WOAC
WASHINGTON OCEAN ACIDIFICATION CENTER

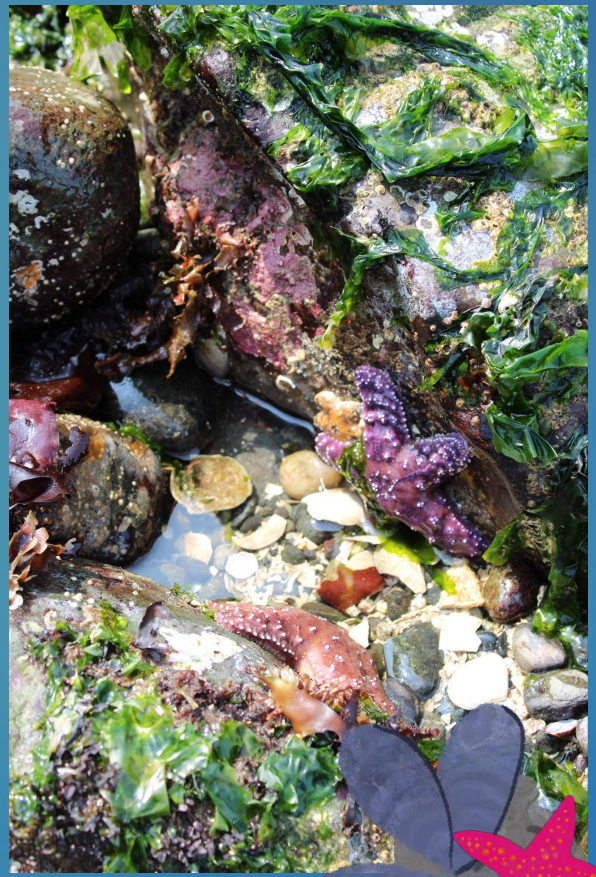
NANOOS

Ocean Acidification and The Intertidal

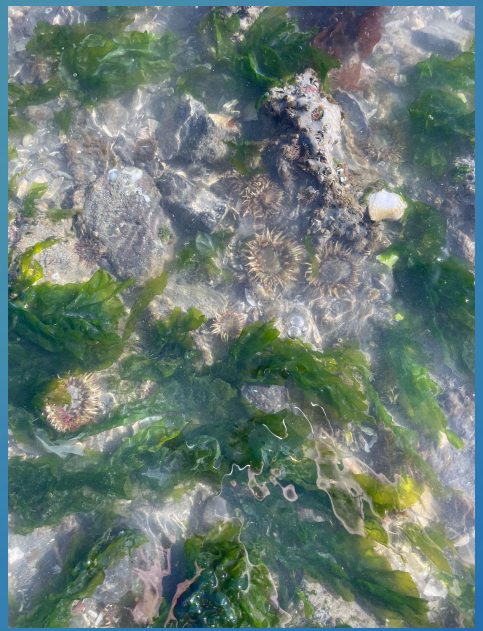
How does Ocean Acidification impact our shores?

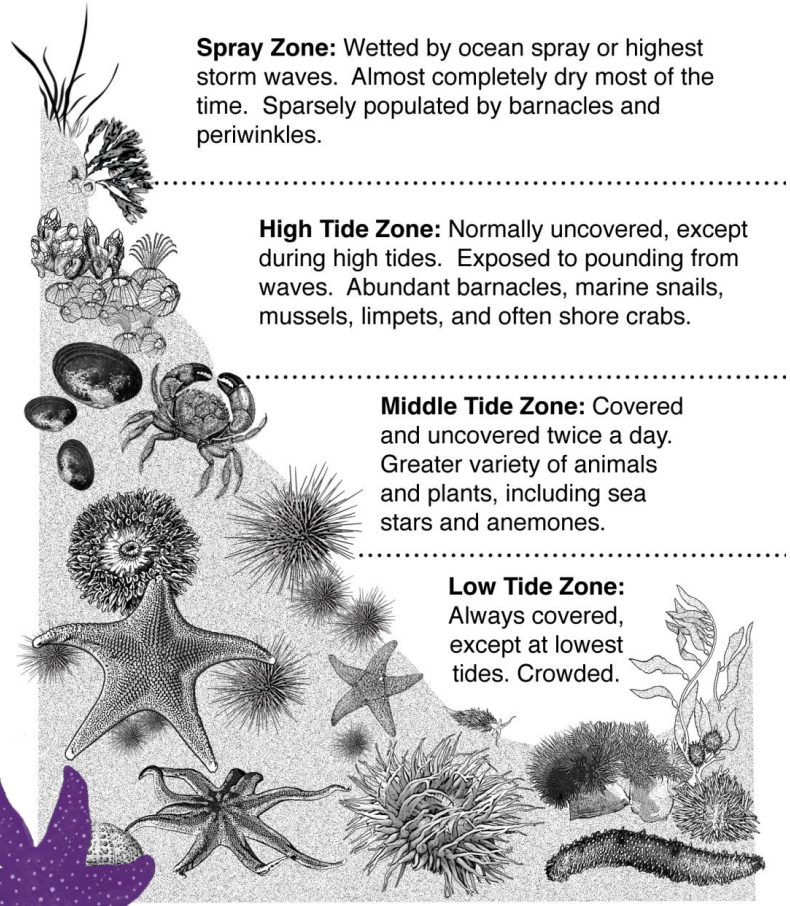
What is the Intertidal

- “The intertidal zone is the area where the ocean meets the land between high and low tides … Intertidal zones exist anywhere the ocean meets the land, from steep, rocky ledges to long, sloping sandy beaches and mudflats that can extend for hundreds of meters.” -
National Oceanic and Atmospheric Administration



Can you name any of these organisms?
Where have you seen them?





