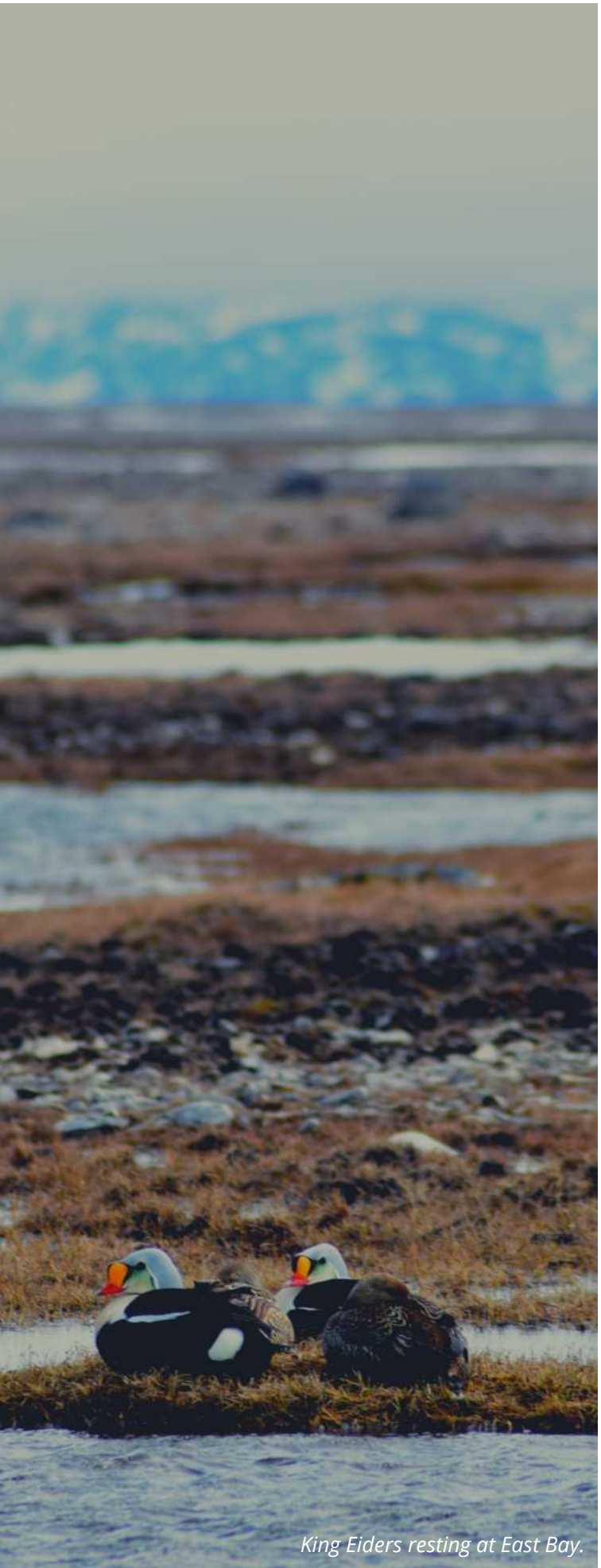
ENVIRONMENT AND CLIMATE CHANGE CANADA

ARCTIC COASTAL BIRDS & ECOSYSTEMS

2019 FIELD SEASON AND RESEARCH REPORT



King Eiders resting at East Bay.

FIELD SEASON OVERVIEW

The goal of our research is to better understand the ecology of coastal tundra ecosystems, so that these important habitats can be better managed and conserved. Shorebirds are the most abundant and diverse group of birds in coastal tundra, and are an important focus of our work. Canada's Arctic-breeding shorebird populations have declined dramatically since the 1970s, making them stand out as a group of conservation concern. We carry out research to 1) evaluate the influence of changing conditions in the Arctic on the breeding ecology of shorebirds and other tundra birds, 2) develop innovative approaches to improve knowledge of population status, and 3) use technology to track Arctic birds throughout the year and understand the ways in which populations are limited throughout the annual cycle.

A recent focus of our work now nearing completion has been a series of studies to understand the effects of overabundant Arctic geese on species such as shorebirds and gulls that nest in the same areas. Few studies have evaluated the impact of overabundant geese on other birds but the possibility exists for strong effects, operating through habitat change or altered predator/prey dynamics. Another key current project involves the use of tracking technology (primarily the MOTUS network) to enhance the monitoring of bird populations. We're combining modern technology with modern statistical methods to integrate behavioral data into monitoring programs, in order to improve our understanding of birds' population status. At the core, our research seeks innovative solutions to conservation challenges.

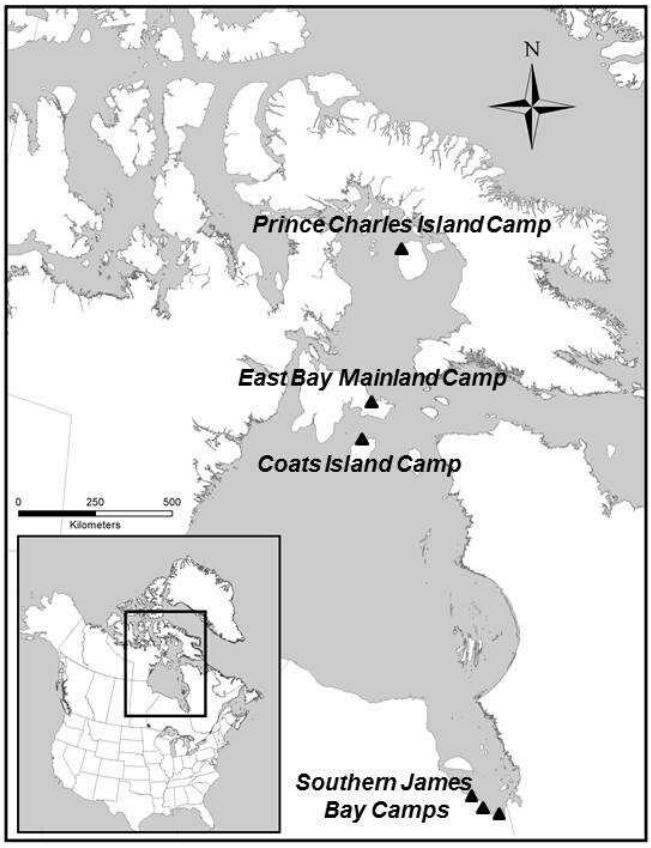


Figure 1. Map of ECCC shorebird research sites in the eastern Canadian Arctic and Subarctic James Bay.

In 2019, we operated out of two low-Arctic field sites: Our primary camp at Qaqsauqtuuq (East Bay Mainland) on Southampton Island, NU, and at our field site on Prince Charles Island in the Foxe Basin, NU (Figure 1). At East Bay Mainland, this year marks 21 years of continual monitoring of Arctic-breeding birds, vegetation and climate by Environment and Climate Change Canada (ECCC) and partners. This site continues to be one of the most valuable long-term northern monitoring and research stations in Arctic North America. 2019 was our second field season operating the Prince Charles Island camp, and we plan to continue operating at this site over the next several years to provide a mid-Arctic reference point for collaborative studies of shorebird breeding ecology across a latitudinal gradient. We also carried out field studies in southern James Bay, in collaboration with the Canadian Wildlife Service. These James Bay sites are used by hundreds of thousands of shorebirds during their southward migrations in July - September. We did not work at the Coats Island shorebird site in 2019, although we continue to use the data collected there in previous years in our research.

Black-bellied Plover nest on Prince Charles Island

EAST BAY MAINLAND

2019 was the best of the last several years for nest survival at East Bay, with 34% of shorebird nests surviving to hatch. However, despite a better nest survival rate than in the past several years, the numbers of breeding shorebirds remain comparatively low. In 2019, we found a total of 74 shorebird nests, in comparison to an average of 100 nests per year in the early 2000s. Several species, such as the Ruddy Turnstone, have declined dramatically in abundance at this site since the late 1990's when monitoring began. Similar to previous years, White-rumped Sandpiper was the most abundant species of nesting shorebird in 2019, followed by Red Phalarope (Figure 2A). This year there were also greater numbers of Ruddy Turnstones than in 2017 and 2018, which was encouraging after several years with very few nesting pairs.

