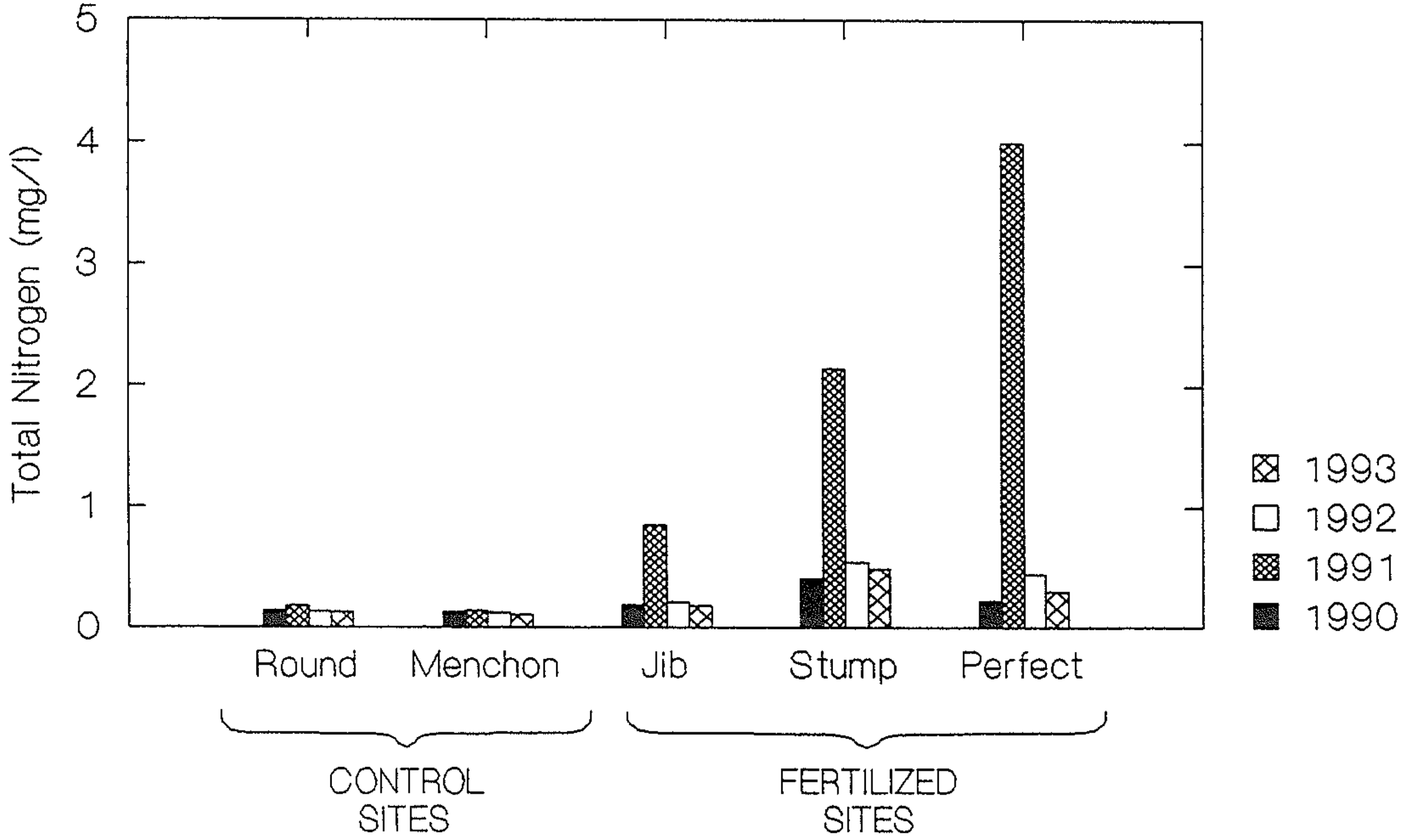

Figure 3. Mean total nitrogen concentrations at control and fertilized sites for the period between 1 May and 15 September of each year.

