

Responding to Change Panel Discussion Paper #1

Panel Members

Dr. Jack Kruse, Chair
Institute of Social & Economic Research
University of Alaska Anchorage
117 N Leverett Road
Leverett, MA 01054
Tel: (413) 367-2240
Fax: call ahead – same number
afjak@uaa.alaska.edu

Dr. John Bengtson
NOAA National Marine Mammal Laboratory
7600 Sand Point Way N.E. F/AKC3
Seattle, WA 98115-6349
(206) 526-4045 (voice)
(206) 526-6615 (fax)
john.bengtson@noaa.gov

Dr. Deanna Kingston
Department of Anthropology
238 Waldo Hall
Oregon State University
Corvallis, OR 97331-6401
541/737-4515
deanna.kingston@oregonstate.edu

Mr. James Magdanz
Division of Subsistence
Alaska Department of Fish & Game
Nordlum Office Bldg.
240 5th Ave. Kotzebue, AK 99752-0689
Phone (907) 442-3420
Fax (907) 442-2420
James_Magdanz@fishgame.state.ak.us

Dr. Nathan Mantua
University of Washington
Climate Impacts Group
Box 354235
Seattle, WA 98195-4235
Office: (206) 616-5347
Fax: (206) 616-5775
Internet: nmantua@u.washington.edu

Dr. Maribeth Murray
UAF Department of Anthropology
310 Eielson Building
P.O. Box 757720
Fairbanks, AK 99775
Phone: 907 474-6751
Fax: 907 474-7453
E-mail: fmsm@uaf.edu

Dr. Mary Pete
Director, Division of Subsistence
Alaska Department of Fish & Game
Capital Office Park
1255 W 8th St Juneau, AK 99802-5526
Phone (907) 465-4147
Fax (907) 465-2066
Mary_Pete@fishgame.state.ak.us

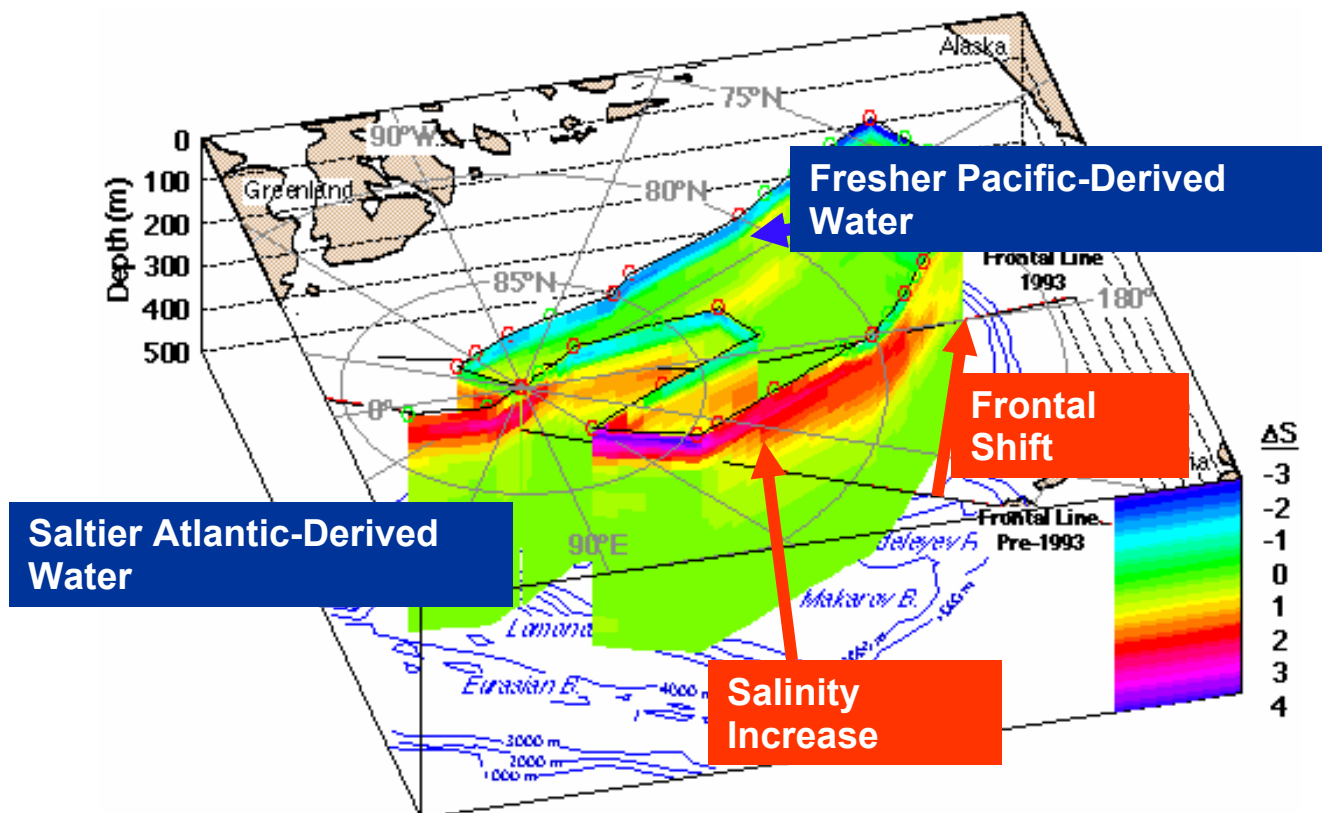
Charge to the Panel

This will come from Peter Schlosser, the chair of the SEARCH Science Steering Committee. You can anticipate what Peter will say by reviewing the SEARCH Implementation Plan, see: <http://www.arcus.org/SEARCH/OSM/publications.html>

I am sending by snail mail a CD that contains a version of the Implementation Plan in which I have highlighted the text most relevant to our panel in yellow. Note that there is relevant text under each of the panel descriptions: Observing Change (in this document “Detecting”), Understanding Change, and Responding to Change. More on the linkages between panel tasks below. Also on the CD are powerpoint presentations relevant to SEARCH as well as the SEARCH Science Plan.

