Relationship between phosphorus release and sediment characteristics in Big Platte Lake, Benzie Co., MI

2005 Summary Report

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Objectives

The overall objective of this study is to better characterize the sediment throughout Platte Lake and to determine the magnitude of internal phosphorus release. The main goal is to examine the effect of seasonal variation in hypolimnetic oxygen concentrations on sediment phosphorus release. In order to thoroughly describe the sediment throughout Platte Lake and to accurately compare Platte Lake to other lakes in similar studies, grain size (%sand: %silt: %clay), % water, % volatile solids, total sediment phosphorus (mg/g dry), and sediment oxygen demand (g O^2/m^2/day) were also measured. Thus, sediment oxygen demand and other sediment parameters are beneficial to better understand phosphorus release from the sediments in Platte Lake.

Methods *(Abridged)*

For 2005, sediment samples were collected from Platte Lake on two dates (2/23/05 and 5/10/05) for analysis of phosphorus release and other sediment characteristics. Four sites (T1-28, T2-22, T1-12 and T3-5) were sampled in Platte Lake during 2005, and SOD (sediment oxygen demand) and anoxic phosphorus release (p-release) were determined from separate sediment cores collected using a modified Kajak-Brinkhurst corer. For the cores collected on 2/23/05, both SOD and anoxic p-release were evaluated for each site. On 5/10/05, two additional cores were collected from both T1-28 and T3-5 to be used as replicates for better estimation of anoxic p-release, thus anoxic p-release was measured in a total of three cores from each site. Mean anoxic p-release rates were calculated for T1-28 and T3-5 to assess the spatial variation present at both sites. To accommodate the extra sediment cores, SOD rates were not determined for any of the sites sampled on 5/10/05.

Grain size, % water, % organic matter, and total sediment phosphorus (TP) were all determined from sediment grab samples. Grab samples were collected on the same dates as phosphorus release core samples using a Mini-Ponar grab sampler. Determination of sediment grain size was conducted during the summer of 2005 using the hydrometer method (Bouyoucos' method) on previously-dried sediment. Percent sand (2.0-0.05 mm), percent silt (0.05-0.002 mm), and percent clay (<0.002 mm) were

established according to Stoke's Law, which is based on the known settling velocity of the different size fractions. *(See previous annual reports for more detailed explanations of the study methods for the parameters other than grain size).*

2005 Results

Grain Size Analysis

During the summer of 2005, relative percentages of sand (2.0-0.05 mm), silt (0.05-0.002 mm), and clay (<0.002 mm) were determined for 13 locations in Platte Lake from grab samples collected during the initial sediment survey on 7-9-03. In general, the sediments at the shallowest locations were composed mainly of sand-sized particles, while the sediments at the deepest locations were composed mostly of finer-grained silt and clay particles (*Figure 1*). Site T3-2 yielded the highest percentage of sand (91.7 %) with a low abundance of silt and clay-sized particles (8.3%). Conversely, the greatest percentage of silt and clay (79.9 %) was found at the deepest site, T1-28. Sites with depths greater than 12 m all showed noticeably lower percentages of sand and higher percentages of silt and clay than sites with a depth of 5 m or less.

2005 General Sediment Characteristics

During 2005, sediment characteristics in Platte Lake (% water, % volatile solids, and total sediment phosphorus) were determined for 4 locations from grab samples collected on 2 dates (*Table 1*). Overall, the highest % water, % volatile solids, and total phosphorus content occurred at the deepest locations in Platte Lake (T1-28 and T2-22). For the samples collected on 2/23/05, site T1-28 yielded the highest volatile solids (14.00 %) and total phosphorus (0.296 mg/g), whereas the greatest volatile solids (13.56 %) and total phosphorus (0.247 mg/g) for the 5/10/05 sample collection occurred at site T2-22. The total phosphorus at site T1-28 was considerably lower on 5/10/05 (0.195 mg/g) than on 2/23/05 (0.296 mg/g). Slightly higher water content was also observed for T1-28 compared to T2-22 on both

occasions (*Table 1*). Similarly on 2/23/05 and 5/10/05, the lowest water content, volatile solids, and total sediment phosphorus were found at site T3-2 (*Table 1*).

