Demographic, ecological and physiological responses of ringed seals to an abrupt decline in sea ice availability

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To assess whether demographic declines of Arctic species at the southern limit of their range will be gradual or punctuated, we compared large-scale environmental patterns including sea ice dynamics to ringed seal (*Pusa hispida*) reproduction, body condition, recruitment, and stress in Hudson Bay from 2003-2013. Aerial surveys suggested a gradual decline in seal density from 1995-2013, with the lowest density occurring in 2013. Body condition decreased and stress (cortisol) increased over time in relation to longer open waterperiods. The 2010 open water period in Hudson Bay coincided with extremes in large-scale atmospheric patterns (NAO, AO, ENSO) resulting in the earliest spring breakup and the latest ice formation on record. The warming event was coincident with the highest stress levels and the lowest recorded ovulation rate and low pregnancy rate, few pups in the Inuit harvest, and observations of sick seals. We conclude that although negative demographic responses of Hudson Bay seals are occurring gradually with diminishing sea ice, a recent episodic environmental event played a significant role in a punctuated population decline.

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ABSTRACT

To assess whether demographic declines of Arctic species at the southern limit of their range will be gradual or punctuated, we compared large-scale environmental patterns including sea ice dynamics to ringed seal (*Pusa hispida*) reproduction, body condition, recruitment, and stress in Hudson Bay from 2003-2013. Aerial surveys suggested a gradual decline in seal density from 1995-2013, with the lowest density occurring in 2013. Body condition decreased and stress (cortisol) increased over time in relation to longer open water periods. The 2010 open water period in Hudson Bay coincided with extremes in large-scale atmospheric patterns (NAO, AO, ENSO) resulting in the earliest spring breakup and the latest ice formation on record. The warming event was coincident with the highest stress levels and the lowest recorded ovulation rate and low pregnancy rate, few pups in the Inuit harvest, and observations of sick seals. We conclude that although negative demographic responses of Hudson Bay seals are occurring gradually with diminishing sea ice, a recent episodic environmental event played a significant role in a punctuated population decline.

Subjects: Animal population, Climate change

Keywords: abundance, body condition, disease, Hudson Bay, *Pusa hispida*, sea ice

BACKGROUND

Organisms evolve specific adaptations to their habitats through natural selection (Mayr 1963) and when their habitats change gradually, organisms can adjust phenotypically within an evolved range of flexibility (Levins 1968). However, this evolved adaptation has limitations and in extreme situations, organisms may not be able to adapt to particular habitats and environmental conditions above an evolved threshold (Southwood 1977). Under these circumstances, populations suffer demographic mortality of individuals and/or immigrate to new habitats that may allow increased demographic success (MacArthur and Wilson 1966). The result is a shift in species distribution (Guisan and Thuiller 2005) and understanding this process by identifying thresholds to adaptability and the demographic mechanism of population decline are both critical to species conservation.

Predicting how climate warming will result in retraction of an Arctic species range northward requires knowledge of demographic changes and their ecological plasticity in response to environmental change. Few studies have linked marine mammal demographic responses to climate change (Poloczanaska et al. 2007) with the notable exception of ringed seals (Meier et al. 2004, Post et al. 2009), where the majority of research results reflect changes in foraging behaviour (Young and Ferguson 2014, Hamilton et al. 2015). Ringed seals (*Pusa hispida*) have a circumpolar distribution and show high variability in the relative importance of predation from polar bears (*Ursus maritimus*) (Thiemann et al. 2008) and to varying food habits (Yurkowski et al. 2016a). However, key habitat attributes are linked to survival and successful reproduction. In particular, ringed seals require sea ice during the critical spring period when reproduction and molting occurs (Smith & Stirling 1975) and a seasonal pulse in food availability in the summer ice-free season (Young & Ferguson 2013). Evolved life history characteristics that match these high-latitude environmental features include relative small body size for a pinniped and a life history characterized by early age of maturation, annual birthing, short lactation duration, widely varying but high pup mortality, relatively low adult mortality, and greater fitness investment in long life (Ferguson & Higdon 2006).

High latitude species are characterized by a strong seasonal cycle of feast and fast with both periods critical to reproduction and survival. Ringed seals are adapted to cycle annually from intensive foraging during the open water season to accumulate fat reserves to sustain them over winter and during the birthing, nursing, and mating periods when adults are restricted to small home ranges with depleted food resources. In spring, pups are independent and adults undergo molting with little feeding opportunities and increased risk of predation (Young and Ferguson 2015). During periods of deteriorating environmental conditions, the phenology of ringed seals can be interrupted leading to inadequate energy reserves prior to the next year's reproduction. Ringed seal populations can also be negatively affected by infrequent, annual, extreme climatic conditions that exert pressure on their demographics.

Endemic Arctic species are challenged by the rapid pace of sea ice declines and resulting changes in ecological dynamics of the marine ecosystem (Post et al. 2013). Southern Hudson Bay represents one of the most southerly distributions of ringed seals and therefore, as an ice-obligate marine mammal, the prediction is for a retraction northward in range from the southern edges of their distribution (Kovacs & Lydersen 2008). The initial characteristics of population and demographic changes may already be occurring with a decrease in ringed seal density observed in western Hudson Bay between the two recent aerial surveys in spring 2010 and 2013 (0.78 to 0.20/km^2) (Young et al. 2015).

