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The Effect of Sea Level Rise on Coastal Communities

One of the most dangerous impacts of climate change deals with how climate change is impacting the oceans. Climate change affects the oceans in many ways, such as increased ocean temperature, ocean acidification, and the melting of sea ice. All of these effects have a significant impact on the oceans, however, the most significant change to oceans due to climate change is the rising sea level. Sea level rise can be considered one of the most important climate change impacts on oceans because of the way it affects coastal communities. Since "40 percent of the population lives in relatively high-population-density coastal areas," sea level rise will have damaging effects on the human population if these levels continue to increase (US Department of Commerce & National Oceanic and Atmospheric Administration, 2008). The average sea level has been rising for centuries, however over the most recent decades, it has been rising at an increasing rate which means the impacts are going to become more severe (US Department of Commerce & National Oceanic and Atmospheric Administration, 2008).

Sea level rise is caused by many different factors, however, the main contributors to sea level rise include the melting of ice from coastal lands, warming ocean, slowing of the gulf stream, and sinking land (SeaLevelRise.org). Although these factors significantly impact sea level rise, they are all influenced by global temperature change. Temperature change caused by the increase of carbon dioxide in the atmosphere is the main driver of global climate change

because of the cascade of effects it has on the environment (Pearce, et al.). Warming temperatures cause ice on land to melt and flow into the oceans which contributes to the rising sea levels on a global scale (SeaLevelRise.org). Increasing global temperatures causes increased ocean temperature as well (SeaLevelRise.org). This causes thermal expansion to occur in the oceans which is when the oceans absorb the heat trapped in the atmosphere which causes the water's volume to rise (Boening, 2019). On a more local level, the slowing of the gulf stream, caused by melting sea ice from warming temperatures, contributes to sea level rise. The gulf stream is “an intense, warm ocean current in the western north Atlantic ocean” (US Department of Commerce & National Oceanic and Atmospheric Administration, 2013). Slowing of the gulf stream slows the pulling of water away from shores which causes local sea levels to rise (SeaLevelRise.org). Lastly, sinking land caused by the use of underground water, drier wetlands, and building heavy infrastructure contributes to this rise. The impact of drier wetlands on sea level rise is partly due to the increase of global temperature as well (Union of Concerned Scientists, 2011). These four main causes of sea level rise are important in understanding how and why the sea level is rising. However, it is important to note that the main underlying driver of these changes is the increase of global temperature.

Sea level rise has created increasing concern as data supports the consensus that sea levels are increasing and will continue to increase at an exponential rate. Rising sea levels are caused by many different factors such as melting ice sheets and warming sea water, however these factors all relate to global temperature change (Shaftel, 2020). According to NASA, the global mean sea level is about 99 mm as of November 2019 (Shaftel, 2020). It is evident from the first and second graphs that sea levels are rising at an increasing rate. The first graph

demonstrates sea height variation in millimeters since 1993 as observed by satellites (Shaftel, 2020). Graph one shows that the sea height variation has continued with an increasing trend since 1993 despite some variation (Fig. 1).The average rate of sea level change in millimeters per year is 3.3 mm which can be collected from analyzing the data from the first graph (Shaftel, 2020). The second graph demonstrates average sea level change in millimeters from 1870 to 2013 from coastal tide gauge data (Shaftel, 2020). Graph two shows the increasing change in sea level since 1870 (Fig. 2). Both graphs help to give accurate information about average sea level change since each data set was collected from a different source, but the information corresponds with each other.

This data was collected from satellite observations and coastal tide gage data (Shaftel, 2020). Satellite observations allow scientists to calculate changing sea levels by using radio waves to measure the height of the ocean's surface (Earth Science Communications Team at NASA's Jet Propulsion Laboratory, 2020). Coastal tide gages are able to collect data about sea level because they are “fitted with sensors that continuously record the height of the surrounding water level” (US Department of Commerce & National Oceanic and Atmospheric Administration, 2017). This data is used to accurately measure the extent to which sea levels are changing in order to come to conclusions and make observations about global climate change as a whole. This data relates to global climate change because of the way rising sea levels correlate with global temperature change. Warming temperatures is one of the main concerns with global climate change and one of the biggest impacts of warming temperatures on oceans is rising sea levels which both graphs effectively demonstrate.

