Wake surfing

Debunking the Narrative

Wake Surfing….educating beyond the narrative!

Their Claim:* Wake Boats are causing shoreline erosion!

Reality:

- **The vast majority of studies, in addition to wave energy knowledge and calculations, show that wind energy and lakeshore development as the key sources of shoreline erosion.**

Their Claim: Wake Boats cause water degradation beyond normal boat traffic!

Reality:

- **Every boat has prop wash that affects resuspension, especially those that operate in shallow water consistently. Studies and actual lake data (tropic state, secchi, etc.) doesn't reflect any trends in the last 15 years in water quality degradation that can be solely attributed to wake boats.**

Their Claim: Wake Boats play a major role in the transfer of invasives species(AIS)!

Reality:

- **The studies identified that ballast, sterndrive engine, outboard motor, livewell, foot well (kayaks), splash well, bilge, and jet can all transport invasive species. If zero tolerance is the goal, then wake boats don't pose any additional threat.**

***- Last Wilderness Alliance, Greenfire, Lakes at Stakes, etc.**

St. Anthony Falls Laboratory Study (Marr, 2022)

What they don't tell you:

- **The study is crowdfunded, primarily by environmental groups. (Follow the money…not "organic")**
- **The study's peer reviewers (McFarlane, Cox) had severe criticisms with the study. These criticisms include a flawed analysis and energy calculations which do not align with previous studies. They were not given the opportunity to view a revised manuscript to ensure their comments were addressed.**
- **They used older and multiple sensors(pads/masts) that introduced varying data sets with no cross-calibration in their analysis. The data is riddled with inconsistencies resulting in a high degree of variance. For example, pad data was used throughout wake boat analysis while mast data was primarily used on the Larson and Response.**
- **This high degree of scatter on the wake boat data yields poor R-squared correlation coefficients which does not explain the data variability.**
- **The study's sample size/selection and methodologies are inconsistent with today's boats and operations.**

St. Anthony Falls Laboratory Study (Marr, 2022)

The study explicitly states it does not address many of the concerns brought forth in the ordinances

6.2.5 Linking wave height, energy and power to environmental impacts

This report only characterizes the wave height, energy, and power of a few recreational watercraft, and does not address potential environmental impacts such as shoreline/riparian

erosion, water quality degradation, or alteration to aquatic habitats. Focus of future research will

St. Anthony Falls Laboratory Study (Marr, 2022)

Sample Selection/Testing Methodology

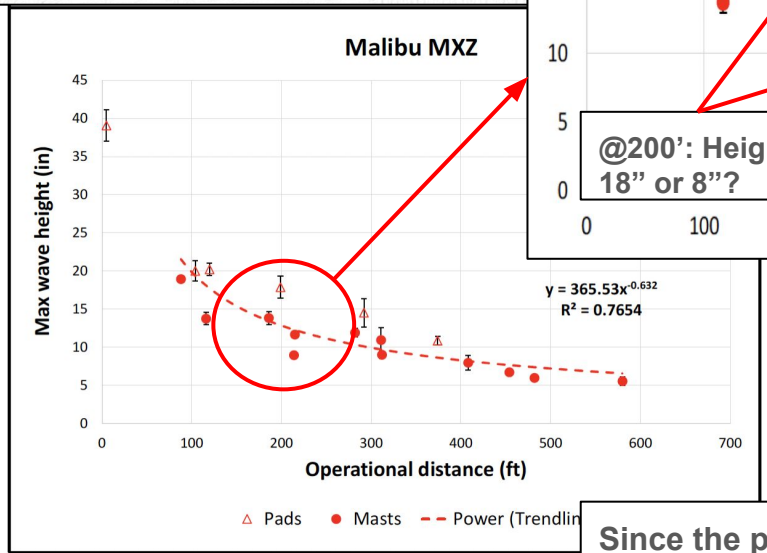
Year	Weight
2004	2950
2004	2450
2019	4200
2019	5500

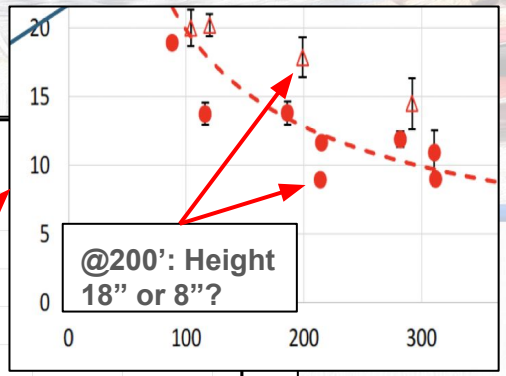
Table 3. Summary of the operating conditions for each boat tested. The only difference between Conditions 1a and 1b for the Malibu Response LX was the wake shaper setting (i.e., on vs off). The only difference between Conditions 1a and 1b for each Malibu Wakesetters was the ballast setting (i.e., full vs empty).

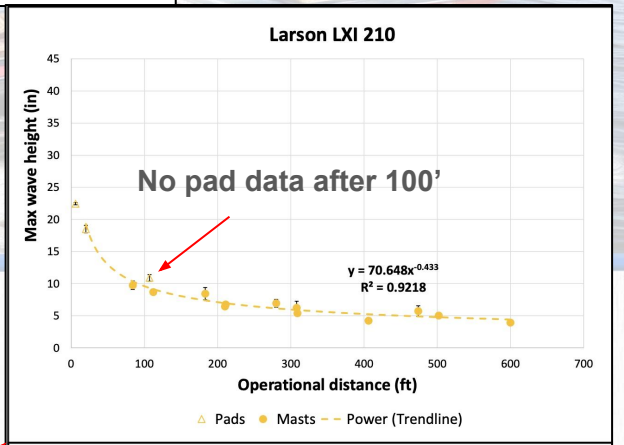
Boat	Condition #	Speed (mph)	Trim Setting (%)	Ballast (% filled)	Hydrofoil/Power Wedge III	Wake Shaper/Surf Gate	People Aboard	Approx. People Weight (lbs.)
Larson LXI 210	1a	10	50 (middle)	N/A	N/A	N/A	2	330
	2	20	100 (down)	N/A	N/A	N/A	2	330
Malibu Response LX	1a	10	N/A	N/A	Down	On – Port Side	2	330
	1b	10	N/A	N/A	Down	Off	2	330
	2	20	N/A	N/A	Down	Off	2	330
Malibu VLX Wakesetter	1a	11	N/A	100	Down – Setting #3	On – Port Side	4	740
	1b	11	N/A	0	Down – Setting #3	On – Port Side	4	740
	2	20	N/A	0	Down – Setting #3	Off	4	740
Malibu MXZ Wakesetter	1a	11	N/A	100	Down – Setting #3	On – Port Side	4	740
	1b	11	N/A	0	Down – Setting #3	On – Port Side	4	740
	2	20	N/A	0	Down – Setting #3	Off	4	740

Currently, there is a 34% difference between the Larson and VLX in weight. Newer boat and same number of people would decrease that to within 10%.