Here, we assess whether a 2010 extreme climatic event was another year in a long-term declining trend for Hudson Bay or an infrequent episodic event that impacted ringed seal demography, body condition, and reproduction. Our objective was to compare annual trends in sea ice breakup and formation and the influence of major climatic indices to biological data from seal collections, 2003-13 that include (1) body fat from seals harvested by Inuit, (2) reproduction from examination of reproductive tracts, (3) recruitment from hunter harvest statistics, and (4) stress from blubber cortisol levels. We hypothesize that gradual deteriorating change in sea ice characteristics will correlate with a gradual decrease in ringed seal body condition, ovulation rate and pup recruitment, whereas an abrupt decline in sea ice availability in 2010 will result in dramatic negative demographic, ecological and physiological responses by ringed seals.

METHODS

Sea ice breakup and freeze-up dates were determined from weekly data obtained from the Canadian Ice Service using Icegraph 2.0 (http://iceweb1.cis.ec.gc.ca/IceGraph/), for eastern Hudson Bay, 1979-2014. For a given region, ice breakup date was defined as the date on which the sea ice concentration decreased and remained below 50% (Stirling et al. 1999). Conversely, freeze-up date was defined as the date on which sea ice concentration increased and remained above 50%. Major climatic indices were obtained from the Climate Prediction Center (http://www.cpc.ncep.noaa.gov/), including the Arctic Oscillation (AO), the North Atlantic Oscillation (NAO), and El Nino-Southern Oscillation (ENSO) for the December to February monthly mean estimates from 1971-2014. We included ENSO due to its significant climatic influence in North America and due to its effect on ecological relationships in several ecosystems across the globe (Wang et al. 2010; Nye et al. 2014; Rustic et al. 2015). The longer time frame available for environmental data provided a background to the 2003-2013 period with available ringed seal biological data.

Morphological measurements and tissue samples were collected from 926 Hudson Bay ringed seals harvested during the Inuit subsistence hunt from Sanikiluaq, NU, Canada (56°32′34″ N, 79° 13′ 30″ W) and Arviat, NU (61° 6′ 29″ N, 94° 3′ 25″ W) from 2003-2013 in autumn when age/sex composition is considered representative of the population (Holst et al. 1999). Permits to collect samples as part of the Inuit subsistence hunts were acquired from Fisheries and Oceans Canada. Canine teeth were extracted from the lower jaw for age determination using annual growth layer groups in the cementum (Chambellant and Ferguson 2009). Reproductive tracts were stored frozen before being examined. After gross examination of reproductive tracts, ovaries were excised, formalin-fixed and sectioned at 2-mm intervals, and examined macroscopically for the presence of a corpus luteum (ovulation in the year of collection) and corpora albicantia (previous pregnancies) (Laws 1956). Pup survival was defined as the percentage of pups (i.e., <1 year) in the autumn subsistence hunt and is considered a good measure of 0-6 month survival (Chambellant et al. 2012). An extraction method for ringed seal blubber samples was used in conjunction with radioimmunoassay to measure cortisol levels representing stress (Trana et al. 2014).

Four separate general linear models were used to investigate relationships between environmental (i.e. duration of the open water period, ENSO, NAO and AO indices) and biological variables (i.e. percentage of ovulating females, percentage of pups in the harvest, body condition and cortisol levels) over time using R v 3.2.3 (R Core Team 2015). Continuous predictor variables were screened for collinearity and removed when a Pearson's correlation coefficient was ≥ 0.6 and a variance inflation factor (VIF) was > 3.0. NAO was highly correlated with AO (0.8), thus was removed from all analyses. Prior to analysis, percentage of ovulating females, percentage of pups in harvest, and body condition were normally distributed upon visual examination of histograms and quantile-quantile plots. Cortisol levels were log-transformed before analysis to improve normality.

RESULTS

Results support a gradual pattern of earlier spring ice breakup and later autumn freeze-up in Hudson Bay; where from 2003-2013, sea ice breakup has varied more widely than freeze-up. No relationship occurred with any climate variability index over 1979-2014, but the NAO and AO have been more positive from 1999-2015 (Fig. 1). The longest ice-free season on record for eastern Hudson Bay occurred in 2010, with the earliest spring breakup (May) and latest freeze-up (January 2011) and an anomalous negative NAO and AO, and a high ENSO index (Fig. 1).