2005 Sediment Oxygen Demand and Anoxic Phosphorus Release

SOD (sediment oxygen demand) was compared for 4 locations in sediment cores collected on one date in 2005 (2/23/05). As was seen with the previous trials of SOD cores from Platte Lake, the SOD rate (g O^2/m^2/day) was generally higher at the deeper sites (*Figure 2*). Site T3-5 yielded the lowest SOD rate (0.53 g O^2/m^2/day), while site T1-28 produced the highest SOD rate (1.28 g O^2/m^2/day). The most visible distinction in SOD rates when comparing each site to the other sites of nearest depth was between site T1-28 (1.28 g O^2/m^2/day) and T2-22 (0.78 g O^2/m^2/day). Therefore, in direct comparison to the deepest site (T1-28), the three shallower sites (T2-22, T1-12, and T3-5) showed a relatively low SOD on 2/23/05.

Anoxic phosphorus release rates during 2005 were measured in sediment cores collected on two dates (2/23/05 and 5/10/05) from 4 locations. For the cores collected on 2/23/05, all of the sediment cores yielded positive anoxic phosphorus release rates (*Figure 3*). The highest anoxic p-release was found at site T1-28 (2968 µg P/m^2/day), while the lowest anoxic p-release was observed at site T2-22 (18 µg P/m^2/day). Furthermore, the 2/23/05 cores for both T1-12 and T3-5 showed moderate anoxic p-release (*Figure 3*)

Similar to the 2/23/05 p-release cores, the anoxic p-release rates for all of the sediment cores collected on 5/10/05 were positive (*Figure 4*). Of the three sediment cores collected at T1-28, the mean anoxic p-release was 845 µg P/m^2/day. For the 5/10/05 cores, the anoxic p-release rates for each of the three cores from T1-28 were comparatively similar (989, 928, and 618 µg P/m^2/day). The mean anoxic p-release for T3-5 was 446 µg P/m^2/day; however the range of the three p-release rates was much greater (705, 579, and 55 µg P/m^2/day). The 5/10/05 cores for both T2-22 and T1-12 produced minor anoxic p-release rates (320 µg P/m^2/day and 127 µg P/m^2/day, respectively).

