

May 20, 2026

Attention: Danielle Butsick
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SLR Project No.: 119.000032.00001
Client Reference No.: P--00321748

**RE: Errata – Incorrect Sensitivity Offset in Data Processing, 1st and 2nd
Quarterly Reports
Port of Seattle Underwater Noise Monitoring Project**

A technical issue was identified affecting the processing of acoustic data collected with the iCListen hydrophones deployed for the Port of Seattle during the first two quarterly reports. The issue was identified by the original developer of the sensitivity algorithm used to convert raw hydrophone data into absolute sound pressure levels (dB re 1 μPa^2). The algorithm incorporated an incorrect voltage-scaling assumption, resulting in calculated absolute sound pressure levels that are approximately 3 dB higher than the true values.

As a result, reported absolute sound levels in the quarterly monitoring reports for the first two monitoring quarters are 3 dB higher than true levels. Note that the raw acoustic data collected by the hydrophone are unaffected, and relative metrics—such as temporal trends and comparisons within the dataset—remain valid.

The following tables and figures have been influenced by the 3 dB offset in the first and second quarterly reports. Sound levels reported in these tables and figures are 3 dB higher than true levels.

Table 1: Affected Tables and Figures (First Quarterly Report, January 2026)

Table(s)	Figure(s)
B-1 through B-4	B-1 through B-17

Table 2: Affected Tables and Figures (Second Quarterly Report, May 2026)

Table(s)	Figure(s)
E.1-1 through E.1-3	E.1-1 through E.1-22
E.2-1 through E.2-3	E.2-1 through E.2-22
E.3-1 and E.3-2	E.3-1 through E.3-3

Regards,

SLR International Corporation



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Underwater Noise Assessment

Phase II Monitoring and Reporting – Second Quarterly Report 2025

Port of Seattle

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Limitations

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The purpose of an environmental assessment is to reasonably evaluate the potential for, or actual impact of, past practices on a given site area. In performing an environmental assessment, it is understood that a balance must be struck between a reasonable inquiry into environmental issues and an appropriate level of analysis for each conceivable issue of potential concern. The following paragraphs discuss the assumptions and parameters under which such an opinion is rendered.

No investigation can be thorough enough to exclude the presence of hazardous materials at a given site. If hazardous conditions have not been identified during the assessment, such a finding should not therefore be construed as a guarantee of the absence of such materials on the site, but rather as the result of the services performed within the scope, practical limitations, and cost of the work performed.

Environmental conditions that are not apparent may exist at the site. Our professional opinions are based in part on interpretation of data from a limited number of discrete sampling locations and therefore may not be representative of the actual overall site environmental conditions.

The passage of time, manifestation of latent conditions, or occurrence of future events may require further study at the site, analysis of the data, and/or reevaluation of the findings, observations, and conclusions in the work product.

This work product presents professional opinions and findings of a scientific and technical nature. The work product shall not be construed to offer legal opinion or representations as to the requirements of, nor compliance with, environmental laws rules, regulations, or policies of federal, state or local governmental agencies.



Executive Summary

The Port of Seattle (Port) has implemented an Underwater Noise Assessment Program to characterize the regional underwater soundscape in Elliott Bay as part of its Underwater Noise Mitigation and Management Plan (UNMMP). The primary objectives of this program are to build an acoustic database and establish a baseline understanding of the underwater soundscape, which can be used to set realistic, measurable noise reduction targets. The program also aims to identify opportunities to reduce noise impacts on marine species while supporting sustainable maritime operations.

Two fixed hydrophone stations, SJBL-01 near Jack Block Park and SAQU-01 near the Seattle Aquarium, collect continuous, high-resolution underwater acoustic data supported by AIS vessel tracking and automated marine mammal detection algorithms. This quarterly report summarizes results from September 1 to mid-November 2025. Data from mid-November to late December was unavailable due to a resolved memory issue.

Environmental conditions had minimal or no measurable influence on the underwater acoustic environment during the monitoring period. Weather remained mild, with no noise variations that align with temperature cycles, and tides followed normal semidiurnal cycles. As a result, environmental noise contributions were negligible, and underwater noise levels were overwhelmingly shaped by anthropogenic factors, specifically vessel traffic.

Marine mammal detections were dominated by harbor seal vocalizations, representing 70.9% of detections at SJBL-01 and 76.3% at SAQU-01. California sea lions accounted for the remaining identified vocalizations. No killer whale calls were detected during this period, likely due to a combination of low vocal activity, distance relative to detection range, or acoustic masking from elevated ambient noise, particularly at SAQU-01, where vessel density is highest. Detection timelines exhibited sporadic clustering, with activity shaped by local noise conditions and species-specific behaviors.

AIS vessel traffic was continuously present at both monitoring stations, with notable spatial differences. SAQU-01 consistently recorded higher vessel density, frequently exceeding 10–20 unique vessels per 5-minute interval, compared to SJBL-01, where vessel presence typically ranged below 10 vessels except for intermittent peaks. Passenger vessels (especially ferries) produced pronounced diurnal patterns, with noise peaking during daytime operating hours. Vessel-class distributions also differed: SAQU-01 detected nearly twice as many unique tug/towing vessels as detected at JBL-01, which generated sustained low-frequency noise evident at both sites. Traffic differences align directly with spatial variations observed in underwater noise levels.

Ambient noise levels across the monitoring period were dominated by low-frequency energy (10–1000 Hz), driven primarily by vessel traffic and propeller cavitation. SAQU-01 maintained higher median broadband SPLs (~129 dB re 1 μ Pa) compared to SJBL-01 (~119 dB re 1 μ Pa), reflecting its proximity to major ferry and commercial routes. Both sites exhibited strong diurnal cycles, with noise rising in the early morning, remaining elevated through the evening, and decreasing overnight. High-frequency noise tones (>10 kHz) occurred intermittently, corresponding to SONAR and echosounder activity. Overall, SAQU-01 displayed a louder and more uniform soundscape, while SJBL-01 showed lower but more variable conditions.

Together, these results reinforce the influence of high vessel density, vessel-class distribution, and daily operational patterns on Elliott Bay's underwater soundscape. Continued long-term monitoring remains essential for identifying trends, evaluating mitigation effectiveness, and informing management actions within the Port's broader environmental stewardship initiatives.



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Appendix B	Environmental Data
Appendix C	Marine Mammal Detections
Appendix D	AIS Data Analysis
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Acronyms and Abbreviations

μPa	micro-Pascal
AIS	Automatic Identification System
ANSI	American National Standards Institute
dB	decibel
HF	High Frequency
Hz	Hertz
ISO	International Organization for Standardization
LLF	Lower Low frequency
LTSA	Long-Term Spectral Average
MF	Medium Frequency
ms	milliseconds
s	seconds
SAQU-01	SLR Seattle Aquarium
SJBL-01	SLR Jack Block Park site
SLR	SLR International Corporation
SPD	Spectral Probability Density
SPL	Sound Pressure Level
ULF	Upper Low Frequency



1.0 Introduction

SLR Consulting was contracted by the Port of Seattle to monitor and collect underwater noise data within Elliott Bay and prepare quarterly reports as part of the Port of Seattle’s (Port’s) Underwater Noise Assessment Program. This program supports the Port’s commitment to environmental stewardship and its goal of advancing its Green Marine certification by evaluating underwater noise levels associated with Port operations and identifying opportunities to reduce impacts on marine species.

Underwater noise monitoring is conducted using two cabled underwater monitoring stations (SJBL-01 and SAQU-01), which have been operational since July 16, 2025 (see Figure A.1-1). Each station is equipped with a calibrated smart hydrophone, the icListen model SJ9-ETH, from Ocean Sonics, and records at a sampling frequency of 128,000 Hz. The stations are located offshore at Jack Block Park and the Seattle Aquarium (see Table A.1-1).

Table A.1-1: Underwater monitoring station, hydrophone, location, and water depth

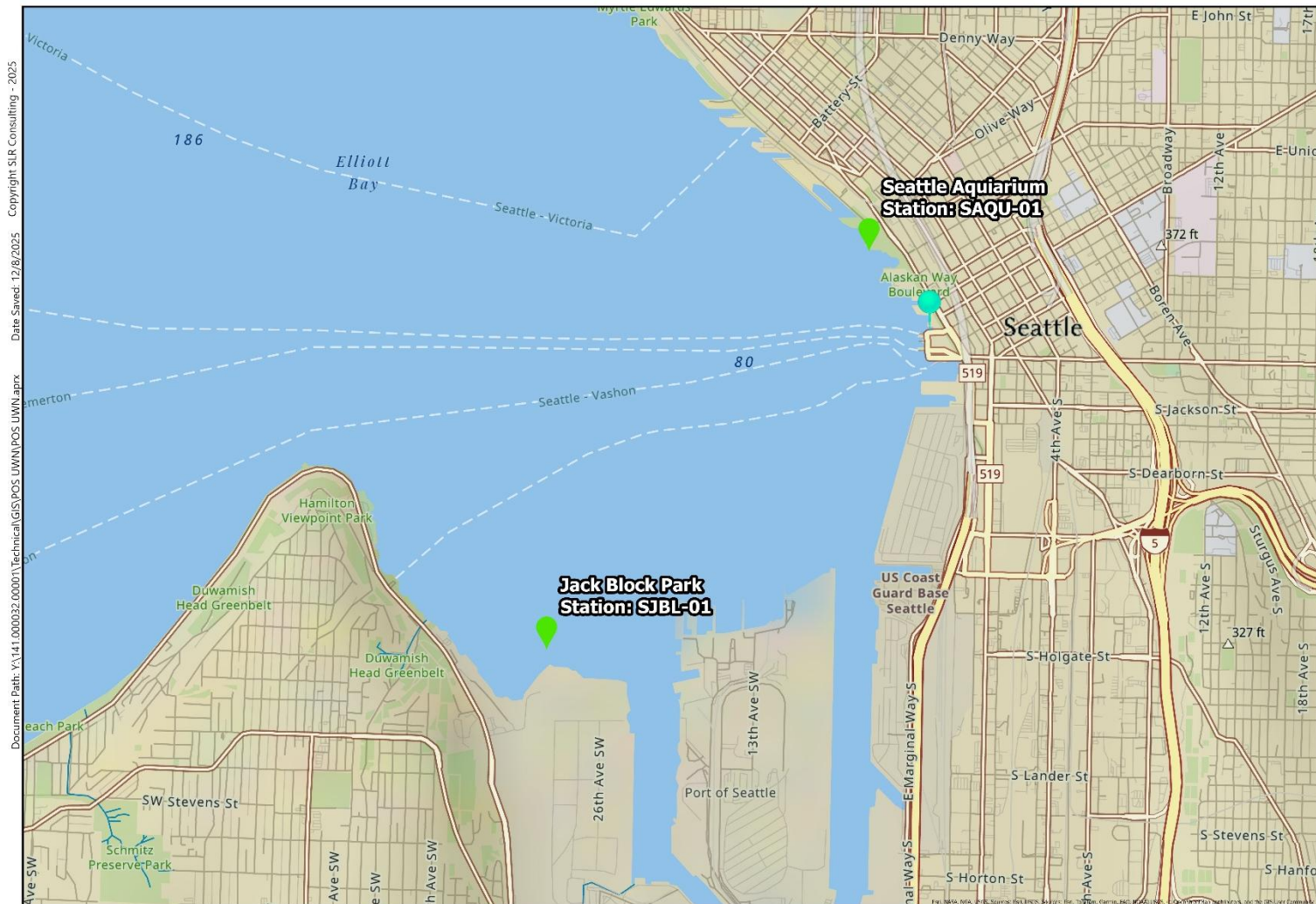
Station	Hydrophone	Serial Number	Location Site	Latitude (N)	Longitude (W)	Water Depth (feet)
SJBL-01	icListen SJ9-ETH	6976	Jack Block Park	47°35'09.2"	122°22'06.2"	~65
SAQU-01	icListen SJ9-ETH	6977	Seattle Aquarium	47°36'25.8"	122°20'38.5"	~65

The methodology is fully described in Appendix A: Methodology. It explains how underwater noise data were collected, processed, and analyzed to ensure consistency with international standards. It describes the acoustic metrics applied, including sound pressure level calculations, and explains the classification of frequency bands used to interpret the soundscape. The section also details the formats used for presenting results and specifies how Automatic Identification System (AIS) vessel data and marine mammal detections were integrated into the analysis. Together, these methods provide a structured framework for evaluating underwater noise and its potential ecological implications.

This report summarizes the data from the start of September to mid-November 2025, the second full recorded set of data since the system's deployment. This second quarterly report represents the fall season dataset for this study. Data for the period between mid-November to end of December was unavailable due to an internal memory issue in both stations, which has been resolved. Due to the necessary processing and validation steps that follow data collection, there is a lag between data collection, processing, and reporting.





Figure A.1-1: Hydrophone Station Deployment Locations



Deployed Hydrophone Locations

Underwater Noise Assessment
Port of Seattle

 Deployment Locations & Station ID

 Tide Gage - Station ID: 9447130



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1.1 Report Schedule

The analysis was conducted over calendar month periods. Table A.1-1 lists the report schedule for the monitoring period analyzed in this report.

Table A.1-1: Report schedule for the recording period analyzed

Station	Month start	Month end	Weeks reported
SJBL-01	1 September 2025 00:00 UTC	15 November 2025 21:55 UTC	Sun 07 Sep to Sat 13 Sep Sun 14 Sep to Sat 20 Sep Sun 21 Sep to Sat 27 Sep Sun 28 Sep to Sat 04 Oct Sun 05 Oct to Sat 11 Oct Sun 12 Oct to Sat 18 Oct Sun 19 Oct to Sat 25 Oct Sun 26 Oct to Sat 01 Nov Sun 02 Oct to Sat 08 Nov Sun 09 Oct to Sat 15 Nov
SAQU-01	1 September 2025 00:00 UTC	14 November 2025 17:45 UTC	Sun 07 Sep to Sat 13 Sep Sun 14 Sep to Sat 20 Sep Sun 21 Sep to Sat 27 Sep Sun 28 Sep to Sat 04 Oct Sun 05 Oct to Sat 11 Oct Sun 12 Oct to Sat 18 Oct Sun 19 Oct to Sat 25 Oct Sun 26 Oct to Sat 01 Nov Sun 02 Oct to Sat 08 Nov Sun 09 Oct to Fri 14 Nov



2.0 Environmental

Environmental inputs such as tides, wind, air temperature, and barometric pressure had minimal or no measurable influence on underwater noise levels. The following sections briefly describe the findings, and the visual data can be found in Appendix B: Environmental Data.

2.1 Weather Station

Environmental data for this reporting period were obtained from two National Oceanic and Atmospheric Administration (NOAA) weather stations in Seattle, Washington (WA) as the closest operating stations to the location of the recording sites (see Table A.1-1 and Figure A.1-1).

Table A.1-1: Details of the location of the NOAA weather station (Seattle, WA)

Environmental Data	Station ID	Location Site (WA)	Latitude (N)	Longitude (W)
Tides/Water Levels	9447130	Seattle	47°36.2	122°20.4
Air Temperature levels	USW00024234	Seattle Boeing Field	47° 32.7324'	122° 18.885'

2.2 Tides/Water Levels

Environmental data show a regular semidiurnal tidal variation, with no significant anomalies or storm surges between September and November (see Appendix B.1: Tides/Water Levels).

Tides did not significantly influence underwater noise. Noise patterns are dominated by maritime traffic, which follows human schedules rather than tidal cycles.

2.3 Air Temperature Levels

Air temperature remained stable throughout the months, with the typical diurnal cycle and mild autumn weather (see Appendix B.2: Air Temperature Levels).

Air temperature affects underwater sound only indirectly through wind generation or atmospheric pressure systems. The acoustic analysis shows no noise variations that align with temperature cycles, so air temperature had no identifiable influence on underwater noise levels.



3.0 Marine Mammal Detections

Automated acoustic monitoring detected vocalizations from marine mammals. The data provides insight into species presence and activity patterns within the study area, supporting efforts to understand how marine mammals interact with underwater noise.

3.1 Detection Algorithm

An automated Whistle and Moan detector developed by PAMGuard (Gillespie et al, 2013) was used to detect any tonal vocalization from pinniped moans and odontocete whistles such as Harbor Seal (*Phoca vitulina*), California Sea Lion (*Zalophus californianus*), and Killer Whale (*Orcinus orca*).

Detection is a multi-stage process, the main steps being:

1. Computation of a spectrogram from raw audio data
2. Processing of the spectrogram to remove noise (especially clicks)
3. Thresholding to create a binary map of regions above the threshold
4. Connecting regions of the binary map to create sounds
5. Breaking and then rejoining branches of complex regions (for instance, if two whistles cross).

Table A.1-1 shows the main settings of the Whistle and Moan detector PAMGuard algorithm used to detect the tonal sounds encountered during the monitoring period. Note: FFT length refers to the number of points used in the Fast Fourier Transform (FFT) when converting a time-domain signal into its frequency-domain representation.

Table A.1-1: Whistle & Moan Detector Settings

Marine Mammal Species	Sample Rate (Hz)	FFT Length	Frequency Resolution (Hz)	Time Resolution (ms)	Minimum Tonal Duration (s)	Bandpass Filter (Hz)
Harbor Seal	4000	4096	0.98	1024	≥0.5	250-2000
California Sea Lion	8000	2048	3.91	256	0.2 – 0.5	500-4000
Killer Whale	64,000	2048	31.25	32	0.3 – 0.5	1000–20,000

3.2 Relative Vocalization Detections by Species

The acoustic data were processed to detect the tonal sounds of marine fauna. These automated detections may represent the presence of the species during this monitoring period. The total number of vocalizations is subject to review and quality control due to high levels of vessel noise and low signal-to-noise (SNR) ratio. The results of data collected from September 1 to mid-November 2025 are presented in the Appendix C: Marine Mammal Detections.

An analysis of these detections shows that marine mammal acoustic activity within Elliott Bay during the September–November 2025 monitoring period was dominated by harbor seal vocalizations, which constituted the clear majority of automated detections at both hydrophone stations. Harbor seal calls represented 70.9% of detections at SJBL-01 and 76.3% at SAQU-01,



indicating regular and consistent use of the monitored areas by this species. California sea lion vocalizations formed a much smaller fraction (29.1% at SJBL-01 and 23.7% at SAQU-01), reflecting a more intermittent presence but still demonstrating ongoing regional activity. Notably, no killer whale calls were detected at either site, suggesting that if killer whales were present in the broader region during this period, they were either silent, beyond the effective detection range, or masked by ambient noise levels.

Time-series call-count plots for harbor seals and sea lions reveal temporal clustering of detections, with both species showing sporadic yet distinct periods of acoustic activity at each station (see Appendix C.1). These activity patterns, however, were not uniform between SJBL-01 and SAQU-01, reflecting the sites' differing acoustic environments and vessel traffic pressures. The consistently louder and more uniform noise levels at SAQU-01, driven by dense vessel presence, likely reduced the effective detection range for quieter or more distant signals, resulting in a lower overall detection rate due to higher local anthropogenic activity.

The relative species-composition pie charts further highlight a stable dominance of harbor seal acoustic activity across the monitoring period at both sites (see Appendix C.2). Because the automated PAMGuard Whistle and Moan detector is sensitive to tonal calls but affected by masking, the high proportion of harbor seal detections suggests that their vocalizations were consistently strong enough to be captured above the ambient noise floor. Meanwhile, the lower detection rate for sea lions may reflect both biological behavior (e.g., seasonal or behavioral variation in vocal activity) and the higher masking potential of low- to mid-frequency vessel noise prevalent in Elliott Bay.

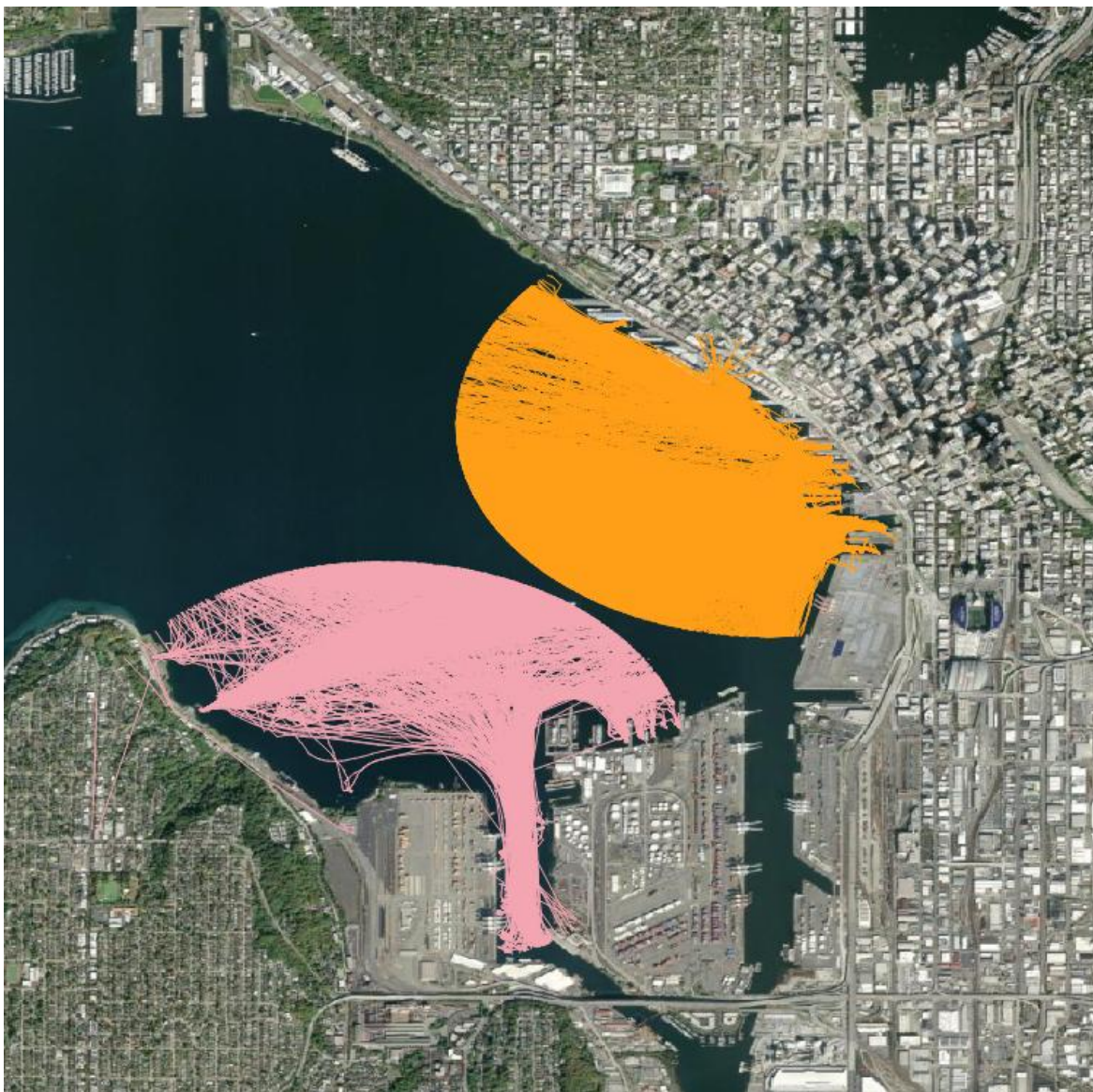
Overall, the automated detections demonstrate that marine mammal acoustic presence in central Elliott Bay is shaped by a combination of species behavior, spatial differences in ambient noise, and anthropogenic masking effects. The findings underscore the importance of interpreting automated detections as relative indicators rather than absolute measures of presence, particularly in high-noise urban marine environments such as the waterfront near the Seattle Aquarium.



4.0 AIS Data Analysis

AIS tracking data provides a detailed overview of vessel activity near the two monitoring stations, including vessel counts, classifications, and temporal patterns that help link marine traffic to observed acoustic conditions. Data were collected every 15 seconds within two defined zones (see Figure A.1-1), one surrounding Jack Block Park (SJBL-01) and the other the Seattle Aquarium (SAQU-01).

Figure A.1-1: AIS Data Collection Zones



Vessel presence within each zone was quantified using a 5-minute moving average and further separated by vessel class (e.g., Passenger). Both hydrophone stations recorded consistent activity from AIS-equipped vessels throughout the monitoring window (see Appendix D: AIS Data Analysis).



Although both monitoring locations exhibit a similar overall temporal structure driven by regional vessel operations, the magnitude of activity differs significantly. SJBL-01 generally shows low vessel presence, commonly registering between 0 and 10 unique vessels per 5-minute interval, with only occasional peaks reaching 12–15 vessels. These counts fluctuate considerably but seldom remain high for extended periods. SAQU-01, however, records much greater activity, frequently showing 10 to more than 20 vessels within the same interval. Peaks occur more often and reach higher values than at SJBL-01, consistent with SAQU-01's proximity to busier transit routes or areas with concentrated vessel movements. Despite these differences, both sites display continuous day-to-day variability with no prolonged quiet periods, indicating steady commercial traffic from September through November (see Appendix D.1: AIS Overall Vessel Presence).

AIS data analysis isolated passenger-class vessels, highlighting activity dominated by large ferry operations. A clear daily schedule is evident, especially at SJBL-01, mirroring local ferry service patterns. This structured pattern is present at SAQU-01 as well, though the effects of multiple overlapping routes create a more complex temporal signature. Passenger-vessel activity follows similar overall trends at both sites but differs markedly in magnitude. SJBL-01 typically registers zero or one passenger vessel in most 5-minute intervals, with only occasional increases to two to four vessels, indicating that major ferry routes rarely pass directly through this zone. SAQU-01, on the other hand, shows significantly higher counts, often between two and seven vessels, with frequent spikes up to eight or nine. This sustained level of traffic is consistent with a location lying along or adjacent to several active ferry corridors. Across the monitoring period, SAQU-01 therefore experiences much denser and more regular ferry traffic than SJBL-01 (see Appendix D.2: AIS Passenger Vessel Presence).

A breakdown of unique vessels detected during the monitoring period by vessel class is shown in Appendix D.3: AIS Unique Vessel Detections by Class. The most notable differences between the two monitoring sites relate to the types of vessels most frequently detected and their associated contributions to underwater noise. SAQU-01 records nearly twice as many "Tug/Towing vessels" (97 vs. 47) and a comparable number of Cargo ships, both classes known to generate high levels of sustained low-frequency noise. In contrast, SJBL-01 shows higher counts of "Passenger-class vessels" (36 vs. 21), the majority of which are large ferry operations; although ferries are strong low-frequency noise sources, their influence is typically more episodic and schedule-driven compared to the continuous activity of tugs and cargo ships. SJBL-01 also shows a higher number of "Pleasure craft" and a substantially larger "Unknown/Undefined" category, though these tend to produce more variable or less intense noise relative to heavy commercial vessels. Taken together, the traffic composition at SAQU-01—dominated by working vessels with powerful propulsion systems—suggests a consistently higher low-frequency noise environment, whereas SJBL-01 experiences more intermittent but distinct ferry-generated noise events.



5.0 Ambient Noise

Underwater noise measurements during the monitoring period reveal patterns across frequency bands and time. The analysis focuses on sound pressure levels at both monitoring stations, identifying dominant sources such as vessel traffic and propeller cavitation, and highlighting variations by day and hour. These observations establish the baseline soundscape for Elliott Bay.

5.1 Jack Block Park (SJBL-01)

5.1.1 Sound Pressure Level (SPL) Box Plot

The SPL box plot for the monitoring period shows distinct patterns across frequency bands (see Figures B1-1 to B1-3 and Tables B1-1 to B1-3). The Mid-frequency (MF) and High-Frequency (HF) decade bands displayed the widest range, extending from 83 to 143 dB. Lower Low-frequency (LLF) decade-band was generally quieter, with medians ranging from 105.0 to 106.6 dB. Upper Low-frequency (ULF) decade band was the loudest, with medians ranging from 116.4 to 117.0 dB, consistent with contributions from vessel traffic and other anthropogenic sources. The broadband noise level for September was highest overall, with a median of 119.2 dB.

5.1.2 Spectral Probability Density (SPD) Plot

The spectral probability density plot for the monitoring period (see Figures B1-4 to B1-6) indicates that the average noise level (L_{eq}) starts at approximately 80 dB at 10 Hz, exceeds sporadically 90 dB between 45 and 360 Hz, and gradually decreases with increasing frequency. The L_{50} (median) curve follows a similar trend, indicating that LF noise dominates the soundscape, likely due to maritime traffic and other anthropogenic sources. In the MF and HF decade bands, noise levels decrease substantially. Very similar patterns are observed each month from September to November, such as a frequent peak at 360 Hz, most likely generated by cavitation from the propeller of a medium-sized commercial vessel. Also notable is the peak at 2.28 kHz, attributed to harmonics from the propeller and engine of small, high-RPM vessels. However, the L5 (upper percentile) and a notable peak at 20,000 Hz during September suggest intermittent high-noise events, consistent with echo sounder transmissions from small vessels operating in Elliott Bay. This frequency range is common in fish finders and depth sounders. Probability density shading confirms that most of the acoustic energy is concentrated in the low-frequency band, with sporadic samples exceeding the 120 dB noise level.

5.1.3 Long-Term Spectral Average (LTSA) and SPL Plot

The weekly LTSA-SPL plots (see Figures E1-7 to E1-16 in Appendix E.1) illustrate temporal and spectral variations in underwater sound levels over this monitoring period, spanning the frequency range of 10 Hz to 55,000 Hz.

The SPL plot shows a pattern each day of elevated SPL during daytime and drops at night, consistent with vessel activity in Elliot Bay. Over all weeks, the SPL ULF decade band (100–1000 Hz) remain consistently the highest, with noise levels at times overpassing 130 dB, reflecting persistent contributions from vessel traffic passing by. The SPL LLF decade-band (10–100 Hz) is generally the lowest during the daytime. These very low-frequency sounds travel long distances with little attenuation, so even when local vessel traffic decreases at night, background low-frequency energy stays relatively high. The MF decade-band (1000–10,000 Hz) contains frequencies that are strongly produced by nearby or passing vessels, but since this



frequency band experiences more acoustic absorption than lower frequencies, it drops quickly when local traffic decreases.

The LTSA plot shows a bright yellow-green band that persists throughout the week, indicating continuous vessel-generated noise. The distinct vertical decade bands of elevated noise levels that appear regularly indicate repeated transient events that produce broadband noise spikes from propeller cavitation. The low-frequency tonal components from vessel engines and propellers appear in the LTSA plot as horizontal bright yellow lines below 100 Hz. These tonal components originate from multiple sources, such as commercial vessels, especially ferries, tug/towing vessels, cargo ships, and large passenger vessels. Occasionally, and more often during the month of September, narrowband bright lines appear in the upper frequencies, consistent with echosounder systems used by fishing or recreational vessels. The slight darkening (reduced intensity) appears during overnight hours when vessel traffic is lower.

In summary, strong diurnal patterns suggest higher noise levels during daytime and early evening when ferry, cargo and passenger vessel traffic is greatest.

5.1.4 7-Day Radial Charts

These radial charts show the average daily levels of underwater noise for each decade frequency band at SJBL 01, revealing how weekday and weekend vessel activity shape the acoustic environment as the region transitions into late fall (see Figures E1-17 to E1-19 in Appendix E.1).

Across the three-month monitoring period from September through November 2025, the day-of-week radial charts at SJBL 01 reveal consistent weekday-dominated underwater noise patterns shaped by vessel traffic, with quieter weekends throughout.

- In September, noise levels across all frequency bands were highest on Fridays, particularly within the LF bands, reflecting strong end-of-week ferry, tug, and cargo vessel activity.
- October maintained this Friday peak for LF noise. Still, it showed a shift in MF and HF decade-bands, which were elevated on Tuesdays and Thursdays, indicating increased mid-week vessel operations and intermittent HF sources such as active echosounders.
- By November, weekday patterns became more structured; LF noise consistently peaked on Mondays, while MF and HF decade-bands, along with broadband levels, concentrated on Wednesdays, demonstrating a clearer separation between the timing of heavy vessel traffic and the use of HF acoustic sources.

Throughout all months, Saturdays and Sundays remained consistently quiet, with the contrast between weekday and weekend noise becoming more pronounced into late fall as overall vessel activity patterns stabilized without the presence of cruise ships (last cruise ship sailed from Pier 66 on October 19, 2025).

5.1.5 24-Hour Radial Charts

Radial charts with 24-hour patterns (see Figures E1-17 to E1-19 in Appendix E.1) reveal acoustic activity as the day progresses. Across the three-month period from September through November 2025, the 24-hour radial charts at SJBL-01 show a highly consistent diurnal pattern dominated by elevated daytime underwater noise levels and substantially quieter nighttime conditions. In all months and across all frequency bands, sound levels begin rising in the early morning hours, increase sharply between 9 AM and 12 PM, and remain elevated through the



late afternoon and early evening, reflecting the strong influence of daytime vessel traffic on Elliott Bay's soundscape.

- September displays the most pronounced midday peaks, particularly in the low-frequency bands, as ferry operations, tug movements, and commercial vessel transits generate continuous propulsion and engine noise throughout daytime hours.
- October exhibits a similar but slightly more intensified midday pattern, with mid- and high-frequency bands showing stronger responses to vessel pass-by, cavitation, and intermittent use of HF acoustic systems.
- By November, the diurnal cycle becomes even more structured and stable across all frequency ranges, with consistently high daytime SPLs and clearer nighttime quiet periods as recreational activity declines and vessel operations follow more predictable late-fall schedules.

Across the entire monitoring period, nighttime intervals—particularly from 12 AM to 6 AM—remain the quietest regardless of month or frequency band, underscoring the strong and recurring relationship between daily vessel activity and the temporal structure of the underwater noise environment at SJBL-01.

5.2 Seattle Aquarium (SAQU-01)

5.2.1 Sound Pressure Level (SPL) Box Plot

The SPL box plot for the monitoring period shows distinct patterns across frequency bands (see Figures E2-1 to E2-3 and Tables E2-1 to E2-3 in Appendix E.2). The LLF decade-band displayed the widest range, extending from 100 to 144 dB. MF decade-band was generally quieter, with medians ranging from 118.6 to 119.9 dB. ULF decade-band was the loudest, with medians ranging from 125.7 to 126.7 dB, consistent with contributions from vessel traffic. The broadband noise level for November was highest overall, with a median of 129.7 dB.

