

## NERRS Science Collaborative Progress Report for the Period 08/31/2012 through 03/1/2013

**Project Title:** Assessing Coastal Uplift and Habitat Changes in a Glacially Influenced Estuary System Located in Kachemak Bay, Alaska

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**Project start date:** 22 September 2010

**Report compiled by:** Angela Doroff

**Contributing team members and their role in the project:** Stacey Buckelew (KBNERR CTP Coordinator), Ed Clark (UAF Geophysical Institute), Jess Ryan, Carmen Field, (KBNERR Education and Outreach), Conrad Field (KBNERR Habitat Biologist)

### A. Progress Overview

Understanding the balance of the conflicting forces of land and sea-level rise is important to the communities surrounding Kachemak Bay, which depend on near-shore fisheries for food and safe harbor infrastructure for transportation. A goal of our project is to provide scientific data to community leaders regarding how land and sea-level changes may impact community services and local ecology. This study builds upon existing work on coastal processes developed by the University of Alaska, Fairbanks (UAF) and monitoring and mapping of salt marsh habitats by the Kachemak Bay National Estuarine Research Reserve (KBNERR). In this study, we will model land and sea-level changes in the Kachemak Bay region based on intensive data collection with high precision global positioning system (GPS) instruments. Much of the infrastructure for the city of Homer is not on bedrock, and may have a different rate of change than bedrock sites. Salt marsh plants range from freshwater to salt-tolerant plants in the vegetation community structure and provide a sensitive indicator of sea-level rise. We will develop a long-term monitoring program of emergent vegetation in select salt marshes in Kachemak Bay. When paired with the GPS data, mapped vegetation plant communities provide valuable information on relative shifts in sea-level rise and land-level change over time. In our region, coastal uplift is due to after-effects from the 1964 earthquake, the steady buildup of strain for the next big earthquake (strain accumulation), and rapid melting of heavy ice contained in local glaciers and ice fields (isostatic re-adjustment). Melting glaciers also contribute to local and global sea level rise.

We have continued to make good progress on data acquisition and have had thoughtful communication among researchers and Core Intended Users (CIU) on this project. We completed all field sampling in the salt marshes by the end of September. On 19 September, we held a CIU meeting to discuss the types of products would be most useful to the group. We also presented a surprising result from the Continuously Operating Reference Station site on the Homer Spit (Spit); land level at this site significantly different than its nearest neighbor at the Public

Works station. All sites are indicating uplift with the exception of the Spit. Methods for assessing the problem were discussed; if it is reflective of the entire Spit, the harbor area will not be out-pacing global sea level rise. We decided to omit the regularly scheduled CIU meeting to be held on 5 December 2012 in favor of having a discussion section at our Kachemak Bay Community Council Meeting on the issue of relative sea level rise for the Spit. While surveying our coastal decision-makers, we had an opportunity to work with the Army Corp of Engineers to share information and data on land level changes based on data they had for the Spit. During the winter, we continued sample analyses and data processing. We developed a data table to facilitate data management and metadata from the project.

## B. Working with Intended Users:

- **Describe the progress on tasks related to the integration of intended users into the project for this reporting period.**

During this reporting period we held one (CIU) meeting with our collaborators on the study (19 September 2012) and we discussed potential methods of communicating the results back to the group. We presented maps of each of four salt marsh sites in the study showing vegetative cover types, relative abundance of fish in tidal channels, and anadromous streams. During the March CIU meeting, sediment transport was still a major concern for the City of Homer, Harbor representatives. As a result of these previous discussions, we worked with a NOAA intern, Taylor Bennett, to provide a poster on sediment transport processes for the Homer area. The goal of the poster was to provide better information on processes influencing sediment transport and to develop a common vocabulary of terms when we discussed the processes. The poster was presented at this meeting and was then transferred to the City of Homer offices (the maps and poster are part of the meeting notes located at <http://www.nerrs.noaa.gov/NSCIndex.aspx?ID=648> (the meeting notes/presentations are along the sidebar)).

