The Challenges That Western Alaska Faces Regarding Coastal Erosion and the Methods Needed to Combat its Long-term Effects

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This research looks at the impact of coastal erosion in Western Alaska, along with examples from other areas of the world. This research also examines two broad methods for combating coastal erosion, along with more specific examples of each. Most of the research is internet-based research, relying on several reliable government sources such as the NOAA and the EPA, along with a few articles that have appeared in scholarly publications. This research will help illuminate the threat of coastal erosion and the multiple methods that can be used to revert or stall the encroaching threat of the ocean's power.

Coastal erosion is a huge problem for many people living on the coast; this particular problem is something nobody wants to deal with. Coastal erosion can cause major property

damage, loss of valuable land, and damage to the economy. It is important to fight against this terrible predicament because property, land, and the economy are important to human nature. Most settlements located on or near the coast have experienced this dastardly mishap caused by nature. Coastal erosion not only affects people, but also the organisms that live on the affected coasts. These creatures may lose their nests, their homes, and maybe even their lives. If these organisms are important to humans and the ecosystem, the impact is far greater.

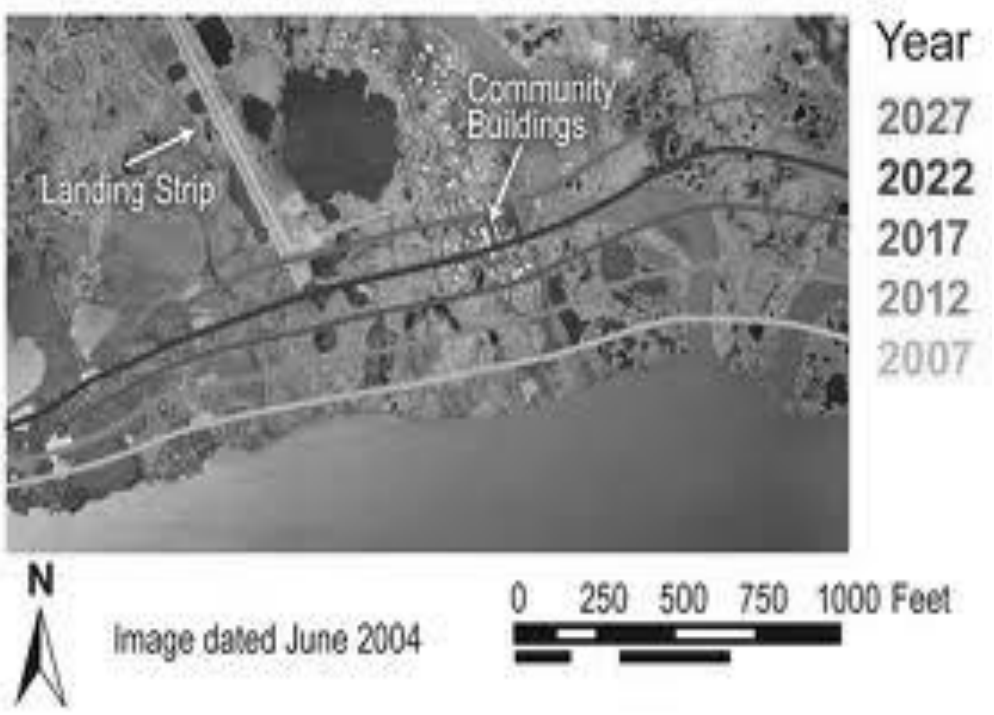
Many settlements have tried to find ways to combat coastal erosion, with a mixture of success and failure. Even though some have failed, the efforts of these settlements have provided examples for the rest of the world. Getting involved with the prevention of coastal erosion will help save other settlements from suffering the same fate of settlements that have already been consumed by coastal erosion. Coastal erosion is a tough quandary to tackle, but cities, states, and nations that are being affected are hard at work trying to stop or slow this crisis as best as possible.

There are two popular methods that can be employed to stop or slow coastal erosion. One method is to set up revetments along the coast and the other is to plant a salt marsh, also known as a halosere, along or near the banks of the affected coast. There are many other methods that can be used; however, they are not as effective as revetments and salt marshes. For example, sand bags, sea walls, and many other methods would stop the current and the waves from getting to the coastline, but they simply cannot match the preservative power of revetments and salt marshes. All of these methods can work, but making them work depends on the type of environment in which they are put.

