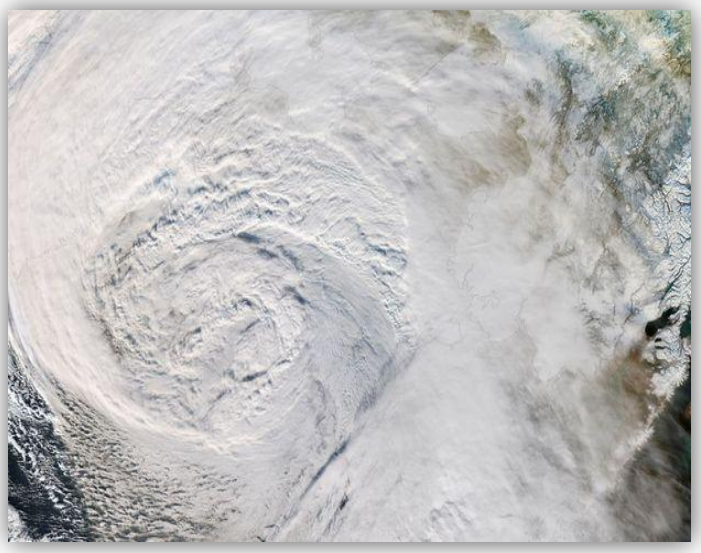
Western Alaska Landscape Conservation Cooperative



In 2012 the cooperative focused on addressing science needs related to changes in coastal storms and their impacts on landscapes, wildlife, and the people who live in western Alaska coastal communities.

2012 Annual Report

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Dear Friends and Colleagues,

Sue Rodman; Western Alaska LCC Chair FY13

After another very productive year for the Western Alaska Landscape Conservation Cooperative (Western Alaska LCC or "the LCC"), we invite you to peruse the accomplishments of 2012. After building our foundation in 2011 and funding several important projects, we continued our momentum with a suite of activities that engaged many people working and living in western Alaska.

While you will find the details of our work within this report, I would like to highlight the concerted effort undertaken by the coordinators and agency partners of this LCC. In hosting the two workshops, *Coastal Hazards* and *Stream and Lake Temperature Monitoring*, the scientists and managers gathered to discuss the science needs and issues in western Alaska demonstrated a confluence of high caliber experts who are dedicating their careers to the natural and cultural resources of the region. In their work lies the connection between the known processes and interactions of our communities and natural resources with the unknowns that lie ahead.

A changing climate forecasts increasing frequency of storms to the coast, increased temperatures, changes in the precipitation and hydrologic regimes and other environmental changes that are likely to impact the fish, wildlife, water and cultural resources upon which people have sustained their lives for centuries. Although change has happened in the past, and people and animals have adapted, the changes to come may be unprecedented in their intensity.

Embarking in climate change research that is relevant to the region's science needs provides information to managers as they examine impacts to resources and must decide how to respond and plan for the future. The Western Alaska LCC provides this forum for discussion, research and applying new information to our changing environment. The gracious contributions from the agencies and

tribal organizations to this forum demonstrate their dedication to find solutions through the combined effort of the LCC partnership.

Through the direction of the steering committee, the LCC coordinators have delivered high quality reports and issued meaningful Requests for Proposals. All of these professionals contribute significant effort and consideration toward achieving the mission of the Western Alaska LCC. It is my honor to serve as a member of this LCC. I believe the results of our combined contributions will support the communities and natural resource managers with meaningful information as we face the frontier of a changing climate.

Sincerely,

Sue Rodman

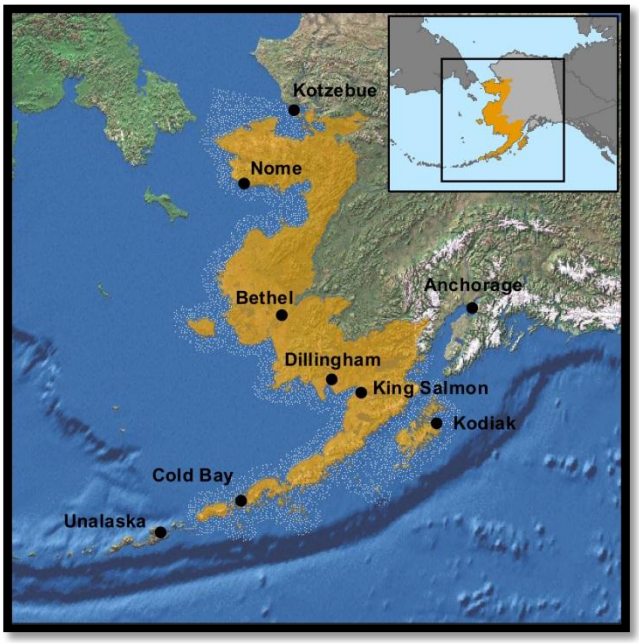
Chair, Western Alaska LCC
Alaska Department of Fish & Game

I. Introduction

We are pleased to release the second annual report for the Western Alaska Landscape Conservation Cooperative (LCC). The year 2012 was the second funding year and a year of great progress. This annual report describes some of the major milestones for the Western Alaska LCC as it has moved from its formative days into a functioning cooperative. Some of the year's highlights include:

- Completion of the Shared Science Needs Workshop report which sets the stage for focusing the LCC's activities.
- Adoption of a unique approach amongst the LCC Network to focus the LCC activities where they can contribute the most to the shared needs of the partnership.
- Completion of a Science and Operating Plan to provide detailed guidance and timelines for the FY12 and FY13 years.
- Launching the Coastal Processes Pilot Program in a manner that brought a diverse group of stakeholders together to identify the focus topic *Changes in Coastal Storms and their Impacts* and define the elements within this topic that represent information needs to support improved management and understanding along the coast.
- Funding a suite of integrated projects that demonstrate the connections between oceanographic systems, through biological systems, all the way to human systems with community observer programs and vulnerability assessments.
- Completion of an intensive outreach effort to the 116 Tribal Councils within the Western Alaska LCC geography.
- Co-hosting a collaborative Coastal Hazards Workshop where participants identified the key science/knowledge gaps that need to be addressed to increase the ability of diverse stakeholders to manage the impacts from changes in coastal processes.
- Co-hosting a collaborative workshop on Stream and Lake Temperature Monitoring where participants identified the steps needed to design a monitoring network across Alaska that would inform predictive models of how water temperature (and thus fish habitat) may change with changing climate.
- Continued collaboration and management on projects funded in 2011 with the completion of our first major project that was led by The Wilderness Society to assess thaw-refreeze patterns in Alaska.

II. A Brief History



Since its beginning in late 2010, the Western Alaska LCC has been identifying and addressing science needs shared by decision makers from across the partnership. The Western Alaska LCC is a self-directed partnership governed by a Steering Committee of Federal and State agencies and individuals who represent Alaskan Native Tribal Perspectives (see our charter on the website). We are also one of 22 LCCs in North America which form an LCC Network with the overarching vision of "Landscapes capable of sustaining natural and cultural resources for current and future generations." [1] We work closely with the Alaska Climate Science Center to understand state-wide climate changes and its local effects in western Alaska.

The landscapes of western Alaska are a diverse and dynamic mix of wetlands, volcanoes, tundra and forests, making the region a hot spot for biodiversity in Alaska. This complex mix includes arctic tundra with permafrost-dominated processes adjacent to areas that have no permafrost which are dominated by volcanic, river or wetland processes. The region contains the continent's westerly extent of conifers, which are slowly expanding west and south onto the Alaska Peninsula. The whole region is very susceptible to the unprecedented rates of landscape change occurring as the climate changes. The effects of changes in western Alaska will be more rapid and potentially more drastic since winter temperatures are already closer to the freezing threshold (32°F). Ocean processes from the Chukchi and Bering Seas and the Pacific Ocean are important drivers for the coastal, terrestrial and freshwater systems of the LCC region. Over half of the nation's seafood comes from the Bering Sea and the terrestrial systems of the Western Alaska LCC are integral in the Bering Sea's productivity.

[1] The use of the term "sustaining" is not intended to imply maintenance of the status quo.

A. Our Mission and Goals

The mission of the Western Alaska LCC is to promote coordination, dissemination, and development of applied science to inform landscape level conservation, including terrestrial-marine linkages, in the face of landscape scale stressors, focusing on climate change.

The LCC has identified five goals to guide how we achieve our mission.

- Promote communications to enhance understanding regarding effects of climate change in Western Alaska,
- Support coordination and collaboration among partners to improve efficiencies in their common science and information activities,
- Identify and support research, and 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 western Alaska through applied science and technology transfer.

Our Governance documents (Charter; Mission, Goals and Guiding Principles; FY12-13 Science and Operating plan) can be found on our website[2]. It is important to emphasize that the LCC has no management authority. Rather, it strives to inform decision makers within the LCC's partnership as they make management decisions.

III. The Western Alaska LCC Partnership

A. A Broad Base

Landscape Conservation Cooperatives throughout the country are broad-partnerships that are not easily defined because they encompass more partners than those participating on Steering Committees or through projects. The Western Alaska LCC partnership is similarly diffuse with 12 entities represented on the Steering Committee but over 70 entities that have been involved in workshops, organizing groups, or through funded projects. In addition to these, many communities in Western Alaska have been involved in the LCC-sponsored projects that work with community observers or address vulnerability to invasive plants and other climate changes.

Breakout session at an LCC workshop

[2] http://www.arcus.org/western-alaska-lcc

B. Engaging with Alaskan Natives

Western Alaska is home to 116 Alaskan Native tribes who have a strong and enduring connection to the landscape. The LCC Steering Committee recognizes the importance of incorporating Alaskan Native perspectives throughout the structure of the LCC (from the Steering Committee to individual LCC-sponsored projects) both because of the important value that Traditional Knowledge and local expertise brings as well as the reality that Tribes, Regional Associations and Corporations all have an interest and role in landscape conservation. Bureau of Land Management loaned us a full time staff person to assist us in making direct contact with Tribal Councils in Western Alaska. From October 2011 through May 2012 we contacted all Tribal Councils and either discussed or mailed information about the LCC and participation opportunities. We typically started with the Administrative Officer for a Tribal Council and asked them to direct us to the person who would have the most interest on the Tribal Council. This was often the Administrative Officer or someone in an Environmental or Natural Resource position for the Council. The goals of this focused outreach were to ensure that all Tribal Councils:

1. were 'introduced' to the LCC and its mission;
2. had an opportunity to discuss the LCC goals and activities;
3. understood what opportunities existed for Tribal involvement in the LCC from the Steering Committee level through to individual project interaction or funding; and,
4. to provide the LCC with a contact within the Tribal Council.

Appendix A includes a sample of the letters and questions that were used to help stimulate discussion about engagement opportunities. Prior to his retirement in June 2012, our BLM staff person had made direct contact with approximately 100 of the 116 Tribal Councils. For those Tribal Councils that we were unable to verify that we had made direct contact we mailed letters via the US Postal Service to provide another means of contacting the Council.

Summary of Feedback. In general, most of the people who were contacted were pleased to learn about the LCC and its focus, especially in the context of bringing multiple agencies together to address climate change science needs. Only a few of the discussions led to presentations at Tribal Council meetings; of these, only one led to a request for participation on the LCC Steering Committee. The Steering Committee extended the offer to the identified contact to participate in the upcoming meetings as a guest while the outreach effort was completed. Unfortunately, repeated attempts to coordinate times and subsequent meeting opportunities failed.

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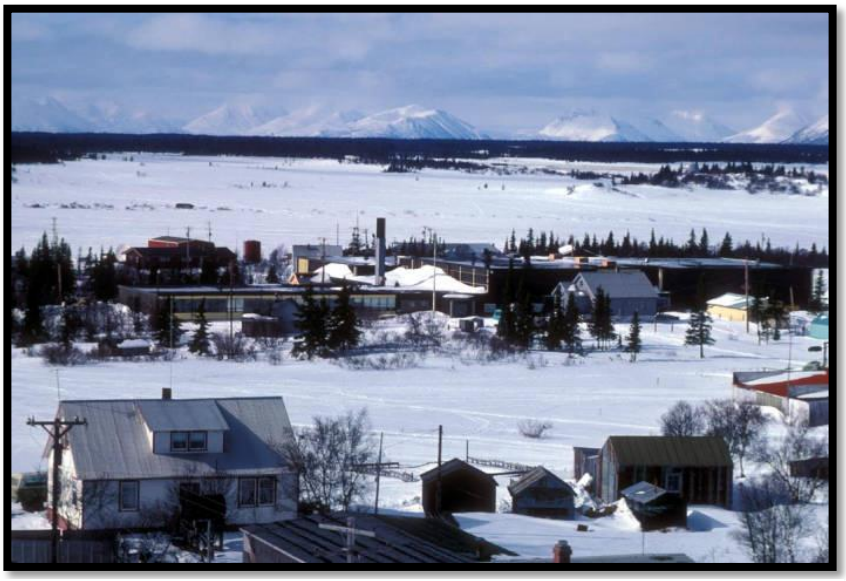
To ensure that Alaskan Native perspectives are represented on the LCC Steering Committee, our charter established Interim Steering Committee members from three of the five Regional Native Associations (Kawerak, Association of Village Council Presidents and Aleutian Pribilof Islands Association Inc.). These members have been invaluable in ensuring that the Steering Committee recognizes key linkages to Tribal and Community needs. Their involvement helped to identify where community observers could inform some of the modeling efforts underway in western Alaska and established the pattern of requiring community outreach for researchers. In 2013 the Steering Committee will implement a process to establish permanent Steering Committee seats to represent Alaskan Native perspectives.

IV. Identifying Shared Needs

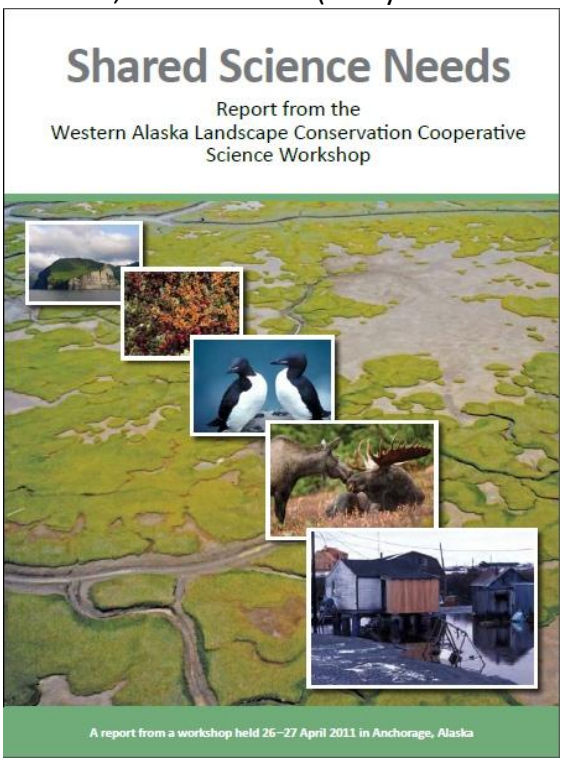
While the LCC was first funded in 2011, months earlier we had started visiting hub communities in western Alaska and planning a *science needs* workshop to help identify how the LCC could best help decision makers in the region. As a partnership, we discussed the types of land, resource and conservation decisions that were made by the different types of partners, and sought to identify where the commonalities in science needs existed. Eight broad categories of outcomes of management interest were identified as shared across the Western Alaska LCC partners. These included:

- Ecosystem Function
- Habitat Quality
- Population health (for individual species and species assemblages)
- Public Health and Safety
- Economic benefits
- Protection of culture
- Community stability
- Quality of outdoor experience.



