SHORT NOTE

Yes, they can: polar bears *Ursus maritimus* successfully hunt Svalbard reindeer *Rangifer tarandus platyrhynchus*

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Abstract
The polar bear *Ursus maritimus* is one of the species most endangered by the rapidly declining sea–ice cover in the Arctic, which they use as a platform to hunt fatty, high-energy seals. In recent decades, more polar bears have been forced to remain longer on land, so their access to seals is limited. The importance of terrestrial food to polar bears is disputable, and more data are needed. Terrestrial ungulates could be an attractive substitute prey for them. Svalbard reindeer *Rangifer tarandus platyrhynchus* are prevalent and their distribution is completely within the range of polar bears. They constitute an attractive potential prey offering a significant energy return. Pre-2000 sources state that polar bears do not attack Svalbard reindeer. This report is the first description and documentation of the complete course of a polar bear hunt for adult reindeer in Hornsund, SW Spitsbergen, and also of the bear’s hunting behaviour and the reindeer’s response. Further, we report several other recent instances of bear–reindeer interactions in Svalbard, suggesting that polar bears now hunt reindeer more frequently than they used to. This increase in hunting is probably linked to the reduced ice cover, with bears spending more time on land, and a growing reindeer population. This study adds to earlier papers on how polar bears in Svalbard have increasingly shifted to a more terrestrial diet, and indicates that they may have an enhanced role as an apex predator in the terrestrial ecosystem.

Keywords Polar bear · Svalbard reindeer · Predation · Spitsbergen

Introduction
The top predator dependent on sea ice in the Arctic ecosystem, the polar bear *Ursus maritimus* is classified as a marine mammal (Amstrup 2003). Wherever its populations exist, its main prey consists of sea–ice-dependent seal species, particularly ringed seal *Pusa hispida*, but in many areas also bearded seal *Erignathus barbatus*. In Svalbard in summer, the latter is even more important (55% by biomass of food consumed) than the former (63% by numbers) (Derocher et al. 2002) because of the bearded seal’s large size (4–5 times larger than ringed seal). Polar bears have a unique ability to digest seal blubber; seals therefore supply most of the energy necessary for bears to survive in the cold Arctic (Best 1977). When on ice, polar bears also occasionally hunt ice-locked cetaceans (Smith and Sjare 1990; Derocher 2012; Aars et al. 2015) and walruses *Odobenus rosmarus* resting on beaches (Donaldson et al. 1995).

Polar bears compelled by the shrinking sea ice extent to stay longer on land, where access to seals is limited, feed opportunistically on whatever resources are available, e.g., dead fish and cetaceans washed ashore, but also numerous terrestrial mammals from rodents to reindeer *Rangifer tarandus* (Gormezano and Rockwell 2013). They may also explore landfills near settlements containing offal and the remains of marine mammals hunted by local people (Russell 1975; Lunn and Stirling 1985).

During the bird breeding season, some polar bears visit bird colonies, eating eggs, chicks and adults caught on the nests. Although only a few specialized bears visit such colonies, they often significantly affect bird breeding success (Rockwell and Gormezano 2009; Prop et al. 2015). They penetrate near-shore waterfowl colonies (Rockwell and
Gormezano 2009; Iverson et al. 2014; Prop et al. 2015), Little Auks Alle alle on debris-covered mountain slopes (Stempniewicz 1993), and the seemingly inaccessible colonies of Brünnich’s Guillemot Uria lomvia and Black-legged Kittiwake Rissa tridactyla, located on steep cliffs (Donaldson et al. 1995). Sometimes, they catch birds at sea by attacking them from below the water or chasing them across the water (Stempniewicz 2006; Stempniewicz et al. 2014). Polar bears also eat marine and terrestrial plants (Russell 1975; Gormezano and Rockwell 2013; Stempniewicz 2017).

Most evidence from the Canadian Arctic suggests that terrestrial food sources cannot normally ensure the survival of polar bears if they have no access to seals at least seasonally (Ramsay and Hobson 1991; Rode et al. 2015a; Pilfold et al. 2016; Molnár et al. 2020). This applies to the growing number of bears forced to stay on land for ever longer periods, fasting because reduced access to sea ice prevents them from hunting seals (Stirling et al. 1999; Derocher et al. 2004; Rode et al. 2010; Derocher 2012; Stirling and Derocher 2012). Despite spending most their time resting to save energy and eating a variety of complementary terrestrial foods, bears on land around the southern Beaufort Sea and western Hudson Bay still lose weight (Stirling et al. 1999).

