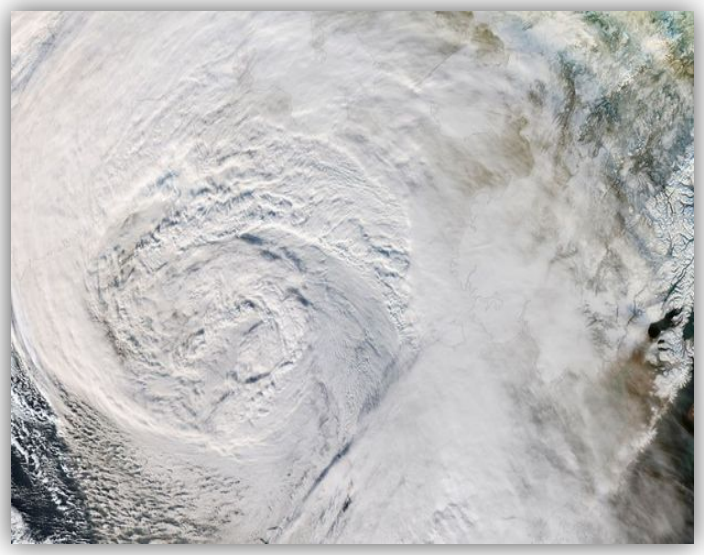
Western Alaska Landscape Conservation Cooperative



In 2012 and 2013 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.

2013 **Annual Report – Year 2 of Coastal Systems theme**

Table of Contents

I. Introduction

In 2013 the Western Alaska Landscape Conservation Cooperative was in its second year of a two-year funding focus on "Changes in Coastal Storms and their Impacts". We are pleased to release the third annual report for the Western Alaska Landscape Conservation Cooperative (LCC). When we began 2013 the LCC had five major tasks in mind to fulfill the activities described in the FY12 – FY13 Science and Operating Plan. These major tasks were:

1. Broaden our Alaska Native engagement, particularly at the Steering Committee level.
2. Continue progress on "Changes in Coastal Storms and their Impacts" focus with the recommendations from the Coastal Hazards Workshop.
3. Collaboratively build off of the recommendations from the Stream and Lake Temperature Monitoring workshop.
4. Develop & adopt a FY14-15 Science and Operating Plan
5. Develop a long-term science strategy and complete a draft plan.
6. Continue to work with partners on projects sponsored by the LCC.

Some of the year's highlights include:

- Adding a new Steering Committee member to represent Alaskan Native perspectives from the Bristol Bay region of the LCC.
- 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 to expand our Changes in Coastal Storms and their Impacts understanding.
- Defining the topic for our Freshwater Systems theme as "Changes in freshwater temperature and its impacts" and implementing a suite of actions that will improve our ability to understand climate change effects on freshwater systems, species and services.
- Public outreach about our proposed long-term strategic science framework that rotates the LCC's funding focus in two-year increments between Coastal, Freshwater and Terrestrial System themes.
- Completion of a Science and Operating Plan to provide detailed guidance and timelines for the FY14 and FY15 years.
- Development of a long-term science strategy Draft Plan.
- Continued collaboration and management on projects funded in 2011 and 2012.

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 14 entities represented on the Steering Committee but over 80 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://westernalaskalcc.org

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. 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 were 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.

Dillingham Alaska

At the start of 2013, the LCC was still operating with its original LCC Steering Committee charter that included three seats for people who could "represent Alaska Native perspectives". With the completion of our concerted outreach effort in 2012 we wanted to expand the representation on the Steering Committee so that all geographic regions of Alaskan Natives within the LCC were included. In 2013 our Steering Committee agreed to ask the four Regional Native Associations within the geography (Kawerak, Association of Village Council Presidents "AVCP", Bristol Bay Native Association "BBNA", and the Aleutian and Pribilof Islands Association "APIA") as well as the collection of Tribes on the Kodiak Archipelago to help us contact and nominate individuals interested in serving on the Steering Committee. By the end of this process we had a new Steering Committee member and an Alternate member representing the Bristol Bay geography, and we had a member from the Sun'aq Tribal Council interested but they ultimately determined that without funding they could not participate at that level of the LCC. Additional contacts have been made and may still result in new members.

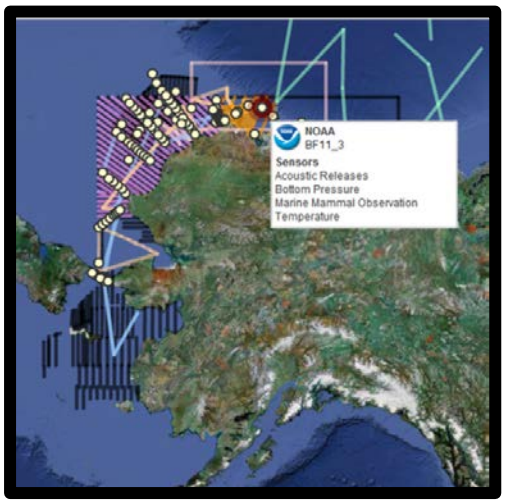
IV. Coastal Systems Theme: "*Changes in Coastal Storms and their Impacts*"

In 2012 the LCC began a two-year focus on "Changes in coastal storms and their Impacts", hereafter referred to as "Coastal Storms Impacts". While this began as a pilot program to enable the LCC to make progress on a topic while long-term planning activities were completed, it became the heart of our long-term science strategy. It quickly became obvious that by putting our energy towards a specific topic, the LCC was able to generate a much more integrated program that stimulated partners to act even beyond the LCC-sponsored activities.

The LCC went through a process to identify potential topics through the Steering Committee entities. We utilized the results of the 2011 Shared Science Needs workshop as a starting point to initially focus the dialog. Based on the feedback received the Steering Committee decided that a coastal processes focus would be best, with hydrological processes a close second. An Organizing Committee was convened to identify a focused topic and a range of actions that could make a difference in reducing the uncertainties for decision makers. That team recommended a focus on "Coastal Storm Impacts". The 2012 Annual Plan describes this effort in more detail and the recommendations produced through the Coastal Hazards workshop.

A. Progress on the FY12 sponsored projects

In a region with two seas and the northern extent of the Pacific Ocean, the impacts from changing climates on sea ice and coastal storms are already being felt at coastal communities. Historically, sea ice formation has occurred before most of the winter storms hit the western coast of Alaska. The sea ice serves like a blanket over the ocean creating a dampening effect on the waves, and shorefast ice protects the coast against wave-based. Over the last several decades, overall sea ice extent has decreased[3], while shorefast ice season has declined by about one week per decade[4,5]. This is due primarily to delayed ice formation in early winter, leaving the coastline, coastal habitats and our coastal communities exposed to intense wave and storm surge action. 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. Table 1 describes the end-to-end view on how the LCC views the coastal storms impacts priorities.



[3] Cavalieri, D.J. and C.L. Parkinson. 2012. Arctic sea ice variability and trends, 1979-2010. *The Cryosphere* 6, 881-889

[4] Mahoney, A., H. Eicken, A. Graves Gaylord and L. Shapiro. Alaska landfast sea ice: Links with bathymetry and atmospheric circulation. *Journal of Biophysical Research* 112, C02001, doi:10.1029/2006JC003559

[5] Yu, Y., H Stern, C. Fowler, F. Fetterer and J. Maslanik. Interannual variability of arctic landfast ice between 1976 and 2007. *Journal of Climate* 27, 227-243

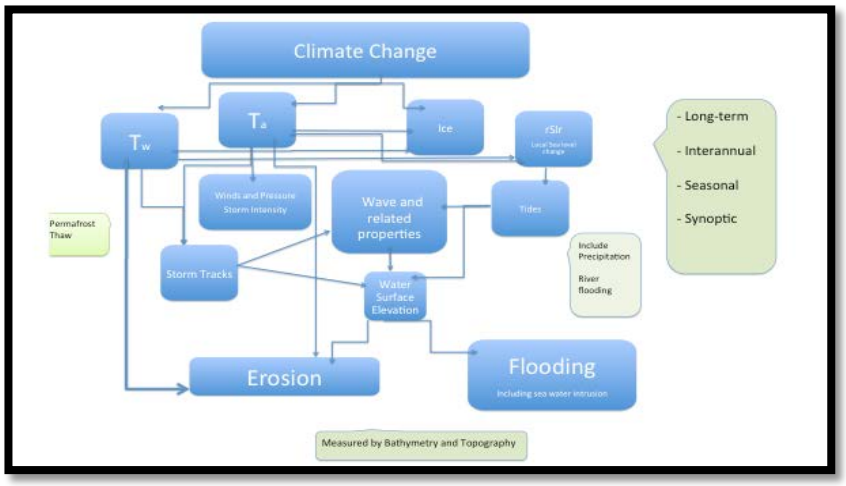
Table 1. Illustrates how the LCC has priorities linking drivers through habitats, through species, to humans in its emphasis on Coastal Storm Impacts.

