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Aleutian and Bering Sea Islands
Landscape Conservation Cooperative

Strategic Science Plan

LANDSCAPE
CONSERVATION
COOPERATIVES

Executive Summary

The Aleutian and Bering Sea Islands Landscape Conservation Cooperative, or ABSI LCC, promotes applied science to inform conservation of natural and cultural resources in the face of climate change and other landscape-scale stressors. Threats from climate change act in concert with other stressors and have broad, yet uncertain, implications for the conservation of natural resources and human communities. This strategic science plan establishes a focus for our investments which aim to complement the efforts of other organizations to refine understanding of these threats and reduce uncertainty for managers and stakeholders from the Aleutian Islands and Bering Sea region.

With great uncertainty and much at stake, there have been numerous efforts made to identify and understand the threats facing the ecosystem of the Aleutian Islands and Bering Sea. These efforts have resulted in dozens of research and management plans which have helped to refine science priorities for the region. Our review and synthesis of these plans identified six landscape-scale stressors of importance in the ABSI region: 1) climate variability and change; 2) commercial fishing; 3) contaminants and pollutants; 4) invasive and introduced species; 5) marine vessel traffic; and 6) ocean acidification.

We conducted an extensive review of literature and an inventory of contemporary research and management efforts related to each of these six stressors. We used this information to develop an initial assessment of conservation threats to seven categories of natural resources and four ecosystem services vital to the ABSI region. We sought feedback on this assessment from a broad community of managers, researchers and stakeholders during a workshop and collected individual input via a survey. The results from these efforts, combined with our earlier plan and literature review allowed us to identify climate change and variability as a *primary* science focus for the LCC. Marine vessel traffic, invasive and introduced species and contaminants and pollutants were assigned to a *secondary* category of focus. Commercial fishing and ocean acidification are considered a *tertiary* focus in large part due to substantial ongoing efforts aimed at these stressors.

This strategic science plan will guide our investments and collaborations over a five-year planning horizon. It is our hope that it will complement previous and contemporary conservation efforts by producing applied science products needed by managers and stakeholders in the ABSI region. This plan is issue-based and as such is focused on evaluating the specific nature of impacts from stressors on key resources and ecosystem services. We also share some likely examples of early science priorities, aimed at helping us to better understand risks and vulnerabilities associated with our primary and secondary stressors. These priorities will be further defined through annual implementation plans that will link to the science foundations established herein. We also establish the foundations of our business model relative to: evaluating our success; communication and outreach to managers and stakeholders; as well as data and information sharing practices.

The planning effort was directed by the ABSI LCC Steering Committee and was informed by targeted subject matter experts. It was further improved by expert and stakeholder outreach efforts that helped to assess the rigor of our initial internal conclusions. These efforts have established a precedent for regular engagement with our partners and stakeholders and expert review that will keep this an evolving strategic science plan.

Acknowledgements

The Aleutian and Bering Sea Islands Landscape Conservation Cooperative is indebted to Vernon Byrd, Interim Science Coordinator during the summer of 2011. Vernon compiled an initial inventory of over 50 research and resource management plans relevant to the species and habitats within the Aleutian and Bering Sea Islands region. His initial synthesis of these plans formed the basis for this Strategic Science Plan. In addition, based on his many years of working in this area, Vernon helped establish a list of organizations and individuals who would become our Partnership Community. Vernon was succeeded by Dr. Glenn Chen,who served as Acting Science Coordinator in early 2012, and continued to build the foundation for this plan.

The development of this Strategic Science Plan was guided by the members of our Steering Committee, who reviewed multiple drafts of the plan and all its appendices. In addition to their valuable insights, we relied on a number of subject-matter experts to review the appendices for each landscape-scale stressor of interest in the Aleutian and Bering Sea Islands region We thank the following list of reviewers for taking to time to help improve this plan: Sarah Allen, Paul Becker, Lawson Brigham, Matthew Forney, Ali Hamade, Phil Johnson, Jeremy Littell, Ed Page, Lorie Rea, Lisa Robbins, Tim Robertson, Mike Sigler, Mark Systma, John Walsh and David Witherell.

Cover photo of the *R/V Tîglax̂* at Little Kiska Island by Tony DeGange (U.S. Geological Survey). Appendices B-H cover photo by Verena Gill (U.S. Fish & Wildlife Service).

Introduction

The Aleutian and Bering Sea Islands Landscape Conservation Cooperative (ABSI LCC) promotes coordination, dissemination, and development of applied science to inform conservation of natural and cultural resources in the face of climate change and other landscape-scale stressors. The geographic scope of the ABSI LCC includes the islands of the Aleutian archipelago, the Pribilof Islands, St. Matthew and Hall Islands, and St. Lawrence Island. It also includes their surrounding marine waters out to the 200 nautical mile Exclusive Economic Zone in the northeast Pacific and Bering Sea and is bounded in the north by the Bering Strait (Figure 1).

The activities of the ABSI LCC were directed by a Steering Committee comprised of federal and tribal members. The role of the Steering Committee includes providing guidance and oversight to the core staff (the LCC's Coordinator and Science Coordinator) and making decisions about project funding. The Steering Committee that directed the development of this plan was composed of designated representatives from Federal and Alaska Native entities with an emphasis on management and conservation of land and natural resources in the ABSI region (Table 1).

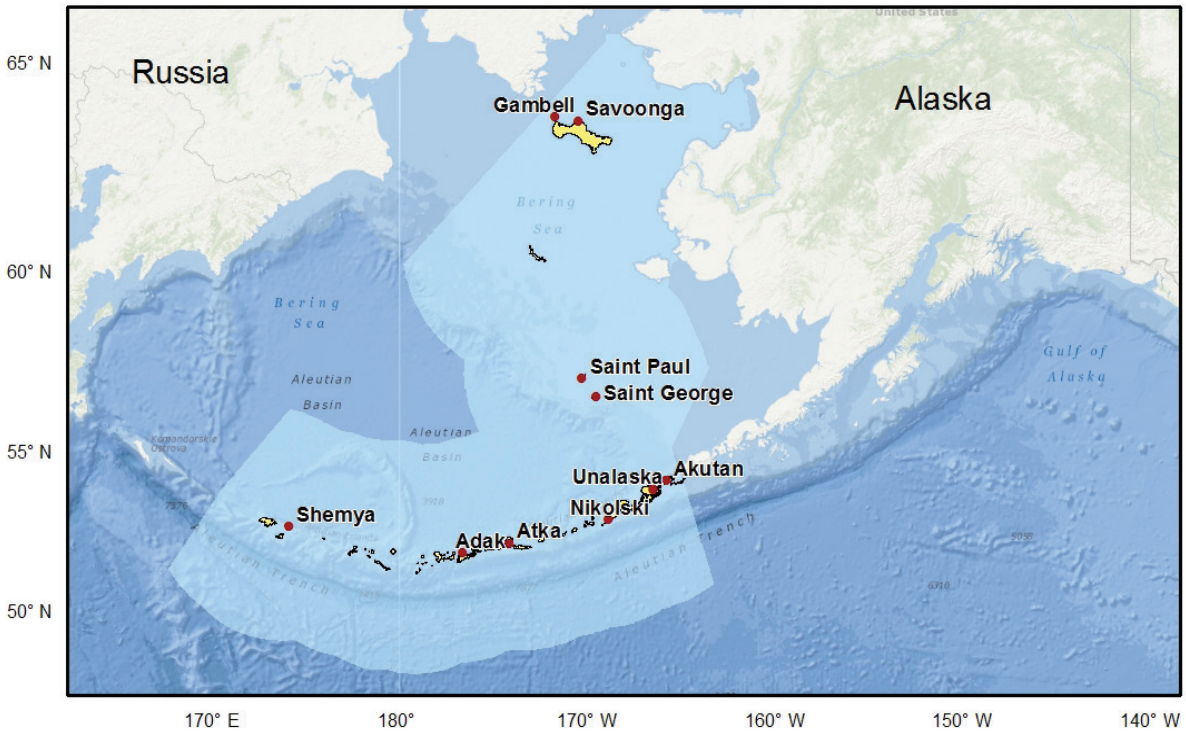

Figure 1. The geographic boundary of the Aleutian and Bering Sea Islands Landscape Conservation Cooperative.