5.2.2 Spectral Probability Density (SPD) Plot

The spectral probability density plot for the entire monitoring period at SAQU-01 (see Figures E2-4 to E2-6) indicates that the average spectrum (L_{eq}) starts at approximately 90 dB at 10 Hz, increases to over 100 dB between 25 and 120 Hz, with multiple outliers exceeding 120 dB throughout the LF decade-band. L_{eq} tends to decrease gradually with increasing frequency; however, numerous sharp peaks, influenced by the L_{95} percentile, are observed in the MF decade band, suggesting the consistent presence of vessel cavitation and intensified harmonic tonal noise during periods of high maritime traffic density across the monitoring period. These sources are not constant but occur frequently enough to influence the L_{95} percentile. The occasional high peak of the L_5 percentile at 20,000 Hz is only observed during the month of September, with the highest recorded sound level, suggesting that the source was closer to SAQU-01.

5.2.3 Long-Term Spectral Average (LTSA) and SPL Plot

The long-term spectral average (LTSA) and synchronized SPL time-series plots for SAQU-01 (Figures E2-7 through E2-16 in Appendix E.2) show a consistently louder and more uniform underwater soundscape compared to SJBL-01, with persistent low-frequency energy and



frequent high-intensity transient events throughout the full September–November 2025 monitoring period.

Across all weeks, the LTSA displays a bright, continuous band of elevated acoustic energy below ~200 Hz, reflecting the near-constant presence of vessel traffic in the central waterfront operating lanes adjacent to the Seattle Aquarium. Vertical streaks of broadband energy appear regularly across the LTSA plots, indicating repeated vessel pass-by, while pronounced narrowband tonal features near 20 kHz occur one to two times per week, consistent with active echosounder or high-frequency SONAR use by commercial or recreational vessels operating in the area.

The SPL traces reinforce these observations: LF decade-bands (10–100 Hz, 100–1000 Hz) remain elevated with only modest nightly reductions, while MF and HF decade bands show sharp daytime peaks and distinct transient bursts corresponding to high-RPM vessels and sonar activity. Nighttime periods exhibit relatively lower levels across all bands but never reach the quiet conditions seen at SJBL-01, reflecting the significantly higher vessel density in this location.

MF levels at SAQU-01 remain comparatively high because of frequent near-field vessel pass-by, propeller cavitation, and intermittent echosounder activity, which suppresses the nighttime quieting observed at SJBL-01. As a result, LLF, ULF, and MF bands at SAQU-01 converge into a more uniform and consistently high-energy soundscape, whereas at SJBL-01 they separate more distinctly due to lower vessel density and stronger diurnal variability.

Overall, the SAQU-01 LTSA and SPL patterns point to a consistently high-energy acoustic environment dominated by dense ferry, tour boat, and commercial vessel operations, with superimposed high-frequency acoustic sources that occur intermittently but regularly throughout the monitoring period

5.2.4 7-Day Radial Charts

The 7-day radial charts for SAQU-01 (Figures E2-17 to E2-19 in Appendix E.2) show a consistently strong weekday-dominated underwater noise structure, with elevated sound levels across all frequency bands driven by dense ferry, tour-boat, and commercial vessel activity along the central Seattle waterfront.

- In September, noise levels peak primarily on Mondays and Thursdays, especially across the HF, and broadband bands, reflecting the combined influence of scheduled ferry operations and intermittent echosounder use detected on Mondays and Thursdays during this period.
- October maintains this weekday-heavy pattern, except for Fridays and Saturdays which shows lower noise levels, aligning with periods of intensified vessel operations and recurring high-frequency acoustic sources.
- By November, the weekly structure becomes more uniform and slightly more subdued at the high end, yet weekday peaks remain prominent across all bands, again centering on Mondays to Thursdays for the LF band, while weekends consistently register the lowest sound levels.

Overall, the three months demonstrate a stable pattern at SAQU-01: strong weekday noise across all bands, heaviest late-week peaks in early fall, and progressively clearer distinctions between weekday and weekend conditions moving into late fall, underscoring the influence of sustained vessel traffic near the Seattle Aquarium on the local underwater soundscape.



5.2.5 24-Hour Radial Charts

The 24-hour radial charts for SAQU-01 (Figures E2-20 to E2-22 in Appendix E.2) show a consistently strong diurnal cycle marked by elevated daytime noise levels across all frequency bands, reflecting the persistently high vessel density along Seattle's central waterfront.

- In September, broadband and decade-band levels exceed 125 dB re 1 μ Pa during the day and early evening (5 AM–10 PM), with the HF band also showing daytime-restricted peaks associated with active acoustic sources.
- October maintains this pattern but demonstrates a more distributed and intensified midday rise in MF and HF bands, consistent with recurring vessel pass-by and high-frequency echosounder activity described earlier in the LTSA analysis.
- By November, the 24-hour structure becomes even more stable, with all frequency bands showing predictable daytime peaks and reduced nighttime variability, while still remaining louder overnight than SJBL-01 due to the nearly continuous presence of vessels near the Aquarium. Across all months, the quietest period occurs between 12 AM and 6 AM, though SAQU-01 never reaches true low-noise conditions (\sim 80 dB re 1 μ Pa) because local and distant vessel traffic continue to contribute LF and MF energy throughout the night.

Overall, the three-month progression illustrates a robust and seasonally consistent diurnal cycle dominated by daytime ferry, tour-boat, and commercial vessel operations, with SAQU-01 exhibiting a uniformly high-energy acoustic environment that persists even during overnight hours.



6.0 Discussion

Beyond vessel traffic, additional human activities influence underwater sound levels. Propeller cavitation and active systems were identified as significant contributors, with acoustic signatures that vary in frequency and intensity.

The monitoring results demonstrate pronounced spatial, spectral, and temporal variability in underwater noise conditions within Elliott Bay, underscoring the acoustic complexity of urban marine environments. Clear differences are observed between the two monitoring locations. The site near the Seattle Aquarium (SAQU-01) consistently exhibits higher sound pressure levels across most frequency bands and a comparatively narrow range of variability, indicating a persistently elevated and uniform acoustic environment. In contrast, the Jack Block Park site (SJBL-01) is characterized by lower median sound levels and greater temporal variability, particularly in the mid and high-frequency bands. These spatial differences reflect the distinct acoustic settings of the two locations and illustrate that underwater sound conditions can vary substantially over relatively short distances. The contrast between sites also highlights the importance of spatially distributed monitoring for characterizing regional soundscapes.

Environmental variables such as tides/water levels, and air temperature, exhibited typical seasonal patterns and showed no strong correlation with observed underwater noise levels. The latter indicates that underwater sound levels during the monitoring period were mostly influenced by anthropogenic processes rather than environmental variables.

Marine mammal acoustic detections provide additional context for interpreting the soundscape. Automated detection analyses identified vocalizations attributed primarily to harbor seals and California sea lions at both monitoring locations. Harbor seal calls account for the majority of detections, suggesting regular use of the monitored areas during the reporting period, while California sea lion detections occur less frequently but consistently, indicating intermittent presence or transit. No killer whale vocalizations were detected during the monitoring period. While this absence does not imply a lack of presence in the broader region, it indicates that detectable vocal activity did not occur within the acoustic detection range of the monitoring systems during the analyzed timeframe. Elevated ambient noise levels, particularly at the SAQU-01 site, are likely to reduce effective detection ranges and may bias detection rates downward, especially for quieter or more distant vocalizations. Consequently, detection results should be interpreted as relative indicators of acoustic activity rather than definitive measures of species abundance or absence.

The AIS data reveal that vessel traffic was continuously present at both monitoring sites, with notable spatial differences that strongly influenced underwater noise conditions. SAQU01 consistently experienced much higher vessel density, frequently recording more than 10–20 vessels per 5-minute interval, while SJBL01 typically saw fewer than 10, with only occasional peaks. Passenger vessel activity, particularly ferries, showed predictable diurnal and weekly patterns at both locations, but remained substantially more frequent and intense at SAQU01. Because large ferries are strong sources of low-frequency acoustic energy, generated by propeller dynamics, hull vibration, and powerful propulsion systems, the elevated and persistent ferry presence at SAQU-01 naturally aligns with higher underwater noise levels. In contrast, the less frequent ferry passages at SJBL-01 result in brief SPL increases when ferries pass nearby.

Across both stations, underwater noise energy is strongly dominated by the low-frequency decade bands, which exhibit the highest median levels and the greatest temporal persistence. This characteristic indicates sustained contributions from continuous anthropogenic sources rather than isolated or impulsive events. Low-frequency noise is the primary driver of broadband sound levels throughout the monitoring period and establishes the foundational acoustic



background of the study area. Mid-frequency decade bands show greater variability, particularly at the SJBL-01 site, where sound levels increase sharply during localized source activity and decrease rapidly during quieter periods, suggesting sensitivity to intermittent or passing sources in relatively close proximity. High-frequency noise is generally intermittent at both locations, appearing as discrete tonal or narrowband features rather than as a sustained background component, consistent with episodic operation of active SONAR or echosounder systems.

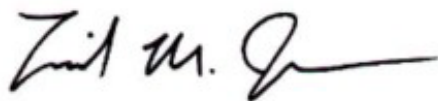
At both monitoring locations, sound pressure levels follow a pronounced diurnal cycle, increasing during the early morning hours, remaining elevated throughout the daytime and early evening, and decreasing overnight. This pattern is most evident in the low and mid-frequency decade bands and reflects the influence of routine human activity cycles on the underwater acoustic environment. Weekly patterns further reveal a weekday-dominated structure, with higher sound levels typically observed during weekdays relative to weekends. At the SJBL-01 site, this contrast becomes more pronounced as the monitoring period progresses into late fall, suggesting stabilization of operational schedules and a reduction in discretionary or seasonal activities over time.

In addition to persistent background noise, the datasets show evidence of specific anthropogenic sources that intermittently elevate sound levels or introduce distinct spectral features. Propeller cavitation events are evident as broadband or low-frequency transients and contribute substantially to short-term variability, particularly at the SJBL-01 site. Although episodic, these events are acoustically prominent when present and play a meaningful role in shaping short-term soundscape dynamics. Sporadic high-frequency tonal signals, typically centered near 20 kHz, occur at both monitoring locations. These signals are infrequent but distinct, producing prominent peaks within high-frequency bands. The narrow spectral bandwidth and short duration indicate that these are active acoustic systems with a specific purpose, rather than incidental noise sources.

Overall, the results of this monitoring period reinforce the importance of sustained, long-term acoustic data collection in complex urban marine environments. Persistent spatial contrasts, stable diurnal and weekly patterns, and recurring spectral signatures establish a solid foundation for assessing future changes. Continued monitoring will be beneficial for tracking long-term trends, evaluating the effectiveness of management or mitigation measures, and supporting informed decision-making related to underwater noise in Elliott Bay.

Regards,

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7.0 References

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Appendix A Methodology

Underwater Noise Assessment

Phase II Monitoring and Reporting – Second Quarterly Report 2025

Port of Seattle

SLR Project No.: 119.000032.00001

May 1, 2026

A.1 Fundamental Concepts of Underwater Noise

Sound is a form of energy made by vibrations. When an object vibrates, it causes the fluid particles around it to move. These particles collide with nearby particles, and this continues until they run out of energy. In underwater acoustics, the word sound is used to describe all the pressure waves that are generated in an underwater medium. Sound waves propagate as alternate phases of compression and rarefaction. Compression occurs when molecules are pressed together. Rarefaction is just the opposite; molecules are allowed to expand.

A **tonal** or tone refers to a signal or component that is dominated by one or a few discrete frequencies, rather than spread across a wide range of frequencies like broadband noise.

A **harmonic** is a frequency component that is an integer multiple of a fundamental frequency. Harmonics often appear in periodic signals like machinery vibrations or propeller noise in underwater acoustics. If the fundamental propeller noise tone is 10 Hz, then harmonics will appear at 20 Hz, 30 Hz, 40 Hz, and so on.

A.1.1 Frequency Band Classifications

Frequency is measured in hertz (Hz), which represents cycles per second. In underwater acoustics, frequency bands are generally categorized based on their propagation characteristics, absorption, and typical applications. Frequency bands refer to ranges of frequencies within the electromagnetic or acoustic spectrum that are grouped for classification and analysis. In acoustics (like underwater noise monitoring), these bands help organize sound energy into manageable segments for interpretation.

A **decade** band refers to a frequency range where the upper limit is ten times greater than the lower limit. In signal processing, it is common to group frequencies into logarithmic rather than linear intervals.

Broadband frequency refers to a wide range of frequencies rather than a narrow or single frequency band. Broadband signals are often used for high-resolution imaging to exploit frequency diversity and reduce noise at specific frequencies.

An **octave band** is a range of frequencies where the highest frequency is twice the lowest frequency. It is a way to group frequencies for analysis, especially in acoustics and noise measurement. A 1/3 octave scale contains finer resolution.

The frequency band classification shown below is widely accepted and serves as a reference for the analyzed data in this report.

Table A.1-1: Frequency Band Classifications

Frequency Band	Decade Bands (Hz)	Anthropogenic Noise
LLF - Lower Low frequency ULF - Upper Low frequency	10-100 100-1000	Propeller cavitation noise from vessels often dominates below 1000 Hz
MF - Medium Frequency	1000-10,000	Pumps, generators, and other machinery can produce tonal components in the 1,000 -10,000 Hz band.
HF - High Frequency	10,000-55,000	Predominant for active sources such as SONAR/echosounders
Broadband	50-55,000	All above



A.2 Underwater Noise Metrics

This analysis incorporates, where possible, recent updates to internationally recognized standards for acoustic terminology and metrics, including American National Standards Institute (ANSI) ANSI S1.13-2013 and International Organization for Standardization (ISO) 18405:2017 and ISO 80000-3:2019. These standards provide consistent definitions and alignment with the best practices in marine noise assessment.

Sound pressure level (SPL) is the primary metric used to indicate the amplitude level of sound at a specific location in space and is a scalar quantity. The level is dependent on the location and distance at which the sound is observed relative to a sound source. Sound pressure is measured in Pascals (Pa) but can be computed in decibels (dB). A standard reference pressure is used to compare sound levels given in decibels to one another. In underwater acoustics, the traditional standard reference pressure (p_0) is 1 micro-Pascal (μPa), leading to the use of the unit dB re 1 μPa , which represents a decibel referenced to a pressure of 1 μPa .

The following acoustic metrics are most commonly applied in this report:

- **zero-to-peak SPL ($L_{p,pk}$, dB re 1 μPa)** measures the maximum instantaneous signal's amplitude without considering time in a stated frequency band. It is used to assess potential permanent or temporary injuries in the hearing of marine mammals, as well as mortality or injuries in fish and sea turtles exposed to impulsive sound.
- **root-mean-square SPL ($L_{p,rms}$, dB re 1 μPa)** is essentially an average intensity over a given amount of time and, therefore, not an instantaneous pressure. This type of metric can be used to assess potential behavioral disturbance in marine mammals from impulsive and non-impulsive sound exposure. It is also used to assess mortality or injury in fish and sea turtles exposed to non-impulsive sound.
- **equivalent continuous sound level (L_{eq} , dB re 1 μPa)**, is a measure used to describe the average sound energy over a specified period, taking into account fluctuations in noise levels.

By applying ANSI and ISO standards, this report ensures that underwater noise metrics are calculated using globally accepted methodologies, supporting scientific rigor and facilitating comparison with other marine acoustic studies.

A.3 Plots Format

Results are shown using visual formats that make patterns in underwater noise easier to interpret. Box plots summarize sound levels across frequency bands, spectral plots show how energy is distributed, and long-term averages highlight trends over time. Radial charts illustrate daily and weekly patterns, while AIS and marine mammal data are displayed in time-series and pie charts for quick comparison.

A.3.1 Ambient Noise

The **acoustic bandwidth** of the recording spans from 10 Hz to 55,000 Hz. The icListen hydrophones have a nominal frequency range of 64,000 Hz. However, they incorporate an anti-aliasing filter that suppresses frequencies above approximately 55,000 Hz. The quarterly report only displays the usable portion of the signal or frequencies that were recorded accurately without being suppressed, which is 10 Hz to 55,000 Hz.

The ambient noise results for this monitoring period are presented in four different formats:



The **SPL box plot** is a summary of the broadband and decade-band statistics of SPL (1-minute) over the month analysis period. Each plot shows the median sound pressure level (center line), the interquartile range (box), and the minimum and maximum values (whiskers). This format provides a quick visual comparison of typical noise levels and variability across frequency bands and monitoring sites. By highlighting both central tendencies and extremes, box plots make it easier to identify patterns, assess variability, and compare conditions without reviewing large datasets. A table of values accompanies each plot for reference.

The **Spectral Probability Density (SPD) plot** illustrates the distribution of underwater sound energy across different frequencies. To create this plot, the acoustic data is divided into 1-second segments, and each segment is processed using a Hanning-windowed spectra with 50% overlap. The Hanning window tapers the edges of each segment to reduce distortion in the frequency analysis (called spectral leakage), while overlapping segments ensure smoother transitions and better time resolution. These 1-second spectra are then averaged into 1-minute periods for stability and clarity.

The 1-minute averages are displayed at the 5th, 50th, and 95th percentile levels, referred to as L_5 , L_{50} , and L_{95} , respectively. According to the ANSI standard, L_5 is the sound level exceeded only 5% of the time (typically the highest value), L_{95} represents the level exceeded 95% of the time (the quieter end), and the L_{50} is commonly referred to as the median. The frequency range is displayed logarithmically and spans the most important acoustic bandwidth of the recordings.

The **Long-Term Spectral Average (LTSA) and SPL plot** is a visual representation of the signal's frequency content and SPL over time. The LTSA plot is used to visualize how the spectral density of a signal evolves through the recording period. Using LTSA helps identify trends and anomalies in noise levels across the full frequency range over extended periods. The SPL plot displays the time series of Sound Pressure Levels of three decade-bands (LLF, ULF, MF) and broadband noise levels (1-minute), synchronized with the LTSA plot. Using the SPL plot helps identify patterns in noise levels over extended periods.

A **Radial chart**, also known as a spider chart, is a two-dimensional chart used to display multivariate data with all axes originating from a common center point. These plots have been adjusted to reflect local time and L_{eq} per day or hour.

A.3.2 AIS Data

AIS is a maritime tracking system that uses transponders on vessels to broadcast real-time information such as position, speed, and heading. This data is collected via satellite and terrestrial receivers, providing a detailed record of vessel movements within the monitoring area. AIS data for this monitoring period has been analyzed to quantify vessel activity as it relates to underwater noise monitoring.

The results are presented as a **time series histogram of vessel counts**, showing frequency and density of vessel presence at very fine temporal resolution (5-minute bins).



A.3.3 Marine Mammal Detections

Marine mammal detections are based on automated acoustic monitoring, which identifies species-specific vocalizations recorded during the monitoring period. These detections provide insight into species presence and activity patterns within the study area, supporting correlation with underwater noise levels.

The marine mammal detections for this monitoring period are presented in two formats:

- Time-series graphs display the 1-minute occurrence for each species for the entire monitoring period. All graphs are in UTC time unless otherwise indicated.
- Pie charts show counts and proportions of automatic vocalization detections by species.





Appendix B Environmental Data

Underwater Noise Assessment

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B.1 Tides/Water Levels

Figure B.1-1: Observed Water Levels (NOAA/Seattle, WA - Station 9447130) over the monthly monitoring period (September 2025)

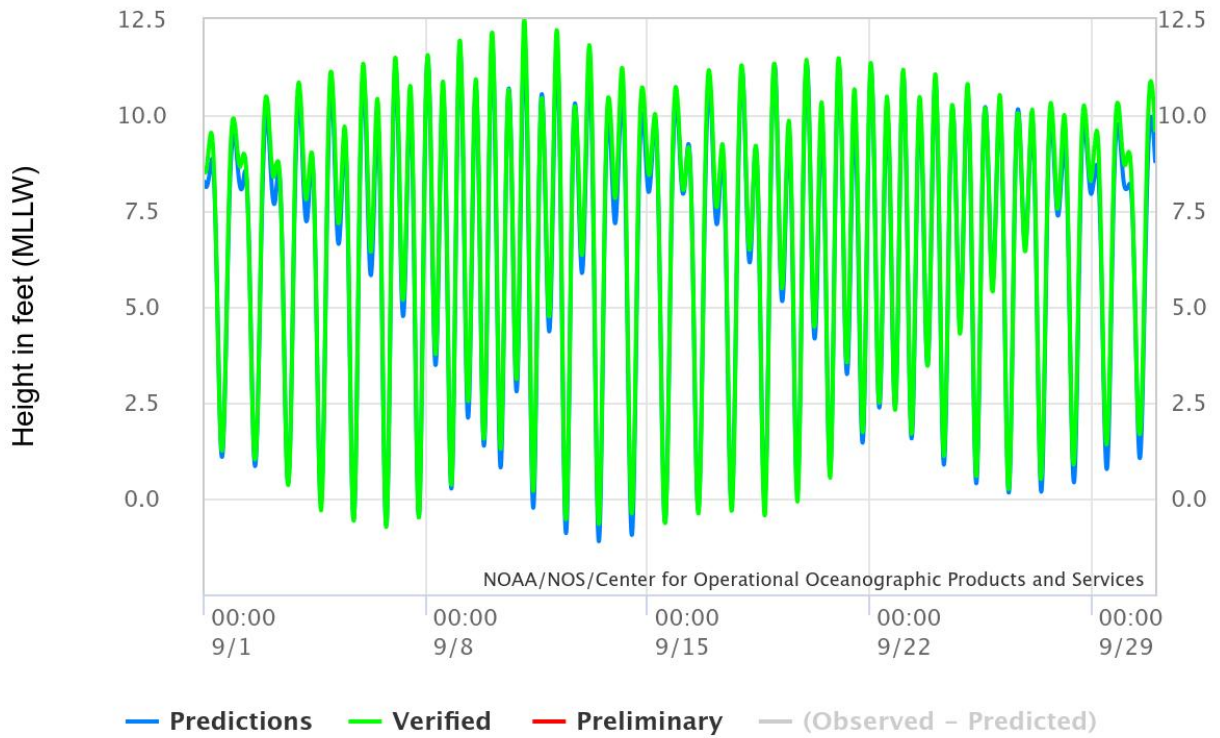


Figure B.1-2: Observed Water Levels (NOAA/Seattle, WA - Station 9447130) over the monthly monitoring period (October 2025)

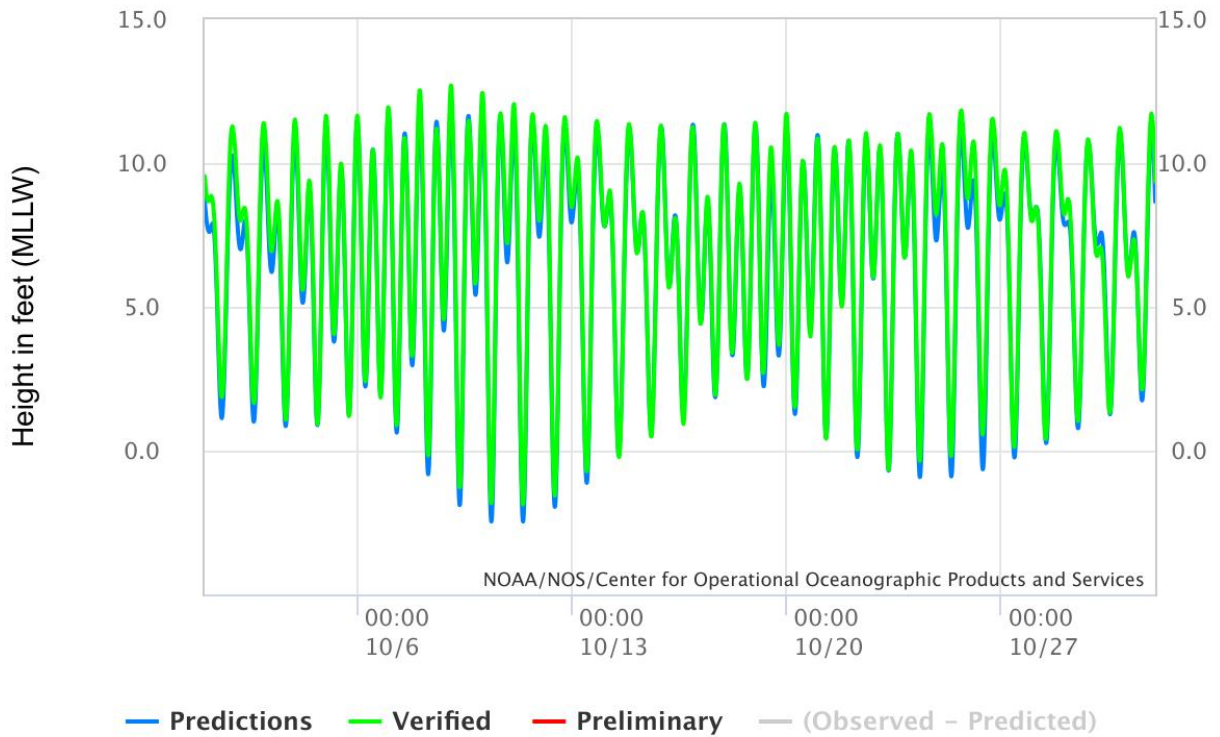
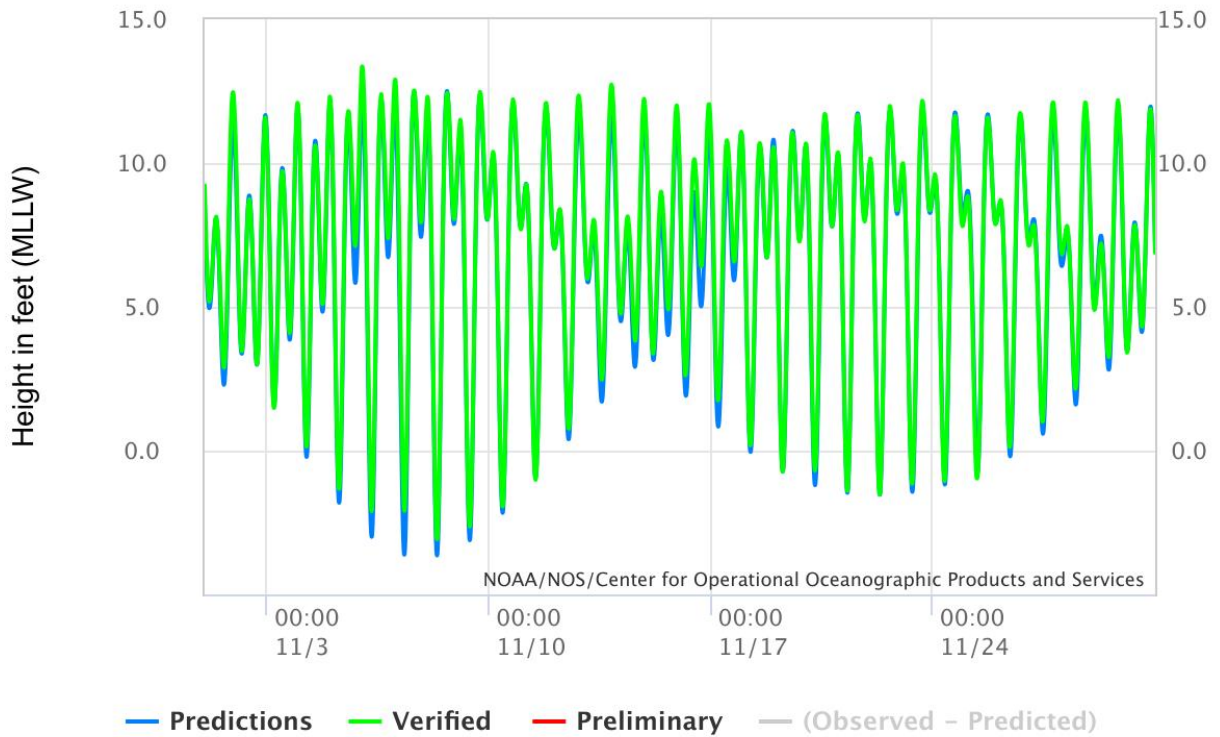


Figure B.1-3: Observed Water Levels (NOAA/Seattle, WA - Station 9447130) over the monthly monitoring period (November 2025)



B.2 Air Temperature Levels

Figure B.2-1: Observed Air Temperature Levels at Seattle City Area, WA over the monthly monitoring period (September 2025)

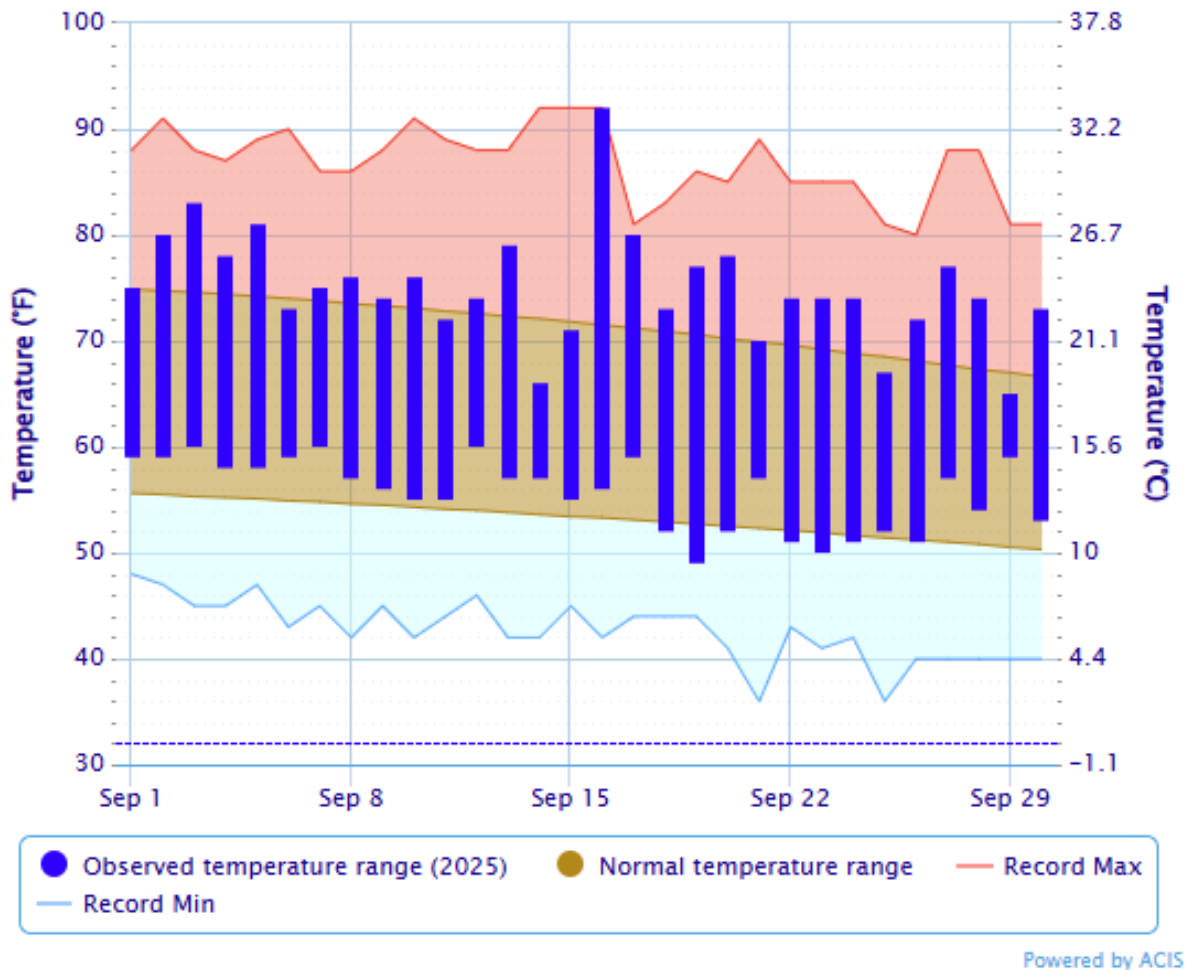
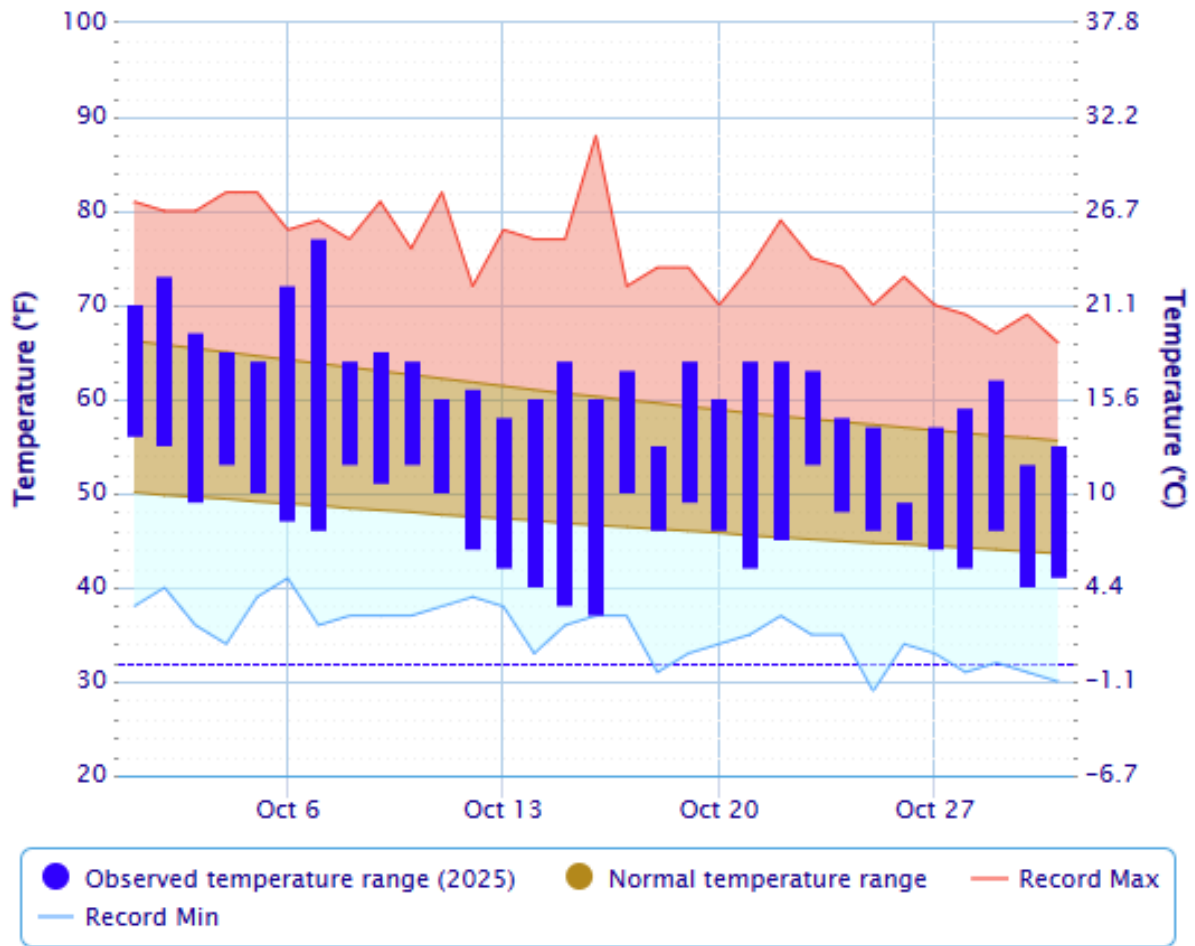


