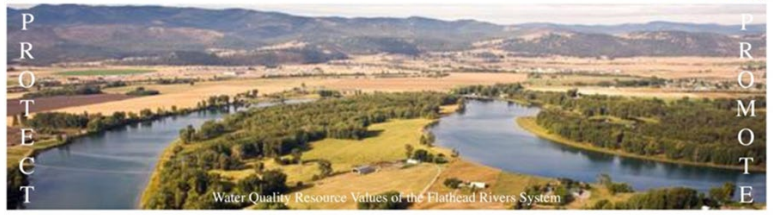
Impacts of Recreational Boating and Wave Energy on the Flathead River

Samantha Tappenbeck
Resource Conservationist

FLATHEAD CONSERVATION DISTRICT
Locally-led Conservation Since 1945

Flathead River Commission



TETRA TECH

The Flathead River: It's Complicated

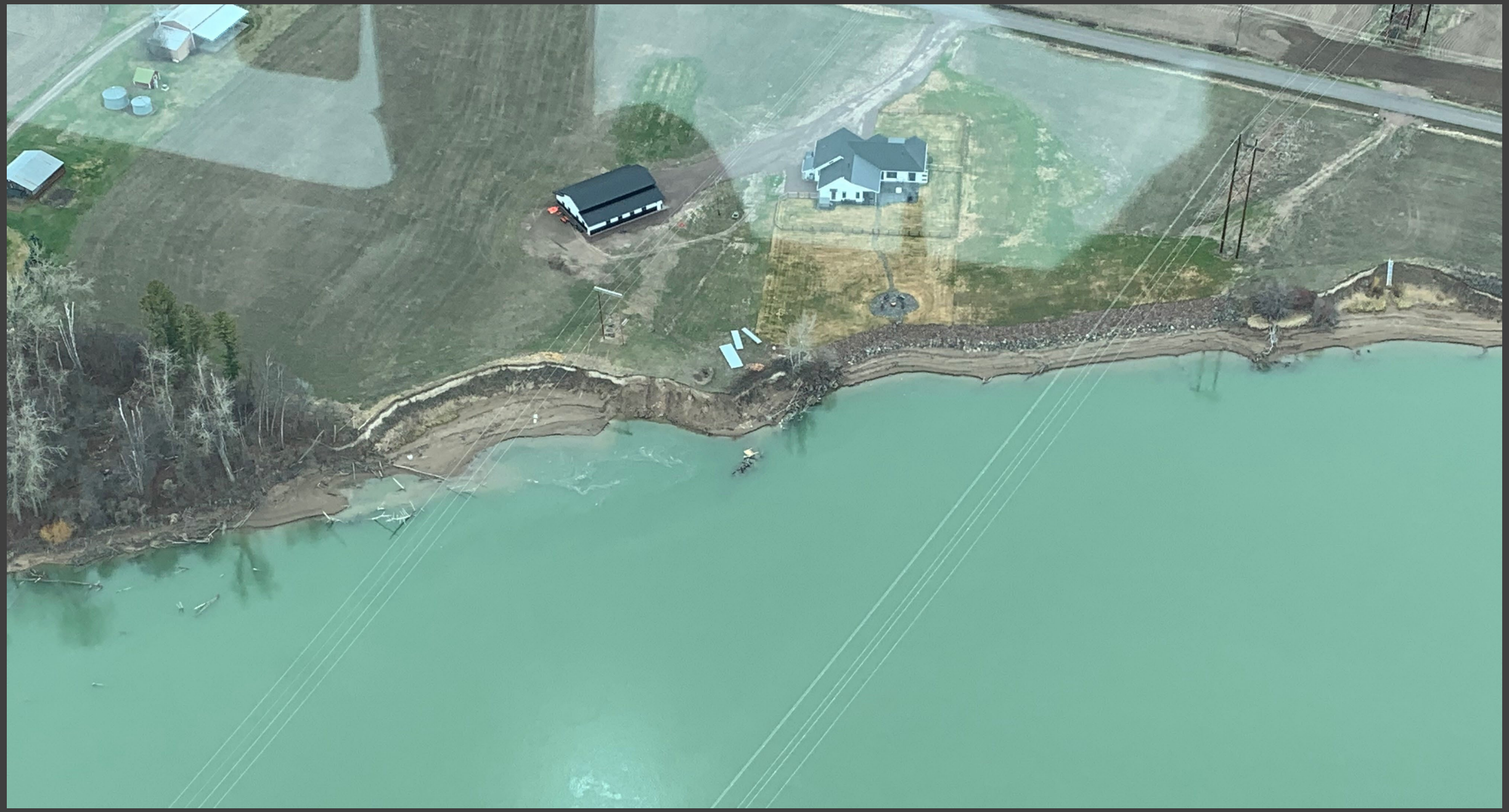
- Lake-level influence
- Currents and velocity
- Development and land use
- Wakes and waves

Water Quality Concerns

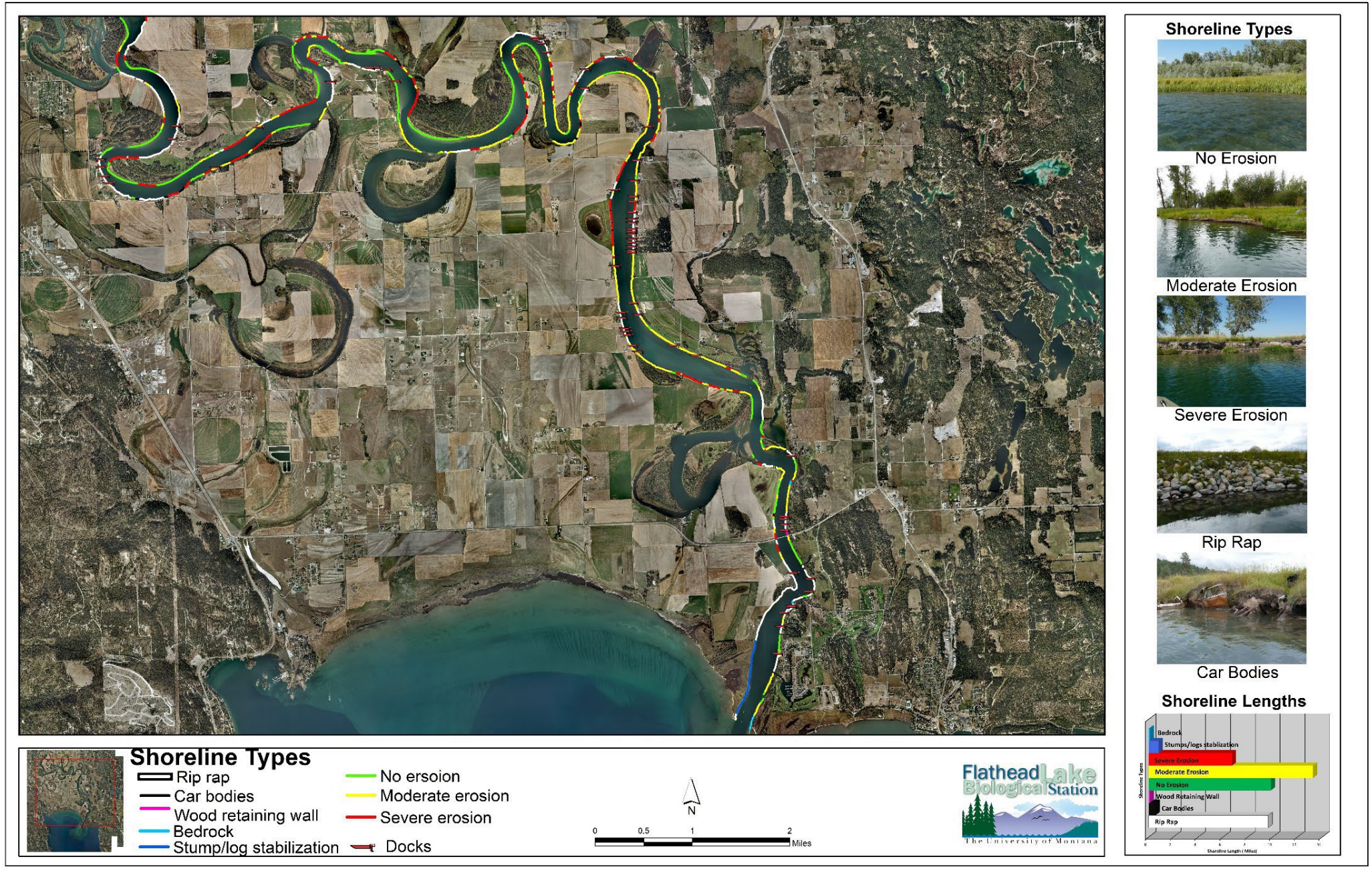
- Streambank erosion = 20-30% of suspended solids, 60% of nutrient loading in Flathead River
- Downstream transport to Flathead Lake
- TMDL identifies erosion as major contributor to pollutant loading in Flathead Lake
- Identified as priority in the Flathead-Stillwater Watershed Restoration Plan