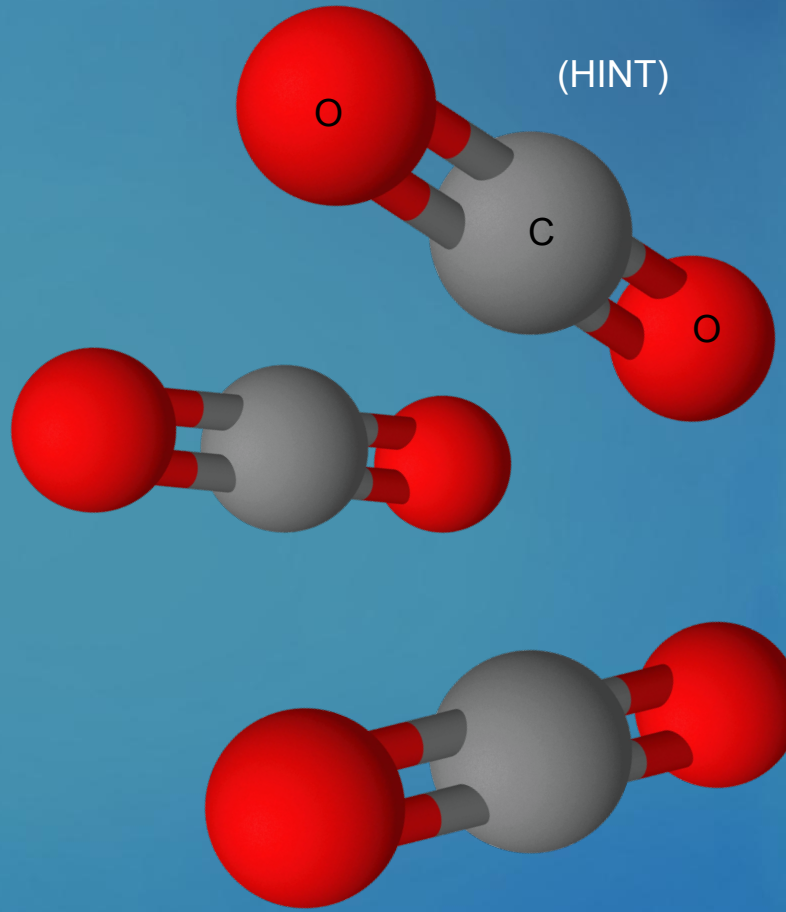
- Organisms in the intertidal play an important part in the food chain, providing energy for both marine and terrestrial animals.
- Many food sources for us come from the intertidal (oysters, mussels, crabs, clams, etc.).
- Intertidal organisms like sea stars act as keystone species, providing a vital role in marine ecosystems.

★ **Due to climate change, intertidal organisms have faced drastic changes in their environment as a result of ocean acidification.**

What is Ocean Acidification?

- **Turn to a partner and discuss what you know about ocean acidification.**

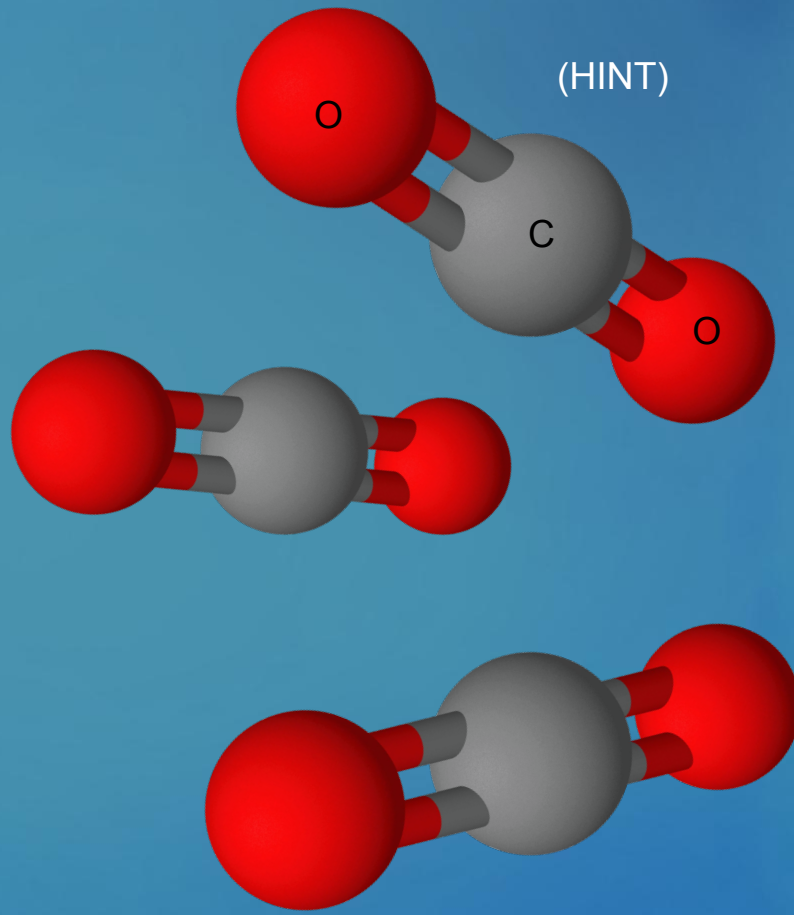
(HINT)

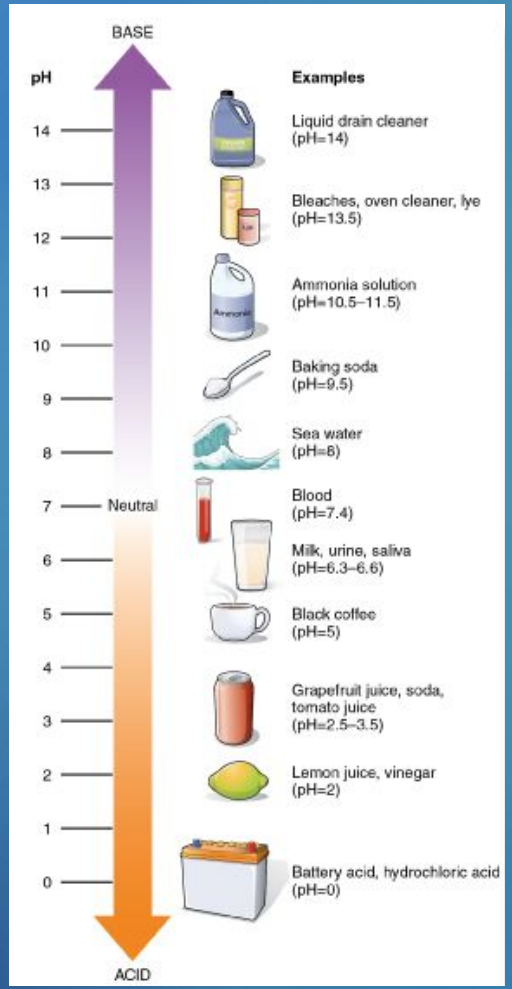


What is Ocean Acidification?

