OBSERVED BEHAVIOR AND VISITOR COUNTS AT FOUR LAKES IN MOUNT RAINIER NATIONAL PARK

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October 2009

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Produced in partial fulfillment of:

Task Agreement J9W88030023 by and between the National Park Service and the University of Washington written against the Pacific Northwest Cooperative Ecosystem Studies Unit Cooperative and Joint Venture Agreement CA9088A0008 entitled "Selecting Visitor Carrying Capacity Indicators and Proposing Potential Standards for Mount Rainier National Park."

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ACKNOWLEDGMENTS

The success of this project depended in large part on the survey workers, Craig Baker, Nick Dolecek, and Joanne Ho. The field manager for the 2004 data collection, Mark Husbands, also was essential. Finally, many MORA staff members provided important feedback, review, and support during data collection. Barbara Samora was particularly helpful.

1. INTRODUCTION

The University of Washington Protected Area Social Research Unit administered this project. It was proposed and funded by Mount Rainier National Park (MORA).

Many lakes, streams, rivers, and other water features are found in MORA. The biological and physical resources in these features and the riparian areas adjacent to them are often particularly susceptible to impact from the activity of visitors. Both the fragility of the resources and the tendency for visitors to congregate around water exacerbate the degree of impact. The general purpose of this study was to use systematic observation to collect information about the level and type of visitor use at four lakes in MORA where studies of resource impact have been, and/or will be, conducted (i.e., Upper Crystal Lake, Mowich Lake, Mystic Lake, and Shadow Lake). This information will help managers assess the relationship between visitor use and resource impacts, and will thereby support more effective planning of visitor management. More specifically, the information will be used in the Visitor Experience and Resource Protection (VERP) planning framework.

1.1 The Visitor Experience and Resource Protection (VERP) Framework

The VERP framework is a tool developed by the National Park Service to address user capacities and thus protect both park resources and visitor experience from impacts associated with visitor use. VERP was used in developing the Mount Rainier National Park General Management Plan, and the park has made a commitment to implement VERP throughout MORA. The VERP framework is an ongoing, iterative process of determining desired conditions (including desired cultural resource conditions, desired natural resource conditions, and desired visitor experiences), selecting and monitoring indicators and standards that reflect these desired conditions, and taking management action when the desired conditions are not being realized. VERP is a decision-making framework, but does not diminish management's role in decision-making.

Information about visitor use is essential because VERP is, at its core, a means of managing the impacts associated with visitor use. It is difficult to imagine how decisions intended to limit the impact of visitation could be made in the absence of information describing current levels and patterns of visitor use.

1.2 The Purpose and Limitations of this Report

Due to time and budgetary constraints, this document does not include a full analysis or discussion of the information collected in the systematic observation study. Instead, this document is intended primarily to report the basic visitor use data that were collected and serve as a guide for future analysis of the study database. Thus, it includes a full description of the methods used to collect the information, some of the simpler descriptive information that was collected, and a discussion of some future analyses that might prove useful to MORA managers.

2. METHOD OF DATA COLLECTION

In the lake observation study, unobtrusive observers systematically recorded the locations, number, and activity of visitors who were visible from a selected location. This information can be used to, a) estimate the number of visitors to each of four lakes, b) describe visitors' spatial and temporal distribution, and c) describe their activities.

2.1 Sampling

2.1.1 Description of Studied Lakes

Four lakes were selected for study because they are also the focus of studies assessing resource impacts. Each of these four lakes (i.e., Upper Crystal Lake, Mowich Lake, Mystic Lake, and Shadow Lake) is shown in Figure 1 and described briefly below.

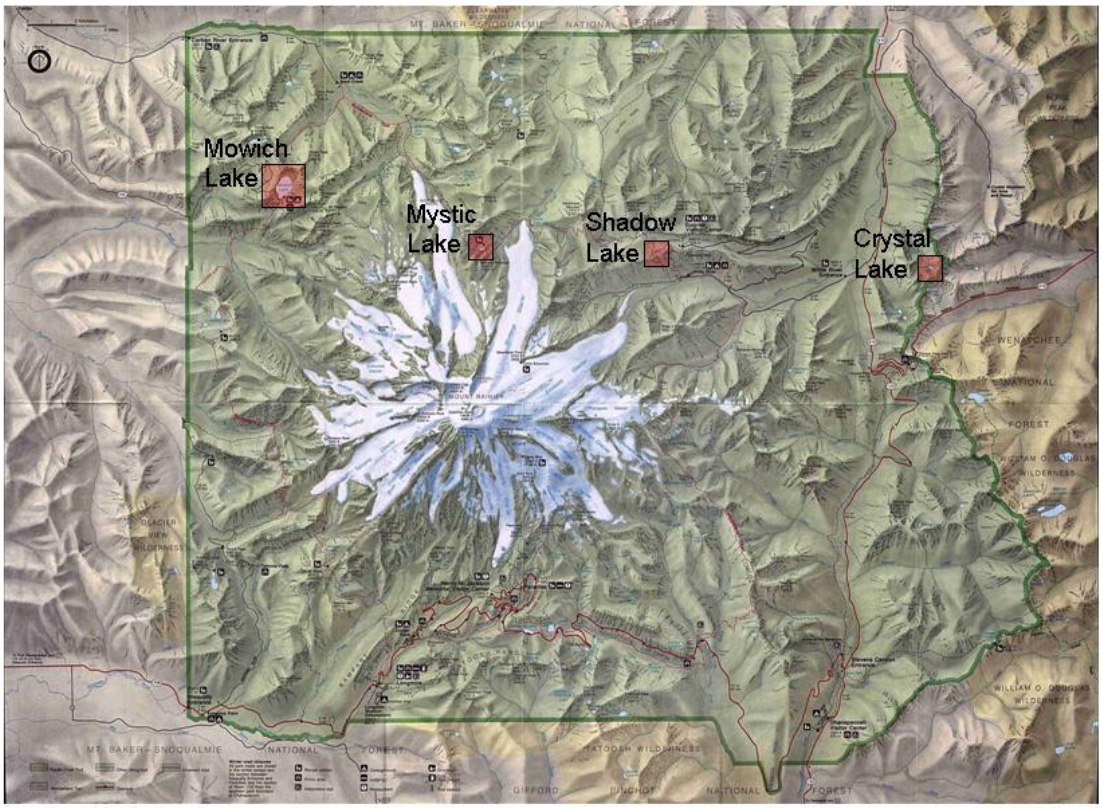


Figure 1. Lakes included in the Lake Observation Study.

Upper Crystal Lake is located in the northeast area of MORA. It is the larger of two lakes usually accessed via the Crystal Lakes Trail, with a trailhead on Highway 410 north of the junction with the Sunrise/White River Road. Located at 5,828 feet, the lake is set in meadows below Sourdough Gap. Most of the shoreline and surrounding area was visible from the observation location. The lake was a common destination and turn-around point for day-hikers, but was also visited by overnight backpackers, some of whom set up camps near the lake.

Mowich Lake (el. 4,950 feet) is the largest lake in MORA, and the most heavily used of the studied lakes. Located in the northwest corner of the park, it is commonly and easily accessed by a gravel road that, in the past, ended very near the lakeshore. The road is now gated so that vehicles must park outside the lake drainage and visitors walk a short distance to reach the lake. Due to the lake's size, the vegetation growth around its shores, and the limited locations available as

observation sites, observation of visitor activity was limited primarily to the most heavily used area of the lakeshore at the south end of the lake near the walk-in campground and ranger cabin. Counts were focused on the immediate vicinity of the lake. Visitors at the campground or walking along the old road were not recorded in the study.

Mystic Lake is located in the north-central area of MORA. It is accessed via the Wonderland Trail. At 7.9 miles from the trailhead, it is beyond easy hiking distance for most day-hikers and is the lake most commonly visited by overnight backpackers, some of whom camp at the trailside camp .3 miles east of the lake. Most of the shoreline and surrounding area was visible from the observation location.

Of the studied lakes, Shadow Lake is the closest to a heavily-used frontcountry area. Located about a mile west of Sunrise Lodge and visitor center, this small lake is ringed by a social trail and visitors' footprints can often be seen in its muddy bottom. A few backpackers pass by, but the vast majority of visitors are day-hikers who park at Sunrise. Shadow Lake is the primary destination for some hikers making relatively short hikes, and one of several destinations visited on longer day-hikes for many other visitors. Due primarily to the small size of the lake, virtually the entire shoreline and surrounding area was visible from the observation location.

2.1.2 Sampling Schedule

The goal of sampling at each lake was to schedule observation on a representative selection of days. It was possible for visitors to be present at virtually any time of day. However, due to constraints on survey workers' time, observations occurred between 6:30 A.M. and 7:00 P.M.

Most observations were recorded on 30-minute intervals. Table 1 below shows the distribution of observed time periods for each of the four observed lakes.

CRYSTAL LAKE															
	Observation Times													Total Obs.	Total Days
	6:00 & 6:30	7:00 & 7:30	8:00 & 8:30	9:00 & 9:30	10:00 & 10:30	11:00 & 11:30	12:00 & 12:30	1:00 & 1:30	2:00 & 2:30	3:00 & 3:30	4:00 & 4:30	5:00 & 5:30	6:00 & 6:30		
WD	0	0	0	3	16	16	20	20	20	17	4	0	0	122	10
WE	0	0	0	9	8	8	8	8	8	8	1	0	0	52	4

MOWICH LAKE															
	Observation Times													Total Obs.	Total Days
	6:00 & 6:30	7:00 & 7:30	8:00 & 8:30	9:00 & 9:30	10:00 & 10:30	11:00 & 11:30	12:00 & 12:30	1:00 & 1:30	2:00 & 2:30	3:00 & 3:30	4:00 & 4:30	5:00 & 5:30	6:00 & 6:30		
WD	1	3	5	8	8	8	10	10	9	9	7	4	4	86	8
WE	0	0	1	8	9	12	12	12	12	7	4	2	3	82	6

MYSTIC LAKE															
	Observation Times													Total Obs.	Total Days
	6:00 & 6:30	7:00 & 7:30	8:00 & 8:30	9:00 & 9:30	10:00 & 10:30	11:00 & 11:30	12:00 & 12:30	1:00 & 1:30	2:00 & 2:30	3:00 & 3:30	4:00 & 4:30	5:00 & 5:30	6:00 & 6:30		
WD	1	2	7	14	16	18	18	16	15	8	4	3	5	127	9
WE	1	4	5	6	6	6	6	5	4	2	2	2	1	50	4

SHADOW LAKE															
	Observation Times													Total Obs.	Total Days
	6:00 & 6:30	7:00 & 7:30	8:00 & 8:30	9:00 & 9:30	10:00 & 10:30	11:00 & 11:30	12:00 & 12:30	1:00 & 1:30	2:00 & 2:30	3:00 & 3:30	4:00 & 4:30	5:00 & 5:30	6:00 & 6:30		
WD	0	0	0	7	16	16	16	14	14	13	1	0	0	97	8
WE	0	0	1	6	8	8	8	8	8	5	0	0	0	52	4

Table 1. Distribution of observed time periods for each of four observed lakes.

