Appendix 1

Agendas for the Extended Assessment Steering Committee (ASC) meeting and Arctic Climate Impact Assessment (ACIA) Scoping Workshop, February 28 – March 1, 2000, Washington, DC

Feb. 28 Extended ASC – First session

0800	Coffee and breakfast rolls
0820	Opening of the meeting, logistic information, meeting objectives – John Calder
0830	Review of progress ■ Status of NSF support for ACIA – Karl Erb/Tom Pyle ■ Status of NOAA support for ACIA – John Calder ■ Status of activities at the International Arctic Research Center – Gunter Weller
0900	Review of the Terms of Reference of the ASC, modifications as needed – Snorri Baldursson
0930	Composition of ASC, election of Chair and Vice-Chair, advertisement for Executive Director – Lars-Otto Reiersen
1000	Break
1015	Discussion of the ASC Secretariat – duties, staffing requirements, hiring process – Odd Rogne
1045	Discussion of climate modeling, a priority requirement for ACIA – Bob Corell
1130	Organization of the Scoping Meeting – work assignments for ASC (session chairs, rapporteurs, etc.) – John Calder
1200	Adjourn ASC and lunch

Arctic Climate Impact Assessment (ACIA) Scoping Workshop – ACIA Organization, Content and Implementation

February 28 Overview of ACIA

1300	Opening of workshop, logistic information, review of agenda – John Calder
1315	Presentation of ACIA, its proposed organization, approach, and time-line, including roles of ASC Chair and Secretariat – Bob Corell
1345	Interactions between ACIA and IPCC 4th Assessment Report – Bob Watson (invited)

1415 Group discussion of ACIA and ways of improving the current model

1500 Break

1530 Group discussion of philosophy, key factors and useful approaches in completing:
1. State of knowledge report
2. Set of climate change scenarios
3. Assessment of impacts (ecosystem, socio-economic, infrastructure)
4. Peer review of draft reports

1715 Establish breakout groups and breakout group leaders for tomorrow:
1. State of knowledge report – Betsy Weatherhead and AMAP
2. Climate change scenarios – Tom Delworth and IASC
3. Socio-economic impacts – Gunter Weller and CAFF

1730 Adjourn for the day

February 29 Developing an implementation strategy for the ACIA

0800 Coffee and breakfast rolls

0830 Plenary session to outline the charge and expectations for both the first and second sessions of the breakout groups

Breakout group strategy and charges

0900 **Breakout groups – First session**

A. Strategies for scenarios, modeling, and paleoenvironmental data and information – Convenor Tom Delworth
B. Indigenous people, Native lands, societal issues – Convenor Barrie Maxwell
C. Marine and coastal systems – Convenor Harald Loeng
D. Terrestrial and ecosystems – Convenor Betsy Weatherhead

Charge to the first session breakout groups: These first session breakout groups are asked to review and make recommendations on the materials that are discussed in the first two implementation sections (pages 15-17 of Appendix I) of ACIA Implementation Plan 2.1 -- namely, "What do we know?" (the state of knowledge) and "What are the likely changes in the future?" (scenarios). Little or no emphasis during this first breakout session should be placed on the third item concerning impacts. The purpose of these first session breakout groups is to evaluate the approach to and strategy for these aspects of the ACIA.

Questions to address: What should the ACIA do to address these matters? Is the approach outlined in Appendix I adequate and encompassing enough? Are the topical areas appropriate? What are the data and information needs that should be addressed? Should there be an explicit attempt to interconnect the Arctic aspects with processes at global scales? What approach/strategy should be used to develop the scenarios that would be used in the ACIA? What process approaches, workshops, task groups, etc. should ACIA use to broaden the participation and enhance the content of the ACIA?

Who are the individual scientists/experts who should be asked to be contributing partners and authors? Other matters the group deems appropriate.

1030 Break

1100 **Breakout groups – Second session**

E. Impacts in marine and coastal systems – Convenor Harald Loeng
F. Impacts on terrestrial landscapes and ecosystems – Convenor Betsy Weatherhead
G. Impacts on indigenous people, human health, and cultural/societal settings – Convenor Barrie Maxwell
H. Infrastructure – Convenor Gunter Weller

Charge to the second session breakout groups: The second session breakout groups are asked to review and make recommendations on the materials that are discussed in the second two implementation sections (pages 17-20 of Appendix I) of the ACIA Implementation Plan 2.1. The primary emphasis should be placed on the third section concerning impacts -- namely, "What are the possible impacts due to climate changes in the future?" (key impact areas) with a secondary emphasis on "What are the likely changes in the future?" (scenarios). The purpose of these second session breakout groups is to identify the impact topics/areas to cover in the ACIA and to evaluate the overall approach to and strategy for impact aspects of the ACIA.

Questions to address: Are the four breakout group topics the best way to aggregate the impact topics or is there a better listing within which the key impact areas can be covered? How should the ACIA address/integrate the 14 topical areas into a smaller set of "mega-impact topics?" Are the listed topical areas appropriate? Are all the needed areas covered? What is missing? What are the data and information needs that should be addressed? Is there a connection between the Arctic impacts and processes at global scales? Are there scenario needs specific to those impact areas, and, if so, what are they (e.g. special time zones, spatial scales, resolution, etc.)? How does the ACIA address the high spatial and temporal variabilities across the Arctic (e.g. do we need local scale workshops, consultations with stakeholders, case studies or other mechanisms to address these differences across the Arctic)? What process approaches, workshops, task groups, etc. should ACIA use to broaden participation and enhance the content of the assessment of impacts? Who are the individual scientists/experts who should be asked to be contributing partners and authors? Other matters the group deems appropriate.

