

## MEMORANDUM

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**To:** Chris Pinney (U.S. Army Corps of Engineers)      **Date:** June 29, 2016  
**From:** Dalton Hance (Anchor QEA, LLC)      **Project:** 151163-01.01  
**Cc:** Joe Miller, Josh Murauskas, Sam Haffey, Mark Weiland,  
Pradeep Mugunthan and Larissa Rohrbach (Anchor QEA);  
Peter Johnson (LGL);  
Geoff McMichael (Mainstem Fish Research);  
Rich Townsend (University of Washington)  
**Re:** Lower Granite Dam Adult Passage and Post-passage Temperature Evaluation  
Weekly Report

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### OVERVIEW

This is the weekly summary report for Week 25, 2016.<sup>1</sup> The report content has been updated to provide a combined status report for two Lower Granite Dam (LGR) projects: (1) the Sound and Vibration Passage Study; and (2) the Post-passage Temperature Study. The data reported here include construction activities, underwater sound and vibration measured in the LGR adult fish ladder, water temperatures, and fish passage through the LGR adult fish ladder. These data are preliminary and may be subject to change.

### Sound Levels in the Fish Ladder

Sound-measuring instruments are deployed at four locations to measure sound-induced ground and structure motion. Three of these locations are within the adult fishway and are equipped with sensors that measure sound-induced pressure waves within the water. Each location has instruments that measure vibrations in the ladder walls and sound pressure in the water. Sound moving through the ladder walls causes the walls to vibrate, and these vibrations are measured by triaxial accelerometers. Sound vibrating the ladder walls could potentially enter the water. Sound transmitted into the water in this way consists of both water particle movements and sound pressure. The pressure component of the sound field is

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<sup>1</sup> Week 25 is the period from midnight (00:00:00) Monday, June 20, 2016, to immediately prior to midnight (23:59:59) Sunday, June 26. Fish passage statistics encompass the non-trapping period from Friday, June 17, 14:00 to Sunday, June 19, 14:00 and the trapping period from Sunday, June 19, 14:00 to Friday, June 24, 14:00.

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measured by a series of three hydrophones deployed in the water at each of the fish ladder sound-monitoring locations.

Sound data generated by this monitoring program are intended to assess if sound and vibration enter the fish ladder and whether these are intense enough to be detected by fish transiting the ladder. Salmon hearing is not sensitive to the pressure component of sound but rather the particle motion component of sound. For this reason, data from the three triaxial accelerometers in the fish ladder are shown to depict vibrations traveling through the walls of the ladder and potentially transferring to the water as particle motion. Figure 1 shows the peak acceleration levels of the vibrations, which is a measure of the maximum sound amplitude per measurement interval. Figure 2 shows the frequency components of the vibrations.

### **Upstream Fish Passage Events**

Total numbers of fish that passed through the fish ladder during the reporting week are shown in Table 1. Cumulative counts to date for 2016 are also shown in Table 1.

Passage monitoring based on passive integrated transponder (PIT) data includes PIT monitoring arrays at the fishway entrance and exit in conjunction with a reduced trapping schedule, allowing volitional passage between approximately 14:00 Friday and 14:00 Sunday each week until August 18, 2016 (exact time of fish trapping is being recorded by the National Marine Fisheries Service and will be included in annual reporting). Table 2 summarizes the number of unique PIT-tagged fish detected anywhere within the ladder, number of unique PIT-tagged fish detected at the ladder entrance, proportion of successful passages, dropback rate, and re-ascension rate for each species during trapping and non-trapping periods. Table 3 summarizes median passage time for each species during trapping and non-trapping periods. The statistics shown in Tables 2 and 3 include all PIT-tagged fish released at or upstream of LGR as juveniles that were detected during the reporting week.

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## **Water Temperature in the Fish Ladder**

Water temperature is measured continuously in the fish ladder using multiple temperature loggers that take readings every five minutes. Data from loggers at the upper end of the fish ladder (ladder exit), mid-ladder auxiliary water supply (diffuser), and lower end of the fish ladder (ladder entrance) for this week are described in Table 4 and shown in Figures 3 and 4. The difference in temperature, or temperature gradient, between the ladder exit and entrance is also shown. Water temperature data contain time periods where measurements are not available for one or more temperature loggers. These time periods are displayed by breaks in the moving average line in Figure 3.

In Week 25, water temperatures recorded at the fish ladder entrance exhibited a higher degree of variability than expected, and observed fluctuations were not congruent with previous observations or other probes in the vicinity of the project. This pattern of variability began on June 21, 2016, after 12:00. Temperature measurements at the ladder entrance during this time period contain extreme values ranging from 55.45°F to 89.65°F. These temperature measurements do not appear accurate in light of the contemporaneous measurements collected at the tailrace observation deck and other locations within the ladder. In short, the ladder entrance and tailrace observation deck temperatures had been highly correlated and nearly identical prior to the variability discussed previously. Therefore, it is suspected that the ladder entrance probe has been periodically exposed to air as the water surface elevation has dropped. The status of the probe will be assessed by the U.S. Army Corps of Engineers (USACE) and, if necessary, installed at a greater depth in the near future.

For the purpose of this summary report, suspected errant water temperature data were filtered by comparing temperatures at the ladder entrance to contemporaneous temperatures at the nearby tailrace observation deck temperature probe. Water temperature data from the entrance exhibiting more than a 0.25°F departure from the tailrace observation deck temperature were omitted from calculations of summary statistics and plots. The 0.25°F exclusion criteria will be revisited after the status of the entrance probe is confirmed.

Additional water temperature metrics will be included in future reports as data from the post-passage behavior study becomes available.

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## **Water Temperature Control Structure**

The water temperature control structure (i.e., spray bar) is operated when temperatures reach a critical threshold determined by the USACE. Periods in which the water temperature control structure is not operational are illustrated as grey rectangle on the upper panel of the temperature plot in Figure 3.