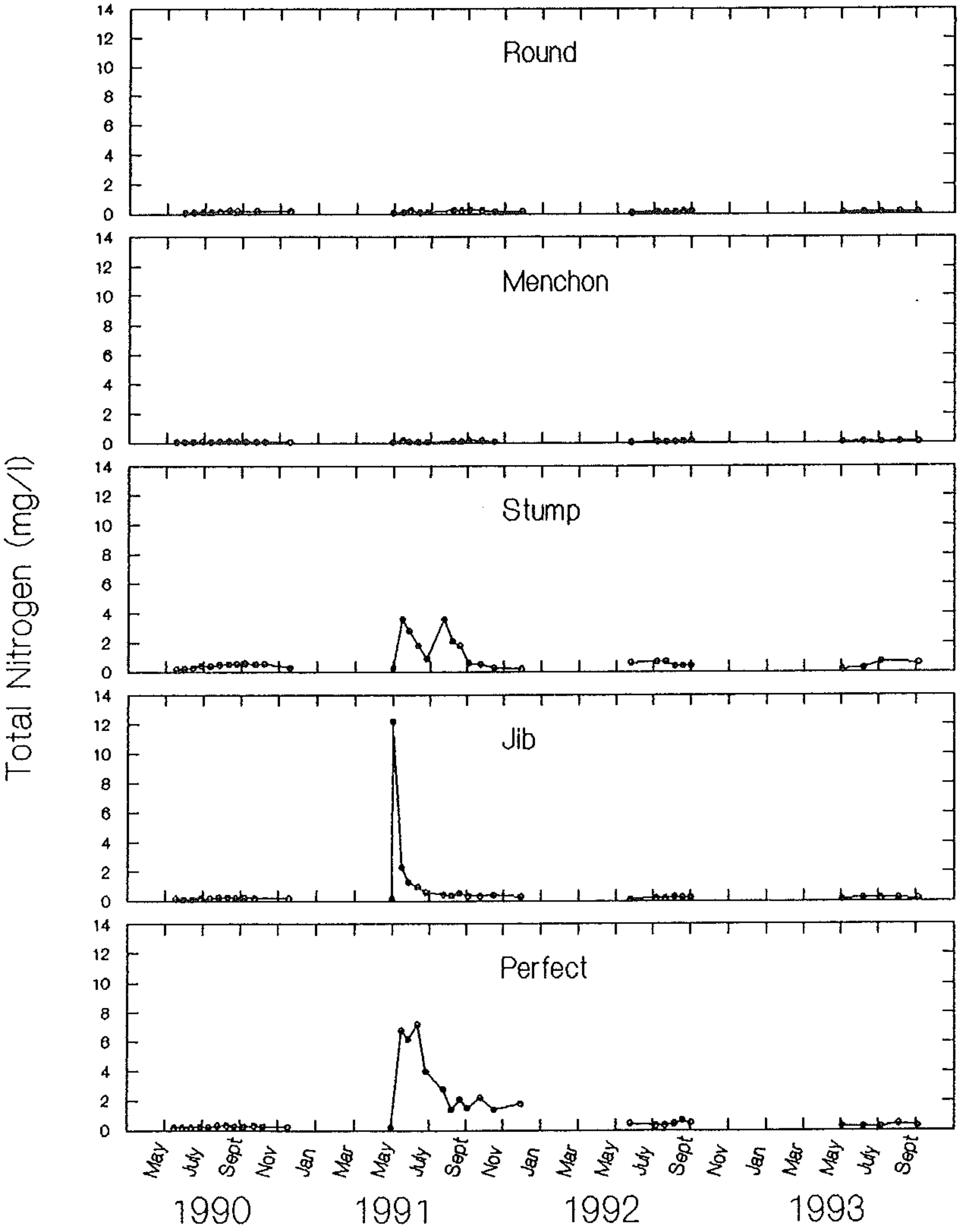

Figure 4. Seasonal variation in total nitrogen concentration at control and fertilized sites.

