REVISED RESEARCH PLAN

A. Signed Cover Page(s)
B. Contact Information
C. Project Title

Long title: Pacific Marine Arctic Regional Synthesis of the Northern Bering, Chukchi and Beaufort Seas
Short title: **Pac**ific **M**arine **A**rctic **R**egional **S**ynthesis (**PacMARS**)
Duration: 15 June 2012-14 June 2014 (24 months), with comprehensive Interim Report in July 2013

D. Proposal Summary

The **Pac**ific **M**arine **A**rctic **R**egional **S**ynthesis (**PacMARS**) effort will facilitate new synergies in understanding of the marine ecosystem in the greater Bering Strait region, including the northern Bering, Chukchi and Beaufort seas. The PacMARS research team and collaborators will: 1) identify and synthesize existing data sets that are critical for evaluating the current state of knowledge of this marine ecosystem, including human dimensions and 2) define the high-priority, overarching scientific themes and research needs for the next decade or more of marine ecosystem studies in the Pacific Arctic Region. This synthesis effort will contribute to NPRB's overall mission to promote understanding of north Pacific ecosystems in order to help enable effective management and sustainable use of marine resources, from subsistence use to fisheries to industrial exploration and development. We will accomplish this work by bringing together multiple data sets and/or providing internet-based linkages to data sets while developing practical synthesis mechanisms. The data assembled and other synthesis products will be publicly available at the National Center for Atmospheric Research (NCAR)'s Earth Observing Laboratory (EOL; http://arctic.eol.ucar.edu). This data inventory and synthesis effort will enable our second objective, the development of forward science planning and identification of science needs for an integrated, multi-agency research and modeling effort in the Chukchi/Beaufort region that could be initiated in 2014. Our large-scale work products will include a mid-term (July 2013) interim report of the synthesis activities and products, along with a summary of future research activities. The final report in 2014 report will be the basis for a peer-reviewed book with individual chapters developed as an interdisciplinary effort.

Table 1. The PacMARS Principal Investigator Team.

Institution	PI	Expertise
University of Maryland Center for Environmental Science (UMCES)	Jacqueline Grebmeier and Lee Cooper	Benthic ecology, interdisciplinary project management, biogeochemistry, biological & chemical oceanography
Florida Institute of Technology (FIT)	John Trefry	Trace metals, contaminants, chemical oceanography
University of Alaska Fairbanks (UAF)	Bodil Bluhm, Steve Okkonen, Gay Sheffield, Sveta Yamin-Pasternak	Benthic ecology, biodiversity, physical oceanography, marine mammals, marine advisory program, cultural anthropology
National Center for Atmospheric Research (NCAR)	James Moore	Data management, GIS data services
University of Rhode Island (URI)	Robert Campbell	Zooplankton ecology, molecular approaches, biological oceanography
University of Texas at Austin (UT)	Kenneth Dunton	Food webs, stable isotopes, benthic ecology
Woods Hole Oceanographic Institution (WHOI)	Carin Ashjian	Zooplankton ecology and lifecycles, biological oceanography

E. Project Objectives

1. Identify and link existing data sets, tabulate data archive sites and provide value-added annotated metadata for existing data that promote understanding of the marine ecosystem extending from north of St. Lawrence Island in the Bering Sea to the Chukchi and Beaufort seas, including traditional ecological knowledge where it can be readily transferred (**Data synthesis**).

2. Synthesize existing scientific and traditional knowledge of the marine ecosystem, with a focus on territorial waters of the United States and its adjoining Exclusive Economic Zone, but to also include input from beyond this region through collaborations with both Russian [e.g. Russian-American Long-term Census of the Arctic (RUSALCA)] and Canadian [e.g. Canada's Three Oceans program (C3O)] scientists who will cooperate with our effort. Other internationally generated data within the Pacific Arctic Group (PAG) international framework will also be contributed, including from Japan (point of contact, Dr. Takashi Kikuchi), Korea (point of contact, Dr. Sung ho Kang), and China (point of contact, Dr. Jianfeng He) (**Data synthesis)**

3. Develop overarching scientific themes and research needs to facilitate the design of the next iteration of integrated marine ecosystem studies in the Pacific-influenced Arctic, including the appropriate temporal and spatial scales of data needed for ecosystem-level assessment. (**Research Needs**).

4. Emphasize system-wide, synoptic understanding, in addition to discipline-specific syntheses of the northern Bering, Chukchi and Beaufort ecosystems. Given time and resource limitations, we will prioritize our efforts towards integrating across disciplines and we will use geographical and habitat-scaled approaches to achieve linkages among bio-physical observations and human communities (**Research Needs**).

5. Undertake a social-ecological science synthesis of (1) major research initiatives, (2) emerging research approaches and methods, and (3) the documented research needs and concerns. Each of these approaches will be geared toward identifying current research directions and gaps in knowledge concerning the maritime societies living within the marine ecosystems of the Northern Bering, Chukchi, and Beaufort Seas. Cumulatively, this contribution will results in an interdisciplinary socio-ecological synopsis of these marine ecosystems **(Research Needs**).

F. Technical Approach

F1. Research Themes. We have identified 6 research themes as foci for the PacMARS synthesis effort, which we think will align with future field research efforts. We provide initially a minimal example of one-to-two specific questions that could be used to address these themes as we begin the synthesis effort.

Theme 1: Ice cover – primary production relationships, currents, winds, bathymetry

1a. Will warmer water temperatures and reduced ice cover result in an increase in primary production in Arctic seas, and if so, how will this affect the sequestration of carbon, ocean acidification and food web dynamics?

1b. What is the connectivity to local/regional biogeochemistry and physical oceanography for the Chukchi and Beaufort Sea food web?

Theme 2: Phenology of biological production cycles in relation to physical environment

2a. How will a changing climate affect the timing, magnitude, and duration of production cycles?

2b. Will changes likely result in successful colonization and replacement of arctic endemics by subarctic populations/species?

Theme 3. Benthic-pelagic coupling in relation to physical-chemical environment
3a. Will future climate conditions alter the strength of benthic-pelagic coupling and if so, in which direction?
3b. How will keystone species be affected?

Theme 4: Current state of lower trophic prey-base and higher trophic feeding hot spots
4a. How will migration routes and important feeding hotspots of marine mammals and seabirds change in response to changing climate conditions and increased industrial and commercial activity?
4b. What are the current relationships between biodiversity and productivity?

Theme 5: Subsistence lifestyles in times of climate change
5a. How will the subsistence food gathering of Native Alaskans in coastal villages change from the northern Bering Sea to the Beaufort Sea as environmental changes occur?
5b. What information is needed by communities to effectively adapt to the changes in the regional ecosystem?

Theme 6: Chemical Contaminants in Sediment and Biota
6a. What are the levels of chemical contaminants in sediments and seawater and how do they move through the food chain?
6b. Are there any potential impacts of varying contaminant burdens in sediment and prey on high trophic organisms, including humans?

F2. Data Synthesis. As a necessary preamble, this project will be undertaken within the context of recent and ongoing synthesis efforts, including:

1. Synthesis of Arctic Research (SOAR) Physics to Marine Mammals in the Pacific Arctic (http://www.noaa.gov/soar)
2. Arctic Ocean Synthesis: Analysis of Climate Change Impacts in the Chukchi and Beaufort Sea with Strategies for Future Research (Hopcroft et al. 2008)
3. International coordination within the Pacific Arctic Group (http://pag.arcticportal.org/)
4. The Chukchi Sea Environmental Studies program (www.fairweatherscience.com)
5. An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas, Alaska (Holland-Bartels et al. 2011)
6. The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment, Grebmeier, JM, and W. Maslowski (eds), Springer, New York, est. publication December 2012
7. Special issue: "Arctic Ocean Diversity Synthesis", *Marine Biodiversity* Number 1/March 2011

Taken together, these prior and on-going formal synthesis efforts indicate strong recognition and scientific consensus that the Bering Strait region, defined here to mean the portions of the northern Bering, Chukchi, and Beaufort Seas heavily influenced by the Pacific inflow through Bering Strait, is an ecosystem at a pivotal point in the context of environmental change. These synthetic efforts, and ours, have been motivated by the rapid changes that have resulted from significant warming (Steele et al. 2008, Polyakov et al. 2010) and dramatic declines in sea ice thickness and extent (Stroeve et al. 2007), enhanced by increased heat fluxes into the Arctic Ocean through Bering Strait (Woodgate et al. 2006, 2010, Shimada et al. 2006). These patterns indicate a shift towards an earlier spring transition between ice-covered and ice-free conditions (Grebmeier et al. 2006, Steele et al. 2008) and increases in primary production (Arrigo et al. 2008, Arrigo and van Dijken 2011).

Many of the unique features of the Pacific Arctic region have been recently reviewed (e.g. Grebmeier et al. 2012, Dunton et al. 2012), including data that are available on noteworthy high biological production, strong pelagic-benthic coupling of organic production, world-class benthic macrofaunal biomass, and

biogeochemical linkages to landscapes and the world ocean. These studies and many others document food webs that support benthic-feeding apex predators and high populations of seabirds, as well as other ecological features that are vulnerable to climate change. Given the availability of these recent ecosystem summaries, we will move forward with the assumption that a synergistic effort to assemble the available knowledge by a strong team of experienced marine and social scientists, together with data management specialists is an appropriate match with the scientific challenge. Our team has been recruited from premier institutions across the United States, with assistance from specialized national and international collaborators, and represents cumulative experience and expertise working in the region of interest that is unmatched in breadth.

