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Wake boats: concerns and recommendations related to natural resource management in Michigan waters

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EXECUTIVE SUMMARY

The operation of wake boats in a manner that creates large waves and increases bottom scour is an emerging threat to natural resources in inland lakes. Wake boats can produce waves with 1.7–17 times the energy of other comparable-sized powerboats and their propellers generate enough turbulence to resuspend bottom sediments in water up to 33 feet deep. The large waves generated by wake boats take between 225–950 feet to dissipate to heights and wave energies observed 100–200 feet away from similar boats operating at cruising speed. Further, the use of ballast tanks in wake boats results in a dramatic increase in risk for transporting Dreissenid mussels and other aquatic invasive species and pathogens among water bodies. The cumulative negative effects of wake boats on natural resources can lead to loss of habitat, resulting in the decline of aquatic ecosystems and angling opportunity.

Michigan's current boating laws and regulations are intended to both promote public safety and prevent damage to aquatic resources but were created prior to the commercialization and popularization of wake boats in the early 2000s. As a result of the large waves and increased scour caused by these vessels, the existing 100-foot operating buffers around docks and shorelines on inland lakes are not sufficient to protect aquatic resources. The Michigan Department of Natural Resources, Fisheries Division (Division) recommends the following to minimize the effects of wake surfing and wake boarding on natural resources:

1. Boats operating in wake-surfing mode or wake-boarding mode, during which boat speed, wave shapers, and/or ballast are used to increase wave height, should operate at least 500 feet from docks or the shoreline, regardless of water depth.
2. Boats operating in wake-surfing or wake-boarding modes should operate in water at least 15 feet deep.
3. Ballast tanks should be completely drained prior to transporting the watercraft over land.
4. Regulatory authorities and the boating industry should implement an increased education and outreach campaign that targets wake boat operators to improve awareness and implementation of the best practices listed above.

INTRODUCTION

Wake boats are powerboats specially designed to increase wave height for watersports. The hull is shaped to achieve maximum wake and many have a hydrofoil device that lowers the stern when the boat is under power. Most wake boats also have built-in ballast tanks that can be filled with lake water to increase the weight in the stern of the boat and create larger waves. While wake boarding, a rider is towed with a rope, usually at a speed of 20–23 mph. They use the wake of the boat to perform jumps and tricks. Wake surfing involves a person trailing behind a boat on a short surfboard and surfing on the boat's wake without being attached to the boat by a rope. Wake surfing generally occurs at speeds of 9–11 mph. Many wake boats can operate in modes to support wake surfing or wake boarding and have the ability to maximize wave height through ballast and wave shapers at the required speed for the respective activity. Through direct observations by Division employees and feedback from the public, it has become clear that waves generated by wake boats create concerns about risks to aquatic natural resources.

The State of Michigan, with the Department of Natural Resources as the trustee, has an obligation to preserve and protect natural resources as required by Article 4, Section 52 of the Michigan Constitution. The Division's mission is to protect and enhance Michigan's aquatic life and habitats for the benefit of current and future generations. Its strategic plan (MDNR 2018) serves as a guide to natural resource managers tasked to maintain healthy aquatic ecosystems and provide world-class angling opportunities that enhance quality of life in Michigan. The first goal listed in this plan is to "ensure healthy aquatic ecosystems and sustainable fisheries". In addition, the Division has identified specific habitat conservation priorities for the nearshore zones of lakes through its Wildlife Action Plan (MDNR 2015). In the context of these priorities to conserve nearshore aquatic habitats, the goals of this document are to review the current state of knowledge regarding the effects of wake boat activity on natural resources and provide the Division's position on the operation of wake boats to regulatory authorities responsible for writing and implementing policies that protect aquatic resources held in public trust.