Body condition significantly decreased over time ($t = -8.2$, $p < 0.001$), from about 55% blubber mass in 2004 to approximately 45% in 2011 (Fig. 2). In addition, body condition significantly decreased with increasing open water period ($t = -2.0$, $p < 0.05$), ENSO index ($t = -2.3$, $p = 0.02$) and NAO index ($t = -2.0$, $p < 0.05$; Table 1; Fig. 3). Ovulation rate varied considerably among years from 100% in 2008 to 56% in 2011, albeit with no relationship with year, open water duration, or climatic indices. Percentage of pups in the harvest, as an estimate of pup survival, exhibited a marginal decline from 2003-2013 ($t = -2.09$, $p = 0.08$) from about 40% of the harvest to about 20% (Table 1; Fig 2). Stress, as measured by cortisol concentration (ng/g), significantly increased over time ($t = 8.0$, $p < 0.001$) from about 0.1 to 0.6ng/g over the 2003-12 period (Table 1; Fig. 2). A significant decrease in cortisol level occurred with NAO index ($t = -2.6$, $p = 0.01$), whereas a marginally significant increase occurred with ENSO index ($t = 1.93$, $p = 0.05$; Fig. 3). In 2010, cortisol levels in ringed seals had the highest amount of variability (standard deviation = 1.84) compared to other years (Fig. 2). The highest stress levels occurred in 2010, and the lowest recorded ovulation rates occurred in 2011 which supports the pattern of a decrease in ovulation rate after the record high stress levels.

DISCUSSION

We predicted demographic change occurring at the southern limit of the ringed seal distribution with both gradual changes in environmental variables and episodic events associated with extreme lows in sea ice concentration. Our results suggest both patterns have occurred in southern Hudson Bay over the past decade. Previous research has indicated that Hudson Bay ringed seals (Chambellant et al. 2012) and polar bears (Derocher et al. 2004) have shown gradual reductions in body condition and survival over the past decades which are concurrent with negative consequences of continued environmental change (Holst et al. 1999; Ferguson et al. 2005). We provide additional evidence for a continuation of these progressive patterns for ringed seals with decreasing body condition and increasing stress over 2003-2013. However, no research results have suggested short-temporal pulses in condition and abundance for either seals or polar bears in the Hudson Bay ecosystem, although a regime shift likely occurred in late 1990s (Gaston et al. 2012). Here, we document for the first time, a relationship with ringed seal demographics and the 2010 climatic event that resulted in a punctuated decrease in ovulation, reduced body condition, reduced seal pups in the following autumn harvest, and increased cortisol levels.

Gradual reduction in body condition could be associated with the recent changes in Hudson Bay prey resource abundance and availability. The prevalence of capelin (*Mallotus villosus*) and sand lance (*Ammodytes spp.*) and decrease in Arctic cod (*Boreogadus saida*) abundance in Hudson Bay since 2000 has caused dietary shifts from endemic Arctic cod to sub-Arctic capelin and sand lance in Arctic marine megafauna including sea birds (Gaston et al. 2003) and ringed seals (Chambellant et al. 2012). In addition, the isotopic niche size of Hudson Bay ringed seals is significantly larger than individuals from higher latitudes which principally consume Arctic cod, indicating a more diverse and omnivorous diet (Young and Ferguson 2013; Yurkowski et al. 2016a, b). Among ringed seal prey items, Arctic cod represent the highest energy content compared to other fish and invertebrate species (Weslawski et al. 1994; Hedeholm et al. 2011) where its decreased consumption in Hudson Bay ringed seal diet and temporal shifts in forage fish availability and abundance may negatively impact ringed seal energetic demands and body condition.

Assessing the causes of an episodic event is more difficult. The extremely low extent and duration of the 2010 ice-covered period in Hudson Bay may have adversely affected the abundance, availability and distribution of prey resources but it is unlikely to have, triggered a punctuated decrease in their physiological and energetic demands. We summarized anecdotal evidence for an episodic event affecting the abundance and body condition of ringed seals in Hudson Bay related in 2010-11 (see supplementary material). Anecdotal observations in 2010 are suggestive of a hitherto never before seen event causing impaired biological responses in ringed seal behaviour including unusual approachability, lethargy, and increased tendency for hauling out on land, possibly due to associated respiratory problems that were first seen during that autumn season. Polar bears are thought to have benefited from this behavior since affected seals were easily captured but no estimate of predation over and above normal could be calculated. Evidence for a biological response to an episodic environmental event comes from the low ringed seal density observed between spring 2010 and 2013 surveys and the unusual environmental patterns that suggest a possible shift in seal condition after 2010 (Table 1).

An Unusual Mortality Event was declared in 2011 by the US government due to a 'new' ulcerative-dermatitis-disease-syndrome of unknown etiology observed in Alaskan ice seals and Pacific walrus (Atwood et al. 2015). A large scale, trans-boundary, interdisciplinary, disease-investigative team from Alaska, Chukotka, Northwest Territories (NWT) and scientists (USA and internationally) found significant pathology of the lung, liver, immune system, and skin of the seals (Barbosa et al. 2015, Bowen et al. 2015). Hundreds of ice seals of all ages had been reported in Alaska (ringed, bearded (*Erignathus barbatus*), spotted (*Phoca largha*), ribbon (*Histriophoca fasciata*) and Pacific walrus

(*Odobenus rosmarus*)), Chukotka (RU) (ice seals and walrus) and NWT (CA) (ice seals) displaying a variety of skin associated lesions distributed around the eyes, snout, hind flippers, tail, and trunk. As observed in Hudson Bay, the affected ice seals displayed uncommon behaviours such as unusual approachability, lethargy, and increased tendency for hauling out on land, as well as respiratory problems. There was some mortality associated with the disease syndrome; however reliable baseline abundance estimates were not available to assess its significance. Alaskans also reported seeing polar bears preying upon affected seals, suggesting that this additional predation is widespread and represent a significant cause of seal mortality. As of the summer of 2016 no cause of the syndrome has yet been identified.

