



2018 Spring-time Bioacoustic Study

Glacier Bay National Park, Alaska

Project Overview

In 2012, Glacier Bay National Park established a long-term acoustic monitoring site to provide park resource staff with information on the status and trends of spring birdsong phenology. To quantify the levels of bioacoustic activity from different songbird species (e.g. fig 1), acoustic data are collected from February through June and processed annually to summarize conditions and compare with previous years. This brief summarizes results for 2018.

To quantify bioacoustic activity, acoustic indices (mathematical summaries of the acoustic energy in an audio recording) are used. Previous research has demonstrated that acoustic indices are representative of the vocal biological community.¹ The specific index used in this assessment, Acoustic Complexity Index (ACI), minimizes the influence of wind, rain, and anthropogenic events in the calculation.

To evaluate trends across years, three metrics from the daily ACI values are extracted: 1) transition days, representing the beginning and end of the songbird vocal activity, 2) duration of the spring songbird season; 3) peak day of bioacoustic activity and species richness on this day.



Figure 1: Varied thrush (*Ixoreus naevius*), one of the many migrating song birds in the region (Photo credit: eBird.org).

2018 Acoustic Monitoring

Acoustic recordings were collected using a Song Meter (SM4), a compact, ruggedized, and programmable recorder developed by Wildlife Acoustics.² The recorder was strapped to a small tree approximately 3 meters off the ground (fig 2) located in Bartlett Cove, near park headquarters (fig 2).



Figure 2: Glacier Bay National Park acoustic monitoring site. (58.45625N and 135.86603W)

The recorder was programmed to record three hours around sunrise (1.5 hours before and 1.5 hours after). Sunrise was calculated using the latitude and longitude of the station. Audio data were saved in stereo and WAV format, collected at a sample rate of 44.1 kHz. The gain on each channel was set to 16 dB and the preamp was off. Each SD card slot contained 128 GB of storage and internal batteries were used. These settings resulted in approximately 200 mornings (February to

¹ Buxton, R. T., Brown, E., Sharman, L., Gabriele, C. M., & McKenna, M. F. (2016). Using bioacoustics to examine shifts in songbird phenology. *Ecology and evolution*, 6(14), 4697–4710.

² <https://www.wildlifeacoustics.com>

June) of recordings before the system ran out of battery.³ GLBA staff periodically visited the site to make sure the instrument was recording, and storage and battery capacity were sufficient.

Metrics of Bioacoustic Activity

2018 audio files were processed in the following steps:

- 1) Convert to sound pressure levels: audio data were converted to calibrated 1-sec 1/3 octave band sound pressure levels based on the system specifications and saved in NPS format ⁴
- 2) Create daily spectrograms: sound pressure levels were plotted using the Acoustic Monitoring Toolbox, a software developed by Natural Sounds and Night Skies Division (fig 3).
- 3) Evaluate data quality: A trained analyst viewed the daily spectrograms to categorize the acoustic conditions for each day; conditions were confirmed by listening to the audio data. Days were labeled as unusable if more than 25% of the recording period (3 hours) contained non-biological sources, such as wind, rain, or anthropogenic source (fig 3).

