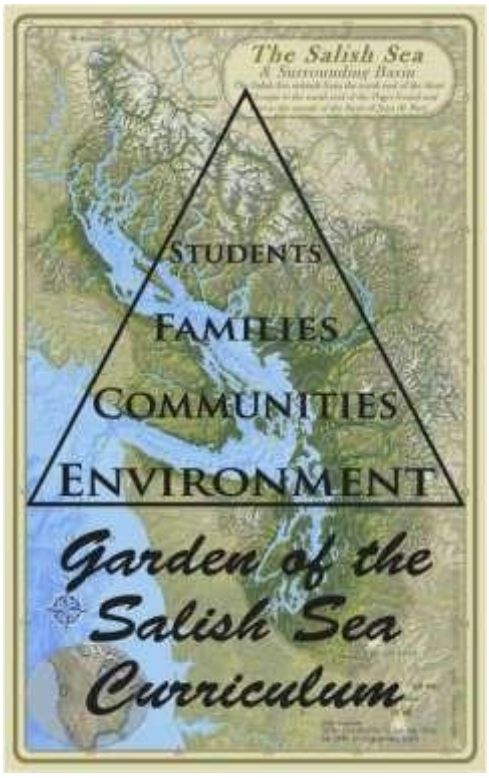
Garden of the Salish Sea Curriculum
Teacher's Guide

Ocean Acidification

Exploring how the human produced imbalance in the carbon cycle results in ocean acidification



Contents

Unit Summary

Garden of the Salish Sea Curriculum (GSSC) is an integrated action based K-12 environmental science and stewardship initiative that provides meaningful context to teach ocean acidification literacy. GSSC uses shellfish as a vehicle to teach stewardship, centered upon hands-on learning through field experience focused on near shore intertidal ecosystems. Through education and outreach, GSSC empowers students, families and communities to practice watershed healthy habits in stewardship of healthy oceans globally and a thriving Salish Sea ecosystem that is a source of healthful foods using a Salish Sea Stewards Challenge. Laboratory inquiry lessons focus on ocean acidification. Each program is place based and geared towards the local watershed and near-shore environment.

Web-based lessons (gardensalishsea.org) are supported by classroom presentations, hands-on laboratories, local intertidal field experiences and scientific learning activities that culminate in student commitments to practicing watershed healthy habits. All web-based materials are posted for download and viewing. Links to resources (including NOAA) are combined with classroom and field lessons tailored to participating classrooms. Our web-pages compile links to existing resources combined with lessons tailored to participating classrooms. The classroom laboratory inquiry lessons focus on ocean acidification. Each program is place based and geared towards the local watershed and near-shore environment.

Ideally, the unit is delivered as a continuum of learning over a period of weeks. Ultimately teachers would deliver the unit using GSSC resources with the support of guest speakers and field coordination. Please show students the preparatory videos accessed on the GSSC website (http://www.gardensalishsea.org/).
Students will answer the questions in the GSSC Notebook (pages 24-26) in preparation for the laboratory.

Marine Marathon Sequence:

- Week 1: Introductory presentation and hands-on lab stations, introduce, Salish Sea Challenge
- Week 2: Classroom laboratory inquiry, pH & ocean acidification
- Week 3: Field Inquiry, visit to a local near shore marine environment, data collection & connect with community. Examples of Field Inquiry Experiences:
    - Local tidelands beach exploration.
    - Visit to tribal or local aquaculture, shellfish hatchery and tideland where field observations and identifications enhance understanding and appreciation of the intertidal zone.
    - Visit local shellfish gardens
    - Conduct intertidal clam survey in partnership local with Marine Resource Committee volunteers.
- Week 4: Wrap up, Salish Sea Challenge reflection
- Use resources on the website that preface laboratories and field inquiry as directed in our website.
- Throughout the unit teachers integrate shellfish studies using resources on website; select at least 3 tie – in lessons.