ENVIRONMENTAL EFFECTS OF WAKE BOATING

The environmental effects of powerboating have been well documented. Waves from powerboats can increase shoreline erosion, decrease water clarity and plant abundance (Asplund and Cook 1997), and increase phosphorus in the water column (Yousef et al. 1980). Recently, there has been an increase in the popularity of wake boats (Gouday and Girod 2015; National Marine Manufacturers Association 2021) which use ballast, wave shapers, and other hull designs to produce waves that are substantially larger and more powerful than those generated by the typical powerboat. For example, Macfarlane (2018) found that wave energy from ballasted wake-surfing craft was 5–17 times higher than a benchmark speedboat and Marr et al. (2022) found that waves produced by wake boats were 2–3 times higher, had 3–9 times more energy, and were 6–12 times more powerful than a typical motorboat. Mercier-Blais and Prairie (2014) compared wave energies produced by a wake boat operated in wake surfing (10 mph, one ballast tank filled), wake boarding (20 mph, both ballast tanks filled), and cruising (30 mph, empty ballast tanks) modes and discovered wave energies were significantly different between operating modes at a distance of 328 feet. The waves created in wake-surfing mode were on average 1.7 times higher than those created in cruising mode. Similarly, Water Environmental Consultants (2021) showed that waves produced by a wake boat in wake-surfing and wake-boarding mode had 581% and 68% more energy, respectively, than waves produced by the same vessel operated in cruising mode at a distance of 100 feet. Both Gouday and Girod (2015) and Ruprecht et al. (2015) found that wake boats operating in wake-surfing mode produced the largest waves compared to other modes, with maximum wave energy approximately four times that of waves generated in wake-boarding mode. The energy created by such large waves requires a substantial distance to dissipate; Mercier-Blais and Prairie (2014) estimated that the distance required for wake boat-generated waves to dissipate completely is approximately 984 feet. This is further supported by Water Environmental Consultants (2021), who determined that waves from a wake boat in wake-boarding and wake-surfing mode would need distances of 225 feet and 950 feet, respectively, to dissipate to the wave heights observed 100 feet from the same boat in cruising mode. Additionally, Marr et al. (2022) found that wake boat waves required substantial distances to attenuate to reference conditions of a typical motorboat operating in planing mode at a distance of 200 feet for wave height (>500 feet), energy (>575 feet), and power (>600 feet, the maximum distance at which waves were measured in the study). Finally, aftermarket wave-shaping fins are sometimes used to increase wake size even on typical motorboats; Marr et al. (2022) found that these devices increased wave height, energy, and power to create waves similar to wake boats.

Shoreline Erosion

Shoreline erosion can lead to degradation of fish habitat and water quality due to physical disruption of rooted plants and resuspension of sediment and nutrients and is a concern for lakefront property owners because it results in a loss of property and can damage infrastructure. The main factors that influence shoreline erosion are wave energy, aquatic plants, the slope of the nearshore and bank areas, and characteristics of the bank material. Recreational boating activity can exacerbate erosion by increasing the wave energy that reaches the shoreline (Johnson 1994; Nanson et al. 1994; Bauer et al. 2002). A recent study on 1,700-acre Whitestone Lake in Ontario (Houser et al. 2021) showed that 61–72% of total wave energy originated from powerboats. Water Environmental Consultants (2021) compared wave energy from wake boats to the monthly maximum wave energy from wind for two locations in Lake Rabun, Georgia; when wake boats passed 100 feet from shore, the wave energy produced in wake-boarding and wake-surfing modes was 553% and 2,546% higher, respectively, than the monthly maximum energy from wind-driven waves. Wake-boat-induced wave energy was 192% higher for wake-boarding mode and 679% higher for wake-surfing mode, compared to wind-driven wave energy, when the wake boats passed 500 feet from shore. It would take between 225 feet (wake-boarding mode) and 950 feet (wake-surfing mode) for waves to decrease to the 0.8-foot wave height typically observed 100 feet from a cruising wake boat. Even though these distances would allow the waves to decrease to similar heights, the waves from wake-boarding and wake-surfing modes had longer wave periods, and therefore more energy, than the cruising mode wake. Wake boats are designed to create larger wakes than traditional watercraft, therefore the greater energy of waves created by wake boats operating in wake-boarding or wake-surfing mode are likely to exacerbate boat wave induced erosion.

Many construction projects that address shoreline erosion occur below the ordinary high-water mark and are regulated by the Michigan Department of Environment, Great Lakes and Energy under Part 301 (Inland Lakes and Streams) of the Natural Resources and Environmental Protection Act (NREPA 1994a). As part of the Part 301 permit review process, the Division is consulted to ensure that projects do not adversely affect fisheries resources. In the past several years, applicants frequently have listed erosion from wake boats as part of their rationale for shoreline armoring. This reactive response of hardening shorelines, as opposed to proactively reducing the erosive forces at the shoreline caused by wake boats, will only lead to greater environmental degradation from armored shorelines due to wave reflection off these structures.

