SECTION 9

Appendix

Chippewa Lake

Carrying Capacity Study

April, 2022

PREPARED FOR:

Medina County Park District

BY:

OHM Advisors

6001 Euclid Avenue, Suite 130

Cleveland, OH 44103

OHM Advancing Communities®

Medina County Park District

Table of Contents

SECTION #1 - INTRODUCTION

1.1 PURPOSE & OBJECTIVES

As more people are attracted to Chippewa Lake for its natural beauty and wide variety of recreational opportunities, lake and user health must be taken into consideration. Overcrowding and poor management could lead to detrimental effects on lake ecology and recreational safety, which is why development and expansion should be balanced with the health of Chippewa Lake. Different lake uses have a range of effects on other uses, ranging from no effects to major effects on impaired activity (see Figure 1).

The purpose of this study is to quantify lake usage during the 2021 boating season, develop methods for estimating lake carrying capacity, and compare current lake usage with optimum usage to determine if the lake is being utilized appropriately.

	Fishing	Motor Boating (Speed)	Motor Boating (Pontoon)	Personal Watercraft (Jet Skiing)	Sailing	Paddle Craft (Kayak, Canoe, Paddleboard)
Fishing						
Motor Boating (Speed)						
Motor Boating (Pontoon)						
Personal Watercraft (Jet Skiing)						
Sailing						
Paddle Craft (Kayak, Canoe, Paddleboard)						

Minor or no effect on impaired activity

Moderate effect on impaired activity

Major effect on impaired activity

Figure 1: Recreational Use Compatibility Matrix

The primary objective of the Chippewa Lake Carrying Capacity Study is to assist the Medina County Park District in understanding the current demands placed on Chippewa Lake and determining if measures should be taken to manage further recreational use.

The secondary objectives are to:

1. Describe the proportions of different types of watercrafts using the lake.
2. Quantify the amount of watercraft using the lake during the primary boating season.
3. Identify the optimum carrying capacity of Chippewa Lake.

Figure 2 explains the public engagement and research taken in meeting these objectives.

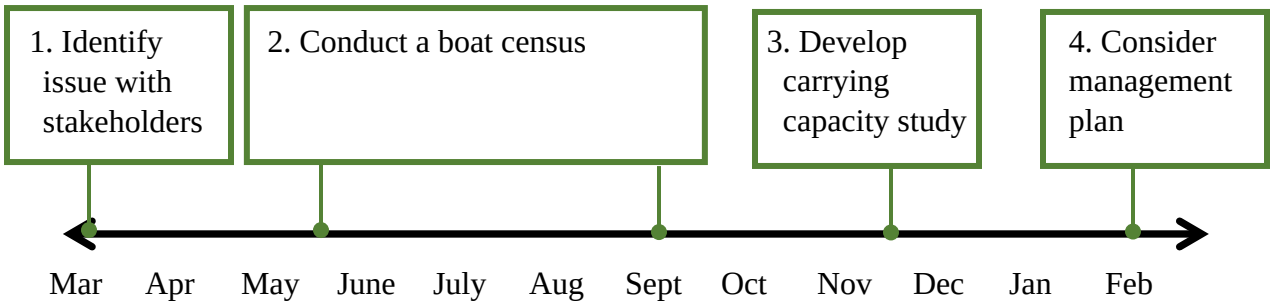

Figure 2: Carrying Capacity Study Timeline (2021-2022)

1.2 EXISTING CONDITIONS

Chippewa Lake is located approximately one hour southwest of Cleveland Ohio, shown in Figure 3. The Lake is managed by the Medina County Park District and has an approximate area of 335 acres and 3.1 mile perimeter shared by the Medina County Park District and private properties. The Lake has a public boat ramp, trailer parking, and restroom facility in the southwest corner. Many people visit the lake for boating, sailing, fishing, and paddle craft during the summer months.