1200 Lunch arrangements decided by each group as either a break or an opportunity for further informal discussion of issues before the group

1300 Re-convene the second session breakout groups to continue discussions

1500 Conference call to Workshop on Climate Change Impacts and Adaptation Strategies for Canada's Northern Territories, Yellowknife, Canada

1545 Short break

1600 Reports from breakout groups (About 10 minutes each, with about 5 minutes for clarifying questions. Please try to summarize results on a few overhead transparencies and, where essential, handouts.)

1730	Plenary adjourns and ASC meets to review the results of the day and make necessary adjustments for the Wednesday morning sessions of the workshop. Anyone may join this discussion.
1900	Dinner hosted by NOAA at the West End Café in the One Washington Circle Hotel

March 1 Determining implementation details for the ACIA

0800	Coffee and breakfast rolls
0830	Prepare integrated implementation plan for ACIA Utilizing breakout group reports, prepare outline of the implementation plan, with reference to breakout group reports for details. This will evolve into ACIA Version 3.0, which will be presented to the SAOs in April, 2000.
0945	Break
1000	Discussion of priority tasks to be completed during 2000 Considering the overall goal of ACIA, what must be accomplished first, and what can be accomplished in the next 9 months?
1100	Discussion of key individuals to be asked to undertake priority tasks
1300	Adjourn workshop

Extended ASC – Second session

1330	Reconvene the ASC Review results of the Scoping Workshop, identify action items and assignments, prepare for SAO meeting, discuss next meeting of ASC, agree on schedule for preparing ACIA Version 3.0.
1600	Adjourn ASC, end of meeting

Appendix 2

ACIA Scoping Workshop
List of Participants

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Appendix 3

Report of the Breakout Group on Strategies for Scenarios, Modeling and Paleoenvironmental Data and Information

Members: Tom Delworth (chair), Manfred Lange (rapporteur), Mike Winton, Hanne Petersen, Gunter Weller, Kostya Vinnikov, Kim Holmen, Trond Iversen, Ed DeFabo, Lev Khrustalev, Odd Rogne

- We want to focus primarily on climate scenarios
- The Arctic is a region that is difficult to handle in GCMs
- The strategy adopted in BESIS, i.e., to use two of the 'better' GCMs and to compare them with extrapolations of current trends, produced satisfactory results
- Others think that this is a 'dangerous' attempt and will lead to erroneous results
- Paleoenvironmental data to be used only for validation of GCM or RCM results
- We suggest a two-tier approach: a) to use existing results as much as possible and b) to start to develop a reliable RCM for the Arctic
- Another option is the use of downscaling for specific regions; this could be used for impact scenarios on the one hand and to understand processes in the Arctic on the other
- Statistical downscaling might also be useful in assessing extreme events
- Another thought is to look at a number of specific regions, e. g., western Greenland and eastern Canada, the Bering Sea region, and the European Arctic
- In order to resolve larger scale, sub-regional trends, one should look at the NAO, which is capable of explaining current trends in terms of physical processes
- In terms of ozone/UV-B issues, a combination of the proposed ozone research center and a modeling approach for stratospheric temperature is a possibility; however, given the time constraints, this should be separated from the provision of climate scenarios for impact studies
- Another approach would be to look at a very limited set of probability distributions for temperature, precipitation, etc.
- In terms of the two-tier approach to the impact assessment, i.e., a circumpolar assessment and a more specific, case-study like assessment, one could utilize this

approach by using the large scale probabilities for the circumpolar assessment and a kind of statistical downscaling of these trends for the more specific assessments

- The links between global climate and Arctic processes need to be addressed explicitly, i.e., the North Atlantic marine exchange processes, the role of the sea ice regime and that of the large scale atmospheric circulation processes in the Arctic for global climate
- The issue is: how do we proceed, given the time constraints? If we want to utilize the IPCC results, the earliest possible provision of scenarios would be in nine months time
- One proposal of the group is to set up a task force for climate modeling that deals with the issue of validating/evaluating IPCC scenarios for the Arctic and to implement plans for a longer term initiative to develop specific Arctic climate models

Summary

- The group agrees to focus on scenarios of future evolutions of the physical climate system.
- How to get to those projections?

Two-tier approach:

a) short term for the assessment

b) longer term

a) a suite of IPCC runs with common radiative forcing

evaluation of credibility of models in simulating climate

time slice: encourage IPCC regional models to have Arctic focus

- We should seek close links to the IPCC in order to encourage a stronger focus on arctic issues/climate modeling in the fourth assessment

Appendix 4

Report of the Breakout Group on Indigenous People, Native Lands, and Societal Issues

Members: Barrie Maxwell (chair), Mark Nuttall (rapporteur), Dolly Garza, Gisli Palsson, Svein Mathiesen, Tatiana Vlassova, Astrid Ogilvie, Igor Krupnik, Jim Berner, Nancy Maynard, Konstantin Vinnikov, Terry Fenge, Tom Murray

1) What do we know? (The state of knowledge)

or 'What is it that we need to know'?

An indigenous peoples' perspective on environmental and climatic change

We know that local/indigenous knowledge already exists on climate change in various formats (archives, oral histories, databases, etc), yet much has not been analyzed.

Using the historical record to understand impact of major changes/major impacts on local communities – looking at archives of oral histories, ethnographic material which may not have been analyzed. What were observations of local people, or other observers/residents?

There is large body of knowledge already in the public domain (e.g. AMAP report) which can be incorporated into ACIA.

What mapped information on land use and occupancy of Native lands is available, yet which has not really been analyzed? A systematic analysis and evaluation of this material is crucial.

What computer databases are available on indigenous people's serial observations of the changing environment and climate? One concern is that local observations should have community-wide systematic verification.

What impact has climate change had on the social/economic environment e.g. break-up of family structures/household composition/demographic situation?

What do people know about climate change?

- what indicators are there, e.g. for effects of UV-B radiation (Native hunters' observations of dogs)?

- what decisions, choices, etc. do they make based upon this knowledge/observations at various levels (household, local)?