## **Turbine Operations**

Turbine operations are summarized as generation flow (cubic feet per second) for the entire project and by individual turbine unit recorded in 5-minute intervals. Operation data are expected to be available for the prior week of reporting for each weekly report. Figure 6 depicts peak acceleration levels of vibrations in the upper ladder aligned to a time series of generation flow for the previous week (Week 24) to assess the potential impact of turbine operation on measured vibration levels.

## **Construction Activities**

Construction activities at LGR occur during both day and night shifts. Activities related to the Juvenile Fish Facility Upgrade Project occur in the vicinity of the adult ladder and can include channel mining, concrete drilling, concrete forming and pouring, and earthwork (excavation and backfilling). Other general construction activities in support of the fish facility upgrade can also occur. Construction activity data shown herein were obtained from daily construction logs submitted to USACE by the construction contractor. At the time of this report, daily construction logs were available from the beginning of this study (July 13, 2015) through June 17, 2016. Combined sound and construction figures for the previous week (Week 24) and 2 weeks ago (Week 23) are provided in Figures 7 to 10.

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**Table 1**  
**Fish Counts**

Species	Fish Window Count	
	This Week	2016 to Date
Chinook	4,054	72,747
Coho	0	0
Sockeye	13	13
Steelhead	75	5,587

**Table 2**  
**Passage Success**

Species	Unique Fish in Ladder	Unique Fish at Entrance	P Success	SE of P Success	P Dropback	SE of P Dropback	P Re-ascent	SE of P Re-ascent
<b>Non-trapping Period</b>								
Chinook	30	26	1.00	0.00	0.03	0.03	0.03	0.03
Coho	0	0	NA	NA	NA	NA	NA	NA
Sockeye	1	1	1.00	0.00	0.00	0.00	0.00	0.00
Steelhead	1	1	1.00	0.00	0.00	0.00	0.67	0.27
<b>Trapping Period</b>								
Chinook	72	69	0.81	0.05	0.02	0.02	0.03	0.02
Coho	0	0	NA	NA	NA	NA	NA	NA
Sockeye	2	2	1.00	0.00	0.00	0.00	0.00	0.00
Steelhead	1	1	1.00	0.00	0.50	0.35	0.00	0.00

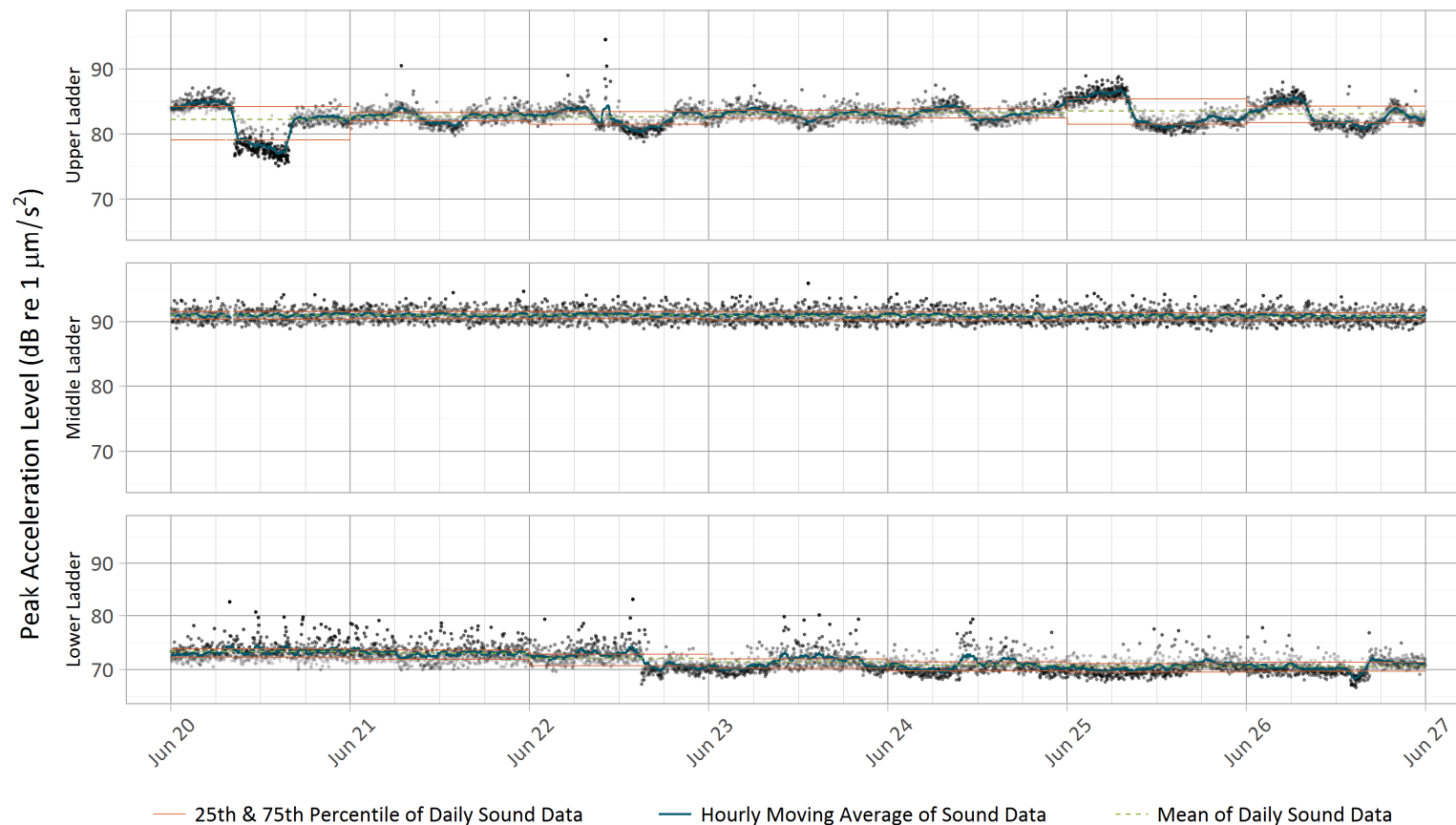
**Table 3**  
**Median Passage Time**

Species	Unique Fish	Median Travel Time (days)
<b>Non-trapping Period</b>		
Chinook	26	0.07
Coho	0	NA
Sockeye	1	0.52
Steelhead	1	2.19
<b>Trapping Period</b>		
Chinook	69	0.16
Coho	0	NA
Sockeye	2	0.31
Steelhead	1	0.11

