Great Lakes Wetlands

Climate Change ADAPTATION Lessons

Financial assistance for this project was provided, in part, by the Michigan Coastal Zone Management Program, Office of the Great Lakes, Department of Environmental Quality, under the National Coastal Zone Management Program, through a grant from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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Great Lakes Wetlands – Climate Change Adaptation Lessons

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Great Lakes Wetlands – Climate Change Adaptation Lessons

A mini-unit to help middle school students understand how climate change affects coastal wetlands in the Great Lakes region.

Purpose:

The five lessons included in this unit are meant as an introduction to further research and education about how climate change impacts wetlands in Michigan, including Great Lakes coastal wetlands.

Each lesson offers simple instruction, a variety of resources, and focus questions to ensure that teachers can offer students both breadth and depth of content.

The lessons and resources contained in this unit are by no means exhaustive and Tip of the Mitt Watershed Council envisions this unit as a "living document" that can be added to, improved, and changed as educators utilize the lessons in their classrooms. Comments, suggestions, and identified resources are encouraged.

Lessons:

Lesson 1: Wetlands in the Great Lakes Region: What are wetlands and how are freshwater coastal wetlands unique?

Lesson 2: Climate Change in the Great Lakes: How does climate change affect the Great Lakes region?

Lesson 3: Coastal Wetland Scenarios: How does climate change affect Great Lakes coastal wetlands?

Lesson 4: Best Management Practices (BMPs): What can humans do to help coastal wetlands "adapt" to changes?

Lesson 5: Taking Action: What stewardship practices help protect and restore coastal wetlands?

Next Generation Science Standards:

In 2010, the National Academy of Sciences, Achieve, the American Association for the Advancement of Science, and the National Science Teachers Association embarked on a two-step process to develop the *Next Generation Science Standards* (NGSS). NGSS are a new set of standards that provide consistent science education through all grades, with an emphasis on engineering and technology.

For an in-depth explanation of the standards referenced in this mini-unit see the Next Generation Science Standards website: **http://www.nextgenscience.org/get-to-know**

NGSS Cross Cutting Concepts

Patterns: Identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. Use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.

Cause and Effect: Classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. Use cause and effect relationships to predict phenomena in natural or designed systems. Understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Stability and Change: Explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.

NGSS Science and Engineering Practices

Asking Questions and Defining Problems: Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Identify and/or clarify evidence and/or the premise(s) of an argument.

Obtaining, Evaluating, and Communicating Information: Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question.

Middle School Earth Space Science Standards:

The Next Generation Science Standards addressed in the mini-unit are Middle School Earth Space Science (MS-ESS) standards. In some lessons, elementary Earth Space Science Standards are addressed.

MS-ESS2.A: Earth Materials and Systems: Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources.

MS-ESS2.C: The Roles of Water in Earth's Surface Processes: Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.

MS-ESS2.D: Weather and Climate: Complex interactions determine local weather patterns and influence climate, including the role of the ocean.

MS-ESS2.E: Biogeology: Changes in biodiversity can influence humans' resources and ecosystem services they rely on.

MS-ESS3.A: Natural Resources: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

MS-ESS3.C: Human Impacts on Earth Systems: Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.

MS-ESS3.D: Global Climate Change: Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.

Great Lakes Wetlands

Lesson 1

Climate Change ADAPTATION

Lesson #1

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Lesson One: Wetlands in the Great Lakes Region

What are Wetlands and How are Freshwater Coastal Wetlands Unique?

Lesson Overview:

This lesson focuses on describing features of wetlands; identifying different types of wetlands, and, specifically, how coastal wetlands are unique. Students will review basic terms and information associated with wetlands to complete a chart that focuses on five types of wetlands.

Focus Questions:

Students answer these essential questions:

- What are wetlands and where are they found in Michigan?
- What are the different types of wetlands?
- Why are wetlands important and what is unique about Great Lakes coastal wetlands?

Next Generation Science Standards:

Obtaining, Evaluating, and Communicating Information: Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question. (2-ESS2-3)

ESS2.E: Biogeology: Living things affect the physical characteristics of their regions. (4-ESS2-1)

ESS3.A: Natural Resources: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

ESS2.C: The Roles of Water in Earth's Surface Processes: Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (2-ESS2-3)

ESS2.C: The Roles of Water in Earth's Surface Processes:
Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

ESS2.A: Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)

Materials:

- Tip of the Mitt Watershed Council, *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan*
- Wetland Background – Student Information Sheet
- Wetlands Habitat Chart – Double sided copy
- Internet access – Additional research

Time: 1-2 class periods

Objectives:

Students will be able to:

1. Define basic terms and processes associated with wetlands.
2. Identify different types of wetlands (marsh, bog, fen, swamp and swale.)
3. Describe the importance of wetlands in the environment.

Advance Preparation:

1. Make copies of Wetland Background – Student Information Sheet and Wetlands Habitat Chart. One set for each pair of students.
2. Have *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* available digitally or printed copies for pairs of students. This document is critical for the mini-unit and it is recommended that copies be produced for use with all lessons.
3. Selected pairs/groups for completing chart.
4. Listed websites for students for extended research.

Common Misconceptions:

Students will learn the basics of what makes a wetland unique, but a common misconception occurs when students research *coastal wetlands* in general because there is a difference between ocean coastal wetlands and Great Lakes (i.e. freshwater) coastal wetland habitats. Make sure to make that distinction clear! Comparing ocean versus freshwater coastal wetlands may be an alternative method of introducing this unit.

Background Information:

The websites listed below are general background about wetlands. Coastal wetlands are a smaller subset that will be the focus of this mini-unit. All wetlands function similarly, but coastal wetlands have specific factors, lake levels and wave action for example, that create unique habitats for students to understand.