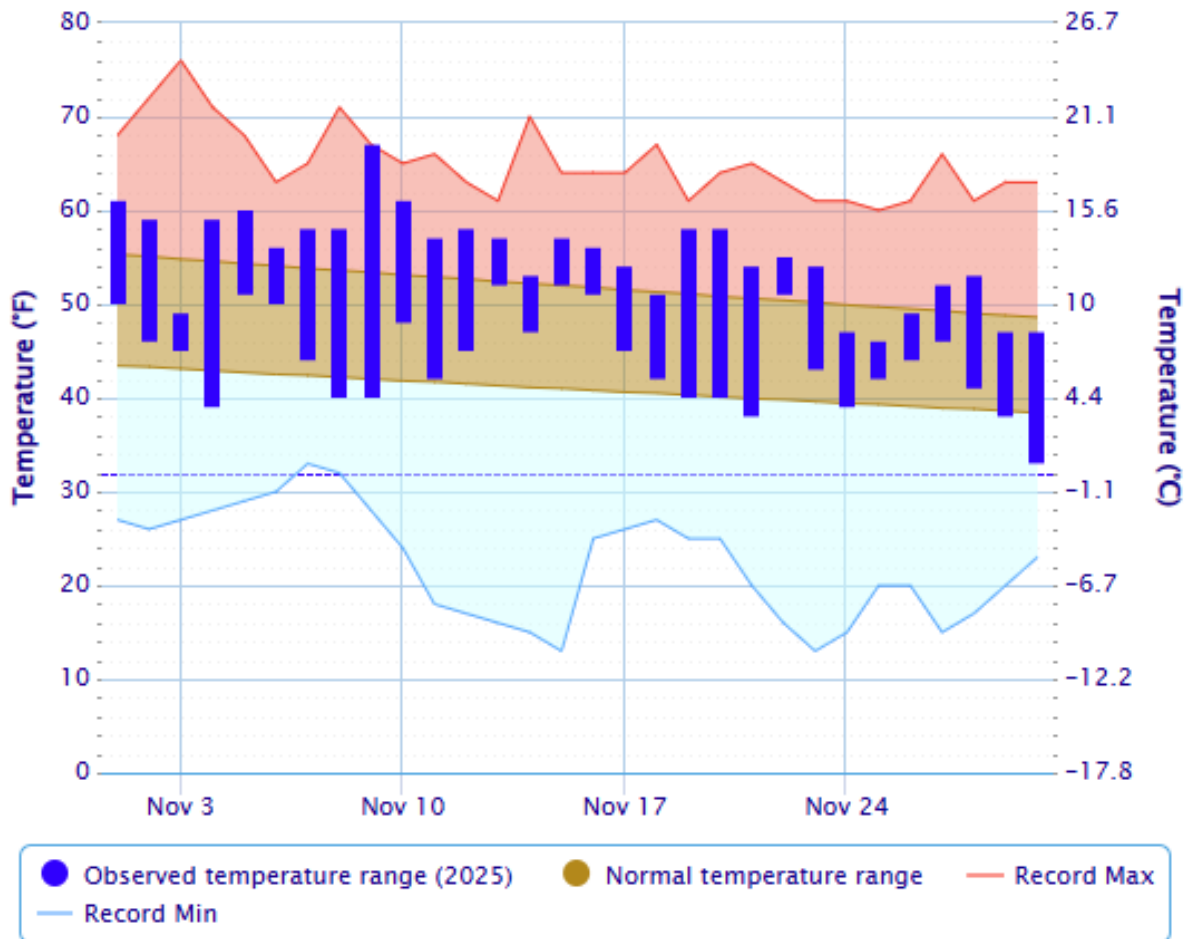
Figure B.2-2: Observed Air Temperature Levels at Seattle City Area, WA over the monthly monitoring period (October 2025)



Powered by ACIS



Figure B.2-3: Observed Air Temperature Levels at Seattle City Area, WA over the monthly monitoring period (November 2025)



Powered by ACIS





Appendix C Marine Mammal Detections

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C.1 Automated Call Count Detections

Figure C.1-1: Call count detections of Harbor Seal at SJBL-01 (top) and SAQU-01 (bottom)

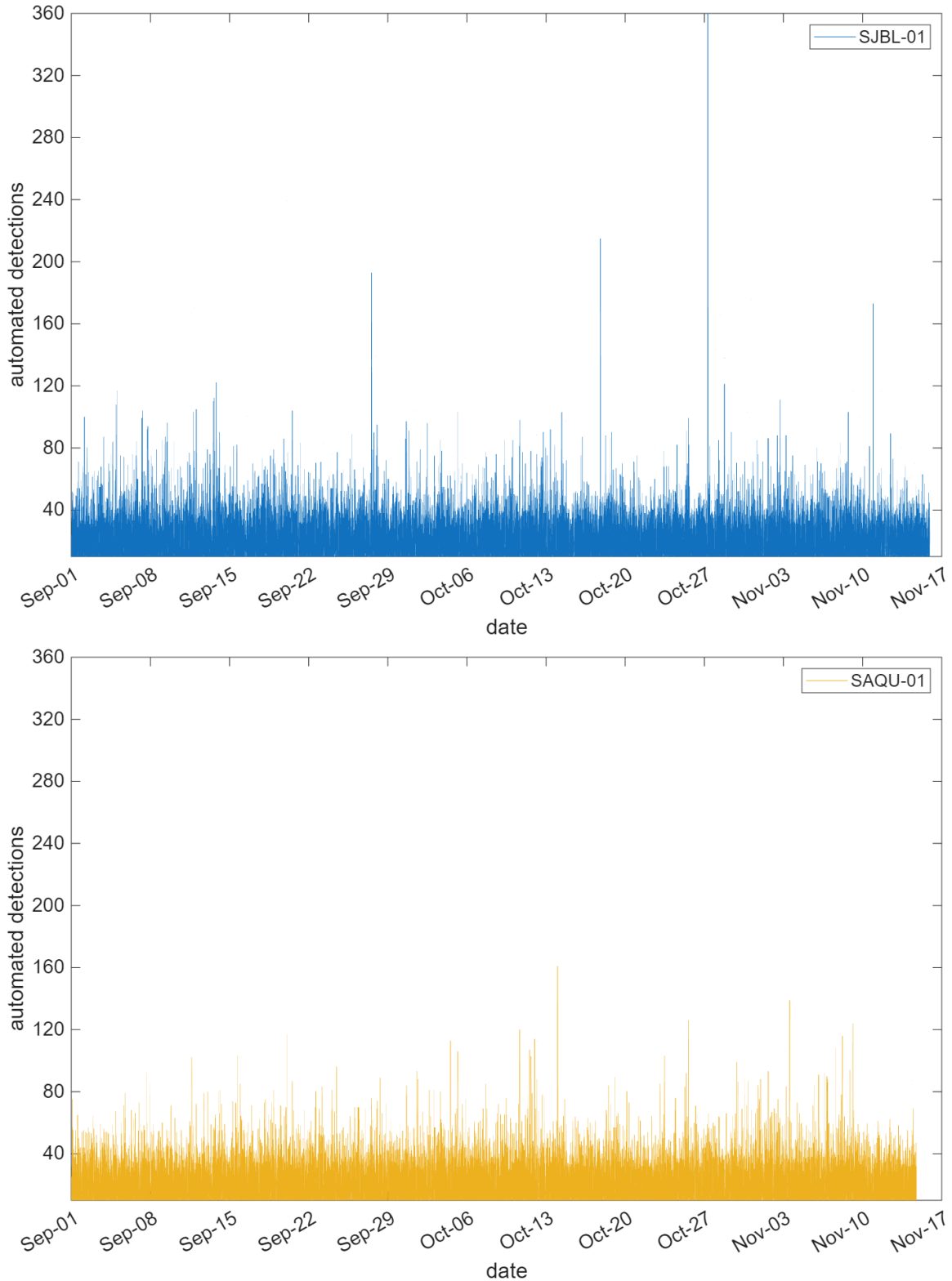
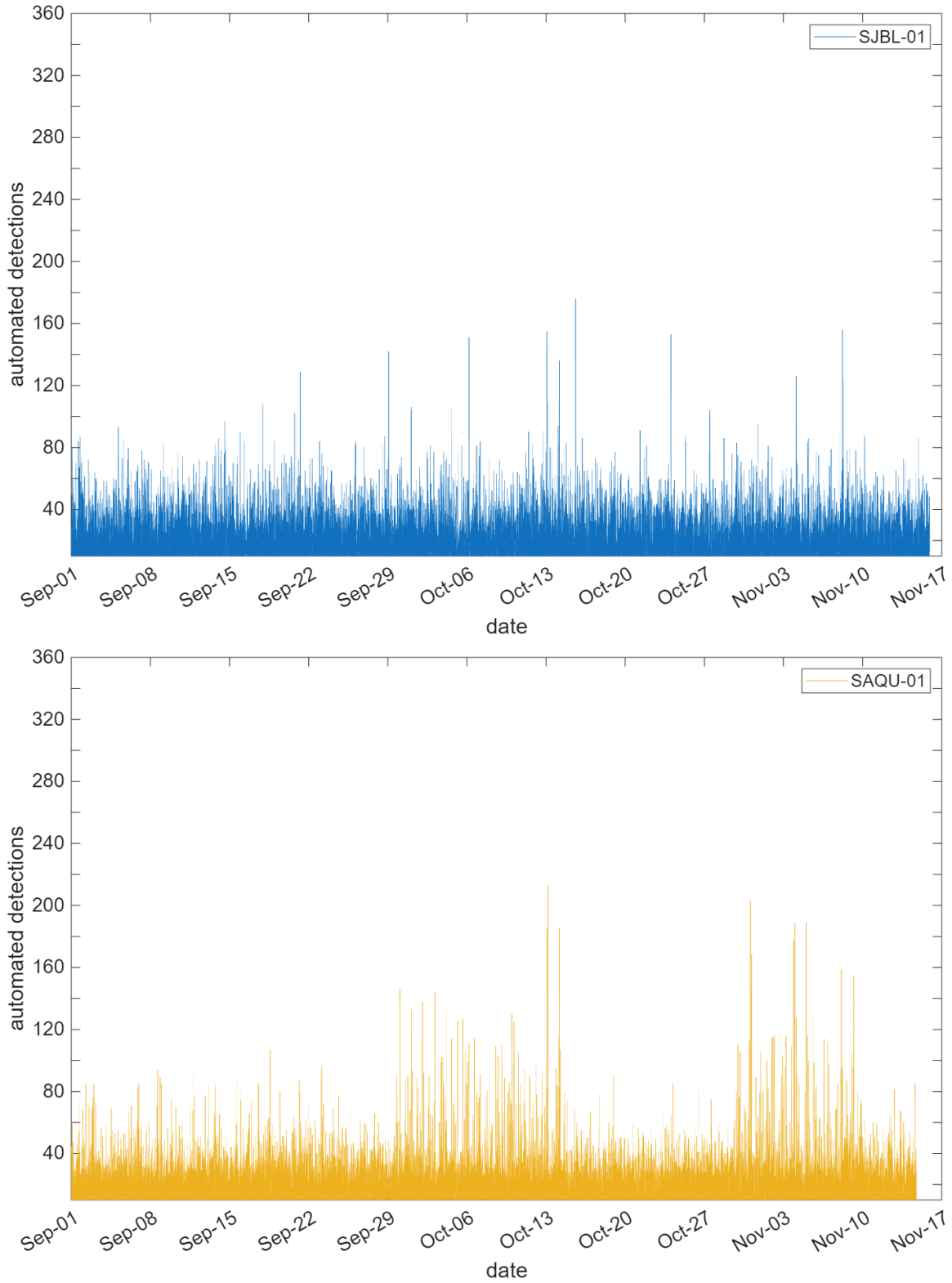
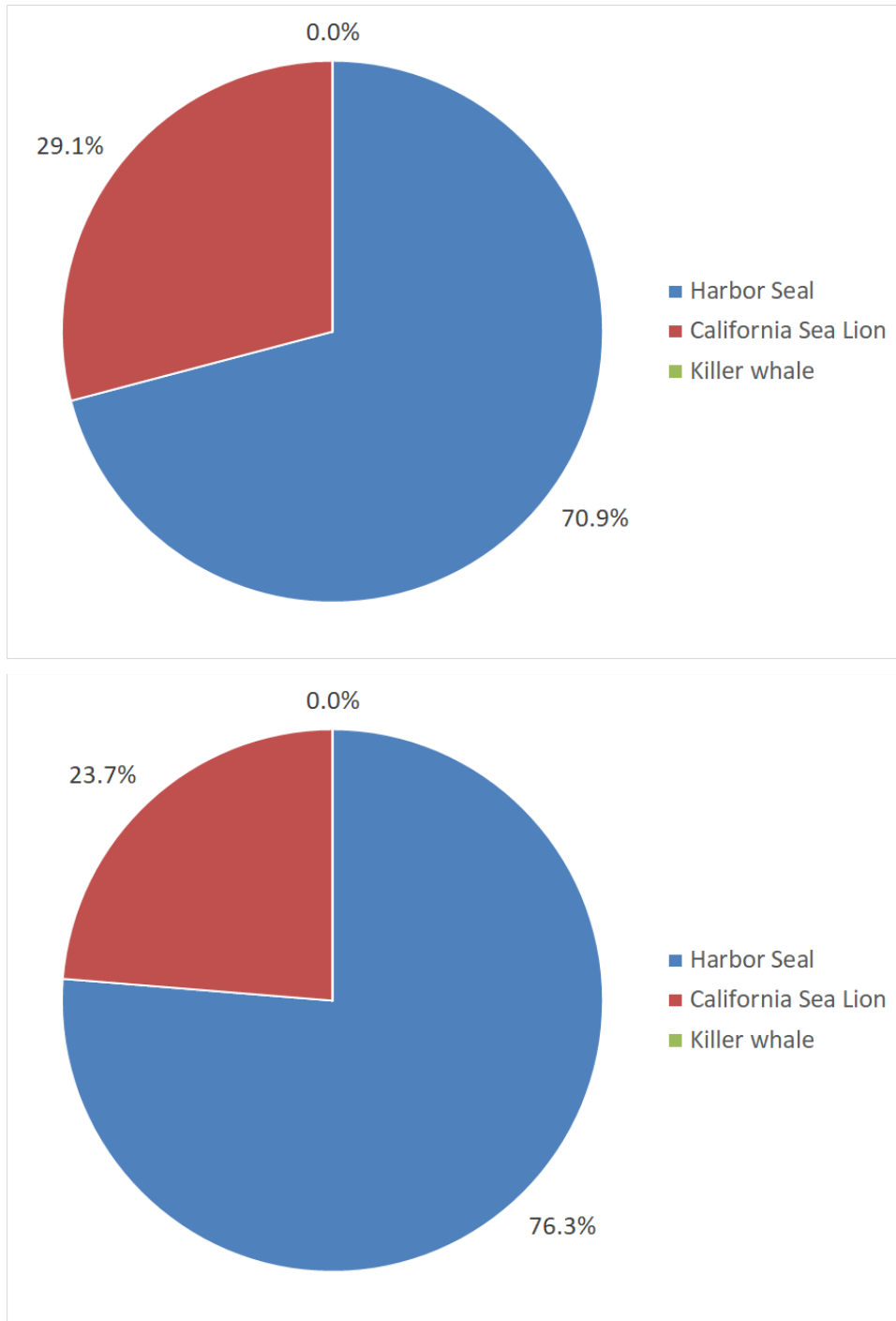


Figure C.1-2: Call count detections of Sea Lion at SJBL-01 (top) and SAQU-01 (bottom)



C.2 Proportion of automated vocalization detections by species

Figure C.2-1: Relative automated vocalization detections by species during the entire monitoring period SJBL-01 (top) and SAQU-01 (bottom)





Appendix D AIS Data Analysis

Underwater Noise Assessment

Phase II Monitoring and Reporting – Second Quarterly Report 2025

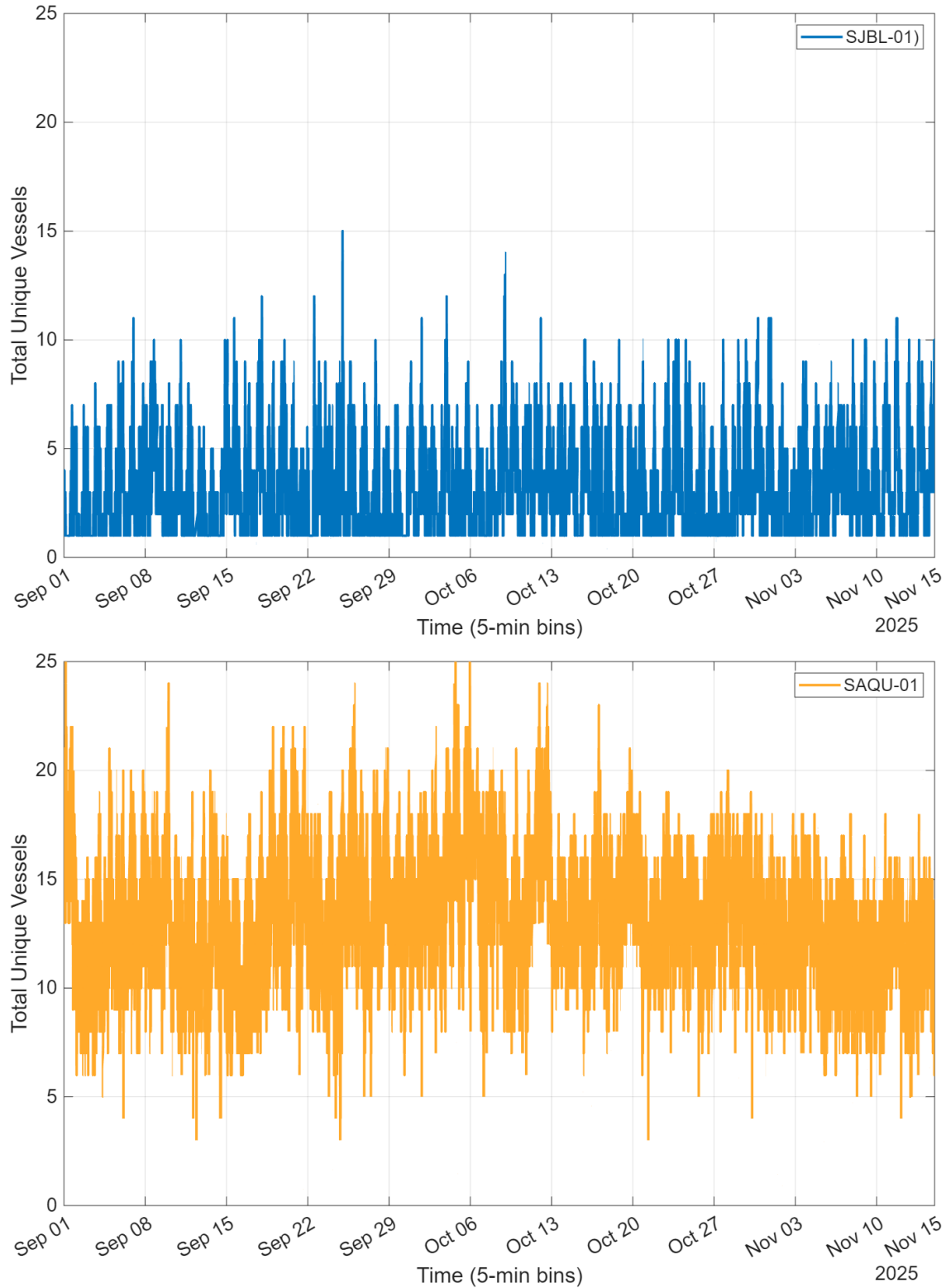
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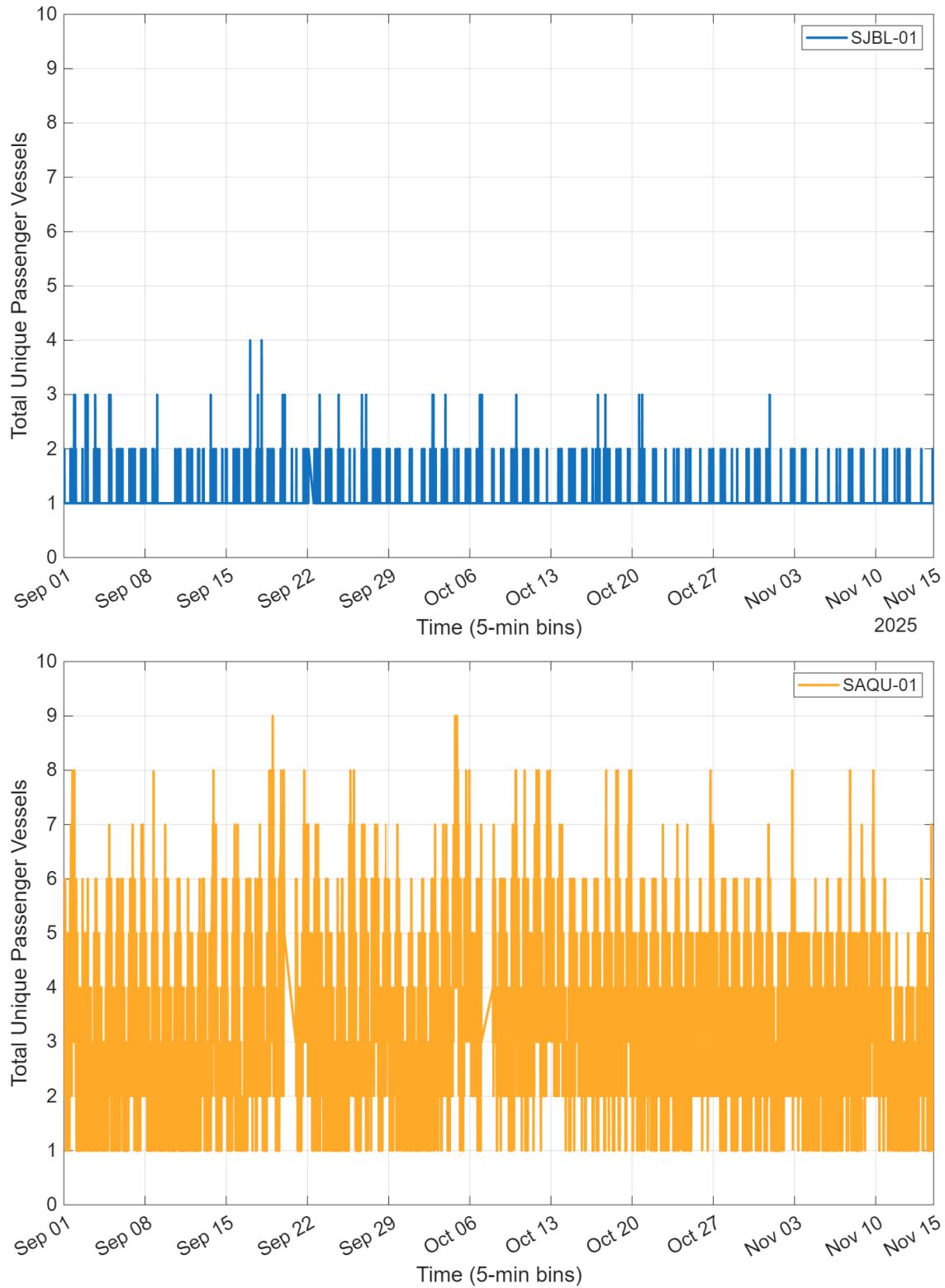
D.1 AIS Overall Vessel Presence

Figure D.1-1: AIS Overall Vessel Presence at SJBL-01 (top) and SAQU-01 (bottom)



D.2 AIS Passenger Vessel Presence

Figure D.2-1: AIS Passenger Vessel Presence at SJBL-01 (top) and SAQU-01 (bottom)



D.3 AIS Unique Vessel Detections by Class

Table D.3-1: AIS Unique Vessel Detections by Class (September 1 – mid-November 2025)

Vessel Class	Unique Detections (SJBL-01)	Unique Detections (SAQU-01)
Tug/Towing vessel	47	97
Cargo ship	47	38
Tanker	3	3
Passenger ship	36	21
Pleasure craft	54	25
Fishing vessel	3	6
High-speed craft	8	7
Sailing vessel	19	7
Search and rescue	15	16
Pilot vessel	1	1
Port tender	4	4
Law enforcement vessel	5	2
Unknown/Undefined	213	96
Total	455	323





Appendix E Ambient Noise Figures and Tables

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E.1 Jack Block Park (SJBL-01)

Figure E.1-1: Summary of the SPL box plot (broadband and decade-band) for SJBL-01 over the monthly monitoring period (September 2025)

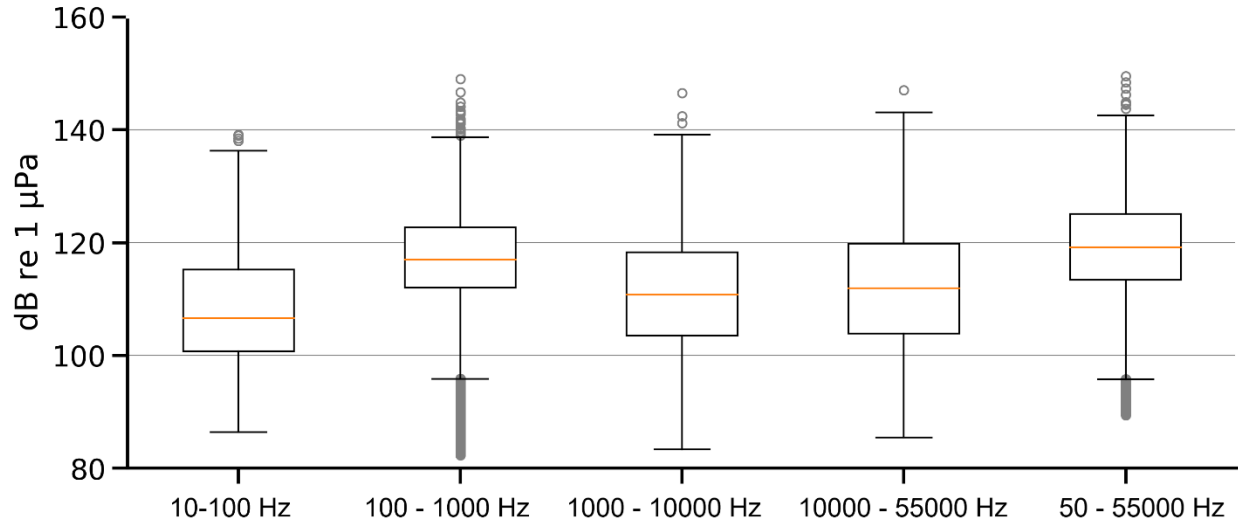


Table E.1-1: Summary of the SPL box plot (values) for SJBL-01 over the monthly monitoring period (September 2025)

Decade-band	Frequency Span (Hz)	Minimum	Q1	Median	Q3	Maximum	IQR
LLF	10 - 100 Hz	86.4	100.8	106.6	115.2	136.3	14.5
ULF	100 - 1000 Hz	95.9	112.0	117.0	122.7	138.7	10.7
MF	1000 - 10000 Hz	83.3	103.5	110.7	118.3	139.2	14.8
HF	10000 - 55000 Hz	85.5	103.9	111.9	119.8	143.1	15.9
Broadband	50 - 55000 Hz	95.8	113.4	119.2	125.1	142.6	11.7



Figure E.1-2: Summary of the SPL box plot (broadband and decade-band) for SJBL-01 over the monthly monitoring period (October 2025)

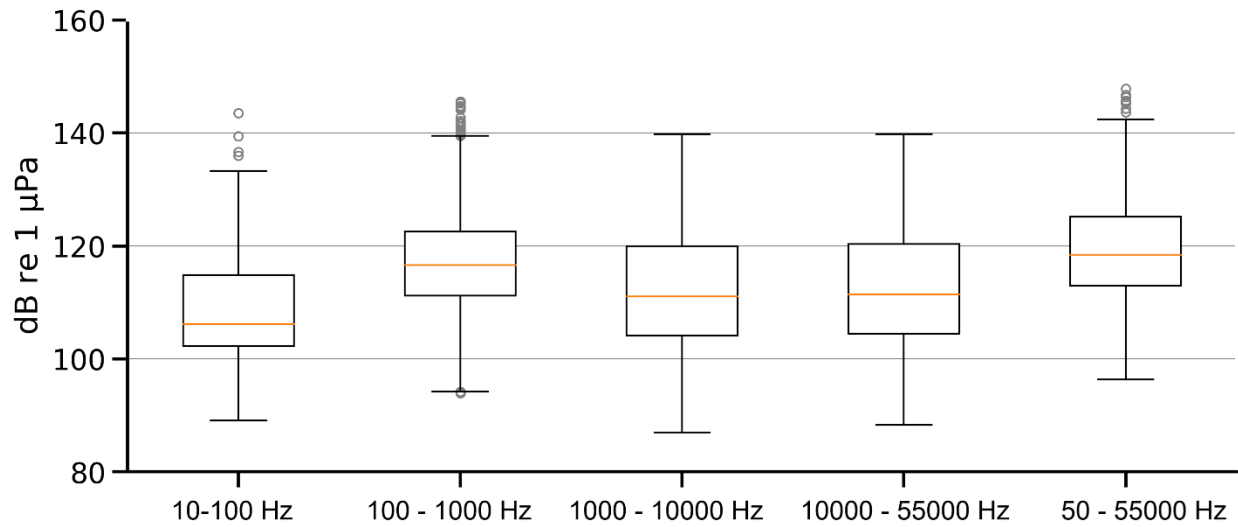


Table E.1-2: Summary of the SPL box plot (values) for SJBL-01 over the monthly monitoring period (October 2025)

Decade-band	Frequency Span (Hz)	Minimum	Q1	Median	Q3	Maximum	IQR
LLF	10 - 100 Hz	89.1	102.3	106.1	114.8	133.3	12.6
ULF	100 - 1000 Hz	94.2	111.2	116.6	122.5	139.5	11.3
MF	1000 - 10000 Hz	87.0	104.1	111.1	120.0	139.8	15.9
HF	10000 - 55000 Hz	88.3	104.4	111.4	120.3	139.8	15.9
Broadband	50 - 55000 Hz	96.3	112.9	118.4	125.2	142.4	12.2



Figure E.1-3: Summary of the SPL box plot (broadband and decade-band) for SJBL-01 over the monthly monitoring period (November 2025)

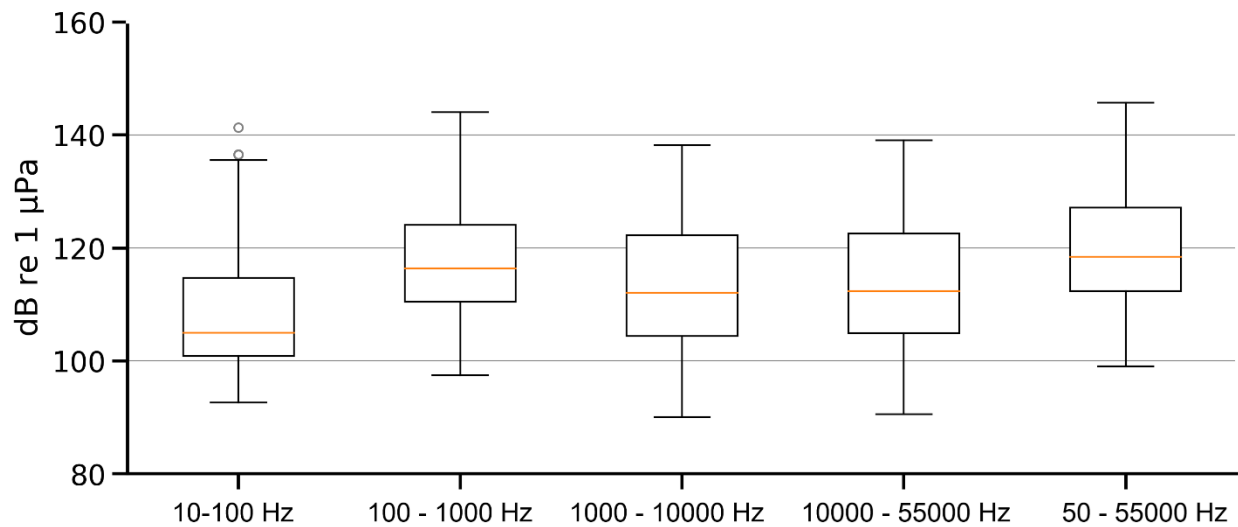


Table E.1-3: Summary of the SPL box plot (values) for SJBL-01 over the monthly monitoring period (November 2025)

Decade-band	Frequency Span (Hz)	Minimum	Q1	Median	Q3	Maximum	IQR
LLF	10 - 100 Hz	92.6	100.8	105.0	114.7	135.5	13.9
ULF	100 - 1000 Hz	97.5	110.4	116.4	124.0	144.1	13.6
MF	1000 - 10000 Hz	90.1	104.4	112.1	122.2	138.2	17.8
HF	10000 - 55000 Hz	90.6	104.9	112.4	122.5	139.1	17.7
Broadband	50 - 55000 Hz	99.1	112.4	118.5	127.2	145.7	14.8



Figure E.1-4: Spectral probability density plot of SJBL-01 over the monthly monitoring period (September 2025)

