The Effects of Motorized Watercraft on Aquatic Ecosystems

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[--Excerpted--]

How might boats affect aquatic ecosystems?

Boats may interact with the aquatic environment by a variety of mechanisms, including emissions and exhaust, propeller contact, turbulence from the propulsion system, waves produced by movement, noise, and movement itself. In turn, each of these impacting mechanisms may have multiple effects on the aquatic ecosystem. Sediment resuspension, water pollution, disturbance of fish and wildlife, destruction of aquatic plants, and shoreline erosion are the major areas of concern and will be addressed in the following pages. Impacts of boats that primarily affect human use of lakes, such as crowding, safety, air quality, and noise will not be addressed specifically.

This report is organized in terms of the aspect of the aquatic ecosystem that may be affected by boat activity:

Water Clarity (Turbidity, nutrients, and algae)

Why is water clarity important in aquatic ecosystems?

Water clarity is important for a number of reasons. It affects the ability of fish to find food, the depth to which aquatic plants can grow, dissolved oxygen content, and water temperature. Water clarity is often used as a measure of trophic status, or an indicator of ecosystem health. Water clarity is important aesthetically and can affect property values and recreational use of a waterbody.

How might boats affect water clarity?

Propellers may disturb the lake or river bottom directly, or indirectly through the wash or turbulence they produce, especially in shallow water. This may affect water clarity by increasing the amount of sediment particles in the water or may cause nutrients that are stored in the sediments, such as phosphorus, to become available for algal growth. Waves created by watercraft may contribute to shoreline erosion, which can cloud the water.

What do we know?

Boats have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems. Shallow lakes, shallow parts of lakes and rivers, and channels connecting lakes are the most susceptible to impacts. Depth of impact varies depending upon many factors including boat size, engine size, speed, and substrate type. Few impacts have been noted at depths greater than 10 feet.

What can we do about it?

No-wake zones in shallow areas of lakes and rivers could help to reduce impacts on water clarity, both by reducing the overall amount of boat activity in these areas and by limiting impacts from high-speed boats. In certain cases it may be beneficial to restrict boat activity altogether, such as in extremely shallow waters where boats can disturb the bottom even at no-wake speeds.

Water Clarity (Turbidity, nutrients, and algae)

Why is water quality important in aquatic ecosystems?

As discussed earlier, nutrients can affect the algal growth in lakes and rivers and have an effect on water clarity. Dissolved oxygen and pH levels influence the type and abundance of fish. In high enough amounts, metals and hydrocarbons can be toxic to fish, wildlife, and microscopic animals. In addition, these substances may have human health effects if a lake or reservoir is also used as a drinking water supply.

How might boats affect water quality?

Boat engines are designed to deliver a large amount of power in a relatively small package. As a result, a certain amount of the fuel that enters into a motor is discharged unburned, and ends up in the water. Two-stroke engines, which make up a vast majority of the motors in use on all types of watercraft, have been particularly inefficient. Estimates vary as to how much fuel may pass into the water column (25-30% is a reasonable average) and depends upon factors such as engine speed, tuning, oil mix, and horsepower. Other

concerns include lowered oxygen levels due to carbon monoxide inputs, and spills or leaks associated with the transfer and storage of gasoline near waterbodies.

What do we know?

There have been numerous studies on the effects of outboard motor exhaust and related pollution from fuel leakage. (See Wagner (1991) for a good review of these studies.) In general, these studies have shown minimal toxic effects on aquatic organisms because 1) the amount of pollution is small compared to the volume of a lake; and 2) most hydrocarbons are volatile and quickly disperse. However, polyaromatic hydrocarbons and fuel additives have been detected in some cases, and could be a concern for drinking water supplies. Build-up of certain compounds in sediments has been documented, especially near marinas or other high concentrations of boats, and may be detrimental to bottom dwelling organisms.

What can we do about it?

Cleaner technology, such as four-stroke engines, and more efficient two-stroke models should help to reduce the inputs of fuel and exhaust into water bodies over time. Education of boaters and stricter controls of places that store and sell fuel near the water would help to reduce sediment contamination from fuel transfer and storage. Keeping engines well-tuned and using manufacturers' recommended mix of oil and gasoline would help engines run more efficiently and reduce the amount of unburned fuel that is discharged.