Websites for Background Information:

U.S. Environmental Protection Agency (EPA): Wetlands Education –General information, great activities and lessons
https://www.epa.gov/wetlands/wetlands-education

Michigan Department of Environmental Quality (MDEQ) Great Lakes Coastal Wetlands - Good background information for teachers on Great Lakes coastal wetlands specifically
http://www.michigan.gov/deq/0,4561,7-135-3313_3687-11177--,00.html

Fabulous Wetlands with Bill Nye The Science Guy – Wetlands video (6:50 min) – Good basic introduction
https://www.youtube.com/watch?v=BeUPbGWg2KU

MDEQ Wetlands Map Viewer – Move around the state to locate different wetlands!
http://www.mcgi.state.mi.us/wetlands/mcgiMap.html

Procedure:

1. Ask students what a wetland is and if they have ever visited a wetland. Students brainstorm features of wetland together or in pairs and then share with class via white board or poster.
2. Identify specific wetlands that will be the focus of the lesson/unit (Examples: Swamp, Bog, Fen, Marsh, Interdunal Swale)
3. Working in pairs, have students use wetlands informational document provided and websites to complete chart.
4. Project chart on white board or create large chart for class to fill in.
5. Invite teams to share information with class - Make sure that all pairs have accurate information!
6. Teams create a visual representation of one type of wetland on chart (poster, picture book, video, etc.). Share with class.
7. Discuss the following questions as a class:
    - What characteristics are shared by these habitats?
    - What species are found in more than one of these ecosystems?
    - What problems might humans cause for plants and animals within these ecosystems? (Global climate change and its effects, erosion, invasive species, habitat destruction, pollution)
    - What problems might nature cause for plants and animals within these ecosystems? (Global climate change and its effects, erosion, weathering)
    - Why is it important to conserve or protect these ecosystems?

Extensions:

1. Students share wetlands projects with another class or the community.
2. As a class, take a field trip to local wetland area and take pictures of wetland features.
3. Make models of wetlands in general, or specifically a Great Lakes coastal wetland. Lesson plans are listed below.

Additional Resources:

Teaching Great Lakes Science: Lessons and Data Sheets
http://www.miseagrant.umich.edu/lessons/

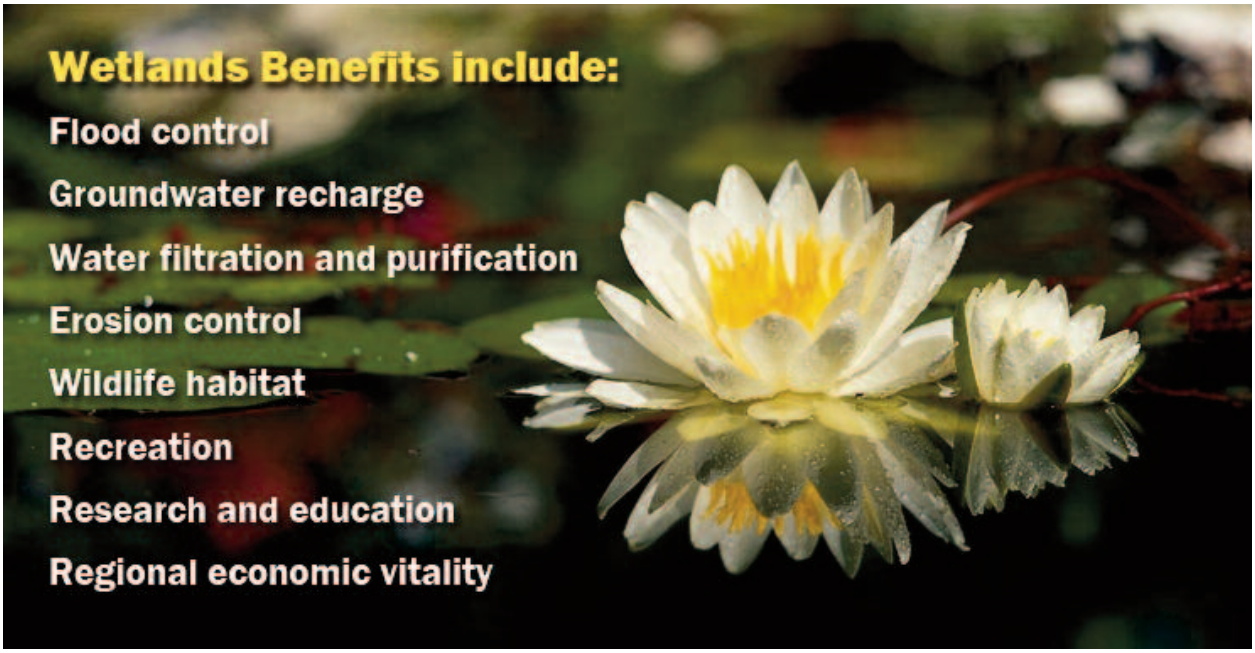
Teaching Great Lakes Science: Wetlands Lesson
http://www.miseagrant.umich.edu/lessons/lessons/by-broad-concept/earth-science/wetlands/

Teaching Great Lakes Science: Activity: Wetland in a Pan
http://www.miseagrant.umich.edu/lessons/lessons/by-broad-concept/earth-science/wetlands/activity-wetland-in-a-pan/

Adapted From:
Alliance for the Great Lakes: Great Lakes in My World Lesson 6
https://greatlakes.org/get-involved/great-lakes-in-your-classroom/k-12-curriculum/

Wetlands Background – Student Information Sheet

Wetlands are some of our most valuable natural resources –they are places of beauty that contribute greatly to the overall health of our environment and our quality of life. They provide untold functions and values that become increasingly important as we continue to lose them. Healthy wetlands protect water quality. They retain or remove nutrients and pollutants, acting as "nature's kidneys." Wetlands are also "nature's nurseries," providing vital habitat to fish, wildlife, and waterfowl. Wetlands control flooding by acting as a sponge. They decrease flood peaks and safeguard downstream property owners. They temporarily store flood waters and replenish ground water supplies. In their natural condition, wetlands associated with rivers and lakes function as a barrier to erosion.



Types of Wetlands

Aquatic Bed
Areas of shallow permanent water that are dominated by plants that grow on or below the surface of the water.

Great Lakes coastal wetlands
The hydrology of these wetlands is driven by Great Lakes water level fluctuations. There are different types of these rare wetlands due to substrate (clay, sand, muck) and exposure to wind and wave action.

