On the Rise *Lesson Plan*

Students will investigate societal, economic and environmental impacts of sea-level rise.

Lesson Summary: The students will investigate the impact, both environmental and economical, that rising sea levels might have on coastal Florida using in-class debate.

Grade Level: High School (9^{th} – 12^{th} Grades)

Time Allotted: 3 class periods (approximately 50 minutes each)

Performance Objectives

References are to the Next Generation Sunshine State Standards (2007).

Social Studies

SS.912.E.2.11	Assess the economic impact of negative and positive externalities on the local, state, and national environment.

Science

SC.912.E.6.5	Describe the geologic development of the present day oceans and identify commonly found features.
SC.912.E.6.6	Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.
SC.912.E.7.2	Analyze the causes of the various kinds of surface and deep water motion within the oceans and their impacts on the transfer of energy between the poles and the equator.
SC.912.E.7.4	Summarize the conditions that contribute to the climate of a geographic area, including the relationships to lakes and oceans.
SC.912.E.7.5	Predict future weather conditions based on present observations and conceptual models and recognize limitations and uncertainties of such predictions.
SC.912.E.7.8	Explain how various atmospheric, oceanic, and hydrologic conditions in Florida have influenced and can influence human behavior, both individually and collectively.
SC.912.E.7.9	Cite evidence that the ocean has had a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water.

Prior Knowledge

Prior experience with in class debate and argument construction is HIGHLY recommended. Some knowledge of climate change, global warming, and rising sea levels is recommend but not required.

Topic Overview

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Students will investigate societal, economic and environmental impacts of sea-level rise.

Florida has about 1,350 miles of shoreline, and about 75% of Florida's population lives on or near its coasts. The International Panel on Climate Change (IPCC) estimates that, driven by global warming, the global average sea level will rise between 0.6 and 2 feet (0.18 to 0.59 meters) in the next century (2007). Even a change at the lower end of that scale would have profound implications for coastal residents.

If atmospheric temperatures continue to rise to the point where polar ice melts, the effects will be dramatic. Many inhabited islands, as well as coastal plains and cities, would be flooded, forcing millions of people to migrate, affecting drinking-water supplies, altering weather patterns, and destroying wildlife habitats. The United States, with 5 percent of the globe's population, now produces about twenty-five (25) percent of the atmospheric carbon dioxide (CO_2) coming from human sources; increased CO_2 levels are believed to be the major cause of the global warming that may now be taking place.

Key Vocabulary

Adaptation
Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects.

Carbon Cycle Circulation of carbon atoms through the Earth systems as a result of photosynthetic conversion of carbon dioxide into complex organic compounds by plants, which are consumed by other organisms, and return of the carbon to the atmosphere as carbon dioxide as a result of respiration, decay of organisms, and combustion of fossil fuels.

Climate
The long-term average of conditions in the atmosphere, ocean, and ice sheets and sea ice described by statistics, such as means and extremes.

Climate change
A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic (human-caused) changes in the composition of the atmosphere or in land use.

Climate Variability
Natural changes in climate that fall within the normal range of extremes for a particular region, as measured by temperature, precipitation, and frequency of events. Drivers of climate variability include the El Niño Southern Oscillation and other phenomena.

Climate
The long-term average of conditions in the atmosphere, ocean, and ice sheets and sea ice described by statistics, such as means and extremes.

Feedback
The process through which a system is controlled, changed, or modulated in response to its own output. Positive feedback results in amplification of the system output; negative feedback reduces the output of a system.

Fossil fuels Energy sources such as petroleum, coal, or natural gas, which are derived from living matter that existed during a previous geologic time period.

Global Warming
The observed increase in average temperature near the Earth's surface and in the lowest layer of the atmosphere. In common usage, "global warming" often refers to the warming that has occurred as a result of increased emissions of greenhouse gases from human activities. Global warming is a type of climate change; it can also lead to other changes in climate conditions, such as changes in precipitation patterns.

Mitigation
Human interventions to reduce the sources of greenhouse gases or enhance the sinks that remove them from the atmosphere.

Sea-level rise
The rise in the world's oceans that is occurring as a result of global warming.

Vulnerability
The degree to which physical, biological, and socio-economic systems are susceptible to and unable to cope with adverse impacts of climate change.

Weather
The specific conditions of the atmosphere at a particular place and time, measured in terms of variables that include temperature, precipitation, cloudiness, humidity, air pressure, and wind.

Materials

- Internet access to www.orange.wateratlas.org
- A notebook or binder that can be used as a journal

References

These references may be found in the Orange County Water Atlas Digital Library.

Climate Literacy: The Essential Principles of Climate Sciences. 2009. U.S. Global Change Research Program.

