Coastal Processes that Influence Sediment Transport Along the Homer Spit

By Taylor Bennett

Longshore Transport

Longshore transport is the process by which suspended beach material is simultaneously carried and deposited throughout the surf zone, parallel to the shoreline (Figure 1). As prevailing winds propel ocean waves towards the coast, interaction with the shoaling ocean floor causes incoming waves to refract and approach the shoreline at an angle. Water is propelled in the direction of wave break causing a longshore current to form in the surf zone, which moves water onshore and along the beach. Longshore currents displace and carry suspended beach sediment for deposition further down the shore [8, 10].

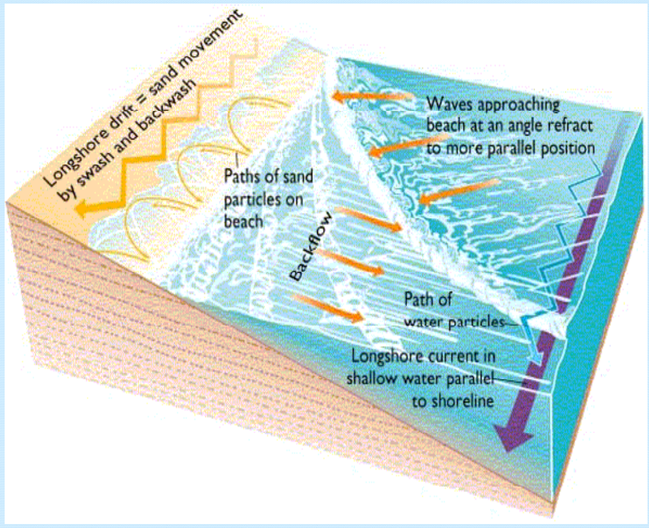


Figure 1. A model of longshore transport along a coast [5].

What Controls the Shape & Location of a Beach?

Waves

Waves in Kachemak Bay are the product of seasonal climatic variations and wind energy, blowing across a **fetch** distance of ~100km without interference [2]. Typical **wave heights**, average 2-4 feet. Larger waves combined with natural forces (i.e. wind, rain, tectonic movement) drive sea cliff retreat mechanics. Eroded material acts as a barrier to protect the cliffs from future incoming waves and forms sand bodies that are directly linked to the development of longshore currents [1, 2, 3].

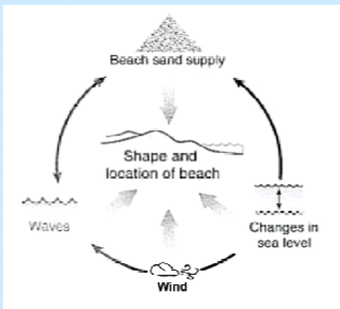


Figure 2. The controls of the shape and location of a beach [10].

Wind

Kachemak Bay is directly influenced by southwesterly winds that blow across lower Cook Inlet as well as the "Iliamna Jet" which blows consistently from the west, passing between Mt. Iliamna and Mt. Saint Augustine [2]. Combined, the Iliamna Jet and trade winds produce a strong **fetch** across lower Cook Inlet that extends into the bay, directly influencing **wave height** [1, 2].

Changes in Sea Level

Globally, the **relative sea level** rise is 3.3mm/year. In Homer, Alaska, an emergent coastline, average land level rise outpaces sea level increase. The uplifting land is a result of **isostatic rebound** and tectonic activity [7].

Beach Sand Supply

The sediment supply is a direct result of the recent deglaciation and rapidly retreating sea cliffs that comprise the western and southwestern side of the Kenai Peninsula. The retreating sea cliffs stretch up through Ninilchik, but are concentrated from Anchor Point along the coast to the base of the Homer Spit [1, 2, 6].

Beach Sand Supply: History

Southern Alaska has been glaciated several times within Earth's history. Kachemak Bay, Cook Inlet and the Homer area were formed during a series of glacial advances and retreats from the Wisconsin (Naptowne) Glaciation that occurred 32,000 – 11,000 years ago [1, 6]. Homer's northern shoreline and retreating cliffs are a product of the Moosehorn stage (30,000 – 18,500 years ago) of the Wisconsin Glaciation [6]. The retreating glacier deposited a shallow submarine bench and several **recessional moraines**. Through the processes of **upwelling**, daily tidal currents and erosion, the submarine bench produces the coarser-grained component (glacial till = cobbles, boulders and sand) of the bimodal glacial sediment found along the Homer Spit today [1, 2, 6]. The Homer Spit represents the remnants of a submarine terminal moraine deposited in the Skilak retreat, approximately 17,500 – 16,000 years ago (Figure 3) [6]. As the glacier receded from Kachemak Bay, rock and soil debris which was transported in on the glacier, were deposited during glacier melt back. In the past 11,000 years, shifting wind and wave regimes established the longshore currents that are constantly working to move and reshape the Homer Spit (Figure 4).