Barrier-beach Wetland
A barrier beach wetland is formed when nearshore currents deposit a sand or gravel barrier bar across the mouth of an embayment. These wetlands form behind the sand barrier. The resulting shallow pond or lagoon is sheltered from the lake's

wave energy; sediments accumulate in the lagoon basin and vegetation can become rooted. Although water levels in the lagoon may be augmented by tributary streams and groundwater seepage, coastal lagoon wetlands are also partially controlled by the Great Lakes, through permanent or intermittent connecting channels, wave overwash, or cross-bar seepage.

Open Embayment
A curving section of shoreline that is open to the lake. Open embayments offer protection from the force of the lake in areas where shallow depth and gently sloping bottom topography reduce wave height and energy.

Protected Embayment
Many stretches of bedrock or till derived shorelines form small protected bays, typically less than three or four kilometers in width. These bays can be completely vegetated with emergent or submergent vegetation. Examples include Duck Bay and Mackinac Bay in the Les Cheneaux Islands on Lake Huron, Matchedash Bay on Lake Huron, and Bayfield Bay on Wolfe Island in Lake Ontario.

Interdunal Swale Wetland
A wetland dominated by grass-like vegetation that occurs in the low areas between sand dunes or beach ridges along the Great Lakes shoreline. These wetlands depend on the Great Lakes for their water source. As such, their water table and period of saturation fluctuates with Great Lakes water levels. Because of the highly variable ecosystem characteristics, and the fact that they exist nowhere else on earth, interdunal swale wetland/upland complexes support many endangered or threatened species such as the Piping Plover, Pitcher's thistle, Lake Huron tansy, and Houghton's goldenrod. Due to a combination of the natural fragility of interdunal wetlands and the loss of shoreline habitat due to development along the Great Lakes shoreline, these habitats are threatened.

River Deltas
River Deltas form as stream sediments deposited at the mouth of a river accumulate and create multiple shallow channels, low islands, and abandoned meanders that allow for extensive wetland development.

Marsh
A frequently or continually inundated wetland characterized by grass-like and other emergent vegetation adapted to saturated soil conditions. Typical marsh plants include rushes, reeds, sedges, cattails, and grasses. They are wet areas which can be periodically covered by standing or slow-moving water and are usually associated with ponds, rivers, streams, inland lakes, and the Great Lakes. Although some marshes have sandy soils, marshes usually have finer textured, nutrient rich soils with a high content of organic matter.

Peatlands
Peatlands occur as thick peat deposits in old lake basins or as blankets of peat across the

landscape. Their formation is due to the combination of cool temperatures and adequate rainfall in northern temperate regions around the earth. Peat-accumulating wetlands include both bogs and fens.

Bog
Bogs form in lake basins that are isolated from sources of ground water. Because normal rainwater (the only water source for true bogs) is slightly acidic, bog water tends to be slightly acidic. The acidic nature of bogs supports acid-loving (acidophilic) vegetation, especially Sphagnum mosses, and contributes to a deficiency in available plant nutrients. As a result, many plants, animals, and microbes have special adaptations.

Fen
A peat-accumulating wetland that receives some inputs of groundwater or drainage from surrounding mineral soils which typically results in alkaline waters and usually supports grass-like vegetation.

Swamp
A wetland dominated by trees or shrubs. Swamps are usually inundated or saturated periodically at some point during the growing season. The soils in swamps are usually rich in nutrients and organic matter. This is due to silt and organic matter deposited by flood events and the accumulation of organic matter (dead trees and other vegetation) over time.

Vernal Pool
An ephemeral wetland usually in a forested area. Vernal pools are small isolated wetlands that only hold water for a short time during the spring. After snowmelt, amphibians congregate in vernal pools to create another generation of frogs, toads, and salamanders. By midsummer, the water is gone from this important, yet ephemeral, wetland.

Wet Meadow
Wet meadows contain grass-like vegetation and saturated soils, but seldom have water standing on the ground surface. Many wet meadows occur in the former lakeplain of the Great Lakes, especially in southeast Michigan and the Saginaw Bay watershed. Because these areas are relics from a former geologic epoch, they provide habitat for many plant species rare in Michigan that are typically adapted to prairies. Unfortunately, a large percentage have been severely degraded or converted to agriculture or housing.

Wet Prairie
Wet prairie is a native lowland grassland occurring on level, saturated and/or seasonally inundated stream and river floodplains, lake margins, and isolated depressions in Southern Lower Michigan. Lakeplain wet prairie is a globally imperiled ecosystem. The majority of wet prairie acreage was converted to agriculture following European settlement. In Michigan, the size and number of wet prairies have been reduced so that today less than 1% of the original community remains. Today, only 15 wet prairies totaling 613 acres remain in Michigan. Lakeplain prairies are among the most diverse plant communities in Michigan, with as many as 200 plant species found within a single prairie remnant. Threats

to remaining sites include hydrologic alteration, nutrient enrichment, siltation, fire suppression, shrub and tree encroachment, and destruction of upland buffers.

For more information on wetlands go to: http://www.watershedcouncil.org/wetlands.html

Wetland Habitat Chart

Use Wetland Background document and websites provided to fill out chart below.
Use bullets to indicate information, draw simple illustration of habitat, and list types of plants/animals.

Wetland Habitat	Description/Physical Characteristics	Flora (Plants)	Fauna (Animals)

Wetland Habitat	Description/Physical Characteristics	Flora (Plants)	Fauna (Animals)

Wetland Habitat	Description/Physical Characteristics	Flora (Plants)	Fauna (Animals)

Great Lakes Wetlands

Lesson 2

Climate Change ADAPTATION

Lesson #2

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Lesson Two: Climate Change in the Great Lakes

How Does Climate Change Affect the Great Lakes Region?

Lesson Overview:

This lesson focuses on the difference between weather and climate, how climate change occurs, and the unique impact that climate change has on the Great Lakes region. Students will distinguish between weather and climate through sorting cards, learn about the effects of climate change in the Great Lakes region, and complete a cause and effect chart with climate factors and impacts.

Focus Questions:

Students answer these essential questions:

- What is the difference between weather and climate?
- What are the effects of climate change on the Great Lakes region?
- How do climate factors impact Great Lakes coastal wetlands?

