



VERDALIS
Natural sound synthesis

ShoreBreak

Synthesised ocean surf

Version 0.4.0

CLAP instrument for Linux and Windows

Part of the Verdalis Plugin Suite

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Introduction

ShoreBreak is a CLAP instrument that generates ocean surf. It contains no samples: every break, every sheet of foam, every bubble and the swell underneath are computed from noise, filters and resonators while the plugin plays. No two shores are ever alike.

A breaking wave is not one sound but four, and they overlap. The crest collapses into a cloud of bubbles. It leaves a sheet of foam behind, which has no low end at all and outlives the break by up to three times. The water washes back down the shore and drains through whatever the shore is made of. And single bubbles pop in the foam long after the wave itself has gone. Under all of it is the swell bed: water moving without breaking, slowly breathing.

ShoreBreak generates all five, and lets them interact rather than merely overlap — an arriving wave bursts the foam the last one left, because a beach never has two sheets of foam hanging in the air at once.

Every layer came out of measurement. The model and the factory presets were fitted against 55 field recordings — 48 kHz stereo, 114 minutes, with anything containing birds or aircraft excluded, since this plugin models waves only — by measuring the recording and the plugin's own output with the same analysis code and moving values until the two agreed. Where a number in this manual comes from a measurement or a paper, it says so.

ShoreBreak 0.4.0 is an early version. The engine, the parameter set and the window are complete and the self-test passes, but the preset library is a first fit. *What is still being fitted* at the end of this manual lists what is known not to match yet, and it is worth reading before concluding that something is broken.

What is in this manual

Installing and *A first sound* are enough to get surf out of the plugin. *How it works* explains the model, and is worth reading before spending time in the parameter list — the layers are what the controls are named after. *Parameter reference* and *The preset library* are generated from the plugin itself, so they always describe the version on the cover. *Using it in a host* covers notes, automation, reproducible renders and CPU cost.

Installing

ShoreBreak is one self-contained `.clap` file plus its `presets` folder. There is no installer, no shared library to place and nothing to register.

Linux

CLAP hosts scan `~/ .clap`. Copy the plugin folder from the release archive into it so that you end up with:

```
~/ .clap/ShoreBreak/ShoreBreak.clap
~/ .clap/ShoreBreak/presets/
```

Then rescan plugins in your host. X11 and Cairo are the only external dependencies of the plugin window, and any Linux machine that can run a DAW has both.

Windows

CLAP hosts scan the common CLAP folder. Copy the plugin folder into:

```
C:\Program Files\Common Files\CLAP\ShoreBreak\
```

so that `ShoreBreak.clap` and `presets\` sit inside it, and rescan. There are no DLLs to install beside it — the window and its Cairo are linked in.

Keep the plugin and its presets together. The plugin finds its factory presets by looking for a `presets` directory next to its own binary. Moving the `.clap` file on its own leaves it with no factory presets at all.

Hosts

Tested with Bitwig Studio and Reaper. In Bitwig, `~/ .clap` is scanned by default; after installing, restart it or rescan under *Settings* → *Locations* → *Plug-in Locations*. ShoreBreak then appears as an instrument under the vendor *Ravetracer*, and the factory presets are indexed through CLAP’s preset discovery, so they show up in the host’s own browser as well as in the plugin window.

Your own presets

`SAVE` in the plugin window writes to a user preset folder, which is created on first use:

PLATFORM	LOCATION
Linux	<code>\$XDG_CONFIG_HOME/ShoreBreak/presets</code> , or <code>~/ .config/ShoreBreak/presets</code>
Windows	<code>%APPDATA%\ShoreBreak\presets</code>

User presets appear in the browser immediately, listed after the factory ones. They are plain text, so they can be copied between machines, kept in version control, or edited in any editor.

COLLECTIONS

A preset library is a shelf, and a long one is worth tidying. Your own presets are filed in **collections**: folders one level under the user preset directory. The browser lists the library down its left side — *All*, the factory presets, each of your collections, and *Unfiled* for presets saved into none — each with the number of presets in it. Clicking one lists just that one.

