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ANNOTATED BIBLIOGRAPHY SERIES IN SUPPORT OF COASTAL COMMUNITY HAZARD PLANNING—NORTHWEST ALASKA

BARROW, ALASKA

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This annotated bibliography is part of a series created to facilitate access to documents useful for coastal geohazard evaluation and community planning in Northwest Alaska. Below is a comprehensive list of community-specific information sources, each with full bibliographic information and an informative-style annotation that highlights content pertaining to the community of Barrow, Alaska. For a detailed description of the preparation and scope of this resource, please refer to this bibliography series' foreword. Any notable errors and/or omissions may be reported to the Coastal Hazards Program manager at the Alaska Division of Geological & Geophysical Surveys (DGGS).

Aguirre, Adrian, 2011, Patterns and controls of erosion along the Barrow Environmental Observatory coastline, northern Alaska [M.S. thesis]: Texas, University of Texas El Paso, 86 p.

Study documenting the erosional patterns of the coastal bluffs near the Barrow Environmental Observatory between 2003 and 2009. Thesis includes an in-depth discussion of dominant erosional processes and the predominant coastal setting.

Alaska Department of Commerce, Community, & Economic Development (DCCED), accessed 2011, Division of Community & Regional Affairs (DCRA) Community Profiles [website]: State of Alaska Department of Commerce, Community, & Economic Development.

http://www.commerce.state.ak.us/dca/profiles/profile-maps.htm

This website provides access to community profile maps for community-based planning. The maps are available in 24" by 36" and 30" by 42" formats. The Barrow maps were created in 1978 based on land survey and/or interpretation of aerial imagery. Subsistence hunting grounds, habitat areas, community buildings and public facilities are delineated. Shoreline position and potential erosion zones are included in the map content. All maps have been sponsored by the Alaska Division of Community & Regional Affairs and contracted to local agencies for production.

Arp, Christopher D., Benjamin J. Jones, Joel A. Schmutz, Frank E. Urban, and M. Torre Jorgenson, 2010, Two mechanisms of aquatic and terrestrial habitat change along an Alaskan Arctic coastline: Polar Biology, vol. 33, p. 1629–1640.

Scientific abstract: "Arctic habitats at the interface between land and sea are particularly vulnerable to climate change. The northern Teshekpuk Lake Special Area (N–TLSA), a coastal plain ecosystem along the Beaufort Sea in northern Alaska, provides habitat for migratory waterbirds, caribou, and, potentially, denning polar bears. The 60 km coastline of N–TLSA is experiencing increasing rates of coastline erosion and storm surge flooding far inland, resulting in lake drainage and conversion of freshwater lakes to estuaries. These physical mechanisms are affecting upland tundra as well. To better understand how these processes are affecting habitat, we analyzed long-term observational records coupled with recent short-term monitoring. Nearly the entire coastline has accelerating rates of erosion ranging from 6 m/year from 1955 to 1979 and most recently peaking at 17 m/year from 2007 to 2009, yet an intensive monitoring site along a higher bluff (3–6 masl) suggested high interannual variability. The frequency and magnitude of storm events appears to be increasing

along this coastline and these patterns correspond to a greater number of lake tapping and flooding events since 2000. For the entire N–TLSA, we estimate that 6% of the landscape consists of salt-burned tundra, while 41% is prone to storm-surge flooding. This offset may indicate the relative frequency of low-magnitude flood events along the coastal fringe. Monitoring of coastline lakes confirms that moderate westerly storms create extensive flooding, while easterly storms have negligible effects on lakes and low-lying tundra. This study of two interacting physical mechanisms, coastal erosion and storm-surge flooding, provides an important example of the complexities and data needs for predicting habitat change and biological responses along Arctic land–ocean interfaces."

Boardman, Stephen C., and Scott R. Marchand, eds., May 2001, Memorandum for Commander, U.S. Army Engineer Division, Pacific Ocean Division: Barrow storm damage reduction project, Barrow, Alaska: U.S. Army Engineer District, Alaska, Anchorage, AK, 20 p.

This is a memorandum outlining the Project Management Plan and Feasibility Cost Sharing Agreement developed for storm damage reduction in Barrow, Alaska. The solution presented to best mitigate erosion problems in Barrow was a partially-hardened, armor-protected shoreline combined with a beach nourishment program. However, economic and source material problems are identified as barriers to project completion.

Brown, Jerry, M. Torre Jorgenson, Orson P. Smith, and William Lee, 2003, Long-term rates of coastal erosion and carbon input, Elson Lagoon, Barrow, Alaska: U.S. National Science Foundation, 6 p.

This report presents historical and recent observations of erosion with associated estimates of sediment and organic carbon inputs into the Elson Lagoon near Barrow, Alaska. This project is a part of the international Arctic Coastal Dynamics (ACD) program. Overall coastal erosion rates at Elson Lagoon were found to be 1.27 meters per year based on photogrammetric analysis of aerial imagery. The primary shoreline process observed to contribute to the erosion is undercutting of coastal bluffs by thermo-erosional notching.

Brunner, Ronald D., Amanda H. Lynch, Jon C. Pardikes, Elizabeth N. Cassano, Leanne R. Lestak, and Jason M. Vogel, 2004, An arctic disaster and its policy implications: Arctic, vol. 57, no. 4, p. 336–346.