The state of Alaska has many locations that are being affected by coastal erosion. These locations are mostly on the western coast of the state. Coastal erosion on the western coast is not

unusual; it is to be expected because of how the coast meets the Bering Sea, which is a vast, rough, active, and wavy sea. There are a few Alaskan villages that are being greatly affected by coastal erosion. For example, there is a village named Newtok that is being forced to relocate because their banks have gotten dangerously close to the village. There is another Alaskan village that is being affected by coastal erosion, the village of Shishmaref.

Here is a visual example of how the coast around Newtok is being eroded, according to the U.S. Global Change Research Program:



(nca2009.globalchange.gov/projected-coastal-erosion-2007-2027-newtok-western-alaska)

A definition of coastal erosion is "a natural process along the world's coastlines that occurs through the actions of currents and waves and results in the loss of sediment in some places and accretion in others (centerforsolutions.org/climate/impacts/cumulative-impacts/coastal-erosion/)." This unwelcome dilemma has occurred in many places that are located near coasts of huge rivers, oceans, or other large bodies of water with currents and big

waves. For example, the village of Happisburgh that is located in Norfolk never used to be a coastal village, but it is now a coastal village. In the years between 1600 and 1850, there was 250 meters of land lost because of coastal erosion (www.bgs.ac.uk/landslides/happisburgh.html).

The villages on the Northeast New England Holderness coast are in danger of being lost to sea. A village that is called Skipsea is so close to the sea that some of their roads are closed due to coastal erosion. This village is one of the villages located on the Holderness coast of New England, one of the fastest eroding coasts in the world (www.bbc.co.uk/news/in-pictures-22025150). States in the U.S. are also being affected by coastal erosion; these states are Alabama, Florida, Louisiana, Mississippi, and Texas. Coastal erosion affects every continent, and it is not an issue that is isolated to one section of the world (library.thinkquest.org/J0110230/States.htm).

Coastal erosion does not only affect life on land; it also affects life in the water. Even though it may seem that the ocean is getting bigger, it is still hurting from erosion. Debris and pollutants may fall into the ocean and pollute the area, thus hurting the organisms that live in the ocean that has been polluted. The debris floating around may clog and block water from going in to a creek or a small stream that may be vital to the ecosystem. The trash that is floating around aimlessly may get caught into a fish's, turtle's, or another living organism's mouth and make them choke and die. If too many animals choke on trash then that will greatly hurt both the ecosystem and the economy.

Coastal erosion causes a lot of issues for the little Alaskan village of Newtok, and a lot of them are very different from each other. This erosion problem obviously causes many financial issues, which of course these problems would cost a lot of money. Coastal erosion not only causes problems for Newtok financially, but also causes problems for their culture. Newtok will

also have environmental impacts due to coastal erosion, and these impacts aren't small, these are huge impacts on the surrounding environment.

Financial problems, no doubt, come along with coastal erosion that may wipe out a village. The Newtok relocation is going to cost from "about $80-130 million, and that's about $2 million per household" (http://www.cakex.org/case-studies/relocating-village-newtok-alaska-due-coastal-erosion). This shows how devastating the effects of coastal erosion can be in a financial sense, and how important it is to try everything to prevent its effects before it comes to the compete relocation of an entire village.

One possible reason for Newtok slipping into the sea could be climate change. Susan Goldenberg states:

> "In Newtok, the residents believe that climate change is the problem and that human activities causes climate change. Others don't argue, but at the same time a few do not believe that human activities is the problem. The state, in the past 60 years, has warmed twice the speed of the rest of the country. This means that the snow is wet and heavier, wildfires become active during summers, and the moose that usually stay in the mid-terrain area of Alaska migrate north into the caribou territory." (www.theguardian.com/environment/interactive/2013/may/13/newtok-alaska-climate-change-refugees)

If this is the case, the town of Newtok should be an example to the world of the potentially devastating effects of climate change to a coastal town.

These changes are happening all over southern and middle Alaska. Climate change is causing the rivers to expand, and many natural resources to erode. Newtok, in the 1990s, began

losing land at a dangerous rate and almost all the coastal villages in Alaska face an imminent threat.