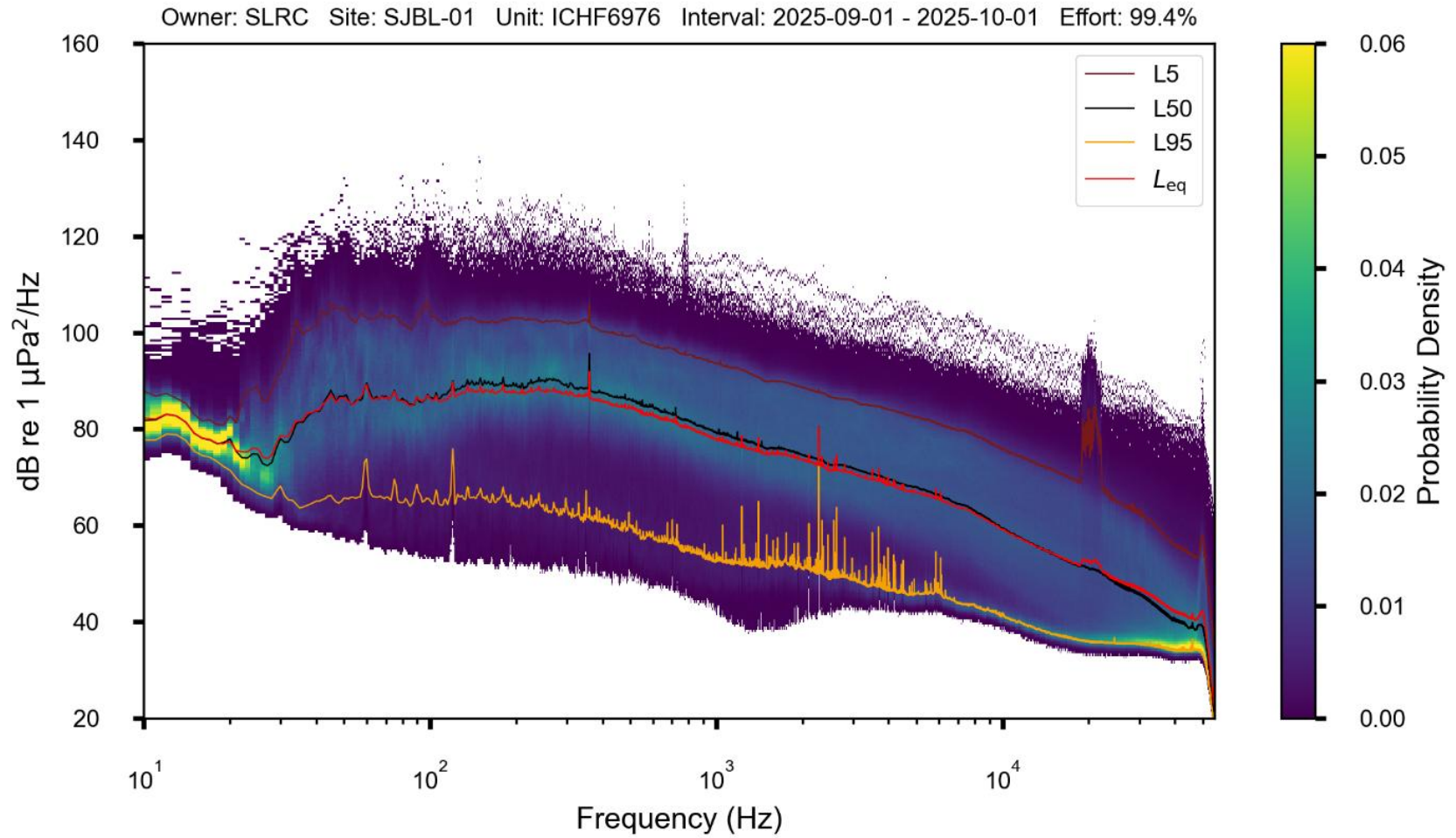


Figure E.1-5: Spectral probability density plot of SJBL-01 over the monthly monitoring period (October 2025)

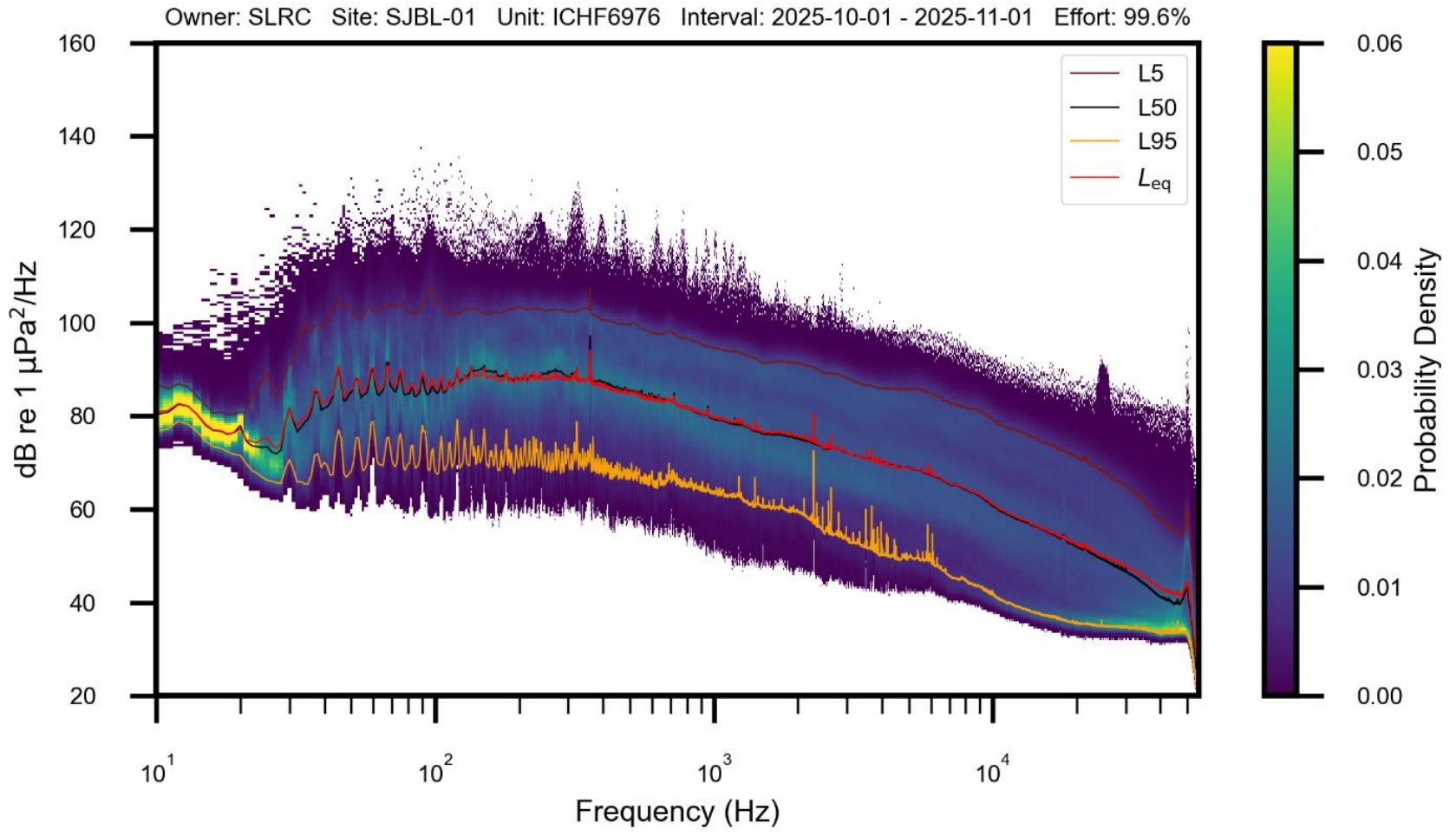


Figure E.1-6: Spectral probability density plot of SJBL-01 over the monthly monitoring period (November 2025)

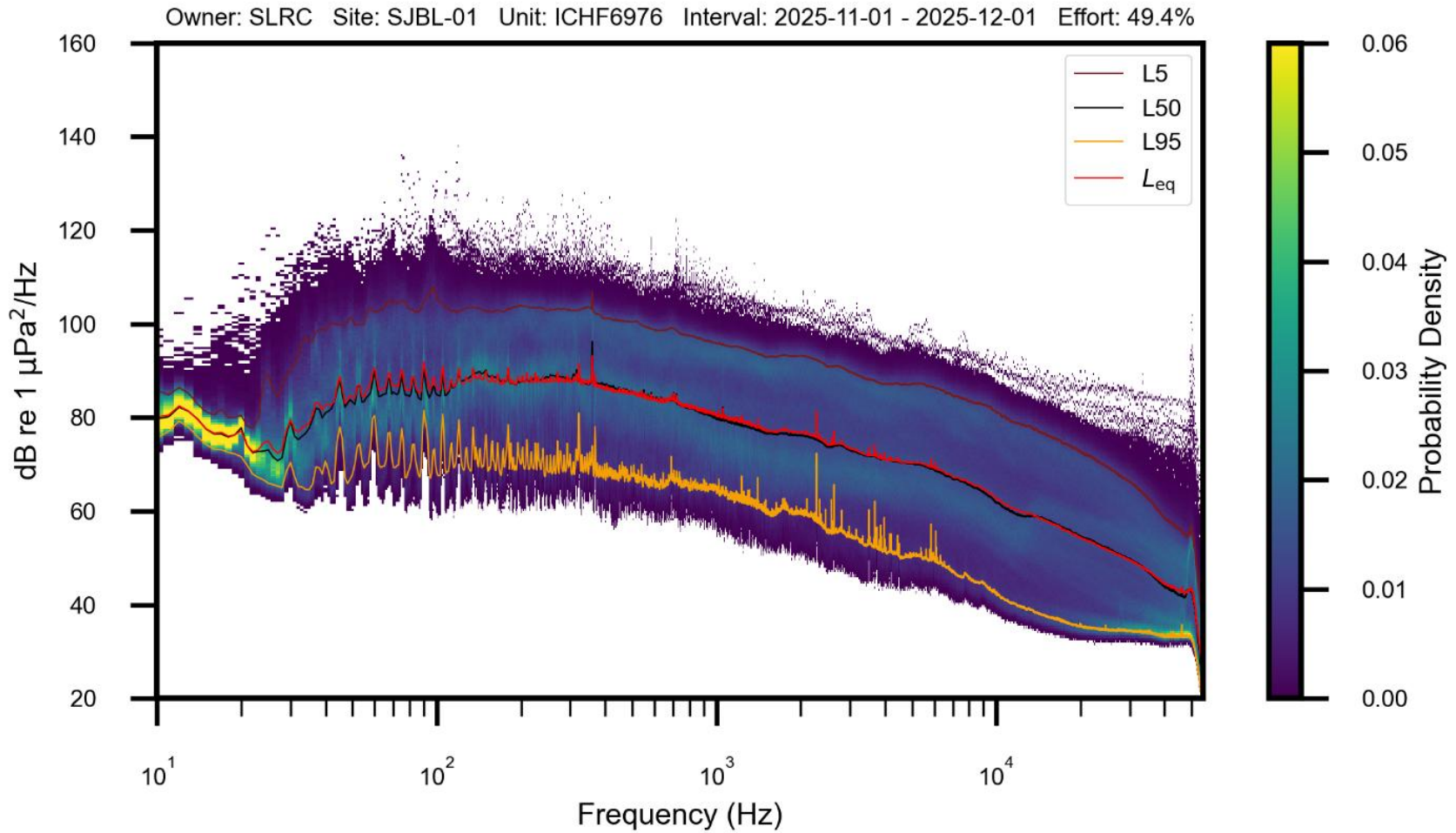


Figure E.1-7: LTSA for SJBL-01 over the weekly monitoring period (Sep 07 to 13, 2025)

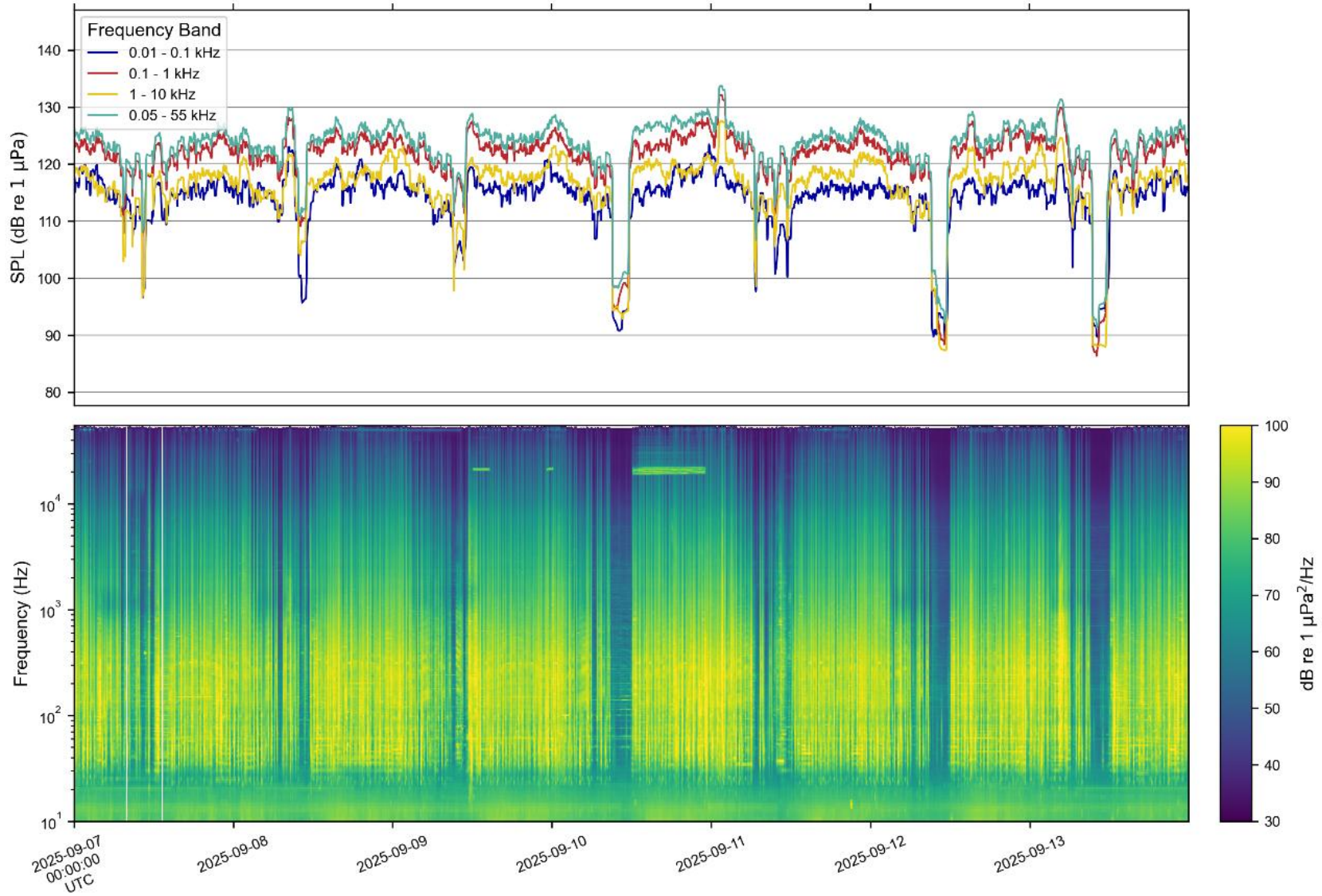


Figure E.1-8: LTSA for SJBL-01 over the weekly monitoring period (Sep 14 to 20, 2025)

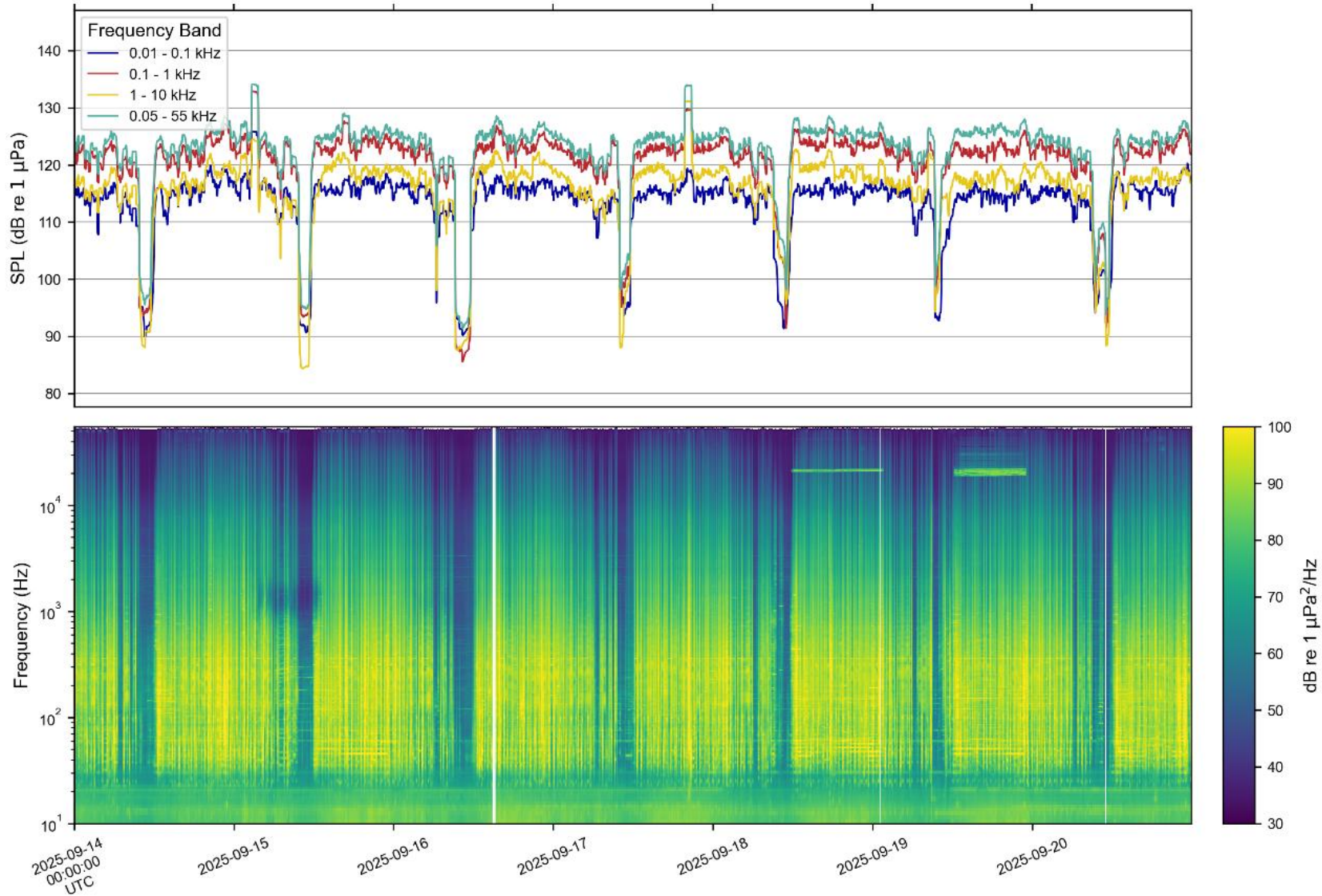


Figure E.1-9: LTSA for SJBL-01 over the weekly monitoring period (Sep 21 to 27)

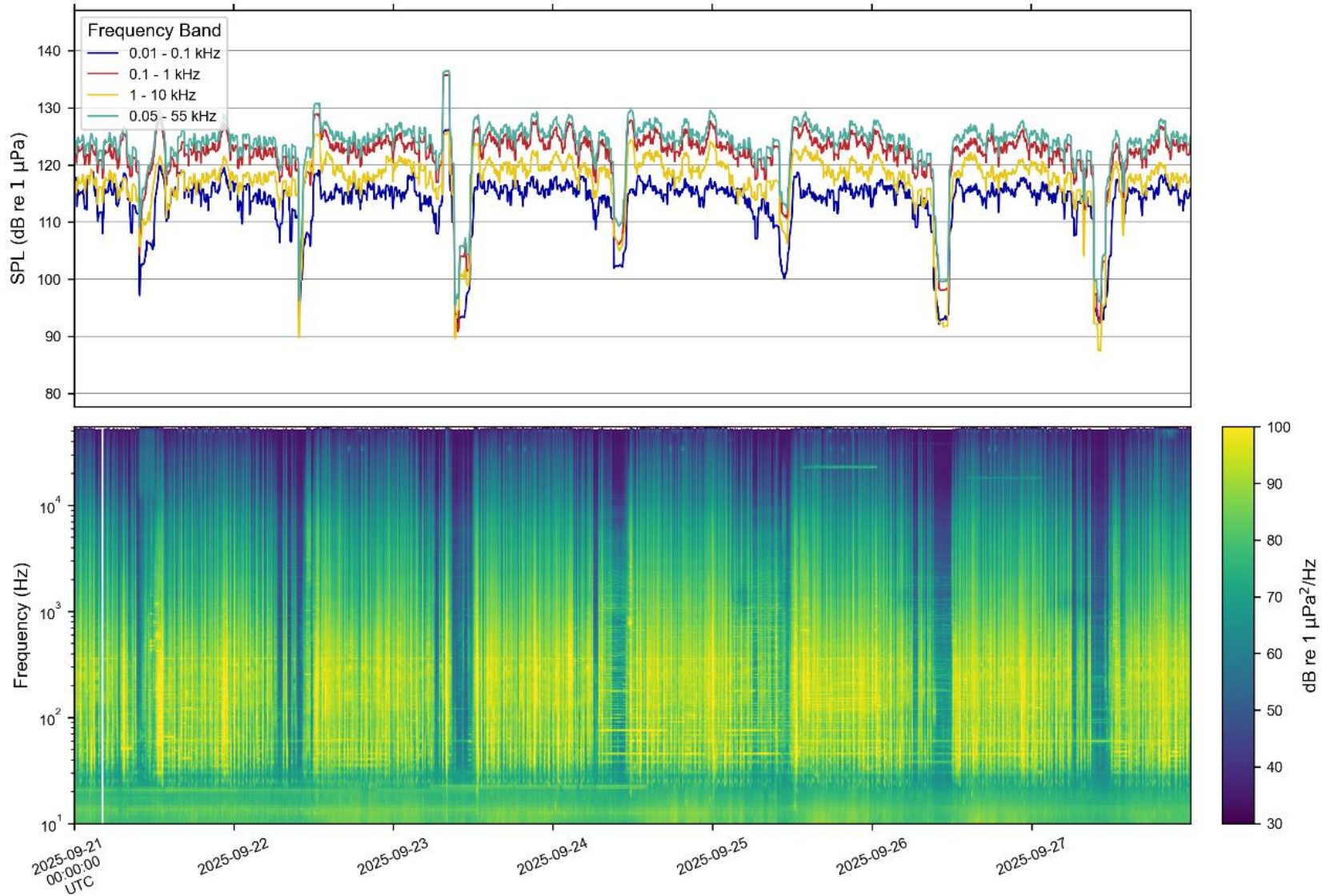


Figure E.1-10: LTSA for SJBL-01 over the weekly monitoring period (Sep 28 to Oct 04)

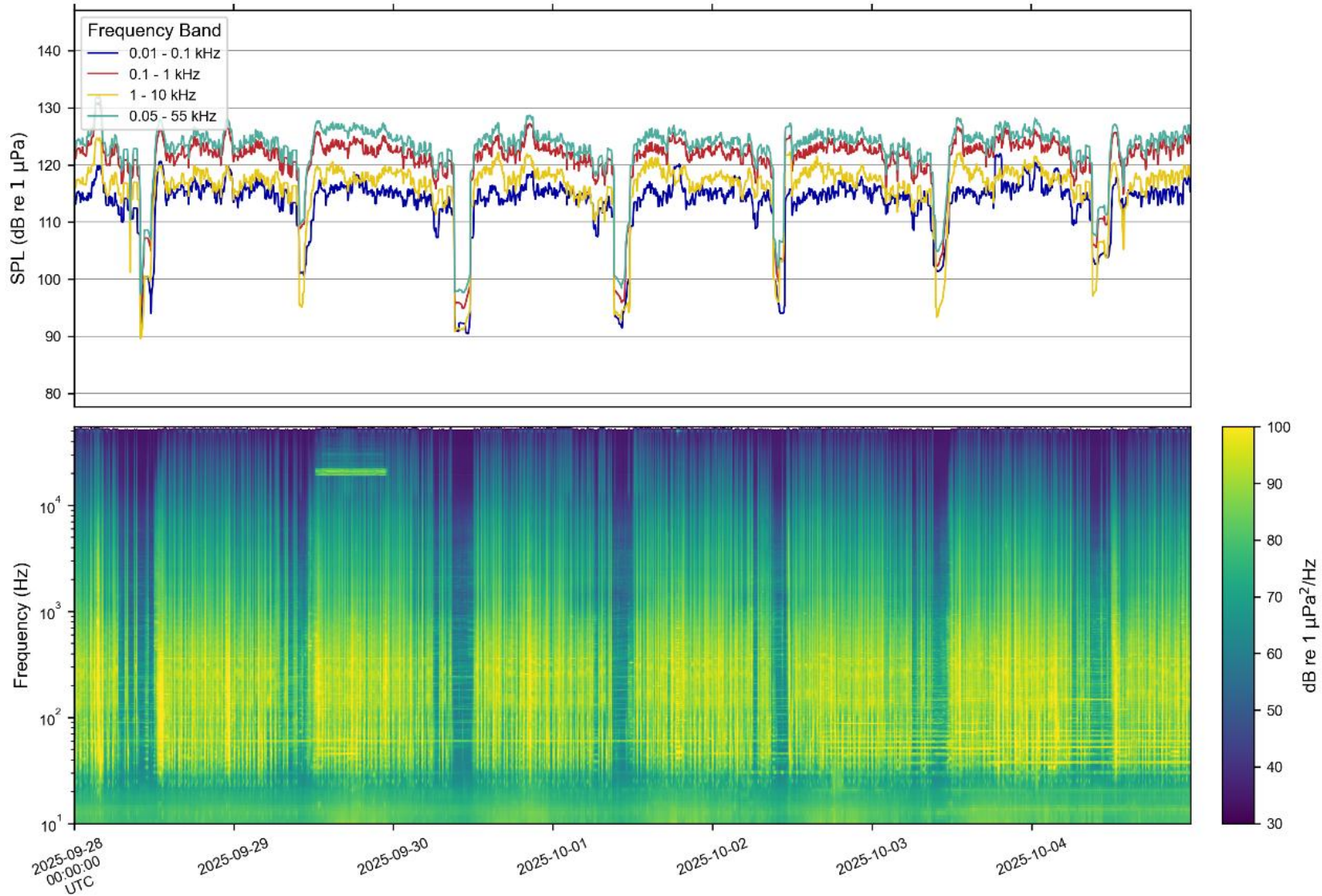


Figure E.1-11: LTSA for SJBL-01 over the weekly monitoring period (Oct 05 to Oct 11)

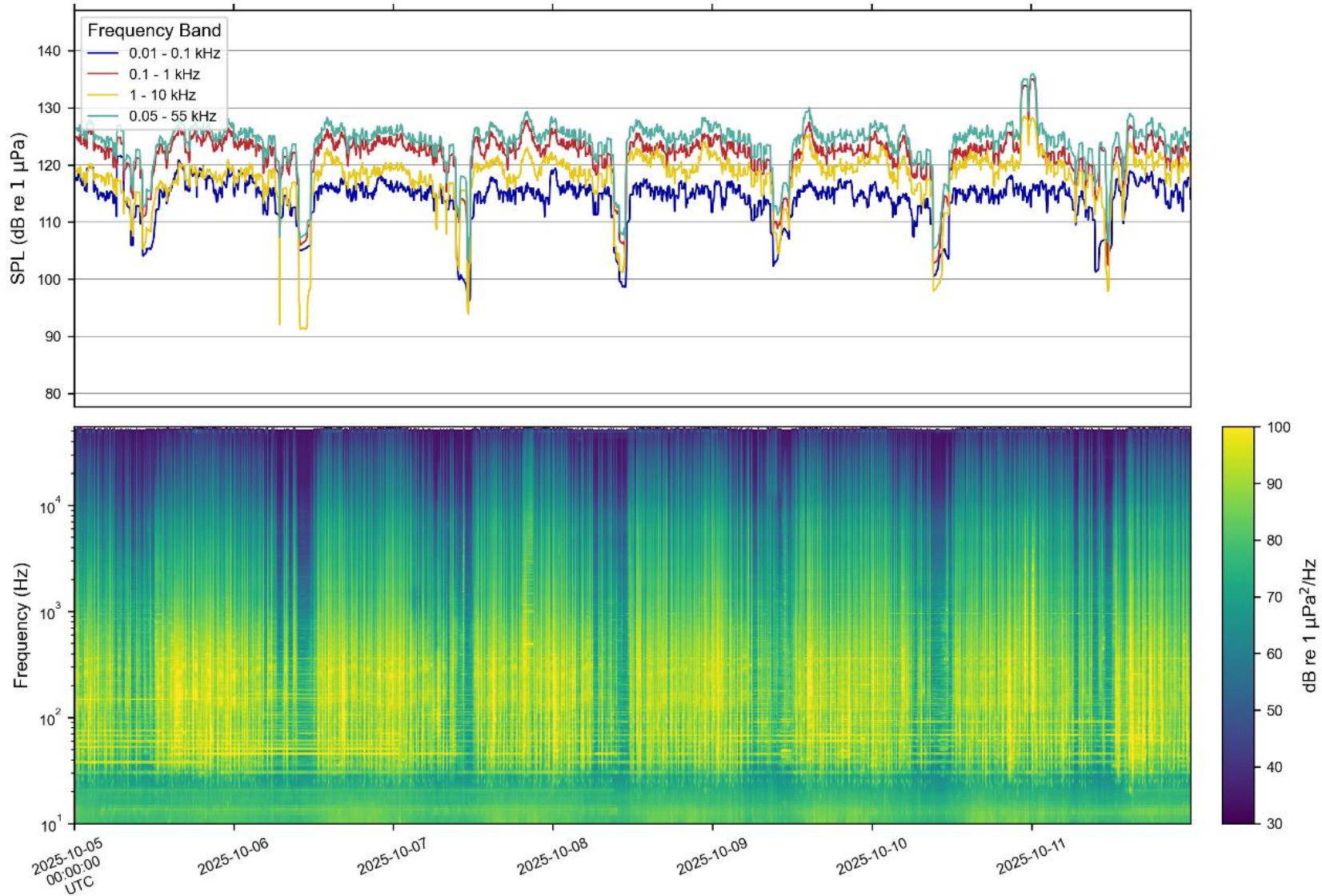


Figure E.1-12: LTSA for SJBL-01 over the weekly monitoring period (Oct 12 to Oct 18)

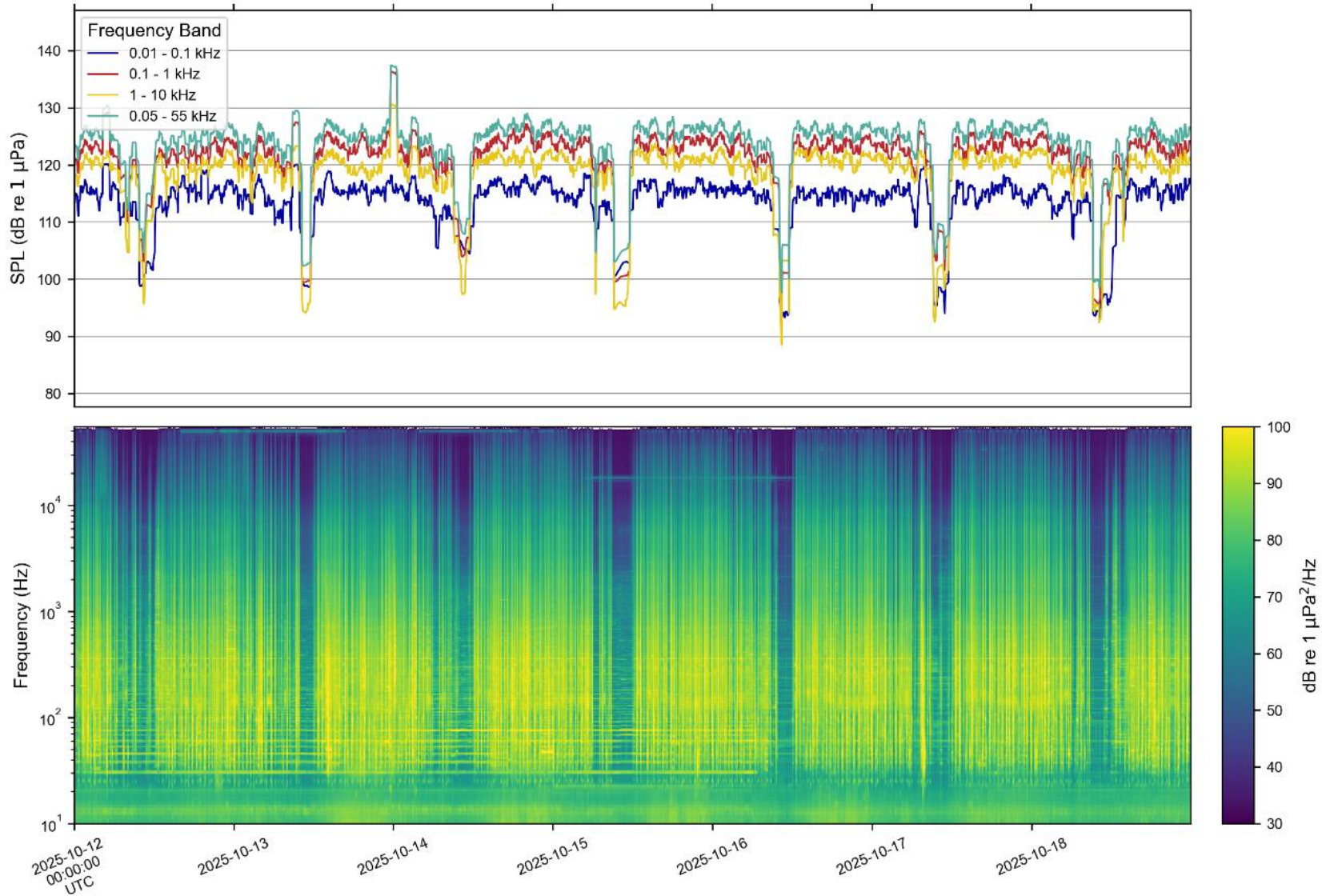


Figure E.1-13: LTSA for SJBL-01 over the weekly monitoring period (Oct 19 to Oct 25)