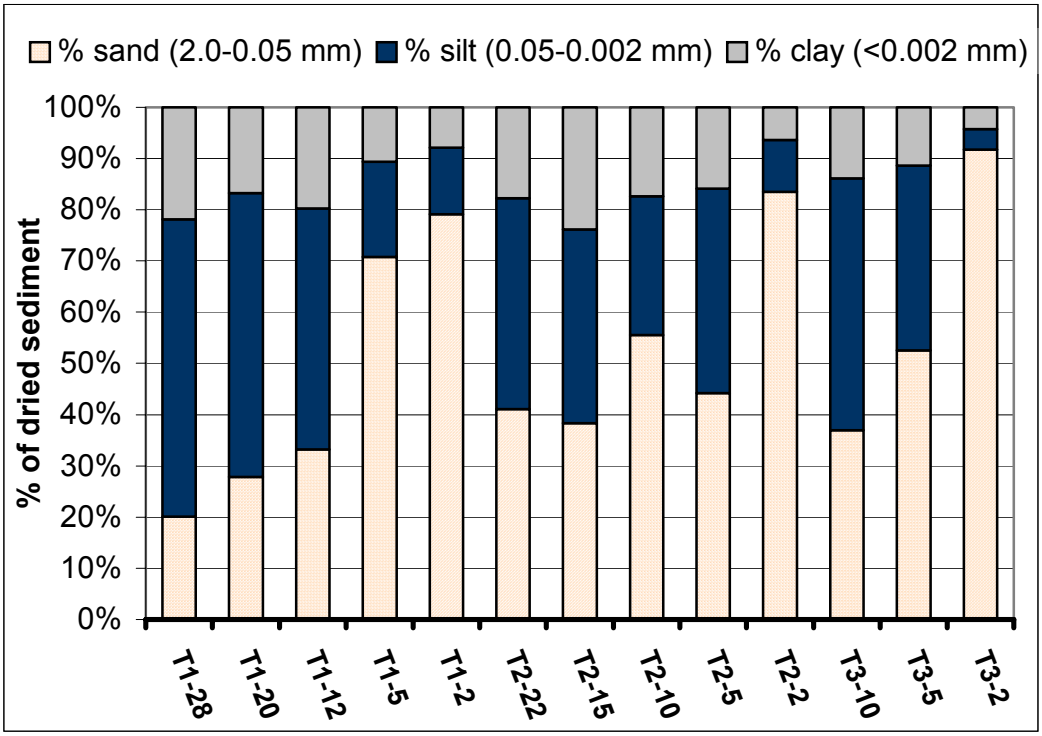

Figure 1: Relative percent distribution of sediment grain size at 13 locations in Platte Lake. Grain size was determined during the summer of 2005 from dried grab samples taken during the initial sediment survey on 7-9-03. The water depth at each site can be identified by the second part of each site designation (i.e. T1-28 corresponds to a depth of 28 m).

Table 1: Sediment data of % water, % volatile solids, and total phosphorus (TP) are shown for 4 locations in Platte Lake. Grab samples were collected on 2 dates in 2005.

	2/23/2005			5/10/2005		
Site	Water Content	Volatile Solids	TP (mg/g dry)	Water Content	Volatile Solids	TP (mg/g dry)
T1-28	77.97%	14.00%	0.296	77.31%	11.97%	0.195
T1-12	71.24%	9.05%	0.163	71.90%	9.46%	0.174
T2-22	77.66%	12.84%	0.229	76.10%	13.56%	0.247
T3-5	46.92%	3.83%	0.101	51.91%	4.63%	0.134