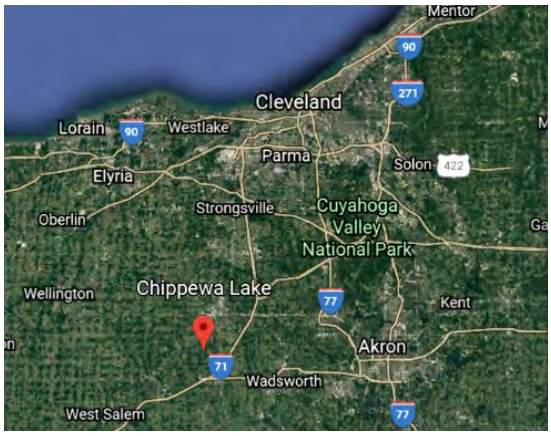

Figure 3: Chippewa Lake Vicinity Map

Lake Type	Glacial
Surface Area	335 acres
Maximum Depth	24 feet
Mean Depth	15 feet
Shoreline Length	3.1 mi

Figure 4: Lake Characteristics

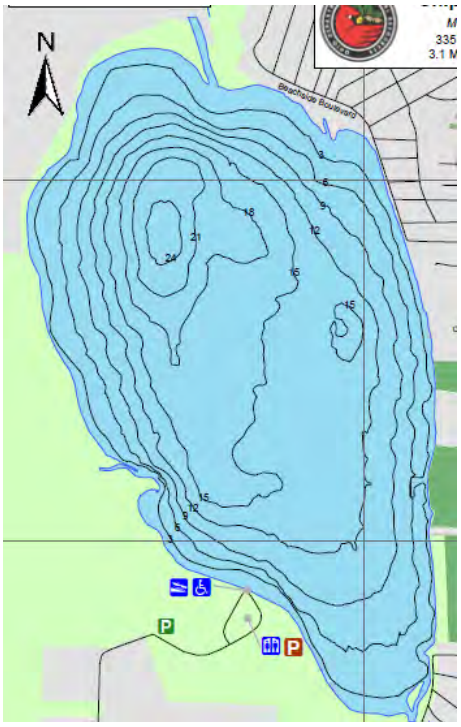

Figure 5: Chippewa Lake Topographic Map (ODNR)

Figure 6: Chippewa Lake Map

1.3 EXISTING LITERATURE

A body of literature has already been created, in which each report develops an optimum density based on different recreational uses of a lake (see Figure 7 for a summary of existing literature). In one of the more recent studies, Bosley (2005) reviewed past studies and used the information to create an average optimum density of 10-15 acres per boat for all uses. It is important to note, as Bosley (2005) points out, "capacity will vary from site to site in accordance with visitor behavior and preferences, as well as management goals".

Source	Density	Use
Ashton (1971)	5-9 acres/boat 4-9 acres/boat 6-11 acres/boat	All uses combined in Cass Lake All uses combined in Orchard Lake All uses combined in Union Lake
Kusler (1972)	40 acres/boat 20 acres/boat 15 acres/boat	Waterskiing & all other uses Waterskiing Coordinated waterskiing
Jaakson et al. (1989)	20 acres/boat 10 acres/boat 8 acres/boat 10 acres/boat	Waterskiing & motorboat cruising Fishing Canoeing, kayaking, sailing All uses combined
Wagner (1991)	25 acres/boat	All boating activities
Warback et al. (1994)	30 acres/boat	All motorized (>5 HP) uses
Bosley (2005)	10-15 acres/boat	All uses

Figure 7: Review of Literature Previously Conducted on Carrying Capacity

SECTION #2 - CARRYING CAPACITY ANALYSIS

2.1 INTRODUCTION

Carrying capacity refers to the idea of how a lake can be safely used to ensure its continued use in the future is safe for the natural environment and recreational users. This study uses an inventory of watercraft types, a thorough analysis of the lake's physical condition, and existing literature to identify an optimum density unique to Chippewa Lake. The combination of methods ensures the study is an accurate and valid representation of current lake use. This study will not make recommendations for management procedures, but it provides a baseline of data for new policies to be created.

2.2 ANALYSIS

The carrying capacity study includes three main factors to determine proper lake use:

1. The proportion of each type of watercraft using the lake.
2. The amount of lake area each type of watercraft requires.
3. The total usable lake area.

