Some Things We Know – and Don't Know –About Polar Bears

by

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SUMMARY FOR POLICY MAKERS

- ***Globally, more than one third of the nineteen subpopulations of polar bears are increasing or stable, while the another third have insufficient data available; its status in the central Arctic Basin, the largest of the nineteen designated regions, is completely unknown.***

- ***All but one of the declining subpopulations listed in 2006 are threatened by over-harvesting, not reduced sea ice.***

- ***The offshore sea ice that lies well north of the pack ice edge has not been surveyed in any comprehensive fashion for polar bears OR ringed seals, their primary prey: we simply do not know how many bears or seals live deep in the polar pack, although several studies suggest that the number of ringed seals living and breeding well offshore must be substantial.***

- ***Virtually the only areas studied in any detail, for polar bears and ringed seals, are the neashore areas of Hudson Bay (Canada), the Beaufort Sea (shared by the USA and Canada) and Svalbald (Norway). Some studies have also been done in Canada's Davis Strait/Baffin Bay and the Canadian High Arctic. There is only about thirty years worth of data for even the most intensely studied populations.***

- ***Most of what we know about polar bear biology is based on the western Hudson Bay population but since this is an anomalous population, Hudson Bay bears are not a good proxy for ALL polar bears.***

- ***Among polar bear females, pelagic-dwelling bears live in drifting sea ice year round, while nearshore-dwelling females inhabit shorefast ice year round. Both pelagic-dwelling and nearshore-dwelling individuals of both sexes are known in all subpopulations studied and each type behaves differently to reduced seasonal ice.***

- ***Polar bears routinely hunt on new ice < 30 cm thick and are quite capable of utilizing thick first year ice (> 120 cm thick or more.) for over-wintering and denning. They do not*** **require** ***thick multi-year ice.***

- ***As offshore sea ice over deep water is suitable for polar cod, it should be suitable for ringed seals and polar bears also; ringed seal and polar bear habitat probably includes ice over water of all depths.***

- ***The polar bear survived two major warming periods over the last 11,000 years, the first of which saw temperatures rise rapidly to at least*** **2.5^0C** ***higher than present and there is no evidence that Arctic sea ice disappeared entirely during those times or that any ice-dependent species became extinct.***

- ***It is highly unlikely that in the future, polar bears would move to land in response to reduced sea ice, although a few might: it is far more likely that most bears would stay out on the sea ice that lies well offshore — as in the past, bears will die on the ice or at sea, leaving no evidence of their existence.***

- ***Sea ice*** **thickness** ***assessments in the huge Arctic Basin region are estimates based on very few actual measurements that have been extrapolated for use in various climate models. Satellite data on sea ice*** **extent** ***have only been available for 30 years: this is insufficient for assessing long-term trends.***

- ***The computer model results, presented in 2007, which forecast dramatic declines in polar bear numbers based primarily on predicted reductions in seasonal sea ice thickness and extent, have not yet been tested against even a single years worth of independent data.***

Some Things We Know — and Don't Know —About Polar Bears

Susan J. Crockford, Ph.D.

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INTRODUCTION

Much of what you hear about polar bears these days ─ their status, their plight ─ is distilled from a literature dominated by studies done within very limited portions of the Arctic: those that are accessible to researchers. Logistical and technical difficulties prevent scientists in all disciplines from traveling to, and working within, the ever-changing sea ice that exists well offshore. As a consequence, the picture that gets painted of polar bear existence sounds more completely understood than it really is. Due to the nature of the beast and the habitat in which it lives, there is in reality a profound uncertainty regarding polar bear population status, some of its life history features and conditions of its habitat, and the status of its primary prey, the ringed seal. However, it is clear from their long-term success surviving within this habitat that the tight association polar bears and arctic seals have with moving sea ice gives them tremendous flexibility and adaptability to changing climatic conditions.

My purpose here is to address some of the bias that mars virtually all general information sources one might consult on polar bears and ice-dependent Arctic seals, in point form for easy reference. Most references cited here are available on request as pdf files. This document was compiled from several papers published on associated topics (Crockford 2004, 2006; 2008; Crockford and Frederick 2007; Crockford and Frederick, in review) and material collected in the course of reviewing the January 2007 draft of the *Report for Congress on Polar Bears* prepared by Library of Congress researcher Eugene H. Buck, filed April/07. This update incorporates information amassed since that date**.**

Note that in regard to ice:

1) *pack ice* and *sea ice* both refer to large sheets or broken chunks of ice that drift with the currents and wind as the seasons change (Rigor and Wallace 2004) ─ ***most Arctic ice is sea ice*** (Ferguson et al. 2000) and the *ice edge* is the southern-most limit of the drifting pack.
2) *fast ice, grounded fast ice, landfast ice* and *shorefast ice* all refer to ice attached to land, although *shorefast ice* is perhaps the least ambiguous terminology.

DISTRIBUTION AND STATUS OF THE POLAR BEAR

- Polar bears world-wide are divided into 19 subpopulations for management purposes (Figure 1).

- Two of these populations, genetically indistinguishable from each other (Cronin et al. 2006), occur within US territory

1) the Southern Beaufort Sea population (SB, shared with Canada, half in US territory) is estimated at 1,526 animals (Regehr et al. 2007b, "1211-1841 at a 95% confidence interval");
2) the Chukchi/Bering Sea population (CB, shared with Russia, half in US territory) is tentatively estimated at 2,000 ─ ***no population survey has yet been done*** (Aars et al. 2006).