Serious Data Quality and Analysis Issues







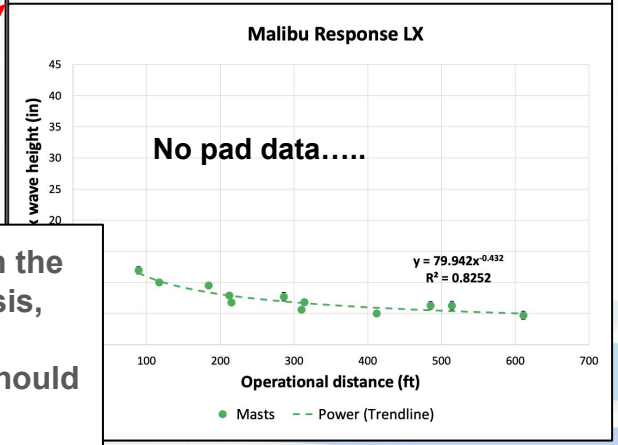


Figure 14. Maximum wave height as a function of distance for the two wat
Condition 1a. The error bars represent the standard deviation. Data points
from the track line were not included in the regression analysis.

Since the pad data wasn't utilized in the majority of the control boat's analysis, the pad data should have been discarded and only the mast data should have been used for the analysis.

“Enhanced wave”....a wave is a wave!

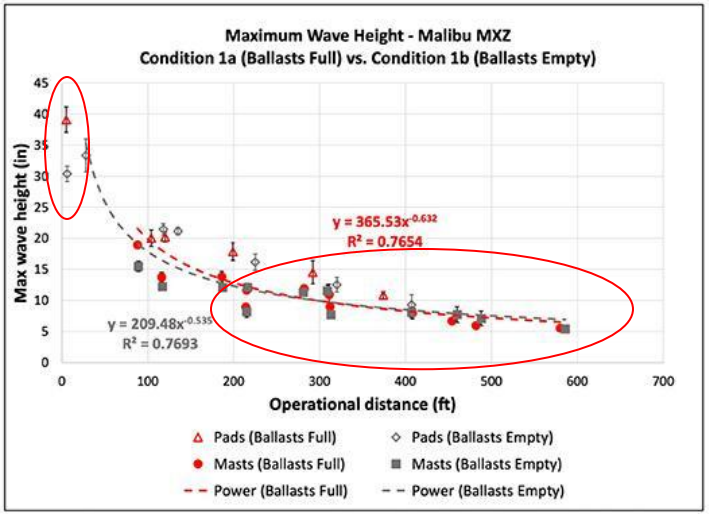


Figure 34. Comparison of the maximum wave height of the Malibu MXZ when the ballast tanks were full and empty. Data points less than one boat length from the track line were not included in the regression analysis.

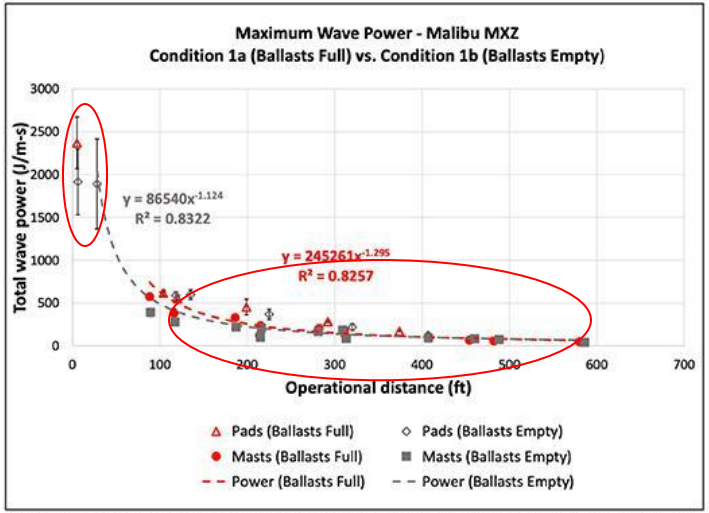


Figure 36. Comparison of the maximum wave power of the Malibu MXZ when the ballast tanks were full and empty. Data points less than one boat length from the track line were not included in the regression analysis.

What does this mean? The ballast is there for an immediate effect for surfing, but after that, the wave dissipates significantly within 200’. At over 100’ out, ballast has little effect on the wave!

Terra Vigilis' Water Quality and Wave Impact Study

Terra Vigilis Test Samples-

- 2020 Super Air Nautique
- 2004 16' Boston Whaler with 40HP (800 lbs.)
- 2001 20' Hurricane Deck Boat with 125HP (2475 lbs.)
- 2014 Sport Nautique
- 1991 20' Sun Cruiser Pontoon with 25HP (2100 lbs.)
- 2004 SeaDoo GTX 4TE

2020 results:

Maximum Wave Height (p. 18): **Wake Boat - 10"** **Pontoon - 8"**

2021 results:

Maximum Wave Height (p. 21): **Wake Boat - 8" (200 ft.)***

Under "Problems/Issues" (p. 22): "....it's unclear why these waves are so much smaller than previous runs and other research."

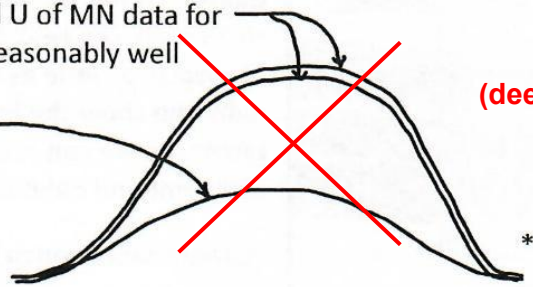
We need to summarize the data….

Key point: Every test involving a wake boat, it is at max ballast to generate the maximum wave height….worst case.

How Do Their Wake Heights Compare?

WSIA-Goudey and U of MN data for real boats agree reasonably well

NMMA-Fay computer model is very different!