The following methods were developed to calculate Chippewa Lake's carrying capacity:

Method #1: Lake Size Capacity	Method #2: Lake Use Capacity
Step 1. Calculate usable lake area	Step 1. Calculate usable lake area
Step 2. Establish optimum boating density	Step 2. Establish optimum boating density
Step 3. Boat census	Step 3. Boat census
Step 4. Lake size carrying capacity calculation	Step 4. Lake users carrying capacity calculation

METHOD #1 & #2:

STEP 1 – Define Usable Lake Area

Calculate the usable lake area that supports a range of boating activities safely without significant environmental impact. Usable lake area is defined as the portion of the lake that is available and unrestricted for all types of watercrafts. Previous studies have shown that shallow areas (0-10 feet) are most susceptible to adverse impacts associated with motor boat activities. Impacts include sediment re-suspension, reduced water clarity, and damage to fish and wildlife habitat, among others. Wagner (1991) observed that the shallowness ratio, which compares the area of the lake less than 5 feet deep to the total area, is more indicative of the lake bottom area likely to be directly affected by motorized watercraft. Based on previous studies, the usable lake area in this study is defined as the lake surface area greater than five feet deep. Previous studies also note an important point regarding water level fluctuations. When the water level drops, the usable lake area is reduced. Carrying capacity would thus be lower during periods of low lake level. This study does not provide any methodological suggestions for accounting for this fluctuation when estimating usable lake area.

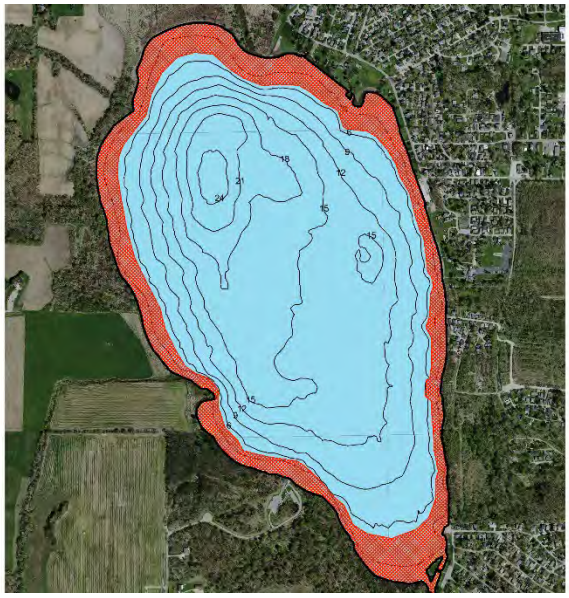

Figure 8: Usable Lake Area
(Contour Map Courtesy of ODNR)

Lake Area	Restricted Area (Area less than 5 feet deep)	Usable Area (Area more than 5 feet deep)
335 acres	70 acres	265 acres

Figure 9: Adjusted Lake Area

Accounting for the 70 acres of the lake less than 5 feet deep, the total usable lake area is 265 acres.

METHOD #1 & #2:

STEP 2 – Determine Spatial Requirements (Optimum Density)

Based on existing literature, establish the minimum spatial requirements for various boating activities/speeds observed. See Figure 10 below for a summary of optimum density for each watercraft type observed on Chippewa Lake.

Type of Watercraft	Optimum Density (Source)
Speed Boats	15 - 20 acres/boat (Bosley 2005)
Pontoon Boats	10 - 15 acres/boat (Bosley 2005)
Fishing Boats	7 - 12 acres/boat (Jaakson 1989)
Sailboats	5 - 10 acres/boat (Jaakson 1989)
Personal Watercraft	2 - 7 acres/boat (Jaakson 1989 and Observation from Boat Census)
Paddle Craft	1 - 6 acres/boat (Jaakson 1989 and Observation from Boat Census)

Figure 10: Existing Literature Optimum Density for Each Watercraft

The spatial requirement for each use is determined using the range of optimum densities defined in Figure 10. This study assumes more space is required for fast-moving watercraft and less space is required for slow-moving watercraft. This study utilizes the determined watercraft density as noted below in Figure 11.