Shoreline Erosion

Why is shoreline erosion important in aquatic ecosystems?

Shoreline erosion may affect water clarity in near shore areas, shading submerged aquatic plants as well as providing nutrients for algal growth. It can interfere with fish use of shallow water habitat, as well as wildlife use of the land-water edge. Excessive shoreline erosion can negatively affect property values and can be expensive for riparian dwellers to prevent and control.

How might boats affect shoreline erosion?

Boats produce a wake, which may in turn create waves that propagate outward until dissipated at the shoreline. Wave height and other wave characteristics vary with speed, type of watercraft, size of engine, hull displacement, and distance from shore. Propeller turbulence from boats operating in near shore areas may also erode shorelines by destabilizing the bottom.

What do we know?

Waves or wake produced by boats is the primary factor by which boats can influence shoreline erosion. Wave heights depend upon speed, size and draft of boat, but can reach heights of 40-50 cm (15-20 in.) equivalent to storm-induced waves. However, wave heights dissipate rapidly as they move away from the boat, while wind waves increase with larger distances. Therefore, river systems, channels connecting lakes, and small lakes are likely to be most influenced by boat-induced waves, as boats may operate relatively close to shore and wind-induced waves are reduced. Shoreline erosion has been documented in river systems and has been attributed to frequency and proximity of boat traffic. Loosely consolidated, steep, unvegetated banks are more susceptible to shoreline erosion.

What can we do about it?

No-wake zones are designed to minimize boat wake, so the obvious solution would be to use no-wake zones to limit shoreline erosion, particularly in channels or small sheltered lakes (i.e. areas where effective wind fetch is less than 1000 feet). Currently in WI, boats are restricted from operating at speeds greater than no-wake within 100 feet from fixed structures such as boat docks and swimming platforms. Many lake communities have established no-wake ordinances at 100 feet from shore or more. Seawalls and riprap have been used extensively in lakes and rivers to prevent shoreline erosion; however, these engineering approaches have little wildlife value and are expensive. Maintaining and restoring natural shorelines would help reduce the impacts of all types of waves on shoreline erosion.

Aquatic Macrophytes (Plant communities)

What do we mean by "aquatic macrophytes?"

Aquatic macrophytes are large rooted plants that inhabit the littoral (shallow water) zone of most lakes and rivers. They are usually divided into three categories: submerged, emergent, and floating-leafed species. Common species include coontail, milfoil, elodea, pondweeds (submerged species), bulrushes, reeds, sedges, wild rice, and cattails (emergent), and water lilies, spatterdock, and lotus (floating).

Why are aquatic macrophytes important in aquatic ecosystems?

Aquatic plants perform many important ecosystem functions, including habitat for fish, wildlife, and invertebrates; stabilization of lake-bottom sediments and shorelines; cycling of nutrients; and food for many organisms. In some lakes, submerged plants grow in abundance, yet they also may compete with algae for nutrients and help maintain better water clarity. Emergent and floating-leafed species may be valued for their aesthetic qualities and help provide a more "natural" buffer between a developed shoreline and the open water.

What factors affect aquatic macrophytes?

There is considerable variability in plant communities, both within the same lake or river and among similar bodies of water. Macrophyte growth is limited by a number of factors, including light availability, nutrients, wave stress, bottom type, water level fluctuations, and water temperature. The shallow water extent of submerged plant growth is usually limited by bottom conditions and wave stress, while the deep water limit is usually dependent upon light availability. Eutrophication, boat traffic, controlled or raised water levels, shoreline development, invasive species, and rough fish can all have in impact upon aquatic plants, either through changes in abundance or species composition.

How might boats affect aquatic macrophytes?

Boats may impact macrophytes either directly, through contact with the propeller and boat hull, or indirectly through turbidity and wave damage. Propellers can chop off plant shoots and uproot whole plants if operated in shallow water. Increased turbidity from boat activity may limit the light available for plants and limit where plants can grow. Increased waves may limit growth of emergent species. Finally, boats may transport non-native species, such as Eurasian water milfoil, from one body of water to another.

