Background

A disused cabin falls into the Beaufort Sea in this photograph, victim to climate-driven coastal erosion

Section 1:

Introduction

Coastal Revegetation & Erosion Control Guide

Photo: Harvey Smith (AK DOT)

Melting permafrost is a natural coastal erosion process, shown in this photograph of the Beaufort Sea coast. This guidebook will address methods using vegetation to mitigate and reduce erosion caused by human activity.

Alaska is known as a land of superlatives. It is the northernmost state, the westernmost state and by some definitions, the easternmost state (the Near Islands and the Rat Islands being west of the 180th Meridian). The state's name is derived from the Aleut word "Alyeska", translated as "the object towards which the action of the sea is directed", and generally taken to mean "Mainland" or "The Great Land".

Alaska is by far the largest state within the United States of America; having more than twice the area of the next largest. Indeed, Alaska by itself covers 1% of the land mass on Earth, and is larger than all but 19 countries on the planet. Its massive land mass notwithstanding, Alaska is first and always a coastal state.

Alaska has more miles of coastline than the contiguous United States

The coastal community of Seldovia, on Kachemak Bay, is bordered by intertidal mud flats

GEOGRAPHY

The Alaska Department of Natural Resources estimated the Alaska coastline to be 44,500 miles long, as measured on the most detailed maps available. Alaska's coastline is larger than the remainder of the United States' combined coastline.

Nearly three quarters of the Alaska's population live in communities along this coastline. The coastal region supports industries like commercial fishing, logging, tourism, and oil and gas production. Production industries, though responsible for a large portion of Alaska's economic product, can have significant impact on coastal areas, and any adverse effects should be mitigated.

HISTORY

Alaska has been peopled for several thousand years. Humans entered Alaska from Asia, either by walking over the Bering Strait or by boat (Mason et al, 1997). Although the earliest known archeological remains in Alaska are just 12,000 years old, radiocarbon dating of a peat bed 150 feet below the surface of the Chukchi Sea show that the land bridge remained exposed until 11,000 years ago; plenty of time for a land crossing (Mason et al, 1997). Complex societies first developed in the Bering Straits region, on Kodiak Island, and in Southeast Alaska, 2000 years ago. Alaska remains home to several indigenous cultures & tribes, such as the Athabascan, Eyak, Haida, Tlingit, Tshimian, Yupik & Inupiat Eskimo, and Aleut peoples.

The area now known as Alaska was first colonized by Tsarist Russia, beginning in 1732. The basic shape of Alaska was established by treaty between Britain and Russia in 1825. Exploitation of Alaska's natural resources was almost exclusively restricted to the coastline until 1867, when the territory was sold to the United States, by Alexander II. A border dispute with Canada over the southeastern portion of the territory was resolved in 1908, when a treaty between the USA and Britain finalized the border.

The 1867 purchase of the territory of Alaska, instigated by Secretary of State William H. Seward, was criticized by contemporaries, and commonly referred to as 'Seward's Folly' or 'Seward's Icebox'. Despite this derision,

Image: US National Archives

1867 U.S. Treasury warrant for the purchase of Alaska from Russia

a $7.2 million treasury warrant was issued, and the purchase made. The United States received the 586,412 square miles, or approximately 365 million acres of land, to be known as the Department of Alaska. Alaska would be classified twice more, as a district and as a territory, before becoming a state. Alaska's constitution was ratified in 1956; "The Great Land" became a state on January 3rd, 1959.

IMPACTS

Many natural events have impacted Alaska's dynamic coastal environment. Impacts such as the 1964 Good Friday Earthquake can cause upheaval on an unprecedented scale, though very little can be done to correct or restore uplift or subsidence of land. Volcanic eruptions, glacial advance and tsunamis can also massively disrupt existing coastlines. These processes are part of the natural progression of landforms, and it is unlikely that human intervention to correct or reverse the resulting changes will ever be effective or practical.

Human caused impacts, both accidental and intentional, have also disrupted natural ecosystems in Alaska. During the early 1940s, the Aleutian Islands were host to a number of military actions and battles associated with World War II. The legacy and impact of this conflict remains today; not only in the lost lives, destroyed villages, and acres of war debris, but also in the form of actual scars on the land surface. These reminders of past actions remain, a lasting impact that has affected generations of coastal residents.

