Why are there methane bubbles in the Ocean, where are they found, and what do they mean?

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Summary: Students will explore the three locations on the Ocean floor off the coasts of Oregon (Cascadia Margin), Texas (Gulf of Mexico), and North Carolina (Atlantic Margin) to locate methane seeps (bubbles) and determine how they occur and if they follow geologic features such as canyons and faults. Students will examine the existence of methane seeps and how they impact the Ocean environment and affect global climate change.

Topic: Methane Seeps in the Ocean
Grade Level: Middle to High School (adaptable)

Background:
Students are familiar with the One Ocean concept: The traditionally labeled parts of the Ocean—the Atlantic, Pacific, Indian, Arctic, and Southern Ocean—are geographic distinctions of Ocean basins that are all part of one singular, interconnected global Ocean. Students have been exposed to tectonic plates, faults, continent names, and differences between bays and gulfs. However, students are often less familiar with methane, seeps, features of the Ocean floor, greenhouse gases and climate change.

The lesson can be differentiated according to student technology capabilities and student background knowledge. Resources and activities can be found at the end of the lesson for refresher experiences.

Performance Expectations

- **NGSS Dimensions**
  - o **HS.ESS2 Earth's Systems**
    - ▪ **HS-ESS2-2. Analyze geoscience data to make claims about the current and past changes in Earth's systems.** *Connection:* Students analyze map data (geoscience data) of seep locations to identify patterns in their distribution. They might infer past geological activity influencing seep formation.
    - ▪ **HS-ESS2-3. Develop a model based on evidence to illustrate the relationships between the cycling of matter and the flow of energy through Earth's systems.** *Connection:* While not directly building a physical model, students are interpreting a visual model (the map) and connecting it to the flow of methane (matter/energy) from the geosphere/hydrosphere into the Ocean and potentially atmosphere.
    - ▪ **HS-ESS2-7. Construct an argument based on evidence for how the cycling of matter and flow of energy through Earth's systems result in**

the formation of mineral resources, fossil fuels, and other natural resources. *Connection:* Methane is a natural gas (fossil fuel). Students are exploring its natural release, which connects to the broader concept of Earth's natural resource cycles.

- o **HS.ESS3 Earth and Human Activity**
    - ▪ **HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** *Connection:* Methane seeps are both a natural resource (potential future energy) and a source of a potent greenhouse gas that impacts climate. They are also linked to tectonic activity (natural hazards like earthquakes, which can expose seeps). Students explore these complex interdependencies.
- o **HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.** (Applicable if the lesson extends to mitigation strategies). *Connection:* While the lesson focuses on data interpretation, discussing *why* scientists study seeps (e.g., impact on climate change) naturally leads to considering human impact and potential solutions.
- o **HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current and future changes to Earth's systems.** *Connection:* Methane is a greenhouse gas. Understanding its release from seeps and the potential for increased release due to warming Oceans [basins] directly links to making forecasts about climate change. Students are analyzing real geoscience data.
- o **HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** *Connection:* Using GIS software or online mapping tools to overlay seep data with bathymetry or tectonic plates is a form of computational representation. The discussion of climate change explicitly addresses human modification of Earth systems.
- o **HS.LS2 Ecosystems: Interactions, Energy, and Dynamics**
    - ▪ **HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** *Connection:* The chemosynthetic ecosystems at seeps represent unique biodiversity. Students would be interpreting the "evidence" (locations) of these ecosystems.
    - ▪ **HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** *Connection:* Methane seeps are examples of dynamic ecosystems influenced by geological processes. The discussion of warming Oceans [basins] potentially destabilizing hydrates touches on "changing conditions" and their impact on these ecosystems.
- o **HS.PS1 Matter and Its Interactions**

        - **HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances and design a model to explain their properties.** *Connection:* While this lesson is more about data analysis than a hands-on investigation of matter properties, the *reason* methane is a potent greenhouse gas relates to its molecular structure and properties. This can be a point of discussion.
        - **HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** *Connection:* The consumption of methane by microbes (oxidation to CO2) is a chemical reaction. While not quantitative in this lesson, it highlights the cycling of matter.
- **Science and Engineering Practices (SEPs):**
    - **Analyzing and Interpreting Data (HS.ESS2-2, HS.ESS3-5, HS-LS2-2):** This is central to the lesson. Students are specifically asked to: Use maps as a form of geoscience data; Look for patterns in the spatial distribution of seeps; and Compare seep locations with other datasets (bathymetry, tectonic features).
    - **Developing and Using Models (HS.ESS2-3, HS.ESS3-6):** Students are using maps as models of the Earth's surface and the processes occurring beneath it. The lesson encourages creating their own interactive maps, which are computational models.
    - **Constructing Explanations and Designing Solutions (HS.ESS3-1, HS.ESS3-4):** Students are asked to explain *why* scientists examine seeps and consider the broader implications (climate, ecosystems, hazards). This leads to constructing explanations.
    - **Obtaining, Evaluating, and Communicating Information:** Students are encouraged to access data from scientific sources (USGS, NOAA) and present their findings, developing communication skills.
    - **Using Mathematical and Computational Thinking (HS.LS2-2, HS.ESS3-5, HS.ESS3-6):** Using GIS, plotting coordinates, and potentially calculating distances or densities of seeps involves computational thinking and mathematical representations.
- **Crosscutting Concepts (CCCs):**
    - **Patterns:** Identifying "hotspots" or alignments of seeps with geological features on the map.
    - **Cause and Effect:** Exploring how tectonic activity causes seeps, how seeps affect climate, and how climate change could affect seeps.
    - **Systems and System Models:** Understanding methane seeps as part of interconnected Earth systems (geosphere, hydrosphere, biosphere, atmosphere) and how these systems interact.
    - **Energy and Matter:** Tracing the flow of methane (matter) and its role as an energy source for chemosynthetic communities and as a heat-trapping gas in the atmosphere.
    - **Stability and Change:** Discussing how these systems maintain stability and how factors like climate change can lead to significant changes.