TO ADD: Social environment/human concerns to be integrated in all sections of ACIA report

The focus should be widened to include other Arctic residents – local communities/non-indigenous peoples

A wealth of information on environmental change exists in Iceland, for example – this could make an important case study, e.g. in coastal and farming areas.

Hunting and trapping by non-Native peoples

Fishing and agriculture/land use and occupancy in areas settled by non-Native people

What can be achieved by 2002?

A list of sources, databases, list of possible projects

Some of the old reports in basements/archives will be time-consuming to access, read etc.

Who is doing what and where?

A system to look at impact of climate change on human health will be in place by 2002.

2) What are the likely changes in the future (scenarios)

Impacts on, for example, water supplies will determine ability of people to live in specific places (possible impact on whole communities/regions) – dwellings will be affected, infant mortality rates will rise.

As warming affects permafrost and water tables, the contamination of surface water with sewage becomes more likely. In that setting, the frequency of gastrointestinal infections in infants as well as adults will produce an increase in serious morbidity, and perhaps mortality.

Temperature

Changes in resources will affect access to subsistence resources which will in turn affect human health and quality of life, as well as economic possibilities.

Migration from small communities to larger centers

To look at the warming process – Alaska and Siberia

To look at the cooling process – Greenland

Some regions are changing under natural variability, others under human-induced conditions and circumstances.

How do people respond to climate change and how is climate change influenced by human activities?

3) What are the possible impacts due to climate changes in the future (key impact areas)?

Impact topical areas:

Marine Environments

Commercial fisheries

- How would a change in ocean temperature, ice coverage and Arctic climate in general affect distribution of fish species and species abundance? What impact would this have on communities dependent on culturally and economically significant fish resources? Focus should also be on food production systems – local, regional, national. What will be impact of sea level rise?

Hunting and fishing

A similar question to the above also arises: With respect to hunting and fishing, how would a change in ocean temperature, ice coverage and Arctic climate in general affect distribution of marine species and species abundance? What impact would this have on communities dependent on culturally and economically significant marine resources, such as marine mammals and fish? It is important to emphasize that not all fisheries or marine mammal hunting practices have an economic importance, but a **cultural** one. Local and regional food production systems. Again, what will be the impact of sea level rise?

Marine mammals

Trapping

Transport system

Sea level rise

Animal health

Conservation and environmental governance

Interactions with lower latitudes

Culturally important species as indicator species to be investigated further - ringed seal, bowhead whale, salmon, sea lion are species for which extensive material is available.

Terrestrial Environments

Traditional food production systems (includes plants/greens/berries, production for local consumption)
Agriculture and livestock production (sheep farming, cattle, crops)
Reindeer/caribou - plant interactions
Forestry and forest management
Animal health
Conservation
Wildlife
Energy and minerals

Interactions with lower latitudes

Culturally important species as indicator species to be investigated further – caribou and reindeer are species for which extensive material is available

Human Health and Well-being

Data are available on how climate-based changes in atmospheric temperature and precipitation have influenced distribution and patterns of infectious diseases. However, they have not yet been analyzed.

Relation of weather patterns to epidemics of infectious disease: Data exist for both weather patterns and epidemics, but neither has been examined with respect to the other to see whether, over time, any particular set of climate variables is predictably associated with any particular disease outbreak.

Influence of climate change on availability of key foods: Change from a traditional diet, due to changing availability of food species, might well be a factor in the increasing incidence of type 2 diabetes in some parts of the Arctic.

Impact of UV on human and animal health

Loss of traditional cultural activities around food gathering. E.g. change from being critically dependent hunting and gathering society to dependence on other foods is a significant health concern.

UV is known to change cell-mediated immune system responses in mammals, including humans. However, to what extent this will occur in Arctic populations is difficult to say at present because of a lack of information. Such information is critical for risk assessment.

Changes in distribution and range of wildlife hosts and vectors of disease are crucially significant – could have major impacts and data are needed. Existing data need to be analyzed. There needs to be co-ordination of surveillance systems that already exist.

Water quality – needs to be looked at. Impacts on water supplies will determine ability of people to live in specific places (possible impact on whole communities/regions) – dwellings will be affected, infant mortality rates will rise.

Allergies (causes) – needs to be looked at

The connection between human and animal health

It is important to note that when we talk about human health, we do not just focus on the health of individuals, but we also need to focus on the health of communities – community sustainability.

Interactions with lower latitudes

Cultural and Community Sustainability

Limited access to resources prevents community viability/sustainability (quality and access to traditional materials).

Limited access to resources hinders economic development based on the production and uses of those resources

Land use and occupancy

Sustainable livelihoods – economic well-being and viability (e.g. tourism, economic development)

Interactions with lower latitudes (e.g. trade)

How to proceed?

How to determine how indigenous peoples/use groups (e.g. reindeer herders) can be integrated into consultation process of ACIA from the start? However, consultation process should not be open-ended, but should be a starting point. Suggestion is to co-opt IPS (Indigenous Peoples' Secretariat) to assist in preparation/consultation exercise.

Should specific geographical areas be suggested as case studies?

One specific task should be to inform and instruct communities on what the risks/impacts are likely to be.