Quick Look Lesson Chart – Ocean Acidification Only

LESSON NAME:	Ocean Acidification		
Essential Question:	How do our actions impact the health of our oceans?		
KEY CONCEPTS	STUDENTS ALSO LEARN	SCIENCE INQUIRY	SCIENCE VOCABULARY
Nature has natural cycles that support life when balanced. All living things require a certain water quality to survive. Human actions can impact natural cycles.	All living things are made of Carbon. Carbon dioxide is a natural byproduct of life.	pH of Household Solutions Students test the pH of household liquids to develop an understanding of what is an acid or a base. Human Smoke Stack Students blow into water with a pH indicator to monitor the change in pH induced by the CO2 in breath. Dissolving Shells Students compare shells soaked in distilled water and in vinegar.	Ocean acidification pH acid base (alkaline) ASSESSMENTS Formative "Tale of Two Cities" felt board group activity. Summative Day 2 Reflection: Thinking about today's activities

Integrated Environmental and Sustainability Standards

Grade Level: 4-5	
Standard:	**Standard 1: Ecological, Social, and Economic Systems**
Description:	Students develop knowledge of the interconnections and interdependency of ecological, social, and economic systems. They demonstrate understanding of how the health of these systems determines the sustainability of natural and human communities at local, regional, national, and global levels.
Standard:	**Standard 2: The Natural and Built Environment**
Description:	Students engage in inquiry and systems thinking and use information gained through learning experiences in, about, and for the environment to understand the structure, components, and processes of natural and humanbuilt environments.
Standard:	**Standard 3: Sustainability and Civic Responsibility**
Description:	Students develop and apply the knowledge, perspective, vision, skills, and habits of mind necessary to make personal and collective decisions and take actions that promote sustainability.

Next Generation Science Standards

Grade 3

3-LS1-1.	**Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.** Disciplinary Core Ideas LS1.B: Growth and Development of Organisms • Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. Crosscutting Concepts Patterns • Patterns of change can be used to make predictions.
3-LS4-4.	**Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*** [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*] Science and Engineering Practices Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. Disciplinary Core Ideas LS2.C: Ecosystem Dynamics, Functioning, and Resilience • When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. *(secondary)*

Grade 5

Students who demonstrate understanding can:

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 models and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model to describe phenomena. - *Connections to the Nature of Science* Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena • Science explanations describe the mechanisms for natural events.	LS2.A: Interdependent Relationships in Ecosystems • The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. **Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.** LS2.B: Cycles of Matter and Energy Transfer in Ecosystems • **Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.**	Systems and System Models • A system can be described in terms of its components and their interactions.

Science Content Background

Shellfish

Ocean Acidification

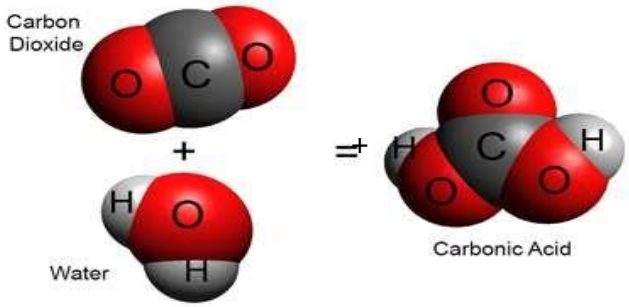
Video Resource: http://www.whoi.edu/home/oceanus_images/ries/calcification.html

Background: Ocean acidification is the ongoing increase in the acidity of the Earth's oceans, caused by the uptake of carbon dioxide (CO_2) from the atmosphere.[2] All life forms on earth are carbon based so that an understanding of the **carbon cycle** will help students recognize different sources of carbon dioxide and how excess carbon emissions can impact oceans.

Shellfish are *calcifiers* that make their shells by removing calcium carbonate ($CaCO_3$) from water and depositing it as the shell or exoskeleton. The mollusc shell is formed and repaired by the organ called the *mantle*. The mantle deposits calcium carbonate minerals that are extracted from water through the gills to form the shell, a process that requires cellular energy. A high pH environment favors shell formation. Increased atmospheric carbon dioxide from fossil fuel combustion, causes ocean acidification. A shift to lower pH (higher H+) conditions make the carbonate ion, CO_3, unavailable for shell formation. That means, the mantle has to pump the excess hydrogen ions (H+) out in order to make the carbonate ion, CO_3, available to make the shell which requires a lot of cellular energy. As a result, shell formation may be interrupted or shells may be thinner, putting organisms at greater risk of predation. Shellfish life cycles can be disrupted: for instance, motile oyster larvae (spat) may not be able to attach to a substrate and survive to adulthood. As oceans become warmer and more acidic their shells will either thin, or the animals will have to expend more energy on making producing thicker shells. This will affect shellfish populations, the ocean food web and the shellfish industry.