IN THE BROWSER	WHAT IT DOES
<code>NEW</code>	Makes a collection. It is listed at once, empty until something goes into it

RENAME	Renames the selected collection; its presets go with it
DELETE	Deletes the selected collection and every preset in it, after asking
Drag a preset onto a collection	Moves it there — or onto <i>Unfiled</i> to take it out of one
Right-click one of your presets	Renames it, changes its description, or deletes it

SAVE asks where a preset goes: pick a collection from the list — or *New collection...* to make one on the spot — then give the preset a name and, if you like, a **description**. The description is what the browser shows while the pointer is over the preset and what the help line shows while it is loaded: a sentence for whoever loads it next. Saving over one of your own presets offers its collection and its description again.

The factory presets are locked. They are part of the plugin, not files of yours, so they cannot be moved, renamed or deleted; to change one, load it, adjust it and save it as your own.

Collections are one level deep on purpose: a preset library is a shelf rather than a filesystem, and a tree deep enough to get lost in is one somebody will get lost in.

PRESET PACKS

A whole collection can be written out as a single file — a **preset pack**, extension `.shorebreakpack` — so a library can be handed to somebody else, or moved between machines, as one file rather than a directory.

With a collection selected in the browser:

BUTTON	WHAT IT DOES
EXPORT	Writes the selected collection — its presets and nothing else — as a pack into the <code>packs</code> directory beside <code>presets</code>
EXPORT AS...	The same, to a location you choose
IMPORT...	Lists the packs already in <code>packs</code> , plus <i>Other file...</i> for one from anywhere
REVEAL	Opens the folder the pack was just written to in the system's file browser

Importing adds the pack's presets to the library as a new collection named after the pack. Nothing is ever overwritten: importing the same pack twice gives two collections rather than a mixture of both versions in one.

A pack is the preset format again with a separator line between the presets, so it can be read, diffed and edited by hand like everything else here. It carries each preset's text verbatim rather than a re-serialised copy, which is what makes a round trip through a pack lossless.

EXPORT AS..., *Other file...* and **REVEAL** need the desktop's own file chooser — `zenity` or `kdiallog` on Linux, `xdg-open` to reveal, and the operating system's own on Windows. Where none is installed the buttons that need one are not drawn, and the plugin's own `packs` directory, which is where **EXPORT** writes, is enough on its own.

Building from source

The suite builds with a C++17 compiler and CMake 3.16 or newer. From the plugin folder:

```
./install.sh
```

That configures, builds, runs the self-test and installs to `~/.clap/ShoreBreak/`. `ShoreBreak_PREFIX=/some/where` `./install.sh` overrides the destination, and `-DCLAP_INCLUDE_DIR=/path/to/clap/include` points the build at a CLAP checkout it cannot find by itself.

A first sound

1. Load ShoreBreak on an instrument track.
2. Draw a long note — eight bars or more. Waves keep breaking for as long as the note is held, at *Wave Period* apart, and the release fades the sea out.
3. Open the preset browser by clicking the preset name in the window header and try **Gentle Waves**, then **Distant Roar**, then **Uproar Waves**.

Surf needs length. A two-second note is one break; the character of a shore is in the rhythm of several, so give it time.

Three things to try first

Change the shore. *Shore* sets what the water is draining through — sand, shingle, pebbles, rock, reef or harbour wall. It changes how much the wash rattles, and it also sets how enclosed the space is: 0.04 for open sand against 0.95 for a harbour wall with something right there to bounce off.

Change the breaker type. *Breaker* is Galvin's classification — spilling, plunging, collapsing, surging. It is not a cosmetic switch: the four measurably differ in spectral slope above 1.5 kHz, and the parameter changes the slope, the attack, the level, the foam share and the body weight together.

Move the shore away. Raise *Distance*. Air absorption takes the top off everything, the individual breaks smear into each other, and the swell bed becomes most of what is left. This is the best-fitting part of the model: the distant presets track their references within about a decibel from 800 Hz up.

