Newman Lake 2012 Water Quality Monitoring

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Water Quality Summary

This report discusses water quality measurements and sample analyses conducted on Newman Lake for 2012. Data files are provided in the accompanying appendix. All sampling stations and methods remained unchanged from previous years and may be found in previous reports

Newman Lake water quality for 2012 was generally good in terms of transparency and algae, but there were some potential indicators that warrant attention. For example, in the former case mid-summer Secchi depths were as high as 4 m, and diatoms, such as *Aulocosierra (Melosira)*, continued to dominate the summer phytoplankton community, with little Cyanobacteria representation. On the other hand, total phosphorus (TP) concentrations were generally higher and volume-weighted total phosphorus (VWTP) for the season was 34 μg/L, a substantial increase from previous years. It should be noted that similar patterns were evident for nearby Liberty Lake for 2012, perhaps suggesting that environmental factors, such as higher summer runoff, may have played a role in external phosphorus loading.

Secchi transparency ranged from a low of 1.5 m in mid-April and September to high values of about 3 to 4 m in late July/early August. The low measurements were made during spring and fall turnover. Consistent with other years, Secchi depths improved immediately with microfloc alum additions. Interestingly, the highest Secchi values were coincident with the highest total phosphorus concentrations.

TP for 2012 ranged from a low value of 19 μg/L to a maximum of 64 μg/L. The high value was measured in a mid-lake bottom sample. Occasionally, bottom samples may be contaminated with sediments, and this sample appears to be inexplicably high. However, bottom concentration for other dates were elevated compared to the overlying waters, and the pattern is certainly real.

VWTP for 2011 and 2012 was 36 and 34 μg/L, respectively. Although this is a slight decrease for 2012, it is not particularly significant, and is very much counter to trends in lake TP for the past 12 years (Figure 1). Indeed, the year 2000 was the last one before 2011 in which seasonal VWTP exceeded 30 μg/L. Target TP for Newman Lake has been about 20 μg/L, with at least half the values for that same 12-year period have been at or below this target. The TP concentration frequency distribution was also heavily weighted at the higher ranges, with 33 and 61% of total measurements in the 21 to 30 and 31 to 50 μg/L ranges, respectively.

Epilimnetic dissolved oxygen (DO) measurements throughout the summer were generally greater than saturation, indicating active photosynthesis in the water column. Measurements were mostly taken between the daylight hours of 11 am and 3 pm; but saturation levels do not indicate particularly intense algae activity.

Hypolimnetic oxygenation was implemented in Newman Lake in 1992 to control phosphorus recycling from anoxic lake sediments, and this has been a major element in restoration and management since that time (Moore et al. 2012). Operational and environmental constraints limited full oxygenation potential of the system until about 2001, when the overall trend in TP began declining (Figure 1). Ideally, minimum hypolimnetic DO should be greater than about 4 mg/L, but DO above 2 mg/L at the sediment/water interface is sufficient to reduce TP internal loading. For 2012, hypolimnetic DO was above this minimum until late July, when DO was less than 1 mg/L at depths of 6 m and below. Low hypolimnetic DO was also evident in the August 8 sampling below about 6 m. By August 30 the lake was essentially isothermal at about 21^{o}C indicating that fall turnover was in progress.

Nurnberg Anoxic Factor (AF) is a widely accepted index to quantify spatial and temporal anoxia in lakes. AF for dimictic, temperate zone lakes with water quality problems related to hypolimnetic anoxia typically ranges from about 20 to 70 days. AF for Newman Lake was greater than 20 until about 2001, when the system was operated full time and within its environmental design values (Figure 2). Since 2001, AF has been lower than 10 days, and was 0 days for 2005 and from 2007 to 2010. The last year was an exception, with seasonal AF of about 19 days.