The Effects of Climate Change on Florida's Ocean & Coastal Resources. 2009. Florida Oceans & Coastal Council.

Global Climate Change Impacts in the United States: Society. 2009. U.S. Global Change Research Program.

Harrington, Julie, and T. L. Walton, Jr. Climate Change in Coastal Florida: Economic Impact of Sea Level Rise. Florida State University.

Other references:

Coastal Zones and Sea Level Rise. U.S. Environmental Protection Agency.

Cook, John. Skeptical Science: Getting Skeptical About Global Warming Skepticism. Website. Accessed June 2011.

Glick, Patty, et al. Preparing for a Sea Change in Florida: A Strategy for Coping with the Impacts of Global Warming on the State's Coastal and Marine Systems. 2008. Florida Coastal and Ocean Coalition.

Intergovernmental Panel on Climate Change. Website. Accessed June 2011.

Power Up Florida (Orlando/Orange County web portal to sites for electrical efficiency, solar usage, electric vehicles, clean technology, Climate Change Education Center, etc.). Accessed July 2011.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. 2007. Cambridge University Press.

Stanton, Elizabeth K., and Frank Ackerman. Florida and Climate Change: The Cost of Inaction. 2007. Tufts University Global Development and Environment Institute and Stockholm Environment Institute—US Center.

A Student's Guide to Climate Change. Website. Environmental Protection Agency. Accessed June 2011.

Procedure – Day 1

Engage/Elicit

Begin by asking the students what they know about climate change and global warming. Some students may see this as a controversial issue and disagree that climate change is occurring, so if you know your class well enough to know that this could be a problem, you may wish to approach the question more as a hypothetical situation.

Regardless of how exactly you approach the issues, try to steer the conversation towards the idea that sea levels will rise if the polar ice caps melt. As the sea levels rise, what does that mean for places like Florida where a large portion of the land area is coastline? Give your students time to discuss these ideas in small groups and with the class at large. At this point, you are simply trying to get them to think about coastal flooding and brainstorming possible consequences.

Explore

After the brainstorming session, direct your students to the Orange County Water Atlas to observe population patterns in Florida. On the main page, under the Data and Mapping button on the navigation bar near the top of the page, have them click on Advanced Mapping tool. Once the Advanced Mapping tool has appeared, direct them to the map layers menu on the right hand side of the screen. Have them click on the + sign next to Demographics and then click on the box next to the 2000 Population Density. Finally, they need to click on the Refresh Map button in the bottom right hand corner of the screen.

Now the map should display colors indicating the population density of Orange County based on the 2000 census. Let the students explore the map, zooming in on different areas and getting a sense for where the major population centers are in Orange County. Which areas are most densely populated? The least dense? Are there any major population centers near or around large bodies of water? What might happen to Orange County population centers if these bodies of water increased in size?

Next have the students research the average elevation of Orange County (relative to sea level). They may look this information up in an atlas, via an internet search, or any other method you deem appropriate. Based on this information, is Orange County likely to experience inundation (assume sea level raises approximately 2 feet)? Even if Orange County is not inundated, but nearby communities are, how might that affect Orange County?

Explain

Orange County itself is likely to be relatively unaffected by rising sea levels: it is too far inland and too relatively high compared to sea level. However, rising sea levels will displace many Floridians that currently live hear the coast and they would have to go somewhere (perhaps Orange County). What might that mean for population densities here in Orange County? Furthermore, much of Florida's

economy is dependent on tourism: people come to visit the beaches. If the beaches are now at the St. Johns River, what might that mean for the economy of Orange County? Have the students read Climate Change in Coastal Florida: Economic Impact of Sea Level Rise (see Resources). It does not discuss Orange County specifically, but the students should be able to get an idea of what Orange County might expect.

Extend

If you have time during your class (and if not you can begin Day 2's lesson with this part), have the students begin to more thoroughly investigate strategies used to combat inundation and flooding of coastal areas: Reinforce, Relocate and Retreat as responses to coastal inundation. What are the strengths and weaknesses of each? The students may search the Atlas for more information, use Internet searches, or any other method you deem appropriate. If the students are having difficulty identifying what the three different strategies might entail, you can briefly describe them as such:

- Reinforce—Dikes, seawalls and coastal armoring to protect infrastructure from inundation.
- Relocate—Structures remain in place but may be raised up above flood level; land use may change to prohibit certain types of activity/construction within the new floodplain.
- Retreat—Structures/population move inland, abandoning flooded/flood-prone areas.

