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Abstract

During my Wonder Expo I compared how the different months of the year affect when snowy owls travel, and how far they travel. To find my answer, I used coordinates obtained through GPS satellite tagging, collected by Project SNOWstorm (a non-profit organization focused on protecting and learning about snowy owls) and calculated the distance between them.

I found that there was a clear connection between when snowy owls traveled, and the different times in an owl's life (wintering, breeding, and migrating). My two study owls (Otter (male) and Columbia (female)) both appeared to migrate at night, which contradicts what some scientists believe about the snowy owls' behavior. When in their wintering grounds, they appeared to both be more active during the daytime, rather than at night. During the breeding season, they appeared to not follow any discernible pattern, as the data showed no distinct similarities.

I also found that the snowy owls appeared to start migrating during the month of April, stopped in July, and started up again during September.

Introduction

Purpose

I chose my Wonder Expo topic because of my love for birds. When I was reading 'A World on the Wing' by Scott Weidensaul, I saw a line referring to Project SNOWstorm, an organization that he had created, which focused on researching snowy owls. Instantly I knew what I wanted to do for my Wonder Expo, as my prior brainstorming had come up empty. I am glad I chose this topic because I have not only learned a lot about snowy owls, I have also become even more fascinated with all birds in general. In the following pages, I hope you will become as interested in birds as I am. I hope that this research will help scientists better understand the snowy owls' migrational movement as well as their behavior.

Background Research Paragraph #1

(what we know)

Through the background research process, I have developed a better understanding of the majestic snowy owl. I have found that there has been a lot of research conducted on the behavioral and migrational aspects of the snowy owl's life.

Scientists have long thought that snowy owls are diurnal (meaning they are active only in the day) but due to new information, some people are starting to question if snowy owls are completely diurnal or only partly so. Whatever the case,

snowy owls are more active at dawn and dusk. This is relevant to my Wonder Expo topic as I am looking at when (during the day and night) snowy owls are most active in the different months of the year. It surprised me to learn that snowy owls do not all migrate, and that some will stay near their breeding grounds during the winter months. The owls that migrate will leave their breeding range in November/December, and travel south to southern Canada or northern USA. When spring arrives, they will travel north towards the arctic circle to breed. I was also surprised to learn that snowy owls behave differently from year to year. Some years they will be nomadic during the winter and travel large distances in pursuit of prey. Other years they will stay almost in the same spot. This change in behavior normally depends on the amount of prey in the area rather than age and sex. Food is important to all living things, and snowy owls have evolved to have three main hunting strategies: flying, perching, and ground hunting. Perching triumphs over the other strategies as it is roughly 14 times more effective at catching prey than ground hunting, and 132 times more effective than flying. This might explain why snowy owls use perching the most out of all the hunting strategies. Perch hunting is conducted by sitting on top of a pole or tree, and then taking off to capture prey. It is obviously more energy efficient than stomping around and looking for prey (i.e., ground hunting) or flying over large areas to find victims (i.e., hunting while flying).

Currently, a few organizations are trying to better understand these mysterious arctic visitors. One of these organizations is called Project SNOWstorm, which is a non-profit organization that GPS tags snowy owls to better understand their behavior and migration routes. All in all, the background research process has only deepened my awe and love for these wonderful birds.

Background Research Paragraph #2

(what we don't know)

There isn't much that scientists don't know about snowy owls as they are a well researched species. That being said, during my research on snowy owls, I found that although there have been many extensive studies done on snowy owls in their wintering grounds, scientists still know little about their activity in their breeding grounds. Although I won't be able to learn much about this in my project, I will still be able to analyze the data showing the distances that snowy owls travel during this time. Scientists also don't really know anything about the snowy owls' social behavior. They have reported that young males sometimes congregate in small groups, but have never observed them playing. Even though it is possible (and likely) that snowy owls aren't social at all, this is still an area in which not much is understood. Another gray area is the snowy owl population. While it sounds easy to figure out, it has posed a problem for scientists for a long time. The reason for this is due to the fact that snowy owls can migrate between North America and Eurasia. This means that an owl which is found in Canada one year, could turn up in Russia the next. Through my analysis of the data from Project SNOWstorm, I hope to discover the answers to two other questions that remain unknown: (1) how do the different months of the year affect when snowy owls travel and how far they travel? and (2) whether this changes based on the gender of the owl. My hope is that throughout my Wonder Expo I will be able to find an answer regarding these questions. In conclusion, although the snowy owl is a well researched species, there are still areas where we can learn more about it.