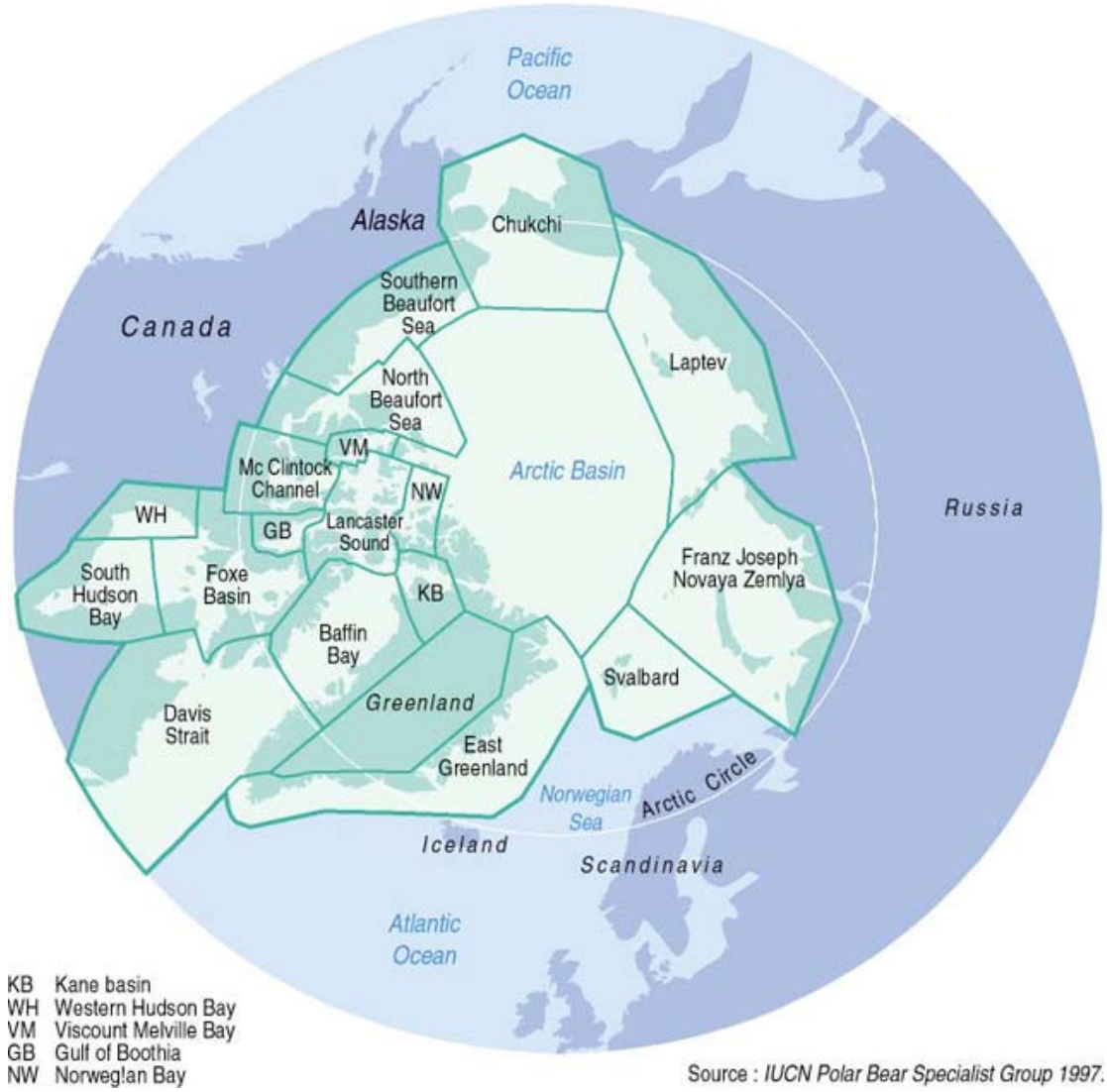

Figure 1. ***The nineteen designated polar bear subpopulation boundaries (courtesy IUCN Polar Bear Specialist Group, see Aars et al. 2006)***

- Globally, less than one third of the nineteen populations are currently estimated as declining, more than one third are increasing or stable, while the remaining third have insufficient data available to estimate population trends: ***the SB population is currently declining, based on presumed consequences of some bears in poor condition, not an actual decline in numbers over time (Regehr et al. 2007b; Rode et al. 2007), the CB trend is unknown (Aars et al. 2006).***

- Four out of the five subpopulations listed as declining in 2006, as well as several others (including CB), are considered at risk from over-harvesting (i.e. hunting), not reduced sea ice (Aars et al. 2006).

- *Some population estimates are based on "mark/recapture" methods, others on aerial survey;* due to fog and cold, ***aerial surveys seldom extend beyond 125km north of the sea ice edg****e (e.g. Aars et al. 2006, 2008, Barents Sea), with at least one exception (Fischbach et al. 2007, Southern Beaufort Sea).*

- ***The status of the polar bear in the central Arctic Basin (see Fig. 1 above), the largest of the nineteen designated regions, is completely unknown (Aars et al. 2006),*** although bears have been reported there (e.g. Van Meurs and Splettstoesser 2003).

DENNING AND OTHER LIFE HISTORY HABITS

- Most of what we know about polar bear biology is based on the easily-accessible animals of Western Hudson Bay (WHB), see references below, which comprise **only 3-5% of the global population** and are anomalous for a number of reasons (Aars et al. 2006; Dyck et al. 2007, 2008; Mauritzen et al. 2001; Regehr et al. 2007a; Schliebe et al. 2008; Stirling et al.1977):
1) WHB is the most second most southerly subpopulation worldwide, so their ice *always* melts earlier in the year than most of the others (however, the **Southern Hudson Bay (SHB) subpopulation is the furthest south and its population has remained stable over the last 20 years** (Aars et al. 2006).
2) WHB population is the most easily accessible and has been under scrutiny since the late 1960s.
3) WHB is the only subpopulation, out of the five considered to be declining, where the population trend is based on a statistically significant decrease in population estimates over time (Aars et al. 2006).
4) WHB is one of the most geographically constrained subpopulations, so they easily get trapped ashore ─ usually for about four months at a time ─ when summer sea ice retreats (**however, this also happens to the SHB subpopulation, without an associated population decline)**.
5) most of the females prefer to den on land or shorefast ice rather than on offshore sea ice (compared to the Southern Beaufort, where about 40-60% den offshore (Fischbach et al. 2007).

-Virtually the **only areas studied in any detail for polar bears and ringed seals**, are the coasts of **Hudson Bay** in Canada (e.g. Amstrup et al. 2007; Derocher et al. 2004; Ferguson et al. 2005; Holst et al. 1999; Lennox and Goodship 2008; Lunn et al. 1997; Regehr et al. 2007a; Stirling and Derocher 2007; Stirling et al. 2008a), the **Beaufort Sea** off Alaska and Northwestern Canada (e.g. Amstrup 1995; Frost et al. 2004; Regehr et al. 2007b; Schliebe et al. 2008; Stirling 2002; Stirling et al. 2007, 2008b), and the **Svalbard** region in the Barents Sea, off Norway (e.g. Aars et al. 2008; Derocher et al. 2002; Holst et al. 2001; Krafft et al. 2006; Labansen et al. 2007; Lydersen and Gjertz 1986; Mauritzen et al. 2001; Wiig et al. 1999). Some studies have also been undertaken in the **Canadian Arctic Archipelago** (e.g. Ferguson et al. 2000; Hammill and Smith 1991; Kelly and Wartzok 1996; Kingsley et al. 1985; Smith and Hammill 1981; Smith et al. 1991; Stirling and Øritsland 1995) and the **Davis Strait/Baffin Bay** region of Canada (e.g. Ferguson et al. 2000; Finley et al. 1983). ***Information on populations elsewhere in the Arctic, including regions north of Greenland and Russia, is very limited or nonexistent (e.g. Aars et al. 2006).***

- Polar bears are *capable of fasting for more than four months at a time while fully awake and mobile, regardless of the season* (they do not need to den or hibernate as other bears do ─ only pregnant female polar bears hibernate over the winter in true bear fashion): as a consequence, polar bears are known to biologists as ***walking hibernators*** (Lennox and Goodship 2008; Stirling and Øritsland 1995).