The field camp at East Bay Mainland in early June, 2019

The moderate hatching success of shorebird nests at East Bay this year was encouraging following several years of extremely poor nest survival - 12% survival in 2018, 21% in 2017, and only 4% in 2016 and 0% in 2015 (Figure 2B). We hypothesize that higher hatch success in 2019 may be attributed to several factors; for instance, the predator guild appeared different this year, with relatively more Parasitic Jaegers but fewer foxes. Foxes pose a greater threat to shorebird nests, because some species can effectively defend against Jaegers but not foxes. Another possibility is that predators were concentrated nearer to the snow goose colony at the head of East Bay, which was very active this year as opposed to last year when many geese did not nest due to poor spring weather.

This year, in addition to our normal science program, we received funding from Polar Knowledge Canada for a pilot project to develop a protocol for use by local community members to monitor goose nesting density, and we made two visits to the goose colony at the head of East Bay to test the sample design and data collection methods. Field personnel counted goose nests and measured eggs along transects within the colony. This project stems from a recommendation from the 2018 Light Goose Management Workshop (reports available at www.kangut.ca) to develop ways for communities to be involved in tracking nesting densities of geese on Southampton Island and monitoring the impacts of overabundant geese on the ecosystem. If taken up by the community, local monitoring initiatives such as this could result in employment opportunities for community members.

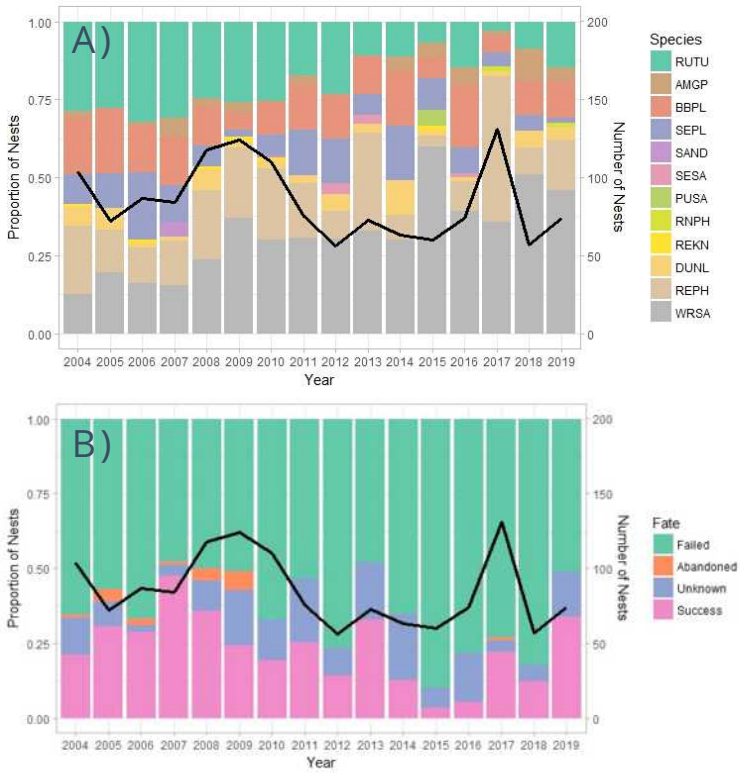


Figure 2. The number of shorebird nests monitored at East Bay (black line, both panels) in a 3 km by 4 km survey area between 2004 and 2019. Underlaid bars show species composition in panel A, and nest fate in panel B.

Snow Goose nest measured during goose density monitoring

We also continued our recapture efforts to collect geolocators that had been deployed on Arctic Terns in 2017 as part of a multi-site collaboration with other researchers throughout North America. We had deployed 20 geolocators in 2017, but only recaptured three in 2018 because of many terns' failure to nest in that year. This year we were able to recapture another six geolocators, and resighted several others that we hope to be able to recapture in future years. Data collected from geolocators deployed and recaptured at East Bay has contributed to a greater understanding of Arctic Tern migration patterns, including the use of a North Atlantic stopover site during the fall migration, and a spring migration pathway that follows the Atlantic coast of Africa northward before crossing the Atlantic towards the east coast of the United States and Canada to continue migrating back to nesting grounds at East Bay. Figure 3 shows the movement maps for two Arctic Terns that nested at East Bay in 2017 and subsequently migrated all the way to the Antarctic Ocean and back.

Right: An Arctic Tern that we recaptured at East Bay in 2019 to retrieve a geolocator that we deployed in 2017.

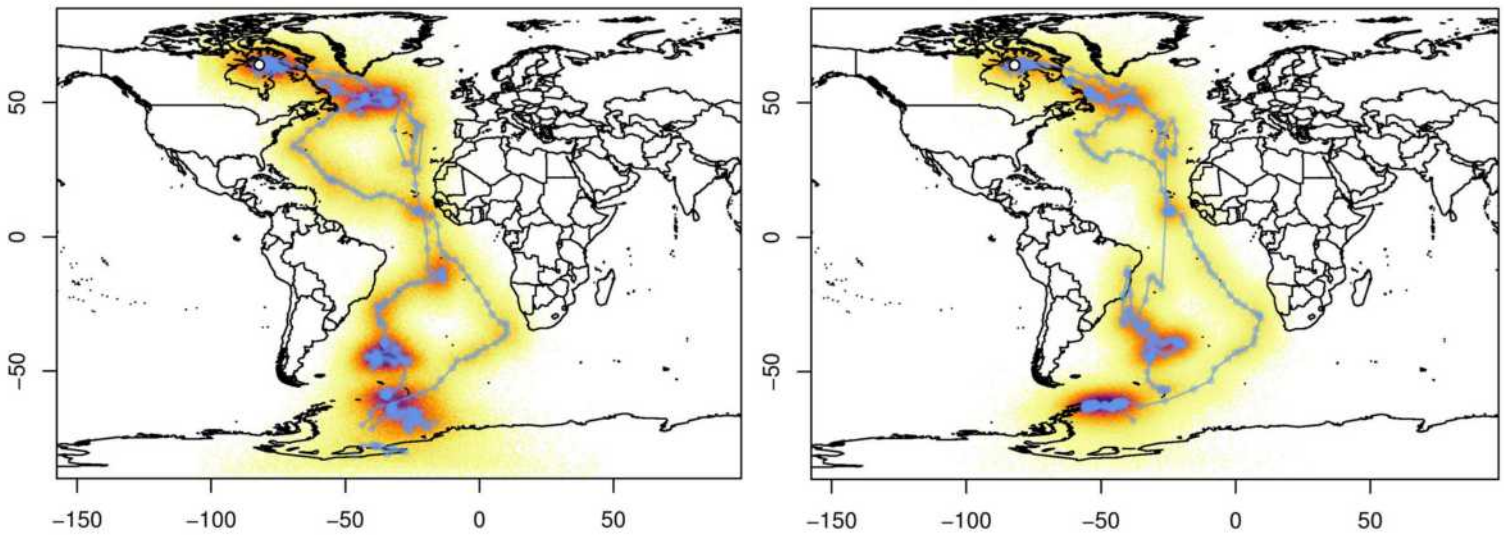


Figure 3. Migration tracks for two Arctic Terns tagged with geolocators at East Bay in 2017. Maps courtesy of Joanna Wong and Mark Mallory (unpublished data).

Above: Caribou, Snow Geese and their young share the landscape on Prince Charles Island

PRINCE CHARLES ISLAND

We developed a camp at Prince Charles Island in 2016 and carried out our first year of field work at this site in 2017. In 2019, we returned to this site and were excited to collaborate with researchers from the Centre National de la Recherche Scientifique, (CNRS, France) who had visited Prince Charles Island in 1996-1997. Together we are undertaking a comparative study of breeding bird density and habitat use by re-surveying plots that were visited more than 20 years prior. Our field crews collected data on nest abundance for several species of shorebird, including White-rumped Sandpiper, Red Phalarope, Dunlin, Black-bellied Plover, and Ruddy Turnstone, and re-visited old nest sites that had been photographed in the late 1990s to document changes to the habitat that had occurred over two decades. Notably, there was a greater density of Snow and Ross' Goose nests than 20 years ago, and the effects of increased goose abundance on the habitat was apparent in many areas that had previously been sedge communities but are now dominated by mosses. In keeping with these changes to habitat, there appeared to be lower densities of grass-nesting species such as White-rumped Sandpiper and Red Phalarope than in the late 1990s, but the abundance of upland nesting species such as Black-bellied Plover and Ruddy Turnstone seemed similar to before. We plan to return to Prince Charles Island for another season of data collection next year, which will serve to verify these observations using multi-year data.