**Table 4**  
**Water Temperatures in the Fish Ladder**

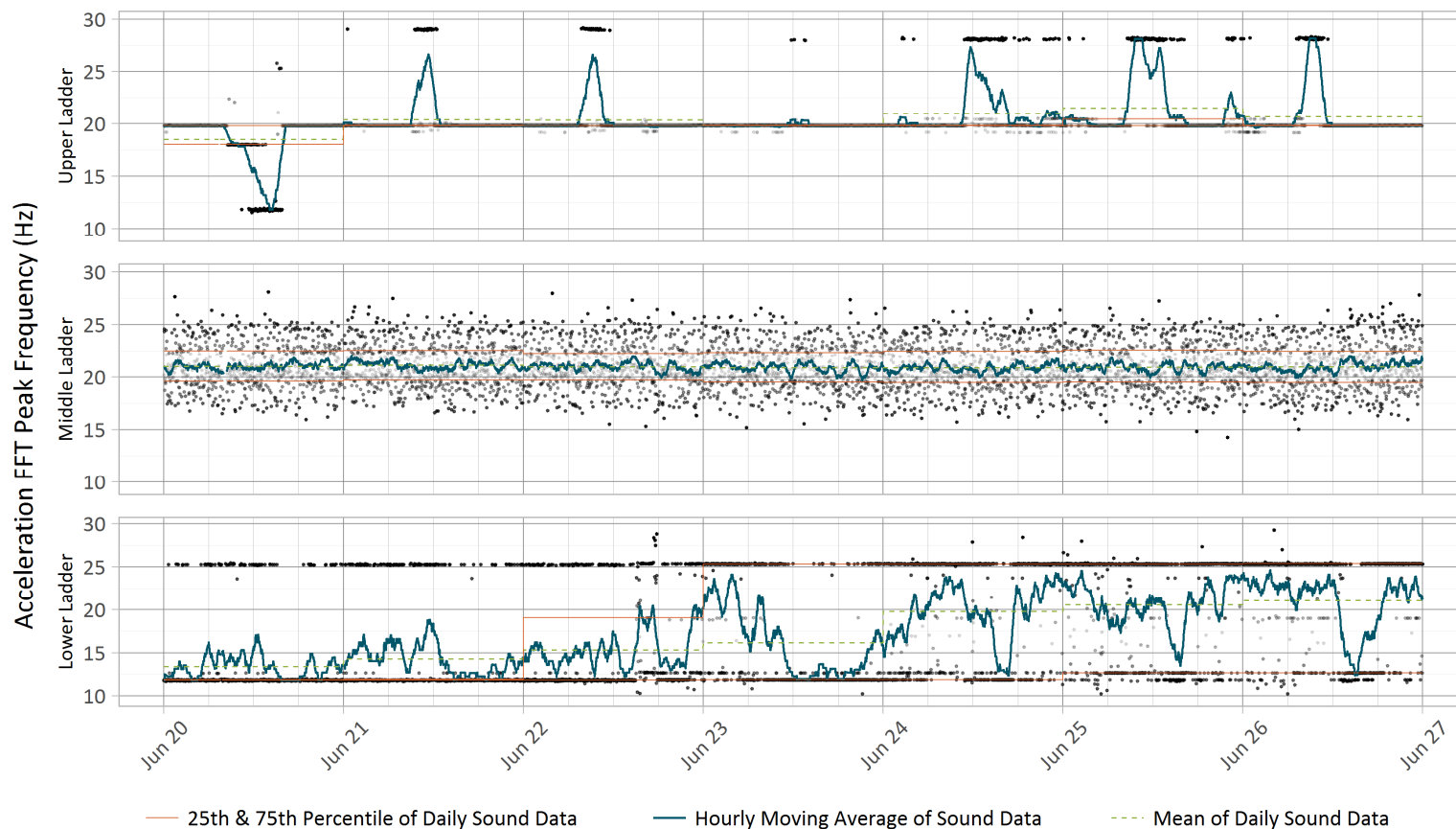
Location in Fish Ladder	Temperature (°F)		
	Min	Mean	Max
Ladder Exit	58.84	61.93	66.70
Diffuser	58.95	62.02	66.78
Ladder Entrance <sup>2</sup>	59.13	60.38	62.83
Temperature Difference (Ladder Exit–Entrance °F)	-0.49	0.45	1.56

<sup>2</sup> Suspected errant water temperature measurements occurring from June 21, 2016, after 12:00 through June 26 have been removed.



**Figure 1**  
**Peak Acceleration Levels Measured by Triaxial Accelerometers for Week 25**

X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Peak acceleration levels depict the maximum sound amplitude recorded per a 1-minute time interval. The sampling rate was 2 kilohertz (kHz), with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 hertz (Hz). Darker-colored dots show larger deviations of a single sound recording from mean sound levels.