2.1.3 Types of Observation

The primary goal of the observation study was to record the number, position, and activities of lake visitors by recording "snapshot" observations on 30-minute intervals. A second goal was to record the path of selected groups or individuals as they moved around the lake. These "tracking"

observations were recorded on data sheets that were separate from the "snapshot" observations.

2.1.4 Observation Procedures

When the observer arrived at the lake for the first time, they located a position that afforded a good view of the lakeshore and immediate area around the lake. On the first day of observation from that location, they marked the observation position on the data sheets/lake maps with a large X. If an area along the lake shore was shielded by forest or another cover type that could prevent the observer from recording activity in that area, the area was also marked on the first-day data sheets/maps with a circle and hash marks to indicate a "blind spot". Upon arrival at the observation position (on the first day and every other sampled day) the observer recorded the arrival time, date, and name of the lake in their logbook.

"Snapshot" observation of visitor activities. As soon as the observer was ready to begin the observation period, they noted the time in their logbook and on the first data sheet/lake map. The observer then marked the location of each visitor who was present at the lakeshore or immediate vicinity of the lake. This was done by marking the visitor's position on the map with a circle, then placing a letter indicating the visitor's activity inside that circle. Coded activities included fishing, picnicking, getting water, swimming/wading, taking photographs, resting, and talking to other parties.

This process was repeated every thirty minutes, with the observation time and the locations of visitors noted on a new data sheet/lake map. In some cases when observers were running short of data sheets and no visitors were present, a note was made in the log book but the time was not written on a new data sheet/lake map (i.e., to avoid using a sheet when the only information on it would be the time of the observation).

"Tracking" observation of visitor activities. In the time between the snapshot observations, observers selected up to three visitors (using a random selection procedure) and recorded their movement around the lake. Each visitor was represented with a unique symbol: a circle, square, or triangle. This helped the observer and the data entry worker distinguish between the three subjects. A letter code (as in the snapshot exercise) was placed in the symbol to identify the visitor's activity. Observers recorded the subject's movement around the lake by tracing the route with a line. When the visitor began a new activity, terminated an activity, or left the area, the location was marked with the appropriate symbol, letter code, and time.

2.2 Data Sheets/Lake Maps

The primary instruments used in the study were the data sheets used to record observations. There was a different data sheet for each lake, although the same sheet format was used for "snapshot" and "tracking" observations. Each sheet had notations at the top for recording information about the observation being made, and a set of codes used in recording visitor activities. A simple map of the lake occupied the majority of the sheet, showing the shoreline and some of the surrounding area. The data sheets can be found in Appendix A.

3. DATA CODING

3.1 "Snapshot" Counts

The information about visitors recorded on each data sheet was entered in an electronic database in the form of points placed on a digital map of MORA. The activity in which each visitor

was engaged was also recorded. Activity codes included:

- Fishing
- Getting water
- Picnicking
- Resting
- Swimming/wading
- Taking photographs
- Talking to other parties
- Walking/hiking
- Other (including boating, setting up camp, observing wildlife)

The digital information was entered using a web-based data entry program that allowed workers to click on a map of MORA to place a point in the same geographic location of the visitor recorded on the data sheet (i.e., the program recorded GIS coordinates locating each point). The data entry program produced a Microsoft Access database. Information from the data sheets (those with *SheetID* or *Description* values between 1,000 and 1,499, 2,000 and 2,499, 3,000 and 3,499, and 4,000 and 4,499) is found in only three of the tables in the Access database (the rest of the tables are used by the entry program). The names of these files are tblUserForms, tblUserFormData, and tblPlaces. The information in these three tables can be linked using the variable UserFormID, which is present in all three.

Figures 2 to 5 show screen-shots of the web-based data entry program for recording digital information at each of the four studied lakes. During data entry, the user could zoom in or out, or pan, showing smaller or larger portions of the lake and surrounding area.

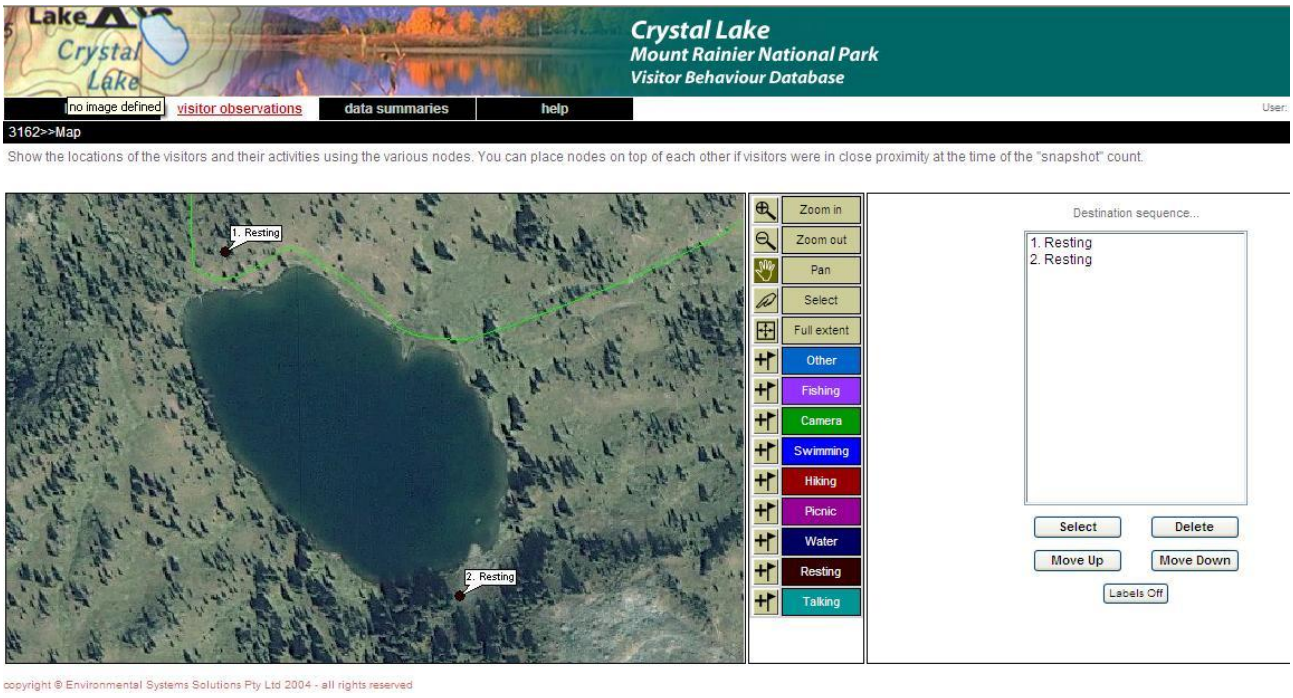


Figure 2. Web-based interface for digitizing Crystal Lake observations.

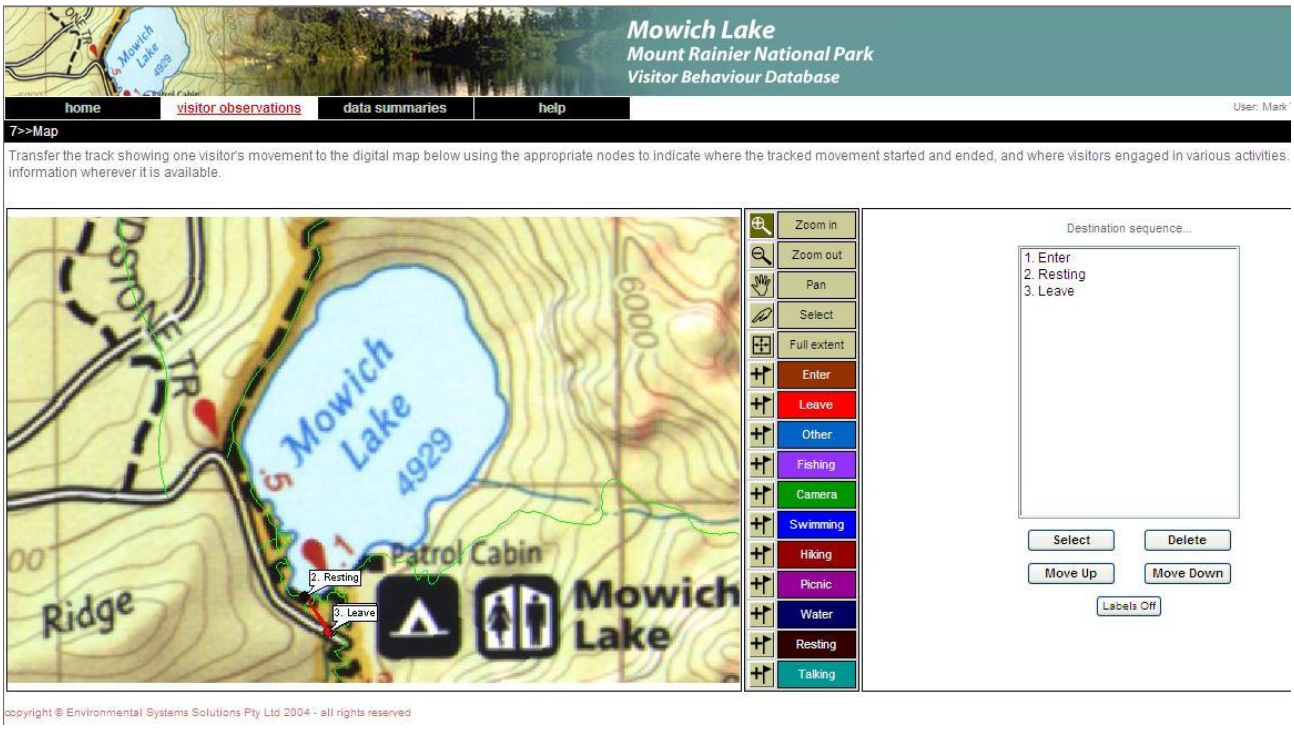


Figure 3. Web-based interface for digitizing Mowich Lake observations.

