Phase 4 Draft Final Report

South Florida Aquatic Preserves
Visitor Use Estimation Study

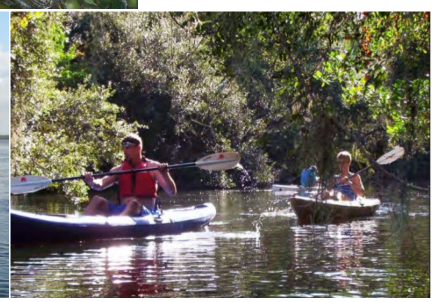

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Table of Contents

List of Tables

South Florida Aquatic Preserves
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Introduction

This is the second of three reports focusing on estimating visitor use in the 41 Florida Aquatic Preserve system. During the first study year (FY 2020-2021), we collected data at 14 aquatic preserves (APs) in Northeast Florida and developed models estimating the annual number of visitors for each AP. Visitor use in the Northeast APs during 2020-2021 was estimated to be 22.7 million visitors.

This second study year (FY 2021-2022) estimated use at 12 APs in South Florida ranging from Biscayne Bay, the Florida Keys, and Southwest Florida. The final phase of the project (FY 2022-2023) will focus on all remaining APs in Northwest Florida from Tampa to Pensacola.

Florida's aquatic preserves (APs) come in a variety of shapes and sizes and offer enormous economic, social, and environmental benefits to Florida citizens and visitors. They contain many features that are unique to an individual aquatic preserve. These features, such as containing islands and bird nesting sites, having Gulf or Atlantic Ocean frontage, incorporating rivers or significant stream segments, and containing seagrass beds help provide diverse and valuable outdoor recreation opportunities. Measuring this recreation value is difficult. One basic measure of recreation value is estimating how many people visit aquatic preserves. However, the diversity and complexity among Florida's APs affects the research methods and procedures used for estimating recreational use. Further complicating recreational use estimates are additional factors such as adjacent population and development levels, shoreline access, and restrictions on using airborne vehicles to collect data. The inherent complexity of many APs further exacerbates the problems associated with estimating recreational use in large areas.

The goal of this project is to improve public access management by developing a visitor use monitoring protocol for Florida's aquatic preserves. The developed protocol will be incorporated into existing management plans. The project will provide statistically reliable state-wide data that can be used to estimate public use of Florida's coastal resources, and assess future management needs to improve visitor experiences and protect coastal and aquatic ecosystems. Specifically, the assessment method developed under this project will provide reliable cost-efficient protocols for AP managers and to assess recreation uses of the coastal and river resources they manage. The identified standard method of visitor assessment will be useful for them to report a reliable number of recreation uses to contribute to the statewide Land Management Uniform Accounting Council report (LMUAC 2016), and other statewide annual and bi-annual reports.

With annual recreational use estimates and economic impacts mandated by the Land Management Uniform Accounting Council for all state managed lands, it can become burdensome for the small staff at each aquatic preserve to conduct comprehensive recreational use studies each year. The open access nature of aquatic preserves and lack of any formal entrance or user fee structure, such as those used by state parks, severely hampers counting visitors over time. Further, the expense of implementing these studies annually would likely consume most AP budgets. Thus, the purpose of this project is to develop methods and procedures to establish baseline recreational use levels and develop models that will allow efficient and reliable year to year use estimates to be calculated from a few highly correlated indicators.

Developing accurate estimates of visitors to outdoor recreation areas like aquatic preserves is difficult. There are a few methods to obtain visitor use information, but many, such as mail or on-site visitor surveys are expensive and time-consuming. They also rely on respondent memory and are subject to declining response rates (Connelly and Brown 2011). Additionally, the incidence of encountering AP visitors in the general population is very low making survey costs extensive.

A useful alternative to visitor surveys is to count visitors at the recreation areas themselves. This has been done for decades primarily at parks and other areas with defined access points. However, for areas with open access or numerous entrances, such as waterways and beaches, counts at these complex sites have been little more than informal guesses (King and McGregor 2012).

