Figure 7: Aerial image of sediment plume from a wake-surf boat operated in shallow water. Note the tracks through the sediments from other boat passage, all emanating from the marina. (Photo from LWA

Prepared by: Larratt, H. R.P. Bio., Schleppe, J. R.P. Bio. and Saunders, P. March 2025.

Definitions & Standards

- What is the definition of wake boat vs power boat? A power boat, or motorboat, is any watercraft that is not manually powered (paddle, sail or foot pedals). A wake boat is special class of power boat designed to displace more water than a ski boat to create bigger, specially shaped waves for wakeboarding and wake surfing. Wake boats often have large ballasts that can be filled with water to increase the mass of the boat, affecting how it generates waves. These ballast can sometimes help direct the prop wash in a downward direction as this boat position generates larger wakes, hence wake boat.

- Where does the safe boat density number come from in the study and is it a standard? This was referenced from:
  Rajan, B., V. M. Varghese, and A. P. Pradeepkumar. 2011. Recreational boat carrying capacity of Vembanad Lake Ecosystem, Kerala, South India. Environmental Research, Engineering and Management 56:11–19.
  We are not aware of any specific legislated standards for BC. However, it is likely that the safe boat density data could be compared to other, new estimates or standards, as they are developed. Each lake (or groups of similar lakes) may require its own unique safe boat density standards.

Water Quality & Ecology Over Time

- How has the algae loading changed over time? Specifically, a longer period which predates high boat usage and 2000's emergence of ballasted boats. Or said another way, is there data from the 60's until now with any statistical meaningful cadence to show changes due to boat/human activity?

  The best way to track change in algae loading is to regularly collect growing season samples. However, long-term sampling is often incomplete. The use of sediment coring can be used to assess algae growth over hundreds of years. Fortunately, a sediment coring study is available for Lake Windermere, completed in 1998, so it cannot address changes over the past 25 years. This study found, "Algal pigment analysis indicates a slight eutrophication since 1960 and a shift from clean-water diatoms to phytoplankton that are potentially bloom-forming ...There is a significant amount of evidence that Lake Windermere water quality is slowly deteriorating" (McDonald 2000). Evidence of bloom-forming types in recent sediments were detected but not at bloom densities from the 1998 core. Algae sampling in 2023 did detect bloom concentrations of cyanobacteria. Incidentally, this sediment core study also found a 5 to 10-fold increase in purple sulphur bacteria from ~1960 to 1998. This increase can be due to greater oxygen deficits in the sediments over the winter period, which suggests lake deterioration.

- Is there data over time on the sediment metals? Sediment metals in the 1998 core showed several elements with altered concentrations after 1950 (McDonald 2000). For example, phosphorus increased in the core after 1950 and it is a key nutrient for algae. Metals reported that showed a dramatic increase after 1950 included zinc and copper. The sediment surface samples in the present study found manganese, arsenic, nickel, guideline exceedances while copper and lead exceeded the 80% of MAC warning threshold.
- What are other indicating data over time, such as fish counts, bird species, etc., that are used to correlate the results? We used water chemistry, sediment grabs, sediment accumulation to correlate with the boat study data. These are standard measures of lake health. For habitat information and how it relates to overall lake health, please refer to the FIM(P) study completed in 2021 (Schleppe & McPherson 2021) After using the FIMP data, and identified Zones of Sensitivity, the published literature was used to help understand and interpret potential impacts. We are not aware of any boat impact studies on a particular species for Windermere Lake.

