Outcome Document, The Research Workshop "Polar bear demography: status and future direction", Lyngen, Norway, 12-14 February 2019

Tuesday, February 12th

1. WELCOME

J. Aars welcomed attendees to Lyngen, Norway, and thanked all in advance for participating in a 3-day workshop to foster discussion on ways by which management goals identified by the Range States in its 2015 Circumpolar Action Plan (CAP) could benefit by enhancement and coordination among ongoing monitoring and research programs currently in place. It is not possible to address all areas of research prioritized in the CAP; the primary objective of the workshop is to focus on the collection and analysis of scientific data to estimate demographic parameters for polar bear subpopulations.

A list of the 19 attendees is attached as Appendix 1.

2. COUNTRY PRESENTATIONS

Presentations on recent and current research undertaken in each of the 5 Range States were given. Collectively, there has been significant activity with respect to the updating of estimates of subpopulation abundance with the completion of studies for Baffin Bay, Chukchi Sea, Kane Basin, Southern Hudson Bay, and Western Hudson Bay. A new survey of the Norwegian side of the Barents Sea was also completed. Fieldwork for new subpopulation estimates for both Gulf of Boothia and M'Clintock Channel has been completed and nearing completion for Davis Strait.

Impacts of climate change on sea ice habitat and polar bears; demography; development of less invasive methodologies; habitat use, behaviour, movement of bears; and genetics, were common themes of the country research presentations.

Challenges and lack of information with respect to research include: monitoring prey availability, relating contaminant and pathogen exposure to polar bear demography, limited environmental/ecological data on which to base habitat use models, improved use of harvest data, resistance to immobilization and collaring in some jurisdictions, and availability of both financial and human resources.

Wednesday, February 13th

3. PHYSICAL CAPTURE-RECAPTURE FIELD PROTOCOLS

J. Aars led a discussion on field protocols and how we can ensure that data are collected in a standardized way, which is important for comparative studies. Although there was an

assumption that everyone collects the same basic information on captured bears, it was clear that this was not the case. Zoological length (ZLEN) is not measured in Canada but it is by others, although it is only used for biological impedance in the US. The taking of ZLEN is a recommended measurement to take. What measurements are taken seemed to be related to who taught current researchers how to handle bears. In the US (and Svalbard), the length of the tail is also measured (base of tail to tip of last bone) because it may or may not influence estimates of body mass and/or overall length, particularly if a bear had an abnormally long or short tail. Straight-line length (SLEN) was discussed and a suggestion that the within variation for an individual can be similar to the variation between individuals of the same age/sex class. Part of the reason for this is trying to estimate when tape measure/rope is at the tip of the nose/tail when looking down from above. Some use a stick or similar object to facilitate this measurement.

Everyone measured head width and length, except Nunavut staff who do not measure length. Axillary girth is measured by all and 'tricks' by which to get a rope underneath were exchanged. The best indices for body condition were discussed in relation to what morphometric measurements people collected, and it was noted that body mass often was the best available measure. A discussion followed on the need to take body mass measurements and it was noted that because of the uncertainties in some length measurements, getting an actual weight of an animal can be important. The need to periodically review and revise a formula for calculating mass based on morphometrics was discussed.

Most do not take pad measurements; those that do are doing so in relation to track size of males and females.

There was a brief discussion of attaching collars; issues of ice build-up were very rare. It was noted that there are different challenges with collar wear in different subpopulations, possibly because of variation in how much fat bears in different subpopulations lose and gain within a year (amplitude). Some bears in some subpopulations get very fat in summer, potentially leading to collar wear.

There was some variation in the timing of when blood samples were collected, the timing of which can be critical depending on what is being measured. Similarly, how much fat is required from a biopsy is dependent on why being taken – if using to within context of body condition, then the biopsy needs to capture the entire length of fat down to the muscle. However, if using as a means to examine diet, then the sample does not need to be as deep.

There were differences with respect to when cubs were drugged in the spring. Most drugged cubs after processing the mother – the cubs recover closer to time mother is coming out and less risk of cubs wandering off. Some drug cubs at the beginning because of concerns that cubs are stressed if left undrugged. Those that drug cubs at the end indicated that cubs generally settle down while their mothers are being processed.

Finally, it was agreed that it would be valuable to exchange field protocols between jurisdictions, so that information on best practices could be exchanged and discussed. There was general agreement that it would be valuable to visit each other's field programs where practical to observe, learn and improve field protocols, and also to aid collaborative research.

