IUCN
The World Conservation Union

Rue Mauverney 28
1196 Gland
Switzerland

Tel +41 22 999 0000
Fax +41 22 999 0002
mail@iucn.org

www.iucn.org

World Headquarters

Polar Bears: Proceedings of the Fourteenth Working Meeting

IUCN

IUCN
The World Conservation Union

Polar Bears

Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20–24 June 2005, Seattle, Washington, USA

Compiled and edited by Jon Aars, Nicholas J. Lunn and Andrew E. Derocher

Occasional Paper of the IUCN Species Survival Commission No. 32

SSC
Species Survival Commission

Polar Bears

Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20–24 June 2005, Seattle, Washington, USA

The Greenland Institute of Natural Resources

Species Survival Commission

Polar Bears

Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20–24 June 2005, Seattle, Washington, USA

Compiled and edited by Jon Aars, Nicholas J. Lunn and Andrew E. Derocher

Occasional Paper of the IUCN Species Survival Commission No. 32

Published by: IUCN, Gland, Switzerland and Cambridge, UK

Citation: Compiled and edited by Jon Aars, Nicholas J. Lunn and Andrew E. Derocher (2006). *Polar Bears: Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20–24 June 2005, Seattle, Washington, USA.* IUCN, Gland, Switzerland and Cambridge, UK.

ISBN-10: 2-8317-0959-8

ISBN-13: 978-2-8317-0959-8

Cover design by: IUCN Publications Services Unit

Cover photo: Polar bears © Jon Aars, Norwegian Polar Institute

Layout by: IUCN Publications Services Unit

Produced by: IUCN Publications Services Unit

Printed by: Henry Ling Ltd, Dorchester, UK

Available from: IUCN Publications Services Unit
219c Huntingdon Road, Cambridge CB3 0DL
United Kingdom
Tel: +44 1223 277894
Fax: +44 1223 277175
E-mail: books@iucn.org
www.iucn.org/publications
A catalogue of IUCN publications is also available.

The text of this book is printed on Fineblade Extra 90 gsm made from low chlorine pulp

Contents

Foreword

Following the First International Scientific Meeting on the Polar Bear, which was held in Fairbanks, Alaska in 1965, the Polar Bear Specialist Group was formed to co-ordinate research and management of polar bears. Eight years following the First Scientific Meeting, the international Agreement on the Conservation of Polar Bears and Their Habitat was signed by the Governments of Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States. Article VII of the Agreement states that "The Contracting Parties shall conduct national research programmes on polar bears, particularly research relating to the conservation and management of the species. They shall as appropriate co-ordinate such research with research carried out by other Parties, consult with other Parties on the management of migrating polar bear populations, and exchange information on research and management programmes, research results and data on bears taken."

As part of their commitment to fulfil the intent of the Agreement, representatives of all five signatory nations, together with invited specialists, attended the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group that was held 20-24 June 2005 in Seattle, Washington and hosted by the U.S. Fish and Wildlife Service. The Specialist Group reviewed overall progress in research and management of polar bears since the previous meeting (Nuuk, Greenland 2001), and identified priorities for future studies. With recent documentation of how a warmer arctic climate might affect the sea ice habitat of polar bears, the predictions of an even warmer climate in the next decades, and documentation of effects on polar bear subpopulations, an evaluation of the red list status of polar bear subpopulations was followed by an increased conservation designation of vulnerable. The meeting also generated substantial debate regarding the data required for changes to subpopulation harvest quotas and whether some proposed quota increases would be unsustainable. In the complexity of possible interactions between climate change, local harvest, and in some areas high levels of pollutants, an increased level of international cooperation was advocated.

These 14th Proceedings provide an overview of the ongoing research and management activities on polar bears in the circumpolar Arctic. Together with the previous 13 proceedings, they provide an historic record of the international effort in protecting, studying and managing polar bears. The document addresses more recent concerns of threats arising as a consequence of increased human activities in both the Arctic and in regions far beyond the realm of polar bears.

Funding for the publication of these proceedings was provided by the Canadian Wildlife Service, the Greenland Institute of Natural Resources, the Norwegian Polar Institute, the Nunavut Department of Sustainable Development, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey.

A note on the use of the terms population and subpopulation

In this volume we have decided to use the term population for all the polar bears in the Arctic. This decision is based on their biology, as polar bears roam over large areas and the genetic structure is low even between areas far apart. However, in earlier issues and in a lot of publications, population has been used to term more local management units. Here those are termed subpopulations. Furthermore, we like to address the fact that the boundaries between these subpopulations will always be based on current knowledge, and that they thus might change as more complete knowledge on their ecology becomes available. Especially in the less studied areas encompassing the Russian Arctic in particular, our view of what the real subpopulations or management units are, and to what degree they interact or are a part of the neighbouring nations' subpopulations, might alter in the near future.

List of participants

PBSG members

Jon Aars
Norwegian Polar Institute
N-9296 Tromsø
Norway
Tel: + 47 77 75 05 24
Fax: + 47 77 75 05 01
E-mail: jon.aars@npolar.no

Steven C. Amstrup
Alaska Science Center
U.S. Geological Survey
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3424
Fax: + 1 907 786 3636
E-mail: steven_amstrup@usgs.gov

Stanislav E. Belikov
All-Russian Research Institute for Nature Protection
Znamenskoye-Sadki
Moscow 117628
Russian Federation
Tel: + 7 494 423 8444
Fax: + 7 494 423 2322
E-mail: sbelik40@online.ru

Andrei N. Boltunov
All-Russian Research Institute for Nature Protection
Znamenskoye-Sadki
Moscow 117628
Russian Federation
Tel: + 7 494 423 8444
Fax: + 7 494 423 2322
E-mail: 3438083@online.ru

Erik W. Born
Greenland Institute of Natural Resources
c/o Danish Polar Center
Strandgade 100H
DK-1401 Copenhagen
Denmark
Tel: + 45 32 88 01 63
Fax: + 45 32 88 01 01
E-mail: ewb@dpc.dk

Andrew E. Derocher
University of Alberta
Department of Biological Sciences
Edmonton, Alberta T6G 2E9
Canada
Tel: + 1 780 492 5570
Fax: + 1 780 492 9234
E-mail: derocher@ualberta.ca

Morten Ekker
Directorate for Nature Management
N-7485 Trondheim
Norway
Tel: + 47 73 58 07 30
Fax: + 47 73 58 05 01
E-mail: morten.ekker@dirnat.no

Nick Lunn
Canadian Wildlife Service
5320-122 Street
Edmonton, Alberta T6H 3S5
Canada
Tel: + 1 780 435 7208
Fax: + 1 780 435 7359
E-mail: nick.lunn@ec.gc.ca

Martyn Obbard
Ontario Ministry of Natural Resources
P.O. Box 7000
300 Water Street, 3rd Floor North
Peterborough, Ontario K9J 8M5
Canada
Tel: + 1 705 755 1549
Fax: + 1 705 755 1559
E-mail: martyn.obbard@mnr.gov.on.ca

Nikita Ovysanikov
Wrangel Island State Nature Reserve
Menzinskogo 25-28
Moscow 129327
Russian Federation
Tel: + 7 494 687 0657 home
E-mail: nikita_ov@mail.ru

Aqqalu Rosing-Asvid
Greenland Institute of Natural Resources
P.O. Box 570
DK-3900 Nuuk
Greenland
Tel: + 299 36 12 47
Fax: + 299 36 12 12
E-Mail: aqqalu@natur.gl

Scott L. Schliebe
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3812
Fax: + 1 907 786 3816
E-mail: scott_schliebe@fws.gov

Ian Stirling
Canadian Wildlife Service
5320-122 Street
Edmonton, Alberta T6H 3S5
Canada
Tel: + 1 780 435 7349
Fax: + 1 780 435 7359
Email: ian.stirling@ec.gc.ca

Mitchell Taylor
Department of Environment
Government of Nunavut
P.O. Box 209
Igoolik, Nunavut X0A 0L0
Canada
Tel: + 1 867 934 2051
Fax: + 1 867 934 2058
E-mail: mtaylor2@gov.nu.ca

Dag Vongraven
Norwegian Polar Institute
N-9296 Tromsø
Norway
Tel: + 47 77 75 06 38
Fax: + 47 77 75 05 01
E-mail: vongraven@nPolar.no

Øystein Wiig
Natural History Museum
University of Oslo
P.O. Box 1172
0318 Oslo
Norway
Tel: + 47 22 85 16 88
Fax: + 47 22 85 18 37
E-mail: oystein.wiig@nhm.uio.no

Invited specialists

Sherman Anderson for **Charles Johnson**
Alaska Nanuuq Commission
P.O. Box 946
Nome, Alaska 99762
USA
Tel: + 1 907 433 5044
Fax: + 1 907 443 5060
E-mail: cj.aknanuuq@alaska.com

Charles D.N. Brower
Department of Wildlife Management
North Slope Borough
P.O. Box 69
Barrow, Alaska 99723
USA
Tel: + 1 907 852 0350
Fax: + 1 907 852 8948
E-mail: charles.brower@north-slope.org

Larry Carpenter
Wildlife Management Advisory Council (NWT)
P.O. Box 2120
Inuvik, Northwest Territories X0E 0T0
Canada
Tel: + 1 867 777 2828
Fax: + 1 867 777 2610
E-mail: wmac_c@jointsec.nt.ca

David C. Douglas
Alaska Science Center
U.S. Geological Survey
3100 National Park Road
Juneau, Alaska 99801
USA
Tel: + 1 907 364 1576
E-mail: david_douglas@usgs.gov

George M. Durner
Alaska Science Center
U.S. Geological Survey
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3366
Fax: + 1 907 786 3636
E-mail: george_durner@usgs.gov

Thomas Evans
US Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3814
Fax + 1 907 786-3816
E-mail: Thomas_Evans@fws.gov

Anatoly Kochnev
Pacific Research Fisheries Center
TINRO/Chukotka Branch
P.O. Box 29
Anadyr, Chukotka 68900
Russian Federation
Tel: + 7 427 222 6647
Fax: + 7 427 222 6761
E-mail: kochnev@anadyr.ru

Jeff Laake
NOAA/National Marine Fisheries Service
National Marine Mammal Laboratory
7600 Sand Point Way, NE
Seattle, Washington 98115-0700
USA
Tel: + 1 206 526 4017
Fax: + 1 206 526 6615
E-mail: jeff.laake@noaa.gov

David Lee
Nunavut Tunngavik Inc.
P.O. Box 280
Rankin Inlet, Nunavut X0C 0G0
Canada
Tel: + 1 867 645 5400
Fax: + 1 867 645 3451
E-mail: dlee@ubishops.ca

Lisa Lierheimer
U.S. Fish and Wildlife Service
Division of Management Authority
4401 N. Fairfax Dr., Room 700
Arlington, VA 22203
USA
Tel: + 1 703 358 2104 ext. 1991
Fax: + 1 703-558-7722
E-mail: lisa_lierheimer@fws.gov

Janni Lønstrup
Ministry of Fisheries and Hunting
Greenland Home Rule
P.O. Box 269
DK-3900 Nuuk
Greenland
Tel: + 299 34 53 34
Fax: + 299 32 47 04
E-mail: JLOE@gh.gl

Trent McDonald
Western Ecosystem Tech, Inc.
2003 Central Avenue
Cheyenne, Wyoming 82001
USA
Tel: + 1 307 634 1754
Fax: + 1 307 637 6981
E-mail: tmcdonald@west-inc.com

Phil McLoughlin
Dept. of Biology
University of Saskatchewan
112 Science Place
Saskatoon, Saskatchewan S7N 5E2
Canada
Tel: + 1 306 966 4451
Fax: + 1 306 966 4461
E-mail: mcloughlin@sask.usask.ca

Susanne Miller
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3828
Fax: + 1 907 786-3816
E-mail: Susanne_Miller@fws.gov

Gabriel Nirlungayuk
Nunavut Tunngavik Inc.
P.O. Box 280
Rankin Inlet, Nunavut X0C 0G0
Canada
Tel: + 1 867 645 5400
Fax: + 1 867 645 3451
E-mail: gabnir@arctic.ca

Frank Pokiak
Inuvialuit Game Council
P.O. Box 2120
Inuvik, Northwest Territories X0E 0T0
Canada
Tel: + 1 867 777 2828
Fax: + 1 867 777 2610
E-mail: igc-js@jointsec.nt.ca

Eric Regehr
U.S. Geological Survey
Alaska Biological Science Center
1011 E. Tudor Road, MS 701
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3827
Fax: + 1 907 786 3636
E-mail: eregehr@usgs.gov

Evan Richardson
Canadian Wildlife Service
5320-122 Street
Edmonton, Alberta T6H 3S5
Canada
Tel: + 1 780 435 7392
Fax: + 1 780 435 7359
E-mail: evan.richardson@ec.gc.ca

Ignatius Rigor
Polar Science Center
Applied Physics Laboratory
1013 NE 40th St.
University of Washington
Seattle, Washington 98105
USA
Tel: + 1 206 685 2571
Fax: + 1 206 616 3142
E-mail: igr@apl.washington.edu

Kristin Simac
Alaska Science Center
U.S. Geological Survey
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3942
Fax: + 1 907 786 3636
E-mail: Kristin_Simac@usgs.gov

Thomas Smith
Alaska Science Center
U.S. Geological Survey
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3456
Fax: + 1 907 786 3636
E-mail: tom_smith@usgs.gov

Christian Sonne
Arctic Wildlife Research Veterinarian
Ministry of Environment
National Environmental Research Institute
Department of Arctic Environment
Frederiksborgvej 399, PO Box 358
DK-4000 Roskilde
Denmark
Tel: + 45 46 30 19 54
Fax: + 45 46 30 19 14
E-mail: csh@dmu.dk

Fernando Ugarte
Ministry of Fisheries and Hunting
Greenland Home Rule
P.O. Box 269
DK-3900, Nuuk
Greenland
Tel: + 299 34 53 43
Fax: + 299 32 47 04
E-mail: FEUG@gh.gl

Geoffrey York
Alaska Science Center
U.S. Geological Survey
1011 E. Tudor Road
Anchorage, Alaska 99503
USA
Tel: + 1 907 786 3928
Fax: + 1 907 786 3636
E-mail: Geoffrey_S_York@usgs.gov

Agenda

Fourteenth Working Meeting of the IUCN/SSC PBSG
Seattle, 20–24 June 2005

Monday 20 June 2005

09.00 **1. Opening and administrative issues (Scott Schliebe)**

1.1 Introductory welcome and remarks/comments from the hosts (Dan Ashe, Science Advisor to Director, USFWS)

1.2 Introduction of participants

1.3 Election of the meeting Chairman

1.4 Election of Secretary for recording notes from the meeting

1.5 Review agenda (additions, deletions, or scheduling for topics), adoption of final agenda

1.6 Production, format, anticipated cost of published proceedings from the meeting

1.7 Election of ad hoc "editors" for compilation of proceedings and the minutes of the meeting

1.8 Election of group to draft press release

1.9 Tabling or introduction of draft resolutions, formation of resolutions committee

1.10 Status report – consolidated report for PBSG to review

10.30 Break

2. Summary of research and status of populations by nation. Future research priorities

2.1 Canada: overview of completed, ongoing and planned research projects
Nick Lunn – Hudson Bay
Martyn Obbard – Southern Hudson Bay (genetics and health/condition of polar bears)
Ian Stirling – Southern Beaufort Sea/ Hudson Bay
Andrew Derocher – University of Alberta studies
Mitch Taylor – Nunavut future research priorities
Other topics/speakers

12.00 Lunch

13.00 2.2 Greenland/Denmark
Erik Born, Aqqalu Rosing-Asvid, Mitch Taylor – Greenland/Canada polar bear studies

2.3 Norway
Jon Aars – Barents Sea population survey status
Dag Vongraven
Morten Ekker

15.00 Break

2.4 Russia
Stanislav Belikov – East Siberian Sea, Chukchi/Bering Seas
Andrei Boltunov – Barents and Kara Seas
Anatoli Kochnev, Charlie Johnson – Fall concentrations of polar bears: Wrangel Island, 1989-98; Chukotka Koluchin Bay study; Traditional Ecological Knowledge
Nikita Ovsyanikov – Current research and conservation of polar bears on Wrangel Island

2.5 USA
Steve Amstrup, George Durner – Southern Beaufort Sea
Tom Smith – Denning ecology
Scott Schliebe – Fall coastal surveys
Susanne Miller – Feeding ecology

Tuesday 21 June 2005

08.00 **3. Summary of management by nation**

3.1 Canada – Mitch Taylor, Nick Lunn, Gabriel Nirlungayuk

3.2 Greenland/Denmark – Erik Born, Aqqalu Rosing-Asvid

3.3 Norway – Dag Vongraven, Morten Ekker

3.4 Russia – Andrei Boltunov, Stanislav Belikov

3.5 USA – Tom Evans, Lisa Lierheimer, Sherman Anderson

10.30 Break

Summary of management by nation (continued from above)

12.00 Lunch

13.00 Summary of management by nation (continued from above)

Wednesday 22 June 2005

08.00 **4. Bi-/multilateral agreements and MOUs related to polar bears**

4.1 Canada-USA (Stirling, Schliebe, Brower, Carpenter)

4.2 Russia-USA (Belikov, Schliebe, Anderson)

4.3 Norway-Russia (Ekker, Belikov)

4.4 Greenland-Canada (Born, Rosing-Asvid, Stirling, Taylor)

12.00 Lunch

13.00 **5. Conservation and environmental issues: contaminants, climate change, harvest, and tourism**

5.1 Toxic chemicals (Sonne, Evans)

5.2 Alaska contaminants, isotope projects (Amstrup, York)

5.3 Immune system effects (Derocher, Lunn, Wiig)

5.4 Climate change (Douglas, Rigor, Derocher, Stirling, Lunn, Rosing-Asvid)

15.00 Break

5.5 Harvest (sex selective harvest, flexible quota system, RiskMan sustainable harvest modeling and management, acceptable levels of risk, traditional knowledge – Taylor, McLoughlin, Laake)

5.6 Tourism (Hudson Bay, viewing in denning areas, regulations regarding tourism – Lunn, others)

5.7 Research priorities (PBSG)

19.00 PBSG members meeting

Issues pertaining to the Agreement

Habitat conservation

Other issues

Thursday 23 June 2005

08.00 **6. Workshop on population inventory and assessment techniques (Moderator – Steve Amstrup)**

6.1 Summary of enumeration: aerial survey (Aars, Laake, Derocher)

6.2 Summary of enumeration: capture-recapture population models MARK etc (Laake, Regehr, Amstrup, Stirling, McDonald, Taylor)

6.3 Methods to assess and monitor the effects of climate change, other topics (TBD)

10.30 Break

Workshop on population inventory and assessment techniques (continued from above)

12.00 Lunch

13.00 6.4 Population inventory new technology

Friday 24 June 2005

08.00 **7. Issues pertaining to the Agreement (TBD based on input of the group)**

7.1 Habitat conservation, CAFF circumpolar monitoring (Vongraven, Belikov)

7.2 Red Data Listing (Wiig, Born)

7.3 Other issues (identify issues of concern/jurisdiction)

10.30 Break

8. Status report review of populations (timely submission and distribution of drafts necessary prior to the meeting)

8.1 Tabling draft status reports by jurisdiction (Canada, Denmark/Greenland, Norway, Russia, USA)

8.2 Review, discussion and recommendations for finalizing status report

9. Resolutions

9.1 Tabling and discussion of draft resolutions

9.2 Review and discussion of resolutions

12.00 Lunch

13.00 **10. IUCN Business**

10.1 Issues handled by the Chairman 2001–2005 (Schliebe)

11. Evaluation of the future status of the PBSG

11.1 Future objectives and actions of the PBSG

11.2 PBSG website (Vongraven)

11.3 Next meeting (group discussion)

12. Election of a new chairman of PBSG

15.00 Break

13. Adoption of the status report

14. Adoption of resolutions presented by various resolution committees

15. Adoption of press release

16. Closing remarks

19.30 Evening banquet at "Ivar's Acres of Clams" on the waterfront, Pier 54

Minutes

of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, Seattle, 20–24 June 2005

Monday June 20th

1. Opening and administrative issues

Introductory remarks

The 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group (PBSG) was called to order by S. Schliebe, Chair of the Group, at 09:10 am in the Rainier Room, Hotel Edgewater, Seattle, Washington, USA. He welcomed the delegates to Seattle, which was followed by a series of introductory and administrative remarks. S. Schliebe invited Dan Ashe, Science Advisor to the Director, U.S. Fish and Wildlife Service (USFWS), to officially open the meeting.

D. Ashe welcomed the delegates to Seattle and noted that this and previous working meetings of the PBSG recognised the ongoing commitment of all five signatory nations to the 1973 *Agreement on the Conservation of Polar Bears and Their Habitat*. Although polar bears evoke powerful imagery and are at the top of the arctic food chain, they are unable to change the world in which they live. polar bears are vulnerable to changes within the arctic marine ecosystem. He noted that the 1973 Agreement was a visionary agreement that has resulted in great success with respect to the conservation of polar bears. However, he cautioned that the challenges and successes of the past will not be the same in the future; complex scientific challenges lie ahead.

He discussed the threat of climate change and, in doing so, warned the Group not to forget that scientific facts often live in a universe that is completely separate from that of public opinion. He noted that climate change was not an issue specific to arctic regions and noted the recent technical review from The Wildlife Society in which climate change was raised as an issue of importance throughout the wildlife conservation community.

In closing, he thanked the PBSG for their continued efforts for the conservation of polar bears for future generations.

Introduction of participants

There was a brief introduction of each participant, a list of which will be included in the Proceedings.

Election of meeting chairman and selection of meeting secretary

S. Schliebe was elected meeting Chair and N. Lunn appointed as meeting Secretary.

Production, format and anticipated cost of published proceedings of this meeting

N. Lunn was Senior Editor of the last proceedings and reviewed the costs and time involved. He noted that it cost £5,000 to publish 1000 copies and an additional £1,200 for shipping. It took about one year to get the proceedings published and we might have been able to get them out sooner had the IUCN Publications Unit not been reprinting their entire catalogue. Most of the editorial work was done by us, which substantially reduced the costs of publication.

There was agreement among the Group that the IUCN format had a good look and feel, and our last three or four proceedings have been published through IUCN. The Group agreed to keep this standard and to publish the proceedings of this meeting with IUCN. When the proceedings would be published was going to be dependent on the printing schedule of the IUCN Publications Services Unit. The Group further agreed that we should take advantage of any publication window available by ensuring that the various reports are submitted to the Group's editors in a timely manner.

N. Lunn suggested that submissions be prepared as if they were being submitted to a journal for publication, which means tables and figures should occur on separate pages at the end of each report. The IUCN Publications Unit required each figure to be in TIFF format at a minimum resolution of 600dpi. The new Editors will circulate the specifics of which journal format is to be followed and any relevant related details.

S. Schliebe confirmed that the USA was committed to paying their share of the publication costs for the proceedings and urged all others to do the same.

Election of editors for the compilation and publication of the proceedings of this meeting

Ø. Wiig nominated J. Aars to be the Senior Editor. Both N. Lunn and A. Derocher offered to help compile and publish the Proceedings, although neither wanted to have the lead responsibility. There was some discussion of the importance of having some continuity with respect to the editors but, at the same time, that the job was demanding and therefore, it should rotate among the members. P. McLoughlin indicated that he too would be willing to help.

It was agreed that there were enough editors and that they should meet to confirm who the Senior Editor would be and to prepare and circulate draft guidelines for the publishing of the proceedings.

Election of group to draft press release

S. Schliebe indicated that he had already received requests from the media with respect to the meeting. Ø. Wiig stated that nothing should be released to the media until after the meeting and that the release should come from the Chair of the meeting. I. Stirling remarked that the number of people attending the working meeting had got larger and that it can be disruptive to have media releases and interactions during the meeting. M. Taylor noted that with any press release or interviews with the media that it is made very clear whether it is a PBSG opinion or an individual's opinion; some members work for agencies that have very specific and structured protocols with respect to media relations.

S. Amstrup, S. Schliebe and G. Nirlungayuk all stressed the importance of getting our information out in a timely manner and to take advantage of media avenues to get what we think is important out to the public.

S. Amstrup, E. Born, G. Nirlungayuk and I. Stirling agreed to draft the press release.

Presentation of draft resolutions

No draft resolutions had been provided prior to the meeting and none were presented. The Group thought that discussion over the course of the working meeting might result in the drafting and tabling of resolutions.

M. Taylor, Ø. Wiig and G. York agreed to co-ordinate the preparation of any resolutions.

Status report

Although most countries had provided status updates, it was felt that a consolidated report was required during the meeting for review by the Group. A. Derocher raised concerns that the status categories used last time (e.g., declining, stable, increasing) needed clarification and/or amendment because they did not necessarily capture what is actually going on, especially for subpopulations that may have been depleted below historical levels. A subpopulation for which a harvest moratorium has recently ended would likely be shown as increasing despite the actual number of bears being well below what it used to be. Some additional documentation is required on the historical subpopulation level and the level required to maintain a healthy, stable subpopulation. This would allow a more accurate evaluation of the current status of a subpopulation.

S. Amstrup, A. Derocher, P. McLoughlin, S. Schliebe and M. Taylor agreed to develop an appropriate structure for the status table and to report back to the Group as early as possible during the meeting.

Additional topics and adoption of final agenda

G. Nirlungayuk indicated that he would like to lead a discussion on the use of traditional knowledge. This was added as a topic to be discussed as part of the Canadian management report.

S. Amstrup noted that although Thursday's workshop deals primarily with science the Group should discuss some of the management consequences.

2. Summary of research and status of subpopulations by nation and future research priorities

Presentations of research and subpopulation status were presented by each nation. Because the minutes and detailed reports from each nation will be included in the Proceedings, only summaries are presented here.

Canada

N. Lunn summarised the Canadian Wildlife Service's ongoing, long-term research on the population ecology of polar bears in western Hudson Bay in relation to climatic change. The break-up of sea ice on Hudson Bay is now about three weeks earlier than it was in the early 1970s. The condition of bears when they come ashore is significantly correlated with break-up; bears come ashore in poorer condition when break-up is early than if break-up is late. The number of occurrences of problem bears handled by Manitoba Conservation staff in Churchill also increases when break-up is early. Analysis of the long-term mark-recapture data shows that the timing of break-up directly affects the survival probabilities of 0–1 year olds, 2–4 year olds, and bears 20+ years. Only the survival probabilities of bears 5–19 years of age were not affected by date of break-up. The number of bears in this subpopulation has declined from 1200 in the mid-1990s to just less than 1000 in 2004.

There were questions related to the role of harvest in the decline and whether there is any evidence of a distributional shift that would explain the lower numbers. N. Lunn replied given the abundance estimate that the current harvest is too high and will be a contributing factor; however, the analysis also indicated a strong relationship between break-up and survival, independent of harvest. Movement patterns recorded from satellite radio collars, recaptures of tagged bears, and tag returns from hunters do not support a distributional shift further to the north.

M. Obbard reported on a study of the genetic structure of the Southern Hudson Bay subpopulation. Samples were obtained from 383 individuals representing four adjacent management units within or near the Hudson Bay region (WH, SH, FB, DS). Independent STRUCTURE analysis identified one genetic cluster in the northern part of the Hudson Bay system (FB-DS) and three genetic clusters in the southern part. Polar bears in the southern portion of Hudson Bay appear to be maintaining three breeding groups, one in the southwest, one in the east, and one in James Bay. Migration and genetic exchange are occurring between the breeding groups, but there appears to be a sufficient level of fidelity or traditional use of breeding areas to maintain the groups as structured groups.

In the general discussion, the inconsistency between tag returns and the genetic structure identified in this study was questioned. M. Obbard noted that gene flow can occur without bears moving into new subpopulations. For example, a Foxe Basin male could easily mate with a Western Hudson Bay female on the sea ice in the spring but both return to traditional summering areas. In response to a question about the validity of current management units, M. Obbard thought that we might have to rethink James Bay; there are only about 100 animals but they appear to be genetically distinct.

I. Stirling summarised an ongoing subpopulation inventory in the Beaufort Sea, which began in spring 2003. The field work in Canada is being co-ordinated with similar studies done at the same time in the Alaskan portion of the Beaufort Sea. The mark-recapture data will be segregated between SB and NB, based on the results of the movement study, and subpopulation sizes determined for each of the two subpopulations. In 2003, capture efforts were hampered by bad weather and limited access to the NB subpopulation; 99 polar bears were caught, mainly in SB, including the overlap area between SB and NB in the area of the Cape Bathurst Polynya. In 2004 and 2005, 258 and 280 polar bears respectively were captured in SB and NB. Of those, 149 and 166 bears were caught in SB in 2004 and 2005. One more year of fieldwork is anticipated in 2006 and a final project report is expected early in 2007. Results of the Alaskan work will be reported separately.

A. Derocher summarised four studies being undertaken by his graduate students at the University of Alberta. Lindsay Towns (M.Sc.) is examining the temporal patterns of polar bear distribution on land in western Hudson Bay during the ice-free period. This study assesses the capture sample collected between 1986 and 2004 within a geographic information system. Significant shifts in the distribution of the subpopulation have been noted with females and their offspring now found closer to the coast. Current analyses suggest relationships between polar bear distribution and sea ice break-up or the North Atlantic Oscillation. Emily Parks (M.Sc.) is examining the home range and movement patterns of polar bears on the sea ice in WH. The historic data on movement and home ranges revealed that both season and reproductive class affected the movement and distribution of WH polar bears, but season appeared to be more important. In general, movement rates were similar to those of other polar bear subpopulations. Annual home range size, total annual distance travelled, and some seasonal movement rates decreased over the study period of 1991 to 2005, as did average annual ice cover, and minimum ice cover. Seth Cherry (M.Sc.) is applying carbon and nitrogen stable isotopes analyses to assess diet in the Beaufort Sea subpopulation. The goal of this work is to develop a greater understanding of the age- and sex-specific diet of polar bears and to assess this approach for long-term monitoring of ecosystem dynamics. Finally, Péter Molnár (Ph.D., mathematical biology) is investigating the mechanisms behind life history phenomena using models of life history optimization. The approach will work with the optimal reaction norm for several life history traits. Validation of the derived models and testing of the associated hypotheses will be done with long-term data from the Canadian Wildlife Service, complemented by data available from the literature. Optimally, the models will enable projection of how the life history of polar bears would be affected by changes in climate.

M. Taylor indicated that the last research initiative in Nunavut occurred in 1998. He indicated that a three-year inventory of the Davis Strait subpopulation is to begin in August–September 2005. Once this work has been completed, the Foxe Basin subpopulation would be the next inventory undertaken by Nunavut.

Greenland/Denmark

E. Born noted that research on polar bears focused on the effects of pollutants in East Greenland and that Christian Sonne will be making a presentation later in the week. Aqqalu Rosing-Asvid has been looking at harvest catch statistics, and new subpopulation estimates for Baffin Bay and Kane Basin are currently in press. Finally, new catch reporting methods were introduced in 1993 and the data from this is being examined. There has been a significant increase in the total catch of polar bears in Greenland and the increase was due entirely to an increase in the catch from the Baffin Bay subpopulation.

Questions were asked as to the perceptions of Greenland hunters with respect to the increased numbers of bears they have been taking recently. E. Born suspects that there has been a change in distribution so that more bears are now along the coast where they are easier to take. Hunters are making general comments on changes in sea ice break-up and formation. M. Taylor added that Nunavut is undertaking a traditional knowledge questionnaire; the perception of Nunavut hunters is that bear numbers are increasing.

Norway

J. Aars provided an overview of Norwegian research and noted that the details are included in their report. He began by listing a number of projects that have been completed and the results published or about to be published. Three students had successfully completed graduate degrees in toxicology (Lie, Ph.D.; Oskam, Ph.D.; Olsen, M.Sc.). Studies had been conducted on fatty acids (Grahl-Nielsen *et al.* 2003), diseases and parasites (Tryland *et al.* 2002), and diet (Derocher *et al.* 2002). Results from the diet study indicated that the prey composition was dominated by ringed seals (63%) when looking at the number of animals taken but dominated by bearded seals (55%) when looking at biomass. A line transect survey of the Barents Sea subpopulation was conducted in 2004 studies (estimate=2997 [2299-4116]) and will be discussed in more detail later in the week. Since 1967, they have marked 1203 bears that have provided 267 recaptures. Over 80% of the captures occurred between 1990 and 2004. They have been studying the behavioural response of bears to snow machine activity. They are looking at bear, seal and ice dynamics and have deployed GPS satellite tags to look at movements in relation to fine-scale maps. Other projects involve population genetics, swimming and diving (preliminary data suggests maximum dive depth of 9m), and analysis of the age structure of bears at Svalbard.

There was considerable interest in the preliminary data on depth of dives. One suggestion was that it may be a hunting strategy for taking bearded seals; bears might dive from hole to hole in order to catch them unaware by coming out of the water instead of over the ice.

Russia

A. Boltunov commented on Russian and Norwegian participation in the survey of polar bears in the Barents Sea. He summarised efforts to collect data on sightings of marine mammals that were recorded during ice reconnaissance surveys undertaken over a 40-year period; polar bears will be a large component of the marine mammal sightings.

Questions were asked about possible changes to the listing of polar bears in the Red Data Book and, if there were going to be changes, would they be more or less protected. S. Belikov replied that any decisions with respect to a change in status are made by Russian management authorities. He hoped that PBSG deliberations this week might influence those decisions.

S. Anderson and A. Kochnev gave a presentation on a joint Umka-Nanuuq project collecting traditional knowledge. Local people were asked questions about movement patterns, feeding areas, and denning areas of polar bears. Twenty communities and 53 respondents were involved. Additional information on illegal take was collected from 16 villages (32 respondents) and they were able to ‘reconstruct’ illegal take from the other four villages based on surrounding villages. Of the illegal take reported, 65.4% occurred on the arctic coast of Chukotka.

A. Kochnev summarised studies of autumn aggregations at Wrangel Island. Ten years of research has been conducted by Reserve staff. The greatest numbers of bears observed on Wrangel Island occur in September and October. An important factor contributing to these aggregations was the large number of dead walruses ashore that occurred approximately once every two years and which was thought to result from animals being crushed when large groups of walruses stampeded. Sea ice conditions are sometimes also a significant factor. He also briefly reported on summer/autumn aggregations of bears along the Chukotka coast in 2003/2004, which were recorded during coastal surveys by boats. Data on numbers, age and sex, and behaviour were collected.

Questions focussed on the illegal take of polar bears. A. Kochnev estimated that the annual illegal kill was about 200 ± 50 animals. The primary reasons for the illegal take were for food and hides. Most of the kills occurred in the mid-1990s when bears were shot for food.

N. Ovysanikov summarised current research on Wrangel Island. Work has focussed on behavioural ecology and has been ongoing since the 1990s. The condition of bears is scored: 1=very thin, 2=thin, 3=normal, 4=fat, 5=very fat. Some bears move inland and feed on reindeer carcasses. Large numbers of walrus carcasses are uncommon; the largest occurrence of carcasses occurred as a result of a stampede caused by low flying ice reconnaissance aircraft. In general, walrus do not provide a reliable source of food. Dead fish come ashore but it is unknown if it is a reliable food source for bears. Walrus no longer haul out on Wrangel Island, possibly because of heavy predation by polar bears or there may have been a change in ice distribution or food resources used by walrus. He provided the following summary of the main findings: optimal ice habitats are turned into marginal habitats in summer, more bears are more frequently exposed to extremes of open water, being forced ashore for longer periods of time. The timing of pregnant bears going into dens is getting later, and there is a greater frequency of bear/human interactions. He suspects increases in bear/human interactions across the Russian Arctic due to more open water environment. Finally, he noted that the current State protected marine zone around Wrangel Island is 12 nautical miles, which will be increased to 24 nautical miles next year.

Questions were asked about bear/human interactions and the increase in open water. S. Belikov indicated that he would be informed of increases in the numbers of problem bears on Novaya Zemlya. N. Ovysanikov agreed that it was more likely to hear of nuisance bear situations from Novaya Zemlya communities but not necessarily hear about them in remote villages. N. Ovysanikov indicated that the information he has suggests an increase in open water across the Russian Arctic and that this is contributing to increased encounters with humans.

Tuesday, June 21st

United States

G. Durner reviewed polar bear research undertaken by US Geological Survey staff. He commented that they have completed a number of projects and that the details are in their research report to the Group. Some of the projects they have been involved with were Western Hudson Bay subpopulation analysis, radio-telemetry to delineate subpopulations and to allocate harvest, modelling the potential effects of oil spills, the use of sea ice habitat by adult females, maternity dens and FLIR, looking at maternal den habitat in the Alaska National Wildlife Refuge, mapping maternal den habit with IFSAR (interferometric synthetic aperture radar), assessment of industrial sounds and vibrations in artificial polar bear maternity dens, intraspecific killings and cannibalism in the Southern Beaufort Sea, establishing paternity with genetic fingerprinting, Alaska Marine Mammal Tissue Archival Project, winter diet from stable isotopes, and the influence of diet on biomagnification of organochlorine pollutants. Future projects being developed were the use of radio frequency tags for grizzly and polar bears and emerging organic contaminants in blood. With respect to the radio tags, these should be readable up to 30m in the field, provide individual identification, last for many years, and would probably be incorporated into ear tags.

Questions were directed towards the modelling of oil spills and the probability models for assigning harvest. With respect to oil modelling, the movements of bears in and out of spill areas are likely to be more important than the densities of bears in particular areas. S. Amstrup replied that you cannot predict individual movement so they used average densities. In addition, the modelling does not include an oil weathering factor, it was assumed that toxicity was constant over a 10-day period. With respect to the probability distribution modelling, there were comments that it was based on the movements of adult females and that the modelling looks back at where the harvest should have been taken but that tags have to be assigned to a particular subpopulation in advance. With respect to movements, S. Amstrup was confident that the movements of adult males and adult females are very similar but cautioned that the big unknown is the movement of subadults. He disagreed with the tag assignment, he saw no reason why, in areas of overlap, you could not assign a tag to a subpopulation once the bear was taken.

T. Smith discussed work on den emergence and response to human disturbance. He noted that activity budgets of undisturbed animals provide a benchmark for comparison. Bears at den sites are highly sensitive to disturbance but specifics are wholly unknown. They undertook a study in which dens were located by telemetry, FLIR, and by Karelian bear dogs. They studied eight den sites and all behaviours were entered into OBSERVER software for subsequent analysis. Data suggest that some bears at den sites may become accustomed to human activity. The mean den emergence date was 12 March, which is about 3 weeks earlier than recorded during the 1980s. Currently they are working on remote video monitoring and exploring other remote observation options.

Questions mainly focussed on the use of hand-held FLIR versus helicopter-mounted units. T. Smith noted that the hand-held units were very sensitive to temperature but that they worked better than the helicopter-mounted units because you could stay in one spot for a longer time, whereas helicopters are limited with respect to hovering ability. Hand-held units are not cheap (US$20,000–50,000) and limit the area that one can cover in a day.

S. Schliebe summarised coastal surveys that had been conducted over the past five years. There have been distribution changes in bears; in the 1950s and 60s it was rare to see bears along the mainland coast, now this has become more common. Aerial surveys were flown Sep/Oct in 2000–2005 to determine location, timing and numbers of bears using coastal areas. During that time, 22 surveys were flown with an average of 60 bears being seen per survey (16–114). Forty-seven percent were family groups. Highest densities were seen within the Barter Island area. The further the ice is offshore, the greater the number of bears seen along the coast; this relationship was the same in all years. Because the availability of bowhead whale carcasses has been constant in all years, it is thought that environmental conditions are influencing the numbers seen.

S. Miller presented information from coastal feeding ecology studies conducted at Cross and Barter Islands. The objectives were to estimate the number, age and sex of bears using Cross and Barter Islands. Over three years, 1,231 hours of observations were recorded. At Barter Island, 6–8 brown bears were observed at bone piles with polar bears. Family groups were more common at Barter Island and single bears at Cross Island. Bears of all age- and sex-classes fed together and no serious injuries were seen. Mothers with cubs tended to be the most aggressive. Mothers and cubs spent less time feeding and more time resting compared to subadult bears. Bears made regular use of the marine habitat (i.e., water) for access to the islands and feeding sites. With respect to brown and polar bear interactions, brown bears were generally more dominant despite their smaller size.

Questions were asked as to whether brown bears actively dominated polar bears or did the polar bears simply avoid contact and the source of the whale carcasses. S. Miller replied that brown bears tended to actively dominate at the beginning but that the displacement of polar bears gradually lessens over the season until they are feeding in proximity to each other. With respect to whale carcasses in this study, they were bowhead whale remains from the Alaska native subsistence hunts.

Status table format update

A. Derocher provided an update on where things stood with respect to an acceptable format for the status table and report. He stressed that the PBSG must be able to stand behind this as representing our best professional opinion. There was considerable debate and disagreement about the use of point estimates for subpopulations that we really do not know much about. In Davis Strait, we have no science-based estimate so some thought we should leave the abundance estimate column blank. Others thought that we should fill it in because we have used ‘guesstimates’ in the past and we certainly know that there are polar bears in Davis Strait. There was comment that ‘guesstimates’ were fine in the past but that with the new management changes in Nunavut that the Group should be very careful in coming up with a number that is not based on science. M. Taylor argued that qualitative information, such as perceived increase in numbers, was sufficient to guide quota decisions when accompanied by accurate harvest monitoring programmes and a systematic consideration of the limitation to subpopulation growth imposed by polar bear life history constraints (i.e., simulation modelling). There was further discussion and some agreement that there should be separate columns for estimates based on science and estimates based on something else. In addition, a comments column should be liberally used to explain the complexities of the table and columns. With respect to the column showing sustainable kill, there was concern that it was based on ranges of values and not on a single, science-based estimate as per the international Agreement. Others thought that there was no obligation on the Group to provide sustainable harvest estimates but rather an obligation to comment on subpopulation estimates. There was still some confusion as to how the estimates based on TEK were derived. M. Taylor indicated that they came from running many simulations and having discussions about risk. In the last proceedings, there was a column for Other Concerns, but that seems to have been deleted in this table. S. Schliebe indicated that it had been discussed and the opinion was that most people would understand that the general concerns for polar bear subpopulations were climate change and industrial development.

There was general agreement that progress had been made but that more work on developing a suitable format was required. The Working Group was asked to continue development.

3. Summary of polar bear management by nation

Presentations on polar bear management were made by each nation. Because detailed reports on management will be included in the Proceedings, only summaries are presented here. S. Schliebe suggested that Canada be moved to the end to ensure that sufficient time was given to the other countries.

Greenland/Denmark

J. Lønstrup stated that in 2000 the Greenland Home Rule government decided to introduce quotas for beluga, narwhal, polar bear and walrus. Quotas for beluga and narwhal were introduced in 2004. In 2005, they are working on a new executive order for polar bears with the intent of implementation of quotas on 1 January 2006. As in the current legislation, females accompanied by cubs and cubs will be protected; all bears will be protected from 1 July through 31 August each year; and taking bears from dens will be prohibited. Motorized vehicles and large boats will not be allowed and there will be specific regulations with respect to calibre of gun. In the new legislation, licenses will be required which will allow the collection of data on each kill. One license will allow the taking of one bear and these licenses will need to be officially stamped in order to sell any part of the harvested bear. With respect to who will be allowed to hunt, the catch of polar bears is and will be restricted to full-time hunters only. However, trophy hunting may be permitted in the future and the sport-hunter will then have to be accompanied by a special, full-time hunter. As part of the introduction of quotas, the Greenland Home Rule government wishes to initiate a co-management agreement with Nunavut.

There were a number of questions that focussed on the reporting of the harvest, quotas and sport-hunts, and a co-management agreement. When questioned about the lack of inspectors or mechanisms of control in Greenland, J. Lønstrup explained that there are fisheries and hunting inspectors even though there are not as many as they wish there were and that they hope that hunters will understand the reasons for reporting the harvest and will comply. Hunters will be required to file a report for each kill. While no decisions have been made with respect to harvest levels, they will be looking at the 1991–2001 data. The number of sport hunts allowed will be determined by the government. Many of the issues raised here will be discussed at upcoming meetings with Nunavut in August. The Greenland delegation was not aware of any discussions with Norway with respect to the East Greenland subpopulation, the only co-management discussions at the moment are with Canada. When the co-management agreement may be in place is not clear at the moment. The Group unanimously agreed that these initiatives represented very important strides being undertaken by the Greenland Home Rule government with respect to the harvesting of polar bears.

Norway

M. Ekker reported that polar bears continue to have complete protection from harvest. The Svalbard Environmental Protection Act entered into force on 1 July 2002 to provide and maintain a virtually untouched environment in Svalbard. In September 2003, three new national parks were established at Spitsbergen (the main island in the Svalbard archipelago) in addition to the protection of Hopen (one of the most important polar bear denning areas at Svalbard) as a nature reserve. The territorial waters around Svalbard were extended from 4 to 12 nautical miles on 1 January 2004. Recent climate models represent concern for the Barents Sea subpopulation and for development within the petroleum industry. The Barents Sea subpopulation has been fully protected by Norway since 1973 and by Russia since 1956. Although the trend is unknown, the subpopulation has been assumed to be slowly increasing because of this full protection. Sixteen bears were killed in the period 2001–2004, most in self-defence.

There were questions relating to the increased protection measures and the basis for assuming the subpopulation may be increasing. The extension of the territorial waters provides protection from drilling and exploration; fishing activities are regulated. Waters within a protected area fall under environmental legislation, waters outside fall under fisheries legislation. There has been no offshore oil exploration around Svalbard, it has been occurring in the SE Barents Sea. It is too early to say what restrictions might be imposed on cruise ships; Svalbard is a very popular cruise ship destination with approximately 40,000 cruise tourists visiting annually. Although the historical size of the Barents Sea subpopulation is unknown, it is known that minimum numbers of bears taken were 500–700 annually.

Russia

S. Belikov noted that polar bears are listed in the Red Data Book of the Russian Federation, which is an official document that reflects state policy for the protection and restoration of rare and endangered species in Russia. The Barents Sea subpopulation is designated Category IV (uncertain taxa), the Laptev Sea subpopulation is Category III (rare taxa), and the Alaska-Chukchi subpopulation is Category V (restoring taxa). The Ministry of Natural Resources is responsible for the management of those species listed in the Red Data Book. The hunting of polar bears continues to be prohibited. The only permitted take is the occasional capture of cubs for public display, which last occurred in 2001. Occasionally polar bears are killed to protect people.

United States

T. Evans reported that the US Marine Mammal Protection Act (MMPA) guides the management of polar bears in the United States. Harvest is not regulated unless the subpopulation is considered depleted. Over the past four years (2001–2004), 324 bears were taken; the mean annual take was 81. Broken down by subpopulation, the total take in the Beaufort Sea was 156 with a mean of 39.3 per year. For the Chukchi subpopulation, 169 bears were taken, with a mean of 42 per year. The number of bears taken in defence of life and property has increased over the period 1990–2004. In the earlier years, it was two or three a year, now it is around 10 per year. Letters of Authorization are required by industry in order that they can work and avoid liability for taking polar bears. The term take includes the unintentional and accidental harassment of polar bears. Harassment by definition includes any alteration of natural behaviour.

There was confusion among a number of delegates regarding Incidental Take Regulations and Letters of Authorization. T. Evans explained that 'take' does not necessarily mean harvesting. Take can include passive forms of harassment or encounters. In order to authorize oil and gas activities, the USFWS must find that the sum total of the planned activities over the projected period of time, up to five years, will have no more than a negligible effect on the subpopulation. In addition, it provides managers an opportunity to review planned activities in polar bear areas.

An update on the practice of leaving whale carcasses onshore was requested because there had been previous discussions with respect to moving them offshore. T. Evans replied that it is already occurring at Barrow but not at Kaktovik. There have been some problems associated with conditioned bears returning to areas where whale carcasses used to be available. There was a suggestion that a 20-year history of tradition should not be used as an excuse for continuing the practice. People should be proactive rather than reactive because it may become more of an issue with changes in sea ice retreat that are currently being recorded.

L. Lierheimer reviewed the U.S. MMPA that was enacted in 1972 to ensure that marine mammals, including polar bears, are maintained or restored to healthy subpopulation levels. The Act has not been reauthorized since 1994, when authority to carry out the provisions of the Act was extended through 1999. In May 2005, the MMPA reauthorization bill H.R. 2130 was submitted to the full House of Representatives for consideration. Exceptions to the MMPA allow for the issuance of permits to import polar bear trophies taken by U.S. hunters in Canada. There are a number of findings that must be made including that the subpopulation from which the bear came has a monitored and enforced harvest programme, the harvest programme is based on scientifically sound quotas, and the take by U.S. hunters will not contribute to illegal trade in bear parts. Factors considered include that reasonable measures have been taken to ensure the subpopulation is managed for sustainability, the harvest is based on science, and that co-management agreements are in place. Six subpopulations are currently approved: Southern Beaufort Sea, Northern Beaufort Sea, Viscount Melville Sound, Western Hudson Bay, Lancaster Sound, and Norwegian Bay. From 1997 to 2004, 705 permits have been issued. The USFWS has recently asked for new information with respect to the management changes announced by Nunavut. If the Service determines that changes in the status of approved or deferred subpopulations are necessary, these will be published for comment. Finally, L. Lierheimer noted that the Service received a petition in February 2005 to list the polar bear as a threatened species because of climate change. If they are listed as threatened under the US Endangered Species Act, the species (or specific subpopulation stock) would be considered as depleted under the MMPA. Such a listing would make it difficult to import sport-hunted trophies under the current MMPA exception.

Questions focussed on how the Service will view increased subpopulation estimates that are not based on science and what the requirements would be for Greenland subpopulations to qualify under the MMPA. With respect to non-science based increases in subpopulation estimates, the USFWS has requested to review all the relevant new information. Currently, the sport-hunt exemptions under the MMPA are specific to Canada. It would require legislation to amend the Act for Greenland. How long that might take is unknown; however, the Service has been working on reauthorizing the Act since 1999 and that has not yet occurred.

S. Anderson reported on co-management in the US and noted that the Alaska Nanuuq Commission was formed in 1994 to represent Alaska native hunters concerning issues related to the conservation and subsistence uses of polar bears. They have just completed their 7th agreement with the Federal government. Initiatives that they have been active in include assisting in feeding ecology studies, polar bear tissue sampling, and public outreach programmes such as the development of interactive, conservation CDs for middle school and high school children in the villages of North and Northwestern Alaska. The Alaska Nanuuq Commission will also distribute to these villages publications concerning the results of polar bear studies, marine mammal contaminant analysis, and progress on the Russia-US Bilateral agreement.

Canada

G. Nirlungayuk made a presentation on traditional knowledge. The Nunavut Land Claims Agreement gives power to Inuit to participate in wildlife management. Knowledge of the environment is passed on from elders and gained from first-hand experience. The current management system for polar bears is different from what Inuit know and they are becoming increasingly frustrated because they are being told what to do with respect to harvest issues rather than being consulted. A new Wildlife Act is being developed that will require the incorporation of traditional knowledge in wildlife management. New scientific data in Western Hudson Bay contradict what the Inuit believe is happening. Adaptive management is required to deal with current uncertainties and he suggested that all Nunavut groups should work together for the sound conservation of polar bears.

Comments supported the value and respect for the Inuit culture and knowledge but also indicated a level of discomfort and scepticism with respect to its application to estimates of subpopulation size. One of the main concerns was that because the observations of hunters are not written down, it is difficult to assess changes or compare observations that may be made in a variety of areas by different people in different years and so on. Everyone shares the same conservation goals but harvest levels need to be based on science. It was recommended that user organizations consider developing a format for recording data that might be useful for interpreting ecological trends and other information.

N. Lunn reported that polar bear management in Canada remained under the jurisdiction of the provinces and territories together with some user groups through the settlement of land claims. The Government of Canada is involved as a signatory to the Agreement, through CITES, and through other federal legislation. Excluding recent changes in Nunavut, there have been no significant management changes within the other provinces and territories. There are two new National Parks: Ukkusiksalik, which encompasses Wager Bay (Foxe Basin) and became a national park in August 2003 and Torngats, which is in northern Labrador (Davis Strait) and became a national park in March 2005. The Government of Canada passed the *Species at Risk Act* (SARA) in December 2002. The purposes of SARA are to prevent wildlife from becoming extinct in Canada, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is to continue to provide independent, scientific assessments of the status of species at risk in Canada. These assessment reports are provided as recommendations to the Government and a copy is placed in the Public Registry. The Government responds to these assessments and decides on which species to list or de-list under SARA. Polar bears have been re-assessed as a species of Special Concern and COSEWIC's report has been submitted to the federal Minister of Environment. A decision on whether or not to add the polar bear to the *List of Wildlife Species at Risk* has been delayed pending further consultation.

M. Taylor discussed the recent management changes in Nunavut and outlined the process of developing regulations. The Government of Nunavut undertook a series of community consultations that resulted in a new Memorandum of Understanding (MOU) for each of the 12 polar bear subpopulations within or shared with Nunavut. The new MOUs identified a protocol where scientific knowledge was used to establish total allowable harvest (TAH) levels, and Inuit knowledge was used to evaluate the TAH levels and adjust them as required. In 2004, new MOUs were signed by the Hunters' and Trappers' Organizations (HTOs) and Regional Wildlife Organizations (RWOs) and conditionally approved by the Nunavut Wildlife Management Board (NWMB). The NWMB decision required some amendments to the MOUs and the amendment process is proceeding. The new MOUs include a larger role for the RWOs in distributing the TAH among communities that share a subpopulation, and more flexibility for the HTOs to open and close their hunting seasons, develop local hunting rules, and utilize Inuit knowledge for polar bear management decisions. The quota increases were put in place for the 2004/05 season and will be in place for at least the coming season (2005/06).

There was considerable debate of the recent changes in subpopulation estimates and quota increases for some polar bear subpopulations in Nunavut. Several members commented that Nunavut increased quotas for some subpopulations following new science-based estimates; however, no one has seen the science or had the opportunity to review it. M. Taylor replied that the papers have been written, some have been submitted for publication, and some are in press and copies can be provided. There was concern expressed about the use of traditional knowledge to increase subpopulation estimates where, at best, there is no new scientific data and in some cases there are strong data available that do not support the increases. There was no disagreement with the accuracy of local knowledge and there was no one doubting that hunters are seeing more bears. What was questioned was that an increasing subpopulation is the only explanation for seeing more bears. G. Nirlungayuk responded that he went on some of the community consultations that led to the revised MOUs. Most of the discussions focused on the most recent science available and the desire of hunters that good science be used. Western Hudson Bay was raised as an example of where scientific knowledge and local knowledge disagree. With the new target subpopulation set at 1400 for WH and science indicating that it is less than 1000, the signed MOU is clear that a moratorium should be put in place until the subpopulation recovers. However, there is no indication that those that signed the MOU will abide by the terms. M. Taylor responded that consultations are to occur this coming fall and management action will follow that. It was asked whether it would be possible to change the target number. M. Taylor said that by doing so, it would set a precedent if Nunavut did not do what it said it would do. There was further concern and reiteration that the Group was being asked to effectively accept numbers that it either had no way to evaluate or had not had the opportunity to review; there was a definite high level of uneasiness. S. Amstrup suggested that the modelling workshop planned for Thursday might give the Group an opportunity to review some of the analysis and science.

Wednesday, June 22nd

4. Bi-/multilateral agreements

Canada-United States

S. Schliebe noted that there was nothing new to report with respect to the Inuvialuit-Inupiat Agreement. It is a user-to-user agreement in which the management agencies act as technical advisors. The Parties meet annually and it is considered to be a positive, proactive agreement. C. Brower, L. Carpenter and F. Pokiak all commented that the agreement has worked well and that the users are happy with it. They recommended that others consider a similar model. F. Pokiak added that users on both sides think the Southern Beaufort Sea subpopulation may be increasing but that no changes in quotas will occur until after the current subpopulation inventory is completed. It was noted that there is still a need for improvement in turning in specimens for age determination in Alaska. Regardless of the need for improvements in some aspects of reporting and specimen collection, I. Stirling noted that the most important take-home message was that the users recognised a problem, agreed that it would not be solved by waiting for government-to-government agreements, and were proactive. G. Nirlungayuk also thought that it was a good model and hoped that agreements between the Northwest Territories (NWT) and Nunavut users would follow the same process. Although M. Taylor agreed that it was a good model, he noted that it would be difficult to follow in Nunavut because the Nunavut Land Claims Agreement dictates how inter-jurisdictional and international agreements are developed.

Russia-United States

Although the "Agreement on the Conservation and Management of the Alaska-Chukotka Polar Bear Subpopulation" was signed in October 2000, enacting legislation has not yet been completed.

S. Belikov noted that their Ministry of Natural Resources is responsible for the Chukotka subpopulation. A draft management plan has already been prepared and they are currently preparing a document on the import and export of polar bear parts. The Ministry has had consultations with some of the Chukotka communities regarding conservation and management issues.

S. Schliebe reported that within the United States it takes an incredible amount of time to put a government-to-government agreement together and that Russia is ahead of the United States with respect to implementation. The U.S. Senate unanimously approved and recommended Presidential ratification. Currently, there is a wait for enabling legislation to be introduced. Once introduced, the legislation will need to be passed in both the Senate and House of Congress. He was optimistic that the United States might see the introduction of enabling legislation by the end of the year.

Norway-Russia

M. Ekker reported that there have been bilateral environmental agreements between Norway and Russia since 1988. There is a joint commission that meets annually and that membership is at the ministerial level. The relevant ministries from both countries were meeting this week to discuss and work on a new marine environmental framework. The emphasis of this cooperation is on marine and terrestrial environments and on cultural heritage. These agreements function through working groups of scientists and experts and aid in the acquisition of funding for polar bear research projects of mutual concern and interest to both countries.

Greenland-Canada

J. Lønstrup reported that, in February 2005, Greenland and Nunavut agreed to develop a joint management agreement for the polar bear subpopulations that they share and that further meetings and discussions are planned for August 2005. As mentioned earlier, Greenland plans to implement quotas in January 2006. M. Taylor commented that this was a very positive initiative, that meetings are being organized at senior levels, and that it was not clear who would be participating. Both Nunavut and Nunavut Tunngavik Inc. would be at the meetings. I. Stirling added that reasonably high-level talks between Nunavut and the Government of Canada are occurring and that there was general acceptance that the agreement would be between the Governments of Canada and Greenland. He added that simple agreements are desirable and that direct communication between Nunavut and Greenland would be good, even if high-level government agreements were also in place. S. Schliebe commented that this was a very positive step and that the PBSG would be willing to consider reviewing whatever information it could if asked.

5. Conservation and environmental issues

Toxic chemicals

C. Sonne presented the results of research on the effects of organohalogens on polar bears from the East Greenland subpopulation. Five components of the study were discussed; changes in concentration over time, pseudo-hermaphrodism, bone mineral composition disruption, liver histology, and renal lesions/pathology. Samples were collected from bears around Scoresby Sound. Concentrations of organohalogens have declined in bears from 1990 to 1999–2001. Pseudo-hermaphrodism was determined not to be the effect; instead it was determined to be clitoral enlargement caused from an inflammatory reaction. The possible effects of organohalogens on bone mineral density were examined using samples taken from skull collections. There were significant declines in bone mineral density for subadult males, subadult females, and adult males around the turn of the century (1892–1932) when compared with recent samples (196601502001). Surprisingly, there was no similar trend in bone mineral density in adult female polar bears. In looking at liver samples, obvious histologic changes were found in 8–100% of bears depending on the aspect of liver histology examined (e.g., lipids, ITO-cell, cell infiltration, lipid granulom, bile duct hyperplasia), however, there were no obvious links to organohalogens. Finally, there were a number of significant relationships between organohalogens and renal lesions. He recommended the continuation of polar bear health assessment studies and suggested undertaking a circumpolar study looking particularly at histology and bone density effects from contaminants and to look for new contaminants.

Questions addressed issues of impacts on humans and impacts at polar bear subpopulation level. C. Sonne replied that there was no human health issue in consuming meat but people should reduce their intake of blubber of marine mammals. With respect to effects on polar bears at the subpopulation level, he thought there were no immediate impacts but likely to be significant impacts on some bears at the individual level.

T. Evans summarised a project looking at contaminants in adult male polar bears in Alaska. The study was undertaken in 1996–2002 and used samples collected by hunters and researchers. Adult male bears were selected because organochlorines vary in adult females due to lactation, adult males are typically harvested at twice the frequency, and they did not want to cause an increase in the harvest of adult females. S-PCBs and S-CHL were significantly greater in bears from the Beaufort Sea than the Chukchi Sea. Reasons may be due to source areas or differences in prey species. Amphipods may concentrate organochlorines so bears spending more time on multi-year ice may subject themselves to increased levels of organochlorines through bio-magnification in the food chain. The distribution of metals in polar bears was similar to the distribution found in terrestrial mammals. Mercury, selenium and cadmium were significantly greater in liver and kidney tissues in bears from the Southern Beaufort Sea than the Chukchi Sea. The study provides baseline data for adult males. They would like to expand the study to all age- and sex-classes. Impacts of these contaminants found in polar bears are likely to increase should subpopulations become more nutritionally stressed.

Alaska contaminants and isotope projects

S. Amstrup indicated that there was nothing new to report.

Immune system effects

A. Derocher, N. Lunn and Ø. Wiig indicated that there was nothing new to report.

Ecotourism

N. Lunn commented that there was nothing new to report with respect to ecotourism in Churchill. Access is restricted to limited areas and tour operators require appropriate permits either from the Parks Canada Agency or the Province of Manitoba (depending on where the tours are operating).

N. Ovysanikov reported that cruise ship traffic in the Russian Arctic was increasing. He has been a lecturer on some of these ships so has direct experience with existing practices. He expressed concern that tours are not properly managed and that there are effects of disturbance from boats and helicopters. These tours have no instructions or restrictions and he would encourage authorities to develop formal restrictions and regulations. He added that there are no major problems with the passage of ships because the captains are generally responsible. However, the greatest concern is with the landing of tourists.

N. Ovysanikov also commented that adventure tourism (e.g., skiing to the North Pole) is also growing in Russia. He was aware of at least three cases where polar bears were shot in self-defence. In general, he felt that most adventurers do not know how to handle interactions with polar bears and, consequently, are more likely to shoot. Again, regulations need to be developed for this type of activity.

S. Schliebe wondered whether anyone had much experience with respect to the effectiveness of pepper spray on polar bears. N. Ovysanikov said that he had been charged on three separate occasions and that in all cases the bear was repelled. He noted that he felt that guns were not necessary and that three other tools were all that were required: electric fences, cracker shells and pepper spray.

S. Belikov added that he was concerned about climate change and the increase in northern shipping that would have huge impacts on polar bears and marine ecosystems. In particular, he expressed concern about occurrences of bears being killed but not in self-defence.

A. Derocher commented that a "Safety in polar bear country" video is being produced with a projected completion of autumn 2005. The same group has also produced safety videos for grizzly and black bears, which he considered to be the best ones currently available.

Climate change

I. Rigor made a presentation on what initiates changes in arctic sea ice. He commented that record minima in sea ice extent were recorded annually from 2002 through 2004 and that the greatest decrease occurred in the Pacific sector of the Arctic. A lot of attention has been focussed on temperature as the prime factor. However, he suggested that the importance of the Arctic Oscillation (AO) had been overlooked. The AO is a significant factor explaining 52% of the variance in sea level pressure during the winter and 36% in the summer. During low AO conditions (1980s), the sea ice in the Beaufort Gyre circulates for over 10 years. By comparison, during high AO conditions (1990s), the recirculation time decreases to 3–4 years. During an extreme high AO in the early 1990s, most of the old ice in the Arctic was flushed out through Fram Strait, new ice formed off Alaska that was re-circulated more quickly and conditioned the ice for greater melt because it was thinner than the previous multi-year ice. Younger, thinner ice persists in the Arctic. Much of the variance in sea ice extent (e.g., >50% in the Beaufort and Chukchi Seas, >80% in Russian Arctic) can be explained by the age of the ice.

Questions focussed on whether we can predict/forecast what the AO will do and reconciliation of temperature and ice models. Being able to predict the AO is limited to about two weeks to, at best, two months. With respect to temperature and ice models, there is a relationship between temperature and AO but other factors are involved. Temperature is not the only factor influencing sea ice extent, but it was the one that caught the public's attention. One needs to be very careful extrapolating the future of sea ice from a short-term trend out to a 100-year time frame.

D. Douglas discussed variations in trends in arctic sea ice melt, cover, age and thickness. He noted that variations in melt dates and ice duration were determined from passive microwave data. Late snow melt years in Alaska are associated with a strong Beaufort High that blocks the flow of warm air associated with the Aleutian Low in the south. From 1978 through 2005, there has been a decline in multi-year sea ice cover. The greatest changes have occurred in sea ice minimums not maximums. The proportion of multi-year ice is declining and annual ice is increasing. There is tremendous variability in the survival of first-year ice. The majority of sea ice from the 1980–1994 generation that survived to 10 years of age was formed in the Beaufort and Chukchi Seas.

The subsequent discussion dealt with inconsistencies of describing years as being early or late ice years with observations of individuals. D. Douglas pointed out that these are explained by issues of scale, the broad picture is not always indicative of events occurring at much smaller regional or local scales.

I. Stirling made a brief presentation on the potential impacts of climatic warming on polar bears and seals. He reviewed data on the earlier break-up of sea ice in Western Hudson Bay and its effect on survival and condition of polar bears. One thing that we have documented is a statistically significant relationship between the number of problem bears handled at Churchill and the date of ice break-up; that is, the earlier the ice break-up, the more problem bears and conversely. In four of the five years between 1991 and 2000, when a sample of ringed seals were taken in the open water during fall by hunters from Arviat, the survival of young-of-the-year was very low. Furthermore, there has been a major shift in the diets of seabirds nesting on Coats Island. He suggested that harvest samples may be useful in the monitoring of marine ecosystems. Davis Strait is another area where there has been great change in sea ice over the past 20 years. He suggested that communities are likely to see increases in problem bears as a consequence of climatic warming; how will this be managed with respect to existing quotas and human safety? He noted that four of the subpopulations in which increases in the number of problem bears have been reported (WH, FB, DS, BB) are ones in which all the ice melts so that the whole bear subpopulation must fast on its stored fat reserves for several months. If, as has now been documented in WH and SH, the break-up in sea ice becomes progressively earlier, it is likely that bears will continue to lose condition and increases in the number of problem bears in other ecologically similar areas will follow.

A. Rosing-Asvid made a presentation on how climate variation may affect polar bears in Greenland. His focus was on the spring because it is an important period for ringed seal predation by polar bears. He suggested that the trends presented by Stirling *et al.* in their 1999 paper indicating negative effects of a warming climate were mainly being driven by the early years prior to the onset of earlier ice break-up, which started around 1993, and further suggested that if those data were removed the trend would probably not exist. He suggested that, based on various studies including the 1999 paper, cub survival is higher in years of early sea ice break-up because bears have greater access to seal pups in warm springs and that this impacts subsequent survival of seal pups. As sea ice extent shrinks, seal densities increase to the benefit of polar bears. Eventually the bear subpopulation declines to a level that is supported by the remaining seals. The Western Hudson Bay subpopulation did not decline during the period 1993–97 with early sea ice break-up and the decline in natality and female body condition in these years is therefore not necessarily a bad sign, but could have been caused by the higher cub survival documented in these years, which would cause a longer birth interval and more energy used on lactation for the average female bear. Over the past 40 years in East Greenland, the numbers of polar bears and ringed seals in the harvest track together at approximately 1 polar bear/200 ringed seals. He noted that the numbers of ringed seals in West Greenland were correlated with temperature during the period from 1873 up to the early 1960s when catches increased significantly following what is believed to be a strong over-harvest of polar bears in Canada. I. Stirling noted in response that the data from Western Hudson Bay presented in the 1999 paper covered the period up to 1997. Data collected since then, when added to the previous records, have resulted in an even stronger statistical relationship.

There was discussion on the possible benefits of climate warming to polar bears. While there may be short-term benefits in areas which are currently covered with multi-year ice, one should probably be cautious about making strong statements that a warming climate will be beneficial in the long-term. In general, the permanent and progressive loss of sea ice will have a negative effect on polar bears. A. Rosing-Asvid replied that the benefit to polar bears only seemed to last for about 10 years before polar bear numbers declined.

Harvest management and assessment

Prior to the upcoming presentation, S. Amstrup asked that, when asking questions, the Group clearly distinguish between the process and the parametric values used/produced by the programme in order that we do not spend all our time debating input/output values but rather take advantage of some of the modelling expertise in the meeting.

M. Taylor provided an overview and demonstration of the program RISKMAN. He noted that the development of RISKMAN, by the Ontario Ministry of Natural Resources and the Nunavut Department of Sustainable Development, began in 1997 as a tool for harvest management. Past and current perspectives on polar bear subpopulations had relied on deterministic simulation models that used generalized and "expert-corrected" estimates of subpopulation number, recruitment rate and survival rate. The uncertainty of the status evaluation was categorized qualitatively (*e.g.*, poor, fair, good). Recent developments in population viability analysis (PVA) simulation models and mark-recapture models provide a more quantitative approach to estimating the uncertainty of status determinations by allowing structured, statistical modelling of capture and survival probabilities and of covariates.

RISKMAN allows for the correct simulation of the three-year life cycle of polar bears and for the actual (estimated from data) selectivity/vulnerability of the harvest to be incorporated directly. Deterministic or stochastic models can be run. The programme incorporates three types of variance: demographic, parameter and environmental. Because it is an individual-based model, full demographic uncertainty is incorporated. The uncertainty associated with estimates of survival and recruitment pools both parameter and environmental uncertainty.

RISKMAN has two distinct uses. First, as a management tool, it can be used to design management strategies and regulations for specific populations of wildlife. Second, as a research tool, it can be used to investigate the behaviour of populations under various management practices and to investigate and understand the effects of uncertainty on population persistence.

S. Schliebe commented that the flexible quota system currently used in Nunavut is not precautionary. He noted that this system, the recent change to allow the return of tags of unsuccessful sport-hunts for re-use, and the existing credit system all appeared designed to maximize harvest opportunities. M. Taylor replied that the conservation of polar bears is important in Nunavut but also that the local hunters should be able to derive a benefit from an identified harvest. All credits are zeroed following the completion of each subpopulation inventory. He also indicated that the hunters have accepted a sex-selective harvest (two males/one female) and are penalized the following hunting season if the number of females is exceeded. If a community exceeds its quota of females, then next year's quota is reduced by three (two males and one female) for each female that they are over. He added that, in some communities, polar bear hunting stops when the last allowable female is harvested even if all the males have not been taken. They voluntarily do that because they do not want to see a quota reduction the following year.

A. Derocher noted that one of the justifications used by the PBSG in the past to defend the sport-hunt was that it had a conservation benefit because any unused tags were not reused so the end result was that fewer bears were killed in total; now that is no longer the case.

C. Sonne remarked that it was not clear to him that there was a real link between modelling and subpopulation numbers re: Davis Strait. He expressed concern that, in the absence of real data, the modelling exercise could result in an over-estimation of the size of that subpopulation and, subsequently, an over-harvest. He felt that in situations where there is such uncertainty that the benefit should go to bears not the hunters. S. Amstrup commented that in North America, most harvesting of animals is done in this way and, in fact, guessing occurs far more frequently than modelling. C. Sonne replied that one cannot compare the harvesting of abundant and widely distributed species like deer in a terrestrial system with less abundant species in a marine system, such as polar bears, because of climate change and sea ice effects.

By consensus, the Group agreed to end the meeting for the day in order to facilitate the Business Meeting of the PBSG.

PBSG Business Meeting

S. Schliebe called the business meeting of the PBSG to order at 17:40. In attendance were:

Canada (I. Stirling, M. Taylor, M. Obbard, A. Derocher, N. Lunn)
Denmark (E. Born, A. Rosing-Asvid)
Norway (J. Aars, Ø. Wiig)
Russia (S. Belikov, A. Boltunov, N. Ovysanikov)
USA (S. Amstrup, S. Schliebe)

S. Schliebe commented that there were only two topics currently on the agenda for the meeting: the structure and format of the status table and any other issues the members wanted to raise.

Structure and format of the status table

There was considerable debate with respect to the structure and format of the proposed status table. There was initial discussion with respect to the use of the word *population* in the table. It was pointed out that it was not that long ago that they were referred to as *subpopulations* and that the use of *population* is more recent. Ø. Wiig, A. Derocher and E. Born all noted that, under IUCN Red List guidelines, all polar bears would be referred to as a single population and what we are now calling *populations* are *subpopulations*. Given that the PBSG is an IUCN group, it seemed logical to revert back to the use of *subpopulations*.

There was general support for the idea that, when stating the basis for determining the status of each subpopulation, the distinction between whether the estimate was based on science (e.g., mark/recapture or aerial survey) or an alternative approach (e.g., simulation, TEK/IQ) needs to be clear.

Much of the discussion focussed on how to portray the status of each subpopulation. In the last three proceedings, the Group indicated status as being one of decreasing, stationary, increasing, or unknown. A. Derocher was concerned that this system did not necessarily reflect what we know about the subpopulation. For example, a subpopulation that was depleted and had been through a harvest moratorium would potentially be shown as increasing even though the current numbers are well below historical levels. Thus, while accurate, the status table would give a misleading impression for some subpopulations. Furthermore, that approach is based on the past and does not necessarily reflect what lies ahead.

It was noted that the above status categories did not really reflect status but rather a trend so that in some cases Not Evaluated or Data Deficient were probably better than Unknown.

M. Taylor suggested the value of incorporating population viability analysis (PVA) into the table because categories are subjective unless they can be based on something objective. PVA removes the subjectivity and provides an objective means of assessing subpopulation status. S. Amstrup and A. Derocher commented that RISKMAN does not allow for stochastic variation in the environment. M. Taylor responded that the RISKMAN PVA model did include environmental variation as a component of the variance of the demographic parameters. However, M. Taylor acknowledged that the duration of many subpopulation inventory studies was too short to capture the full range of environmental variability; and that RISKMAN could not currently model a systematic decline in vital rates such as could occur as a result of climate change. J. Aars, A. Rosing-Asvid and E. Born commented that models are only useful if there is sufficient and appropriate data to run them; otherwise one is simply guessing. N. Ovysanikov noted that when running models, we might not know all the factors influencing a subpopulation. S. Amstrup commented that there was certainly value in M. Taylor's approach but one of the primary issues was the Group's comfort level.

A. Derocher suggested that, instead of a single column *Status,* we should consider three columns *Trend*, *Status* and *Risk*. *Trend* would give an indication of the direction of the current estimate of subpopulation size (e.g., decrease, stable, increase); *Status* would compare the current estimate of subpopulation size with historical size (e.g., depleted, not reduced); and *Risk* would be a projection of the risk of a future decline that would use qualifiers based on PVA (e.g., low, intermediate, high).

There seemed to be a general agreement with this approach. S. Schliebe asked M. Taylor and A. Derocher to develop this further and to bring it back to the Group.

Membership

N. Lunn raised the issue of membership because of discussions that occurred at the 2005 meeting of the Canadian Polar Bear Administrative Committee, which is composed of senior managers from the jurisdictions that have the management authority for polar bears. The current PBSG guidelines state that membership must reflect technical expertise in polar bear research and management. The concern was that these guidelines prevent individuals that are not technical experts but who may have a lot of knowledge to contribute from being members. Could the PBSG deny membership in the Group to an individual appointed by a signatory nation if that individual was not a technical expert?

Ø. Wiig commented that, historically, one of the strengths of the PBSG was that it was a small group of technical experts. The intent of the membership guidelines that were published in the Proceedings of the 11th Working Meeting was to maintain that. S. Schliebe noted that, while it was unclear why Canada (or any other signatory nation) would want to appoint someone that could not contribute to the Group, he did not think that the Group would be able to prevent such an appointment. There was general agreement that the Group should continue to build on its strength of small size and technical expertise.

The business meeting ended at 19:25.

Thursday, June 23rd

6. Workshop on population inventory and assessment techniques

S. Amstrup provided a brief introduction to the workshop and noted that it would focus on two techniques for population assessment: aerial surveys and mark-recapture. He thanked Jeff Laake (National Marine Fisheries Service) and Trent McDonald (Western Ecosystem Tech. Inc.) for participating and sharing their knowledge plus Jon Aars and Eric Regehr for making presentations on the application of these techniques to polar bears.

Enumeration: Line transects (overview)

J. Laake provided an overview of population enumeration. Inventories are often necessary for species management. To manage effectively, we need information on abundance, survival, reproduction and movement (e.g., immigration/emigration). There are different techniques but they do not all provide the same types of information. For example, pup counts of Stellar sea lions documented dramatic declines but did not provide any information as to why.

The advantages of conducting a mark-recapture study to assess population size include the ability to estimate demographic parameters in addition to abundance, harvest can be incorporated, biological samples can be collected while individuals are being handled, and that all the collected data can be encapsulated into population models. However, there are also disadvantages to consider. Several sampling periods are required, which has implications with respect to financial resources and personnel, the field trips to capture bears can be hazardous, and heterogeneity in capture-recapture samples can result in significant biases when estimating parameters. Heterogeneity may lead to the overestimation of capture probability and the underestimation of abundance.

Line transects require only a single sample, can be implemented on a wide scale in a relatively short period of time, are less likely to be influenced by issues of heterogeneity, and typically are more cost effective with respect to personnel and funds. However, they are also potentially hazardous because of the amount of time spent in survey aircraft far from logistic or search and rescue facilities, result in very little or no demographic information, and depend on the detection of all individuals on the transect line (i.e., g(0)=1). Also, a single sample can only provide an estimate of the statistical error around the point estimate at the time of survey. Information regarding biological uncertainty due to interannual variation in distribution is not available from a single aerial survey alone. For a single sample to be reliable, additional information verifying the portion of the population occurring in the survey area must be available. If all individuals on the transect line are not seen, then a bias is introduced. If g(0)=0.9 (i.e., only 90% are seen) then the abundance estimate will only be 90% of the true number of animals.

Questions focussed on how line transect surveys accommodate clumped distributions, variation in habitat types, variation in daily weather conditions, and movement of animals during the survey that might lead to double-counting. J. Laake indicated that a family group would be counted as one group of three bears and that you would incorporate a covariate based on group size. With respect to varying conditions or habitat, detection functions can be pooled so long as one is only interested in the total number of individuals in the entire area. There are a couple of ways to deal with movement and double-counting; space the timing far enough apart or space the distance between transects wide enough.

Enumeration: Line transects (Barents Sea example)

J. Aars presented a summary of their recent line transect survey to estimate the size of the Barents Sea subpopulation (N=2997, 95% CI=2299-4116). The survey, which was a collaborative effort between Norway, Russia and the modelling group at the University of St. Andrews, was flown in August 2004. Satellite data were used to help delineate the area to fly. Three methods were used depending on the area in question: total counts (small islands and fjords), line transects (large areas of habitat with low bear densities), and satellite telemetry (areas not covered by line transects or total counts). Helicopters were used to fly at moderate speed (185km/h) and at low altitude (200ft) in order to ensure that g(0) was close to one. There were four observers (including the pilot): two in the front and two in the back. Transects were spaced every 3, 6 or 9km depending on area and conditions. Distance from the line to a bear was measured by GPS. When spotted, the helicopter would fly out to the spot to record the position and then return to the transect line. The total estimate came from the total counts (96), line transects (1394, CI=1171-1861), and satellite telemetry (1507; CI=916-2609). They concluded that in areas where polar bears are roaming over large areas, line transects using a helicopter may be the best method for estimating subpopulation size. However, there are practical limitations including limited flying range because of fuel and variable weather conditions.

Questions were asked about the flushing of other bears when flying out to get a GPS position of a sighting, how much of a real difference would be required between this and another survey in order to detect a change in subpopulation size, whether there were problems with respect to individual observer abilities to spot bears, and that the method gives you a single estimate taken in a single year but we know that there can be considerable annual variation with respect to the distribution of both ice and bears. Neither J. Aars nor Ø. Wiig thought that flushing was a problem, they were in separate helicopters and it occurred on perhaps one or two occasions. Because of the large CI, there would have to be a very large difference in estimates to detect a real change in subpopulation size. With respect to observer variability there were some differences, particularly in the front, because of the pilot having to fly and observe. In general, it was not considered a significant problem. J. Laake commented that the concern about a single count and inter-annual variability was good; how significant the issue is depends on whether you are surveying a closed or open population.

Enumeration: Mark–recapture (overview)

S. Amstrup noted that J. Laake had already summarised the basics of mark-recapture in his earlier overview. S. Amstrup reviewed the early application of mark-recapture and that some of the bigger challenges were estimating the ratio of marked to unmarked individuals and also estimating capture probability. Although there has been considerable progress made in the development of models, these same challenges still remain. Sophisticated models have assumptions based on the estimation of some of these parameters. For example, Jolly-Seber models assume that all individuals (marked and unmarked) have equal probability of capture between occasions and of survival between occasions. Cormack-Jolly-Seber models have the same assumptions but the models are only concerned about marked individuals.

Enumeration: Mark–recapture (Baffin Bay example)

J. Laake provided a few comments about the programme MARK, which actually provides the user with the ability to fit a number of models including Jolly-Seber, Cormack-Jolly-Seber, Brownie and Burnham/Barker. Model selection depends on the situation. JS models use first captures and subsequent recaptures, CJS use recaptures, Burnham/Barker models allow you to use recaptures and tag recoveries. When estimating population size for long-lived animals, recapture intervals should be longer. While you get increased precision, the modelling complexity can also increase because of other factors. In selecting a candidate model, it is important to consider the biology of the animal, historical knowledge of past analyses and/or harvest, and sample size. AIC and quasi-AIC are means by which to objectively identify 'best' models. It is also important to remember that models provide an estimate of total survival, which is the sum of the natural and harvest mortality. There are methods to estimate natural survival.