In some other areas, e.g. the Chukchi Sea, polar bears lose no weight when on land (Rode et al. 2015b). Svalbard supports a large and growing population of Svalbard reindeer R. tarandus platyrhynchus (henceforth “reindeer”), estimated at 22,000 individuals (Le Moullec et al. 2019). Their distribution is completely within the range of polar bears. Sufficiently large (summer adults weigh 70–90 kg; Reimers 1984) and numerous, they provide enough energy to reduce or prevent bears losing weight while onshore, assuming that they can utilise this resource. Earlier reports suggested that polar bears were incapable of taking reindeer, so typically ignored them (Lønø 1970; Larsen 1978). In Western Hudson Bay, Brook and Richardson (2002) reported a failed attempt by a young bear to hunt caribou. Stempniewicz et al. (2014) described a similar case from Spitsbergen. However, Derocher et al. (2000) reported several cases where there was either firm evidence of polar bears successfully depredating reindeer in Svalbard, or at least strong signs of such predation. Nonetheless, these authors concluded that reindeer were probably of minor importance to the foraging ecology of polar bears in Svalbard at that time.

At 18:00 h on 21 August 2020, a polar bear was spotted ca 200 m from the Polish Polar Station in Hornsund (point 1 on the map; ca 77° 00′ N, 15° 57′ E), apparently a young adult female in good condition. The sky was overcast, the air temperature was +5.4 °C, the water temperature 0.0 °C, and there was a slight ENE wind (3 m/s). The bear was walking east towards the shore of Isbjørnhamna and disregarded some rather noisy people, who were about 100 m away. The bear frequently raised its head, sniffing intensely. Five to seven reindeer were grazing and resting nearby. They were

Recent records of polar bear hunting reindeer in Svalbard

Here, we list all records known to us of polar bear predation and scavenging on reindeer from the Svalbard archipelago after the period covered by Derocher et al. (2000), which ended in 1999 (Table 1).

Description of the hunt

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separated by the pipeline from the station, which could have been difficult to cross. Most of the reindeer were between the station and the sea, two were beyond the pipeline. The bear proceeded directly towards the latter. Initially, the bear and these two reindeer were ca 500 m apart, and it took the bear ca 2 min to cover this distance. As the bear crossed the path from the station to the observatory, it must have seen one of the two reindeer and accelerated, no longer raising its

**Table 1** Records of polar bear *Ursus maritimus* hunting reindeer *Rangifer tarandus platyrhynchus* in the Svalbard archipelago