Our crew on Prince Charles Island also assisted the Canadian Wildlife Service in conducting 10 days of helicopter surveys for shorebirds following the Arctic Program for Regional and International Shorebird Monitoring (PRISM) protocol. Plots on Prince Charles Island were among the first to be surveyed under this protocol in 1996 and 1997, and this year marked the first opportunity to re-visit some of the original plots to evaluate how shorebird density has changed. A regional-scale comparison such as this, over a period of more than 20 years, is an extremely rare opportunity to examine changes in the densities of bird populations in the Arctic.

The research camp at Prince Charles Island

During the PRISM surveys, we documented Dunlin nests on Foley Island and western Baffin Island, which are areas further north than they were expected to breed previously; potentially a northward range shift is occurring as a consequence of climate change. We also documented several large nesting colonies of Ross' Geese, previously not known to nest on the islands of the Foxe Basin, but expanding rapidly to the east and north across Nunavut.

INUIT FIELD TRAINING PROGRAM

2019 was the second consecutive year that we offered the Inuit Field Training Program at the East Bay Mainland camp. The program was initiated by Environment and Climate Change Canada in 2018 and is led in collaboration with a community based steering committee. The program was developed in response to a need expressed by Inuit communities for local opportunities for Inuit youth to engage and get exposure to training and employment opportunities in environmental fields.

At East Bay, the Inuit Field Training Program offers young Inuit an opportunity to experience living and working in a northern research camp, led by a team of Inuit mentors and scientists. In 2019, the local steering group from Coral Harbour selected eight participants who traveled to East Bay for 10 days in late July to learn about environmental monitoring techniques, skills required for living and working safely in remote research camps, educational and employment opportunities available to them in environmental fields, and Inuit traditional knowledge taught by a local elder. Following two successful deliveries of the program, we are exploring partnerships with other federal departments to expand the program in 2020.

The Inuit Field Training Program is an innovative and focused approach to address a real need – helping Inuit youth succeed in making the transition from secondary school to further opportunities. In the long-term, this initiative could make a meaningful contribution to science-based departments' achievement of their Inuit employment goals, and more generally, to the Government of Canada's objective of meaningful inclusion of Inuit in environmental research and monitoring in the North.

2019 Inuit Field Training Program participants and leaders.

PROJECT HIGHLIGHTS

Much of the work at our field sites is done in partnership with universities and other organizations. Students play an important role in our research, and we describe some of the 2019 highlights of these student-led projects below. These students and post-doctoral fellows are supervised by Paul Smith, in collaboration with colleagues at Trent, Carleton and York Universities.

Right: PhD student Christine Anderson holds a Snow Goose gosling during field work

Arctic-breeding shorebirds and snow geese: an argument for amensalism

Lisa Kennedy - PhD Candidate, Trent University

Snow Geese are increasing in abundance across the Arctic and breed sympatrically with shorebirds. However, interactions between increasing goose populations and declining shorebirds are poorly understood. Lisa's project hypothesizes that high densities of snow geese negatively impact shorebird breeding success through direct physical goose presence and the indirect effects of habitat degradation from extensive foraging or from attraction of predators. In addition to direct or indirect effects on nest survival, shorebirds may suffer other consequences from the presence of geese such as disruption of incubation behaviour, or increased levels of stress leading to poorer physical condition. Similarly, the behaviour or physiology of shorebirds could be influenced indirectly by changes in habitat quality stemming from goose foraging or increased predator abundance near goose colonies. Lisa's thesis aims to bring empirical evidence to the relative importance of each of these potential mechanisms of interaction between geese and sympatric shorebirds using East Bay and Coats Island as study sites. Lisa has completed the data collection phase of her project and is in the final year of study.

Preliminary results suggest that shorebirds have reduced physiological condition in response to degraded habitat around snow goose colonies. This reduced condition is reflected in lower size-corrected body mass for shorebirds at East Bay

versus Coats Island, where no snow goose colony occurs. There is also evidence of higher baseline corticosterone and total white blood cell (WBC) counts in shorebirds in areas near snow goose colonies, however not in several other physiological parameters such as heterophil to lymphocyte ratios, difference in baseline to heightened stress response, and the number of polychromatic cells in the blood. This demonstrates that the physiological response of individuals to habitat degradation varies, and that comprehensive assessments of condition provide a better indication of condition than any single physiological parameter.

Further evidence of the negative impact of geese on shorebirds comes from incubation behavior monitoring using time-lapse cameras, particularly outside the goose colony when shorebirds are at peak-incubation and lesser snow geese are moving around the tundra brooding their young. Screen shots visually demonstrate that shorebirds cease incubation when approached by geese in small and large family groups up to dozens of birds. Larger and more defensive species, like Black-bellied Plovers, alarm call, escort, and perform broken wing displays indicating direct disruption in daily incubation activities. Remote cameras provide insight into behavioural interactions that would not have been observed in person given the sensitivity of shorebird species during incubation and the vulnerable, flightless circumstances of goose families post-breeding.

Left: Remote camera footage showing male Black-bellied Plover (circled in red) flushing from the nest as a Snow Goose family group passes between the nest and the camera at East Bay.

Right: Increases in Snow Goose abundance is having an impact on sympatric species and Arctic environments at our field sites, and throughout the Arctic.

Above: Snow Geese in flight at East Bay

Effects of geese on predator abundance and risk of predation for sympatric-nesting shorebirds

Scott Flemming - PhD, Trent University

An important focus of our research is to understand how geese are influencing Arctic habitats and predator-prey relationships, and what this means for other birds. Overgrazing by Lesser Snow Goose populations has had adverse impacts on the suitability of shorebird nesting habitat. Risk of nest predation near snow goose colonies has also increased in conjunction with increases in the local populations of generalist egg predators. In addition to these effects, habitat change may also influence the availability of invertebrate shorebird prey items.

Scott addressed this latter research question in the final chapter of his PhD thesis, which he successfully defended in September 2019. First, Scott used DNA metabarcoding to identify the presence of prey species in shorebird fecal samples. Crane flies (Tipulidae) were the most frequently occurring prey family across all shorebird species, while flies (Muscidae) and midges (Chironomidae) also contributed to the diet of some species.

To quantify the total biomass of shorebird prey items at each study site varying with goose disturbance, we placed pitfall traps in 2015 and 2016 at sites with variable levels of goose disturbance to passively sample invertebrates. We then categorized and measured individual

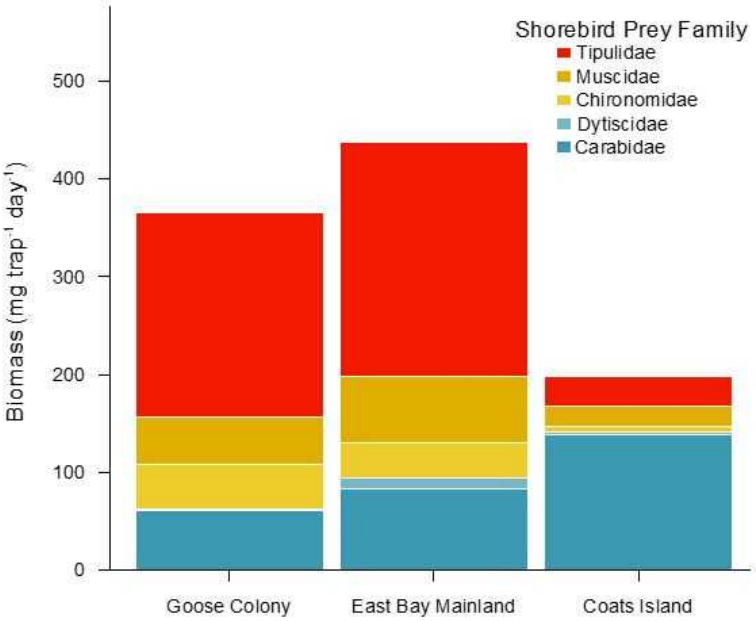


Figure 4. Estimated biomass of dominant invertebrate prey items for shorebirds measured using pitfall traps at three study sites in 2015 and 2016.

invertebrates. Total biomass was highest at East Bay Mainland (Figure 4). We believe that in places with high levels of habitat disturbance from goose foraging, invertebrate community abundance may be reduced, but sites with moderate levels of disturbance may be benefiting from nutrient input through goose feces. Overall, Scott's thesis results suggest that overabundant geese may negatively impact shorebird nest site selection and risk of predation, but increase the biomass of important prey items. However, the positive effect on shorebird prey likely does not offset the other negative effects.

