Acoustic Monitoring for Migratory Birds in Northeastern Siberian Arctic Tundra

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Project Summary

Indigirka River Delta is one of the most productive tundra area in Siberia that supports 40 – 60 migratory bird species each summer. Despite the magnificent avifauna, only few research expeditions had been conducted in the delta since it is difficult and expensive to survey with human observers. Automated acoustic recording systems are potential solutions enabling large scale monitoring. However, previous studies had shown the importance of evaluating the detection performance of recorders under spatially variable survey conditions in advance of implementation. In this study, we will investigate the utility of an acoustic recorder for monitoring abundance of tundra birds relative to point count surveys. Our objectives are to 1) compare the number of bird species detected by a field observer and an acoustic recorder among the same time period; 2) evaluate the effect of distance on detection probability of birds for a field observer and an acoustic recorder; and 3) evaluate how the difference of detection probability between a field observer and an acoustic recorders relates to habitat characteristics (i.e., shrub characteristics). This study will provide detailed evaluations of detection performance of acoustic recorders in Indigirka River Delta arctic tundra. Applying the acoustic recorders as a supplement to, or replacement for, field observers for long-term monitoring in the Indigirka River Delta arctic tundra is desired ultimately.

Special qualifications, certifications relevant to the project

My previous experience working on tundra makes me confident in accomplishing this project.

In the summer of 2017, I collaborated with Sergei M. Sleptsov from Russian Academic of Sciences to record the extraordinary avifauna of the Arctic tundra in Indigirka River Delta area. The sounds I collected had been published in the world's biggest bird sound sharing website, Xeno-Canto. It was the first time to have a recordist record bird sound in the Siberian tundra and the recordings are rare, also extremely precious. One of my recordings from Siberian Cranes was even selected as the spotlight of the website (https://www.xeno-canto.org/collection/spotlight/105). The introduction of acoustic recordings in the Siberian arctic tundra is a new concept and will definitely enhance the research work in the arctic tundra.

Siberian tundra area is a place with strict control by government and almost not possible to get access to without the help from local people to apply the required documents. My local collaborator, Sergei, will play a crucial role for this project. He is an ornithologist from Russian Academy of Sciences and has been working on tundra every summer for 27 years. He will assist the project with his expertise in tundra birds and also be in charge of the required paperwork. With Sergei's help and the support from Russian Academic of Sciences, we are optimistic in carrying out the research.

Career goals

My previous visit in the Siberian tundra inspired me to put more efforts on the conservations of tundra birds. Having a chance to visit arctic tundra is definitely one of the most precious opportunities I got in my life. I not only saw the magnificent wilderness, but also realized how hard the local scientists try to protect the wonderful land they have. My local collaborator, Sergei, told me not only once that only few people are able to study tundra birds due to the harsh nature environments and limited resources. With my research focus on avian acoustics. I would like to apply my expertise on helping conservation activities all around the world, and the Siberian arctic tundra will be my first step.

This project will be the first attempt to apply acoustic recorders in monitoring Siberian tundra birds. Sergei and I are excited about the project, however, funding resource is a challenge. We will use the grant from National Geographic mainly on purchasing the acoustic recording systems, the most crucial equipment in this project.

Getting a funding from National Geographic is not only getting a support for a study, but also getting a chance to know more amazing people. There are so many people working hard to make this planet more beautiful. I believe the National Geographic grant will open up more possibilities toward achieving my career goal: help conservation activities with the application of avian acoustics.

Background and Relevance

Located in northeastern Russia, Siberian arctic tundra is favored by numerous migratory bird species due to its wide marsh areas (Pearce et al., 1998b). Indigirka River Delta (IRD, 5,000 km^2) is among the most productive tundra area in Siberia that supports 40 – 60 breeding species (Goryachkin, 1994; Pearce et al., 1998a). The delta is the main breeding ground for several rare species, such as Siberian Crane (*Leucogeranus leucogeranus*), Yellow-billed Loon (*Gavia adamsii*), Ross's Gull (*Rhodostethia rosea*), and Steller's Eider (*Polysticta stelleri*). There is no doubt this magnificent avifauna deserves continued monitoring and conservation, however, only few research expeditions had been conducted since it is difficult and expensive to survey with field observers (Pearce et al., 1998a). A new method, potentially acoustic recording systems, could be introduced to enhance the scale of avian monitoring in the Indigirka River Delta tundra area.