Landowner Concerns

- Riverfront landowners are losing substantial acreage
- Threats to loss of structures and agricultural land
- Expense of stabilization measures
- Factors leading to accelerated erosion

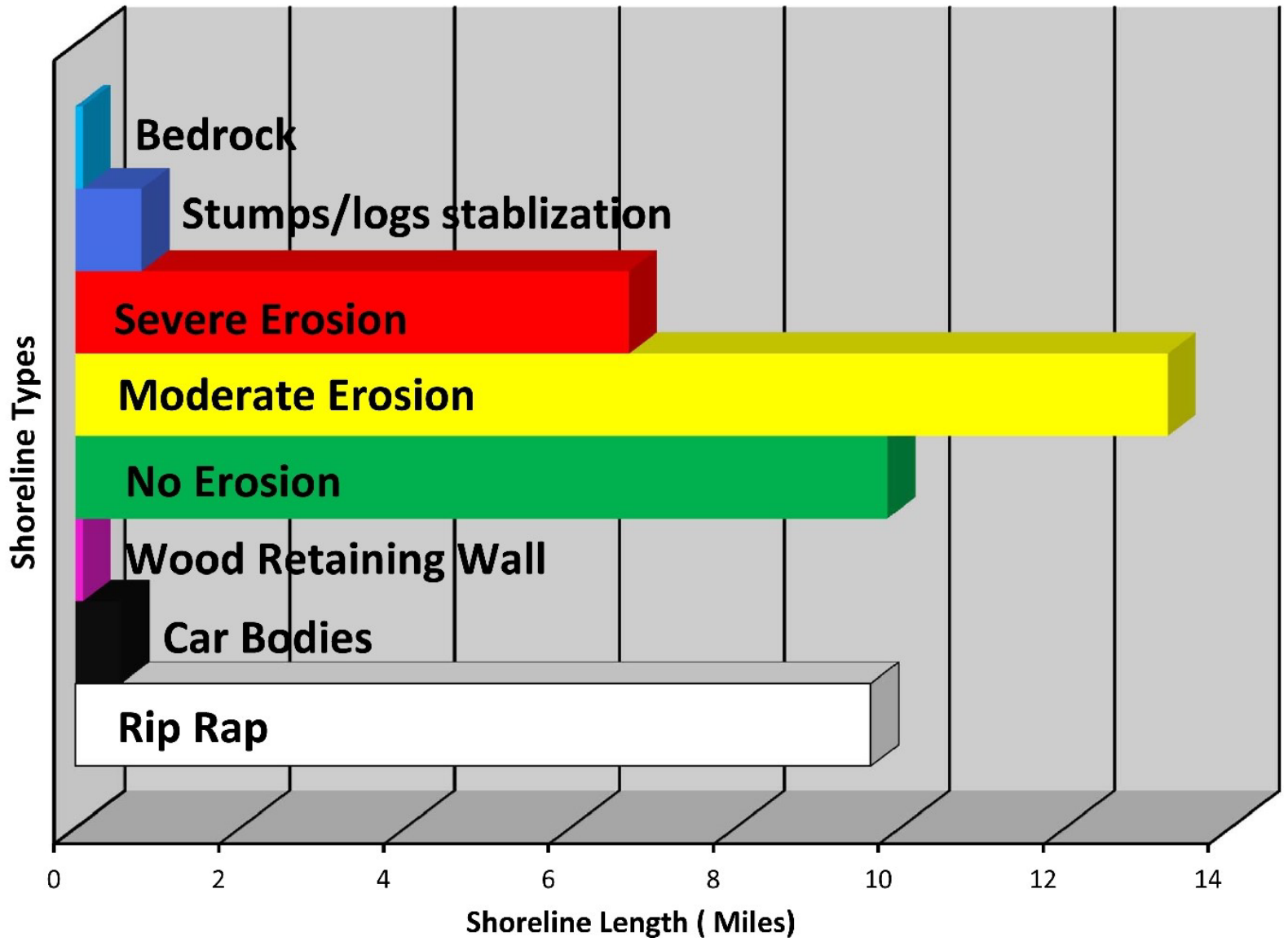


2010


Shoreline Types
Rip rap
Car bodies
Wood retaining wall
Bedrock
Stump/log stabilization
No ersoion
Moderate erosion
Severe erosion
Docks
N
0
0.5
1
2
Miles
Flathead Lake Biological Station
The University of Montana
Shoreline Types
No Erosion
Moderate Erosion
Severe Erosion
Rip Rap
Car Bodies
Shoreline Lengths
Bedrock
Stumps/logs stablization
Severe Erosion
Moderate Erosion
No Erosion
Wood Retaining Wall
Car Bodies
Rip Rap
Shoreline Types
Shoreline Length (Miles)