- **Interdependence of Science, Engineering, and Technology:** The reliance on advanced mapping technologies (acoustic surveys, GIS) to discover and study these remote environments.

- **Texas Essential Knowledge and Skills (TEKS)**
  - **Middle School:**
    - **8.9(A)**: Describe the historical development of evidence that supports plate tectonic theory. *Students explore methane seep locations along tectonic margins, reinforcing the link between geological activity and Ocean features.*
    - **8.9(C)**: Interpret topographic maps and satellite views to identify land and erosional features and predict how these features may be reshaped. *Students examine maps of the Ocean floor and geologic features (e.g., canyons, faults) associated with methane seeps.*
  - **High School:**
    - **ESS.6(A)**: Analyze the characteristics of the Ocean floor such as trenches, ridges, and seamounts. *Students explore methane seep locations and their connection to Ocean floor features like canyons and faults.*

- **Texas ELPS (English Language Proficiency Standards (§120.21)**
  - **Aligned ELPS Standards (Grades 4–12). Examples in the lesson:**
    - Sentence stems for discussion: *"I think methane bubbles occur because…"*
    - Visuals and graphic organizers: Maps, Ocean floor profiles, gas hydrate diagrams, and seep comparison charts.
    - Graphic organizers for comparing seep location.

Listening

§120.21(d)(1)(B): Use contextual factors or word analysis such as cognates... to comprehend content-specific vocabulary when heard during formal and informal classroom interactions. Students listen to teacher-guided discussions about seep formation and methane gas and use context clues to understand new terms.

§120.21(d)(1)(E): Demonstrate listening comprehension... by restating, responding, paraphrasing, summarizing, or asking for clarification. Students respond to guiding questions during bubble demonstrations and methane seep video clips.

Speaking

§120.21(d)(2)(B): Speak using content-area vocabulary during formal and informal classroom interactions. Students describe seep locations and tectonic features using terms like "methane," "fault," and "continental margin."

§120.21(d)(2)(E): Narrate, describe, explain, justify, discuss, elaborate, or evaluate orally with increasing specificity and detail. Used during group analysis, class debates on climate impacts, and sharing hypotheses.

Reading

§120.21(d)(3)(C): Use high-frequency words**, contextual factors, and word analysis... to comprehend content-area vocabulary in text. Students read and interpret bathymetric maps and scientific descriptions of seep ecosystems.**

§120.21(d)(3)(F): Derive meaning from and demonstrate comprehension of content-area texts using visual, contextual, and linguistic supports. Maps, diagrams, and location guides scaffold comprehension.

Writing
§120.21(d)(4)(C): Write using a combination of high-frequency words and content-area vocabulary. Students describe seep formation and environmental implications in journal entries and lab books.

§120.21(d)(4)(F): Write to narrate, describe, explain, respond, or justify with supporting details and evidence. Used for student reflection prompts, seep case study reports, and peer-reviewed concept maps.

- **Ocean Literacy Principles**
    - o **OLP 1:** Earth has one big Ocean with many features.
    - o **OLP 7:** The Ocean is largely unexplored.

5E Lesson Plan

ENGAGE - Spark curiosity about methane bubbles and their presence in the Ocean.		
Teacher Does	*Student Does*	*Concept*
PreLab Hook/Demonstration: Teacher uses a flat table, straw, dove soap, salt solution, and sugar solution. Ask students to hypothesize which solution will make the biggest bubbles and why. Using straw, blow bubbles with the two different solutions (place straw at an angle in contact with the table for better results). See additional information in the resources section for “Bubbleology” activity (Exploring Bubble Size with Different Solutions). Optional: Display an image of bubbles emerging from sediments.	Students observe, compare, and contrast bubble size based on salt and sugar bubble solutions.	The sugar solution should produce larger bubbles due to the differences in how sugar and salt affect surface tension and viscosity. Sugar molecules make the solution thicker, slowing down the evaporation of the water from the bubble, allowing the bubble to grow larger before popping. Sugar = stronger, more elastic film = bigger bubbles. Salt = weaker, more brittle film = smaller bubbles.

Show short video clip(s) of methane seeps on the Ocean floor (e.g., NOAA ROV footage). Highly recommend showing: **Deep Hotspots of Biodiversity | Canyons, Vents, and Seeps of the Chile Margin** and the ***Bubbles ROV Video*** (link to Jeff's video in google drive)	Watch the video or examine the image closely, noting observations (in writing and drawings) and questions.	Methane seeps are a real and observable phenomenon occurring on the Ocean floor.
Ask guiding questions: "What do you notice?" "Where do you think this is happening?" "Why might bubbles be rising from the Ocean floor?" "Why do methane bubbles occur in the Ocean?" "Where are they most often found, and why does it matter?"	Respond to questions by making observations, predictions, or hypotheses based on prior knowledge.	Curiosity is activated through inquiry; methane release prompts questions about geologic and Ocean processes.
Create a K-W-L chart to record class brainstorm: "What do you Know? What do you Wonder?"	Contribute to building a class K-W-L chart with facts and questions.	Build relevance and ownership of the learning process through curiosity and personal engagement.
Lead a Think–Pair–Share discussion to reflect on what students already know about methane, natural gas, or Ocean gases.	Discuss ideas with a partner and share thoughts with the class.	Connect prior knowledge about gases, geologic activity, and climate to new phenomena.

Engage Questions

- What do you notice?
- Where do you think this is happening?
- What makes bubbles?
- Where do you find bubbles in nature?
- Why might bubbles be rising from the Ocean floor?
- What could cause gas to escape from beneath the Ocean floor?