- **“Ocean Acidification is the ongoing change in the chemistry of the ocean caused primarily by the ocean's absorption of carbon dioxide from the atmosphere.” – NANOOS**
- “Ocean acidification refers to a **reduction in the pH** of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO2) from the atmosphere” - *National Oceanic and Atmospheric Administration*

(HINT)



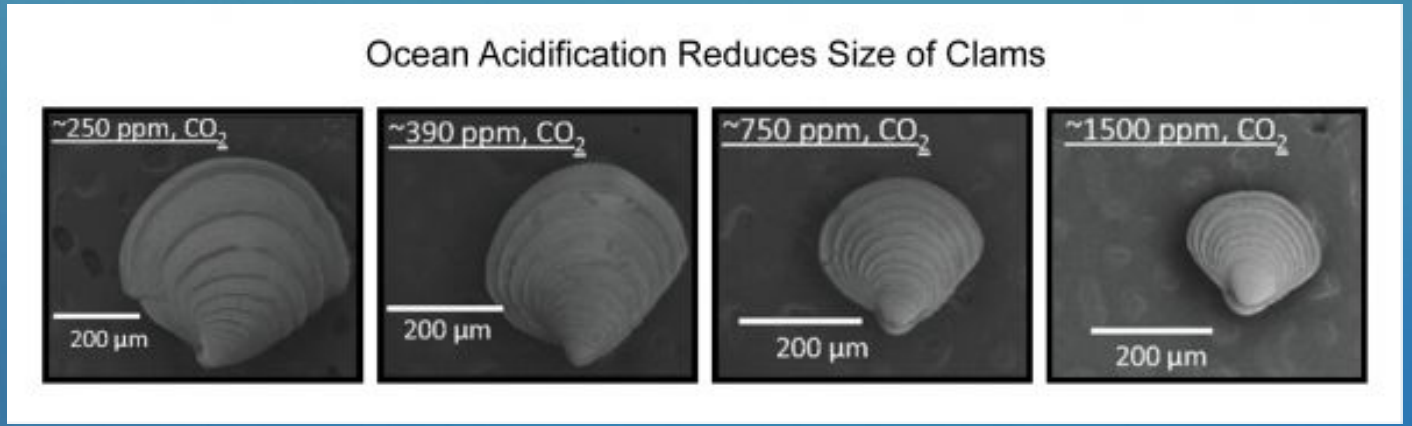


What is pH?

- pH is a measure of how acidic or basic water is.
  - Scale of 0-14 with 7 being neutral
  - pH greater than 7 is basic, pH less than 7 is acidic
- The pH scale is **logarithmic** (base 10).
  - This means that a change of 1 pH unit corresponds to a 10x change in hyrdogen ion concentration
  - For example, a pH of 7 is ten times more acidic than a pH of 8 and 100 times more acidic than a pH of 9
  - **Small changes in pH can mean large changes to the ecosystem!**
- The pH of the ocean is averaged to be 8.1, but was recorded to be 8.2 before the industrial revolution. Now, we are seeing certain areas drop below 8.0 (sometimes closer to 7).

What does pH change do?

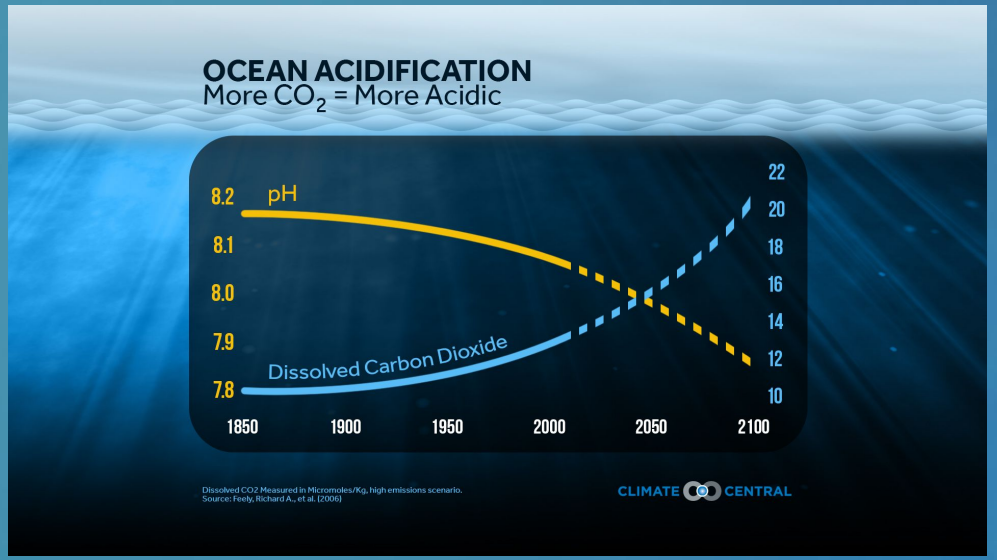
- When something becomes acidified, the chemical composition of the solution changes entirely.
- Ocean pH change can cause many organisms physiological, behavioral, and biological changes.
  - In the ocean, organisms have a small range of tolerance for pH.

