Power boats on shallow lakes: A brief summary of literature and experience on Lake Mohegan (NY)

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and Kenneth J. Wagner

Introduction

Among the questions the authors are most often asked at various lake management conferences is whether there is any information available concerning the impacts of powers boats on shallow lakes (defined as those ≤ 30 ft). Unfortunately, the issue of managing powerboating too often is based entirely on subjective criteria—residents opposing noisy powerboats, for example—and too infrequently based upon sound scientific considerations. This article attempts to summarize the state of the literature, with a bibliography to help lake managers conduct analyses for themselves and presents a preliminary case history of this issue at Lake Mohegan, NY.

Early Studies

The early scientific concern was largely with the emissions of outboard motors. Studies by academic institutions and the outboard motor industry, many with the support of government agencies, analyzed whether the two-cycle engines were polluting lakes with their by-products, unburned hydrocarbons and lead. In the 1970's, the general consensus came to be that advances in engine technology meant that there was little risk to the lake environment from release of lead and hydrocarbons.

These studies generally concluded that outboard engines, with recent technological improvements, had minor impacts on water quality because there was little increase in the concentration of hydrocarbons. This, however, missed a major impact of powerboating on shallow lakes—the impact of stirring up bottom sediments that increased turbidity and accelerated algae growth. This problem was particularly acute in soft-bottomed lakes with sediments rich in nitrogen and phosphorus.

1974 EPA Study

In 1974, the EPA published a study by Yousef, conducted at several Florida lakes, analyzing the impact of boating activity on turbidity in shallow lakes. Based on a review of the "Monthly List of Government Publications," from 1974 to 1990, this appears to be the only study published by the EPA on this issue. The study focused on "shallow" lakes, defined as lakes with a maximum depth of 30 ft and examined the impact of varying horsepower engines on lakes of varying depths. The study concluded that even 10 horsepower engines could produce significant stirring of bottom sediments at depths up to 15 ft, and that engines with greater horsepower can do even more damage than smaller engines.

The 1974 EPA study found that the activity of a 100 hp outboard motorboat causes significant increases in turbidity (Fig. 1), orthophosphorus (Fig. 2) and total phosphorus (Fig. 3). A primary reason for the decision by the Mohegan Lake District to seek a powerboat ban is the concern that power boats stir up the nutrient-rich bottom sediments in shallow Lake Mohegan, which releases phosphorus and accelerates algae growth. The 1974 study confirms that this occurs—at horsepowers well below those currently used on lakes deeper than Lake Mohegan.

As Figures 1 through 3 show, at shallow Lake Osceola, the impact of a 100 hp powerboat even for 30 minutes could produce increases in turbid-

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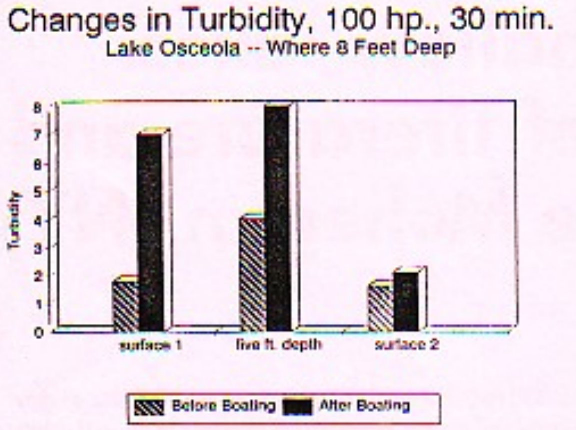

Figure 1.—Turbidity caused by boating in Lake Osceola (Yousef et al., 1979).

ity and phosphorus concentrations of 40 to 500% in test plots. Indeed, even a 10 hp engine, operated for one hour, produced significant increases in turbidity (Fig. 4), orthophosphorus (Fig. 5), and total phosphorus (Fig. 6). These increases ranged from 25 to 1,000%.

The study also detected impacts in an area of Lake Mizell which was 16 ft deep (at least as deep as the deepest area of Lake Mohegan), when the horsepower was increased to 50 hp. Even a low horsepower engine was found to stir up the bottom of Lake Mizell, as far as 15 ft. down (Fig. 7).

Although effects varied from lake to lake, the study found a clear relationship between engine size and "Effective Mixing Depth"—the maximum depth at which the engine stirred up the water (and, of course, the sediments) (Table 1):

Table 1.—Effective mixing depth by engine size

Horsepower	Mixing Depth
10	6 feet
28	10 feet
50	15 feet

The importance of these findings is that powerboating on shallow lakes is likely to stir up bottom sediments, increasing turbidity and probably accelerating deterioration of water quality. Since organic bottom sediments generally are rich in nutrients, lake managers should be concerned. Recycling of nutrients from bottom sediments has the distinct potential to increase algae growth and worsen water quality. Even without increased nutrient levels, water clarity (and therefore public safety) is decreased.

