

Characterization of Locomotive Engineer Schedules

Technical Memorandum

DOT/FRA/ORD-14/01

Judith Gertler

Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02451-1196

Prepared for:
Thomas Raslear
Michael Coplen

U. S. Department of Transportation
Office of Research and Development
Federal Railroad Administration
Washington, DC

March 2001

Forward (January 2014)

This document was originally written as a Technical Memorandum for internal use by FRA in 2001. A substantial amount of research has been undertaken in the dozen years since this memorandum was produced, including a series of diary studies that provides details about when signalmen, maintenance of way employees, locomotive engineers and conductors, and dispatchers work and sleep (for a summary see *Fatigue Status of the U.S. Railroad Industry* <http://www.fra.dot.gov/eLib/details/L04320>). By contrast, this memorandum examines 39 examples of nominal work schedules for locomotive engineers and conductors in passenger service, which may be of interest to researchers who are evaluating and analyzing work schedules and fatigue. In the interest of promoting further research, FRA makes this memorandum available to the public.

Preface

This report presents the data, methods, and results of a preliminary analysis of selected locomotive engineer schedules. The focus of the analysis was on characterizing the railroad employee work (and rest) schedules of subjects on whom data was collected. The work was performed under contract DTFR53-95-C-00049 for the Federal Railroad Administration (FRA). Mr. Michael Coplen of the Office of Research and Development, FRA, was the COTR. The author wishes to thank Mr. Coplen and Dr. Thomas Raslear, also from the Office of Research and Development, for guidance and advice in the conduct of this work. Ms. Susan McDonough, Foster-Miller, was responsible for manipulating the schedule data and preparing the tables and graphs in this report. Thanks are also due to Dr. Stephen Popkin, Volpe National Transportation Systems Center, who provided guidance to Foster-Miller in working with the schedule data, and to Dr. John Pollard, also a Volpe Center staff member, for working with Amtrak to obtain the schedule data.

Contents

1	Introduction.....	1
1.1	Background.....	1
1.2	Objectives	1
1.3	Fatigue and Shiftwork Terminology.....	2
2	Work Schedule Characteristics.....	3
2.1	Development of Engineer Schedules	3
2.2	Description.....	3
2.3	Shift Assignments.....	4
2.4	Work Periods	7
2.5	Work Patterns.....	7
2.6	Start Time Variability	16
	APPENDIX A: Amtrak Shift Data	A-1
	APPENDIX B: Raster Plots.....	B-1

Illustrations

Figure 1. Standardized Average Shift Length for SPK Division..... 12

Figure 2. Standardized Average Shift Length for SAS Division..... 13

Figure 3. Standardized Average Shift Length for CDL Division 13

Figure 4. Standardized Average Shift Length for JAX Division..... 14

Figure 5. Standardized Average Shift Length for CHAR Division 14

Figure 6. Standardized Average Shift Length for FLO Division..... 15

Figure 7. Standardized Average Shift Length for BUF Division 15

Figure 8. Distribution of Start Times for SPK Division 16

Figure 9. Distribution of Start Times for SAS Division 17

Figure 10. Distribution of Start Times for CDL Division 17

Figure 11. Distribution of Start Times for JAX Division 18

Figure 12. Distribution of Start Times for CHAR Division 18

Figure 13. Distribution of Start Times for FLO Division..... 19

Figure 14. Distribution of Start Times for BUF Division..... 19

Figure 15. Sample Raster Plot 20

Tables

Table 1. Typical core hours	4
Table 2. Work periods by day and summary statistics for all jobs and divisions.....	5
Table 3. Shift length, time off, and duty cycle characteristics for all jobs and divisions	8
Table 4. Average shift length by job standardized against division	11

1 Introduction

1.1 Background

The railroad industry is characterized by continuous operation, 24 hours a day, 7 days a week. This type of industry requires workers to perform their jobs at all hours of the day and night, many times on an irregular schedule. The Hours of Service Act, passed by Congress in 1906 and amended as recently as 1969, limits the maximum hours on duty for all railroad employees involved in the movement of trains.¹ The Act also prescribes a corresponding minimum rest period per 24-hour interval. However, these regulations do not account for the cumulative fatigue resulting from successive days of night work, an irregular schedule, or the timing of a rest period.

The underlying problem with night work, or any schedule that requires an individual to be awake when he or she would normally be sleeping, is that it requires the individual to override their circadian clock, which pre-programs humans for daytime activity and nighttime sleep. If a worker's schedule requires the night shift consistently, some adaptation may occur due to the adjusted work-rest pattern. However, this adjustment is difficult due to the biological cues of the night-day cycle and our predominantly daytime-oriented society. In addition, shift workers tend to revert to a normal day schedule on their non-work days, thus limiting their physiological adaptation to working nights.

Previous research has consistently shown that employees with irregular work schedules and/or night shifts report higher levels of fatigue and poorer sleep patterns than those working a regular day or evening shift. The night shift is especially problematic because, in addition to the circadian disruption stated above, the period between 0300 and 0500 is a low point for body temperature, performance, and alertness. During this time workers are more prone to distractions, lack of focus, poor memory, bad mood, and slow reaction times. Individuals performing safety critical jobs at this time must take precautions to counteract the feelings of sleepiness that are likely to occur and thus minimize the risk of an accident and personal injury.

In 1997, Amtrak began operating several of its overnight runs with one engineer rather than the traditional two-person crew in the locomotive cab. Following an accident in 2001 on a train with a one-person operation, the Federal Railroad Administration (FRA) suspended this practice pending an examination of the safety risks. This analysis was conducted to provide FRA with information for use in assessing the nominal work schedules of Amtrak locomotive engineers required to work between 1200 and 0600.

1.2 Objectives

The overall objective of this work was to generate data regarding the characteristics of Amtrak's 1200 to 0600 locomotive engineer runs. Below are the specific tasks involved in accomplishing the work:

1. Formalize a methodology for analysis of the schedules.
2. Aid in the collection of nominal work schedules for the 39 affected jobs across eight divisions.
3. Characterize the schedules in terms of weekly job starts, work patterns, and start time variability.

¹ Hours of Service law and regulation have subsequently been changed. See *Fatigue Status of the U.S. Railroad Industry* <http://www.fra.dot.gov/eLib/details/L04320>, section 1.1 for an update.

4. Organize the database to enable a more rigorous analysis planned by the government to develop fatigue indices.

1.3 Fatigue and Shiftwork Terminology

The analysis and discussion of the Amtrak engineer work schedules make use of specialized terminology for describing and analyzing fatigue and shiftwork issues. The following terminology is relevant to the present study:

Actual schedule – Actual hours worked, which may differ from the nominal schedule due to overtime, days off, or re-assignments.

Circadian rhythm – A self-sustained biological rhythm in which an organism's natural environment is normally synchronized to a 24-hour period.

Clockwise or forward shift rotation – A work schedule in which the shifts move forward, from day to evening to night.

Counterclockwise or backward shift rotation – A work schedule in which the shifts move backward from night to evening to day.

Double shift – Two consecutive shifts worked in one 24-hour period.

Duty cycle – Time between the start of consecutive work periods or shifts.

Fast rotation – A work schedule in which shift rotations occur from day to day.

Fixed shift – A work schedule in which the hours of work remain the same from day to day.

Irregular shift – A work schedule that is variable and erratic.

Job – The planned hours of work for each day of the week.

Nominal schedule – Scheduled on-duty and off-duty times. Since extraboard personnel do not work a regular assigned schedule, these individuals do not have nominal schedules.

Off time – The hours that an individual is not normally required to be on duty.

Rotating shift – Work in which the hours change regularly.

Shift – Time on a given day that an individual is scheduled to be on duty. One of the work periods that make up a job.

Shiftwork – Any non-standard schedule in which most of the work hours are outside the period 8 a.m. to 4 p.m.

Split shift – A schedule of full-time work in which a period of work is followed by a break and then another period of work.

Work cycle – The number of days in the repeating pattern of scheduled work periods.

2 Work Schedule Characteristics

The characterization of the Amtrak locomotive engineer schedules involved a variety of graphical and analytical methods. This section begins with a description of the process for developing these work schedules and then describes the raw work schedule data. An explanation of the various metrics used to characterize the schedules follows, along with the results.

2.1 Development of Engineer Schedules

Twice a year, in the spring and fall when Daylight Savings Time changes occur, Amtrak adjusts its train schedules to accommodate anticipated changes in ridership. These schedule requirements determine the times when engineers are needed to operate Amtrak's services. With the exception of the Northeast Corridor, most Amtrak corridors have only one or two trains a day so there are limited options for scheduling crews.

Development of individual jobs to cover the required service is more of an art than an exact science for Amtrak. Each Corridor Service Manager is responsible for defining the jobs for his or her corridor. The local union chairman may also be consulted. The train schedule, existing crew bases, and union agreements, as well as Hours of Service requirements, all constrain the Service Manager's options. In recent years, Amtrak has also attempted to incorporate ergonomic principles into this process.

Twice a year the Service Manager reviews the existing jobs and makes adjustments to them. Most likely, he or she will do this in consultation with the local union chairman. Then the jobs are posted for competitive bidding on a seniority basis.

2.2 Description

Amtrak provided data for review in the form of nominal schedules current as of June 28, 2000. The nominal schedule indicates the days and hours of each work or on-duty period. Actual hours worked by each job incumbent were not provided. The work cycle for each of these jobs is 1 week. This means that the job incumbent repeats the same series of work periods every week. Many locomotive engineers jobs have fixed shifts where the same hours are worked on each work day. The remaining jobs have irregular shifts.

All of the data was coded and entered into an Excel spreadsheet for analysis. The data for 39 different jobs from 7 divisions is presented in spreadsheet format in Appendix A. Each job and its associated work periods were entered as a separate row. Columns of the spreadsheet contain the following:

- Job ID as assigned by Amtrak.
- Day, start, and end time of each run or work period.
- Length of the work period.
- Time off between the end of the prior work period and the start of the current work period.
- Duty cycle, defined as time between the beginning of the prior work period and the start of the current work period.

2.4 Shift Assignments

Each work period was classified into one of three shifts based on when it occurred during the day. First, second, and third shifts are usually considered eight hours in length with at least seven consecutive hours within core shift hours. Core hours for different shifts are shown in Table 1.

Table 1. Typical Core hours

Shift	Core Hours	
1	0600	1600
2	1500	0100
3	2200	0700

The Amtrak locomotive engineer runs cannot be readily classified as typical shifts. The average run duration for the Amtrak engineers is less than 6 hours. Most of the runs do not have the required core hours for standard shift classification because their start and stop times span two of the above shift definitions. In these instances, the work period was assigned to the shift having the majority of the hours. In addition to the general core shift hours, if a job involved being on duty at 0400, the job was considered a third shift job. This hour is of particular concern because human alertness tends to be at a minimum at around 0400. The left-hand portion of Table 2 describes each job in terms of the various days and shifts that comprise the job. A “0” indicates that the job does not work for the day. This table provides a shorthand representation of each job and the work periods that make up each job.

Table 2. Work periods by day and summary statistics for all jobs and divisions

Division	Job	M	T	W	Th	F	Sa	Su	Number of Work Periods per week	Mean Work Periods	StdDev Work Periods	Consec Night Shifts	Number of Night Shifts	Multiple Daily Work Starts
SPK	ESPK-3	0	0	3,2	0	3,2	0	3,2	6				3	3
	ESPK-5	0	3,2	0	0	3,2	0	3,2	6				3	3
	ESPKR-1	0	3,2	0	3,2	0	0	3,2	6				3	3
	ESPK-2	0	3,2	0	3,2	0	3,2	0	6				3	3
	ESPK-4	3,2	0	0	3,2	0	3,2	0	6				3	3
	ESPK-6	3,2	0	3,2	0	0	3,2	0	6				3	3
	ESPK-1	3,2	0	3,2	0	3,2	0	0	6				3	3
(vacant)	XESPK51	3,2	0	3,2	0	3,2	0	0	6				3	3
										6	0			
SAS	EAN-5	0	0	0	1,1	2	0	1,2	5					2
	FAN-05	0	0	0	1,1	2	0	1,2	5					2
	EAN-7	0	1	2	0	1	3	0	4				1	
	FAN-7	0	1	2	0	1	3	0	4				1	
										4.5	0.58			
CDL	ECDL-2	0	3,2	0	3,2	2	2	0	6				2	2
	ECDL-7	0	3,2	2	2	0	0	3,2	6				2	2
	ECDL-4	2	0	0	3,2	0	3,2	2	6				2	2
	ECDL-5	2	2	0	0	3,2	0	3,2	6				2	2
	ECDL-1	3,2	0	3,2	2	2	0	0	6				2	2
	ECDL-6	3,2	2	2	0	0	3,2	0	6				2	2
										6	0.00			
JAXsouth	EJL-2	0	3,2	0	3,2	0	0	3,2	6				3	3
	ESPC-2	0	3,2	0	3,2	0	0	3,2	6				3	3
	EJMLR-2	1	1	0	1	0	3,2	0	5				1	1

Division	Job	M	T	W	Th	F	Sa	Su	Number of Work Periods per week	Mean Work Periods	StdDev Work Periods	Consec Night Shifts	Number of Night Shifts	Multiple Daily Work Starts
	EJL-1	3,2	0	3,2	0	3,2	0	0	6				3	3
	ESPC-1	3,2	0	3,2	0	3,2	0	0	6				3	3
										5.8	0.45			
CHAR	XFCW-52	0	0	0	0	0	0	3,2	2				1	1
	ECW-04	0	3,2	0	3,2	0	3,2	0	6				3	3
	XFCW-50	0	3,2	0	3,2	0	3,2	0	6				3	3
	ECWR-2	1	0	3,2	0	0	2	1	5				1	1
	ECW-06	3,2	0	0	1	0	3,2	0	5				2	2
	XFCW-51	3,2	0	3,2	0	3,2	0	0	6				3	3
										5	1.55			
FLO5	EFR-02	1	3	1	3	1	0	3	6				3	
(-RICHM)	E03-FL5	2	0	0	0	1	3	2	4				1	
	EFR-03	2	2	2	2	2	2	0	6					
	EFR-01	3	1	3	1	3	0	1	6				3	
										5.5	1.00			
BUF	EBS-44	0	0	3	3	3,1	1,2	1,2	8			1	3	3
	EBS-43	0	3	3	3,1	1,2	1,2	0	8			1	3	3
	EBS-46	1,2	1,2	0	0	3	3	1,1	8			1	2	3
	EBS-45	1,2	0	0	3	3	3,1	2,2	8			1	3	3
	EBS-41	3	3,1	1,2	1,2	0	0	3	8			1	3	3
	EBS-40	3,1	1,2	1,2	0	0	3	3	8			2	3	3
										8	0.00			
									All jobs		5.83	1.11		

2.5 Work Periods

One important characteristic of a job is the pattern of work periods over the course of the week. The right-hand portion of Table 2 provides summary statistics for each of the jobs and each division. This group of engineer jobs has between two and eight work periods per week. The average number of work periods or job starts per division ranges from 4.5 to 8 per week. All but 6 of the 39 jobs involve multiple job starts within 1 day (midnight to midnight). Fifteen jobs are comprised entirely of work days with multiple job starts. (Multiple job starts refers to days when the engineer has two distinct work periods separated by a break of several hours. This is not referred to as a split shift because the second work period does not necessarily involve a repeat of the work done in the first work period.) All but the San Antonio (SAS) jobs require fast backward rotation.

All but three of the jobs involve a night shift, as defined in section 2.3. Only the jobs in the Buffalo (BUF) division have night shifts occurring on consecutive days.

2.6 Work Patterns

Table 3 contains summary statistics with regard to work patterns for each job, each division, and the entire group of 39 jobs. The average shift length for the group of 39 jobs is 5 hours 59 minutes with a minimum of 3 hours 8 minutes and a maximum of 10 hours and 16 minutes. The range in shift length across divisions is an average of 4 hours 26 minutes for the BUF division and 7 hours 56 minutes for SAS.

Table 3. Shift length, time off, and duty cycle characteristics for all jobs and divisions

Division	Job	Work Shift			Time Off					Duty Cycle					
		Avg	Min	Max	Average		Min	Maximum		Average		Minimum		Maximum	
					Days	Hrs:Min		Days	Hrs:Min	Days	Hrs:Min	Days	Hrs:Min	Days	Hrs:Min
SPK	ESPK-5	4:10	3:56	4:25		23:49	14:42	2	0:57	1	4:00		19:07	2	4:53
SPK	ESPK-6	4:10	3:56	4:25		23:49	14:42	2	0:57	1	4:00		19:07	2	4:53
SPK	ESPK-1	6:09	5:24	6:55		21:50	13:21	1	22:20	1	4:00		20:16	2	3:44
SPK	ESPK-2	6:09	5:24	6:55		21:50	13:21	1	22:20	1	4:00		20:16	2	3:44
SPK	ESPK-3	4:37	4:25	4:50		23:22	14:17	2	0:28	1	4:00		18:42	2	5:18
SPK	ESPK-4	4:37	4:25	4:50		23:22	14:17	2	0:28	1	4:00		18:42	2	5:18
SPK	ESPKR-1	4:59	3:56	6:55		23:00	13:21	1	23:57	1	4:00		18:42	2	3:53
SPK	XESPK51	6:14	5:17	7:11		21:46	13:02	1	22:30	1	4:00		20:13	2	3:47
SPK		5:08	3:56	7:11		22:51	13:02	2	0:57	1	4:00		18:42	2	5:18
SAS	EAN-7	8:48	8:18	9:05	1	9:11	23:30	1	23:44	2	6:00	1	8:17	2	16:56
SAS	FAN-7	8:48	8:18	9:05	1	9:11	23:30	1	23:44	2	6:00	1	8:17	2	16:56
SAS	EAN-5	7:05	5:55	10:16	1	10:54	10:35	3	1:15	2	0:00		16:50	3	7:10
SAS	FAN-05	7:05	5:55	10:16	1	10:54	10:35	3	1:15	2	0:00		16:50	3	7:10
SAS		7:56	5:55	10:16	1	10:03	10:35	3	1:15	2	3:00		16:50	3	7:10
CDL	ECDL-1	6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
CDL	ECDL-2	6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
CDL	ECDL-4	6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
CDL	ECDL-5	6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
CDL	ECDL-7	6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
CDL	ECDL6	6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
CDL		6:23	5:15	8:00		21:36	9:35	2	2:45	1	4:00		16:04	2	10:45
JAX	EJL-1	6:13	6:01	6:26		21:46	13:09	1	22:24	1	4:00		19:35	2	4:25
JAX	EJL-2	6:13	6:01	6:26		21:46	13:09	1	22:24	1	4:00		19:35	2	4:25
JAX	ESPC-1	6:13	6:01	6:26		21:46	13:09	1	22:24	1	4:00		19:35	2	4:25
JAX	ESPC-2	6:13	6:01	6:26		21:46	13:09	1	22:24	1	4:00		19:35	2	4:25
JAX	EJMLR-2	7:56	6:01	9:44		23:34	13:09	1	18:46	1	14:24		19:33	3	4:20
JAX		6:34	6:01	9:44		22:08	13:09	1	22:24	1	6:04		19:33	3	4:20
CHAR	ECW-04	6:27	6:18	6:37		21:32	14:16	1	20:49	1	4:00		20:34	2	3:26
CHAR	ECW-06	6:46	6:18	8:00	1	2:49	9:10	2	1:43	1	9:36		15:40	2	8:20
CHAR	ECWR-2	6:06	4:43	8:00	1	3:29	8:42	2	12:58	1	9:36		13:35	2	19:35
CHAR	XFCW-50	6:27	6:18	6:37		21:32	14:16	1	20:49	1	4:00		20:34	2	3:26
CHAR	XFCW-51	6:27	6:18	6:37		21:32	14:16	1	20:49	1	4:00		20:34	2	3:26
CHAR	XFCW-52	6:27	6:18	6:37	3	5:32	14:16	5	20:49	3	12:00		20:34	6	3:26

Division	Job	Work Shift			Average		Time Off		Maximum		Duty Cycle					
		Avg	Min	Max	Days	Hrs:Min	Min	Days	Hrs:Min	Average	Minimum		Maximum			
										Days	Hrs:Min	Days	Hrs:Min	Days	Hrs:Min	
CHAR		6:27	4:43	8:00	1	8:44	8:42	5	20:49	1	15:12		13:35	6	3:26	
FLO	E03-FL5	5:57	5:51	6:07	1	12:02	10:34	3	11:49	2	0:00		16:25	3	17:41	
FLO	EFR-01	5:59	5:51	6:07		22:01	10:34	2	1:28	1	16:00		16:25	3	7:35	
FLO	EFR-02	5:59	5:51	6:07		22:01	10:34	2	1:28	1	16:00		16:25	3	7:35	
FLO	EFR-03	5:56	5:52	6:01		22:03	11:01	2	1:06	1	16:00		17:02	3	6:58	
FLO		5:58	5:51	6:07	1	1:31	10:34	3	11:49	1	18:00		16:25	3	17:41	
BUF	EBS-40	4:24	3:08	6:37		16:35	4:45	1	23:20	1	3:00		8:40	2	2:28	
BUF	EBS-41	4:41	3:08	6:37		16:18	2:50		20:54	1	3:00		8:40	2	2:08	
BUF	EBS-44	4:24	3:08	6:37		16:35	4:45	1	23:20	1	3:00		8:40	2	2:28	
BUF	EBS-45	4:23	3:08	6:37		16:36	1:20	1	23:20	1	6:00		5:10	2	2:28	
BUF	EBS-46	4:24	3:08	6:37		16:35	0:50	1	23:20	1	3:00		4:45	2	5:04	
BUF	EBS-43	4:24	3:08	6:37		19:35	5:39	1	23:20	1	10:17		12:15	2	3:55	
BUF		4:26	3:08	6:37		17:03	0:50	1	23:20	1	4:42		4:45	2	5:04	
All Jobs		5:59	3:08	10:16	1	0:37	0:50	5	20:49	1	9:53		4:45	6	3:26	

Summary statistics for time off and duty cycle are also presented in Table 3. For this group of jobs the average length of the off-duty period (time between the end of one shift and the start of the next) over the 1-week work cycle is 1 day. However, the time off for these schedules ranges from 50 minutes to 5 days 20 hours. If Job XFCW-52, which consists of only two work periods on Sunday, is not considered, then the maximum off-duty period is 3.5 days. The jobs in the BUF division have the shortest average off-duty periods and average 17 hours. Nearly all of the jobs provide 2 consecutive days off (see Table 2).

With regard to duty cycle (time between consecutive shift starts), the average is 1 day 10 hours. Excluding Job XFCW-52, the range in off-duty time is from 4 hours 45 minutes to 3 days 17 hours. The SAS division has the longest duty cycle with an average of 2 days 3 hours. All of the other divisions have significantly shorter average duty cycles.

To facilitate comparison of jobs within a division, the average shift length for each job was converted to a standardized score (Z-score). The Z-score for the i th job is computed from the following:

$$Z_i = \frac{(x_i - \bar{X})}{\sqrt{\sum_{i=1}^N (x_i - \bar{X})^2 / N}}$$

where

\bar{X} = arithmetic average of shift length for a group of N jobs

x_i = average shift length for the i th job

This transformation produces a distribution of values with an average of zero, where zero represents the mean shift length for the division. The values between +1.0 and -1.0 indicate an average shift length that is within one standard deviation for that division. Table 4 contains the values for shift length by job standardized against division.

Table 4. Average shift length by job standardized against division

Division	Job	Avg	Min	Max	Std Dev	Z-score
SPK	ESPK-5	4:10	3:56	4:25	0:15	-2.54
SPK	ESPK-6	4:10	3:56	4:25	0:15	-2.54
SPK	ESPK-1	6:09	5:24	6:55	0:49	2.66
SPK	ESPK-2	6:09	5:24	6:55	0:49	2.66
SPK	ESPK-3	4:37	4:25	4:50	0:13	-1.36
SPK	ESPK-4	4:37	4:25	4:50	0:13	-1.36
SPK	ESPKR-1	4:59	3:56	6:55	1:03	-0.41
SPK	XESPK51	6:14	5:17	7:11	1:02	2.86
SPK		5:08	3:56	7:11	0:22	
SAS	EAN-7	8:48	8:18	9:05	0:21	0.84
SAS	FAN-7	8:48	8:18	9:05	0:21	0.84
SAS	EAN-5	7:05	5:55	10:16	2:07	-0.84
SAS	FAN-05	7:05	5:55	10:16	2:07	-0.84
SAS		7:56	5:55	10:16	1:01	
CDL	ECDL-1	6:23	5:15	8:00	0:57	0.00
CDL	ECDL-2	6:23	5:15	8:00	0:57	0.00
CDL	ECDL-4	6:23	5:15	8:00	0:57	0.00
CDL	ECDL-5	6:23	5:15	8:00	0:57	0.00
CDL	ECDL-7	6:23	5:15	8:00	0:57	0.00
CDL	ECDL6	6:23	5:15	8:00	0:57	0.00
CDL		6:23	5:15	8:00	0:00	
JAX	EJL-1	6:13	6:01	6:26	0:13	-0.51
JAX	EJL-2	6:13	6:01	6:26	0:13	-0.51
JAX	ESPC-1	6:13	6:01	6:26	0:13	-0.51
JAX	ESPC-2	6:13	6:01	6:26	0:13	-0.51
JAX	EJMLR-2	7:56	6:01	9:44	1:43	2.05
JAX		6:34	6:01	9:44	0:40	
CHAR	ECW-04	6:27	6:18	6:37	0:10	0.01
CHAR	ECW-06	6:46	6:18	8:00	0:41	0.68
CHAR	ECWR-2	6:06	4:43	8:00	1:21	-0.73
CHAR	XFCW-50	6:27	6:18	6:37	0:10	0.01
CHAR	XFCW-51	6:27	6:18	6:37	0:10	0.01
CHAR	XFCW-52	6:27	6:18	6:37	0:13	0.01
CHAR		6:27	4:43	8:00	0:28	
FLO	E03-FL5	5:57	5:51	6:07	0:07	-0.17
FLO	EFR-01	5:59	5:51	6:07	0:08	0.52
FLO	EFR-02	5:59	5:51	6:07	0:08	0.52
FLO	EFR-03	5:56	5:52	6:01	0:04	-0.86
FLO		5:58	5:51	6:07	0:01	
BUF	EBS-40	4:24	3:08	6:37	1:00	-1.00
BUF	EBS-41	4:41	3:08	6:37	1:06	5.27
BUF	EBS-44	4:24	3:08	6:37	1:00	-1.00
BUF	EBS-45	4:23	3:08	6:37	1:00	-1.23
BUF	EBS-46	4:24	3:08	6:37	1:00	-1.00
BUF	EBS-43	4:24	3:08	6:37	1:05	-1.04
BUF		4:26	3:08	6:37	0:02	
Amtrak Totals		5:59	3:08	10:16	0:32	

Figures 1 through 7 contain graphical presentations of this information. The graphs illustrate that in all but the CDL division there is variation in average shift length among the jobs in the divisions.

