# Twin Cities Life-Jacket Wear-Rate Observational Study, 2007


Minnesota Department of Natural Resources

July 2008

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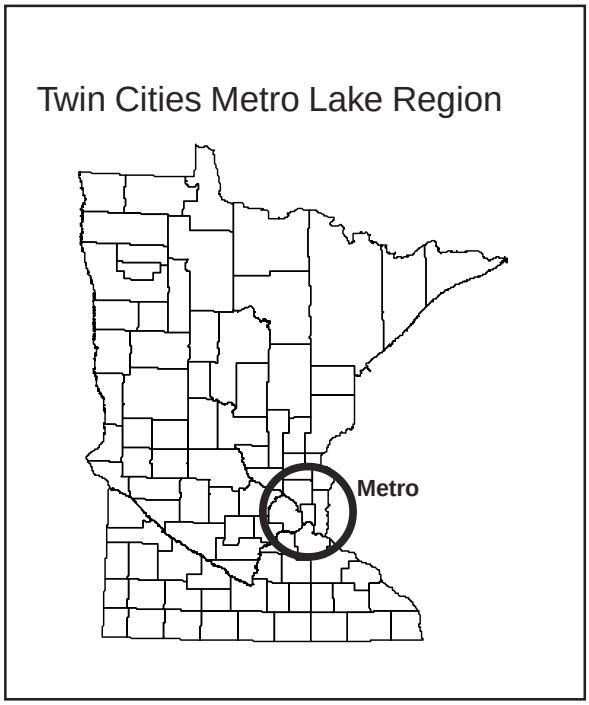


The 2007 Wear-Rate Study was a cooperative research project of the Minnesota Department of Natural Resources Boating Safety Program, and Office of Management and Budget Services

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July 2008

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*Cover photo by Tim Smalley*

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### Introduction

As outdoor recreators, Minnesotans are decidedly oriented to water. Minnesota is number one in the nation in recreational boats per capita and in fishing participation, most of which occurs from a boat. Remarkably, boating is second only to walking as the top outdoor recreation activity in the state.

With all the time Minnesotans spend boating, water safety is a major concern. A primary way to practice safe boating is to wear a life jacket (personal flotation device or PFD).

The 2007 Twin Cities PFD study was designed to answer some basic questions about PFD wear-rates. The first question concerned the frequency with which boaters wear PFDs and the factors that influence wear-rates. Two types of wear-rates were of interest: overall, which includes all boaters; and voluntary, which excludes boaters required by law to wear a PFD. Factors measured that might influence wear-rates included time and place items, ambient conditions (e.g., water temperature), boat-related variables, and boater characteristics.

The study was large. It included nearly 600 hours of field observations, during which 6,700 boats were observed with nearly 18,000 boaters on board. A question the study wanted to answer is: How small could the study have been to provide reasonable estimates of just the overall and voluntary wear-rates both in the Twin Cities and other regions of the state?

The boater observational methods for the study were modeled on the National PFD Wear-Rate Study conducted by JSI Research and Training Institute for the U.S. Coast Guard. The study was funded by the Minnesota Department of Natural Resources, Boating Safety Program. A private contractor was hired and trained by DNR staff to conduct the field work for the study.

### Results: Wear rates

For time and place factors, variation around the overall and voluntary wear rates (18% and 9%, respectively) are not large, and the percent of wear-rate variance accounted for by any of the factors is quite small. Some consistent patterns, however, are evident in the place (lake class) factor. The large water resources (Lake Minnetonka and St. Croix River) have lower wear rates and the more urban lakes (Cat 2) have higher wear rates. Mostly these patterns are due to the higher prevalence of larger boats (with lower associated wear rates) on the big waters and higher prevalence of smaller boats and less stable boats (canoes, kayaks—with higher associated wear rates) on the urban lakes.

Ambient condition factors (e.g., water temperature) have little consistent effect on wear rates, and the portion of wear-rate variance explained by any factor is very small.

The boat-related items have some noticeable effects on wear rates, and some account for a modest amount of the variation in wear rates. Wear rates are lowest for the large boats, whether measured

by length or type (e.g., cabin cruiser, houseboat or pontoon), and are higher for the less stable craft (canoes, kayaks, sail boats). Personal watercraft (PWC) riders, also known as jet skiers, are required by law to wear a PFD and 94 percent do.

Two of the boater-related items (age, and whether the person is being towed on skis, inner tube etc.) have a noticeable effect on wear rates, while gender does not. The effect of age is mainly due to the law that requires the young to wear a PFD.

From all of these wear-rate results, two factors (type of boat, and age of boater) are important in understanding overall wear-rate patterns. The same two factors are less important in understanding voluntary wear rates, indicating that their primary effects on overall wear rates is due to laws requiring the wearing of a PFD. The voluntary wear rate excludes the legal requirements, and the remaining effects of boat type and age are much reduced. The factors that have a sizable influence on voluntary wear rates are largely unknown through this study.

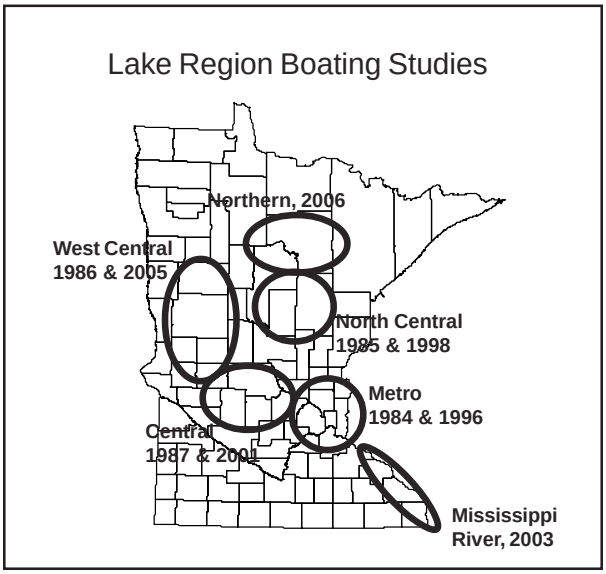
Results: Minimal study size to determine wear rates

The study was large. It included nearly 600 hours of field observations, during which 6,700 boats were observed with nearly 18,000 boaters on board. A question the study wanted to answer is: How small could the study have been to provide reasonable estimates of just the overall and voluntary wear-rates in the Twin Cities and other regions of the state?

The precision commonly designed for in DNR recreational studies is having the 95 percent confidence interval within +/- 15 percent of the target estimate. In this case we have two targets: the overall wear rate (17.9%) and the voluntary wear rate (9.1%). The +/- 15 percent precision is reached with as few as 1000 boater observations for the overall wear rate, but requires nearly 2000 observations for the voluntary wear rate. Since wear rates are not affected by day of week, the requisite sample of 2000 boaters can be gathered in fewer hours on weekend/holidays, when boating-use levels are higher.