Next Generation Science Standards:

> **Stability and Change:** Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)
>
> **ESS3.D: Global Climate Change**: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)
>
> **ESS3.C: Human Impacts on Earth Systems:** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

Materials:

- Tip of the Mitt Watershed Council, *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan*
- Weather or Climate? Matching Activity - Scissors and tape or glue, per team
- Climate Factor and Impact Chart Worksheet
- Internet access – Additional research

Time: 1-2 class periods

Objectives:

Students will be able to:

1. Identify the difference between weather and climate.
2. Understand how climate change affects the Great Lakes region.
3. Identify the impacts to coastal wetlands from environmental factors due to climate change.

Advance Preparation:

1. Make copies of Weather or Climate? Matching Activity and Climate Factor and Impact Chart. One copy each per pair of students. Scissors and tape or glue are needed, per pair.
2. Have *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* available digitally or printed copies for pairs of students. This document is critical for the mini-unit and it is recommended that copies be produced for use with all lessons.
3. Selected pairs/groups for matching activity and completing chart.
4. Listed websites for students to visit for background.

Common Misconceptions:

Students understand the difference between weather and climate, but a common misconception occurs when we apply their understanding to climate change. This occurs when seemingly contradictory events: water is evaporating and water is declining in some parts of the world, while at the same time polar melting is occurring, creating an increase in sea levels. Climate change data is collected over decades and projected in computer models, another confusing concept for students.

Background Information:

How can there be global warming if it is snowing outside in April when it should be 50 to 60 degrees Fahrenheit? This is a very common question, and the answer lies in the difference between weather and climate.

Weather is highly variable and is made up of specific atmospheric conditions including temperature, rainfall, wind, and humidity. It occurs at any given place and time. Weather occurs over a short term (today, tomorrow, last week, etc.).

Climate (according to the National Weather Service's definition) is the average of weather over at least a 30 year period. Climate is much less variable; it is the typical weather for any given area, averaged out over many years. General weather conditions such as temperature, precipitation, humidity, air pressure, sunshine, cloudiness, and wind are averaged out over many decades to characterize climate.

Climate (according to the American Meteorological Society's definition) is "the slowly varying aspects of the atmosphere–hydrosphere–land surface system." More specifically, climate is frequently defined to be the average of weather over at least a 30 year period. Climate is much less variable; it is the typical weather for any given area, averaged out over many years. General weather conditions such as temperature, precipitation, humidity, air pressure, sunshine, cloudiness, and wind are averaged out over many decades to characterize climate.

A climograph is a way to represent the three most important elements of climate: average temperature, average precipitation, and seasonality. Typically, when climatologists talk about the mean temperature, they are referring to the average of the maximum and minimum temperatures.

The monthly temperature and precipitation for each year is averaged and represented in the climograph. Climographs usually represent data that occurred in a period of time, usually 30 years.

There are many different terms associated with climate, including global warming, climate change, and global change, but these terms cannot be used interchangeably. Climate is commonly defined as the average weather for a specific location, region, or the entire globe over an extended period of time (decades).

Atmospheric scientists investigating the possibility that human influences are changing the Earth's climate confront a significant problem: how do we actually detect climate change? We know that weather can be highly variable, but climate, which is based on longer time scales, can be variable as well. If the last 30 years were generally warmer worldwide than the previous 30 years, would this be solid evidence that the climate is changing in a particular direction? Or could this only be a long-term, normal statistical fluctuation in climate? This is a critical and surprisingly difficult question for atmospheric scientists to answer. While computer models may predict climate change, citizens are unlikely to support significant social, economic, and/or technological changes to slow the rate of change unless they are sure that the climate is truly changing, not just experiencing random variability.

It is important to understand what constitutes normal climate variability versus actual climate change. **Climate variability** as the way climatic variables (such as temperature and precipitation) depart from some average state, either above or below the average value. **Climate change** can be defined as a trend in one or more climatic variables characterized by a fairly smooth continuous increase or decrease of the average value during the period of record. As we look at 30-year average values, however, we also detect variability.

The term **global warming** refers to a sustained increase in global average surface temperature and the lowest layer of the atmosphere and is just one aspect of climate change. Global warming does not imply that the world will warm uniformly. In fact, as with

any average, there will be places that warm more or less than the average. Some areas may even cool.

Climate change refers to a long-term shift in climate measured as a change in some or all of the features associated with weather, such as temperature, wind, precipitation. It is a long-term continuous change to the average weather (e.g., warming or cooling as indicated by the average temperature) as well as changes to the range of various weather conditions (e.g., high and low temperatures) and extreme events (e.g., frequency of tornadoes). Climate change can result from either natural or anthropogenic (human-influenced) causes. For example, natural factors affecting climate include changes in the Sun's energy or slow changes in the Earth's orbit around the Sun. Human activities that change the atmosphere's make-up (e.g. burning fossil fuels) and the land surface (e.g. cutting down forests, planting trees, etc.) also affect the climate.

Global change is the broadest term and it encompasses more than just climate change. According to the U.S. Global Change Research Act of 1990, global change is defined as: "changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life."
Additional background can be found in extensions and resources below.

Procedure:

1. Ask students to think about the difference between weather and climate. Create a simple two-column chart on white board and have students come up with examples of each.
2. Hand out Weather or Climate? Matching Activity to pairs of students. Scissors and tape or glue will be needed for completing the activity.
3. Working in pairs, students complete the matching activity. Share and compare choices.
    - Students cut out Weather or Climate Cards.
    - Students place Weather or Climate Cards in the corresponding column on the Weather or Climate? Worksheet.
4. Use chart on white board to review accurate answers.
5. Teams read pgs. 3-5 in *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* and discuss as a class each "arrow" on page 4 that represents observable changes over the last century. This should be an open-ended discussion, focused on data recorded.
6. Read aloud to class: Page 5 Climate Change Impacts to Wetlands.
7. Hand out Climate Factor and Impact Chart per team. Students use the chart on page 6 to complete the chart. This chart will be used in Lesson 3.
8. Discuss the following questions as a class:
    - What climate factor do you think has the most impact?
    - What impact would climate factors have on plants and animals in coastal wetlands? (Refer to Lesson 1- Coastal Wetland Habitats)

- What impacts might affect how humans enjoy and use these coastal wetlands?
- Why is it important to understand how climate change affects Great Lakes coastal wetlands?