Background on how SEARCH came to be

Please keep in mind that this is my first person take. I am sending this to Peter and Jamie for vetting at the same time I send it to you, so please consider it a draft for our own internal use for now. I attended a meeting of the Arctic System Science (ARCSS) Ocean-Atmosphere-Ice Interactions (OAI) Steering Committee in 1997 as newly appointed chair of the ARCSO Committee (an ARCUS committee to help integrate ARCSO). Jamie Morrison of the Applied Physics Laboratory at the University of Washington came to the meeting to share evidence of remarkable changes in the Arctic Ocean. This a version of a key diagram he talked about:



I didn't immediately understand the diagram, but I could understand Jamie's enthusiasm for taking the steps necessary to document and understand the changes he and others were observing. He was thinking at the time of working through OAI to make funding available for researchers to propose to place additional measurement buoys and other devices in the Arctic

Ocean. Following this meeting, he took the lead in asking scientists to join in signing an open letter highlighting the importance of this research (see the Science Plan at the same web address as given above or on the CD).

I was impressed at the influence this grass-roots effort had on research priorities at the national level. I've used this example more than any other to make the point that research can and does emerge from the community at large, even though it can easily be misinterpreted later on (in its manifestations as science plans and announcements of opportunity) as an initiative of government.

From 1997 to 2005 is a long time and lots of people put in lots of effort to develop the idea Jamie first raised into a research initiative. Here is a later diagram that summarizes the main ideas underlying the physical science of SEARCH

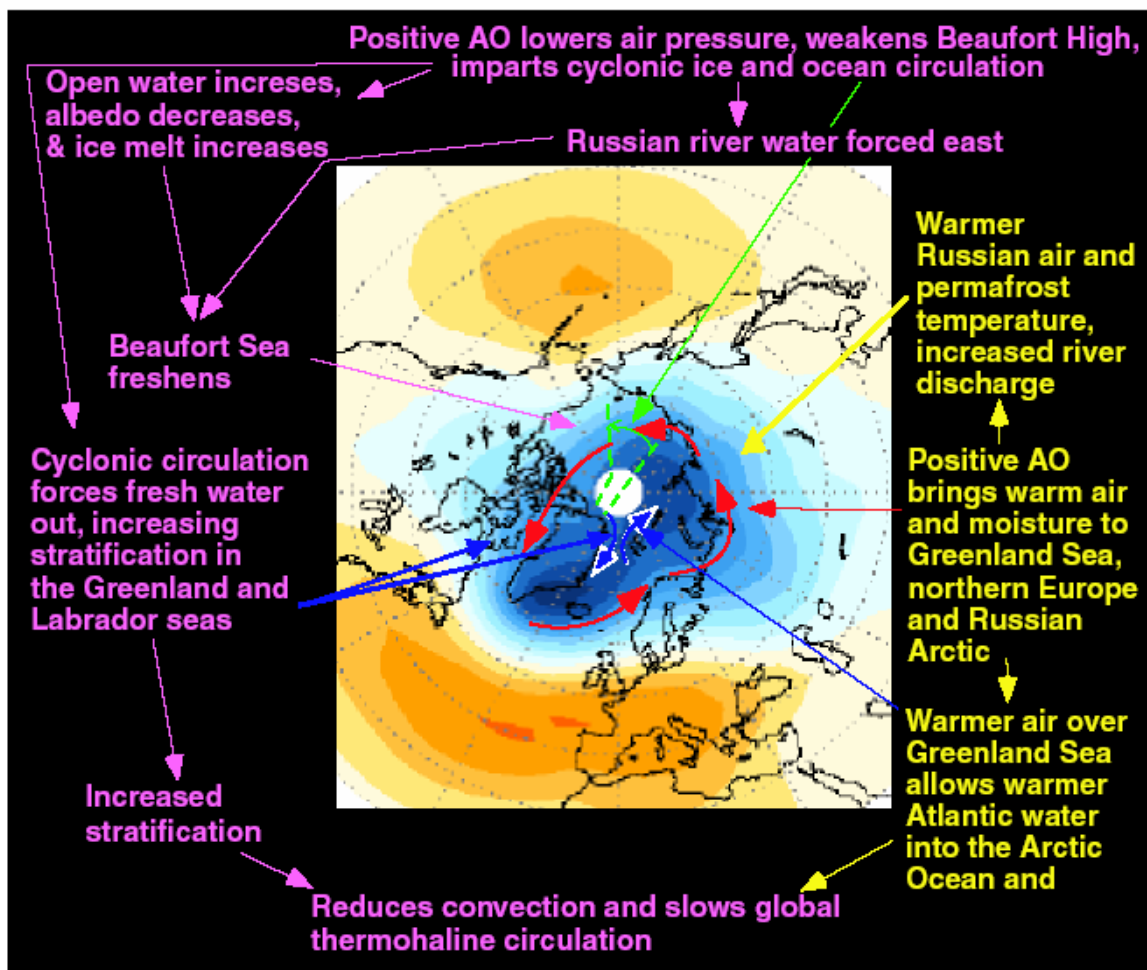


Figure 3-1 Schematic of how AO (illustrated here by the first EOF of sea level pressure from Thompson and Wallace, 1998) may force the other changes comprising Onami. (Reproduced with permission of American Geophysical Union.)

The problem has been funding. There were already other major research initiatives underway under OAIL and other ARCSS programs. My impression is that NSF Program Officers saw the solution to the problem in terms of how to shape SEARCH into something that could garner new funds from Congress. They encouraged Jamie and others on the SEARCH Science Steering Committee to think broadly in terms of the impacts of the changes they were seeing on the natural and human environments. To their credit (being mostly physical scientists), those

developing SEARCH looked to the broader scientific community for linkages to the natural and human components of the arctic system.