Scientific abstract: "The purpose of the research reported here is to help the community in Barrow, Alaska, clarify its vulnerability to extreme weather events, and devise better-informed policies for reducing that vulnerability and adapting to climate variability and change. We examine the worst disaster on record there—a storm that struck on 3 October 1963—from different disciplinary perspectives and in the context of other severe storms. The major policy responses to date have been a beach nourishment program, a feasibility study of additional means of erosion control, and an emergency management plan. Additional possible responses have been identified in the community's cumulative experience of these storms, but have not yet been fully explored or implemented. Meanwhile, given inherent uncertainties, it is clear that sound policies will allow for corrective action if and when expectations based on the best available knowledge and information turn out to be mistaken. It is also clear that the people of Barrow are in the best position to understand the evolving situation and to decide what to do about it."

Chronic, Steve W., ed., *of* LCMF Incorporated *for* North Slope Borough, CIPM, 2000, 1999 Barrow beach nourishment post-season report: LCMF Incorporated, Anchorage, AK, 3 p.

This report presents the overall expenditures, purchases, operations and production of the 1999 Beach Nourishment Project in Barrow, Alaska, conducted by LCMF Inc. The total cost of the project amounted to $4,984,814 for a 1,800 foot length of beach. This was the first full season of active beach nourishment in Barrow. Detailed descriptions are provided regarding the dredge and application process.

Drew, J.V., May 1957, A pedological study of arctic coastal plain soils near Point Barrow, Alaska [PhD thesis]: Rutgers University, State University of New Jersey, 117 p.

This dissertation presents one of the first studies of soil-forming processes in Alaskan Arctic soils. A previous lack of specific information about the region resulted in soil groups being defined on the Great Soil Group level as Tundra soils. This study was designed to improve the existing knowledge of soil genesis and classification in the area of Point Barrow.

Drobot, Sheldon, December 2003, Long-range statistical forecasting of ice severity in the Beaufort–Chukchi Sea: American Meteorological Society, vol. 18, p. 1161–1176.

The author of this article presents a method of seasonal ice severity forecasting that uses the Barnett Severity Index (BSI) in the Beaufort and Chukchi Seas. BSI is a measure of the distance from the summer sea ice edge to Point Barrow, Alaska combined with regional atmospheric characteristics, such as the number of heating degree days during the shipping season. This report explains the simplification of BSI results by categorically ranking relevant parameters. The most significant predictors of the BSI value, using hindcasting methods, were multiyear ice gradient, total ice concentration, and atmospheric teleconnection indices.

Druckenmiller, Matthew L., Hajo Eicken, Mark A. Johnson, Daniel J. Pringle, and Christina C. Williams, 2009, Toward an integrated coastal sea-ice observatory: System components and a case study at Barrow, Alaska: Cold Regions Science and Technology, vol. 56, p. 61–72.

Scientific abstract: "The morphology, stability and duration of seasonal landfast sea ice in Alaska's coastal zone is changing alongside large-scale ice thinning and retreat. The extent and complexity of change at the local level requires an integrated observing approach to assess implications of such change for coastal ecosystems and communities that rely on or make use of the sea-ice cover. Barrow, Alaska is an example of a community that experiences and utilizes a broad range of sea-ice types and conditions. The local population is increasingly forced to adapt to less stable sea ice, loss of multiyear ice and a shorter ice season. We are working toward an integrated coastal ice observatory to monitor landfast and adjacent pack ice and to maximize the usefulness of information to the community. The observatory includes: (1) satellite remote-sensing datasets distributed in near real-time; (2) a coastal sea-ice radar and webcam that monitor ice movement and evolution; (3) a mass-balance site that provides temperature profiles and thickness information for ice and snow; (4) sea-level measurements; (5) periodic ice thickness surveys using direct drilling and electromagnetic induction sounding; and (6) a program of regular, undirected observations by Iñupiat sea-ice experts. We examine two significant landfast ice breakout events off Barrow in spring of 2007. During these events, Barrow's subsistence whaling community partook in a successful hunting season observing and responding to these breakout events and their impacts on ice stability. Using local expert knowledge to parse geophysical datasets obtained from the observatory has provided deeper insight into different approaches for assessing ice stability, and integrating information on ice growth, origin, morphology, and dynamics, as well as winds, weather, and currents."

Eisner, Wendy R., Chris J. Cuomo, Kenneth M. Hinkel, Benjamin M. Jones, and Ronald H. Brower, Sr., December 2009, Advancing landscape change research through the incorporation of Iñupiaq knowledge: Arctic, vol. 62, no. 4, p. 429–442.

Scientific abstract: "Indigenous knowledge is a valuable but under-used source of information relevant to landscape change research. We interviewed Iñupiat elders, hunters, and other knowledge-holders in the villages of Barrow and Atqasuk on the western Arctic Coastal Plain of northern Alaska to gain further insight into the processes governing the ubiquitous lakes and the dynamics of landscape change in this region of continuous permafrost. The interviews provided a suite of information related to lakes and associated drained lake basins, as well as knowledge on landforms, environmental change, human events, and other phenomena. We were able to corroborate many observations independently and verify the timing of several large and significant lake drainage events using either aerial photography or remotely sensed time series. Data collected have been incorporated into a geodatabase to develop a multi-layer Geographic Information System that will be useful for local and scientific communities. This research demonstrates that indigenous knowledge can reveal a new understanding of landscape changes on the Arctic Coastal Plain in general and on lake processes in particular. We advocate ongoing, community-oriented research throughout the Arctic as a means of assessing and responding to the consequences of rapid environmental change."