Extensions:

These additional lessons address climate change in the Great Lakes in depth.

1. Great Lakes Climate Change Curriculum: How will Climate Change Affect a Great Lakes State? (Background and Teacher Guide)
2. Great Lakes Climate Change Curriculum: Water Levels on the Great Lakes http://changingclimate.osu.edu/assets/docs/2013edu_CurriculaWaterLevelsV3.pdf

Additional Resources:

Union of Concerned Scientists: Climate Hot Map – Global Warming Effects Around the World
http://www.climatehotmap.org/

Great Lakes Climate Change Curriculum: How Will Climate Change Affect A Great Lake State?
http://changingclimate.osu.edu/assets/docs/2012edu_CurriculaGoogleV3.pdf

EPA: A Student's Guide to Global Climate Change https://www3.epa.gov/climatechange/kids/index.html

National Oceanic and Atmospheric Administration (NOAA) – Great Lakes Environmental Research Laboratory: Great Lakes Maximum Ice Cover on the Great Lakes https://www.glerl.noaa.gov//data/ice/historicalAnim/

Great Lakes Literacy Resources
http://greatlakesliteracy.net/resources/3/

Adapted From:
Michigan Environmental Education Curriculum Support (MEECS): Understanding Climate Change

Weather or Climate Cards

The sun rose at 7:36 am	Today the sky is sunny
It has only rained twice this month	Michigan winters are cold and snowy
On average there is less than 3 inches of rainfall in April in Michigan	For the winter of 2010-2011, Muskegon received 103.1 inches of snow
The average yearly snowfall over the past 96 years for Lansing, MI has been 48.8 inches.	In the last 100 years, there has not been a hundred degree day in April in Michigan
Over the course of the day, the barometric pressure dropped	It is 50 degrees outside now
There is a tornado watch	I will have to wear a coat to stay warm today
Over the past fifty years, the average temperature has never been above 34 degrees in February in Michigan	Michigan summers are always warmer than Michigan winters
It snowed 12 inches last weekend	Friday it's predicted to rain

Weather or Climate? Matching Activity

Weather	Climate

Climate Factor and Impact Chart

What Climate Factors are Causing Impacts in the Great Lakes Region?

Use page 6 of *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* to complete chart.

Great Lakes Region IMPACTS	Climate FACTORS
Frequency of heavy rainfall events increasing year-round	
Variable by lake; Lake Michigan likely to become ice free soonest	
Lake Superior warming fastest; warmer water holds less oxygen for fish and other animals	
Summer warming faster than winters	
Decrease likely, but increase also plausible; lake level variability to continue regardless	
Increase in lake effect snow, likely decrease in snowfall otherwise	
Up overall, but variable by season	
Heat waves are likely to be more frequent, longer lasting and more severe	
Average wind speeds declining, but may have more high intensity wind events	
Increase larger in summer; loss of winter lake ice will increase evaporation off lakes	
Up overall, but variable by season: Fall and winter much rainier, summers drier	
Likely to increase by 3-6 weeks by the end of the century	

Great Lakes Wetlands

Lesson 3

Climate Change ADAPTATION

Lesson #3

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Lesson Three: Coastal Wetland Scenarios

How Does Climate Change Affect Great Lakes Coastal Wetlands?

Lesson Overview:
This lesson focuses on the impacts that climate change will have on Great Lakes coastal wetlands. Students will use information from prior lessons to put together scenarios to show climate change impacts on specific wetland types. Scenarios focus on impacts to environment, vegetation, and wildlife.

Focus Questions:

Students will answer these essential questions:

- How will Great Lakes coastal wetlands be impacted by climate change?
- What factors of climate change will affect wildlife and vegetation?
- Will climate change impact wetland types differently?

Next Generation Science Standards:

Cause and Effect: Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)

ESS3.C: Human Impacts on Earth Systems: Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

ESS3.A: Natural Resources: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

ESS3.D: Global Climate Change: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)

Stability and Change: Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Materials:

- Tip of the Mitt Watershed Council Publication, *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan*
- Wetland Background – Student Information Sheet (Lesson 1)
- Wetlands Habitat Chart – Double sided copy (Lesson 1)
- Climate Factor cards
- Climate Impact chart

Time: 1 class period

Objectives:

Students will be able to:

1. Identify climate change factors.
2. Describe the flora and fauna of wetlands.
3. Identify impacts of climate change on specific wetland environments.
4. Communicate the impacts of climate change on coastal wetlands to the public.

Advance Preparation:

1. Make copies of Climate Factor cards (one set per group) and Climate Impact chart (one per student).
2. Have *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* available digitally or printed copies for student groups.
3. Selected groups for completing chart.

Background Information:

The documents and websites listed below give information on the impact that climate change could have on Great Lakes coastal wetlands. As the climate changes we will see a wide range of changes in the Great Lakes environment, from more severe storm events to variable water levels.

These changes will have various effects on the coastal wetland environments in Michigan. For example, we may see longer growing seasons for vegetation of all sorts, warmer temperatures may lead to later or earlier reproduction seasons for wildlife, and variable water levels may lead to loss of habitat for flora and fauna.

Documents and Websites for Background Information:

Tip of the Mitt Watershed Council: Great Lakes Climate Change Information
https://www.watershedcouncil.org/climate-change.html

Climate Change Impacts – Table 2 and 3 for scenario examples
https://www.researchgate.net/profile/Linda_Mortsch/publication/226519225_Assessing_the_Impact_of_Climate_Change_on_the_Great_Lakes_Shoreline_Wetlands/links/54733d780cf216f8cfaec85e.pdf

Procedure:

1. Review types of wetlands.
    a. Ask students what types of habitats, animals, and vegetation is in each.
2. Share with students that they will be applying what they learned about climate change and its effects on the Great Lakes and applying it to coastal wetlands.
3. Have students get into groups.
4. Have student groups select a wetland type.
5. Have students cut out Climate Impact cards.
6. Have students place cards on chart then discuss and record the impact that the climate factor would have on the wetland environment.
    a. Remind students that some climate changes may result in similar impacts.
    b. Remind students to think about impacts to environment as well as wildlife, vegetation, and humans.
7. Have students share/present their scenarios to the class.