Even after the Second World War, other threats to peace caused the coastline of Alaska to take center-stage. In the Cold War drama that began in the 1950s and continued for decades, the Defense Early Warning System was established at several locations in the Aleutian Islands, and along the Western and Arctic coastlines of Alaska. These 'D.E.W. Line' sites were not in themselves detrimental, but what was left behind often was. Debris, petroleum contamination, and toxic substances all contributed to coastal impact. Environmental remediation and cleanup activities at many of these remote sites was undertaken by the Department of Defense in the 1980s and 1990s. Federal legislation, notably the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and its subsequent amendment, the Superfund Amendments and Reauthorization Act of 1986 (SARA), was instrumental in accomplishing the cleanup.

Construction impacts associated with industrial progress and commerce are expected with a growing society and its communities. One example of this is the construction of the Valdez Marine Terminal, the

Cannakin nuclear warhead being lowered into position on Amchitka Island in 1971

southern terminus of the Trans Alaska Pipeline System (TAPS). This 1,000 acre terminal was carved out of a mountainside, allowing tanker ships to load north slope crude oil for transport to market. Before the first drop of oil was transported through the TAPS, the coastal impact of this development was considerable.

On occasion, progress can seem to take a step backward. Alaska's coastline witnessed the underground detonation of three nuclear devices between 1965 and 1971, in the western Aleutians. These three events were collaborative efforts between the Atomic Energy Commission and the Department of Defense. Amchitka Island, in 1965, saw the detonation of an 80 kiloton device, followed by a 1 megaton blast in 1969, and in 1971, the detonation of the largest nuclear weapon ever on US soil, under Project Cannikin. Amchitka Island was selected as the test site because the warhead was too large to be safely detonated in Nevada. The continued impact is only now being determined.

The quest to use nukes on coastal Alaska actually started earlier than the Amchitka exercises, with the 1958 Project Chariot study near Point Hope. Project Chariot was a part of a national effort known as Operation Plowshare, an attempt to use the nuclear arsenal for peaceful projects like construction. While the intended goal of the project, the excavation of a harbor using nuclear detonations, never came pass, the environmental impacts of the study remained until the site was rehabilitated in the 1990s.

Impacts to the coastal environment continued with the development of the Alaskan economy. These impacts, though not as large as the events previously mentioned, were expected and often mitigated. As oil development on the Arctic Coast ramped up in the 1970s and 1980s, impacts to the coastline were managed, and lasting disturbances minimized. Methods have been developed to mitigate these impacts, such as limiting travel along the arctic coastal plain to the winter months, when snowpack protects the fragile tundra. These techniques reinforce the age-old maxim that an ounce of prevention is worth a pound of cure.

Cleanup efforts underway in Prince William Sound in May of 1989.

Alaskans' view of their coastline was changed forever, just a few minutes into the morning of March 24, 1989. Residents awoke to the news that the oil tanker Exxon Valdez was hard aground on the largest charted reef adjacent to the shipping lanes near the port of Valdez. The tanker was leaking its load of crude oil into Prince William

Sound. Eventually, 1,300 miles of pristine coastline was covered with a 30 million gallons of crude oil (AK DOL, 1990; Ott, 1996). This single occurrence is widely viewed as the most significant event to impact the Alaska coastline, severely affecting beaches, wildlife, plant communities, and the region's industries. Paradoxically, in some areas more damage may have resulted from misguided cleanup efforts than the oil itself.

In a 2005 assessment of remaining impacts, the National Oceanic and Atmospheric Administration's Office of Response and Restoration made the following observation: "..rocky sites ... stripped of heavy plant cover by high-pressure, hot-water cleaning remain mostly bare rock" (NOAA, 2005). As the nation continues to deal with the ongoing impacts from the oil disaster in the Gulf of Mexico, the lessons learned from the Exxon Valdez Spill are taking center stage.