Table 1. The 2010-2013 members of the ABSI LCC Steering Committee.

Name	Affiliation	Department
John Bengtson	NOAA	National Marine Mammal Laboratory
Tony DeGange	USGS	Alaska Science Center
Carol Fairfield[a]	BOEM	Environmental Sciences Management
Lynn Fuller[a]	Pacific Coast Joint Venture	Alaska Region
Joel Garlich-Miller	USFWS	Marine Mammals Management
Stephen Gray[b]	USGS	Alaska Climate Science Center
William Lekanoff	Qawalangin Tribe of Unalaska	Tribal Council
Patricia Livingston	NOAA	Resource Ecology and Fisheries Management Division
Heather Renner	USFWS	Alaska Maritime National Wildlife Refuge
Lyman Thorsteinson	USGS	Office of the Regional Director for Alaska
Karen Pletnikoff[c]	Aleutian Pribilof Islands Association	Community Services

[a] Joined the in August 2013
[b] Non-voting member
[c] Joined in December 2012

The general focus of the ABSI LCC is on the natural and cultural resources and their associated marine and terrestrial ecosystems. The ABSI LCC will strive to avoid duplication with other entities, and coordinate on issues of mutual interest. In 2012, the ABSI LCC Steering Committee identified five central conservation goals:

- Promote communications to enhance understanding regarding effects of climate change and other landscape-scale stressors in the ABSI region.
- Support coordination and collaboration among partners to improve efficiencies in their common science and information activities.
- Identify and support research, including data collection, analysis, and sharing that address common information needs of land and resource management decision makers.
- Enable synthesis of information at landscape and larger spatial scales.
- Enhance resource management in the ABSI region through applied science, analytical tools, data management, and information transfer.

The ABSI LCC will focus on activities that complement existing programs and missions of the organizations represented on the Steering Committee, as well as other resource managers and stakeholders from the ABSI region.

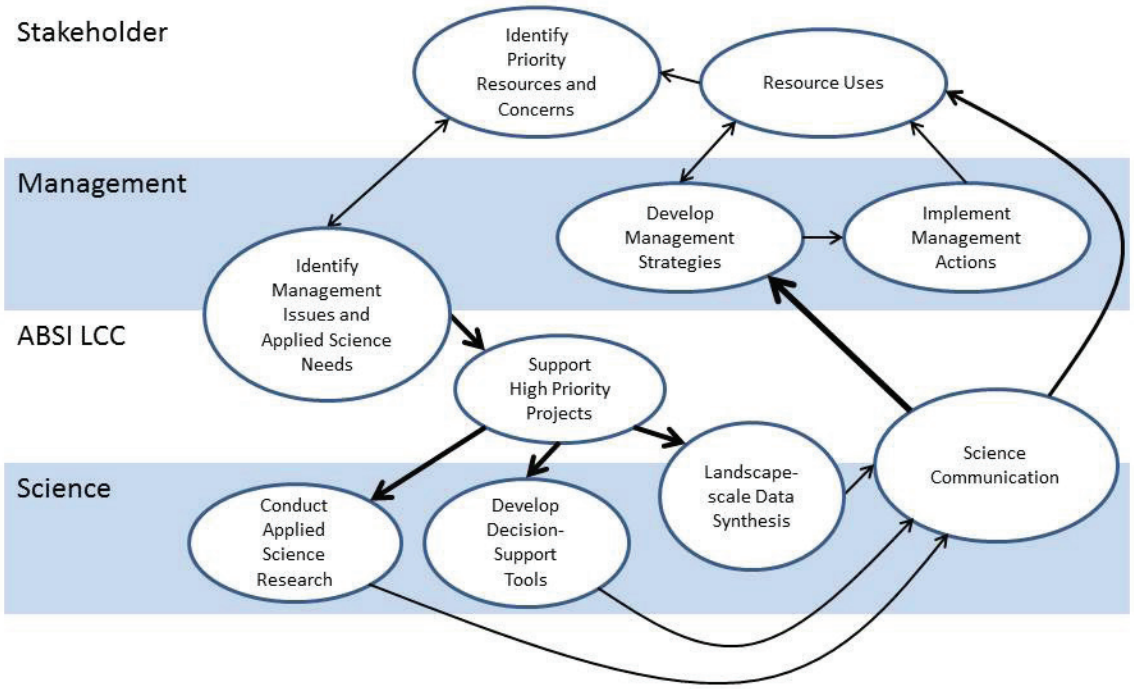

Figure 2. A strategy map describing the relationship of the ABSI LCC with respect to three sectors of the conservation community active in the Aleutian and Bering Sea Islands region.

The role of the ABSI LCC in the delivery of applied science to support natural resource management can be illustrated using a strategy map (Figure 2). In the case of the ABSI LCC we identify three broad sectors of the conservation community: Stakeholder, Management, and Science. Together, these constitute the broader Partnership Community as defined in the ABSI LCC charter. It is important to note that agencies and organizations can belong to more than one community. For example, NOAA and the USFWS are both resource managers and science organizations. Although not depicted here, the Alaska Climate Science Center (AK CSC) occupies the same conceptual space and fulfills a similar role to the ABSI LCC with a more targeted focus on climate change. The ABSI LCC and AK CSC work together to identify climate related science needs, support projects, and communicate results.

Our strategy map is similar to other adaptive management systems such as the USFWS Strategic Habitat Conservation (SHC) approach. In addition to funding high priority projects, the ABSI LCC aims to be a vibrant connection between researchers, managers and stakeholders concerned about resource issues in the region. This connection is vital in terms of helping scientists learn about high priority environmental science needs in the region *and* helps to ensure that results of research are communicated back to managers and stakeholders in a manner that allows for management adaptation. This connection is facilitated at a high-level through the collaboration of our Steering Committee members as they direct the actions of the ABSI LCC. Connection is also fostered by the efforts of our staff and the projects we fund including: applied science, decision support tools and landscape level data synthesis efforts. Much like other granting organizations (e.g., NSF and NPRB) projects funded by ABSI will include broad data sharing requirements and specific investments in communicating research

results with managers and stakeholders. This operational approach, as well as targeted efforts to engaged ABSI communities in research efforts, will help to ensure a continuous flow of communication between all parties working toward conservation in the region.

Background on the National Network of LCCs

The Department of Interior (DOI) established Landscape Conservation Cooperatives (LCCs) and Climate Science Centers (CSCs) as a means to integrate science and management expertise within the Department and its partner organizations in a coordinated response to climate change (Secretarial Order 3289) and other landscape-scale stressors (Landscape Conservation Cooperatives and Climate Science Centers Implementation Guidance, January 11, 2011). Each LCC functions within a specific geographic region, but is also part of a national/international network. Each LCC is directed by a Steering Committee representing partners working within a given region. The LCCs are true cooperatives, composed of land, water, fisheries, wildlife and cultural resource managers, as well as interested public and private scientific organizations. Federal, state, tribal, and local government and non-governmental organizations are all vital LCC participants. An important distinction about LCCs, relative to other conservation partnerships, is their focus on providing information to managers rather than explicitly developing management plans. The multiple jurisdictions of the agencies, tribes and organizations within each cooperative make this a fundamental tenet of LCCs.