Additional Resources:

North American Lake Management Society: Climate Impacts on Lakes
https://www.nalms.org/home/our-mission/nalms-position-papers/climate-change-impacts-on-lakes/

Union of Concerned Scientists : Climate Hot Map – Global Warming Effects Around the World
http://www.climatehotmap.org/

MDEQ Great Lakes Coastal Wetlands - Background
http://www.michigan.gov/deq/0,4561,7-135-3313_3687-11177--,00.html

Climate Factor Cards

Decreased Lake Ice Cover Variable by lake; Lake Michigan likely to become ice free soonest	**Increased Air Temperature** Summer warming faster than winters	**Increased Rainfall** Up overall, but variable by season: fall and winter much rainier, summers drier	**Snowfall** Increase in lake effect snow, likely decrease in snowfall otherwise
Wind Average wind speeds declining, but may have more high intensity wind events	**Heat Waves** Heat waves are likely to be more frequent, longer lasting, and more severe	**Longer Growing Season** Likely to increase by 3-6 weeks by the end of the century	**Extreme Rains** Frequency of heavy rainfall events increasing year-round
Evaporation and Drought Increase larger in summer; loss of winter lake ice will increase evaporation off lakes	**Decrease in lake level** Decrease likely, but increase also plausible; lake level variability to continue regardless	**Increased Runoff** Up overall, but variable by season	**Increased Lake Temperature** Lake Superior warming fastest; warmer water holds less oxygen for fish and other animals

Climate Impact Chart

Type of Wetland:

Climate Factor	Impact on Wildlife	Impact on Wildlife	BMP

Great Lakes Wetlands

Lesson 4

Climate Change ADAPTATION

Lesson #4

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Lesson Four: Best Management Practices

What can Humans do to Help Coastal Wetlands "Adapt" to Changes?

Lesson Overview:

This lesson focuses on the practices to best manage and reduce the impacts caused by climate change. Students will use the climate impact scenarios that they developed in the previous lesson to brainstorm a way to reduce or avoid the negative climate impact.

Focus Questions:

Students will answer these essential questions:

- How can the impacts of climate change be reduced?
- What steps can the state take to protect the Great Lakes and coastal wetlands against climate change?

Next Generation Science Standards:

> **ESS3.D: Global Climate Change**: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)
>
> **ESS2.E: Biogeology:** Living things affect the physical characteristics of their regions. (4-ESS2-1)
>
> **ESS3.C: Human Impacts on Earth Systems:** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

Materials:

- Tip of the Mitt Watershed Council Publication, *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan*
- Wetlands Habitat Chart – Double sided copy (Lesson 1)
- Climate Impact Chart (Lesson 3)

Time: 1 class period

Objectives:

Students will be able to:

1. Define and identify best management practices for protecting and preserving coastal wetlands.
2. Communicate the importance of protecting coastal wetlands.

Advance Preparation:

1. Have *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* available digitally or printed copies for pairs of students. This document is critical for the mini-unit and it is recommended that copies be produced for use with all lessons.
2. Selected pairs/groups for matching activity and completing chart.

Background Information:

There are many ways that we can protect our Great Lakes wetlands from the negative effects of climate change. The Tip of the Mitt Watershed Council publication *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* names some of these best management practices.

A **Best Management Practice (BMP)** is a practice or combination of practices that is determined to be an effective and practical means of preventing pollution or protecting the environment. BMPs in our case refer to protecting and preserving coastal wetlands.

Coastal wetland BMPs can be split into three main categories: Preservation and Protection, Stormwater Management and Green Infrastructure, and Wetland Management, Creation, and Restoration.

Preservation and Protection BMPs include ordinances, easements, laws, and regulations. These types of protective measures are typically implemented by local and state governments and agencies.

Stormwater Management and Green Infrastructure BMPs include installation of structures that will lessen the impact that developments like residences, businesses, and roadways have on the local watershed. The structures include rain barrels, rain gardens, native landscaping, natural shorelines, riparian buffers, and permeable paving. These BMPs can be implemented by anyone, anywhere!

Wetland Management, Creation, and Restoration BMPs include practices such as removal or treatment of invasive species, restoration of wetlands, creation of stormwater wetlands, or landscape level assessments.

For more information on the wetland BMPs, refer to pages 8-30 of the *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* publication.

Procedure:

1. Ask students to think about the negative impacts that climate change will have on Great Lakes coastal wetlands. Refer to the scenarios that the students developed in the previous lesson.
2. Explain to students that they will be brainstorming "adaptations" or ways to reduce or avoid impacts caused by climate change.
3. Explain to the students that these adaptations are called best management practices (BMPs) and there are recommended BMPs for coastal wetlands in the *Climate Change Adaptation for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* publication.
4. Have students work in groups to develop adaptations. Students may refer to BMPs in the *Climate Change Adaptations for Coastal Wetlands* publication.
5. Students can write their suggestions in the space in the BMP section on the Climate Impact Chart. (Lesson 3)
6. Have groups present their BMP to the rest of the class.
7. Engage students in class discussion on local issues and what could be done to fix them.

Additional Resources:

Sea Grant Michigan: Climate Adaptation
http://www.miseagrant.umich.edu/explore/climate-weather-and-the-great-lakes/climate-adaptation/

North American Lake Management Society: Climate Impacts on Lakes
https://www.nalms.org/home/our-mission/nalms-position-papers/climate-change-impacts-on-lakes/

Great Lakes Wetlands

Lesson 5

Climate Change ADAPTATION Lesson #5

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Lesson Five: Taking Action

What Stewardship Practices Help Protect and Restore Coastal Wetlands?

Lesson Overview:

This lesson focuses on helping students take action to protect and restore coastal wetlands and the surrounding watershed. Students will learn about how individual and group actions can have a positive impact on addressing many of the potential impacts of climate change. Students will plan a stewardship action and communicate their plan to the public.

Focus Questions:

Students answer these essential questions:

- How do my actions affect coastal wetlands and the greater watershed?
- What stewardship action could I plan to have a positive impact on coastal wetlands?
- How do I communicate what I have learned about climate change effects on coastal wetlands and actions everyone can take to help?