Changes in coastal storms and their impacts priority resource focus			
Oceanographic Drivers	**Coastal Feature**	**Key Species**	**Human Systems**
			
Drivers: Sea Ice change and Coastal Storms	Features: coastline, nearshore habitats, coastal plains and inundation zones	<u>Waterbirds:</u> Greater White-fronted geese, Emperor geese, black brant, red-throated and yellow-billed loons, black scoter, spectacled eiders	Primary Nexus: coastal communities and infrastructure; human safety; subsistence access
Changes in occurrence, intensity, duration and effects; changes in protective barriers provided by sea ice berms and barrier islands	Changes in erosion, salinity, frequency, depth and duration of inundation	Exposure to salinity, altered vegetation, potential shift in breeding distribution	Coastal erosion putting communities at risk, weak real-time forecasting models to guide safety response, safety concerns over traditional access to subsistence species
Applications: storm forecasting; wave dynamics; ocean habitat modeling	Applications: coastal vulnerability assessments; emergency response planning	Applications: species vulnerability assessments, predictive modeling, subsistence opportunities	Applications: emergency forecasting, community planning, adaptation strategies, safety plans
LCC Projects: ocean circulation models; wave buoy data; storm surge models; sea ice berm formation	LCC Projects: Coastal mapping; nearshore bathymetry; tidal benchmarks; storm surge models; coastal erosion mapping	LCC Projects: breeding waterbird vulnerability to historical and predictive storm surges and sea level rise.	LCC Projects: Local observer training; local input to sea ice berm formation models; community vulnerability; erosion mapping; emergency response tools

Seven 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 2012 the remaining four were the focus for the RFP announced in January 2012. See our website for a description of the Collaborator Projects funded in 2012.

1. ***Inventorying Activities in Coastal Areas:*** Status = completed. 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:*** Status = Completed. 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.



3. ***Modeling the ocean dynamics that drive storms:*** Status = On-going. Unlike other parts of the country's coastline, Alaska is very poorly instrumented for wave and tidal data collection. This has handicapped the development of oceanographic models that are used elsewhere in forecasting and predicting storms and their impacts. Through our

Coastal Hazards workshop and through the proposals received in 2012, we were able to identify steps that could be taken today to improve circulation models for the Bering Sea. In partnership with NOAA's National Weather Service and Notre Dame University we are sponsoring that model improvement and testing it against historical storm characteristics.

In addition to the above work, we expanded work already underway on the Yukon and Kuskokwim River Delta (YK Delta) to downscale the broad circulation model and "join it" to the land so that storm surges can be modeled across this vast low-elevation critical wetland. This effort, co-funded with the Alaska CSC is being conducted by the University of Alaska Anchorage. As with the broader model, the same historical storms are being assessed and the model is then re-run with two future potential sea level rises. Initial results show that the storm surge patterns will expand far inland from their current inundation levels with even a slight rise in sea level (Fig. 1)

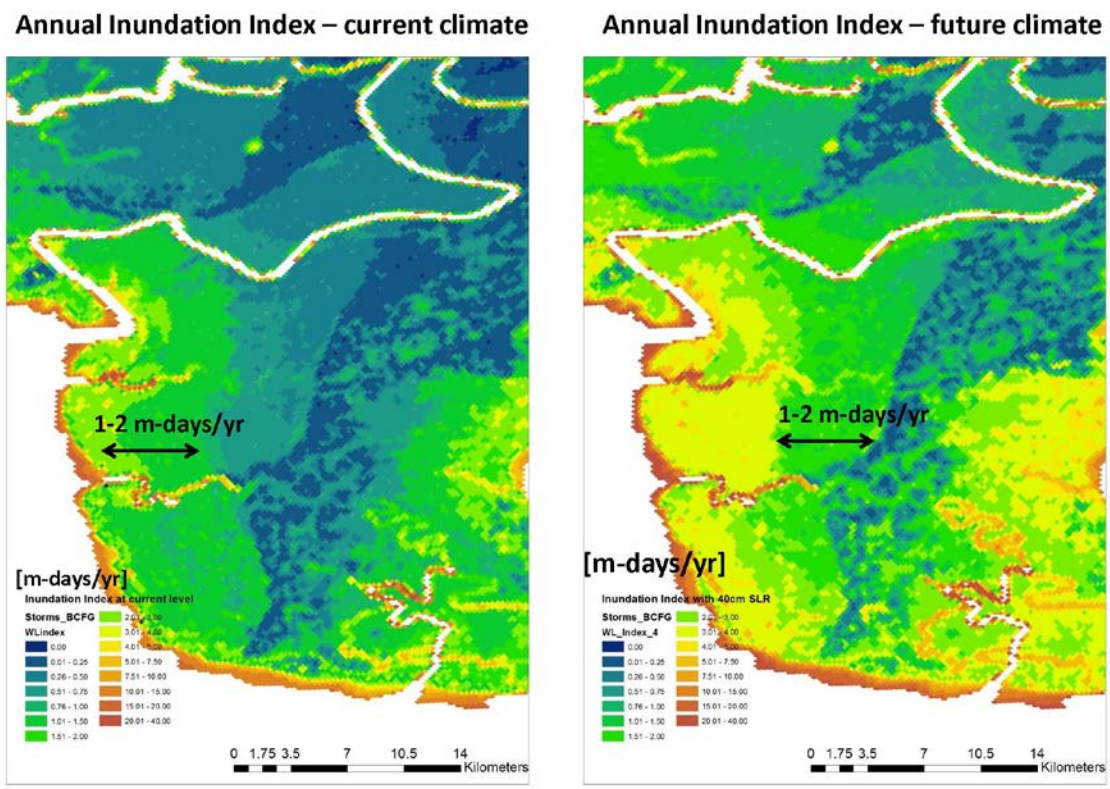
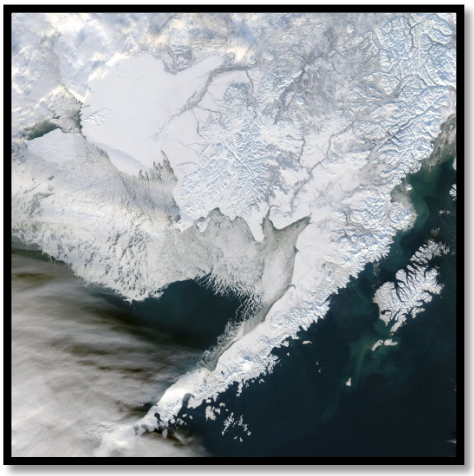


Fig. 1. Storm surges are likely to extend inland under scenarios of sea level rise, suggesting a shift in the location of Brackish Wet Sedge Meadow vegetation type..

