ANCHOR QEA

23 South Wenatchee Avenue, Suite 220
Wenatchee, Washington 98801
Phone 509.888.2070
www.anchorqea.com

MEMORANDUM

To:	Chris Pinney (U.S. Army Corps of Engineers)	**Date:**	August 16, 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		

OVERVIEW

This is the weekly summary report for Week 32, 2016.[1] 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

[1] Week 32 is the period from midnight (00:00:00) Monday, August 8, 2016, to immediately prior to midnight (23:59:59) Sunday, August 14. Fish passage statistics encompass the non-trapping period from 14:00 Friday, August 5, to 14:00 Sunday, August 7, and the trapping period from 14:00 Sunday, August 7, to 14:00 Friday, August 12.

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. A running summary of weekly estimates of passage success, dropback probability, and passage time is depicted in Figure 7. The estimates in Figure 7 are based on a pooling of trapping and non-trapping periods.

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 6. The difference in temperature, or temperature gradient, between the ladder exit and entrance is also shown. Water temperature data cover time periods where measurements were not available for one or more temperature loggers. These time periods are displayed by breaks in the moving average line in Figure 3.

Water temperature at the fish ladder entrance for the period from June 21 after 12:00 through July 5 exhibited potential errant measurements and missing records. Fish ladder entrance data became available again on July 6. During this period, data from the tailwater observation deck were used to fill data gaps and filter errant records from the ladder entrance. In Figure 6, maximum temperatures are shown for both the ladder entrance and tailwater observation deck in the upper panel. In the middle panel, temperature gradients for all weeks except Weeks 25 and 26 are based off of raw, unfiltered ladder entrance temperature data. For Week 25, ladder entrance measurements were filtered by removing records exhibiting more than a 0.25 °F departure from the tailwater observation deck. For Week 26, tailwater observation deck water temperature measurements are used as a surrogate for ladder entrance measurements in calculating the temperature gradient.

Water Temperature Control Structure

The water temperature control structure (i.e., spray bar) is operated when temperatures reach a critical threshold determined by the U.S. Army Corps of Engineers (USACE). The water temperature control structure was operational continuously throughout Week 32. Periods during which the water temperature control structure was not operational are depicted as grey rectangles in Figure 3; the water temperature control structure was operational throughout Week 32, so grey rectangles are not plotted. The exact start and stop times for spray bar operations will be confirmed with the USACE operations logs in the final report.

Water Temperature in the Forebay

Water temperature in the forebay is being measured continuously along a vertical profile by a thermistor string attached to a buoy located approximately 50 feet upstream from the fishway exit. The thermistor string is equipped with 12 temperature sensors spaced at 6-foot depth intervals from 3 to 57 feet, with two additional sensor at depths of 72 and 87 feet. Forebay water temperatures along the vertical depth profile throughout Week 32 are depicted in a contour plot in Figure 4.

ARIS

The ARIS system was installed on June 20 and deployed 60 feet below the water surface from the trolley pipe on the north side of the fishway exit. The ARIS is attached to a rotator programmed to aim the ARIS in five unique positions each hour to allow for data collection throughout a sample volume that extends 80 feet upstream of the dam. The system has been collecting data continuously since 11:00 on June 21.

ARIS data processing involves reviewing imagery files and marking fish that pass through the fields-of-view. Criteria used to select fish to be marked include estimated total length, body shape, and swimming behaviors (e.g., occurrence of schooling is used to exclude American shad from the data set). A subset of 5 hours of data per day are processed between the hours of 06:00 to 21:00 to capture the bulk of historically observed adult salmonid movements. For the final report, fish observation data will be presented using vector and distribution plots. For the in-season weekly reports, plots will present the counts of marked fish per hour on a daily basis, as shown in Figure 5.

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 8 depicts peak acceleration levels of vibrations in the upper ladder aligned to a time series of generation flow for the previous week (Week 31) 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 August 5, 2016. Combined sound and construction figures for the previous week (Week 31) are presented in Figures 9 and 10.

Table 1
Fish Counts

Species	Fish Window Count	
	This Week	2016 to Date
Chinook	733	81,340
Coho	0	0
Sockeye	9	806
Steelhead	957	9,589

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
Non-trapping Period								
Chinook	4	1	1.00	0.00	0.00	0.00	0.00	0.00
Coho	0	0	NA	NA	NA	NA	NA	NA
Sockeye	2	1	0.00	0.00	0.00	0.00	1.00	0.00
Steelhead	3	2	1.00	0.00	0.00	0.00	0.00	0.00
Trapping Period								
Chinook	7	6	0.00	0.00	NA	NA	NA	NA
Coho	0	0	NA	NA	NA	NA	NA	NA
Sockeye	0	0	NA	NA	NA	NA	NA	NA
Steelhead	12	10	0.10	0.09	0.00	0.00	0.00	0.00

Table 3
Median Passage Time

Species	Unique Fish	Median Travel Time (days)
Non-trapping Period		
Chinook	1	0.09
Coho	0	NA
Sockeye	1	0.21
Steelhead	2	0.08
Trapping Period		
Chinook	6	NA
Coho	0	NA
Sockeye	0	NA
Steelhead	10	0.52

Table 4
Water Temperatures in the Fish Ladder

Location in Fish Ladder	Temperature (°F)		
	Min	Mean	Max
Ladder Exit	65.89	68.15	70.21
Diffuser	66	68.23	70.3
Ladder Entrance	63.23	64.92	65.95
Temperature Difference (Ladder Exit – Entrance °F)	0.92	3.24	6.14