- While polar bears that spend extensive time on land during the summer months (such as those in WHB) may fast for up to four months, previous research has shown (Stirling and Øritsland 1995) that bears in most regions are at their lowest body weight in *spring* (i.e. March). This suggests that winter fasting leading to starvation may be a more limiting factor for polar bears and this may be particularly true if winters are associated with development of especially thick shorefast ice. *Such cold winters in the past, as occurred during the mid-1960s, mid-1970s, mid-1980s, and early 1990s, led to marked reductions in polar bear numbers (Stirling 2002; Stirling and Lunn 1997) due to dramatic declines in availability of young ringed seals.* In Greenland, ringed seals are known to move offshore when shorefast ice becomes too thick for them to maintain their breathing holes (Vibe 1967).

- Over most of their range, most polar bears remain on the sea ice year-round or at most spend only short periods on land. Schliebe et al. (2008) found that from 2000-2005, on average 3.7% of all Southern Beaufort Sea polar bears in Alaska spent time on land between mid-September and the end of October. While nearshore-dwelling Davis Strait bears were found to spend two-three months on Baffin Island (Ferguson et al. 1997), polar bears in WHB are unique in *routinely* spending about four months on land from summer through fall (Regehr et al. 2007a; Schliebe et al. 2008).

- In October and November, male polar bears head out on the sea ice where they spend the winter. Pregnant females either seek sites on offshore ice, or on shorefast ice/shoreline areas (snow covered land), to dig large dens in snow where they give birth and spend the winter.

- Den locations chosen by female polar bears in the Southern Beaufort Sea region have varied since the early 1980's: 62% of dens were on offshore sea ice from 1985-1994 but only 37% of dens were offshore from 1998-2004 (Fischbach et al. 2007). It is possible that world wide, the general pattern for polar bear dens is an almost equal number on offshore sea ice and shorefast ice/land (with WHBay being anomalous). Dens are known to be difficult to spot from the air (e.g. Ferguson et al. 1997).

- *Polar bear females appear to have individual habitat and denning preferences:* ***females do not require mainland or shorefast ice sites for denning but some individuals prefer them.*** *(Mauritzen et al. 2001):*

1) bears that choose "pelagic" habitats generally live on offshore drifting sea ice year round.

2) bears that choose "nearshore" habitats generally live on shorefast ice year round.

- When seasonal ice recedes north in summer, as it does every year in most areas, pelagic-dwelling bears stay on the drifting sea ice while nearshore-dwelling bears move to land. ***Both pelagic-dwelling and nearshore-dwelling individuals of both sexes are known in all subpopulations studied*** **(Mauritzen et al. 2001; Ferguson et al. 2000; Schliebe et al. 2008).**

- ***The fact that pelagic-dwelling bears not only exist but behave differently than nearshore-dwelling bears to reduced sea ice is critical to predicting how polar bears as a species might react to changes in ice conditions: unfortunately, we simply do not know how many bears den out of study range.***

- While there is extensive evidence that virtually all Arctic marine mammal populations are negatively impacted by increased sea ice conditions (Stirling 2002; Laidre et al. 2008; Harington 2008), evidence for how these animals react to decreased sea ice is extremely limited, coming from extensive studies in the anomalous WHB region and a few short term studies in the southern Beaufort Sea. In other words, **what we know for sure is that *increased sea ice is associated with a decline* in polar bear and ringed seal numbers; *we don't really know what impact decreased summer sea ice might have on polar bears and ringed seals that inhabit other regions of the Arctic.***

- Computer models that predict extinction of polar bear populations within this century due to human-induced global warming (e.g. Derocher et al. 2004) do not take into account adaptations of bears and their prey to reduced sea ice extent (Armstrong et al. 2008; Bodkin et al. 2007), even though both bears and their prey have clearly done so in the past (e.g. Kochnev 2006; Vibe 1967). Such adaptation would likely involve living year round within the mobile offshore sea ice that is now beyond study range (wherever it occurs), without a shift to land.

- Even if substantial declines in polar bears and their prey do occur because of anthropogenic global warming, as predicted by Amstrup et al. (2007) and others (e.g. Laidre et al. 2008; Stirling and Derocher 2007), this does not doom them to extinction: many species have recovered from far more dramatic declines in population than predicted by even the most pessimistic scenarios conceived of by climate models, including humpback whales (Dalton 2008), gray whales (Reeves et al. 2002), northern fur seals (Reeves et al. 2002), Atlantic cod (Bigg et al. 2008), and sea otters (Doroff et al. 2003; Estes 1990), among others. Contrary to common biological assumption, small populations often retain sufficient genetic variation for significant recovery (e.g. Aguilar et al. 2004; Kaeuffer et al. 2007).

- Adaptation of a *species* is not the same as adaptation of individuals: the death of some individuals during changing conditions is likely inevitable but this does not mean the *species* (i.e. the entire population) is not adaptable (e.g. Grant and Grant 2002; Grime et al. 2008). *Polar bear populations may have declined and recovered many times in the past in response to changing sea ice conditions, without us knowing.*

PREY SPECIES DISTRIBUTION AND STATUS

- Survival of polar bears is dependent on available prey, which consists **primarily** of ringed seal, *Phoca hispida* and (depending on region and/or season) bearded seal, *Erignathus barbatus* (Derocher et al. 2002, 2004; Stirling and Øritsland 1995). They occasionally take walrus, *Odobenus rosmarus* and small whales (such as beluga, *Delphinapterus leucas,* and narwhal, *Monodon monoceras*) and scavenge large whale carcasses (such as bowhead, *Balaena mysticetus*).

- Ringed seals have a circumpolar distribution and are associated with ice year round. They give birth and mate on ice and are not known to haul out on land. Some ringed seals prefer to over-winter and give birth on shorefast ice while others live their lives well offshore in the drifting sea ice (Born et al. 2004; Davis et al. 2008; Ferguson et al. 2000; Finley et al. 1983; Wiig et al. 1999), similar to the known "pelagic-dwelling" and "nearshore-dwelling" preferences of individual polar bears (see discussion above). Ringed seals feed throughout the darkness of the Arctic winter and are available prey for polar bears wintering in the offshore pack ice (Kelly and Wartzok 1996).

- Most marine mammal researchers working in the Arctic assume that ringed seals breed primarily in shorefast ice habitats (e.g. Burns 1970; Derocher 2004; Frost et al. 2004; Hammill and Smith 1981, 1991; Holst et al. 1999, 2001; Kingsley et al. 1985; Krafft et al. 2006, 2007; Lydersen and Gjertz 1986; Smith

and Hammill 1981; Stirling 2002; Stirling and Øritsland 1995), despite several well-documented studies that conclude ***a significant portion of all ringed seals must live and breed well offshore, out of study range*** (Born et al. 2004; Davis et al. 2008; Ferguson et al. 2000; Finley et al. 1983; Wiig et al. 1999).

- Ringed seals eat primarily young polar cod, *Boreogadus saida,* which live under the ice (e.g. Born et al. 2004; Labansen et al. 2007), although they eat other types of fish as well as the amphipods and small copepods (shrimp-like invertebrates) that polar cod themselves eat.