Sediment Resuspension

Sediment resuspension decreases water clarity in lakes, subsequently reducing the ability of fish to find food, the depth to which aquatic plants can grow, and the dissolved oxygen content within the water column (Gardner 1981; Canfield et al. 1985; Chambers and Kaiff 1985; Barrett et al. 1992; Irvine et al. 1997; Stuart-Smith et al. 2004; Trebitz et al. 2007). In addition, as sediments are resuspended and nutrients become available in the water column, excessive algae growth can occur. Boat wakes resuspend sediments, especially fine substrates such as silt or sand, in shallow waters (USACE 1994) and this resuspension increases with wave energy. Existing studies have shown that resuspended sediments caused by powerboats increase turbidity and phosphorus concentrations in rivers, lakes, and shallow experimental ponds (Yousef et al. 1980; Johnson 1994; USACE 1994; Asplund 1996, 1997; Anthony and Downing 2003). Wake boats have greater potential to exacerbate sediment resuspension through increased wave energy and propeller turbulence. Mercier-Blais and Prairie (2014) determined sediment resuspension was significantly higher than background conditions up to 492 feet from wake boats operating in wake-surfing mode and 656 feet from wake boats operating in wake-boarding mode and was highest when wake boats were operated in wake-surfing mode at a speed of 10 mph. Previous studies of typical powerboats indicated that propellers from outboard engines create turbulence that can reach as deep as 10 feet (Gucinski 1982; Keller 2017). Field testing by Raymond and Galvez (2015) found that wake boat propellers generated water velocities with the capacity to resuspend unconsolidated sand, silt, and smaller organic materials at a depth of 15 feet while the boat was in wake-boarding or wake-surfing modes. Ray (2020) estimated that modern wake boats can cause sediment resuspension in water up to 33 feet deep.

Aquatic plants

Reductions in native aquatic plants will affect fish populations. Aquatic vegetation provides rearing areas for juvenile fishes (Bryan and Scarnecchia 1992), allows for increased fish growth and total fish biomass (Radomski and Goeman 2001; Nohner et al. 2018), and reduces wave energy in the nearshore zone. While there are no studies that directly address the effects of wake boats on aquatic plants, previous research on powerboats provides a basis for inference. For example, Asplund and Cook (1997) documented 20% reductions in aquatic plant coverage because of recreational boating. They also found that excluding powerboats from experimental plots dramatically increased aquatic plant biomass, coverage, and shoot height compared to areas with boats. Results indicated that powerboats affected plant growth through scouring of the sediments and direct cutting as opposed to increased turbidity, and it was unclear if the amount of plant material lost would have larger-scale or long-term impacts on the ecosystem (Asplund 2000). Murphy and Eaton (1983) documented an inverse relationship between recreational boating traffic and both submersed and emergent aquatic plant abundance in canals in British Columbia. Since wake boats produce greater wave energy, propeller turbulence, and sediment resuspension compared to the powerboats observed in these studies, it follows that wake boats could significantly disrupt native aquatic vegetation in inland lakes.

Aquatic Invasive Species

Aquatic invasive species (AIS) are non-native organisms that cause significant negative effects when introduced to inland lakes and other aquatic ecosystems. The State of Michigan's AIS Management Plan (MDEQ 2013) prioritizes the need for preventing accidental AIS introductions, which may be greatly increased by wake boats due to the presence of large ballast tanks that can be filled from or emptied directly into the water body they are operating on. For example, research has shown that ballast tanks from wake boats operated on a lake infested with the Zebra Mussel *Dreissena polymorpha* typically carried 247 Zebra Mussel veligers per sample (Doll 2018), which was much greater than stern drive motor compartments (13 veligers per sample), outboard motor lower units (1 veliger per sample), live wells, or bilges. Although wake boat ballast tanks are typically emptied before trailering, they are rarely ever completely dry which increases the survival time for invasive species potentially trapped inside. Doll (2018) found that 5% of zebra mussel veligers remained alive in ballast tanks after 48 hours. Transportation of other invasive species and fish pathogens is also possible, and the greater propeller turbulence and increased scouring caused by wake boats may result in fragmentation and proliferation of aquatic invasive plants (Keller 2017).