Exchange/Evaluate

Have the students record all the information they researched in a journal. This would include their thoughts on climate change and rising sea levels, population density with respect to rising sea levels, economic impact of rising sea levels, and methods to combat rising sea levels. You may wish to collect the journal entries to verify that the students are using them, but there has been no actual assignment to grade yet. You may award point for participation and time on task if you wish.

Procedure – Day 2

Engage/Elicit

If the students did not finish researching the methods to combat rising sea levels on Day 1, have them do so at the start off class.

Once the class has begun, inform students that you will hold an in-class debate to consider the following four coastal policy land use questions:

1. Should we continue to do beach nourishment, and if so, who should pay for it?
2. Should we continue to fund other types of coastal reinforcement, like sea walls, and if so, who should pay for it?
3. Should new construction be allowed in flood-prone areas? If so, what types?
4. Should flood insurance continue to be subsidized?

The class will divided into four groups, one for each question, and each group will be further subdivided into two teams; one team will argue for the affirmative position ('Yes, we should do…') and one will argue for the negative position ('No, we should not do…') for each question. You can assign the teams any way you choose (volunteer, randomly, your choice, etc), but the students need to understand that they must create and present an argument in support of the position they have been assigned, even if they do not necessarily *agree* with it.

Tell the students that in the next class session, they will present their arguments to the class. Each side will have 3 minutes to present an opening argument, the opposing team will and the class at large will be allowed 2 minutes to ask questions/poke holes in each argument, and then the presenters will have 1 more minute to address the questions and make their concluding remarks. Each member of the group will be required to speak (so if you have 4 members, you might have three of them take turns in the opening arguments and the fourth one do the closing argument).

Explore

The students can use this class period to begin researching and crafting their arguments. They may have to do a lot of research (for example, they may not know what 'beach nourishment' is, much less why it might cause controversy), so give them as much time as possible. Any research that is not completed on Day 2 should be continued as a homework assignment. The students may use any resource at their disposal, including the Water Atlas and anything they learned on Day 1, and the resources suggested in the References section of this lesson plan.

Remind students that they need to research not only their own argument, but they should also research the opposing argument at least a little so that they can have an idea of what they might need to address in their closing remarks (and know what areas they might be able to most easily question during the opponents' argument).

Explain

See Procedure – Day 3.

Extend

If you have not done debates in your class before, this may seem very new and alien to the students, so may wish to modify this activity slightly by having each group collaboratively write a persuasive essay for their assigned position, instead of doing an in-class debate. A persuasive essay should include evidence to support the assigned position, as well as statements that disprove or counter the opposing, or potentially opposing, positions.

Exchange/Evaluate

There is no assignment to turn in today. Students should continue to record their information for their arguments in their journals. You may award point for participation and time on task if you wish.

Procedure – Day 3

Engage/Elicit

Today is the day! Debate time. These debates will likely take the entire class period, so unless there is some pressing issue that must be addressed, simply remind the students of the format (each side will present for 3 minutes, 2 minutes for questions/rebuttal, 1 minute for concluding remarks) and then get to it.

Explore

As the students present their arguments, their opponents may wish to jot down some quick notes so that they are better prepared when it comes to the question period.

Explain

Depending on how you wish conduct the class, you may have the other groups (not the two that just presented an issue) vote to see which group was more persuasive in their argument or you may simply choose to declare a winner on your own. See the following rubric for scoring the debate. These scores may be used for grading purposes, as well as for deciding the apparent victor in each debate.

Criteria	Score		
	3 points	**2 points**	**1 point**
Viewpoint	Viewpoint(s) is clear and organized	Viewpoint(s) is somewhat clear and organized	Viewpoint(s) is unclear or disorganized
Use of Facts	Argument(s) are supported with many facts and examples	Argument(s) are supported with few/single fact and example	Arguments lack factual support
Supporting Arguments	All supporting arguments are relevant	Some relevant supporting arguments	Few/no relevant supporting arguments
Strength of Arguments	All arguments are strong and convincing	Some arguments are convincing	Arguments are not convincing
Speaking Voice	Voice can always be heard	Voice is heard most of the time	Voice is difficult to hear
Preparation	Group is well prepared	Needs more preparation	Group is unprepared/unable to defend argument

Extend

Have each group write out their argument in essay form and post it on the Orange County Water Atlas Watershed Excursion.

Exchange/Evaluate

Collect the journals now that they have made their arguments (and no longer need the journals for research purposes) and grade them for content: did the student record their information in the journal or is it largely blank? Additionally, grade the argument or persuasive essays (recommend using the rubric above to grade the argument; you can easily tweak the rubric for a written essay).

Curriculum developed for Orange County Environmental Protection Division by USF's Florida Center for Community Design & Research. This material is based upon work supported by the Department of Energy under Award Number DE-EE0000791.

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