

could listen first and then read the book. Do whatever works best for you, but above all don't miss out on the detailed track descriptions in The Audio Book.

### *The Sonagram Is a Window on the Mind of a Singing Bird*

(Note: You have my blessing to skip this section if you wish. Although I believe that *seeing* birdsong is half the fun, you can certainly enjoy the seasons of birdsong without sonagrams in your life.)

Sonagrams! I can't imagine a world without sonagrams; they are windows on the minds of singing birds. Without these visual images of bird sounds, we would know so little of what these feathered creatures are saying.

I do realize, of course, that just the sight of sonagrams scares some people, so let's try to fix that in this brief sonagram primer. It may help first of all to think of a sonagram as a musical score for birdsong. Hasn't the sonagram become far friendlier already?

But, to the fundamentals. The format for a sonagram is much the same as that for a score of human music: We read it from left to right, and frequency (or pitch) is on the vertical. In human music, we think in terms of octaves and doubling of frequencies, so that a sound at middle A on a piano vibrates the airwaves 440 times a second, the A above that at  $440 \times 2 = 880$  times a second, the A below at  $440 \div 2 = 220$  times a second. For birdsong, instead of using this octave scale, we simply plot the actual frequency on the vertical axis and label the frequency in cycles per second, or hertz (the unit named after Dr. Heinrich Hertz, a German physicist who studied these things). The highest note on a piano, then, is about 4,000 cycles per second, also written as 4,000 Hz, or 4 kilohertz, abbreviated 4 kHz. The relative loudness of a note on a sonagram is indicated by darkness.

Those are the fundamentals. Now let's look at and listen to some examples. That's the key to appreciating sonagrams, by the way: Hearing what we simultaneously see, perhaps slowed down so that we can hear the details, makes all the difference. And you can "hear" most sonagrams in this book—just check the code in the time scale beneath the sonagram to find where to listen. For the first great blue heron call in figure 3 (page 28), for example, "T1-11, 0:35" means you can find this sound on CD 1, track 11, at 0:35.

Some sounds are harsh and not the least bit musical or tonal. A gunshot or a door slam, for example, would produce a vertical mark on a sonagram, because such a noise contains a wide range of frequencies (or pitches) at any given instant. Some bird sounds are similarly harsh and atonal. Consider the *fraaahnk*, *fraaahnk*, *fraak*, *fra* of a great blue heron, for example (figure 3, page

28); see in the sonogram how the sounds span the frequency spectrum from near 0 up to 6 kilohertz. Listen to these sounds on track 1-11, and you hear the nonmusical, grating effect of this heron's calls. Other such harsh calls are those of the Florida scrub-jay (see figure 6 on page 52, track 1-22, for example) or the *CHRRR!* of the northern mockingbird defending her winter territory (figure 45 on page 255; track 2-52).

Other sounds are far more musical, or tonal. A pure tone at middle A on a piano, for example, would be a horizontal line at 440 hertz across the sonogram. Some birds produce such pure tones that are held fairly constant in frequency. The opening whistle of a hermit thrush song is a striking example (figure 42 on page 244; track 2-6). Other examples include the beautiful whistles on the end of the Cassin's sparrow songs (figure 14, page 115; track 1-49; although the last notes in Songs A and C have a slight vibrato effect) and the whistled *see* notes of a cedar waxwing (figure 29, page 182, middle left; track 2-24).

Many bird sounds consist of a rather pure tone that is not held constant in frequency but rather is rapidly slurred through a range of frequencies. A favorite example is the song of the Baltimore oriole (figure 12, page 103; track 1-45) or the northern cardinal (track 1-60; not illustrated in a figure). The banded wren from the Neotropics also has such a beautiful song (figure 9, page 81; track 1-39).

Many bird sounds contain noticeable harmonics. Let's revisit that middle A string on a piano; when it vibrates, it produces a fundamental tone of 440 hertz, but because of the physics of a vibrating cord, also in the sound are harmonics at  $440 \times 2 = 880$  hertz,  $440 \times 3 = 1,320$  hertz,  $440 \times 4 = 1,760$  hertz, and so on. An example of such harmonic structure in a bird sound is in the calls of the limpkin. In figure 4 (page 38), see the lowest fundamental note in each phrase and then all of the harmonic notes stacked above; in the third phrase of the third row in that figure is a picture-perfect "harmonic stack," for example, in which the fundamental note rises to about 1,600 hertz, and harmonics above that are in multiples of 1,600 hertz, at about 3,200 hertz, 4,800 hertz, 6,400 hertz, 8,000 hertz, and so on. When listening to such sounds, we don't hear the harmonic notes separately but instead hear them all together with a unique quality, or timbre. Other examples of harmonics in bird sounds can be found in the calls of a pileated woodpecker (figure 1, page 6; track 1-1), the great kiskadee (figure 8, page 78; track 1-38), and the white-breasted nuthatch (figure 46, page 268; track 2-65).

And what fun when the sonograms reveal clearly how the bird uses his

two voice boxes to produce two different sounds at the same time, sounds that are not harmonically related and therefore cannot be produced by one voice box alone. For the cedar waxwing, see figure 30 (page 186) for clear evidence that the calling bird uses both voice boxes. Another example is provided by the American robin (figure 48, page 273; track 2-66); in the three examples in that figure, the robin sings entirely different phrases above and below 5,000 hertz, again revealing the simultaneous use of the two voice boxes. Such simultaneous use of the two voices can be detected in sonagrams, but when a bird uses his two voices successively, there's no way to know if he's alternating quickly between his two voices or being especially acrobatic with just one.

And birds got rhythm. I just love following along in sonagrams as I listen to a bird leap through frequency and time. Some of my favorites are the songs of white-eyed vireos (figure 11, pages 94–95; track 1-43), lark buntings (figure 15, page 118; track 1-50), and especially Cassin's sparrows (figure 14, page 115; track 1-49). As I listen, I am the song, generated high in the brain and surging along the nerves down the sides of the neck to the two voice boxes; I am the air, beginning deep in the lungs, now pressurized and forced through the voice boxes; I am the two voice boxes themselves, my membranes vibrating in rhythm with the precision-guided puffs of air shunted to the left and the right passageways. I am as close to being the bird as I can imagine.

I invite you to listen and revel in the sight of these songs, as *any listening experience* is richer if the sound can be *seen* and *heard* at the same time. For an even richer listening experience, I encourage you to use the free Raven Lite software from Cornell University ([www.birds.cornell.edu/brp/raven/Raven.html](http://www.birds.cornell.edu/brp/raven/Raven.html)) so that you can watch the sonagrams and listen to any of the sounds on the two compact discs at any speed you wish. Slow the songs to half or quarter speed, or even down to one-eighth speed, as I have done for you with hermit thrushes (track 2-6; figure 42); at these speeds, I am convinced that we are hearing details in the songs that the birds themselves hear. And that is where I want to be, as close to being and experiencing a singing bird as possible.

### *How to Record Your Own Bird Sounds*

Listening to birds and identifying with them is enormously satisfying, and the next logical step is capturing the sounds of birds and taking those sounds home with you. In Appendix 2, I offer some advice on how to do just that.