Lake Windermere Health & Trophic Status

- Lake Windermere has previously been classed as oligotrophic. After completing the study, can you confirm if it has moved into the mesotrophic category? The criteria for determining trophic level are provided in Appendix 1. Most Windermere criteria fall into the mesotrophic range, a desirable, moderate position for a lake. What we don't want to see is a continued increase in the trophic level, which was the main finding of the McDonald (2000) report.
- How is water temperature related to cyanobacteria? Cyanobacteria grow fastest at temperature exceeding 18°C with an optimum above 25 °C. With the current warming trend, BC lakes including Windermere are in the temperature zone for rapid cyanobacteria growth more frequently and for longer periods of each summer. These problematic blooms also require nutrients, from the watershed or from disturbed sediments. An increasing trend in lake phosphorus has been detected year over year despite its rapid flushing rate.
- Please comment on the Lake Windermere flushing rate of 47 days and how this relates positively or negatively to the findings from the study? The short flushing rate means a theoretical full exchange of the lake volume in 47 days. It is a product of the inflow/outflow rates in a relatively small lake volume. This short water residence time limits the accumulation of water-borne contaminants in Lake Windermere sediments compared to a similar-sized deep lake with a flushing rate measured in years. However, the shallow depth of Lake Windermere places it at much greater risk of powerboat sediment disturbance that returns contaminants from the sediments to the water column. Since the sediments show metal and nutrient

accumulations, this is a measurable risk to lake health. For example, a 25 % increase in water phosphorus concentration was measured after just two wake boat passes. A short flushing rate does mean that there is a greater potential for downstream movement of water borne contaminants, but downstream risks were not evaluated in this study.

- Would it be beneficial to collect water samples from Lake Windermere and send them to the lab to test for metals, monthly? Certainly, more data is always welcome but expensive. We would suggest aligning sampling with other regions so (1) spring overturn (2) early summer (3) late summer and possibly (4) winter. It is more important to have a financially sustainable sampling program spanning decades than it is intensive sampling for a few years.

Sediment Transport & Resuspension

- Could fixing the sediment erosion event from Windermere Creek help improve the levels of sediment deposition? The short answer is yes - reducing the inputs of sediments from Windermere Creek will help reduce sediment loading to the downstream system.

  Extreme flow/Flood events in 2011 and 2020e significantly altered Windermere Creek's morphology, hydrology, and sedimentation patterns, as well as the historic role of existing wetlands. Of particular concern is the creek's changed routing around the wetlands east of Windermere Loop Road. A severe flooding and erosion event in 2011, just upstream of monitoring site NAWIN03, led to high sediment loading and severely impacted the benthic invertebrate community (McPherson et al. 2014). Some remedial work in 2012 temporarily redirected most of the creek back into the wetlands with positive results until the freshet of 2020. However, both the 2011 and 2020 freshets scoured a new channel down to the existing tufa bedrock, resulting in extreme sediment flow to the lake, increased flow velocity, higher turbidity, culvert undercutting, and erosion of creek bank vegetation (Kootenay Conservation Program, n.d.).

  This will be beneficial mostly for the creek. The reduction in sediment into the lake will help areas in closer proximity to the creek, but the extent is not known. Thus, this work may impact sediment deposition rates around the fan areas of the creek as it enters the lake and stream velocity slows. This project will not however, help sediment resuspension from boat wake. In short, the two processes are different, each having different impacts.

- What is the contribution of impacts to the lake receptors (shoreline erosion, sediment resuspension, etc.) from natural wave action from wind or storms vs. those waves caused by boats? Has this been studied? Do you think that would be a valuable

undertaking to compare to the contribution from boats? Wake waves and wind waves are not the same. They differ in direction/angle of shoreline impact, frequency and energy delivered. The impact of these waves also varies with the level of human disturbance along the shoreline. As riparian vegetation is cleared, shorelines are hardened, and other impacts occur, the resultant impact from waves can increase. For instance, waves that hit hardened retaining walls are known to deflect that energy elsewhere, resulting in further erosion.

Boat wakes, especially from wake boats, tend to be more energetic and have higher wave heights compared to typical wind waves (Bilkovic et al. 2017) and this increased energy can cause more significant erosion, particularly in areas close to the shore (Johnson 2022). Studies have shown that the energy of boat wakes can far exceed that from wind waves, especially in inland lakes (Johnson 2022). While wind waves are a natural part of the environment, the concentrated energy from boat wakes can cause more immediate and severe erosion.

