The Bear Book
Volume II
POLAR BEAR

The Polar Bears of Summer: What Do You Eat While the Ice is Gone?

By Dr. Robert F. Rockwell

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By mid-July, it is not unusual for polar bears to wander past our camp in the braided delta of the Mast River on the Cape Churchill Peninsula. Our standard safety protocol requires everyone in camp to get on the roof of the main building and wait quietly until the bear moves on or until it walks to our electric fence and gets shocked. Once shocked, the bear runs and as it does, we fire a few noise-making rounds from a shotgun to scare it a bit more and hopefully associate the shock with noise for future visits. On that July morning in 2003, one of the team members let us know a bear was approaching and we went to the roof. Sitting there just enjoying the bear and the view, it took about 10 minutes for us to realize that this bear’s behavior was different.

He was a sub-adult male in the 400-600 pound range, the type typically displaced from prime seal hunting spots by the 1200 pound mature males when the sea ice begins breaking up. The sub-adults often come ashore presumably looking for food, like any ever-hungry “teenager”. The braided river delta contains many small islands that are used by common eider ducks for nesting and we noticed he was moving from one island to the next. As he stepped onto an island, the female ducks sitting on their nests flushed and landed in the river. He appeared to be inspecting the spots the females left.
Several of us suddenly had the same thought and, after watching more closely through binoculars, **it was clear what he was doing – eating the eggs!!** In some cases we could see entire eggs enter his mouth while in others he seemed to break them and lap up the contents. Close inspection through a powerful spotting scope confirmed these patterns and that eating of whole eggs was more common. During the following 96 hours, he ate the eggs from 220 of the 325 nests we had marked in the area.

**ACTIVITY 1:** Estimate the number of Kcal the sub-adult polar bear consumed during the 96 hour period.

**HINT:** Calculate this answer using data in the free Student Pages that correspond with this story: [www.beartrust.org/polar-bears-of-summer-2](http://www.beartrust.org/polar-bears-of-summer-2)
Like most arctic groups working on long-term research projects (our research project is 46 years old), we have noticed changes consistent with a warming climate for our latitude (~59°N). There is often more snow in the late winter and early spring and this is no doubt related to warmer temperatures that facilitate air holding more moisture. We have noticed increasing numbers of once rare, more southern birds including robins, mourning doves and mockingbirds and earlier flowering by plants such as bearberry, dwarf willow and sea-side silverweed.
These general “climate change” observations fit well with a 1999 paper by Ian Stirling and his colleagues showing that spring break up of Hudson Bay sea ice was occurring earlier and that, coincident with this shift, the condition and reproductive performance of female polar bears was declining. Subsequent work by Ian Stirling and colleagues has further documented these declines as well as reductions in survival of some age classes and abundance of polar bears of the west Hudson Bay population. The prevailing view is that as sea ice breaks up earlier, polar bears are forced ashore before being able to finish their spring hunt of ringed seal pups that provides a large portion of their annual energy budget. These observations of climate change, combined with the gluttonous behavior of the 2003 sub-adult polar bear, tweaked our research interest in land-based foraging by polar bears.

We examined our records for onshore arrival by polar bears and found that beginning in the late 1990’s we were seeing polar bears near our research camp, and on the Cape Churchill Peninsula, earlier than during our project’s previous 30 years. This trend was also being observed further north in Hudson Bay and on Svalbard, an arctic archipelago north of Norway. In some years, the onshore arrival of polar bears on the Cape Churchill Peninsula seemed to overlap the incubation period of snow geese and, like our gluttonous sub-adult polar bear, there was evidence that some polar bears arriving onshore earlier were eating eggs from goose nests as well. Other colleagues were finding similar trends: some polar bears were consuming goose and duck eggs in some areas from Akimiski Island in James Bay (a southern arm of Hudson Bay) to Southampton Island in northern Hudson Bay as well as at several island sites in Svalbard. In some places, the eggs and young of other bird species were being consumed as well.

**CHECK THIS OUT!** Watch a video showing a polar bear climbing cliffs to eat bird eggs and chicks: [https://www.youtube.com/watch?v=lrwy1fb7DrQ](https://www.youtube.com/watch?v=lrwy1fb7DrQ)
An obvious question arises: If polar bears are coming ashore earlier are some bears going to begin regularly foraging on the eggs of land-nesting ducks, geese, and other waterbirds? The answer is actually related to a problem posed by Lewis Carroll in *Through the Looking Glass*. The Red Queen told Alice, “Now, here, you see, it takes all the running you can do, to keep in the same place”. You have likely encountered this problem yourself. If you are in a race and you speed up to overtake the leader, you will be successful only if the leader does not also speed up.