The ABSI LCC is one of 22 LCCs that have been established since 2010 –including four others that cover parts of the state of Alaska: Arctic, Northwest Boreal, North Pacific and Western Alaska LCCs (Figure 3). The Western Alaska LCC adjoins ABSI along the west coast of the state including the Alaska Peninsula and is likely the most similar as a result of the coastal influences

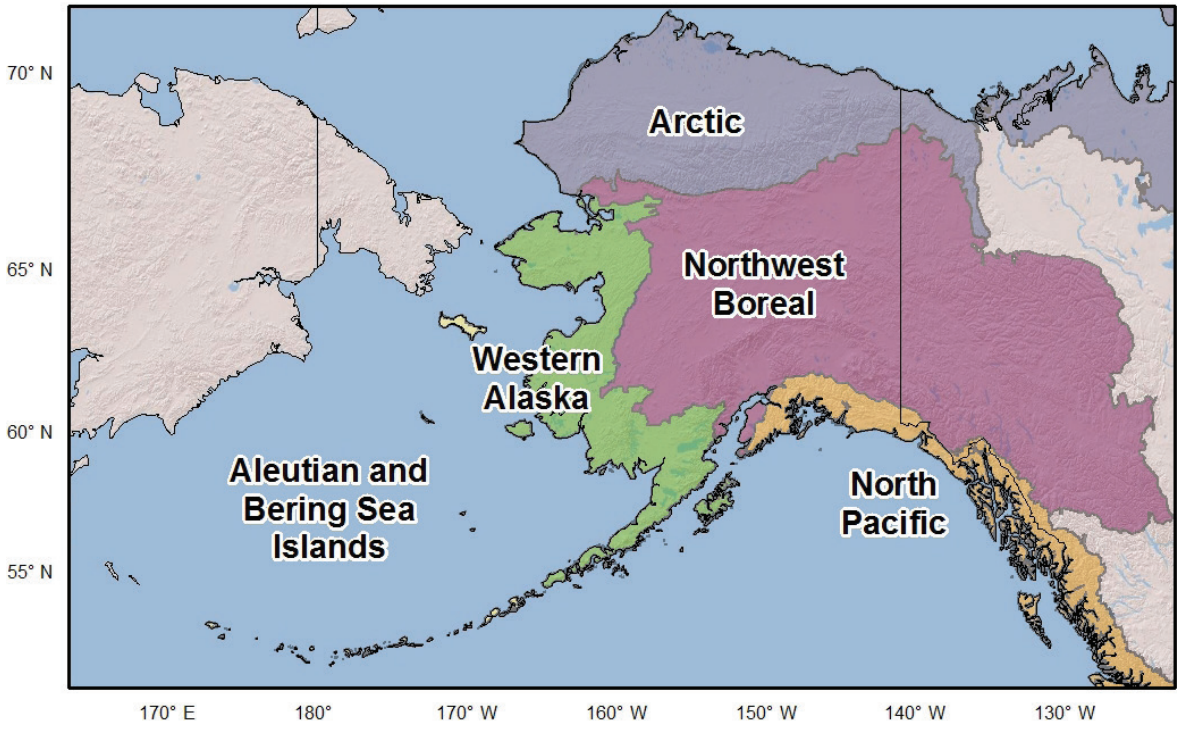

Figure 3. Geographic coverage of five Landscape Conservation Cooperatives in Alaska.

of the Bering Sea and Gulf of Alaska. In addition our connectivity through ocean currents, migratory species, reliance of residents on natural resources, and common socioeconomic challenges faced by our communities result in a number of overlapping areas of scientific and management concern.

Plan Rationale and Development

The ABSI region is a tremendously productive and dynamic ecosystem. This productivity is in part reflected in its commercial fisheries and the subsistence lifestyles enjoyed by its communities. Yet the resources that support these activities are threatened by climate change and other landscape-scale environmental stressors. These threats range from potential impacts to populations to wider ranging effects like changes in food webs and cascading effects on ecosystems and their dependent human communities. Numerous local, state, national and international organizations are planning and conducting research in the Bering Sea and Gulf of Alaska to understand these threats. Each effort contributes new data and information leading to greater ecosystem understanding and improved management regimes for the natural resources. An integral part of all LCCs is their inherent focus on the most urgent natural resource issues such that, through coordination and collaboration, they can be addressed at the most appropriate scale.

Given our focus on large scale threats, the complexity of ecosystems, and the limited resources of the ABSI LCC, this plan takes an issue-based approach to identifying a targeted set of science needs. A first step in analyzing the regional issues was the ABSI LCC's review of over 50 existing research and resource management plans relevant to the region (Appendix A). These plans range from applied science approaches in support of single and multi-species management plans, to more basic science approaches in support of ecosystem management. Collectively they represent a rich legacy of effort from countless resource managers and researchers working in the region over several decades. They are a valuable source of knowledge to resource managers and stakeholders and through our analysis of these plans we have identified six landscape-scale stressors of greatest concern to the natural and cultural resources of the region:

- Climate Variability and Change
- Commercial Fishing
- Contaminants and Pollutants
- Invasive and Introduced Species
- Marine Vessel Traffic
- Ocean Acidification

The core staff and Steering Committee completed a structured analysis of each threat provided as individual narratives in Appendices B-G. Each of these synthesis papers includes a literature review of what is known about each threat in the ABSI region, an evaluation of potential ecological impacts, documentation of information and data sources, and lists potential ABSI LCC collaborators. Each narrative was peer-reviewed and provides information about possible stressor effects across 11 categories that represent conservation priorities within the ABSI region. These priorities include categories of natural resources that were commonly identified in the research and management plans inventoried to initiate this planning process. They represent a number of the iconic species from the region including federal agency trust species

and species vital to the social and economic wellbeing. One resource category is the sites and artifacts that tell the story of the region's cultural heritage. Potential impacts to regional ecosystems are addressed by considering four priority *ecosystem services* as described by the Millennium Ecosystem Assessment (2005).

Priority Natural and Cultural Resource Categories:

- Seabirds
- Marine Mammals
- Fishes
- Coldwater Corals
- Invertebrates/Shellfish
- Terrestrial Vegetation
- Cultural Artifacts/Sites

Priority Ecosystem Services:

- Subsistence Culture
- Commercial Fishing
- Trophic Function
- Human Community Sustainability

The Steering Committee decided that categories of priority resources and ecosystem services should remain relatively broad to allow for flexibility in funding and strategic collaborations. Though broadly inclusive, the Steering Committee determined that the resulting structure of six stressors evaluated relative to 11 conservation priorities, was a sufficient framework for identifying initial applied science needs relevant to a majority of managers and stakeholders in the ABSI region. Further, given the enormity of the region and the complexity of issues, the Steering Committee felt it was necessary to initially keep a more generalized focus that will be refined through future investments focused on our conservation priorities.

The Steering Committee's intent is that this plan provides broad guidance for a five-year period that will be stepped-down through a series of annual Implementation Plans. Specific science questions will be established as part of these annual plans and will be used to develop Requests for Proposals (RFP), and guide project selection as well as establish science collaborations and direct other ABSI LCC activities.

Environmental Stressors

General predictions of continued global warming in this century have strong implications for species and human communities dependent on Alaskan coastal and marine environments. Average Bering Sea surface air temperatures are projected to increase approximately 1.0 to 1.5° C in the next 10 to 20 years and by 3 to 4° C by the turn of the century. Understanding the potential effects of this warming trend is complicated by the climatic variability observed in this region over recent decades. The combination of variability and increasing temperatures have largely unknown, yet potentially severe impacts to resources and human communities of the region --including the loss of sea ice, increased storm activity, uncertain shifts in species distributions, and changes in marine and terrestrial food webs.

Threats associated with climate change and variability act in concert with other stressors that operate at landscape scales. These include changes in human use associated with the commercial fishing industry as well as increasing vessel traffic from an international shipping industry. The long-distance transport and fate of pollutants and contaminants additional threats and may lead to bio-accumulation in regional food webs and effect apex predators such as marine mammals, seabirds and subsistence hunters. A legacy of harmful invasive species introduced to the Aleutian Islands continues to alter terrestrial systems and new concerns have been raised about invasive aquatic species threatening the marine environment. These threats are underscored by the lesser-known stressor of ocean acidification as the seas absorb increasingly abundant CO_2 in the earth's atmosphere.