Possible agencies/organizations for support:

AMAP
RAIPON
Local and federal governments in Russia
Alaska Native Science Commission (Garza or Cochran)
Native American Fish and Wildlife Society (AK office, Michele Davis)
Indigenous Peoples' Council of Marine Mammals (Carl Jack at RuralCAP)
Association of World Reindeer Herders (Johan Mathis Turi, president)
Indigenous Peoples' Secretariat
Arctic Council Permanent Participants (to meet with them at Arctic Council meetings – briefing meeting in April, with meeting at full Arctic Council meeting)

Overarching issues

- **Pollution**
- **Risks and Hazards**
- **Climate Feedback**
- **Interactions with Lower Latitudes**

Marine Environment	**Terrestrial Environment**	**Health**
- fisheries	- traditional food	- human health
- mammals	- agriculture & livestock	- animal health
- offshore energy & marine transportation	- reindeer & caribou	- recreation
	- forestry	
	- wildlife	
	- infrastructure	
	- energy & minerals	

Cultural and Community Sustainability

- Hunting/fishing/trapping/gathering
- Reindeer herding
- Wildlife management
- Access to resources
- Sustainable livelihoods

Appendix 5

Report of the Breakout Group on Marine and Coastal Systems

Session I

Members: Harald Loeng (Chair), Kit Kovacs, Jerry Brown, Snorri Baldursson, Florence Fetterer, Ken Drinkwater (rapporteur), Hjalmar Vilhjalmsson, Bob Dickson, Mike Papst, Ed DeFabo

It was felt that impacts could not be separated easily, so we decided to include discussions on impacts in this session, although we did not concentrate on them.

A strawman to organize our discussion was presented by Bob Dickson. He highlighted the Arctic-Subarctic linkages, his rationale being:

(1) some of the changes in the Arctic are imposed from the sub-Arctic seas and are due to sub-Arctic forcing;
(2) there is feedback from the Arctic Ocean to the sub-Arctic; and
(3) the socio-economic impacts on adjacent seas are high.

He proposed focusing on 4 separate climate periods: paleoclimate, 1920-1960 (weak forcing by NAO), 1960-present (strong forcing by NAO), and the future. He also proposed to look at several different issues related to these time periods: what is the evidence for climate changes within the period, have the changes been modeled, what were/are the impacts, and what is required to improve our understanding of what happened in each of these time periods?

Bob presented a matrix with some preliminary ideas on each of these issues for each of the separate periods (Table 1).

After this presentation, there were some general comments. First, it was pointed out that socio-economic aspects extend beyond impacts on fish (recruitment and growth) and includes other aspects. Bob noted, for example, that heating costs during the winter in Norway are strongly related to the NAO index. Second, it was noted that temperature is considered the most important variable in terms of impacts to fisheries and therefore this variable should be emphasized in the written document. Third, the group was concerned about the possible shut down of the thermohaline circulation caused by a freshwater cap over northern waters due to melting of the sea ice under CO_2 warming scenarios.

The chair noted that Bob's strawman is an excellent starting point but that there remain gaps with such a matrix, e.g. it does not include anything on mammals or birds etc.

Some of the group felt that the matrix concentrated too much on factors relevant only to the North Atlantic and that we need to know what knowledge we have for other areas as well. Also, while the matrix was felt to be a good summary, it does not deal with inputs from land. Another suggested approach was to discuss changes in terms of the coastal zone rather than in terms of the deeper marine waters as had been presented. The group felt that the ACIA needs to address contaminant issues, which were not included in the matrix. It was noted that changes in the ocean could be regarded as changes in the habitat for marine mammals. Other discussions noted that one-third of the sea-ice habitats disappeared in recent times and that paleoclimate studies have shown evidence of large changes in Arctic climate.

The group also discussed whether climate changes in the Arctic are primarily forced from the south or are due to local processes. No conclusion could be reached, but this issue was felt to be one that could be explored with models.

Also, it is important to note that there will be effects on anadromous fish as well as fully marine species. These anadromous species, such as char, are very important economically within the Arctic. Currently, they are not "assigned" to either the marine or freshwater breakout groups.

There was discussion on whether to subdivide the 1900s as presented in Table 1. It was felt by some that it is very important to subdivide in order to highlight the different forcing mechanisms between 1920-1960 and post 1960. In the former, the changes appear uncorrelated with the NAO pressure patterns, whereas post 1960 they are highly correlated with the NAO index. The spatial variability in temperature changes will depend on the pattern of atmospheric forcing. Also, with regard to future climate scenarios, there is the question not only whether the NAO is high or low but perhaps more importantly whether the atmospheric circulation pattern is dominated by the NAO or not.

The chair reminded the group that what we are trying to do is to give a framework for others to use. The group then discussed how to organize Session I on what we know about the description of the past physical environment, for the marine system (item E on page 16 of the ACIA draft).

Information on the paleoclimate is required to know the range of change that has previously occurred. Some in the group felt that we should not start with the paleoclimate but rather begin with what we know now best (i.e. the present) and then go back in time.

There was some discussion on coastal erosion lead by Jerry Brown. He described a project on Arctic Coastal Dynamics (ACD) that deals with coast mapping and erosion. Although not a climate program, its results will be very important for ACIA. There are six areas of research within ACD: shoreline classification and mapping, processes of coastal erosion and aggradation, ground-ice estimates and mapping, monitoring and site

observations, environmental data applications, and cultural and economic implications. There was a plea for atmospheric, oceanographic, hydrological, and sea ice databases in order to address studies of coastal erosion. Data availability is an important issue for increasing our knowledge, not only for coastal erosion but for other issues as well. This brought up the issue of knowledge gaps. The group concluded that these needed to be included in the knowledge section. Jerry Brown provided some documentation on the program and the environmental data requirements on coastal erosion. One important issue we had not discussed was storminess.

One problem identified by the group was the lack of expertise from the Pacific and Bering Sea regions. Scientists from these areas will be essential in the report writing.

The view was expressed that none of the biological data collected in Canada was designed for addressing climate change purposes. Therefore, there may be a danger of using biological data that have been collected for other purposes for climate change studies. It was pointed out that some biological datasets have been collected specifically to monitor climate-associated variability in the Atlantic, e.g. continuous plankton recorder (CPR) data. There are none in the Arctic, however. It was further noted that there is a general paucity of biological data in the Arctic, but it is an issue that is being addressed with monitoring programs. Some members noted that time series do not have to be collected for climate change purposes in order to be used in climate studies.