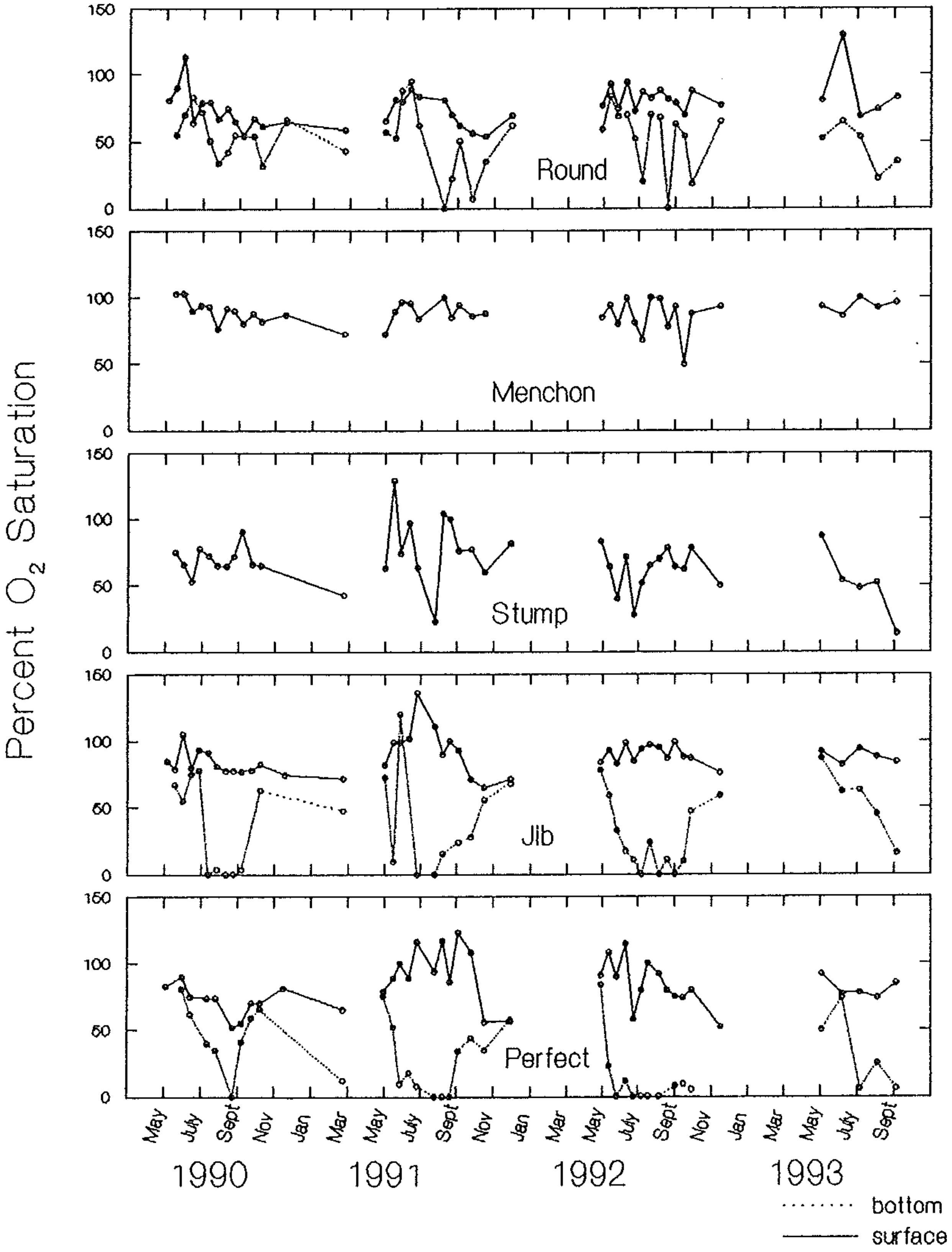

Figure 5. Seasonal variation in dissolved oxygen concentration at control and fertilized sites.

Table 2. Summary of mean values (sd) of biological parameters for the period 1 May to 15 September of each year.

Site	**Year**	**Phytoplankton. (*u*g Chl *a* / l)**	**Periphyton Growth (*u*g Chl *a* / Slide mo)**	**Zooplankton (No / Sample)**
Round	1990	1.427 (2.741)	1.443 (1.458)	5.921 (5.782)
	1991	0.929 (0.616)	0.292 (0.461)	15.854 (27.720)
	1992	0.907 (0.330)	0.429 (0.359)	41.340 (25.047)
	1993	0.804 (0.697)	1.085 (1.302)	32.849 (32.034)
Menchon	1990	0.703 (0.481)	0.480 (0.324)	5.325 (6.146)
	1991	0.583 (0.854)	0.259 (0.278)	65.115 (136.736)
	1992	0.413 (0.299)	0.619 (0.739)	47.980 (35.727)
	1993	0.425 (0.101)	0.624 (0.656)	30.264 (22.178)
Stump	1990	4.050 (2.172)	2.110 (1.431)	6.447 (5.865)
	1991	35.297 (35.331)	5.720 (2.691)	69.862 (118.478)
	1992	6.731 (7.045)	1.559 (0.841)	76.239 (72.704)
	1993	4.591 (4.176)	3.000 (3.218)	108.891 (198.286)
Jib	1990	2.082 (0.980)	2.228 (1.914)	20.562 (19.539)
	1991	24.562 (15.898)	1.483 (1.671)	263.745 (621.615)
	1992	3.628 (2.230)	1.054 (0.775)	381.799 (381.679)
	1993	2.115 (1.226)	4.693 (8.197)	116.099 (110.543)
Perfect	1990	2.540 (1.137)	0.325 (0.334)	17.721 (16.332)
	1991	109.670 (99.349)	0.806 (0.842)	57.012 (79.187)
	1992	13.900 (12.135)	3.950 (4.570)	175.549 (158.800)
	1993	6.936 (6.366)	3.679 (4.197)	196.397 (166.654)