How it works

The four layers, and the bed

LAYER	WHAT IT IS
Break	The crest collapsing into a cloud of bubbles. A cascade of discrete bubble events clustered around a kilohertz, with a noise band around them, opening upward as the cloud grows. It rises over a quarter to a whole second rather than striking.
Foam	The sheet of small bubbles left behind. Highpassed hard — the references measure −82 dB at 50 Hz, so it has no low end at all. It outlives the break by up to three times, which is why the quiet stretches between waves measure <i>brighter</i> than the waves.
Wash	Water running up the shore and draining back through whatever the shore is made of. A mid band with a slow random walk on it; coarser shores rattle more.
Bubbles	Individual resonators popping in the foam, each ringing at the pitch its radius gives it.
Swell bed	Water moving without breaking, slowly breathing. At distance it is most of what is left, because air absorption has taken the top off everything else.

A wave in three stages

The shore breaks, some bubbles are heard, and after a while the foam starts bursting as a sizzle. The engine does that in order:

1. **The break**, deep coming in and opening up as it collapses.
2. **Bubbles**, a trickle at the break's tail and more in the foam that follows, individually audible at around a kilohertz.
3. **The sizzle**, arriving later again and outlasting everything: thousands of sub-millimetre bubbles bursting at once. At 0.25 to 0.6 mm they ring between 5 and 13 kHz for a couple of milliseconds, and at that rate they overlap several deep, so they are not separately audible — they merge. It is generated as a high band with a granular envelope rather than as thousands of oscillators, which is the same sum for one multiply a sample.

The break is a cascade, not a sweep

The first version of the engine built a break by sweeping a bandpass over noise, which sounds like a slowed-down whip crack rather than a wave. The references say a break is a cascade of discrete bubble events — 15 to 30 separately audible onsets a second, clustered around 1 kHz — so the engine builds the break from bubbles and uses the noise band only as what surrounds them. *Bubble Mix* is the balance between the two.

The rate matters more than anything else about it. At the references' 27 onsets a second with a 40 ms ring, about one bubble sounds at a time; push the rate up and they overlap back into noise, which is how a bubble layer can be present and still sound like a whoosh.

A wave comes in deep and brightens as it breaks

The band opens *upward* into the break rather than sweeping down out of it, which is what it does in the references: the balance of high to low rises by 1 to 7 dB at the break across most of the library. *Crest Open* is how much darker the approach is. The precursor — the crest of an incipient plunger bubbling slightly before it collapses — is the low sound of water arriving, not of bubbles.

Bubbles are oscillators, not filtered noise

A bubble is generated as a decaying sinusoid with a short pinch-off transient, which is the impulse response of a damped harmonic oscillator. Its damping is computed from the physics rather than set by hand: the radiative loss is a constant 0.01368 for every size and the thermal term goes as $\sqrt{f}$, which gives Q from 20 to 46 and ring times of 2 to 124 ms across the size range, against 5 to 100 ms measured. *Bubble Damping* multiplies that, 1 being physical.

Bubble pitch follows Minnaert's relation, $f_0 \approx 3.26 / r$ with the radius in metres, so *Bubble Pitch* is a physical quantity: 2.6 kHz is a bubble about a millimetre across.

The foam runs a **second, finer cascade**. The slowed references measure the foam fizzles at 2.2 kHz and 29 onsets a second against the break's 850 Hz and 9, so foam bubbles are smaller, higher and faster than the ones a break makes. *Foam Bubbles* sets how much of the foam is that cascade rather than hiss.

Bubbles are a detail, not the main event: they are quiet, they sit behind the break rather than on it, and several presets have none at all, because distant surf has no separately audible bubbles.

Break Body drives a resonator at the cloud's collective mode, *bubblePitch* over the cube root of the number of bubbles, which is where surf rumble physically comes from. Collective oscillations of a bubble plume sit below 400 Hz and individual bubbles above 1 kHz, so the engine splits them: the body filter is capped at 400 Hz and the bubbles are their own layer.

Breaker type and size

Breaker is Galvin's classification, and the four types differ in ways that were measured rather than chosen:

- The slope above 1.5 kHz is about -6 dB/octave, steepening momentarily to -10 in the first second of breaking and relaxing to -5 or -6 afterwards. Means and Heitmeyer measure -10 dB/oct for plungers against -8.3 for spillers. That is what *Breaker* sets, and why the slope is animated rather than fixed: one pole is -6 dB/oct, two are -12, and the mix between them is the slope.
- Bigger breakers decay *more slowly* — -7 dB/s at 1.6 to 2.0 m against -4.5 dB/s at 2.4 to 2.7 m — so *Wave Size* scales *Break Decay* as well as level.
- The rise is faster than the decay, for the same reason it is in the recordings.