4. ECOTOXICOLOGY

H. Routti reviewed ecotoxicology studies in relation to CAP action items. A recent review of the scientific literature resulted in a "state of knowledge" publication of exposure and potential health effects on polar bears across the circumpolar Arctic (Routti et al. 2019; Science of the Total Environment 664:1063–1083). She noted that perfluoroalkyl sulfonates are the largest/most prominent group of contaminants found in polar bear plasma from the Barents Sea. Studies have shown that levels of lipid-soluble pollutants in polar bears are related to condition – bears in poorer condition had increased levels of pollutants. Although most pollutants have been declining over time in the Arctic, their cumulative impacts on polar bear life history are poorly known. Do we have the necessary tools and/or data to assess? One avenue to address impacts on life history would be linking through demographic modelling, for example, multi-state models. One question addressed was how many bears would be required for such a study because one of the challenges can be that there may not be enough variation in a covariate to detect. Further, small changes in mean survival may be biologically significant but too small to detect.

If undertaking a cross-subpopulation comparison of contaminants and life history, what parameters might be the most useful to use? Adult survival is less variable than dependent young and 2-4 year olds. One approach could be to use contaminant levels in the mother versus survival of their young. Combining data from several subpopulations could also improve analyses by introducing more variability and larger datasets.

5. POPULATION GENETICS

J. Aars provided an overview of genetics and some of the areas in which it is being used – developing family trees / pedigrees, subpopulation structure, evolutionary history, and demography. He also noted that it is a less invasive technique than chemical immobilization and handling. However, it was noted that while one can do a lot of things with genetics, there are trade-offs, particularly with respect to information that you do not get – specific ages, measurements, deployment of collars, and some types of samples. Thus, it is critical that the questions being asked are clear so that the most appropriate scientific methods are used.

One of the advantages of genetics is that it is possible to get samples from areas where it might not be possible to get information any other way. One can get genetic ids from hair found in day-beds. Genetics can also provide insights into adaptation (e.g., heart muscle in Norwegian Bay polar bears). Circumpolar collaborative studies can shed light on genetic variation within polar bears, and it is a goal in the CAP to increase collaboration between jurisdictions. The genetics lab in Svanhovd, Norway, which is doing the analyses for the Norwegian program, is eager to collaborate.

There was a discussion on how genetic methods/tools change over time, for example, the use of microsatellites and SNPs. Calibration is needed if we are going to make comparisons between studies that used different techniques. In both collaborative and comparative studies, there is a general tendency for labs wanting to do their own analysis rather than simply contributing samples.

With the recent move by some agencies to use genetic capture-recapture methods to estimate abundance, it was noted that one does not necessarily have to use SNPs because microsatellites are already well-established.

6. POPULATION DEMOGRAPHY

E. Regehr led a review of population demography. The goals of population demography include estimates of abundance, status and trend, mechanisms of population change, and cumulative effects of stressors. The primary methods are capture-recapture, aerial survey, and analysis of sex, age, reproduction, and body condition data. There are, of course, challenges with each. For capture-recapture – high cost, bias in survival and abundance estimates, difficulty in interpretation of abundance estimates, opposition to physical handling, and limitations of genetic sampling methods. For aerial surveys – snapshot in time estimate of abundance only, susceptible to changes in distribution, and potentially low statistical power to detect trend.

There was a discussion of integrated population models, which are based on Bayesian modelling approaches. These can make better use of harvest data, result in informed decision-making, evaluate density-dependent versus density-independent effects, inform state-dependent management approaches, evaluate cumulative effects of multiple stressors, and can be used for forecasting and scenario planning. However, there are some challenges, including how to quantitatively integrate Traditional Ecological Knowledge.

J. Aars reviewed aerial surveys in studies of population demography. He stressed the need for having basic ecological data in advance for appropriate study design, particularly relevant telemetry data for movement behavior and habitat use. Aerial surveys can be done in one year and are less invasive than other approaches. However, less data are collected, they are vulnerable to weather/sea ice conditions, and it can be difficult to estimate G(0). Additional data could be collected if combined with genetic sampling that would provide data on sex ratio.

E. Regehr gave a brief overview of their use of an integrated population model approach to the Chukchi Sea. Field data from 2008-2011, 2013, 2015, and 2016 were used along with multiple lines of evidence/information. Multi-state models were used that included both observable and unobservable states. Harvest modelling was incorporated for which knowing risk tolerance is critical; an annual harvest of 50-120 bears/year was recommended.