| Area                                | Coordinates     | Date            | Short description                                                                 | Data source            |
|-------------------------------------|-----------------|-----------------|-----------------------------------------------------------------------------------|------------------------|
| Svartrangen (SW Edgeøya)            | 77° 31’ N, 20° 55’ E | August 1998   | PB* sneaking up, catching and killing R** (unknown sex/age of PB and R) | S. Onarheim, pers. comm |
| N Spitsbergen and Van Mijenfjorden, Bellsund | IX, X, XI, II 2008–2015 | 3 kills and 1 likely; 2 ad♂♂ and 2 ♀♀ PB involved; prey caught after a short chase from the spot where R was surprised (2 cases); PB chasing 150 m before catching ad ♂ R (1 case) | Sandal (2015) |
| Magdalene-fjorden, NW Spitsbergen   | 79° 34’ N, 11° 07’ E | 25 VII 2011 | Prolonged chasing of ad ♂ R by subad PB, both on land and in the sea               | Stempniewicz et al. (2014) |
| Blåbukta, E Edgeøya                | 78° 05’ N, 23° 15’ E | IX 2013        | Freshly killed ad R found with a 2-year old ♂ PB eating from it; R’s skull was punctured, signs on ground indicated that PB ambushed R from a crag above | NPI PB mp *** |
| Van Mijenfjorden, Bellsund         |                 | 21 VI 2015     | ♂ PB observed hunting R while her cubs were plundering eider nests; this was one of PBs reported by Sandal (2015) as taking R in Van Mijenfjorden, Bellsund | J. Prop (pers. comm.) |
| N Edgeøya                          | 78° 21’ N, 22° 20’ E | IV 2018       | 2-Year old ♂ PB found with freshly killed R of unknown sex/age                       | NPI PB mp |
| Wijdefjorden, N Spitsbergen        | 79° 25’ N, 15° 80’ E | IV 2018       | R calf bitten in neck, found freshly killed by ad ♂ PB; calf possibly weakened by starvation and unable to escape from PB | NPI PB mp |
| Skansbukta, Billefjorden           | 78° 55’ N, 16° 25’ E | 3 IX 2018     | Well-fed ad ♂ PB feeding on fresh carcass of ad R                                    | Kavan (2018) |
| Van Keulenfjorden                  | 78° 20’ N, 16° 25’ E | XI 2019       | R killed by PB after ambush (unknown sex/age of PB and R)                              | F. Strøm (pers. comm.) |
| Blomstrandhalvøya, Kongsfjorden     | 77° 33’ N, 15° 04’ E | VIII 2020    | Fresh carcass of ad ♂ R found with PB (unknown sex/age) eating from it                | Pedersen (pers. comm.) |
| Alkehornet, Isfjorden              | 78° 13’ N, 13° 49’ E | VII 2020      | Ad ♂ PB with two bucks seen beside fresh R kill; this was one of PBs reported by Sandal (2015) as taking R in Van Mijenfjorden, Bellsund | J. Mosbacher (pers. comm.) |
| Vinoddøn, Isfjorden                | 78° 20’ N, 16° 25’ E | 19 X 2020    | Ad ♂ PB with cub of the year killing young R                                            | S. Onarheim (pers. comm.) |

*PB – polar bear(s)
**R – reindeer(s)
***NPI PB mp – Norwegian Polar Institute, polar bear monitoring programme
head or sniffing. The terrain there is flat with scattered rocks, which could conceal both bear and reindeer. On entering a depression in the tundra, the bear vanished from the observers’ sight. A few seconds later, it sprang out of the hollow and galloped towards the nearest reindeer, an adult male in good physical condition, which was facing away from the bear and only now noticed the attacker (point 2). It got up – this took a moment – and ran directly to the seashore about 30 m away. The bear dashed into the water behind the fleeing prey (Fig. 1).

Initially, the reindeer was about 4 m ahead of the bear, but he swam very fast, quickly catching up with the reindeer (point 3). On reaching its prey, about 25 m offshore, the bear first grasped the reindeer’s rump, then sank its claws into it, bringing its prey to a halt. It then climbed onto the reindeer, using its weight to submerge the prey, so that only the latter’s head and neck were still visible above the water. Then with its teeth it grabbed the reindeer by the nape and immersed it completely. Prey and attacker struggled for a while, parts of each animal appearing alternately on the surface. Then, the bear gripped the reindeer’s neck from below and dispatched it within about a minute. The bear then turned the reindeer over, submerging it repeatedly for about 15 min, even though it was already dead (Fig. 2; Online Resources).

The bear now dragged the reindeer ashore to some 7 m above the waterline, then began to rip it open and eat its flesh. This continued for about 2 h, during which time it ate ca 60% of the flesh. The bear guarded the carcass, chasing away Arctic foxes *Vulpes lagopus* and Glaucous Gulls *Larus hyperboreus*, while continuing to feed until it had eaten most of the meat. It covered the carcass with stones before leaving it to reduce the chance of kleptoparasitism by scavengers visually detecting carrion (Stirling et al. 2019). Then, it walked to the nearby rocks where it rested or slept for 12 h until the next morning. During that time, three foxes and about ten Glaucous Gulls fed on the remains of the carcass. By noon the next day, the bear alternately lay near the carcass or went to eat the leftovers. In all, it consumed ca 80% of the reindeer’s flesh. Around noon, it moved a kilometre inland, where it lay in the foothills until evening (Fig. 3; Online Resources).

