SEARCH Responding to Change Panel (RCP) Position Paper
Preparation for SEARCH Implementation Workshop
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I. INTRODUCTION: WHAT THIS POSITION PAPER IS ABOUT

SEARCH (Study of Environmental Arctic Change) is a U.S. plan to research change in the Arctic. It has a developing international counterpart called the International Study of Arctic Change (ISAC). U.S. agencies such as the National Science Foundation (NSF) and the National Oceanographic and Atmospheric Administration (NOAA) have implemented some elements of the SEARCH plan.

SEARCH science planning is directed by a SEARCH Science Steering Committee and a SEARCH Interagency Program Management Committee (IPMC). Three panels under the SEARCH Science Steering Committee are responsible for developing SEARCH priorities and implementation strategies. The names of the panels describe their responsibilities: "Observing Change," "Understanding Change," and "Responding to Change." This position paper is intended to be the first step of the Responding to Change Panel in developing priorities and implementation strategies. Members of the panel are listed in the appendix at the end of this paper.

2. POSITION PAPER "BOTTOM LINES"

Key Points:

1. People are already responding to changes in the arctic system.
2. SEARCH results could affect people's adaptive responses to change.
3. The work of all three SEARCH panels (observing, understanding, and responding to change) is potentially relevant to people's adaptive responses.
4. People are interested in the factors that cause changes in their resources or environment. Research into the past can help them develop an understanding of how to translate real-time observations into short-term predictions. This understanding, or context, can also help them give meaning to predictions.
5. For predictions and observations to be relevant, people who are responding to changes need to be involved in defining them.
6. Research designs should focus on adaptive responses to change among groups of people dealing with the same cluster of related changes.
7. Fisheries, subsistence harvests, and transportation constitute good first categories defining an initial set of clusters of related changes.
8. Within each of these categories, researchers need to be more precise about the resource (e.g. species, transportation route) in order to identify related physical, biological, and human changes.
9. Identifying at least one cluster of related changes in each of the three categories (fisheries, subsistence harvests, and transportation) in the IPY phase of SEARCH will help ensure that SEARCH is responsive to a diverse set of stakeholders.
10. Taking fisheries, subsistence harvests, and transportation together, at a minimum stakeholder groups would include commercial fishers and processors, subsistence

hunters and fishers, the marine transportation industry and industries potentially taking advantage of Arctic marine transportation opportunities.

11. The Implementation Strategy identifies some two-dozen research activities that logically involve people who are responding to the same cluster of changes.
12. These activities would need to be replicated in somewhat different forms for each subsistence, fishery, or transportation system considered.
13. Whichever of the above activities are initiated, relevant groups of people responding to change should be directly involved.

Recommendation #1: We recommend that we implement a "responding to change" component for at least one specific cluster of related changes within each of the three categories (subsistence harvests, fisheries, transportation). The specific cluster in each category could be left to those responding to the announcement of opportunity.

Recommendation #2: We recommend that SEARCH (1) identify a group of people responding to regional manifestations of pan-arctic changes; (2) establish a community/industry network or ecological knowledge cooperative to facilitate involvement of the group in SEARCH; (3) work through the network or cooperative to identify relevant predictions; and, (4) work through the network or cooperative to make near-real time observations available.

3. POSITION OF RESPONDING TO CHANGE PANEL WITHIN SEARCH

The intent of SEARCH is to understand a complex of interrelated, pan-arctic changes occurring across terrestrial, oceanic, atmospheric and human systems. Our way of thinking about human systems has evolved in the SEARCH science planning process from one of impacts on biological and human systems to one of interactions between physical, biological, and human systems.

The Science Plan took the approach of impacts on biological and human systems. One of the four major SEARCH activities identified in the Science 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 Implementation Strategy benefited from a combined biological and human systems workshop. The results of this workshop reflect a change in paradigm from one of impacts to one of interactions. The idea is that biological and human systems interact with the physical system, producing changes in all three. Thus "responding to change" is not only a matter of responding to impacts, it is a much more complex pattern of responses over time to anticipated, observed, experienced, and learned changes in the arctic system.