2010

Shoreline Lengths

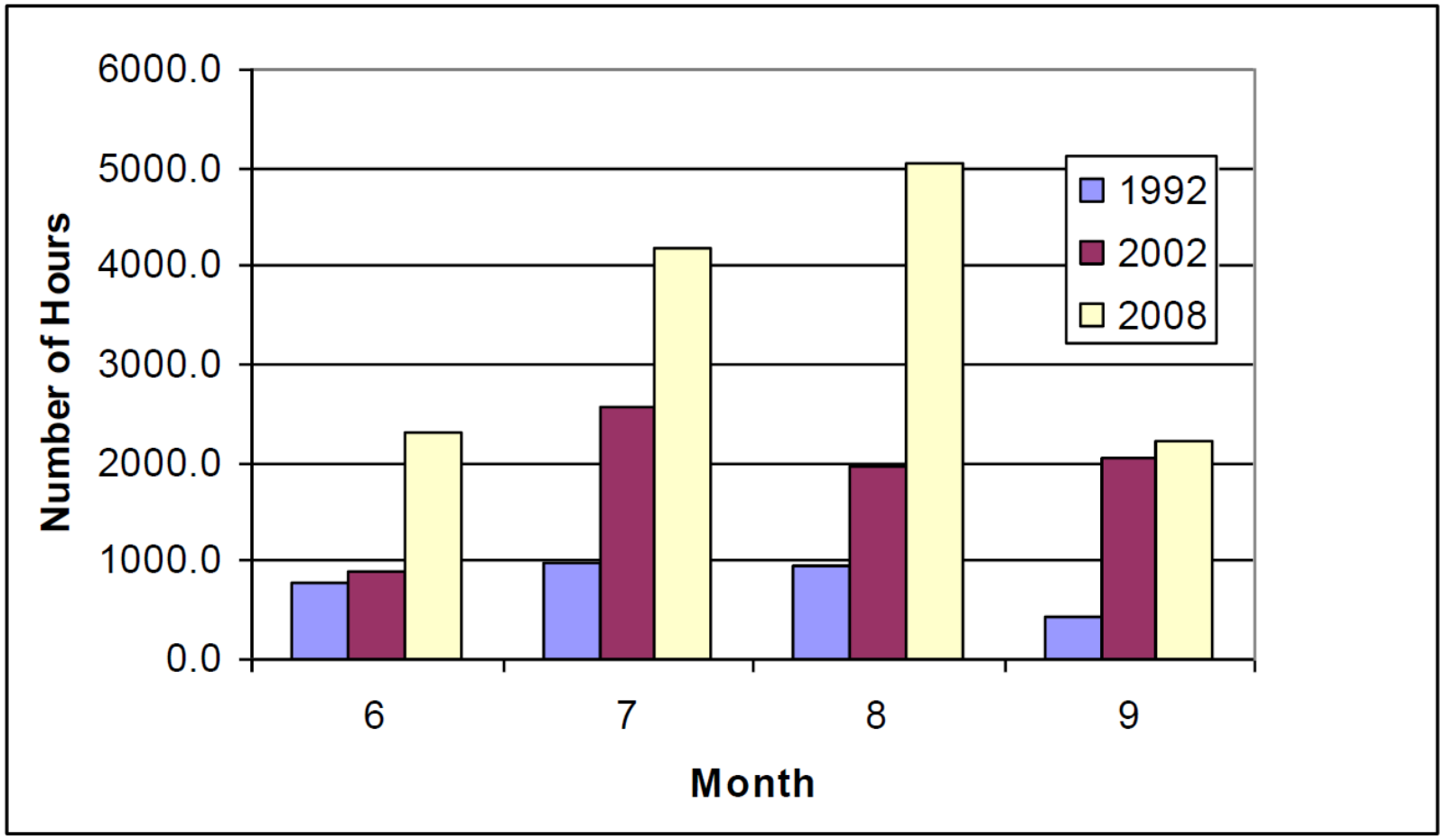


The Flathead River: It's Complicated

- Lake-level influence
- Currents and velocity
- Development and land use
- Wakes and waves

What is driving the <u>acceleration</u> of erosion?

Boat use estimates for the Flathead River



- Nearly doubled between 2002 and 2008
- More than quadrupled since 1992
- Study concluded there is likely an increased rate of bank erosion

Data from Montana Fish, Wildlife & Parks Boating Survey on the Flathead River and Sloughs Upstream of Flathead Lake, 2008

What are the impacts of recreational boating?

- Complex system
- Easy to measure sediment loads, difficult to measure erosion from specific drivers
- Anecdotal evidence that increased boat use is driving accelerated rates of erosion

Flathead River Erosion Prevention & Mitigation: Boat Wake Study

- Grant funding from DNRC
- Partner funding: Flathead CD, Flathead Lakers
- Fill information/data gap

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The Montana Department of Natural Resources & Conservation

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Flathead River Commission

FLATHEAD LAKERS
DEFENDERS OF THE WATERSHED

Flathead River Erosion Prevention & Mitigation: Boat Wake Study

Objectives:

1. Quantify total wake wave energy and maximum wake wave power generated by boats of various types and uses.
2. Correlate and compare total wake wave energy and maximum wake wave power to type of boat and type of use.
3. Evaluate and refine means and methods for identifying and quantifying wake generated erosion from other causes for future studies.

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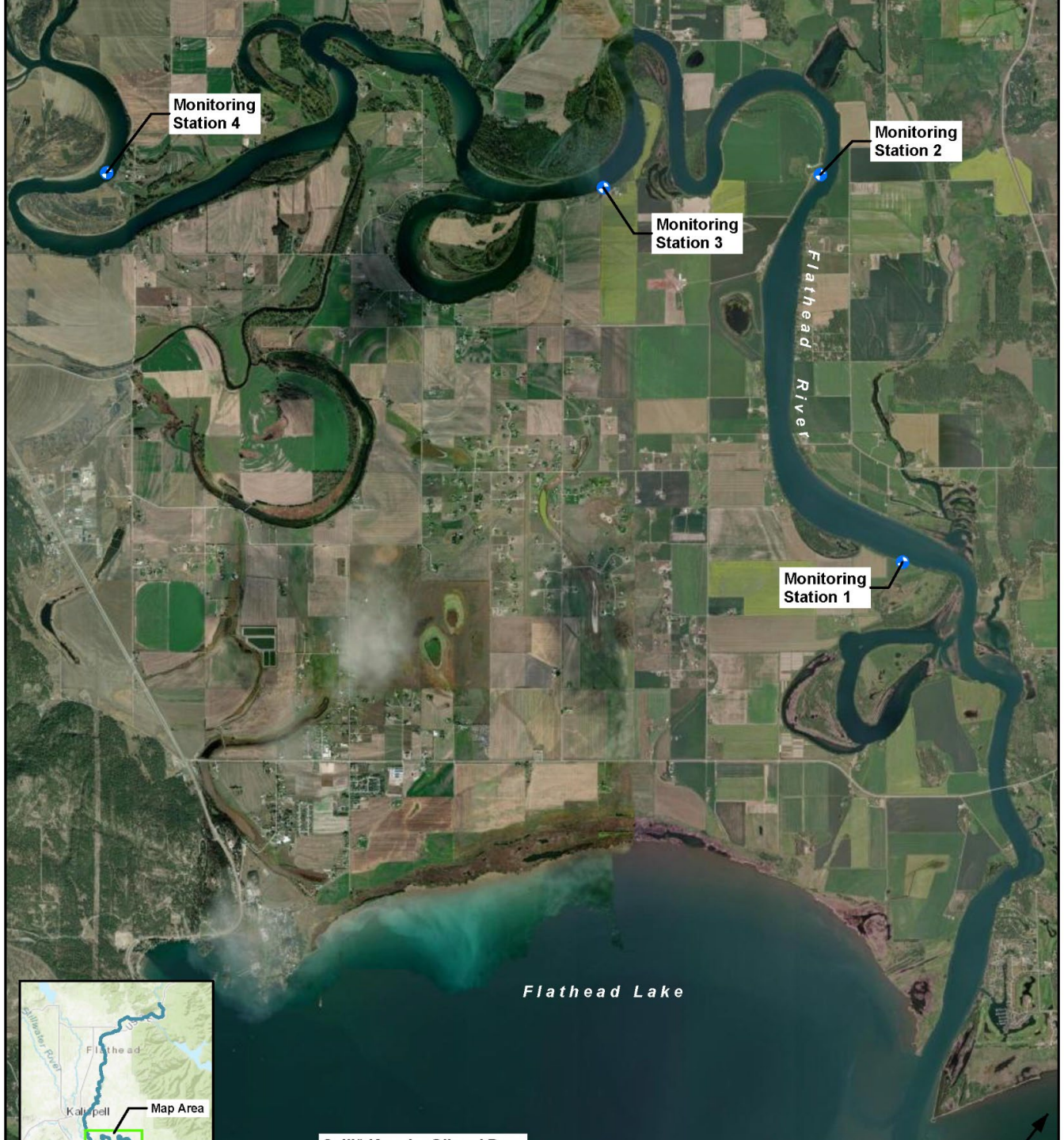
Monitoring Station 4
Monitoring Station 3
Monitoring Station 2
Monitoring Station 1
Flathead River
Flathead Lake
Flathead
Kalispell
Map Area

Data Analysis

- Total # of discrete wave events
- Maximum wave height (ft)
- Maximum wave power (kW/m)
- Total wave energy (J/m^2)

- Boat type and/or types that generated the wave event
- Boat use during the wave-generated event
- Qualitatively evaluate turbidity generated during the wave event