In reviewing the Baffin Bay analysis, J. Laake noted that the available data included spring captures (n=458) that had occurred at irregular intervals over the period 1974–1992 plus data from the fall capture programme (763 first captures, 151 recaptures) conducted in 1993–95 and 1997. Burnham models were fitted that included age, sex, year and season effects. The final abundance estimate was 2,074 bears.

In the discussion, a point was raised about the observation that two neighbouring subpopulations (Lancaster Sound and Davis Strait) appear to be increasing while Baffin Bay may be decreasing. How do models tease out the possibility of movement of animals out of Baffin Bay into these neighbouring ones? J. Laake replied that telemetry data were used to help delineate subpopulation boundaries. With respect to the models, you could incorporate the harvest data from the subpopulations of concern, assuming that these data were collected in the same years for all subpopulations.

Enumeration: Mark–recapture (Regression approach)

T. McDonald reviewed the basics of mark-recapture by noting that a sample of individuals are captured, marked and released at intervals over time. The recapture of marked animals in the subsequent sampling periods enable the estimation of capture and survival probabilities, which in turn allow the estimation of abundance. Program MARK pulls together in one package a number of models that can be used. For many, Program MARK is sufficient. However, there are limitations with some of the models available through MARK, particularly with respect to the fitting of complex models. He has taken a regression approach to the estimation of capture and survival probabilities. All models which can be fit in MARK can also be fit using the regression approach. In particular, complex models are much easier to specify and/or fit using his regression approach than they are using Program MARK. He has developed the program MRAWIN5 (Mark-Recapture Analysis for Windows) that is a set of S-Plus and R-Code routines. He noted that there is a fairly steep learning curve with respect to both programmes but, once that has been overcome, it becomes relatively easy to specify and modify any number of models.

Enumeration: Mark–recapture (Mark Analysis R-Code)

J. Laake commented that R-Code is an open source programme that is free off the web (cran.r-project.org) but echoed Trent's comment that there is a steep learning curve and it is not user-friendly. He has developed MARC, which is a collection of R-Code functions that act as a replacement to the existing Program MARK interface because he found the latter to be both difficult and tedious to use. He stressed that Program MARK consists of two primary programs *MARK.EXE*, which is the actual programme and is excellent and *MARKINT.EXE*, which is the interface in Program MARK.

Enumeration: Mark–recapture (Western Hudson Bay example)

E. Regehr presented his analysis of the long-term capture data for the Western Hudson Bay subpopulation. He noted that his analysis had three important components: exploratory data analysis, goodness-of-fit analysis and capture-recapture analysis. He remarked that exploratory data analysis is a critical but sometimes overlooked step. This is the step at which one does quality control and ensures that the data are clean. With the goodness-of-fit analysis, you are looking for violations of model assumptions. With respect to the Western Hudson Bay dataset, there were no violations, which he thought reflected the large number of marked animals, the long duration of the data, and the effort put into the annual capture samples. What this also means is that one can have high confidence in the abundance estimate. Although he did not revisit mark-recapture theory, he suggested the power of these types of models is in the ability to constrain capture and survival probabilities to be linear functions of whatever information one believes to be relevant. He noted that the date of sea ice break-up was a significant factor in the survival of three of four age groups (0–1 yrs, 2–4 yrs, and 20+ yrs). Date of break-up had no effect on the survival of prime (5–19 yrs) bears. Capture probability was related to the sex of the bear, time and a 'trap' response. Bears first handled by Manitoba Conservation staff were more likely to be recaptured than bears first handled by Canadian Wildlife Service (CWS) staff. The capture-recapture analysis was run on the CWS-only data (N=750) and also on the CWS and Manitoba data combined, which resulted in an overall abundance estimate of 950.

With respect to the relationship between survival and ice break-up, some scepticism was expressed about the recent increases in quotas when the data suggest the subpopulation is declining. With respect to survival and sea ice, E. Regehr replied that the modelling exercise involved 'hundreds' of runs with numerous covariates and that the date of sea ice break-up was determined to be a significant factor for some age groups. M. Taylor added that this was a demonstration of a clear environmental effect (i.e. climate change) having a direct effect on demographic parameters. The quota increase in Western Hudson Bay followed the procedure that is required by Nunavut legislation and it cannot be changed without complete community consultation. At the time of the increase, the information presented here was not available. I. Stirling noted that while the analysis presented by Regehr was not available, CWS had been warning Nunavut for 2–3 years that they thought the subpopulation was declining. Because of concern about the possibility that the subpopulation might be declining, the Nunavut Wildlife Management Board was one of the agencies that committed three years of financial support to ensure a larger sample size for the purpose of re-estimating subpopulation size. Thus, it is not quite correct to say there was no information prior to the increase in the quota for WH. Although the Nunavut Department of Environment had drafted a new plan to reduce quotas, after the new scientific information was presented to the Nunavut Wildlife Management Board in June, it was not supported by the Minister. The increased quota will be maintained during the 2005–2006 hunting season. After that, community consultations will be undertaken, though there is no guarantee ahead of time what the outcome of those might be. One suggestion offered was that the hunters could show conservation leadership, be proactive, and decide amongst themselves not to use the increases in quotas for bears in Western Hudson Bay. G. Nirlungayuk commented that there was going to be a regional meeting of hunters in the fall and that all options will be discussed.

Enumeration: General discussion

S. Amstrup thanked all the presenters and, given the invited expertise in the room, opened the discussion up to any relevant topics.

Loss of marks. Is tag loss an issue? It can be significant if the tattoos are illegible. In general, if capture probabilities are high, then the 'loss' of previously known individuals is not a significant issue. However, if capture probabilities are low, then the loss of known individuals results in decreased survival probabilities and increased abundance estimates. Can you use bears that you know have been handled (holes in ears or illegible tattoos) but you cannot identify the individual? There are models that incorporate identification uncertainty but they require a lot of other variables and information to make useful; unless there are a lot of unknown identification numbers, it is probably not worth trying to incorporate.

Other methods. Capture-recapture studies for polar bears are expensive and not practical for some subpopulations. There have been huge advances in closed-population modelling that might allow you to reduce the time required to get abundance estimates. A Manly-Parr model with the incorporation of age has the potential for reduced time requirements but is still in development. Radio-frequency ID tags also have potential because they would allow you to 'quickly scan' an animal from the air to find out who it was. Again this is also still in the development stage. An urgent estimate is required for the Chukchi subpopulation but it is next to impossible both logistically and financially to undertake a capture-recapture inventory. Line transects would seem like a reasonable approach but it is still very expensive, requires significant logistic support, and depends on having appropriate weather conditions. The method will also depend on specific needs, if you require vital rates, then it has to be mark-recapture. One option might be to couple mark-recapture with line transects as has been done with killer whales. A line transect is set up and flown. The sightings would be transmitted to others who would then go out and capture these bears. In some parts of the western Chukchi, it might be possible to get information from a combination of den surveys and line transects.

Quotas. New and updated science-based subpopulation estimates have resulted in substantial changes with respect to community quotas, including harvest moratoriums. A more precautionary and conservative approach to quotas might be the safest approach over the longer term. Instead of taking all of a potential new quota, it could be brought in gradually or restrict the increase to males only. One of the risks of taking all of a large quota increase is that one cannot predict possible environmental influences. If there is a large error, it can take a significant period of time for the subpopulation to recover after significant reductions in harvest have been brought into effect, which may cause significant hardship to local communities.

Heterogeneity. Remains a problem with mark-recapture. It is important that one puts capture effort into all areas. Effort should be guided to some degree by distribution (e.g., sample more in high density areas and less in less dense areas). Heterogeneity has much more of an effect on capture probability than on survival probability.

Friday, June 24th

S. Schliebe opened the last day of the meeting by noting that yesterday's workshop was excellent, thanking all participants, and thanking S. Amstrup in particular for organizing it.

8. Status report

S. Schliebe prefaced the discussion by commenting that the public will be looking for direction and leadership from the PBSG over the next 4–5 years with respect to issues facing polar bears. This Group cannot afford to be silent or we will lose credibility.

S. Schliebe summarised that over the course of the meeting that we had come a long way with respect to developing a status table that we could all stand behind. There was still more work to do and it was suggested that a new draft status table be given to the new Chair within two weeks (10 July) with the goal of completion by the beginning of August.

A new draft status table format had been circulated. A. Derocher summarised the intent of the *Trend*, *Status* and *Risk* categories that had been discussed at the Group's business meeting. The proposed qualifiers for each category were:

Trend – increase, stable, decrease, data deficient
Status (relative to historical estimate) – not reduced, reduced, severely reduced, data deficient
Risk – low, moderate, intermediate, high, severe, data deficient

In addition to the table, there would also be subpopulation-by-subpopulation paragraphs providing any necessary background, similar to what was done in the last proceedings. M. Obbard asked how we were going to deal with *Risk* for those subpopulations for which there was no recent data. M. Taylor replied that it was only to be done on subpopulations where there is sufficient data to run PVA. If there is no recent data, then Data Deficient would be entered in the *Risk* column.

S. Schliebe asked that appropriate coordination within jurisdictions occur to ensure numbers are correct in order to complete by 1 August. A. Derocher noted that we collectively needed to push this so that it is ready for publication. We cannot afford to wait six months for the status table because we might miss a publication window. There was discussion that it might not be possible to have a completed status table ready by 1 August but that we should set a date rather than give a vague deadline of the autumn. T. Evans suggested 1 October. The Group felt that was an appropriate time frame.

7. Issues pertaining to the Agreement

Circumpolar tissue/bone health assessments of polar bears

C. Sonne briefly summarised a proposal to undertake a circumpolar assessment of polar bear health that builds, in part, upon his East Greenland study presented earlier in the meeting. The five primary components would be histological/chemical sampling, biopsy, new contaminants, bone mineral density and education.

M. Taylor suggested that given that it is a circumpolar study it would seem appropriate to get direction and support from the PBSG. A. Derocher noted that there was some overlap with ongoing projects. G. Nirlungayuk commented that studies on animal health are very important to Inuit because of their dependence on the resource. There was overall support from the Group but a detailed proposal needs to be developed so everyone participating knows how and what to collect, sample size required, timelines on who is doing what and when, plus expectations of what those participating will be getting back.

Habitat conservation

D. Vongraven noted that in the late 1990s the Conservation of Arctic Flora and Fauna (CAFF) developed a circumpolar monitoring programme. The programme had no dedicated funds and, therefore, looked for linkages to existing programmes. Very little progress was made. In the winter of 2004, senior CAFF officials agreed to seek funding in order that they would be able to contribute something to those that participate in the programme. They developed a new approach in April 2005 whereby a small suite of appropriate indicators would be selected. CAFF may or may not select polar bears as one of the indicators to be used in the circumpolar monitoring programme and CAFF may approach the PBSG. He suggested that if the Group thought there was value in using the polar bear as an indicator in the CAFF programme, he could respond on the Group's behalf.

S. Schliebe thought that it was appropriate that polar bears at least be considered and that the Group should anticipate and be prepared to provide a response. In the general discussion that followed, there was conceptual support but the Group had some reservations that included ensuring that the PBSG maintained independence from CAFF, that it was clear what the PBSG would get in return given the anticipated time/work commitment and lack of funding, and that polar bears are already used as indicator species by the Arctic Monitoring and Assessment Programme (AMAP) that is already linked with CAFF. There was some discussion of the benefits of linking with existing organizations such as CAFF because it would allow the PBSG to provide input into information that gets put out for public consumption. Otherwise, we run the risk of other individuals and/or organizations taking existing data, interpreting it, and putting out misleading or inaccurate information. The PBSG does not have a profile outside that provided by the Proceedings and website.

It was supported that D. Vongraven go back to CAFF to get additional information and to provide feedback to the Group.

IUCN Red Data assessment

Ø. Wiig made a presentation on the possible change in status of the polar bear using the IUCN's new assessment criteria. This re-assessment was initiated through Scott Schliebe and subsequently passed on to Ø. Wiig. The first evaluation of the polar bear by the PBSG occurred in 1994 and resulted in a classification of Lower risk: conservation dependent. The IUCN implemented new assessment criteria in 2001 and new risk categories, which include Least Concern (LC) and Near Threatened (NT). There is also a Threatened Group that includes three risk categories; Critically Endangered (CR), Endangered (EN) and Vulnerable (VU).

While going through the re-assessment, there were a number of terms defined by the IUCN, which included:

- population – total number of mature individuals of the taxon
- sub-population – geographic or otherwise distinct groups in the population
- generation – average age of parents of current cohort
- extent of occurrence – the area contained within the shortest continuous imaginary boundary that

can be drawn to encompass all the known, inferred or projected sites of present occurrence of a species, excluding cases of vagrancy

- area of occurrence – area within the 'extent of occurrence' that is occupied by a species, excluding cases of vagrancy. This measure reflects the fact that a species will not usually occur throughout its extent of occurrence because that area may contain unsuitable or unoccupied habitats

Ø. Wiig used a generation time of 15 years, which was calculated from the age of maturity (five years) plus half the length of the reproductive period in a complete life cycle (10 yrs; =0.5 x 20 yrs). For each of the Red List Categories, there are five quantitative criteria (Population Reduction, Geographic Range, Population Size, Very Small or Restricted Populations, and Quantitative Analysis); meeting any one of these criteria qualifies a species for listing at that level of threat. In his review and re-assessment, Ø. Wiig found that polar bears did not meet any of the criteria to qualify them as either Endangered or Critically Endangered. However, given the projected decline in sea ice, polar bears would probably meet the Population Reduction criteria that would result in their being listed as Vulnerable. A projected or suspected population reduction of ≥ 30% that would be met within the next 10 years or three generations (up to 100 years), whichever is greater, qualifies a species as Vulnerable.

In the discussion that followed, the Group thanked Ø. Wiig and S. Schliebe for their efforts on behalf of the PBSG. S. Schliebe noted that under IUCN guidelines, species are expected to be re-evaluated on a three-year cycle. M. Taylor wondered whether it would be worth performing a PVA in order to get one more piece of information. S. Amstrup thought that this should be done at the subpopulation level and, if re-evaluated every three years that the Group would be in a stronger position the next time around. D. Lee suggested that we should be cautious when including climate change effects because of uncertainties relative to long-term sea ice modelling and forecasting. Because of the model projections and the dependence of polar bears on sea ice, it was important that a precautionary approach was taken in the re-assessment of polar bears under the new IUCN Red List criteria.

The Group supported the assessment and conclusion that polar bears should be listed as Vulnerable. The members were instructed to review the draft assessment document and provide comments to Ø. Wiig to be incorporated into a final document.

9. Resolutions

Six resolutions were tabled for review and discussion. All were adopted by the Group (five by consensus and one by vote).

Resolution 1 – A precautionary approach when setting catch levels in a warming Arctic
Resolution 2 – An international study of the effects of pollution on polar bears
Resolution 3 – Status of the Western Hudson Bay (WH) subpopulation analysis
Resolution 4 – Implementation of the U.S./Russia bilateral agreement
Resolution 5 – Risks to polar bears from arctic shipping
Resolution 6 – Wrangel Island Nature Reserve and other protected areas

Resolution 1 resulted in the greatest amount of discussion among the Group. Ø. Wiig stressed that the purpose of the resolution was to confirm that the International Agreement guides management decisions and, therefore, that harvest quotas cannot be increased without well-founded scientific studies. M. Taylor expressed concern that the Group previously accepted a non-scientific based estimate of 1,400 for Davis Strait when that estimate came from scientific experts but now has difficulty accepting an increase to 1,650 based on hunter observations. I. Stirling clarified that the acceptance of a minimum subpopulation estimate of 1,400 for DS at that time was not solely based on observations of hunters. There were several other independent sources of information available on the age-structure of the subpopulation, numbers of bears captured per helicopter flying hour along the Labrador coast in the 1970s and 1990s, and on the large proportion of old male bears continuing to be seen and/or harvested throughout the DS area. Furthermore, all of that was occurring during a period of several cold years with a lot of sea ice and a rapidly expanding harp seal population with the potential to provide a plentiful food base. It was also suggested that, based on monitoring of the harvest, the apparent sustainability of the existing harvest provided additional support for the hypothesis that the DS subpopulation had to be at least 1,400 animals. Taken together, all these observations suggested that an increased harvest had a good chance of being sustainable. However, the main point relative to this discussion is that hunters' observations were used in the old DS revision, but they were *also* supported by several other independent sources of information, none of which on its own would have been sufficient to justify an increase but when taken together gave sufficient comfort to justify the increase. Put simply, there is no comparison between the recent increases in subpopulation estimates and quotas in some subpopulations, where for some at least there are strong data to the contrary, and the discussions about subpopulation size in DS several years ago.

After a lengthy discussion, M. Taylor suggested that we should put Resolution 1 to a vote. S. Schliebe indicated that he would prefer that the Group reach consensus but realized that it had been debated long enough. He indicated that if it was put to a vote that the formal process is one vote per country.

M. Taylor motioned to call the question and Ø. Wiig seconded the motion. S. Schliebe instructed each country to vote to either accept or reject the resolution as read. Canada (I. Stirling), Denmark (E. Born), Norway (J. Aars), Russia (S. Belikov), and USA (S. Amstrup) all voted to accept the resolution. The motion was carried with five in favour and none opposed. M. Taylor requested that the minutes record that, although Canada voted to accept the resolution, there was a difference of opinion within the Canadian Delegation (I. Stirling and M. Obbard supported the motion, whereas M. Taylor did not).

Resolutions 2–6 were all passed by consensus of the Group following discussion and relatively minor changes to the wording of each.

10. IUCN business

Issues handled by the Chair

S. Schliebe noted that he had frequent interaction with IUCN over a number of issues including early efforts on the Global Mammal Assessment/Red List process, Species Survival Strategic Plans, and has contributed articles for publication in the IUCN newsletter *Species* on behalf of the PBSG. In addition, he has written articles on the Group's activities for the International Bear Association's newsletter *International Bear News* and the World Wildlife Fund's *Arctic Bulletin*. He also interacted with the Council on Arctic Flora and Fauna (CAFF) and facilitated dialogue between the PBSG and the IBA with respect to the IBA's ongoing initiative to seek potential donors to a Bear Conservation Fund that would subsequently grant funds to projects that address conservation needs identified by species-specific bear expert teams.

11. Future objectives and actions of the PBSG

PBSG website

D. Vongraven reported that he has been unable to spend much time working on the site recently because of other commitments. Regardless, he does need input from the PBSG members with respect to the site. Ø. Wiig asked whether we should make recent publications available in PDF format. D. Vongraven indicated that currently visitors to the site can access a list of general and scientific references and a second list of Russian literature. He would like to develop a searchable reference database but there have been reasons as to why this has not yet been accomplished. S. Schliebe thanked D. Vongraven on behalf of the PBSG for his efforts in maintaining the website and to the Norwegian Polar Institute for hosting the site.

Next meeting

There was a brief discussion of the location of the next meeting. There was agreement that there was no requirement to identify the location of the next working meeting prior to the end of the current meeting. E. Born indicated that should there be difficulties in finding a suitable location, he would be happy to offer Copenhagen as one option for consideration by the Group.

12. Election of a new chair of the PBSG

E. Born nominated Andrew Derocher (University of Alberta, Canada) as a candidate. As no other nominations were made, he was elected the new Chair of the IUCN/SSC Polar Bear Specialist Group.

13. Adoption of status report

The Group had already dealt with this agenda item earlier.

14. Adoption of resolutions

The Group had already adopted all six resolutions earlier in the meeting.

15. Adoption of press release

The Group reviewed and edited the official press release from the meeting.

16. Closing remarks and adjournment

The 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group was adjourned at 18:25.

Status of the polar bear

Status and distribution

Polar bears are not evenly distributed throughout the Arctic, nor do they comprise a single nomadic cosmopolitan population, but rather occur in 19 relatively discrete subpopulations (Figure. 1). There is however an uncertainty about the discreteness of the less studied subpopulations, particularly in the Russian Arctic and neighbouring areas, due to very restricted data on live capture and tagging. The total number of polar bears worldwide is estimated to be 20,000–25,000. The following subpopulation summaries are the result of discussions of the IUCN/SSC Polar Bear Specialist Group held in Seattle, Washington, USA in June 2005 and updated with results that became available up to June 2006. The information on each subpopulation is based on the status reports and revisions given by each nation. We present estimated subpopulation sizes and associated uncertainty in estimates, historic and predicted human-caused mortality, and subpopulation trends, and rationale for our determinations of status. Where data allowed, or the approach was deemed appropriate for a jurisdiction, results of stochastic subpopulation viability analyses (PVA) to estimate the likelihood of future population decline are presented.

Figure 1. Distribution of polar bear populations throughout the circumpolar basin.

Status table structure

Subpopulation size

Table 1 presents subpopulation sizes and uncertainty in the estimates as ± 2 standard errors of the mean, 95% CI, or ranges. These estimates are based on scientific research using mark and recapture analysis or aerial surveys and the years in which data were collected are presented to give an indication of the current reliability of subpopulation estimates. For some subpopulations, scientific data were not available and population estimates were extrapolated from density estimates and/or local traditional ecological knowledge (TEK). In some cases, this also includes simulations based on the minimum size necessary to support local knowledge of subpopulation trends. Although these data are presented in addition to or in some cases as an alternative to dated scientific estimates, methods other than mark and recapture analysis or aerial surveys have unknown and in most cases inestimable errors.

Human-caused mortality

For most subpopulations, particularly those in North America, harvesting of polar bears is a regulated activity. In many cases, harvesting is the major cause of mortality for bears. In most jurisdictions, the total numbers of bears killed by humans in pursuit of sport and subsistence hunting, accident, and in defence of life or property are documented. Where data allow, we present the five-year mean of known human-caused mortality (removals) for each subpopulation. We also present the anticipated removal rate of polar bears in each jurisdiction based on known increases in hunting quotas and/or the average removal rate of polar bears by jurisdiction over the past five years.

Trend and status

Qualitative categories of trend and status are presented for each polar bear subpopulation (Table 1). Categories of trend include our assessment of whether the subpopulation is currently increasing, stable, or declining, or if we have insufficient data to estimate trend (data deficient). Categories of status include our assessment of whether subpopulations are not reduced, reduced, or severely reduced from historic levels of abundance, or if we have insufficient data to estimate status (data deficient).

Table 1. TR Status Report

	Aerial Survey/M-R Analysis		Additional/Alternative Analysis										
Sub-population	Number (year of estimate)	estimate ±2 SE or 95% CI[1]	Number (year of estimate)	estimate ±2 SE[1] or min-max[2] range	Simulation	Density	TEK/IQ	Historical annual removals (5 yr mean)	Potential maximum annual removals	Observed or predicted trend	Status	Estimated risk of future decline (10 yrs)	Comments
East Greenland	unknown							70	50	Data deficient	Data deficient	No Estimate	No subpopulation inventories have been conducted in East Greenland and therefore the size of the subpopulation is not known. During the last decades the extent of sea ice has decreased in the East Greenland area (e.g. Parkinson 2000). This decline is likely to continue (e.g. Rysgaard *et al.* 2003) resulting in a continued habitat destruction for polar bears in this area. Furthermore, various studies indicate that East Greenland polar bears may be negatively affected by relatively high body burden of organic pollutants (cf. Born and Sonne, this volume). During the last 5 years the total catch from the East Greenland subpopulation has decreased from 81 (1999) to 59 (2003) (Born and Sonne, this volume). Proposed quota (effective 1 Jan 2006) for East Greenland is 50 bears/year.
Barents Sea	2997 (2004)	2299 - 4116[1]						na		Data deficient	Data deficient	No Estimate	There has probably been an increase in the subpopulation size after 1973 until recently, but current subpopulation growth trend is unknown.
Kara Sea	unknown							na		Data deficient	Data deficient	No Estimate	The subpopulation size is unknown and no population surveys have been conducted in the Kara Sea.
Laptev Sea	800-1200 (1993)							na		Data deficient	Data deficient	No Estimate	The subpopulation size is based on Belikov (1993) using aerial counts of dens on the Severnaya Zemlya in 1982 and on anecdotal data collected in 1960-80s on the number of females coming to dens on Novosibirsk Islands and on mainland coast. The estimate should therefore be regarded as preliminary.
Chukchi Sea			2000 (1993)			X		43 - Alaska, unk. but substantial in Chukotka	uncertain	Data deficient	Data deficient	No Estimate	The subpopulation was estimated at 2000-5000 animals (Derocher *et al.* 1998) based on extrapolation of multiple years of spring den numbers data collected on Wrangel Island. The estimate was revised to 2000 animals with low confidence (Lunn *et al.* 2002). Abundance estimates with measurable levels of precision are not available. The subpopulation trend is believed to be declining and the status relative to historical levels is believed to be reduced based on harvest levels that were demonstrated to be unsustainable in the past. These harvest levels have been occurring for approximately the past 10–15 years. Without implementation of US-Russia polar bear treaty the levels of harvest are expected to continue and the risk for subpopulation depletion is rated as high.
Southern Beaufort Sea	1500 (2006)	1000 - 2000						58	81	Declining	Reduced	No Estimate	The 2006 subpopulation estimate is based on a preliminary analysis of capture-recapture data collected jointly by the U.S. and Canada, from 2001–2006. The 2006 subpopulation estimate was derived using the historic management boundaries for the SB subpopulation (i.e., from Icy Cape, Alaska, to Pierce Point, Northwest Territories, Canada). A final analysis of the recent capture-recapture data will be reported in 2007, along with suggestions for new management boundaries based on recent analyses of radiotelemetry data.
Northern Beaufort Sea	1200 (1986)	133 - 2097						36	65	Stable	Not reduced	No Estimate	A coordinated, intensive mark and recapture study covering the whole of the Beaufort Sea and Amundsen Gulf will be completed in 2006; a final analysis and report will follow.
Viscount Melville	161 (1992)	121 - 201	215 (1996)	99 - 331[1]	X			4	7	Increasing	Severely reduced	Very Low	14.0% of PVA simulation runs resulted in subpopulation decline after 10 years (86.0% resulted in subpopulation increase after 10 years). Simulations based on 1996 projected abundance.

* Where PVA simulations have been conducted, risk of decline is classed as Very Low (0–20%), Lower (20–40%), Moderate (40–60%), Higher (60–80%), and Very High (80–100%).

Table 1. TR Status Report (cont.)

	Aerial Survey/M-R Analysis		Additional/Alternative Analysis										
Sub-population	Number (year of estimate)	estimate ±2 SE or 95% CI[1]	Number (year of estimate)	estimate ±2 SE[1] or min-max[2] range	Simulation	Density	TEK/IQ	Historical annual removals (5 yr mean)	Potential maximum annual removals	Observed or predicted trend	Status	Estimated risk of future decline (10 yrs)	Comments
Norwegian Bay	190 (1998)	102 - 278						3	4	Declining	Not reduced	Higher	79.7% of PVA simulation runs resulted in population decline after 10 years (20.3% resulted in population increase after 10 years).
Lancaster Sound	2541 (1998)	1759 - 3323						74	85	Stable	Not reduced	Higher	78.3% of PVA simulation runs resulted in subpopulation decline after 10 years (21.7% resulted in subpopulation increase after 10 years). PVA estimate should be regarded as conservative due to unique male-bias in harvest (males decline over short term but not females); over longer time horizons PVA suggests sustainability of harvest.
M'Clintock Channel	284 (2000)	166 - 402						3	3	Increase	Severely reduced	Very Low	3.1% of PVA simulation runs resulted in subpopulation decline after 10 years (96.9% resulted in subpopulation increase after 10 years).
Gulf of Boothia	1523 (2000)	953 - 2093						46	74	Stable	Not reduced	Lower	21.0% of PVA simulation runs resulted in population decline after 10 years (79.0% resulted in population increase after 10 years).
Foxe Basin	2197 (1994)	1677 - 2717	2300 (2004)	1780 - 2820[1]	X		X	97	109	Stable	Not reduced	Lower	N = 2197, SE = 260 in 1994 based on Jolly-Seber M-R with tetracycline biomarking and harvest recoveries. Using Baffin Bay survival and recruitment rates, 25.9% of PVA simulation runs resulted in subpopulation decline after 10 years (74.1% resulted in subpopulation increase after 10 years).
Western Hudson Bay	935 (2004)	794 - 1076						45	64	Declining	Reduce d	Very High	100.0% of PVA simulation runs resulted in subpopulation decline after 10 years (0.0% resulted in subpopulation increase after 10 years).
Southern Hudson Bay	1000 (1988)	684 - 1116						37	43	Stable	Not reduced	Lower	22.7% of PVA simulation runs resulted in population decline after 10 years (77.3% resulted in population increase after 10 years).
Kane Basin	164 (1998)	94 -234						11	15	Declining	Reduce d	Very High	100.0% of PVA simulation runs resulted in subpopulation decline after 10 years (0.0% resulted in subpopulation increase after 10 years).
Baffin Bay	2074 (1998)	1544 - 2604	1546 (2004)	690 - 2402[1]	X			217	234	Declining	Reduce d	Very High	100.0% of PVA simulation runs resulted in subpopulation decline after 10 years (0.0% resulted in subpopulation increase after 10 years).
Davis Strait			1650 (2004)	1000 - 2300[2]	X		X	65	74	Data deficient	Data deficient	Lower	The subpopulation was estimated at 1,400 in 1996 based on traditional ecological knowledge (TEK) that the subpopulation had increased with historical harvest levels; and simulation results suggesting that subpopulation could not have sustained the historical harvest at numbers less than 1,400. In 2004, the subpopulation estimate was increased to 1,650 based on TEK that the subpopulation had continued to increase; and simulations suggesting that an increase of about 250 (from 1,400 to 1,650) from 1996 was reasonable at post-1996 harvest levels. In 2005 a multi-year M-R survey was initiated to confirm subpopulation numbers and status. Using Baffin Bay survival and recruitment rates, and abundance as above, 23.4% of PVA simulation runs under projected harvest (potential maximum removals) resulted in subpopulation decline after 10 years (76.6% resulted in subpopulation increase after 10 years).
Arctic Basin	unknown							na					

* Where PVA simulations have been conducted, risk of decline is classed as Very Low (0–20%), Lower (20–40%), Moderate (40–60%), Higher (60–80%), and Very High (80–100%).

Subpopulation Viability Analysis

For some subpopulations, recent quantitative estimates of abundance and parameters of survival and reproduction are available to determine likelihoods of future subpopulation decline using stochastic subpopulation viability analysis (PVA). We used the PVA model RISKMAN (Taylor *et al.* 2001a) to estimate risks of future declines in polar bear subpopulations given demographic parameters and uncertainty in data. The model and documentation detailing the model's structure are available at www.nrdpfc.ca/riskman/riskman.htm. Publications based on the RISKMAN model include Eastridge and Clark (2001), McLoughlin *et al.* (2003), and Taylor *et al.* (2002).

RISKMAN can incorporate stochasticity into its subpopulation model at several levels, including sampling error in initial subpopulation size, variance about vital rates due to sample size and annual environmental variation (survival, reproduction, sex ratio), and demographic stochasticity. RISKMAN uses Monte Carlo techniques to generate a distribution of results, and then uses this distribution to estimate subpopulation size at a future time, subpopulation growth rate, and proportion of runs that result in a subpopulation decline set at a predetermined level by the user. We adopted the latter to estimate persistence probability.

Our approach to variance in this simulation was to pool sampling and environmental variances for survival and reproduction. We did this because: 1) variances for reproductive parameters often did not lend themselves to separating the sampling component of variance from environmental variance, and 2) we were interested in quantifying the risks of subpopulation decline including all sources of uncertainty in the data (i.e., pooling sampling error with environmental error presents more conservative outcomes of subpopulation persistence).

For each subpopulation model, the frequency of occurrence of subpopulation declines and/or increases after 10 years was reported as the cumulative proportion of total simulation runs (2,500 simulations). We chose to conduct model projections using these criteria because: 1) the subpopulation inventory cycle for most areas is planned to be 10–15 years in duration, and 2) we do not advocate using PVA over long time periods in view of potential significant changes to habitat resulting from arctic climate change. Individual runs could recover from 'depletion', but not from a condition where all males or all females or both were lost. Required subpopulation parameter estimates and standard error inputs included annual natural survival rate (stratified by age and sex as supported by the data), age of first reproduction, age-specific litter production rates for females available to have cubs (i.e., females with no cubs and females with 2-year-olds), litter size, the sex ratio of cubs, initial subpopulation size, and the sex, age, and family status distribution of the harvest. Input data may be found in Tables 1–3.

The standing age distribution was always female-biased, likely due to long-term harvesting of males in subpopulations for which simulations were performed (Table 1). Because we wished to err on the side of caution, for all simulations we used the stable age distribution expected for the subpopulation at the anticipated annual removal rate as the initial age/sex distribution (i.e. initializing the subpopulation at the stable age distribution produced more conservative outcomes compared to that of the existing standing age distribution). The harvest selectivity and vulnerability array was identified by comparing the standing age distribution of the historical harvest of subpopulations to the total mortality, stable age distribution. Harvest was stratified by sex, age (cubs and yearlings, age 2–5, age 6–19, and age >20) and family status (alone, or with cubs and yearlings, or with 2-year-olds). We ran harvest simulations using natural survival rates, upon which anticipated annual removal rates (i.e., human-caused mortality from all sources) were added.

East Greenland (EG)

No inventories have been conducted in recent years to determine the size of the polar bear subpopulation in eastern Greenland. Satellite-telemetry has indicated that polar bears range widely along the coast of eastern Greenland and in the pack ice in the Greenland Sea and Fram Strait (Born *et al.* 1997, Wiig *et al.* 2003). However, various studies have indicated that more or less resident groups of bears may occur within this range (Born 1995, Sandell *et al.* 2001). Although there is little evidence of a genetic difference between subpopulations in the eastern Greenland and Svalbard-Franz Josef Land regions (Paetkau *et al.* 1999), satellite telemetry and movement of marked animals indicate that the exchange between these subpopulations is minimal (Wiig 1995, Born *et al.* 1997, Wiig *et al.* 2003).

During 1999–2003 (last five years of recording), the annual catch in eastern and southwestern Greenland averaged 70 bears (range, 56–84 bears per year) (Born and Sonne, this volume). The catch of polar bears taken in southwestern Greenland, south of 62ºN, must be added to the catch statistics from eastern Greenland because polar bears arrive in the southwestern region

Table 2. **Mean (and standard error [SE]) of natural (i.e., unharvested) survival parameters used in the assessment of risk for subpopulations listed in Table 1, and best estimates of parameters to model natural survival in FB, SH, WH, DS, NB, and SB.** ***It is to these rates that anticipated annual removal rates are added for simulation.***

	Males Survival estimates of unharvested Bears				Females Survival estimates of unharvested Bears			
Subpopulation	**Cubs-of-the-year**	**1–4 yrs**	**5–20 yrs**	**>20 yrs**	**Cubs-of-the-year**	**1–4 yrs**	**5–20 yrs**	**>20 yrs**
BB	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
DS[1]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
FB[2]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
GB	0.817 (0.201)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)	0.817 (0.201)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)
KB	0.345 (0.200)	0.663 (0.197)	0.997 (0.026)	0.997 (0.026)	0.410 (0.200)	0.756 (0.159)	0.997 (0.026)	0.997 (0.026)
LS[3]	0.634 (0.123)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
MC	0.619 (0.151)	0.983 (0.034)	0.921 (0.046)	0.921 (0.046)	0.619 (0.151)	0.983 (0.034)	0.977 (0.033)	0.977 (0.033)
NW[3]	0.634 (0.123)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
SH[2]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
VM	0.448 (0.216)	0.924 (0.109)	0.924 (0.109)	0.924 (0.109)	0.693 (0.183)	0.957 (0.028)	0.957 (0.028)	0.957 (0.028)
WH[4]	0.500 (0.033)	0.870 (0.026)	0.940 (0.010)	0.780 (0.023)	0.610 (0.028)	0.920 (0.020)	0.940 (0.008)	0.810 (0.020)

[1] Incorporates 1993–1998 BB data (Taylor *et al.* 2005).
[2] Incorporates 1993–1998 BB data (Taylor *et al.* 2005).
[3] Survival estimates pooled for LS and NW (see text for LS and NW).
[4] Based on vital rates provided by E. Regehr (USGS, Alaska Science Center, Anchorage, AK). Survival rates for WH were estimated using an age structure that differs slightly from Table 2. The "Cubs-of-the-year" survival rate in Table 2 applies to WH juvenile polar bears (age 0–1 yr); the "1–4 yrs" survival rate in Table 2 applies to WH subadult polar bears (age 2–4 yrs). Standard errors represent estimated sampling variance only.

Table 3. Mean (and standard error [SE]) of reproductive parameters (standing age capture data) used in the assessment of risk for populations listed in Table 1, and best estimates of parameters to model FB, SH, WH, DS, NB, and SB.

		Litter-production rate				
Subpopulation	**Litter size**	**4-year-olds**	**5-year-olds**	**6-year-olds**	**>6-year-olds**	**Proportion male cubs**
BB	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
DS[1,2]	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
FB[1]	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
GB	1.648 (0.098)	0.000 (0.000)	0.194 (0.178)	0.467 (0.168)	0.965 (0.300)	0.460 (0.091)
KB	1.667 (0.083)	0.000 (0.000)	0.000 (0.000)	0.357 (0.731)	0.478 (0.085)	0.426 (0.029)
LS	1.688 (0.012)	0.000 (0.000)	0.107 (0.050)	0.312 (0.210)	0.954 (0.083)	0.531 (0.048)
MC	1.680 (0.147)	0.000 (0.000)	0.111 (0.101)	0.191 (0.289)	0.604 (0.928)	0.545 (0.057)
NW	1.714 (0.081)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.689 (0.534)	0.544 (0.066)
SH[2]	1.575 (0.116)	0.087 (0.202)	0.966 (0.821)	0.967 (0.022)	0.967 (0.022)	0.467 (0.086)
VM	1.640 (0.125)	0.000 (0.000)	0.623 (0.414)	0.872 (0.712)	0.872 (0.712)	0.535 (0.118)
WH[2]	1.540 (0.110)	0.000 (0.000)	0.257 (0.442)	0.790 (0.180)	0.790 (0.180)	0.480 (0.110)

[1] Reproductive estimates from BB (Taylor *et al.* 2005).
[2] Best estimates for modelling exercise only (from standing age capture data).

with the drift ice that comes around the southern tip from eastern Greenland (Sandell *et al.* 2001). During 1993 (first year of instituting a new catch recording system) and 2003 there was no significant trend in the catch of polar bears in eastern and southwestern Greenland (Born and Sonne, this volume).

Despite an increasing practice by hunters from Scoresby Sound in Central East Greenland to go further north to take polar bears during spring, there is no information to indicate an overall increase in hunting by East Greenlanders (Sandell *et al.* 2001). Based on harvest sampling from 109 polar bears in Scoresby Sound during 1999–2001 (Danish National Environmental Research Institute, unpubl. data), the proportion of adult (=independent) female polar bears in the catch in eastern Greenland is estimated at 0.43.

Given the estimates of the proportion of adult females in the catch and an annual catch of about 70 bears (*i.e.*, eastern and southwestern Greenland combined), a minimum subpopulation of about 2000 individuals would be needed to sustain this take. However, the actual number of animals in the exploited subpopulation is unknown.

During the last decades, the ice in the East Greenland area has diminished both in extent and thickness (*e.g.* Parkinson 2000). It has been predicted that this trend will continue in this century (Rysgaard *et al.* 2003). Furthermore, polar bears in East Greenland have relatively high body burdens of organic pollutants (Norstrom *et al.* 1998, Dietz *et al.* 2004) and levels of these pollutants seem to have increased between 1990 and 1999–2001 (Dietz *et al.* 2004). Several studies indicate that organic pollutants may have negatively affected polar bears in this region (overview in Born and Sonne, this volume).

The effects of arctic warming on East Greenland polar bears have not been documented. However, considering the effects of climate change in other parts of the Arctic (e.g. western Hudson Bay), these environmental changes cause concern about how polar bears in East Greenland may be negatively affected.

Barents Sea (BS)

The size of the Barents Sea subpopulation was estimated to be about 3000 in August 2004 (see section "Line transect estimate of the subpopulation size of polar bears in the Barents Sea", this volume). This suggests that earlier estimates based on den counts and ship surveys (Larsen 1986) were too high. This suggestion is further supported by ecological data that indicate the subpopulation grew steadily the first decade after protection from hunting in 1973, and then either continued to grow or flattened out after that. Denning occurs on several islands both on Franz Josef Land (Belikov and Matveev 1983) and Svalbard (Larsen 1985). Studies on individual movement and subpopulation ecology by use of telemetry data and mark-recapture have been conducted in the Svalbard area since the early 1970s (Larsen 1972, 1986, Wiig 1995, Mauritzen *et al.* 2001, 2002). Studies on movements using telemetry data show that some polar bears associated with Svalbard are very restricted in their movements but bears from the Barents Sea range widely between Svalbard and Franz Josef Land (Wiig 1995, Mauritzen *et al.* 2001). Subpopulation boundaries based on satellite telemetry data indicate that the Barents Sea has a natural subpopulation unit, albeit with some overlap to the east with the Kara sea subpopulation (Mauritzen *et al.* 2002). Although overlap between the Barents Sea and East Greenland may be limited (Born *et al.* 1997), low levels of genetic structure among all these subpopulations indicates substantial gene flow (Paetkau *et al.* 1999). The Barents Sea subpopulation is currently unharvested with the exception of bears killed in defence of life and property (Gjertz and Persen 1987, Gjertz *et al.* 1993, Gjertz and Scheie 1997). The subpopulation was depleted by over-harvest but a total ban on hunting in 1973 in Norway and in 1956 in Russia allowed the subpopulation to increase (Larsen 1986, Prestrud and Stirling 1994). High levels of PCBs have been detected in samples of polar bears from this area which raises concern about the effects of pollutants on polar bear survival and reproduction (Skaare *et al.* 1994, Bernhoft *et al.* 1997, Norstrom *et al.* 1998, Andersen *et al.* 2001, Derocher *et al.* 2003). Recent studies suggest a decline and levelling of some pollutants (Henriksen *et al.* 2001) while new pollutants have been discovered (Wolkers *et al.* 2004). Oil exploration in polar bear habitat may increase in the near future (Isaksen *et al.* 1998). The natural history of this subpopulation is well known (Lønø 1970, Derocher 2005).

Kara Sea (KS)

This subpopulation includes the Kara Sea and overlaps in the west with the Barents Sea subpopulation in the area of Franz Josef Land and Novaya Zemlya archipelagos. Data for the Kara and Barents Seas, in the vicinity of Franz Josef Land and Novaya Zemlya, are mainly based on aerial surveys and den counts (Parovshikov 1965, Belikov and Matveev 1983, Uspenski 1989, Belikov *et al.* 1991, Belikov and Gorbunov 1991, Belikov 1993). Telemetry studies of movements have been done throughout the area but data to define the eastern boundary are incomplete (Belikov *et al.* 1998, Mauritzen *et al.* 2002). The subpopulation estimate should be regarded as preliminary. Reported harvest activities have been limited to defence kills and an unknown number of illegal kills and these are not thought to be having an impact on the size of the subpopulation. However, contaminant levels in rivers flowing into this area and recent information on nuclear and industrial waste disposal raise concerns about the possibility of environmental damage. Recent studies clearly show that polar bears from the Kara Sea have some of the highest organochlorine pollution levels in the Arctic (Andersen *et al.* 2001, Lie *et al.* 2003).

Laptev Sea (LS)

The Laptev subpopulation area includes the western half of the East Siberian Sea and most of the Laptev Sea, including the Novosibirsk and possibly Severnaya Zemlya islands (Belikov *et al.* 1998). The estimate of subpopulation size for the Laptev Sea (800–1,200) is based on aerial counts of dens on the Severnaya Zemlya in 1982 (Belikov and Randla 1987) and on anecdotal data collected in 1960–80s on the number of females coming to dens on Novosibirsk Islands and on mainland coast (Kischinski 1969, Uspenski 1989). This estimate should therefore be regarded as preliminary. Reported harvest activities in this subpopulation are limited to defence kills and an apparently small but unknown number of illegal kills. The current levels of harvest are not thought to be having a detrimental impact on the subpopulation.

Chukchi Sea (CS)

Cooperative studies between the USA and Russia have revealed that polar bears in this area, also known as the Alaska-Chukotka subpopulation, are widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portions of the East Siberian seas (Garner *et al.* 1990, 1994, 1995). Based upon these early telemetry studies, the western boundary of the subpopulation was set near Chaunskaya Bay in northeastern Russia. The eastern boundary was set at Icy Cape, Alaska, which is also the previous western boundary of the Southern Beaufort Sea subpopulation (Amstrup *et al.* 1986, Amstrup and DeMaster 1988, Garner *et al.* 1990, Amstrup *et al.* 1995, 2004, 2005). This eastern boundary constitutes a large overlap zone with bears in the SB subpopulation.

Estimates of the size of the subpopulation have been derived from observations of dens, and aerial surveys (Chelintsev 1977, Stishov 1991a,b, Stishov *et al.* 1991). However, these estimates have wide ranges and are considered to be of little value for management. Reliable estimates of subpopulation size based upon mark and recapture have not been available for this region although recent studies provide data for analyses using new spatial modelling techniques as reported in the southern Beaufort Sea subpopulation section. Probabilistic distribution information for zones of overlap between the Chukchi and Southern Beaufort Sea subpopulations is now available. This information can be used to more accurately describe sustainable harvest levels once defensible estimates of abundance are developed (Amstrup *et al.* 2004, 2005). The approximate boundaries of this subpopulation for illustration purposes are as described above and as reported previously (Lunn *et al.* 2002).

The status of the Chukchi subpopulation, which was believed to have increased after the level of harvest was reduced in 1972, is now thought to be uncertain or declining. The absolute numbers of animals in the subpopulation remain a research challenge and recent reports of substantial levels of illegal harvest in Russia are cause for concern. Legal harvesting activities are currently restricted to Inuit in Western Alaska. In Alaska, average annual harvest levels declined by approximately 50% between the 1980s and the 1990s (Schliebe *et al.* 1998) and remain depressed today. There are several factors potentially affecting the harvest level in western Alaska. The factor of greatest direct relevance is the substantial illegal harvest in Chukotka. In addition, other factors such as climatic change and its effects on pack ice distribution as well as changing demographics and hunting effort in native communities (Schliebe *et al.* 2002) could have influencing the declining take. Recent measures undertaken by regional authorities in Chukotka may have reduced the illegal hunt. The unknown rate of illegal take makes the stable designation uncertain and tentative and as a precaution the Chukchi subpopulation is designated as declining.

Implementation of the Russia-United States Agreement on the Conservation and Management of polar bear is designed to ensure a scientifically-based sustainable management programme is instituted. Management will include active involvement of Native hunters' organizations from Alaska and Chukotka.

As with the Beaufort Sea subpopulation, the primary concerns for this region are the impacts of climate change, human activities including industrial development within the near-shore environment, increases in the atmospheric and oceanic transport of contaminants into the region, and possible over-harvest of a stressed or declining subpopulation.

Southern Beaufort Sea (SB)

The Southern Beaufort Sea (SB) polar bear subpopulation is shared between Canada and Alaska. During the early 1980s, radio-collared polar bears were followed from the Canadian Beaufort Sea into the eastern Chukchi Sea of Alaska (Amstrup *et al.* 1986, Amstrup and DeMaster 1988). Radio-telemetry data, combined with earlier tag returns from harvested bears, suggested that the SB region comprised a single subpopulation with a western boundary near Icy Cape, Alaska, and an eastern boundary near Pearce Point, Northwest Territories, Canada (Amstrup *et al.* 1986, Amstrup and DeMaster 1988, Stirling *et al.* 1988). Recognition that the polar bears within this region were shared by Canada and Alaska prompted development of the "Polar Bear Management Agreement for the Southern Beaufort Sea" (Agreement) between the Inuvialuit Game Council (IGC) of Canada, and the North Slope Borough (NSB) of Alaska. The Agreement was ratified by both parties in 1988. The text of the Agreement included provisions to protect bears in dens and females with cubs, and stated that the annual sustainable harvest from the SB polar bear subpopulation would be shared between the two jurisdictions. Harvest levels also were to be reviewed annually in light of the best scientific information available (Treseder and Carpenter 1989, Nageak *et al.* 1991). An evaluation of the effectiveness of the Agreement during the first 10 years (Brower *et al.* 2002) concluded that the Agreement had been successful in ensuring that the total harvest, and the proportion of the harvest comprised of adult females, remained within sustainable limits. The evaluation also noted that increased monitoring efforts and continued restraint in harvesting females were necessary to ensure continued compliance with the provisions of the Agreement.

Early estimates suggested the size of the SB subpopulation was approximately 1,800 polar bears, although uneven sampling was known to compromise the accuracy of that estimate (Amstrup *et al.* 1986, Amstrup and DeMaster 1988, Amstrup 1995). New population estimation techniques are emerging and continue to be refined (Amstrup *et al.* 2001, 2005; McDonald and Amstrup 2001). The field work for an intensive capture-recapture effort in the SB region, coordinated between the U.S. and Canada, was conducted between spring 2001 and spring 2006. Analysis of the joint data collected between 2001 and 2006 was completed in September 2006. That analysis produced a population estimate for the region between Icy Cape and Pearce Point of 1,526 polar bears (95% confidence interval: 1,211, 1,841). Although the point estimates (1,800 previously and 1,525 now) suggest a decline in numbers, the overlap of the current confidence interval with the previous point estimate prohibits an unequivocal statistical conclusion that the sub-population has declined. Whereas we cannot draw a purely statistical conclusion that the sub-population level has declined; declines in cub survival, and other ecological evidence are consistent with a changing sub-population status. Also, observations of changes in polar bear body condition and unusual hunting behaviours in polar bears (e.g. cannibalism, digging through solid ice to find seals) suggest a sub-population that may be under nutritional stress (Amstrup *et al.* 2006, Stirling unpublished observations). These observations parallel those made in western Hudson Bay (see below), where changes in sea ice, caused by warmer temperatures, have caused sub-population reductions. These observations, therefore, mandate increased vigilance in the southern Beaufort Sea region.

Stirling (2002) reviewed the ecology of polar bears and seals in the Canadian sector of the Beaufort Sea from 1970 through 2000. Research incorporating the collection and analysis of radio-telemetry data in the SB region has continued on a nearly annual basis through the present time. Recent analyses of radio-telemetry data using new spatial modelling techniques suggest realignment of the boundaries of the SB area (Amstrup *et al.* 2004, 2005). We now know that nearly all bears in the central coastal region of the Beaufort Sea are from the SB subpopulation, and that proportional representation of SB bears decreases to both the west and east. For example only 50% of the bears occurring in Barrow (Alaska) and Tuktoyaktuk (Northwest Territories) are SB bears, with the remainder being from the Chukchi (CS) and northern Beaufort Sea (NB) subpopulations, respectively. The recent radio-telemetry data indicate that bears from the SB subpopulation seldom reach Pearce Point, which is currently on the eastern management boundary for the SB subpopulation.

Historically, a principal assumption of the IGC/NSB Agreement was that polar bears harvested within the SB region came from a single subpopulation. However, our improved understanding of the spatiotemporal use patterns of bears in the SB region provides the foundation for improved harvest management, based on the geographic probability of bears occurring in specific areas at specific times of the year (Amstrup *et al.* 2005). Assignment of new boundaries based upon this information will probably necessitate a readjustment of the total size of the SB subpopulation, to correspond with a smaller geographic area. This adjustment is likely to reduce the estimated size of the SB subpopulation because some polar bears formerly assigned to the SB will be re-assigned to the NB and CS subpopulations. However, for purposes of this report we continue to use the previously-published boundaries for the SB subpopulation. This subpopulation is assessed using the sustainable yield criteria previously reported.

The primary management and conservation concerns for the SB subpopulation are: 1) climate warming, which continues to increase both the expanse and duration of open water in summer and fall; 2) human activities, including hydrocarbon exploration and development occurring within the near-shore environment; 3) changing atmospheric and oceanic transport of contaminants into the region; and 4) possible inadvertent over-harvest of the SB subpopulation, if it becomes increasingly nutritionally-stressed or declines due to some combination of the aforementioned threats.

Northern Beaufort Sea (NB)

Studies of movements and subpopulation estimates of polar bears in the eastern Beaufort Sea have been conducted using telemetry and mark-recapture at intervals since the early 1970s (Stirling *et al.* 1975, 1988, DeMaster *et al.* 1980, Lunn *et al.* 1995). As a result, it was recognized that there were separate subpopulations in the North and South Beaufort Sea areas and not a single subpopulation as was suspected initially (Stirling *et al.* 1988, Amstrup 1995, Taylor and Lee 1995, Bethke *et al.* 1996). The density of polar bears using the multi-year ice north of the main study area was lower than it was further south. The subpopulation estimate of 1,200 polar bears (Stirling *et al.* 1988) for the North Beaufort Sea (NB) was believed to be unbiased at the time but the northwestern coast of Banks Island was not completely surveyed because of perceived conflicts with guided sport hunters in the area at that time. A coordinated, intensive mark and recapture study covering the whole of the Beaufort Sea and Amundsen Gulf will be completed in 2006; a final analysis and report will follow. Until this new estimate is available, the previous estimate and quota will continue to be used for management purposes. The harvest is being closely monitored and appears to be sustainable.

Recent analyses, using data from satellite tracking of female polar bears and new spatial modelling techniques, indicate the boundary between NB and the southern Beaufort Sea (SB) subpopulations needs to be adjusted, probably expanding the area occupied by bears from NB and retracting that of SB (Amstrup *et al.* 2004, 2005).

The primary concerns for this subpopulation are from climate warming that continues to expand both the expanse and duration of open water in summer and fall, changing characteristics of atmospheric and oceanic transport of contaminants into the region, and possible inadvertent over-harvest of a subpopulation stressed or declining as a result of the previous threats.

Viscount Melville Sound (VM)

A five-year study of movements and size of the Viscount Melville Sound (VM) subpopulation, using telemetry and mark-recapture, was completed in 1992 (Messier *et al.* 1992, 1994, Taylor *et al.* 2002). Subpopulation boundaries are based on observed movements of female polar bears with satellite radio-collars and movements of bears tagged in and out of the study area (Bethke *et al.* 1996, Taylor *et al.* 2001*b*). The current subpopulation estimate of 215 (SE = 58) was based on estimates time referenced to 1993 (Taylor *et al.* 2002). When quotas were originally allocated in the 1970s, the size and productivity of the subpopulation was thought to be greater because they occurred in such a large geographic area. However, this area is characterized by heavy multi-year ice and low densities of ringed seals (Kingsley *et al.* 1985), and the productivity and density of polar bears was lower than initially expected. Consequently, quotas were reduced and a five-year moratorium on hunting began in 1994/95. Hunting resumed in 1999/2000 with an annual quota of four bears.

In 1999, the former Northwest Territories (NWT) was divided into two new territories: NWT and Nunavut and resulted in the VM subpopulation being shared between the two jurisdictions. In 2004/2005 the annual quota was increased to seven bears (NWT – four, Nunavut – three).

Norwegian Bay (NW)

The Norwegian Bay (NW) polar bear subpopulation is bounded by heavy multi-year ice to the west, islands to the north, east, and west, and polynyas to the south (Stirling 1980, 1997, Taylor *et al.* 2001b, unpubl. data). From data collected during mark-recapture studies, and from satellite radio-tracking of adult female polar bears, it appears that most of the polar bears in this subpopulation are concentrated along the coastal tide cracks and ridges along the north, east, and southern boundaries (Taylor *et al.* 2001b). The preponderance of heavy multi-year ice through most of the central and western areas has resulted in low densities of ringed seals (Kingsley *et al.* 1985) and, consequently, low densities of polar bears. Based on preliminary data, the current (1993–97) estimate for this subpopulation is 190 bears (SE = 48.1) (M.K. Taylor *et al.*, unpubl. data). Survival rate estimates for the NW subpopulation were derived from pooled Lancaster Sound and NW data because the subpopulations are adjacent and because the number of bears captured in Lancaster Sound was too small for reliable survival estimates. Recruitment estimates were derived from the standing age distribution (Taylor *et al.* 2000). The harvest quota for the NW subpopulation was reduced to four bears (three males and one female) in 1996.

Lancaster Sound (LS)

The central and western portion of the Lancaster Sound (LS) subpopulation region is characterized by high biological productivity and high densities of ringed seals and polar bears (Schweinsburg *et al.* 1982, Stirling *et al.* 1984, Kingsley *et al.* 1985, Welch *et al.* 1992). The western third of this region (eastern Viscount Melville Sound) is dominated by heavy, multi-year ice and apparently low biological productivity, as evidenced by low densities of ringed seals (Kingsley *et al.* 1985). In the spring and summer, densities of polar bears in the western third of the area are low; however, as break-up occurs, polar bears move west to summer on the multi-year pack. Recent information on the movements of adult female polar bears monitored by satellite radio-collars, and mark-recapture data from past years, has shown that this subpopulation is distinct from the adjoining Viscount Melville Sound, M'Clintock Channel, Gulf of Boothia, Baffin Bay and Norwegian Bay subpopulations (Taylor *et al.* 2001b). For PVA in this status report, survival rates of polar bears in the Norwegian Bay and Lancaster Sound subpopulations were pooled to minimize sampling errors. The current subpopulation estimate of 2,541 bears (SE = 391) is based on an analysis of both historical and current mark-recapture data to 1997 (M.K. Taylor *et al.*, unpubl. data). This estimate is considerably larger than a previous estimate of 1,675 that included Norwegian Bay (Stirling *et al.* 1984), and was considered to be conservative. Taylor *et al.* (unpubl. data) also estimate a suite of survival and recruitment parameters (Table 2) that suggest this subpopulation has a lower renewal rate than previously estimated.

M'Clintock Channel (MC)

The current subpopulation boundaries for the M'Clintock Channel (MC) subpopulation of polar bears are based on recovery of tagged bears and movements of adult females with satellite radio-collars in adjacent areas (Taylor and Lee 1995, Taylor *et al.* 2001*b*). These boundaries appear to be a consequence of large islands to the east and west, the mainland to the south, and the heavy multi-year ice in Viscount Melville Sound to the north. A six-year mark-recapture study covered most of this area in the mid-1970s (Furnell and Schweinsburg 1984). An estimate of 900 bears was derived from the data collected within the boundaries proposed for the M'Clintock Channel subpopulation, as part of a study conducted over a larger area of the Central Arctic (Furnell and Schweinsburg 1984). More recently, local hunters suggested 900 might be too high, so the Canadian Polar Bear Technical Committee accepted a recommendation to reduce the estimate to 700.

Following the completion of a mark-recapture inventory in spring 2000, the subpopulation was estimated to number 284 (SE = 59.3) (Taylor *et al.* in review). Natural survival and recruitment rates (Table 2) were also estimated at values lower than previous standardized estimates (Taylor *et al.* 1987). The Government of Nunavut implemented a moratorium on hunting for the 2001/2002 and 2002/2003 hunting seasons. The current annual quota for MC is three bears.

Gulf of Boothia (GB)

The subpopulation boundaries of the Gulf of Boothia (GB) polar bear subpopulation are based on genetic studies (Paetkau *et al.* 1999), movements of tagged bears (Stirling *et al.* 1978, Taylor and Lee 1995), movements of adult females with satellite radio-collars in GB and adjacent areas (Taylor *et al.* 2001b), and interpretations by local Inuit hunters of how local conditions influence the movements of polar bears in the area. An initial subpopulation estimate of 333 bears was derived from data collected as part of a study conducted over a larger area of the Central Arctic (Furnell and Schweinsburg 1984). Although subpopulation data from GB were limited, local hunters reported that the subpopulation was stable or had increased since the time of the Central Arctic Polar Bear survey. Based on Inuit knowledge, recognition of sampling deficiencies, and polar bear densities in other areas, in the 1990s an interim subpopulation estimate of 900 for GB was established.

Following the completion of a mark-recapture inventory in spring 2000, the subpopulation was estimated to number 1,523 bears (SE = 285) (M.K. Taylor *et al.*, unpubl. data). Natural survival and recruitment rates (Table 2) were estimated at values higher than the previous standardized estimates (Taylor *et al.* 1987).

Foxe Basin (FB)

Based on 12 years of mark-recapture studies, tracking of female bears with conventional radios, and satellite tracking of adult females in western Hudson Bay and southern Hudson Bay, the Foxe Basin (FB) subpopulation of polar bears appears to occur in Foxe Basin, northern Hudson Bay, and the western end of Hudson Strait (Taylor and Lee 1995). During the ice-free season, polar bears are concentrated on Southampton

Island and along the Wager Bay coast; however, significant numbers of bears are also encountered on the islands and coastal regions throughout the Foxe Basin area. A total subpopulation estimate of 2,119 bears (SE = 349) was developed in 1996 (M.K. Taylor, unpubl. data) from a mark-recapture analysis based on tetracycline biomarkers (Taylor and Lee 1994). The marking effort was conducted during the ice-free season, and distributed throughout the entire area. The subpopulation estimate is believed to be accurate, but dated. Simulation studies suggest that the previous harvest quotas prior to 1996 reduced the subpopulation from about 3,000 bears in the early 1970s to about 2,100 bears in 1996. Harvest levels were reduced in 1996 to permit slow recovery of this subpopulation, provided that the kill in Québec did not increase.

In December 2004, TEK indicated that the subpopulation had increased. After consultations with native communities, Nunavut increased the harvest quota to a level consistent with a subpopulation level of 2,300 bears. Co-management discussions with Québec are ongoing. Survival and recruitment rates used for risk assessment are based on the detailed rates obtained for the adjacent Baffin Bay subpopulation (Taylor *et al.* 2005).

Western Hudson Bay (WH)

The distribution, abundance, and population boundaries of the Western Hudson Bay (WH) polar bear subpopulation have been the subject of research programmes since the late 1960s (Stirling *et al.* 1977, 1999, Derocher and Stirling 1995a,b, Taylor and Lee 1995, Lunn *et al.* 1997). Over 80% of the adult subpopulation is marked, and there are extensive records from capture-recapture studies and tag returns from polar bears killed by Inuit hunters. During the open water season, the WH subpopulation appears to be geographically segregated from the Southern Hudson Bay subpopulation to the east and the Foxe Basin subpopulation to the north. During the winter and spring, the three subpopulations mix extensively on the sea ice covering Hudson Bay (Stirling *et al.* 1977, Derocher and Stirling 1990, Stirling and Derocher 1993, Taylor and Lee 1995). The size of the WH subpopulation was estimated to be 1,200 bears in autumn, in 1988 and 1995 (Derocher and Stirling 1995*a*, Lunn *et al.* 1997). At that time, the size of the WH subpopulation appeared to be stable, and the harvest was believed to be sustainable.

Over the past three decades, there have been significant declines in the body condition of adult male and female polar bears, and in the proportion of independent yearlings captured during the open water season in western Hudson Bay (Derocher and Stirling 1992, 1995b, Stirling and Lunn 1997, Stirling *et al.* 1999, N. Lunn and I. Stirling, unpubl. data). Over the same period, the average date of spring break-up of the sea ice in the region has advanced by three weeks (Stirling *et al.* 1999, 2004), presumably due to increasing spring air temperatures. Warming rates in western Hudson Bay between 1971 and 2001 ranged from a minimum 0.5°C per decade at Churchill, Manitoba, to 0.8°C per decade at Chesterfield Inlet, Nunavut (Gagnon and Gough 2005). Stirling *et al.* (1999) documented a significant correlation between the timing of sea ice break-up and the body condition of adult female polar bears (i.e., early break-up was associated with poor body condition). Stirling *et al.* (1999) also suggested that the declines in various life history parameters of polar bears in western Hudson Bay were the result of nutritional stress associated with the trend toward earlier break-up, which in turn appears to be due to long-term warming.

An updated analysis of capture-recapture data from the WH subpopulation was completed in 2005 (E. Regehr *et al.*, U.S. Geological Survey, in review). Between 1987 and 2004, the number of polar bears in the WH subpopulation declined from 1,194 (95% CI = 1020, 1368) to 935 (95% CI = 794, 1076), a reduction of about 22%. This decline appears to have been initiated by progressive declines in the body condition and survival of cubs, subadults, and bears 20 years of age and older, caused by the earlier break-up of spring sea ice as a result of climate warming. Once the subpopulation began to decline because of changing environmental conditions, the existing harvest was no longer sustainable, and the additive effects of climate change and over-harvest most likely accelerated the decline in subpopulation size between 1987 and 2004. The harvest sex ratio of two males per female has resulted in a skewed sex ratio within the subpopulation of 65% female and 35% male polar bears (E. Regehr *et al.*, U.S. Geological Survey, unpubl. data).

Concurrent with the recent re-assessment of the size of the WH subpopulation, an increased number of polar bears have been reported in and around human settlements along the coast of western Hudson Bay. In some communities, this increase in polar bear sightings has been interpreted as evidence that the size of the WH subpopulation is increasing. Based on this perception, the government of Nunavut in December 2004 increased its quota for the number of polar bears that could be harvested from the WH subpopulation from 55 to 64 polar bears. In order to sustain this increased level of harvest, Nunavut estimated that the size of the WH subpopulation would have to be at least 1,400 bears; this is the subpopulation estimate currently used by Nunavut for management purposes. An alternate explanation for the apparent increase in polar bears in the vicinity of human settlements and hunting camps is that, because of declines in body condition associated with the earlier sea ice break-up, polar bears in western Hudson Bay have less time to accumulate the fat reserves that they depend on during the open water season. As polar bears deplete their fat reserves toward the end of the open water season, they are more likely to seek alternative food sources around human settlements to sustain themselves until freeze-up.

Southern Hudson Bay (SH)

Boundaries of the Southern Hudson Bay (SH) polar bear subpopulation are based on movements of marked bears and telemetry studies (Jonkel *et al.* 1976, Kolenosky and Prevett 1983, Kolenosky *et al.* 1992, Taylor and Lee 1995). Recently completed research using satellite radio-collared bears was aimed at refining the boundaries of this subpopulation (M. Obbard, M.K. Taylor, and F. Messier, unpubl. data) and estimating the subpopulation size and rates of birth and death (M. Obbard, unpubl. data). The current estimate of the size of the subpopulation comes from a three-year (1984–1986) mark-recapture study, conducted mainly along the Ontario coastline (Kolenosky *et al.* 1992). This study and the more recent telemetry data have documented seasonal fidelity to the Ontario coast during the ice-free season, and some intermixing with the Western Hudson Bay and Foxe Basin subpopulations during months when the bay is frozen over. In 1988, the results of a modelling workshop included an increase in the subpopulation estimate from 900 to 1,000 bears because portions of the eastern and western coastal areas were not included during original sampling. Additionally, the area away from the coast may have been under-sampled due to difficulties in locating polar bears inland (i.e., below the tree line). Thus, some classes of bears, especially pregnant females, may have been under-sampled. The estimate of 1,000 bears in this status report is considered dated. The final year of a mark-recapture inventory was completed in fall 2005; a new subpopulation estimate should be available soon.

Based on the estimate of 1,000 bears, the total harvest by Nunavut, Ontario, and Québec appears to be sustainable. Recent analysis of coastal survey data (Stirling *et al.* 2004) suggests that polar bear numbers in SH have remained unchanged in recent years. However, Stirling *et al.* (1999) and Derocher *et al.* (2004) contend that climate-related reductions in sea ice appear to have resulted in declines in body condition and in reproductive rate in the Western Hudson Bay subpopulation. A similar pattern of decline in body condition was documented for the SH subpopulation when comparing bears captured in 1984–86 with those captured in 2000–04 (M. Obbard, unpubl. data); however, it is unknown whether changes in demographic parameters have occurred.

Kane Basin (KB)

Based on the movements of adult females with satellite radio-collars and recaptures of tagged animals, the boundaries of the Kane Basin (KB) polar bear subpopulation include the North Water Polynya (to the south of KB), and Greenland and Ellesmere Island to the west, north, and east (Taylor *et al.* 2001b). Polar bears in Kane Basin do not differ genetically from those in Baffin Bay (Paetkau *et al.* 1999). Prior to 1997, this subpopulation was essentially unharvested in Canadian territory because of its distance from Grise Fiord, the closest Canadian community, and because conditions for travel in the region are typically difficult. However, this subpopulation has occasionally been harvested by hunters from Grise Fiord since 1997, and continues to be harvested on the Greenland side of Kane Basin. In some years, Greenland hunters have also harvested polar bears in western Kane Basin and Smith Sound (Rosing-Asvid and Born 1990, 1995).

Few polar bears were encountered by researchers along the Greenland coast from 1994 through 1997, possibly because of previously intense harvest pressure by Greenland hunters. The current estimate of the KB subpopulation is 164 (SE=35) (M.K. Taylor, unpubl. data) and the best estimate of the Greenland kill is 10 bears per year during 1999–2003 (Born 2005, Born and Sonne 2005). However, the actual number being taken by Greenland hunters is uncertain (Born 2001, Born and Sonne 2005) and must be validated. The Canadian quota for this subpopulation is five and if Canadian Inuit continue to harvest from this area, over-harvest and subpopulation depletion could occur. The annual combined Canadian and Greenlandic take of 10–15 from the KB subpopulation is unsustainable (Table 1). Although the habitat appears suitable for polar bears on both the Greenland and Canadian sides of Kane Basin, the densities of polar bears on the Greenland (harvested) side were much lower than on the Canadian side, suggesting that this subpopulation may have been larger in past years, and could be managed for subpopulation increase. Co-management discussions between Greenland and Canada are continuing; Greenland has decided to move to a quota system taking effect from 1 January 2006 (Lønstrup, this volume).

Baffin Bay (BB)

Based on the movements of adult females with satellite radio-collars and recaptures of tagged animals, the area in which the Baffin Bay (BB) subpopulation occurs is bounded by the North Water Polynya to the north, Greenland to the east, and Baffin Island to the west (Taylor and Lee 1995, Taylor *et al.* 2001b). A relatively distinct southern boundary at Cape Dyer, Baffin Island, is evident from the movements of tagged bears (Stirling *et al.* 1980) and recent movement data from polar bears monitored by satellite telemetry (Taylor *et al.* 2001b). A study of micro-satellite variation did not reveal any genetic differences between polar bears in Baffin Bay and Kane Basin, although Baffin Bay bears differed significantly from Davis Strait and Lancaster Sound bears (Paetkau *et al.* 1999). An initial subpopulation estimate of 300–600 bears was based on mark-recapture data collected in spring (1984–1989) in which the capture effort was restricted to shore-fast ice and the floe edge off northeast Baffin Island (R.E. Schweinsburg and L.J. Lee, unpubl. data). However, recent work has shown that an unknown proportion of the subpopulation is typically offshore during the spring and, therefore, unavailable for capture. A second study (1993–1997) was carried out annually during the months of September and October, when all polar bears were ashore in summer retreat areas on Bylot and Baffin islands (Taylor *et al.* 2005). Taylor *et al.* (2005) estimated the number of polar bears in BB at 2,074 bears (SE = 266).

The BB subpopulation is shared with Greenland, which does not limit the number of polar bears harvested. Using mark-recapture, Taylor *et al.* (2005) estimated the Greenland annual removal at 18–35 bears for the period 1993–1997. However, Born (2002) had reported that the estimated Greenland average annual catch of polar bears from the BB subpopulation was 73 over the period 1993-1998. More recently, Born and Sonne (this volume) indicated the BB average annual kill from 1999-2003 for Greenland was 115 (range: 68-206 bears per year) with an increasing trend. In December 2004, based on reports from Inuit hunters that polar bear numbers in BB had grown substantially, Nunavut increased its BB polar bear quotas from 64 to 105 bears.

The BB subpopulation appears to be substantially over-harvested. The current (2004) estimate of subpopulation size is less than 1,600 bears based on simulations using the pooled Canadian and Greenland harvest records (Table 1). Co-management discussions between Greenland and Canada are ongoing. At the 2005 meeting of the IUCN/SSC Polar Bear Specialist Group, Greenland indicated its intention to adopt a quota system effective 1 January 2006.

Davis Strait (DS)

Based on the movements made by tagged animals and, more recently, of adult females with satellite radio-collars, the Davis Strait (DS) subpopulation includes polar bears in the Labrador Sea, eastern Hudson Strait, Davis Strait south of Cape Dyer, and along the eastern edge of the Davis Strait-southern Baffin Bay pack ice. When bears occur in the latter area they are subject to catch from Greenlanders (Stirling and Kiliaan 1980, Stirling *et al.* 1980, Taylor and Lee 1995, Taylor *et al.* 2001b). A genetic study of polar bears (Paetkau *et al.* 1999) indicated significant differences between bears from Davis Strait and both Baffin Bay and Foxe Basin. The initial subpopulation estimate of 900 bears for DS (Stirling *et al.* 1980) was based on a subjective correction from the original mark-recapture estimate of 726 bears, which was felt to be too low because of possible bias in the sampling. In 1993, the Canadian Polar Bear Technical Committee increased the estimate to 1,400 bears to account for bias in sampling created by the inability of researchers to survey the extensive area of offshore pack ice (I. Stirling and M.K. Taylor, unpubl. data). Traditional ecological knowledge also suggested that the subpopulation had increased over the last 20 years. The principal justification for this adjustment is based on the observation that the annual harvest has been sustained for the last 20 years and on non-quantitative observations that continue to suggest the subpopulation has increased.

The IUCN Polar Bear Specialist Group has at its 11th, 12th and 13th meetings indicated that the DS subpopulation was either stable or perhaps declining due to over-harvest (IUCN/SSC Polar Bear Specialist Group 1995, 1998, 2002).

In December 2004, Nunavut increased its polar bear quota in DS by 12 bears based on Inuit reports that the subpopulation had increased since 1996. In order to sustain this increased level of harvest, Nunavut estimated that the size of the DS subpopulation would have to be at least 1,650 bears; this is the subpopulation estimate currently used by Nunavut for management purposes. A mark-recapture inventory is currently underway to assess the size of the DS subpopulation. Within Canada, this subpopulation is harvested by Inuit from Nunavut, Québec, and Labrador. The combined harvest by these jurisdictions, Nunavut and Greenland (*c.* one per year in Greenland during 1999–2003; Born and Sonne, this volume) totalled 65 (Table 1). Co-management discussions between Greenland and Canada are continuing, and Greenland has indicated its intention to move to a quota system taking effect from 1 January 2006. A population inventory began in summer of 2005 to develop a scientific estimate of subpopulation numbers. Survival and recruitment rates used for risk assessment are based on the detailed rates obtained for the adjacent Baffin Bay subpopulation (Taylor *et al.* 2005).

Arctic Basin (AB)

The Arctic Basin subpopulation is a geographic catch-all to account for bears that may be resident in areas of the circumpolar Arctic that are not clearly part of other subpopulations. Polar bears occur at very low densities here and it is known that bears from other subpopulations use the area (Durner and Amstrup 1995). As climate warming continues, it is anticipated that this area may become more important for polar bears as a refugia but a large part of the area is over the deepest waters of the Arctic Ocean and biological productivity is thought to be low.

Threats and uncertainties

Anthropogenic and natural changes in arctic environments, as well as new recognition of the shortcomings of our knowledge of polar bear ecology, are increasing the uncertainties of polar bear management. Higher temperatures and erratic weather fluctuations, symptoms of global climate change, are increasing across the range of polar bears. Following the predictions of climate modellers, such changes have been most prevalent in arctic regions (Stirling and Derocher 1993, Stirling and Lunn 1997, Stirling *et al.* 1999, Derocher *et al.* 2004), and have already altered local and global sea-ice conditions (Gloersen and Campbell 1991, Vinnikov *et al.* 1999, Serreze *et al.* 2000, Parkinson and Calvalieri 2002, Comiso 2002, 2003, Gough *et al.* 2004). Because changes in sea-ice are known to alter polar bear numbers and productivity (Stirling and Lunn 1997, Stirling *et al.* 1999, Derocher *et al.* 2004), effects of global climate warming can only increase future uncertainty and may increase risks to the welfare of polar bear subpopulations. Uncertainty about effects of climate change on polar bears must be included in future management and conservation plans. In the face of climate change, the need for rigorous scientific information will increase.

Persistent organic pollutants, which reach arctic regions via air and water currents, also increase uncertainty for the welfare of polar bears. Recent studies document new pollutants in polar bear tissues (Smithwick *et al.* 2005, Verrault *et al.* 2005, Muir *et al.* 2006). The effects of pollutants on polar bears are only partially understood. Levels of such pollutants in some polar bear subpopulations, however, are already sufficiently high that they may interfere with hormone regulation, immune system function, and possibly reproduction (Wiig *et al.* 1998, Bernhoft *et al.* 2000, Skaare *et al.* 2000, 2001, Henriksen *et al.* 2001). Subpopulation level impacts on polar bears are unknown, at present, but reproductive and survival rates may be affected (Derocher *et al.* 2003, Derocher 2005).

Our understanding of polar bear subpopulation dynamics has greatly improved with increasing development of analysis methods (Lebreton *et al.* 1992, Amstrup *et al.* 2001, McDonald and Amstrup 2001, Manley *et al.* 2003, Taylor *et al.* 2002, 2005). These new tools suggest that previous estimates of subpopulation parameters and numbers can be biased. Vital rates are subpopulation specific, and different from the generalized rates that were often used to generate previous status reports (Taylor *et al.* 1987). Additionally, computer simulations (e.g., Taylor *et al.* in review) suggest that harvesting polar bear subpopulations at or near maximum sustained yield puts the subpopulation at greater risk than previously believed.

The International Polar Bear Agreement

In the early 1960s, great concern was expressed about the increasing harvest of polar bears. In 1965, representatives from the five "polar bear countries" met in Fairbanks, Alaska to discuss protection of polar bears. At the time that this first international meeting was convened, there was little management in effect except for the USSR, where polar bear hunting was prohibited in 1956 (Prestrud and Stirling 1994). At this meeting the following points were agreed upon:

- The polar bear is an international circumpolar resource.
- Each country should take whatever steps are necessary to conserve the polar bear until the results of more precise research findings can be applied.
- Cubs, and females accompanied by cubs, should be protected throughout the year.
- Each nation should, to the best of their ability, conduct research programmes on polar bears within its territory.
- Each nation should exchange information freely, and IUCN should function to facilitate such exchange.
- Further international meetings should be called when urgent problems or new scientific information warrants international consideration.
- The results of the First International Scientific Meeting on the polar bear should be published.

Following the first international meeting on polar bear conservation, the IUCN Polar Bear Specialist Group (PBSG) was formed to coordinate research and management of polar bears on an international basis. In addition, this group took on the role of developing and negotiating the Agreement on the Conservation of Polar Bears and Their Habitat (the Agreement). That Agreement was signed in Oslo, Norway in May 1973 and came into effect for a 5-year trial period in May 1976. The Agreement was unanimously confirmed for an indefinite period in January 1981.

Article VII of the Agreement stipulates that: "The Contracting parties shall conduct national research programmes on polar bears, particularly research relating to the conservation and management of the species. They shall as appropriate coordinate such research with the research carried out by other Parties, consult with other Parties on management of migrating polar bear populations, and exchange information on research and management programmes, research results, and data on bears taken." To meet the conditions of Article VII of the Agreement, the IUCN PBSG meets every 3–5 years.

The Agreement did not provide for protection of female polar bears accompanied by cubs or for the cubs themselves. Annex E to the Agreement drew attention to the need for this protection (Appendix 2). In 1997, the PBSG reviewed Annex E and reaffirmed the need for special protection measures for adult females (Appendix 2), but noted that the occasional take of cubs for cultural and nutritional purposes by subsistence users did not present a conservation concern.

The importance of the Agreement

A primary goal of the Agreement was to limit the hunting of polar bears to sustainable levels. Because so many management changes had already been put in place during the period when the Agreement was being negotiated, there was little detectable impact immediately following it being signed and ratified (Prestrud and Stirling 1994). However, there is no doubt that the knowledge that the Agreement was being negotiated, and was likely to be successful, was a significant stimulus (Fikkan *et al.* 1993). The Alaskan harvest rate was reduced by 50% following the MMPA in 1972.

To date, the Agreement has been the most important single influence on the development of internationally coordinated management and research programmes, which have ensured the survival of polar bears (Prestrud and Stirling 1994). The Agreement is not enforceable by law in any of the countries that have signed it, a weakness that has been identified in previous reviews of international wildlife law. It has been successful in bringing the harvest of polar bears within sustainable limits for most populations, while still facilitating harvest by local people. Most of the original habitat of polar bears is still intact (although not protected) and uninhabited. The polar bear is the only bear, and probably one of the only large carnivores, that still occurs throughout most of its original range.

The IUCN Polar Bear Specialist Group

The work of the PBSG has always been important to the Agreement. Initially, membership was limited to government biologists working on polar bears because one of the principal tasks was negotiation of the Agreement. After the Agreement was signed, "Invited Specialists" were included to facilitate the input of experts in fields like population dynamics and physiology. One of the reasons the PBSG has been so successful is that members have been appointed by government agencies and have usually been polar bear specialists as well. Because governments have been more directly involved in the work of this Specialist Group, they have also had a vested interest in its success. Consequently, the people going to meetings have had a fair amount of authority to make decisions and commitments.

The PBSG has no regulatory function and the main function is to promote cooperation between jurisdictions that share polar bear populations, facilitate communication on current research and management, and monitor compliance with the agreement. The PBSG is not an open forum for public participation; it is a technical group that meets to discuss technical matters that relate to the Agreement. The deliberations and resolutions adopted by the PBSG are available to the public as are the published proceedings of the meetings. They have been published in the IUCN Occasional Papers Series of the IUCN Species Survival Commission (SSC).