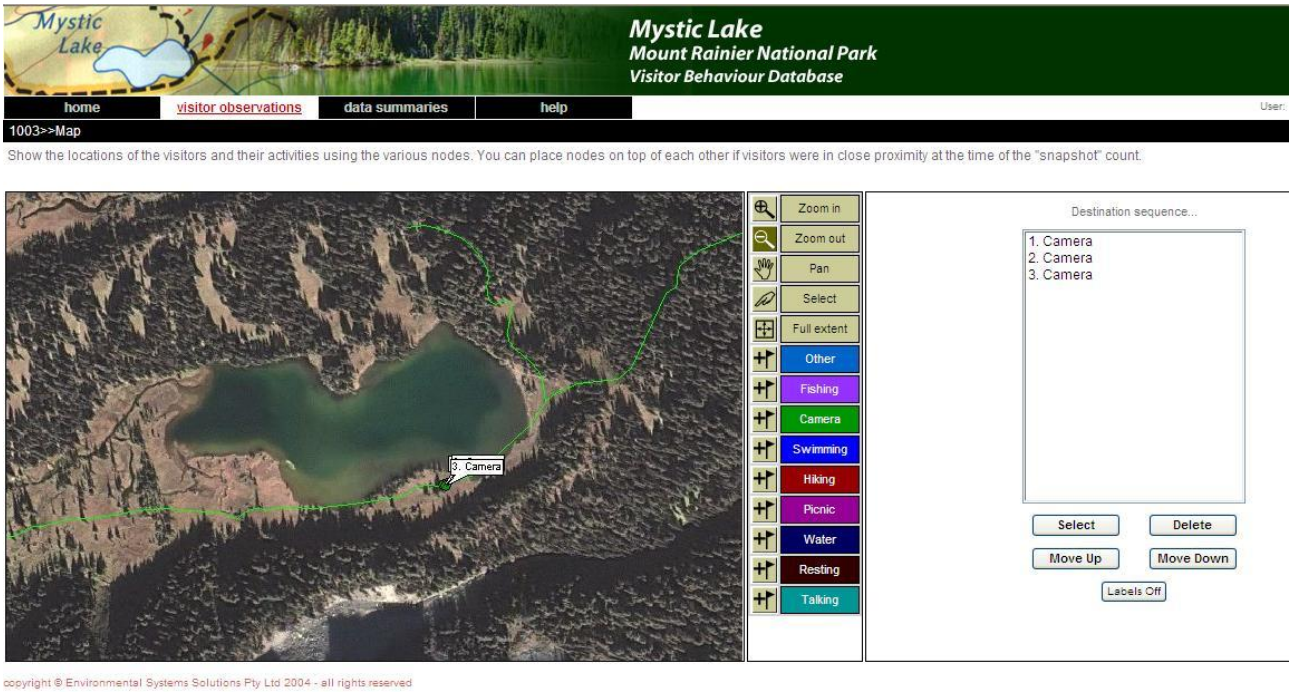


Figure 4. Web-based interface for digitizing Mystic Lake observations.

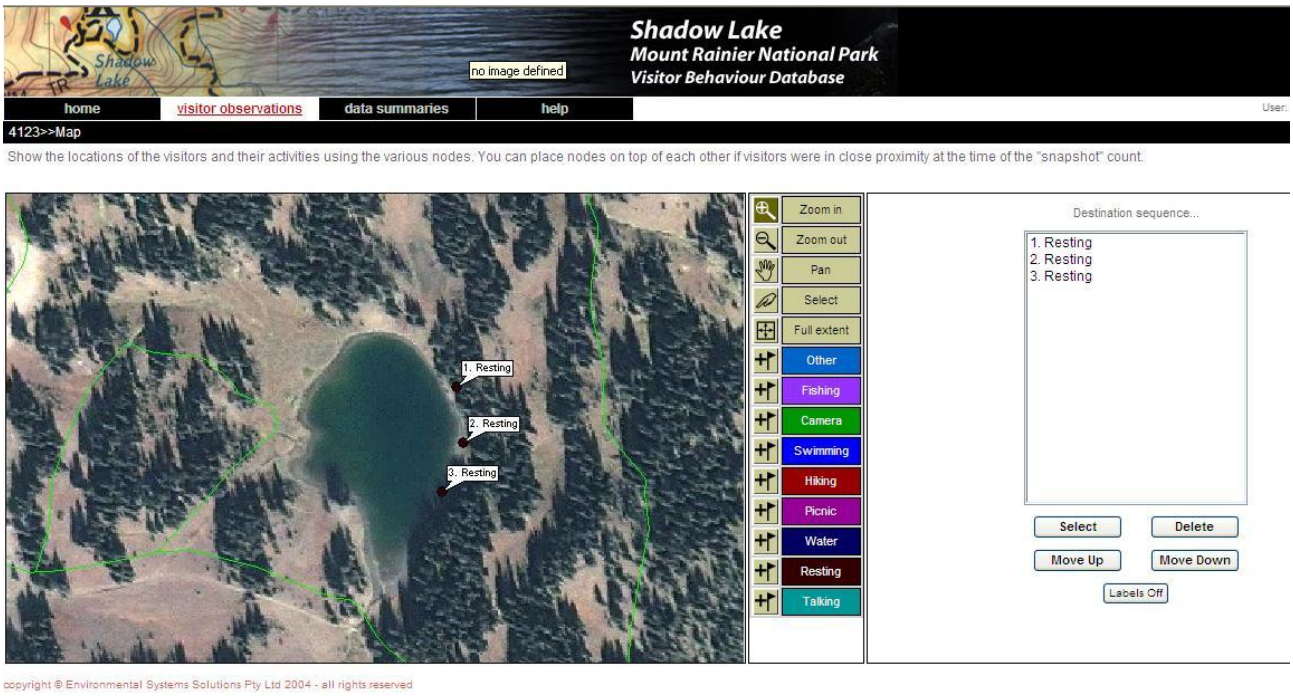


Figure 5. Web-based interface for digitizing Shadow Lake observations.

3.2 "Tracking" Observations

The same tables in the Access database that hold information from the snapshot counts also contain information from the tracking observations. Digital information from the data sheets (those with *SheetID* or *Description* values between 1,500 and 2,000, 2,500 and 3,000, 3,500 and 4,000, and greater than 4,500) was entered using the same web-based data entry program used for the snapshot counts. The program allowed workers to click on a map of MORA to place a point in a specific geographic location (i.e., the program recorded GIS coordinates locating each point).

Points were labeled with the same activity codes used for the snapshot counts, with two additions: first, the sequence of the points was also recorded, so that a route showing visitor movement was recorded by the line drawn between the points associated with a specific party of visitors, and second, some points that were necessary to show visitors' movement but did not record changes in visitor behavior were simply labeled "tracking".

The process of recording the tracking observations in the digital database proved to be very challenging. The lines showing visitor movements on the data sheets were often woven together and difficult to disentangle. In addition, information about visitors who stayed for considerable periods of time was often spread across several different data sheets. For these reasons, the reliability of the routes recorded by the tracking observations is questionable at best. The simplest types of information recorded during tracking, such as the time that parties entered or exited the observed area, are the most reliable.

4. DATA ANALYSIS

Due to time and budgetary constraints, this section does not include a full analysis or discussion of the information collected in the systematic observation study. Instead, only limited descriptive analyses were conducted to produce, for each lake, estimates of the number of visitors

observed in the snapshot counts, the distribution of those visitors across the observed time periods, the average duration of visitors' stays, and the total number of visits per day. The sections below present the results of these analyses.

4.1 Visitor Counts at Crystal Lake

4.1.1 Snapshot Counts

Crystal Lake was primarily visited by small groups of day-hikers, most of whom reached the lake in the afternoon. Much of the time, there were fewer than two persons at the lake. The figure below shows the average number of visitors observed at the lake at times during the observed period.

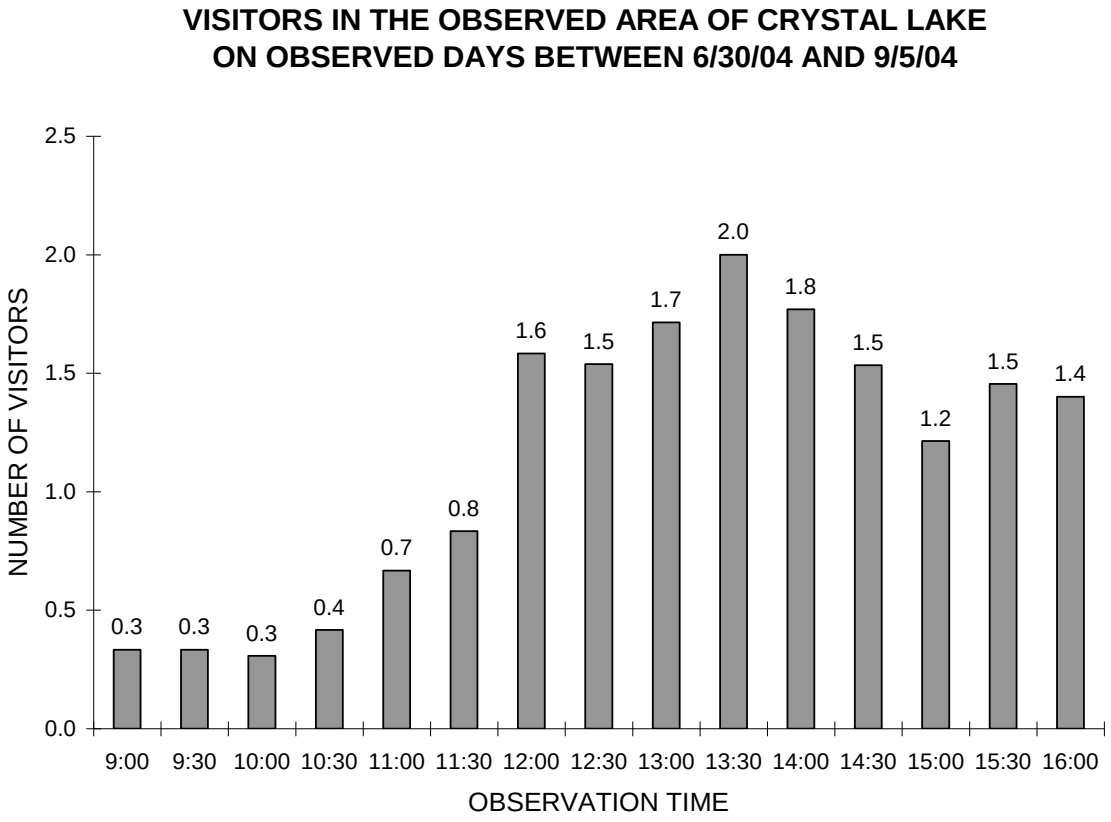


Figure 6. Visitors in the observed area of Crystal Lake.