Distance from boat's path

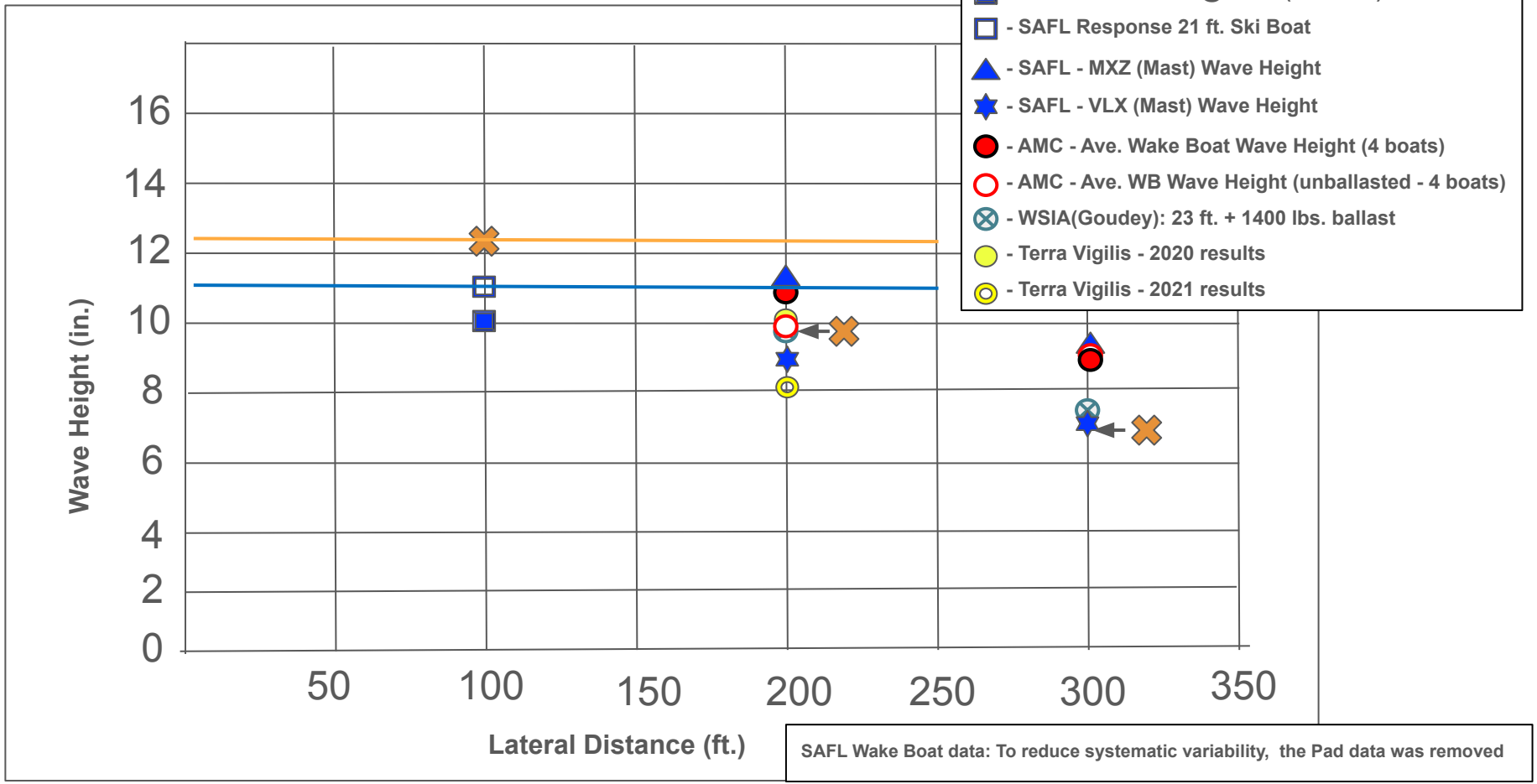
	Wave Height	66 ft	100 ft	200 ft	300 ft	
(deep)	WSIA-Goudey	>20"	20"	16"	13"	+1400 lbs.
	U of MN	>20"	20"	13"	10"	2%
	NMMA-Fay	9"	*	*	*	
	VLX (U of MN)*	15"	13"	10"	8"	98+%

*no data beyond 66 ft; Fay says resolution "deteriorates"

(shallow) WSIA	19"	17"	10"	7"	+1400 lbs.
Larson (max wave)	13"	10"	8"	6"	(add +1200 lbs?)
Terra V. Sup. Air Naut.	?"	?"	8"	4.5"	

Considered Acceptable!

Wave Height Decay - Leading Studies



SAFL Wake Boat data: To reduce systematic variability, the Pad data was removed

Wave Height Decay - Leading Studies

- AMC 21 ft. Fishing Boat (4100 lbs.)
- SAFL 21 ft. Larson @100 ft. (2950 lbs.)
- SAFL Response 21 ft. Ski Boat
- SAFL - MXZ (Mast) Wave Height
- SAFL - VLX (Mast) Wave Height
- AMC - Ave. Wake Boat Wave Height
- AMC - Ave. Wake Boat Wave Height (unballasted)
- WSIA(Goudey): 23 ft. + 1400 lbs. ballast
- Terra Vigilis - 2020 results
- Terra Vigilis - 2021 results

Wave Height (in.)

16
14
12
10
8
6
4
2
0

50 100 150 200 250 300 350

Lateral Distance (ft.)

Acceptable

Not Acceptable?

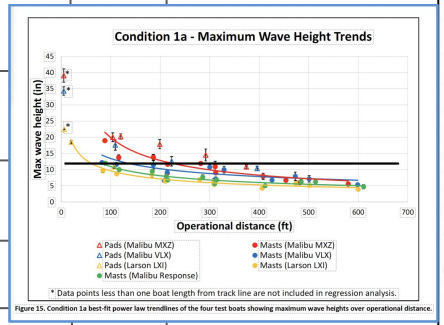
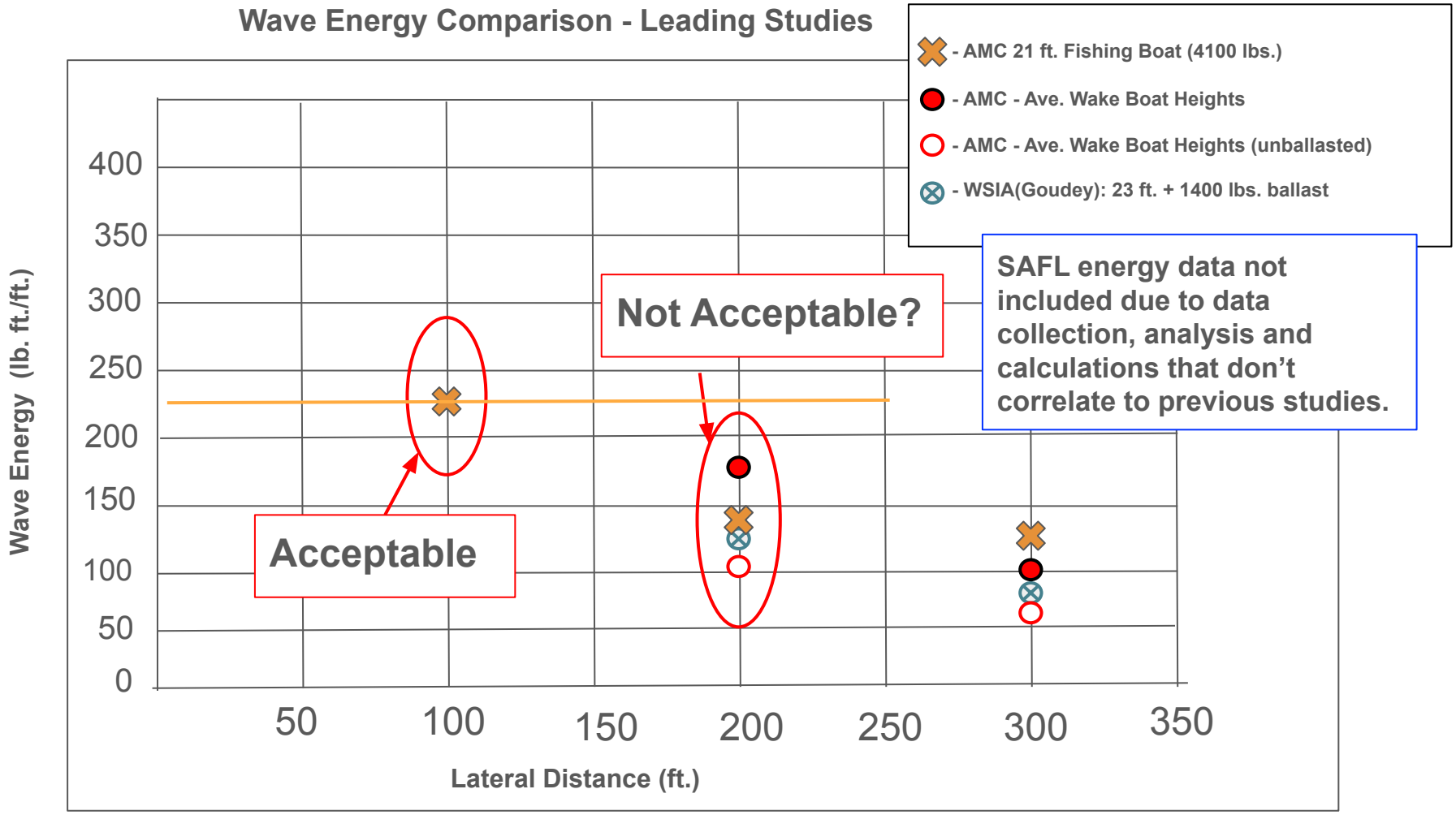


Figure 15. Condition 1a best-fit power law trendlines of the four test boats showing maximum wave heights over operational distance.