The next day (23 August) a field team sailing to the Hans glacier spotted the bear on the rocks in Isbjørnhamna next to another freshly killed reindeer (point 4; Fig. 1; 3). After about 20 min, the bear dragged its prey ashore at the base of Cape Baranowski, ca 500 m away, and started eating it (point 5). However, being apparently less hungry than when taking the first reindeer two days earlier, it now actively consumed the reindeer’s flesh for only about an hour during the five hours which it spent near the prey. This time it did not chase away foxes or Glaucous Gulls competing for the meat. It then left the carcass and went to its previous resting place, where it lay for the next two days, moving only short distances. It had eaten ca 40% of the soft body parts of the second reindeer, leaving so much meat that the foxes and gulls were able to feed on the carcass for another 10 days.

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**Fig. 1** Observation area: (1) bear’s initial position; (2) first reindeer’s initial position; (3) pursuit in the sea; (4) here, the bear spotted the second reindeer; (5) here, the second reindeer was pulled ashore and eaten
Four days after the first observation, the bear disappeared and was not seen again in the vicinity.

**Discussion**

These observations provide the first detailed description of a complete and successful polar bear hunt of a fully functional, adult Svalbard reindeer. Polar bears can travel very quickly over short distances (Derocher 2012), so
presumably most reindeer taken by polar bears are killed because the attacking bear gets close up to the reindeer before the latter can react. The most interesting aspect of this particular observation is that the bear drove the reindeer male into the water and was then able to catch it because it could swim faster than the reindeer, although an earlier observation (Stempniewicz et al. 2014) showed that a reindeer was capable of escaping from a younger polar bear in open water. The differences in predation success may depend on both the distance between hunter and prey at the beginning of the pursuit, and individual factors relating to the two animals, such as age, size and physical condition. The second reindeer, killed only two days later by the same bear seemingly using much the same method, may indicate that this particular bear has become specialized in hunting reindeer, and possibly, that reindeer may be an important prey to that bear, at least in summer, when the lack of sea ice may prevent it from taking seals.

In general, reindeer run faster and have greater stamina than polar bears over longer distances (Brook and Richardson 2002). This also applies to the Svalbard reindeer, despite its shorter legs, compact body, and therefore, slower speed. A bear is a short-distance runner and can overheat if it has to run fast for a longer time (Hurst et al. 1982; Pagano et al. 2018), although chasing prey in cold water minimizes this risk. Whenever possible, a polar bear uses the terrain to creep up to within a few metres of its prey before the attack. This method of hunting is possible thanks to its ability to smell potential prey from a distance. When chasing prey, the bear was observed accelerating rapidly. It performed such a charge right at the beginning of the attack, but might also have repeated it later. This behaviour of polar bears (three instances) has been observed both on land and in water when they hunted caribou/reindeer (Brook and Richardson 2002; Stempniewicz et al. 2014) and flightless geese (Stempniewicz 2006).

Polar bears may succeed in driving the deer into the water, especially where the water is shallow and the bottom is rocky and uneven. They can also gain an advantage in areas where the reindeer are hindered by the terrain. Reindeer often feed on steep mountain slopes. There have been many observations of crippled reindeer found in such rubble-covered areas in Svalbard, and these animals may be easy prey for bears (Derocher et al. 2000; Stempniewicz et al. 2014). Reindeer can break their legs when trying to escape a bear on steep scree, but also when they feed on steep icy slopes in winter and lose their footing. In addition, to the reindeer they actually kill, other carcasses may be available to bears and contribute to their diet. The high frequency of reindeer remains found in polar bear scats from Svalbard, reaching 27.3% in summer, suggests that reindeer may be a significant part of the polar bear’s diet in that area, whether from carcasses or predation (Iversen et al. 2013).

