Background Information

Climate Change

One of the greatest challenges facing humanity today is **climate change**, or the long-term change in average global temperatures and weather patterns (NASA, "Global Warming vs. Climate Change", 2022). These global changes in temperature and weather impact local and regional environments in different ways, such as increased drought and wildfires in some areas and increased rainfall and flooding in others. Earth's climate has alternated between warmer and colder climate periods throughout its 4.5-billion-year history. An example would be the Pleistocene, commonly known as the Ice Age, a geological epoch where global temperatures were on average 5-10 degrees Celsius colder, which lasted from approximately 2.5 million years to 12,000 years ago. Most of these past changes in Earth's climate are attributed to very small variations in Earth's orbit, which affect the amount of solar energy, or sunlight, the planet receives (Buis 2020).

Current climate change is different because it is the result of recent human activity. Specifically, current climate change is directly related to the mass burning of **fossil fuels** by humans from the mid-19th century onwards. The sustained, mass burning of fossil fuels has resulted in excessive **greenhouse gases** being released into the atmosphere, trapping more solar energy, and increasing Earth's average surface temperature (NASA, "How Do We Know Climate Change Is Real?", 2022). The Intergovernmental Panel on Climate Change's Sixth Assessment report, published in 2021, found that human greenhouse gas emissions have increased the global average temperature by nearly 2 degrees Fahrenheit since 1750, with the global average temperature expected to rise to or exceed 3 degrees Fahrenheit in the next few decades (NASA, "The Effects of Climate Change", 2022).

Humanity's impact on the Earth's climate is so great that many scientists are calling for the designation of a new geological epoch, called the **Anthropocene**. What makes the designation of the Anthropocene different from previous geologic time markers is that it is directly tied to human activity. Logically, archaeology and anthropology can play a key role in discussing the Anthropocene and the relationship between humans and the environment, both past and present (Braje and Erlandson 2013:117).

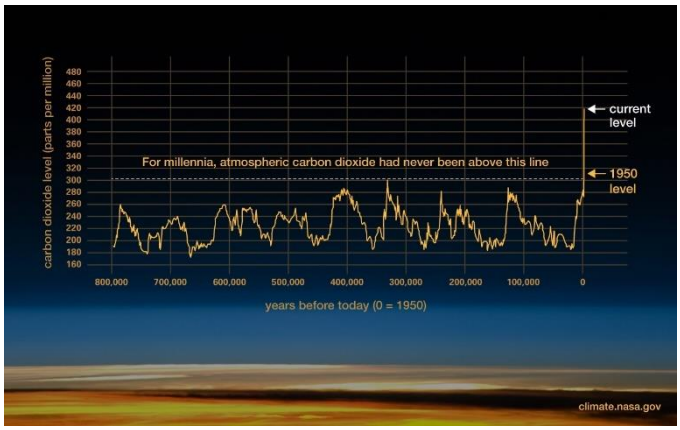

Figure 1: Graph showing the increase in atmospheric carbon dioxide over time (Credit: Luthi, D., et al.. 2008; Etheridge, D.M., et al. 2010; Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO_2 record, https://climate.nasa.gov/evidence/).

Archaeology and Climate Change

Archaeology is the scientific study of past human cultures by analyzing the material culture of human activity. Material culture includes **artifacts** (a portable object made, modified, or used by people), **features** (immovable material culture of human activity), and **sites** (a place where human activity occurred). One way archaeology can contribute to the conversation surrounding climate change is by studying past human response and adaptation to environmental change at local and regional levels (Wright 2016:256). One of the growing trends in archaeology is a focus on the long-term relationship between humans and their natural environment (Braje and Erlandson 2013: 119). Archaeologists are learning to read the entangled history of climate and human activity and interpret how environmental and cultural circumstances furthered or impeded the development of human societies (Crumley 2013:274).

