FAQs: Boat-generated wake wave study

- **What was the study?**

This research project focused on measuring the maximum height, total energy, and maximum power of the waves (defined as wake waves) produced by four recreational boats common to Minnesota lakes. The researchers also measured how the wake waves changed as they moved away from the boat and towards shore. Two of the boats were modern wakesurfing boats and two were typical non-wakesurf boats that have been operating on Minnesota waters for decades. The study highlights the differences in the wake wave characteristics of these four boats.

- **Where and when was the study conducted?**

This field study took place on Lake Independence in Maple Plain, Minnesota between September-October 2020.

- **What boats were part of the study?**

Two of the boats were recreational boats commonly operated on Minnesota waters for a range of activities including cruising, tubing, waterskiing, and wakeboarding. These two boats were a 21-foot Larson LXI 210 and 20-foot Malibu Response LX.

Two 2019 wakesurf boats were also part of the study. These boats were a 21-foot Malibu VLX Wakesetter and 25-foot Malibu MXZ Wakesetter. The wakesurf boats are specifically designed to produce a large wave directly behind the boat for the sport of wakesurfing.

- **How was the study conducted?**

Details of the study can be found in the Executive Summary and in the full report (links below). In summary, five wave height sensors were installed at the test shoreline of Lake Independence and these remained in place over the duration of study. Over the course of the field campaign, wave data were collected on each of the four different boats - one boat took a single day to evaluate.

Boats were driven at four different distances from shoreline (225 ft, 325 ft, 425 ft and 625 ft) and under three different operating conditions.

Wave height data were collected for each boat and then post-processed after the field campaign. Analysis of the data involved calculation of maximum wave height, total wave energy, and maximum wave power produced by each boat and each condition.

- **Who conducted this study?**

This study was conducted by a small team of professional research staff. The team included:

- Jeff Marr, Associate Director of Engineering and Facilities at the St. Anthony Falls Laboratory (SAFL), Project Lead
- Andrew Riesgraf, SAFL Researcher
- Matt Lueker, SAFL Associate Engineer
- William Herb, SAFL Research Associate
- Jess Kozarek, SAFL Research Associate & Outdoor StreamLab Manager
- Kimberly Hill, Associate Professor of Civil, Environmental & Geo- Engineering

- **What did the study find?**

Major findings include the following:

- All boats produced their smallest wake waves when they were operated under the highest speed test condition (20 mph) and were planing on the water surface. Planing, a condition familiar to boaters, is when the boat rides on top of the water and is the mode of operation for waterskiing, cruising or other types of high speed activities.

- All boats generated their largest wake waves when operating at the slower speed test condition (~10 mph) . This was a condition where the trim (i.e., angle of the boat to the water surface) of the boat was high, and the boat's hull was displacing a large amount of water. Wakesurf boats are designed to operate around this condition during wakesurfing. For non-wakesurf boats, this is a condition that boats typically transition through quickly as they accelerate or decelerate.

- The study compared the wake wave characteristic of the boats under each of their "typical operating conditions." This was planing speed for the two non-wakesurf boats, and plowing speed for the wakesurf boats. **When comparing the boats under typical operating conditions at a distance of 100 ft from the boat, the wakesurf boats produced maximum wave heights that were ~2-3 time larger, total wave energies that were ~6-9 times larger, and maximum wave powers that were ~6 to 12 times larger than the non-wakesurf boats.**

- The study considered one example of an aftermarket wake shaper - a paddle-type device attached to the outside hull of a non-wakesurf boat, which helps create wake waves suitable for wakesurfing. The results suggest that this aftermarket device was successful in increasing the wake wave characteristics, indicating that "modified" non-wakesurf boats are capable of producing large and energetic waves.

