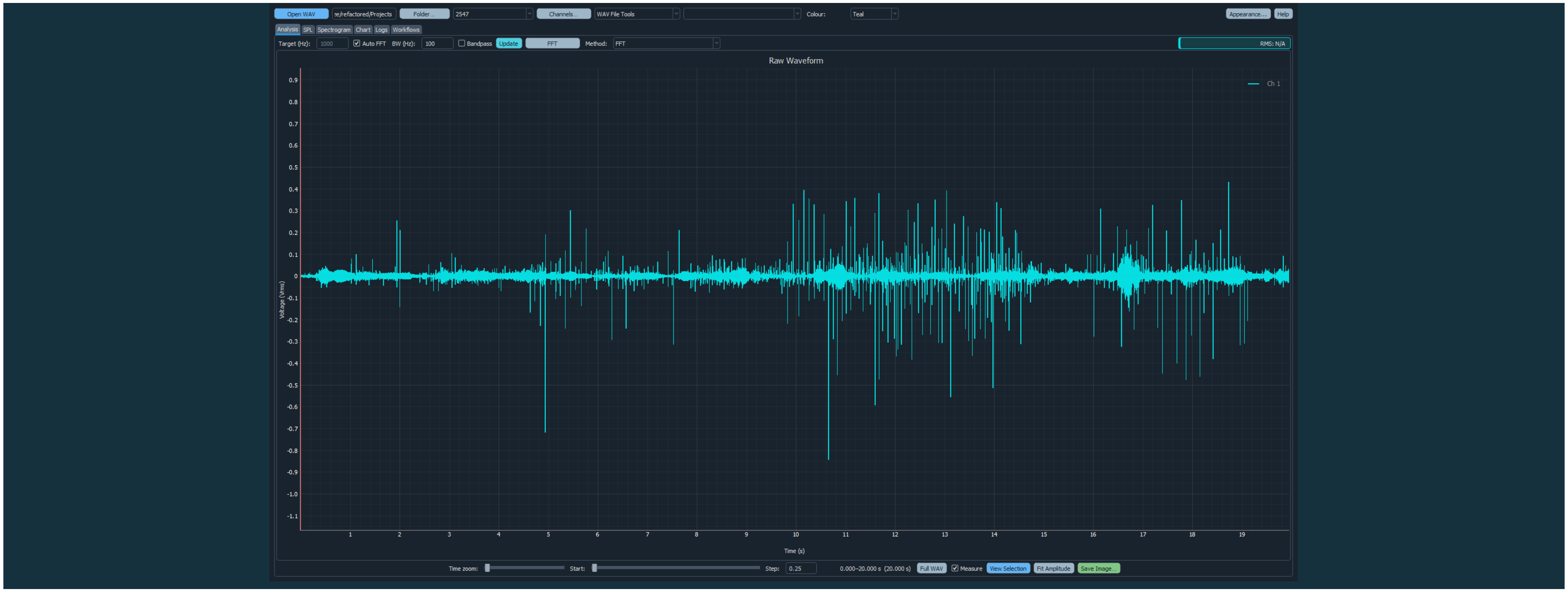
BLACKFISH ACOUSTICS

ANALYZE

From raw WAV to defensible acoustic evidence.

User Manual & Detailed Tool Guide

Current interface, operating procedures, and technical methods



60 TOOLS | WAV, MEASUREMENT, MODELLING, DETECTION & DATABASE

DETAILED TOOL GUIDE EDITION

Updated August 2026 | Supersedes the July 2025 manual

Contents

Update this field in Word to generate the contents.

Navigation: The contents includes every Heading 1–3 entry. In Word, Ctrl+click a contents entry to jump to that section; the Navigation pane provides the same hierarchy. Screenshots reflect the current maximized Windows build.

1. What Analyze does

Analyze brings the major steps of an underwater-acoustics review into one application. It reads WAV audio, keeps files and results organized by project, supports single- and multi-channel analysis, and stores measurements in a local database.

- Open a WAV file or work from a project folder; select and configure channels.
- Inspect the full waveform, zoom to a region, and switch to an FFT view.
- Measure RMS voltage in a selected time and frequency band using FFT-based methods.
- Convert voltage results to calibrated SPL using hydrophone sensitivity or TVR data.
- Create and search spectrograms, annotate events, preview audio, and export clips, views, or video.
- Import GPS tracks, bathymetry, CTD profiles, DIFAR bearings, and waypoints for spatial review.
- Filter, plot, export, and delete voltage and SPL records.
- Assign repeatable workflows to project files and track completion.

Terminology: The application window is titled “Waveform Analyser,” while the product and this manual use “Analyze.”

2. Installation, licensing, and data

Install and start

Use the supplied Windows application package or organization-approved installer. The customer build includes its required runtime; end users should not install Python packages or run the source file.

1. Copy or install the complete application package in a writable location approved by your organization.
2. Start Analyze from the supplied executable or shortcut.
3. If the licensing dialog appears, enter your name and email and choose Generate Request Code.
4. Send the generated request file to the licensing contact shown by the application. Place the returned license file beside the application as instructed, then restart.

Where data is stored

- Projects are stored beneath the configured Projects folder. Selecting a project causes Analyze to mirror or organize working files in that project.
- Measurements, calibration curves, projects, workflow status, and related metadata are kept in the local Analyze database.

- Generated output is project-scoped. Raw-waveform images use raw_wav, FFT images use fft, spectrogram images and videos use spectrograms, selected audio clips use clips, propagation exports use propagation_model, and converted or processed WAV files use wav_file_tools.
- If no project is active, project-scoped save and export actions prompt for a project before writing output.

Backups: Back up both the Projects folder and the Analyze database. Copying only WAV files does not preserve measurement logs, calibration records, workflow assignments, or annotations.

3. Quick start

1. Choose a project from the project list, or select Add project to create one.
2. Select Open WAV and choose an audio file. For a project-managed job, prefer a file within the project or allow Analyze to copy it into the project.
3. Choose Channels to enable the channels you need and enter per-channel calibration values where applicable.
4. On Analysis, drag across the waveform to select a time region. Enable Measure when the selection should immediately create a measurement. Set Target (Hz) and BW (Hz), and enable Bandpass only when filtering is intended.
5. Choose Update to refresh the selected analysis, then use FFT to inspect the spectrum. Confirm the spectral method before recording a result.
6. Review the new record on Logs. If a hydrophone or TVR calibration applies, create the SPL result on the SPL tab.
7. Use Spectrogram for event review and annotation, Chart for spatial context, and Workflows for repeatable multi-file processing.

Good practice: Record calibration source, gain, channel, target band, and selection limits before comparing results between files.

4. Application frame and projects

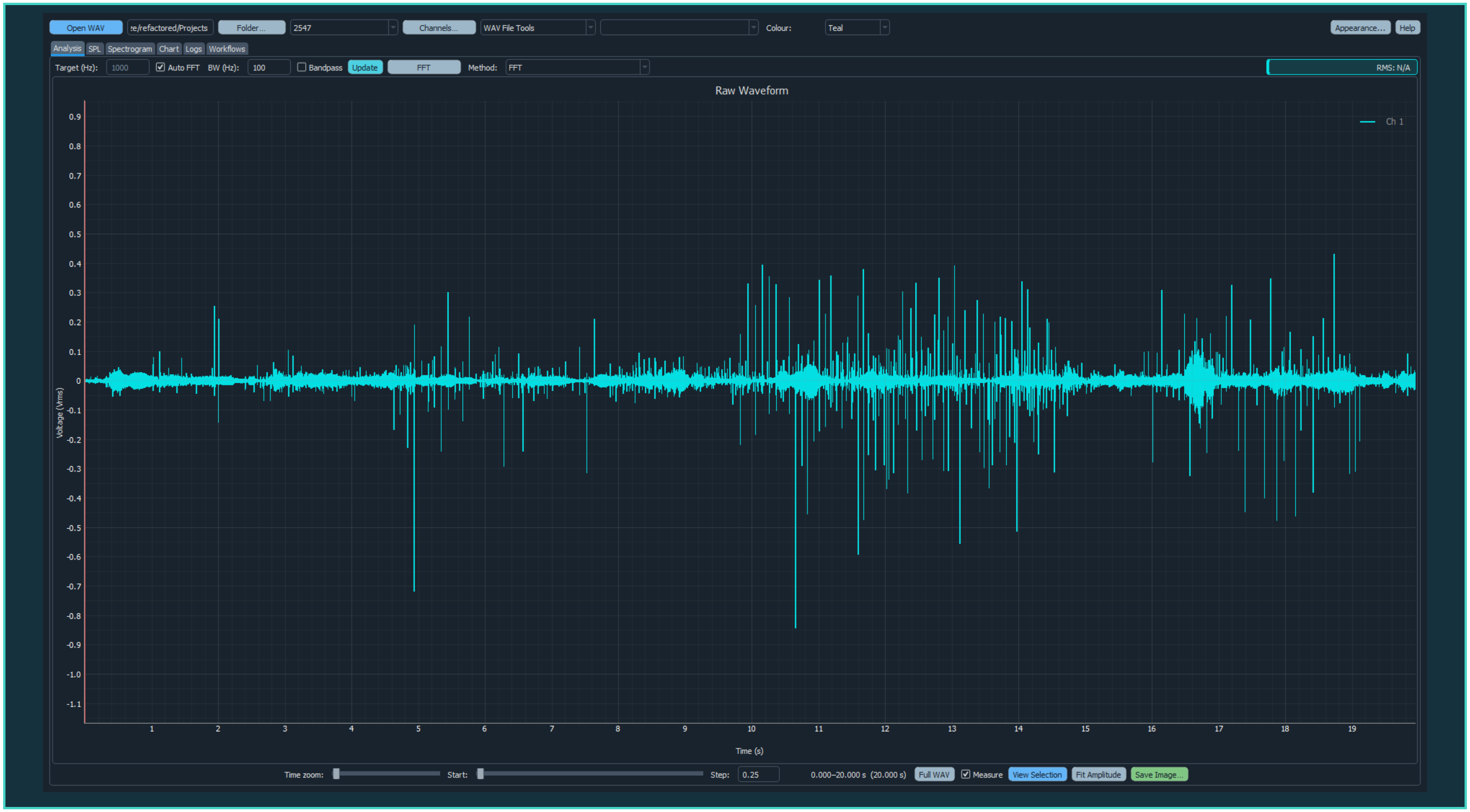


Figure 1. Analysis workspace displaying the real NoiseMiner recording across the full 20-second WAV.

Control / area	Purpose
Open WAV	Select an audio file. Supported channel handling is determined after the file is opened.
Folder	Open or change the working/project folder.
Project selector	Select no project, an existing project, add a project, or remove the current project.
Channels	Choose active channels and configure channel-specific calibration settings.
Tool category and tool	Choose WAV File Tools or another enabled category, then select the operation to run.
Colour	Change the application graph accent colour.
Appearance	Choose a coordinated button-colour profile and an optional application background colour; Use Theme Default restores the active light or dark theme background.
Tabs	Move among Analysis, SPL, Spectrogram, Chart, Logs, and Workflows.
Help	Open the built-in help window.

Projects

A project is the main organizational boundary. Project filters appear in Logs, SPL, Spectrogram, Chart, and Workflows so that measurements and derived files stay associated with the work that created them.

1. Create or select the project before loading files.
2. Use the project folder and Workflows tab to import and classify files into groups and folders.
3. Keep derived files linked to the same project; use descriptive groups, stages, and run names.
4. Verify the active project before deleting or exporting filtered results.

5. Analysis: waveform, FFT, and voltage

Analysis controls

Control / area	Purpose
Target (Hz)	Center frequency used for a band-limited measurement.
Auto FFT	Automatically refresh the FFT as applicable when the selection or controls change.
BW (Hz)	Measurement bandwidth around the target frequency.
Bandpass	Applies a bandpass filter. It is off by default because filtering changes the measurement.
Update	Recalculates the current selection using the displayed settings.
FFT / Waveform	Switches between time-domain and frequency-domain views.
Method	Selects the spectral method, such as FFT, Welch, or another enabled method.
RMS display	Shows the current calibrated RMS result or N/A when no valid selection is available.

Waveform workflow

1. Open the WAV and choose channels.
2. Use Time zoom and Start to move through long recordings, or choose Full WAV. Enter Step and use Left/Right (or A/D) to move by that many seconds without changing the zoom; Home and End jump to the recording boundaries.
3. Set Measure as required, then drag across the plot. With Measure selected, releasing the drag immediately calculates and logs the measurement; with it cleared, the time region is retained without measuring. Choose View Selection when you need a closer view.
4. Choose Fit Amplitude to rescale the vertical axis.
5. Enter target frequency and bandwidth, decide whether Bandpass is appropriate, then choose Update.
6. Save the graph with Save Image when a visual record is required. Measurement screenshots may also be linked from Logs.

FFT workflow

Switch to FFT after selecting a stable time region. Inspect peaks, frequency limits, leakage, and noise floor before accepting a numerical measurement. Longer windows improve frequency resolution but reduce time localization.

- FFT is suitable for a direct spectrum of the selected window.
- Welch averaging reduces variance for noise-like signals but changes frequency resolution.
- Multitaper or other optional methods may be available in some profiles.
- Keep the same method, window length, bandwidth, and calibration when comparing results.

Caution: Do not enable Bandpass simply to make a trace look cleaner. Treat it as part of the measurement method and record its use.

6. SPL calculations and review

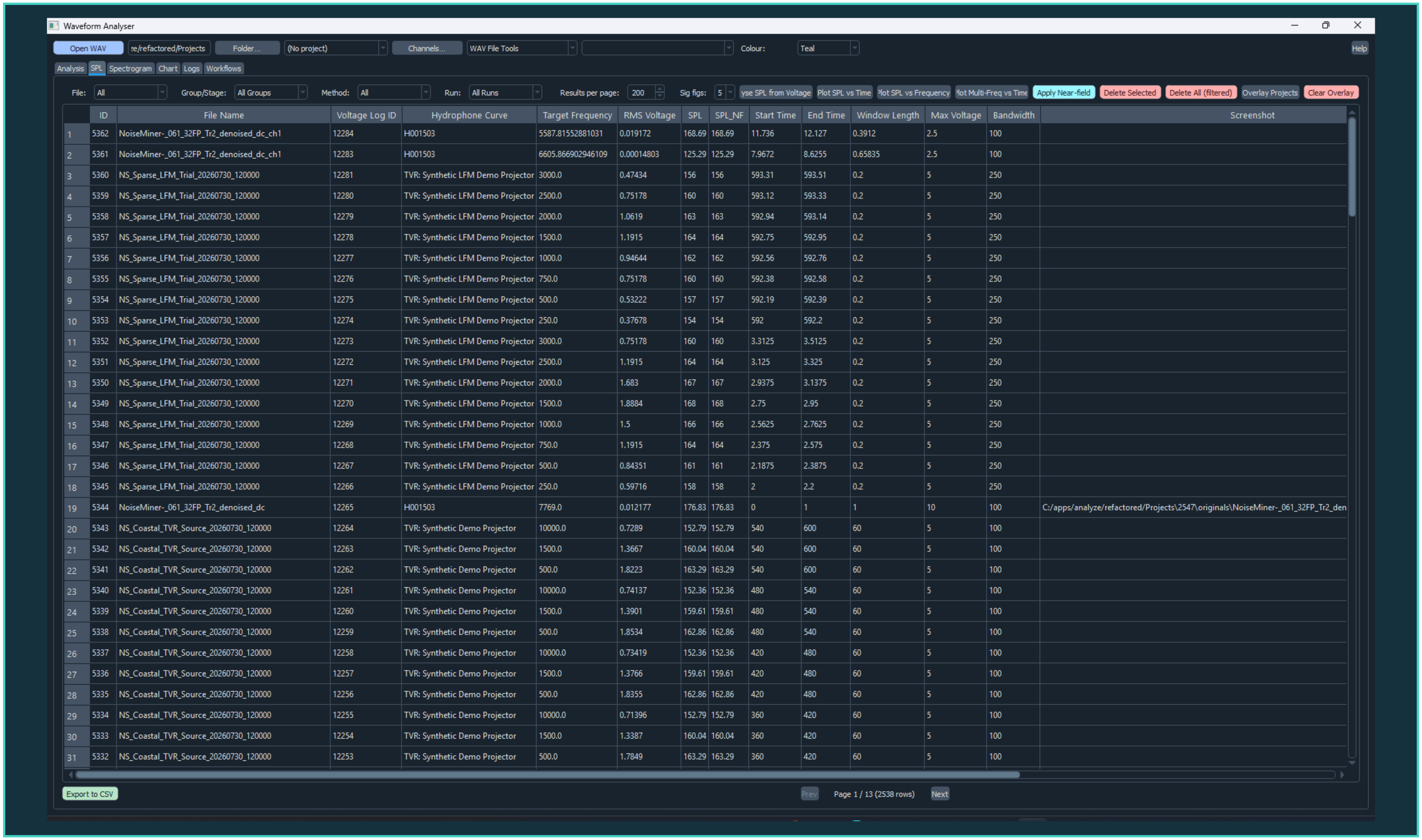


Figure 2. SPL records with project, group/stage, method, and run filters.