One strength of the group has always been its small size. Because of the relationship of the PBSG to the Agreement, membership must reflect not only technical expertise in polar bear research and management, but also equal representation of the nations signatory to the Agreement. For this reason, each nation is entitled to designate three full members. However, in matters that require a vote (*e.g.*, elections and resolutions), each member nation is allowed only one vote. Each nation is at liberty to independently determine their process for casting a single vote. Only government-appointed members may vote. Government-appointed members are chosen by their respective governments.

In addition to government-appointed members, the chairman may, as per IUCN guidelines for membership in Specialist Groups, appoint five full members so long as they qualify as polar bear specialists. Full members appointed by the chair and government appointed members constitute the membership of the PBSG between meetings. The chair-appointed members are considered members until the election of a new chairman, which occurs at the end of each meeting. In this way the number of members of the PBSG will not exceed 20.

A third category titled: "Invited Specialists" is recognised. These individuals are not considered full members, but are invited to participate in a given meeting or parts of the meeting as designated by the Chairman.

These guidelines are intended to maintain the integrity of the PBSG as a small working group of technical specialists on polar bears while still ensuring that it is responsible to the governments signatory to the Agreement, the IUCN, and the international conservation community.

Conservation Action Plan for polar bears

The PBSG considers the Agreement to be an action plan for the conservation of polar bears.

References

Amstrup, S.C. 1995. Movements, distribution, and population dynamics of polar bears in the Beaufort Sea. Ph.D. Dissert. Univ. Alaska, Fairbanks, Alaska. 299 pp.

Amstrup, S.C. and DeMaster, D.P. 1988. Polar bear *Ursus maritimus*. Pp. 39-56 In Lentfer, J.W. (ed.). *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations*. Marine Mammal Commission, Washington, DC, USA.

Amstrup, S.C., Durner, G.M., Stirling, I. and McDonald, T.L. 2005. Allocating harvests among polar bear stocks in the Beaufort Sea. *Arctic* **58**:247-259.

Amstrup, S.C., Garner, G.W. and Durner, G.M. 1995. Polar bears in Alaska. Pp. 351-353 In *Our Living Resources*. U.S. National Biological Service, Washington, DC, USA.

Amstrup, S.C., McDonald, T.L. and Durner, G.M. 2004. Using satellite radio-telemetry data to delineate and manage wildlife populations. *Wildl. Soc. Bull.* **32**:661-679.

Amstrup, S.C., McDonald, L.L. and Stirling, I. 2001. Polar bears in the Beaufort Sea: a 30-year mark-recapture case history. *J. Agr. Biol. Environ. Stat.* **6**:201-214.

Amstrup, S.C., Stirling, I. and Lentfer, J.W. 1986. Past and present status of polar bears in Alaska. *Wildl. Soc. Bull.* **14**:241-254.

Andersen, M., Lie, E., Derocher, A.E., Belikov, S.E., Bernhoft, A., Boltunov, A.N., Garner, G.W., Skaare, J.U. and Wiig, Ø. 2001. Geographical variation of PCB congeners in polar bears (*Ursus maritimus*) from Svalbard east to the Chukchi Sea. *Polar Biol.* **24**:231-238.

Belikov, S.E. 1993. The polar bear. Pp. 420-478 In Vaysfeld, M.A. and Chestin, I.E. (eds.). *Bears*. Moscow, Nauka. (In Russian with English summary).

Belikov, S.E., Chelintsev, N.G., Kalyakin, V.N., Romanov, A.A. and Uspenski, S.M. 1991. Results of the aerial counts of the polar bear in the Soviet Arctic in 1988. Pp. 75-79 In Amstrup, S.C. and Wiig, Ø. (eds.). *Polar Bears: Proceedings of the Tenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Belikov, S.E., Garner, G.W., Wiig, Ø., Boltunov, A.N. and Gorbunov, Y.A. 1998. Polar bears of the Severnaya Zemlya archipelago of the Russian Arctic. *Ursus* 10:33-40.

Belikov, S.E. and Gorbunov, Yu.A. 1991. Distribution and migrations of the polar bear in the Soviet Arctic in relation to ice conditions. Pp. 70-74 In Amstrup, S.C. and Wiig, Ø. (eds.). *Polar Bears: Proceedings of the Tenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Belikov, S. and Matveev, L.G. 1983. Distribution and number of polar bears and their dens on Franz-Josef Land. Pp.84-85. In: *Rare Mammals of USSR and Their Protection*. Materials of the III All-Union Meeting, Moscow. (In Russian).

Belikov, S.E. and Randla, T.E. 1987. Fauna of birds and mammals of Severnaya Zemlya. Pp. 18-28 In Syroyechkovskiy, E.E. (ed.). *Fauna and Ecology of Birds and Mammals in Middle Siberia*. Nauka, Moscow. (In Russian)

Bernhoft, A., Skaare, J.U., Wiig, Ø., Derocher, A.E. and Larsen, H.J.S. 2000. Possible immunotoxic effects of organochlorines in polar bears (*Ursus maritimus*) at Svalbard. *J. Toxicol. Environ. Health A* **59**:561-574.

Bernhoft, A., Wiig, Ø. and Skaare J.U. 1997. Organochlorines in polar bears (*Ursus maritimus*) at Svalbard. *Envir. Poll.* **96**:159-175.

Bethke, R., Taylor, M.K., Amstrup, S.C. and Messier, F. 1996. Population delineation of polar bears using satellite collar data. *Ecol. Appl.* **6**:311-317.

Born, E.W. 1995. Research on polar bears in Greenland, ultimo 1988 to primo 1993. Pp.105-107 In Wiig, Ø., Born, E.W. and Garner, G.W. (eds.). *Polar Bears: Proceedings of the Eleventh Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Born, E.W. 2001. The Greenland catch of polar bears from the Davis Strait, Baffin Bay and Kane Basin areas, 1993-99. Working paper to the Canadian Polar Bear Technical Committee meeting, 7-9 February 2001, Edmonton, 7 pp.

Born, E.W. 2002. Research on polar bears in Greenland 1997-2001. Pp.67-74 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Born, E.W. 2005. The catch of polar bears in Greenland 1993-(2004). Working paper to the Canadian Polar Bear Technical Committee meeting, 7-9 February 2005, Edmonton, 10 pp.

Born, E.W. and Sonne, C. This volume. Research on polar bears in Greenland 2001-2005. Report to the 14th Working Meeting of the IUCN Polar Bear Specialist Group. Seattle, U.S.A., 20-24 June 2005.

Born, E.W., Wiig, Ø. and Thomassen, J. 1997. Seasonal and annual movements of radio collared polar bears (*Ursus maritimus*) in NE Greenland. *J. Mar. Syst.* **10**:67-77.

Brower, C.D., Carpenter, A., Branigan, M.L., Calvert, W., Evans, T., Fischbach, A.S., Nagy, J.A., Schliebe, S., Stirling, I. 2002. The polar bear management agreement for the Southern Beaufort Sea: An evaluation of the first ten years of a unique conservation agreement. *Arctic* **55**:362-372.

Chelintsev, N.G. 1977. Determination of the absolute number of dens based on the selective counts. Pp. 66-85 In Uspenski, S.M. (ed.). *The polar bear and its conservation in the Soviet Arctic*. Moscow, Central Laboratory on Nature Conservation. (In Russian with English summary).

Comiso, J.C. 2002. Correlation and trend studies of the sea ice cover and surface temperatures in the Arctic. *Annal. Glaciol.* **34**:420-428.

Comiso, J.C. 2003. Warming trends in the Arctic from clear-sky satellite observations. *J. Climatol.* **16**:3498-3510.

DeMaster, D.P., Kingsley, M.C.S. and Stirling, I. 1980. A multiple mark and recapture estimate applied to polar bears. *Can. J. Zool.* **58**:633-638.

Derocher, A.E. 2005. Population ecology of polar bears at Svalbard, Norway. *Pop. Ecol.* **47**: 267-275.

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

Derocher, A.E. and Stirling, I. 1990. Distribution of polar bears (*Ursus maritimus*) during the ice-free period in western Hudson Bay. *Can. J. Zool.* **68**:1395-1403.

Derocher, A.E. and Stirling, I. 1992. The population dynamics of polar bears in western Hudson Bay. Pp. 1150-1159 In McCullough, D.R. and Barrett, R.H. (eds.). *Wildlife 2001: Populations*. Elsevier Applied Science, London, UK.

Derocher, A.E. and Stirling, I. 1995a. Estimation of polar bear population size and survival in western Hudson Bay. *J. Wildl. Manage.* **59**:215-221.

Derocher, A. E. and Stirling, I. 1995b. Temporal variation in reproduction and body mass of polar bears in western Hudson Bay. *Can. J. Zool.* **73**:1657-1665.

Derocher, A.E., Stirling, I. and Calvert, W. 1997. Male-biased harvesting of polar bears in western Hudson Bay. *J. Wildl. Manage.* **61**:1075-1082.

Derocher, A.E., Wolkers, H., Colborn, T., Schlabach, M., Larsen, T.S. and Wiig, Ø. 2003. Contaminants in Svalbard polar bear samples archived since 1967 and possible population level effects. *Sci. Total Envir.* **301**:163-174.

Dietz, R., Riget, F.F., Sonne, C., Letcher, R., Born, E.W., and Muir, D.C.G. 2004. Seasonal and temporal trends in polychlorinated biphenyls and organochlorine pesticides in east Greenland polar bears (*Ursus maritimus*), 1990-2001. *Sci. Total Envir.* **331**:107-124.

Durner, G.M. and Amstrup, S.C. 1995. Movements of a female polar bear from northern Alaska to Greenland. *Arctic* **48**:338-341.

Eastridge, R. and Clark, J.D. 2001. Evaluation of 2 soft-release techniques to reintroduce black bears. *Wild. Soc. Bull.* **29**:1163–1174.

Fikkan, A., Osherenko, G. and Arikainen, A. 1993. Polar bears: the importance of simplicity. Pp. 96-151 In Young, O.R. and Osherenko, G. (eds.). *Polar Politics: Creating International Environmental Regimes*. Cornell Univ. Press, Ithaca, USA.

Furnell, D.J. and Schweinsburg, R.E. 1984. Population dynamics of central Canadian Arctic polar bears. *J. Wildl. Manage.* **48**:722-728.

Gagnon, A. S. and Gough, W. A. 2005. Trends in the dates of ice freeze-up and break-up over Hudson Bay, Canada. *Arctic* **58**:370-382.

Garner, G.W., Belikov, S.E. Stishov, M.S. and Arthur, S.M. 1995. Research on polar bears in western Alaska and eastern Russia 1988-92. Pp. 155-164 In Wiig, Ø. Born, E.W. and Garner, G.W. (eds.). *Polar Bears: Proceedings of the Eleventh Working Meeting of IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Garner, G.W, Belikov, S.E., Stishov, M.S., Barnes Jr., V.G. and Arthur, S.M. 1994. Dispersal patterns of maternal polar bears from the denning concentration on Wrangel Island. *Int. Conf. Bear Res. Manage.* **9**:401-410.

Garner, G.W., Knick, S.T. and Douglas, D.C. 1990. Seasonal movements of adult female bears in the Bering and Chukchi seas. *Int. Conf. Bear. Res. Manage.* **8**:219-226.

Gjertz, I., Aarvik, S. and Hindrum, R. 1993. Polar bears killed in Svalbard 1987-1992. *Polar Res.* **12**:107-109.

Gjertz, I. and Persen, E. 1987. Confrontations between humans and polar bears in Svalbard. *Polar Res.* **5**:253-256.

Gjertz, I. and Scheie, J.O. 1998. Human casualties and polar bears killed in Svalbard, 1993-1997. *Polar Rec.* **34**:337-340.

Gloersen, P. and Campbell, J. 1991. Recent variations in Arctic and Antarctic sea-ice covers. *Nature* **352**:33-36.

Gough, W.A., Cornwell, A.R. and Tsuji, L.J.S. 2004. Trends in seasonal ice duration in southwestern Hudson Bay. *Arctic* **57**:298-304.

Henriksen, E.O., Wiig, Ø., Skaare, J.U., Gabrielsen, G.W. and Derocher, A.E. 2001. Monitoring PCBs in polar bears: lessons learned from Svalbard. *J. Environ. Monit.* **3**:493-498.

Isaksen, K., Bakken, V. and Wiig, Ø. 1998. Potential effects on seabirds and marine mammals of petroleum activity in the northern Barents Sea. *Norsk Polarinst. Medde.* **154**, 66 pp.

IUCN/SSC Polar Bear Specialist Group. 1995. Summary of polar bear population status. Pp. 19-24 In Wiig, Ø., Born, E.W. and Garner, G.W. (eds.). *Polar Bears: Proceedings of the Eleventh Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN/SSC Polar Bear Specialist Group. 1998. Status of the polar bear. Pp. 23-44 In Derocher, A.E., Garner, G.W., Lunn, N.J. and Wiig, Ø. (eds.). *Polar Bears: Proceedings of the Twelfth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN/SSC Polar Bear Specialist Group. 2002. Status of the polar bear. Pp. 21-32 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Jonkel, C., Smith, P., Stirling, I. and Kolenosky, G.B. 1976. *The present status of the polar bear in the James Bay and Belcher Islands area*. Can. Wildl. Serv. Occ. Paper No. 26. 42 pp.

Kingsley, M.C.S., Stirling, I. and Calvert, W. 1985. The distribution and abundance of seals in the Canadian High Arctic, 1980-82. *Can. J. Fish. Aquat. Sci.* **42**:1189-1210.

Kischinski, A.A. 1969. The polar bear on the Novosibirsk Islands. Pp.103–113 In Bannikov, A.G., Kischinski, A.A. and Uspenski, S.M. (eds.). *The polar bear and its conservation in the Soviet Arctic*. Leningrad, Hydrometeorological Publishing House. (In Russian with English summary).

Kolenosky, G.B., Abraham, K.F. and Greenwood, C.J. 1992. Polar bears of southern Hudson Bay. Polar bear Project, 1984-88, Final Report, Ont. Min. Nat. Res., Maple, Ontario, 107 pp.

Kolenosky, G.B. and Prevett, J.P. 1983. Productivity and maternity denning of polar bears in Ontario. *Int. Conf. Bear Res. Manage.* **5**:238-245.

Larsen, T. 1972. Air and ship census of polar bears in Svalbard (Spitsbergen). *J. Wildl. Manage.* **36**:562-570.

Larsen, T. 1985. Polar bear denning and cub production in Svalbard, Norway. *J. Wildl. Manage.* **49**:320-326.

Larsen, T. 1986. Population biology of the polar bear (*Ursus maritimus*) in the Svalbard area. *Norsk Polarinstitutt Skrifter* **184**, 55 pp.

Lebreton, J.-D., Burnham, K.P., Clobert, J. and Anderson, D.R. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecol. Monogr.* **62**:67-118.

Lie, E., Bernhoft, A., Riget, F., Belikov, S.E., Boltunov, A.N., Derocher, A.E., Garner, G.W., Wiig, Ø. and Skaare, J.U. 2003. Geographical distribution of organochlorine pesticides (OCPs) in polar bears (*Ursus maritimus*) in the Norwegian and Russian Arctic. *Sci. Tot. Envir.* **306**:159-170.

Lønø, O. 1970. The polar bear (*Ursus maritimus* Phipps) in the Svalbard area. *Norsk Polarinstitutt Skrifter* **149**, 103 pp.

Lønstrup, J. This volume. Polar bear management in Greenland. Report to the 14th Working Meeting of the IUCN Polar Bear Specialist Group. Seattle, U.S.A., 20-24 June 2005.

Lunn, N.J., Schliebe, S. and Born, E.W. (Eds.). 2002. *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Lunn, N.J., Stirling, I. and Andriashek, D. 1995. Movements and distribution of polar bears in the northeastern Beaufort Sea and M'Clure Strait: Final Report by Canadian Wildlife Service to the Inuvialuit Wildlife Management Advisory Committee, Inuvik, NWT. Can. Wildl. Serv., Edmonton, 65 pp.

Lunn, N.J., Stirling, I., Andriashek, D. and Kolenosky, G.B. 1997. Population monitoring and assessment of polar bears in Western Hudson Bay. *Arctic* **50**:234-240.

Manly, B.F.J., McDonald, T.L., Amstrup, S.C. and Regehr, E.V. 2003. Improving size estimates of open animal populations by incorporating information on age. *BioScience* **53**:666-669.

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

Mauritzen, M., Derocher, A.E., Wiig, Ø., Belikov, S.E., Boltunov, A.N., Hansen, E. and Garner, G.W. 2002. Using satellite telemetry to define spatial population structure in polar bears in the Norwegian and western Russian Arctic. *J. Appl. Ecol.* **39**:79-90.

McDonald, L.L. and Amstrup, S.C. 2001. Estimation of population size using open capture-recapture models. *J. Agr. Biol. Environ. Stat.* **6**:206-220.

McLoughlin, P.D., Case, R.L., Gau, R.J., Mulders, R., Cluff, H.D., Taylor, M. and Messier, F. 2003. Population viability of barren-ground grizzly bears in Nunavut and the Northwest Territories. *Arctic* **56**:177–182.

Messier, F., Taylor, M.K. and Ramsay, M.A. 1992. Seasonal activity patterns of female polar bears (*Ursus maritimus*) in the Canadian Arctic as revealed by satellite telemetry. *J. Zool., Lond.* **218**:219-229.

Messier, F., Taylor, M.K. and Ramsay, M.A. 1994. Denning ecology of polar bears the Canadian Arctic Archipelago. *J. Mammal.* **75**:420-430.

Muir, D.C.G., Backus, S., Derocher, A.E., Dietz, R., Evans, T.J., Gabrielsen, G.W., Nagy, J., Norstrom, R.J., Sonne, C., Stirling, I., Taylor, M.K. and Letcher, R.J. 2006. Brominated flame retardants in polar bears (*Ursus maritimus*) from Alaska, the Canadian Arctic, east Greenland, and Svalbard. *Envir. Sci. Tech.* **40**:449-455.

Nageak, B.P., Brower, C.D. and Schliebe, S.L. 1991. Polar bear management in the Southern Beaufort Sea: An agreement between the Inuvialuit Game Council and North Slope Borough Fish and Game Committee. *Trans. N. Am. Wildl. Nat. Res. Conf.* **56**:337-343.

Norstrom, R.J., Belikov, S.E., Born, E.W., Garner, G.W., Malone, B., Olpinski, S., Ramsay, M.A., Schliebe, S., Stirling, I., Stishov, M.S., Taylor, M.K. and Wiig, Ø. 1998. Chlorinated hydrocarbon contaminants in polar bears from eastern Russia, North America, Greenland, and Svalbard: biomonitoring of arctic pollution. *Arch. Environ. Contam. Toxicol.* **35**:354-367.

Paetkau, D., Amstrup, S.C., Born, E.W., Calvert, W., Derocher, A.E., Garner, G.W., Messier, F., Stirling, I., Taylor, M.K., Wiig, Ø. and Strobeck, C. 1999. Genetic structure of the world's polar bear populations. *Mol. Ecol.* **8**:1571-1584.

Parkinson, C.L. 2000. Variability of arctic sea ice: The view from the space, an 18-year record. *Arctic* **53**:341-358.

Parkinson, C.L. and Cavalieri, D.J. 2000. A 21 year record arctic sea ice extents and their regional, seasonal, and monthly variability and trends. *Ann. Glaciol.* **34**:441-446.

Parovshikov, V.Y. 1965. Present status of polar bear population of Franz Josef Land. Pp. 237-242 In *Marine mammals*. Moscow, Nauka. In Russian.

Prestrud, P. and Stirling, I. 1994. The international polar bear agreement and the current status of polar bear conservation. *Aquatic Mammals* **20**:113-124.

Rosing-Asvid, A. and Born, E.W. 1990. [Catch of polar bears in the municipalities of Avanersuaq and Upernavik: an interview survey]. Tech. Rep., Greenland Home Rule, Dept. Wildl. Manage. No. 23, 63 pp. (In Danish with English summary).

Regehr, E.V., Lunn, N.J., Amstrup, S.C. and Stirling, I. in review. Survival and population size of polar bears in western Hudson Bay in relation to earlier sea ice breakup. *J. Wildl. Manage.*

Rosing-Asvid, A. and Born, E.W. 1995. The catch of polar bears in northwestern Greenland. Pp.188 In Wiig, Ø., Born, E.W. and Garner, G.W. (eds.). *Polar Bears: Proceedings of the Eleventh Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Rysgaard, S., Vang, T., Stjernholm, M., Rasmussen, B., Windelin, A. and Kiilsholm, S. 2003. Physical conditions, carbon transport, and climate change impacts in a Northeast Greenland fjord. *Arctic Antarctic Alp. Res.* **35**:301-312.

Sandell, M., Sandell, B., Born, E.W., Dietz, R. and Hansen, C.S. 2001. [Polar bears in eastern Greenland: An interview survey about the occurrence of polar bears and the hunt, 1999.] Tech. Rep. Greenland Inst. Nat. Res., No. 40, 94 pp. (In Danish with English summary).

Schliebe, S., Bridges, J., Evans, T., Fischbach, A., Kalxdorff, S. and Lierheimer, L. 2002. Polar bear management in Alaska 1997-2000. Pp. 89-99 in Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Schliebe, S.L., Evans, T.J., Fischbach, A.S. and Kalxdorff, S.B. 1998. Summary of polar bear management in Alaska. Pp. 115-123 in Derocher, A.E., Garner G.W., Lunn, N.J. and Wiig, Ø. (eds.). *Polar Bears: Proceedings of the Twelfth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN Gland, Switzerland and Cambridge, UK.

Schweinsburg, R.E., Lee, L.J. and Latour, P.B. 1982. Distribution, movement, and abundance of polar bears in Lancaster Sound, Northwest Territories. *Arctic* **35**:159169.

Serreze, M.C., Walsch, J.E., Chapin III, F.S., Osterkamp, T., Dyurgerov, M., Romanovsky, V., Oechel, W.C., Morison, J., Zhang, T. and Barry, R.G. 2000. Observational evidence of recent change in the northern high latitude environment. *Clim. Change* **46**:159-207.

Skaare, J.U., Bernhoft, A., Derocher, A., Gabrielsen, G.W., Goksøyr, A., Henriksen, E., Larsen, H.J., Lie, E. and Wiig, Ø. 2000. Organochlorides in top predators at Svalbard - occurrence, levels and effects. *Toxicol. Lett.* **112**:103-109.

Skaare, J.U., Bernhoft, A., Wiig, Ø., Norum, K.R., Haug, E., Eide, M.D. and Derocher, A.E. 2001. Relationships between plasma levels of organochlorines, retinol and thyroid hormones from polar bears (*Ursus maritimus*) at Svalbard. *J. Toxicol. Environ. Health A* **62**:227-241.

Skåre, J.U., Wiig, Ø. and Bernhoft, A. 1994. Klorerte organiske miljøgifter; nivåer og effekter på isbjørn. [Chlorinated organic pollutants; levels and effects on polar bears.] *Norsk Polarinstitutt Rapportserie* **86**, 23 pp.

Smithwick, M., Muir, D.C.G., Mabury, S.A., Solomon, K., Sonne, C., Martin, J.W., Born, E.W., Dietz, R., Derocher, A.E., Evans, T., Gabrielsen, G.W., Nagy, J., Stirling, I. and Taylor, M.K. 2005. A circumpolar study of perfluoroalkyl contaminants in polar bear hepatic tissue (*Ursus maritimus*). *Environ. Sci. Technol.* **39**:5517-5523.

Stirling, I. 1980. The biological importance of polynyas in the Canadian Arctic. *Arctic* **33**:303-315.

Stirling, I. 1997. The importance of polynyas, ice edges, and leads to marine mammals and birds. *J. Mar. Syst.* **10**:9-21.

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

Stirling, I., Andriashek, D., Latour, P. and Calvert, W. 1975. The distribution and abundance of polar bears in the eastern Beaufort Sea. Final Report to the Beaufort Sea Project. Fisheries and Marine Service, Dep. Envir. Victoria, B.C., 59 pp.

Stirling, I., Andriashek, D., Spencer, C. and Derocher, A.E. 1988. Assessment of the polar bear population in the eastern Beaufort Sea. Final Report to the Northern Oil and Gas Assessment Program. Can. Wildl. Serv., Edmonton, Alberta, 81 pp.

Stirling, I., Calvert, W. and Andriashek, D. 1980. *Population ecology studies of the polar bear in the area of southeastern Baffin Island*. Can. Wildl. Serv. Occ. Paper No. 44, 30 pp.

Stirling, I., Calvert, W. and Andriashek, D. 1984. Polar bear ecology and environmental considerations in the Canadian High Arctic. Pp. 201-222 In Olson, R., Geddes, F. and Hastings, R. (eds.). *Northern Ecology and Resource Management*. University of Alberta Press, Edmonton, Canada.

Stirling, I. and Derocher, A.E. 1993. Possible impacts of climatic warming on polar bears. *Arctic* **46**:240-245.

Stirling, I., Jonkel, C., Smith, P., Robertson, R. and Cross, D. 1977. *The ecology of the polar bear (*Ursus maritimus*) along the western coast of Hudson Bay*. Can. Wildl. Serv. Occ. Paper No. 33, 64 pp.

Stirling, I. and Kiliaan, H.P.L. 1980. *Population ecology studies of the polar bear in northern Labrador*. Can. Wildl. Serv. Occ. Paper No. 42, 19 pp.

Stirling, I. and Lunn, N.J. 1997. Environmental fluctuations in arctic marine ecosystems as reflected by variability in reproduction of polar bears and ringed seals. Pp. 167-181 In Woodin, S.J. and Marquiss, M. (eds.). *Ecology of Arctic Environments*. Special Publication No. 13 of the British Ecological Society, Blackwell Science Ltd., Oxford, UK.

Stirling, I., Lunn, N. J., Iacozza, J., Elliot, C. and Obbard, M. 2004. Polar bear distribution and abundance on the southwestern Hudson Bay coast during open water season, in relation to population trends and annual ice patterns. *Arctic* **57**:15-26.

Stirling, I., Lunn, N.J. and Iacozza, J. 1999. Long-term trends in the population ecology of polar bears in western Hudson Bay. *Arctic* **52**:294-306.

Stirling, I., Schweinsburg, R.E., Calvert, W. and Kiliaan, H.P.L. 1978. Population ecology studies of the polar bear along the proposed Arctic Islands Gas Pipeline Route. Final Report, Environmental Management Service, Dep. Envir. Edmonton, Alberta, 93 pp.

Stishov, M.S. 1991a. Results of aerial counts of the polar bear dens on the arctic coast of the extreme Northeast Asia. Pp. 90-92 In Amstrup, S.C. and Wiig, Ø. (eds.). *Polar Bears: Proceedings of the Tenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Stishov, M.S. 1991b. Distribution and number of polar bear maternity dens on the Wrangel and Herald islands in 1985-1989. Pp. 91-115 In Amirkhanov, A.M. (ed.). *Population and Communities of Mammals on Wrangel Island*. Moscow, CNIL Glavokhoty RSFSR. (In Russian).

Stishov, M.S., Garner, G.W., Arthur, S.M. and Barnes, V.G.B., Jr. 1991. Distribution and relative abundance of maternal polar bears dens in the Chukotka Peninsula region, U.S.S.R. P. 67 In Abstracts, Ninth Biennial Conference on the Biology of Marine Mammals, 5-9 December 1991, Chicago, Illinois, U.S.A.

Taylor, M.K., DeMaster, D.P., Bunnell, F.L. and Schweinsburg, R.E. 1987. Modeling the sustainable harvest of polar bears. *J. Wildl. Manage.* **51**:811-820.

Taylor, M. and Lee, J. 1994. Tetracycline as a biomarker for polar bears. *Wildl. Soc. Bull.* **22**:83-89.

Taylor, M.K. and Lee, L.J. 1995. Distribution and abundance of Canadian polar bear populations: A management perspective. *Arctic* **48**:147-154.

Taylor, M.K., Kuc, M. and Abraham, D. 2000. Vital Rates: Population parameter analysis program for species with three year reproductive schedules. Government of Nunavut, Iqaluit, Nunavut Territory, 30 pp.

Taylor, M.K., Obbard, M., Pond, B., Kuc, M. and Abraham, D. 2001a. *RISKMAN: Stochastic and Deterministic Population Modeling RISK MANagement decision tool for harvested and unharvested populations*. Government of Nunavut, Iqaluit, Nunavut Territory. 40 pp.

Taylor, M.K., Akeeagok, S., Andriashek, D., Barbour, W., Born, E.W., Calvert, W., Cluff, H.D., Ferguson, S., Laake, J., Rosing-Asvid, A., Stirling, I. and Messier, F. 2001b. Delineating Canadian and Greenland polar bear (*Ursus maritimus*) populations by cluster analysis of movements. *Can. J. Zool.* **79**:690-709.

Taylor, M.K., Laake, J., Cluff, D., Ramsay M. and F. Messier. 2002. polar bear (*Ursus maritimus*) population inventory for Viscount Melville Sound. *Ursus* **13**:185-202.

Taylor, M.K., Laake, J., McLoughlin, P.D., Born, E.W., Cluff, H.D., Ferguson, S.H., Rosing-Asvid, A., Schweinsburg, R. and Messier, F. 2005. Demography and population viability of a hunted population of polar bears. *Arctic* **58**:203-215.

Taylor, M.K., Laake, J., McLoughlin, E.W., Cluff, D. and Messier, F. [In review]. Demographic parameters and harvest-explicit population viability analysis for polar bears in M'Clintock Channel, Nunavut. *J. Wildl. Manage.* **00**:000-000.

Treseder, L. and Carpenter, A. 1989. Polar bear management in the southern Beaufort Sea. *Information North* **15**:2-4.

Uspenski, S.M. 1989. *The polar bear*. Rudenko, I.A. (ed.). Moscow, Agropromizdat, 189 pp. (In Russian).

Vinnikov, K.Y., Robock, A., Stouffer, R.J., Walsh, J.E., Parkinson, C.L., Cavalieri, D.J., Mitchell, J.F.B., Garrett, D. and Zakharov, V.F. 1999. Global warming and northern hemisphere sea ice extent. *Science* **286**:1934-1937.

Verreault, J., Muir, D.C.G., Norstrom, R.J., Stirling, I., Fisk, A.T., Gabrielsen, G.W., Derocher, A.E., Evans, T., Dietz, R., Sonne, C., Sandala, G.M., Gebbing, W., Riget, F.F., Born, E.W., Taylor, M.K., Nagy, J. and Letcher, R.J. 2005. Chlorinated hydrocarbon contaminants and metabolites in polar bears (*Ursus maritimus)* from Alaska, Canada, East Greenland, and Svalbard: 1996–2002. *Sci. Total Environ.* **351-352**:369-390.

Welch, H.E., Bergmann, M.A., Siferd, T.D., Martin, K.A., Curtis, M.F., Crawford, R.E., Conover, R.J. and Hop, H. 1992. Energy flow through the marine ecosystem of the Lancaster Sound Region, Arctic Canada. *Arctic* **45**:343-357.

Wiig, Ø. 1995. Distribution of polar bears (*Ursus maritimus*) in the Svalbard area. *J. Zool., Lond.* **237**:515-529.

Wiig, Ø., Born, E.W. and Pedersen, L.T. 2003. Movements of female polar bear (*Ursus maritimus*) in the east Greenland pack ice. *Polar Biol.* **26**:509-516.

Wiig, Ø., Derocher, A.E, Cronin, M.M. and Skaare, J.U. 1998. Female pseudohermaphrodite polar bears at Svalbard. *J. Wildl. Dis.* **34**:792-796.

Wolkers, H., Van Bavel, B., Derocher, A.E., Wiig, Ø., Kovacs, K.M., Lydersen, C. and Lindstrom, G. 2004. Congener-specific accumulation and food chain transfer of polybrominated diphenyl ethers in two arctic food chains. *Envir. Sci. Tech.* **38**:1667-1674.

Resolutions

of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, Seattle, 20–24 June 2005

1. A precautionary approach when setting catch levels in a warming Arctic

The IUCN Polar Bear Specialist Group

Recognising that the sea ice is critical to the continued survival of polar bears; and

Recognising that during recent decades the area of the sea ice in the Arctic has declined significantly as a response to climate warming, and that ice break-up in many areas is occurring earlier and freeze-up later;

Recognising that the degradation of the sea ice habitat, which is predicted to continue, is having negative effects on survival rates and abundance of polar bears in western Hudson Bay; and

Noting that in several areas both local hunters and scientists have observed an increased occurrence of polar bears near settlements and outposts and on near-shore sea ice in recent years; and

Noting that increased occurrences may not reflect an increased population size; and

Noting that the Agreement for Conservation of Polar Bears (Article I and II) identifies the right of local hunters to conduct sustainable harvests; and

Noting that based upon local and traditional knowledge, Nunavut (Canada) has increased its quotas for some of its polar bear populations where polar bears must spend several months of the open water period on land surviving on their stored fat reserves; and

Noting that also the catch of polar bears in Greenland near shore has increased substantially; and

Noting that polar bear populations may be seriously threatened by the combined effect of rapid habitat loss and increased exploitation; therefore

Recommends that polar bear harvests can be increased on the basis of local and traditional knowledge only if supported by scientifically collected information.

2. An international study of the effects of pollution on polar bears

The IUCN Polar Bear Specialist Group

Recognising that the polar bear – as an arctic apex predator – is susceptible to the effects of pollutants; and

Recognising that such effect may be exacerbated through habitat changes driven by global warming; and

Recognising the scientific merit in studying such effects in all polar bear subpopulations; and

Recognising that previously a world-wide study – facilitated through the IUCN Polar Bear Specialist Group – of organochlorine levels was successful; and

Noting that pollution-induced histopathological and bone mineral density changes probably occur in East Greenland polar bears, as well as the occurrence of diseases; the group

Recommends Denmark coordinate a circumpolar study of health effects from pollution on vital organs, skeletal and other systems in polar bear subpopulations.

3. Status of the Western Hudson Bay (WH) population analysis

The IUCN Polar Bear Specialist Group

Recognising that the largest and best developed scientific database for any polar bear population is the WH database, and

Recognising that the current WH mark-recapture population analysis has used multiple standardized methodologies which produced equivalent estimates, and

Recognising that the analysis results are consistent with independent population simulation results, and

Recognising that the data used for these estimates have been carefully checked and validated, and

Noting that the decline of WH polar bears from approximately 1200 in 1987 to less than 950 in 2004 is conclusive,

And accepting that the decline was due to a combination of anthropogenic removals (defence and harvest kills) and reduced demographic rates from climate warming, therefore

Recommends that appropriate management action be taken without delay.

4. Implementation of the U.S./Russia bilateral agreement

The IUCN Polar Bear Specialist Group

Recognising that Article II of the 1973 Agreement for the Conservation of Polar Bears calls for each nation to manage polar bear populations in accordance with sound conservation practices based on the best scientific available data;

Recognising the United States and Russia's commitment to the long-term conservation and management of the Alaska-Chukotka polar bear population and that on October 16, 2000, both countries signed the *Agreement between the United States and the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population;*

Recognising that polar bears are a significant resource of the arctic region and of cultural and economical value to aboriginal peoples that have the right to harvest polar bears;

Recognising that sound conservation practices for the sustainable harvest of polar bears requires accurate information on the number, sex, age, and location of harvested animals;

Recognising the lack of a valid population estimate and concern that the current combined legal harvest from Alaska and illegal harvest of polar bears from Russia may exceed the sustainable harvest limits for the Alaska-Chukotka sub-population;

Recognising the need to coordinate and conduct research on the Alaska-Chukotka sub-population, shared between the United States and Russia, and the need to obtain a scientifically valid population estimate, estimates of survival and recruitment, and to document changes in distribution and habitat use;

Recommends that the United States and Russia immediately enact and enforce the terms of the *Agreement between the United States and the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population.*

5. Risks to polar bears from arctic shipping

The IUCN Polar Bear Specialist Group

Recognising that the sea ice is critical to the continued survival of polar bears; and

Recognising that during recent decades the area of the sea ice in the Arctic has diminished significantly; and

Recognising that in some areas where polar bears live, ice break-up has become significantly earlier due to global warming; and

Recognising that this warming is predicted to continue in the future; and

Recognising that the reduction in extent and thickness of the sea ice has encouraged the development of increased commercial and tourism ship traffic; and

Recognising that increased ship traffic results in increased risks for polar bears from contaminants, bilge dumping, fuel spills, habitat alteration and bear-human encounters; therefore:

Recommends that each jurisdiction take appropriate measures to monitor, regulate and mitigate ship traffic impacts on polar bear subpopulations and habitats.

6. Wrangel Island nature reserve and other protected areas

The IUCN Polar Bear Specialist Group

Recognising the increasing role of Wrangel Island as a refuge for an essential part of the Alaska-Chukotka polar bear population, and

Noting the importance of continuous polar bear research on Wrangel Island as an essential part of Alaska-Chukotka population status assessment, therefore

Recommends that polar bear research on Wrangel Island should continue without time gaps at the level necessary to monitor population status and health, and

Recommends creation of protected nature areas throughout polar bear range to conserve key polar bear habitats, with particular focus on terrestrial summer retreat habitats.

Press Release

14th Meeting of the IUCN/SSC Polar Bear Specialist Group

The 14th meeting of the IUCN/SSC World Conservation Union, Species Survival Commission, Polar Bear Specialist Group (PBSG) was held in Seattle, WA, USA, during 20–24 June 2005, under the Chairmanship of Scott Schliebe. In fulfilment of the terms of the 1973 Agreement on the Conservation of Polar Bears, delegates representing each of the five circumpolar nations signatory to the Agreement for the Conservation of Polar Bears (Canada, Denmark/Greenland, Norway, Russia, USA) were in attendance. Also attending as invited specialists were representatives from the Greenland Home Rule Government, the Alaska Nanuuq Commission (Alaska), the Inuvialuit Game Council and Wildlife Management Advisory Council, Nunavut Tunngavik Incorporated (Canada), National Oceanographic and Atmospheric Administration (NOAA, USA), National Environmental Research Institute (Denmark) and other specialists. The PBSG meets every 3–5 years to review and exchange information on progress in the research and management of polar bears throughout the Arctic and to review the worldwide status of polar bears. Invited specialists from the US National Marine Fisheries Service and Western Ecosystems Technology were instrumental in the development of new analysis procedures for population data.

The world's polar bears are distributed in 19 subpopulations over vast and sometimes relatively inaccessible areas of the Arctic. Thus, while the status of some subpopulations in Canada and the Barents Sea is well documented, that of several others remains less known. Thus, it is not possible to give an accurate estimate of the total number of polar bears in the world, although the range is thought to be 20–25,000.

Research in several geographic areas indicates the greatest challenge to conservation of polar bears may be large-scale ecological change resulting from climatic warming, if the trend documented in recent years continues as projected. A new analysis of the long-term subpopulation data base in Western Hudson Bay confirms the size of that subpopulation has declined from 1200 to less than 1000. The group concluded the decline was caused by reductions in condition and survival, especially of young bears, because climatic warming has caused the sea ice to break up about three weeks earlier now than it did only 30 years ago. Thus, polar bears have less time to feed and store the fat needed to survive on shore for four months before the ice re-freezes. Significant reductions in the apparent survival of ringed seal pups and changes in the diet of sea birds in northern Hudson Bay, coincident with larger amounts of open water earlier in the summer, have also been reported. Taken together, these results suggest that unknown changes in the marine ecosystem of Hudson Bay are now underway. Similarly, the minimum extent of multi-year ice in the Polar basin continues to decline at the rate of 8–10% per decade, resulting in unusually extensive areas of open water in regions such as the Beaufort/Chukchi Seas and East Greenland. The Group emphasised the importance of continuing to monitor polar bear subpopulations in order to quantitatively assess the affects of climatic warming.

High levels of PCBs and pesticides were found in East Greenland polar bears. There was a strong indication of a relationship between contaminants and skull mineral density indicating possible disruption of the bone mineral composition. The changes were related to ageing, infections and chronic exposure. The Group felt these results confirmed the importance of continuing to monitor and study the effects of contaminants on polar bears.

With the results of the foregoing research and related uncertainties in mind, the Group reviewed the status of polar bears using the 2001 IUCN Red List categories and criteria. The Group concluded that the IUCN Red List classification of the polar bear should be upgraded from Least Concern to Vulnerable based on the likelihood of an overall decline in the size of the total population of more than 30% within the next 35 to 50 years. The principal cause of this decline is climatic warming and its consequent negative affects on the sea ice habitat of polar bears. In some areas, contaminants may have an additive negative influence.

Harvesting of polar bears continues to be of primary importance to the culture and economy of aboriginal groups throughout much of the Arctic. Therefore, maintaining a harvest within sustainable limits, in relation to subpopulation size and trends, remains a priority. It was also recognised that aboriginal people resident throughout the Arctic are uniquely positioned to observe both wildlife and changes in the environment. Thus, the Group confirmed the importance of integrating traditional ecological knowledge (termed IQ in Nunavut) with scientific studies to aid polar bear conservation wherever possible. Since the last meeting of the PSBG four years ago, significant new reports on traditional ecological knowledge of polar bears and their habitat have been completed in Chukotka, Alaska, and Canada. The results of these and future studies need to be incorporated into research and management where possible but the Group agreed that estimates of subpopulation size or sustainable harvest levels should not be made solely on the basis of traditional ecological knowledge without supporting scientific studies. Furthermore, because of continuing changes in ice cover, with unknown consequences for the arctic marine ecosystems of which polar bears are a part, the precautionary principle should be observed in determining harvest quotas, regardless of how certain the combined information appear to be.

There was substantial discussion about large quota increases in some polar bear subpopulations in Nunavut where there has continued to be uncertainty about subpopulation size and trends despite scientific studies augmented by computer simulations and traditional ecological knowledge. The group concluded that increases in harvest levels or estimates of subpopulation size should not be based on traditional ecological knowledge without support from sound scientific data and further, that regardless of how certain the combined information appears to be, increases in quotas should be implemented with the precautionary principle.

Although the harvest of polar bears in Greenland has been poorly regulated, the Greenland Home Rule government announced that quotas are to be implemented and enforced as of January 1 2006. Hunters will have to have a special license for each polar bear hunted and this will be used to track the sale of hides or trading in parts. Preliminary discussions have been held with Canada to develop co-management agreements and determine the size of shared sustainable quotas for subpopulations of polar bears shared between the two countries using both scientific information and traditional ecological knowledge. The Group commended Greenland on this initiative and emphasised the importance of ensuring a sustained effort to monitor the harvest and enforce regulations. Further, the Group noted the critical importance of continuing a programme of public education through the transition period to ensure understanding and acceptance of the vital need to improve the present system of management.

Similar to Greenland the group acknowledged significant harvest levels were occurring unregulated in Chukotka, Russia. The group urged both the United States and the Russian Federation to move rapidly to implement the Bilateral Treaty already signed between the two countries.

Future challenges for conserving polar bears and their arctic habitat will be greater than at any time in the past because of the rapid rate at which environmental change appears to be occurring. The complexity and global nature of the issues continue to require a significant degree of international cooperation and development of diverse and new approaches.

Polar bear management in Alaska 2000–2004

Scott Schliebe, United States Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Thomas J. Evans, United States Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Susanne Miller, United States Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Craig Perham, United States Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
James Wilder, United States Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Lisa J. Lierheimer, United States Fish and Wildlife Service, Division of Management Authority, 4401 Fairfax Drive, Suite 700, Arlington, VA 22203, USA

Since the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group in 2001, a number of management actions for polar bears have occurred in Alaska. The U.S. Fish and Wildlife Service (USFWS) continues to advocate for passage of enabling legislation by Congress to implement the "Agreement on the Conservation and Management of the Alaska-Chukotka Polar Bear Population" signed on October 16, 2000 by the governments of the United States and the Russian Federation. This agreement provides substantial benefits for the effective conservation of polar bears shared between the U.S. and Russia. Also during this period the USFWS continued to implement 1994 amendments to the Marine Mammal Protection Act (MMPA) which allow polar bear trophies taken in approved Canadian subpopulations by U.S. citizens to be imported into the United States. A summary of the regulatory actions and a table listing subpopulations approved for importation and the number of polar bears imported into the U.S. since 2001 are included in this report. In addition, the Service continued to implement regulations regarding oil and gas activities in polar bear habitat. Three sets of regulations authorizing the incidental, non-intentional, taking of small numbers of polar bears concurrent to oil and gas activities have expired and draft regulations have been developed to extend the life of the regulations an additional five years.

Cooperation continued with the Alaska Nanuuq Commission, representing the native polar bear hunting communities in Alaska, as well as with the North Slope Borough and the Inuvialuit Game Council in their agreement for management of the Southern Beaufort Sea polar bear subpopulation. Financial support is provided annually to the Alaska Nanuuq Commission, through section 119 of the MMPA, to represent Alaska Native hunters concerning subsistence and conservation issues related to polar bears. In addition grant funding from the National Fish and Wildlife Foundation was obtained to assist the North Slope Borough in monitoring and hazing polar bears that enter North Slope communities as they travel along the coast. The USFWS is continuing to cooperatively develop community-based action plans to minimize polar bear-human conflicts in North Slope communities.

The U.S. Fish and Wildlife Service continued to monitor the harvest of polar bears in Alaska and collect and analyse specimens for presence and concentrations of organochlorine compounds and trace elements. In addition, the USFWS conducted autumn aerial surveys in the central Southern Beaufort Sea from 2000–2004 to document changes in polar bear distribution along the coast during the autumn open water and freeze-up period. Research on a finer scale was also conducted during 2002–2004 to evaluate the demographics, habitat use and behaviour of polar bears using coastal areas. The USFWS in partnership with the U.S. Geological Survey, Alaska Science Center participated in research to characterize the activity budgets of polar bears emerging from maternal dens in the spring and to further evaluate their reactions to various anthropogenic sources of disturbance. A time-lapse video camera system was developed to promote neutral-effect data collection during emergence. To enhance our capabilities to detect the location of bear dens, the USFWS tested the ability of trained dogs to scent dens. In addition, the USFWS made refinements in the application of Forward Looking Infrared thermal scanning techniques. Both techniques, scent-trained dogs and FLIR, have been incorporated into a suite of mitigation practices to limit the disturbance of oil and gas activities.

Polar bear kills

Alaska harvest summary

The total Alaska harvest of polar bears from July 2000 to June 2004 was 325 (Table 4) with a mean of 81 animals per year (range 60–108) (Table 4). In addition to the subsistence hunt, two orphaned cubs were sent to the San Diego Zoo and there was one research mortality. There continues to be a significant ($t = 2.46$, $df = 10.9$, $p < 0.03$) downward trend in the Alaska harvest, due mostly to declines in Chukchi/Bering Sea harvest, for the two periods 1980 to 1990 (mean = 131) and 1990–2004 (mean = 82). During the 1980s two-thirds of the Alaska polar bear harvest came from the Chukchi/Bering Sea subpopulation. The reported polar bear harvest from the Chukchi/Bering Sea subpopulation declined by 47% from the 1980s (mean = 92.1, se = 16.4, n = 10) to the 1990s (mean = 48.7, se = 7.4, n = 10) and continues to decline in recent years (2000–2004, mean = 42.5, se = 12.9, n = 4). During the past two years (2002/03–2003/04) the polar bear harvest from the Chukchi/Bering Sea subpopulation, 24 and 18 respectively, has been less than half of the harvest from the Southern Beaufort Sea. The population dynamics of

Table 4. Number of polar bears killed in Alaska by village, harvest year[a] and sex

Village	2000/01[b c]			2001/02			2002/03			2003/2004			Total		
	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U
Atqasuk[d]	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1
Barrow[d]	11	6	10	18	3	4	22	2	1	10	7	2	61	18	17
Brevig Mission	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Little Diomede	4	3	3	-	5	1	-	-	2	5	2	1	9	10	7
Gambell	4	4	-	17	5	-	-	-	-	-	-	-	21	9	-
Kaktovik[d]	-	1	-	2	-	1	1	2	1	-	2	5	3	5	7
Kivalina	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Nome	1	-	-	-	-	2	-	-	-	-	-	-	1	-	2
Nuiqsut[d]	2	2	1	1	-	2	2	1	-	1	1	-	6	4	3
Point Hope	12	2	1	3	5	1	8	4	-	6	4	-	29	15	2
Point Lay	-	1	-	1	-	-	-	-	-	1	-	-	2	1	-
Savoonga	6	2	1	18	8	7	4	-	1	-	-	-	28	10	9
Shishmaref	5	1	-	1	-	-	2	1	-	-	-	-	8	2	
Wainwright[d]	7	2	1	2	-	-	2	2	1	4	2	7	15	6	9
Wales	-	-	-	1	-	-	1	-	-	-	-	-	2	-	-
Sub Total	53	24	17	64	26	18	43	12	8	27	18	15	187	80	58
Annual Total	94			108			63			60			325		

[a] Harvest year is from July 1 to June 30
[b] Subsistence harvest does not include two cubs sent to San Diego Zoo
[c] Subsistence harvest does not include one research mortality
[d] Villages harvesting polar bears from the Southern Beaufort Sea subpopulation

the Chukchi/Bering Sea subpopulation are poorly known thus it is not known whether this decline in the harvest reflects a true population decline. Changes in movement of the sea ice due to wind and tidal currents, the increase of less stable first-year ice and decrease in the multi-year pack ice may affect both the bear distribution and the availability and accessibility of bears to hunters. The harvest decline in western Alaska may also be due to a decline in the number of active polar bear hunters from Native hunting villages and an increased polar bear harvest in Chukotka, Russia. In contrast, overall harvest levels from the Southern Beaufort Sea have remained relatively constant since 1980 at 36 bears per year. During the period from 2000–2004 the Southern Beaufort Sea subpopulation accounted for 48% of the statewide harvest.

The sex ratio of known-sex bears harvested since 1980 has remained relatively consistent at 66% males and 34% females, although annual variation by region is evident. The harvest age class composition from 2000 to 2004, which was similar to the long-term average since 1980, was 14.7% cubs, 35% sub-adults, and 50.3 % adults (Table 5). Complete age and sex was available for 51% of the harvested animals which is the same as was reported at the last PBSG meeting in Nuuk, Greenland (Lunn *et al.* 2002), despite increased efforts to encourage compliance. Some incentives, implemented in the 2002/2003 harvest season, include increased payment to village Marking, Tagging, and Reporting Program (MTRP) taggers for recording data on harvested bears, a letter of appreciation from the U.S. Fish and Wildlife Service along with a complimentary knife to hunters that provide complete harvest information, increased law enforcement, and more frequent visits to the villages by biologists.

Statewide, harvests occurred in all months during 2000–2004. The greatest monthly harvest for the period occurred during February (15%). The combined months of November to May, when the pack ice is in proximity to shore, accounted for 82.5% of the harvest. The months of June to September, when the pack ice is retreating to its minimum, accounted for 17.5% of the harvest which was similar to the 1995/96–1999/2000 period. Differences in the chronology of the harvest were evident between the Beaufort Sea region and the Chukchi and Bering seas. The harvest from the Southern Beaufort Sea, in the northern Alaska, declined from 56% to 38.2% during the fall-early winter period (September to December), and increased during April and May from 15.2% to 29.3% since the last PBSG report. The surge in spring harvest from the northern Alaska is associated with whaling activities near the open lead systems. The January to May 2000–2004 harvest from the Chukchi/Bering seas subpopulation in western Alaska, which coincides with the arrival of the pack ice, was similar to the previous four year period (81.1% vs. 88.2%). Since 1980, significantly more bears have been harvested in the fall (October–December) in the Southern Beaufort Sea than in the Chukchi/Bering seas ($X^2 = 171.6$, df = 2, $p<0.001$), although this trend was not significant for the period from 2000–2004. Polar bears from both Alaskan subpopulations remain with the pack ice throughout the year. The pack ice is generally

Table 5. Numbers of polar bears harvested in Alaska, 2000/01–2003/04a, in relation to age class. Ages are based on cementum annuli in the first premolar tooth (cubs, 0–2.3 yrs, subadults, 2.33–4 yrs; adults, 5+ yrs). Percentages are in parentheses

	2000/01	2001/02	2002/03	2003/04[b]	Total
Cubs	5	10	4	4	**23**
(%)	(13.2)	(15.1)	(15.4)	(14.8)	**(14.7)**
Subadults	16	17	7	15	**55**
(%)	(42.1)	(25.8)	(26.9)	(55.5)	**(35.0)**
Adults	17	39	15	8	**79**
(%)	(44.7)	(59.1)	(57.7)	(29.7)	**(50.3)**
Total	**38**	**66**	**26**	**27**	**157**

[a] Harvest year is from July 1 to June 30
[b] Ages have yet to be determined for one additional tooth

absent from coastal areas during the summer months (July and August) and as a result, few bears are harvested during this time (3.5%). In addition, global climatic changes could affect the seasonal availability of polar bears to hunters in both subpopulations due to changes in the sea ice extent, sea ice characteristics, and the timing of ice formation in the fall and break-up in the spring. Changes in the minimum sea ice extent in the Arctic between the periods 1979–1989 and 1990–2000 were greatest in the northern Chukchi and southern Beaufort seas (Comiso 2003).

In 1994 polar bear harvest certificates were modified to include a section as to whether polar bears were harvested as part of the normal subsistence hunt or in defense of life and property (DLP). The number of bears harvested for safety reasons since 1993, based on a three-year running average, has risen steadily from about three per year, to about 12 in 1998, and has remained at about 10 in recent years (Figure 2). There are several plausible explanations for this increase. First it could be an artifact of increased reporting by the hunters. Second, polar bears from the Southern Beaufort and Chukchi/Bering Sea subpopulations typically move from the pack ice to the near shore environment in the fall to take advantage of the higher productivity of ice seals over the continental shelf. To take advantage of this feeding opportunity in the fall, polar bears remain near-shore until sea ice formation accommodates travel. In the 1980s and early 1990s the near shore environment would have been frozen by early or mid October, allowing polar bears to effectively hunt seals near their breathing holes. Since the late 1990s the timing of ice formation in the fall has occurred in late November or early December, resulting in an increased amount of time polar bears are on land and not feeding. This increases the probability of bear-human interactions occurring in coastal villages. The increased use of coastal habitats by polar bears during the fall in recent years is further supported by data from aerial surveys along the coast and barrier islands from Barrow to the Canadian border and information from local residents in coastal villages in northern and western Alaska.

Southern Beaufort Sea harvest summary

The total Alaska harvest, from July 2000 to June 2004, by Alaska villages party to the Inuvialuit Game Council and North Slope Borough management agreement, was 156 polar bears, with an average of 39 bears per year (range 33–43) from a quota of 40 (Table 6). One additional removal not included in the subsistence harvest was a research mortality.

The sex ratio of the harvest from 2000–2004 was 72:28 males to females. Complete information on the age and sex of harvested bears (123/156) was available for 79% of the harvest. Net mean annual removal of females was calculated by summing the known-sex females, adding 50% of the unknown sex bears for the 2000–2004 period and dividing the sum by the number of years. The mean annual removal of females (12.9) for this period was below the sustainable yield calculation (SY = 13.2)

Figure 2. The number of polar bears taken in defence of life and property since 1988

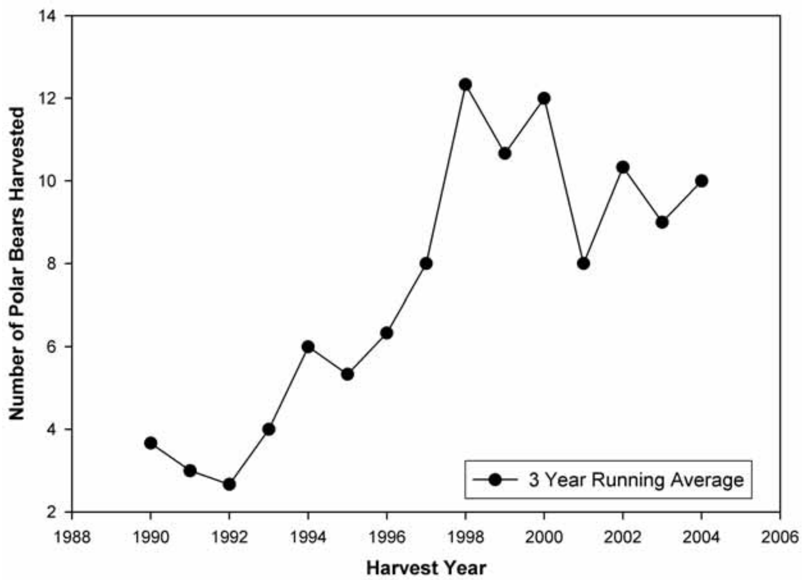


Table 6. Number of polar bears harvested from the Southern Beaufort Sea 2000/01–2003/04 by village, harvest year and sex. M = Males, F = Females, U = Unknown

Village	2000/01[a]			2001/02			2002/03			2003/2004[b]			Total		
	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U
Atqasuk	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1
Barrow	11	6	10	18	3	4	22	2	1	10	7	2	61	18	17
Kaktovik	-	1	-	2	-	1	1	2	1	-	2	5	3	5	7
Nuiqsut	2	2	1	1	-	2	2	1	-	1	1	-	6	4	3
Wainwright	7	2	1	2	-	-	2	2	1	4	2	7	15	6	9
Sub Total	20	11	12	23	3	7	28	7	4	15	12	14	86	33	37
Annual Total	43			33			39			41			156		

[a] Harvest season extends from July 1 to June 30
[b] Subsistence harvest does not include one research mortality

which is based upon a 2:1 male to female sex ratio. The harvest age class composition from 2000 to 2004 was 13.7% cubs, 47.1% sub-adults, and 39.2% adults. The statewide harvest from the Southern Beaufort Sea occurred in all months except June, and showed a bimodal distribution between September to January (49.1%) and April to May (29.3%).

Bio-monitoring

Samples continue to be collected from all sex and age classes through the Polar Bear Bio-Monitoring Program for contaminant analysis, genetic analysis, food habitat studies, assessment of physiological parameters, and long-term archival through the Alaska Marine Mammal Tissue Archival Project (AMMTAP). Two reports, *Concentrations of Selected Essential and Non-Essential Elements in Adult Male Polar Bears (*Ursus maritimus*) from Alaska* (Evans 2004a) and *PCBs and Chlorinated Pesticides in Adult Male Polar Bears (*Ursus maritimus*) from Alaska* (Evans 2004b) were completed and are available. The reports will be submitted for publication in peer-reviewed journals.

Tissue samples from Alaskan polar bears have been submitted to the circumpolar contaminant study for analysis. This project focuses on PCB metabolites (Verrault *et al*. 2005), brominated flame retardants (PBDEs), and perfluoro-compounds (Smithwick *et al.* 2005) in polar bears and provides baseline information on concentrations of PCBs and metals. This research augments previous contaminant studies of adult males in Alaska (Evans 2004a, 2004b).

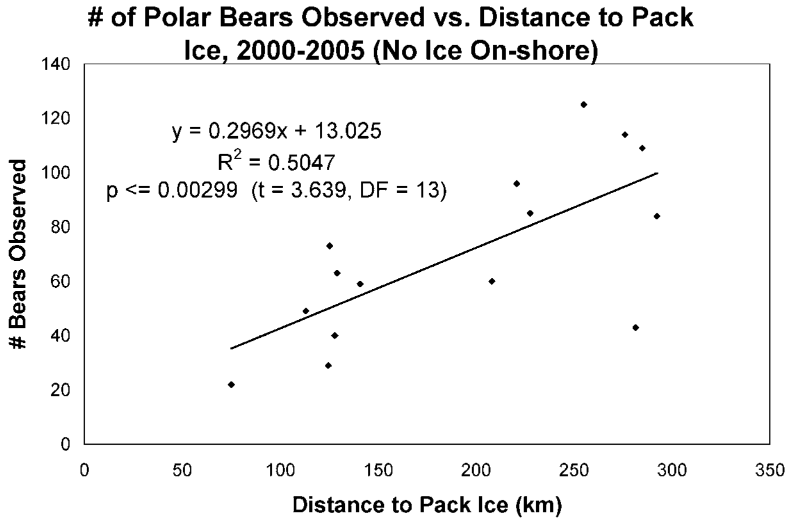
Population status and trend

Coastal surveys: Southern Beaufort Sea

The U.S Fish and Wildlife Service, in cooperation with BP Exploration (Alaska), Inc. and LGL Alaska Research Associates, Inc., completed weekly aerial surveys associated with the Northstar Project, along the coastline and barrier islands in the central Beaufort Sea (1999–2002). Data collected on the abundance and spatial distribution of polar bears during the fall open water and freeze-up period has provided information to assess the importance of these habitat areas to polar bears for resting and feeding. This data will also be useful in assessing distribution patterns in relationship to potential impacts of climate change and offshore oil exploration and production activities. In 2003 and 2004 the U.S. Fish and Wildlife Service continued and extended these aerial surveys to Barrow in the west and to the Canadian border in the east. Each survey period took two days to complete, versus one day in previous surveys. Aerial surveys will be conducted over the same area in 2005.

A majority of the bears observed in 2003 and 2004 were seen in the area between Atigaru Point, west of Prudhoe Bay, and Jago Spit, east of Kaktovik. Only those bears seen in the area surveyed for the Northstar surveys were used for comparison between years. A total of 73% of the bears observed in all surveys (955 of 1301) were seen within a 12km radius of Barter Island and the village of Kaktovik. The area between Atigaru Point to east of Barrow had very low bear densities.

Figure 3. **Chart of regression relationship between the numbers of polar bears present on shore and the distance the pack ice was located from shore**



A total of 215 polar bears were seen during four surveys in the fall of 2003 and 374 polar bears were seen during five surveys in 2004. The total number of bears seen during the weekly surveys increased only slightly from the first survey unlike the 2000 and 2002 surveys which showed a marked increase during the last week of September and first week of October. Although the actual number of bears observed varied considerably during the 2000–2003 fall freeze-up period, the percentage of adult females with dependent young have remained fairly consistent (range 47.0–53.6%).

Regression analysis of the number of bears using coastal habitats and the distance to the pack ice was calculated as well (Figure 3). Ice imagery files were obtained from the National Ice Center and imported into GIS. Distance to the ice edge was calculated from four points within the 2000–2002 survey area and six points within the expanded 2003–2004 survey area. Distances from the selected points on shore were calculated as the shortest distance to 1–3/10th sea ice coverage as depicted on the ice imagery files and these were then averaged for the survey period. In all years, the number of bears on shore in the fall increased until the extensive near-shore ice became available. At this time the number of bears on the barrier islands and coastal line decreased as they dispersed on to the ice. When the distance of ice to shore was zero or when extensive near-shore ice was present data were excluded from the analysis. There was a significant relationship between the mean distance to ice edge and the numbers of bears observed on the coast (Figure 3). As distance to ice increased, the number of bears near shore increased; conversely as ice advanced the number of bears near shore decreased.

Coastal feeding ecology study: southern Beaufort Sea

The U.S. Fish and Wildlife Service conducted a polar bear feeding ecology study on Cross and Barter islands during the fall open water period in September/October 2002–2004. The purpose of the study was to monitor the number, age, sex, and behaviour of polar bears at two bowhead whale carcasses, as a result of subsistence whaling activities. The study was supported by Minerals Management Service, the Alaska Nanuuq Commission, North Slope Borough, Alaska Eskimo Whaling Commission, Arctic National Wildlife Refuge, village residents of Nuiqsut and Kaktovik, and the USGS Alaska Science Center.

Data was collected by direct observation of polar bears during three-hour sessions systematically selected during the following time periods: dawn (6:00–9:00h), day (9:00–18:00h), dusk (18:00–21:00h), and night (21:00–6:00h). Whole island counts were conducted to obtain daily estimates of polar bears in the area. Scan sampling (15-minute intervals) was used to determine the number, age and sex of bears present at study sites; focal animal sampling of randomly selected individuals was used to record behaviour (during 20-minute intervals) and frequency of marine habitat use.

A total of 1,230 hours of observations were conducted at Barter and Cross islands during the course of the study, including 4,733 scans and 925 focal samples (Table 7). Results from whole island counts indicate that a daily three-year mean of 33.1 (SD = 15.5) polar bears occurred at Barter Island, 27.7 (SD = 10.1) polar bears per scan at the Bernard Spit study site, and 4.9 (SD = 4.9)

Table 7. Monitoring effort for polar bear coastal feeding ecology study at Barter and Cross Islands, Alaska, September/October, 2002–2004

	Barter Island			Cross Island		
	2002	2003	2004	2002	2003	2004
Study period	3–29 Sep.	8 Sep.–3 Oct.	9 Sep.–4 Oct.	11–25 Sep.	15–27 Sep.	16–27 Sep.
# Hours monitored	209	247	277	184	170	144
# Scan samples	739	831	1085	770	714	594
# Focal samples	213	229	290	23	38	133

polar bears per scan at the feeding site. The greatest number of polar bears seen at the feeding site (n = 37) occurred at night. Interestingly, 8–12 brown bears also accessed food at the Barter Island carcass site during 2003 and 2004 and were frequently seen interacting with polar bears. Brown bears tended to dominate interactions.

Based on the whole island counts, fewer bears occurred at Cross Island (mean three-year daily average = 6.1, SD = 3.8, max = 13) than Barter Island. During the three-year study period, a mean of 2.8 (SD = 2.7) bears occurred at the feeding site during the day. Due to safety reasons and the distance of the study site from the observation platform accurate counts could not be made at night. Mean bear numbers at both islands increased over the three-year study period.

All age/sex classes of polar bears were observed at Barter and Cross islands. The highest proportion (47%) of animals observed at the Barter Island feeding site were bears in family groups (17% adult females, 30% dependent cubs) , whereas the highest proportion (66%) of animals on Cross Island were single bears (63% adults, 3% sub-adults). Approximately 18% of bears observed at the Barter Island feeding site and 7% at the Cross Island feeding site could not be classified as to age or sex. Our data indicate that time of day may affect the age-sex composition of bears present at the Barter Island feeding site. For example, family groups comprised the majority of bears at the Barter Island feeding site during the day (62%), and dawn/dusk (57%), whereas single bears (41%) were more prevalent at night, compared to family groups (34%). Segregation at the feeding site among the sex and age classes may be related to the high density of bears at Barter Island. At Cross Island, the proportion of family groups using the feeding site was greatest during the day, whereas the proportion of single adults was greater during the dawn/dusk period. Night data for Cross Island was excluded from the analysis because we were not able to accurately sex and age the bears due to the long distance from the viewing platform and the bears.

Behaviours observed included: laying, sitting, standing, walking, running, swimming, feeding, interacting, playing with objects, digging, and rolling. Generally, polar bears tended to be least active (laying, sitting) during day and more active (walking, feeding, swimming, interacting) during dawn and dusk. Night-time behaviour is only reported for the Barter Island feeding site because viewing distances of greater than 500m at Bernard Spit and Cross Island limited the utility of the data. At Cross Island, we did observe bears becoming more active at dusk and also feeding at night, however, the amount of time is not quantified.

Generally, polar bears spent little time interacting and appeared to tolerate each other in fairly high densities. We did not observe any serious injuries as a result of polar bear interactions.

When behavioural data were grouped by cohort (females with dependent cubs, single adults or sub-adults), adult females with dependent cubs spent more overall time sitting, standing, or laying at the Barter Island feeding site, perhaps in vigilance of their cubs. They also spent more time swimming than other cohorts (this was observed for Cross Island as well). Sub-adults spent more overall time walking and engaged in intraspecific interactions at the Barter Island study sites.

Information from this study will be used for community-based interaction plans, polar bear awareness training, oil and gas lease sale planning, oil spill modelling, and environmental assessments. In 2005, we plan to: 1) continue with aerial surveys of the Beaufort Sea coastline to document polar bear abundance and distribution; 2) work with village residents to minimize bear-human conflicts; and 3) initiate a study to document polar bear-brown bear and bear-human interactions at Barter Island.

An assessment of the use of trained dogs to verify polar bear den occupancy

The oil and gas industry conducts many activities during the winter season on the North Slope of Alaska. During winter 2002, a pilot study was conducted to determine if trained dogs could verify the locations of known or suspected maternal polar bear dens by scent. Approximately 18km of bluff coastline on Cottle, Bodfish, and Pingok islands in the central Beaufort Sea of Alaska were surveyed with dogs on 20 and 21 February 2002. The dogs alerted at dens of three radio-instrumented bears, but did not alert on any of four hotspots previously identified during forward-looking infrared (FLIR) aerial surveys conducted in mid-December 2001. None of the four FLIR hotspots turned out to be dens. In addition, the dogs alerted at a location on Bodfish Island, which had not been located by earlier FLIR surveys, that was determined to be a bear den. Based on this pilot study, the use of trained dogs to locate occupied polar bear dens appears to be a viable technique that could help minimize impacts from oil and gas industry activities on denning polar bears.

Incidental take by oil and gas operators

The MMPA allows for the incidental, but not intentional, take of small numbers of marine mammals during specific activities at specific geographical sites, provided that the USFWS makes a finding that the activities authorized will not have a greater than negligible effect on the polar bear population. Section 101(a)(5) of the MMPA specifies that the total taking during a five-year period will have a negligible impact on the species and will not have an unmitigable adverse impact on the availability of such species for taking for subsistence uses. Regulations to authorize and govern the incidental take of small numbers of polar bear and Pacific walrus during oil and gas industry operations (exploration, development, and production) in the southern Beaufort Sea and adjacent northern coast of Alaska have been issued since 1993.

The most recent regulations were issued November 28, 2003 and expired on March 28, 2005 (68 FR 66744). New incidental take regulations for the oil and gas industry on the North Slope have been drafted and will be published in the Federal Registrar for public comments. Following publication of final regulations the USFWS anticipates to continue to issue Letters of Authorization (LOAs) and conditions for specific activities.

During 2004, 19 LOAs were issued to the oil and gas industry to take a small number of polar bears and Pacific walrus incidental under the Incidental Take Regulations. The number of LOAs issued remained the same as 2003 (19 LOAS). Annual LOAs issued under the Incidental Take Program since its inception in 1993 have ranged between 4 and 62 (Figure 4). In 2004,

Figure 4. The number of Letters of Authorization issued by the USFWS to incidentally take small numbers of polar bears, during oil and gas activities on the North Slope of Alaska, 1993–2004

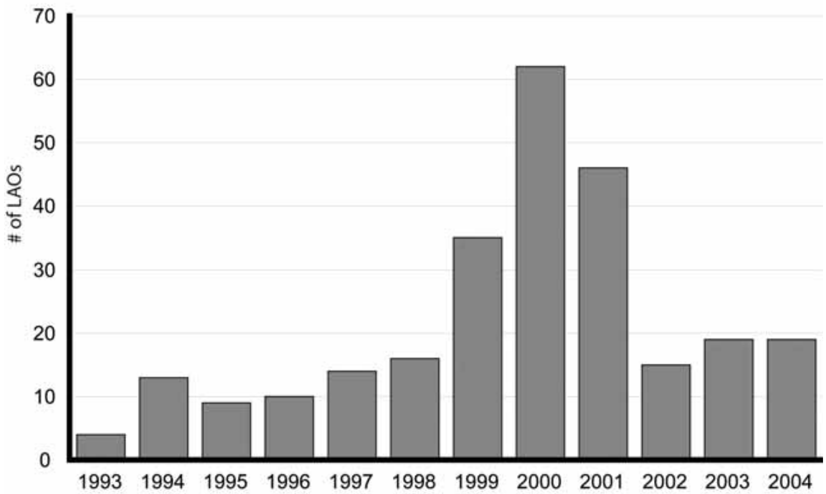
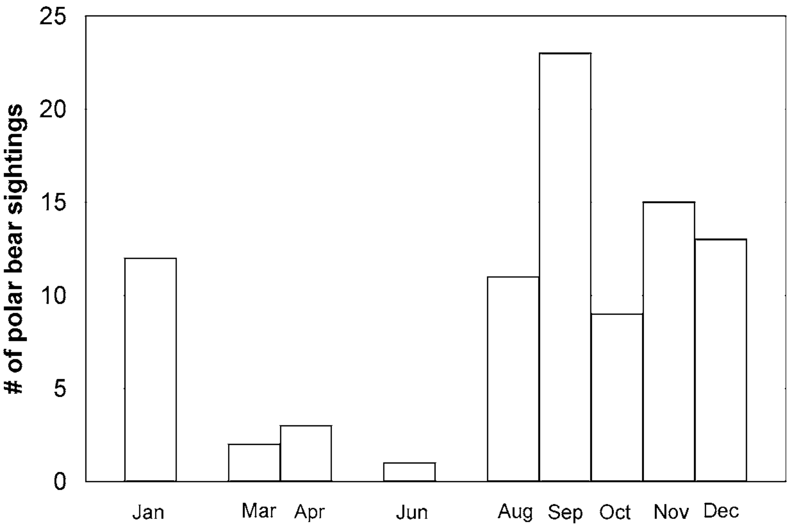


Figure 5. The number of polar bear sightings by month reported by North Slope oil and gas operators as a condition of their LOAs to incidentally take small numbers of polar bears during oil and gas activities on the North Slope of Alaska, 2004



ConocoPhillips Alaska, Inc., which is conducting oil and gas exploration within National Petroleum Reserve - Alaska (NPRA), accounted for 8 LOAs. Seven were for exploration and one was for production. The USFWS issued ExxonMobil two development LOAs, and Kerr-McGee Corporation two exploration LOAs. LOAs were also issued to ChevronTexaco and Pioneer Natural Resources Alaska, two seismic companies, a construction company, and the Bureau of Land Management.

In addition, three Intentional Take Authorizations were issued to the oil and gas industry in 2004, the same as were issued in 2003. These authorizations allowed companies to legally deter polar bear from industry activities for reasons of public safety.

During 2004, the oil and gas industry reported 89 polar bear sightings involving 113 individual bears. Polar bears were sighted more frequently during the months of August to January (Figure 5). Seventy-four sightings were of single bears and 15 sightings were family groups. Fifty-nine percent (n = 53) of polar bear sightings consisted of observations of polar bears travelling through or resting near the monitored areas with no perceived reaction to human presence. Forty-one percent (n = 36) of polar bear sightings involved Level B harassment, where bears were deterred from industrial areas. We have no data that indicates the encounters, which alter the behaviour and movement of individual bears, have a long-term effect on the Southern Beaufort Sea subpopulation.

The USFWS continues to work with oil and gas companies to improve monitoring procedures and techniques of polar bears within and around the North Slope oil and gas fields. Based on recommendations from a Polar Bear Monitoring Workshop held in Anchorage in 2003, the USFWS has increased its presence on the North Slope and its level of outreach activities for North Slope personnel. These include polar bear awareness programmes, such as safety training, attendance at safety fairs, as well as deterrence training which now includes oil spill response teams in Nuiqsut and Barrow. Future plans include revising the polar bear observation form that is used by industry personnel to report polar bear sightings, revising the polar bear hazing protocol, and improving the polar bear information collection process with the industry groups responsible for polar bear monitoring.

Marine Mammal Protection Act

MMPA Reauthorization

The U.S. Marine Mammal Protection Act (MMPA) was enacted in 1972 for the protection and conservation of marine mammals and their habitats, including polar bears. The Fish and Wildlife Service shares jurisdiction for marine mammals with our sister agency, National Marine Fisheries Service (NMFS). NMFS has jurisdiction over all cetaceans and pinnipeds (excluding walrus). The USFWS has jurisdiction of all other marine mammals, including Pacific walrus, sea otter, western manatee, and the polar bear. In general, it is prohibited to 1) take, 2) import, and 3) possess, transport, sell, export, or offer to purchase, sell, or export marine mammals or their products. However, some exceptions may be made for pre-MMPA specimens, Alaska natives, and by permit for scientific research, public display, enhancing the survival or recovery of a species, importation of sport-hunted polar bear trophies, and incidental take.

The MMPA was reauthorized in 1994, when authority to carry out the provisions of the Act was extended through 1999. Major amendments to the MMPA are typically made during the reauthorization process, although the Act may also be amended at other times.

Since the reauthorization process began in 1999, the U.S. Congress has held a number of public hearings and proposed several reauthorization bills. The Service, along with other federal agencies with responsibilities under the MMPA, has developed an "Administration" reauthorization proposal that recommends revisions to the MMPA based on our experience implementing the Act. The Administration's proposal is in the process of being resubmitted to the 109th Congress.

One important component of the Administration's reauthorization proposal is an amendment that would authorize harvest management agreements with the Alaska Native community. These agreements are designed to build important partnerships to prevent the depletion of marine mammal stocks in Alaska. The proposed amendment allows regulation of subsistence take of non-depleted marine mammal stocks, thus, providing substantial conservation benefits to marine mammals. The proposal also provides new responsibilities and a meaningful role for the Alaska Native community in resource management. Another provision recommended by the Administration proposal would streamline the permitting process to import sport hunted polar bear trophies from approved subpopulations in Canada.

On May 18, 2005, the newly introduced MMPA reauthorization bill H.R. 2130 was reported favourably by the House Resources Committee to the full House of Representatives. Although H.R. 2130 does not include either of the above amendments, Representative Gilchrest indicated H.R. 2130 is a work in progress that "partially authorizes some provisions of the MMPA." The USFWS hopes that the harvest management agreement language will be included in a substitute amendment prior to consideration of H.R. 2130.

Importation of polar bear trophies

The 1994 amendments to the MMPA allow for the importation of sport-hunted polar bear trophies from Canada by permit when the USFWS finds that management programmes ensure quotas are at sustainable levels. In order for a polar bear subpopulation to be approved for the import of trophies, the USFWS must make the following determinations: 1) Canada has a monitored and enforced sport hunting programme consistent with the purposes of the *Agreement on the Conservation of Polar Bears*; 2) Canada has a sport hunting programme based on scientifically sound quotas ensuring the maintenance of the affected population stock at a sustainable level; 3) the export and subsequent import are consistent with the provisions of the Convention on International Trade in Endangered Species of Wild Fauna and Flora and other international agreements and conventions; and 4) the export and subsequent import are not likely to contribute to illegal trade in bear parts.

The MMPA was amended on November 10, 2003, (H.R. 2691) to expand the period for allowing grandfathered trophy imports from April 1994 to February 1997 for sport-hunted bears from currently deferred subpopulations. A previous amendment to the MMPA (H.R. 1871, June 12, 1997) had grandfathered trophies taken from all subpopulations then comprising the Northwest Territories if legally sport hunted prior to April 30, 1994. The importation of polar bear trophies taken after February 18, 1997, will continue to be allowed only from approved subpopulations.

Six Canadian polar bear subpopulations are currently approved for the import of sport-hunted trophies by permit: 1) Southern Beaufort Sea; 2) Northern Beaufort Sea; 3) Viscount Melville Sound; 4) Western Hudson Bay; 5) Lancaster Sound; and 6) Norwegian Bay. Approval for the M'Clintock Channel subpopulation was withdrawn in 2001 in response to information provided by the Canadian Wildlife Service that this subpopulation had severely declined and that harvest quotas had not ensured a sustainable level. The M'Clintock Channel subpopulation remains approved only for bears sport-hunted on or before May 31, 2000. A fact sheet with information on which subpopulations are approved for the import of polar bear trophies by permit, which trophies qualify, what permits are required, and guidelines on how to import these trophies is available on-line at: http://international.fws.gov/pdf/polarbearsporthunted.pdf

In response to an increased population estimate for the Gulf of Boothia polar bear subpopulation, the

USFWS has been conducting a review of whether this subpopulation should be added to the list of subpopulations approved for the import of sport-hunted polar bears by U.S. residents. Approval of the Gulf of Boothia subpopulation, along with several other subpopulations, was deferred in 1997 pending additional information to make the necessary findings required under the MMPA.

Nunavut's recent management programme changes add a new dimension to our review. In order for a polar bear subpopulation to be approved for the import of sport-hunted trophies, the USFWS must consider the overall sport-hunting programme, including such factors as whether the programme includes: 1) reasonable measures to make sure the subpopulation is managed for sustainability (i.e., monitoring to identify problems, ways of correcting problems, etc.); 2) harvest quotas calculated and based on scientific principles; 3) a management agreement between the representatives of communities that share the subpopulation to achieve the sustainability of the programme through, among other things, the allocation of the quota; and 4) compliance with quotas and other aspects of the programme as stipulated in the management agreement or other international agreements.

In light of Nunavut's management changes, the USFWS recently requested confirmation from Canada on the status of changes to the currently approved management programmes, and the scientific basis for those changes to determine if these programmes continue to meet the sustainability standards of the MMPA, including our consideration of the possible impacts to the approval status of the Gulf of Boothia and other subpopulations. Once the USFWS receives the requested information from Canada we will determine the appropriate course of action, including whether authorizing imports of trophies taken from the Gulf of Boothia polar bear subpopulation is warranted. If, after reviewing Nunavut's new management plan, the USFWS determines that changes to the list of approved subpopulations is necessary, we will publish one or more proposed rules in the *Federal Register* and seek public

Table 8. Number of polar bear importation permits issued to US hunters by year [1]

	Subpopulation	1997	1998	1999	2000	2001	2002	2003	2004	Total
Approved subpopulations (includes pre-Amendment bears[2])	Southern Beaufort Sea	32	12	16	18	9	5	13	14	119
	Northern Beaufort Sea	41	4	8	9	16	4	13	16	111
	Viscount Melville Sound	5	4	0	0	1	4	5	4	23
	Lancaster Sound	17	16	104	31	33	28	29	30	288
	Norwegian Bay	0	0	1	1	2	4	0	1	9
	Western Hudson Bay	0	2	2	2	3	3	4	9	25
Subpopulation approval withdrawn (includes pre-Amendment bears[2])	M'Clintock Channel[3]	23	13	10	14	7	0	1	0	68
Deferred subpopulations (pre-Amendment[2] and grandfather[4] bears ONLY)	Gulf of Boothia	3	2	0	0	0	0	1	7	13
	Kane Basin	0	0	0	0	0	0	0	0	0
	Baffin Bay	3	2	0	0	0	0	0	8	13
	Foxe Basin	5	2	0	0	0	0	1	14	22
	Davis Strait	3	3	1	1	0	0	1	5	14
	Southern Hudson Bay	0	0	0	0	0	0	0	0	0
	Queen Elizabeth Islands	0	0	0	0	0	0	0	0	0
	TOTAL	132	60	142	76	71	48	68	108	705

[1] Bears may have been harvested in previous years
[2] Bears taken prior to April 30, 1994 (date of enactment of the MMPA Amendments of 1994) [permits issued 1997 to 2003]
[3] Approved only for bears lawfully taken on or before May 31, 2000
[4] Grandfather trophies taken prior to February 18, 1997 from deferred subpopulations (per MMPA Amendment of 11/2003) [permits issued 2004]

comment on the proposed changes to our regulations. The rule would also update the USFWS's regulations to reflect recent changes in the MMPA which grandfathered the import of trophies legally sport-hunted prior to February 18, 1997, from Nunavut or Northwest Territories, Canada.