Background Research Paragraph #3 + #4

(Additional Information)

When researching snowy owls I came across an interesting piece of information which doesn't really belong in the two categories above. It has to do with snowy owl irruption years. An irruption year is when there is an abrupt increase in the population of an animal species. Every once in a while there are large influxes of snowy owls in their wintering grounds. During those years, birders have reported huge numbers of snowy owls in places where they wouldn't normally be. The next year, there were reports of dramatically fewer snowy owls in the same area. The reason why this happens has puzzled ornithologists for a long time, but it appears they have now come to a conclusion. They believe that the snowy owl population is tied to the lemming population. Lemmings are the snowy owls' main food source in the summer months. The problem with lemmings is that their population varies dramatically over different years. When there are lots of lemmings, snowy owls will have lots of food to feed their young, leading to a lot of baby snowy owls. When there are few lemmings, snowy owls might not breed at all due to the shortage of food. To recap, during my research I have learned that the snowy owl population is tied to the lemming population.

Another interesting piece of information I discovered relates to how birds migrate. How do birds know where to go? This question puzzled ornithologists for a long time. At first, scientists believed that birds had a piece of magnetic metal in their bill, which enabled them to sense the magnetic fields of the earth. This was incorrect.

When they reached the correct answer, it was so otherworldly that most scientists didn't believe it. The answer was quantum entanglement, a form of quantum mechanics. Quantum entanglement does seem a bit far-fetched when you think of it. Quantum entanglement dictates that if two protons or electrons are entangled, they will be forever connected. This means that if one of them is spinning, the other is doing the same thing, even if they are separated by large distances of space. Even Albert Einstein (who discovered quantum entanglement) was scared of it, dubbing it "spooky actions at a distance". Why does this relate to birds you might ask. Inside the migratory bird's eye there are entangled electrons. When a blue photon of light comes into the eye it pushes these electrons apart from each other. The slight difference of distance between the entangled electrons causes the bird to see the magnetic fields of the earth. It's like having an internal GPS system enabling the bird to know where to go even when it is in unknown territory. In conclusion, over the course of history, birds have evolved an incredible ability to aid them with migration.

Interview with Scott Weidensaul

Before we get too far in with this interview, I would like to introduce our guest Scott Weidensaul. Scott Weidensaul is both an ornithologist as well as an author, who is very interested in the natural world, particularly bird migration. He has written many books (roughly 30) including one of my favorites: A World On The Wing, which focuses on all aspects of bird migration. I love it because it not only is interesting to learn from, it is also fun to read.

As an ornithologist he has banded Northern Saw-whet owls, as well as other species, and has created Project SNOWstorm. Another of his accomplishments is that he is one of the 200 ish individuals in North America who are allowed to band hummingbirds. Now, here is my interview with Scott Weidensaul.

Q. How can we help snowy owls?

A. In big-picture terms, one of the most important changes would be reining in climate change, since the Arctic is warming faster than anywhere else on the planet, and snowy owls already breed as far north as one can go. They have no room to shift even farther north. And their summertime prey, lemmings, are very sensitive to changing winter climate. (Ironically, warmer winters are bad for them, because the snow isn't as deep, fluffy and insulating.)

On a more individual scale, though, one of the most important things to do is just give a snowy owl space. Because they are so big and beautiful (and can sometimes

be remarkably approachable, especially young owls who have never encountered humans before), and because they're often roosting in the open, people frequently crowd and harass them, even without meaning too — photographers trying to get a good picture, birders trying to get a close look. As a result, snowy owls in accessible places like beaches and coastlines often get pushed from place to place all day long, never having a chance to rest. Sometimes they get chased into traffic.

Under no circumstances should anyone ever try to feed a snowy owl, which unfortunately some photographers do, throwing them live pet-store mice to get action pictures. This teaches the owl that humans are a source of food, and can bring them into even closer contact with people who may harm them.

Q. How do their migrational routes/activity patterns change over the different years?

A. That's a complicated question, because snowy owls are complex creatures. Some individuals return every winter to the same small territory in the south, while others wander hundreds (sometimes thousands) of miles from one year to the next. A few don't migrate at all, but remain in the Arctic through the winter. The biggest changes we see from year to year, though, involve the overall numbers of snowy owls in any given region. Roughly every four years we usually see a big spike in the number of owls coming south, called an irruption. Generally, these irruptions are the result of a population boom in the hamster-like lemmings the owls hunt in summer in the Arctic, and the lemming boom means a boom in young snowy owls.