$Ca^{++} + CO_3^{--} \Leftrightarrow CACO_3$

Calcium ion + Carbonate ion $\Leftrightarrow$ Calcium carbonate (used for shell formation in *calcification.*)



H^+ - free hydrogen ions increase acidity, decrease carbonate needed to form shells.

Lesson 2: OCEAN ACIDIFICATION

Overview/Background:

Human actions have created an excess of CO2 in the atmosphere. The ocean absorbs CO2 as part of the natural carbon cycle, but the excess amount is changing the pH of the ocean from slightly alkaline to acidic. This change is already impacting the bottom of the food web by threatening organisms with shells including oysters and clams.

Guiding Question:

How do OUR actions impact the health of our oceans?

Key Concepts

- Nature has natural cycles that support life when balanced.
- All living things require a certain water quality to survive.
- Human actions can impact natural cycles.

Vocabulary

- **Ocean acidification**: The decrease in the pH of the Earth's oceans, caused by the absorption of carbon dioxide (CO_2) from the atmosphere.
- **pH**: the power of hydrogen
- **Base (Alkaline)**: Have a **pH** greater than 7 and a low concentration of hydrogen ions.
- **Acid**: Have a **pH** of less than 7 and a high concentration of hydrogen ions.

Assessment

Felt Board activity on Slide 30

This class activity gives students the opportunity to share the understanding of the impact of too much CO2 in the atmosphere. Teachers check for understanding and misconceptions of key points including:

- CO2 is part of the natural balance of the Carbon Cycle.
- CO2 is also created by cars and factories. This puts more CO2 into the atmosphere causing the Carbon cycle to be out of balance.
- Ocean acidification is the result of too much CO2 in the atmosphere.
- Ocean acidification is harmful to shellfish.
- Day 2 Reflection: Thinking about today's activities in science notebook. Can be filled out at your convenience.

Timeline

Ocean Acidification	**Estimated Time**
Ocean Acidification Power Point (Part 1)	15 minutes
pH Experiment	20 minutes
Ocean Acidification Power Point (Part 2)/ Human Smokestack/I'm Melting	30 minutes
Becoming stewards and the Salish Sea Challenge	5 minutes
TOTAL CLASS TIME	**70 minutes**

Materials

For the class presentation

- Computer and projector with internet connection.
- Ocean Acidification Power Point
- Chart from Lesson 1 on "How humans are connected to the ocean."
- Chart with guiding question “How do OUR actions impact the health of our oceans?” to record student ideas
- Sentence strips with key concepts written on them
- A hard copy of the Salish Sea Watershed Challenge

For each student

- Science notebook
- Pencil

For each group
ph of Household Solutions experiment

- Solutions to test: vinegar, lemon juice, club soda, pure water, baking soda, tums, and seawater
- 4 sets of labelled cups (36 total)
- Litmus paper cut into 1/2 to 1 inch lengths in a cup
    - Be careful not to handle the end of the litmus paper that will be dipped into the solution as that can change the results.
- A laminated pH scale that goes with the litmus paper
- A discard cup for used litmus paper.
- White surface (paper or cardboard).

Human Smokestack demonstration

- One set of clear plastic cups per student (#1 cup, #2 cup, plastic lid, and straw)
- Mineral water
- Red cabbage pH indicator in a dropper bottle.
- White surface (paper or cardboard).

I’m Melting demonstration

A pair of plastic jars with oyster shells in them.

- One jar is filled with vinegar
- One jar is filled with water

Teacher considerations/Prep

1. Set up computer and projector.
2. Review the Power Point to be sure background information is adequately understood to explain to students.
3. Have chart from Lesson 1 ready to review and add to if necessary.
4. Have chart with guiding question ready to record student ideas at beginning and end of lesson.
5. May want parent support to help with pH solution experiment and Human Smokestack demonstration.