A total of 705 polar bear trophy import permits were issued between April 1997, when regulations authorizing these imports went into effect, and December 2004 (Table 8). Funds from a $1,000 permit issuance fee are dedicated to support conservation initiatives for polar bear stocks shared between the U.S. and Russia and have been used to: 1) develop a bilateral conservation agreement; 2) conduct population surveys; 3) collect knowledge of polar bear habitat use; 4) develop standard surveying protocols; and 5) develop outreach materials.

The MMPA directs the USFWS to undertake a scientific review of the impact of the issuance of import permits on polar bear subpopulations in Canada. The USFWS previously received information for the report from the Canadian Wildlife Service, Government of Nunavut Department of Sustainable Development, Government of Northwest Territories Department of Environment and Natural Resources, and the Polar Bear Technical Committee. Due to other priorities, the polar bear assessment report has not yet been completed. Once the report has been completed, the draft report will be available for review and comment. Comments may be submitted by all interested parties and the final report will include a response to such comments.

Co-management: Alaska Nanuuq Commission

The Alaska Nanuuq Commission (ANC), which consists of representatives from 15 villages from northern and western coastal Alaska, was formed in 1994 to represent Alaska Native hunters on issues related to the conservation and subsistence uses of polar bears. The ANC executive committee meeting met in Nome on August 17–18, 2004 in conjunction with the Polar Bear Commission of the Association of Traditional Mammal Hunters of Chukotka (ATMHC).

Specific co-management accomplishments from 2001–2004 included: 1) incorporation of the Indigenous Peoples Council on Marine Mammals (IPCoMM) under the Alaska federation of Natives; 2) meetings with U.S. Congress, Marine Mammal Commission, U.S./Russia Polar Bear Working Group, IPCoMM, Alaska Native Harbor Seal Commission, Association of Traditional Marine Mammal Hunters of Chukotka (ATMMH), and the U.S. Fish and Wildlife Service regarding re-authorization of the MMPA and ratification and implementation of the U.S./Russian Polar Bear Bilateral Treaty; 3) development of a Native-to-Native Treaty; 4) participation in meetings concerning local subsistence uses, setting co-management priorities within the Native community; 5) technical expertise and financial support for the Chukotka Traditional Polar Bear Habitat Use Study and a traditional ecological knowledge study of Cultural roles of polar bears to Native peoples of Alaska; 6) organized the Ice-Seal Working group; and 6) participated in the ice seal and polar bear sampling programme. The ANC also provided quality hunting knives and letters of appreciation to 20 hunters who provided complete harvest information.

U.S./Russian Polar Bear Bilateral Treaty

The Executive Director and a representative from the Association of Traditional Marine Mammal Hunters of Chukotka (ATMMHC) are preparing for meetings in Washington D.C, to encourage passage of implementing legislation for the U.S./Russian Polar Bear Bilateral Treaty and the MMPA.

Synthesis of traditional knowledge

Two ongoing projects were initiated in 2003, one to develop an annotated bibliography of material related to the cultural role of polar bears to the Native Peoples of Alaska and the other to interview Alaska Native elders on their memories regarding oral tradition and cultural practices concerning polar bears. The annotated bibliography, by John Russell and Barbara Bamberger of EDAW Inc., is completed. John Burns conducted interviews with Native elders in Nome, Shishmaref, Wales, Anchorage, and Savoonga. Twelve tapes from the interviews which have been reviewed for accuracy and editing are being converted to transcripts.

North Slope studies

Sherman Anderson, ANC wildlife biologist, assisted the U.S. Fish and Wildlife Service Feeding Ecology study in Kaktovik in 2003 and 2004. The ANC, due to the close contact with Native subsistence hunters in each of the villages, has a unique opportunity to facilitate the collection of tissue samples for scientific analyses. Unusual weather conditions resulted in relatively few seal and polar bear samples being collected from subsistence harvested animals for scientific studies.

Education and outreach

The ANC web site is being reviewed and updated by Rex Snyder who previously assisted in the design and development of the web site for the Alaska Eskimo Whaling Commission and was the project leader for development of the web site for the Alaska Native Harbor Seal Commission. Elementary class presentations on the biology and management of polar bears are routinely made in village schools.

Collection of tissue samples

The ANC organized an Ice-Seal Working Group with representatives from the five regions that harvest ice-seals: North Slope, Maniilaq, Kawerak, AVCP and Bristol Bay. The former Deputy Director of the Alaska Native Harbor Seal Commission, Rex Snyder, was hired to direct the tissue sample collection programme.

The ANC supported a proposal from John Reynolds, for the fatty acid analysis of polar bears, ringed and bearded seals, and Pacific walrus tissues to determine the presence and relative importance of prey species. The ANC is working with the Alaska Department of Fish and Game, National Marine Fisheries Service, and the U.S. Fish and Wildlife Service to coordinate this effort. A funding proposal for the ice-seal studies has been submitted to Senator Stevens.

International treaties and conventions

U.S./Russia Bilateral Agreement

On October 16, 2000, the United States and Russia signed a long-term bilateral agreement for the conservation and management of polar bears shared between the two countries, *Agreement between the United States of America and the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population*. Draft legislation has been prepared and provided to committees of the U.S. Senate and the U.S. House of Representatives. Congressional enactment of the implementing legislation and Senate ratification of the treaty are required to enable new authorities within the agreement and to give the treaty the force of law in the United States. Russia has ratified all documents necessary to give the Treaty the effect of law. There is continuing concern that without implementation of the treaty, illegal and unquantified harvest in Russia along with the unrestricted harvest in Alaska will continue, resulting in depletion of the Chukchi/Bering seas polar bear subpopulation. Our inability to assess, monitor, and determine a population estimate in combination with changes in the sea ice habitat and the illegal harvest require implementation of the Bilateral treaty. Unilateral actions, by each country, would probably be ineffective in resolving these and other management concerns and would not address collaborative research needs.

The Agreement represents a significant effort by the United States and Russia and parties to the *1973 Agreement on the Conservation of Polar Bears* to implement a ground-level unified conservation programme for this shared subpopulation. The primary purpose is to ensure the long-term conservation of the Chukchi/Bering seas polar bear subpopulation and its habitat through science-based programmes which can be carried out in both countries. The Agreement is unique in the international arena since it provides for meaningful involvement by both Alaska and Chukotka native people and their organizations through a joint Commission which would help administer implementation of the Agreement. Specific management and research programmes would be identified collaboratively through the joint Commission comprised of a government and a Native representative from each country. A scientific group would also be formed to provide technical advice to the Commission.

The Agreement recognises the needs of native people to harvest polar bears for subsistence purposes and includes provisions for developing binding harvest limits, allocation of the harvest between both countries, compliance and enforcement. Each jurisdiction is entitled to up to one-half of the harvest limit. The Agreement reiterates requirements of the 1973 Five-Party Agreement on the Conservation of Polar Bear and includes restrictions on harvesting denning bears, females with cubs, and cubs less than one year old, as well as prohibitions on the use of aircraft, large motorized vessels, and snares or poison for hunting polar bears. The Agreement does not allow hunting for commercial purposes or commercial uses of polar bears or their parts. It also commits the parties to the conservation of ecosystems and important habitats, with a focus on conserving important feeding, denning, and concentration areas.

In the past, the shared Alaska-Chukotka polar bear subpopulation has been subject to different management strategies, hence coordination of research and studies has been difficult. In 1956 hunting of polar bears was banned in the former Soviet Union. Recently that level of protection has diminished due to an inability to enforce the 1956 nationwide ban on hunting polar bears. In Alaska, subsistence hunting by natives is not restricted provided that the polar bear subpopulation is not depleted. In addition, while several joint research and management projects have been successfully undertaken in the past, comparable efforts are either no longer occurring, or are conducted unilaterally. Therefore, the primary factors motivating the development of this agreement were the need to coordinate and regulate harvest practices, to protect polar bear habitat, and to conduct or expand joint research and management programmes.

Inuvialuit Game Council/North Slope Borough Agreement

The Inuvialuit Game Council and the North Slope Borough (IGC/NSB) held their annual meetings on the *IGC/NSB Agreement on the Management of Polar Bears* in the Southern Beaufort Sea in 2001, 2002, 2003, and 2005. Each year the commissioners agreed to continue to maintain the harvest level within the existing quotas, 40 for each jurisdiction, and to work towards increasing marking, tagging and reporting compliance in all the villages. Collection of specimens for verification of sex and age and harvest information continues to be excellent in Canada. Other recommendations made between 2001 and 2004 were to: 1) evaluate and discuss how to incorporate the probability distribution model into management decisions; 2) discuss the options concerning disposal of the bowhead whale remains in the villages; and 3) to continue support for the animation of polar bear movements, the mark-recapture study for the Southern Beaufort Sea, monitoring bear aggregations in coastal areas during the fall, and long-term monitoring and research on ice seals.

The total harvest from the Southern Beaufort Sea subpopulation from 2000/2001 to 2003/2004 (four years) was 261 bears with an average of 65.3 bears per year which is below the sustainable harvest level of 80 bears. The sex ratio of the harvested bears from 2001–2004 was 149 males to 79 females. The net mean annual removal of females, which includes the addition of 50% of the unknown sex bears to the known female harvest, from 2001–2004, was 23.4 bears. This is less than the sustainable yield calculation of 27.7 bears, which is based on 2/1 male to female sex ratio in the harvest. Information was available for the sex of 85% of the animals harvested during this period. This agreement has been effective at maintaining harvest at or below the sustainable harvest levels.

References

Comiso, J.C. 2003. Warming trends in the Arctic from clear sky satellite observations. *Journal of Climate* **16**:3498-3510.

Evans, T.J. 2004a. *Concentrations of selected essential and non-essential elements in adult male polar bears (*Ursus maritimus*) from Alaska*. U.S. Fish and Wildlife Service, Anchorage, AK. Technical Report MMM 04-02.

Evans, T.J. 2004b. *PCBs and chlorinated pesticides in adult male polar bears (*Ursus maritimus*) from Alaska*. U.S. Fish and Wildlife Service, Anchorage, AK. Technical Report MMM 04-01.

Lunn, N.J., Schliebe, S., and Born, E.W. (comps and eds.) (2002). *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, Nuuk, Greenland*. IUCN, Gland, Switzerland and Cambridge, UK.

Smithwick, M., Martin, J.W., Mabury, S.A., Solomon, K., Sonne, C., Martin U.W., Born, E.W., Dietz, R., Derocher, A.E., Letcher, R.J., Evans, T.J., Gabrielsen, G.W., Nagy, J., Stirling, I., Taylor, M.K. and Muir, D.C.G. 2005. circumpolar study of perfluoroalkyl contaminants in polar bears (*Ursus maritimus*). *Environmental Science and Technology* **39**:5517-5523.

Verreault, J., Muir, D.C.G., Norstrom, R.J., Stirling, I., Fisk, A.T., Gabrielsen, G.W., Derocher, A.E., Evans, T.J., Dietz, R., Sonne, C., Sandala, G.M., Gebbink, W., Taylor, M.K., Nagy, J. and Letcher, R.J. 2005. Chlorinated hydrocarbon contaminants and metabolites in polar bears (*Ursus maritimus*) from Alaska, Canada, East Greenland, and Svalbard: 1996-2002. *Science of the Total Environment* **351**:369-390.

Polar bear research in Alaska

George M. Durner, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Steven C. Amstrup, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Geoff York, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Eric V. Regehr, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Kristin S. Simac, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Tom S. Smith, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Steven T. Partridge, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
Torsten Bentzen, Institute of Arctic Biology and Department of Biology and Wildlife, University of Alaska Fairbanks, Fairbanks, Alaska 99775, USA
Kristin Amstrup, U. S. Geological Survey, Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA
David Douglas, U. S. Geological Survey, Alaska Science Center, Biology and Geography Sciences, Juneau Office, 3100 National Park Road, Juneau, Alaska 99501, USA

Since the 13th Working Meeting of the Polar Bear Specialist Group the U.S. Geological Survey (USGS) has seen the completion of many research projects and the start of many new ones. Much has been accomplished and yet we have new challenges awaiting us. This report summarises our focal questions and progress in those areas.

The spring of 2005 was the fifth year of a five-year effort to determine the current subpopulation size of polar bears in the southern Beaufort Sea through mark-recapture methods. We continue to improve analysis techniques and subpopulation estimations for the polar bear subpopulation in the Beaufort Sea and assist the Canadian Wildlife Service with the subpopulation in Hudson Bay. We have advanced methods of using radio-telemetry data to delineate wildlife populations. This has allowed us to understand the distribution of polar bear subpopulations that occurs in Alaska and adjacent Canada. A practical application of this work includes helping resource managers to allocate harvest of polar bears in the Beaufort Sea region. Also, our new estimates of subpopulation density have allowed us to revisit the potential risks and effects of oil spills on polar bears in the Beaufort Sea. In late 2003 we were awarded funding to investigate the effects of climate change on polar bears in Alaska. Progress has also been made in the modelling of polar bear and sea ice relationships and preliminary results were included in conference proceedings published in early 2004.

We continued to develop methods of protecting maternal dens by completing our studies of Forward-Looking Infrared (FLIR) sensors as a means for detecting denning polar bears. We have refined our understanding of denning habitats in the central Alaskan coast, and extended our map of denning habitats to include those on the Arctic National Wildlife Refuge. Likewise, we are evaluating Interferometric Synthetic Aperture Radar (IFSAR) for delineating polar bear den habitat in the National Petroleum Reserve – Alaska. Rare opportunities to observe the post-emergence behaviour of polar bear families at den sites have presented themselves. These observations have allowed us to begin to understand the range of natural behaviours and some responses to human activity. We have worked with private agencies and industry to assess industrial sounds and vibrations received in artificial polar bear dens.

During winter and spring of 2003 we and our colleagues with the Canadian Wildlife Service encountered three rare events of intraspecific killings by polar bears. These predation events appeared to be nutritionally motivated and, we suspect, may be tied to changes in sea ice quality due to climate warming. A study of establishing paternity with genetic fingerprinting suggests reproductive patterns of polar bears may not be that different from other Ursids. Preliminary analysis suggested that a relatively small number of the possible males dominate most of the breeding. A study on the trophic levels of different foods consumed by polar bears is nearly complete, as is an investigation of the influence of diet on biomagnification of organochlorines in polar bears. Finally, we are continuing the collection and long-term archival of marine mammal tissues, including polar bears.

New studies are also slated to begin in 2005. We have continued to search for funding sources to test the feasibility of Radio Frequency Identification (RFID) tags as an alternative marking system for capture-recapture studies. We have, through collaboration with the University of Alaska and the Alaska Department of Fish and Game, secured new funding for this potentially valuable project. We also are collecting an array of tissue samples for a new project to develop methods for determining health and immune status of free ranging polar bears and examining "emerging" contaminants.

Western Hudson Bay population analysis

The polar bear subpopulation in Western Hudson Bay (WH) is the most intensively studied polar bear subpopulation in the world; subpopulation metrics and capture-recapture data have been collected consistently since the early 1980s (Ramsay and Stirling 1988). In addition to the wealth of scientific data, unique ecological aspects make WH an ideal area to study polar bear biology and population dynamics. First, during the summer months Hudson Bay is ice-free and the bears are confined to a limited geographic area to which they show a high degree of fidelity (Derocher and Stirling 1990). Also, as one of the southern-most polar bear subpopulations, population dynamics in WH may be among the first to respond to climatic warming in the arctic ecosystem (Derocher *et al.* 2004, Gough *et al.* 2004).

Several articles have appeared in the recent scientific literature concerning the status of WH polar bears in relation to climate change (e.g. Stirling and Derocher 1993, Stirling *et al.* 1999, Stirling *et al.* 2004). The prevailing view of the research community is that the WH subpopulation is under increasing nutritional stress. A causal link is hypothesised between this stress and a decrease in the polar bears' ability to access their primary prey, ringed seals (*Phoca hispida*). Decreased access to ringed seals is presumably related to earlier ice breakup, which forces the bears onto land earlier and prolongs their seasonal fast (Stirling *et al.* 2004). However, not all indicators of the status of bears in WH suggest a struggling subpopulation. Like many communities in the Canadian Arctic, Churchill, Manitoba has experienced an increase in the number of bears that visit the town prior to freeze-up each fall. Some might conclude, more numerous bear sightings in town suggest an increasing subpopulation.

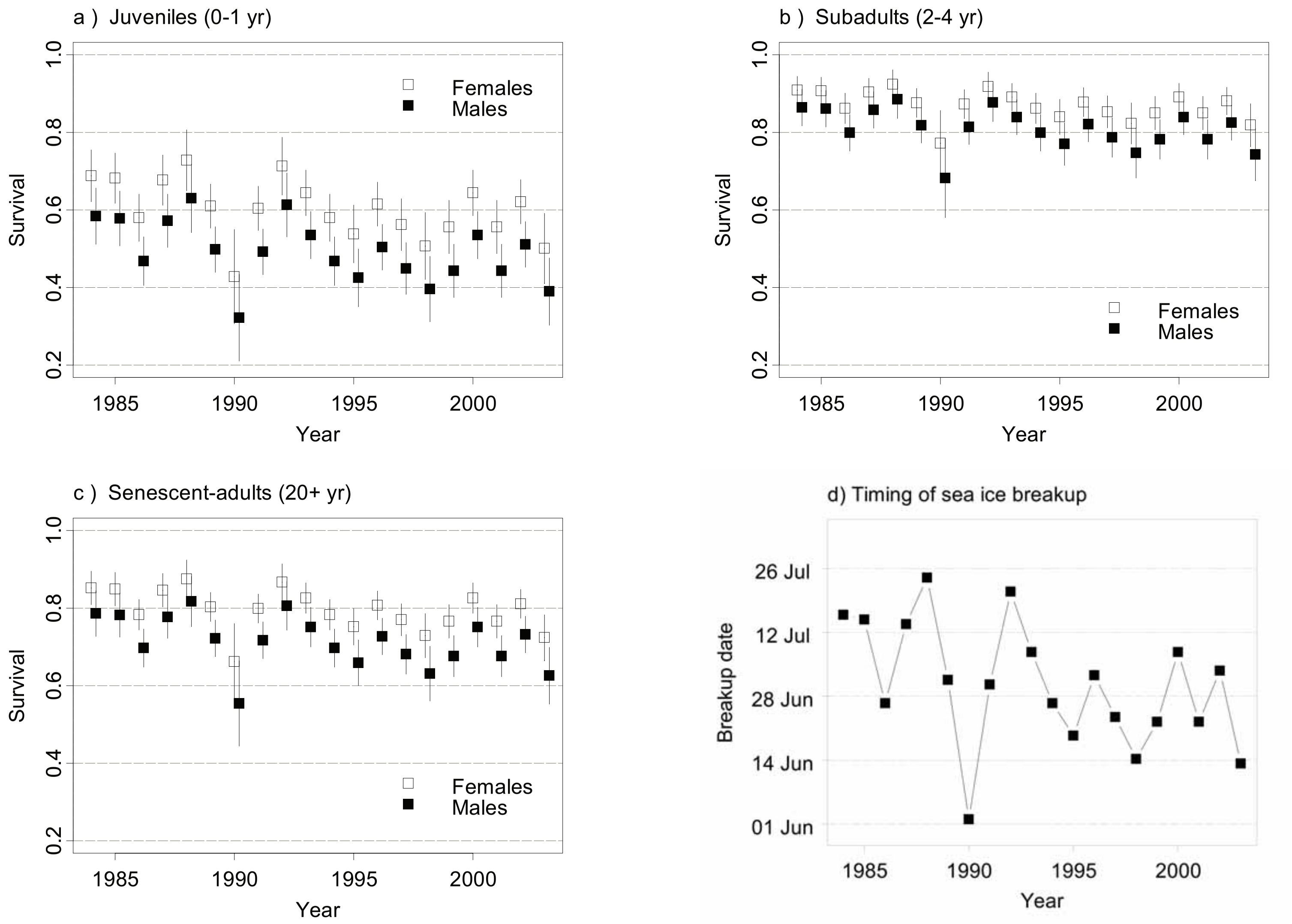
The most recent quantitative analysis of WH capture-recapture data was published nearly 10 years ago (Lunn *et al.* 1997). In 2005 the Canadian Wildlife Service (CWS), in collaboration with the U.S. Geological Survey (USGS), completed a comprehensive analysis of the WH capture-recapture data for the period 1984–2004. This analysis includes data collected by the CWS as part of their ongoing capture-recapture study, as well as data collected by the Manitoba Conservation for bears handled in the vicinity of Churchill.

The 2005 WH subpopulation analysis consisted of three main stages: (1) data preparation and summary of ecological metrics; (2) goodness-of-fit (GOF) assessment; and (3) open population capture-recapture analysis and abundance estimation. The primary purpose of the data preparation phase was to ensure quality control and establish an intuitive understanding of major patterns in the data (Tukey 1980). We then revisited the ecological metrics that have been used as indicators of the status of the WH polar bear subpopulation (Stirling *et al.* 1999).

The GOF analysis, performed in programmes RELEASE (Burnham *et al.* 1987) and U-CARE (Choquet *et al.* 2002), looked for major patterns in the data, tested whether the data met the standard capture-recapture modelling assumptions (Pollock *et al.* 1990), and identified a suitable "global" model. GOF also estimated the variance inflation factor $\hat{c}$, which adjusts variance estimates to account for un-modelled overdispersion in the data (White *et al.* 2001). After partitioning the data by age and sex (Sendor and Simon 2003), the GOF analysis did not identify any unmanageable lack of fit in the data.

The capture-recapture analysis, performed using the programme MARK (White and Burnham 1999) and open population software in S-PLUS (Amstrup *et al.* 2005), consisted of a survival analysis using conditional open population (e.g. Cormack-Jolly-Seber [CJS]) models per Lebreton *et al.* (1992), followed by abundance

Figure 6. a – c) Total apparent survival and 95% confidence intervals for juvenile, subadult, and senescent-adult polar bears in western Hudson Bay, estimated from the low-AICc Cormack Jolly Seber model fit to capture-recapture data collected by the Canadian Wildlife Service, 1984–2004. d) Timing of sea ice breakup in the Western Hudson Bay polar bear management area, which was the best predictor of survival for juvenile, subadult, and senescent-adult polar bears



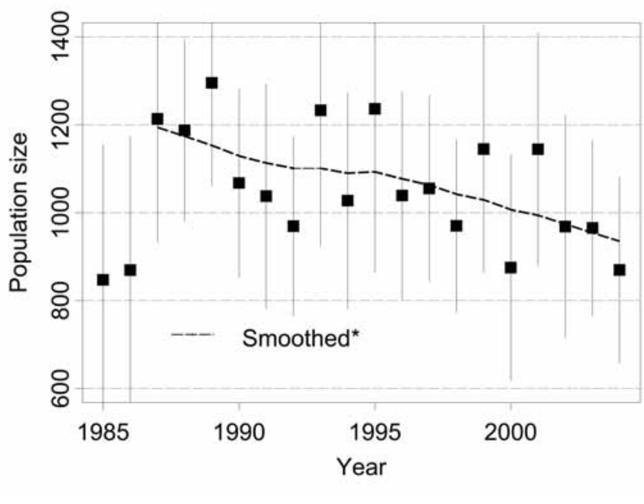
estimation using a Horvitz-Thompson (HT) type estimator (McDonald and Amstrup 2001). Symmetric 95% confidence intervals were derived using the method of Laake (Taylor *et al.* 2002). Inference regarding survival rates was based on the CWS-only portion of the dataset, as these data were collected with the goal of minimizing violations of capture-recapture assumptions (Lunn *et al.* 1997). Inferences regarding subpopulation size were based on the integrated CWS and Manitoba Conservation datasets because we believe that handlings in Churchill vicinity accessed a portion of the WH subpopulation (e.g. subadult males) under-represented in the CWS samples.

The analysis culminated in a CJS model with six parameters for survival probability and 22 parameters for recapture probability. Total apparent survival estimates for prime adult ($5 \leq$ age ≤ 19) males and females were stable over the course of the study at 0.893 (95% CI = 0.875, 0.908) and 0.929 (95% CI = 0.914, 0.941) respectively. A statistical correlation was established between the timing of spring ice breakup in the WH polar bear management area and survival rates for all other age classes ($0 \leq$ age ≤ 1, $2 \leq$ age ≤ 4, age ≥ 20) (Figure 6). This provides quantitative evidence for a population-level effect of the climate-related nutritional stressors that have been identified in the WH subpopulation (Derocher and Stirling 1996, Stirling *et al.* 2004).

Following the survival analysis, the low-AIC$_c$ model for the CWS-only dataset was generalized to accommodate differences between the CWS and Manitoba Conservation sampling protocols. A parsimonious model was selected for inference regarding capture probabilities (and ultimately abundance). There was a marked increase in the capture probability of bears handled by Manitoba Conservation vs. bears captured exclusively by the CWS, presumably related to geographic effects as well as the behavioural response of more frequent returns to the town of Churchill following an initial visit (this effect was strong for subadults, non-existent for prime adults).

The overall size of the WH subpopulation declined from about 1,200 individuals in 1987 to less than 950 individuals in 2004 (Figure 7). For management purposes, estimates of total subpopulation size were based on a smoothed curve fit to the 1987–2004 point estimates only, because estimates from the early years of the study were biased by expansion of the geographic area that was sampled. Model selection uncertainty was low with regards to the trend in WH subpopulation size; i.e., the post-1990 decline was evident in all reasonable CJS models, as well as several types of models not reported here (e.g. Jolly-Seber lambda estimation methods [Pradel 1996], an *ad hoc* implementation of the robust design [Kendall *et al.* 1997], and the Manly-Parr with age model [Manly *et al.* 2003]). It is also worth noting that, while the average subpopulation size for 2000–2004 was 964, the

Figure 7. Population size and 95% confidence intervals for polar bears in western Hudson Bay, estimated from the low-AIC$_c$ model fit to capture-recapture data collected by the Canadian Wildlife Service and handling data collected by the Manitoba Conservation, 1984–2004.



average subpopulation size for this period based on the low-AIC_c model for the CWS-only dataset was 798. This suggests that the Manitoba Conservation data represented some polar bears that were consistently missed by the CWS sample (i.e., younger polar bears, which constituted a high proportion of the Manitoba Conservation sample). The decline in the size of the WH polar bear subpopulation was likely the result of both increased natural mortality of young polar bears associated with earlier sea ice breakup, and the continuation of harvest at formerly-sustainable levels. An integrated investigation of the population dynamics of polar bears in western Hudson Bay is needed (i.e., via individual-based modelling of the demographic parameters estimated from the capture-recapture analysis).

The availability of both rigorous capture-recapture data (collected by CWS) and reliable records regarding which individually-identified bears visit the town of Churchill (collected by Manitoba Conservation) offers a unique opportunity to resolve the apparently contradictory phenomena of a declining subpopulation and an increasing number of bears being seen near communities. In this case, the answer is simply that a larger portion of the WH subpopulation is visiting the town of Churchill each year. This response makes biological sense: if the subpopulation is experiencing increasing nutritional stress, more bears will be lured into the Churchill vicinity by the odour (and potential reward) of food in the town dump.

Using radiotelemetry to allocate harvests among polar bear stocks occupying the Beaufort Sea Region

Effective implementation of the "Polar Bear Management Agreement for the Southern Beaufort Sea" (Agreement; Treseder and Carpenter 1989, Nageak *et al.* 1991) between Inupiat hunters of Alaska and Inuvialuit hunters of Canada is dependent on the best information on the discreteness and overlap of neighboring polar bear subpopulations. The three recognised subpopulations in the Beaufort and Chukchi Seas, northern Beaufort (NB), southern Beaufort (SB) and Chukchi Sea (CS) (Lunn *et al.* 2002) have traditionally been presented with hard boundaries that do not account for this overlap. With this study we improve the efficacy of the Agreement through a new analytical procedure that quantifies the degree of overlap between adjacent subpopulations and allows for better management of the harvest of polar bears in the Beaufort and Chukchi Seas.

We analysed locations of satellite radio-collar (PTT) equipped polar bears captured by scientists with the USGS and the Canadian Wildlife Service from 1985 to 2003 in the Beaufort and Chukchi Seas. Our study area was a prediction grid of 660 square cells (5km x 5km) extending from west of Wrangel Island (Russia) east to Banks Island (Canada), and from near the North Pole southward into the Bering Sea. We used a two-dimensional Gaussian kernel density estimator to calculate individual home ranges and Ward's clustering algorithm (Johnson and Wichern 1988, Norusis 1994) to assign membership to one of three subpopulations. We then calculated population ranges by combining relocations of all members of each subpopulation and smoothing and scaling the raw frequencies of locations in each subpopulation with a 2-D Gaussian kernel density estimator. Relative probabilities that a member of each subpopulation would occur in each cell of our grid were calculated by scaling kernel density estimates for each cell for each subpopulation so that they summed (integrated) to 1. The relative probability of occurrence of bears from each subpopulation in each grid cell was calculated using an estimate of the size of each subpopulation. Multiplying scaled density estimates of each subpopulation within each cell by the estimated size of each subpopulation yielded expected numbers of bears from each subpopulation in each grid cell. We tested for seasonal differences by calculating the relative probabilities and associated standard errors for each cell on an annual (year-round) basis, and for the fall (September–January) and winter (February–May) seasons during which bears are most frequently hunted. We tested for differences between annual and seasonal relative probabilities by calculating t-like test statistics for each cell in the grid. Grid cells in which these values exceed 1.96 revealed significant differences between the annual and seasonal values at the p-value of 0.05 level.

We used 15,308 locations of 194 female polar bears wearing satellite radio collars to delineate subpopulations and estimate encounter probabilities. We used 6,151 satellite relocations from 92 PTT-equipped bears that clustered into the CS subpopulation, 6,410 locations from 71 SBS bears and 2,747 locations from 31 NBS bears. Probability values allowed distributions of each subpopulation to be illustrated by 50% and 95% kernel estimates of the intensity with which bears from each subpopulation used different portions of the study area (Figure 8). No "t" values were >1.96. Hence, significant differences between seasonal and annual P's were absent. Relative probabilities of these three subpopulations varied greatly across the study area (Figure 9). Near Barrow, Alaska, 50% of harvested bears are predicted to

Figure 8. Intensity of use or boundary contours (50% and 95%) for three subpopulations occupying the Beaufort Sea region. Also shown are previously identified boundaries for the same subpopulations (Lunn *et al.* 2002).

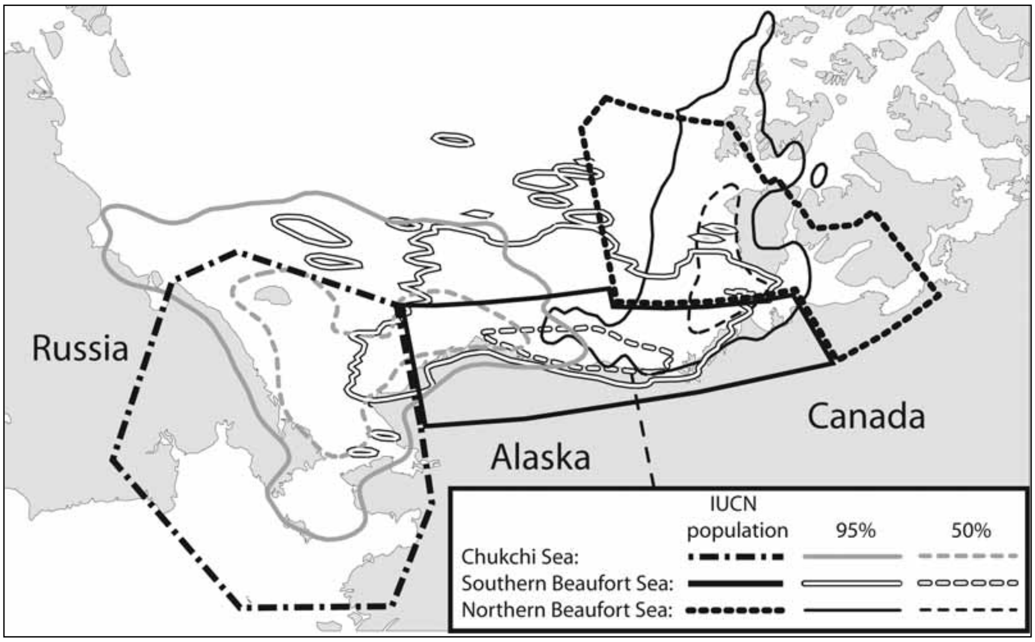


Figure 9. Contours of the relative probability of occurrence for members of three subpopulations of polar bears identified from radiotelemetry data in the Beaufort Sea region

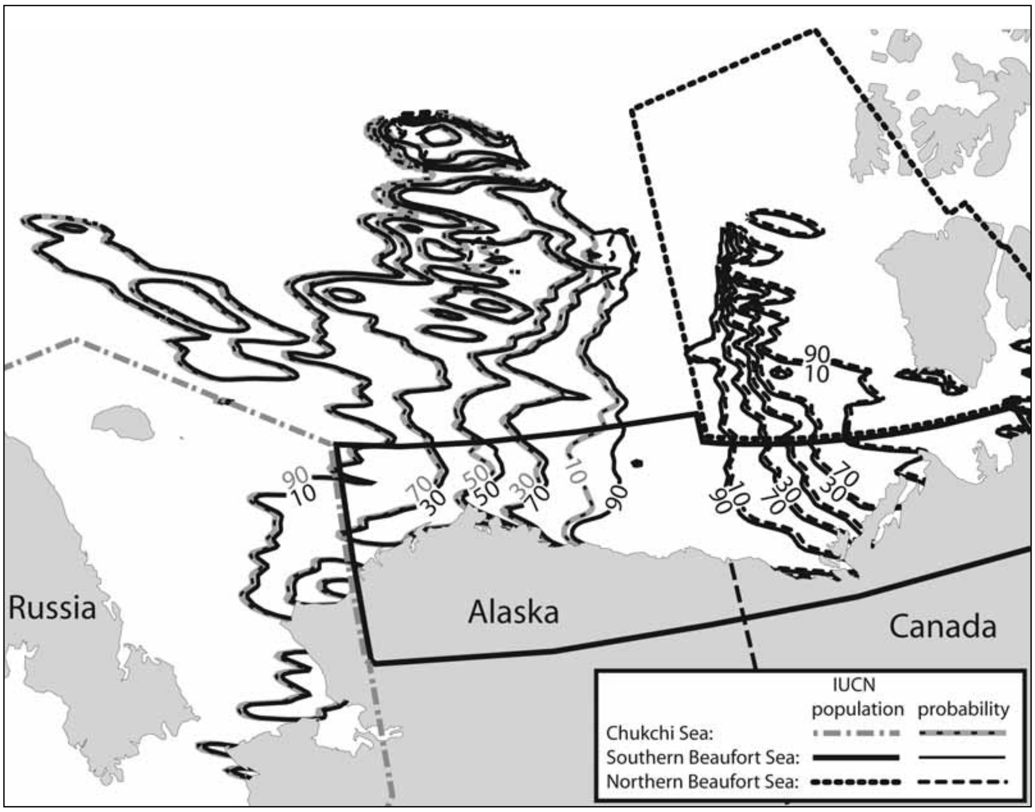
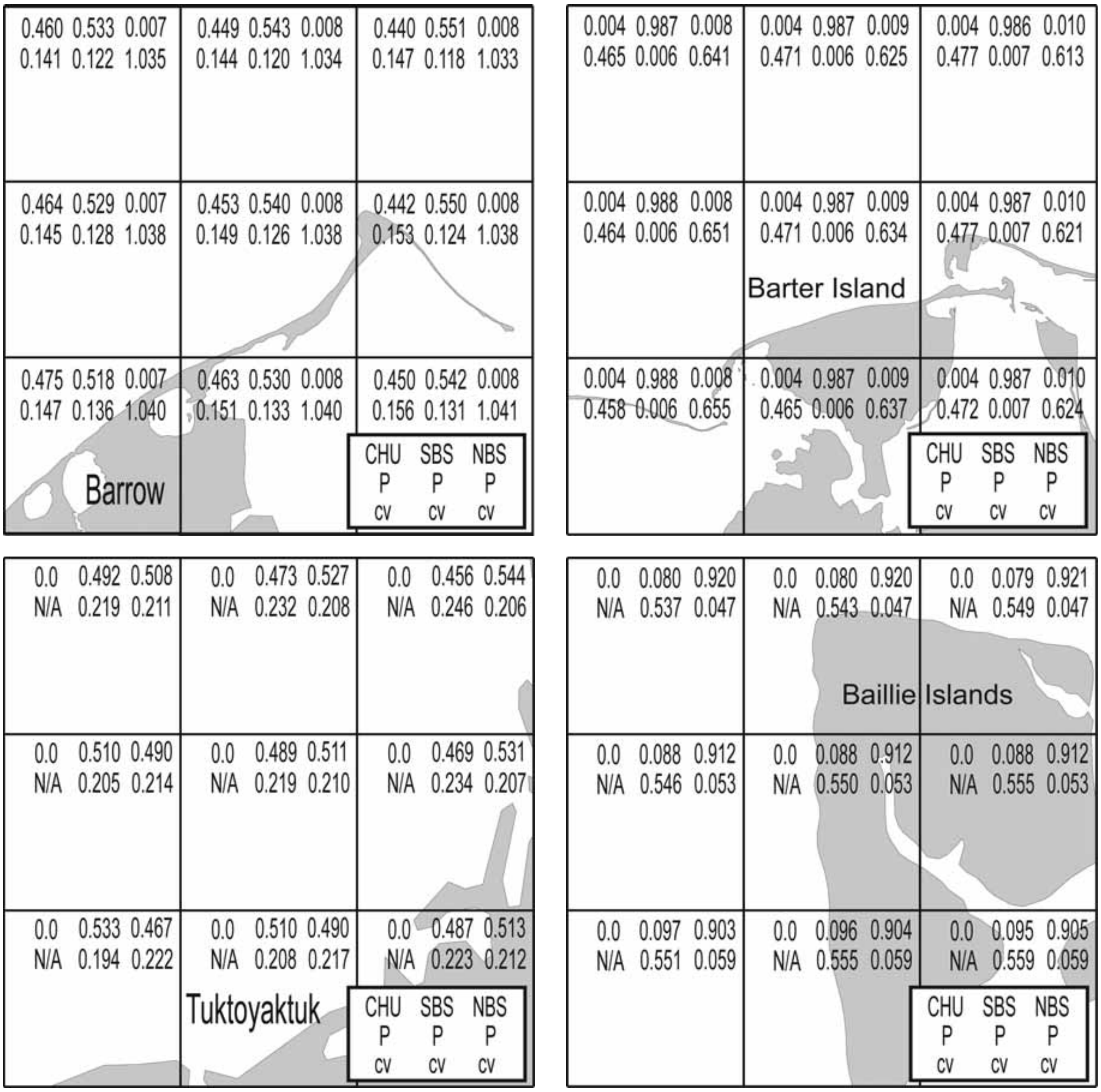


Figure 10. Estimated probabilities (pi) and coefficient of variation (cv) of harvesting a polar bear from each of three subpopulations in individual grid cells near Barrow (a), Barter Island (b), Tuktoyaktuk (c), and Baillie Islands (d).



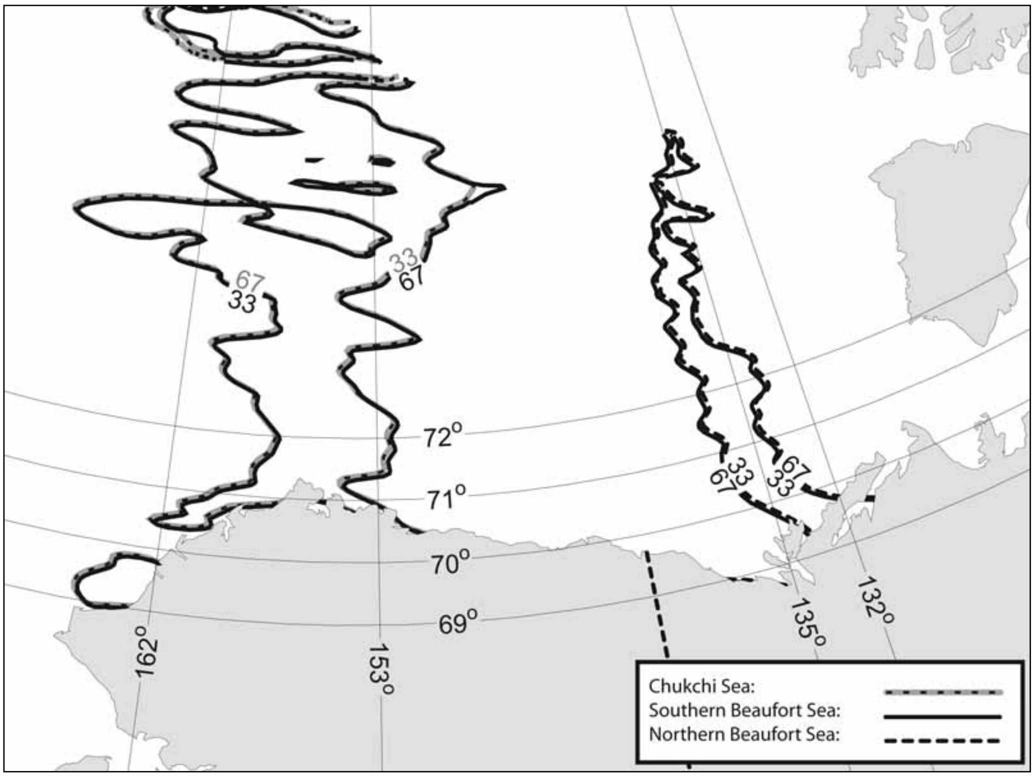
be from the CS subpopulation and 50% from the SBS subpopulation (Figures 8 and 9a). Nearly 99% of the bears taken by Kaktovik hunters are from the SBS (Figure 10b). At Tuktoyaktuk, Northwest Territories, Canada, 50% are from the SBS and 50% from the NBS subpopulation (Figure 10c), while bears harvested near Baillie Islands are mostly from the NBS subpopulation (Figure 10d).

Coefficients of Variation (CVs) for harvest probability estimates were small across most of our study area, lending credence to these estimated probabilities (Figure 10). The probability of occurrence of bears from each subpopulation can be displayed on a very fine scale for each cell in our grid (Figure 10) or as maps with contour lines that delineate subpopulation subunits (Figure 11). This new analytical approach allows previously accepted population management units to be subdivided in ways that will greatly improve the accuracy of allocation of harvest quotas among hunting communities and jurisdictions while assuring that harvests remain within the bounds of sustainable yield.

Amstrup, S.C., Durner, G.M, Stirling, I. and McDonald, T.L. 2005. Allocating harvests among polar bear stocks in the Beaufort Sea. *Arctic* **58**:247–259.

Amstrup, S.C., McDonald, T.L. and Durner, G.M. 2004. Using satellite radio-telemetry data to delineate and manage wildlife populations. *Wildl. Soc. Bull.* **32**:661–679.

Figure 11. Example of hypothetical polar bear hunting subunit boundaries in the SBS based upon 50% relative probabilities. Bears taken between 135º and 153º longitude would be classified as SBS polar bears, and would be allocated to the SBS harvest quota. Only half of the bears taken between 153º and 162º and between 132º and 135º would be allocated to the SBS harvest quota.



Estimating potential effects of hypothetical oil spills on polar bears

Polar bears are most common near the continental shelf, an area also preferred for hydrocarbon exploration and development. We used our ability to predict polar bear occurrence (see previous section) to estimate the impact of oil released by hypothetical spills from the existing North Star Oil production facility, and the site of the proposed Liberty production facility, in the central Beaufort Sea. We estimated the number of bears, and standard errors, likely to occur in each 1.00km2 cell of a grid superimposed over our study area. Oil spill footprints for September and October, the times during which we hypothesised effects of an oil-spill would be worst, were estimated using real wind and current data collected between 1980 and 1996. We used ARC/Info software to calculate overlap (numbers of bears oiled) between oil-spill footprints and polar bear grid-cell values.

Numbers of bears potentially oiled by a 5,912 barrel spill ranged from 0 to 27 polar bears for September open water conditions, and from 0 to 74 polar bears in October mixed ice conditions. Median number of bears oiled by the 5,912 barrel spill from Liberty in September and October were 1 and 3 bears; equivalent values for Northstar were 3 and 11 bears. Calculated variances of estimated bear densities were very low, and essentially all variation among oil spill scenarios was the result of differences among those scenarios and not the result of variation in the bear data. In October, 75% of trajectories from the 5,912 barrel spill at Liberty oiled 9 or fewer bears while 75% of the trajectories affected 20 or fewer polar bears at Northstar. Northstar Island is nearer the flaw zone than Liberty, and is not sheltered from deep water by barrier islands. Those characteristics bring more polar bears into close proximity with the island and also would allow oil to spread more effectively and more consistently into surrounding areas. By comparison, oil spills at Liberty were much more erratic in the areas they covered and the numbers of bears impacted. Hence, larger numbers of bears were consistently exposed to oil by Northstar simulations than those modeled for Liberty. This difference was especially pronounced in October spill scenarios (Figures 12 and 13). In October, the land fast ice, inside the shelter of the islands and surrounding Liberty, dramatically restricted the extent of most oil spills in comparison to Northstar which lies outside the barrier islands and in deeper water. At both locations, oil-spill trajectories affected small numbers of bears far more often than they affected larger numbers of bears. At Liberty, the number of bears affected dropped off much more quickly, however, than they did at Northstar. From the standpoint of polar bears, the proposed Liberty Island production site involves less risk than the existing facility at Northstar Island.

Amstrup, S.C., Durner, G.M. and McDonald, T.L. 2005. Estimating potential effects of hypothetical oil spills on polar bears. In prep.

Figure 12. Numbers of Bears estimated to be oiled by simulated oil spills from the Northstar site during the month of October. Shown here is the frequency histogram resulting from 499 simulated spills (trajectories) of 5,912 barrels of crude oil. October conditions were predominated by open and refreezing sea-water and mixed new and older ice.

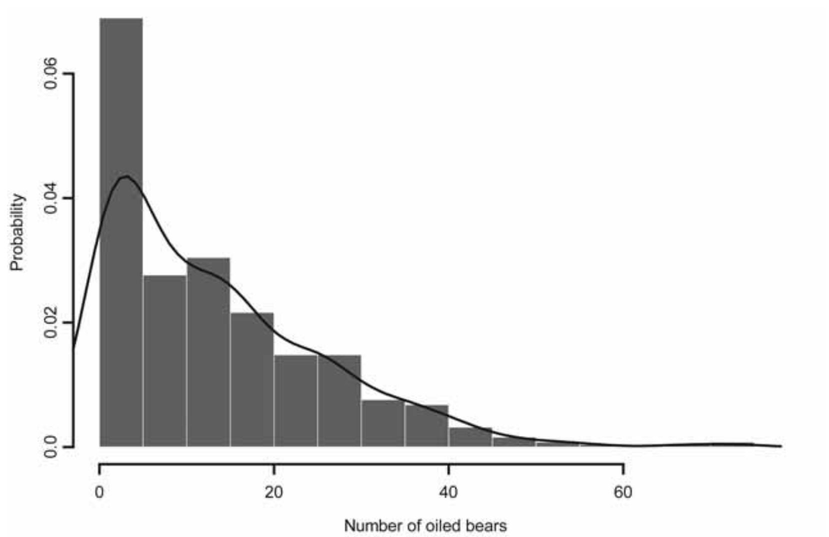
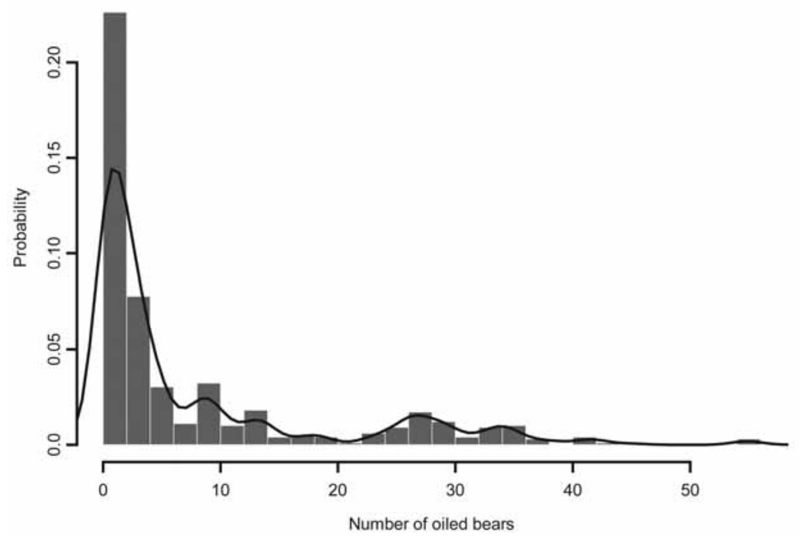


Figure 13. Numbers of Bears estimated to be oiled by simulated oil spills from the Liberty site during the month of October. Shown here is the frequency histogram resulting from 499 simulated spills (trajectories) of 5,912 barrels of crude oil. October conditions were predominated by open and refreezing sea-water and mixed new and older ice.



Use of sea ice habitat by female polar bears in the Beaufort Sea

Polar bears depend on ice-covered seas to satisfy life history requirements. Modern threats to polar bears include oil spills in the marine environment and degradation of the sea ice environment as a result of climate change. Managers need practical models that explain the distribution of bears in order to assess the impacts of these threats. Here, we explored the use of discrete choice models to describe habitat selection by satellite radio-collared female polar bears in the Beaufort Sea.

We analysed 1,780 satellite-radio locations from 53 polar bears, collected from 1997–2001, sea ice data derived from the National Ice Center and the Canadian Ice Service charts, and ocean depth data. Each bear location was compared to approximately 100 available random locations. Using stepwise logistic regression we generated resource selection models of habitat use for four seasons. We set the critical level of covariate entry as ≤ 0.1 for the adjusted score ÷2 (Klein and Moeschberger 1997). Each forward selection step was preceded by a backward removal step, where the variable with the smallest Wald ÷2 value was dropped from the model, provided that á > 0.1. We performed cross-validation of the final models by creating a map of Resource Selection Function (RSF) values for each season and comparing this map to the distribution of an independent source of polar bear location data.

Models generated for each of four seasons confirmed complexities of habitat use by polar bears and their response to numerous factors (Table 9). Bears preferred shallow water areas where different ice types intersected. Variation among seasons was reflected mainly in differential selection of total ice concentration, ice stages, floe sizes, and their interactions. Distance to the nearest ice interface was a significant term in models for three seasons. Water depth was selected as a significant term in all seasons, possibly reflecting higher productivity in shallow water areas.

Our cross-validation indicates close concordance of an independent set of polar bear locations with RSF derived from an average of sea ice conditions during this study. In every season, the majority of polar bear locations fell within the highest RSF regions (Figure.14). This preliminary test indicates that seasonal RSF models can predict polar bear distribution based on prior sea ice charts and bathymetry data. This greater understanding of polar bear sea ice preferences is an important step in understanding how climate change will influence the distribution of polar bears in Alaska.

Durner, G.M., Amstrup, S.C., Nielson, R. and McDonald, T.L. 2004. Using discrete choice modeling to generate resource selection functions for female polar bears in the Beaufort Sea. Pp.107–120 In Huzurbazar, S. (ed.). *Proceedings of the 1st Conference on Resource Selection Modeling*. Western EcoSystems Technology Inc., Cheyenne, Wyoming.

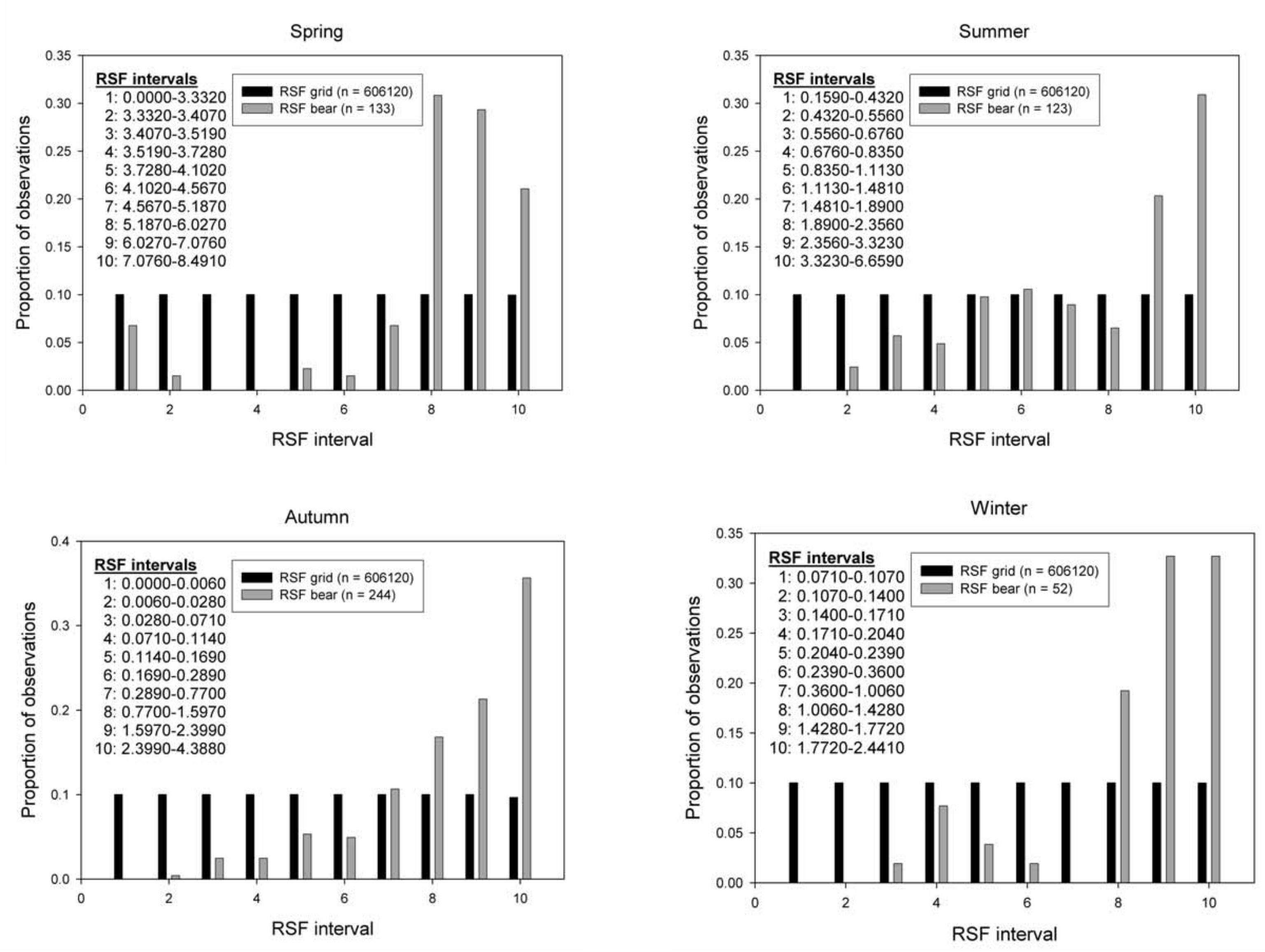
Detecting denning polar bears with Forward-Looking Infrared Imagery (FLIR)

Polar bears give birth in snow dens in mid winter, and remain in dens until early spring. Survival and development of neonates is dependent on a stable environment within the maternal den. In Alaska, petroleum-related activities currently span approximately 200km of the Alaskan Beaufort Sea coastal area. New

Table 9. Seasonal discrete choice models predicting relative probability, w(x), of an adult female polar bear selecting a point in the landscape characterized by x, in the Beaufort Sea, 1997–2001

Season	Model (standard errors are in parentheses below coefficients)
Spring	w(x) = exp{-0.0002402(*depth*) + 0.52481(*vastfloe*) + 3.99265 (*totcon*)}
Summer	w(x) = exp{-0.01085(*edge*) + 6.58263(*oldice*) - 4.93599(*oldice*^{2}) 0.0003382(*depth*)
	+ 1.21442(*firstyr*) + 4.52479(*youngice*) - 0.29138(*edge**youngice*)}
Autumn	w(x) = exp{-0.00152(*depth*) – 0.02968(*edge*) + 3.99265(*totcon*)
	+ 0.000000231511(*depth*^{2}) – 2.70505(*totcon*^{2})}
Winter	w(x) = exp{-0.00170(*depth*) + 0.000000349299(*depth*^{2}) + 0.44398(*vastfloe*)
	+ 1.94584(*youngice*) – 0.00524(*edge*) + 0.47312(*firstyr*)}

Figure 14. **Comparing the seasonal distribution of RSF values in the Beaufort Sea to RSF values at known polar bear locations during 2002. Grid RSF values were calculated from averaged ice data derived from NIC and CIS charts between 1997–2001.**



and proposed developments are expected to dramatically expand the area influenced by petroleum activities. These activities are a potential threat to denning polar bears, especially as they might disturb denning females.

To help manage and mitigate potential disruptions of polar bear denning, we tested the ability of Forward-Looking Infrared (FLIR) viewing devices to detect the heat signature of maternal polar bear dens. We tested this concept by flying transects over habitat containing known dens with FLIR equipped aircraft. We recorded flight and weather conditions at each observation and tallied whether or not the den was detected.

We viewed bank and bluff habitat features in which known dens were located with a FLIR Safire II mounted on the nose of a Bell 212 helicopter. Transects were flown at approximately 800ft AGL and 40kts. To avoid interference from solar warming of the landscape, we attempted to fly transects at night or during civil twilight of the arctic winter. Transects were ground referenced by GPS, and all were video recorded. Transects included other thermal signatures (hotspots) known not to be dens. We also recorded verification flights during which the helicopter hovered over each hotspot at low altitude and varying view angles. We visited most dens multiple times and noted whether known dens were detectable.

We conducted FLIR surveys, between 1999–2001, on 23 known polar bear dens on 67 occasions (1 to 7 times each). Four dens were never detected (17%), but three of those were only visited under marginal conditions. Nine dens were detected on all visits and 10 dens visited more than once were detected on some flights and not on others. Detection was dependent on weather conditions and solar radiation. For every one-degree (C) increase in temperature dew-point spread, the odds of detecting a den increased 3 fold. We were 4.8 times more likely to detect a den when airborne moisture (snow, blowing snow, fog etc.) was absent than when it was present, and we were approximately 28 times more likely to detect a den at night than we were after sunrise. Our data suggest some dens never will be detectable with FLIR. Conversely, we feel FLIR surveys conducted during conditions that maximize odds of detection will locate most dens most of the time and can be an important management/mitigation tool.

Amstrup, S.C., York, G. McDonald, T.L., Nielson, R. and Simac, K. 2004. Detecting denning polar bears with Forward-Looking Infrared imagery (FLIR). *BioScience* 54:337–344.

Polar bear maternal den habitat on the Arctic National Wildlife Refuge, Alaska

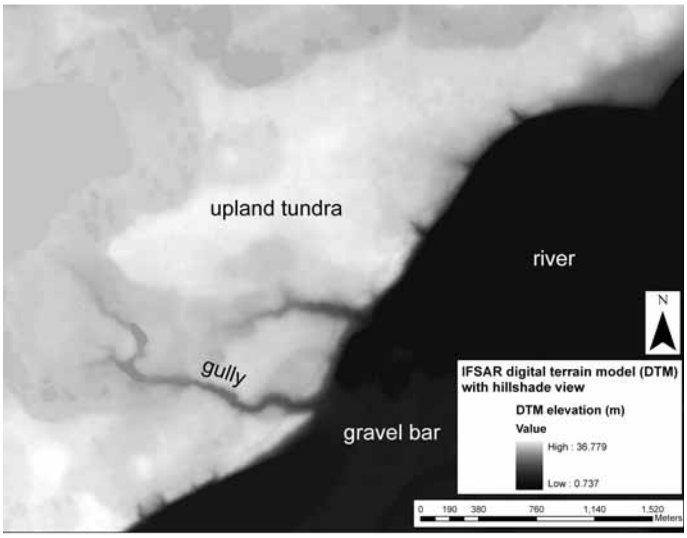
Successful reproduction in polar bears is dependent on landscape features that catch enough autumn snow to allow females to dig dens to protect newborn cubs (Blix and Lentfer 1979). In 2001, we identified denning habitats in the central coastal plain of northern Alaska through interpretation of high resolution landscape photography (Durner *et al.* 2001). This knowledge, incorporated in a geographic information system (GIS), will help managers develop a resource management plan to protect polar bears in maternal dens. This can reduce or eliminate potential conflicts between human activities and denning bears by simply avoiding habitats that polar bear prefer (Clough *et al.* 1987).

Interest continues in opening the 1002 area of the Arctic National Wildlife Refuge (ANWR) for petroleum extraction. The ANWR coastal plain, however, is an important region for polar bear denning. Also, our prior map included only a small portion of the northwest ANWR. Here, we proceed where we left off in our earlier work and describe a maternal den habitat map for the coastal plain of the ANWR. This map provides managers with the unique opportunity to consider polar bear maternal den habitat as a part of a decision making process in any management plan for the ANWR.

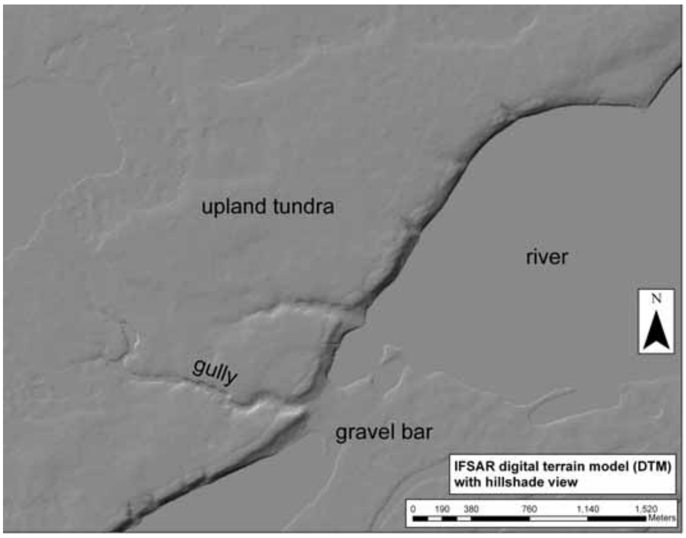
Methods followed those of Durner *et al.* (2001). We examined high resolution colour aerial photographs (n = 1655; scale: 2.56cm = 457.2m) taken along east/west transects within the ANWR coastal plain and adjacent coastal islands from the east side of the Canning River to the Canada border and south to the southern border of the 1002 area or the foothills of the Brooks Range. We identified linear features that could hold ? 1m of snow. The final map was provided as an ARCVIEW shapefile (ESRI, Redlands, Ca.). We verified the final map for precision and omission of qualifying den habitats with aerial surveys and on the ground measurements. Mapped den habitat also was compared to the distribution of the known locations of 38 dens and tested for uniformity on the landscape.

A total of 3,621km of den habitat was mapped within the coastal plain of the ANWR. This habitat represented only 23.2km^2, or 0.29%, of the 7,994km^2 ANWR coastal plain but had a relatively uniform distribution. Our ground-truthing revealed that our photo-interpretation correctly identified 91.5% of available den habitat on the ANWR. Further confidence was demonstrated by comparing the distribution of 39 polar bear dens located in recent years, within the area of our habitat map. Of those, 33 (84.6%) were within 145m of mapped bank

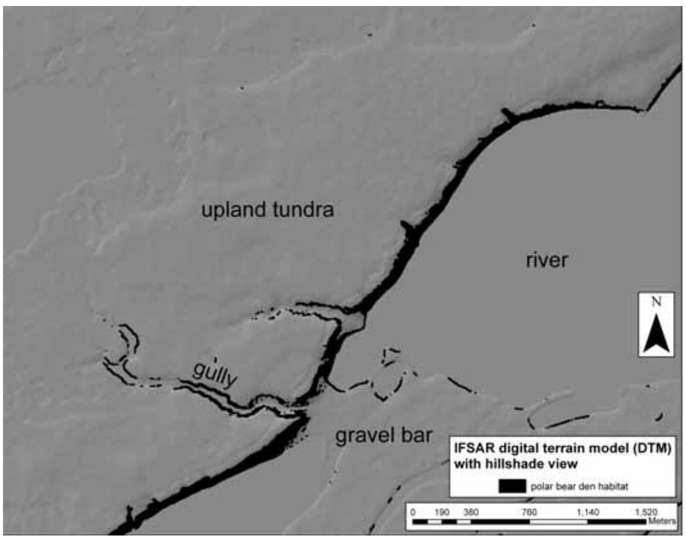
Figure 15. IFSAR digital terrain model data for a portion of the NPRA, Alaska.



a. **Elevation data are represented in 5m pixels where light shades are high elevations and dark shades are low elevations.**



b. **The same area as Figure 10a, but with a hillshade view, shows an abrupt bank interspersed with gullies, between upland tundra and a river.**



c. **Polar bear den habitat is identified where the difference between neighboring pixels is ≥ 1m.**

habitat. Our map of den habitat on the ANWR indicates 38% more den habitat than on the central coastal plain of northern Alaska and greater distributional uniformity (Durner *et al.* 2001), suggesting that more bears may use the ANWR coastal plain for denning simply because there appears to be more den habitat per unit of area. Habitats that polar bears prefer for giving birth to their young constitute a critical life history component that may be easily incorporated, with the information provided here, into a resource management plan for public lands.

Durner, G.M., Amstrup, S.C. and Ambrosius, K. 2006. Polar bear maternal den habitat in the Arctic National Wildlife Refuge, Alaska. *Arctic* 59:31–36.

Mapping polar bear maternal den habitat in northern Alaska with interferometric synthetic aperture radar data – an initial evaluation

While much of the northern Alaska coastal plain has been mapped for potential polar bear maternal den habitat, the distribution of den habitat in the National Petroleum Reserve – Alaska (NPRA) is largely unknown. We have identified many polar bear maternal dens in NPRA, indicating that NPRA is an important denning region. Previously, however, the distribution of suitable denning habitats there has not been known. This is an important management limitation because petroleum exploration in NPRA is ongoing. Because high resolution aerial photography is not available for NPRA, we investigated the use of very high resolution Interferometric Synthetic Aperture Radar (IFSAR; Intermap Technologies Corp., Ontario, Canada) digital terrain model (DTM) data for delineating polar bear maternal den habitat. Raster format IFSAR data has a resolution (horizontal cell dimension: 5m × 5m; vertical cell resolution: 0.01m) that lends itself well to identifying fine-scale landscape features. We used ARC/INFO tools to identify DTM pixels whose elevation difference with neighbouring cells was ? 1.0m. Specifying 1.0m elevation difference would effectively identify polar bear maternal den habitat (Durner *et al.* 2001).

We examined 89 IFSAR tiles in NPRA (total area of 10,670km^2) and identified 37km^2 of polar bear den habitat (0.35% of the total study area). Den habitat was readily apparent along coastlines, riverbanks and lakeshores (Figure 15). Limited ground-truthing showed that six (17%) precision points did not meet the specified height to be classified as den habitat (precision error: 17.1%). Two of these may be explained by incorrect IFSAR processing. At both waypoints, we encountered abrupt hedges of willows between 1–2m in height, suggesting errors in the Intermap algorithms to distinguish vegetation from ground topography. Of the 29 precision points that met our criteria for den habitat, 22 (77%) of those fell directly on the ground-level feature. Nine omission points were identified during ground-truthing. This translates into an omission error of [9/(35 + 9)] × 100% = 20.4%.

The distribution of eight polar bear dens largely agreed with the distribution of mapped den habitat. In every case dens occurred directly on or within 30m of den habitat delineated with IFSAR. IFSAR data indicated polar bear den habitat throughout the coastal areas of NPRA. Den habitat occurred where expected, i.e., coastal and river banks and lake shores. The distribution of den habitat derived from IFSAR appears similar to the distribution of den habitat identified using standard aerial photo interpretation techniques in other regions of the Alaska coastal plain. Den habitat on the NPRA shows a uniform distribution and it represents a fraction of the total landscape (0.35% of total area).

Two shortcomings are apparent in this application of IFSAR. The IFSAR DTM twice identified banks where there was a hedge of willows, demonstrating that algorithms used to filter structures and vegetation to produce the DTM are not always successful. Secondly, our analysis of IFSAR shows a relatively high omission error rate (20.4%). This may suggest that the horizontal resolution (5m) may not be sufficient to capture some narrow landscape features. Despite these shortcomings, IFSAR presents several advantages over standard photogrametric methods for mapping and identifying habitat. First, the data are already interpreted by Intermap, negating the need to have personnel physically examine remotely gathered landscape data and interpret that data. Second, features identified on maps are typically right on or very close to where they occur on the ground. Third, as standard GIS format, it is relatively easy to apply GIS tools to IFSAR data for analysis.

Northern Alaska polar bear den site behaviour and response to human disturbance

The activity budgets of undisturbed animals provide a basic understanding of their behaviour patterns as well as a benchmark against which human impacts can be evaluated. Denning in polar bears is an integral part of the reproductive process rather than a response to resource scarcity, and involves only pregnant females (Ramsay and Stirling 1988). From entry until emergence, the den's primary role is to provide a secure environment for the gestation and bearing of young. Following den emergence, however, continued den residence is beneficial in that it provides opportunities for acclimatization to the harsh arctic environment, development of locomotor skills, and an increase in body weight and overall size. It seems unlikely mothers and cubs would emerge and remain for weeks at the den site if the only function of dens was to provide a suitable environment for gestation and parturition. However, polar bears at den sites forage minimally, are susceptible to predation, and are thought to be sensitive to anthropogenic disturbance. Depending on the cub's maturation level, disruption that results in premature abandonment of the den could reduce cub survival. During the winters of 2002–03, several radio-tagged polar bears denned in close proximity to the Prudhoe Bay oil field. This provided an opportunity for us to document the post-emergence behaviour of family groups at den sites in Alaska.

We used focal scan sampling procedures to document the behaviour of radio-tagged polar bears from observation blinds positioned approximately 400m from dens. Using computers we continuously logged behaviours of adult polar bears. We visited den sites daily to determine when bears first emerged. Upon emergence, our observations continued daily, weather permitting, until family groups abandoned the den site.

We logged 459 hours of direct observation at eight den sites in March of 2002 and 2003. Eight adult female polar bears were observed outside their dens a total of 37.5 hours (8.2% of total observation time) during 40 focal observation sessions. Additionally, we recorded activities of five cubs during 11 focal observation sessions.

Polar bear families remained at den sites from 1.5 to 14 days (mean = 8.1 ± 5.1 days, N = 8) post-emergence. Lunn *et al.* (2004) reported similar results for Hudson Bay females and cubs with a range of 4 to 18 day stays near their den sites following emergence (mean = 8.7 ±1.8 days, N = 8). Diurnal activity for bears at all dens was trimodal (Figure 16), with peaks in the early morning, mid-day, and evening. In both years of study, mothers and cubs were mostly in the den during observation periods (91.8%). Hansson and Thomassen (1983) similarly reported that adult females and their cubs spent 80.6% and 85.5% of their time, respectively, in dens in the Svalbard region of Norway. Adult female polar bears in Alaska were inactive (e.g., sitting, standing and resting behaviours) 49.5% of the time while outside the den, whereas cubs were inactive only 13.4%. Hansson and Thomassen (1983) provided the only other study with comparable activity data, noting that females were inactive 66.4% and cubs 41.6%, while outside the den. Since adult females we observed spent > 91% of their time in dens, inactivity accounted for > 95% of their total activity budget.

The lengths of in-den and outside den time periods we observed varied significantly between years (2002: in-den 1.79 h, outside den 0.49 h; 2003: in-den 4.82 h, outside den 0.18 h; N = 46, *t*-statistic = -2.848, P = 0.003; N = 62, *t*-statistic = 2.3038, P = 0.012). Bears may have

Figure 16. The temporal pattern of polar bear activity (n = 8) at den sites, North Slope, Alaska. Dashed line represents the smoothed mean.

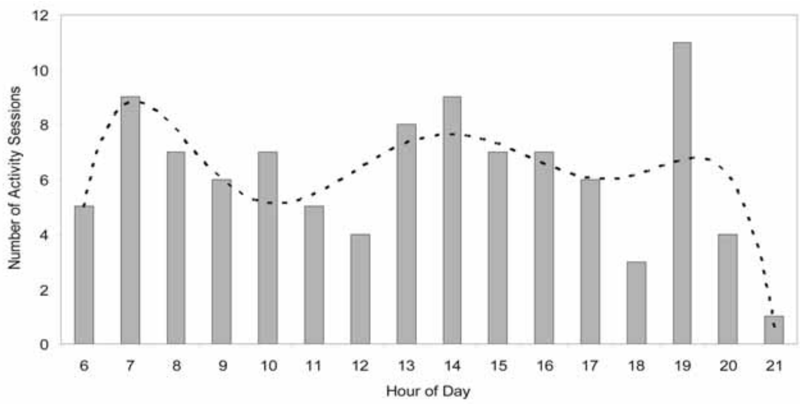
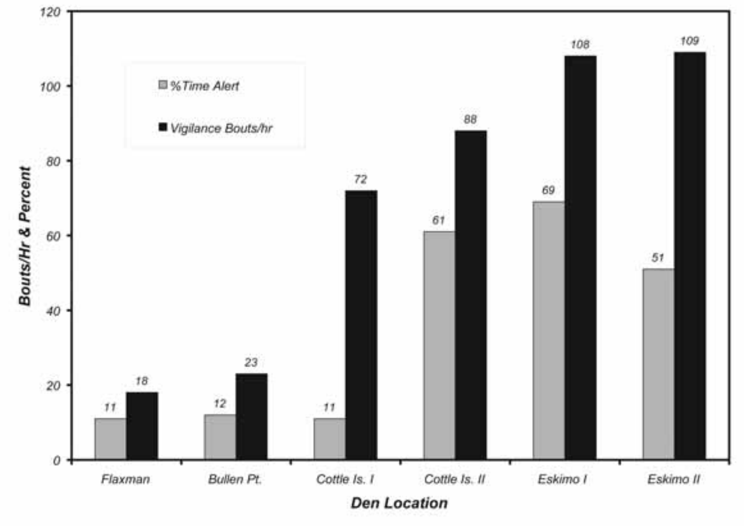


Figure 17. Amount of time spent alert and bouts of vigilance per hour at polar bear den sites, North Slope, Alaska 2002–2003.



chosen to remain in their dens longer in 2003 due to significantly colder weather than the year previous (-25.2° C vs. -20.6° C; N = 732, *t*-statistic =12.31, P < 0.000), although it was not significantly windier (-4.5 m/s vs. -4.6 m/s; N = 732, *t*-statistic = 0.863, P < 0.194).

Anecdotal observations of polar bear reactions to human activity showed a variety of responses. Activity budgets of two maternal groups which denned within 1km of a heavily used ice road were compared with those of four maternal groups which denned in undisturbed areas. Notably, female polar bears at den sites near the ice road exhibited significantly fewer bouts of vigilant behaviours (*t*-statistic = -5.5164, df = 4, P = 0.003), than bears at undisturbed den sites (Figure 17). Although the percentage time spent in vigilant behaviours at sites near the ice road was not significantly different than at undisturbed sites (*t*-statistic = -1.8902, df = 4, P = 0.066), results suggest a real difference exists. The most likely explanation for these observations is that bears exposed to heavy truck traffic habituated to it (i.e., ceased responding to stimuli that lacked negative consequences). The critical question, however, is whether or not there are negative consequences associated with a reduction in vigilance. Clearly, additional work is needed to refine our understanding of human disturbance and its effects on denned bears.

Assessment of industrial sounds and vibrations received in artificial polar bear dens, Flaxman Island, Alaska

Expansion of winter-time petroleum exploration and development in the Arctic has increased concerns that oil and gas activities could disturb denning polar bears, resulting in premature den abandonment and cub mortality. In the Beaufort Sea, female polar bears usually enter maternity dens from late October through early November and emerge with cubs in late March or early April. The period of denning coincides with the time of greatest industrial activity in northern Alaska. Dens are excavated in snow drifts on land or offshore pack ice. Amstrup and Gardner (1994) reported that 47% of maternal dens found in Alaska occurred on land. Bears denning on land are more likely to be exposed to industrial activities than bears denning on the offshore pack ice. Indeed, two maternity dens were located within 2.8km (1.7 miles) of a production facility in 1991 (Amstrup 1993), and female polar bear dens have been found near industrial activities on Flaxman Island. Due to this temporal and spatial concordance, there are valid concerns that noise and vibration caused by industrial activities may disturb denning bears.

Potential sources of noise and vibration during winter include exploratory drilling, vibroseis, production facilities, ice-road and ice pad construction, and aircraft traffic. Although Blix and Lentfer (1992) documented sound levels from petroleum-related activities at artificial dens, there is currently a lack of pertinent information that is necessary to determine how industrial noise and vibration effects on polar bears should be mitigated. Effects of industry-produced noise and vibration could include loss of denning habitat because pregnant females may avoid denning in the vicinity of the noise and vibration source, and reduced cub survival due to premature den abandonment.

As a part of research efforts, biologists with the USGS, Alaska Science Center, document the locations of polar bear maternal dens in Alaska. This information is provided to the U.S. Fish and Wildlife Service (USFWS), who in turn uses this data to manage industrial activities relative to denning polar bears. The oil and gas industry communicates with the USFWS to determine the location of known dens relative to their activities. In an effort to minimize disturbances to denning polar bears, the petroleum industry is required to avoid all known polar bear dens by 1.6km (1 mile), unless given special permission by the USFWS after obtaining a Letter of Authorization (LOA) allowing incidental taking. This 1.6km buffer around dens was arbitrarily established, and has been questioned. Hence, there is a need to understand the potential exposure levels of industrial noise and vibrations on polar bears in dens.

In March 2002, biologists from USGS, USFWS, LGL Alaska Research Associates, Inc. (LGL), JASCO Research LTD, and Exxon Mobil Production Co., collected noise and ground vibration data at four artificial dens in polar bear habitat on Flaxman Island, in northern Alaska. The study site was selected for its close proximity to ongoing remediation activities involving the use of heavy equipment and blasting. We conducted measurements to determine the absolute sound levels of various industrial activities and estimate potential noise and vibration exposure to denning polar bears. Comparison of sound levels, measured with microphones placed outside and inside the dens, permitted estimation of the sound-insulating properties of the dens. Vibration data were acquired from sensors placed in the tundra and snow of the den floors. Measurements of noise and vibration were made for the following vehicles: front-end loader, grinder, gravel hauler, fuel truck, pickup truck, Hägglund track vehicle, and a Tucker Sno-Cat. A single blast event, which was used to cut a well pipe, was recorded in the dens. In addition, noise and ground vibration data were obtained for Bell 212 and Bell 206 helicopters during manoeuvres around the dens.

Sound level and ground vibration measurements were made as vehicles approached and passed (speed: 17–32km/hr) all four den sites along the ice road connecting two remediation pits, although data from only one or two dens are presented in this report for brevity. Vehicle traffic sounds were reduced between 30dB and 42dB by the snow surrounding the artificial dens (Table 10). Most vehicle noise was undetectable within the den when the source was 500m away. In two instances, however, vehicle sounds were detectable at distances greater than 500m from the source. Vibrations for all ground vehicles, except the Hagglund, were not detectable beyond 90m (Table 11).

The general broadband sound pressure levels for seven vehicles that operated on Flaxman Island during this study, and accompanying background noise, show an approximately 15dB range between the loudest and quietest vehicles. Background sound energy, primarily caused by wind turbulence on the microphones, dominated measurements of vehicle noise below 10–20Hz. It is important to note that vehicle noise results were obtained by filtering the data to remove background noise levels. If this step had not been taken then wind noise levels would have been much higher and

Table 10. Received sound pressure levels (SPL; re 20 μPa) and distances of closest point of approach (CPA) of all-terrain tracked vehicles at Dens 5 (D5) and 7 (D7). Separate values for Range to Background are provided where significant difference was noted between the two dens

Vehicle	CPA (m)	In-den SPL at CPA (dB)	Outside den SPL at CPA (dB)	In-den SPL background (dB)	In-den range to background (m)
Hägglunds BV206	18	55	85	30	D5-400 D7-1000
Tucker Sno-Cat	20	38	80	27	400
Gravel Hauler (Empty)	12	47	84	30	D5-500 D7-2000
Gravel Hauler (Loaded)	12	48	87	30	500
Front End Loader	12	43	81	27	500
Pick-up truck	12	37	71	25	100
Fuel truck	12	50	80	29	300

Table 11. Vehicle ground vibration metrics and corresponding distances of closest point of approach (CPA) of all-terrain tracked vehicles

Vehicle	CPA (m)	Ground acceleration at CPA (mm/s^2)	Snow acceleration at CPA (mm/s^2)	Snow velocity at CPA (mm/s)	Range to acceleration < .5mm/s^2 (m)
Hägglunds BV206	18	10	11	13	90
Tucker Sno-Cat	20	1.2	1.5	1.9	30
Gravel Haul (Empty)	23	3.8	5.5	3.1	40
Gravel Haul (Loaded)	23	3.7	4.2	2.5	60
Front End Loader	22	8.0	8.5	3.5	60
Pick-up truck	22	1.5	1.5	1.3	43
Fuel truck	12	Data unavailable			

would have contaminated the broadband measurements of vehicle noise.