- Both polar cod and their prey live under ice of all types, including multi-year and first year drifting sea ice *regardless of the ocean depth* (Lønne and Gulliksen 1989): in other words, cod do not require ice that is positioned over shallow, continental shelf waters and therefore, neither do ringed seals or polar bears, contrary to common assumption (e.g. Derocher et al. 2004). While Arctic deep water is often assumed to be of low productivity (e.g. Fischbach et al. 2007), this has not be demonstrated. ***If offshore sea ice over deep water is suitable habitat for polar cod, it should be suitable for ringed seals and polar bears also.*** This assumption is supported by reports at the North Pole of "small fish" (estimated as 5-8cm, presumably young cod,) thrown up by ice-breakers, algal growth noted on the underside of broken ice, and the presence of ringed seal (Todd et al. 1992), as well as reports of polar bears themselves (Van Meurs and Splettstoesser 2003).

- As for polar bears, **much of ringed seal habitat, especially the drifting sea ice that lies well offshore, has not been surveyed**, leading to much uncertainty regarding population size and status of ringed seal: *the current estimate used for the global population numbers for ringed seal is about seven million* (Davis et al. 2008; Wiig et al. 1999; Nowak 2003; Reeves et al. 2002).

Although climate models predict that future summer pack ice declines will decimate polar bear populations (e.g. Laidre et al. 2008; Stirling and Derocher 2007), forecasting a loss of from 66% of the world total population by 2050 (Amstrup et al. 2007) to outright extinction (Derocher et al. 2004), such conclusions do not take into account the fact that polar bears can fast for more than four months when required and are capable of living entirely at sea, in the ice that lies well offshore where there are substantial numbers of seals, without ever setting foot on land. Nor do such dire prophecies take into account the kind of adaptability described by a Russian researcher: "our investigations on Wrangel Island have shown that the polar bear is a very plastic animal: it can rapidly change its way of life, spatial distribution and behavior according to new ecological conditions" Kochnev (2006:163).

HOLOCENE AND PLEISTOCENE HISTORY

-Polar bears evolved from brown bears (*Ursus arctos*) during the last Ice Age and while they are thus a relatively new species (no more than 200,000 years old, probably much younger), ringed seals and bearded seals have been around for at least two million years (Arnason et al. 1995, 2006; Davis et al. 2008; Kurten 1988; Harington 2008).

-Polar bears are close genetically to brown bears although they are a distinct species (Cronin et al. 1991; Talbot and Shields 1996). Mitochondrial DNA sequences of polar bear are closer to one particular population of brown bear from Southeast Alaska than some dogs are to wolves (Crockford 2004, 2006).

Although we know polar bears can successfully interbreed with brown bears (Duff-Brown 2007), this reflects their recent common ancestry ─ it does not call into question their status as a distinct species or detract from their divergent ecological, morphological and physiological features (Crockford 2004, 2006; Cronin 2007).

-The polar bear survived two major warm periods over the last 11,000 years (*The Holocene*):

1) **The Early Holocene.** At the end of the last Ice Age, the Northern Hemisphere in particular entered an extended period of rapid warming, with temperatures in Arctic regions eventually reaching levels several degrees warmer than today. At that time, the sea ice above western North America is known to have retreated substantially, allowing arctic species such as bowhead whales and walrus to move northward into areas of the Canadian arctic they cannot reach today (Dyke et al. 1999, Dyke and Savelle 2001; Fisher et al. 2006).

The Early Holocene Climatic Optimum peaked at about 11,000-9,000 years ago near Alaska and at 8,000-5,000 years ago near Greenland & northern Europe: in both areas, temperatures rose rapidly 10-15^{0}C to a point significantly warmer than present (about 2.5^{0}C warmer) in most places and up to 7^{0}C warmer in Northern Russia
(MacDonald et al. 2000)
about 5-10^{0}C of that warming took place within 30 years or less
(Alley 2000; Bennike 2004; Dahl-Jensen et al. 1998; Jennings et al. 2002; Kaufman et al. 2004; Steffensen et al. 2008).
The rate of warming that took place in the early Holocene far exceeds any climate model predictions of warming over the rest of this century.

2) **The Late Holocene**. Another significant but shorter warm period occurred about 1000 years ago, when arctic temperatures were slightly warmer than today. This warming, known as the Medieval Warm Period, also triggered sea ice reductions in arctic regions and was accompanied by significant reductions in Greenland glaciers, that created so much arable land that Viking farms established in west Greenland were occupied for 400 years. *During the Medieval Warm Period, ca. 800-1200 A.D., temperatures in Greenland rose about 1^{0}C above modern levels (Fagan 2000; Soon and Baliunas 2003), allowing establishment of Viking settlements in areas of western Greenland that today are covered in glaciers; in Finland, pine forests existed further north than they do today, with temperatures ca. 0.5^{0}C warmer than present (Kultti et al. 2006).*

- There is no evidence to suggest that ice in the Arctic Basin disappeared entirely during either the early or late Holocene warm periods or that any ice-dependent species disappeared: polar bears (and their known prey species, ringed seals, bearded seals and walrus) existed before the last Ice Age and significant populations of them remain today (although we don't know how large any of the ancient populations actually were).

- Based on the evidence of extensive polar ice (Bradley and England 2008) and fossil remains of seals and polar bears found outside the Arctic, most Arctic populations appear to have been displaced south during the last Ice Age (Dyke et al. 1999; Harington 2008; Kurten 1988).

- Note that during previous Holocene warm periods mentioned above, skeletal remains of bowhead whales and walrus on shorelines mark the their prior distributions (Dyke et al. 1999, Dyke and Savelle 2001; Dyke and England 2003; Fisher et al. 2006): there are no bones of polar bears found amongst these (Art Dyke, pers. comm., 2007).

- Fossil and subfossil remains of polar bears (who presumably died of natural causes, not killed by humans) are exceedingly rare: there are exactly **6 (six)** Pleistocene age specimens of polar bear worldwide (Harington 2001; Kurten 1988) and one major Holocene deposit from a natural trap cave on the Pribilof Islands, in the Bering Sea, that is about 4,500 years old (Veltre et al. 2008). More polar bear remains are found in Late Holocene archaeological deposits in the Arctic than in natural-death contexts, although they are still quite rare (e.g. Murray 2008; Harington 2001, 2008).

- In other words, the suggestion that polar bears would have moved to land during early Holocene warm periods (in response to reduced ice cover worldwide) is pure conjecture and not supported by any evidence. Virtually all polar bears must die on the ice where their remains sink to the bottom of the ocean: fossil finds are rare because the Arctic sea ice habitat is not conducive to discovery.

SEA ICE THICKNESS AND EXTENT (ESSENTIAL POLAR BEAR HABITAT)

- Many statements made regarding sea ice thickness in the Arctic do not acknowledge the incompleteness of this data: *one frequently cited study (Laxon et al. 2003) surveyed (via satellite) only ½ of permanent sea ice and did not include ANY of the region in the central Arctic Basin (above 81^0 N).*

-Another frequently cited reference (Lindsay and Zhang 2005) concludes that Arctic sea ice is experiencing a continual decline that cannot easily be reversed, but this is *not* a data-based paper ─ it is a *model* based on what is now considered old, substandard data from coastal submarine surveys.