Dillingham Alaska

Of these, the first three (Ecosystem function, Habitat Quality, and Population Health) are directly tied to the Western Alaska LCC's mission. However, it was also clear that there are often links to other outcome categories when action is taken to address the first three categories. These relationships were described in our 2011 report "Decision Analysis Framing and Structuring" for the Western Alaska LCC[3]. This work provided important guidance in the organization and implementation of a Shared Science Needs workshop (April 2011) where partners were brought together to discuss and identify the key climate change related science and knowledge needs in western Alaska and ways we might begin addressing them.



In 2012, a comprehensive report was completed to document the recommendations that were developed during the workshop. The 150 participants identified species, species assemblages and habitats that would be important from a climate change perspective in relation to the following initial criteria:

- Species of common management interest to WALCC partners,
- Species or assemblages needed to support species of common management interest,
- Species or assemblages anticipated to be most vulnerable to climate change, and
- Sentinel species or assemblages— i.e. those sensitive enough to climate-induced changes in ecosystems to provide early indications of pending negative effects on species of concern.

The participants were also asked to identify:

1) The most important management-relevant species or assemblages expected to change with climate and ecosystem change,
2) The geophysical process changes most important to the chosen species or assemblages, and
3) Information needed to meet future shared management objectives for the chosen species or assemblages.

[3] http://www.arcus.org/western-alaska-lcc/spring-workshop-2011/background-resources

As expected, there are tremendous science and information needs in western Alaska, which is a reflection of the limited suite of studies and instrumentation that has occurred in this region relative to other parts of Alaska or the country. Appendix B includes the Executive Summary from the Shared Science Needs workshop report. The full report can be found on our website at: http://www.arcus.org/western-alaska-lcc/spring-workshop-2011. Over 50 important species or species assemblages were identified along with ten vegetation communities or systems. Similarly, over 150 high priority science needs were identified which were winnowed down to 47 common needs.

Some clear recommendations were consistently raised by all breakout groups. The most important process change identified was *change in various aspects of the hydrologic cycle*, which included changes in water budget and seasonality; base flows; flood timing, frequency, and magnitude; or timing of snow melt. The two process changes that tied for next most important were *vegetation changes* (plant succession and distribution) and *changes in coastal processes* (inundation, erosion, salinization, and shore-fast ice dynamics). The six taxa groups unanimously identified three broad needs:

- Developing linkages among physical processes, ecological processes, and important species;
- Conducting data synthesis;
- Improving data management, long-term data care and archiving, access and sharing.

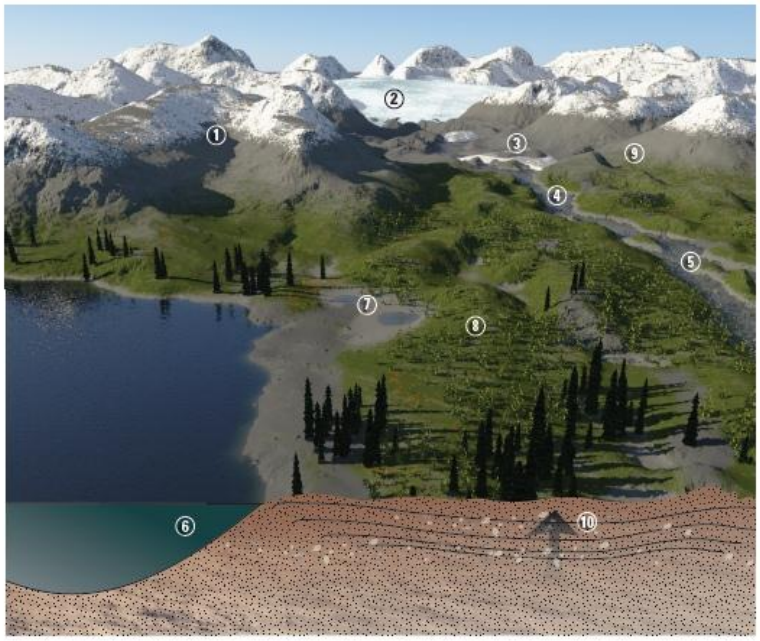


Figure 3.9. Conceptual model illustrating important ecological processes affecting changes in mountain landscapes with strong altitudinal zonation and large lakes. (Illustration by Torre Jorgenson and Russ Mitchell.)

Two additional needs were raised by five of the six groups:

- Maintaining and expanding hydrological data collection stations; and
- Conducting gap analyses to identify key data on important species and/or physical/climate parameters that is currently unavailable.

These results provided our LCC with the starting place to discuss and refine priorities. They have been fundamental in the planning and implementation of activities in 2012 and 2013 (see the FY12-13 Science and Operating plan discussion), and we will continue to refine these recommendations to guide decisions over the next several years.

V. Focusing our Actions

A. Science and Operating Plan for FY12 and FY13

The Science Workshop results provided a strong foundation for the LCC to build upon to guide its future work; however, the Western Alaska LCC Steering Committee recognizes that further prioritization of these science needs is required to enable the LCC to substantially contribute to these important topics. The Western Alaska LCC Steering Committee adopted a FY12-13 Science and Operating Plan to provide direction for the LCC. The plan describes the major scientific focus for these two years to be on a "Coastal Processes" Pilot Program, with a "mini" Pilot Program to advance state-wide discussions on Stream and Lake Temperature Monitoring as a component of broader "Hydrological Process" needs identified in the Science Workshop. These two pilot efforts are discussed in more detail in upcoming sections within this annual report. The plan also provides direction for broadening the LCC Partner Engagement with emphasis on outreach to Tribal Governments throughout western Alaska; engaging with neighboring LCCs, and the Alaska Climate Science Center. Finally, the plan describes the process and timeline for developing the Western Alaska LCC's Long-term Strategic Science Strategy which will guide the LCC over the next decade. The full operating plan is on our website at: http://www.arcus.org/western-alaska-lcc.

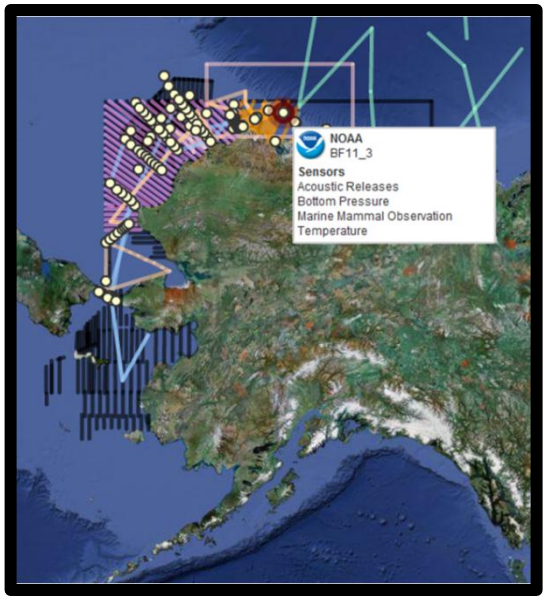
VI. Coastal Processes Pilot Program focuses on *"Changes in Coastal Storms and their Impacts".*

A. Organizing Committee Refines Program Focus

"Changes in Coastal Processes" is a broad topic for a region with three seas and the northern extent of the Pacific Ocean. To refine this theme into a manageable topic, the Steering Committee convened an organizing team of 21 scientists, managers and local experts familiar with the region and the topic to refine program objectives, and identify key components, strategies and opportunities for leveraging. The team discussed the many ways changes in climate may cause changes in the physical drivers of coastal processes (i.e., storms, sea level rise, nearshore ice, tides, freshwater hydrology inputs, etc.) and potentially impact subsistence and other coastal resources. Ultimately, the team recommended focusing on *Changes in Coastal Storms and their Impacts*. Large changes in coastal storm characteristics (frequency,

intensity etc.) are expected due to climate change[4]. Storms have a wide range of impacts on local, regional, and national decisions and there is limited coordination occurring across a wide range of stakeholders, providing real opportunities to promote partner engagement, leveraging, collaboration and synthesis.

Six areas of emphasis were recommended for the first year of the Program on *Changes in Coastal Storms and their Impacts*. The results from the first two activities described below were used to guide our work on the pilot program in 2013 the remaining four were the focus for the RFP announced in January 2012.

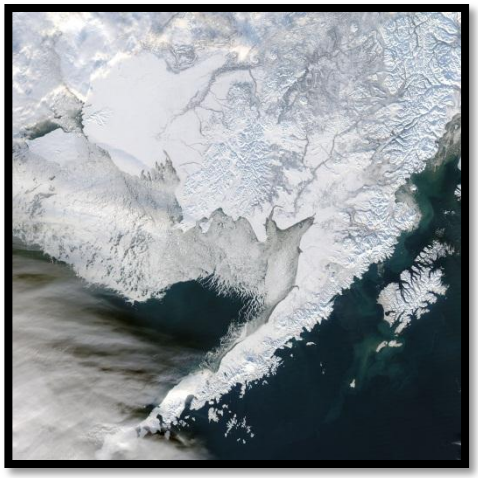


1. ***Inventorying Activities in Coastal Areas:*** A key step for the Coastal Pilot Program in 2012 was to document recent, on-going, and newly funded activities related to coastal processes data collection, assessment, research and instrumentation, as well as those activities which provide information about biological and human resource use along coastal regions of the Western Alaska LCC. This goal merged nicely with an already planned effort by the Alaska Ocean Observatory System (AOOS) to refresh their "Marine Assets" map in the Beaufort and Chukchi Seas and expand this map south along the western coast of Alaska. The results of this collaboration can be found at: http://data.aoos.org/maps/arctic_assets/.

2. ***Developing the Conceptual Basis for Future Work:*** Conceptual models are one of the fundamental tools used to identify data gaps and provide a focus for future activities and research. Conceptual models provide a framework for understanding how different components of a complex system are interconnected and can be used to highlight where the greatest uncertainties exist in our ability to understand these complex systems. Developing a conceptual model that describes coastal processes and how those processes interact with biological and terrestrial systems was an important step to help the LCC guide both the FY13 portion of the pilot program's focus on changes in coastal storms and their impacts, as well as other work related to coastal processes in the future. In partnership with AOOS and the Alaska Climate Science Center a combination of researchers, decision-makers and local experts familiar with coastal processes in western Alaska were brought together to develop a strong conceptual model (or models) for the LCC and provide recommendations for next steps related to coastal processes and their impacts.

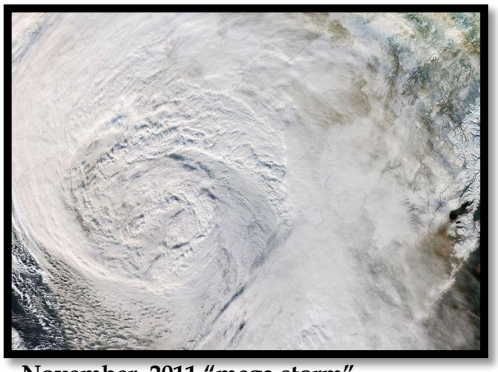
[4] http://ine.uaf.edu/accap/documents/2012-13_Winter_ClimateDispatch.pdf

3. ***Shorefast ice dynamics.*** Develop and apply methods to document shorefast ice characteristics and long-term dynamics. Of particular interest are ice timing, residency, extent and characteristics (i.e. from slush to solid). Ultimately, the WALCC is interested in synthesizing long-term shorefast ice dynamics and relating it to existing data on nearshore salinity, biological populations and ecological processes. Proposals that use readily available data (such as the National Ice Center "ice charts") or imagery (such as MODIS) were preferred.



4. ***Local involvement in monitoring coastal dynamics.*** Instrumentation to document changes in relative sea level, wave height, storm surge extent, shorefast ice dynamics and coastal erosion in western Alaska are extremely limited. However, residents of coastal communities across western Alaska observe these changes as they occur throughout the year, offering a potential source of baseline information for assessing storm effects. Successful proposals developed, tested, demonstrated, and/or expanded approaches that utilized the expertise of local residents to provide data for assessing or strengthening physical models of coastal processes.

5. ***Effects of changes in coastal storms on coastal biological resources (including subsistence resources and habitats).*** This was an open category where we entertained a wide range of ideas on the topic. Ultimately, the WALCC is interested in understanding the relationships between storms, habitat change, and biological resources. We expected three broad types of proposals in this category:



November 2011 "mega storm"

- synthesis or integration of existing data;
- data collection or methods development;
- physical modeling and vulnerability assessments of biological resources and their habitats.

The Alaska CSC also assisted in meeting the goals of

this category by sponsoring research using a targeted request for proposals (RFP). The Alaska CSC engaged coastal storm and/or coastal-erosion experts as a means to *a) assess the capabilities of existing storm/erosion models; b) assess needs related to input datasets; and c) develop a conceptual framework for how storm/erosion models might address key management and conservation issues*.

6. ***Opportunities to leverage deployment of instrumentation or data collection.*** We considered proposals for the purchase of instrumentation, or expansion of data collection efforts, for measuring parameters associated with coastal storms or their impacts *if the proposal* leveraged planned deployment/collection activities. For example, through proposing to expand the spatial coverage or increase the spatial density of an instrument deployment already funded by another entity or organization. Parameters of particular interest included relative sea level, wave height, tides, storm surge, nearshore bathymetry and topography, salinity, etc.

B. LCC sponsored projects in 2012

Western Alaska
Landscape Conservation Cooperative

2012 Collaborator Projects

In 2012, the Western Alaska Landscape Conservation Cooperative (LCC) sought projects addressing science needs related to *Changes in Coastal Storms and their Impacts*, a top priority for Western Alaska identified by resource managers, researchers, and local knowledge experts. Based on input from a partnership "organizing team" who recommended the focus for the *Changes in Coastal Storms and their Impacts* pilot program, the LCC solicited proposals related to shorefast ice dynamics, local involvement in monitoring coastal dynamics, effects of changes in coastal storms on coastal biological resources, and opportunities to leverage data collection. The LCC Steering Committee selected 10 projects from 28 proposals. The projects leverage existing efforts in western Alaska and address shared science needs. Collectively, they will produce both short term results and long term benefits to an array of stakeholders.