Q. Where is the largest concentration of snowy owls when they are in their wintering grounds?

A. In North America, the places that most consistently have large numbers of snowy owls in winter stretch from the northern Great Plains in the western U.S. and Canadian prairies, east around the Great Lakes, along the Ottawa and St. Lawrence river valleys in southern Canada, and along the coast of Atlantic Canada and New England. Less regularly, you'll get large numbers maybe once a decade along the Pacific Northwest coast.

Q. When do you think we will have the next major irruption year?

A. That's the million-dollar question! We had a decent irruption in eastern North America in the winter of 2021-22, so I'd expect another in three or four years (2024-'25 or '25-'26) but there's always the chance of a big lemming explosion somewhere in the Arctic that produces a bumper crop of owls sooner. The Northwest is overdue for an irruption. The *really* big irruptions are impossible to predict. The mega-irruption we experienced in 2013-14 in the East was the biggest since at least 1926-27, and maybe as far back as the 1890s. But you never know, which is part of the excitement.

Hypothesis

If we compare when and how far snowy owls travel in relation to the different months of the year, then we will find that they will be active (meaning how far they travel) earlier in the summer and later in the winter. We will also find that they will travel greater distances during the months of June and December while barely traveling during July.

This is because snowy owls are thought to be diurnal and most active at dawn and dusk. This means that when the days lengthen they should be active earlier in the morning and later in the evenings. When the days shorten they will be active later in the morning and earlier in the evenings.

Because snowy owls migrate from the high arctic down to southern Canada during the months of June and back up to the arctic in December, we will see a spike during these months.

Snowy owls breed during July meaning that they should stay in the same spot for most of the month (more so in females as they have to guard their eggs). This should translate into a decrease in the amount they travel.

Meet the Owls

Photo of Otter by © Tom McDonald

Otter

Otter is an adult male snowy owl tagged in Northern New York.

Photo of Columbia by © Monica Hall

Columbia

Columbia is an adult female snowy owl tagged in Wisconsin

Procedure and Materials List

Materials list:

- Computer/Electronic device (preferably one with lots of memory).

Wonder Expo Procedure

In my procedure, I am gathering the data for when the snowy owls travel during each hour for every Saturday of the year 2022 for both Otter and Columbia. This translates into 2544 data points. I find the sunrise/sunset times for each month based on their location (24 data points), as well as how far they travel during each month (the location between their original location, to their end location) (24 data points).

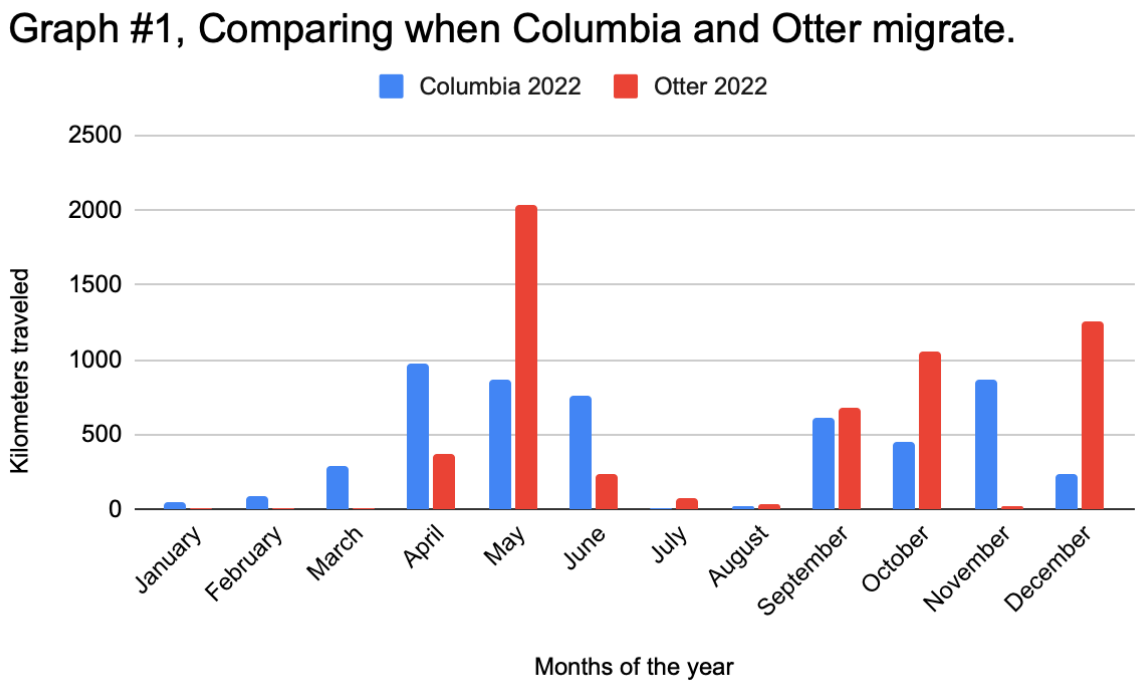
1. Contact Project SNOWstorm and ask for Otter and Columbia's data sheet.
2. Open up the data sheet for Columbia.
3. Find January 1 2022 on the data sheet.
4. Copy the coordinates of 6am
5. Open up another tab on your computer.
6. Go into google maps.
7. Paste the coordinates you copied in step 6 into google maps.
8. Open up another tab on your computer.