The overall goal of the data synthesis is to document where relevant data resides, but not to put all data sets into a data archive. However, as new data sets are identified and/or reformatted they will be submitted to the data archive at NCAR/EOL (PI: Moore). All submitted data sets will be organized with the help of discovery metadata that will be accessible and usable by the PacMARS team and the broad scientific community (see http://arctic.eol.ucar.edu). PacMARS will set up a website at EOL to supply the links to data sets it archives as well as link to data sets that it does not archive. Links to all datasets related to the project and archiving of new synthesis products developed during the effort will be provided. All PacMARS data, metadata and documentation will be linked directly into the Advanced Cooperative Arctic Data and Information System (ACADIS). Data can be restricted to only PacMARS participants as required during the contract period. Data questionnaires will be utilized to facilitate the gathering of relevant data and information for PacMARS. Information from the questionnaire will result in a comprehensive data table that will be used to track the ingestion of datasets, availability of news products (e.g. GIS layers) and other synthesis products. A focused data workshop will be held in November 2012 to provide ready access to all available data, augment GIS overlay content, discuss synthesis products and tune priorities for the subsequent synthesis activities.

Specific activities by the PacMARS PIs are presented below and summarized in **Table 2**, including proposed data synthesis products and approaches that the PacMARS team will use to address the 6 core themes of the synthesis outlined earlier. We will initiate the PacMARS project using the process of data collection compilation and subsequent synthesis of disciplinary data placed into gridded data sets that can be visualized in GIS and compared statistically. The specific PacMARS PIs or collaborators associated with each of the 6 themes are listed in the **Table 2**.

We will use gridded data such as produced by GIS to synthesize the multiple data sets and to form the foundation for the comparisons and statistical analyses with which we will address the research questions. For each discipline/variable, the data sets will be compiled into a common format. Spatial gridded distributions of variable will be calculated based on the compiled data sets for that variable using statistical mapping such as GIS or krigging. For each distribution, both mean field and an error field will be calculated, permitting an assessment of the strength of the estimate. Common grid points will be identified between data sets so that gridded synthetic data can be directly compared on a point-to-point basis where the data density permits.

Some of the data sets we hope to access are presently being analyzed by colleagues or the students of colleagues. We anticipate that our approach (synthesizing data into mean fields) will not preclude or pre-empt ongoing analysis by our colleagues or their students since their data will be subsumed into a larger data set and will become a part of a mean field. However, we will be sensitive to the need to preserve the ability of our colleagues and their students to independently analyze their data and to retain first rights of publication for the goals of their research. As noted above, the extent to which our objectives can be achieved will depend on the spatial and temporal density of the data that we can bring to the task. This in turn will depend on the temporal and spatial sampling conducted on cruises as well as our ability to gather data from a variety of national and international sources.

I. Major Research Initiatives: Natural Science

Physical: Sea Ice, Physical Oceanography, Hydrography

The physical environment is perhaps the best studied of the oceanographic disciplines, with data available from multiple cruises and moored or ice-tethered instrumentation. Considerable variability exists however, such that synthesis of the available data should be able to resolve the information into the dominant current/advective fields and hydrographic features, such as seawater temperature, salinity, density, and current fields (e.g., see Pickart 2004 as an example of the determination of a mean current field). As with other variables, the data are limited temporally, with greatest spatial extent available during the spring-to-early fall period when ice cover permits ship-based sampling. Data will be combined and used to calculate mean fields of hydrography, including pycnocline depth, and velocity. These fields then can be compared to the biological fields in investigating the research themes and questions.

The analysis will concentrate initially on data collected during the 2000s. Although data were collected during earlier decades, it is likely that these represent a state of the ecosystem with greater seasonal extent of sea ice that more recently and thus will be considered separately than those data collected during the past 10-12 years. If time permits, synthesis of the earlier data sets also will be initiated. The extent to which the following research plan can be accomplished will depend on the availability of data (when/where data sets exist and which sets we can obtain) and the spatial distribution of sampling.

Phytoplankton Standing stock and Primary Production

We will 1) determine the spatial distribution of phytoplankton standing stock (chlorophyll), total zooplankton abundance and biomass, and the abundance and biomass of selected copepod species/life stages for different periods during the year across the region; 2) determine the spatial distribution of biological rate processes including primary production and zooplankton grazing and production; 3) determine the associations of variations in the above with mean advective and hydrographic fields; 4) Identify hot-spots of phytoplankton and zooplankton abundance/ biomass/production; 5) Determine associations between phytoplankton and zooplankton standing stocks and rate processes and other biological variables such as benthic biomass and the distribution of zooplankton predators; 6) Use above analyses to address research themes. The analysis will concentrate initially on data collected during the 2000s as it is likely that these represent the current state of the ecosystem. If time permits, synthesis of the earlier data sets also will be initiated. The data then will be separated into different periods such as seasons (e.g., spring, summer) or months. These fields (biomass, abundance, rate processes) then can be mapped geographically and compared to each other (e.g., phytoplankton and zooplankton, different species/taxa of zooplankton) on a point-to-point basis as well as to other biological variables (e.g., benthic biomass, abundance of seabirds) and to mean advective and hydrographic fields. The fields will provide a set of abundances across the geographic range of the data for each variable that can be used quantitatively in comparisons and correlations.

Compiled data on chlorophyll and primary production completed by Matrai et al. (http://psc.apl.washington.edu/cgi-bin/PPobs/PPobs.cgi?page=Data&id=0.2510676975362) will form the basis of the phytoplankton analysis. Additional data sets from studies conducted since the end date of the Matrai et al. synthesis will be added. Data on zooplankton are complex and difficult to synthesize because of the great diversity of taxa and because of inconsistencies between collection methodologies. Nonetheless, we believe that a good synthesis can be obtained through careful selection of target species that should have been effectively collected by the multiple methodologies. Zooplankton rate processes will be calculated based on standing stock using empirical relationships and measured weight-specific rates (e.g., Båmstedt et al. 2000; Campbell et al., 2009).

Table 2. Summary of the PacMARS research theme, and the data syntheses and approaches that will be used to address them. All listed syntheses will be started in Quarter 3 following the compilation and synthesis of disciplinary data into gridded data sets that can be visualized in GIS and compared statistically.

Cross-disciplinary theme (relates to question # in proposal) and PACMARS activities	**Synthesized data products and analyses that will be used to address theme**	**Lead(s): PacMARS PI's and collaborators (including SOAR effort)**
1. Ice cover – primary production relationships, currents, winds, bathymetry	o Spatial/GIS overlays of chlorophyll, primary production, and hydrography, currents, winds o Peer reviewable manuscripts	o Okkonen o Frey, K (Collaborative participation in data workshop; also SOAR project) o SOAR (Arrigo, Frey)
2. Phenology of biological production cycles in relation to physical environment	o GIS overlays of phytoplankton, zooplankton and hydrography, currents, winds. Gridded data to be used correlatively o Peer reviewable manuscripts	o Ashjian, Campbell, Okkonen o Frey, K (Collaborative participation in data workshop confirmed; also SOAR project) o Pickart (collaboration physical oceanography)
3. Benthic-pelagic coupling in relation to physical-chemical environment	o Grids of pelagic and benthic abundances and distributions, zooplankton grazing impacts, hydrography, currents, sediments o Statistical analyses using PRIMER and other programs for data analysis o GIS layer comparison efforts of pelagic distributions with benthic distributions o Peer reviewable manuscripts	o Grebmeier, Cooper, Dunton, Trefry, Okkonen, Ashjian, Campbell, Bluhm
4. Current state of lower trophic prey-based and higher trophic feeding hot spots	o GIS overlays of key trophic lower to higher trophic levels at hotspots relative to GIS environmental layers o Statistical analyses using PRIMER and other programs for data analysis o GIS layer comparison efforts of primary and secondary production and zooplankton impacts, higher trophic focal feeding areas o Peer reviewable manuscripts	o Grebmeier, Bluhm, Cooper, Dunton, Ashjian, Campbell, Okkonen o Grebmeier, Bluhm (per SOAR project) o Ashjian, Campbell, Okkonen (chlorophyll, zooplankton, hydrography, currents, winds) o Jay, C. (collaborative PacMARS letter; also SOAR project participant) o Kuletz (per collaboration with PacMARS and lead on SOAR project) o Moore, S (collaboration between PacMARS and SOAR) o Nelson, J (collaboration with PacMARS for zooplankton at hotspots)

		o Norcross, B (collaboration with PacMARS for fish populations) o Pickart (collaboration with PacMARS and SOAR focus project on Barrow Canyon with Grebmeier/Cooper)
1-4. Overview of current Chukchi and Beaufort Sea food webs with relationships to local / regional biogeochemistry and physical oceanography	o Conceptual food web models o GIS maps of stable isotopic signatures for end-member sources of C and N over the western Arctic o Geostatistical GIS overlays among stable isotopic signatures and water mass characteristics o Regional comparisons of cluster analyses of faunal feeding modes, niche spaces, and organic matter transfer to higher trophic levels o Peer reviewable manuscripts	o Dunton, Cooper, Okkonen o Pickart (collaboration with PacMARS and SOAR focus project on Barrow Canyon w/ Grebmeier/Cooper)
1-4. Current relationships of biodiversity and productivity	o GIS overlays of benthic species diversity (richness) in select areas (likely northern Chukchi and eastern AK Beaufort Seas) o Identified relationships of taxon richness to measure of primary productivity o Primary productivity, chlorophyll concentrations (measured or satellite-derived) o Peer reviewable manuscripts	Bluhm, Dunton, Grebmeier, Ashjian
5. Subsistence livelihoods in times of climate change	Emerging methodologies in collaborative and community-based research on Arctic livelihoods o Hub community meetings o Community one-pagers with science summaries and community input from hub meetings o Review of regional advisory board meetings transcripts, agency and community-based participatory project reports, and literature on climate-adaptive strategies in subsistence practices and innovative approaches o Peer reviewable manuscripts	o Sheffield, Yamin-Pasternak o Grebmeier, Cooper, Ashjian, Dunton, Okkonen and other PacMARS science participants
6. Chemical Contaminants in Sediment, Water and Biota	o GIS overlays of chemical contaminants in sediments and water (e.g., Hg, Pb, radionuclides, PAHs, other POPs) o Statistical identification of contaminants that exceed	o Trefry, Sheffield, Cooper, Others o Other collaborations

	background or threshold concentrations o Statistical overview and analysis of chemical contaminants in representative biota (bivalves, crabs, fish, seals, whales) o Peer reviewable manuscripts	

Benthic Faunal Populations and Standing Stock

We will identify and collate available benthic infaunal and epifauanal data, including abundance, standing stock, biodiversity and rate process. The purpose of the activity is to prepare regional and spatial distribution maps, using GIS or krigged gridded data of key benthic parameters in the study area. These data will be overlain with temporal and spatial measures of environmental parameters, such as seawater temperatures, salinity, winds, currents, nutrients, and chlorophyll standing stock, as well as sediment parameters, such as grain size, organic carbon and nitrogen content, and chlorophyll a content, when available. We will identify data sets and work with other project leads to find the location or input the data into the EOL data archive. Our goal is to compile data sets into a common format and then identify target species of importance to higher trophic levels. By using GIS and krigging approaches, we will derive gridded products of abundance and standing stock for benthic infauna and epifauna by seasons and/or annually for comparative purposes. We will compare maps of gridded data of benthic parameters to physical and sediment parameter, coincident to both zooplankton population measures and higher trophic feeding spatial areas in order to address the core PacMARS themes.