To help with broadening the scope of SEARCH, Jamie applied for, and received, incubation funding from NSF for a biocomplexity workshop. To give you an idea of the disciplinary breadth at this point, participants in the first workshop included:

| | |
|---------------------|---|
| Dave McGuire | climate-terrestrial-flux |
| Gus Shaver | terrestrial ecology-flux |
| Doug Wallace | climate-ocean-flux |
| Mark Serreze | climate |
| Robby MacDonald | marine flux |
| Alan Springer | biological oceanography-modeling |
| Sue Moore | climate-ocean-marine mammals |
| Rick Brodeur | marine biology-fish |
| Pati Matrai | marine biogenic gases (DMS, bromide) |
| Brad Griffith | climate-NDVI-terrestrial |
| Egil Sakshaug | climate-biological oceanography |
| Gunnar Knapp | subarctic fisheries, world fisheries |
| Jim Schumacher | climate-ocean-fish |
| Henry Huntington | marine human dimension |
| Jim Overland | climate-ocean-fish |
| Phyllis Stabeno | ocean-fish |
| Larry Hamilton | climate-fish-economy |
| Kim Peterson | terrestrial ecology-flux |
| Jamie Morison | climate |
| Jackie Grebmeier | climate-benthic production |
| Lou Codispoti | marine biogeochemical, carbon, N, trace gases |
| Glen Cota | primary productivity, remote sensing |
| John Walsh | climate modeling |
| Jack Kruse | climate-marine-terrestrial-social effects |
| Vera Alexander | Bering Sea primary production |
| George Hunt | Bering Sea birds |
| Terry Chapin | climate-terrestrial-flux-landscape |
| Pat Wheeler | biological oceanography-modeling, Biogeo cycles |
| Vladimir Romanofsky | permafrost |

Here is an example of the result in the SEARCH Science Plan:

It is clear that a complex suite of significant, interrelated, atmospheric, oceanic, and terrestrial changes has occurred in the Arctic in recent decades. This event is affecting every part of the arctic environment and is having repercussions on society. .. Because the observed changes have made it harder for those who live in the North to predict what the future may bring, we have given the name Unaami (the Yup'ik word for "tomorrow") to the complex of intertwined, pan-arctic changes... As a working definition based on present knowledge, we define Unaami as the recent and ongoing, decadal (e.g., 3–50 year), pan-arctic complex of interrelated changes in the Arctic. These changes include, among other things, a decline in sea level atmospheric pressure, an increase in surface air temperature, cyclonic ocean circulation, and a decrease in sea ice cover. The physical changes are producing changes in the ecosystem and living resources and affecting the human population. The changes are affecting local and hemispheric

economic activities such as shipping and fisheries totaling billions of dollars. These biological and societal consequences may be considered part of Unaami. (Executive Summary)

One of the four hypotheses in the SEARCH science plan reflects this broadened scope: *The physical changes of Unaami have large impacts on the Arctic ecosystems and society.*

Note that in the Science Plan the paradigm is one of impacts. One of the four major SEARCH activities identified in the plan is:

Application of what we learn to understanding the ultimate impact of the physical changes on the ecosystems and societies, and to distinguish between climate-related changes and those due to other factors such as resource utilization, pollution, economic development, and population growth.

The SEARCH SSC reached out to the Native community in Alaska to understand what changes people had already observed. Examples appear in the Science Plan. Here's one example:

Charlie Johnson of Nome (Johnson, 2000) remarked, "Is there going to be some conclusion at the end of three years about the effect of climate change on the observations people are making? When the winds and weather patterns are different, it will bring a lot of change. It could change how contaminants travel. It might not be just the temperature, but it may also be the sand flowing on the ice and melting it faster." (p.27 Science Plan)

The Science Plan was published in 2001. Meanwhile the idea of SEARCH had outgrown OAI and even NSF (I think as part of the strategy to attract Congressional support). At NSF's invitation, other agencies like NOAA and NASA had become involved in an initiative to make a joint request for funds from Congress. I admire Jamie for the grace with which he adapted his original plea for buoys to a multi-agency, multidisciplinary, multi-million effort. The problem still remained one of money. The requested funds were not forthcoming.

I should mention here that operating in parallel with the SEARCH Science Steering Committee (SSC) has been the Interagency Working Group (IWG), lead by John Calder of NOAA.

To keep forward momentum, the SEARCH SSC – with IWG oversight – worked on an Implementation Plan. As part of this work, the SSC applied remaining incubation funding to develop the natural and human dimension components of the plan. A combined biology and human dimensions workshop was held in Seattle in 2002. Participants included: Orville Huntington, Matt Berman, Gary Kofinas, Don Russell, Phyllis Stabeno, Henry Huntington, Larry Hamilton, Carin Ashjian, Bruce Forbes, Shari Fox, Kenny Kelso, David Yessner, Lee Cooper, and myself (this list may omit some of the biology participants; I will expand it if I find it is short).

The results of this workshop, reflected in the Implementation Plan, reflect a change in paradigm from one of impacts to one of interactions. The idea is that natural and human systems interact with the physical system, producing changes in all three. Thus "responding to change" is not simply a matter of responding to impacts, it is a much more complex pattern of responses over time to anticipated, observed, and experienced changes in the arctic system.

Matt Berman, who took the lead in organizing the human dimensions workshop, prepared a summary of the 2002 workshop that I've incorporated into this paper. I think that it is the most concise description of the interrelated tasks relevant to the Responding to Change panel. Compare it to the relevant contents of the Implementation Plan reproduced later in this paper.

Summary of Human Dimensions SEARCH Workshop Seattle, 2002

Detecting change research tasks

Food gathering, processing, and consumption. Collect and document evidence of variation in local and regional resource use over time. Use archeological data, historical accounts, and contemporary harvest data to record amount and quality of important food sources, trends in total harvest effort, changes in seasonal effort, shifts to alternative food types, and changes in processing and preservation methods. Also compile evidence of changes in condition of harvested resources including factors affecting human health and nutrition and culturally significant indicators of quality (e.g., blubber thickness, caribou hide quality, fish health).

Changes in physical environment important to Arctic residents. Monitor erosion and coastal flooding due to storm surges, river flooding, changes in sea, river, lake ice conditions, changes in timing of freeze up and breakup and ice road construction.