The Hägglund tracked vehicle produced some of the loudest recorded sound pressure levels detectable at far distances, while noise generated from the Tucker Sno-cat and pick-up trucks were hard to detect above in-air background levels.

The maximum distance vehicle noise was detected above background noise in the dens ranged from < 500m to 2000m. In-den sound pressure levels (SPL) for vehicles at the closest point of approach ranged from 37–55dB re 20 µPa. The Hägglund track vehicle produced the loudest noises near the den, while the Tucker Sno-Cat and pick-up trucks produced the lowest. Helicopter noise was well above background levels in the den until helicopters were at least 1000m from the den. The maximum noise level measured was 82dB (flat–slow) for the Bell 206 as it hovered 16m directly above the den. Noise signatures suggests that the Bell 212 and the Bell 206 produce similar broadband noise levels, however, noise from the 212 was concentrated at lower frequencies, suggesting that the Bell 206 may be more audible to polar bears if their hearing is more sensitive to frequencies above 50Hz than below.

The artificial dens were found to be very good at reducing noise exposure. The snow surrounding the man-made dens reduced the level of outside sounds by 25dB at 50Hz, and by 40dB at 1000Hz. The in-den ambient noise levels for the man-made dens were typically very low. Third-octave band levels for ambient noise levels were less than 40dB below 100Hz, and less than 20dB for bands greater than 100Hz. Low frequency sound levels were directly related to wind speed. Results of this study are summarised in a consultant's report.

MacGillivray, A., Hannay, D., Racca, R., Perham, C.J., MacLean, S.A. and Williams, M.T. 2003. Asssessment of industrial sounds and vibrations received in artificial polar bear dens, Flaxman Island, Alaska. Final report to ExxonMobile Production Co. By JASCO research Ltd., Victoria British Columbia and LGL Alaska Research Associates, Inc., Anchorage, Alaska. 60pp.

Intraspecific killings and cannibalism among polar bears in the Southern Beaufort Sea

Intraspecific killing has been reported among polar bears, brown bears (*Ursus arctos*), and black bears (*U. americanus*). Although foraging for food is one motivation for such killings and subsequent cannibalism, the ecological factors mediating such events are poorly understood. During 24 years of research on polar bears in the SBS region of northern Alaska and 34 in northwestern Canada, we only have seen two incidents of intraspecific killings in Alaska which appeared nutritionally motivated. In contrast to this, Alaskan and Canadian research teams discovered three confirmed instances of intraspecific predation and cannibalism between 24 January and 10 April 2004. These were discovered while conducting ongoing polar bear research in this region. One of these, the first of this type ever reported for polar bears, was a parturient female removed from her maternal den on a barrier island off of Alaska's north coast. The predating bear was clearly hunting in a known maternal denning area and apparently discovered the den by scent. Three other known polar bear dens near the predated one were abandoned in late winter, perhaps in response to the hunting behaviours of this bear. A second predation event involved an adult female just out of her den with a new cub, and the third was a yearling male. We hypothesise that the unusual frequency of such killings in the Beaufort Sea may reflect nutritional stress related to the longer ice-free seasons that have predominated in this region in recent years. A manuscript describing these events is being drafted mutually by the Alaskan (USGS and USFWS) and Canadian (CWS) research teams.

Smith, T.S., Amstrup, S.C., Stirling, I., Perham, C. and Thiemann, G.W. 2005. Intraspecific killings and cannibalism among polar bears in the Beaufort Sea. Submitted to *Polar Biology*.

Establishing paternity with genetic fingerprinting

Polar bears are the most mobile of all quadrupeds. Their movements are more variable than most other bears, and surprisingly, male polar bears appear to be no more mobile, in some locales and at some times of the year, than female polar bears. This suggests that a breeding pattern different from that in other bears is possible.

To explore breeding patterns in polar bears, we extracted DNA from blood and tissue samples and amplified the DNA using PCR. We used acrylamide gel electrophoresis to sequence the samples and identify specific alleles. Scores obtained were used to determine how closely individual polar bears might be related. Mother-offspring and sibling pairs were known because family groups often are captured together during spring fieldwork. Such physical evidence of paternity is not available because male polar bears accompany females only during breeding.

In a preliminary analysis of a limited number of microsatellite loci, we were able to exclude many male polar bears from consideration as fathers of our sampled offspring, and we noted that a small number of male bears were the putative fathers of large portions of the sample of cubs. This pattern is similar to that observed in limited samples from grizzly bears. This similarity in paternity patterns suggests that despite expansive movements over a moving substrate, some male polar bears dominate other males in terms of breeding success just as do terrestrial bears. We are currently reassessing this pattern by evaluating a larger number of microsatellite loci for a larger number of male bears.

Alaska Marine Mammal Tissue Archival Project

The banking of environmental specimens under cryogenic conditions for future retrospective analysis is an important part of wildlife health and environmental monitoring programmes. The goal of the Alaska Marine Mammal Tissue Archival Project (AMMTAP) is to collect tissue samples from marine mammals for archival in the National Biomonitoring Specimen Bank (NBSB) at the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, USA. Samples are collected under exacting protocols and stored under the best conditions so that they can be analysed for a variety of environmental parameters in the future.

This programme was brought under the umbrella of the Alaskan Polar Bear Project in 1998. It began, however, under the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service Outer Continental Shelf Environmental Assessment Program in 1987. The USGS, Alaska Biological Science Center (ABSC), the NOAA Fisheries, Office of Protected Resources (NMFS), and the NIST conduct this partnership project. Minerals Management Service (MMS) is the primary client agency for the AMMTAP providing programmatic guidance and review.

A substantial part of the sample collection is from arctic species and, since most of the animals sampled are from Alaska Native subsistence harvests, the project relies on cooperation and collaboration with several Alaska Native organizations and local governmental agencies. Through AMMTAP, samples are collected for real-time contaminant monitoring in the Marine Mammal Health and Stranding Response Program. In addition, the project has provided samples and/or data for many research programmes, both inside and outside the U.S., on a variety of subjects, including: genetics research, the circumpolar distribution of chlorinated hydrocarbons in beluga whales, baseline levels of trace elements in tissues, the identification of arsenic and mercury species in marine mammal tissues, biomarker research, nutritional studies, and studies on potential human health effects of Alaska Native subsistence foods.

Winter diet of Southern Beaufort Sea polar bears: the importance of bowhead whales inferred from stable isotope analysis

Polar bears are the top carnivore in the arctic marine ecosystem, with ringed seals (*Phoca hispida*) representing the majority of their annual diet. This dependency on ringed seal likely varies temporally and spatially based on availability of sea ice, ringed seals and other prey sources. Polar bears also feed on bearded seals (*Erignathus barbatus*), beluga whales (*Delphinapterus leucas*), and walrus (*Odobenus rosmarus*). They also scavenge beach cast carcasses of gray whales (*Eschrichtius robustus*), and they feed intensively on remains of bowheads landed by native subsistence hunters (*Balaena mysticetus*). Bowhead whales represent a food source which is lower in trophic level than ringed seal, bearded seal, or beluga whale. We used stable isotopes δ15N and δ13C to help determine the importance of low trophic level prey in the diet of 139 free ranging polar bears sampled along Alaska's Beaufort Sea coast in spring 2003 and 2004. The δ15N values ranged from 18.2% to 21.4% with a mean of 19.5% (SD=0.70) in 2003 and 19.9% (SD=0.68) in 2004 (Figure 18). Two-element three-source mixing models indicated that low trophic level prey, such as bowhead whale, may have composed 11–26% (95% CI) of the diet of southern Beaufort Sea polar bears in 2003, and 2–14% (95% CI) of the diet in 2004 (Figure 19). Bearded seals appeared to have composed a smaller proportion of prey consumed during both 2003 and 2004 (3 –35%, 95% CI). We found little significant variation in trophic position between sex, capture location, age, or weight of polar bears. This suggests there may be little sex or age segregation among polar bears in regard to scavenging lower trophic level prey such as bowhead whales. Our data suggests that relatively few whale carcasses are necessary to make a significant contribution to the diet of

Figure 18. **$\delta^{15}N$ signatures of polar bear red blood cells captured in spring 2003 (a) and 2004 (b), separated by sex and capture location (±SE).**

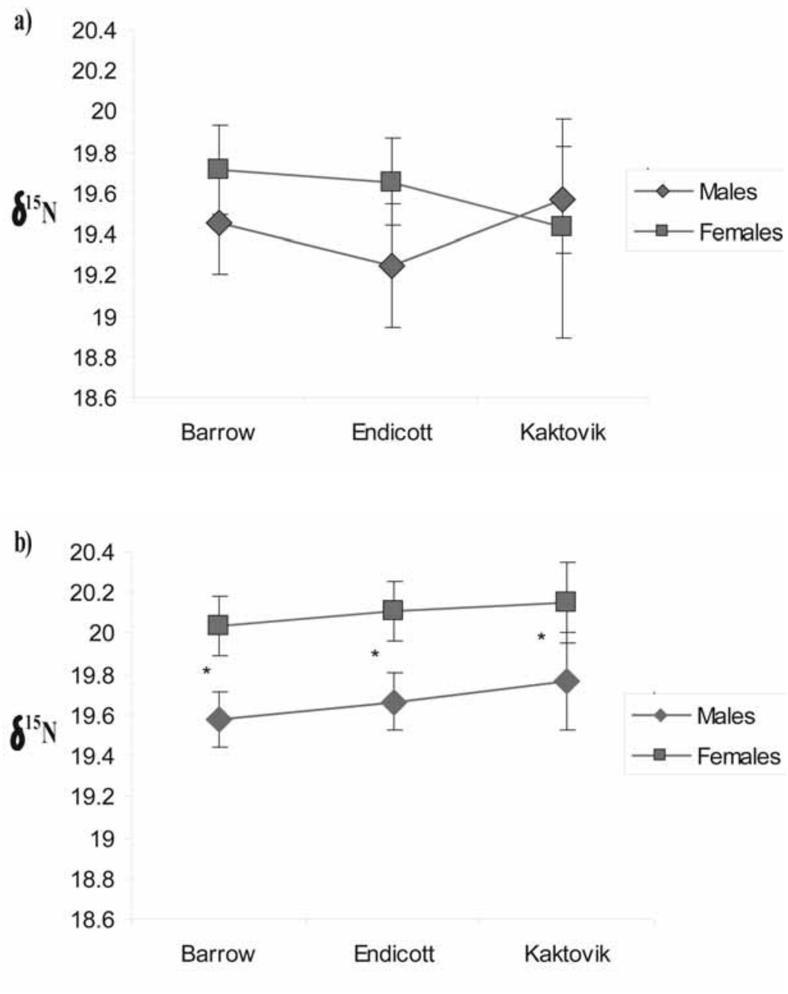
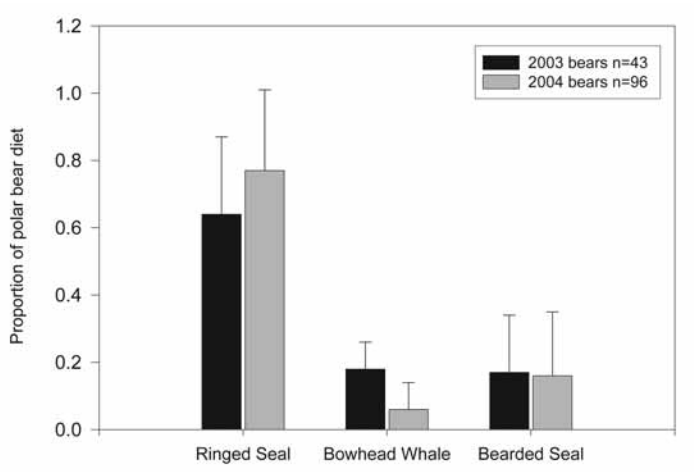


Figure 19. Dietary proportions of the three food sources for southern Beaufort Sea polar bears in the winters of 2002–2003 and 2003–2004. All means were calculated using the Isoerror model (Phillips and Gregg 2001) which includes 95% CI around all diet estimates.



polar bears in the southern Beaufort Sea. Observations also confirm that most polar bears probably presently have little opportunity to scavenge bowhead carcasses. The importance of beach scavenged foods to polar bear diets, however, may increase with prolonged open water seasons due to climate warming. It should be noted that the mixing models of the type employed in this analysis, can result in dietary proportions that are not bound between 0 and 100% (Ben-David and Schell 2001). Working out the complications with mixing models remains a challenge with regard to dietary information these isotope values convey. Nonetheless, with refinement of the mixing models and their inputs, we are hopeful that important information on polar bear dietary patterns may emerge.

Influence of diet on biomagnification of organochlorine pollutants in polar bears

Although studies of tissues collected under AMMTAP have been a small part of the programme, we plan to expand such studies as time and resources are made available. Along these lines we have initiated a collaborative effort with the North Slope Borough Department of Wildlife Management, and the University of Alaska Fairbanks to investigate the influence of diet on biomagnification of organochlorine pollutants in polar bears.

Varying concentrations of organochlorine (OC) contamination have been found in the tissues of polar bears throughout their range. Many of these organic pollutants are biomagnified with each trophic transfer in the food web and are found at extremely high concentrations in polar bears when compared to background environmental levels.

However, contaminant burdens can vary greatly among individual polar bears within the same subpopulation. This variation has not been explained fully by capture location, age, sex, condition, or reproductive status of the bear. Although ringed seal (*Phoca hispida)* may represent the majority of their annual diet throughout the Arctic, Beaufort Sea polar bears are opportunistic predators and consume a variety of species including bearded seal (*Erignathus barbatus*), beluga whale (*Delphinapterus leucas*), and walrus (*Odobenus rosmarus*), as well as scavenge on the carcasses of bowhead whales (*Balaena mysticetus*) landed by native subsistence hunters. Through dietary pathways, these species expose polar bears to a variety of contaminant profiles and burdens, ranging from the comparatively pollution free tissues of the lower trophic level bowhead whale to the more contaminated tissues of the ringed seal which represent a high trophic level.

Analysis of this data is currently underway in collaboration with Environment Canada and Dr Derek Muir. A publication is planned for winter 2005–06. An additional paper is also planned incorporating the chemical data and the isotope data previously mentioned.

Future projects: Radio Frequency Identification (RFID) Tags for grizzly and polar bear research

Grizzly bears (*U. arctos*) and polar bears are important species for subsistence communities along the Beaufort Sea coast for food, fur, and for their cultural importance. Much of our current knowledge about bear subpopulations, habitat use, movements, and interactions with oil and gas activities on the Alaska northern coast (North Slope) has been the result of repeated captures of tagged individuals. Application of existing and emerging Radio Frequency Identification (RFID) technology, currently used for military and commerce, has the potential to significantly increase the sample size of marked bears by decreasing the cost of recapturing bears. Another advantage of RFID tags is that fixed point readers could be installed on towers or other structures where bears frequently travel or concentrate. This would make remote recaptures possible.

An RFID system contains two major components: tags and a reader. The tags are currently capable of transmitting 100m under laboratory conditions when interrogated by the reader. Neither the current generation of readers (receivers) nor the tags has been attached to large mammals under arctic environmental conditions where aircraft are used extensively. The goal of this research and development project is to modify the RFID system and test its feasibility for grizzly and polar bear research and management by modifying the tags so they can be attached to bear ears and by modifying the reader for use in aircraft and land vehicles. Testing the RFID system will initially focus on grizzly bears marked during 2005 for the Oilfield Grizzly Bear Project before being tested on polar bears. RFID tags will be deployed on polar bears in spring 2006.

Emerging organic contaminants in blood and adipose of Alaska polar bears and relationship with haematological-based effects assessment

Based on studies in Svalbard (Norway) there is concern contaminants have resulted in immune compromised polar bears (e.g. reduced life expectancy and reproductive performance; Wiig *et al.* 1998). Persistent organic pollutants (POPs) and heavy metal concentrations in polar bears appear to vary widely geographically and within subpopulations. Some aspects of POPs biotransformation have been addressed (Letcher *et al.* 1998) and potential interactions with molecular plasma constituents (Skaare *et a*l. 2001) and highly selective accumulation of some enantiomers (Wiberg *et al.* 2000) may have a direct role in immune suppression. However, these data result from study of one subpopulation of polar bears.

Specific aims (long-term objective and specifics proposed)

Aim #1: Develop clinical (molecular and biochemical) battery of assays for determining health and immune status of free ranging Alaska polar bears using samples of subcutaneous adipose tissue and blood (including serum and plasma) in relation to "emerging" contaminants impacts.

Aim #2: Develop in vitro immune bioassays for testing the effects of well studied (OCs) and emerging contaminants on immune functions (i.e., contaminant and potential pathogen interactions) from polar bears.

References

Amstrup, S.C. 1993. Human disturbances of denning polar bears in Alaska. *Arctic* **46**:246–250.

Amstrup, S.C. and Gardner, C. 1994. Polar bear maternity denning in the Beaufort Sea. *J.Wildl. Manage.* 58:1–10.

Amstrup, S.C., McDonald, T.L., and Manly, B.F.J. (eds.). 2005. *Handbook of Capture-Recapture Analysis*. Princeton University Press, Princeton and Oxford. 313 pp.

Ben-David, M. and Schell, D.M. 2001. Mixing models in analysis of diet using multiple stable isotopes: A response. *Oecologia* **127**:180–184.

Blix, A.S. and Lentfer, J.W. 1992. Noise and vibration levels in artificial polar bear dens as related to selected petroleum exploration and developmental activities. *Arctic* **45**:20–24.

Blix, A.S. and Lentfer, J.W. 1979. Modes of thermal protection in polar bear cubs - at birth and on emergence from the den. *Am. J. Physiology* **236**:R67–R74.

Burnham, K.P., Anderson, D.R., White, G.C., Brownie, C. and Pollock, K.H. 1987. *Design and analysis methods for fish survival experiments based on release-recapture*. American Fisheries Society Monograph No. 5.

Choquet, R., Reboulet, A.M., Pradel, R., Gimenez, O. and Lebreton, J.D. 2002. User's manual for U-CARE. Mimeographed document, CEFE/CNRS, Montpellier, France.

Clough, N.K., Patton, P.C. and Christiansen, A.C. (eds.). 1987. *Arctic National Wildlife Refuge, Alaska, coastal plain resource assessment: Report and recommendation to the Congress of the United States and final legislative environmental impact statement.* U.S. Fish and Wildlife Service, U.S. Geological Survey, and U.S. Bureau of Land Management, Washington, DC, USA. Two volumes. 1306 pp.

Derocher, A.E., Lunn, N.J. and Stirling, I. 2004. Polar bears in a warming climate. *Integr. Comp. Biol.* **44**:163–176.

Derocher, A.E. and Stirling, I. 1990. Distribution of polar bears (*Ursus maritimus*) during the ice-free period in western Hudson Bay. *Can. J. Zool.* **68**:1395–1403.

Derocher, A.E., and Stirling, I. 1996. Aspects of survival in juvenile polar bears. *Can. J. Zool.* **74**:1246–1252.

Durner, G.M., Amstrup, S.C. and Ambrosius, K.J. 2001. Remote identification of polar bear maternal den habitat in northern Alaska. *Arctic* **54**:115–121.

Gough, W.A., Cornwell, A.R. and Tsuji, L.J.S. 2004. Trends in seasonal sea ice duration in southwestern Hudson Bay. *Arctic* **57**:299–305.

Hansson, R. and Thomassen, J. 1983. Behavior of polar bears with cubs in the denning area. *Int. Conf. Bear Res. Manage.* **5**:246–254.

Johnson, R.A. and Wichern, D.W. 1988. *Applied Multivariate Statistical Analyses*. Second edition. Prentice Hall, Englewood Cliffs, New Jersey. 607 pp.

Kendall, W.L., Nichols, J.D. and Hines, J.E. 1997. Estimating temporary emigration using capture-recapture data with Pollock's robust design. *Ecology* **78**:563–578.

Klien, J.P. and Moeschberger, M.L. 1997. *Survival analysis, techniques for censored and truncated data*. Springer, New York, USA.

Lebreton, J.-D., Burnham, K.P., Clobert, J. and Anderson, D.R. 1992. Modeling survival and testing biological hypotheses using marked animals: A unified approach with case studies. *Ecol. Monogr.* **62**:67–118.

Letcher, R.J., Norstrom, R.J. and Muir, D.C.G. 1998. Biotransformation versus bioaccumulation: Sources of methyl sulfone PCB and 4,4'-DDE metabolites in the polar bear food chain. *Environ. Sci. Tech.* **32**:1656–1661.

Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar Bears. Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Grou*p. IUCN, Gland, Switzerland and Cambridge, UK. 153 pp.

Lunn, N.J., Stirling, I., Andriashek, D. and Kolenosky, G.B. 1997. Re-estimating the size of the polar bear population in western Hudson Bay. *Arctic* **50**:234–240.

Lunn, N.J., Stirling, I., Andriashek, D. and Richardson, E. 2004. Selection of maternity dens by female polar bears in western Hudson Bay, Canada and the effects of human disturbance. *Polar Biol.* **27**:350–356.

Manly, B.F.J., McDonald, T.L., Amstrup, S.C. and Regehr, E.V. 2003. Improving size estimates of open animal populations by incorporating information on age. *BioScience* **53**:666–669.

McDonald, T.L. and Amstrup, S.C. 2001. Estimation of population size using open capture-recapture models. *J. Agric. Biol. Environ. Stat.* **6**:206–220.

Nageak, B.P., Brower, C.D. and Schliebe, S.L. 1991. Polar bear management in the Southern Beaufort Sea: An agreement between the Inuvialuit Game Council and North Slope Borough Fish and Game Committee. *Trans. North Am. Wildl. Nat. Resour. Conf.* **56**:337–343.

Norusis, M.J. 1994. *SPSS Professional Statistics 6.1*. SPSS, Inc., Chicago, Illinois. 385 pp.

Phillips, D.L., and Gregg, J.W. 2001. Uncertainty in source partitioning using stable isotopes. *Oecologica* **127**: 171–179.

Pollock, K.H., Nichols, J.D., Hines, J.E. and Brownie, C. 1990. Statistical inference for capture-recapture experiments. *Wildl. Monogr.* **No. 107**.

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. *Biometrics* **52**:703–709.

Ramsay, M.A. and Stirling, I. 1988. Reproductive biology and ecology of female polar bears (*Ursus maritimus*). *J. Zool. Lond.* **214**:601–634.

Sendor, T. and Simon, M. 2003. Population dynamics of the pipistrelle bat: effects of sex, age and winter weather on seasonal survival. *J. Anim. Ecol.* **72**:308–320.

Skaare, U.J., Bernhoft, A., Wiig, Ø., Norum, K.R., Haug, E., Eide, M.D. and Derocher, A.E. 2001. Relationships between plasma levels of organochlorines, retinol and thyroid hormones from polar bears (*Ursus maritimus*) at Svalbard. *J. Toxicol. Environ. Health, Part A* **62**:227–241.

Stirling, I., Lunn, N.J., Iacozza, J., Elliott, C. and Obbard, M. 2004. Polar bear distribution and abundance on the southwestern Hudson Bay coast during open water season, in relation to population trends and annual ice patterns. *Arctic* **57**:15–26.

Stirling, I. and Derocher, A.E. 1993. Possible impacts of climatic warming on polar bears. *Arctic* **46**:240–245.

Stirling, I., Lunn, N.J. and Iacozza, J. 1999. Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. *Arctic* **52**:294–306.

Taylor, M.K., Laake, J., Cluff, H.D., Ramsay, M. and Messier, F. 2002. Managing the risk from hunting for the Viscount Melville Sound polar bear population. *Ursus* **13**:185–202.

Treseder, L. and Carpenter, A. 1989. Polar bear management in the southern Beaufort Sea. *Information North* **15**:2–4.

Tukey, J.W. 1980. We need both explanatory and confirmatory. *Am. Stat.* **34**:23–25.

White, G.C. and Burnham, K.P. 1999. Program MARK: Survival estimation from populations of marked animals. *Bird Study* **46**(supplement):120–138.

White, G.C., Burnham, K.P. and Anderson, D.R. 2001. Advanced features of program MARK. Pp.368-377 In Field, R., Warren, R.J., Okarma, H. and Sievert, P.R. (eds.). *Wildlife, Land, and People: Priorities for the 21st Century. Proceedings of the Second International Wildlife Management Congress*. Wildlife Society, Bethesda, MD, USA.

Wiberg, K., Letcher, J., Sandau, C.D., Norstrom, R.J., Tysklind, M. and Bidleman, T.F. 2000. The enantioselective bioaccumulation of chiral chlordane and alpha-HCH contaminants in the polar bear food chain. *Environ. Sci. Technol.* **34**:2668–2674.

Wiig, Ø., Derocher, A.E., Cronin, M.M. and Skaare, J.U. 1998. Female pseudohermaphrodite polar bears at Svalbard. *J. Wildl. Dis.* **34**:792–796.

Polar bear management in Canada 2001–2004

N. J. Lunn, Canadian Wildlife Service, 5320-122 St., Edmonton, AB, T6H 3S5, Canada
M. Branigan, Department of Environment and Natural Resources, Bag Service #1, Inuvik, NT, X0E 0T0, Canada
L. Carpenter, Wildlife Management Advisory Council (NWT), PO Box 2120, Inuvik, NT, X0E 0T0, Canada
K. Chaulk, Labrador Inuit Association, PO Box 382, Station C, Happy Valley-Goose Bay, NL, A0P 1C0, Canada
B. Doidge, Makivik Corporation, Kuujjuaq Research Centre, PO Box 179, Kuujjuaq, QC, J0M 1C0, Canada
J. Galipeau, Nunavut Wildlife Management Board, PO Box 1379, Iqaluit, NU, X0A 0H0, Canada
D. Hedman, Manitoba Conservation, PO Box 28, 59 Elizabeth Road, Thompson, MB, R8N 1X4, Canada
M. Huot, Direction du développement de la faune, 675 boulevard René-Lévesque Est, Québec City, QC, G1R 5V7, Canada
R. Maraj, Department of Environment, PO Box 2703, 10 Burns Road, Whitehorse, YT, Y1A 2C6, Canada
M. Obbard, Ministry of Natural Resources, PO Box 7000, 300 Water St., Peterborough, ON, K9J 8M5, Canada
R. Otto, Department of Environment and Conservation, PO Box 2007, Corner Brook, NL, A2H 7S1, Canada
I. Stirling, Canadian Wildlife Service, 5320-122 St., Edmonton, AB, T6H 3S5, Canada
M. Taylor, Department of Environment, PO Box 209, Igloolik, NU, X0A 0L0, Canada
S. Woodley, Parks Canada Agency, 25 Eddy Street, Hull, QC, K1A 0M5, Canada

This report summarises the changes in the management of polar bears in Canada that have occurred since the 13th Working Meeting of the IUCN/SSC Polar Bear Specialist Group (PBSG) in 2001. Changes made prior to 2001 are outlined in the Canadian management reports included in the proceedings of previous working meetings of the PBSG. A summary of the regulations covering polar bear management in Canada, as of 31 December 2004, is presented in Table 12.

The Federal-Provincial-Territorial Technical and Administrative Committees for Polar Bear Research and Management (PBTC and PBAC respectively) consisting of representatives from the Government of Canada, three territories (Northwest Territories[NWT], Nunavut and the Yukon Territory), four provinces (Manitoba, Newfoundland and Labrador, Ontario, and Québec), and six co-management boards/resource user groups (Inuvialuit Game Council, Labrador Inuit Association, Makivik Corporation, Nunavut Tunngavik Incorporated, Nunavut Wildlife Management Board, Wildlife Management Advisory Council (NWT)), continued to meet annually to discuss research results and to make management recommendations.

Status report on polar bear subpopulations within and shared by Canada

The status of the 13 polar bear subpopulations that lie either within Canada's borders or are shared with Greenland and Alaska (Figure 20, Tables 13–16) is determined by the number of individuals in the subpopulation, the rates of birth and death, and the rate at which animals are harvested. Subpopulation boundaries were initially proposed based on barriers to movements, reconnaissance surveys, traditional knowledge, and partly on management considerations (Taylor and Lee 1995). Past revisions to the initial boundaries have occurred following reviews of the movements of individuals determined from mark-recapture studies, mark-kill data, and VHF and satellite telemetry (e.g. Taylor *et al.* 2001). The current subpopulation boundaries were established by the PBTC in 1996 (Lunn *et al.* 1998), although some minor "smoothing" of the boundaries has occurred more recently. In the Northwest Territories, the management boundaries differ slightly from the subpopulation boundaries (discussed further in the NWT section).

In May 2003, based on a review and recommendation by the PBTC, the PBAC agreed that the Queen Elizabeth Islands (QE) subpopulation would no longer be identified as a Canadian subpopulation but rather that any bears there should be included as part of an unknown Arctic Basin subpopulation. The QE subpopulation only existed because it occurred in that part of the range of polar bears in the Canadian High Arctic that was left over following the determination and mapping of the boundaries of the other Canadian polar bear subpopulations. The area is characterized by heavy

Table 12. Summary of regulations covering polar bear management in Canada as of 31 December 2004.

Category	Jurisdiction						
	Manitoba	Newfoundland and Labrador	Northwest Territories	Nunavut	Ontario	Québec	Yukon
Hunting	Closed	Reviewed annually: hunting permitted Feb–Jun in portion of Labrador north of Cape Harrison	Season varies between polar bear Management Areas: longest 1 Oct–31 May; shortest 1 Jan–31 May	No closed season	Closed	No sport hunting	1 Oct–31 May in GMZ1 only
Who can hunt	A person who possesses a Ministerial permit	Licences distributed by Labrador Inuit Association	A person who possesses a tag. Tags are distributed by the HTCs	A person who possesses a tag. Tags are distributed by the HTOs	Permissible kill by Treaty Indians	Inuit and Indians	Inuit only who are issued polar bear tags
Quota	27 (19 on loan to Nunavut; 8 retained for the polar bear Alert Program)	6	By settlement: 2004–05 quota is 103 (97 + 6 administered on behalf of the Yukon)	By settlement: 2004–05 quota is 507	Permissible kill of 30 (by restricting sales over 30)	None	6 (all of which are administered by the NWT)
Females and cubs protected by law	Yes	Females accompanied by cubs-of-the-year may not be taken	Yes, cub defined by hide length	Yes	No	Yes	Yes
Bears in dens protected by law	Yes	Yes	Yes, also protects bears constructing dens	Yes, also includes bears constructing dens	No	Yes	Yes
Proof of origin of untanned bear	Documented proof	Documented proof (no seal on hide implemented to date)	Tag on hide and export permit	Tag on hide and export permit	Seal on hide, proof of origin required on imported hides	Seal on hide	Seal on hide, kill monitored by export permit
Export permit required and cost (out of province or territory of origin)	Required: no cost	Required: no cost	Required: no cost. There is a $750.00 Trophy Fee for non-residents and non-resident aliens	Required: no cost. There is a $750.00 Trophy Fee for non-residents and non-resident aliens	Required: no cost	Required: no cost	Required: no cost
Export permit out of Canada	Required by CITES for all polar bears or parts thereof exported out of Canada; obtained in Province or Territory exporting from						

Table 12. Summary of regulations covering polar bear management in Canada as of 31 December 2004 (cont.).

Category	Jurisdiction						
	Manitoba	Newfoundland and Labrador	Northwest Territories	Nunavut	Ontario	Québec	Yukon
Scientific Licences	Discretion of Minister	Discretion of Minister	Discretion of Director, Wildlife and Fisheries	Discretion of Superintendent of Wildlife	Discretion of District Manager	Discretion of Minister	Discretion of Director, Field Services Branch
Selling of hide by hunter	Subject to conditions of Ministerial permit	Yes, must be taken legally	Yes, must have tag attached	Yes, must have tag attached	Must be sealed by Ministry staff	Must be sealed; fee 5% of average value of last two years	Permit required from Conservation Officer
Basis of Regulation	The Wildlife Act; reclassified as protected species in 1991	Wildlife Act, Chapter W-8 of The Revised Statutes of Newfoundland, 1990; classified as big game	Wildlife Act and Regulations; 1960 Order in Council (Endangered Species)	Wildlife Act and Regulations	Fish and Wildlife Conservation Act, 1997 (Statutes of Ontario, 1997 Chapter 41)	Wildlife Conservation and Management Act 1983; Order in Council 3234-1971; Bill 28-1978 (James Bay Agreement)	Wildlife Act 1981; Wildlife Regulations
Fur Dealer Authority	$25 general $25 travelling	Fur Dealer's Licence: no cost	$200 Fur Dealer's Licence for first year, $100 each year after	$200 Fur Dealer's Licence for first year, $100 each year after	$28 licence	$335 licence	$25 Resident $300 Non-resident $5 Agent $25.00 Non-resident restricted
Taxidermy	$30 licence	Yes, must be taken legally; legislation under review	$100 Taxidermist Licence for first year, $50 for each year after	$100 Taxidermist Licence for first year, $50 for each year after	See Tanner's Authority	See Tanner's Authority	$25 Resident Licence $30 Non-resident Licencea
Tanner's Authority	$30 licence	No legislation at present	$100 Tanner's Licence for first year, $50 each year after	a$100 Tanner's Licence for first ayear, $50 each year after	Fish and Wildlife Conservation Act, 1997 ($28 licence)	$256 Tanner's Licence	$2 Resident $10 Non-resident
Live Animal Capture	Ministerial permit	Ministerial permit	$5 licence to capture live wildlife	$5 licence to capture live wildlife	District Manager	Ministerial permit	Free Wildlife Research Permit, $5 fee for capture of live wildlife
Live Animal Export	Ministerial permit	Ministerial permit	Licence to Export Live Wildlife, $3000/polar bear	Licence to Export Live Wildlife, $3000/polar bear	District Manager	Ministerial permit	Special permit

Table 13. Status of Canadian polar bear subpopulations using risk analysis and incorporating harvest statistics from 1999–00 to 2003–04, including kills reported in Alaska and Greenland. Risk values are determined as the percent (%) of runs that result in a subpopulation decline after 15 years that would require five years or longer to recover to the original estimate with no harvest. Draft criteria for risk evaluation: <10% then acceptable; 10-20% then acceptable only if local knowledge indicates the subpopulation is long-term stable or increasing with current harvest rates; >20% then unacceptable.

			Mark-recapture or survey data		Perceived abundance[1]		Five-year mean (1999–2000/2003–04)			Three-year mean (2001–02/2003–04)			One-year (2003–04)		Projected[2]	
Sub-popul.	λ_N[3]	SE[4]	Estimate	SE	Estimate	SE[5]	Kill	SE	% Risk	Kill	SE		Kill	% Risk	Kill	% Risk
BB[6]	1.055	0.011	2074	265			192.4	25.5	90.3	224.7	28.3	98.3	236	99.9	234	99.8
GB	1.064	0.018	1523	285			39.2	1.7	0.4	40.7	1.5	0.4	41	0.4	74	9.9
KB	1.005	0.021	164	35			9.8	1.2	99.0	10.7	1.3	99.2	8	98.7	15	99.9
LS	1.030	0.011	2541	391			71.6	2.8	10.7	73.7	2.7	14.5	79	17.1	85	39.2
MC	1.031	0.012	284	284			7.0	4.4	0.5	0.3	0.3	0.0	0	0.0	3	2
NB[7]	1.067	0.012	1200	491			37.6	2.2	9.1	38.0	2.0	9.1	36	7.8	41	9.4
NW	1.011	0.020	190	44			2.6	0.7	54.0	1.7	0.7	40.5	3	64.3	4	82.1
SB	1.054	0.009	1800	360			58.2	4.2	2.5	62.0	5.1	5.9	65	6.7	65	6.7
VM	1.065	0.028	215	58			4.2	0.2	1.4	4.3	0.3	1.7	5	2.1	6	3.2
WH	1.032	0.011	1000	108			46.8	4.9	74.8	50.7	3.5	84.8	52	90.1	62	98.0
DS	1.055	0.012			1650	325	64.8	4.8	3.2	63.7	8.4	3.5	80	11.7	74	7.9
FB	1.055	0.011			2300	500	97.4	0.8	6.4	96.7	1.2	7.3	95	7.5	109	5.5
SH	1.059	0.013			1000	200	40.4	5.3	4.7	45.0	3.8	6.4	44	5.3	43	3.7
Subpopulation totals			10991		4950		709.6			750.2			780		856	

1 Mark-recapture/survey-based subpopulation estimate revised following consultations with Inuit who perceived that some subpopulations were increasing due to more frequent sightings, changes in distribution suggesting an extension of seasonal range, and increased bear-human problems (DS, FB) or scientific discussion of possible sampling bias (SH).
2 Projected harvest based on anticipated Nunavut quotas plus five-year average harvest from shared jurisdictions.
3 Natural (unharvested) finite rate of subpopulation growth as determined by natural survival rates (Table 3) and recruitment data (Table 4).
4 Bootstrapped estimate of standard error (SE) of lN based on natural survival rates (Table 3) and recruitment data (Table 4).
5 Standard errors referenced to the likely lower 95% confidence limit of minimum possible subpopulation size (e.g., for DS, lower limit is approximately 1000 bears [mean – 1.96*SE]).
6 Assumes Greenland kill of 129 bears (five-year mean), 159 bears (three-year mean), and 164 bears (one-year).
7 Based on female, cub, and yearling survival rates for SB (Regehr, unpublished data), subadult survival from WH, adult male survival rates from LS-NW.

Table 14. Mean (and standard error) of natural (i.e., unharvested) survival parameters used in the assessment of risk for subpopulations in Table 2, and best estimates of parameters to model natural survival in DS, FB, NB, SB, SH, and WH.

Subpopulation	Males				Females			
	COY	1–4 years	5–20 years	>20 years	COY	1–4 years	5–20 years	>20 years
BB	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
DS[1]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
FB[1]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
GB	0.817 (0.201)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)	0.817 (0.201)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)
KB	0.345 (0.200)	0.663 (0.197)	0.997 (0.026)	0.997 (0.026)	0.410 (0.200)	0.756 (0.159)	0.997 (0.026)	0.997 (0.026)
LS[2]	0.634 (0.123)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
MC	0.619 (0.151)	0.983 (0.034)	0.921 (0.046)	0.921 (0.046)	0.619 (0.151)	0.983 (0.034)	0.977 (0.033)	0.977 (0.033)
NB[3]	0.651 (0.020)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.651 (0.020)	0.860 (0.040)	0.996 (0.005)	0.996 (0.005)
NW[2]	0.634 (0.123)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
SB[3]	0.651 (0.020)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.651 (0.020)	0.860 (0.040)	0.996 (0.005)	0.996 (0.005)
SH[2]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
VM	0.448 (0.216)	0.924 (0.109)	0.924 (0.109)	0.924 (0.109)	0.693 (0.183)	0.957 (0.028)	0.957 (0.028)	0.957 (0.028)
WH[4]	0.625 (0.072)	0.625 (0.072)	0.974 (0.030)	0.715 (0.095)	0.709 (0.065)	0.709 (0.065)	0.975 (0.029)	0.832 (0.048)

1 Incorporates 1993–1998 BB data (Taylor *et al.* 2005).
2 Survival estimates pooled for LS and NW.
3 Based on female, cub, and yearling survival rates for SB (Regehr, unpublished data). Subadult survival (ages 2–4) from WH (0.900, SE = 0.058 males, SE = 0.048 females [not shown]). Adult male survival rates from LS-NW (see text).
4 Based on survival rates provided by E. Regher (USGS, Alaska Science Centre, Anchorage, AK). Subadult survival (ages 2–4) from WH is 0.900, SE = 0.058 males, SE = 0.048 females (not shown]). Adult male survival rates from LS-NW (see text).

Table 15. Mean (and standard error) of reproductive parameters used in the assessment of risk for subpopulations in Table 2, and best estimates of parameters to model DS, FB, NB, SB, SH, and WH.

Subpopulation	Cub litter size	Female litter production rate				Proportion of male cubs
		4-year-olds	5-year-olds	6-year-olds	>6-year-olds	
BB	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
DS[1,2]	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029
FB[1]	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
GB	1.648 (0.098)	–	0.194 (0.178)	0.467 (0.168)	0.334 (0.300)	0.460 (0.091)
KB	1.667 (0.083)	–	–	0.357 (0.731)	0.478 (0.085)	.426 (0.029)
LS	1.688 (0.012)	–	0.107 (0.050)	0.312 (0.210)	0.954 (0.083)	0.531 (0.048)
MC	1.680 (0.147)	–	0.111 (0.101)	0.191 (0.289)	0.604 (0.928)	0.545 (0.057)
NB[2]	1.756 (0.166)	–	0.118 (0.183)	0.283 (0.515)	0.883 (0.622)	0.502 (0.035)
NW	1.714 (0.081)	–	–	–	0.689 (0.534)	0.544 (0.066)
SB[2]	1.600 (0.300)	–	0.103 (0.046)	0.338 (0.241)	0.942 (0.193)	0.515 (0.077)
SH[2]	1.575 (0.116)	0.087 (0.202)	0.966 (0.821)	0.967 (0.022)	0.967 (0.022)	0.467 (0.086)
VM	1.640 (0.125)	–	0.623 (0.414)	0.872 (0.712)	0.872 (0.712)	0.535 (0.118)
WH[2]	1.540 (0.098)	–	0.257 (0.442)	0.950 (0.352)	0.950 (0.022)	0.490 (0.022)

1 Reproductive estimates from BB (Taylor *et al.* 2005).
2 Best estimates for modelling exercise only (from standing age capture data).

Figure 20. Canadian polar bear subpopulations as of 31 December 2004. BB: Baffin Bay; DS: Davis Strait; FB: Foxe Basin; GB: Gulf of Boothia; KB: Kane Basin; LS: Lancaster Sound; MC: M'Clintock Channel; NB: Northern Beaufort Sea; NW: Norwegian Bay; SB: Southern Beaufort Sea; SH: Southern Hudson Bay; VM: Viscount Melville Sound; WH: Western Hudson Bay.

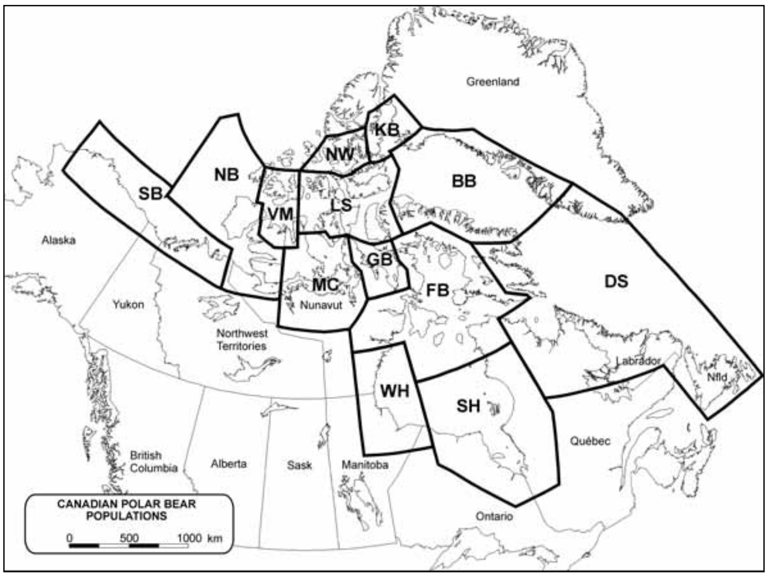


Table 16. Status of Canadian polar bear subpopulations using maximum sustainable harvest and historical harvest levels (1999–2000 to 2003–04), including kills reported in Alaska and Greenland, and maximum sustainable harvest levels. The percent female statistic excludes bears of unknown sex.

			Five-year average (1999–2000/2003–04)			Three-year average (2001–02/2003–04)			One-year (2003–04)			
Subpop.	Estimate	Reliability[1]	Kill	% female	Sustain-able harvest[2]	Kil	% female	Sustain-able harvest	Kill	% female	Sustain-able harvest	Status[3] (5yr/3yr/1yr)
BB[4]	2074	good	192.4	33.7	92.4	224.7	46.4	67.0	236	33.1	93.4	(-/-/-)
DS[4]	1400	poor	65.2	39.3	53.4	61.3	35.3	59.4	72	33.3	63.0	(-/0/-)
FB	2119	good	96.6	32.7	95.5	96.3	41.5	76.5	95	26.3	95.5	(0/-/0)
GB	1523	good	39.2	38.3	59.7	40.7	39.3	58.1	41	39.0	58.5	(+/+/+)
KB[4]	164	good	9.8	34.7	7.1	10.7	46.9	5.2	8	37.5	6.6	(-/-/-)
LS	2541	good	71.6	23.5	114.5	73.7	24.9	114.5	79	27.8	114.5	(+/+/+)
MC[5]	284	good	7.0	28.6	12.8	0.3	0.0	12.8	0	0.0	12.8	(+/+/+)
NB	1200	fair	37.6	36.2	49.7	38.0	42.3	42.5	36	33.3	54.0	(+/+/+)
NW	190	good	2.6	23.1	8.6	1.7	20.0	8.6	3	33.3	8.6	(+/+/+)
SB	1800	fair	58.2	32.8	81.1	62.0	52.5	51.4	65	48.1	56.2	(+/-/-)
SH	1000	poor	38.8	38.0	39.5	40.7	32.8	45.0	36	33.3	45.0	(0/+/+)
VM	215	good	4.2	19.0	9.7	4.3	38.5	8.4	5	20.0	9.7	(+/+/+)
WH[6]	1000	good	46.8	36.1	41.6	50.7	44.4	33.8	52	31.4	45.0	(-/-/-)
Total	15510		670.0		665.4	705.0		583.3	728		662.7	

1 Good: minimum capture bias, acceptable precision; fair: capture bias, precision uncertain; poor: considerable uncertainty, bias and/or few data; none – no information available.

2 Except for the VM subpopulation, sustainable harvest is based on the subpopulation estimate (N) for the area, estimated rates of birth and death, and the harvest sex ratio (Taylor *et al.* 1987):

$$\textit{Sustainable harvest} = \frac{(N \times 0.015)}{\textit{Proportion of harvest that was female}}$$

The proportion of the harvest that was female is the greater of the actual value or 0.33. Unpublished modelling indicates a sex ratio of 2 males to 1 female is sustainable, although the mean age and abundance of males will be reduced at maximum sustainable yield. Harvest data (Lee and Taylor 1994) indicate that selection of males can be achieved.

A five-year voluntary moratorium on harvesting bears in VM ended with the 1998–99 season. The rate of sustained yield of this subpopulation is lower than other subpopulations because of lower cub and yearling survival and lower recruitment. In 1999–2000, an allowable quota of four bears began, with the expectation that only males would be killed. However, a kill of one female per year is allowed.

3 Subpopulation status designation is conditional on the harvest continuing at the same level with the same sex ratio: + under harvest; - over harvest; 0 no change (kill within 5% of the sustainable harvest).

4 The Greenland harvest information is that reported in "Piniarneq" for 1997–2004 by year (Sept to Sept). The harvest year is assigned to the Canadian "season" with the same January to June period. The sex ratio is assumed to be the same as was estimated in the 1997–2001 Piniarneq sample.

5 Harvests in MC from 1995–96 through 1999–2000 were within quota limits, but the subpopulation estimate was retroactively reduced from 700 to 240 after the 1999–2000 season, based on new information.

6 Historical harvest levels based on subpopulation estimate of 1,200, which indicated a sustainable annual harvest of 50. However, preliminary estimate from ongoing inventory that will be completed in Autumn 2005 indicated that the subpopulation has declined to approximately 1000.

multi-year ice, except for a recurring lead system that runs along the Queen Elizabeth Islands from the northeastern Beaufort Sea to northern Greenland. Although no systematic inventory has been done and almost certainly never will be undertaken, limited work in the area found densities of polar bears to be low relative to the southern parts of the Northern Beaufort Sea. The PBTC had made an educated guess of a subpopulation of perhaps 200 animals. The subpopulation was unharvested except for an occasional defence kill, typically by "Polar adventurers".

Polar bear kills by jurisdiction

The quota for polar bears taken in each jurisdiction is based on recommendations by the Federal-Provincial-Territorial Committees. Table 17 summarises the annual quotas and numbers of polar bears killed each season from 2000–01 through 2003–04 and the recommended quotas for 2004–05.

Management changes and reports

Provincial and territorial jurisdictions

Manitoba

No changes in the management of polar bears have occurred since the last meeting of the Specialist Group.

The annual polar bear Alert Program for the Churchill townsite and surrounding area continues each autumn. The objectives of this programme are to (1) ensure the safety of people and the protection of property from damage by polar bears and (2) ensure that bears are not unnecessarily harassed or killed. Programme highlights are summarised in Table 18.

Newfoundland and Labrador

No changes in the management of polar bears have occurred since the last meeting of the Specialist Group.

Northwest Territories

In June 2002, the Wildlife Management Advisory Council in the North-West territory (WMAC-NWT) and the Inuvialuit Game Council (IGC) held a workshop in

Table 17. Quotas[1] and known numbers of polar bears killed[2] in Canada, 2000–01 through 2003–04.

	Man.[3]	Nfld.	NWT	Nunavut	Ont[4]	Qué.[5]	Yukon[6]	Total
2000–01 quota	8	6	97	395	30	62	6	604
Killed	3	5	53	348	5	37	2	453
Sent to zoos	0	0	0	0	2	0	0	2
2001–02 quota	8	6	93	408	30	62	6	613
Killed	9	6	59	398	9	31	0	512
Sent to zoos	0	0	0	0	0	0	0	0
2002–03 quota	8	6	97	392	30	62	6	601
Killed	7	6	73	377	7	25	0	495
Sent to zoos	0	0	0	0	1	0	0	1
2003–04 quota	8	6	97	398	30	62	6	607
Killed	2	8	62	421	8	28	0	529
Sent to zoos	0	0	0	0	0	2	0	2
2004–05 quota	8	6	97	507	30	62	6	716

[1] Management year extends from 1 July to 30 June the following year. Numbers may change as more information is received from the communities.
[2] All known kills, including quota and sport-hunt kills, problem kills, illegal kills, and bears that die while being handled by scientists.
[3] 19 of Manitoba's quota of 27 for the Western Hudson Bay subpopulation are loaned to Nunavut. This loaned quota is administered by Nunavut and the kills included in the Nunavut total.
[4] Permissible kill.
[5] The total allowable kill in Québec is controlled through agreements with Natives; length of hunting season is adjusted and only certain sex- and age-categories can be taken.
[6] Yukon quota is administered by the NWT but kills are included in the Yukon total.

Table 18. Manitoba Polar Bear Control Program 2001–2004.

	2001	2002	2003	2004
Occurrences[1]	201	209	345	302
Bears captured	142	121	176	102
Bears killed by Department personnel	2	2	0	1
Bears killed by public	0	0	3	1
Handling deaths	6	4	1	0
Natural deaths	0	1	0	0
Bears sent to zoos	0	0	0	0

[1] All bears reported to or observed by Manitoba Conservation staff in the Churchill control zone and peripheral area.

Holman at which Nunavut user groups and agencies also participated. At the workshop, a draft inter-jurisdictional government-to-government Memorandum of Understanding (MOU) for the NB and VM subpopulations was drafted. In December 2004, since no progress had been made on the agreement, WMAC-NWT and IGC suggested jointly that the users consider an alternative to the government-to-government agreement drafted in Holman. They suggested that an agreement similar to the Inuvialuit-Inupiat agreement for the Southern Beaufort Sea subpopulation be used as a model. Discussions on an inter-jurisdictional agreement continue.

At the 2002 workshop, the SB Agreement was revised, changed to an MOU and sent to the IGC for review. The IGC decided the MOU for SB should be forwarded to the Hunters' and Trappers' Committees (HTCs) for approval. In 2005, representatives from the Government of the NWT, WMAC-NWT and IGC began a series of joint public meetings in the four NWT communities signatory to the SB MOU. The objective of these consultations is to ensure community support for all aspects of the MOU and to produce a final MOU that is ready for signing. Changes to the subpopulation boundaries will need to be discussed in relation to the management zones identified in the MOUs before they are finalized.

After discussions with Nunavut representatives in Holman 2002, where the modelling results were reviewed, WMAC-NWT recommended to the Government of North West Territory (GNWT) Minister an increase to the VM quota. On February 18, 2004, the NWT portion of the VM quota was increased to four bears annually.

Nunavut

In 2000, the Government of Nunavut (GN) began a review of the existing polar bear MOUs that had been in place since 1996. A polar bear MOU Working Group was formed with representatives from Nunavut Tunngavik Incorporated (NTI), the Nunavut Wildlife Management Board (NWMB), the Regional Wildlife Organizations (RWO), and the Department of Sustainable Development (now Department of Environment). The GN undertook a series of community consultations that resulted in a new set of MOUs for each of the 12 polar bear subpopulations within or shared with Nunavut. The new MOUs identified a protocol where scientific knowledge was used to establish total allowable harvest (TAH) levels, and Inuit knowledge was used to evaluate the TAH levels and adjust them as required.

In 2004, new MOUs were signed by the Hunters' and Trappers' Organizations (HTOs) and RWOs and conditionally approved by the NWMB. The NWMB decision required some amendments to the MOUs and the amendment process is proceeding. The new MOUs include a larger role for the RWOs in distributing the TAH among communities that share a subpopulation, and more flexibility for the HTOs to open and close their hunting seasons, develop local hunting rules, and utilize Inuit knowledge for polar bear management decisions.

These new MOUs identified quota increases for eight subpopulations (Table 19). The current population estimates for eleven subpopulations (BB, FB, GB, KB, LS, MC, NB, NW, SH, VM and WH) are science-based.

Table 19. Changes to Nunavut quota allocations (2004–05 harvest) as reflected in the new Polar Bear Management Memoranda of Understanding.

	Estimate of subpopulation size[1]			Nunavut quota allocation		
Subpopulation	**Previous**	**Current**	**Target**	**Previous**	**Current**	**Difference**
Entirely within Nunavut						
GB	900	1500	1500	41	74	+33
LS	1700	2500	2500	78	85	+7
MC	700	284	750	0	3	+3
NW	100	200	200	4	4	0
Shared with at least one other jurisdiction						
BB	2200	2100	2100	64	105	+41
KB	200	164	500	5	5	0
NB	1200	1200	1200	6	6	0
SH	1000	1000	1000	25	25	0
VM	161	215	500	2	3	+1
DS	1400	1650	1650	34	46	+12
FB	2100	2300	2300	97	106	+9
WH	1200	1400	1400	47	56	+9

[1] Previous – historical estimates on which previous quota allocations based; Current – new estimates based on existing or recent mark-recapture studies or surveys (BB, GB, LS, MC, NB, NW,SH, VM) or based on these but increased following consultations with Inuit who perceived that some subpopulations were increasing due to more frequent sightings, changes in distribution suggesting an extension of seasonal range, and increased bear-human problems (DS, FB, WH); Target – the size of the subpopulation that Nunavut is managing for.

DS has not been accurately inventoried and the previous subpopulation estimate was based on the perception that the average kill had been sustained. In the new MOUs for three subpopulations (DS, FB and WH), the previous estimates were increased based on the perception by Inuit that these subpopulations had been increasing under the historical harvest regimes.

Although five of the subpopulations (BB, DS, FB, VM and WH) where quotas were increased are shared with other jurisdictions, the increases followed the process identified in the *Nunavut Land Claim Agreement* (NLCA). Although it does not require Nunavut to seek permission from other jurisdictions, the NLCA does recognise that certain subpopulations of wildlife found in the Nunavut Settlement Area cross jurisdictional boundaries and are harvested outside the Nunavut Settlement Area by persons resident elsewhere and, therefore, requires that Nunavut and the NWMB take into account the harvesting activities outside the Nunavut Settlement Area and the terms of domestic inter-jurisdictional agreements or international agreements pertaining to wildlife. Nunavut is interested in developing inter-jurisdictional co-management agreements to address any concerns from other jurisdictions that share polar bear subpopulations with Nunavut.

The polar bear MOUs between the Department of Environment and the local HTOs identify a continuing need to research and develop better methods to deter problem bears, prevent polar bear damage to property, and prevent loss of meat caches to polar bears. To address these objectives polar bear management plans are being developed for every community and outpost camp in Nunavut. Community involvement and cooperation are integral parts of these plans, which are intended to be proactive rather than reactive.

Ontario

No changes in the management of polar bears have occurred since the last meeting of the Specialist Group. The polar bear was listed as Vulnerable by the Ontario

Ministry of Natural Resources (OMNR) in 2000 following recommendations by the Committee on the Status of Species at Risk in Ontario (COSSARO). In October 2002, COSSARO re-evaluated the status of polar bear based on an addendum to the 1999 status report (Stirling and Taylor 1999) prepared for the federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and on recent unpublished research on changes in body condition in the SH subpopulation (M. Obbard and M. Cattet, unpublished data). OMNR confirmed the status of Vulnerable for polar bear in Ontario at that time. In September 2004, OMNR changed the name of the status category 'Vulnerable' to 'Special Concern' to conform to the category names used at the national level by COSEWIC.

Québec

No changes in the management of polar bears have occurred since the last meeting of the Specialist Group.

Yukon Territory

No changes in the management of polar bears have occurred since the last meeting of the Specialist Group. The quota of six continues to be administered by the NWT.

Management Boards and Resource User Groups

Labrador Inuit Association

No changes have occurred since the last meeting of the Specialist Group.

Nunavik (northern Québec)

Under the James Bay and northern Québec Agreement (JBNQA) of 1975, the taking of polar bears is restricted to aboriginals, to protect the traditional subsistence harvesting rights of northern Québec natives. In law, provisions have been made to ensure the Inuit of Nunavik have exclusive access to an agreed level of harvest (Guaranteed Harvest Level (GHL)), subject to the principles of conservation, before any sport or commercial activity would be permitted. Set at 62 polar bears per year for the entire region, this level of harvest is based on the recorded subsistence take during 1976–80. While the GHL is not linked to a specific polar bear subpopulation, the greatest numbers of bears harvested come from SH. Although the Government of Québec retains the right to institute conservation measures, this has not been considered necessary to date.

Under present legislation, sport hunting is not permitted and polar bears may only be harvested for subsistence use. The hide may be sold if a provincial tag is obtained and attached.

The Inuit of Nunavik continue to express a willingness to consider establishing harvest quotas for polar bears in northern Québec, similar to what has been suggested by the PBTC and previous inter-jurisdictional co-management agreements. They also support subpopulation studies to ensure that the eventual harvest quota is established within sustainable limits.

Nunavut Wildlife Management Board

The Nunavut Wildlife Management Board (NWMB) is an institution of public government established by the *Nunavut Land Claims Agreement* (NLCA) and composed of nine members. Four are appointed by Inuit, three by Canada, one by the Nunavut Government, and the last – the Chairperson – is nominated by the eight other members and appointed by Canada. The members do not act as representatives of their appointing agencies, and are specifically required by the NLCA to act impartially in carrying out their functions. The NWMB is the main instrument of wildlife management and the main regulator of access to wildlife – including polar bears – in the Nunavut Settlement Area. It exercises co-jurisdictional decision-making with relevant Ministers of the Crown regarding a variety of wildlife management matters – including the establishment, modification and removal of restrictions on the harvest of polar bears. Under that co-jurisdictional arrangement, both the NWMB and the territorial Minister of Environment may only impose restrictions on the harvest of polar bears within limits set by the NLCA. For instance, decisions of the NWMB or the Minister are permitted to restrict or limit Inuit harvesting only to the extent necessary to affect a valid conservation purpose or to provide for public health or public safety.

Wildlife Management Advisory Council (NWT)

The Council consists of three members appointed by the Inuvialuit, two members appointed by the Government of the Northwest Territories (GNWT), one member appointed by the Government of Canada, and a Chair. The Chair is appointed by the GNWT with the consent of the Inuvialuit and Canada.

The Council's jurisdiction is that part of the Inuvialuit Settlement Region (ISR) within the Northwest Territories. The Council's mandate is to advise appropriate ministers on all matters relating to wildlife policy, and the management, regulation, research, enforcement and administration of wildlife, habitat and harvesting for the Western Arctic Region, within the NWT. It is the responsibility of the Council to prepare conservation and management plans, and to determine and recommend harvestable quotas. The Council also reviews, and advises the appropriate governments on, existing or proposed wildlife legislation and any proposed Canadian position for international purposes that affect wildlife in the Western Arctic Region.

All harvest of polar bears in the NWT occurs within the ISR. Within the ISR, the Council is the primary vehicle for wildlife management. The Council makes recommendations for any management changes within the ISR, including quotas, to the NWT Minister of Environment and Natural Resources (formerly Resources Wildlife and Economic Development). The Inuvialuit Game Council (IGC) allocates the total quota among the communities.

Agencies and Committees

Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

COSEWIC was established in 1977 to provide a single, scientifically sound classification of wildlife species at risk of extinction in Canada. It is a committee of representatives from federal, provincial, territorial, and private agencies, as well as independent experts. COSEWIC assessed and designated the polar bear a species Not at Risk in 1986, which was upgraded to Vulnerable in 1991. No change in status was recommended in an updated report submitted to COSEWIC in 1998 (Stirling and Taylor 1999). After reviewing this report, COSEWIC again listed the polar bear as Vulnerable in April 1999.

In November 2002, COSEWIC updated the status of polar bears using the April 1999 listing plus a two-page addendum. In addition to this new information, the listing criteria used to assess species at risk had also changed (Table 20). Polar bears were designated by COSEWIC as a species of Special Concern, which was the category that replaced Vulnerable.

Parks Canada

Parks Canada Agency is responsible for the management of Canada's system of protected heritage areas, including national parks and national historic sites. Parks Canada's primary and legislated mandate is to maintain or restore ecological integrity of the national parks (*Parks Canada Guiding Principles and Operational Procedures* (Parks Canada, 1993), *Canada National Parks Act* (R.S.O. 2000)). There are currently eight national parks that contain polar bears: Ivvavik in the Yukon; Aulavik in the NWT; Auyuittuq, Quttinirpaaq, Sirmilik and Ukkusiksalik in Nunavut; Wapusk in Manitoba; and Torngats in Labrador.

Torngats National Park became Canada's 43rd national park in March 2005. This park is located in northern Labrador in the Torngat Mountains and includes Atlantic Ocean coastal habitat where polar bears are regularly observed.

Parks Canada's interest in conservation of polar bears and their habitat comes from its ecological integrity mandate and policies of ecosystem-based management and inter-jurisdictional cooperation. Parks Canada contributes to sustaining polar bear subpopulations by protecting important habitats: maternal denning and coastal ice-off retreat areas. Parks Canada has supported and will continue to support polar bear research and monitoring efforts in areas within and adjacent the national parks.

Parks Canada also has a public safety duty: to minimize human-bear encounters and conflict within the national parks. Park visitors, researchers, military personnel, local residents, park staff and Inuit all have the potential to come into contact with polar bears. Human and polar bear activity overlaps in space and time, particularly during April–October. To date, the number of park visitors and park users are low and the number of encounters has been correspondingly low. Measures in place to reduce the risk of encounters are: mandatory park visitor registration and an orientation that includes polar bear safety messages. All other park users receive a polar bear safety pamphlet and discuss location-specific risks and mitigative measures with knowledgeable park staff and community members. Polar bear safety plans and operational procedures are in place or being developed for the fore-mentioned national parks.

Federal Government

CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) (CITES) has been in effect since July 1975. Polar bears are included in Appendix II to the Convention.

Since July 1975, a permanent record of all polar bears, hides, or any other products legally exported from or imported to Canada has been maintained by the Federal Government through the issue of permits. Data for 1975-1998 were included in the management reports prepared for the previous four IUCN Working Meetings. The 1999 through 2004 data are summarised in Table 21.

Table 20. COSEWIC's revised criteria to guide the status assessment of species. These were in use by November 2001 and based on the revised IUCN Red List categories.[1] (COSEWIC Operations and Procedures Manual Appendix E3, November 2004).

	Endangered	Threatened
A. Declining Total Population		
Reduction in population size based on any of the following four options and specifying a–e as appropriate:		
	≥ 70%	≥ 50%
(1) population size reduction that is observed, estimated, inferred, or suspected in the past 10 years or three generations, whichever is longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) one or more of a–e below		
	≥ 50%	≥ 30%
(2) population size reduction that is observed, estimated, inferred or suspected over the last 10 years or three generations, whichever is longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) one or more of a-e below		
(3) population size reduction that is projected or suspected to be met within in the next 10 years or three generations, whichever is longer (up to a maximum of 100 years), based on (and specifying) one or more of b-e below		
(4) population size reduction that is observed, estimated, inferred, projected or suspected over any 10-year or three-generation period, whichever is longer (up to a maximum of 100 years), where the time period includes both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) one or more of a-e below		
a) direct observation b) an index of abundance appropriate for the taxon c) a decline in area of occupancy, extent of occurrence and/or quality of habitat d) actual or potential levels of exploitation e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites		
B. Small Distribution, and Decline or Fluctuation		
(1) Extent of occurrence	< 5,000km^2	< 20,000km^2
OR		
(2) Area of occupancy	< 500km^2	< 2,000km^2
For either of the above, specify at least two of a-c:		
a) either severely fragmented or known to exist at # locations	≤ 5	≤ 10
b) continuing decline observed, inferred or projected in one or more of the following: i) extent of occurrence ii) area of occupancy iii) area, extent and/or quality of habitat iv) number of locations or populations v) number of mature individuals		
c) extreme fluctuations in one or more of the following:	> 1 order of magnitude	> 1 order of magnitude
i) extent of occurrence ii) area of occupancy iii) number of locations or populations iv) number of mature individuals		

C. Small Total Population Size and Decline		
Number of mature individuals and one of the following 2:	< 2,500	< 10,000
(1) an estimated continuing decline of at least:	20% in five years or two generations (up to a maximum of 100 years in the future)	10% in 10 years or three generations (up to a maximum of 100 years in the future)
(2) continuing decline, observed, projected, or inferred, in numbers of mature individuals and at least one of the following (a–b):		
(a) fragmentation-population structure in the form of one of the following:	(i) no population estimated to contain >250 mature individuals (ii) at least 95% of mature individuals in one population	(i) no population estimated to contain >1,000 mature individuals (ii) all mature individuals are in one population
(b) extreme fluctuations in the number of mature individuals		
D. Very Small Population or Restricted Distribution		
(1) Number of mature individuals	< 250	< 1,000
OR		
(2) Applies only to threatened: Population with a very restricted area of occupancy (area of occupancy typically < 20km²) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus is capable of becoming highly endangered or even extinct in a very short time period		
E. Quantitative Analysis		
Indicating the probability of extinction in the wild to be at least:	20% in 20 years or five generations, whichever is longer (up to a maximum of 100 years)	10% in 100 years

Special Concern

Those species that are particularly sensitive to human activities or natural events but are not endangered or threatened species

Species may be classified as being of Special Concern if:

(a) the species has declined to a level of abundance at which its persistence is increasingly threatened by genetic, demographic or environmental stochasticity, but the decline is not sufficient to qualify the species as Threatened; or
(b) the species is likely to become Threatened if factors suspected of negatively influencing the persistence of the species are neither reversed nor managed with demonstrable effectiveness; or
(c) the species is near to qualifying, under any criterion, for Threatened status; or
(d) the species qualifies for Threatened status but there is clear indication of rescue effect from extra-limital populations

Examples of reasons why a species may qualify for "Special Concern":

- a species that is particularly susceptible to a catastrophic event (e.g., a seabird population near an oil tanker route); or
- a species with very restricted habitat or food requirements for which a threat to that habitat or food supply has been identified (e.g., a bird that forages primarily in old-growth forest, a plant that grows primarily on undisturbed sand dunes, a fish that spawns primarily in estuaries, a snake that feeds primarily on a crayfish whose habitat is threatened by siltation; or
- a recovering species no longer considered to be Threatened or Endangered but not yet clearly secure

Examples of reasons why a species may not qualify for "Special Concern":

- a species existing at low density in the absence of recognised threat (e.g., a large predatory animal defending a large home range or territory); or
- a species existing at low density that does not qualify for Threatened status for which there is a clear indication of rescue effect

Guidelines for use of Extirpated

A species may be assessed as extinct or extirpated from Canada if:

- there exists no remaining habitat for the species and there have been no records of the species despite recent surveys; or
- 50 years have passed since the last credible record of the species, despite surveys in the interim; or
- there is sufficient information to document that no individuals of the species remain alive.

Guidelines for use of Data Deficient

Data Deficient should be used for cases where the status report has fully investigated all best available information yet that information is insufficient to: a) satisfy any criteria or assign any status, or b) resolve the species' eligibility for assessment.

Examples:

- Records of occurrence are too infrequent or too widespread to make any conclusions about extent of occurrence, population size, threats, or trends;
- Surveys to verify occurrences, when undertaken, have not been sufficiently intensive or extensive or have not been conducted at the appropriate time of the year or under suitable conditions to ensure the reliability of the conclusions drawn from the data gathered;
- The species' occurrence in Canada cannot be confirmed or denied with assurance.

Data Deficient should not be used if: a) the choice between two status designations is difficult to resolve by COSEWIC, or b) the status report is inadequate and has not fully investigated all best available information (in which case the report should be rejected), or c) the information available is minimally sufficient to assign status but inadequate for recovery planning or other such use.

[1] IUCN. 2001. *IUCN Red List Categories and Criteria: Version 3.1*. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Table 21. Number of permits issued and number of live polar bears and polar bear parts legally exported from Canada, 1 January 1999 to 31 December 2004 (Canadian Wildlife Service CITES unpublished data).

	1999		2000		2001		2002		2003		2004		Total	
	Permits	Parts	Permits	Parts	Permits	Parts	Permits	Parts	Permits	Parts	Permits	Parts	Permits	Parts
Bones	30	30	33	33	47	47	41	41	46	46	30	30	227	227
Claws	0	0	1	20	0	0	5	65	5	70	9	284	20	439
Clothing	0	0	0	0	0	0	1	2	0	0	0	0	1	2
Hides[1]	221	394	148	214	146	191	160	213	186	698	170	558	1031	2268
Live polar bears[2]	2	2	2	2	0	0	0	0	0	0	3	3	7	7
Scientific specimens	5	284	3	143	3	253	1	80	1	40	0	0	13	800
Skulls/jaws/teeth	77	77	91	92	73	83	91	103	95	101	84	94	511	550

[1] Includes head mounts, whole mounts, and pieces.
[2] Sent to zoos.

Species at Risk Act (SARA)

Parliament passed the *Species at Risk Act* on 12 December 2002. The purposes of SARA are to prevent wildlife from becoming extinct in Canada, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. The Act came into force in three phases in order to help ensure a smooth delivery, more effective policy and programme development, and provide the time necessary to carry out additional consultation and discussion with those who will be most affected by the new legislation. The implementation of SARA resulted in the coming into force of those sections of the Act that amended other related federal laws (Phase 1, 24 March 2003), promoted the protection of species at risk through collaborative efforts (Phase 2, 5 June 2003), and covered prohibitions including critical habitat protection and enforcement of the law (Phase 3, 1 June 2004). COSEWIC is to continue to provide independent, scientific assessments of the status of species at risk in Canada. These assessment reports are provided as recommendations to the Government and a copy is placed in the Public Registry. The Government responds to these assessments and decides on which species to list or de-list under SARA.

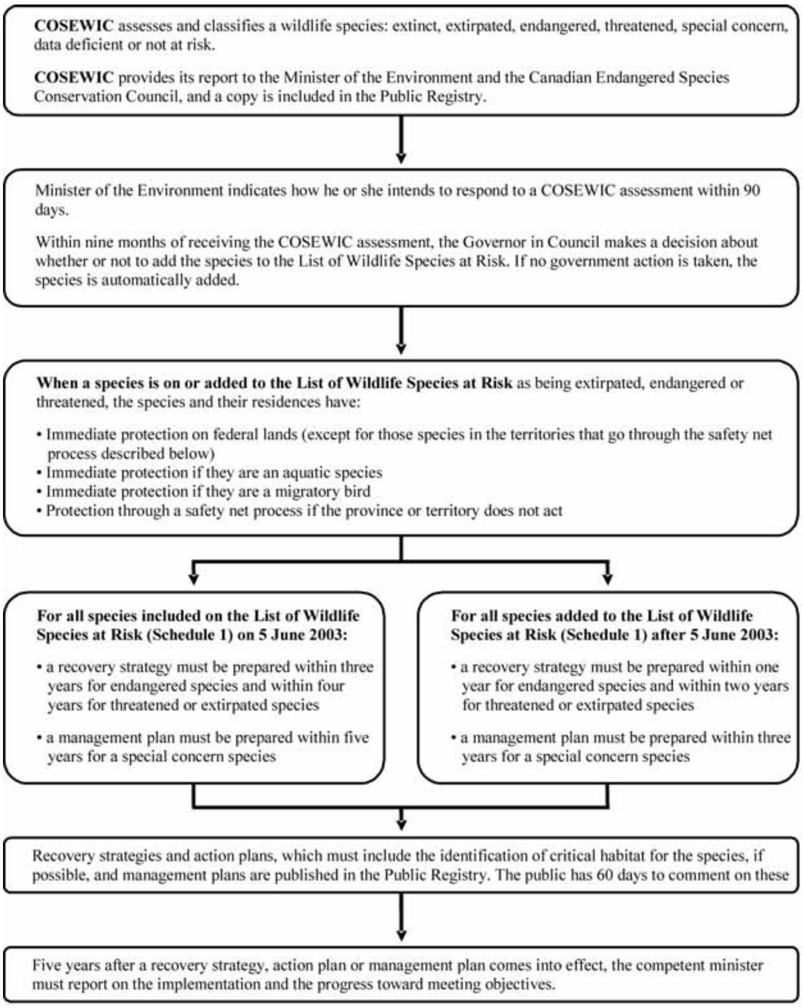
Individual species were included on one of three Schedules that formed part of the Act upon proclamation. Schedule 1 is the *List of Wildlife Species at Risk* and contains species in four risk categories – Extirpated, Endangered, Threatened, or Special Concern. Species on Schedule 1 had already been re-assessed by COSEWIC using the new updated assessment criteria and current information. Species that had previously been designated by COSEWIC as being at risk but had not yet been re-assessed using the new criteria and current information by the end of 2001 were listed on either Schedule 2 (Extirpated, Endangered, or Threatened) or Schedule 3 (Special Concern).

The provisions of the Act apply only to those species listed on Schedule 1. The Act prohibits the killing, harming, harassing, or taking of extirpated, endangered or threatened species; provides authority to prohibit the destruction of the critical habitat of these species; and, requires the preparation of recovery strategies and action plans (Figure 21). For species listed on Schedule 1 as being of special concern, the Act only requires the preparation of a management plan.

SARA provides emergency authority to protect species in imminent danger, including emergency authority to prohibit the destruction of the critical habitat of such species.

When SARA was proclaimed, COSEWIC had not re-assessed polar bears using the new criteria and were, therefore, listed on Schedule 3. The polar bear has since been re-assessed as a species of Special Concern and COSEWIC's report has been submitted to the federal Minister of Environment. A decision on whether or not to add the polar bear to the *List of Wildlife Species at Risk* has been delayed pending further consultation.

Figure 21. The process for protecting a species under Canadian *Species at Risk* legislation.



References

Lunn, N.J., Stirling, I., Andriashek, D. and Kolenosky, G.B. 1997. Re-estimating the size of the polar bear population in western Hudson Bay. *Arctic* **50**:234–240.

Lunn, N.J., Taylor, M., Calvert, W., Stirling, I., Obbard, M., Elliott, C., Lamontagne, G., Schaeffer, J., Atkinson, S., Clark, D., Bowden, E. and Doidge, B. 1998. Polar bear management in Canada 1993-1996. Pages 51-68 In Derocher, A.E., Garner, G.W., Lunn, N.J. and Wiig, Ø. (eds.). *Polar Bears: Proceedings of the Twelfth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Stirling, I. and Taylor, M.K. 1999. *COSEWIC status report on polar bear*, Ursus maritimus. Committee on the Status of Endangered Wildlife in Canada, 31pp.

Taylor, M.K., Akeeagok, S., Andriashek, D., Barbour, W., Born, E.W., Calvert, W., Cluff, H.D., Ferguson, S., Laake, J., Rosing-Asvid, A., Stirling, I. and Messier, F. 2001. Delineation of Canadian and Greenland polar bear *(Ursus maritimus)* populations using cluster analysis of movements. *Can. J. Zool.* **79**:690–709.

Taylor, M.K., Laake, J., McLoughlin, P.D., Born, E.W., Cluff, H.D., Ferguson, S.H., Rosing-Asvid, A., Schweinsburg, R. and Messier, F. 2005. Demography and viability of a hunted population of polar bears. *Arctic* **58**: 203–214.

Taylor, M. and Lee, J. 1995. Distribution and abundance of Canadian polar bear populations: a management perspective. *Arctic* 48:147–154.

Research on polar bears in Canada 2001–2004

E. Richardson, Canadian Wildlife Service, 5320-122 St., Edmonton, AB, T6H 3S5, Canada
M. Branigan, Department of Environment and Natural Resources, Bag #1, Inuvik, NT, X0E 0T0, Canada
W. Calvert, Canadian Wildlife Service, 5320-122 St., Edmonton, AB, T6H 3S5, Canada
M. Cattet, Canadian Cooperative Wildlife Health Centre, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK, S7N 5B4, Canada
A.E. Derocher, Dept. of Biological Sciences, University of Alberta, Edmonton AB, T6G 2E9,Canada
W. Doidge, Makivik Corporation, Kuujjuaq Research Centre, PO Box 179, Kuujjuaq, QC, J0M 1C0, Canada
D. Hedman, Manitoba Conservation, PO Box 28, 59 Elizabeth Road, Thompson, MB, R8N 1X4, Canada
N.J. Lunn, Canadian Wildlife Service, 5320-122 St., Edmonton, AB, T6H 3S5, Canada
P. McLoughlin, Department of Biology, University of Saskatchewan, 112 Science Place Saskatoon, Saskatoon S7N 5E2, Canada
M.E. Obbard, Ontario Ministry of Natural Resources, 300 Water St., 3rd Floor N., Peterborough, ON, K9J 8M5, Canada
I. Stirling, Canadian Wildlife Service, 5320-122 St., Edmonton, AB, T6H 3S5, Canada
M. Taylor, Department of Environment, PO Box 209, Igloolik, NU, X0A 0L0, Canada

Most polar bear research in Canada is conducted by Federal, Territorial and Provincial governments. Primarily because of the cost involved, but also because of the management responsibilities of the various governments, co-operative research is often undertaken where the project is of interest to several jurisdictions. In addition, international co-operation for specific projects or shared subpopulations is also undertaken with scientists in Alaska, Denmark, Greenland, and Norway. Some research projects conducted by university researchers are co-ordinated with government scientists through bilateral agreements and through the Federal-Provincial-Territorial Polar Bear Technical Committee (PBTC). Other projects are supported by funds from wildlife management boards established by the land claims process, by independent foundations, and through grants to graduate students co-supervised by government and university researchers. This report summarises research conducted in Canada between 2001–2004, organized by research topic, and lists related publications and reports completed or in press.

Subpopulation delineation, estimation and modelling

Subpopulation delineation studies

Southern and Northern Beaufort Sea

Polar bears in the Beaufort Sea were initially believed to constitute one subpopulation. However, subsequent mark-recapture studies by the Canadian Wildlife Service (CWS) in the 1980s and movement studies by the US Fish and Wildlife Service using VHF and satellite radios confirmed there were two subpopulations – Southern Beaufort Sea (SB), which extends along the mainland coast from about the Cape Bathurst polynya west into Alaska and Northern Beaufort Sea (NB) that extends along the western coast Banks Island and into the Cape Bathurst Polynya and Amundsen Gulf. The Joint Commission of the Inuvialuit-Inupiat Management Agreement for Polar Bears of the Southern Beaufort Sea have requested that the border between the Northern and Southern Beaufort polar bear subpopulations be re-assessed and more accurately defined than was possible from the previous mark-recapture data.

In April 2000, 20 satellite collars were deployed on adult females in the area of overlap between southern Banks Island and the mainland. The data from these most recent satellite radio collars, radios deployed on the western coast of Banks Island in the late 1980s and early 1990s, and a much larger number deployed along the north coast of Alaska have been analysed and it now appears the boundary between the two subpopulations lies further west than was previously believed. It is possible this has been influenced by changes in patterns of breakup and freeze-up and the greater amount of open water in recent years. The results of the analysis of movements of collared bears are currently in press (Amstrup *et al.* 2005).