Wind waves are generally more consistent and spread over a larger area. They are influenced by factors like wind speed, duration, and fetch (the distance over which the wind blows). Wind waves are part of natural processes that shape shorelines over time. While they can cause erosion, they also contribute to sediment transport and deposition, which can help build up other areas of the shoreline. During storm events, wind waves can become significantly larger and more destructive, leading to rapid and severe erosion. However, these events are less frequent than the regular impact of boat wakes in heavily trafficked areas. Further, wind waves strike predictable, experienced shorelines because valleys direct wind, and do not strike all shorelines as wake waves do.

The waves created by wake boats can produce up to 6 – 9 times more energy than other cruising vessels. These large, powerful wakes can strike shorelines. Below the waterline, larges wake boats force columns of turbulence downward, stirring up sediment. This deep disturbance causes impacts including destroying underwater plants, disrupting aquatic life including fish, and accelerating algae blooms from released nutrients (another side effect of wake boats operating in shallow water) (Francis et al. 2023).

Over a summer of monitoring on an 877-acre Canadian lake, 72% of all total wave energy was attributed to recreational boats; monitoring occurred at approximately 902 ft from a main sailing line and 1,640 ft from allocated wakeboarding areas (Houser et al. 2021).

The interested reader can look at existing studies that are applicable to Lake Windermere: McDonald 2000; Hildebrand 2022; Masse & Miller 2005; Schleppe & McPherson 2021; Neufeld 2010; Bilkovic et al. 2017; Johnson, 2022.

- If we do see evidence of sediment resuspension from wake surfing in our lake at some depth, then what is the relative impact of this vs. the sediment inputs in the spring freshet, and how detrimental are the impacts of wake surfing in the larger picture? Wake boats and their enhanced ability to resuspend sediment and weaken thermoclines compared to motorized non-wake boats raise serious ecological concerns (Ortiz et al. 2024). Scouring visible from aerial images and turbidity measurements attest to the sediment disturbance occurring in areas that are only a few meters deep in several lakes where monitoring has occurred, including Lake Windermere.

  Natural sediment inputs to lakes are necessary processes. These usually occur in proximity to stream confluences. The new sediment is beneficial to create more floodplain habitat. These processes can take hundreds of years to occur. Again, focus here should be placed on differentiating the sediment deposition and disturbance processes. Some sediment inputs from creeks are necessary for habitat function, but this is markedly different than ongoing resuspension of lakebed sediments from prop wash.

- What are the deposition and suspension rates of sediment due to natural factors? Natural deposition rates in BC lakes relate to factors including watershed disturbance and frequency of storm events. Measured accumulation rates range from a few mm per year to several cm. For comparison, Okanagan Lake has an average sedimentation rate of 0.1 cm/yr or 1000 years to accumulate 1 meter. Unfortunately, most of the sediment traps LAC installed in Lake Windermere were stolen, meaning the few remaining traps could not provide spatial statistics. These traps did show an elevated sedimentation rate. For example, the Marina 2 site appeared to have unusually high sedimentation rates. The Ecoscape FIM team and the LAC field team both witnessed sediment plumes emanating from the marina for hours during peak boating activity. Aerial photography confirms the repeated scouring of the shallow sediments by boats as tracks where the deeper anoxic sediment layer become exposed.

- What are the sedimentation rates in various/numerous areas of the lake due to boating (at different depths)? How do you differentiate them from the natural rates associated with deposition and resuspension by the flood pulse, water flow, and wind? How is it related to the type of substrate? How much traffic in one area is required to see an impact, and at what depths? Sediments on the bottom of lakes accumulate over centuries and store large quantities of nutrients, metals and contaminants originating from the watershed and especially from on-water sources. This storage in sediments is a beneficial service that all lakes provide. Sediment storage needs to stay undisturbed to preform its function. Several studies have found one boat pass is sufficient to disturb sediments (Self and Larratt 2020). Sediment

disturbance depends on boat type and operation, and on water depth and sediment type.

- The sediment metal concentrations correlate to the deeper portion of the lake. What would be the scientific background for this? And how does it relate to the recommendations provided in the study? All lakes experience a process called sediment focussing, where inflowing and disturbed settlements form large plumes (creek inflow) and smaller plumes (in-lake sediment disturbance) that transport sediment to deeper water. That is why sediment cores to study lake history are always collected from the deepest area of a lake. The deep area sediments have the best record of lake health over time. Please refer to this study and McDonald 2000 for more information.