N. Hostetter discussed integrated population modelling in more detail. Multiple data sources are used to estimate abundance, movement, and demographic rates. These models are able to improve estimates of vital rates and abundance by using all sources of data, they are flexible

(integrating multiple data sources), and facilitate many types of evaluations. Spatial capture-recapture models can aid with heterogeneity in detection probabilities by using both survey effort (where and when) together with individual identification. The need to collect data on survey effort (during search for bears to capture and handle) and also to use effort for resighting bears was noted as being important. Further, the ability to identify individual bears, when resighted, is a key component of these models.

Thursday, February 14th

7. Less-Invasive Capture-Recapture Field Protocols

L. Peacock reviewed less-invasive methods to traditional physical capture-recapture studies noting that such methods are dependent on the questions being asked – in some cases, it is not possible to answer without physically handling animals. Some of the earliest studies on polar bears were done by direct observations and the findings were broadly similar to more recent observational studies. Other less-invasive methods include line surveys, satellite imagery, genetics, and tissue samples.

Aerial surveys are useful for obtaining abundance estimates (recognizing that these are snapshots in time), direct counts, and studies of habitat use and maternal den distribution. There has been work on the use of satellite imagery in studies of polar bears. FLIR cameras have been shown to be useful but require optimal conditions. It is possible to count bears on satellite imagery but disadvantages include the availability/expense of imagery covering the area in question, the time it would take to process all the images and/or to try to automate the counting process. Again, clear images readily show polar bears under certain conditions but other objects in the images can be problematic. Some initial studies have used drones to take still images and/or video of bears. It is an emerging technique but drones have limited duration, have not currently been designed with harsh Arctic conditions in mind, and still require someone to operate them.

In recent years, there has been an increase in the use of genetics to estimate abundance through the use of biopsy darts and harvest samples. Baffin Bay was highlighted as being the first subpopulation of polar bears for which genetics was used in a capture-recapture design. It was noted that while biopsies are good for such studies, they are less so for studies of diet and/or body condition due to the amount of fat that is collected.

There was discussion as to the use of both aerial surveys and genetics to improve data collected. Combining the two not only provides an estimate of abundance but the genetic component can give additional information on sex structure (some age information if animals known from previous studies) and foraging.

Finally, there was mention of the improvements being made with respect to integrated population models (IPM). It was noted that there is value in using IPMs but to be cautious with respect to expectations of incorporating opportunistic data – it was thought to be better if

standardized data is used because it is very important to be able to estimate probability of detection as best as possible.

8. TELEMETRY STUDIES

K. Laidre provided an overview of the use of telemetry in studies of polar bears. Telemetry data provide key insights into a wide range of research including subpopulation delineation, identification of critical habitat, movement patterns, denning chronology, demography, geolocation, modelling oil exposure and impact of shipping, density, energy budgets, basic ecology, swimming/activity/behaviour/video cameras, pollutants, and digital elevation models.

There was a discussion on how researchers fit telemetry devices, particularly with respect to questions of animal welfare. Improvements in collar design and physical construction have occurred over time, but some issues still remain such as the failure of release mechanisms. One of the problems in trying to find out the causes of some of these types of failures is that it requires being able to recover the collar, which is not always easy when they are not working as they should. There is some ongoing research/development into satellite ear tags and new glues for attaching devices. Currently, there are not a lot of people using ear tag transmitters because of experiences with devices being torn out of ears and resultant animal welfare concerns. Depending on the questions being asked, there are not a lot of alternatives available. Genetics could be used for questions of delineation, although it does not take that many bears to move to keep subpopulations homogeneous.

The primary reasons for opposition to telemetry collars by communities in Nunavut are that bears have to be chemically immobilized (meat tastes different), concerns that the collars prevent bears from being able to hunt successfully, and also that polar bears have a spiritual place within Indigenous cultures.

Key areas identified where telemetry would be particularly useful included the Russian Arctic, Norwegian Bay, and boundary assessments. In addition, telemetry could improve predictions of habitat use by bears and how this may change over time. There was discussion that it would be useful to revisit Durner et al. 2009 (Ecological Monographs 79:25–58) to see whether sea ice habitat and polar bear distribution have changed as projected.

9. HEALTH AND PHYSIOLOGY

K. Rode provided a review of polar bear health and physiology. Health can be used as an indicator of vital rates, population trends, and mechanistic relationships. Physiology, on the other hand, provides understanding of the limitations to adaptation and can be used to develop and/or improve field methodologies. Patyk et al. 2015 (Science of the Total Environment 514:371-378) provides a definition of polar bear health. Some metrics of health include body condition, disease and parasites, contaminants, and reproductive success. It can be measured in many ways – axillary girth, body mass index, body condition index, energy density, fat index (1 to 5), body mass, skull width, % lipid in fat biopsy, and % body fat. The question(s) being asked will largely dictate what is the most useful way to measure. Studies have shown that both

energy density and fatness index are related to litter size and that body mass is a good predictor of cub production, mass, and survival.