Potential repercussions of a gradual sea ice decline and punctuated decreases in some years include a continual reduction in ringed seal body condition and greater stress leading to implications on their demographics. The years marked by extremes in climatic indices (Fig. 1) are associated at higher latitudes with excessive sea ice extremes; whereas our results at the southern range of ringed seals indicate a lack of sea ice may have attributed to decreased body condition, increased stress, and low ovulation rates and pup recruitment. Spring 2010 recorded an unusually early ice breakup that may have predisposed seals to a delayed molt. In the fall of 2010, numerous (100's) moribund seals were found in distress along the shore of western Hudson Bay. Rising temperatures, reduction of sea ice, reduction in body condition and the resulting stress are known to increase the likelihood of disease outbreaks (Burek et al. 2008). Severity of enzootic diseases can increase and new disease presentations are also likely (Burge et al. 2014) as was seen in Hudson Bay ringed seals in 2010.

Numerous examples of episodic events causing major ecological shifts include regime shifts (Hughes et al. 2013), continental growth (Santosh 2013), drought (Ireland et al. 2012), disease (Pickles et al. 2013), and range shifts due to climate (Baker et al. 2008, Seppä et al. 2009, Chen et al. 2011). For ringed seals, the literature suggests periods of ringed seal crashes in abundance associated with poor reproduction during significant heavy ice years. Variation in ringed seal density associated with ENSO events include 1973 (Smith and Stirling 1978), 1992 (Ferguson et al. 2005), 1998 (Smith and Harwood 2001), and in 2010 (Fig. 1). Evidence of high latitude regime shifts include 1977 and 1989 (Hare and Mantua 2000), 1998-99 (Litzow 2006, Benson and Trites 2002). Synchronous fluctuations of seabird species across the entire Arctic and sub-Arctic regions were associated with changes in sea surface temperatures that were linked to two climate shifts, in 1977 and again in 1989 (Irons et al. 2008), and 1998 (Flint 2013), including Hudson Bay in 1998 (Gaston et al. 2012). Major atmospheric patterns suggest that we can expect episodic events occurring once every 10-15 years and that they are largely unpredictable in timing but have major consequences on ecosystem structure and function (Ottersen et al. 2004).

CONCLUSIONS

Considerable uncertainties exist with deciphering past patterns to determine possible cause and effect relationships among environmental variation, body condition, and their demographic responses. However, mounting evidence indicates endemic Arctic species, such as ringed seals, are under immense pressure from climate change and complex spatio-temporal shifts in ecology have subsequently resulted in decreased abundance as a harbinger of range shift. Managers need to be wary of climate change culminating in both a

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gradual decline in condition and unpredictable episodic events that when combined can have major abundance and distribution consequences.

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ADDITIONAL INFORMATION AND DECLARATIONS

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Competing Interests

The author's declare there are no competing interests.

Author Contributions

Steven H. Ferguson conceived and secured the funding for the project and wrote the first draft. All authors contributed to the writing process. David J. Yurkowski and Brent G. Young ran the statistical analysis and developed the figures. Randi Anderson ran the cortisol experiment. Cornelia Willing conducted the reproductive assessments. Ole Nielsen worked on the disease studies.

Animal Ethics

Permits to collect samples as part of the Inuit subsistence hunts were acquired from Fisheries and Oceans Canada.

Data availability

Raw environmental data and a summary of observations associated with unusual seal behaviour in 2010-11 is available as electronic supplementary material.

Supplemental Information

Supplemental information for this article can be found online at:

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Table 1. Relationships between Hudson Bay ringed seal biological parameters and environmental correlates assessed using general linear models, 2003-2013.

Covariates	Ovulation rate (%)	Pup recruitment (%)	Seal condition (blubber %)	Cortisol (ng/g)
Intercept	-48.00 ± 69.51	60.03 ± 28.56[a]	**23.82 ± 2.85*** **	**-34.90 ± 43.48*** **
Year	0.02 ± 0.03	-0.03 ± 0.01[a]	**-0.01 ± 0.001*** **	**0.002 ± 0.0002*** **
Ice-free period (days)	0.0003 ± 0.006	0.0008 ± 0.002	**-0.0004 ± 0.0002***	0.00003 ± 0.0005
El-Niño Southern Oscillation	0.004 ± 0.01	-0.02 ± 0.05	**-0.009 ± 0.004***	0.001 ± 0.006[b]
North Atlantic Oscillation	0.011 ± 0.012	-0.0008 ± 0.05	**-0.009 ± 0.005***	**-0.02 ± 0.007 ***

[a] = 0.08; [b] = 0.055; * P < 0.05; ** P < 0.01; *** P < 0.001

R^2 was 0.40 for ovulation rate model, 0.46 for pup recruitment model, 0.09 for body condition model, and 0.21 for cortisol level model.