In the case of potential land-based foraging by polar bears during the ice free period, bears that arrive onshore relatively earlier will only have access to the eggs of incubating geese IF the geese are not also starting their 24 day incubation period earlier. We need two data sets to examine this phenomenon; one showing the rate of advance in onshore arrival by polar bears and one showing the rate of advance in mean hatching date for snow geese.

**ACTIVITY 2:** In your Student Pages you will find both data sets. Follow the instructions to use these data to examine this phenomenon.

**More about Snow Geese and Eggs**

If onshore arrival of polar bears outpaces the mean hatching date for snow geese, there is an additional benefit to the bears, described in detail in a 2009 paper published in the scientific journal *Polar Biology* entitled “The Early Bear Gets The Goose: Climate Change, Polar Bears And Lesser Snow Geese In Western Hudson Bay” by Dr. Robert Rockwell and Dr. Linda Gormezano (this paper is provided for download with your Student Pages). Fertile snow goose eggs turn into goslings after being incubated by the female for 24 days. During that time period, the yolk and albumin (egg white) are transformed into a gosling, including bone, beak and down – along
with fleshy tissue. During the process, however, the caloric value of the parts of an egg that a polar bear can digest decreases (Figure 1). So, polar bears that arrive earlier in the incubation period have access to a higher energy resource than those bears arriving later during the incubation period.

![Graph showing the decline in available energy (K-calories) during the incubation period.](image)

Figure 1. The bear-digestible caloric value of a snow goose egg declines during the incubation period as yolk and albumin are converted into a gosling.

**Match or Mismatch?**

The onshore arrival of polar bears is mainly influenced by sea ice dissolution which is affected primarily by air and water temperature. While the initiation of snow goose nesting is also influenced by temperature – snow has to melt before geese can build nests – it is primarily determined by day length and also influenced by weather encountered during migration. Even though climate change is increasing the mean temperature in the Arctic, there is annual variation – some years are warmer than expected while others are colder. As a consequence, there is annual variation in the onshore arrival of
polar bears and of the mean hatching date of snow geese. Because the variation in these two processes is somewhat uncoupled (each process is dependent on different factors and not perfectly correlated with the factors affecting the other process), there will be years when polar bears arrive onshore AFTER goose hatching is complete and other years when polar bears arrive VERY EARLY in the goose egg incubation period.

We modeled this relationship and projected the degree to which polar bear onshore arrival and snow geese hatching might overlap during 25 years.

![Figure 2. Projection model results of polar bear and snow geese hatching overlap over 25 years](image)

Figure 2 shows that although mean overlap (■) of arriving polar bears with the snow goose incubation period increases over time, there is variation such that even after 25 years, there is some chance that bears will arrive after snow geese hatch is over (mismatch). During these years, the arriving bears
will not have access to eggs because the goslings will have already hatched. Therefore, the snow geese should have a successful breeding season allowing the population of snow geese to partially recover from possible predation from polar bears during years of match. The lines marked with ▲ delineate the 95% boundary of expected outcomes of 1000 computer projections and the unmarked fine lines depict 20 of those projections.

**ACTIVITY 3:** There is extensive literature on matches/mismatches; read about it at this website [http://en.wikipedia.org/wiki/Match/mismatch](http://en.wikipedia.org/wiki/Match/mismatch). In your Student Pages, provide one example of how climate change can affect trophic exchange with respect to match/mismatch:

In the particular case of polar bears and the possibility of them consuming nesting snow geese eggs, there is a more complex dynamic occurring that may help the polar bears in the long run. In years of partial or complete mismatch, snow geese are able to successfully hatch their eggs and their reproductive potential is sufficiently high that periodic spurts of such success will likely prevent the snow goose population from being completely decimated. This dynamic is examined in detail in a scientific paper published in the scientific journal *Oikos* entitled “Trophic Matches And Mismatches: Can Polar Bears Reduce The Abundance Of Nesting Snow Geese In Western Hudson Bay?” by Dr. Robert Rockwell, Dr. Linda Gormezano and Dr. David Koons (this paper is provided for download with your Student Pages).

In this paper, the scientists used computer simulations to show that even catastrophically high predation in years of match will not extirpate snow geese from the Cape Churchill Peninsula. Although a match can mean no snow goose productivity in some years, the years of mismatch allow the
geese a burst of productivity. Similarly, a mismatch may mean no eggs for arriving bears that year but it increases the likelihood there will be eggs to eat in the future.