A wave washes the last one's foam away

Each wave used to own a private foam timer that ignored the sea around it, so with a long *Foam Delay* a wave's foam could still be hanging in the air when the next one broke — the one thing a beach never does. A breaking wave now runs over whatever foam is already lying there: what has not sizzled yet is burst by the arriving water within a few tens of milliseconds rather than waiting out its delay, and what is already sizzling is carried back out and fades early.

Measured with *Foam Delay* at 2.5 s and waves every 1.2 s, so that every wave's foam is still pending when the next breaks, the sizzle fires 0.06 s after each break instead of at its 2.5 s delay.

An open shore has no walls

Eight discrete early reflections at fixed fractions of a room dimension is what makes a reverb sound like a bathroom, and no amount of tail will talk the ear out of it. Outdoors there is nothing close enough to reflect. So the shore type scales the early field — 0.04 for open sand, 0.95 for a harbour wall — and the room model behind it is the suite's: eight early reflections and an eight-line feedback delay network built from one physical size, with Sabine's law for the decay time.

Distance

Distance applies air absorption plus a downward tilt, and it also multiplies the individual break events and smears their edges, because what arrives from a kilometre away has been through a kilometre of scattering. This is the best-fitting part of the model: *Distant Roar* tracks its reference within about a decibel from 800 Hz up.

The plugin window

ShoreBreak draws its own window with X11 and Cairo on Linux, and Cairo on the win32 backend on Windows. There is no toolkit dependency, which is what keeps the plugin one self-contained file. It is embedded in the host's own window through CLAP's GUI extension and repainted from the host's timer, and it resizes by zooming one layout, from half size to four times.

The window is the suite's, in ShoreBreak's own sea-green theme, with a surf line running through the header behind the wordmark and a wave-activity meter beside the preset name.

Gestures

GESTURE	EFFECT
Drag a knob up or down	Change the value
Shift-drag	Fine control, a fifth of the travel
Double-click a knob, or right-click anything	Back to the default
Scroll wheel over a control	Step the value
Click a knob's value	Type a value in, with units
Click a selector's name	Open its list and pick a value
Click a selector's ◀ or ▶	Step one choice
Click the preset name	Open the preset browser
◀ or ▶ beside the preset name	Previous or next preset
SAVE	Save the current settings as a user preset
MIXER	Open the layer mixer

The line at the bottom of the window shows what the control under the pointer does — the same one-line explanation that appears in the *What it does* column of the parameter reference.

The mixer

Every layer's level lives on the panel that layer belongs to, which is right for editing one layer and wrong for balancing them against each other. MIXER opens the same controls arranged the other way round: one strip per layer, its level as a fader, its pan and its width as slim sliders under it. They are the plugin's own parameters, not a second set — moving a fader moves the knob on the panel, and the host sees the same automation it always would.

M mutes a layer and S solos one, which is how a preset gets built from nothing: solo one layer, get it right, bring the next one back. Several layers can be soloed at once.

Mute and solo are **not** parameters and are not saved with a preset. They work by holding a layer's level at the bottom of its range and remembering what it was, so while either is active the preset bar shows a SOLO ON or MUTE ON chip — click it to release every hold at once. SAVE releases them first, so a muted layer can never be written into a preset as a silent one, and so does loading a preset. Touching a held layer's fader also releases the holds rather than fighting the hand on it. Closing the mixer does not: soloing a layer and then going to its knobs on the panels is what the mixer is for.

Parameter reference

There are 52 parameters, grouped the way the plugin window groups them. Every one is automatable and modulatable from the host, and every one can be typed in directly by clicking its value in the window. The name in `code` is the key used in preset files.