Changes in land use. Monitor changes in seasonal resource use, relocation of camps, structures, or entire communities as a result of environmental changes. Monitor spread of urbanization and resource development and tourism activities in the Arctic and associated environmental impacts.

Transportation and infrastructure. Monitor changes in transportation strategies (water vs. snow), changes in gasoline and heating oil or other fuel demand and costs. Monitor changes in commercial shipping by water, air, or other means, as well as diffusion of new technologies for transportation for household use and for commercial and industrial activities. Monitor changes in safety of transportation by all modes. Record number of structures lost by region due to coastal erosion/storm surge, riparian erosion and flooding, wildfire, permafrost melting.

Resource abundance and distribution. Compile historical and contemporary data on stock abundance and distribution, and migration routes for key species across places and time. Key industrial fisheries with potential biophysical relationships to polar vortex/AO in the N. Atlantic include Atlantic cod, herring, shrimp, capelin; in the North Pacific, Pollock, Pacific cod, herring, and several crab species are important. Marine mammals as well as Arctic cod, and some salmon runs are important species for subsistence use. Terrestrial species of greatest interest are Rangifer (caribou/reindeer), and moose.

Commercial resource use. Monitor fisheries harvests by species, change in location of fish harvests, and change in health and quality of harvested fish. Compile data on location and intensity of oil and gas development onshore and offshore in the Arctic, changes in patterns of tourism and recreation, and changes in technology used in commercial activities as it may be related to Unaami.

Livelihood strategies. Establish data collection programs for data not routinely collected through established censuses and other government statistical programs to monitor changes in demographic characteristics of Arctic communities, changes in employment in established communities and development enclaves, changes in types of jobs located in the Arctic and in seasonal patterns of employment, and migration by demographic characteristics.

Quality of life. Establish data collection programs for data not routinely collected through established censuses and other government statistical programs to monitor changing social structure, changing time spent on the land, changes in sharing and other risk-coping strategies,

and community events related to resource harvests. Monitor loss of traditional knowledge and activities, and loss of aboriginal languages related to changes in the land. Monitor birth and death rates and indicators of social pathologies such as crime, substance abuse, and injury deaths.

General notes: Ecological Knowledge Coops can participate in many of the above data collection programs. Some coops are already established, but coops need to be expanded, with greater use of standardized protocols, requiring a coordinated program. The community-industry data network concept overlaps with knowledge coops, and should include state and federal agency data. Coordination with coops is needed. Planning data collection throughout SEARCH should be sensitive to local community concerns. Working with coops, SEARCH data collection build on existing programs such as CAFF: biodiversity monitoring initiative that is species oriented (reindeer/caribou, polar bears, sea birds,).

Understanding Change

Integrated analysis and modeling of linked natural and social systems. Model links between social and environmental change by integrating analyses of paleo, historical, and contemporary observation data to understand: (1) how have social and economic factors filtered or moderated the observed effects of historical and recent climate change; and (2) how have climate change effects interacted with ecosystem and human system dynamics? Using archeological techniques, historical methods, and oral histories, compare past responses to environmental to contemporary responses such as shifts in subsistence patterns, technological change, and migration to identify similarities and differences.

Subsistence patterns. Analyze harvest data and relate to other environmental and social variables to determine:

- Relationship between changes in resource abundance and distribution and changes in harvest
- How variable is the response of communities to Unaami?
- How exceptional is Unaami compared to paleo evidence?
- What explains the variation in community response (alternative resources, institutions)
- What are thresholds of change (i.e., in use areas, species), and what determines the thresholds?

Mixed economies. Analyze data on resource harvests, demographics, and the cash economy, to ascertain how modes of subsistence (mixed economic systems) may be shifting in response to Unaami? Undertake comparative case-study analyses to develop understanding of key relationships between changes in resource use and indicators of health and well-being. Includes examining how systems of resource exchange and risk-coping mechanisms are able to accommodate Unaami and/or may be changing in response to Unaami. Develop models on a variety of relevant temporal and spatial scales to simulate changes in resource use and associated indicators of well-being, including perceptions of change as viewed by Arctic residents.

Transportation and infrastructure. Analyze data on changing seasons for river freezeup and breakup, sea ice conditions, snow cover, and ice road construction to assess how Unaami may change local and regional access to resources. Assess the consequences for commercial and subsistence activities if ice-based transportation modes become unavailable at key times. Where new modes of access may be required, assess the affect of changing access modes on local economies. Examine the costs and risks involved in changing from permafrost to a non-permafrost soils for remote rural communities and resource development enclaves.

Resource development. Identify linkages between global systems and change in prices and production of Arctic resources. For example, sub-Antarctic fisheries may be targeted by displaced harvesters of sub-Arctic fisheries; Atlantic cod declines may cause prices to rise for Pacific pollock and cod, increasing harvest pressure on these and other species.

Human and ecosystem health. Examine links between changing air and water temperatures and changes in the abundance and distribution of invasive species, parasites, disease vectors, and other species that may affect health of humans and subsistence resources. In general, terrestrial and marine ecosystem research should place sufficient emphasis on modeling Unaami in upper trophic levels to analyze ecosystem effects relevant to people, who primarily consume resources at upper levels.

Quality of life. Examine the association between Unaami and social indicators of human health, well-being, and cultural activities that reflect on the quality of life in Arctic communities. Examine non-Arctic residents' perceptions of the Arctic, Arctic people and ecosystems, and climate change, and how Unaami may change these perceptions.

Adaptation. Evaluate the comparative role of institution factors, social structure, information flow, social, human, and physical capital, technology, and political empowerment in enhancing or inhibiting the capacity of Arctic communities to adapt to Unaami. Identify interactions from changes in markets, technology, and resource management resulting from Unaami. Examine variations in responses and outcomes to Unaami-like change across different circumpolar locations and different time periods (e.g., changes in patterns of resource use, population movements, technological changes, demographic change, other economic responses). Examine effectiveness and effects of opportunistic and change-buffering adaptations to Unaami such as sharing, migration, resource management, and government policies. Identify differential vulnerabilities, and the winners and losers from adaptations.

