

Svalbard's Ringed Seals in a Changing Climate

Harvest-based sampling programme 2012-2017

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Introduction and project rationale:

Ringed seals (*Pusa hispida*) have evolved in close association with Arctic sea ice and depend on it for virtually all aspects of their life history. This high Arctic endemic seal begins its life on land-fast sea ice in fjords and along coastlines in arctic waters including those in Svalbard in most areas where land-fast sea ice forms. Some birthing also takes place in areas of drifting sea ice in some parts of the Arctic including the Barents Sea, though land-fast ice appears to be a strongly favoured habitat for birthing and mating. Ringed seal pups are born in snow caves (birth lairs) that are dug out of snow drifts on the sea ice above a breathing hole. The birth lair is essential for the survival of pups, which weight only ca. 4 kg when they are born; it provides thermal protection and also some protection against polar bears (*Ursus maritimus*), arctic foxes (*Alopex lagopus*) and other predators. Each mother has a series of lairs and if the lair where her pup is resting is attacked, she will move it to another location. If there is not sufficient ice with enough snow cover by late winter to build such a series of shelters, pup mortality levels are very high in this species. Ice stability is also important because ringed seals have the longest nursing period of any of the northern true seals (members of the family Phocidae) and need stable ice throughout the period of maternal care, which lasts about six weeks. Warm spring temperatures or rain during the nursing period can result in lair collapse and hence reproductive failure. Loss of lairs impacts all age classes and both sexes because all ringed seals use lairs to avoid harsh weather conditions and predators, although pups are certainly the most vulnerable age class. Ringed seals also use sea ice as a platform for their annual moult in late spring, when they replace their hair coat (and upper skin layers). Moulting in the water is energetically costly and is much more stressful for the animals than when it occurs on sea ice where they can sun bathe and circulate the blood to the skin in the air (without the high heat loss that would occur in water). Ringed seals also depend on sea ice for resting at other times of year, close to food sources. They feed predominantly on ice-associated prey, including polar cod (*Boreogadus saida*), arctic cod (*Arctogadus glacialis*) and large arctic zooplankton species such as *Parathemisto libellula* that are part of the sea ice ecosystem.

The ringed seal's extreme affiliation with sea ice raises serious concern for their future survival in a warming world (Kovacs and Lydersen 2005, 2008). Dramatic reductions in sea ice have already taken place in recent decades in the Arctic and these declines are predicted to continue, and in fact escalate, in the decades to come. Reductions in this unique habitat reflect a direct loss of habitat availability for ringed seals. Climate change will also pose other risks to this arctic resident via: impacts of reduced availability of their traditional lipid-rich prey species due to shifts occurring in arctic food webs stimulated by ice cover declines and water temperatures; increased risk of disease; increased predation by killer whales in some regions; increased human impacts from shipping and development in the North and the potential for increased effects of pollution (Schipper et al. 2008, Kovacs et al. 2011, 2012, CAFF 2013). Declines in pup production, body condition and ovulation rates associated with changing ice conditions have been documented for ringed seals in the Canadian Arctic, where extensive hunt monitoring is undertaken. In the United States, a status review of ringed seals has led to the listing of this species (and bearded seals) on the Endangered Species list of the US, because a significant

portion of their range is expected to be lost in the foreseeable future (Gill et al. 2011, Gilg et al. 2012).

Svalbard is a “hot-spot” in the context of climate change. Sea ice has declined markedly in the Archipelago over the last three decades, with precipitous changes since 2006 (e.g. Laidre et al. 2015, Muckenhuber et al. 2016) and temperature increases in this region in both the water and the air are well above the norm for the Arctic as a whole (Forland et al. 2011, Isaksen et al. 2016). These changes are undoubtedly impacting the ringed seal population, but there is little data regarding the effects that these on-going changes are having on this species in this region in terms of population demography. Ringed seals are difficult (and expensive) to survey, so it is common to resort to looking at biological parameters measured on hunted animals to determine changes in population parameters and to infer population trajectories from such data. Ringed seals are harvested by local hunters and trappers in Svalbard in addition to intermittent research collections (the last research collection was conducted a decade ago in 2002-2004)(Lydersen and Gjertz 1987, Krafft et al. 2006). The ringed seal harvest in Svalbard is small but biological data collected from locally hunted animals, grouped into time intervals (several years together to provide sufficient sample sizes) can provide information that is valuable for management decisions and these data can also provide insight regarding whether the ringed seal population in the Archipelago is experiencing changes in vital parameters (age at maturity, pregnancy rates etc.), growth rates or body condition in relation to climate change.

The Svalbard Environmental Protection Fund provided financial support in 2012 for a pilot project to collect biological samples from sport hunters and trappers, and has later supported harvest sampling (and aging) for five hunting seasons – 2013 and 2017.



Ringed seal. Photo Kit Kovacs/Christian Lydersen

Results and discussion:

One hundred and eighty nine sets of samples were turned in to the Norwegian Polar Institute by hunters during the years 2012 - 2017. Hunting took place from Wijdefjorden and Kongsfjorden in the north to Van Mijenfjorden in the south (Figure 1), with most animals being taken in St Johns fjorden and Isfjorden.