The purpose of this report is to provide a guide to understanding the procedures we used in estimating visitor use at Florida's aquatic preserves. It details how data for initial use estimates were collected and analyzed, and the basis for selecting and using analytical techniques to aid in the estimation process. Knowing how these factors were used to build the Visitor Use Estimation Model is important for AP managers when using or explaining visitor use estimates to others. It is also important to recognize the need to make data collection and use estimation in future years as practical and efficient as possible to ease the workload burden. Within the context of this report, use estimates for the 2021-2022 fiscal year for the 12 aquatic are presented.

Use Estimation Procedures

Outdoor recreation researchers have typically been estimating visitor use at these complex sites using one of two types of methods. First are access point counts. These methods used personnel or mechanical counters to detect the number of visitors passing through the entry/exit point during the day. These methods are relatively labor intensive as personnel time must be allocated to the counting duties or to servicing mechanical counters regularly. Also, they are most effective when most visitors use a single entry/exit area. For areas, like aquatic preserves, that have many access points, access point counts are not feasible.

The second method involves counting recreation visitors at a specific location at specific times, referred to in the literature as "instantaneous counts" or "periodic counts" primarily developed for fisheries management (Hoenig et al. 1993). Instantaneous count methodologies have been widely used by researchers to estimate changes in recreational use in natural resource damage assessments associated with wildfires and oil spills. Instantaneous counts are often conducted using aerial overflights, drone flights, and direct observation.

In our study of AP visitor use, it was more practical to use the instantaneous count method because of the resources available and the need to cover 12 aquatic preserves during the study year. By implementing instantaneous counts at a sample of times, the number of visitor hours can then be estimated and then converted into a trip estimate by dividing by the average duration of a trip (Hoenig et al. 1993).

DJI Mavic 2 drones were used at sample locations throughout an AP to photograph surrounding AP waters. Depending upon FAA restrictions, drones were flown to altitudes ranging from 100 to 400 feet above the launch point and positioned to take overlapping photographs in a panoramic fashion starting at the northern edge of the shoreline and sweeping around to the southern edge. All watercraft (power boats, sailboats, kayaks, canoes, and jet-skis) within the view field were counted.

The number of drone flight sampling locations varied by AP due to differences in AP configuration, shoreline access, and FAA and local authority regulations governing drone flights. These limitations are discussed fully in each appendix summarizing the research for individual APs. We encountered no restrictions at sample locations where trailer and car counts were made as these were all on publicly accessible locations like boat ramps, parks, and roadway waysides.

To determine the AP sampling area that was observed by drone or observation, the furthest distinguishing landmark (e.g., shoreline building or feature, island) nearest to where watercraft at their furthest visible point was identified. This landmark was then identified on Google Earth Pro and measured from the launch point. This provided a radius for calculating the area, in acres, of the view field. Summing the areas of all the view fields and dividing by the total surface water area of the AP provided the percentage of an AP sampled. This percentage was used in the use estimation model to extrapolate watercraft counts from the sampled areas to the entire AP.

We obtained the average trip duration by using time-lapse cameras at boat ramps to determine amount of time vehicles with trailers were parked between unloading and reloading the boat. Vehicles with boat trailers were identified and monitored by time-lapse cameras set at a rate of one frame per minute. Vehicles with trailers were identified throughout the day and parking times calculated to ensure boats launching later in the afternoon, with potentially shorter time on the water, would be included in the analysis.

To calculate the point-estimate of the number of watercraft visiting the sample area daily, we used the following formula explicated by Lockwood and Rakozy (2005). This procedure estimates daily watercraft (W) by multiplying the hours boats will be on the water during the sampling day (H) by the quotient of the number of watercraft counted (C) divided by the duration of the count (D) in hours or fraction of an hour. In our study, the duration of our drone flights while photographing averaged between 10 and 15 minutes. We opted for the more conservative time and used .25 hours as our duration measure. As suggested by Leggett (2017), we then divide the daily watercraft count for the sampling areas by the average time (T) watercraft remain in the water. This data came from the time-lapse camera trailer tracking data. This procedure was necessary to account for the multiple counting of a watercraft traveling through the sampling area during the visit. This is an essential concern when extrapolating the counts from sample areas to the entire AP.