- Sea ice *thickness* in the huge Arctic Basin region is based on very few actual measurements that have been extrapolated to represent the entire region and used in various climate models to predict future conditions (Rothrock et al. 2003; Yu and Rothrock 1996); ice *extent* data from satellites used in these models have been available only since 1979; ***these data are insufficient for assessing long-term trends.***

- Limited coverage of some of these surveys, in addition to the fact that the models do not take effects of wind into account, have almost certainly led to overestimates of sea ice reduction and ice thinning (Holloway 2001; Holloway and Sou 2002): wind can temporarily concentrate ice in areas that are not surveyed.

> ***Polar bears that live in regions of extensive sea ice routinely hunt on newly-formed ice that is less than 30 cm thick (about 1 ft.) and are quite capable of utilizing "thick" first year ice (more than 120 cm thick, or about 4 ft.) for over-wintering activities, including denning: they do not*** **require** ***thick multi-year ice*** **(Ferguson et al. 2000).** ***First year ice in March of this year was about 1.6m thick (NSIDC 2008).***

- Recent predictions of future sea ice conditions, as they might impact polar bears, are adaptations of unverified "general circulation models" intended to forecast *global* temperatures (Amstrup et al. 2007; Armstrong et al. 2008; Koutsoyiannis et al. 2008). Such models are conditional on global temperatures being *amplified* by an hypothesized amount over the entire Arctic (Polyakov et al. 2002; Serreze and

Francis 2006). None of these models take into account the fact that Arctic climate is subject to profound regional variation and influenced by a host of little-understood drivers of wind and weather patterns, including the Arctic Oscillation (e.g. Overland and Wang 2005; Polyakov et al. 2002) and Pacific Decadal Oscillation (Biondi et al. 2001; Newman et al. 2003), which are known to shift precipitously on decadal and multidecal time scales.

- **Models of future climate change in the Arctic predict** ***sea ice reductions to occur primarily in winter, while all observed sea ice changes so far reported have occurred in spring and summer*** (NASA 2007; NSIDC 2008; Overland and Wang 2005) and ***most of these reductions are not Arctic-wide but confined to the western Arctic*** (Rigor and Wallace 2004; Rigor et al. 2002).

- So far, there is no firm evidence that there has yet been "unidirectional" warming in the Arctic over the last 100 years (e.g. Fisher et al. 2006; Kahl et al. 1993), nor an unprecedented, irreversible decline in either sea ice extent or thickness (Holloway and Sou 2002) — neither is there firm evidence that an "Arctic amplification" effect is markedly and uniformly magnifying circumpolar Arctic temperatures (Polyakov et al. 2002; Serreze and Francis 2006).

- Note that the computer model results presented late last year (Amstrup et al. 2007), which forecast dramatic declines in polar bear numbers based on predicted reductions in seasonal sea ice thickness and extent due to human-generated increases in atmospheric CO_2, have not yet been tested against even a single years worth of independent data.

References

Aars J, Lunn N J, and A.E. Derocher (eds). 2006. *Polar Bears: Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20-24 June 2005, Seattle, Washington, USA*. Occasional Paper of the IUCN Species Survival Commission 32. Gland (Switzerland) and Cambridge (UK): IUCN.
Aars, J., Marques, T.A., Buckland, S.T., Andersen, M., Belikov, S., Boltunov, A., and Ø. Wiig. 2008. Estimating the Barents Sea polar bear subpopulation size. *Marine Mammal Science* in press.

Aguilar, A., Roemer, G., Debenham, S., Binns, M., Garcelon, D., and R.K. Wayne. 2004. High MHC diversity maintained by balancing selection in an otherwise genetically monomorphic mammal. *Proceedings of the National Academy of Sciences USA* 101:3490-3494.

Alley, R. B.. 2000. The Younger Dryas cold interval as viewed from central Greenland. *Quaternary Science Reviews* 19:213-226.

Amstrup, S.C. 1995. Movements, distribution, and population dynamics of polar bears in the Beaufort Sea. Ph.D. dissertation, University of Alaska, Fairbanks.

Amstrup, S.C., Marcot, B.G., and D.C. Douglas. 2007. Forecasting the rangewide status of polar bears at selected times in the 21st century. Administrative Report, U.S. Department of the Interior-U.S. Geological Survey, Reston, VA.

Armstrong, J.S., Green, K.C., and W. Soon. 2008. Polar bear population forecasts: a public-policy forecasting audit. *Interfaces* in press.

Arnason, U., Bodin, K., Gullberg, A., Ledje, C. and Mouchaty, S. 1995. A molecular view of pinniped relationships with particular emphasis on the true seals. *Journal of Molecular Evolution* 40:78-85.

Arnason, U., Gullberg, A., Janke, A., Kullberg, M., Lehman, N., Petrov, E.A., and R. Väinölä. 2006. Pinniped phylogeny and a new hypothesis for their origin and dispersal. *Molecular Phylogenetics and Evolution* 41:345-354.

Bennike, O. 2004. Holocene sea-ice variations in Greenland: onshore evidence. *The Holocene* 14: 607-613.

Bigg, G.R., Cunningham, C.W., Ottersen, G., Pogson, G.H., Wadley, M.R., and P. Williamson. 2008. Ice-age survival of Atlantic cod: agreement between palaeoecology models and genetics. *Proceedings of the Royal Society B* 275:163-172.

Biondi, R., Gershunov, A. and D.R. Cayan. 2001. North Pacific decadal climate variability since 1661. *Journal of Climate* 14:5-10.

Bodkin, D.B., Saxe, H., Araújo, M.B., Betts, R., Bradshaw, R.H.W., Cedhagen, T., Chesson, P., Dawson, T.P., et al. 2007. Forecasting the effects of global warming on biodiversity. *BioScience* 57:227-236.

Born, E.W., Teilmann, J., Acquarone, M., and F.F. Riget. 2004. Habitat use of ringed seals (*Phoca hispida*) in the North Water area (North Baffin Bay). *Arctic* 57:129-142.

Bradley, R.S., and J.H. England. 2008. The Younger Dryas and the sea of ancient ice. *Quaternary Research* 70:1-10.

Burns, J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. *Journal of Mammalogy* 51: 445-454.

Cronin, M.A. 2007. Limitations of molecular genetics in conservation. *Nature* 447:638.

Cronin, M.A., Amstrup, S.C., and G.W. Garner. 1991. Interspecific and intraspecific mitochondrial DNA variation in North American bears (*Ursus*). *Canadian Journal of Zoology* 69:2985-2992.

Cronin, M.A., Amstrup, S.C., and K. T. Schribner. 2006. Microsatellite DNA and mitochondrial DNA variation in polar bears (*Ursus maritimus*) from the Beaufort and Chukchi seas, Alaska. *Canadian Journal of Zoology* 84:655-660.

Crockford, S J. 2004. Animal Domestication and Vertebrate Speciation: A Paradigm for the Origin of Species. Ph.D. dissertation. University of Victoria, Canada.