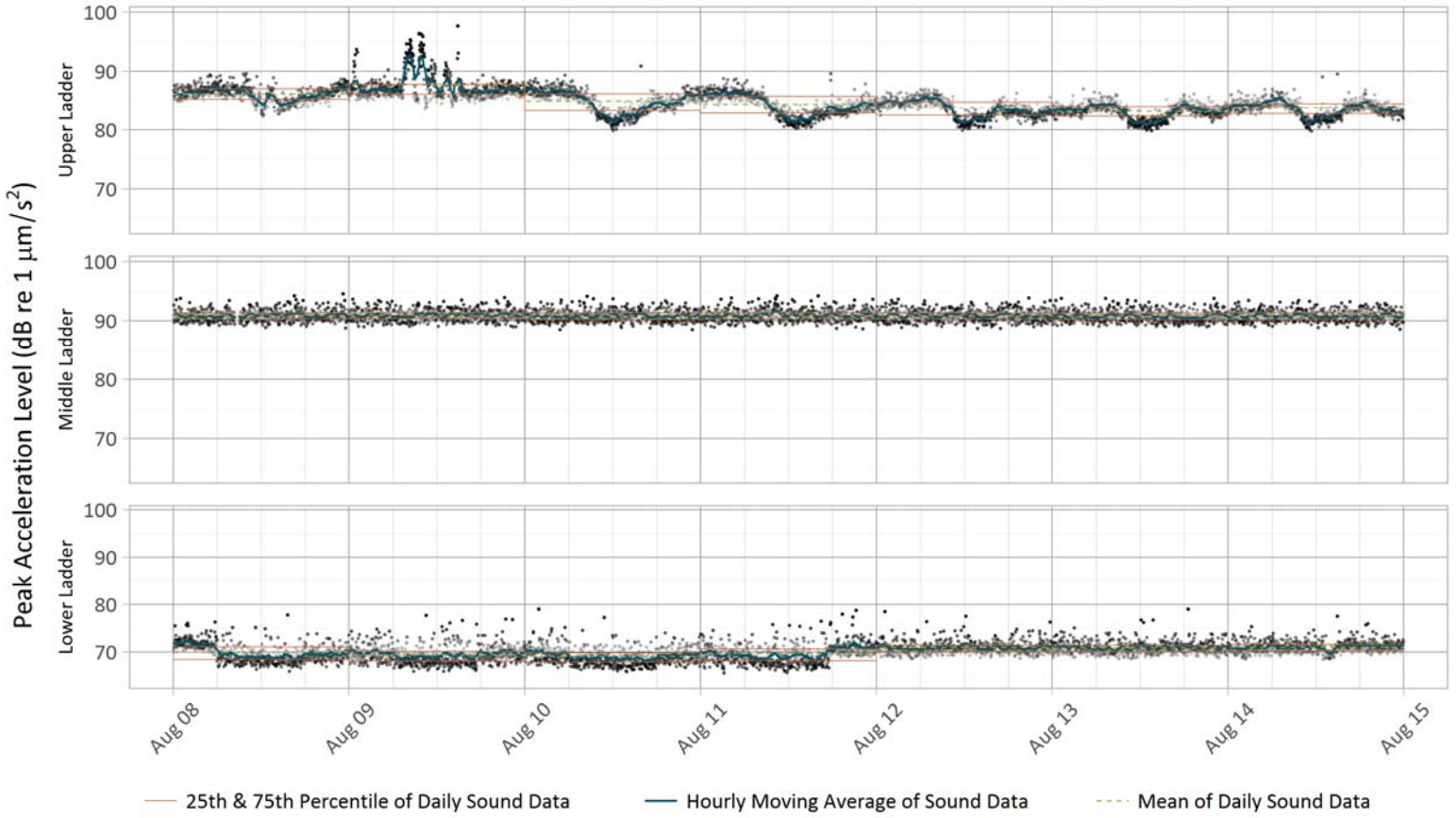

Figure 1

Peak Acceleration Levels Measured by Triaxial Accelerometers for Week 32

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.