We also re-visited the draft parameters for developing products from the study to help refine formats that will be beneficial to the end users of the information. In general, not much new was added at the time of this meeting. The any new information is in italic font below:

- a. Making the Time Scale Relevant to Users Needs: Implementation of plans happens within a 5-year time frame but planning for larger-scale fiscal process is longer.
  - i. The information on RSL may or may not be at a scale that is useful on the short-term decision-making. *There was general agreement from the group on this.*
  - ii. The information is more relevant for long-term budget planning such as 20yr to 50 yr time frame. *ACOE has a longer-term planning*

*process (20yrs) for major projects. In general, this still seemed about right from the group.*

- b. The City of Homer CIUs recommended the following focal areas to provide higher resolution map products for:
  - i. Homer Harbor (Homer Spit),
  - ii. Kachemak Drive,
  - iii. the Seawall area,
  - iv. Any area where the bathymetry is a shallow basin and would exaggerate effects of RSL change.
  - v. *No new sites were recommended by the group*
  
- c. Other information or data layers that are important to decision-making
  - i. For infrastructure and land use planning, include coastal erosion rates to the uplift projections.
  - ii. Physical processes such as sediment transport and coastal erosion are part of the equation.
  - iii. *No other data layers were identified at this time*
  
- d. Information Transfer doesn't stop here with the researchers and Core Intended Users. People involved in city planning and budgeting need to be comfortable communicating the results of this study to other people they work with such as ACOE, financial planners, and collaborators.
  - i. Presenting results from the past (1970s), present, and future case scenarios to help frame the discussions.
  - ii. *The group liked this idea*
  
- e. How do we share data and data products from this project? *There wasn't a lot of discussion on this, perhaps more will come in the future. We felt that we would get more of a response when people had something in front of them to provide specific feedback.*

During the CIU meeting, Jeff Freymueller presented on an 'accidental tide gauge' for the Peterson Bay CORS site; this is a novel method for determining water level change over time. He reviewed the ice and tectonic models that he will be updating with this and last year's data. The new data will help validate the existing model structures and perhaps shed some light on post seismic, tectonic and glacial rebound sources of land-level change. The surprising result at the moment is that the CORS site on the Homer Spit (Spit) is significantly different than its nearest neighbor at the Public Works station. All sites are indicating uplift (regardless of whether they are on bedrock on unconsolidated substrates) with the exception of the Spit. At this point, it is unclear if that is true for the entire length of the Spit or if there is something site-specific about the location of the CORS site. Methods for assessing the problem were discussed; if it is reflective of the entire Spit, the harbor area will not be out-pacing global sea level rise.

We decided to omit the regularly scheduled CIU meeting to be held on 5 December 2012 in favor of having a discussion section at our Kachemak Bay Community Council Meeting (also held on 5 December) on the issue of relative sea level rise for the Spit. After a short presentation to introduce the issue we discussed the relative importance of the information to the community. We discussed whether it was warranted to pursue another year of Science Collaborative funding to more accurately determine the rates of land-level change for this area. To aid us in determining the next steps, we used a short key-pad polling survey to gather information from the Community Council; they were in favor of pursuing more information on land-level changes for the Spit. Through email, we further expanded our survey to a larger audience of potential Core Intended Users of the information. Coastal decision-makers demonstrated interest in the problem, particularly how these changes may impact harbor and road infrastructure, land-use planning, and local biology. Of the survey respondents, 60% had participated previously in some or all of the current Science Collaborative work groups. Of these individuals, 82% indicated that the collaborative process has improved their ability to make science-based decisions relating to land and sea-level change and said they would be committed to participation in future meetings and workgroups, assistance in monitoring, and application of study results in their work. Based on this information, we developed a pre-proposal for the Science Collaborative RFP.

- **What did you learn? Have there been any unanticipated challenges or opportunities? Who has been involved?** During this reporting period, staff involved on the project included: the principal investigators, Ed Clark (UAF Geophysical Institute), Carmen Field (KBNERR Education and Outreach), Conrad Field (KBNERR Habitat Biologist), Tammy Hoem Neher (KBNERR Wildlife Technician), and Taylor Bennett (NOAA Intern), and the CIUs.

KBNERR hired a new Coastal Training Program Coordinator, Stacey Buckelew. Stacey has been getting up to speed on the project and has been assisting in the preparation for the next CIU meeting in March.