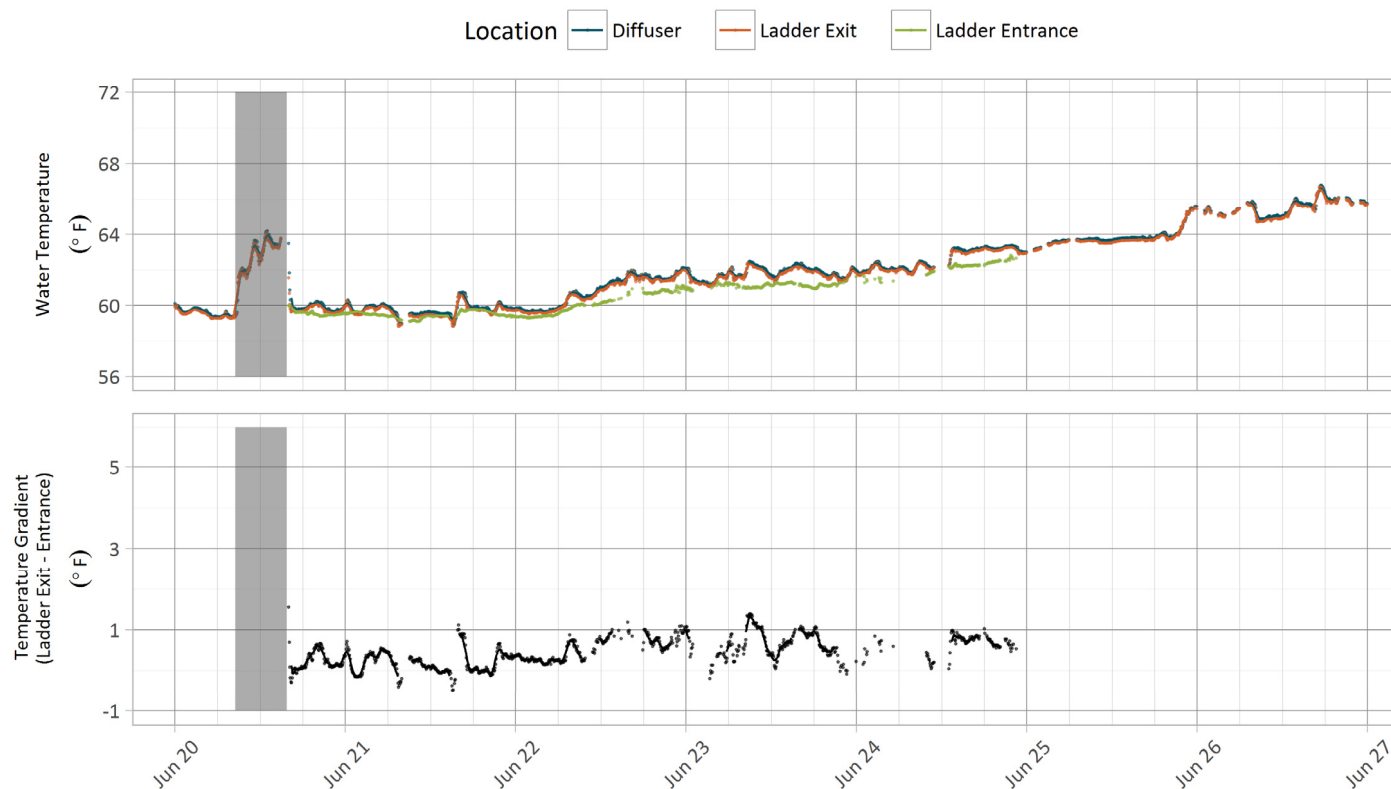


**Figure 2**

**Acceleration Peak Frequencies Measured by Triaxial Accelerometers for Week 25**

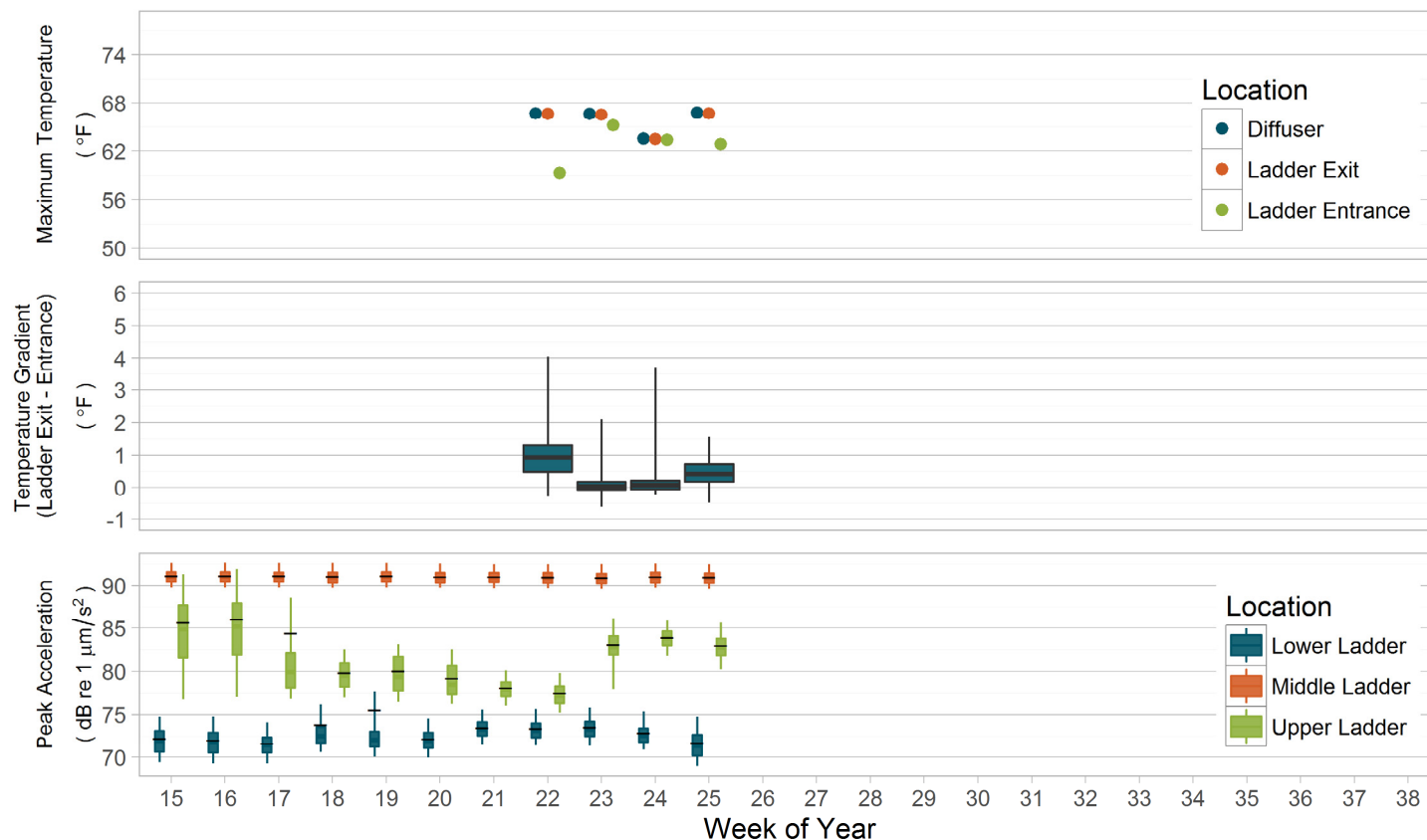
X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Acceleration Fast-Fourier (FFT) transformed peak frequency depicts the largest peak in the frequency spectrum per a 1-minute time interval. The sampling rate was 2 kHz, with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 Hz. Darker-colored dots show larger deviations of a single sound recording from mean sound levels.