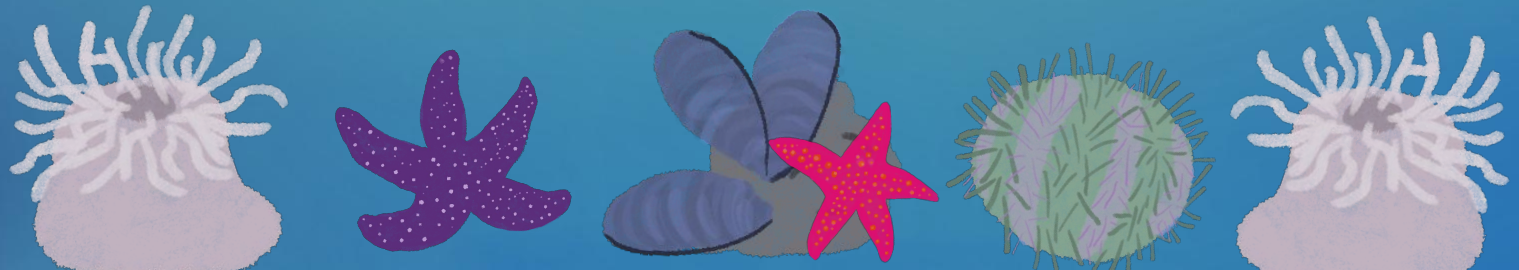


What causes Ocean Acidification?

Brainstorm with a partner:

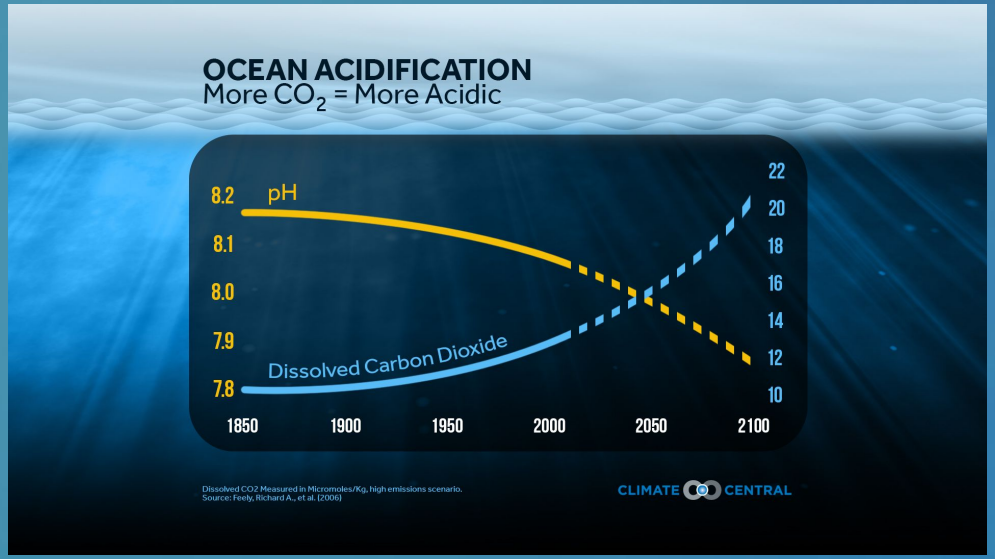
- **What can you think of that can change the pH of the ocean?**

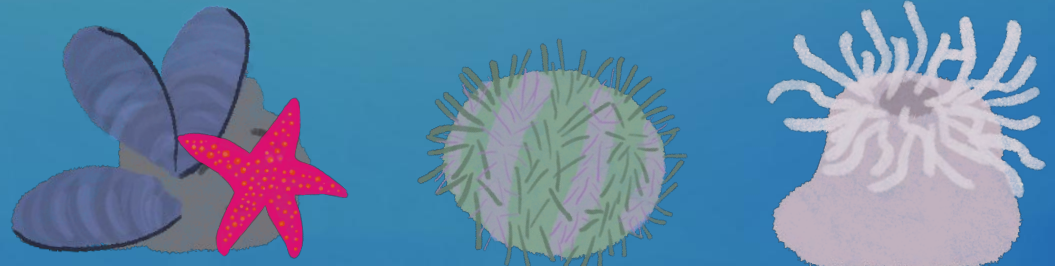




What causes Ocean Acidification?

- Absorption of atmospheric CO_2
- Anthropogenic CO_2 emissions
- Fossil fuel burning
- Industrialization
- Food web interference
- Upwelling
- Nutrient loads
- And many more!





What organisms are affected by ocean acidification?

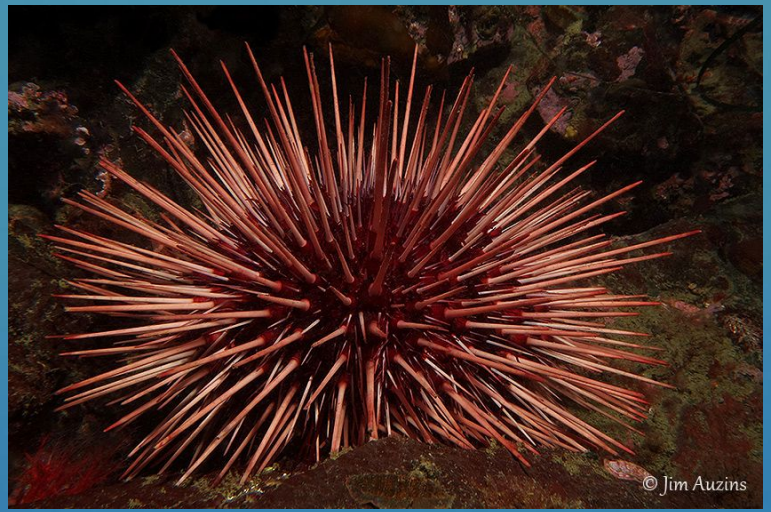
- Brainstorm and share with a partner
  - Use the space given on your worksheet to make a list
- How are these organisms impacted? Does it affect their function, habitat, food source, etc.?
- How do you think this impact will affect the ocean systems?