It takes 30 to 46 weekend/holiday observation hours, depending on the month, to get 2000 voluntary boater observations. Thus, if some 45 hours is allocated to the study, the study could start in any month and get reasonable wear-rate estimates.

In other regions of Minnesota, it will take more hours to observe 2000 voluntary boaters, because boating use levels are smaller outside the Twin Cities metro region. Most of the regions are in the 130 to 150 hour range. The Northern Region, with its light boating levels, would take over 300 observational hours.



# INTRODUCTION

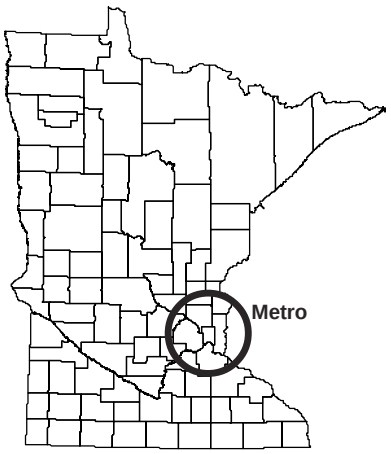
As outdoor recreators, Minnesotans are decidedly oriented to water. Minnesota is number one in the nation in recreational boats per capita and in fishing participation, most of which occurs from a boat (References 1 and 2). Remarkably, boating is second only to walking as the top outdoor recreation activity in the state (Reference 3).

With all the time Minnesotans spend boating, water safety is a major concern. A primary way to practice safe boating is to wear a life jacket (personal flotation device or PFD). Some boaters are required by law to wear a PFD (e.g., children under 10), but most are not. Each year serious accidents including fatalities could probably have been averted had the boater worn a PFD.

The 2007 Twin Cities PFD study was designed to answer some basic questions about PFD wear-rates (Figure 1). The first question concerned the frequency with which boaters wear PFDs and the factors that influence wear-rates. Two types of wear-rates were of interest: overall, which includes all boaters; and voluntary, which excludes boaters required by law to wear a PFD. Factors measured that might influence wear-rates included time and place items, ambient conditions (e.g., water temperature), boat-related variables, and boater characteristics.

Figure 1

Twin Cities Metro Lake Region




The study was large. It included nearly 600 hours of field observations, during which 6,700 boats were observed with nearly 18,000 boaters on board. A question the study wanted to answer is: How small could the study have been to provide reasonable estimates of just the overall and voluntary wear-rates? And, by extension, what is required size of similar studies in other boating regions of Minnesota to provide reasonable estimates of the two wear rates?

The study was funded by the Minnesota Department of Natural Resources, Boating Safety Program. A private contractor was hired and trained by DNR staff to conduct the field work for the study.

# METHODOLOGY

The boater observational methods for the study largely followed the National PFD Wear-Rate Study conducted by JSI Research and Training Institute for the U.S. Coast Guard (Reference 4). Adaptations of the methods were made for Minnesota boats and boating conditions. The one substantive change in the boater observation was adding a check box for "could not determine if the boater was wearing a PFD." In the JSI procedures, such cases are categorized as not wearing a PFD. Although this turned out to little practical effect on results, it seems to be a clearer way of handling such cases.

The specifics information of what is collected on boats and boaters is shown in the form below. The form covers one boat and all the boaters that can be observed on board:

**TIME:** **DATE:** **LAKE:** **(**

| **BOAT** | | | | **SAILBOAT** |
|---|---|---|---|---|
| utility/fishing | houseboat | inflatable/raft | kayak | sailboard |
| runabout/spdboat | pontoon | canoe | other | day sailor |
| cabin cruiser | PWC | | | cabin sailboat |
| **POWER TYPE** | | | **POWER TYPE** | |
| outboard | | paddles/oars | | sail only |
| inboard/stern-drive | | air fan | | sail & motor |
| **SIZE** | **MOVEMENT** | | **ACTIVITY** | |
| under 16 feet | cruising | drifting | fishing | swimming |
| 16-20 feet | sailing | anchored | skiing/tubing | cruising |
| over 20 feet | row/paddling | trolling | | other |
| **COMMENT** | | | | |

**OBSERVATION SITE:**

| **GENDER** | | | | **AGE(years)** | | | | | **PFD** | | | | | **WS** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **M** | **F** | **??** | **0 5** | **6 12** | **13 17** | **18 64** | **65 +** | **old** | **new** | **inf** | **??** | **no** | |
| **OP** | | | | | | | | | | | | | | **yes** |
| **P1** | | | | | | | | | | | | | | |
| **P2** | | | | | | | | | | | | | | |
| **P3** | | | | | | | | | | | | | | |
| **P4** | | | | | | | | | | | | | | |
| **P5** | | | | | | | | | | | | | | |
| **P6** | | | | | | | | | | | | | | |
| **P7** | | | | | | | | | | | | | | |
| **P8** | | | | | | | | | | | | | | |
| **P9** | | | | | | | | | | | | | | |

In addition to the boat form, each observational hour had ambient conditions recorded, which are shown on the site form:

**Site Information**

| | |
|---|---|
| Observer: | Lake/Water: |
| Observation Site: | Type of Site: |
| Date of Observation: | Day of Week: |
| Observation Start Time: | Observation End Time: |

**Site Conditions**

| Weather | Water Conditions | Visibility | Sky Conditions |
|---|---|---|---|
| Air Temp: _____°F | Calm | Good | Sunny |
| Water Temp: _____°F (at 1 ft depth) | Choppy | Fair | Partly Cloudy |
| Wind Speed: ____mph | White Caps | Poor | Cloudy |
| Comment: | | | Raining |

Observations were conducted according to a sampling plan (see Appendix A). To get a representative sample of Twin Cities boating, the observational study was run from mid May to mid September 2007. Sampling occurred at an even rate over these months, and was stratified by the following:

- Lake class (5 classes)
- Day of week (weekends/holidays and weekdays)
- Time of day (early, mid day, late day)

Five lake classes were used in the study, and these are the same lake classes used in the most recent (1996) regional boating study of the Twin Cities metropolitan area (Reference 5): two large boating resources, each forming its own class (Minnetonka and St. Croix River); other large boating lakes (Cat 1); medium-sized or small boating lakes located near the center of the metropolitan area (Cat 2); and medium-sized for smaller boating lakes located in the more rural parts of the metropolitan area (Cat 3). All the lakes in the study have a public access, and accesses were commonly used as observation sites.

Lake classes were sampled at nearly the same intensity, so results could be reported for each class with similar statistical confidence. Such a distribution of sampling effort, however, is not proportional to boating use. To remove the

effects of disportionate sampling effort when results for lake classes are combined, the boating use estimates from the 1996 boating study were used to weight the sample boat observations. Weighting was done by lake class and day of week.