- Confirming all sediments are within acceptable guidelines and geographic/geology considerations/limits? There was no contamination evident. Not quite. While dangerous sediment contamination was not found, exceedances were identified for manganese, arsenic, nickel, guideline exceedances while copper and lead exceeded the 80% of MAC warning threshold. Please refer to the report for context. We also need to consider the trajectory of sediment chemistry based on the past 300 years and current practises on Lake Windermere and its watershed. Also please bear in mind that we could not check for numerous emerging contaminants such as PFAS, MeHg, personal care products, etc. given the budget restraints.

- Should more sediment data be collected on Lake Windermere? What information could we gain from it? More data is always welcome. The biggest missing piece concerns sediment disturbance/accumulation rates. We deployed 8 sediment traps and all but 2 were vandalized. If we could come up with a vandal-proof design or better yet, get the vandals to see the benefit of the study to continued Windermere Lake health, they might see that their fun depends on lake management as the pressures on Lake Windermere mount year over year.

Boating Impacts & Comparisons to Other Lakes

- Can you comment on potential lake health risks from power boat activity on lakes such as Wasa Lake (BC)—given its shallow depth, soft bottom, small size, and lack of surface water flushing? LAC/Ecoscape have not studied Wasa Lake but given its bathymetry and limited study, we would expect similar issues to Lake Windermere.

- Are the findings from this study transferable to other East Kootenay Lakes? Yes – provided they have similar bathymetry, sediment type, recreational use, local wind regime, etc etc. Every lake is different and hopefully we can identify lake features that need more protection, and those areas that are suitable for power boats. Please refer to the Lake Suitability Index and apply it to the lakes of concern.

- There is talk in the report (and in the media) about banning wake surfing from waters <8 m deep. Unfortunately, there is zero peer-reviewed evidence to support this conclusion in the report. On p. 20, it says, "We can safely conclude that wake boats can disturb fine sediments throughout the entirety of Lake Windermere with its average depth of 3.4 m and maximum depth of 6.4 m." after citing an unpublished master's thesis that is a modelling study, a technical report that shows that there is water movement detected down to 4.5m (just movement of the water, nothing more), and a study from Kalamalka Lake where they put cameras at varying depths and went over top with a boat in wake-surf mode. There was sediment resuspension at 4 m and less, but here is what they say about deeper areas: "At 5 m and deeper, there was no observed sediment resuspension, but the wake was clearly seen impacting the bottom at 8 m, the deepest buoy deployed." from Self, J., Larratt, H. (2020). *2019 Kalamalka Lake Boating Impact Study*. Prepared for RDNO, GVW, and DLC. (attached). They are telling us there is no material impact (sediment resuspension) at 5 m, but there is an undescribed 'impact' at 8 m. I assume this means the vegetation moved with water movement, but it is not clear. At a minimum, there is no clear evidence here for detrimental impacts to 5 or 8 m. Incidentally, they don't cite a peer-reviewed modelling study that concluded there wouldn't be impacts at this depth—Please comment or provide context and sources. There is an unfortunate gulf in the budget required to reach the level of study suggested in the above. We were *not* attempting to do focussed journal research, but rather to do demonstrations that are accessible to decision-makers. We are planning to publish our findings in peer-reviewed journals – just as soon as we find the time.

  Please pay attention to the ever-expanding body of literature on boat-lake health impacts. Also please refer to the Transport Canada regulation changes regarding wake-surf boats. This reflects community experience across Canada. As wake-surf boats get more numerous and progressively more powerful, boaters can expect restrictions. Also please do not forget that invasive mussels are introduced most often by boats with reservoirs for engine cooling or ballast tanks. An infestation in Lake Windermere would damage lake values permanently and introduce these invaders to the Columbia headwaters (please refer to the Mussel Guide (OBWB 2024)1. Also, the decision on Lake Windermere management should, in our opinion, reside primarily with the resident and traditional communities.

  Additionally, as studies provide mounting evidence the following changes are legislated in the US as of 2024:

  Oregon banned wake surfing altogether along sections of the Willamette River.