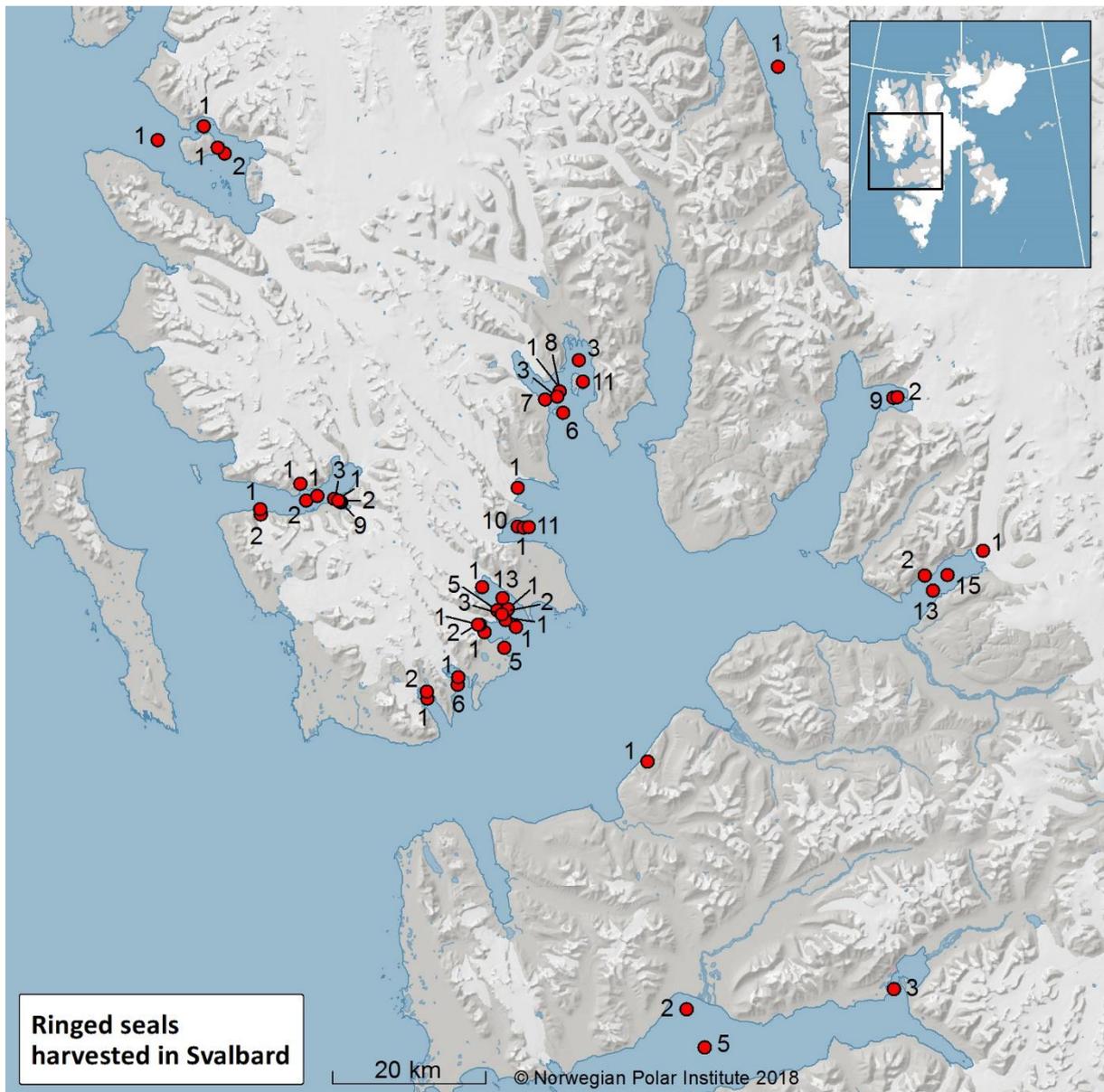


Figure 1. Ringed seal harvest locations from 2012 to 2017.

The number of animals reported in each year varied from 25 to 42, with a variable seasonal spread between years (Figure 2). Some seals were harvested on the sea ice in late winter and spring (March-June), but most hunting took place during the ice free season.