Figure 11: Watercraft Density Matrix

METHOD #1 & #2:

STEP 3 – Complete Boat Census

A boat census for Chippewa Lake was conducted from June 11, 2021 to September 6, 2021 to gather data on how many and what type of watercraft use the lake on a given day. A total of 1,226 boats were observed over 22 days, creating an average of 55 boats each day. Most of these boats were stationary or slow cruising as opposed to fast moving, with the heaviest usage occurring on the weekend. See Figures 12, 13, and 14 for a summary of the observed conditions. Although efforts were made to minimize errors, there is always the possibility for over- or under-counting. A complete record of data from the boat census is included in the appendix.

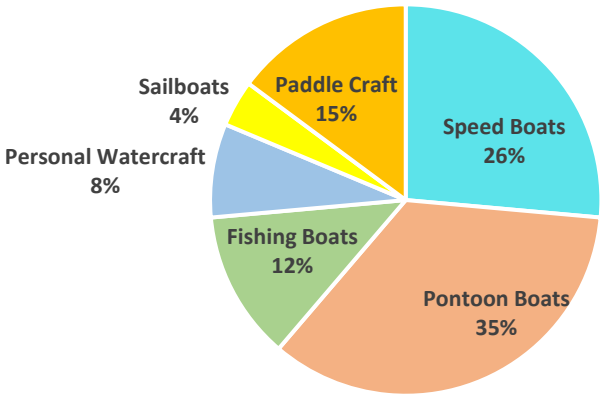

Figure 12: Proportion of Watercraft Observed

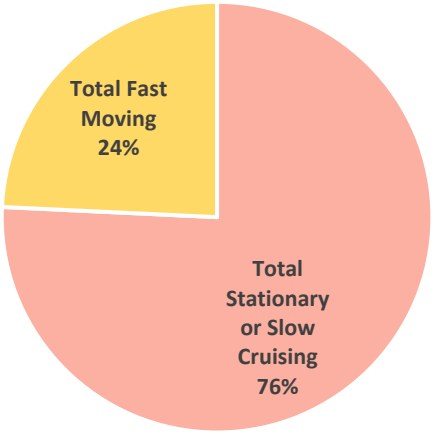

Figure 13: Proportion of Boats Observed Based on Speed

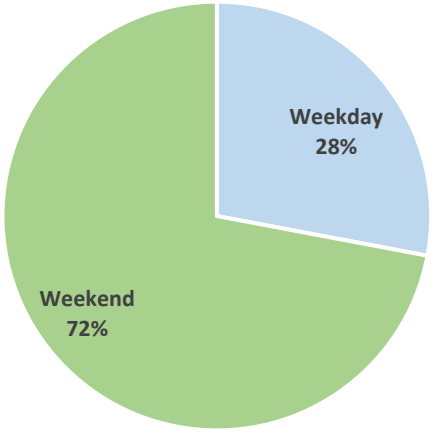

Figure 14: Proportion of Boats Observed Based on Day

METHOD #1:

STEP 4 – Lake Size Carry Capacity Calculation

To determine the appropriate size of Chippewa Lake based on the current users, the formula below was developed, where the average number of watercraft observed per day is derived from the boat census, and the optimum density as determined in Step 2, Figure 11.

Formula:

> Average # of Watercraft Observed per Day (#) * Optimum Density (Acres/Boat) = Minimum Spatial Requirement (Acres)

The table below in Figure 15, equates the Minimum Spatial Requirement for each type of watercraft and sums the total Minimum Spatial Requirement based on the Average Number of Watercraft Observed per Day.

Type of Watercraft	Average # of Watercraft Observed per Day	Optimum Density	Minimum Spatial Requirement
Speed Boats			
Fast	7	20 acres/boat	140 acres
Slow	8	15 acres/boat	120 acres
Pontoon Boats			
Fast	2	15 acres/boat	30 acres
Slow	18	10 acres/boat	180 acres
Fishing Boats			
Fast	1	12 acres/boat	12 acres
Slow	6	7 acres/boat	42 acres
Sailboats	2	5 acres/boat	10 acres
Personal Watercraft	4	2 acres/boat	8 acres
Paddle Craft	8	1 acres/boat	8 acres
Total Minimum Spatial Requirement:			**550 acres**

Figure 15: Minimum Spatial Requirement

Based on the existing lake users, a calculated 550 acres is needed to safely support those users without harming the environment and creating an unsafe condition for recreational users, which is **207% greater** than the existing usable lake area of 265 acres.