Migration speed of shorebirds

Dr. Sjoerd Duijns - Postdoctoral Fellow, Environment and Climate Change Canada

Shorebirds are generally assumed to be limited more by time during spring migration compared to autumn migration. Previous studies have described these broad patterns of behaviour during spring versus fall migration; however, subtle behavioural metrics such as flight speed have been more difficult to obtain because of the difficulties of tracking animals with high temporal resolution over large geographic areas. Sjoerd's research addressed this important gap in studies of migration ecology of shorebirds using data collected through the MOTUS automated VHF telemetry network. Most studies use the behavioural metric of kilometres travelled per day to identify migration speed, however this does not account for seasonal differences in environmental conditions, such as wind, that influence flight speeds irrespective of birds' behavioural decisions. With the MOTUS network, the movements of four different shorebird species were collected on a continental scale with unprecedented temporal resolution.

Between 2014 and 2016, 1,937 radio transmitters were deployed at 13 sites distributed across North America on Red Knots, Ruddy Turnstones, Sanderlings, and Semipalmated Sandpipers. Using the conventional metric of km per day, all species completed migrations more quickly in spring versus autumn, primarily due to differences in stopover duration. However, all species had higher flight speeds (m per second) in autumn, even after controlling for seasonal differences in wind (Figure 5). These higher airspeeds in autumn allow shorebirds to migrate ahead of a wave of avian predators, which could suggest that shorebirds' autumn migration behaviour is constrained by predation pressure as opposed to time. Conversely, the results of this study demonstrate that airspeeds are not in fact "maximized" in spring; arriving at the breeding grounds in good body condition is beneficial for survival and reproductive success, and this energetic constraint might have been underestimated previously. These results reaffirm the general pattern of faster migration in spring versus fall, but by using an innovative new tracking technology with high temporal resolution, we present a new perspective on the proximate mechanisms and behavioural decisions underlying these patterns.

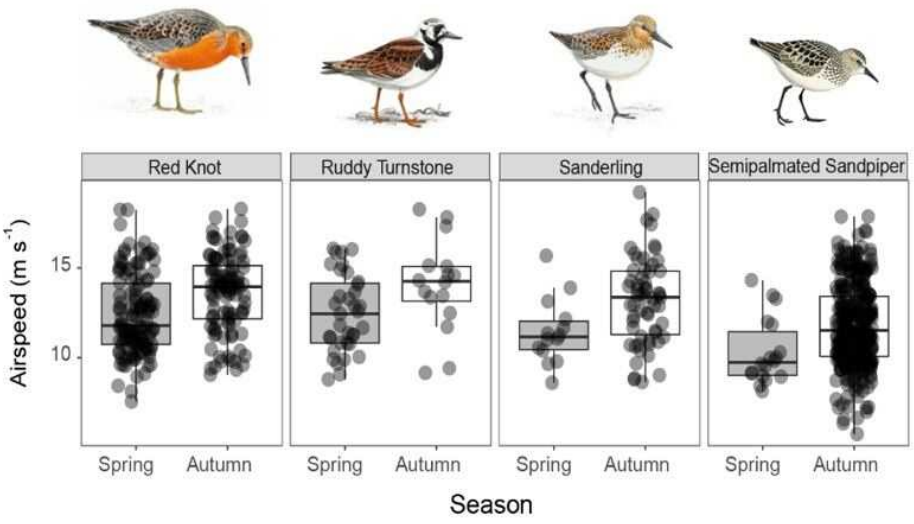


Figure 5. Spring and autumn airspeeds measured using MOTUS tracking data for four shorebird species migrating along the Atlantic flyway.

Improving migration monitoring and tracking

Dr. James McLaren - Postdoctoral Fellow, Environment and Climate Change Canada

Dr. McLaren is studying the migratory behaviour of Arctic-breeding shorebirds using modeling techniques and data from the Motus Wildlife Tracking Network for radio-tagged birds. These data provide unprecedented resolution, with hundreds of towers sampling every 6 seconds. This sheer volume of data presents unique challenges, and unique opportunities, for analysis. Dr. McLaren is using diverse modelling approaches to deduce flight trajectories, stopover durations at staging areas, and birds' behaviour in response to wind conditions.

Dr. McLaren's research focus in 2019 has been to develop mathematical models to track the movement of migrating shorebirds through three-dimensional space, to help understand how shorebirds adjust flight behaviour during migration to account for variable wind conditions along altitudinal gradients (Figure 6). When surface wind conditions were unfavourable (headwinds), migrating Red Knots were able to select flight altitudes that increased wind support. However, under favourable surface wind conditions (tailwinds), Red Knots appeared to select flight altitudes based on factors other than maximal wind support (Figure 7). This research is part of an effort to assess the exposure of Arctic-breeding shorebirds to offshore wind energy development areas along the Atlantic coast of the United States. More broadly, Dr. McLaren's research contributes to a framework for assessing migratory strategies at the individual and population level in terms of trade-offs and risk aversion, given endogenous and exogenous factors, and the extent to which phenotypic plasticity and within-population diversity allow populations to cope with environmental variability and climate change.

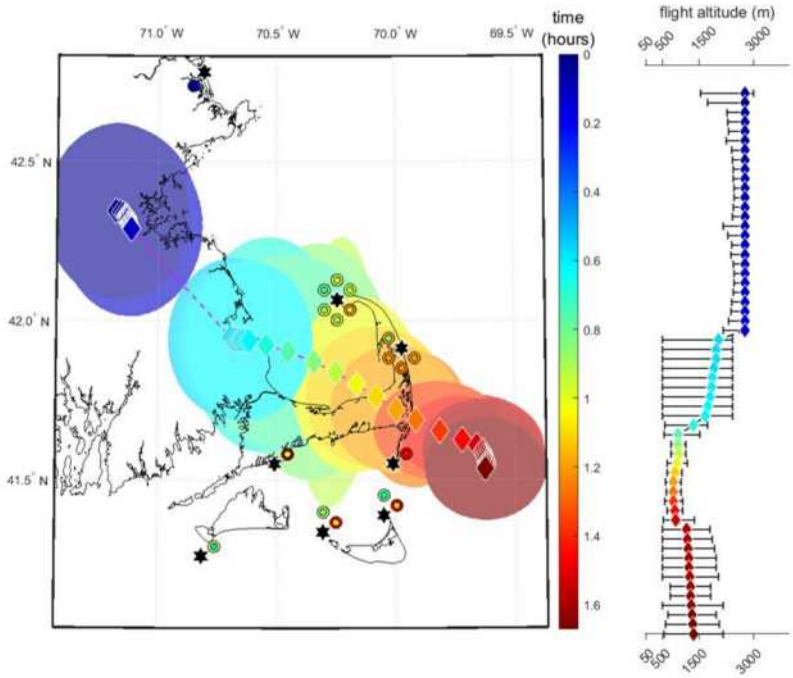


Figure 6. Example of three-dimensional model output showing the estimated trajectory of a high-flying Red Knot passing over Cape Cod on August 7, 2016. Diamond shapes depict detection events and ellipsoids depict standard error, both colour-coded for detection time. Detecting receivers are represented by black stars, with colour of inner and outer circles depicting time of first and last detection, respectively. The estimated flight altitudes for this trajectory over time are indicated in the rightmost panel. For this individual, flight altitudes ranged between 920-1210 m above sea level.