For the last 2 years, AF increased, corresponding with increased TP. Although this does not demonstrate cause/effect, substantial research shows that AF is a strong predictor of internal TP load. Mechanistically, this is the very reason for hypolimnetic oxygenation, and AF also provides a measure of system performance. For 2012, compressor overheating caused system outages during July and August. This is typically a period of maximum sediment oxygen demand (SOD). The net results is that oxygen inputs were below the threshold necessary to satisfy SOD and thus to maintain adequate DO. Research has also demonstrated oxygen transfer efficiency in Speece cones is highly dependent on oxygen/water flow rates. Our work has also shown that the Newman Lake system is capable of delivering adequate oxygen, but that it does not have significant excess capacity. Therefore it is important that the system be run at maximum capacity during the *entire* period of stratification.

Increases in lake phosphorus are of concern as they may ultimately lead to high algae productivity and to Cyanobacteria blooms. Various measures of phytoplankton were indeed higher for 2012, but Cyanobacteria were not significant in those measures (Figures 3 and 4). Average photic zone whole lake algae biomass data (estimated by biovolume) from 1986 through 2012, for all years in which adequate data are available, are shown in Figure 3. For both 2011 and 2012, it is clear that Bacillariophyta (diatoms) dominated the Newman Lake plankton assemblages, with some minor representation of Chlorophyta (greens) and Pyrrophyta (golden-brown).

This later group was primary represented by *Dinobryon*, which has been common in early spring. *Dinobryon* has frequently appeared in large numbers in Newman Lake soon after spring turnover, and is responsible for the brownish coloring and slight odor that has been noted at those times. The literature on lake restoration indicates that blooms of *Dinobryon* and other Pyrrophyta are common in restored lakes, but mechanisms are not well understood. *Dinobryon* is usually found in small numbers throughout the year in Newman Lake samples, and does appear to be able to reproduce rapidly when temperatures are cold. Many diatoms also are capable of rapid reproduction in colder temperature and are thus responsible for the first burst of algal productivity in spring as soon as the lake thaws and turnover begins. It is very likely that *Dinobryon* “blooms” when diatoms have depleted spring silica reserves in the lake, limiting diatom growth. Typically, the Pyrrophyta blooms decline rapidly, usually within a few days.

Overall, the *Dinobryon* blooms do not constitute a significant problem or indicate major water quality declines. However, we are concerned with potential for increased Cyanobacteria with increased phosphorus in Newman Lake. A likely mitigating factor for the past few years is that TN/TP ratios have been above the Redfield ratio, which is a common measure of how to assess nutrient limitation. Total nitrogen to total phosphorus ratios (TN/TP) averaged about 11 for the season, significantly above about 7 (weight/weight basis) that would indicate a transition to nitrogen limitation (Table 1). TN/TP for individual dates are above 7 more most of the samplings in 2012, except for July when some of the ratios were slightly less. Overall, the data show that phosphorus is still limiting to primary productivity in Newman Lake. However, is should be emphasized that all efforts to reduce both external and internal loading to Newman Lake should be pursued vigorously.

Other measurements such as pH and alkalinity were within acceptable ranges for 2012. There was no indication of significant decreases in pH within the summer hypolimnion, and alkalinity values showed that buffering capacity was not being negatively impacted. Zooplankton and benthic invertebrate densities were consist with past years, and indicated healthy overall ecological conditions in the lake.

Management Recommendations

With over 20 years experience with hypolimnetic oxygenation in Newman Lake, it is clear that the system is capable of maintaining adequate oxygen to reduce internal phosphorus load. The system is not oversized, so operation throughout stratification at maximum capacity is necessary. Minor problems, such as power outages, may cause the system to shut down briefly, and these incidents will not significantly impact oxygen delivery or lake DO. However, extended down time is of concern. As system components age, they may be more susceptible to problems. Therefore, it is recommended that the District ensure procedures are in place to monitor operation frequently and respond rapidly to restart after any shutdowns. Also, maintenance should be performed regularly with major activities scheduled as much as possible for winter months. The District has already implemented most of these recommendations. However, it is suggested that some telemetered, remote monitoring might be implemented on the compressors at very modest cost. Costs could potentially be offset by reduced expenditures for personnel site visits.