Two halves of the freighter *Selendang Ayu*, adrift north of Unalaska Island - December, 2004

The 1989 spill, though the largest, was by no means the last maritime event to strongly impact the Coast of Alaska. In late 2004, a freighter laden with over 60 tonnes of soybeans, en route from Seattle, Washington to Xiamen, China, suffered engine problems near Dutch Harbor. Heavy seas and a strong wind complicated rescue efforts, pushing the stricken vessel towards the coast of Unalaska Island. The ship subsequently broke in two, spilling its cargo, along with 350,000 gallons of bunker oil and diesel fuel (PAME, ongoing). Wave action deposited large quantities of the cargo onto the north coast of Unalaska Island. In 2006, the Alaska Department of Environmental Conservation determined that the decomposing beans presented no danger to human health, and all incident response activities were suspended.

A rocky beach on Unalaska Island coated with spilled soybean cargo from the wrecked *Selendang Ayu*

PURPOSE

This guidebook was developed to aid in the process of coastal revegetation. The intended audience is private property owners, as well as state and local government.

For the purpose of this document, revegetation is defined as:

> *The re-establishment of plant cover by means of seeding or transplanting on a site disturbed by natural or man-caused actions.*

Impacts, both large and small, will continue to disrupt the coastal regions of Alaska. The coasts experience natural soil erosion

caused by water (fluvial), wind (eolian), and gravity. Combinations of waves, frost heaving and unobstructed fetch along miles of coastline present ample opportunities for soil loss. Removal of vegetation and soils proceeds at unsustainable rates in some areas, changing the dynamics of natural ecosystems. Recovery (defined as the presence of self-sustaining vegetation cover, and limited erosion) of most sites will require human intervention to correct limitations and guide the ecosystem towards a desired end state. Material presented in this manual focuses on the "soft approach" to erosion control, using vegetation. While the "hard approach" (i.e. the use of rip-rap) is an effective means of stabilizing an area, these non-vegetative methods will be left to Coastal Engineers.

Numerous approaches are available for reintroducing vegetation on a site. This manual details a logical sequence of surface preparation, fertilization, and seeding. When followed on a site, this sequence will usually result in a self-sustaining native plant community that requires minimal management input. When conditions allow, most disturbed sites will naturally be re-colonized with plants from the surrounding area. This "do-nothing" approach is rarely used, however, as it does not provide aesthetic cover quickly enough for highly visible areas. Natural Reinvasion, as this technique is known, is effective, but it may take years for a plant community to become established. As nearly three quarters of the state's population lives in communities along the coast, political and aesthetic consideration frequently preclude this option.