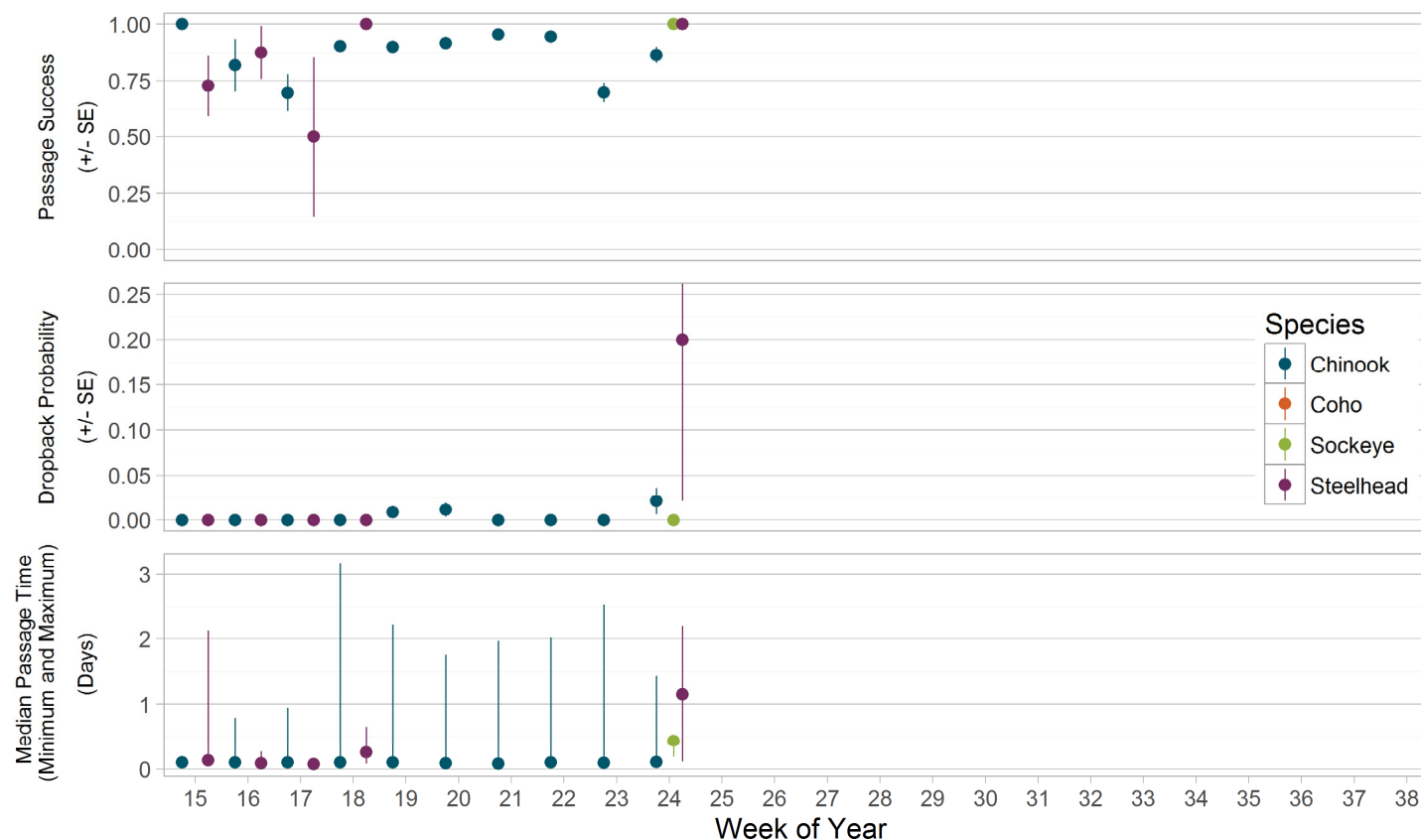
**Figure 3**  
**Water Temperatures in the Fish Ladder for Week 25**

X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Water temperature is recorded in 5-minute time intervals and summarized with an hourly moving average line. Water temperature data contain time periods where measurements are not available for one or more temperature loggers. These time periods are displayed by breaks in the moving average line. Time periods during which the water temperature control structure is not operational are indicated by the shaded area. Suspected errant water temperature measurements for the ladder entrance occurring from June 21, 2016, after 12:00 through June 26 have been removed.