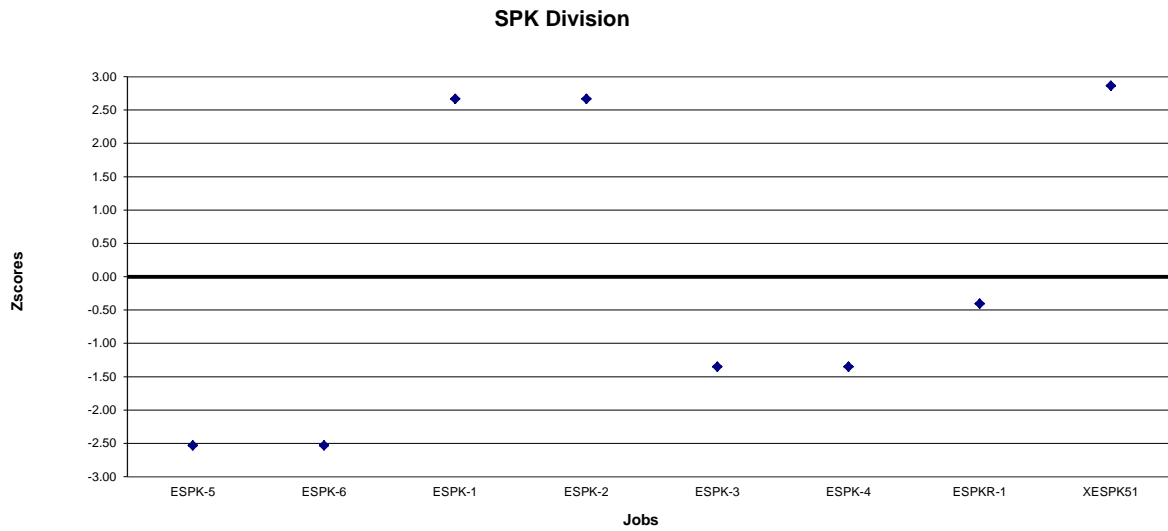


Figure 1. Standardized Average Shift Length for SPK Division

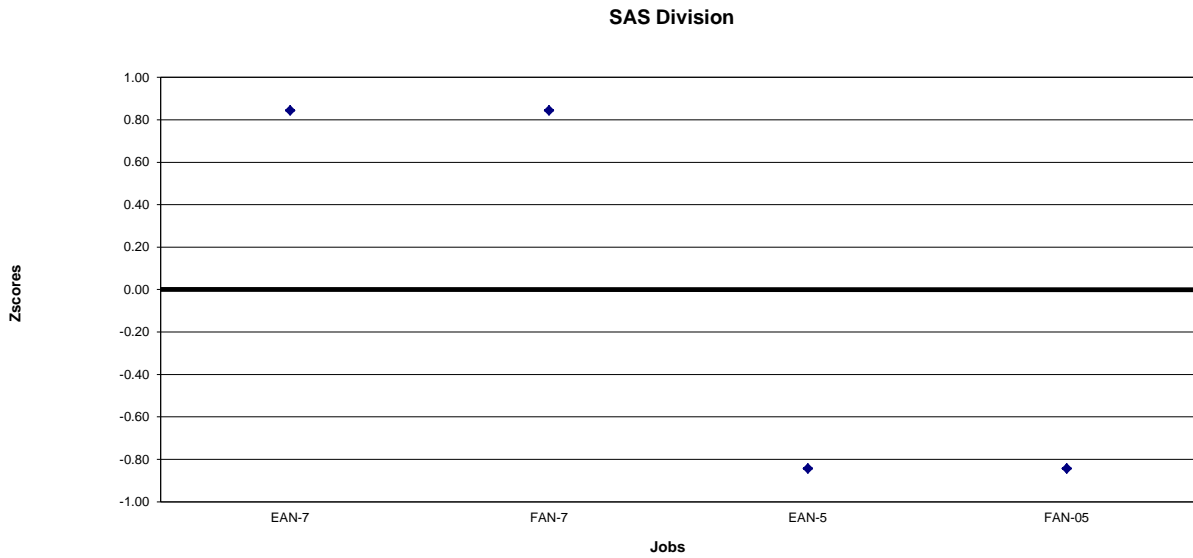


Figure 2. Standardized Average Shift Length for SAS Division

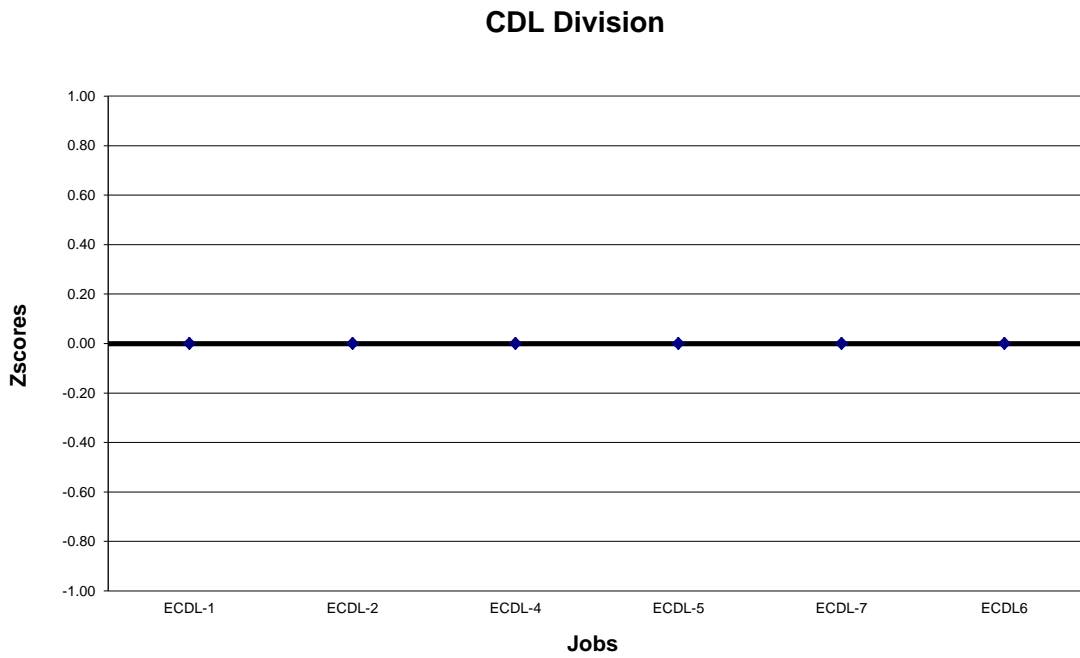


Figure 3. Standardized Average Shift Length for CDL Division

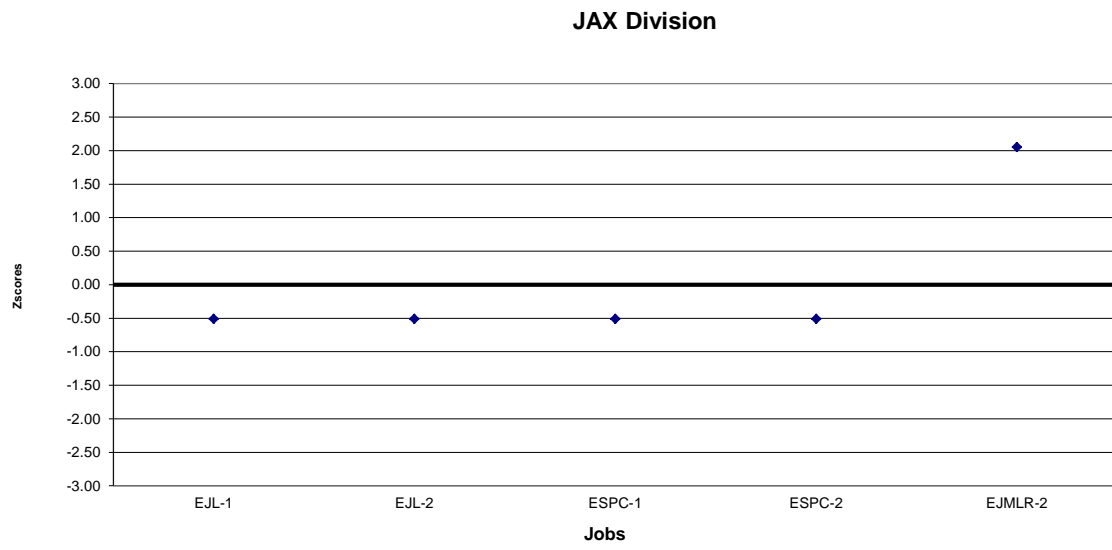


Figure 4. Standardized Average Shift Length for JAX Division

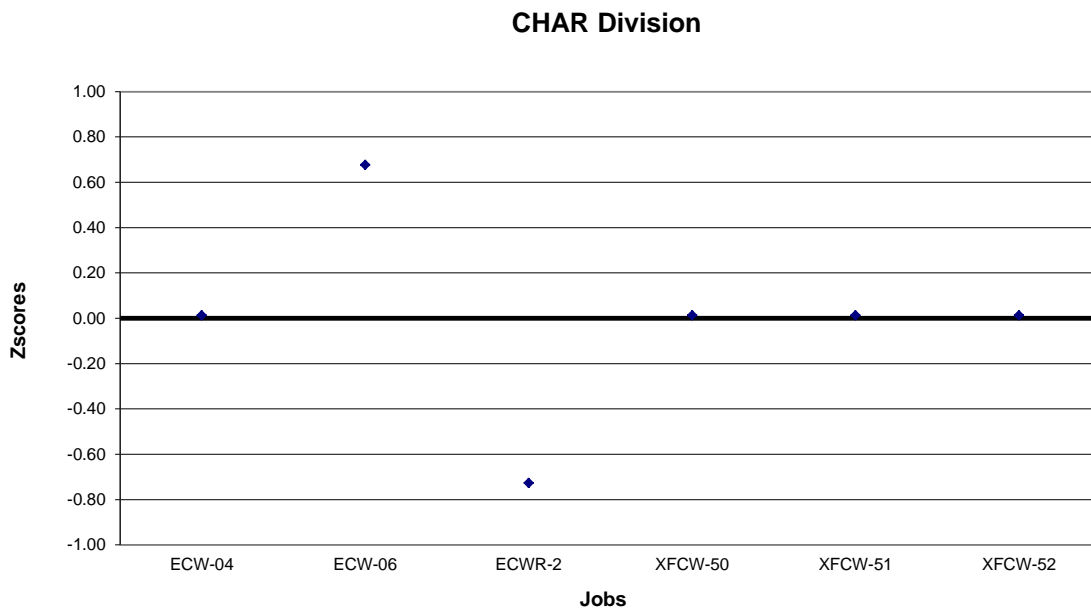


Figure 5. Standardized Average Shift Length for CHAR Division

FLO Division

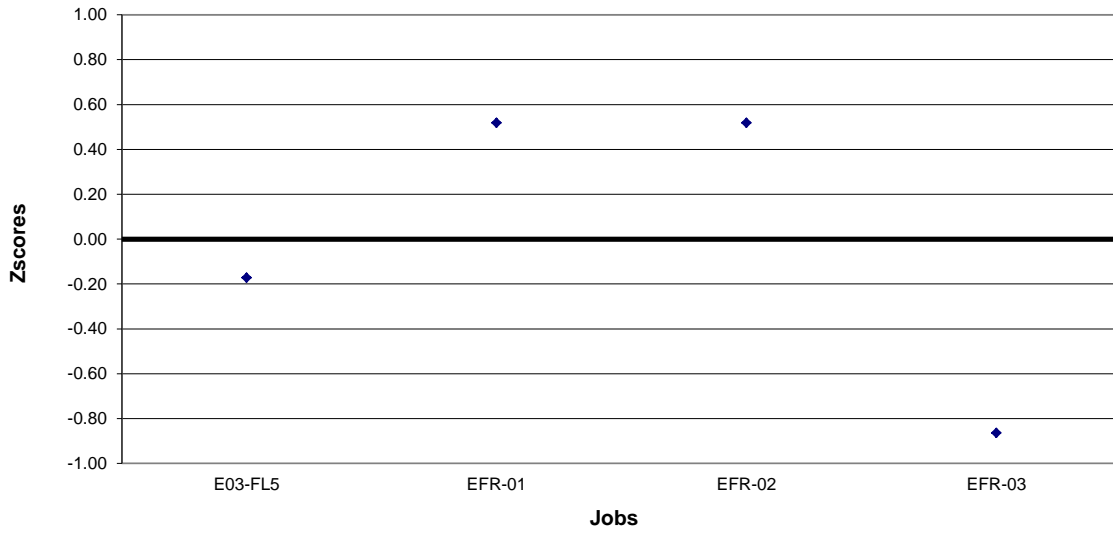


Figure 6. Standardized Average Shift Length for FLO Division

BUF Division

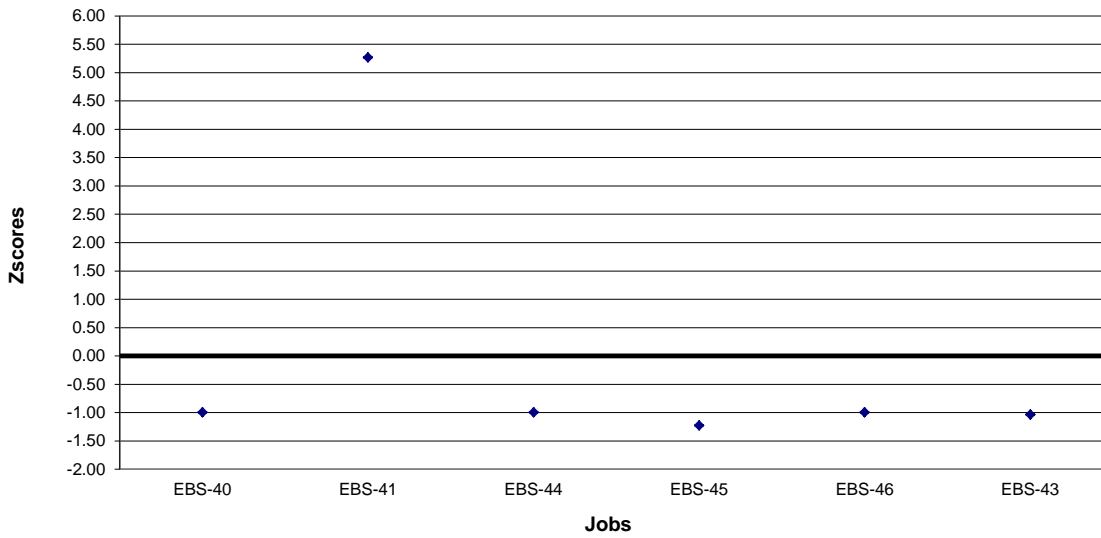


Figure 7. Standardized Average Shift Length for BUF Division

2.6 Start Time Variability

Start time variability refers to the consistency in the start time of work periods over the work cycle. Examination of the raw data in Appendix A is one means to determine the extent to which there is a regular pattern for a given job. Alternatively, the start times associated with each job can be displayed graphically. Figures 8 through 14 contain graphical representations of the shift start times for each job by division. Based on these graphs, the CDL and BUF divisions appear to have the greatest variability in start times. Two jobs in the CHAR division (ECW-06 and ECWR-2) also have variability in their start times.