Last year, we recommended that alum supplies be directed at spring turnover. The same recommendation is appropriate, with an additional comment that some reserves be maintained for summer. If the in-lake pump is not operational, then alum cannot be delivered. However, in situations in which the PSA generators cannot deliver oxygen, or compressors cannot run, it is still possible to inject alum. Summer alum injections whenever oxygen is not being delivered could, at least partially, mitigate oxygen depletion. Alum in the summer hypolimnion would scavenge recycled sediment phosphorus, preventing re-injection into the epilimnion and photic zone. Overall, these proposals require only minor alterations in the established alum plan, but may involve some changes in priorities with less emphasis on fall turnover.

We have good understanding of lake nutrient status and biology. However, we do not currently conduct stream monitoring; this is largely a function of personnel time and budget constraints. One paragraph from the 2011 report is repeated here, as it is still germane to understanding the source(s) of increased lake TP: “To help identify external loading trends and potential sources, it is recommended that the District reemploy volunteer monitoring efforts. These would be similar to those of previous years, but of more limited extent and volunteer time commitments. Grab samples from Thompson Creek for nutrient analyses, along with regular recording of staff gage height are especially important. Samples and readings could be taken at approximately one-week intervals, from the Thompson Creek bridge, which is an established monitoring location in previous studies. District and WSU staff should work on recalibration of the staff gage for a stream-rating curve that will allow for calculation of gage height to stream discharge in the current stream geometry. Coupled with the nutrient analysis, these efforts would again permit construction of phosphorus loading estimates from Thompson Creek, with reasonable extrapolation to other sub-watersheds.”

Other monitoring and operating procedures for 2013 should be consistent with past practices. Again, suggestions from the previous year report remain relevant and important: “These efforts should be continued, but emphasis on, and new strategies for, watershed nutrient reduction should be sought for protecting future water quality in Newman Lake.”

Moore, BC, BK Cross, M Beutel, S Dent, E Preece, and M Swanson. 2012. Newman Lake restoration: A case study Part III: Hypolimnetic oxygenation. *Lake and Reservoir Management 28(4): 311-327.*

Figure 1. Average annual volume-weighted total phosphorus in Newman Lake. Values in ug/L, as phosphorus. WL alum = whole lake alum treatment; Ox = hypolimnetic oxygenation; 100F = 100 yr flood event; OxOS = system out of service; MF alum = microfloc alum.