The following section offers short synopses describing conservation threats from the six landscape-scale stressors based on what is known about each within the ABSI Region. Full descriptions for each stressor are included as individual Appendices B-G.

Climate Variation and Change (Appendix B)

The resilience of many ecosystems is likely to be exceeded by an expected increase of 1.5 to 2.5°C in global average temperature by the end of the 21st century. Changes in climate affecting the frequency and intensity of storms, species range shifts and major trophic changes will likely combine with other threats. The overexploitation of resources, land-use change, pollution, and fragmentation of natural systems are expected to profoundly affect all regions of the planet. The International Panel on Climate Change (IPCC) defines four areas of special concern including: the Arctic, because of the impacts of high rates of projected warming on natural systems and human communities; and small islands where there is high exposure of population and infrastructure to projected climate change impacts (IPCC 2007). Changes in ocean and air temperature in the ABSI region have resulted in changes in winter sea ice extent and season, species shifts, changes in storm regimes and coastal erosion. Further changes are expected in ocean circulation, salinity, and sea level. These changes are expected to further threaten resources and the resilience of human communities (NOAA 2011). Adding to the concern is the history of climate variation for the Bering Sea, where abrupt regime shifts have had lasting effects on nutrient cycling, species assemblages, and ecosystem function (Grebmeier *et al.* 2006). This regional variation further complicates the picture when attempting to evaluate implications of long-term trends and effects of global climate change.

Affected Priority Resources and Ecosystem Services: subsistence culture, commercial fishing, marine mammals, seabirds, trophic function, community resilience, and cultural resources.

Commercial Fishing (Appendix C)

The Bering Sea and Aleutian Islands region supports some of the largest and most valuable commercial fisheries in the United States (e.g., Worm *et al.* 2009) including the Bering Sea walleye pollock fishery and Bristol Bay red king crab and Bering Sea snow crab fisheries. Other important species that allow this region to claim almost 50% of U.S. seafood landings include golden king crab, Tanner crab, scallops, Dungeness crab, pacific cod, sablefish, Pacific salmon, and Pacific herring and several flatfish species including halibut. These fisheries provide vital, year-round economic opportunity for residents of extremely isolated communities (Sepez *et al.* 2007). The largest fishery for *groundfish* (those species living on, in, or near the bottom) has been rigorously studied and monitored for potential environmental impacts ranging from individual species take, to habitat destruction by fishing gear and disruption of trophic connections by harvesting apex predators or key forage species. Though managers believe long-term impacts are currently minimal a number of uncertainties exist around the cumulative effects of the industry relative to climate variation and change. Additionally, a number of ecological drivers and trophic connections of fisheries stocks remain poorly understood (Livingston *et al.* 2011).

Affected Priority Resources and Ecosystem Services: fishes, invertebrates/shellfish, seabirds, trophic function, coldwater corals, community sustainability, subsistence culture, and marine mammals.

Contaminants and Pollutants (Appendix D)

The Arctic acts as a "cold trap" and is a hemispheric sink for a number of pollutants and contaminants that are transported via prevailing atmospheric and oceanic currents from warmer, more densely populated regions of the globe. A number of these global transport pathways converge within, and travel through, the Aleutian Islands and Bering Sea bringing contaminants to the region ranging from harmful bio-accumulating heavy metals like mercury to persistent organic pollutants (AMAP 2011) as well as plastics and other marine debris (Morishige *et al.* 2007). The remoteness of this region has not spared it from local point sources of contaminants primarily from former military operations in the region. As a result, wildlife and people may be exposed to relatively high levels of contaminants from both distant and localized sources including a network for former military sites in the Aleutians. Though remediation efforts are designed to remove contamination from known point sources, questions remain about the effectiveness of these cleanup efforts. Exposure to contaminants from distant sources is likely to increase due to increased globalization and the effects may be compounded by climate change (AMAP 2011).

Affected Priority Resources and Ecosystem Services: subsistence culture, marine mammals, seabirds, fishes, and commercial fishing.

Invasive and Introduced Species (Appendix E)

The introduction, establishment and subsequent spread of invasive species potentially threaten to harm native flora and fauna, disrupt ecosystems, and cause significant socioeconomic damage. The severe consequences of introduced rats, foxes, cattle, and reindeer are of particular concern for terrestrial ecosystems in the ABSI region. Predation, competition, and habitat alteration by these non-indigenous species has impacted the abundance, diversity, and distributions of native species (Ebbert and Byrd 2002). Less is known about possible threats from aquatic invertebrates, bacteria, diseases or viruses inadvertently introduced by ships transiting the ABSI region that have potential to disrupt marine communities (AISWG 2010).

Similarly, invasive plant species have established themselves in locations near communities but little is known about their distribution or effects on native plant communities and wildlife habitats.

Affected Priority Resources and Ecosystem Services: Seabirds, terrestrial vegetation, commercial fisheries, subsistence culture and invertebrates/shellfish.

Marine Vessel Traffic (Appendix F)

Large commercial vessels currently use transportation routes through the Bering Sea and pose a variety of significant environmental risks to ABSI resources and services including contaminant spills, disturbance of marine mammals and seabird habitat, accidental invasive species introductions and direct mortalities resulting from collisions (AMSA 2009). In the North Pacific, a great circle route from the western United States to eastern Asia passes through Unimak Pass and the western Aleutian Islands (Halpren *et al.* 2008). It crosses the transit lanes and fishing grounds of the largest fisheries in North America, as well as the Alaska Maritime National Wildlife Refuge, home to 40 million seabirds and numerous marine mammals. As many as 9-12 vessels per day use this route through the Aleutian Archipelago at Unimak Pass, with many continuing on and passing west of Tanaga Island (MXAK 2009). A second great circle companion route passes south of the Aleutians and is generally used for voyages from East Asia to North America. Assuming trade continues to expand between Asian markets and the U.S., traffic will likely increase in coming years. In addition to these historically well-travelled routes, 2012 traffic along the Northern Sea Route through the Bering Strait was 0.6-0.7 vessels per day (MXAK 2012) and will likely increase as transpolar routes become more accessible due to reduced summer sea ice in the Arctic Ocean (AMSA 2009).

Affected Priority Resources & Ecosystem Services: marine mammals, seabirds, invertebrates/shellfish, fishes, commercial fishing and subsistence culture.

Ocean Acidification (Appendix G)

A decrease in ocean pH of approximately 0.3 is predicted by the year 2100 which will result in more acidic marine waters across the globe. This phenomenon is the result of oceans absorbing carbon dioxide released from anthropogenic sources following industrialization (IPCC 2007). Increased acidity has already been documented in the Arctic and the Bering Sea (Mathis *et al.* 2012) and is of special concern to Alaska due to prevalence of cold marine waters, oceanic circulation patterns (Feely *et al.*2008) and rapid climate changes resulting in more inputs of freshwater (Fabry *et al.* 2009, Yamamoto *et al.* 2012). Increased acidity impacts the ability of marine calcifiers, such as plankton, corals and shellfish, to make shells and skeletons. This occurs as a result of increased dissolution rates for two carbonate compounds, aragonite and calcite, which are needed to produce calcified shells and plates. There are direct implications for commercial and subsistence fisheries targeting these species groups which could further affect fish, and possibly marine mammals, and seabirds through reduced abundance of calcareous plankton at the base of the food web (e.g., Ainsworth *et al.* 2011). Ocean acidification is a poorly understood phenomenon and research identifying specific effects to species and taxanomic groups is still in its infancy.

Affected Priority Resources and Ecosystem Services: commercial and subsistence fisheries, invertebrates/shellfish, coldwater corals, fishes, marine mammals, and seabirds.