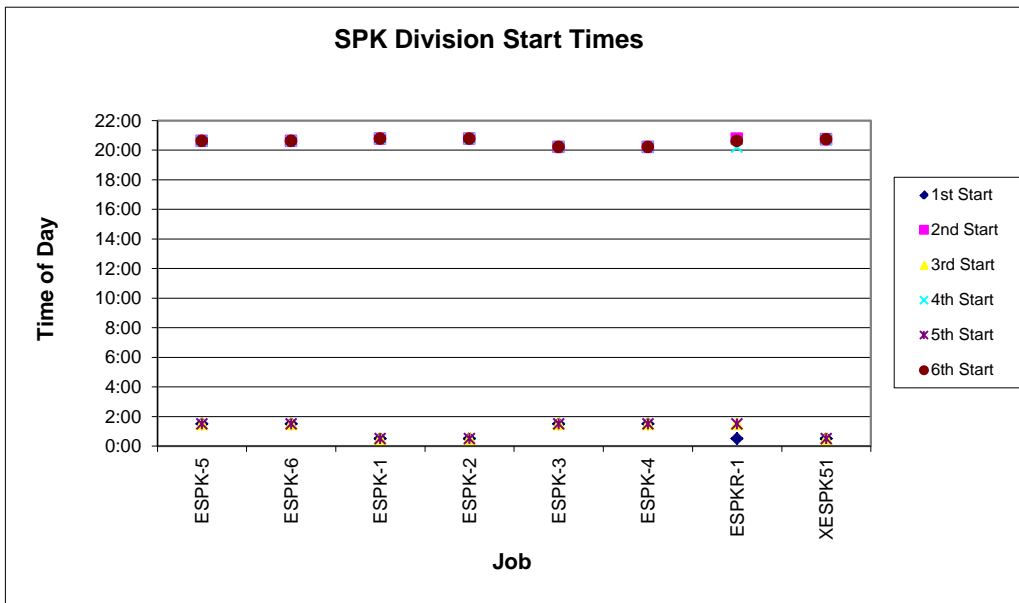


Figure 8. Distribution of Start Times for SPK Division

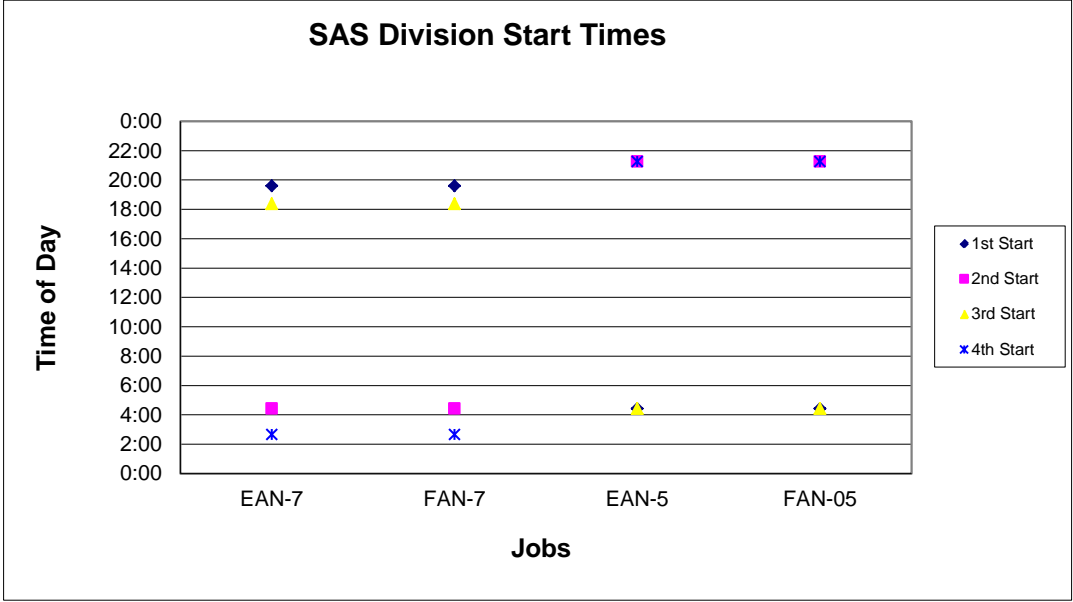


Figure 9. Distribution of Start Times for SAS Division

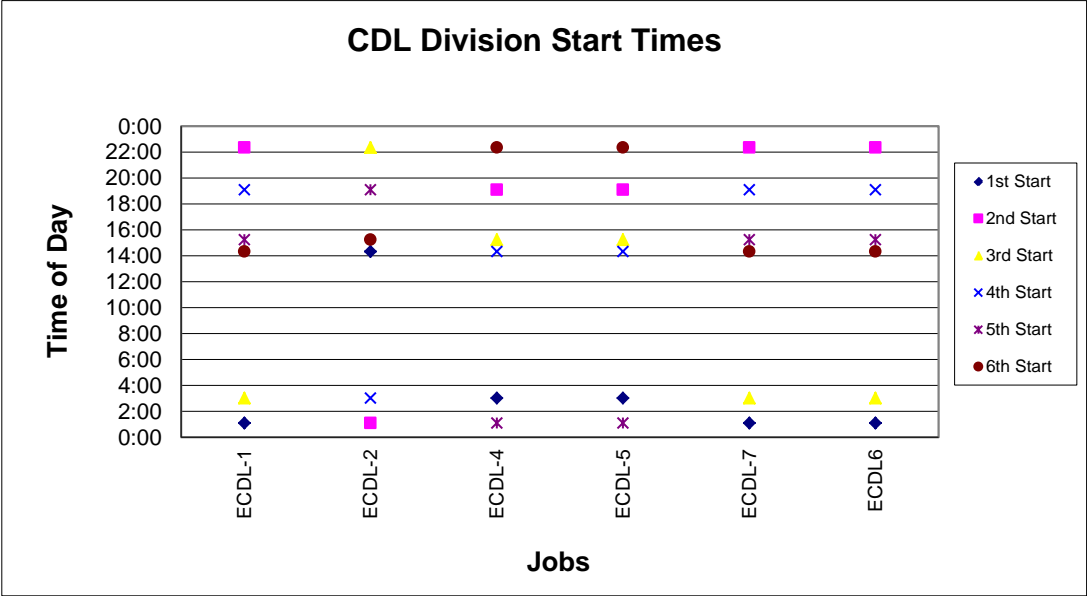


Figure 10. Distribution of Start Times for CDL Division

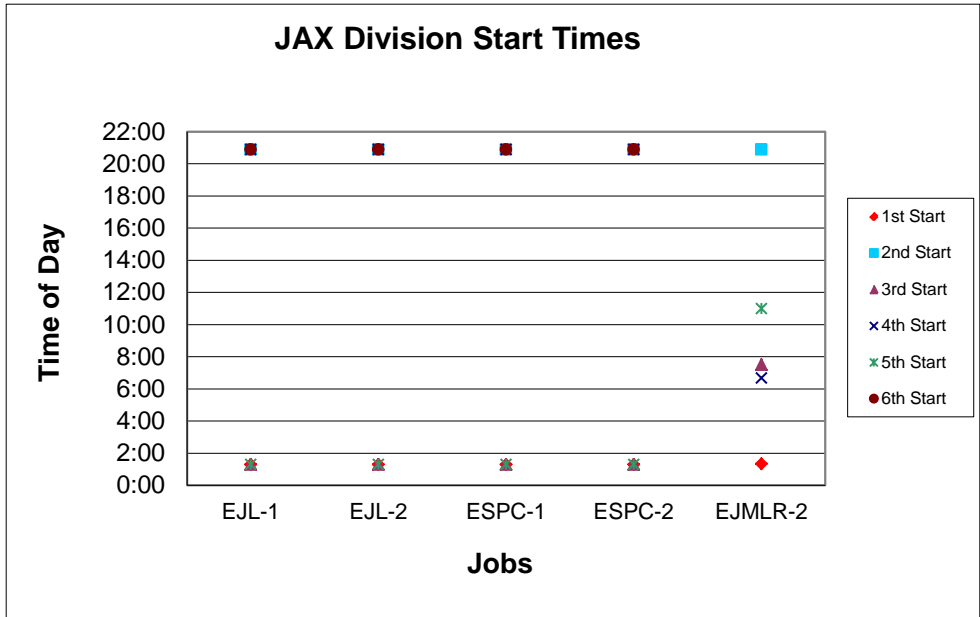


Figure 11. Distribution of Start Times for JAX Division

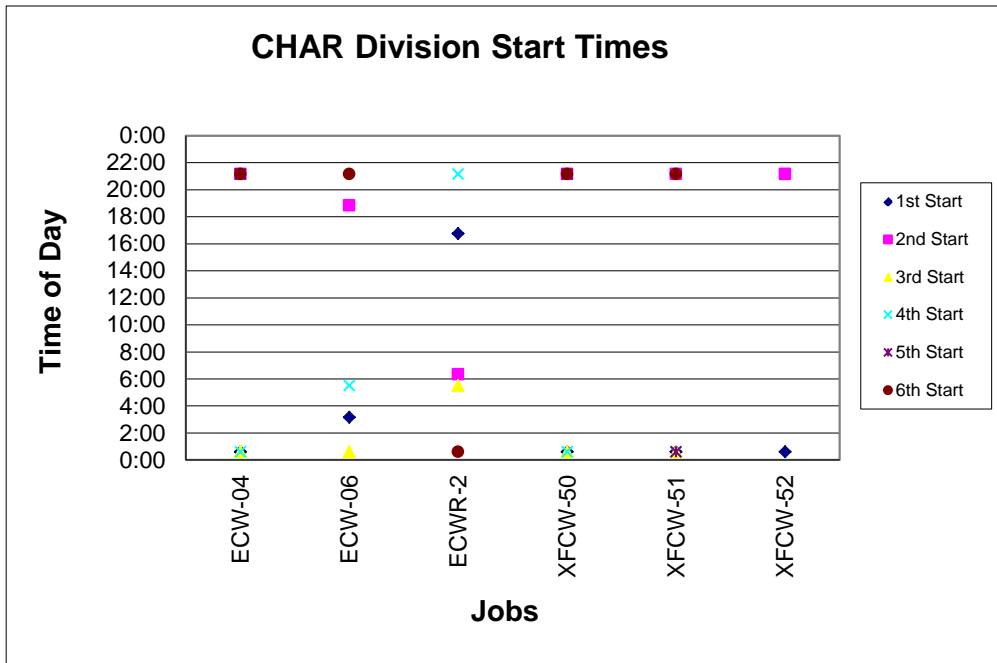


Figure 12. Distribution of Start Times for CHAR Division

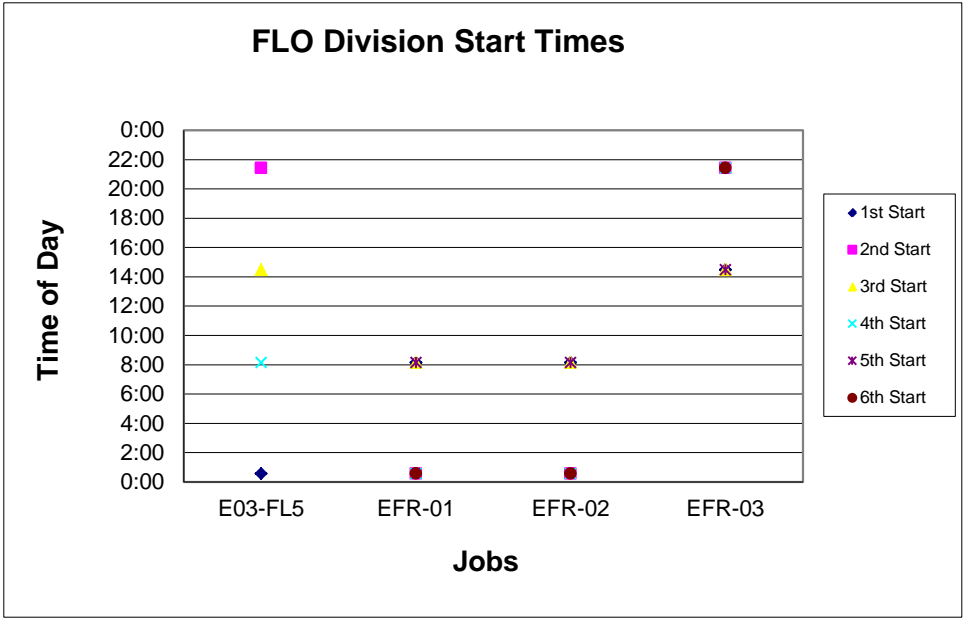


Figure 13. Distribution of Start Times for FLO Division

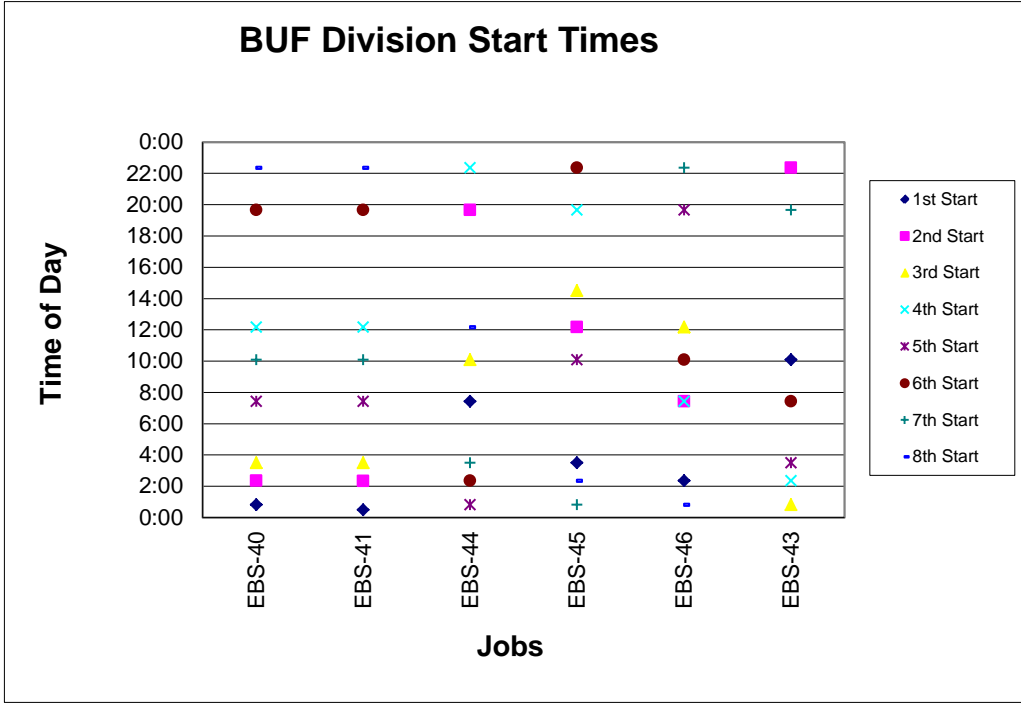


Figure 14. Distribution of Start Times for BUF Division

Raster plots offer an alternative means of visualizing start time variability, as well as the pattern of the work periods for a job. A sample raster plot is shown in Figure 15. (Appendix B contains raster plots for all 39 jobs.) In this representation of a job, the vertical axis corresponds to the days of the week and the horizontal axis indicates the hour of the day. The black horizontal bars represent the work periods that make up the job. Consecutive days are represented on the horizontal axis so that overnight work periods are apparent. The raster plot is also useful for determining the regularity in the work pattern of a job. Based on a visual inspection of the raster plots, 17 of the 39 jobs have regular work patterns with work periods occurring at the same time on each workday.

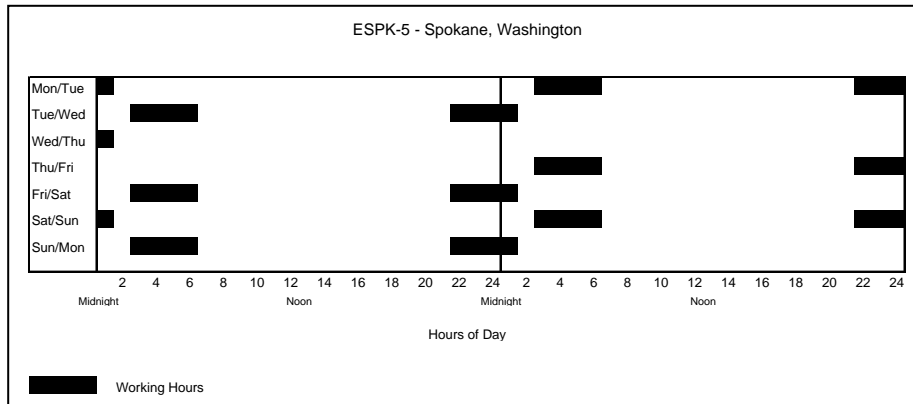


Figure 15. Sample Raster Plot

APPENDIX A: Amtrak Shift Data

Division	ID	Work Shift					Time Off		Duty Cycle	
		Start Date	End Date	Start Time	End Time	Shift Length	Days	Hrs:Mins	Days	Hrs:Mins
SPK	ESPK-5	7/2/2000	7/2/2000	1:30	5:55	4:25	1	0:57	1	4:53
	ESPK-5	7/2/2000	7/3/2000	20:37	0:33	3:56		14:42		19:07
	ESPK-5	7/4/2000	7/4/2000	1:30	5:55	4:25	1	0:57	1	4:53
	ESPK-5	7/4/2000	7/5/2000	20:37	0:33	3:56		14:42		19:07
	ESPK-5	7/7/2000	7/7/2000	1:30	5:55	4:25	2	0:57	2	4:53
	ESPK-5	7/7/2000	7/8/2000	20:37	0:33	3:56		14:42		19:07
SPK	ESPK-6	7/1/2000	7/1/2000	1:30	5:55	4:25	2	0:57	2	4:53
	ESPK-6	7/1/2000	7/2/2000	20:37	0:33	3:56		14:42		19:07
	ESPK-6	7/3/2000	7/3/2000	1:30	5:55	4:25	1	0:57	1	4:53
	ESPK-6	7/3/2000	7/4/2000	20:37	0:33	3:56		14:42		19:07
	ESPK-6	7/5/2000	7/5/2000	1:30	5:55	4:25	1	0:57	1	4:53
	ESPK-6	7/5/2000	7/6/2000	20:37	0:33	3:56		14:42		19:07
SPK	ESPK-1	7/3/2000	7/3/2000	0:30	7:25	6:55	1	22:20	2	3:44
	ESPK-1	7/3/2000	7/4/2000	20:46	2:10	5:24		13:21		20:16
	ESPK-1	7/5/2000	7/5/2000	0:30	7:25	6:55		22:20	1	3:44
	ESPK-1	7/5/2000	7/6/2000	20:46	2:10	5:24		13:21		20:16
	ESPK-1	7/7/2000	7/7/2000	0:30	7:25	6:55		22:20	1	3:44
	ESPK-1	7/7/2000	7/8/2000	20:46	2:10	5:24		13:21		20:16
SPK	ESPK-2	7/1/2000	7/1/2000	0:30	7:25	6:55		22:20	1	3:44
	ESPK-2	7/1/2000	7/2/2000	20:46	2:10	5:24		13:21		20:16
	ESPK-2	7/4/2000	7/4/2000	0:30	7:25	6:55	1	22:20	2	3:44
	ESPK-2	7/4/2000	7/5/2000	20:46	2:10	5:24		13:21		20:16
	ESPK-2	7/6/2000	7/6/2000	0:30	7:25	6:55		22:20	1	3:44
	ESPK-2	7/6/2000	7/7/2000	20:46	2:10	5:24		13:21		20:16
SPK	ESPK-3	7/2/2000	7/2/2000	1:30	5:55	4:25	1	0:28	1	5:18
	ESPK-3	7/2/2000	7/3/2000	20:12	1:02	4:50		14:17		18:42
	ESPK-3	7/5/2000	7/5/2000	1:30	5:55	4:25	2	0:28	2	5:18
	ESPK-3	7/5/2000	7/6/2000	20:12	1:02	4:50		14:17		18:42
	ESPK-3	7/7/2000	7/7/2000	1:30	5:55	4:25	1	0:28	1	5:18
	ESPK-3	7/7/2000	7/8/2000	20:12	1:02	4:50		14:17		18:42
SPK	ESPK-4	7/1/2000	7/1/2000	1:30	5:55	4:25	1	0:28	1	5:18
	ESPK-4	7/1/2000	7/2/2000	20:12	1:02	4:50		14:17		18:42
	ESPK-4	7/3/2000	7/3/2000	1:30	5:55	4:25	1	0:28	1	5:18
	ESPK-4	7/3/2000	7/4/2000	20:12	1:02	4:50		14:17		18:42
	ESPK-4	7/6/2000	7/6/2000	1:30	5:55	4:25	2	0:28	2	5:18
	ESPK-4	7/6/2000	7/7/2000	20:12	1:02	4:50		14:17		18:42
SPK	ESPKR-1	7/2/2000	7/2/2000	0:30	7:25	6:55	1	23:57	2	3:53
	ESPKR-1	7/2/2000	7/3/2000	20:46	2:10	5:24		13:21		20:16
	ESPKR-1	7/4/2000	7/4/2000	1:30	5:55	4:25		23:20	1	4:44
	ESPKR-1	7/4/2000	7/5/2000	20:12	1:02	4:50		14:17		18:42
	ESPKR-1	7/6/2000	7/6/2000	1:30	5:55	4:25	1	0:28	1	5:18
	ESPKR-1	7/6/2000	7/7/2000	20:37	0:33	3:56		14:42		19:07
SPK	XESPK51	7/3/2000	7/3/2000	0:30	7:41	7:11	1	22:30	2	3:47
	XESPK51	7/3/2000	7/4/2000	20:43	2:00	5:17		13:02		20:13
	XESPK51	7/5/2000	7/5/2000	0:30	7:41	7:11		22:30	1	3:47

	XESPK51	7/5/2000	7/6/2000	20:43	2:00	5:17		13:02		20:13
	XESPK51	7/7/2000	7/7/2000	0:30	7:41	7:11		22:30	1	3:47
	XESPK51	7/7/2000	7/8/2000	20:43	2:00	5:17		13:02		20:13
SAS	EAN-7	7/1/2000	7/2/2000	19:36	4:41	9:05		7:53	1	16:56
	EAN-7	7/4/2000	7/4/2000	4:25	12:43	8:18	1	23:44	2	8:49
	EAN-7	7/5/2000	7/6/2000	18:23	3:10	8:47	1	5:40	1	13:58
	EAN-7	7/7/2000	7/7/2000	2:40	11:43	9:03		23:30	1	8:17
SAS	FAN-7	7/1/2000	7/2/2000	19:36	4:41	9:05		7:53	1	16:56
	FAN-7	7/4/2000	7/4/2000	4:25	12:43	8:18	1	23:44	2	8:49
	FAN-7	7/5/2000	7/6/2000	18:23	3:10	8:47	1	5:40	1	13:58
	FAN-7	7/7/2000	7/7/2000	2:40	11:43	9:03		23:30	1	8:17
SAS	EAN-5	7/2/2000	7/2/2000	4:25	10:40	6:15	1	1:15	1	7:10
	EAN-5	7/2/2000	7/3/2000	21:15	3:10	5:55		10:35		16:50
	EAN-5	7/6/2000	7/6/2000	4:25	14:41	10:16	3	1:15	3	7:10
	EAN-5	7/7/2000	7/8/2000	21:15	3:10	5:55	1	6:34	1	16:50
SAS	FAN-05	7/2/2000	7/2/2000	4:25	10:40	6:15	1	1:15	1	7:10
	FAN-05	7/2/2000	7/3/2000	21:15	3:10	5:55		10:35		16:50
	FAN-05	7/6/2000	7/6/2000	4:25	14:41	10:16	3	1:15	3	7:10
	FAN-05	7/7/2000	7/8/2000	21:15	3:10	5:55	1	6:34	1	16:50
CDL	ECDL-1	7/3/2000	7/3/2000	1:05	6:39	5:34	2	2:45	2	10:45
	ECDL-1	7/3/2000	7/4/2000	22:21	3:36	5:15		15:42		21:16
	ECDL-1	7/5/2000	7/5/2000	3:01	9:30	6:29		23:25	1	4:40
	ECDL-1	7/5/2000	7/6/2000	19:05	1:40	6:35		9:35		16:04
	ECDL-1	7/6/2000	7/6/2000	15:15	21:45	6:30		13:35		20:10
	ECDL-1	7/7/2000	7/7/2000	14:20	22:20	8:00		16:35		23:05
CDL	ECDL-2	7/1/2000	7/1/2000	14:20	22:20	8:00		16:35		23:05
	ECDL-2	7/4/2000	7/4/2000	1:05	6:39	5:34	2	2:45	2	10:45
	ECDL-2	7/4/2000	7/5/2000	22:21	3:36	5:15		15:42		21:16
	ECDL-2	7/6/2000	7/6/2000	3:01	9:30	6:29		23:25	1	4:40
	ECDL-2	7/6/2000	7/7/2000	19:05	1:40	6:35		9:35		16:04
	ECDL-2	7/7/2000	7/7/2000	15:15	21:45	6:30		13:35		20:10
CDL	ECDL-4	7/1/2000	7/1/2000	3:01	9:30	6:29		23:25	1	4:40
	ECDL-4	7/1/2000	7/2/2000	19:05	1:40	6:35		9:35		16:04
	ECDL-4	7/2/2000	7/2/2000	15:15	21:45	6:30		13:35		20:10
	ECDL-4	7/3/2000	7/3/2000	14:20	22:20	8:00		16:35		23:05
	ECDL-4	7/6/2000	7/6/2000	1:05	6:39	5:34	2	2:45	2	10:45
	ECDL-4	7/6/2000	7/7/2000	22:21	3:36	5:15		15:42		21:16
CDL	ECDL-5	7/2/2000	7/2/2000	3:01	9:30	6:29		23:25	1	4:40
	ECDL-5	7/2/2000	7/3/2000	19:05	1:40	6:35		9:35		16:04
	ECDL-5	7/3/2000	7/3/2000	15:15	21:45	6:30		13:35		20:10
	ECDL-5	7/4/2000	7/4/2000	14:20	22:20	8:00		16:35		23:05
	ECDL-5	7/7/2000	7/7/2000	1:05	6:39	5:34	2	2:45	2	10:45
	ECDL-5	7/7/2000	7/8/2000	22:21	3:36	5:15		15:42		21:16
CDL	ECDL-7	7/2/2000	7/2/2000	1:05	6:39	5:34	2	2:45	2	10:45
	ECDL-7	7/2/2000	7/3/2000	22:21	3:36	5:15		15:42		21:16
	ECDL-7	7/4/2000	7/4/2000	3:01	9:30	6:29		23:25	1	4:40
	ECDL-7	7/4/2000	7/5/2000	19:05	1:40	6:35		9:35		16:04
	ECDL-7	7/5/2000	7/5/2000	15:15	21:45	6:30		13:35		20:10
	ECDL-7	7/6/2000	7/6/2000	14:20	22:20	8:00		16:35		23:05
CDL	ECDL6	7/1/2000	7/1/2000	1:05	6:39	5:34	2	2:45	2	10:45
	ECDL6	7/1/2000	7/2/2000	22:21	3:36	5:15		15:42		21:16

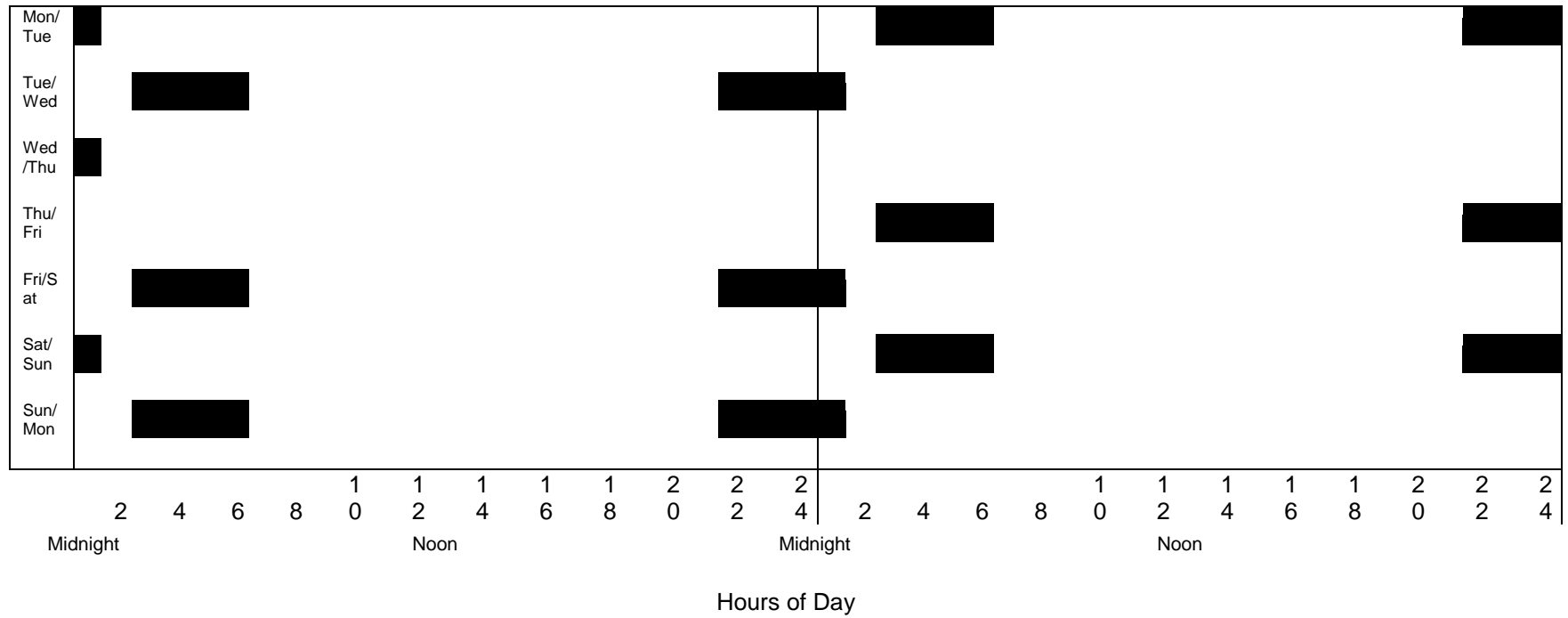
	ECDL6	7/3/2000	7/3/2000	3:01	9:30	6:29		23:25	1	4:40
	ECDL6	7/3/2000	7/4/2000	19:05	1:40	6:35		9:35		16:04
	ECDL6	7/4/2000	7/4/2000	15:15	21:45	6:30		13:35		20:10
	ECDL6	7/5/2000	7/5/2000	14:20	22:20	8:00		16:35		23:05
JAX	EJL-1	7/3/2000	7/3/2000	1:18	7:44	6:26	1	22:24	2	4:25
	EJL-1	7/3/2000	7/4/2000	20:53	2:54	6:01		13:09		19:35
	EJL-1	7/5/2000	7/5/2000	1:18	7:44	6:26		22:24	1	4:25
	EJL-1	7/5/2000	7/6/2000	20:53	2:54	6:01		13:09		19:35
	EJL-1	7/7/2000	7/7/2000	1:18	7:44	6:26		22:24	1	4:25
	EJL-1	7/7/2000	7/8/2000	20:53	2:54	6:01		13:09		19:35
JAX	EJL-2	7/2/2000	7/2/2000	1:18	7:44	6:26	1	22:24	2	4:25
	EJL-2	7/2/2000	7/3/2000	20:53	2:54	6:01		13:09		19:35
	EJL-2	7/4/2000	7/4/2000	1:18	7:44	6:26		22:24	1	4:25
	EJL-2	7/4/2000	7/5/2000	20:53	2:54	6:01		13:09		19:35
	EJL-2	7/6/2000	7/6/2000	1:18	7:44	6:26		22:24	1	4:25
	EJL-2	7/6/2000	7/7/2000	20:53	2:54	6:01		13:09		19:35
JAX	ESPC-1	7/3/2000	7/3/2000	1:18	7:44	6:26	1	22:24	2	4:25
	ESPC-1	7/3/2000	7/4/2000	20:53	2:54	6:01		13:09		19:35
	ESPC-1	7/5/2000	7/5/2000	1:18	7:44	6:26		22:24	1	4:25
	ESPC-1	7/5/2000	7/6/2000	20:53	2:54	6:01		13:09		19:35
	ESPC-1	7/7/2000	7/7/2000	1:18	7:44	6:26		22:24	1	4:25
	ESPC-1	7/7/2000	7/8/2000	20:53	2:54	6:01		13:09		19:35
JAX	ESPC-2	7/2/2000	7/2/2000	1:18	7:44	6:26	1	22:24	2	4:25
	ESPC-2	7/2/2000	7/3/2000	20:53	2:54	6:01		13:09		19:35
	ESPC-2	7/4/2000	7/4/2000	1:18	7:44	6:26		22:24	1	4:25
	ESPC-2	7/4/2000	7/5/2000	20:53	2:54	6:01		13:09		19:35
	ESPC-2	7/6/2000	7/6/2000	1:18	7:44	6:26		22:24	1	4:25
	ESPC-2	7/6/2000	7/7/2000	20:53	2:54	6:01		13:09		19:35
JAX	EJMLR-2	7/1/2000	7/1/2000	1:20	7:44	6:24	1	6:20	1	14:20
	EJMLR-2	7/1/2000	7/2/2000	20:53	2:54	6:01		13:09		19:33
	EJMLR-2	7/3/2000	7/3/2000	7:31	17:15	9:44	1	4:37	1	10:38
	EJMLR-2	7/4/2000	7/4/2000	6:40	16:14	9:34		13:25		23:09
	EJMLR-2	7/6/2000	7/6/2000	11:00	19:00	8:00	1	18:46	2	4:20
CHAR	ECW-04	7/1/2000	7/1/2000	0:36	6:54	6:18		20:49	1	3:26
	ECW-04	7/1/2000	7/2/2000	21:10	3:47	6:37		14:16		20:34
	ECW-04	7/4/2000	7/4/2000	0:36	6:54	6:18	1	20:49	2	3:26
	ECW-04	7/4/2000	7/5/2000	21:10	3:47	6:37		14:16		20:34
	ECW-04	7/6/2000	7/6/2000	0:36	6:54	6:18		20:49	1	3:26
	ECW-04	7/6/2000	7/7/2000	21:10	3:47	6:37		14:16		20:34
CHAR	ECW-06	7/1/2000	7/1/2000	3:10	9:40	6:30	1	13:40	1	21:40
	ECW-06	7/1/2000	7/2/2000	18:50	1:18	6:28		9:10		15:40
	ECW-06	7/3/2000	7/3/2000	0:36	6:54	6:18		23:18	1	5:46
	ECW-06	7/3/2000	7/4/2000	21:10	3:47	6:37		14:16		20:34
	ECW-06	7/6/2000	7/6/2000	5:30	13:30	8:00	2	1:43	2	8:20
CHAR	ECWR-2	7/1/2000	7/1/2000	16:45	21:38	4:53	2	12:58	2	19:35
	ECWR-2	7/2/2000	7/2/2000	6:20	11:03	4:43		8:42		13:35
	ECWR-2	7/3/2000	7/3/2000	5:30	13:30	8:00		18:27		23:10
	ECWR-2	7/5/2000	7/5/2000	0:36	6:54	6:18	1	11:06	1	19:06
	ECWR-2	7/5/2000	7/6/2000	21:10	3:47	6:37		14:16		20:34
CHAR	XFCW-50	7/1/2000	7/1/2000	0:36	6:54	6:18		20:49	1	3:26
	XFCW-50	7/1/2000	7/2/2000	21:10	3:47	6:37		14:16		20:34