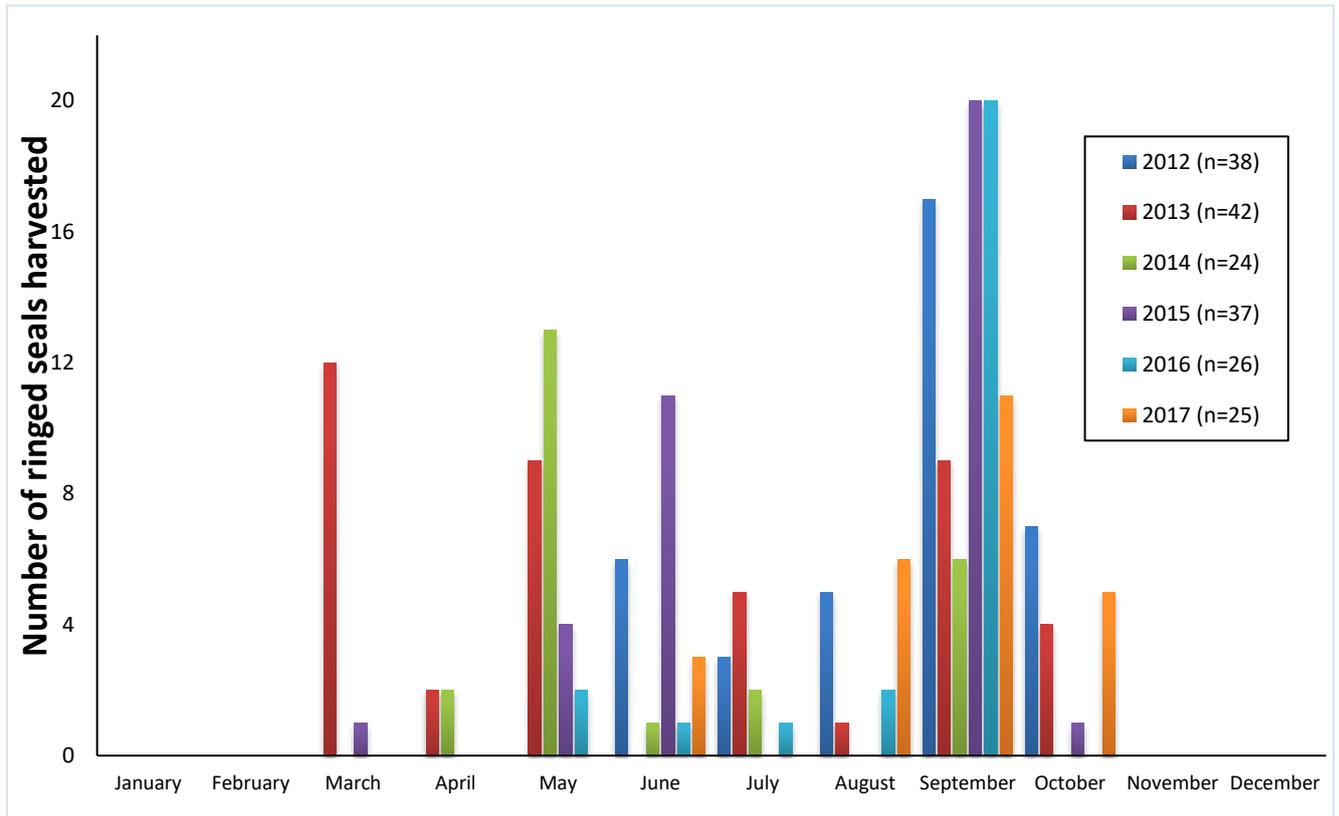


Figure 2. Seasonal spread of ringed seal harvesting in Svalbard during 2012-2017.

The youngest age class grouping was the most numerous in the harvest, which is typical for seal hunts generally (Figure 3). This is due to the fact that naïve animals are easier to shoot because they are less wary. Additionally, young animals are proportionally speaking more numerous. But despite the 0-2 age group being the most strongly represented age group in the hunt, young age classes in the Svalbard harvest are somewhat under-represented compared to what is expected in a marine mammal population (Figure 3). This could be a small sample size artefact, but it is also possible that the under-representation of juvenile age classes might be due to low production of pups in recent years, or low survivorship of pups in the springs from 2006 through to the present, because of the reduced spring ice cover in the west coast fjords in Svalbard resulting in smaller cohort groups (total young-of-the-year production). Although no scientific data has been collected on survivorship in this period on Svalbard, opportunistic observations during spring research activities in the polar bear and sea ice programmes suggest that very high mortalities of ringed seal pups have taken place in recent springs. Additionally, the seals that have been visible on the spring sea ice have been concentrated in the small areas of available sea ice, and little snow cover on the ice because of the short ice season has left ringed seal pups very exposed to predators.