Automated acoustic recording systems are recognized as a powerful tool for studying bird across broad landscapes due to its capacity in collecting large amounts of vocalization data (Sidie-Slettedahl et al., 2015). Advantages of acoustic recorders include the remote monitoring, and the programmable collection of acoustic data 24 hr/day, which provide spatial and temporal replication for monitoring bird communities. Another advantage is the reduction of inter-observer error (Alldredge et al., 2007; Celis-Murillo et al., 2009). Furthermore, acoustic recorders provide permanent recordings that can be examined repeatedly with spectrograms, resolving the logistical problems often encountered in field studies, such as the limited availability of field observers (Hobson et al., 2002).

Despite the advantages, the difference between acoustic recorders and field observers needs to be carefully evaluated before the implementation in a new environment (Haselmayer & Quinn, 2000). Acoustic recorders are not able to detect non-vocalizing birds, implying the existence of species bias. Furthermore, the effective sampling distance of recorders may differ from that of a field observer and depend on the habitat characteristics (Mc New & Handel, 2015). Previous research has shown that acoustic recorders often perform better than field observers when measuring species diversity, especially when different species are vocalizing simultaneously (Acevedo & Villanueva-Rivera, 2006; Bart & Schoultz, 1984). Still other research, however, found acoustic recorders perform poorly in densely forested landscapes due to the obstruction of vegetation (Hutto & Stutzman, 2009). These results suggest the importance of evaluating the detection performance under spatially variable survey conditions in advance of implementation (Hutto & Stutzman, 2009).

In this study, we are interested in examining the potential of using acoustic recorders as a tool to investigate seasonal patterns of avian abundance in the tundra areas, which are difficult and expensive to survey with human observers. We will compare the detection performance between acoustic recorders and field observers to access the feasibility of introducing acoustic recorders in Indigirka River Delta. Our objectives are to 1) compare the number of bird species detected by a field observer and an acoustic recorder among the same time period; 2) evaluate the effect of distance on detection probability of birds for a field observer and an acoustic recorder; and 3) evaluate how the difference of detection probability between a field observer and an acoustic recorders relates to habitat characteristics (i.e., shrub characteristics). This study will provide detailed evaluations of detection performance of acoustic recorders in Indigirka River Delta arctic tundra. Applying the acoustic recorders as a supplement to, or replacement for, field observers for long-term monitoring in the Indigirka River Delta arctic tundra is desired ultimately.

Goals and Objectives

*Goal 1: Compare the detection performance of acoustic recorders and field observers for monitoring Siberian tundra bird communities

Objective 1-1: Compare the number of bird species detected by a field observer and an acoustic recorder among the same time period. We hypothesize the field observer will detect more bird individuals and species comparing to recorders since the records can not detect non-vocalizing birds. On the other hands, we also hypothesize that the recorders will catch some birds species missed by the field observer during periods of high song activity.

Objective1-2: Evaluate the effect of distance on detection probability of birds for a field observer and an acoustic recorder. We hypothesize the distance will have a non-linear effect on detection probability of birds for both recorders and field observers. The detection rate will be highest between 50 to 100 meters to the point count center and decrease in when getting closer and further of the point count center.

Objective1-3: Evaluate how the difference of detection probability between a field observer and an acoustic recorders relates to habitat characteristics (i.e., shrub characteristics). We hypothesize the shrub characteristics will influence the difference of detection probability between field observers and acoustic recorders. Furthermore, different guild of birds will have different react to shrub characteristics since vertical structure, density and diversity of shrubs were proven to influence on both the occurrence and detectability of birds in the arctic (Amundson et al., 2014). We are particularly interested in defining the influence of shrub characteristics on the difference of detection probability between a field observer and an acoustic recorders. This result will provide us an idea whether we will need a habitat-specific correction when setting acoustic recorders in different habitats in future studies.