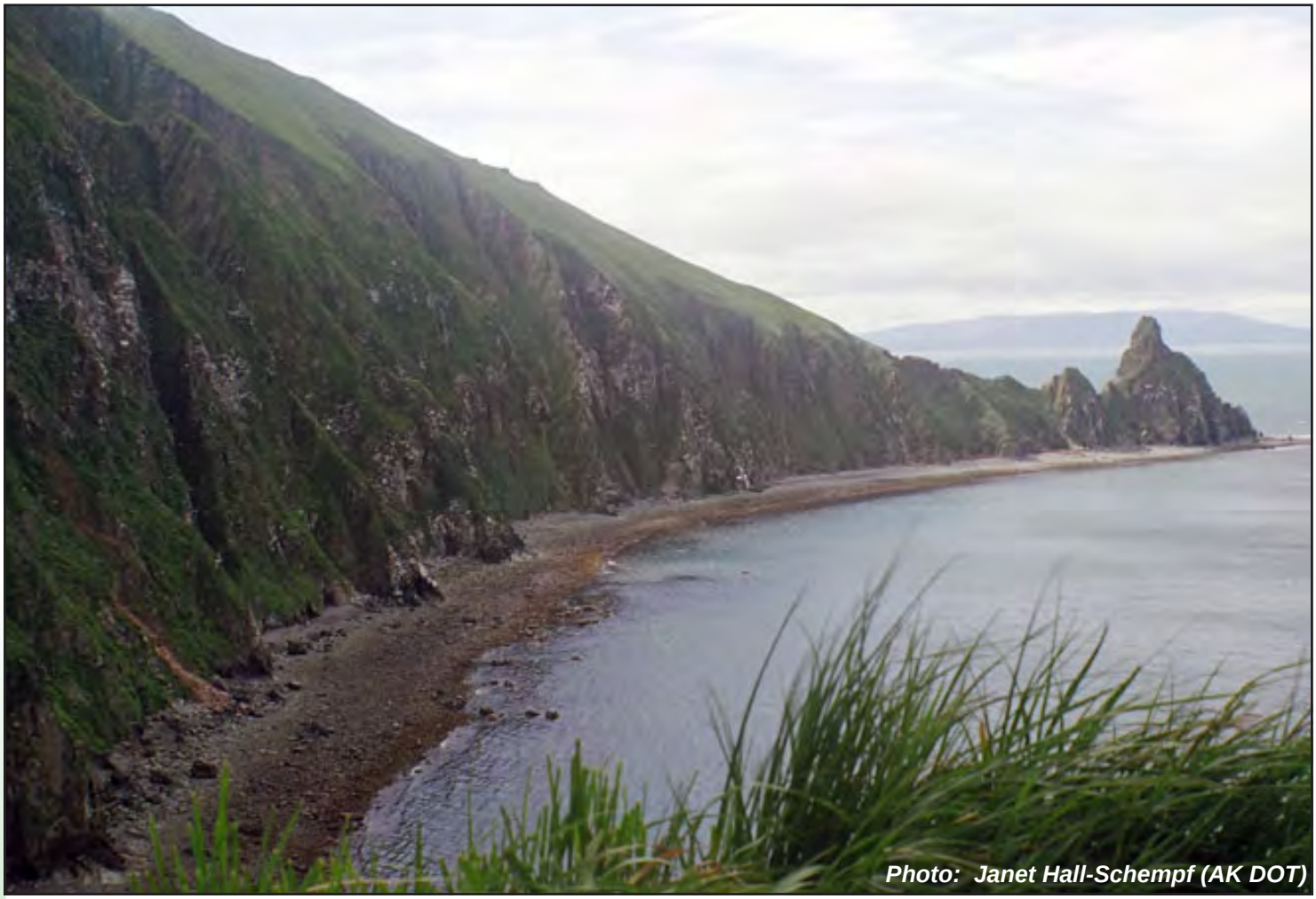
METHOD

The sheer size of the state, along with considerable differences in climate and vegetation in different areas, necessitated the division of Alaska into five coastal regions: Arctic, Western, Southwest, Southcentral, and Southeast Alaska. Vegetation communities present in each region are described in detail, and a list of appropriate revegetation species for the region is included in the Adapted Plants section.

A map of Coastal Zone boundaries, included on the inside front cover, is used to define what is 'Coastal'. These zones vary in size considerably, depending on the terrain and elevation. Coastal zones can extend inland over several atlas quads in western Alaska, or stop very near the coastline in southcentral parts of the state.

A sizable portion of this manual is dedicated to case studies, highlighting past revegetation projects that have occurred on coastal sites in each region of Alaska. These and future case studies can also be found online, at plants.alaska.gov/reveg/.

Coastlines



Steep, vegetated cliffs dominate this beach on Walrus Island, near Togiak, Alaska

Alaska has a long and diverse coastline, representing several unique eco-regions. An eco-region can be defined as a large area of land and waters containing vegetation communities that share ecological dynamics, environmental conditions, and interactions that are critical for their long-term persistence (Nowacki, et al, 2001). It is necessary to address the issue of revegetation in the context of an eco-region, as this will effect species selection and other planting requirements.

Within each eco-region, and across Alaska, several different types of coastline exist. In this section, you will find a short description of several coastline types and the geomorphic factors that influence each.

Coastal Glossary:

Fetch:

An extent of open water across which the wind is blowing (Bird, 2008).

Beach:

The area between high tide and the coastline. The beach is defined as an accumulation of loose sediment, sand, gravel, or boulders (Bird, 2008).

Shore Zone:

The area influenced by tidal forces. Stops at the border with the coastline.

Coastline:

The edge of the land at highest tides, at the upper limit of the shore platform. Frequently indicated by the seaward boundary of terrestrial vegetation.

Intertidal Zone:

The area between high tide and low tide, below the beach.

Shore Line:

The edge of the waterline, moving as the tide rises and falls. Typically measured at low, mid, and high tides (Bird, 2008).