EXPLORE - Investigate methane seep locations and their relationship to Ocean floor features.		
Teacher Does	*Student Does*	*Concept*
Divide class into groups. Provide access to printed maps showing seep locations off the coasts of Oregon, Texas, and North Carolina. See sample digital maps below.	Analyze the map provided (either Oregon, Texas, or North Carolina coastal map) to identify the Ocean basin, record latitude and longitude coordinates, add locational metadata, and methane seeps in different regions of the Ocean.	Methane seeps are found in specific Ocean regions, often associated with geologic features.
Guide students in examining bathymetric and tectonic maps to identify nearby features (e.g., Ocean basins,	Compare methane seep locations with nearby geological features (e.g. Faults, canyons, ridges, etc.) to identify spatial patterns.	Seep formation is related to plate boundaries, faults, and seafloor structures.

continental margins, faults, canyons, etc.).		
Direct students to work in their assigned small groups to collect and record data on seep locations, depth, and geologic context.	Collaborate in groups to gather and record evidence about where and why seeps occur.	Scientific investigation involves observation, data collection, and pattern recognition.
Encourage use of color-coded mapping or charting tools (digital or paper) to organize findings.	Create annotated maps or visual representations of seep sites and surrounding features.	Spatial data can be used to reveal relationships between geological processes and Ocean phenomena.
Circulate to ask probing questions like, "What do you think causes the methane to escape here?" or "What patterns are you seeing?"	Engage in discussion, propose explanations, and start to build conceptual understanding.	Early hypotheses form as students make connections between data and geological processes.

Explore Questions

- What is a seep?
- Where are they most often found, and why does it matter?
- What geologic features are near the seeps?

Students Record the following information in their lab books:

- Seep location
- Latitude/longitude
- Nearby geologic features
- Hypothesis (why here?)
- Actual seep location (comparison)

Activity Part 1: Before Viewing the Methane Seep Map (Hypothesizing)

Instructions for the Teacher: Present the students with the bathymetry map of the Cascadia Margin. Do not provide any information about methane seeps yet. Give students time to observe the map and discuss their initial thoughts in small groups or as a class.

Guiding Questions for Students:

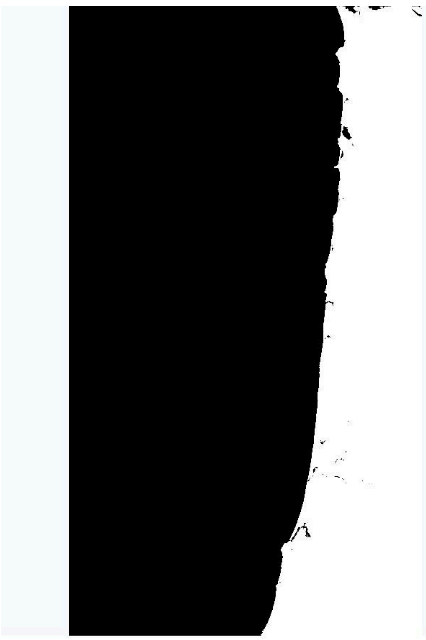
1. **Map Analysis:** Take a close look at the bathymetry map. What do the different colors or contour lines represent? What are some of the most prominent features you can identify on the seafloor? (e.g., mountains, valleys, plains, trenches).
2. **Geological Context:** The Cascadia Margin is an active geological region where two tectonic plates are interacting. Based on the features you see, what might be happening beneath the seafloor?
3. **Hypothesis Formulation:** Methane is a gas that can be trapped in the seafloor sediments. It can be released naturally through "seeps." Where do you predict these methane seeps

are most likely to be located on this map? Use a marker to circle or identify 3-5 locations where you think seeps might be found.

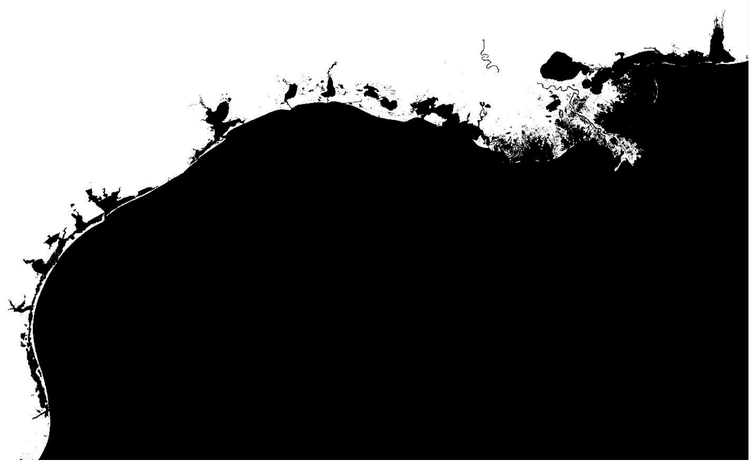
4. **Justification:** Explain the reasoning behind your predictions. What specific geological features or patterns on the map led you to believe methane seeps would be located there?