George, John C., Henry P. Huntington, Karen Brewster, Hajo Eicken, David W. Norton, and Richard Glenn, December 2004, Observations on shorefast ice dynamics in arctic Alaska and the responses of the Inupiat hunting community: Arctic, vol. 57, no. 4, p. 363–374.

This study focuses on two nearshore ice hazard events in 1957 and 1997 that threatened the lives and confidence of whale hunters in Barrow. Each event is examined in terms of the mechanics of shore fast ice and described in detail. The factors considered in the events were the relationship of the hunters with the ice, natural causes of the failures, technological advancements for prediction of failures, ice behavior, and long *term effects of global climate change. The authors identify people's uses of sea ice as a necessary factor when assessing risks and benefits of developing sea ice technology.*

Hamilton, Thomas D., and Julie Brigham-Grette, 1991, The last interglaciation in Alaska: Stratigraphy and paleoecology of potential sites: Quaternary International, vol. 10, p. 49–71.

The authors of this paper identify 20 sites in Alaska where deposits from the last interglacial maximum have been reported. The sites represent a wide range of geologic environments from throughout the state. Barrow is included as a location where fossiliferous Pelukian deposits have been consistently observed at approximately 10 meters ASL over a distance of 600 kilometers.

Harper, John R., August 1978, The physical processes affecting the stability of tundra cliff coasts [PhD thesis]: Louisiana State University, Department of Marine Sciences, 212 p.

According to Dr. Harper, "the single most significant point of the research is how excess pore ice in the tundra contributes to coastal stability. [P]eriglacial process[es] tend to concentrate ice in the upper surface of the tundra so there is excess ice, often 70% by volume near the surface of the tundra. [T]his makes tundra or permafrost coasts (especially low coasts) fundamentally different than non-permafrost coasts. When that ice melts, there is going to be supersaturated sediments and the actual volume of minerals in an eroded cubic meter of cliff may be quite small."

Harper, John R., December 1978, Coastal erosion rates along the Chukchi Sea coast near Barrow, Alaska: Arctic, vol. 31, p. 428–433.

Coastal erosion rates between Peard Bay and Barrow are described as highly variable over a 21-year period (1948-1969) suggesting that the temporal variations in erosion rates are related to the passage of intense storms and that spatial variation is related to the presence of offshore bars and borrow pits.

Hartig, Larry, *of* Alaska Department of Environmental Conservation & Governor's Climate Change Sub-Cabinet, October 2010, State of Alaska and State/Federal Executive Roundtable Activities Regarding the Arctic [presentation]: Anchorage, Alaska, Northern Waters Task Force, 53 p.

http://housemajority.org/coms/anw/pdfs/26/NWTF_Powerpoint_Hartig_01Oct10.pdf

This is a powerpoint presentation about the state and federal executive roundtable activities regarding the Arctic. The discussion includes hazards associated with declining Arctic sea ice extent, melting of permafrost, storm surges, and coastal erosion. Thirty-one villages are identified as imminently threatened: Barrow, Kivalina, Selawik, Allakaket, Hughes, Huslia, Shishmaref, Deering, Teller, Koyukuk, Nulato, Golovin, Shaktoolik, Unalakleet, Saint Michael, Kotlik, McGrath, Emmonak, Alakanuk, Chevak, Newtok, Nunapitchuk, Lime Village, Eyak (Cordova), Napakiak, Akiak, Chefornak, Kwigillingok, Dillingham, Clark's Point, and Port Heiden. Specific photos and engineering initiatives for four communities are discussed, including: Kivalina, Shishmaref, Unalakleet, and Newtok.

Hinkel, K.M., F.E. Nelson, Y. Shur, Jerry Brown, and K.R. Everett, 1996, Temporal changes in moisture content of the active layer and near-surface permafrost at Barrow, Alaska, U.S.A., 1962–1994: Arctic and Alpine Research, vol. 28, no. 3, p. 300–310.

This paper addresses the movement of water between the active layer and permafrost at annual and multidecadal time scales, through sequential and replicate analysis of frozen soil cores from Barrow, Alaska. During the long term (30 year) analysis of difference in soil cores, average water enrichment increases by 5%. In the short term (1 year) analysis, an average of 3% depletion was reported. These results suggest that the migration of water by vaporization or liquid flowing on an annual cycle occurs after November in Barrow.

Hume, James D., and Marshall Schalk, 1967, Shoreline processes near Barrow, Alaska: A comparison of the normal and the catastrophic: Arctic, vol. 20, p. 86–103.

