Erosion, Invasive Species, and Climate Change

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Abstract

The world's oceans are changing rapidly. This is shown to be evident in the villages of Kivalina, Alaska, the East Coast of the United States, and the town of Nice, France.

Much like Kivalina, Nice is riddled with coastal erosion. However, it challenges this with the reinforcement of gravel and sand.

The Kenai Watershed Council has managed Reed Canary grass (*Phalaris Arudinacea*), an invasive species that has made itself present in Alaska and Washington.

Lionfish (*Pterois)* is another invasive species that has dominated the the east coast of Florida. They are known to reproduce rapidly, and pose a large threat to the native species' of fish in the region.

The climate of the earth is getting warmer and becoming increasingly harmful. Due to human activity and the use of fossil fuels, this is occurring at an unprecedented rate. Contributing to this problem has proven to be more expensive than practicing control over it. Raising public awareness is the first step to challenging a problem of this magnitude.

Coastal Erosion of Kivalina

Coastal erosion is the wearing away of the shore due to a few processes. Coasts can be eroded by wave action, winds, extreme weather, and the melting of permafrost.

In the Northwest Arctic Region of Alaska, coastal erosion is prevalent. Kivalina is a prime example of coastal erosion. The village is a scant 2 square miles, barely big enough for its estimated 400 residents (http://nana.com/regional/about-us/overview-of-region/kivalina/). The village sits atop a barrier island consisting of gravel and sand, held together by beach grass, and roughly 10 feet above sea level. Kivalina is unprotected from the wind, waves, and storm surges.

The worst of the erosion occurs during fall storms, which can also flood the village. Coastal erosion is made even worse by melting permafrost, the permanently frozen layer of earth, that provides stability to arctic landscapes and the homes built on them. The formation of single-year ice surrounding Kivalina protects the village from erosion through the winter months. Ice is forming later and breaking up earlier than in the past. Since the 1980's, "summer", where the water is ice-free around Kivalina, has increased from three months to up to five months in length (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm). The longer the beach is exposed, the more rough water and storm conditions generate erosion. Important structures in the village have been damaged or are being threatened by erosion, such as the school and teacher housing, and the washeteria (akin to a laundromat and one of the few buildings in town with a piped water system).

Erosion of the banks of the Wulik River, from which Kivalina sources all of its drinking water, also causes problems for the village. In the summer Kivalina produces its supply of drinking water for the year by piping water from the Wulik River into a 700,000 gallon tank in the village. From this holding tank the water passes through a filter and then is treated with chemicals. The permafrost that largely holds the banks of the Wulik is melting, causing the river

to become turbid. The filtration system cannot safely filter water when it is too turbid, and there is risk of adverse chemical reactions between the sediment in the water and the treatment chemicals.

History

Flooding was historically what made the placement of Kivalina Controversial. In 1970 there was flooding from a 13 foot sea rise, and in 1976 a fall storm flooded a third of the village. Only more recently, however, arose the need to relocate due to erosion. In 2000 a new location for the village was decided upon (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm). The new location, Kiniktuuraq, is susceptible to storm surge and the ground will not be stable if permafrost melt continues; those qualities are why the US Army Corps of Engineers does not recommend Kiniktuuraq for further consideration as a future location of Kivalina.

In October of 2002 and 2004 fall storms swept through Kivalina; in 2004 there was a loss of 40 feet of shore. More storms in September and October of 2005 resulted in the loss of 70 feet of shoreline. All four of these storms warranted disaster declarations. The last two storms had townspeople trying to make a seawall out of anything: 55 gallon drums, the fuselage of an abandoned cargo plane, scrap metal, etc. (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm)

The Northwest Arctic Borough installed gabions, cylinders filled with sand or stones, as an erosion deterrent in 2006. The effort failed shortly after and resulted in the worsening of erosion in Kivalina (http://www.poa.usace.army.mil/Portals/34/docs/civilworks/reports/Kivalina%20Erosion%20Control%20Environmental%20Assessment%20and%20FONSI.pdf). The following summer the

gabions were reinforced with sandbags as a temporary erosion deterrent. In 2008 a rock revetment wall, a large rock wall protecting the beach, was started to protect the village while planning and executing relocation commenced; the revetment is expected to last 10 to 15 years, and up to 25 years if it is maintained properly (http://www.relocate-ak.org/wordpress/wp-content/uploads/2012/09/Kivalina_Consensus_Building_Project_Final_Report_July_20106.pdf).