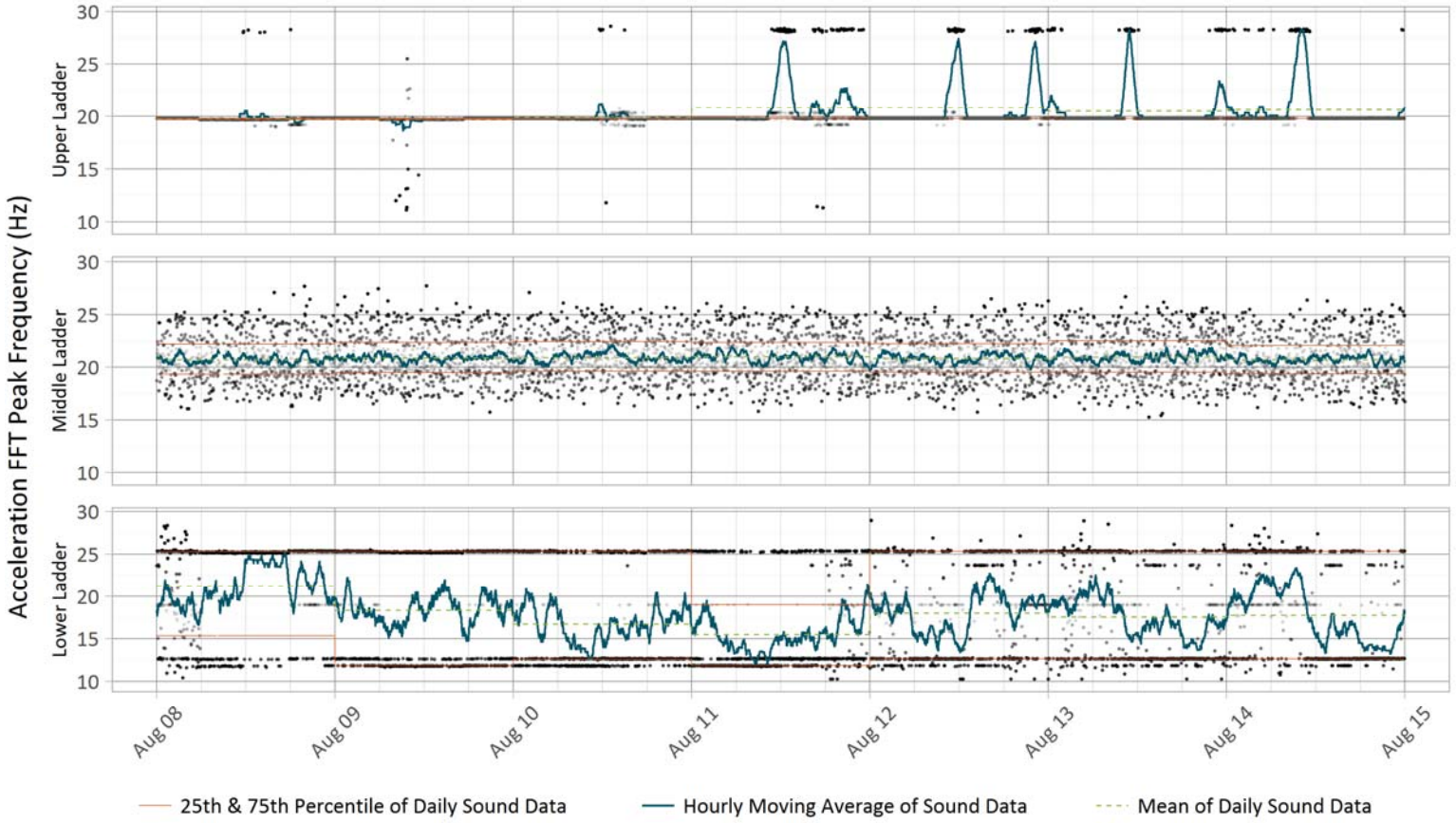

Figure 2

Acceleration Peak Frequencies Measured by Triaxial Accelerometers for Week 32

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.

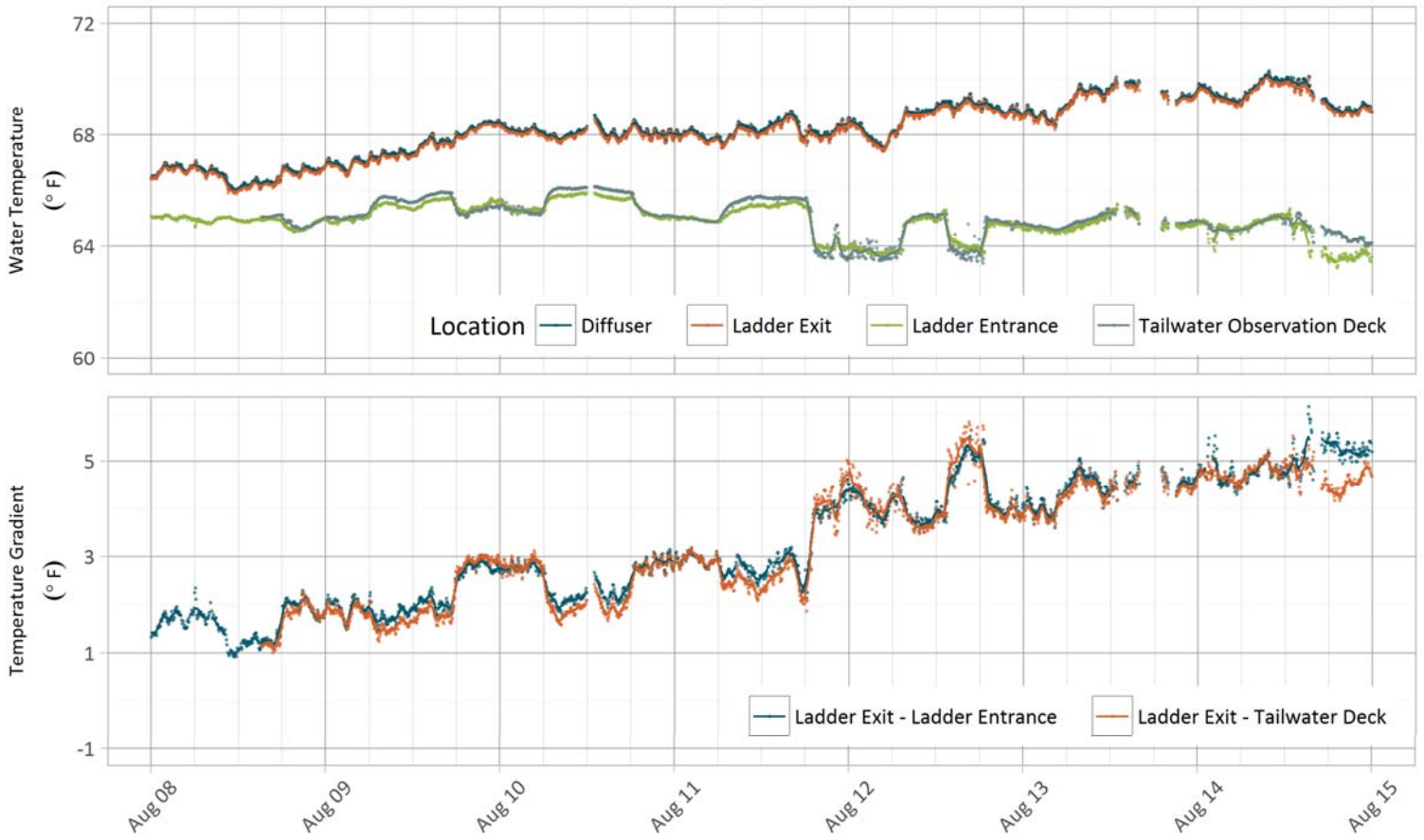

Figure 3

Water Temperatures in the Fish Ladder for Week 32

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.

