Summary of: Boating Impacts

- compilation by Gwen White including:

Physical Impacts of Boating on Lakes by David F. Hill (who has consulted on the impacts of prop wash on eelgrass habitat and conducted field experiments on lakebed disturbances due to passing boats)

. **The wave height** required to dislodge sediment will be a strong function of the characteristics of the bank (ex: is the soil well-consolidated, with woody debris providing a sheltering effect, or is the soil sandy and cohesionless, with no protective vegetation?) A number of studies have suggested that near-bank wave heights of approximately 0.5 feet mark the onset of bank sediment motion.

On a shoreline that is simultaneously subject to large boat wakes and large wind-driven waves, the impacts of the intermittent boat wakes are likely to be negligible compared to the much more sustained lading of the wind waves.

For boats operating in six feet of water, the boat speed corresponding to this worst-case scenario is approximately 9.5 mph. Past and present engineering studies of boating in lakes have proven valuable. Some familiarity with results of previous studies combined with, if possible**, site-specific studies will enable regulatory agencies to enact reasonable and prudent limits on near-shore use.**

The Effects of Motorized Watercraft on Aquatic Ecosystems by Timothy R. Asplund (Wisconsin Department of Natural Resources, Bureau of Integrated Science Services and University of Wisconsin – Madison, Water Chemistry Program)

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.

Studies:

Yousef and others (1980) is the most often cited publication on motor boat impacts. Turbidity, phosphorus, and chlorophyll *a* (chl *a*) were measured. Maximum increases in turbidity and phosphorus occurred within the first two hours of boating activity. Turbidity declined at a slower rate after boating ceased, taking more than 24 hours to return to initial levels.

Hilton and Phillips (1982) 8 to 44% of the turbidity in the river could be attributed to motorboat activity, depending upon the amount of algal growth that occurred at the test sites.

Johnson (1994) Peak turbidity corresponded with peak boating activity, but only in sites with high boating activity.

Conclusions:

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**.**

What factors affect shoreline erosion?

Shoreline erosion is affected by two main factors: 1) the intensity or energy of the erosive agent, i.e. water movement; and 2) the characteristics of the bank material itself. Water currents, **waves, and water levels are the primary agents that cause shoreline erosion**, although overland runoff can also erode shorelines.

Studies:

Nanson and others (1994) Most of the measurements of the boat waves were positively correlated to rates of bank recession. Over a 3.5 year period, shoreline recession of up to 14 feet was observed in a channel subjected to intense boating activity (Main Channel) compared to less than 3 feet in a channel with similar river currents and light boating activity (Wisconsin Channel). [Author's update: Transects resurveyed in 1997 indicated 28 ft. of recession in the Main Channel compared to 4 ft. in the Wisconsin Channel. On average, the riverbank is eroding at a rate of 3 feet per year.]. **The surveys suggest that foot-traffic trampling and boat waves are major contributing influences to shoreline erosion in the study area**. In the summer of 1998, additional investigations of off-peak and peak boating days included the measurement of maximum wave heights, number and type of boats, and shoreline sediment mobilization (erosion and resuspension). The study results confirmed that wave heights below 0.4 feet did not mobilize sediments, as determined in controlled run studies. However, the more boat waves 0.4 feet and higher in a 30 minute monitoring period, the greater the amount of sediment mobilized. Likewise, the larger the maximum wave height in a 30-minute monitoring period, the greater the amount of sediment mobilized. Of all the boat types recorded, runabouts and cruisers had the highest correlation to the measured maximum wave heights, amount of sediment mobilized, and number of waves greater than the sediment mobilization threshold (0.4 feet). Wind-generated waves above the threshold were not recorded during the study period.

Conclusions:

What do we know?

Waves or wake produced by boats is the primary factor by which boats can influence shoreline erosion. **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.

What don't we know?

It is unclear what effect boat waves have on shoreline erosion or bank recession in lake or still water environments. All studies to date have been on river systems. Also unknown is the cumulative impacts that boat waves can have on shorelines, especially in combination with wind-induced waves. While equations exist to predict how much of a wake a given boat can produce, very little information is available to suggest how much boat traffic a given shoreline can sustain. Also, individual boat waves may dissipate quickly, but boat traffic often mixes waves from several boats and can create much bigger waves that persist for longer periods of time.