Food Web Component

We will explore the functional role of different organismal groups to investigate the biological processing of organic matter within the western arctic shelf ecosystem. Previous studies have grouped organisms according to phylogenetic relationships, but this generalization does not provide a mechanistic approach to assess species-level function. Instead, our synthesis of the Chukchi and Beaufort Sea food webs will focus on the grouping of pelagic and benthic consumers into trophic guilds, or groups of organisms that exploit the same resource(s) in a similar manner. By incorporating functional morphology (i.e. feeding mode), we hope to elucidate the pathways by which organic matter is processed and delivered to higher trophic levels as a function of water mass types. This approach will incorporate the more practical realization that marine food webs often represent a “trophic continuum” rather than a food web with discrete trophic levels. Previous studies that have used the trophic guild approach, in concert with stable isotope analyses, described organic matter assimilation pathways in food webs in a variety of ecosystems, from the deep sea to polar shelves. We will present results that incorporate interdisciplinary studies conducted over the past several decades in the Chukchi and Beaufort Seas sponsored by both industry and federal agencies. A major goal of our synthesis is to determine the organic matter sources assimilated by benthic and pelagic food webs throughout the western arctic using a variety of geostatistical and modeling approaches.

Biodiversity-productivity

In marine ecosystems, biodiversity loss has been documented to decrease valuable ecosystem services such as the capacity to provide marine fisheries (Worm et al. 2006). Biodiversity-productivity relationships remain largely undocumented for the Arctic (see Witman et al. 2008 for the only exception), but elsewhere diversity either increases monotonically with productivity (Mittelbach et al. 2001) or the relationship is hump-shaped with highest diversity at intermediate productivity levels (Waide et al. 1999). In the past few decades data sets on Arctic marine biodiversity (species richness) and measures of primary

productivity have been compiled (e.g. Matrai et al. 2010, Bluhm et al. 2011a) and lend themselves for synthetic analyses. We will examine the relationship of biodiversity to primary productivity in selected areas of the Chukchi and Beaufort Seas. Initially, we will compile and merge relevant and available data sets on species richness of benthic infauna and/or epifauna into a coherent format, and generate GIS overlays from those data. Benthic fauna is best suited for this approach, since taxa inhabiting the seafloor comprise over 90% of the Arctic invertebrate fauna (Bluhm et al. 2011b). We envision focal areas to include the northeastern Chukchi Sea shelf and the nearshore eastern Beaufort Sea where PIs of this proposal hold relevant data sets. Other areas might be included depending on data availability. Jointly with PI Ashjian and others, we will then expand the chlorophyll *a* and/or primary production database by Matrai (2011). In a third step, we will describe the relationships of species richness and statistical measures of primary productivity. The resulting relationship(s) in combination with published observations, scenarios and predictions of regional changes in primary production might enable us to suggest the future development of Arctic marine biodiversity.

Chemical Contaminants in Sediments, Water and Biota

We will identify and compile data for metals and organic contaminants in sediment, water and biota. Data for chemicals in sediments will be presented in summary tables and GIS maps with an emphasis on defining background concentrations. We will identify background metal concentrations using metal/Al ratios and a well-established graphical procedure. Background concentrations of naturally occurring organic contaminants will be determined as a function of sediment grain size and organic carbon content. The sediment portion of our contaminant synthesis will establish background concentrations as a point of reference for future investigations; we also will identify present-day locations where concentrations of contaminants are above background. The approach for synthesizing the water column data for contaminants will be similar to that described for sediments; however, the data set will be much smaller and thus we will identify important geographic gaps in the water data for contaminants. Concentrations of contaminants in biota will be grouped by species and location on both a dry weight and wet weight basis. We will focus on species for which sufficient data are available to identify distributions and trends. We also we will seek to obtain data for a cross section of trophic levels in the food web including plankton, amphipods, bivalves, crabs, selected fish and birds, and marine mammals. Although GIS techniques will be used to present the data, location is a less valuable parameter for highly mobile species. The primary goal of our synthesis is to provide a present-day status of chemical contaminants in northern Bering, Chukchi and Beaufort seas

II. Major Research Initiatives: Social Science

Socio-Ecological Contributions

Sveta Yamin-Pasternak will lead socio-ecological contributions to the PacMARS project. This effort as outlined above will be geared toward identifying current research directions and gaps in knowledge concerning the maritime human communities living within the marine ecosystems of the Northern Bering, Chukchi, and Beaufort Seas. Cumulatively, this contribution will result in an interdisciplinary socio-ecological synopsis of these marine ecosystems. We expect that this will help expand the scope of the project from that of a study of the marine ecosystem in the greater Bering Strait region to a truly interdisciplinary study of social-ecological processes in arctic systems. Recommendations from communities to be documented during the proposed hub meetings and in the course of the project will be incorporated appropriately within this work effort.

The goal of this component is to identify the sources of useful social science datasets, pertinent for the understanding of the social-ecological systems of the project's focus area. To be included in the synthesis are studies in cultural anthropology, human geography, co-management and policy research, and multi-

disciplinary social science. The timeframe to be considered is predominantly the work done over last ten years, but less recent works that are relevant will be annotated as well. This effort will link research initiatives across scales, i.e.: from the international multi-institution projects including those that were part of the International Polar Year to local community surveys, ethnographic monographs, and regional subsistence harvest reports. Alongside the project information, the overview will contain the synopsis of the hosting or collaborating institutions, noting the overall goals of the Indigenous organizations, agencies, and various programs involved in the research.

E. Project Design and Conceptual Approach

As part of the overall synthesis portion, we will bring together as many data sets or links to data that can be utilized in developing system-level synthesis chapters for both a comprehensive interim and final report as well as a planned peer-reviewed synthesis book in the 2nd year of this grant. PI Grebmeier is on the editorial board for the new Springer "Polar Ecosystems" book series that we expect can be an outlet for our efforts. In order to produce consistent and useful geographically-based imagery, we will use a staff GIS specialist, Alynne Bayard, at the Chesapeake Biological Laboratory of UMCES to assist with development of standardized mapping products for the project. EOL will provide GIS mapping capability using their field catalog approach (see for example http://mapserver.eol.ucar.edu/), but publication quality GIS figures will still be needed. For those PIs with their own GIS capability, Ms. Bayard will coordinate standardized templates. We will collaborate with EOL as accomplished in the past using the GIS Map Server to connect the GIS and data sets. We will develop standardized display modes, and content for each layer. We also expect to draw upon the many recent planning documents and internet-based resources that serve as portals to natural and social science data sources and agency research needs in the Pacific Arctic region, many of which are included in **Table 3.** There are also many projects the PacMARS PIs can leverage to access data to submit to the EOL-ACADIS web portal as show in **Table 4.**

An important component within the PacMARS synthesis activity will be the involvement of local communities in the Pacific Arctic region. We will seek feedback on research needs as they are perceived by local communities, as well as ecological insights available from subsistence hunters specifically and local residents in general. As part of our effort, we are proposing three regional "Town Hall" meetings, with scientific representation from the PacMARS team and collaborators with the AOOS together with representatives of Alaskan coastal communities. The hub meetings will also be used as a forum to provide the information the communities often ask for, e.g., "what are the results of research that has been going on in our back yard? What are the results of the research we've participated in?" and will be useful in documenting community feedback - which in turn would help direct science programs in the future. The social science oriented effort in the local communities will be facilitated by both co-PI Yamin-Pasternak and Sheffield and they will work to compile and review the community concerns, and needs as described by coastal communities in the open forums. Expected products will include identifying the top priorities from the community perspective. Also, it would be important to summarize the large gaps in coverage and topics that need to be addressed in order for more effective community/scientific integration to be achieved.