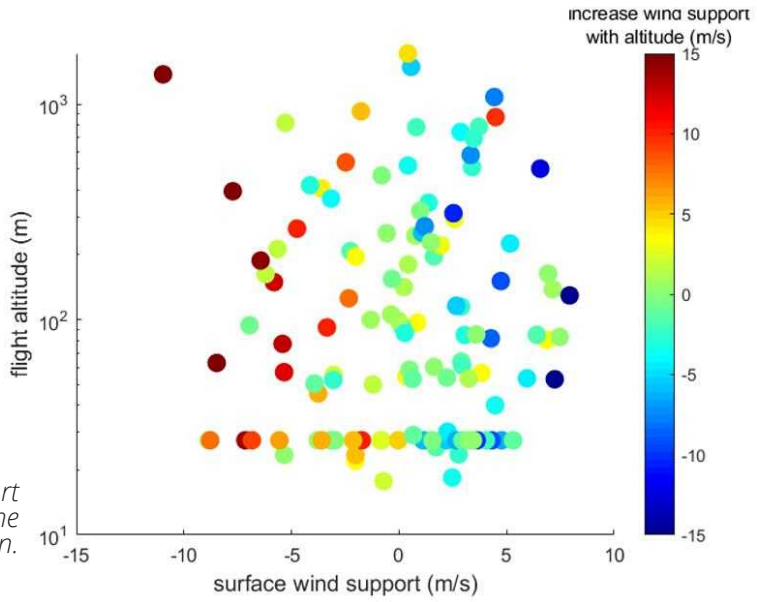


Figure 7. Effect of flight altitude on wind support (tailwinds, m/s) for Red Knots migrating across the Eastern Seaboard in autumn.

Mitigation of mining impacts on Arctic-nesting birds using deterrents

Gill Holmes - MSc Candidate, Trent University

Mining and other forms of resource development frequently result in disturbance to wildlife that is difficult to avoid. Technological options to mitigate these impacts are therefore of great interest to resource developers and conservationists alike. Gill's study is a collaboration between Trent University, Environment and Climate Change Canada and Agnico Eagle Mines Ltd. and explores options to deter birds from nesting where the tundra would be flooded due to water diversion from a mine expansion in Whale Tail Lake (90 km north of Baker Lake, NU). The Migratory Birds Convention Act (1994) prohibits the harm of migratory birds and the disturbance or destruction of nests and eggs; therefore, the company is committed to avoiding or minimizing this harm and developing mitigation strategies.

Above: Female Lapland Longspur banded during the 2019 season. This species is a common breeder in the proposed mine site.

The objective of the research is to assess the degree of risk posed to migratory birds by mining-induced flooding during the nesting period, and to determine what the most effective bird deterrents are. 2019 was the second of three field seasons for this study. Gill's team monitored 31 plots, each 6 ha in size, 8 of which were within the potential flood area around the south basin of Whale Tail Lake. Two deterrent treatments (mylar flash tape and audio deterrents) and a control were deployed across the plots for a 6 week period from early June to mid July. 134 nests of 8 bird species were found within the plots, 37 of which were found within the potential flood zone, and 6 nests suffered direct impacts from flooding (loss of an active nest containing either eggs or nestlings). The rate of nest success for unimpacted nests was 61%, as compared to nest success of 52% estimated in 2018.

Ongoing analyses will examine nest initiation dates and deterrent deployment dates in detail to determine how deterrents influence breeding decisions, and analysis of data from temperature loggers will reveal any changes in incubation behaviour between treatment and control plots. These results can help to inform mitigation activities to reduce the impacts of mining-related disturbance on breeding birds in vulnerable Arctic environments.

This past year, Gill presented at the ArcticNet Annual Scientific Meeting in Ottawa, Ontario, and the Association of Canadian Universities for Northern Studies (ACUNS) Conference held in Edmonton, Alberta where Gill received an award for Third Place Master's oral presentation. Goals for the coming year involve attending the Waterbird Society Meeting in Maryland, and providing a poster for the Western Hemisphere Shorebird Conference in Panama.

Environmental change, migratory strategies, and flexibility in the responses of shorebirds at a key Subarctic stopover site in James Bay, Canada

Alexandra Anderson - PhD Candidate, Trent University

Allie's PhD research seeks to understand how shorebirds respond to environmental change at a key stopover site during southbound migration, the southwestern coast of James Bay. While some accessible stopover sites are well-studied from a western science perspective, there are significant knowledge gaps about resource needs and risks for shorebirds at other more remote sites, such as James Bay. This research examines resource needs and risks for shorebirds at this site as well has how individuals and populations respond to changing environmental conditions.

Allie conducted field work for this project 2014 - 2018 with the James Bay Shorebird Project, which is coordinated by Christian Friis of the Canadian Wildlife Service. Allie spent 2019 preparing her thesis, with plans to defend in December of 2019. Two chapters from Allie's thesis were published recently in PLOSONE and Frontiers in Ecology and Evolution. In one chapter, the results showed that wing lengths of sandpipers are shorter, more convex, and more maneuverable at James Bay than those measured 40 years ago, which supports the hypothesis that wings shape has changed in response to increased predation risk (Figure 8). The second chapter of Allie's PhD thesis found that migratory strategies of shorebirds from James Bay could be explained by migration distance, but strategies changed for individuals with different body conditions. Additional work on annual variation in dry/wet conditions in James Bay and shorebird habitat use and diet are in preparation for publication.

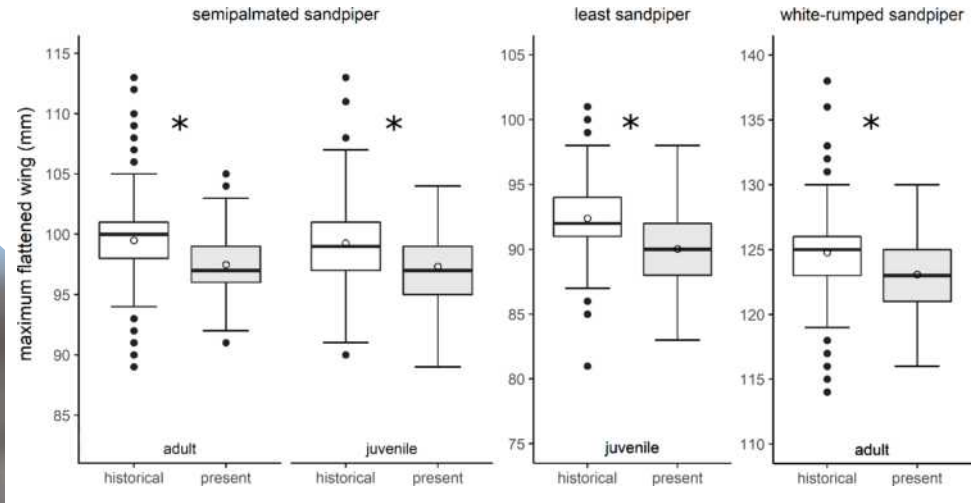
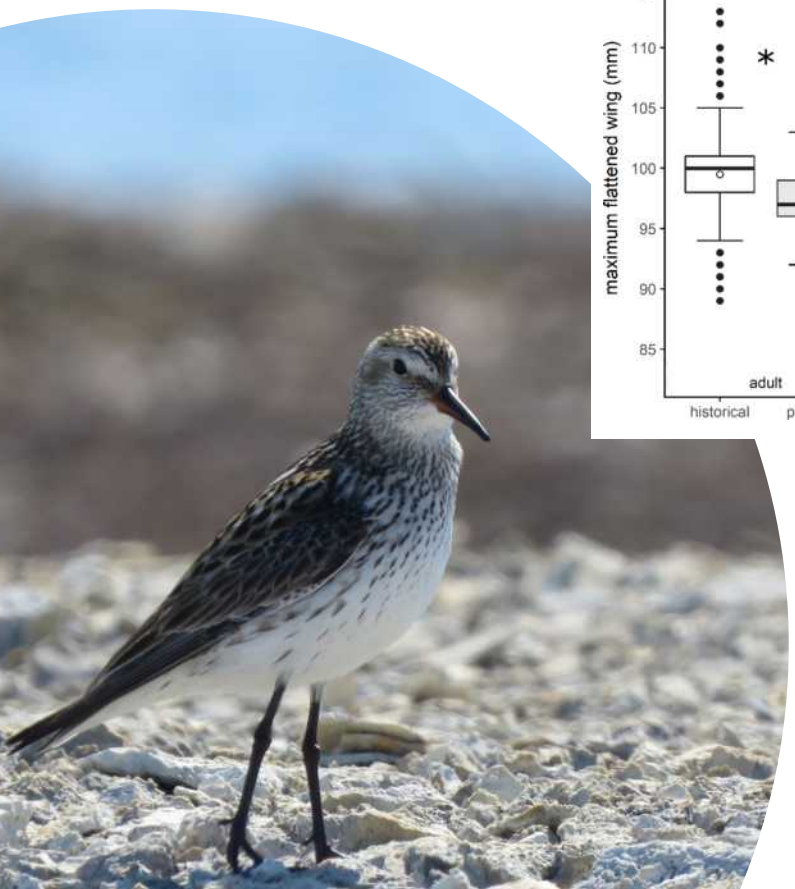


*Figure 8. Wing lengths of three sandpiper species are shorter than in the 1980s. Historical (1974–1982) and present-day (2014–2017) differences in wing lengths of semipalmated, least, and white-rumped sandpipers. Significant differences are designated with * (α = 0.05). Open circles represent model predicted least squares means. Reproduced from Anderson et al. 2019 PLOSONE.*



Left: Wing lengths of White-rumped Sandpipers are shorter than in the 1980s, which supports the hypothesis of an adaptive response to increased predation risk.