By studying past human-environment relationships, archaeologists can provide data

about human adaptation strategies, resilience, and collapse in the face of environmental change to help inform solutions to the modern climate crisis (Wright, 2016, p. 264). It is important to understand and bring awareness to histories and knowledge systems of successful adaptation to environmental change as this can combat pessimistic attitudes regarding environmental catastrophe (Lane 2015:24-25).

Another way archaeologists are addressing climate change is by focusing on the threats and vulnerabilities rapid climate change poses to cultural sites and their future, otherwise known as "**Heritage at Risk**". Such attention requires an improved understanding of climate processes and their implications for site preservation and salvage (Wright 2016:256). One of the ways archaeologists who study Heritage at Risk mitigate the effects of climate change on sites is through "**archaeological triage**", or the process of inventorying sites at risk, prioritizing research at sites that are most in danger of being lost, and the long-term monitoring of sites to better frame and contextualize the effects of climate change (Grinnan 2021).

By utilizing different measurements, such as erosion rates and storm surges, to determine the level of danger a site is in, archaeologists can determine how urgent excavation, preservation, and education of the public should be (Borowy 2022:3). Archaeology can influence the public conservation around climate change by highlighting past human-nature interactions and by helping the public gain a better understanding of what is at stake in the face of global climate change (Wright 2016:267).

Underwater Archaeology and Heritage at Risk

Underwater archaeology, also known as maritime archaeology, is a subfield of archaeology that studies past human activity and culture through the exploration and analysis of submerged sites and artifacts, like shipwrecks and underwater ruins. Underwater archaeologists work in a variety of conditions and locations, such as lakes, rivers, estuaries, as well as coastal and deeper ocean waters.

Like terrestrial archaeologists, underwater archaeologists have also begun to study links between underwater cultural heritage and climate change. The management of cultural sites always includes consideration of site vulnerabilities and preservation options **in situ** (Wright 2016:257). While underwater archaeologists have long addressed natural and human threats to sites, climate change presents new risks and challenges to protecting and managing underwater, **littoral**, and coastal sites. Such risks include sea level rise, ocean warming, and ocean acidification. By analyzing the potential impacts climate change poses to submerged sites and artifacts, underwater archaeologists can create effective management strategies for underwater and coastal cultural sites (Wright 2016:257).

Figure 2: Underwater archaeologists at work (Credit: Elpida Hadjidaki, "Excavation of the Alonnisos shipwreck in 2000", CC-BY-SA-4.0, https://commons.wikimedia.org/wiki/File:Alonnisos_Excavation.jpg).

Sea level rise is one of the most commonly discussed aspects of global climate change by archaeologists (Wright 2016:257). Based on the 2014 International Panel on Climate Change report, global sea levels rose approximately 7.5 inches between 1901 and 2010 (Grinnan 2021). Sea level rise also increases storm surge heights and major storm frequency, which also contributes to increased coastal site vulnerability (Wright 2016:259). Cultural sites along

coastlines often experience episodes of being covered and uncovered by sand, mud, and water. **Coastal erosion** is a natural process, but climate change has sped up the rate of erosion in many coastal areas through increased wave action, higher high tides, and larger, more severe storms. These phenomena have a negative effect on the stability and integrity of coastal and littoral sites (Grinnan 2021).

Climate change also poses risks to sites that are already underwater. Like Earth's surface temperature, climate change has caused global sea temperature to also rise, with NOAA estimating an average rise in sea temperatures of 1.3 degrees Fahrenheit between 1915 and 2015 (Grinnan 2021). **Ocean warming**, particularly in depths shallower than 100 meters, affects submerged site preservation by increasing the rate of deterioration of organic material, like wood, as well as the corrosion of metal (Wright 2016:260).

Likewise, climate change has also increased the acidity of Earth's oceans. Due to global greenhouse emissions, oceans dissolve more carbon dioxide than before, resulting in the increased production of carbon acid that lowers the pH value of water (Grinnan 2021). If greenhouse gas emissions continue at the present rate to the end of the 21st century, the ocean will be approximately three times more acidic than it currently is (Wright 2016:261). **Ocean acidification**, like ocean warming, also increases the rate of deterioration of organic and metal material.