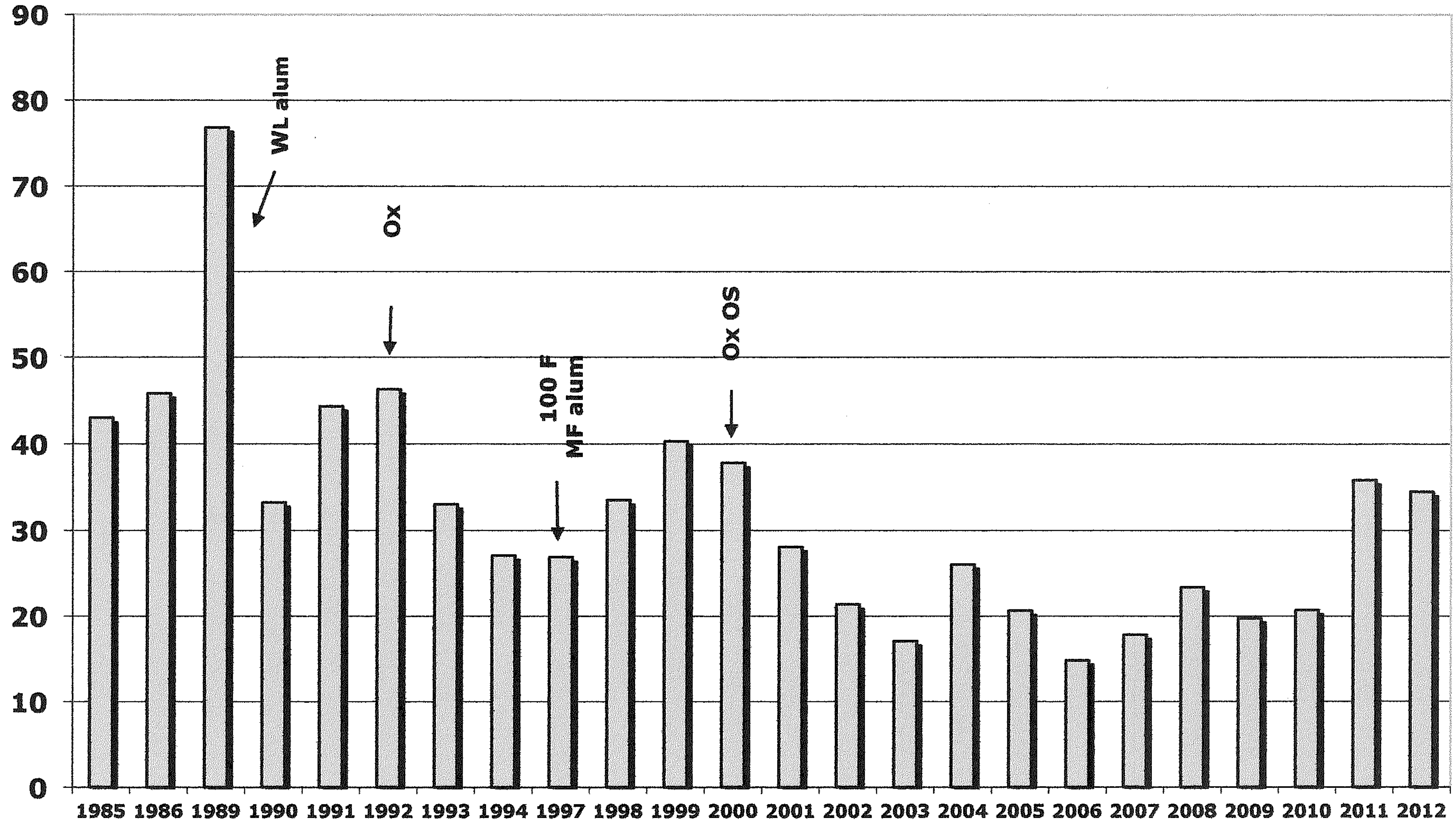

Figure 2. Summer Anoxic Factors in Newman Lake 1986 to 2009