Lesson Plan

Before the Lesson

Have students watch and answer questions in the science notebook for

"The Other CO2 Problem" https://www.youtube.com/watch?v=kvUsSMa0nQU

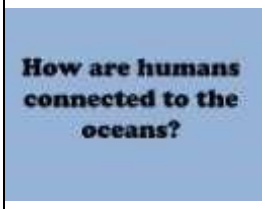
(7.5 min) is a fun clay stop motion animation. Subsea creatures are suffering as the ocean becomes more acidic as a result of human activity. Produced by Ridgeway School (Plymouth, UK) and Plymouth Marine Lab for primary grades & above. **3rd grade+**

Other optional videos are listed on the Garden of the Salish Sea website.
http://www.gardensalishsea.org/

Day of Lesson

The Power Point is set up to guide you through the content of the lesson prompting discussion and content. Pictures of each slide with its corresponding number are included to help you keep track of where you are. The notes in the lesson plan can also be seen in the Power Point if used in presenter's view.

Activating Prior Knowledge
Slide 2



Use the chart from lesson 1 to review how humans are connected to the oceans emphasizing:

- Intertidal ecosystems provide an important function.
- Shellfish are important for a healthy ocean.
- People eat shellfish for food.

Introducing the Essential Question
Slide 3

Use another chart with the essential question on the top to record student answers. (This chart will be used again at the end to record what they learned.)

Exploring natural cycles in nature
Slide 4

- Other natural cycles may include
- The water cycle to renew our sources of fresh water
- The seasons are a cycle of renewed life after dormancy
- Any plant or animal life cycle.
- The salmon life cycle that keeps a supply of food for many animals and ultimately nourishes the forest when their bodies decay.

Introducing the Carbon Cycle as a natural cycle.
Slide 5

Emphasize the Carbon Cycle is an important part of the natural life cycle in nature and necessary for the balance of the environment and to sustain life on Earth.

Natural ways Carbon is added to the cycle
Slides 6-7

This slide and the next one show natural ways carbon is added to the Carbon cycle.

- "We are a natural part of the Carbon cycle along with all other living organisms."

Emphasize that

- CO_2 is a natural byproduct of every life cycle.
- Nature expects and needs these things to happen to sustain life.

Natural ways Carbon is absorbed from the cycle
Slides 8-10

Emphasize that

- In a cycle, what is created is then used or absorbed to start over again.
- Plants absorb and use the CO2 humans and other living things give off and give off the oxygen living things need to survive.

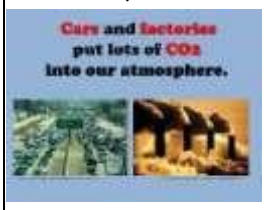
Water also absorbs CO2 as part of the Carbon cycle.

Be sure students understand that CO2 is a natural byproduct of life that nature needs to sustain life using the Carbon Cycle.

Introduce KEY CONCEPT 1: Nature has natural cycles that support life when balanced.
Slide 11

Put up sentence strip with key concept in a permanent visible place so it can be referred to later

Identify the problem: What could impact the natural balance of the Carbon Cycle?
Slides 12, 13



- Solicit students' answers to the question.
- Ask for ideas on how we would know if something had an impact on the cycle.
- What ideas might change?
- Ideas: Animals might change their habits or start to die, plants in an area might start to die or a different type may flourish.

- Human actions such as driving cars and creating factories have increased the amount of C02 in the atmosphere, shifting the balance of the carbon cycle.
- Do you think it would impact what happens in what happens in the cycle?

Impact and Vocabulary: Ocean Acidification
Slide 14

Have students explain what they think "ocean acidification" means in their own words. Point out the root *"acid"* in the term *acidification* to help students connect the impact to the experiment.

What is pH? Vocabulary: pH, acid, base (alkaline)
Slide 15

"PH stands for the power of hydrogen. We are able to measure if a solution is an acid or a base using the *pH* scale. The pH is measured on a scale from 0 to 14 where a pH of 7 is neutral, pH below 7 is acidic and a pH above 7 is basic or alkaline. Solutions at the extremes of the pH scale are corrosive. "

Be sure students understand the concept of the ranges on the pH scale before moving on. This is important for the following experiment.

What is pH? pH of Household Solutions experiment
Slides 16, 17, 18

Preparation:

- Emphasize the use of the elements of the scientific method listed.
- Let them know this is the way scientists do experiments if they do not already now.
- Why would each element be important?
- PREDICTION: So we know what we are expecting and so will know if we were right or wrong.
- CONTROL AND CHANGING VARIABLES: Change one variable at a time so we know whether or not that variable makes a difference.
- REPEAT: Check to be sure results are consistent and not the result of a mistake.