For day of week, the sampling effort was evenly distributed between weekends/ holidays and weekdays, a distribution of effort in accordance with expected boating use.

For time of day, the mid-day time period (11:30 AM to 4:00 PM) was sampled more intensely in an effort to place more effort near the diurnal boating peaks.

Further details on the sampling plan can be found in Appendix A.

## RESULTS

### Number of observations

Over the course of study, nearly 600 hours of observations were conducted, with nearly 6700 boats and 18000 boaters observed (Table 1). Field staff could determine a high percentage of the time (98%) whether a PFD was or was not being worn. Most of the boaters observed (87%) were not required by law to wear a PFD. Those required by law to wear a life jacket are personal watercraft riders (jet skiers), and children under 10 years of age.

Table 1

Useable observation records for PFD wear-rate study

| Item | Value |
|---|---|
| Number of one-hour observation blocks | 584 |
| Number of boats observed | 6,699 |
| Number of people observed | 17,697 |
| Number of people could observe whether wearing a PFD (base for overall wear rate) | 17,406 |
| Number of people could observe whether wearing a PFD who are over 12 years old and not riding a PWC (base for voluntary wear rate) | 15,168 |

## Wear rates

Wear rates were summarized for time and place variables, ambient conditions, boat-related items and boater-related items. For each item, the results tables contain the percent of boaters in a category, the overall wear rates, and the voluntary wear rates. In addition, the magnitude of the effect of any factor (such as month) on wear rates is presented in a separate table, which has the percent of wear-rate variation accounted for the by factor.

For time and place factors, variation around the overall and voluntary wear rates (18% and 9%, respectively) are not large (Table 2), and the percent of wear-rate variance accounted for by any of the factors is quite small (Table 3). Some

### Table 2

PFD wear rates for time and place breakdowns

(percentage base is the number of people could observe whether wearing a PFD: Overall = 17,406, and Voluntary = 15,168)

| Breakdown | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| **Total** | 100% | 18% | 9% |
| **Month** | | | |
| May | 8% | 14% | 9% |
| June | 20% | 18% | 8% |
| July | 28% | 20% | 10% |
| August | 28% | 17% | 9% |
| September | 17% | 18% | 9% |
| **Day of week** | | | |
| Weekend/holiday | 52% | 18% | 9% |
| Weekday | 48% | 18% | 9% |
| **Time of Day** | | | |
| Early (7:00 to 11:30) | 25% | 16% | 9% |
| Mid day (11:30 to 16:00) | 43% | 19% | 10% |
| Late (16:00 to 20:00) | 32% | 18% | 9% |
| **Lake Class** | | | |
| Lake Minnetonka | 31% | 16% | 6% |
| St. Croix River | 19% | 15% | 7% |
| Cat 1 (other large lakes; all have public access) | 11% | 20% | 9% |
| Cat 2-PA (remaining boating lakes in the more urbanized part of the metro area; all have public access) | 12% | 23% | 19% |
| Cat 3-PA (remaining boating lakes in the more rural part of the metro area; all have public access) | 26% | 19% | 10% |

consistent patterns, however, are evident in the place (lake class) factor. The large water resources (Lake Minnetonka and St. Croix River) have lower wear rates and the more urban lakes (Cat 2) have higher wear rates. Mostly these patterns are due to the higher prevalence of larger boats (with lower associated wear rates) on the big waters and higher prevalence of smaller boats and less stable boats (canoes, kayaks—with higher associated wear rates) on the urban lakes.

## Table 3

Percent of wear-rate variance explained by individual items
(based on analysis of variance)

| Group | Item | Overall wear-rate variance (percent) | Voluntary wear-rate variance (percent) |
|---|---|---|---|
| **Time and place** | | | |
| | Month | 0.4% | 0.0% |
| | Day of week | 0.0% | 0.0% |
| | Time of Day | 0.2% | 0.1% |
| | Lake Class | 0.3% | 2.1% |
| **Ambient conditions** | | | |
| | Air temperature ($^{o}$F) | 0.3% | 0.1% |
| | Water temperature ($^{o}$F) | 0.0% | 0.0% |
| | Wind speed (mph) | 0.1% | 0.2% |
| | Water conditions | 0.0% | 0.1% |
| | Visibility | 0.0% | 0.1% |
| | Sky conditions | 0.0% | 0.0% |
| **Boat-related items** | | | |
| | Boat type | 20.9% | 6.1% |
| | Boat power type | 2.5% | 5.3% |
| | Boat movement | 2.8% | 6.6% |
| | Boat length | 4.0% | 1.0% |
| | Main activity observed on boat | 1.3% | 0.8% |
| **Boater-related items** | | | |
| | Gender of boater | 0.1% | 0.0% |
| | Age of boater | 22.0% | 2.4% |
| | Person observed is being towed? | 4.1% | 4.7% |
| **Boat-related item combinations** | | | |
| | Boat type with power type | 21.2% | 6.6% |
| | Boat type with movement | 20.9% | 6.1% |
| | Boat type with length | 20.9% | 7.4% |
| | Boat type with activity | 22.7% | 8.4% |
| **Selected combinations** | | | |
| | Boat type with age | 44.9% | 10.3% |
| | Boat type with age and being towed | 47.2% | 14.2% |
| | Boat type with age and being towed and activity | 47.2% | 14.2% |

Ambient condition factors have little consistent effect on wear rates (Table 4), and the portion of wear-rate variance explained by any factor is very small (Table 3).

## Table 4

PFD wear rates for ambient conditions at the time of boater observations
(percentage base is the number of people could observe whether wearing a PFD: Overall = 17,406, and Voluntary = 15,168)

**Air temperature ($^{o}$F)**

| Range | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| 70 or lower | 12% | 13% | 7% |
| 71 to 80 | 29% | 19% | 10% |
| 81 to 90 | 39% | 20% | 10% |
| 91 or higher | 20% | 16% | 7% |
| All boaters | 100% | 18% | 9% |

**Water temperature ($^{o}$F)**

| Range | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| 70 or lower | 18% | 19% | 10% |
| 71 to 80 | 62% | 18% | 9% |
| 81 to 90 | 20% | 16% | 7% |
| 91 or higher | (no data) | (no data) | (no data) |
| All boaters | 100% | 18% | 9% |

**Wind speed (mph)**

| Range | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Calm | 19% | 16% | 7% |
| 1 to 5 | 48% | 18% | 10% |
| 6 to 10 | 24% | 19% | 9% |
| Over 10 | 9% | 18% | 9% |
| All boaters | 100% | 18% | 9% |

**Water conditions**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Calm | 66% | 18% | 10% |
| Choppy | 28% | 17% | 9% |
| White caps | 6% | 18% | 6% |
| All boaters | 100% | 18% | 9% |

**Visibility**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Good | 83% | 18% | 9% |
| Fair or poor | 17% | 18% | 11% |
| All boaters | 100% | 18% | 9% |

**Sky conditions**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Sunny | 70% | 18% | 9% |
| Partly cloudy | 13% | 18% | 10% |
| Cloudy | 13% | 19% | 11% |
| Raining | 4% | 17% | 8% |
| All boaters | 100% | 18% | 9% |

The boat-related items have some noticeable effects on wear rates (Table 5), and some account for a modest amount of the variation in wear rates (Table 3). Wear rates are lowest for the large boats, whether measured by length or type (e.g., cabin cruiser, houseboat or pontoon), and are higher for the less stable craft (canoes, kayaks, sail boats). Personal watercraft (PWC) riders, also known as jet skiers, are required by law to wear a PFD and 94 percent do.