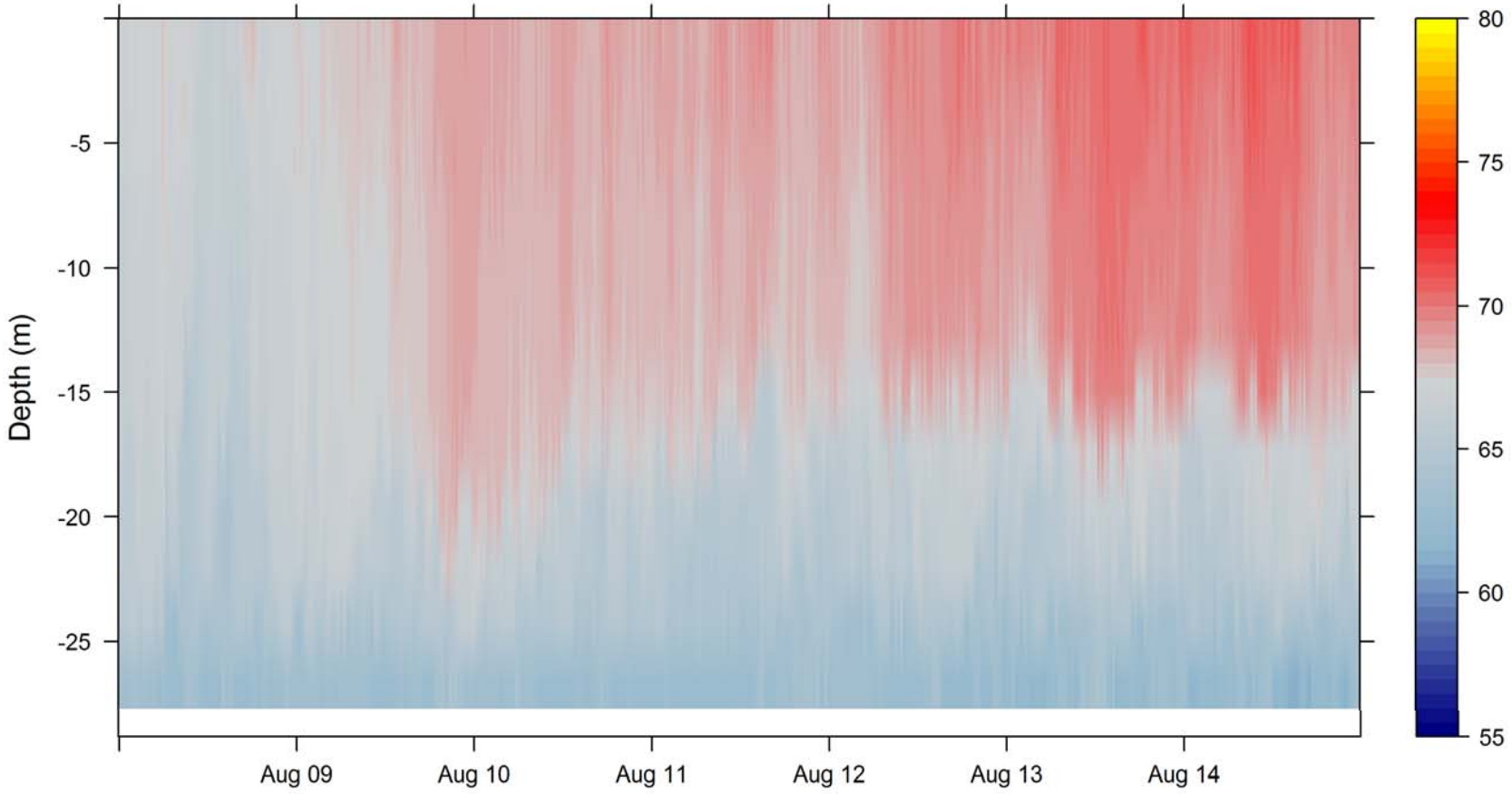

Figure 4

Water Temperatures in the Forebay for Week 32

Water temperature in the forebay is summarized with a contour plot depicting temperature along a vertical depth profile extending from approximately 1 meter to approximately 26 meters. X-axis major tick marks are shown at midnight for each day.