Repeatedly during the discussions held in the marine breakout group, the fact that biological issues were not receiving sufficient attention was raised. Impact assessment is normally focused on the biotic components of the system. Physical changes in ocean currents, temperatures, ice cover, etc. are very important data for determining potential scenarios for plants, non-human animals, and human populations. But, the biotic components of the Arctic ecosystem should be the focus of the ACOA "product." This led to a lot of discussion, and restructuring the outline for writing the final report was considered. The group decided that the traditional model of beginning with the physical changes should be adopted, but that potential biological impacts need to be emphasized in the final written report. In order to obtain the needed biological focus, biologists need to participate in the drafting of the ACIA document.

Humans have had an important influence on many aspects of the marine system through harvesting and fishing. For this reason, monitoring of non-commercial species of high ecosystem importance, including key planktonic species and non-commercial fishes such as Arctic cod and sand lance, is important. This has begun in some countries but lags far behind monitoring of the physical environment.

Ed DeFabo stated that the problem of UV radiation needs to be included in the overall assessment. There is some information on the changes in UV, but not very much. The increases in UV have important implications for biology, e.g. larvae near the surface are the most vulnerable as well as phytoplankton.

Session II

Members: Harald Loeng (Chair), Kit Kovacs, Florence Fetterer, Ken Drinkwater, Hjalmar Vilhjalmsson, Bob Dickson, Mike Papst, Tom Delworth, Mike Winton and Trond Iversen, Konstantin Vinnikov

The Chair reminded the group that we need to come up decisions on what the content of the report should be, including different scenarios. Also, we need to provide a list of candidates who are willing to write different sections of the chapter.

Information on state-of the-art modeling is needed in the report.

We should begin with information on the paleoclimate based on sediment cores, ice cores, and tree rings.

For the present time period, a general description of Arctic climate variability over the past century or so should be included.

We began to compile a list of important parameters for Arctic climate studies. These were temperature (including deep-water properties), salinity, air temperatures, winds, storminess, and hydrology. Also, the knowledge section should contain information on the biology, i.e. the impacts. For example, the migration of cod along Greenland in response to warming in 1920s, the changes in the Arcto-Norwegian herring migrations, etc. It was noted that when there are cold conditions off West Greenland, there are no cod. Temperature has been shown to control growth, recruitment and distribution of cod in sub-Arctic locations. Ice cover as well as ice quality (phenology, extent, topography, presence of leads and polynyas) are very important to the mammals inhabiting the Arctic. Ice is "habitat" for many animal species in the Arctic. And variables such as snow cover on the ice are very important – e.g. essential determinant of reproductive success for ringed seals. Some examples of what variables are important for certain focal or key stone species in the Arctic and sub-Arctic should be presented.

Are there gaps in our knowledge that could be addressed? The group felt that there certainly are. One source is Russian meteorological, hydrographic, and sea-ice data. A data rescue project is needed to address this. There are also lots of CTD, ice-cover and meteorological data, etc. in other Arctic countries that are not yet archived or analyzed. The drafting group will have to address this issue in more detail.

While there is much information on sea ice, homogenous records are needed for comparison with models. Such data are available from passive microwave measurements taken via satellite. There is a need to reanalyze earlier microwave data (5 years in the 1970s) to extend our database back in time. Also, there is a need to fill in gaps in the sea ice records during the years of World War II. Data were collected at that time, but they need to be retrieved. More and better information on ice thickness is required. Russians

have a lot of data on ice thickness, but they have not made it available. Efforts should be made to obtain these data, if possible. Russian data are available back to 1950s, comprehensively back to 1970s. It was pointed out to the group that ice datasets go back several hundred years for some regions.

Sea level issues need to be included in the written document. There is a Canadian assessment of the impacts of sea level rise on Canadian coasts.

The group discussed another approach that they felt might help to organize and summarize what we know. It consists of a table of variables (such as UV, temperature, runoff, sedimentation, winds, ice, sea level) against issues (such as plankton, fish, coastal erosion, marine mammals, anadromous fish, birds, humans). The group felt priorities could be added to such a table, for example what issues were felt to be the most important. While we discussed some of the specifics, it was felt that these could be left to those drafting the document whether they thought this would be worthwhile.

Finally there is a need to include what we know from modeling along with such an approach.

Session III

Members: Harald Loeng, Kit Kovacs, Trond Iversen, Ken Drinkwater, Hjalmar Vilhjalmsson, Bob Dickson, Mike Papst, Tom Delworth, Mike Winton, and Konstantin Vinnikov

The group began with a discussion of Section II on page 17 of the ACIA draft document: what are the likely changes in the future (a set of scenarios)? After some discussion, it was decided that we were being asked if we agreed with the 5 scenarios laid out on page 17. We went through the list and decided that they were. We had no new scenarios to add.

We then discussed modeling. Those who had joined us from the modeling group indicated that their discussions were centered on atmospheric climate models and, although the models are coupled between the atmosphere and the ocean, they are not ocean climate models. Some members of the group felt that ocean climate models would be needed to address some ocean issues such as the flow of North Atlantic waters into the Arctic. Presently, this is not well understood or modeled. It was pointed out that we want to know if we are acquiring the necessary skills in modeling. Some of the difficulties in modeling were addressed by Tom Delworth. He noted that the internal dynamics of the system within the models means that there is a lot of noise in the system. This means we will not necessarily be able to model every major event. It was also noted that models do not have to be large numerical models but also include conceptual models. Conceptual models also have information to offer. Indeed, there is a range of model types available.

The Chair suggested that the group move on to address Impacts as outlined on pages 18-20 of the ACIA draft. We went through each in turn.