Collaborators: Northwest Territories, USGS, Canadian Wildlife Service

Southern Hudson Bay
In 1997 a co-operative study was initiated to examine movement patterns and subpopulation boundaries for the SH subpopulation, including bears in James Bay, by deploying Argos satellite collars on females accompanied by yearlings in fall, to describe maternity denning habitat requirements, to evaluate the role of Polar Bear Provincial Park in protecting critical polar bear habitat, and to provide data to pool with CWS tracking data from Western Hudson Bay to re-assess the boundary between those two subpopulations. The project continued in 2001 with the primary objectives being to remove collars originally deployed in fall 1999 and to deploy five additional satellite collars on females accompanied by yearlings. Collars originally deployed in 2000 were removed in September 2002, and collars deployed in 2001 were removed in September 2003. Plans are to evaluate all movement data for WH, SH and FB bears at the same time. In addition, new information on the genetic structure of the SH subpopulation should also be available (see Genetics section). Data from these two sources, plus information on tag returns from hunter-killed animals, will be used in a comprehensive evaluation of the current subpopulation boundaries in Hudson Bay in collaboration with Nick Lunn and Ian Stirling, CWS.

Collaborators: Ontario, Nunavut, University of Saskatchewan

Subpopulation assessment studies

Gulf of Boothia and M'Clintock Channel
Analysis of the inventory data collected from 1998 to 2000 has been completed. The movements from bears radio-collared in GB indicate that the majority of movements remained within the GB boundaries; no permanent movements into Lancaster Sound (LS) were recorded. These movements supported the current boundary separating the GB and LS subpopulations.

The three years of capture data in M'Clintock Channel and Gulf of Boothia were examined using various stratified mark-recapture models that were specified in a modification of the software programme MARK, but Taylor and Laake were not able to obtain reasonable estimates from either the GB or MC data. It appeared that unexplained heterogeneity in capture probabilities between years was too large, and an estimated two or possibly three additional years of sampling were thought to be required to obtain meaningful estimates of survival and subpopulation numbers. However, additional analyses of the data augmented with the harvest record of marked and unmarked bears allowed better estimates of capture, harvest, and survival probabilities. Survival, subpopulation size, and variance estimates were obtained that were comparable to those determined from other subpopulation inventories. The new total subpopulation size estimate for the M'Clintock Channel subpopulation is 284 (SE=59.3). The new total subpopulation size estimate for the Gulf of Boothia subpopulation is 1523 (SE=284.7).

Using the best model, it seems that the historical level of harvest caused a depletion of the M'Clintock Channel polar bear subpopulation that occurred gradually over a long (>30 years) time. This information is also consistent with the reduced overall number, the skewed sex ratio, and the very few old animals. However, local hunters disputed that the reduction in numbers was due solely to over-harvest, and suggested that polar bears may have been pushed out of the area by declining environmental conditions or disturbance. Unusual ice conditions were reported in 1999 and 2000; such effects could contribute to capture heterogeneity.

The new subpopulation estimates for MC and GB created a need for management action in both areas. During the 2001–02 harvest season, the usual quota of 41 for GB was retained but a harvest moratorium for MC was imposed. The time estimated for a polar bear subpopulation to double is about 25 years, so a long period of reduced harvest will be required if the MC subpopulation is to recover to its former numbers. A moratorium on harvest is unlikely to result in zero human-caused mortality because of defence kills. Without immigration, even low harvests (3–4 bears per year) in MC will extend the time required for recovery to 50 or more years. The current quota in MC is three. The current quota for GB is 77.

Collaborators: Nunavut

Western and Southern Hudson Bay
Knowledge of subpopulation boundaries, size, and trend are necessary to manage the sustainable harvest of polar bears in Hudson Bay. This marine ecosystem supports two subpopulations, Western Hudson Bay (WH) and Southern Hudson Bay (SH), which are managed by two and three jurisdictions respectively. Recent analysis has shown that the sea ice is breaking up significantly earlier in western and southern Hudson Bay and freezing significantly later in northwestern Hudson Bay (Stirling *et al.* 1999, Gagnon and Gough 2005). Because the presence of sea ice is critical to polar bears, diminished ice cover and extended ice-free seasons are likely to have significant impacts on the ability of polar bear

subpopulations to sustain themselves, particularly those at the southern extreme of their range (Stirling and Derocher 1993, Stirling *et al.* 1999). Significant declines in the body condition of polar bears in both the WH (Stirling *et al.* 1999) and SH (M. Obbard and M. Cattet, unpublished data) subpopulations have already been documented over the past two decades. Thus, climate change might be expected to have a negative effect on subpopulation abundance through lower cub production, lower recruitment, and increased mortality.

Because of concern that these populations might be declining and that the current harvest would therefore be unsustainable, a three-year project was initiated in fall 2003 to re-assess the size of the WH and SH polar bear subpopulations. In contrast, Inuit in settlements along the Western coast of Hudson Bay have been reporting seeing more polar bears in recent years and this has been interpreted as evidence that the population is increasing (Inuit Qaujimajatuqangit).

Two field seasons have been completed. In 2003 and 2004, 184 and 149 bears were caught in Western Hudson Bay and 181 and 150 were caught in Southern Hudson Bay for totals of 365 and 299 respectively. The last year of this sampling should be completed in 2005 and the final re-estimates should be available by spring 2006.

In an extensive analysis of the subpopulation data from Western Hudson Bay from 1984 through 2004, Eric Regehr and Steve Amstrup (USGS Anchorage) developed and tested subpopulation models with the Canadian Wildlife Service. The best preliminary estimate from the model development suggests that the size of the WH subpopulation in autumn 2003 was 977 ± 108 bears and the subpopulation trend was clearly declining (Regehr *et al.* unpublished data).

Collaborators: Canadian Wildlife Service, Ontario, Ontario Parks, Parks Canada, Manitoba, Nunavut NWMB, Nunavut DSD, Makivik Corporation, La Fondation de la faune du Québec, Les Brasseurs du Nord, La Societé de la faune et des parcs du Québec, Safari Club International (Ontario and Detroit chapters), World Wildlife Fund, Northern Environmental Initiative, University of Alberta, NSERC

Northern Beaufort and Southern Beaufort Sea

In co-ordination with researchers in Alaska, a subpopulation reassessment for the Northern Beaufort (NB) and Southern Beaufort Sea (SB) polar bear subpopulations began in the spring of 2003. The field work in Canada is being coordinated with similar studies done at the same time in the Alaskan portion of the Beaufort Sea by biologists from the USGS Biological Science Office in Anchorage. The mark-recapture data will be segregated between SB and NB, based on the results of the movement study, and subpopulation sizes determined for each of the two subpopulations. Age determination of all bears captured in both Canada and Alaska will be done in the CWS laboratory in Edmonton to ensure consistency of methodology.

Field work in the Beaufort Sea began in the spring of 2003. Capture efforts were hampered by bad weather and limited access to the NB subpopulation as a result of sport hunters in the study area so the field work intended for the west coast of Banks Island was cancelled. Between 6 and 30 April, a total of 99 polar bears were caught, mainly in SB, including the overlap area between SB and NB in the area of the Cape Bathurst Polynya. In the Alaskan sector of SB, Alaskan biologists captured 104 bears in the spring of 2003. Results of the Alaskan work will be reported separately.

In April and early May of 2004 and 2005 258 and 280 polar bears respectively were captured in SB and NB. Of those 149 and 166 bears were caught in SB in 2004 and 2005. Satellite collars were removed from three radio-collared female bears. Access throughout the entire study area was coordinated with local Hunters and Trappers Associations ahead of when the field work was done and this greatly increased our ability to effectively survey both the SB and NB management areas.

Subpopulation estimates from the mark-recapture data and subsequent modelling will be led by Regehr and Amstrup (NBS) in collaboration with CWS. One more year of field work is anticipated in 2006 and a final project report is expected early in 2007.

Collaborators: Canadian Wildlife Service, Northwest Territories, USGS, Inuvialuit Game Council, Polar Continental Shelf Project, University of Alberta

Davis Strait

The Nunavut Department of Environment and the Nunavut Wildlife Management Board recently announced plans to initiate a mark-recapture inventory of the Davis Strait subpopulation in 2005 in cooperation with the other jurisdictions that share this subpopulation.

Collaborators: Nunavut, NWMB, Labrador Inuit Association, Newfoundland and Labrador, Makivik Corporation

Population modelling studies

RISKMAN and MARK

Research on population modelling and the accurate estimation of abundance are essential for the sustainable harvest of polar bears in Canada. Mark-recapture studies remain the primary means for subpopulation estimation among polar bear subpopulations in Canada. Research continues to address heterogeneity present in most mark-recapture data allowing for more accurate estimates of subpopulation abundance.

Development of the population simulation model, RISKMAN, continued in 2002-04 funded primarily by Nunavut Department of Sustainable Development and under the direction of Mitch Taylor. The Ontario Ministry of Natural Resources (OMNR) also provided funding for development and maintenance of the system. RISKMAN uses its stochastic and deterministic implementation of a simple life-table model to track life history of one-, two- or three-year reproductive cycle species. RISKMAN supports definition of strata dependent on age, sex, and encumbrance. It incorporates strata-dependent survival, recruitment and harvest. RISKMAN is compatible with Windows 98, ME, NT, 2000 and XP. By arrangement with OMNR, the most recent version of RISKMAN (V. 1. 9.002) can be downloaded from the web site hosted by the Natural Resources DNA Profiling and Forensics Centre of Trent University at: www.nrdpfc.ca/RISKMAN. Downloads are free, though users must register with the Ontario Ministry of Natural Resources and agree to the licence agreement. Registration of users enables OMNR to distribute information on the availability of future upgrades.

Mitch Taylor and Jeff Laake continue to work together using programme MARK, which has become increasingly powerful and easier to use. Some improvements were made to resolve limitations they encountered, and they also developed some additional programmes to make calculation of natural survival rates easier from MARK output. Current research is focusing on the creation of "general models" that would allow the use of AIC criteria for model comparison as well as the incorporation of harvest data to update subpopulation demographics and assess risk on an annual basis.

Collaborators: Nunavut, Ontario, National Marine Mammal Laboratory (NOAA)

Long-term monitoring and ecosystem change

Monitoring long-term trends in condition and reproduction of polar bears in relation to climatic warming in western Hudson Bay

From 1981 through 2004, the condition of adult male and female polar bears has declined significantly in western Hudson Bay, as have natality and the proportion of independent yearling cubs caught during the open water period. During this same period, the breakup of the sea ice on western Hudson Bay has been occurring earlier. There was a significant negative correlation between the time of breakup and the condition of adult females (the earlier the breakup, the poorer the condition of the bears) and a correlation between the trend toward earlier breakup and a decadal-scale pattern of warming of air temperatures over the study area in spring between 1950 and 1990. It appears that the proximate cause of the decline in physical and reproductive parameters of polar bears in western Hudson Bay over the last 20 years has been a trend toward earlier breakup, which has resulted in the bears coming ashore in progressively poorer condition. The ultimate factor responsible for the earlier breakup in western Hudson Bay appears to be a long-term warming trend in atmospheric temperatures from April through June.

Continuing to monitor the long-term trends discussed above is a high priority for CWS as climatic warming is predicted to continue in northern areas and has the potential to have significant impacts on polar bears and other components of the marine ecosystem. The long-term study in western Hudson Bay is the only one in the Arctic from which we may be able to assess how ecological variation in general and climatic warming in particular may affect polar bears. Bears are sampled in the spring and autumn to take standard morphometric measurements and to assess body condition. Conventional radio collars are put on a sample of adult females to monitor cub survival and to facilitate the collection of longitudinal data on individual reproductive histories. Satellite collars have been used to determine winter and spring movement on the sea ice, determine habitat use by females on shore during the summer, and to examine maternity den selection. In addition, other specimens (e.g. blood and tissues) continue to be collected and archived for collaborative projects. In Churchill, the principal focus for monitoring is the condition of adult males and females accompanied by dependent cubs, though data are collected from bears of all age- and sex-classes during the subpopulation sampling.

Collaborators: Canadian Wildlife Service, Parks Canada Agency, Manitoba, Nunavut Wildlife Management Board, World Wildlife Fund, Northern Environmental Initiative, University of Alberta, NSERC

Reproductive rates of ringed seals in northwestern Hudson Bay

Over the past 20–25 years, the decline in the reproductive rate and cub survival of polar bears in western Hudson Bay has been primarily attributed to changes in the availability of sea ice. However, because polar bears are depending upon ringed seals for food, a potential hypothesis for the document decline might be a change in the abundance of seals. In addition to aerial surveys the age composition, food habitats and reproductive rates of ringed seals were investigated using harvested seals.

Reproductive parameters were determined from a sample of ringed seals collected by Inuit hunters during their annual open water harvest in autumn at Arviat, Nunavut, on the western coast of Hudson Bay, Canada, in 1991–1992 and 1998–2000. Ovulation rates of adult females were high and similar to rates recorded from studies of ringed seals in other geographic areas. However, pregnancy rates averaged only 55% and were significantly lower than in other studies, and the proportions of young-of-the-year were only 4.8, 4.2, 7.5, 4.1, and 23% for the mentioned years, respectively, instead of being >30% as expected. These results appear to indicate that reproductive parameters of ringed seals and survival of their young are exhibiting long-term shifts rather than short-term fluctuations, and that the trend is downward. Furthermore, these downward trends in reproduction, in conjunction with changes in the proportions of different seal species in the diet of polar bears, climatic warming in western Hudson Bay, and progressively earlier breakup of sea ice over the last 25 years, suggest that major changes are occurring in the marine ecosystem of Hudson Bay. The pathways involved are poorly understood and merit further study. Detailed analyses examining food habitats of ringed seals harvested during the open water season are now being investigated by scientists at the Department of Fisheries and Oceans.

Collaborators: Canadian Wildlife Service, Nunavut, Arviat Hunters' and Trappers' Organization, Nunavut Wildlife Management Board

Changes in body condition of bears in SH

To assess whether the body condition of polar bears in the SH subpopulation has changed over the past 20 years, we calculated Body Condition Index (BCI) values [an estimate of the standardized residual of the regression of total body mass against straight-line body length (Cattet *et al.* 2002)] for 293 polar bears handled in Ontario from 1984–1986 and 400 polar bears handled from 2000–2004. Animals were grouped into the following age and reproductive classes for statistical analysis: solitary adult females (SF), adult females accompanied by offspring (AF), adult males (M), and sub-adult bears of either sex (SA). In the SH subpopulation, average BCI values in all age and reproductive classes were poorer in bears captured from 2000 to 2004, than in bears captured from 1984 to 1986 (mean ± SE for all bears in 2000–04: +0.03 ± 0.03, n = 400 vs. all bears in 1984–86: +0.85 ± 0.04, n = 293).

Stirling *et al.* (1999) suggested that a long-term decline in body condition for WH polar bears could be attributed to global warming shortening the period when Hudson Bay is ice-covered each year. Global warming may also be a factor explaining the decline in the body condition of SH polar bears over the past 20 years.

Collaborators: Canadian Wildlife Cooperative Health Centre, Ontario

Other ecological studies

Diet studies of polar bears

As top predators in the Arctic, polar bears provide unique and valuable information on changes in ecosystem structure and function over time. Yet because polar bears are so wide-ranging, there has been little quantitative data gathered on their diets and the ecological (such as climate warming) and demographic factors that influence prey selection. Throughout much of their Canadian range, polar bears prey predominantly on ringed seals. However, the degree to which polar bears prey on other species of seals, walruses, belugas, and narwhals is largely unknown. Specific data on polar bear foraging are essential to understanding the overall functioning of arctic ecosystems, as well as for management applications, as the prey assemblage will partially determine the size of polar bear subpopulations that can be maintained. In polar bears, as in all monogastric carnivores, dietary fatty acids (FAs, the main component of most lipids) are incorporated into the adipose tissue of the consumer with little or no modification. As a result, the "signature" of FAs in the predator's adipose tissue reflects its diet. We are using the FA signatures of polar bears and their available prey, along with a powerful new technique called Quantitative Fatty Acid Signature Analysis (QFASA) to determine polar bear diets and foraging patterns.

The QFASA model requires establishment of a large-scale database of polar bear and prey FA signatures. To this end, we received outstanding cooperation from a number of collaborators listed below. Together with their help and our own sampling efforts in western Hudson Bay and the Beaufort Sea, we have collected fat samples from more than 800 bears and 600 prey, since 2000. Our initial analyses indicate that polar bear FA signatures (and therefore, diets) vary by region, age class, and sex. Between subpopulations, differences in polar bear FA profiles are consistent with geographical relationships. For instance, bears in western- and southern Hudson Bay have similar fatty acid profiles, as do bears in northern- and southern Beaufort Sea. Interestingly, the Baffin Bay and Lancaster Sound subpopulations also appear very similar, while the Davis Strait and Gulf of Boothia subpopulations are the most distinct. The particular diets and foraging patterns that account for these relationships will be determined by mathematical modelling. Environmental factors affecting foraging ecology will also be examined. In a related project with the Nunavut Department of Sustainable Development multiple fat samples from each of 12 polar bears killed by hunters were collected near Arviat in 2002. Superficial adipose tissue was sampled from the rump, belly, and baculum of each male bear and from the rump and belly of each female. Results from these samples indicate that there is no difference in either percent lipid content or fatty acid composition between sites. Greg Thiemann from the University of Dalhousie is currently writing up the results of this study for his Ph.D.

Collaborators: Canadian Wildlife Service, Dalhousie University, Department of Fisheries and Oceans, Ontario, Northwest Territories, University of Saskatchewan, Labrador Inuit Association, Nunavut

Effects of disturbance on denning female Bears in WH

In September 1996 a four-year study was conducted examining the effects of handling on denning female bears in western Hudson Bay. Nineteen satellite radio collars were deployed on adult female polar bears in western Hudson Bay to study how pregnant females select maternity-den sites and the degree to which human disturbance might influence this process. To eliminate the possibility that being handled while pregnant might influence the final choice of a suitable site, the collars were attached one year before the females were expected to select dens. All other researchers working in the area were provided with the locations of these females, once ashore and were requested not to disturb the bears.

Our results indicated that pregnant females moved inland and selected an area to den shortly after coming ashore in the summer and remained there if not disturbed. This extended period of den occupancy is believed to be an important means of energy conservation for bears in western Hudson Bay. We analysed 24 years of consecutive data (1979–2002) to examine whether disturbance of pregnant females in the denning area in the autumn affected litter size or mass of cubs the following spring. We defined three levels of disturbance (none – bear not seen; low – bear seen but not handled; high – bear seen and handled), and found that disturbance had no effect on either litter size or the mass of male cubs. However, we did find that females handled in the autumn had significantly lighter female cubs than females that were not seen. Our disturbance of pregnant females occurred in August and September, which is only a few months prior to parturition; it is not known what the effects of disturbance might be in late October or early November, closer to the time when cubs are born.

Collaborators: Canadian Wildlife Service, Parks Canada Agency, National Fish and Wildlife Foundation

Maternity den site selection and habitat modelling in WH

In the fall of 2001 a two-year study examining maternity den site selection and the effects of forest fires on maternity denning habitat was initiated. The objectives of the study were to (1) examine site level habitat characteristics at maternity dens (2) to use this information to develop a resource selection function model to identify denning habitat at the landscape scale and (3) to determine the effects of forest fires on polar bear maternity denning habitat.

Data were provided from habitat characteristics of 101 polar bear den sites and 83 adjacent unoccupied sites in western Hudson Bay, Canada, between mid-August and early October 2001 and 2002. Bears denned almost exclusively in peat banks (n = 100) along the edge of creeks, rivers and lakes adjacent to open lichen tundra sites. Den sites differed from unoccupied sites by having greater tree cover, less moss cover and less herbaceous cover. The presence of tree roots improved substrate stability providing support to den structures. Den entrance azimuths were weighted toward a southeasterly aspect away from the prevailing northwest winds. To identify habitats with the greatest relative probability of having a den, a resource selection function (RSF) model was developed using remote sensing imagery and 1,245 known den locations. High normalized difference vegetation index (NDVI) and brightness values derived from Landsat imagery, that were in close proximity to water, corresponded well with polar bear den sites. The results from this portion of the study have been accepted for publication in the Canadian Journal of Zoology. During the same time period we investigated the potential impacts of forest tundra fires on maternity denning habitat. Physical characteristics of 48 burned and 101 unburned den sites were compared to determine the effects of forest tundra fires on maternity dens. Our results indicated that fire significantly altered vegetation and permafrost composition, resulting in a decrease in the stability of den sites, the collapse of dens, and degradation of the surrounding habitat. Although bears investigated burned areas, analysis of mark recapture data, satellite telemetry, radio-telemetry, and field observations all indicated that bears do not use burned areas for denning. Although peat denning habitat is likely not limiting at this time, the re-use and occupancy of peat den sites during the summer is believed to be an important means of energy conservation for pregnant female bears in western Hudson Bay. Increased energy expenditures in association with increased search times for suitable den sites and the excavation of new dens could potentially affect reproductive success. Predicted increases in forest fire activity as a result of climate change, along with potential long-term recovery of denning habitat may limit the availability of suitable denning habitat in the future. Resource managers need to be aware of the potential for shifts in the distribution of denning bears as well as the threat of a significant decrease in the availability of maternity denning habitat in western Hudson Bay.

Collaborators: Canadian Wildlife Service, University of Alberta, NSERC, polar bears International, Parks Canada Agency, World Wildlife Fund

Polar bear maternity denning habitat in SH

In 2001, with financial support from Ontario's Species at Risk Fund, a study was initiated to conduct a helicopter survey of potential maternity denning habitat in the vicinity of polar bear Provincial Park Ontario. A survey was designed based on the fact that satellite-collared pregnant female polar bears appeared to be using elevated inland beach ridges in fall. Beach ridges were identified inside the study areas using available aerial photography images. Helicopter surveys were conducted by flying at a low level over all potential beach ridges. Excavations or disturbed areas were investigated and the general characteristics of the ridge and each den were noted. The location, compass orientation of ridge, height, and slope for each ridge were recorded. For each excavation that we concluded had been used recently (absence of re-vegetation), we recorded den type (pit, shallow den, deep den), placement of den on ridge (linear distance from top and bottom of ridge), width, length, and depth of excavation, depth and width of overhang, substrate type, slope of ridge at den location, aspect of den, and distance to nearest water (creek, pond, or lake). For excavations where the digging scar was becoming re-vegetated, we scored the disturbance as of "medium" or "old" age and noted location only. Some scars had been re-vegetated by woody vegetation such as willow or scrub birch or with lichen, indicating that many decades had passed since the disturbance. If no excavations were seen on a ridge, we recorded a general description of the ridge including estimated height. If flying time allowed, we landed and measured compass orientation of ridge, height, and slope.

For 12 elevated habitat features (beach ridges or peat hummocks), the mean aspect was measured. Two features had only westerly-facing slopes, one had only a southerly-facing slope, but for all other nine features, bears could choose either a westerly- or easterly-facing slope. In these cases, all dens were located on the easterly aspect of the ridge. The predominantly westerly and north-westerly winds in winter would likely create snowdrifts over the dens located on the lee side of the ridge. The ratio of linear distance to the excavation from the bottom of the ridge to the total height of the side of the ridge from bottom to top was used to calculate the proportional placement of dens on ridge sides (a value of 1 indicated the den was located at the top of the ridge, and a value of 0 that it was located at the bottom). The mean value for proportional placement of dens on the ridge sides was 0.65; most dens were located between 40% and 85% of the way from the bottom to the top of the ridge. Most dens were located in elevated structures with a high proportion of gravel in the substrate. Twenty-nine of 51 recently-used dens were located in substrate that was at least 50% gravel. Eleven of 51 dens were located in organic peat hummocks. In 2002 and 2003, funding was again provided by Ontario's Species At Risk programme to continue the helicopter survey of potential maternity denning habitat in the Hudson Bay Lowlands west of Polar Bear Provincial Park. The same methodology was used as in 2001. Prior to this study very limited information existed on the habitat requirement of denning female bears in this region.

Historic late-summer and winter aerial survey data were analysed to evaluate the importance of Polar Bear Provincial Park in protecting critical polar bear habitat in Ontario. The park provides protection to about 70% of the SH subpopulation occupying summer retreat habitat; 23% occupies habitat outside the park boundary in Ontario, and 7% occupies islands in James Bay. Thirty-six per cent of maternity denning occurs within Polar Bear Provincial Park, 55% outside the park boundary in Ontario, and 9% on islands in James Bay.

Collaborators: Ontario Parks

Movements of adult male polar bears using satellite ear-tag radios

The current boundaries of each subpopulation of polar bears have been determined from mark-recapture studies, tag returns from the Inuit harvest, and from the movements of adult females tracked by satellite. No satellite tracking of the movements of adult males or sub-adults has been possible due to limitations of existing technology. For subpopulation assessment and management, it has been assumed that the size of the home ranges of adult males in each subpopulation is similar to that of adult females. However, this has remained untested. More specifically to western Hudson Bay, adult males are more common along the coast but every year, several large adult males are also found in the inland areas. The proportion of adult males that move inland and the significance of these movements are not known. Hypotheses to explain such movements include that they are 1) simply re-visiting areas they went to as cubs when still with their mothers and 2) possibly looking for predation opportunities on younger bears or caribou. If the period of time bears spend on land becomes longer because of progressively earlier breakup of the annual ice, there may be a strong stimulation for all bears to seek some supplemental food sources while ashore. If there are areas or habitats in the inland areas that are of specific importance to adult males and sub-adults, we are unable to identify them with the data we currently have. Thus, for the last several years the CWS have been developing and deploying satellite ear-tag radios on adult male polar bears in western Hudson Bay as well as the Beaufort Sea. In western Hudson Bay tags were deployed in 1999 (n = 3) and 2000 (n = 6). Four radios never transmitted due to software problems related to a saltwater switch while five stopped shortly after deployment – lasting from 13 to 62 days. Two of these five were recovered and found to have broken antennae. Consequently, the cause of the failures appears to be technical in nature rather than a result of the devices falling off or being damaged by the bears themselves.

The bears carrying the remaining two radios were not seen and no transmissions were received from them. Of the two radios that did transmit, one transmitted on 15 days over a 47-day period, during which time, the bear travelled a minimum distance of 66.4km. The second radio transmitted on 21 days over a 62-day period and that bear travelled a minimum distance of 96km. Both bears remained along the coast and travelled northwards, presumably in anticipation of freeze-up. For subpopulation assessment and management, it has been assumed that the size of the home ranges of adult males in each subpopulation is similar to that of adult females. Although this hypothesis is largely untested, analyses of distances moved between seasons by adult males and females were not found to be significantly different, and movements of male polar bears with implanted satellite radios over periods of up to 161 days showed no significant differences from movements of females.

During the spring of 2004 in association with ongoing mark-recapture field work in the Beaufort Sea three new ear-tag radios were deployed on adult male polar bears in the Southern Beaufort Sea. All of the radios failed within the first three days of deployment. It is believed that much of the limited success of ear-tag radios to date may be a result of antenna failure. Although no further development has occurred in the last 12 months, the CWS continues to be interested in the development of satellite radios for adult male and subadult polar bears.

Collaborators: Canadian Wildlife Service, Northwest Territories, Wildlife Computers (Seattle), Polar Continental Shelf Project

Ecology of harbour seals in western Hudson Bay

Warren Bernhardt (M.Sc. candidate) is investigating the ecology of harbour seals (*Phoca vitulina*) in western Hudson Bay to define seasonal habitat occupied by harbour seals in western Hudson Bay, with particular reference to ice and open water; to assess their vulnerability to predation by polar bears and how that might be affected by climate change; and to determine other ecological attributes (e.g. feeding areas, pupping areas) of harbour seals in the area. Eight animals were caught in the Churchill River in September 2001 and fitted with time-depth recorders. In 2002, 11 harbour seals were captured and equipped with satellite-linked telemetry tags.

Harbour seal habitat selection will be investigated at multiple scales by comparing seal location information provided by the satellite tags with habitat characteristics derived from satellite imagery of ice cover and other habitat parameters such as bathymetry, sea surface temperature (during open water periods), and distance to shore. One of the objectives is to produce a habitat selection model that will be useful towards predicting the probability of harbour seals using a given area, depending upon habitat characteristics of that area. This in turn will be used to try and predict where and during what time of the year harbour seals could be most vulnerable to predation by polar bears. Additional ecological information such as the location and habitat of foraging and pupping areas may also be determined from seal movement and dive information provided by the satellite tags.

Collaborators: Canadian Wildlife Service, University of Alberta, Manitoba Hydro, NSERC

Movements and habitat use of female bears in western Hudson Bay

Emily Parks (M.Sc. student) is examining the home range and movement patterns of polar bears on the sea ice in WH. The study has two components: the first examines the longer term data set on movements and home range size using conventional satellite telemetry (Doppler shift collars) and geographic positioning system collars (GPS). The historic data on movement and home ranges revealed that both season and reproductive class affected the movement and distribution of WH polar bears, but season appeared to be more important. In general, movement rates were similar to those of other polar bear subpopulations; however, home range sizes, net and total displacement of WH bears were unlike those of other Canadian subpopulations, and more like those of polar bears in the Barents Sea. Directional patterns appear to be unique to WH bears due to their annual return to terrestrial denning sites. Annual home range size, total annual distance traveled, and some seasonal movement rates decreased over the study period of 1991 to 2005, as did average annual ice cover, and minimum ice cover. Research is ongoing to develop models to describe movement patterns from GPS collared bears. The goal is to continue the GPS telemetry programme for long-term monitoring of the subpopulation.

Collaborators: University of Alberta, Canadian Wildlife Service, NSERC

Shifts in the terrestrial distribution of bears in Western Hudson Bay

In cooperation with Nick Lunn and Ian Stirling of the Canadian Wildlife Service, Lindsay Towns (M.Sc. student) is examining the temporal patterns of polar bear distribution on land in western Hudson Bay (WH) during the ice-free period. This study assesses the capture sample collected between 1986 and 2004 within a geographic information system. Significant shifts in the distribution of the subpopulation have been noted with females and their offspring now found closer to the coast. A northward shift in the distribution has also been noted across the subpopulation. Current analyses suggest relationships between polar bear distribution and sea ice break-up or the North Atlantic Oscillation. A possible confounding issue is the possible change in subpopulation structure over the study. The second component of the study involves the analysis of the problem bears near the Churchill Townsite in cooperation with Manitoba Conservation. Using capture records both in the Churchill area and the surrounding areas, the study will examine correlates with the number of occurrences in the Town with environmental and distribution patterns noted during the mark and recapture studies.

Collaborators: University of Alberta, Canadian Wildlife Service, Manitoba, NSERC

Diet analysis of polar bears in the Beaufort Sea

Carbon and nitrogen stable isotopes analyses are being applied to the polar bear subpopulation in the Beaufort Sea to assess diet. These studies are being conducted by Seth Cherry (M.Sc. student) in cooperation with Ian Stirling and Keith Hobson of the Canadian Wildlife Service. The goal of this work is to develop a greater understanding of the age- and sex-specific diet of polar bears and to assess this approach for long-term monitoring of ecosystem dynamics. Samples of fat, hair, claw and blood have been collected from over 100 bears on the Canadian side of the South Beaufort and North Beaufort subpopulations.

Collaborators: University of Alberta, Canadian Wildlife Service, NSERC

Modelling polar bear life history strategies

Péter Molnár (Ph.D. candidate in mathematical biology co-supervised with Mark Lewis) is investigating the mechanisms behind life history phenomena using models of life history optimization. The approach will work with the optimal reaction norm for several life history traits. Validation of the derived models and testing of the associated hypotheses will be done with long-term data from Ian Stirling and Nick Lunn from the Canadian Wildlife Service, complemented by data available from the literature. Optimally, the models will enable projection of how the life history of polar bears would be affected by changes in climate. The research will also model the subpopulation dynamics of polar bears and investigate how these would respond to climatic warming. polar bear dynamics are mainly driven by ringed seal dynamics, at least where ringed seals are their primary prey, thus this predator-prey system will be modelled using both dynamical systems and age-structured models. After we have understood the current subpopulation dynamics, we will be in a powerful position to analyse how climate change will affect the system and its dynamics. Ultimately, an interaction between life history patterns and subpopulation dynamics is to be expected (different life history tactics will likely have different effects on subpopulation growth rates, for example), but for simplicity, the first approach will treat these two levels of organization separately. Eventually, the interactions and their importance will be examined. Finally, the subpopulation dynamics of polar bears from the newly constructed models will be contrasted with projections from the RISKMAN model. The strengths and weakness of both methods will be examined from both a theoretical and management perspective.

Collaborators: University of Alberta, Canadian Wildlife Service

Mercury concentrations in polar bear hair in western Hudson Bay

In the fall of 2004 a project was initiated by Vince St. Louis and Sarah Downey at the University of Alberta to examine the potential use of polar bear hair for mercury contaminant analysis. The following is a summary of the results from the study. A total mercury (THg) analysis was performed on hairs collected from 80 polar bears in western Hudson Bay. Females had significantly higher concentrations of THg in their hair than males. There was no relationship between concentrations of THg in polar bear hair and their age, weight, or an interaction between the two. The effect of sex on THg levels in polar bear hair, which is atypical, is likely due to the high proportion of females that were nursing or rearing cubs. Within females, the hairs of nursing females had significantly higher concentrations of THg than the hairs of non-nursing females indicating the effects of high rates of fat tissue depletion are resulting in overall higher relative concentrations of THg in nursing females. The non-significance of age is in agreement with previous studies conducted on polar bear hair, but runs counter to analyses conducted on other tissues, which accumulate mercury (Hg). With respect to previous studies, results from this study show an increase in mercury in polar bear hair from western Hudson Bay, which may be due to seasonal variation or variation in prey availability in response to changing sea ice dynamics in that region. It may also indicate an increase in the total environmental burden of Hg in that region, which has implications for arctic biota as well as for humans in that region that rely on traditional foods.

Collaborators: University of Alberta, Canadian Wildlife Service, NSERC

Bacular growth of polar bears in the Canadian Arctic

Data collected during regular harvest sample collections were used to examine growth of the baculum of polar bears. Length, mass, diameter, and density were used in subsequent analyses. Preliminary results indicated that the baculum reaches about 97% of its mature dimensions between the ages of six and seven. This information may be useful for examining reproductive behaviour and physiology of male polar bears and how these may relate to the current sex-selective harvest that is biased towards males (e.g., age versus reproductive potential).

Collaborators: Nunavut

Genetics

Reproductive success of polar bears in Western Hudson Bay

Long-term mark-recapture studies of polar bears in Western Hudson Bay have enabled a detailed understanding of female reproductive success. However, because mating is only rarely observed, the relative reproductive success of male bears remains unknown. In order to gain a greater understanding of polar bear mating systems we are using molecular markers to construct a pedigree of bears sampled in Western Hudson Bay during the last 30 years.

Throughout the Canadian Arctic, the sustainable harvest levels for polar bears from subpopulations of known size are estimated to be 1.5% of the independent females and double that (3%) for adult males. These guidelines, when followed, mean that males are harvested at twice the rate of females, even though the normal sex ratio in most subpopulations is roughly 1:1. Amongst the harvested males, there is additional pressure to harvest large males, especially in areas where hunters guide non-resident sport hunters and the largest males in the subpopulation are most sought after as trophies. As a result, in some subpopulations, most of the largest adult males may be eliminated. The rationale for harvesting bears at the ratio of 2 males to 1 female is based on two hypotheses. Firstly, adult males are likely to mate with more than one female during the breeding season such that even if the number of large males is reduced, enough males will still remain to successfully mate with all the available females. Secondly, younger males are still in abundance and capable of completing enough matings to make up for any reduction in the number of older, dominant males in the subpopulation. Therefore the reproductive potential of adult females is not compromised by removal of a large proportion of males. There are few data to evaluate the strength of these hypotheses. Although the effects on the fitness of a subpopulation of the systematic removal of the largest, and possibly most reproductively successful males, are largely unknown, these effects are expected to be greatest in a long-lived species with low reproductive rates, such as polar bears.

In the Western Hudson Bay polar bear subpopulation, males and females have been harvested in a 2:1 ratio for more than 20 years, resulting in a permanent skew in the sex ratio (now approximately 58% female, 42% male). In this subpopulation, however, because of the way animals are distributed at the time the harvest is taken, sub-adult males make up the majority of the annual harvest. Thus, while some dominant adult males are taken each season, many remain in the subpopulation. Therefore, it should be possible to determine the relative fitness and genetic importance of dominant males in a subpopulation where they have not yet been significantly reduced.

Using a suite of 24 Mendelian-inherited di-nucleotide microsatellite markers, we will determine individual relationships amongst approximately 2,300 polar bears sampled in western Hudson Bay since 1966. Approximately 85% of the adult females have been sampled, and many have been captured in subsequent years, allowing for an examination of successive litters from the same mother. Through the genetic assignment of individual offspring to adult males, this study will allow for the determination of basic parameters of male reproductive success (mean and variance of reproductive success, age at first reproduction). Due to the extensive annual sampling of the subpopulation, measures of male and female reproductive lifespan, and lifetime fitness can also be assessed. Likewise estimates of long-term effective subpopulation size, mate choice, and inbreeding avoidance may be assessed from a long-term dataset. An estimation of these parameters will be unique for a long-lived mammal. Using data on the age and condition of individual bears, we will assess the heritability of reproductive success in relation to physical characteristics. Most importantly, we will assess the importance of dominant adult males in the subpopulation and the effect of their removal. This will allow for a direct examination of the effects of current management practices on the genetic structure and long-term fitness of the subpopulation. DNA has been extracted from all bears and the genotyping has been completed.

Collaborators: Canadian Wildlife Service, University of Alberta, Manitoba

Paternity analysis MC and GB

Brenda Saunders (M.Sc. candidate) is looking at paternity in polar bear subpopulations in the central Arctic, especially MC and GB. In current management, males are considered to be surplus. Her preliminary data show that males are not all equal because, although both young and old males do sire cubs, males 8–14 years of age are most successful. Her results also indicate that there have been more movements of males from GB to MC than had originally been hypothesised. However, more samples from males are needed to improve the estimate of age-specific movements.

Collaborators: Nunavut, Queens University

Genetic structure of the SH polar bear subpopulation

In October 2004, Ashleigh Crompton completed her M.Sc. programme in conjunction with the Natural Resources DNA Profiling and Forensics Centre at Trent University Peterborough, Ontario. The objective of this study was to characterize the genetic structure of the SH polar bear subpopulation and to compare it to the WH, FB and DS subpopulations.

Tissue samples were obtained from 383 individuals representing the four Hudson Bay region management units (WH, SH, FB, DS). Independent STRUCTURE analysis of individuals identified one genetic cluster in the northern part of Hudson Bay system (FB_DS), and three genetic clusters in the southern part of the Hudson Bay system. There is geographic overlap of individuals from the three southern genetic clusters during the ice-free period; however, there is limited movement and gene flow between individuals from western regions in James Bay. Long-range dispersal of both males and females from the southern areas to northern area was identified; however, no dispersal form the north to the south could be identified due to the high level of mixed ancestry in the northern genetic cluster.

Polar bears in the southern portion of Hudson Bay appear to be maintaining three breeding groups, one in the southwest, one in the east, and one in James Bay. Migration and genetic exchange are occurring between the breeding groups, but there appears to be a sufficient level of fidelity or traditional use of breeding areas to maintain the groups as structured groups. Fidelity to summering areas appears to be independent of fidelity to breeding areas. The reason for the existence of the three genetic groups in southern Hudson Bay is unclear, but it may be related to distribution of seals and patterns of ice break-up. By disrupting east-west dispersal patterns for bears in southern Hudson Bay, there is the potential for climate change to lead to the increased isolation of these breeding groups if ice freeze and thaw patterns continue to change. Polar bears from the three subpopulations recognised for management purposes in the Hudson Bay system (SH, WH, and FB) likely overlap to some extent during the mating period when Hudson Bay is ice-covered in the spring. As a result, there is the opportunity for genetic exchange among the subpopulations; however, the extent of genetic exchange is currently unknown. A previous study examined the genetic structure of most of the world's polar bear subpopulations and related the observed genetic partitioning to recognised management units. However, samples were not available from SH bears during the time of that study so management unit boundaries for SH currently recognised by the PBTC have not been confirmed by genetic analysis.

Collaborators: Ontario, Trent University, Nunavut, Canadian Wildlife Service, Makavik Corporation, World Widlife Fund (Canada)

Research techniques

Anaesthetic drugs for Bears

During the summer of 2001, Marc Cattet and N. Lunn tested a combination of xylazine and Telazol™ (XZT) on 17 free-ranging polar bears of the western Hudson Bay subpopulation. A manuscript presenting the results from this work, and from research on the behavioural and physiological effects of XZT and Telazol™ on captive bears conducted during 1998, was published in the *Journal of Wildlife Diseases* in 2003. XZT and the antagonist drug, atipamezole, have been used since to capture 160 polar bears. The following summary is taken from the report by Cattet *et al.* (2003):

The immobilization features and physiologic effects of combinations of xylazine-zolazepam-tiletamine (XZT) and zolazepam-tiletamine (ZT or Telazol™) were compared in nine captive and 17 free-ranging polar bears between 1998 and 2001. Immobilization was effective and reliable with XZT at a dosage of 4 to 6 mg/kg (with a 2:3 ratio of xylazine to ZT). Nonetheless, XZT was safely tolerated at two to three times the recommended dosage of 5 mg/kg. Although induction time was similar between drugs, induction dosage and volume were less with XZT. Induction of immobilization with XZT was predictable and smooth, muscle relaxation was good, and all bears remained completely immobilized and unresponsive to stimuli throughout a one-hour handling period. Bears immobilized with XZT had slower pulse rates, higher mean arterial pressures, lower arterial oxygen tensions, and rectal temperatures that increased slowly over time (~0.5°C per hr). Nevertheless, although the physiological effects of immobilization with XZT were more pronounced than with ZT, these effects were not severe enough to pose significant risk to healthy bears. Based on response to a painful stimulus (compression of a claw bed), XZT was a more effective analgesic than ZT, and is preferable for painful procedures such as tooth extraction or tissue biopsy.

The immobilization effects of XZT can be reversed to some extent with the alpha-2 antagonist drugs, yohimbine or atipamezole. However, these drugs only reverse the effects of xylazine, so the time to complete reversal where a bear is standing and ambulatory is highly variable and largely dependent on the amount of ZT that was initially administered. The alpha-2 antagonist tolazoline does not appear to be effective in polar bears.

Collaborators: Canadian Cooperative Wildlife Health Centre, Canadian Wildlife Service

Defining conditions for the estimation of body mass by morphometry

Body mass is an important biological attribute that provides a measure of health in individual animals and, when measured across many animals, insight into the status of subpopulations. However, weighing large animals such as polar bears can be difficult, requiring equipment, staff, and time. Consequently, estimation of body mass through the measurement of form (morphometry) is common practice. Nevertheless, opinions differ regarding the utility of morphometry to estimate body mass. In 2003, M. Cattet and M. Obbard examined: (1) the effects of sample size and time on the accuracy of estimating body mass in polar bears of the southern Hudson Bay (SH) subpopulation, and (2) how the estimation of body condition is affected when estimated body mass is used as a predictor variable instead of observed body mass. The results of this analysis were published in the journal *Ursus* in 2005. The following summary is taken from the manuscript:

The objective of this study was to define the conditions under which the body mass of polar bears can be estimated by morphometry with acceptable accuracy (high precision and low bias). Morphometric and body mass values from 563 polar bears captured and handled in southern Hudson Bay during 1984–86 and 2000–03 were analysed to determine the effects of sample size and time on the accuracy of estimated body mass (EBM) and to determine the effect of using EBM versus observed body mass (OBM) to calculate body condition index (BCI) values (Cattet *et al.* 2002). When sample size was small (≤25), variation around the difference between OBM and EBM was large. However, precision improved markedly with increasing sample size, stabilizing within approximately 3% for sample sizes ≥100. Morphometric-body mass relationships developed for SH polar bears in the mid-1980s consistently overestimated body masses of bears handled since 2000 by approximately 4%, suggesting relationships within the subpopulation had changed over time (increased bias). This was verified by new prediction equations developed for each period that showed the EBM of polar bears captured in 2000–03 is 7–18% less than that for bears captured in the mid-1980s when morphometric values are held constant. Accuracy was reduced when EBM, instead of OBM, was used as a predictor variable for calculation of the BCI. This was caused by both loss of precision and increase in bias as a result of compounding the error associated with the EBM. Although body mass can be estimated accurately by morphometry under specific conditions, we recommend that investigators routinely weigh a proportion of bears captured per field season to ensure and maintain accuracy. The OBM values can be used to both verify the accuracy of EBM values and to calculate BCI values for representative bears.

Collaborators: Canadian Cooperative Wildlife Health Centre, Ontario

Evaluation of the potential for injury with remote drug delivery systems

The development of reliable remote drug delivery systems (RDDS) in conjunction with safer injectable anaesthetic drugs over the past four decades has greatly facilitated the capture and handling of many different free-ranging species. Although RDDS technology has improved in this period, occasional reports still appear in the scientific literature that describe serious injury caused by RDDS. However, the potential for causing injury remains largely unknown because the causative factors have not been clearly identified. Further, it is likely the frequency of injury is underestimated because many dart injuries go undetected, concealed well by fur and skin.

In 2003, M. Cattet and co-investigators with the Royal Canadian Mounted Police (RCMP) and the Government of the NWT-Environment and Natural Resources conducted a study to identify the characteristics of RDDS that can contribute to injury in animals by using techniques employed to study wound ballistics in humans. The study was conducted on an indoor firing range at the RCMP Forensics Laboratory at Regina, Saskatchewan. A report from this research was submitted to the Wildlife Society Bulletin in March 2005. The following summary is taken from the report:

We evaluated the potential for different types of remote drug delivery systems (RDDS) to cause significant injury to target animals. We recorded dart velocity, time, and distance from projector muzzle at 8.5ms intervals by Doppler radar chronograph for four types of RDDS (HR – heavy mass, rapid-injection; LR – light mass, rapid-injection; HS – heavy mass, slow-injection; LS – light mass, slow-injection) using darts of different volume and various combinations of charges, power settings and target distances set in accordance with manufacturer's recommendations. Variation in the drop of repeated shots per trial was >10cm for 28 of 90 trials (five replicates per trial), with heavy mass darts showing the lowest precision. Impact velocities were high (> 60m/s) in trials using small volume (3 and 5ml) heavy darts and LR darts, often exceeding empirical skin penetration threshold velocities. We determined the characteristics of the permanent wound cavity (PWC) by firing dye-filled darts into ordnance gelatin covered tightly by a fresh elk hide (three replicates per trial), and into the thighs of calf carcasses (one dart per trial). We recorded dart impact using high-speed digital video. Rapid-injection darts fitted with end-ported needles consistently: 1) forced hair and skin into the PWC and between the elk hide and gelatin; 2) formed a long PWC (2–3 × needle length) due to the forceful ejection of dye; and 3) retracted the needle from the PWC and pulled the hide away from the gelatin before the dye was completely ejected from the dart. Although we did not observe these effects in trials using slow-injection darts fitted with side-ported needles, we observed that the small diameter (7.2mm) needle seals used on the side-ported needles consistently penetrated the elk and calf hide. We conclude injury is minimized when using RDDS that use lightweight, slow-injection darts, fitted with side-ported needles and broad diameter needle seals, and that impact target animals at moderate velocity (40–50m/s) with high precision. We recommend against the use of darts with rapid-injection mechanisms and end-ported needles because of their potential to cause deep, chronic wounds.

Collaborators: Canadian Cooperative Wildlife Health Centre, Northwest Territories, RCMP

Development of biomarkers for the detection of long-term physiological stress in polar bears

The physiological stress response is an evolutionarily conserved process in vertebrate animals. The short-term (acute) stress response is a beneficial response to immediate stressors such as predators (the classic "fight-or-flight" response). However, the physiological stress response to long-term stressors can result in negative effects on health, including decreased immune function, reproduction and growth. Our research is based on the premise that, if health of polar bears is affected adversely by global warming, persistent organic contaminants and other human-caused stressors, it will manifest first as long-term physiological stress in individual animals before effects (e.g., impaired reproduction, diminished growth, reduced survival) occur at the subpopulation level. Thus, sensitive and reliable measures of stress and health in individual bears are urgently needed as part of a working model to forecast the potential effects of environmental stressors.

The development of long-term stress biomarkers is occurring along two different paths. Since 2004, we have been collaborating with Dr Matt Vijayan (Dept. of Biology, University of Waterloo) and his M.Sc. student, Jason Hamilton, to develop blood serum-based indicators of long-term stress. Recently, cortisol binding globulin (CBG) was isolated and purified from polar bear sera, and is now being used to develop antibodies for the detection of bear-specific CBG. In addition, commercial kits for the detection of heat shock proteins (hsps) are being used to measure levels of hsps 60 and 70 in polar bear sera collected from polar bears of the southern Hudson Bay subpopulation since 1999. Although these serum-based indicators hold promise as reliable biomarkers of long-term stress, their application is limited primarily to live-captured bears.

The other path, lead by Dr David Janz (Dept. of Veterinary Biomedical Sciences, University of Saskatchewan) and his Ph.D. student, Ruth Carlson, is the development of a sensitive protein microarray for detecting long-term physiological stress. It offers several important advantages over serum-based indicators. First, because the microarray will yield expression profiles for multiple stress-activated proteins, it will provide insight into the nature of the long-term stressors (e.g., contaminants or reduced food availability) and their likely health effects (e.g., reduced immunity or stunted growth), information that cannot be gleaned from any single measure of stress. Second, because the microarray will include evolutionarily conserved proteins, its application has potential for other species, including those at risk such as woodland caribou (*Rangifer tarandus caribou*) and the wolverine (*Gulo gulo*). Third, and of particular importance from an animal welfare perspective, the microarray will yield expression profiles for stress-activated proteins found in many body tissues. Therefore, sampling should not require the capture and handling of large numbers of animals. Instead, remote biopsy techniques can be used to quickly sample free-ranging animals; viable samples also may be opportunistically collected from recently deceased animals (e.g., hunter-killed).

Collaborators: Canadian Cooperative Wildlife Health Centre, Ontario, University of Saskatchewan, University of Waterloo

Disease

Rabies and polar bears

Rabies has been present in the Arctic for over a century and is always present (enzootic) among arctic fox populations. The fox is believed to serve as a source of infection for other animals, including river otters, caribou, wolves, coyotes, reindeer, cats, and dogs. Oddly, rabies has been documented in only one polar bear despite extensive geographic overlap in the ranges of arctic foxes and polar bears, and presumably frequent and direct interactions between the species over time.

In an effort to understand why the apparent prevalence of rabies is extremely low in polar bears, a serological investigation of archived polar bear sera was carried out by the Canadian Cooperative Wildlife Health Centre in 2002. The sera comprised 167 samples, including 121 samples collected from the western Hudson Bay subpopulation in the vicinity of Churchill, MB, during 1995 and 1996, and 46 samples collected from the Lancaster Sound subpopulation during the same period. Collection of samples from polar bears near Churchill was also concurrent with a confirmed outbreak of rabies among arctic foxes. Frozen sera were sent from Saskatoon and tested using enzyme-linked immunosorbent assay (ELISA) at the Institute of Virology, Erasmus University, Rotterdam, The Netherlands.

Results were negative in all cases indicating neutralizing antibodies against the rabies virus could not be detected in any of the samples. These results are consistent with findings from previous serological investigations of polar bear sera collected at Svalbard. The lack of positive results suggests at least three possibilities: polar bears infected with rabies die quickly and go undetected; polar bears infected with rabies do not produce antibodies against the virus; or polar bears rarely become infected with rabies despite their close association with arctic foxes.

Collaborators: Canadian Cooperative Wildlife Health Centre, University of Saskatchewan

Trichinella sp. in polar bears

The prevalence of *Trichinella nativa* in walrus and polar bears is continuing to be monitored in Nunavik. Bears and walruses in SH have a much higher prevalence of this parasite to bears and walrus in FB and DS. Of 52 walrus examined in 2001, six tested positive for *Trichinella*. Of eight walrus harvested on the Sleeper Islands by Inukjuak hunters, four were positive. In collaboration with Mike Hammill and Veronique Lesage of DFO, approximately 100 samples of tissue were sent for stable isotope analysis to determine if infected walrus are feeding at a different trophic level. The trophic study will be expanded to include fatty acid analysis, once funding and collaboration has been confirmed. Polar bear heads sent to FAPAQ by Nunavik hunters continue to provide a source of masseter muscle or tongues used in the *Trichinella* study.

Collaborators: Makivik Corporation, DFO

Deterrent studies

Characteristics of polar bear problem kills in Nunavut, 1970–2000

As the bear deterrence and human conflict management initiatives progressed, Nunavut DSD examined existing data of problem bear kills for the past 30 years in Nunavut. Preliminary examination showed that between 1 July 1970 and 30 June 2000, 618 polar bears were killed as a result of bear-human interactions (i.e., problem bear kills). Age and sex of killed bears, time of year, general circumstances, and distribution by polar bear subpopulation, community, and region were characterized. Males represented 66% of the sexed bears. Subadults constituted 30% of the aged sample of bears. Of the sexed and aged bears, male cubs and subadults were killed 2–3 times more often than females. Family groups, although protected, constituted 17% of the total sample. Most problem kills occurred between August and November. polar bears of the Baffin Bay subpopulation represented 30% of all kills. The community with the most problem kills for the study period was Resolute (16% of total kill). In 266 cases where the circumstances surrounding the death were known, 74% occurred at outpost camps, 4% at industry type camps, 18% at settlements, and 4% during research activities. The difficulty in deterring bears from outpost camps is because of attractants, which are food items for polar bears and humans alike. The most promising solution for reducing problem bear kills at outpost camps seems to be a reduction in the availability of food items.

Collaborators: Nunavut

Churchill Polar Bear Alert Program

Although mostly a management programme, the Churchill Polar Bear Alert (PBA) Program is an important source of data on polar bears near Churchill, Manitoba. Each year in the autumn, bears that approach too closely to the town area are held until the ice forms, or are airlifted away from the town site. Every bear is marked and measured as part of the overall mark and recapture programme in western Hudson Bay, and the data are logged with the National Polar Bear Database. In the past 12 years, most handled bears have been sub-adults, with more male than female bears in both adult and sub-adult age classes.

One of the best measures of the success of the PBA Program is the reduction in problem bear kills. During the 10-year period from 1970 to 1979, there was an average of 17.2 bears killed per year (109 by the public and 63 by the department). In contrast, the 10 years from 1990 to 1999 had an average of 4.4 bears killed per year (18 defence kills and 26 bears killed by the department). This reduction in bear deaths occurred even though numbers of bears handled under the programme during five of those years were the highest recorded (range = 79 to 113), and seven years had higher than average numbers of bear occurrences in the control zone around Churchill. It appears that the combination of public education in bear awareness and prevention of food conditioning of polar bears are the main factors contributing to fewer problem bears. The success of the Polar Bear Alert Program has continued from 2001 to 2004. The number of bears killed averaged five bears per year including defence kills by the public and Manitoba Conservation as well as handling deaths. This occurred despite an increase in the number of bear occurrences and the number of bears handled by Manitoba Conservation (see Management of polar bears in Canada). Data from the Polar Bear Alert Program is currently being incorporated into subpopulation modelling estimates for WH.

Collaborators: Manitoba

Data management

National Polar Bear Database

In Canada, there is no overall standard for data collection or management and it is up to each jurisdiction to decide how they handle their data. However, several values are collected by every jurisdiction, and similar data forms are used by most. Data from each jurisdiction are sent to the CWS lab in Edmonton and included in a National Polar Bear Database. DOS-based relational database management software (Advanced Revelation) is used and incorporates multi-values within fields, similar to large mainframe DBMS. It is especially flexible for exports and imports of data with other software programmes and web-based applications. Although an updated 32-bit Windows-based version is now available for the software, CWS has retained the DOS-compatible version for the time being. Some modifications to the entry and edit windows and programmes continue to be made to meet changing needs. Programmes have also been written to ease the exchange of data between jurisdictions, and to control the edit procedures. Modified records are written to a zipped file that is easily exchanged using electronic mail or floppy disk.

Since 1995, Nunavut has also used Advanced Revelation for data entry and extractions, in order to use the software applications that have been designed for the National Database. All Nunavut records for captured or killed bears are entered and edited in Advanced Revelation format in Igloolik before being sent to Edmonton. Records of bears killed in the NWT are entered in Inuvik using other software, then an MS Excel copy is sent to Edmonton for subsequent re-formatting and entry to the National Database. Copies of the updated records are then sent back to Nunavut and NWT. Records from other jurisdictions are incorporated whenever they are available.

Currently, the database contains about 42,000 separate records of polar bear occurrences, including bears sighted and handled during mark-recapture programs, and all bears recorded as killed or found dead. Supplementary to the records on polar bears, separate files are maintained to track the hide tag numbers assigned to the quota, and whether or not they were filled.

Collaborators: Canadian Wildlife Service, Manitoba, Newfoundland and Labrador, Northwest Territories, Nunavut, Ontario, Québec, Yukon

References

Amstrup, S.C., Durner, G.M., Stirling, I. and McDonald, T.L. 2005. Using radiotelemetry to allocate harvests among polar bear stocks occupying the Beaufort Sea Region. *Arctic* **58**:247–259.

Cattet, M.R.L., Caulkett, N.A., Obbard, M.E. and Stenhouse, G.B. 2002. A body condition index for ursids. *Can. J. Zool.* 80: 1156–1161.

Cattet, M.R.L., Caulkett, N.A. and Lunn, N.J. 2003. Anesthesia of polar bears using xylazine zolazepam-tiletamine or zolazepam-tiletamine. *J. Wildl. Dis.* 39:655–664.

Comiso, J.C. 2002. A rapidly declining perennial sea ice cover in the Arctic. *Geophys. Res. Lett.* **29**:1956,doi:10.1029/2002/GLO15650.

Gagnon, A.S., and Gough, W.A. 2005. Trends in the dates of ice freeze-up and breakup over Hudson Bay, Canada. *Arctic* **58**:370–382.

Gough, W.A., Cornwell, A.R. and Tsuji, L.J.S. 2004. Trends in seasonal sea ice duration in southwestern Hudson Bay. *Arctic* **57**: 299–305.

Stirling, I. and Derocher, A.E. 1993. Possible impacts of climatic warming on polar bears. *Arctic* **46**:240–245.

Stirling, I., Lunn, N.J. and Iacozza, J. 1999. Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. *Arctic* **52**:294–306.

Polar bear management in Greenland

J. Lønstrup, Ministry of Fisheries and Hunting, Greenland Home Rule Government, P.O. Box 269, DK-3900 Nuuk, Greenland

Regulations for the management and protection of polar bears in Greenland were introduced in 1994. In October 2005, a new Executive Order came into force. Some important protective measures in the new Executive Order on the Protection and Hunting of Polar Bears are:

- year round protection of all cubs (regardless of age) and females accompanied by cubs. The executive order also introduces a prohibition of the export of polar bear cubs;
- protection of all polar bears from 1 July to 31 August; in the local authority districts of Ittoqqortoormiit og Ammassalik from 1 August to 30 September;
- prohibition to disturb or dig out polar bears in dens;
- introduction of quotas from 1 January 2006 and the possibility that part of the quota may be used for trophy hunting. Special provisions on trophy hunting will be laid down in a separate executive order;
- only Greenland residents who hunt as a full-time occupation are allowed to hunt polar bears;
- it is mandatory to report to the Greenland management authorities all catches including struck-and-lost polar bears;
- aircraft, helicopters, motorized vehicles, including snow scooters and boats larger than 20 GRT/15 GT are not allowed in the hunt or for transportation to and from the hunting grounds;
- poison, traps, foot snares or self-shooting guns are not allowed; and,
- rim-fire rifles, shot guns or semi- or fully automatic weapons are not allowed. Polar bears may only be hunted using a rifle with a minimum caliber of 30.06 (7.62mm).

Introduction of quotas

The first quota year begins on 1 January 2006. The quota was fixed in consideration of international agreements, biological advice, users' knowledge, and after consultation with the Hunting Council. For the first year, the quota in Greenland will be 50 bears for east Greenland and 100 for west Greenland.

The quota will be distributed among the local authorities, which are to administer the issuance and distribution of permits and establish sound control to ensure that the allocated quota is not exceeded.

After each hunt, a permit must be stamped by the local authority or settlement office, and polar bear parts must not be sold unless a copy of the stamped permit, signed by the permit holder, accompanies the sale. This will counteract sales of illegally killed polar bears and increase control possibilities. A catch reporting form must be delivered to the local authority or settlement office simultaneously with the stamping of the permit. If no polar bear parts are to be sold, a duly completed catch reporting form will still be required to be delivered to the local authority or settlement office. The purpose of this is to ensure that catches are reported and that the necessary information from the catch reporting form is included in the management work that will be used in part in the setting of the quota for the next year. Conditions for the delivery of polar bear parts for biological studies may be laid down in the permit.

All parts from a polar bear killed as a result of necessity or self-defence in accordance with the provisions of the Criminal Act thereon will go to the Greenland Home Rule Government, and the Department of Fisheries and Hunting must be informed. In addition, a report must be prepared to the Chief Constable to enable him to evaluate the sequence of events.

Export of polar bear parts

The Executive Order contains a prohibition of the export of polar bear gall bladders or parts thereof. For the export of other polar bear parts from Greenland, a CITES export permit is required. Further, a copy of the permit, which should be stamped by the local authority and furnished with the permit holder's signature, must accompany each sale or purchase of polar bear parts.

Illegal hunting

The Minister for Fisheries and Hunting may reduce a local authority's quota for the quota year concerned or for the subsequent quota year if any illegal hunting of polar bears is discovered in the local authority district.

Persons infringing the Executive Order may be held liable to a fine or confiscation. In the event of intentional or repeated instances of grossly negligent infringements of the provisions relating to hunting, the person may also be disqualified, under the Hunting Act, from having the right to hold or acquire a hunting licence.

National parks

Specific regulations apply to the traditional take of polar bears within the National Park of North and East Greenland and the Melville Bay Nature Reserve.

Hunting statistics

In recent years, the Ministry of Fishery and Hunting has improved the hunting statistics and implemented a new database, which should improve the keeping and reporting of accurate hunting statistics.

Co-management with the Government of Nunavut (Canada)

During the fall of 2000, the Greenland Home Rule Government signed a Memorandum of Understanding (MOU) with the Government of Nunavut (Canada). An appendix to this MOU contains a prioritized list of items, including that there should be cooperation between both regarding shared polar bear populations. It is the intention of the Greenland Home Rule Government to continue the dialogue with the management authorities of the Government of Nunavut for the possible establishment of a Memorandum of Understanding regarding co-management of polar bear populations that are shared between Canada and Greenland. Potentially, this could be an extension of the MOU between Canada and Greenland regarding co-management of beluga and narwhal. Meetings between Greenland and Nunavut were planned to take place during the fall of 2005, but because of the election call in Greenland, the meeting was postponed until a new Cabinet was set. The meeting is expected to take place during the first half of 2006.

Management plans for polar bears

In 2006, the administration will be working on polar bear management plans.

Research on polar bears in Greenland 2001–2005

E.W. Born, Greenland Institute of Natural Resources, P.O. Box 570, DK-3900, Nuuk, Greenland
Christian Sonne, National Environmental Research Institute, Department of Arctic Environment, P.O. Box 358, Frederiksborgvej 399, DK-4000 Roskilde, Denmark

This report summarises research undertaken on polar bears in Greenland since the 13th meeting of the IUCN/SSC Polar Bear Specialist Group in Nuuk (Greenland), June 2001. The research has focused on enumeration of the number of polar bears in subpopulations shared with Canada, tracking of individual polar bears in East Greenland and studies of the effects of organohalogen compounds (OHC) on polar bears in East Greenland. The report also presents information on the catch of polar bears in Greenland.

Subpopulation studies

Four subpopulations of polar bears occur in Greenland – Baffin Bay (BB), Davis Strait (DS), East Greenland (EG), and Kane Basin (KB). Three of these (BB, DS, and KB) are shared with Canada (Taylor *et al.* 2001). Mark-recapture data were used to estimate the size of the Baffin Bay subpopulation (Taylor *et al.* 2005). This demographic analysis included a detailed assessment of age- and sex-specific survival and recruitment from >1,000 marked polar bears. Using information contained within the standing age distribution of these captures and mark-recapture analysis using the MARK programme resulted in an estimate of mean total abundance of 2,074 (SE ± 266) for the period 1994–1997. The total abundance included 1,017 (± 192) females and 1,057 (± 124) males.

Analysis of mark-recapture data (1993–1997) from the Kane Basin resulted in an estimate of 165 polar bears (SE: ± 35) (Taylor *et al.* unpublished).

Due to the lack of comprehensive population inventories, valid estimates of population size do not exist for the other two Greenland subpopulations. "Guesstimates" of 1,400 and 2,000 polar bears for the Davis Strait and East Greenland subpopulations, respectively, have been previously proposed (IUCN/SSC Polar Bear Specialist Group 2002).

Between the fall of 1994 and the summer of 1998 the movements of two adult female polar bears in East Greenland and the Greenland Sea area were studied by use of satellite telemetry (Wiig *et al.* 2003). One female was tracked for a total of 621 days and the other for 1,415 days. During this time, these bears spent almost all of the survey period offshore in the pack ice of the Greenland Sea, although maternity dens on land were used. Excluding the periods spent on land in maternity dens, the females used about 73% and 100% of the survey time in the offshore pack ice. Both bears had very large home ranges (242,000 km^2 and 468,000 km^2) within the dynamic pack ice of the Greenland Sea and suggested that East Greenland subpopulation of polar bears may make intensive use of offshore pack-ice habitats.

The reproductive biology of polar bears in Greenland has also been studied (Rosing-Asvid *et al.* 2002). The mt-DNA coding sequence of an East Greenland bear was included in a study of the mammalian mitogenomic relations and the root of the eutherian tree (Arnason *et al.* 2002).

Pollution studies

Marine mammals in the Arctic, including polar bears in East Greenland, have accumulated considerable amounts of anthropogenic persistent organic industrial chemicals and pesticides (*e.g.* PCBs and DDTs) since *c.* 1960, when many of these substances came into use. The molecular structures of some of these pollutants are similar to those of the hormonal steroids/peptides, which make them prone to act as endocrine disruptors of physiologic homeostasis with potential negative biological effects on hormone systems, and reproduction and immunological functions. To investigate the relationships between histological and internal morphological structures and levels of organohalogen compound (OHC) pollution, adipose tissue, internal organs and skulls were sampled from more than 100 polar bears (1999–2002) that were killed during traditional hunts by the hunters living in central east Greenland (69°00'N to 74°00'N).

Analyses of organochlorines (PCBs, DDTs, CHLs, dieldrin, HCHs and HCB) in 92 individual polar bears sampled from 1999 to 2001 showed age and sex differences for all contaminants and seasonal (yearly) patterns for most age and sex groups. A comparison with samples from 1990 from the same region suggested a temporal decline in levels between *c.* 20% and 70% depending on contaminant group. However, final conclusions could not be drawn about the time trend as it was based on only two different sampling periods within the 10-year period (Dietz *et al.* 2004, Sandala *et al.* 2004, Sonne 2004, Bossi *et al.* 2005, Smithwick *et al.* 2005a,b, Verreault *et al.* 2005).

A histological examination of clitoral enlargement in a 23-year-old female polar bear from central east Greenland (1999) revealed intense, chronic, ulcerative and perivascular *clitoriditis* and indicated that the enlargement was an inflammatory reaction and not *pseudohermaphroditism*. The condition had probably been caused by licking and biting (resembling acral lick dermatitis in the domestic dog). Except for the clitoral enlargement, all dimensions of the external and internal reproductive organs of the bear were similar to a reference group of 23 normal adult female polar bears from the same area (1999–2002). Furthermore, the female bear showed normal genotype, and a macroscopical examination of her internal reproductive organs indicated that she was reproductively functional. Furthermore, concentrations of OHCs in the subcutaneous adipose tissue showed that mean levels were up to 3 times lower than in the reference group animals and lower than the threshold levels of known exposure to these compounds (Sonne 2004, Sonne *et al.* 2005b).

Trends in developmental instability measured as fluctuating asymmetry (FA) were analysed in 283 polar bear skulls sampled in East Greenland during 1892–2002. FA was analysed in relation to (1) period (before and after the supposed onset of pollution – *c.* 1960) and in relation to (2) individual levels of the analysed OHCs. Two different analyses showed that for 10 bilateral traits, the degree of FA did not differ statistically between the two periods and, in four traits, FA was higher in the period of no pollution. The analysis also indicated a higher developmental instability in adults compared to subadults whereas no obvious sex differences were found. A correlation analysis of FA in the skull versus individual levels of the OHCs in 94 individuals showed no significant trend. The result is possibly influenced by genetic (metabolic), environmental (*e.g.* temperature) and sampling frequency factors which we could not avoid and, in addition, the OHC exposure could have been below the biological threshold for FA. Nothing was known about the effects of exposure to OHC at early critical life stages (*in utero* and neonatally) (Sonne 2004, Sonne *et al.* 2005c).

To detect changes in the bone mineral content caused by possible endocrine disruption due to relatively high levels of OHCs, the bone mineral density (BMD) of hydroxyapatite was determined by X-ray (DXA) scanning of 139 skulls and 52 bacula (penis bones). The study showed a clear difference in BMD between subadults of both sexes and adults, increasing in the order subadults < adult females < adult males. In addition, the BMD increased with age in subadults but not in adults. There were indications of a decrease in skull BMD in old females (postmenopausal?) but this could not be confirmed statistically due to too few observations in this age/sex group. BMD in skulls sampled in the pre-OHC period (1892–1960) was significantly higher compared to the OHC- pollution period (1961–2002) for both subadults and adult males. In addition, a negative correlation between contaminants and skull BMD was found for PCBs and chlordanes in subadults and dieldrin and DDTs in adult males. Also, prevalence of periodontitis within each of the two periods (*i.e.* 1892–1960 and 1961–2002) was compared. No difference between periods was found in any of the age/sex groups, whereas periodontitis was highly correlated with individual age. The significant time trend analysis and the strong negative correlation between various OHCs and BMD suggested that disruption of bone mineral content may have been caused by exposure to OHC compounds, but other stressors (*i.e.* nutritional and climatic oscillations) cannot be ruled out (Sonne 2004, Sonne *et al.* 2004).

A study of the hepatic histology in 79 polar bears found significant relationships between histological changes and individual levels of OHC-contaminants in subcutaneous adipose tissue. Furthermore, the character of the findings was similar to those observed in several controlled studies of the toxicity of PCBs, DDTs and dieldrin. Signs of chronic inflammation and lipid accumulation were probably a result of infectious agents and chronic exposure to toxic OHC-contaminants (Sonne 2004, Sonne *et al.* 2005a, Heier *et al.* in press).

The histology of kidneys in 75 polar bears (1999–2002) was studied in relation to individual levels of OHCs. Various types of globular and tubular lesions were observed (glomerular capillary wall thickening, glomerular mesangial deposits, tubular epithelial cell hyperplasia, hyalinization of the tubular basement membrane, tubular dilatation, atrophy and necrosis, tubular hyaline casts, interstitial fibrosis and mononuclear cell infiltration) all of which (except mononuclear cell infiltrations) were correlated with age while none were associated with sex. However, several of the lesions were positively correlated with level of various OHCs. The lesions were similar to those reported in highly OHC contaminated seal populations in the Baltic Sea and exposed laboratory animals. The study suggested that the lesions observed were a result of ageing and that long-term exposure to OHC was a major exacerbating co-factor (Sonne *et al.* in press).

Individual levels of OHC contamination and possible changes in selected immunological organs (lymph nodes, spleen, thymus and thyroid tissue) were studied in 82 polar bears (1999–2002). No histopathological changes (*e.g.* neoplasia) were found in any of the organs and it was concluded that the exposure of OHC to polar bears are unlikely to have resulted in adverse effects on the tissues in question (Kirkegaard *et al.* 2005).

Overall, the study suggested a decrease in adipose tissue concentrations of OHCs in East Greenland polar bears from 1990 to 1999–2001. Two of the potential biological effect parameters (FA and enlarged clitoris) did not indicate a link to the relatively high levels of OHCs. However, there were strong indications of a relationship between various OHCs and skull mineral density indicating disruption of the bone mineral composition. The histopathological changes found in liver and kidney tissue might have resulted from ageing, infectious agents, season *or* chronic exposure to OHCs. An impact on the health of the bears is probable at the individual level, however, it cannot be excluded that they may affect reproductive performance and thereby population status. The significance of the pathological changes at the individual level is difficult to evaluate, but controlled studies on West Greenlandic sledge dogs (*Canis familiaris*) and arctic fox (*Alopex lagopus*) are currently being conducted in order to elucidate the physiological effects of OHCs on arctic top predators.

The catch of polar bears in Greenland

Recent information about the catch of polar bears in Greenland was presented to the Canadian Polar Bear Technical Committee by Born (1999, 2001, 2005, and *in litt.* 2002, 2003).

The catch of polar bears in Greenland has been reported through the "*Piniarneq*" (*i.e.* "the catch") system that was introduced in 1993 (see section: The "*Piniarneq*"system). Information on the polar bear catch during 2000–2004 was compiled by the Greenlandic Ministry for Fisheries (*in litt.* 3 February 2005). Data for 2004 are provisional.

The reported catch of polar bears in Greenland for the period 1993 to 2003 is presented by municipality and polar bear population in Table 22, which also presents provisional data for 2004 (for municipalities, see Figure 22).

Figure 22. Map of Greenland with borders of the municipalities and the National Park of North and Northeast Greenland.

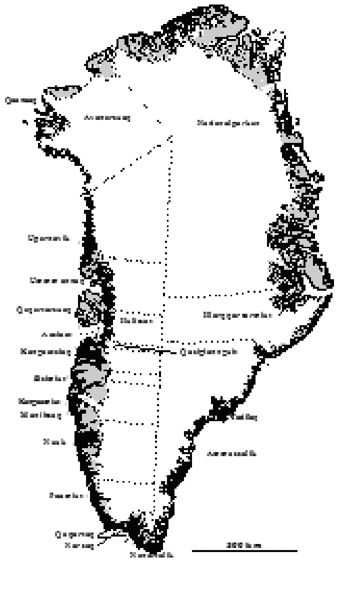


Table 22. The reported catch of polar bears in Greenland, 1993–2004. Data for 2004 are only for the first nine months of the year.

Polar bear subpopn	Region	Municipality reporting	Year											
			1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Kane Basin	NW Greenland	Qaanaaq[1]	10	10	10	10	10	10	10	6	10	12	12	8
		Sub Total	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**6**	**10**	**12**	**12**	**8**
Baffin Bay	NW Greenland	Qaanaaq[1]	14	23	13	20	31	12	11	10	10	23	35	18
		Upernavik	43	25	27	40	38	48	49	40	64	72	135	79
		Uummannaq	3	0	4	5	2	9	9	6	8	0	18	8
		Qeqertarsuaq/Disko	6	1	1	0	0	5	2	7	1	3	0	7
		Ilulissat	1	1	2	0	0	1	5	0	1	3	3	3
		Aasiaat	4	3	1	0	3	3	8	2	0	3	2	3
		Qasigiannguit	0	0	2	0	2	5	3	2	0	0	0	3
		Kangaatsiaq[2]	1	6	10	1	2	0	6	0	2	10	10	5
		Kangerlussuaq/Sdr. Strom[2]	0	0	0	0	0	1	0	0	0	0	0	0
		Sisimiut[2]	0	1	4	1	1	12	4	1	11	4	3	24[3]
		Sub Total	**72**	**60**	**64**	**67**	**79**	**96**	**97**	**68**	**97**	**118**	**206**	**158**
Davis Strait	Central West Greenland	Maniitsoq	4	0	5	1	4	22	0	0	1	1	1	10[3]
		Nuuq	0	0	1	4	0	0	2	0	0	1	0	1
		Sub Total	**4**	**0**	**6**	**5**	**4**	**22**	**2**	**0**	**1**	**2**	**1**	**11**
East Greenland	SW Greenland[4]	Ivittuut	0	0	0	0	0	0	0	0	0	0	0	0
		Paamiut	1	2	1	1	5	1	0	0	1	3	3	3
		Narsaq	1	0	0	0	2	0	0	2	0	0	10	0
		Qaqortoq	0	0	2	0	0	4	1	3	0	0	0	0
		Nanortalik	1	0	6	3	6	9	11	4	1	3	3	1
	East Greenland	Ammassalik	15	14	22	23	9	13	14	40	29	35	24	11
		Illoqqortoormiut/Scoresbysund	28	35	26	26	34	43	55	35	41	15	19	28
		Sub Total	**46**	**51**	**57**	**53**	**56**	**70**	**81**	**84**	**72**	**56**	**59**	**43**
		Total	**132**	**121**	**137**	**135**	**149**	**198**	**190**	**158**	**180**	**188**	**278**	**220**

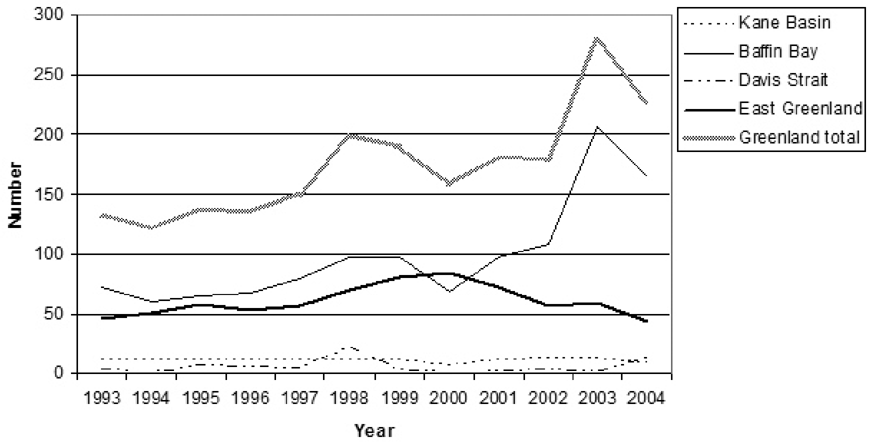
[1] Some of the catch from the Qaanaaq municipality was likely taken in Kane Basin (inferred from settlement reporting).
[1] Some (perhaps all) of the catch reported for Kangaatsiaq, Kangerlussuaq, and Sisimiut may have been taken from the Davis Strait subpopulation.
[3] Likely mis-reporting.
[4] Bears taken in SW Greenland likely come from the East Greenland subpopulation.

During 1993–2003 the total catch of polar bears in Greenland has increased significantly (r=0.80, z=3.08, p=0.002, n=11). This increase was exclusively due to an increase in the catch from the Baffin Bay subpopulation, (see Figure 23).

In the following the catch of polar bears is described by region from NW Greenland around the southern tip of Greenland to E Greenland.

The polar bear catch in western Greenland reported from the municipalities from Qaanaaq south to Nuuk (Figure 22) may arbitrarily be allocated to the three subpopulations (Kane Basin, Baffin Bay, and Davis Strait) that are shared with Canada (Taylor *et al.* 2001). Bears taken between Qaanaaq and Sisimiut are taken from the KB and BB subpopulations, whereas those taken in Maniitsoq and Nuuk likely are extracted from the DS group (Table 22).

Figure 23. The total Greenlandic catch of polar bears, 1993–(2004) and also given by polar bear population. The data were compiled via the Piniarneq system (see text). Data for 2004 are provisional (include only the first nine months of the year).



In western Greenland, the occurrence of polar bears in the northernmost municipalities (i.e. Qaanaaq and Upernavik) is more regular than in the areas farther south. Hunters from the municipality of Qaanaaq hunt polar bears in three areas: (1) in the Kane Basin region (i.e. between approximately 78°30´N and 80°N), (2) the central parts of the municipality (i.e. between approximately 76°N and approximately 78°N), and (3) Melville Bay. The hunters from northern Upernavik also hunt bears in the Melville Bay. In this area and in KB the bears are taken during hunting trips specifically for polar bears, whereas the take of a polar bear is a more occasional event in the other parts of these two municipalities (Rosing-Asvid 2002).

In the areas between Uummannaq (about 72°30´N) and Sisimiut (67°N) – covering eight municipalities (Table 22) – polar bears are hunted either on the shore-fast ice or from boats operating at the eastern edge of the Baffin Bay pack ice. North of Kangaatsiaq (*c.* 68°30´N) the ice conditions are usually more stable than further south (Rosing-Asvid 2002).

Kane Basin: A certain number of the polar bears reported from the Qaanaaq municipality have likely been taken from the KB population. Hunters from the settlement of Siorapaluk (the northernmost settlement in this municipality) usually go north to hunt polar bears in Kane Basin, whereas the hunters from the town of Qaanaaq sometimes go north and sometimes go south to the Melville Bay. Due to lack of information about the exact sites of kill, it was suggested that the Greenlandic catch from the KB group averaged 10 per year during the period 1993-1999, which included stragglers from KB that are shot in other parts of the municipality than the Kane Basin proper (Born 2002). Based on information from which settlements the reports came, the catch from KB was estimated for the period 2000–2004 by the Ministry for Fisheries (*in litt.* 2005) (Table 22). In the present report, the catch estimated for KB was subtracted from the total reported catch from the Qaanaaq municipality; the remainder was assumed to have been taken from the Baffin Bay population (Table 22).

During the last five years with complete reporting (1999–2003), an estimated average of 10 polar bears were taken by Greenlanders from the KB population (sd = 2.45, range: 6–12). The corresponding data for the last three years with full reporting (2001–2003) were: mean = 11, sd = 1.16, range 10–12 bears.

Baffin Bay: The catch reported from the region "Qaanaaq (minus Kane Basin, see above)-Sisimiut" is likely taken from the Baffin Bay population. In the five-year period 1999–2003 the catch reported in *"Piniarneq"* for this region averaged 115 bears per year (sd = 52.9; range: 68–206 bears; Table 22). During the last three years (2001–2003) an average of 137 bears/year has been taken in this region (sd = 60.0, range: 97–206 bear per year). The increase during 1993–2003 in the Greenlandic catch from the BB population was statistically significant ($r = 0.72$, $z = 2.57$, $p = 0.01$, $n = 11$) (see Figure 23).