9. Type https://en.wikipedia.org/wiki/Time_in_Canada#/media/File:Canada_time_zone_map_-_en.svg into the search bar.
10. Compare the time zone map with google maps.
11. Find the time zone the coordinates are in.
12. Find the conversion from Universal standard time to the time zone you just found.
13. Convert 12 am in the coordinated time zone to UST (universal standard time) to find time H1.
14. Copy the coordinates of time H1 (please note that the time will not be perfect, and you will have to round the number to the nearest hour. Also look out for times when they give you the coordinates every 30 min or even 8 min, ignore these).
15. Type https://boulter.com/gps/distance/?from=&to=&units=k into the search bar.
16. Paste the coordinates of time H1 into the 'From' box in the coordinate distance calculator.
17. Go back onto the data sheet for Columbia.
18. Find the hour after H1 (H2).
19. Copy the coordinates corresponding to hour: H2.
20. Paste the coordinates of hour: H2 into the open box in the coordinate distance calculator.
21. Calculate the distance.
22. Record the distance you calculated.

23. Go back onto the data sheet for Columbia.
24. Find the hour after H2 (H3).
25. Copy the coordinate corresponding to the hour: H3.
26. Repeat steps 20 - 23 but with H3 instead of H2.
27. Repeat steps 22 - 26 but with the hours H4 all the way to H24.
28. Open up another tab on your computer.
29. Find a calendar of 2022.
30. Find next Saturday (eg. January 8, 2022).
31. Repeat steps 4 - 27
32. Repeat steps 29 - 31 until you have finished the month.
33. Go back to the data sheet for Columbia.
34. Find January 1 and copy the coordinates at 6am.
35. Go to google maps.
36. Paste the coordinate you copied in step 34.
37. Compare the time zone map with google maps.
38. Find the time zone your coordinate is in.
39. Convert 12am in this time zone to UST (universal standard time)
40. Copy the corresponding coordinates to the hour you found in step 40.
41. On a different tab type in https://www.timeanddate.com/sun/ into the search bar.
42. Paste the coordinates into the Sunrise, Sunset calculator.
43. Find the Sunrise and Sunset times of January 1.
44. Record the Sunrise and Sunset times.
45. Go back to the coordinate distance calculator.

46. Paste the coordinates you copied in step 41 into the coordinate distance calculator.
47. Go back to the data sheet for Columbia.
48. Find the last day of January (January 31) and copy the coordinates at 6am.
49. Go to google maps.
50. Paste the coordinate you copied in step 48.
51. Compare the time zone map with google maps.
52. Find the time zone your coordinate is in.
53. Convert 11pm in this time zone to UST (universal standard time)
54. Copy the corresponding coordinates to the hour you found in step 53.
55. On a different tab type in https://www.timeanddate.com/sun/ into the search bar.
56. Paste the coordinates into the Sunrise, Sunset calculator.
57. Find the Sunrise and Sunset times of the last day of January (January 31).
58. Record the Sunrise and Sunset times.
59. Go back to the coordinate distance calculator.
60. Paste the coordinate you copied in step 54.
61. Calculate the distance between the coordinate from step 40 and from step 54.
62. Repeat steps 17 - 61, 11 more times but with the different months (February through December).
63. Repeat steps 2 - 62 but with Otter instead of Columbia.
64. Congratulations you have finished.

Snowy Owl Data Analysis



This graph compares how far Columbia and Otter travel over the different months of the year.

I have learned a lot during the process of the Wonder Expo. In my graph #1 (see below) I compared when and how far my 2 study owls (Otter (male) and Columbia (female)) traveled. Looking at the data, we can see that the different owls appear to follow the same time pattern, migrating in the spring towards their breeding range, and south again in the fall. It appears that Otter decided to start migrating later than Columbia. Whether this was due to their different genders I cannot tell, though it is more likely that individual snowy owls don't migrate at the same time. Nevertheless, I still find it weird that Otter waited 2 whole months before starting after Columbia (this being said, Columbia didn't migrate too far during February).