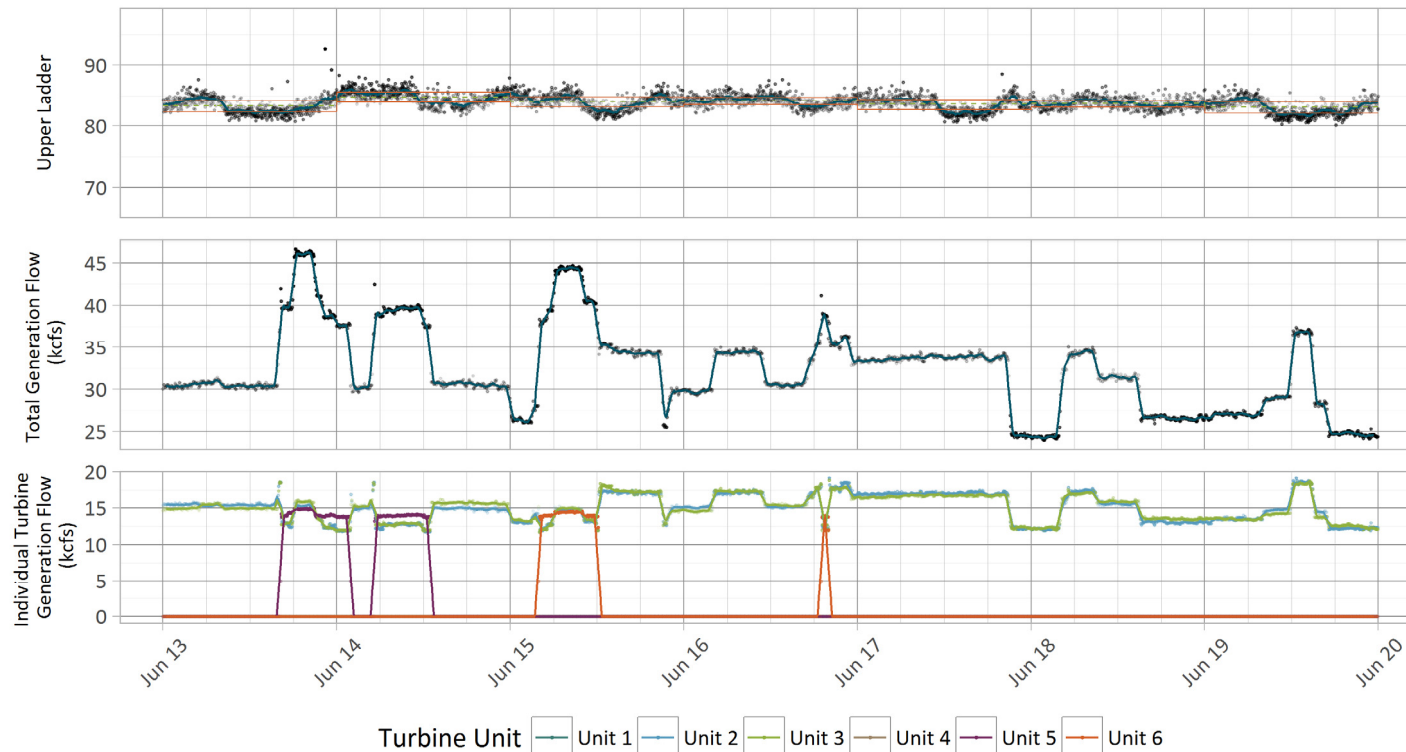
**Figure 4**  
**Running Summary of Weekly Temperature and Sound and Vibration in the Fish Ladder**

Maximum temperature shows the maximum recorded 5-minute-interval temperature measurement. Box plots of the temperature gradient show the mean, interquartile range, and 5th and 95th percentiles of the difference in temperature between the fish ladder exit pool and fish ladder entrance. Box plots of sound show the mean, interquartile range, and minimum and maximum measurements. Note: The suspected errant water temperature measurements for the ladder entrance occurring from June 21, 2016, after 12:00 through June 26 have been removed.



**Figure 5**  
**Running Summary of Fish Passage Metrics**

Passage success and dropback probability and median passage time for each species in each week are based on pooling trapping and non-trapping periods. Error bars around the proportion of passage success and dropback probability represent plus or minus one standard error, for passage time they represent the minimum and maximum passage time for that week. For weeks with larger numbers of fish the standard error may be so small as to not be apparent. The numbers used to plot passage success are broken out by trapping and non-trapping periods for this week in Table 4.