What do we know?

Several researchers have documented a negative relationship between boat traffic and submerged aquatic plant biomass in a variety of situations. The primary mechanism appears to be direct cutting of plants, as many have noted floating plants in the water following heavy boat use. Other researchers have determined that scouring of the sediment, uprooting of plants, and increased wave activity may also be factors. Where frequent boat use has created channels or tracks, it was noted that these scoured areas persist for several years.

What can we do about it?

No-wake zones and restricted motor areas effectively reduce the impact of boats on aquatic plants (see Asplund and Cook 1999[1]). Limiting boat traffic in areas with sensitive species or where a large proportion of the plant material is floating or emergent may be a good way to guide boat activity to more appropriate parts of a waterbody. While no-wake zones do not prevent all impacts, they do serve to reduce the overall amount of boat activity in a given area. Basing no-wake zones on water depth or the maximum depth of plant growth may be more useful than those based upon fixed distances from shore.

Fish

Why are fish important in aquatic ecosystems?

Fish form an important part of the food web in aquatic ecosystem, and can be either top predators, intermediate herbivores, or plankton eaters. A variety of birds and other animals depend upon fish as their primary food source. The presence or absence of individual species, as well as overall fish numbers can be an indicator of ecosystem health and can affect water clarity and water quality. Fisheries form an important resource for food and recreation for humans as well. In fact, angling is the most popular recreational activity on most Wisconsin waters.

How might boats affect fish?

Direct contact of boats or propellers may be a source of mortality for certain fish species, such as carp. Pollution from exhaust or spills may be toxic to some fish species. Boat movement can affect individual fish directly by disturbing normal activities such as nesting, spawning, or feeding. Increased turbidity from boats may interfere with sight-based feeding or success of eggs or fish spawning. On a population level, boats may affect fish through habitat alteration caused by waves or propeller damage.

What do we know?

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[1] Asplund, T. R., and C. M. Cook. 1999. Can no-wake zones effectively protect littoral zone habitat from boating disturbance? Lakeline, 19(1): 16-18+.

Very few studies have documented direct impacts of boat activity upon individual fish behavior or mortality. The few studies cited here demonstrate that boat activity can disturb fish from their nests, but that overall breeding success is likely not affected. Toxic effects on fish have generally not been observed, except in extreme situations (such as near boat testing facilities). Of much greater concern and effort, however, is the effect of boats on fish habitat (water quality, clarity, and aquatic plants) which subsequently may impact fish populations. These studies have been summarized elsewhere.

What can we do about it?

Keeping boats out of known fish spawning areas may help to improve overall fish success, however, it would be detrimental to anglers. Most boat activity usually occurs after peak fish spawning times, but extending protection of critical areas through early June may help to protect certain species. A more useful approach would be to protect shallow waters and plant beds from boat activity through the use of no-wake zones. No-wake zones in prime fishing areas may also help to reduce user conflicts by creating a separation between anglers and high-speed boaters.

Aquatic Wildlife

Why are aquatic wildlife important in aquatic ecosystems?

Aside from the aesthetic value of being able to see eagles, loons, deer, and other animals near water, certain species form an essential part of the food chain, especially those that feed on detritus or carrion or those that feed on the top predator fish. The presence of loons and osprey can be an important indicator of ecosystem health.

How might boats affect aquatic wildlife?

Boats may have direct impacts on wildlife through contact with propellers or disturbance of nests along the shoreline by excessive wave action. Disturbance by the fast movement of watercraft or even the presence of humans near feeding ground or breeding areas may prevent certain species, especially birds from being successful. Noise or harassment may cause some wildlife to vacate nests, leaving eggs or young vulnerable to predators. Indirect effects may include destruction of habitat or food source in littoral areas, or impaired water quality.

What do we know?

Boat activity certainly causes many wildlife species to be disturbed from a variety of activities. For some species, this may represent just a temporary disturbance, with little long-term effect. For other species, or in cases where unique habitats are disturbed by high frequency or intensity of boat use, boat activity can have effects on the entire population. Migratory birds may require more protection as their energy needs can easily be disrupted by excessive disturbance.