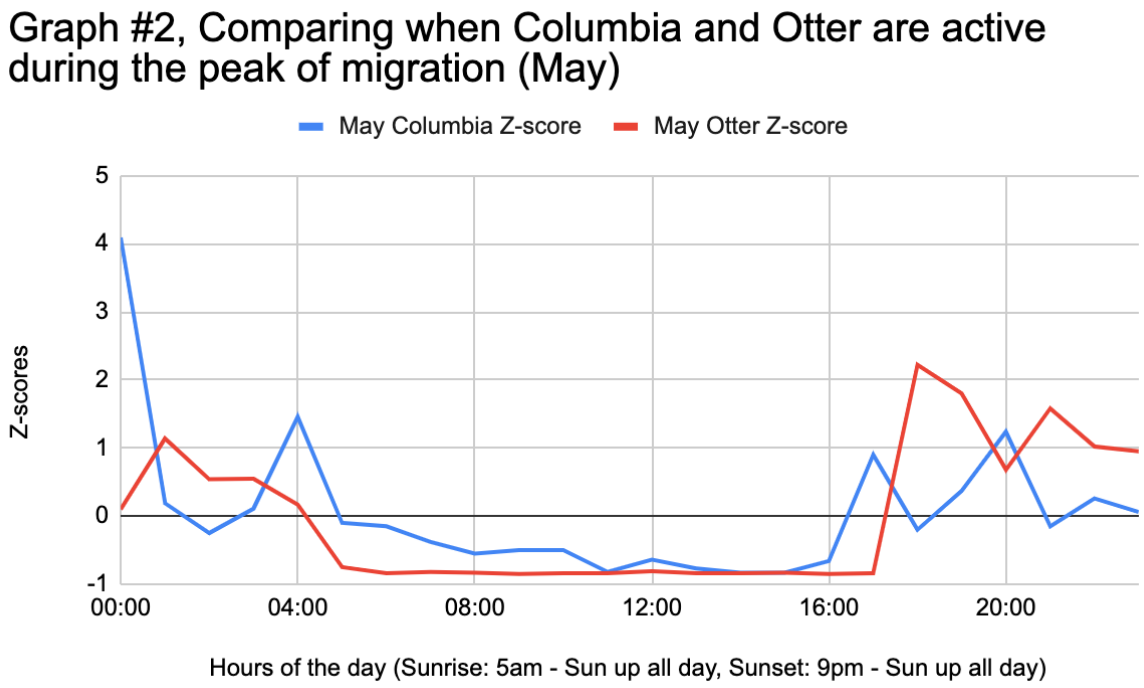
Although the two owls followed a clear pattern during their spring migration, coming back was a different story. They both started flying south in September (after barely moving in July and August (more so in Columbia than Otter, most likely due to the fact that Columbia seems to have nested, and had to guard the nest)) both traveling roughly 600 kilometers. In October they appeared to still be migrating (Otter traveling farther than Columbia) but this changed in November. As we can see on the graph, Otter barely moved in November, traveling a distance of 24 km. I would have assumed that he had stopped migrating altogether (quite a probable answer) except that his migration picked up again in December, traveling over 1000 km in a month. If he was still in migration, then why would he waste time in stopping over at Polar bear provincial park in Northern Ontario. The most likely reason is that he found a high amount of food there, quite probable due to the open habitat. Data from iNaturalist shows that most of the Snowy owls' regular prey resides in the park, including ptarmigan, grouse, small passerines, shorebirds, foxes, and seabirds such as grebes and loons. Using this information, I believe that the most likely reason for this low in migrational activity is due to the abundance of prey, which a weary owl can't ignore. This would also explain the upwards spike in December, as Otter would likely be behind schedule, but full of energy, enabling him to travel farther. Columbia on the other hand had a substantial drop in December, most likely due to the fact that she was reaching her wintering grounds as she traveled only 2 kilometers between the end of December to midway through February the next year. Of course I wasn't really there with the two owls during their migration so it is hard to tell exactly what was happening.

Map comparing the migrational movement of Otter and Columbia.

Using what I talked about in the large paragraph above, we will turn to the map displaying the migration routes of both Otter and Columbia. Instantly we can see that although they winter far apart from each other (roughly 1300 km) they spend their summer within 400 km of each other. Although this still sounds like a lot, it is actually a 70% decrease in the distance between them. This means that although they winter far apart, the patch of land around Taloyoak (in Nunavut) might be important for snowy owls.