Calcifying organisms

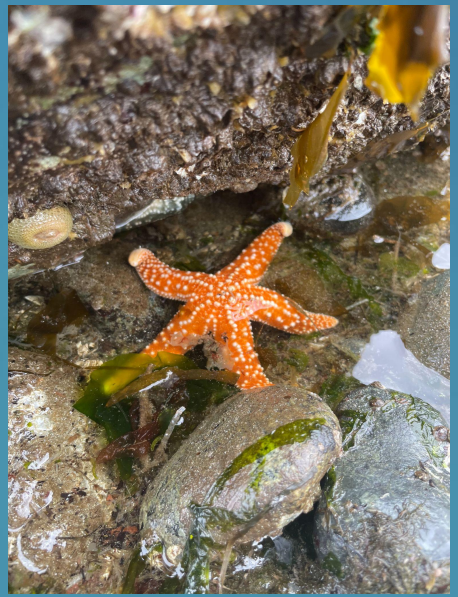
- Calcifying organisms: organisms that can synthesize calcium carbonate into shells and other structures
- Examples of calcifying organisms
  - Oysters
  - Clams
  - Sea urchins
  - Corals
  - Us! (Example: teeth)
- Ocean acidification impacts calcifying organisms greater than non-calcifiers
  - Acidified water can cause calcium carbonate shells to dissolve along with other physiological and behavioral effects.

