Harvest Assessment for the Baffin Bay and Kane Basin Polar Bear Subpopulations

Presentation to the Nunavut Wildlife Management Board
Iqaluit
March 7, 2018

Harvest Assessment for the Baffin Bay and Kane Basin Polar Bear Subpopulations

Re-Assessment of the Baffin Bay and Kane Basin Polar Bear Subpopulations

Final Report to the Canada-Greenland Joint Commission on Polar Bear from the Scientific Working Group (SWG) of the Canada-Greenland Joint Commission on Polar Bear

Prepared by: Stephen Atkinson (SWG), Erik W. Born (SWG), Kristin L. Laidre (SWG), Nicholas J. Lunn (SWG), Øystein Wiig (SWG) and external experts Todd Arnold, Markus Dyck, Eric V. Regehr, Harry Stern, and Seth Stapleton

Edited by: Kristin L. Laidre and Nicholas J. Lunn

31 July 2016

Please cite as: SWG [Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear]. 2016. Re-Assessment of the Baffin Bay and Kane Basin Polar Bear Subpopulations: Final Report to the Canada-Greenland Joint Commission on Polar Bear. 31 July 2016: x + 636 pp.

Harvest Assessment for the Baffin Bay and Kane Basin Polar Bear Subpopulations

Final Report to the Canada-Greenland Joint Commission on Polar Bear

Eric V. Regehr[1], Stephen Atkinson[2,*], Erik W. Born[3,*], Kristin L. Laidre[1,2,*], Nicholas J. Lunn[4,*], and Øystein Wiig[5,*]

[1] Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle, Washington 98105, USA

[2] Box 19, Group 7, RR#2, Dugald, Manitoba, R0E 0K0, Canada

[3] Greenland Institute of Natural Resources, 3900 Nuuk, Greenland

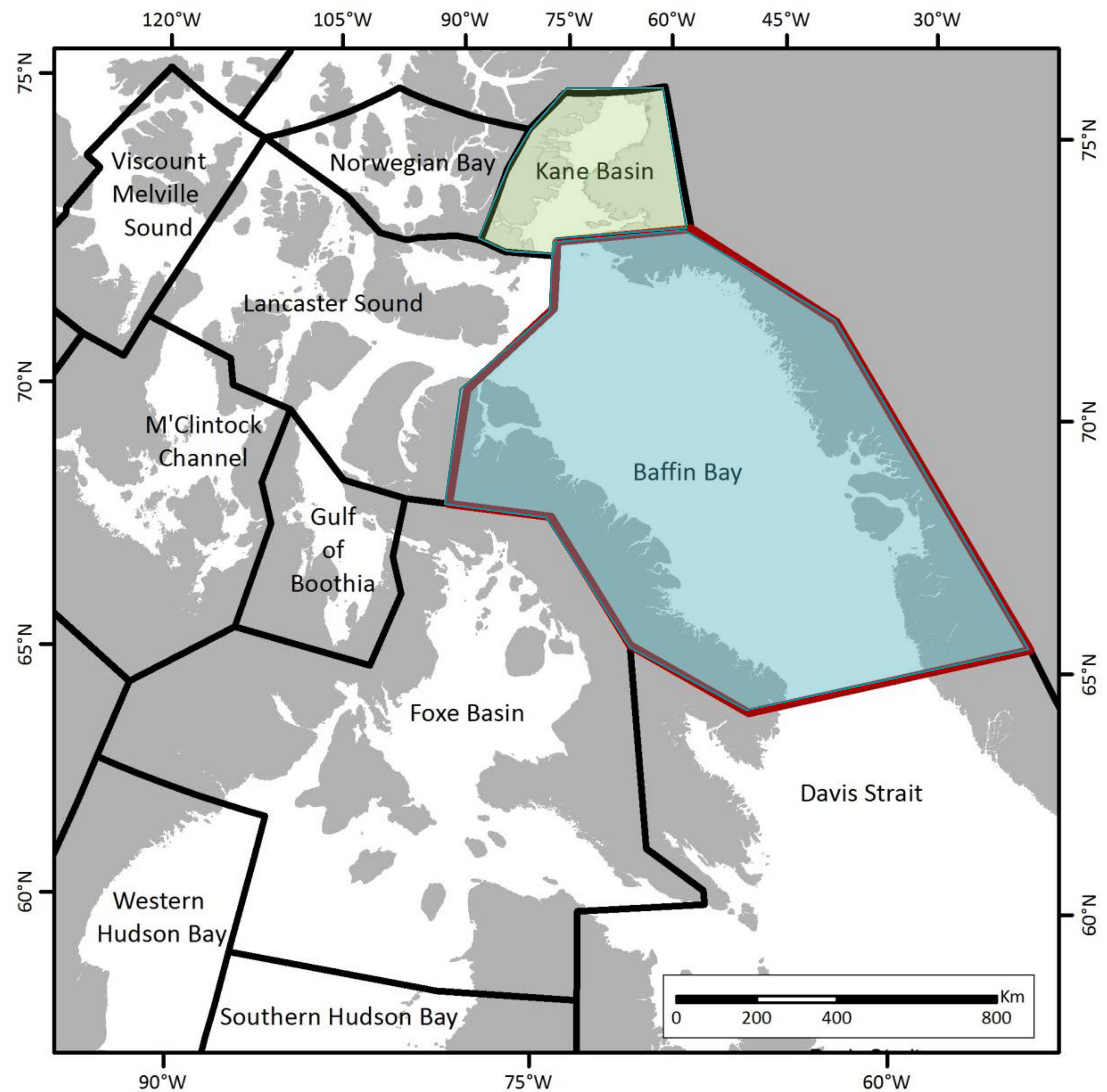
[4] Environment and Climate Change Canada, University of Alberta, Edmonton, Alberta, T6G 2E9 Canada

[5] Natural History Museum, University of Oslo, NO-0318 Oslo, Norway

[*] Scientific Working Group of the Canada-Greenland Joint Commission on Polar Bear

31 July 2017

Please cite as: Regehr, E.V., S. Atkinson, E.W. Born, K.L. Laidre, N.J. Lunn, and Ø. Wiig. 2017. Harvest Assessment for the Baffin Bay and Kane Basin Polar Bear Subpopulations: Final Report to the Canada-Greenland Joint Commission on Polar Bear, 31 July 2017: iii + 107 pp.


120°W
105°W
90°W
75°W
60°W
45°W
30°W
75°N
70°N
65°N
60°N
Viscount Melville Sound
Norwegian Bay
Kane Basin
Lancaster Sound
M'Clintock Channel
Baffin Bay
Gulf of Boothia
Foxe Basin
Davis Strait
Western Hudson Bay
Southern Hudson Bay
Km
0
200
400
800
90°W
75°W
60°W

Canada-Greenland Joint Commission (JC)

Joint Commission

- Established in 2009
- Coordinated management of BB and KB
- Commissioners appointed from government and Inuit organizations
- Working Groups – Scientific, IQ
- 2010: Requested advice
  - Propose Total Allowable Harvest (TAH) levels
  - Advice for monitoring the effects of habitat changes on polar bears.