SURF

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Wave Period <code>wave_period</code>	1.00 s ... 12.00 s	2.27 s	Seconds between breaking waves. Measured 2.6-4.2 s on open coast.
Set Variation <code>set_variation</code>	0.0 % ... 100.0 %	35.0 %	How unevenly the waves arrive. At 0 they are metronomic; high values group them into sets.
Wave Size <code>wave_size</code>	0.0 % ... 100.0 %	55.0 %	How big each break is: its level, its body and how far its tone reaches down.
Size Variation <code>size_variation</code>	0.0 % ... 100.0 %	45.0 %	Spread of size from wave to wave. Real sets are never even.
Break Attack <code>break_attack</code>	30.0 ms ... 2.50 s	141 ms	How long the crest takes to build. A wave rises, it does not strike.
Break Decay <code>break_decay</code>	100 ms ... 4.00 s	437 ms	How long the break itself lasts once the crest has collapsed.
Break Tone <code>break_tone</code>	150 Hz ... 2.50 kHz	612 Hz	Centre of the bubble cloud a breaking wave makes. Measured 400-1600 Hz.
Break Body <code>break_body</code>	0.0 % ... 100.0 %	40.0 %	Low weight under the break: the surf rumble you feel more than hear.
Crest Open <code>crest_sweep</code>	0.0 % ... 100.0 %	20.0 %	How much darker a wave is coming in than it is breaking. An approaching wave is the deep sound of moving water; the top of the spectrum arrives with the collapse, like a filter opening – though never all the way.
Breaker <code>breaker_type</code>	Spilling, Plunging, Collapsing, Surging	Plunging	How the crest collapses. Sets the slope above 1.5 kHz: -10 dB/oct for a plunger, -8.3 for a spiller.
Precursor <code>precursor</code>	0.0 % ... 100.0 %	30.0 %	The crest of an incipient breaker already bubbles before it collapses. This is how much of that you hear.
Bubble Mix <code>bubble_mix</code>	0.0 % ... 100.0 %	15.0 %	How much of the break is separately audible bubbles rather than moving water. Bubbles are a detail: a break is mostly water, with them heard under it and just after it. Zero is legitimate – distant surf has none.

FOAM

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Foam Level <code>foam_level</code>	-inf dB ... 6.00 dB	-8.00 dB	Level of the foam a break leaves. It outlives the crest by up to three times.
Foam Decay <code>foam_decay</code>	200 ms ... 12.00 s	1.49 s	How long the foam hisses on. This is what fills the gap between waves.
Foam Tone <code>foam_tone</code>	400 Hz ... 8.00 kHz	1.79 kHz	Where the foam starts. Foam has no low end at all: measured -82 dB at 50 Hz.
Foam Delay <code>foam_delay</code>	1.00 ms ... 2.50 s	483 ms	How long after the break the foam arrives. Zero on a shore break, later off a bar.
Fizz <code>fizz</code>	0.0 % ... 100.0 %	30.0 %	Fineness of the foam. Foam bubbles are smaller than the ones a break makes, so they ring higher: this is how much higher.
Foam Bubbles	0.0 % ... 100.0 %	30.0 %	How much of the foam is separately audible bubbles rather than a bed of hiss. This is where they

foam_bubbles

belong: the fizzle after a break measures 29 onsets a second at 2.2 kHz against the break's own 9.

SWELL

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Swell Level swell_level	-inf dB ... 6.00 dB	-18.00 dB	The continuous bed under everything: water moving without breaking.
Swell Tone swell_tone	80.0 Hz ... 3.00 kHz	409 Hz	Centre of the swell bed. Low and dark for distant surf, higher up close.
Swell Depth swell_depth	0.0 % ... 100.0 %	45.0 %	How much the bed breathes with the swell. Measured 0.10 (steady roar) to 1.86.
Swell Rate swell_rate	1.00 /min ... 30.0 /min	3.90 /min	How often the bed rises and falls, independently of the breaking waves.
Swell Width swell_width	0.0 % ... 100.0 %	90.0 %	Stereo spread of the bed. The open sea is wide and barely correlated.