Figure 1. Top: Annual winter (December to February) North Atlantic Oscillation index (NAO), Arctic Oscillation (AO), and El Nino-Southern Oscillation (ENSO), 1971-2014. Note red arrows indicate possible regime shifts (1977, 1989, 1989/99, 2010) and black arrows possible years with poor ringed seal condition: 1973/74, 1983, 1992, 1998, 2010. Bottom: Sea ice patterns over the day of the year showing inter-annual variation in timing of spring breakup, duration of open water season, and time of freeze-up, 2003-2013. Note that autumn 2010 freeze-up did not occur until January 2011.

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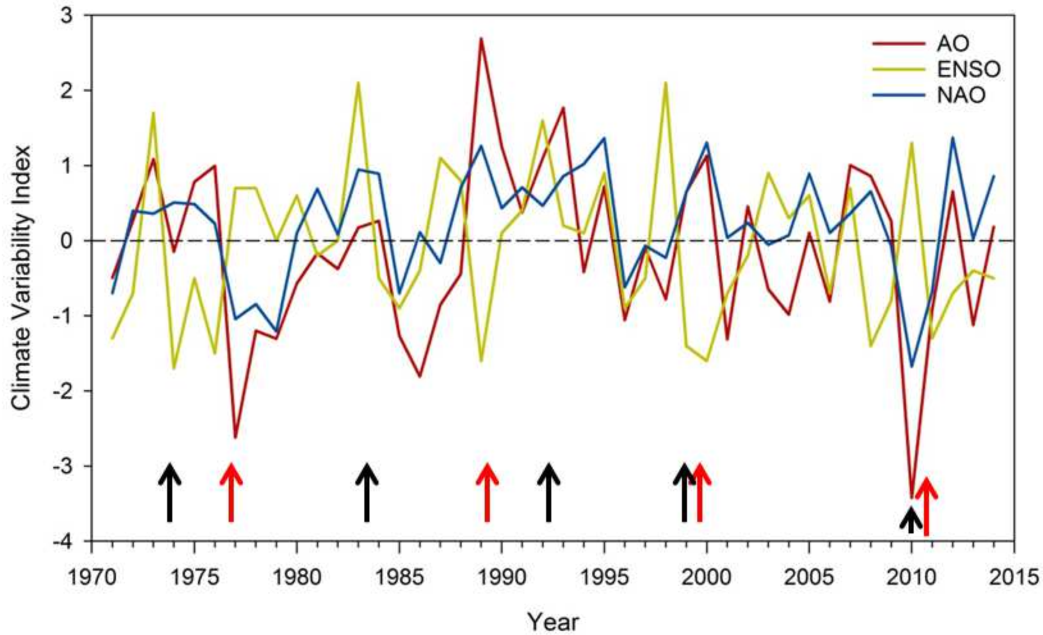
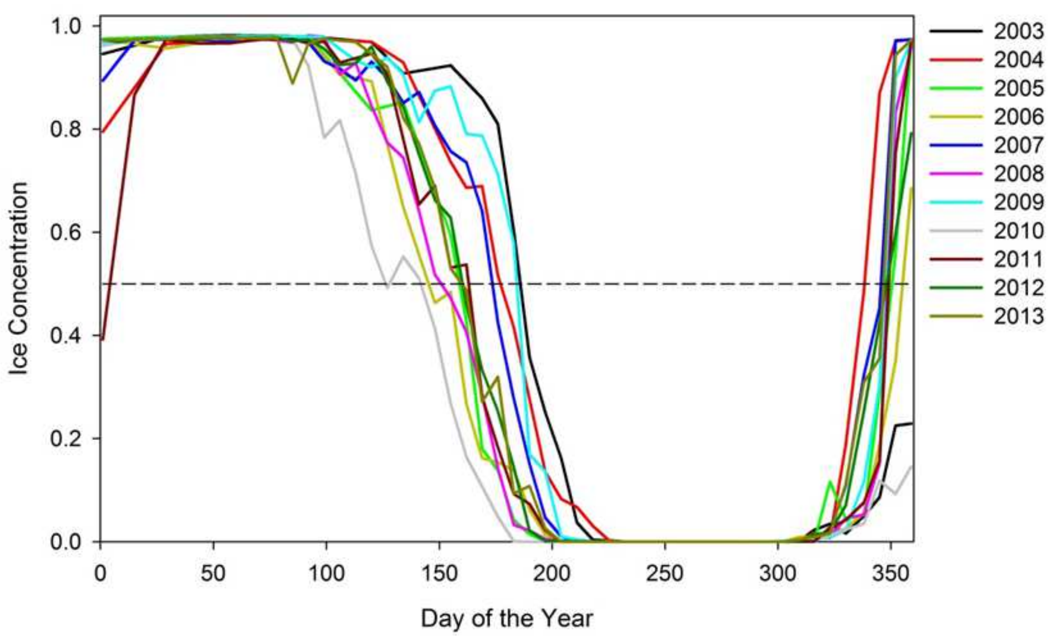

AO
ENSO
NAO
Climate Variability Index
Year
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
3
2
1
0
-1
-2
-3
-4


2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Ice Concentration
Day of the Year
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
350

453

454

455

Figure 2. Barplots (A and B) of annual ovulation rates (%) from adult females and annual percentage of pups in the harvest. Linear regressions between ringed seal body condition and harvest year (C; slope = -0.01, t = -8.2, p <0.001), and cortisol level and harvest year (D; slope = 0.02, t = 8.0, p < 0.001). Sample sizes (n) by year: 2003 (115), 2004 (56), 2005 (88), 2006 (82), 2007 (126), 2008 (105), 2009 (51), 2010 (96), 2011 (97), 2012 (65) and 2013 (45).