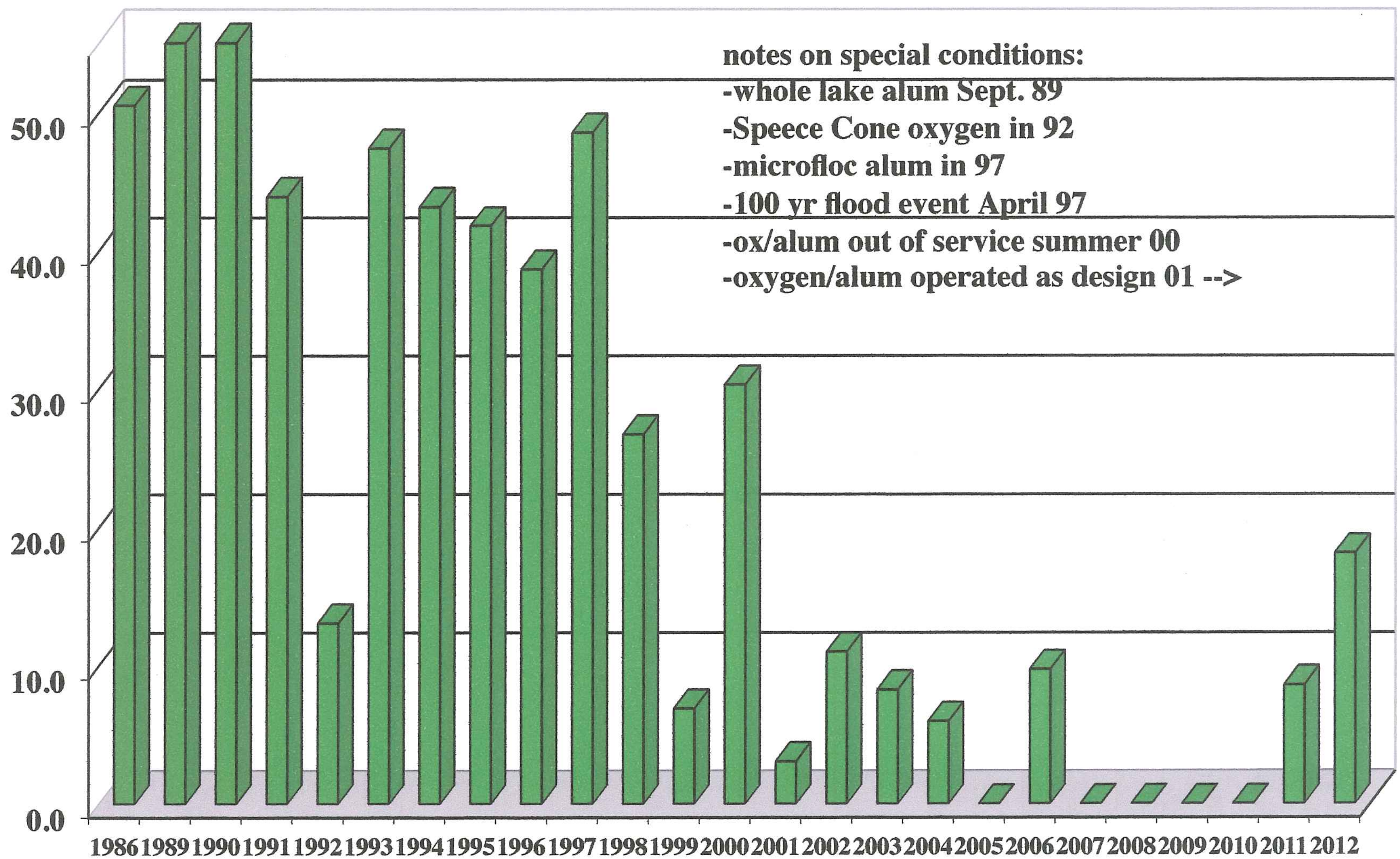

Figure 3. Total average photic zone algae biomass in Newman Lake.