Above: a flock of Red Knots takes flight on the southwestern James Bay coast

Red Knot passage population demography in southwestern James Bay, Ontario

Amie MacDonald - MSc Candidate, Trent University

Every year, thousands of endangered Red Knots pass through southwestern James Bay during migration between Arctic breeding grounds and non-breeding areas as distant as Tierra del Fuego. To understand population declines and move towards recovery of the species, we need to study the Red Knot's full annual cycle, including investigating use of James Bay as stopover habitat for the species. Despite recording daily maximum counts as high as 6000 birds, we lack a quantitative estimate of how many *rufa* Red Knots use James Bay as a stopover site. Nearly 8% of Red Knots in James Bay have been marked with uniquely coded leg flags that can be read without recapture, and by analyzing resighting patterns of individuals and surveying adult and juvenile birds, we can estimate how many birds stage in James Bay during southbound migration, how long they stay in the area, and what proportion of staging Red Knots are juveniles.

Amie's field work for this project (2017-2018) was part of the James Bay Shorebird Project, coordinated by the Canadian Wildlife Service, Moose Cree First Nation, Trent University, and other partners. In 2019, Amie spent much of her time analyzing data and writing. She used an integrated population model to simultaneously analyze resighting and survey data and estimated that over 9200 and 13200 Red Knots used James Bay as a stopover site during southbound migration in 2017 and 2018, respectively, and spent just under two weeks in the area. Amie also developed a novel analysis method to include juveniles in stopover population estimates to enable a more complete understanding of juvenile abundance than was previously possible for Red Knots. In 2017 and 2018, 21% and 14% of Red Knots that staged in James Bay were juveniles, respectively. Overall, as much as a quarter of the total *rufa* Red Knot population may stage in James Bay in some years. Amie presented this research at the American Ornithological Society meeting in Anchorage, Alaska in June 2019. In July and August 2019, Amie returned to James Bay to work for the Canadian Wildlife Service as a crew leader at one of their remote shorebird field camps.

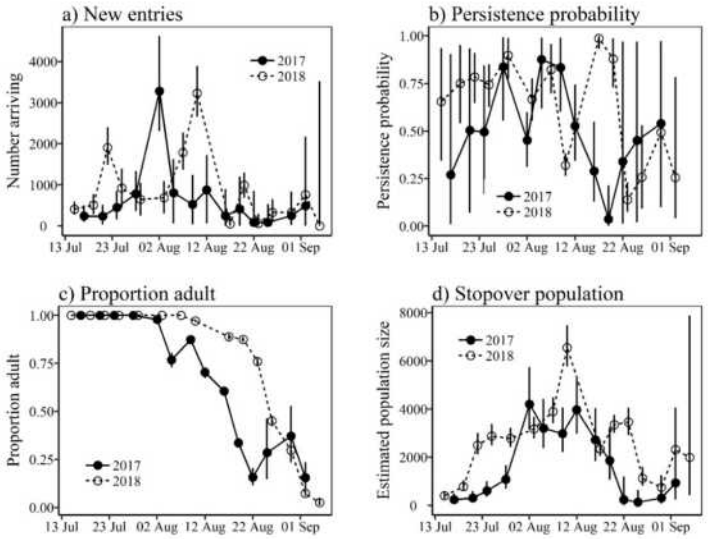


Figure 9. a) Number of Red Knots arriving in James Bay per 3-day survey period during southbound migration; b) probability of a Red Knot remaining in James Bay from one 3-day period to the next; c) proportion of the stopover population comprising adult Red Knots; and d) number of Red Knots staging in James Bay during each 3-day survey period.

Adult and juvenile Red Knots feed on invertebrates on intertidal mudflats

Carry-over effects in Arctic-breeding shorebirds

Willow English - PhD Candidate, Carleton University

Technological limitations have necessitated that many studies of migratory birds focus on only one part of their geographic range. Innovations in tracking technology have recently allowed individuals to be followed throughout the entire annual cycle, which in turn has allowed an appreciation for the importance of carry-over effects on demography and phenology. In species where tracking remains unfeasible, other methods of assessing the impacts of carry-over effects are necessary.

One such technique is using feather corticosterone (fCORT), as feathers are thought to incorporate blood corticosterone during their growth, and retain representative levels after feathers are no longer vascularized. Thus, fCORT in feathers collected during the summer can be linked to stress levels occurring during the period of feather growth, and can be compared to breeding characteristics to determine whether carry-over effects are present.

This year, Willow and her field team at East Bay collected secondary feathers from 40 individuals of 6 species of shorebird that will be analyzed to determine fCORT levels. Willow's thesis will use these data, in addition to samples collected during previous seasons at East Bay and at other sites, to investigate whether fCORT levels explain variation in breeding parameters such as nest initiation date, egg size, and daily nest survival, and to assess whether these patterns vary between geographic areas and over time. A pilot batch of feathers have been analyzed to determine which species are suitable candidates for this method (Figure 9), and a larger batch of feathers are currently undergoing fCORT analysis.

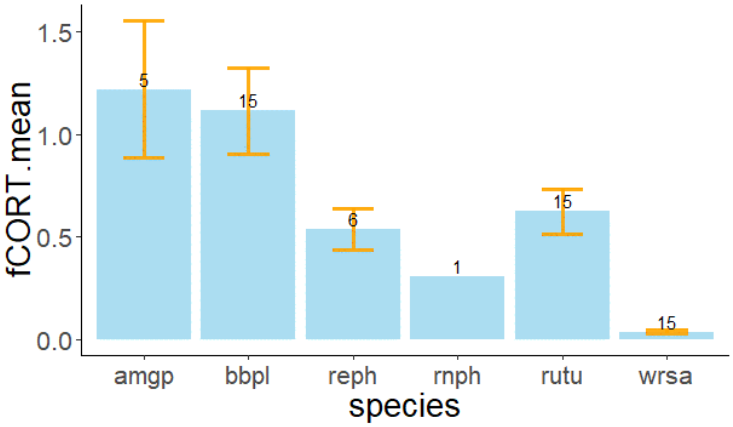


Figure 9. Levels of corticosterone (pg/mm) found in feathers of six species of shorebird breeding at East Bay.

Above: a Red Phalarope incubates its nest at East Bay

Willow presented her initial results from fCORT testing at the Western Hemisphere Shorebird Group Meeting in Panama City in October 2019, and is currently teaching Ornithology at Carleton as a contract instructor. Willow is entering the third year of her PhD program, and plans to lead an additional year of field data collection at East Bay in 2020.

How will shorebirds adapt to climate change? Factors influencing the distribution of shorebirds across the Canadian Arctic

Christine Anderson - PhD Candidate, Carleton University

Shorebirds nest in a wide variety of habitats across the Arctic landscape. However, current understanding of what habitats breeding shorebirds use in the Arctic is patchy, limited to local or regional studies. Christine's thesis aims to identify the key environmental characteristics that predict where different species of breeding shorebirds are found at the continental scale. This information will be useful for identifying how much of their total breeding habitat will be protected by conservation areas, or how their ranges may shift in response to climate change.