## Table 5

PFD wear rates for boat-related items

(percentage base is the number of people could observe whether wearing a PFD: Overall = 17,406, and Voluntary = 15,168)

**Boat type**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Utility/fishing | 29% | 14% | 10% |
| Runabout/speedboat | 39% | 15% | 7% |
| Cabin cruiser or houseboat | 10% | 7% | 3% |
| Pontoon | 11% | 6% | 3% |
| PWC | 4% | 94% | (excluded) |
| Canoe or kayak | 3% | 42% | 41% |
| Sail craft | 2% | 35% | 30% |
| Other | 1% | 37% | 32% |
| All boaters | 100% | 18% | 9% |

**Boat power type**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Outboard | 46% | 13% | 8% |
| Inboard/stern-drive | 48% | 20% | 6% |
| Paddles/oars | 4% | 41% | 40% |
| Sail only or sail and motor | 2% | 36% | 32% |
| Air fan | 0.02% | 60% | 0% |
| All boaters | 100% | 18% | 9% |

**Boat movement**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Cruising | 51% | 19% | 8% |
| Sailing | 1% | 32% | 28% |
| Row-paddling | 3% | 56% | 54% |
| Drifting | 32% | 14% | 6% |
| Anchored | 10% | 13% | 9% |
| Trolling | 2% | 11% | 5% |
| All boaters | 100% | 18% | 9% |

**Boat length**

| Range | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| under 16 feet | 22% | 33% | 15% |
| 16-20 feet | 63% | 15% | 9% |
| over 20 feet | 15% | 9% | 4% |
| All boaters | 100% | 18% | 9% |

**Main activity observed on boat**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Fishing | 20% | 14% | 10% |
| Skiing/tubing | 3% | 36% | 23% |
| Swimming | 2% | 13% | 8% |
| Cruising | 44% | 20% | 9% |
| Other (mostly "drifting") | 31% | 16% | 8% |
| All boaters | 100% | 18% | 9% |

The boat-related items are highly inter-correlated, as is shown in Table 3 for percent of wear-rate variance explained under the category "boat-related item combinations." Boat type alone accounts for 20.9 and 6.1 percent of overall and voluntary wear rates, respectively. When power type is combined with boat type, the percent of variation explained increases only a small amount. The small increase is due to the close association between specific boat types and specific power types. Similarly, combining boat movement, length or activity with boat type produces little if any increase in the percent of wear-rate variance explained.

Two of the boater-related items (age, and whether the person is being towed on skis, inner tube etc.) have a noticeable effect on wear rates, while gender does not (Table 6). The effect of age is mainly due to the law that requires the young to wear a PFD (Table 3).

## Table 6

PFD wear rates for boater-related items

(percentage base is the number of people could observe whether wearing a PFD: Overall = 17,406, and Voluntary = 15,168)

**Gender of boater**

| Class | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Male | 66% | 17% | 9% |
| Female | 34% | 19% | 9% |
| Unknown | 1% | 43% | 28% |
| All boaters | 100% | 18% | 9% |

**Person observed is being towed?**

| Being towed? | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| Yes | 1% | 100% | 100% |
| No | 99% | 17% | 9% |
| All boaters | 100% | 18% | 9% |

**Age of boater**

| Range | Overall percent of boaters | Overall wear rate percent | Voluntary wear rate percent |
|---|---|---|---|
| 0-5 years* | 1.6% | 93% | (excluded) |
| 6-12 years* | 6.7% | 69% | (excluded) |
| 13-17 years | 10% | 28% | 22% |
| 18-64 years | 78% | 11% | 8% |
| 65+ years | 4% | 8% | 7% |
| All boaters | 100% | 18% | 9% |
| ** 0-12 years* | *8.3%* | *73%* | *(excluded)* |

From all of these results, two factors (type of boat, and age of boater) are important in understanding overall wear-rate patterns (see last category in Table 3). The same two factors are less important in understanding voluntary wear rates, indicating that their primary effects on overall wear rates is due to laws requiring the wearing of a PFD. Adding an additional factor (boater being towed) increases the percent of variance explained for both overall and voluntary wear rates. The further addition of boating activity has no effect on wear-rate variance explained.

In summary, the overall wear rate is largely influenced by boat type and laws that require the wearing of a PFD. The voluntary wear rate excludes the legal requirements, and the remaining effects of boat type and age are much reduced. The factors that have a sizable influence on voluntary wear rates are largely unknown through this study.

## Minimal study size to determine wear rates

The study was large. It included nearly 600 hours of field observations, during which 6,700 boats were observed with nearly 18,000 boaters on board. A question the study wanted to answer is: How small could the study have been to provide reasonable estimates of just the overall and voluntary wear-rates? And, by extension, what is required size of similar studies in other boating regions of Minnesota to provide reasonable estimates of the two wear rates?

Guidance on minimal study size can begin by examining the confidence interval around the wear-rate percents as a function of the number of boater observations and specifying the precision of the estimates (Table 7). The precision commonly designed for in DNR recreational studies is having the 95 percent confidence interval within

Table 7

Confidence intervals for wear rates, based on the wear-rate percents found in the study: overall wear rate = 17.9%, and voluntary wear rate = 9.1%
(a "voluntary" boater is one not required by law to wear a PFD)

| | ------- *Number of observations* ------- | | |
|---|---|---|---|
| | 1000 | 1500 | 2000 |
| **95% confidence interval value** | | | |
| Overall wear rate | 2.4% | 1.9% | 1.7% |
| Voluntary wear rate | 1.8% | 1.5% | 1.3% |
| **95% confidence interval as percent of wear rate** | | | |
| Overall wear rate | 13.3% | 10.9% | 9.4% |
| Voluntary wear rate | 19.6% | 16.0% | 13.9% |

+/- 15 percent of the target estimate. In this case we have two targets: the overall wear rate (17.9%) and the voluntary wear rate (9.1%). The +/- 15 percent precision is reached with as few as 1000 boater observations for the overall wear rate, but requires nearly 2000 observations for the voluntary wear rate.