Mussels, clams, scallops, oysters

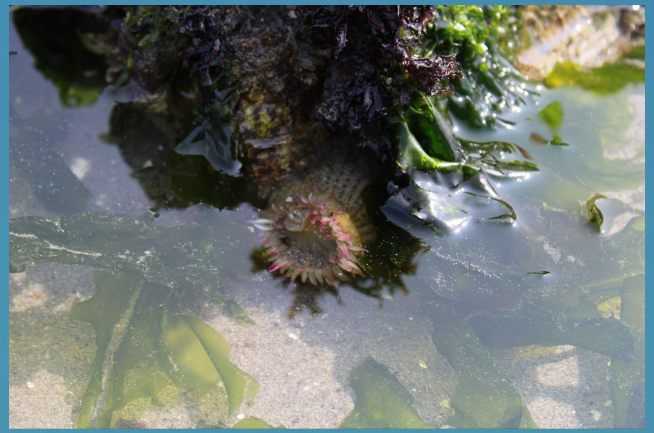
Urchins



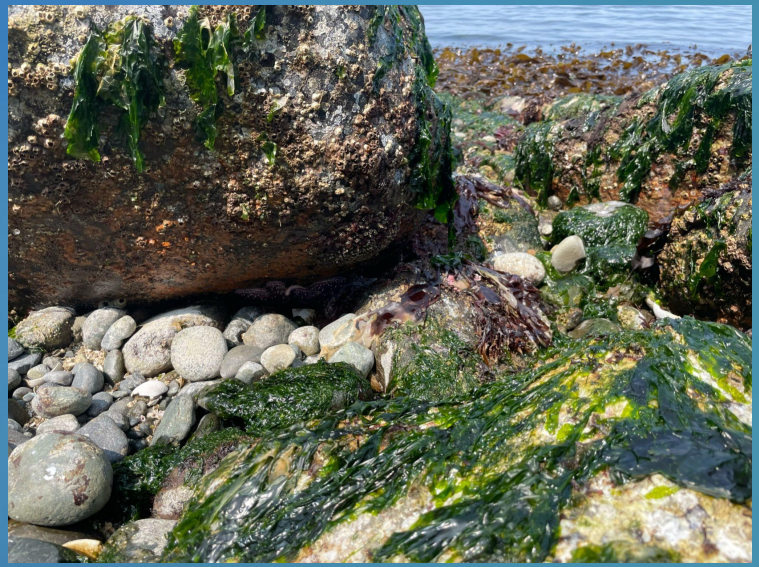
Sea stars

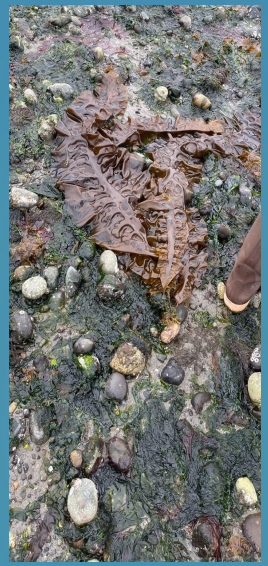


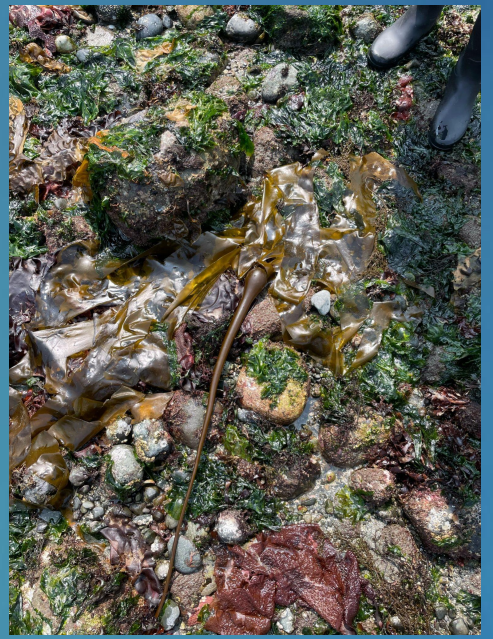
Sea anemones



Kelps and seaweeds

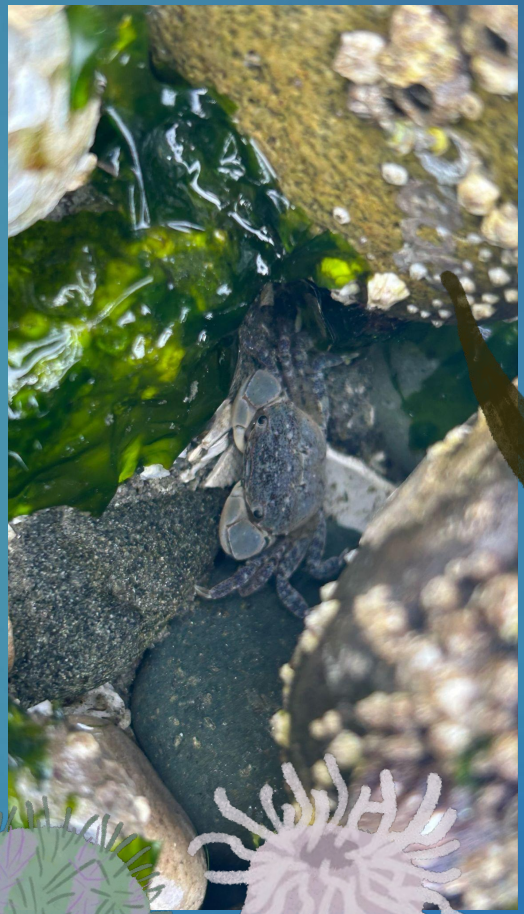






Other organisms impacted:

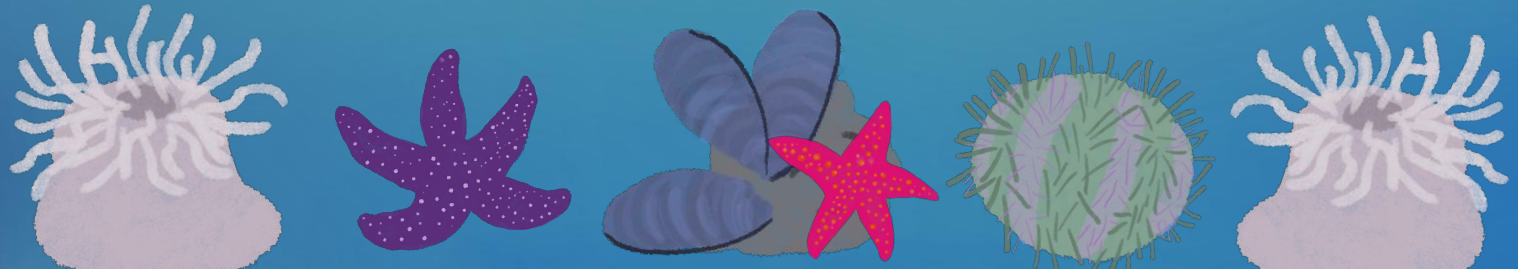
- Crabs
- Abalone
- Sea snails and slugs
- Brittle Stars
- Sea cucumbers
- Us!



How do ocean acidification impacts on organisms affect us?

Brainstorm with a partner and discuss:

- How does this impact our economy here in the Pacific Northwest?
- How does this affect the severity of climate change?
- How does this impact the things we like to do?



Practice Problem

Work through the instructions and questions on your worksheet!

pH Project

pH Project

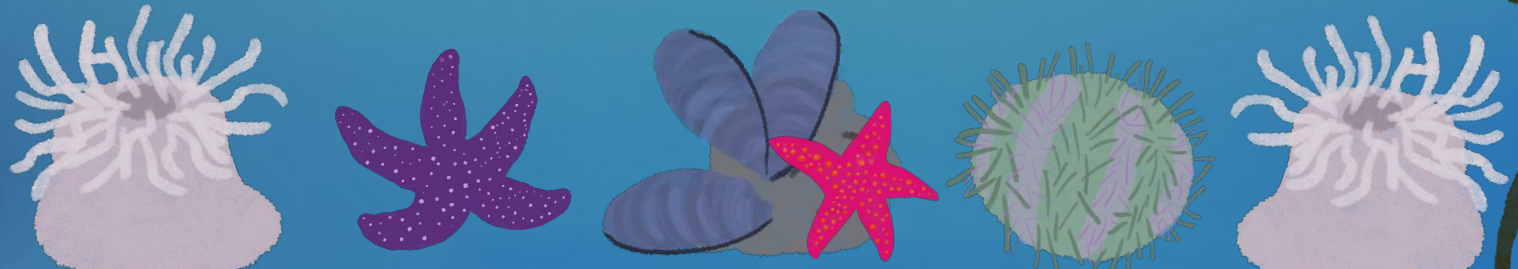
Work through the instructions and questions on your worksheet!

Reflect:

- How does the pH change of the ocean impact organisms?
- What will happen if these factors continue to change?
- How will this impact us?

What Can You Do?

- Do your part in combating climate change!
  - Tell your friends and family about ocean acidification and why it's important.
  - Reach out to local leaders to urge implementation of climate action to combat ocean acidification.
- Go outside! Explore the intertidal yourself to put your knowledge into action!



Thank You!

Acknowledgements:

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Rachel Wold - NANOOS Education and Outreach Lead

Josephine Grell - WOAC/NANOOS Intern with UW Earthlab

Name:_____ Date:_____

How Does Ocean Acidification Impact Our Shores?

1. While listening to the presentation, fill in the definitions *in your own words* for the following vocabulary:

The Intertidal:

Ocean Acidification:

pH:

Calcifying Organisms:

2. A. Brainstorm: What organisms are affected by ocean acidification?

B. How are these organisms impacted? Does it affect their function, habitat, food source, etc.?

C. How do you think this impact will affect the ocean?

3. Name two examples of calcifying organisms

1.

2.

4. What non-calcifying organisms are impacted by ocean acidification? Where do you usually find them? Have you personally seen these organisms before?

5. Use the space below to brainstorm about how ocean acidification impacts us:
(*Think How does this impact our economy here in the Pacific Northwest? How does this affect the severity of climate change? How does this impact the things we like to do?*)

6. *Bonus question:* What is your favorite intertidal organism and how do you think it could be affected by ocean acidification?