There was a discussion of various health metrics and their ability to predict breeding probability and overall fitness and how factors such as age and precision in measurements can bias condition metrics. It was noted that measures such as body condition index, body mass index, and energy density have no apparent advantage to body mass for predicting fitness. How one measures condition is also dependent on the methods used. For example, there are many tools to measure condition if bears are being handled. In comparison, condition scores can be used on aerial surveys and fat samples and condition scores could be used from harvested animals.

The importance of understanding underlying physiology is important when undertaking mechanistic studies as it can aid in the interpretation of consequences of ecological change. Polar bear energetics can help us understand the consequences of increased swimming events and the potential implications of an extended open-water season. Physiological adaptations will constrain the ability of polar bears to adapt to a changing Arctic.

Some of the challenges include how we can assess health without handling individuals, consistency in measures of condition, better coordination between researchers (cross-population studies), and the need for more studies to link measures of health to fitness (particularly adult survival). Years ago, researchers were looking for useful health biomarkers but have since moved towards more specific measures.

10. Data Guidelines and Recommendations

There was a discussion of the merits of making data available to others, how to share it, who would potentially use it, and how it would be controlled. There was considerable sensitivity to raw data being made available to whomever wanted it. There was consensus to maintain the status quo but that better communication amongst researchers would be beneficial. Researchers generally know who is doing what, data that may be available, and who to engage with respect to potential collaborative projects. A number of attendees noted that there are existing data policies not only at institutions but also as condition of publication in some journals.

It was noted that there is a large difference between agencies/organizations with respect to research mandates. For some, there is a great latitude for research on topics applicable across the circumpolar Arctic and researchers not as restricted as to where they can work. Others are often geographically limited and working on subpopulations in their “own backyard” on particular issues. These differences can lead to challenges with respect to comparative studies.

The attendees discussed the objective of this workshop and what recommendations could be made to Norway with respect to the CAP. It was noted that the CAP contains very ambitious research plans but that little headway has been made as to how to achieve them largely due to absence of funding. It was agreed that providing a long list of research initiatives, all of which would be worthwhile doing, will unlikely result in much progress being made. There was

general agreement that providing a short list would be better and that these recommendations should be realistic and fit into the 2-year implementation table. The issues should be important to the CAP, possible to conduct without starting new data collections, be related to demography, and have a relatively short time line. Thus, the attendees agreed on coming up with several recommendations that are reasonably easy to deliver together with some recommendations to go back to the Range States of research that is important but which would require funding. Thus, the Range States would have to decide what it felt to be important research and to come up with necessary resources.

The following were agreed to be the research recommendations that would be given to Norway for subsequent discussion by the Range States: (*relevant recognized CAP items in italic*)

1. Review of research methodologies for estimating abundance
   This would be a relatively easy recommendation to deliver. L. Peacock expressed potential interest in leading.
   CAP 11. Examine the efficacy of BMPs as they relate to polar bear conservation and revise as appropriate

2. Cross-subpopulation condition indices
   This would be an analysis of existing data from polar bear subpopulations and likely need to be hierarchical because of differences in available data. It would seek to give advice on best methods to use for monitoring condition. K. Rode indicated potential interest in leading.
   CAP 23. Develop models to better understand the potential effects of climate change within the circumpolar region on polar bear subpopulations

3. Re-do of the Durner et al. 2009 paper
   An update of this paper to see whether sea ice habitat and polar bear distribution have changed as projected. No one indicated their interest in leading, however Greenland is the lead country under the CAP.
   CAP: No 3. Identify essential polar bear habitat and redefine it as changes occur over time

4. Estimating sustainable harvests in changing climates
   Effort is already underway with respect to harvest risk assessment modelling that incorporates a changing environment. E. Regehr offered to lead this and noted that some funds are already available to do this work.
   CAP 30. Obtain information, where possible, on vital rates for all 19 subpopulations of polar bears. Improve methods to evaluate ecological indicators…
   CAP 32. Improve methods to use all available information to address management questions.

5. Demographic changes across subpopulations where long-term data sets currently exist
   This was considered important especially with respect to the goal of this workshop being to identify research that fulfill goals within the CAP, particularly with a focus on demography. There was no indication of interest in leading. However, Eric Regehr was not at meeting at this section, and J Aars noted he would be the natural person to ask.