Use Estimation Formula:

$$W = (H * (C/D))/T$$

Where:

W = Total daily number of watercraft estimated

H = Number of hours in sample period (day)

C = Number of watercraft counted during sampling period

D = Duration of the count in hours (or fraction of hour)

T = Time boats remain in the AP

This use estimation formula was then used to develop a visitor use estimation model extrapolating daily watercraft counts from sampled areas to the entire AP. This was achieved by dividing the sample area counts by the percentage of total AP surface water area to estimate daily watercraft use in the entire AP. Total daily watercraft use was then multiplied by 365 days in the study year to produce annual watercraft use. Multiplying annual watercraft use by the average number of individuals per vessel produces an estimate of total AP visitor use. We averaged occupancy data from several boating studies (Sidman et al. 2004, 2007, 2009; Ault 2008) over a variety of locations for our occupancy rate of 2.5 visitors per watercraft.

These procedures were used in calculating visitor use for each AP. Specific details of sampling locations, sampling days, and visitor use calculation procedures are provided in the appendix for each for the 12 APs studied during this phase of the Florida Aquatic Preserve Visitor Use Estimation Project.

Data Collection and Model Development

This section of the report summarizes the steps used to collect data and how that data were analyzed to develop visitor use prediction models. Specifically, it will discuss:

- Collecting watercraft data,
- Determining the weighting process of weekend and weekday sampling days,
- Predicting daily watercraft from shoreside facilities, and
- Developing the model to estimate total use.

Throughout this report we use several terms to describe the data we collected. Defining these terms will clarify their meaning and use in estimating aquatic preserve visits.

Watercraft Count – the number of watercraft identified from drone photographs or personal observation within the view field.
Trailer Count – the number of watercraft trailers attached to vehicles in a parking area.
Car Count – the number of non-trailered vehicles in a parking area.
All-Vehicle Count – the sum of trailered vehicles and non-trailered vehicles in a parking area.

Data Collection Summary

Each aquatic preserve is unique in its size, configuration, shoreline, access, and potential data collection sites. Locations from which we could legally launch drones to count watercraft were constrained by several factors, such as FAA flight restrictions, local community restrictions, proximity and access to an AP, and line of sight flight limitations on flight distance. Further, drone launch sites were not evenly spaced within an AP. As a result, we had to collect watercraft counts from locations falling within these limitations and infer visitor use levels to areas of the AP where we did not have the capability to collect data. In some of the APs, we were able to cover nearly half of the water surface with drone photographs. In others it was 20% or less. These coverage issues are presented and discussed for each AP in their respective appendix of this report.

The number of days sampled at each aquatic preserve varied due to several factors. Weather conditions were chief among these factors as drones were unable to fly during rain or high wind events. Additional days were substituted for sample days cancelled by weather. Another factor that impacted sample days was the usefulness of a sampling location. As we began data collection, it became apparent that some sample locations had little to no activity related to the AP. Other locations were then substituted, and additional sampling days used to ensure adequate sample numbers would be achieved for analysis and model building.

Sampling days and type of data collected at each AP is shown in Table 1. Sampling days varied from 10 to 15 across all APs. Drones were used for watercraft counts at 11 of the 12 AP locations. For Biscayne Bay - Cape Florida to Monroe County Line (Cape Florida) AP we were unable to secure permission from the Bill Baggs Cape Florida State Park manager to make drone flights within the park. This is the only accessible public location to adequately view boating activity on aquatic preserve waters, which extend east and south of the park. We will pursue drone flight approval from the Florida Park Service and include this AP in the 2022-2023 study.

We conducted watercraft trailer counts and car counts at all sample locations where available. We counted boat trailers and cars separately as each provides a different measure for predicting AP use at that location. Some locations were used nearly exclusively by boaters as only vehicles with trailers were present while other locations had a mix of trailers and cars. Depending upon the location, cars were generally tied to beach visitors, kayak and canoe visitors, or visitors accompanying boaters.