The SPL tab converts stored voltage measurements using an imported hydrophone sensitivity curve or supported TVR calibration. It also provides plotting, near-field correction, project overlays, deletion, and CSV export.

Control / area	Purpose
Filters	Limit the table by file, group/stage, method, and run.
Results per page / Sig figs	Control paging and displayed numeric precision.
Analyse SPL from Voltage	Choose a voltage log, calibration curve, and calculation inputs to create an SPL record.
Plots	Open a maximized tabbed window containing SPL vs Time, SPL vs Frequency, and Multi-Frequency vs Time graphs.
Apply Near-field	Apply the supported piston near-field correction using radius, range, and sound speed inputs.
Overlay Projects / Clear Overlay	Compare results from multiple projects, then remove the overlay.
Delete / Export CSV	Remove records or export the current result set.

Create an SPL result

1. Confirm the voltage measurement on Logs, including channel, target frequency, time limits, maximum voltage, bandwidth, and filter state.
2. Choose Analyse SPL from Voltage.
3. Select the voltage record and the correct hydrophone sensitivity or TVR curve.
4. Verify that the target frequency lies within the valid calibration range.
5. Calculate and review the SPL value, units, and supporting metadata before accepting it.

Calibration and correction warning: A plausible number is not proof of correct calibration. Confirm curve units, gain convention, channel scaling, reference pressure, and frequency coverage. Near-field correction is optional; use it only when the measurement geometry and model assumptions apply, and preserve the uncorrected SPL and correction delta.

7. Spectrograms, playback, annotation, and export

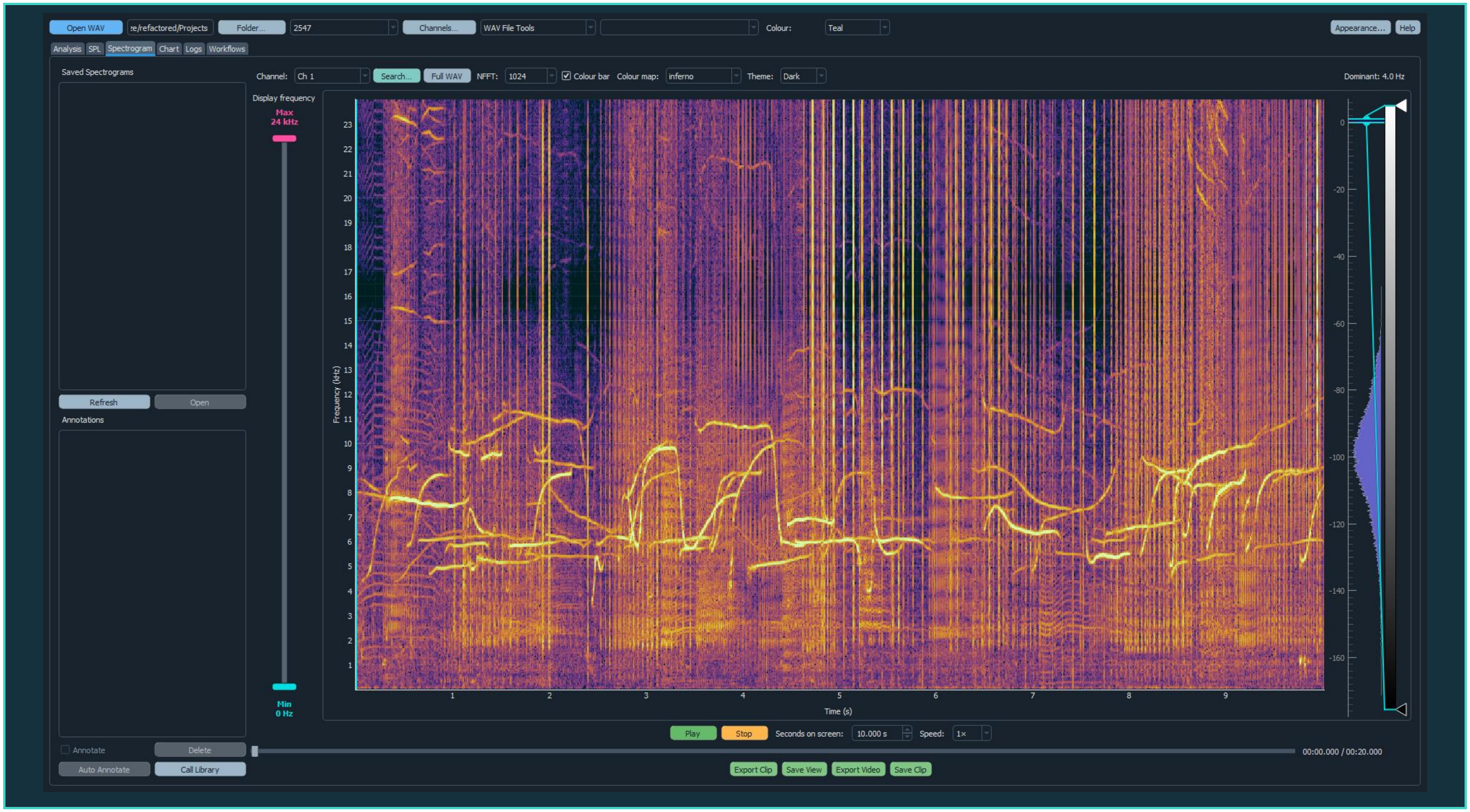


Figure 3. Ten-second NoiseMiner spectrogram showing tonal structure, transients, playback, frequency controls, and export actions.

Control / area	Purpose
Saved Spectrograms	Refresh and open saved spectrogram products for the active project.
Channel	Choose the source channel.
Search / Full WAV	Search with a saved profile or display the complete file. Full WAV also sets Seconds on screen to the complete recording duration.
NFFT	Set FFT length for the time-frequency display.
Colour bar / Colour map / Theme	Control the spectrogram presentation.
Frequency sliders	Set the displayed minimum and maximum frequency.
Playback controls	Play or stop, choose seconds on screen and playback speed, and scrub the timeline.
Annotations	Create, select, delete, auto-annotate, or inspect categorized events.
Call Library	Manage or use the installed call/event library.
Export Clip / Save View	Export audio for the chosen interval or save the displayed spectrogram view.
Export Video	Create a moving spectrogram video; FFmpeg is required.
Save Clip	Name and save the selected audio interval in the active project's clips folder.

Review and annotate

1. Choose the channel and generate Full WAV or run a saved Search profile.
2. Set the frequency limits and NFFT to suit the expected signal.
3. Use playback and the time scrollbar to localize the event.
4. Enable Annotate, mark the event region, and add the required label or note.

5. Save the view or export a clip when evidence is needed outside the database.

Performance: Large files, high NFFT settings, and video export require more memory and processing time. Narrow the time range when a full-file render is unnecessary.

8. Chart and map

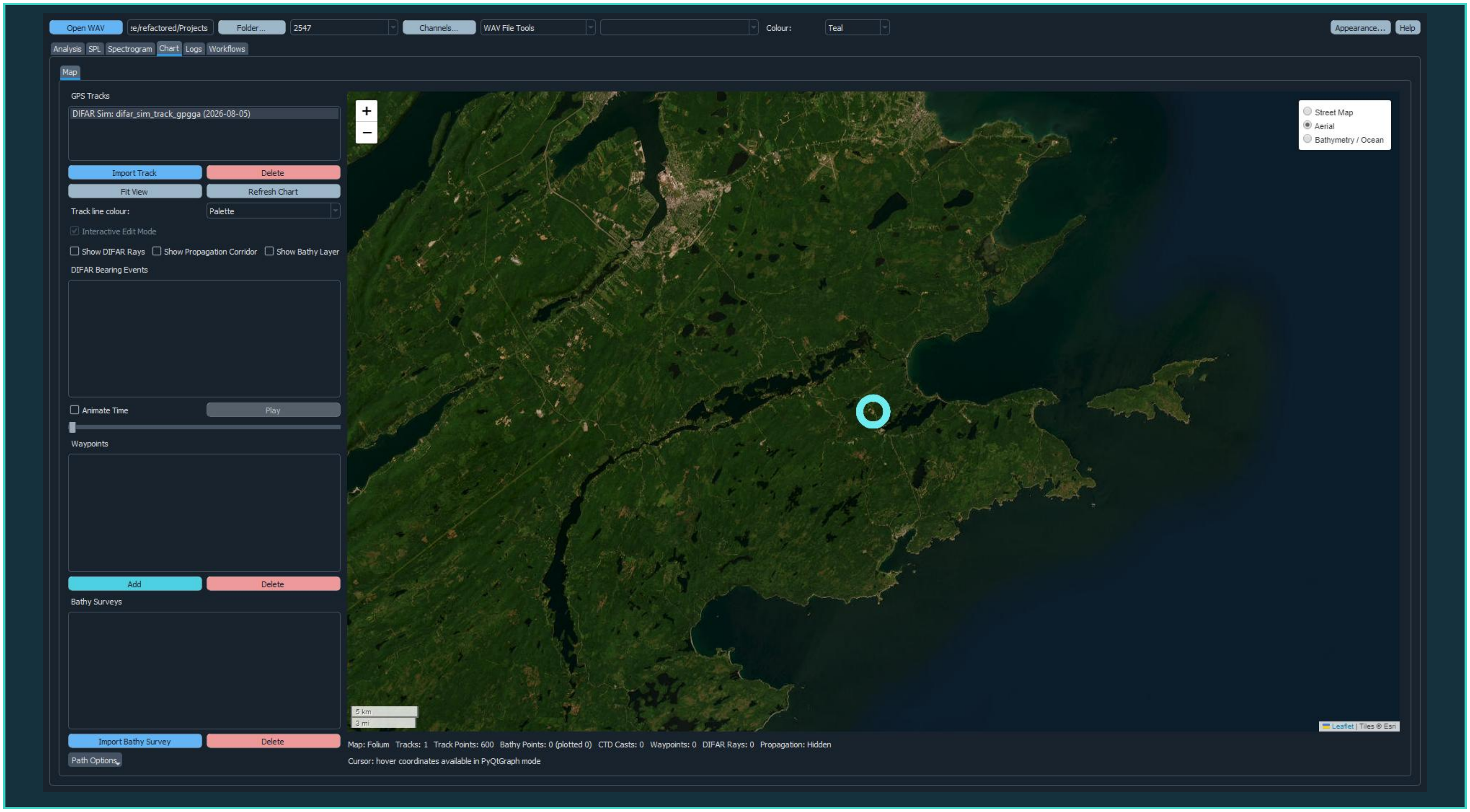


Figure 4. Chart workspace with a single fully rendered Aerial base map and an imported GPS track.

The Chart tab combines navigation and environmental context. Available layers include GPS tracks, DIFAR bearing rays, propagation corridors, bathymetry, waypoints, and CTD-derived information.

Control / area	Purpose

Control / area	Purpose
GPS Tracks	Import, delete, fit, refresh, recolour, and optionally edit loaded tracks.
Base map	Aerial is shown by default. Choose street, aerial, or bathymetry/ocean layers, and zoom or pan directly on the map.
DIFAR Bearing Events	Display mapped bearing events and toggle DIFAR rays.
Propagation corridor	Show modelled or configured spatial uncertainty/propagation corridors.
Animate Time	Play time-linked track data.
Waypoints	Add and delete points of interest.
Bathy Surveys	Import or delete bathymetry survey data.
Path Options	Configure path-related display or processing options.

Recommended map workflow

1. Import the GPS track using the format expected by the import dialog.
2. Choose Fit View and verify location, timestamp alignment, and coordinate interpretation.
3. Add DIFAR events, waypoints, bathymetry, or CTD information as required.
4. Use layer checkboxes to separate navigation, bearing, and environmental evidence.
5. Treat third-party base maps as context; retain the original track and survey files as authoritative data.

9. Logs and result management

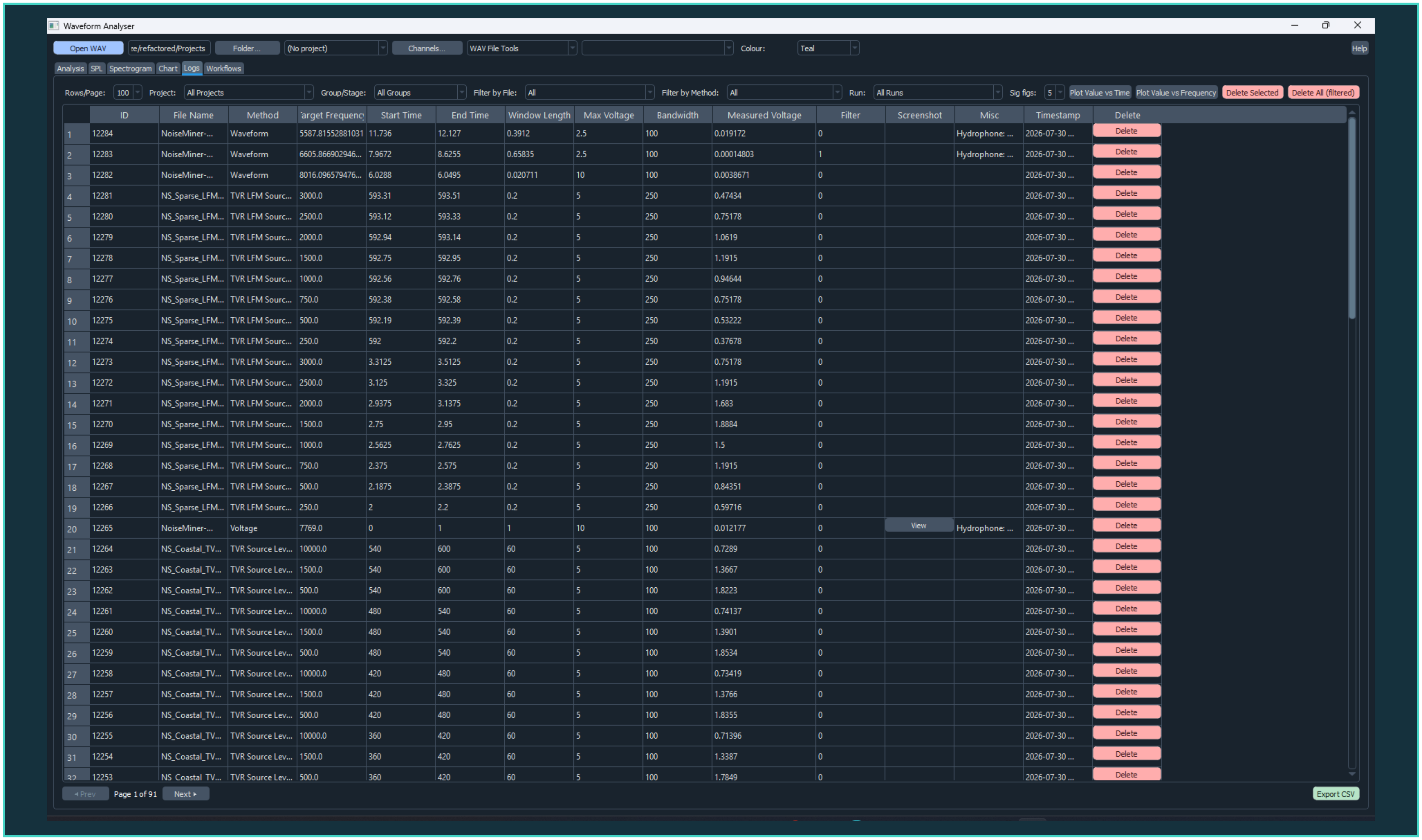


Figure 5. Voltage and analysis logs with filters, paging, plotting, screenshots, deletion, and export.

Logs is the audit trail for waveform, voltage, TVR, and other measurements. Each row records the method and measurement inputs alongside its result.

Control / area	Purpose
Rows/Page	Controls page size for large result sets.
Project / Group/Stage / File / Method / Run	Filters the visible records.
Sig figs	Changes displayed numeric precision without changing stored values.
Plots	Opens a maximized tabbed window containing Value vs Time and Value vs Frequency plots for the filtered or selected records.
Screenshot View	Opens the saved measurement screenshot when present.
Delete	Deletes an individual record.
Delete Selected / Delete All (filtered)	Deletes chosen rows or the entire filtered set.
Export CSV	Exports log data for external analysis or reporting.