METHOD #2:

STEP 4 – Lake User Carrying Capacity Calculation

To determine the appropriate number of users based on the existing usable lake area, the formula below was developed, where percentage of fast/slow moving watercraft is derived from the boat census, and the optimum density per watercraft as determined in Step 2, Figure 11.

Formula:

Usable Lake Area (Acres) / Weighted Average Optimum Density (Acres/Boat)
= Lake User Capacity (Boats)

- The Usable Lake Area (Acres) is defined in Step 1, Figure 9.

- The Weighted Average Optimum Density (Acres/Boat) is calculated by weighting the average optimum density of fast / slow moving boats, as shown in the formula below:

  - (Percentage of Fast-Moving Use) * (Fast-Moving Average Optimum Density (Acres/Boat)) + ((% of Slow-Moving Uses) * Slow-Moving Average Optimum Density (Acres/Boat) = Weighted Average Optimum Density (Acres/Boat)

  - Where the boat census determined the following percentage of fast-moving versus slow/stationary uses.

    24% Fast-moving uses 76% Slow/stationary uses

  - Previous literature and observations of Chippewa Lake determined average optimum density. Based on the Watercraft Density Matrix in Figure 11, the optimum densities for fast- and slow-moving watercraft are as follows:

Type of Fast-Moving Watercraft	Optimum Density
Speed Boats (Fast)	20 acres/boat
Pontoon Boats (Fast)	15 acres/boat
Fishing Boats (Fast)	12 acres/boat
Average Optimum Density:	**15.7 acres/boat**
Type of Slow-Moving Watercraft	Optimum Density
Speed Boats (Slow)	15 acres/boat
Pontoon Boats (Slow)	10 acres/boat
Fishing Boats (Slow)	7 acres/boat
Sailboats	5 acres/boat
Personal Watercraft	2 acres/boat
Paddle Craft	1 acres/boat
Average Optimum Density:	**6.7 acres/boat**

- Based on the defined information, calculate the Weighted Average Optimum Density:
  (% of Fast-Moving Uses * Fast-Moving Average Optimum Density) + (% of Slow-Moving Uses * Slow-Moving Average Optimum Density) = Weighted Average Optimum Density

  (0.24*15.7 acres/boat) + (0.76*6.7 acres/boat) = **8.9 acres/boat**

With the Weighted Average Optimum Density defined, calculate the carrying capacity of lake users:

Usable Lake Area (Acres) / Weighted Average Optimum Density (Acres/Boat)
= Lake User Capacity (Boats)

265 acres / 8.9 acres/boat = **30 boats**

Based on the boat census, an average of 55 boats currently use the lake per day, which is **183%** greater than the calculated carrying capacity of 30 boats.

2.3 CONCLUSION

The above findings indicate there is a high probability of conflict between different users and subsequent environmental degradation on Chippewa Lake. Both carrying capacity calculation methods result in a significant overuse of Chippewa Lake, which raises the importance of proper lake management. Some common methods of regulation include charging launch fees, limiting the number of available permits, and creating strict horsepower and speed limits. Some lakes impose rules to allow only certain types of watercrafts at certain times of the day. Regardless of the method of regulation on Chippewa Lake, it is critical to educate the public about the condition of the lake and how they can help to maintain a safe and healthy environment.

2.4 POTENTIAL MANAGEMENT CONSIDERATIONS

Strategy	Regulations	Example
Regulations limiting the amount or type of boating activity.	Lake zoning ordinance.	An established no-wake zone(s), or low-speed time period, can be established for part of each day or on selected days.
Regulations limiting lake speed limits.	Lake zoning ordinance.	Reducing the lake horsepower reduces the lake speed limits and decreases the space required per boat, allowing more boats to safely use the lake.
Limit public access.	Local ordinance and enforcement.	Limited parking at lake landings affects the number of boats launched at public access sites and requires local enforcement.
Law enforcement.	Lake zoning ordinance.	Add a permanent watercraft law enforcement presence.
Manage and mitigate private lake access.	Land use zoning.	Land use zoning or other policies can limit high density shoreline development to mitigate lake over-use.