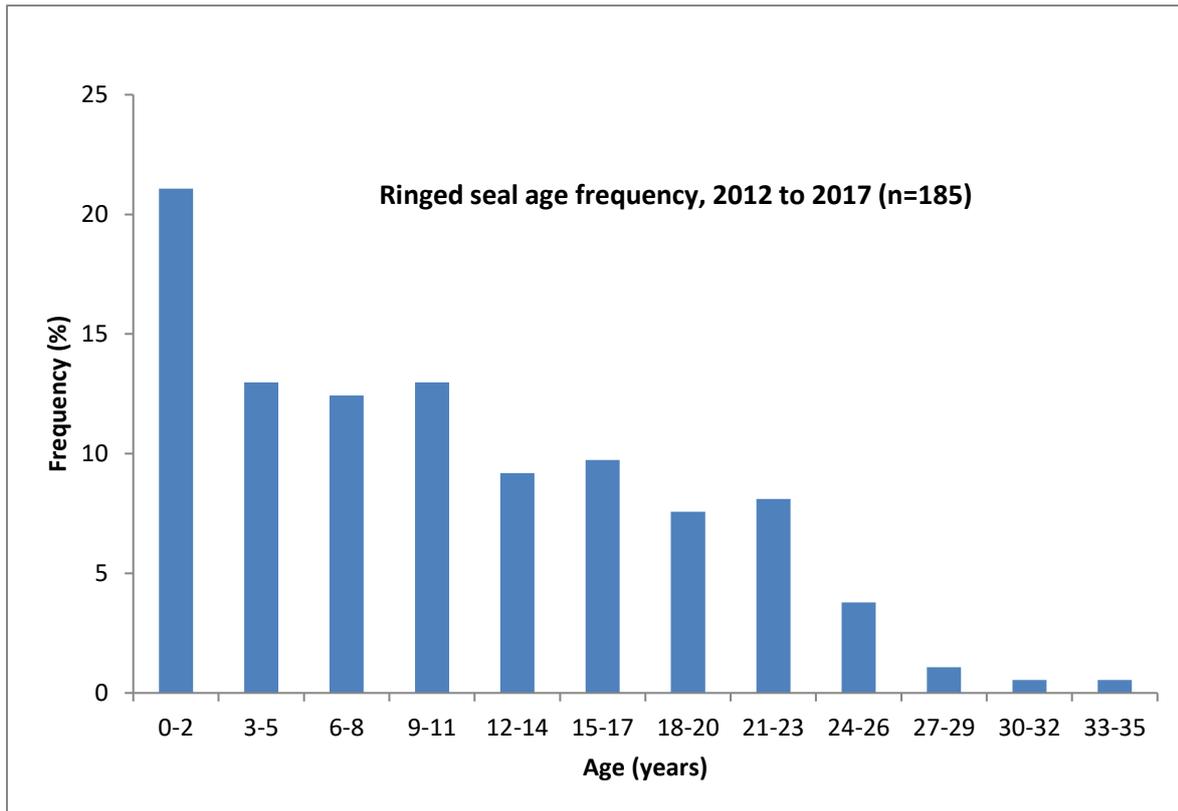


Figure 3. Frequency of age classes (in three-year clusters) in the Svalbard ringed seal harvest in 2012 -2017 (both sexes combined).



Ringed seal at breathing hole in the fast ice. Photo Kit Kovacs/Christian Lydersen

If we compare the cumulative proportions of the various age classes in our harvest with the norm for large-scale harvests elsewhere in the Arctic (see Figure 4) we see that they are quite similar, but with a somewhat lower representation of the middle aged animals. In the Svalbard ringed seal harvest, similar to indigenous harvests of this species elsewhere, we believe that hunters take animals opportunistically and do not intentionally avoid young animals, so the depressed representation of juveniles in the population could indicate a slightly skewed age distribution in the Svalbard population. However, it must be noted that the harvest in Svalbard is small, as is the sample size in the current study.

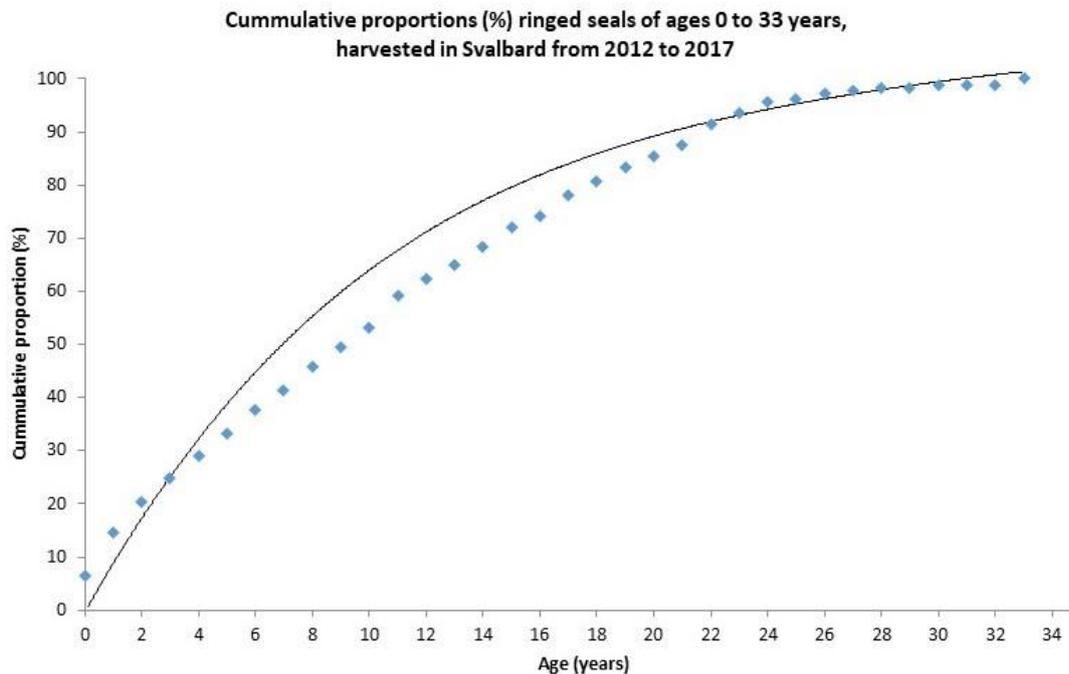


Figure 4. *Cummulative proportion of the ringed seal harvest according to age for Svalbard in comparison to the norm for large-scale harvests elsewhere in the Arctic.*

Phocid seals usually reach sexual maturity when they have grown to approximately 80% of their final body size. Thus, there is some flexibility in the age when they are first able to reproduce depending on how fast they grow, which in turn depends on food availability. Age of first maturity for ringed seals in Svalbard dropped between the 1980s and the early part of this century, reaching a minimum for this species at 3.8 years of age in the early 2000s (Krafft et al. 2006). This was either due to fewer seals competing for food or greater availability of prey resources for this population. Given the small hunt in Svalbard and the good ice conditions (i.e. good breeding habitat conditions) prior to the most recent scientific harvest (2002-2004), the drop in age at sexual maturity was likely due to abundant food resources. The sample size in this harvest project (2012-2017) is too small to say anything definitive regarding the current age at sexual maturity based on the analysis of reproductive organs. But body size vs age in the

current sample spans the earlier sampling periods in 1981-1982 and 2002-2004, suggesting that no dramatic changes are likely to have occurred in this biological parameter recently (Figure 5, Figure 7, Table 1).