1. Commercial Fisheries
- We discussed whether the word commercial should be deleted. This was because it was felt by some that key species in the Arctic marine ecosystem should be included. It was generally agreed that we should include some high energy, high biomass plankton and Arctic cod, although some members of the group felt that it might make the writing too difficult. They felt that there should be little emphasis on plankton. It was also felt that the word commercial should be kept because it will catch the attention of politicians and policy makers.
- The group eventually agreed to the need to include non-commercial species because they are so important in the ecosystem, e.g. Arctic cod are essential for Arctic birds and marine mammals. They also will help to define responses to climate change without problems related to fishing or harvesting.
- However, there are many gaps in our knowledge for non-commercial species and these need to be highlighted (e.g. on arctic cod, plankton).
- It was also noted that we only have a few examples of temperature effects on certain species and these were commercial species.
- It was decided to suggest a change of the title to "Commercial Fisheries and the Marine Food Chain".
- The first and second question under this topic, as listed on page 18 of the draft document, should not be restricted to productivity. It should include migration, distribution and habitat.
- For species in the subarctic it was suggested that it might be useful to concentrate on cod and capelin, species for which we have the most complete information.

2. Hunting and Fishing: An indigenous peoples perspective.
- We decided to leave this section as is.

3. Marine Mammals
- Upwelling and polynyas, for example, are important for marine mammals, in addition to sea ice. The second bullet should reflect other physical variables besides sea-ice.
- Changes in plankton production are also important for marine mammals, but it was decided that plankton should be dealt with under the commercial fish section.

4. Civil Infrastructure/Engineering
- The group felt that impacts on shipping due to changes in sea-ice distribution needed to be addressed.

5. Energy
- Impacts of sea-ice on drilling rigs and pipelines are required.

6. Reindeer Herding, Food and Agriculture.

- The group noted that the impacts of climate change on aquaculture are important.

7. Conservation and Wildlife Management
- The group noted that the majority (both in terms of numbers and biomass) of migratory birds to the Arctic are sea birds. This needs to be addressed in the written report.

8. Pollution
- Changes in circulation in the Arctic will affect the transport of contaminants.
- With the ice withdrawn from land, mixing has increased in nearshore waters so that pollutants are mixed deeper and their residence times have changed.
- Pollutants are transported by sea-ice so that change in sea-ice will change pollutant pathways.
- Changes in sea level and ice distributions will influence coastal erosion.

9. Climate Feedbacks
- It was noted that, if there were increased primary production in the Arctic under climate change, these would act as an additional sink of CO_2.

10. Interactions with Lower Latitudes.
- Interactions go both north and south. Processes and events in the Arctic affect sub-Arctic areas and vice versa.
- The thermohaline circulation can be affected by freshwater output from the Arctic, to the point where it may shut down this circulation.

- The group also discussed feedbacks in the physical system.
- The position of the polar fronts is important in North Atlantic. Under different CO_2 scenarios, what happens to the position of the polar front?
- There will be changes in the wintertime convection in the Labrador Sea and the Greenland Sea.
- With changes in the advective circulation, both horizontal and vertical, what will happen to contaminants?
- If THC changes, what will happen to thermal structure and circulation?
- The group felt that ocean models would be needed for exploring climate feedbacks.

We also discussed the problem of continued warming in future climates. For example, will the relationships that we have established in recent times still hold under a different thermal regime? How might such relationships change with increasing temperature?

The group also discussed modeling: What would happen to sub-Arctic and Arctic boundary conditions under different climate change scenarios?

It was noted that some modeling of the biological system is presently ongoing and that these could be used to predict possible impacts to climate change, given the outputs of future climate from the physical models.

The group discussed the issue of possible authors but fell short of coming up with specific names during this session.

Table 1. Bob Dickson's Matrix on

Marine Arctic-Subarctic Linkages

Rationale for choosing this issue:

1. Arctic ocean change may be imposed from subarctic seas due to subarctic climate forcing.

2. Arctic Ocean change currently reflects changing balance of Atlantic and Pacific inputs (mainly Atlantic).

3. Arctic Ocean change feeds south to affect thermohaline circulation in many models.

4. The socio-economic impacts on adjacent seas/shelves are high, i.e. in the Barents Sea, Davis Strait, around Iceland, Greenland and off Newfoundland.

	Paleoclimate	1920-60's	1960-90's	Future
Evidence	-Sediments show evidence of THC shutdown -Greenland ice cores as proxy for SST -O18 in clams gives 1000-yr temperature proxy -500-yr Morocco tree rings as proxy for NAO	-SST data indicate warm and salty in North gyre -multi-decadal Hydro Sections -Cod Colonized W. Greenland -100-yr high in YCS/ Growth in Barents S. Cod	-Extreme NAO in over 170-yr record -SCICEX surveys since 1993 -Hydrographic sections -Meteorological data -Satellite/ULS Ice Flux	
Model	-Ice/Freshwater Release during post-glacial era	-Kushnir's U Index (EOF2 became EOF1) -Delworth and Knutson, 2000, THC + (Global) -German (Eden & Jung, 2000), THC changes (Atlantic)	-Dominated by NAO -UKMO -Natural but rare part of Atlantic Climate System? -L&B Models forced by ocean convection, advection, and feedbacks	-Some concensus towards AO+/NAO+ under higher CO2+ scenarios (Gillet Study)
Impacts	-Thermohaline Circulation shutdown, occurred rapidly (Heinrich-0)	-Greenland cod 450,000t -Good YCS Barents -Contribution to extra-tropical warming in N. hemisphere -Norway-Iceland herring migration route disrupted.	-Storminess/Production timing delayed -Warmer Atlantic sublayer spreads in AO plus weaker CHL = ½ ice thickness in Eurasian Basin -Good Cod YCS in Barents, poor in North Sea and W. Greenland	-Effect of THC slow down on (1) present 5-10C T anom. NW Europe, (2) Nordic/subArctic ecosystems (regional cooling), (3) ocean polar front change, Nfld. to Barents Sea, (4) vertical circ and exchange. (peak CO2 around 2100)
Needs	-Analysis of more sediment and ice cores/sites -More long-term clam records analyzed	-Data mining (mainly Russia), assembly, modelling -Levitus Ocean Data -H&D EOFs	-Continue time series of main fluxes, coordinated and sustained -Pacific-Atlantic balance -Tracers	-Arctic version of TOGA TAO array to keep pace with change and feed data to model development.