Wave Energy Comparison - Leading Studies
- AMC 21 ft. Fishing Boat (4100 lbs.)
- AMC - Ave. Wake Boat Heights
- AMC - Ave. Wake Boat Heights (unballasted)
- WSIA(Goudey): 23 ft. + 1400 lbs. ballast
SAFL energy data not included due to data collection, analysis and calculations that don't correlate to previous studies.
Not Acceptable?
Acceptable
Wave Energy (lb. ft./ft.)
400
350
300
250
200
150
100
50
0
50
100
150
200
250
300
350
Lateral Distance (ft.)

Wave Energy and Shoreline Erosion:

"The dynamic stability of a shoreline impacted upon by a natural wind wave climate is more likely to be maintained provided the incident wave energy is dominated by height and not period." In other words, wave height is not the critical factor in predicting shoreline erosion. (Cox; Sex, Lies and Wave Wake)

Wave energy dissipates faster than wave height.

Mistake of Emphasizing Wave Height- Erosion Determined by **Energy** (and Power)

$$E = \frac{\rho g^2 H^2 T^2}{16\pi}$$

E= Wave energy (per meter)

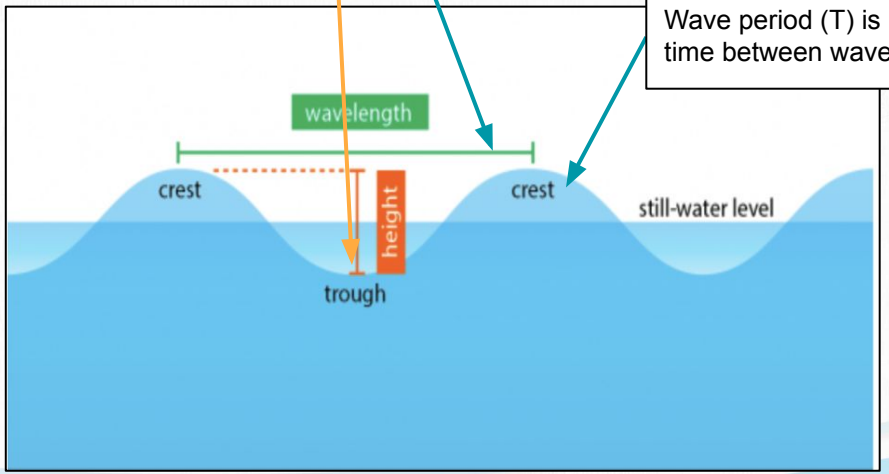
ρ = density of water ($\frac{1000kg}{m3}$)

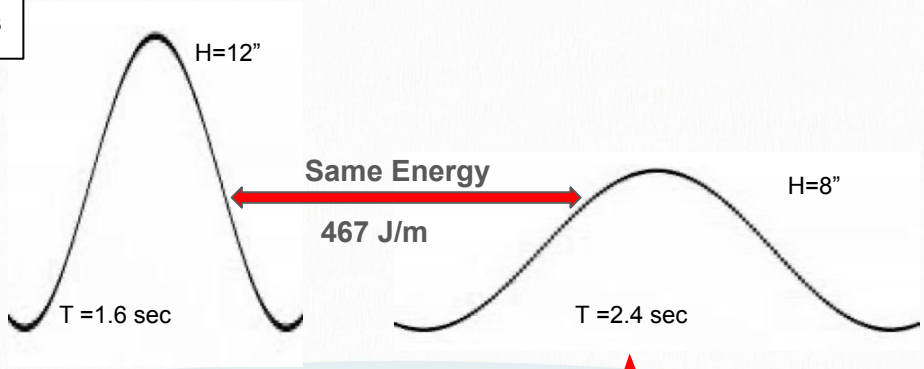
g = acceleration of gravity (9.8m/ s^2)

H= wave height (m)

T= wave period (s)

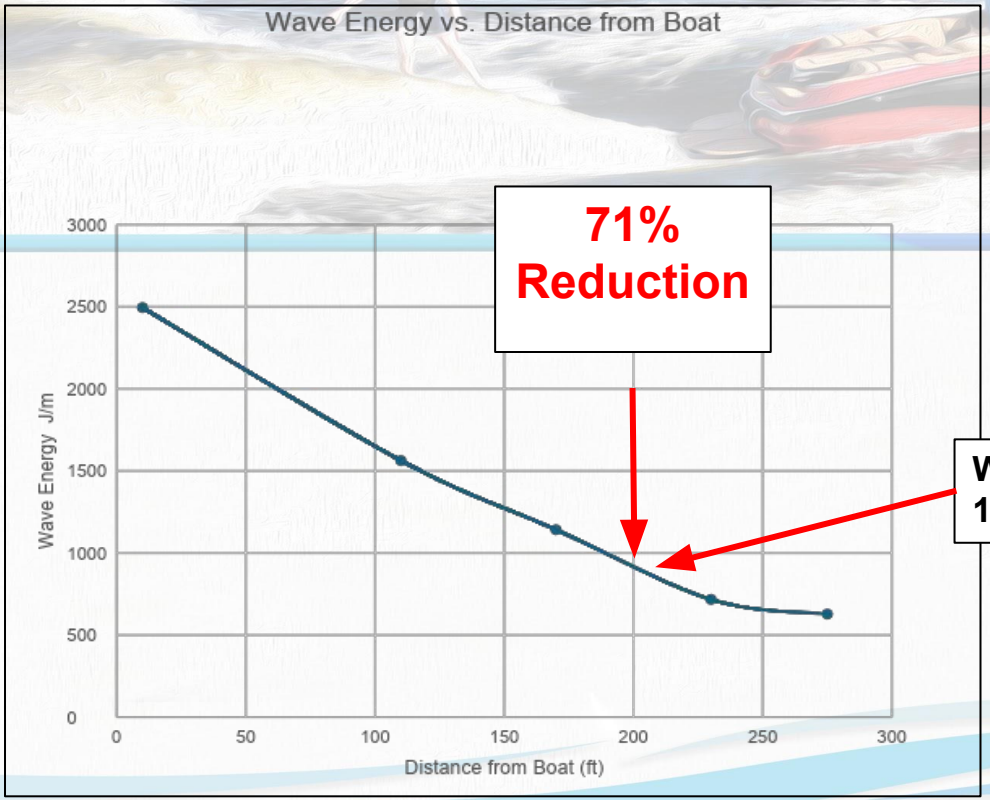
Wave period (T) is time between waves





Larger erosion potential

Wave Energy rapidly dissipates faster than wave height



Distance	Energy (J/m)
10	2,495
110	1,563
170	1,142
230	717
275	628

Wind wave, 20 mph, 1 mile = 790 (J/m)