Responding to Change

Pan-Arctic database. Establish pan-Arctic virtual repositories or meta-database to provide access to relevant real-time and historical data from industry, scientific studies (past and ongoing), agencies, and communities. For example, a circumpolar database showing local variations in soil temperature, soil characteristics, aspect, and vegetative insulation, and other factors could help predict areas where permafrost is likely to become unstable if regional climate warms.

Community-industry-science data networks. Establish community-industry-science agency networks to exchange information. Engage local communities and stakeholders in design, implementation, and review of studies of impacts of change. Conduct workshops for resource managers, stakeholders, and communities on applications of SEARCH science to resource management and land-use decisions. Use networks to communicate what science is working to ultimately predict, and what is inherently unpredictable.

Effectiveness of institutional responses to effects of Unaami. Undertake comparative studies of the different institutions that various Arctic nations have developed to address the effects of Unaami on Arctic populations and industries; assess the comparative responsiveness of those institutions to stakeholder interests and community needs. Analyze impediments to resource managers applying SEARCH and related research on climate variability.

End of Workshop Summary

Implementation Plan

It is worthwhile to read the entire Implementation Plan, but here text segments containing key points for us:

2.1 Research Questions

Question 6: What changes in populations, biodiversity, key species, and living resources are associated with Unaami?

- b) How does Unaami, as reflected in populations, biodiversity, key species, and ecosystems, interact with driving forces such as harvesting and cumulative impacts of regional development?

Question 7: What are likely effects of Unaami on the health and well being of arctic residents?

- a) How might Unaami affect marine and terrestrial subsistence and commercial harvests and associated ways of life in the Arctic?
- b) How does Unaami interact with other changes (technology, markets) and social change?
- c) How might Unaami interact with other changes to affect arctic human settlements, transportation systems, and economic development?
- d) How might Unaami interact with other changes to affect the spread of diseases, health of resources and people, and quality of life?

Question 8: How can we characterize the adaptive responses of arctic communities?

- a) How have arctic people adapted to past environmental change?
- b) How do social factors (institutions, social structure, information flows, empowerment, social capital, human capital, infrastructure) affect the contemporary adaptive responses of arctic communities to Unaami and other coupled changes?

Question 9: How might Unaami affect people outside the Arctic?

- a) How might Unaami affect arctic and subarctic fisheries?
- b) How might Unaami affect species and habitats of special concern? (e.g., arctic migratory species, endangered species)
- c) How might Unaami affect transportation, resource development, and other economic activities?
- d) How might Unaami affect international relations and national security?
- e) How might Unaami affect energy use and cost?

2.2 Application Questions

Question 11: How can understanding of Unaami be used to develop adaptive responses?

- a) How do we communicate scientific understanding of Unaami?
- b) How do we communicate community needs?
- c) How effective or adequate are contemporary responses?
- d) What responses would be most effective?

3.1 SEARCH Organization: Responding to Change Panel

Plans for the SEARCH Responding to Change Panel will follow the general scheme of the Observing Change Panel and Understanding Change Panel. It is sensible to have this panel work from the very beginning to incorporate and test application of what is learned to predicting the impact of Unaami on the ecosystem and society. The vision of how the RCP will function will have to evolve during the early stages of SEARCH.

3.2.4 (Terms of Reference) Responding to Change Panel (RCP)

1. Advises and aids the SSC in development of the application component of the implementation plan. In this area especially the initial plan will not be well developed so that revisions will be critical and the panel's activity will probably increase with time.

2. Works with the DCP and UCP to ensure planned observations and modeling provide the data needed for application.

3. Has oversight of the details of the application program. This will be a working panel and should be small enough to be intensely active. The panel should include six or seven members with at least one expert on the marine environment, terrestrial environment, and the atmosphere. Several members should be expert in the human dimension. Disciplines not represented directly will be represented through use of specialized working groups. Joint membership on more than one panel (DCP, UCP, and RCP) will be permitted and may be advisable to maintain close ties between the panels. At least one member of each panel should be appointed by the panel to attend meetings of the other panels on an ex-officio basis. One SSC members will be appointed by the SSC to attend ex officio the meetings of the RCP. (The chairs of the RCP will also attend the SSC meetings ex officio.)

The chair and members will be appointed by the SSC with the approval of the IPMC. They will serve for three years with the possibility of one additional three-year term. Start dates will be staggered among the members.

4. SEARCH IMPLEMENTATION ACTIVITIES AND ACTIVITY AREAS

...As SEARCH proceeds, increasing emphasis will be given to applying, testing and improving this prototype system and applying its products to prediction of impacts on the ecosystem and society.

...The early components of SEARCH aimed at responding to change will emphasize application of research on Unaami to fisheries, subsistence hunting, transportation, and other related social and economic issues of interest to industry and government decision-makers. It will also develop a systematic method of connecting SEARCH science with northern communities and society in general.

...This section discusses the SEARCH activities broken down first by the Detecting, Understanding, and Responding paradigms and then in subsections by activity area. Operationally the activities of SEARCH fall naturally into eight interdisciplinary activity areas that closely interact with each other. These SEARCH operational activity areas take advantage of common science infrastructure and logistics. Most of them fall largely under Detecting, Understanding, or Responding to change, but several fall under two such categories.

They are:

8. SOR—Social Response
Responding to Change

4.1.1 DQU - Detecting and Quantifying Unaami and Other Modes of Variability

1. Develop multiple lines of evidence (physical, biological, and human) for large-scale spatial covariability and change in the Arctic.
 - h. Compile historical data on stock abundance and distribution, and migration routes for key species across places and time. Key industrial fisheries with potential biophysical relationships to polar vortex/AO in the North Atlantic include Atlantic cod, herring, shrimp, and capelin; in the North Pacific, pollock, Pacific cod, herring, and several crab species are important. Marine mammals as well as Arctic cod, and some SEARCH salmon runs are important species for subsistence use. Terrestrial species of greatest interest are rangifer (caribou and reindeer), and moose.
 - i. Collect and document evidence of variation in local and regional resource use over time. Use archeological data, historical accounts, oral histories, and contemporary harvest data to record amount and quality of important food sources, trends in total harvest effort, changes in seasonal effort, shifts to alternative food types, and changes in processing and preservation methods.
 - j. Find long-term records of human activity [e.g., shipping, development, fishing, subsistence, transportation (air, boat, overland)] to analyze for variability and social and/or environmental changes.
 - k. Interview arctic residents and others with long experience and knowledge of oral history in the region to identify the timing and types of change for further investigation; compare oral history to evidence from paleoclimatic data.