Review checklist

- File and channel are correct.
- Method, target frequency, start/end time, and window length match the intended selection.
- Maximum voltage and bandwidth match the acquisition and analysis setup.
- Measured voltage is within a physically credible range.
- Filter state and miscellaneous calibration notes are present.
- A screenshot is retained for measurements that require visual traceability.

Deletion warning: Delete All (filtered) applies to every record matching the current filters. Re-check every filter and export a backup before confirming.

10. Workflows

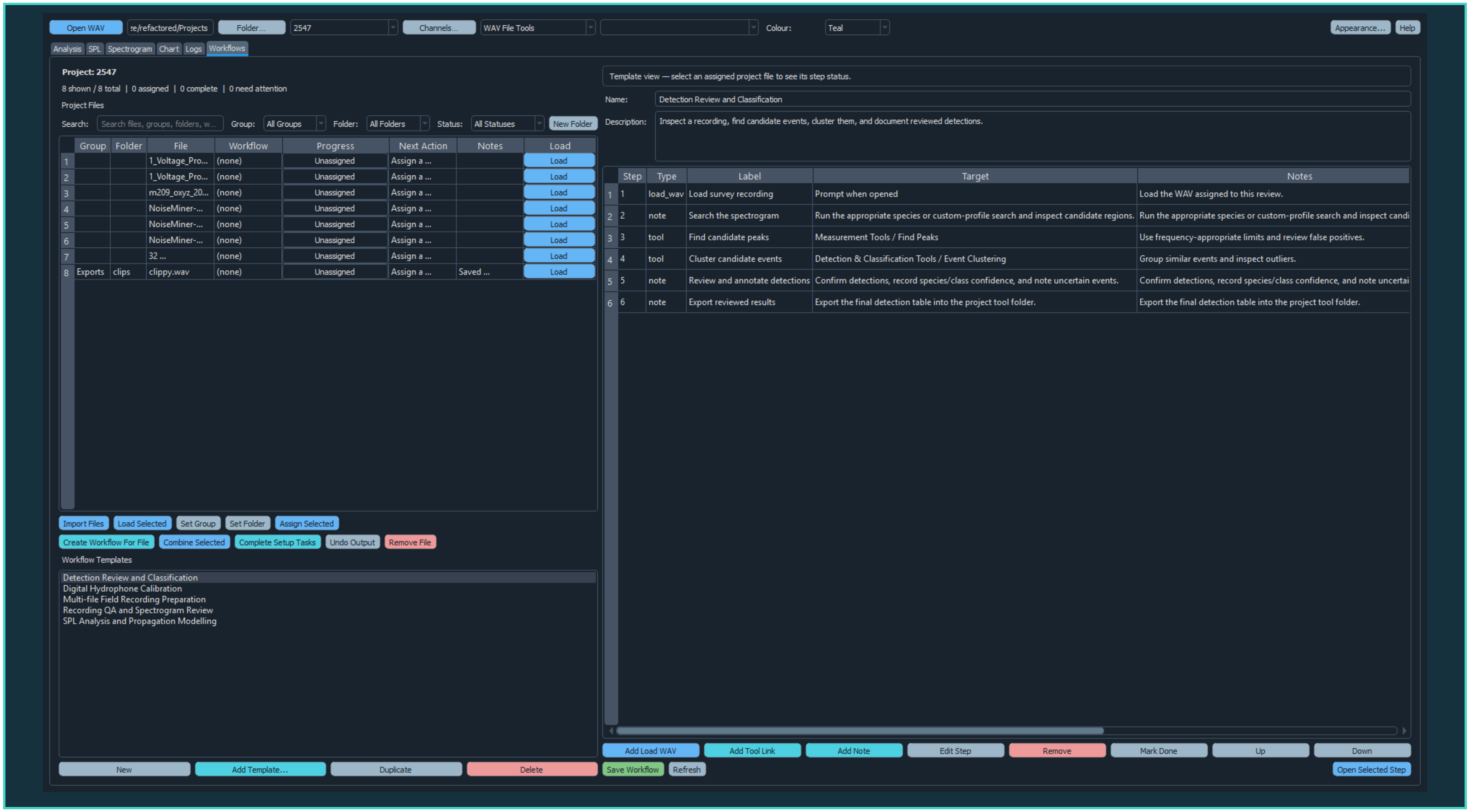


Figure 6. Populated project workspace with NoiseMiner files and the Detection Review and Classification workflow template.

Workflows turn a repeatable analysis process into named steps that can be assigned to project files. The left side organizes files and templates; the right side shows the selected file's steps, targets, notes, status, and active output.

Build and use a workflow

1. Select a project, then import files into the Project Files list.
2. Use Group, Folder, and New Folder to organize the project.
3. Choose Add Template, name the workflow, and add WAV, tool-link, or note steps.
4. Order steps with Up and Down; edit labels, targets, and notes.
5. Save the workflow and assign it to selected project files.
6. Load a file and open the next step. Complete setup tasks or mark a step done.
7. Use Create Workflow For File, Combine Selected, Undo Output, or Remove File only after confirming the selected items.

Control / area	Purpose
Progress / Next Action	Shows file-level completion and the next required step.
Add Load WAV	Creates a step that loads the required WAV or workflow output.
Add Tool Link	Creates a step that opens a particular analysis tool.
Add Note	Adds guidance or a checkpoint without launching a tool.
Complete Setup Tasks	Marks preparatory/setup steps complete where supported.
Undo Output	Reverts the tracked output association for the selected item.

11. Complete tool reference

Choose a category in the first toolbar list and a tool in the second. The selected tool opens a dialog or performs an action, then the tool list returns to no selection. Tools shown here are those enabled by the current customer profile; another licensed build may expose a different subset.

Before using a tool: Select the correct project, load the intended WAV where required, configure channels and calibration, and confirm the output location. Tools that change audio should create a derived file; retain the original recording.

11.1 WAV File Tools

These tools prepare, transform, combine, protect, or synchronize recordings. After every operation, verify the new file’s duration, sample rate, channel order, bit depth, amplitude, and timestamp relationship.

Control / area	Purpose
Trim File	Extract a chosen time range from the loaded WAV and save it as a new working file.
Denoise File	Preview an adjustable per-channel Wiener filter in aligned before/after spectrograms, then accept a denoised copy or decline without changing the source.
High/Low Pass Filter	Apply a high-pass, low-pass, or band-limiting filter using user-entered cutoff settings and save the filtered result.
Anti-Aliasing Filter	Apply a low-pass anti-alias filter before a sample-rate reduction or other operation that lowers the usable Nyquist frequency.
Recommend Sample Rate	Inspect the signal or chosen frequency limit and recommend a practical output sample rate with appropriate Nyquist margin.
Remove DC Offset	Estimate and remove the waveform’s DC bias, producing a centered derived file.
Normalise File	Scale the recording toward a selected peak or full-scale target while preserving relative waveform shape; check for clipping and document the gain.

Control / area	Purpose
Convert WAV Format	Convert the loaded WAV to PCM16, PCM24, PCM32, Float32, Float64, or unsigned PCM8 without changing its sample rate or channel count. PCM16 is the default.
Downsample Bit Depth	Convert the sample representation to a lower bit depth, with the selected conversion settings, and save a new WAV.
Split Multichannel to Mono	Export each selected channel of a multichannel WAV as a separate mono file with traceable channel naming.
Wav File Combine	Join compatible WAV files in sequence to create one continuous output; source format and ordering must be checked.
Stack WAV Channels	Combine separate compatible mono or multichannel files as parallel channels in one output WAV.
Scale WAV Amplitude	Multiply waveform amplitude by a specified factor or target level and save a scaled copy.
Create WAV Playlist	Build and save an ordered playlist of WAV files for managed review or playback without merging the source files.
Secure WAV Bundle (Pack/Unpack)	Package WAV material and associated metadata into a protected bundle, or unpack an authorized bundle. Retain required credentials and verify extracted hashes/files.
Channel Sync Tool	Estimate or apply inter-channel timing offsets so channels or separate recordings align to a common event or reference.

Audio processing record: For a derived file, record the parent file, tool, parameter values, software version, output filename, and validation result. Normalization, filtering, denoising, resampling, and synchronization can all change downstream measurements.

11.2 Measurement Tools

Measurement tools calculate acoustic or signal metrics and may save results to Logs, SPL, project folders, plots, or exported files. Review the tool dialog for channel, selection, frequency limits, calibration, averaging, and output choices.

Control / area	Purpose
Ambient Noise	Measure background-noise levels over a selected interval and frequency range, with calibration and summary output where configured.
Electrical Noise	Inspect mains-related tones, harmonics, and other narrowband electrical interference in the recording.
Peak Prominences Analysis	Find spectral peaks and quantify their prominence relative to the surrounding spectrum or local baseline.
Interval Analysis	Measure repeated events or time intervals and summarize spacing, timing, or interval-based signal metrics.
Depth Sounder Analysis	Identify and measure depth-sounder pulses or tonal returns using configured timing and frequency constraints.
Slope De-Clipper	Reconstruct or soften clipped waveform regions using neighboring slopes; save a derived file and validate it against the original.
Find Peaks	Detect candidate peaks within configured time, amplitude, distance, prominence, or frequency constraints.
Short-Time RMS	Calculate RMS over moving windows to show how signal level changes through time.
Crest Factor	Calculate peak-to-RMS ratio to characterize impulsiveness, clipping risk, or waveform dynamics.
Octave-Band Analysis	Calculate octave or fractional-octave band levels over a chosen interval and present band-by-band results.
SNR Estimator	Estimate signal-to-noise ratio from selected signal and noise regions or the tool’s configured estimator.
LFM Analysis	Analyze a linear-frequency-modulated pulse for timing, sweep limits, duration, level, and related pulse metrics.
LFM Batch Analysis	Apply LFM analysis across multiple pulses or files using common settings and export consolidated results.

Control / area	Purpose
HFM Analysis	Analyze a hyperbolic-frequency-modulated pulse and report sweep and timing characteristics.
Multi Frequency Analysis	Measure a set of specified frequencies from the same selection and compare their voltage or level results.
SPL Transmit Analysis	Convert calibrated transmit-recording measurements into SPL/source-level results and save them for plots or modelling.
Hydrophone Calibration	Create a hydrophone sensitivity curve from reference/projector TVR data and measured hydrophone and voltage-probe values.
Generate TVR Curve	Generate a projector Transmitting Voltage Response curve from measured acoustic and drive-voltage data.
Workflow Manager	Open the Workflows workspace to create templates, assign them to project files, and track step completion and derived outputs.
Duty Cycle Analysis	Calculate active versus inactive time for pulses or events over the selected observation period.
Exceedance Curves Lx	Calculate and plot statistical exceedance levels such as L10, L50, and L90 from a level time series.
LTSA + PSD Percentiles	Generate a long-term spectral average and percentile power spectral density summaries for long recordings.
SEL	Calculate Sound Exposure Level over selected events or intervals using the configured calibration and reference units.
Recurrence Periodicity	Estimate repeating-event periods and recurrence patterns from detected or measured event times.
Dominant Frequencies Over Time	Track the strongest frequency components through successive windows and plot or export their evolution.

Measurement interpretation: A measurement is only comparable when channel scaling, calibration curve, units, frequency range, windowing, averaging, filter state, and time selection are controlled. Review the saved log metadata before reporting results.

11.3 Modelling & Plotting Tools

These tools create reference curves, environmental scenarios, spatial inputs, or engineering calculations. Their outputs are model results, not direct observations; retain assumptions and input sources.

Control / area	Purpose
Wenz Curves	Plot empirical ocean ambient-noise reference curves and compare measured spectra with typical shipping, wind, thermal, and turbulence regimes.
Propagation Modelling	Model received level or detection range from stored SPL/source-level data across environmental, sea-state, bottom, frequency, and threshold scenarios.
Cable Loss & Hydro Sensitivity	Calculate or plot cable attenuation and its effect on effective hydrophone sensitivity over frequency.
Simulated GPS Track Generator	Create a synthetic timestamped GPS track for testing map, timing, DIFAR, or workflow behavior.

Model validation: Check units, geometry, sound speed, source level, frequency, absorption, bottom and surface assumptions, detection threshold, and any interpolation before using a model result operationally.

11.4 Detection & Classification Tools

These tools locate or group candidate acoustic events. Automated output requires analyst review; false positives, missed events, and class ambiguity should be recorded.

Control / area	Purpose

Control / area	Purpose
Active Sonar	Detect and analyze active-sonar transmissions or echoes, including timing, frequency, pulse, and range-related metrics where configured.
Cepstrum Analysis	Use the cepstrum to reveal periodic spectral spacing, echoes, harmonic structure, or repetition in a signal.
Event Clustering	Group detected events by their measured features to support review, outlier inspection, and candidate classification.
DIFAR Processing	Process directional sonobuoy channels to estimate bearings, review DIFARgrams, and save bearing events for mapping.

Analyst review: Treat detections and clusters as candidates until the waveform, spectrum/spectrogram, timing, channel quality, and contextual evidence have been reviewed.

11.5 Database Tools

Database tools export, filter, annotate, correct, or maintain stored results and calibration data. Back up the database before bulk correction, cleaning, or maintenance.

Control / area	Purpose
Export Logs to Excel	Export measurement and related log records to a structured Excel workbook for reporting or further analysis.
Filter Measurements	Build criteria for selecting measurement records by fields such as file, method, frequency, value, project, or metadata.
Filter Logs by Date/Time	Restrict log records to a chosen timestamp or recording-time range.
Database Maintenance	Run supported integrity, optimization, cleanup, or administrative operations on the Analyze database.

Control / area	Purpose
Clean Measurement Data	Identify and remove or correct invalid, duplicate, incomplete, or out-of-scope measurement rows using the dialog’s safeguards.
Annotate Measurements	Add or edit notes, labels, group/stage information, or other supported metadata on measurement records.
Annotate SPL	Add or edit annotations and project metadata associated with stored SPL calculations.
Calibration Curve Manager	Import, inspect, rename, export, or delete hydrophone sensitivity curves and their frequency coverage.
TVR Curve Manager	Manage projector Transmitting Voltage Response curves used by calibration and transmit-analysis workflows.
Measurement Voltage Correction	Apply a documented correction to selected stored voltage measurements and dependent metadata/results as supported by the dialog.
CTD Import	Import, inspect, save, export, and activate conductivity-temperature-depth profiles and derived sound-speed data.

Database safety: Export the affected records and back up the database before Clean Measurement Data, Database Maintenance, bulk annotations, voltage correction, or curve deletion. Recalculate dependent SPL results when an underlying voltage or calibration value changes.

11.6 Choosing the right tool

Control / area	Purpose
Prepare audio	Use WAV File Tools; always preserve and link the unmodified parent file.
Calculate a metric	Use Measurement Tools and review the saved units, calibration, and selection metadata.

Control / area	Purpose
Estimate a scenario	Use Modelling & Plotting Tools and retain every assumption and input source.
Find or classify events	Use Detection & Classification Tools, then perform analyst validation.
Manage stored results	Use Database Tools only after narrowing the selection and making a backup.

12. Detailed operator guide for every tool

This chapter expands every tool enabled in the current customer profile. Use the toolbar category selector, then the tool selector shown in Figure 1. Dialog wording may vary slightly by file state and licensed build. A step is unavailable when its required WAV, project, calibration, or database selection is missing.

How to use this chapter: Start with When to use, follow the numbered procedure, then read Method and underlying math before interpreting the output. Verification lists the minimum checks needed before a result is accepted or reported.

12.1 WAV File Tools

These procedures create or organize derived audio. Keep the source recording read-only, use traceable filenames, and retain every processing parameter.

12.1.1 Trim File

When to use: Use when only a defined time interval should be retained for review, sharing, or downstream analysis.

How to use: Follow these steps in order:

1. Load the source WAV and confirm the channel layout.
2. Open WAV File Tools > Trim File.
3. Enter the start time and either the end time or duration, then choose a derived-file destination.
4. Run the trim and open the result to confirm its boundaries.

Method and underlying math: For sample rate fs, time bounds are converted to sample indices n0 = round(t0 fs) and n1 = round(t1 fs). The output is x[n0:n1]; no interpolation is required when cuts fall on sample boundaries.

Verify before accepting: Confirm duration, first and last audible events, channel count, sample rate, bit depth, and retained metadata.

12.1.2 Denoise File

When to use: Use to create a Wiener-filtered working copy while visually comparing it with the unchanged source.