The implication of an interactive approach to understanding responses to change is that these responses can take place *in anticipation of change*, subsequent to *personal observations of change,* and *in reaction to what people learn from others*. In other words, people are already responding; they won't wait for compilations of observations or release of predictions. The SEARCH Implementation Strategy focuses on adaptive responses to change. Thus the charge to the Responding to Change Panel is to address the question, "How can understanding of [pan-Arctic changes] be used to develop adaptive responses?"

Examples of how SEARCH could affect people's adaptive responses to change include:

- SEARCH observations, particularly if available in close to real time, may affect people's day-to-day decisions.
- SEARCH model exercises, particularly if presented in a form accessible to the general public, may affect people's perceptions. Commercial fishers, for example, might form new perceptions about how climate change and commercial fish harvests may interact to affect future stocks.
- SEARCH predictions, particularly if made at relevant scales of space and time, may affect people's investments for resource use and community infrastructure.

Key Points:

1. People are already responding to changes in the Arctic system.
2. SEARCH results could affect people's adaptive responses to change.
3. The work of all three SEARCH panels (observing, understanding, and responding to change) is potentially relevant to people's adaptive responses to change.

4. APPROACH TO INVOLVING PEOPLE WHO ARE RESPONDING TO CHANGE

RCP panel members exchanged experiences working with people who are responding to change. These are the points of consensus:

- People are keenly interested in predictions that are relevant to their daily lives.
- What is being predicted matters. If predictions are developed without the involvement of the people for whom they are intended, they are likely to be flawed or irrelevant to potential users. Nate Mantua, for example, said that a climate impact assessment group in the Pacific Northwest developed their own predictions and later found that the intended user groups did not think the predictions were useful. A key to making climate predictions relevant to stakeholders lies in establishing links between climate forecasts and local/regional resources of interest to specific groups of people – this calls for place-based applied research projects.
- Observations, if near real-time and relevant, are widely used by people responding to change.
- People are aware of multiple changes. They want to know how these changes will all stack up to affect their lives (and their grandchildren's lives) as a whole.
- The aspects of system change, or anticipated aspects of change, to which people are responding varies by region and even by community. Changes need to be explicitly identified, or else the idea of responding to change is too abstract for people to handle. We should therefore start with clusters of closely related changes, recognizing that it will take time to build a comprehensive view.

Based on these points of consensus the panel developed the following general approach:

- Engage people who are responding to changes in SEARCH from the beginning. Under this paradigm, people are involved in the following questions relevant to SEARCH, "What are you observing that you would like to know more about? What additional observations would be helpful? What useful data could you collect if you had the necessary resources? What predictions would be helpful? What do you make of these results? What relationships 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? Here are research predictions we think are relevant to your responses; tell us what you think."

- Engagement of people (stakeholders) takes time to set up and an investment to keep it going. Face-to-face contact, for example, is critical. Web sites and other technology can be very helpful, but they cannot substitute for face-to-face contact.
- Focus on the ability to predict changes that map onto decisions that people make every year (we understand we have a lot research to do before predictions can even be attempted).
- Make available observations that map onto decisions people make in near real time.
- Observations are critical to building our understanding of the arctic system and ultimately to our ability to predict changes. Relevant observations include not only changes in the physical system, but also changes in the biological system and the human system. Clusters of related changes include people's responses to changes (or anticipated changes) in the biological and physical environment. We therefore need to build observations of human responses into the observation system.
- Build research designs focusing on adaptive responses to change around clusters of related changes. For example, some communities are dependent primarily on migratory species; others are dependent on resident species. Some depend primarily on ocean or river ice for transportation; others do not. Some are vulnerable to erosion; others are not. It could be useful to facilitate connections between groups of people in similar situations who are disconnected because of geographic or political boundaries. This probably means starting with a physical change relevant to one or more of these clusters of related changes. The focus would be on decisions of a group of people dealing with one of these clusters (e.g. decisions of seal hunters in the face of changes in near shore sea ice conditions). It may also mean starting with one region, or a group of communities in several regions that face similar decisions, and then scaling up by adding more regions or more communities.
- Take advantage of prior work. Build on the work of the Regional Integrated Sciences and Assessments (RISA) program (http://www.ogp.noaa.gov/mpe/csi/events/risa_021804/index.html). Here is an extract of a 2004 RISA workshop report:
  - Useful decision support from the scientific community has a number of characteristics, including:
    - Information focuses on a critical societal issue, providing more than a state-of-the knowledge assessment
    - Information answers specific questions identified by stakeholders
    - Information is provided in a timely fashion, fitting into the timeframe of the decision-maker
    - Information is directly relevant in form and content to the decision at hand, reflecting an understanding of the decision context
    - Information is communicated in accessible language and formats
    - Information includes an evaluation of the degree of uncertainty, limitations in scientific understanding, and the confidence in the results provided
    - Research products are the result of close science-stakeholder interaction