Note that the figure excludes two outlier observations. At 12:00 and 12:30 on June 30, the observer recorded 16 and 17 visitors, respectively. Apparently a large group, such as a Boy Scout troop or Mountaineers outing was present at that time. At no other observed time were more than 10 visitors observed. If those outlier observations were to be included in the chart, the mean observation at 12:00 would be 2.7 visitors, and at 12:30 would be 2.6 visitors.

The average count across all observed times was 1.21 visitors (SD = 1.5). When the outlier observations are included, the average was 1.39 visitors (SD = 2.2).

4.1.2 Duration of Stays

One of the simplest and most reliable types of information available from the tracking observations were the times at which observed visitors entered and left the observed area. In this section, these times are used to calculate the duration of stays for visitors at Crystal Lake.

Calculation of the duration of stays is complicated by the fact that some visitors were present when observation started and others had not departed when observation ended.[1] Analysis can either exclude those visitors from calculations, or use the beginning and ending times of observation to estimate their minimum duration of stay. Either method underestimates the total duration of stays. We found that analyses which included the estimated durations were more accurate because they increase the average duration (i.e., we know that if two estimates are both low, then the higher of the two must be more accurate).

Visitors to Crystal Lake spent an average of 62.8 minutes in the observed area (SD = 48.0). The distribution of stay times (see the figure below) shows that more than one-quarter of visitors spent less than 30 minutes in the observed area and that almost 90 percent of visitors spend less than two hours at the lake.

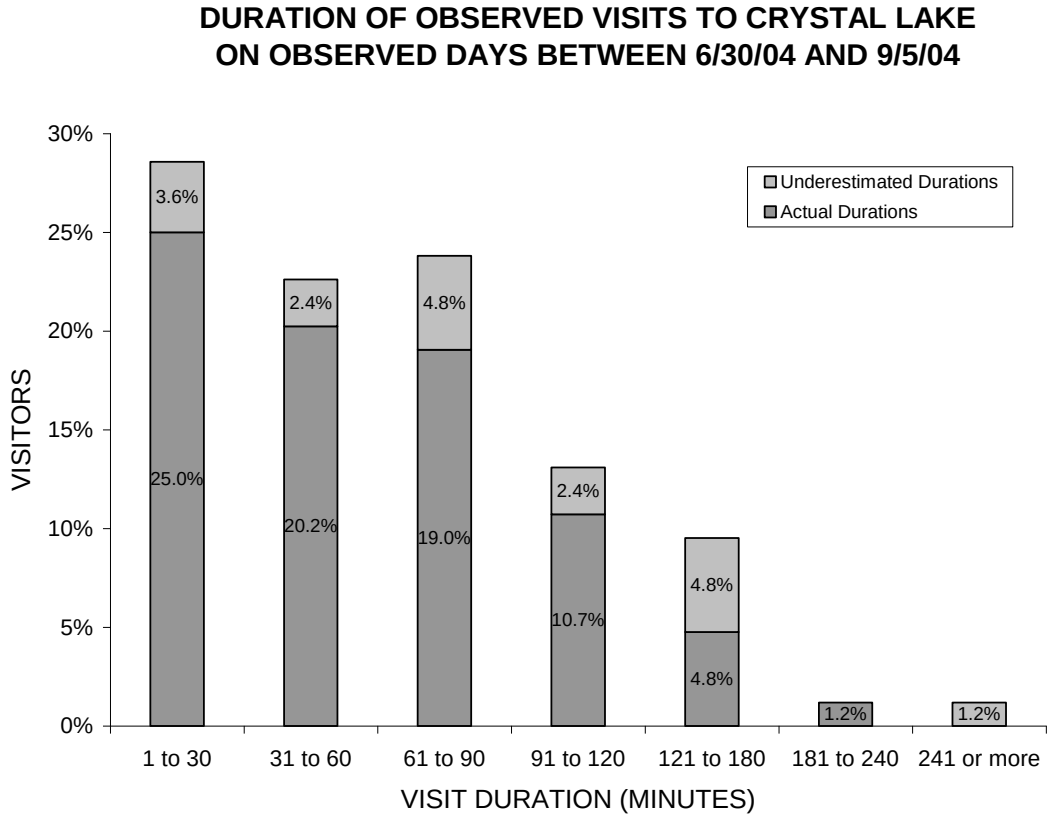


Figure 7. Duration of observed visits to Crystal Lake.

[1] The number of visitors who were present for the entire observation period (i.e., who were there both when the observer began and ended observation) was extremely small. Such stays are not included in the duration of stay analyses and results.

4.1.3 Total Visitation

The formula for estimating the daily total of visitors to Crystal Lake based on the snapshot counts and stay durations during the observed time period is as follows:

Visitors (9:00 to 4:00) = sum(half-hourly counts) / mean duration (in half-hours)

Using this formula and the data collected during the observation study, we estimate that between June 30 and September 5, the area in the immediate vicinity of Crystal Lake attracts an average of 8.2 visitors per day between 9:00 and 4:00.

It is important to note that the average visit duration reported above and used in this section is known to underestimate the average amount of time that visitors actually spent in the vicinity of Crystal Lake. When used in the equation above, such an underestimate leads to overestimation of the number of total visitors. The degree of overestimation is directly related to the degree of underestimation in the duration estimate. Although both such numbers are unknown at this time, the relatively small number of visit durations that were truncated (see the figure above) suggest that the bias is slight. It is safe to say that on average, no more than the estimated number of visitors enters the observed area between 9:00 and 4:00.[2]

4.1.4 Limitations

A number of issues limit the precision of these estimates of use. Each of those issues is described briefly below.

Observed time periods. Observations were made at Crystal Lake between 9:00 and 4:00, but some visitors were present at times outside that period. This issue introduces bias into estimates of visit durations (see Section 4.1.2), leading to their underestimation. The limited observation time may also bias estimates of the number of lake visitors if some visitors depart before the observer arrives or arrive after the observer departs. At Crystal Lake, the only visitors likely to do so are backpackers who camp in the vicinity of the lake. Visits by virtually all day-hikers overlap with the observed time.

Observation days at Crystal Lake were distributed across weekdays and weekends at the appropriate 5 to 2 ratio. Thus, the data are likely to be representative of an "average" day at Crystal Lake. It is likely, however, that weekdays are less busy than weekends, and in actuality, there may be very few days that have "average" visitation. Nonetheless, the number of observed days is not sufficient to provide good estimates of the difference in weekend and weekday visitation, and thus the aggregate data are presented above.

Observed areas of the lakes. The fact that all portions of the lakeshore and surrounding area were not visible to observers means that counts of visible visitors will underestimate the actual number of people present at the lake. At Crystal Lake, this issue is of relatively low importance because the observation site provided a clear view of most of the area to be observed. Any small underestimation of the number of total visitors per day is likely to be offset by the slight overestimation effect introduced by the duration estimate (see Section 4.1.3).

[2] The number of visitors to Crystal Lake outside the observed time period could be estimated based on the hourly distributions of use recorded by electronic trail counters (see Vande Kamp, 2008). Such analyses might be conducted in the future if MORA managers see a need for more complete description of visitor use.

4.2 Visitor Counts at Mowich Lake

4.2.1 Snapshot Counts

Mowich Lake is visited for a variety of reasons. Trailheads for several popular day-hikes are located nearby and there is a walk-in campground at the terminus of the old road near the lakeshore. The figure below shows the average number of visitors observed at the lake at times during the observed period. The distribution of use at the lake shows a mid-afternoon peak and a second peak in early evening. However, there were relatively few days when observations continued into the evening hours and the second peak is based on only three or four observations. Even if the evening peak was overestimated, between 11:00 and 18:00 one would expect to see between one and seven visitors along the shore of Mowich Lake.