Bathymetry Maps – Oregon, Texas, and North Carolina

Oregon Cascadia Margin Bathymetry

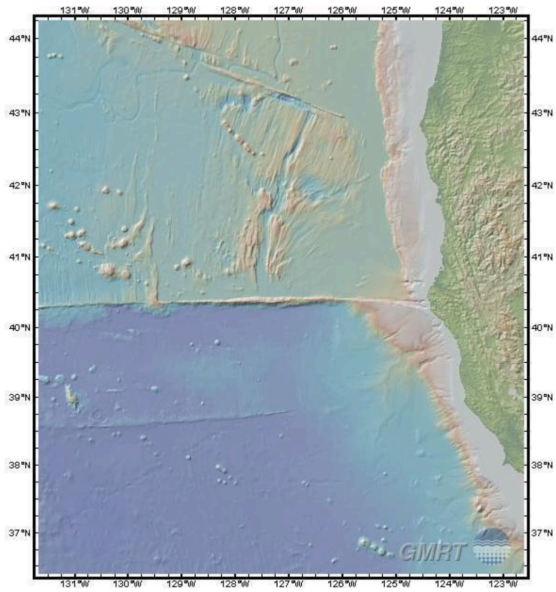


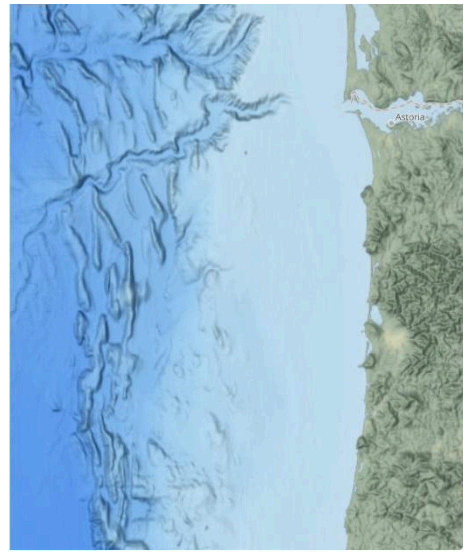
Gulf of Mexico Bathymetry



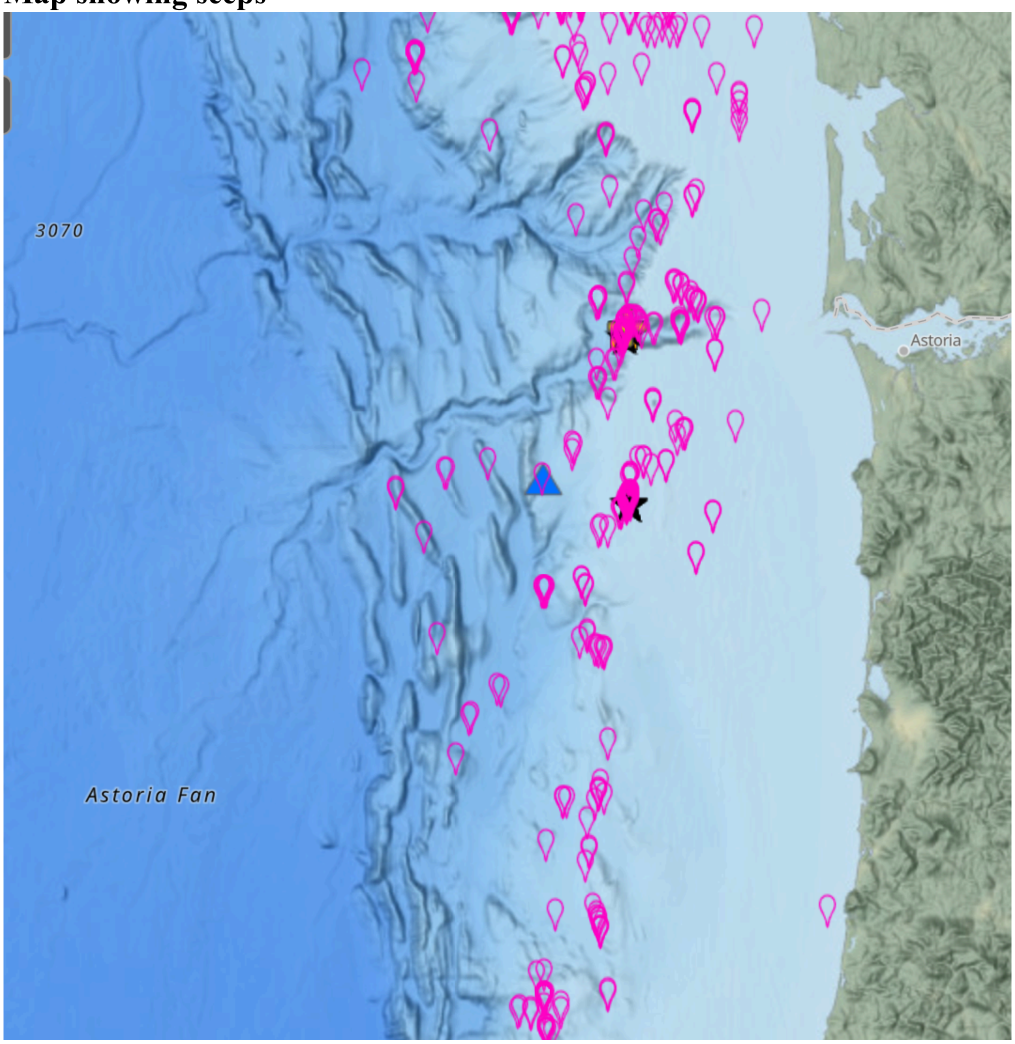
Outter Banks Region Bathymetry

Oregon (Cascadia Margin) Bathymetry Maps

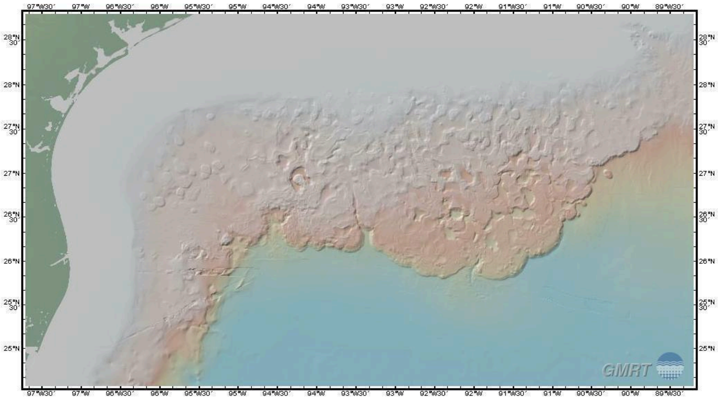


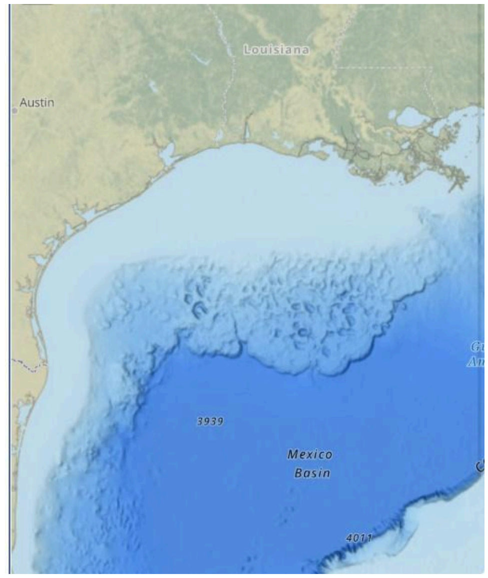


Map showing seeps

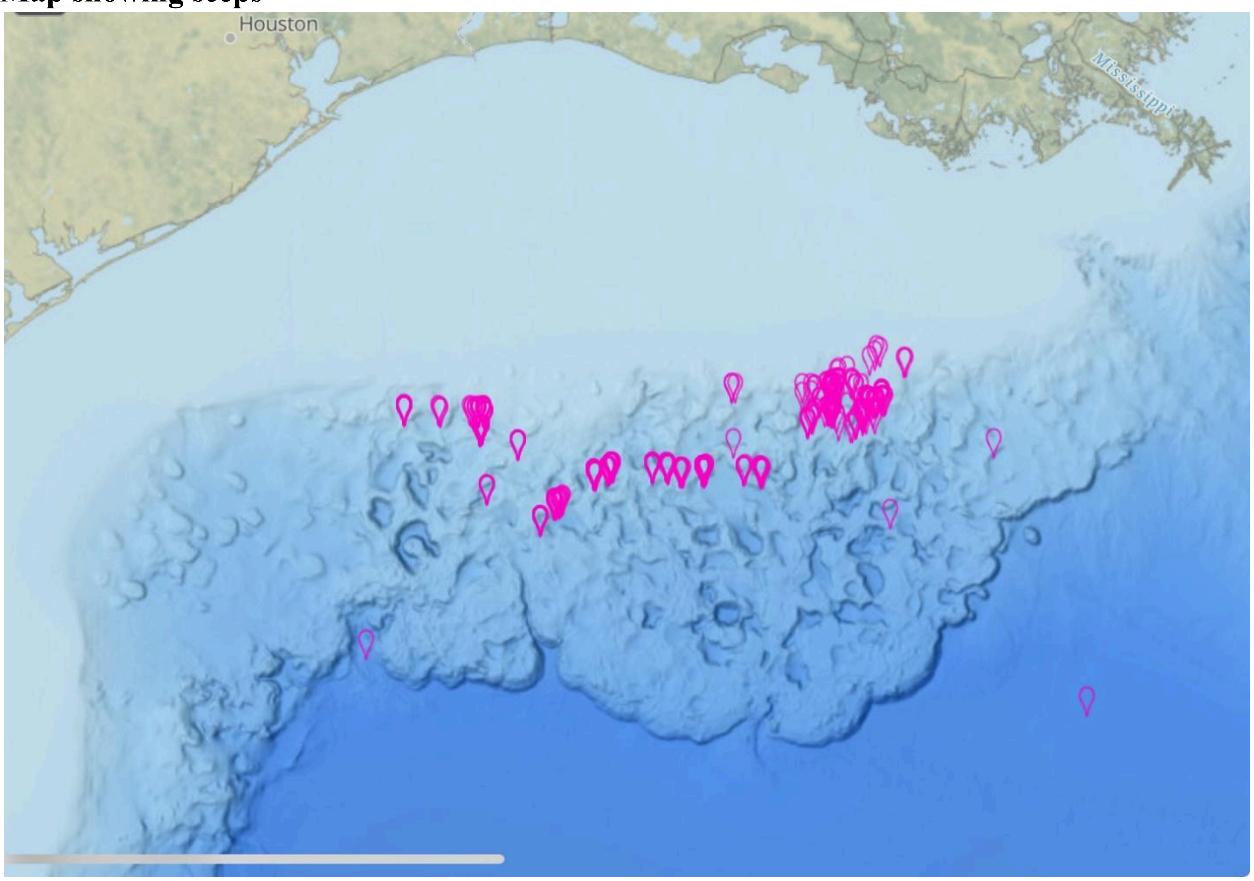


Texas (Gulf of Mexico) Bathymetry

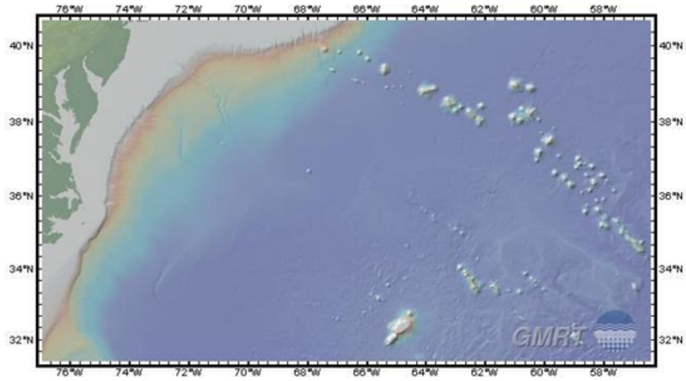


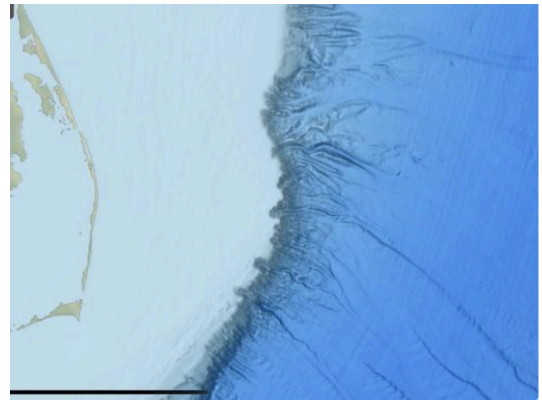


Map showing seeps

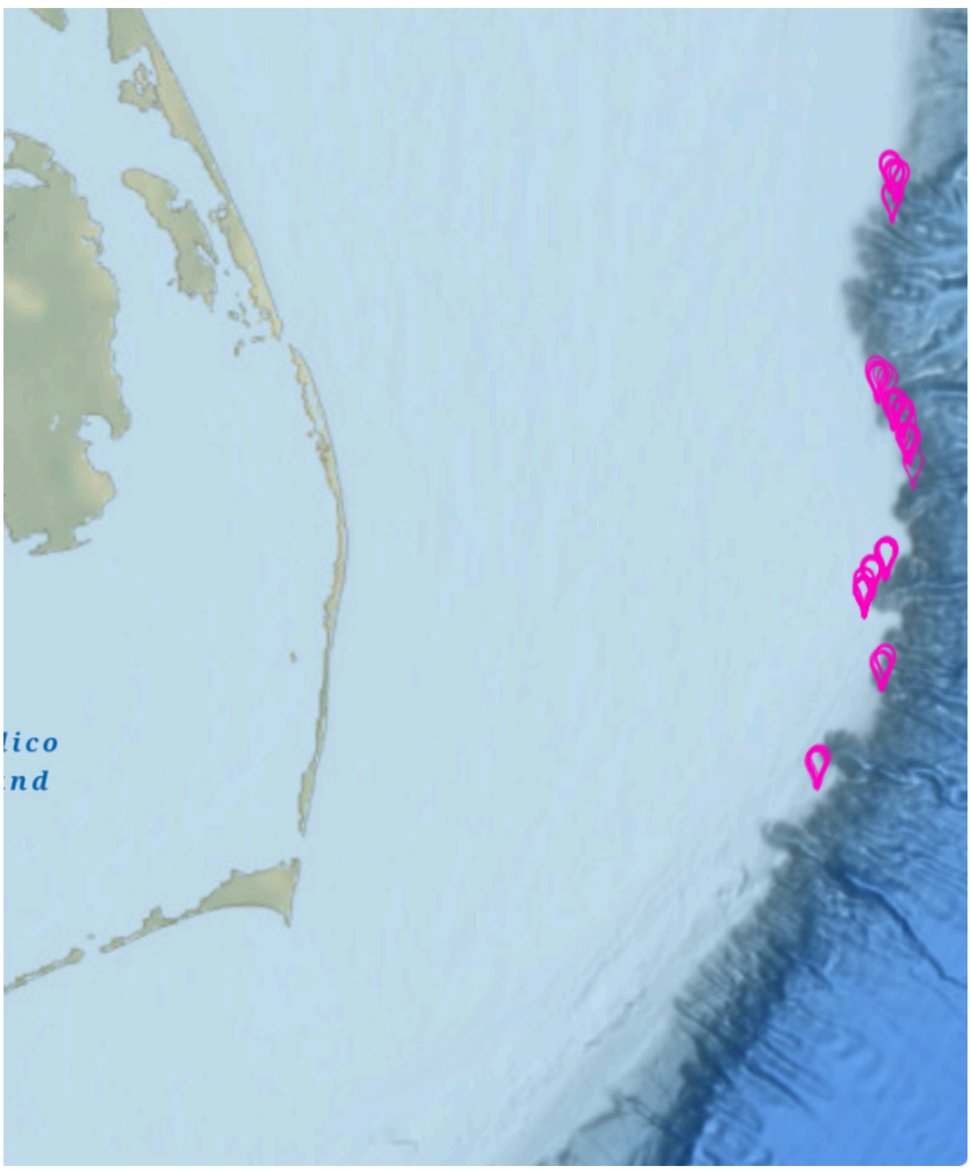


North Carolina (Atlantic Margin) Bathymetry Maps





Map showing seeps



EXPLAIN - Build understanding of how methane seeps form and their significance.		
Teacher Does	*Student Does*	*Concept*
Facilitate groups to share their regional case studies (Oregon, Texas, or North Carolina).	Explain findings from the data exploration. Discuss the causes, impacts, and environmental implications of methane seeps in their assigned region.	Methane seep characteristics vary by region due to tectonic, biological, and sedimentary differences.