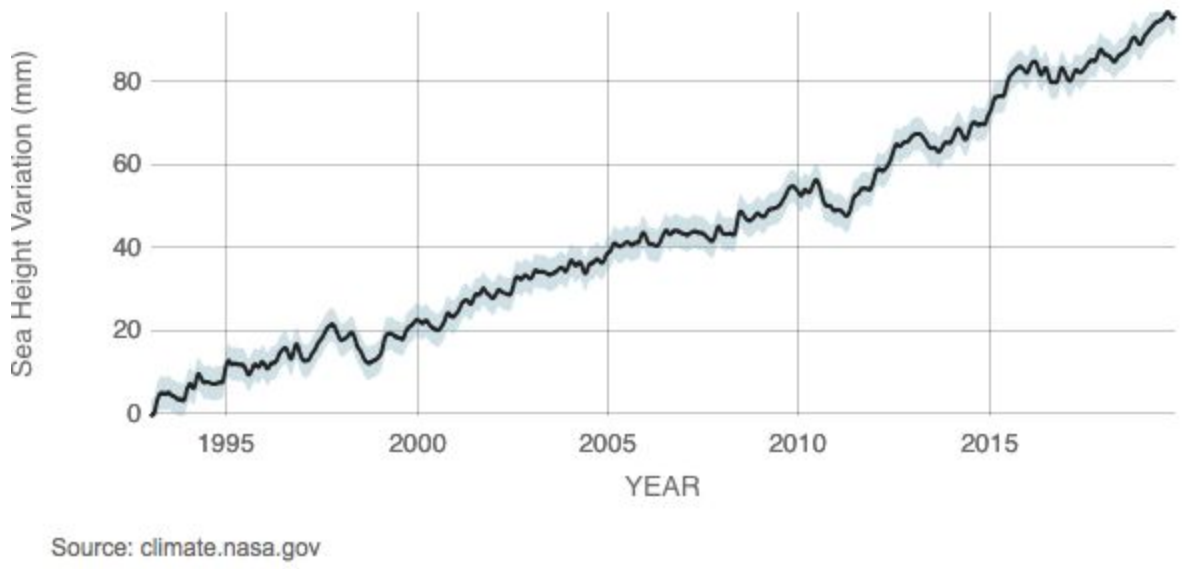

Figure 1. Sea Level Satellite Data: 1993-Present. Satellite sea level observations from NASA Goddard Space Flight Center (Shaftel, 2020).