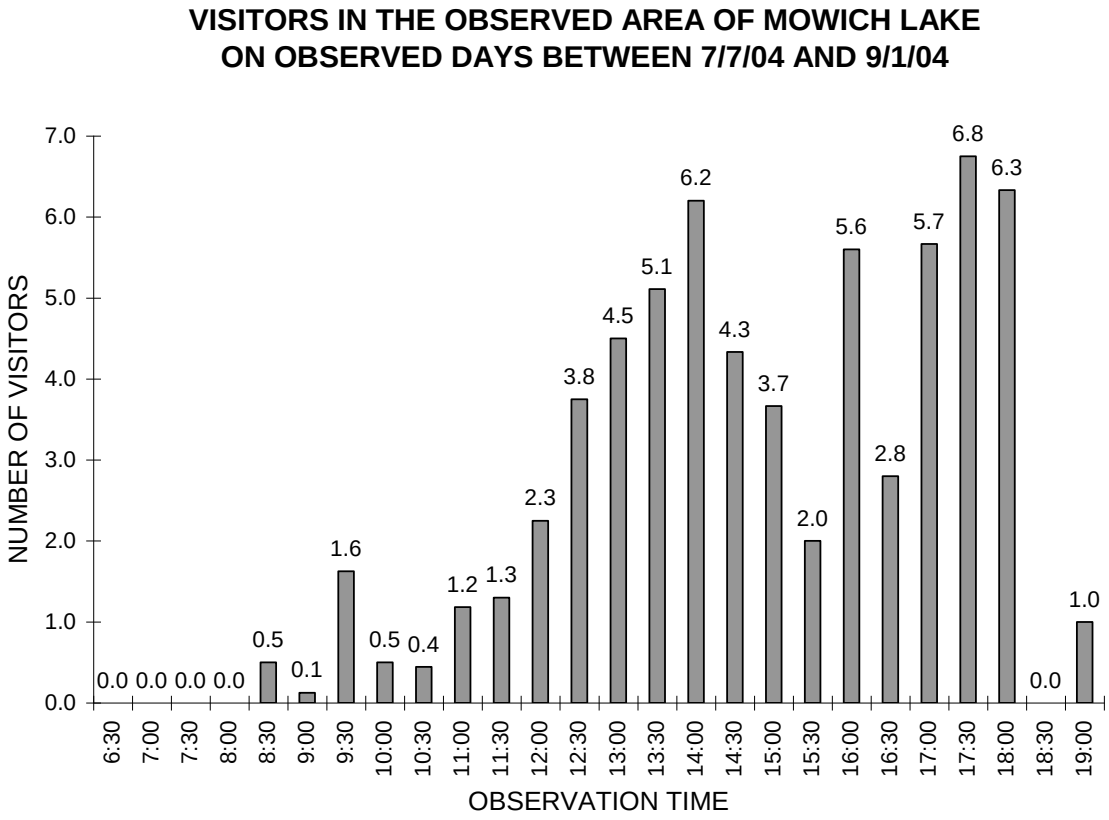


Figure 8. Visitors in the observed area of Mowich Lake.

The average count across all observed times was 2.86 visitors (SD = 4.38).

4.2.2 Duration of Stays

One of the simplest and most reliable types of information available from the tracking observations were the times at which observed visitors entered and left the observed area. In this section, these times are used to calculate the duration of stays for visitors at Mowich Lake.

Calculation of the duration of stays is complicated by the fact that some visitors were present

when observation started and others had not departed when observation ended.[3] Analysis can either exclude those visitors from calculations, or use the beginning and ending times of observation to estimate their minimum duration of stay. Either method underestimates the total duration of stays. We found that analyses which included the estimated durations were more accurate because they increase the average duration (i.e., we know that if two estimates are both low, then the higher of the two must be more accurate).

Visitors to Mowich Lake spent an average of 22.2 minutes in the observed area (SD = 23.7). The distribution of stay times (see the figure below) shows that most visitors spent less than 15 minutes along the lakeshore, and 90 percent of visitors spent less than an hour. These figures do not represent the total amounts of time that visitors spent in the larger vicinity of Mowich Lake. A visitor who hung out at the campground for some time and then walked down to the lakeshore to fill a water bottle would be recorded in our study only during the period when they were within approximately 10 meters of the lake.

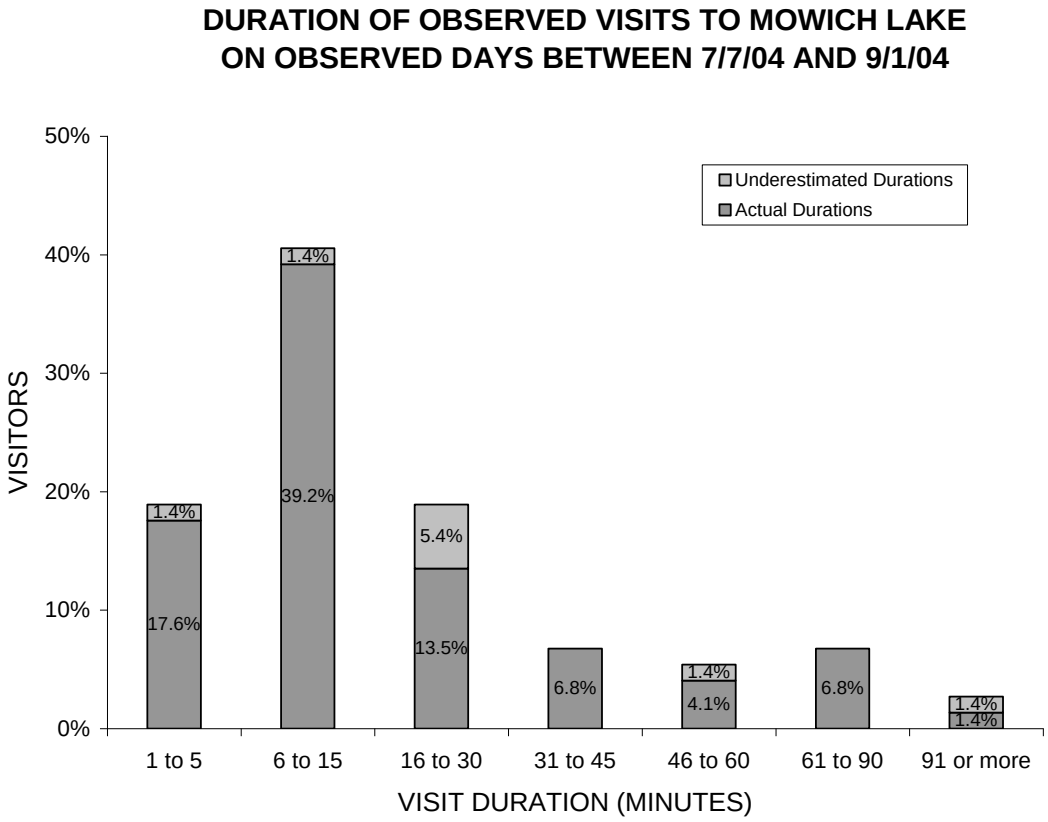


Figure 9. Duration of observed visits to Mowich Lake.

[3] The number of visitors who were present for the entire observation period (i.e., who were there both when the observer began and ended observation) was extremely small. Such stays are not included in the duration of stay analyses and results.

4.2.3 Total Visitation

The formula for estimating the daily total of visitors to Mowich Lake based on the snapshot counts and stay durations during the observed time period is as follows:

Visitors (6:30 to 7:00) = sum(half-hourly counts) / mean duration (in half-hours)

Using this formula and the data collected during the observation study, we estimate that between July 7 and September 1, the area in the immediate vicinity of Mowich Lake attracts an average of 88.6 visitors per day between 6:30 and 7:00.

It is important to note that the average visit duration reported above and used in this section is known to underestimate the average amount of time that visitors actually spent in the vicinity of Mowich Lake. When used in the equation above, such an underestimate leads to overestimation of the number of total visitors. The degree of overestimation is directly related to the degree of underestimation in the duration estimate. Although both such numbers are unknown at this time, the relatively small number of visit durations that were truncated (see the figure above) suggest that the bias is slight. It is safe to say that on average, no more than the estimated number of visitors enters the observed area between 6:30 and 7:00.

4.2.4 Limitations

A number of issues limit the precision of these estimates of use. Each of those issues is described briefly below.

Observed time periods. Observations were made at Mowich Lake between 6:30 and 19:00, a longer time period than was observed at Crystal Lake. Nonetheless, some visitors were present at times outside that period, leading to bias in the estimates of visit durations (see Section 4.2.2). The limited observation time may also bias estimates of the number of lake visitors if some visitors depart before the observer arrives or arrive after the observer departs. At Mowich Lake, the only visitors likely to do so are visitors who camp at the walk-in campground. Visits by most other visitors overlap with the observed time.

Observation days at Mowich Lake were distributed across weekdays and weekends at a 4 to 3 ratio that under-represented weekdays. Thus, the data are more representative of average weekends than average weekdays at Mowich Lake. It is likely that weekdays are less busy than weekends, and that these visitation figures are higher than the true "average" visitation. However, the number of observed days is not sufficient to provide good estimates of the difference in weekend and weekday visitation, and thus the aggregate data are presented above.

Observed areas of the lakes. The fact that all portions of the observed area were not visible to observers means that counts of visible visitors will underestimate the actual number of people present at the lake. At Mowich Lake, this issue is of greater importance than at the other lakes because the lake's size and the surrounding vegetation limited the observer's ability to see all visitors. On the other hand, observations were focused on the portion of the shore that was most heavily used by visitors, and much of the shoreline that was less visible was very difficult to access and very seldom visited. Some of the underestimation of the number of total visitors per day due to limited vision of the observed area is likely to be offset by the slight overestimation effect introduced by the duration estimate (see Section 4.2.3).

4.3 Visitor Counts at Mystic Lake

4.3.1 Snapshot Counts

Mystic Lake was primarily visited by a mix of backpackers and day-hikers. Most of the time, there were fewer than two persons at the lake. The figure below shows the average number of visitors observed at the lake at times during the observed period. There is a peak around noon that may arise from backpacking parties stopping to have lunch at the lake, and a second peak in mid-afternoon that is more likely to correspond with the arrival of day-hikers.