Scientific Working Group

- Scientists from Canada/Greenland and an independent
- 2010: Reviewed available science
  - Scientific information outdated
  - Recommended new studies
  - Survey options report
  - Research plan

Background

<u>Baffin Bay</u>:

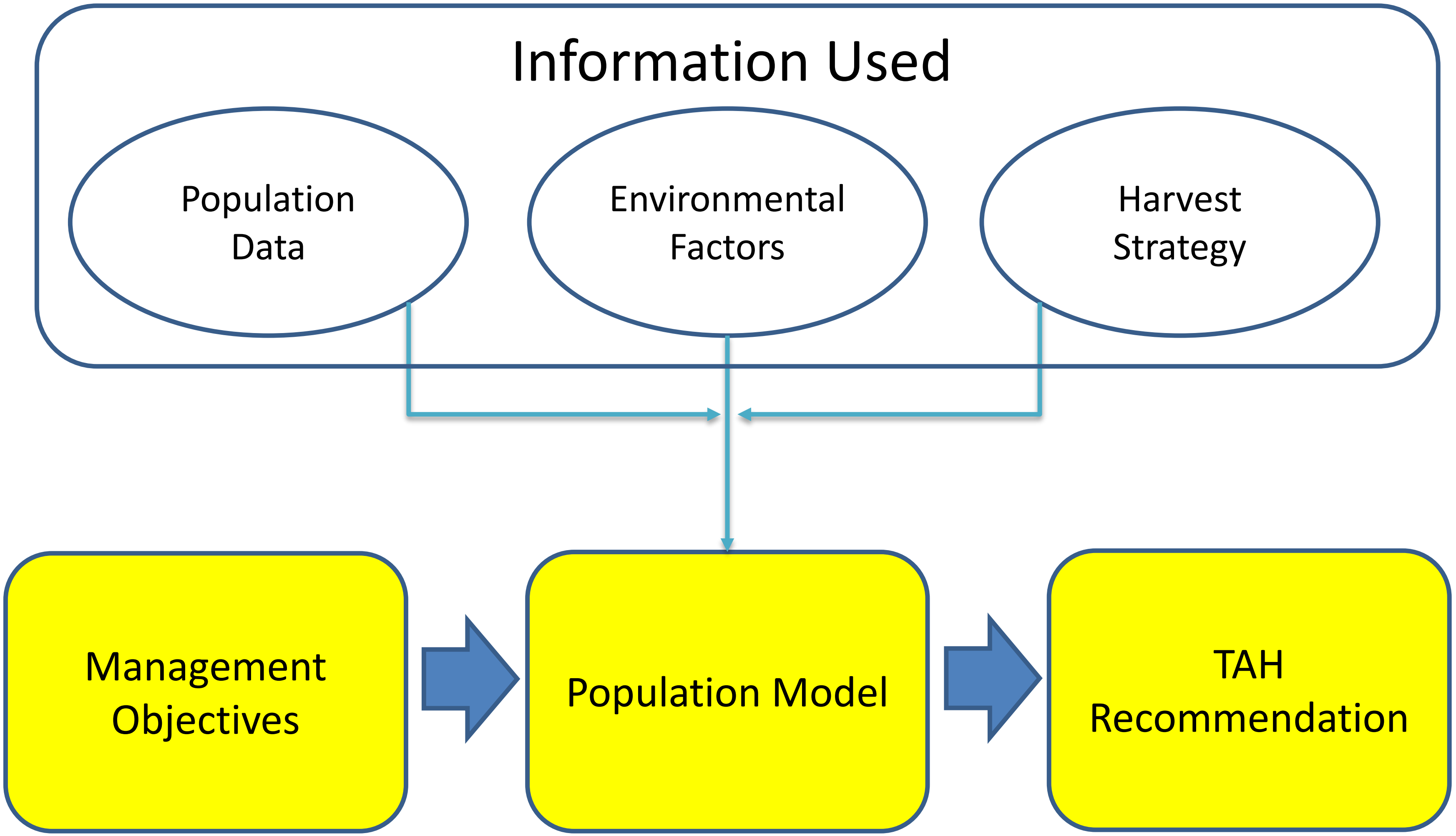
- Changes in range, movements, habitat use, body condition and reproduction.
- Concurrent decline in sea-ice extent, duration and quality.
- Abundant subpopulation (2,826 bears, 2011-13)
- Uncertain trend

Background

Kane Basin:

- Transitioning toward seasonal sea-ice regimen
- Expanding range especially during summer
- Larger, more variable home ranges
- Lower sea-ice concentrations
- Current abundance estimate of 357 bears (2012-14)
- Stable or increasing

Harvest Assessment Approach



Numerous factors and options to consider

Management Objectives

Specified by the JC:

1. Maintain a stable population at the current subpopulation estimate (BB and KB) – Above 90% of starting value
2. A TAH that would ensure maximum sustainable yield (BB and KB)
3. Managed subpopulation reduction to 70% of current numbers (approx. 2,000 bears) in 10-15 years (BB only)

Expected 7–15 year frequency between subpopulation surveys. Look at differing survey precision

Management Objectives

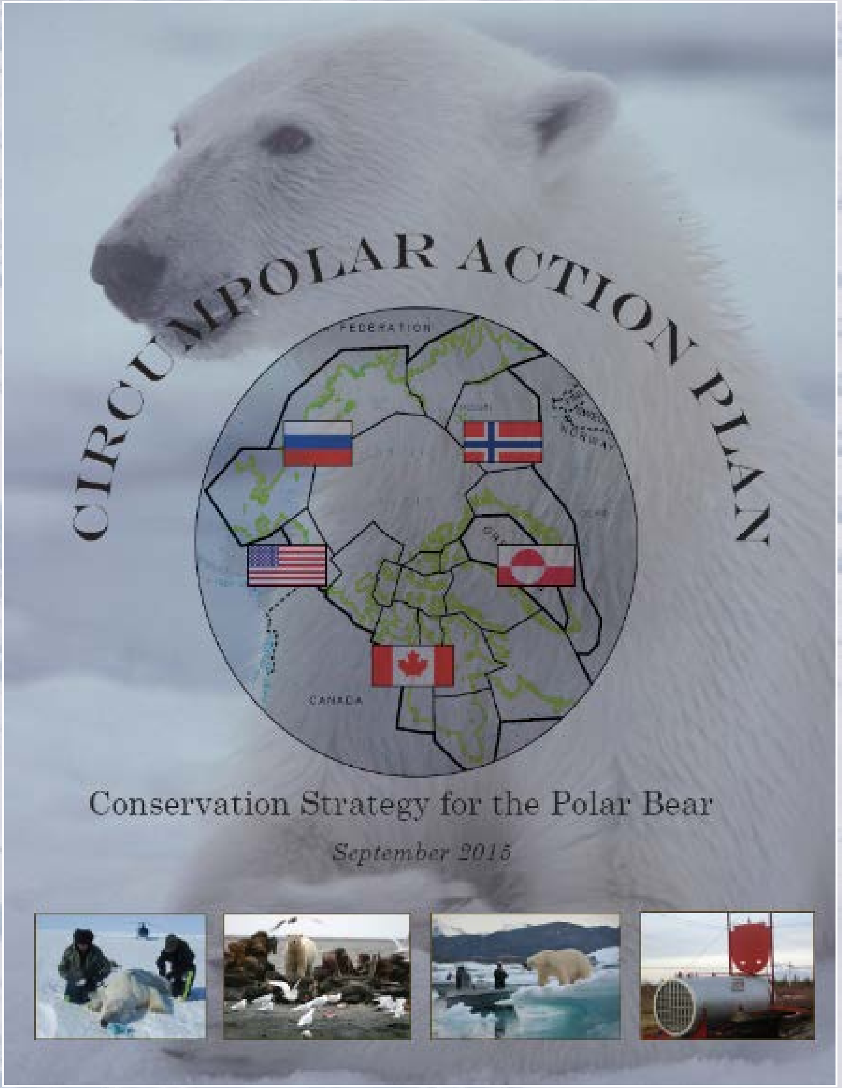
Risk Tolerance:

- "Low" risk = 90% chance of success (10% failure)
- "Medium" risk = 70% chance of success (30% failure)

Management Objectives

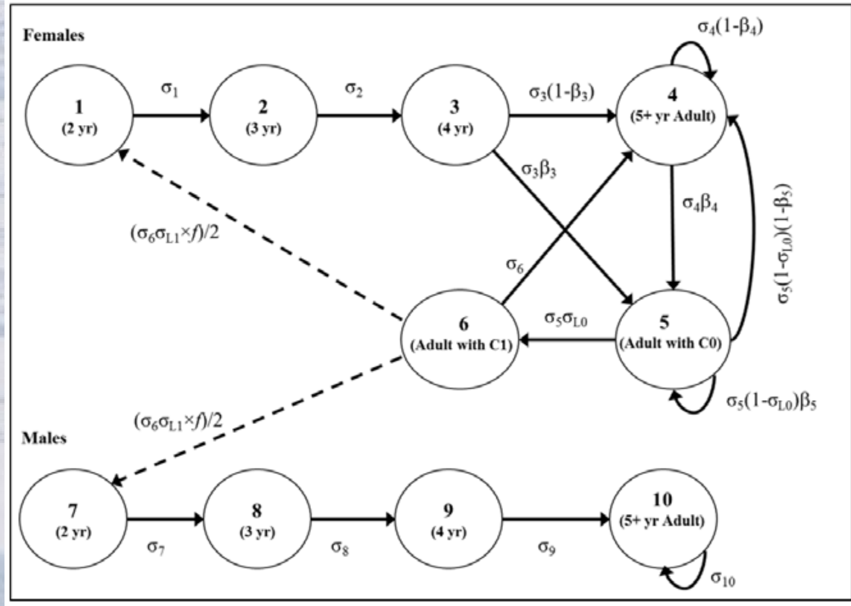
- The Polar Bear Range States recommended: "considering the cumulative effects of climate change and human activities… when making management decisions using tools such as predictive modeling".
- This is especially important for harvest assessments, due to CITES and international attention on the primary threat of sea-ice loss due to anthropogenic climate change

Polar Bear Range States (2015)



The Model

- Based specifically on the biology of polar bears
- Considers population data - Abundance, survival and reproductive rates
- Species-specific model of density dependence



Regehr, E. V., R. R. Wilson, K. D. Rode, M. C. Runge, and H. L. Stern. 2017b. Harvesting wildlife affected by climate change: a modeling and management approach for polar bears. Journal of Applied Ecology doi:10.1111/1365-2664.12864.

The Model

Also considers:

- Carrying capacity (*K*) – Capacity of environment to support polar bears (trends and annual variation)

- Allee effect in mating system – Baffin Bay (66% females, low male survival)

- Harvest strategies - Harvest level and composition, timing and precision of future surveys, management interval

Population Data

Key Assumption:

Current estimates of vital rates (i.e., survival and reproduction) corresponded to a subpopulation size near *maximum net productivity level.*

Baffin Bay and Kane Basin are not currently experiencing density-dependent effects on survival or reproduction due to environmental changes. Both populations are functioning near maximum productivity.

Population Data (Baffin Bay)

Used 3 vital rate scenarios

- Same reproductive rates - Estimated CR data 2011-2013
- Three survival rate scenarios considered, due to uncertainty and potential bias in some results from CR studies (low, most plausible, average)

Parameter	Mean	SE
Litter production rate for adult females (β_4)	0.93	0.08
C0 per adult female	0.58	0.04
Proportion of adult females with C0	0.38	0.02
C0 litter size	1.55	0.04
C1 per adult female	0.35	0.03
Proportion of adult females with C1	0.24	0.02
C1 litter size	1.47	0.05

Table BB2 in Regehr et al. 2017

			2011-2013 Likely low		1998-2010 Most plausible		Avg. for subpopulations	
			Scenario 1		Scenario 2		Scenario 3	
Sex	Age class	Stage	Mean	SE	Mean	SE	Mean	SE
female	C0	†	0.88	0.06	0.88	0.06	0.88	0.06
female	C1	†	0.89	0.06	0.89	0.06	0.89	0.06
female	2-4 year	1-3	0.91	0.05	0.96	0.02	0.93	0.05
female	≥5 year	4-6	0.91	0.05	0.96	0.02	0.93	0.05
male	C0	†	0.88	0.06	0.88	0.06	0.88	0.06
male	C1	†	0.89	0.06	0.89	0.06	0.89	0.06
male	2-4 year	7-9	0.83	0.06	0.91	0.02	0.92	0.06
male	≥5 year	10	0.83	0.06	0.91	0.02	0.92	0.06

Table BB3 in Regehr et al. 2017

Population Data (Kane Basin)

- Reproductive rates estimated directly from CR data 2012-2014
- Survival—two scenarios considered, due to low estimates and high uncertainty for 1992-2014 time-constant survival. Increases offspring survival to match population growth rate.

Parameter	Mean	SE
Litter production rate for adult females (β_4)	0.71	0.16
C0 per adult female	0.55	0.10
Proportion of adult females with C0	0.34	0.06
C0 litter size	1.64	0.10
C1 per adult female	0.22	0.06
Proportion of adult females with C1	0.17	0.04
C1 litter size	1.23	0.12

Table KB1 in Regehr et al. 2017

			Scenario 1		Scenario 2	
Sex	Age class	Stage	Mean	SE	Mean	SE
female	C0	†	0.45	0.15	0.74	0.25
female	C1	†	0.74	0.15	0.87	0.15
female	2 year	1	0.74	0.15	0.87	0.15
female	3 year	2	0.97	0.04	0.97	0.04
female	4 year	3	0.97	0.04	0.97	0.04
female	≥5 year	4-6	0.97	0.04	0.97	0.04
male	C0	†	0.45	0.15	0.70	0.23
male	C1	†	0.54	0.17	0.74	0.23
male	2 year	7	0.54	0.17	0.74	0.23
male	3 year	8	0.90	0.06	0.90	0.06
male	4 year	9	0.90	0.06	0.90	0.06
male	≥5 year	10	0.90	0.06	0.90	0.06

Table KB2 in Regehr et al. 2017

Environmental Conditions

Both Baffin Bay and Kane Basin are undergoing long-term changes in sea-ice.