Procedure:

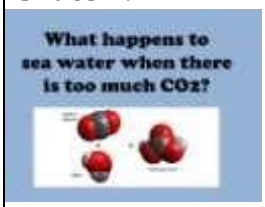
- Leave this slide up while students are doing the experiment for reference.
- The teacher or helper will pass out (1 or 2) cups with various household solutions to each small group at a time.
- As a group, students will predict the pH of the solution BEFORE measuring.
- Students will take turns measuring and recording the pH of each solution until the procedure is completed 3 times for each solution.
- Students will measure pH by holding the litmus paper in the solution to the count of one - one thousand and match the color of the litmus paper with the laminated pH scale to determine the pH.
- Students should be careful not to handle the end of the litmus paper that will be dipped into the solution as that can change the results.
- Students should identify the pH of each solution with a range on the pH scale; acid, neutral or basic.

Results:

- Go through each of the questions with the students as they come up and have them reflect on their results.
- Emphasize that blood is neutral.
- After answering the last question, make the point "Most living organisms can live in the neutral range between pH 6-8."

Introduce KEY CONCEPT #2: Most living things like an optimal pH range close to neutral like blood or water. Put sentence strip with key concept up next to #1.

Application of Learning
Slides 19



Ask:

- "Now that we know what pH is, let's think about the term 'ocean acidification.'
- "What was the definition?" Have someone read it from their notebook glossary.
- "What do you think happens to the ocean when there is too much CO2?"

Demonstration: Human Smokestack
Slide 20

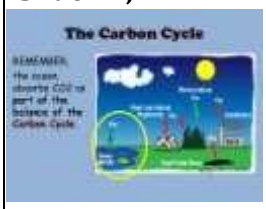
- Tell students "We produce CO2 from burning oxygen as part of our natural life cycle. Cars and factories produce CO2 from burning oxygen too.
- We can use our breath to demonstrate what happens when that natural cycle is out of balance."
- Ask students, "What do we think happens to the water when more CO2 is absorbed?"
- Response: "It becomes more acidic."

Leave this slide up during the experiment and have students follow instructions on the sheet in their science notebooks.

Procedure:

- Each student will receive 2 cups labeled 1 and 2 filled to the bottom line with water, placed on a white surface (paper or cardboard).
- The teacher or helper will add 6 full droppers of RED CABBAGE INDICATOR to each cup and cover cup 2.
- Students will blow their breath through a straw into cup #2 (the changing variable) until there is a change in color from blue to purple or pink, when compared to cup #1 (the control or unchanged solution).
- Students should blow slowly into the cup. The color change could take a couple of minutes. Students should take care not to blow too hard because they can become lightheaded.
- **Students should understand that the CO2 from their breath is a natural source of carbon dioxide and is NOT part of the CO2 problem.**
- Ask students, "Look at the change in color and tell me what the color change means".
    - Response: The water changed color because it absorbed CO2 from my breath that made it more acidic.
- Ask students, "What pH do most living organisms need to survive?"
    - Response: Neutral.
- "Does water that has absorbed a lot of CO2 provide a good environment for living organisms? Why?"
    - Response: No, too acidic.
- "What causes too much CO2 in the ocean making it more acidic?"
    - Response: Too much CO2 in the air from things like cars and factories.

Review
Slide 21, 22



- Tell students, "Remember, the ocean absorbs CO2 as part of the natural Carbon cycle and keeps water close to neutral when in balance creating a supportive balance for life. The ocean does not have an off switch. If there is more CO2 out there, it will keep absorbing it – even if it impacts what happens in the Carbon cycle."

- "When there is more CO2 in the atmosphere, the ocean keeps absorbing it and what happens?"
  Response: Ocean acidification

The Impact on Shellfish
Slides 23 -28

Ask students, "Do you have any ideas?"

Ask students, "Thumbs up if you like oysters… shrimp… clam chowder?"

Response: Students hold up thumb in response.

"What would happen if this seafood went away? Did not exist anymore?"
Responses may be mostly impact to us.

"Would their absence impact other organisms in the sea that eat these shellfish too?