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1 https://obwb.ca/preparing-for-invasive-mussels-vulnerability-assessment-guide-for-raw-water-infrastructure/

Vermont adopted new rules restricting wake surfing to designated areas, following the guidelines listed above (zones are at least 500 feet from shore, 200 feet wide, and greater than 20 feet deep).

South Carolina passed a law requiring wake sports occur 200 feet from docks, swimmers, and other anchored craft.

Minnesota will, by 2025, require boaters engaging in wake sports to attend an education class and receive a boater education card. The state also now requires wake sports on Caribou Lake take place at least 500 feet from shore, and in water at least 20 feet deep.

Always check your local and state laws before engaging in wake sports. As more environmental impact studies circulate across the US, it is likely more locales will adopt similar rules.

- Are there examples of lakes in Canada where boating restrictions have been put in place? What has the impact been on the health of the lake post-restrictions? The Crown land designation makes this more difficult than it is in the USA, where numerous lakes are protected by town ordinances against wake-surfing (e.g., Bass Lk WI, Hayward WI, Round Lk WI , Huner WI; Norway WI Lake Toxaway NC Sevens Lk NC, Spokane R Idaho, Willamette R. Idaho). Where we could find post-closure work, the rate of water body deterioration slowed after the closures (e.g., Lake Toxaway). However, the pressure to remove boat closures remains.
- Do you have an estimate of how many humans or wind-powered users can be safely accommodated on the lake? We do not. The number of human/human powered craft that could safely operate on a lake would be much high than the estimates proved for power craft. Indicators such as E. coli at beaches could be used to track swimmer use.

  There is relationship between speed of recreation and area needed per vessel. Stand up paddle boards are slow. Thus, the lake could likely safely accommodate many, many users, compared to power craft. Thus, to truly answer this question, the community may be better to start at and agree upon the "quality" of each recreation type they want or need. From there, answering this question would be easier.

Economic & Regulatory Considerations

- What regulatory agencies need to be engaged on the recommendations being made? Water Sustainability Act is the Province of BC. Boating regulations are typically governed under Transport Canada. Fisheries and Oceans Canada is responsible for all fisheries related matters, and work in collaboration with the Province under the Water Sustainability Act.

- Implementing the recommendations may cause an economic downturn in the local economy, but the study does not address this. How can these recommendations be made without addressing the economic consequences of implementing them? This is a common and legitimate concern. It often comes down to short-term economic consequences versus long-term economic consequences. We proposed getting local stakeholders together to hammer out a management plan that balances lake health with the tourism-centric local economy. Processes to manage the volume of tourism are already in place at iconic destinations worldwide to prevent their destruction by over-tourism, as described in the report.

  The study was not tasked with this question. Rather, the study does suggest that it is possible to over-recreate within our communities, and that this may cause other harmful impacts to long-term economic health. The community is best suited to tackle and find its economic balance.

- Are there any similar cases of over-tourism where your recommendations or similar have led to positive changes? Please refer to the 2024 Waterton Lakes National Park boat ban. Waterton Lakes National Park took additional steps to protect park and regional waters from harmful aquatic invasive species (AIS), including invasive mussels and whirling disease beginning in 2024. At minimum this ban which includes non-motorized craft, will slow the spread of these devastating invasive species.

External Influences on the Lake

- How do the particles coming off the trains affect the lake compared to what is focused on in the study (boat traffic)? Great question, but outside the scope of this study. We have studied the potential impact of rail transport within meters of Kalamalka Lake BC and found that derailment was the biggest concern to lake health. This rail system was converted to a biking/walking path. However, other modes of transport and watershed activities also have the potential to impact lake health (e.g., tire fragment contaminants, pesticides, excess nutrients).