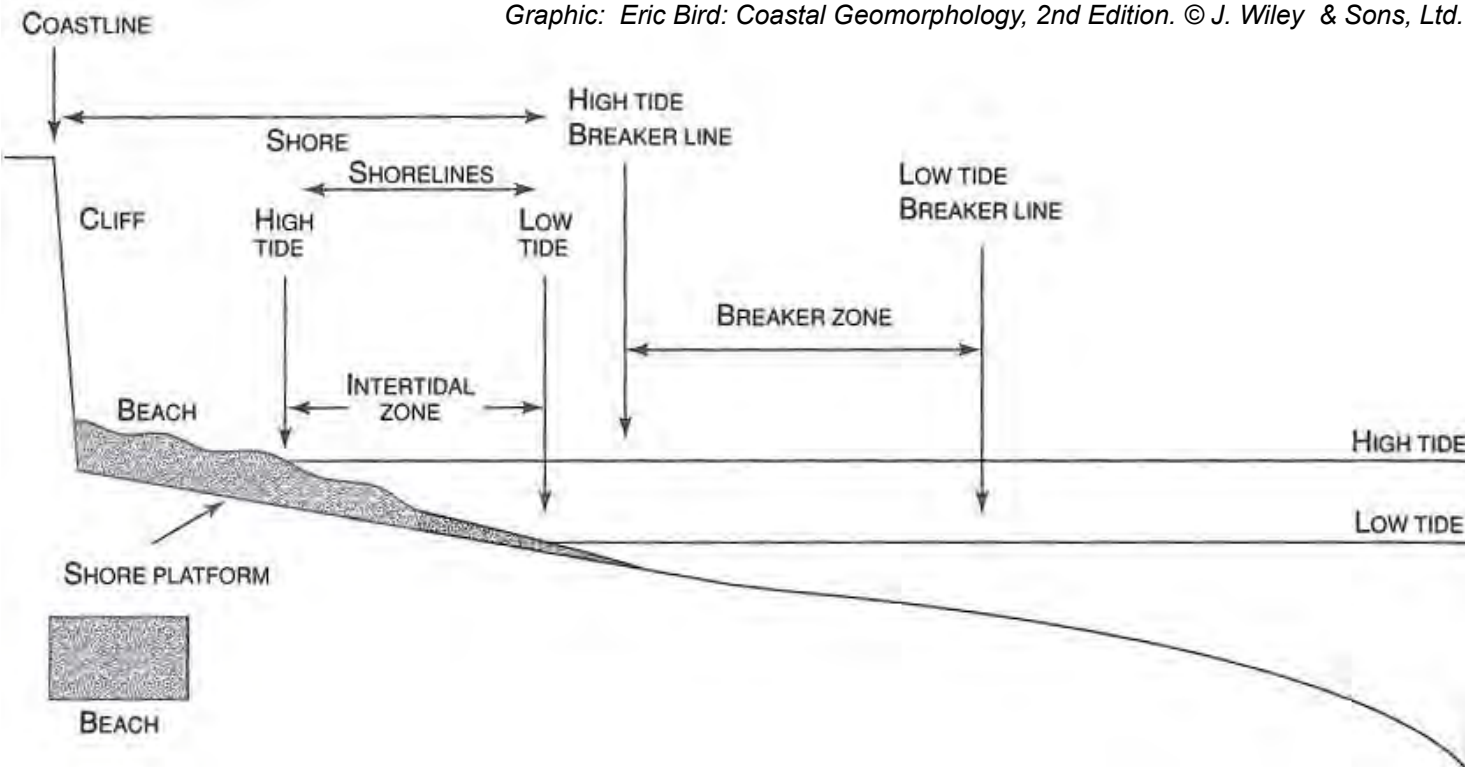
Shore Platform:

The shore platform includes the area defined by the tidal range, up to the coast line, typically demarcated by a cliff or steep slope.

Intertidal Mud Flats:

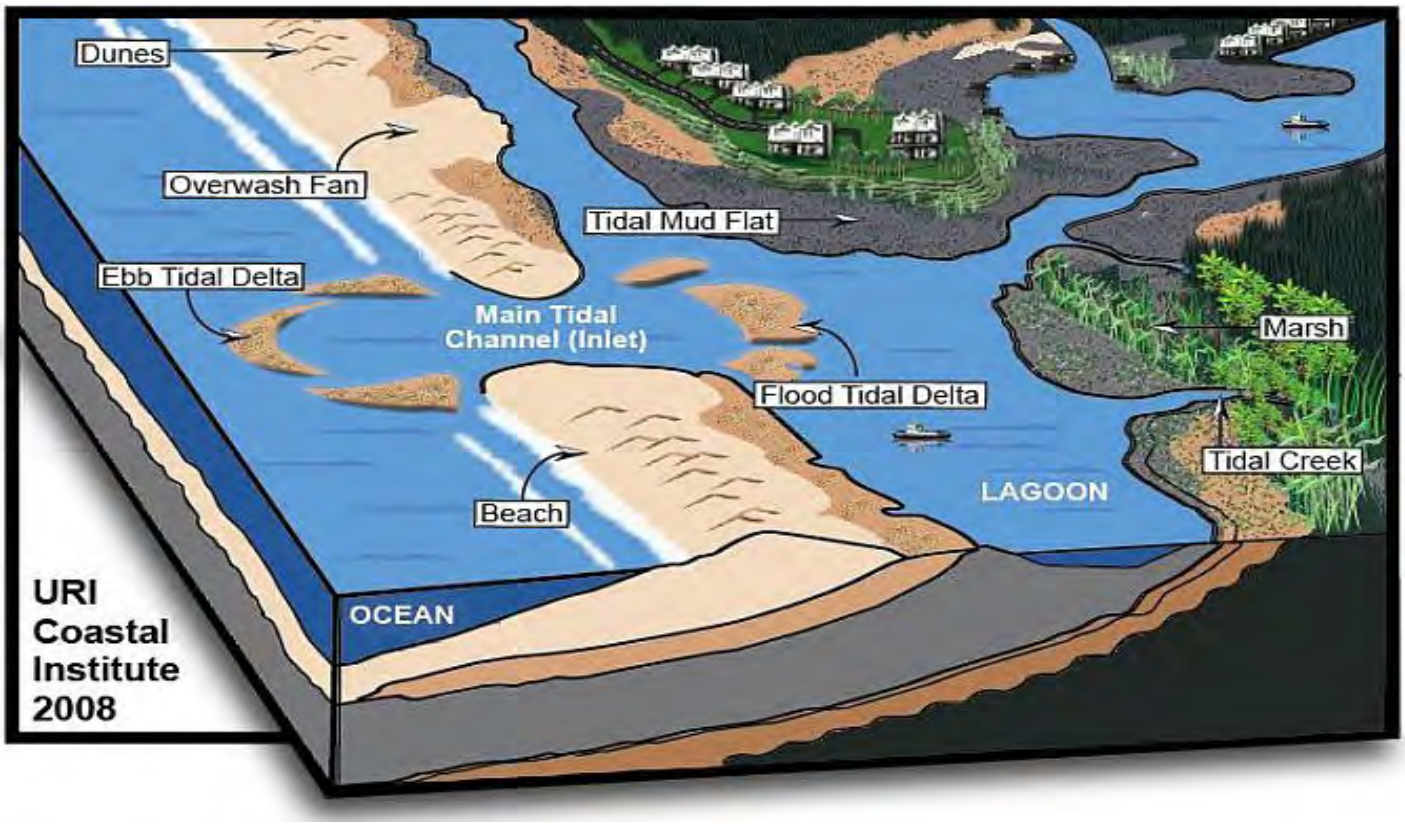
Mud flats consist of sediment built up along coastlines. Mud Flats are found in sheltered areas such as bays, lagoons and estuaries, near salt marshes.

Coastline Types:



Graphic: Eric Bird: Coastal Geomorphology, 2nd Edition. © J. Wiley & Sons, Ltd.

Figure 1: Coastal Terminology



Graphic: Nate Dibble (University of Rhode Island, Coastal Institute)

Figure 2: Diagram of barrier island, tidally influenced areas

Coastline Types:

Mendenhall Wetlands State Game Refuge

Intertidal Wetlands:

Intertidal wetlands refer to a range of the shore between high and low tides. This zone experiences regular tidal inundation, and is typically cut by meandering channels branching out to the ocean.

This type of coast occurs predominantly in Southern Alaska.

Coastal Lagoons:

Coastal lagoons are areas of relatively shallow water that have been separated from the sea by coastal barriers. These areas can exhibit high variability in salinity, changing from brackish to hypersaline (Davis, Fitzgerald, 2004).

Like estuaries, these areas have a mixture of fresh and sea water (Bird, 2008). Species diversity is typically low, although the hardy species that can tolerate the high salinity are found in abundance.