G23 with full ballast + 1400 lbs of additional ballast added

Goudey 2015 https://www.wsia.net/wp-content/uploads/2020/03/WSIA_draft_report_Rev_II.pdf

Wind Wave vs. Wake Boat Energy

WIND
Constant Waves
Period: ~1.6-2.6s
Duration: HOURS

Calculated Energy @ 20mph: 790 (J/m)
(1 mile fetch)

WAKE
Large initial wave breaks up into multiple smaller waves
Period: ~1.6-2 s
Duration: ~ 40 s @210’

Measured Energy: 692 - 821(J/m)

G23 w/ +1400lbs additional ballast

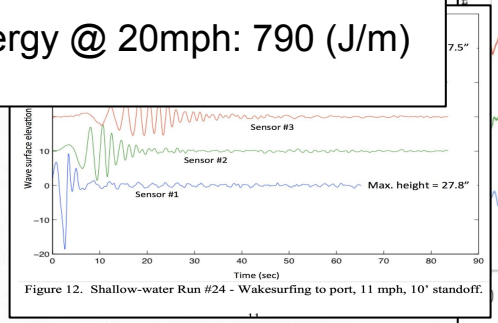


Figure 12. Shallow-water Run #24 - Wakesurfing to port, 11 mph, 10’ standoff.

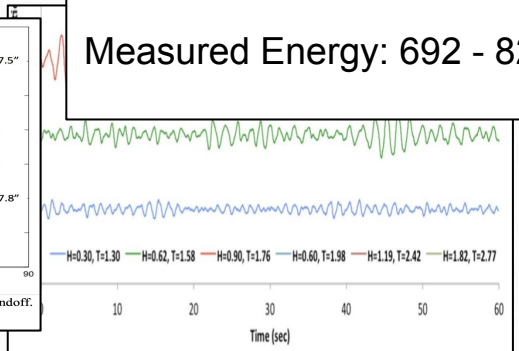


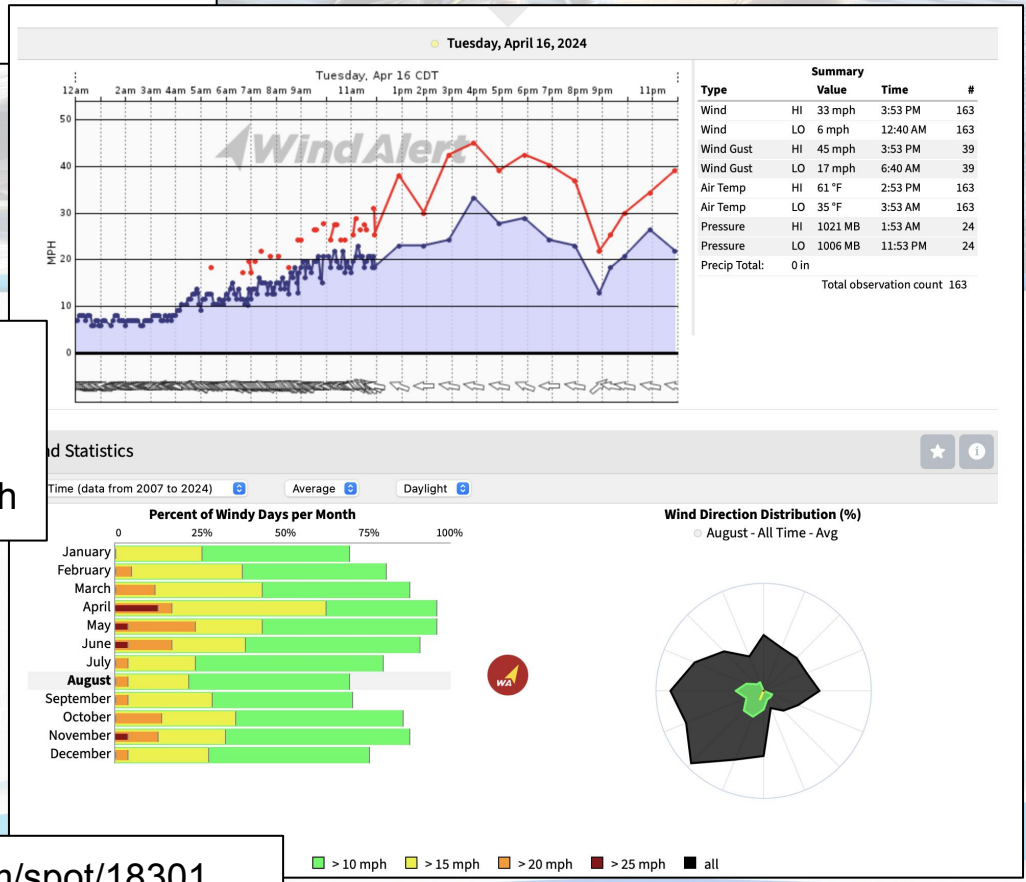
Figure 29. WAFO sea spectra time series for six wave specifications

What does this mean?
During windy months like April/May/October, a shoreline will see the equivalent of thousands of wake boat passes from wind driven wave energy alone.

Wind Speed: Historical

April/May/October Averages:

- >20% of days with wind >20 mph;
- And April: 10% >25 mph with gust > 40 mph



https://windalert.com/spot/18301

Wind Wave Energy: Primary Source

More studies have concluded that wind energy makes up the majority of any impact on a shoreline.*

ST. ANTHONY
FALLS LABORATORY

Project Report No. 598

Quantifying Wave Energy on Minnesota Lakes

Final Report

By

William Herb, Ben Janke and Heinz Stefan
University of Minnesota, St. Anthony Falls Lab
Meijun Cai and Lucinda Johnson
University of Minnesota, Natural Resources Research Institute

Prepared for:
Legislative-Citizen Commission on Minnesota Resources
St. Paul, MN

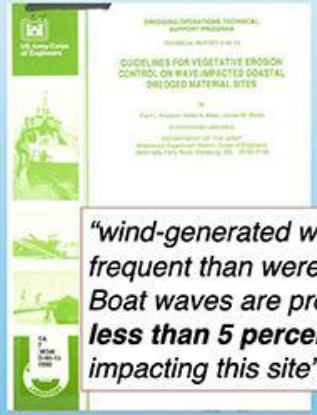
January 2022
Minneapolis, Minnesota

College of Science & Engineering
University of Minnesota

"Shoreline Erosion is driven mainly by wind-generated wave energy"

Wind Energy >> Boat Wake

5 sites over 2 years and wake energy from boats ~5-10% of wind, except when boats were < 200 feet from shore and then only 20%


GUIDELINES FOR VEGETATIVE EROSION CONTROL ON WAVE-IMPACTED COASTAL DREDGED MATERIAL SITES

*"wind-generated waves were 10 times more frequent than were boat-generated waves. Boat waves are probably responsible for **less than 5 percent** of the wave energy impacting this site".*

Page 15 Knutson PL, Allen HH, Webb JW. 1990. Guidelines for vegetative erosion control on wave-impacted coastal dredged material sites. Technical Report D 90-13. Vicksburg (MS): Army Engineer Waterway Experiment Station, Environmental Laboratory, 33p


FINAL REPORT ON THE ROLE OF BOAT WAKES IN SHORE EROSION IN ANNE ARUNDEL COUNTY, MARYLAND

*"Note that Figure 7.7 shows **boats were not the principal source of wave energy at any of the shoreline sites during the summer months".***

Page 7-15 Zabawa C, Ostrom C. 1980. Final report on the role of boat wakes in shore erosion in Anne Arundel County, Maryland. Maryland: Tidewater Administration, Maryland Department of Natural Resources

In Summary - Shoreline Erosion???