Key Points:

1. People are interested in the factors that cause changes in their resources or environment. Retrospective research can help them develop an understanding of how to translate real-time observations into short-term predictions. This understanding, or context, can also help them give meaning to predictions.
2. For predictions and observations to be relevant, people who are responding to changes need to be involved in defining them.
3. Build research designs focusing on adaptive responses to change around groups of people dealing with the same cluster of related changes.

5. CLUSTERS OF RELATED CHANGES

According to the Implementation Strategy (p.12), "The early components of SEARCH aimed at responding to change will emphasize application of research on Unaami to fisheries, subsistence harvests, 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."

Each of these areas – fisheries, subsistence harvests, and transportation – reflects major areas of interest raised by stakeholder groups. "How does climate change interact with fisheries harvests to influence fish stocks?" "Will observed changes in sea ice and associated marine mammal distributions continue?" "Will reductions in summer sea ice extent permit expansion of Arctic marine transport?" Stakeholders include both Arctic residents and those interested in Arctic resources living outside the Arctic.

RCP members conclude that fisheries, subsistence harvests, and transportation are useful first categories for defining initial sets of clusters of related changes. The Implementation Strategy identifies other categories as well (e.g. infectious diseases, international relations). For SEARCH to be relevant to groups of people responding to change the starting point for definition of any cluster of related changes needs to be more precise: What changes in which fishery? What changes to which subsistence species? What changes to which marine transportation route?

According to the Implementation Strategy, key industrial fisheries with potential biophysical relationships to climate change in the North Atlantic include Atlantic cod, herring, shrimp, and capelin; and in the North Pacific include Pollock, Pacific cod, herring, and several crab species. 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.

Hunters of marine mammals in the eastern Bering Sea are an example of a sufficiently precise starting point in defining a cluster of related changes. These hunters live in many, but not all, villages located in the regions adjoining the eastern Bering Sea. The RCP thinks that defining the related physical and biological changes is a research activity in itself.

Key Points:

1. Fisheries, subsistence harvests, and transportation constitute good first categories for defining initial sets of clusters of related changes.
2. Within each of these categories, researchers need to be precise about the resource (e.g. species, transportation route) in order to identify related physical, biological, and human changes.
3. Identifying at least one cluster of related changes in each of the three categories (fisheries, subsistence harvests, and transportation) in the IPY phase of SEARCH will help ensure that SEARCH is responsive to a diverse set of stakeholders.
4. Taking fisheries, subsistence harvests, and transportation together, stakeholder groups include at a minimum commercial fishers and processors, subsistence hunters and fishers, the marine transportation industry and industries potentially taking advantage of Arctic marine transportation opportunities.

6. RESEARCH QUESTIONS

Narrowly speaking, the Implementation Strategy identifies the following research questions relevant to people's adaptive responses to change and thus to the main charge to the Responding to Change Panel:

- How do we communicate scientific understanding of coordinated, pan – arctic change?
- How do we communicate community needs?
- How effective or adequate are contemporary responses?
- What responses would be most effective?