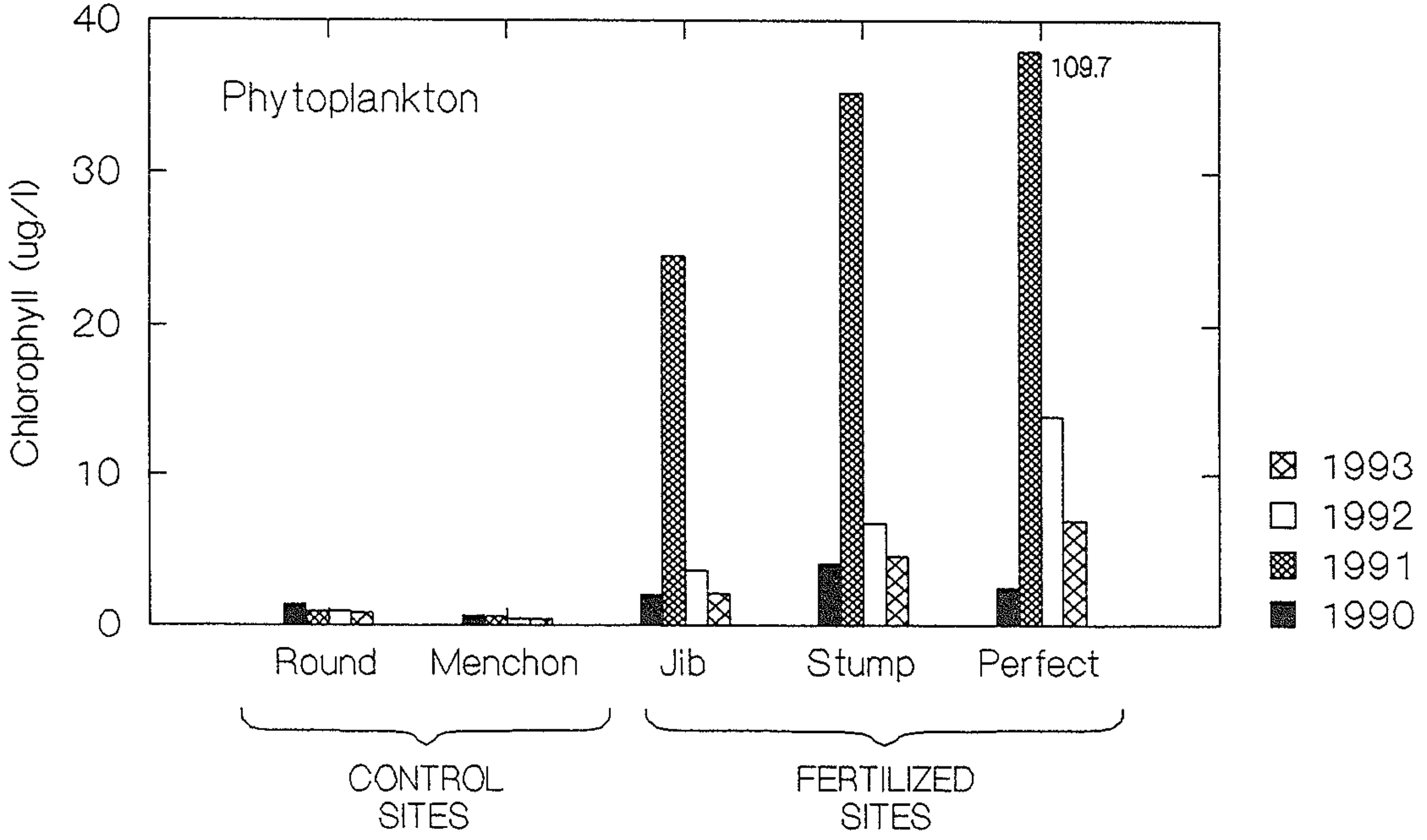

Figure 6. Mean phytoplankton chlorophyll *a* concentration at control and fertilized sites for the period between 1 May and 15 September of each year.