The level of alertness observed among Svalbard reindeer is very low. When selecting feeding and resting sites, they appear to underestimate the risk of a bear attack. In Hornsund they often graze and lie among the rocks, which limit their field of view; this makes it even easier for a predator to hide and catch a reindeer by surprise. In addition, the relatively long time it takes for a reindeer to get to its feet also reduces its chances of escaping when ambushed by a bear. Our own observations of the reactions of reindeer to people walking on the tundra seem to confirm this low level of vigilance. This modest reaction of Svalbard reindeer to an approaching bear was known to trappers (Lønø 1970). Part of the reason may be the absence of other large terrestrial predators in Svalbard. This behaviour may also be a pointer to the past, perhaps a period when, due to over-hunting by humans, both bears and reindeer became rare in Svalbard and the frequency of their contacts was very low. At the same time, the cold climate continued to favour the availability of seals to bears. Under such conditions, polar bears may have had no interest in hunting reindeer. Reimers et al. (2011), however, showed that the flight distance of reindeer in different parts of Svalbard was the greatest on Edgeøya, where the probability of interaction with polar bears was high. Elsewhere in the polar bear’s distribution, they coexist on shores with brown bears Ursus arctos, which hunt caribou. Thus, the greater use of reindeer in Svalbard relative to that of caribou by polar bears elsewhere in the Arctic could be a result both of competition with brown bears and wolves Canis lupus, and the heightened vigilance of caribou in areas where these predators occur, making reindeer a more challenging prey for polar bears. As the frequency of bears hunting for reindeer increases, strong selection pressure may come into play in favour of increased vigilance and other adaptations against predators in Svalbard reindeer.

The number of direct observations of polar bears hunting Svalbard reindeer appear to have been increasing in recent years. In addition, there are now a significant number of cases where predation can be assumed (Table 1). Although bears in the area are most likely to be fully dependent on the much more energy-rich seals hunted on sea ice, at least from spring to early summer, the rather frequent reports of the successful hunting of reindeer by Svalbard polar bears may mean that the importance of such prey in their diet has either been underestimated, or more likely, that this phenomenon has become more common in recent years. It is hard to believe that such behaviour was ubiquitous before the 1970s, when Lønø (1970) stated that bears did not hunt reindeer, given all the extensive knowledge he had accumulated as a trapper and scientist himself, and from other trappers that had hunted in the area for decades.

Land-based food sources cannot provide bears with sufficient energy, and bears in the southern Beaufort Sea and western Hudson Bay lose weight when on land (Stirling
et al. 1999; Rode et al. 2010). In other areas (e.g., the Chukchi Sea), increased land use has occurred but without weight loss among bears in the population (Rode et al. 2015a, 2015b). In Svalbard, reindeer are numerous and easily available. As prey, they may offer bears a considerable energy return. In late summer, the Svalbard reindeer are in prime condition. The average body weight of adult males shot in August was ca 118 kg, including lean body weight (37 kg), digestive tract (30 kg), skin, head, hooves (23 kg) and fat (28 kg) (Reimers 1984). The bear observed in Hornsund ate ca 80% of the soft body parts of the first reindeer it killed and ca 40% of the second one, an estimated consumption of ca 70–80 kg of meat, innards and fat. This is a large amount of food, equivalent in weight to one adult or two young ringed seals, even though reindeer carcasses may provide only about half the energy per unit weight (Best 1977). Even before the hunt, the bear we observed was in excellent condition. Moreover, the ease with which it hunted two adult reindeer within a short time strongly suggests that it had few problems maintaining an energy balance.

Currently, nearly 300 polar bears live in Svalbard all the year round (Aars et al. 2017), and the number of local bears in Spitsbergen (W Svalbard) has increased significantly in recent decades (Prop et al. 2015). They have been shown to be highly philopatric, using the same area year after year, and also over generations. If polar bear mothers learn to hunt reindeer efficiently, their offspring, which stay with their mothers for over two years, may also become reindeer hunters. Reindeer numbers in the area may continue to increase, given the increased productivity of the tundra as the climate warms. The local bears, numbering about a tenth of the Barents Sea population where most hunt along the ice edge and visit the islands more sporadically (Aars et al. 2017), may become an increasingly important component of Svalbard’s terrestrial ecosystem. Their impact on colonial birds, not only on the reindeer population, is expected to increase, although one can assume that predation on sea ice of the associated seal species in spring and early summer will still provide the major item in their diet.

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Author contributions L. S. conceived the study and drafted the manuscript. I. K. performed and described the field observations. J. A. compiled other observations of polar bear-reindeer interactions collected by the Norwegian Polar Institute. All the authors read and approved the final manuscript.