Crockford, S J. 2006. *Rhythms of Life: Thyroid Hormone and the Origin of Species.* Victoria, Trafford. www.rhythmsoflife.ca

Crockford, S.J. 2008. Be careful what you ask for: archaeozoological evidence of mid-Holocene climate change in the Bering Sea and implications for the origins of Arctic Thule. In *Islands of Inquiry: Colonisation, seafaring and the archaeology of maritime landscapes*. Pp. 113-131. G. Clark, F. Leach and S. O'Connor (eds.). Terra Australis 29 ANU E Press, Canberra.

Crockford, S. and G. Frederick. **2007.** Sea ice expansion in the Bering Sea during the Neoglacial: evidence from archaeozoology. *The Holocene* 17:699-706.

Crockford, S. and G. Frederick. **in review.** Neoglacial distribution of North Pacific pinnipeds addresses fundamental questions about ringed seal and fur seal life history. *In* T. Braje and R. Torrey, eds. *Sea Dogs of the North Pacific: The Archaeology and Historical Ecology of Seals, Sea Lions.* University of California Press, Los Angeles.

Dahl-Jensen, D., Mosegaard, K., Gundestrup, N., Clow, G.D., Johnsen, S.J., Hansen, A.W., and N. Balling. 1998. Past temperatures directly from the Greenland Ice Sheet. *Science* 282:268-271.

Dalton, R. 2008. Whales are on the rise. *Nature* 453:433.

Davis, C.S., Stirling, I., Strobeck, C., and D.W. Coltman. 2008 Population structure of ice-breeding seals. *Molecular Ecology* 17: 3078-3094.

Derocher, A.E., Lunn, N.J. and I. Stirling. 2004. Polar bears in a warming climate. *Integrative and Comparative Biology* 44:163-176.

Derocher, A.E., Wiig, Ø., and M. Andersen. 2002. Diet composition of polar bears in Svalbard and the western Barents Sea. *Polar Biology* 25: 448-452.

Doroff, A.M., Estes, J.A., Tinker, M.T., Burn, D.M., and T.J. Evans. 2003. Sea otter population declines in the Aleutian Archipelago. *Journal of Mammalogy* 84:55-64.

Duff-Brown, B. 2006. DNA test confirms hybrid bear in the wild. ABC News Internet Ventures, Associated Press. accessed Feb. 27, 2007. http://abcnews.go.com/Technology/wireStory?id=1951208

Dyck, M.G., Soon, W., Baydack, R.K., Legates, D.R., Baliunas, S., Ball, T.F., and L.O. Hancock 2007. Polar bears of western Hudson Bay and climate change: are warming spring air temperatures the "ultimate" survival control factor? *Ecological Complexity* 4:73-84.

Dyck, M.G., Soon, W., Baydack, R.K., Legates, D.R., Baliunas, S., Ball, T.F., and L.O. Hancock 2008. Reply to response to Dyck et al. (2007) on polar bears and climate change in western Hudson Bay by Stirling et al. (2008). *Ecological Complexity* in press.

Dyke, A.S., and J. England. 2003. Canada's most northerly postglacial bowhead whales (*Balaena mysticetus*): Holocene sea-ice conditions and polynya development. *Arctic* 56:14-20.

Dyke, A.S., Hooper, J., Harington, C.R., and J.M. Savelle. 1999. The late Wisconsinan and Holocene record of walrus (*Odobenus rosmarus*) from North America: a review with new data from arctic and Atlantic Canada. *Arctic* 52:160-181.

Dyke, A.S. and Savelle, J.M. **2001**. Holocene history of the Bering Sea bowhead whale (*Balaena mysticetus*) in its Beaufort Sea summer grounds off southwestern Victoria Island , western Canadian Arctic. *Quaternary Research* 55: 371-379.

Estes, J.A. 1990. Growth and equilibrium in sea otter populations. *Journal of Animal Ecology* 59:385-401.

Fagan, B. 2000: *The Little Ice Age: How Climate Made History, 1300-1850.* Basic Books.

Ferguson, S.H., Taylor, M.K., and F. Messier. 1997. Space use by polar bears in and around Auyuittuq National Park, Northwest Territories, during the ice-free period. *Canadian Journal of Zoology* 75:1585-1594.

Ferguson, S.H., Taylor, M.K., and F. Messier. 2000. Influence of sea ice dynamics on habitat selection by polar bears. *Ecology* 81:761-772.

Ferguson, S.H., Stirling, I. and P. McLoughlin. 2005. Climate change and ringed seal (*Phoca hispida*) recruitment in western Hudson Bay. *Marine Mammal Science* 21:121-135.

Finley, K.J,, Miller, G.W., Davis, R.A., and W.R. Koski. 1983. A distinctive large breeding population of ringed seal (*Phoca hispida*) inhabiting the Baffin Bay pack ice. *Arctic* 36:162-173.

Fischbach, A.S., Amstrup, S.C., and D.C. Douglas. 2007. Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. *Polar Biology* 30:1395-1405.

Fisher, D., Dyke, A., Koerner, R., Bourgeois, J., Kinnard, C., Zdanowicz, C., de Vernal, A., Hillaire-Marcel, C., Savelle, J., and A. Rochon. 2006. Natural variability of arctic sea ice over the Holocene. *EOS, Transactions of the American Geophysical Union* 87(28):273-280.

Frost, D.J., Lowry, L.F., Pendleton, G. and H.R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida,* in the Alaskan Beaufort Sea, 1996-99. *Arctic* 57:115-128.

Grant, P.R., and B.R. Grant. 2002. Unpredictable evolution in a 30-year study of Darwin's finches. *Science* 296:707-711.

Grime, J.P., Fridley, J.D., Askew, A.P., Thompson, K., Hodgson, J.G., and C.R. Bennett. 2008. Long-term resistance to simulated climate change in an infertile grassland. *Proceedings of the National Academy of Sciences USA.* 105:10028-10032.

Hammill, M.O. and T.G. Smith. 1991. The role of predation in the ecology of the ringed seal in Barrow Strait, Northwest Territories, Canada. *Marine Mammal Science* 7:123-135.

Harington, C.R. 2001. *Annotated Bibliography of Quaternary Vertebrates of Northern North America.* Toronto, University of Toronto Press.

Harington, C.R. 2008. The evolution of Arctic marine mammals. *Ecological Applications* 18 (Suppl.):S23-S40

Holloway, G. 2001. Is Arctic sea ice rapidly thinning? *Ice and Climate News* 1 (Sept):2-5.

Holloway, G. and T. Sou. 2002. Has Arctic sea ice rapidly thinned? *Journal of Climate* 15:1691-1701.

Holst, M., Stirling, I., and W. Calvert. 1999. Age structure and reproductive rates of ringed seals (*Phoca hispida*) on the northwest coast of Hudson Bay in 1991 and 1992. *Marine Mammal Science* 15:1357-1364.

Holst, M., Stirling, I., and K.A. Hobson. 2001. Diet of ringed seals (*Phoca hispida*) on the east and west sides of the North Water polynya, northern Bafffin Bay. *Marine Mammal Science* 17:888-908.