CAP 23. Develop models to better understand the potential effects of climate change within the circumpolar region on polar bear subpopulations
CAP 30. Obtain information, where possible, on vital rates for all 19 subpopulations of polar bears. Improve methods to evaluate ecological indicators…

*6. A review of the importance of polar bear telemetry studies: use and insight gained

Kristin Laidre made Jon Aars aware, after the workshop, that this was discussed among several participants during the telemetry session and acknowledged it would be an important project. It was however forgotten at the plenary discussion. It is therefore added to the list. K Laidre volunteer to lead.
relevant to a long list of CAP priorities, including e.g. CAP 3 and 23. Develop models to better understand the potential effects of climate change within the circumpolar region on polar bear subpopulations

Possible project that would address impact of contaminants on polar bear life history characteristics

There was a general agreement that developing a project on cumulative effects of contaminants, diseases and environmental change on polar bear vital rates would be an important issue to consider.
(CAP action 43. Examine the impact of contaminants and pollution on polar bear life history characteristics)

There was a discussion on how to rank the identified recommendations. The agreed process is that J. Aars/M. Andersen/N. Lunn would write up and circulate the list to the attendees and that everyone would rank.

11. CONCLUSION

The attendees agreed and concluded that workshops, such as this one, increased contact between researchers in different jurisdictions, are important for better and increased cooperation, and that both exchanging research plans, field protocols, field exchange programs and future research workshops would be ways to improve contact and cooperation.

12. CLOSING OF MEETING

J. Aars closed the meeting by thanking all the attendees for taking time out of their schedules and travelling distances to make this a very productive meeting. The attendees agreed that the success of the workshop was due to the facilitation by Norway and by the meeting being held in a more remote location away from the potential distractions of a large venue/city.

APPENDIX 1. Participants, Polar Bear Research Workshop, Lyngen, Norway, 12-14 February 2019.

Name	Range State
Jon Aars	Norway
Magnus Andersen	Norway
Stas Belikov	Russia
Jan Paul Bolstad	Norway
Andrei Boltunov	Russia
Sarah Converse	United States
Markus Dyck	Canada
Nathan Hostetter	United States
Kristin Laidre	Greenland
Nick Lunn	Canada
Lily Peacock	United States
Nikita Platonov	Russia
Eric Regehr	United States
Evan Richardson	Canada
Karyn Rode	United States
Heli Routti	Norway
Andreas Schei	Norway
Øystein Wiig	Norway
Jim Wilder	United States

APPENDIX 2. A subgroup met the 14 Feb to suggest a sampling protocol for harvested polar bears.

Harvest Sampling for Polar Bears

Ad hoc meeting of participants at the workshop "Polar bear demography: status and future direction"

Lyngen, Norway

14 February 2019

Goal: Exchange information on harvest sampling methods. This can help management agencies identify the most important data and samples and, where appropriate, establish consistency in harvest sampling across jurisdictions.

Participants: Eric Regehr (organizer), Kristin Laidre, Lily Peacock, Markus Dyck, Nick Lunn, Stanislav Belikov, Evan Richardson

- Guiding principles for harvest sampling:
  - Keep it simple
  - Be consistent over time in what data and samples are requested from hunters
- Most important harvest data:
  - Date of harvest
  - Type of kill (e.g., subsistence harvest, problem bear)
  - Location of harvest (Global Positioning System location or description of area)
  - Sex
  - Age class
  - Body condition using the standardized Fatness Index on a 1-5 scale (e.g., per the Body Condition Index score card)
- Most important harvest samples:
  - Premolar tooth, either the extracted tooth or an entire lower jaw, which can be returned to hunters
  - Muscle (e.g., piece of meat or tip of the tongue)
  - Proof of sex (e.g., baculum) unless there is a system to obtain sex from genetic analyses
  - Research markings including the unique identification number of lip tattoos, ear tags, or tracking devices (or, at minimum, a clear picture of the tattoo and/or ear tag)
- Additional samples that are useful but not necessarily part of core monitoring:
  - Fat—the group considered this to be the most useful additional sample for scientific analyses

- Other points:
    - Participants noted a general lack of success in collecting physical measurements from bears as part of harvest sampling
    - It is important to use trained and/or paid personnel to collect samples that are needed for a short-term project but are not part of core harvest monitoring
        - ACTION ITEM: the group discussed the usefulness of developing a more detailed list of data and sample requirements that can be collected by trained personnel
    - It can be difficult to deliver samples from remote areas, especially in Russia
    - It is important to provide hunters with information about research marks they have turned in, and in general to have good communication about what the harvest data and samples are used for (e.g., management organizations should present communities with posters containing this information)