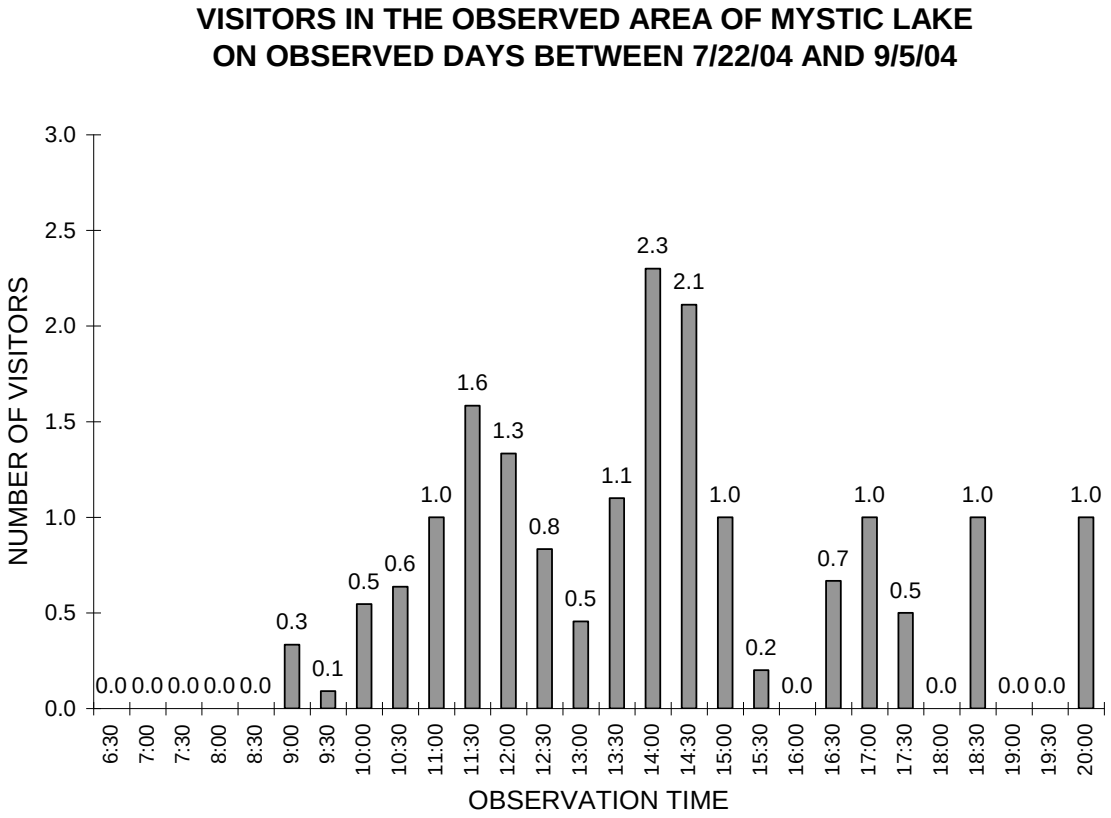


Figure 10. Visitors in the observed area of Mystic Lake.

The average count across all observed times was 0.82 visitors (SD = 2.1).

4.3.2 Duration of Stays

One of the simplest and most reliable types of information available from the tracking observations were the times at which observed visitors entered and left the observed area. In this section, these times are used to calculate the duration of stays for visitors at Mystic Lake.

Calculation of the duration of stays is complicated by the fact that some visitors were present when observation started and others had not departed when observation ended.[4] Analysis can either

[4] The number of visitors who were present for the entire observation period (i.e., who were there both when the observer began and ended observation) was extremely small. Such stays are not included in the duration of stay analyses and results.

exclude those visitors from calculations, or use the beginning and ending times of observation to estimate their minimum duration of stay. Either method underestimates the total duration of stays. We found that analyses which included the estimated durations were more accurate because they increase the average duration (i.e., we know that if two estimates are both low, then the higher of the two must be more accurate).

Visitors to Mystic Lake spent an average of 23.7 minutes in the observed area (SD = 28.6). The distribution of stay times (see the figure below) shows that most visitors spent less than 15 minutes in the observed area and that almost 90 percent of visitors spend less than one hour at the lake.

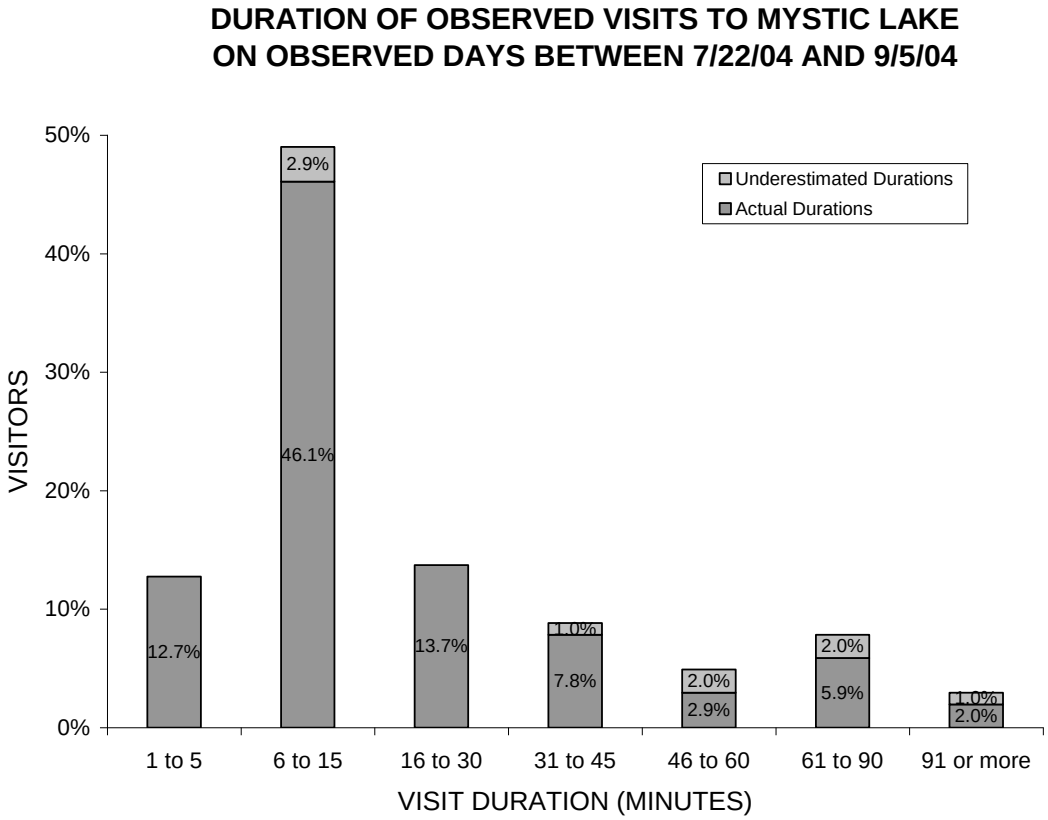


Figure 11. Duration of observed visits to Mystic Lake.

4.3.3 Total Visitation

The formula for estimating the daily total of visitors to Mystic Lake based on the snapshot counts and stay durations during the observed time period is as follows:

Visitors (6:30 to 20:00) = sum(half-hourly counts) / mean duration (in half-hours)

Using this formula and the data collected during the observation study, we estimate that between June 30 and September 5, the area in the immediate vicinity of Mystic Lake attracts an average of 22.4 visitors per day between 6:30 and 20:00.

It is important to note that the average visit duration reported above and used in this section

is known to underestimate the average amount of time that visitors actually spent in the vicinity of Mystic Lake. When used in the equation above, such an underestimate leads to overestimation of the number of total visitors. The degree of overestimation is directly related to the degree of underestimation in the duration estimate. Although both such numbers are unknown at this time, the relatively small number of visit durations that were truncated (see the figure above) suggest that the bias is slight. It is safe to say that on average, no more than the estimated number of visitors enters the observed area between 6:30 and 20:00.

4.3.4 Limitations

A number of issues limit the precision of these estimates of use. Each of those issues is described briefly below.

Observed time periods. Observations were made at Mystic Lake between 6:30 and 20:00, a longer time period than was observed at Crystal Lake. Nonetheless, some visitors were present at times outside that period, leading to bias in the estimates of visit durations (see Section 4.3.2). The limited observation time may also bias estimates of the number of lake visitors if some visitors depart before the observer arrives or arrive after the observer departs. At Mystic Lake, the only visitors likely to do so are backpackers who camped at the trailside camp near the lake. Visits by virtually all day-hikers overlap with the observed times.

Observation days at Mystic Lake were distributed across weekdays and weekends at a 9 to 4 ratio that differed only slightly from the appropriate ratio of 5 to 2. Accordingly, the data are likely to be representative of an "average" day at Mystic Lake. It is likely, however, that weekdays are less busy than weekends, and in actuality, there may be very few days that have "average" visitation. Nonetheless, the number of observed days is not sufficient to provide good estimates of the difference in weekend and weekday visitation, and thus the aggregate data are presented above.

Observed areas of the lakes. The fact that all portions of the lakeshore and surrounding area were not visible to observers means that counts of visible visitors will underestimate the actual number of people present at the lake. At Mystic Lake, this issue is of relatively low importance because the observation site provided a clear view of most of the lakeshore. Any small underestimation of the number of total visitors per day is likely to be offset by the slight overestimation effect introduced by the duration estimate (see Section 4.3.3).

4.4 Visitor Counts at Shadow Lake

4.4.1 Snapshot Counts

Shadow Lake was primarily visited by small groups of day-hikers, virtually all of whom reached the lake in the afternoon. Much of the time, there were fewer than two persons at the lake, but the average was approximately two persons from 14:00 to 15:30. The figure below shows the average number of visitors observed at the lake at times during the observed period. Note that the 16:00 bar is based on only one observation. It is possible that the number of visitors does not drop off as sharply after 15:30 as the last bar implies.

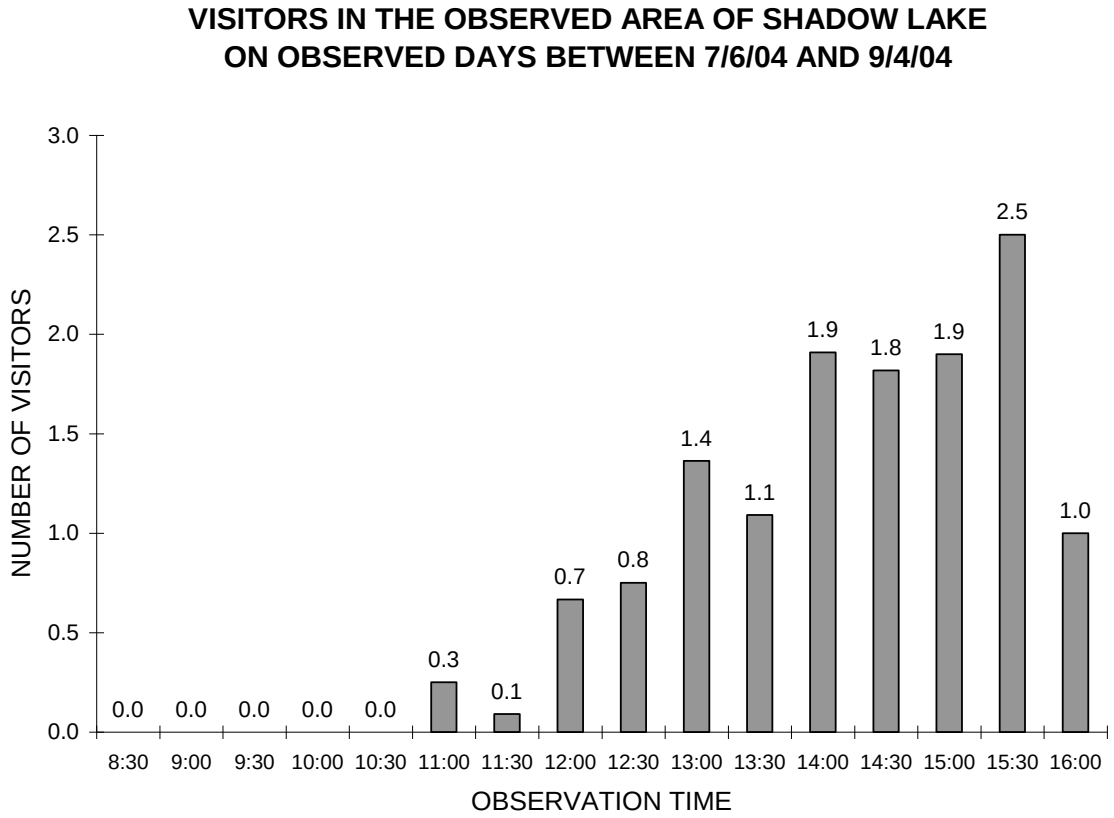


Figure 12. Visitors in the observed area of Shadow Lake.