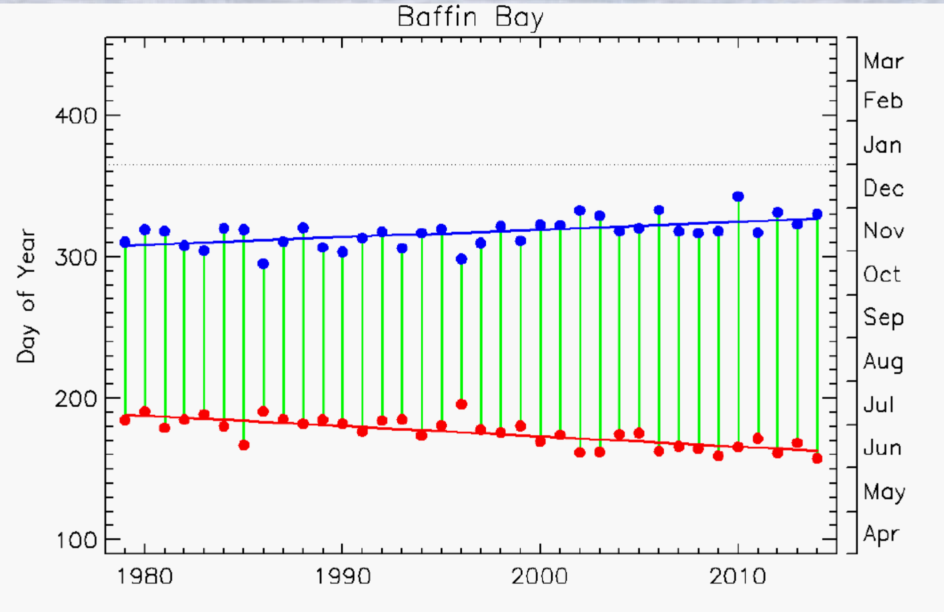


Figure 4.2 in SWG 2016

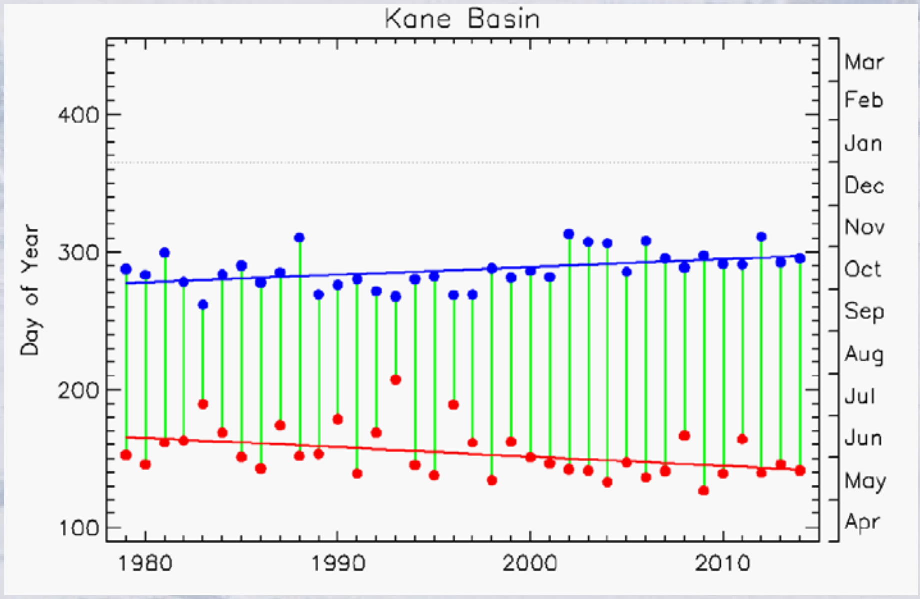
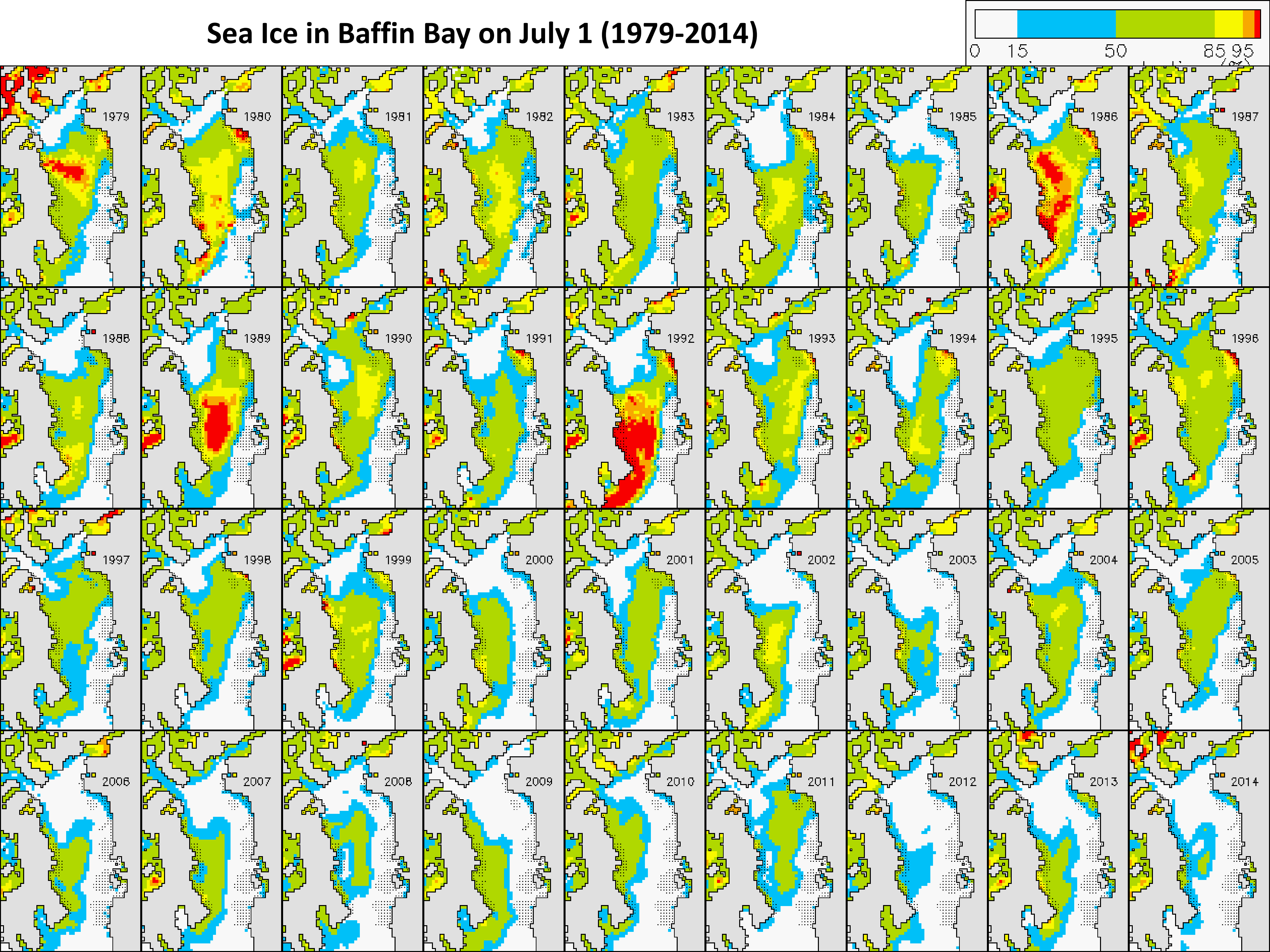