	XFCW-50	7/4/2000	7/4/2000	0:36	6:54	6:18	1	20:49	2	3:26
	XFCW-50	7/4/2000	7/5/2000	21:10	3:47	6:37		14:16		20:34
	XFCW-50	7/6/2000	7/6/2000	0:36	6:54	6:18		20:49	1	3:26
	XFCW-50	7/6/2000	7/7/2000	21:10	3:47	6:37		14:16		20:34
CHAR	XFCW-51	7/3/2000	7/3/2000	0:36	6:54	6:18	1	20:49	2	3:26
	XFCW-51	7/3/2000	7/4/2000	21:10	3:47	6:37		14:16		20:34
	XFCW-51	7/5/2000	7/5/2000	0:36	6:54	6:18		20:49	1	3:26
	XFCW-51	7/5/2000	7/6/2000	21:10	3:47	6:37		14:16		20:34
	XFCW-51	7/7/2000	7/7/2000	0:36	6:54	6:18		20:49	1	3:26
	XFCW-51	7/7/2000	7/8/2000	21:10	3:47	6:37		14:16		20:34
CHAR	XFCW-52	7/2/2000	7/2/2000	0:36	6:54	6:18	5	20:49	6	3:26
	XFCW-52	7/2/2000	7/3/2000	21:10	3:47	6:37		14:16		20:34
FLO	E03-FL5	7/1/2000	7/1/2000	0:34	6:41	6:07		10:34		16:25
	E03-FL5	7/2/2000	7/3/2000	21:26	3:27	6:01	1	14:45	1	20:52
	E03-FL5	7/3/2000	7/3/2000	14:28	20:20	5:52		11:01		17:02
	E03-FL5	7/7/2000	7/7/2000	8:09	14:00	5:51	3	11:49	3	17:41
FLO	EFR-01	7/2/2000	7/2/2000	8:09	14:00	5:51	2	1:28	2	7:35
	EFR-01	7/3/2000	7/3/2000	0:34	6:41	6:07		10:34		16:25
	EFR-01	7/4/2000	7/4/2000	8:09	14:00	5:51	1	1:28	1	7:35
	EFR-01	7/5/2000	7/5/2000	0:34	6:41	6:07		10:34		16:25
	EFR-01	7/6/2000	7/6/2000	8:09	14:00	5:51	1	1:28	1	7:35
	EFR-01	7/7/2000	7/7/2000	0:34	6:41	6:07		10:34		16:25
FLO	EFR-02	7/1/2000	7/1/2000	8:09	14:00	5:51	2	1:28	2	7:35
	EFR-02	7/2/2000	7/2/2000	0:34	6:41	6:07		10:34		16:25
	EFR-02	7/3/2000	7/3/2000	8:09	14:00	5:51	1	1:28	1	7:35
	EFR-02	7/4/2000	7/4/2000	0:34	6:41	6:07		10:34		16:25
	EFR-02	7/5/2000	7/5/2000	8:09	14:00	5:51	1	1:28	1	7:35
	EFR-02	7/6/2000	7/6/2000	0:34	6:41	6:07		10:34		16:25
FLO	EFR-03	7/1/2000	7/1/2000	14:28	20:20	5:52		11:01		17:02
	EFR-03	7/3/2000	7/4/2000	21:26	3:27	6:01	2	1:06	2	6:58
	EFR-03	7/4/2000	7/4/2000	14:28	20:20	5:52		11:01		17:02
	EFR-03	7/5/2000	7/6/2000	21:26	3:27	6:01	1	1:06	1	6:58
	EFR-03	7/6/2000	7/6/2000	14:28	20:20	5:52		11:01		17:02
	EFR-03	7/7/2000	7/8/2000	21:26	3:27	6:01	1	1:06	1	6:58
BUF	EBS-40	7/1/2000	7/1/2000	0:49	5:27	4:38	1	23:20	2	2:28
	EBS-40	7/2/2000	7/2/2000	2:21	6:36	4:15		20:54	1	1:32
	EBS-40	7/3/2000	7/3/2000	3:30	7:25	3:55		20:54	1	1:09
	EBS-40	7/3/2000	7/3/2000	12:10	16:35	4:25		4:45		8:40
	EBS-40	7/4/2000	7/4/2000	7:25	11:20	3:55		14:50		19:15
	EBS-40	7/4/2000	7/5/2000	19:40	0:01	4:21		8:20		12:15
	EBS-40	7/5/2000	7/5/2000	10:05	16:42	6:37		10:04		14:25
	EBS-40	7/5/2000	7/6/2000	22:21	1:29	3:08		5:39		12:16
BUF	EBS-41	7/2/2000	7/2/2000	0:29	5:27	4:58	1	23:00	2	2:08
	EBS-41	7/3/2000	7/3/2000	2:20	6:36	4:16		20:53	1	1:51
	EBS-41	7/4/2000	7/4/2000	3:30	9:20	5:50		20:54	1	1:10
	EBS-41	7/4/2000	7/4/2000	12:10	16:35	4:25		2:50		8:40
	EBS-41	7/5/2000	7/5/2000	7:25	11:20	3:55		14:50		19:15
	EBS-41	7/5/2000	7/6/2000	19:40	0:01	4:21		8:20		12:15
	EBS-41	7/6/2000	7/6/2000	10:05	16:42	6:37		10:04		14:25
	EBS-41	7/6/2000	7/7/2000	22:21	1:29	3:08		5:39		12:16
BUF	EBS-44	7/1/2000	7/1/2000	7:25	11:20	3:55		14:50		19:15

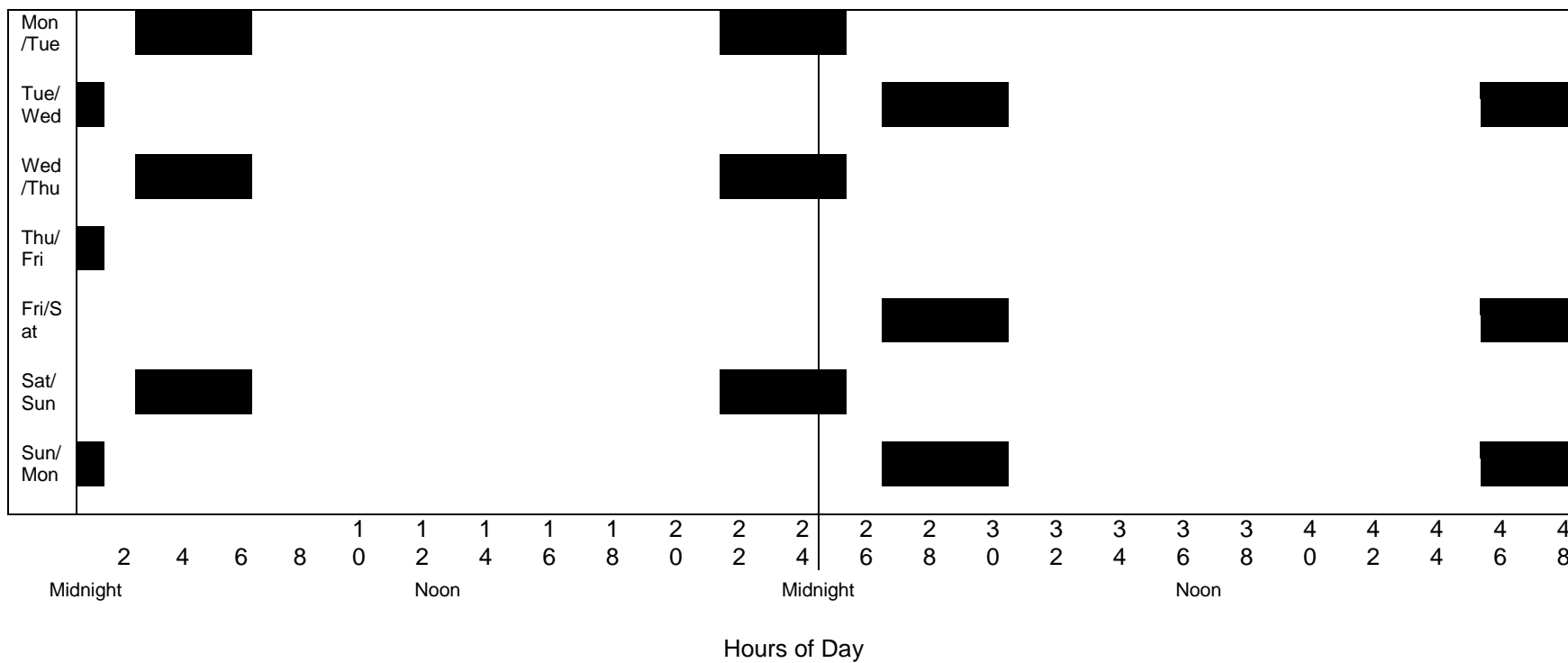
	EBS-44	7/1/2000	7/2/2000	19:40	0:01	4:21		8:20		12:15
	EBS-44	7/2/2000	7/2/2000	10:05	16:42	6:37		10:04		14:25
	EBS-44	7/2/2000	7/3/2000	22:21	1:29	3:08		5:39		12:16
	EBS-44	7/5/2000	7/5/2000	0:49	5:27	4:38	1	23:20	2	2:28
	EBS-44	7/6/2000	7/6/2000	2:21	6:36	4:15		20:54	1	1:32
	EBS-44	7/7/2000	7/7/2000	3:30	7:25	3:55		20:54	1	1:09
	EBS-44	7/7/2000	7/7/2000	12:10	16:35	4:25		4:45		8:40
BUF	EBS-45	7/1/2000	7/1/2000	3:30	7:25	3:55		20:54	1	1:09
	EBS-45	7/1/2000	7/1/2000	12:10	16:35	4:25		4:45		8:40
	EBS-45	7/2/2000	7/2/2000	14:30	18:20	3:50		21:55	1	2:20
	EBS-45	7/2/2000	7/3/2000	19:40	0:01	4:21		1:20		5:10
	EBS-45	7/3/2000	7/3/2000	10:05	16:42	6:37		10:04		14:25
	EBS-45	7/3/2000	7/4/2000	22:21	1:29	3:08		5:39		12:16
	EBS-45	7/6/2000	7/6/2000	0:49	5:27	4:38	1	23:20	2	2:28
BUF	EBS-45	7/7/2000	7/7/2000	2:21	6:36	4:15		20:54	1	1:32
	EBS-46	7/1/2000	7/1/2000	2:21	6:36	4:15		20:54	1	1:32
	EBS-46	7/2/2000	7/2/2000	7:25	11:20	3:55	1	0:49	1	5:04
	EBS-46	7/2/2000	7/2/2000	12:10	16:35	4:25		0:50		4:45
	EBS-46	7/3/2000	7/3/2000	7:25	11:20	3:55		14:50		19:15
	EBS-46	7/3/2000	7/4/2000	19:40	0:01	4:21		8:20		12:15
	EBS-46	7/4/2000	7/4/2000	10:05	16:42	6:37		10:04		14:25
BUF	EBS-46	7/4/2000	7/5/2000	22:21	1:29	3:08		5:39		12:16
	EBS-46	7/7/2000	7/7/2000	0:49	5:27	4:38	1	23:20	2	2:28
	EBS-43	7/1/2000	7/1/2000	10:05	16:42	6:37		10:04		14:25
	EBS-43	7/1/2000	7/2/2000	22:21	1:29	3:08		5:39		12:16
	EBS-43	7/4/2000	7/4/2000	0:49	5:27	4:38	1	23:20	2	2:28
	EBS-43	7/5/2000	7/5/2000	2:21	6:36	4:15		20:54	1	1:32
	EBS-43	7/6/2000	7/6/2000	3:30	7:25	3:55		20:54	1	1:09
BUF	EBS-43	7/7/2000	7/7/2000	7:25	11:20	3:55	1	0:00	1	3:55
	EBS-43	7/7/2000	7/8/2000	19:40	0:01	4:21		8:20		12:15