One way to examine what polar bears might be able to gain if they eat snow goose eggs during this possible “match” of polar bear and snow goose egg overlap is to estimate what polar bears lose from lost seal hunting opportunities in the spring as sea ice breaks up earlier. Remember, it is generally believed that polar bears gain most of their annual fat reserves during spring while sea ice is available. During this time, polar bears feed primarily on the pups produced by ringed seals in subnivean lairs built on the sea ice. By mid-to late July, the sea ice melts in western Hudson Bay. Where do the polar bears go then? They come ashore until the sea ice freezes again in fall. While ashore, polar bears are in a negative energy balance. The period that polar bears spend ashore is projected to increase with climate change because warming temperatures will likely keep Hudson Bay ice free for increasingly longer periods. So, polar bears will lose opportunities to hunt seals for longer periods of time.

Using data collected by Ian Stirling and his colleagues, we were able to compute that, on average, a polar bear obtains approximately 22,432 Kcal of energy each day from the consumption of seals during the spring. This estimate accounts for the age structure of the seals consumed, assumes that the bears primarily eat the fat from the seals they catch and also assumes they can digest 97% of that fat. For simplicity, we can think of this amount of energy as a seal day. It follows that each day a bear cannot hunt because the sea ice is breaking up earlier, it loses a seal day’s worth of its potential spring diet. As bears begin coming ashore earlier these losses can be viewed as an energy deficit the bears carry as they arrive onshore.
ACTIVITY 4: In 2006, there were 48,855 pairs of nesting snow geese on the Cape Churchill Peninsula. Use data in your Student Pages to calculate the estimated energy available in the eggs in those nests.

We have often been asked if we are suggesting that snow goose eggs can replace seals and fully sustain the polar bears. Our answer? Of course not! Snow goose eggs can’t completely replace polar bears’ dependency on seals. We know that polar bears are in the Arctic all year while snow geese are only there at most for 4 months and eggs are available for less than 1 month each year.

As scientists we are more interested in whether waterfowl eggs and chicks might help offset some of the lost opportunities for polar bears to hunt seals because of climate change. Owing to an odd twist of fate, snow goose eggs are increasingly available to potentially make up for some of the caloric deficit accrued through lost seal hunting opportunities related to advancing sea ice break-up. Making up some or all of that deficit will hopefully help those bears that take advantage of it. Research by our team and others is showing that polar bears are increasingly taking advantage of this new resource as well as a number of other land-based foods. Details can be found in our paper published in *Ecology and Evolution* entitled “What to Eat Now? Shifts in Polar Bear Diet During the Ice-Free Season in Western Hudson Bay” (a copy of this paper is provided with your Student Pages).
If snow goose eggs could make up part of the deficit, an obvious question is: Are there other resources that polar bears could exploit to make up some of the energy deficit associated with lost seal hunting opportunities? One possibility is snow geese. After the incubation period there will be more than 175,000 flightless goslings that are growing from about 100 grams to 1000 grams in 30 days. Two weeks after the incubation period ends, the parents lose their primary flight feathers and are flightless until they re-grow them about 3 weeks later. This adds more than 90,000 adult geese to the potential prey base on the Cape Churchill Peninsula and there are 10 to 15 million adult snow geese breeding farther north that could be available to some of the polar bears sharing their habitats. Some scientists have said polar bears do not catch flightless geese and others have argued the bears will not spend the energy to catch flightless birds since they would expend more energy than they would gain catching them.

That’s one hypothesis. An alternative competing hypothesis is that polar bears WILL attempt catching flightless birds. We have watched some polar bears do this since the 1980’s and we finally captured it on film. A
detailed account of successful hunts of snow geese by polar bears was recently published in the scientific journal *Polar Biology*, the paper is entitled “Terrestrial Predation By Polar Bears: Not Just A Wild Goose Chase” by David Iles, Stephen Peterson, Dr. Linda Gormezano, Dr. David Koons and Dr. Robert Rockwell. As scientists, we focus on data and findings. We also value sharing findings with others. We do not suggest necessarily that all polar bears are currently catching flightless birds. We just know that some polar bears are, and here’s proof:

**CHECK THIS OUT!** Watch this video showing a polar bear chasing snow geese: [http://beartrust.org/polar-bears-of-summer-2](http://beartrust.org/polar-bears-of-summer-2)

**Do Polar Bears Fast During Summer?**

A number of polar bear biologists refer to polar bears as *fasting* during the period when the sea ice on Hudson Bay disappears. The ice free period usually lasts from late June to early November but this period is getting longer. The Oxford English Dictionary (the most authoritative source for the English language) defines the verb “to fast” as: *To abstain from food, or to restrict oneself to a meagre diet, either as a religious observance or as a ceremonial expression of grief.* It is clear from our observations that polar bears do not fully abstain from food during the ice-free period and that if their diet is “meagre” it is not likely due to religion or grief. Many biologists feel that the amount and quality of food that polar bears might obtain during the summer makes a minor contribution to their annual energy budget. This may or may not be true. These are hypotheses worthy of testing.