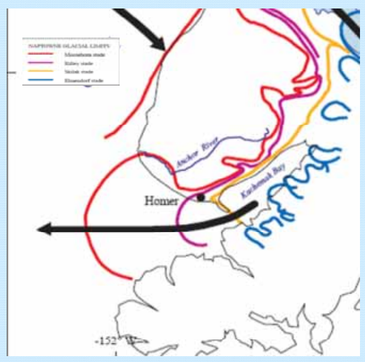


Figure 3. Diagram representing the ice flow limits of the Wisconsin Glaciation. The yellow limit shows the Skilak advance which deposited the sediment for the basis of the Homer Spit. The red line delimits the Moosehorn advance where deposited sediment forms the basis of the submarine bench and retreating cliffs along Homer's northern shoreline today [6].

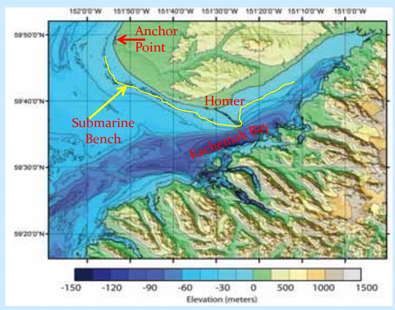


Figure 4. Topographic map of the Kenai Peninsula and Kachemak Bay. Note the shallow submarine bench (0 m to -30 m) outlined in yellow [1].

Beach Sand Supply: Contemporary Processes

Slumping Bluffs : Eroding coastal bluffs fuel the sediment transport process in the Kachemak Bay area [1]. As a result of frequent **mass wasting** events and human impact on the coast, the bluffs are lacking the critical balance needed to maintain stability and not exceed their **angle of repose**. However, without the constant input of sediment from the eroding cliffs, the Homer spit would not be as well formed as it is today [1,2,6]. The five main types of mass wasting events include: creep, slumping, landslides (rock falls), mud flows and avalanches [9]. Along Homer's northern shoreline, slumping is the most prevalent form of mass wasting. Upon further inspection of slump sites in the vicinity, it was determined that most sites are the product of two or more mass wasting events (Figure 5).

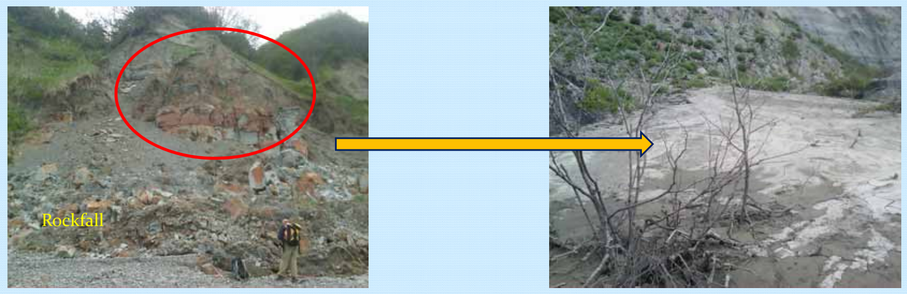
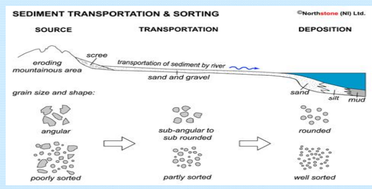


Figure 5. (Left) Slumping block of a coastal bluff (shown in red) with evidence of a previous rock fall at the base. (Right) Mudflow fan located on site as a result of precipitation and unconsolidated material from rock fall and slump. Site location: Bishop's Beach, Homer, AK. Photos by Taylor Bennett.

Sedimentation via Slumping Coastal Bluffs

In order for mass movements to take place, materials on Earth's surface must first be weakened by fracturing or **weathering**. Next, **relief** must develop. Once relief has been established, gravity pulls material from a higher elevation to a lower elevation. When material starts moving on an unstable slope, a slope failure has occurred. Slope failures occur because the downslope force, which is controlled by gravity, has exceeded the resistance force which inhibits sliding. Factors that may trigger this downslope force include: gravity, freeze and thaw, wind, wave dissipation, torrential rainfall, burrowing of small animals, natural groundwater flow, earthquakes, floods and volcanic activity [9]. The types of sediment that the slumping bluffs contribute to the sediment transport system of the Homer spit include: loosely consolidated sandstone, siltsone, mudstones (shale) and subbituminous coal [1, 2, 6]. Sediment may be transported by gravity (i.e. mass wasting), water (i.e. rainfall, rivers, storm surges) or glaciers (i.e. glacial moraine). The longer the transportation process (both in time and distance) the more rounded and better sorted the sediment grains become. Well-sorted deposits are of one grain size (i.e. sand, silt) located furthest from their source. Sediment size decreases with increasing distance from the source [4, 9].