Two additional projects were developed in partnership with the Alaska Ocean Observatory System (AOOS) to address fundamental information needs for the *Changes in Coastal Storms and their Impacts* pilot program. First, AOOS has expanded an inventory of recent and current coastal processes and systems work in the Chukchi and Beaufort Seas to include the Western Alaska LCC geography. Next, the LCC, AOOS and the Alaska Climate Science Center (ACSC) are collaborating to host a conceptual modeling workshop to better define the relationships between coastal processes and impacts to help guide science efforts in the future.

In addition to the pilot program projects, the LCC Steering Committee agreed to continue its investment in the multi-year "Alaska Integrated Ecosystem Model" along with the ACSC and Arctic LCC. Following is a brief summary of each project, its principle investigators and collaborators. In all, 11 organizations/entities are involved as project leads or co-leads, and an additional 8 are participating as collaborators. The LCC invested $611,000 in the 10 coastal pilot projects in 2012. These projects collectively included $775,000 in leveraged (contributed) funding or support. An additional $50,000 was invested in the Alaska Integrated Ecosystem Model with leveraged costs of $500,000.

The Mission of the WALCC is to promote coordination, classification, and development of applied science to inform landscape level conservation, including terrestrial-marine linkages, in the face of landscape scale stressors, focusing on climate change.

As described above, the LCC solicited proposals related to shorefast ice dynamics, local involvement in monitoring coastal dynamics, effects of changes in coastal storms on coastal biological resources, and opportunities to leverage data collection. Although the LCC had reduced project funding available in 2012 compared to 2011, the LCC Steering Committee selected 10 projects from 28 proposals as part of the *Coastal Storms* pilot program (Figure 1). The projects leverage existing efforts in western Alaska and address shared science needs. Collectively, they will produce both short term results and long term benefits for an array of stakeholders including resource managers, community leaders, planners and researchers.

Appendix C includes a brief summary of each project, its principle investigators and collaborators. In all, 11 organizations/entities are involved as project leads or co-leads, and an additional nine are participating as collaborators. The LCC invested $611,000 in the 10 coastal pilot projects in 2012. These projects collectively included $775,000 in leveraged (contributed) funding or support. In addition to these 10 pilot program projects, the LCC Steering Committee agreed to continue its investment in the multi-year "Alaska Integrated Ecosystem Model" with a contribution of $50,000 that was leveraged with $500,000 from other sources.

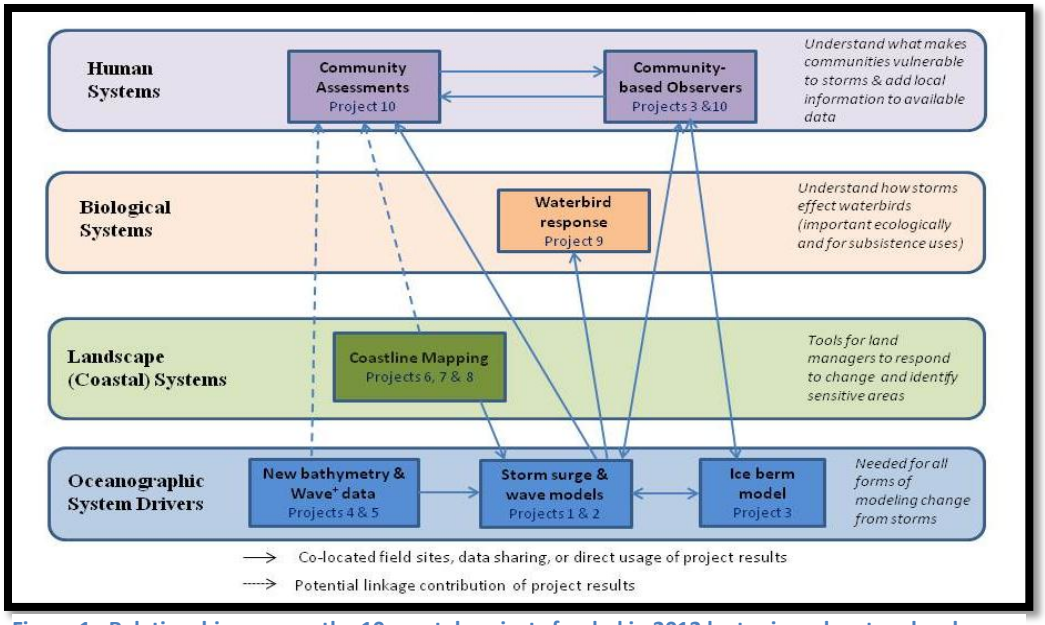


Figure 1. Relationships among the 10 coastal projects funded in 2012 by topic and system level. Appendix C describes each project.

C. Promoting Project Linkages

One of the exceptional roles that the Western Alaska LCC serves is to enhance the linkages and coordination across LCC sponsored projects. By funding a suite of projects within a particular topic, we found that we were able to increase the cross coordination and collaboration amongst the project principal investigators and interested stakeholders. Figure X illustrates the connections that we recognized when the Steering Committee chose to sponsor this suite of projects. Mutual interactions, or *linkages,* among pairs of projects were further developed during creation of the project agreements and included both direct coordination between projects and situations in which the products of one project would be of value to the future

Webinar Increases Efficiency

In October, 2012, the LCC Science Coordinator and the Coastal Storms and their Impacts project principal investigators (PIs) met via webinar to

- identify opportunities to promote efficiencies;
- promote collaborations among project PIs;
- help identify opportunities to link with community-based observation programs; and,
- generally advance communications among all of the PIs.

Each PI (or other project representative) was given seven minutes to briefly summarize the project goals and the planned activities for the coming year. The webinar was very successful in all of the above categories but also through the identification of data sources unknown to a PI which meant an enormous savings by avoiding a duplication of work.

efforts of PIs leading another project. These connections were nearly doubled after the LCC Science Coordinator convened a webinar amongst the Principal Investigators to discuss their projects and opportunity for collaboration.

D. Coastal Workshop with AOOS and ACSC

The Alaska Ocean Observing System (AOOS), Western Alaska LCC, and the USGS Alaska Climate Science Center (ACSC) jointly conducted a Coastal Hazards Workshop May 30-31, 2012. Participants included a broad array of subject matter experts and stakeholders involved in coastal issues from a variety of perspectives, including:

- coastal residents,
- those collecting coastal or marine information,
- local, state and federal agency managers,
- University researchers, and
- participants to represent other information sharing and collaboration efforts.

Workshop participants reviewed the current state of the coast and the state of understanding of the coast from a systems perspective, discussed stakeholder information needs and developed the framework for a conceptual model focused on natural-human system impacts due to coastal erosion and inundation. The full workshop report and supporting presentations can be found at either http://www.aoos.org/workshops-and-reports/ or http://www.arcus.org/western-alaska-lcc/workshops.

An overview of new sea ice modeling coupled with local observations, coastal landforms, and weather patterns provided a backdrop for evaluating coastal hazards. Adjacent marine studies in the Bering Sea through the North Pacific Research Board also provided insights for evaluating coastal issues. Ultimately, the ongoing project to digitally map Alaska will provide an important base layer for evaluating coastal issues.

Participants at the Coastal Hazards Workshop, 2012

Part of the workshop focused on the Coastal Hazards section of a proposed 10-year build out plan for AOOS. Workshop participants identified specific types of information needed to improve forecasts of extreme weather events. Recommendations called for identification of those gaps in both information types and geographic areas, which currently limit a more complete assessment of vulnerability.

Workshop participants developed framework elements for a conceptual model of the coastal ecosystem that ties together near-shore and marine processes that form and affect coastal landforms and human and biological use of this region and their resources. With further refinements, the conceptual model can be utilized to identify vulnerable locations and weather events that may affect coastal stability and near-shore function, and with further work, to assess relative vulnerability of coastal facilities and systems.

Developing the conceptual model (Figure 2) allowed participants to identify specific information needs and gaps in current research and monitoring efforts. These were then prioritized based on perceived importance and feasibility. Of note, all recommendations carried high importance but varied in feasibility; the highest importance needs included:

- Evaluate existing coastal models linking nearshore and terrestrial components (relevant data and existing data) for applicability to western Alaska coastal hazards.
- Collect vertical datum with tidal benchmarks
    - Terrestrial benchmarks tied to water level measurements particularly related to mean sea level
    - This information provides a "Rosetta Stone" for linking bathymetry and

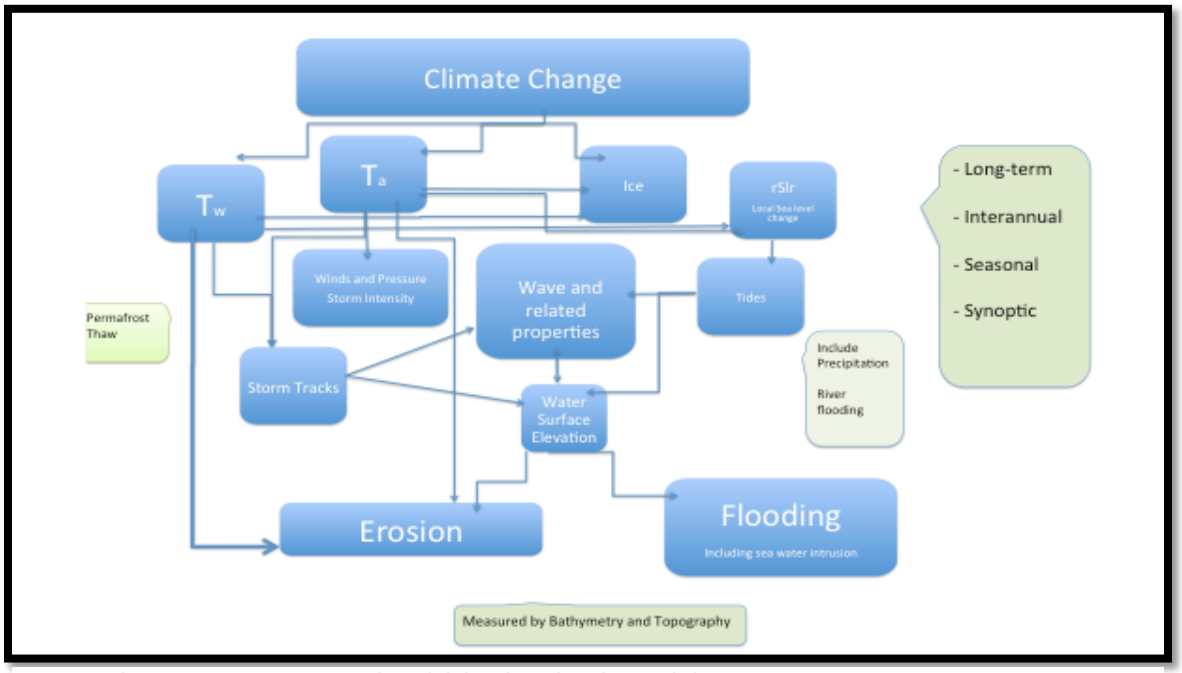


Figure 2. The open-water conceptual model developed at the workshop.

topography and thus near-shore and on-shore processes

- Utilize community observations for storm surge, tide height, and general ice observations (such as ice-berm formation)
- Establish coastal "Sentinel Sites" for co-located collection of chemical, physical, and biologic parameters, providing a basis for elucidating the relationships among them.
    - Example of Bristol Bay pilot program (Nushagak Bay Diversity Project, UAF Bristol Bay Campus, Environmental Science Laboratory) as a mechanism for site establishment that employs scientists, students and local residents to conduct baseline studies and long-term monitoring of physical parameters.

1Alaskan residents of Kivalina battle storm effects. Photo courtesy of Millie Hawley.

E. Setting the stage for the second year of coastal projects

Based on the recommendations from the Coastal Hazards Workshop, the Western Alaska LCC Steering Committee considered the high priority projects from 2012 that were either under-funded or not funded due to budget limitations. The second phase of three projects were selected for funding in 2013 as well as two additional project proposals that fit directly into the recommendations from the Coastal Hazards workshop. The three projects from 2012 that will be expanded are described in Appendix C by their project number and title:

- Project 1 – High-resolution model coupling effects of sea ice, tide, wind-driven wave dynamics, and currents in the formation of storm surges in Western Alaska (NOAA and University of Notre Dame);
- Project 2 – Storm surge impacts on biological resources in the Yukon Kuskokwim Delta (Manomet Center);
- Project 9 – The Impacts of storm surges on breeding waterbirds on the Yukon-Kuskokwim Delta, Alaska: past effects and future projected impacts (University of Alaska Anchorage).

In all cases, the expansion supports development of future predictions.

In addition, two new projects from the 2012 proposals will be funded. These include a project that uses satellite imagery to assess coastal erosion rates and change across western Alaska (ABR Inc) and a project that will fund improved instrumentation for water and tidal level data on Kigigak Island on the Yukon Kuskokwim Delta (U.S. Fish & Wildlife Service). Kigigak Island is an important site for breeding waterfowl including spectacled eiders and potentially Steller's eider. Improving the instrumentation will improve the robustness of studies important to waterfowl and subsistence management conducted in this area. Additional projects to increase the "trifecta" of data (nearshore bathymetry, fine resolution topography and robust water levels) in western Alaska are under consideration.

VII. Stream and Lake Temperature Monitoring Workshop

A. Concept & Planning

Ultimately, it's about fish. This workshop was an important step towards answering questions like: *Which streams may become too hot for salmon or whitefish? Can we expect salmon to move north into streams where whitefish or sheefish now dominate? Will there be competition between the species? Which streams will remain colder and perhaps become refugia for the fish species there today?*

When the Steering Committee decided to include a "mini-Pilot Program" on hydrological processes in its FY12-FY13 Science and Operating Plan there was recognition that most hydrological topics span beyond the Western Alaska LCC geography. Therefore, it is important to involve others throughout the state in discussing approaches for addressing climate change effects on hydrology and the species that depend upon these freshwater systems. Based on input from specialists within the partnership and on the science workshop feedback, it was decided that stream and lake temperature were among the most tractable hydrological characteristics that have obvious connections to changing climate and probable effects on important fisheries.