Sea Level Ground Data: 1870-2013

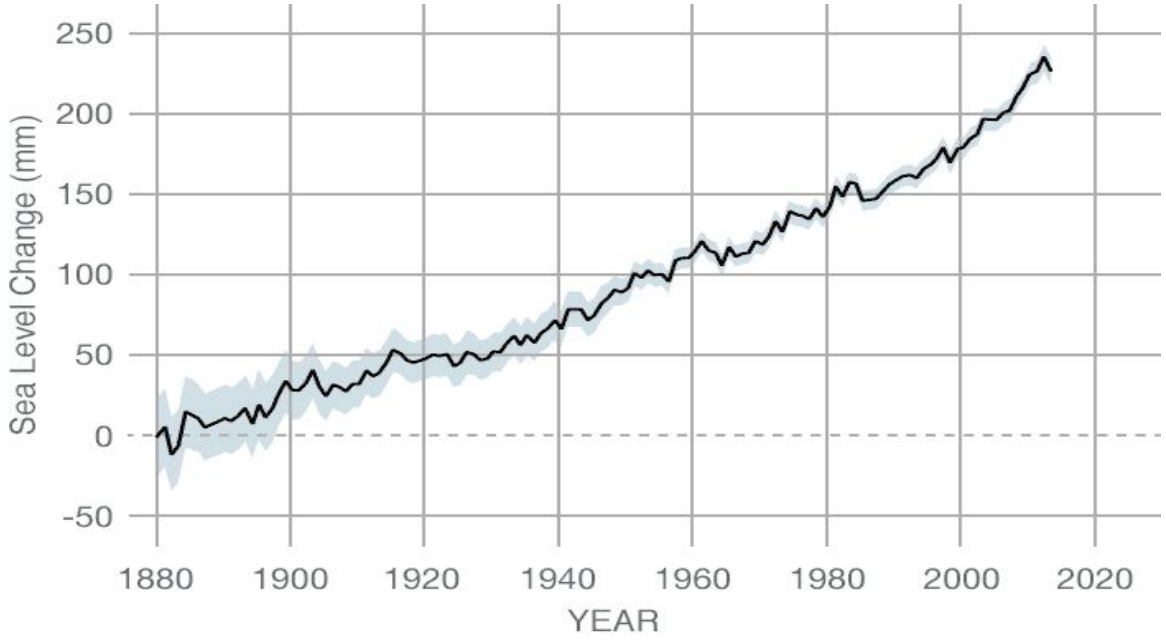

Figure 2. Sea Level Ground Data: 1870-2013. Coastal tide gauge records from CSIRO (Shaftel, 2020).

The impact of the rise in the average sea level will continue to have increasingly damaging effects on the society and environment of coastal communities. Since the sea level rises at a rate that doesn't seem significant to many on a day to day basis, many people are not worried about these impacts or they do not see the rise in sea level as a threat to coastal communities. However, the impacts of sea level rise will continue to increase and become more dangerous as levels get higher and higher. Eventually, the impacts will be severe and cause a lot of significant damage to coastal communities and coastal environments. Likely future impacts of the rise in sea level include increased flooding, more severe storms, shoreline erosion and saltwater intrusion, along with the economic consequences that these cause.

As the sea level continues to rise, flooding will become a big issue, especially in coastal communities. Increase in sea level has caused on average a 233% increase in tidal flooding across the United States in the last 20 years (Sealevelrise.org). Although flooding occurs today, rising sea level will cause flooding to happen more frequently and leave more damaging effects on the environment and society. One of the biggest threats of flooding is that it destroys buildings and houses around coastlines (US Department of Commerce, 2009). Also, flooding over roads, which is already becoming more common in some places during high tides, can cause traffic jams and block emergency vehicles from reaching flooded areas (Willis, 2019). Flooding is already beginning to impact coastal communities and causing them to spend a large amount of money to repair the damages caused by them (Willis, 2019) For example, Florida is facing a lot of damaging impacts from tidal floods that would not be happening in the absence of the rise in the sea level caused by human emissions (Willis, 2019).

In addition to flooding, saltwater intrusion is becoming an issue due to sea level rise

because of the numerous amount of effects it has on drinking water, ecosystems, farmers and fisheries. Saltwater intrusion allows salty ocean water to flow underground into groundwater reservoirs, which are used for drinking water (Willis, 2019). Additionally, saltwater can flow into the water table below the surface of the land, making the soil too salty for trees and plants to grow which can mean death for these ecosystems (Willis, 2019). Saltwater flooding can kill plants and irreversibly alter soil chemistry which has a heavy effect on farmers (Willis, 2019). Lastly, saltwater intrusion can also affect estuaries and freshwater areas that fisheries and coastal communities rely upon (Willis, 2019). All of these effects will continue to get worse and impact coastal communities into the future if measures are not taken to stop the human emissions causing the rising sea level.