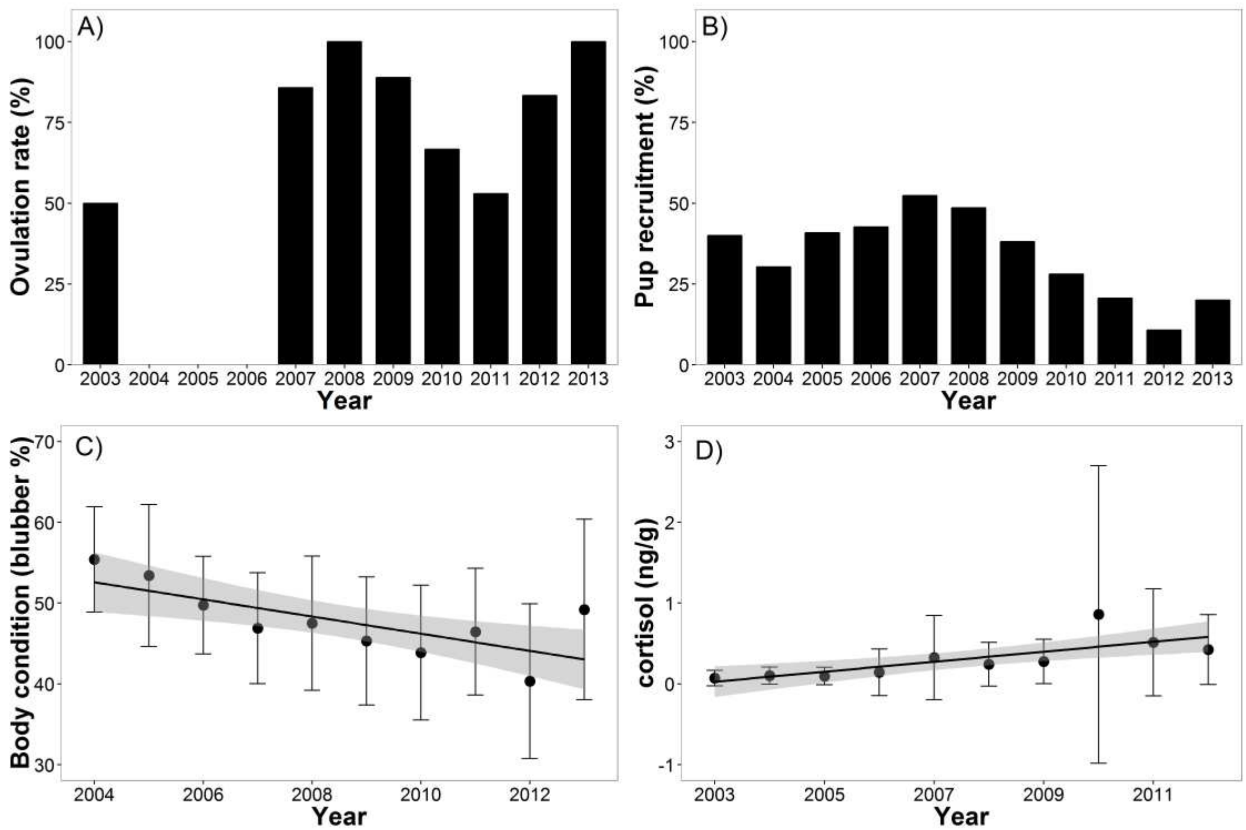
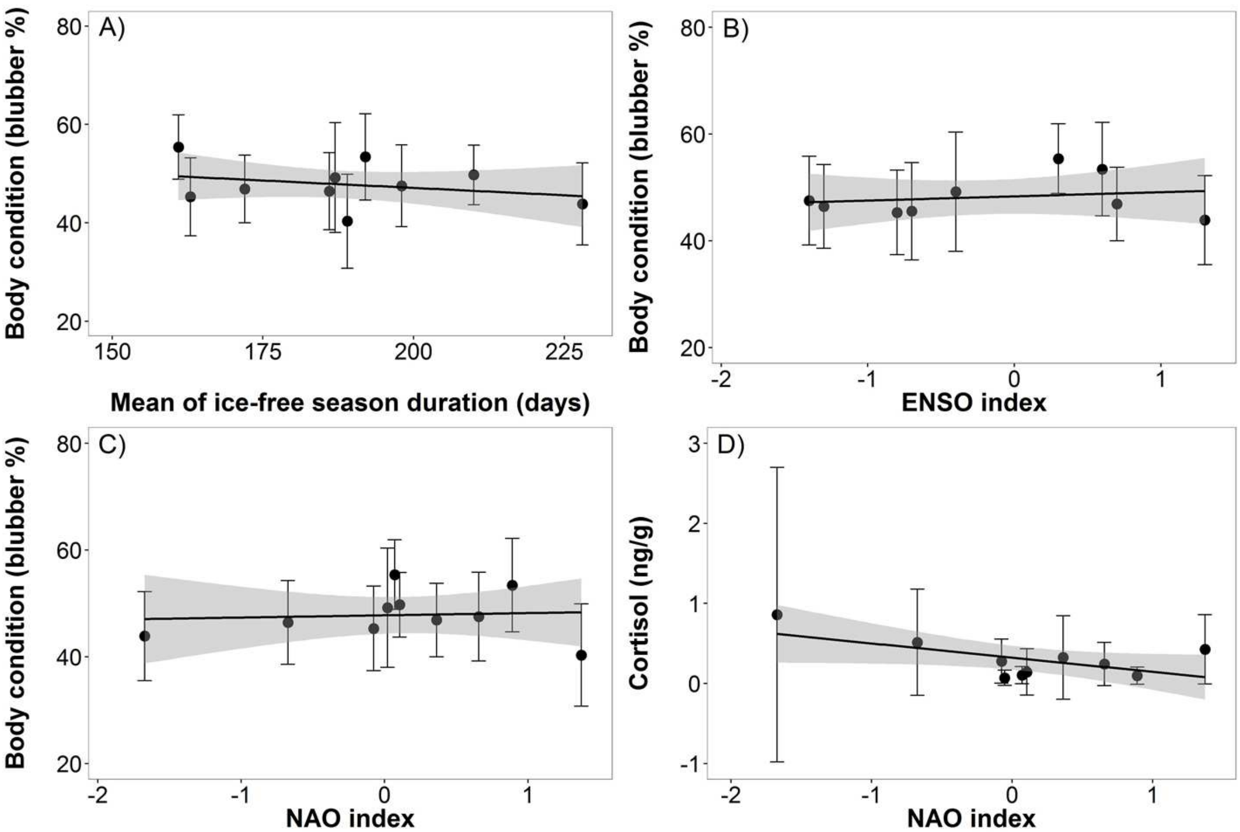