McFarlane states that shorelines are generally dynamically stable and formed according to naturally occurring waves generated by the wind conditions.

What do we know?

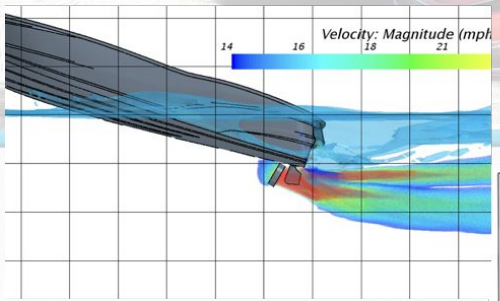
- Shorelines are considered dynamically stable from decades of weather (wind, severe storms, ice, etc.)
- Wake boats at 200+ ft from shore have degrees of wave energy less than 20 mph wind energy (farther from shore and representative boats results in even less energy). Furthermore, the testing shows that data from representative control samples/test boats results in comparable wave heights and energy than wake boats while surfing.

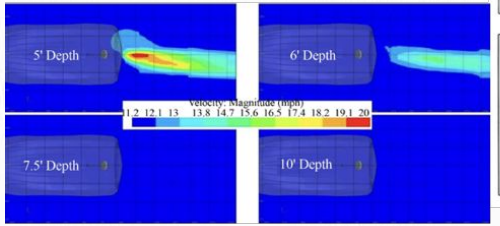
Wake Prop Wash

Sediment Resuspension?

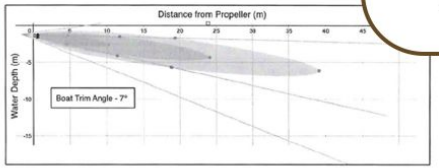
MODELS

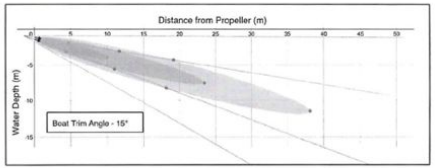
Fay et.al 2022





Ray 2020





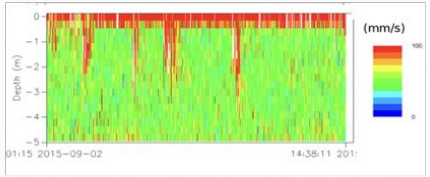
Contradictory Models

Speculation on Impact

All need Validation

EXPERIMENTS

Raymond & Galvez-Cloutier 2015



"This was confirmed by the observations of the diver visible in Figure 11. **He did not notice any material suspended as a result of the passage of the boats**. "

Wake Prop Wash

Yousef's work (1970's):

- **Many of the studies cited reference and widely accept a key metric that Yousef theorized for prop wash….that .25m/sec of water velocity will move a 0.30mm particle of sediment.**
- **But Yousef also theorized that a 100 hp engine on a standard boat will move that same 0.30mm sediment at a depth of 8 ft…..yet they ignore this.**

These arguments are made in a vacuum:

How can we point to a couple of boats in the deepest areas of the lake when dozens of boats and jet skis, with engines greater than 100 hp (and up to 400 hp), operate in 5'-10' depths?

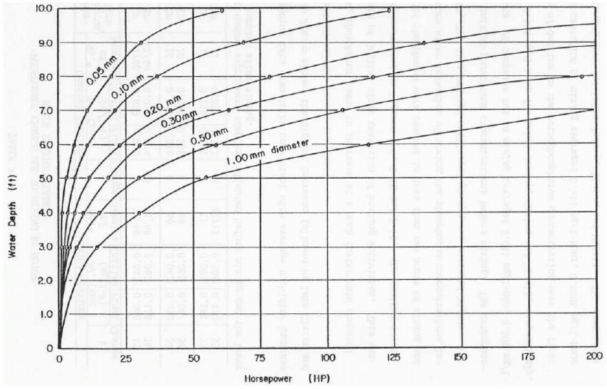


Figure 13: Calculations (graph?) produced by Youssef (1978) linking the power of a boat (HP) and the maximum disturbance depth of particles of different sizes according to Beachler (2002).

Sediment Resuspension:

Terra Vigilis:

- Testing found “25%” increase in phosphorus after 30 minutes (0.012 -> 0.015(mg/l)…. a 0.003 difference). Sampled 30 min after boat pass.

What they don’t tell you:

- Continued to test all summer at Site 3… resulted in a 46% variation throughout the summer.
- The study also stated:
  - “All boats tested had both surface and subsurface impacts”
  - “...this sediment deposition could not be solely attributed to only wakeboard boats…”(all watercraft; boat traffic)

	Phosphorus
Date	Site 3
27-Jun	0.0184
29-Jun	0.0168
4-Jul	0.0191
6-Jul	0.0211
10-Jul	0.0209
13-Jul	0.0201
18-Jul	0.0161
20-Jul	0.0174
25-Jul	0.0143
27-Jul	0.0147
1-Aug	0.0162
3-Aug	0.0156
8-Aug	0.0157
10-Aug	0.0206
22-Aug	0.0159
24-Aug	0.0159

Table 1: Phosphorus

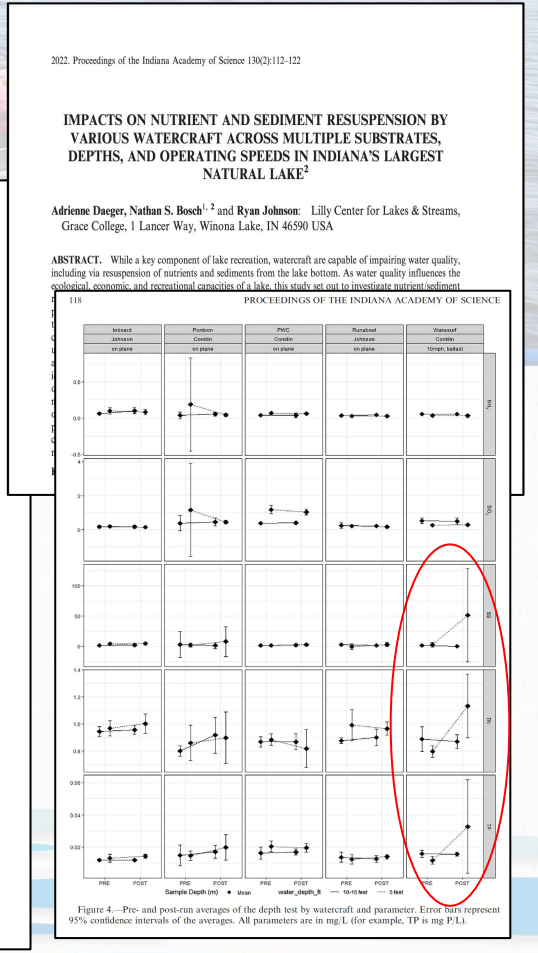
Indiana Resuspension Study

Impacts on Nutrient and Sediment Resuspension by various Watercraft Across Multiple Substrates, Depths, and Operating Speeds in Indiana's Natural Lake. (2022. Proceedings of the Indiana Academy of Science 130(2):112–122)

- Designed to determine the smallest depth of water required to minimize or inhibit sediment resuspension for each watercraft type. Boats ran through 5, 10 and 15 ft depths.
- Boats tested: Inboard, I/O runabout, personal watercraft (PWC), standard pontoon, and a wake boat under ballast.
- Nutrient/suspended sediment samples at multiple sites dependant on bottom composition were collected before and after the watercraft passed through the sampling area and their averages were compared using t-tests.