4.1.3 DMO - Distributed Marine Observatories

- i. Repeated Census of Key Marine Species ... In the sub-arctic seas, such as the Bering Sea, it will be important to continue and expand time series on fish populations and other biota. In the Bering Sea, it would be useful to extend fisheries surveys to the north, to detect northward shifts in fish populations and their effects on the pelagic and benthic ecosystems.
- m. Pollutant Sampling... Because there is considerable biological magnification of organic pollutants in the food chains leading to human consumption of higher trophic level carnivores, collections of fat samples from the harvests of subsistence hunters would provide a direct measure of the level of contaminants to which people dependent on these resources are exposed. The Arctic Monitoring and Assessment Program (AMAP) may undertake this requirement.
- r. Ecological Knowledge Cooperatives - Utilize ecological knowledge cooperatives to bring local and traditional knowledge of marine climate and ecosystem variability as described under SEI below.
- s. Community/Industry Data Networks I - Establish community and industry (e.g., fisheries, shipping) data gathering networks that provide marine data as described for SEI below.

4.1.4 DTO - Distributed Terrestrial Observatories

j. Ecological Knowledge Cooperatives. Utilize ecological knowledge cooperatives to bring local and traditional knowledge of terrestrial climate and ecosystem variability as described under SEI below.

4.1.5 SEI - Social and Economic Interactions

a. Harvests. Monitor trends in total harvest effort, changes in seasonal effort, shifts to alternative food types, and changes in processing and preservation methods. Also monitor evidence of changes in condition of harvested resources including factors affecting human health and nutrition and culturally significant indicators of quality (e.g., blubber thickness, caribou hide quality, fish health).

b. Erosion and Flooding. Monitor erosion and coastal flooding due to storm surges, river flooding, changes in sea, river, and lake ice conditions, changes in timing of freezeup and breakup, and ice road construction.

c. Resource Use. Monitor changes in seasonal resource use, relocation of camps, structures, or entire communities as a result of environmental changes. Monitor spread of urbanization and resource development and tourism activities in the Arctic and associated environmental impacts.

d. Transportation. Monitor changes in transportation strategies (water vs. snow), changes in gasoline and heating oil or other fuel demands and costs. Monitor changes in commercial shipping by water, air, or other means, as well as diffusion of new technologies for transportation for household use and for commercial and industrial activities. Monitor changes in safety of transportation by all modes. Record number of structures lost by region due to coastal erosion/storm surge, riparian erosion and flooding, wildfire, and permafrost melting.

e. Commercial Fishing. Monitor commercial fisheries harvests by species, change in location of fish harvests, and change in health and quality of harvested fish. Compile data on location and intensity of oil and gas development onshore and offshore in the Arctic, changes in patterns of tourism and recreation, and changes in technology used in commercial activities as it may be related to Unaami.

f. Livelihood Strategies. Establish data collection programs for data on livelihood strategies not routinely collected through established censuses and other government statistical programs to monitor changes in demographic characteristics of arctic communities, changes in employment in established communities and development enclaves, changes in types of jobs located in the Arctic and in seasonal patterns of employment, and migration by demographic characteristics.

g. Quality of Life. Establish data collection programs for quality of life indicators not routinely collected through established censuses and other government statistical programs to monitor changing social structure, changing time spent on the land, changes in sharing and other risk-coping strategies, and community events related to resource harvests. Monitor loss of traditional knowledge and activities, and loss of aboriginal languages related to changes in

the land. Monitor birth and death rates and indicators of social pathologies such as crime, substance abuse, and injury deaths.

h. Community/Industry Data Networks II. Establish community and industry data gathering networks that provide data on terrestrial ecological change that are important to the communities and industries. The community-industry data network concept overlaps with knowledge co-ops, and should include state and federal agency data. Coordination with co-ops is needed. Planning data collection throughout SEARCH should be sensitive to local community concerns. Working with co-ops, SEARCH data collection can build on existing programs such as CAFF, a biodiversity monitoring initiative that is species oriented (e.g., reindeer and caribou, polar bears, and sea birds).

4.2 Understanding Change - 4.2.2 ASR - Arctic System Reanalysis

c. Expand to Other Parts of the Arctic System. Expand the reanalysis concept to develop the Arctic System Reanalysis (ASR). This is to estimate hard-to-measure variables that pertain to all parts of the Arctic system. Various data assimilation or reanalysis philosophies may be necessary to include variables in the atmospheric, oceanic, terrestrial, ecological, and social parts of the system. The geographic limits of the arctic system may be extended (e.g., recent observations that the Arctic hydrologic cycle may be affecting Atlantic Ocean salinities as far south as 30°N). Useful models already exist for the physical and ecological parts of the system. Social models only exist for small regions of the Arctic. System reanalysis is likely to require use of simple social models or models extrapolated from small regions pending significant improvement in these areas.

d. Linkages with Ecosystems and Society. Model links will be made between social and environmental change by integrating analyses of paleo, historical, and contemporary observation data to understand (1) how social and economic factors have filtered or moderated the observed effects of historical and recent climate change, and (2) how climate change effects have interacted with ecosystem and human system dynamics. Using archeological techniques, historical methods, and oral histories, compare past responses to environmental to contemporary responses such as shifts in subsistence patterns, technological change, and migration to identify similarities and differences.