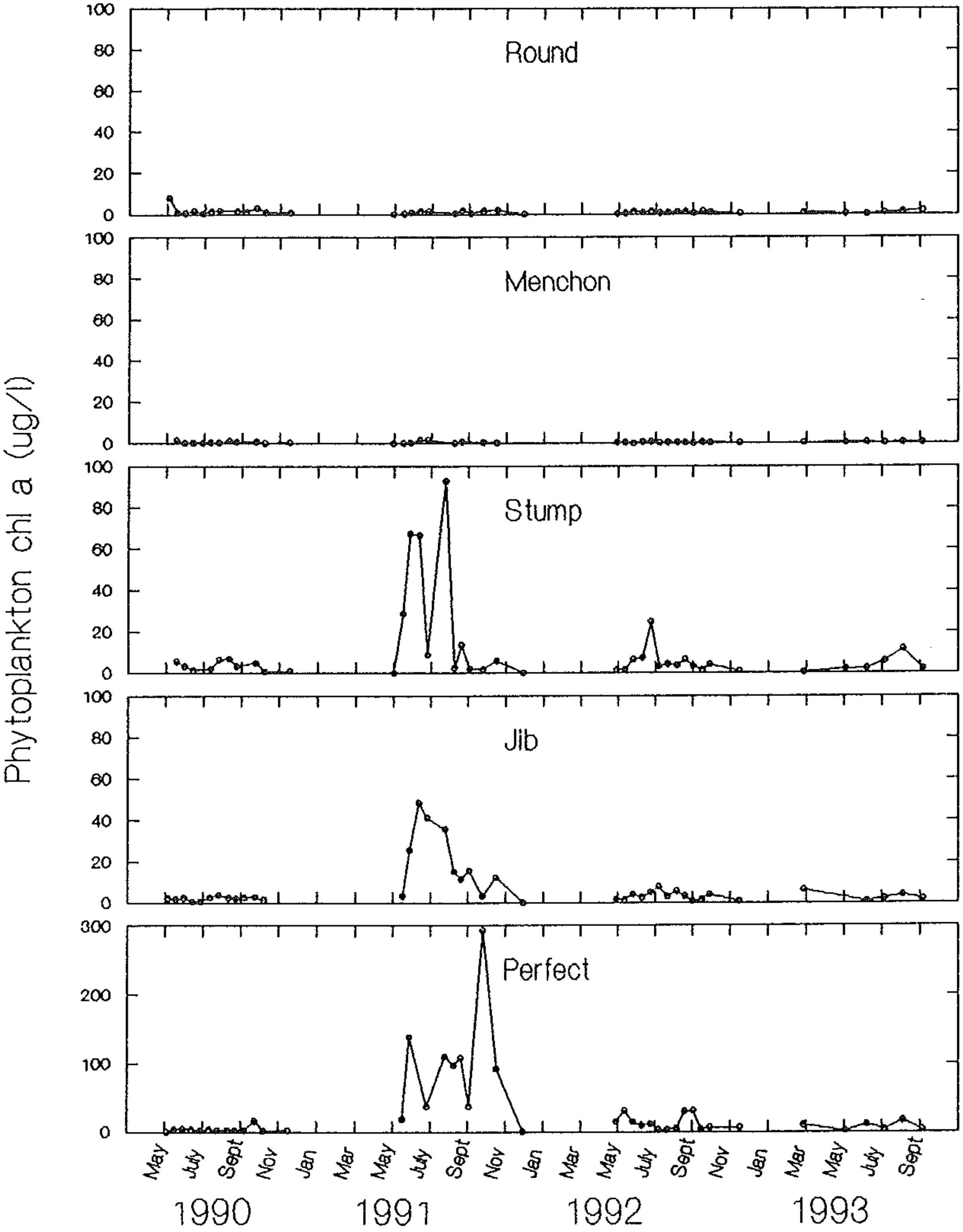

Figure 7. Seasonal variation in phytoplankton chlorophyll *a* concentration at control and fertilized sites.