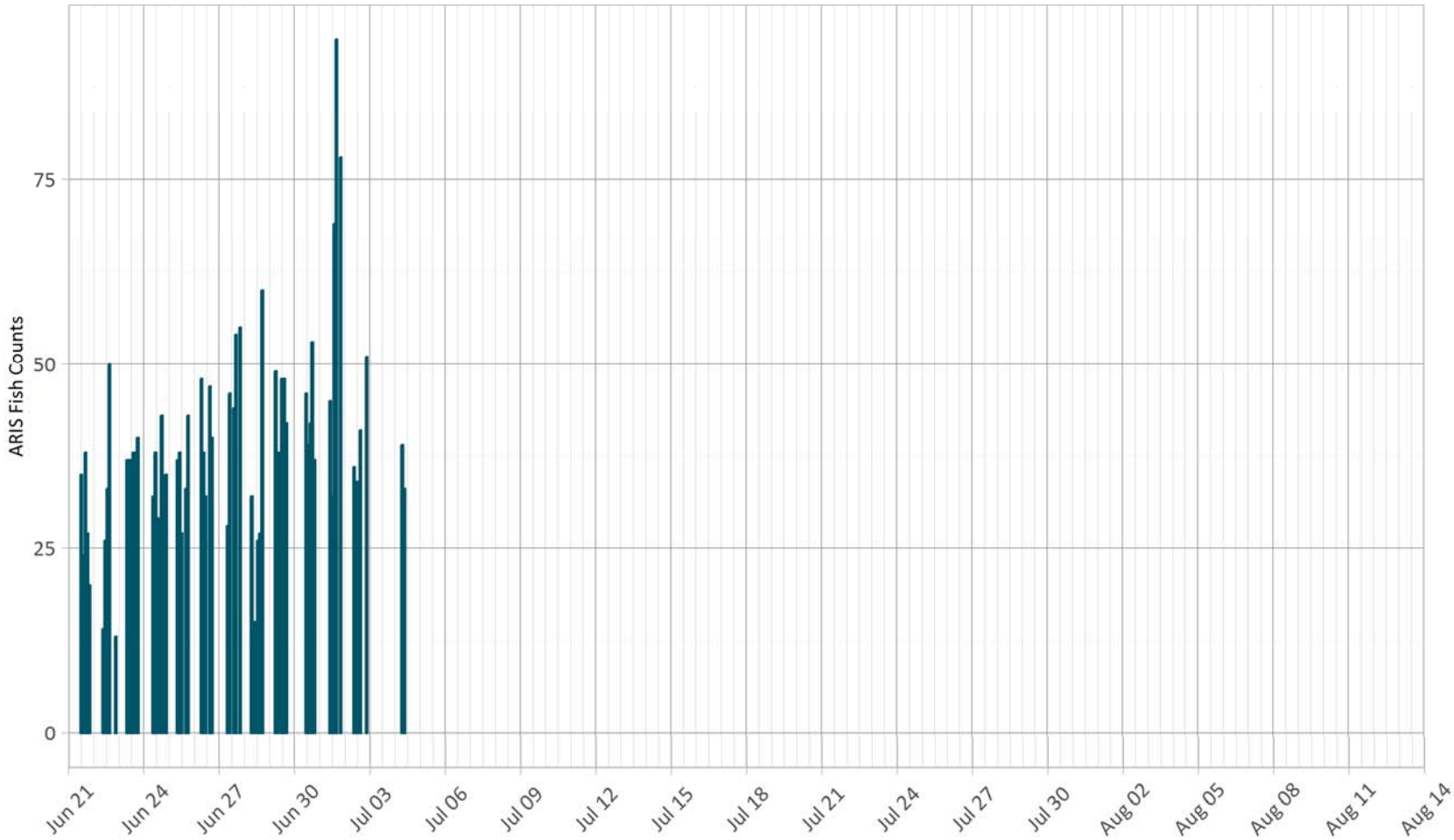

Figure 5

ARIS Fish Counts

The counts of marked fish by hour and day are shown for all days in which data processing has been completed. For each hour the counts reflect the sum total of fish marked within each of the five ARIS aiming positions.