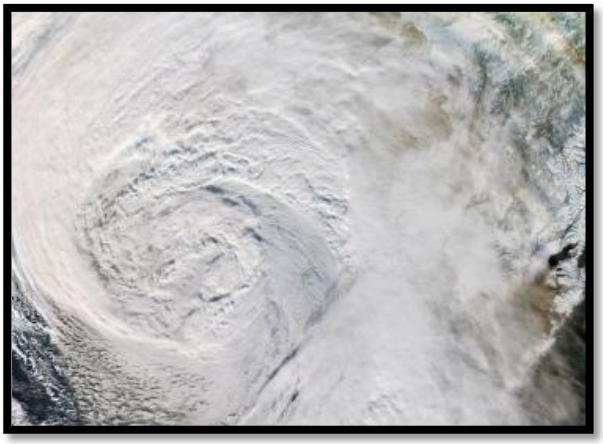
4. ***Shorefast ice dynamics:*** Status = on going. We considered proposals to develop and apply methods to document shorefast ice characteristics and long-term dynamics. Of particular interest were ice timing, residency, extent and characteristics (i.e. from slush to solid). The LCC funded a project that will engage with coastal communities to help modellers identify the ice development conditions that lead to the formation of ice berms. Ice berms can be beneficial in providing a barrier to on-coming waves and storm surges and thus provide a dampening affect. Ice berms can also be incredibly destructive if they break free because they can scour the earth as they are moved inland. The University of Alaska Fairbanks is interested in incorporating these effects into simulation and storm tracking models but need information from locals on the conditions that cause them to form. In addition to LCC-sponsored work, partners have been working to compile an atlas of historical sea ice. The beta version of the atlas is now available at: http://seaiceatlas.snap.uaf.edu/.



5. ***Local involvement in monitoring coastal dynamics*:** Status = on going. 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. The LCC funded the Alaska Native Tribal Health Consortium (ANTHC) to work with the LCC on a project with two major components. One part is to work with a couple of coastal communities to conduct vulnerability assessments relative to coastal storms. These assessments will help provide a framework that can be used in other communities. The second component is to utilize the Local Environmental Observer (LEO) network to train and garner input from LEO's across Alaska (see http://www.anthc.org/chs/ces/climate/leo/). Specifically, ANTHC conducts monthly webinars which are partially used for training and partially an information exchange forum. We coordinate with ANTHC to provide training and presentations related to the coastal storm impacts work. These exchanges have provided real-time information to modelers about weather and ice conditions, and have generated a lot of discussion and information exchange with local communities.

6. Effects of changes in coastal storms on coastal biological resources (including subsistence resources and habitats). Status: On-going. Ultimately, the LCC is interested in understanding the relationships between storms, habitat change, and biological resource response. The LCC built upon, and linked, on-going work from the U.S. Geological Survey (USGS), FWS, the Alaska CSC, Manomet Center and the University of Alaska Anchorage) to create vulnerability assessments for water birds on the YK Delta. The YK Delta is a wetland of international importance providing key breeding area for many bird species. Among these are several of the species identified as important for the LCC in our 2011 Shared Science Needs workshop. The first step is to develop habitat suitability models for these breeding birds, then look at FWS breeding bird survey data to determine their historical breeding areas, and finally, take the historical storm models from #3 above and see if there was a distribution change the following breeding season which may be a result of a change in habitat suitability conditions. Finally, the future storm projections will be evaluated against the habitat suitability data to provide managers with a scenario of how populations may respond changes caused by coastal storm changes.

We also sponsored completion of ShoreZone inventory and mapping activities in the Kotzebue Sound region, Bristol Bay and portions of the Alaska Peninsula. ShoreZone is an important tool for decision makers to use in planning coastal activities and emergency response. ShoreZone identifies sensitive areas based on their biological community composition, shoreline characteristics and their potential vulnerability to change.



7. ***Opportunities to leverage deployment of instrumentation or data collection.*** Status: On-going. 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. Two projects were funded under this topic one re-deployed a Triaxys buoy in the Bering Sea to provide additional real-time data about water movement for oceanographic models. This project is in partnership with

the University of Victoria, the Alaska Ocean Observatory Systems (AOOS) and NOAA. In the autumn of 2013 when this buoy was due to be picked up before sea ice formed, the storms prevented vessels in the area from retrieving the buoy. After attempts by three different vessels, a vessel under contract by Shell Oil was able to retrieve the buoy. We are grateful for both the crew and Shell Oil's assistance in reclaiming this important equipment.

The second project is one that came from partners who were at the Coastal Hazards workshop and were trying to find ways to meet one of the key recommendations from the group. The recommendation was that we needed to get more sites along the coast that had three key pieces of empirical data: tidal benchmarks, nearshore bathymetry, and high resolution topographic data. These three data elements are necessary to model the interaction between the ocean and the land which is key to understanding and addressing impacts to coastal priority resources and communities. In partnership with the Alaska Department of Natural Resources (ADNR), and AOOS, we helped support nearshore bathymetry data collection near six communities in western Alaska.

B. LCC sponsored projects in 2013

In 2013, the Western Alaska LCC continued to fund projects addressing science needs related to *Changes in Coastal Storms and their Impacts*. Several of these projects are a result of proposals submitted under the 2012 solicitation related to shorefast ice dynamics, local involvement in monitoring coastal dynamics, the effects of coastal storms on biological resources, and opportunities to leverage data collection. These projects were identified as high priorities in 2012, but were not funded until 2013. The suite of coastal projects, which will result in key datasets for resource managers and researchers addressing climate-related changes to coastal processes and resources, represents a $395,000 investment by the Western Alaska LCC in 2013, and leverages $633,000 in contributed support.

New projects funded in 2013 for the Coastal Storms Impacts topic include the mapping of coastal change, specifically erosion, using historical landsat data for the entire coast of the LCC. This will help managers understand the distribution, magnitude and rate of change along the coastline. This project is being conducted in partnership with the Alaska Biological Research, Inc. In addition, the Alaska Department of Natural Resources revisited and calibrated tidal benchmarks in several coastal communities to help improve models and the development of tidal datums for new communities.

Finally, the LCC provided support to the FWS for new instrumentation of Kigigak Island on the YK Delta. This island is within the storm surge modeling zone and the data will prove useful to that effort as well as to the FWS studies on the nesting and brood-rearing habitats for several species of waterbirds. The site is also being considered as a potential reintroduction site for Steller's eider and the instrumentation will help refine models to understand the sites long-term viability as an eider breeding location.