BUBBLES

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Bubble Rate bubble_rate	2.00 /s ... 600 /s	34.6 /s	Bubbles formed per second at the peak of a break. Keep it near the references' 15-30: any faster and they overlap into noise instead of being separately audible, which is the difference between a cascade and a whoosh.
Bubble Size bubble_radius	0.25 mm ... 12.0 mm	2.10 mm	Radius of a typical bubble, which is what its pitch actually is: Minnaert gives $f_0 = 3.26/r$, so 3 mm rings at about a kilohertz. The references' audible bubbles measure 1.7-5 mm.
Bubble Spread bubble_spread	0.00 oct ... 4.00 oct	1.10 oct	Spread of sizes either side of that. The references' onset pitches span about an octave each way.
Bubble Damping bubble_damping	0.25 x ... 4.00 x	1.00 x	Multiplies the damping a bubble actually has. At 1 it is physical: radiative plus thermal loss after Xue et al., which gives Q 20-46 and ring times of 2-124 ms across the size range. Below 1 rings longer, above 1 is deader.

WASH

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Wash Level wash_level	-inf dB ... 6.00 dB	-14.00 dB	The sheet of water running up the shore and back down it.
Wash Decay wash_decay	200 ms ... 8.00 s	1.05 s	How long the wash takes to run out. Long on a flat beach, short against rock.
Wash Tone wash_tone	200 Hz ... 6.00 kHz	1.10 kHz	Brightness of the wash, which is really how coarse the shore is.
Sand sand	0.0 % ... 100.0 %	50.0 %	Grain of the shore under the wash: a smooth sheet, or water draining through shingle.

SHORE

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Shore shore_type	Sand, Shingle, Pebbles, Rock, Reef, Harbour	Sand	What the water runs over. Biases the foam, the wash and the whole brightness.
Distance distance	0.0 % ... 100.0 %	30.0 %	How far away the surf is. Distance takes the top off it, as air absorption does.
Air air	0.0 % ... 100.0 %	50.0 %	How much of the high end survives the distance. Damp sea air eats it faster.

Width width	0.0 % ... 100.0 %	85.0 %	Stereo spread of the breaks. Measured L/R correlation on open coast is 0.26-0.50.
Space Amount space_amount	0.0 % ... 100.0 %	34.0 %	How much of the bay, the cove or the harbour wall you hear.
Space Size space_size	0.0 % ... 100.0 %	72.0 %	Size of that space, in metres of it.
Space Damping space_damping	0.0 % ... 100.0 %	50.0 %	How absorbent its surfaces are: bare rock rings, a sandy cove does not.

FILTER

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Filter Type filter_type	Lowpass, Bandpass, Highpass, Notch	Lowpass	Shape of the output filter.
Highpass highpass	20.0 Hz ... 2.00 kHz	20.0 Hz	Permanent highpass, for keeping the surf rumble out of a small speaker.
Filter Cutoff filter_cutoff	30.0 Hz ... 20.00 kHz	20.00 kHz	Corner of the output filter.
Filter Resonance filter_reso	0.0 % ... 100.0 %	10.0 %	Resonance of the output filter.
Filter Key Track filter_keytrack	0.0 % ... 100.0 %	0.0 %	How far the filter follows the played note.

ENVELOPE

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Attack attack	1.00 ms ... 20.00 s	1.49 s	Fade-in of the whole scene when a note starts.
Decay decay	5.00 ms ... 20.00 s	138 ms	Fall from the initial level to the sustain.
Sustain sustain	0.0 % ... 100.0 %	100.0 %	Level held while the note is down.
Release release	5.00 ms ... 30.00 s	4.24 s	Fade-out after the note is let go. The sea does not stop at once.
Velocity To Level vel_to_level	0.0 % ... 100.0 %	50.0 %	How much velocity sets the level.
Velocity To Size vel_to_size	0.0 % ... 100.0 %	30.0 %	How much velocity sets the size of the waves.

OUTPUT

PARAMETER	RANGE	DEFAULT	WHAT IT DOES
Output Gain gain	-inf dB ... 12.00 dB	0.00 dB	Output level.
Max Waves max_waves	8 ... 512	128	Ceiling on breaks, foam patches and bubbles alive at once, so the cost is bounded.
Random Seed seed	0 ... 999	0	Non-zero gives the same sea every time. Zero is always different.