Determining the carrying capacity of a lake and deciding how to prevent overcrowding will inspire some disagreement. However, studying a lake's recreational carrying capacity can bring lake users and managers together, with the ultimate goal of increasing all users' enjoyment of the lake. Assessing carrying capacity is a measure to protect lake users. Users can be involved in the lake management plan through public meetings, surveys, or volunteering to help with the plan. The more users can be involved in finding ways to better manage the lake, the better the solution will be.

SECTION #3 - LITERATURE CITED

Ashton, P.G. (1971). *Recreational Boating Carrying Capacity: A Preliminary Study of Three Heavily Used Lakes in Southeastern Michigan*. PhD thesis, Michigan State University, School of Environmental Sciences.

Bosley HE. (2005). *Techniques for estimating boating carrying capacity: a literature review*. A report for the Catawba-Wateree Relicensing Coalition.

Jaakson, R., Buszynski, M.D., & Botting, D. (1989). *Carrying capacity and lake recreation Planning*. The Michigan Riparian.

Kusler, Jon A. (1972). *Carrying Capacity Controls for Recreational Water Uses*. Upper Great Lakes Regional Commission.

ODNR (2012). *Chippewa Lake Fishing Map*. Ohio Department of Natural Resources, Ohio Division of Wildlife.

Wagner, Kenneth J. (1991). *Assessing Impacts of Motorized Watercraft on Lakes: Issues and Perceptions*. Proceedings of a National Conference on Enhancing States' Lake Management Programs. Northeastern Illinois Planning Commission.

Warbach, J.D., M.A. Wyckoff, G.E. Fisher, P. Johnson and G. Gruenwald (1994*). Regulating keyhole development: Carrying capacity analysis and ordinances providing lake access regulations*. Planning and Zoning Center, Inc.

SECTION #4 – APPENDIX (BOAT CENSUS)

Medina County Park District

OHM

Chippewa Lake Master Plan - Active Boat Census

Instruction: On days you are able to collect data, randomly choose a time to count actively used boats within each of the three time blocks: 7am-12pm, 12pm-4pm, and after 4:00pm. Please make every attempt to perform a count during each time block, as much as possible. Observations to be made from a clear vantage point where all areas of the lake can be seen at one time.