Lagoons occur across Alaska, especially in the northwestern region.

James Lagoon, McCarty Fjord, near Seward, Southcentral Alaska

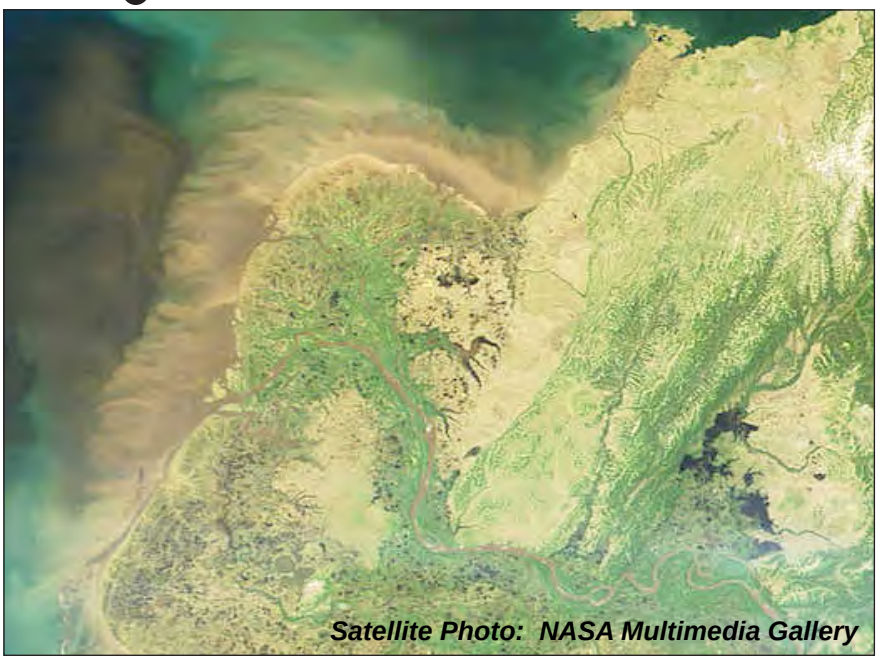
Chickimin River estuary, Southeast Alaska

Estuary:

An estuary is a zone where freshwater from rivers and streams meets the sea, mixing with salt water from the ocean. Estuaries are among the most productive ecosystems, harboring unique plant communities, specially adapted to this brackish mix of waters (NOAA, 2007).

Gradual elevation gains in these areas can extend the coastal habitat range inland for several miles. Saline tolerant species should be selected for an estuarine vegetation mixture.

Coastline Types:



Yukon River delta, Western Alaska. Note sediment fan.

Deltas:

Deltas form at the mouths of large rivers. Sediment deposition creates enlarged intertidal areas, making the shore-zone shallower.

Silts and clay soils are prevalent in Deltas. On cold and arid coasts, delta vegetation is sparse and sediments are coarse with large amounts of sand and gravel (Bird, 2008).

In Alaska, the major river deltas are the Yukon-Kuskokwim, the Copper River, and the Colville, on the north slope.

Sheer Cliffs:

Sheer cliffs are areas where the coastline rises steeply from the end of the shoreline. Vertical cliffs occur in homogenous geologic strata, such as sandstone and limestone (Bird, 2008).

The shore zone may be all but non-existent in Fjords. When a cliff rises 500 meters vertically within 50 meters of the shore line, the coastal vegetation can be very different from that which is present on the shore.

A sheer cliff rises from the shore in the McNeil River State Game Refuge, Southwest Alaska

Rocky Coastline in Prince William Sound, near Whittier

Rocky Beaches:

Rocky Beaches are the norm in Alaska. These beaches have low erosion potential, and low dynamics.

Sparse vegetation cover and gravelly soils typify these areas. Pebbles and rocks dominate the shore zone. Terrain tends to be stony right up to the coastline, where terrestrial vegetation begins.

Coastline Types:

Atsakirak Mound, a coastal barrier island northwest of Kivalina

Coastal Barriers:

Coastal barriers and barrier islands are elongated land forms formed by the deposition of beach materials offshore. Barriers consist of sand or gravel deposited by long-shore drifting or carried in from the sea floor (Bird, 2008). The landward side of these features often enclose lagoons and wetlands. Coastal barriers are a prevalent geomorphic feature in northwest Alaska.