Davis Strait: The polar bear catch north of Paamiut (*c.* 62°N; see Figure 22) can more or less arbitrarily be divided into a portion that may have been taken from the BB population and a portion that may have been taken from the DS population. Usually, the Davis Strait-Baffin Bay pack ice lies close to the Greenland coast north of about 67°N (Sisimiut) from fall to late spring. The boundary between the Canadian BB and DS management zones crosses the coast of Greenland at 66°30´N (e.g. Taylor *et al.* 2005). Therefore the catch of bears reported from the municipalities of Nuuk and Maniitsoq (i.e. between 62°N and 65°30´N at Maniitsoq) may represent the Greenlandic take of polar bears from the DS subpopulation (Table 22).

During the period 1999–2003, an average of one bear/year (sd = 0.84; range: 0–2 bears) has been reported from Nuuk and Maniitsoq (Table 22). For the last three years (2001–2003) an average of one bear was taken annually in this region (sd = 0.58, range: 1–2 bear per year). There was no significant trend in the annual catch during 1993–2003 (r = -0.16, z = -0.47, p = 0.64, n = 11).

SW Greenland and East Greenland: The polar bears that are caught in SW Greenland (*i.e.* south of Paamiut; see Figure 22) likely arrive in this area with the heavy pack ice (*stor is*; "big ice") coming around the southern tip of Greenland from the east coast. In SW Greenland the catch of polar bears peaks in the period March-June, when the *stor is* has its maximum extension. There is a stretch of several hundred kilometres of open water between the E Greenland pack ice along the coast south of Paamiut and the eastern edge of the DS pack ice. Contact between bears in SW Greenland and DS therefore appears highly unlikely.

During 1999–2003 the reported catch of polar bears in SW plus E Greenland averaged 70 bears/year (sd = 12.6, range: 56–84; Table 22). During the last three years (2001–2003) an average of 62 bears/year has been taken in this region (sd = 8.51, range: 56–72 bear per year). There was no significant trend in the annual catch during 1993–2003 (r = -0.52, z = 1.64, p = 0.10, n = 11).

Reasons for an increase in the Greenlandic catch from the Baffin Bay subpopulation

The Greenlandic catch of polar bears in Baffin Bay has increased significantly since 1993 and was particularly high during 2002–2004 (Table 22, Figure 23). There is no information as to whether the hunting effort has increased in this area (e.g. more hunters active or more bears being taken during the open water season). However, it cannot be precluded that some of the observed increase in reported catches stems from the fact that the *Piniarneq* system has become more efficient since its introduction (i.e. more hunters reporting).

However, since 2001 the sea ice cover in eastern Baffin Bay appears to have decreased (Figure 24, Area 12). A similar decrease has been observed in Davis Strait (Figure 24, Areas 13 and14), but not in western Baffin Bay (Figure 24, Area 15).

During recent years, the hunters of the Qanaaq and the Upernavik municipalities have noticed that the sea ice has formed later in the season and has become more unstable. Furthermore, there have been reports of an increased number of polar bears occurring on the coast and near the settlements. The marked increase in number of bears taken particularly in the Upernavik area (Table 22) may reflect that an increased number of polar bears have been forced on shore because of the decrease in sea ice.

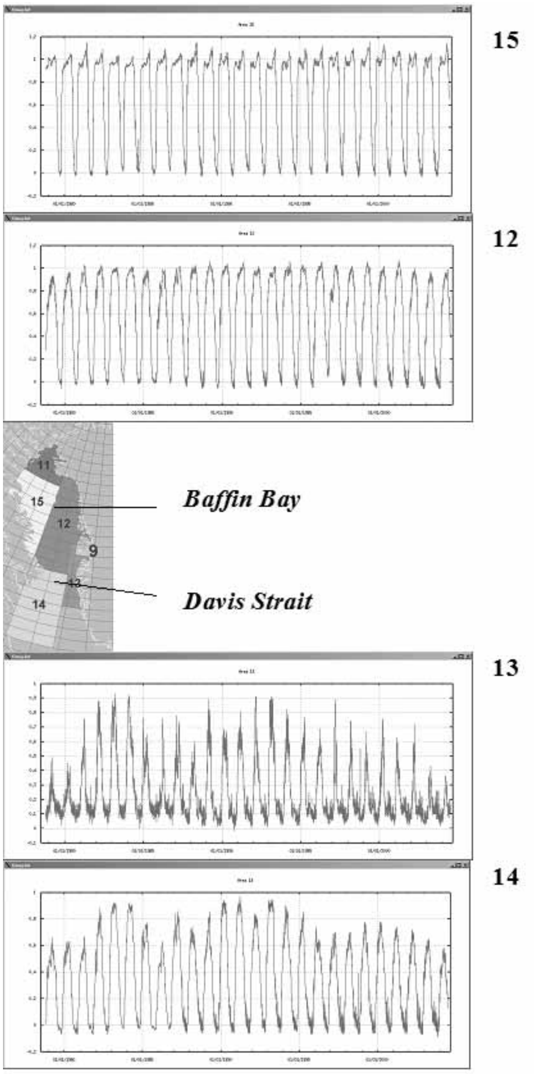
It is less likely that the catch reflects an increase in the size of the Baffin Bay subpopulation given the best population estimate available and the combined Canadian and Greenlandic harvest from this subpopulation during the last decade. Based on an extensive mark-recapture study, the estimate of mean abundance of the BB population for the years 1994–1997 was 2,074 (SE = 266) polar bears (Taylor *et al.* 2005). The potential annual growth rate of an *unharvested* polar bear population is estimated at *c.* 4% (Anon. 2004, Taylor *et al.* 2005). Sustainable catch is *c.* 1.5% of the total population of females older than 2 years and *c.* 3% of males older than two years (Anon. 2004). The catch during 1993–1997 of a total of 130 polar bears (*c.* 60 per year in Canada and *c.* 70 per year in Greenland) amounts to *c.* 6% of the point estimate of the size of the Baffin Bay subpopulation (and about 5% of the upper limit of the confidence interval of the population estimate leaving very little, if any, room for an increase of the population).

The combined Canadian and Greenlandic catch from Baffin Bay during 1999–2003 totalled 170–80 polar bears per year (Anon. 2004; this study).

The "Piniarneq" system

In Greenland, there are no quotas for the catch of polar bears and hence no administrative allocation of the catch to management areas or putative subpopulations. Since 1 January 1993, information about the catch has been obtained when the hunters, on a voluntary basis, report their catch via the *Piniarneq* system. The system is linked to the issuing of hunting licenses, of which two categories exist: one for full-time hunters and another for part-time hunters. Hunters in both categories have to pay a small fee for renewal of the license, at which time they

Figure 24. Annual ice cover index for various parts of the Baffin Bay-Davis Strait area, 1979–(2004 until Sep.). Whereas the sea ice in East Greenland has decreased during the last decades, the decrease in the Davis Strait (and eastern Baffin Bay) is more recent. Data for 1978–1987 from the NIMBUS-7 microwave-radiometer SMMR, and for later years from the DMSP (Defense Meteorological Satellite Program) micro-wave radiometer SSM/I (number 8,11 and 13).



Source: L. Toudal (Danish Center for Remote Sensing, Oersted*DTU, Technical University of Denmark).

are obliged to report their catches during the previous 12 months (i.e. from September to September). Only full-time hunters are allowed to hunt polar bears. In the summaries, the catch is reported by municipality and therefore in *Piniarneq* there are no records of the exact site of kill.

In *Piniarneq*, each hunter must report his own catch. However, according to Kapel and Rosing-Asvid (1996) some hunters are not used to paper work and may not see the point of keeping exact notes on the dates and numbers of animals taken. Whether this leads to an under-reporting, over-reporting, or just arbitrary reporting in order to meet requirements when renewing licenses is not clear (*Ibid.*). An example of sources of error is the report in 2004 of 24 and 10 polar bears reported for Sisimiut and Maniitsoq, respectively (Table 22). Some of these (10 and 5) were reported by hunters with a "part-time" hunting license and are suspected to be of muskoxen. This is currently being investigated by the Greenlandic Ministry of Fisheries (O. Heinrich *in litt.* 2005).

In the case of polar bears, often two or more hunters participate in the hunt, and therefore there may be instances where they all have reported a particular kill in the *Piniarneq* which would result in "over-reporting" or multiple reporting of the same bear kill. Whether or to what extent this happens has not been determined. Generally, the numbers reported in *Piniarneq* are higher than those reported in the previous system of recording catches (i.e. The Hunters Lists of Game, *cf.* Teilmann and Kapel 1998). This apparent difference may be caused by several factors: (1) previous information was incomplete and the estimates of non-reported catches too low, (2) the recent system overestimates the catch due to over-reporting, and (3) a real increase in the catch, or (4) a combination of two or all of these factors.

Rosing-Asvid (2002) compared information from various sources (trade in hide, information from sampling of biological tissues, *Piniarneq*) about the catch of polar bears in Greenland for the period 1993–1998. He found cases of under-reporting in *Piniarneq* in East Greenland and of over-reporting in central west Greenland (i.e. the Nuuk-Uummanaq area). Because of a good correlation between the number of ringed seal hides traded and the number of ringed seals reported in the Upernavik municipality, Rosing-Asvid (2002) concluded that generally the *Piniarneq* system works well in this area. In the *Piniarneq*, simple errors like ringed seals reported as walruses or polar bears occur. However, validation of the information is not a standard procedure and some over-reporting is found in most of the species where the annual catch is low (Rosing-Asvid 2002).

Another type of error may occur because the hunter does not have to report to *Piniarneq* where the polar bear was shot. The kill is assigned to the municipality in which the hunter lives and is therefore in some cases misplaced if the hunter has taken the bear in another area (Rosing-Asvid 2002).

In 2005, the Greenland Ministry of Fisheries and Hunting (GMFH, Nuuk) initiated the validation of polar bear catch figures reported for 2004 (M. Lillelund, GMFH, pers. comm. 15 June 2005).

References

Anon. 2004. Minutes of the 2004 meeting of the Federal-Provincial-Territorial Technical Committee for Polar Bear Research and Management, 15-17 February 2004, Winnipeg, Manitoba, Canada.

Arnason, U., Adegoke, J.A., Bodin, K., Born, E.W., Esa, Y.B., Gullberg, A., Nilsson, M., Short, R.V., Xu, X. and Janke, A. 2002. Mammalian mitogenomic relationships and the root of the eutherian tree. *Proc. Natl. Acad. Sci.* (USA) 99:8151–8156.

Born, E.W. 1999. The Greenland catch of polar bears from the Davis Strait, Baffin Bay and Kane Basin areas. Working paper to the Canadian Polar Bear Technical Committee meeting, 7–9 February 1999, Edmonton, Alberta, Canada.

Born, E.W. 2001. The Greenland catch of polar bears from the Davis Strait, Baffin Bay and Kane Basin areas, 1993–99. Working paper to the Canadian Polar Bear Technical Committee meeting, 4–5 February 2001, Edmonton, Alberta, Canada.

Born, E.W. 2002. Research on polar bears in Greenland 1997-2001. Pp. 67–74 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SCC Polar Bear Specialist Group, 23–28 June 2001, Nuuk, Greenland.* IUCN, Gland, Switzerland and Cambridge, UK.

Born, E.W. 2005. The catch of polar bears in Greenland, 1993–(2004). Working paper to the Canadian Polar Bear Technical Committee meeting, 7–9 February 2005, Edmonton, Alberta, Canada.

Bossi, R., Vorkamp, K., Riget, F.F., Dietz, R., Sonne, C. and Fauser, P. 2005. Perfluorinated surfactants in fish, mammals and birds from Greenland and Faroe Islands. Results from a preliminary screening. *Environ. Pollut.* 136:323–329.

Dietz, R., Riget, F.F., Sonne, C., Letcher, R.J., Born, E.W. and Muir D.C.G. 2004. Seasonal and temporal trends in polychlorinated biphenyls and organochlorine pesticides in East Greenland polar bears (*Ursus maritimus*), 1990–2001. *Sci. Total Environ.* 331:107–124.

Heier, A., Sonne, C., Gröne, A., Leifsson, P.S., Dietz, R., Born, E.W. and Bacciarini, L.N. [In press]. Liver RBP immunohistochemistry in free-ranging polar bears. An immunohistochemical study of retinol-binding protein (RBP) in livers of polar bears (*Ursus maritimus*) from East Greenland. *Zoo and Wild. Med.*

IUCN/SSC Polar Bear Specialist Group. 2002. Status of the polar bear. Pp. 21–35 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SCC Polar Bear Specialist Group, 23-28 June 2001, Nuuk, Greenland.* IUCN, Gland, Switzerland and Cambridge, UK.

Kapel, F.O. and Rosing-Asvid, A. 1996. Seal hunting statistics for Greenland 1993 and 1994, according to a new system of collecting information, compared to the previous Lists-of-Game. *NAFO Sci. Coun. Studies* 26:71–86.

Kirkegaard, M., Sonne, C., Leifsson, P.S., Dietz, R., Born, E.W., Letcher, R.J. and Muir, D.C.G. 2005. Histology of selected immunological organs in polar bear (*Ursus maritimus*) from East Greenland in relation to levels of organohalogenes. *Sci. Total Environ.* 341:119–132.

Rosing-Asvid, A. 2002. The polar bear hunt in Greenland. Greenland Institute of Natural Resources, Technical Report No. 45.

Rosing-Asvid, A., Born, E.W. and Kingsley, M.C.S. 2002. Age at sexual maturity of males and timing of the mating season of polar bears (*Ursus maritimus*) in Greenland. *Polar Biol.* 25:878–883.

Sandala, G.M., Sonne, C., Dietz, R., Muir, D.C.G., Valters, K., Bennett, E.R., Born, E.W. and Letcher, R.J. 2004. Hydroxylated and Methyl Sulfone PCB Metabolites in Adipose and Whole Blood of Polar Bear (*Ursus maritimus*) from East Greenland. *Sci. Total Environ.* 331:125–14.

Smithwick, M.S., de Silva, A., Muir, D.C.G., Mabury, S., Solomon, K., Sonne, C., Dietz, R. and Born, E.W. 2005a. Perfluorinated acids in heptatic tissue from East Greenland polar bears (*Ursus maritimus*) 1999–2001. *Environ. Toxicol. Chem.* 24:981–986.

Smithwick, M., Muir, D.C.G., Mabury, S.A., Solomon, K., Sonne, C., Martin, J.W., Born, E.W., Dietz, R., Derocher, A.E., Evans, T., Gabrielsen, G.W., Nagy, J., Stirling, I. and Taylor, M.K. 2005b. A circumpolar study of perfluoroalkyl contaminants in polar bear hepatic tissue (*Ursus maritimus). **Environ. Sci. Technol.*** 39:5517–5523.

Sonne, C. 2004. Organohalogen concentrations and a gross and histologic assessment of multiple organ systems in East Greenland polar bears (*Ursus maritimus*). Ph.D. thesis. National Environmental Research Institute, Roskilde, Denmark.

Sonne, C., Dietz, R., Born, E.W., Riget, F.F., Kirkegaard, M., Hyldstrup, L., Letcher, R.J. and Muir, D.C.G. 2004. Is bone mineral composition disrupted by organochlorines in East Greenland polar bears (*Ursus maritimus*)? *Environ. Health Perspect.* 112:1711–1716.

Sonne, C., Dietz, R., Leifsson, P.S., Born, E.W., Kirkegaard, M., Letcher, R.J., Muir, D.C.G., Riget, F.F. and Hyldstrup, L. [In press]. Environmental organohalogen contaminants as a co-factor in the development of renal lesions in East Greenland polar bears (*Ursus maritimus*). *Environ. Toxicol. Chem.*

Sonne, C., Dietz, R., Leifsson, P.S., Born, E.W., Letcher, R.J., Kirkegaard, M., Muir, D.C.G., Riget, F.F. and Hyldstrup, L. 2005a. Do organohalogen contaminants contribute to histopathology in liver from East Greenland polar bears (*Ursus maritimus*)? *Environ. Health Perspect.* 113:1569–1574.

Sonne, C., Leifsson, P.S., Dietz, R., Born, E.W., Letcher, R.J., Kirkegaard, M., Muir, D.C.G., Andersen, L.W., Riget, F.F. and Hyldstrup, L. 2005b. Enlarged clitoris in wild polar bears (*Ursus maritimus*) can be misdiagnosed as pseudohermaphroditism. *Sci. Total Environ.* 337:45–58.

Sonne, C., Riget, F.F., Dietz, R., Kirkegaard, M., Born, E.W., Letcher, R.J. and Muir, D.C.G.· 2005c. Trends in fluctuating asymmetry in East Greenland polar bears (*Ursus maritimus*) from 1892 to 2002 in relation to organohalogen pollution. *Sci. Total Environ.* 341:81–96.

Taylor, M.K., Akeeagok, S., Andriashek, D., Barbour, W., Born, E.W., Calvert, W., Cluff, D., Ferguson, S., Laake, J., Rosing-Asvid, A., Stirling, I. and Messier, F. 2001. Delineation of Canadian and Greenland polar bear (*Ursus maritimus)* populations by cluster analysis of movements. *Can. J. Zool.* 79:690–709.

Taylor, M.K., Laake, J., McLoughlin, P.D., Born, E.W., Cluff, H.D., Ferguson, S.H., Rosing-Asvid, A., Schweinsburg, R. and Messier, F. 2005. Demography and population viability of a hunted population of polar bears. *Arctic* 58:203–214.

Tielmann, J. and Kapel, F.O. 1998. Exploitation of ringed seals (*Phoca hispida*) in Greenland. *NAMMCO Sci. Publ.* 1:130–151.

Verreault, J., Muir, D.C.G., Norstrom, R.J., Stirling, I., Fisk, A.T., Gabrielsen, G.W., Derocher, A.E., Evans, T., Dietz, R., Sonne, C., Sandala, G.M., Gebbing, W., Riget, F.F., Born, E.W., Taylor, M.K., Nagy, J. and Letcher, R.J. 2005. Chlorinated hydrocarbon contaminants and metabolites in polar bears (*Ursus maritimus)* from Alaska, Canada, East Greenland, and Svalbard: 1996?2002. *Sci. Total Environ.* 351–352:369–390.

Wiig, Ø., Born, E.W. and Toudal Pedersen, L. 2003. Movement of female polar bears (*Ursus maritimus*) in the East Greenland pack ice. *Polar Biol.* 26:509–516.

Polar bear management and research in Norway 2001–2005

J. Aars, Norwegian Polar Institute, N-9296, Tromsø, Norway
A.E. Derocher, Department of Biological Sciences, University of Alberta, Edmonton, Canada
M. Andersen, Norwegian Polar Institute, N-9296, Tromsø, Norway
D. Vongraven, Norwegian Polar Institute, N-9296, Tromsø, Norway
M. Ekker, Directorate for Nature Management, N-7485, Trondheim, Norway
Ø. Wiig, Natural History Museum, University of Oslo, N-0318 Oslo, Norway

Management

Since the last meeting of the IUCN/SSC Polar Bear Specialist Group in Nuuk in 2001, several important issues have occurred that have possible repercussions for polar bears in the Barents Sea: development plans for oil and gas in the Barents Sea area that will pose potential threats to the polar bears in the region and several changes in protection of areas to protect habitat.

New legislation in Svalbard: Relevance to polar bears

The new Environmental Act passed by the Norwegian Parliament (Derocher *et al.* 2002b) came into force in July 2002.

This new legislation was meant to meet the high ambitions held by the authorities regarding protection and management of the natural and cultural resources of the Svalbard Archipelago. The new Environmental Act introduced the "mirroring" principle, which has been in force on the mainland for decades and ensures that all wildlife is protected, with exceptions made for hunting. The intentions behind the new legislation are described by Derocher *et al.* (2002b).

New regulations were developed under the new Act and came into force in June 2002. These included regulations on harvesting, on motorized traffic, on camps and camping, on mandatory leashing of dogs, on handling of environmental pollutants, and on environmental impact assessments in connection with planning around the settlements. Some regulations had special emphasis on protection of polar bears by enforcing temporal and spatial restrictions on motorized traffic, giving provisions on how and where to camp, and ensuring adequate security concerning polar bears in the area.

Protected areas in Svalbard

Six new protected areas were established on Svalbard in 2003: two nature reserves, three national parks and one "biotope protection area". The new protected areas are mostly located around Isfjord, the most populated fjord on the west side of the archipelago. Another protected area is Hopen, which has special importance for the protection of polar bears because it is one of the most important denning areas on Svalbard. Until 2003, Hopen had no special protection.

In 2004, marine protection was increased when the territorial borders of existing protected areas were increased to 12 nautical miles.

Currently, the protected areas of Svalbard cover 44,490km^2, which is 8% of the archipelago's total area and 65% of the total land area.

Tourism and local activities

Tourism is still one of the main commercial activities in Svalbard. In summer, the main activities are ship cruises and trekking. In winter, the main activities are snowmobile trips and ski trekking. Although in general, tourists and ships represent only minor disturbance for polar bears, there are ongoing processes within the tourist industry and the environmental management bodies that continue to work towards reducing impacts of tourism on wildlife.

Industrial development

The southern part of the Barents Sea was legally opened for oil and gas development in 1989. Although there has been some development in the southern ice-free part of the Barents Sea during the 1990s, this has not been on a very large scale. One large gas field, Snøhvit, is being developed

Table 23. Polar bears killed in Svalbard 2001–2005

Date	Place	Cause	Involved	Sex	Age	Bear's history
2001-Apr-26	Bjørnøya	SD	C	Male	7	recap
2001-Jul-02	Kapp Amsterdam, Sveagruva	PM	GO	Female	adult	new
2002-Jul-10	Eholmen, Bellsund	SD	T	Male	adult	recap
2002-Jul-16	Colesbukta	PM	GO	Female	7	recap
2002-Jul-16	Colesbukta	PM	GO	Male	1.5	new
2002-Jul-16	Colesbukta	PM	GO	Female	1.5	new
2002-Dec-07	Isbjørnhamna, Hornsund	SD	C	Male	subadult	new
2003-Feb-03	Austfjordneset	SD	C	Male	17	recap
2003-May-13	Adventdalen	PM	GO	Male	subadult	recap
2003-May-17	Mushamna	SD	C	Male	adult	new
2004-Feb-24	Vestpynten	SD	T	Female	subadult	new
2004-Apr-21	Van Keulenfjorden	Accident	S	Male	adult	recap
2004-May-10	Van Mijenfjorden	AM	GO	Male	0.5	new
2004-Jun-09	Fridtjofhamna	Prosecuted	T	Male	subadult	new
2004-Dec-30	Barentsburg	PM	GO	Male	subadult	new
2005-Mar-05	Kapp Lee, Edgeøya	SD	S	Male	adult	new

Source: County Governor of Svalbard, 2005
AM=act of mercy, C=station crew, GO=Governor's Office, PM=precautionary measure, S=scientist, SD=self defence, T=tourist

into a fully productive gas field. There are also a number of exploratory drilling activities occurring in the region.

Since 2002, environmental authorities have been carrying out environmental impact assessments in the Barents Sea. These impacts have been grouped into petroleum activities, fisheries, shipping, and external pressures (e.g., long-transport pollutants, climate change and introduced species). These assessment reports were finalized during winter-spring 2004/2005 and, together with additional reports on prioritized needs for new research and monitoring, will be synthesised into an integrated management plan for the entire Barents Sea during 2006. This plan will most likely be presented as a White Paper to the Norwegian Parliament. The intention is to merge all environmental, political and commercial needs, and other interests into a plan that will hopefully strike a balance between activities and, thus, the impacts, for the overall betterment of the environment.

Petroleum exploration is still prohibited in the northern part of the Barents Sea, north of Bjørnøya ("Bear Island", 74°30'N).

Polar bears killed in Svalbard 2001–2005

From 2001 through April 2005, a total of 16 polar bears were killed in Svalbard; one at Bear Island, one at Edgeøya and the rest at Spitsbergen (Table 23). All except three were killed in self defence or as a precautionary measure. The numbers shot during this period are similar to previous years (Figure 25).

Figure 25. The numbers of bears shot at Svalbard in defence of humans or property, 1972–2005.

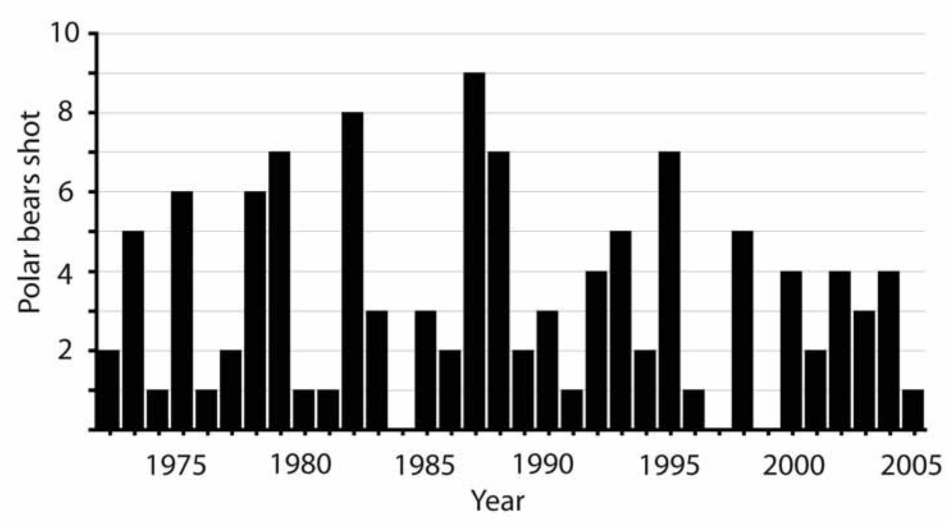


Table 24. CITES permits for import, export and re-export of polar bear skins and parts of skins in Norway, 2001–2004.

Year	Import	Export (all scientific samples)	Re-export (origin not reported)
2001	38 skins (22 from CA and 16 from GL) and 4 claws	4 x 10g fat to SE 100 teeth	9 skins to DK, CH, CN, SE, PL, NL, CA, RU (2)
2002	43 skins and 2 skulls (40 skins from CA, the rest from GL)	10 x 5ml blood/liver to UK 50 teeth to CA 50 ml blood to CA 50 ml fat to CA 270 teeth to CA 6 eyes to DE	8 skins and 425 skin pieces to SE (3 skins), CA (2 skins), FR, CZ, RU (2 skins)
2003	46 skins and 10 skulls (4 skins from Greenland, 1 illegally imported from Russia and the rest from Canada)	4 x 5ml blood to IT 150 teeth to CA 50ml blood to ES 200 teeth to DK	7 skins to AU, CA, DE, ES, SE, IT, DE (2)
2004	38 skins and 1 claw (37 skins from CA and the rest from GL)	11 x 5ml blood to UK 5g fat to DE 15g plasma to DE	11 skins to RU (3), NZ, ES (3), UK (2), DE, SE and 140 claws to GL

Canada = CA, Greenland = GL, Sweden = SE, Denmark = DK, Switzerland = CH; China = CN, Poland = PL, Netherland = NL, Russia = RU, United Kingdom = UK, Germany = DE, France = FR, Czech Republic = CZ, Italy = IT, Spain = ES, Australia = AU, New Zealand = NZ

Human casualties

There have been no human casualties in the period 2001–2005.

Use and trade of polar bear products

All trade in Norway is controlled by CITES permits administered by the Directorate for Nature Management.

Between 2001 and 2004 Norway exported 35 skins, 425 skin pieces and 140 claws (Table 24). All exports originating from Norway were scientific samples. During the same period, 165 skins, 12 skulls and five claws were imported. Of the 165 imported skins, 140 came from Canada, 24 from Greenland, and one came illegally from Russia.

Population status

Following protection in 1973 and in the absence of any hunting, the Barents Sea population has recovered to approximately 3,000 bears. Given the substantial harvesting that occurred between 1870 and 1970, this population was either considerably larger or experienced significant immigration from neighbouring populations. Although the population trend is unknown, after more than 30 years of protection, it may only be slowly increasing because population growth may be affected by high levels of pollutants (Derocher *et al.* 2003, Derocher 2005).

Population delineation

On Svalbard, some bears stay on the islands or nearby surrounding areas all year whereas others roam over large areas eastwards to Franz Josef Land or north of the ice edge in the Barents Sea (Mauritzen *et al.* 2002). When the ice is at maximal extent, bears from this population are also found down on the west coast of Novaya Zemlya. Although the Barents Sea seems to be a natural population unit, limited exchange with individuals from the Kara Sea population to the east and the East Greenland population to the west has been confirmed by low genetic differentiation (Paetkau *et al.* 1999).

Environmental concerns

There is still concern that the high levels of pollutants may be inhibiting population growth. Oil development and increased tourism are other environmental concerns. However, climate change represents the largest threat to polar bears, especially if the projections of climate models come true. Models run at the Nansen Environmental and Remote Sensing Centre in Bergen have shown an almost ice-free Polar Basin in the summertime at the end of this century (Bobylev *et al.* 2003).

Harvest

There is no harvest of polar bears in Norwegian territories because they are a protected species in Norway. However, there are issues with respect to neighbouring populations; specifically, a possible illegal harvest in northwest Russia and an over-harvest in Greenland.

Research

Movement

Polar bear research in Norway is lead by the Norwegian Polar Institute. In 2002, M. Mauritzen completed her PhD dissertation that examined the movements of adult female polar bears using satellite telemetry data from 137 radio collars and 125 different bears (Mauritzen 2002). Since 2002, high resolution GPS collars have been used that provide more detailed habitat use and movement pattern data than earlier collars, with up to six different locations per day. Twenty GPS collars were deployed. Data from these bears are currently being used in analyses of movement and time use relative to occurrence of local ice types and ice coverage under the Project "Seals, Bears and Ice". In 2005, another 10 satellite collars were deployed with the objective of monitoring the amount of time that mothers spend in or use water. The collars have a saltwater switch and give exact time budgets on land and in water. The main purpose is to link these data to climate to determine how vulnerable mothers with dependent young will be to rapid changes in sea ice conditions that might result in challenges for mothers moving between land and sea ice hunting habitat in a changing environment. Also, data on the time bears spend in water will be important for examining their vulnerability to an oil spill. A depth recorder also provides information on diving behaviour.

Population dynamics and reproductive rates

Mark and recapture methods have been applied in the Norwegian Arctic to determine basic demographic rates. Since 1967, 1,203 different bears have been marked and have provided 267 recaptures. Eighty percent of the captures were conducted between 1990 and 2004 with an average of 65 captures per year. Data on demographic rates from the period 1988–1993 are available in Wiig (1998) and for temporal patterns during the same period in Derocher (2005). Lack of funding, inaccessibility of the study area, and difficult access and logistics in the Russian areas preclude adequate sampling of the whole population.

Denning areas and denning ecology

A GIS database of all maternity dens with observed locations (n=471) in the Svalbard area, from 1972 to the present, has been established. In one of the denning areas, the island Hopen (SE Svalbard), there is a strong negative correlation between the number of dens and the date of sea ice arrival in the autumn (Derocher *et al.* in prep), which suggests that a warmer climate may pose a significant threat to potential population growth of the Barents Sea population (Derocher *et al.* in prep).

Diet

Based on 135 opportunistic observations of kills in the Svalbard and Western Barents Sea area, Derocher *et al.* (2002a) found ringed seals (63%), bearded seals (13%), and harp seals (8%) to be the most important prey in terms of numbers, but bearded seals (55%) to be the most important prey by weight. It is likely that this study might underestimate the importance of harp seals as prey, due to the opportunistic sampling. Telemetry studies on both bears and seals could provide further insight into the relative importance of the different prey species.

The use of fatty acid (FA) signature analyses has been proposed as a new method to determine the diet of polar bears. Grahl-Nielsen *et al.* (2003) compared the composition of FA in polar bears with the composition of FAs in their assumed prey species. It was concluded that polar bear adipose tissue has a unique FA composition that is not a straightforward mixture of what they consume. This view has generated some debate.

Aerial surveys

A large study on the size of the Barents Sea polar bear population was conducted in the area between Svalbard and Franz Josef Land and along the ice edge to the north in August 2004. This study is described in detail elsewhere in this volume. The main result was that were approximately 3,000 (CI 2,299–4,116) polar bears in the Barents Sea area. This was a co-operative project between polar bear scientists at the Norwegian Polar Institute and VNII Priroda in Russia, and the University of Oslo, Norway, and statistical expertise at the University of St. Andrews in Scotland.

Ecotoxicology

Ecotoxicology research on polar bears in the Norwegian Arctic is a priority activity. Ecotoxicology research has been co-ordinated by the Norwegian Polar Institute in co-operation with the University of Oslo, the Norwegian Veterinary Institute and the Norwegian School of Veterinary Science. The scope of these investigations is wide ranging with the central theme of monitoring trends and assessing potential impacts. Samples from Svalbard were also sent to the Natural Water Research Institute, Canada, for scanning of a range of toxic components in a wide all-arctic international study in 2004. Several papers from this study are in prep or in press, and give a more up-to-date picture of pollutants in polar bears in Svalbard and how these bears compare with other arctic populations.

In August 2004, E. Lie, Norwegian School of Veterinary Science, completed her Ph.D. that looked at organochlorine (OC) contaminants in polar bears (Lie 2004). She studied the geographic patterns of levels in bears from Svalbard, Russia and Alaska, and found that the levels were especially high in bears from Franz Josef Land and the Kara Sea (Andersen *et al.* 2001, Lie *et al.* 2003). She further studied the immunotoxic effects of the contaminants and infection resistance. Her findings showed that following immunization with different agents the ability to produce protective antibodies was impaired in the bears with the highest levels of OCs (Lie *et al.* 2004). She also found a decreased *in vitro* mitogen and antigen induced lymphocyte proliferation in bears with the highest OC levels that were associated with impaired ability to produce antibodies (Lie *et al.* 2005). These immunotoxic studies were done in cooperation between Canadian and Norwegian scientists and involved field studies in Canada.

I. Oskam completed her Ph.D. at the Norwegian School of Veterinary Science in October 2004. She examined the effects of OCs on mammalian reproductive and endocrine system by comparing results from field studies of polar bears and laboratory studies on goats and mice (Oskam 2004). The results revealed a significant negative relationship between OC levels and plasma testosterone concentrations in male polar bears (Oskam *et al.* 2003). Furthermore it was found that the overall contribution of OCs to the variation in plasma cortisol was negative for both sexes of bears (Oskam *et al.* 2004). By comparing the field studies with the laboratory studies, she concluded that the timing of exposure was more important than the total doses of PCBs. Possible detrimental effects on the reproductive system, caused during fetal life, may have irreversible damaging effects on the reproductive function during adult life.

G. Olsen completed a Master's at the University of Science and Technology, Trondheim that found a positive effect between home range size and PCB levels in female polar bears (Olsen *et al.* 2003). It was thought to be related to a higher food intake due to higher energy requirements in bears that have larger home ranges. It could also be related to different prey choice related to the pelagic space use strategy.

Based on blood samples collected in 1967 and 1993–1994 at Svalbard, we investigated changes in contaminant levels during this 25-year period (Derocher *et al.* 2003). The increase in levels of different congeners was generally higher in females than in males. The maximum change was a nine-fold increase in PCB 153 in females. The impacts of contaminants on the Svalbard polar bear population were discussed. There are suggestions of contaminant-related population level effects that could have resulted from reproductive impairment of females, lower survival rates of cubs, or increased mortality of reproductive females.

Disease and parasites

Disease and parasite surveys have been conducted by the Norwegian Polar Institute in co-operation with the Department of Arctic Veterinary Medicine, the Norwegian School of Veterinary Science, Tromsø, Norway. A scanning of plasma biochemical values from 35 healthy bears in Svalbard was done to provide baseline values for future studies of polar bear health (Tryland *et al.* 2002). A serologic screening for selected virus infections in polar bears at Svalbard showed that polar bears in this region have been exposed to morbillivirus and calicivirus Tryland *et al.* (In press). While these viruses are potential pathogens in seals, their effect with respect to health of polar bears is currently unknown.

Behavioural response to snowmobiles

In 2004 and 2005, a study on how polar bears reacted to approaching snowmobiles was conducted. The conclusion was that polar bears frequently reacted (reaction was defined as walking or running away as a response to the snowmobiles) at long distances (average = 843m, range = 112–3,272m, n = 20). The distance of response was largest for females with cubs (average = 1,534m, range 307–2,644m, n = 4). Details are published in Andersen and Aars (2005).

Priorities for polar bear research in Norway

In 1996, the Norwegian National Committee on Polar Research, The Research Council of Norway, identified the need to increase and improve the co-ordination of the Norwegian efforts in polar bear research. A working group was therefore appointed in 1999, which commenced its work in 2000.Two documents had recently given a detailed account of research activities and the status of knowledge (Wiig *et al.* 2000) and reviewed the need for research and management actions (Vongraven 2001) of polar bears in Norway. The working group was therefore asked to provide a short report that identified the most important research issues that required attention.

The working group identified the following priorities for Norwegian polar bear research (Wiig *et al.* 2001):

- **Population delineation:** Movement studies of bears in the Greenland Sea and Arctic Ocean.
- **Population size:** Estimate the total population size.
- **Population demographics:** Determine age specific reproductive rates. Identify when (in the season) the cubs die. Determine the reason for and apparent skewed age distribution of females (few females older than 15 years of age in samples).
- **Energetics:** Identify polar bear choice of prey. Determine daily and seasonal changes in activity patterns.
- **Anthropogenic threats:** Study endocrine disruption in females and males. Survey the population for new toxic compounds. Create a predictive model that links polar bear distribution and habitat use with potential oil spill impact regimes. Assess population level effects of climate change, toxic chemicals, oil development, tourism, and harvest.
- **Ecosystem modelling:** Develop an ecosystem model focusing on polar bears in their habitat.
- **Monitoring parameters:** population size, population spatial distribution, life history parameters, pollution levels, diseases, develop new cost-effective monitoring methods.

References

Andersen, M. and Aars, J. 2005. Behavioural response of polar bears to disturbance by snowmobiles. Brief Report Series, Norsk Polarinstitutt, Tromsø, Norway.

Andersen, M., Lie, E., Derocher, A.E., Belikov, S.E., Bernhoft, A., Boltunov, A., Garner, G.W., Skaare, J.U. and Wiig, Ø. 2001. Geographic variation of PCB congeners in polar bears (*Ursus maritimus*) from Svalbard east to the Chukchi Sea. *Polar Biol.* 24:231–238.

Bobylev, L., Kondratyev, K.Y. and Johannessen, O.M. 2003. *Arctic Environment Variability in the Context of Global Change*. Springer-Praxis Books in environmental sciences, Springer-Praxis Publishing, Chichester, UK.

Derocher, A.E. 2005. Population ecology of polar bears at Svalbard, Norway. *Popul. Ecol.* **47**:267–275.

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

Derocher, A.E., Wiig, Ø., Andersen, M., Vongraven, D. and Ekker, M. 2002b. Polar bear research and management in Norway 1997-2000. Pp. 75-84 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SCC Polar Bear Specialist Group, 23-28 June 2001, Nuuk, Greenland.* IUCN, Gland, Switzerland and Cambridge, UK.

Derocher, A.E., Wolkers, H., Colborn, T., Larsen, T.S., Schlabach, M. and Wiig, Ø. 2003. Contaminant in Svalbard polar bears samples archived since 1967 and possible population effects. *Sci. Total Environ.* **301**:163–174.

Grahl-Nielsen, O., Andersen, M., Derocher, A.E., Lydersen, C., Wiig, Ø. and Kovacs, K.M. 2003. Fatty acid composition of the adipose tissue of polar bears and their prey: ringed seals, bearded seals and harp seals. *Mar. Ecol. Prog. Ser.* **265**:275–282.

Lie, E. 2004. Organochlorine contaminants in polar bears (*Ursus maritimus*). Geographical trends and possible immunotoxic effects. Ph.D. thesis, Norwegian School of Veterinary Science, Oslo.

Lie, E., Bernhoft, A., Riget, F., Belikov, S.E., Boltunov, A.N., Derocher, A.E., Garner, G.W., Wiig, Ø. and Skaare, J.U. 2003. Geographical distribution of organochlorine pesticides (OCPs) in polar bears (*Ursus maritimus*) in the Norwegian and Russian Arctic. *Sci. Total Environ.* **306**:159–170.

Lie, E., Larsen, H.J.S., Larsen, S., Johansen, G.M., Derocher, A.E., Lunn, N.J., Norstrom, R.J., Wiig, Ø. and Skaare, J.U. 2004. Does high OC exposure impair the resistance to infection in polar bears (*Ursus maritimus*)? Part I: Effect of OCs on the humural immunity. *J. Toxicol. Environ. Health A* **67**:555–582.

Lie, E., Larsen, H.J.S., Larsen, S., Johansen, G.M., Derocher, A.E., Lunn, N.J., Norstrom, R.J., Wiig, Ø. and Skaare, J.U. 2005. Does high organochlorine (OC) exposure impair the resistance to infection in polar bears (*Ursus maritimus*)? Part II: Possible effect of OCs on mitogen- and antigen-induced lymphocyte proliferation. *J. Toxicol. Environ. Health A* **68**:457–484.

Mauritzen, M. 2002. Pattern and processes in female polar bear space-use. Dr. Sci. thesis, University of Oslo.

Mauritzen, M., Derocher, A.E., Wiig, Ø., Belikov, S.E., Boltunov, A.N., Hansen, E. and Garner, G.W. 2002. Using satellite telemetry to define spatial population structure in polar bears in the Norwegian and western Russian Arctic. *J. Appl. Ecol.* **39**:79–90.

Olsen, G.H., Mauritzen, M., Derocher, A.E., Sørmo, E.G., Skaare, J.U., Wiig, Ø. and Jenssen, B.M. 2003. Space-use strategy is an important determinant of PCB concentrations in female polar bears in the Barents Sea. *Environmental Science and Technology* **37**:4919–4924.

Oskam, I.C. 2004. Effects of organochlorine contaminants on mammalian reproductive and endocrine systems. Ph.D. thesis, Norwegian School of Veterinary Science, Oslo.

Oskam, I., Ropstad, E., Lie, E., Derocher, A.E., Wiig, Ø., Dahl, E., Larsen, S. and Skaare, J.U. 2004. Organochlorines affect the steroid hormone cortisol in polar bears (*Ursus maritimus*) at Svalbard, Norway. *J. Toxicol. Environ. Health A* **67**:959–977.

Oskam, I., Ropstad, E., Lie, E., Derocher, A.E., Wiig, Ø., Dahl, E., Larsen, S., Wiger, R. and Skaare, J.U. 2003. Organochlorines affect the major androgenic hormone, testosterone, in male polar bears (*Ursus maritimus*) at Svalbard. *J. Toxicol. Environ. Health A* **66**:2119–2139.

Paetkau, D., Amstrup, S.C., Born, E.W., Calvert, W., Derocher, A.E., Garner, G.W., Messier, F., Stirling, I., Taylor, M.K., Wiig, Ø. and Strobeck, C. 1999. Genetic structure of the world's polar bear populations. *Mol. Ecol.* **8**:1571–1584.

Tryland, M., Brun, E., Derocher, E.W., Arnemo, J.M., Kierulf, P., Ølberg, R. and Wiig, Ø. 2002. Plasma chemistry in free-ranging polar bears from Svalbard. *J. Wildl. Dis.* **38**:566–575.

Tryland, M., Neuvonen, E., Huovilainen, A., Tapiovaara, H., Osterhaus, A., Wiig, Ø. and Derocher, A.E. [In press]. A serologic screening for selected virus infections in polar bears at Svalbard. *J. Wildl. Dis.*

Vongraven, D. 2001. Forslag til framtidige prioriteringer innen overvåking og forskning på isbjørn (in Norwegian). Internal Report, Norwegian Polar Institute, Tromsø, Norway.

Wiig, Ø. 1998. Survival and reproductive rates for polar bears at Svalbard. *Ursus* **10**:25–72.

Wiig, Ø., Blix, A.S., Derocher, A.E., Kovacs, K. and Schweder, T. 2001. National priorities for polar bear research in Norway. Report to the Norwegian National Committee on Polar Research, The Research Council of Norway, Oslo.

Wiig, Ø., Derocher, A.E., Gjertz, I. and Scheie, J.O. 2000. Kunnskapsstatus for isbjørn ved Svalbard, og framtidige behov for kartlegging, overvåkning og forskning. (Status of information on polar bears of Svalbard with requirements for future mapping, monitoring, and research). Norsk Polarinst. Medd. **160**, (in Norwegian).

Polar bear management and research in Russia 2001–2004

S.E. Belikov, All-Russian Research Institute for Nature Protection, Moscow, Russia
A.N. Boltunov, All-Russian Research Institute for Nature Protection, Moscow, Russia
N.G. Ovsianikov, Wrangel Island State Nature Reserve, Russia
G.I. Belchanskiy, Institute of Problems of Ecology and Evolution, Moscow, Russia
A.A. Kochnev, Chukotka Branch of the Pacific Research Fishery Center, Anadyr, Russia

Management

Legislative basis for protection and management of polar bear subpopulations

The polar bear is listed in the Red Data Book of the Russian Federation (2001). The subpopulation in the Barents Sea and part of the Kara Sea (Barents Sea subpopulation) is designated Category IV (uncertain status taxa and populations); the subpopulation of the eastern Kara Sea, Laptev Sea and the western East-Siberian Sea (Laptev subpopulation) – Category III (rare taxa and populations); the subpopulation inhabiting the eastern part of the East-Siberian Sea, Chukchi Sea, and the northern portion of the Bering Sea (Chukchi (Alaska-Chukotka) subpopulation) – Category V (recovering taxa and populations). The Red Data Book is an official document that contains information about rare and endangered species of animals and plants, and describes measures for protecting and rehabilitating these species.

Federal and regional laws and statutory acts dealing with rare and endangered species form the legislative basis for polar bear management in Russia. For the Chukchi Sea polar bear subpopulation, the "Agreement between the Government of the United States of America and the Government of the Russian Federation on the conservation and management of the Alaska-Chukotka polar bear population" signed on the 16th of October 2000 in Washington, DC is a major part of this legislative basis.

On March 10, 2005, the Government of the Russian Federation adopted a Decree concerning this Agreement which states that the Ministry of Natural Resources of the Russian Federation is responsible for fulfilling the obligations of the Russian Federation invoked by the Agreement. In 2003–2004, the Ministry of Natural Resources of the Russian Federation initiated work on a statutory act to regulate the hunting and use of polar bears in the Chukotka area. In 2004, the draft document was discussed with native hunters and representatives of local authorities in Lorino and Lavrentiya settlements (Chukotskiy District, Chukotskiy Autonomous Okrug). The draft document was modified based on the results of these discussions. In spring 2005, the revised draft document was distributed among hunters in Vankarem village (Iultinskiy District, Chukotskiy Autonomous Okrug). Meetings with native hunters in Chukotka villages were supported by World Wildlife Fund (WWF).

Natural Protected Areas

Polar bears are protected in Natural Protected Areas (NPA) that cover the range of the species. The NPAs are represented by State Nature Reserves (*Zapovedniks*), Refuges (*Zakazniks*) and Natural parks. The protection level and regime are defined by corresponding laws and statutory acts and by regulations of each NPA. Absolute protection of the species is provided in State Nature Reserves: "Wrangel Island", "Ust-Lenskiy", "Bolshoy Arkticheskiy", "Gydanskiy" and "Nenetskiy". In NPAs of other types, there are prohibitions on industrial and other kinds of economic activity causing threat to polar bears.

Use of polar bears

Polar bear hunting has been totally prohibited in the Russian Arctic since 1956. In the last half century, the only permitted take of polar bears has been limited to catching cubs for public entertainment and education (zoos and circuses). Cubs were last removed from the wild in spring 2001 when six cubs-of-the-year were caught in the Kara Sea. In some years, zoos adopt 1–2 orphan cubs. Polar bears are occasionally killed to protect people.

Poaching

Some illegal take of polar bears occurs in different parts of the Russian Arctic with the most problematic area in north-east Russia (Chukotka). Polar bear poaching has increased there in the late 20th century and beginning of the 21st century. Although the number of illegally killed bears is unknown, the level of poaching is high enough to pose a serious threat to the population. Federal and regional authorities have undertaken measures to reduce polar bear poaching but the measures have had limited success.

Research

Russian-Norwegian survey of polar bears in the Barents Sea

In August 2004, polar bears were surveyed in the northern part of the Barents Sea including areas of Svalbard and Franz-Josef Land. The work was conducted under the Russian-Norwegian scientific and technical co-operation in the area of Arctic and North Research between the Ministry of Science and Technologies of the Russian Federation and the Norwegian ministry of Environment. A transect survey was performed using a helicopter based on the research vessel "RV Lance" of the Norwegian Polar Institute. The Norwegian Polar Institute, All-Russian Research Institute, Zoological Museum of the Oslo University and Centre for Environmental Research of St. Andrews University (Scotland, UK) participated in the design and implementation of the survey.

Assessing arctic sea-ice habitat in conditions of global change based on multi-sensor satellite monitoring and biotelemetry data

The research was conducted within the framework of the Area V U.S./Russia Environmental Agreement (project 02.05-7105 "Applications of Contemporary Technologies in Ecological Studies of Large Mammals"). Participants were the Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia and USGS Alaska Science Center, Alaska Biology and Geography Sciences, Juneau, AK, USA. The research included:

1. Investigating variability in the distribution, age structure and thickness of the arctic perennial sea ice based on analysis of the SMMR/SSM/I and Okean/Radarsat satellite data (1979–2005);
2. Investigation of mechanisms associated with fluctuations of the arctic perennial sea ice using SMM/R/SSM/I passive microwave and Okean/Radarsat active microwave satellite data (1979–2005), NSIDC ice motion data and IABP SAT;
3. Investigation of the mechanisms responsible for recent changes in sea ice extent, structure of perennial ice age and thickness, and improving our ability to predict future conditions;
4. Studying interannual variability of sea ice parameters in the Beaufort and Chukchi Seas and their influence on polar bear distribution in conditions of global climate change.

New methods of multiyear sea ice mapping and estimating using artificial neural networks (ANN) were developed. The methods use microwave satellite data and different ANN learning algorithms. The subject of studies included seasonal, interannual and regional variability of sea ice habitats and its relationship with melt duration. Negative linear trends of multiyear sea ice area (1979-2004) were found in the Arctic Ocean and adjacent seas. The methods for estimating arctic sea ice age and thickness and their distribution were studied over 1989–2004. Absolute ice thickness increased during 1979–89 and then significantly decreased. Regional and interannual dynamics of melt season on sea ice and snow cover during 1979–2004 was estimated. The cluster analysis identified five subpopulations inhabiting the Barents, Kara and Laptev seas. The analysis of habitat selection models has shown sophisticated habitat use and its dependence on several factors (shallow waters with different sea ice types and concentrations, ice development stages, floe sizes, among others). The results suggest that using seasonal models allows prediction of polar bear distribution based on sea ice and bathymetry data. Habitat types corresponded to the most probable seal pupping locations during spring. The feasibility of habitat use was analysed basing on movement autocorrelation over one year. Polar bear female movements were annular and annual home range size changed depending on reproductive status and geographic location. Different habitat use strategies were caused by the amount of food and sea ice dynamics. Selection function values show that polar bear locations fall into maximum value areas during spring and winter.

Current polar bear research on Wrangel Island

Current polar bear research on Wrangel Island is focused on monitoring number, demographic composition, physical status, distribution and activity of bears landing at the Island during late summer-autumn. The main methodology of this research/monitoring is based on a combination of stationary observations at permanent plots – two sites of regular walrus haul out activity, one at Cape Blossom and the other at Doubtful Spit – and regular surveys along the coast and inland of the island.

The basic scheme of autumn polar bear research varies depending on the current ice situation in the surrounding sea, which, in its turn, determines polar bear activity on the Island. In sea ice-free seasons around the Island, when polar bears gather in numbers at the plots and most of the stranded bears eventually visit these sites, stationary observations are the primary method. In seasons when the ice does not recede far north and variable ice activity is recorded in coastal waters during the entire season, priority is given to route surveys because bears in such years are distributed widely and the majority of them do not come to the plots. This approach seems effective in recording as many polar bears as possible during the season. In 2004, for instance, a total of 1,746km was surveyed and when combined with data obtained through the stationary observations, 261 bear sightings were recorded. The following data was recorded for each bear observed – date/time, place, social unit (lone, family group, alliance), age category, sex (when possible), physical condition, and activity. In additional, occasional polar bear observations were provided by the reserve's staff researchers, and rangers from other places. Additional observations during summer, conducted during surveys for other research projects, provided additional information on bears visiting the Island.

Polar bear research in Chukotka

In 2001–04, the Chukotka branch of the Pacific Research Fishery Center (ChukotTINRO) continued work on regular autumn observations of polar bears at their aggregations on Wrangel Island (1990–98). A computer database was developed for data storage and analysis including data on daily counts of polar bears, age and sex of observed animals and litter sizes. At present the database has 1,540 records. An independent database contains 137 records on polar bear sightings in 1978–98 when there were no regular observations or surveys.

In 2003, the project "Traditional knowledge of native people of Chukotka about polar bears and their habitats" was completed. The project was initiated in 1999 by the Chukotka Association of Traditional Marine Hunters (ChAZTO) in cooperation with the Alaska Nanuuq Commission. Scientific support was provided by ChukotTINRO. The project was financed by U.S. National Park Service. The main purpose of the project was to collect information about location of polar bear dens, feeding grounds, and seasonal movements of polar bears in Chukotka. Data were collected from 53 interviews (hunters, reindeer keepers and elders) from 20 national villages.

In 2004, ChAZTO in cooperation with the Alaska "Nanuuq" Commission and participation of the ChukotTINRO and Museum Center "Chukotka Heritage" started another project dealing with traditional knowledge of native people of Chukotka. The three-year project "The polar bear in material and spiritual culture of Chukotka native people" is financed by the US National Park Service. The purpose of the project is to evaluate the effects caused by the long ban on polar bear hunting (since 1956) on traditions, culture and mentality of native people. The project will also collect information about the place of the polar bear in material and spiritual culture. The information is meant to be taken from ethnographic publications, handicrafts, folklore and the traditional knowledge of native people. The questions for interviews cover traditional ways of polar bear hunting and use, methods for avoiding conflicts with polar bears, and ceremonies and customs related to the species. Information obtained during the project was used for expert estimation of the level of illegal take of polar bears in Chukotka.

In 2003, ChukotTINRO conducted new observations of autumn aggregations of polar bears on the Chukchi Sea coast (Arctic Expedition of the ChukotTINRO). From mid June to the beginning of September, several survey routes were conducted by motorboat. Routes covered coastal areas from Cape Vankarem to Belyaka Spit including complete inspection of Kolyuchinskaya Inlet. From mid August to mid September, observations were performed on Kolyuchin Island where comparatively considerable number of polar bears (24 animals) stayed after the sea ice disappeared. Data on number dynamics, age and sex of the animals, their behaviour, and information concerning illegal polar bear hunting in the area of the Island were collected. Special attention was paid to interactions of polar bears and walruses. Observations were continued in 2004 but due to ice conditions in the summer and autumn, there were no polar bears on the island until November when ice formation started.

Research on polar bear autumn aggregations on Chukotka, 1989–2004

A.A. Kochnev, Pacific Research Fisheries Center (TINRO), Chukotka Branch, Box 29, Otke 56, 689000, Anadyr, Russian Federation

This report includes results of investigations on polar bear aggregations that formed on islands and the continental coast in the western part of the Chukchi Sea during autumn. Fieldwork was conducted on Wrangel and Herald islands in 1989–98 and on the arctic continental coast of Chukotka in 2002–04 (Figure 26). Data were collected from a motor boat and by direct observation in key areas inhabited by bears. Some additional information was obtained from the archives of the National Wrangel Island Reserve and from discussions with hunters from Chukotka coastal villages.

Wrangel Island

Visual surveys were conducted from August to November in two areas – on Blossom Cape and on the Somnitel'naya Spit (Figure 27). Polar bears were observed from a 12m high navigation watchtower close to the areas with the highest density of bears. From August to early October, surveys were conducted two times a day (in the morning and in the evening). As the day length shortened (usually after October 10), polar bears were observed once per day. Binoculars (12x40) were used to count all animals. Field of view varied with weather conditions reaching a maximum of 6km under ideal conditions. Each bear's activity (resting, feeding, moving, interacting) was documented along with the location of the animal (feeding grounds, snowdrifts, young ice, hummocks, etc.), sex, and relative age (adult, subadult) when possible using phenotypic characteristics and behaviour. When a family group was observed, the number and age of offspring was determined. The distribution of bears on the coast

Figure 26. Map of Chukotka with the various study areas (1 – 1989–98; 2 – 2002; 3 – 2003–04).

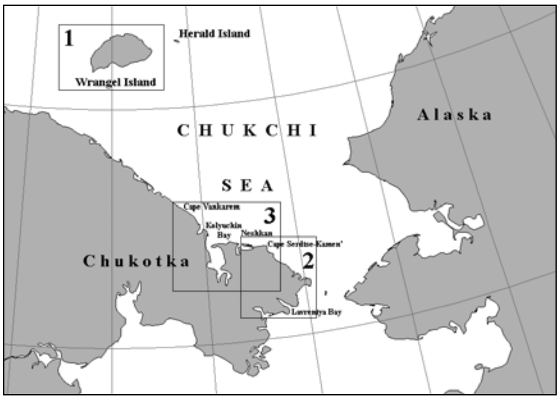


Figure 27. Study area on Wrangel Island, 1989–98.

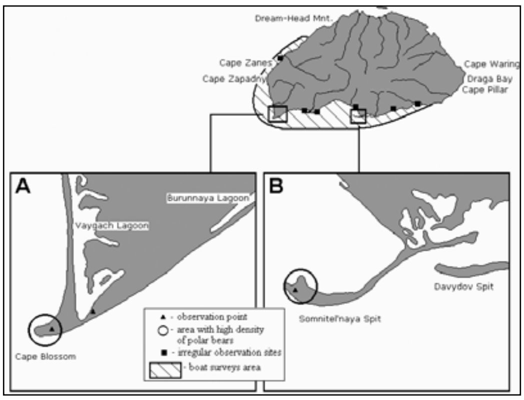


Figure 28. Ice edge positions with maximum open water in summer and autumn in the Wrangel Island area, 1989–1998 (the year is shown near the ice edge line; below the year is the number of Polar Bears in aggregations determined when the ice was in this position; the maximum number of Polar Bears in aggregations, observed during the whole season, is given in brackets).

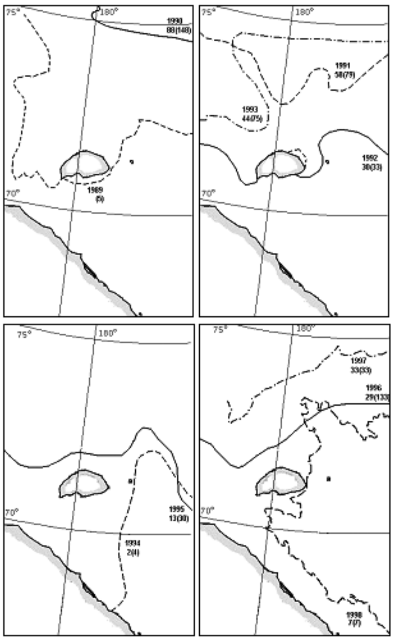
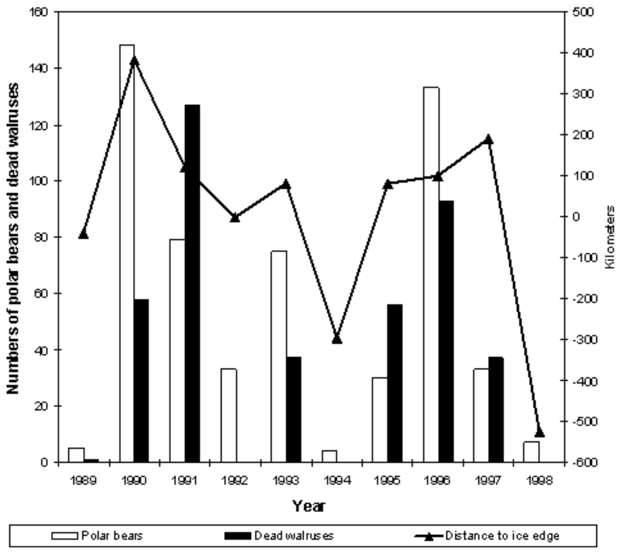


Table 25. Abundance of food available to polar bears on walrus haul-out sites on Wrangel Island, autumn 1989–1998 (combined data for Blossom Cape and the Somnitel'naya Spit)

Year	Number of Polar Bears	Number of polar bears before freeze-up	Number of walrus carcasses	Biomass, tons	Food/polar bear before freeze-up, tons	Quantity of food per polar bear (from the total numbers), tons
1989	5		1	0.54		0.108
1990	148	148	58	17.03	0.115	0.115
1991	79	79	127	44.77	0.567	0.567
1992	33		0	0		0.000
1993	75	75	37	14.98	0.200	0.200
1994	4		0	0		0.000
1995	30	13	56	19.89	1.530	0.663
1996	133	44	93	37.3	0.848	0.280
1997	33	31	37	8.19	0.264	0.248
1998	7		0	0		0.000
M_1	54.7		40.9	14.27		0.261
M_2	83	65	68	23.69	0.587	0.346

Key: M_1 – mean for the whole observation period, M_2 – mean for years in which walruses hauled out.

Figure 29. The number of polar bears in autumn aggregations on Wrangel Island, 1978–1998.



was observed during trips by boat and by land: occasional observations in other parts of the island were also used. The total sample combines data from 1989–98 and includes 549 days of counts and 8,580km of surveying. The sample includes observations from research assistants at the Wrangel Island State Reserve (116 days).

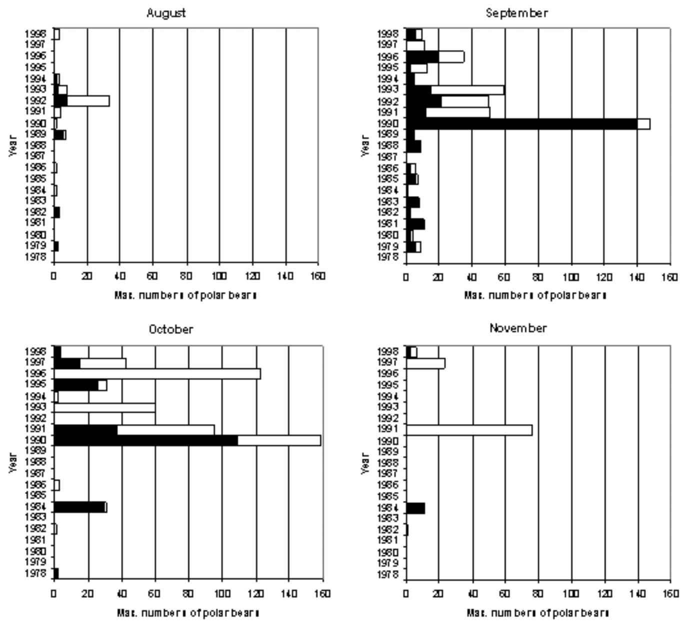
In the autumn seasons of 1990, 1991, 1993, 1995, 1996, and 1997 the ice edge was to the north and west at 80–380km from Wrangel Island (Figure 28). In those years, walruses used coastal haulout sites and were a food source for polar bears. The maximum number of bears was seen on Blossom Cape and Somnitel'naya Spit with the aggregations existing for the longest period. At the initial stage of concentration (late August–early September), 10–15 bears were present. polar bears fed on the remains of walruses which had died in previous years and hunted walruses on the coast. With the exception of 1995, walruses formed large haulouts on the Somnitel'naya Spit. When walruses were panicked, 24–104 were killed after they were crushed. The carcasses were the main factor attracting bears (Kochnev 2001a). The death of most walruses occurred in a short period (2–4 days). Following these mortality events, the concentration of bears rapidly increased and usually reached its peak in the second half of October. In the absence of walrus carcasses on Blossom Cape the number of polar bears gradually decreased.

Aggregation existence depended on food abundance as much as on rate of sea ice formation. The total biomass of dead walruses varied from 8 to 45 tons/per season (mean=23.7 tons/season) on both haulout sites (Table 25). The consumption of walrus meat, fat and viscera by bears was assessed by taking into account the maximum number of bears in the aggregations. In the seasons when walruses formed haulout sites, each bear had about 346kg of food. When predators reached their maximum density before the sea froze over and the level of walrus mortality was not high, the bears usually consumed all available food and left the coast as soon as ice consolidated. In 1995–96, the aggregations of polar bears before freeze-up were small and each animal could consume from 848 to 1,530kg of food. More bears appeared on the island after consolidated ice had formed and the total number of bears increased. In years when ice was constantly near the island, freeze-up did not noticeably influence bear numbers.

The relationships between the maximum number of polar bears in aggregations and the number of dead walruses, quantity of accessible food, and distance to the ice-edge were examined (Figure 29). The Spearman R correlation coefficient was calculated and in all three relationships a high correlation was found ($p < 0.05$). The relationship between the number of bears and distance to the ice-edge (Spearman rank order correlation $R = 0.823$) and the quantity of walrus carcasses ($R = 0.769$) were strong while the influence of walrus biomass was weaker ($R = 0.702$).

Historical data are inadequate to assess the temporal development of autumn bear aggregations on Wrangel Island. Some reports (Ognev 1931, Starokadomskii 1946) claim that in the beginning of the 20th century bears used to concentrate near walrus haulout sites if the sea did not freeze. The first period of the Island exploration (1926–33) was described in detail (Mineev 1935, 1946,

Figure 30. Relationship between the number of polar bears in autumn aggregations on Wrangel Island and food abundance and ice pattern in the Chukchi and East Siberian seas, 1989–1998.



Ushakov 1972). Harshening of the Chukchi sea ice conditions and absence of walruses on coastal haulout sites were common. Nevertheless, it was reported that one could meet polar bears in autumn (mainly in October) more frequently than during summer.

There is no information on the frequency of meeting polar bears on Wrangel Island in autumn 1934–59, the period of active hunting in the Soviet Arctic, which resulted in a decline in polar bear numbers. During this period, hunters lived on Blossom Cape and Somnitel'naya Spit all year. The anthropogenic disturbance was so strong that even when sea was clear of ice and walruses hauled out, bears did not aggregate in the vicinity of haulout sites.

After polar bear harvesting was prohibited in 1956 and Wrangel Island was designated as a reserve in 1960, bears regularly visited walrus haulout sites on Blossom Cape and on Somnitel'naya Spit. In periods when water surrounding Wrangel Island was free of ice and walruses hauled out, the number of bears left was usually very small. Bears began to concentrate on feeding grounds after the sea had frozen and animals from the consolidated pack ice had come (Velizhanin 1965, Fedoseev 1966, Kistchinsky and Uspensky 1973). Despite the high mortality of walruses in these years, when 245 animals on average died each season (Kochnev 2001a, Table 26), the aggregations of bears were less than 20–30 individuals and many unused carcasses were left for winter. In some years, bears on Blossom Cape continued to feed on walrus carcasses until May and formed aggregations of 4–10 animals (Kistchinsky and Uspensky 1973, Belikov and Kupriyanov 1977a,b).

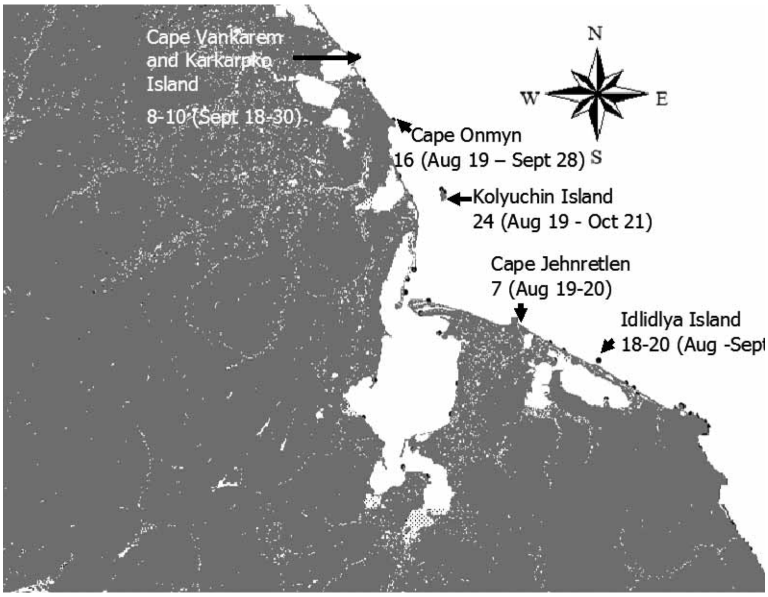
From 1976, when the Wrangel Island State Reserve was organized, the frequency of ecological observations increased. However, large aggregations of bears were still not reported (Figure 30). In the 1980s, small groups of bears were regularly observed in September, even when the ice covered the sea near the island and walruses hauled out and died on the land rarely (Kochnev 2001a, Table 26). In the course of that decade, bears usually fed on old dry skins and other remains of walruses that had died in the 1960–70s on Blossom Cape. The largest aggregations of polar bears were observed on Blossom Cape in September 1981 (11 animals), and in October and November, 1984 (30 and 10 animals respectively). In the Somnitel'naya Spit area, researchers did not note more than three animals simultaneously.

The large aggregations of polar bears in the vicinity of walrus haulout sites observed regularly on Wrangel Island in the 1990s were the result of protection measures and changes in the sea ice. The correlation between bear numbers and remoteness of ice edge indicates that the concentration of bears depends on ice patterns in the Chukchi and East Siberian seas. The same ice conditions force walruses to haul out, thus the remoteness of the ice edge influences walrus numbers and mortality rate

Table 26. Autumn conditions and food resources for polar bears on Wrangel Island, 1960–1999

Decade	No. seasons with the Chukchi Sea free of ice	No. seasons that walruses hauled out	Mean no. dead walruses/decade	Mean (per decade) peak no. polar bears in aggregations
1960–69	5	5	318 (n=1)	8–20
1970–79	4	6	191.5 (lim 0-574, n=6)	5.5 (lim 2-9, n=2)
1980–89	1	3	0.4 (lim 0-1, n=3)	7.7 (lim 0-30, n=10)
1990–99	7	7	68 (lim 37-127, n=6)	54.7 (lim 4-140, n=9)

Figure 31. Study area on the Chukotka coast (2003–2004) and the location of the largest aggregations of polar bears in summer and autumn of 2003.



(Kochnev 1999, 2004). Additional factors influence the formation of bear aggregations and the number of animals in groups: the speed of ice break-up in summer and the distribution of bears and their prey in surrounding waters when the ice edge moves north. The arrival of bears, searching for food, in large numbers on the coast after sea freezing (October–November) is apparently caused by their unsuccessful hunting of seals near the edge of the pack ice the previous month.

Chukotka Arctic coast

Observation routes and stationary counts of polar bears took place from August 1 to September 2 in 2002 in the coastal waters from Lavrentya Bay (Bering Strait) up to Neshkan village (Chukchi Sea); from July 19 to October 30 in 2003 from Vankarem Cape to Kolyuchin Bay (Chukchi Sea); from August 13 to November 4 in 2004 in the coastal waters of the Chukchi Sea from Serdtse-Kamen' Cape to Kolyuchin Island (Figures 26 and 30). Land-based observations were made on Kolyuchin Island in 2003–04 using the same methods as on Wrangel Island. The total survey route was 1,906km.

In 2002, only one polar bear was encountered (August 26) on the coast between the Chegitun' River mouth and Inkigur Cape. As reported by hunters, bears began to visit the area near Vankarem Cape after the sea had frozen (end of October–beginning of November). Bears formed small feeding aggregations near walrus carcasses on the haulout sites of Karkarpko Island and Vankarem Cape. The same situation was observed in 2004. In the absence of ice cover in our study area during August, September and October single bears were met only twice (at the end of August in the vicinity of Nutepel'men village and at the end of September near Vankarem

Cape). Bears started to visit walrus haulout sites on Karkarpko Island and Vankarem Cape in the first 10 days of November, i.e. 1–1.5 weeks after the ice had reached the coast.

The situation was different in 2003. On August 20, up to 18 bears of different sex and age were counted along the coastline of Kolyuchin Island. About 20 bears lived on the Island until the end of September. The maximum number of bears (24) was noted on September 6. The aggregation could have been larger if natives did not hunt there. On Kolyuchin Island and area, on the continental coast, not less than 17 polar bears were killed at the end of August and September. As the reports of native people suggested, from 7 up to 20 bears concentrated in five coastal areas in autumn 2003 (Figure 7). The aggregation of animals on Kolyuchin Island persisted until freeze-up (late October), though some animals began to leave the island in early October.

Autumn and summer seasons of all three years (2002–04) were characterized by similar ice and open water conditions in the Chukchi Sea. Walruses formed large haulouts on the arctic coast of Chukotka in all years. At the same time, the dynamics of ice break-up varied each summer. In 2002 and 2004, the ice edge moved to the north and the majority of polar bears followed it. In July and in early August 2003, the ice conditions were close to average: the central part of the Chukchi Sea was ice free, while a strip of half-consolidated ice moved along the Chukotka coast – from the East Siberian Sea through Long Strait down to the Bering Strait. From August 11–18, however, a strong storm, accompanied by northern winds, broke up the coastal ice fields. polar bears that lived there, moved onto the coast and became isolated from the main ice.

Discussion

Large regular aggregations of polar bears were observed in the vicinity of walrus haulout sites on Wrangel Island in autumn 1990. The dramatic increase in the aggregations and the number of bears was connected to altered ice conditions in the Chukchi Sea and the eastern part of the East Siberian Sea and was related to walrus mortality (Table 2). The same ice situation was typical of the 1960–70s when walrus mortality was even higher. However, in those years, bears began to concentrate in areas with haulout sites only after freeze-up and they were not as abundant. These patterns could be explained by the high level of anthropogenic disturbance (the reserve was not organized yet) and by the low numbers of animals in the population.

On the arctic coast of Chukotka, in the same sea ice and feeding conditions as on Wrangel Island, the aggregations of polar bears near walrus haulout sites were not as regular and included smaller numbers of animals. The geographical position of Wrangel Island makes it unique: this isolated structure is the only large land area in the vast range of polar bears in the Chukchi Sea subpopulation (Chukotka-Alaska).

Bears feeding on whales and pinniped carcasses along the Chukotka coast in November–April have been noted repeatedly since the mid 1970s (Smirnoff 1983, Stashkevich 1986). However, in the last 10–15 years, the number of such observations has increased (Kochnev *et al.* 2003). Thus, polar bears began visiting coastal haulout sites more frequently in November and December and when carcasses were abundant, they formed large aggregations. The observations in 2003 suggest that certain patterns of ice break-up cause bear concentrations on the coast even at the end of summer and polar bears head for walrus haulout sites, both actual and potential. In 2003, walruses hauled out on Vankarem and Onmyn Capes, Karkarpko and Kolyuchin Islands (Figure 31). Although Jehnretlen Cape and Idlidlya Island were not visited by walrus in 2003, animals used them for rest during autumn migrations. If hunting was not so intense and the level of anthropogenic disturbance was not so high, the regularity of bear concentrations in these areas of the continental coast, the duration of their existence and the number of animals in them could be similar to Wrangel Island.

The concentration of bears on walrus haulout sites of Wrangel Island is somewhat unique. Aggregations of this kind, forming in summer and autumn, are nowadays known only in the southern part of polar bears' natural habitat (Hudson and James Bays in Canada). After the ice breaks up, the whole subpopulation comes to the coast. However, the density of predators is not as high as on Wrangel Island: bears are scattered along the coast and further inland, because food resources are equally scattered (Latour 1981, Derocher and Stirling 1990a,b). Abundance of food, concentrated in small coastal areas of Wrangel Island, promotes the formation of aggregations. Aggregations with similar density can appear near food resources such as dead whales (belugas, sperm whales, grey and bowhead whales). Indeed, they were noted repeatedly on the Chukotka and in other arctic regions (Smirnoff 1983, Stashkevich 1986, Larsen 1986, Kalxdorf 1997, Derocher *et al.* 2002, Kochnev *et al.* 2003). However, the appearance (place and time) of whale carcasses cannot be predicted, while walrus haulout sites usually form in traditional areas of the coast when the larger part of the Chukchi sea is clear of ice (Kochnev 1999).

When ice conditions prevent polar bears hunting seals, walrus haulouts are an important food resource in autumn and early winter. The regularity and predictability of walrus arrival allows bears to head for the coastal haulout sites when they move on ice and land near the coast in summer and autumn. Abundance of food, long-term aggregation existence and number of animals in aggregations can cause high levels of intraspecific interactions (Kochnev 2001b, 2002, Ovsyanikov 2005). Thus, taking into account the regular nature of such aggregations, one can conclude that they play an important role in forming and supporting connections between individual animals. These situations allow opportunities to look at the social structure of bears in the subpopulation from a different viewpoint.

The problem of global climatic warming is widely discussed nowadays and a lot of attention is drawn to the possible influence of arctic warming on the survival of the polar bear as species (Stirling and Derocher 1993). The subpopulation of Hudson Bay is the most vulnerable to climatic changes, because bears have to wait through the long period (3–4 months) of ice absence on land, when they practically do not feed (Stirling *et al.* 1999). The Chukchi Sea (Chukotka-Alaska) subpopulation occupies a more northern habitat area and is less vulnerable to warming. Our investigations on Wrangel Island have shown that the polar bear is a very plastic animal: it can rapidly change its way of life, spatial distribution and behaviour according to new ecological conditions.

Comparing the situation in 1980s and 1990s, one can easily trace the changing Chukchi Sea ice conditions (Table 2). This process is still ongoing. From 1999 to 2004 bears continued to form large aggregations on the Wrangel Island coast, although walrus numbers and mortality rates on haulout sites decreased (Ovsyanikov 2005, I.P. Oleynikov, L.L. Bove, V.V. Baranyuk, G.N. Kaurgin, personal communications).

If the process of warming lasts for a long time and feeding conditions near the ice edge in summer and autumn are not satisfactory, the life cycle of the Chukchi Sea subpopulation could shift to a similar one to the Hudson Bay subpopulation. In the absence of ice, the majority of bears will move to land and spread out over the islands and continental coast of the Chukchi and East Siberian seas. Nevertheless, feeding conditions in the north are better than in the Hudson Bay area. From 10 to 13 walrus haulout sites usually function in summer and autumn on the arctic coast of Chukotka (Gilbert *et al.* 1992, Kochnev 2004). In addition not less than 7–8 dead whales are thrown on land from the sea every year (Kochnev 1998).

On the American side of the Chukchi Sea walrus haulout sites are rare but on the Beaufort Sea coast in recent years, bears form feeding aggregations in places where bowhead whales have been butchered on land (see Schliebe *et al.* this volume). Thus the pattern of behaviour observed in the 1990s on Wrangel Island, when animals formed coastal aggregations near the food source, may spread over the whole coast of the Chukchi Sea and alter the life cycle of the subpopulation if arctic warming continues and is irreversible.

References

Belikov, S.E. and Kupriyanov, A.G. 1977a. Geographicheskiye osobennosti nekotorykh aspectov povedeniya belogo medvedya. Pp.202–212 in *Povedeniye mlekopitayushchikh*. Nauka, Moskva [Geographical peculiarities of some aspects of polar bear behaviour. In *Behaviour of mammals*]. (In Russian).

Belikov, S.E. and Kupriyanov, A.G. 1977b. Povedeniye belogo medvedya na o. Vrangelya. Pp.40–54 in Uspensky, S.M. (ed.). *Beliy medved' i ego okhrana v Sovetskoy Arktike*. Central'naya laboratoriya okhrany prirody MSKh SSSR, Moskva [Polar bear behaviour on Wrangel Isl. In *The polar bear and its conservation in the Soviet Arctic*. Central laboratory of nature conservation, Ministry of agriculture USSR, Moscow]. (In Russian with English summary).

Derocher, A.E. and Stirling, I. 1990a. Observations of aggregating behaviour in adult male polar bears (*Ursus maritimus*). *Can. J. Zool.* **68**:1390–1394.

Derocher, A.E. and Stirling, I. 1990b. Distribution of polar bears (*Ursus maritimus*) during the ice-free period in western Hudson Bay. *Can. J. Zool.* **68**:1395–1403.

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

Fedoseev, G.A. 1966. Aerovizualniye nablyudeniya za morskimi mlekopitayushchimi v Beringovom i Chukotskom moryakh [Airplane survey of marine mammals in the Bering and Chukchi seas]. *Izv. TINRO.* **58**:173–177. (In Russian).

Gilbert, J., Fedoseev, G., Seagars, D., Razlivalov, E. and Lachugin, A. 1992. Aerial census of Pacific walrus, 1990. USFWS Administrative Rep. R7/MMM 92-1, Anchorage, USA.

Kalxdorf, S.B. 1997. Collection of local knowledge regarding polar bear habitat use in Alaska. Tech. Rep. MMM 97-2.

Kistchinsky, A.A. and Uspensky, S.M. 1973. Novye dannye po zimney ecologii belogo medvedya na o. Vrangelya. Pp.10–28 in Sokolov, V.E. (ed.). *Ecologiya i morphologiya belogo medvedya*. Nauka, Moskva [New data on the winter ecology of the polar bear on Wrangel Island. In *Ecology and morphology of the polar bear*]. (In Russian with English summary).

Kochnev, A.A. 1998. Gibel' kitoobraznykh (Cetacea) v Chukotskom more i prolive Longa: vidovoy sostav, raspredeleniye i prichiny gibeli [Death of whales (Cetacea) in the Chukchi Sea and the Long Strait: species composition, distribution and causes of death]. *Zool. J.* **77(5)**:601–605. (In Russian with English summary).