Coastal erosion is forcing Newtok to relocate to a new location, and this changes almost everything for the people in Newtok. The residents of Newtok are racing against time to successfully relocate all of the population:

> "Newtok is also part of about 178 Alaskan communities threatened by the erosion happening. But, only a few are having critical problems. Such as; Shishmaref, Kivalina and of course Newtok. Back in 2006, a non-governmental organization known as the Newtok Planning Group helped the village in making the choice to move to the location of Mertarvik, a settlement several miles from the village of Newtok." (http://www.epa.gov/climatechange/impacts-adaptation/alaska-adaptation.html)

If the residents don't act swiftly, they could end up watching their village and culture slowly be consumed by the sea.

The relocation will be a huge change because of the difference of the building arrangements, the way the village looks, and the way the things are done. It will also affect the wildlife around Mertarvik. That means the wildlife will also have to relocate. But this will help the population of Newtok in many ways. The residents won't have to worry about big floods, erosion, and public property being damaged by floods.

The impact to Alaska's environment is not isolated to the southwestern coast, as stated in this report:

> "Environmental impacts are happening all over Alaska and not only around the town of Newtok. For instance, the permafrost throughout the state thaws and

> causes some structures within the soil that the permafrost is thawing to be damaged. The way that happens is that the permafrost thaws that is in the soil, then the soil sinks, buildings or structures in the soil are then damaged by a slow impact or the structures stands bending and breaking." (http://www.epa.gov/climatechange/impacts-adaptation/alaska.html)

Even if a town is not on the coast, that does not mean they are safe from other types of soil erosion. Villages could be faced with rapidly melting permafrost that weakens buildings and homes.

If no one does anything about the village slowly going away, in about 15-20 years from now, the village can be halfway under water or worse. This would be catastrophic to those who live in the village of Newtok. Without a place to live, the only other option for residents would be to move to surrounding villages or to another village that has relatives.

The first part of the plan is to stem the tide of coastal erosion, which would be using permeable or impermeable revetments. These revetments could be gabions, rock revetments, impermeable sea walls, or barricade-like revetments, such as wooden or concrete fences. According to the Federal Highway Administration, "inadequate recognition of potential erosion processes at a particular site may lead to failure of the revetment system (http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec11si.pdf)," which shows the importance of proper maintenance in order to have a successful revetment system. Without proper maintenance, they would fail to give any positive effect to the ecosystem.

One type of revetment that would help would be a gabion revetment. Gabions are a wire mesh basket filled with stones. The size and shape of these can vary, from a big cube-shaped

wall to a sloped surface that follows the shoreline. The former of the two is used for banks and cliffs; the latter is used for beaches.

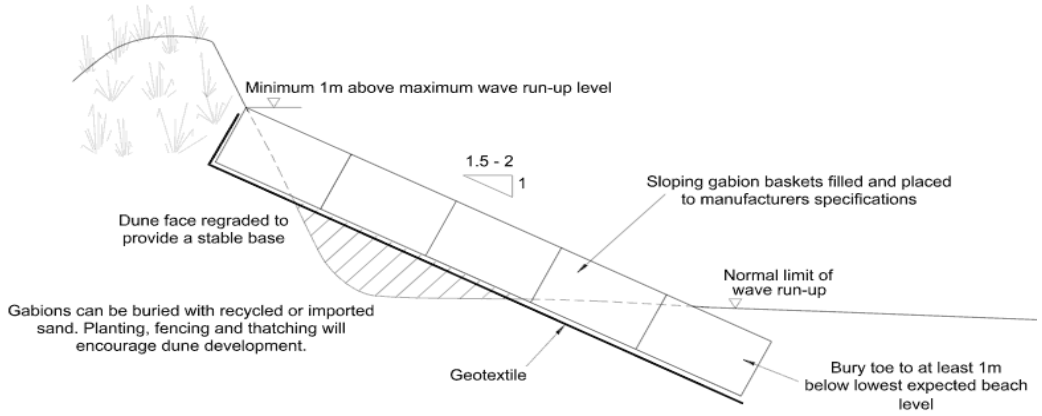
The overall use for gabions is to protect the backshore from eroding by absorbing wind and wave energy (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml). They can do this due to their porous structure. Gabions also can trap wind blown sand or dust and help promote the growth of vegetation and promote upper beach or shore stability. Though, only gabion revetments, which were introduced as sloped gabions, can do this.