The preceding is a statistical formula that provides guidance, but how well does it hold up in practice? To answer this, the study observations were sampled. Since wear rates are not affected by day of week, only weekend/holiday observations were sampled, because there is substantially more boating on weekends/holidays and getting the requisite sample of 2000 boaters can be gathered in fewer hours.

Samplings were done starting each summer month and adding weekends until 2000 voluntary boaters were observed (Table 8). In June it took 4 weekends to reach 2000, in July 2 weekends, and in August 3 weekends. By the time 2000 voluntary boaters were observed, all the overall wear rates were within the precision target and two of three voluntary wear rates were within the target (last set of columns in table). The August voluntary wear rate was within the target after two weekends, but jumped outside by adding more observations from the third weekend. The data were examined for reasons why the third weekend

## Table 8

PFD wear-rate estimates for weekend/holiday time periods beginning each summer month and going until at least 2000 boaters were observed

(a "voluntary" boater is one not required by law to wear a PFD)

| Month to start evaluation | Number of weekends | Observation hours | -- *Number of boaters* -- Overall | -- *Number of boaters* -- Voluntary | -- *Estimated wear rates* -- Overall | -- *Estimated wear rates* -- Voluntary | --------- *Percent difference from full study wear rates* (absolute value)* --------- Overall | --------- *Percent difference from full study wear rates* (absolute value)* --------- Voluntary |
|---|---|---|---|---|---|---|---|---|
| June | 2 | 24 | 707 | 630 | 16.0% | 9.0% | 10.6% | 1.5% |
| | 3 | 39 | 1,732 | 1,474 | 20.3% | 9.3% | 13.9% | 2.4% |
| | 4 | 50 | 2,492 | 2,156 | 19.5% | 9.7% | 9.3% | 6.2% |
| July | 1 | 22 | 1,466 | 1,306 | 17.8% | 10.7% | 0.1% | 17.2% |
| | 2 | 38 | 2,898 | 2,493 | 20.4% | 9.4% | 13.9% | 3.2% |
| August | 1 | 18 | 537 | 493 | 15.9% | 9.7% | 11.0% | 6.1% |
| | 2 | 38 | 1,836 | 1,600 | 18.2% | 7.8% | 1.8% | 14.8% |
| | 3 | 49 | 2,568 | 2,251 | 16.3% | 7.2% | 8.8% | 20.7% |

* Full study wear rates are: overall = 17.9%, and voluntary = 9.1%

produced these results, but none was found. This outcome is unusual, but does happen in real world applications.

In summary, having 2000 voluntary boater observations should provide a reasonable estimate of boat wear rates. It takes 30 to 46 observation hours, depending on the month, to get 2000 voluntary boater observations (Table 9). Thus, if some 45 hours is allocated to the study, the study could start in any month and get reasonable wear-rate estimates.

Table 9

Weekend/holiday observation hours required to observe 2000 voluntary boaters

(a "voluntary" boater is one not required by law to wear a PFD)

| Month to start evaluation | Observation hours |
|---|---|
| June | 46 |
| July | 30 |
| August | 44 |

In other regions of Minnesota, it will take more hours to observe 2000 voluntary boaters, because boating use levels are smaller outside the Twin Cities metro region (Table 10—Reference 6). Use levels are some three to seven times smaller than the metro region, which translates in three to seven times more observation hours outside the metro region to observe 2000 voluntary boaters. Most of the regions are in the 130 to 150 hour range. The Northern Region, with its light boating levels, would take over 300 observational hours, which is over half the total hours devoted to this metro study.

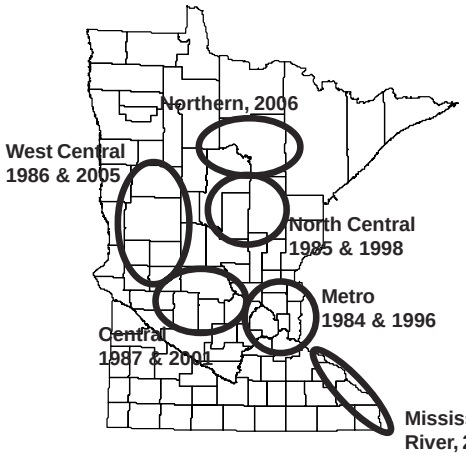
Table 10

Estimated weekend/holiday observation hours required to observe 2000 voluntary boaters by lake region

(a "voluntary" boater is one not required by law to wear a PFD)

| Lake region | Observation hours |
|---|---|
| ***Twin Cities Metro*** | ***45*** |
| Central | 145 |
| North Central | 154 |
| Mississippi River, Pools 4 to 9 | 130 |
| West Central | 140 |
| Northern | 329 |

Lake Region Boating Studies



## REFERENCES


1. U.S. Department of Homeland Security, U.S. Coast Guard, Office of Auxiliary and Boating Safety. 2008. Recreational Boating Statistics 2007. U.S. Department of Commerce, Census Bureau. 2007 state populations estimates.

2. U.S. Department Interior, Fish and Wildlife Service; and U.S. Department of Commerce, Census Bureau. 2007. 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.

3. Minnesota Department of Natural Resources, Office of Management and Budget Services. 2005. 2004 Outdoor Recreation Participation Survey of Minnesotans.

4. JSI Research and Training Institute. 2006 National PFD Wear-Rate Study Observation Guide. This wear-rate study was conducted for the U.S. Coast Guard.

5. Minnesota Department of Natural Resources, Office of Management and Budget Services. 1997. Boating in the Twin Cities Metropolitan Area: Current Status (1996) and Trends Since 1984.

6. Boating use comparisons between regions can be found in the most recent regional boating report: Minnesota Department of Natural Resources, Office of Management and Budget Services. 2007. Boating in Northern Minnesota, Summer 2006.

# APPENDIX A

## Sampling Plan for Twin Cities PFD Wear-Rate Observational Study

Background

To get a representative sample of Twin Cities boating, the observational study was run from mid May to mid September 2007. Sampling occurred at an even rate over these months, and was stratified by the following:

- Lake class (5 classes)
- Day of week (weekends/holidays and weekdays)
- Time of day (early, mid day, late day)

Five lake classes were used in the study, and these are the same lake classes used in the most recent (1996) regional boating study of the Twin Cities metropolitan area (Reference 5): two large boating resources, each forming its own class (Minnetonka and St. Croix River); other large boating lakes (Cat 1); medium-sized or small boating lakes located near the center of the metropolitan area (Cat 2); and medium-sized for smaller boating lakes located in the more rural parts of the metropolitan area (Cat 3). All the lakes in the study have a public access, and accesses were commonly used as observation sites.

Lake classes were sampled at nearly the same intensity, so results could be reported for each class with similar statistical confidence. Such a distribution of sampling effort, however, is not proportional to boating use. To remove the effects of disportionate sampling effort when results for lake classes are combined, the boating use estimates from the 1996 boating study were used to weight the sample boat observations. Weighting was done by lake class and day of week. The boating use estimates from the 1996 study are the following for both days of the week combined: Minnetonka—30%, St. Croix—18%, Cat 1—11%, Cat 2—15%, Cat 3—26%. Based on the 1996 boating study, half of each boating use estimate is expected on weekends/holidays and half is expected on weekdays.