Ocean warming and ocean acidification also negatively impact shallow water ecosystems. These environments, such as coral reefs, seagrass meadows, kelp beds, and intertidal pools, are critical ecosystems rich in marine life that also help stabilize underwater cultural sites. These marine ecosystems are incredibly vulnerable to sea level rise, ocean warming, and ocean acidification, and their loss, besides disrupting Earth's marine biosphere, can also lead to increased instability of underwater sites and artifacts (Grinnan 2021).

How can underwater archaeologists address these issues? One option is to examine the short-term and long-term consequences of climate threats to specific sites and to begin developing specific response strategies (Wright 2016:263). Most underwater archaeology projects already include a monitoring plan for the site. It is often best practice to simply keep underwater sites underwater and monitor changes in their preservation. The information generated by this approach has the potential to inform other scientists monitoring climate change about the condition of underwater sites as well as local changes in the environment.

Case Study: Fort Frederick Barrel Well

According to the Digital Index of North American Archaeology (DINAA), a one-meter rise in sea level will result in over 13,000 cultural sites being lost across the southeastern United States (Anderson et al. 2017). One of these sites is Fort Frederick Heritage Preserve in Beaufort County, South Carolina. While Heritage at Risk is a term most associated with sites destroyed within short periods of time, Fort Frederick serves as an example of slow deterioration over centuries (SCDNR-HTP 2019).

Located along the Beaufort River, Fort Frederick was constructed of tabby, a concrete-like material made of oyster shell, sand, lime, and water, by the British colonial government between 1730 and 1734 in Port Royal, South Carolina. Within six years, Fort Frederick was falling apart so much so that it was considered unfit for service. By 1757, the fort was abandoned. In 1785, the fort and its surrounding land were sold to Captain John Joyner. Under Joyner and later his grandson, John Joyner Smith, the fort became part of a plantation, known as Old Fort or Smith's Plantation. In November 1861, the fort and surrounding plantation were occupied by Union forces following the Battle of Port Royal Sound. By this point, Fort Frederick was already eroding into the Beaufort River and the fort's tabby walls served as a dock platform for Union Navy ships.

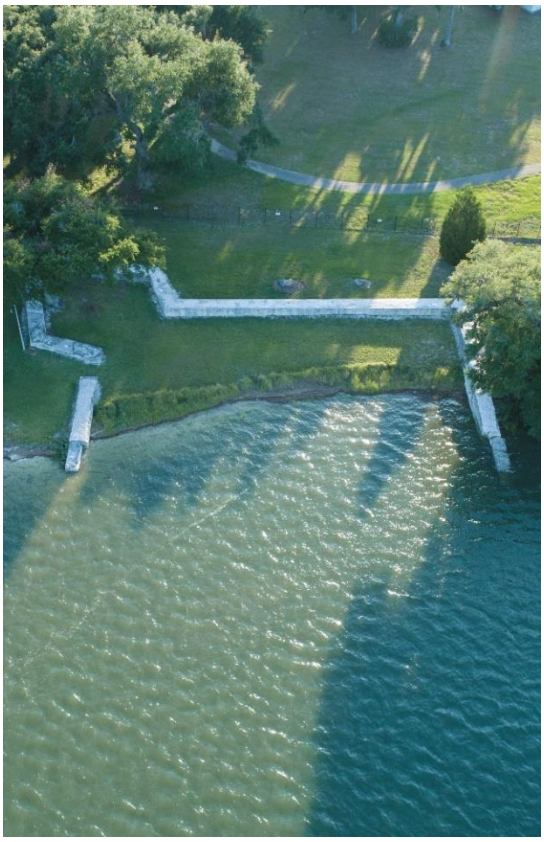

Figure 3: Remains of Fort Frederick, Fort Frederick Heritage Preserve, Beaufort County, 2019 (Credit: Jamie Koelker and Meg Gaillard, SCDNR-HTP).