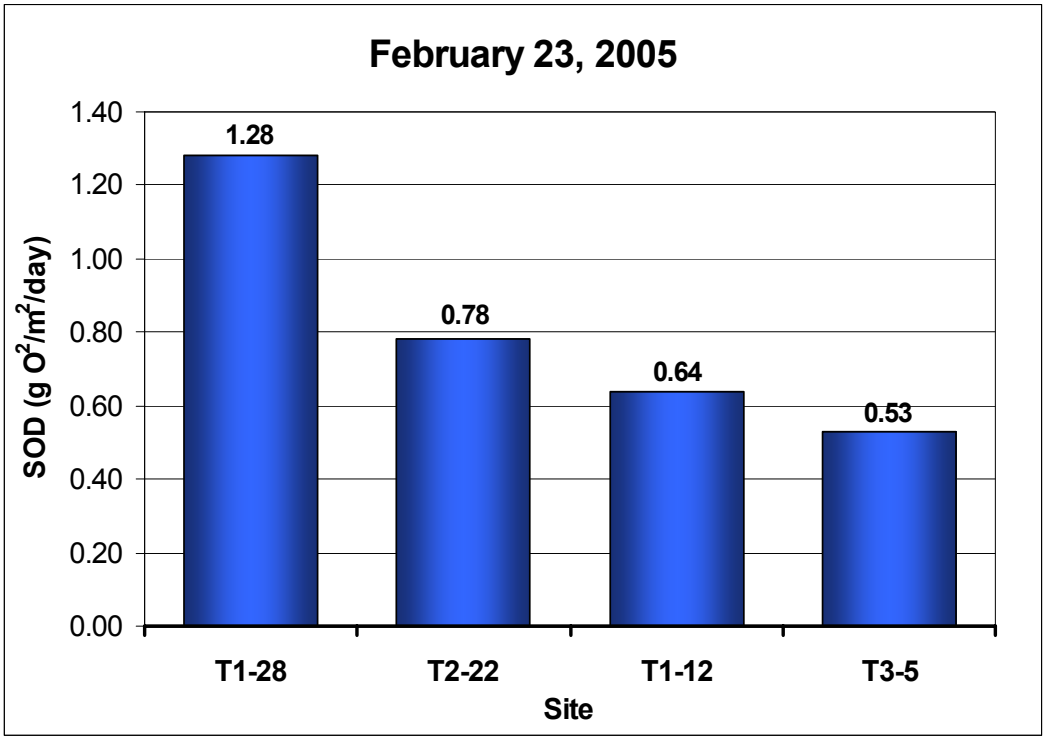

Figure 2: Comparison of sediment oxygen demand (SOD) among 4 sites in Platte Lake. SOD rates were determined over an 8-hour period in sediment cores collected on February 23, 2005.

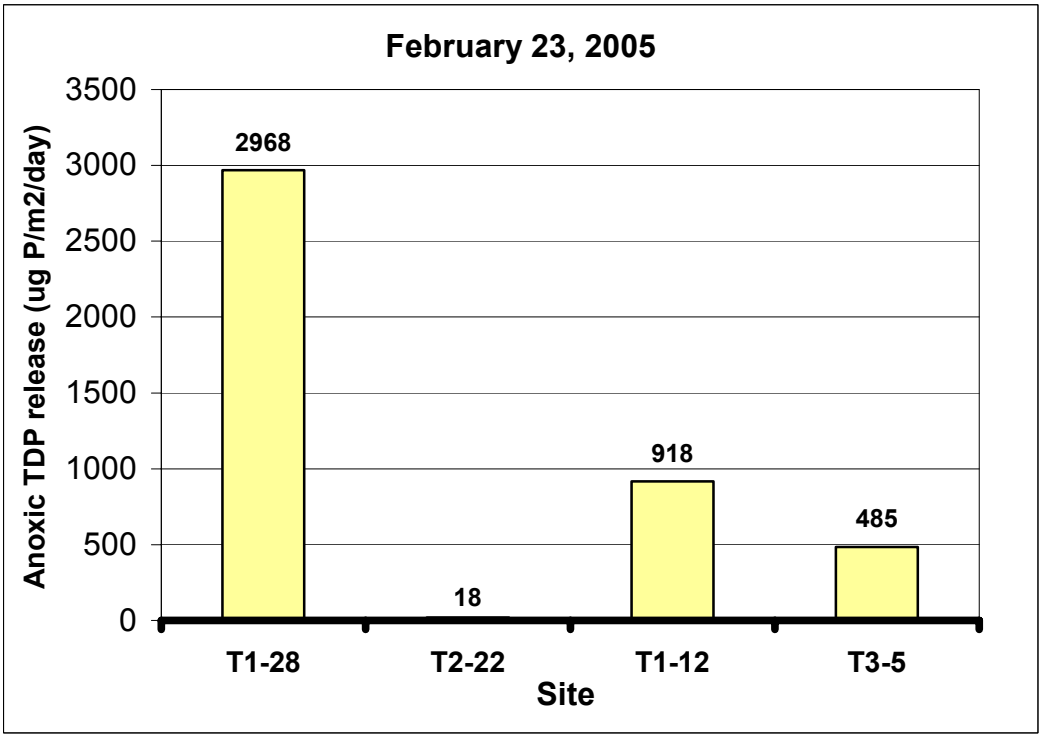

Figure 3: Comparison of anoxic total dissolved phosphorus (TDP) release rates among 4 sites in Platte Lake. Release rates were determined over a 10-day period from sediment cores taken on February 23, 2005.