With the help of the Northwest Boreal LCC and members of the Arctic LCC's "Hydro-climate Workgroup" the Western Alaska LCC and the Alaska Climate Science Center convened a workshop to discuss Stream and Lake Temperature Monitoring in Alaska. The Wildlife Management Institute hosted the workshop in Anchorage in November 2012. The workshop brought 28 hydrologists, researchers, fisheries biologists, local experts and managers together to discuss the steps necessary to be able to utilize existing and future water temperature data to allow for the development of

regional-scale predictive models of changes in water temperature. The ability to conduct these models is a critical step in understanding how changes in temperature may affect fisheries habitat over the next century.

The top recommendations include:

1. Clearly articulate the goals & objectives of the proposed regional network for monitoring stream and lake water temperature.
2. Conduct a more comprehensive inventory of project metadata and attributes (e.g., who, what, where, when) for current and past stream and lake temperature monitoring efforts.
3. Identify a network of 'reference sites', to be maintained in perpetuity (20 year minimum), that will serve as the network's core observational framework to which observations from shorter duration sites can be linked and 'anchored.'
4. Demonstrate the power and value of predictive scenarios based on water temperature data for pilot regions in Alaska.
5. Develop minimum data collection standards that a project must meet for its water temperature observations to be usable in a regional network analysis.
6. Define the characteristics (architecture) for storing and distributing water temperature data for Alaska.

The Western Alaska LCC and the Alaska Climate Science Center have committed a portion of their FY13 project funding to implementing these workshop recommendations. We plan to initiate efforts on recommendations 1 and 2 in FY13. A complete workshop report will be available in the spring of 2013. The workshop record is already posted on our website at: http://www.arcus.org/western-alaska-lcc/stream-lake-temp-workshop.

VIII. Highlighted Projects

The Western Alaska LCC first funded projects in late 2011. Of the 12 projects funded that year, two were essentially instrumentation projects that were completed quickly. Of the remaining ten projects, the Wilderness Society has completed their project applying recent remote sensing methods to detect thaw/re-freeze events (Figure 3) across the state, by week, from 2001-2008[5], which is the focus of the summary below. The findings are reported in the journal Polar Biology at: http://link.springer.com/article/10.1007%2Fs00300-012-1272-6.

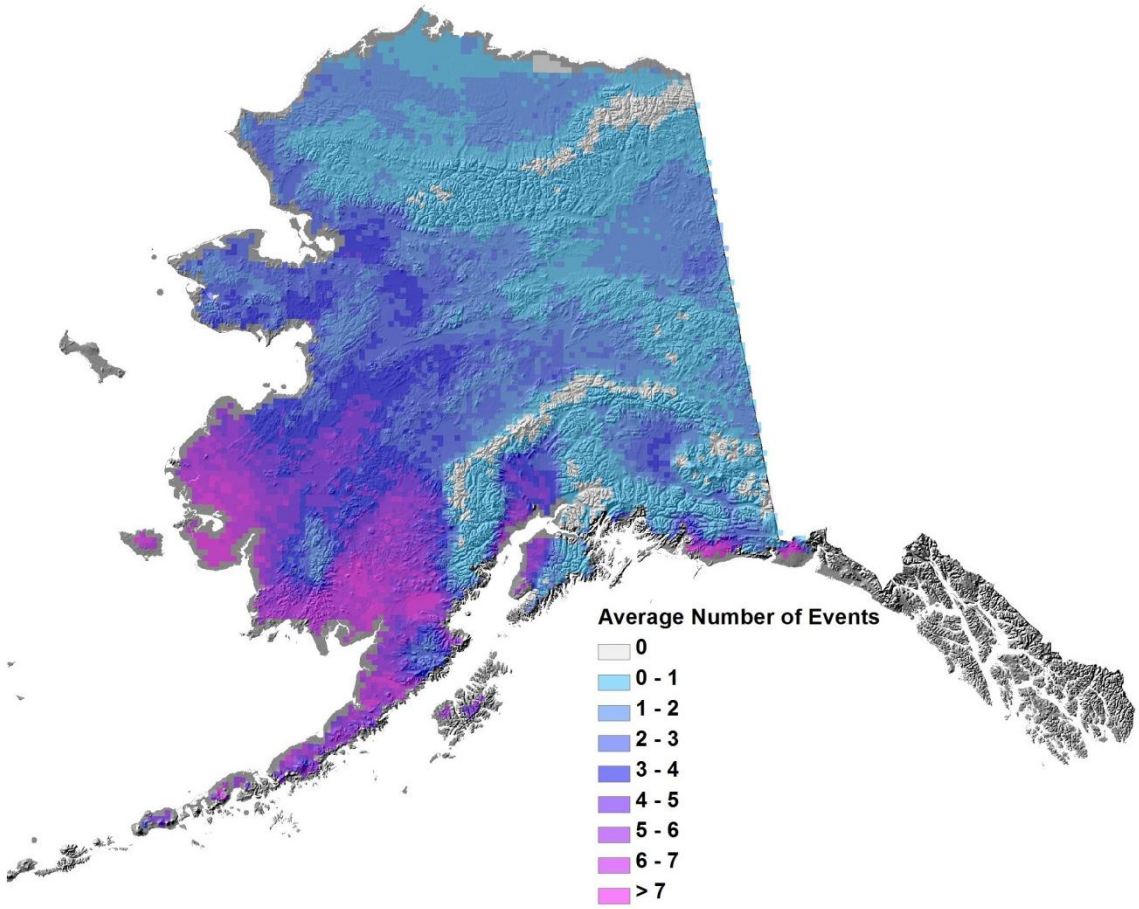


Figure 3. Calculated average number of thaw-refreeze events around Alaska (Wilson R., A. Bartsch, K Joly, J.H. Reynolds, A. Orlando, W.M. Loya. 2013. Frequency, timing, extent, and size of winter thaw-refreeze events in Alaska 2001-2008 detected by remotely sensed microwave backscatter data. Polar Biology 36 (3) pp 419-126).

A. Frequency, timing, extent, and size of thaw-refreeze events in Alaska

Thaw-refreeze events create a layer of ice on top of the snow which sometimes persists throughout the winter within the snow profile. Wildlife can be impacted adversely depending on the thickness of the ice and the spatial extent of the ice layer. Thaw/Re-Freeze events occur for a variety of reasons, including rain-on-snow events, temperatures abruptly warming above

[5] The satellite was decommissioned in 2008. The project also investigated the potential of adapting the remote sensing methodology to a current generation satellite

freezing, and wind. The ice layer that is developed during these events is known to impact forage ability for ungulates, especially caribou. The mobility of animals across the landscape may be affected, sometimes reducing ungulate mobility while increasing mobility of lighter predators.

Winter temperatures throughout Alaska are already warmer than historical records and there is suspicion that this may be increasing the frequency of thaw/re- freeze events in regions of the state. These events can be captured in weather station records; however, the lack of weather stations across western Alaska means there has been very little information on the seasonal timing, frequency, and spatial extent of these events.

Key project findings are summarized below. The summary data layers are available online at http://climate.iarc.uaf.edu/geonetwork/srv/en/main.home (search for 'refreeze'). The project also produced a number of outreach summary reports specifically aimed at key groups in western Alaska for whom these results were expected to be of interest, including the area wildlife biologists in the Alaska Department of Fish &Game (ADF&G) Game Management Units 9 and 17 – 24; each of Selawik, Yukon Delta, Togiak, and Alaska Peninsula/Becharof National Wildlife Refuges; the National Parks/Preserves in northwestern Alaska (Bering Land Bridge, Cape Krusenstern, Kobuk Valley, Noatak, and Gates of the Arctic); and the Western Arctic Caribou Herd Technical Working Group.

1. Project Findings

From 2001-2008, southwestern Alaska had the highest frequency of thaw/re-freeze events in the state. The events were especially common in low elevation areas adjacent to coastlines and river deltas. Within the Western Alaska LCC geography there were usually > 5 events / winter, with events occurring most frequently from the Yukon River south along the coastal margins of Bristol Bay and onto the Alaska Peninsula, especially in the deltas of the Yukon, Kuskokwim, and Nushagak Rivers. The period of winter in which events were most frequent varied across the regions of the state, but in the LCC, events were most frequent in April. The spatial extent of events was highly skewed, with many small events and fewer very large events. Within the LCC, the spatial extent of events on the Alaska Peninsula was usually < 100,000 km^2 (< 38,610 mi^2) while those in the Nulato Hills region (east of Norton Sound) were usually > 250,000 km^2 (> 96,525 mi^2).

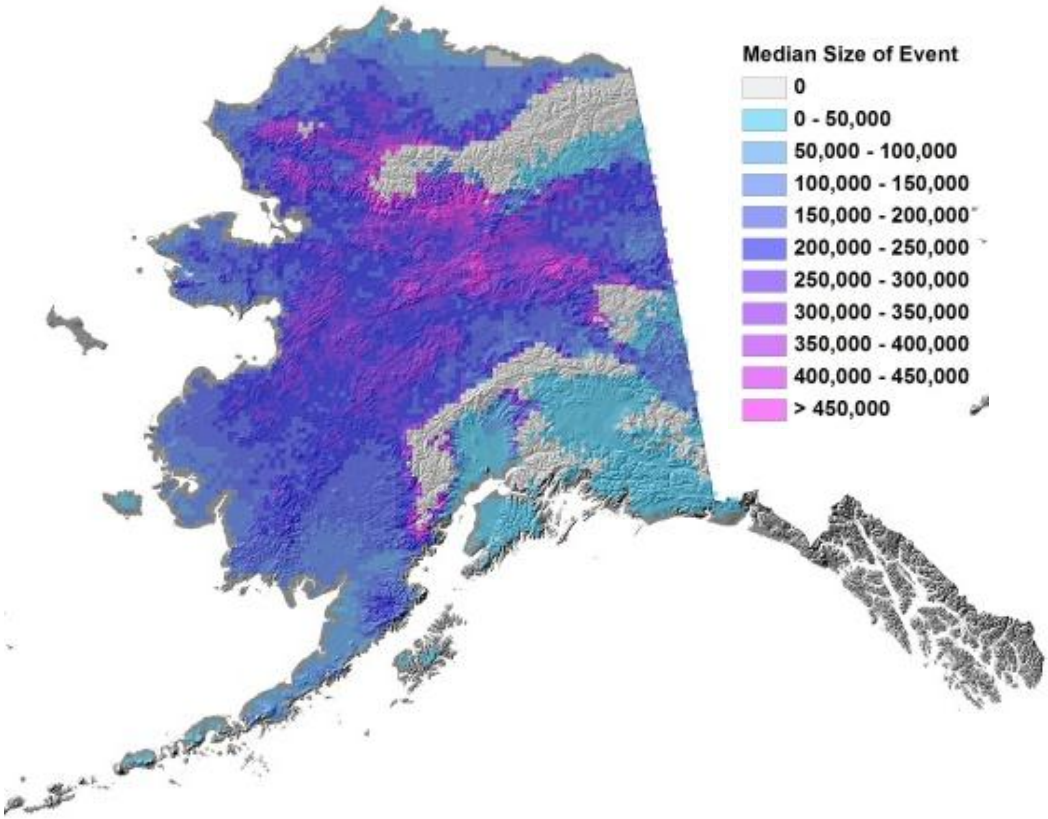


Figure 4. Median size (km^2) of events throughout Alaska.

2. Potential Implications for Caribou

Caribou are highly adaptable animals capable of moving large distances to find suitable habitat. Adverse impacts to caribou from thaw/re-freeze events would likely occur when the events were large in spatial extent, created a thick ice layer, and when winter conditions kept the temperatures below freezing for a long period of time following the development of the ice layer.

The Nulato Hills region had the largest thaw/re-freeze events in Alaska during the 2001-2008 timespan. This region is an important wintering area for the large Western Arctic caribou herd. Should a massive event, like those recorded in the last decade, occur while the herd is in the area it would likely affect a large number of individual animals, especially if a thick ice layer endured for a long time period. This region is likely to see an increase in frequency of events this next century as winter temperatures increase toward the 32 degree freezing mark.

The high frequency areas in Southwestern Alaska overlap considerably with the winter ranges of Nushagak and Mulchatna Caribou Herds. However, these areas also include numerous locations (at higher elevations) with low frequency of events, and the events are generally smaller in spatial extent than elsewhere in the state. In regions where caribou have limited options of moving to different wintering areas, the impact of large-scale thaw/re-freeze events may be most severe especially if they last for a long period. Climatic warming trends in these wintering areas suggest that events may decline in frequency in the later parts of the next century as winter temperatures continue to warm.

The thaw-refreeze study assessed one habitat component important in understanding climate change effects on caribou. Additionally, the LCC funded a study of habitat change and nutrient cycling on important caribou habitats on the Alaska Peninsula. That project is led by the University of Alaska Anchorage and includes collaborators from the U.S. Fish & Wildlife Service, ADF&G and others; results will be available in early 2014. The LCC is also contributing to the state-wide "Integrated Ecosystem Model" project which is integrating independent models of fire disturbance, tree-line shift, vegetation succession, carbon cycling and permafrost change. This model will provide managers with another landscape-wide tool to explore potential changes to habitat of caribou and other species under different climate scenarios.

IX. Science Planning in 2013

A. Long-term Strategic Science Plan

The experiences gained through the Coastal Processes pilot program gave the Steering Committee a new strategy to consider for a long-term science plan. It is clear that having a stronger focus during each funding cycle can improve the ability of the LCC to make a difference in improving the information available to decision makers. The long-term strategic plan needs to provide a platform that will help the LCC meet its mission, with the primary focus on making a difference to conservation and resource management decisions in western Alaska. By the end of 2012, the Western Alaska LCC Steering Committee decided to continue the pilot program "approach" of selecting a theme and focused topic for each two year period as its preferred basis for the long-term strategic plan over the next decade.

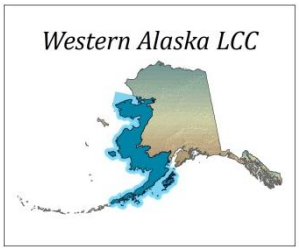
The LCC Steering Committee discussed many approaches to describing "themes". We considered approaches that would describe the "theme" in terms of the end-goal (such as "Suitable fish habitat") to those that would describe the "theme" in terms of the primary processes (e.g. "Coastal Processes"). A preliminary decision was made to identify three themes based on processes: *Coastal Systems, Freshwater Systems and Terrestrial Systems*. The details of this approach will be refined in 2013 and distributed for public comment before adoption.

B. FY14-15 Science and Operating Plan

In FY2014 we will begin a focus on the theme of Freshwater Systems. Under our basic long-term science strategy framework, we will refine the broad theme of 'Freshwater Systems' to a particular topic or two during the spring of 2013, with development of the FY2014-2015 Operating Plan during summer 2013. While the long-term strategic science plan will provide the basic framework for addressing shared science needs, the two year science and operating plans will provide more specific information. These documents will be available in 2013.