During the Civil War, the site was renamed to Camp Saxton and became the headquarters for the 1st South Carolina Regiment of Volunteers, one of the first African American regiments in the Union army composed of formerly enslaved people. On January 1, 1863, many formerly enslaved people arrived by boat and walked over the fort's walls to hear the first reading of the Emancipation Proclamation in the southern states. In 1974, Fort Frederick was nominated to the National Register of Historic Places. In 1999, the fort and three acres of surrounding land were acquired by the South Carolina Department of Natural Resources Heritage Trust Program and dedicated as Fort Frederick Heritage Preserve. In 2017, Fort Frederick became part of the Reconstruction Era National Monument. Throughout the centuries, Fort Frederick continued to slowly erode into the river. Today, only around half of the fort's walls remain above water.

This lesson plan focuses on the case of a **barrel well** discovered near Fort Frederick by the Underwater Archaeology Division at the South Carolina Institute of Archaeology and Anthropology (SCIAA). In 1997-1998, SCIAA conducted a survey of littoral and underwater cultural sites and artifacts in Port Royal Sound. Located a little north of Fort Frederick, the topmost barrel of the barrel well was found exposed along the riverbank due to coastal erosion (Spirek 1998:24). The well was constructed by digging a hole down to the water table and placing barrels with their tops and bottoms removed atop one another to the desired level and then filling in around the barrels. The barrels prevented the well from collapsing and the closefitting barrel staves deterred saltwater from contaminating the well's water (Spirek and Amer 1997:25).

The barrel well may be associated with the colonial occupation of Fort Frederick, with the plantation period, or with the occupation of the plantation during the Civil War. Because the top barrel was exposed, archaeologists worked to stabilize the barrel to slow erosion until a long-term solution could be developed. In the activity, students will discuss possible options and develop a solution for monitoring the site and protecting the barrel well from further erosion.

Vocabulary

- **Anthropocene –** An unofficial term for the current geological age, viewed as the period during which human activity has been the dominate influence on climate and the environment.
- **Archaeological Triage –** The process of inventorying sites at risk, prioritizing research at sites that are most in danger of being lost, and the long-term monitoring of sites to better frame and contextualize the effects of climate change.
- **Archaeology –** The scientific study of past human cultures by analyzing the material culture (sites and artifacts) that people left behind.
- **Artifacts** – A portable object made, modified, and used by people in the past.
- **Barrel Well** – A well created by stacking wooden barrels with their bottoms removed on top of each other down to the water table in order to provide freshwater.
- **Climate Change –** Long-term changes in average global temperatures and weather patterns. These changes may be natural, but since the 1800s, human activities have been the main driver of climate change, mainly due to the burning of fossil fuels which produces heat-trapping greenhouse gases.
- **Coastal Erosion** – The process by which sea level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast.
- **Features** – Material culture that cannot be removed from a site such as roasting pits, fire hearths, house floors, or post molds.
- **Fossil Fuels –** Material made from decomposing plant and animal matter that contain carbon and hydrogen and can be burned for energy. Examples include coal, oil, and natural gas.
- **Greenhouse Gases** – Gases that trap heat in the atmosphere, such as carbon dioxide and methane. The burning of fossil fuels release greenhouse gases into the atmosphere.
- **Heritage at Risk** – A global term used to define cultural resources that are threatened by natural and human impacts, and that are often at risk of destruction over a short period of time.
- **In Situ** – In place.
- **Littoral** – Relating to or situated on the shore of the sea or lake.
- **Ocean Acidification** – A reduction in the pH of the ocean over an extended period of time, caused primarily by the excessive uptake of carbon dioxide from the atmosphere.
- **Ocean Warming** – An increase in sea surface temperatures brought about by the ocean absorbing more heat due to greenhouse gases trapping more solar energy from the sun.
- **Sea Level Rise –** An increase in the level of the world's oceans due to the effects of global warming.
- **Sites** – A place where human activity occurred and material culture were deposited.
- **Underwater Archaeology –** the scientific study of submerged artifacts and underwater sites for the interpretation of past human cultures.