How to use: Follow these steps in order:

1. Load the WAV and open Denoise File.
2. In Review Denoise Result, choose the channel and preview start time.
3. Set the odd Wiener window in samples; smaller values retain brief detail, while larger values smooth more strongly.
4. Compare the aligned Before denoise and After denoise spectrograms, then choose Accept and Save Denoised WAV or Decline.

Method and underlying math: For each channel, the one-dimensional Wiener filter estimates local mean and variance over the selected sample window and suppresses deviations consistent with estimated noise. It is adaptive smoothing, not a learned species detector and not a user-selected noise-profile subtraction method.

Verify before accepting: Inspect transient loss, smearing, tonal changes, and level changes in the preview. Accept writes and loads a new _denoised.wav file; Decline leaves the source unchanged.

12.1.3 High/Low Pass Filter

When to use: Use to reject energy outside a documented frequency band before analysis or export.

How to use: Follow these steps in order:

1. Load the WAV and open the filter tool.
2. Choose high-pass, low-pass, or the available combined band option.
3. Enter cutoff frequency and supported order/settings; ensure cutoffs are below Nyquist.
4. Save a derived file and inspect its waveform and spectrum.

Method and underlying math: A digital filter applies y[n] = sum(bk x[n-k]) - sum(ak y[n-k]). Its frequency response H(e^jw) determines attenuation and phase. If zero-phase filtering is offered, forward and reverse filtering squares the magnitude response and cancels phase delay.

Verify before accepting: Confirm passband preservation, stopband attenuation, transient behavior at file ends, and whether phase-sensitive work permits the selected mode.

12.1.4 Anti-Aliasing Filter

When to use: Use immediately before reducing sample rate or whenever the new Nyquist frequency would be below existing signal energy.

How to use: Follow these steps in order:

1. Determine the intended output sample rate.
2. Set the low-pass edge below one-half of that rate with transition margin.
3. Apply the filter to a derived file.
4. Only then perform the resampling operation.

Method and underlying math: Sampling at fs can represent frequencies below fs/2. Components above the new Nyquist frequency fold to |f - k fs| after decimation. The anti-alias filter suppresses those components before samples are removed.

Verify before accepting: Inspect energy near the new Nyquist limit and confirm that wanted bandwidth was not unnecessarily removed.

12.1.5 Recommend Sample Rate

When to use: Use when selecting a smaller but defensible sample rate for storage or processing.

How to use: Follow these steps in order:

1. Load a representative file or enter the highest frequency that must be preserved.
2. Run the recommendation.
3. Review the proposed Nyquist margin and choose a supported standard rate.
4. Apply anti-alias filtering before any actual rate reduction.

Method and underlying math: Nyquist requires fs > 2 fmax. A practical recommendation adds transition-band margin, commonly fs >= 2 fmax/(normalized passband edge), then rounds upward to a supported rate.

Verify before accepting: Confirm the recommendation covers transients, harmonics, calibration bandwidth, and any later analyses—not only the dominant visible frequency.

12.1.6 Remove DC Offset

When to use: Use when the waveform is displaced above or below zero because of recorder or sensor bias.

How to use: Follow these steps in order:

1. Load the complete file or a representative stable interval.
2. Open Remove DC Offset and choose the required channels.
3. Run the operation to a new file.
4. Compare waveform centering and low-frequency spectrum.

Method and underlying math: The offset is usually the sample mean mu = (1/N) sum x[n]. The corrected signal is y[n] = x[n] - mu. Robust variants may use a median or slowly varying baseline.

Verify before accepting: The mean should be near zero afterward. Ensure genuine very-low-frequency content was not mistaken for bias.

12.1.7 Normalise File

When to use: Use to create a consistently scaled listening or processing copy when absolute recorded amplitude need not be preserved.

How to use: Follow these steps in order:

1. Choose peak or other supported normalization target.
2. Enter the target level with headroom.
3. Run to a derived file.
4. Check the resulting peak and document the applied gain.

Method and underlying math: For peak normalization, gain g = A_target / max(|x[n]|) and y[n] = g x[n]. In decibels, gain_dB = 20 log10(g). Normalization does not improve SNR.

Verify before accepting: Verify no clipping, preserve inter-channel ratios when required, and do not use the normalized file for absolute SPL unless the gain is carried into calibration.

12.1.8 Convert WAV Format

When to use: Use when a loaded WAV must be delivered or processed in a different PCM or floating-point sample encoding, such as Float32 to PCM16.

How to use: Follow these steps in order:

1. Load the source WAV and open WAV File Tools > Convert WAV Format.
2. Review the detected subtype, sample rate, and channel count.
3. Choose PCM16, PCM24, PCM32, Float32, Float64, or unsigned PCM8; edit the proposed output name if required.
4. Keep out-of-range normalisation enabled for PCM conversion unless clipping is intentionally required, then convert and inspect the derived WAV.

Method and underlying math: The converter reads normalised floating-point blocks and quantises them to the selected PCM subtype or writes the chosen floating-point subtype. It preserves sample rate and channel count. If floating-point magnitude exceeds 1.0, optional normalisation scales the peak to full scale before PCM quantisation.

Verify before accepting: Confirm output subtype, duration, channels, peak level, quantisation noise, and whether normalisation changed absolute calibration. The original is preserved and the output is stored in the project's wav_file_tools folder.

12.1.9 Downsample Bit Depth

When to use: Use to reduce storage or meet a delivery format after confirming the reduced quantization is adequate.

How to use: Follow these steps in order:

1. Select the destination bit depth and supported dither option.
2. Confirm that amplitude scaling is correct.

3. Export to a new WAV.
4. Compare quiet passages and the noise floor.

Method and underlying math: For B-bit signed PCM, the quantization step is approximately Delta = full-scale range / 2^B. Ideal quantization-noise SNR for a full-scale sine is about 6.02B + 1.76 dB. Dither decorrelates quantization error.

Verify before accepting: Check file format, clipping, low-level distortion, dither noise, and preservation of channel metadata.

12.1.10 Split Multichannel to Mono

When to use: Use when channels must be processed, reviewed, or delivered independently.

How to use: Follow these steps in order:

1. Load the multichannel WAV and inspect channel names/order.
2. Select the channels to export.
3. Choose an output folder and naming convention.
4. Run and open each mono result.

Method and underlying math: Splitting is an indexing operation: output channel k is yk[n] = x[n,k]. It should not change samples, rate, or timing.

Verify before accepting: Confirm every expected channel exists, lengths match, filenames identify source/channel, and no channel was swapped.

12.1.11 Wav File Combine

When to use: Use to concatenate sequential compatible recordings into one continuous timeline.

How to use: Follow these steps in order:

1. Add files in chronological order.
2. Resolve or reject sample-rate, channel-count, and sample-format mismatches.
3. Choose the output name and run the combine operation.
4. Inspect every join point.

Method and underlying math: Concatenation forms y = [x1, x2, ..., xM]. Duration is the sum of input durations. Discontinuities at joins can create clicks because the boundary step contains broadband energy.

Verify before accepting: Confirm order, total duration, timestamps, channel layout, and absence of gaps, overlaps, or boundary clicks.

12.1.12 Stack WAV Channels

When to use: Use to place synchronized recordings side by side as channels in a multichannel WAV.

How to use: Follow these steps in order:

1. Add source files and assign their channel order.
2. Confirm sample rates and time alignment.
3. Choose the length-handling rule if files differ.
4. Create the stack and inspect channel synchronization.

Method and underlying math: Stacking forms $y[n] = [x1[n], x2[n], \ldots, xK[n]]$. Files require a common sample grid; resampling or padding changes alignment and must be documented.

Verify before accepting: Confirm channel labels/order, equal sample rate, chosen padding/truncation behavior, and alignment against a shared event.

12.1.13 Scale WAV Amplitude

When to use: Use when a known linear or decibel gain must be applied to a derived file.

How to use: Follow these steps in order:

1. Select linear factor or dB mode.
2. Enter the gain and preview the predicted peak.
3. Save a scaled copy.
4. Record the exact gain in project notes.

Method and underlying math: Linear scaling is $y[n] = g\, x[n]$. For a voltage/amplitude gain specified in dB, $g = 10^{(gain\_dB/20)}$.

Verify before accepting: Check peak headroom, clipping count, channel consistency, and whether calibration metadata must be updated.

12.1.14 Create WAV Playlist

When to use: Use to define a repeatable playback/review order without modifying or merging source WAV files.

How to use: Follow these steps in order:

1. Add WAV files to the playlist.
2. Reorder and remove entries as needed.
3. Choose relative or supported stored paths and save the playlist.
4. Reopen it and test unavailable-file handling.

Method and underlying math: A playlist stores an ordered sequence of references; audio samples are unchanged. Total play time is the sum of item durations, subject to playback gaps or transition rules.

Verify before accepting: Confirm ordering, path portability, duplicate entries, and access to every referenced file.

12.1.15 Secure WAV Bundle (Pack/Unpack)

When to use: Use to package recordings and related metadata for controlled transfer or to open an authorized bundle.

How to use: Follow these steps in order:

1. For packing, add the permitted files and metadata, choose the destination, and enter the required protection credentials.
2. Create the bundle and retain credentials separately.
3. For unpacking, select the bundle, authenticate, and choose a safe empty destination.
4. Verify the extracted manifest and hashes.

Method and underlying math: Secure containers normally combine compression with authenticated encryption. Integrity is checked with a cryptographic digest or authentication tag; identical hash values indicate unchanged bytes but do not prove analytical validity.

Verify before accepting: Confirm authorization, manifest completeness, hash verification, destination free space, and that sensitive credentials are not stored with the bundle.

12.1.16 Channel Sync Tool

When to use: Use when channels or separate recorders have fixed or drifting time offsets that affect localization or comparison.

How to use: Follow these steps in order:

1. Choose a reference channel and channels to align.
2. Select a shared event or analysis interval.

3. Estimate offsets, review correlation peaks, and reject ambiguous matches.
4. Apply approved shifts to derived outputs and verify at multiple times.

Method and underlying math: Cross-correlation Rxy[k] = sum x[n]y[n+k] estimates delay at the lag k that maximizes similarity. Time offset is tau = k/fs. Drift requires offsets at multiple times and a fitted clock-rate correction.

Verify before accepting: Check correlation strength, polarity, residual delay, edge padding, drift, and whether sample-rate correction—not only a fixed shift—is needed.

12.2 Measurement Tools

These procedures calculate signal or acoustic quantities. Select and document channel scaling, calibration, units, time bounds, frequency bounds, windowing, and averaging before comparing results.

12.2.1 Ambient Noise

When to use: Use to quantify background acoustic level over a representative interval and band.

How to use: Follow these steps in order:

1. Select a noise-only time interval and calibrated channel.
2. Set frequency limits, windowing, and averaging.
3. Run the analysis and review spectra/statistics.
4. Save or export results with conditions and calibration.

Method and underlying math: Power spectral density estimates power per hertz. Band level is L = 10 log10(integral Sxx(f) df / pref^2); RMS pressure level is 20 log10(prms/pref). Averaging reduces estimator variance.

Verify before accepting: Reject intervals with transient contamination; verify units, reference pressure, calibration, bandwidth, and stationarity.

12.2.2 Electrical Noise

When to use: Use to diagnose mains hum, harmonics, switching tones, or recorder self-noise.

How to use: Follow these steps in order:

1. Choose an input channel and stable quiet interval.
2. Set mains frequency and analysis bandwidth where offered.
3. Run the spectral analysis.
4. Export the plot/data and compare harmonic families.

Method and underlying math: An FFT or PSD locates narrowband energy. Harmonics occur near k f0; levels may be expressed as dBV/sqrt(Hz) or calibrated pressure density. Window choice controls leakage.

Verify before accepting: Check 50/60 Hz selection, spectral resolution, window leakage, grounding context, and whether peaks are acoustic or electrical.

12.2.3 Peak Prominences Analysis

When to use: Use when meaningful spectral peaks must be separated from a sloping or noisy baseline.

How to use: Follow these steps in order:

1. Select the spectrum/time interval.
2. Set minimum prominence, distance, frequency range, and smoothing.
3. Run and inspect accepted/rejected peaks.
4. Export peak frequency, level, width, and prominence.

Method and underlying math: Prominence is the vertical difference between a peak and the higher of its surrounding bases before a higher peak is encountered. It is more robust than absolute height on changing baselines.

Verify before accepting: Confirm frequency resolution, baseline behavior, minimum separation, and that smoothing did not merge nearby tones.

12.2.4 Interval Analysis

When to use: Use to measure spacing, repetition, or timing statistics among detected events.

How to use: Follow these steps in order:

1. Select a channel and event-detection rule or imported event set.
2. Set thresholds and minimum/maximum interval.
3. Run the analysis and review marked events.
4. Export intervals and summary statistics.

Method and underlying math: For event times ti, intervals are Delta_i = t_(i+1)-t_i. Mean, median, standard deviation, coefficient of variation, and histograms describe regularity.

Verify before accepting: Inspect missed/double detections, edge events, clock accuracy, and whether the chosen event marker is consistent.

12.2.5 Depth Sounder Analysis

When to use: Use to detect and characterize periodic depth-sounder pulses or returns.

How to use: Follow these steps in order:

1. Select channel, time range, and expected frequency band.
2. Set pulse threshold, duration, and repetition constraints.
3. Run detection and review pulse overlays.
4. Export timing, frequency, and level metrics.

Method and underlying math: Band-limited energy or matched filtering identifies pulses. If a transmit-return delay is measured, one-way depth is approximately d = c tau/2, using sound speed c.

Verify before accepting: Validate pulse identity, sound speed, multipath, blanking time, false alarms, and whether delay represents two-way travel.

12.2.6 Slope De-Clipper

When to use: Use experimentally when clipped waveform peaks must be reconstructed for qualitative review.

How to use: Follow these steps in order:

1. Select clipped regions and conservative slope/model settings.
2. Preview reconstruction against neighboring unclipped samples.
3. Save only as a derived file.
4. Compare spectrum and peak metrics with the original.

Method and underlying math: Clipping replaces values beyond a limit with a constant. Reconstruction extrapolates from surrounding slopes or a fitted local model; lost information cannot be uniquely recovered.

Verify before accepting: Treat reconstructed peaks as estimates, mark modified intervals, and do not report them as directly measured amplitudes.

12.2.7 Find Peaks

When to use: Use for general-purpose detection of local maxima in a waveform, envelope, or spectrum.

How to use: Follow these steps in order:

1. Choose the data domain and analysis interval.
2. Set height, prominence, width, and minimum distance.
3. Run detection and inspect markers.
4. Save or export accepted peaks.

Method and underlying math: A local maximum exceeds neighboring samples. Additional constraints use prominence, full width at a chosen relative height, and minimum sample separation d = round(tmin fs).

Verify before accepting: Review threshold sensitivity, endpoint behavior, overlapping events, polarity, and sampling resolution.

12.2.8 Short-Time RMS

When to use: Use to track level changes through time without retaining waveform polarity.

How to use: Follow these steps in order:

1. Select channel and time range.
2. Choose window duration, hop/overlap, calibration, and optional band.
3. Calculate and inspect the time series.
4. Export values with window settings.

Method and underlying math: For a window of N samples, RMS[m] = sqrt((1/N) sum x_m[n]^2). Overlap controls time spacing, while window length trades time resolution for variance.

Verify before accepting: Confirm full-scale scaling, window/hop, edge handling, filter state, and whether linear averaging or dB conversion is appropriate.

12.2.9 Crest Factor

When to use: Use to quantify impulsiveness or available headroom relative to RMS level.

How to use: Follow these steps in order:

1. Choose channel and representative interval.
2. Run on unfiltered or documented filtered data.
3. Review peak, RMS, and crest factor together.
4. Compare only intervals with consistent settings.

Method and underlying math: Crest factor CF = max(|x|)/xrms; in dB, CFdB = 20 log10(CF). A sine has CF = sqrt(2), about 3.01 dB.

Verify before accepting: Check clipping, DC offset, isolated glitches, interval length, and whether absolute or percentile peak is used.

12.2.10 Octave-Band Analysis

When to use: Use when reporting energy in standardized octave or fractional-octave bands.

How to use: Follow these steps in order:

1. Select channel, interval, band fraction, and frequency range.
2. Choose calibration and averaging.
3. Run and inspect band levels.
4. Export band centers, limits, and levels.

Method and underlying math: For center fc and fraction b, band edges follow constant ratios (for example octave edges fc/sqrt(2) and fc sqrt(2)). Band power integrates PSD or filtered mean-square energy between edges.

Verify before accepting: Confirm standard/center-frequency convention, valid bands below Nyquist, filter class, reference units, and averaging method.

12.2.11 SNR Estimator

When to use: Use to compare a signal interval with representative background noise.