Appendix A: Engaging Alaskan Natives

C. Sample letter to Alaskan Tribal Councils



TRIBAL PARTICIPATION IN THE WESTERN ALASKA LCC

Over the last year several letters and emails with updates on the initial activities of the new Western Alaska Landscape Conservation Cooperative (WLCC or the Cooperative) have been sent to Tribal Councils in western Alaska. The purpose of this information was to inform your tribe about the Cooperative and its potential importance to you and your Tribal members.

The Cooperative brings together a partnership to address the shared science and knowledge needs about how the environment is likely to respond to climate change. By participating in this Cooperative, you can help ensure that the topics considered include the resources upon which you depend; it will also ensure that your Tribe is aware of the information and other products produced by the Cooperative which may be useful in your tribal and community planning efforts.

Our mission is to promote coordination, dissemination, and development of applied science to inform landscape level conservation, including terrestrial-marine linkages, in the face of landscape scale stressors, focusing on climate change. Your help is needed if we are to be successful in developing useful tools to help land managers and Alaska residents address the impacts from these changing conditions.

In 2011, the WLCC has been taking the initial steps to form the Cooperative and we are beginning to discuss the long-term direction to guide the work of the WLCC. Information about the activities of the LCC is available at http://www.arcus.org/western-alaska-lcc. You might be interested to see the types of projects funded by the Cooperative in its first year. The WLCC invested $1.3 million dollars in 12 projects. These projects collectively included $1.75 million dollars in leveraged (contributed) funding or support. The LCC Steering Committee selected these projects, from 78 Proposals, to provide a strong foundation for initiating the LCC's applied conservation science efforts.

At this point, we are trying to determine how each tribe wishes to engage with the Western Alaska LCC. So, we have developed a series of questions, with some explanatory information on LCC governance structure, to aid in your understanding about how LCCs are structured, and where you can be involved. We hope you will use these questions and bits of information in tribal discussions as you decide how you would like to engage with the Western LCC.

LCCs are comprised of the following groups: Steering Committee, LCC core staff, the Science and Traditional Ecological Knowledge Community, Partnership Community, working groups or teams, and interested members of the public. The basic organizational structure also includes the Science/Traditional Ecological Knowledge Community and Partnership Community. The

Science and Traditional Ecological community and Partnership Community, along with State, Federal and Alaskan Native participants, represent the majority of the Cooperative's participants and serve as the membership pool for working groups or teams. Participation in the Cooperative is voluntary.

Questions for Tribes to address in deciding how they can best participate in the ALCC

1- How would you like to participate on the Western Alaska LCC? At which of the following levels would you like to see your Tribal Council engage with the LCC? (Science and TEK Community, Partnerships Community, Workgroups, or Steering Committee, General Public or "remove from mailing list")

Science & Traditional Ecological Knowledge Community

The Science & Traditional Ecological Knowledge (TEK) Community (Science Community) is the collective science and TEK capacity within the LCC, including university, government and nongovernmental scientists, researchers, and specialized science and technical expertise, including traditional knowledge experts and elders from western Alaska. Individuals from this Community participate, as permitted through their respective organizations, in various specialized science panels or working groups and in the review of the science strategy for the LCC. The LCC staff coordinates with appropriate expertise within this Community to meet specific shared information needs of the LCC partners.

Partnership Community

The Partnership Community is the collective conservation partnerships and partners within Western Alaska LCC and includes landscape, marine, species, habitat and/or issue specific partnerships, management and organizational representatives and other conservation partners. The role of the Partnership Community is to help identify shared science needs, collaborate and leverage opportunities to address shared science needs, and to help the LCC avoid duplication of effort. The LCC will engage with the partnership either through its Core Staff or through Steering Committee members engaged in the partnership and in the LCC. Members of the Partnership Community shall identify a point-of-contact for their partnerships to be kept informed of the LCC activities through the LCC website and emails with the LCC Core Staff.

LCC Workgroups or Teams

Working groups may be comprised of individuals from organizational entities with natural or cultural resource conservation and management responsibilities or science capacities in the geographic area or that have skills that can meaningfully inform management decisions related to this LCC. The members of technical working groups shall have expertise appropriate to that working group. Technical working groups shall be formed by the Steering Committee or core staff to address a specific LCC need. In addition, the Science or Partnership Communities and core staff can request that the Steering Committee establish additional technical working group(s). At this time, no LCC workgroups have been established however, workgroups are expected to serve an important role in the future.

Steering Committee:
The Steering Committee is comprised of the designated representatives of State, Federal and Alaskan Native entities participating in the Western Alaska LCC with an emphasis on field level managers responsible for management and conservation of land and natural resources in Western Alaska (see Attachment 1 showing the 2011 State and Federal agencies on the Steering Committee).

Three Steering Committee seats will be available for individuals who can contribute Alaskan Native perspectives to the LCC. At this time these three seats are temporarily filled by Tim Andrew, AVCP; Rose Fosdick, Kawerak; and Karen Pletnikoff, Aleutian Pribilof Islands Association. Identification of individuals to permanently fill these seats will come through discussions with Tribal and Native entities within the Western Alaska LCC geographic area. If more than three individuals are interested in serving on the Steering Committee, alternates and a rotation pattern will be developed by the interested participants with the approval of the existing Steering Committee.

Of course, we also have a "General Public" mailing list that would keep you informed of activities and opportunities to participate as they become available. You have already been added to this mailing list, so if you do not wish to receive updates from the Cooperative please ask to be removed from the mailing list.

2- **Are there other groups or individuals that are addressing the impacts of climate change on traditional lands used by your tribe? If so, who should we contact to learn more about these activities?**

3- **How would you recommend we interact with your tribe, municipal and borough governments and regional Native corporations in an efficient and effective manner?**

4- **The LCC staff and several current Steering Committee members will be available to discuss the Western AK LCC and opportunities for involvement on December 1st at the BIA Service Providers Conference. Would you be interested in meeting them there at that time?**

After you have had time to contemplate these questions, please feel free to call us to discuss your desired level of participation in this important Conservation partnership. We look forward to hearing from you.

To discuss how you can participate in the Western Alaska LCC, please contact Karen A. Murphy, WLCC Coordinator, who can be reached by, email Karen_A_Murphy@fws.gov, or by phone, #907-786-3501, or George Oviatt at George_P_Oviatt@fws.gov or #907-786-3346.

Appendix B

Excerpts from the Shared Science Needs Workshop Report

Shared Science Needs

Report from the Western Alaska Landscape Conservation Cooperative Science Workshop

A report from a workshop held 26–27 April 2011 in Anchorage, Alaska

Shared Science Needs

Report from the Western Alaska Landscape Conservation Cooperative Science Workshop

Report From a Workshop Held
26–27 April 2011
Anchorage, Alaska

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The workshop was only possible thanks to the ideas, time, and efforts of Karen Murphy, Mark Shasby, Karen Jenni, Tim Neiman, Lynne Koontz, Billy Gascoigne, Holly Miller, Cathy Thomas, Nicole Gustine, Jennifer Jenkins, Stephanie McCafee, Wendy Loya, the ARCUS staff, and through the support of the Interim Steering Committee of the WALCC (see appendix 4) and especially its co-chairs, Ann Rappoport (USFWS) and Doug Vincent-Lang (Alaska Department of Fish and Game).

The workshop plenary speakers provided important background information for workshop participants and contributed substantially to chapter 3. The plenary speakers were John Walsh, Vladimir Romanovsky, Joshua Koch (for Rob Striegl), David Atkinson, Amy Breen, Mark Wipfli, and Torre Jorgenson.

Special thanks to the reporting group leads who captured the workshop's intensive discussions: Peter Bente, Keith Boggs, Heather Coletti, Craig Ely, Dan Gillikin, Grant Hildebrand, Claudia Ihl, Torre Jorgenson, Rick Lanctot, Bill Leacock, Doug McBride, Jim MacCracken, Brian McCaffery, Amy Miller, Matt Nemeth, Lori Polasek, Dan Reed, Susan Savage, Sadie Wright, and Kate Wynne.

Earlier drafts of this report were made available for review to all workshop participants. Additional review was provided by the WALCC Steering Committee and Mari Reeves, Karen Jenni, and Tim Nieman.

A final thank you to all workshop participants for sharing their time, ideas, and experiences.

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Cover background: Yukon-Kuskokwim Delta, photo by Torre Jorgenson

Inset cover photos: U.S. Fish and Wildlife Service Archive: (1) Cape Promontory, (2) Togiak bearberry and dwarf birch, (3) thick-billed murres, (4) common murres in Shumagin Islands, (5) Bethel village flooding

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Izembek National Wildlife Refuge; Ryan Hagerty, USFWS

Ice wedge, Ikilyariak Creek; USFWS

One: Executive Summary

Climate change is one of the greatest conservation challenges of the twenty-first century, and the communities of Western Alaska are already feeling its effects. Understanding climate change effects and responding effectively will require unprecedented communication among researchers, managers, decision makers, resource users, and other stakeholders from across public agencies and private organizations. The goal of Landscape Conservation Cooperatives (LCCs) is to facilitate this landscape-level collaboration and communication to help manage effectively in the face of climate change. The mission of the Western Alaska Landscape Conservation Cooperative (WALCC) is to promote coordination, dissemination, and development of applied science to inform landscape level conservation, including terrestrial–marine linkages, in the face of landscape-scale stressors, with a focus on climate change.

The goals of the WALCC are to:

- promote communication about climate change effects in Western Alaska;
- improve efficiencies in science activities by supporting partner coordination and collaboration;
- identify research and share data to support land and resource management;
- enable synthesis of information at landscape and larger spatial scales; and
- enhance resource management in Western Alaska through applied science and technology transfer.

To further its mission, the WALCC hosted a Science Workshop in Anchorage, Alaska on 26–27 April 2011. The workshop aimed to identify common science needs, focusing on current and anticipated changes in climate and their ultimate effects on biological resources. The workshop was co-sponsored by the U.S. Geological Survey's Alaska Climate Science Center (CSC), the Bureau of Land Management (BLM), and the WALCC. It brought together 150 managers, field specialists, researchers, and local knowledge experts to identify climate change-related science needs for land and resource management in Western Alaska. It was immediately followed by a small workshop, sponsored by the CSC and the University of Alaska Fairbanks, focused on downscaling climate model projections (http://ine.uaf.edu/accap/research/downscaling_ws.htm).

The main goal of the Science Workshop was to ***identify the priority science needs for meeting shared management objectives in light of projected climate change impacts***, where "shared management objectives" refers to those common to multiple resource management agencies (see chapter 2). The workshop also aimed to:

- increase understanding of the effects of projected climate change on Western Alaska ecosystems;
- provide a forum for communication across organizations, disciplines, and perspectives (scientists, managers, decision makers, and resource users);
- increase awareness of linkages between physical processes and ecological systems; and
- share information with those unable to participate, via this workshop report.

Before the Science Workshop, the WALCC held a Framing Workshop in February 2011, where participants identified climate-relevant resource management decisions commonly made by WALCC partner agencies and outcomes of common interest. These were used to organize Science Workshop discussions. The Science Workshop began with plenary presentations that summarized predictions about climate change effects in Western Alaska ecosystems. Participants were then split into breakout groups to discuss expected changes in physical processes and their impacts on taxa. The structure of the Science Workshop discussions is detailed in chapter 2.

Most Important Changes in Geophysical Processes

The breakout discussions in the Science Workshop resulted in assessments of most important changes in geophysical processes (summarized in chapter 4). Overall, the most important process change identified was change in aspects of the hydrologic cycle, which included changes in water budget and seasonality; base flows; flood timing, frequency, and magnitude; and timing of snow melt. The next most important process changes were vegetation changes (plant succession and distribution) and changes in coastal processes (inundation, erosion, salinization [increased saltiness], and shore-fast ice dynamics).

Common Science Needs

The breakout groups identified key science needs (summarized in chapter 5). All breakout groups were unanimous in identifying three broad needs:

- developing linkages among physical processes, ecological processes, and important species;
- conducting data synthesis; and
- improving data management, long-term curation, access, and sharing.

Two additional needs were raised by five of the six groups:

- maintaining and expanding hydrological data collection stations, and
- conducting gap analyses to identify key data on important species and/or physical and climate parameters that are currently unavailable.

Most of the identified needs reflect problems common to long-term knowledge management in organizations that mainly support short-term projects to address near-term objectives. Resources are allocated to the pressing needs of current data collection and analysis sufficient to generate the necessary information for the immediate objectives, but are not allocated for long-term data management, sharing, and curation in order to support future analysis needs. That all breakout groups unanimously identified needs for science integration and support services also indicates problems common in multidisciplinary studies.

Many groups also recommended specific science strategies and approaches (detailed in chapter 5). The majority of these reflect specific facets of the underlying need for more effective communication between scientists, managers, decision makers, and resource users. This becomes a central concern when focusing on planning decision-relevant science.

Next Steps in WALCC Science Planning

The Science Workshop was a forum for communication across agencies, organizations, disciplines, and cultures, in alignment with the mission of the WALCC. As expected in any crossdisciplinary, integrative effort, the dominant workshop challenges related to communication. Many groups recommended improving collaboration. This was raised in terms of integrative, multidisciplinary studies; involving local residents; and incorporating local and traditional ecological knowledge. A summary of "Lessons Learned" regarding the design of the workshop is in appendix 6.

Both the Framing Workshop and Science Workshop results have identified gaps and science needs that limit the ability of resource management agencies to predict the outcomes that are of interest to them. These results provide a foundation for the science planning activities of both the WALCC and the U.S. Geological Survey (USGS) Alaska Climate Science Center.

The next steps in developing a WALCC long-term science plan include defining criteria for deciding which projects and portfolios of activities to pursue. Such criteria will provide a consistent approach for strategic decision-making and allow for a transparent process. More information about the WALCC planning processes is briefly discussed in chapter 6.

Aghileen Pinnacles; John Sarvis, USFWS

Six: Summary and Next Steps

6.1. Important Results

The workshop was a successful forum for interaction and communication across agencies and organizations as well as across disciplines and cultures, in alignment with the mission of the WALCC. One immediate product of the workshop discussions was a continual, if implicit, acknowledgement of the common science needs shared by participants from different decision-making groups and stakeholders. This reinforced the need for and potential of the LCC concept. The most commonly identified needs are briefly summarized below. As expected in any crossdisciplinary, integrative effort, the major workshop challenges related to communication. This was especially true given the complexity of the discussion topics and the diversity of participants. A summary of lessons learned regarding the workshop structure and design of the breakout sessions and activities is in appendix 6.