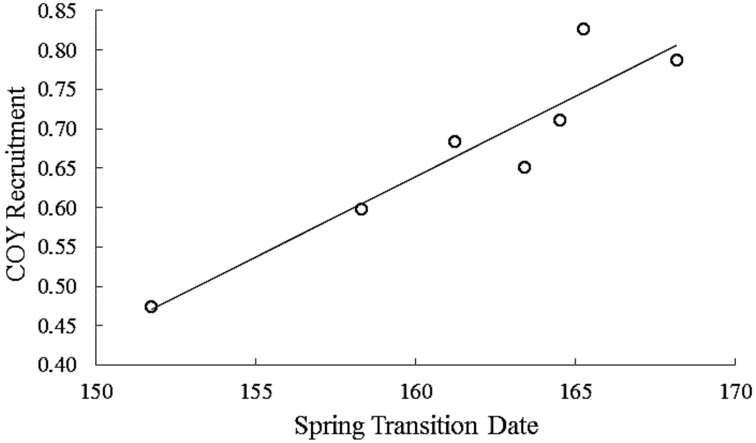
Figure 9.3 in SWG 2016

Sea Ice in Baffin Bay on July 1 (1979-2014)



Baffin Bay – Body Condition and Reproduction

- Body condition and an index of cub production both closely associated with the timing of spring sea-ice break up
- Evidence of decline since the 1990s
- Annual yearling recruitment index ranged from 0.24 to 0.51
- Continues to exhibit the level of reproduction required for a viable population



Environmental Conditions

For Baffin Bay

- Number of ice-covered days per year declining 5.5% per decade.
- Evidence of range contraction, days on land, declining reproduction and body condition
- Model was set-up to implement a changing carrying capacity - Gradual decline in abundance in the absence of harvest.

For Kane Basin

- Evidence of change towards a seasonal ice regime
- No evidence of negative polar bear impacts – Stable or increasing population.
- Model was set without carrying capacity effect

Harvest Strategy -Things We Can Adjust

- Harvest level (e.g. TAH) = No. of bears removed
- Composition of harvest – Age and sex ratio of harvest
- Management interval - How often do you intend to adjust TAH to meet objective? State-dependent management
- Timing and precision of future surveys

Multiple alternative harvest strategies evaluated to identify the strategies that met management objectives

Harvest Composition - Sex Ratio

Considered three scenarios for sex ratio (SR):

- Non-selective = one male per female (SR = 1)
- Sex-selective = Two males per female (SR = 2)
  - Current Nunavut strategy
- ‘Status Quo’ = Estimated sex ratio of combined Canada-Greenland Harvest (1998-2013)
  - Based on recent genetic sampling (2011-13) – limited N
  - For Baffin Bay SR = 1.25 (male biased but not 2:1)

Harvest Composition - Age

- Assumed that age composition of harvest would be the same as the last 20 years of harvest data.

- Data indicated a slight preferential selection for subadult males in the harvest relative to their abundance in population

State-dependent Management

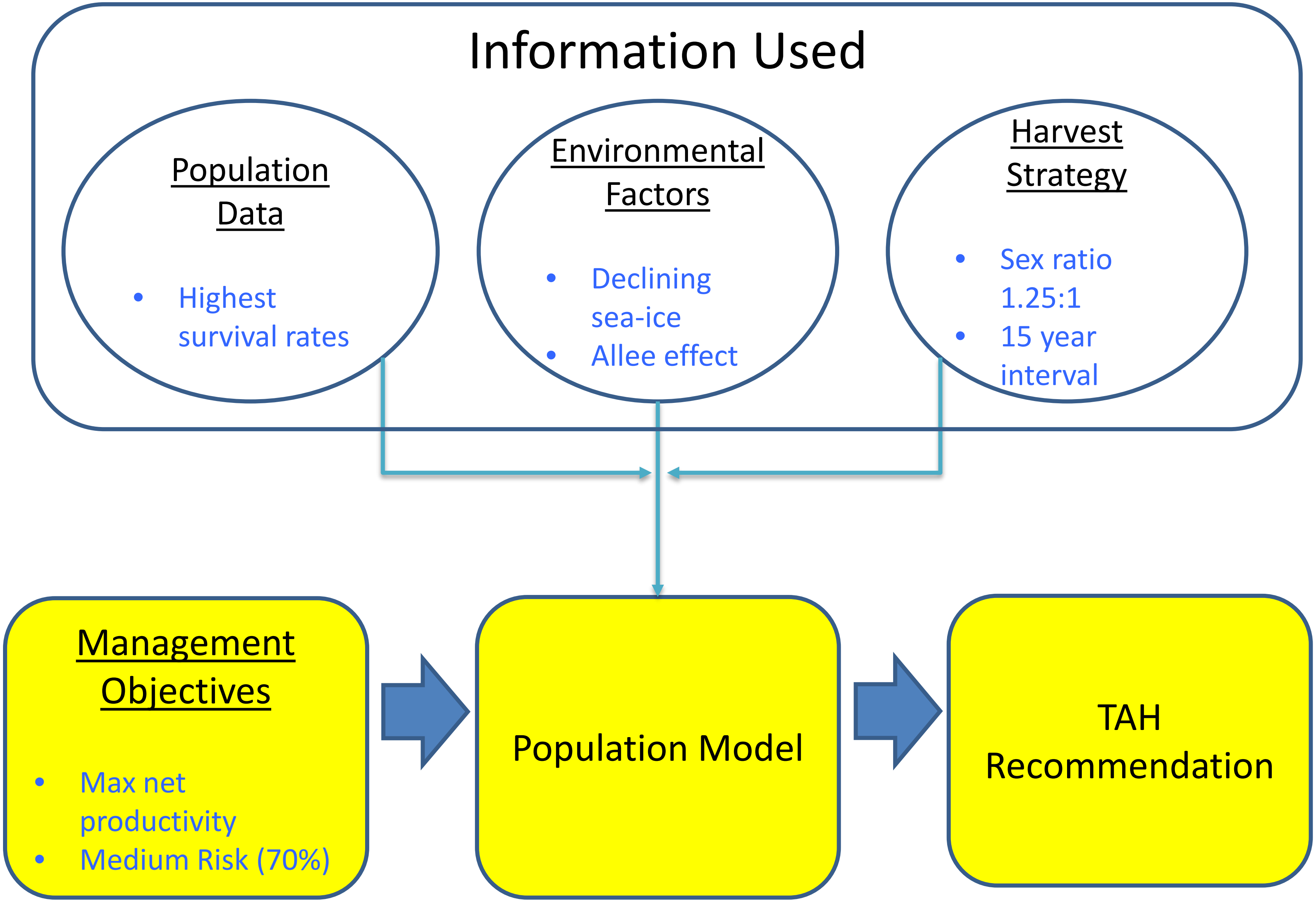
- All harvest strategies used a state-dependent (i.e., dependent on current conditions) management approach.
- Assumes that there is a commitment to regular surveys.
- A state-dependent approach is an effective way to protect the subpopulation while maintaining, or maximizing, the opportunity for use
- A state-dependent approach is especially important if habitat conditions are changing, as they are for both BB and KB

Management Interval

- Number of years between changes in harvest management.
- Includes time required for response to new survey information.
- Evaluated 10, 15, 20 years intervals. Survey precision varied.
- 15-20 years approximates current practices for BB and KB.
- For BB and KB, interval between two most recent surveys was 18 years (1993-2011)

Checking The Model

- Retrospective population projections performed using reported harvest.
- For BB, this produced a stable subpopulation from 1998-2010 with survival rates from Scenario 2 and the observed harvest of approx. 162 bears/year
- For KB, the model matched the estimated subpopulation increase from 1998-2014 with survival rates from Scenario 2 and the observed harvest of approx. 8 bears/year
- For both, subpopulation sex ratios in the final year that closely matched results from the CR study
- Suggests the model and input data provided reasonable representations.