What can we do about it?

Buffer zones have been suggested for a variety of bird species, ranging from 100 to 180 m. Protecting littoral zone habitat or known breeding areas with no-wake zones would help to provide this buffer, though it would not eliminate boat activity. Preventing access to undisturbed shorelines or areas may be warranted if it can be shown that these areas provide a unique resource to wildlife populations. Loon nesting sites, heron rookeries, “turtle beaches,” and eagle wintering sites, would all be possible candidates for such a restriction. In some cases, all human activity, not just motor boat use, may need to be restricted in order to protect wildlife populations.

Personal Watercraft (“Jet skis”)

What do we mean by "personal watercraft?"

Personal watercraft (PWCs), commonly referred to as “jet skis”, include a variety of watercraft that are designed for use by one or two individuals (though newer models are being developed for 3 people). Riders either sit or stand, depending upon the design. Propulsion systems are generally quite different from traditional outboard motors, making use of a water pump rather than propellers to move the craft through the water. Steering is accomplished by ejecting the water at high force through a movable nozzle. PWCs are designed to be powerful and maneuverable and can operate in waters less than 12 inches deep.

Why are PWCs important in aquatic ecosystems?

Since the introduction of the first Jet Ski in 1973, PWC use has skyrocketed throughout the country, especially since the late 1980’s. It is estimated that 200,000 PWCs are sold annually in the U.S., representing 30% of all new sales of watercraft. They still represent a small proportion of overall

watercraft in use (about 1 million compared to 12 million outboards), but on certain lakes and rivers, they can achieve relatively high numbers. Along with the increase in numbers has come increasing conflicts with other users, as they tend to be more noticeable and create noise and perceptions of reduced safety and increased crowding.

How might PWCs affect aquatic ecosystems?

PWCs can have many of the same effects as described in other sections. However, because of their unique propulsion systems and use characteristics, this special section has been included to summarize studies that have addressed the impacts of PWCs specifically. For example, PWCs are often criticized for the noise that they produce, due to their frequent stops and starts and operation at full throttle. Most PWCs employ two-stroke technology for their engines, thus making them a concern for their air and water emissions of hydrocarbons and other pollutants. Because PWCs can be operated in shallow water, at high speeds, and in remote areas not usually frequented by boats, disturbance to wildlife may be more of a concern than other types of watercraft. Finally, while PWCs do not generally have propellers, the turbulence produced by the jet propulsion may still disturb plant growth and sediments, especially during acceleration or turns when the thrust may be oriented downward.

Studies:

Noise

Wagner (1994) described a study of PWC noise vs. outboard motor noise on a heavily used lake. The study showed that the actual noise level (in terms of decibels) is not much higher than most other types of watercraft. The loudness decreased with distance from the watercraft, such that the sound level was within background levels at distances of 300 feet or more. However, the PWCs tended to have more variable sound levels and a higher pitch than most other types of watercraft. These frequent changes in pitch tend to make the noise more noticeable to human ears, and were usually the cause of complaints. Responding to these concerns, PWC manufacturers have introduced quieter technology in recent years.

What can we do about it?

Manufacturers have voluntarily been introducing quieter, cleaner burning machines in response to citizen complaints and EPA rules requiring 75% reductions in air emissions from all marine engines by 2025. Wisconsin currently has a no-wake rule for PWCs within 200 feet of shore, which effectively minimizes the effect of PWCs on shallow water habitat. This no-wake restriction also reduces the noise level experienced by people on shore. Enforcement of this no-wake rule would go a long way toward minimizing the effects of PWCs. Restricting PWC use in natural areas or critical bird breeding areas may be justified in some cases; however restricting all motorized watercraft may be necessary to truly protect species of concern. Some states and the National Park Service have considered or enacted bans on PWCs within their jurisdiction, largely based upon disturbance to wildlife and the noise issue.

Summary

What do we know?