Compounding factors

The effects of wake boats are not the only changes occurring on Michigan's lakes. Shoreline armoring such as seawalls and riprap are being installed throughout the state, and this shoreline armoring reflects wave energy back into the lake as well as laterally toward neighboring properties. Shoreline armoring degrades up to 54% of lake shorelines in some highly populated areas (Wehrly et al. 2012), which are also the areas that receive greater boating traffic. Shoreline armoring increases wave energy in lakes and is often present on lakes with wake boats, thus it exacerbates the effects of wake boats on aquatic resources. These effects are further compounded by the reductions in aquatic vegetation (Radomski and Goeman 2001) and large woody habitat that historically occurred throughout Michigan's inland lakes (Wehrly et al. 2012). Aquatic plants and large woody habitat reduce wave energy in the nearshore zone, so their removal creates circumstances for increased wave erosion and reflection.

CURRENT BOATING LAW

Existing boating law in Michigan states, “A person shall not operate a vessel on the waters of this state at a speed greater than slow–no wake or the minimum speed necessary for the vessel to maintain forward movement when within 100 feet of the shoreline where the water depth is less than 3 feet, as determined by vertical measurement, except in navigable channels not otherwise posted.” Furthermore, reckless operation that disregards the safety or rights of others or endangers the property of others is illegal; causing damage with a vessel’s wake is a specific example of recklessness identified in the boating regulations (NREPA 1994b). These laws are intended to both promote public safety and prevent damage to aquatic resources but were created prior to the commercialization and popularization of wake boats in Michigan in the early 2000s. As a result of the effects of wake boats outlined above, the Division concludes that the current 100-foot buffer is not sufficient to protect public trust aquatic resources.

POTENTIAL SOLUTIONS

The negative effects of a wake boat decline as the boat travels farther away from the shoreline. Increasing the minimum distance that boats are allowed to operate at greater-than-no-wake speed near docks and shoreline would allow more time for wave energy to dissipate and increase protection of nearshore areas. Other jurisdictions have changed or are considering increased buffer distances in response to wake boats. For example, the Oregon Marine Board banned wake boats in three of five zones of the Willamette River and requires that boats maintain extended distances from docks, boathouses, or moorages when operating for the purpose of wake boarding (200 feet) or wake surfing (300 feet) (OAR 2020). However, if increased buffer distance requirements are considered for smaller lakes, there may be less space for any motorized boats to operate above no-wake speed. This situation can be compounded if the lake has large shoals or shallow water areas less than 3 feet deep that would further restrict boat use. Therefore, a minimum lake size could be considered for wake boats. For example, Indiana law restricts operation of a boat at a speed greater than 10 mph on a lake less than 300 surface acres in size (Harwood 2017). Shallow water increases the likelihood that turbulence from wake boat propellers can scour the bottom, disrupt aquatic plants, and resuspend sediment; accordingly, requiring a minimum water depth for wake boat operation would provide additional protection of aquatic resources (Keller 2017). The Division recommends that wake boats operating in wake-surfing or wake-boarding mode do so in water that is at least 15 feet deep. Ecozones, which protect significant ecological areas within lakes where the use of watercraft may be limited or prohibited for fish, wildlife, botanical resource management or the protection of users, could also be implemented to mitigate wake boat damage. The State of Indiana began using “ecozones” to protect aquatic habitat in 2000 (Harwood 2017; Asplund 2000).

Education and awareness campaigns are an important component of a comprehensive approach to protecting inland lakes from damage caused by wake boats. Providing operational recommendations in the recreational boating handbook (MDNR 2021), incorporating educational materials on responsible wake boat operation in boating safety classes, and providing informational flyers to new wake boat owners may improve awareness and implementation of best operation practices. Similar practices have been implemented elsewhere; for example the State of Oregon requires boaters to complete an educational program to wake board and wake surf on certain sections of the Willamette River.

CONCLUSION

Wake boats provide a means of outdoor recreation but the waves and propeller turbulence they generate can damage aquatic environments through a number of mechanisms. The cumulative effects of these damages will lead to loss of habitat and resulting declines in aquatic ecosystems and angling opportunity. The recommendations below are intended to provide guidelines under which the recreational opportunities that wake boats provide can be enjoyed in a manner that minimizes harm to the natural resources and property of Michigan citizens:

1. Boats operating in wake-surfing mode or wake-boarding mode, during which boat speed, wave shapers, and/or ballast are set to maximize wave height, should operate at least 500 feet from docks or the shoreline, regardless of water depth.
2. Boats operating in wake-surfing or wake-boarding modes should operate in water at least 15 feet deep.
3. Ballast tanks should always be drained prior to transporting the watercraft over land.
4. Regulatory authorities and the boating industry should implement an education and outreach campaign that targets wake boat operators to improve awareness and implementation of the best practices listed above.

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