Later Studies

Some subsequent studies confirmed and reinforced the findings of the 1974 EPA study, although there has been considerable variability across the range of lakes studied. In 1979, Yousef again published a report indicating that the increases in turbidity which were found to result from boating activity were generally accompanied

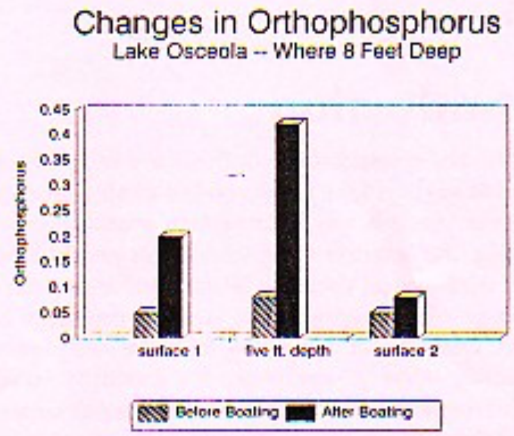

Figure 2.—Boating-related changes in orthophosphorus in Lake Osceola (Yousef et al., 1979).

by increases in phosphorus concentrations. The study found significant increases in phosphorus as a result of boating activity—16 to 73%—and concluded that "substantial water quality effects are possible due to recreational boating on shallow lakes."

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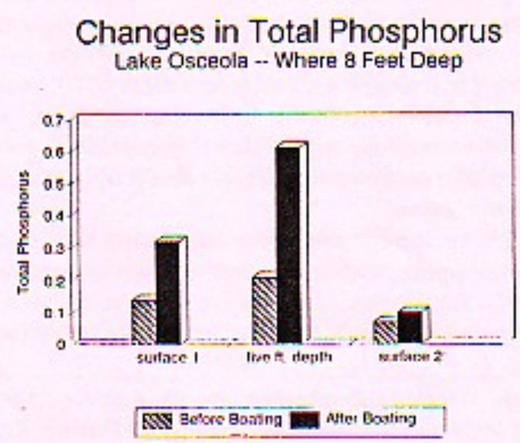

Figure 3.—Changes in total phosphorus caused by boating in Lake Osceola (Yousef et al., 1979).

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In 1988, Baystate Environmental Consultants (BEC) performed a study of several Massachusetts lakes, reaching generally the same conclusions as the 1974 EPA study. Of particular interest were the results for Furnace Pond in Pembroke, MA, which is very similar to Lake Mohegan and suffers from boating-induced turbidity.

With this study as a springboard, Wagner (1990) prepared a paper summarizing the literature and itemizing the characteristics of boats, engines and lakes that determine boating impacts (Tables 2 and 3). Lake managers and residents should consider these specific criteria as applied to their lakes before passing judgment on boating, but the potential for negative impact is clear. In contrast, none of the claims of lake improvement by boating—such as the claim that power boats aerate the water—appears credible.

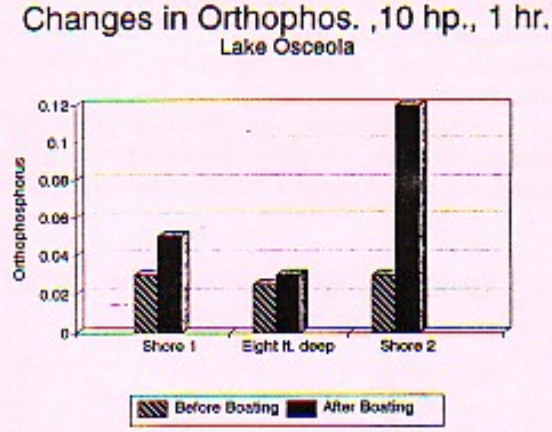

Figure 5.—Orthophosphorus changes caused by low-horsepower boating at Lake Osceola (Yousef et al., 1979).