Next Generation Science Standards:

> **ESS3.C: Human Impacts on Earth Systems:** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)
>
> **ESS3.A: Natural Resources:** Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

Materials:

- Tip of the Mitt Watershed Council, *Climate Change Adaptations for Coastal Wetlands*
- Student Stewardship Plan
- National Oceanic and Atmospheric Association (NOAA) – 10 Things You Can Do for Coastal Wetlands – Posted or copy

Objectives:

Students will be able to:

1. Identify individual and group actions to help protect and restore coastal wetlands.
2. Understand how stewardship actions positively impact coastal wetlands and the surrounding watershed.
3. Create a stewardship action plan and communicate both the action and results to the public.

Advance Preparation:

1. Make copies of Student Stewardship Plan and NOAA – 10 Things You Can Do for Coastal Wetlands. One copy each per pair of students.
2. Have *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* available digitally or printed copies for pairs of students. This document is critical for the mini-unit and it is recommended that copies be produced for use with all lessons.
3. Selected pairs/groups for brainstorming stewardship projects.
4. Listed websites for students to visit for background.

Common Misconceptions:

Students sometimes have the perception that they cannot make a difference, even though they have fabulous ideas and projects. The most important outcome of this lesson is that each student, individually or as a team, is confident that they can make an impact and help conserve and restore coastal wetlands. Individual efforts, like picking up waste, can collectively have a huge impact on the surrounding environment.

Background Information:

What is Stewardship?

Stewardship includes taking care of natural systems and ensuring their functioning in the future. (Notes on coastal stewardship from United Nations Educational, Scientific and Cultural Organization (UNESCO))

- Coastal stewardship is characterized by efforts to ensure the sound and sustainable use of coastal resources. The complex issue of promoting stewardship should be seen as a challenge to inform, educate, empower, and motivate people towards becoming managers and custodians of their coastal environment.
- Coastal stewardship should focus on conservation and sustainable use of coastal and marine environments so that future generations will be able to benefit from coastal and marine environments.

- Coastal stewardship incorporates tourism, recreation, and commercial uses of coastal areas. Stewardship activities may stimulate students to participate in decision-making that can improve and reverse the abuse of coastal resources.
- Stewardship projects can include education, monitoring, restoration, or many other activities.

First there is a **preparation phase**, which involves students in discussions about a question, problem, or issue. The **action phase** is next and includes an outdoor experience and making observations and collecting data. This phase could include helping with projects that result in positive impacts to the environment. Finally, there is a **reflection phase**, which includes evaluating the activity, analyzing conclusions, and sharing the results.

The stewardship project could be incorporated into the action phase or could be designed by the students during the reflection stage as a culminating follow up activity.

Ideally, stewardship projects should:

- Address a resource management need in the students' own area.
- Be student driven.
- Include outreach to a broader community (beyond their own class).
- Utilize knowledge or practice skills learned in class.
- Be an integral part of the instructional program.
- Include collaboration with a community organization or volunteer expert.

It can be very powerful for students to "adopt" the coastal wetland in their community. They could work to quantify and communicate the value of protecting or restoring their wetland. Students would learn all they can about their wetland, including the history of its use, area, species, and pressures on it. Students could teach the community about the ecological roles of their wetland and also about its aesthetic value, and they can emphasize the economic value it has as for its ecological services.

Procedure:

1. Ask students to read NOAA – 10 Things You Can Do for Coastal Wetlands and select one action from the list they could do. Discuss whether or not they would need to make a plan for this action.
2. Brainstorm actions that can be completed as a group, for example Great Lakes Adopt-A-Beach program, website listed below. Use actions listed in *Climate Change Adaptations for Coastal Wetlands: A Toolkit of Best Management Practices for Coastal Wetlands in Michigan* pgs. 15-30 for additional examples.

3. Hand out Student Stewardship Plan to pairs of students. Read through the plan and have students select an action from the brainstormed list they think would need a plan. Discuss how they would fill out the Stewardship Plan to carry out the action selected.
4. As a whole class, select an action as an example or class choice and fill out the plan together.
5. Discuss the following questions as a class:
    - Why is it important to make a plan for your stewardship action?
    - What is the difference between individual and group stewardship action?
    - Why should you care about the affect of climate change on coastal wetlands?
    - Describe the experience would you like to have while you/your class completes a stewardship plan.

Extensions:

Make a commitment to monitor and/or clean up a local wetland area.

Additional Resources:

NOAA:What You Can Do - 10 Thing You Can Do for Coastal Wetlands
http://www.habitat.noaa.gov/protection/wetlands/whatyoucando.html

Michigan Water Stewardship Program: Environmental Educator Resources
http://www.miwaterstewardship.org/educators

EPA: A Student's Guide to Global Climate Change – Interactive Website
https://www3.epa.gov/climatechange/kids/index.html

EPA: A Student's Guide – Taking Action/Stewardship
https://www3.epa.gov/climatechange/kids/scientists/citizen-science.html

Alliance for the Great Lakes: Great Lakes Adopt-A-Beach program - Stewardship
https://greatlakes.org/get-involved/adopt-a-beach/

University of Wisconsin – Environmental Resources Center: Give Water a Hand – Young People Taking Action - Stewardship
http://erc.cals.wisc.edu/gwah/

NOAA – What You Can Do
10 Things You Can Do for Coastal Wetlands

- Participate in programs that help protect and restore wetlands. Contact your local, state or federal agencies, community groups, environmental organizations or a non-government organization.
- Report illegal activity such as filling, clearing, or dumping in wetlands to government authorities, such as the U.S. Environmental Protection Agency or the Army Corps of Engineers.
- Pick up all litter and dispose in appropriate trash containers. Keep surface areas that wash into storm drains clean of pet feces, toxic chemicals, fertilizers, and motor oil, which eventually reach and impair our wetlands.
- Plant only native species of trees, shrubs, and flowers to preserve the ecological balance of local wetlands.
- Use "living shoreline" techniques that make use of plant roots to stabilize soil if you own waterfront property and your shoreline or riverbank needs to be stabilized.
- Avoid wetlands if you are expanding your home or installing a shed.
- Use phosphate-free laundry and dishwasher detergents. Phosphates encourage algae growth, which can suffocate aquatic life.
- Use paper and recycled products made from unbleached paper. Bleached paper contains toxic chemicals that can contaminate water.
- Use non-toxic products for household cleaning, lawn and garden care. Never spray lawn or garden chemicals on a windy or rainy day, as they will wash into the waterways.
- Reduce, reuse and recycle household items and waste.