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). Maintaining and restoring natural shorelines would help reduce the impacts of all types of waves on shoreline erosion.

Aquatic macrophytes

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.

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.

What factors affect aquatic macrophytes?

Eutrophication, boat traffic, controlled or raised water levels, shoreline development, invasive species 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.

Conclusions:

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. 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**). 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.**

> The study also includes a section on boating impacts on fish and aquatic wildlife (waterfowl, shorebirds, herons, eagles, turtles, frogs). The results are to be expected (greater distances, slower moving boats etc.).

Summary Section

Potential mechanisms by which boats impact aquatic ecosystems and the effects that they can have on the aquatic environment. Shaded areas indicate where a “Mechanism” has an “Effect.”

Mechanism: *Effect:*	**Emissions and exhaust**	**Propeller or hull contact**	**Turbulence**	**Waves and wake**	**Noise/ Movement**
Water Clarity (turbidity, nutrients, algae)		*XXXXXXX*	*XXXXXX*	*XXXXXX*	
Water Quality (metals, hydrocarbons, other pollutants)	*XXXXXXX*				
Shoreline Erosion				*XXXXXX*	
Macrophytes (plant communities)		*XXXXXXX*	*XXXXXXXX*	*XXXXXX*	

Fish	*XXXXXXXX*	*XXXXXXX*	*XXXXXXX*		*XXXXX*
Wildlife (Birds, mammals, frogs, turtles)		*XXXXXXX*		*XXXXXX*	*XXXXX*
Human enjoyment (air quality, peace and quiet, safety, crowding)	*XXXXXXX*			*XXXXX*	*XXXXX*

What do we know?
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 not exposed to high winds (less than 1000 feet of open water). 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 shallowwater, 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.

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. 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.

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.

The Effects of Boat Propeller Wash on Shallow Lakes
by David Hill and Michele Beachler (Civil & Environmental Engineering Penn State University)

• The scope of the current study is to investigate the potential for sediment resuspension due to prop / jet wash.

– Specific goal is to be able to predict the combination of depth, speed, and power required to initiate sediment motion.

• 'Near-plane' operating speeds are by far the worst.

• Is resuspension of bottom sediments an important process? This is a 'site-specific' issue, but implications include:

– Eutrophication due to increased nutrient loading.

– Increased turbidity.

• The scope of the current study is to investigate the potential for sediment resuspension due to prop / jet wash.

Background

• Gucinski (1982) suggested that planing craft were more likely to induce resuspension than slowly moving craft.

• Hilton and Phillips (1982) found turbidity levels to be correlated with boating activity.

• Garrad and Hey (1987) measured turbidity underneath individual non-planing boats. Turbidity levels increased for increasing boat speed.

Finer sediments are disturbed *slightly* more easily and stay in suspension *far* longer.

Conclusions & Recommendations

• 'Near-plane' operating speeds are by far the worst.

• Speed limits often inadvertently place boats right at these speeds! No-wake restrictions are far more effective, provided they are enforced.

Additional Issues

• The experiments were for boats traveling at a constant speed in a straight line. What about maneuvering / accelerating?

– These situations will be of greater impact, due to additional force required to provide acceleration. This was investigated but proved to be technically difficult

• Waves cause sediment resuspension and shoreline erosion.

Stirring up Trouble? Resuspension of Bottom Sediments by Recreational Watercraft by: M. M. Beachler and D. F. Hill (Dept o Civil and Environmental Engineering, The Pennsylvania State University)

An experimental and theoretical study of the hydrodynamic impacts of recreational watercraft in shallow waterbodies is presented. …Of interest is the ability of turbulent prop wash to resuspend bottom sediments. Intuition suggests, and the experiments confirm, that this ability is a strong function of boat speed and water depth… The results of this study demonstrate that boats operating at high speed have no greater impact on the lake bed than boats traveling at idle speeds. The greatest impact is seen when boats are traveling at 'near-plane' speeds. This critical speed is a function of the boat size and water depth.

This study has investigated the mechanism of bottom stirring by recreational watercraft through a combination of field experimentation and mathematical modeling.