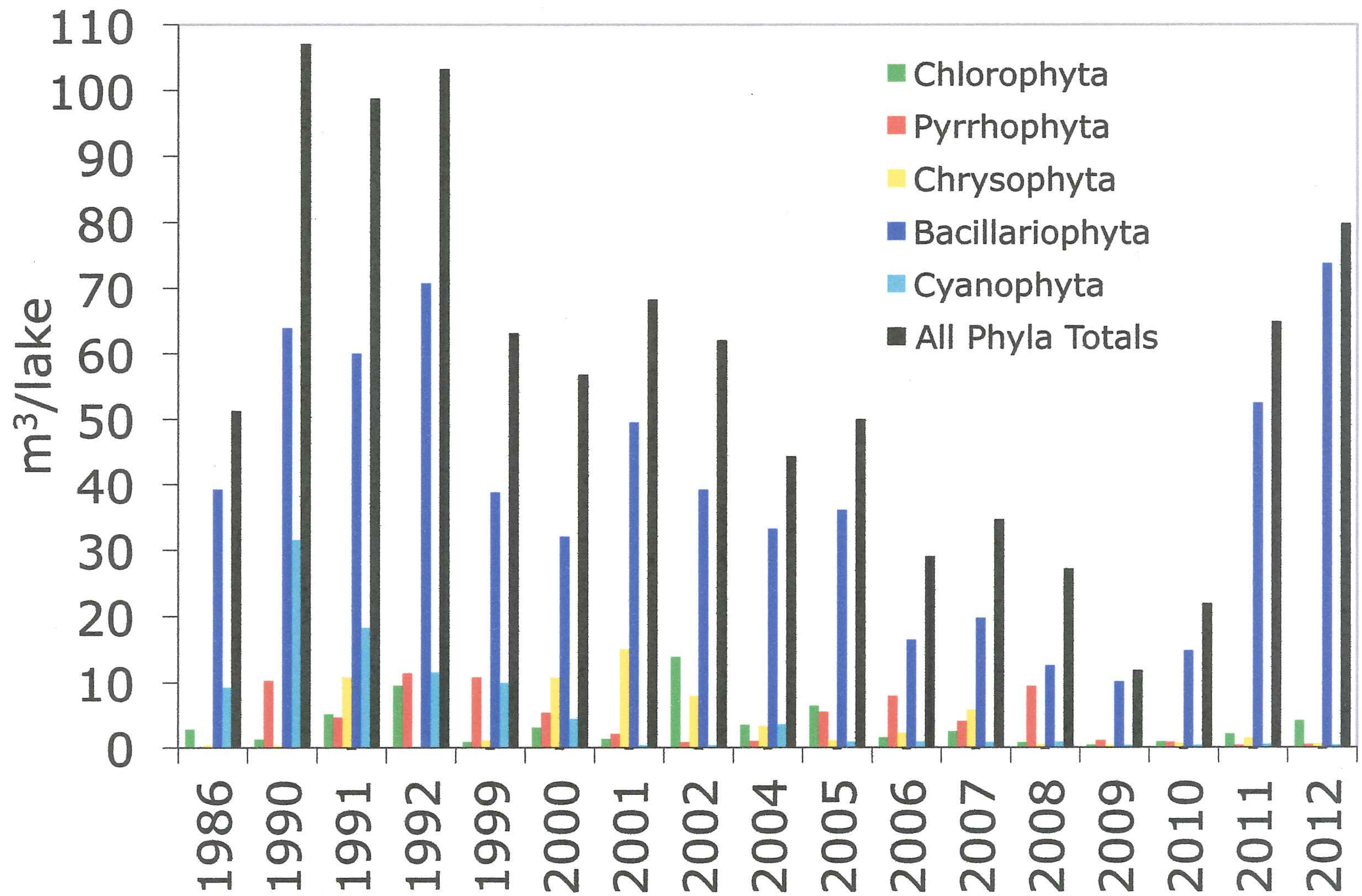

Figure 4. Peak total and blue-green phytoplankton biovolumes,Newman Lake 1989 to 2012.