The average count across all observed times was 0.87 visitors (SD = 1.9).

4.4.2 Duration of Stays

One of the simplest and most reliable types of information available from the tracking observations were the times at which observed visitors entered and left the observed area. In this section, these times are used to calculate the duration of stays for visitors at Shadow Lake.

Calculation of the duration of stays is complicated by the fact that some visitors were present when observation started and others had not departed when observation ended.[5] Analysis can either exclude those visitors from calculations, or use the beginning and ending times of observation to estimate their minimum duration of stay. Either method underestimates the total duration of stays. We found that analyses which included the estimated durations were more accurate because they increase the average duration (i.e., we know that if two estimates are both low, then the higher of the two must be more accurate).

Visitors to Shadow Lake spent an average of 12.3 minutes in the observed area (SD = 15.1). The distribution of stay times (see the figure below) shows that almost half the visitors spent less than 5 minutes in the observed area and that almost 90 percent of visitors spend less than thirty minutes at the lake.

[5] There were no visitors who were present for an entire observation period (i.e., who were there both when the observer began and ended observation).

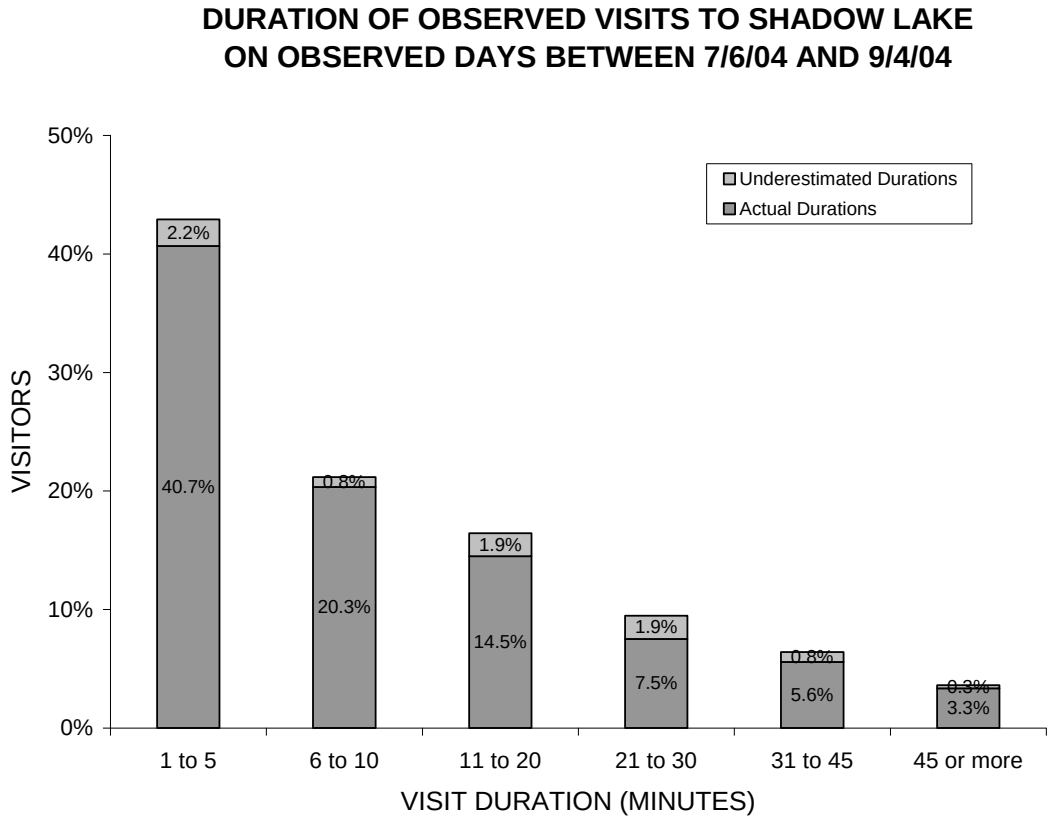


Figure 13. Duration of observed visits to Shadow Lake.

4.4.3 Total Visitation

The formula for estimating the daily total of visitors to Shadow Lake based on the snapshot counts and stay durations during the observed time period is as follows:

Visitors (8:30 to 4:00) = sum(half-hourly counts) / mean duration (in half-hours)

Using this formula and the data collected during the observation study, we estimate that between July 6 and September 4, the area in the immediate vicinity of Shadow Lake attracts an average of 32.5 visitors per day between 8:30 and 4:00.

It is important to note that the average visit duration reported above and used in this section is known to underestimate the average amount of time that visitors actually spent in the vicinity of Shadow Lake. When used in the equation above, such an underestimate leads to overestimation of the number of total visitors. The degree of overestimation is directly related to the degree of underestimation in the duration estimate. Although both such numbers are unknown at this time, the relatively small number of visit durations that were truncated (see the figure above) suggest that the bias is slight. It is safe to say that on average, no more than the estimated number of visitors enters

the observed area between 8:30 and 4:00.[6]

4.4.4 Limitations

A number of issues limit the precision of these estimates of use. Each of those issues is described briefly below.

Observed time periods. Observations were made at Shadow Lake between 8:30 and 4:00, but some visitors were present at times outside that period. This issue introduces bias into estimates of visit durations (see Section 4.4.2), leading to their underestimation. The limited observation time may also bias estimates of the number of lake visitors if some visitors depart before the observer arrives or arrive after the observer departs. At Shadow Lake, an unknown and possibly substantial number of visitors may visit the lake in the late afternoon and evening. Counts of visitors using the Shadow Lake trail (see Vande Kamp, 2008) suggest that between 25 and 30 percent of visitor use may occur after the observed time (and thus the number of visitors per day may but considerably more than the 32.5 visitors estimated to visit between 8:30 and 4:00).

Observation days at Shadow Lake were distributed across weekdays and weekends at a 4 to 2 ratio that slightly under-represented weekdays. Thus, the data are more representative of average weekends than average weekdays at Shadow Lake. It is likely that weekdays are less busy than weekends, and that these visitation figures are higher than the true "average" visitation. However, the number of observed days is not sufficient to provide good estimates of the difference in weekend and weekday visitation, and thus the aggregate data are presented above.

Observed areas of the lakes. The fact that all portions of the observed area were not visible to observers means that counts of visible visitors will underestimate the actual number of people present at the lake. At Shadow Lake, this issue is of relatively low importance because the observation site provided a clear view of most of the lakeshore and surrounding area. Any small underestimation of the number of total visitors per day is likely to be offset by the slight overestimation effect introduced by the duration estimate (see Section 4.4.3).

5. FUTURE ANALYSES

The information about visitor use at the four lakes observed in this study can be analyzed in ways that are much more sophisticated than the relatively simple descriptive analyses presented above. In this chapter, a few such analyses are discussed.

5.1 Further Analyses of Use Levels and Visit Characteristics

The analyses reported above describe visitor use on an "average" day during the observed time period at each lake. There are two important limitations to such estimates, each of which might be addressed by more sophisticated analyses. First, the estimates of visitor use presented above might be more useful if they represented use for the full day rather than being limited to the observed time period. Using information from electronic trail counters placed on the Crystal Lakes Trail, Mowich Lake and Spray Park Trails, and the Shadow Lake Trail (see Vande Kamp, 2008), such full-day estimates could be produced for at least three of the four observed lakes.

Second, although weekdays and weekends are likely to differ considerably, the estimates

[6] The number of visitors to Shadow Lake outside the observed time period could be estimated based on the hourly distributions of use recorded by electronic trail counters (see Vande Kamp, 2008). Such analyses might be conducted in the future if MORA managers see a need for more complete description of visitor use.

reported above represent an "average" day. The average day may be useful for estimating use across longer time periods (e.g., weeks, months, or the summer season), but may not represent the conditions that a visitor should expect on any specific day. Here again, information about levels of visitor use, whether from electronic trail counters or gate counts of vehicles entering specific areas of MORA, could be used to produce separate estimates for weekends and weekdays.

The reported analyses might also prove more useful if they were broken down for specific activities. For example, managers might wonder whether visitors who fish spend more time at lakes than visitors doing other activities, or similarly, they might wonder whether visitors who swim or wade in the lakes spend more time in the observed areas. Analyses describing the duration of visits by visitor activity could address those questions.[7]

5.2 Geographic Analyses

The second major form of future analysis would take advantage of the fact that visitors' geographic locations were recorded on the data sheet and entered into the digital database as GIS coordinates. At the most basic level, GIS analysis would produce maps showing the distribution of visitors in the observed areas at the four lakes in the study. Such maps might be overlaid with other maps showing existing impacts or sensitive resources to assess actual or potential relationships between visitor use and damage to park resources.

Further refinement of the GIS analysis might include mapping of visitors engaged in specific activities. For example, the shorelines most commonly used by anglers might be identified using the recorded GIS data. Similarly, the locations used by visitors who made longer visits to the observed areas might be compared and contrasted with areas used by visitors who made brief visits. For some resources (nesting birds, perhaps), the number of visitor hours in a specific area may be more predictive of resource damage than the number of different visitors.