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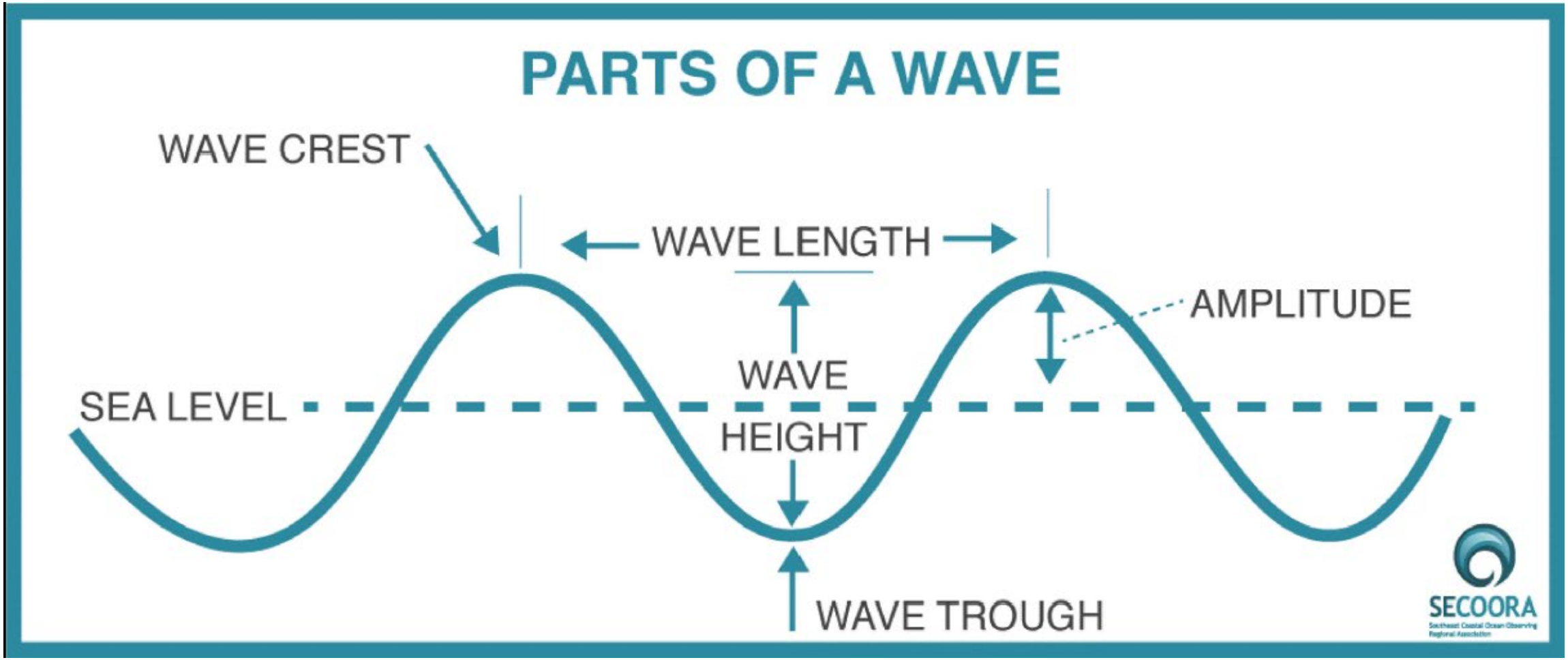

PARTS OF A WAVE
WAVE CREST
WAVE LENGTH
AMPLITUDE
WAVE
HEIGHT
SEA LEVEL
WAVE TROUGH
SECOORA

Weekend Snapshot – Monitoring Station 2

Sat. 16 July 2022

78 Wave Events Recorded

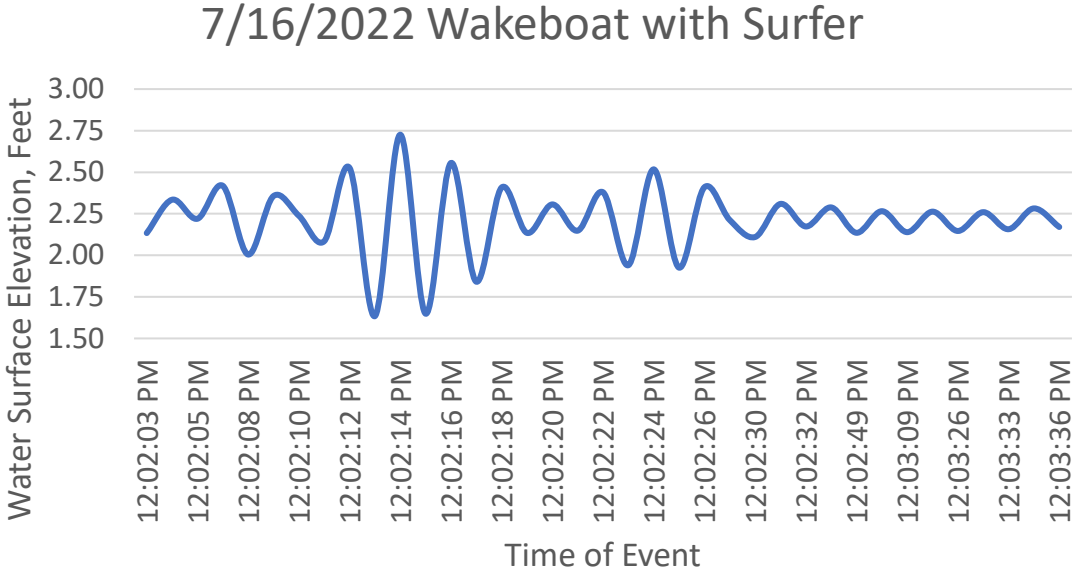
- 50 attributable to boats or series of boats
- 17 occurred before or after video recording timeframe
- 11 attributable to wind

71 Wave Events Recorded

- 50 attributable to boats or series of boats
- 13 occurred before or after video recording timeframe
- 8 attributable to wind