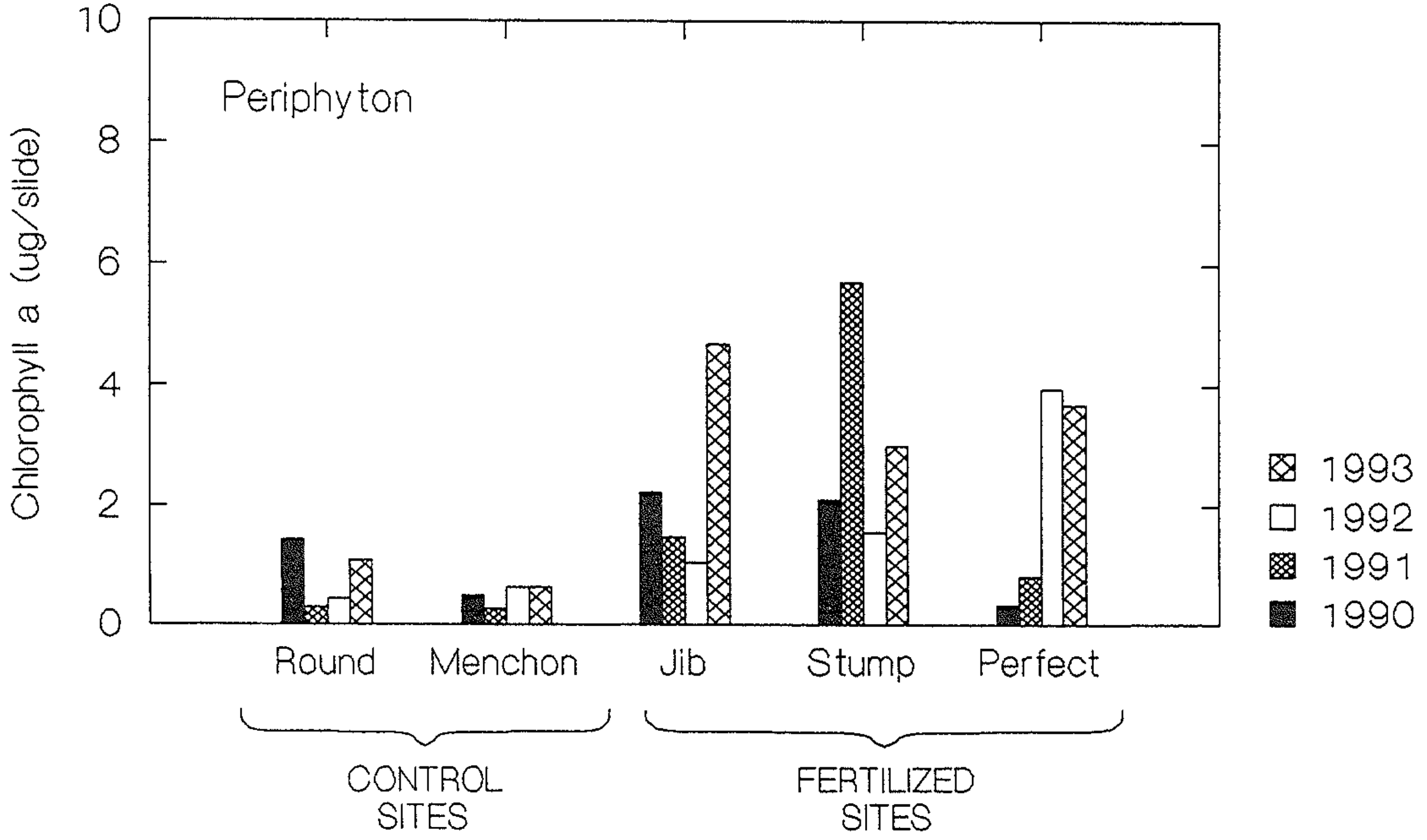

Figure 8. Mean periphyton growth at control and fertilized sites for the period between 1 May and 15 September of each year.

decreasing unless, perhaps, shading by phytoplankton was an important factor limiting periphyton growth during 1991.

Observations of macrophytes during 1990-1992 suggested that emergent and floating leaved macrophytes appeared to be healthier following fertilization as evidenced by their robust appearance and dark green colour. Observations during 1993 suggest that this is still true and it is probable that available nutrients within the sediments of the fertilized sites still persist at an increased level.

Zooplankton numbers showed various trends (Table 2 and Figure 9). At Jib, they decreased markedly and at Stump and Perfect they were slightly greater than during 1992. In all cases zooplankton abundance was considerably greater than prior to fertilization. There were also some notable changes in zooplankton composition (Figure 10). Copepods, as opposed to rotifers, were the most abundant group at Jib. At Stump, cladocerans replaced copepods and at Perfect rotifers replaced copepods.

Round and Menchon, the two control sites monitored during 1993, showed little difference in biological characteristics over that observed in previous years indicating that the natural variability of these systems tends to be small.

4. DISCUSSION

Although the 1993 monitoring programme was limited relative to that carried out during 1990-1992, the results seem to confirm the conclusion that enhancement of productivity through artificial nutrient addition by the method employed in this study (i.e. a large one-time addition of fast release fertilizer) has limitations with respect to producing long-term enhancement of productivity (Brylinsky 1993). This conclusion, however, is based primarily on observations of water column nutrient concentrations and phytoplankton chlorophyll *a* levels which, three years after fertilization, are very close to those observed prior to fertilization. Other biological components, in particular periphyton and zooplankton, and perhaps macrophytes, appear to be still benefiting from fertilization. These components may actually be of more relevance than phytoplankton from the viewpoint of waterfowl habitat. For example, there is considerable evidence that macrophytes and periphyton are important, as both a food source and as a substrate, for organisms thought to be important food sources of waterfowl. As a result, conclusions based on phytoplankton and water column nutrient concentrations alone may be somewhat misleading.