APPENDIX B: Raster Plots

ESPK-5 - Spokane, Washington

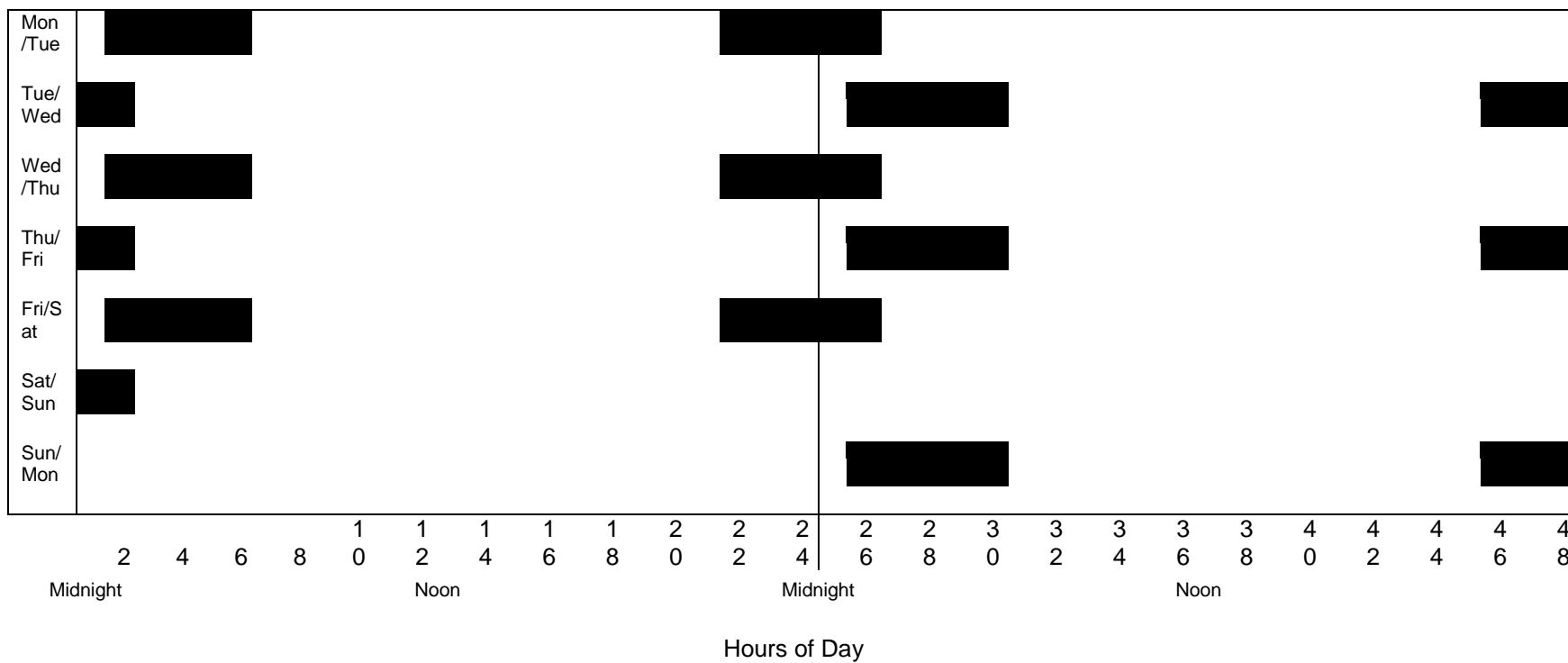


ESPK-6 - Spokane, Washington



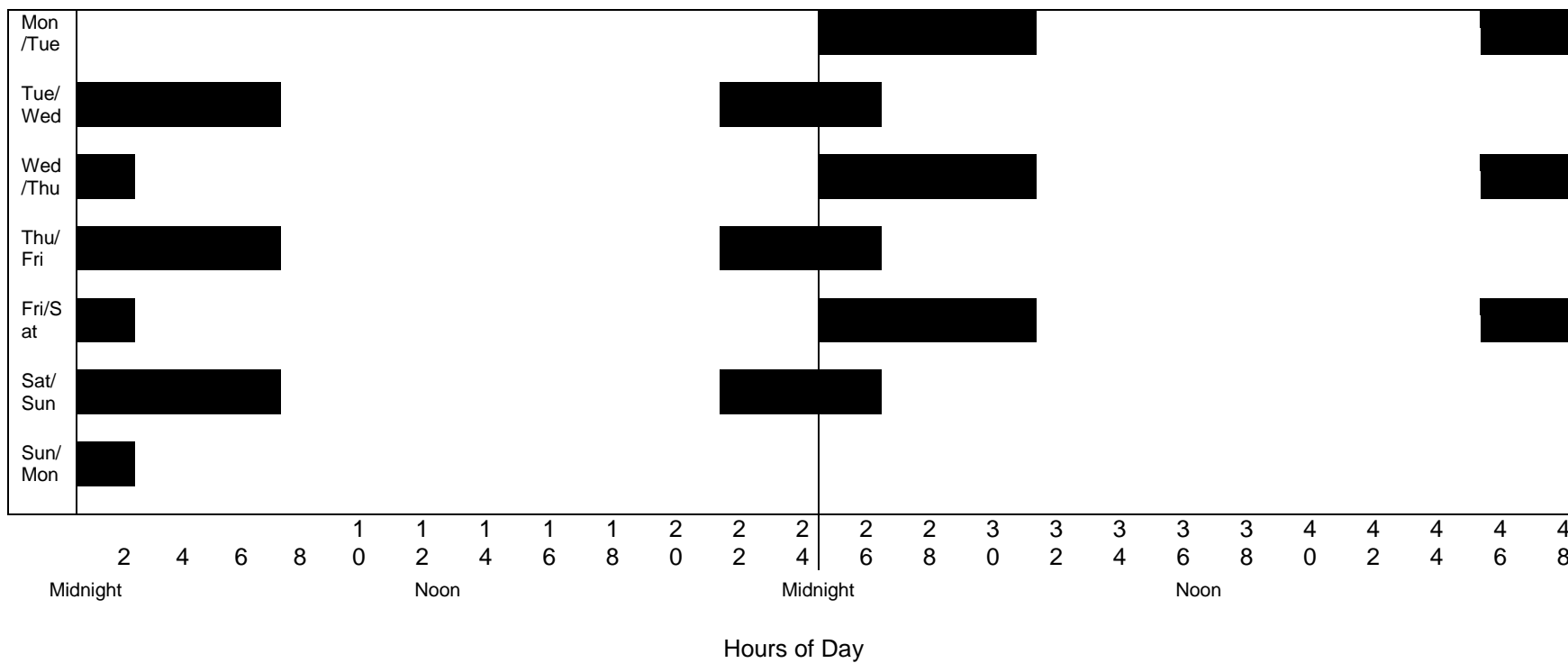
 Working Hours


ESPK-1 - Spokane, Washington



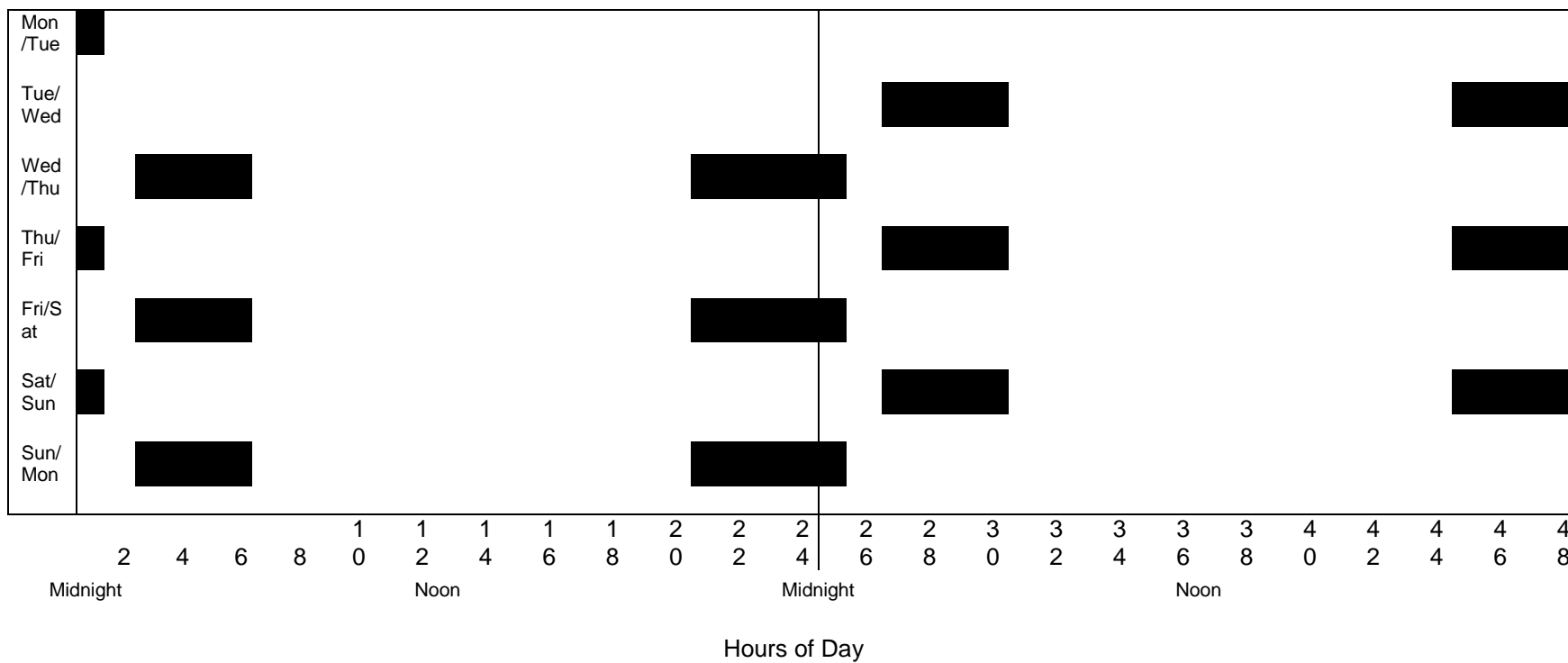
 Working Hours

ESPK-2 - Spokane, Washington



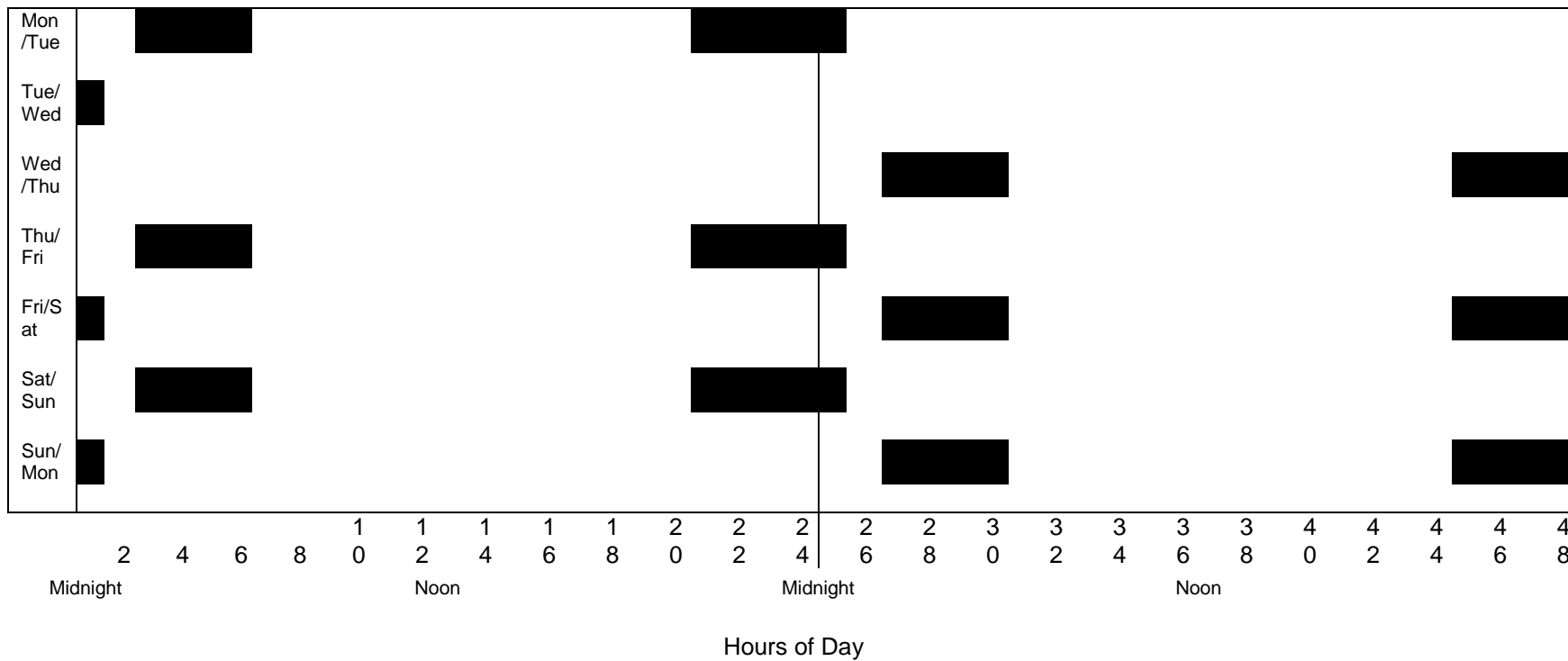
 Working Hours

ESPK-3 - Spokane, Washington



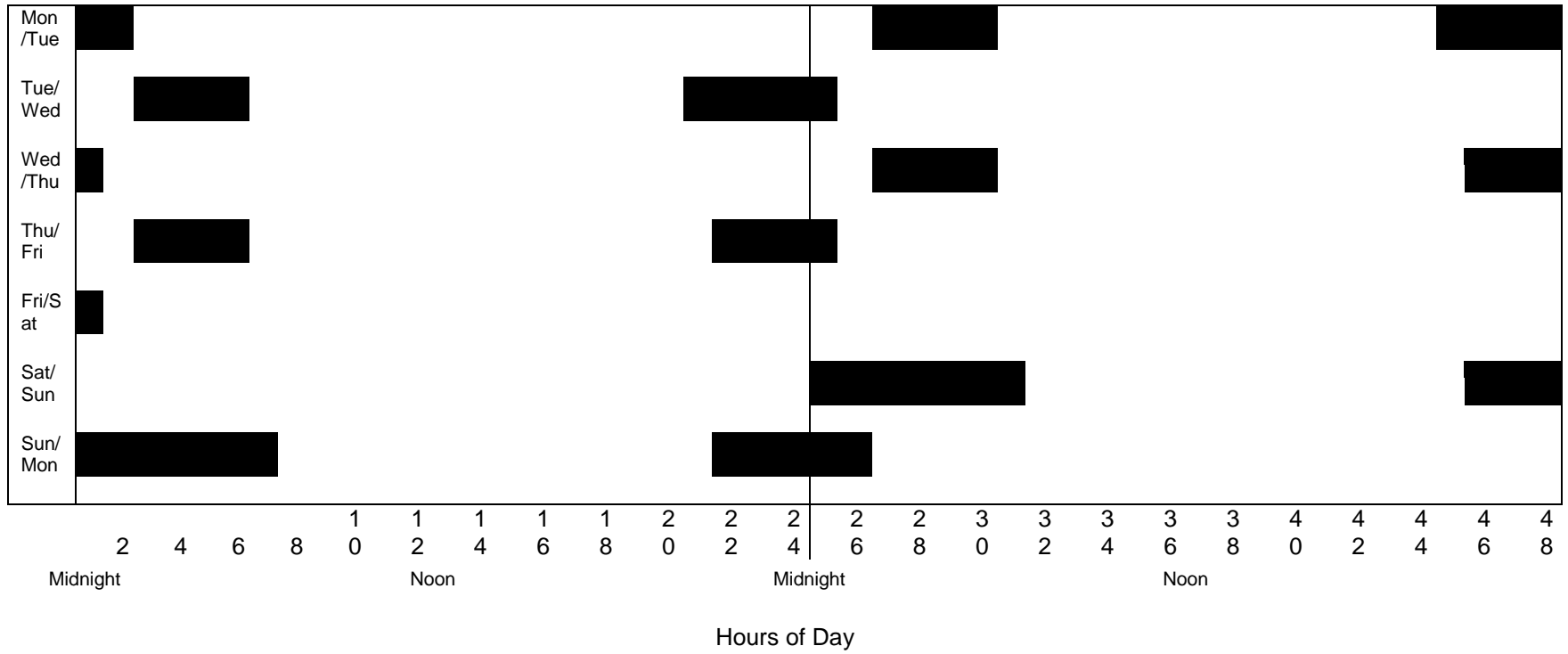
 Working Hours

ESPK-4 - Spokane, Washington



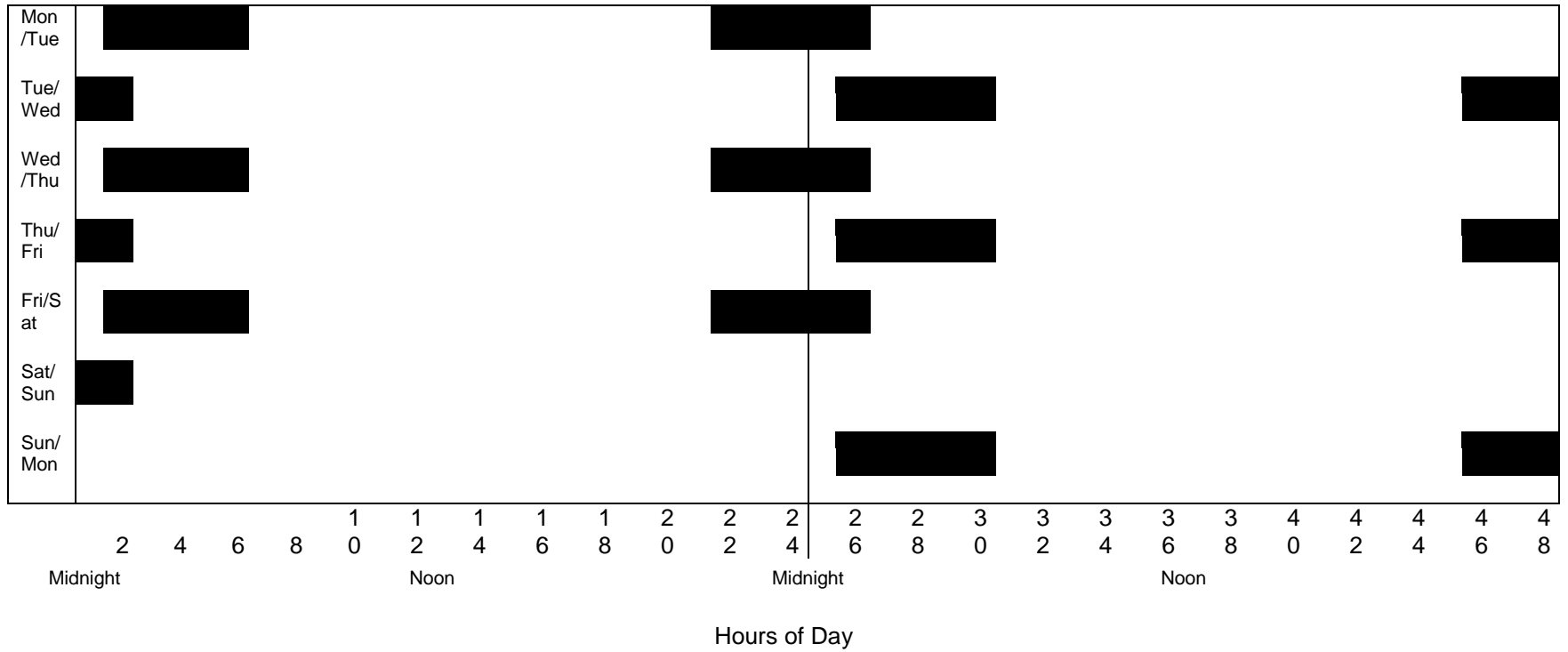
 Working Hours

ESPKR-1 - Spokane, Washington

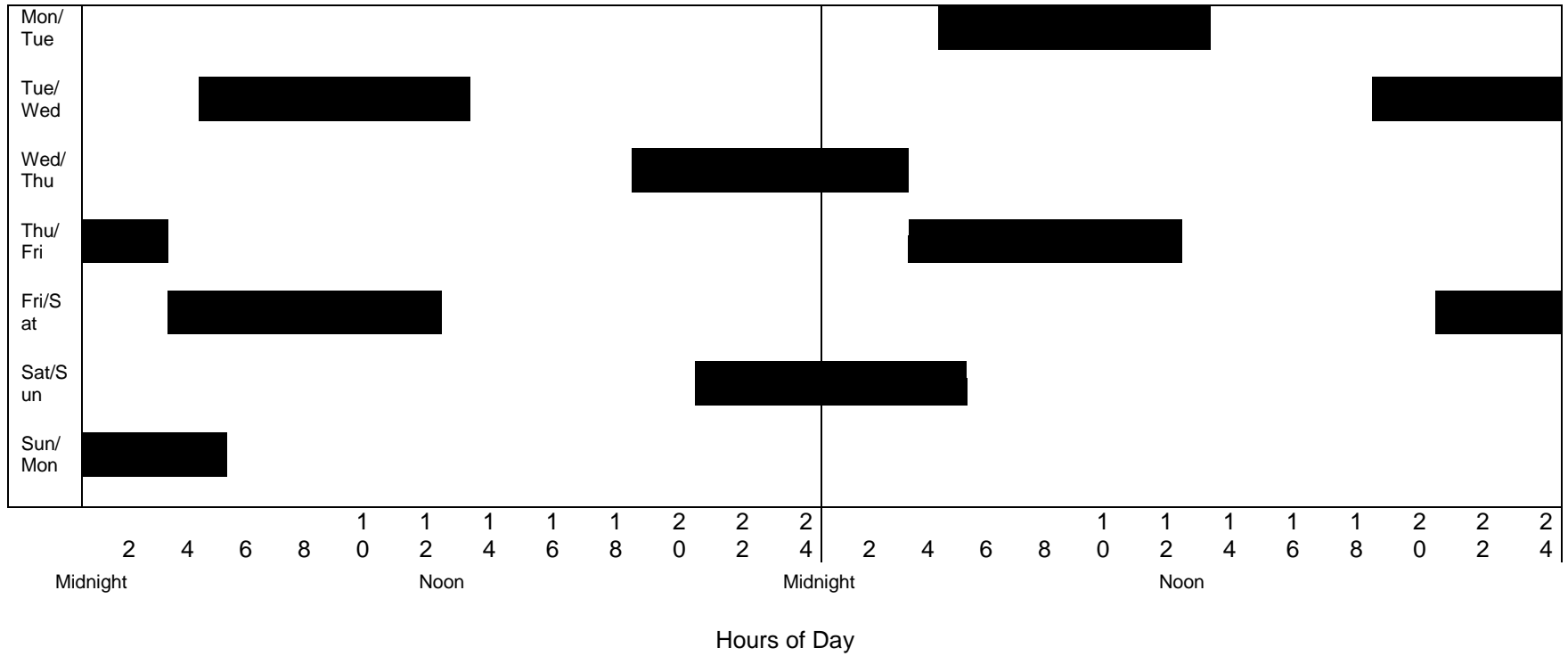


 Working Hours

XESPK51 - Spokane, Washington

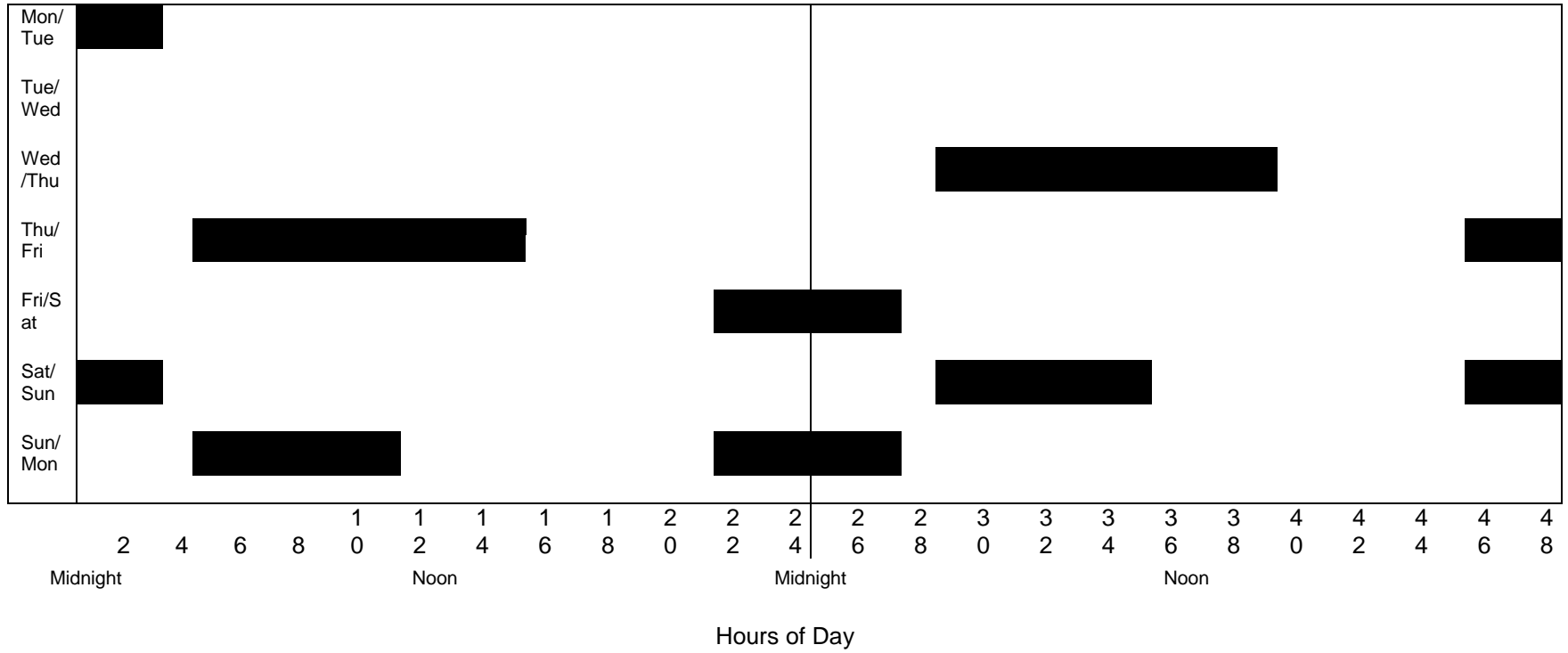


EAN-7 - San Antonio, Texas



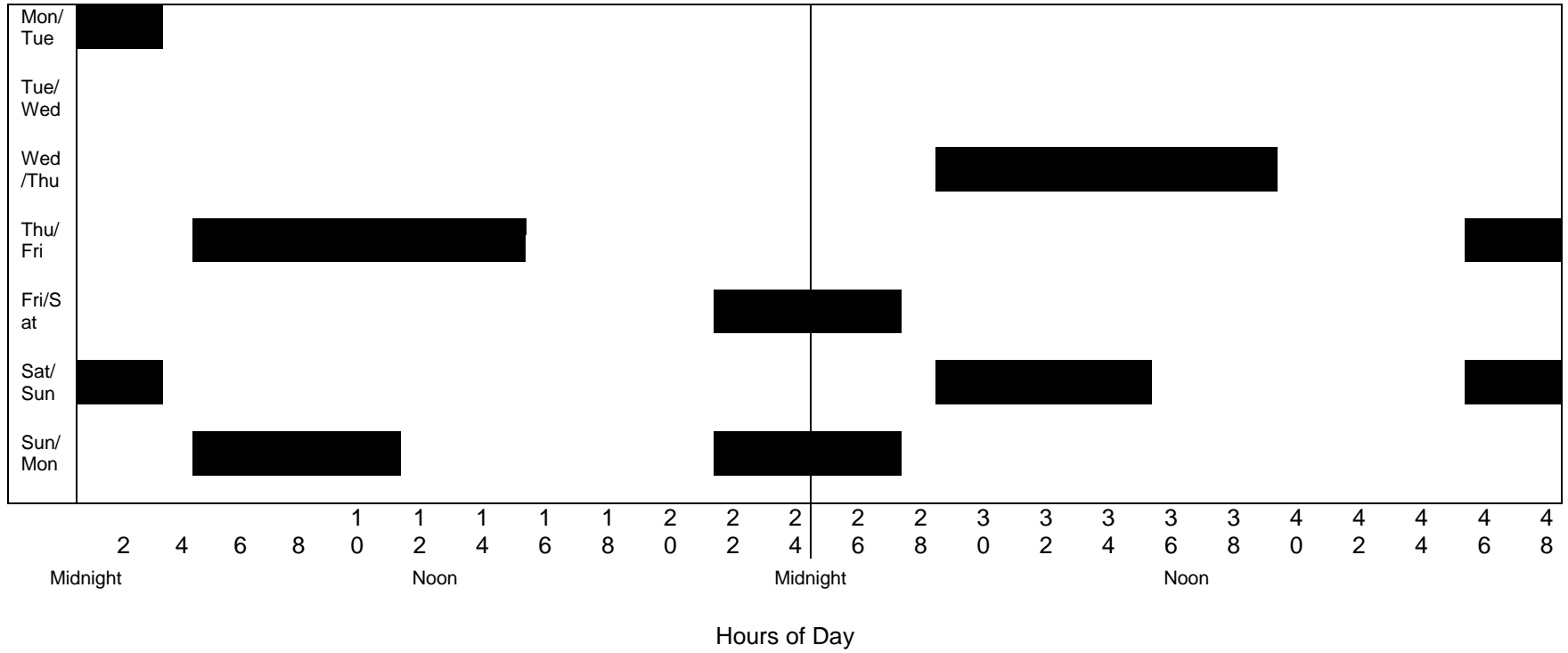
 Working Hours

EAN-5 - San Antonio, Texas