				Boat Counts									Summary			
Recorder Initials JA= Joan JS= John LK=Lisa	Date	Time	Day of the Week	# Speed Boats (Fast)	# Speed Boats (Slow / Stationary)	# Pontoon Boats (Fast)	# Pontoon Boats (Slow / Stationary)	# Fishing Boats (Fast)	# Fishing Boats (Slow / Stationary)	# Personal Watercraft (Jet Skis)	# Sailboats	# Paddle Craft (Kayak, Canoe, Paddleboard)	Total Boats	Total Stationary or Slow Cruising	Total Fast Moving	
LK	6/11/2021	9:30	Friday		1		1	1	4			9	16	15	1	
LK	6/11/2021	14:20	Friday	2	2				1	1		1	7	4	3	
LK	6/11/2021	18:35	Friday	1	3		5		3	3		4	19	15	4	7 anchored at Public Ramp
LK	6/12/2021	8:20	Saturday	3	1	1	1		7			2	15	11	4	
LK	6/12/2021	15:10	Saturday	4	7		10		2	5		5	33	24	9	12 anchored at Public Ramp
LK	6/12/2021	17:05	Saturday	4	10		20		5	4		3	46	38	8	20 anchored at Public Ramp
LK	6/17/2021	8:50	Thursday	1					2			4	7	6	1	
JS	6/17/2021	12:30	Thursday	1	1		2		5		2	2	13	12	1	
JS	6/17/2021	18:00	Thursday	4	5	1	3		3	3		2	21	13	8	
LK	6/20/2021	9:25	Sunday	3			1	1	10	2	1	4	22	16	6	
LK	6/20/2021	12:50	Sunday	3	5	3	7		1		7	4	30	24	6	8 anchored at Public Ramp
LK	6/20/2021	17:10	Sunday	3	6	1	15			2	1	6	34	28	6	17 anchored at Public Ramp
JS	6/29/2021	10:25	Tuesday			1	1		1				3	2	1	
JS	6/29/2021	12:40	Tuesday	5			1		2	1		2	11	5	6	(6 trailers in public parking)
LK	7/10/2021	8:25	Saturday	2			2		8			5	17	15	2	
LK	7/10/2021	14:45	Saturday	2	3	3	17		4	2		1	32	25	7	14 anchored at Public Ramp
LK	7/10/2021	18:05	Saturday		5		7		2	1		5	20	19	1	8 anchored at Public Ramp
LK	7/27/2021	7:50	Tuesday						3			3	6	6	0	
JS	7/27/2021	14:15	Tuesday	3			3		2			4	12	9	3	
JS	7/27/2021	20:00	Tuesday	3	4		7	2	1	6		2	25	14	11	
LK	7/28/2021	8:40	Wednesday		1				3			4	8	8	0	
JS	7/28/2021	15:30	Wednesday	2	3		2				1	4	12	10	2	
JS	7/28/2021	19:45	Wednesday	3	4	1	5		2	4	2	3	24	16	8	
LK	7/30/2021	10:35	Friday	1			1		3			4	9	8	1	
LK	7/30/2021	15:25	Friday	3		1	1		2				7	3	4	
LK	7/30/2021	19:00	Friday	2	2		2		2				8	6	2	
LK	7/31/2021	8:25	Saturday	4	1		2		2			8	17	13	4	
JS	7/31/2021	16:00	Saturday	4	8	2	17		5	6	3	1	46	34	12	13 anchored at public dock
LK	8/6/2021	8:30	Friday		1				5			2	8	8	0	
JS	8/6/2021	15:30	Friday	3	3	1	5		1		3	4	20	16	4	
LK	8/6/2021	17:55	Friday			1	5		2			2	10	9	1	4 anchored at public dock
LK	8/7/2021	9:00	Saturday	4					5		1	11	21	17	7	
LK	8/7/2021	13:50	Saturday	1	1		14		1	2	1	2	22	19	3	14 anchored at public dock
JS	8/8/2021	17:20	Sunday	7	10		29		2	3		1	52	42	10	21 anchored at public dock
LK	8/14/2021	9:20	Saturday		2				6			2	10	10	0	
LK	8/14/2021	14:10	Saturday	5	6	2	11			1	2	6	33	25	8	13 anchored at public dock
JS	8/14/2021	16:05	Saturday	6	11		17		1	6	2		43	31	12	18 anchored at public dock
LK	8/15/2021	9:15	Sunday	1			1		4		1	7	14	13	1	
JA	8/15/2021	15:15	Sunday	7	13	4	18	2	4	12	2	4	66	41	25	20 anchored at public dock (both sides) (some jet skis)
LK	8/15/2021	18:40	Sunday	1	7		9		2		1	3	23	22	1	8 anchored at public dock
LK	8/19/2021	9:55	Thursday						5			4	9	9	0	
JS	8/19/2021	13:00	Thursday	1	1	2			3	1		2	10	6	4	
JS	8/19/2021	17:30	Thursday	3		2	2		3			4	14	9	5	
LK	8/21/2021	8:40	Saturday	3	2				3			3	11	8	3	
JA	8/21/2021	14:15	Saturday	5	6		15		1		2	5	34	29	5	16 anchored at public dock
LK	8/21/2021	17:25	Saturday	5	8		21		1	5	1		41	31	10	18 anchored at public dock
LK	8/22/2021	9:15	Sunday	3		1	2		2			9	17	13	4	
JA	8/22/2021	13:45	Sunday	7	5		17			5	7		41	29	12	16 anchored at public dock
JA	8/22/2021	16:30	Sunday	5	11	2	22			8		2	50	35	15	22 anchored at public dock (2 of 11 slow speedboats are actually anchored jet skis)
LK	8/28/2021	9:05	Saturday	4	2		1		1			1	9	5	4	
JA	8/28/2021	17:30	Saturday	10	7	6	26	1	1	6		5	62	39	23	20 anchored at public dock
JS	9/3/2021	12:00	Friday	2	2		1	1		2		3	11	6	5	
JS	9/5/2021	13:45	Sunday	2		3	24			2	7		38	31	7	20 anchored at public dock
JS	9/6/2021	11:30	Monday	4	2	1	15	1	4	2		8	37	29	8	5 anchored at public dock