The workshop provided assessments of the most important changes in geophysical processes from nine distinct perspectives: either from impacts on a specific subregion's landscapes (day 1) or from impacts on specific major taxa group or landscapes (day 2). Eight of the top ten most commonly identified processes were associated with aspects of hydrology or coastal processes, the exceptions being vegetation change and permafrost change (table 4.4). The central role of these processes in influencing all higher-level taxa was similarly identified as priority "cross-cutting" themes in arctic Alaska (Martin et al. 2009).

There is very limited baseline data in Western Alaska for most of these processes. For example, there are two reference tide guages on the 750+ mile coastline of the WALCC. This lack of data compounds the inherent uncertainty regarding how these drivers of landscape change may be impacted by climate change. It also generates a common need for baseline data. Thus, even though the specific components of hydrology that drive habitat suitability will differ across taxa and subregions, maintaining and expanding hydrologic monitoring (i.e., flow, seasonality, water balance, temperature, etc.) was identified as the highest priority data collection need (tables 5.2 and 5.3; five of the six taxa groups). The other commonly identified data collection needs also were associated with aspects of these core processes: hydrology, weather, coastal processes, and vegetation or habitat mapping; the exceptions were the common need for digital elevation models and species-specific information (tables 5.2 and 5.3). Note that within these common processes, different decision-making objectives will likely require information on different parameters gathered with different measurement intensities.

The most common priority needs, however, were not in the category of *Data Collection* but rather in the categories of *Data Integration and Analysis* and *Data Management, Stewardship, and Access* (tables 5.4 and 5.5):

- developing linkages among physical processes, ecological processes, and important species;
- conducting data synthesis; and
- improving data management, stewardship, archiving, and access.

That all taxa groups unanimously identified needs for science integration and support services, e.g., data management, is indicative of problems common in both multidisciplinary studies and long-term knowledge management. Effectively informing resource management decision-making in the face of climate change requires a greater focus on learning about the systems. Barriers to understanding these systems reduce the effectiveness and efficiency of decision-making. Such barriers can delay recognition of system changes, reduce management response options, slow learning about the system, and waste resources. In the long run, these barriers introduce the risk of severe impacts to the system that might have been averted and the loss of institutional support for management programs.

Improving understanding of the system requires greater attention to and support for integration and synthesis of multiple types of data (i.e., physical, biological, etc.) (NRC 2010). Supporting integrative studies requires a focus on both new multidisciplinary data collection and integrative analysis of the often large backlog of existing data.

However, such integrative data analyses require the ability to readily discover and access existing data. The importance of effective data sharing and stewardship is increasingly acknowledged by the science community

(Hanson et al. 2011; NRC 2007; Reichman et al. 2011; Whitlock et al. 2010). This need will only be met with long-term institutional support in both resources and commitment (NRC 2007; Reichman et al. 2011). Institutional support for long-term knowledge management programs will likely only come with broader recognition of the costs resulting from their absence.

The need for strategic planning of science activities was reflected in the taxa groups' recommendations of gap analyses, which identify key missing information (table 5.4, raised by five of six groups) and the recommendation to improve the scientific community's understanding of the information needs of managers and decision-makers (table 5.6, raised by half of the groups). Both activities would help focus scientific activities on priority decision-maker needs and improve the effectiveness and usefulness of the science activities. The first principle of effective decision support is "begin with the users' needs" (NRC 2009).

Similarly, attention should be given to improving communication of science information and needs to managers, decision-makers, policy-makers, and stakeholders whose actions could be affected by the information. This often requires more inclusive modes of communication than those usually employed within the science community and will require focused effort. Ultimately, this would allow user groups to better incorporate science into their own planning.

Improving collaborations was recommended as a strategy by many groups (table 5.6). This was raised in terms of both integrative, multidisciplinary studies (discussed above) and involving local residents and incorporating local and traditional ecological knowledge. Engaging local residents in designing and participating in long-term monitoring projects will provide ownership in data collection and interpretation to support science programs, help distribute the costs of conducting long-term monitoring, and provide an ongoing communication structure between local residents, scientists, resource managers, and decision-makers.

6.2. Next Steps

The needs identified by the Science Workshop will inform the near-term planning activities of both the WALCC and the Alaska Climate Science Center. However, this list of priority needs is not itself a science plan. Developing a science plan will require consideration of additional factors, such as what science needs should be addressed over the next five years and how they should best be addressed.

The WALCC science planning process has just begun and details remain to be resolved. This section describes the remaining steps required to turn the identified science needs into an integrated science plan. There are different ways to accomplish this overall task, and the description below is just one scenario. Regardless of how the specific steps are undertaken, the approach adopted must:

1. identify a method for assessing the relative value of addressing different information needs, in terms of the benefit of that information for relevant management decisions;
2. identify a method for assessing how effective different proposed activities are at addressing science needs; and
3. account for high-level (LCC) strategic considerations in putting together the science plan's portfolio of activities.

The following steps start where the Science Workshop ended—with a comprehensive list of information needs—and describe one way to develop the list into a science plan.

Step 1. Prioritize the Information Needs. The Framing Workshop and Science Workshop results have identified information gaps ("science needs") that limit the ability of resource management agencies to predict the outcomes that are of interest to them. Determining which needs are of higher priority requires judgments about the size of the information gap and the relative importance of information in addressing various objectives. The decision analysis principles being followed in this overall process emphasize that the value of information depends on its potential to affect relevant management decisions, and this basic criterion of decision-relevance should drive the overall prioritization of science needs. Judging decision-relevance, of course, requires the improved understanding of decision-maker needs that was raised during the workshop (table 5.6). Thus a key component in developing an effective prioritization process is ensuring ongoing communication between scientists, managers, and decision-makers.

Step 2. Identify and Develop Project-level and Portfolio-level Criteria. The prioritized list of science needs from step 1 will not typically provide the details needed for design of an optimal portfolio of science projects or activities. First, projects or activities to address each of those needs must be developed, and alternative approaches for addressing a specified need must be evaluated to determine what the most beneficial (or most cost-effective) projects are. Project-level evaluation criteria will likely be required. These criteria

might include the time and resources required for the activities, the effectiveness of proposed activities at reducing the information gaps, how proposed activities relate to each other and to existing work, and so forth.

Selecting a portfolio of activities to pursue also involves consideration and definition of additional factors, especially how well those proposed activities fit into an overall strategic context and how well the set of activities meets the goals of the WALCC. Several valid strategies for planning a long-term research program exist. One strategy, for example, might involve "deep" investment in projects addressing one or two high-priority information gaps, such as integrated studies on a particular topic or at a particular location, or developing decision-support tools or information infrastructure for a particular topic. Another strategy might involve "broad" investment, where projects are selected to investigate a much wider range of information gaps. Other considerations may include, but are not limited to, ensuring that the science strategy is coordinated across agencies and organizations, is coordinated with existing programs, addresses a breadth of management decisions and objectives, provides for integration of activities spatially, and contains an effective mix of types of activities (e.g., design or planning, method or decision-support tool development, data collection, data analysis, data management, communication, and outreach). Again, these portfolio-level factors and strategy remain to be developed by the WALCC Steering Committee.

Step 3. Develop a Consistent Approach and Tools to Evaluate Current and Future Needs and Activities. The Science Workshop resulted in the identification of numerous needs, but additional needs will come to light and a variety of opportunities to address those science needs will arise over the next several years. The Science Plan will guide that process, but it will also be beneficial to have a well-defined approach to evaluate future science project proposals or other proposed WALCC activities as they arise. The approach should be designed so that it can be updated as WALCC goals and priorities evolve.

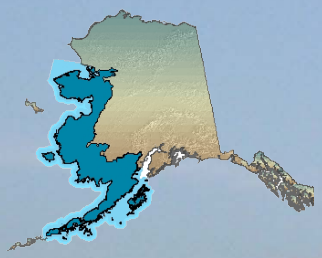
The first two steps above define the basis for evaluating and prioritizing both individual activities and portfolios of activities. This third planning step is to take that information and turn it into a process and/or tool to actually prioritize activities. Portfolio decision analysis methods can be used to develop and evaluate sets of activities that address high-priority science needs, are consistent with the overall strategy, and form a coherent portfolio of activities to promote and fund. There are a variety of specific methods that could be used (Hammond et al. 1999).

Prioritization should be designed to be easily updated, so that as new information needs are discovered (or information gaps are closed) and new activities are proposed, their priorities relative to other activities can be easily determined. The approach would form a critical part of evaluating future project proposals both in relation to each other and in the context of past and ongoing work.

Step 4. Develop a Feedback Process for Evaluating Success. It is fundamental to the success of the WALCC that planning be approached as a dynamic evolving process, not a static set of one-time choices. Therefore, the planning steps should include a process for evaluating the WALCC's activities, measuring achievement of the WALCC's strategic goals and objectives, and reviewing current strategic planning decisions in light of this performance. This will allow the WALCC to improve its own effectiveness and efficiency as well as help model the benefits of an adaptive approach to program management.

Appendix C: Summary of 2012 Collaborator Projects

Western Alaska
Landscape Conservation Cooperative

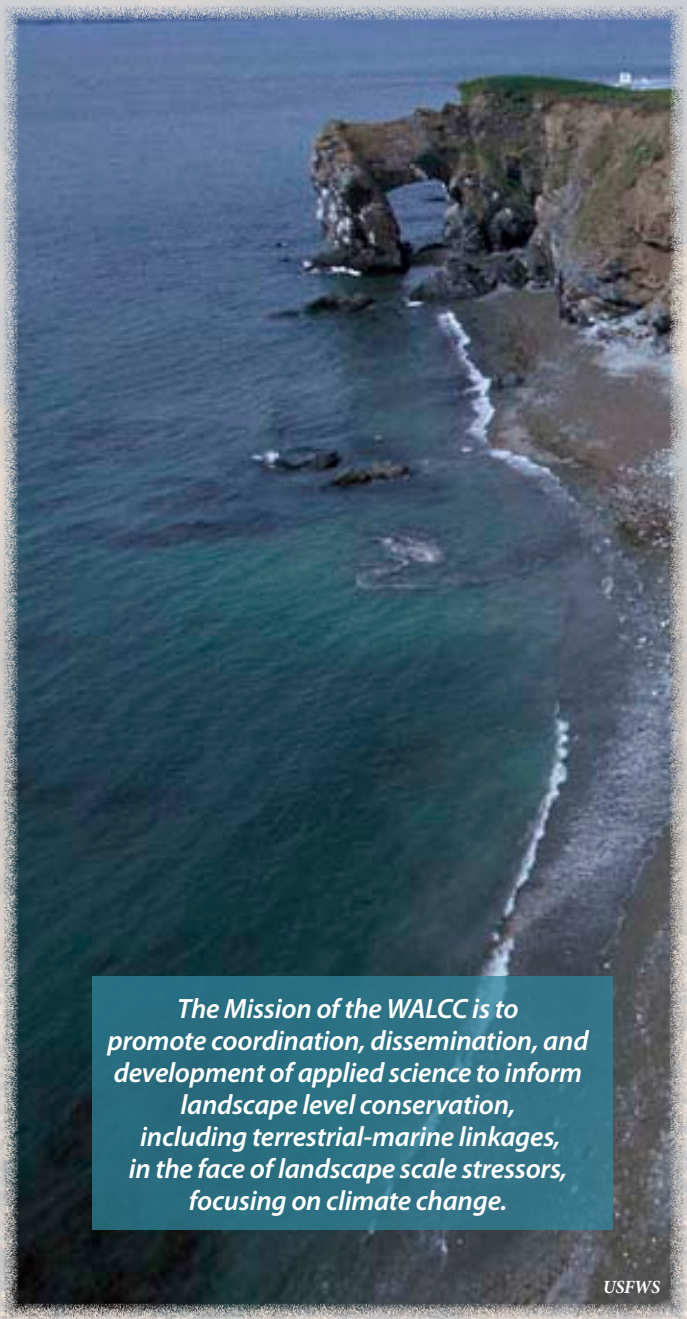


2012 Collaborator Projects

In 2012, the Western Alaska Landscape Conservation Cooperative (LCC) sought projects addressing science needs related to *Changes in Coastal Storms and their Impacts*, a top priority for Western Alaska identified by resource managers, researchers, and local knowledge experts. Based on input from a partnership "organizing team" who recommended the focus for the *Changes in Coastal Storms and their Impacts* pilot program, the LCC solicited proposals related to shorefast ice dynamics, local involvement in monitoring coastal dynamics, effects of changes in coastal storms on coastal biological resources, and opportunities to leverage data collection. The LCC Steering Committee selected 10 projects from 28 proposals. The projects leverage existing efforts in western Alaska and address shared science needs. Collectively, they will produce both short term results and long term benefits to an array of stakeholders.

Two additional projects were developed in partnership with the Alaska Ocean Observatory System (AOOS) to address fundamental information needs for the *Changes in Coastal Storms and their Impacts* pilot program. First, AOOS has expanded an inventory of recent and current coastal processes and systems work in the Chuckchi and Beaufort Seas to include the Western Alaska LCC geography. Next, the LCC, AOOS and the Alaska Climate Science Center (ACSC) are collaborating to host a conceptual modeling workshop to better define the relationships between coastal processes and impacts to help guide science efforts in the future.

In addition to the pilot program projects, the LCC Steering Committee agreed to continue its investment in the multi-year "Alaska Integrated Ecosystem Model" along with the ACSC and Arctic LCC. Following is a brief summary of each project, its principle investigators and collaborators. In all, 11 organizations/entities are involved as project leads or co-leads, and an additional 8 are participating as collaborators. The LCC invested $611,000 in the 10 coastal pilot projects in 2012. These projects collectively included $775,000 in leveraged (contributed) funding or support. An additional $50,000 was invested in the Alaska Integrated Ecosystem Model with leveraged costs of $500,000.



The Mission of the WALCC is to promote coordination, dissemination, and development of applied science to inform landscape level conservation, including terrestrial-marine linkages, in the face of landscape scale stressors, focusing on climate change.

USFWS

NPS

The Western Alaska LCC will spend two years focused largely on the *Changes in Coastal Storms and their Impacts* pilot program while the long-term science strategy for the LCC is developed. The suite of projects funded in 2012 will produce products useful in both the short- and long-term for an array of stakeholders including resource managers, community leaders, planners and researchers. Prior to the selection of these projects we asked decision makers to tell us how they might use the products as described in the proposal abstracts.

The LCC is especially pleased that these projects will advance and refine understanding and modeling of nearshore and coastal surge processes, ultimately providing both near-'real-time', region-wide projections for communities (at a resolution of 100s m) and a framework for assessing fine-scale (10-20m) impacts on key resources in key locales. While distinct, these related capacities are the foundation for investigating surge impacts, historic and in real-time, on coastal communities and resources. Some applications for the selected projects are listed (right).