- **Has interaction with intended users brought about any changes to your methods for integration of intended users, the intended users involved, or your project objectives?** Thus far, no changes to the methods or sampling have been recommended by our CIU. We are in the process of discussions about how to provide the information generated in this study to decision-makers.
- **How do you anticipate working with intended users in the next six months?**

In the next six months we will be conducting two more CIU meetings (20 March and 5 June 2013). The meeting in March will be held in Soldotna to facilitate greater participation in by the Kenai Peninsula Borough attendees and will be focused on data discussions and draft products.

We will continue to post meeting materials on our KBNERR and Community Council websites and to encourage additional CIU participants to the meetings.

### **Progress on project objectives for this reporting period:**

- **Describe progress on tasks related to project objectives for this reporting period.**

*Objective 1: To determine if bedrock uplift rates in the area are uniform, or if they vary along the length of the Bay.*

- *Hypothesis 1: Bedrock uplift rate is non-uniform, with slower uplift rates at the head of the Bay.*

- Progress to date: The longer time series data (10yrs) are suggesting a fairly uniform uplift rate around Kachemak Bay. In which case, it appears that hypothesis 1 has failed. Given uplift rates are more uniform than suspected, it might allow us to make a more precise estimate of sea level change by averaging in space.

Independent work ongoing at UAF is showing a great deal of promise for modeling seasonal variations in the GPS data. Seasonal variations do exist in the data (to a greater extent for the horizontal movements than the vertical). The next steps include removal of seasonal variations based on a physical model, and this should give us more accurate estimates of vertical site velocities to test this hypothesis.

- You can access the data at:
  - **UAF:** <ftp://gps.alaska.edu/pub/gpsdata/permanent/YYYY/ddd/>
  - **UNAVCO:** <ftp://data-out.unavco.org/pub/rinex/obs/YYYY/ddd/>
  - **UNAVCO:** <http://facility.unavco.org/data/dai2/app/dai2.html>

*Objective 2: To determine if areas surrounding the coastline of Kachemak Bay that are largely comprised of unconsolidated glacial till are experiencing similar uplift projections to sites located on bedrock, and to monitor elevation and changes in vegetation in salt marshes as an indicator of the balance between sea level rise and coastal rebound.*

- *Hypothesis 2: Soft sediments subside and compact, with the surface moving downwards relative to bedrock, and these locations experience less net uplift than bedrock sites.*
- *Hypothesis 3: Increasing sedimentation and relative sea level fall are shifting salt marsh habitats seaward.*

Progress to date: In a preliminary assessment of the data to date, there is no evidence for uplift rates being different for soft sediments on the north side of the Bay versus the bedrock sites on the south side of the Bay. In the salt marsh habitats, the data time series is not yet long enough to evaluate how land level changes are trending relative to the whole study area.

In order to evaluate shifts in salt marsh habitat, we need to have accurate vegetation cover maps and measures of sediment accumulation or loss at the site. We collected vegetation data for all 4 salt marsh sites and are in the process of updating the vegetation cover maps with data from 196 permanent vegetation plot and an additional 576 plots collected from our community monitors. We have completed high resolution leveling measurements at all 4 salt marsh study sites relative to our benchmarks and to our permanent vegetation monitoring plots. We will also have access to 2012 aerial imagery data for China Poot and Sadie Cove salt marsh sites in the near future.

*Objective 3: To improve earlier estimates of coastal uplift rates, which were generated for the greater Kenai Peninsula; refine models to better predict uplift rates in areas between measurement sites; refine estimates of regional sea level rise; and assess the impacts of coastal change for all coastal habitats of Kachemak Bay.*

- *Hypothesis 4: Observed uplift rates can be explained by a model that combines isostatic adjustment due to melting of glaciers and icefields, steady tectonic deformation, and post-seismic deformation following the 1964 earthquake. Regional sea level rise can be explained by a combination of global sea level rise and changes in the shape of the mean sea surface related to the deglaciation of southern Alaska. If hypothesis 2 is confirmed, then compaction and subsidence of sediments would need to be added to the model for non-bedrock sites.*

Progress to date: The data mentioned above will help greatly in testing these hypotheses. The data from the pre-existing GPS sites are the most valuable for this work, as their long measurement histories mean they have the most precise estimates of motions. Quantitative testing of this hypothesis is in progress. At present, a postdoctoral researcher (Yan Hu) at UAF is working on an improved model for glacial isostatic adjustment across all of southern Alaska; an update for our region is still in progress.