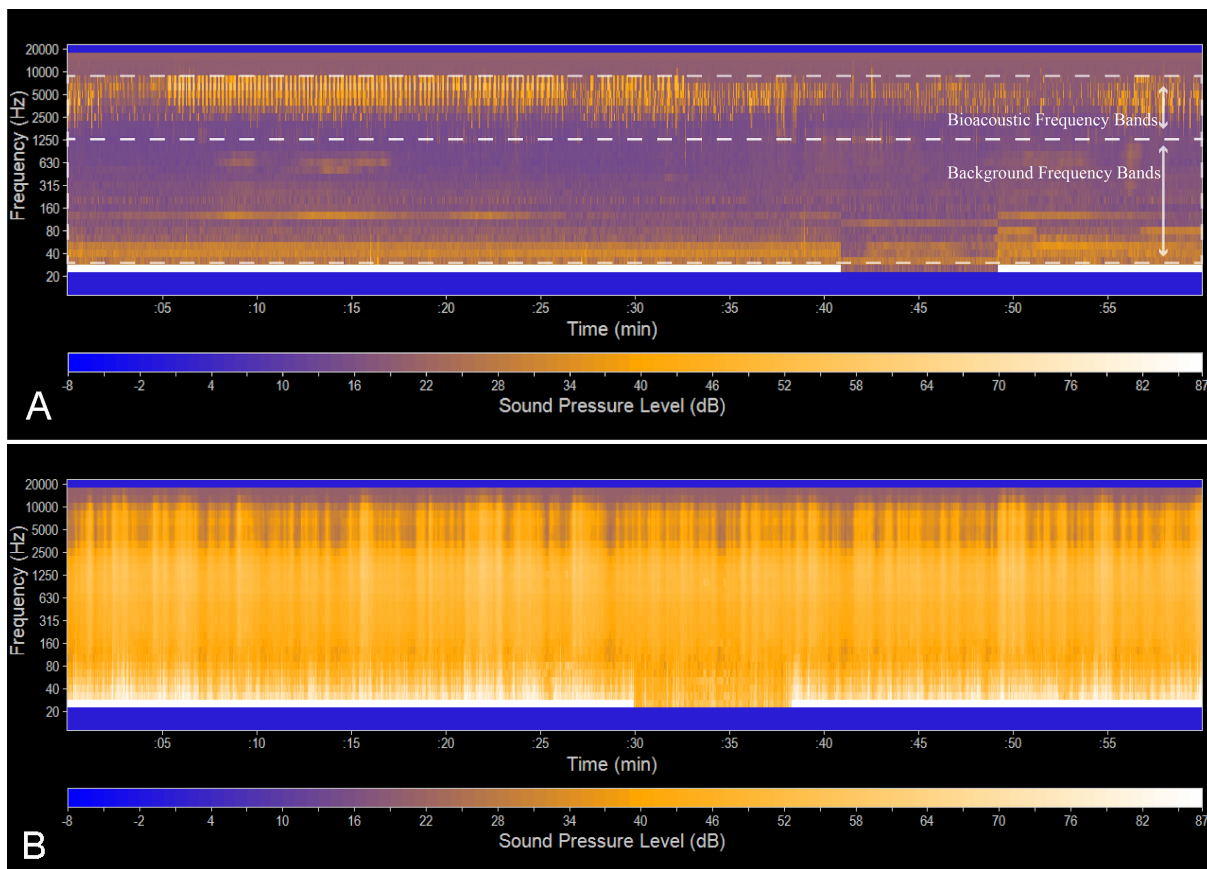


Figure 3. Example hourly spectrograms: (A) Acoustic data from 29 May 2018, peak acoustic complexity day. Dashed areas indicate the frequency bands the acoustic indices were calculated over. Biological band and background band are both used in the calculations; (B) Strong winds on 01 March 2018.