Information Used
Population Data
Highest survival rates
Environmental Factors
Declining sea-ice
Allee effect
Harvest Strategy
Sex ratio 1.25:1
15 year interval
Management Objectives
Max net productivity
Medium Risk (70%)
Population Model
TAH Recommendation

Results (Baffin Bay)

Model was run for 35 years into the future; approximately 3 polar bear generations

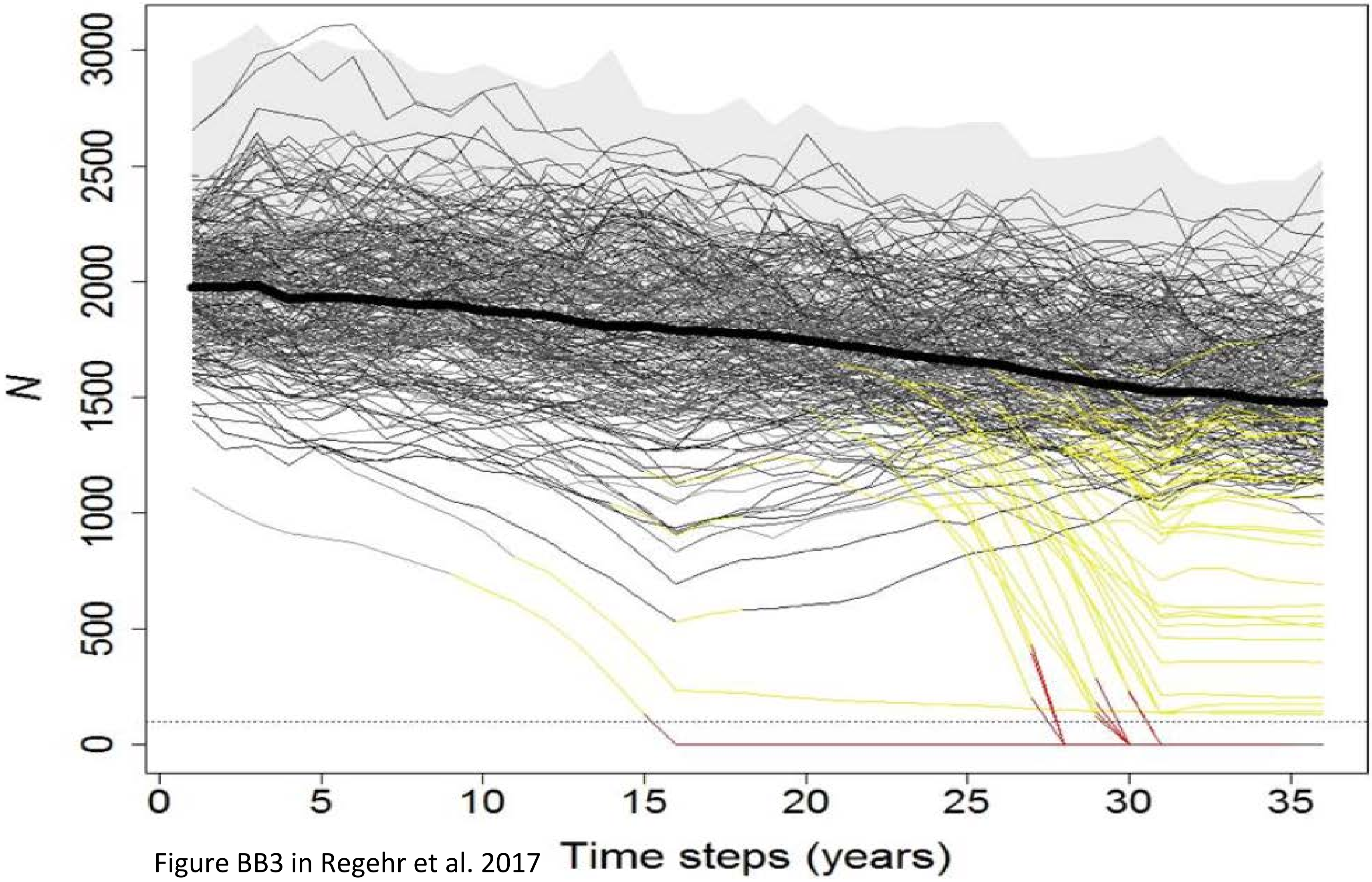


Figure BB3 in Regehr et al. 2017

Results (Baffin Bay)

Example for vital rates scenario 2, which included the most plausible—and highest—survival rates

- Intrinsic population growth rate (*r*) = 8%, indicating <u>strong potential</u> for growth
- Results focus on Management Objective 2, which is most relevant for a subpopulation experiencing habitat loss
- Assume that management changes will be made at a 15-year interval, and future population studies will have precision similar to the current study

Results (Baffin Bay)

For harvest at the *status quo* sex ratio *SR* = 1.25, the following current harvest met Management Objective 2:

- "Low" risk: up to 4.3% harvest rate, or 120 independent bears/year
- "Medium" risk: up to 5.7% harvest rate, or 160 independent bears/year

Management objective	SR = 1.0			SR = 1.25			SR = 2.0		
	F_O	$H_{t=1}$	$h_{t=1}$	F_O	$H_{t=1}$	$h_{t=1}$	F_O	$H_{t=1}$	$h_{t=1}$
1a	NA	NA	NA	NA	NA	NA	NA	NA	NA
1b	0.00	0	0.0%	0.00	0	0.0%	0.00	0	0.0%
2a	0.78	120	4.3%	0.69	120	4.3%	0.43	100	3.6%
2b	1.03	160	5.7%	0.92	160	5.7%	0.60	140	5.0%
3a	1.03	160	5.7%	0.92	160	5.7%	0.60	140	5.0%
3b	1.16	180	6.4%	1.15	200	7.1%	0.78	180	6.4%

Table BB6. Summary of primary simulations for the Baffin Bay polar bear subpopulation, using Scenario 2 of the vital rates. All simulations followed a state-dependent management approach with a 15-year management interval and baseline data precision (i.e., *rsd.mod* = 1).

TAH Recommendation for Baffin Bay

- Joint Commission met in October 2017
- Reviewed array of harvest assessment results and harvest strategy options
- Recommended combined harvest of up to 160 bear per year.
- Recommended TAH for Nunavut = 80 bears per year. Sex ratio of 1:1.
- Community consultations in Nunavut in February 2018.