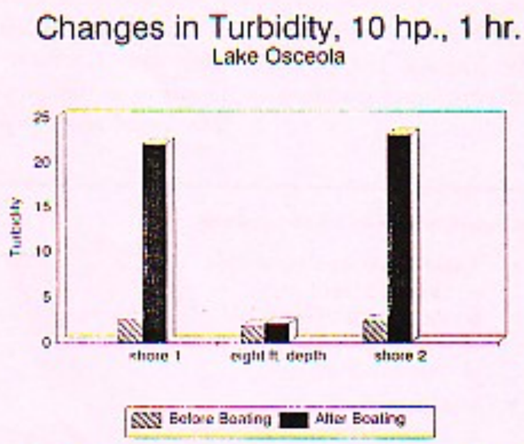

Figure 4.—Changes in turbidity at low horsepower, Lake Osceola (Yousef et al., 1979).

Perhaps most dramatic were the study's findings with respect to the shallowest lake studied, Furnace Pond. The study found increases in turbidity of more than 100% during and after powerboating activity (Fig. 8).

The Experience of Mohegan Lake

On a preliminary basis in 1991, the Mohegan Lake District, which manages 105-acre Lake Mohegan located in Northern Westchester County, New York, found results similar to those which BEC had observed at Furnace Pond. Lake Mohegan has a maximum depth of 15 ft, and an average depth of about 9 ft. It experiences heavy loading of nutrients from septic systems, road runoff and other nonpoint sources. During the early part of the 1991 boating season, the Lake District requested that powerboating be banned on Lake Mohegan, a shallow hypereutrophic lake. Although the local Town Board did not immediately adopt such a law, power boat activity declined dramatically as boaters voluntarily reduced their boat usage. The water clarity of the lake improved dramatically, a change believed to be attributable in

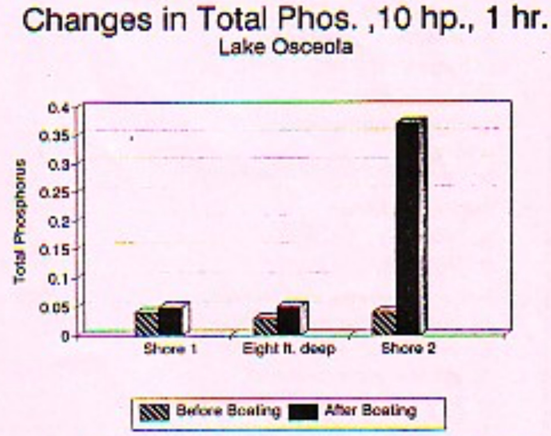

Figure 6.—Changes in total phosphorus at low horsepowers in Lake Osceola (Yousef et al., 1979).

part to the reduction in boating activity. Secchi depth, which had fallen to 1 1/2 - 3 ft in prior years, increased to readings of 5-6 ft for much of the season.

In response to the Lake District's proposal to ban power boats, the powerboat owners of Mohegan Lake relied upon a 1979 summary of litera-

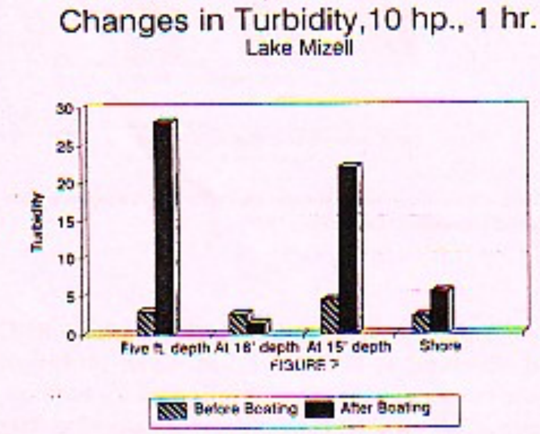

Figure 7—Changes in turbidity caused by boating at Lake Mizell (Yousef et al., 1979).

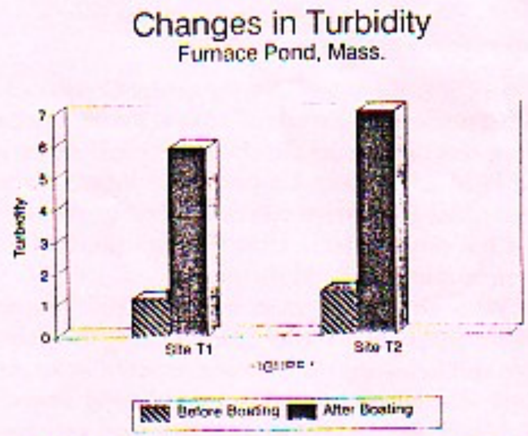

Figure 8—Changes in turbidity caused by boating in Furnace Pond, MA (Wagner, 1990).

ture prepared by the Montreal engineering firm (Bahl et al., 1979). The summary apparently examined only the impacts of outboard engines "dock mounted in fixed positions" as related to their potential emission of unburned hydrocrbons and heavy metals, however, and did not address the impact that powerboating may have on the stirring up of nutrient-rich bottom sediments. Al-

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Table 2.—Characteristics of motorized watercraft which influence ecological impact on lake ecosystems.