**Figure 6**

**Peak Acceleration Levels Measured by Triaxial Accelerometers in the Upper Ladder with Turbine Operations for Week 24**

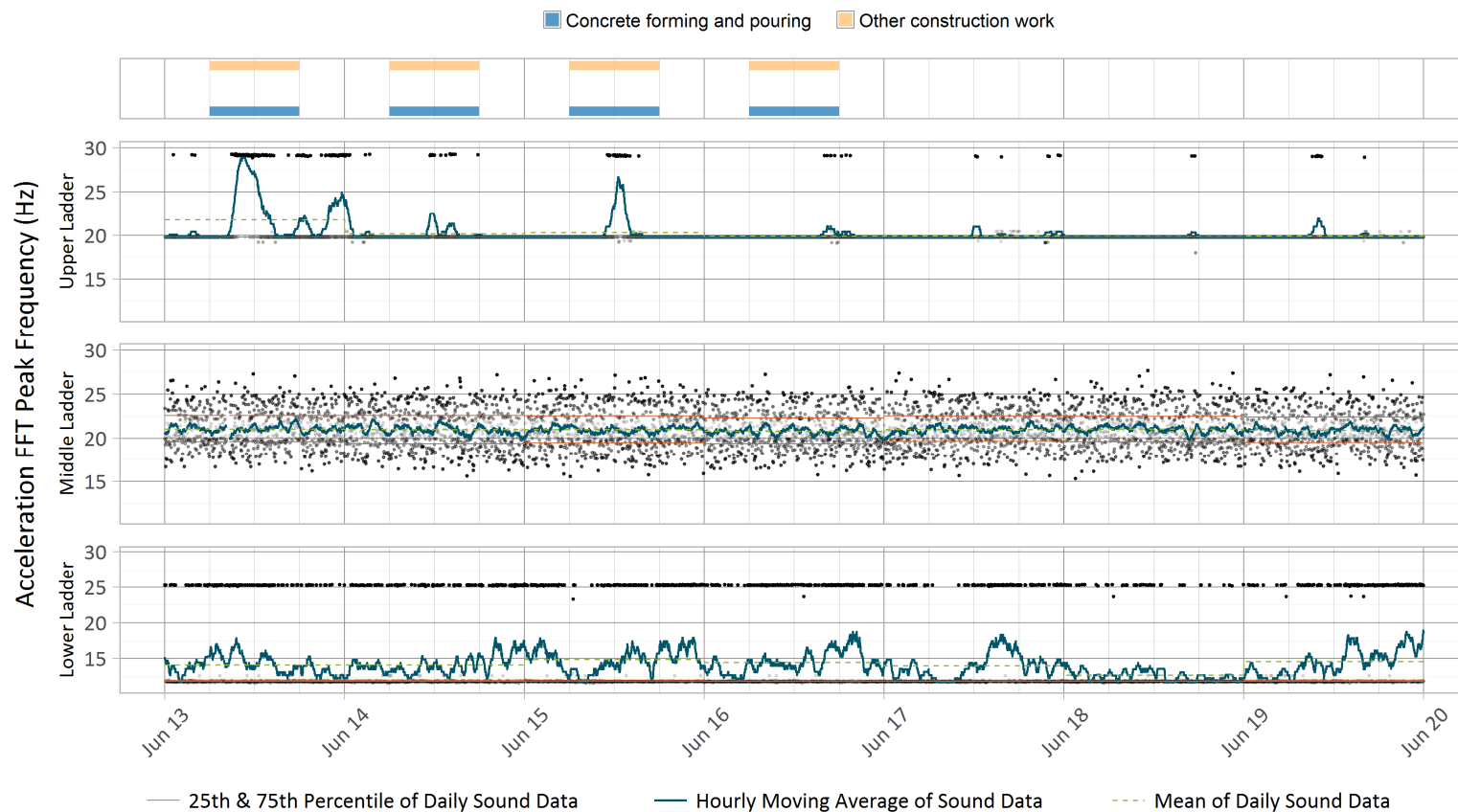
X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Peak acceleration levels depict the maximum sound amplitude recorded per a 1-minute time interval in the upper ladder. The sampling rate was 2 kHz, with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 Hz. Darker-colored dots show larger deviations of a single sound recording from mean sound levels. Individual turbine unit and overall generation flow are recorded in 5-minute time intervals and summarized with an hourly moving average line.



**Figure 7**

**Peak Acceleration Levels Measured by Triaxial Accelerometers with Construction Information for Week 24**

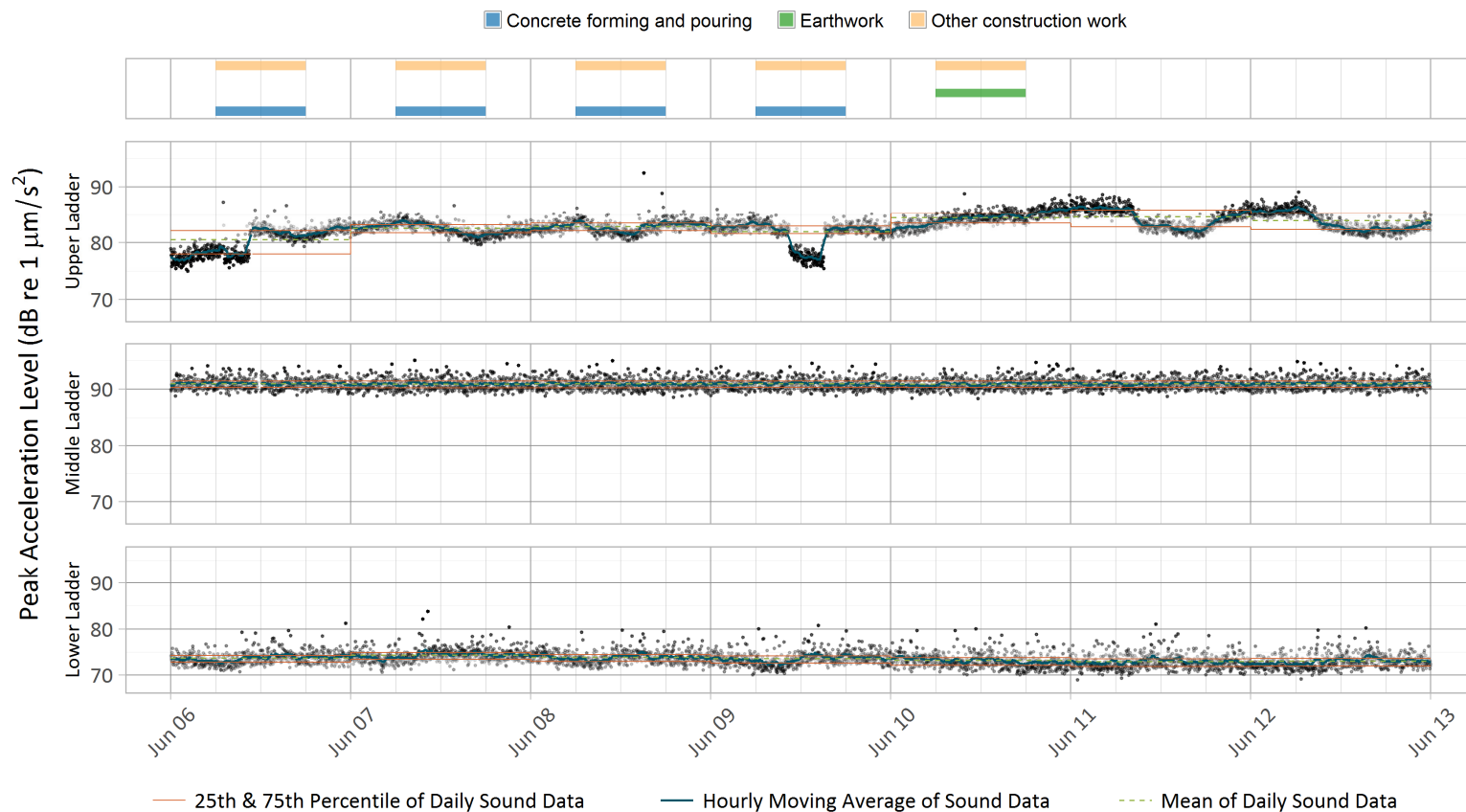
X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Peak acceleration levels depict the maximum sound amplitude recorded per a 1-minute time interval. The sampling rate was 2 kHz, with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 Hz. Darker-colored dots show larger deviations of a single sound recording from mean sound levels.