The increase of more frequent and severe storms will likely be a damaging impact of sea level rise into the future. Increased storm surges, severe thunderstorms, tsunamis, and hurricanes could become an issue because of sea level rise (Willis, 2019). Over the next century, hurricanes are estimated to grow between 2 and 11 percent stronger on average, according to NOAA (Willis, 2019). The increase of storms will cause the increase of shoreline erosion which reshapes coastlines, damages coastal habitats, and negatively impacts coastal animal species (Willis, 2019). Many animals rely on low-lying habitats and the coastal environment for breeding, laying eggs, finding food, or using it as a place to live (Willis, 2019). For example, sea turtles lay their eggs on beaches and return to the same location each year (Willis, 2019). When beaches erode or are covered by flooding and rising sea levels, their options will become more limited (Willis, 2019). Shoreline erosion and the increase of storms and flooding will damage these habitats and negatively affect these species.

The environmental consequences of rising sea level cause severe economic consequences as well. The cost of damage from these changing conditions is immense. Increased storms and hurricanes are contributing to major economic losses in places all over the world. The economic losses from the 2005 hurricane season, which included Hurricanes Katrina and Rita, were $200 billion, the costliest season ever (US Department of Commerce, 2009). Many states and communities are already spending billions of dollars to prevent these damages from occuring in the first place. For example, Louisiana has allocated $25 billion for risk reduction in their coastal master plan and the Texas Gulf Coast has an $11.6 billion storm surge protection plan (Sealevelrise.org). Additionally, New York City has a $3.7 billion coastal protection plan for the next 10 years (Sealevelrise.org). These costs will continue to rise and negatively affect the economy as the sea levels continue to increase.

The rising sea level will continue to negatively impact the environment and society as it continues to rise. These impacts will be severe and affect coastal communities in many types of ways. It will affect coastal environments, cities, farmers, fisheries, animals and much more. Efforts need to begin now in order to slow down the rise in sea level in order to prevent the severity of these impacts in the future. Although the impacts may not seem as severe in present day, they will leave significant damage on coastal communities in the future.

The potential impacts of sea level rise on coastal communities are predicted to be severe if there are no strategies put in place to stop them. Strategies to combat these impacts often differentiate based on location-specific challenges of different coastal communities, however, almost all coastal communities across the globe are eventually going to be impacted by sea level rise in some way. There is no definite solution to climate change or sea level rise, however,

adaptation and mitigation strategies can be used to help combat and reduce these impacts. Adaptation strategies are used to respond to the negative impacts of climate change after the damage has already been done. However, mitigation policies are used to avoid climate change in the first place, thereby preventing/minimizing the impacts that occur. Mitigation focuses on the factors influencing emissions such as population, affluence, and technology. A combination of these two strategies must be used in order to help stop the projected impacts of sea level rise on coastal communities. Both strategies ultimately require a large amount of money to be spent in order to effectively reduce the impacts of sea level rise, however, it will cost less money in the future if these strategies are put in place today.

Adaptation strategies are the strategies most commonly used to combat the effects of climate change. It tends to be the easiest and most necessary option at the time since mitigation focuses more on the future and adaptation strategies are used to help make the impacts that have already occurred less severe. To help adapt to sea level rise, there are many adaptations that can be made to help combat effects such as flooding, storm surges and saltwater intrusion. Flooding has already become a big problem for many coastal communities around the world. Adaptation strategies such as the development and maintenance of water utility infrastructure can help combat the increased flooding and storm surges from sea level rise (Climate Adaptation and Sea Level Rise, 2016). Building flood-proof structures and floating platforms for agriculture can help farmers and civilians to adapt to increased flooding as well (John A. Dutton e-Education Institute, 2017). Additionally, some coastal communities are already investing in one way stormwater valves to address more frequent and intense flooding during high tides (Climate Adaptation and Sea Level Rise, 2016). In order to decrease the impacts of rising waters,

structures such as polders, which reclaim inundated coastal regions, and coastal defenses such as dikes and beach nourishments can be built to help impede rising waters (John A. Dutton e-Education Institute, 2017). Other adaptation strategies used against sea level rise include new construction as well as increased planning, monitoring, and modeling strategies (Resilient Strategies Guide for Water Utilities, 2019). New construction can include relocating facilities to higher elevations, installing low head dam for saltwater wedge and freshwater pool separation, diversifying options for water supply and expanding current sources, as well as building flood barriers to protect infrastructure (Resilient Strategies Guide for Water Utilities, 2019). These adaptive strategies will be able to help combat the societal and environmental impacts that will result from the rise of sea levels around the world.

