Critical Issues with the Maars et al. MN St. Anthony Falls Wake Study

Boat wakes have been a subject of scientific inquiry since the 1960s, initially focusing on wave energy to estimate vessel resistance. Numerous studies have examined the wake characteristics and impact of wake boats. The 2022 study by Maars et al. at the MN St. Anthony Falls Lab is frequently cited by groups opposing wake boats despite the fact his study was not novel, and was never published in a scientific journal, nor did it follow peer review protocols. This study suffers from severe flaws in data collection and analysis. It fails to adhere to standard scientific conventions. This work does not rise to the level required for policy decisions. Below are the key issues that undermine its credibility:

1. Data Collection: Massive Variability Lacking Precision

The studies used two different types of sensors, creating discrepancies in the data. Their acoustical Doppler current sensors consistently measured higher wave heights than the pressure sensors, yet they used both data sets in their analysis of wake boats, introducing systematic error. There was no cross-calibration of the different sensors nor explanation for the discrepancy. Both of these sensors are inferior to capacitance sensors other researchers have used. State-of-the-art researchers use above-surface radar sensors, which are simpler and more robust.

The wave height data collected in this study is riddled with inconsistencies, rendering it impossible to analyze confidently. For instance, wave heights measured 200 feet from the MXZ boat varied wildly, with reported values of 9 inches and 18 inches. A 100 % discrepancy is unacceptable. The standard for reliable data is no more than a 20% variance. Similar prior studies exhibited 10%. The significant scatter in the data effectively renders it useless for any meaningful analysis. Even using just their mast sensors they have >50% variation in data.

The authors attempted to obscure this lack of precision by applying regression to fit a curve. Averaging data with such a high degree of scatter yields poor R-squared correlation coefficients, indicating they are not explaining the data variability with their equation. Averaging data to reduce random noise is acceptable, but averaging to reduce systemic errors is not. The exponential coefficients of their fit are not consistent with prior work.

2. Failure to Compare Data with Prior Studies

In any rigorous scientific study, it is essential to compare new data and analysis with existing research, identifying and explaining any discrepancies. The authors of the St. Anthony Falls study failed to do so, disregarding significant relevant prior work. For example, they include a reference to Ruprecht J, et. al., which uses similar watercraft, but they never compare their energy calculations to that work. Goudey and Girod conducted an extensive measurement analysis of wakeboard waves in 2015, followed by a similar study by McFarlane in 2018. Both studies offer superior data quality and analysis. However, the St. Anthony Falls study ignores these efforts, claiming they were not journal articles which their report is neither. This is particularly disturbing since their analysis is inconsistent with the prior art. In addition, they attempt to calculate total wave power while other experts such as Greg Cox and McFarlane have shown that max wave energy and period are the most useful parameters to consider in erosion. (Cox and McFarlane 2019)

3. Flawed Analysis & Energy Calculations

Poor-quality data undermine the study's attempts to characterize waves. Further degrading the usefulness of this paper is the analysis approach. The best practice for this type of work is to accurately measure wave height and period and then calculate the max wave energy (Cox and McFarlane 2019). Due to the dispersive nature of boat wakes in this regime, the initial large wave observed at the boat breaks up into multiple lower-amplitude waves. The further from the sailing line, the more waves and the smaller the height. Using the max wave height is the standard practice for this type of work. The St. Anthony Fall's authors did not adopt this approach but rather attempted to calculate the total cumulative energy of all waves in a boat wake wave packet. This approach is fraught with challenges even when using good data. The authors need to determine the duration of the packet. They assume the endpoint of the packet is when the next wave contributes less than 1% to the total wave energy. Given this was an experimental study, it inherently had noise from wind drive waves, reflected waves, and other boat waves. This can be seen in Figure 12. Their data for the unique boat wake waves are confounded by the superposition of other waves from wind, reflection, and other boats. In the example they present, they summed no less than 16 individual waves with no definitive way to know if these are actual boat wakes or waves from interference.

The authors also adopt a nonstandard approach, converting their wave periods to wavelengths. Even when wave characteristics appear similar to previous studies, the energy calculations presented in this study are 3 to 8 times higher than previously reported results. For instance, the study calculates a wave energy of 16,000 J/m at the boat for the Malibu MXZ; Goudey and Girod, who used a similar approach, calculated a total wave energy of 1800 J/m. To demonstrate how absurd this value is, The Australian Maritime College measured the wake of a 118-foot, 116-ton catamaran at 14,000, 3 boat lengths away from the craft.

The St. Anthony Falls study reports wildly inconsistent energy values. At 100 feet from the boat, they report both 9,000 J/m and 4,800 J/m—raising the question, which should be believed? Goudey and Girod's calculations for similar conditions yielded 1,200 J/m in deep water.

These analysis errors are particularly troubling since wave energy calculations are critical for comparing different watercraft and forming the basis for recommended setbacks from shorelines.

Conclusion

The St. Anthony Falls wake study was severely criticized by its reviewers, and they were not given an opportunity to view a revised manuscript to ensure their comments were addressed. It is fundamentally flawed, both in its data collection and analysis. The combination of unacceptable scatter in the experimental data and erroneous calculations makes it impossible to draw reliable conclusions from this work. Given the availability of superior research from more experienced scientists, the conclusions drawn from this study should not be considered credible or used in policymaking.

References

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