"What is SPAT?"
Response: It is when the baby oyster transitions from its swimming stage to its attached stage.
"What would happen if it did not attach?"
Response: It would not be able to grow into an adult or reproduce to make more shellfish

"This is what SPAT looks like when it is attached and starting to grow."

Shellfish, crabs, and many other sea organisms are called **calcifiers**, because they take calcium from the water to make their shells under neutral pH range.

Impact Demonstration
Slide 29

- Students turn to this page shown on slide in science notebook.
- Students compare shells soaked in vinegar and shells soaked in water and record observations in their notebook.
- Ask "What did you observe?
- Response: Shells are dissolving
- "Why do you think this is happening?"
- Response: Because they are in an acid.
- "What impact do you think it has on the organism?"
- Response: They aren't able to grow or reproduce.
- "Do you think this is this what happens with ocean acidification?"
- Response: Yes

Introduce KEY CONCEPT #3: Human actions can impact natural cycles.

Assessment
Slide 30

Lead a discussion about how two cities with different amounts of CO2 in the atmosphere would look. Have students show their ideas by creating scenes on the story board.

CHECK FOR UNDERSTANDING:

- CO2 is part of the natural balance of the Carbon Cycle.
- CO2 is also created by cars and factories. This puts more CO2 into the atmosphere causing the Carbon cycle to be out of balance.
- Ocean acidification is the result of too much CO2 in the atmosphere.
- Ocean acidification is harmful to shellfish.

Record Learning - Answer the question
Slide 31

Add new student responses on chart under guiding question.

Empowerment _ Stewardship
Slides 32-40

Read slide to students.

Salish Sea Watershed challenge was introduced in week 1.
Ask for thumbs up, sideways, or down to show how students are doing with it.
"Let's look at a few reminders of things you can do."

"Remember what we learned about cars?"

"All of these things help cut down on the amount of CO2 that goes into the air. Every time you make a choice to do one of them instead of taking your own car, you are helping to keep our world healthier. They are a part of the Salish Sea Watershed Challenge"

These things are in the bottom section of the Salish Sea Watershed Challenge titled "Conserve Energy, Reduce Carbon Dioxide Emissions!"

"What other things are part of the Salish Sea Watershed Challenge that can help the Salish Sea be healthy?"

Read the slide to students.

"This is very important. It is also the law."

"Did you know that when you wash your car in the driveway, all of that dirt and soap goes through the storm drain right out into the Salish Sea? Car washes clean the water before it gets there."

Pledge Slide 40

"The more we learn, the more we can do. We know how important it is to be a steward of the Salish Sea, so let's commit to doing what we can. Please rise and hold up your right hand."

Students stand and raise their right hand as they read the pledge together.

Assessment: Reflection

At a convenient time, have students complete the reflection to see how they can apply what they have learned.

Optional Activities

Videos

Questions for these three videos are in the science notebook.

- The Other CO_2 Problem https://www.youtube.com/watch?v=kvUsSMa0nQU
- Hermie the Hermit Crab https://www.youtube.com/watch?v=RnqJMInH5yM
  (1:36 minute) A short animation from the Great Barrier Reef Marine Park Association (GRMPA). Hermie the Hermit Crab has trouble finding a shell to live in with ocean acidification. **3rd grade+**
- Acidifying Water Takes Its Toll on Northwest Shellfish
  https://vimeo.com/54408927
  (6 minutes) Listen to the news story and view the video to learn more about local impacts.

Other videos on Ocean Acidification

- Alliance for Climate Education https://www.youtube.com/watch?v=Wo-bHtlbOsw
  (3:01) Animation explains ocean acidification chemistry. **3rd grade+**
- Ocean Acidification https://www.youtube.com/watch?v=kxPwbhFeZSw
  (1:50 minutes) This is a short video that explains ocean chemistry and how ocean acidification can affect ocean life.
- Acid Test: The Global Challenge of Ocean Acidification
  https://www.youtube.com/watch?v=5cqCvcX7buo
  (21:34) This groundbreaking NRDC documentary explores the startling phenomenon of ocean acidification. The film, featuring Sigourney Weaver, originally aired on Discovery Planet Green. **5th grade +**

Check out the **Garden of the Salish Sea** website for more information and activities on ocean acidification, shellfish, and stewardship.
http://www.gardensalishsea.org