Sun. 17 July 2022

July 7-22: total wave energy = 15 kJ m^{-2}


7/16/2022 Wakeboat with Surfer
Water Surface Elevation, Feet
3.00
2.75
2.50
2.25
2.00
1.75
1.50
12:02:03 PM
12:02:05 PM
12:02:08 PM
12:02:10 PM
12:02:12 PM
12:02:14 PM
12:02:16 PM
12:02:18 PM
12:02:20 PM
12:02:22 PM
12:02:24 PM
12:02:26 PM
12:02:30 PM
12:02:32 PM
12:02:49 PM
12:03:09 PM
12:03:26 PM
12:03:33 PM
12:03:36 PM
Time of Event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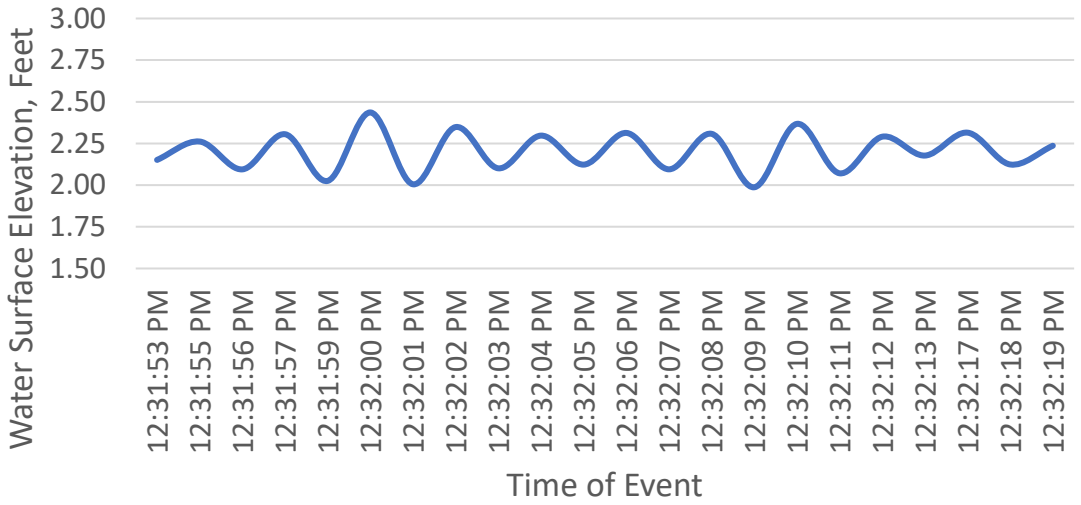
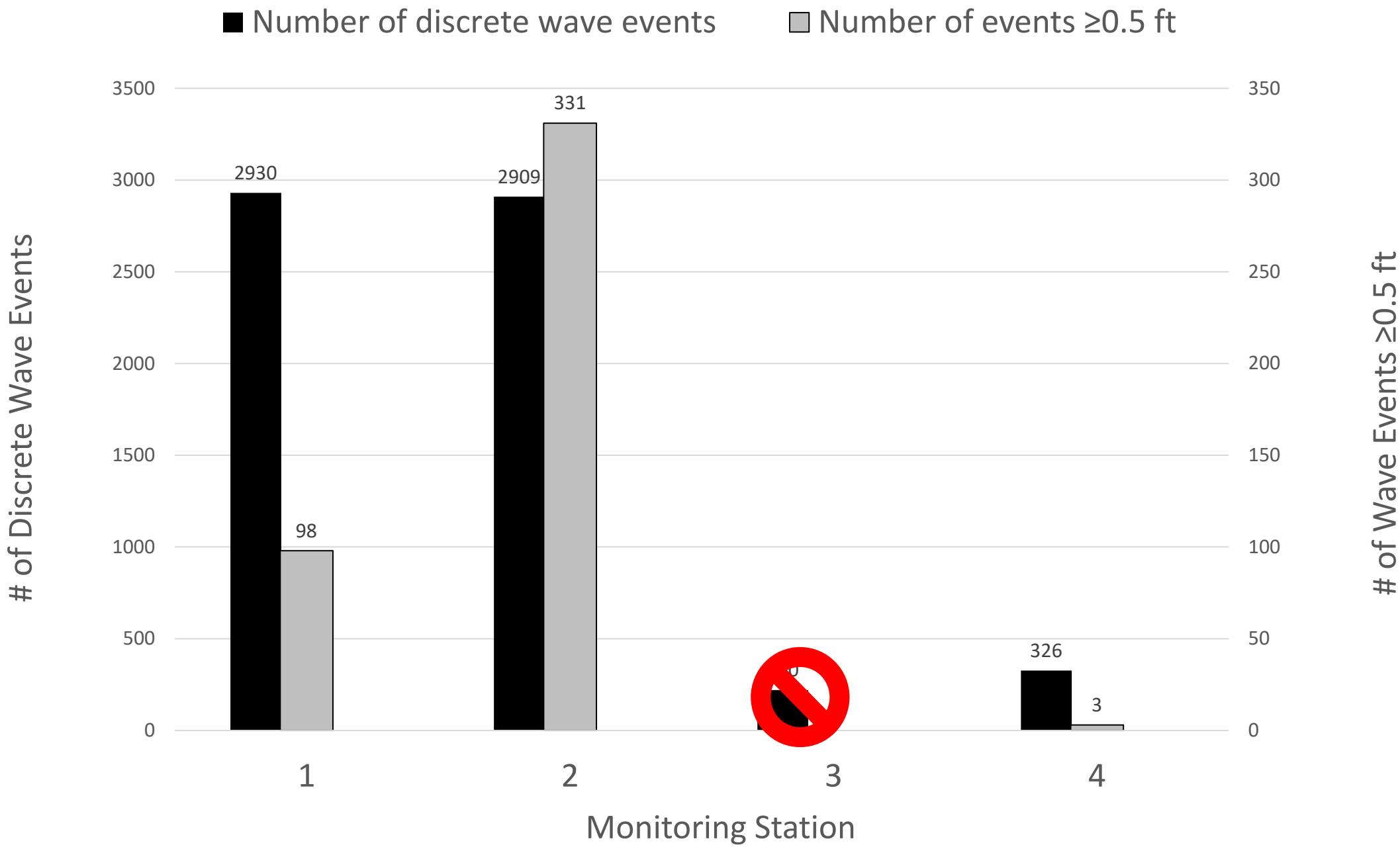
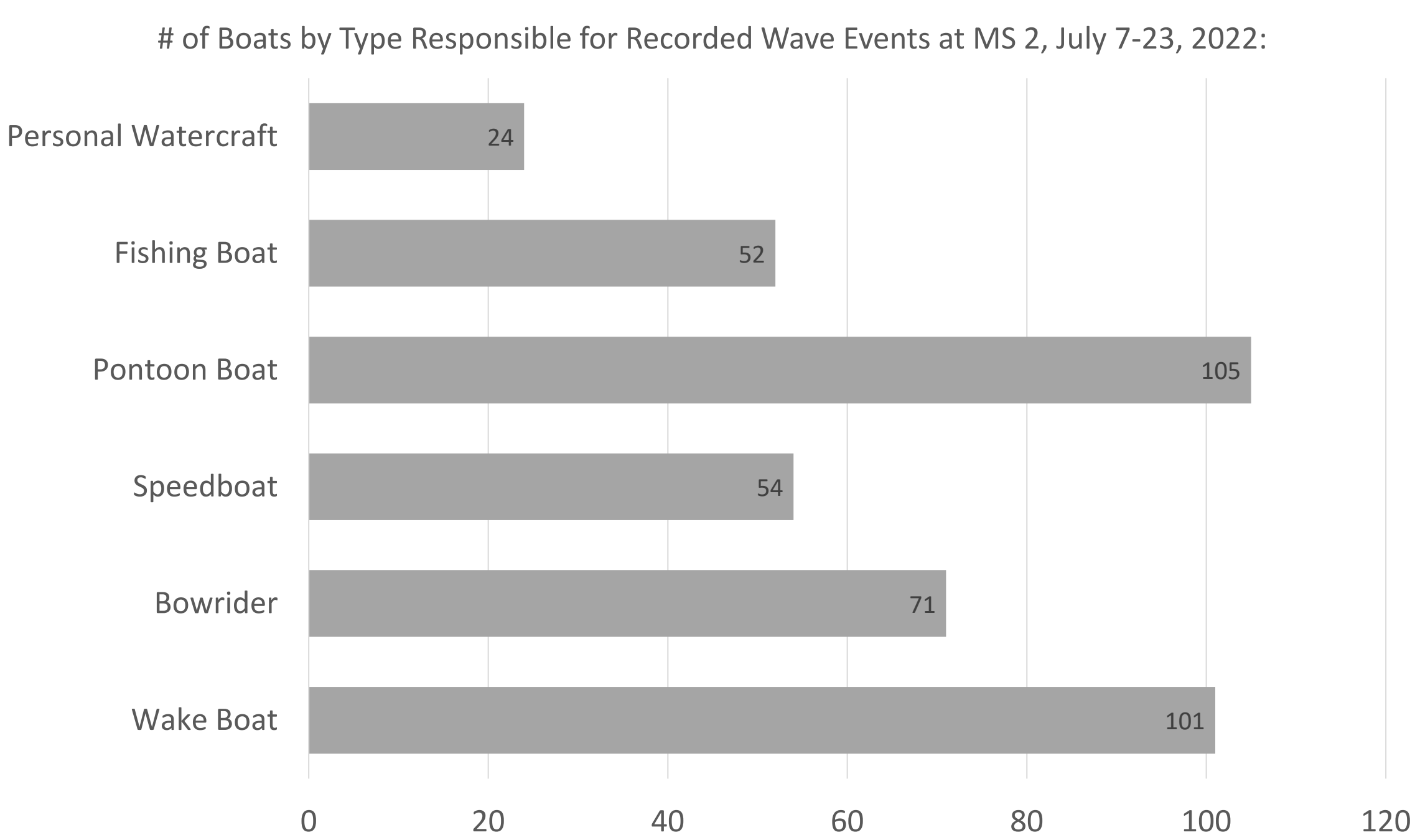
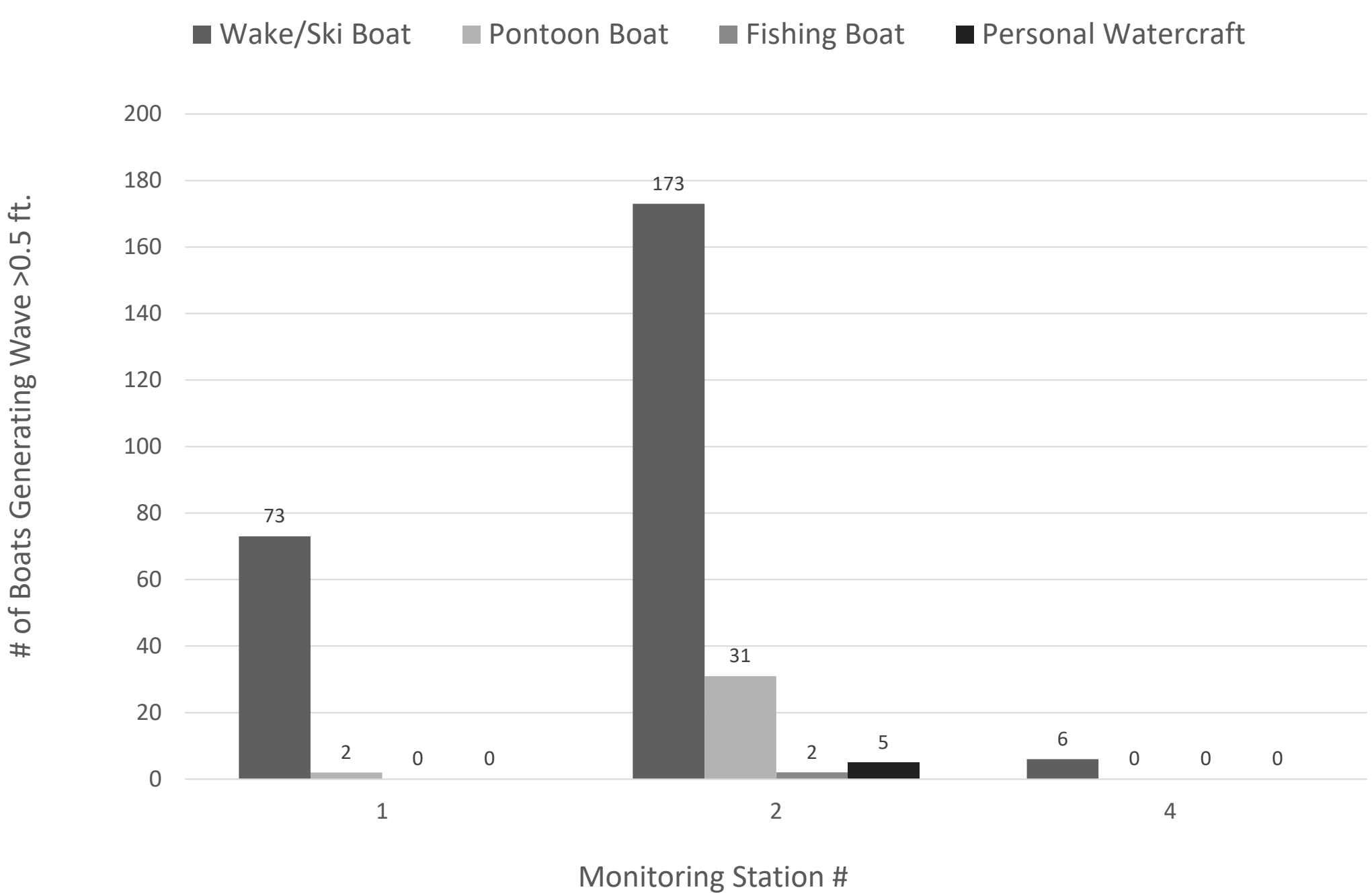
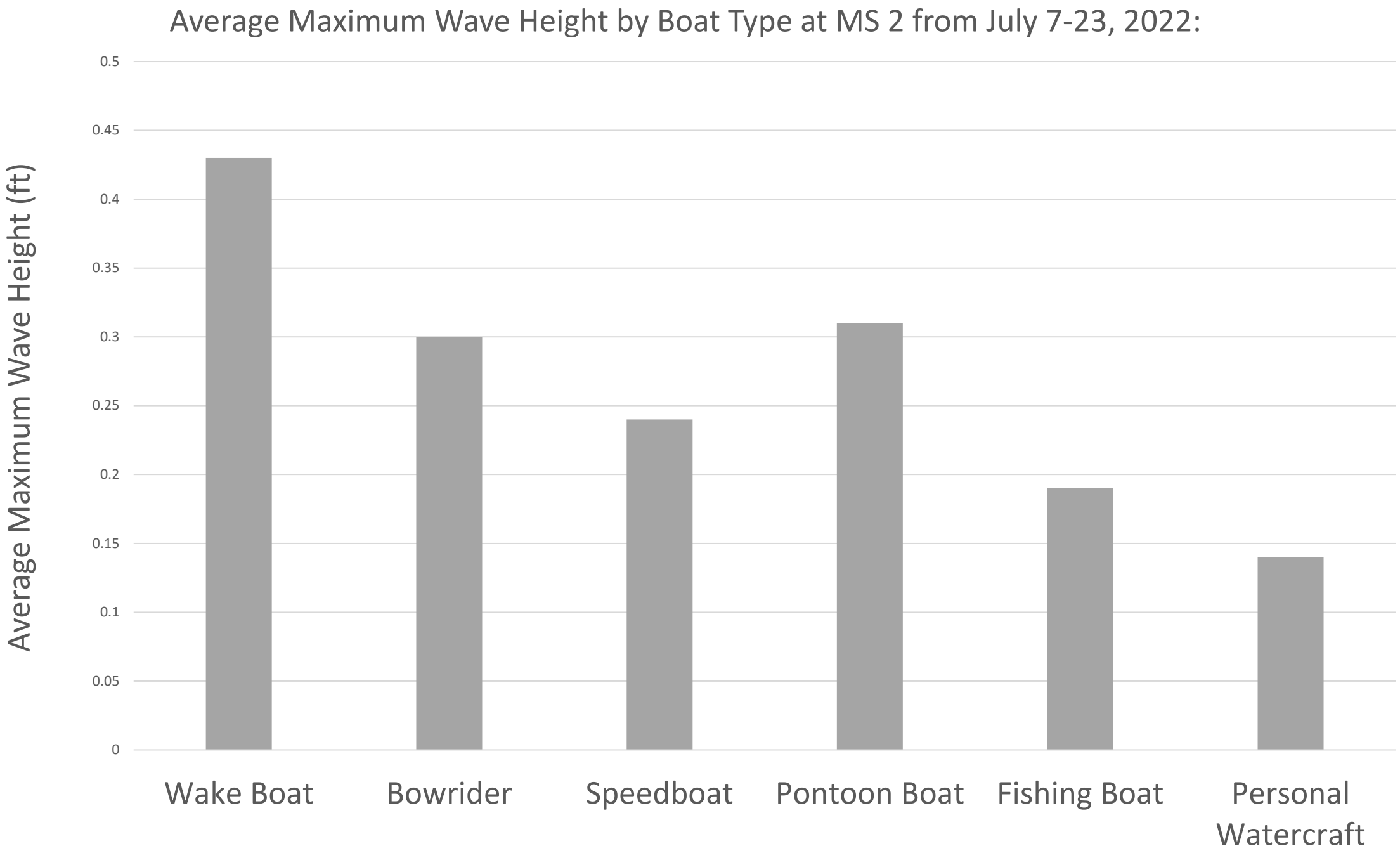