3 See settings file: GLBABART_2018.SM4S

4 Code available upon request.

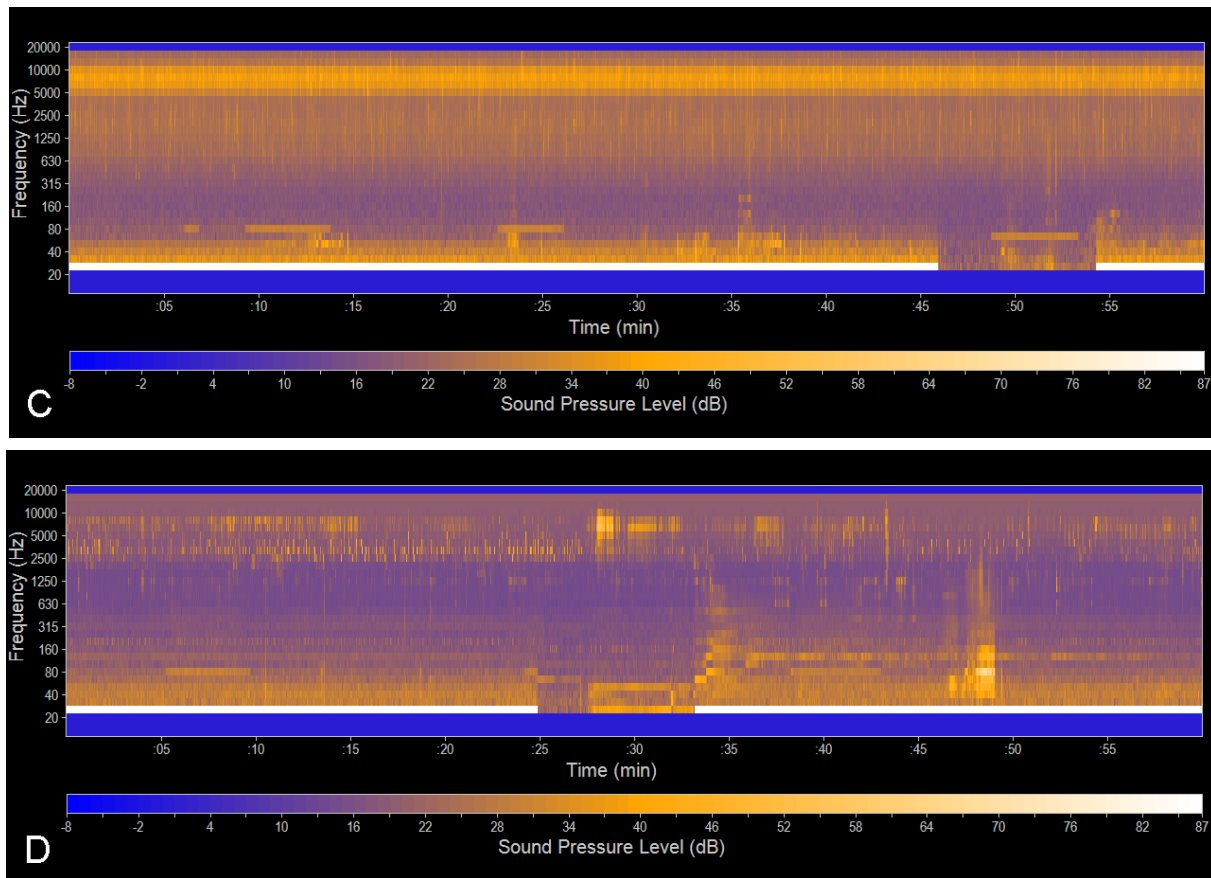


Figure 3 (continued). Example hourly spectrograms: (C) Constant rain on 23 February 2018; (D) Anthropogenic activity on 07 May 2018.

- 4) Calculate bioacoustic indices: Using the sound pressure levels, generated in step 1, six acoustic indices were calculated to track patterns in bioacoustic activity: Acoustic Complexity Index (ACI), Acoustic Activity (AA), Roughness (R), Acoustic Diversity (AD), Spectral Persistence (SP), and Acoustic Richness (AR). A slightly different analysis protocol was adopted in 2018 to improve computational efficiency and previous years (2012–2015) were reanalyzed with this method.⁵ For simplicity, this report for 2018 only shows results for the Acoustic Complexity Index (ACI) as a measure of conditions at this site. ACI is an algorithm created to produce a direct quantification of the complex biotic songs by computing the variability of the intensities registered in audio-recordings, despite the presence of constant human-generated noise.⁶ High values indicate a variety of signals are present; low values indicate constant (e.g. wind) or minimal signals present.
- 5) Identify peak activity and condition change: a statistical method known as a breakpoint analysis⁷ was run to identify peak activity day and transition days in daily time series of ACI values. Transition days are calculated as days with higher probability of a change in bioacoustic activity as indicated in the breakpoint analysis.
- 6) Determine species richness on peak day: a trained analyst identified all bird species present on the peak day in acoustic activity using a subsample of the 3 hour period (first 15 minutes of each hour). All calls were marked during this period using Raven Pro 1.5 (Cornell Lab of Ornithology) and summarized using custom scripts in R statistical software. This is a time-intensive analysis and requires expert knowledge of the species calls. The process was optimized to capture the most species present with more realistic time requirement.

2018 Patterns in Bioacoustic Activity

A total of 116 mornings were recorded in 2018, starting on February 23 and ending on June 18. There were no data gaps this year. Twenty-nine percent of the mornings (34 mornings) were found to contain more than 25% of a non-biological source and removed from further analysis. Most of the removed days were from wind and rain.

⁵ Code available upon request.

⁶ Pieretti, N., Farina, A., & Morri, D. (2011). A new methodology to infer the singing activity of an avian community: The Acoustic Complexity Index (ACI). *Ecological Indicators*, 11(3), 868–873.

⁷ bcp, R Package for Performing Bayesian Change Point Problems, R Statistical Software.