Table 1: Sampling days and type of data collected by aquatic preserve

	Days	Watercraft Count		Vehicle Counts	
Aquatic Preserve	Sampled	Drone	Observation	Trailer	Car
Lemon Bay	12	X		X	X
Cape Haze	12	X		X	X
Gasparilla Sound - Charlotte Harbor	12	X	X	X	X
Pine Island Sound	12	X	X	X	X
Matlacha Pass	12	X		X	X
Estero Bay	15	X		X	X
Rookery Bay	15	X		X	X
Cape Romano - Ten Thousand Islands	15	X		X	X
Biscayne Bay	12	X		X	X
Biscayne Bay - Cape FL to Monroe Co. Line	12	X		X	X
Lignumvitae Key	10	X			X
Coupon Bight	10	X		X	X

The number of watercraft survey sites varied among APs (Table 2). These survey sites ranged from two at Cape Haze and Lignumvitae Key to nine at Biscayne Bay. As mentioned earlier, the number of sites we could use at each AP was limited by local agency regulations, proximity to AP waters, private riparian land ownership, and FAA flight restrictions.

In Table 2, instantaneous counts of watercraft for each AP were summed across all drone flight locations and the mean count presented for all sample days and separately for weekday and weekend days. These means represent the number of watercraft observed at the time of the count. Weekend watercraft counts were greater than weekday counts in eight of the 11 APs where boats were counted. However, only one of these counts was significantly different – Biscayne Bay. In fact, weekend counts were 73% greater than weekdays at Biscayne Bay. In three of the 11 APs, Estero Bay, Lignumvitae Key and Coupon Bight, weekend counts were less than weekday counts; however, these differences were small and were not statistically different. The differences between weekday and weekend counts is important and is discussed later in this report.

The small number of observations and variability in watercraft count data is reflected in the relatively large mean standard errors (MSE) associated with total, weekend, and weekday counts (Table 2). Dividing MSE by the count mean results in the percent MSE. This provides a better understanding of the variability in the count data. Total count mean standard errors ranged from 2.2% for Cape Haze and Lignumvitae Key to 22.9% for Biscayne Bay and averaged 13.4% overall. Weekday MSE percentages ranged from 1.4% for Cape Romano to 19.8% for Rookery Bay and averaged 12.3% overall. Weekend MSE percentages were somewhat larger than weekday MSEs for some APs as they ranged from 2.8% for Cape Hays to 218% for Estero Bay and averaged 18.7% overall.

Table 2: Number of watercraft survey sites and mean daily counts by aquatic preserve

Aquatic Preserve	Number of Sites	Total Count		Weekday Count		Weekend Count		Statistics	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	t	P
Lemon Bay	6	75.8	8.5	69.3	5.0	82.2	16.6	0.75	.471
Cape Haze	2	29.1	2.2	26.7	3.3	31.5	2.8	1.13	.286
Gasparilla Sound - Charlotte Harbor	7	95.2	6.1	91.0	9.7	99.3	7.9	0.67	.519
Pine Island Sound	4	29.8	2.8	29.7	2.9	30.0	5.0	0.06	.955
Matlacha Pass	3	29.8	2.9	28.2	4.4	31.3	4.1	0.53	.610
Estero Bay	4	103.3	15.2	126.3	19.8	87.9	21.0	1.26	.229
Rookery Bay	5	31.7	4.6	30.0	3.1	32.8	7.5	0.34	.740
Cape Romano - Ten Thousand Islands	4	12.5	1.9	11.2	1.4	13.4	3.1	0.57	.580
Biscayne Bay	9	247.3	22.9	198.6	9.6	344.5	9.6	6.73	<.001
Biscayne Bay - Cape Florida	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lignumvitae Key	2	21.8	2.2	24.5	2.6	20.0	3.1	1.03	.335
Coupon Bight	3	33.1	13.3	38.0	10.2	29.8	14.9	0.95	.370

Trailer and car counts were conducted at boat ramps adjacent to APs where drone flights occurred and at other ramps where we were prohibited from flying by local or FAA restrictions. For some APs, trailer counts at boat ramps where drone flights did not occur were the best predictors of total boat counts. Where this occurred, it will be pointed out in the individual AP summaries in the appendices.

Our sampling location strategy initially included several sites that were subsequently eliminated. However, after several sample days were completed, many of these sites had very low use levels, did not have adequate surface water area to attract boaters, or lacked vessel launching and/or vehicle parking facilities to correlate with watercraft count data. Our objective was to optimize the number of access points for drone flights, in order to cover as much of the AP's surface waters as possible, and to identify boat ramp trailer and car counts that may be strongly correlated with watercraft counts.