Figure 3. Linear regressions between ringed seal body condition and ice-free duration (A; slope = -0.0004, t = -2.0, p < 0.05), body condition and El-Nino Southern Oscillation (ENSO) index (B; slope = -0.009, t = -2.32, p = 0.02), body condition and North Atlantic Oscillation (NAO) index (C; slope = -0.009, t = 2.0 , p < 0.05), and cortisol and NAO index (D; slope = -0.02, t = 2.6, p = 0.01).



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Supplementary Table1. 1971-2014 NAO, AO, ENSO, and eastern Hudson Bay breakup and freeze-up from 1979 to 2014.

Year	AO	ENSO	NAO	Breakup	Freeze-up
1971	-0.49459	-1.3	-0.69667		
1972	0.264983	-0.7	0.396667		
1973	1.08517	1.7	0.36		
1974	-0.1462	-1.7	0.506667		
1975	0.781803	-0.5	0.486667		
1976	0.993478	-1.5	0.226667		
1977	-2.6173	0.7	-1.04333		
1978	-1.20007	0.7	-0.84667		
1979	-1.30322	0	-1.20667	166	340
1980	-0.56821	0.6	0.1	163	335
1981	-0.16841	-0.2	0.69	191	337
1982	-0.37507	0	0.08	164	334
1983	0.17346	2.1	0.946667	171	339
1984	0.262857	-0.5	0.89	156	328
1985	-1.2665	-0.9	-0.7	151	333
1986	-1.80645	-0.4	0.11	185	326
1987	-0.85368	1.1	-0.29667	180	345
1988	-0.44515	0.8	0.7	154	342
1989	2.688033	-1.6	1.26	180	334
1990	1.252883	0.1	0.433333	180	335
1991	0.374647	0.4	0.706667	174	336
1992	1.094977	1.6	0.466667	181	329

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1993	1.768833	0.2	0.856667	169	328
1994	-0.41784	0.1	1.02	180	348
1995	0.722987	0.9	1.363333	173	334
1996	-1.05476	-0.9	-0.62	184	357
1997	-0.09629	-0.5	-0.06667	164	330
1998	-0.7783	2.1	-0.22667	159	352
1999	0.648627	-1.4	0.643333	146	350
2000	1.1297	-1.6	1.303333	157	351
2001	-1.31188	-0.7	0.04	150	361
2002	0.454133	-0.2	0.236667	171	338
2003	-0.64532	0.9	-0.05333	185	362
2004	-0.98303	0.3	0.07	177	338
2005	0.105223	0.6	0.89	158	350
2006	-0.81005	-0.7	0.104837	145	355
2007	1.002867	0.7	0.36307	173	345
2008	0.859387	-1.4	0.6561	150	348
2009	0.25841	-0.8	-0.07584	184	347
2010	-3.42177	1.3	-1.67293	141	369
2011	-0.9129	-1.3	-0.67427	163	349
2012	0.654935	-0.7	1.371767	159	348
2013	-1.12184	-0.4	0.02096	159	346
2014	0.183305	-0.5	0.85704	168	341

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Supplementary Table2. Chronology of unusual ringed seal and polar bear observations gathered from Hudson Bay communities related to a warming event in 2010.