7/16/2022 Pontoon
Water Surface Elevation, Feet
3.00
2.75
2.50
2.25
2.00
1.75
1.50
12:31:53 PM
12:31:55 PM
12:31:56 PM
12:31:57 PM
12:31:59 PM
12:32:00 PM
12:32:01 PM
12:32:02 PM
12:32:03 PM
12:32:04 PM
12:32:05 PM
12:32:06 PM
12:32:07 PM
12:32:08 PM
12:32:09 PM
12:32:10 PM
12:32:11 PM
12:32:12 PM
12:32:13 PM
12:32:17 PM
12:32:18 PM
12:32:19 PM
Time of Event

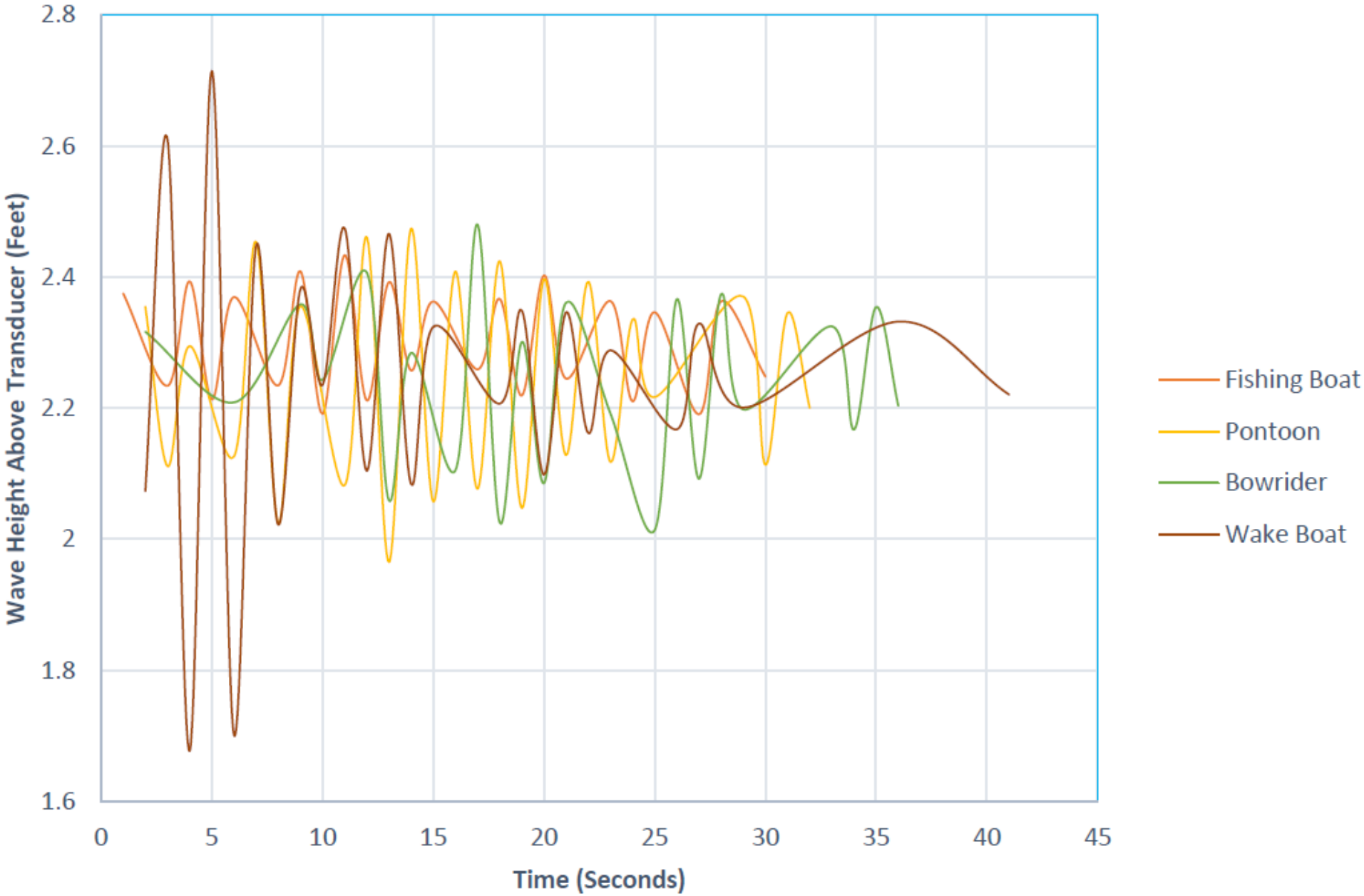

Number of discrete wave events
Number of events ≥0.5 ft
# of Discrete Wave Events
# of Wave Events ≥0.5 ft
3500
3000
2500
2000
1500
1000
500
0
350
300
250
200
150
100
50
0
2930
98
2909
331
0
326
3
1
2
3
4
Monitoring Station


# of Boats by Type Responsible for Recorded Wave Events at MS 2, July 7-23, 2022:
Personal Watercraft
24
Fishing Boat
52
Pontoon Boat
105
Speedboat
54
Bowrider
71
Wake Boat
101
0
20
40
60
80
100
120


Wake/Ski Boat
Pontoon Boat
Fishing Boat
Personal Watercraft
# of Boats Generating Wave >0.5 ft.
200
180
160
140
120
100
80
60
40
20
0
73
2
0
0
173
31
2
5
6
0
0
0
1
2
4
Monitoring Station #


Average Maximum Wave Height by Boat Type at MS 2 from July 7-23, 2022:
Average Maximum Wave Height (ft)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Wake Boat
Bowrider
Speedboat
Pontoon Boat
Fishing Boat
Personal Watercraft