How to use: Follow these steps in order:

1. Select signal and noise regions with matching bandwidth.
2. Choose power or amplitude method.
3. Calculate SNR and inspect both component levels.
4. Save the intervals and estimator settings.

Method and underlying math: For uncorrelated powers, SNRdB = 10 log10(Ps/Pn). If the signal region contains signal plus noise, estimated signal power is max(Ptotal-Pn,0).

Verify before accepting: Ensure noise is representative, gains are unchanged, bandwidths match, and subtraction is not unstable when levels are close.

12.2.12 LFM Analysis

When to use: Use to measure a single linear-frequency-modulated chirp.

How to use: Follow these steps in order:

1. Select the pulse or search interval.
2. Enter expected start/end frequency, duration, and detection threshold.
3. Run and inspect the detected ridge or matched-filter peak.
4. Save timing, sweep, bandwidth, and level results.

Method and underlying math: An ideal LFM chirp has instantaneous frequency $f(t)=f0+kt$, with chirp rate $k=(f1-f0)/T$. Matched filtering correlates the recording with a reference chirp and compresses energy into a detection peak.

Verify before accepting: Confirm sweep direction, time-frequency resolution, Doppler, clipping, multipath, and that the selected pulse is isolated.

12.2.13 LFM Batch Analysis

When to use: Use to apply one validated LFM method to many pulses or files.

How to use: Follow these steps in order:

1. Validate settings on representative pulses first.
2. Select files/runs and common parameters.
3. Run the batch and monitor failures.
4. Review outliers before exporting consolidated results.

Method and underlying math: The per-pulse LFM calculations are unchanged; batch statistics summarize repeated estimates. Robust summaries such as median and MAD reduce sensitivity to outliers.

Verify before accepting: Check that files share calibration and signal type, inspect failed/edge cases, and retain batch settings and software version.

12.2.14 HFM Analysis

When to use: Use to measure a hyperbolic-frequency-modulated chirp, including Doppler-tolerant sonar signals.

How to use: Follow these steps in order:

1. Select a pulse and expected sweep bounds.
2. Set duration and detection constraints.
3. Run and inspect the time-frequency trace.

4. Save sweep, timing, and level metrics.

Method and underlying math: An HFM sweep is linear in reciprocal frequency: 1/f(t) changes approximately linearly with time. This produces a hyperbolic f(t) and different Doppler behavior from LFM.

Verify before accepting: Confirm the modulation model, sweep direction, parameter convention, Doppler/multipath effects, and calibration.

12.2.15 Multi Frequency Analysis

When to use: Use to compare voltage or SPL at several specified tones from the same interval.

How to use: Follow these steps in order:

1. Select channel and stable interval.
2. Enter target frequencies and bandwidths.
3. Choose FFT/PSD method and calibration.
4. Run, inspect, and export the frequency table.

Method and underlying math: Each target integrates or samples spectral energy around fi. RMS from a one-sided PSD uses x_rms,i = sqrt(integral_band_i Sxx(f)df); level conversion then uses 20 log10(x/ref).

Verify before accepting: Ensure bins/bands resolve adjacent tones, apply consistent bandwidth, and record leakage, window, and filter state.

12.2.16 SPL Transmit Analysis

When to use: Use to convert calibrated transmit measurements into source or sound-pressure levels for projector testing.

How to use: Follow these steps in order:

1. Select stored voltage/acoustic measurements and the correct TVR or hydrophone calibration.
2. Enter geometry and supported corrections.
3. Calculate and inspect intermediate values.
4. Save results with run and calibration identifiers.

Method and underlying math: Hydrophone pressure follows Lp = 20 log10(Vrms/Vref) - M, where M is sensitivity in dB re V/Pa (with consistent references). Source level may add transmission-loss or range normalization terms.

Verify before accepting: Verify sign/reference conventions, gain, frequency interpolation, range, near-field assumptions, and traceability to the raw voltage log.

12.2.17 Hydrophone Calibration

When to use: Use to derive hydrophone sensitivity from a known acoustic field or calibrated projector/reference sensor.

How to use: Follow these steps in order:

1. Select reference measurements, hydrophone voltage measurements, and frequency points.
2. Enter gains, distances, and reference/TVR data.
3. Generate and inspect the curve.
4. Name, save, and export the calibration with provenance.

Method and underlying math: Sensitivity M(f)=20 log10(Vhyd(f)/Pref(f)), commonly dB re 1 V/uPa. If pressure is inferred from projector source level, apply the propagation/range model before division.

Verify before accepting: Check units, polarity/sign convention, interpolation, reference validity, geometry, environmental conditions, uncertainty, and frequency coverage.

12.2.18 Generate TVR Curve

When to use: Use to derive projector transmitting-voltage response from measured pressure and drive voltage.

How to use: Follow these steps in order:

1. Select acoustic measurements and synchronized projector voltage data.
2. Enter range and supported propagation corrections.
3. Calculate TVR at each frequency.
4. Inspect, name, and store the curve.

Method and underlying math: TVR(f) is source level per drive voltage, typically TVR = SL(f) - 20 log10(Vdrive/1 V), with SL referenced to 1 m under the selected propagation convention.

Verify before accepting: Confirm RMS/peak convention, distance normalization, hydrophone calibration, amplifier/cable losses, near-field effects, and units.

12.2.19 Workflow Manager

When to use: Use to make a repeatable multi-file procedure with traceable status and outputs.

How to use: Follow these steps in order:

1. Create or select a project.
2. Build a template from load, tool-link, and note steps.
3. Assign it to files and complete steps in order.
4. Review status and linked outputs before marking complete.

Method and underlying math: This is process control rather than signal mathematics. A workflow is an ordered state machine: each file advances through defined steps, with status and output references stored as metadata.

Verify before accepting: Confirm active file/project, step parameters, output linkage, completion evidence, and safe behavior of undo/remove actions.

12.2.20 Duty Cycle Analysis

When to use: Use to measure the fraction of an observation period occupied by detected activity.

How to use: Follow these steps in order:

1. Choose a channel, interval, and event/activity threshold.
2. Set minimum event and gap durations.
3. Run and inspect the activity mask.
4. Export active time, observation time, and duty cycle.

Method and underlying math: Duty cycle $D = T_{active}/T_{observation}$, usually reported as $100D$ percent. Gap-merging and event thresholds determine T_{active}.

Verify before accepting: Review threshold sensitivity, merged events, excluded gaps, observation boundaries, and confidence intervals for short records.

12.2.21 Exceedance Curves Lx

When to use: Use to report statistical levels exceeded for a chosen percentage of time.

How to use: Follow these steps in order:

1. Select or calculate a calibrated level time series.
2. Set interval, averaging, and percentile convention.
3. Generate the exceedance curve.
4. Export Lx values and supporting distribution.

Method and underlying math: Sort levels in descending order and associate each with exceedance probability. L10 is exceeded 10% of the time; L50 is the median and L90 often represents background.

Verify before accepting: Confirm whether averaging occurred in linear energy or dB, sample weighting, missing values, stationarity, and the Lx convention.

12.2.22 LTSA + PSD Percentiles

When to use: Use for compact long-duration spectral summaries and frequency-dependent percentile levels.

How to use: Follow these steps in order:

1. Choose files, channels, frequency range, FFT length, segment duration, and averaging.
2. Run the long-term analysis.
3. Inspect the LTSA and percentile spectra.
4. Export images/data with complete settings.

Method and underlying math: Short-time PSDs $S_{xx}(f,t)$ are averaged into longer bins for the LTSA. At each frequency, percentile curves are quantiles of the PSD distribution across time.

Verify before accepting: Check units per hertz, window normalization, overlap, time-bin coverage, missing blocks, dynamic range, and computational load.

12.2.23 SEL

When to use: Use to quantify total acoustic energy of an event or observation interval.

How to use: Follow these steps in order:

1. Select calibrated channel and event bounds.
2. Choose band/filter and reference duration convention.
3. Calculate SEL and inspect the integration interval.
4. Save with event metadata.

Method and underlying math: SEL = 10 log10((1/(p0^2 t0)) integral p^2(t)dt), commonly with t0=1 s. For constant SPL over T seconds, SEL = SPL + 10 log10(T/t0).

Verify before accepting: Confirm pressure calibration, reference units, integration bounds, background treatment, clipping, and whether multiple events are summed in linear energy.

12.2.24 Recurrence Periodicity

When to use: Use to identify repeating patterns in event times or a level time series.

How to use: Follow these steps in order:

1. Choose detected events or a prepared time series.
2. Set period search range and tolerance.
3. Run autocorrelation/period analysis.
4. Inspect candidate periods and phase consistency.

Method and underlying math: Autocorrelation R[k]=sum x[n]x[n+k] reveals repeated lags. Event-time methods may histogram pairwise differences or evaluate phase concentration for trial periods.

Verify before accepting: Check harmonics/subharmonics, missing events, observation length, nonstationary rate, significance against random timing, and boundary effects.

12.2.25 Dominant Frequencies Over Time

When to use: Use to track changing tonal content or frequency trajectories.

How to use: Follow these steps in order:

1. Choose channel, interval, window/hop, frequency limits, and number of peaks.

2. Run the time-frequency analysis.
3. Inspect tracks and reject noise-floor peaks.
4. Export time, frequency, and level values.

Method and underlying math: An STFT X(m,f) is calculated for successive windows. Dominant frequencies are local maxima of |X| or PSD in each frame; optional tracking links peaks between frames by frequency/level proximity.

Verify before accepting: Balance time and frequency resolution, verify peak threshold and track continuity, and watch for harmonic switching and spectral leakage.

12.3 Modelling & Plotting Tools

These procedures estimate scenarios or engineering effects. Their outputs depend on assumptions and are not direct observations.

12.3.1 Wenz Curves

When to use: Use to compare measured ocean-noise spectra with classic environmental reference regimes.

How to use: Follow these steps in order:

1. Select a measured spectrum or create an empty reference plot.
2. Set sea state, shipping activity, frequency range, and display units.
3. Generate the curves and overlay compatible measured data.
4. Export the plot and inputs.

Method and underlying math: Wenz curves are empirical frequency-dependent approximations for turbulence, shipping, wind/waves, and thermal noise. Contributions in power add as Ltotal=10 log10(sum 10^(Li/10)), not by arithmetic dB addition.

Verify before accepting: Treat curves as broad references, confirm PSD units and one-hertz normalization, and do not infer site-specific conditions from a visual match alone.

12.3.2 Propagation Modelling

When to use: Use for scenario estimates of received level or detection range from source/SPL data.

How to use: Follow these steps in order:

1. Select source-level data and frequency.
2. Enter range grid, sound speed/environment, spreading, absorption, and threshold assumptions.
3. Run the model and inspect sensitivity to inputs.
4. Export results with every assumption.

Method and underlying math: The sonar balance is RL = SL - TL, with simple TL = N log10(r) + alpha r (N=20 spherical or 10 cylindrical, subject to units). Detection compares signal excess against noise, directivity, processing gain, and threshold.

Verify before accepting: Validate model domain, units, geometry, absorption, boundaries, bathymetry, near field, source directivity, and uncertainty. Model output is not a measurement.

12.3.2A Propagation Modelling: complete GUI breakdown

The maximized Propagation Modelling window combines source selection, environmental configuration, time alignment, plots, tabular output, and a map preview. Work from left to right across the top bar, configure the assumptions, then compute before exporting or interpreting a range.

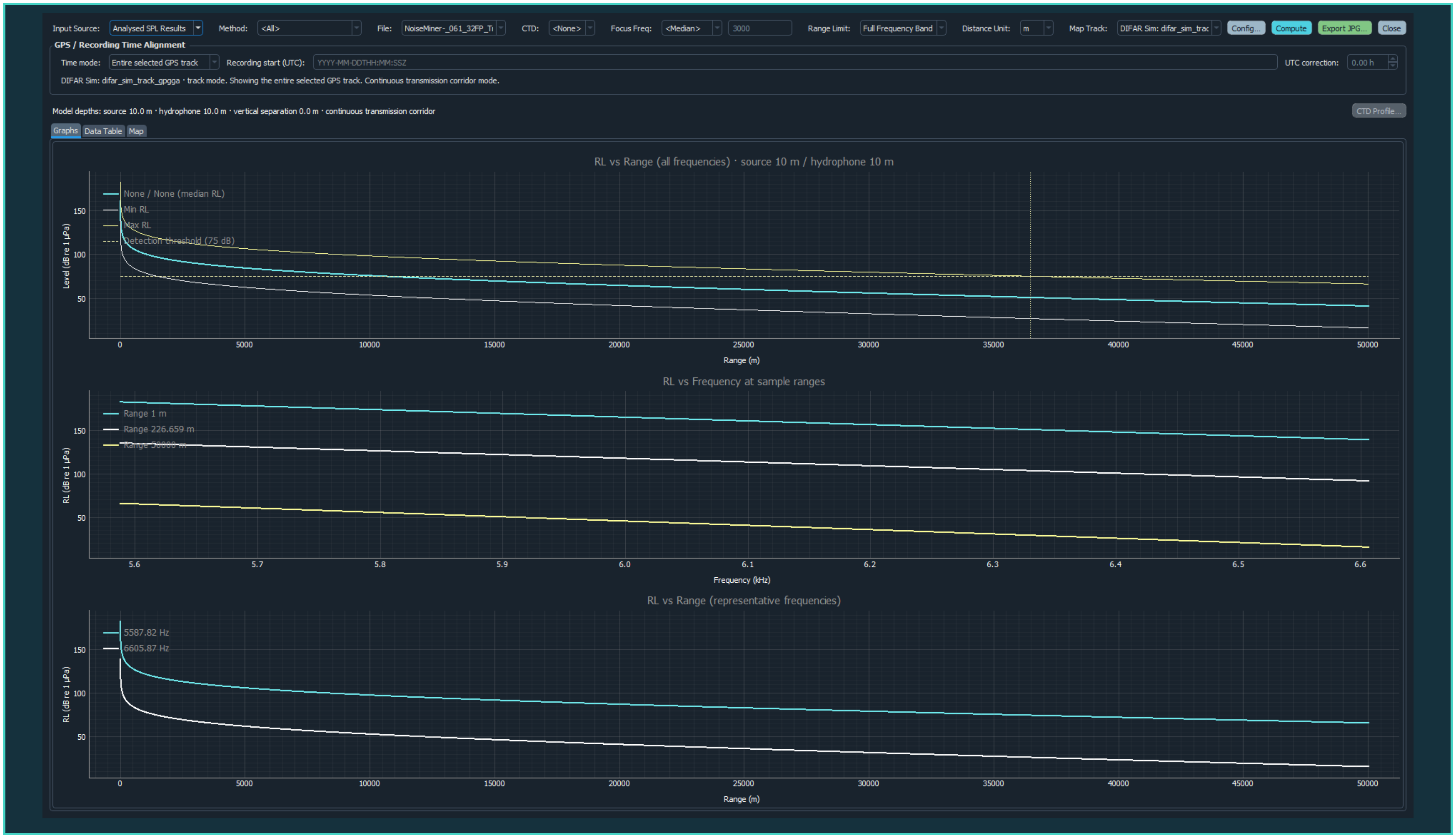


Figure 6. Computed NoiseMiner propagation results near 5.59 and 6.61 kHz, including receive-level curves, detection threshold, depth assumptions, and GPS-track alignment.

Top-bar controls: These controls define the input data and the way the result is displayed or positioned:

Control / area	Purpose
Input Source	Analysed SPL Results uses saved measurements; Frequency / SPL Table exposes a manual table for one or more frequency, level, and optional measurement-range rows.
Method	Filters saved SPL rows by analysis method. <All> includes every compatible method for the selected file.
File	Chooses the analysed recording whose SPL rows provide source levels, frequencies, measurement ranges, and timestamps.
CTD	Selects a stored conductivity-temperature-depth cast. It supplies sound-speed and depth-aware absorption information when supported.
Focus Freq	Uses the median frequency, a selected measured frequency, or a custom value for representative plots and focus-frequency range limits.
Range Limit	Full Frequency Band uses the combined band result; Focus Frequency bases the limiting detection range on the selected focus frequency.
Distance Unit	Changes displayed/exported distance units only; internal propagation ranges remain physically consistent.
Map Track	Auto matches the recording interval to a project GPS track; a named track forces that track; No map overlay computes without positioning a footprint.
Config	Opens the six-tab Propagation Configuration dialog described below.
Compute	Validates the inputs, calculates each selected environmental scenario, fills all result tabs, and prepares any Chart overlay.
Export JPG	Exports the current propagation graphs as a report image.
Close	Closes the modelling window; export required results first.

GPS / recording time alignment: Time mode selects metadata/filename recording time, the entire GPS track, or a manually entered UTC start. Recording start shows the resolved UTC time. UTC correction shifts detected time by the entered hours. The status line explains whether the file and track overlap; do not map a corridor until this check succeeds.