- What are the stressors caused by boating that are actually being seen on Lake Windermere? What scientific data has come back that was outside of acceptable limits? We detected four main areas of impact in this study, while the FIMP study considered shoreline habitat impacts. Stressors detected in the recreation study include: (1) Lake bed scouring (2) Sediment exceedances (3) altered sediment chemistry since 2000 and especially since European settlement (4) increased algae blooms dominated by concerning species of cyanobacteria (5) turbidity plumes that can direct released sediment contaminants at community drinking water intake(s)

- Can you comment on what happens when the resuspended sediments are flushed down into the Columbia Valley Wetlands? Again, great question, but outside the scope of this study. The Wetlands will have an assimilative capacity to improve many sediment chemistry concerns. Exceeding that capacity or accelerating the rate of sedimentation within the wetlands would be concerning and worthy of study.
- If sediments are not disturbed and are allowed to settle and bury the metals, won't the lake get even shallower over time? Correct. All lakes gradually infill over time. Re-suspending sediments may not reduce the rate of total sedimentation measurably, but meanwhile sediment disturbance does measurably increase nutrient/contaminant release (multiple studies). The main way to slow lake sediment infill is to slow erosion in the watershed but especially show shoreline erosion. Preventing generation of high-energy large wakes that can slam into all shorelines (unlike wind waves) would measurably slow lake infill.
- Does the flow in the lake and natural storms move the sediment downstream naturally? Correct – most likely, but we did not study this as it was beyond the limited project scope. You might be able to see this process from the air during freshet.
- Since Lake Windermere is part of a river system, do the effects of boating on water quality and sediment travel downstream, or is the flow weak enough that they are isolated to Lake Windermere? Would it be worthwhile to monitor/test sediment & water downstream to understand more about boating impacts, or would it essentially get "diluted" and be negligible? Great question, and worthy of a PhD thesis. It might be a great idea to see if you can attract researchers from College of the Rockies, U Calgary, U Lethbridge or UBC, etc. They would be interested in local support. Back to your question, sediment origin and accumulation rates can be determined using tools such as ^{228}Th ^{210}Pb ^{228} Ra decay.

Stewardship & Future Management

- Are there resources available for developing a lake stewardship plan under the Water Sustainability Act? Yes. And please plan for a long-term project. Please refer Water Sustainability Plans (WSPs) that are enabled under WSA ss. 64-85.

  Water Sustainability Plans (WSPs They are initiated by ministerial order and can provide for extensive change in how a watershed is managed. A planning area can include both public and private land. WSPs can be developed to address conflict between users, between the needs of users and environmental flow needs, risks to water quality or to aquatic ecosystem health, or to identify restoration measures in relation to a damaged aquatic ecosystem. Both WSA Objectives and WSPs enable a whole of watershed management approach. WSPs can include regulations that

apply to all of part of the plan area. These plan regulations are described in WSA ss. 76-85.

The Water Sustainability Act Objectives are enabled under WSA s. 43. They are an area-based planning tool that be established to sustain water quality and quantity for specified uses and to sustain aquatic ecosystems. WSA Objectives would be considered for a variety of decisions and statutes. The WSA Objectives Interim Policy (PDF, 379KB) describes the Province's approach to developing WSA Objectives under WSA s. 43. The WSA Objectives Technical Guidance (PDF, 863KB) document provides technical guidance to support the WSA Objectives development process.

The Province will fall in line with local consensus found in a Water Sustainability Plan. Since Syilx Water Law pre-dates Provincial jurisdiction, UNDRIP/DRIPA mandates that the Province is obligated to regard indigenous water law. Collaborative watershed governance is envisioned moving forward. Local Government has more discretion than senior governments to engage with First Nations -D. Coran[2] 2024.

Community Survey:

- Why was the survey released August 31 to October 1, after the boating season?

The dates were selected arbitrarily, and timing was based on LWA capacity. The purpose was to gain an understanding about how the local community felt about recreation on Lake Windermere.

Additional answers to survey questions can be found here:

Survey-LWA-Recreational-Carrying-Capacity-2024-AP.pdf

Misinformation:

Misinformation abounds on wake-surfing, and I'm sure most boat operators do not want to damage the lake/river they play on.