Cultural Impacts

Kivalina's erosion influences its residents' lifestyles. Beaches are traditionally where fish and other marine animals are cut and processed, nets are cast, and boats are docked. Children use the beach as an area to play. Without the beach, there is one less place to prepare traditional food. Children play around town and in the streets. There is a chance that Kivalina will relocate to a place where subsistence takes more effort than it is worth, where an extensive amount of travel is required to reach resources. The new location could also make it more expensive to ship goods and building materials, skyrocketing the cost of living.

The ground beneath buildings near the shore has been eroding and threatening to cause houses to collapse into the sea (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm). With no further implementation of erosion control in Kivalina, it is predicted that the school, Washeteria, public offices, and fuel storage tanks would be rendered unusable within the next few years.

Erosion additionally causes a problem by discouraging agencies from funding village improvements, such as sewer and inorganic waste management services, because of the plan to relocate the village in the future. This lowers the standard of living and raises concerns about the health of the people of Kivalina.

Financial Impacts

Kivalina has spent an estimated total of slightly over 1.3 million dollars on erosion prevention and emergency erosion control from 1985 to 2002 (http://www.poa.usace.army.mil/Portals/34/docs/civilworks/BEA/Kivalina_Final%20Report.pdf). The proposed evacuation road/bridge out of Kivalina would cost an estimated 20 to 39 million dollars (http://www.relocate-ak.org/wordpress/wp-content/uploads/2012/09/Kivalina_Consensus_Building_Project_Final_Report_July_20106.pdf). Co-locating Kivalina with the regional hub of Kotzebue, Alaska, would cost an estimated 95 million dollars. Relocation is estimated by the US Army Corps of Engineers to cost 125 million dollars. The people of Kivalina are more inclined to relocate as opposed to co-locate.

Energy Impacts

Relocating Kivalina is projected to result in the doubling of the population within 20 years (http://www.relocate-ak.org/wordpress/wp-content/uploads/2012/09/Kivalina_Consensus_Building_Project_Final_Report_July_20106.pdf). With the projected population growth it is expected that energy usage increase at a similar increment. Population growth also necessitates constructing housing. All the construction materials of the relocated village would have to be brought up to the site by barge or flown in, then transported to the relocation site for Kivalina.

Environmental Impacts

Erosion is a natural occurrence along the shore, continually shifting and changing the shape of where land meets water. Accretion, the sedimentation and building up of the shoreline, shapes the coast of and around Kivalina to a minimal extent. The implementation of revetments

to the shores of Kivalina over the years has the potential to affect longshore drift in the area, however, Kivalina is expected to relocate before the area is substantially affected.

Erosion on the lagoon side of Kivalina has put garbage and human waste into the water, and erosion on the banks of the Wulik River introduces greater amounts of sediment into the river and the Kivalina Lagoon. Both of these factors affect the marine life that utilize the Wulik and immediate bodies of water, by polluting the water or reducing the oxygen fish eggs receive in the river bed due to turbidity.

Projected Implications

Relocation of the village is necessary, but will take time and require a cooperation between the village and state government that is currently riddled with distrust and misunderstanding. With the eventual relocation of the village, funding is hard to obtain to improve Kivalina. The reality is that relocation could take 15 years. In that time the citizens of Kivalina will be subjected to overcrowding, accidental spillage and hazardous disposal of human waste and garbage, an inadequate water system that routinely runs dry of water well before "water making season" begins, and the dilapidation of public buildings such as the school and washeteria (http://www.relocate-ak.org/wordpress/wp-content/uploads/2012/09/Kivalina_Consensus_Building_Project_Final_Report_July_20106.pdf).

With the relocation of Kivalina, it is expected that the population would double in 20 years and the standard of living would rise substantially with the introduction of public water and sewer systems. It is a possibility that Kivalina relocates to a place where it is inconvenient to participate in subsistence activities and subsistence would become less of an essential part of Kivalina economy and lifestyle.

Solutions

In the event of a storm warranting evacuation of Kivalina, there is no overland route to evacuate the village. If there is ample prior warning (if weather is clear enough to safely land aircrafts), the village is evacuated by plane. When it becomes unsafe to land planes, people are taken to the mainland, by boat, across the lagoon. Then, people are driven to the Red Dog Mine by all terrain vehicles (ATVs), which serves as an emergency storm shelter. (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm) To aid in the evacuation of the village when rough weather hits, a road or bridge has been proposed to provide a land route out of Kivalina. The evacuation route would lead from Kivalina to the mainland just east of the village.