We expect that the proposed three Town Hall meetings to be held in Nome, Kotzebue and Barrow will help us identify research needs that will benefit the local represented communities. We will also connect with local community organizations, including those in the North Slope and Northwest Arctic Boroughs to help identify the oceanographic research needs that may be a factor in issues of current concern, such

377 **Table 3. Data matrix by project name, type of data (natural or social science), and accessibility via web line for use in PacMARS effort.**

Project	Type	Link
ACADIS	Advanced Cooperative Arctic Data and Information Service to provide data archival, preservation and access for all projects funded by NSF's Arctic Science Program (ARC)	http://www.aoncadis.org/home.htm
	Alaska Department of Fish and Game Subsistence Division Publications Searchable Database	http://www.adfg.alaska.gov/sf/publications/
AEWC	Alaska Eskimo Whaling Commission	http://www.bluediamondwebs.biz/Alaska-aewc-com/default2.asp
Alaskan OCSEAP	Alaskan Outer Continental Shelf Environmental Assessment Program	http://www.lib.noaa.gov/uhtbin/cgisirsi/x/x/0/5?searchdata1=OCSEAP&Submit=Find
	An Adventure Learning Program for k-12 Students in the Circumpolar North [including Chukotka, Russia and Alaska Arctic Slope]	
	Arctic Living Conditions	http://www.arcticlivingconditions.org/
ANAMIDA	Beaufort Sea BOEM studies, 2004-2007	http://www.duxbury.battelle.org/cANIMIDA/home/index.cfm
AKMAP	Alaska Monitoring and Assessment Program	http://www.dec.state.ak.us/water/wqsar/monitoring/AKMAP.htm
AHDR	Arctic Human Development Report	http://www.svs.is/AHDR/
ANWAP	Arctic Nuclear Waste Assessment Program	http://www.nsidc.co
	Alaska Department of Fish and Game Subsistence Division Publications Searchable Database	http://www.adfg.alaska.gov/sf/publications/
AON	Arctic Observing Network and the Advanced Cooperative Arctic Data and Information Service	http://www.aoncadis.org/
AOOS	Alaska Ocean Observing System Arctic Assets	http://data.aoos.org/maps/arctic_assets/
ArcOD	Species presence or abundance, biomass: benthos: Kotzebue Sound macro-, epifauna Feder 1976; Canada Basin macrofauna Bluhm et al. 2002/5; Beaufort Sea polychaetes Carey 1970s (Dunton. personnal communication); some ZINRAS macrofauna various years Zooplankton (Hopcroft compiled all these): Chukchi 1953/4, Tiglax Bering Strait 1991, NOGAP Canadian Beaufort 1984/5, ISHTAR 1985/6, WEBSEC 1971 Beaufort, part of CASES 2003/4	www.arcdiv.org, www.iobis.org

	Fish (Mecklenburg-compiled) presence records: Western Arctic fish museum collections Ice: Canada Basin ice meiofauna, ice chl etc. 2002, 2003, 2005, 2009	
Arctic Eis	Arctic Integrated Ecosystem Survey 2012-2013 project, funded by BOEM, will survey the entire US Chukchi Sea for pelagic and benthic fishes (and coarse epifauna categories) and the northern Bering for pelagic fishes at a spatial resolution applied in the Eastern Bering Sea trawl surveys	http://www.commerce.state.ak.us/dca/planning/cciap/ArcticEcosystemIntegratedSurvey.htm
Arctic ERMA	ERMA (Environmental Response Management Application) is an online mapping tool that integrates both static and real-time data, such as Environmental Sensitivity Index (ESI) maps, ship locations, weather, and ocean currents, in a centralized, easy-to-use format for environmental responders and decision makers.	http://response.restoration.noaa.gov/maps-and-spatial-data/environmental-response-management-application-erma/arctic-erma.html
AHHI	Arctic Human Health Initiative	http://www.arctichealth.org/ahhi/
Arctic Report Card 2011	NOAA Arctic website	http://www.arctic.noaa.gov/reportcard/
	Arctic Social Indicator Project	http://www.svs.is/ASI/ASI.htm
ARC	Scaling Studies in Arctic System Science and Policy Support: A Call to Research	
ASI	Arctic Social Indicator Project	http://www.svs.is/ASI/ASI.htm
Atlas of seabirds	Atlas of the Chukchi and Beaufort Sea	http://ak.audubon.org/birds-science-education/arctic-marine-synthesis-atlas-chukchi-and-beaufort-seas)
BASIS	Bering-Aleutian Salmon International Survey	http://www.afsc.noaa.gov/ABL/MESA/archives/mesa_occ_basis.htm
Bathymetry		http://www.fairweatherscience.com
	Bering Strait Native Organization, Kawerak Social Science Research Program	http://www.kawerak.org/tribalHomePages/index.html
	Bering Sea Sub-Network Indigenous Communities of the Bering Sea Respond to the Need for Adaptation to Environmental and Socio Economic Changes	http://www.bssn.net/
BERPAC	Program for long-term ecological research of ecosystems of the Bering and Chukchi Seas and the Pacific Ocean)	http://www.lib.noaa.gov; http://www.lib.noaa.gov/uhtbin/cgisirsi/x/x/0/5?searchdata1=BERPAC&Submit=Find

BEST	NBS Chl ice, 5 m water, ice meiofauna, macroinfauna, physics to biology	http://bsierp.nprb.org/
BOEM	COMIDA and other BOEM projects	http://www.boemre.gov/eppd/sciences/esp/index.htm
BOWFEST	Bowhead whale feeding ecology study	http://www.afsc.noaa.gov/nmml/PDF/BOWFEST-2010-Report.pdf
BSEO	Bering Strait Environmental Observatory	http://arctic.cbl.umces.edu; Cooper et al. 2006
BSMIZ	Bering Sea Marginal Ice Zone	NODC
	Bureau of Land Management Arctic Field Office National Petroleum Reserve Subsistence Studies Database	
BSSN	Bering Sea Sub Network Indigenous Communities of the Bering Sea Respond to the Need for Adaptation to Environmental and Socio Economic Changes	http://www.bssn.net/
BWASP	Bowhead Whale Aerial Survey Project	http://www.afsc.noaa.gov/NMML/cetacean/bwasp/flights_BWASP.php)
C3O	Canada's Three Oceans	http://www.dfo-mpo.gc.ca/science/Publications/article/2008/17-06-2008-eng.htm
CADIS	CADIS project that supports the Arctic Observing Network (AON)	http://www.aoncadis.org
cANIMIDA	Continuation of Arctic Nearshore Impact Monitoring in Development Area (ANIMIDA)	http://www.duxbury.battelle.org/cANIMIDA/home/index.cfm
CAVIAR	CAVIAR Community Adaptation and Vulnerability in Arctic Regions	http://www.ipy.org/news-a-announcements/item/2097-caviar-community-adaptation-and-vulnerability-in-arctic-regions
CASES	Canadian Arctic Shelf Exchange Study (CASES;	http://www.cases.quebec-ocean.ulaval.ca/welcome.asp),
CHAOZ	Chukchi Acoustic, Oceanographic, and Zooplankton	http://www.pmel.noaa.gov/foci/operations/2010/1AE10/CHAOZ2010_CruiseReport.pdf
CHINARC	Chinese Arctic Expedition 2008	
Chirikov Basin macrobenthos	Ampeliscid amphipod abundance, biomass; partial: macrobenthos abundance, biomass	www.nodc.noaa.gov ; also Grebmeier EOL BEST site
Chukchi Sea	Chukchi Sea Environmental Studies Program 2008-2010 (ConocoPhillips Company, Shell Exploration and Production Company and Statoil USA E&P Company)	www.fairweatherscience.com
	Chukotka Native Marine Mammal Hunter	www.pacificwalrus.ru

	Association	
COMIDA CAB	Chukchi Offshore Monitoring in Drilling Area (COMIDA) Chemistry and Benthos	http://www.comidacab.org/
COMIDA HS	Chukchi Offshore Monitoring in Drilling Area (COMIDA) Hanna Shoal (HS)	http://www.boemre.gov/eppd/sciences/esp/index.htm
CSESP	Chukchi Sea Environmental Studies (Conoco Phillp-Shell-Statoil)	http://www.fairweatherscience.com/reports/Reports/tabid/184/Default.aspx
DBO	Distributed Biological Observatory	http://www.arctic.noaa.gov/dbo/
EDMIZ	Emerging Dynamics of the Marginal Ice Zone	http://www.onr.navy.mil/Science-Technology/Departments/Code-32/All-Programs/Atmosphere-Research-322/Arctic-Global-Prediction/Marginal-Ice-Zone-DRI.aspx
	Extractive Industries Working Group	http://www.arcticcentre.org/InEnglish/RESEARCH/Extractive_Industries_Working_Group.iw3
ELOKA	Exchange for Local Observation and Knowledge of the Arctic	http://eloka-arctic.org/
EWC	Eskimo Walrus Commission	http://www.kawerak.org/servicedivisions/nrd/ewc/
Fish datasets	Western Arctic Fish (Museum collection) data base; 10, 000 records	www.arcodiv.org/Database/Fish_datasets.html
	Geographic Information Network of Alaska (GINA)	http://www.gina.alaska.edu/
	Government Accountability Office Report GAO-09-551, Alaska Native Villages	
IARPC	Interagency Arctic Research and Policy Committee (IARPC) draft plan	http://www.arctic.gov/publications/2011-12_usarc_goals.html
ICESCAPE	Impacts of Climate change on the Eco-Systems and Chemistry	http://www.espo.nasa.gov/icescape/
	Inuit Circumpolar Conference (ICC and ICC Alaska)	http://www.inuitcircumpolar.com/
	International Polar Year, 2007-2008, Understanding Earth's Polar Challenges, Summary by the IPY Joint Committee	http://www.icsu.org/publications/reports-and-reviews/ipy-summary
ISHTAR	Inner Shelf Transfer and Recycling (1984-1988)	http://www.lib.noaa.gov/uhtbin/cgisirsi/x/x/0/5?searchdata1=ISHTAR&Submit=Find
JWACS	Joint Western Arctic Climate Study	http://martechpolar.com/JWACS%202004/JWACS%202004%20Index.htm
	Moved by the State: Perspectives on Relocation and Resettlement in the Circumpolar North	http://www.alaska.edu/move/