Misinformation Example: From on-line forum jetboaters.net member discussion: "Yamaha states I would stay in at least 3' of water and the draft of my v-drive is a little over 3' of water so it was really no different where I took the v-drive or how I behave while navigating compared to my jet boat. (Many wake surf boats have inboard v-drive). COMMENT: I do not know what correspondence the member is referencing, but 3 ' (1 m) of water depth would not create a surfable wake and would be

2 D. Curran University of Victoria Professor
Executive Director, Environmental Law Centre

guaranteed to churn up the substrates. I doubt Yamaha meant operating speed – I suspect they meant launch-dead slow. FYI when wave energy reaches the lake bottom, drag forces slow it down and the shape of the surface wave is not as “clean”. One manufacturer recommends 8 m for optimal wave shape. , an interesting coincidence with LAC measurements in Kalamalka Lk.

Misinformation Example: Drive back through your own wake (it's a repetitive pass, but the 2 neutral out). This was from a respectful boarder, and he correctly advised avoiding turning. Sadly, repetitive passes amplify the lake impacts, even to the point of affecting thermal stratification.

Positive Examples:

POSITIVE EXAMPLE: **Tips for Bigger Wakes (and Safer Runs)** Beyond these two basic conditions, there are some other tips to follow to ensure you've got a clean line to run on the lake, while also reducing risks to yourself, other boaters, and the lake itself:

- Operate in depths of 20 feet or more to produce the largest (and least impactful) wakes.
- Find a line in the water that allows for a straight run, with room to decelerate before turning.
- Avoid quick directional changes at speed, and power down before turning to gather a surfer or start a return run.

Operating your wake boat within these parameters not only ensures you enjoy big, uninterrupted waves to ride freely, but that your boat doesn't negatively impact the lake environment itself -- which ensures the water stays open to wake surfers, without restrictive legislation being passed that curtails the sport. – *(Bart’s watersports https://www.barts.com/blogs/news/wake-surf-boating-what-depth-distance-is-best?srsltid=AfmBOooemkldZ_q5vJtQl37RRxMtYaHDg7ZDj4JmQieWLG0-plQpS-TC). When we where at Prinville we went past the marina and the water dropped to under 30ft (9 m) and our surf wave was losing push. Of course I don't even like being in water under 30ft.*

POSITIVE EXAMPLE **Lowered emissions:** Wake boat manufacturers make various claims regarding the emissions of their vessels, particularly in response to evolving environmental regulations and consumer demand for greener technologies. For instance, Evinrude's E-TEC engines were recognized for their low emission levels, earning the U.S. Environmental Protection Agency's Clean Air Excellence Award in 2004. These engines reportedly emitted 30 to 50 percent less carbon monoxide than comparable four-stroke engines and significantly lower particulate matter. However, while individual engines may meet certain emission standards, the overall environmental impact of wake boats also depends on factors such as operational practices, design and features, weight, speed, fuel consumption, and the cumulative effect of multiple vessels on a water body. Therefore, while manufacturers may highlight advancements in engine efficiency and reduced emissions, the broader ecological implications of wake boat usage remain a topic of ongoing research and discussion.

Photo from a boating forum asking for monster wave photos – note proximity to shore

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Appendix 1 Trophic levels

The following tables present information that supports the concepts used in this report.

Table A-1: Lake Classification by Trophic (Nutrient) Status Indicators

Trophic Status	chlorophyll-a ug/L chl-a	Total phosphorus ug/L as P	Total Nitrogen ug/L as N	Secchi disc m	Primary production mg Carbon/m^2/day	TSI Index
Ultra-oligotrophic	<0.95	<4	< 75	>10	< 50	<30
Oligotrophic (low nutrients)	1 – 2	4 – 10	<100	6 -12	50 - 300	30 - 40
Mesotrophic (moderate)	2 – 5	10 – 20	100 – 500	3 – 6	250 – 1 000	40 - 50
Meso-eutrophic	5 - 7	20 - 35	500 - 900	2 - 3		50 - 60
Eutrophic (high nutrients)	7 - 25	35 - 100	900-1500	1 - 2.5	>1 000	60 - 70
Hyper-eutrophic	>25	>100	>1500	<1		70 - 80+

(Ashley 1996, Carlson 1983, Wetzel 2001, Carlson and Simpson 1996, Vollenweider and Kerekes, 1982, Kasprzac et al. 2008)