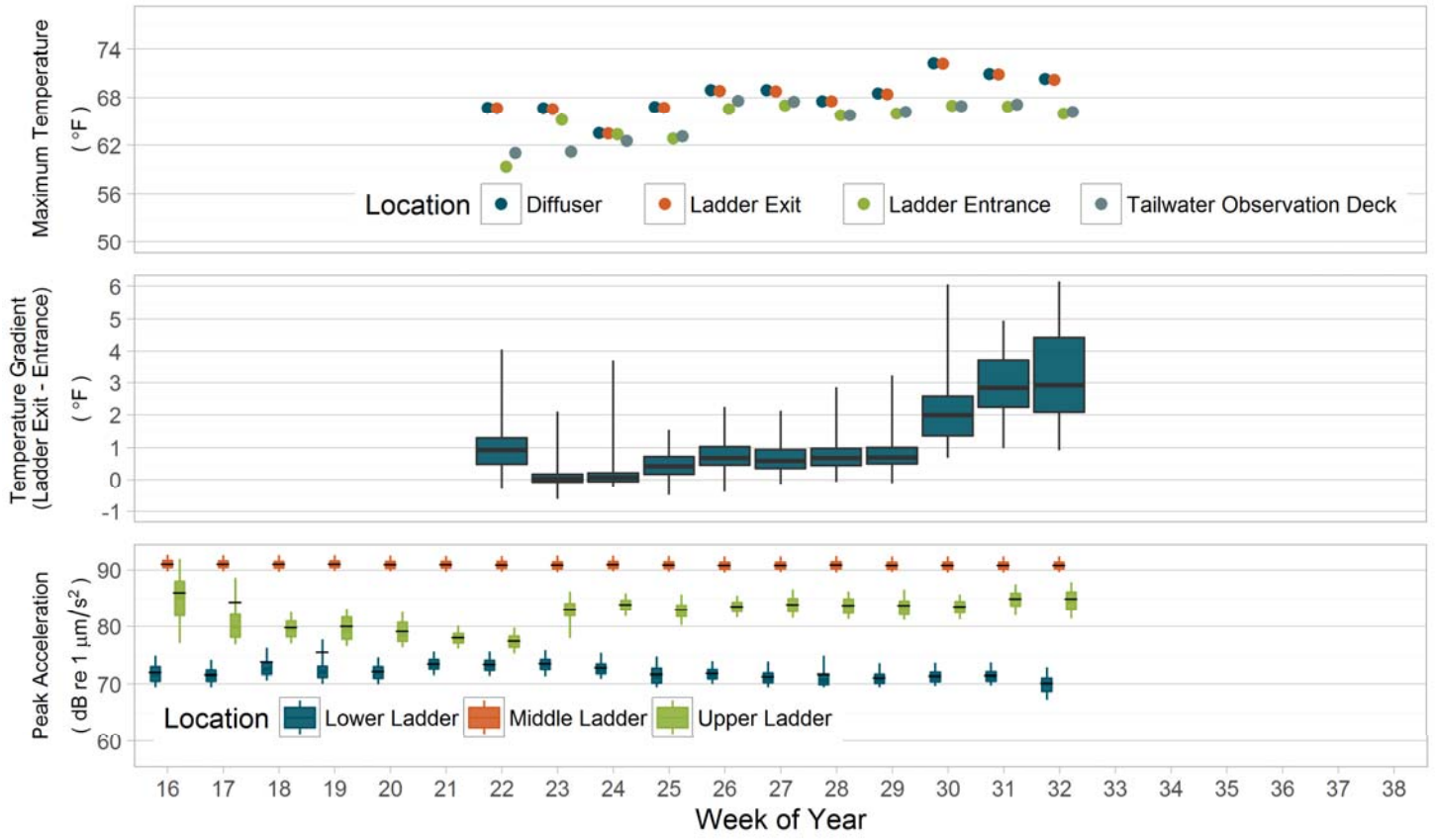

Figure 6

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: Suspected errant water temperature measurements for ladder entrance occurring from June 21 after 12:00 through June 26 have been removed.

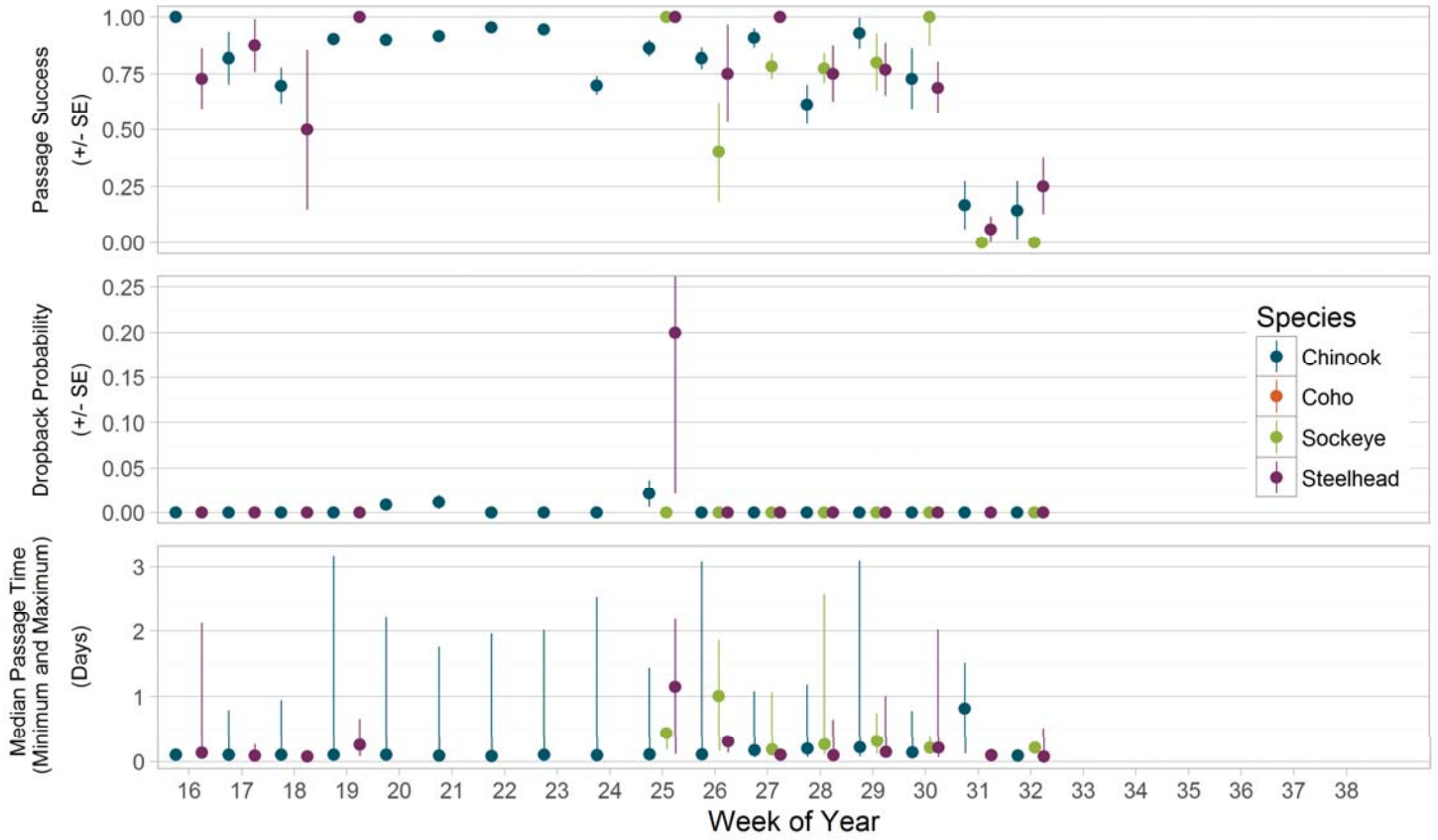

Figure 7

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 and travel time are broken out by trapping and non-trapping periods for this week in Tables 2 and 3.