4.2.2 LGC - Linkages and Global Coupling

g. Global Climate Connection of AO and Unaami: Ecological Effects. Model links between North Atlantic/Arctic and North Pacific/Bering Sea/Arctic marine ecosystem changes associated with changes in thermohaline circulation in subarctic and adjacent arctic seas to understand connection between ENSO/AO/NAO and their interrelated ecological effects.

n. Feedbacks Within the Arctic System: Ecosystem and Social Feedbacks. Develop, validate, and refine multiscale models of the coupled response of humans and key populations of animals, freshwater vertebrates, plants, and microbes to Unaami. Focus on (a) the dynamic linkages (energetic pathways) to reproductive and socio-economic strategies and performance, and on (b) the feedbacks among trophic levels (e.g., decomposers, primary producers, and herbivores and their natural and human consumers). For example, model the implications of temporal (days to decades) and spatial (local to continental) variability in snowmelt, green-up, summer warming, and winter warming and associated icing on (a) the performance (distribution and demography) of wide-ranging migrants such as caribou and reindeer and their important forage species, (b) the interactions of caribou and

reindeer and their forage species with biogeochemical cycles within ecosystems, and (c) the accessibility and influence of reindeer and caribou on indigenous subsistence cultures.

o. **Feedbacks Within the Arctic System: Marine Production Feedbacks.** Model the marine response to Unaami and feedbacks through population cycles of key marine species (for example, impacts of sea ice ecosystem changes on ice optical and mechanical properties). Examine how changes in the timing and location of sea ice extent, the types of ice present, stratification, nutrient and property gradients, and material fluxes and transport (including benthic processes and cross-shelf fluxes to the basins) would be expected to influence marine ecosystems. Model the energetic pathways of a few key marine species, including lower and upper trophic levels, to explore the links between life history characteristics of organisms (e.g., life span, reproductive strategies) and modes of ocean variability.

p. **Feedbacks Within the Arctic System: Marine Harvest Practices and Thermohaline Changes.** Model changes in marine food webs as fish harvesting and aquaculture activities combine with thermohaline changes and biogeochemical cycling to change the ecosystem.

q. **Feedbacks Within the Arctic System: Feedbacks from Society at Large.** Model interactions between global and arctic social and environmental change. Model how arctic environmental changes affect environments and societies “downstream” at lower latitudes. Model how lower-latitude environmental, economic and social changes affect arctic ecosystems and societies.

4.2.4 SEI - Social and Economic Interaction

a. **Subsistence Harvest Impact.** Analyze subsistence harvest data in relation to other environmental and social variables to determine:

- i. the relationship between changes in resource abundance and distribution and changes in harvest
- ii. the variability of the response of communities to Unaami
- iii. the exceptionality of Unaami compared to paleo evidence
- iv. the variation in community response (alternative resources, institutions)
- v. the thresholds of change (i.e., in use areas, species), and what determines the thresholds

b. **Resource Use Adaptation to Unaami.** Analyze data on resource harvests, demographics, and the cash economy to ascertain how modes of subsistence (mixed economic systems) may be shifting in response to Unaami. Undertake comparative case-study analyses to develop understanding of key relationships between changes in resource use and indicators of health and well being. This includes examining how systems of resource exchange and risk-coping mechanisms are able to accommodate Unaami and/or may be changing in response to Unaami. Develop models on a variety of relevant temporal and spatial scales to simulate changes in resource use and associated indicators of well being, including perceptions of change as viewed by arctic residents.

c. **Access and Transportation.** Analyze data on changing seasons for river freezeup and breakup, sea-ice conditions, snow cover, and ice road construction to assess how Unaami

may change local and regional access to resources. Assess the consequences for commercial and subsistence activities if ice-based transportation modes become unavailable at key times. Where new modes of access may be required, assess the effect of changing access modes on local economies. Examine the costs and risks involved in changing from permafrost to non-permafrost soils for remote rural communities and resource development enclaves.

d. Identify linkages amongst global systems, prices, and production of arctic resources. Sub-Antarctic fisheries may be targeted by displaced harvesters of subarctic fisheries; Atlantic cod declines may cause prices to rise for Pacific pollock and cod, increasing harvest pressure on these and other species.

e. Examine links between changing air and water temperatures and changes in the abundance and distribution of invasive species, parasites, disease vectors, and other species that may affect health of humans and subsistence resources. In general, terrestrial and marine ecosystem research should place sufficient emphasis on modeling Unaami in upper trophic levels to analyze ecosystem effects relevant to people, who primarily consume resources at upper levels.

f. Examine the association between Unaami and social indicators of human health, well being, and cultural activities that reflect on the quality of life in arctic communities. Examine non-arctic residents' perceptions of the Arctic, arctic people and ecosystems, and climate change, and how Unaami may change these perceptions.

g. Evaluate the comparative role of institutional factors, social structure, information flow, social, human, and physical capital, technology, and political empowerment in enhancing or inhibiting the capacity of arctic communities to adapt to Unaami. Identify interactions from changes in markets, technology, and resource management resulting from Unaami. Examine variations in responses and outcomes to Unaami-like change across different circumpolar locations and different time periods (e.g., changes in patterns of resource use, population movements, technological changes, demographic change, and other economic responses). Examine effectiveness and effects of opportunistic and change-buffering adaptations to Unaami such as sharing, migration, resource management, and government policies. Identify differential vulnerabilities, and the winners and losers from adaptations.