Importantly, if the opportunities for spring seal hunting decline and the length of the ice free period lengthens, then food obtained during the summer might become increasingly important to polar bears. As scientists, when we
observe wild animals behave in ways that have rarely been observed in the past, we have an obligation to examine the underlying reasons and consequences.

We began a detailed study that examined the current terrestrial diet of polar bears on the Cape Churchill Peninsula and compared results to a similar study carried out during the mid to late 1960’s before climate change effects had begun. Our recent research was overseen by Dr. Linda Gormezano as part of her Ph.D. research. It is rare to see polar bears foraging and even when you do, the observations are limited to a small number of locations and a limited time period. Dr. Gormezano decided that a better way to evaluate polar bear diet was to examine the feces (scat) they leave behind on the land. She also quickly sorted out that while some piles of scat are obvious others are not and that correct sampling requires you find them all, or at least a high proportion of them.

To achieve this, she trained a Dutch shepherd puppy named Quinoa (keen-wah) to find polar bear scat. Using dogs to find items like this is a form of passive sampling wherein the research animals of interest are not disturbed at all. Quinoa was trained to signal by sitting and looking up when he finds a pile of scat. He is rewarded for his successes with either tosses of his favorite ball or a brief game of tug-of-war. When the reward is finished he gets back to work to earn the next reward. He walked many kilometers of coastal and inland tundra and in the course of 3 years happily found over 1200 piles of polar bear scat.
For those of us helping Dr. Gormezano, the fun of the project was walking the tundra with her and Quinoa. Dr. Gormezano, however, was equally excited going through the piles of scat and identifying and quantifying all the items they contained. Identifying items to species is sometimes difficult as one often has only a few feathers, a bone shard or tooth, or a piece of vegetation. Among the thousands of food items she found in the scat, she was able to key many of them to 1 of more than 25 different species and the rest to broader classes (e.g. mammal, bird, grass). Food items ranged from mushrooms, to berries, to eggs, geese and caribou. (Oh, there was also a watch band). Several piles of scat are below. What can you identify?

Dr. Gormezano compared the results of her study to that of a study by Russell, carried out in the same area more than 40 years earlier. A detailed accounting of that work and a detailed analyses of the spatial distribution of land-based foraging have been published in the scientific journals, *Ecology and Evolution* and *BMC Ecology*. One paper, “What To Eat Now? Shifts In Terrestrial Diet In Western Hudson Bay” is the focus of Activity 5.
ACTIVITY 5: You will find data from this study in the Student Pages. Follow instructions to evaluate foods eaten by polar bears.

Foraging Flexibility?

The ability of an animal to shift its diet is often referred to as foraging flexibility. This is related to a more general phenomenon that concerns the expression of an individual’s genetic makeup when the environment changes. The general phenomenon is termed “phenotypic plasticity” and is of crucial importance to the persistence of species in the face of climate change. Being able to shift foods is extremely important for apex predators that live in an unpredictable environment. Unlike adaptive evolution, phenotypic plasticity (and hence foraging flexibility) allows for extremely rapid shifts in response to environmental change (Box 1).

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<th>Box 1- Adaptive Evolution or Adaptability?</th>
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<td><strong>Adaptive evolution</strong> results from a gradual change in the genetic structure of a population. Alleles that confer higher fitness are favored and gradually increase in frequency. This is the process of natural selection and in most situations several generations are required for a population to change in response to environmental change.</td>
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| **Adaptability**, by contrast, allows members of a population to respond almost immediately to an environmental change. It relies on phenotypic plasticity, the tendency of some genotypes to alter their phenotypic expression in response to environmental change. Alleles whose plastic expression produce phenotypes that are more fit in the altered environment will have been historically favored in populations that are exposed to variable environments. Once such alleles predominate in a population, they allow for immediate shifts in phenotypic expression that maintains high fitness. |
It is possible that the opportunistic and flexible foraging behavior we are beginning to see in some polar bears is a genetic legacy from their most recent ancestor, the brown bear, that is known to have an extremely diverse and flexible diet.