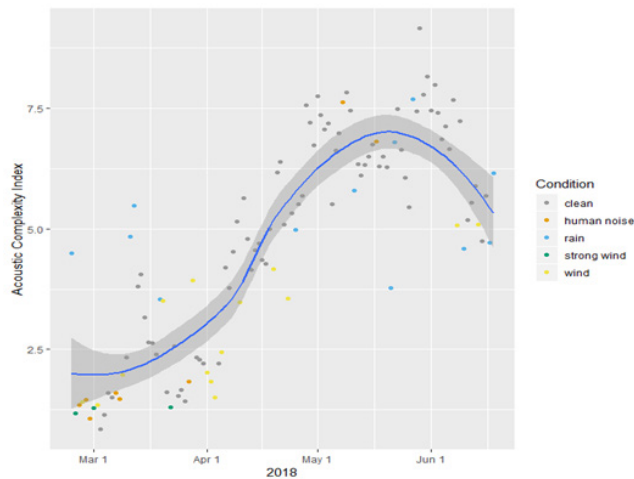


Figure 4: Acoustic complexity across the 2018 season. The acoustic conditions for each day are shown (wind, rain, or anthropogenic noise present). A loess smoother (blue line) is applied to the data for the entire season.

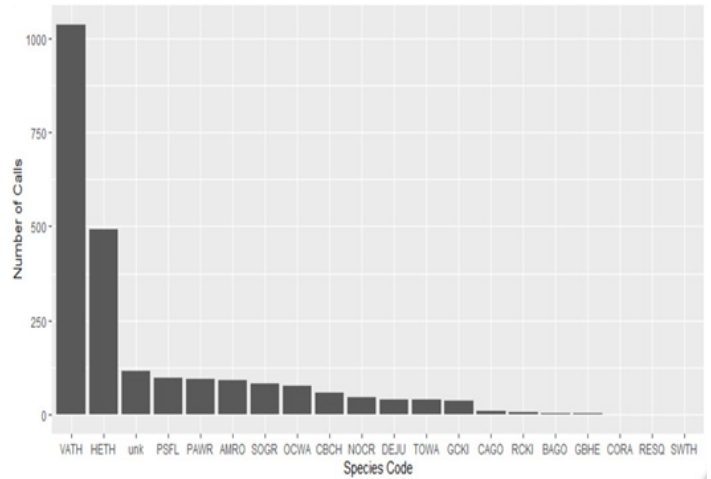


Figure 5: Summary of the number of calls heard on the peak day of bioacoustics activity (ACI). All calls were marked and identified by a trained analyst listening to and examining spectrograms of the first 15 minutes of each hour of recording. Species codes for the most common: VATH – varied thrush; HETH – hermit thrush; unk – unknown; PSFL – pacific slope flycatcher; PAWR – pacific wren; AMRO – American robin; SOGR – sooty grouse; OCWA – orange crowned warbler; CBCH – great blue heron; NOCR – northwestern crow; DEJU – dark eyed junco; TOWA – Townsend’s warbler; GCKI – golden crowned kinglet.

Results for 2018 showed that spring transition, defined as days with higher probability of a change in bioacoustic activity, occurred on April 4th and ended on June 9th (fig 4).

The peak day of bioacoustic activity in 2018 was on May 29th, later than estimated for 2012–2015 (table 1). On this peak day, a variety of species were detected (total species = 23 of 43 likely heard species⁸; species richness = 20). On peak day, bioacoustic activity was dominated by a few species: varied and hermit thrush, pacific slope flycatcher, and pacific wren (fig 5)⁹.

Comparison of 2018 with other Years

In 2012–2014, ACI was reported as an index of spring transition¹⁰, calculated for the three hours around sunrise. To compare more directly with 2018 results, ACI and breakpoint analysis were recalculated for the previous years (fig 6, table 1), using the same methods as 2018. Further, to compare changes over the same time period each year, dates for the analysis were truncated to include March 23 to June 3 for all years. In 2016–2017 equipment failure prohibited data collection over the entire period and these years were not included in this comparison.

Table 1. Comparison of peak and transition days across years using Acoustic Complexity Index (ACI) Note: *outside date window common to all years.

Year	Peak	Start	End
2012	May 5	April 16	NA
2013	May 6	April 16	June 2
2014	April 28	April 13	June 1
2018	May 29	April 4	June 9*

In 2018, the day of the first transition (“Start” in table 1) occurred earlier in the season (April 4) and the day of peak activity occurred later in May (May 29) when compared to other years (table 1). In 2018, no transition to a decrease in activity was identified before June 3rd; however, when the full dataset was analyzed a drop occurred on June 9th, which was 6 days later than previous years (table 1). These results suggest an earlier start and extended period of higher bioacoustic activity in 2018 compared to previous years.

⁸ ebird <https://ebird.org/barchart?r=L920855&byr=1900&eyr=2020&m=5> and verified by expert N. Drumheller.

⁹ Using Raven 1.5 software.