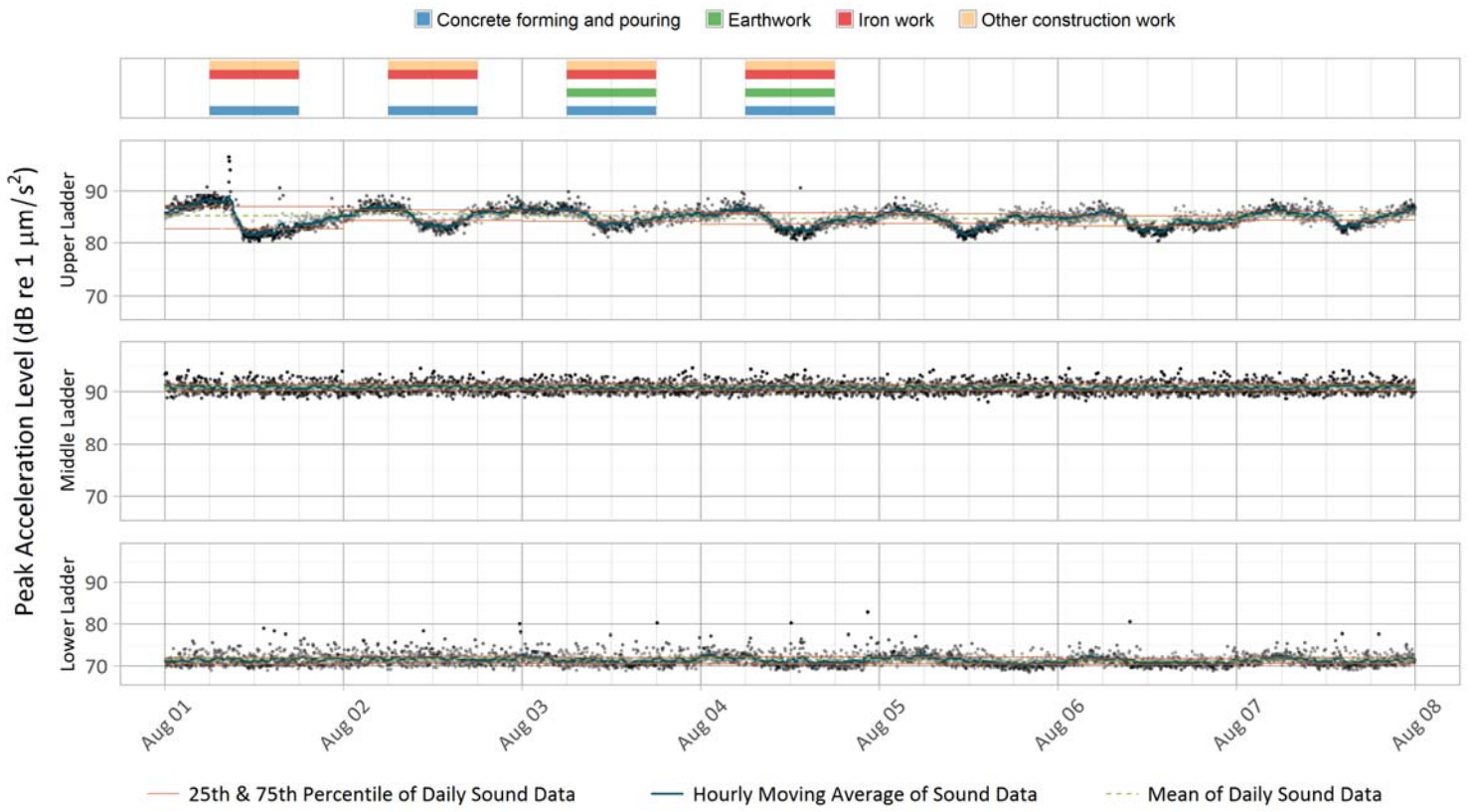

Figure 8

Peak Acceleration Levels Measured by Triaxial Accelerometers in the Upper Ladder with Turbine Operations for Week 31

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.