This is a study of shoreline processes in Barrow, Alaska. The authors discuss surveys from 1948 to 1962 that provide evidence for annual longshore transport rates of ~10,000 cubic yards to the northeast, west of Point Barrow and ~9,500 cubic yards to the southeast, east of Point Barrow. Detailed observations of the coastal response to the 1963 storm reveal volumes of sediment transport equivalent to 20 years of typical transport over the course of hours. The report includes maps of shoreline position based on air photo interpretation, *grain size analysis of beach sediments, and an hourly account of the 1963 storm. Maps and coastal profiles showing the coastal response to this event are estimated to be a 200 year storm.*

Hume, James D., Marshall Schalk, and Patricia W. Hume, 1972, Short-term climate changes and coastal erosion, Barrow, Alaska: Arctic, vol. 25, p. 272–278.

In this report, beach sedimentation for Barrow, Alaska, is described based on the Gubik Formation sediment and ice action. The effects of construction have been measured to show removal of about 30,000 m^3 of beach sediment in 1961, causing shoreline retreat of 3.2 m. Storms are shown to be the most critical factor in both bluff erosion and retreat of the shoreline. High sea level in combination with storms also speeds melting of bluffs by exposing new frozen ground. Rainfall is another factor melting ice and transporting sediment; however, sediment would also be transported by gravity alone in this case. In the future, erosion will depend on meteorological data, which is uncertain for the area, because of incomplete ice data.

Immediate Action Workgroup (IAWG), Michael Black, and Patricia Opheen, eds., March 2009, Recommendations to the Governor's Subcabinet on climate change: Immediate Action Workgroup, 162 p.

The Immediate Action Workgroup was established to address known threats to Alaskan communities caused by coastal erosion, thawing permafrost, flooding, and fires. This report is a follow-up to the recommendations made in April 2008 (in which Barrow was not mentioned), and provides recommendations for actions and policies to be implemented in 2009 and 2010. The community of Barrow has been recognized as receiving agency actions from the U.S. Army Corps of Engineers (COE) and the Alaska Department of Transportation & Public Facilities (ADOT&PF). One ADOT&PF project in Barrow relocated the Arctic Research Center access road due to erosion.

Jones, Benjamin M., Kenneth M. Hinkel, Christopher D. Arp, and Wendy R. Eisner, 2008, Modern erosion rates and loss of coastal features and sides, Beaufort Sea coastline, Alaska: Arctic, vol. 61, no. 4, p. 361–372.

Scientific abstract: "This study presents modern erosion rate measurements based upon vertical aerial photography captured in 1955, 1979, and 2002 for a 100 km segment of the Beaufort Sea coastline. Annual erosion rates from 1955 to 2002 averaged 5.6 m a-1. However, mean erosion rates increased from 5.0 m a-1 in 1955–79 to 6.2 m a-1 in 1979–2002. Furthermore, from the first period to the second, erosion rates increased at 60% (598) of the 992 sites analyzed, decreased at 31% (307), and changed less than ±30 cm at 9% (87). Historical observations and quantitative studies over the past 175 years allowed us to place our erosion rate measurements into a longer-term context. Several of the coastal features along this stretch of coastline received Western place names during the Dease and Simpson expedition in 1837, and the majority of those features had been lost by the early 1900s as a result of coastline erosion, suggesting that erosion has been active over at least the historical record. Incorporation of historical and modern observations also allowed us to detect the loss of both cultural and historical sites and modern infrastructure. U.S. Geological Survey topographic maps reveal a number of known cultural and historical sites, as well as sites with modern infrastructure constructed as recently as the 1950s, that had disappeared by the early 2000s as a result of coastal erosion. We were also able to identify sites that are currently being threatened by an encroaching coastline. Our modern erosion rate measurements can potentially be used to predict when a historical site or modern infrastructure will be affected if such erosion rates persist."

Jorgenson, M.T., and J. Brown, 2005, Classification of the Alaskan Beaufort Sea coast and estimation of carbon and sediment inputs from coastal erosion: Geo-Marine Letters, vol. 25, no. 2-3, p. 69–80.

Scientific abstract: "A regional classification of shoreline segments along the Alaskan Beaufort Sea Coast was developed as the basis for quantifying coastal morphology, lithology, and carbon and mineral sediment fluxes. We delineated 48 mainland segments totaling 1,957 km, as well as 1,334 km of spits and islands. Mainland coasts were grouped into five broad classes: exposed bluffs (313 km), bays and inlets (235 km), lagoons with barrier islands (546 km), tapped basins (171 km), and deltas (691 km). Sediments are mostly silts and sands, with occasional gravel, and bank heights generally are low (2–4 m), especially for deltas (<1 m). Mean annual erosion rates (MAER) by coastline type vary from 0.7 m/year (maximum 10.4 m/year) for lagoons to 2.4 m/year for exposed bluffs (maximum 16.7 m/year). MAERs are much higher in silty soils (3.2 m/year) than in sandy (1.2 m/ year) to gravelly (0.3 m/year) soils. Soil organic carbon along eroding shorelines (deltas excluded) range from 12 to 153 kg/m2 of bank surface down to the water line. We assume carbon flux out from depositional delta sediments is negligible. Across the entire Alaskan Beaufort Sea Coast, estimated annual

carbon input from eroding shorelines ranges from -47 to 818 Mg/km/year (Metric tons/km/year) across the 48 segments, average 149 Mg/ km/year (for 34 nondeltaic segments), and total 1.8·105 Mg/year. Annual mineral input from eroding shorelines ranges from 1,863 (accreting) to 15,752 Mg/ km/year, average 2,743 Mg/km/year, and totals 3.3 ·106 Mg/year."