Result tabs: Graphs shows received level versus range, received level versus frequency at sample ranges, and representative-frequency range curves. Data Table lists scenario, sea state, bottom type, frequency, horizontal and slant range, received level, and Detectable status, with an environment filter and modelling-data export. Map plots the time-aligned GPS track and propagation footprint before it is sent to Chart.

12.3.2B Propagation Configuration options

Control / area	Purpose
Propagation - Range min/max/N	Defines the model grid. N is the number of evaluated range samples; more points improve curve resolution but increase output size and computation.
Propagation - Spreading model	Spherical uses 20 log10(r), cylindrical uses 10 log10(r), and hybrid changes from spherical to cylindrical at Hybrid r0.
Propagation - Absorption	None omits water absorption; Thorp uses an empirical frequency law; Francois-Garrison uses CTD-aware water properties where available.
Propagation - Depth mode	Deployed depths uses the entered source and hydrophone depths. CTD recommended depth uses the active cast recommendation. Fallback depth is used when the chosen absorption model lacks usable depth data.
Environment - Sea states	Selects one or more surface-loss scenarios. User dB/km supplies the custom surface-loss rate.
Environment - Bottom types	Selects one or more seabed-loss scenarios. User dB/km supplies a custom bottom-loss rate. None is exclusive.
Detection / Echo - Minimum RL	Shows the range at which the direct received level falls below the entered dB re 1 uPa threshold.
Detection / Echo - Simple bounce	Adds a single-bounce echo curve with the entered echo loss and optional echo detection threshold.

Control / area	Purpose
CTD Viewer	Controls thermocline shading and start/end lines in the CTD profile viewer; these are display aids, not extra loss terms.
Map / Time - Emission mapping	Automatic detects sparse pings; Continuous draws a corridor; Discrete creates timestamped ping footprints.
Ping grouping gap	Rows separated by no more than this interval are treated as one transmission.
Playback persistence	Controls how long a discrete ping footprint remains visible during Chart playback.
Points	Limits the run to selected SPL rows. With no selection, every compatible row is used.

Propagation math: For source level SL referenced to 1 m, direct received level is RL(f,r)=SL(f)-TL(f,r). Geometric loss is 20log10(r/rref) for spherical spreading or 10log10(r/rref) for cylindrical spreading. Hybrid spreading changes coefficient at r0 while preserving continuity. Absorption and selected surface/bottom rates add frequency- and distance-dependent loss. Slant range is sqrt(horizontal_range^2 + (source_depth-hydrophone_depth)^2). A point is Detectable when RL is at or above the configured minimum received level. Echo output applies the outward and return paths plus the configured echo loss; it is a simplified screening model, not a full ray tracer.

Interpretation limits: The result is only as valid as SL reference range, timestamp alignment, CTD applicability, spreading regime, bathymetry, surface/bottom approximations, depth, source directivity, receiver sensitivity, and detection threshold. Compare scenarios and report assumptions; do not present the maximum plotted range as a measured detection range.

12.3.3 Cable Loss & Hydro Sensitivity

When to use: Use to estimate how cable attenuation changes effective sensor sensitivity over frequency.

How to use: Follow these steps in order:

1. Load or enter cable parameters and hydrophone sensitivity.
2. Set length and frequency range.

3. Calculate attenuation and effective sensitivity.
4. Export the curve and component assumptions.

Method and underlying math: For transfer magnitude $|H_c(f)|$, cable loss is $20 \log_{10}|H_c|$ dB and effective sensitivity is $M_{eff}(f)=M_{hydro}(f)+20 \log_{10}|H_c(f)|$. RC loading depends on source impedance and cable capacitance.

Verify before accepting: Confirm impedance model, capacitance/length, preamplifier input, units, measured versus nominal parameters, and frequency validity.

12.3.4 Simulated GPS Track Generator

When to use: Use to create synthetic navigation data for testing maps, timing, DIFAR, and workflows—not operational navigation.

How to use: Follow these steps in order:

1. Choose start position/time, duration, speed, heading, sample interval, and track pattern.
2. Generate and preview the track.
3. Export the supported NMEA/debug files.
4. Import the result into Chart and verify timing.

Method and underlying math: Position advances from speed and elapsed time along geodesic bearings; small offsets may use local latitude/longitude approximations, while distance checks use a haversine or spherical-Earth relation.

Verify before accepting: Confirm UTC timestamps, latitude/longitude sign, NMEA checksum, sampling interval, physically plausible speed/turn rate, and clearly label the track as simulated.

12.4 Detection & Classification Tools

These procedures generate candidate events, bearings, or groups. Analyst review of the waveform, spectrum, spectrogram, and context remains mandatory.

12.4.1 Active Sonar

When to use: Use to detect and measure active-sonar transmissions and echoes, including optional range/bearing products.

How to use: Follow these steps in order:

1. Select channels and expected pulse type/band.
2. Configure waveform, duration, repetition, threshold, and array/geometry inputs.
3. Run detection and inspect matched-filter/time-frequency evidence.
4. Review each accepted echo before exporting results.

Method and underlying math: Matched filtering computes y(t)=integral x(tau)s*(tau-t)d tau. Delay gives range r=c tau/2 for monostatic two-way travel. Array phase/time differences can estimate bearing; Doppler relates frequency shift to radial velocity.

Verify before accepting: Validate sound speed, transmit reference, multipath, sidelobes, false alarms, array geometry, synchronization, near field, and detection threshold.

12.4.2 Cepstrum Analysis

When to use: Use to reveal echoes, periodic harmonic spacing, or repetition hidden in a spectrum.

How to use: Follow these steps in order:

1. Select a stable interval and frequency range.
2. Choose real/power cepstrum settings and liftering if available.
3. Run and inspect quefrency peaks.
4. Relate candidate peaks back to waveform/spectrum evidence.

Method and underlying math: The real cepstrum is c(tau)=IFFT(log|FFT(x)|). Periodic spectral spacing produces peaks at corresponding quefrency; an echo delay can also appear as a cepstral peak.

Verify before accepting: Avoid log-of-zero problems, check windowing and dynamic range, distinguish pitch period from echo delay, and confirm findings in another domain.

12.4.3 Event Clustering

When to use: Use to group already detected events by measured features for review and candidate classification.

How to use: Follow these steps in order:

1. Select an event set and features.
2. Choose scaling, cluster method, cluster count or density parameters.
3. Run and inspect plots/outliers.
4. Assign human-reviewed labels only after listening and visual inspection.

Method and underlying math: Clustering operates on feature vectors. Distance-based methods require scaling; k-means minimizes within-cluster squared distance, while density methods group points with sufficient local neighbors and identify noise/outliers.

Verify before accepting: Check missing data, feature scaling, sensitivity to parameters, class imbalance, cluster stability, and never equate an unsupervised cluster with a biological/operational class automatically.

12.4.4 DIFAR Processing

When to use: Use with compatible directional sonobuoy channels to estimate acoustic bearings and create mapped bearing events.

How to use: Follow these steps in order:

1. Load and identify omni/cosine/sine channels and calibration/orientation.
2. Select the event/time-frequency region.
3. Run DIFAR processing and inspect the DIFARgram/bearing ambiguity.
4. Save only reviewed bearings, then display them on Chart.

Method and underlying math: Directional channels encode orthogonal components. Bearing is estimated from vector components, commonly theta=atan2(Y,X), with energy/coherence weighting across selected time-frequency bins. Compass/orientation corrections rotate the result.

Verify before accepting: Confirm channel order/polarity, magnetic-versus-true reference, calibration, array orientation, coherence, left-right ambiguity, platform motion, and mapped timestamp.

12.4.4A DIFAR Processing: complete GUI breakdown

DIFAR Processing converts calibrated OMNI and orthogonal particle-velocity channels into time-varying bearing estimates. The left side defines the run and map behavior; the right side displays the selected pressure and velocity calibration curves.

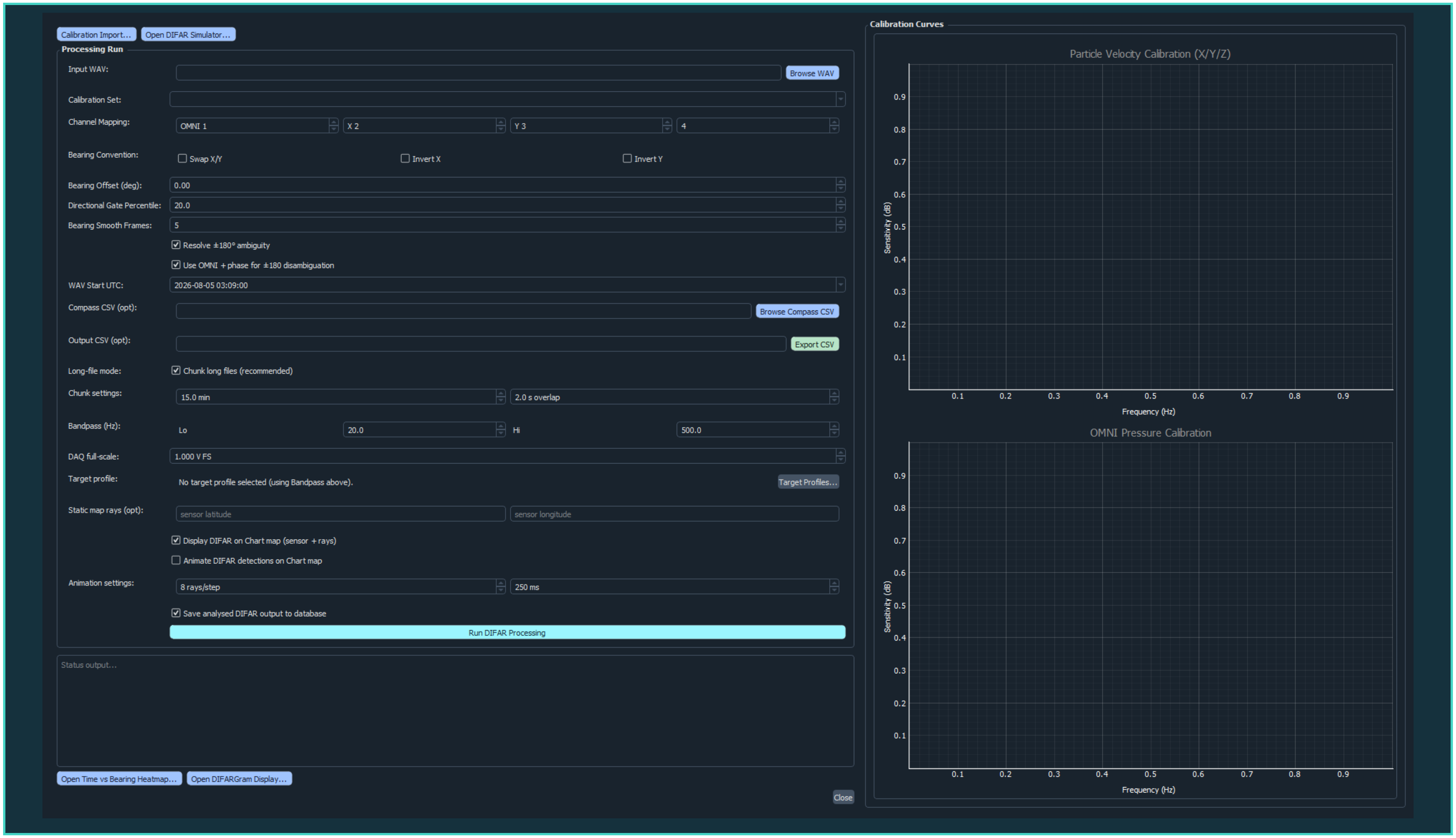


Figure 7. DIFAR Processing window with processing, calibration, mapping, chunking, and review controls.

Control / area	Purpose

Control / area	Purpose
Calibration Import	Imports a named CSV/TSV calibration set for OMNI pressure and X/Y/Z particle-velocity sensitivity versus frequency.
Open DIFAR Simulator	Opens the synthetic-data generator described in the next section.
Input WAV	Uses the loaded WAV or a browsed multichannel file. Confirm sample rate, channel count, and acquisition full-scale.
Calibration Set	Applies the selected sensor calibration and plots its curves at right. Do not extrapolate outside supported frequency coverage.
Channel Mapping	Assigns OMNI, X, Y, and optional Z channel numbers. Z=unused performs horizontal-bearing processing only.
Swap X/Y; Invert X/Y	Corrects recorder wiring or axis conventions before bearing calculation. Each change rotates or mirrors the result; document it.
Bearing Offset	Adds a constant orientation/installation correction in degrees after the vector bearing is calculated.
Directional Gate Percentile	Rejects low directional-energy frames relative to the run distribution; higher values retain fewer, stronger frames.
Bearing Smooth Frames	Applies temporal smoothing over the requested number of bearing frames. Large values suppress jitter but smear turns and short events.
Resolve +/-180 ambiguity	Enables the selected disambiguation logic instead of leaving the axial bearing pair.
Use OMNI + phase	Uses pressure/vector phase relationship to choose between opposite directions when calibration and signal coherence permit.
WAV Start UTC	Defines the time origin for saved detections, compass lookup, and Chart animation.

Control / area	Purpose
Compass CSV	Optionally supplies timestamped heading. Matching headings rotate sensor-relative bearings to the required geographic convention.
Output CSV	Sets an optional detailed bearing-result export path.
Chunk long files	Processes long WAVs in bounded blocks. Chunk length controls memory/work size; overlap protects events and smoothing at boundaries.
Bandpass Lo / Hi	Limits the frequencies contributing to the directional estimate unless a target profile supplies the active band.
DAQ full-scale	Physical volts represented by digital full scale. Incorrect scaling biases calibrated pressure and velocity levels.
Target Profiles	Creates/selects reusable frequency-band and target settings; the summary shows whether the profile overrides the manual bandpass.
Static map rays	Latitude and longitude locate the sensor when no other positioned context is available.
Display on Chart	Publishes reviewed sensor and bearing rays to the project Chart.
Animate detections	Plays bearings in time order. Rays/step controls batch size and milliseconds controls refresh interval.
Save to database	Stores the analysed run and bearing output for heatmap, DIFARGram, comparison, and map recall.
Run DIFAR Processing	Validates inputs, calibrates channels, estimates bearings/confidence, saves selected outputs, and updates the status area.
Time vs Bearing Heatmap	Bins saved bearings by time and angle; options include run, time bins, bearing bins, count/confidence weighting, playback, and JPG export.
DIFARGram Display	Reviews a selected time window with NFFT, frequency limits, colormap, smoothing mode/window, and export controls.

DIFAR math: After calibration, the horizontal vector components X(f,t) and Y(f,t) form the directional vector. A basic bearing is theta=atan2(Y,X), converted to degrees and wrapped to 0-360. Swap/invert controls transform the axes before atan2; the bearing offset and compass heading then rotate the result. Directional magnitude is proportional to sqrt(X^2+Y^2). Confidence/gating uses directional energy and pressure-vector consistency across the selected time-frequency bins. OMNI/vector phase can distinguish theta from theta+180 degrees, but only when polarity, phase calibration, coherence, and SNR are reliable. Circular smoothing must average unit vectors, not ordinary degree values, to behave correctly across 0/360 degrees.

Required review: Check channel order and polarity with a known bearing, calibration coverage, frequency band, UTC and compass reference, magnetic versus true north, ambiguity decisions, chunk boundaries, low-confidence frames, platform motion, and map position before saving operational bearings.

12.4.4B DIFAR Simulator: purpose and window layout

The DIFAR Synthetic Generator creates controlled multichannel WAV data, a timestamped GPGGA track, truth/debug data, and metadata for testing the processing chain. The right pane always shows true/processed track, range, and bearing; the left pane is divided into Setup, Motion, Source, Effects, and Output tabs.