¹⁰ Buxton, R. T., Brown, E., Sharman, L., Gabriele, C. M., & McKenna, M. F. (2016). Using bioacoustics to examine shifts in song-bird phenology. *Ecology and evolution*, 6(14), 4697–4710.

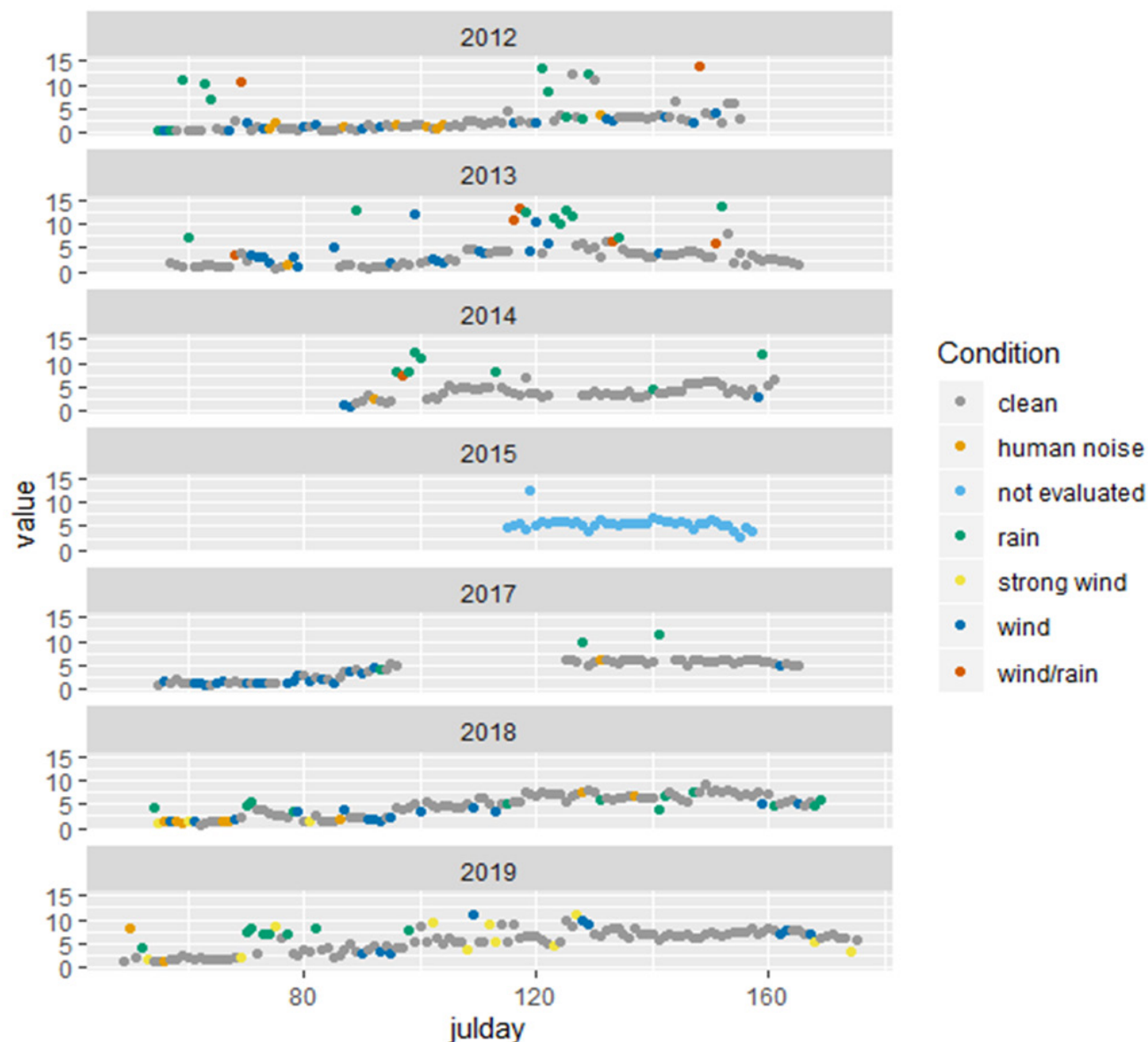


Figure 6: Comparison of sunrise bioacoustic activity (measured as ACI 3 hours around sunrise) from 2012–2019, excluding 2016, where data were not collected due to equipment failure. The graph shows the data gaps in 2015 and 2017, rendering those years unavailable for comparison. Data points are colored by acoustic conditions on that day, only “clean” samples were included in the statistical analysis comparing bioacoustic activity across years.

More Information

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