However, their structure can be a problem too. The rocks have to be rounded, not sharp or angled and should not be put along shingle beaches, as wear and tear damage would cause nonnative rocks to rapidly spread and create an unnatural beach. Additional problems could occur if the baskets were to tear. Near vertical gabions also would suffer toe scour and structural damage, as they can't dissipate wave energy during a storm (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml). Due to this, near vertical gabions are not as favorable as gabion revetments, which fair better than the former (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml).

Another thing to note is that there is a certain way to lay it out. The slope of the basket must be at least a 1:2, however, the slope can change depending on how flat the terrain is; the basket must have a stable base (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml). As for the toe of the basket, it should be near the estimated limits of the wave run-up and have some stone placed along the to prevent any scouring (http://chl.erdc.usace.army.mil/library/publications/chetn/pdf/cetn-iii-31.pdf).

Observing and recording the position of the strand line during spring tide periods during winter storms and wave conditions can establish this. Then there needs to be some geotextile placed on the back of the basket. If desired, one can also bury the gabion with imported or recycled sand to help encourage dune development, which also is a key part in absorbing wave energy. Gabions should be placed and used in estuaries. They may be made with PVC-coated wires or galvanized wire. The latter is preferred, as it would provide a better service (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml).

The following figure shows what was explained:



(http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml)

In general, gabions should be used along beaches or shores suffering from moderate to sever erosion and is useful for estuary bank protection and is a great substitute for rock armor, which are better known as rock revetments.

The cost to build and maintain a gabion ranges from $6,780 to $67,800 per 110 yards and the life expectancy of a gabion is 5-10 years, which isn't long, but is effective if placed correctly and maintained well enough (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.8.shtml). These costs may seem high, but it is nothing compared to the relocation of an entire village.

Examples of gabions would be in Kotzebue and Ketchikan, with both having had gabions in the late 1970's (http://chl.erdc.usace.army.mil/library/publications/chetn/pdf/cetn-iii-31.pdf). The tests were not successful, but that's because they weren't maintained well. Another example would be one that was found in Geneva State Park, Geneva, Ohio, which was a success, but only lasted for a year from direct exposure to the waves (http://chl.erdc.usace.army.mil/library/publications/chetn/pdf/cetn-iii-31.pdf).

The other type of revetment, a rock revetment-often called ripraps-would be another solution. As the name suggests, this type of revetment requires rocks to blanket the face of a shore, protecting further erosion by dissipating the energy from normal waves and storm waves of the backshore if they are maintained and designed well enough.

These are the most widely used and desirable type of revetment in the U.S, as it is "compatible with most environmental settings (http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec11si.pdf)". The reason why they are so favorable is the fact that they can be placed, dumped, hand placed or plated (http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec11si.pdf). Each type of rock revetments can help, but they do have their drawbacks.

Dumped ripraps is basically graded stone that is dumped on a slope, which would form a layer of loose material. Though, this has to be done through mechanical means, such as a crane. If a truck were to do this, segregation, or the separation of rocks according to their size, would happen and would reduce the stability (http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec11si.pdf).

As for the hand-placed ripraps, they are stones that are put together by hand, with large spaces between large rocks. The appearance of this would look neat and orderly. Not only does

the hand-placed ripraps look orderly, they can also reduce the flow of the water and provide support for the shore. However, once they are broken by a storm surge, they would be expensive to repair. They also are labor intensive. There is another type of riprap like this; it is called a plated, or keyed, riprap. The only difference is how it is laid out.

Another choice for protecting the coast would be a sea wall. Seawalls are nearly vertical structures made of concrete. The tops of these walls may be curved or slanted to lower the chance of overtopping.

Due to them being such big structures, it would be reasonable that they would cost about $271,260 to $678,150 per 110 yards (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.16.shtml). Other than price, they would also disrupt the formation of dune processes and would require heavy construction equipment, thus ruining the environment.

Despite those cons, the sea wall is still in use though. One example of a seawall would be one found in New Brighton around the Wallasey Embankment; it is called the 'Kings Parade Sea Wall' and is still in use today (http://www.wirral.gov.uk/my-services/environment-and-planning/coastal-protection). So far, the wall has prevented flooding and revealed about 100 kilometers of land. Another example of a sea wall would be one found in Ketchikan, Alaska. It is known as the Thomas Basin Seawall, or the Thomas Basin Promenade (ftp://www.city.ketchikan.ak.us/pub/agenda/131107k.pdf). Both of them proved to help the communities.