Typically, grassy vegetation is prevalent on these coastlines.

Coastal Dunes:

Coastal dunes are characterized by high quantities of sand and exist in a place of significant tidal action. Dunes have a very dynamic and transitional nature.

Typically, dunes support Beach Wildrye communities. This species is uniquely able to tie together loose-grained, sandy soil. Coastal dunes provide critical protection for beaches and inland areas against storm surges.

Coastal dunes on the Kenai peninsula. Note stabilizing vegetation.

The Homer Spit protrudes 4.5 miles into Kachemak Bay, about 19 feet above sea level

Spits:

Spits are beaches built up above the high tide level, protruding into the water, usually ending in one or more landward hooks or recurves (Schwartz, 1972). Spits are deposition landforms, caused when waves hit the coast at oblique angles, moving sediment down the beach. As spits grow, a salt marsh is likely to develop behind them, in the area sheltered from the wind and waves.

The Homer spit and the Port Clarence spit are examples of this geomorphic feature in Alaska.

Coastline Types:

A sandy beach in Prince William Sound

Sandy Beaches:

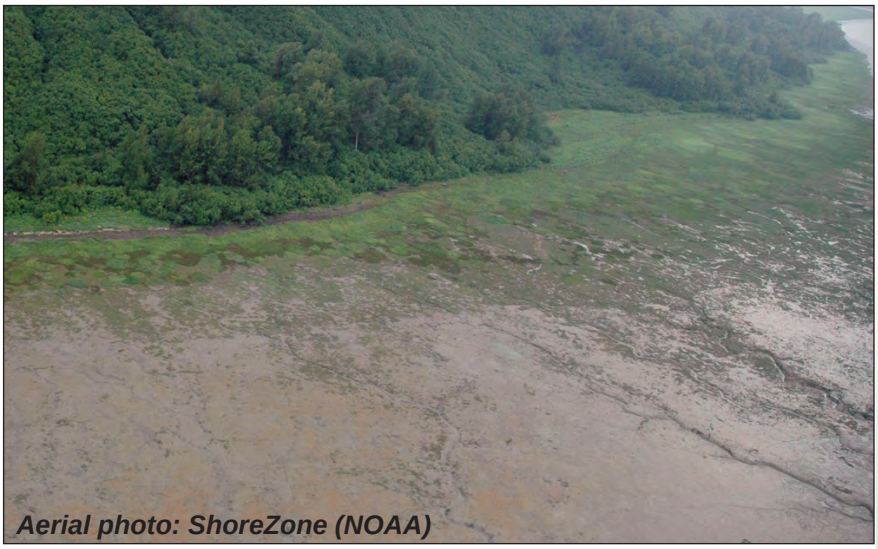
Sandy beaches can be found in Alaska. This one is from the western edge of Prince William Sound, at the edge of the Chugach National Wildlife Refuge.

Sandy beaches form by accretion of sediment. Species that thrive in these areas must be adapted to loose-grained soils. Notable examples include Beach Wildrye (*Leymus mollis*) and Bering Hairgrass (*Deschampsia beringensis*).

Tidal Mudflats:

Mudflats form when fine sediments such as silts and clays are deposited along the shoreline. These areas can extend the intertidal zone significantly.

Vegetation is limited in tidal mud flats, due to the tidal fluctuations and salinity. Species most adapted to this type of coast include Seashore Alkaligrass (*Puccinellia sp.*), Seaside Arrowgrass (*Triglochin sp.*), and Seaside Plantain (*Plantago maritima*).



Vegetation along a tidal mudflat in Cook Inlet

A high energy beach in the Walrus Islands State Game Sanctuary

High Energy Coasts:

High energy coasts are those with very little natural protection from the ocean's waves. The continental slope tends to drop off sharply in these areas. A long fetch means that high energy coasts are subjected to strong wave action and erosive influences.

These beaches are characterized by large rocks and very little vegetation growth. Some high-energy beaches can be sandy, however, such as those in the western Aleutians.

High energy coasts are sometimes characterized by rugged cliffs and long, curving beaches. The long, curving type of high energy beaches are generally found where the continental slope is shallower. (Bird, 2008)