*Goal 2: Sharing bird sound recordings in public database

Objective 2-1: Increasing the collection of bird sounds on Xeno-Canto. In Xeno-Canto, the world's biggest bird sound database, there are only 55 recordings from 10 species being recorded in Siberian arctic tundra. We will provide all the recordings from our study in this public platform and thus provide materials for future studies.

Methodology Detail

Study area

The study location will be in the arctic tundra of Indigirka River Delta area, specifically around the Dzhyukarskoe Lake (70˚56′37.0″N, 148˚00′22.3″E). Typical vegetation in the area is composed of shrubs, such as dwarf birch (*Betula spp.*), ericaceous shrubs (*e.g., Empertrum, Vaccinium spp.*), willow (*Salix spp.*), and cottongrass (*Eriophorum spp.*). The subsoil is permafrost. Climate in the Indigirka River Delta area is characterized by long cold winters (October to April, -20˚C to -30˚C) and cool summers (May to July, -4˚C to 22˚C) (Pearce et al., 1998a). We will sample birds and vegetation at 60 sites separated by 500 meters along 10 transects. Transects will be set in different habitats such as creek and hills. Two rounds of point counts and recording will be conducted for each of the points. The Indigirka River Delta is within the Kytalyk Reserve. We will request required permit from Siberian Branch of the Russian Academy of Sciences, one of the collaborators of this study.

Recording equipment

The type of recording system we plan to use is the Song Meter SM4 Acoustic Recorder (Wildlife Acoustics, Inc., Maynard, MA, USA). Two built-in microphones in SM4 are omnidirectional (i.e., capture sound equally from all directions) with sensitivity at -28dB +/- 3dB at 1kHz. The frequency response of the microphones ranges from 20Hz to 48kHz, which fully covers the frequency of bird sounds, ranging from 1kHz to 8kHz. The SM4 features on its low power consumption, large data storage (i.e., more than one terabyte total capacity), and malleable operation environment (i.e., during rain and low temperature down to -20˚C). Furthermore, it provides the flexibility in powering system so that the external solar panels can be connected to provide extra electricity. The combination of these features makes SM4 a suitable acoustic recorder in our study.

Field procedures

A field observer will conduct point counts while simultaneously recording bird sounds at each of the survey points. After arriving the point center, a field observer will set up the recorder on a tripod at height of one meter. The date, point count station, weather (i.e., cloud cover, temperature, wind speed, and precipitation), observer, and the stating time will be recorded both on data sheet and into audio recordings. Standard point count protocol will be used in our study (Ralph et al., 1995). Each round of point count will last for 10 minutes. All birds in the period will be recorded when they are first heard or seen. For each individual detected, we will record 1) the distance of the bird in intervals of 0-25 m, 26-50 m, 51-100 m, 101-250 m, or more than 250 m; 2) minute of the survey that the bird is detected; and 3) vocalization type and behavior (i.e., vocalization was recorded as full song, partial song, call, alarm call, or winnow; behavior was recorded as flying, flight display, feeding, sitting, or walking.).

Vegetation survey will be conducted right after all bird surveys had been conducted for the season. Nine shrub characteristics will be measured in each of point count station along from 10 subsampling points. We will measure the height of the tallest shrub and estimated coverages of each shrub species. The visual obstruction, an index of vegetation height and density, will also be estimated from each subsampling points (Robel et al., 1970).

Audio interpretation

The analysis of collected audio recordings can be broken into two stages: signal detection and signal classification. Signal detection involves the extraction of structured sounds of interest while signal classification involves the identification of bird species. We will apply occupancy model to detect the presence of birds in each audio file, then identified the species by comparing the recordings with the bird sound database: Xeno-Canto. Species detected in the audio files will be compared with that detected by field observers.

Methodology Justification

In the summer of 2017, I cooperated with Dr. Sergei M. Sleptsov from Russian Academic of Sciences to record tundra birds in the Indigirka river delta area. Based on the experience, I listed two potential constrains in this study and the reasons why I am optimistic in achieving the goals.