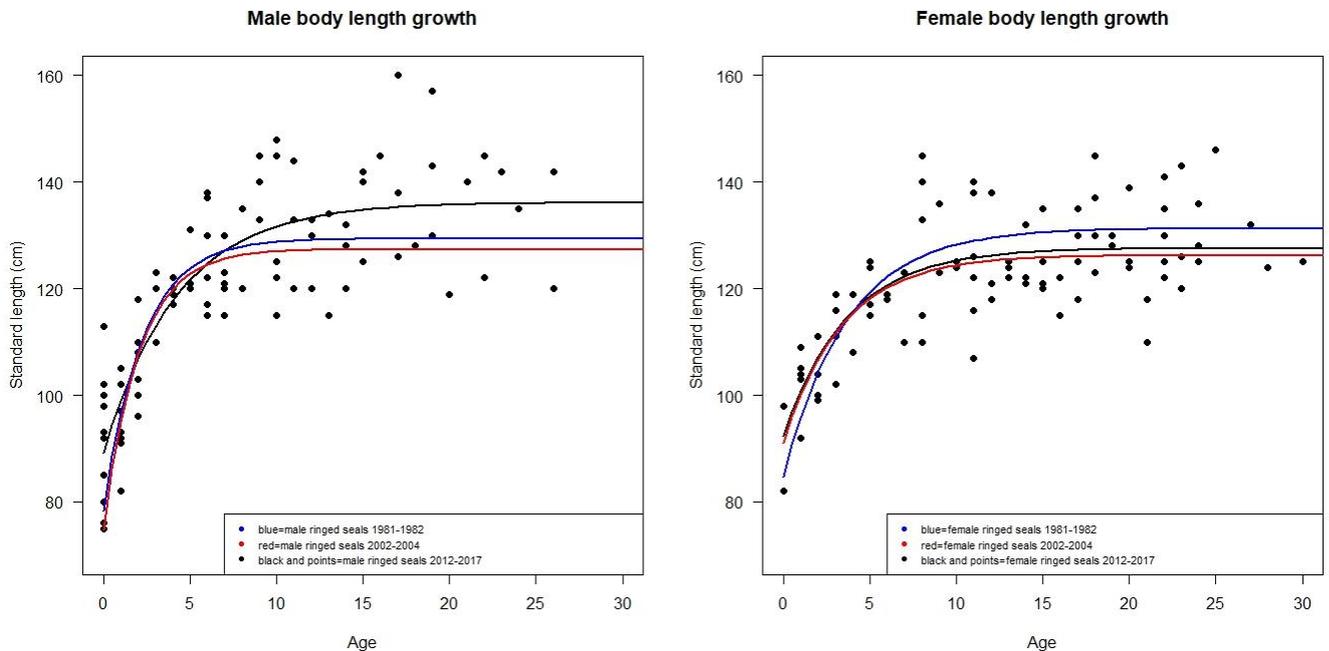


Figure 5. Standard length vs age for male and female ringed seals harvested in 2012-2017 (black curves and sampling points) vs two earlier scientific sampling collections.

Body length of adult animals (8+ years of age) over the three collection periods differed both for males ($F=7.51$, $P < 0.05$), and females ($F = 8.84$, $P < 0.05$) (Figure 6). While males were slightly longer in the most recent sample compared to both the earlier samples, females were slightly longer in the oldest sample relative the most recent data. Small-scale regional variance in environmental conditions and food resources might play a role in this high variability (Lowther et al. 2017).



Ringed seal resting on glacier ice. Photo Kit Kovacs/Christian Lydersen

Table 1. Von Bertalanffy growth function parameter estimates for ringed seal length–age data collected during three periods (1981-1982, 2002-2004 and 2012-2017) in the Svalbard area. Growth functions were fitted using the *vbFuns*-function in the *FSA*-package (<http://www.rforge.net/FSA/InstallFSA.R>) for R (R version 3.2.2 (2015-08-14)).

Growth parameter	n	Parameter estimates		
		L_{∞}	a	b
Male length 1981-82	131	129,39 ± 1,1	0,44 ± 0,06	-2,10 ± 0,46
Female length 1981-82	144	131,35 ± 1,1	0,27 ± 0,04	-3,80 ± 0,79
Male length 2002-04	170	127,42 ± 0,8	0,49 ± 0,07	-1,82 ± 0,51
Female length 2002-04	103	126,30 ± 1,2	0,29 ± 0,07	-4,38 ± 1,50
Male length 2012-17	93	136,17 ± 2,2	0,24 ± 0,0	-4,50 ± 0,84
Female length 2012-17	92	127,61 ± 1,4	0,27 ± 0,06	-4,73 ± 1,38

There are marked differences fjord to fjord in Svalbard in the prevalence of different water masses (Atlantic Water versus Arctic Water), water temperature, and wind exposure and hence in the probability that ice will form. This has large impacts on community structure and the availability of different types of prey for ringed seals and other top predators.