**Figure 8**

**Acceleration Peak Frequencies Measured by Triaxial Accelerometers with Construction Information for Week 24**

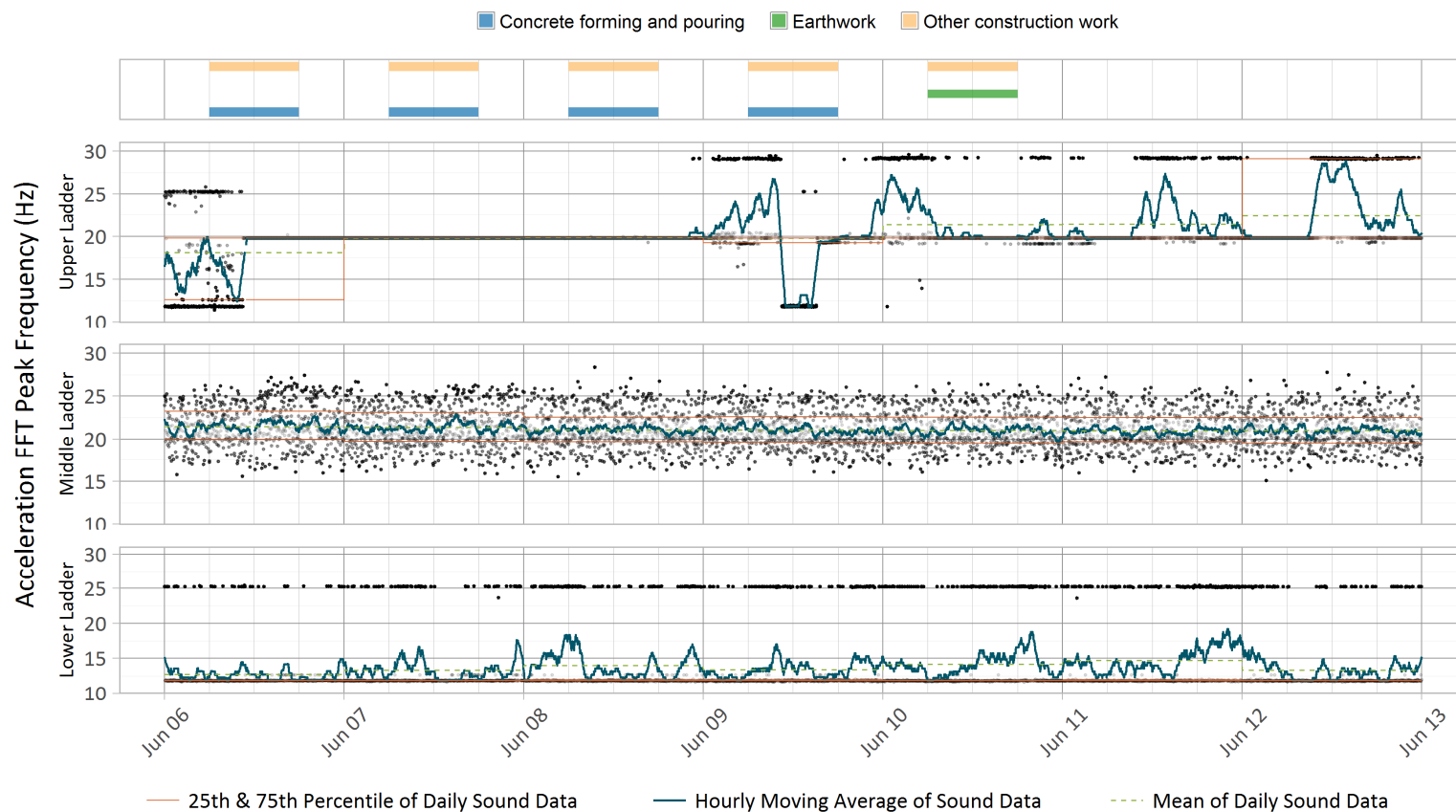
X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Acceleration FFT transformed peak frequency depicts the largest peak in the frequency spectrum per a 1-minute time interval. The sampling rate was 2 kHz, with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 Hz. Darker-colored dots show larger deviations of a single sound recording from mean sound levels.



**Figure 9**

**Peak Acceleration Levels Measured by Triaxial Accelerometers with Construction Information for Week 23**

X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Peak acceleration levels depict the maximum sound amplitude recorded per a 1-minute time interval. The sampling rate was 2 kHz, with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 Hz. Darker-colored dots show larger deviations of a single sound recording from mean sound levels.



**Figure 10**

**Acceleration Peak Frequencies Measured by Triaxial Accelerometers with Construction Information for Week 23**

X-axis major tick marks are shown at midnight, and minor tick marks are shown at 6-hour intervals. Acceleration FFT transformed peak frequency depicts the largest peak in the frequency spectrum per a 1-minute time interval. The sampling rate was 2 kHz, with a sampling duration of 60 seconds, 50% duty cycle, and band-pass filtered with cutoff frequencies of 10 and 30 Hz. Darker-colored dots show larger deviations of a single sound recording from mean sound levels.