*Location selection and accessibility

The Indigirka River Delta area is one of the most productive tundra delta consisting 57 breeding species, including the majority of the population of several rare species. The delta is no doubt the best location to apply long-term acoustic monitoring to understand the Arctic birds. My local cooperator, Sergei M. Sleptsov, is an ornithologist from Russian Academy of Sciences. He is an experienced researcher working in tundra and visits Indigirka River Delta area every summer. He will help to apply the permit to get to the Kytalyk Reserve and arrange all the local transportations.

*Recording system

Recording bird sounds in the tundra is a challenging task due to the extreme weather conditions (i.e., low temperature, limited electricity source, and strong winds). In my 2017 visit, I used Telinga SM2 parabolic microphone system and successfully got high quality recordings (https://www.xeno-canto.org/contributor/SPMWIWZKKC). According to this experience, I listed possible challenges for the SM4 we are going to use in this study.

-Low temperature: The lower limit of SM4 operation temperature (i.e., -20˚C) is lower than the lowest temperature of summer in the tundra area (i.e., -4˚C), so the system will operate well. However, the low temperature will substantially reduce the battery life, which we will discuss in the next paragraph.
-Limited electricity source: The SM4 build-in batteries can support 300 hours of recording. The SM4 also supports external power so we will connect the SM4 with extra solar panels.
-Strong wind: The wind speed in tundra is around 70 km/hr. We will use extra windshield layers on the SM4 microphones to prevent noise due to the wind.

Summary of Outputs and Results

Please describe all relevant outputs you expect to produce (data, new method, media) Describe the changes, if any, you expect to result from these outputs and specify who/what will benefit.

*New Method: This project will give a detailed evaluation of applying acoustic recorders in the arctic tundra. The results will provide us an idea whether we will need a habitat-specific correction

when setting acoustic recorders in different tundra habitats. We expect to introduce the acoustic recorders in the tundra for monitoring migratory birds and thus assess seasonal patterns of avian abundance across a broad array of tundra habitats.
*Data: We will collect audio recordings for tundra birds in the Indigirka River Delta. The audio recording of bird sounds will be precious for future bird sound research, such as seasonal variation of bird sounds.

How do you plan to disseminate your results and to whom?
*BranchLine: A seasonal journal from University of British Columbia (UBC) which allows UBC students to public their research works. The journal will be delivered to universities in all around Canada. The readers are from diverse background, from faculty members to the public.
*Xeno-Canto: A world-wild bird sound sharing platform open to public. We will public our recordings for each tundra species and provide detailed information for audio. Avian acoustic researchers will be able to assess the audios and conduct future research.
*Russia Academy of Science: We will provide a detailed report to Russia Academy of Science.
*Paper publication: We will write our research results as peer-reviewed journal paper. Targeted journals include Wildlife Society Bulletin, Journal of Field Ornithology, Ecological Applications.

How will you evaluate your work and results? Please list the indicators you will use to monitor progress toward your goal. Include current baselines and expected targets, if applicable.
*Number of species detected: Currently, there are only 10 species recorded in the Siberian arctic tundra. We would like to increase the species number to at least 30 species with each of them at least 5 recordings.

External Capacity Development

Russia Academy of Science has been monitoring Siberian Crane (*Leucogeranus leucogeranus*) in Indigirka River Delta for decades since the delta is the breeding ground for most of the Siberian Crane individuals. This study will provide the evaluation of applying acoustic monitoring in Siberian tundra. Applying the acoustic recorders as a supplement to, or replacement for, field observers for long-term monitoring in the Indigirka River Delta arctic tundra is desired ultimately.

Budget

5300 USD (NG) + 3000 USD (Other funding source)

Video

In a short video, tell us **(1)** how your project will make a difference in your field, **(2)** what makes your work interesting, and **(3)** how this project will contribute to your growth as a leader in your chosen career. The video is intended as an opportunity to propose your idea in a less formal way than a traditional written proposal, and it helps us gauge your current ability to communicate your idea.

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Other information

Date: Project from Feb. 15 to Dec 15, 2019. Fieldwork from May 15 to July 15, 2019

Location: Siberia Arctic Tundra, Russia (70.943601, 148.006196)

Focus: Conservation, Research for Wildlife

Field: Biodiversity Conservation, Ecology, Ornithology, Acoustic Monitoring