In the past decade, sand filled gabions have been installed to the Kivalina coast, the gabions have been reinforced with sandbags, and a rock revetment wall have been installed. These erosion control efforts, along with the proposed land evacuation route to the mainland, are temporary measures to protect Kivalina from erosion and flooding until relocation is achieved. Multiple sites for relocation have been proposed by the US Army Corps of Engineers, and one site is heavily favored by the people of Kivalina, but there is no consensus on where to relocate.

Our recommendation is that Kivalina devise a strategic plan for relocating the village before applying for funding. A strategic plan would entail Kivalina developing a vision of what the aspects of the relocated village would be, analyzing the strengths and weaknesses of contingencies, developing goals for the community to meet, strategizing how to achieve their goals, identifying alternatives, and out the work that needs to be done to achieve everything (http://www.relocate-ak.org/wordpress/wp-content/uploads/2012/09/Kivalina_Consensus_Building_Project_Final_Report_July_20106.pdf).

Monitoring and Funding

Monitoring coastal erosion is already underway in Kivalina. What is less certain is funding for relocation. Funding would be obtained through government agencies, after a plan is composed. One such source for funding is the Indian Reservation Roads Fund, which could fund an emergency evacuation route off of Kivalina.

To stress a point, relocating Kivalina will be exorbitant. With a plan of how the village is going to be relocated, agencies are more likely to contribute funding.

Coastal Erosion of France

Similar to Kivalina, Nice, France, struggles with coastal erosion. This is averse because the beach is a social and economical asset to the town of Nice. Some of the shoreface slopes are steep, some slopes rangeing from 4º to 6º steep. Surprisingly, the waves on a normal day tend to be low-energy wind waves that reach the height of 0.6 meters. The most destructive waves occur on stormy days, the highest of which have reached 3.1 meters.
(http://mediterranee.revues.org/182)

History

Beach nourishment, the supplementing of shorelines with imported gravel and sand, has been how erosion in Nice has been managed since 1976 (http://www.brynmawr.edu/geology/geomorph/beachnourishmentinfo.html). There has been more concentration of beach nourishment on the west side of Nice beach as compared to the east end (http://mediterranee.revues.org/182).

Impacts

The continual nourishment of the beach disrupts the utilization by the people of Nice. Beach nourishment is a temporary solution to a long-term problem, and while it manages the erosion for the time being, without a more-permanent solution beach nourishment will need to be continued indefinitely. Indefinite continuation will be more costly than a solution, such as a revetment wall, that requires less maintenance yearly.

Solutions

As aforementioned, beach nourishment is being used to manage the erosion of Nice Beach (http://mediterranee.revues.org/182). Several solutions should be considered for impeding erosion, such as a revetment wall or gabions, as a long-term solution.

Monitoring and Finances

Monitoring of the erosion at Nice Beach is currently being conducted, and should be monitored in the future. Beach nourishment is provided at no cost for the people of Nice. The Environmental services pay for the operations (http://mediterranee.revues.org/182). If the erosion of the beach worsens and cannot be managed through beach nourishment alternate solutions should be considered to control erosion.

Invasive Species of Alaska (reed canary grass)

An invasive species is an organism moving to another habitat, reproducing, and dominating in said habitat. It can harm the environment by taking the food source of many organisms, and may upset the balance of the food chain. Many invasive species cases were caused by a lack of food sources, and having to move to another habitat. In some cases, invasive species have brought positive effects to both the economy and the ecosystem. For instance, many

livestock and crops in the U.S. were brought by another country, such as cattle and chicken, which brought different food options in America.

History

Phalaris arundinacea, or reed canary grass, was introduced in Alaska as a forage crop, and has been used to revegetate along roadsides, because it can grow in heavy soils, spread rapidly while forming dense sod that prevents soil erosion. In 1999, about 150 dead pre-spawn coho salmon were found in a creek near King County, Washington that had reed canary grass growing around the creek (http://www.kenaiwatershed.org/restoration/reedcanarygrass.html).

Solutions

Reed canary grass hasn't been a problem in Alaska yet, Kenai Watershed Forums (KWF) have asked both the people of Washington and Alaska to report any reed canary grass sightings so the possible infestation can be quickly disposed. The KWF board receives yearly funds by the Alaska Sustainable Salmon Fund and the City of Kenai, allocating $30,000 to $50,000 each fall to hire workers who work about 100 hours each year. In the past, the workers of KWF have laid down tarpaulin, or tarp, over reed canary grass in an attempt to stop photosynthesis and kill the grass. However, this method did not work, and the KWF board decided to hand-pull the grass. The KWF has also discussed using herbicides in areas that have a larger population of grass. If this option were implemented, the workers are required to be certified by the Department of Environmental Conversation to handle pesticides (Zutuela, Rebecca. pers. comm.).