The final type of revetments that can help would be a timber revetment. These can be made to be an impermeable blockade that has a life expectancy of 10 or higher, or a temporary shielding that lasts between 5 to 10 years (http://www.snh.org.uk/publications/on-

line/heritagemanagement/erosion/appendix_1.15.shtml). The former of these two is mainly used as a final line of defense and the final is used to slightly dissipate the wave energy before it reaches the shore.

Because they are made of wood, these revetments are widely used as it only costs about $2,712 to $67,580 to make one for every 110 yards and doesn't have as much of a negative impact on the environment (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.15.shtml). In addition to that, timber revetments have many ways it can be made and their purposes can vary.

Some places that use timber revetments would be Norfolk, a city located in Virginia (http://www.southwestcoastalgroup.org.uk/cc_defence_revetments.html). The revetments lasted about 20 years before they needed to be replaced.

One can be found in Nome, Alaska as well. This was started in the 1970's, and was exchanged for a modified sea wall in the late 1980's. In spite of this, the revetment had done a good job in protecting the coast.

The second major way to decrease the impact of coastal erosion is by using haloseres. Haloseres are an ecological succession. Salt marshes are the most common haloseres. Salt marshes are formed near the coastlines due to the constant coming and going of the tide. Salt marshes are composed of mud and peat (http://oceanservice.noaa.gov/facts/saltmarsh.html).

Peat is formed from decomposed plants that are usually several feet thick. They are very spongy. Since salt marshes are repeatedly under water, they contain a lot of decomposed plant matter. These decomposed plant matter, or peat, is able to have exceedingly low oxygen levels. This process is known as hypoxia. The growth of bacteria during hypoxia is the reason that the

smell of rotten-eggs is related to salt marshes and mud flats. Mud flats are usually around salt marshes (http://oceanservice.noaa.gov/facts/saltmarsh.html).

Salt marshes are also referred as tidal creeks that are snaking channels that fill with seawater during high tide and drain during low tide. This is why flounders and mullets live in marsh creeks (http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar06a_saltmarsh.html).

There are also levees, which are areas of higher ground that border the marsh creeks. Marsh flats are located between these levees and tidal creeks. These marsh flats contain pools and salt panes. Salt panes are depressions that contain high concentration of salt. The salt panes are able to retain seawater for a short while (http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar06a_saltmarsh.html).

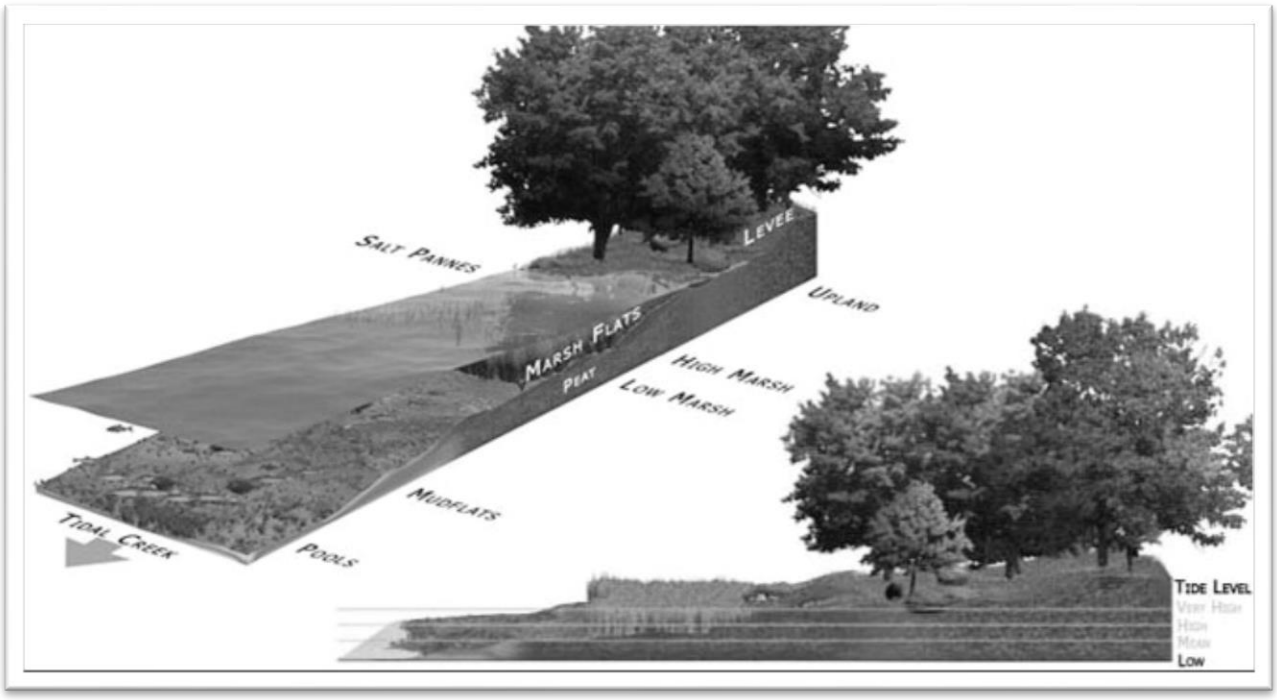
Salt marshes can be found worldwide depending on the altitude of the region. They are able to protect coastline form erosion and are estuaries. The animals that live with in the estuaries are shrimp, blue crab, finfish, marsh rabbit, waterfowl, diamondback terrapin, clapper rail, worms, and mollusks.. (http://saltmarshlife.com/salt-marsh/animals.html).