Appendix 6

Report of the Breakout Group on Terrestrial Environment and Ecosystems

Present outline
terrestrial is well divided – physical and effects on biotic environment

need circumpolar perspective before regional summaries will involve duplication

biotic divided by ecosystem function and ecosystem structure (include species) effects

global overview – should include the theory before dealing with trends etc.; then what is unique on a regional basis or what are the gaps?

What are the regions?
North America is too broad – data in Alaska is rich, in parts of Canada it is poor – it may give the wrong impression to lump them together

have to refer to geopolitical boundaries – but overlay or explain warming trends or obvious geographical differences – e.g. Alaska is Cordilleran, while much of Canada is Shield country and the high arctic is not present in Alaska

recognize that the marine group would not have similar boundaries

Scandinavia should be renamed European Arctic

consensus: stick to present divisions and subdivide as appropriate, depending on biota being developed

recognize that Russia needs to be subdivided – western portion closer to Fenno-Scandia

What is the difference between what we know versus what are the impacts?
a lot of concern that what we know is intertwined with what are the impacts

Terry's model -- what we know about holocene, recent past, what now, drivers for change, likely to happen, areas of uncertainty

is the state of knowledge a political requirement?

What do we include?
have to include what we don't know – have to assess the uncertainty

point out high risk or sensitive

should be rigorous with what information we have – question what we think we know

where should our uncertainty be included? -- in the "what we know" section

Discussion on whole process

not clear where we make crosslinks between groups, e.g. link with climate group

also, where do people issues come into the terrestrial analyses?

should we include societal impacts before the regional discussion?

also, interaction between climate impacts and other impacts

Terry's model again - what we know, what will happen, drivers (import from other groups), then export impacts to other groups .

groups have to have the same assumptions

Models and Scenarios

what do we what? – a Chapman and Walsh figure for the 4 seasons for 2050 for terrestrial and sea ice

discussion on time frame 40 vs. 50 vs. 100 years – the farther out we go, the less confidence we will have

for temperature, precipitation snow, ice cover

need variability as well as trend – in some cases more important

analyses of extreme events – Pinatubo eruption caused global cooling in Arctic

need UVB for 2050

should include likely changes in nitrogen deposition and carbon cycling

we need changes in human settlement

What do we know?

how does climate change impact distribution of pollutants?

impacts of climate change and tourism, increased access

impacts of animal health – invading species, more infectious diseases

can be covered under ecosystem structure

must capture carbon/nitrogen cycles, changes in albedo

should we discuss impacts on forestry? – can't take on impacts of boreal forest as well as tundra

consider only treeline transition and not the "productive" forests

From the modelers
they like to deal with averages

the terrestrial group needs variability

to what degree are extreme events important? – they are important

Impacts
predictions of what will happen versus impact of 1 degree change

Boreal forests

forestry have to determine whether this is politically required

important in Finland – CAFF has considered

should be considered, but not dealt with in as great detail as tundra

bring to plenary session and discuss the problems and workload implications

Conservation and wildlife management

discussion on why topics are divided on an economic basis.

biodiversity should be a topic – e.g. lichen distribution may decrease

we should stick to ecosystem function and structure and hand (export) info to groups that deal with, for example, reindeer herding.

Function examples

carbon cycling

Structure examples

biodiversity, permafrost, treeline

will hunting and fishing be captured under structure and function?

we should assess impacts and discuss implications (e.g. hunting and fishing), and these implications can be exported as impacts to societal group

need to better define: structure and function – what is there and what does it do?

EFFECTS OF CLIMATE CHANGE – TERRESTRIAL

Physical

- Soil
  - thermokarst
  - active layer
  - permafrost
- Air
  - Ozone/UVB
  - clouds
  - climate temp., precip., wind, variability, circulation patterns, irradiance, UVB, snowfall, snow depth, snow duration (input to us)
  - timing of first frost, last freeze, snow free period, growing degree days
  - pollution deposition
  - nitrogen deposition
  - particulates and pollutants
  - clouds, cloud patterns – not just terrestrial
  - climate change and stratospheric ozone – not just terrestrial
  - upper air temperature changes -- not just terrestrial
- Water
  - soil moisture
  - river run-off patterns and amount including dissolved organics
  - freeze-up and break-up dates on major rivers and lakes
  - pollution deposition
  - net drying of wetlands
  - coastal erosion (marine)
  - sea level rise (marine)
  - ice sheets and glaciers

Biological

- Ecosystem Structure
  - treeline
  - animal population and structure
  - immigrant plant and animal species
  - biodiversity

rare and endangered species
animal migration
soil biota

Ecosystem Function
nutrient cycling
decomposition
carbon cycling
energy budget
water cycling (both directions)
green up patterns / changes in albedo due to vegetation changes

Implications (People and resources)
hunting (key species: reindeer)
fishing (key species: whitefish, Arctic Char, Mir)
reindeer herding
agriculture
forestry
protected areas / conservation and wildlife management
effects of increased tourism on terrestrial systems and effects of climate forcing resulting from changes to arctic ecosystems

Other things are changing at the same time
pollution (nitrogen deposition, mercury pathways)
population changes
land use changes

Individual country summaries
8 separate summaries, including clear statements about gaps and needs

Plenary questions:
Is river run-off terrestrial?
Are polar bears? Sea birds?
Boreal Forests?