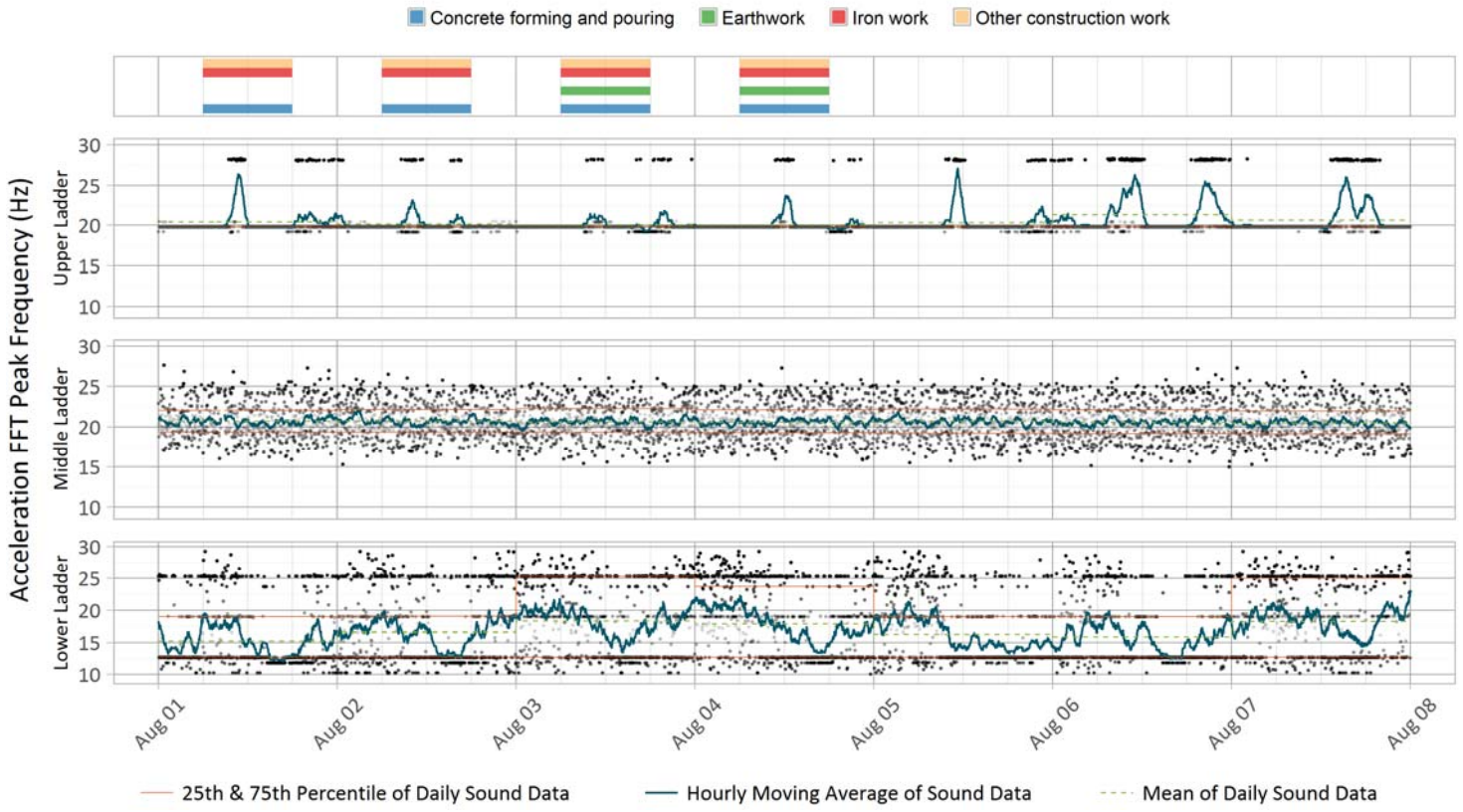

Figure 9

Peak Acceleration Levels Measured by Triaxial Accelerometers with Construction Information for Week 31

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.

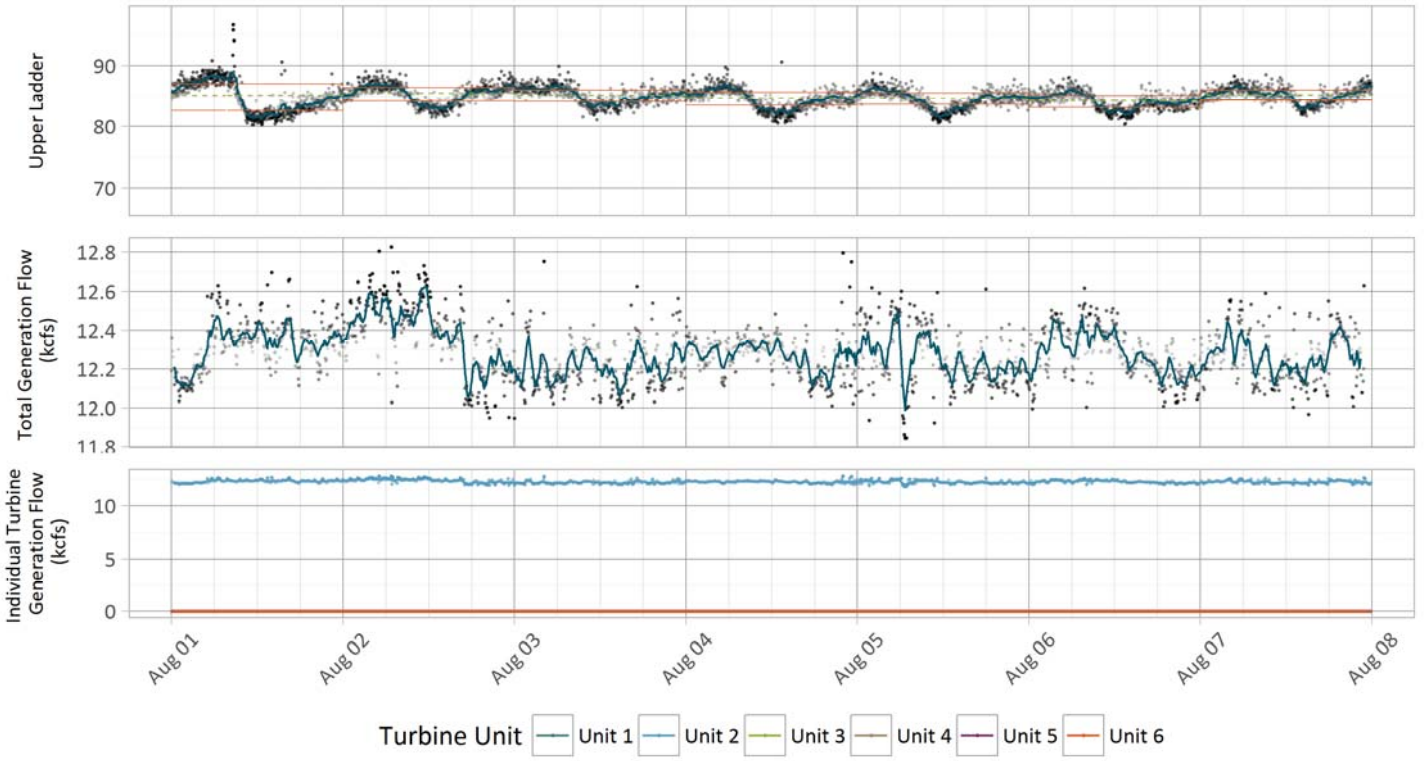

Figure 10

Acceleration Peak Frequencies Measured by Triaxial Accelerometers with Construction Information for Week 31

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.