An additional collaboration on the project came from Kristine Larson from the University of Colorado, who is in the process of completing a paper on tidal variations observed at PBAY (Peterson Bay CORS) using variations in multipath from signals that reflect off the ocean surface and reach the GPS antenna. Given the huge tidal range, it turns out that the GPS receiver makes an excellent "accidental tide gauge". Jeff Freymueller presented these results at our September CIU meeting.

*Objective 4: To identify the biotic diversity and community composition among salt marshes which are: ground and surface water fed, glacial melt water fed, and salt marsh habitat historically fed by glacial melt water but which is no longer fed by glaciers.*

- *Hypothesis 5: Biological diversity is influenced by the source of freshwater input to the salt marsh habitat.*

Progress to date: With our education team, we developed and implemented a series of trainings for community monitors to and utilized their help in data collections to assess the biological diversity in the 4 salt marsh sites in our study. In addition to the annual monitoring of permanent emergent vegetation plots in the salt marsh sites, we have added

the following one-time sampling at each site: 144 additional vegetation plots, 12 insect fallout traps, 12 insect sweeps, 12 samples for infaunal invertebrates, fish sampling (tidal & freshwater), and bird and mammal species lists. We are currently working with the University of Washington to provide identification of the insects and infaunal invertebrates. The data from the vegetation monitoring will also be used to assist in validation of the vegetation cover-type maps generated in the study. Lists of birds, mammals, and tidal channel fish have been generated for each site. A short summary of all data have been compiled.

*Objective 5: To involve and educate local and regional coastal decision makers, local community residents, K-16 students, and other potential Core Intended Users (CIUs) of the information during and after the study.*

- *Hypothesis 6: Local decision makers (CIUs) will be able to 1. communicate the benefits and goals of this study to others and 2. integrate and use the data generated from this study if they have opportunities to learn more about the basic geomorphic processes occurring in our region.*
- *Hypothesis 7: By making our outreach and education available to the general public, we will identify additional CIUs of the information generated in this study.*

Progress to date: We have had no formal education outreach activities specific to the Science Collaborative project during this reporting period. We presented the project at Quarterly Community Council meetings as well as surveyed a broad audience of coastal decision-makers to obtain feedback on preliminary results of land level change for the Homer Spit. We devoted an entire Kachemak Bay Research Reserve News letter to the activities of this project in November (see attached).

- **What data did you collect?** We continued data collection through the reporting period and data processing. All CORS sites have been operational for the past 6 months and data collection continues at those sites. Attached is a data table for the project.
- **Has your progress in this period brought about any changes to your methods, the integration of intended users, the intended users involved or the project objectives?**  
There have been no changes to project methods or project objectives to date.
- **Have there been any unanticipated challenges, opportunities, or lessons learned?**  
Overall, our field season is fairly short with abrupt periods of inclement weather; this makes the field schedule condensed and the window for accomplishing all work outlined a challenge.
- **What are your plans for meeting project objectives for the next six months?**  
In the next six months, we will hold two more CIU meetings focusing on CIU presentations, sharing preliminary data, and refining the delivery of the information generated in this study to meet the needs of the CIUs. We will continue working with the data gathered this spring and summer (data entry, error checking, permit reporting, and

summaries) and begin developing specific deliverables from the data sets acquired. This spring, we will have two events associated with this projects, one at a What's New In the Bay Discovery Lab (DL) on Climate Change and the second, a complete DL associated without reaching this project and will be summarizing the results of those and all education outreach efforts for the final report.

**C. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.**

- a. A major benefit to the NERRS is that KBNERR has acquired high-precision GPS and leveling equipment which meets the national program standards. This results in one less reserve needing to borrow the shared equipment.
- b. Setting up the long-term vegetation transects utilizing the national program's methods ensure that these data will be compatible with NERRS protocols, which is a benefit.
- c. By modeling sea and land-level changes with high precision, we are contributing valuable information to our partners in the National Park Service, U.S. Geological Survey, and U.S. Fish and Wildlife Service who are currently relying on the SLAMM model for sea level rise without the benefit of land-level change.

**D. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.**

1. A data table for the project (see attached)
2. A draft schematic illustration how the data flow contribute to RSL estimates
3. A KBNERR Newsletter highlighting our project