- The data collected can be used to evaluate equivalent operational distance for different types of boats or operating conditions. Our report demonstrates two examples, where a 200 foot operational distance for non-wakesurf boats is selected as the reference condition (i.e., the distance from shoreline/other structures currently recommended by the Minnesota DNR). In the first example, the wake wave characteristics of a planing non-wakesurf boat (20 mph) were used as reference. **The data suggest that operational distances greater than 500 feet are required for the wake waves generated by a wakesurf boat to attenuate to similar wake wave characteristics as the non-wakesurf boat reference**. In the second example, the reference condition was a non-wakesurf boat at slower plowing speeds (~10 mph). **Here, the data suggest that operational distances greater than 425 feet are required by the wakesurf boats**.

- **What do those findings mean more broadly?**

This study is focused on producing robust data on the characteristics of wake waves generated by recreational boats found on lakes. The data, and our example method of comparing non-wakesurf boat and wakesurf boat operational distances, can be used to help inform recommendations, policy or legislation. However, establishing recommendations, policy, or legislation is not the role of our research team.

The report indicates the following outcomes:

1. Wake waves produced by wakesurf boats during wakesurfing are measurably larger than non-wakesurf boats in terms of maximum wave height, total wave energy and maximum power.

2. How a boat is used, or its "typical operation," is an important consideration. Non-wakesurf boats can generate large waves when they plow water during acceleration to or deceleration from planing, but these boats generally spend little time in this condition. Wakesurf boats used for wakesurfing generally spend a majority of time in this condition. Non-wakesurf boats can be outfitted with aftermarket devices, like a wake shaper, to create wake waves suitable for wakesurfing.

3. Data like those produced in this report can be used to inform guidance on operational distance. For example, this study infers, depending on which non-wakesurf boat reference condition is selected, that at 200 feet of operational distance, the wakesurf boats would need to operate at distances greater than 500 feet or 425 feet from shore/structure/object, etc.

4. This study was limited to four boats and the testing period was relatively short. The study's data and findings are important additions to the growing body of research in the area of wake waves; however, more studies of this type, as well as studies focusing on

how waves and propeller wash interact with lake bottoms, shorelines and structures, are needed.

- **Did this study examine shoreline erosion or failure of shoreline protection resulting from large boat waves?**

No. The study did not investigate these topics; rather, it focused on characterizing the wake waves themselves. The results of this study will support further research focusing on environmental impacts like shorelines.

- **Are there plans to continue research, and what will be studied?**

St. Anthony Falls Laboratory intends to continue conducting research on boat-generated wake wave impacts. The next phases of research will focus on the following questions:

- What are the characteristics of propeller wash, (i.e., the high velocity water jet produced by the boat propeller), and how does it vary with the type of boat and mode of operation of the boat? At what depth range does propeller wash begin to interact with the lake bottom?
- How do large wake waves interact with the lake environment, including the lake bottom, shorelines (natural and riprap), structures in the water like docks and lifts, vegetation, and fish habitat?

- **How was this project funded?**

This study was funded entirely through a crowdfunding campaign conducted by the University of Minnesota Foundation, with over 200 donors contributing. Donations were received from across the country, with a majority from within Minnesota and other Upper Midwest states.

- **Were donors or other outside groups involved in the research design, analyses or final report?**

No. Donors had no input in the design or scope of this research project. Analysis and report development involved only the University of Minnesota - St. Anthony Falls Laboratory research team. The only exceptions to this were the third party review facilitator and the report's two external reviewers.

- **Is the crowdfunding campaign still accepting donations and how can I contribute?**

The original crowdfunding campaign has ended but individuals or organizations can still contribute directly to the SAFL Healthy Waters Initiative through the St. Anthony Falls Laboratory website. Donation will go directly to the research program and the next phases of the project. Donate to SAFL's Healthy Waters Initiative.

- **Where can I get more information?**

Please follow the links below for additional information:

- Full report: "A Field Study of Maximum Wave Height, Total Wave Energy, and Maximum Wave Power Produced by Four Recreational Boats on a Freshwater Lake"

- News release: "University of Minnesota researchers study waves created by recreational boats"

- **Who can I contact about this report?**

Please send all media requests to **Savannah Erdman**, University Public Relations, at erdma158@umn.edu, or to the University Relations' main news line at unews@umn.edu.