Something else interesting is that both Otter and Columbia (more so Columbia than Otter) return to almost the exact same wintering grounds, the next year. This is pretty crazy when you realize that they have no GPS device and not even a physical map. It gets even more amazing when you look at exactly how far away the breeding

grounds are from the wintering grounds. For Columbia this is 2075 km, while for Otter it's 2441 km. And to think that they return to an area relatively close to where they began (180 km for Columbia, and 480 km for Otter). I know that this sounds like a large amount but take into account the fact that they traveled 2000'ish kilometers to get there. Obviously they would stray a bit off course, and end up a bit off of where they had wintered last time. Currently scientists believe that snowy owls don't have a fixed wintering ground. Although this might be true, we can still see that they travel back to the same vicinity, and not somewhere completely different. This could mean that although snowy owls might not have a fixed wintering ground, they might always return nearby, like what we see in Otter and Columbia. Obviously this has to be studied further as these cases could be outliers. To figure this out I would use a larger data set with more owls and more years.

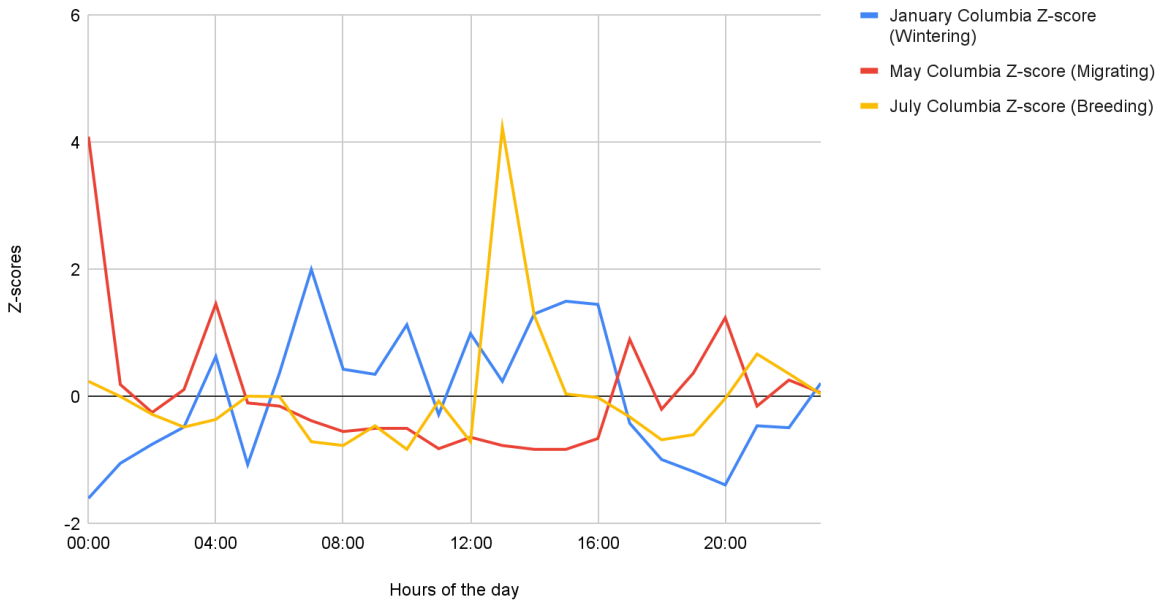


Graph comparing when Columbia and Otter are active during migration.

In graph #2 I decided to compare the Z-scores (a Z-score is the amount of standard deviations a certain point is from the average, calculated by the formula (x - average)/the standard deviation) of Otter and Columbia with the time of day (measured in hours not position of the sun). I had chosen a line graph because I am dealing with a trend over a period of time, most suited for a line graph. We can quickly see that they appear to have the same trend, with a higher Z-score before and around Sunrise and Sunset, while quite low during Midday. As graph #2 is of their activity during mid migration, we can easily see that the bulk of their migration is done when there is little light. This is especially astounding due to the fact that scientists have long thought that snowy owls are almost completely diurnal (that being said, Project SNOWstorm and other science organizations don't agree with this theory). My findings completely contradict the scientists' point while agreeing with Project SNOWstorm's belief, and show that even one of the most diurnal of all the owls, is still more active in migration around nighttime. That being said, most birds migrate at night because of the cooler atmosphere (which means they lose less water), meaning that snowy owls are another of these birds.