Kowalik, Z., *of* Institute of Marine Science, University of Alaska, Fairbanks, November 1984, Storm surges in the Beaufort and Chukchi Seas: Journal of Geophysical Research, vol. 89, no. C6, p. 10,570–10,578.

This article describes a numerical model designed to determine storm surge characteristics including sea level, mean currents and ice motion on the Beaufort and Chukchi Seas. The equations employed by the model proved to be effective in predicting sea ice edge locations during three modeled storm surge events. Velocity was shown to parallel sea level contours in both the Beaufort and Chukchi Seas, generating gyres around offshore storm surge bulges.

Lynch, Amanda H., and Ronald D. Brunner, February 2007, Context and climate change—An integrated assessment for Barrow, Alaska: Climate Change, vol. 82, p. 93–111.

The purpose of this study is to examine the vulnerability of the community of Barrow to flooding and erosion problems through the lens of social conditions and priorities. The authors highlight that sound science cannot reduce the uncertainty associated with natural hazard events, they merely clarify underlying dynamics. The ideas held by local community members about climate change are reported as contributors to the human interaction with the natural world. Traditional knowledge is identified as the main basis for decision and policy making within the community.

Lynch, Amanda H., Elisabeth N. Cassano, John J. Cassano, and Leanne R. Lestak, April 2003, Case studies of high wind events in Barrow, Alaska—Climatological contexts and development processes: Monthly Weather Review, vol. 131, p. 719–732.

Scientific abstract: "The Beaufort–Chukchi cyclones of October 1963 and August 2000 produced the highest winds ever recorded in Barrow, Alaska. In both cases, winds of 25 m/s were observed with gusts unofficially reported at 33 m/s. The October 1963 storm caused significant flooding, contaminated drinking water, and interrupted power supplies. The August 2000 storm caused the wreck of a $6 million dredge, and removed roofs from 40 buildings. Both storms were unusual in that they tracked eastward from the East Siberian Sea into the Chukchi and Beaufort Seas, rather than following a more typical northward track into the Arctic Ocean. This paper addresses, through modeling and analysis, the development processes of these two storms. The October 1963 system was a long-lived, warm core, zonally elongated cyclone that traversed around the Arctic basin through the Canadian Archipelago. The August 2000 system was an open-wave cyclone that dissipated rapidly into a weak, cold core eddy in the Alaskan sector of the Beaufort Sea. Approximating the contributions to development using terms in a quasigeostrophic omega equation, it was found that both storms were characterized by the increasing importance of the convergence of the Q vector (representing differential vorticity advection and thermal advection) in the midtroposphere, at the expense of forcing by the turbulent fluxes of heat, moisture, and momentum in the boundary layer. However, the influence of surface turbulent fluxes in the early stages of development was important, particularly for the August 2000 cyclone, which passed over an extensive coastal lead in the East Siberian Sea. This study concludes that the observed retreat in western Arctic ice cover is unlikely to be an important contributor to increasing cyclonic activity in the region, but that ice retreat north of Eurasia could have an impact."

Lynch, Amanda H., J.A. Curry, R.D. Brunner, and J.A. Maslanik, February 2004, Toward an integrated assessment of the impacts of extreme wind events on Barrow, Alaska: American Meteorological Society, vol. 85, no. 2, p. 209–221.

A project is presented in this paper that aims to improve local understanding of climate variability in Barrow in order to improve local decision making regarding marine and coastal resource management. Included is an overview of the oceanic setting of Barrow on the North Slope. There are several insets that expand on topics, including the ways in which climate change, mineral resource extraction and political issues threaten subsistence lifestyles and how perceptions of local residents corroborate scientific measurements of a changing climate. Central to this article is an overview of meteorological patterns, including shifting winds and reduced snow cover duration, which have been associated with climate change and may have direct impacts on the residents of Barrow.

The authors describe policy research that is being organized and coordinated through continuing discussion seminars that bring together residents and project personnel. In these meetings the primary goals are analysis (what is happening), synthesis (what are the regional impacts) and communication. The project is designed to assess the quality and practical use of various information sources, to create a record of how communities have been responding to natural disaster events and to tap into local knowledge that can guide future research.

Lynch, Amanda H., Leanne R. Lestak, Petteri Uotila, Elizabeth N. Cassano, and Lian Xie, March 208, A factorial analysis of storm surge flooding in Barrow, Alaska: Monthly Weather Review, vol. 136, p. 898–912.

The intent of this study is to test a methodology that may be used to fill the predictive gap between forecasted weather and flood inducing storms. Return periods for high wind events are associated with intense cyclones; however, the return periods for these cyclones are changing in a non-linear way. Simulation of events were modeled as a mesoscale atmospheric model and a storm surge model. The atmospheric model exhibited high simulation quality and compared well to available data at the Barrow National Weather Service site. The storm surge model performed well, but has not previously been used in this type of setting before. Using these two models allows for a method of analysis linking forecast weather to likelihood of a flood. The most significant correlation revealed that forecasts of strong (30 mph) sustained (20h+) winds are the most reliable predictor of severe flood events in the Barrow area.