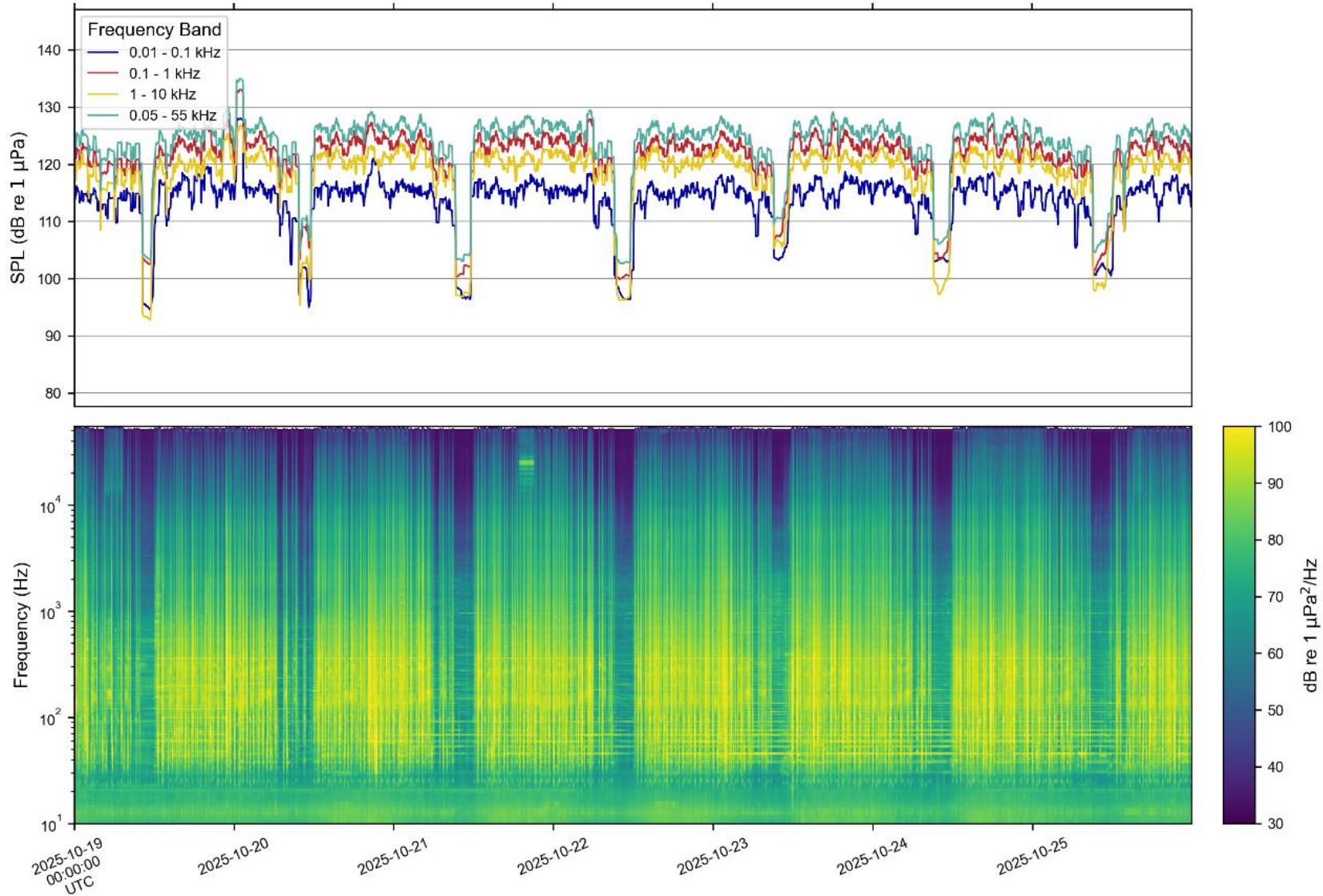


Figure E.1-14: LTSA for SJBL-01 over the weekly monitoring period (Oct 26 to Nov 01)

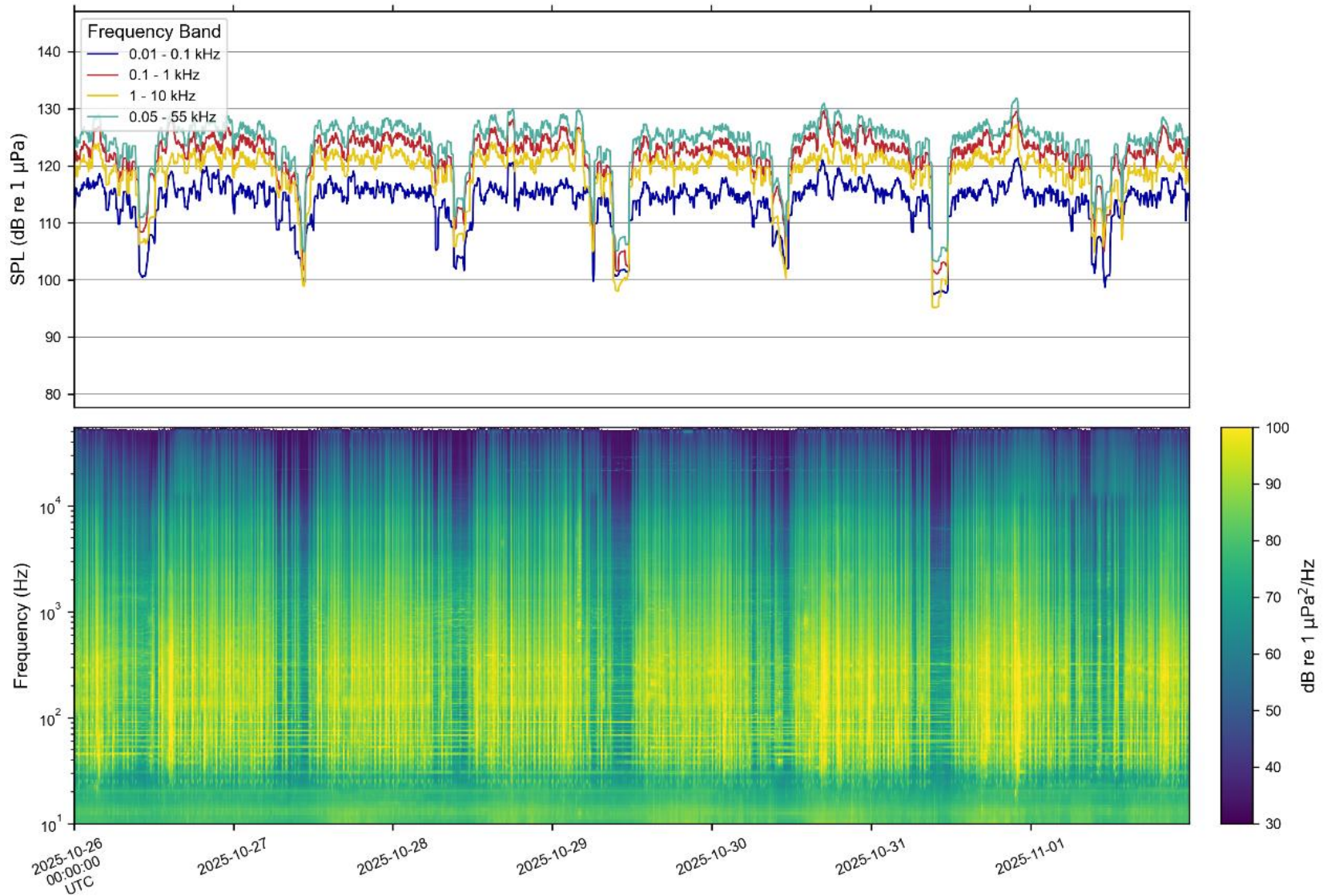


Figure E.1-15: LTSA for SJBL-01 over the weekly monitoring period (Nov 01 to Nov 08)

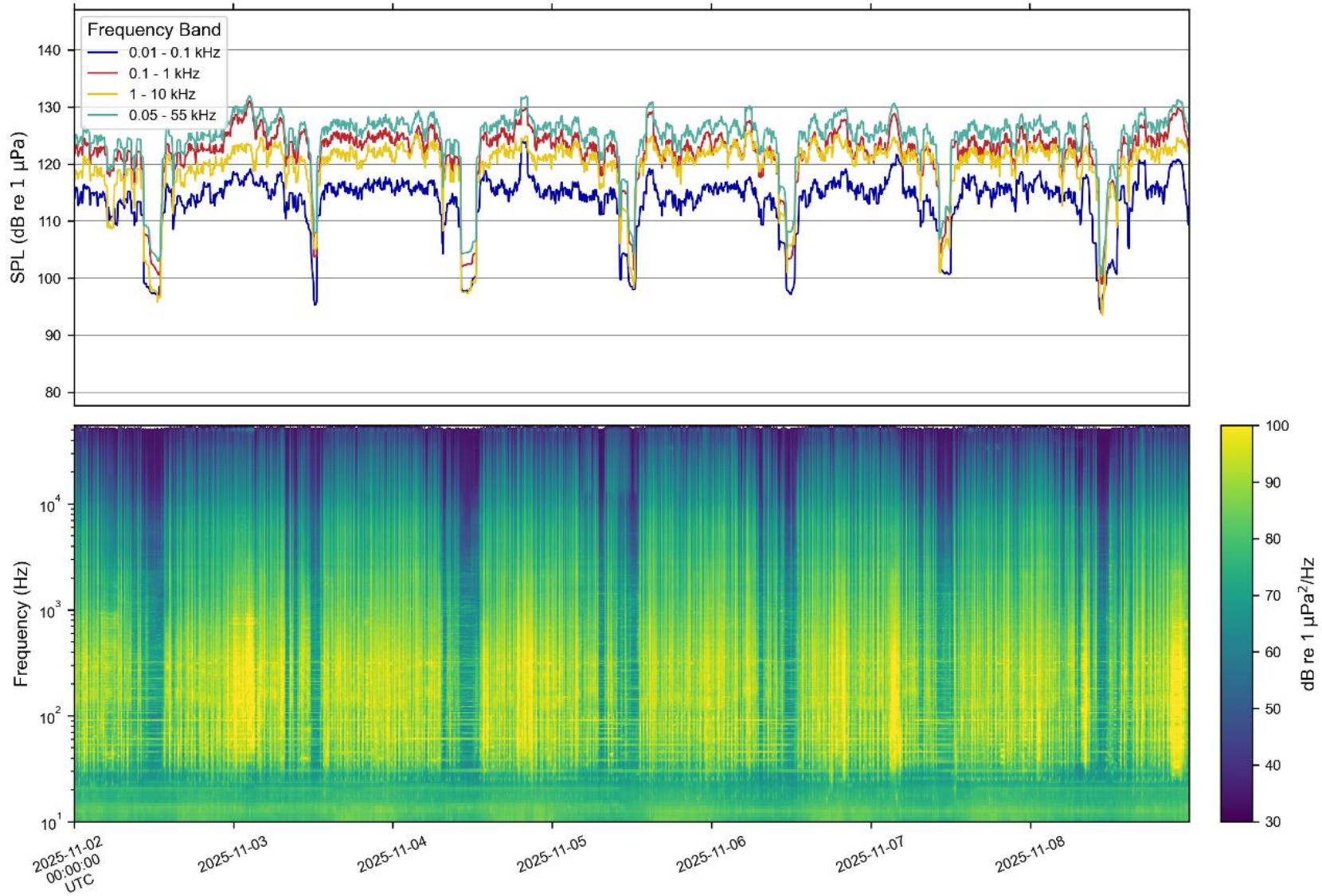


Figure E.1-16: LTSA for SJBL-01 over the weekly monitoring period (Nov 09 to Nov 15)

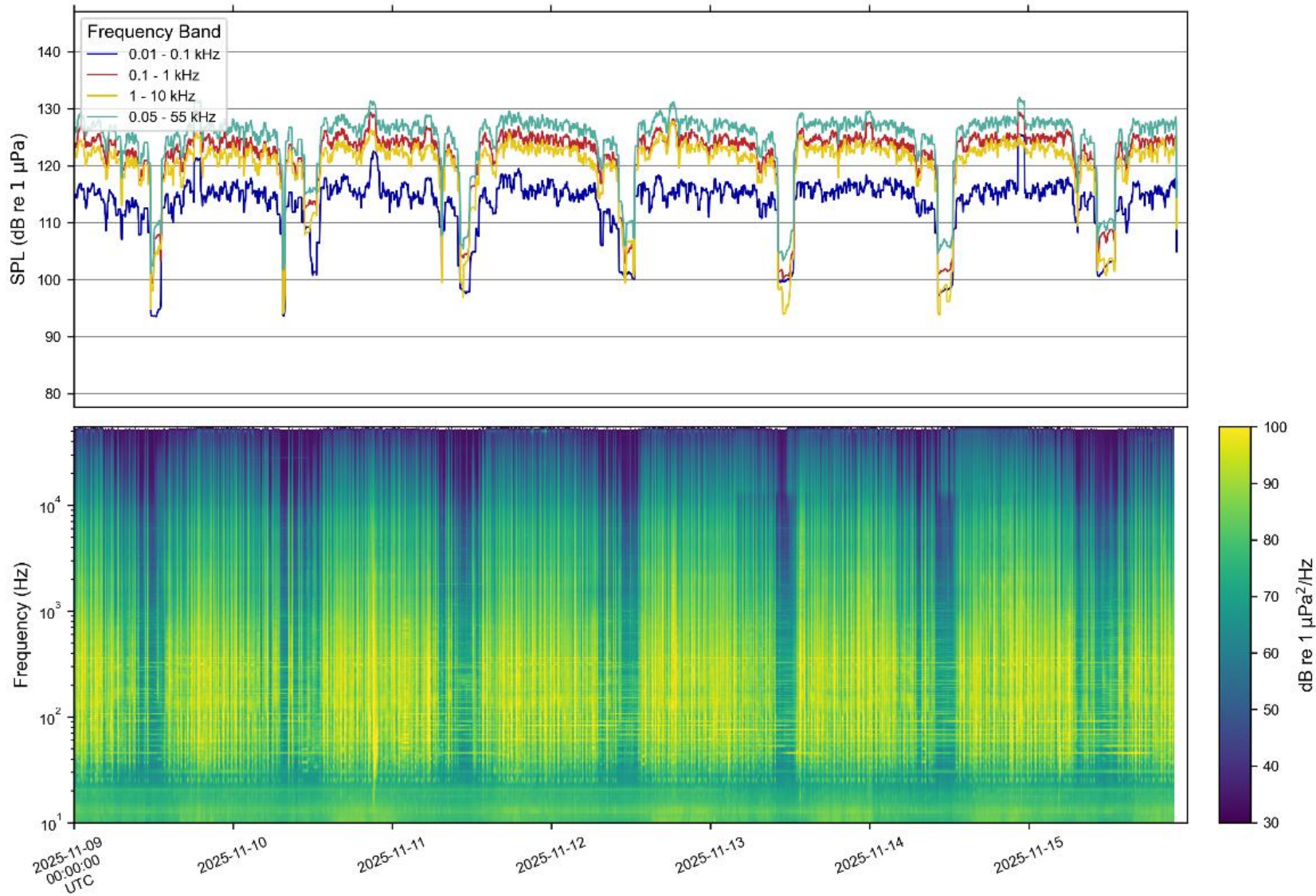


Figure E.1-17: Representative radial charts for SJBL-01 noise levels (L_{eq}) of the seven day-of-week pattern for each decade-band of the monthly monitoring period (September 2025)

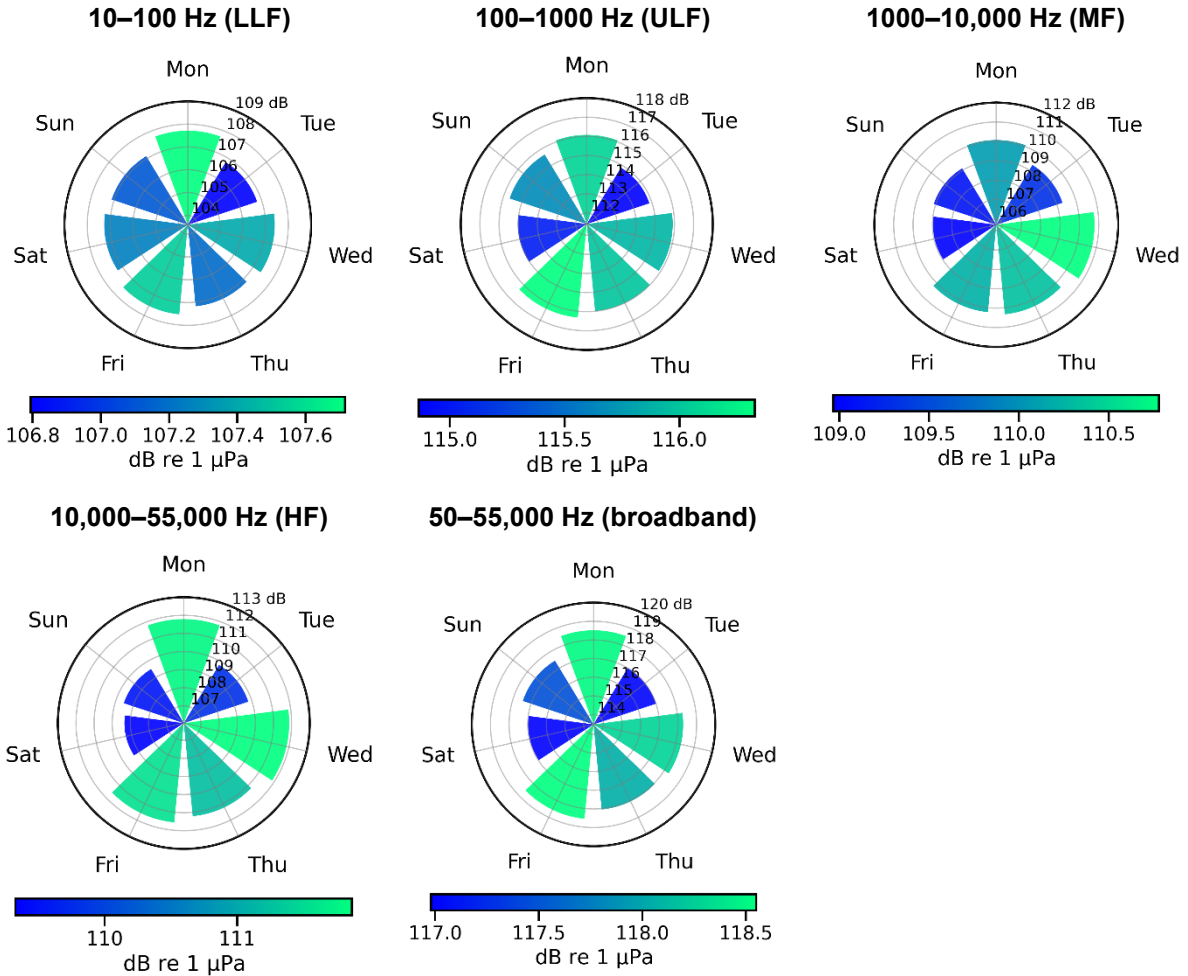


Figure E.1-18: Representative radial charts for SJBL-01 noise levels (L_{eq}) of the seven day-of-week pattern for each decade-band of the monthly monitoring period (October 2025)

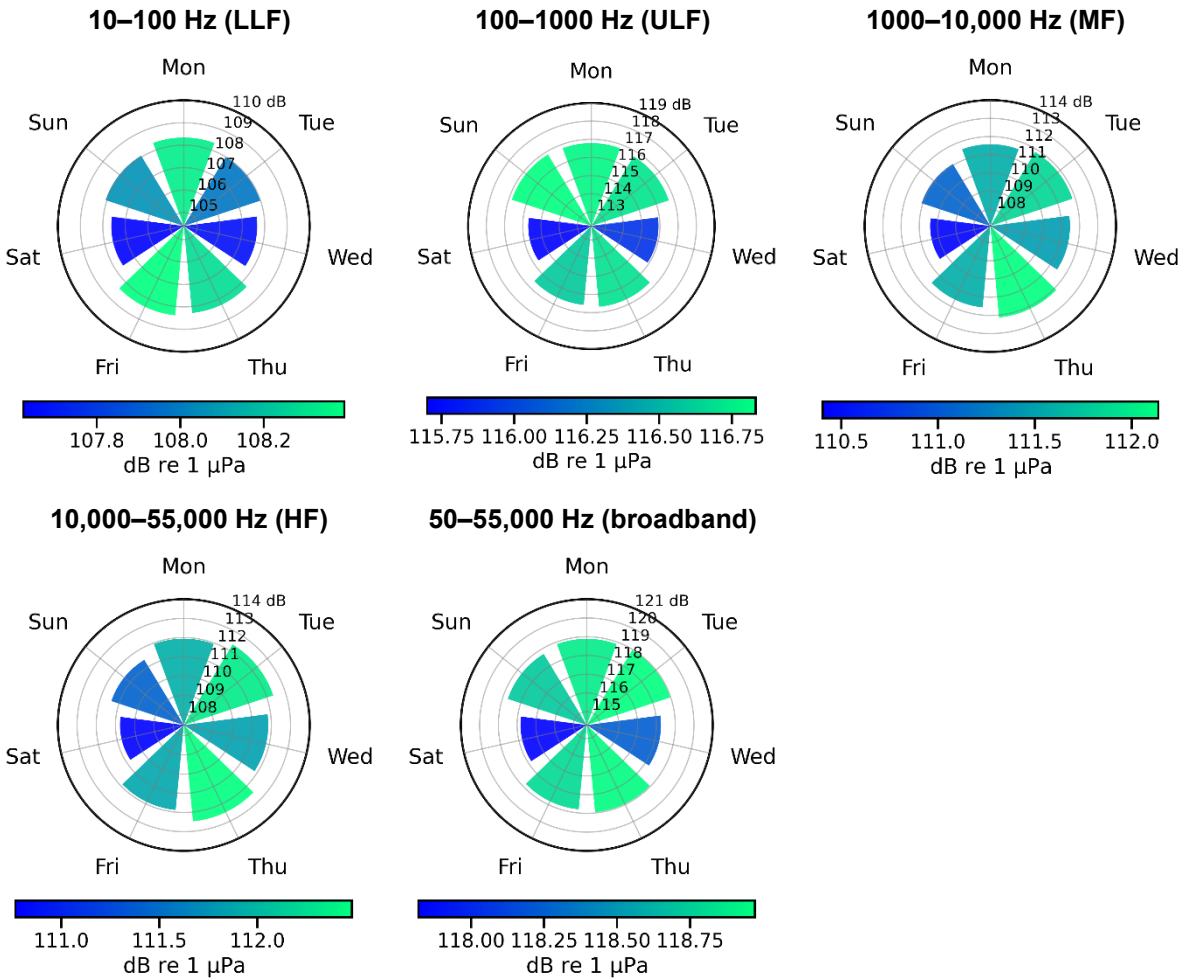


Figure E.1-19: Representative radial charts for SJBL-01 noise levels (L_{eq}) of the seven day-of-week pattern for each decade-band of the monthly monitoring period (November 2025)

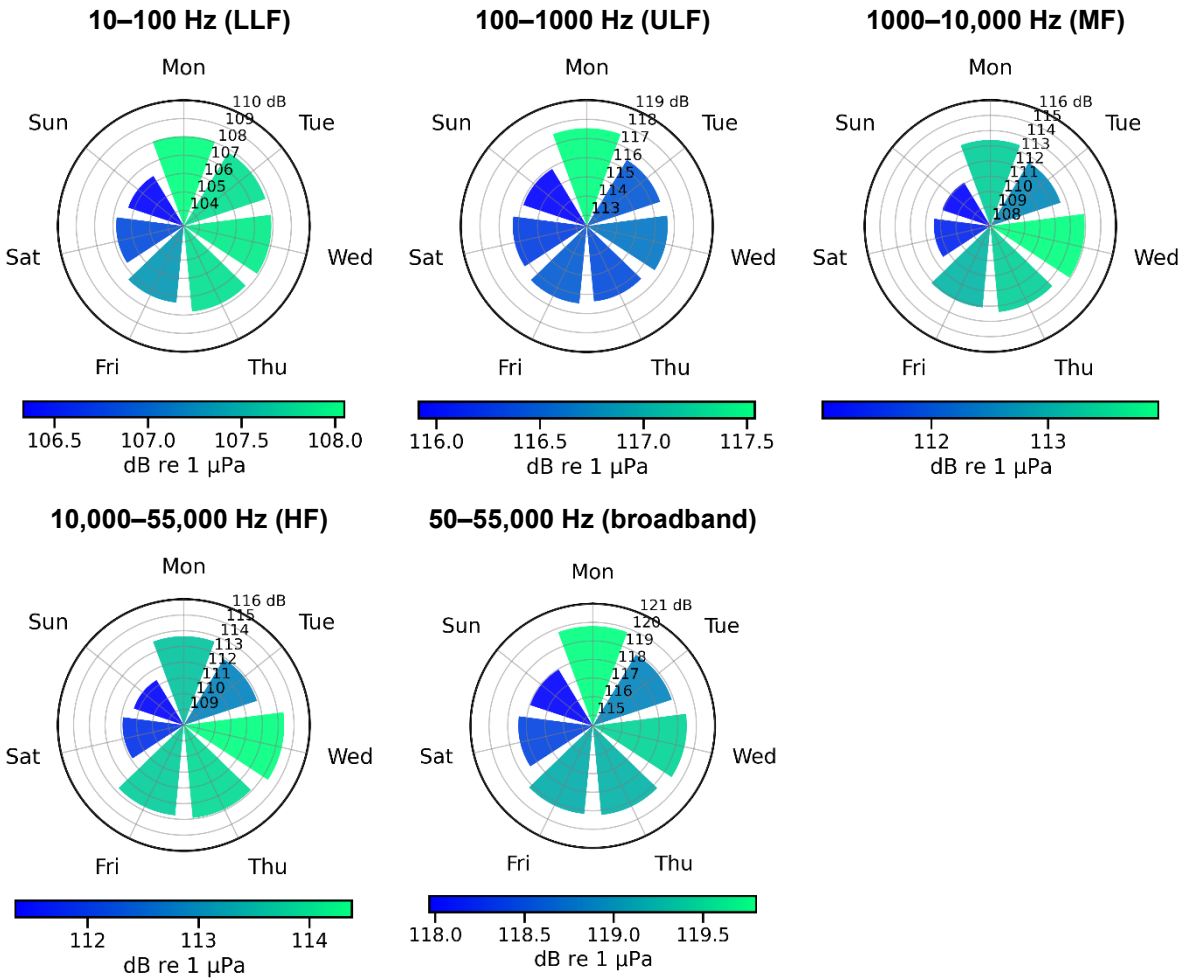


Figure E.1-20: Representative radial charts for SJBL-01 noise levels (L_{eq}) of the 24-hour pattern for each decade-band of the monthly monitoring period (September 2025)

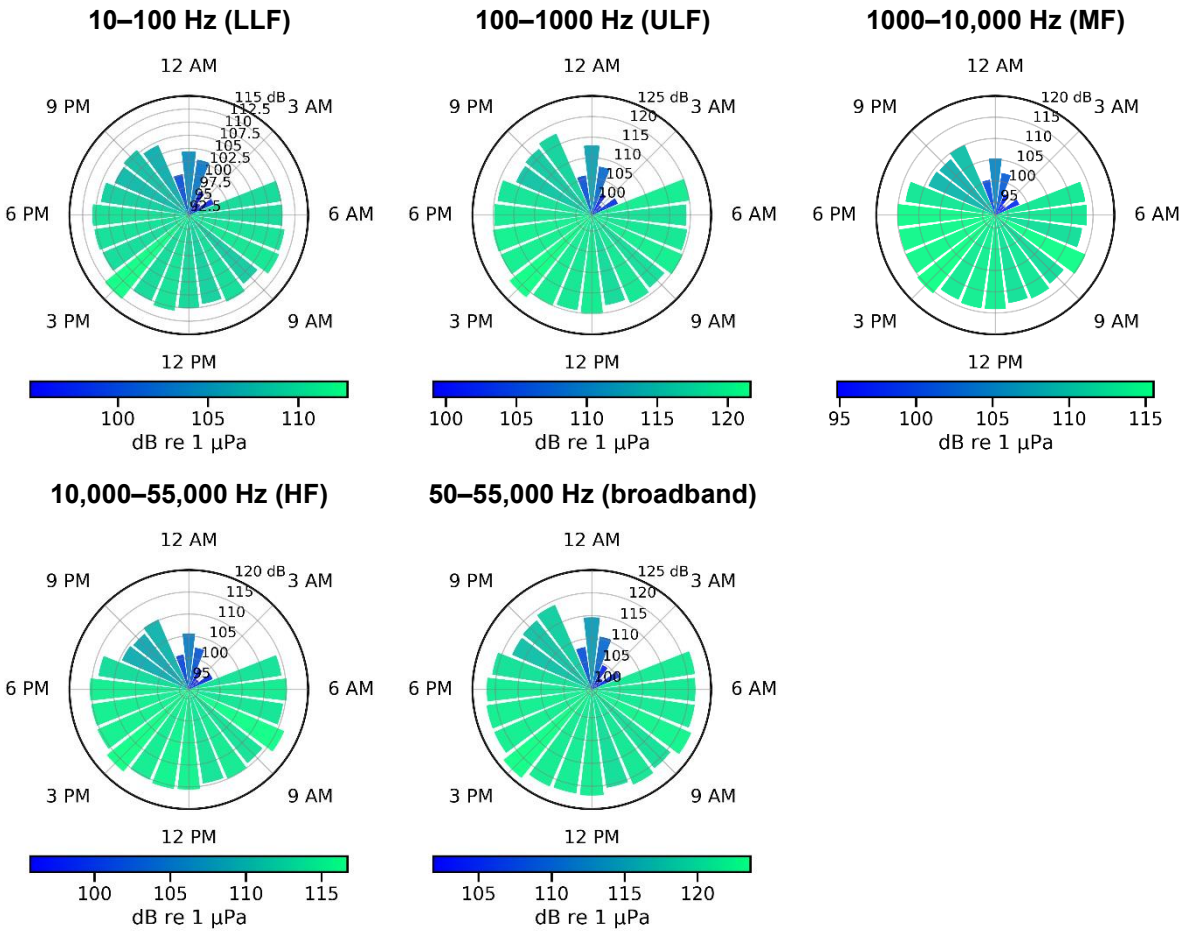


Figure E.1-21: Representative radial charts for SJBL-01 noise levels (L_{eq}) of the 24-hour pattern for each decade-band of the monthly monitoring period (October 2025)

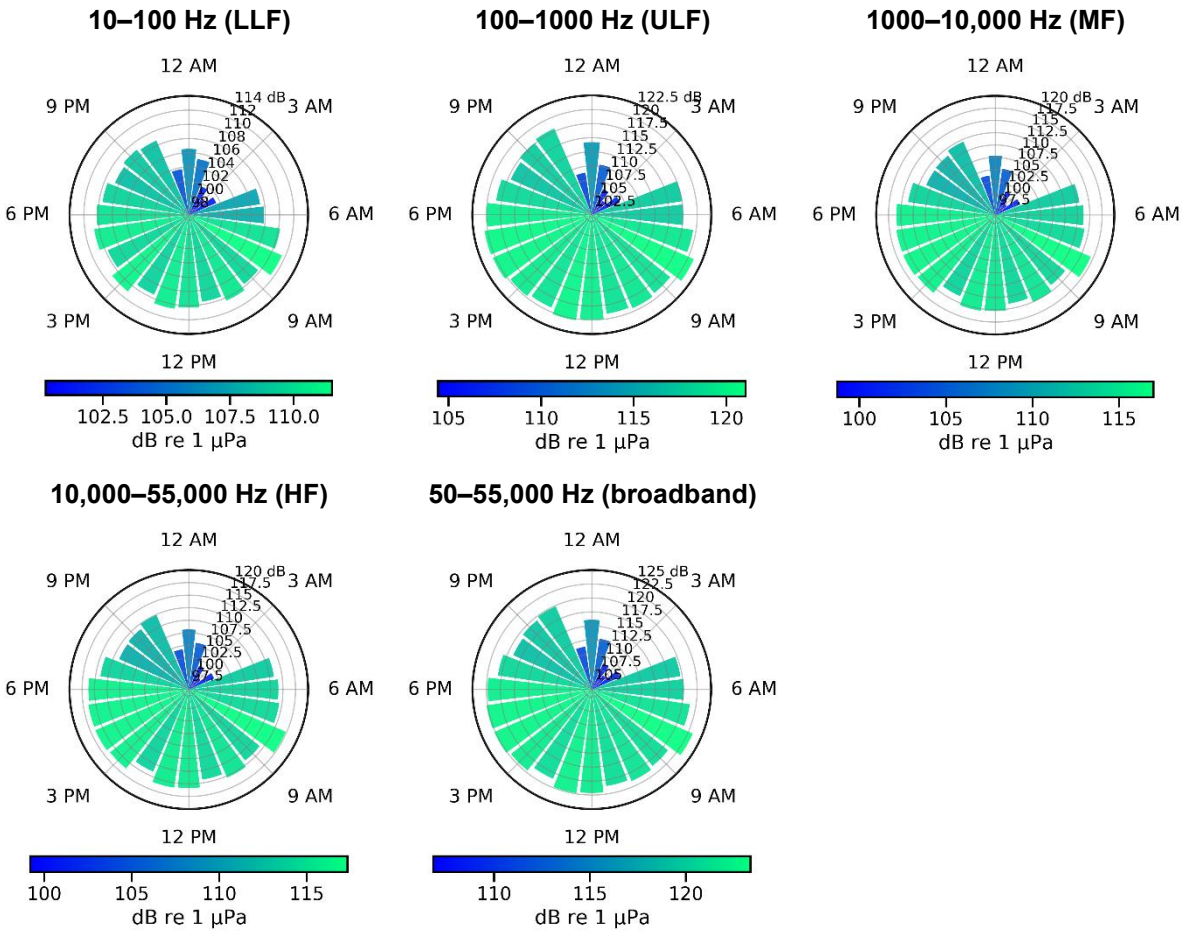
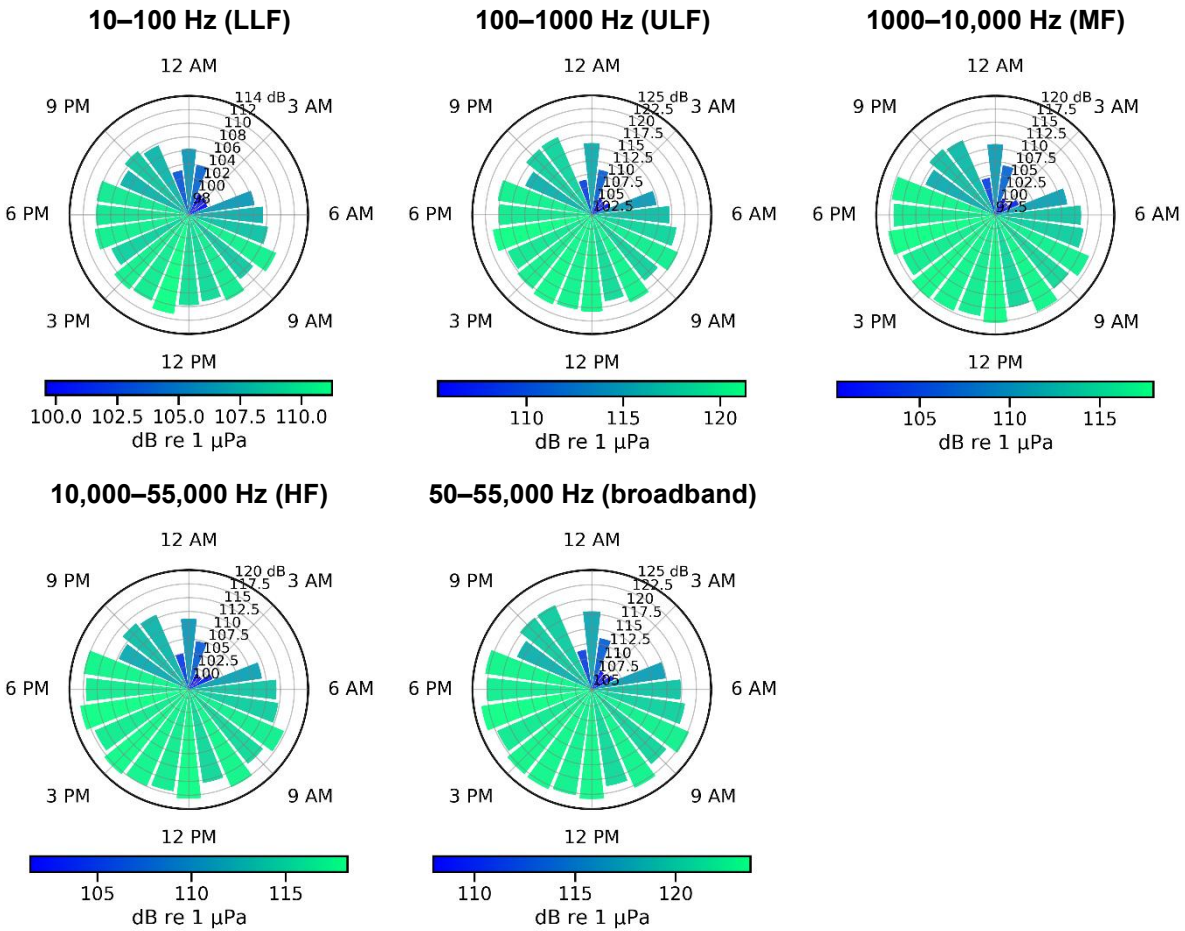