Invasive Species of the World (Lionfish)

The invasive lionfish (Pterois) is not native to the Atlantic Ocean. The lionfish is a venomous and aggressive eater who will eat anything and everything. Florida pet owners are

blamed for their release of the lionfish into new water, and the lionfish population started with only six to eight female lionfish. While eating so much they get liver disease; the liver increases five times the regular size. Many people in the marine preservation field are concerned for the marine life which lives around the lionfish. The lionfish produces 30,000 to 40,000 eggs every few days and is sexually mature by one years old. You can find them all over the Amazon, the Bahamas, the Caribbean, and in the waters along North Carolina (http://www.cnn.com/2013/10/18/tech/innovation/lionfish-infestation-atlantic-linendoll).

Future Migrations of Lionfish

It is likely that the lionfish will invade the Gulf of Mexico and South America in the future. The lionfish are piscivores that feed on important reef fishes (http://aquaticcommons.org/2847/1/NCCOS_TM_99.pdf).

Reproduction

The lionfish affair happens shortly before dark and it will increase into the nighttime hours. The female swims up to the surface and releases two egg masses from each ovary lobe, at the end of the affair. The spawning of the lionfish generates over two million eggs every two weeks and it spawns throughout the year (http://aquaticcommons.org/2847/1/NCCOS_TM_99.pdf).

Problems

The lionfish dorsal, ventral, and the anal spines are venomous. But, the meat is edible except for the spine. When the tissue of the lionfish is disturbed the venom is released and this is when the spine enters the person or fish. The venom is made up of acetylcholine and a neurotoxin that cause pain and other problems to humans. The lionfish stings can be treated by

using heat and anti-venom from the linked stonefish (one of the most venomous fish currently known in the world). The lionfish venom can kill other fish species. (http://aquaticcommons.org/2847/1/NCCOS_TM_99.pdf).

Symptoms from the Lionfish Venom

The sting from the spine of a lionfish may be painful and will cause redness, and swelling around the wound. The pain goes away after a couple hours, and some people report or announce that they still feel pain or a tingling feeling for a couple days or sometimes weeks. Sometimes, if the venom spreads to other parts of the body, people can get feverish symptoms such as headaches, chills, cramps, nausea, and some people may experience paralysis and seizures (http://oceanservice.noaa.gov/education/stories/lionfish/lion04_biology.html).

Lionfish Prey

The average adult lionfish in the Bahamas feeds on more than 40 species of prey including, small goby, wrasse, basslet, cardinalfish, and pomacentridae as well as juveniles of bigger anthiinae, goatfish, snapper and others. Lionfish's ability to resist long periods of fast-moving is explained by the enlargement of the stomach to over 30 times the initial volume after ingesting a large meal (http://aquaticcommons.org/2847/1/NCCOS_TM_99.pdf).

Industries

The socio-economical of lionfish has not been thought of to date and could include impacts on common fisheries, the aquarium trade, or coastal tourism industries of the Southeast U.S.A. and Caribbean (http://aquaticcommons.org/2847/1/NCCOS_TM_99.pdf).

Pressure on the Lionfish

The creation of wide-scale lionfish control strategies is cumbersome given the the rapidness of lionfish reproduction. Human consumption of lionfish is a reasonable option to generate harvest pressure as lionfish meat is mild and firm, two required forms for edible and palatable fish. The lionfish meat not poisonous and it is edible. (http://aquaticcommons.org/2847/1/NCCOS_TM_99.pdf).

Costs Associated with Invasive Lionfish

Lionfish are a relatively new invasive species, and as such does not have an abundance of research as compared to other invasive species. The fish does not destroy property as erosion might, but it affects industries. The Atlantic fishing industry loses potential catch when lionfish feed on commercially fished species. Lionfish have also become exponentially more common, which can negatively impact its sales as an exotic species for use in aquariums.

Climate Change

Climate change is a problem that the entire world is facing. A change in climate usually occurs over a long period of time, usually in decades or centuries. It is characterized not only by average temperature, but also by type, duration, and intensity.