Threat Assessment and Partnership Community Review

Six Steering Committee members and two LCC core staff participated in an initial assessment of priority needs by completing online surveys for each landscape-scale stressor. Evaluations drew on the professional experience of each reviewer as well as the information presented in the stressor synthesis papers (Appendices B-G). The eight respondents used ordinal scores to rank the relative threat of the interaction of each stressor on natural and cultural resource and ecosystem service categories as follows:

Natural and Cultural Resource Scores

0 - None: No reasonably foreseeable effects.

1 - Possible: Suspected or potential localized effects impacting species or resources of conservation or management concern.

2 - Moderate: Demonstrated or potential broad scale effects impacting species or resources of conservation or management concern.

3 - High: Demonstrated broad scale effects on many taxa OR potential population level impacts to key species of conservation or management concern.

Ecosystem Services Scores

0 - None: No reasonably foreseeable effects on ecosystem linkages.

1 - Possible: Suspected or potential effects on ecosystem linkages.

2 - Moderate: Demonstrated effects on some key ecosystem linkages.

3 - High: Known widespread effects to many key ecosystem linkages that will result in negative impacts.

Average scores were computed for each interaction between stressor and resource or ecosystem service. A quartile classification was applied to the range of values to delineate four threat categories across an overall *threat matrix* (Table 2). Generally the Steering Committee's initial evaluation was that interactions in the red and orange categories, high and moderate, respectively, could become higher priority science areas for the ABSI LCC.

At the outset of our planning efforts the Steering Committee and core staff recognized the importance of engaging with experts including regional managers, stakeholders and leading scientists. The depth and breadth of research expertise as well as local and traditional ecological knowledge about the region were imperative to incorporate into our process of assessing threats and establishing investment priorities. Engagement with this *partnership community* is central to ensuring that our investments are relevant and will be embraced by regional managers and stakeholders. Further, by identifying key information needs of interest to many, the ABSI LCC is in a better position to facilitate collaborative conservation efforts. To gather these insights, we

organized two forums to support our planning process including an interactive workshop at the 2013 Alaska Marine Science Symposium in Anchorage and an online survey tool hosted through the ABSI LCC website.

Manager and Stakeholder Workshop

On January 25, 2013, the ABSI LCC hosted a workshop to present information about the development of this Strategic Science Plan for the region. The workshop, held in association with the Alaska Marine Science Symposium, was attended by over 50 participants with an interest in the conservation of natural and cultural resources in the ABSI region. This facilitated workshop was structured to solicit input from the participants on the initial threat assessment of the six landscape-scale stressors conducted by the Steering Committee and core staff. Participants were asked to identify critical management issues, their associated applied science needs, interested potential collaborators, and the best role for the ABSI LCC to advance the science related to each identified issue.

The rationale and results of the Steering Committee's initial assessment of potential priorities for investment was shared with workshop participants. The results in Table 2 were central to conveying preliminary threat assessments made by the Steering Committee and core staff. Some overarching perspectives of the Steering Committee were presented as follows: 1) in the case of commercial fishing and ocean acidification, considerable resources are already directed toward these stressors by others; 2) ocean acidification has significant uncertainty surrounding it and identifying applied research efforts to address unclear impacts would be problematic; 3) strategic investments in the areas of climate variability and change, marine shipping, invasive and introduced species, and contaminants and pollutants might be more appropriate for the ABSI LCC; and 4) climate change is a focus of all LCCs nationally and has profound interactions across *all* five of the other stressors being considered.

Workshop participants identified 18 potential management issues and associated information needs across the six landscape-scale stressors which are described in detail by Burn and Poe (2013). Some of the major themes that emerged during the workshop:

- Increased consideration of cultural resources and the perspectives of cultural resource specialists and stakeholders are needed.
- An effort should be made to share the LCC's strategic science planning process with community stakeholders and gain their insights on important science needs.
- Education/outreach that facilitates the sharing of scientific information broadly, including with stakeholders and communities in the region, should be a key activity for the LCC and could be accomplished in part by having local communities help with data collection and sharing.
- Investments in baseline data like the coastal mapping products from ShoreZone as well as those that synthesize existing data to power better models (e.g., current data for vessel and spill response as well as climate and community models) are useful for a number of managers.

There was broad agreement about the importance of understanding climate change and the potential impacts to natural and cultural resources in the ABSI region. The importance of education, especially about the prevention of invasive and introduced species, was recognized

Table 2. An Initial threat assessment for landscape-scale stressors relative to resources and ecosystem services completed by ABSI LCC Steering Committee and core staff.

Resource or Ecosystem Service	Climate Variability and Change	Commercial Fishing	Marine Shipping	Invasive and Introduced Species	Contaminants and Pollutants	Ocean Acidification
Seabirds	2.3	1.7	2.3	2.8	1.8	1.0
Marine Mammals	2.8	1.9	2.3	1.0	1.8	1.0
Fishes	2.1	2.1	1.6	1.4	1.5	1.3
Invertebrates/ Shellfish	2.1	1.7	1.3	1.6	1.4	2.0
Subsistence Culture	2.1	1.4	1.6	1.4	1.8	1.5
Commercial Fishing	1.6	2.0	1.7	1.1	1.1	1.3
Trophic Function	2.3	1.6	1.0	1.1	1.1	1.7
Human Community Sustainability	1.8	1.5	1.1	0.8	1.1	1.5
Coldwater Corals	1.6	2.0	0.8	0.7	0.6	1.7
Terrestrial Vegetation	1.9	0.1	0.1	1.8	0.9	0.0
Cultural Artifacts/Sites	1.5	0.5	0.8	0.6	0.8	0.0

Minimal: 0 - 0.75	Low: 0.76-1.5	Moderate: 1.51 - 2.25	High: 2.26 – 3.0

as a high priority need by workshop participants. Participants also noted that knowledge about ocean acidification will likely change substantially in the near future and that the ABSI LCC should revisit conclusions about its associated conservation threat, management issues and science needs in the near future.

Partnership Community Threat Assessment Survey

Beginning in March 2013 the staff of the ABSI LCC launched an online survey tool to collect input from researchers, managers, and stakeholders from the region. We advertised the survey broadly requesting submissions from: our ABSI LCC contact list (over 100 members); all individuals who attended our 2013 workshop; Alaska Native tribal and other local government representatives; the EPA's environmental coordinators in the region; and key research experts identified by our Steering Committee. In all instances recipients were encouraged to share the survey with their network of contacts to maximize response.

Respondents were asked to rank the conservation threats posed to 11 resources and ecosystem services by each landscape-level stressor in a process similar to that which generated Table 2. The average threat scores for each stressor by resource/service interaction were summarized and compared to those returned by the Steering Committee and core staff. We also requested narrative input similar to that asked of our 2013 workshop participants (i.e. key management issues and their associated science needs for each stressor). During the two-month survey period we received 20 responses. The majority of respondents identified themselves as federal employees (n=15) with two respondents each from university and tribal entities, and one from a non-governmental organization.

The concerns about conservation threats from stressors were similar to those identified by the Steering Committee and core staff for climate change and variation, commercial fishing, and invasive and introduced species (Table 3). Respondents from the partnership community had somewhat less overall concern for threats from marine vessel traffic. The greatest differences were observed for ocean acidification and contaminants and pollutants, respectively. In the case of these stressors, respondents evaluated them as being of greater threat to resources and ecosystems in the ABSI Region. Respondents submitted a number of narrative comments specific to the conservation threats management questions and information needs. These and other details about the survey effort are described in Appendix H.

Summary Considerations

The management issues and science needs identified during the January 2013 workshop were similar to those offered by with survey respondents. Understanding the interacting relationships among landscape-scale stressors was described in both forums as a key role that could be fulfilled by the ABSI LCC (e.g., how the biological availability of contaminants is changing as a result in changes in climate). The multiple vulnerabilities of cultural resource sites were identified as a key gap in our consideration of conservation threats. Workshop attendees and some survey respondents identified impacts from climate change and site degradation by introduced ungulates, compounded by the potential for looting.