Date	Comment	Reporter
4 Nov. 2010	I've only seen about 3 kills in the 11 years I've worked for you guys and now 7 in a month?	Marc Hebert, Manitoba Conservation Officer
14 Nov. 2010	He has also seen quite a few seals and seal kills by Polar Bears. He also flew over Button Bay and saw a number of seal kills that hadn't been consumed.	Mike Macri (Sea North Tours, Churchill)
16 Nov. 2010	He states that seals are venturing inland than normal. Bears are eating seals. The only physical problems or abnormalities he notes he has seen is one seal that appeared to be bleeding from the anus. Sick seals -- showing evidence of hair loss.	Amanda Currie (DFO) conversation with Donnie (Great White Bear tours).
16 Nov. 2010	Recently found a seal that was still alive but crawling over land near the Rx road just out of the Town of Churchill.	LeeAnn Fishback (CNSC) with Manitoba Conservation
17 Nov. 2010	First Vince had heard of dead seals. But noted Darryl Hedman flew coast and saw over 300 bears - saw 18 dead seals that had been killed so he says by bears - when I	Ole Nielson (DFO Science) with Vince Crichton (Manitoba

	asked him how the bears were catching seals he said they are likely getting caught on the flats when tide goes out and bears just taking advantage of easy meal - maybe something wrong with seals that they are getting caught like this.	Conservation Manager, Game Fur & Problem Wildlife)
18 Nov. 2010	They both confirm they're have been no reports of any killer whale sightings in the area, as its too late in the seasons for Killer Whales. Also the local polar bears are also very fat, and several appear to be 'stock piling' the seals they catch (i.e. some people have witness and photographed the bears stock piling or buried seals inland instead of eating them). Mike was on a flight a week ago and saw a fat polar bear kill a seal, walk away and kill another seal on the shore, drag it back to the first, and then walk away without eating either. And another sow with cubs had a dead seal and was not eating it. Another seal was seen moving along RX road about 1-2 km from shore. Received two pictures of this from Mike Macri.	Tara Bortoluzzi (DFO Science) spoke with Mike Macri and Bob Windsor (Conservation Officer in Churchill)
24 Nov. 2010	I met two hunters from Chesterfield Inlet and Whale Cove in the Iqaluit airport on Monday that were also very concerned with the 'behavior' of ringed seals near their	Ole Nielsen (DFO)

	communities this fall. I'm following up with them and several other HTOs. They reported that they are catching more adult seals this year which are really large, and very few pups. The seals are also very easy to catch, in many cases they said 'too easy'. One hunter caught 30 seals in one day trip. The seals are also coming inland and hanging around the shoreline for extended periods of time. Of course, it's great for hunting, but they were really concerned as this is very unusual.	
26 Nov. 2010	Some of the Hunters and Trappers Organizations in the Kivalliq region have recently reported concerns with 'odd behaviour' of ringed seals near the communities (i.e. seals coming close to shore and hanging around, and hauling out on shore), as well as some seals that appears to be sick (i.e. molting and loss of hair, seal pocks, low fat content, etc.).	Tara Bortoluzzi (DFO) summarizing response from Kivalliq Region communities
26 Nov. 2010	She has heard the same concerns from hunters: "After discussion with my board of directors, they have reported some hunters catching seals on shore, and far away from shore with loss of hair (like bald patches) but nobody took pictures and the seals were used as dog food."	Leah Muckpah (Arviat HTO Manager)

27 Nov. 2010	He hasn't seen any more seals on shore, neither have the helicopters or tundra buggy camps. Also notes another odd thing, the zodiacs, for the first time ever, are covered with scratches from bearded seals who were hauling up into them in September.	email from Mike Macri (Sea North Tours)
17 Dec. 2010	"A couple weeks ago while he was out of town, Lucasssie Takatak, found 6 dead seals on the beach, their heads seem to be craving for air like their heads up back."	Lucassie Arragutainaq (Secretary Manager Sanikiluaq HTO)
06 Jan. 2011	They observed a very few number of seals were shedding and that even a few number of them were sinking after being shot. The seal harvest in Arviat is usually done when the first ice forms in the salt water, usually late October to Late November. During that time, it is unheard of that seals would be shedding fur and that they would sink after being shot.	reports from local hunters of Arviat
26 Jan. 2011	Ringed seals usually molt in the spring but locals noted seals molting in the fall. The local Conservation Officer sent seal parts to DFO showing the unusual molt. During fall large numbers (100s) of seals were observed along shorelines. Other communities including Repulse Bay also noted the same unusual conditions. Coral Harbour	Ferguson phone conversation with Noah Nakoolak of Coral Harbour HTO

seldom sees seals near town but this past fall large numbers were in the Harbour and some went on land in the harbour (very unusual).

His own personal experience - he was traveling along shoreline in August and found a seal on the beach. The ringed seal kept traveling up the shore – unusual behaviour. Three weeks later he was in a different area and saw a harp seal on land – about ¼ mile inland. It was a late freeze up this autumn and a very warm fall. The ice formed along the shoreline twice in mid-November but drifted off with winds both times before it finally formed fast in December. In December rain fell.

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