For day of week, the sampling effort was evenly distributed between weekends/holidays and weekdays, a distribution of effort in accordance with expected boating use.

For time of day, the mid-day time period (11:30 AM to 4:00 PM) was sampled more intensely in an effort to place more effort near the diurnal boating peaks.

Steps in the creation of the sampling plan

1. Lakes are placed into clusters (see pages 22 and 23). Each cluster is a person-day of work; a cluster has 4 observation hours; one hour at each observations site. Observation sites are commonly public accesses, fishing piers and bank fishing areas.

2. The clusters are sampled at rates that spread sampling effort to each of the lake classes, so results can be reported for each class; when classes are combined, results will be use-weighted.

Cluster sampling rates

| | | ------- *Number of observation sites by lake class* ------- | | | | |
|---|---|---|---|---|---|---|
| Cluster | Percent of sampling effort | Minnetonka | St. Croix | Cat 1 | Cat 2 | Cat 3 |
| M | 19% | 4 | | | | |
| S | 19% | | 4 | | | |
| C1 | 4% | | | | | 4 |
| C2 | 8% | | | 1 | 2 | 1 |
| C3 | 12% | | | 2 | | 2 |
| C4 | 8% | | | | 4 | |
| C5 | 8% | | | | 4 | |
| C6 | 12% | | | 2 | | 2 |
| C7 | 12% | | | 2 | | 2 |
| Total percent | 100% | | | | | |

Allocation of sampling effort

| | ---------- *Distribution of observation hours* ---------- | | |
|---|---|---|---|
| Lake class | Ideal | Obtained on weekends/holidays | Obtained on Weekdays |
| Minnetonka | 20% | 18% | 19% |
| St. Croix | 20% | 18% | 19% |
| Cat 1 | 20% | 19% | 20% |
| Cat 2 | 20% | 19% | 16% |
| Cat 3 | 20% | 25% | 26% |
| Total percent | 100% | 100% | 100% |

3. There are two workday schedules, one for early hours and one for later hours; the start and stop times define the observational hour; the mid-day time period (11:30 AM to 4:00) is sampled more intensely in an effort to place more effort near the diurnal boating peaks:

| Time period | Start | Stop |
|---|---|---|
| early | 7:30 | 8:30 |
| early | 9:00 | 10:00 |
| early | 10:30 | 11:30 |
| early | 12:00 | 13:00 |
| late | 14:00 | 15:00 |
| late | 15:30 | 16:30 |
| late | 17:00 | 18:00 |
| late | 18:30 | 19:30 |

4. Follow the following procedures to generate the field sampling plan, which extends from May 19 to September 16, 2007 (see results on pages 24 to 27):

**Weekends/holidays**

| Step | Description |
|---|---|
| 1 | Select 2 weekend/holidays each week; if 3 weekend/holidays in a week, select two at random. |
| 2 | Assign two work periods to each selected day (two clusters are done each selected day) |
| 3 | Select early/late work-day schedule for each period without replacement; each period done independently |
| 4 | Assign clusters based on sampling rates for each cluster |
| 5 | If same cluster selected for both periods in one day, assign next cluster in random listing used in step 4 |

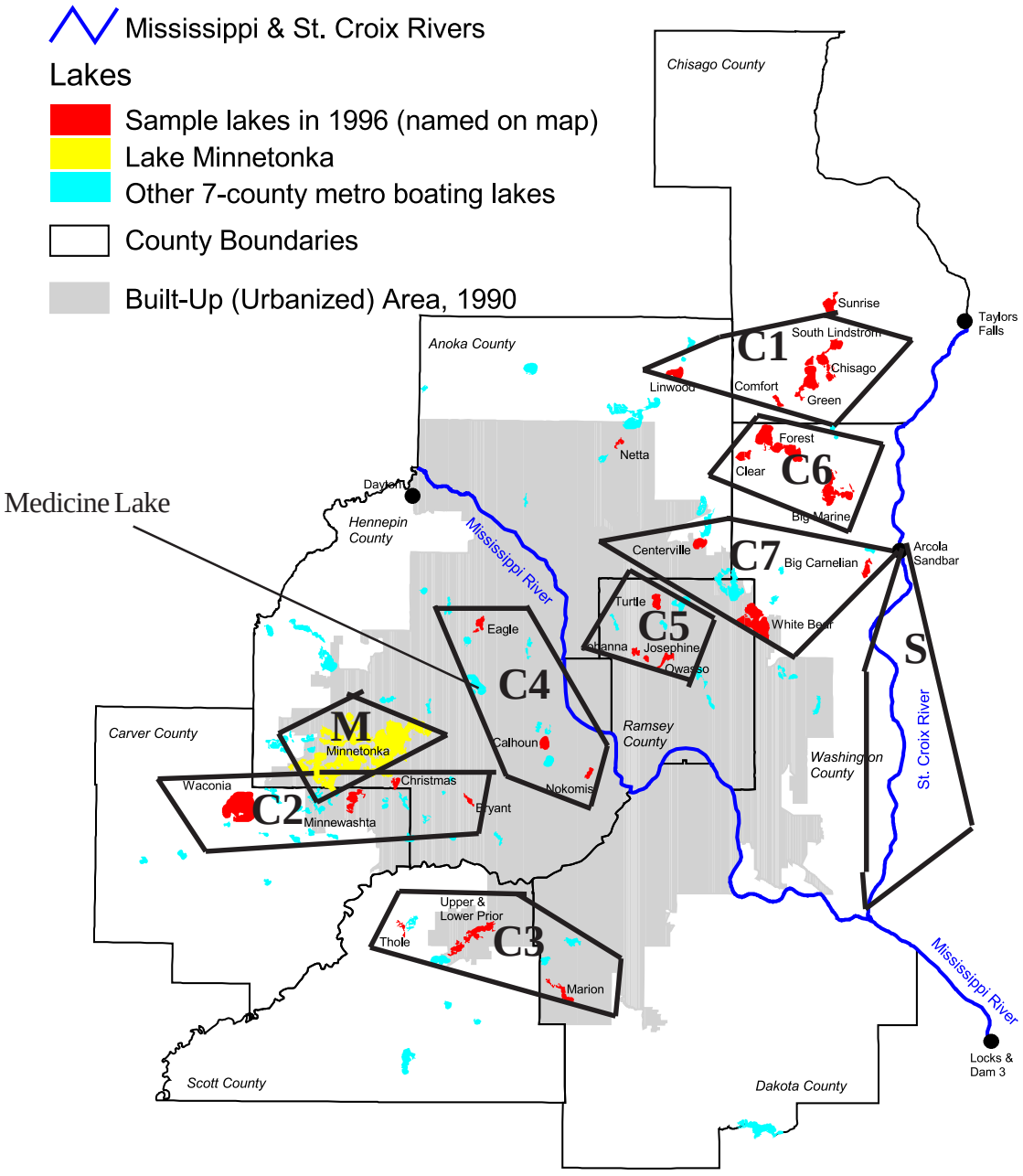
**Weekdays**

| Step | Description |
|---|---|
| 1 | Select 4 weekdays each week without replacement |
| 2 | Select early or late work-day schedule for each period without replacement |
| 3 | Assign clusters based on sampling rates for each cluster |