OCEANOGRAPHIC DATA ACQUISITION AND STORM SURGE MODELING

- Provides vital input for accurate storm surge and wave generation models
- Contributes data for surge model assessment
- Increases efficiency of data collection and robustness of data
- Begins to fill existing data gaps in operational models, improving the ability to forecast coastal storm surge and investigate historic and potential future impacts on communities and resources

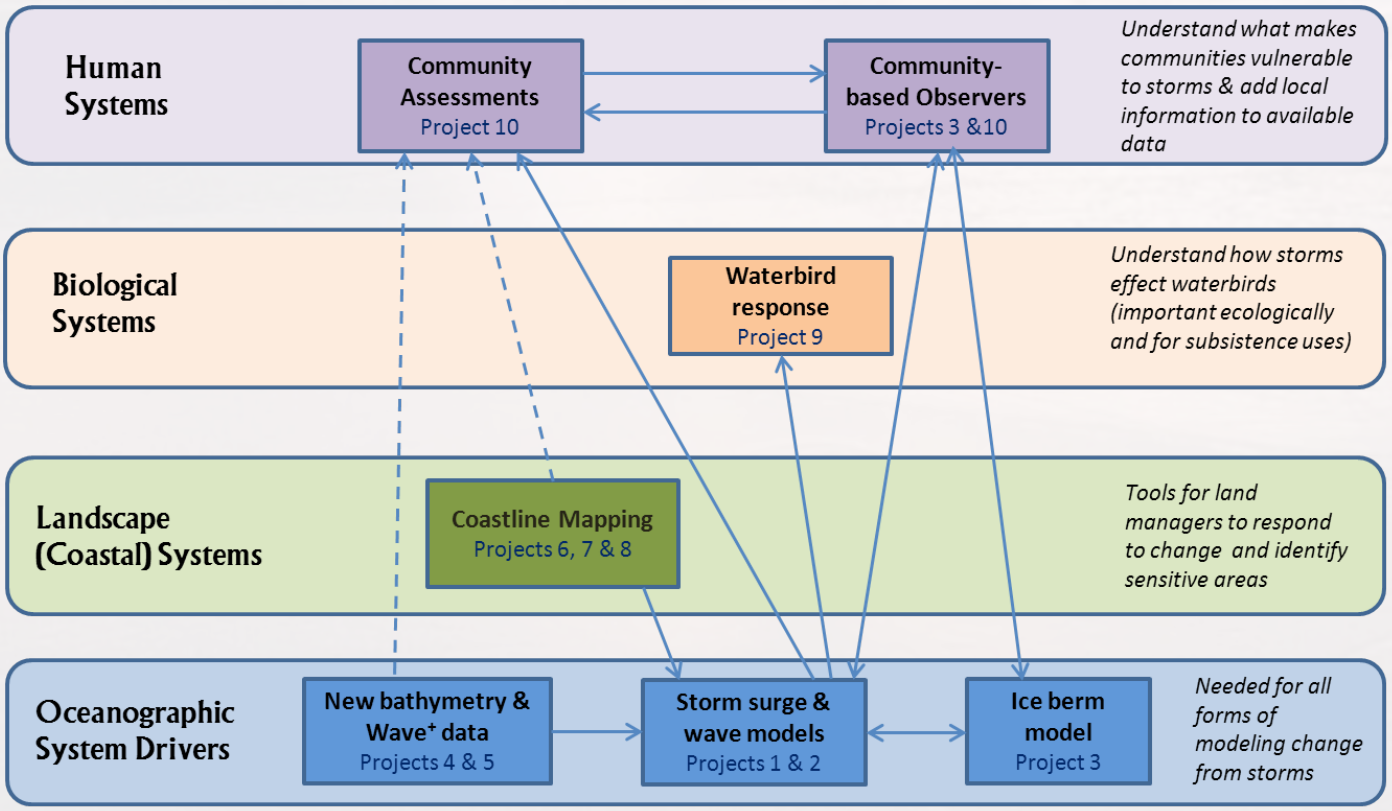
IMPACTS ON COMMUNITIES AND BIOLOGICAL RESOURCES

- Assists decision makers in protecting communities, infrastructure, and lands in Western Alaska
- Contributes to the development of village and borough comprehensive plans
- Aids in long term planning for waterbirds by identifying vulnerable habitats as well as risk and changes to critical habitats

COASTLINE MAPPING

- Provides a baseline for evaluation of ongoing change, including changes resulting from coastal erosion or oil spills
- Informs the evaluation of coastal erosion and coastal construction projects
- Useful for examining coastal conditions near landfills at risk of eroding into marine waters
- Useful in planning community relocation and barge access routes
- Allows for improved delineation of management area boundaries
- Inventories natural and cultural resources to inform response planning for oil spills, shipping accidents, flooding, etc.
- Provides a better understanding of critical habitat occurrence

Relationships among the 10 coastal pilot program projects funded by the Western Alaska LCC in 2012. Each box represents major topics and includes the corresponding project number(s).



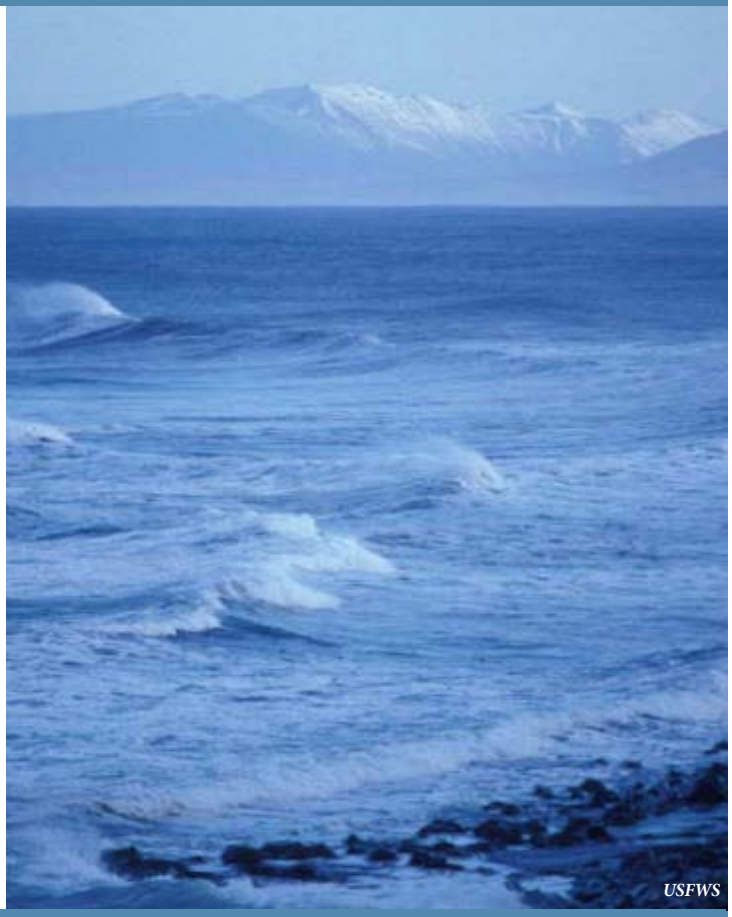
NPS

OCEANOGRAPHIC SYSTEM DRIVERS

1 High-resolution model coupling effects of sea ice, tide, wind-driven wave dynamics, and currents in the formation of Storm Surges in Western Alaska

The western coastline of Alaska is highly susceptible to coastal storms, which can cause coastal erosion, flooding, and can affect commercial efforts. The reduction in ice coverage due to climate change could potentially increase the frequency and degree of coastal flooding and erosion. This project will quantify the effect that the reduction of nearshore ice coverage has on coastal flooding by developing a model accounting for sea ice, tide, wind-driven wave dynamics, and currents on storm surges along the Western Alaska coast. Versions of the modeling system will be evaluated for transition into operations at NOAA/NCEP, including experimental real-time predictions of storm surges. In 2012, the LCC is supporting the consolidation and processing of historical storm data, the first step towards development of a fully functional and validated model.

Project Principal Investigator: Robert Grumbine - National Oceanic and Atmospheric Administration (NOAA)
Collaborators: Joannes Westerink and Patrick Kerr (University of Notre Dame); Andre van der Westhuysen, Hendrik Tolman, Jesse Feyen, and Yuji Funakoshi (NOAA)
Anticipated Completion: Part 1 (Winter 2013)
Related Projects: Ravens (2), Atkinson (3), McCammon (4), Kinsman (5), Brubaker (10)


USFWS

2 Storm surge impacts on biological resources in the Yukon Kuskokwim Delta

USFWS

The primary goal of this project is to expand an existing fine-scale storm surge model to span the Yukon-Kuskokwim (Y-K) Delta from Cape Romanzoff to Nelson Island. Results of the model will be used by collaborator Sarah Saalfeld to examine the relationship between flooding due to particular storms and temporal changes in waterbird abundance and nesting locations (see project 9). The model will also have applicability for future studies related to habitat suitability for a variety species on the Y-K Delta.

Project Principal Investigator: Thomas Ravens - University of Alaska Anchorage (UAA)
Collaborators: Sarah Saalfeld - Manomet Center for Conservation Sciences (MCCS)
Anticipated Completion: Spring 2014
Related Projects: Grumbine (1), Saalfeld (9), Brubaker (10)

Collaborator abbreviations: Alaska Department of Natural Resources (ANDR), Alaska Ocean Observing System (AOOS), Alaska Native Tribal Health Consortium (ANTHC), Arctic Landscape Conservation Cooperative (ALCC), Manomet Center for Conservation Sciences (MCCS), National Park Service (NPS), National Oceanic and Atmospheric Administration (NOAA), University of Alaska Anchorage (UAA), University of Alaska Fairbanks (UAF), University of Victoria (UV), U.S. Fish and Wildlife Service (USFWS)

OCEANOGRAPHIC SYSTEM DRIVERS

3 Community observations to delineate factors influencing the formation of ice berms during storms on the Bering Sea coast, Western Alaska

USFWS

Storm winds can create water level surges that inundate low-lying coastal margins, adversely affecting ecosystems and human activity and infrastructure. The Alaska Bering Sea coast is particularly susceptible to surges because it is regularly affected by strong storms and possesses extensive, low-lying regions. The formation of ice berms can either limit or enhance the adverse impact of storm surge. Using community-based observations of ice conditions, combined with NOAA sea-surface temperature maps, this project will result in a simple model of ice berm development.

Project Principal Investigator: David Atkinson - University of Victoria (UV)
Collaborators: Hajo Eicken and Craig Gerlach - University of Alaska Fairbanks (UAF)
Anticipated Completion: Spring 2015
Related projects: Grumbine (1), Brubaker (10)

4 Leveraging opportunity for wave buoy data collection

One of the largest challenges in understanding changes in coastal processes is the lack of measured ocean data in western Alaska. This project will support data collection in the Bering Sea from a Triaxys oceanographic wave buoy to supplement existing stationary sensors for an additional 2 -3 years. Wave buoy data has numerous applications for both science and industry, and it is a primary tool that will provide real-time data about the volume and direction of water movement towards the shore.

Project Principal Investigator: Molly McCammon (AOOS)
Collaborators: John Walsh (UAF); Rob Bochenek (Axiom Consulting and Design); David Atkinson (UV)
Anticipated Completion: Fall 2014
Related projects: Grumbine (1)

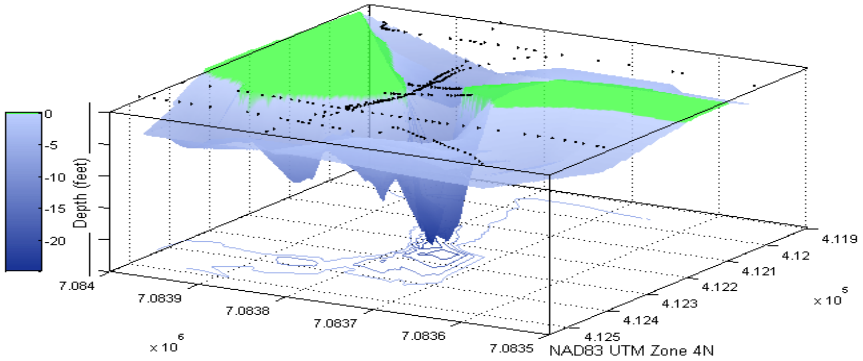
AOOS

OCEANOGRAPHIC SYSTEM DRIVERS

5 Nearshore bathymetric data collection in the vicinity of Western Alaska Communities

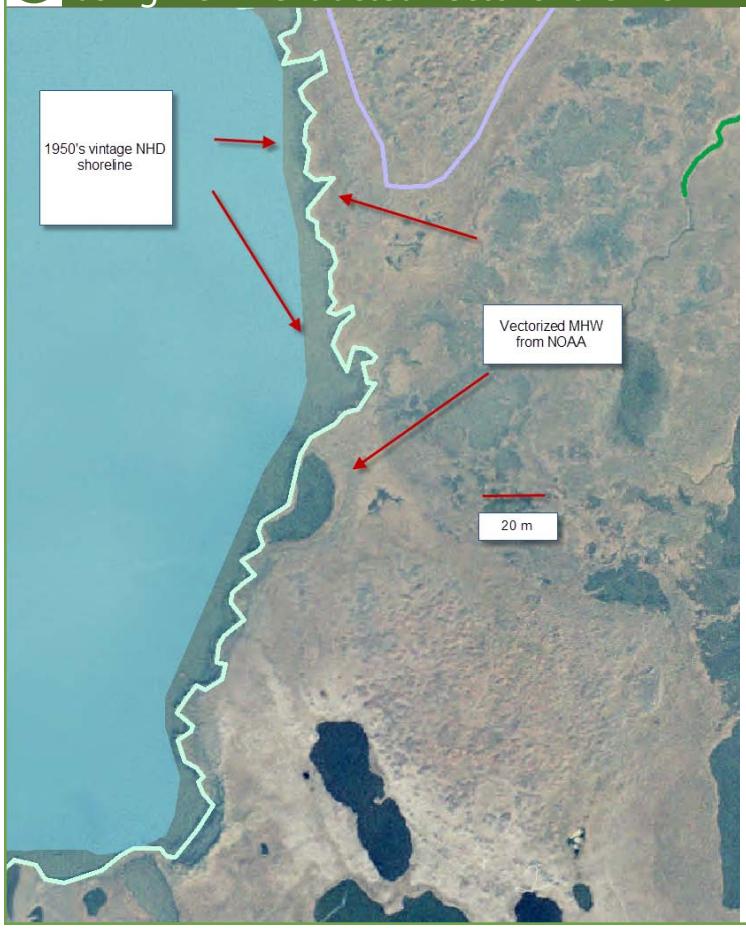
Nearshore bathymetry is a vital link that joins offshore water depths to coastal topography. Seamless water depth information is a critical input parameter for reliable storm surge models, enables the calculation of sediment budgets and is necessary baseline data for a range of coastal management decisions. This project will lead to the collection of nearshore bathymetry around at least five WALCC communities in western Alaska by funding field equipment capable of shallow water measurements in rural settings.