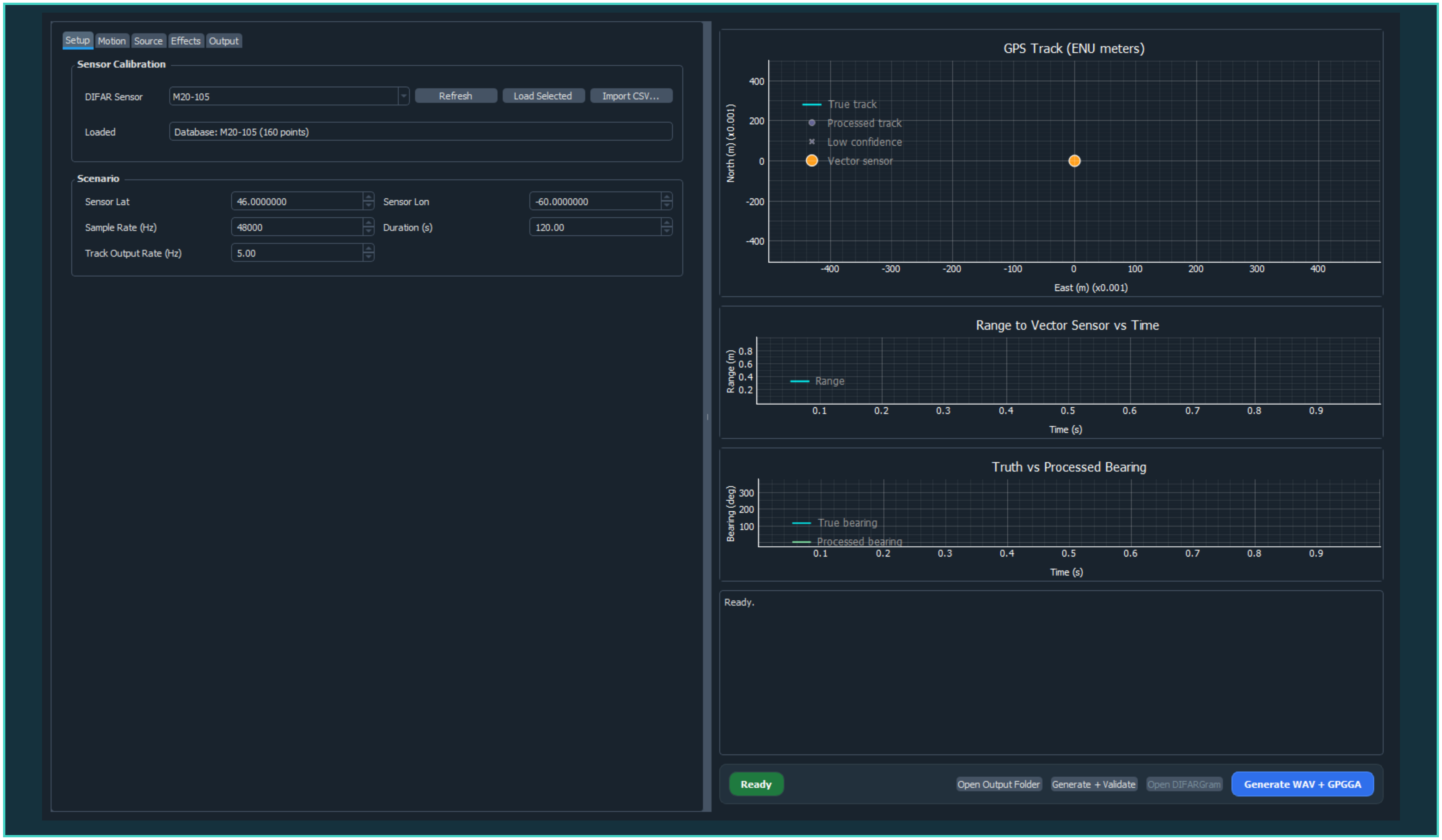


Figure 8. DIFAR Simulator Setup tab: sensor calibration and scenario timing/location.

Control / area	Purpose
DIFAR Sensor	Selects a calibration stored in the active database. Refresh reloads the list; Load Selected activates it; Import CSV adds a calibration file. Loaded identifies the active set.

Control / area	Purpose
Sensor Lat/Lon	Sets the vector sensor position used to convert simulated ENU motion into geographic GPGGA coordinates.
Sample Rate	Sets WAV samples per second. It must exceed twice the highest generated frequency with practical anti-alias margin.
Duration	Sets the total scenario and WAV length.
Track Output Rate	Sets how often truth/GPGGA positions are written; it does not change the audio sample rate.

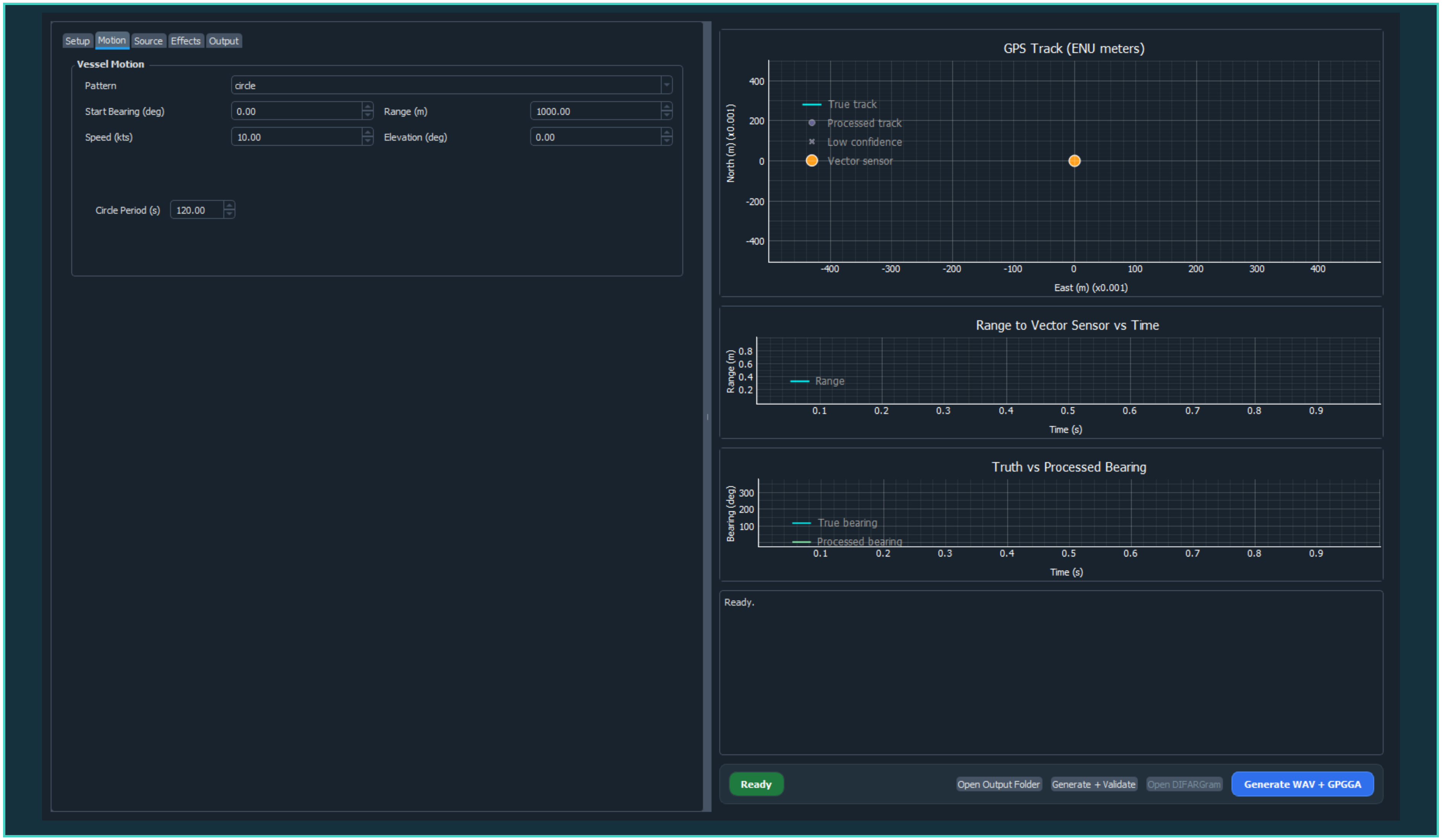


Figure 9. DIFAR Simulator Motion tab and live truth/processed plots.

Control / area	Purpose
Pattern	circle, back_forth, straight_pass, racetrack, spiral, approach, or recede.

Control / area	Purpose
Start Bearing / Range / Speed	Defines initial geometry and target speed. For straight_pass, Range is closest approach; approach/recede use radial speed.
Elevation	Adds source elevation for 3-D vector response when Z is used.
Circle	Circle Period controls one revolution at the selected range.
Back/forth	Swing is angular excursion and Rate is oscillations per second.
Racetrack	Long/Short define track dimensions; centre East/North offsets position it relative to the sensor.
Spiral	Start/end ranges and Revolutions control the radial change and total turns.

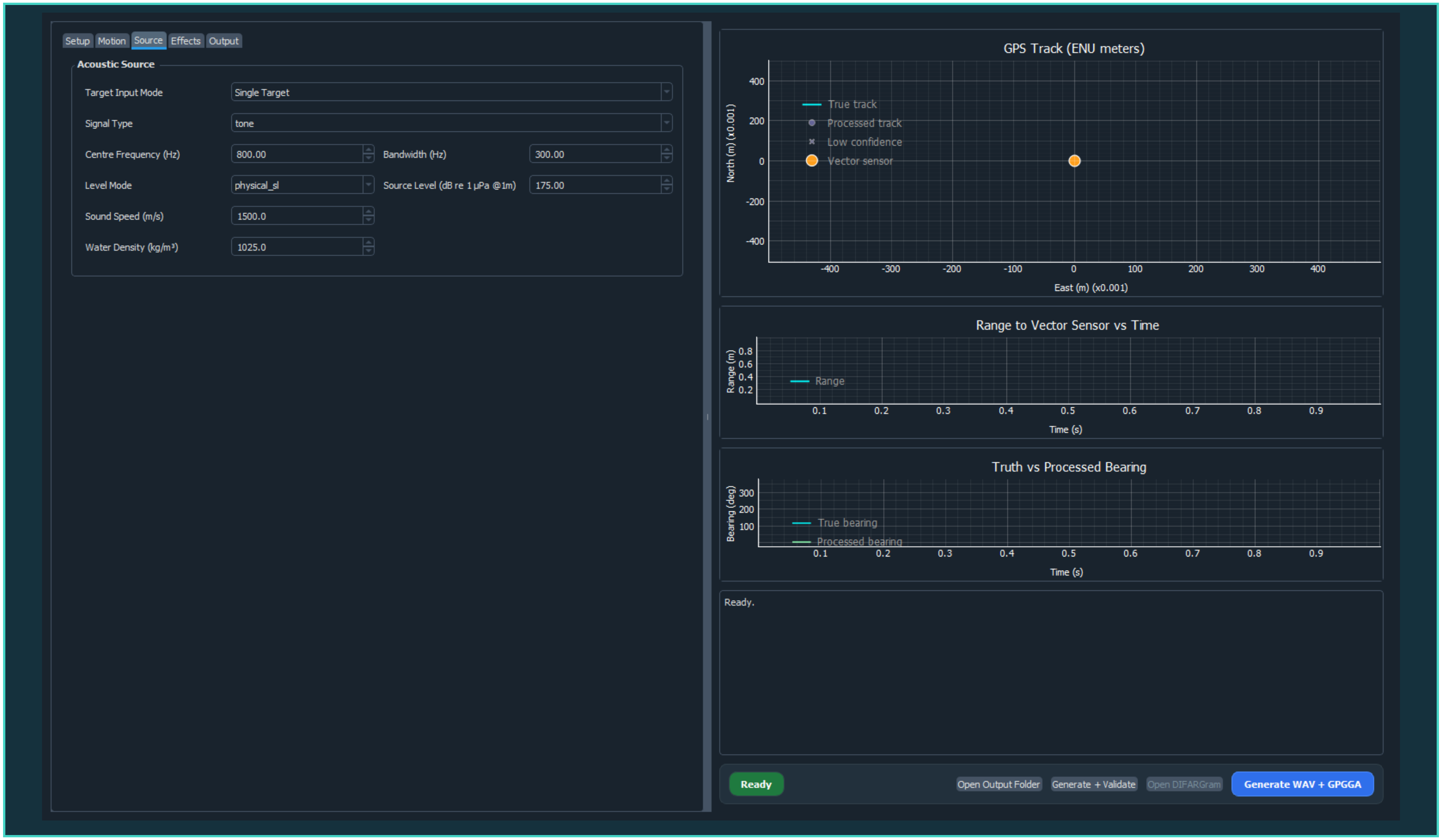


Figure 10. DIFAR Simulator Source tab: signal, level, propagation, and target controls.

Control / area	Purpose
Target Input Mode	Single Target uses the visible source and motion settings. Multi-Target Queue schedules separate targets with individual gap, duration, geometry, speed, frequency, level, signal type, bandwidth, and elevation.

Control / area	Purpose
Signal Type	tone creates a sinusoid; am_tone amplitude-modulates it; band_noise creates band-limited noise; vessel_noise creates a broadband, coloured vessel-like source.
Centre Frequency / Bandwidth	Sets tone centre or noise-band placement and width.
Level Mode	physical_sl propagates Source Level from 1 m; constant_received_level forces the entered receiver level independent of range for calibration tests.
Source Level / Constant RL	Sets dB re 1 uPa @1 m or dB re 1 uPa at the receiver according to Level Mode.
Sound Speed	Controls travel delay and Doppler conversion.
Water Density	Used when converting between acoustic pressure and particle velocity.
Target Queue	Add Target appends the entered specification; Remove Selected and Clear Queue edit the schedule. Gap Before offsets each target start.

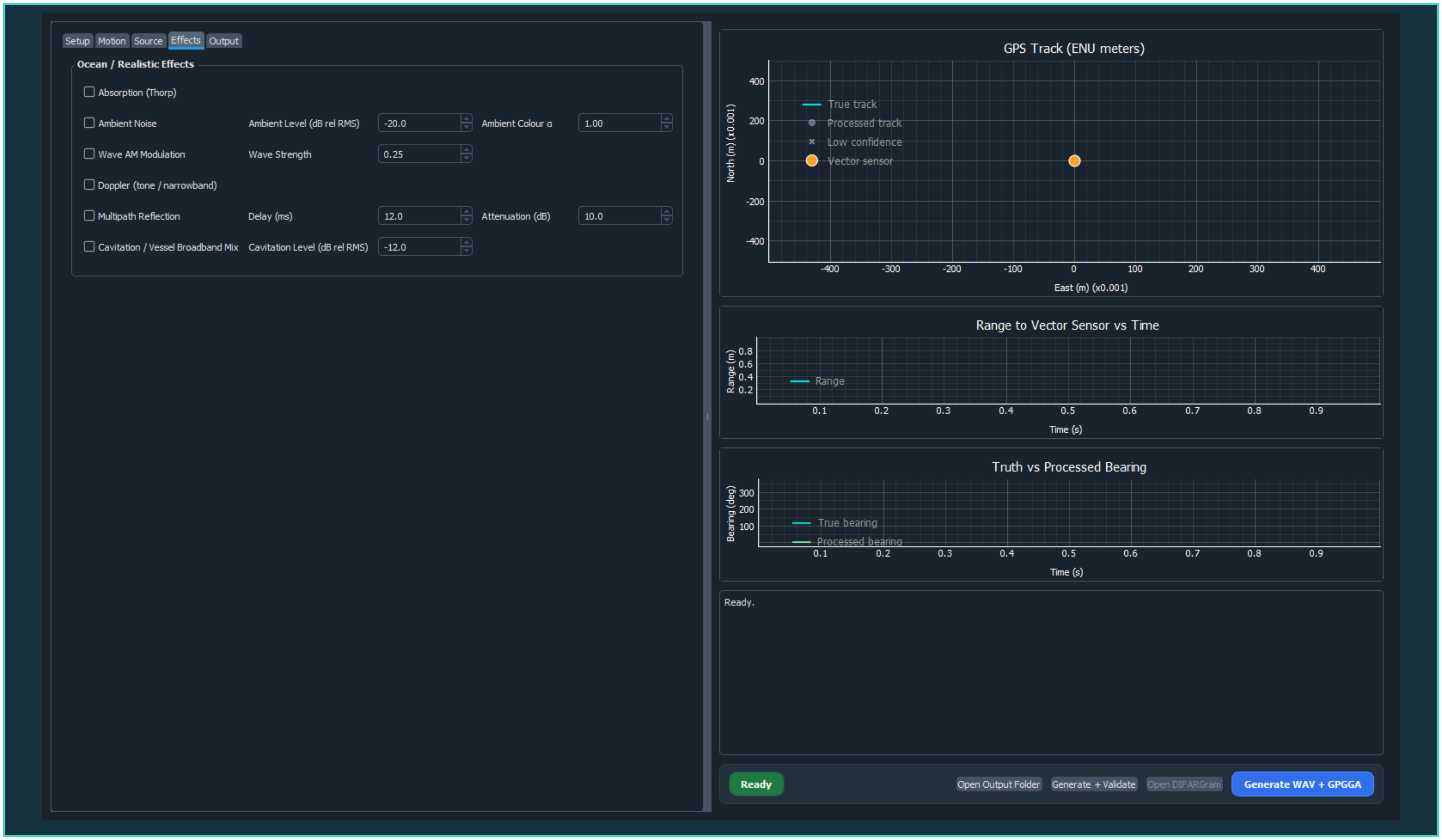


Figure 11. DIFAR Simulator Effects tab: optional propagation and realism controls.