Weighting Weekend Vs. Weekday Counts

The importance of differences between weekday and weekend watercraft counts is depicted in Table 3. Data from Biscayne Bay were used as an example to demonstrate the impact of calculating visitor use using three different methods that affect visitor use totals. These methods include calculating visitor use for weekend and weekday observations separately then adding the results, calculating visitor use from weekend and weekday observations combined, and weighting weekend and weekday observations by their proportion during the year. This comparison of methods is important as it informed how we proceeded in building visitor use estimation models for each aquatic preserve. The example in Table 3 isolates the effect of these calculation methods and does not include the procedures for extrapolating the daily drone count to the entire year as these factors are constants across all methods.

The first estimate multiplies weekday and weekend mean watercraft counts by the number of weekdays and weekend days, respectively, in the research year (July 1, 2021 through June 30, 2022) and summing them. This yields a total of 87,954 visitors. While using these individual means would be optimal for calculating visitor use, for many APs we were unable to produce separate regression equations with significant predictors for watercraft use. Thus, we needed to evaluate alternative strategies that would yield significant predictive variables. The alternatives in the two remaining examples combined weekend and weekday counts.

Table 3: Effects of weighting weekday and weekend daily watercraft counts on annual visitor use estimates for Biscayne Bay aquatic preserve.

	Mean Watercraft Count	Days	Visitor Use	Difference from Sum
Weekday Count	198.6	259	51,437	
Weekend Count	344.5	106	36,517	
Sum Weekday and Weekend			87,954	
Unweighted Combined Count	247.3	365	90,265	2.6%
Weighted Combined Count	223.4	365	81,541	-7.3%

In the second calculation we use the mean of all weekday and weekend counts combined (unweighted), the result is 90,265 visitors. This estimate is 2.6% greater than calculating weekday and weekend visitors separately and then summing the results.

The final example shows the effect of weighting daily watercraft counts on calculating visitor use. Since we did not sample weekday and weekend days proportional to their occurrence throughout the year, weighting them to control for this effect is advisable. During the study year, we sampled weekend and weekdays relatively evenly. However, 71% of the days in the study year were weekdays and 29% weekend days. Weighting counts for each sample day eliminates the “weekend bias” of greater counts on weekends noted in Table 2. If we weight each weekday and weekend count based upon their respective number of days in the year, the unweighted mean count of 247.3 is reduced to 223.4. The result is a decline in visitor use of 6,413 or -7.3% compared to visitor use calculated from separate weekday and weekend estimates (Table 3). The use of weighting was necessary to ensure we do not overestimate visitor use and because we were unable to produce separate regression equations for weekend and weekday strata in most cases.

In the Biscayne Bay AP, using the weighted mean count over the unweighted mean count would reduce the visitor use estimation by about 1.7 million visitors when extrapolated to the entire year when compared to using separate weekday and weekend models. The result is much more conservative but appropriate given the limitations of our data noted above.

We conducted this same comparative analysis for all 11 aquatic preserves and found consistent results (Table 4). Combined weekday and weekend count data (unweighted) overestimated or underestimated separate weekday and weekend daily visitor counts to a greater degree than weighted counts. By weighting weekday and weekend counts, visitor use estimates were much smaller.

Table 4: Summary of differences in unweighted and weighted daily visitor use estimates by aquatic preserve

	Difference from Summed Weekday and Weekend Counts	
Location	Unweighted	Weighted
Lemon Bay	3.8%	0.1%
Cape Haze	0.1%	-0.7%
Gasparilla Sound - Charlotte Harbor	1.9%	0.0%
Pine Island Sound	0.0%	-0.1%
Matlacha Pass	2.4%	0.0%
Estero Bay	-10.3%	-3.0%
Rookery Bay	2.9%	0.8%
Cape Romano - Ten Thousand Islands	5.6%	1.6%
Biscayne Bay	2.6%	-7.3%
Lignumvitae Key	-6.0%	-1.7%
Coupon Bight	-7.1%	-2.0%
Average Difference	-0.4%	-1.1%

Limitations on the resources available for this study for sampling frequency and the future data collection burden on AP staff both guided our decision to use weighted watercraft counts as the basis for our models. The one or two weekday and weekend sampling days we could allocate to each AP per month precluded us from developing separate visitor use models for weekday and weekend days as discussed below. Clearly, weighting weekend and weekday counts provides the most useful approach for estimating visitor use. Additionally, it will require AP staff to collect data on a minimum of one weekday and one weekend day per month. This is an important consideration as AP staff may not work near data collection sites during any given month which would require sending someone on a special trip. Further, by weighting and combining weekday and weekend data, the measurement error is reduced considerably over separate weekday and weekend estimates and combined unweighted estimates.