5.3 Conclusion

VERP planning can benefit greatly from relatively simple summary statistics of the type presented in this report. By describing visitation in terms of the number of visitors and their distribution in time, these analyses provide a basis for judgments concerning relationships between visitor use and the quality of park resources and visitor experiences. More sophisticated analyses of the observation data could be conducted to inform managers about specific impacts that might be of particular concern.

In addition, these descriptive data might be combined with more general estimates of projected use to predict visitation at the observed lakes under various conditions. For example, the effect of a fishing ban might be compared to the effect of an across-the-board reduction in visitation. Although such predictions always rest on a number of assumptions, they can be very useful in helping managers implement policies that will best protect both visitor experiences and physical resources.

[7] The tracking data were intended to provide additional information about the specific amount of time visitors spent doing each activity (e.g., fishing, swimming/wading). However, such analyses are severely limited by the problems associated with recording those data and entering them into the digital database (see Section 3.2).

6. REFERENCE

Vande Kamp, M. E. (2008). *Visitor Use in the Management Zones of Mount Rainier National Park.* Draft Technical Report. Protected Area Social Research Unit, College of Forest Resources, University of Washington, Box 352100, Seattle, WA, 98195-2100. 65 pp.

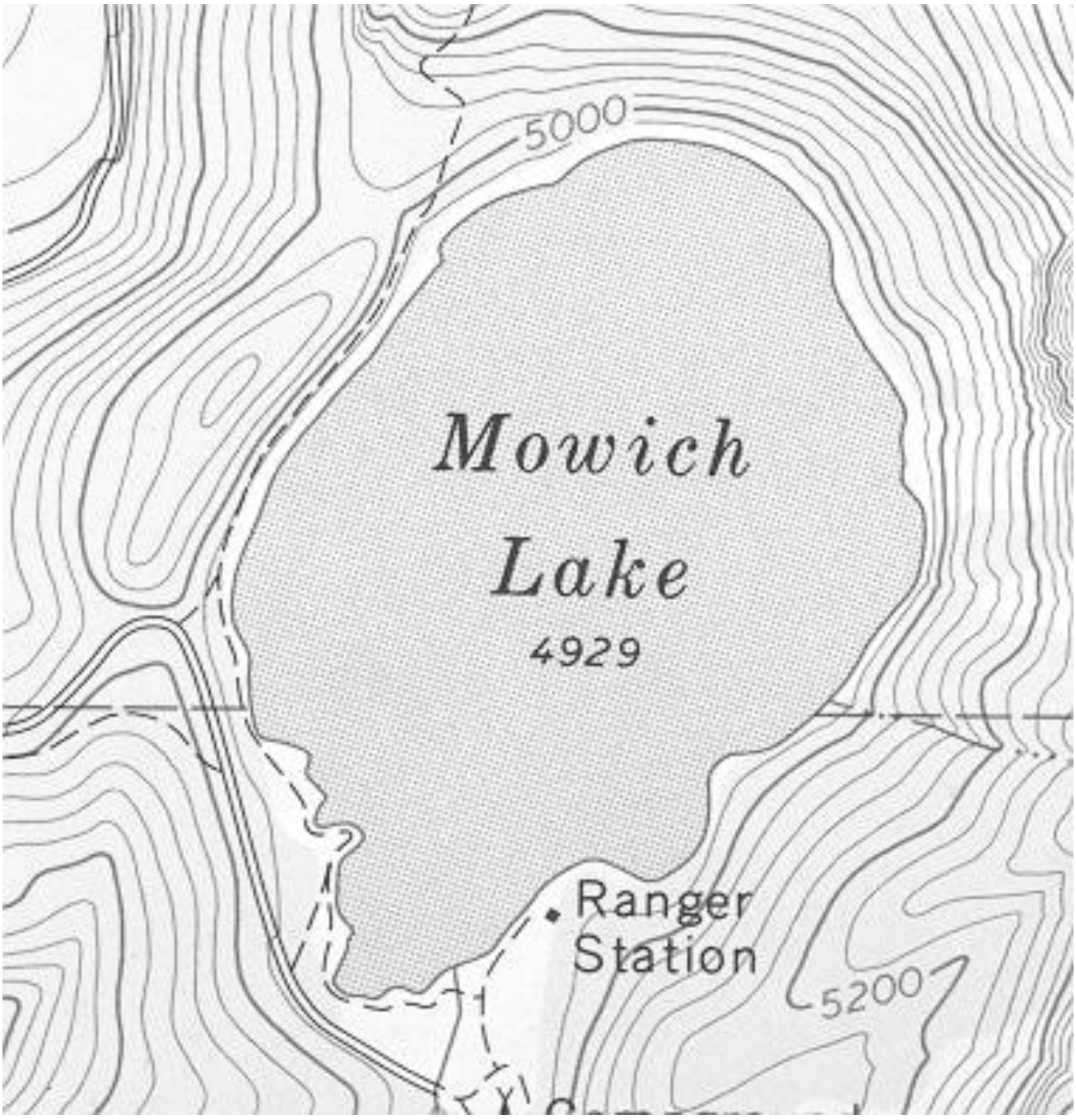
APPENDIX A: MAPS USED TO RECORD OBSERVATIONS

CRYSTAL
Observer _____Date _____Time _____Interval _____

F	**F**ishing	**P**	**P**icnicking
C	using a **C**amera to take pictures	**W**	getting **W**ater (for drinking or camp)
S	**S**wimming/Wading	**R**	At **R**est
L	**L**eaves the observation area	**T**	**T**alks to another person

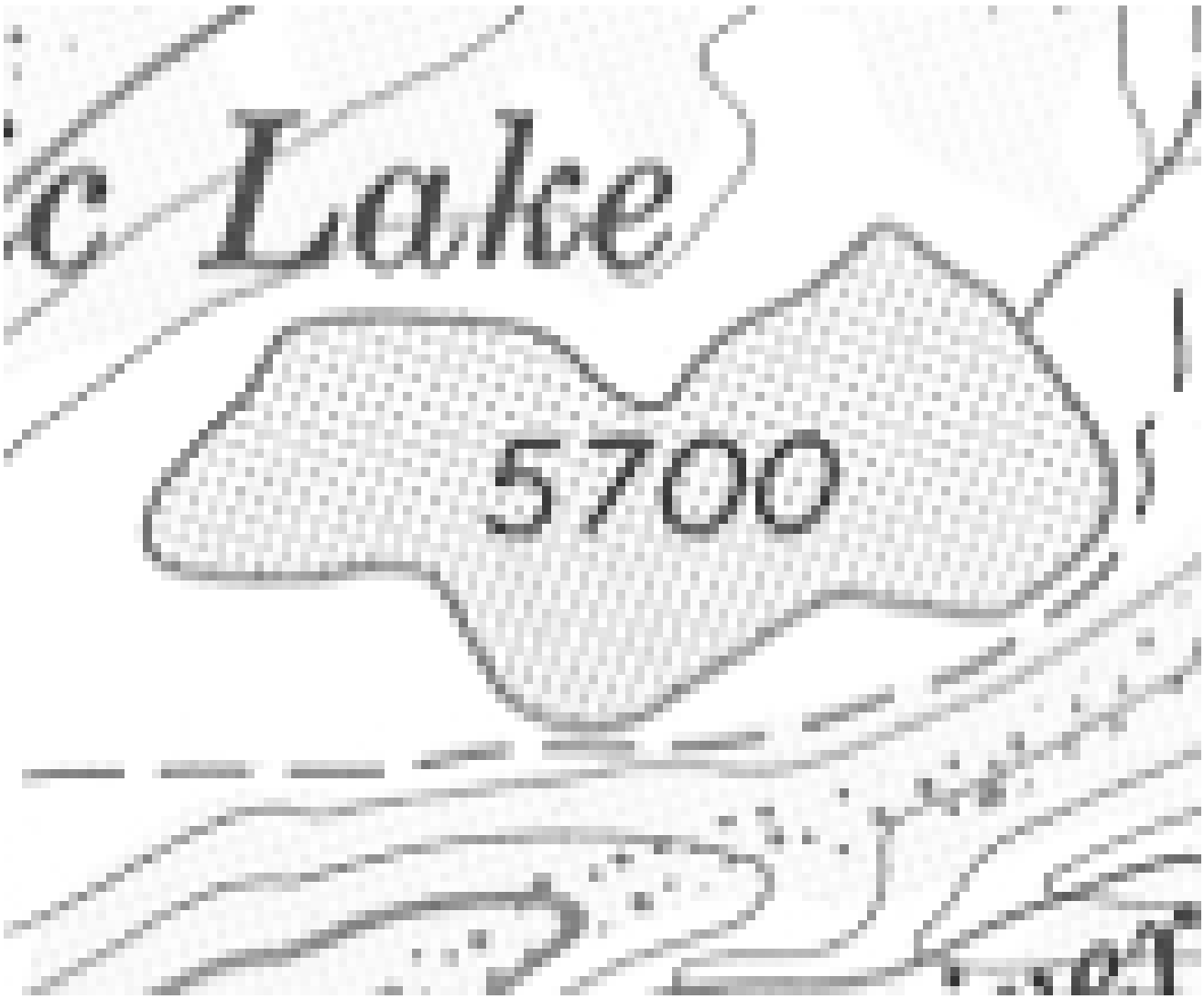
MOWICH
Observer _____Date _____Time _____Interval _____

F	**F**ishing	**P**	**P**icnicking
C	using a **C**amera to take pictures	**W**	getting **W**ater (for drinking or camp)
S	**S**wimming/Wading	**R**	At **R**est
L	**L**eaves the observation area	**T**	**T**alks to another person



MYSTIC
Observer _____Date _____Time _____Interval _____

F	**F**ishing	**P**	**P**icnicking
C	using a **C**amera to take pictures	**W**	getting **W**ater (for drinking or camp)
S	**S**wimming/Wading	**R**	At **R**est
L	**L**eaves the observation area	**T**	**T**alks to another person



SHADOW
Observer _____Date _____Time _____Interval _____

F	**F**ishing	**P**	**P**icnicking
C	using a **C**amera to take pictures	**W**	getting **W**ater (for drinking or camp)
S	**S**wimming/Wading	**R**	At **R**est
L	**L**eaves the observation area	**T**	**T**alks to another person

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interest of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.