Mahoney, Andrew, Hajo Eicken, Allison Graves, Lewis Shapiro, and Patrick Cotter, 2004, Landfast sea ice extent and variability in the Alaskan arctic derived from SAR imagery: IEEE, Fairbanks, AK, p. 2146–2149.

This is a report that explains the use and reliability of a new technique using synthetic aperture radar (SAR) to derive seaward landfast ice edge positions as they migrate. The presented data spans the Alaskan Arctic coast, from east of Point Lay to the Mackenzie Delta.

Mahoney, Andrew, Hajo Eicken, and Lewis Shapiro, 2007, How fast is sea ice? A study of the attachment and detachment of nearshore ice at Barrow, Alaska: Cold Regions Science and Technology, vol. 47, p. 233–255.

Scientific abstracts: "During the two winters between 2003 and 2005, a land-based marine radar observed the nearshore ice motion during the development and decay of landfast ice near Barrow, Alaska. The radar imagery captured individual events at high temporal resolution, revealing deformation processes and allowing calculation of ice velocity and acceleration. Atmospheric forcing during these events appeared to be irrelevant since no corollary was found in local meteorological observations. Detailed examination of the radar imagery showed that backscatter from sea ice targets oscillated (flickered) in signal strength prior to detachment, as previously observed by L.H. Shapiro (1987, Mechanical Properties of Sea Ice Deformation in the near Shore Zone, in OCSEAP Final Reports, v.72, pp. 357–584, U.S. Department of Commerce, NOAA). Determination of ice acceleration after detachment allowed estimation of water drag beneath the ice. The distribution of grounded ridges at the end of each annual cycle was determined from field measurements of ice elevation, ice thickness and water depth. Applying a simple theoretical treatment of coupling between a first-year ridge keel and the seabed, we calculate that the anchoring strength provided by ridges was 2–3 orders of magnitude greater than typical wind or water stresses. Therefore, we conclude that additional decoupling processes, such as sea level surges or thermal erosion of keels, must occur in addition to offshore current stress in order to cause the landfast ice to detach. Although the nature of these processes is not clear, they are likely to be the cause of the flickering observed in radar imagery, which could therefore be useful in short-term prediction of detachment events."

Mars, J.C., and D.W. Houseknecht, July 2007, Quantitative remote sensing study indicates doubling of coastal erosion rate in past 50 yr along a segment of the Arctic coast of Alaska: Geology, vol. 35, no. 7, p. 583–586.

Scientific abstract: "A new quantitative coastal land gained-and-lost method uses image analysis of topographic maps and Landsat thematic mapper short-wave infrared data to document accelerated coastal land loss and thermokarst lake expansion and drainage. The data span 1955–2005 along the Beaufort Sea coast north of Teshekpuk Lake in the National Petroleum Reserve in Alaska. Some areas have undergone as much as 0.9 km of coastal erosion in the past 50 yr. Land loss attributed to coastal erosion more than doubled, from 0.48 km^2*/yr during 1955–1985 to 1.08* km^2*/yr during 1985–2005. Coastal erosion has breached thermokarst lakes, causing initial draining of the lakes followed by marine flooding. Although inland thermokarst lakes show some uniform expansion, lakes breached by coastal erosion display lake expansion several orders of magnitude greater than inland lakes."*

Owens, E.H., and J.R. Harper *of* Coastal Studies Institute, Louisiana State University, 1977, Frost-table and thaw depths in the littoral zone near Peard Bay, Alaska: Geography Programs, Office of Naval Research, Arlington, VA, p. 155–168.

The objective of this study was to determine how rates of thaw in the littoral zone on the coast of Peard Bay compare to previously reported thaw rates, whether any variations exist in depth of thaw across the beach, and whether any alongshore variations exist in the depth of thaw. The major factors found to lower the level of the frost-table and increase depth of thaw were increasing temperature and net radiation, decreasing snow cover, and the presence of open water in the nearshore zone.

Péwé, Troy L., David M. Hopkins, and Arthur H. Lachenbruch *of* U.S. Geological Survey *for* U.S. Atomic Energy Commission, April 1958, Engineering geology bearing on harbor site selection along the northwest coast of Alaska from Nome to Point Barrow, U.S. Geological Survey (USGS) trace elements investigations report no. 678, 57 p.

This report provides geologic and oceanographic information from previous investigations, aerial imagery, and reconnaissance field work regarding the optimal location of a deep-water harbor. The harbor was to be constructed using modern nuclear explosives and located at a point along the northwest coast of Alaska between Nome and Point Barrow. The project was not undertaken.

Reimnitz, Erk, and Douglas K. Maurer, 1979, Effects of storm surges on the Beaufort Sea coast, northern Alaska: Arctic, vol. 32, no. 4, p. 329–344.

Scientific abstract: "In 1970, a major storm surge caused by gale-force westerly winds inundated low-lying tundra plains and deltas as far as 5000 m inland and left a driftwood line as much as 3.4 m above normal sea level along the Beaufort Sea coast of Alaska. The height of the surge followed a predictable pattern and was highest along windward-facing shorelines. Coastal retreat and thermoerosion are greatly accelerated on such west-facing shores with eastward sediment transport opposite to normal littoral drift. Evidence suggests an approximate 100-year recurrence interval for similar surges, with potential for damaging the developing oil fields on the North Slope."