Salt marshes are able to protect coastlines with the plant life that they contain. The main plants found in haloseres are halophytes, which are salt-tolerant plants. These plants are able to buffer incoming waves to slow down the process of erosion. They even decrease flooding by taking in access rainwater and maintain water quality. The water quality of salt marshes ranges from salt water to freshwater (http://oceanservice.noaa.gov/facts/saltmarsh.html).

The halophytes are also able to help trap the sediment from receding tides. They are able to do this because of how they are formed. All halophytes do not grow in the same area. Each of

them has a different tolerance to salt. The more tolerant the plant is to the salt the lower they are in the marsh. The less tolerant the plant is, the higher they are in the marsh. (http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar06a_saltmarsh.html).

Image of a Salt Marsh from NOAA website:



A plan to help slow coastal erosion is to plant salt marshes in certain areas around the town of Newtok. To make these salt marshes we would grow the plants that are found in salt marshes. These salt marshes would be able to help decrease the speed of erosion that has been occurring in Newtok. Not only would these salt marshes protect Newtok from erosion but the would also protect the water quality.

The cost range for planting these salt marshes is between $900 and $90,000. The cost is dependent on a number of factors. One of the factors would be on the condition of how the site was before the salt marsh was planted. Another would be the method that was used to grow the salt marsh. The third would be dependent on how much of the land would be planted. The final

reason would be dependent on the season the salt marshes had been planted. The weather would affect the state of the salt mash.

(http://www.edc.uri.edu/restoration/html/tech_sci/socio/costs.htm)

The chances of success for this plan are high. Vince and Winter state:

> Marshes are scarce along the shores of California, Oregon, and Washington, where coastal uplift has restricted the development of coastal lowlands, but are more numerous and extensive in Alaska, where high silt deposition at the mouths of rivers provides the intertidal substratum required for salt marsh formation. (651)

Another reason that the salt marshes would be successful is because a river is located near the village of Newtok. The river near the village also leads into a bay where the salt water would flow into the region. This would lead to a successful salt mash.

Salt marshes are also successful in other regions around the world. There is a large amount of salt marshes around the Gulf Coast. These marshes have protected the coast and sheltered a lot of animal life.

There are issues that deal with salt marshes. Many of these issues are applied to humans. One of these issues would be down river pollution. Down river pollution is caused by trash being drawn into a river and led out into the sea. This is a major issue to salt marshes because they are located next to rivers. This issue can be dealt with a number of solutions. One of them would be helping clean up areas along rivers so the salt marshes would remain clean.

The second issue deals with areas along ports. Due to how salt marshes grow they cause a lot of issues for sailors. One of the problems would be leaving and entering ports. The way that this is dealt with is by destroying the salt marsh completely or most of the area around the salt

marsh. The way this problem can be avoided is by planting the salt marshes away from designating ports.

The third issue is caused by the scent of the salt marsh. This is a small issue compared to the rest because the sent of the salt marsh is a natural occurrence and it can't be dealt with. The salt marshes appearance is also concerned but much like its sent it is also a natural occurrence.