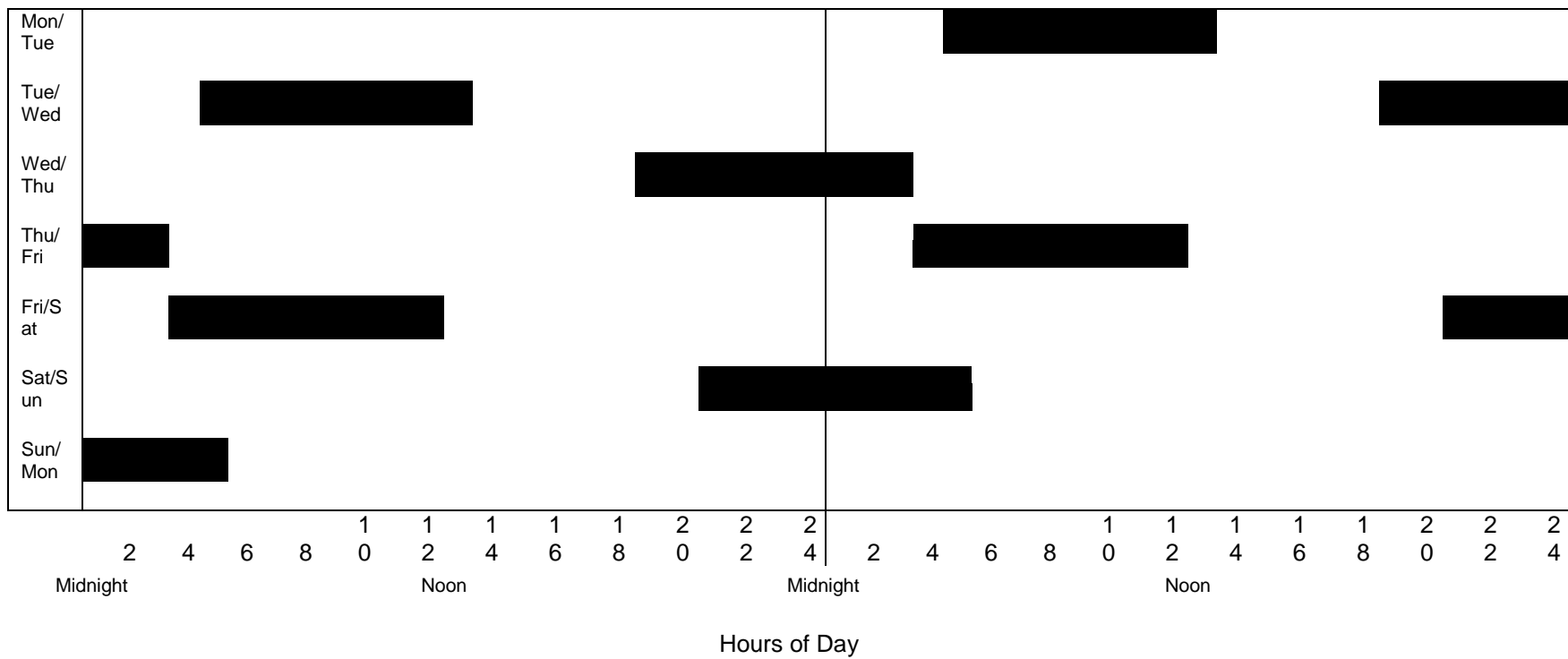
 Working Hours

FAN-5 - San Antonio, Texas

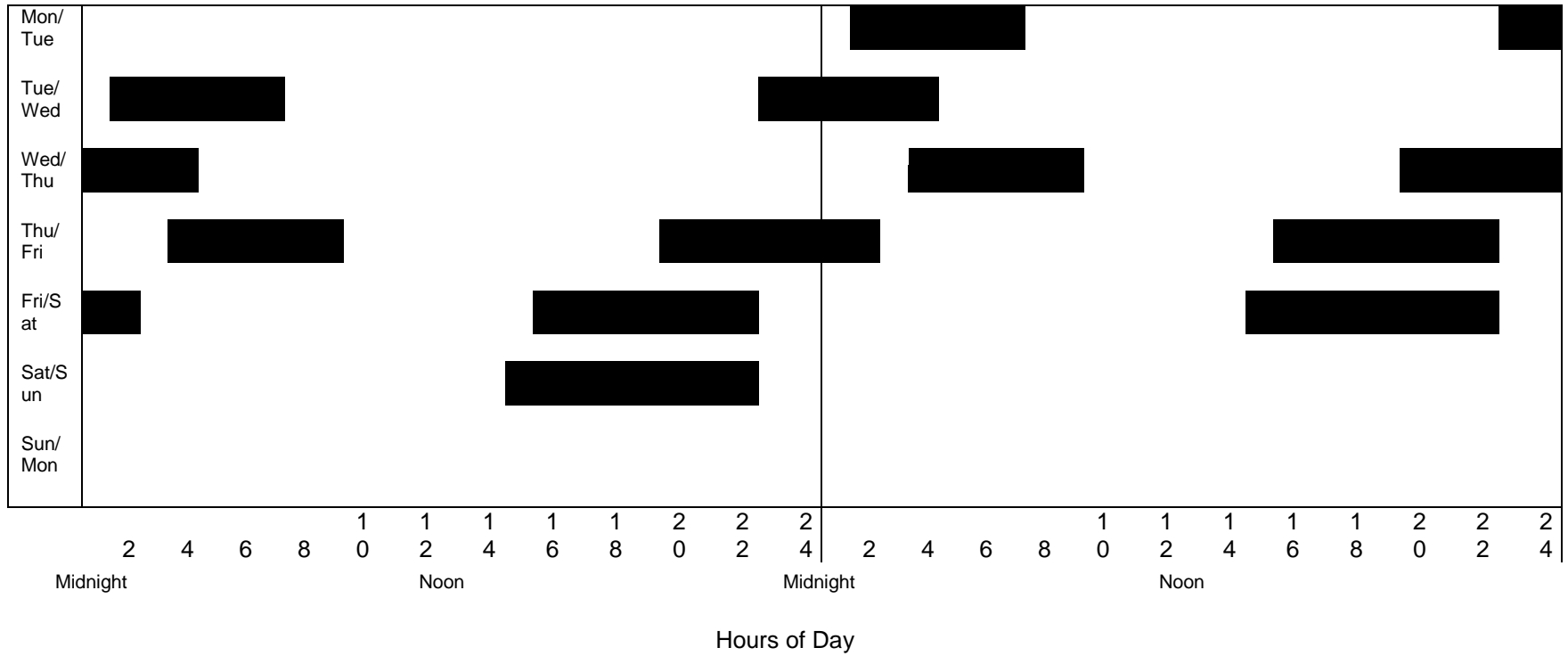


 Working Hours

Fan-7 - San Antonio, Texas

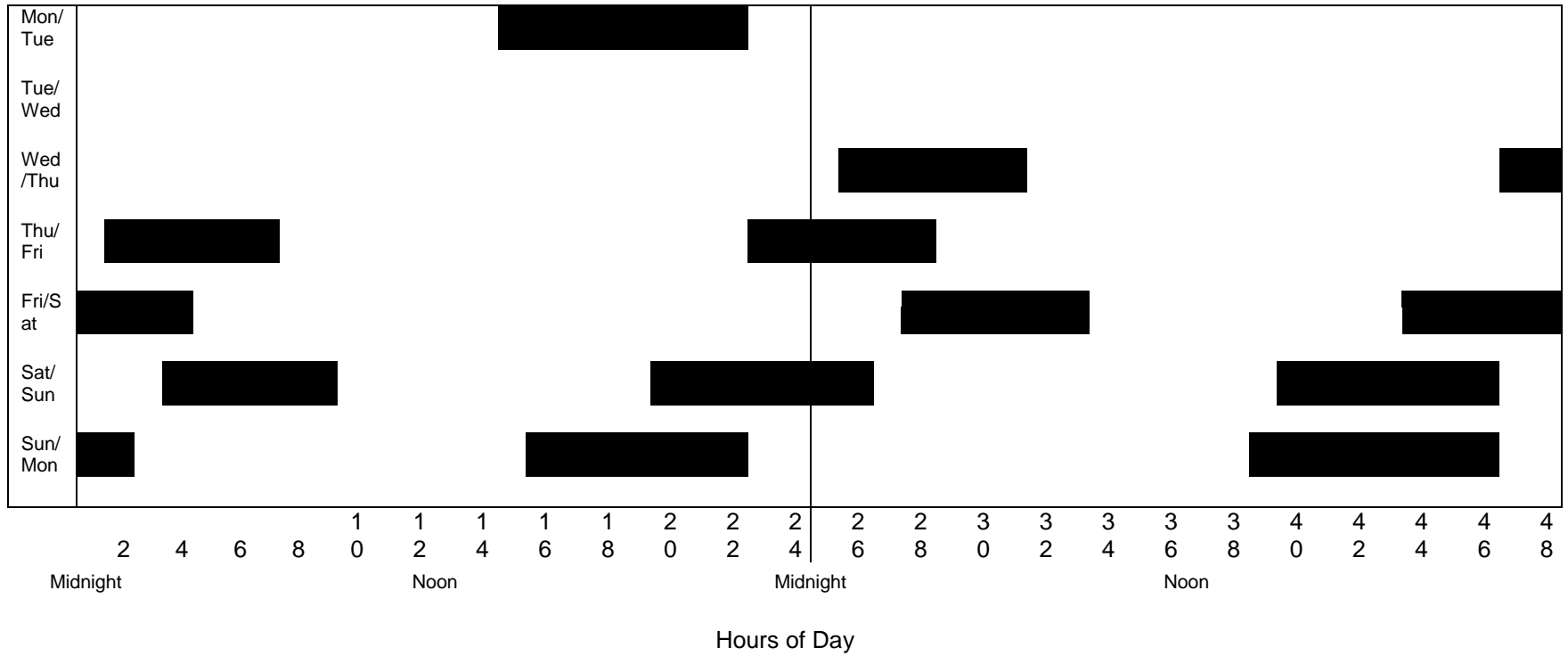


ECDL-2 - Carbondale, IL



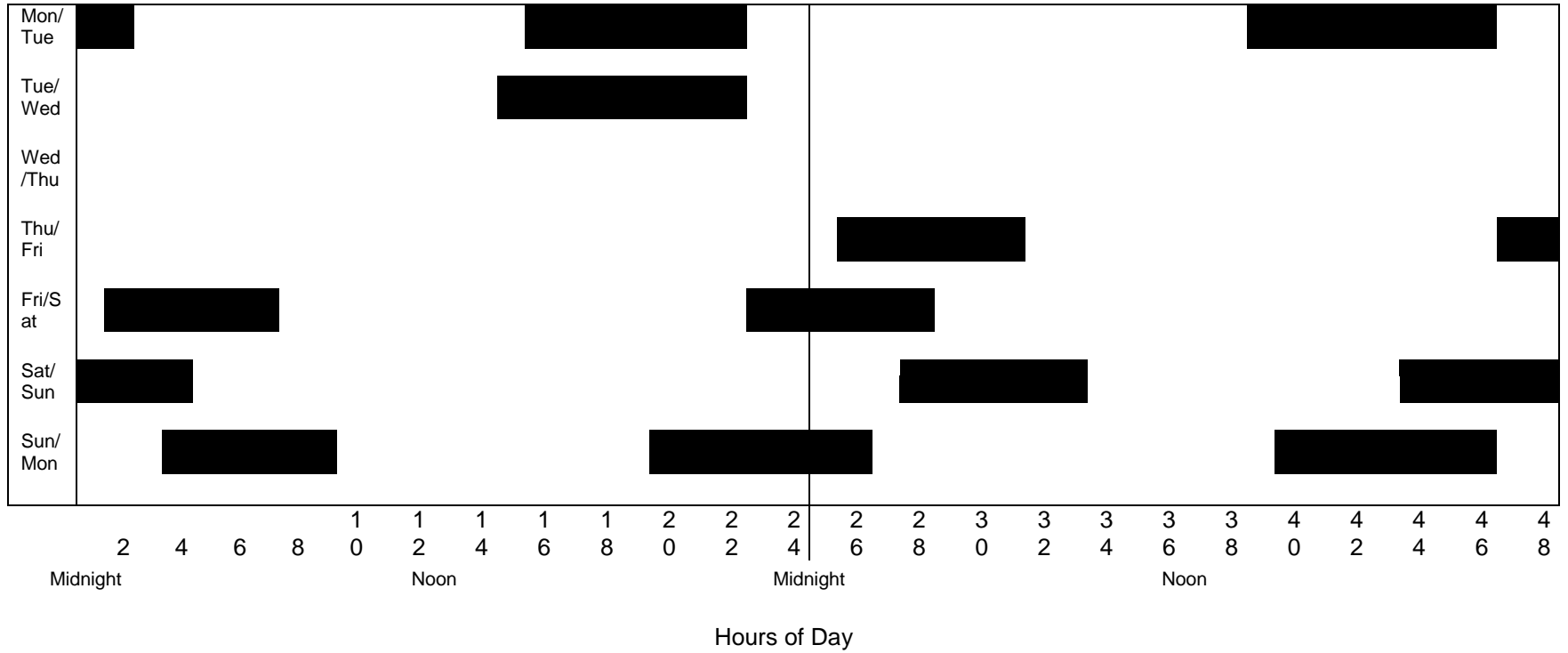
Working Hours

ECDL-4 - Carbondale, IL

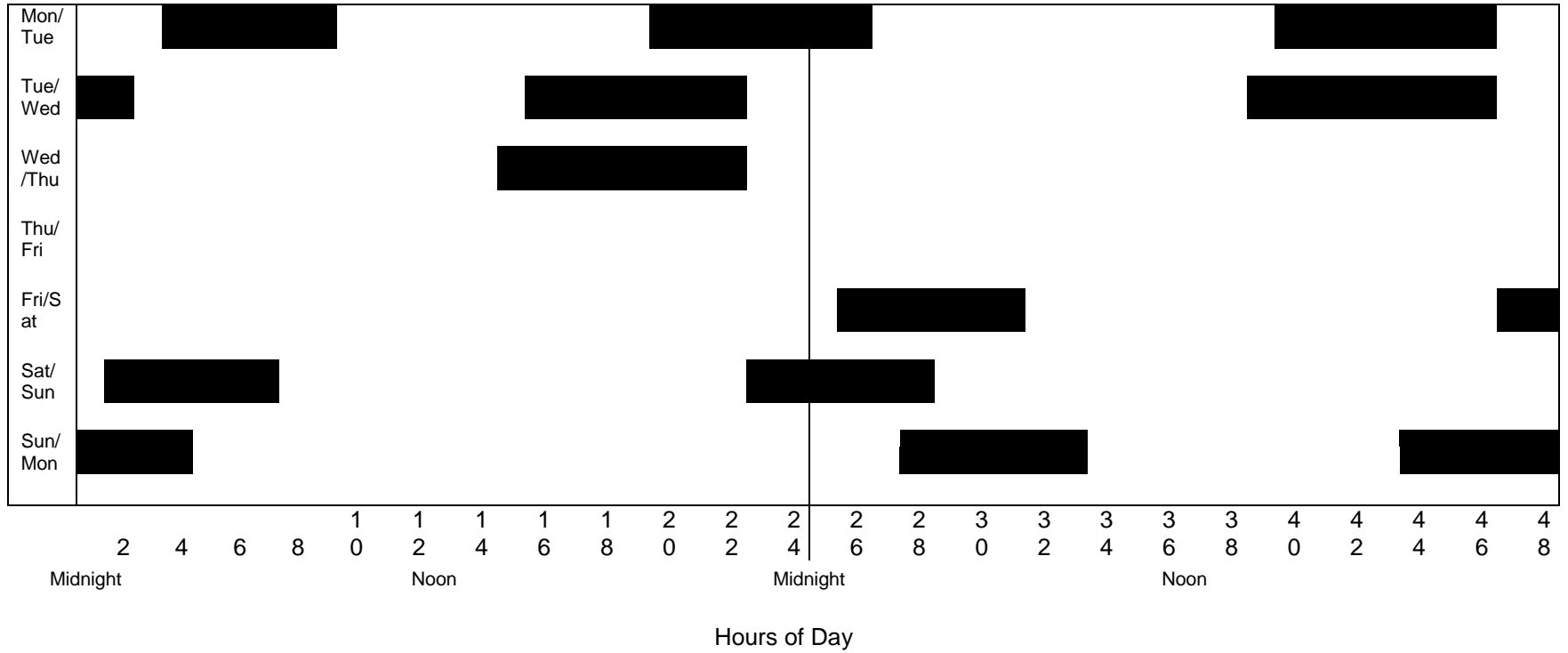


Working Hours

ECDL-5 - Carbondale, IL

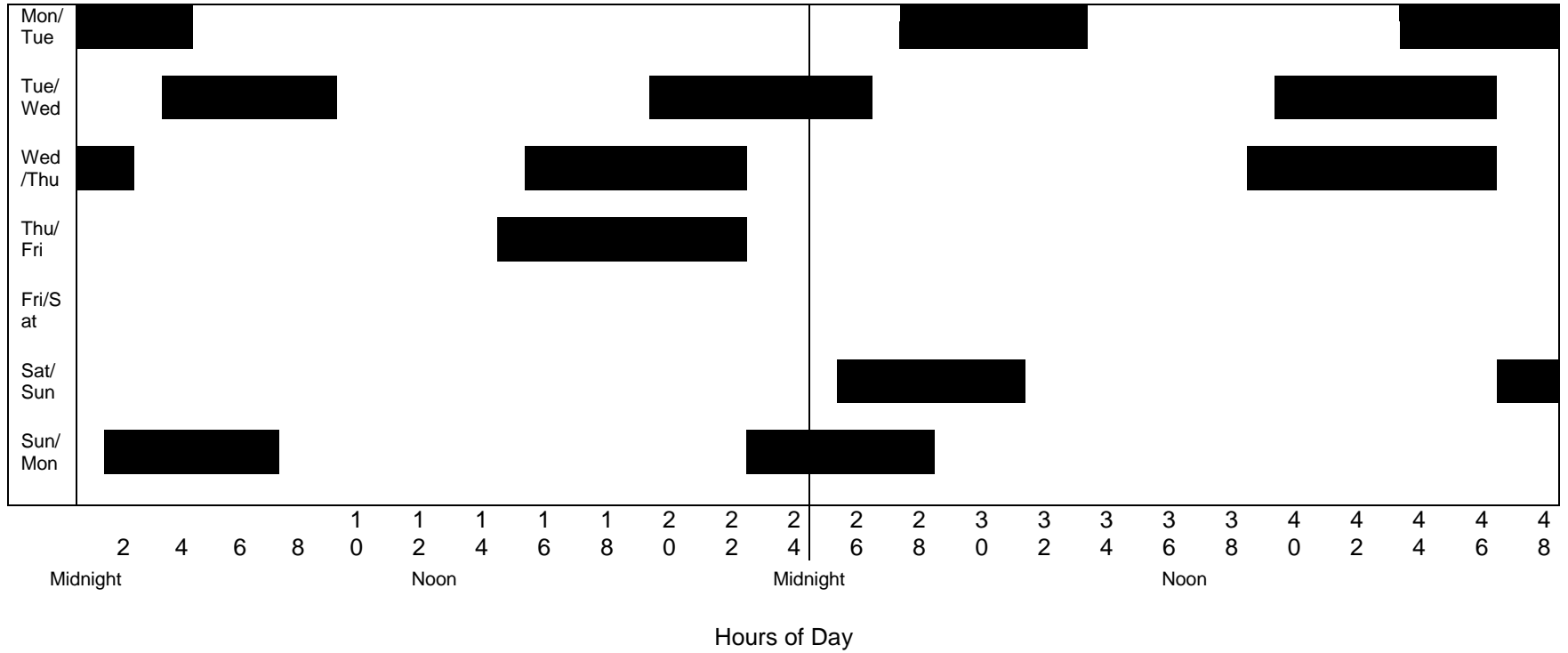



ECDL-6 - Carbondale, IL



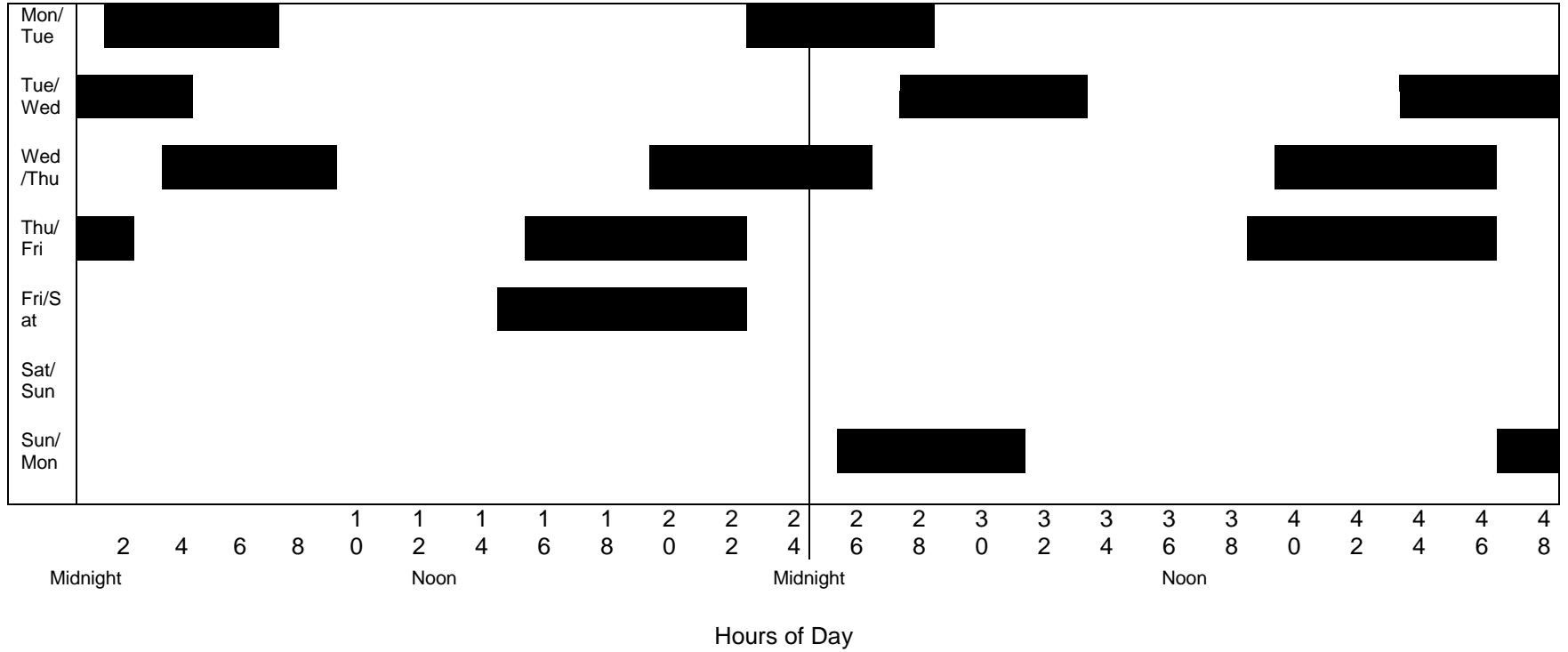
Working Hours

ECDL-7 - Carbondale, IL



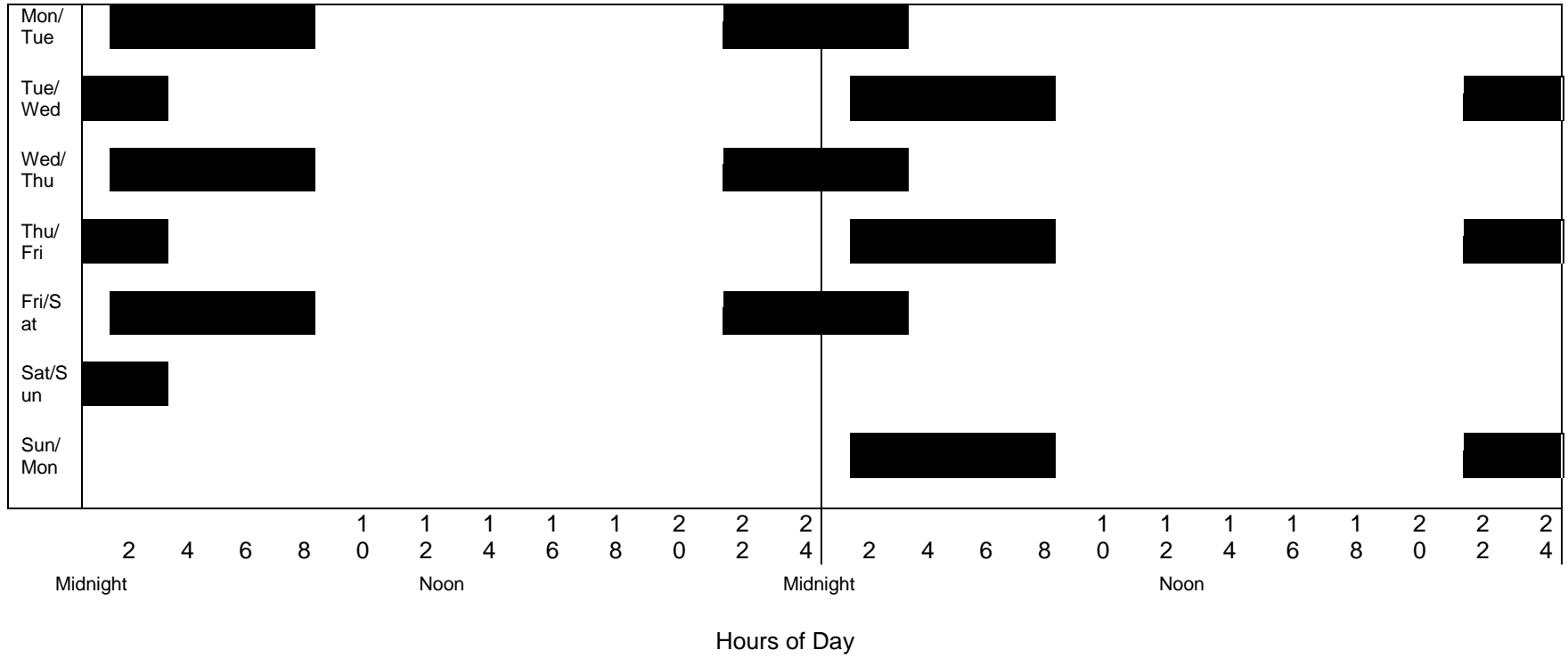
 Working Hours

ECDL-1 - Carbondale, IL



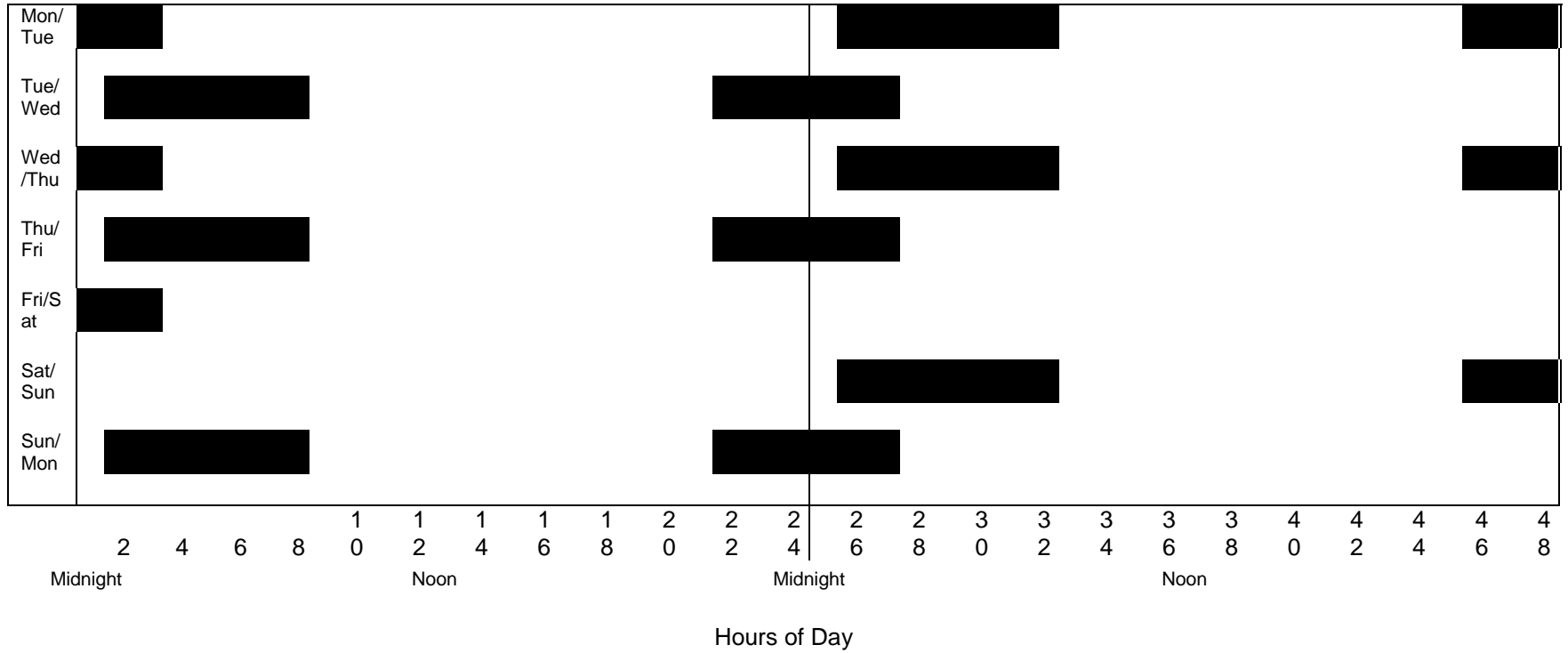
Working Hours


EJL-1 - Jacksonville, FL



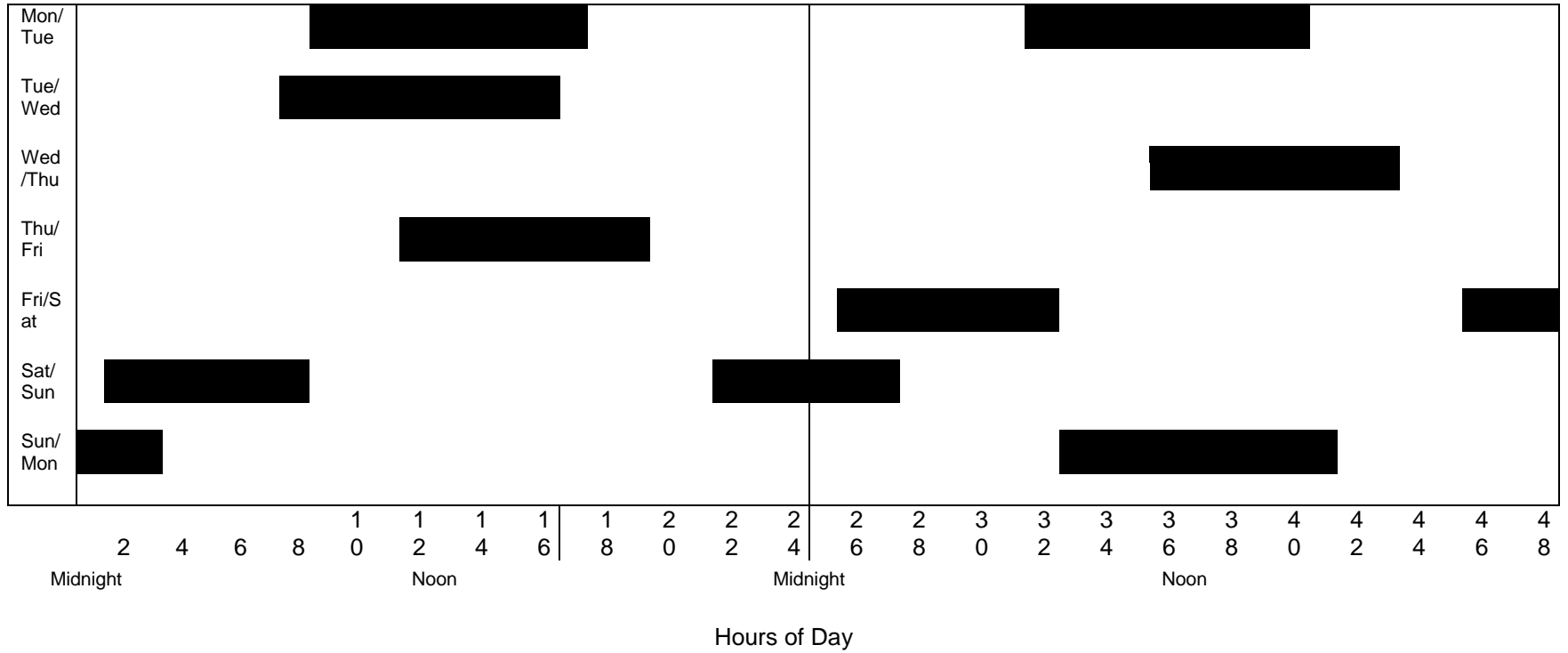
 Working Hours


EJL-2 - Jacksonville, FL