NOAA - What You Can Do - 10 Thing You Can Do for Coastal Wetlands
http://www.habitat.noaa.gov/protection/wetlands/whatyoucando.html

Student Stewardship Plan

Planning Your Stewardship Project

Stewardship = to care for or maintain something

Team name: _____
Participants: _____
Project Title: _____

Thinking It Through

- What do you plan to do for your wetland or waterway?
- Describe your stewardship project idea in one or two paragraphs.
- What do you hope to accomplish by doing this project?
- How does your project help protect wetlands?
- How will this project make a difference and for whom?

Planning

- When do you plan to begin (now, next month, next semester, etc.)?
- How much time will you need to complete the project?
- To your knowledge, has this type of project been done before? If so, what were the results? How will your project be different?
- List any community members, community organizations, state or national organizations that might be able to help you with your project. Include names of individual contacts and how to contact them (email address, phone numbers, etc.)
- List any special services you might need to complete your project. (This might include things like transportation, garbage disposal, etc.)
- Will there be any costs associated with your project? If so, how do you plan to pay the costs? (List costs and possible sources of funding.)
- List any other resources, materials, or supplies that you will need for the project (gloves, trash bags, tarps, etc.):
- If your project requires group work, where and when can you and the other group members get together to work on the project?

Actions

Now outline the specific steps or actions your group will take to accomplish the project. Assign specific tasks to each person with clear instructions and completion times.

Action Item 1: _____

Lead Student: _____Completion Date: _____

Action Item 2: _____

Lead Student: _____Completion Date: _____

Action Item 3: _____

Lead Student: _____Completion Date: _____

Action Item 4: _____

Lead Student: _____Completion Date: _____

Action Item 5: _____

Lead Student: _____Completion Date:_____

Reviewing & Reporting

- Did you complete your project and meet your goal?
- Did you learn anything that surprised you during your project?
- Were there any unexpected things you had to overcome in order to complete your project?
- How can you share the information you learned and results with others?
- Did your project bring up any other questions or issues that could become future project ideas?
- What is the most important thing you learned from doing this project?

Great Lakes Wetlands

Climate Change ADAPTATION Resources

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Resources
Wetlands and Climate Change in the Great Lakes Region

U.S. Environmental Protection Agency (EPA): Wetlands Education
https://www.epa.gov/wetlands/wetlands-education

Sea Grant Michigan: Climate Adaptation
http://www.miseagrant.umich.edu/explore/climate-weather-and-the-great-lakes/climate-adaptation/

Teaching Great Lakes Science: Lessons and Data Sheets
http://www.miseagrant.umich.edu/lessons/

Teaching Great Lakes Science: Wetlands Lesson
http://www.miseagrant.umich.edu/lessons/lessons/by-broad-concept/earth-science/wetlands/

Teaching Great Lakes Science: Activity: Wetland in a Pan
http://www.miseagrant.umich.edu/lessons/lessons/by-broad-concept/earth-science/wetlands/activity-wetland-in-a-pan/

Center for Great Lakes Literacy
http://www.cgll.org/

North American Lake Management Society: Climate Impacts on Lakes
https://www.nalms.org/home/our-mission/nalms-position-papers/climate-change-impacts-on-lakes/

Alliance for the Great Lakes: K-12 Curriculum Great Lakes in My World
https://greatlakes.org/get-involved/great-lakes-in-your-classroom/k-12-curriculum/

Union of Concerned Scientists : Climate Hot Map – Global Warming Effects Around the World
http://www.climatehotmap.org/

Michigan Water Stewardship Program: Environmental Educator Resources
http://www.miwaterstewardship.org/educators

What Could Changing Great Lakes Water Levels Mean for our Coastal Communities: A case for climate-adapted planning approaches
http://www.nature.org/ourinitiatives/regions/northamerica/areas/greatlakes/explore/great-lakes-lake-levels-case-study.pdf

Michigan Department of Environmental Quality (MDEQ) Wetlands Map Viewer
http://www.mcgi.state.mi.us/wetlands/mcgiMap.html

Great Lakes Climate Change Curriculum: How Will Climate Change Affect A Great Lake State?
http://changingclimate.osu.edu/assets/docs/2012edu_CurriculaGoogleV3.pdf

MDEQ Great Lakes Coastal Wetlands
http://www.michigan.gov/deq/0,4561,7-135-3313_3687-11177--,00.html

EPA: A Student's Guide to Global Climate Change
https://www3.epa.gov/climatechange/kids/index.html

EPA: A Student's Guide – Taking Action/Stewardship
https://www3.epa.gov/climatechange/kids/scientists/citizen-science.html

National Oceanic and Atmospheric Administration (NOAA) – Great Lakes Environmental Research Laboratory: Great Lakes Maximum Ice Cover on the Great Lakes
https://www.glerl.noaa.gov//data/ice/historicalAnim/

NOAA: What You Can Do -10 Thing You Can Do for Coastal Wetlands
http://www.habitat.noaa.gov/protection/wetlands/whatyoucando.html

Michigan Department of Technology, Management and Budget (DTMB): Wetland Inventory Maps by County
http://www.michigan.gov/cgi/0,4548,7-158-52927_53037_12540_13817_22351-58858--,00.html

Alliance for the Great Lakes: Great Lakes Adopt-A-Beach program
https://greatlakes.org/get-involved/adopt-a-beach/

University of Wisconsin – Environmental Resources Center: Give Water a Hand
http://erc.cals.wisc.edu/gwah/

Tip of the Mitt Watershed Council: Wetlands
http://www.watershedcouncil.org/wetlands.html

Fabulous Wetlands with Bill Nye The Science Guy (Video 6:50 min)
https://www.youtube.com/watch?v=BeUPbGWg2KU

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