NVS Data Explorer Project

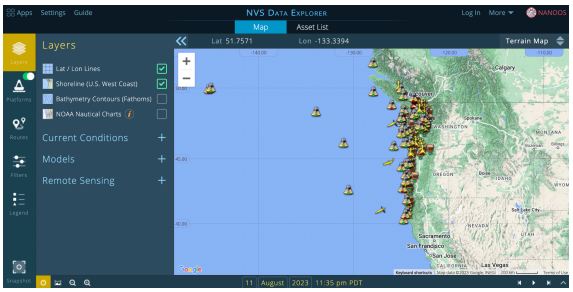
The Northwest Association of Networked Ocean Observing Systems (NANOOS), the regional association of U.S. Integrated Ocean Observing System (U.S. IOOS) for the United States Pacific Northwest, developed the NANOOS Visualization System (NVS, nvs.nanoos.org) to provide users with a rich interface to access observations, forecasts, and satellite overlays from a wide range of ocean and coastal assets.

Practice question: This is for you to become familiar with the data explorer before you jump into the real questions.

1. Open up the NVS Data Explorer - On your computer type in <nvs.nanoos.org>

2. Find the data explorer button (shown below) and click on it

3. Once in the data explorer go to the bar on the left side of the screen and click on layers. It should look like the picture below



4. From there click on the drop-down menu for Models. Scroll down to the LiveOcean section and select the box for pH.

5. Zoom into the Puget Sound/Greater Seattle Area.

6. Compare the color of the model in the area to the color scale given.

a. Record any observations you have about the color.

b. Estimate the pH of one specific spot bordering the land at the surface. Is this higher or lower than what the ocean should be (8.1)?

c. If this area is lower than 8.1, what could have caused this change?

pH Project

1. Stay on the page you were on before (N*VS Data Explorer → layers → models → LiveOcean → pH*)
2. Choose an area of focus (for example: The Puget Sound, Oregon Coast, Vancouver, Ca)
    a. Area of focus:

    b. What is the Surface pH in this area?

    c. What is the pH at -98 feet?

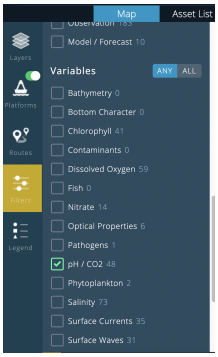
    d. What is the pH at the bottom?

    e. Comparing these values what do you see? How does pH differ from the surface to the bottom?

    f. What could this mean for our intertidal ecosystems?

    g. Can you think of any specific causes of these pH changes?

3. Return to the bar on the left-hand side of the screen, and select the filters icon. Scroll down to the Variables section and select the box for pH/CO2.



4. In this area you chose, find an icon that looks like this   & click on it. A data box should pop up.

    a. Review the data given in the pop-up, what are some notable numbers?

    b. Scroll down to where the pH measurement is given, is this measurement similar to the estimate from the model?

    c. Are there any other factors in the data that could impact this pH level? How does this change the pH?

    d. Does this fall in a healthy pH range? If not, what do you expect to happen to the organisms living in this area?

5. Share with a partner and compare the data you found, why do different places have different pH levels?

<u>Reflection</u>

1. What is one thing you will remember from this lesson?

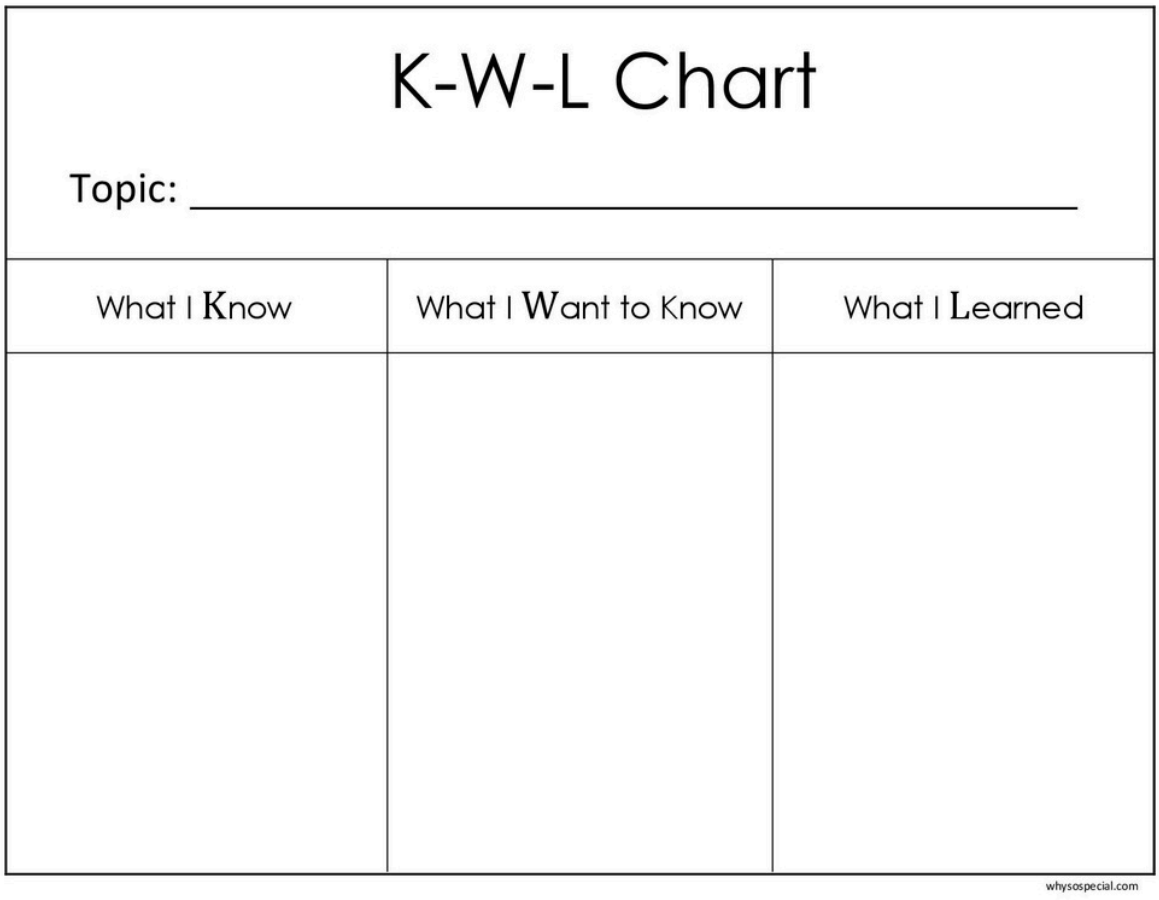
2. If someone were to ask you what ocean acidification is and how it impacts the world what would you tell them?