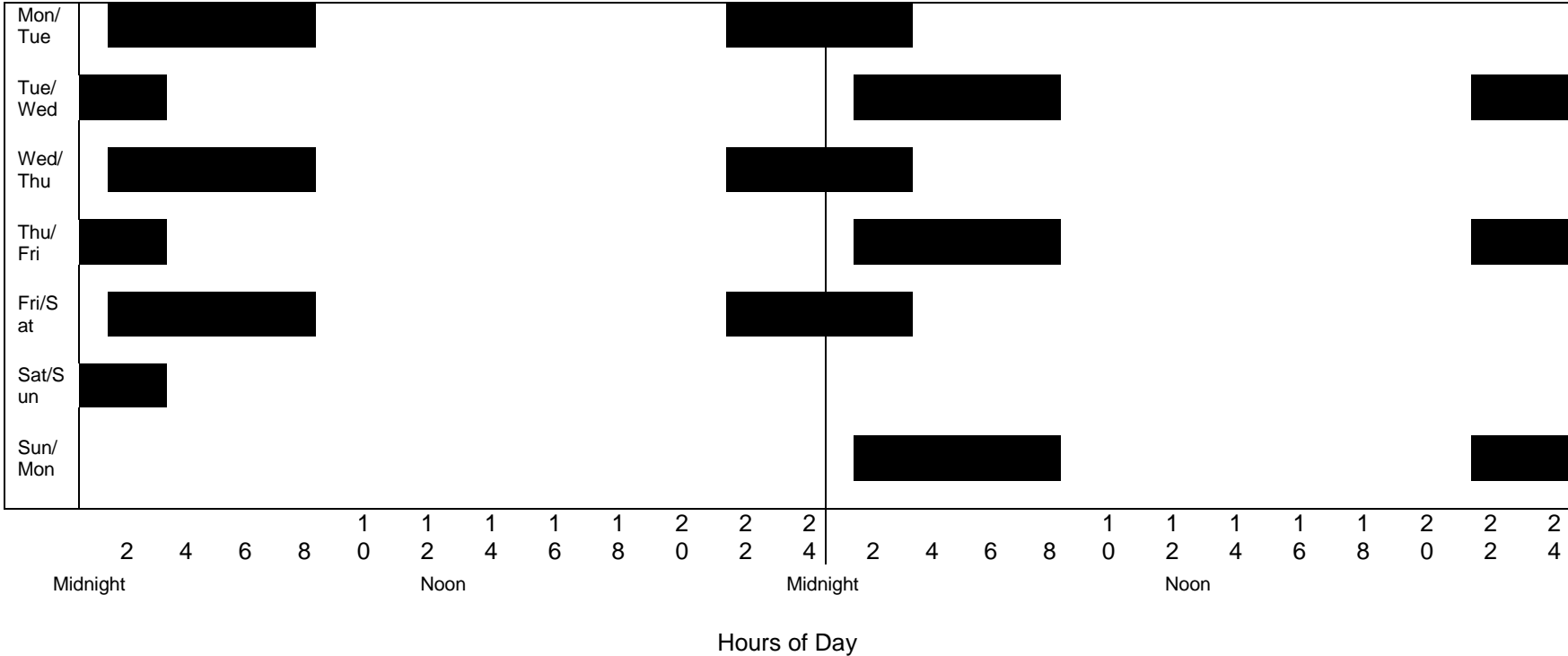
 Working Hours

EJMLR-2 - Jacksonville, FL



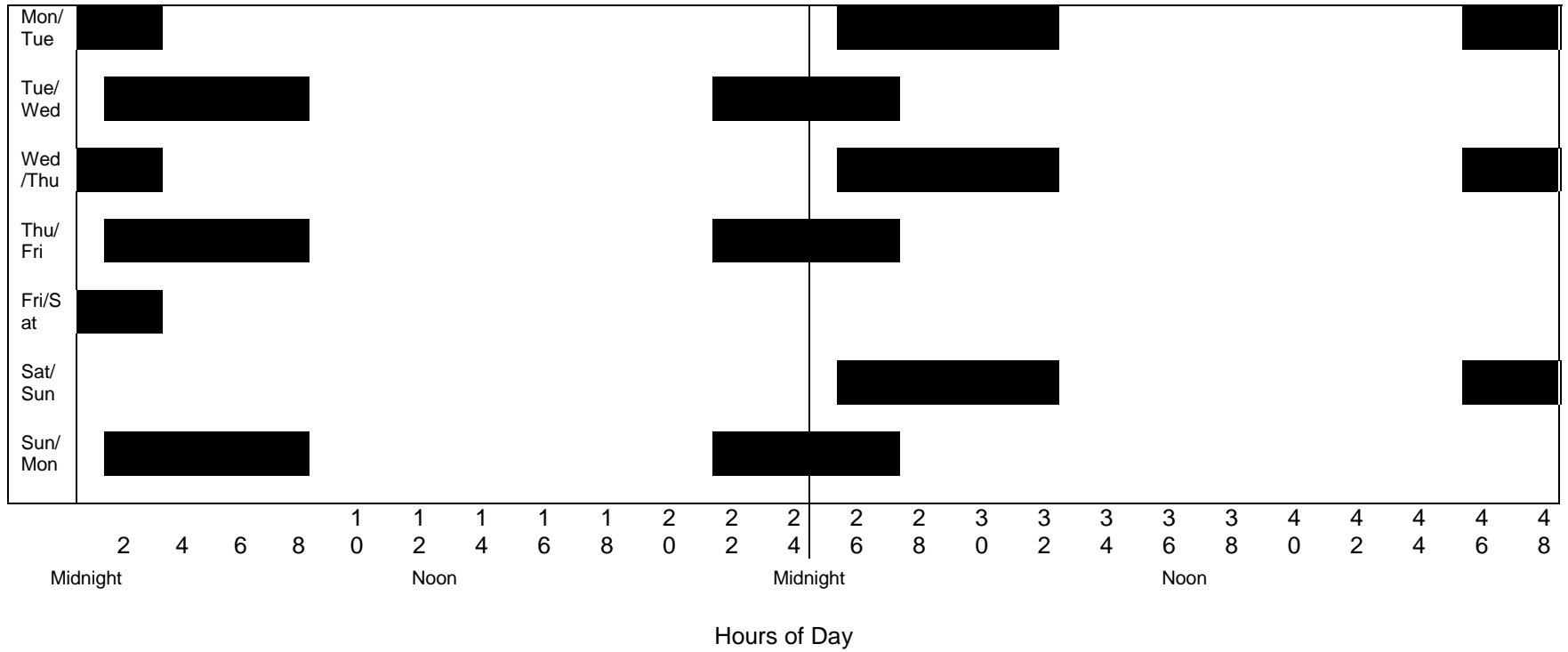
 Working Hours


ESPC-1 - Jacksonville, FL



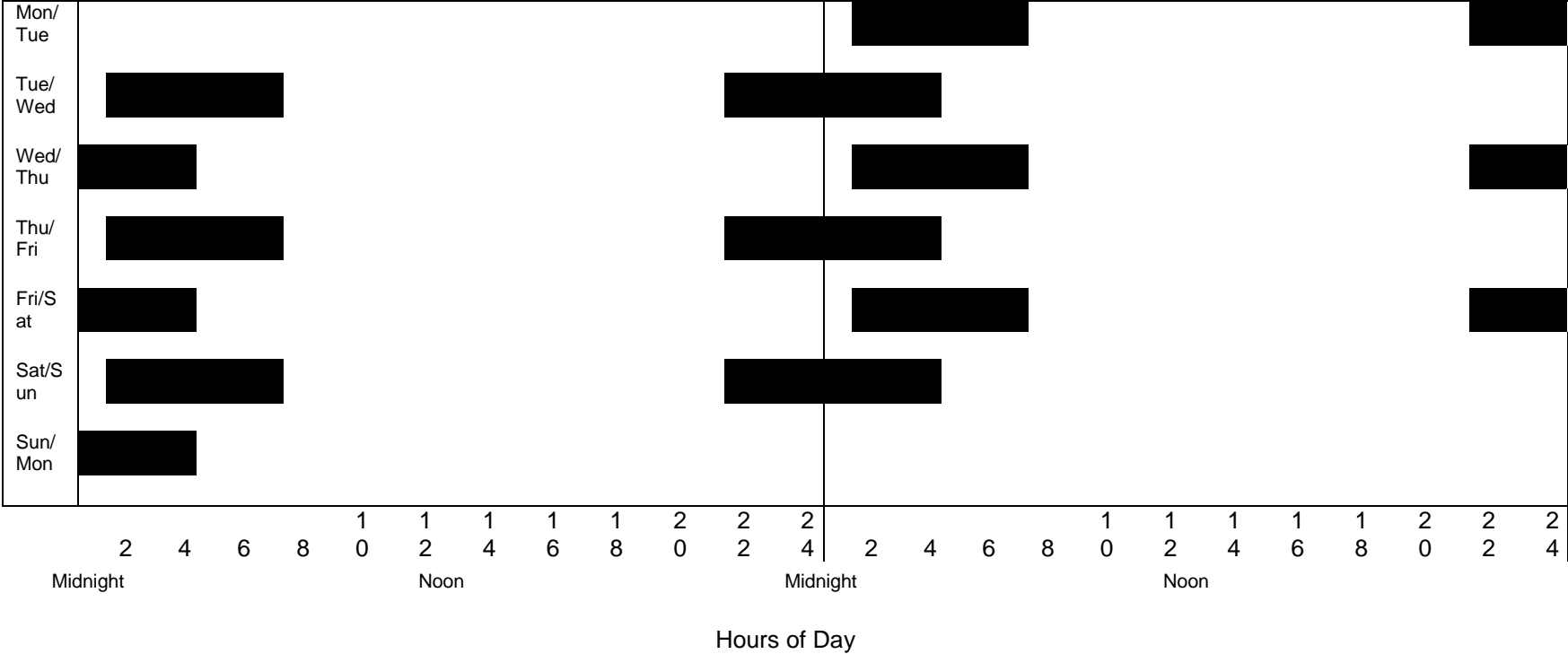
 Working Hours

ESPC-2 - Jacksonville, FL

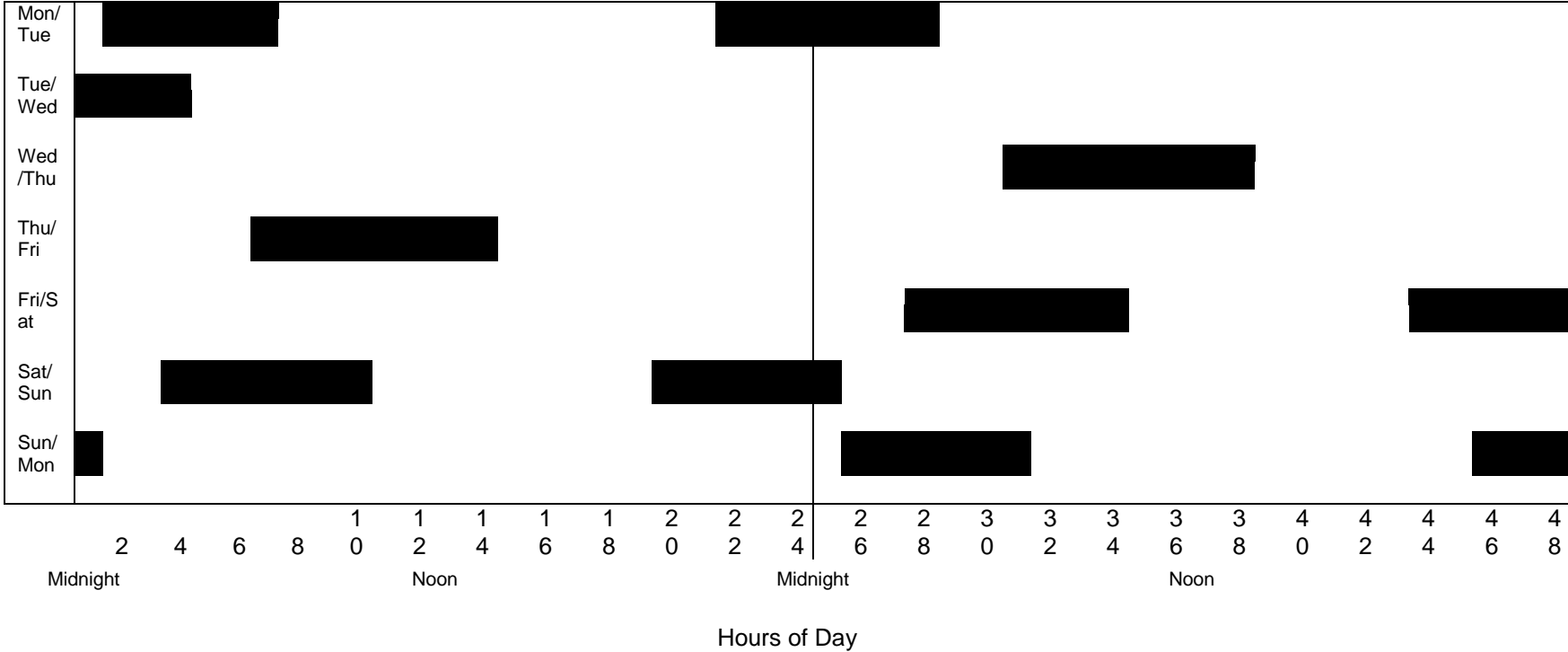


 Working Hours

ECW-04 - Charlottesville, VA

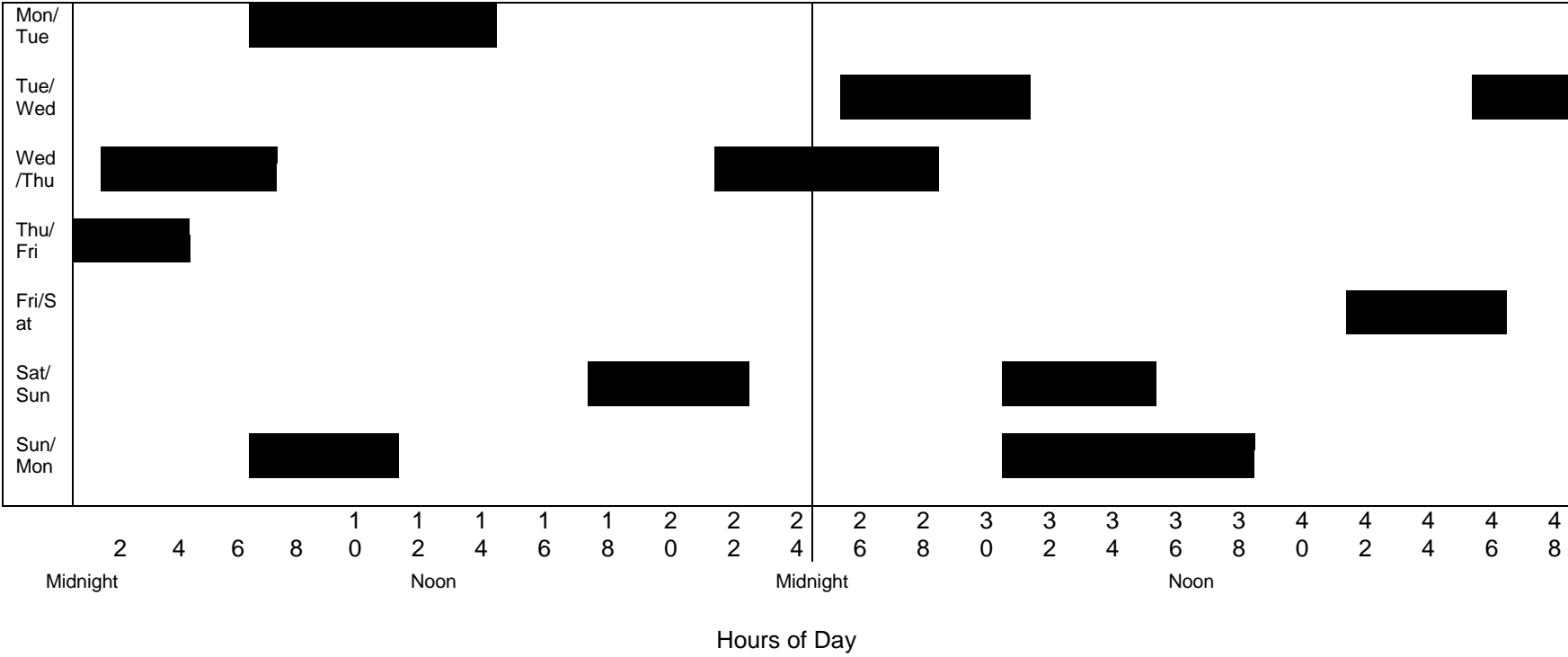



ECW-06 - Charlottesville, VA



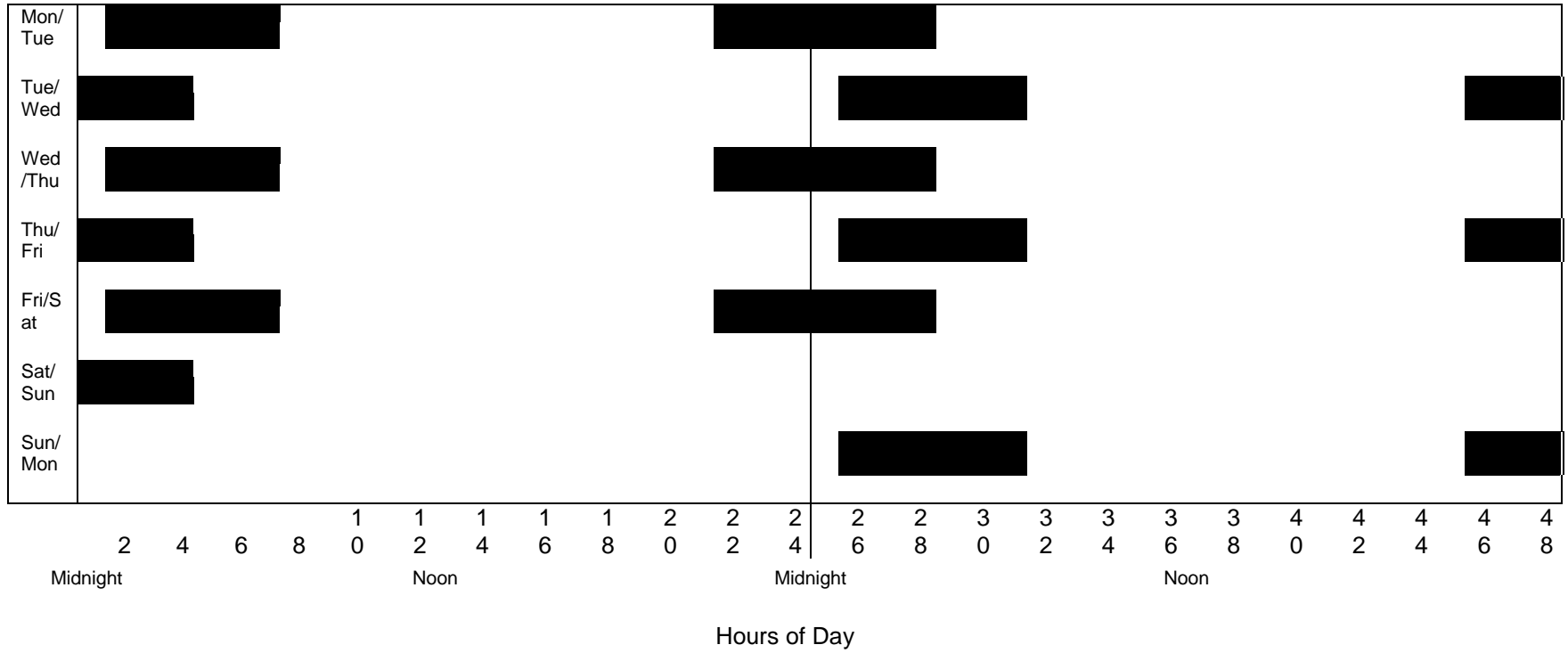
 Working Hours

ECWR-2 - Charlottesville, VA



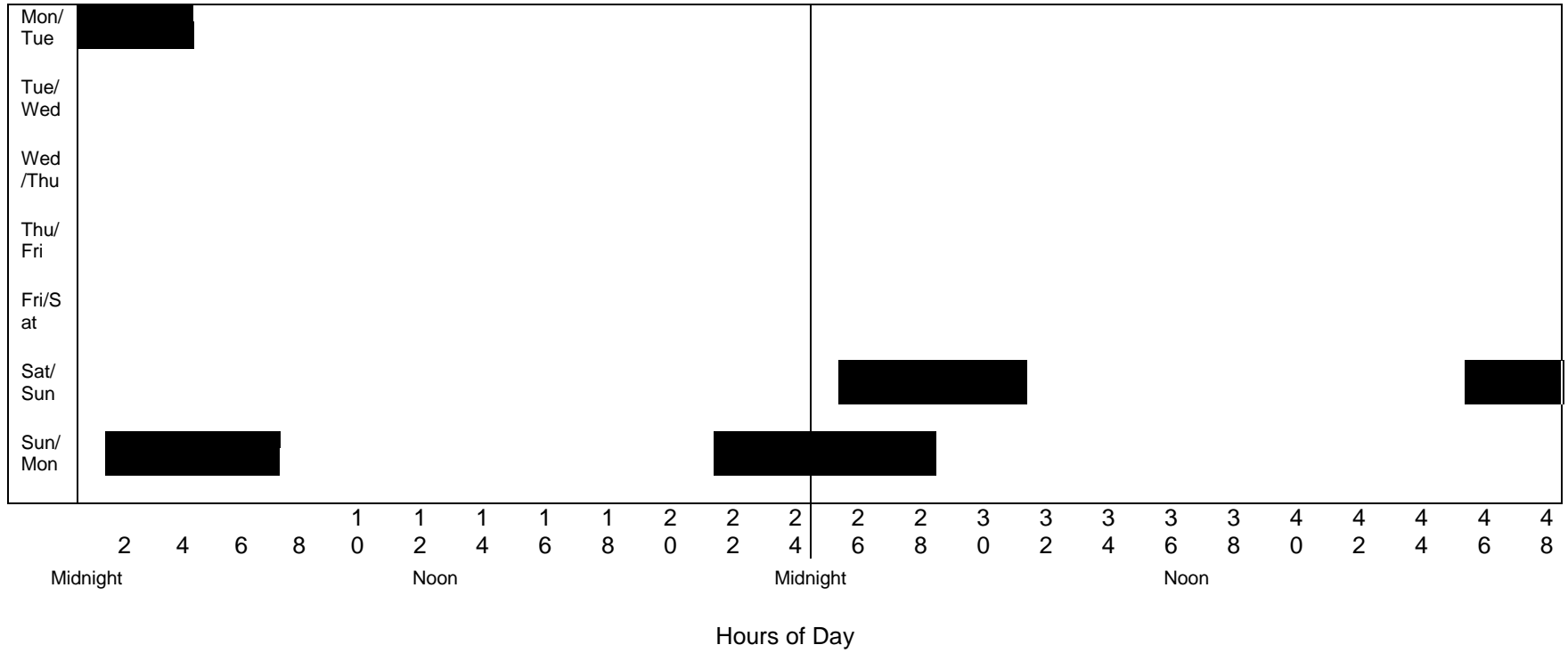
 Working Hours

XFCW-51 - Charlottesville, VA



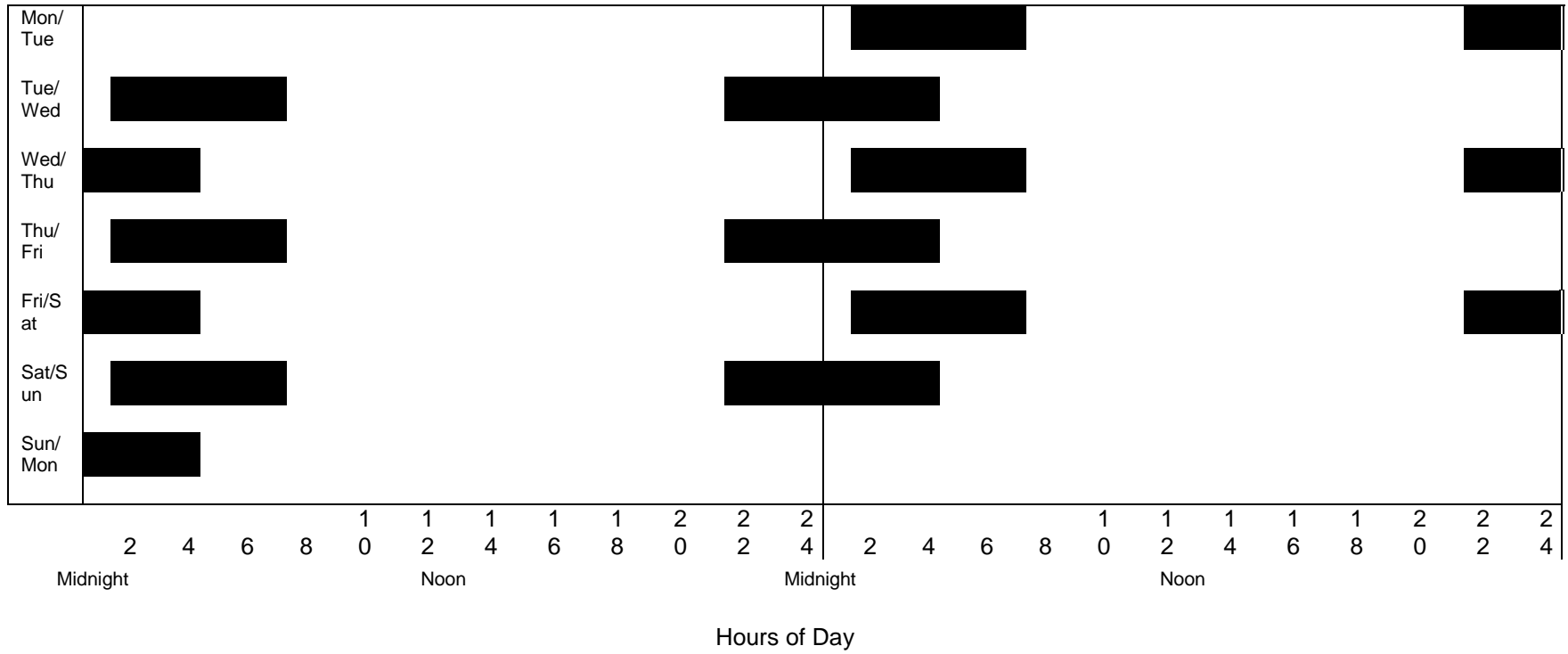
 Working Hours

XFCW-52 - Charlottesville, VA



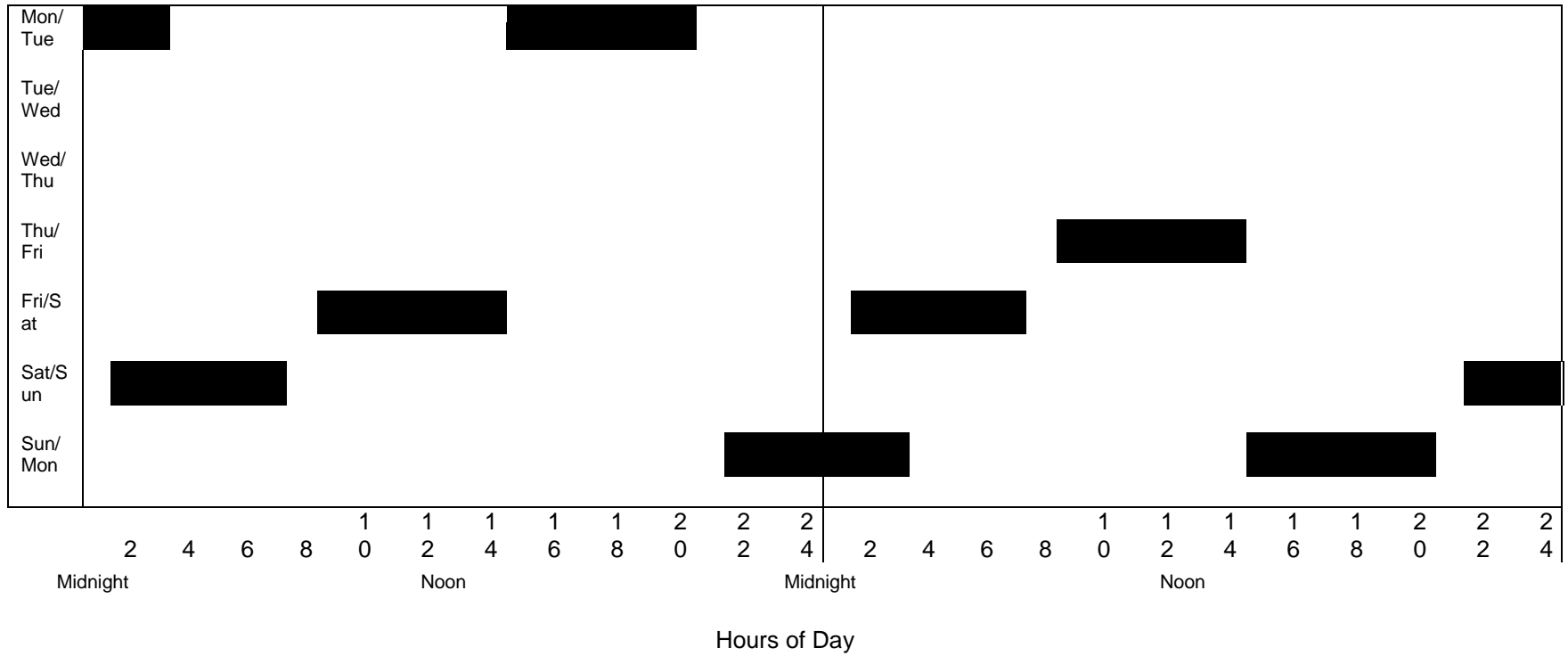
 Working Hours

XFCW-50 - Charlottesville, VA



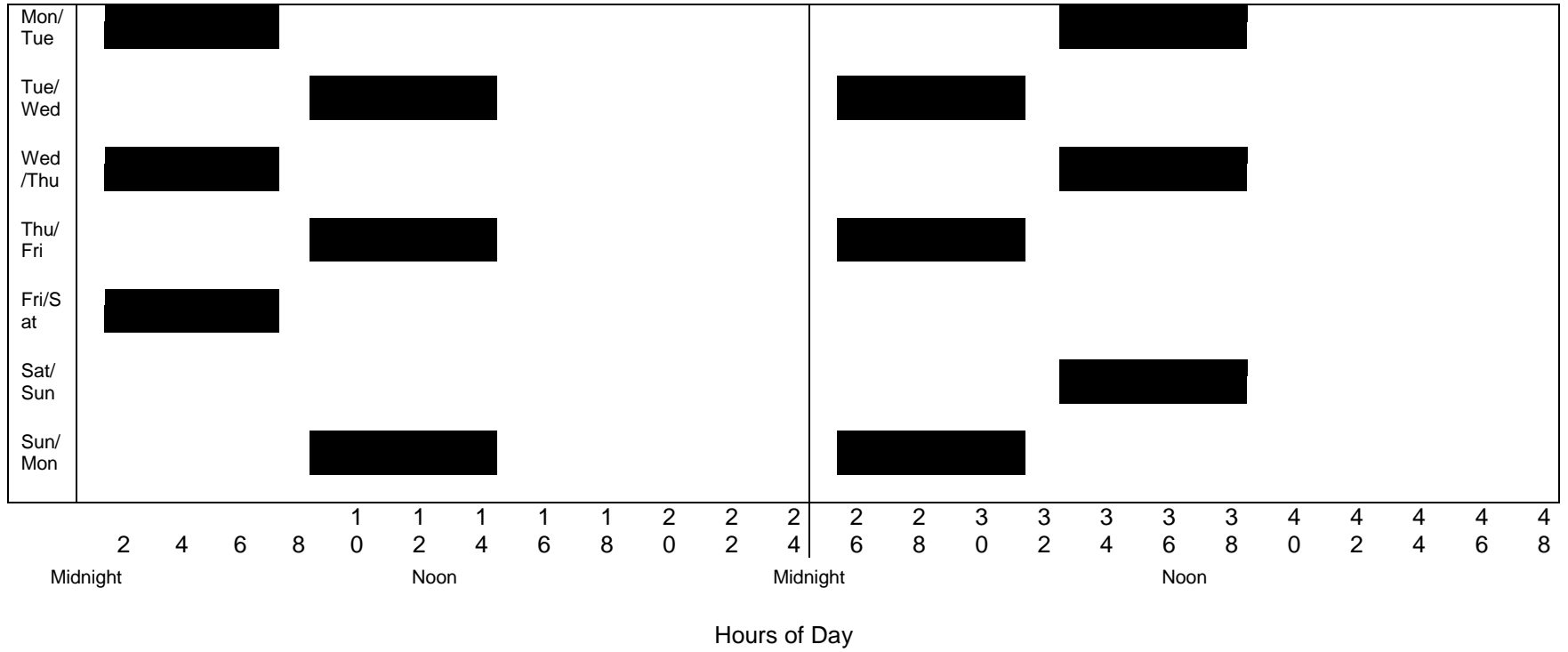