While the effects of boats on aquatic systems are complex and depend on a number of factors, a few general observations can be made. First, the physical effects of propeller, waves, and turbulence appear to be more of an issue than engine fuel discharge. Water clarity, aquatic plant disturbance, and shoreline erosion all are serious issues that can be exacerbated by boat traffic. Second, **most of the impacts of boats are felt most directly in shallow waters (less than 10 feet deep) and along the shoreline of lakes and rivers.** Third, these effects can have repercussions for other features of the aquatic ecosystem, including the fish community, wildlife use, and nutrient status. These observations all emphasize that the most important area of a lake or river to protect is the shallow-water, near-shore habitat known as the littoral zone. Boats that operate in deep waters with large surface areas are not likely to be impacting the aquatic ecosystem.

What can we do about it?

No-wake zones

Given that most impacts of boats are exhibited in shallow-water near-shore areas, protecting these areas with no-wake zones would be the most effective way of reducing impacts. No-wake zones have a dual benefit by both slowing boats down and directing traffic elsewhere. Currently in Wisconsin, boats are required to operate at no-wake speeds within 100 feet of piers, docks, and moored boats, while PWCs are required to operate at no-wake

speeds within 200 feet of the shoreline. Lakes less than 50 acres in size are entirely no-wake. While established primarily for safety and navigation reasons, these restrictions appear to be adequate for protecting against shoreline erosion, at least in developed lakes. In many cases, however, these restrictions do not adequately protect shallow-water sediments or beds of aquatic macrophytes. **Some communities have extended no-wake restrictions to 200 or even 300 feet through local ordinances. These extended no-wake areas have the potential to protect a much more significant proportion of the littoral zone and may help to reduce shoreline erosion.**

A much more useful way of establishing a no-wake area would be to determine the depth at which plants grow in a given waterbody, and then establish a no-wake zone based upon water depth and vegetation parameters. **At minimum, a no-wake zone based upon a 6-foot depth would reduce disturbance to sediments.** A deeper depth threshold could be justified if the tops of plants come within 5 feet of the surface, or if the sediments were particularly fine. These guidelines could then be coupled with the minimum 100-foot no-wake zone to protect shorelines.

Restricted areas

In some cases, protection of aquatic resources may require restricting all boat activity, not just speed. Boats can still disturb plants, sediments, and wildlife at no-wake speeds. These types of restrictions need to be based upon unique features of a resource and are often used to provide a certain type of experience on remote or "wild" lakes. For example, to adequately protect waterbird breeding areas, a "buffer zone" of at least 100 m (300 feet) has been suggested, in which all human activity would be banned. Similar areas could be established for emergent or floating-leafed plant beds, which may be impacted by boats operating at any speed. Research on Long Lake in the Kettle Moraine State Forest – Northern Unit showed that no-motor zones did a better job of preventing disturbance of submerged plants than simple no-wake zones (Asplund and Cook 1999). Some lakes currently have electric-motor only or no-boat restrictions, which may help to protect particularly unique or sensitive natural areas. These types of restrictions need to balance protection of the resource with the right of public access.

Enforcement and Education

Many of the environmental problems associated with boat activity could be resolved with better enforcement of existing ordinances or regulations and promoting awareness among boaters. Slow-no-wake rules are often ignored or misunderstood by boaters, such that impacts to sediments, aquatic plants, and shorelines occur even in no-wake zones. Another important avenue is informing recreators about the value of plants, littoral zones, and natural shorelines and how their activities may affect the aquatic ecosystem. If people understand that their activities may be hurting the ecosystem, they may be willing to confine their activities to more appropriate places.

Technology

Recent technology spurred by Federal air quality standards has the potential to reduce water pollution impacts from outboard motors as well. All 2-stroke engine manufacturers, including traditional outboard motors and PWCs, must reduce air emissions by 75% by the year 2025. Most manufacturers have already introduced cleaner burning 2-stroke engines and PWCs. Four-stroke engines, which use fuel more efficiently, produce cleaner exhaust, and run more quietly than traditional 2-stroke engines, are becoming much more common. However, technology may have the opposite effect on physical impacts, as engine sizes continue to increase and PWC manufacturers continue to emphasize speed and power. The consequences of operating bigger and faster machines in our inland waterways must continually be addressed in the future.