Figure E.1-22: Representative radial charts for SJBL-01 noise levels (L_{eq}) of the 24-hour pattern for each decade-band of the monthly monitoring period (November 2025)



E.2 Seattle Aquarium (SAQU-01)

Figure E.2-1: Summary of the SPL box plot (broadband and decade-band) for SAQU-01 over the monthly monitoring period (September 2025)

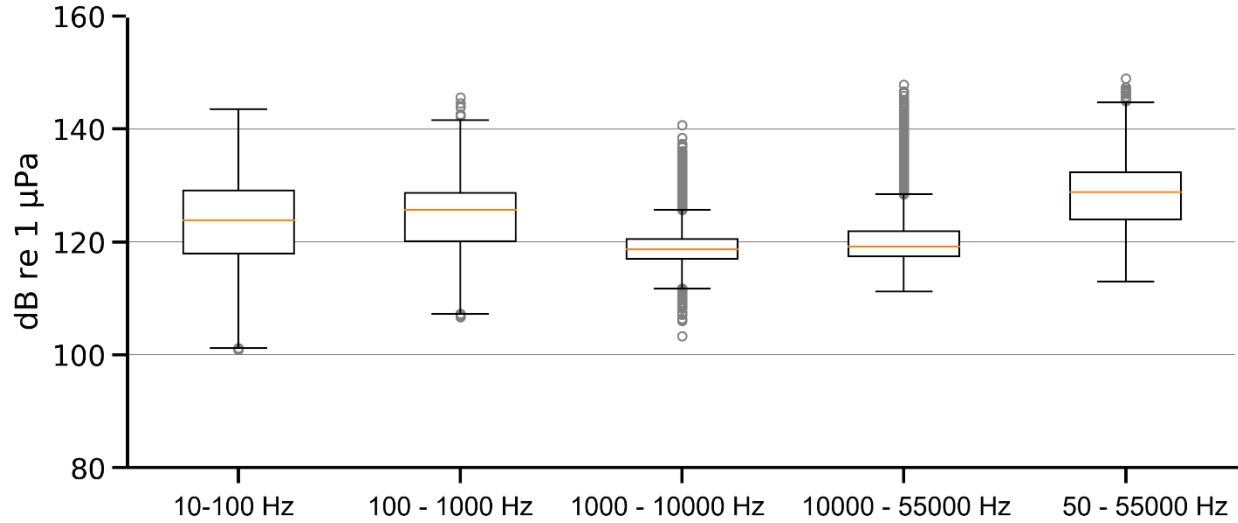


Table E.2-1: Summary of the SPL box plot (values) for SAQU-01 over the monthly monitoring period (September 2025)

Decade-band	Frequency Span (Hz)	Minimum	Q1	Median	Q3	Maximum	IQR
LLF	10 - 100 Hz	101.2	117.9	123.9	129.1	143.5	11.2
ULF	100 - 1000 Hz	107.2	120.1	125.7	128.7	141.6	8.6
MF	1000 - 10000 Hz	111.7	117.0	118.6	120.5	125.7	3.5
HF	10000 - 55000 Hz	111.2	117.4	119.2	121.8	128.4	4.4
Broadband	50 - 55000 Hz	112.9	124.0	128.9	132.3	144.7	8.3



Figure E.2-2: Summary of the SPL box plot (broadband and decade-band) for SAQU-01 over the monthly monitoring period (October 2025)

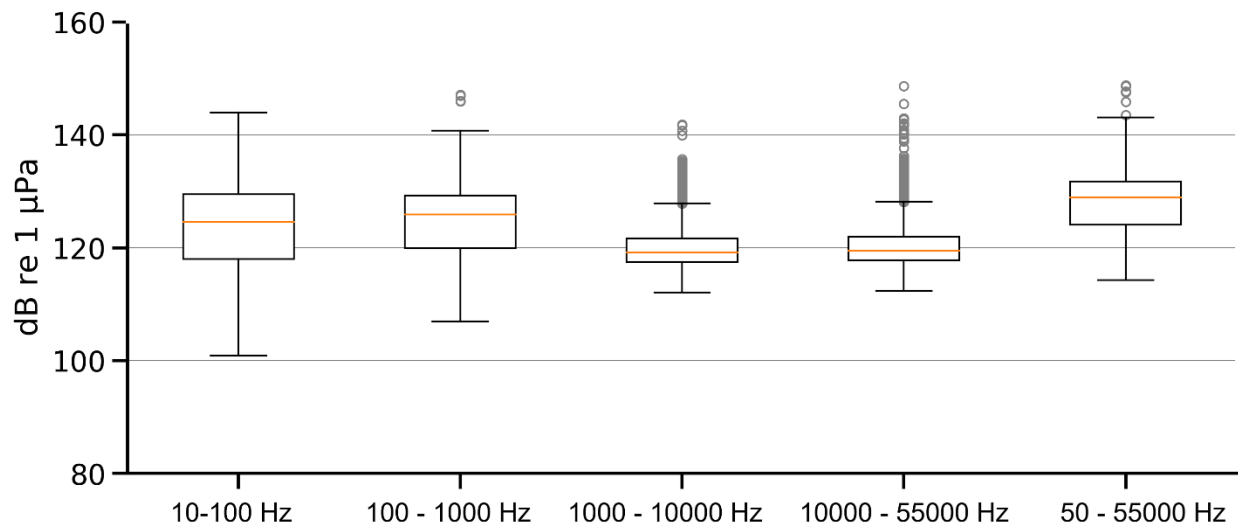


Table E.2-2: Summary of the SPL box plot (values) for SAQU-01 over the monthly monitoring period (October 2025)

Decade-band	Frequency Span (Hz)	Minimum	Q1	Median	Q3	Maximum	IQR
LLF	10 - 100 Hz	100.9	118.0	124.6	129.5	144.0	11.5
ULF	100 - 1000 Hz	106.9	119.9	125.9	129.3	140.8	9.4
MF	1000 - 10000 Hz	112.0	117.5	119.2	121.6	127.9	4.2
HF	10000 - 55000 Hz	112.4	117.8	119.5	121.9	128.1	4.1
Broadband	50 - 55000 Hz	114.2	124.1	128.9	131.8	143.1	7.7



Figure E.2-3: Summary of the SPL box plot (broadband and decade-band) for SAQU-01 over the monthly monitoring period (November 2025)

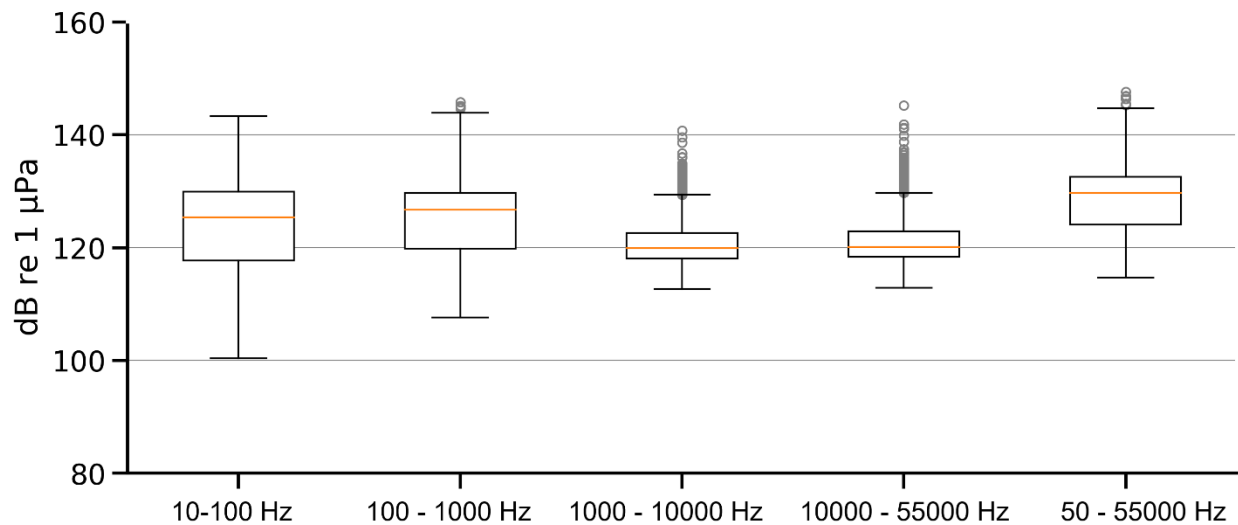


Table E.2-3: Summary of the SPL box plot (values) for SAQU-01 over the monthly monitoring period (November 2025)

Decade-band	Frequency Span (Hz)	Minimum	Q1	Median	Q3	Maximum	IQR
LLF	10 - 100 Hz	100.3	117.7	125.4	129.9	143.3	12.2
ULF	100 - 1000 Hz	107.6	119.8	126.7	129.7	143.9	9.9
MF	1000 - 10000 Hz	112.6	118.1	119.9	122.6	129.4	4.5
HF	10000 - 55000 Hz	112.9	118.3	120.2	122.9	129.7	4.6
Broadband	50 - 55000 Hz	114.7	124.0	129.7	132.5	144.7	8.5



Figure E.2-4: Spectral probability density plot of SAQU-01 over the monthly monitoring period (September 2025)

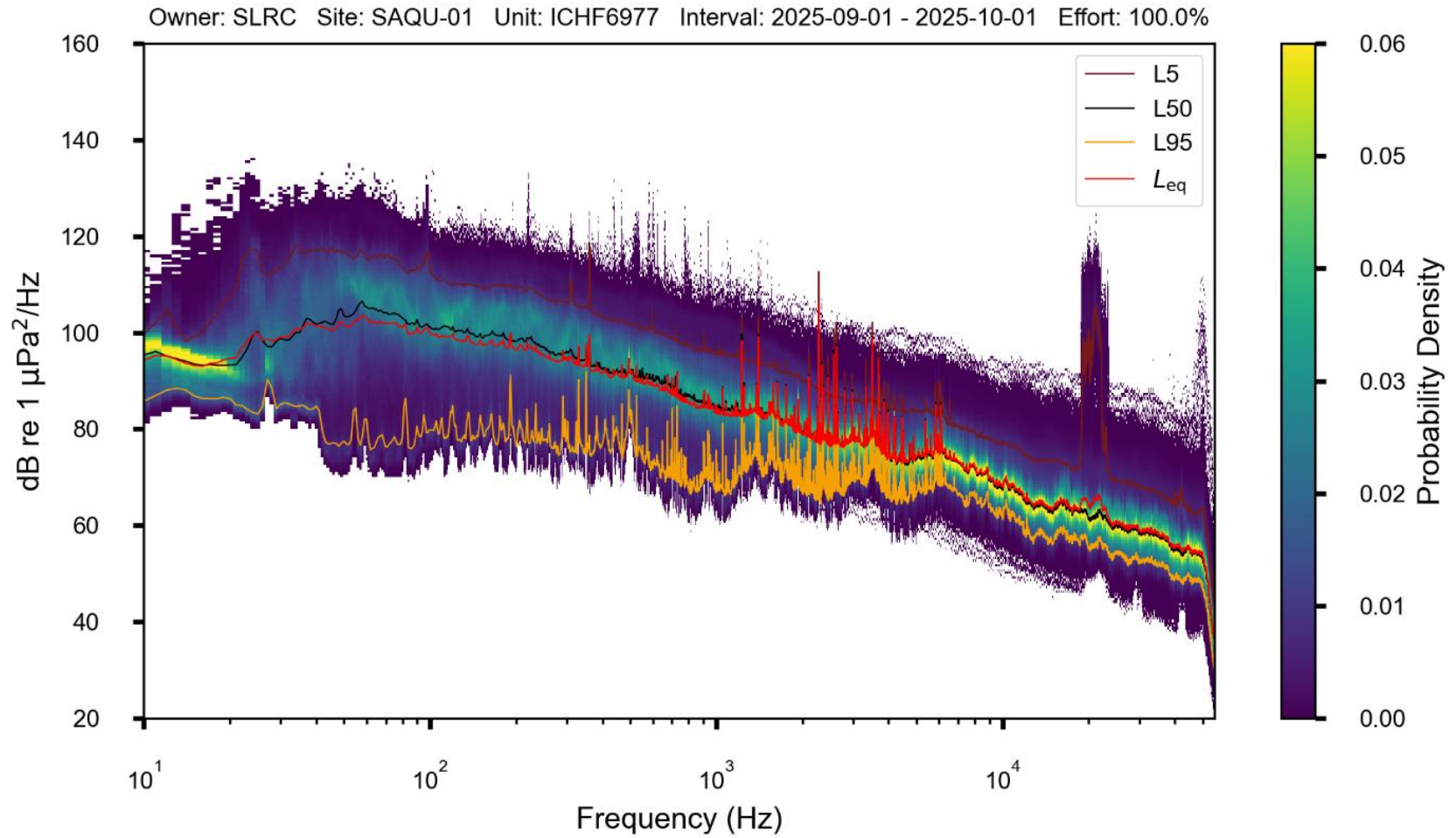


Figure E.2-5: Spectral probability density plot of SAQU-01 over the monthly monitoring period (October 2025)

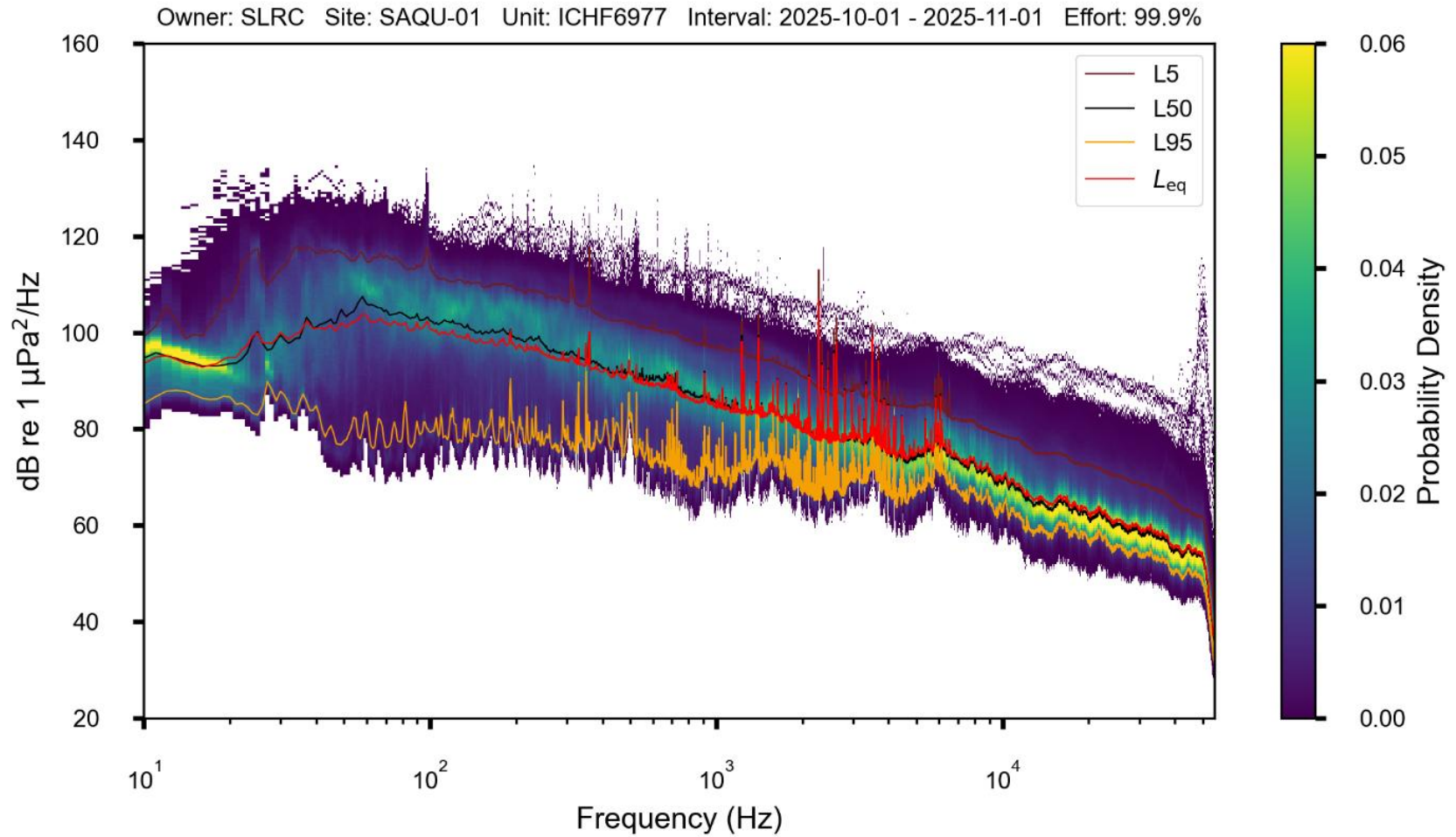


Figure E.2-6: Spectral probability density plot of SAQU-01 over the monthly monitoring period (November 2025)

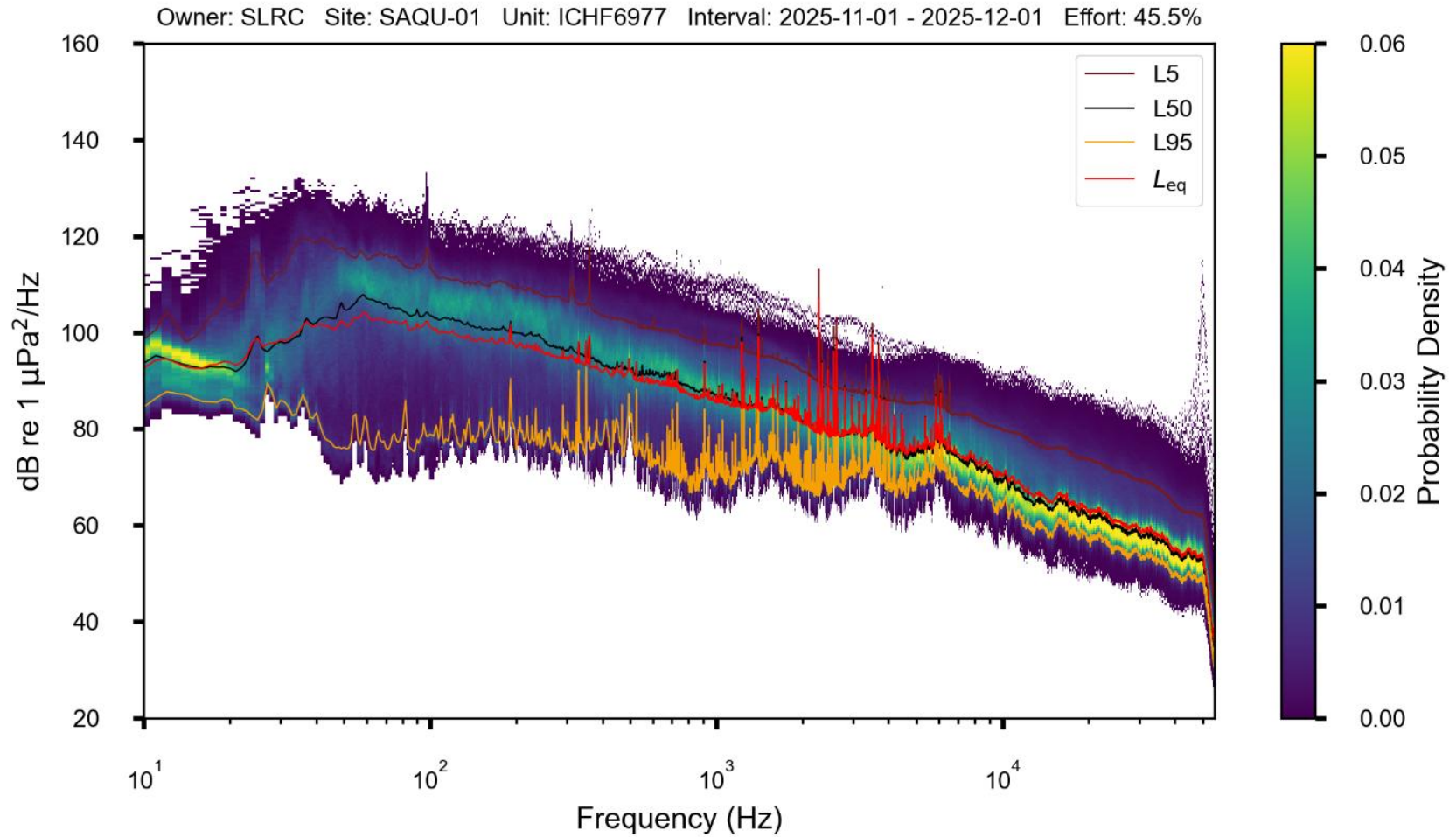


Figure E.2-7: LTSA for SAQU -01 over the weekly monitoring period (Sep 07 to 13, 2025)

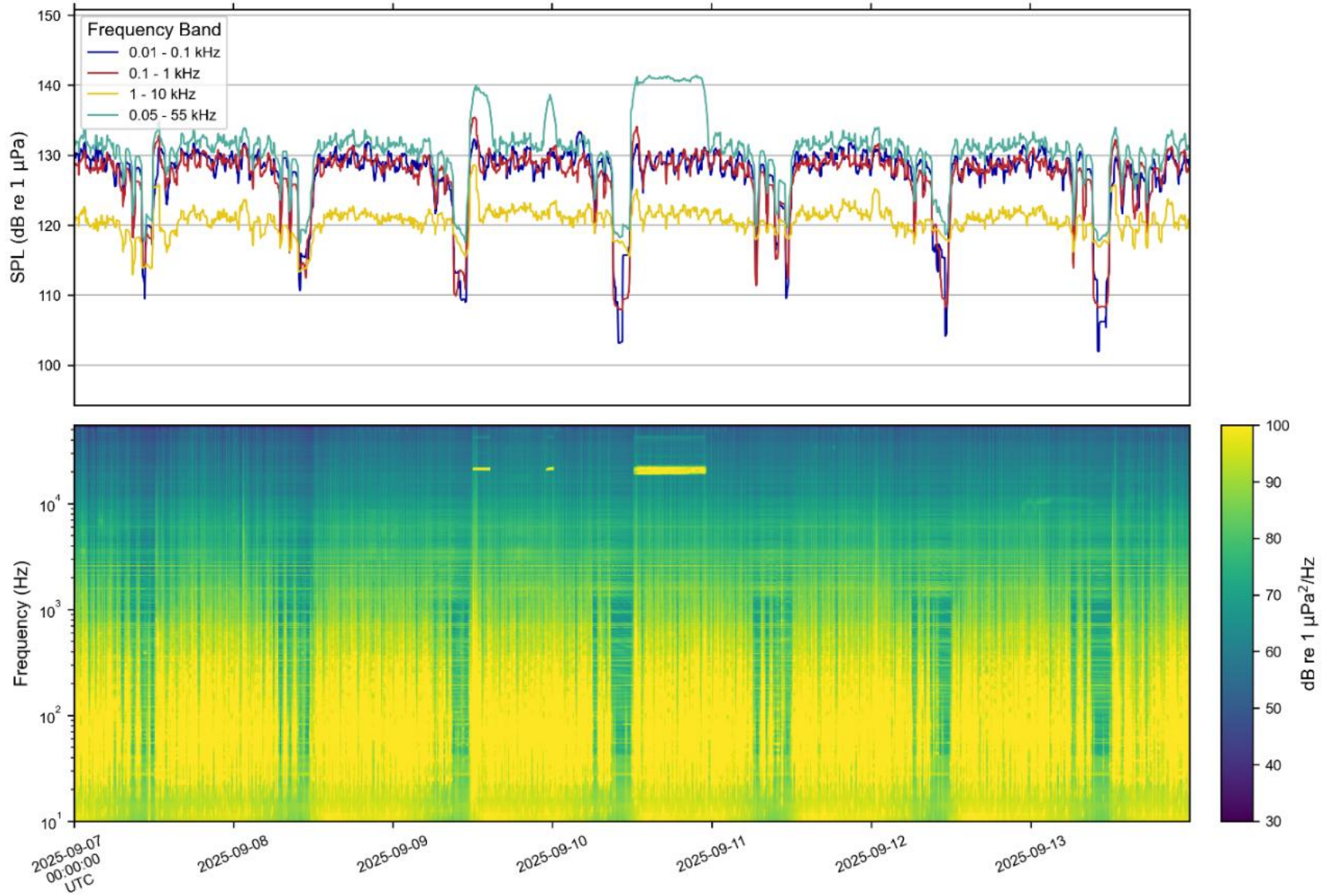


Figure E.2-8: LTSA for SAQU -01 over the weekly monitoring period (Sep 14 to 20, 2025)

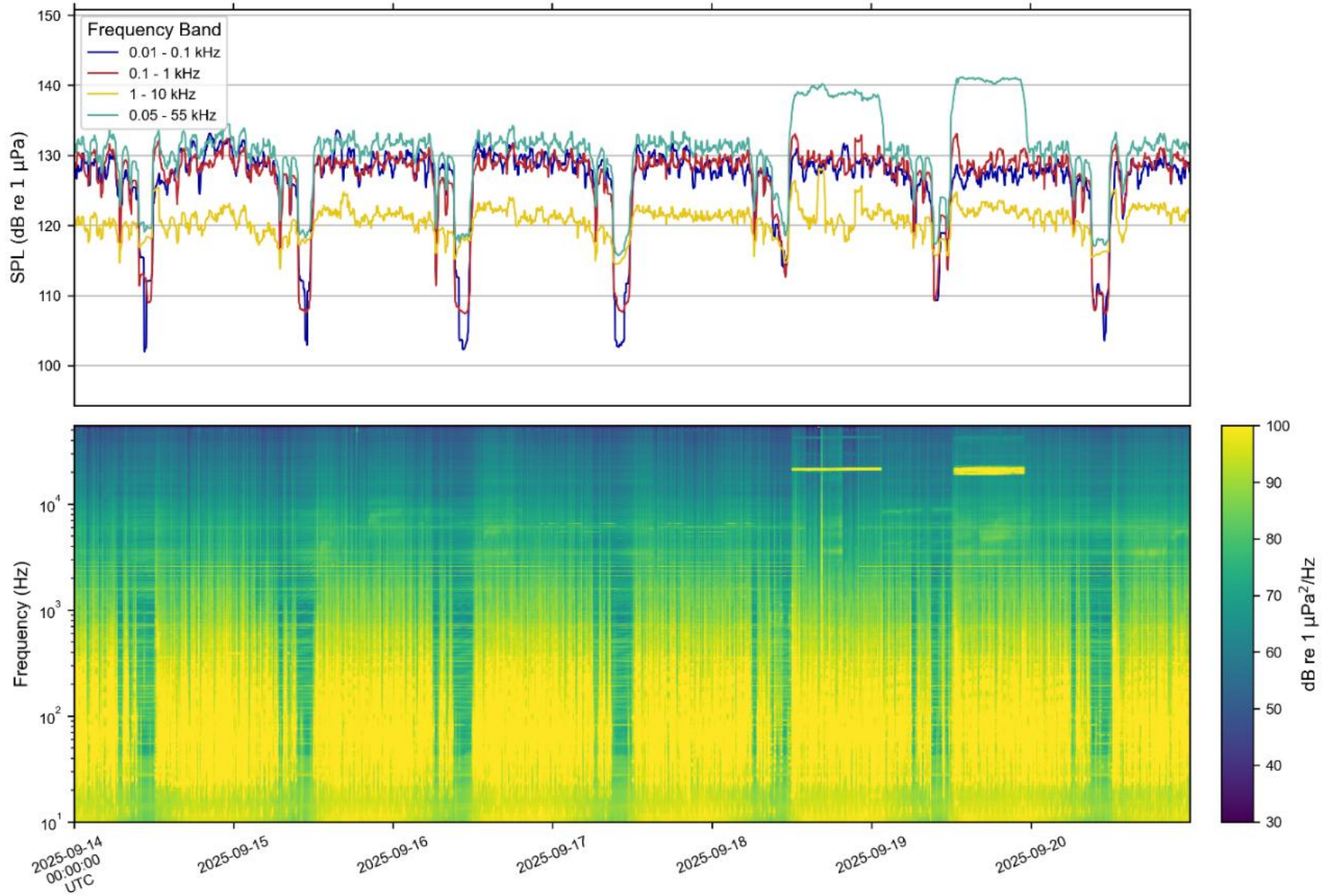


Figure E.2-9: LTSA for SAQU -01 over the weekly monitoring period (Sep 21 to 27)

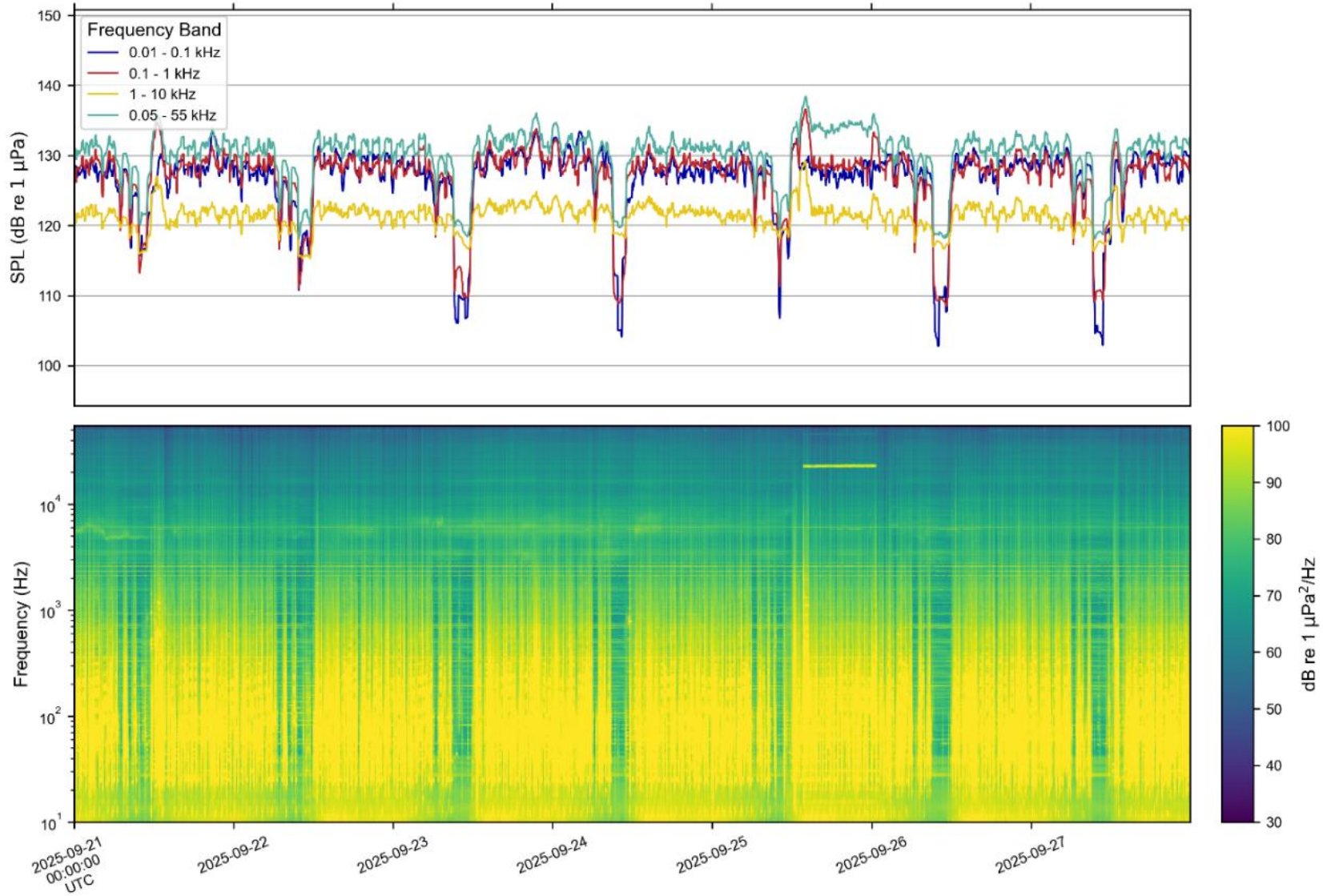


Figure E.2-10: LTSA for SAQU -01 over the weekly monitoring period (Sep 28 to Oct 04)