Kochnev, A.A. 1999. Tikhookeanskiy morzh v pribrezhnykh vodakh o. Vrangelya (1991–1994). 1. Chislennost' i raspredelenye v zavisimosti ot gidrologicheskikh usloviy i khistchnichestva belykh medvedey [The Pacific walrus in the coastal waters of Wrangel Island (1991–1994). 1. Numbers and distribution depending on hydrological conditions and polar bear predation]. *Izv. TINRO.* **126**:447–464. (In Russian with English summary).

Kochnev, A.A. 2001a. Tikhookeanskiy morzh v rayone ostrovov Vrangelya i Geralda i ego okhrana. Pp.180–205 in Pavlov, D.S. and Bychkov, V.A. (eds.). *Morzh: Obraz vida.* Nauka, Moskva. [The Pacific walrus in the Wrangel and Herald islands area and its conservation // In: *The Walrus: Mode of the Species.* Nauka, Moscow]. (In Russian).

Kochnev, A.A. 2001b. Povedeniye osirotevshikh medvezhat i otnoshenie k chuzhomu potomstvu u belykh medvedey (*Ursus maritimus* Phipps) v prirode [The behaviour of orphaned cubs and attitude to non-own posterity among wild polar bears (*Ursus maritimus* Phipps)]. *Bull. MOIP, Ser. Biol.* **106(3)**:13–21. (In Russian with English summary).

Kochnev, A.A. 2002. Autumn aggregations of polar bears on the Wrangel Island and their importance for the population. Pp.137–138 In Belkovich, V.M. (ed.). *Marine Mammals of Holarctic. Abstracts of the Second International Conference.* KMK, Marine Mammal Council, Moscow, Russian Federation.

Kochnev A.A., 2004. Warming of eastern Arctic and present status of the Pacific walrus (*Odobenus rosmarus divergens*) population. Pp.284–288 In Belkovich V.M. (ed.). *Marine Mammals of the Holarctic. Papers of the Third International Conference.* Marine Mammal Council, Moscow, Russian Federation.

Kochnev, A.A., Etylin, V.M., Kavry, V.I., Siv-Siv, E.B. and Tanko, I.V. 2003. Traditional knowledge of Chukotka native peoples regarding polar bear habitat use. Final Rep. Prep. for the U.S. National Park Service. ATMMHC Executive Secretariat, Anadyr, Russian Federation.

Larsen, T. 1986. Population biology of the polar bear (*Ursus maritimus*) in the Svalbard area. Norsk Polarinst. Skr. 184.

Latour, P.B. 1981. Spatial relationships and behavior of polar bears (*Ursus maritimus* Phipps) concentrated on land during the ice-free season of Hudson Bay. *Can. J. Zool.* **59**:1763–1774.

Mineev, A.I. 1935. Beliy medved' (ostrov Vrangelya). [The polar bear (Wrangel Island)]. *Sovetskaya Arktika.* **5**:33–44. (In Russian).

Mineev, A.I. 1946. *Ostrov Vrangelya* [Wrangel Island]. Izd. Glavsevermorputi, Moskva, Leningrad, Russian Federation. (In Russian).

Ognev, S.I. 1931. *Zveri Vostochnoy Evropy i Severnoy Azii. T.2. Khistchnye* [Mammals of Eastern Europe and Northern Asia. V.2. Carnivores]. Gosizdat, Moskva, Leningrad, Russian Federation. (In Russian).

Ovsyanikov, N.G. 2005. Povedeniye belykh medvedey v congregatsiyakh na poberezhye [Behaviour of polar bears in coastal congregations]. *Zool. J.* **84**:94–103. (In Russian with English summary).

Smirnoff, G.P. 1983. On the number of polar bears on the Arctic coast of the Chukotka Autonomous District. Unpubl. Report.

Starokadomskii, L.M. 1946. *Expeditsiya Severnogo Ledovitogo okeana, 1910–1915 gg.* [Expedition to the Arctic Ocean, 1910-1915]. Izd. Glavsevermorputi, Moskva, Leningrad, Russian Federation. (In Russian).

Stashkevich, L.F. 1986. Arkticheskaya zapoved' [Arctic precept]. *Okhota i okhotnichye khozyaystvo*. **5**:18–19. (In Russian).

Stirling, I. and Derocher, A.E. 1993. Possible impacts of climatic warming on polar bears. *Arctic* **46**:240–245.

Stirling, I., Lunn, N.J. and Iacozza, J. 1999. Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. *Arctic* **52**:294–306.

Ushakov, G.A. 1972. *Ostrov meteley* [The Island of snowstorms]. Gidrometeoizdat, Leningrad, Russian Federation. (In Russian).

Velizhanin, A.G. 1965. Zametki po faune nazemnykh pozvonochnykh ostrova Vrangelya [Notes on fauna of terrestrial vertebrates of Wrangel Island]. *Zapiski Primorskogo filiala Geographicheskogo o-va SSSR*. **24(1)**:67–78. (In Russian).

Research and conservation of polar bears on Wrangel Island

N.G. Ovsyanikov, Wrangel Island State Nature Reserve, Chukotka, Russia

Introduction

Current research on polar bears on Wrangel Island is focused on the behavioural ecology of the species and has continued since 1990. The main objectives of this long-term project are: (1) population status in terms of bear numbers and health; (2) demographic structure of the local population; (3) changes in litter size with the age of cubs and cub survival; (4) how global environmental changes are impacting polar bear activity, especially key processes such as the timing of pregnant females entering dens and changes in environmental conditions during den settlement; (5) hunting behaviour of polar bears under various conditions, availability of prey in relation to ice conditions, availability of alternative food during critical periods when environmental changes prevent them from hunting on their usual prey; (6) social behaviour of polar bears, behavioural rules that govern encounters between bears in various situations – on ice, on land, in congregations on the coast; social-related risks for polar bear survival and advantages of living with con-specifics; (7) polar bear-human encounters, environmental and behavioural causes of polar bear-human encounters and conflicts, polar bear responses to human encounters, and optimal ways to manage conflict between humans and polar bears in various situations.

Spring observations at maternity denning areas on Wrangel Island time were last conducted in 1999. Since 2000, only late summer-autumn observations were conducted on an annual schedule (except 2001). This research includes: (1) stationary observations at two permanent observation plots – Cape Blossom (the main site), and Doubtful Spit (additional plot) and (2) ground surveys along the coast and inland using an ATV (All Terrain Vehicle) or snowmobile. Both plots are traditional walrus haul-out sites where polar bears usually congregate during ice-free periods. Exact routing for the ground route surveys for each season varied with environmental conditions and polar bear distribution. During the autumn, open water around the Island forced many bears on land for extended periods and, as the season advances, they gather at these two plots. In such seasons, priority was given to stationary observations, while route surveys were shortened. During seasons of more or less ice covered sea, gatherings do not occur and animals spread widely along the shore. In such seasons, priority is given to survey routes to find and watch more bears. The following data was recorded for each bear – date/time, place, social unit (lone, family group, alliance), age category, sex, physical condition, activity.

This paper presents the brief results of the most recent local population status assessment conducted in autumn 2004 and conclusions drawn from this season.

Materials and methods

In 2004 data on the status of the local polar bear population was collected from August 17 through September 29. Standard methods were used including stationary observations at Cape Blossom and Doubtful Bay and ground surveys along the southern, western and northern coasts, and through central parts of the Island, including valleys of six major rivers. The total length of ground surveys was 1,746km with 261 bears recorded (Table 1). Data was collected through direct observation with opportunistic recording of some episodes of polar bear activity, and social and foraging behaviour. For each bear, sex- and age-class was identified via exterior morphological features, distance and visibility permitting. The following age categories were distinguished: **juv** – cub-of-the year; **yr** – yearling cub; **ty** – two-year-old-cub; **subad** – cub without mother, aged from 1–3.5 years (meeting a cub-of-the year without mother during autumn is a rare exception, normally this category is represented by single cubs from 1.5 years old); **ad** - adult – sexually mature bear >4 years. Within this last category, for more detailed demographic analysis, three categories were identified, when possible: (1) adult young bear (aged from 4 to 7–8 years); (2) adult mature bear (between 7–8 and 12–14 years old); (3) adult old bear (large bear of either sex, apparently >12–14 years). For detailed analysis estimated age of subadults was recorded too.

For all bears observed at short distance (<1km), physical condition was recorded using a five-point scale: 1 – very thin bear; 2 – thin, evidently underfed bear; 3 – normally fed bear of normal shape; 4 – thick, well-fed bear; 5 – very fat bear. Binoculars from 8X to 15X power were used for regular observations and a scope 20–45X for identifying animals at greater distance. Stationary observations at Cape Blossom were carried out for 27 days between 17 August and 29 September. At Doubtful Bay, 11 days of observations were conducted between 20 August and 12 September. In addition, during July to the first part of August, inland ground surveys were conducted by Irina Menyushina. Additional information on bears visiting the base camp in Doubtful was registered by the reserve's scientists and rangers (A. Gruzdev, E. Kuzmin, V. Kazmin), who were working at the camp from 18 August to 28 September. Information on polar bears visiting Ushakovskoe village at the south-east coast of Wrangel Island was recorded by the reserve's ranger G. Kaurgin in August-September.

Results

During the summer, occurrences of polar bears on land were not recorded. The first record was on August 16 with four other observations in the next 12 days. Bears were only recorded irregularly at Cape Blossom and along the southern coast of the island until September.

Active arrival of polar bears to the land began in early September. Congregations of bears on shore were not observed during 2004. Bears were widely and relatively evenly distributed along southern, western and northern coasts. Eastern and north-eastern coasts could not be accessed. Dynamics of polar bear records and sex-age composition of the local population is shown in Table 1. The highest density of bears was observed at denning areas on the slopes of Thomas Mountain and Pavlov Mount in the south-west of Wrangel Island.

The second recording of animals was excluded if they were observed twice or for which the probability of double counting appeared to be high. However, the probability of double counting certain individuals can not be completely excluded, when met in different areas at different time, as some bears were moving. Probability of double counting applies most to the category of "unidentified lone adults" because individual identification of other categories was more evident. Thus, biases in estimated numbers are likely to be small.

There were no congregations of polar bears at Cape Blossom or Doubtful Spit, or at any other surveyed coastal areas. At Cape Blossom, bears appeared during the entire autumn observation period but the majority of them passed without staying. Only one family group (female with two juveniles) was permanently at Cape

Figure 32.

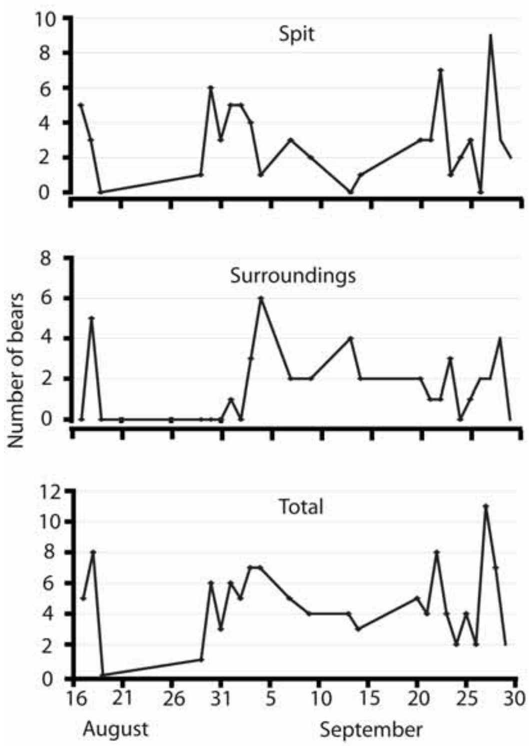


Table 27. Number of polar bears in different areas of of Wrangel Island, Russia, autumn 2004

Area	Total	Adult	Subadult	Yr/Ty&F	Juv&F	Lit&F
Cape Blossom	76	46	9*	1	14	6
Doubtful Bay	33	14	1	1	16	1
Southern coast	46	27	2	5	12	0
Western coast	16	9	4	1	2	0
Northern coast	16	10	1	1	4	0
Inland	15	11	0	1	3	0
Ushakovskoe	14	8	0	2	4	0
Denning areas:						
Thomas Mt.	15	9	0	0	6	0
Pavlov Mount	17	13	0	0	0	2
Small Drem-Khed	12	8	0	1	2	1
Big Drem-Khed	3	3	0	0	0	0
Total	**261**	**158**	**17***	**13**	**63**	**10**

Key: Yr/Ty&F – total number of cubs older than one year (yearlings and two-year-olds) with mother in family group; Juv&F – total number of cubs-of-the-year with mother in family group; Lit&F – total number of litters in family groups with unidentified age and number of cubs. (Because number of cubs in unidentified litters could be more than one, total estimated number of bears may be slightly lower than actual – within a few cubs).
*/- including one, apparently lost, cub-of-the-year that passed Cape Blossom.

Blossom and in the vicinity in September. Beside this unit, only a few family groups and lone bears – adult females and subadults – visited the Spit more than once and stayed there for a few days. The number of bears that were recorded at Cape Blossom varied between 0–9 animals (Figure. 31). At Doubtful Bay, the major concentration of bears consisted of family groups observed at the base of the spit near the western end of Davidov Lagoon. There were very few bears at the tip of the spit – only single family groups were recorded.

During autumn 2004 bears which landed on Wrangel Island were dominated by family groups and adult females (Table 27). Adult males were recorded sporadically and only 16 males were found, four of which passed through cape Blossom and three seen along the western and northern coasts.

Category "LONE" (lone unidentified bears) comprised animals observed at long distance, sleeping bears and young animals, in which secondary sexual features could not be seen well enough for reliable identification. Bears with recorded physical condition 1 and 2 were considered starving or severely underfed. Such animals comprised 15% of the total. Half of all bears were in medium condition (Table 28). Underfed animals were observed among adult males, females with cubs-of-the-year and yearlings, and lone subadults.

Number and size of litters of different age is shown in Table 29. Litters, for which the probability of repeated recording was high, were excluded. During summer to autumn on Wrangel Island, the remains of fresh carcasses of two dead bears were found. On 7 July, an adult male was found 3km west of Devil Creek with evidence of being eaten by other animals (pers. comm. A. Gruzdev). On 4 September, a juvenile bear was found near the inner coast of Vaigach Lagoon with evidence of being fed upon.

During the autumn, eight sightings of bears or family groups were recorded near Ushakovskoe village – Wrangel Island's main human settlement. Only family groups and females entered the village a few times. No serious polar bear-human conflicts occurred during this season, although visits of bears to Ushakovskoe during recent years have become more common.

Discussion

The autumn season of 2004 was characterized by: (1) an average number of bears on land; (2) an obvious prevalence of adult females and family groups; and (3) a wide distribution of bears along the shore without congregations at the traditional sites at southern spits (Cape Blossom and Doubtful Spit). Similar to the 2002 and 2003 seasons, some bears regularly penetrated inland and fed on reindeer carcasses.

Table 28. Physical condition (1 to 5 with 1 = very poor) of polar bears in percent by age- and sex-categories, Wrangel Island, Russia, autumn 2004

	Condition					
Group	1	2	3	4	5	*n*
M ad	7.1	21.4	57.1	14.2	0	14
F ad	0	0	20	26.7	53.3	15
F/juv	0	14.3	57.1	23.8	4.8	21
F/yr	0	25	50	25	0	4
F/ty	0	0	0	0	0	0
LONE	0	0	0	0	100	1
Subad	0	25	50	12.5	12.5	8
Yr or Ty/F	0	25	50	25	0	4
Juv/FG	0	12.1	63.6	18.2	6.1	33
Overall	1	14	52	20	13	100

Note: n – number of bears of this category with identified physical condition. M = male, F = female, ad = adult, juv = cub of the year, yr = one year old, ty = two year old, FG = family group. When group consists of more than one individual, the one for which the condition was recorded is typed before the slash (/), and the type of bear it was together with after the slash (e.g. Juv/FG is the condition of any juveniles in family groups).

Table 29. Number and size of litters observed on Wrangel Island, Russia, autumn 2004

Age	*n* (litters)	*n* (cubs)	One cub litters	Two cub litters	Three cub litters	Mean litter size
Cubs-of-the-year	36	58	15	20	1	1.61
Yearlings	9	9	9	0	0	1.00
Two-year-olds	2	2	2	0	0	1.00

Cape Blossom as the place of bear concentrations during the period of stranding significantly decreased in 2004. Previously bears congregated at very high densities (15–38 bears per hectare at the tip of the spit). The change is primarily due to a reduction of old walrus skins in the area. Since 1990, during all autumn ice-free seasons, polar bears gathered at Cape Blossom due to the presence of a great supply of old walrus skins, which provided food for bears in the absence of opportunities to hunt seals and walruses on the ice, or live walruses at coastal rookeries. When walruses were hauling out at this spot, polar bears hunted them and walrus mortality led to additional accumulation of fresh skins, which partly compensated for old skin consumption. Since autumn 1999, however, walruses have not hauled out at Cape Blossom. Over the last five years, the remaining skins have been mostly consumed, washed away by strong autumn storms, partly pulled by bears on to the ice in winter-spring seasons and drifted away. In 2004, only a few (about 10) skin pieces suitable as food remained, compared to the early 1990s when there were tens of skins, many of full size.

Both Doubtful Spit and Cape Blossom have had stranded polar bears as they are traditional walrus haul-out sites. There was no such multi-year skin accumulation at Doubtful as at Cape Blossom. In 2004, bears did not gathered at Doubtful either. The trend of use by bears during recent years for these two places is similar.

Coastal walrus rookeries on Wrangel Island were recorded in 1990, 1991, 1993, 1995, 1996, 1997, and 1999 at both sites. In 2004, a herd of approximately 400–500 walruses made only one short attempt to haul out in Doubtful (21/09). The reasons why walruses quit hauling out at Wrangel Island cannot be discussed productively without more detailed information on walrus distribution on the ice and the dynamics of marginal ice fields in the region during summer-early autumn seasons of the last years. However, one may speculate that two major factors are important for causing these changes in walrus hauling-out activity: (1) almost permanent polar bear presence at traditional walrus haul-out sites of Wrangel Island during the autumns of the last 15 years and accordingly high polar bear predation upon the hauling out walruses; (2) changed pattern of walrus distribution in the surrounding sea, which may be due to changes in the dynamics of ice and/or to walrus food resources.

The autumn of 2004 was also characterized by an unusually high density of polar bear females at two traditional denning sites of the south-west of the Island – Thomas Mountain and Pavlov Mount. The number (density) of females at major denning areas in the north-west and west of the Island – Small and Big Drem-Khed mountain areas, and Bezimyannie Mountains – in the early autumn settling period was low. Combining direct records of denned females with the distribution of bear tracks, which were recorded during route surveys, a conclusion can be made that the first (early autumn) flow of females, arriving on the island for hibernation from the East-Siberian Sea was from the south-western sector of the surrounding sea. A late autumn wave of additional females might change this to some extent. During the last decade, in all seasons of the ice-free periods, autumn arrival of denning females was delayed for about one month compared to the timing of settling observed in 1980s and the early 1990s, which is considered normal for the polar bear life cycle in the region.

The proportion of under-fed bears during the 2004 autumn season was high (15%), although the season was not the worst and the ice conditions were a little better for bears, than in 2002 and 2003. Together with low mean size of the litters older than one year, this may be considered an indication that local population is increasingly stressed or that there is a trend for such development.

During the last five years, when deprived of hunting seals from the ice and walruses on the beach, polar bears on Wrangel Island have started to scavenge more intensively upon reindeer carcasses and beached arctic cod as additional food sources. This trend became evident in autumn 2002 and may be considered a new tradition for the local population. The amount of arctic cod thrown on the beach by waves increased during the last three years, with the highest recorded amount available for polar bears in autumn 2003. The growing number of reindeer on Wrangel Island should be considered a positive factor for polar bears because increased reindeer mortality during the rut overlaps with the period polar bears are on the Island. The strict protective regime of Wrangel Island Nature Reserve provides reliable protection for the local population. For the time being, Wrangel Island remains the only area in the entire Chukotka, where polar bears are fully protected from shooting. The only bear killed by humans at Wrangel Island during the last 10 years was a problem adult female that killed a woman at Ushakovskoe in autumn 2003 – the animal was shot by the reserve's ranger at the site of the accident with the shooting permit confirmed by the responsible Department of the Ministry of Nature Resources. The risk of incidental illegal shooting on Wrangel Island, however, does exist from the degraded Polar weather station that is still functioning in Ushakovskoe village with a staff of 5–6 people, who are not under the jurisdiction of the Nature Reserve's administration. Developing shipping activity in the region may cause an increase in disturbances for polar bears and increase the risk of poaching.

Changes in the quality of surrounding habitats and in polar bear activity observed on Wrangel Island during the last five years under climatic change may be similar to trends for many parts of the species distribution:

1. Optimal ice habitats are turned into marginal hunting habitats in summer-autumn.
2. More bears are exposed to extremes of open sea environment.
3. More bears are forced to land on islands and mainland and strand there for extended periods of time.
4. Time of pregnant female settling is delayed.
5. Polar bears are and will be exposed to food deprivation and risk of conflicts with humans will increase.

Line transect estimate of the subpopulation size of polar bears in the Barents Sea

J. Aars, Norwegian Polar Institute, N-9296, Tromsø, Norway
M. Andersen, Norwegian Polar Institute, N-9296, Tromsø, Norway
S. Belikov, All-Russian Research Institute for Nature Protection, 113628, Moscow, Russia
A. Boltunov, All-Russian Research Institute for Nature Protection, 113628, Moscow, Russia
S.T. Buckland, Centre for Research into Ecological and Environmental Modelling, University of St. Andrews, St. Andrews, KY16 9LZ, Scotland
T.A. Marques, Centre for Research into Ecological and Environmental Modelling, University of St. Andrews, St. Andrews, KY16 9LZ, Scotland
Ø. Wiig, Natural History Museum, University of Oslo, N-0318 Oslo, Norway

In a joint project, the Norwegian Polar Institute (Norway), VNII Priroda (Russia), The University of Oslo (Norway), and The University of St Andrews (UK) estimated the size of the Barents Sea polar bear sub-population in August 2004. Based on a combination of telemetry data (Wiig 1995, Mauritzen *et al.* 2001, 2002) and genetic markers (Paetkau *et al.* 1999), the current view is that the Barents Sea area hosts one natural sub-population unit, but with profound exchange of individuals or genes from East Greenland to the west and the Kara Sea to the east. The size of the polar bear sub-population for the Barents Sea area was suggested to be somewhere between 2,000 and 5,000 (IUCN/SSC Polar Bear Specialist Group 2002). This interval was based on earlier attempts to estimate the sub-population size up to the early 1980s (Larsen 1986), based on some ship surveys and den counts in parts of the sub-population area, and the assumption of a stagnation or moderate change in sub-population size since then. Results from the study we present here is the first from the area that is based on a more systematic survey covering the whole distribution area of the sub-population. We had to combine systematic line transect surveys with data from telemetry to estimate densities further north of the ice edge than we could possibly reach with helicopters under the weather conditions we encountered.

The best available method to estimate number of individuals distributed over large open areas is using line transects. The statistical methods are well developed (Buckland *et al.* 2001, 2004). Given that a) the probability of detecting individuals close to the line (termed g(0)) is 1, b) that measured distances from the line to the individuals are accurate, and c) any movement of objects in response to observer is slow, the estimate provided should be unbiased. We used helicopters (Eurocopter AS350 Ecureuil) flying at moderate speed (185km/h) at low height (200 feet) to ensure that g(0) was close to one. Furthermore, we had four observers including the pilot; two in the front that focused on the line, and one covering each side from the back seats. The distance to each bear was measured as the perpendicular line between the GPS track line of the helicopter and a GPS position taken above the place where the bear was initially observed (Marques *et al.* in press).

On some smaller islands and in some fjords at Svalbard, we conducted a total count rather than using line transects. This was done where densities of polar bears were relatively high or where the terrain was easy to search without too much effort. Except from the fjords, most of western Spitsbergen was excluded from the survey due to an assumed low density of bears. On all other larger islands of Svalbard (except Bjørnøya and Hopen, which are too far south to have bears at that time of the year) and on the islands of Franz Josef Land transect lines were distributed in a systematic grid at 3km intervals. These lines were laid across all islands, but also extended to the sea areas around. When transects were flown over land areas and glaciers, they were continued over the sea wherever there was ice (fast ice or drift ice) present. GPS positions were recorded when transects crossed from one habitat type to another (land, glacier, or sea). Along the ice edge between Svalbard and Franz Josef Land transect lines were spaced 9km apart.

Telemetry data from the area (Norwegian Polar Institute unpublished data) indicate that bears are rarely found more than 200km north of the ice edge. Although our survey design aimed for transect coverage to 200km north of the ice edge, we were rarely able to achieve this because of safety reasons related to fog and icing. The average distance of transects flown was 125km, with a range from 43 to 232km. In addition, a gap of 17 lines within the Russian sector was not covered due to continuously bad weather at the end of the survey period.

For analysis, we used DISTANCE version 4.1 (www.ruwpa.st-and.ac.uk/distance/). Different detection functions for different habitat types were employed in a post stratifying procedure. In some areas, only each second or third line was flown, and in some cases coverage was not complete due to changing weather conditions. Because we had to combine the actual observations from line transects at the ice edge with the expected number of observations from a ratio estimator based on telemetry data in the areas not covered, a boot-strapping procedure was written in R to interact with DISTANCE. The program and details are available via the internet (www.creem.st-and.ac.uk/tiago/webpages/runingDistancefromR.htm).

In total, we estimated the size of the Barents Sea sub-population to be 2,997 (CI 2,299; 4,116) polar bears. This sum came from a) total counts, 96 bears; b) line transects, 1,394 (CI 1,075; 1,765); and c) satellite positions in areas not covered, 1,507 (CI 916; 2,609). The line transect estimate is based on 189 observations of 263 bears. The estimate for animals in areas not covered by transects was based on satellite tracking data from 169 data points (both within and north of the line transects) from 44 different adult females in July, August, and September from 1989 to 1999. In the future, we plan on undertaking re-assessments of sub-population size every 5th year in order to follow trends in the size of the sub-population.

For subpopulations of polar bears that roam over large areas, line transects with helicopter may be the best available method for estimating sub-population size. Even so, we experienced practical limitations, the two main ones being the limited range of the helicopter out to the ice edge due to fuel and poor weather conditions that restrict or prevent flying. These aspects were challenging, and forced us to combine line transect data with data on satellite telemetry to get a total estimate with uncertainty for the whole area. For surveys covering such large areas, it is not likely that a planned design will ever be able to be followed in detail, especially in Arctic areas where weather conditions are both variable and unpredictable. It is important to allow for long periods of time with no flying. Another important issue to address is related to g(0), the probability of seeing a bear "on the line". We found no practical way to check that g(0) was 1 (or how close to 1 it was) with the limited numbers of observations we expected on the line in our study. Rather we focused a lot on observations on the line under the survey, with the two front observers paying particular attention to observations in the front, and the two observers at the back narrowing the search when conditions for observing were challenging (ice with much structure). This together with the low altitude (200ft above ground or ice) we think was sufficient to ensure a high g(0). In most areas we covered, bears were relatively easy to spot. In some areas with heavily screwed ice, bears were not easy to detect even close to the helicopter, but fortunately this made up only a small fraction of the total length of the transects. In conclusion, we think g(0) in our study was sufficiently close to 1, that the estimate of 3,000 bears is not likely to be more than a slight underestimate. Even so, we will argue that a validation of g(0) in future studies should have high priority, if it is possible to find a reasonable method for this.

References

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D. and Thomas, L. 2001. *Introduction to distance sampling - Estimating abundance of biological populations.* Oxford University Press, Oxford.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D. and Thomas, L. 2004. *Advanced Distance Sampling.* Oxford University Press, Oxford.

IUCN/SSC Polar Bear Specialist Group. 2002. Status of the polar bear. Pp. 21–35 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SCC Polar Bear Specialist Group, 23-28 June 2001, Nuuk, Greenland.* IUCN, Gland, Switzerland and Cambridge, UK.

Larsen, T. 1986. Population biology of the polar bear (*Ursus maritimus*) in the Svalbard area. Norsk Polarinst. Skrifter 184.

Marques, T.A., Andersen, M., Christensen-Daalsgaard, S., Belikov, S., Boltunov, A., Wiig, Ø., Buckland, S. and Aars, J. [In press]. The use of GPS to record distances in a helicopter distance sampling survey. *Wildl. Soc. Bull.*

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

Mauritzen, M., Derocher, A.E., Wiig, Ø., Belikov, S.E., Boltunov, A.N., Hansen, E. and Garner, G.W. 2002. Using satellite telemetry to define spatial population structure in polar bears in the Norwegian and western Russian Arctic. *J. Appl. Ecol.* **39**:79–90.

Paetkau, D., Amstrup, S.C., Born, E.W., Calvert, W., Derocher, A.E., Garner, G.W., Messier, F., Stirling, I., Taylor, M.K., Wiig, Ø. and Strobeck, C. 1999. Genetic structure of the world's polar bear populations. *Mol. Ecol.* **8**:1571–1584.

Wiig, Ø. 1995. Distribution of polar bears (*Ursus maritimus*) in the Svalbard area. *J. Zool. Lond.* **237**:515–529.

Appendix 1

Agreement on the Conservation of Polar Bears and Their Habitat

Oslo, 15 November 1973

The Governments of Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States of America,

Recognizing the special responsibilities and special interests of the States of the Arctic Region in relation to the protection of the fauna and flora of the Arctic Region;

Recognizing that the polar bear is a significant resource of the Arctic Region, which requires additional protection;

Having decided that such protection should be achieved through coordinated national measures taken by the States of the Arctic Region;

Desiring to take immediate action to bring further conservation and management measures into effect;

Have agreed as follows:

ARTICLE I

1. The taking of polar bears shall be prohibited except as provided in Article III.

2. For the purpose of this Agreement, the term "taking" includes hunting, killing and capturing.

ARTICLE II

Each Contracting Party shall take appropriate action to protect the ecosystems of which polar bears are a part, with special attention to habitat components such as denning and feeding sites and migration patterns, and shall manage polar bear populations in accordance with sound conservation practices based on the best available scientific data.

ARTICLE III

1. Subject to the provisions of Articles II and IV, any Contracting Party may allow the taking of polar bears when such taking is carried out:
   a) for bona fide scientific purposes; or
   b) by that Party for conservation purposes; or
   c) to prevent serious disturbance of the management of other living resources, subject to forfeiture to that Party of the skins and other items of value resulting from such taking; or
   d) by local people using traditional methods in the exercise of their traditional rights and in accordance with the laws of that Party; or
   e) wherever polar bears have or might have been subject to taking by traditional means by its nationals.

2. The skins and other items of value resulting from taking under sub-paragraphs (b) and (c) of paragraph 1 of this Article shall not be available for commercial purposes.

ARTICLE IV

The use of aircraft and large motorized vessels for the purpose of taking polar bears shall be prohibited, except where the application of such prohibition would be inconsistent with domestic laws.

ARTICLE V

A contracting Party shall prohibit the exportation from, the importation and delivery into, and traffic within, its territory of polar bears or any part or product thereof taken in violation of this Agreement.

ARTICLE VI

1. Each contracting Party shall enact and enforce such legislation and other measures as may be necessary for the purpose of giving effect to this Agreement.

2. Nothing in this Agreement shall prevent a Contracting Party from maintaining or amending existing legislation or other measures or establishing new measures on the taking of polar bears so as to provide more stringent controls than those required under the provisions of this Agreement.

ARTICLE VII

The Contracting Parties shall conduct national research programmes on polar bears, particularly research relating to the conservation and management of the species. They shall as appropriate coordinate such research with the research carried out by other Parties, consult with other Parties on the management of migrating polar bear populations, and exchange information on research and management programmes, research results and data on bears taken.

ARTICLE VIII

Each Contracting Party shall take actions as appropriate to promote compliance with the provisions of this Agreement by nationals of States not party to this Agreement.

ARTICLE IX

The Contracting Parties shall continue to consult with one another with the object of giving further protection to polar bears.

ARTICLE X

1. This Agreement shall be open for signature at Oslo by the Governments of Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States of America until 31st March, 1974.
2. This Agreement shall be subject to ratification or approval by the signatory Governments. Instruments of ratification or approval shall be deposited with the Government of Norway as soon as possible.
3. This Agreement shall be open for accession by the Governments referred to in paragraph 1 of this Article. Instruments of accession shall be deposited with the Depository Government.
4. This Agreement shall enter into force ninety days after the deposit of the third instrument of ratification, approval or accession. Thereafter, it shall enter into force for a signatory or acceding Government on the date of deposit of its instrument of ratification, approval, or accession.
5. This Agreement shall remain in force initially for a period of five years from its date of entry into force, and unless any Contracting Party during that period requests the termination of the Agreement at the end of that period, it shall continue in force thereafter.
6. On the request addressed to the Depository Government by any of the Governments referred to in paragraph 1 of this Article, consultations shall be conducted with a view to convening a meeting of representatives of the five Governments to consider the revision or amendment of this Agreement.
7. Any Party may denounce this Agreement by written notification to the Depository Government at any time after five years from the date of entry into force of this Agreement. The denunciation shall take effect twelve months after the Depository Government has received this notification.
8. The Depository Government shall notify the Governments referred to in paragraph 1 of this Article of the deposit of instruments of ratification, approval, or accession, for the entry into force of this Agreement and of the receipt of notifications of denunciation and any other communications from a Contracting Party specially provided for in this Agreement.
9. The original of this Agreement shall be deposited with the Government of Norway, which shall deliver certified copies thereof to each of the Governments referred to in paragraph 1 of this Article.
10. The Depository Government shall transmit certified copies of this Agreement to the Secretary-General of the United Nations for registration and publication in accordance with Article 102 of the Charter of the United Nations.

[The Agreement came into effect in May 1976, three months after the third nation required to ratify did so in February 1976. All five nations ratified by 1978. After the initial period of five years, all five Contracting Parties met in Oslo, Norway, in January 1981, and unanimously reaffirmed the continuation of the Agreement.]

Appendix 2

Annex E, Resolution on Special Protection Measures, and a recent related resolution from the PBSG

Annex E, Resolution on Special Protection Measures

The conference,

Being convinced that female polar bears with cubs and their cubs should receive special protection;

Being convinced further that the measures suggested below are generally accepted by knowledgeable scientists to be sound conservation practices within the meaning of Article II of the Agreement on the Conservation of Polar Bears;

Hereby requests the Governments of Canada, Denmark, Norway, the Union of Soviet Socialist Republics and the United States of America to take such steps as possible to:

1. Provide a complete ban on the hunting of female polar bears with cubs and their cubs; and,

2. Prohibit the hunting of polar bears in denning areas during periods when bears are moving into denning areas or are in dens.

Clarification of the need for special protection measures for female polar bears

(Resolution from the 1997 PBSG Meeting)

The IUCN Polar Bear Specialist Group,

Recognising that the RESOLUTION ON SPECIAL PROTECTION MEASURES appended to the 1973 Agreement for the Conservation of Polar Bears urges a complete ban on hunting females with cubs and their cubs; and

Recognising the requirement for sound conservation measures identified in the Agreement for the Conservation of Polar Bears; and

Recognising that the polar bear is a significant cultural, nutritional, and economic resource for local subsistence users; and

Recognising that adult females have relatively greater reproductive value compared to other sex and age groups; and

Acknowledging that harvest management practices that accommodate the occasional take of dependent young for cultural reasons are consistent with sound conservation practices so long as the mother continues to be protected; therefore

Recommends special protection for adult females and emphasises that harvest management practices that select for males and young animals may aid in offering protection for adult females.

Appendix 3

Recent publications and reports 2001–2005

Aars, J., Andersen, M., Belikov, S.E., Boltunov, A.N., Buckland, S., Marques T. and Wiig, Ø. 2004. The Barents Sea polar bear (*Ursus maritimus*) population size estimated by line transects. Pp. 19–20 in Belkovich, V.M. (ed.). *Marine Mammals of the Holarctic.* 2004. Collection of Scientific Papers. Moscow, KMK.

Ainley, D.G., Tynan, C.T. and Stirling, I. 2003. Sea ice: a critical habitat for Polar marine mammals and birds. Pp. 240–266 In Thomas, D.N. and Dickmann, G.S (eds.). *Sea Ice - An Introduction to its Physics, Biology, Chemistry and Geology.* Blackwell Science, Oxford, UK.

Amstrup, S.C. 2003. Polar bear, *Ursus maritimus.* Pp. 587–610 In Feldhamer, G.A., Thompson, B.C. and Chapman, J.A. *Wild Mammals of North America: Biology, Management, and Conservation.* Johns Hopkins University Press, Baltimore, USA.

Amstrup, S.C., Durner, G.M., Fischbach, A.S., Simac, K. and Weston-York, G. 2002. Polar bear research in the Beaufort Sea. Pp. 109–125 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group.* IUCN, Gland, Switzerland and Cambridge, UK.

Amstrup, S.C., Durner, G.M, Stirling, I. and McDonald, T.L. 2005. Allocating harvests among polar bear stocks in the Beaufort Sea. *Arctic* **58**:247–259.

Amstrup, S.C., McDonald, T.L and Durner, G.M. 2004. Using satellite radio-telemetry data to delineate and manage wildlife populations. *Wildl. Soc. Bull.* **32**:661–679.

Amstrup, S.C., McDonald, T.L. and Manly, B.F.J. (eds.). 2005. *Handbook of Capture-Recapture Analysis.* Princeton University Press, Princeton and Oxford.

Amstrup, S.C., McDonald, L.L. and Stirling, I. 2001. Polar bears in the Beaufort Sea: a 30-year mark-recapture case history. *J. Agr. Biol. Environ. Stat.* **6**:201-214.

Amstrup, S.C., York, G., McDonald, T.L., Nielson, R. and Simac, K. 2004. Detecting denning polar bears with Forward-Looking Infrared imagery (FLIR). *BioScience* **54**:337–344.

Andersen, M. and Aars, J. 2005. *Behavioural response of polar bears to disturbance by snowmobiles.* Brief Report Series, Norsk Polarinstitutt, Tromsø, Norway.

Andersen, M., Lie, E., Derocher, A.E., Belikov, S.E., Bernhoft, A., Boltunov, A.N., Garner, G.W., Skaare, J.U. and Wiig Ø. 2001. Geographical variation of PCB congeners in polar bears (*Ursus maritimus*) from Svalbard east to the Chukchi Sea. *Polar biology* **24**:231–238.

Anon. 2004. Minutes of the 2004 meeting of the Federal-Provincial-Territorial Technical Committee for polar bear Research and Management, 15–17 February 2004, Winnipeg, Manitoba, Canada.

Arnason, U., Adegoke, J.A., Bodin, K., Born, E.W., Esa, Y.B., Gullberg, A., Nilsson, M., Short, R.V., Xu, X. and Janke, A. 2002. Mammalian mitogenomic relationships and the root of the eutherian tree. *Proc. Natl. Acad. Sci. (USA)* **99**:8151–8156.

Belchansky, G.I. 2004. Arctic Ecological Research from Microwave Satellite Observations. CRC Press, Boca Raton, USA.

Belchansky, G.I., Alpatsky, I.V. and Petrosyan, V.G. 2001. The dependence of seasonal movements of female polar bears on the reproductive status. *Reports of Biochemistry and Biophysics, Russian Academy of Sciences* **379**: 290–293.

Belikov, S.E. 2002. Russian-American agreement on conservation and management of polar bears. Pp. 27–28 In Belkovich, V.M. (ed.) *Abstracts of reports of the 3rd Conference Marine Mammals of the Holarctic.* Moscow, Russian Federation. (In Russian).

Belikov, S.E., Boltunov, A.N. and Zdor, E.V. 2004. Monitoring of the Chukchi-Alaskan population of polar bears (*Ursus maritimus*). Pp. 42–45 In Belkovich, V.M. (ed.). *Marine Mammals of the Holarctic.* Collection of Scientific Papers. KMK, Moscow, Russian Federation.

Born, E.W. 2001. The Greenland catch of polar bears from the Davis Strait, Baffin Bay and Kane Basin areas, 1993–99. Working paper to the Canadian polar bear Technical Committee meeting, 4–5 February 2001, Edmonton, Alberta, Canada.

Born, E.W. 2002. Research on polar bears in Greenland 1997–2001. Pp. 67–74 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SCC Polar Bear Specialist Group, 23-28 June 2001, Nuuk, Greenland*. IUCN, Gland, Switzerland and Cambridge, UK.

Born, E.W. 2005. The catch of polar bears in Greenland, 1993–(2004). Working paper to the Canadian Polar Bear Technical Committee meeting, 7-9 February 2005, Edmonton, Alberta, Canada.

Bossi, R., Vorkamp, K., Riget, F.F., Dietz, R., Sonne, C. and Fauser, P. 2005. Perfluorinated surfactants in fish, mammals and birds from Greenland and Faroe Islands. Results from a preliminary screening. *Environ. Pollut.* **136**:323–329.

Braathen, M., Derocher, A.E., Wiig, Ø., Sørmo, E.G., Lie, E., Skaare, J.U. and Jenssen, B.M. 2004. Relationships between PCBs and thyroid hormones and retinol in female and male polar bears (*Ursus maritimus*). *Environmental Health Perspective* **112**: 826–833.

Brook, R.K. and Richardson, E.S. 2001. Observations of polar bear, *Ursus maritimus*, predatory behaviour toward caribou, *Rangifer tarandus*, in Wapusk National Park, Manitoba. *Arctic* 55:193–196.

Brower, C.D., Carpenter, A., Branigan, M.L., Calvert, W., Evans, T., Fischbach, A.S., Nagy, J.A., Schliebe, S. and Stirling, I. 2002. The polar bear management agreement for the Southern Beaufort Sea: An evaluation of the first ten years of a unique conservation agreement. *Arctic* **55**:362–372.

Calvert, W., Branigan, M., Cattet, M., Doidge, W., Elliott, C., Lunn, N.J., Messier, F., Obbard, M., Otto, R., Ramsay, M., Stirling, I., Taylor, M. and Vandal, D. 2002. Research on polar bears in Canada 1997–2000. Pp. 53–63 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Cattet, M.R.L., Caulkett, N.A. and Lunn, N.J. 2003. Anesthesia of polar bears using xylazine-zolazepam-tiletamine or zolazepam-tiletamine. *J. Wildl. Dis.* **39**:655–664.

Cattet, M.R.L., Caulkett, N.A., Obbard, M.E. and Stenhouse, G.B. 2002. A body condition index for ursids. *Can. J. Zool.* **80**:1156-1161.

Cattet, M.R.L., Duignan, P.J., House, C.A. and St. Aubin, D.J. 2004. Antibodies to canine distemper and phocine distemper viruses in polar bears from the Canadian Arctic. *J. Wildl. Dis.* 40:338–342.

Cattet, M.R.L. and Obbard, M.E. 2005. To weigh or not to weigh – conditions for the estimation of body mass by morphometry. *Ursus* **16**:102–107.

Cattet, M.R.L., Watts, P.D. and Sim, J.S. 2001. Variation in the chemical composition of adipose tissue of three species of ursids. *Can. J. Zool.* **79**:1512–1517.

Caulkett, N.A. and Cattet, M.R.L. 2002. Anesthesia of bears. In Heard, D. (Ed). *Zoological Restraint and Anesthesia*. International Veterinary Information Service (www.ivis.org), Ithaca, New York, USA.

Clark, D. 2003. Polar bear-human interactions in Canadian national parks, 1986–2000. *Ursus* **14**: 65–71.

Crompton, A. 2005. A genetic assignment of the population structure of polar bears (*Ursus maritimus)* in the greater Hudson Bay ecosystem. Master of Science Thesis, Trent University.

Davis, C. 2003. Population genetics of ice breeding seals: the influence of breeding habitat and phylogeny. Doctor of Philosophy, University of Alberta, Edmonton.

Derocher, A.E. 2005. Population ecology of polar bears at Svalbard, Norway. *Popul. Ecol.* **47**:267–275.

Derocher, A.E., Belikov, S.E., Boltunov, A.N., Wiig, Ø. and Mauritzen, M. 2002. Pp. 10–15 in Belkovich, V.M. (ed.) *Abstracts of reports of the 3rd Conference Marine Mammals of the Holarctic*. Moscow. (In Russian).

Derocher, A.E., Lunn, N.J. and Stirling, I. 2004. Polar bears in a changing climate. *Integr. Comp. Biol.* **44**:163–176.

Derocher, A.E. and Wiig, Ø. 2002. Postnatal growth in body length and mass of polar bears (*Ursus maritimus*) at Svalbard. *Journal of Zoology* **256**:343–349.

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

Derocher, A.E., Wiig, Ø., Andersen, M., Vongraven, D. and Ekker, M. 2002. Polar bear research and management in Norway 1997–2000. Pp. 75–83 In Lunn, N.J., Schliebe, S. and Born, E.W (Eds.). Polar bears. *Proceedings of the 13th Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Derocher, A.E., Wolkers, H., Colborn, T., Larsen, T.S., Schlabach, M. and Wiig, Ø. 2003. Contaminant in Svalbard polar bears samples archived since 1967 and possible population effects. *The Science of the Total Environment* **301**:163–174.

Dietz, R., Riget, F.F., Sonne, C., Letcher, R.J., Born, E.W. and Muir D.C.G. 2004. Seasonal and temporal trends in polychlorinated biphenyls and organochlorine pesticides in East Greenland polar bears (*Ursus maritimus*), 1990–2001. *Sci. Total Environ.* **331**:107–124.

Durner, G.M., Amstrup, S.C. and Ambrosius, K. [In press]. Polar bear maternal den habitat on the Arctic National Wildlife Refuge, Alaska. *Arctic* **00**:000-000.

Durner, G.M., Amstrup, S.C. and Fischbach, A.S. 2003. Habitat characteristics of polar bear terrestrial maternal den sites in northern Alaska. *Arctic* **56**:55–62.

Durner, G.M., Amstrup, S.C., McDonald, T., Smith, C. and Johnson, W. 2001. Predicting the numbers of polar bears impacted by oil spills.P.64 In *14th Biennial Conference on the Biology of Marine Mammals, Abstracts*. Society for Marine Mammalogy.

Durner, G.M., Amstrup, S.C., Nielson, S. and McDonald, T.L. 2004. Using discrete choice modeling to generate resource selection functions for female polar bears in the Beaufort Sea. Pp.107–120 In Huzurbazar, S. (ed.). *Proceedings of the 1st Conference on Resource Selection Modeling*. Western EcoSystems Technology Inc., Cheyenne, Wyoming, USA.

Dyck, M.G. 2001. Effects of tundra vehicle activity on polar bears (*Ursus maritimus*) at Churchill, Manitoba. Unpublished M.N.R.M. Dissertation, University of Manitoba, Winnipeg, Manitoba, Canada.

Dyck, M.G. and Baydack, R.K. 2004. Vigilance behaviour of polar bears (*Ursus maritimus*) in the context of wildlife-viewing activities at Churchill, Manitoba, Canada. *Biol. Conserv.* **116**:343–350.

Dyck, M.G., Bourgeois, J. and Miller, T.R. 2004. Bacular growth and variation of polar bears (*Ursus maritimus*) in the Canadian Arctic. *J. Zool.* **264**:105–110.

Dyck, M.G. and Daley, K.J. 2002. Cannibalism of a yearling polar bear (*Ursus maritimus*) at Churchill, Canada. *Arctic* **55**:190–192.

Evans, T.J. 2004. Concentrations of selected essential and non-essential elements in adult male polar bears (*Ursus maritimus*) from Alaska. U.S. Fish and Wildlife Service, Anchorage, AK, USA. Technical Report MMM 04-02.

Evans, T.J. 2004. PCBs and chlorinated pesticides in adult male polar bears (*Ursus maritimus*) from Alaska. U.S. Fish and Wildlife Service, Anchorage, AK, USA. Technical Report MMM 04-01.

Evans, T.J., Fischbach, A.S., Schliebe, S.L., Manly, B.F., Kalxdorff, S.B. and York, G.S. 2003. Polar bear aerial survey in the eastern Chukchi Sea: a pilot study. *Arctic* **56(4)**: 359–366.

Evans, P.E. and Stirling, I. 2001. Life History Strategies of Marine Mammals. Pp. 7–58 In Evans, P.E. and Raga, A. (eds.) *Marine Mammals: Biology and Conservation*. Plenum Press, London, UK.

Ferguson, S., Laake, J., Rosing-Asvid, A., Stirling, I. and Messier, F. 2001. Delineating Canadian and Greenland polar bear (*Ursus maritimus*) populations by cluster analysis of movements. *Can. J. Zool.* **79**:690709.

Ferguson, S.H., Stirling, I. and McLoughlin, P. 2005. Climate change and ringed seal (*Phoca hispida*) recruitment in western Hudson Bay. *Mar. Mamm. Sci.* **21**:121–135.

Ferguson, S.H., Taylor, M.K., Born, E.W., Rosing-Asvid, A. and Messier, F. 2001. Activity and movement patterns of polar bears inhabiting consolidated versus active pack ice. *Arctic* **54**:49–54.

Ferguson, S.H., Taylor, M.K., Rosing-Asvid, A., Born, E.W. and Messier, F. 2000. Relationships between denning of polar bears and conditions of sea ice. *J. Mamm.* **81**:1118–1127.

Gagnon, A.S. and Gough, W.A. 2005. Trends in the dates of ice freeze-up and breakup over Hudson Bay, Canada. *Arctic* **58**:370–382.

Grahl-Nielsen, O., Andersen, M., Derocher, A.E., Lydersen, C., Wiig, Ø. and Kovacs, K.M. 2003. Fatty acid composition of the adipose tissue of polar bears and their prey: ringed seals, bearded seals and harp seals. *Marine Ecology Progress Series* **265**:275–282.

Grahl-Nielsen, O., Andersen, M., Derocher, A.E., Lydersen, C., Wiig, Ø. and Kovacs, K.M. 2004. Reply to Comment on Grahl-Nielsen *et al.* (2003). Sampling, data treatment and predictions in investigations on fatty acids in marine mammals. *Marine Ecology Progress Series* **281**:303–306.

Haave, M., Ropstad, E., Derocher, A.E., Lie. E., Dahl, E., Wiig, Ø., Skaare, J.U. and Jenssen, B.M. 2003. PCBs and reproductive hormones in female polar bears. *Environmental Health Perspectives* **111**:431–436.

Heier, A., Sonne, C., Gröne, A., Leifsson, P.S., Dietz, R., Born, E.W. and Bacciarini, L.N. [In press]. Liver RBP immunohistochemistry in free-ranging polar bears. An immunohistochemical study of retinol-binding protein (RBP) in livers of polar bears (*Ursus maritimus*) from East Greenland. *Zoo and Wild. Med.*

Holst, M. and Stirling, I. 2002. A comparison of ringed seal (*Phoca hispida*) biology on the east and west sides of the North Water Polynya, Baffin Bay. *Aqua. Mamm.* **28**:221–230.

Howell-Skalla, L.A., Cattet, M.R.L., Ramsay, M.A. and Bahr, J.M. 2002. Seasonal changes in testicular size and serum LH, prolactin and testosterone concentrations in male polar bears (*Ursus maritimus*). *Reproduction* **123**:729–733.

Howlin, S., Stishov, M., McDonald, L.L. and Schliebe, S.L. 2001. Modeling polar bear den site selection on Wrangel Island. Submitted *Journal of Agricultural, Biological, and Environmental Statistics.*

IUCN/SSC Polar Bear Specialist Group. 2002. Status of the polar bear. Pp. 21–35 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar Bears: Proceedings of the 13th Working Meeting of the IUCN/SCC Polar Bear Specialist Group, 23-28 June 2001, Nuuk, Greenland.* IUCN, Gland, Switzerland and Cambridge, UK.

Kalxdorff, S., Schliebe, S.L. and Belikov, S. 2001. U.S./Russia Bilateral Agreement on polar bears Breaks New Ground in International conservation. In: CAFF: *Arctic Flora and Fauna: Status and Conservation*. Helsinki, Finland.

Kalxdorff, S., Schliebe, S.L., Evans, T. and Proffitt, K. 2002. Aerial surveys of polar bears along the coast and barrier islands of the Beaufort Sea, Alaska, September–October 2001. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, Alaska, USA.

Kalxdorff, Susanne B. 2003. Demography and behavior of polar bears feeding on stranded marine mammal carcasses in the Beaufort Sea region, Alaska. Interim Report to Minerals Management Service, Marine Mammals Management, Anchorage, Alaska, USA.

Kannan, K., Koistinen, J., Beckman, K., Evans, T., Gorzelany, J.F., Hansen, K.J., Jones, P.D., Helle, E., Nyman, M. and Geisey, J.P. 2001. Accumulation of perflurooctane sulfonate in marine mammals. *Environmental Science and Technology* **35**:1593–1598.

Kern, J.W., McDonald, T.L., Amstrup, S.C., Durner, G.M. and Erickson, W.P. 2003. Using the bootstrap and fast Fourier transform to estimate confidence intervals of 2D kernel densities. *Environ. Ecol. Stat.* **10**:405–418.

Kirkegaard, M., Sonne, C., Leifsson, P.S., Dietz, R., Born, E.W., Letcher, R.J. and Muir, D.C.G. 2005. Histology of selected immunological organs in polar bear (*Ursus maritimus*) from East Greenland in relation to levels of organohalogenes. *Sci. Total Environ.* **341**:119–132.

Kochnev, A.A. 2001. The behavior of orphaned cubs and attitude to non-own posterity among wild polar bears (*Ursus maritimus* Phipps). *Bulletin of Moscow Society of Naturalists. Biological series* **106**:13–21. (In Russian with English summary).

Kochnev, A.A. 2001. Walruses on Wrangel Island and polar bear impact on them. Pp.86–87 In Vladimirov, V.A. (ed.). Results of the Far East Marine Mammal Researches in 1991–2000: Materials to the 16th Working Group Meeting under Project 02.05-61 "Marine Mammals" within the framework of the U.S.-Russia Agreement on Cooperation in the Field of Environmental Protection. VNIRO Publishing, Moscow, Russian Federation. (In Russian).

Kochnev, A.A. 2001. Pacific walrus in the area of the Wrangel and Herald islands and its protection. Pp.180–205 In Pavlov, D.S. and Bychkov, V.A. (eds.). *The Walrus: Mode of the Species*. Nauka, Moscow, Russian Federation. (In Russian).

Kochnev, A.A. 2002. Autumn aggregations of polar bears on the Wrangel Island and their importance for the population. Pp.137–138 in *Marine Mammals of the Holarctic. Abstracts of the Second International Conference.* KMK, Moscow, Russian Federation.

Kochnev, A.A. 2002. Marine mammals investigations and management in Wrangel Island State Reserve. Pp.135–136 in *Marine Mammals of the Holarctic. Abstracts of the Second International Conference*. KMK, Moscow, Russian Federation.

Kochnev, A.A. 2002. The factors of the Pacific walrus mortality at the coastal haulouts at the Wrangel Island. Pp. 191–215 in Aristov, A.A. *et al.* (eds.). *Marine mammals: results of investigations conducted in 1995–1998*. MMC, Moscow, Russian Federation. (In Russian with English summary).

Kochnev, A.A. 2004. Warming of eastern Arctic and present status of the Pacific walrus (*Odobenus rosmarus divergens*) population. Pp. 284–288 in *Marine Mammals of the Holarctic*. Collection of Scientific Papers. Moscow.

Kochnev, A.A. 2004. The polar bear in Chukotka: concerns and hopes. *Wildl. Conserv.* **3**:7–14 (In Russian).

Kochnev, A.A., Etylin, V.M., Kavry, V.I., Siv-Siv, E.B. and Tanko, I.V. [In press]. The role of devotions and beliefs in the traditional subsistence lifestyle of the Chukotka natives (by the example of the polar bear). Proceedings of the conference "Chukotka Heritage". (In Russian).

Lie, E. 2004. Organochlorine contaminants in polar bears (*Ursus maritimus*). Geographical trends and possible immunotoxic effects. Ph.D. thesis, Norwegian School of Veterinary Science, Oslo.

Lie, E., Bernhoft, A., Riget, F., Belikov, S.E., Boltunov, A.N., Derocher, A.E., Garner, G.W., Wiig, Ø. and Skaare, J.U. 2003. Geographical distribution of organochlorine pesticides (OCPs) in polar bears (*Ursus maritimus*) in the Norwegian and Russian Arctic. *Science of the Total Environment* **306**:159–170.

Lie, E., Larsen, H.J.S., Larsen, S., Johansen, G.M., Borgen, T., Derocher, A.E., Lunn, N.J., Norstrom, R.J., Wiig, Ø. and Skaare, J.U. 2005. Does high OC exposure impair the resistance to infection in polar bears (*Ursus maritimus*)? Part II: Effect of OCs on the cellular immunity. *J. Toxicol. Environ. Health A* **68**:457–484.

Lie, E., Larsen, H.J.S., Larsen, S., Johansen, G.M., Derocher, A.E., Lunn, N.J., Norstrom, R.J., Wiig, Ø. and Skaare, J.U. 2004. Does high organochlorine (OC) exposure impair the resistance to infection in polar bears (*Ursus maritimus*)? Part I: Effect of OCs on the humoral immunity. *J. Toxicol. Environ. Health A* **67**:555–582.

Lie, E., Larsen, H.J.S., Larsen, S., Johansen, G.M., Derocher, A.E., Lunn, N.J., Norstrom, R.J., Wiig, Ø. and Skaare, J.U. 2005. Does high organochlorine (OC) exposure impair the resistance to infection in polar bears (*Ursus maritimus*)? Part II: Possible effect of OCs on mitogen- and antigen-induced lymphocyte proliferation. *Journal of Toxicology and Environmental Health Part A* **68**:457–484.

Lunn, N.J., Atkinson, S., Branigan, M., Calvert, W., Clark, D., Doidge, B., Elliott, C., Nagy, J., Obbard, M., Otto, R., Stirling, I., Taylor, M., Vandal, D. and Wheatley, M. 2002. Polar bear management in Canada 1997–2000. Pp. 41–52 In Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Lunn, N.J., Schliebe, S. and Born, E.W. (eds.). 2002. *Polar bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Lunn, N.J., Stirling, I., Andriashek, D. and Richardson, E. 2004. Selection of maternity dens by female polar bears in western Hudson Bay, Canada and the effects of human disturbance. *Polar Biol.* **27**:350–356.

Manly, B.F.J., McDonald, T.L., Amstrup, S.C. and Regehr, E.V. 2003. Improving size estimates of open animal populations by incorporating information on age. *BioScience* **53**:666–669.

Mauritzen, M. 2002. Pattern and processes in female polar bear space-use. Dr. Sci. thesis, University of Oslo.

Mauritzen, M., Belikov, S.E., Boltunov, A.N., Derocher, A.E., Hansen, E., Ims, R.A., Wiig, Ø. and Yoccoz, N. 2003. Functional responses in polar bear habitat selection. *Oikos* **100**:112–124.

Mauritzen, M., Derocher, A.E., Pavlova, O. and Wiig, Ø. 2003. polar bears (*Ursus maritimus*) on drift ice – walking the treadmill. *Animal Behaviour* **66**:107–113.

Mauritzen, M., Derocher, A.E., Wiig, Ø., Belikov, S.E., Boltunov, A.N., Hansen, E. and Garner, G. 2002. Using satellite telemetry to define spatial population structure in polar bears in the Norwegian and western Russian Arctic. *Journal of Applied Ecology* **39**:79–90.

McDonald, T.L., Amstrup, S.C. and Manly, B.F.J. 2003. Tag loss can bias Jolly-Seber capture-recapture estimates. *Wildl. Soc. Bull.* **31**:814–822.

Obbard, M.E. and Walton, L.R. 2004. The Importance of Polar Bear Provincial Park to the Southern Hudson Bay Polar Bear Population in the Context of Future Climate Change. Pp.105-116 In Rehbein, C.K., Nelson, J.G., Beechey, T.J. and Payne, R.J. (eds.). *Parks and protected areas in Ontario, 2004: planning northern parks and protected areas. Proceedings of the Parks Research Forum of Ontario Annual General Meeting, May 4–6, 2004, Thunder Bay, Ontario, Canada.*

Olsen, G.H., Mauritzen, M., Derocher, A.E., Sørmo, E.G., Skaare, J.U., Wiig, Ø. and Jenssen, B.M. 2003. Space-use strategy is an important determinant of PCB concentrations in female polar bears in the Barents Sea. *Environmental Science and Technology* **37**:4919–4924.

Oskam, I.C. 2004. Effects of organochlorine contaminants on mammalian reproductive and endocrine systems. Ph.D. thesis, Norwegian School of Veterinary Science, Oslo.

Oskam, I., Ropstad, E., Lie, E., Derocher, A.E., Wiig, Ø., Dahl, E., Larsen, S. and Skaare, J.U. 2004. Organochlorines affect the steroid hormone cortisol in polar bears (*Ursus maritimus*) at Svalbard, Norway. *Journal of Toxicology and Environmental Health Part A* **67**:959–977.

Oskam, I., Ropstad, E., Lie, E., Derocher, A.E., Wiig, Ø., Dahl, E., Larsen, S., Wiger, R. and Skaare, J.U. 2003. Organochlorines affect the major androgenic hormone, testosterone, in male polar bears (*Ursus maritimus*) at Svalbard. *Journal of Toxicology and Environmental Health Part A* **66**:2119–2139.

Plante, A., Messier, F., Romito, T. and Taylor, M. 2001. *Atlas of Polar Bear Movements in Nunavut, Northwest Territories and Neighbouring Areas*. Nunavut Wildlife Service, Department of Sustainable Development and University of Saskatchewan. Hardcopy and Compact Disk Formats.

Polischuk, S.C., Hobson, K.A. and Ramsay, M.A. 2001. Use of stable-carbon and -nitrogen isotopes to assess weaning and fasting in female polar bears and their cubs. *Can. J. Zool.* **79**:499–511.

Polischuk, S.C., Norstrom, R.J. and Ramsay, M.A. 2002. Body burdens and tissue concentrations of organochlorines in polar bears (*Ursus maritimus*) vary during seasonal fasts. *Environ. Pollut. Vol.* **118**:29–39.

Pomponi, M., Bertonati, C., Patamia, M., Marta, M., Derocher, A.E., Lydersen, C., Kovacs, K.M., Wiig, Ø. and Bårdgard, A.J. 2002. Polar bear hemoglobin and human HbA: same 2,3-Diphosphoglycerate binding site but asymmetry of the binding? *Hemoglobin* **26**:363–371.

Pomponi, M., Gavuzzo, E., Bertonati, C., Derocher, A.E., Lydersen, C., Wiig, Ø. and Kovacs, K.M. 2004. Hemoglobin, pH and DPG/Chloride shifting. *Biochimie* **86**:927–932.

Richardson, E.S. 2004. Polar bear (*Ursus maritimus*) maternity den site selection and the effects of forest fires on denning habitat in western Hudson Bay. Unpublished M.Sc. Dissertation, University of Alberta, Edmonton, Canada.

Richardson, E., Stirling, I. and Hik, D.S. 2005. Polar bear (*Ursus maritimus*) maternity denning habitat in western Hudson Bay: a bottom-up approach to resource selection functions. *Can. J. Zool.* **83**:860–870.

Rosing-Asvid, A. 2002. The polar bear hunt in Greenland. Greenland Institute of Natural Resources, Technical Report No. 45.

Rosing-Asvid, A., Born, E.W. and Kingsley, M.C.S. 2002. Age at sexual maturity of males and timing of the mating season of polar bears (*Ursus maritimus*) in Greenland. *Polar Biol.* **25**:87–883.

Sandala, G.M., Sonne, C., Dietz, R., Muir, D.C.G., Valters, K., Bennett, E.R., Born, E.W. and Letcher, R.J. 2004. Hydroxylated and Methyl Sulfone PCB Metabolites in Adipose and Whole Blood of Polar Bear (*Ursus maritimus*) from East Greenland. *Sci. Total Environ.* **331**:125–14.

Schliebe, S.L. 2001. United States-Russia sign polar bear accord. In: *Arctic Bulletin* World Wildlife Fund **No. 4**:17.

Schliebe, S.L., Bridges, J.W., Evans, T.J., Kalxdorff, S.B., Fischbach, A.S. and Lierheimer, L. 2002. Polar bear management in Alaska 1997–2000. In: *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*. IUCN, Gland, Switzerland and Cambridge, UK.

Schliebe, S., Kalxdorff, S. and Evans, T. 2001. Aerial surveys of polar bears along the coast and barrier islands of the Beaufort Sea, Alaska, September–October 2000. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, Alaska, USA.

Scott, P.A. and Stirling, I. 2002. Chronology of terrestrial den use by polar bears in western Hudson Bay as indicated by tree growth anomalies. *Arctic* **55**:151–166.

Simac, K., Amstrup, S., Weston York, G., McDonald, T., Durner, G. and Fischbach, A. 2001. Forward-Looking Infrared (FLIR): A new method for detecting maternal polar bear dens (poster). P.197 In *14th Biennial Conference on the Biology of Marine Mammals, Abstracts*. Society for Marine Mammalogy.

Skaare, J.U., Larsen, H.J., Lie, E.; Bernhoft, A., Derocher, A.E., Norstrom, R., Ropstad, E., Lunn, N.J. and Wiig, Ø. 2002. Ecological risk assessment of persistent organic pollutants in the Arctic. *Toxicol.* **181–182**:193–197.

Skaare, J.U., Larsen, H.J., Lie, E., Ropstad, E., Bernhoft, A., Derocher, A.E., Lunn, N.J., Norstrom, R. and Wiig, Ø. 2001. Relationships between high loads of organic contaminants and health effects in arctic mammals – Immune response and chlorinated environmental pollutants in polar bear. *Pharmacol. Toxicol.* **88** (Suppl. 1):14.

Smith, T.S. and Johnson, B.A. 2004. Modeling the effects of human activity on Katmai brown bears (*Ursus arctos*) through the use of survival analysis. *Arctic* **57**:160–165.

Smith, T.S. and Partridge, S.T. 2004. Dynamics of intertidal foraging by coastal brown bears in southwestern Alaska. *.J. Wildl. Manage.* **68**:233–240.

Smithwick, M.S., de Silva, A., Muir, D.C.G., Mabury, S., Solomon, K., Sonne, C., Dietz, R. and Born, E.W. 2005a. Perfluorinated acids in heptatic tissue from East Greenland polar bears (*Ursus maritimus*) 1999–2001. *Environ. Toxicol. Chem.* **24**:981–986.

Smithwick, M., Martin, J.W., Mabury, S.A., Solomon, K., Sonne, C., Born, E.W., Dietz, R., Derocher, A. E., Letcher, R.J., Evans, T.J., Gabrielsen, G.W., Nagy, J., Stirling, I., Taylor, M.K. and Muir, D.C.G. [In prep.] Perfluoroalkyl contaminants in polar bears (*Ursus maritimus*). *Environmental Science and Technology*.

Smithwick, M., Muir, D.C.G., Mabury, S.A., Solomon, K., Sonne, C., Martin, J.W., Born, E.W., Dietz, R., Derocher, A.E., Evans, T., Gabrielsen, G.W., Nagy, J., Stirling, I. and Taylor, M.K. 2005b. A circumpolar study of perfluoroalkyl contaminants in polar bear hepatic tissue (*Ursus maritimus*). *Environ. Sci. Technol.* **39**:5517–5523.

Sonne, C. 2004. Organohalogen concentrations and a gross and histologic assessment of multiple organ systems in East Greenland polar bears (*Ursus maritimus*). Ph.D. thesis. National Environmental Research Institute, Roskilde, Denmark.

Sonne, C., Dietz, R., Born, E.W., Riget, F.F., Kirkegaard, M., Hyldstrup, L., Letcher, R.J. and Muir, D.C.G. 2004. Is bone mineral composition disrupted by organochlorines in East Greenland polar bears (*Ursus maritimus*)? *Environ. Health Perspect.* **112**:1711–1716.

Sonne, C., Dietz, R., Leifsson, P.S., Born, E.W., Kirkegaard, M., Letcher, R.J., Muir, D.C.G., Riget, F.F. and Hyldstrup, L. [In press]. Environmental organohalogen contaminants as a co-factor in the development of renal lesions in East Greenland polar bears (*Ursus maritimus*). *Environ. Toxicol. Chem.*

Sonne, C., Dietz, R., Leifsson, P.S., Born, E.W., Letcher, R.J., Kirkegaard, M., Muir, D.C.G., Riget, F.F. and Hyldstrup, L. 2005a. Do organohalogen contaminants contribute to histopathology in liver from East Greenland polar bears (*Ursus maritimus*)? *Environ. Health Perspect.* **113**:1569–1574.

Sonne, C., Leifsson, P.S., Dietz, R., Born, E.W., Letcher, R.J., Kirkegaard, M., Muir, D.C.G., Andersen, L.W., Riget, F.F. and Hyldstrup, L. 2005b. Enlarged clitoris in wild polar bears (*Ursus maritimus*) can be misdiagnosed as pseudohermaphroditism. *Sci. Total Environ.* **337**:45–58.

Sonne, C., Riget, F.F., Dietz, R., Kirkegaard, M., Born, E.W., Letcher, R.J. and Muir, D.C.G. 2005c. Trends in fluctuating asymmetry in East Greenland polar bears (*Ursus maritimus*) from 1892 to 2002 in relation to organohalogen pollution. *Sci. Total Environ.* **341**:81–96.

Stirling, I. 2001. Polar bear. Pp.76–77 In Macdonald, D. (ed.). *The New Encyclopedia of Mammals*. Oxford University Press, Oxford, UK.

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

Stirling, I. 2002. Polar bear *Ursus maritimus*. Pp.945–948 In Perrin, W.F., Würsig, B. and Thewissen, J.G.M. (eds.). *Encyclopedia of Marine Mammals*. Academic Press, San Diego, USA.

Stirling, I. 2005. Reproductive Rates of Ringed Seals and survival of pups in Northwestern Hudson Bay, Canada, 1991–2000. *Pol. Biol.* **28**:381–387.

Stirling, I., Lunn, N.J., Iacozza, J., Elliott, C. and Obbard, M. 2004. Polar bear distribution and abundance on the southwestern Hudson Bay coast during open water season, in relation to population trends and annual ice patterns. *Arctic* **57**:15–26.

Stirling, I. and Smith, T.G. 2004. Implications of warm temperatures and an unusual rain event on the survival of ringed seals on the coast of southeastern Baffin Island. *Arctic* **57**:59–67.

Stirling, I. and Thomas, J.A. 2003. Relationships between underwater vocalizations and mating systems in phocid seals. *Aquat. Mamm.* **29**:247–246.

Stone, R.S., Belchansky, G., Drobot, S. and Douglas, D.C. 2004. Diminishing sea ice in the western Arctic Ocean. Pp.S32–S33 In Levinson, D.H. and Waple, A.M. (eds.). *State of the climate in 2003. Bulletin of the American Meterological Society* **85**(6).

Taylor, M.K., Akeeagok, S., Andriashek, D., Barbour, W., Born, E.W., Calvert, W., Cluff, H.D., Ferguson, S., Laake, J., Rosing-Asvid, A., Stirling, I. and Messier, F. 2001. Delineating Canadian and Greenland polar bear (*Ursus maritimus*) populations by cluster analysis of movements. *Can. J. Zool.* **79**:690–709.

Taylor, M.K., Laake, J., Cluff, H.D., Ramsay, M. and Messier, F. 2002. Managing the risk of harvest for the Viscount Melville Sound polar bear population. *Ursus* **13**:185–202.

Taylor, M.K., Laake, J., McLoughlin, P.D., Born, E.W., Cluff, H.D., Ferguson, S.H., Rosing-Asvid, A., Schweinsburg, R. and Messier, F. 2005. Demography and population viability of a hunted population of polar bears. *Arctic* **58**:203–214.

Taylor, M.K., Obbard, M., Pond, B., Kuc, M. and Abraham, D. 2001. RISKMAN: Stochastic and Deterministic Population Modelling RISK MANagement decision tool for harvested and unharvested populations. Government of Nunavut, Iqaluit, Nunavut Territory.

Tielmann, J. and Kapel, F.O. 1998. Exploitation of ringed seals (*Phoca hispida*) in Greenland. NAMMCO *Sci. Publ.* **1**:130–151.

Tryland, M., Brun, E., Derocher, E.W., Arnemo, J.M., Kierulf, P., Ølberg, R. and Wiig, Ø. 2002. Plasma chemistry in free-ranging polar bears from Svalbard. *Journal of Wildlife Diseases* **38**:566–575.

Urashima, T., Nagata, H., Nakamura, T., Arai, I., Saito, T., Imazu, K., Hayashi, T., Derocher, A.E. and Wiig, Ø. 2003. Differences in oligosaccharid pattern of polar bears colostrums and mid-lactation milk. *Comparative Biochemistry and Physiology* **136**: 887–896.

Van de Velde, F., Stirling, I. and Richardson, E. 2003. Polar bear (*Ursus maritimus*) denning in the area of the Simpson Peninsula, Nunavut. *Arctic* **56**:191–197.

Verreault, J., Muir, D.C.G., Norstrom, R.J., Stirling, I., Fisk, A.T., Gabrielsen, G.W., Derocher, A.E., Evans, T., Dietz, R., Sonne, C., Sandala, G.M., Gebbing, W., Riget, F.F., Born, E.W., Taylor, M.K., Nagy, J. and Letcher, R.J. 2005. Chlorinated hydrocarbon contaminants and metabolites in polar bears (*Ursus maritimus)* from Alaska, Canada, East Greenland, and Svalbard: 1996?2002. *Sci. Total Environ.* **351–352**:369–390.

Vongraven, D. 2001. Forslag til framtidige prioriteringer innen overvåking og forskning på isbjørn. Internal Report, Norwegian Polar Institute, Tromsø, Norway. (In Norwegian).

Wiig, Ø., Blix, A.S., Derocher, A.E., Kovacs, K. and Schweder, T. 2001. National priorities for polar bear research in Norway. Report to the Norwegian National Committee on Polar Research, The Research Council of Norway, Oslo, Norway.

Wiig, Ø., Born, E.W. and Toudal Pedersen, L. 2003. Movements of female polar bears (*Ursus maritimus*) in the East Greenland pack ice. *Polar Biology* **26**:509–516.

Wolkers, H., van Bavel, B., Derocher, A.E., Wiig, Ø., Kovacs, K., Lydersen, C. and Lindström, G. 2004. Congener-specific accumulation and food chain transfer of polybrominated diphenyl ethers in two arctic food chains. *Environ. Sci. Technol.* **38**:1667–1674.

Appendix 4

Numbers allocated to each country for eartags and tattoos used in polar bear management and research

Number Series	Letter[1]	Country	Year Assigned
1–249	A	USA	1968
250–499	N	Norway	1968
500–749	X	Canada	1968
750–999	C	USSR	1968
1000–1999	A	USA	1969
2000–5999	X	Canada	1971–76
6000–6999	A	USA	1976
7000–7499	D	Denmark	1976
7500–7999	N	Norway	1976
8000–8499	C	USSR	1976
8500–9999	X	Canada	1980
10000–19999	X	Canada	1984
20000–22999	A	USA	1984
23000–23999	N	Norway	1984
24000–24999	D	Denmark	1984
25000–25999	C	USSR/Russia	1984
26000–29999	N	Norway	1997
30000–39999	X	Canada	1997

[1] A unique letter has been assigned to each country for use on eartags and in tattoos in combination with the above number series

Occasional Papers of the IUCN Species Survival Commission

1. *Species Conservation Priorities in the Tropical Forests of Southeast Asia*. Edited by R.A. Mittermeier and W.R. Constant, 1985, 58pp. (Out of print)
2. *Priorités en matière de conservation des espèces à Madagascar*. Edited by R.A. Mittermeier, L.H. Rakotovao, V. Randrianasolo, E.J. Sterling and D. Devitre, 1987, 167pp. (Out of print)
3. *Biology and Conservation of River Dolphins*. Edited by W.F. Perrin, R.K. Brownell, Zhou Kaiya and Liu Jiankang, 1989, 173pp. (Out of print)
4. *Rodents. A World Survey of Species of Conservation Concern*. Edited by W.Z. Lidicker, Jr., 1989, 60pp.
5. *The Conservation Biology of Tortoises*. Edited by I.R. Swingland and M.W. Klemens, 1989, 202pp. (Out of print)
6. *Biodiversity in Sub-Saharan Africa and its Islands: Conservation, Management, and Sustainable Use*. Compiled by Simon N. Stuart and Richard J. Adams, with a contribution from Martin D. Jenkins, 1991, 242pp.
7. *Polar Bears: Proceedings of the Tenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group*, 1991, 107pp.
8. *Conservation Biology of Lycaenidae (Butterflies)*. Edited by T.R. New, 1993, 173pp. (Out of print)
9. *The Conservation Biology of Molluscs: Proceedings of a Symposium held at the 9th International Malacological Congress, Edinburgh, Scotland, 1986*. Edited by Alison Kay. Including a Status Report on Molluscan Diversity, written by Alison Kay, 1995, 81pp.
10. *Polar Bears: Proceedings of the Eleventh Working Meeting of the IUCN/SSC Polar Bear Specialist Group, January 25-28 1993, Copenhagen, Denmark*. Compiled and edited by Øystein Wiig, Erik W. Born and Gerald W. Garner, 1995, 192pp.
11. *African Elephant Database 1995*. M.Y. Said, R.N. Chunge, G.C. Craig, C.R. Thouless, R.F.W. Barnes and H.T. Dublin, 1995, 225pp.
12. *Assessing the Sustainability of Uses of Wild Species: Case Studies and Initial Assessment Procedure*. Edited by Robert and Christine Prescott-Allen, 1996, 135pp.
13. *Tecnicas para el Manejo del Guanaco [Techniques for the Management of the Guanaco]*. Edited by Sylvia Puig, Chair of the South American Camelid Specialist Group, 1995, 231pp.
14. *Tourist Hunting in Tanzania*. Edited by N. Leader-Williams, J. A. Kayera and G. L. Overton, 1996, 138pp.
15. *Community-based Conservation in Tanzania*. Edited by N. Leader-Williams, J. A. Kayera and G.L. Overton, 1996, 226pp.
16. *The Live Bird Trade in Tanzania*. Edited by N. Leader-Williams and R.K. Tibanyenda, 1996, 129pp.
17. *Sturgeon Stocks and Caviar Trade Workshop. Proceedings of a workshop held on 9-10 October 1995 Bonn, Germany by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Agency for Nature Conservation*. Edited by Vadin J. Birstein, Andreas Bauer and Astrid Kaiser-Pohlmann. 1997, viii + 88pp.
18. *Manejo y Uso Sustentable de Pecaries en la Amazonia Peruana*. Richard Bodmer, Rolando Aquino, Pablo Puertas, Cesar Reyes, Tula Fang and Nicole Gottdenker, 1997, iv + 102pp.
19. *Proceedings of the Twelfth Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 3-7 February 1997, Oslo, Norway*. Compiled and edited by Andrew E. Derocher, Gerald W. Garner, Nicholas J. Lunn and Øystein Wiig, 1998, v + 159pp.
20. *Sharks and their Relatives - Ecology and Conservation*. Written and compiled by Merry Camhi, Sarah Fowler, John Musick, Amie Bräutigam and Sonja Fordham, 1998, iv + 39pp. (Also available in French)
21. *African Antelope Database 1998*. Compiled by Rod East and the IUCN/SSC Antelope Specialist Group, 1999, x + 434pp.
22. *African Elephant Database 1998*. R.F.W. Barnes, G.C. Craig, H.T. Dublin, G. Overton, W. Simons and C.R. Thouless, 1999, vi + 249pp.
23. *Biology and Conservation of Freshwater Cetaceans in Asia*. Edited by Randall R. Reeves, Brian D. Smith and Toshio Kasuya, 2000, viii + 152pp.
24. *Links between Biodiversity Conservation, Livelihoods and Food Security: The sustainable use of wild species for meat*. Edited by S.A. Mainka and M. Trivedi, 2002, ix + 137pp. (Also available in French)
25. *Elasmobranch Biodiversity, Conservation and Management. Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997*. Edited by Sarah L. Fowler, Tim M. Reed and Frances A. Dipper, 2002, xv + 258pp.
26. *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 23-28 June 2001, Nuuk, Greenland*. Compiled and edited by N. J. Lunn, S. Schliebe and E. W. Born, 2002, viii + 153pp.
27. *Guidance for CITES Scientific Authorities: Checklist to assist in making non-detriment findings for Appendix II exports*. Compiled by A.R. Rosser and M.J. Haywood, 2002, xi + 146pp.
28. *Turning the Tide: The Eradication of Invasive Species. Proceedings of the International Conference on Eradication of Island Invasives*. Edited by C.R. Veitch and M.N. Clout, 2002, viii + 414pp.
29. *African Elephant Status Report 2002 : an update from the African Elephant Database*. J.J. Blanc, C.R. Thouless, J.A. Hart, H.T. Dublin, I. Douglas-Hamilton, C.G. Craig and R.F.W. Barnes, 2003, vi + 302pp.
30. *Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health*. Compiled and edited by Steven A. Osofsky; Associate editors: Sarah Cleaveland, William B. Karesh, Michael D. Kock, Philip J. Nyhus, Lisa Starr and Angela Yang. 2005, xxxiii +220pp.
31. *The Status and Distribution of Freshwater Biodiversity in Eastern Africa*. Compiled by W. Darwall, K. Smith, T. Lower and J.-C. Vié, 2005, viii + 36pp.

Many of these publications are available online at: www.iucn.org/themes/ssc/publications/thematic_pubs.htm