When sunlight enters our atmosphere, the land surfaces and oceans warm up. The earth then releases this heat back into the atmosphere. However, certain gases in the atmosphere, called greenhouse gases, prevent the atmosphere from releasing this heat. Greenhouse gases, such as water vapor, carbon dioxide, and methane are important to our atmosphere because they keep the earth's surface from freezing.

Over the past century, scientists have noted that more and more greenhouse gases have been collecting in Earth's atmosphere, effectively trapping heat and creating a rise in temperature. This fluctuation can act as a catalyst for adverse change around the world.

Climate Change vs. Global Warming

Global warming and climate change are often spoken about interchangeably, however, they are two separate concepts. Global warming is limited to describing the average increase in global temperature. Climate change includes global warming and everything else that increasing greenhouse gases will affect (http://www.nasa.gov/topics/earth/features/climate_by_any_other_name.html).

History

The earth's climate has changed throughout history. Over the last 650,000 years there have been seven cycles of glacial advance and retreat. When the last ice age ended about 7,000 years ago, the modern climate era began.

The current warming period is of importance because it is heavily influenced by human activity due to the use of fossil fuels. It is also accelerating at a rate that is unprecedented.

Financial Impacts

Climate change has been linked to greenhouse gases; the increase is caused largely by the burning of fossil fuels, heating and cooling of buildings, and operating vehicles. Contributing to climate change is more expensive than practicing control over it.

Cultural Impacts

Climate change has few benefits to offer in comparison to its negative aspects. In rural areas such as Kivalina, community members rely heavily on subsistence. Warming temperatures threaten the traditional lifestyle of the area. Kivalina, and the arctic on a larger scale, is being affected greatly by Climate Change. Single-year ice is not forming as fast as it once did, and the ice that does form is thinner than in past years. For Kivalina (a community where most residents feed themselves through subsistence, not Wal-Mart), thinner single-year ice means a shorter hunting period, less food on the table. In the spring of 2010, ice was too thin to travel safely on, increasing the danger of losing equipment, and people, to ice that detaches from the shore or breaks underfoot (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm). With spring being the traditional time to hunt Beluga Whale in Kivalina, ice conditions and the formation of multiple leads (where in the past there have been only two leads) did not assist in the take of a whale that could feed Kivalina for a year. No Belugas have been taken by Kivalina in over a decade.

Energy Impacts

Increases in temperature will have an influence on how much energy is consumed. It will also have an affect on our ability to produce and deliver electricity. In warmer temperatures, more electricity is used for air conditioning. On the other hand, heating consumes more electricity in colder temperatures than cooling does in warmer temperatures.

Sustainable energy resources could also be affected by climate change, but there is little research in this area. Current climate models are unable to project the changes in wind and cloud cover patterns; factors necessary to predict how sustainable energy resources are affected (http://www.epa.gov/climatechange/impacts-adaptation/energy.html).

Environmental Impacts

There are several positive effects that can be brought on by warmer temperatures. A shortened flu season and more diverse variety of food sources are among these benefits. In Kivalina, an extended summer can provide more time to produce drinking water for the year. (http://www.anthc.org/chs/ces/climate/climateandhealthreports.cfm).

Warming temperatures can also reduce heating costs and help improve circumstances for agriculture. However, radical conditions can lead to more harm than good. For example, severe storms can lead to property damage, population displacement, and a disruption in everyday services like transportation, communications, and water supplies.

Future Impacts

Climate change has had enormous effects on the environment. Glaciers have shrunk, ice breaks up sooner, and oceans have warmed and become more acidic. Effects that had been predicted due to climate change in the past are occurring now: sea levels are rising, storms are more extreme, and heat waves are increasing in length (http://climate.nasa.gov/effects).

The transpiration of these events is detrimental and scientists are confident this trend will continue well into the next century. The Intergovernmental Panel on Climate Change (IPCC) expects a temperature rise of 2-10 degrees fahrenheit. This is unusual in Earth's history, where average temperature had previously been stable for centuries. In addition to this, studies have shown that small temperature changes relate inversely to the changes they create in the envoronment (http://climate.nasa.gov/effects).

Solutions

Climate change is a serious problem, with dangerous consequences. Although there is no cure-all for its effects, we can practice measures to cut back on fossil fuel use. The first step is to ensure that community members are aware of the severity that climate change can present. Many states in the America already have plans in place to address extreme weather events and infectious diseases brought on by climate change.

Monitoring Climate Change

Human activity has released heavy amounts of greenhouse gases into the earth's atmosphere. Understanding of climate change is important in predicting future changes in both local and global regions. Climate models have proven to be extremely useful in this endeavor.

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