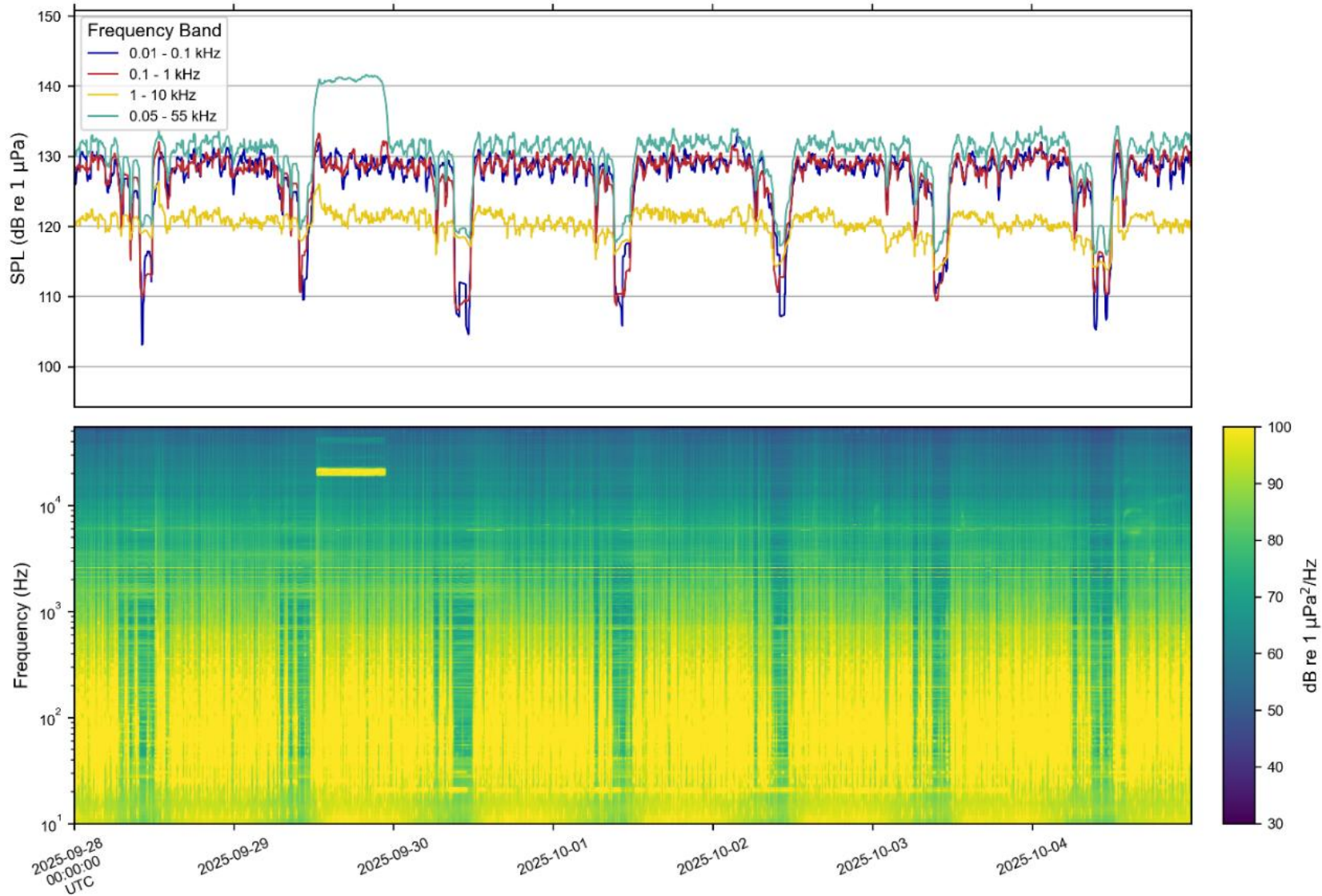


Figure E.2-11: LTSA for SAQU-01 over the weekly monitoring period (Oct 05 to Oct 11)

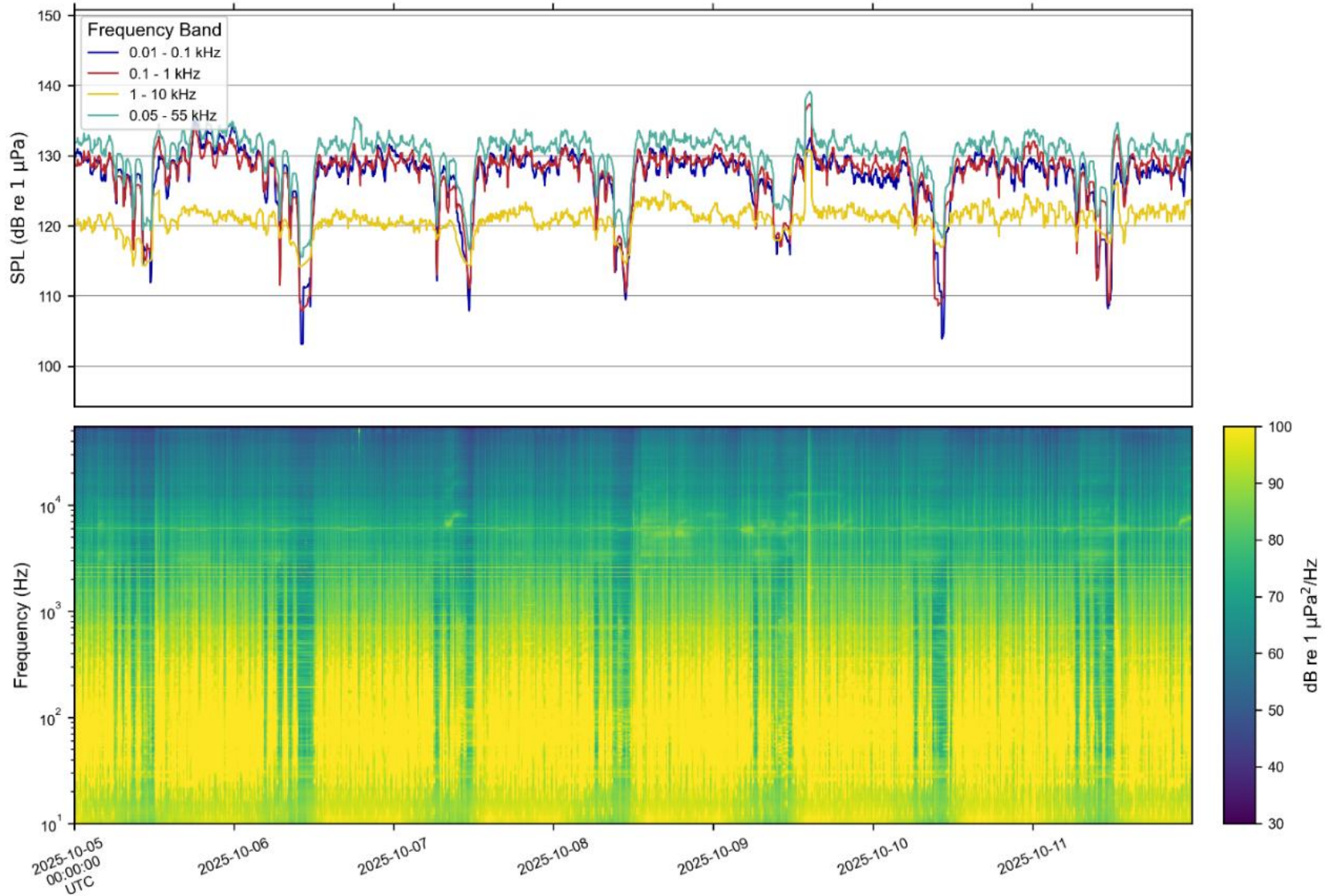


Figure E.2-12: LTSA for SAQU-01 over the weekly monitoring period (Oct 12 to Oct 18)

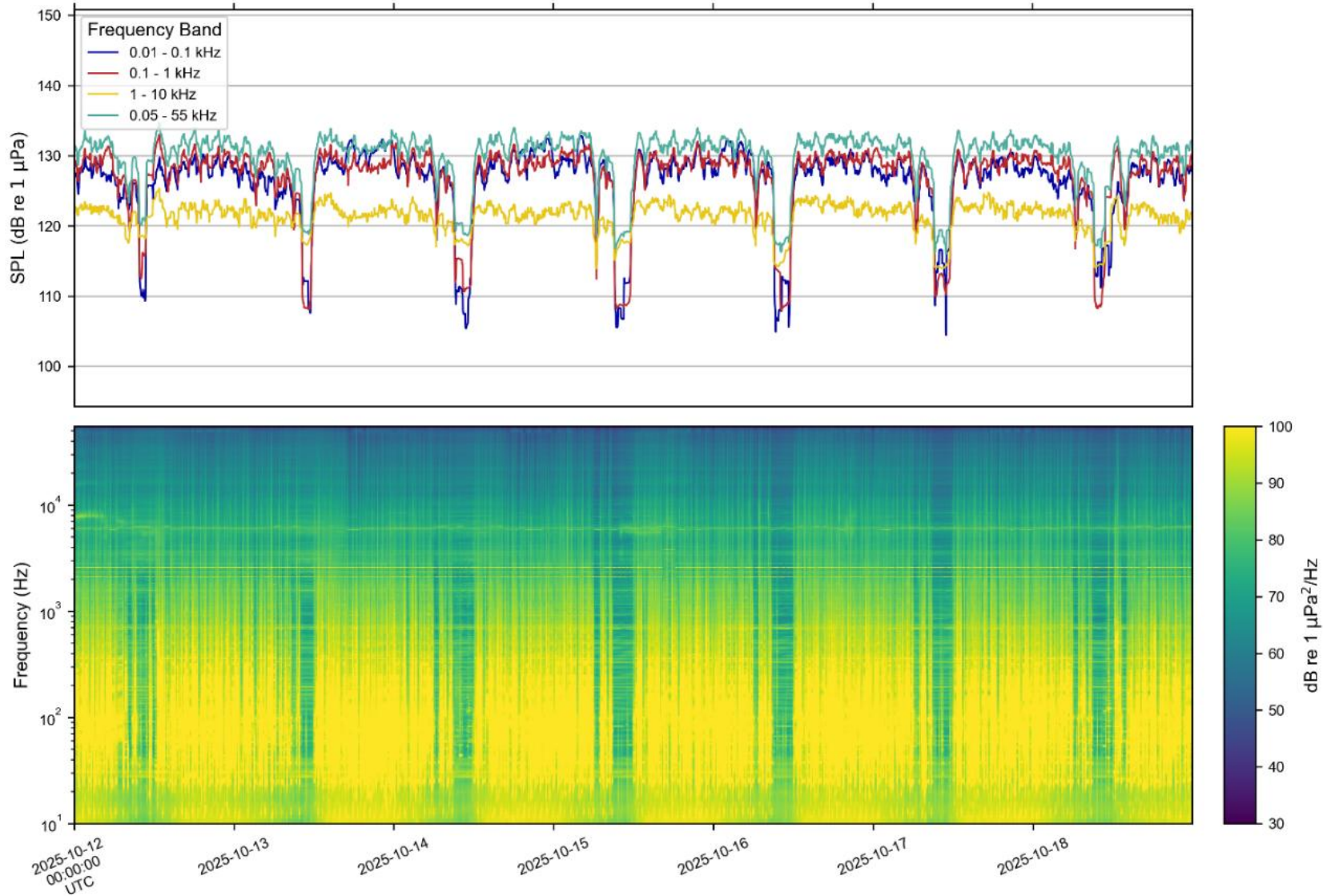


Figure E.2-13: LTSA for SAQU-01 over the weekly monitoring period (Oct 19 to Oct 25)

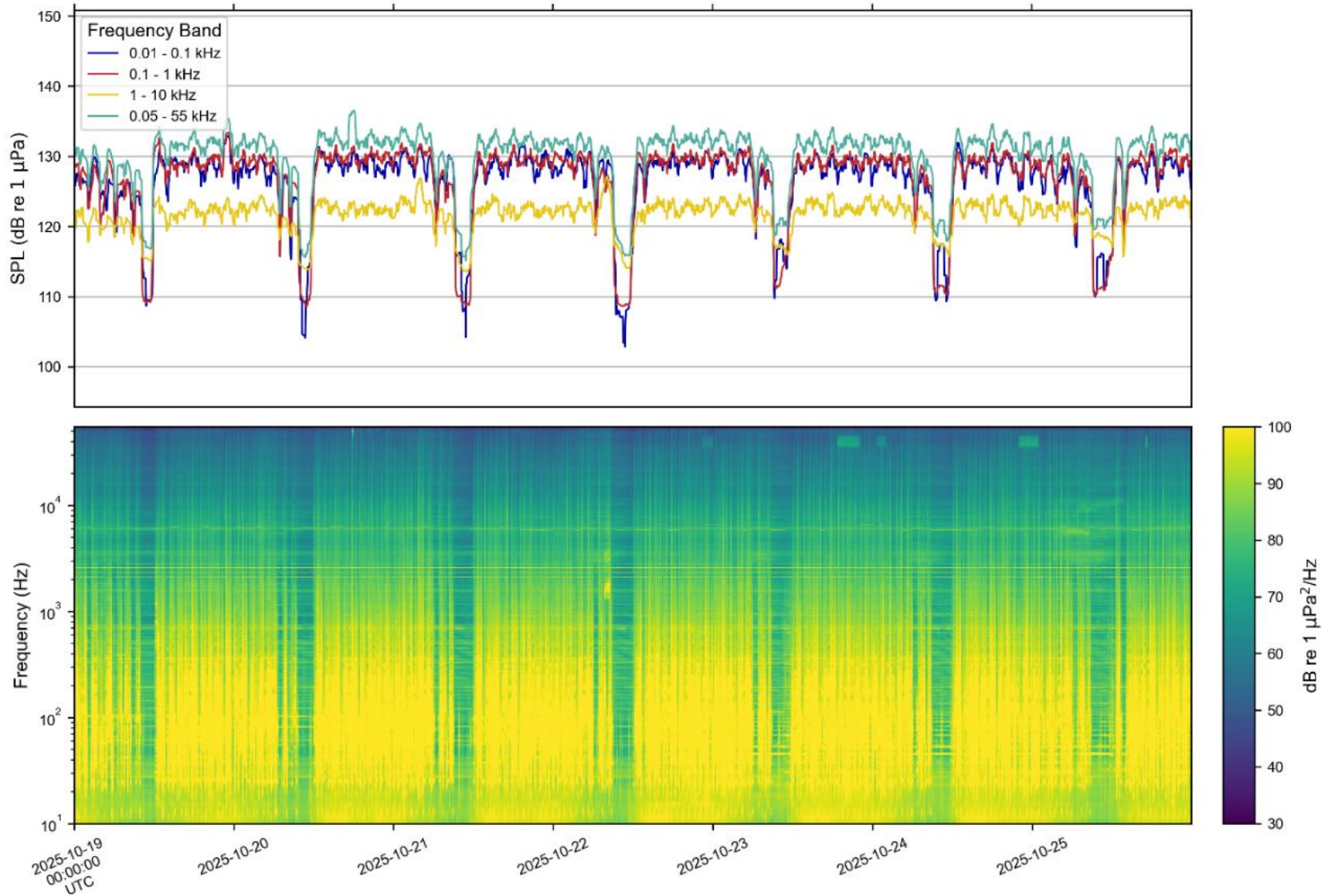


Figure E.2-14: LTSA for SAQU-01 over the weekly monitoring period (Oct 26 to Nov 01)

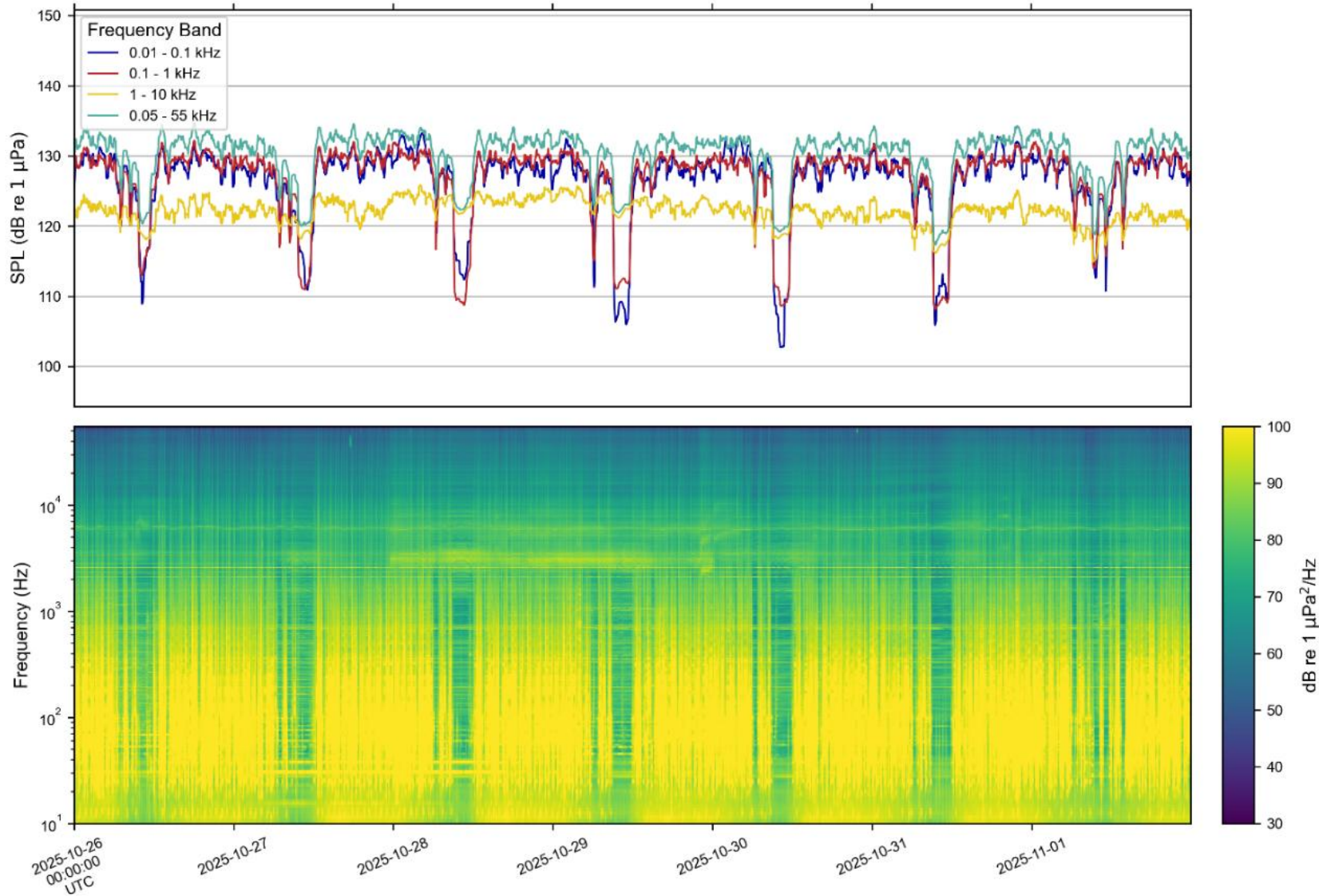


Figure E.2-15: LTSA for SAQU-01 over the weekly monitoring period (Nov 01 to Nov 08)

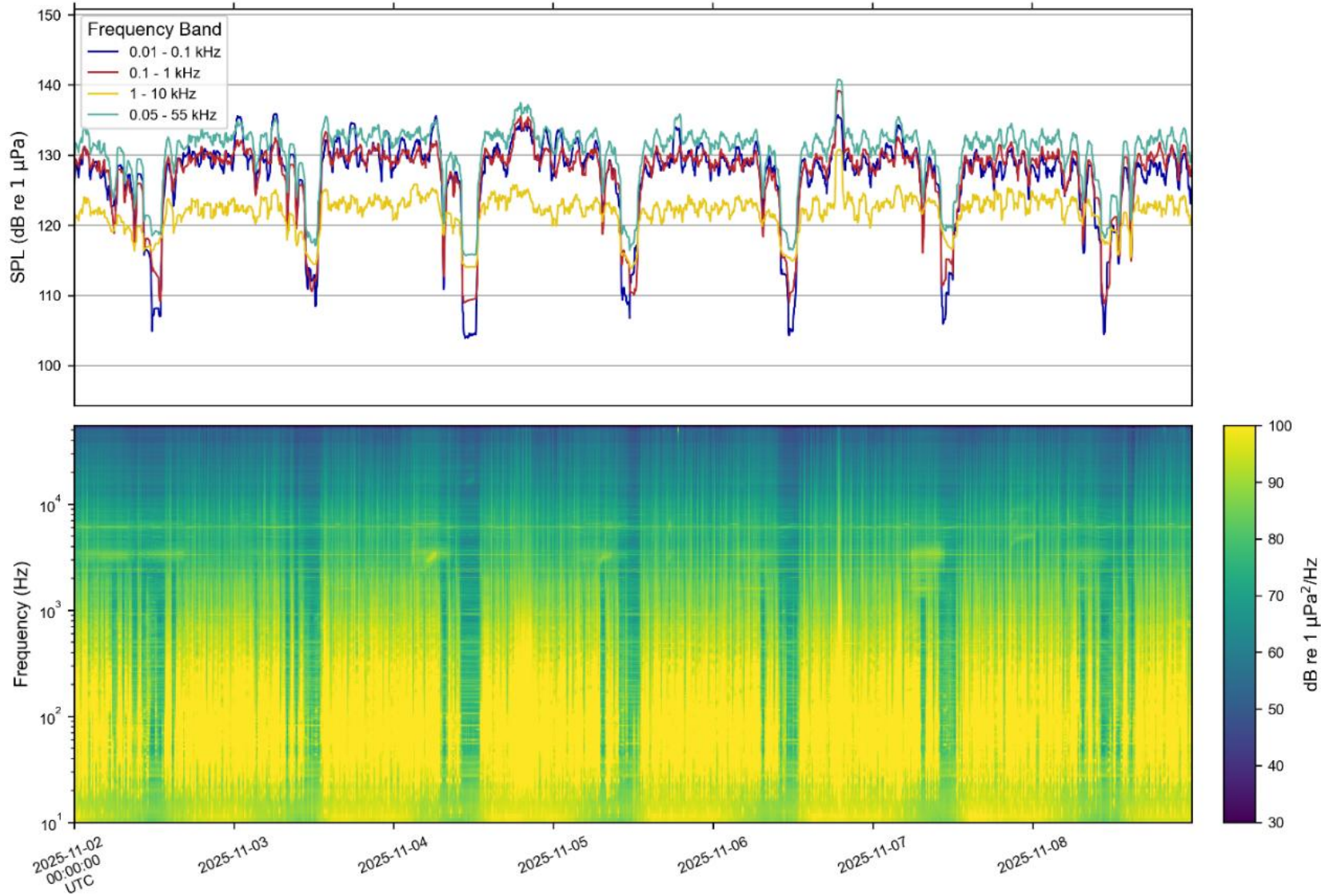


Figure E.2-16: LTSA for SAQU-01 over the weekly monitoring period (Nov 09 to Nov 15)

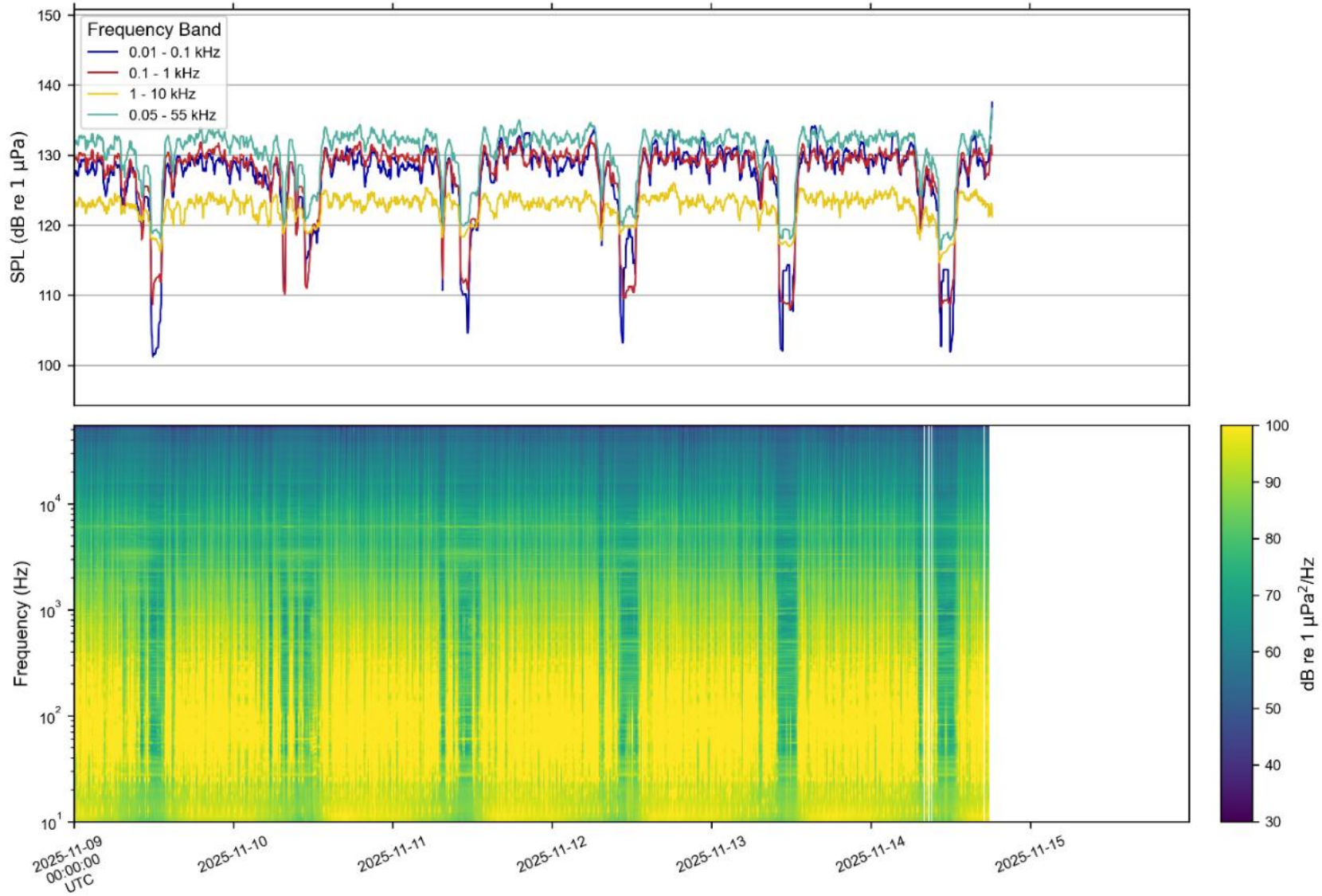


Figure E.2-17: Representative radial charts for SAQU-01 noise levels (L_{eq}) of the seven day-of-week pattern for each decade-band of the monthly monitoring period (September 2025)

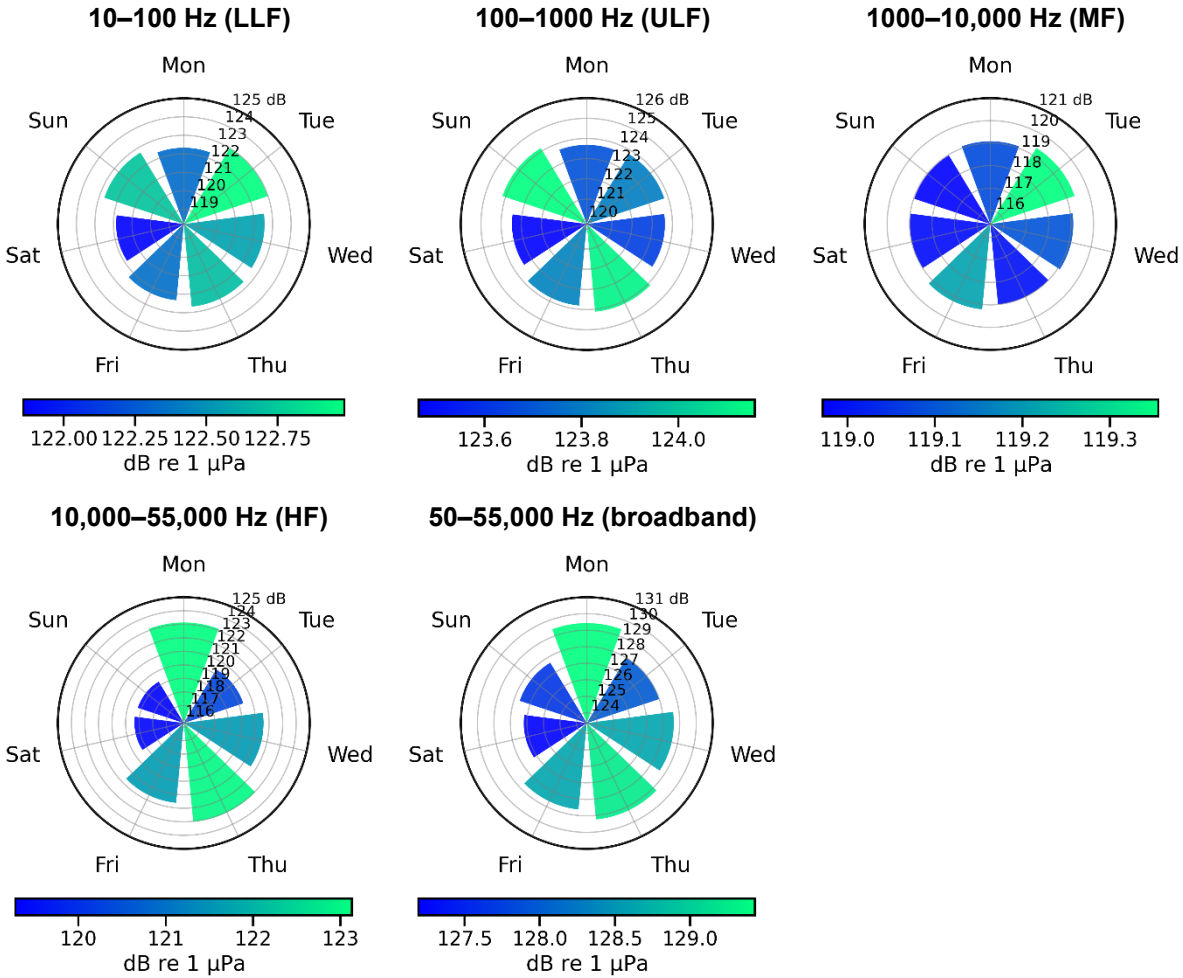


Figure E.2-18: Representative radial charts for SAQU-01 noise levels (L_{eq}) of the seven day-of-week pattern for each decade-band of the monthly monitoring period (October 2025)

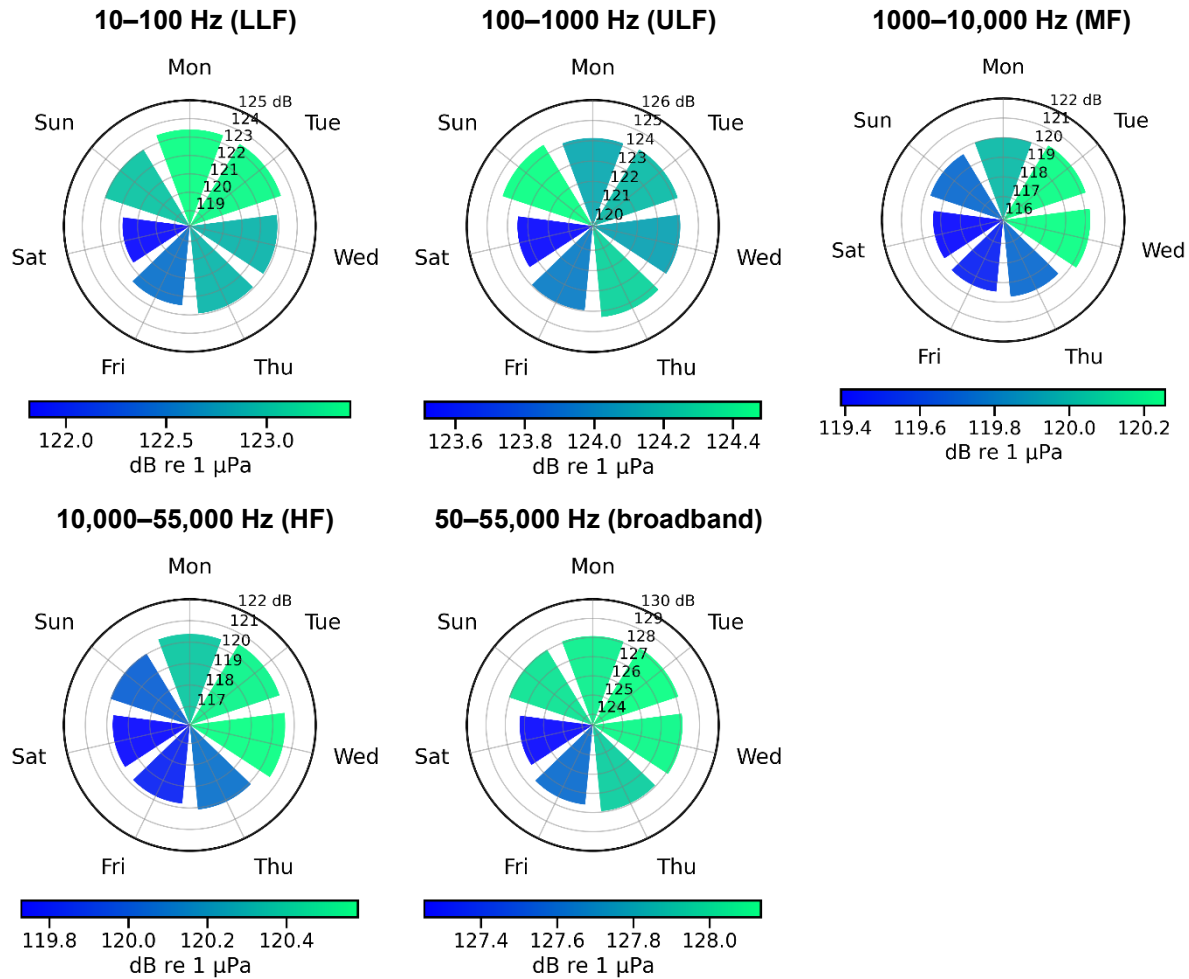


Figure E.2-19: Representative radial charts for SAQU-01 noise levels (L_{eq}) of the seven day-of-week pattern for each decade-band of the monthly monitoring period (November 2025)