Even the fact that they have the same trend is pretty astonishing as well. Although the vast majority of birds migrate at night, scientists haven't looked far into whether all birds follow the same timer. Graph #2 shows that the two snowy owls I tracked follow roughly the same trend, even though they are of different genders. Additionally, they appear to start and end each days migration at roughly the same time (+/- 1 hour) even though they are in vastly different areas and even different time zones (which might explain why we have a slight discrepancy in the data).

Graph #3, Comparing how the major moments of Columbia's life in 2022 (wintering, migration, and breeding) have an effect on when they're active.



Graph comparing how Columbia's activity pattern changes based on the different major moments of Columbia's life in 2022.

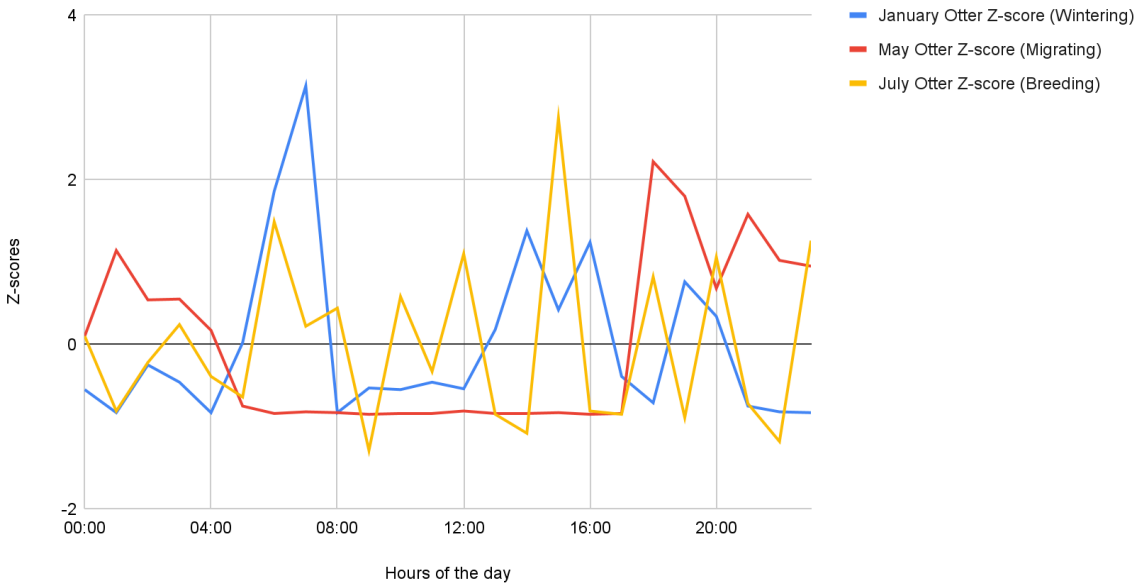
In graph #3, I am comparing how Columbia's activity changes during migration, breeding, and wintering. I used Z-scores to represent how active (how far she traveled) Columbia was, and chose a line graph due to the fact we are dealing with time. Quite quickly, we can see that there is a distinct difference between January and May. Columbia seems to be more active during the day, and less so at night during the month of January, but appears to be more active at night, and less so during the day in May. These dramatic changes in behavior are most likely due to what the owl's ultimate goal is during the month. In January, the goal is to find as much food as possible to stock up fat reserves for migration. When in their wintering grounds, snowy owls can either hunt at night or during the day. Looking at the graph, it is unclear if Columbia is hunting at night, or during the day, but I think she hunted at night for the following reasons. The

upwards spike in activity during the day could simply mean that she is moving to better hunting grounds so she will be ready to hunt when night comes around. While it is possible she hunts while flying, this method is not only more energy consuming than her favorite hunting strategy (perch hunting), it is also less effective. A different possibility is that Columbia does hunt during the day, but takes multiple short flights in between, which comes up as a spike in the graph. During the month of May on the other hand, although it is obvious that Columbia migrates at night (when it is substantially cooler), I am unsure what exactly she does during midday. Almost no studies have been conducted on what owls do during migration, so I don't have much evidence to find the answer. When snowy owls are wintering, studies have shown that they appear to loaf at around midday. This means it is entirely possible that that is what she is doing. The other possibility is that she is perch hunting. This is also a probable explanation because she would most likely be weary from the long flight and would need to regain energy.