4.3 Responding to Change -4.3.1 SOR - Social Response

a. Apply research on Unaami to fisheries, subsistence hunting, transportation, and other related social and economic issues of interest to industry and government decision-makers.

i. Make pilot application of the prototype Arctic System Reanalysis (ASR) to ecosystem and social variables important to communities and industries. Review reanalysis products, the changes they reveal, and their relation to the variables and changes observed by and which are of greatest concern to arctic residents (see c below).

ii. Establish pan-arctic virtual repositories or meta-database to provide access to relevant real-time and historical data from industry, scientific studies (past and ongoing), agencies, and communities. For example, a circumpolar database showing local variations in soil temperature, soil characteristics, aspect, and vegetative insulation, and other factors could help predict areas where permafrost is likely to become unstable if regional climate warms.

b. Establish SEARCH related communication with social and economic entities concerned with conditions in the Arctic.

i. Conduct workshops for resource managers, stakeholders, and communities on applications of SEARCH science to resource management and land-use decisions.

ii. Community/Industry Data Networks II. Establish community and industry data gathering networks that provide data that are important to the communities and industries.

iii. Establish science/local community communication forums in which researchers share data and findings with local governments and citizens and receive regular feedback on issues of concern, research hypotheses, and explanations of observed and predicted change.

c. Assess responsiveness and effectiveness of local, regional, and national institutions in addressing social and economic concerns associated with Unaami.

i. Undertake comparative studies of the effectiveness of institutions of arctic nations to address the effects of Unaami on arctic populations and industries. Assess the comparative responsiveness of those institutions to stakeholder interests and community needs. Analyze impediments to resource managers applying SEARCH and related research on climate variability.

ii. Gauge the community, industry, and government perception of and response to Arctic environmental risks and uncertainties. Analyze how uncertainty affects societal response to perceived threats, and how the responses affect ecosystem dynamics. For example, if reanalysis were to predict that the bowhead whale population may decline, but the decline is uncertain, how do local hunters, the Alaska Eskimo Whaling Commission, and the International Arctic Whaling Commission perceive the risk of decline, and do they change their harvest quotas and hunting practices? Consider how culture affects perception and response to environmental uncertainty, and what strategies might change these perceptions and responses.

End of excerpts from Implementation Plan

Preparing to meet our charge: questions for discussion

A note on “who” is responding to change: animals and plants are responding as well as people. I think animal and plant responses – that is responses of the natural environment – are meant to be handled as feedbacks, and thus under the Understanding Change panel’s responsibilities. But we want to be sure that these responses, and their consequences, don’t go unaddressed. I am assuming that we are talking about people responding to change.

1. How do we involve people who are responding to change in SEARCH?

One way of thinking about responding to change is to say, “Here are research results we think are relevant to your responses, tell us what you think.” Operating under this paradigm, our panel could prepare for how we can take SEARCH research to groups of people who are likely to be the ones responding to change. We would evaluate how useful the data is, and carry feedback from each group to the scientific community.

I am hoping that our panel's view is extend the involvement of groups to the beginning of the research process. Under this paradigm, questions to groups would include, "What are you observing that you would like to know more about? What data do you think would be helpful? What data could you collect if you had the necessary resources? What do you make of these results? What would you look at to advance our understanding of what is happening? What changes do you anticipate? What are you doing in anticipation of change? And then the questions under the first paradigm. In other words, I'm suggesting that we think of those responding to change as an integral part of the SEARCH research team.

I'd like the panel to begin by deciding how we see people being involved in SEARCH. That will influence all that we do later.

2. Who are the responding populations?

Based on the content of the Implementation Plan, we are at least talking about two (overlapping) groups of people: Arctic communities and Arctic/subarctic fishing industries. Thinking about working with people to define key observation variables, to set up observation networks, to interpret the meaning of observations, and to develop responses to change – is it helpful to think of Arctic communities and Arctic/subarctic fishing industries as two different groups?

One of the key features of the Unaami pattern is regional differences. The Eastern Canadian Arctic, for example, seems to show a cooling trend when the Western Canadian Arctic (and Alaska) shows a warming trend. Is it useful to think our "target" populations in regional terms?

What other groups should our panel identify as "target" groups? Some examples that come to mind include:

- Government and NGO officials who make decisions that affect Arctic peoples and Arctic industries.
- People who work in the Arctic but live elsewhere (of course, this group includes a lot of commercial fishers, but in addition includes mine and oilfield workers among others)
- Those currently and potentially involved in Arctic marine transportation
- The general public – this is a tricky one; where is the boundary between research and dissemination of results? I'm wondering if we might handle this through long-term arrangements with specific journalists (e.g. Andy Revkin, New York Times; Ned Rozell – or Doug O'Hara? – or Sean Cockerham?, Anchorage Daily News; Tom Paulson, Seattle-Post Intelligencer)

3. How do we best work with each population?

- a. What organization or organizations (perhaps by region or industry) are best to work with?
- b. What are the best ways to communicate with the organization(s) and its constituency?
- c. What experience can we draw on?
 - i. El Niño? Check out the following websites as examples:
 1. International Research Institute for Climate Prediction (IRI) <http://iri.columbia.edu/>
 2. NOAA at <http://www.pmel.noaa.gov/tao/elnino/nino-home.html>
 3. And select the "TAO Story" at <http://www.pmel.noaa.gov/tao/>

4. How to we best organize our work?

We may want to consider defining working groups that involve one or more of our panel members, perhaps a member from another panel, and people bringing in required expertise. We'll get more advice on this from Peter Schlosser.

We can organize by task or by target population group; I'm thinking by group makes the most sense, at least to start. There may be specialized tasks – like setting up the infrastructure to make SEARCH results available, or working with single contacts like press people – that are best handled by a working group or even one person. What do you think?

5. How do we proceed?

All is subject to change as we learn more from Peter. In the meantime, I'd like to suggest the following:

- a. Would each of you send me a paragraph describing who you are and how you see connecting with the work of the panel? I'll compile and distribute these to the group.
- b. Please correct any of the contact information I listed at the top of this document.
- c. I'm thinking that as a general rule, it's a good idea to use two week turnaround times. Tell me if you can generally live with that.
- d. Assuming 2 week turn around times, by Feb. 18th please put this document in revision mode and type in questions, comments, and ideas. Rename the document by adding your initials at the end, like _JK.doc and email it back to me. I'll compile these and send out a composite, adding – if I can – some ideas to bring us into consensus.
- e. Going by two-week turnarounds, the week of March 7-11 would be our next target, but I expect to be in Ottawa 6-10 March, so how about the week of 14-18 March between the hours of 10am – 2pm PST? Which days and times would you be available for an hour conference call?

Thanks all! I look forward to working with you.

Jack