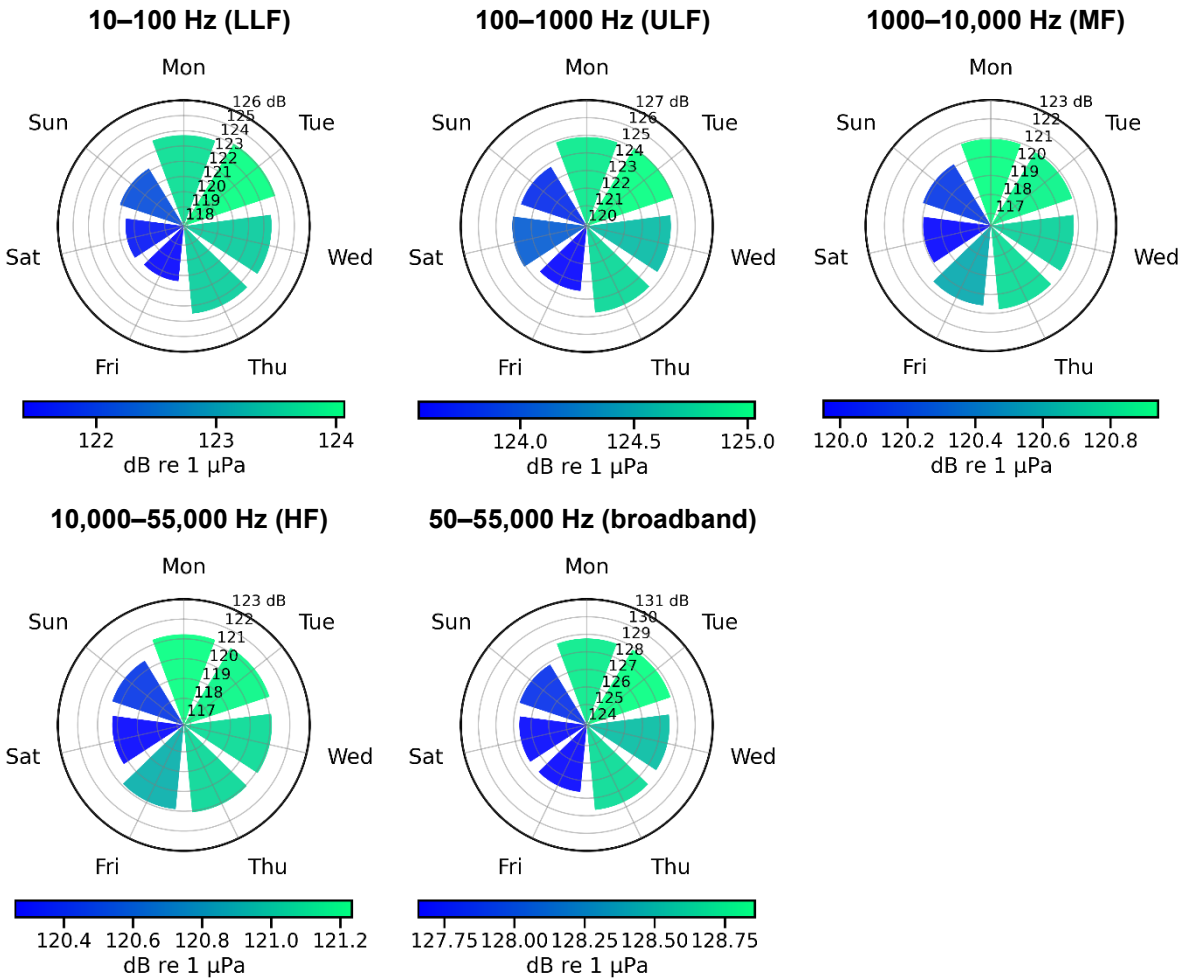


Figure E.2-20: Representative radial charts for SAQU-01 noise levels (L_{eq}) of the 24-hour pattern for each decade-band of the monthly monitoring period (September 2025)

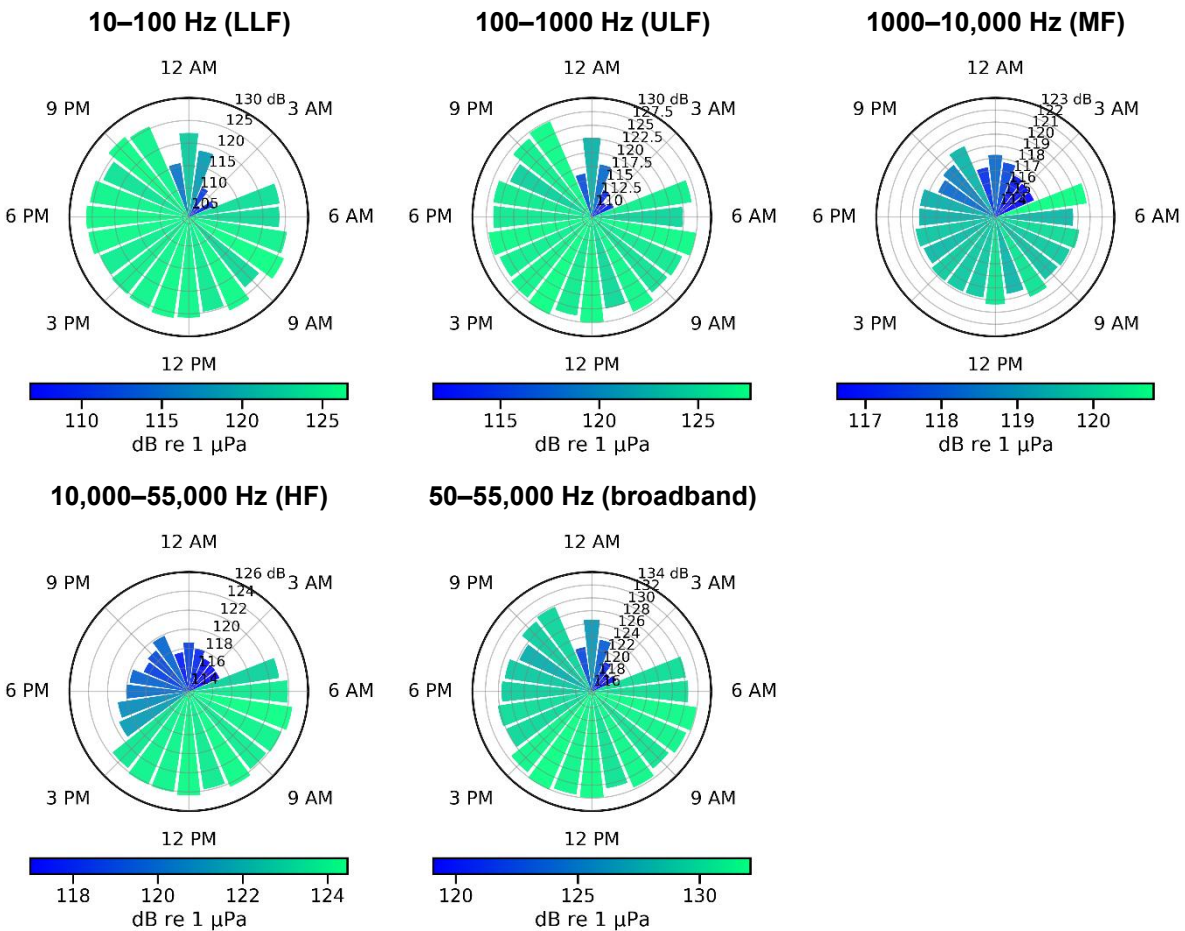


Figure E.2-21: Representative radial charts for SAQU-01 noise levels (L_{eq}) of the 24-hour pattern for each decade-band of the monthly monitoring period (October 2025)

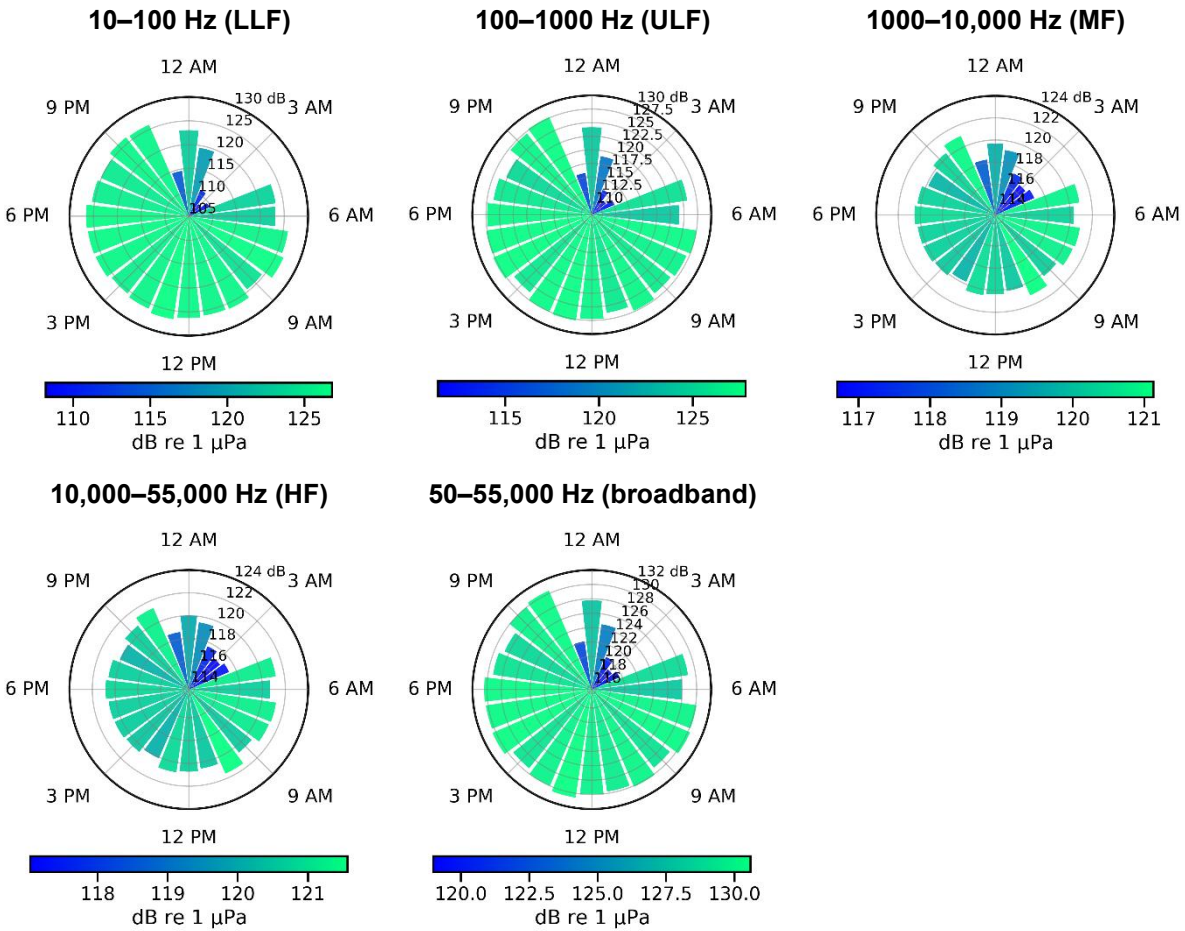
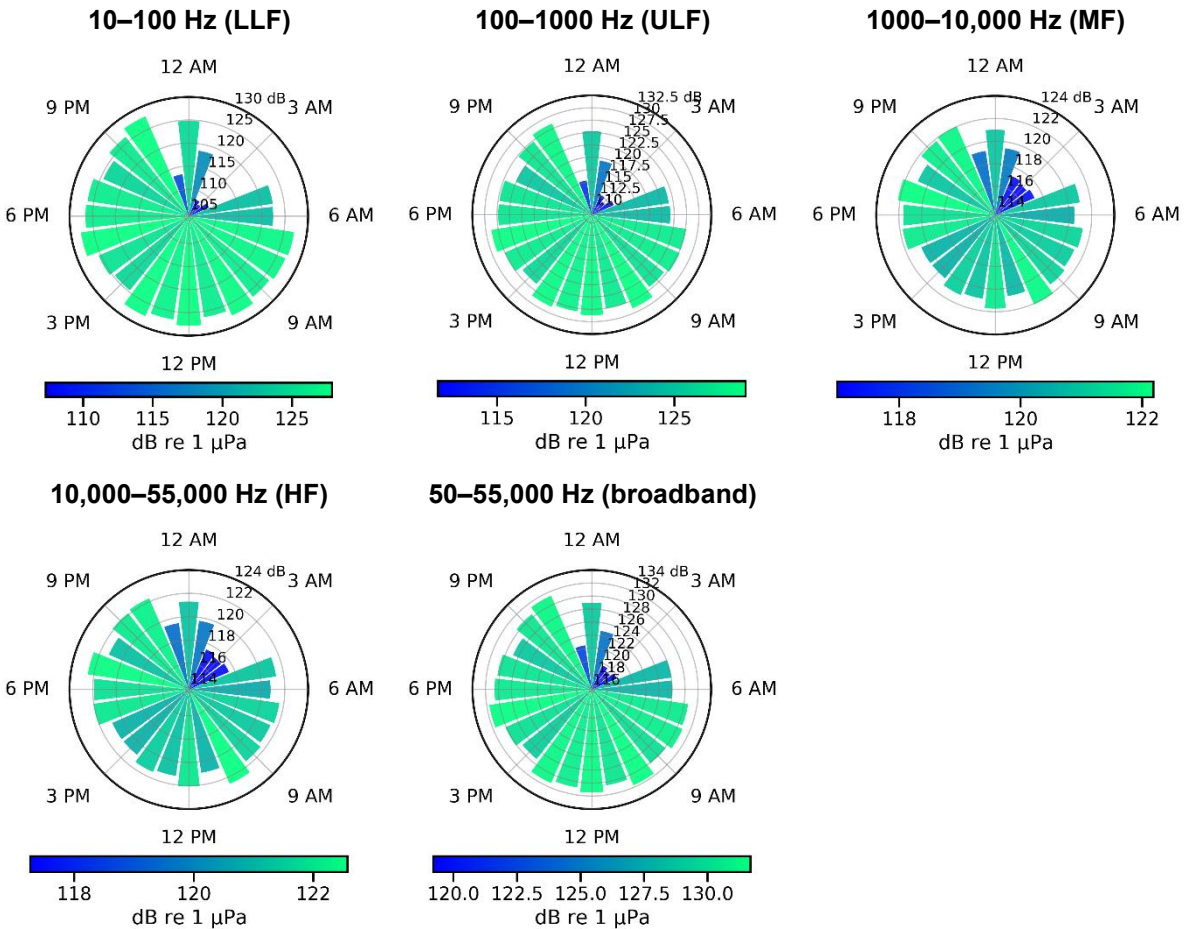


Figure E.2-22: Representative radial charts for SAQU-01 noise levels (L_{eq}) of the 24-hour pattern for each decade-band of the monthly monitoring period (November 2025)



E.3 Comparison of ambient noise levels

Figure E.3-1: Comparison of ambient noise levels (L_{eq}) of the two underwater monitoring stations throughout the monthly monitoring period (September 2025)

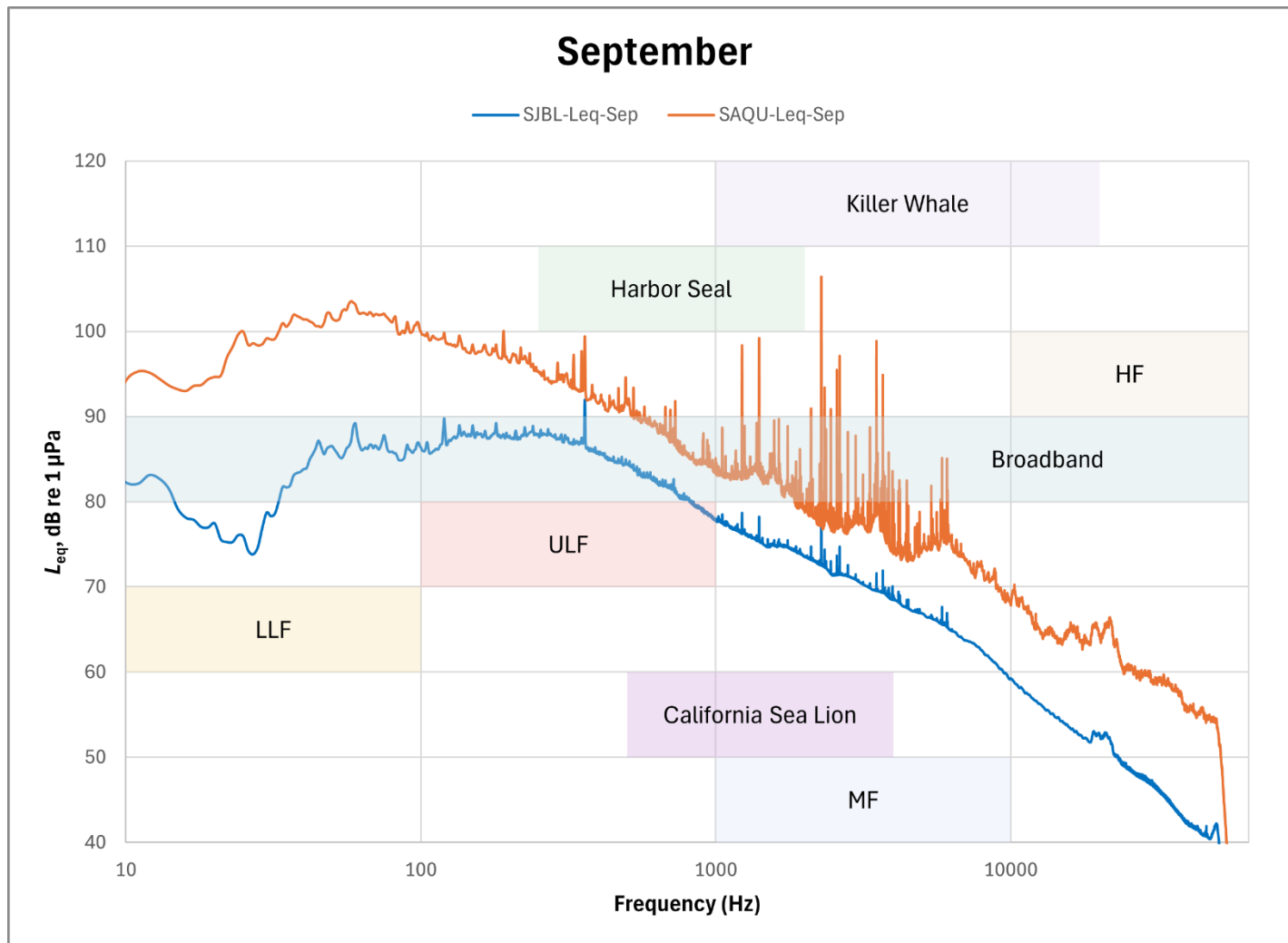


Figure E.3-2: Comparison of ambient noise levels (L_{eq}) of the two underwater monitoring stations throughout the monthly monitoring period (October 2025)

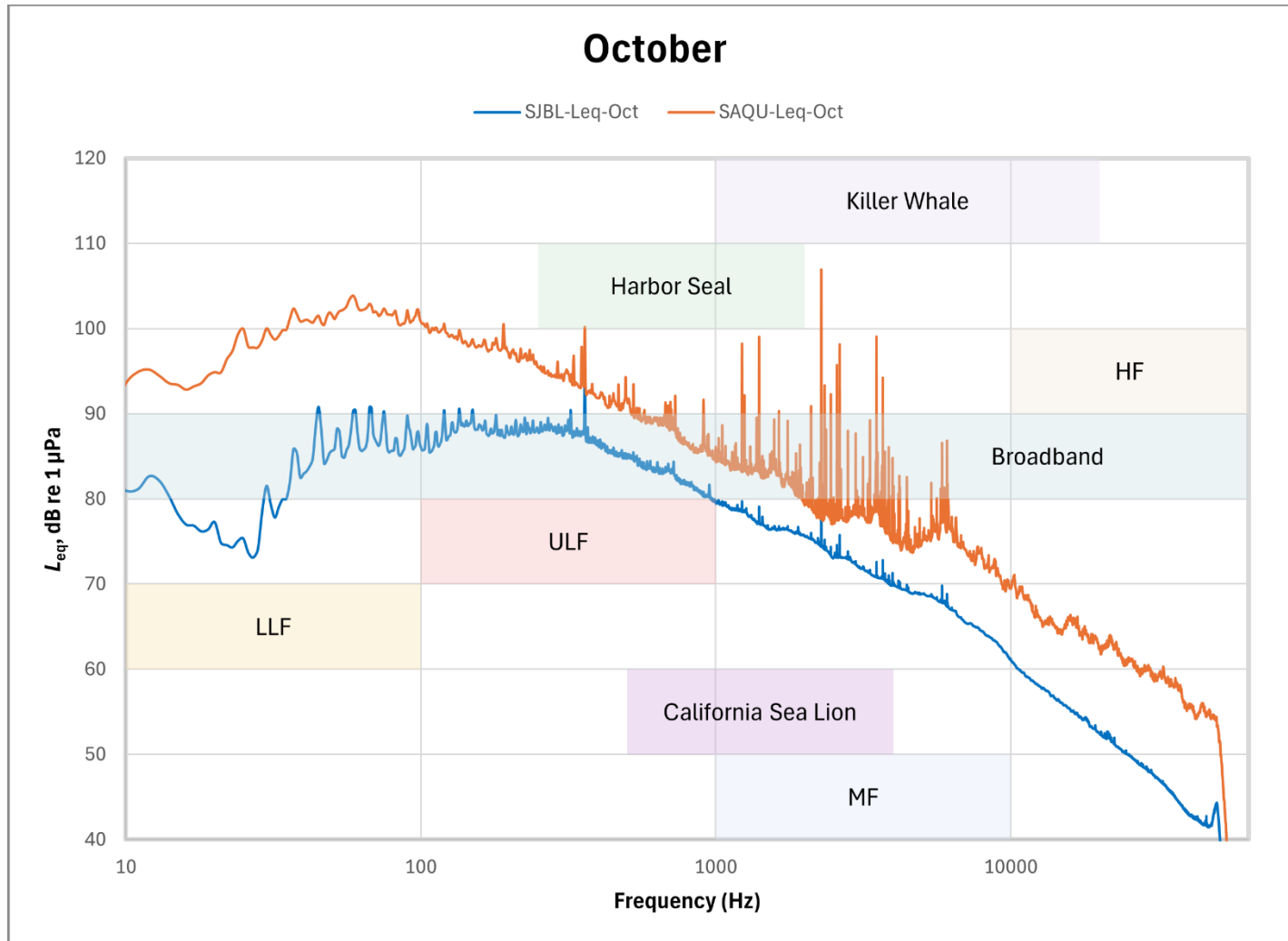


Figure E.3-3: Comparison of ambient noise levels (L_{eq}) of the two underwater monitoring stations throughout the monthly monitoring period (November 2025)

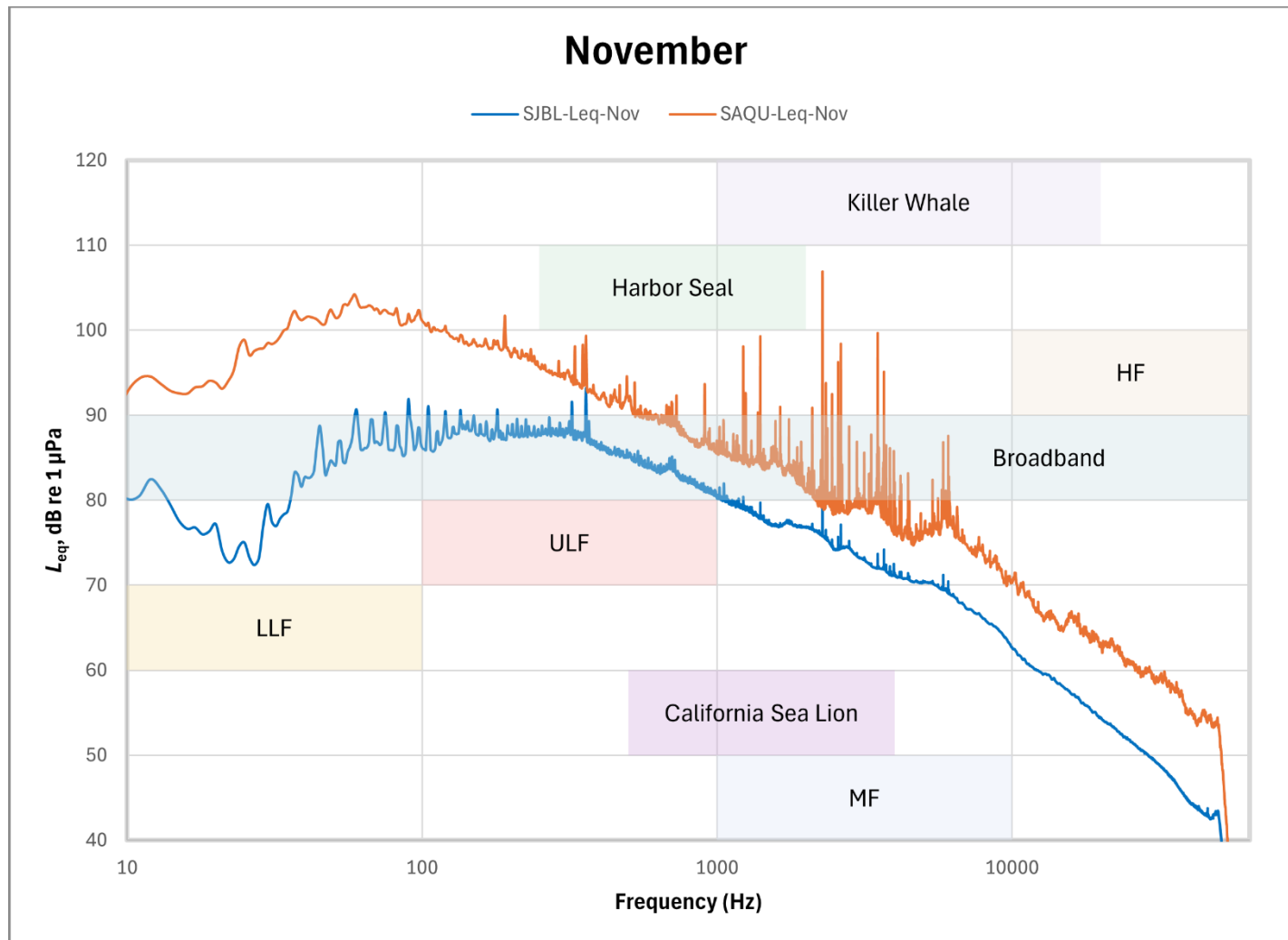


Table E.3-1: L_{eq} (1-min SPL) for the 1/3 octave band center frequencies of SJBL-01 for the quarterly monitoring period (Sep to Nov 2025)

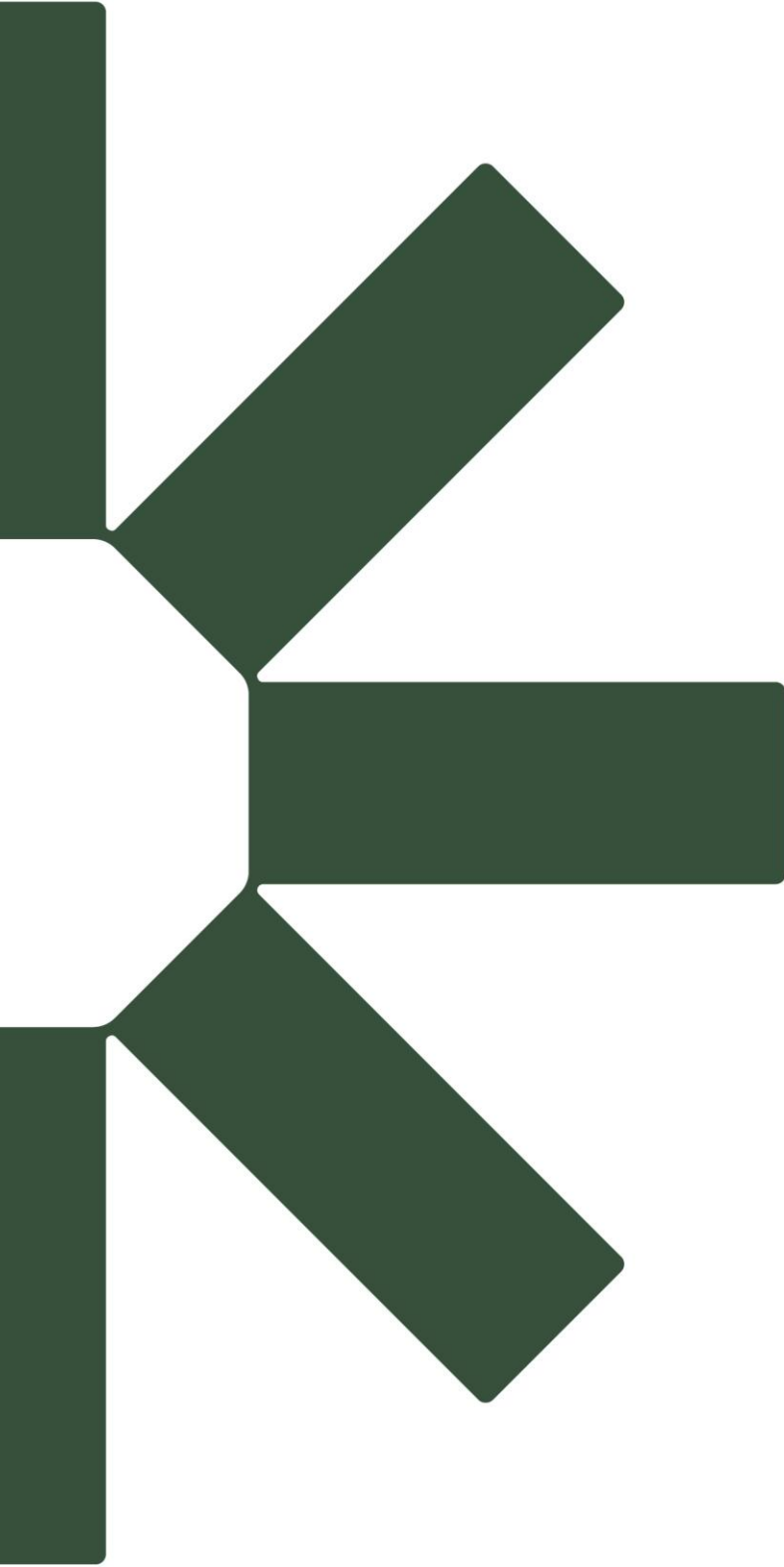
1/3 Octave Band (Hz)	L_{eq} dB re 1 μ Pa			1/3 Octave Band (Hz)	L_{eq} dB re 1 μ Pa		
	Sep	Oct	Nov		Sep	Oct	Nov
10	82.3	81.0	80.2	800	80.3	81.6	82.0
12.5	82.9	82.4	81.9	1000	77.9	79.6	80.3
16	78.1	77.0	76.6	1250	76.5	78.5	78.9
20	77.5	77.3	77.2	1600	74.9	76.4	77.0
25	75.9	75.3	75.0	2000	73.6	75.7	76.8
31.5	78.5	78.6	77.2	2500	71.4	73.0	74.2
40	83.8	82.9	82.7	3150	70.3	71.8	73.0
50	86.5	85.7	84.4	4000	68.5	69.9	71.1
63	86.1	85.6	85.9	5000	66.9	68.9	70.3
80	85.9	85.7	85.9	6300	64.8	67.0	68.8
100	86.4	86.1	86.2	8000	62.5	64.5	66.1
125	87.3	87.4	87.3	10000	59.3	61.2	62.8
160	88.0	88.6	87.8	12500	56.3	58.1	59.8
200	87.7	87.6	87.7	16000	53.4	55.2	57.2
250	87.9	87.9	87.6	20000	52.8	52.5	54.4
315	87.5	88.9	89.0	25000	48.9	50.0	51.8
400	85.8	86.3	86.2	31500	46.3	47.2	48.9
500	84.5	84.7	85.0	40000	42.5	43.2	44.6
630	82.7	83.8	84.0	50000	42.1	44.3	43.4



Table E.3-2: L_{eq} (1-min SPL) for the 1/3 octave band center frequencies of SAQU-01 for the quarterly monitoring period (Sep to Nov 2025)

1/3 Octave Band (Hz)	L_{eq} dB re 1 μ Pa			1/3 Octave Band (Hz)	L_{eq} dB re 1 μ Pa		
	Sep	Oct	Nov		Sep	Oct	Nov
10	94.2	93.6	92.7	800	85.5	86.6	87.3
12.5	94.8	94.8	94.1	1000	83.6	84.7	85.8
16	93.0	92.8	92.5	1250	85.3	86.2	86.7
20	94.7	94.9	93.8	1600	83.9	84.7	85.7
25	100.0	100.0	98.9	2000	78.8	79.3	81.0
31.5	99.1	99.0	98.5	2500	76.6	77.2	78.6
40	101.4	100.9	101.4	3150	77.7	78.3	79.4
50	101.6	101.6	101.9	4000	74.6	75.9	76.6
63	102.1	102.2	102.7	5000	74.2	75.0	76.3
80	101.1	101.6	101.8	6300	74.8	76.3	76.8
100	99.9	100.8	101.2	8000	72.2	73.2	73.6
125	98.5	99.0	99.3	10000	68.0	69.7	70.7
160	97.6	97.9	98.1	12500	65.1	66.2	66.8
200	96.3	96.6	96.9	16000	65.5	66.0	66.4
250	95.3	95.4	95.7	20000	64.4	62.7	63.1
315	94.2	94.9	95.0	25000	60.9	61.1	61.0
400	91.6	91.9	91.9	31500	59.1	59.0	58.9
500	91.8	91.7	92.2	40000	55.8	55.6	55.2
630	89.1	89.6	90.0	50000	53.9	53.7	53.6





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