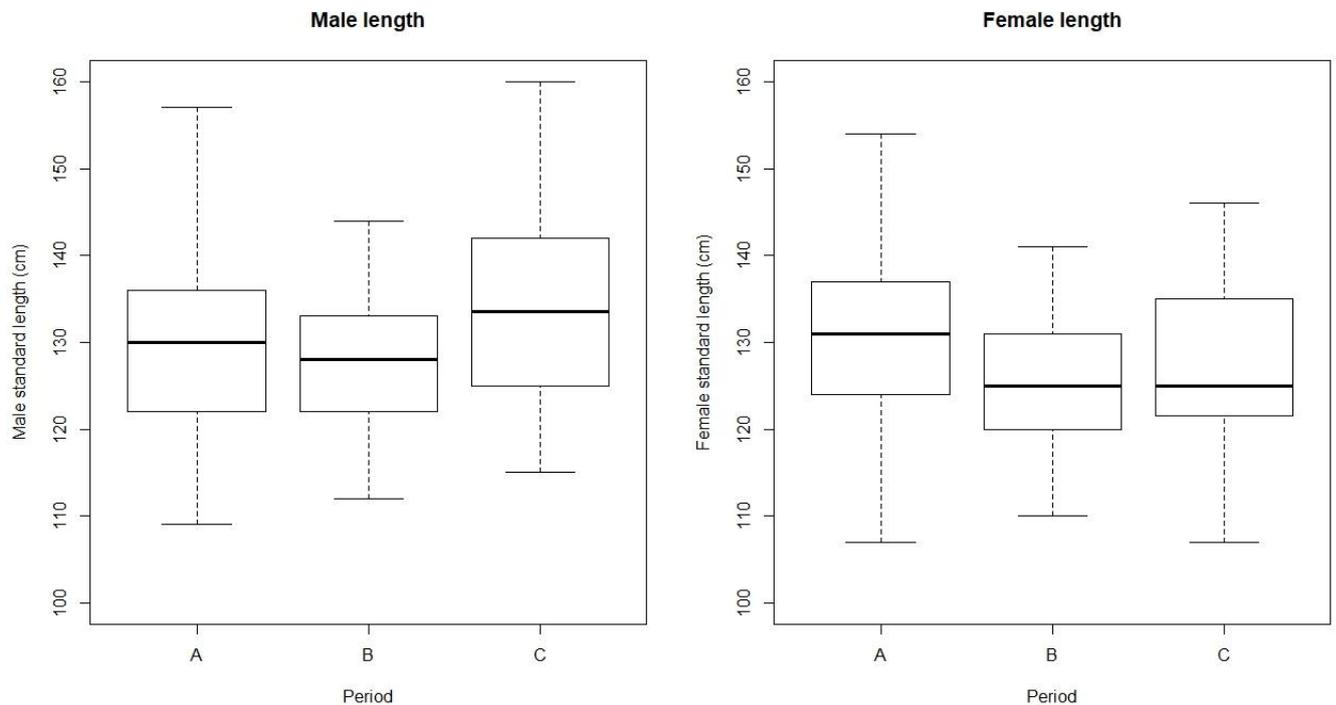


Figure 6. Standard length comparisons between two earlier periods of scientific sampling (A= 1981-82, B=2002-04) and the current local harvest of ringed seals (C= 2012-2017)(adult male and female ringed seals (8+ years of age)).

Body mass data was not collected for all animals during 2012-2017, but girth and length provide a means to estimate total body mass. Estimated body mass values from the 2012-2017 harvest according to seal age are again quite variable, but suggest that males are heavier in the current sampling period compared to earlier ($F=18.17$, $P<0.05$), while females are similar between periods ($F=2.95$, $P=0.05$)(Figure 7 and 8).