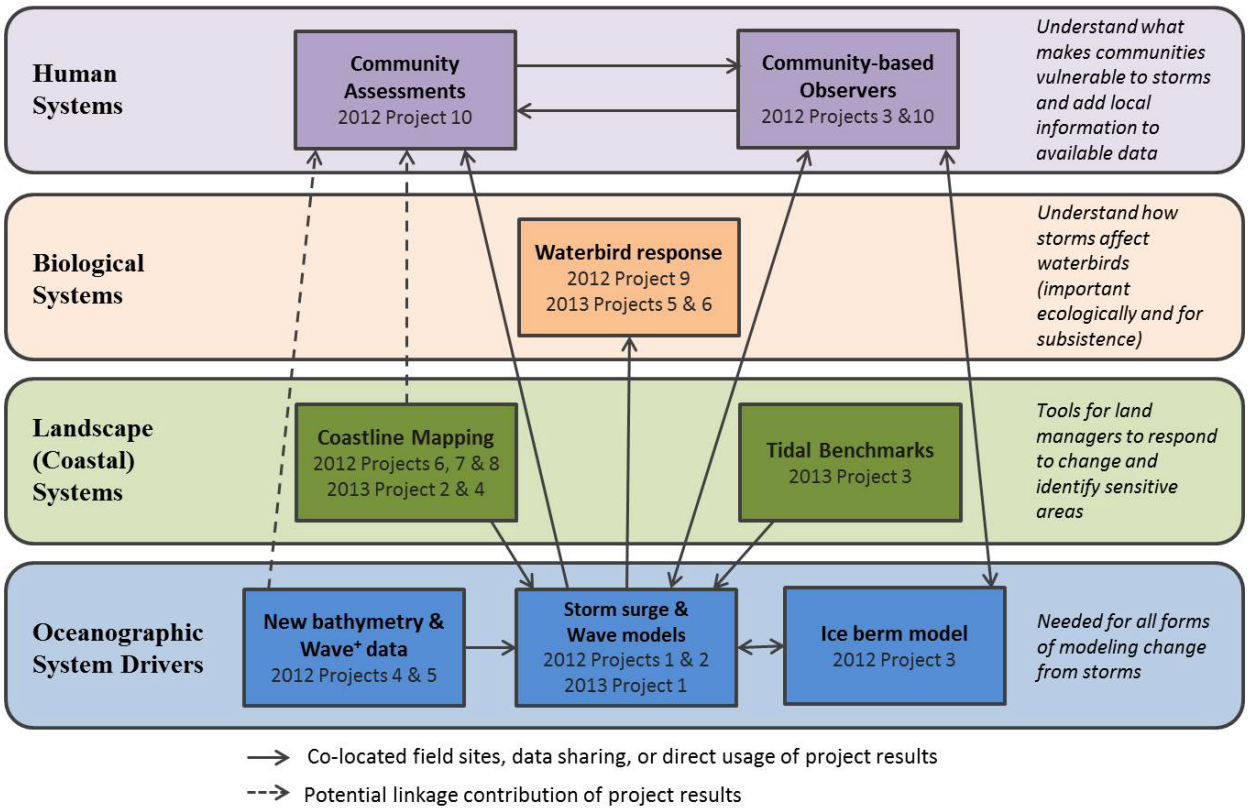


Fig. 2. Relationships among the Coastal Storms and their Impacts projects funded by the Western Alaska LCC in FY12-13. Each box represents major topics and includes the corresponding project number(s).

In addition to the coastal projects, the LCC invested in two additional projects. In response to the results of a jointly-hosted Stream and Lake Temperature Monitoring Workshop, funding was provided for the creation of a geospatial database to document where freshwater temperature data are being collected across Alaska. This project is part of the LCC's mini pilot program on *Hydrological Processes*, and will provide segue into the 2014-2015 *Freshwater Streams* funding focus. This is described in more detail in section V of this report. Finally, in collaboration with the DOI Alaska Climate Science Center and the Arctic LCC, the Western Alaska LCC continues to invest in the Integrated Ecosystem Model for Alaska and Northwest Canada. Collectively, the LCC invested $495,000 in 8 projects to address climate-related science priorities for Alaska. See project descriptions on our website here.

C. Partner Activities

One of the challenges faced by the LCC, and any partnership cooperative, is to be able to understand how their actions may serve as a catalyst for partners to act outside of the LCC sponsored activities. In a region where many groups are trying to understand climate change, and where recent storms are highlighting the impacts to communities and resources, there are a lot of related activities underway. In 2013, USGS provided funding for the LCC to put towards communications/outreach products. The Steering Committee decided to seek partners in these activities through a Request for Proposals (RFP) released in September 2013. The RFP sought partners in three topic areas 1) the development of an Alaska focused invasive plant

identification App for smart phones; 2) compilation of partner activities related to coastal change projects; and, 3) social media assistance to the LCC partnership. Proposals selected for the first two (none were received for the third topic) and will be started in 2014.

The compilation of partner activities will provide a tool for decision makers to identify coastal projects in their area and also provide the LCC with a starting place to reassess progress on coastal change issues when we revisit the Coastal Systems theme in 2017 as we plan for FY18 and 19.

V. Freshwater Systems Theme

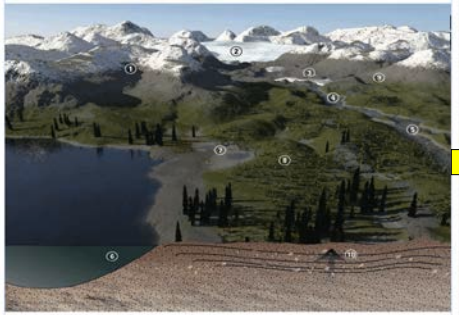
A. *"Changes in Freshwater Temperature and its Impacts"*

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.

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?*

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. Table 2 describes how freshwater temperature change links to LCC priorities for FY14-15.

Table 2. LCC Priorities for the 'Changes in freshwater temperature and its impacts' topic.

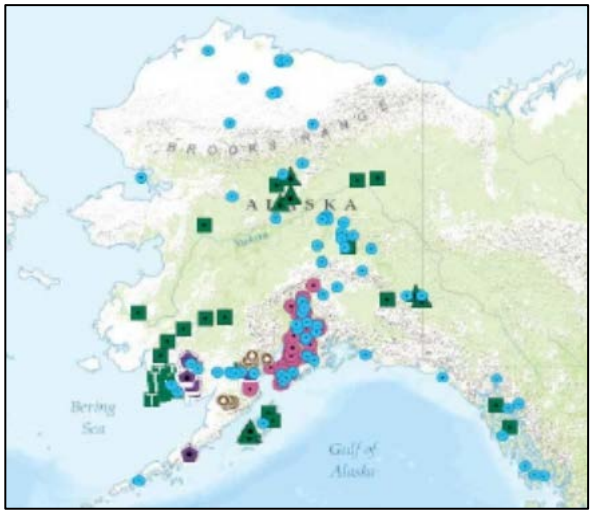
"Changes in freshwater temperature and its impacts" priority resource focus			
Hydrological Driver	**Landscape features**	**Key Species**	**Human Systems**
			
Priority Drivers: water temperature change (*major uncertainty in relationship to climate variables)	Features: lakes, streams and rivers	Fish: sockeye salmon, chinook salmon, other salmonids, whitefish and sheefish Bears: brown and black bears (lower priority in FY14-15)	Primary Nexus: changes in species variability and distribution. Economic, subsistence and ecosystem management links. Algae in community water sources.
Links to snowpack (1); glacial retreat (2); sedimentation (5); lake/stream dynamics: flow, turnover, chemicals (6); changes in perched lakes; vegetation colonization.	Changes in water temperature linked to stream flow, primary productivity, contaminant(s) availability.	Potential shifts in habitat suitability for spawning, rearing, and over-wintering fish species.	High dependence of Alaskan communities on fisheries resources; on marine transport of nutrients to support bear populations; water treatment challenges.
Applications: predictive models of system change. Change in variability of system types.	Applications: habitat suitability and vulnerability.	Applications: stock assessment, ecosystem health	Applications: fisheries management for subsistence, commercial, recreation uses
LCC Projects: goals/objectives linked to climate change; water temp data standards; snow contributions to stream chemistry; identification of monitoring units	LCC Projects: Large lake and lagoon temperature; Demonstration of regional climate analyses with water temperature data	LCC Projects: Impact of water temperature change on sockeye salmon embryo development; snow input into stream characteristics and changes on fish availability	LCC Projects: two of five subregions are starting water temperature monitoring network implementation plans; community vulnerability assessments.

The workshop recommendations and the LCC's actions to follow-through on the recommendations are described in detail in the FY14-15 Science and Operating Plan. In general the top recommendations from the workshop 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 committed a portion of their FY13 project funding to implementing these workshop recommendations. The workshop report is posted on our website Science page. In 2013, the LCC began to take action on the first two recommendations in recognition that these are crucial before a more comprehensive suite of activities could be implemented. Recommendation #1 was completed in 2013 and described in the FY14-15 Science and Operating Plan. Although there are many purposes that a water temperature monitoring network could achieve, the goals and objectives described are for the LCC and Alaska CSC whose primary interest is in utilizing these data for climate change analyses and predictions.

The second recommendation to complete a comprehensive inventory of project metadata and attributes (e.g., who, what, where, when) for current and past stream and lake temperature monitoring efforts was put out in an RFP in early 2013. The University of Alaska Anchorage's Natural Heritage Program is now partnering with the LCC to complete a spatial inventory of existing water temperature monitoring efforts. This statewide database will be analyzed by the Alaska CSC and USGS to be used as a tool for a designing a water temperature monitoring network (Recommendation #3).



Early geospatial database of AK temperature monitoring studies. Jan 2014.