Predicting Watercraft Visitor Use

The next section of this report focuses on visitor use estimation model development. The model we used is based on estimating daily watercraft and extrapolating that to total visitor use. Predicting daily watercraft from shoreside facilities is the first step in building the model. We use data from Biscayne Bay AP to illustrate the steps used in building the model.

First, we needed to identify which boat trailer and/or car count location(s) best predicted watercraft counts. To accomplish this step, we used a stepwise, weighted least squares regression. In the regression for Biscayne Bay (Table 5), we used trailer counts from six locations, car counts from the same six locations, and created six new variables by summing trailer and car counts for additional independent variables (All-Vehicle Counts). The stepwise regression identified the boat trailer count from Matheson Hammock boat ramp as the variable significantly predicting the summed watercraft counts from the six drone flight locations. The mean instantaneous trailer count from Matheson Hammock was 30.03.

Next, we needed to predict the watercraft count from the trailer count variable. To do this, we use the regression results in the following formula:

Predicted Watercraft Count = Constant + (Beta x Mean Trailer Count)

Substituting the Constant and Beta coefficients from the regression results and the mean trailer count into the formula in Table 5 results in a predicted watercraft count of 223.4. The prediction equation is highly significant ($p < .001$) and trailer count data accounts for 92% of the variation in watercraft counts. This percentage is excellent when considering the variability in the data (see Table 2) and the relatively small sample size (12 observations) in the study. The equation in Table 5 will be used in the visitor use estimation model discussed below. The Constant and Beta coefficients will be used to calculate Matheson Hammock boat ramp watercraft counts collected by AP staff in the future.

Table 5: Regression equation predicting watercraft counts for Biscayne Bay AP

Constant	Matheson Hammock					
	Beta	Mean Daily Trailer Count	Predicted Watercraft Count	R-Square	F	P
144.63	2.623	30.03	223.4	0.922	122.07	<.001

The same stepwise, weighted least squares regression was run for each of the remaining 10 aquatic preserves. Table 6 shows the number of predictor variables, F value and significance level, and R-Square for each of the resultant equations. In each of the regressions we use separate trailer and car counts, and all-vehicle counts for each survey location. The regressions resulted in one or two independent variables predicting mean daily watercraft counts. For all APs, only boat trailer counts were significant predictors of watercraft counts. The equations were all highly significant and the predictor variables accounted for 77% to 96% of the variation in daily watercraft counts. Again, this is an excellent prediction based on the number of sampling days and diversity in the data. Overall, boat ramp trailer counts were found to be excellent predictors of watercraft using AP waters. Details of each regression and estimation formula for individual APs can be found in the appendices at the end of this summary report.

Table 6: Summary of regression equations predicting watercraft counts for all APs				
AP Location	Number of Predictors	R-Square	F	P
Lemon Bay	1	0.933	140.10	<.001
Cape Haze	1	0.777	34.80	<.001
Gasparilla Sound - Charlotte Harbor	1	0.953	201.73	<.001
Pine Island Sound	2	0.958	103.00	<.001
Matlacha Pass	1	0.889	79.94	<.001
Estero Bay	1	0.931	176.08	<.001
Rookery Bay	1	0.964	351.32	<.001
Cape Romano - Ten Thousand Islands	1	0.788	48.445	<.001
Biscayne Bay	1	0.922	102.660	<.001
Biscayne Bay - Cape FL to Monroe Co. Line	0	n/a	n/a	n/a
Lignumvitae Key	0	n/a	n/a	n/a
Coupon Bight	1	0.886	62.010	<.001

Model Development

Model development extrapolates the mean watercraft count, estimated by the regression equation, to the entire year. To estimate the total number of watercraft using the entire AP, we employed an adaptation of the following commonly used instantaneous count formula (Lockwood and Rokoczy 2005) for estimating wildlife and recreational visitors.