Currently I have just compared Columbia's activity in the wintering grounds and migration, but have not touched on what her activity is during the breeding season. Looking at graph #1, we can see that Columbia barely moved during this time period, going a total distance of 0.64 km. This probably means that she is nesting during this time period. Now back at graph #3, we see that Columbia barely moves between 7am - 10am. This could mean that she is sitting on the nest during this time. We can also see that her activity spikes at 1pm. This is either an outlier, or a quick food run. Personally I believe this is most likely because of an outlier. Male snowy owls bring food for the young and their mates so it is improbable that Columbia flew far away from the nest, when she could have her food delivered to her. It is also possible that owl pairs may

take turns foraging for food, and which has gone unnoticed by scientists. It is also possible that Columbia did not nest, and instead stayed within a small perimeter for a long period of time. This would explain why she moves a little, but not much during the month of July.

Graph #4, Comparing how the major moments of Otter's life in 2022 (wintering, migration, breeding) have an effect on when they are active.



Graph comparing how Otter's activity pattern changes based on the different major moments of Otter's life in 2022.

In graph #4, I am comparing how Otter's activity (how far he flies) changes during migration, breeding, and wintering. I used Z-scores to represent how active (how far he traveled) Otter was, and chose a line graph due to the fact we are dealing with time. If we compare this graph with graph #3, we see that both Otter and Columbia seem to follow the same pattern during the months of January and May. The large difference happens during July. I assume that the reason for this change is because of the different roles and responsibilities of snowy owls during the breeding season. Male snowy owls find food, while females incubate the eggs. As Otter and

Columbia are of different genders, this is a possible answer. Another potential explanation is that Otter may not have bred during July. This is probable because he traveled a total distance of 70 kilometers. This could either mean that he was 70'ish kilometers away from his nest at the start of July, or he never nested, and hunted for himself, which would have allowed him to cover more ground.

The graph above shows that Otter's activity (how far he flies) changes dramatically during the month of July, with a large spike followed by an equally large drop (in most cases). This probably means that either he flew far, and then rested, or he flew to find good hunting grounds, and then barely moved. Both are probable cases, and both could be correct depending on the time of day. Of course, I don't know as I was not there with him. Another interesting thing I noticed when looking at the graph above is that Otter seems equally active throughout the day in July, unlike January and May. The most probable reason for this would be the dramatic change in sunrise/sunset times or the change from wintering to migrating to breeding.

There are multiple uncontrollable variables in my lab. As I can't be there with the owls, I can't see if a low in their activity is because of bad weather, or because that's what they always do. There are multiple more uncontrollable variables which I couldn't deal with such as food scarcity, and habitat loss. It's entirely possible that 5 years ago, these same owls used completely different routes and had different activity patterns, which I couldn't compare due to lack of time. Because I can't see what they're doing, I have to speculate, and my speculations might not be true.

I didn't add the other central tendencies as they wouldn't be useful to my Wonder Expo topic, this is why I limited myself to the use of Z-scores.

There are multiple ways I could have improved my Wonder Expo. Firstly I could have used a larger number of snowy owls in my data collection. This would have given me more data to compare, and would have been better overall for the experiment (however, unfortunately such data did not exist for the 2022 calendar year). Another way I could have improved my experiment would have been to include data from multiple years instead of just one. Then I could have seen how the snowy owls' behavior changes from year to year. In the end, I did not have enough time to get the data from multiple years (which surprised me since I had started collecting data in mid January) although this might have been too large in scope for my Wonder Expo.

Conclusion

In conclusion, when analyzing the data I had collected for my Wonder Expo I found remarkable correlations between the different sets of data. The Z-scores I compared show that snowy owls seem to migrate at roughly the same time, even if they are separated by large distances of land. The data also shows that snowy owls aren't as diurnal as previously thought, and are partly nocturnal as well.
I've also noticed that although the two owls traveled large distances during migration, they seemed to return close to their previous wintering grounds, suggesting that snowy owls might have a more fixed wintering ground than previously thought. This would make sense as scientists have found that other bird species appear to show the same trend.

I believe that my hypothesis was only partially correct. I had correctly believed that the activity pattern of snowy owls would change over the different months, but I had not realized it would be because of the change from wintering to migrating to breeding. I had incorrectly believed that the change in their activity pattern would be due to the change in sunrise/sunset times. Nevertheless, it appears that the sunrise/sunset times might have some effect on their activity as Otter seemed equally active throughout the day and night during July, unlike the months of January (when he was more active during the daytime) and May (when he was more active during the nighttime). I was also only partially correct for the next part of my hypothesis, where I believed that the owls would travel the farthest in June and December. Otter traveled the farthest during the month of May (not June) but did migrate quite far in December. Columbia on the other hand traveled the furthest distance in April and November (not

June and December). That being said, I had correctly predicted that the snowy owls would barely travel in July.

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