Project Principal Investigator: Nicole Kinsman - Alaska Department of Natural Resources (ADNR)
Collaborators: Molly McCammon (AOOS)
Anticipated Completion: Fall 2014
Related projects: Grumbine (1), Brubaker (10)



LANDSCAPE (COASTAL) SYSTEMS

6 Compilation of NHD Compliant shoreline from Cape Prince of Wales to Cape Espenberg using NOAA extracted vector shoreline



The compilation of an accurate and contemporary digital shoreline for Alaska is a critical step in understanding coastal processes and measuring changes in coastal storm characteristics and impacts. This project is an expansion of work conducted by the National Park Service and will result in a complete, mean high water, digital shoreline for coastal Western Alaska stretching from Cape Prince of Wales to Cape Espenberg. This shoreline dataset will replace existing U.S. Geological Survey (USGS) topographic shoreline data currently represented in the National Hydrographic Dataset and will be publicly available for ongoing investigations into coastal processes. It will serve to strength the ShoreZone mapping project for the Kotzebue Sound and northern Seward Peninsula.

Project Principal Investigator: Andrew Robertson - Saint Mary's University
Collaborators: Joel Cusick - National Park Service (NPS)
Anticipated Completion: Fall 2013
Related projects: Grumbine (1), Neitlich (7), Underwood (8)

LANDSCAPE (COASTAL) SYSTEMS

7 ShoreZone Mapping in Kotzebue Sound

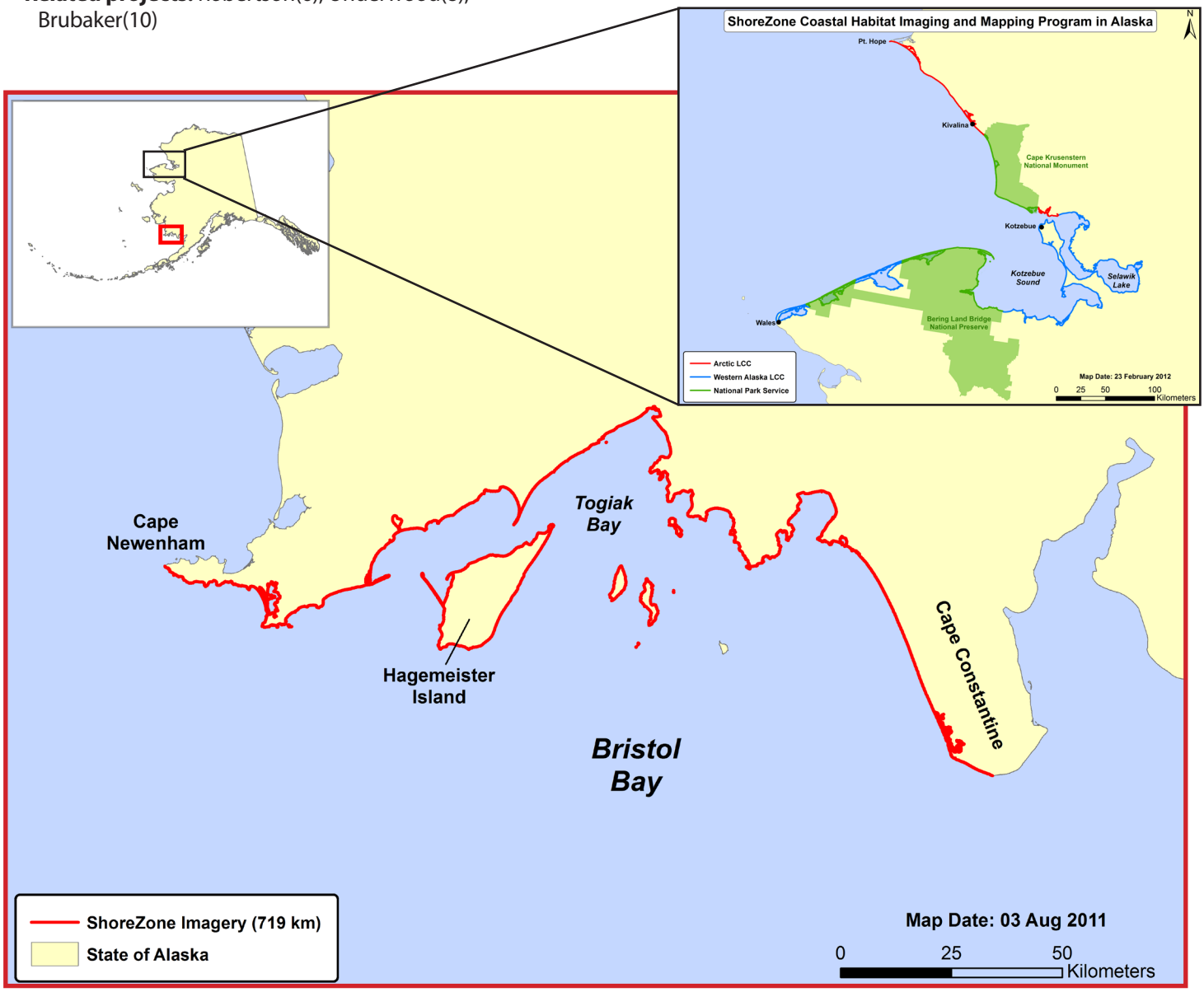
This project will use ShoreZone imagery collected as part of another partnership effort to map nearly 1,600 km of coastline between Wales and Kotzebue, completing the Kotzebue Sound shoreline for inclusion in the state-wide ShoreZone dataset. The complete dataset will be used to conduct a coastal hazards analysis and create maps that identify areas undergoing rapid coastal erosion and areas that are sensitive to inundation by storm surge and sea level rise.

Project Principal Investigators: Peter Neitlich (NPS) and Cindy Hartmann Moore (NOAA)
Collaborators: Tahzay Jones and Steve Lewis (NOAA); Marci Johnson (NPS); Greg Balogh (Arctic LCC); Nicole Kinsman (ADNR)
Anticipated Completion: Winter 2014
Related projects: Robertson(6), Underwood(8), Brubaker(10)

8 ShoreZone Mapping in Bristol Bay

This project will use existing ShoreZone coastal imagery to map 719 km of shoreline in Bristol Bay, from Cape Constantine to Cape Newenham. This section of coastline is an extremely important herring spawning area and an important component of the Bristol Bay fisheries. Intertidal and nearshore vegetation, on which herring spawn, will be catalogued as part of the ShoreZone mapping and, along with shore types, coastal substrate, and coastal biota, added to the state-wide ShoreZone dataset.

Project Principal Investigators: Tevis Underwood - US Fish and Wildlilfe Service (USFWS); Cindy Hartmann Moore (NOAA)
Collaborators: Steve Lewis (NOAA)
Anticipated Completion: Fall 2015
Related projects: Robertson (6), Neitlich (7), Brubaker (10)



BIOLOGICAL SYSTEMS

9 The impacts of storm surges on breeding waterbirds on the Yukon-Kuskokwim Delta, Alaska: past effects and future projected impacts

The Yukon-Kuskokwim (Y-K) Delta, one of the most productive breeding areas in the world for waterbirds, is already experiencing effects from global climate change. Understanding the potential impacts to waterbird habitat resulting from increased storm intensity and frequency, decreased sea ice, and thawing of permafrost is necessary to effectively manage this key region. To evaluate the potential impacts of changes on waterbird habitat due to climate change, this project examines historic responses of water birds to storm surges on the Y-K Delta by examining waterbird breeding parameters before and after coastal storm surges between 1985 and 2012.

Project Principal Investigator: Sarah Saalfeld (MCCS)
Collaborators: Julian Fischer (USFWS); Thomas Ravens (UAA); Stephen Brown (MCCS)
Anticipated Completion: Spring 2014
Related projects: Ravens (2)

Tasha DiMarzio

HUMAN SYSTEMS

10 Community Observation and Vulnerability Assessment

Millie Hawley

No one has better knowledge, and opportunity to document, how coastal storms affect the coast than the people who live in coastal communities. By training the network of Local Environmental Observers (LEOs), and others, in Alaska to collect coastal storm data we improve local capacity to engage in coastal observations. This project builds on the climate change vulnerability assessments performed in Bristol Bay, expanding the assessment process to Northwestern Alaska, and prioritizing communities for climate vulnerability assessments. Through these efforts, Alaska's climate change surveillance system is strengthened, understanding about climate vulnerability is increased, and partnerships to address impact are expanded.

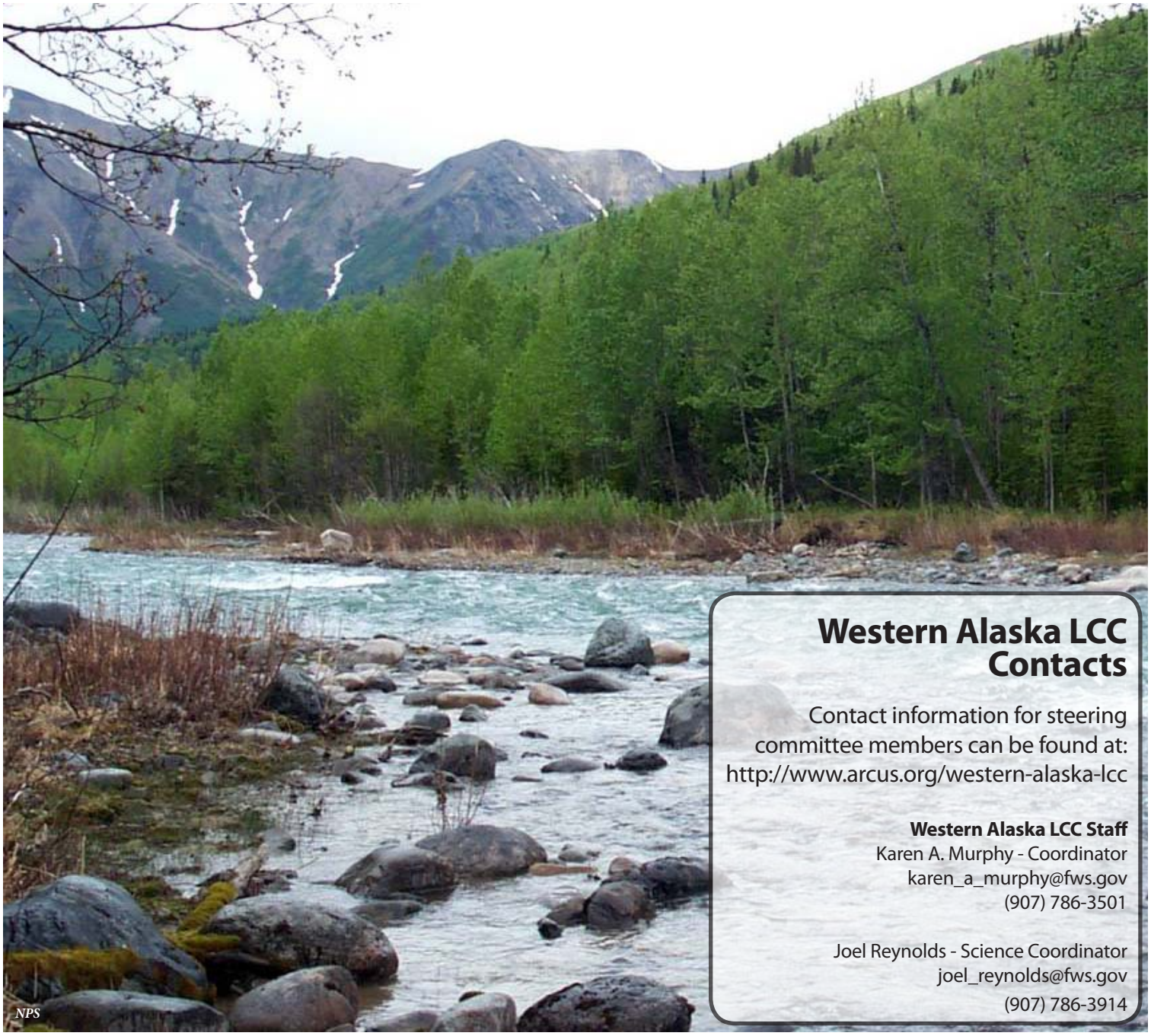
Project Principal Investigator: Michael Brubaker; Alaska Native Tribal Health Consortium (ANTHC)
Collaborators: James Berner (ANTHC); Kevin Zweifel (Norton Sound Health Corporation); Anahma Shannon (Kawerak, Inc.); Paul Eaton (Maniilaq Association); John Chase (Northwest Arctic Borough)
Anticipated Completion: Summer 2014
Related projects: Grumbine (1), Ravens (2), Atkinson (3)

LANDSCAPE SYSTEMS - continuation from 2011

11 Integrated Ecosystem Models for Alaska

This multi-year effort aims to integrate existing models of vegetation, disturbance, and permafrost into a complete ecosystem model for Alaska. Model coupling has been completed and, in collaboration with LCC partners, priority issues have been identified for incorporation into the synchronous model. This year's work will focus on integrating tundra fire processes and treeline dynamics into the model. The completed model will improve understanding and provide accurate change projections to land managers and decision makers across Alaska.

Project Principal Investigators: Scott Rupp and A. David McGuire (UAF)
Collaborators: Amy Breen, Eugenie Euskirchen, Sergey Marchenko, Vladimir Romanovsky (UAF), Arctic LCC, DOI Alaska Climate Science Center, The Wilderness Society
Anticipated Completion: Fall 2015
Related projects: Spalinger (FY11), Fleming (FY11), Romanovsky (FY11), Grosse (FY11)



Western Alaska LCC Contacts

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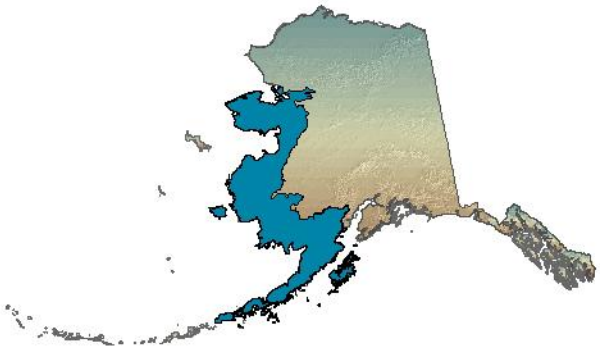
Western Alaska LCC



LANDSCAPE CONSERVATION
COOPERATIVES