Key Features of This TAH Recommendation

Assumptions:

- Highest rates of survival and reproduction
- Population is presently at or near maximum productivity; not affected by climate change
- Population will gradually decline in future
- New survey (with similar precision) and a TAH adjustment will be made within 15 years

Key Features of This TAH Recommendation

- Harvest rate of 5.7%.
- One of highest of any sub-population. (>4.5%)
- Meets the objective of keeping the population near maximum productivity (i.e. largest potential TAH) with 70% chance of success (medium risk)
- Sex ratio may be 1:1 (equal males to females) or 1.25:1
- Demonstrates that populations subject to climate change effects can be sustainably harvested (addressing international concerns)

Caveats

- Increasing potential for severe depletion of adult males toward the end of projections
- If the lower estimates of survival from 2011-2013 (Scenario 1) are accurate and reflect declining subpopulation status due to sea-ice loss, then the harvest rates indicated here would be associated with a high risk; significantly lower harvest rates would be necessary to meet management objectives
- The model did not include potential density-independent effects of sea-ice loss.
- Negative effects of sea-ice loss could occur more rapidly in the future than included in our model

Results (Kane Basin)

Example

- For Scenario 2 the population growth rate = 5%, indicating moderate potential for growth
- More likely representation of the subpopulation
- High uncertainty in the vital rates meant that objectives could not be met at the “low” risk tolerance, even in the absence of harvest.
- Management Objectives 1 and 2 met at the “medium” risk tolerance.

Results (Kane Basin)

- At the *status quo* sex ratio *SR* = 0.94, the following current harvest met objectives as the “medium” risk tolerance:
    - Management Objective 1: up to 1.7% harvest rate, or 6 independent bears/year
    - Management Objective 2: up to 1.1% harvest rate, or 4 independent bears/year
- These harvests are lower than the observed harvest of approx. 8 bears/year from 1998-2013…
- <u>The small size of the KB subpopulation combined with relatively small sample sizes, due to logistical constraints, results in high uncertainty in estimates of vital rates for KB</u>

Results (Kane Basin)

- Given evidence for the transition to a seasonal ice regime, stable to increasing subpopulation trend, and TEK, additional modeling performed to evaluate impact of high uncertainty in vital rates:

  - Scenario 2 was further modified to reduce the statistical uncertainty in estimates of survival for younger bears

  - Under these conditions, Management Objective 1 at a “medium” risk tolerance could be met with a current harvest rate of 2.2-2.8% (8-10 independent bears/year)

<u>Considering available evidence, current harvest of up to 10 independent bears/year is unlikely to have negative effects</u>

TAH Recommendation for Kane Basin

- Joint Commission met in October 2017
- Reviewed array of harvest assessment results and harvest strategy options
- JC unable to agree on recommended harvest level.
- GN recommended TAH for Nunavut = 5 bears per year. (same as current TAH)
- Community consultations in Nunavut in February 2018.

Key Features of this TAH recommendation:

- Assumes the highest rates of survival and reproduction
- Assumes population is presently at or near maximum productivity; not affected by climate change
- Assumes population will not decline due to environmental change in the near future.
- Assumes a new survey (with similar precision) and a TAH adjustment will be made within 15 years
- Meets the objective of keeping the population near maximum productivity (i.e. largest potential TAH)
- Medium risk (i.e. 70% chance of success)
- Sex ratio may be 1:1 (equal males to females) or 1.25:1


Thank you

Results (Baffin Bay)

- Management Objective 3 consisted of a managed subpopulation reduction from 2,826 to approximately 2,000 bears in 10-15 years, due to concerns about human-bear conflicts
- A reduction of this magnitude, over such a short timeframe, is probably not possible within the risk tolerance specified by the JC
  - For example, it was possible to achieve a 25% reduction in 15 years, within the risk tolerance provided by the JC, only if a state-dependent approach is followed with near-optimal conditions: a 5-year management interval, and increased data precision from future population studies
  - Under this harvest strategy, a starting harvest rate of 8.7% (245 independent bears per year) would be maintained for 5 years, after which a new survey would have been completed and a new harvest calculated
- Further exploration of managed reduction is possible. Such strategies are likely to (i) involve higher risk of negative outcomes; (ii) require large reductions in harvest over a short time; and (iii) result in a subpopulation size below MNPL, and therefore loss of sustainable harvest opportunity

(a) male-to-female sex ratio in harvest (*SR*) = 1.0

						t = 1					
F_O	0.000	0.516	0.646	0.775	0.904	1.033	1.162	1.291	1.420	1.549	1.679
$h_{t=1}$	0.0%	2.8%	3.6%	4.3%	5.0%	5.7%	6.4%	7.1%	7.8%	8.5%	9.2%
$H_{t=1}$	0	80	100	120	140	160	180	200	220	240	260
mgmt.interval	15	15	15	15	15	15	15	15	15	15	15
rsd.mod	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
						t = 15					
N_t/N_1	1.14	1.03	1.01	0.97	0.95	0.87	0.85	0.77	0.73	0.57	0.47
N_t/K_t	1.00	0.91	0.89	0.86	0.83	0.78	0.75	0.68	0.64	0.51	0.41
H_t	0	82	102	122	142	162	180	198	220	220	225
$P_{extirpation}$	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.03	0.16	0.21
$P_{male.dep}$	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.10	0.12	0.21	0.26
$P_{Objective1}$	1.00	0.98	0.92	0.83	0.68	0.45	0.31	0.17	0.09	0.04	0.03
$P_{Objective2}$	1.00	1.00	0.99	0.95	0.91	0.79	0.66	0.45	0.34	0.19	0.14
$P_{Objective3}$	1.00	1.00	1.00	0.97	0.96	0.90	0.80	0.62	0.55	0.36	0.27
						t = 36					
N_t/N_1	0.96	0.86	0.84	0.80	0.78	0.72	0.69	0.62	0.57	0.39	0.20
N_t/K_t	1.00	0.90	0.88	0.85	0.81	0.77	0.72	0.65	0.59	0.41	0.21
H_t	0	72	86	97	104	105	107	105	108	94	90
$P_{extirpation}$	0.00	0.00	0.00	0.00	0.01	0.03	0.07	0.14	0.18	0.35	0.43
$P_{male.dep}$	0.00	0.00	0.00	0.00	0.02	0.04	0.05	0.08	0.11	0.13	0.13
$P_{Objective1}$	0.75	0.32	0.22	0.13	0.08	0.05	0.03	0.02	0.02	0.01	0.00
$P_{Objective2}$	1.00	1.00	0.99	0.95	0.84	0.71	0.55	0.40	0.30	0.18	0.11
$P_{Objective3}$	1.00	0.99	0.97	0.91	0.80	0.66	0.50	0.33	0.24	0.14	0.08