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References

Aars J, Andersen M, Brenière A, Blanc S (2015) White-beaked dolphins trapped in the ice and eaten by polar bears. Polar Res. https://doi.org/10.3402/polar.v34.26612

Aars J, Marques TA, Lone K, Andersen M, Wiig Ø, Bardalén-Floystad IM, Hagen SB, Buckland ST (2017) The number and distribution of polar bears in the western Barents Sea. Polar Res. https://doi.org/10.1080/17518369.2017.1374125

Amstrup SC (2003) The Polar Bear—Ursus maritimus. In: Feldhamer GA, Thompson BC, Chapman JA (eds) Wild Mammals of North America. John Hopkins University Press, Baltimore, pp 587–610

Best RC (1977) Ecological aspects of polar bear nutrition. John Hopkins University Press, Baltimore. pp 587–610

Brook RK, Richardson ES (2002) Observations of polar bear predatory behaviour toward caribou. Arctic 55:193–196

Derocher AE (2012) Polar bears: a complete guide to their biology and behaviour. John Hopkins University Press, Baltimore

Derocher AE, Wiig Ø, Bangjord G (2000) Predation of Svalbard reindeer by polar bears. Polar Biol 23:675–678

Derocher AE, Wiig Ø, Andersen M (2002) Diet composition of polar bears in Svalbard and the western Barents Sea. Polar Biol 25:448–452

Derocher AE, Lunn NJ, Stirling I (2004) Polar bears in a warming climate. Integr Comp Biol 44:163–176. https://doi.org/10.1093/icb/44.2.163

Donaldson GM, Chapdelaine G, Andrews JD (1995) Predation of thick-billed murres, Uria lomvia, at two breeding colonies by polar bears, Ursus maritimus, and walruses, Odobenus rosmarus. Can Field Nat 109:112–114

Gormezzano LJ, Rockwell RF (2013) Dietary composition and spatial patterns of polar bear foraging on land in western Hudson Bay. BMC Ecol. https://doi.org/10.1186/1472-6785-13-51

Hamilton CD, Kovacs KM, Ims RA, Aars J, Lydersen C (2017) An Arctic predator–prey system in flux: climate change impacts on coastal space use by polar bears and ringed seals. J Anim Ecol 86(5):1054–1064. https://doi.org/10.1111/1365-2656.12685

Hurst RJ, Leonard ML, Watts PD, Beckerton P, Ørstedt NA (1982) Polar bear locomotion: body temperature and energetic cost. Can J Zool 60:40–44. https://doi.org/10.1139/z82-005

Iversen M, Aars J, Haug T, Alsos IG, Lydersen Ch, Bachmann L, Kovacs KM (2013) The diet of polar bears (Ursus maritimus) from Svalbard, Norway, inferred from scat analysis. Polar Biol. https://doi.org/10.1007/s00300-012-1284-2
Iverson SA, Gilchrist HG, Smith PA, Gaston AJ, Forbes MR (2014) Longer ice-free seasons increase the risk of nest predation by polar bears for colonial breeding birds in the Canadian Arctic. Proc R Soc B 281:20133128. https://doi.org/10.1098/rspb.2013.3128

Kavan J (2018) Observation of polar bear (Ursus maritimus) feeding on Svalbard reindeer (Rangifer tarandus platyrhynchus) – exceptional behaviour or upcoming trend? Czech Polar Rep 8(2):243–248

Larsen T (1978) The world of the polar bear. Chartwell Books, Secaucus, New Jersey

Le Moullec M, Pedersen ÅO, Stien A, Rosvold J, Hansen BB (2019) A century of conservation: the ongoing recovery of Svalbard reindeer. J Wildl Manage 83:1686–1686

Lone K, Merkel B, Lydersen C, Kovacs KM, Aars J (2018) Sea ice resource selection models for polar bears of the Barents Sea sub-population. Ecography. https://doi.org/10.1111/ecog.03020

Lønø O (1959). Reinen på Svalbard. Norsk Polarinsitutt, Oslo, Norway

Lønø O (1970) The polar bear (Ursus maritimus Phipps) in the Svalbard area. Nor Polarinst Skr 149:1–115

Lunn NJ, Stirling I (1985) The significance of supplemental food to polar bears during the ice-free period of Hudson Bay. Can J Zool 63:2291–2297