Recommendations #4 and #5 were a part of an RFP open from late August to late October 2013. There were three topics within the RFP. The first was to develop the baseline standards necessary for water temperature data to be used for climate change analyses. This work will be conducted by the Alaska Natural Heritage Program at the University of Alaska Anchorage. Second, we recruited lead partners in different sub-regions across the LCC (that are ecologically different from each other) to develop implementation plans for how they would serve the broad range of stakeholders in the area to build a voluntary participation water temperature monitoring network. Two regions submitted successful proposals and we are moving forward with this strategy in both the Bristol Bay and Kodiak Archipelago subregions of the LCC.

The final topic in the RFP was a request for proposals to demonstrate/document/predict the impacts of temperature change on priority resources (processes, species or services in this case). Fourteen proposals were received on this topic. We selected a proposal from researchers at the University of Alaska Fairbanks, who seek to understand how changes in water temperature influences population-specific patterns of embryo incubation, timing of hatching and fry emergence, and embryo survival of sockeye salmon in the Bristol Bay region.

To address the "Demonstration Project" of recommendation #4, the LCC determined that there was only one partner and subregion in the LCC where there may be sufficient data and longevity of data collection to conduct this demonstration project. We asked for a proposal to be developed and it was selected for inclusion in the suite of funded projects.

B. Updating Alaska's National Hydrography Dataset

Throughout our planning phase to launch the "Freshwater Systems" theme, we kept hearing about how partners were struggling to get a version of the National Hydrographic Dataset (NHD) for Alaska that met national standards. The NHD provides the geospatial data for anyone who needs to know where lakes, rivers and streams are located across the landscape, as well as provide a rigorous coastline delineation. Unfortunately the NHD for Alaska is outdated and has some serious inaccuracies. It was originally based on 1950's topographic data which were developed without the modern tools that provide greater accuracy. Errors in the dataset can be severe, such as streams or rivers that appear to be a ¼ mile or more off from their true positions, in some cases leading to the digital appearance of the stream running upslope!

The magnitude of the problem to review, correct and update the NHD over Alaska's 365 million acres has challenged partners for many years. It has prevented Alaska from being included in

some National Assessments of fish habitat because it could not be rolled up to match with data from the rest of the country. The process to repair the dataset requires either ground-truthed data or high resolution imagery which is cost prohibitive across the full state. Nevertheless, Alaskan partners have been working to correct the data layers as they initiate projects throughout the state. The actual uploading process to make these corrections available to all partners has been one of the limiting factors in actually updating the NHD. The Interagency Hydrologists Committee for Alaska (IHCA) identified the need to update NHD as its number one recommendation of a tractable action for the Alaska Climate Change Executive Roundtable to support.

In 2013 the Western Alaska LCC led a multi-LCC, USGS and Alaska CSC effort to secure national LCC funding to help us resolve some of the NHD issues in Alaska. The USGS established an Alaska Hydrology Working Group which will help guide the project. The project will establish an NHD Coordinator for Alaska for an 18-month position with the University of Alaska. This person will expand upon work done in southeastern Alaska to make a refined user interface tool available throughout the state, help facilitate its use by partners and oversea the final QA/QC before providing updates to the NHD.

VI. 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 from those 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"). The decision was made to identify three themes based on processes: *Coastal Systems, Freshwater Systems and Terrestrial Systems*.

Preceding the first FY of a funding program, the LCC will undertake a planning phase of six to twelve months to identify the priority *topic*, *resources,* and (at least initial) *strategic activities* to focus on during the next two-year program (Table 3). The LCC staff will engage partners in collaboratively developing recommendations. The development process will use relevant information needs, strategic plans and activities of partners, shared science needs identified at

the 2011 Science Workshop, and other appropriate resources. The Steering Committee selects the final topic.

In all cases, topic development should involve consideration of three components, each of which may require its own development efforts:

1. The priority *information needs* of decision-makers and priority outcomes of interest related to the theme. Specifically, the LCC should place priority on those topics and associated activities that allow the decision-makers to better understand the potential impacts of climate change, and their decisions, on the common outcomes of interest.
2. The associated priority *science needs* - major sources of uncertainty regarding impacts of climate change on priority outcomes of interest, or activities necessary to improve understanding of these impacts and meet the information needs of the decision-makers.
3. Strategic opportunities for *leveraging* and *promoting collaborative partnerships* in addressing the science needs – among partners operating within the LCC, with local communities, with neighboring LCCs, the Alaska CSC or other statewide entities and organizations, etc.

Table 3. The planned sequence of LCC emphasis through 2021.

	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
Coastal Systems	Funding Year	Funding Year	Coastal Projects Completed							
Freshwater Systems		Planning Phase	Funding Year	Funding Year	Freshwater Projects Completed					
Terrestrial Systems				Planning Phase	Funding Year	Funding Year	Terrestrial Projects Completed			
Coastal Systems						Planning Phase	Funding Year	Funding Year	Coastal Projects Completed	
Freshwater Systems								Planning Phase	Funding Year	Funding Year
Terrestrial Systems										Planning Phase

In March 2013, we proposed this framework in an outreach document distributed to partners and the public. In general, feedback on the approach was very positive, though caution to ensure that the LCC also sought to understand the interrelationships across themes was important feedback.

With the long-term science strategy framework in place we began drafting a 10-year science plan. The draft plan is currently under Steering Committee review and will be made available in 2014. In addition to guidance on determining the priority topic focus for each funding-cycle theme, it also describes the LCC's approach for identifying priority resources through their linkages to the selected topic, the LCC's role in long-term monitoring and data management, and steps to evaluate and review our progress. The long-term science strategy draft also

includes a cross-walk between the LCC program and the strategies outlined in the National Fish, Wildlife and Plants Climate Adaptation Strategy.

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 refined the broad theme of 'Freshwater Systems' to the priority topic of "*Changes in Freshwater Temperature and its Impacts*." Section V of this report (pg 13) describes the selection of this topic and the actions already undertaken or planned for in FY14 and 15. Additional details are found in the FY2014-2015 Science and Operating Plan. 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.

The new Science and Operating plan also describes the broader range of LCC activities and decision strategies. Section III of the plan provides an updated Operating Plan for the LCC. We outline our communications strategy, the anticipated steps to prepare for the *Terrestrial Systems* theme, and refinements to our administrative management of the LCC. This includes decisions that the Steering Committee made to:

1. equalize partners' ability[6] to use the seed money provided via the US Fish & Wildlife Service for LCC-sponsored projects
2. preserve the flexibility to address time-sensitive needs that do not fit within the programmatic topic or theme
3. guide the data management of LCC-sponsored projects.

In 2014, the LCC will also launch two projects made possible by funding from the USGS Alaska Science Center. The funds were provided to the LCC for projects that utilize social media or smart phones and for communication products that would contribute to the Western Alaska LCC's science planning. The Steering Committee issued an RFP in September 2013 and decided to fund two projects:

1. The development of a smartphone App (Android and iPhone applications) to enable identification of invasive plants in western Alaska.
2. Develop an outreach document that describes the suite of coastal change studies underway in western Alaska. This document will be designed to enable decision makers in western Alaska to find projects already underway in their area or on a topic they are interested in understanding. It will also provide the LCC with a starting place when we begin to evaluate the state-of-the-knowledge and progress made on coastal storm impacts when we begin planning our next round of Coastal Systems focus in 2017.

[6] The federal funds are designated as "two year" funding which limits Federal partners ability to utilize these funds beyond the two-year time period. In contrast, non-governmental partners can utilize these funds for up to five years.

VII. Summary

The Western Alaska LCC made significant progress in solidifying business models and in initiating actions to meet its mission. We began the year with the five major tasks described below:

1. Broaden our Alaska Native engagement, particularly at the Steering Committee level.

   We continued outreach efforts among the 116 Tribal Councils and five Regional Native Associations and recruited an additional Steering Committee member. There are now two of six seats filled to represent Alaska Native perspectives at the governing level of the LCC.