 Working Hours


E03-FL5 - Florence, SC - Richmond, VA



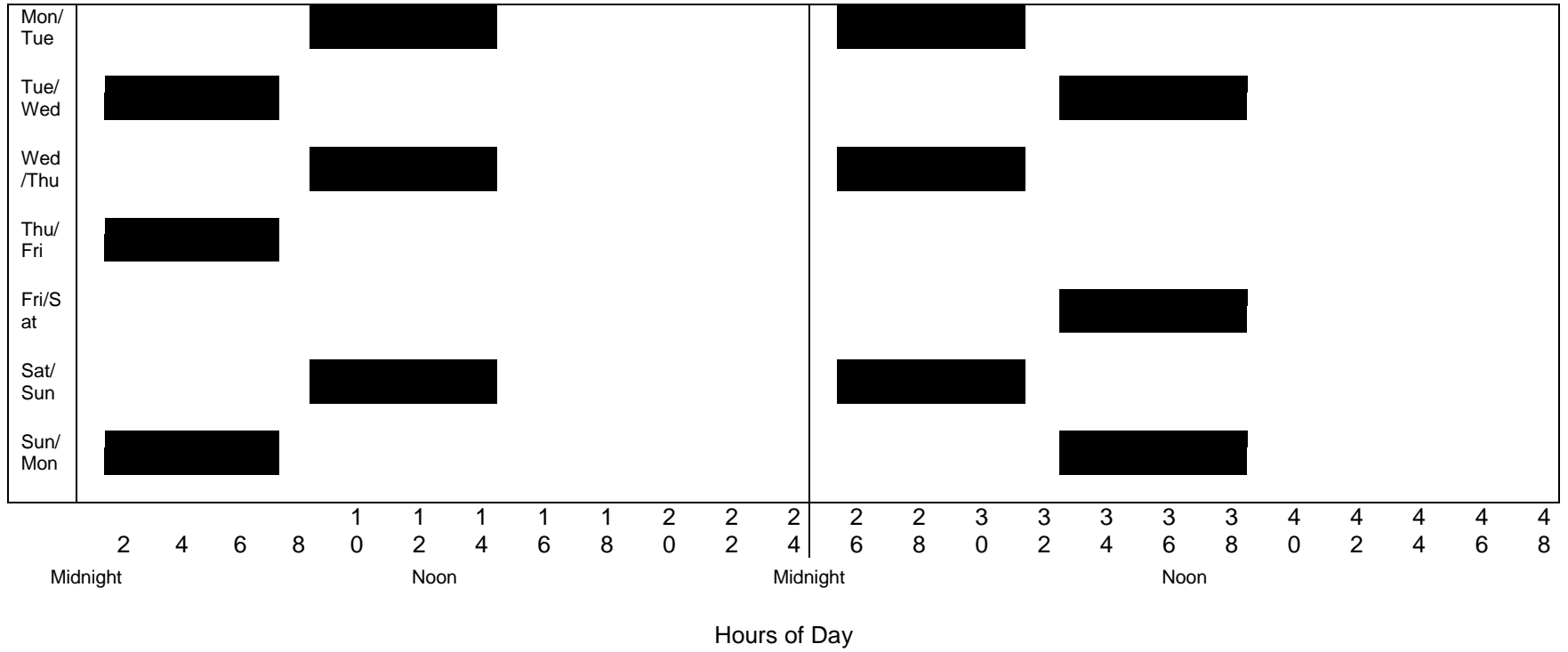
 Working Hours

EFR-01 - Florence, SC - Richmond, VA



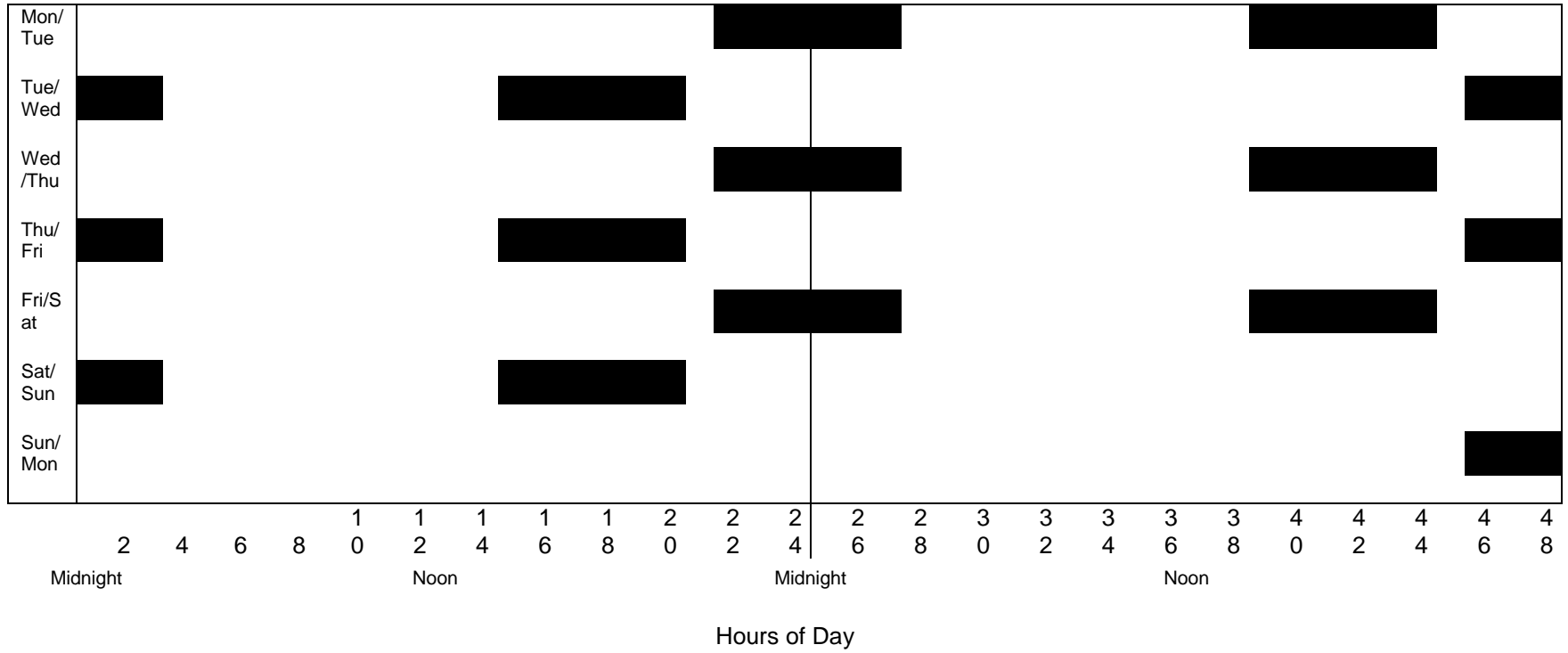
 Working Hours

EFR-02 - Florence, SC - Richmond, VA



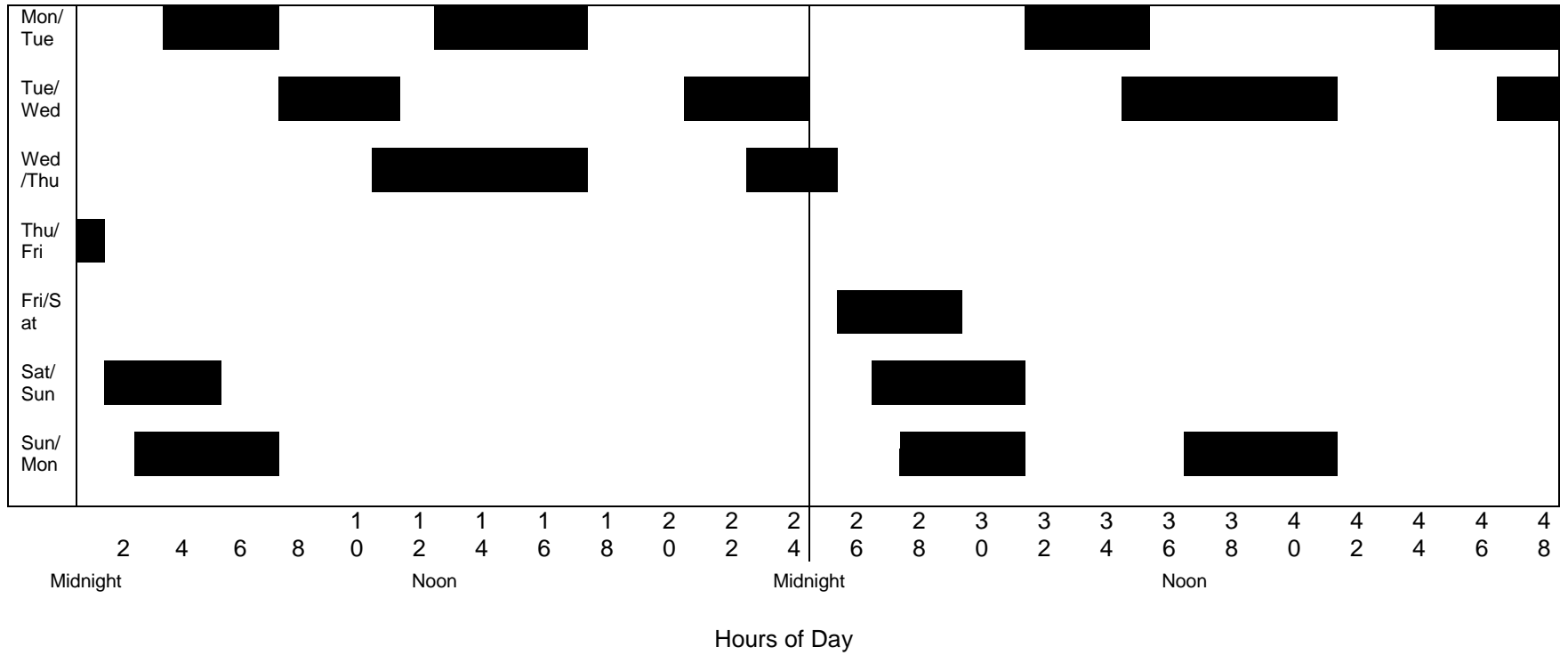
 Working Hours


EFR-03 - Florence, SC - Richmond, VA



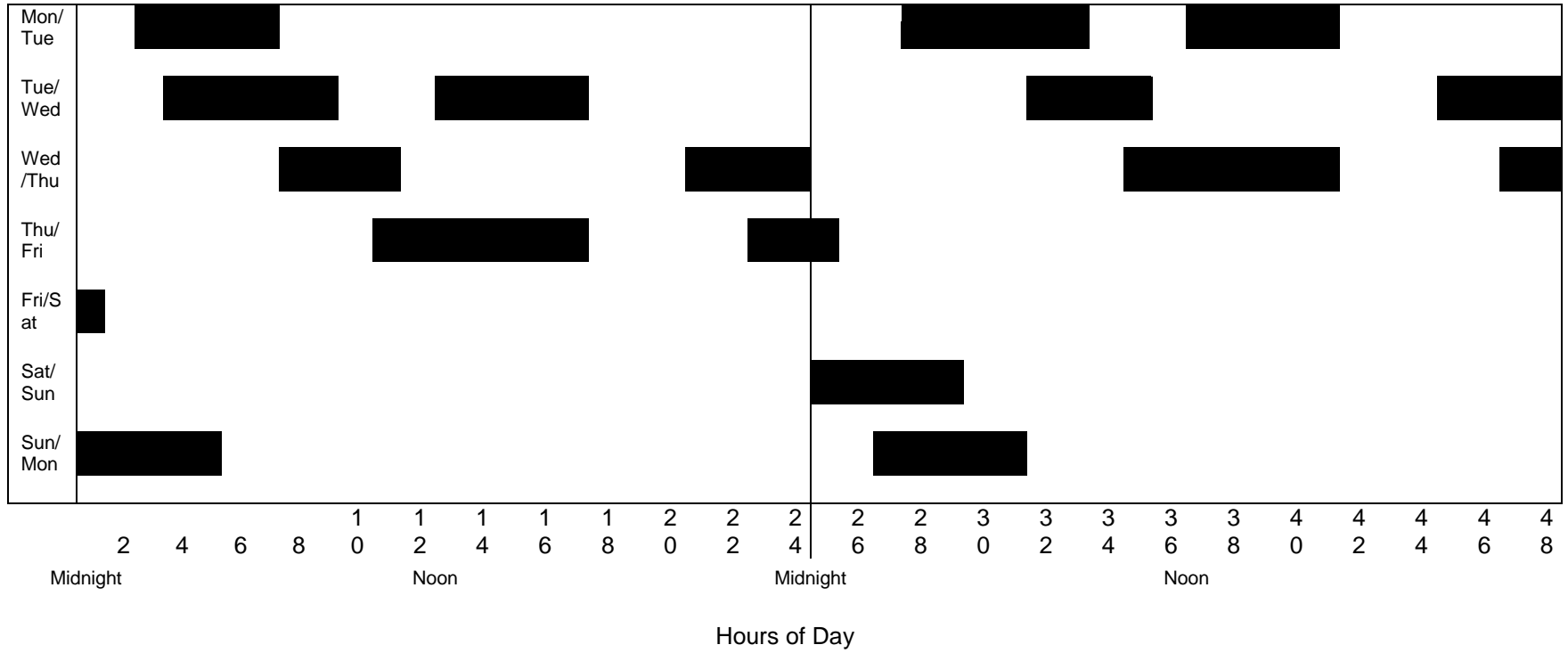
 Working Hours

EBS-40 - Buffalo, NY

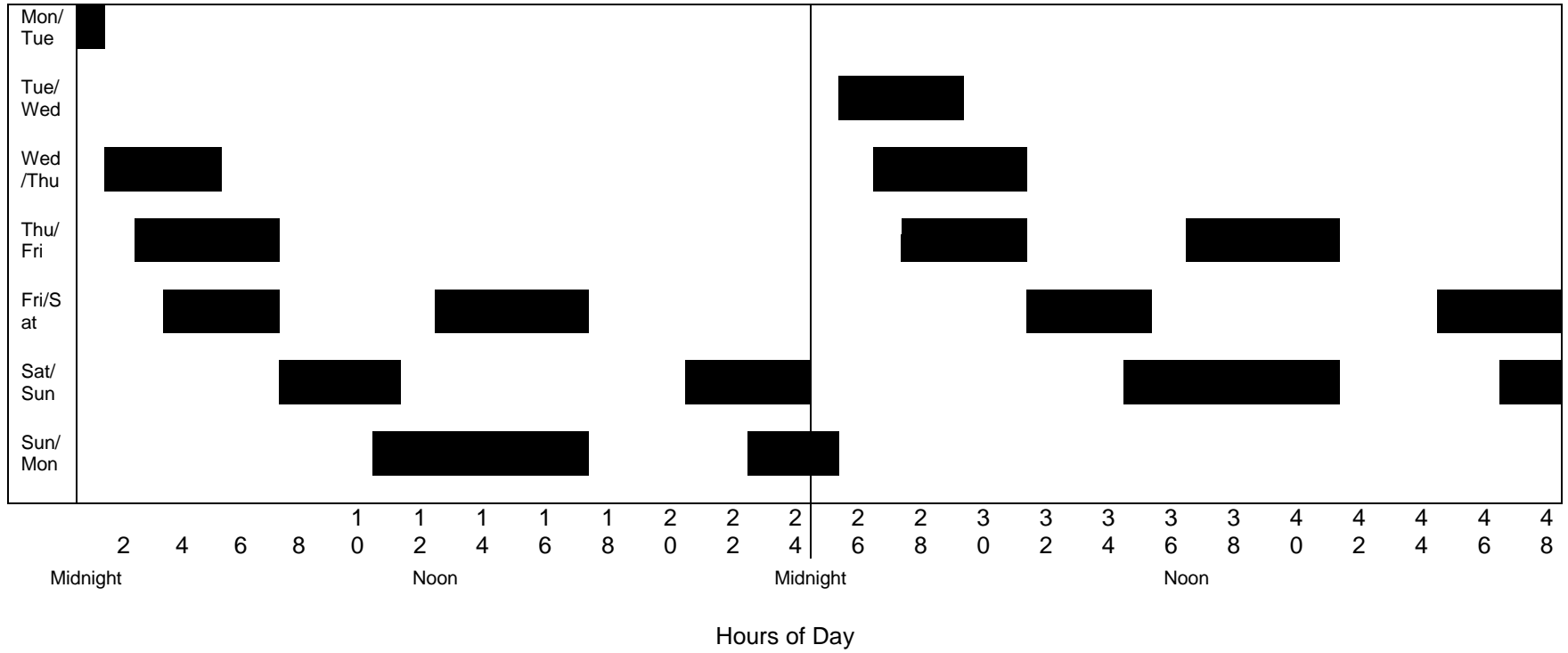



 Working Hours

EBS-41 - Buffalo, NY

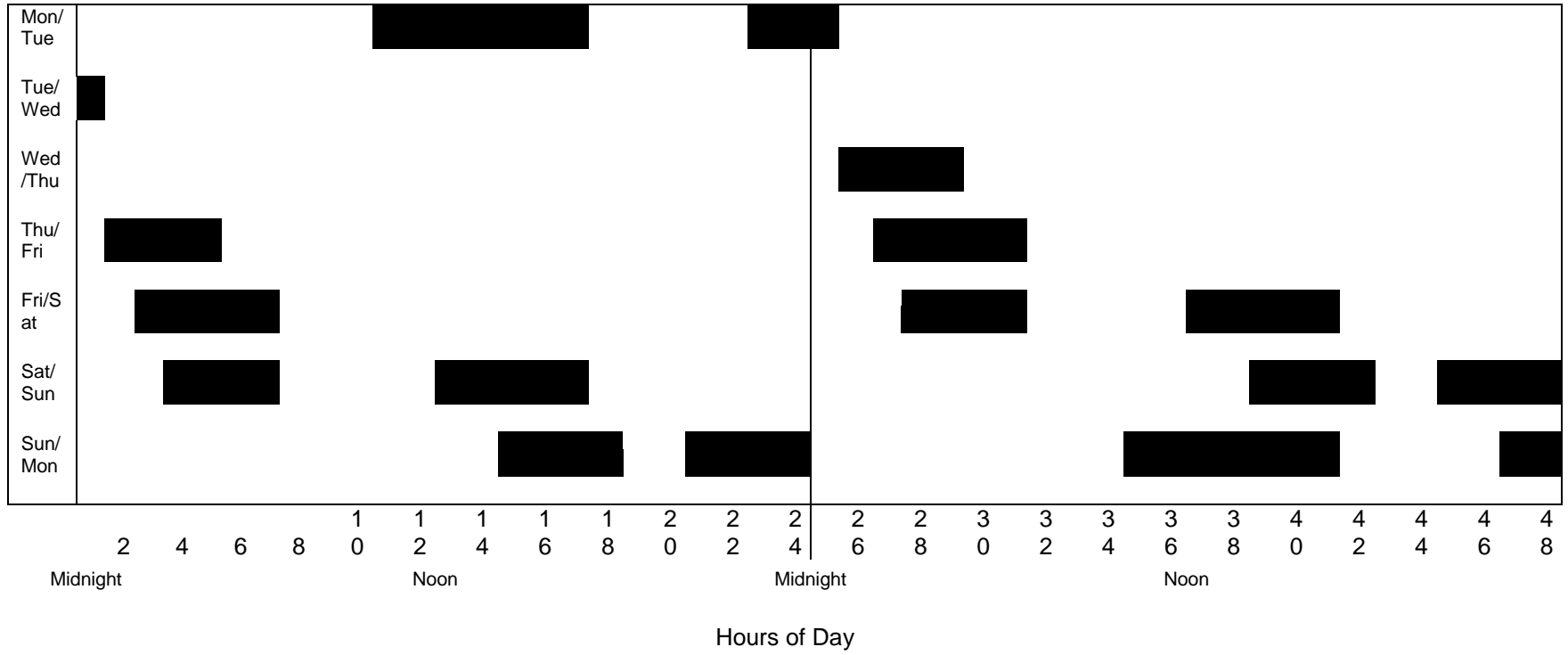



EBS-44 - Buffalo, NY



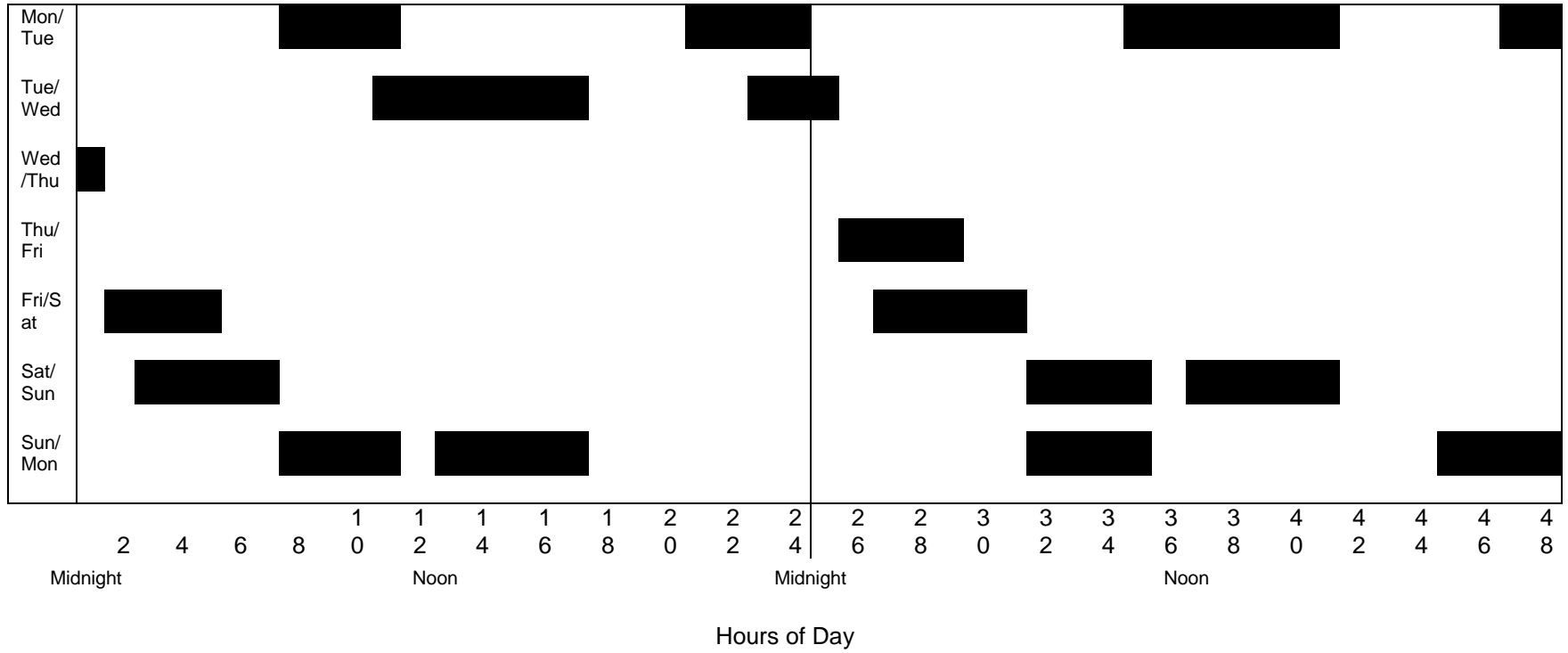
 Working Hours


EBS-45 - Buffalo, NY



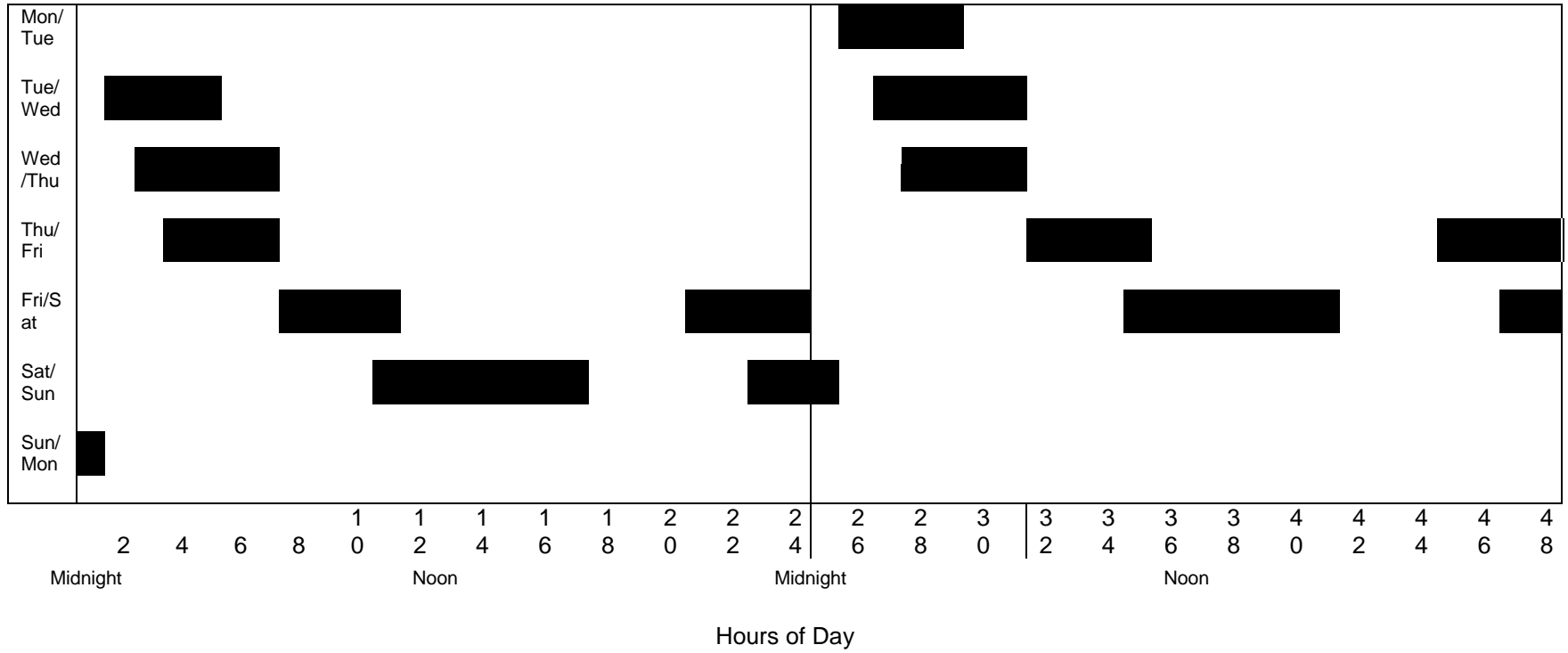
 Working Hours

EBS-46 - Buffalo, NY



 Working Hours

EBS-43 - Buffalo, NY



 Working Hours