NRC	Frontiers in Understanding Climate Change and Polar Ecosystems: Report of a Workshop, National Research Council, 2011	
NASA	Physical Oceanography, Distributed Archive Center (PODAAC) for NASA's satellite oceanographic data	http://podaac.jpl.nasa.gov/
NOP	National Ocean Policy	
NBS SLIP	Northern Bering Sea projects	http://www.eol.ucar.edu/projects/sbi/
NOAA	NOAA Arctic Theme page	http://www.arctic.noaa.gov/
NOAA	NOAA 2011 Arctic Vision and Strategy and draft NOAA 2012 Arctic Implementation Plan	
NPRB #503	Arctic Ocean Synthesis 2008, Russell Hopcroft, Rolf Gradinger, Bodil Bluhm, Brenda Norcross, Thomas Weingartner, Alan Springer, Terry Whitledge (editors)	http://doc.nprb.org/web/05_prjs/503_final.pdf
NSB	North Slope Borough projects	http://www.north-slope.org/departments/wildlife/studiesNresearch.php)
NSSC	North Slope Science Catalog	http://www.north-slope.org/departments/wildlife/studiesNresearch.php
NSSI	North Slope Science Initiative	http://www.northslope.org/
OBIS	Ocean Biodiversity Information System	http://dbmuseblade.colorado.edu/ObisUsaTest/portal/ParticipantsAndDatasets.php)
OCES	NOAA's Ocean Exploration_	http://oceanexplorer.noaa.gov/explorations/05arctic/logs/summary/summary.html
PWID	Pacific walrus international database	http://alaska.usgs.gov/science/biology/walrus/pwid/index.html
	Rural Alaska Community Action Program	http://www.ruralcap.com/
RUSALCA	Epifauna abundance, biomass; food web	http://www.arctic.noaa.gov/aro/russian-american/); will go into RUSALCA database at UAF and EOL
SBI	Western Arctic Shelf-Basin Interactions (1999-2008)	http://www.eol.ucar.edu/projects/sbi/; http://arctic.cbl.umces.edu/sbi/web-content/
SCICEX	Submarine Arctic Science Program	http://nsidc.org/scicex/data_inventory.html
	The Arctic Council Sustainable Development Working Group (SDWG)	http://www.arctic-council.org/index.php/en/sdwg
SHEBA	Surface Heat Budget of the Arctic	http://data.eol.ucar.edu/codiac/projs?SHEBA
SDWG	The Arctic Council Sustainable Development Working Group	http://www.arctic-council.org/index.php/en/sdwg
SIKU	Sea Ice Knowledge and Use (SIKU)	
SIWO	Sea Ice for Walrus Outlook	http://www.arcus.org/search/siwo

SNACS	Study of the Northern Alaska Coastal System (SNACS) 2005-06	http://www.arcus.org/arcss/snacs/
SOAR	Synthesis of Arctic Research (SOAR) Physics to Marine Mammals in the Pacific Arctic	http://www.arctic.noaa.gov/soar/
SLICA	Survey of Living Conditions in the Arctic (SLICA)	
	The First Alaskans Institute	http://www.firstalaskans.org/
	Thesis and Dissertation Project Database of the University of Alaska Resilience and Adaptation Program	http://www.uaf.edu/rap/students/Alumni/
	The Alaska Nanuuq Commision	http://www.nanuuq.info/
TOS	The Changing Arctic Ocean: Special Issue on the International Polar Year (2007–2009)	
USARC	US Arctic Research Commission Report on Goals and Objectives for Arctic Research 2011-2012	
USGS	USGS report on OCS science needs	http://pubs.usgs.gov/circ/1370/pdf/circ1370.pdf
	U.S. National Assessment Alaska Regions Bering Sea Impact Study	http://www.besis.uaf.edu/
USN	US Navy Road Map http://www.navy.mil/navydata/documents/USN_artic_roadmap.pdf	
	US National Park Service Shared Beringia Heritage Program	http://www.nps.gov/akso/beringia/
USDS	US State Department-Foreign data sets	
US	US government ocean data portal	www.arcticdata.org
WEBSEC	Western Beaufort Sea Ecological Cruises	http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA012351
WBSFS	Western Beaufort Sea Fisheries Study	http://www.alaska.boemre.gov/reports/2010rpts/2010_048.pdf.
Western Beaufort survey 2008	Epifauna abundance	NOAA RACE division
WAFish	Western Arctic Fish (Museum collection) database is online and has close to 10,000 records. Since ArcOD and RUSALCA have funded much of this, we might be access to an updated version	www.arcodiv.org/Database/Fish_datasets.html
WCCY	What is Climate Change to You? (WCCY) –	http://2011.polarhusky.com/support/wccy/what-is-climate-change-to-you/

Table 4. Data matrix of key projects and associated PI participation allowing data set project submission to PacMARS project EOL data portal (see Table 2 at http://arctic.cbl.umces.edu/PacMARS.htm). KEY: Location: BS=Beaufort Sea, CS=Chukchi Sea, and NBS=northern Bering Sea.

		PacMARS Principal Investigator Institution							
Project	Location	CBL	FIT	UAF	EOL	URI	UTMSI	WHOI	Collaborators and Advisors
AON	NBS, CS, BS	x		x	x	x		x	x
BEST	NBS	x		x	x	x		xPI m	x
BOWFEST	CS, BS			x		x		x	
cANIMIDA	BS		x				x		
C30	NBS, CS	x							x
COMIDA CAB & HS	CS	x	x			x	x	x	x
CSESP	CS			x					
DBO	NBS, CS	x	x	x	x	x	x	x	x
ICESCAPE	CS	x							x
ISHTAR	NBS, CS	x							
RUSALCA	CS	x		x				x	x
SBI	CS	x			x	x	x	x	x
SHEBA	BS				x	x		x	
SLIP	NBS	x		x	x				
SNACS	CS, BS			x	x	x	x	x	x
SOAR	NBS, CS	x	x	x	x	x	x	x	x

as the Arctic Pinniped Unusual Mortality Event now being observed throughout the Pacific Arctic region. It is clear that successfully involving local communities in our synthesis efforts is one of the more challenging aspects of this project. The PacMARS team and collaborators are well prepared to incorporate local ecological knowledge in our synthesis effort, including the articulation of local needs for research products in the Pacific Arctic Region. PI Grebmeier traveled to communities in the North Slope Borough (Barrow, Point Hope, and Wainwright), for example during the Shelf-Basin Interactions program to address local community concerns about the offshore research. PI Sheffield has worked in almost all of the communities to be represented in the three workshops and is professionally known throughout the region. PI Ashjian has been invited to represent scientific interests at meetings of the Barrow Whaling Captains Association and the Alaska Eskimo Whaling Commission, and works on a daily basis with North Slope residents during an on-going and extensive field program mounted out of Barrow. PI Cooper has been involved in efforts through the Arctic Icebreaker Coordinating Committee to reduce potential conflicts between scientific research efforts and subsistence hunting (see http://www.icefloe.net/community-primer) and encourage local community participation in research cruises (e.g. http://arctic.cbl.umces.edu/Healy_trip_report.htm). He has also worked at Diomede for extended periods on community based data collection efforts that included marine mammal tissue collections that address local community concerns about marine mammal health. He was a convener of a successful workshop in Nome in 2010 that involved local communities in the Bering Strait region in specifying environmental observation needs (see http://arctic.cbl.umces.edu/#_DBO). We expect that the particularly high level of local experience within the PacMARS team should serve us well in efforts to incorporate local community insights into the larger synthesis efforts, as well as to help articulate the research products and knowledge that would most benefit local communities.

Although meaningful dialogues should ideally occur in every coastal community, given the funding and timing constraints on this activity, this is not realistically feasible. It can be argued that such an extensive

effort might even be counter-productive if construed as just another rushed visit by outside scientists, further exacerbating the gap in integrating community needs/knowledge with the scientific efforts expanding in the Arctic. The NPRB solicitation specified that no-new data should be collected during the project. Therefore we are avoiding direct consultation, interviews, etc. that would require human subject research approval and a larger budget and more time than provided in this opportunity. Instead, we will work through tribal entities (i.e. IRA offices and other stakeholders) to identify the representatives from each community to be invited to the "hub" Town Hall meetings. It should be noted that nearly 50% of the PIs have field programs in the Arctic and interface with local governmental committees and we will leverage our visits to discuss PacMARS issues as no cost to this proposal. We expect that the social science functions of this proposal would be well served by compilation and review of the concerns, and other input as provided by the coastal communities. Therefore an expected product would include a compilation of the top priorities that come out of the community meeting process. Also, it would be important to outline the expected large gaps in coverage and topics that need to be addressed in order to achieve a significantly better community/scientific integration. Our approach to meet these challenging goals will include outreach from the AOOS that will be supported through attendance at the community meetings, participation by PacMARS PIs, and particularly the involvement of University of Alaska Fairbanks Marine Advisory Program Agent, Gay Sheffield and Dr. Sveta Yanik-Pasternak. These joint, leveraged efforts will identify research needs that will benefit the local represented communities as well as document traditional knowledge that informs the scientific community.

Another product we are considering is provided by the example of the recent collaboration between the Bering Sea Elders Council and Dorothy Childers of the Alaska Marine Conservation Council that has beautifully documented traditional subsistence hunting efforts and regions of critical importance for subsistence food gathering in the Bering Strait region. We recognize that many local communities are concerned about climate change and its effect on hunting success, and risks to hunters venturing further with changed seasonal sea ice conditions. The potential expansion of commercial fisheries and the impacts of industrial activities are additional concerns. For these reasons, we expect that local communities can contribute important information and concerns to the synthesis activity, and we will endeavor to include their valuable input in the final products of this project. For example, there was a very successful application of the EOL Mapserver for Local Traditional Knowledge data from Nelson Island as a part of the BEST project (http://mapserver.eol.ucar.edu/best/). We are proposing that the three community meetings be held in Nome, Kotzebue and Barrow, and include representatives from pertinent, marine-oriented villages along the Alaskan coast that will be selected in-village by individual IRA Tribal Councils or other appropriate means (**Table 5).** These meetings will be planned for mid-winter 2013 to coincide with periods of limited hunting. We have budgeted travel money if necessary for Gay Sheffield to attend IRA Council meetings ahead of the Town Halls to help explain our objectives and needs. One of the expected outcomes of the local meetings will be to identify spatially areas of community concern (e.g. hotspots of animal locations or where changes are occurring to be overlain on maps of prey bases, currents, upwelling/downwelling locations, ice concentrations, etc.).

Table 5. Representatives from the following marine-oriented Alaska communities will be invited to one of these Town Hall meetings to receive input on the synthesis activities and priorities for future research.