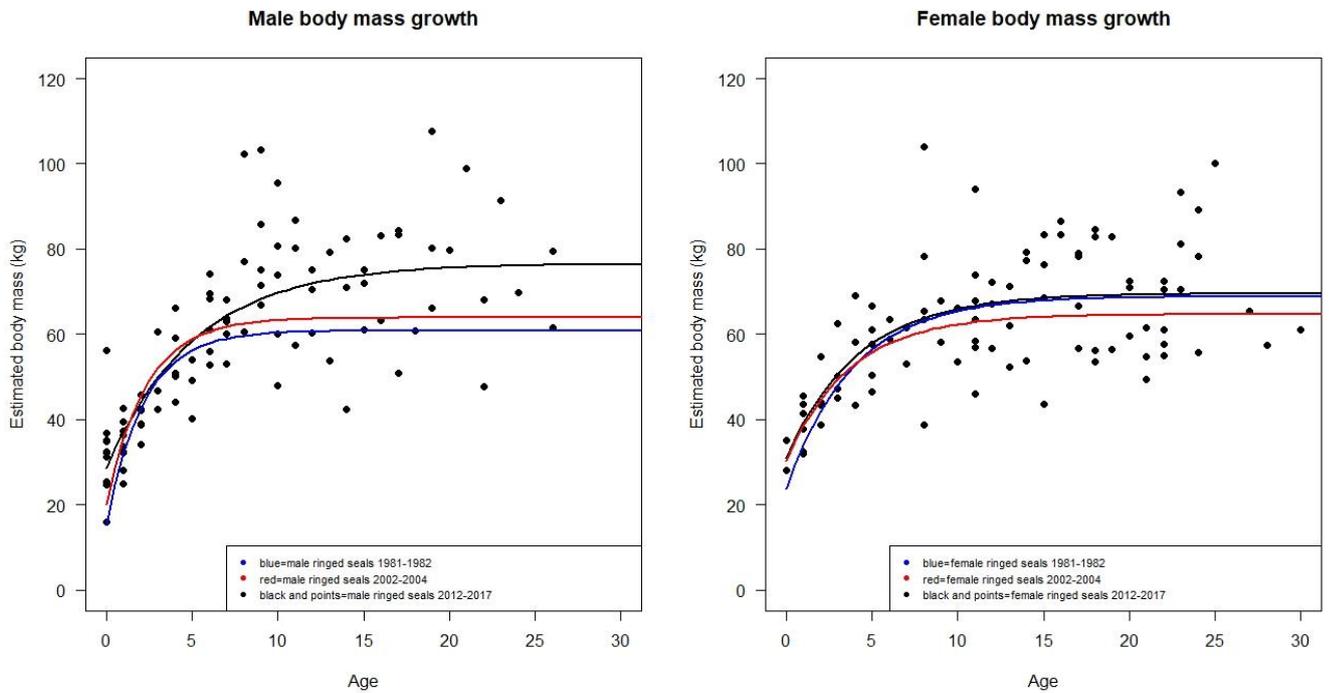


Figure 7. Estimated body mass vs age for male and female ringed seals harvested in 2012-2017 (black curves and sampling points) vs two earlier scientific sampling collections.



Polar bear hunting in ringed seal breeding habitat in spring. Photo Magnus Andersen

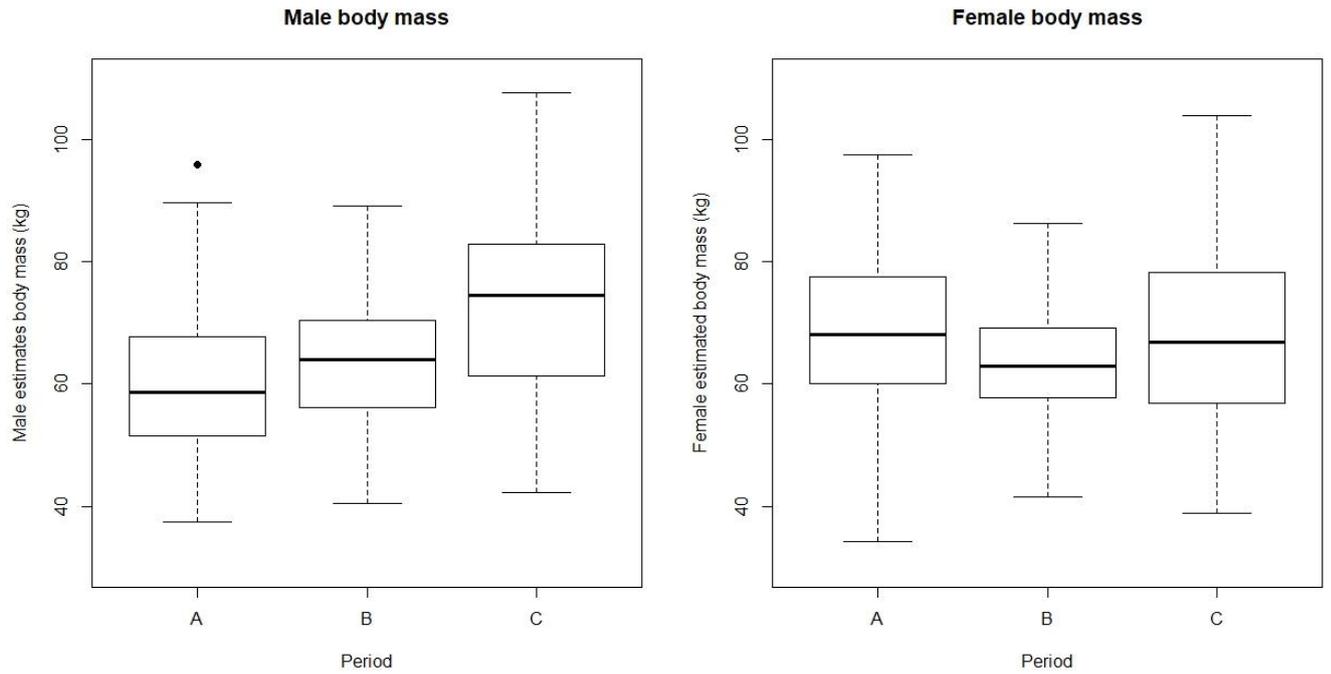


Figure 8. Estimated total body mass of adult male and female ringed seals from the 2012-2017 harvest in Svalbard compared to earlier scientific sampling periods in 1981-1982 and 2002-2004.



Adult ringed seal killed by a polar bear at a breathing hole in the fast ice habitat. Photo Magnus Andersen

A body condition index (based on length and girth $CI = \text{Girth} \times 100/\text{length}$) suggests that males in 2012-17 and 2002-04 were in better condition ($F=18.60$, $P < 0.05$) than in 1981-82, and that females were in better condition in 2012-17 than in 1981-82 ($F=4.73$, $P < 0.05$) (Figure 9).