Polar bears in the southern reaches of their range are losing days to hunt seals, and many individuals are currently experiencing difficulties because of this. Yet, we’ve observed a surprising number of polar bears partaking in novel foraging behaviors that suggest the species might be plastic enough to cope with changing environmental conditions. The most challenging task when trying to forecast what will happen in a warmer climate is that we’ve never collected scientific observations in such conditions. Basing predictions only on what we have observed in the past quickly becomes a slippery slope of uncertainty. Our research team thinks that such predictions should be based in part on how the bears are responding NOW and not just on what they did BEFORE the environment began changing.

Too often, people think past experience or shared “common knowledge or belief” are the best predictors of the future (or even the present!). For example, the concept of a spherical Earth had been developed by Pythagoras in around 550 BC (and studied by Aristotle in about 350 BC). However, perhaps because the underlying mathematics were daunting, most Europeans (including most scientists) were not convinced the earth was spherical. They shared a belief in a “flat earth” that would lead to sailors falling off the edge if they went too far. It was not until Columbus successfully sailed to the Americas in 1492 that belief in a flat earth began to wane.

One of our recent examples of refuting this type of thinking involves grizzly bears on the Cape Churchill Peninsula. The species was listed as extirpated in Manitoba and many people simply accepted that there were no grizzly bears in the province. However, in 2006, we saw one and, after looking into other reports, we published a paper establishing that there are
grizzly bears in Manitoba. We and others now regularly see them, often near our camp. The point is that sometimes one has to go beyond the past and/or shared beliefs and go out and see what is happening.

To avoid making such errors, we try to keep an open mind and continue to observe the polar bears of the Cape Churchill Peninsula both directly from the ground and air and remotely with cameras to see how they are responding to climate change. In 2007, for example, we observed an exceptionally, jiggly fat sub-adult polar bear charging the edge of a caribou herd with approximately 300 individual caribou. The bear could successfully split a single animal from the herd and then chase it. The chase would often last 2-3 minutes but the caribou always outran the bear and made it safely back to the herd. We recounted this story to an elder of the Fox Creek Cree First Nation. He listened carefully and then smiled and said: “When he loses a bit more weight, then he will catch it”. The elder added that much can be learned from seeing how the bears react to all these changes. We have tried
to incorporate that approach – quiet, objective observation of what is happening, untrammeled by preformed notions – into our research program.

We have now recorded polar bears along the shore of Hudson Bay eating seals, beluga whales and caribou. In some cases they may be scavenging prey killed by other predators like wolves and grizzly bears but in others we have watched them perform as successful apex predators.
**Traditional Knowledge**

A recent evaluation of Traditional Knowledge from Alaska native hunters was published in *Arctic* in 2014 by Dr. Voorhees, Dr. Sparks, Dr. Huntington, and Dr. Rode. Alaska native hunters state that they believe seals to be the major prey of polar bears, but they’ve also seen polar bears consuming carcasses of beluga whales, bowhead whales, gray whales, and walrus, along with human trash. Evidence from across the Arctic, published in scientific journals, suggests that polar bears might be flexible foragers. Our research team is beginning to examine the energetic costs and nutrient and energetic gains associated with land-based foraging and how this might affect polar bears’ reproductive output and survival. We feel this will give us a much better idea of what the future may hold for this iconic species.

In 2008, Dr. Shari Gearheard, a scientist with the National Snow and Ice Data Center at the University of Colorado at Boulder, interviewed Ilkoo Angutikjuak, an elder from the Clyde River community in Nunavut and published an article about this interview in *Natural History*. In his “Uqarumajakka” (“What I have to say”) on climate change and polar bears, Ilkoo Angutikjuak said,

“I’ve heard that because they depend on sea ice, polar bears will go extinct, but I don’t believe it. They are very adaptable. As the sea ice changes, polar bears might get skinnier and some might die, but I don’t think they will go extinct”.
DNA Results

Recent DNA analyses add support to hypothesis that polar bears could be flexible foragers. Results of DNA analyses show that polar bears have been distinct from brown bears for much longer than previously thought (at least 600,000 years). If true, this means polar bears have persisted through four warming periods on par with current day conditions:

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240,000\text{BP} & \quad 410,000\text{BP}
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Populations of polar bears were no doubt reduced during these warming periods, but the species did not go extinct. We are hopeful that merging modern molecular approaches with traditionally-oriented observations of how the polar bears are responding to climate change will provide information that will help us contribute to the persistence of this iconic species. You can follow our bear research at: http://research.amnh.org/~rfr/hbp/bears.html.