Communication between SEARCH researchers and groups of people responding to change will be effective only if people responding to change are involved at the outset of SEARCH activities. Below is an example taken from the Implementation Strategy of research activities for subsistence harvests that logically involve people responding to change. Fisheries-related and Transportation-related research activities would look somewhat different and are also detailed in the Implementation Strategy. Note that these research activities are organized according to panel (observations, understanding, responding) and not intended to indicate an order of implementation:

Subsistence Harvests: Observations

- Compile historical data on stock abundance and distribution, and migration routes for key species across places and time.
- Collect and document evidence of variation in local and regional resource use over time.
- Find long-term records of human activity
- 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
- 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.

- Ecological Knowledge Cooperatives - Utilize ecological knowledge cooperatives to bring local and traditional knowledge of marine climate and ecosystem variability as described under SEI below
- 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).
- 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
- Quality of Life - Establish data collection programs for quality of life indicators not routinely collected.

Subsistence Harvests: Understanding

- 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… 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.
- 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.
- Feedbacks within the Arctic System - Ecosystem and Social Feedbacks. Develop, validate, and refine multi-scale 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 biological and human consumers).
- Subsistence Harvest Impact - Analyze subsistence harvest data in relation to other environmental and social variables to determine:
    - the relationship between changes in resource abundance and distribution and changes in harvest;
    - the variability of the response of communities to Unaami;
    - the exceptionality of Unaami compared to paleo evidence;
    - the variation in community response (alternative resources, institutions); and
    - the thresholds of change (i.e., in use areas, species), and what determines the thresholds.
- 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.

- Access and Transportation - Analyze data on changing timing of river freeze-up and break-up, sea-ice conditions, snow cover, and ice road construction to asses 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.
- 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.

Subsistence Harvests – Responding to Change

- Apply research on Unaami to fisheries, subsistence harvests, transportation, and other related social and economic issues of interest to industry and government decision-makers.
    - 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.
    - Establish pan-arctic virtual repositories or meta-databases to provide access to relevant real-time and historical data from industry, scientific studies (past and ongoing), agencies, and communities.

- Establish SEARCH-related communication with social and economic entities concerned with conditions in the Arctic.
    - Conduct workshops for resource managers, stakeholders, and communities on applications of SEARCH science to resource management and land-use decisions.
    - Community/Industry Data Networks II. Establish community and industry data gathering networks that provide data that are important to the communities and industries.
    - 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.

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

The broad scope of human and biological systems research should be evident in the above example. The above research tasks would differ in their application by specific type of subsistence harvest (e.g. seal vs. caribou), thereby multiplying the tasks by the number of different harvest systems considered. Likewise, the number of fisheries considered would multiply a similar list of research activities.

Key Points:

1. The Implementation Strategy identifies some two-dozen research activities that logically involve people who are responding to the same cluster of changes.
2. These activities would need to be replicated in somewhat different forms for each fishery, subsistence, or transportation system considered.
3. Whichever of the above activities are initiated, relevant groups of people responding to change should be directly involved.

7. PRIORITY RESPONSES TO CHANGE IN SEARCH/IPY

As stated at the outset, the intent of SEARCH is to understand a complex of interrelated, pan-arctic changes occurring across terrestrial, oceanic, atmospheric and human systems. One of the key challenges is identifying what biological and human system changes are most likely to be related to the observed physical pan-arctic changes. Even when the relationships between cyclical changes and secular trends in the physical environment appeared to be strong, uncertainties about the role of these pan-arctic changes in the local/regional biological and human environments were high. Now that the cyclical changes (for example the Arctic Oscillation or AO) appear to be more loosely related to secular trends (for example, decreasing trend in landfast ice), the uncertainty is even higher.

Given the high level of uncertainty about physical-biological-human environment relationships, it makes sense to give great weight to the concerns raised by people responding to change. The three areas of concern targeted in the implementation plan – subsistence harvests, fisheries, and

transportation – have the advantage of involving largely (but certainly not wholly) different groups of people, including Arctic residents (subsistence harvests), Arctic and sub-Arctic residents and industry (fisheries), and multinational industries (marine transportation and resource extraction).