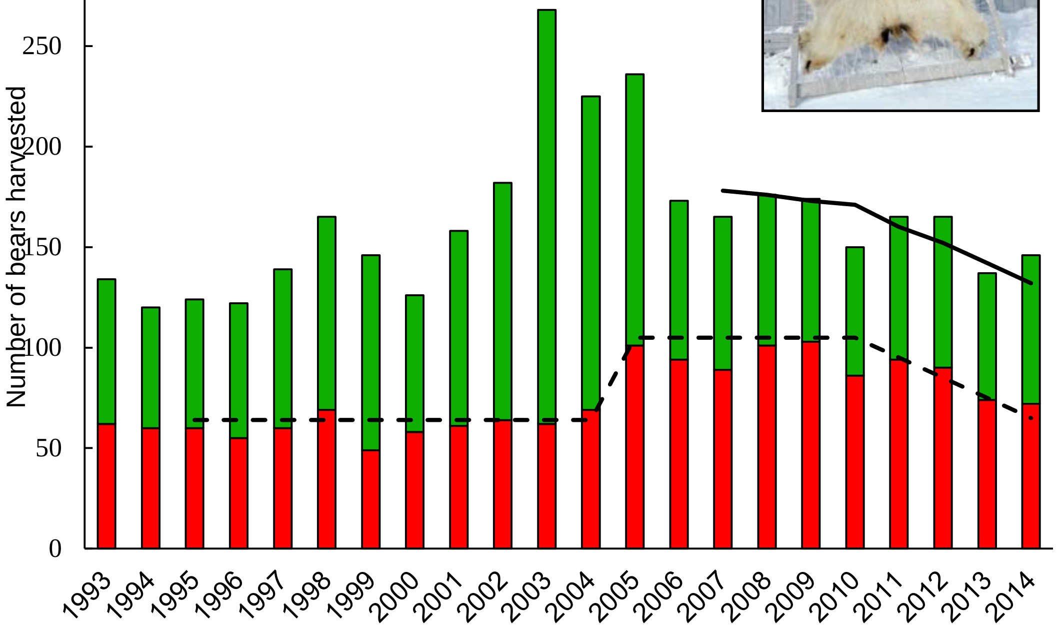
Table S.BB2. Continued

(b) male-to-female ratio in the harvest (*SR*) = 1.25

						$t = 1$					
F_O	0.000	0.459	0.574	0.689	0.804	0.918	1.033	1.148	1.263	1.378	1.492
$h_{t=1}$	0.0%	2.8%	3.6%	4.3%	5.0%	5.7%	6.4%	7.1%	7.8%	8.5%	9.2%
$H_{t=1}$	0	80	100	120	140	160	180	200	220	240	260
mgmt.interval	15	15	15	15	15	15	15	15	15	15	15
rsd.mod	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
						$t = 15$					
N_t/N_1	1.12	1.06	1.00	0.96	0.96	0.92	0.88	0.80	0.75	0.59	0.41
N_t/K_t	1.01	0.92	0.89	0.87	0.85	0.82	0.78	0.71	0.66	0.53	0.37
H_t	0	81	101	122	142	161	181	198	211	212	205
$P_{extirpation}$	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.07	0.18	0.28
$P_{male.dep}$	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.14	0.23	0.34	0.39
$P_{Objective1}$	1.00	0.98	0.93	0.86	0.75	0.59	0.43	0.26	0.16	0.07	0.03
$P_{Objective2}$	1.00	0.99	0.98	0.96	0.93	0.85	0.73	0.55	0.42	0.25	0.12
$P_{Objective3}$	1.00	1.00	0.99	0.98	0.97	0.92	0.85	0.72	0.58	0.39	0.24
						$t = 36$					
N_t/N_1	0.94	0.88	0.85	0.81	0.78	0.75	0.71	0.65	0.56	0.37	0.14
N_t/K_t	1.00	0.91	0.89	0.87	0.82	0.79	0.74	0.68	0.58	0.39	0.15
H_t	0	71	81	89	93	94	98	100	99	96	93
$P_{extirpation}$	0.00	0.00	0.00	0.00	0.02	0.04	0.11	0.16	0.25	0.36	0.45
$P_{male.dep}$	0.00	0.00	0.01	0.02	0.08	0.12	0.14	0.20	0.22	0.21	0.23
$P_{Objective1}$	0.76	0.39	0.28	0.21	0.13	0.09	0.06	0.04	0.03	0.02	0.01
$P_{Objective2}$	1.00	1.00	0.99	0.95	0.84	0.74	0.64	0.51	0.37	0.25	0.17
$P_{Objective3}$	1.00	0.99	0.97	0.93	0.81	0.69	0.57	0.42	0.29	0.18	0.12

Characteristics of the Polar Bear Harvest in Baffin Bay

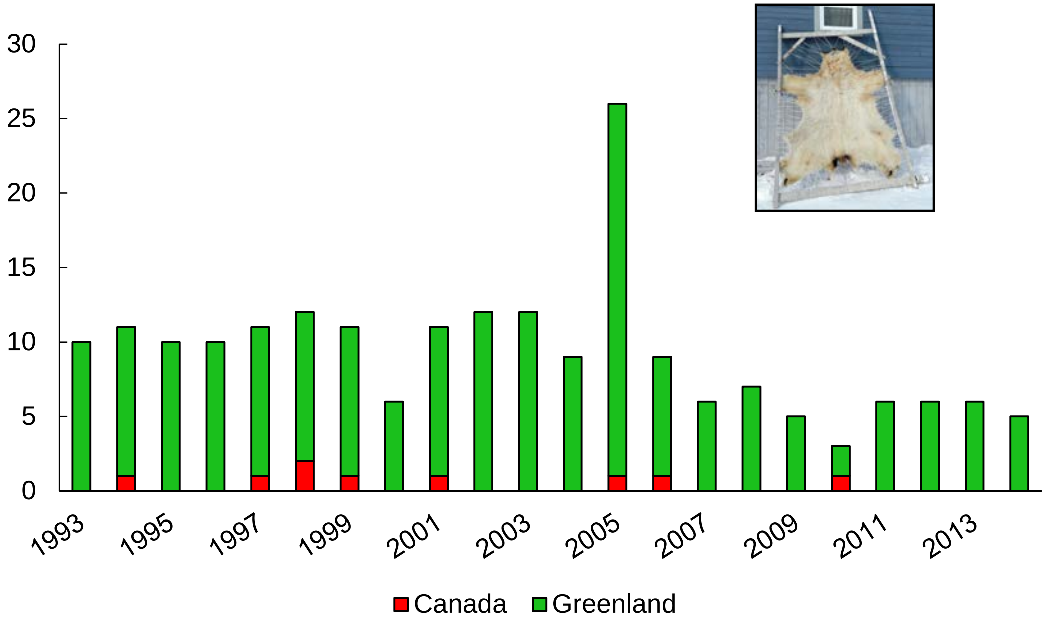
- Yearly average total of 163 (1992-2014)
- Peaked in 2003 with 263 bears
- 2004: Nunavut TAH increased from 64 to 105
- 2006: Greenland quota introduced
- 2010-2014: Nunavut TAH reduced from 105 to 65



Canadian (red) and Greenlandic (green) harvest of polar bear in Baffin Bay

Harvest - Kane Basin (KB)

- Yearly average total of 9 (1993-2014)
- 2006: Greenland quota introduced
- Nunavut TAH of 5 bears unchanged
- Few bears harvested in Nunavut



Conclusions

- A harvest assessment for the BB and KB subpopulations using information from a comprehensive research assessment (SWG 2016)
- Model included the effects of habitat change as variable and declining *K* for BB, and as variable but stable *K* for KB. The proxy for *K* was based on the projected number of ice-covered days per year (SWG 2016)
- Considered multiple scenarios of survival for each subpopulation. This helped establish the best-possible representations of the subpopulations while taking into account variation and potential bias in estimates of survival from CR studies, as well as other information including subpopulation trend and TEK
- Population reconstruction indicated that the model could reproduce plausible histories for both subpopulations over the past several decades

Conclusions

- We identified harvest strategies that met management objectives as specified by the JC:
  - For BB, this corresponded to current TAH at a harvest rate up to 4.3 - 5.7% (120 - 160 independent bears per year)
  - For KB, we suggest that current TAH at a harvest rate up to 2.8% (10 independent bears per year) can be supported if there is effective monitoring

- These findings require new population studies, and updated harvest levels every 15 years.

- For both BB and KB, lower survival of adult males led to skewed subpopulation sex ratios and the potential for severe male depletion. The lower survival of males may represent an emerging conservation concern