The studies carried out during 1990-1992 were not able to detect any changes in benthic and emergent insect abundance (the most important organisms with respect to waterfowl) as a result of fertilization, but it was suggested that these groups may take a longer period of time, because of their generally longer generation times, to exhibit the benefits of the increased primary production. Unfortunately the 1993 field study did not continue to

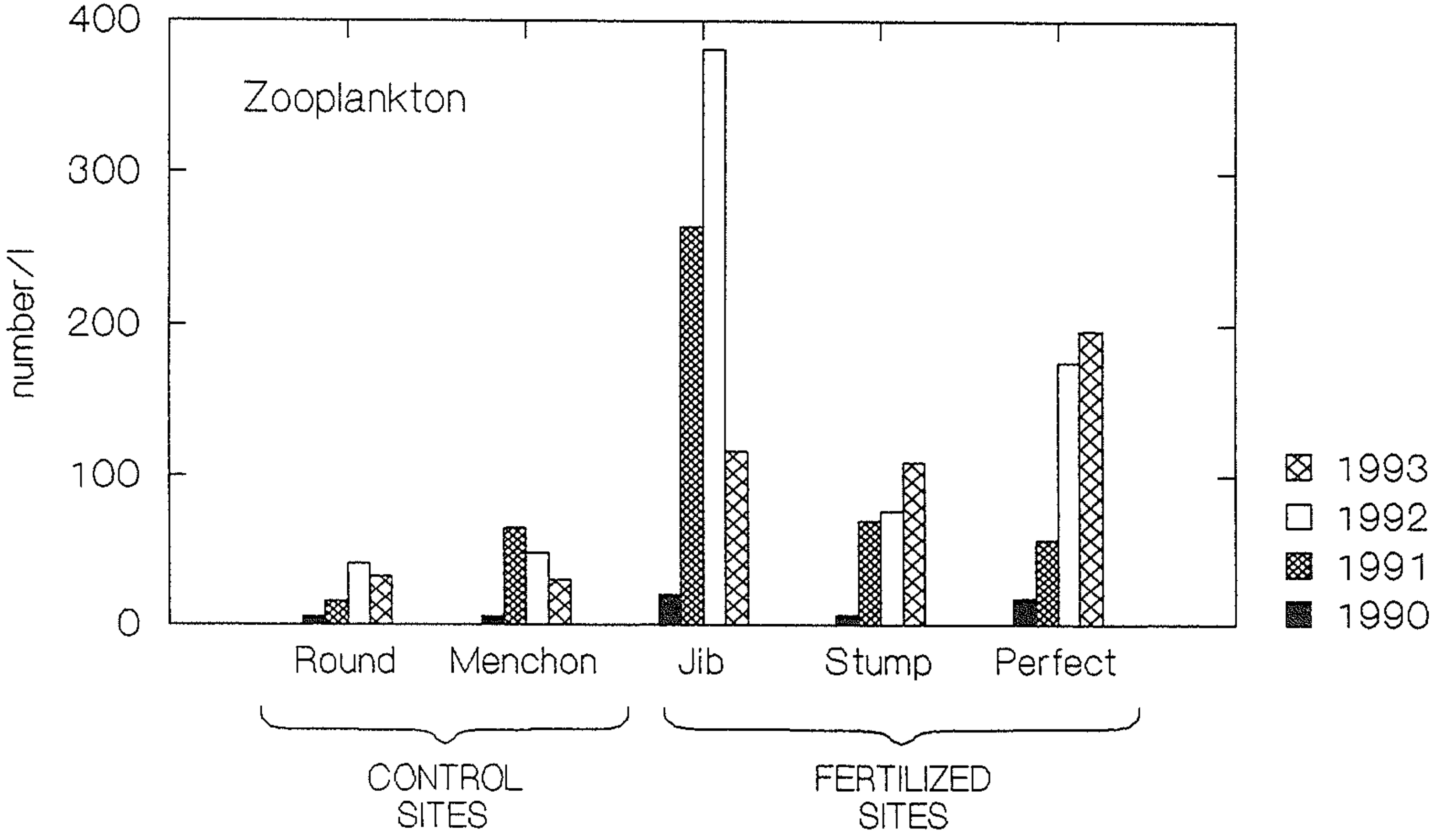

Figure 9. Mean zooplankton numbers at control and fertilized sites for the period between 1 May and 15 September of each year.