Contaminants and pollutants, and ocean acidification, were thought to be of greater concern by the partner community than was indicated by the Steering Committee/core staff evaluation. This could be a result of the widespread impacts predicted of these stressors being poorly understood and thus interpreted as having greater potential conservation threat. As Steering Committee and core staff considered threats that would drive science priorities we placed

Table 3. Comparison of average threat ranks between the ABSI LCC Steering Committee and core staff (n =8) and partner community (n = 20) for landscape-scale environmental stressors in the ABSI LCC.

Stressor	Steering Committee	Survey Respondents	Difference
Climate Variability and Change	1.99	2.04	0.05
Commercial Fishing	1.51	1.61	0.10
Marine Vessel Traffic	1.31	1.16	-0.15
Invasive and Introduced Species	1.29	1.36	0.07
Contaminants and Pollutants	1.25	1.49	0.25
Ocean Acidification	1.18	1.59	0.41

relevance on investments that could: benefit multiple managers and stakeholders; leverage existing efforts *or* fill a unique niche in the region; and address an information need that would result in products useful in the near term. This simultaneous consideration of the context for evaluating conservation threats likely had some influence on our overall evaluations. For instance, we recognize ocean acidification to be a broad-based threat with cascading impacts similar to climate change. However, given the paucity of specific information about the threat and the number of organizations currently working on this issue, was difficult to envision new lines of inquiry that would result in science products to guide near term management decisions.

Similarly, though we understand that commercial fishing is a significant stressor within the ABSI region, when considering our focus we are sensitive to the mandates, jurisdictions and the substantial investments of other resource managers. For example, organizations like the North Pacific Fishery Management Council (NPFMC), NOAA, the North Pacific Research Board (NPRB), and the State of Alaska currently have lead roles in the management of commercial fisheries in the ABSI region. Recognizing the extent of these organizations' activities the Steering Committee made careful consideration about ABSI LCC investments relative to commercial fishing. Though commercial fishing has important potential threats, the Steering Committee felt that the ABSI LCC should only play a limited role with respect to science needs that support sustainable commercial fishing.

Science Focus

Our resulting science focus represents a year of Steering Committee and core staff deliberation over each landscape-scale stressor (Appendices B-G) summarized in part by our initial threat assessment (Table 2). It was further informed by two engagement and consultation forums with researchers and managers –first in the January 2013 workshop (Burn and Poe 2013) and then via online survey (Appendix H). In addition to evaluating information shared in those efforts we also considered ways that LCC investments would:

- Inform understanding of risk and identify appropriate adaptation to multiple and interacting stressors.
- Result in applied products that many managers can use to the benefit of multiple resources and ecosystem services.
- Leverage the science investments of other conservation organizations already working in the ABSI region –and not duplicate or conflict with existing efforts of others.
- Result in the two-way exchanges of information between scientists/managers and community stakeholders.

Given that our engagement efforts identified a wide array of science needs with clear benefits to management, a tightly focused agenda of prioritized investments seems unwarranted at this time. Rather, it's possible for the ABSI LCC to make substantial contributions to managers and stakeholders in the region without initially restricting our focus. Further, as a new entity we aim to maintain flexibility to collaborate with a diverse conservation community composed of dozens of research, management, and community organizations. As the risks associated with these six landscape-scale stressors become better defined and our relationship to the existing conservation community becomes clearer, we may establish a more explicit science agenda. For the purposes of this science plan we instead are adopting a generalized ranking system defining each stressor as *primary, secondary, or tertiary*. Our investments, including staff time and project funding, will generally parallel these categories of priority with our initial focus on science needs relative to primary and secondary stressors.

The rationale for the Steering Committee's assessments of priority is offered for each of the six landscape-scale stressors. Where further focus of investments is justified, based on our analyses and engagement efforts, those refinements are shared as well. Specific examples of information needs with obvious benefits toward understanding each stressor are also presented. These examples are not intended to be comprehensive in nature but rather aim to convey the types of management questions and projects of likely interest to the ABSI LCC.

Primary Focus: Climate Variability and Change

The ABSI region is one of demonstrated climate change effects and relatively recent, rapid climate regime shifts. A clear driver in the system is changing sea ice and impacts relative to changes in trophic function, storm patterns, and coastal erosion. Further, this stressor has documented interactions with all of the others considered in this plan. These interactions and changing conditions are expected to affect the sustainability of many resources as well as human communities that depend on access to subsistence activities and sustainable commercial fisheries. Our initial assessment is that climate change and variation affects *all* resources categories and ecosystem services. Further, climate variability and change is the only

landscape-scale stressor specifically identified by name in the ABSI LCC mission statement and is considered a focus of all 22 LCCs across the country.

This stressor will be of primary interest for future investments of the ABSI LCC. Our initial efforts will have a dual focus of: 1) understanding how climate change will affect key marine mammal, seabird and fish species and regional food webs; and 2) understanding the socioeconomic risks faced by regional communities. Potential management questions and collaborations may focus on any number of the following:

- Identify focal species for studies of effects of warming conditions using life cycle models leading to population and community level analyses.
- Review of temporal and spatial structure of existing regional monitoring networks to evaluate their utility to monitor trends and effects of climate change and variation.
- Climate change effects on island biogeography to determine how climate and other landscape processes may influence species distribution, abundance and population structure for fish, wildlife and plants.
- The vast and complex BEST/BSIERP program is producing final results in 2014 and efforts should be made to share results with ABSI region managers and stakeholders as well as explore potential steps toward integrating these results into impact analyses for our key resources and ecosystem services.

Secondary Focus: Marine Vessel Traffic

There is increasing traffic and longer seasons of operation on sea routes for commercial shipping through the Aleutian Islands and Bering Strait. In addition to vessels that transit through the region, there is also a large and active fishing fleet that operates in the ABSI region. Marine vessel traffic carries the potential risk of oil spills and invasive species introductions which are likely the greatest threats with expected impacts at the landscape level. Localized disturbance impacts to marine species (e.g., noise effects) at key wildlife migration corridors like the Bering Strait may also have affects that scale up to landscape-level impacts for species and subsistence communities.

Our initial investments for this stressor will be aimed at understanding and addressing vulnerabilities associated with oil spills and invasive species introductions. Connections between these risks and expected changes in shipping patterns associated with climate variation and change (e.g., increased traffic and longer seasons of operation with decreased ice) will be of particular interest. Potential management questions and collaborations may focus on some of the following:

- Develop explicit characterizations of vessel transit pathways and seasonality of traffic based on available data to assess the vulnerabilities of priority resources like seabirds and marine mammals as well as areas of commercial fishing and subsistence harvest activities.
- Conduct a spatial and seasonally explicit travel simulation of commercial shipping traffic along the Northern Great Circle Route and through the Bering Strait to examine the relative risk of spills over a 20+ year horizon. A scenario-based approach could be

used to look at a variety of simulated scenarios of vessel types as and traffic intensities. And ideally be integrated with oceanographic data to inform oil dispersal models and cleanup/vessel response times to quantify risk parameters for marine mammals and seabirds as well as high value commercial fishing and subsistence resource areas.

- Support efforts to collect/update shoreline data useful for oil spill response such as Shorezone and Environmental Sensitivity Index layers.

Secondary Focus: Invasive and Introduced Species

A substantial amount of work on invasive and introduced terrestrial species has been done by the Alaska Maritime National Wildlife Refuge (AMNWR) to address the impacts of introduced predators (such as rats and foxes) including prevention, inventory and eradication. These efforts continue as introduced and invasive species remain a threat to seabird colonies and other components of island ecosystems. Introduced ungulates are also known to have effects on upland and coastal habitats as well as cultural resource sites. The potential for introduction of invasive marine species and terrestrial plant species is not well understood though introductions are expected to increase with further development in the region including increased vessel traffic. Climate change and variation resulting in milder seasonal climates may enhance the suitability of the region for colonization by invasive and introduced species, both aquatic and terrestrial.