Molnár PK, Bitz CM, Holland MM, Kay JE, Penk SR, Amstrup SC (2020) Fasting season length sets temporal limits for global polar bear persistence. Nat Clim Change. https://doi.org/10.1038/s41558-020-0818-9

Pagano AM, Durner GM, Rode KD, Atwood TC, Atkinson SN, Peacock E, Costa DP, Owen MA, Williams TM (2018) High energy, high-fat life-style challenges an Arctic apex predator, the polar bear. Science 359:568–572. https://doi.org/10.1126/science.aan8677

Pilfold NW, Hedman D, Stirling I, Derocher A, Lunn N, Richardson E (2016) Mass loss rates of fasting polar bears. Physiol Biochem Zool 89:377–388. https://doi.org/10.1086/687988

Prop J, Aars J, Bardsen B-J, Hanssen SA, Bech C, Bourgeois S, de Fouw J, Gabrielsen GW, Lang J, Noreen E, Oudman T, Sittler B, Stempniewicz L, Tombre I, Wolters E, Moe B (2015) Climate change and the increasing impact of polar bears on bird populations. Front Ecol Evol. https://doi.org/10.3389/fevo.2015.00033

Ramsay MA, Hobson KA (1991) Polar bears make little use of terrestrial food webs - evidence from stable carbon isotope analysis. Oecologia 86:598–600. https://doi.org/10.1007/BF00318328

Reimers E (1984) Body composition and population regulation of Svalbard reindeer. Rangifer 4(2):16–21

Reimers E, Lund S, Ergon T (2011) Vigilance and fright behaviour in the insular Svalbard reindeer (Rangifer tarandus platyrhynchus). Can J Zool 89:753–764. https://doi.org/10.1139/z11-040

Rockwell RF, Gormezano LJ (2009) The early bear gets the goose: climate change, polar bears and lesser snow geese in western Hudson Bay. Polar Biol 32:539–547. https://doi.org/10.1007/s00300-008-0548-3

Rode KD, Amstrup SC, Regehr EV (2010) Reduced body size and cub recruitment in polar bears associated with sea ice decline. Ecol App 20:768–782

Rode KD, Robbins CT, Amstrup SC, Nelson L (2015a) Can polar bears use terrestrial foods to offset lost ice based hunting opportunities? Front Ecol Environ 13:138–145

Rode KD, Wilson RR, Regehr EV, St. Martin M, Douglas DC, Olson J (2015b) Increased land use by Chukchi sea polar bears in relation to changing sea ice conditions. PLoS ONE 10(11):e0142213. https://doi.org/10.1371/journal.pone.0142213

Russell RH (1975) The food habits of polar bears of James Bay and southwest Hudson Bay in summer and autumn. Arctic 28:117–129

Sandal T (2015) Om isbjørn og svalbardrein. Svalbardposten 15:20–21

Smith TG, Sjare B (1990) Predation of belugas and narwhals by polar bears in nearshore areas of the Canadian high Arctic. Arctic 43:99–102

Stempniewicz L (1993) The polar bear Ursus maritimus feeding in a seabird colony in Franz Josef Land. Polar Res 12:33–36

Stempniewicz L (2006) Polar bear predatory behaviour toward molting barnacle geese and nesting glaucous gulls on Spitsbergen. Arctic 59:247–251

Stempniewicz L (2017) Polar bears observed climbing steep slopes to graze on scurvy grass in Svalbard. Polar Res 36:1326453. https://doi.org/10.1080/17518369.2017.1326453

Stempniewicz L, Kidawa D, Barcikowski M, Iliszko L (2014) Unusual hunting and feeding behaviour of polar bears on Spitsbergen. Polar Rec 50:216–219

Stirling I, Derocher AE (2012) Effects of climate warming on polar bears: a review of the evidence. Glob Change Biol 18:2694–2706

Stirling I, Lunn NJ, Iacozza J (1999) Long-term trends in the population ecology of polar bears in Western Hudson Bay in relation to climate change. Arctic 52:294–306

Stirling I, LaMaire KL, Derocher AE, Van Meurs R (2019) The ecological and behavioral significance of short-term food caching in polar bears (Ursus maritimus). Arct Sci 4:41–52. https://doi.org/10.1139/as-2019-0008

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