Lead student discussion about how methane seeps connect to the carbon cycle and global climate. Provide a visual diagram of the carbon cycle showing methane movement from the seafloor to the atmosphere.	Trace how methane released from the Ocean floor can enter the atmosphere and impact climate change. Students create a flowchart/cause-effect map showing: seep formation, gas migration, and impact on climate.	Methane is a greenhouse gas, and Ocean processes contribute to Earth's carbon and energy cycles.
Facilitate a classroom debate or structured discussion: "Should we be concerned about natural methane seeps as contributors to climate change?"	Participate in discussion or debate, using evidence from research to support claims.	Scientific understanding helps inform environmental decision-making and policy development.
Introduce technology used to monitor methane seeps (e.g., ROVs, sonar, gas sensors).	Learn about Oceanographic tools and how scientists investigate underwater gas emissions.	Technology enables exploration and monitoring of remote Ocean environments.

Activity Part 2: After Viewing the Methane Seep Map (Analyzing and Comparing)
Instructions for the Teacher: After students have completed their predictions, present the answer key map that shows the actual locations of the methane seeps. Give them time to compare their hypotheses with the real data.

Guiding Questions for Students:

1. **Comparison:** How did your predictions compare to the actual locations of the methane seeps? Were you surprised by their actual distribution?
2. **Association:** Look at the locations where the seeps are actually found. What geological features do they seem to be associated with? Are they on flat plains, near ridges, in canyons, or along specific fault lines?
3. **Drawing Conclusions:** Based on the evidence from the map, what can you conclude about the relationship between seafloor geology and the location of methane seeps?
4. **Deeper Thinking:** Why do you think these specific geological features are prime locations for methane to escape from the seafloor? Consider what you know about tectonic activity and the pressure on deep Ocean sediments.
5. **Further Inquiry:** What other information would you need to better understand why methane seeps occur in these locations? (e.g., data on plate movement, sediment composition, or fluid flow).