Wave Event Pattern by Boat Type

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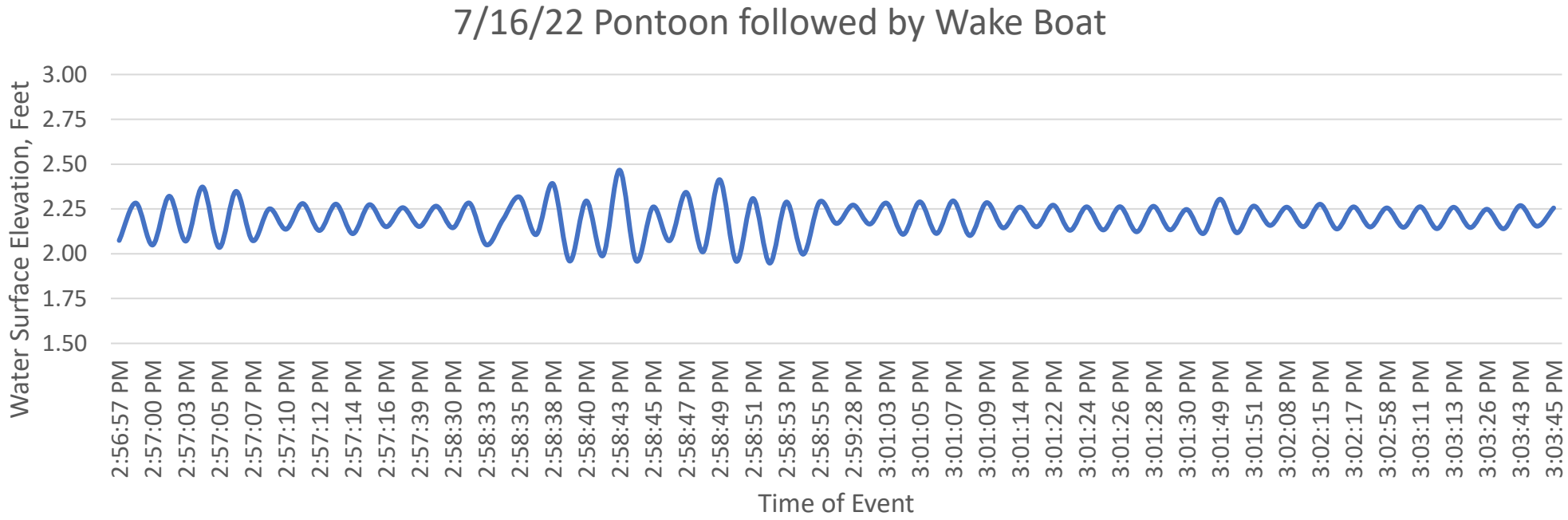
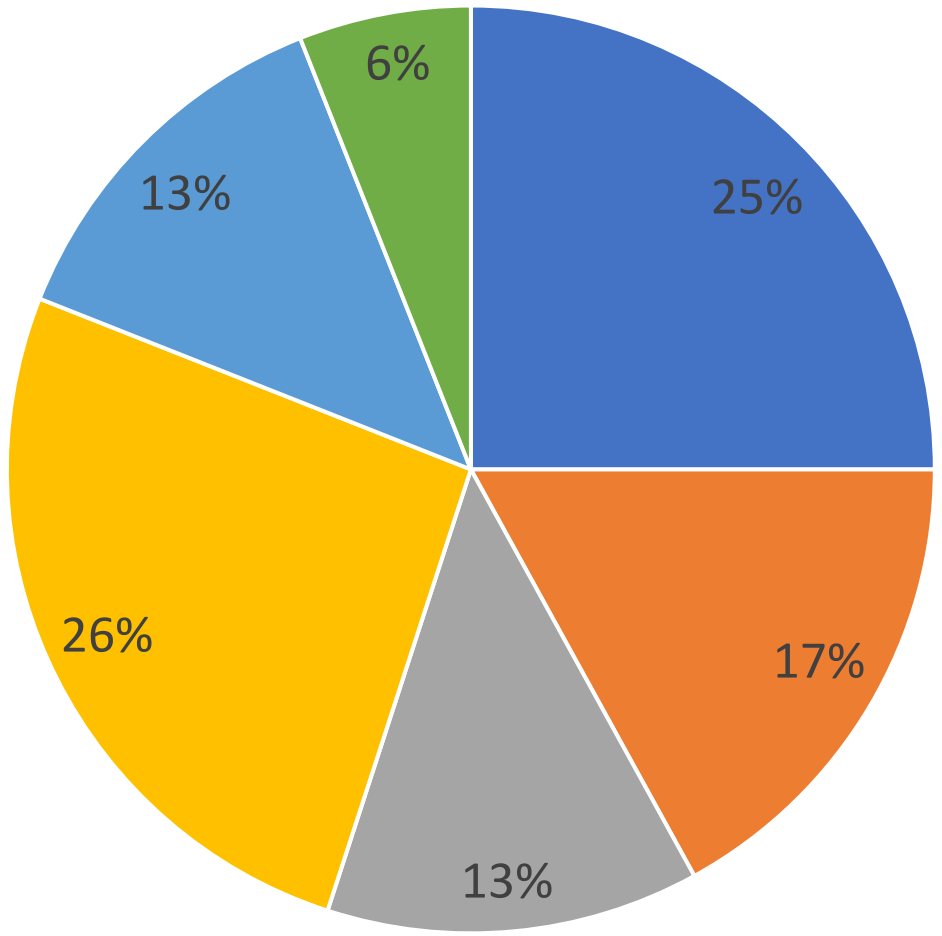

7/16/22 Pontoon followed by Wake Boat
Water Surface Elevation, Feet
3.00
2.75
2.50
2.25
2.00
1.75
1.50
2:56:57 PM
2:57:00 PM
2:57:03 PM
2:57:05 PM
2:57:07 PM
2:57:10 PM
2:57:12 PM
2:57:14 PM
2:57:16 PM
2:57:39 PM
2:58:30 PM
2:58:33 PM
2:58:35 PM
2:58:38 PM
2:58:40 PM
2:58:43 PM
2:58:45 PM
2:58:47 PM
2:58:49 PM
2:58:51 PM
2:58:53 PM
2:58:55 PM
2:59:28 PM
3:01:03 PM
3:01:05 PM
3:01:07 PM
3:01:09 PM
3:01:14 PM
3:01:22 PM
3:01:24 PM
3:01:26 PM
3:01:28 PM
3:01:30 PM
3:01:49 PM
3:01:51 PM
3:02:08 PM
3:02:15 PM
3:02:17 PM
3:02:58 PM
3:03:11 PM
3:03:13 PM
3:03:26 PM
3:03:43 PM
3:03:45 PM
Time of Event

Percentage Breakdown of Wake Activity at MS 2 from July 7-23, 2022:



The maximum wave heights recorded across all wave events were generated by wake boats:

Monitoring Station ID	Wave Characteristics	
	Maximum Wave Height in Feet	Maximum Wave Power in KW/ meter
MS 1	0.93	0.12
MS 2	1.09	0.16
MS 4	0.99	0.13

Individual and total wave energy in a single discrete wave event:

Wave No.	Monitoring Station 1 – Wave Packet	
	Maximum Wave Height in Feet	Maximum Wave Energy in Joules/sq. meter
1	0.19	2.05
2	0.40	8.91
3	0.81	37.00
4	0.72	29.25
5	0.59	19.83
6	0.54	16.72
7	0.48	12.99
8	0.39	8.63
9	0.27	4.03
10	0.24	3.22
11	0.30	5.22
Total Wave Energy		147.85 Joules/sq. meter

Summary of Findings

Discrete wave event duration ranged from 3-5 seconds (1-2 wave peaks) to ~8 minutes (220 wave peaks)

- Wind driven events of small ,uniform wave heights can extend for long periods
- An 8-minute event generated ~750 J/m^2 of wave energy

Maximum wave heights varied across boat types and boat use

- The largest wave heights recorded were attributable to wake boats
- Average maximum wave height for wake boats was 0.12 ft higher than any other boat type at MS2 between July 7-23

Maximum wave power is non-linear as wave height increases.

- 2-3X increase in maximum wave power between waves of 0.5 ft and 1 ft
- 5-7X increase in maximum wave power between waves of 0.25 and 1 ft

Wave height is more influential on total wave energy than number of waves.

- It takes 3-4 waves of ~0.5 ft to equal the wave energy of a single 1-ft wave
- It takes 7-10 waves of ~0.25 ft to equal the wave energy of a single 1-ft wave

Average maximum wave energy generated by wake boats at MS 2 from July 7-23, 2022, was:

- 5.4X higher than jet skis
- 5.2X higher than fishing boats
- 3.6X higher than speedboats
- 2.3X higher than bowriders
- 2.2X higher than pontoon boats

Study Recommendations (what next?)

- Controlled boat wake study: wave height, wave power, wave energy generated by different boat types at varying distance from shore
  - Monitor turbidity and localized erosion rates
- Reduce volume of data and cost of analysis
  - Collect raw water surface elevations at targeted times throughout boating season to quantify discrete wave events, reduce volume of data
  - Lower cost alternative to camera system to pair with dataloggers
  - Automate data analysis

FLATHEAD
CONSERVATION DISTRICT

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STREAMBANK PROTECTION, PEDERSON-SONSTELIE, 1966