Mitigation strategies to reduce the cause of sea level rise are a bit more challenging to achieve because it requires an in depth look into the future impacts of climate change as well as figuring out what policies to put in place today that will limit these effects in the future. The most important mitigation measure to reduce sea level rise is the reduction of carbon dioxide (CO2) emissions (Hunt, 2019). This task can be accomplished by the removal of CO2 in the atmosphere with biomass-based carbon capture and storage and other proposed measures, with the intention of reducing, stopping, or reverting global warming and its impact on sea level rise (Hunt, 2019). Mitigation policies and strategies often depend on location and the severity of the impact that sea level rise is having on that specific area. However, sea level rise will potentially have many similar impacts among coastal communities around the world and there are many mitigation policies that can be applied in some way to coastal communities everywhere. Thoughtful stormwater management planning that addresses flooding problems is needed

because flooding is one of the impacts of sea level rise that is predicted to be the most severe in the upcoming future (Kotz, 2017). Another mitigation strategy to help combat flooding would include reducing the obstruction of drains, swales, and pipes as well as investigating the use of physical structures in localized areas to slow nuisance flooding or storm surge (Kotz, 2017). Continued attention to the integrity of the drainage system through reviews of the appropriate size, proactive maintenance and necessary repair and replacement of pipes is critical as well and using the best available tools to improve stormwater drainage can potentially help stop the most severe impacts of future flooding (Kotz, 2017). In addition to flooding, mitigation strategies to help protect against erosion, infrastructure damage, and coastal wildlife populations are extremely important. Advanced planning for access to beach compatible sand in case beach renourishment is needed as well as monitoring the beach and its wildlife populations are strategies to prevent damaging impacts (Kotz, 2017). The construction of buildings and recreational facilities seaward into the dune system should be discouraged or prohibited (Kotz, 2017). Additionally, living shoreline construction may be appropriate in some locations to protect marshes from sea level rise induced erosion (Kotz, 2017). Lastly it is important to educate citizens of coastal communities about the potential impacts that will occur in their communities if actions are not taken to prevent them. This can be used as a mitigation strategy because it keeps the public well informed and can persuade them to vote in favor of certain climate change policies.

The impacts of sea level rise on coastal communities will eventually prove to be severe and have many damaging effects of the environment and society. Mitigation and adaptation strategies can be used to combat effects such as flooding, saltwater intrusion, erosion, wildlife

protection and much more. It is important to utilize both adaptation and mitigation strategies in order to reduce these impacts the most. It is required that new and improved strategies are developed as time moves forward in order to successfully diminish the most severe impacts of sea level rise in order to protect the environment and society of coastal communities.

In my opinion, there are a lot of strategies that need to be put in place now in order to lessen the damaging impacts sea level rise will have on coastal communities. Since flooding is most likely to be the most damaging effect of sea level rise, adaptation and mitigation strategies should be put in place to combat this threat. For example, the development and maintenance of water utility infrastructure, building flood-proof structures and floating platforms for agriculture, and investing in one way stormwater valves are adaptation strategies that should be put in place to help with increased flooding (Climate Adaptation and Sea Level Rise, 2016, John A. Dutton e-Education Institute, 2017). Mitigation strategies such as thoughtful stormwater management, reducing the obstruction of drains, swales, and pipes, and continued attention to the integrity of the drainage system should be put in place to prepare for and prevent future flooding threats (Koltz, 2017). In addition to flooding, actions should be taken to protect coastal communities against saltwater intrusion. These strategies include installing a low head dam for saltwater wedge and freshwater pool separation and diversifying options for water supply and expanding current sources. (Resilient Strategies Guide for Water Utilities, 2019). New and improved strategies need to be employed in order to stop the potential damages that sea level rise will have on coastal communities around the world.

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