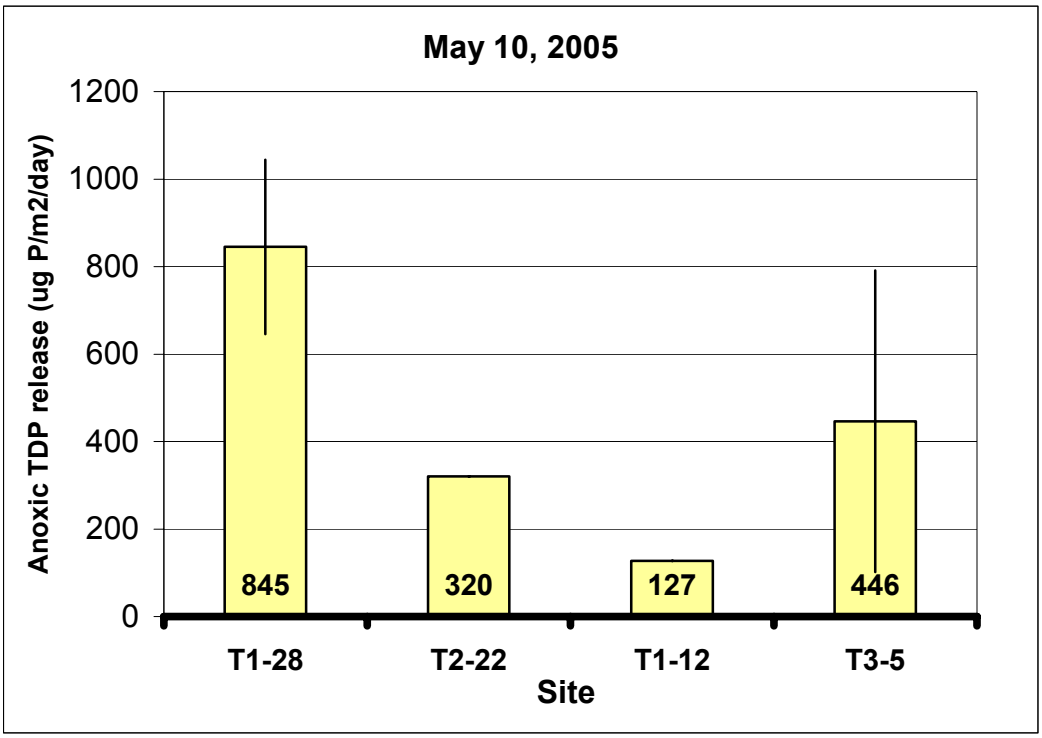

Figure 4: Comparison of anoxic total dissolved phosphorus (TDP) release rates among 4 sites in Platte Lake. Release rates were determined over a 10-day period from sediment cores taken on May 10, 2005. The values indicated for sites T1-28 and T3-5 are mean rates determined from 3 cores collected at each location. The values for sites T2-22 and T1-12 were established from one core collected at each location.

Discussion

The general trend of increasing percentages of silt and clay-sized particles with depth that is evident in Platte Lake is common in most lakes due to the increased resuspension of fine-grained particles in shallow-water areas from the scouring effect of regular wind/wave action on the sediment surface. The sediment surface in deep-water areas is not physically impacted by wind/wave action as consistently as shallow-water areas, if at all, resulting in increased deposition of silt and clay-sized particles. Based on the range of depths sampled in Platte Lake, depths of approximately 10-12 m appear to be the cut off between sediments comprised mostly of sand and sediments composed mainly of silt and clay-sized particles, although the sample from site T2-10 was composed of more sand-sized particles than the other locations of similar depths.

Prior to beginning this study, it was expected that % water, % volatile solids, and total sediment phosphorus would increase with depth in Platte Lake, and this prediction has generally held true over

multiple sampling periods. The deepest part of Platte Lake (T1-28) has continually been found to contain high % water, % volatile solids, and total sediment phosphorus, whereas the lowest % water, % volatile solids, and total sediment phosphorus concentrations have mainly come from the shallowest sites.