Nome Workshop		**Kotzebue Workshop**	**Barrow Workshop**
Diomede	Teller	Kotzebue	Barrow
Gambell	Shishmaref	Point Hope	Wainwright
Savoonga	King Island	Kivalina	Nuiqsut
Brevig Mission		Buckland	Kaktovik
Wales			Point Lay

Our workshop strategy will serve both synthesis and research need identification aspects through other focused workshops, one of which will be held in Boulder, Colorado in November 2012, hosted by EOL for PIs and invited guests. This workshop will be devoted to available data resources, and by extension, identifying subject areas where extensive data and understanding are lacking. Data available in the archive (both in-house and submitted between June and the meeting date) will be used as an integration mechanism for synthesis maps of available data. The workshop will develop tasks and promote discussion concerning development of long term monitoring in the Chukchi-Beaufort region. We will use information gathered at this workshop to seek wider opinions about research needs and synthesis products through a one-day workshop at the Alaska Marine Science Symposium in Anchorage in 2013.

E2. Research Needs, Education and Outreach

Natural Science

The identification of needs for future research will be iteratively and intrinsically related to the development of synthesis activities proposed by the PacMARS team. We will use a comprehensive, ecosystem-wide approach to identify and prioritize research needs to be addressed by future multi-disciplinary, integrated marine ecosystem research programs. The research needs or themes are derived from broad-scale ecological questions that pertain to important issues that we have identified or will identify through data synthesis and critical contributions from the local Alaska communities in the region.

Finally, through international collaborative projects such as RUSALCA, the Pacific Arctic Group and Canada's Three Oceans Project, in which two to several PIs on this proposal are actively participating, we expect to be able to solicit and compile the research needs that are perceived on the international level, whether that is the tele-connections between the Arctic Oscillation and the strength of the summer monsoon in China, or evaluating the economics of ice-free ship transportation through Canadian and Russian waters in and near the Bering Strait region. The research need identification process will necessarily prioritize observations that should be made and the appropriate methodologies for making the measurements, and a structured and tracked review process will be undertaken to insure wide input from academic, industry, NGO, local community, state, and federal stakeholders. We will use experience we have had in assembling journal special issues (e.g. Deep-sea Research, Marine Biodiversity) and edited books (Springer and Academic Press) to insure high quality review and vetting of the final report document that will include the research needs as well as synthesized current.

The research direction identified in part 2 of this proposal will be identified and prioritized based on a process that will weigh the importance of research needs relative to advancing our understanding of ecosystem processes and providing guidance for policy and management decisions. We envision an important outcome of this process will include a series of recommendations for sampling methods and spatial and temporal sampling designs that should be considered when designing future multidisciplinary, marine ecosystem research programs. Each of the workshops will play a role in enabling identification of research needs.

Social Science

Whereas the previous components focus largely on the projects that either have been completed or are currently in the advanced stages of research, this part of the effort will delineate concerns that are yet to be addressed. Questions and gaps in knowledge identified by the Arctic communities, resource managers, interagency working groups, and social scientists will be included. In addition to the recommendations for future research that have been incorporated within the concluding remarks of published and disseminated research, this component will turn to such documents as archived meeting summaries and transcripts of time-sensitive community deliberations in our study region.

The specific social science component will draw on the synthesis of major resource initiatives to outline key innovative approaches and research methods implemented in the studies of social-ecological systems. It is anticipated that thesis and dissertation research coming out of prominent interdisciplinary and experimental programs (such as the NSF IGERT Integrative Graduate Education and Research Traineeship (IGERT)), projects oriented toward stakeholder processes and conflict resolution, and projects structured within the community based participatory research framework.

G. Deliverables and Timelines

Project start date: June 15, 2012

Project duration: 24 months, end of project: June 14, 2014

Table 6 briefly outlines the milestones for this project whereas **Table 7** provides the specific quarterly milestones associated with each theme starting June 15, 2012.

Table 6. Brief overview of PacMAR timeline milestones.

Date	Milestones
2012	Notification of support
June 15	Funds allocated, with PI coordination conference call planned the following week; Submit completed data sets to EOL, identify new data sets, work on synthesis products
Sept 15	Quarterly Report to NPRB #1: status report
Sept 26-28	PacMARS PI meeting, Annapolis, MD (alternate venue, Seattle, had higher total airfares for all participants); Sue Moore will participate to link with SOAR
Nov 2012- Mar 2013	Alaska community "Town Hall" input meetings at 3 hub cities to entrain local participants from various local communities from Nome to Kaktovik; attended by designated members of the PacMARS team
Nov 26-30	Data workshop at Boulder, CO, with invitees to utilize computer networking of data sets already preloaded via the EOL-ACADIS website for use to start to develop synthesis products, maps, and develop chapter outlines
Dec 15	Quarterly Report to NPRB #2
Jan 2013	1-day workshop on Sun or Mon prior to the Jan 2013 AMSS in Anchorage (all PI travel on this proposal, leverage others going to meeting to attend): purpose to give update on preliminary results and open discussion of developing themes for science direction
Mar 15, 2013	Quarterly Report to NPRB #3
Apr-June 2013	Draft chapters for interim report
June 15, 2013	Quarterly Report #4-submission of PacMARS interim report
June-Sept 2013	Continuation of finalizing synthesis publications and feedback to local Alaska communities via no-cost by PIs during field season community outreach
Sept 15, 2013	Quarterly Report #5-report on community interactions; status publications
Sept –Dec 2013	Continuation of synthesis analyses and draft manuscript preparations
Dec 15, 2013	Quarterly Report #6-update on synthesis products, book preparation
Jan 2014	PacMARs presentations at the AMSS2014; recommendation for PacMARS-SOAR open community meeting, with focus on social community feedback
Mar 15, 2015	Quarterly Report #7-report from open AMSS NPRB/PacMARS workshop, finalize all synthesis publications and submission for polar PacMARS book
June 15, 2013	Final report to NPRB; PacMARS book in ready to publish stage

Table 7. Summary of type of data of activity within the PacMARS project, syntheses products by discipline, milestones and associated PI and/or collaborator.

Type of Data or Activity	**Synthesis products to be developed**	**Milestones (by quarter, 1-8) (Note: All efforts will produce a preliminary final report after 4th quarter)**	**PIs or other collaborators**
Physical/chemical water type:T, S, sea ice, column and current, wind data, bathymetry, nutrients, contaminants	Bathymetry+Seasonal and interannual changes in T, S (river discharge), winds, currents	(1) Identify data sets; contact data owners where necessary while some PIs in field; Temporal/spatial variations in stratification (T,S), nuts, winds, currents, including focal maps for pelagic, benthic, and higher trophic level themes (2) Compile data sets into common format (3) Use krigging or GIS to derive gridded parameters for periods (e.g., season, month) when data density permits. (4) Compare physical fields with biological fields as described below. (5-8) Draft peer reviewable manuscript	PIs: Okkonen, Cooper, Dunton, Trefry OTHERS: Frey, Pickart,
Pelagic (Phytoplankton and Zooplankton) Standing Stocks and Rate Processes	Regional and spatial distributions (GIS or krigged gridded data) of pelagic standing stocks (phytoplankton, zooplankton), of estimates of grazing impacts and primary and secondary production, and where possible, phenology of biological production cycles	(1,2) Identify data sets; contact data owners where necessary while some PIs in field (2,3) Compile data sets into common format; identify target species (3,4) Use krigging or GIS to derive gridded products of standing stock variables for periods (e.g., season, month) when data density permits. Estimate grazing impacts and secondary production from derived grids based on grazing rate determinations from Campbell et al. (2009, in prep.) and empirical metabolic relationships. 4) Compare maps of gridded data and data to physical (advective, hydrographic) and biological (e.g., benthic biomass) fields to address themes; Identify future research needs based on syntheses. 5-8) Draft peer reviewable manuscript	PIs: Ashjian, Campbell, Bluhm, Cooper, Okkonen OTHERS: Frey, Hopcroft, Nelson
Benthic (Infauna and Epifaunal) Abundance,	o Regional and spatial distributions (GIS or krigged gridded data) of	1,2) Identify data sets; contact data owners where necessary (2,3) Compile data sets into common format; identify target species; (3,4) Use krigging or GIS to derive	PIs: Bluhm, Cooper, Dunton, Grebmeier OTHERS: Frey, S. Moore, Jay

Standing Stocks, Biodiversity and Rate Processes	benthic standing stocks (infauna and epifauna) o Temporal/spatial variations in stratification (T,S), nutrients, winds, currents,	gridded products of abundance and standing stock variables for periods (e.g., season, month) when data density permits. 4) Compare maps of gridded data and data to physical, lower trophic and higher trophic feeding spatial areas) to address themes. Identify future research needs based on syntheses. 5-8) Draft peer reviewable manuscript	
Higher trophic organisms	o Regional and spatial distributions (GIS or krigged gridded data) of feeding locations of marine mammals, seabirds, and fish	(1-4) Coordinate and link data collections through PacMARS collaborators; link with SOAR that is driven by synthesis of data sets specific to higher trophic organism parameters and link to people; request input into mid-report (1-4) (5-8) Request draft higher trophic peer reviewable manuscript in context of PacMARS effort to include in synthesis book (5-8)	PIs: Sheffield, Cooper, Grebmeier OTHERS: PacMARS SOAR collaborators S Moore, Jay, Kuletz, Norcross (see collaborative letters), and other SOAR participants
Food web evaluations and analyses in relation to local and regional environmental parameters	o Conceptual food web models o GIS maps of stable isotopic signatures for end-member sources of C and N over the western Arctic o Geostatistical GIS overlays among stable isotopic signatures and water	(1,2) compile data into common format (2,3) produce GIS maps; temporal/spatial variations in stratification (T,S), winds, currents, (3,4) produce conceptual food web models; Identify future research needs based on syntheses (4-8) Draft peer reviewable manuscript	PIs: Dunton, Bluhm, Cooper, Okkonen OTHERS: Pickart (collaboration with PacMARS and SOAR focus project on Barrow Canyon w/ Grebmeier/Cooper)
Sediment grain size, carbon content, and potential chemical and radioactive contaminants	o Regional GIS maps o Peer-review arcticle	(1) compile data into common format (2) produce GIS maps (3) Initiate exchanges with local communities regarding contaminants in higher trophic level biota (4-5) Draft peer reviewable manuscript	PIs: Cooper, Trefry
Subsistence lifestyles in times of climate change	o Community one-pagers with science and local input summaries o Peer-reviewed article	1,2) Develop a working bibliography of library and web-based sources, begin Alaska Arctic Slope region review 2,3) Initiate exchanges with communities, preliminary recommendations assessment, hub meetings planning, continue Alaska	PIs: Yamin-Pasternak, Sheffield