Use Estimation Formula:

$W = (H * (C/D))/T$

Where:

W = Total daily number of watercraft estimated
H = Number of hours in sample period (day)
C = Number of watercraft counted during sampling period (estimated from regression equation)
D = Duration of the count in hours (or fraction of hour)

T = Time boats remain in the AP

Table 7 shows the components of the model plus further steps to expand the watercraft use estimate to total AP visits. Formula components are shown at the top of Table 7. There are several variables in this table that needed verification during the project. First was the duration of sample day (H). We were able to sample during the period of sunrise to sunset. The number of hours between sunrise and sunset in Florida varies from 10 to 14 hours daily throughout the year. We averaged the number of hours of daylight occurring on the first day of each month (12 hours) to represent this variable.

Table 7: Calculations for estimating Biscayne Bay AP visitor use

H	C	D	T	W	Extrapolation					
Hours /sample	Mean Watercraft Count	Duration of Count (hrs.)	Time in AP	Daily Watercraft Estimate	% of Use	Total Daily Watercraft	User Days	Total Watercraft Visits	Individuals / Watercraft	Total Visits
12	223.4	0.25	6.6	4,423	25.12%	17,609	365	6,427,197	2.5	16,067,992

Second, we determined that watercraft remain in in AP waters (T) for an average of 6.6 hours after launching. Time-lapse camera data from boat ramp parking areas were used to estimate this variable. We tracked individual trailers over time on weekends and weekdays to calculate this average which was the same for both types of days.

Third, we needed to estimate the percentage of AP use that the watercraft counts included (Table 8). For Lemon Bay we had the majority of the AP covered with drone photographs, while others were only 5%-47% covered. The wide differences in percentage of AP coverage centered on lack of shoreline access and large expanses of water where drone flights could occur. We used mapping technology to quantify drone coverage areas and management plan data to make these estimates.

Table 8: Proportion of aquatic preserve waters covered by drone flights (in acres)

AP Location	Drone Coverage	AP Size	Percentage Covered
Lemon Bay	4,151	7,227	57.4%
Cape Haze	1,011	12,716	8.0%
Gasparilla Sound - Charlotte Harbor	8,914	84,500	10.5%
Pine Island Sound	7,762	58,500	13.3%
Matlacha Pass	1,868	14,600	12.8%
Estero Bay	6,493	13,800	47.1%
Rookery Bay	8,093	32,500	24.9%
Cape Romano - Ten Thousand Islands	1,669	33,175	5.0%
Biscayne Bay	12,358	49,196	25.1%
Biscayne Bay - Cape FL to Monroe Co. Line	n/a	n/a	n/a
Lignumvitae Key	2,477	6,700	37.0%
Coupon Bight	2,231	5,400	41.3%

Finally, we counted the number of occupants of watercraft to derive an average number of individuals occupying each watercraft. We used data from time-lapse cameras, drone photographs, and personal observations at boat ramps to assist with this task. In addition, we compared our estimate of 2.5 individuals to Florida boating research. This was consistent with several studies (Sidman et al. 2004, 2007, 2009; Ault 2008) that reported boat occupancy data.

The sample model in Table 7 is built upon data from the Biscayne Bay AP. The predicted watercraft count (30.03) was from the regression model in Table 5. Based upon this count and using the above formula, an estimated average of 4,423 watercraft (W) used the AP area covered by drone observations each day. We determined that the drone observations capture 25.12% of visitor use in the AP for a single day. Dividing the daily watercraft estimate (W) by the coverage percentage extrapolates daily visitor use to the entire AP. Multiplying total daily watercraft by 365 days in the year yields an estimated 6,427,197 total watercraft visits during a year. Multiplying total watercraft visits by individuals per watercraft results in the total number of visits (16,067,992) made to the Biscayne Bay AP annually.