Our initial investments for this stressor will be aimed at understanding the increasing risk of invasions associated with marine shipping as well as climate variability and change. Our science approach will include increasing local community capacity for prevention and early detection. Potential management questions and collaborations may focus on some of the following:

- Complete a data review and summary of the occurrence and likely sources of invasive animal species within ABSI. This summary could be paired with an evaluation that considers distribution, dispersal capability, ecological impacts, and feasibility of control to assess the relative risk of potential invasive species within the ABSI region. An analysis for ABSI would include a spatially explicit evaluation of major transmission vectors from marine ballast water and coastwise fishing fleet as well as international traffic.

- Compile a comprehensive geospatial database of what is known about introduced and invasive species to help prioritize future work on this stressor. The Alaska Natural Heritage Program is interested in establishing a statewide database that would allow community stakeholders to track invasive animal infestations and treatment actions which may be a partnership opportunity for the ABSI LCC.

- Complete a data review and summary of the invasive plant species occurrence, likely vectors for invasion, invasiveness risk and for those determined to be of greatest threat develop early detection and prevention tools.

Secondary Focus: Contaminants and Pollutants

Contaminants and pollutants enter the ecosystem of the ABSI region by a number of different pathways including global transport in the atmosphere and marine waters; “bio- transport” by migratory species; and from a network of former military sites distributed throughout the Aleutians. The availability of these contaminants in the ecosystem has a number of interactions with climate change and variation. This stressor also includes marine debris which poses well-

documented physical, and emerging toxicological, hazards to wildlife. Contaminants impacts are observed through bio-accumulation for top-level predators like marine mammals, fishes and seabirds where it can be passed on to human communities through subsistence lifestyles. This trophic cascade of contaminants is of key concern for our partnership community, members of which reinforced the need to understand effects and pathways of exposure.

This stressor would be a secondary focus with initial investments aimed at understanding increasing risk of biologically-available pollutants and contaminants relative to expected effects of climate change and variation. Given the topical complexity, specialized nature of environmental contaminants, and emerging connections to climate change, our initial investment will include establishing and supporting a Technical Working Group of contaminants specialists. This working group will advise the Steering Committee on priority management questions and science needs relative to this stressor which will be pursued as part of this science plan. Early management questions and collaborations may focus on some of the following:

- Collaborate or leverage regional synthesis efforts to understand transportation pathways and deposition rates for contaminants that include predictions about variation in those rates relative to climate change with a focus on providing insights into exposure of key species and human communities.
- Synthesize information about contaminants cycling that incorporates expected changes in meteorologic, hydrologic, oceanographic, and biogeochemical cycling resulting from climate change and/or ocean acidification.
- Leverage ABSI region community efforts aimed at monitoring the contaminants present in subsistence foods within the region and connect those efforts to larger scale contaminants monitoring of key species in the region.

Tertiary Focus: Commercial Fishing

Commercial fishing is a vital economic engine within the ABSI region and more broadly within the State of Alaska, the Pacific Northwest, and the nation. Given its significance, fisheries management for the Bering Sea and Aleutian Islands has complex jurisdictional considerations. Organizations such as NPFMC, NPRB and the State of Alaska currently make significant investments in research and management aimed at providing for sustainable fisheries in the region. Recognizing the extent of these activities, the ABSI LCC is organizationally better suited to a supporting role with respect to investments related to commercial fishing as an environmental stressor.

Where this stressor intersects others of primary and secondary focus, we will look for strategic opportunities to collaborate with institutions and agencies leading efforts on research and management of fisheries. Some management questions and collaborations that connect to stressors of primary and secondary concern include:

- The risk posed by potential introduction of invasive species, either through rat spills, or as marine species has not been quantified. This information could be critical to preventing transport by a fishing fleet that includes vessels making regular transits

and calling on ports throughout the Pacific Northwest where marine invasives possibly suited to the ABSI region have been well-documented.

- Identification or development of socio-economic indicators of community sustainability that can be incorporated into ongoing ecosystem assessments in the region.
- Improvements in understanding both the nature and direction of future climate variability and effects on biota critical to the trophic functions like small pelagics including mytcophids and squids supporting the region's commercial fisheries.

Tertiary Focus: Ocean Acidification

Ocean acidification is currently a poorly understood threat that may have cascading effects up through food webs potentially impacting numerous natural resources and ecosystem services within the ABSI region. Effects are thought to be especially acute within North Pacific and Arctic marine waters. This stressor also has a number of expected complex interactions with climate variability and change. Our Steering Committee's evaluation found that this stressor is less well understood and specific impacts are difficult to predict. Therefore investments that result in applied science products are less clear at this point when compared to the other stressors under consideration. Further, there are a number of organizations working on understanding this issue, currently led by NOAA nationally and in Alaska by the Alaska Fisheries Science Center as well as the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks.

Though substantial concern was expressed by the partnership community, ocean acidification will initially be a tertiary focus for the ABSI LCC. As specific management implications become more clear this will likely change and we will look for strategic opportunities to collaborate with institutions and agencies leading efforts on research on this stressor. At the present time our investments will be limited to increasing our own understanding of the issue as well as serving a role of transferring emerging knowledge to the region's managers and stakeholders.

Next Steps - Integrating Science Products

Many of these early efforts by the ABSI LCC discussed above focus on producing spatially and temporally explicit risk and vulnerability assessments associated with our primary and secondary stressors. We expect a suite of products that will help rigorously define the: *where, when, and magnitude* of risk –and in so doing identify which species, sites, and ecosystem linkages are most at risk. A key aspect of these efforts will be to better understand interactions between stressors that may have compounding impacts. This type of integrated vulnerability assessment will be a unifying science objective for our LCC and will set stage for further science investments. As with the development of our science focus in this plan, we will again facilitate broad engagement from the ABSI region over the results of early science products. By conducting these deliberations together, we ensure that further refinement our science focus continues to serve the needs of many managers and stakeholders.

Evaluating Success and Adaptation

It is critical that information generated through our investments in projects and collaborative relationships is used by a diversity of managers and stakeholders to improve the management of priority resources and ecosystem service. Understanding *if,* and *how*, managers benefit from our collaborations, data products and management tools is a complicated but essential endeavor. The national network of 22 LCCs has developed an accounting system to track the performance of LCCs. Some performance elements in this system aim to promote continuous improvement of LCC function by tracking information and conservation delivery –i.e., products, technologies, and tools are being delivered effectively and used to improve management.

Borrowing from this approach, we propose a set of simple internal tracking efforts to evaluate the effectiveness of this science planning strategy. We will attempt to pilot a suite of indicators in a two-tier system where Tier I indicators track conservation delivery (i.e., the science translates into management) and capacity development, and Tier II indicators track the effectiveness of information delivery by the ABSI LCC. They are as follows:

Tier I. Conservation delivery and capacity development

- The number of management initiatives or plans that are informed by datasets, tools or information forums generated through ABSI LCC investments in projects or collaborations.
- The amount of in-kind support and direct financial support we are able to leverage from partners toward investments in ABSI LCC science priorities.
- The number and approximate value of collaborative endeavors launched based on grants received that address ABSI LCC priorities.
- Numbers of individual conservation partners engaged in cooperative projects with the ABSI LCC.

Tier II. Informing information delivery

- The cumulative annual activity of managers and stakeholders using the ABSI LCC website.
- Numbers of downloads of datasets produced by ABSI LCC and hosted on our website or by third party sites.
- Numbers of participants in forums, webinars, workshops, and conferences sponsored by ABSI LCC that deliberate over our science products and activities.
- Numbers of presentations at conferences of regional stakeholders and managers that feature products and tools produced by the LCC.
- Numbers of presentations at professional conferences or scientific societies that feature research results from projects sponsored by the LCC.