2. Continue progress on "Changes in Coastal Storms and their Impacts" focus with the recommendations from the Coastal Hazards Workshop.

   Six new projects were initiated related to coastal storm impacts. Two of the original seven tasks identified in through the partnership workshop were completed in 2013, the remainder all have at least one project underway to advance our ability to address uncertainties.

3. Collaboratively build off of the recommendations from the Stream and Lake Temperature Monitoring workshop.

   Several of the workshop recommendations required completion of a geospatial map of existing water temperature monitoring efforts in Alaska. The LCC funded this effort and it should be completed by the end of FY14. The workshop recommendations were used to develop a request for proposals released in August 2013, and the Steering Committee selected projects/actions to fund in 2014. These include developing base standards for water temperature monitoring to use in climate change assessments, selection of two sub-geographies to develop implementation plans to lead a voluntary participation water temperature monitoring network, a demonstration project to illustrate how these data can be used to inform decision makers, and two projects looking at the effects of temperature change on priority resources.

   In addition to the Stream and Lake Temperature activities, the LCC partnered with the USGS, the Fish Habitat Partnerships and the other LCCs in Alaska to advance the ability for partners to update the National Hydrography Dataset (NHD) in Alaska. Co-led by the Western Alaska LCC staff and the USGS, we will expand upon existing work from southeast Alaska to establish an NHD Coordinator for Alaska, train users, and improve the update "flow" into the national dataset. New regions of the state will also have upgraded data provided as a result of the project.

4. Develop and adopt a FY14-15 Science and Operating Plan

This plan was completed in 2013 and is now available on line at https://westernalaskalcc.org/science/SitePages/operatingplan.aspx. It describes refinement to our business model (operating plan) and describes the science focus for FY14 and FY15.

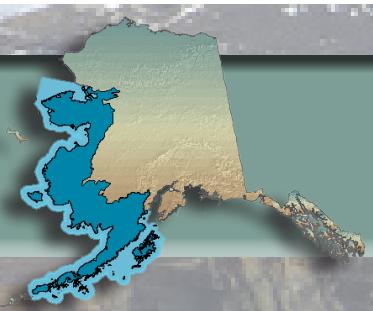
5. Develop a long-term science strategy and complete a draft plan.

   The initial draft plan was completed in 2013. It is currently out for review with the Steering Committee.

6. Continue to work with partners on projects sponsored by the LCC.

   The LCC continues to manage the cooperative agreements established over the last three years. Most of the projects begun in 2011 will be completed in 2014, as were some of the initial coastal systems projects. We continue close collaboration with the Alaska Climate Science Center and other partners to effectively leverage our on-going and future activities.

Appendix C: Summary of 2013 Collaborator Projects



Western Alaska
Landscape Conservation Cooperative

2013 Projects: Coastal Systems

In 2013, the Western Alaska LCC continued to fund projects addressing science needs related to *Changes in Coastal Storms and their Impacts*. Several of these projects are a result of proposals submitted under the 2012 solicitation related to shorefast ice dynamics, local involvement in monitoring coastal dynamics, the effects of coastal storms on biological resources, and opportunities to leverage data collection. These projects were identified as high priorities in 2012, but were not funded until 2013. The suite of coastal projects, which will result in key datasets for resource managers and researchers addressing climate-related changes to coastal processes and resources, represents a $395,000 investment by the Western Alaska LCC in 2013, and leverages $633,000 in contributed support.

In addition to the coastal projects, the LCC invested in two additional projects. In response to the results of a jointly-hosted Stream and Lake Temperature Monitoring Workshop, funding was provided for the creation of a geospatial database to document where temperature data are being collected across Alaska. This project is part of the LCC's mini pilot program on Hydrological Processes, and will provide a segue into the 2014-2015 Freshwater Streams funding focus. Finally, in collaboration with the DOI Alaska Climate Science Center and the Arctic LCC, the Western Alaska LCC continues to invest in the Integrated Ecosystem Model for Alaska and Northwest Canada. Collectively, the LCC invested $495,000 in 8 projects to address climate-related science priorities for Alaska.

Mission

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.

Coastal

...AND THEIR IMPACTS

Through expansion of existing efforts and the inclusion of complementary projects, the 2013 Coastal Storms projects build on work funded by the LCC in 2012 (see http://westernalaskaLCC.org for more information). The new 2013 projects continue to target key uncertainties and science priorities identified by managers and scientists for Western Alaska. They will result in improved understanding of nearshore and coastal processes and provide much needed information and products to planners, researchers and resource managers.

Two projects from 2012 were expanded. New projects include a remote sensing image analysis to detect coastal erosion along the entire Western Alaska LCC coast; ShoreZone Mapping on the Alaska Peninsula; expanded instrumentation to merge biological and tidal information on the Yukon Kuskokwim Delta; and leveraging work by the State of Alaska to revisit some tidal benchmarks in western Alaska communities.

Coastal Projects Funded in 2012

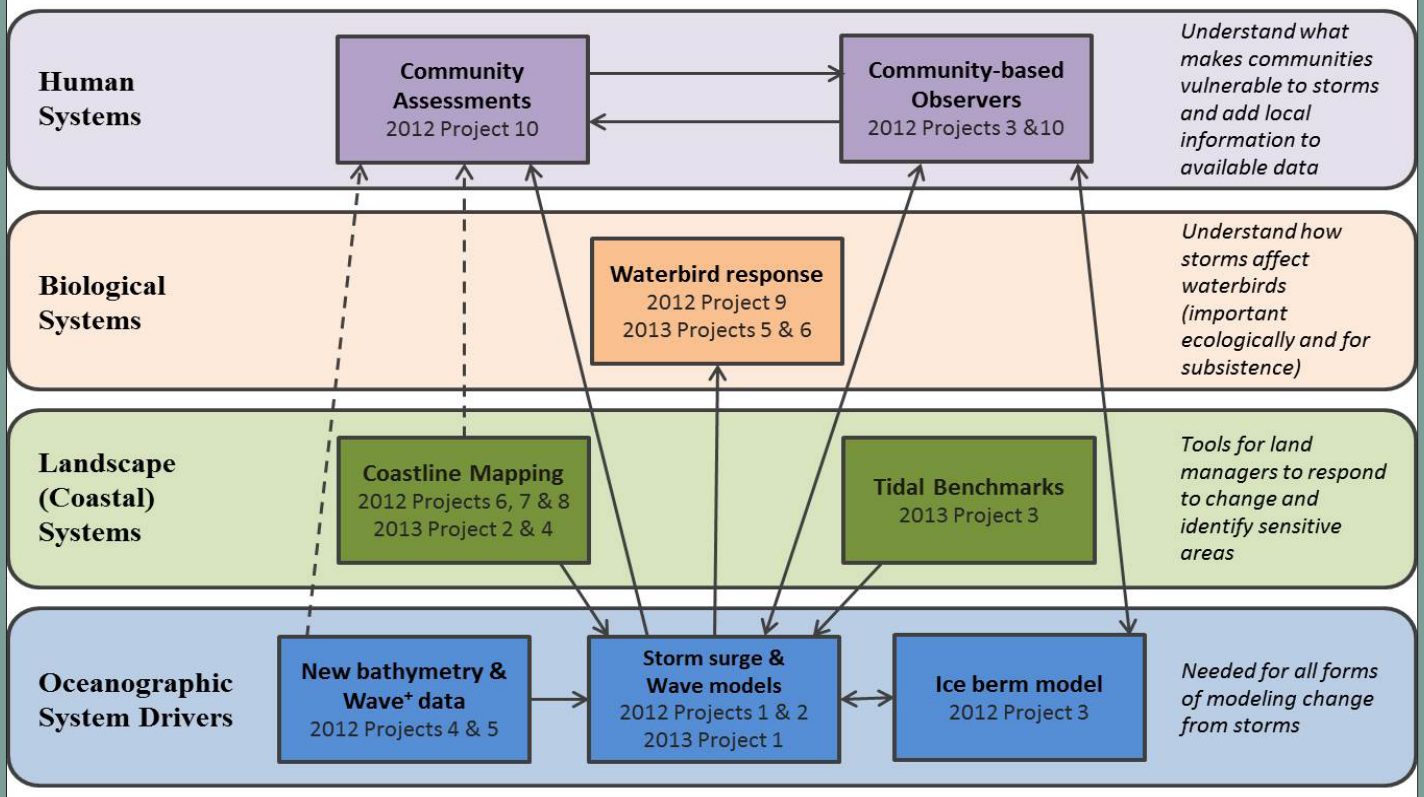
1	High-resolution model coupling effects of sea ice, tide, wind-driven wave dynamics, and currents in the formation of storm surges in Western Alaska (Part 1)
2	Storm surge impacts on biological resources in the Yukon Kuskokwim Delta
3	Community observation to delineate factors influencing the formation of ice berms during storms on the Bering Sea coast, Western Alaska
4	Leveraging opportunity for wave buoy data collection
5	Nearshore bathymetric data colletion in the vicinity of Western Alaska Communities
6	Compliation of NHD compliant shoreline from Cape Prince of Wales to Cape Espenberg using NOAA extracted vector shoreline
7	ShoreZone mapping in Kotzebue Sound
8	ShoreZone mapping in Bristol Bay
9	The impacts of storm surges on breeding waterbirds on the Yukon-Kuskokwim Delta, Alaska: Past effects and future projected impacts (Part 1)
10	Community observation and vulnerability assessment