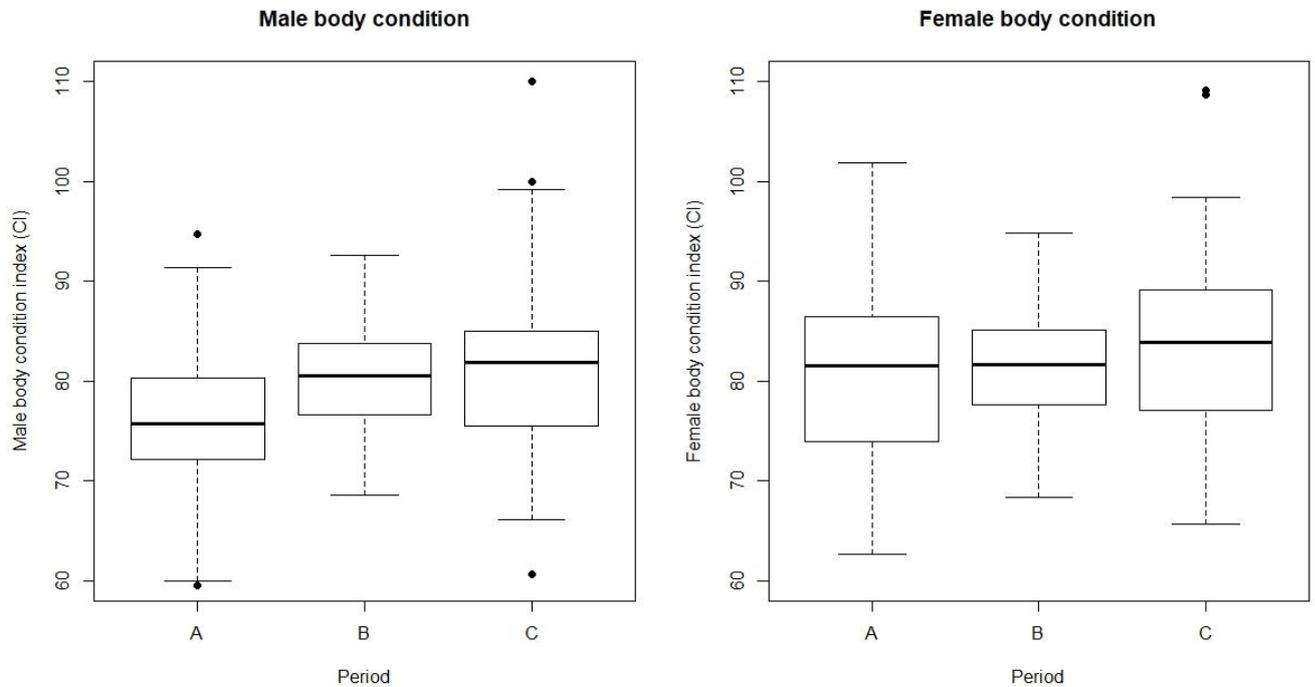


Figure 9. Box plots comparing estimated body condition of male and female ringed seals from the period C (2012-2017) harvest in Svalbard to earlier scientific sampling periods in A (1981-1982) and B (2002-2004).

Ringed seals mate in late spring, but the fertilized egg does not implant in the uterine wall until approximately 4 months later making pregnancy difficult to detect before the autumn. Forty female seals in our sample (from the fall and winter) were old enough to be sexually mature; 65% of these were pregnant (Table 2). This is low compared to the norm for ringed seals (and other phocid seals), which is often 90% or more.

Table 2. Number of mature and immature female ($n=87$) and male ($n=85$) ringed seals (for which data was available) in Svalbard from 2012 to 2017, and the number (and %) of mature females that were pregnant carrying fetuses in the period from the period when detection of pregnancy is feasible.

Year	F _{immature}	F _{mature}	Fetus/F _{mature}	M _{immature}	M _{mature}
2012-2017	17	70	26/40 (65%)	36	49

Conclusions:

The ringed seal harvest in Svalbard is very small, with less than 100 animals taken annually, from a population that likely numbers in the 10s of thousands locally, and is hence unlikely to impact population abundance or trends. The data from the 2012-2017 hunts suggest that ringed seals in Svalbard are growing normally and have good body condition (and hence are finding enough food). However, the data also suggest that the production or survival of young animals might be low, with juvenile age classes not being represented as fully as would be expected in the hunt. Additionally, pregnancy rates appear to be lower than the norm for this species. Low pup production/survival and pregnancy rates are not unexpected, given that there has been 11 years (since 2006) with markedly reduced ice cover in west coast fjords. Even when the sea ice has formed such that ice extent is quite large in some years in this period, the ice has started to form later than normal and hence has insufficient snow depth for optimal ringed seal breeding conditions.

Sampling of the local harvest in Svalbard should be continued to gain further insight into possible changes in age structure, condition and life-history parameters during this time of marked environmental change. This analysis should also be supplemented by additional monitoring activities to study potential dietary shifts and regional patterns of change within different fjords in Svalbard. There is a marked contrast in the rate of environmental change in west coast vs east coast fjords, which could provide considerable insight into ringed seals responses to climate change and the overall status of this species in our region.

Financial reporting:

Funding given by the Svalbard Miljøvernfond covered announcements in local media to bring awareness of the sampling program to local hunters, salaries and fees to hunters for collection of samples, equipment, shipping of samples and analyses of the samples collected:

<i>Salaries/fees to hunters:</i>	<i>52 500 nok</i>
<i>Announcements, equipment, shipping:</i>	<i>9 000 nok</i>
<i>Aging (analyses)</i>	<i>128 500 nok</i>
<i>Admin fee</i>	<i>10 000 nok</i>
<u>Total spending (rounded figures):</u>	<u>200 000 kr</u>

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