Where possible results will be tabulated relative to the stressors, resources and ecosystem services such that the ABSI LCC can evaluate progress of its specific investments in these topics.

Pending feasibility, these pilot indicators will be evaluated annually through consultation with a combination of Steering Committee members, project Principal Investigators, the ABSI LCC Partnership Community, as well as Alaska Native Tribal entities and community governments within the region. They will also be tracked through careful record keeping by ABSI LCC staff as well as usage queries for websites hosting our data products and information. Results will be evaluated by the Steering Committee and core staff annually and documented in annual reports. The results will inform the development of annual Implementation Plans as well as subsequent revisions to this Science Plan.

It is equally important that new information about landscape-scale stressors, vulnerabilities of priority resources, and emerging threats is incorporated into our ongoing planning efforts. Similarly, there is a need for the ABSI LCC to constantly be looking outward for new information and opportunities for partnership that further our science objectives. There are a number of sources of information, data, and knowledge key to the continued adaptation of our science planning efforts. These are documented for each stressor in Appendices B-G and a few of the most prominent include:

The Alaska Ocean Observing System (AOOS) is a consortium of federal and state government agencies and industry affiliated with a national program of Integrated Ocean Observation System which aims to obtain, synthesize and rapidly disseminate key coastal and ocean data. In Alaska they host the Arctic Assets portal that provides a variety of climate information and also hosts a number of real time weather and ocean sensors. They also synthesize data inputs and serve back spatial data, including sea ice distribution derived from satellite data collected by the National Snow and Ice Data Center.

The North Pacific Research Board has an annual multi-million dollar investment in research in Alaska marine waters. Their efforts, many of which focus on fisheries-related issues, range from individual species investigations to integrated ecosystem synthesis efforts. They also have a practice of partnering with other organizations around joint-RFPs aimed at issues of mutual concern. Recently NPRB partnered with the National Science Foundation to launch a research consortium conducting a comprehensive, $52 million study of the eastern Bering Sea ecosystem from 2007–2012. The effort included more than one hundred federal, state, university, and private institution scientists studying a range of issues, from atmospheric forcing and physical oceanography to humans and communities and associated economic and social impacts of a changing ecosystem. They also convene the largest annual marine conference in Alaska where hundreds of presenters share results of work germane to the ABSI Region.

Other Landscape Conservation Cooperatives: The ABSI LCC borders the Western Alaska LCC (extending from Kotzebue Sound south to the Alaska Peninsula and includes Kodiak Island) and has an overall focus on climate change. The profound effects that changes in the Bering Sea and Gulf of Alaska have on this LCC give them common cause with a number of ABSI LCC interests. For example in 2012 they launched an effort assessing hazards for communities of western Alaska from coastal erosion and flooding. Other Alaskan LCCs have some overlapping interests in protecting subsistence culture and concerns about exposure to contaminants. Collectively the Alaska-based LCCs have also launched efforts to gather statewide datasets that have potential utility to managers within the ABSI region. Perhaps of greatest importance is the connection that all LCCs have to the national LCC network which serves as a clearinghouse for information, data and models that support landscape level analyses and a community of individuals using collaborative research techniques and tools.

Traditional Ecological Knowledge: Other LCCs, most notably the North Pacific LCC (extending from northern California to the eastern Kenai Peninsula) have recognized the contributions that Traditional Ecological Knowledge (TEK) makes toward addressing landscape-level stressors. The ABSI LCC is similarly interested in working with the communities and tribes of our region to incorporate TEK into the adaptation of our science planning efforts. Our intent for incorporating this information is the same as that for scientific information: to maximize the ability of managers and stakeholders to make informed decisions about priority natural and cultural resources affected by stressors. However, we recognize that special caution needs to be applied so that incorporation of this knowledge is done in a culturally appropriate way that is sensitive to the intellectual property rights of ABSI communities.

Communication and Outreach

Significant effort will be made to communicate to researchers, managers, and stakeholders about the applied science endeavors and resulting products sponsored by the ABSI LCC. These communications have a dual focus of ensuring greater awareness about the availability of data products and tools, as well as broadly publicizing our science focus with the intent of developing conservation collaborations and fostering integrated science.

An important insight gained from our engagement efforts with managers and stakeholders was the need for increased communication about the science underway in the ABSI region. It was impressed upon us that spatial datasets and models are often produced and published with results that are not shared in a form useful to regional managers and stakeholders. Our intent is that efforts sponsored by the ABSI LCC not suffer this same fate. Prominent research organizations such as the NSF and NPRB require a significant investment in communication of project results that is focused on managers and stakeholders as a key element of any proposals submitted for funding. The ABSI LCC will adopt a similar approach such that our sponsored collaborators will have to demonstrate a commitment to science communication. Similarly, we will look for opportunities to serve or republish existing key datasets that support science priorities of the ABSI LCC in formats useful to regional managers and stakeholders.

Direct, one-on-one communication will also be an important component of ABSI LCC communications. A key venue for this type of information exchange is the Alaska Marine Science Symposium held every January in Anchorage which attracts hundreds of researchers and managers. Similarly, the Alaska Forum on the Environment held every February in Anchorage attracts hundreds of managers, community stakeholders and industry specialists. The ABSI LCC will encourage principal investigators of sponsored projects to present results of their work at one or both of these venues. Further, the ABSI LCC maintains a policy of open Steering Committee meetings which can be attended virtually or in person under prior arrangement with LCC core staff.

Beyond researchers and managers, we expect that communities and industries within the region to be rich potential audiences for our science products. The continued development of our partnership community, website, and social media platforms will be a conduit for reaching some of these audiences that are not often reached by scientists and managers. Efforts in this arena may also be essential to establishing an exchange of TEK and local knowledge that can better inform scientific endeavors. It is our hope that these investments in alternative communication will also allow for the development of effective citizen science programs that monitor and detect changes near communities within the ABSI region.

Data and Information Sharing

Data sharing is an essential component of rapid response as managers attempt to adapt management strategies to landscape-scale environmental stressors. Nationwide all LCCs are committed to acquisition, synthesis, and distribution of information needed by managers, stakeholders and researchers. The ABSI LCC is in the process of establishing a data sharing policy that will likely be similar to those of other Alaska LCCs.

Data products will be published with supporting metadata that meet standards established by the Alaska Data Integration Working Group (or "ADIwg") such that our products will integrate with other data being produced by Alaska's leading environmental research organizations and agencies. We intend to use platform(s) for dissemination of data that emphasize ease of access and maximum utility for broad audiences while allowing for controlled access to certain sensitive datasets (e.g., cultural resource sites). By using existing platforms we intend to capitalize on the investments of other organizations that have already attracted audiences of ABSI region managers and stakeholders and have the capacity to host and maintain complex spatial datasets, model simulations and data visualizations.

An example platform with these capabilities is Arctic Environmental Response Management Application, or Arctic ERMA which is an online tool developed to aid in response to oil spills by serving up spatial data layers through an web browser interface. It is managed by the NOAA Office of Response and Restoration as a user-friendly, interactive map-based tool which includes numerous geospatial data layers. Other platforms such as the Arctic Assets portal managed by AOOS or the Geographic Network of Alaska (GINA) may be used as well. Datasets may also be cross-posted in an effort to reach a maximum number of audiences in formats and on platforms used by different communities of researchers, managers and stakeholders.

Other products including literature libraries, final project reports, recorded webinars and presentations will be hosted on the ABSI LCC website. In this environment these products are available for cataloguing by internet search engines. Staff from the ABSI LCC will make an effort to optimize the detectability so that interested parties can be connected to our research and data products via a simple online search. Links from data serving platform sites back to our website will also drive audiences from established sites to ours and vice versa, creating greater awareness of ABSI LCC data products and research endeavors.

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Appendix A. List of existing research and resource management plans relevant to ABSI region.

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