Storms

Coastal Projects Funded in 2013

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 (Part 2)
2	Extensive mapping of Bering Sea and Gulf of Alaska coastal change by Landsat time series trend analysis, 1985-2012
3	Reconnaissance static occupation of Tidal Benchmarks in Western Alaska
4	ShoreZone mapping on the southern Alaska Peninsula
5	Expanding environmental monitoring instrumentation on Kigigak Island
6	The impacts of storm surges on breeding waterbirds on the Yukon-Kuskokwim Delta, Alaska: Past effects and future projected impacts (Part 2)

Relationships among the *Coastal Storms & their Impacts* projects funded by the Western Alaska LCC in 2012-2013. Each box represents major topics and includes the corresponding project number(s). Visit westernalaskalcc.org.

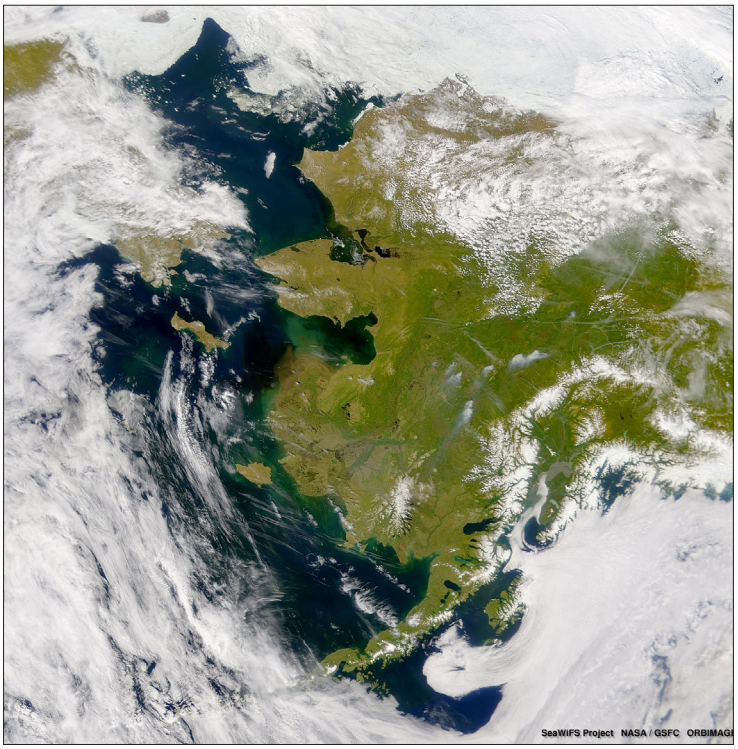


OCEANOGRAPHIC SYSTEM DRIVERS

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

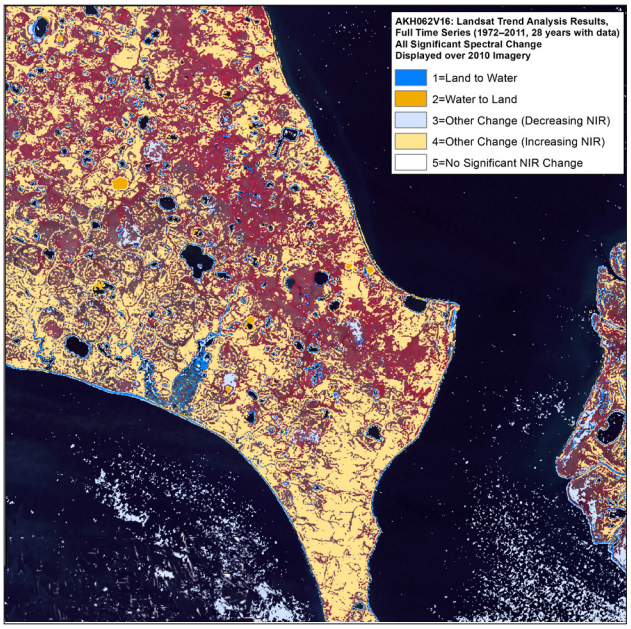
Principle Investigator: Robert Grumbine, National Oceanic and Atmospheric Administration
Collaborators: Joannes Westerink & Patrick Kerr, University of Notre Dame; Andre van der Westhuysen, Hendrik Tolman, Jesse Feyen & Yuji Funakoshi, National Oceanic and Atmospheric Administration
Anticipated Completion: Fall 2014
Related Projects: 2, 3, 4, 5, 10 (2012)

Reduction in nearshore ice coverage due to climate change may increase the degree and frequency of coastal flooding and erosion along the coastline of western Alaska. This project, which was partially funded by the Western Alaska LCC in 2012, will quantify the effects of reduced ice coverage on storm surges through the development of a model that accounts for sea ice, tide, wind-driven wave dynamics and currents. This work provides the foundation for the development of an improved operational model and better forecasting capabilities for western Alaska.



LANDSCAPE (COASTAL) SYSTEMS

2 Extensive mapping of Bering Sea and Gulf of Alaska coastal change by Landsat time series trend analysis, 1985-2012



Principle Investigator: Matthew Macander, ABR, Inc.
Collaborators: N/A
Anticipated Completion: Fall 2014
Related Projects: 7, 8 (2012); 3, 4 (2013)

The extent of change to the coastline and to coastal features, such as spits, barrier islands, estuaries, tidal guts and lagoons, is known to be substantial in some areas along the western Alaskan coast (e.g., portions of the Yukon-Kuskokwim Delta). However, the extent of change along the full Western Alaska LCC coast is not well documented. This project will provide important baseline information on the distribution and magnitude of landscape changes over the past 41 years, and will result in an assessment of habitat loss and identification of hotspots of change, providing guidance for selecting areas for further research and monitoring.