To understand what environmental characteristics make good breeding habitat for different species of shorebirds, Christine is comparing shorebird density data from the Program for Regional and International Shorebird Monitoring (PRISM) surveys to maps of the climate, timing of snowmelt, geology and vegetation created using satellite measurements. PRISM is an international collaboration between the Canadian Wildlife Service, the US Fish and Wildlife Service, and industry partners. Different regions of tundra habitat in Canada and Alaska have been systematically surveyed in the past 20 years, with 2018 marking the end of the first round of surveys to cover the entire region. Christine was part of the crew conducting PRISM surveys on Prince Charles Island and eastern Foxe Basin this summer.

Christine's preliminary case studies illustrate some of the similarities and differences in habitat that different species of shorebirds use. Both American Golden-Plovers and Red Phalaropes were less likely to be found in areas with acidic underlying geology, which may affect the plants and insects that they rely on for shelter and food. Interestingly, American Golden-Plovers seem to be more common in areas that were not covered by glaciers during the last ice age. This suggests that it can take thousands of years for species to move into the new habitats that appear when the climate changes.

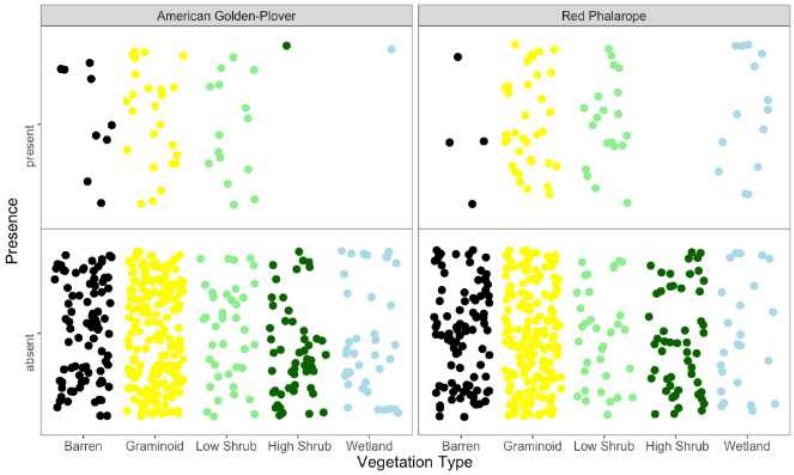


Figure 10. Dominant vegetation types of plots where American Golden-Plovers were observed to be present or absent. Each dot represents a plot that was surveyed for shorebirds in locations across the Canadian Arctic between 2004 and 2016.

Christine presented these findings at the Western Hemisphere Shorebird Group, and was awarded a scholarship from the Weston Foundation in support of her doctoral studies. In addition to her PhD research, Christine has been working to mentor Inuit youth interested in environmental issues. She helped lead ECCC's Inuit Field Training Program at the East Bay Mainland field camp this summer, and works as an academic mentor for students at Nunavut Sivuniksavut, an Inuit Studies program based in Ottawa.

Effects of resource availability on growth and survival of Dunlin chicks

Brandan Norman - MSc Candidate, York University

Long distance migrants such as Arctic-nesting shorebirds rely upon a finely tuned synchrony between nest hatching and peaks in arthropod abundance in order to capitalize on food resources and ensure growth and survival of their broods. Variation in arthropod abundance is a key driver of community structure and composition in Arctic food webs, providing a resource for many species. Shorebird chicks are mobile soon after hatch, and can forage for themselves without aid from their parents. When chicks hatch at times that do not coincide with arthropod resource peaks, this mobility may permit them to mitigate the negative effects of the mismatch in timing by taking advantage of fine scale spatial and temporal variation in arthropod abundance.

Brandan's thesis investigates the relationship between fine-scale variation in arthropod biomass and Dunlin growth and survival. Using data on local-scale arthropod biomass and Dunlin detection and growth data from Churchill, Manitoba, Brandan built survival models and home ranges and calculated spatial overlap between Dunlin broods and arthropod biomass. Preliminary results indicate that Dunlin chicks did not respond significantly to arthropod biomass; however, survival was high with an 85% probability of each chick surviving through the monitoring

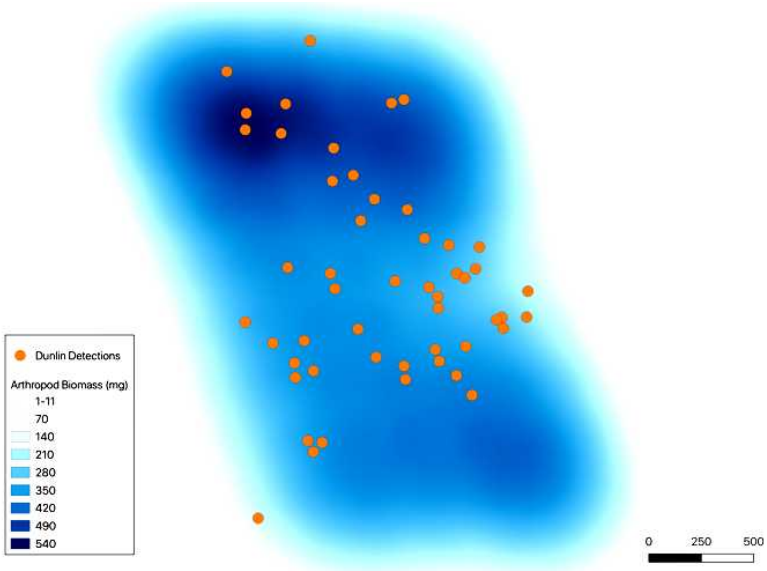


Figure 11. Detection data of Dunlin broods from Churchill, Manitoba collected in 2011 overlaid on a heat map of arthropod biomass (mg).

period. Brood home ranges averaged ~10 hectares with some home ranges having significant overlap (16 – 99%). These results suggest that prey abundance was not limiting for Dunlin broods. This research provides valuable baseline information for Dunlin early life history and survival. Future directions for this research include an examination of the factors influencing local-scale arthropod variation (chronology, weather, habitat type) and Dunlin density, to provide a greater understanding of the adaptability of Dunlin and other shorebird species to mismatches between nest hatching and peaks in arthropod abundance.

Below: A Dunlin pair foraging in sedge habitat at East Bay

Above: The ore loading dock of Baffinland Iron Mines' Mary River Project on Baffin Island.

Using PRISM data to conduct a regional analysis of the cumulative effects of mining on breeding bird densities in the Canadian Arctic

Natalie Grishaber - MSc Candidate, Trent University

As a result of increasing mining activity in the Arctic, there is a growing need to understand how the cumulative effects of mining are influencing Arctic habitats and wildlife, including shorebird densities. With the increase in alterations to natural habitat and ecosystems, there is a reduction in suitable breeding habitat for shorebird species. This could contribute to a further reduction in shorebird abundance, many of which have already declined and several of which are under consideration for listing as Species at Risk.

Natalie's thesis explores the changes in habitat and bird abundance due to mining activities using the PRISM shorebird survey dataset which provides density estimates dating back to 1994. Increased mining is expected to reduce the suitability of nearby habitats, not only through the loss of preferred habitat types, but also through the creation of "habitat" and the provision of food resources that may favour generalist predators, such as ravens, gulls, and foxes. These habitat changes could result in locally depressed nesting densities, while subsidized populations of predators could lead to regionally depressed densities of breeding birds. However, species-specific nesting behaviours and sensitivity to human presence may also play a role in how shorebird species are impacted. At this point, the magnitude of impact on range-wide populations of Arctic-breeding shorebirds is assumed to be small, given the limited footprint of mining in Canada's North. However, ongoing declines in many shorebird populations and the expanding interest in developing mineral resources in the Arctic make it important to clarify the scale of these impacts and the mechanisms through which they operate (e.g., habitat vs. predators).

In support of her MSc thesis, Natalie assisted the Canadian Wildlife Service with PRISM surveys on Baffin Island and Prince Charles Island in 2018 and 2019, with several plots located within the Mary River (Baffinland) mine property. These data, as well as the entirety of the PRISM dataset collected since 1994 at mines and undisturbed sites, form the basis of Natalie's thesis, which will examine the geospatial and temporal factors that impact the relationships between breeding shorebird densities and mine development.

INUIT PARTICIPATION

Jupie Angootealuk has worked with us at East Bay since 2013, and has proven himself as a highly effective research assistant. Jupie occupied important roles on our research teams once again this year, including as mentor/leader for the Inuit Field Training Program that took place in August at the East Bay Mainland camp.