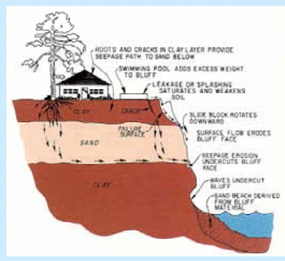


Figure 6. The amount of sediment being added to the sediment transport system may increase by means of: deforestation, overloading building atop cliff), over-steepening of slope, irrigation, drainage and artificial fillings in the landscape [3, 9].

Building homes along the bluffs of Homer's northern shoreline offers spectacular views of Cook Inlet and outer Kachemak Bay, however, having oceanfront property comes with a series of risks affecting both the homeowner and the sensitive sediment transport system (Figure 6). Along the coastline from Bishop's Beach to Anchor Point, both natural and human-induced erosion is threatening the loss of homes over the bluffs. Over time, coastal development increases natural bluff erosion and bluffs retreat. Bluff material being added to a beach may act as a buffer to dissipate incoming waves, however, deflecting waves from one area of a beach results in an increased concentration of wave attack further down the beach [1, 2, 3].

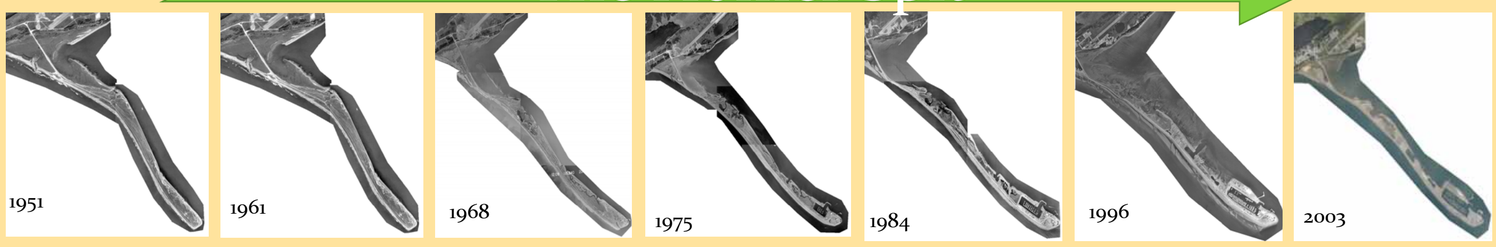
Glossary of Terms [8, 9]

Angle of Repose - the maximum angle that a soil, sediment or other loose material can accumulate and remain stable.
Fetch – the uninterrupted distance over which the wind blows without a significant change in direction.
Glacial Moraine – a hill or ridge of sediment deposited by a glacier.
Isostatic rebound – the rising of the land due to removing the weight of glaciers & ice sheets on the crust of the Earth.
Mass wasting – the downslope movement of soil, sand or regolith due to the force of gravity.
Recessional Moraine - a moraine left by a glacier during a temporary halt in the retreat of the ice.
Relative sea level – the level of the sea minus the level of the land.
Relief – the difference in elevation between two adjacent locations.
Upwelling – circulation pattern in which deep, cold, usually nutrient-laden water moves toward the surface.
Wave height – the vertical distance between a wave crest and the adjacent wave troughs.
Weathering – the processes that break up and corrode solid rock, eventually transforming it into sediment.

References:

[1] Adams, P. N., P. Ruggiero, G. C. Schoch, and G. Gelfenbaum (2007), Intertidal sand body migration along a megatidal coast, Kachemak Bay, Alaska, *J. Geophys. Res.*, *112*, F02007, doi:10.1029/2006JF000487. [2] Adams, P.N., P. Ruggiero. Wave energy dissipation by intertidal sand waves on a mixed-sediment beach. Proceedings of the 5th International Conference on Coastal Dynamics, 2005. [3] Army Corps of Engineers. Low Cost Shore Protection…a Property Owner's Guide. PA: GAI Consultants, INC., 1981. [4] Basic Geological Classification. 1 August 2012 <http://www.northstonematerials.com/about-us/education/basic-geological-classification/>. [5] Beaches, Waves, and Longshore Drift. 2 August 2012 <http://www.daukas.com/Geoscience/MAtour/CCC/background.html>. [6] Berg, Ed. "Kenai Tectonic History and Isostatic Upliff". Kenai National Wildlife Refuge. Homer, AK. 30 May 2012. [7] Freymueller, Jeff. "Land Level Change and Relative Sea Level Change". Geophysical Institute, University of Alaska Fairbanks. 2004. [8] Garrison, Tom. Essentials of Oceanography. Belmont: Brooks/Cole, Cengage Learning, 2011. [9] Marshak, Stephen. Essentials of geology. New York: Norton, 2009. [10] Pilkey, Orrin H. The world's beaches. Berkeley: University of California P, 2011. [11] R.D. Reger, A.G. Sturmann, E.E. Berg, and P.A.C. Burns. A Guide to the Late Quaternary History of Northern and Western Kenai Peninsula, Alaska. State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys, 2007. [12] Wind Driven Surface Currents: Upwelling and Downwelling. 28 August 2012 <http://oceanmotion.org/html/background/upwelling-and-downwelling.htm>.

The Homer Spit



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