LANDSCAPE (COASTAL) SYSTEMS

3 Reconnaissance static occupation of Tidal Benchmarks in Western Alaska

DNR Photo by Nicole Kinsman

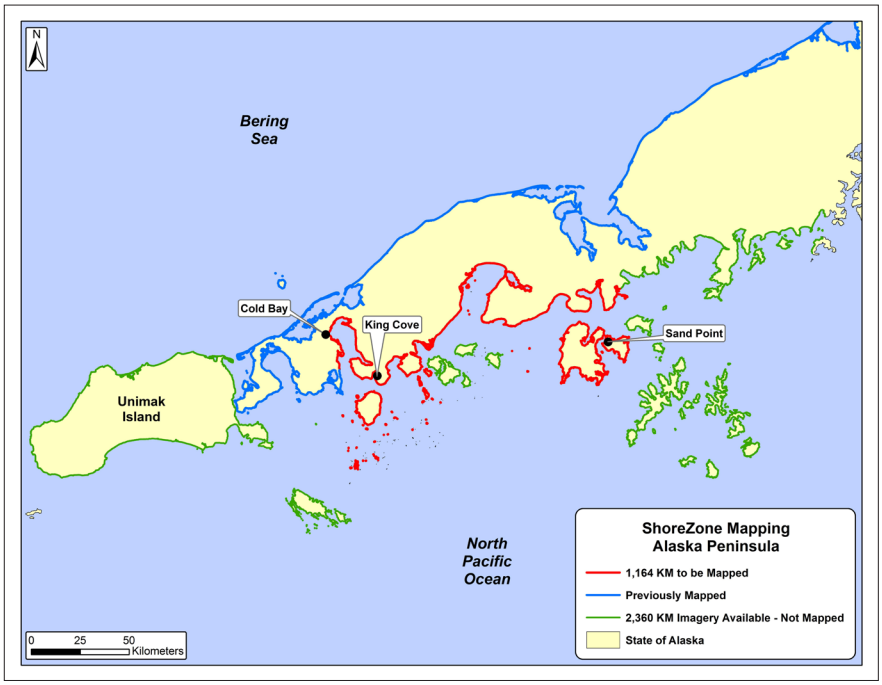
Principle Investigator: Nicole Kinsman, Alaska Department of Natural Resources
Collaborators: Jeff Freymueller, University of Alaska Fairbanks
Anticipated Completion: Fall 2014
Related Projects: 1, 2, 7, 8 (2012); 2, 4 (2013)

Understanding the causes of relative sea level rise requires knowledge of changes to both land (uplift and subsidence) and sea level. However, measurements of coastal uplift or subsidence are almost completely lacking in western Alaska. This project will result in precision measurements of prioritized benchmarks across the Western Alaska geography. This will improve the network of published tidal benchmark elevations, allowing for tidal datum conversion in more places, and providing a necessary component for improved inundation studies in coastal communities and low-lying areas.

4 ShoreZone mapping on the southern Alaska Peninsula

Principle Investigator: Cindy Hartmann-Moore, National Oceanic and Atmospheric Administration
Collaborators: Steve Lewis & Mandy Lindeberg, National Oceanic and Atmospheric Administration
Anticipated Completion: Winter 2015
Related Projects: 6, 7, 8, 10 (2012); 2 (2013)

ShoreZone provides an inventory of the biological and geographical resources along Alaska's coast. To facilitate completion of ShoreZone Mapping on the southeastern Alaska Peninsula, the Western Alaska LCC will support mapping of 1,164 km from Cold Bay to Balboa Bay and including Unga Island. Mapping data will be added to the state-wide ShoreZone dataset and will be publically accessible online for oil spill and emergency planning and response, community planning, habitat management, invasive species detection and monitoring, and other uses.



NOAA Map

BIOLOGICAL SYSTEMS

5 Expanding environmental monitoring instrumentation on Kigigak Island

Principle Investigator: Melissa Gabrielson, US Fish & Wildlife Service
Collaborators: Nathan Graff & Tuula Hollmen, University of Alaska Fairbanks; Thomas Ravens, University of Alaska Anchorage; Sarah Conn, US Fish & Wildlife Service
Related Projects: 2, 9, (2012); 6 (2013)

Baseline hydrologic and topographic data in relation to waterfowl productivity is very limited on the Y-K Delta. When considering the potential impacts of climate-driven change to nesting and brood-rearing habitats, these baseline data are important for making informed management decisions. This project takes advantage of a long-term field camp on Kigigak Island to expand instrumentation for monitoring pond water levels and salinities, and tidal dynamics. It will also support elevation surveys and the synthesis of environmental and biological datasets for inclusion in climate change models.

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

Principle Investigator: Sarah Saalfeld, Manomet Center for Conservation Sciences
Collaborators: Julian Fischer, US Fish & Wildlife Service; Thomas Ravens, University of Alaska Anchorage; Stephen Brown, Manomet Center for Conservation Sciences
Anticipated Completion: Spring 2015
Related Projects: 2 (2012); 6, 9 (2013)

This project, which was partially funded in 2012, evaluates the potential impacts of a changing climate on waterbird habitat on the Y-K Delta. Utilizing existing, long-term datasets, as well as new storm surge models currently under development (2012 WALCC funding), this project analyzes waterbird distribution and breeding parameters before and after historic storms. It will result in the development of habitat selection models and habitat suitability maps for breeding waterbirds, and will identify potential refugia. Results will inform management decisions related to designing and monitoring surveys, regulating harvest, conserving endangered species, and managing at-risk habitats.

NON-COASTAL PROJECTS

FRESHWATER SYSTEMS

7 Alaska online aquatic temperature site (AK-OATS)

Principle Investigator: Jamie Trammell, University of Alaska Anchorage
Collaborators: Dan Bogan, Rebecca Shaftel & Marcus Geist, University of Alaska Anchorage
Anticipated Completion: Fall 2014

The first of two projects funded outside of the Coastal Processes theme, this work is the beginning of our transition from Coastal topics to Freshwater topics.

Alaska's freshwater resources, vitally important for salmon and other species, are vulnerable to changes resulting from climate change. Though temperature is a critical element in the suitability of aquatic habitats, Alaska's stream and lake temperature monitoring is occurring through independent agencies/partners without a means to link and share data. Because a coordinated network of monitoring data can help scientists and managers understand how aquatic systems are responding to climate change, conducting an inventory of past and present stream and lake temperature monitoring efforts has been identified as a priority science need for Alaska. This project will consolidate existing monitoring site locations and attributes into a statewide, spatially referenced dataset and will result in the development of an online interface that will enable partners to add additional information. This is not a database for storing temperature data, rather the first step in creating a network which should ultimately link data.

USFWS Photo by Katrina Mueller

NON-COASTAL PROJECTS

TERRESTRIAL SYSTEMS

8 Integrated Ecosystem Model for Alaska and Northwest Canada

Principle Investigator: Scott Rupp & David McGuire, University of Alaska Fairbanks
Collaborators: Eugenie Euskirchen, Sergei Marchenko & Vladimir Romanovsky, University of Alaska Fairbanks; Arctic LCC; DOI Alaska Climate Science Center
Anticipated Completion: Fall 2015

The second project funded outside of the Costal Processes theme is the result of a multi-year investment by the LCC and other organizations.

The Integrated Ecosystem Model for Alaska and Northwest Canada is designed to help resource managers understand landscape change due to climate-driven changes in vegetation, disturbance, hydrology, and permafrost. This multi-year projects leverages contributions from several partners, and will result in a broad variety of datasets for use by managers and researchers. Currently, IEM is developing new functionality to better address additional ecosystem dynamics, including thermokarst and wetland dynamics.

Contact the Western Alaska LCC

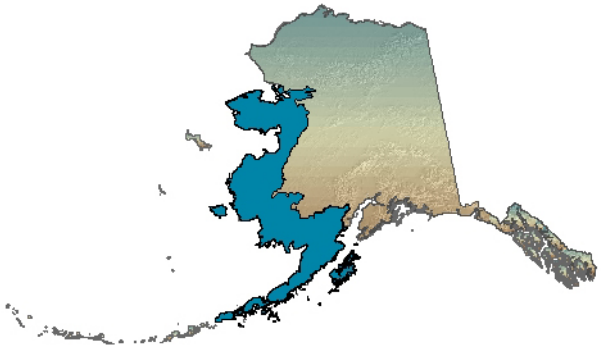
Steering Committee
http://westernalaskalcc.org/governance/sitepages/steeringcommittee.aspx

Karen Murphy, Coordinator
karen_a_murphy@fws.gov
(907) 786-3501

Joel Reynolds, Science Coordinator
joel_reynolds@fws.gov
(907) 786-3914

LANDSCAPE CONSERVATION COOPERATIVES

Western Alaska LCC



LANDSCAPE CONSERVATION COOPERATIVES