Teacher Supplemental Notes

Preparing for the Ocean Acidification and the Intertidal lesson plan

Preparation before the lesson:

- Take a look at the background resources below for you to gain a better understanding or review OA and the intertidal.
- Provide a worksheet for each student or an online version for them to work on and a computer for each student/pair/group!
- Link to the data explorer: https://nvs.nanoos.org/Explorer
- Optional KWL worksheet for the students to fill out while brainstorming before and after the lesson!
- Depending on the level of the students, you can take a period to scaffold the *vocabulary given below and watch some videos also given below before the lesson! (pick your favorite)



IMPORTANT:

- For slides 12-16 give a brief overview of the organisms and ask students:
  - Have they seen the organism?
  - Where have they seen it?
  - How could these be impacted?
- There are resources below that can answer the impact question so you have an answer prepared! (a quick google can work too) Feel free to go as in depth or surface-level as you want with this, use it the way you want.

Additional articles for background:

The Intertidal:

- National Oceanographic and Atmospheric Administration (NOAA) Intertidal webpage: (https://oceanservice.noaa.gov/facts/intertidal-zone.html#:~:text=The%20intertidal%20zone%20is%20the,extend%20for%20hundreds%20of%20meters.)
- PDF on intertidal ecology by Project Oceanography: (https://www.marine.usf.edu/pjocean/packets/sp02/sp02u1p3.pdf)

Ocean Acidification:

- National Oceanographic and Atmospheric Administration (NOAA) Ocean Acidification: (https://oceanservice.noaa.gov/facts/acidification.html)
- Wikipedia Ocean Acidification page: (https://en.wikipedia.org/wiki/Ocean_acidification)
- NASA Climate Kids Ocean Acidification page: (https://climatekids.nasa.gov/acid-ocean/)
- Smithsonian Ocean Acidification page: (https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification)
- National Park Service *Investigating Ocean Acidification in the Rocky Intertidal*: (https://www.nps.gov/articles/ocean-acidification-in-the-rocky-intertidal.htm#:~:text=Ocean%20acidification%20makes%20it%20more,other%20functions%20essential%20for%20life.)
- EPA *Effects of Ocean and Coastal Acidification on Marine Life*: (https://www.epa.gov/ocean-acidification/effects-ocean-and-coastal-acidification-marine-life)

pH:

- United States Geological Survey (USGS) *pH and Water*: (https://www.usgs.gov/special-topics/water-science-school/science/ph-and-water)

Organisms:

- The Henry M. Jackson School of International Studies *Intertidal Species in the Salish Sea* by Anna Everett: (https://jsis.washington.edu/canada/wp-content/uploads/sites/20/2021/09/Intertidal-Species-in-Salish-Sea-Guide_reduced.pdf) (mostly for fun with pictures and maps)
- National Oceanic and Atmospheric Administration (NOAA) intertidal organisms: (https://marinedebris.noaa.gov/sites/default/files/Intertidal%20Zone%20Animals%20Field%20Guide%201.pdf) (intertidal organisms found in the Olympic Coast but many found here! Fun pictures)

- The Oregon Conservation Strategy *Climate Change and Oregon's Intertidal Habitats*: (https://www.dfw.state.or.us/conservationstrategy/docs/climate_change/Intertidal_Fact_Sht.pdf)

Videos:

- Action for the Climate Emergency *What is Ocean Acidification?*: https://www.youtube.com/watch?v=gZGj0BbDT38
- The University of Plymouth *What is Ocean Acidification?*: https://www.youtube.com/watch?v=L2bxwnm7JG4
- California Academy of Science's *Demystifying Ocean Acidification and Biodiversity Impacts*: https://www.youtube.com/watch?v=GL7qJYKzcsk (a bit longer but good context!)
- NWA New Zealand *Ocean Acidification - What does it mean for Shellfish?*: https://www.youtube.com/watch?v=DtENyHKZPIU (Would be great to play after the organism slides in the lesson slides!)
- PBS NewsHour *Acidifying Waters Corrode Northwest Shellfish*: https://www.youtube.com/watch?v=x7MpI9dZIjk&t=46s (Would also be great to play after the organism slides in the lesson slides! PNW Specific!)

*Optional vocabulary to cover before for background:

- Organism
- Habitat
- Ecosystem
- Climate Change
- Carbon Dioxide
- Anthropogenic
- Emissions
- Calcium carbonate
- Atmosphere
- Food web
- Keystone species
- Upwelling

Optional field trip!:

- Take your students to the intertidal! Tide-pooling is an amazing hands-on activity that can be a helpful addition for students to understand what organisms and topics this lesson covers!

Optional "lab":

- A great way to understand the impact pH has on calcium carbonate structures is to have an eggshell in vinegar demonstration!
    - Imagination Station Toledos guide to this experiment: https://www.imaginationstationtoledo.org/education-resources/diy-activities/naked

-eggs#:~:text=If%20you%20soak%20this%20egg,as%20bubbles%20on%20the%20shell.
    - Time-lapse video of what happens: https://www.youtube.com/watch?v=cs0gTrKkD5Q (Jump to 0:45) (Ignore the “we don’t know why this happens because we do!)
- This is an extreme representation of what is happening in the ocean but shows just how much an acidic solution can impact calcium carbonate structures.

Any questions? Contact us at: http://www.nanoos.org/contact_us/contact_us.php