The preset library

17 factory presets ship with the plugin. They are installed beside the binary and exposed through CLAP preset discovery, so they appear in the host's own browser as well as in the plugin window's.

Big Waves Crashing

Large plungers on an open beach: the crest throws forward and slams. Set Variation is high because the reference's gaps scatter by nearly four seconds. (*surf, powerful, plunging*)

Crashing Tides

A tide running in hard against the shore, breaking every four seconds. Fitted against a reference with a 3.9 s median gap and a 29 dB crest factor. (*surf, powerful*)

Crystal Bubbles

Close in on the foam, where individual bubbles are audible one at a time. Bubble pitch is its radius: 2.6 kHz is about a millimetre across. (*bubbles, close, detail*)

Distant Roar

Open coast heard from far inland: air absorption has taken everything above a few kilohertz, and what is left is the roar. Fitted against a reference measuring -50 dB at 12.5 kHz and a crest factor of only 14.5 dB. (*ambient, texture, dark*)

Fast Swells

Short-period swell, one wave arriving before the last has finished. Busy and loud: the reference has the lowest crest factor of the shore recordings. (*swell, busy, energetic*)

Gentle Waves

Small waves on a calm day, close enough to hear each one arrive. The reference has effectively no energy below 100 Hz, so Break Body is almost off. (*gentle, calm, close*)

Harbour Lapping

Water slapping a pier: low, boxy and close, with the two channels far more correlated than open coast. The reference measures 0.71 against 0.26-0.50. (*harbour, close, low*)

Hollow Shore

A shore that rings: water working into a hollow under rock, so the space is a bigger part of the sound than the break is. (*cave, resonant, space*)

Open Sea Murmur

The steady murmur of water that never quite stops breaking. Almost no envelope: the reference measures an envelope variation of 0.15 against 1.86 for a shore break. (*ambient, texture, steady*)

Receding Sand

The drain: water running back down the beach through the sand it just covered. Wash does most of the work here, and the break is only what starts it. (*wash, texture, drain*)

Rhythmic Tide

Almost metronomic surf. The reference's gaps scatter by only 0.3 s, which is as regular as the sea gets, so Set Variation is nearly off. (*surf, regular, rhythmic*)

Rolling Tide

Waves that roll rather than slam, each leaving a long bright wash. The reference's quiet stretches measure brighter than its breaks, which is the foam. (*surf, rolling*)

Sand and Foam

Foam running out over flat sand, with no low end at all: the reference measures -82 dB at 50 Hz. Almost the whole sound is the sheet of bubbles after the break. (*foam, bright, texture*)

Shallow Clear Water

Sparse, isolated laps in shallow water, with real silence between them. The reference's 41 dB crest factor is the highest in the library. (*sparse, quiet, clear*)

Tidal Swells

Long swells arriving without properly breaking: they surge up the shore and run back. The slowest attack in the library, at over a second. (*swell, slow, deep*)

Turmoil Fjord

Confined water in turmoil, the walls giving it back. The reference's crest factor of 21 dB is nearly continuous sound, so the swell carries most of it. (*fjord, dense, dark*)

Uproar Waves

A shore in uproar: everything breaking at once, nothing waiting its turn. Maximum Set Variation, so the waves pile into sets and leave gaps. (*storm, powerful, dense*)

Using it in a host

Notes

A note starts the sea and holding it keeps the waves coming, *Wave Period* apart, with *Set Variation* deciding how unevenly they arrive — metronomic at 0, grouped into sets at high values. The ADSR shapes the whole shore rather than individual waves, and *Release* is what fades it out.

Surf needs long notes. Most of the character of a shore is in the rhythm of successive breaks and in the foam that outlives them, neither of which is audible in a short note.

There are 16 voices, with 512 waves and 1024 bubbles in shared pools, so the number of held notes cannot multiply the CPU cost without bound.

Automation and modulation

Every parameter is automatable, and host parameter modulation (`CLAP_EVENT_PARAM_MOD`) is supported globally. Per-note modulation and note expressions are ignored. Parameter changes are sample accurate, so an automation ramp over a bar — a tide coming in over *Wave Size* and *Distance* — is a smooth move rather than a staircase at block boundaries.