Similar to previous cores from Platte Lake in which SOD was determined, the 2/23/05 cores from sites T1-28 and T2-22 continued to have the highest SOD rates in comparison to other locations in Platte Lake. A probable explanation for a high SOD at deep-water sites is the longer *in situ* duration of anoxia compared to shallow-water sites along with typically higher % volatile solids and total phosphorus. Moreover, the SOD rates for 2/23/05 were lower than SOD rates determined from cores collected during other times of the year. The highest SOD rate measured in the 2/23/05 cores was 1.28 g O^2/m^2/day at site T1-28, whereas SOD rates above 2 g O^2/m^2/day have been measured in multiple cores with a maximum corrected SOD rate of 2.87 g O^2/m^2/day for T1-28 from the 8/25/04 cores. The lower SOD rates for 2/23/05 may be explained by a combination of decreased microbial activity and decreased deposition of fresh organic matter during the colder winter months, which would slow oxygen consumption by sediments.

Furthermore, sediment cores from site T1-28 have continued to show substantially higher anoxic phosphorus release rates than the other sites. The high anoxic p-release rates from site T1-28 are likely related to the high volatile solids and high total sediment phosphorus content. Interestingly, the anoxic p-release rate of 2968 µg P/m^2/day measured in the 2/23/05 core for T1-28 was the highest anoxic p-release rate determined in any of the cores collected from Platte Lake. The subsequent cores collected at T1-28 on 5/10/05 had a mean anoxic p-release rate of 845 µg P/m^2/day, which seems to indicate that a considerable amount of phosphorus was released under natural conditions from the deepest location in Platte Lake between 2/23/05 and 5/10/05; the much lower total sediment phosphorus on 5/10/05 (0.195 mg/g) compared to the concentration on 2/23/05 (0.296 mg/g) also substantiates this contention.

Over the course of this study, site T3-5 has yielded some surprisingly higher anoxic p-release rates, although not consistently. The three anoxic p-release cores examined on 5/10/05 further demonstrated this unpredictable pattern at T3-5. Upon review of the observational data recorded for each sediment

core, all the cores from T3-5 that produced higher than expected anoxic p-release rates contained deceased chironomid larvae (*Diptera: Chironomidae*) and common burrower mayfly larvae (*Ephemeroptera: Ephemeridae*) at the sediment surface at the end of the 10-day experimental period, which were not present at the onset of the 10-day period. Some of the cores with relatively low anoxic p-release rates from T3-5 and from other sites also had dead macroinvertebrates on the sediment surface after 10 days, however only the smaller chironomid larvae were visible in these cores. Thus, it appears likely that the visible mayfly larvae that were present only in the cores from T3-5 with high anoxic p-release rates influenced the phosphorus dynamics in these cores. Since the cores from shallow-water locations were not likely exposed to sustained anoxia under natural conditions, the macroinvertebrates were probably not accustomed to survival under constant anoxic conditions. Physical disturbance of the sediment-water interface by large macroinvertebrates (such as mayfly larva) during the dying process, which would result in higher concentrations of phosphorus being released into the overlying water, seems plausible.

The other two sites in Platte Lake (T1-12 and T2-22) also produced some interesting results for anoxic p-release rates and related sediment characteristics. The 2/23/05 anoxic p-release rate for T1-12 (918 μg P/m^2/day) was higher than any of the other anoxic p-release rates estimated for this site. In addition, for the 2/23/05 core collection, T2-22 continued to show surprisingly low anoxic p-release based on the relatively high % volatile solids and high total phosphorus content. The anoxic p-release rates for site T2-22 have repeatedly been comparable to the release rates of the shallow-water sites.

Currently, no further laboratory analysis or field collection of sediment cores or grab samples is planned for use with this study. All of the Platte Lake sediment data collected since 7/9/03 has been evaluated, and statistical analysis along with compilation into additional figures and tables is complete. A more detailed assessment of the relationship between phosphorus release and sediment characteristics in Platte Lake is presently underway for submittal to the Central Michigan University Department of Biology to meet formal thesis requirements.