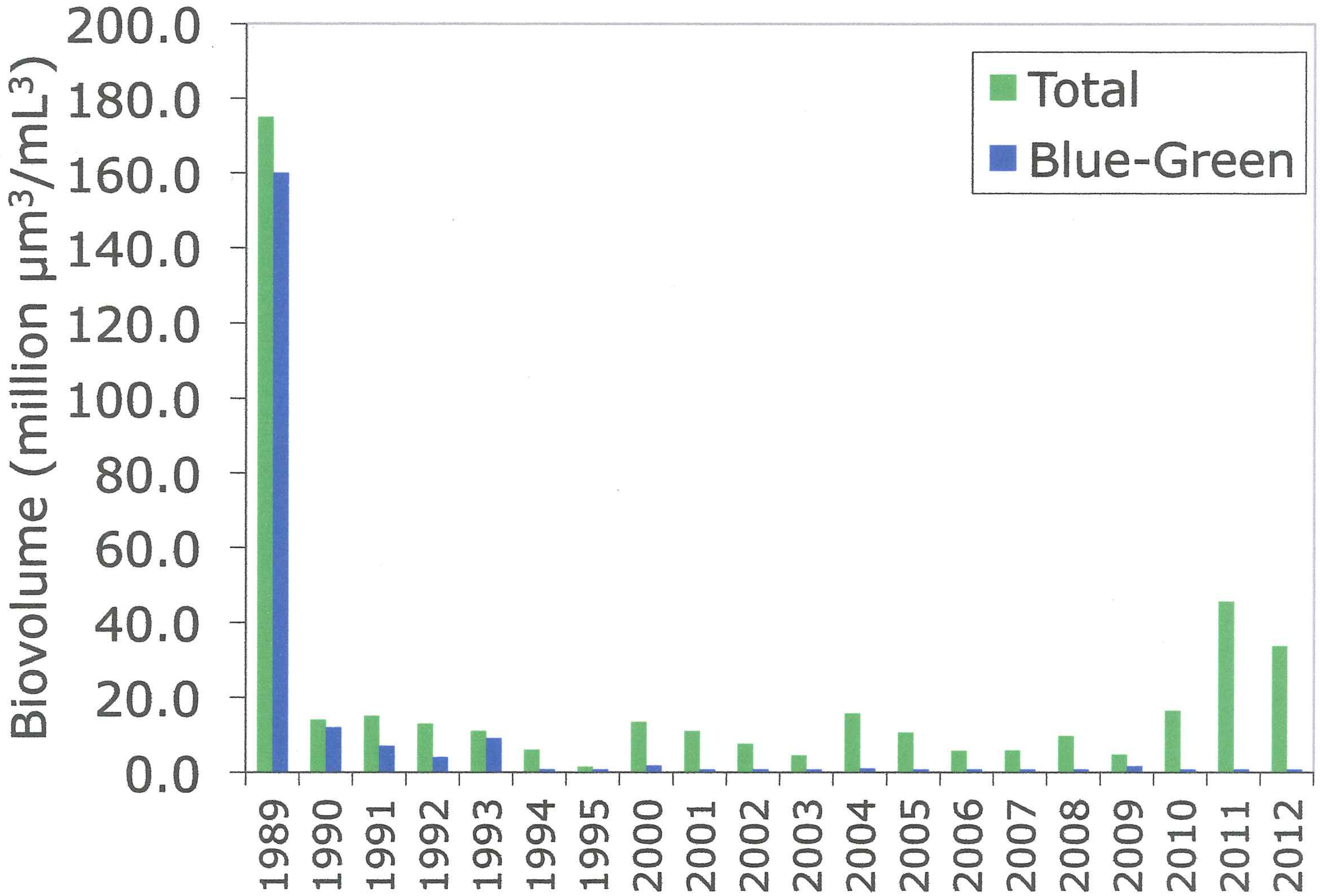

Table 1. Total nitrogen to total phosphorus ratios (TN/TP) for Newman Lake, 2012. Values are expressed on a weight/weight basis.

	Apr-19	*May-17*	*May-30*	*Jun-14*	*Jun-28*	*Jul-12*	*Jul-31*	*Aug-08*	*Aug-30*	*Sep-13*	*Sep-27*	*Oct-10*
North-top	13	12	11	8	7	9	10	9	12	13	13	18
North-mid	11	12	11	8	7	9	9	9	10	9	11	11
North-bot	10	11	10	7	6	11	8	7	10	9	9	11
Mid-top	14	13	11	8	8	10	9	10	11	10	11	16
Mid-mid	12	11	11	7	7	11	8	9	11	9	-	11
Mid-bot	11	11	11	5	6	8	8	9	8	8	10	10
South-top	12	13	19	7	7	9	8	9	10	10	11	11
South-mid	13	12	11	8	6	10	9	9	10	8	9	10
South-bot	12	12	11	8	7	9	8	8	11	8	9	10