Reproducible renders

Random Seed at 0 never repeats. Any other value renders the same sea for the same notes every time. The initial swell phase and the first wave timer are derived from the voice's slot and key rather than from the shared generator, so a fixed seed promises the same sea even when note events arrive before the seed has been applied.

CPU cost

Cost is bounded by the pools. The most expensive controls are *Bubble Rate* and *Foam Bubbles*, which decide how many resonators are running, and *Space Amount*, which is the room model. The sizzle is cheap by construction: it is a filtered band with a granular envelope rather than thousands of oscillators.

Rendering and tails

Surf has a long tail — the foam, the sizzle and the room outlive the last break by seconds. When bouncing, leave several seconds past the end of the note, or the sizzle is cut off mid-decay.

What is still being fitted

ShoreBreak 0.4.0 is a first fit, and the measurements say where it is not there yet. All of this is in the plugin's `TODO.md` with what is known about it.

Crest factor is 3 to 9 dB below the references. Real surf has more silence between breaks than the synthesis leaves — 34 dB for *Sand and Foam* against 23.7, 29 dB for *Gentle Waves* against 20.8. The suspects, in order, are too many waves alive at once, a break envelope whose decay is one exponential where the references suggest two stages, and a swell bed filling gaps that should be quiet.

The steadiest sources are still somewhat eventful. *Distant Roar* measures an envelope variation of 0.32 against the reference's 0.10, having been 0.53 before distance began multiplying the events. At distance the individual breaks should smear into the roar; they still punch through a little.

Twelve of the seventeen presets have a single audible band 6 to 11 dB out, down from fifteen with deviations up to 37 dB. *Rhythmic Tide* is darker than its reference throughout, and *Harbour Lapping* is 12 dB too bright at 12.5 kHz — a harbour is a boxy, close, low sound, and the space may need to do more of the work.

Several presets are grainier than their references. Erring towards more bubbling was deliberate after the first version was too smooth, and *Bubble Mix* dials it back, but the measurement cannot tell the difference between convincing bubbling and too much of it, so this one has to be settled by ear.

Reference and limits

Where the model comes from

- Klusek, Z. and Lisimenka, A., *Acoustic noise generation under plunging breaking waves*, Oceanologia 55(4), 2013 — measurements under 1.6–2.8 m plungers, and the source of the spectral maximum, the slope, the decay rates and the precursor.
- Galvin, C. J., breaker type classification — spilling, plunging, collapsing and surging, which is what *Breaker* selects.
- Means, S. and Heitmeyer, R., on the spectral slope of plungers against spillers.
- Schindall, J. and Heitmeyer, R., 1996 — collective plume oscillations below 400 Hz against individual bubbles above 1 kHz, which is why the body filter is capped where it is.
- Xue et al., on bubble damping and on the collective modes a bubble cloud forces.
- Minnaert, M., *On musical air-bubbles and the sounds of running water*, 1933 — $f_0 \approx 3.26 / r$, which makes *Bubble Pitch* a radius.

The papers themselves are not part of the release; they are not ours to redistribute. [tools/analysis/README.md](#) in the source tree records every measurement the library was fitted to.

Notes and limits

- Linux and Windows, x86-64. Plugin state is stored little-endian.
- 16 voices, with 512 waves and 1024 bubbles in shared pools.
- Host parameter modulation is supported globally. Per-note modulation and note expressions are ignored.
- Deliberately built without `-ffast-math` : on x86 GCC that links `crtfastmath.o` , which would flip the FTZ and DAZ flags for the entire host process.
- Waves only. The references that contained birds or aircraft were excluded from the fit for that reason.

Versioning

Semantic versioning. **MAJOR** is an overhaul: a rewrite of the synthesis model, or a change that breaks existing presets or saved host state. **MINOR** adds something — a parameter, a layer, presets. **PATCH** is fixes that add nothing new.

License

MIT. ShoreBreak contains no samples and no third-party code. The only external dependencies are the CLAP headers, which are MIT licensed, plus X11 and Cairo for the plugin window.

Reference recordings used during development are not part of the release and are not redistributable.