Lake clusters for PFD observational study (each cluster is a person-day of work, a cluster has 4 observation hours; one hour at each site)

| Lake Number | Name | Cluster | Lake Class | Lake Acres | Number of observation sites | Observation sites (codes from Twin Cities Water Recreation Guide) |
|---|---|---|---|---|---|---|
| 270133 | Minnetonka | M | Minnetonka | 14,034 | 4 | Causeway shorefish site between Grays and Wayzata Bay; 3 platform sites: H50, H51 and H53 |
| St. Croix River | St. Croix River | S | St. Croix River | 8,215 | 4 | W22-access, W25-bankfish, W27-access, W24-platform |
| 20026 | Linwood | C1 | Cat 3 | 567 | 1 | A15-platform |
| 130041 | Green | C1 | Cat 3 | 1,830 | 1 | Access on south side |
| 130053 | Comfort | C1 | Cat 3 | 220 | 1 | Access on north side |
| 130012 & 130028 | Chisago,S Lindstrom | C1 | Cat 3 | 1,594 | 1 | Pier at north end |
| 100009 | Minnewashta | C2 | Cat 1 | 763 | 1 | C16-pier |
| 100059 | Waconia | C2 | Cat 3 | 3,196 | 1 | C29-access |
| 270067 | Bryant | C2 | Cat 2 | 199 | 1 | H2-pier |
| 270137 | Christmas | C2 | Cat 2 | 274 | 1 | H8-access |
| 190026 | Marion | C3 | Cat 3 | 489 | 1 | D17-pier |
| 700120 | Thole | C3 | Cat 3 | 131 | 1 | S18-access |
| 700026 & 700072 | L & U Prior | C3 | Cat 1 | 1,146 | 2 | S13-pier, S14-access |
| 270104 | Medicine | C4 | Cat 2 | 924 | 1 | H33-pier |
| 270019 | Nokomis | C4 | Cat 2 | 199 | 1 | H63-pier |
| 270031 | Calhoun | C4 | Cat 2 | 416 | 1 | H5-pier |
| 270111 | Eagle | C4 | Cat 2 | 470 | 1 | H15-pier |
| 620056 | Owasso | C5 | Cat 2 | 360 | 1 | R21-access |
| 620057 | Josephine | C5 | Cat 2 | 110 | 1 | R10-access |
| 620061 | Turtle | C5 | Cat 2 | 444 | 1 | R29-access |
| 620078 | Johanna | C5 | Cat 2 | 211 | 1 | R9-pier |
| 820052 | Big Marine | C6 | Cat 1 | 1,577 | 2 | W4-access, W5-access |
| 820159 | Forest | C6 | Cat 3 | 2,206 | 1 | W12-access |
| 820163 | Clear | C6 | Cat 3 | 400 | 1 | W8-access |
| 20006 | Centerville | C7 | Cat 3 | 464 | 1 | A2-access |
| 820049 | Big Carnelian | C7 | Cat 3 | 444 | 1 | W3-access |
| 820167 | White Bear | C7 | Cat 1 | 2,410 | 2 | R32-access, R34-pier |

# Metro Boating Study Lakes & Rivers



**Weekends/holidays**

| Sequence | Week | Date | Period | Time of day | Cluster |
|---|---|---|---|---|---|
| 1 | 1 | 19-May-07 | 1 | early | C4 |
| 2 | 1 | 19-May-07 | 2 | early | C7 |
| 3 | 1 | 20-May-07 | 1 | late | M |
| 4 | 1 | 20-May-07 | 2 | late | C6 |
| 5 | 2 | 26-May-07 | 1 | early | S |
| 6 | 2 | 26-May-07 | 2 | late | C7 |
| 7 | 2 | 28-May-07 | 1 | late | C2 |
| 8 | 2 | 28-May-07 | 2 | early | C7 |
| 9 | 3 | 2-Jun-07 | 1 | late | C5 |
| 10 | 3 | 2-Jun-07 | 2 | late | C7 |
| 11 | 3 | 3-Jun-07 | 1 | early | M |
| 12 | 3 | 3-Jun-07 | 2 | early | C4 |
| 13 | 4 | 9-Jun-07 | 1 | early | S |
| 14 | 4 | 9-Jun-07 | 2 | early | M |
| 15 | 4 | 10-Jun-07 | 1 | late | S |
| 16 | 4 | 10-Jun-07 | 2 | late | C1 |
| 17 | 5 | 16-Jun-07 | 1 | early | M |
| 18 | 5 | 16-Jun-07 | 2 | early | C7 |
| 19 | 5 | 17-Jun-07 | 1 | late | S |
| 20 | 5 | 17-Jun-07 | 2 | late | M |
| 21 | 6 | 23-Jun-07 | 1 | early | C6 |
| 22 | 6 | 23-Jun-07 | 2 | late | C2 |
| 23 | 6 | 24-Jun-07 | 1 | late | S |
| 24 | 6 | 24-Jun-07 | 2 | early | C3 |
| 25 | 7 | 30-Jun-07 | 1 | late | C5 |
| 26 | 7 | 30-Jun-07 | 2 | early | S |
| 27 | 7 | 1-Jul-07 | 1 | early | C6 |
| 28 | 7 | 1-Jul-07 | 2 | late | C3 |
| 29 | 8 | 7-Jul-07 | 1 | early | C2 |
| 30 | 8 | 7-Jul-07 | 2 | late | C4 |
| 31 | 8 | 8-Jul-07 | 1 | late | M |
| 32 | 8 | 8-Jul-07 | 2 | early | C6 |
| 33 | 9 | 14-Jul-07 | 1 | late | C4 |
| 34 | 9 | 14-Jul-07 | 2 | late | S |
| 35 | 9 | 15-Jul-07 | 1 | early | S |
| 36 | 9 | 15-Jul-07 | 2 | early | C6 |