		Arctic Slope region review 3) Participate in Hub Meetings and draw summaries, begin Northwest Alaska region review 4) Northern Bering Strait region review, extrapolation of innovative and effective approaches, community one-pagers; identify future research needs based on syntheses 5-8) Draft peer reviewable manuscript	
<u>Data archiving and GIS mapping efforts</u>	o Data moved onto public data portalGIS layer capability for all scientists to use o Develop PacMARS data table o Access to all PacMARS compiled and supporting datasets and synthesis products	(1) Data questionnaires developed to facilitate the gathering of relevant data and information for PacMARS (2) Develop PacMARS data management webpage for data upload and GIS mapping protocols and layers (3) Implement GIS MapServer capabilities to facilitate the PacMARS team to visualize and access available marine ecosystem data, products and other value added content (4) Develop standardized shape files of available data for use by PacMARS team (5) Organize and host PacMARS data workshop in November 2012 for all PIs to work on data compilation, GIS analysis and synthesis products	o Moore, J. o McCammon, M. (subaward to facilitate industry data transfer)
<u>Project Management</u>	o Development of GIS data overlays for analyses and publications o development standardized shape files o PacMARS website at CBL o Quarterly, interim and final reports to NPRB o Workshop reports o Lead editors for PacMARS book	1) Organize fall PI meeting and monthly conference calls 2) Develop PacMARs project website as outreach tool; cross-line with co-PI J Moore's A-CADIS PacMARS data website 3) Organize PacMARS open community workshop, facilitate invitee participation 4) Facilitate and participate in local community Hub meetings 5) Coordinate and finalize PacMARS quarterly reports, interim July 2013 report and final report 6) Edit and coordinate PacMARs synthesis book	Grebmeier, Cooper, CBL staff; facilitate data products and connection with ACADIS PacMARS effort

H. Management Approach and Personnel Qualifications

PI Grebmeier will share overall management of the project with co-PI Cooper. We have also identified a senior level project assistant, Ms. Eva Bailey, who has polar shipboard science experience and over 10 years of experience with state and federal agencies working in environmental management of the Chesapeake Bay ecosystem. She currently serves as the key project assistant to Dr. Walter Boynton, President of the Coastal and Estuarine Research Federation, and she will be loaned in service for the duration of this project. Ms. Bailey will maintain regular email and phone contact with all PIs, set up the monthly conference calls, organize the PI data meeting and AMSS associated open workshop for science community input. She will be responsible for drafting the subsequent meeting reports as well as coordinate input of the quarterly reports from all the 11 PIs on this project. She will also maintain the PacMARS project website, which will be housed using an existing webserver at the Chesapeake Biological Laboratory.

H1. PacMARS PIs-Personnel

Lead PI JM Grebmeier will have overall project management for this synthesis team through the University of Maryland Center for Environmental Science. An experienced manager of multidisciplinary arctic science programs, she served as the Director for the Shelf-Basin Project office in the 2000s. This work was in addition to individual scientific contributions in process-oriented benthic studies during the program in Chukchi seas. Other work published over the past 30 years includes contributions to Nature, Science, and other prominent professional journals. Currently, she is Lead Scientist for the International Pacific Arctic Group. She is also the US representative to the International Arctic Science Committee (IASC) and serves as a Vice-President on the IASC Executive Committee. She is also providing oversight and logistical management for the 10 US delegates appointed to the US National Arctic Committee under the US National Academies Polar Research Board. In this proposed effort, she will provide oversight on all operations, including arranging consulting contracts and reimbursement, development of a project website linked to the EOL data archive, promote within-project data exchange, communicate public goals, organize meetings and monthly conference calls to maintain internal continuity. PI Grebmeier has participated in many interdisciplinary projects, including ISHTAR (1984-1988, as a PhD student), and as a co-PI on BERPAC, RUSALCA, SBI, SLIP, BEST, BSIERP C30, and COMIDA projects, both CAB (Chemistry and Benthos) and the upcoming Hanna Shoal program (2009-2016).

Co-PIs

Lee Cooper will co-manage the PacMARS team effort at CBL. He previously managed the NSF funded Project Office for the US-Russian Initiative for Shelf-land Environments (RAISE; archived inactive website at: http://arctic.cbl.umces.edu/RAISE/index.html). He has research interests that include biogeochemical cycling in high-latitude ecosystems through the use of isotopic and elemental tracers, and he has been the lead or co-author on nearly 100 peer-reviewed publications, many of which cover the study area from the northern Bering Sea to the Beaufort Sea. He has extensive polar shipboard research experience including service as chief scientist or co-chief scientist on 12 US Coast Guard icebreaker missions, including coordination of several multidisciplinary research programs. He served as a member of a National Academy of Sciences study committee on designing an Arctic Observing Network and he currently serves as deputy chair of the UNOLS Arctic Icebreaker Coordinating Committee. He has also been active in working to improve collaborative bi-national research in the Russian Arctic through participation as the U.S. representative in an International Arctic Science Committee working group that exchanges information with other arctic countries on multinational research activities in the Russian Arctic.

Carin Ashjian will collaborate in the compilation of the pelagic components of the data sets. Ashjian is a

biological oceanographer with a focus on zooplankton ecology and biophysical interactions. She has worked in oceanic environments ranging from subtropical to polar but in recent years has focused on the Arctic Ocean, participating in a number of multidisciplinary, multi-investigator programs (e.g., SBI, BEST, SNACS, RUSALCA, SHEBA). Most recently, she has been working together with other observationalists and modelers to use biological-physical models to understand Arctic ecosystems and their response to ongoing climate change. She is leading an ongoing effort to describe the importance of a bowhead whale feeding "hotspot" near Barrow, an effort supported since 2005 by the NSF, NOAA, BOEM, NOPP, the UAF CMI, and the WHOI Arctic Initiative. She is a member of the Science Advisory Board for the Bering Sea Program (NSF/NPRB supported) and was Chief Scientist for three, 6-week cruises as part of that multidisciplinary, multi-investigator program. She is past chair of the UNOLS Arctic Icebreaker Coordinating Committee and is a member of a number of committees and panels promoting and directing research in the Arctic. In addition to her work on the pelagic data sets, she will oversee travel arrangements and support for the workshops, which have been centralized for time and monetary efficiencies at WHOI.

Bodil Bluhm is a Research Associate Professor with the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks. She has conducted benthos and sea ice-related research in polar areas in the fields of community ecology, biodiversity, foods webs, cryo-pelagic-benthic coupling and invertebrate population dynamics based on over 35 grants from a variety of funding sources since 1996, and has participated in a total of 14 months of related field work. She managed the recent international 7-year Arctic Ocean Diversity (ArcOD) Census of Marine Life project, which served as the lead Marine Biodiversity cluster during the International Polar Year. In these efforts, Bluhm gained experience in collating and analyzing biodiversity data sets on a pan-Arctic scale, prepared standardized metadata for those data, made them available in online open access data portals in accepted data standards, guest-edited several special issues, chaired conference sessions, and organized international meetings. During the proposed project, Bluhm will focus on the synthesis of biodiversity data and explore the relationship of biodiversity and productivity in the Pacific Arctic.

Robert Campbell is a biological oceanographer and plankton ecologist whose primary research focuses on biological rate processes. His work spans temperate to Arctic regions and estuarine to open ocean ecosystems. Research topics have included studies linking secondary production to fisheries, harmful algal bloom dynamics, methods of controlling invasive planktonic species, and assessing the impact of climate change on planktonic ecosystems in Arctic and subarctic seas. He has participated in a number of large federally sponsored research programs including: GLOBEC, ECOHAB, SHEBA, SBI, SNACS, BOWFEST, BEST, and AON. He was a member of the Science Advisory Committee for the NSF's Shelf Basin Interactions program, he has served on several NSF review panels, and he is currently a member of the NSF-supported Arctic Icebreaker Coordinating Committee.

Kenneth Dunton is a marine ecologist who uses stable isotopes to characterize arctic and temperate food webs, with a particular emphasis on the differential assimilation of carbon sources from phytoplankton, ice algae, microphytobenthos, and terrestrial sources on the nearshore and mid shelf regions. He uses GIS as a tool to graphically display data for the Beaufort Sea, in particular he will provide: 1) a detailed integrative examination at Beaufort and Chukchi food webs, 2) a documentation of the productivity and food web structure of estuarine lagoons and deltas in the western arctic, particularly in Camden Bay adjacent to the Arctic National Wildlife Refuge, the site of proposed oil exploration by Shell in summer 2012 and beyond; 3) characterization of existing or likely "hot spots" of high benthic diversity or biomass in the northern Chukchi and Beaufort Seas, from Barrow Canyon type areas to kelp beds; 4) identification of gaps in knowledge and understanding of key biological and biogeochemical processes, especially in relation to changing ice conditions and the resiliency of the benthic arctic ecosystem.

James Moore is a data management specialist with extensive experience handling arctic data and will

have the overall responsibility of the PacMARS data management support at EOL-ACADIS in Boulder, CO. This includes general coordination with the PI team, participation in all data management activities including direct interaction with collaborators and contractors. Moore brings 30 years experience in field project management and specialized data management support to Alaska and Arctic regional projects including SHEBA, SBI, BSIERP and BEST. Steve Williams is the Manager of Data Services for the Computing, Data and Software (CDS) facility in EOL. He will make sure resources and effort can be applied to PacMARS activities to ensure timely completion of tasks. Williams brings 25 years experience in project management with an emphasis on data management implementation, dataset archive development and documentation. Don Stott is the EOL technical lead for the PacMARS data management support effort with an emphasis on web tool development and visualization. He will have day-to-day responsibility for the support to PIs, primary point of contact with the PIs for questions, and handle advanced programming tasks for integrating and visualizing data and metadata within the EOL EMDAC system.