Schalk, Marshall, *of* Department of Geology, Smith College, June 1963, Study of near-shore bottom profiles east and southwest of Point Barrow, Alaska—Comparison of profiles and the barrier islands in the Point Lay and Plover Islands areas: Northampton, Massachusetts, Smith College, Department of Geology, Smith College, 16 p.

This report includes nearshore bottom profiles and sediment sample descriptions of coastal locations at Barrow, Wainwright, and Point Lay, Alaska. Repeat coastal surveys were conducted 1954-1962. Offshore of Barrow, a submerged bar that was relatively stable in the 1950s is shown to broaden and move inland in the 1962 survey data. A more complex bar system was observed in the 1950's surveys, believed to have developed following a large storm in 1954. Surveys of the barrier islands a Point Lay highlight areas of stability and instability in the barrier island system.

Simpson, J.J., January 1984, Final report, task force on erosion control: Alaska Department of Transportation & Public Facilities, project no. R-30023, 101 p.

The Erosion Control Task Force was appointed to investigate and inventory potential erosion problems on a statewide basis, to prioritize the erosion problem sites by severity and need, and to provide preliminary design plans where immediate remedial action is required. Sites were rated based on public safety, public property, private property, time of projected loss, ability to move, approximate replacement value, and economic value. Projected costs of erosion protection measures were analyzed totaling $16,802,300 for all projects. This report outlines specific engineering projects to reduce the effects of coastal and riverine erosion for communities throughout Alaska.

Erosion at Barrow is summarized in this report as being initiated by thermal erosion; the eroded material is later carried away by wave transport processes. Previous engineering measures have been taken to curtail rates of erosion in this area, but are considered short term projects. The authors of this report conclude that an in-depth analysis of erosion at Barrow would be a duplication of work being done by the North Slope Borough, and they refer the reader to recommendations made in that report.

Sprenke, James, Stephen Gill, Jena Kent, and Mike Zieserl, September 2011, Tides under the ice—Measuring water levels at Barrow, Alaska, 2008–2010: Silver Spring, MD, National Oceanic and Atmospheric Administration (NOAA), technical report no. NOS CO-OPS 062, 29 p.

Because of the difficulty of maintaining ocean water level sensors in the Arctic, NOAA developed a method to use the Seabird SBE26+ tide gauge in a specialized metal mount. The testing of this sensor is discussed in this paper, and long term hourly and monthly tide information is provided for Barrow, Alaska. The pressure sensor was released far enough offshore to avoid destruction from sea ice pressure ridges, but near enough to ensure retrieval of the data throughout the collection period and recovery of the gauge at the end of each year. Along with tidal elevations, water conductivity and temperature were also collected.

Stierle, Arron P., and Hajo Eicken *of* Geophysical Institute, University of Alaska Fairbanks, 2002, Sediment inclusions in Alaskan coastal sea ice—Spatial distribution, interannual variability, and entrainment requirements: Arctic, Antarctic, and Alpine Research, vol. 34, no. 4, p. 465–476.

The authors argue that reduction in sea ice and increased rates of erosion in the Arctic raise interest in the transport processes of sedimentation by sea ice. The numerous mechanisms for the incorporation of sediments into sea ice include: eolian deposition, river discharge onto ice, bottom adfreezing, anchor ice formation, and suspension freezing. In Elson Lagoon, near Barrow, Alaska, ice core sediment appeared diffusely distributed and fine grained, possibly due to the long fetch during freeze up. The observers noted significant natural variability, both spatially and temporally within the sea-ice cover. The results of the study strengthen the argument that environmental conditions at the time of fall freeze-up are a primary control on total sediment load and its spatial distribution within the ice.

Taylor, Ronald J., *of* Department of Biology, Western Washington University, March 1981, Shoreline vegetation of the arctic Alaska coast: Arctic, vol. 34, no. 1, p. 37–42.

This study was administered by the Outer Continental Shelf Environmental Assessment Program (OCSEAP). The primary objective of this work is to provide descriptions and definitions of vascular beach plants along the arctic coast of Alaska in order to better predict the effects of oil spills on the region's ecosystems. Point Barrow was used as a research station representative of a salt marsh habitat. Vegetation in this environment is controlled by mean high water level. Tidal storms were found to influence vegetation growth because of salt burn, represented by varying degrees of plant tissue death.

Tetra Tech *for* Immediate Action Workgroup: Advisory Group of the Governor's Climate Change Sub-Cabinet, June 2010, Imperiled community water resources analysis: Anchorage, AK, Tetra Tech, 47 p.

This report summarizes climate-related threats to water and wastewater infrastructure within Alaskan communities including those at risk to flooding, saltwater intrusion, loss of surface water supply, erosion, and sedimentation of the source region. The primary objectives of the analysis were to:

1. *Identify and select study group communities whose water infrastructure is threatened*
2. *Collect information on the threatened water infrastructure for the study group communities*
3. *Analyze information to determine the climate-related impacts to study group community water infrastructure. (p. 2)*

A permafrost depth profile is provided for Barrow that extends 1,330 feet below the surface. The diagram is meant to show the effects of global climate change on soil temperature and active layer thickness. Barrow is described as being exposed to a long fetch, with a continuous 200° arc of exposure to the Arctic Ocean.