Another issue is that Alaska's seasonal weather change would affect the growth of salt marshes. This would limit the growth and planting of salt marshes but they would still be effective during the spring and summer months.

The fourth issue would be the concern of existing salt marshes in Alaska. These salt marshes would need to be restored and protected from human actions. The problem can be taken care of by people monitoring these existing salt marsh and restrain them from overgrowing along ports.

These factors can be dealt with in many different ways and when the factors are dealt with then the planting of the salt marshes would be successful. These issues do not determine the inability of a flourishing salt marsh because they are limitations that can be taken care of.

There are many factors to consider on how to make this plan work. For this plan, there is going to have to be research, monitoring and figuring out who can pay for the plan.

Back in 2007, Newtok's residents reported that their coast was eroding rapidly. Their coast was eroding at the rate of 100 feet per year. This eroding coast concerned the residents of Newtok that it would get worse in the future (http://nca2009.globalchange.gov/projected-coastal-erosion-2007-2027-newtok-western-alaska).

Newtok residents haven't attempted any methods, yet. Although, organizations suggested some methods for Newtok to prevent the coastal erosion. The only method Newtok tried or has

done was relocating Newtok to a new location. Newtok residents moved nine miles south to Mertarvik. Some of the residents said that it's not like Newtok, it's mostly like camping (http://www.alaskapublic.org/2012/09/10/newtok-moves-forward-with-relocation-plans/).

Another research for the plan is predicting the impact of the revetments and haloseres. In other words, the research also would have to be based on predicting what would happen to the environment and salt marsh if one of the methods were to be used. For example, if the revetments were to be placed on the coast, it may affect the wild life by ruining the environment where the wild life once lived.

Other research that is needed for the plan would be to see if people would agree to the plan. The Newtok's residents may agree to the idea or the plan what would be provided or given. If Newtok residents don't agree to the plan, there should be some way to persuade the residents to agree to the plan, so that there would be some progress on avoiding more eroding of the coast.

There would have to be monitoring of the plan. An organization or someone would have to monitor a few things for this plan. Some organizations, like the Alaska Wildlife Fish and Game or the EPA, would monitor the coastal erosions that occur.

One other monitoring that is needed is progress of salt marsh. In other words monitor how the salt marsh is increasing in size. An organization would may want to see how the coast is eroding. Like observing how long the coast eroded, how long it took, and how fast the rate is for the coast to erode.

More monitoring that should be done is monitoring the revetments. If the revetments were to be monitored, then the revetments will need to be monitored on a regular basis. A person or organization, such as the Alaska Wildlife Fish and Game or the EPA, would have to monitor

how the revetments would work or help the erosion of the coast. By monitoring to revetments, an organization should be able to see if the revetments are making progress or not.

Other monitoring for this plan is monitoring the effects of the salt marshes to wild life. In other words, how the salt marsh affect wild life in the areas. Another monitoring suggestion is monitoring the coast. An organization would have to monitor the coast on a regular basis, and should be able to observe how the salt marsh's growth and the effects of it. There should be a probable artificial spit to be formed in front of the shore.

This plan may have a lot of money put into it. The equipment and supplies would be needed for this plan. This would cost tens of thousands of dollars or more. If the Alaska's State Government may help out on paying for the equipment, then there will be no worries. But, if not, volunteers, or charities may donate money.

These are factors to consider on how to make the plan work, and its based off of research and monitoring that is needed for the plan to make progress.

Coastal erosion is a huge problem for residents in Alaska, especially for the people living on the coast and those located near enormous rivers. This is a dilemma nobody wants to face, because of the many issues erosion causes. Erosion can cause people to lose their homes, their land, and part of their culture. Erosion can cause unwanted problems that will cost too much money to pay for. Erosion can cause huge impacts on the environment that may change the environment around the affected area forever.

Although coastal erosion has affected the environment, the economy, the culture of the people living in Newtok, AK, the residents can fight back. Citizens can set up revetments along their banks to repel the wave energy that is wasting the banks away. The community of Newtok can put in the haloseres to absorb wave energy and trap sediments carried by waves. As long as

the government, or somebody does something about this quandary, chances for the village surviving will be greater. Fighting against this huge problem is better than doing nothing at all about it, because if nothing is going to be done about this erosion problem, then the village is already lost.

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