Mark Eetuk was a keen participant in the Inuit Field Training Program at East Bay Mainland in 2018. This year, we were able to hire Mark as a field assistant at East Bay through the IFRA program, and his positive attitude and excellent work ethic made him a great fit with the field team. We look forward to working with Mark again in the future.

Lenny Emiktaut was introduced to us in winter 2017/2018, when he was trained as a community researcher as part of our IQ study exploring the effects of Snow Geese on wildlife and habitats. Subsequently, Lenny assisted us at East Bay as a field technician for several weeks during the summer of 2018, and then later he returned as a participant in the Inuit Field Training Program. Lenny joined us again for the entire 2019 field season as a valuable member of our field team, and has since secured a position with the Canadian Wildlife Service in Iqaluit as a Protected Areas Officer. We look forward to continuing to work on projects with Lenny as his career in wildlife management progresses.

Josiah Nakoolak has worked with us a guide and research assistant every year since 1997 and was recently awarded the Community Contribution to Research Award by the Northern Contaminants Program. Josiah's wisdom and guidance is essential to the safe operation of our East Bay and Coats Island field camps and he also acts as a mentor to our younger guides.

Paolassie Ottokie worked with us at Prince Charles Island as a guide and research assistant this summer. Paolassie also worked with us in 2017 during the first field season at this site, and we were happy to have him back this year as his knowledge and hard work made him a great asset to have as part of our field team.

Adamie Samayualie worked with us at Prince Charles Island as a guide and research assistant this summer. Adamie also worked with us in 2016 and 2017 when the camp was established, and we were happy to have him back this year as his help and enthusiasm for being out on the land were greatly appreciated.

Right: Paolassie Ottokie at Prince Charles Island

STUDENTS & POSTDOCS

Dr. Sjoerd Duijns recently completed a Post-Doctoral Fellowship at Carleton University where he used the MOTUS automated telemetry network to study the migratory ecology of shorebirds, focusing on the endangered *rufa* Red Knot. Dr. Duijns recently accepted a position as a Project Manager in Bird Ecology with Bureau Waardenburg BV in the Netherlands.

Dr. Scott Flemming recently defended his PhD thesis at Trent University studying the effects of increasing goose populations on the nesting habitat and food of shorebirds, and the abundance and behaviour of predators in the Canadian Arctic. Dr. Flemming has accepted a position with the Canadian Wildlife Service as a Shorebird Biologist in Delta, BC.

Dr. James McLaren was an NSERC Visiting Fellow at the National Wildlife Research Centre whose research aimed to refine the tracking abilities of the MOTUS network and improve stopover duration estimates. Dr. McLaren recently accepted a Post-Doctoral Fellowship in Math Modelling at the University of Oldenburg Institute for Marine Chemistry and Biology in Germany.

Alexandra Anderson (PhD candidate, Trent University) is studying the migration ecology of shorebirds using James Bay as a stopover site.

Christine Anderson (PhD candidate, Carleton University) is studying the effects of climate change on the distributions of shorebirds breeding in the eastern Canadian Arctic.

Willow English (PhD candidate, Carleton University) is studying the links between migration and breeding ecology for Arctic-shorebirds, in order to understand the role of "carry-over effects".

Lisa Kennedy (PhD candidate, Trent University) is studying the effects of increasing goose populations on the nesting behavior and physiology of shorebirds breeding in the Canadian Arctic.

Sarah Bonnett (MSc candidate, Trent University) joined the lab in 2019. Sarah is studying the breeding success of Lapland Longspurs across an elevation gradient in an area where mining activity will induce hydrological changes.

Natalie Grishaber (MSc candidate, Trent University) is studying the impacts of mining activity in the Arctic on breeding shorebird densities using the PRISM database.

Gill Holmes (MSc candidate, Trent University) is studying the use of deterrents on breeding migratory birds to mitigate the impacts of mining-induced flooding on migratory bird nesting success.

Amie MacDonald (MSc candidate, Trent University) is using mark-recapture methods to estimate the passage population size and annual survival of Red Knots in James Bay, to determine its importance as a staging area for Knots.

Brandan Norman (MSc candidate, York University) is studying the effects of resource availability on shorebird chick growth and survival at nesting sites on Southampton Island, Nunavut and Churchill, Manitoba.

RECENT POPULAR PRESS & OUTREACH

Barrio, IC. **Hyperabundant herbivores limit habitat availability and influence nest site selection of Arctic-breeding birds.** The Herbivory Network, January 16, 2019. *https://herbivory.lbhi.is/2019/01/16/hyperabundant-herbivores-limit-habitat-availability-and-influence-nest-site-selection-of-arctic%e2%80%90breeding-birds/*

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The Canadian Press. **Booming snow goose population affecting shorebird habitat in Nunavut, study says.** The Globe and Mail, March 5, 2019. *https://www.theglobeandmail.com/canada/article-booming-snow-goose-population-affecting-shorebird-habitat-in-nunavut-2/*
Derivatives of this piece were published by the National Post, Toronto Star, CityNews, CTV News, 24News.ca, Edmonton Journal, Yahoo News, Reston Recorder, Medicine Hat News, and on several radio shows nation wide.

Brisson-Curadeau, E. **Curious Coats Island.** UpHere, November 5, 2018. *https://uphere.ca/articles/curious-coats-island*

Kobilinsky, D. **Overabundant snow geese graze through shorebird habitat.** The Wildlife Society, April 2, 2019. *https://wildlife.org/overabundant-snow-geese-graze-through-shorebird-habitat/*

In response to the publication of the article "**Decline of the North American avifauna**" in Science in September 2019, there were more than 300 news articles published worldwide, and the media response is in the top 5% of all articles tracked by the website Altmetric. (*https://www.altmetric.com/details/66844566*). In addition, Paul Smith and other co-authors did 17 radio interviews in the week following the release of the article.

RECENT SCIENTIFIC PUBLICATIONS

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Duijns S, AM Anderson, Y Aubry, A Dey, SA Flemming, CM Francis, C Friis, E Nol, J Rausch, PA Smith, et al. 2019. Long-distance migratory shorebirds travel faster towards their breeding grounds, but fly faster post-breeding. ***Scientific Reports*** 9: 9420

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Above: A White-rumped Sandpiper hovering at East Bay

RESEARCH PARTNERS AND FINANCIAL SUPPORT

The research projects described in this report are a combined effort of many people and organizations. Dr. Paul Smith (Environment and Climate Change Canada, ECCC) leads the program together with key collaborators Dr. Erica Nol (Trent University), Jennie Rausch (CWS), Christian Friis (CWS), Dr. Grant Gilchrist (ECCC), Dr. Jean-Louis Martin (CNRS), Dr. Tanguy Daufresne (CNRS), and Dr. Pam Loring (USFWS). Technical leadership and coordination is provided by Doug MacNearney (ECCC), with assistance and support in 2019 from Holly Hennin, Bronwyn Harkness, and Bonnie Taparti (ECCC).

These projects are logistically complicated and labour intensive, requiring a large, dedicated crew of students and biologists. Our East Bay Mainland and Prince Charles Island field crews in 2019 included Christine Anderson, Jupie Angootealuk, Dr. Tanguy Daufresne, Lenny Emiktaut, Willow English, Natalie Grishaber, Ariel Lenske, Doug MacNearney, Dr. Jean-Louis Martin, Josiah Nakoolak, Sarah Neima, Paolassie Ottokie, Julia Prokopick, Adamie Samayualie, Brian Smith, and Dr. Paul Smith.

Research in Canada's north is expensive and funding for this work is necessarily provided by a network of partnerships that includes but is not limited to: Environment and Climate Change Canada Wildlife Research Division, the Canadian Wildlife Service – Northern Division, The Bureau of Ocean Energy Management, The United States Fish and Wildlife Service, Trent University, Carleton University, Polar Continental Shelf Program, ArcticNet, the Nunavut Wildlife Management Board via the Nunavut Wildlife Research Trust, Agnico Eagle Mines Ltd., Baffinland Iron Mines, Northern Scientific Training Program, Polar Knowledge Canada, CanNor, Institut Polaire Français Paul-Émile-Victor (IPEV), the Natural Sciences and Engineering Research Council, and the W. Garfield Weston Foundation.

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