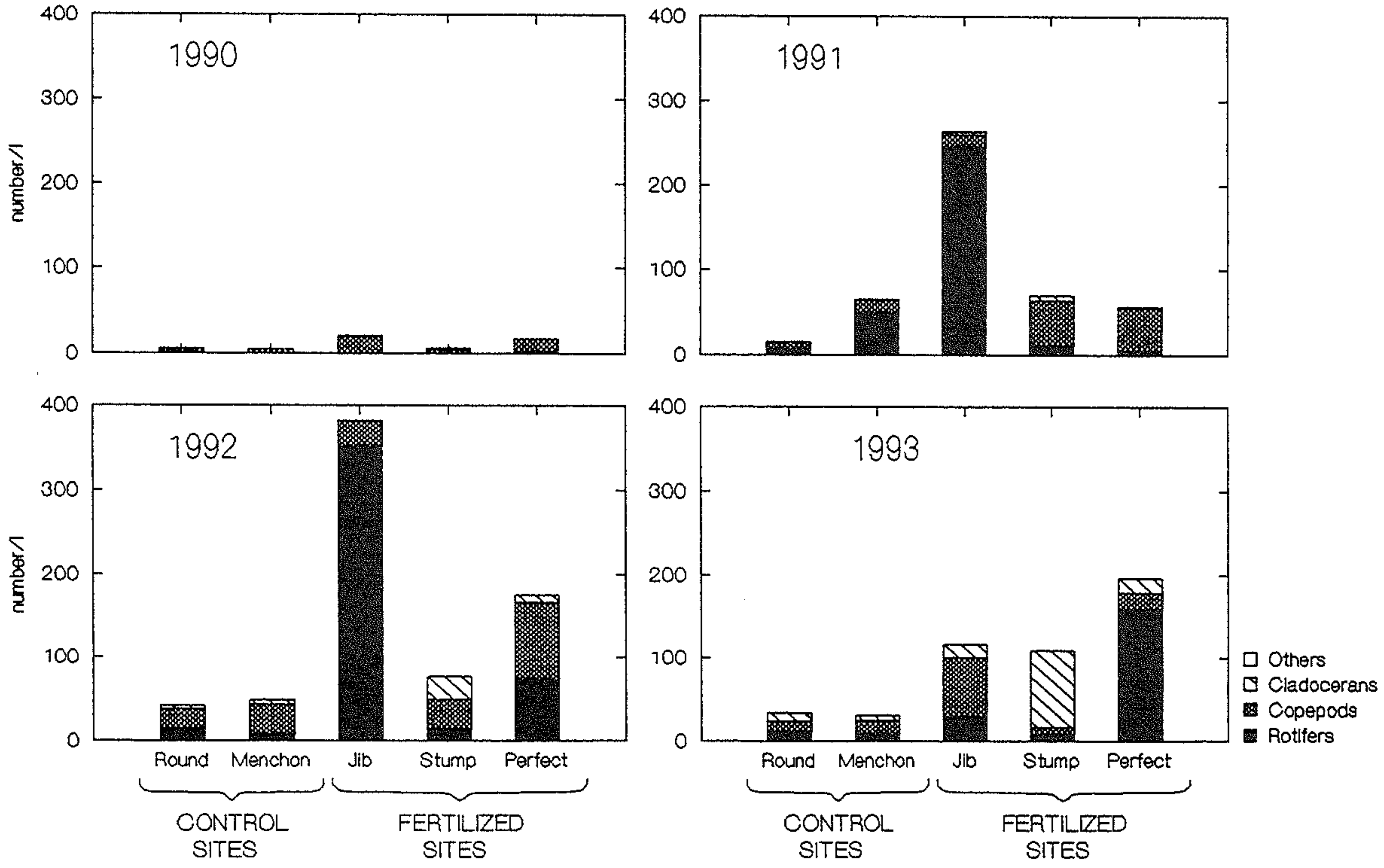

Figure 10. Zooplankton composition at control and fertilized sites for the period between 1 May and 15 September of each year.

monitor these components and the question of whether or not this occurs remains unanswered.

5. ACKNOWLEDGMENTS

This report was prepared with the help of Jamie Gibson. Field sampling and sample analyses were carried out by Jamie Gibson and Kuflom Kuflu. Reg Melanson and Randy Milton of the Nova Scotia Department of Natural Resources provided valuable logistic support. Dr. Joseph Kerekes of the Canadian Wildlife Service arranged for the chemical analysis of water samples which was carried out by the Inland Waters Directorate of Environment Canada at Moncton, N. B.

6. REFERENCES

Brylinsky, M. 1993. Evaluation of controlled fertilization of acidified wetlands for enhancement of waterfowl production. Acadia Centre for Estuarine Research Report No. 28, Acadia University, Wolfville, N.S.