Total Visitor Use Estimates

This total visitor use estimation procedure was used for all 11 APs in the study are detailed in the individual AP reports found in the appendices. A summary of visitor use for the APs in this study is shown in Table 8. Biscayne Bay and Gasparilla Sound - Charlotte Harbor APs had the largest amount of use with about 16 million visits each. Differences in the number of visits is directly influenced by the surrounding population level and to some degree the size of the AP. Access is also another factor limiting use. Some reaches of APs are several miles from the nearest boat ramp and receive relatively little use. Overall, we estimated over 59 million visits were made to the 11 APs during the 2021-2022 fiscal year.

Table 9: Total visitor use estimate by aquatic preserve

Aquatic Preserve	Total Visits
Lemon Bay	2,299,796
Cape Haze	6,384,332
Gasparilla Sound - Charlotte Harbor	15,999,263
Pine Island Sound	4,053,063
Matlacha Pass	4,929,250
Estero Bay	3,965,744
Rookery Bay	2,254,063
Cape Romano - Ten Thousand Islands	1,727,953
Biscayne Bay	16,067,943
Biscayne Bay - Cape FL to Monroe Co. Line	0
Lignumvitae Key	0
Coupon Bight	1,526,144
Total Visits	59,207,552

Total visits do not represent unique individuals. Boaters and other users in each AP often spend several days on the water each year, many of these in their local AP. The focus of this study was on the number of visits made to aquatic preserves and not the number of individual visitors. To estimate the number of individuals, total visits would need to be divided by the average number of trips made by individuals to the AP annually.

Discussion

The goal of this project was to develop an efficient and reliable method for managers to estimate visitor use in their respective aquatic preserves. We were unable to complete data collection at two of the APs in the region: Biscayne Bay – Cape Florida and Lignumvitae Key. We were unable to receive permission to fly our drone at Bill Baggs - Cape Florida State Park which is the only location to adequately photograph boat use at Biscayne Bay – Cape Florida AP. We will reapply for permission during the 2022-2023 project and add it as a study site. While we were able fly our drone at two locations to collect boat use data at Lignumvitae Key AP, the only local boat ramp was blocked throughout the year by road construction. Attempts to use boat ramp data from other locations to predict watercraft visits was not successful. Here again, we will restudy this AP during the 2022-2023 year. Results and visitor use models for both locations will be included in the 2022-2023 final report.

Establishing baseline watercraft use levels and predicting that use with shoreside boat trailer counts at boat ramps resulted in equations that reliably estimate visitor use over the course of the study year. All equations were highly significant ($p \leq .001$) and all R-Square value equaled or exceeded .777, which were excellent considering the relatively small number of observations for each AP. These results reflect similar findings by Aldt et al. (2008) who found R-Square values of .800 or greater for the relationship of boat trailer counts to a single aerial boat census in Biscayne National Park.

AP staff will be able to collect trailer count data monthly from one or two locations and feed the data into a spreadsheet database contained in their respective spreadsheet models. The spreadsheet will automatically weight the counts and place the weighted count into a regression model (similar to Table 5) that estimates the watercraft count. This watercraft count will then be automatically transferred to the Visitor Use Estimation Model (Table 7) to produce total annual visits at the end of the fiscal year. Optimally, data collection should occur on at least one randomly selected weekday and one randomly selected weekend day per month and at randomly selected times between 10:00 and 16:00 hours.

The Visitor Use Estimation Model should be viable for several years unless changes in the recreational infrastructure system in the region occurs. Boat ramps and parking areas may be closed for construction or from storms and rising water levels, for example. In these cases, we should be able to identify an alternate sampling location as many trailer count locations we used in the study were highly inter-correlated which should allow for substitutions. In this case, we would only need to re-run the regression without the closed site in the independent variable pool and update the Constant and Beta coefficients in the regression model. All other coefficients and calculations in the visitor use estimation model would remain unchanged.

Visitor use estimates should be considered conservative. Weighting weekend and weekday counts produced results close to separate efforts that were summed. Weighting was necessary because we were unable to produce separate regression equations for both weekend and weekday strata in many cases. The small overestimates or underestimates from weighted equations were offset by the inability to identify small watercraft, such as kayaks, at the edge of the view field or watercraft in amongst vegetation. Further, our sampling only included daylight hours. Watercraft often are seen on AP waters at night as anglers fish, boaters return from trips outside the AP, or paddlers enjoy moonlight trips on the water.

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