U.S. Army Corps of Engineers, accessed 2011, Civil works floodplain management services [website]: U.S. Army Corps of Engineers, Alaska District.

http://www.poa.usace.army.mil/en/cw/fld_haz/floodplain_index.htm

This website provides flood hazard data for communities throughout Alaska. A link to a flood hazard-specific bibliography, maintained by the U.S. Army Corps of Engineers, is provided. The most recent flood event on record for Barrow was during 1970, and the worst flood event reported on record occurred during 1963 due to wind-driven waves. The city of Barrow is participating in the National Flood Insurance Program and a link is available at this site to the most recent FEMA published flood insurance rate maps.

U.S. Army Corps of Engineers, March 2009, Study findings and technical report—Alaska baseline erosion assessment: Elmendorf Air Force Base, AK, U.S. Army Corps of Engineers, Alaska District, 68 p.

http://www.poa.usace.army.mil/AKE/Home.html

This statewide assessment was conducted by the U.S. Army Corps of Engineers to coordinate, plan, and prioritize responses to erosion throughout Alaska. The report designated 26 communities, including Barrow, as priority action communities. The erosion at Barrow has been identified as coastal erosion along the Chukchi Sea aggravated by beach material mining. This report suggests that the average annual erosion rate is 1 foot per year.

The Corps has also completed a technical report on erosion and storm mitigation projects in Barrow, the cost of the projects were shared with the North Slope Arctic Borough. The report identifies possible structural solutions to erosion problems in the community.

U.S. Army Corps of Engineers, September 2007, Erosion information paper—Barrow, Alaska: U.S. Army Corps of Engineers, Alaska District, 6 p.

This report gives an overview of the current state of erosion and erosion mitigation projects in Barrow, Alaska. The orientation of Barrow makes the community most susceptible to storms from the north and west. The coastline is composed of 30 foot coastal bluffs with narrow fronting beaches in some areas and wide gravel beaches backed by low relief tundra elsewhere. The most extreme erosion event for Barrow was during 1963 when an average 14 feet of erosion occurred at bluffed locations.

The average erosion rate for the Barrow coastline is reported in this overview as 1 foot per year, but extreme events like the one above can cause dramatic changes. These events are responsible for the erosion of portions of a historic/archaeological site, roads, and homes in Barrow.

Past efforts by the North Slope Borough to lessen the amount of erosion and flooding are discussed with photographs of several projects.

U.S. Government Accountability Office (GAO), June 2009, Report to congressional requestors—Alaska Native villages, limited progress has been made on relocating villages threatened by flooding and erosion: U.S. General Accountability Office Report GAO-040895T, 53 p.

http://www.gao.gov/products/GAO-09-551

This report is a follow up to the 2003 GAO report on flooding and erosion in Alaska Native villages, and was completed to identify concerns due to climate change that have increased the urgency of federal and state efforts. The GAO developed recommendations for Congress that include:

1. *A flooding assessment to augment the erosion assessment completed by the Army Corps of Engineers.*
2. *An amendment to federal legislation that would allow 64 more villages to be eligible for grants.*
3. *The designation of a federal entity to oversee and coordinate village relocation efforts.*

This report recognizes Barrow as one of 31 villages facing imminent threats from flooding and erosion. Federal Emergency Management Agency (FEMA) hazard mitigation grants require communities to complete hazard mitigation plans before funding projects, which Barrow has completed. The US Army Corps of Engineers was given authority in 2006 to complete erosion projects within Barrow and 8 other communities amounting to $2.4 million.

U.S. Government Accounting Office (GAO), 2003 [2004], Alaska Native villages—Most are affected by flooding and erosion, but few qualify for federal assistance: U.S. General Accounting Office Report GAO-04-142, 82 p.

http://www.gao.gov/products/GAO-04-142

This study was conducted to provide recommendations to Congress that would improve how state and federal agencies respond to flooding and erosion in Alaska. This was done by:

1. *Determining the extent to which these villages were affected.*
2. *Identifying federal and state flooding and erosion programs.*
3. *Determining the current status of efforts to respond to flooding and erosion in nine villages.*
4. *Identifying alternatives that Congress may wish to consider when providing assistance for flooding and erosion. (pg. introduction)*

The recommendations provide alternatives to current actions taken during flooding and erosion responses by including federal agencies and the Denali Commission. The adoption of policies by the Denali Commission would guide investments in infrastructure for Alaska Native villages affected by flooding and erosion. Barrow is recognized in this report as one of 184 Alaska Native Villages facing threats from flooding and erosion, and one of nine communities for which a detailed review is presented. The report presents statistics such as, in Barrow, an estimated $500 million of infrastructure is located within a FEMA designated flood zone, and each time a major flood event occurs nearly $500,000 is spent to respond to losses.

Wise, James L., Albert L. Comiskey, and Richard Becker, 1981, Storm surge climatology and forecasting in Alaska: Anchorage, AK, Arctic Environmental Information and Data Center, University of Alaska, 26 p.

The objective of this study was to improve the quality of life and the security of property in coastal areas susceptible to flooding by enhancing the decision-making process for human activities and development. This study compiles historical climatological data to develop a surge forecast regression equation. Storm profiles specific to Barrow are recorded for 1963, 1968, 1970, 1977, and 1978.