Recommendation #1: We recommend that we implement a "responding to change" component for at least one specific cluster of related changes within each of the three categories (subsistence harvests, fisheries, transportation). The specific cluster in each category could be left to those responding to the announcement of opportunity.

8. PRIORITY RESEARCH ACTIVITIES FOR SEARCH/IPY

Initial research activities logically include a compilation of existing data and the design and implementation of an observation system. These activities are included in the Implementation Strategy. We look forward to interacting with the Observing and Understanding Change panels on this point. The RCP identified three related priorities: (1) identification of the predictions that would be most useful to those responding to a given cluster of related changes; (2) establishing near-real time data outlets relevant to those responding to change; and, (3) establishing community/industry data networks and ecological knowledge cooperatives.

Identification of Predictions Most Useful

The panel's experience is that the predictions most useful to climatologists may not be the predictions most useful to people responding to change. This makes sense when one considers the difference in use of observations and predictions. Climatologists focus on system level changes using observations and predictions that integrate over large geographic regions. People responding to changes often focus on a much broader suite of changes (climate+vegetation+fish and wildlife populations and migrations+wildfire+ice etc.) in a local region and are interested in observations and predictions at this local scale specific to resources or impacts of interest. Predicting changes in the ice mass balance of the Arctic Ocean is not the same thing as predicting changes in nearshore ice in coastal areas of the Bering Sea. We think that the integration of SEARCH can best be achieved in the long run by an early consideration of the system variables most useful as predictors at both geographic scales. Early consideration will likely open up opportunities in the observation and modeling stages to find innovative ways of meeting multiple objectives. In fact our understanding of the arctic system depends upon coupling system-level changes with local-scale changes. Identifying what predictions people would find most useful also will help define what current observations they find most useful.

Establishing Near-Real Time Data Outlets

Recognizing that people are already responding to change and that observation and modeling tasks will precede even initial attempts at prediction, the next most useful output of SEARCH is relevant near-real time data such as sea ice conditions and caribou locations. As an example, Jim Magdanz provided a URL to a NOAA river breakup map for Alaska: http://aprfc.arh.noaa.gov/data/maps/brkup_map.html. Jim notes that underlying the map is an easily accessible database. When he is headed to camp in the spring, he checks this map every day. It is very helpful in helping him to predict when he probably will be able to put the boat in the water and head up river from Shungnak. Of course, just as the relevance of predictions is specific to people responding to a particular cluster of related changes, so are relevant observations specific.

Establishing Community/Industry Networks and Ecological Knowledge Cooperatives
The intent of both community/industry networks and ecological knowledge cooperatives is the same: support the involvement of groups of people responding to change in SEARCH. The difference has mostly to do with the heritage of the terms, with community/industry networks most commonly associated with commercial fisheries and ecological knowledge cooperatives most commonly associated with subsistence harvest systems. For related website examples, see http://www.beringsea.com/ (this site is no longer current, but the relevance to SEARCH is obvious) and http://www.taiga.net/coop/index.html.

The Implementation Strategy discussion of networks and cooperatives focuses primarily on the data gathering and the contribution of local and traditional knowledge. The list of research activities dependent on the establishment of networks or cooperatives includes, among many other activities listed in the Implementation Strategy:

- Identification of clusters of related-changes in the physical, biological, and human systems;
- Identification of the most relevant predictions;
- Compilations of historical data;
- Designing and implementing observation systems;
- Establishing near-real time data outlets;
- Interpretation of modeling results in the context of local knowledge;
- Outreach to users; and
- Dissemination and assessment of SEARCH results

Recommendation #2: We recommend that SEARCH (1) identify a group of people responding to regional manifestations of pan-arctic changes; (2) establish a community/industry network or ecological knowledge cooperative to facilitate involvement of the group in SEARCH; (3) work through the network or cooperative to identify relevant predictions; and, (4) work through the network or cooperative to make near-real time observations available.

Appendix: Responding to Change Panel Members

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