**Weekends/holidays**

| Sequence | Week | Date | Period | Time of day | Cluster |
|---|---|---|---|---|---|
| 37 | 10 | 21-Jul-07 | 1 | late | C4 |
| 38 | 10 | 21-Jul-07 | 2 | early | M |
| 39 | 10 | 22-Jul-07 | 1 | early | M |
| 40 | 10 | 22-Jul-07 | 2 | late | C3 |
| 41 | 11 | 28-Jul-07 | 1 | late | C1 |
| 42 | 11 | 28-Jul-07 | 2 | early | S |
| 43 | 11 | 29-Jul-07 | 1 | early | M |
| 44 | 11 | 29-Jul-07 | 2 | late | C3 |
| 45 | 12 | 4-Aug-07 | 1 | early | C7 |
| 46 | 12 | 4-Aug-07 | 2 | early | C5 |
| 47 | 12 | 5-Aug-07 | 1 | late | C4 |
| 48 | 12 | 5-Aug-07 | 2 | late | M |
| 49 | 13 | 11-Aug-07 | 1 | early | S |
| 50 | 13 | 11-Aug-07 | 2 | late | M |
| 51 | 13 | 12-Aug-07 | 1 | late | C5 |
| 52 | 13 | 12-Aug-07 | 2 | early | C3 |
| 53 | 14 | 18-Aug-07 | 1 | late | C3 |
| 54 | 14 | 18-Aug-07 | 2 | late | C5 |
| 55 | 14 | 19-Aug-07 | 1 | early | C7 |
| 56 | 14 | 19-Aug-07 | 2 | early | C4 |
| 57 | 15 | 25-Aug-07 | 1 | late | M |
| 58 | 15 | 25-Aug-07 | 2 | early | S |
| 59 | 15 | 26-Aug-07 | 1 | early | S |
| 60 | 15 | 26-Aug-07 | 2 | late | C3 |
| 61 | 16 | 1-Sep-07 | 1 | early | C6 |
| 62 | 16 | 1-Sep-07 | 2 | late | C7 |
| 63 | 16 | 2-Sep-07 | 1 | late | C3 |
| 64 | 16 | 2-Sep-07 | 2 | early | S |
| 65 | 17 | 8-Sep-07 | 1 | late | C7 |
| 66 | 17 | 8-Sep-07 | 2 | late | C1 |
| 67 | 17 | 9-Sep-07 | 1 | early | M |
| 68 | 17 | 9-Sep-07 | 2 | early | C1 |
| 69 | 18 | 15-Sep-07 | 1 | late | C7 |
| 70 | 18 | 15-Sep-07 | 2 | early | C2 |
| 71 | 18 | 16-Sep-07 | 1 | early | C3 |
| 72 | 18 | 16-Sep-07 | 2 | late | C7 |

**Weekdays**

| Sequence | Week | Date | Time of day | Cluster |
|---|---|---|---|---|
| 1 | 1 | 21-May-07 | early | M |
| 2 | 1 | 22-May-07 | late | C1 |
| 3 | 1 | 24-May-07 | early | S |
| 4 | 1 | 25-May-07 | late | C7 |
| 5 | 2 | 29-May-07 | late | C2 |
| 6 | 2 | 30-May-07 | early | C7 |
| 7 | 2 | 31-May-07 | early | M |
| 8 | 2 | 1-Jun-07 | late | C5 |
| 9 | 3 | 4-Jun-07 | late | C3 |
| 10 | 3 | 5-Jun-07 | early | C1 |
| 11 | 3 | 6-Jun-07 | early | C7 |
| 12 | 3 | 7-Jun-07 | late | C3 |
| 13 | 4 | 11-Jun-07 | early | C7 |
| 14 | 4 | 12-Jun-07 | late | S |
| 15 | 4 | 13-Jun-07 | early | C6 |
| 16 | 4 | 15-Jun-07 | late | C3 |
| 17 | 5 | 19-Jun-07 | late | M |
| 18 | 5 | 20-Jun-07 | early | S |
| 19 | 5 | 21-Jun-07 | early | C4 |
| 20 | 5 | 22-Jun-07 | late | S |
| 21 | 6 | 25-Jun-07 | late | C6 |
| 22 | 6 | 27-Jun-07 | early | M |
| 23 | 6 | 28-Jun-07 | early | C1 |
| 24 | 6 | 29-Jun-07 | late | M |
| 25 | 7 | 2-Jul-07 | late | C7 |
| 26 | 7 | 3-Jul-07 | early | C7 |
| 27 | 7 | 5-Jul-07 | late | C6 |
| 28 | 7 | 6-Jul-07 | early | C4 |
| 29 | 8 | 9-Jul-07 | early | M |
| 30 | 8 | 10-Jul-07 | late | S |
| 31 | 8 | 12-Jul-07 | early | M |
| 32 | 8 | 13-Jul-07 | late | M |
| 33 | 9 | 16-Jul-07 | early | S |
| 34 | 9 | 17-Jul-07 | late | M |
| 35 | 9 | 18-Jul-07 | early | C7 |
| 36 | 9 | 20-Jul-07 | late | C1 |

**Weekdays**

| Sequence | Week | Date | Time of day | Cluster |
|---|---|---|---|---|
| 37 | 10 | 23-Jul-07 | early | C7 |
| 38 | 10 | 24-Jul-07 | late | C4 |
| 39 | 10 | 25-Jul-07 | early | C7 |
| 40 | 10 | 26-Jul-07 | late | M |
| 41 | 11 | 30-Jul-07 | late | C6 |
| 42 | 11 | 1-Aug-07 | early | C7 |
| 43 | 11 | 2-Aug-07 | late | C4 |
| 44 | 11 | 3-Aug-07 | early | C2 |
| 45 | 12 | 7-Aug-07 | early | C5 |
| 46 | 12 | 8-Aug-07 | late | C3 |
| 47 | 12 | 9-Aug-07 | late | C3 |
| 48 | 12 | 10-Aug-07 | early | C3 |
| 49 | 13 | 13-Aug-07 | early | M |
| 50 | 13 | 14-Aug-07 | late | C3 |
| 51 | 13 | 15-Aug-07 | late | C7 |
| 52 | 13 | 17-Aug-07 | early | S |
| 53 | 14 | 21-Aug-07 | early | M |
| 54 | 14 | 22-Aug-07 | late | S |
| 55 | 14 | 23-Aug-07 | late | C5 |
| 56 | 14 | 24-Aug-07 | early | M |
| 57 | 15 | 27-Aug-07 | late | C3 |
| 58 | 15 | 29-Aug-07 | early | C2 |
| 59 | 15 | 30-Aug-07 | early | M |
| 60 | 15 | 31-Aug-07 | late | M |
| 61 | 16 | 4-Sep-07 | early | C5 |
| 62 | 16 | 5-Sep-07 | late | S |
| 63 | 16 | 6-Sep-07 | early | M |
| 64 | 16 | 7-Sep-07 | late | C6 |
| 65 | 17 | 11-Sep-07 | late | C4 |
| 66 | 17 | 12-Sep-07 | early | C6 |
| 67 | 17 | 13-Sep-07 | late | C2 |
| 68 | 17 | 14-Sep-07 | early | S |