1. Type of engine
   - a. Two-cycle
   - b. Four-cycle
   - c. Jet propulsion
2. Engine design/age
   - a. Conventional (most pre-1977 engines)
   - b. Modified for fuel efficiency
3. Size of engine
   - a. Small (<20 hp)
   - b. Medium (20-100 hp)
   - c. Large (>100 hp)
4. Crankcase size relative to engine size)
   - a. Small
   - b. Large
5. Engine condition
   - a. Tuned
   - b. Untuned
6. Fuel ratio (gas:oil) and oil type
   - a. Meets engine specifications
   - b. Differs from specifications
7. Speed of engine operation
   - a. Idle or trolling (<1500 rpm)
   - b. Cruising (1500-2500 rpm)
   - c. Racing (>2500 rpm)
8. Speed of watercraft operation
   - a. Slow (<5 mph)
   - b. Medium (5-15 mph)
   - c. Fast (15-30 mph)
   - d. Very fast (>30 mph)
9. Displacement of water
   - a. Low (<5 cubic yards)
   - b. Medium (5-15 cubic yards)
   - c. Large (15-30 cubic yards)
   - d. Very large (>30 cubic yards)
10. Density of motorized watercraft
    - a. Low (>25 ac/boat)
    - b. Medium (10-25 ac/boat)
    - c. High (5-10 ac/boat)
    - d. Very hiugh (<5 ac/boat)
11. Frequency of traffic
    - a. Rare (<100 passes/yr)
    - b. Low (100-1000 passes/yr)
    - c. Medium (1000-2000 passes/yr)
    - d. High (2000-4000 passes/yr)
    - e. Very high (>4000 passes/yr)
    Also consider daily/weekly/seasonal pattern of use)

Table 3.—Characteristics of lake ecosystems which influence ecological impact by motorized watercraft.

1. Lake area
   a. Low (<20 ac)
   b. Medium (20-100 ac)
   c. Large (100-300 ac)
   d. Very large (>300 ac)
2. Epilimnetic volume
   a. Low (<130 million gal)
   b. Medium (130-653 million gal)
   c. Large (653-1960 million gal)
   d. Very large (>1960 million gal)
3. Hydraulic residence time
   a. Low (<21 days)
   b. Medium (21-90 days)
   c. High (90-365 days)
   d. Very high (>365 days)
4. Shoalness ratio
   (area <20 ft deep/total area)
   a. Low (<0.25)
   b. Medium (0.25-0.50)
   c. High (0.50-0.75)
   d. Very high (0.75-1.00)
5. Shallowness ratio
   (area <5 ft deep/total area)
   a. Low (<0.10)
   b. Medium (0.10-0.25)
   c. High (0.25-0.50)
   d. Very high (>0.50)
6. Shoreline development
   (shoreline length/circumference of circle with lake area)
   a. Low (<1.5)
   b. Medium (1.5-3.0)
   c. High (>3.0)
7. Littoral zone bottom coverage by rooted plants
   a. Low (<25%)
   b. Medium (25-50%)
   c. High (50-75%)
   d. Very high (75-100%)
8. Substrate type
   a. Cobble
   b. Gravel or sand
   c. Silt or clay
   d. Organic muck

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though we do not know the purpose for which this one-sided summary was prepared, or who was paying for it, we can state that Bahl et al.'s summary of literature is incomplete and misleading. While it purports to summarize the literature, it ignore the only study ever published by the EPA, as well as a wealth of other literature available. It claims to summarize a study prepared for (and paid for by) the Association of Outboard Motor Manufacturers, and comes to conclusions that not only contradict a wealth of scientific evidence—but also violate common sense.

Conclusion

The outcome of the struggle between powerboaters and those seeking a powerboat ban on Lake Mohegan is as yet uncertain. As has been the case at many other lakes, emotions are strong and a careful scientific study is lacking. As enforcement of boating regulations has greatly reduced boating activity and improved water clarity, the Mohegan Lake District believes that a power boat ban will serve both water quality and public safety interests. Furthermore, powerboating threatens the success of other management actions, such as alum application, and interferes with the aesthetic interests of other lake users.

While this article, and the scientific literature, cannot resolve what may ultimately be a political issue, we can state with reasonable certainty that power boating is likely to have harmful impacts on shallow lakes.

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