- **Topics to Cover:**
  - Methane formation from decomposing organic matter
  - Role of sediment and tectonic plate boundaries
  - Methane hydrates and stability conditions
  - Methane as a greenhouse gas
- **Visual Aids:**
  - Diagrams of continental margins and gas hydrate layers
  - Chart comparing CO_2 and CH_4 in terms of warming potential

Potential Vocabulary (introduce as age appropriate):

- Anaerobic oxidation of methane (AOM)
- Bathymetry
- Chemosynthesis
- Continental margin
- Greenhouse gas
- Hydrate
- Methane (CH_4)
- Ocean basin
- Sampling bias
- Seep
- Subduction zone

ELABORATE - Connect methane seeps to broader Earth systems and climate change, and demonstrate the process of obtaining maps used for analyses.		
Teacher Does	*Student Does*	*Concept*
Demonstrate how the data graphs were generated. Note expectation for students to create maps similar to those viewed previously.	Take notes on steps to generate data maps and graphs.	Prepare students to use data visualization software/tools.
Instruct students to work in their group to find a location of interest to map.	Identify location and begin mapping.	Students use data visualization software/tools.
Facilitate group explorations.	Hands-on computer exploration.	Mastery of computer visualization tools.
Monitor student progress and output.	Generate maps and reports.	Students interpret and analyze the existence of methane seeps and how they impact the Ocean environment and affect global climate change.

Questions

- What do you notice about the slope near seep locations?

- Is there a relationship between bathymetry and seep occurrance?
- Do tides affect seeps?
- Do Low tides cause less pressure or more pressure on seeps?
- What is methane?
- Why do methane bubbles appear/occur in the Ocean?
- Do methane seeps appear randomly or in patterns?
- Does methane released in the Ocean contribute to global warming?
- How much methane is absorbed by the Ocean? Released into the air?
- How might tectonic activity influence seep locations?
- Why do you think scientists are interested in this information?

Instructions for individual site explorations utilizing GMRT Map Tool

- Select focus area
- Select Geotiff and Resolution options
- Zoom in for smaller grid size (to focus on one specific area)
- Select single band pseudo color and slope
- Download–drag and drop into QGIS
- Focus on Explain and Elaborate activities: Students make correlations between coastline and engage in Q&A discussions.

EVALUATE - Assess student understanding and ability to synthesize information.		
Teacher Does	*Student Does*	*Concept*
Distribute a reflection prompt asking, "Why do methane bubbles occur in the Ocean? Where are they found, and why does it matter?"	Write a paragraph summarizing the causes, locations, and impacts of methane seeps.	Methane seeps are linked to tectonic and geologic features and affect the Ocean and atmosphere.
Provide a blank concept map template with labeled domains (geosphere, hydrosphere, atmosphere, biosphere, climate). Include a rubric or success criteria for the concept map and paragraph writing (e.g., includes cause, location, impact, crosscutting concepts).	Complete a concept map connecting methane seeps to Earth systems and global change, including causes, locations, and implications of methane seeps.	Methane moves through and affects multiple Earth systems, influencing climate and ecosystems.
Give a short exit quiz or oral check-in (3–5 questions). Example: "What geological feature is often near a methane seep?"	Exit Ticket: Answers multiple-choice or short-answer questions based on lesson content. The exit ticket could be interactive via tools like Kahoot,	Methane seeps are located along tectonic margins and can influence Ocean chemistry and climate.

	Google Forms, or sticky notes for formative assessment.	
Review group case study or infographic presentations (e.g., Oregon, Texas, North Carolina seep sites).	Presents findings from seep case study, explaining key facts and implications.	Regional Ocean floor features influence the presence and impact of methane seeps.
Facilitate peer feedback on concept maps or written responses.	Reviews and comments on another student's reflection or concept map.	Critical thinking and scientific communication support understanding of complex Ocean phenomena.
Ask extension prompt: *If you were a marine geologist studying a new Ocean basin, where would you look for methane seeps and why?*	Apply knowledge of Ocean floor features, tectonic activity, and methane seep patterns to hypothesize potential seep locations. Support response with evidence from maps, prior activities, and scientific reasoning.	Scientific reasoning involves using data and patterns to make informed predictions. Methane seeps are commonly found near tectonic margins, faults, and continental slopes (areas of geologic activity that allow gas to escape from sediments).

Differentiation / Modifications / Additional Activities

- **Offer sentence stems** (starters) for emerging writers: *"I think methane bubbles occur because…"*
- **Create and paint clay models** showing bathymetry of selected areas of the Ocean floor.
- **Student Reflections:** Write science journal entries.
- **Concept Map:** Connect methane seeps to geology, biology, climate, and human impact.
- **Investigate technologies** used to detect and monitor methane seeps (e.g., remotely operated vehicles (ROVs), sonar).
- **Recommend scaffolded task:** Students first do mapping with provided data, then research and upload their own dataset if time allows.
- **Case Study Analysis:** Assign student groups a case study (e.g., Oregon margin seep discovery) and have them:
    - Identify causes and implications
    - Create a short presentation or infographic
- **Carbon Cycle Connection:**
  Map how methane moves through Earth's systems—from seabed to atmosphere.

- **Debate or Discussion Prompt:**
  Should we be concerned about methane seeps as a source of global warming?
- **Makerspace:** Use a 3D printer to make bathymetric models and students paint to show different data discoveries.
- **Design Challenge:** Design a system or policy to monitor methane seep activity and reduce emissions.

