

## 4 humpback whales singing together

4-part singing with spectrograms and notation  
100-3000 Hz - spectrum up to 16 kHz

recording of the video : "Der Gesang der Buckelwale": <https://youtu.be/x0AdHNA0YRo>

00:07 - 4-part singing - 100-1000 Hz - 3 min  
03:13 - 2-fold slowed down - 50-500 Hz - with notation  
09:18 - the twittering conversation of the humpback whales  
filter: only the spectrum from 1200 Hz to 12 kHz  
12:28 - polyphonic singing - glissandi through triad figures (4:6:5)  
in rhythmic and harmonical relationship  
16:02 - arpeggios of the upper voice through high sound spheres  
from 3200 Hz down to 700 Hz - G7→F5 : through two octaves  
Spectrum up to 9 kHz (10th partial) - 8-fold slowed down with notation  
18:32 - 2 arpeggios compared: Ab7/9 and Bb7  
20:31 - a sound experience: 21 arpeggios through high sound spheres  
performed on the piano - 1 octave lower - with notation  
34:11 - appendix: underwater singing with an ensemble of pilot whales

4 humpback whales can be heard in this recording, singing together in 4 voices in rhythmic and harmonical relationship. There is 1 bass voice, 2 middle voices and 1 upper voice. Each whale has obviously its own voice pitch and certain characteristic sound figures or tone sequences.

When sounding together, all 4 voices form a multi-colored moving network of manifold sounds, from the full-sounding depth of the bass voice to the swinging movements of the middle voices to the arpeggios of the upper voice that sparkle down from the highest heights. It sounds as if the four whales were stimulating each other with their specific timbres and sound figures, as if they were throwing the balls to each other like in a game, sometimes in corresponding movements, sometimes as a solo, sometimes in pairs in intervallic relationships or together in unison, sometimes synchronously, sometimes alternating. Again and again, a coherently structured spectrum is formed, which is traversed by up and down sliding movements. And in the harmony of two, three or four voices, harmonic structures are heard for a moment or for a phrase: 4x a C major sound and a D# major sound, 3x Bb major and F# major, 2x D major and then G major and G# major. And in different constellations, the whole scale of spectra appears with the basic sounds of A#-B-C-C#-D-D#-E-F-G-G#.

The 4 whales sing in a range of 100-3000 Hz. Taken together, that is 5 octaves. Their measurable total spectrum extends to over 16 kHz. As far as I could tell from the analysis in the spectrogram, the individual voices have a range of 1.5 to 3.5 octaves.

bass voice: range F2-E4 (100-300 Hz) - main sounds between B2 and D#3 - intensive spectrum 1st to 4th partial - total spectrum continuous up to the 32nd partial (7000 Hz) - several brilliant formants between 1.5 and 4 kHz - volume -5dB to -15dB  
shorter strong fundamental notes with small glissandi (D#3-D-C#-D# or C#3-B2-D3) - third glissandi (F#3-D-F#-D or E3-C-E) - special tone sequences and sound figures (E4-C-G3 = C+, C4-A3-F = F+, D3-G-B-D-C#-D#-D = G+, C3-F-E = C+) - sequences of all 4 voices with 3-4 sounds of the bass part

upper voice: range C5-G7 (500-3000 Hz) - main sounds at G4-B4 (4-500 Hz) and at G5-B6 (800-1000 Hz) - full spectrum up to the 8th partial - total spectrum up to the 32nd partial (16 kHz)  
loudest sound at -15dB

Specialty: descending arpeggios through 2 octaves from 3000 Hz down to 700 Hz (G7-F5), in various tone sequences and at the end with long tenuto sounds (5x with tone sequence A-F-C = F-quart sext, Ab7/9, Bb7, D+, G+, F#)

2 middle voices: Range B2-F6 (125-1500 Hz) - main sounds B2-G3 (125-200 Hz) and B3-E5 (250-700 Hz) - strong spectrum up to 4th partial - total spectrum up to 32nd partial (5 kHz) - brilliant formant at 16th-20th partial (2-2.5 kHz) - loudest sound at -12dB

Specialty of whale 2: glissandi through triadic figures in rhythmic and harmonic relationship (4:6:5 = C-G-E, Bb-F#-D#, Bb-F-D), W2 and W3 repeatedly with long gliding tones, long whirring/buzzing

sounds (in German "schwirren") in the high register around 900 Hz (pulsating sounds with about 50 pulses per second)

09:18 - a twittering conversation

In this recording, only the sounds above 1200 Hz can be heard, i.e. the arpeggios of W4, the spectrum of W1 from the 8th partial (4th octave) and the spectrum of W2 and W3 from the 3rd partial (3rd octave). Regardless of their different pitches, all 4 voices form a common, diverse sound space with their high, dense and intense spectrum. The spectrogram shows how the sounds interpenetrate, relate to and correspond with each other despite their different pitches.