Jennings, A.E., Knudsen, K.L., Hald, M., Hansen, C.V. and Andrews, J.T. 2002. A mid-Holocene shift in Arctic sea ice variability on the East Greenland Shelf. *The Holocene* 12:49-58.

Kaeuffer, R., Coltman, D.W., Chapius, J.-L., Pontier, D., and D. Réale. 2007. Unexpected heterozygosity in an island mouflon population founded by a single pair of individuals. *Proceedings of the Royal Society B* 274:527-533.

Kahl, J.D., Charlevoix, D.J., Zaftseva, N.A., Schnell, R.C., and M.C. Serreze. 1993. Absence of evidence for greenhouse warming over the Arctic Ocean in the past 40 years. *Nature* 361:335-337.

Kaufman, Ager, T.A, Anderson, N.J., Anderson, P.M., Andrews, J.T., Bartlien, P.J., Brubaker, L.B., Coats, L.L., et al. 2004. Holocene thermal maximum in the western Arctic (0-180^{0}W). *Quaternary Science Reviews* 23: 529-560.

Kelly, B.P. and D. Wartzok. 1996. Ringed seal diving behavior in the breeding season. *Canadian Journal of Zoology* 74: 1547-1555.

Keenlyside, N.S., Latif, M., Jungclaus, J., Kornblueh, L., and E. Roeckner. 2008. Advancing decadal-scale climate prediction in the North Atlantic sector. *Nature* 453: 84-88.

Kingsley, M.C.S., Stirling, I., and W. Calvert. 1985. The distribution and abundance of seals in the Canadian High Arctic, 1980-1082. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1189-1210.

Kochnev, A.A. 2006. Research on polar bear autumn aggregations on Chukotka, 1989-2004. In Aars J, Lunn N J, and A.E. Derocher (eds), *Polar Bears: Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20-24 June 2005, Seattle, Washington, USA*. Pp. 157-165. Occasional Paper of the IUCN Species Survival Commission 32. Gland (Switzerland) and Cambridge (UK): IUCN.

Koutsoyiannis, D., Efstratiadis, A., Mamassis, N., and A. Christofides. 2008. On the credibility of climate predictions. *Hydrological Sciences* 53:671-684.

Krafft, B.A., Kovacs, K.M., Frie, A.K., Haug, T., and C. Lydersen. 2006. Growth and population parameters of ringed seals (*Pusa hispida*) from Svalbard, Norway, 2002-2004. *ICES Journal of Marine Science* 63: 1136-1144.

Krafft, B.A., Kovacs, K.M., and C. Lydersen. 2007. Distribution of sex and age groups of ringed seals *Pusa hispida* in the fast-ice Breeding habitat of Kongsfjorden, Svalbard. *Marine Ecology Progress Series* 335:199-206.

Kultti, S., Mikkola, K., Virtanen, T., Timonen, M., and M. Eronen. 2006. Past changes in the Scots pine forest line and climate in Finnish Lapland: a study based on megafossils, lake sediments, and GIS-based vegetation and climate data. *The Holocene* 16:381-391.

Kurtén, B. 1988. *On Evolution and Fossil Mammals*. Columbia University Press, New York.

Labansen, A.L., Haug, C., and K.M. Kovacs. 2007. Spring diet of ringed seals (*Phoca hispida*) from northwestern Spitsbergen, Norway. *ICES Journal of Marine Science* 64:1246-1256.

Laidre, K.L., Stirling, I., Lowry, L.F., Wiig, Ø., Heide-Jørgensen, M.P., and S.H. Ferguson. 2008 Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. *Ecological Applications* 18(2, Suppl.):S97-S125.

Laxton, S., Peacock, N., Smith, D. 2003. High interannual variability of sea ice thickness in the Arctic region. *Nature* 425:947-950.

Lennox. A.R. and A.E. Goodship 2008. Polar bears (*Ursus maritimus*), the most evolutionary advanced hibernators, avoid significant bone loss during hibernation. *Comparative Biochemistry and Physiology Part A* 149: 203-208.

Lindsay, R.W. and J. Zhang. 2005. The thinning of arctic sea ice, 1988-2003: have we passed a tipping point? *Journal of Climate* 18:4879-4894.

Lønne, O.J. and B. Gulliksen. 1989. Size, age and diet of polar cod, *Boreogadus saida* (Lepechin 1773), in ice covered waters. *Polar Biology* 9:187-191.

Lunn, N.J., Stirling, I., and S.N. Nowicki. 1997. Distribution and abundance of ringed (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) in western Hudson Bay. *Canadian Journal of Fisheries and Aquatic Sciences* 54:914-921.

Lydersen, C. and I. Gjertz. 1986. Studies of the ringed seal (*Phoca hispida* Schreber 1775) in its breeding habitat in Kongsfjorden, Svalbard. *Polar Research* 4:57-63.

Macdonald, G.M., Velichko, A.A., Kremenetski, C.V., Borisova, O.K., Goleva, A.A., Andreev, A.A., Cwynar, L.C., Riding, R.T., Forman, S.L., Edwards, T.W.D., Aravena, R., Hammarlund, D., Szeicz, J.M., and V.N. Gattaulin. 2000. Holocene treeline history and climate change across Northern Eurasia. *Quaternary Research* 53:302-311.

Murray, M.S. 2008. Zooarchaeology and arctic marine mammal biogeography, conservation and management. *Ecological Applications* 18 (Suppl):S41-S55.

Mauritzen, M., Derocher, A.E., and Ø. Wiig. 2001. Space-use strategies of female polar bears in a dynamic sea ice habitat. *Canadian Journal of Zoology* 79:1704-1713.

Newman, M., Compo, G.P., and M.A. Alexander. 2003. ENSO-forced variability of the Pacific Decadal Oscillation. *Journal of Climate.* 16:3853-3857.

Nowak, R.M. 2003. *Walker's Marine Mammals of the World.* John's Hopkins University Press, Baltimore.

NSIDC (National Snow and Ice Data Center). 2008. "A different pattern of sea ice retreat." July 17, 2008. http://nsidc.org/arcticseaicenews/index.html

NASA press release. 2007. "NASA Examines Arctic Sea Ice Changes Leading to Record Low in 2007." Oct. 1, 2007. http://www.nasa.gov/vision/earth/lookingatearth/quikscat-20071001.html

Overland, J.E. and M. Wang. 2005. The Arctic climate paradox: the recent decrease of the Arctic Oscillation. *Geophysical Research Letters* 32:L06701 doi:10.1029/2004G021752.

Polyakov, I.V., Alekseev, G.V., Bekryaev, R.V., Bhatt, U., Colony, R.L., Johnson, M.A., Karklin, V.P., Makshtas, A.P., Walsh, D. and A.V. Yulin. 2002. Observationally based assessment of polar amplification of global warming. *Geophysical Research Letters* 29(18):1878 (25-1 to 25-4) doi 10.1029/2001GL011111.

Reeves, R.R, Stewart, B.S., Clapham, P.J. and **Powell, J.A. 2002**. *National Audobon Society's Guide to Marine Mammals of the World.* Alfred A. Knopf.