Steve Okkonen is a physical oceanographer who has participated in multi-disciplinary field studies of the Bering, Chukchi, and Beaufort Seas (AON, BOWFEST, ICEX, NOPP, SCICEX, SNACS). He has spent the past seven summers investigating the biophysics of Barrow Canyon and the western Beaufort shelf and its role in promoting feeding hotspots for bowhead and beluga whales. His disciplinary interests include near-shore dynamics, shelf-slope exchange, and satellite remote sensing of the ocean. In particular, he uses satellite imagery (visible band, ocean color, sea surface temperature, synthetic aperture radar) and sea surface topography to illustrate topical oceanographic features and phenomena and to provide local-to-regional scale context for interpreting spatially limited in situ oceanographic data. During the past few years, he has led/is leading the production of bilingual (English/Iñupiat) outreach products (poster, calendar, digital animated film), directed at lay audiences that illustrate biophysical phenomena related to the life history of bowhead whales. PI Okkonen has primary responsibility for identifying physical oceanographic data sets. Within the context of the synthesis goals of this project, he will identify physical oceanographic data sets relevant to geographic- or habitat-based ecosystem analyses. Where appropriate, he will provide the science lead for the production of artistic renderings of selected ecosystems.

Gay Sheffield is the Marine Advisory Agent for the University of Alaska Fairbanks in Nome. A professional marine mammal biologist who has facilitated better understanding of marine mammal health and movements, as well as bowhead whale and walrus food preferences, she has collaboratively worked with Native communities throughout the study region. Her work has resulted in the acquisition of valuable samples for use in multiple collaborative projects with a wide variety of researchers. She is well known as a committed researcher and communicator and is trusted in villages from Gambell to Kaktovik.

John Trefry, a biogeochemist, will help synthesize the large chemical data sets that have been produced and link them with the ecosystem processes that are a primary focus of the synthesis. He was a PI on the ANIMIDA and cANIMIDA Projects in the Beaufort Sea (1999-2007) and is a PI on the COMIDA PROJECT, including the upcoming Hanna Shoal component (2009-2016). He also has participated in oil industry studies in both seas (2007-2012). Trefry has played a key role in producing a large fraction of all the chemical data generated for trace metals and hydrocarbons in biota, sediment and water for the Beaufort and Chukchi seas. He will combine the relevant descriptive data with process data that inform ecosystem analysis on past, present, and potential future impacts on the ecosystem from climate change and human activities. Trefry also will add a geological perspective to the team as we consider the past and future history of the seafloor.

Sveta Yamin-Pasternak is a cultural anthropologist with broad interdisciplinary training, specializing in knowledge systems and human adaptation in the Circumpolar North. Dr. Yamin-Pasternak, while an early career scientist, has extensive experience in conducting ethnographic research over the past 12 years in

communities in both Alaska and the Russian Far East. During her postdoctoral work she examined questions related to food systems, housing, cultural landscape, identity, migration, subsistence economies, and human relationships with fresh water in the Bering Strait region. Especially relevant to the proposed endeavor is the analysis of cross-generational use of marine resources in the diet and material cultures of the Indigenous communities in the coastal western Alaska and the Russian Far East. Dr. Yamin-Pasternak has added social science themes and product components to this revised proposal and will participate in all the PacMARS-sponsored community hub meetings as well as group meetings and workshop.

H2. PacMARS Consultant Advisors

We have confirmed participation by two senior and well-respected advisors to contribute to the "big picture" synthesis envisioned for this the project: Dr. Eddy Carmack and Dr. Robert Ulanowicz. These advisors will both participate in the PI meetings, monthly conference calls, and the AMSS2013 meeting. They will be responsible for reviewing and providing recommendations on the ongoing efforts of the PacMARS team. Eddy Carmack (for more information, see http://www.meds-sdmm.dfo-mpo.gc.ca/sdb-bds/profile-profil.do?id=785&lang=eng and http://www.rcgs.org/awards/massey_medal/winner_massey2007.asp) recently retired as a Senior Research Scientist and climate oceanographer from the Institute of Ocean Sciences, Fisheries and Oceans Canada. He has participated in over 80 field investigations in rivers, lakes and seas spanning from the Antarctic to the Arctic and from the Yukon to Siberia. Dr. Carmack's research interests are in the role of continental shelf areas in water mass formation and modification, the mechanisms by which coastal runoff influences regional ocean circulation and climate (especially in the North Pacific and Canadian Arctic), and the formation and behavior of subsurface water masses in the open ocean and on the continental shelves. He was one of the principal investigator joint Canada/US/Russia project sin the N. Pacific and he led Canada's Three Oceans Project, for the International Polar Year program. We anticipate that Carmack's recent efforts with C.S. "Buzz" Holling, the father of resilience theory (http://en.wikipedia.org/wiki/C._S._Holling) will contribute to understanding how biocomplexity approaches can be used to understand ecological processes in the northern Bering, Chukchi and Beaufort Sea region. A colleague of Hollings as an emeritus faculty member associated with the University of Florida, Robert Ulanowicz (for more information, please see http://en.wikipedia.org/wiki/Robert_Ulanowicz) is a well-known and globally respected expert in network theory and ecosystem connectivity. Ulanowicz will serve as a second high-level senior advisory consultant and will use his knowledge of network theory and ecosystem science to help provide a higher level of understanding and connections to globally distributed ecosystems. We anticipate that these two scientists will work together, using in part our synthesis products to develop a high-level overview chapter in the polar book that will be one product of this effort in year 2. Both of these advisors are very interested in a collaborative contribution and advisory capacity to PacMARS, based upon emailed discussions over the past two weeks. Particularly since Dr. Carmack is traveling internationally, it was not practical to provide formal letters of collaboration, but we have appended copies of the emails that were exchanged.

H3. Collaborators

The role of collaborators in the PacMARS effort will be important. These collaborators bring expertise and knowledge of publicly available data archives from many sources, including higher trophic organisms. These specialists will complement our efforts, fill some knowledge gaps and provide connectivity to other on-going research programs and synthesis efforts, as well as contribute to identifying research needs.

1. Sue Moore, NOAA/Fisheries Office of Science & Technology. Dr. Moore is one of the leaders in the five-year NOAA-BOEM cooperative SOAR program (see appended letter). We have had extended discussions with Dr. Moore and expect that the combined SOAR and PacMARS efforts will be

synergistic and positive. Dr. Moore will also assist with coordinating access to higher trophic data sets available through NOAA and other public archives. She will advise us at no cost as a federal employee, and we will arrange her travel to a data sharing meeting planned in November 2012 in Boulder Colorado, as well as the meeting with a socioeconomic approach planned for Annapolis.

2. Robert Pickart, Woods Hole Oceanographic Institution. Dr. Pickart has emerged over the past decade as one of the key physical oceanographers working in the Pacific Arctic region through participation in the SBI, AON, and RUSALCA programs. He has an active moored and ship-based observational research program. He will attend the data workshop in Boulder and provide no-cost advising to the PacMAR team (see appended letter) concerning the synthesis efforts.
3. Molly McCammon, AOOS. AOOS is a critical link to providing integrated visualization tools and generating products that can be widely used, particularly within communities throughout Alaska. AOOS has received funding from NOAA (January 2012) and been designated as a regional partner through the Regional Ocean Partnership Funding Program with the funding channeled through the Seward Association for the Advancement of Marine Science. The $760,000 award is to develop stakeholder-driven visualization and decision-support tools for Alaska and the U.S. Arctic for a range of ocean and coastal uses. As discussed previously, AOOS is also developing a portal for environmental data funded by the oil and gas industry. PI Jim Moore has participated in discussions with Ms. McCammon and PIs Cooper and Grebmeier about how we will jointly share visualization, geographical information, and data management expertise. The relationship between AOOS and the small start-up business Axiom Consulting and Design in Anchorage dictates a formal, but small subcontract that is embedded within the proposed award to UMCES (see appended letter).
4. John Nelson, Institute of Ocean Sciences, Fisheries and Oceans Canada. Dr. Nelson, who is also affiliated with the University of Victoria, will play a key role in facilitating the transfer of data collected during the Canada's Three Oceans project, and preceding efforts that used the annual CCGS Sir Wilfrid Laurier cruise to sample in Alaska waters during its transit every July from Victoria to the Canadian Arctic (see appended letter). His expertise in genetics of zooplankton and arctic cod should also complement other strengths among the PIs. This expertise will also be helpful in identifying new research initiatives such as applications of molecular tools that will address the research needs component of the proposal.
5. Brenda Norcross, University of Alaska Fairbanks. Dr. Norcross is one of the best-known and most widely published specialists on fish in the Pacific Arctic region. She will provide expertise on species diversity, abundance and distributions through a small personal subcontract (see appended letter).
6. Kathy Kuletz, US Fish and Wildlife Service. Dr. Kuletz has contributed enormously to the knowledge of seabird distributions in Alaskan waters over a 30-year career. She is the at-sea coordinator of the Division of Migratory Bird Management (USFWS) and has been PI for numerous projects that examined seabird distribution relative to oceanographic and biological variables. She is currently PI for a BOEM-funded project to investigate seabird distributions in the Chukchi and Beaufort seas. She will contribute processed data on bird distributions, assist with interpretation of results, and help identify research needs involving bird populations and the related ecosystem. She will participate in our meetings, for which we will arrange travel (see appended letter).
7. Chad Jay, US Geological Survey. Dr. Jay, a marine research ecologist at the Alaska Science Center in Anchorage, will provide expertise on geographical distributions of marine mammals, particularly walruses, and assist in collaborative access to data sets that can be used in conjunction with benthic biological data to support synthesizing ecosystem level understanding of how marine mammal populations are being affected by changing sea ice and food availability (see appended letter). He will also be a valuable asset for identifying available marine mammal data and emerging research needs.
8. We have also allocated consulting funds for 5 other experts to participate in the data preparation effort.

I. Tables (embedded in text)

J. References

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