Appendix 7

Report of the Breakout Group on Infrastructure

Members: Gunter Weller (chair), Manfred Lange (rapporteur), Lev Khrustalev, Terry Fenge, Jerry Brown

- We extended the scope of the group to include impacts on four major sectors: engineered structures, resource development, transportation, and community development

- The discussion centered around two tables, which are given below.

Topical/Thematic Assessment

Change in	Impacts	
Permafrost	Road construction and maintenance	-
	Airfields	-
	Houses/structures	-
	Coastal & river erosion/accretion	-
	Mining/pipelines	-
	Offshore pipelines/structures	-
	Nuclear/military waste underground storage	-
	Ice cellars	-
Sea ice	Harbors	+
	Marine transportation	+
	Offshore oil and gas exploration and production platforms	+
	Coastal erosion/sediment transport	-
	More/severe storm surges	-
	Overice transport	-
	Ice gauging	+
Glaciers	Water and sediment loads on hydropower generation	-
	Sea level rise	-
	Iceberg hazards to shipping	-
	Surges/glacier-damned lakes	?
River and lake ice	River traffic/navigation	+/-
	Hydropower generation	?
	Ice jams	?
	Ice forces on bridges/docks	+
	Flooding	-

Seasonal snow cover	Avalanche hazards Oversnow roads Breakup and runoff Snow loads on bridges Igloo production	- +/- - - -
Climate change direct effects	Fuel consumption Design criteria Construction and maintenance Community location	+ ? ? -

Issue-driven Assessments

Impacts on	**Due to changes in**
Engineered structures Roads/railways Airfields Harbors Houses/structures	Permafrost thawing Coastal erosion More/severe storm surges Snow loads Sea ice conditions
Resource development Mines Oil/gas fields Pipelines Power plants Hydrodams Transmission lines Gravel sources	 Permafrost Glacier melting River discharge Seasonal snow cover changes
Transportation Marine River Air Roads/railways	 Sea ice reductions River and lake ice reductions Permafrost thawing More severe weather
Community Development Waste disposal Water supply Relocation	 Permafrost thawing Seasonal snow cover changes Coastal erosion/storm surges

Regional Aspects

We realize that the assessment of climate impacts on infrastructure needs a regional differentiation.

We propose the following subdivision:

North America

- Alaska/Mackenzie Basin
- Eastern Canada/Western Greenland

Nordic Countries/Kola Peninsula

Russia

- European part of Russian North
- Siberia
- Far East

Needs

We also realize that additional information is needed in the impacts assessment, particularly with regard to

Long term observations

Permafrost

- Deep and shallow borehole temperatures
- Active layer thickness
- Spatial extent

Sea ice

- Sea ice thickness distribution

Glaciers

- Mass balances

River and lake ice

- Freeze up and break up dates

- Streamflow/discharge

Snow cover

- Thickness
- Water content

Analysis of Economic Impacts

- Maintenance of existing facilities
- Cost of climate related damage
- Specification of design criteria/codes for new facilities

Groups to do the Impacts Assessment

USA

- UAA Engineering School/CRREL (Smith)
  (have conducted five infrastructure workshops)

Russia

- Moscow State University (Khrustalev)
- AARI, St. Petersburg
- Permafrost Institute, Yakutsk

Canada

- MBIS (Maxwell, Cohen)
- National Resources Canada

Europe

- NGI (Norwegian Geotechnical Institute)
- Seppo Saarlainen (Finland)
- Hydropower (Norway)

International

- o BESIS/BASIS Projects of IASC (Lange, Weller); (Romanovsky, Osterkamp)
- IPA (Brown)

Appendix 8

Terms of Reference for the Assessment Steering Committee (ASC) of the Arctic Climate Impact Assessment (ACIA)

An **Assessment Steering Committee** (ASC) is composed of two representatives each from AMAP, CAFF and IASC, and a person representing the Arctic indigenous peoples (Permanent Participants). The US, as a Lead-country, will have a seat in the ASC. Lead-authors, responsible for drafting the Scientific Document, will be members of the ASC. The ASC may invite representatives from international organizations that contribute in a major way to the assessment. Through these appointments it is expected that all Arctic countries will participate in the ASC.

The responsibilities of the ASC are to:

1. Oversee the Arctic Climate Impact Assessment (ACIA) process and to coordinate all work related to the preparation of the assessment reports;
2. Foster cooperation and cross-fertilization between the Lead-authors and the groups comprising the ASC;
3. Undertake joint planning and implementation of inputs from AMAP, CAFF and IASC, as well as observer countries and/or organizations;
4. Ensure circulation of draft reports for thorough scientific and national comments;
5. Ensure independent peer review of final drafts;
6. Coordinate and forward assessment results, including conclusions and recommendations, to the AMAP and CAFF Working Groups for drafting of the Policy Document;
7. Cooperate with appropriate international organizations;
8. Identify resource needs for further consideration by AMAP, CAFF and IASC;
9. Report to AMAP, CAFF and IASC.

The ASC will be responsible for drafting the ACIA Synthesis Document. AMAP and CAFF will be responsible for drafting the ACIA Policy Document.

The ASC elects an **ASC Chair** and a **Vice-chair** for a three-year period, which may be extended another 3-year period:

- The ASC Chair will preside over ASC meetings and carry out any duties entrusted upon the Chair by the ASC;
- The Chair and the Vice-chair will decide on division of labor as appropriate.

An **ASC Executive** will consist of the ASC Chair, Vice-chair, the Executive Director of the ACIA Secretariat, a person representing the Arctic indigenous peoples, and a member ensuring representation of the three main partners:

- The Executive Body will oversee ACIA activities between meetings.

The US will establish a **Secretariat** to assist the ACIA through 2004:

- The ACIA Secretariat will serve the ASC and ACIA as needed.
- An Executive Director for ACIA Secretariat will be approved by the ASC.