Regehr, E.V., Lunn, N.J., Amstrup, S.C., and I. Stirling. 2007a. Survival and population size of polar bears in western Hudson Bay in relation to earlier sea ice breakup. *Journal of Wildlife Management* 71:2673-2683.

Regehr, E.V., Hunter, C.M., Caswell, H., Amstrup, S.C., and I. Stirling. 2007b. Polar bears in the southern Beaufort Sea I: survival and breeding in relation to sea ice conditions, 2001-2006. Administrative Report, U.S. Department of the Interior-U.S. Geological Survey, Reston, VA.

Rigor, I.G. and J.M. Wallace. 2004: Variations in the age of Arctic sea ice and summer sea ice extent. *Geophysical Research Letters* 31:L09401.

Rigor, I.G., Wallace, J.M., and R.L. Colony. 2002. Response of sea ice to the Arctic Oscillation. *Journal of Climate* 15:2648-2663.

Rode, K.D., Amstrup, S.C., and E.V. Regehr. 2007. Polar bears in the southern Beaufort Sea III: stature, mass, and cub recruitment in relationship to time and sea ice extent between 1982 and 2006. Administrative Report, U.S. Department of the Interior-U.S. Geological Survey, Reston, VA.

Rothrock, D.A., Zhang, J., and Y. Yu. 2003. The arctic ice thickness anomaly of the 1990s: a consistent view from observations and models. *Journal of Geophysical Research* 108(C3) 3083:28-1 – 28-10.

Serreze, M.C. and J.A. Francis. 2006. The Arctic amplification debate. *Climate Change* 76:241-264.

Schliebe, S., Rode, K.D., Gleason, J.S., Wilder, J., Proffitt, K., Evans, T.J., and S. Miller. 2008. Effects of sea ice extent and food availability on spatial and temporal distribution of polar bears during the fall open-water period in the southern Beaufort Sea. *Polar Biology* 31:999-1010.

Smith, T.G. and M.O. Hammill. 1981. Ecology of the ringed seal, *Phoca hispida,* in its fast ice breeding habitat. *Canadian Journal of Zoology* 59:966-981.

Smith, T.G., Hammill, M.O., and G. Taugbøl. 1991. A review of the development, behavioural and physiological adaptations of the ringed seal, *Phoca hispida,* to life in the arctic winter. *Arctic* 44:124-131.
Soon, W. and Baliunas, S. 2003: Proxy climatic and environmental changes of the past 1000 years. *Climate Research* 23:89-110.

Steffensen, J.P., Andersen, K.K., Bigler, M., Clausen, H.B., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M., Johnsen, S.J., Jouzel, J. et al. 2008. High-resolution Greenland ice core data show abrupt climate change happens in few years. *Science* 321:680-684.

Stirling, I. 2002. Polar bears and seals in the eastern Beaufort Sea and Amundsen Gulf: a synthesis of population trends and ecological relationships over three decades. *Arctic* 55 (Suppl. 1):59-76.

Stirling, I. and A.E. Derocher 2007. Melting under pressure: the real scoop on climate warming and polar bears. *The Wildlife Professional* Fall:24-27.

Stirling, I., Derocher, A.E., Gough, W.A., and K. Rode. 2008a. Response to Dyck et al. (2007) on polar bears and climate change in western Hudson Bay. *Ecological Complexity* in press.

Stirling, I., Jonkel, C., Smith, P., Robertson, R., and D. Cross. 1977. The ecology of the polar bear (*Ursus maritimus*) along the western coast of Hudson Bay. *Canadian Wildlife Service Occasional Paper* 33, Edmonton.

Stirling, I. and Lunn, N.J. 1997. Environmental fluctuations in arctic marine ecosystems as reflected by variability in reproduction of polar bears and ringed seals. In *Ecology of Arctic Environments,* S. J. Woodin and M. Marquiss (eds), pp.167-181. Blackwell Science, Oxford.

Stirling, I., McDonald, T.L., Richardson, E.S., and E.V. Regehr. 2007. Polar bear population status in the Northern Beaufort Sea. Administrative Report, U.S. Department of the Interior-U.S. Geological Survey, Reston, VA.

Stirling, I. and N.A. Øritsland. 1995. Relationships between estimates of ringed seal (*Phoca hispida*) and polar bear (*Ursus maritimus*) populations in the Canadian Arctic. *Canadian Journal of Fisheries and Aquatic Sciences* 52:2594-2612.

Stirling, I., Richardson, E., Thiemann, G.W., and A.E. Derocher. 2008b. Unusual predation attempts of polar bears on ringed seals in the southern Beaufort Sea : possible significance of changing spring ice conditions. *Arctic* 61:14-22.

Talbot, S. L., and G.F. Shields 1996. Phylogeography of brown bears (*Ursus arctos*) of Alaska and paraphyly within the Ursidae. *Molecular Phylogenetics and Evolution* 5:477-494.

Todd, F.S., Headland, R.K., and N. Lasca. 1992. Animals at the North Pole. *Polar Record* 28:321-322.

Van Meurs, R. and J.F. Splettstoesser 2003. Farthest North Polar Bear (Letter to the Editor). *Arctic 56:309.*

Veltre, D.W, Yesner, D.R., Crossen, K.J., Graham, R.W., and J.B. Coltrain. 2008. Patterns of faunal extinction and paleoclimatic change from mid-Holocene mammoth and polar bear remains, Pribilof Islands, Alaska. *Quaternary Research* 70:40-50.

Vibe, Christian. 1967. Arctic animals in relation to climatic fluctuations. *Meddelelser om Grønland.* 170(5). C. A. Reitzels Forlag, Copenhagen.

Wiig, O., Derocher, A.E. and Belikov, S.E. 1999. Ringed seal (*Phoca hispida*) breeding in the drifting pack ice of the Barents Sea. *Marine Mammal Science* 15:595-598.

Yu,Y. and D.A. Rothrock. 1996. Thin ice thickness from satellite thermal imagery. *Journal Geophysical Research – Oceans* 101 (C11):753-778.

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Bio:

Susan Crockford (Ph.D., University of Victoria, Canada) is an evolutionary biologist with more than 30 years experience in the specialized field of archaeozoology and is a world-renowned expert in the identification and analysis of animal bone (including fish, birds and marine mammals) recovered from archaeological sites and animal digestive tracts. She is particularly interested in vertebrate evolution, especially of dogs, polar bears, and humans. She has written a book for non-scientists based on her dissertation topic ("Rhythms of Life: Thyroid Hormone and the Origin of Species") and in 2006, appeared prominently in the PBS NATURE documentary "Dogs That Changed the World." She has many peer-reviewed academic publications (see www.pacificid.com and www.rhythmsoflife.ca) and recently published a paper with colleague Gay Frederick on the effects of climate cooling on marine mammal distributions in the North Pacific Ocean within the past 5,000 years (Sea ice expansion in the Bering Sea during the Neoglacial: evidence from archaeozoology. 2007. "The Holocene" 17:699-706). She runs a private research firm (Pacific Identifications Inc.) with two colleagues and holds an adjunct faculty position at the University of Victoria.

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