Findings:

- Nutrient resuspension was observed after the wake boat in 5 ft of water (with ballast), and no resuspension by any watercraft in 10-15 ft of water ("..a test of the wake boat with an empty ballast was not performed….").
- Runabout and inboard watercraft may also be capable of impacts in 5 ft of water. (common depth for these watercraft)



2022. Proceedings of the Indiana Academy of Science 130(2):112-122

IMPACTS ON NUTRIENT AND SEDIMENT RESUSPENSION BY VARIOUS WATERCRAFT ACROSS MULTIPLE SUBSTRATES, DEPTHS, AND OPERATING SPEEDS IN INDIANA'S LARGEST NATURAL LAKE[2]

Adrienne Daeger, Nathan S. Bosch[1, 2] and **Ryan Johnson**: Lilly Center for Lakes & Streams, Grace College, 1 Lancer Way, Winona Lake, IN 46590 USA

ABSTRACT. While a key component of lake recreation, watercraft are capable of impairing water quality, including via resuspension of nutrients and sediments from the lake bottom. As water quality influences the ecological, economic, and recreational capacities of a lake, this study set out to investigate nutrient/sediment

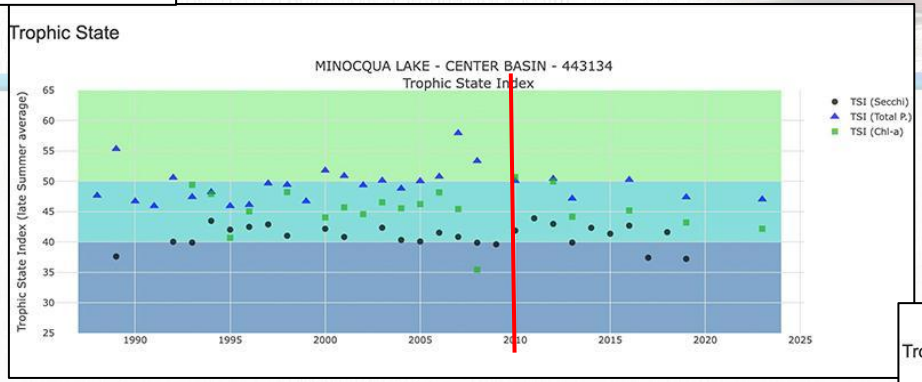
Figure 4.—Pre- and post-run averages of the depth test by watercraft and parameter. Error bars represent 95% confidence intervals of the averages. All parameters are in mg/L (for example, TP is mg P/L).

Water Clarity - Historical Testing and Data

Minocqua Lake

Oneida County

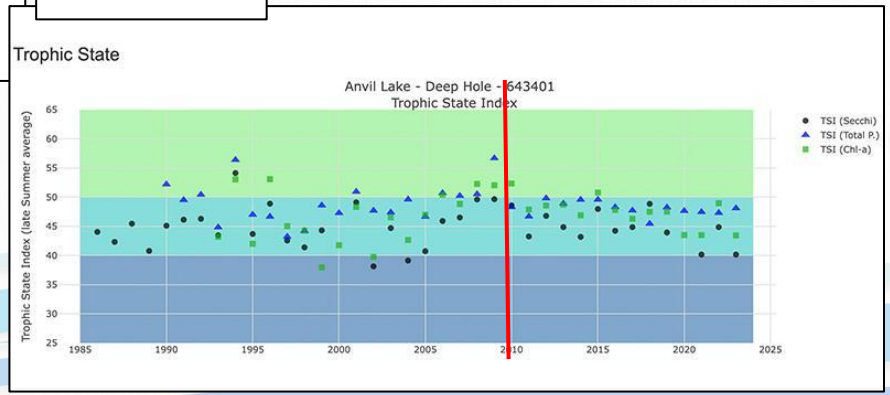
1,339 acres



Anvil Lake

Vilas County

377 acres



WEx WDNR https://dnr-wisconsin.shinyapps.io/WaterExplorer

Ballast Tanks and Aquatic Invasive Species:

Two recent studies

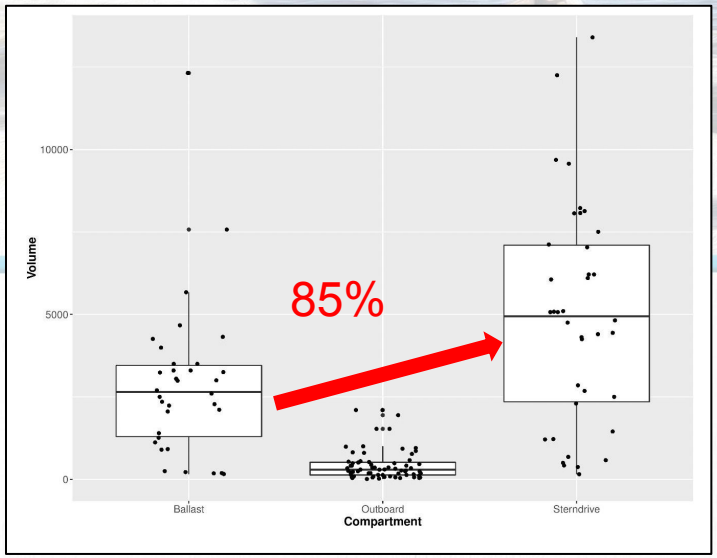
- University of Minnesota Study: Occurrence and Survival of Zebra Mussel Veliger Larvae in Residual Water Transported by Recreational Watercraft, Adam Doll (2018).
- University of Wisconsin Study: Volume and contents of residual water in recreational watercraft ballast systems, Campbell (2016)

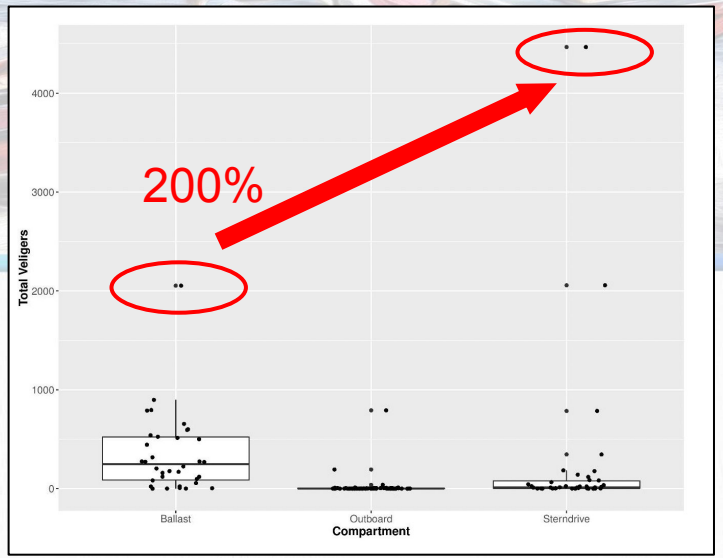
Discussion:

- The U of M study is more comprehensive and identified that ballast, sterndrive engine, outboard motor, livewell, foot well (kayaks), splash well, bilge, and jet can all transport invasive species.
- Heidi Wolf, Invasive Species Supervisor for the MN DNR stated, "under that strategy, wakeboard boats shouldn't be singled out,...."
- DNR Natural Resources Board Agenda (June 2024): "While ballast tanks in wake boats can serve as a pathway for AIS to spread, AIS were already established in hundreds of inland lakes in Wisconsin prior to the rise in wake boat popularity…..To fully understand the impact of wake boats on the spread of AIS, more information is needed,....and the frequency with which wake boats move amongst bodies of water."

Zero tolerance???

“Increase Risk of AIS?”





SternDrive (inboard/outboard) had 85% more residual volume and the largest # of Veligers observed
Wake Boat operate in deeper water where Milfoil less prevalent

Occurrence and Survival of Zebra Mussel (*Dreissena polymorpha*) Veliger Larvae in Residual Water Transported by Recreational Watercraft, Adam Doll, Uminn thesis 2018

ENFORCEMENT????

THE LAKELAND TIMES

MINOCQUA, WISCONSIN • FRIDAY, MARCH 15, 2024

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LET THE SUN SHINE IN

The Lakeland Times grades officials on government openness

Page 1

Zero enforcement on wake boats, enhanced or hazardous wakes in Oneida and Vilas counties

DNR, Oneida and Vilas county sheriff's offices can't or won't enforce local boating ordinances

By Trevor Greene

OF THE LAKELAND TIMES

Oneida County sheriff Grady Hartman, Vilas County sheriff Joe Fath and his chief deputy Pat Schmidt said there would be no enforcement by

wakes and wake boats.

Regulating wake boats or drafting ordinances regarding enhanced or hazardous wakes has been a hot button topic appearing in front of area town board's the last few years. While a number

Supreme Court hears censorship cases against states

Tech platform challenges Florida, Texas laws as unconstitutional

...ews analysis

be found on pages 12 and 13 of today's edition.

THE LAKELAND TIMES

MINOCQUA, WISCONSIN • FRIDAY, MAY 24, 2024

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DNR official cautions towns about enhanced wake regulations

Local enforcement could cross constitutional limits

By Richard Moore

He said the sheriff's office "will not be getting involved with it."

"The amount of money they would have to pay would far exceed any benefit that (a) town gets," Hartman said, adding he could see it amounting to over $100,000. "Because I really don't want anything to do with it. We got real (crimes to worry

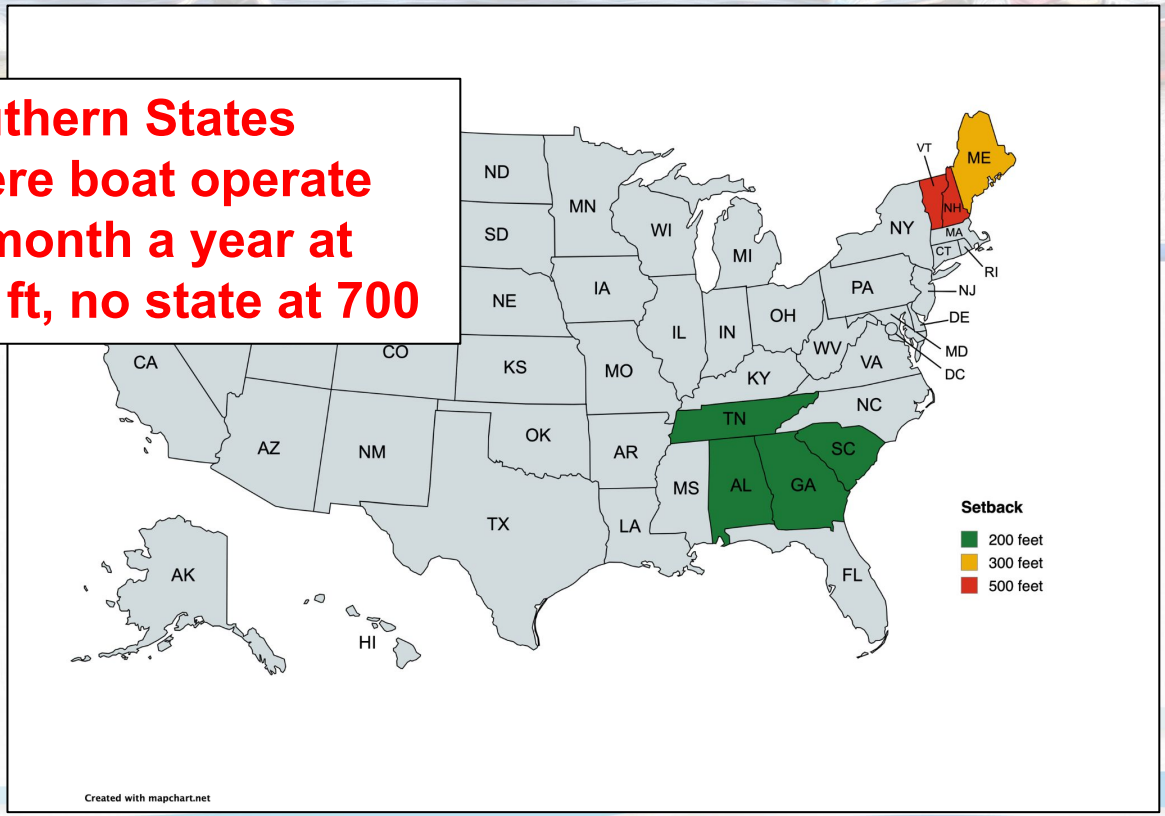
Hartman indicated he could see difficulties arise from residents who try and enforce wake ordinances themselves, especially if they don't have any law enforcement experience. Instances like that also open up the possibility for those trying to enforce a wake ordinance of being arrested themselves.

County Sheriff's will not enforce…. burden is on Township

An unenforced ordinance creates liability for a town

Other State Precedents

Southern States where boat operate 12 month a year at 200 ft, no state at 700



In Summary

- **Wake boats, even at maximum settings aren't generating the wave energies to be a critical factor in shoreline erosion, especially compared to wind energy, severe storms, and shoreline development.**
- **Wake boats, even at maximum settings are within inches for wave height of underpowered, and underweight control boats at appropriate distances…and are comparable to what we see on today's lakes (tritoons, jet boats, 23+ ft. stern drives).**
- **Studies and actual lake data show that wake boats aren't posing any additional risk to water clarity and sediment resuspension, considering overall lake traffic depths.**
- **Studies and the DNR have identified that traversing lakes is the primary factor in AIS. If zero tolerance is the goal, and it should be, then any policy needs to address all watercraft and not single out wake boats.**
- **Due to this information, any ordinances are capricious and just targeting wake boats.**