Control / area	Purpose
Absorption (Thorp)	Adds frequency-dependent seawater absorption to spherical transmission loss.

Control / area	Purpose
Ambient Noise	Adds coloured noise at the selected level relative to RMS; alpha controls spectral colour (approximately 0 white, 1 pink, 2 brown).
Wave AM Modulation	Applies slow random amplitude variation; Strength sets modulation depth.
Doppler	Changes narrowband instantaneous frequency using radial velocity and sound speed.
Multipath Reflection	Adds a delayed copy. Delay sets arrival separation in milliseconds and Attenuation sets reflection loss.
Cavitation/Vessel Mix	Adds broadband vessel/cavitation energy at the chosen relative RMS level.

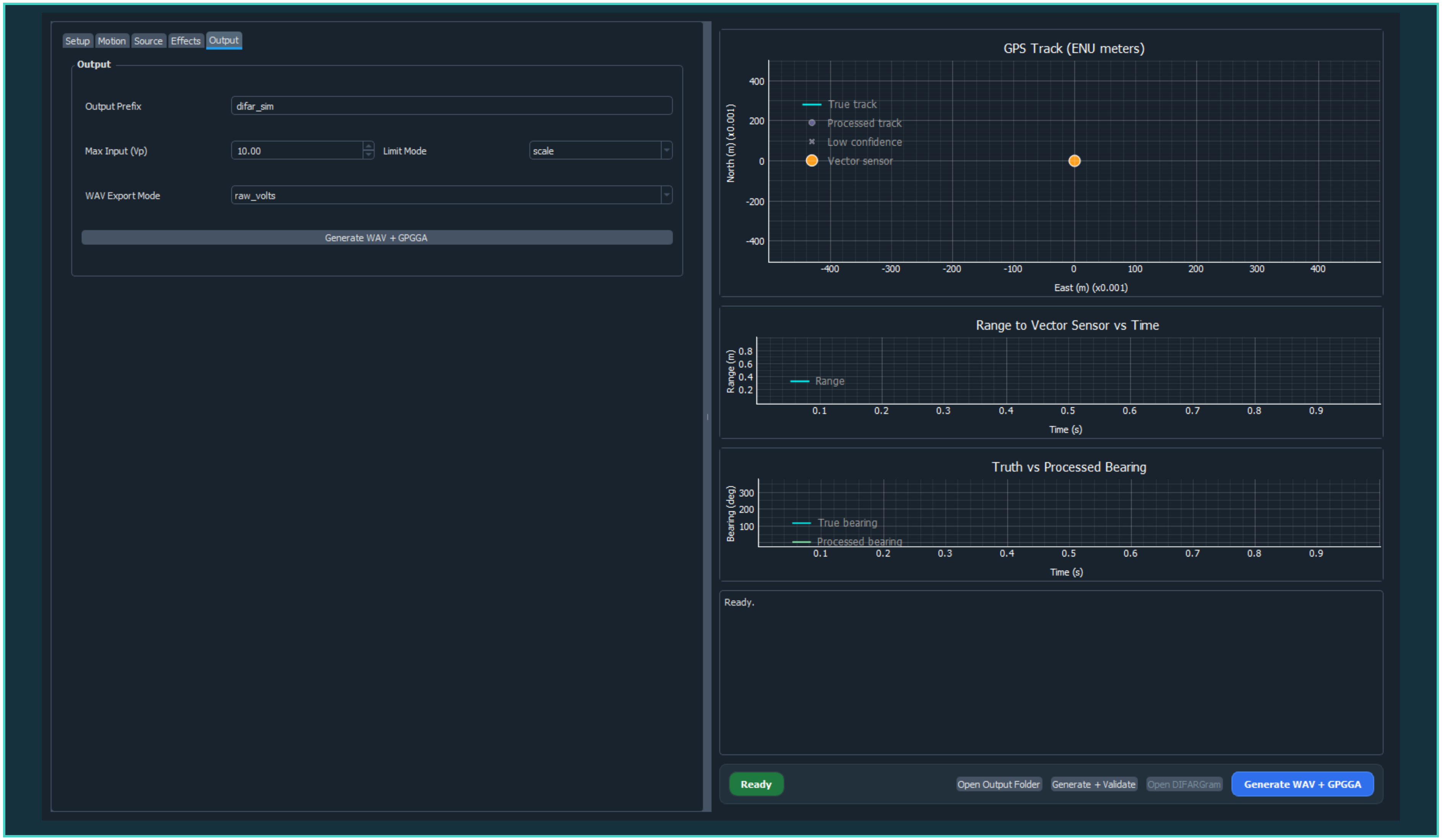


Figure 12. DIFAR Simulator Output tab and generation/validation actions.

Control / area	Purpose
Output Prefix	Base path/name for WAV, GPGGA, metadata, truth/debug, and validation products.

Control / area	Purpose
Max Input (Vp)	Maximum peak voltage permitted in the generated acquisition channels.
Limit Mode	scale reduces the whole multichannel signal consistently; clip hard-limits peaks and intentionally introduces distortion.
WAV Export Mode	raw_volts preserves simulated physical voltage; normalize_to_full_scale maps the limited peak to digital full scale.
Generate WAV + GPGGA	Creates audio and track outputs with metadata.
Generate + Validate	Generates, runs the validation processor, and overlays truth and processed bearings/confidence.
Open DIFARGram	Opens the generated result in the DIFARGram reviewer after data is available.
Open Output Folder	Opens the scenario output directory.

Simulator math: Physical source mode uses RL=SL-[20log10(r)+alpha(f)r_km]. Pressure is p=10^(RL/20) uPa. For a plane wave, particle velocity magnitude is approximately u=p/(rho c); the X/Y/Z components are projections onto the arrival-direction unit vector and are converted through the selected sensitivity curves. Doppler is approximately f'=f c/(c-vr) for the implemented radial-velocity sign convention. Multipath adds 10^(-A/20) times a delayed signal. Max-input scale mode applies one common gain so inter-channel ratios and bearings are retained; clip mode truncates samples beyond +/-Vp.

12.5 Database Tools

These procedures act on stored records and curves. Preview the affected scope and create a recoverable backup before bulk changes.

12.5.1 Export Logs to Excel

When to use: Use to create a structured reporting or audit workbook from stored records.

How to use: Follow these steps in order:

1. Set project/file/method/run filters.
2. Open Export Logs to Excel and choose fields/sheets if offered.
3. Select a destination and export.
4. Open the workbook and compare row counts with the filtered view.

Method and underlying math: Export is a relational query and serialization operation; it does not recalculate measurements. Numeric precision and date formatting may change display without changing stored values.

Verify before accepting: Confirm filters, row counts, units, identifiers, timestamps/time zones, significant figures, and that sensitive fields are appropriate for release.

12.5.2 Filter Measurements

When to use: Use to narrow database records before review, correction, export, or deletion.

How to use: Follow these steps in order:

1. Open the filter builder.
2. Add field/operator/value criteria and combine them with the intended AND/OR logic.
3. Preview the matching count and sample rows.
4. Apply the filter and keep it visible during subsequent actions.

Method and underlying math: A filter maps to Boolean predicates over database columns. AND returns the intersection of conditions; OR returns the union. Range endpoints and NULL values require explicit handling.

Verify before accepting: Check operator precedence, units, inclusive/exclusive bounds, NULLs, text case, project scope, and final row count.

12.5.3 Filter Logs by Date/Time

When to use: Use to restrict records to a known recording or processing time window.

How to use: Follow these steps in order:

1. Choose the timestamp field.
2. Enter start/end times and time-zone interpretation.
3. Preview and apply the range.
4. Cross-check boundary records.

Method and underlying math: A range predicate is typically start <= timestamp < end. UTC/local conversion adds or subtracts the applicable offset; daylight-saving transitions can create ambiguous local times.

Verify before accepting: Confirm timestamp meaning, UTC offset, inclusive boundaries, date format, recorder clock drift, and records with missing timestamps.

12.5.4 Database Maintenance

When to use: Use for supported integrity, optimization, backup, or cleanup operations when the application indicates maintenance is required.

How to use: Follow these steps in order:

1. Close or pause other database-writing work.
2. Create a verified backup.
3. Select only the required maintenance action and run it.
4. Reopen the application and perform integrity/record spot checks.

Method and underlying math: SQLite-style integrity checks validate page and index structure; VACUUM rewrites the database to reclaim space; ANALYZE refreshes query-planner statistics. These actions do not validate measurement science.

Verify before accepting: Confirm backup recovery, free disk space, exclusive access, completion status, database integrity, and unchanged record counts where expected.

12.5.5 Clean Measurement Data

When to use: Use to identify and safely remove or correct invalid, duplicate, incomplete, or out-of-scope measurement rows.

How to use: Follow these steps in order:

1. Export and back up the affected scope.
2. Define cleaning rules and preview every candidate class.
3. Apply the smallest approved action.
4. Re-run validation queries and dependent calculations.

Method and underlying math: Duplicate detection compares selected keys; outlier rules may use fixed ranges or robust statistics. Deletion changes relational state and can orphan or invalidate dependent SPL results unless constraints/cascades are handled.

Verify before accepting: Verify candidate counts, primary/foreign-key effects, audit trail, backups, dependent records, and post-clean recalculation.

12.5.6 Annotate Measurements

When to use: Use to add or revise notes, labels, group/stage, or other metadata without changing measured numeric values.

How to use: Follow these steps in order:

1. Filter and select exact records.
2. Choose the annotation fields and whether to append or replace.
3. Preview the affected count.
4. Apply and inspect representative rows.

Method and underlying math: Annotation is metadata update logic. Bulk updates apply one value or transformation to a selected set; selection accuracy is therefore the main control.

Verify before accepting: Confirm project scope, append/replace mode, affected count, author/date conventions, and that numeric measurement fields remain unchanged.

12.5.7 Annotate SPL

When to use: Use to add context or project metadata to stored SPL calculations.

How to use: Follow these steps in order:

1. Filter SPL results and select records.
2. Enter the annotation or classification fields.

3. Preview and apply.
4. Inspect the SPL table and exports.

Method and underlying math: This updates descriptive fields associated with calculated levels; it does not alter the SPL formula unless a correction field is explicitly changed.

Verify before accepting: Confirm identifiers, affected count, calibration/run association, and whether annotations propagate to reports.

12.5.8 Calibration Curve Manager

When to use: Use to import, inspect, rename, export, or retire hydrophone sensitivity curves.

How to use: Follow these steps in order:

1. Open the manager and select import or an existing curve.
2. Review units, sign convention, frequency points, source, and date.
3. Save with an unambiguous name or export a backup.
4. Before deletion, identify measurements that reference the curve.

Method and underlying math: Measurements interpolate sensitivity M(f) between stored calibration points. Linear-frequency or log-frequency interpolation can produce different values; extrapolation outside the measured range is generally unsafe.

Verify before accepting: Check curve units, monotonic frequency ordering, duplicates, interpolation, range coverage, provenance, and dependencies before rename/delete.

12.5.9 TVR Curve Manager

When to use: Use to manage projector transmitting-voltage-response curves used in transmit analysis.

How to use: Follow these steps in order:

1. Import or select a TVR curve.
2. Inspect frequency, TVR values, units, projector, drive chain, and date.
3. Rename/export as needed.
4. Check dependencies before deletion.

Method and underlying math: TVR values are interpolated versus frequency and combined with 20 log10(drive voltage/reference voltage) to estimate source level.

Verify before accepting: Confirm voltage convention, range normalization, frequency interpolation, drive-chain corrections, provenance, and linked measurements.

12.5.10 Measurement Voltage Correction

When to use: Use when documented recorder scaling or gain information requires correction of stored voltage measurements.

How to use: Follow these steps in order:

1. Back up and export affected records.
2. Filter to the exact acquisition/run scope.
3. Enter the linear or dB correction and preview before/after values.
4. Apply, audit, and recalculate dependent SPL records.

Method and underlying math: A multiplicative correction uses Vnew=g Vold. For a dB correction, g=10^(Delta_dB/20). Dependent level changes by 20 log10(g).

Verify before accepting: Verify sign, RMS/peak convention, units, affected count, audit notes, screenshots, and every dependent SPL/calibration result.

12.5.11 CTD Import

When to use: Use to import conductivity-temperature-depth profiles and derive environmental/sound-speed data for mapping or modelling.

How to use: Follow these steps in order:

1. Choose the source file and map columns/units.
2. Review depth ordering, location/time, and invalid values.
3. Calculate or import sound speed and preview profiles.
4. Save/activate the profile for the intended project.

Method and underlying math: Sound speed is derived empirically from temperature, salinity/conductivity, and pressure/depth using a selected oceanographic equation. Interpolation provides c(z) between samples.

Verify before accepting: Confirm units, datum, latitude-dependent depth/pressure conversion, salinity scale, monotonic depth, spikes, equation choice, timestamp/location, and active-project assignment.

13. Calibration and measurement guidance

Channel configuration

Multi-channel files can use channel-specific names, selection states, maximum RMS voltage, hydrophone curves, and TVR curves. Configure channels before comparing results. A calibration entered for one channel must not be assumed to apply to another.

Maximum voltage

Maximum voltage defines the physical RMS voltage represented by digital full scale for the acquisition chain. Use the value and convention provided by the recorder, ADC, or calibration procedure. Incorrect scaling transfers directly into voltage and SPL error.

Bandwidth and filtering

Bandwidth defines the frequency interval around the target. Bandpass filtering is optional and materially changes a result; its state is stored in the log. Use a bandwidth wide enough to include the intended energy and narrow enough to exclude irrelevant components, based on a documented method.

Hydrophone sensitivity and TVR

- Confirm curve units and sign convention before import.
- Confirm the target frequency lies inside the curve’s supported range.
- Use a stable, descriptive curve name that identifies the sensor/projector and calibration date.
- Do not substitute a nominal curve when traceable calibration is required.

Reproducibility

For every reported result, retain the source file, channel, time bounds, method, target frequency, bandwidth, filter state, voltage scaling, calibration curve, software version, and any correction parameters.

14. Troubleshooting and safe operation

Control / area	Purpose
No audio loaded	Choose Open WAV and confirm the file is a valid, readable WAV. If the file is remote, copy it locally and retry.
RMS shows N/A	Select a valid time region, choose an enabled channel, confirm target/bandwidth values, and choose Update.
Unexpectedly low/high voltage	Check channel scaling, maximum voltage, clipping, target band, filter state, and selection limits.
FFT is noisy or smeared	Adjust window length and method; verify the selection contains a stationary signal and that frequency limits are appropriate.
SPL cannot be calculated	Confirm a voltage log exists, a valid calibration curve is selected, and the frequency falls within the curve.
Spectrogram is slow	Reduce time span, NFFT, visible frequency range, or project gallery size.
No spectrogram video	Install or place the approved FFmpeg executable where Analyze can find it, then retry.
Map is blank or incomplete	Check network access for base-map tiles, then verify track coordinates and timestamps.
Logs appear missing	Clear project, file, method, group/stage, and run filters; check paging.
Workflow has no files	Select a project and import files into Project Files before assigning a template.
Application will not start	Confirm the full application package and license files are present and writable. Record the startup message for support.

Safe operating rules

- Work from copies of irreplaceable recordings.
- Export logs before bulk deletion or database maintenance.

- Do not interpret modelled corrections or propagation results without checking assumptions.
- Keep calibration, CTD, GPS, and bathymetry source files with the project.
- Do not distribute the software or license files outside the terms supplied with the application.

15. Glossary

Control / area	Purpose
Bandwidth (BW)	The frequency interval included around a target frequency.
CTD	Conductivity, temperature, and depth profile used to derive environmental properties such as sound speed.
DIFAR	Directional Frequency Analysis and Recording; a method for estimating acoustic bearings.
FFT	Fast Fourier Transform; converts a time signal into a frequency spectrum.
NFFT	FFT length used in a spectral or spectrogram calculation.
RMS voltage	Root-mean-square voltage representing signal magnitude over a selected interval.
SPL	Sound pressure level, normally reported in dB re 1 μPa for underwater acoustics.
SPL_NF	SPL after the supported near-field correction has been applied.
TVR	Transmitting Voltage Response, used for projector/source calibration.
Welch method	An averaged spectral estimate computed from overlapping signal segments.

Support information

When requesting support, include the application version, Windows version, exact error message, operation being performed, file format and channel count, active project, and a small non-sensitive reproduction file where permitted.