STEM Career Connections: Throughout the lesson, real-world roles can be integrated to help students see the value of what they're learning:

Career	Connection
Marine Geologist	Studies Ocean floor features and tectonic plate interactions
Chemical Oceanographer	Analyzes gases like methane in Ocean water and sediments
Climate Scientist	Monitors greenhouse gas emissions and their effects on global warming
ROV Pilot / Engineer	Operates remotely operated vehicles to study deep-sea environments
Environmental Policy Analyst	Interprets scientific data to recommend climate or Ocean protection policies

Career Extension Idea: Invite a guest speaker/scientist (virtually or in person), or use a short video from NOAA or NASA about methane seeps and Ocean research careers.
[Scientific Discovery at NOAA PMEL]

Helpful Resources:

Schmidt Ocean – [Canyons, seeps and vents]

- **Schmidt Ocean Institute cruise page featuring international seep research and data:** SOI Canyons, Vents, and Seeps of the Chile Margin. Video used in Engage: **[Deep Hotspots of Biodiversity | Canyons, Vents, and Seeps of the Chile Margin]**
- **Bubbles ROV Video (Note to Jenn–please link the video here. Thank you.)**
- **Videos: Seeps along the U.S. West Coast**
  - **[Seafloor Mapping Data Reveals Large Number of Gas Seeps Off U.S. West Coast]**
  - **[E/V Nautilus NA128 Cruise Page—methane seep exploration along the Cascadia Margin]**
- **Videos: Seeps in the Gulf of Mexico**
  - **[Natural seep 3600 ft deep in the Gulf of Mexico]**
  - **[Active Asphalt Seep Discovered in the Northern Gulf of Mexico]**
- **Videos: Seeps in North Carolina**
  - **[Discoveries at a Methane Seep Field Offshore Bodie Island]**

- **Additional Images** **(Note to Jenn–please link images here. Thank you.)**
    - **Oregon Margin Bathymetry**
    - **Gulf of Mexico Bathymetry**
    - **Outter Banks Region Bathymetry**

Software Programs

- **NOAA GeoPlatform** **SEAfloor Fluid Expulsion Anomalies (SEAFLEAs) Web Map Application**
- GMRT **GMRT MapTool** (interactive global multibeam bathymetry viewer developed by Lamont Earth Observatory) and **QGIS** (free, open-source Geographic Information System for spatial data analysis and mapping). Many other Oceanographic datasets can be imported here. Optional: NOAA's interactive methane seep maps or Google Earth files showing seep locations off the coasts of Oregon, Texas, and North Carolina.
    - **How to create Story Maps with Quantum GIS**
- **Google Earth Pro** — Downloadable tool for exploring global bathymetry and topography. Great for classroom mapping exercises.

Materials – Research Papers

- **Monterey Bay cold-seep biota: Assemblages, abundance, and….**
- **Tracking California Seafloor seeps with bathymetry, backscatter, and…**

MBARI Resources

- **Ripple Effect: Hawai'i's Changing Water Cycle • MBARI**
- **Taking a Dip in the Ocean Data Pool • MBARI**
- **Ocean Acidification: Is there a Problem? • MBARI**
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Instructions for Engage Activity: Bubbleology--Exploring Bubble Size with Different Solutions

Introduction: Bubbles are fascinating, ephemeral spheres of liquid enclosing a gas. Their formation and stability are influenced by the properties of the liquid, particularly its surface tension and viscosity. In this lab, you will investigate how adding solutes like salt and sugar to water affects the size of bubbles you can create.

Materials:

- Drinking straws (one per student or pair)
- Small containers or beakers (at least 3 per group)
- Water
- Table Salt (NaCl)

- Granulated Sugar
- Liquid Dish Soap (Dawn or similar, known for good bubble-making)
- Measuring spoons (teaspoon, tablespoon)
- Measuring cups (for water)
- Ruler or measuring tape
- Optional: Camera or smartphone for photo documentation

Safety Precautions:

- Do not ingest the solutions.
- Wipe up spills immediately to prevent slips.

Procedure:

Part 1: Preparing Your Bubble Solutions

1. **Label your containers:** Label three containers clearly as:
   - Container A: "Plain Water"
   - Container B: "Salt Solution"
   - Container C: "Sugar Solution"
2. **Prepare Solution A (Control - Plain Water):**
   - Pour 1/2 cup (120 mL) of water into Container A.
   - Add 1 tablespoon (15 mL) of liquid dish soap to Container A. Stir gently to mix, avoiding excessive bubbling.
3. **Prepare Solution B (Salt Solution):**
   - Pour 1/2 cup (120 mL) of water into Container B.
   - Add 1 tablespoon (15 mL) of liquid dish soap.
   - Add 2 teaspoons (10 mL) of table salt to Container B. Stir thoroughly until the salt is mostly dissolved and the soap is well mixed, again avoiding excessive bubbles.
4. **Prepare Solution C (Sugar Solution):**
   - Pour 1/2 cup (120 mL) of water into Container C.
   - Add 1 tablespoon (15 mL) of liquid dish soap.
   - Add 2 teaspoons (10 mL) of granulated sugar to Container C. Stir thoroughly until the sugar is mostly dissolved and the soap is well mixed.

Part 2: Blowing and Measuring Bubbles

1. **Dipping the Straw:** Dip one end of your straw into Solution A, ensuring the tip is fully coated with the bubble solution.
2. **Blowing a Bubble:**
   - Bring the coated end of the straw close to your mouth.
   - Place straw on table, Gently and steadily blow air through the straw to create a bubble. Aim to create the largest possible bubble you can without it popping immediately. You might need to practice a few times.
   - *Tip:* Blowing onto a clean, flat surface (like a table wiped down with a damp cloth) can sometimes help stabilize bubbles and allow them to grow larger.

3. **Measure and Record (Solution A):**
   - Once you've created a large bubble, quickly measure its approximate diameter using your ruler. If it pops too fast, try again.
   - Record the diameter in a data table (see "Data Collection" section below).
   - Repeat this process at least 3-5 times for Solution A, recording each measurement.
4. **Rinse and Repeat for Other Solutions:**
   - Thoroughly rinse your straw with plain water. You may want to use a separate straw for each solution to avoid cross-contamination.
   - Repeat steps 1-3 for Solution B (Salt Solution).
   - Repeat steps 1-3 for Solution C (Sugar Solution).