Ice Floe Identification

On September 20, 2019, the MOSAiC (**M**ultidisciplinary Drifting **O**bservatory for the **S**tudy of **A**rct**i**c **C**limate) research expedition officially launched when the icebreaker *RV Polarstern* set out from Tromsø, Norway and traveled north into the Arctic. The goal was to freeze the icebreaker in the Arctic sea ice and drift along with the ice across the Arctic for an entire year. This would allow scientists to study Arctic climate processes over a full seasonal cycle while also experiencing firsthand the Arctic *transpolar drift*. The first and most crucial step in freezing the icebreaker in the sea ice was locating a suitable *ice floe***,** or large flat piece of sea ice, that the icebreaker could attach itself to when Arctic sea ice was at a seasonal minimum. The ice floe had to have very specific characteristics to be a suitable candidate. In this 2-day lesson, students will analyze Arctic sea ice data similarly to how MOSAiC scientists did to find a suitable ice floe for a similar Arctic research expedition.

Photo Credit: Sebastian Grote

Lesson Overview

Day 1

- *Part 1 - (15 minutes) Polarstern Searches for a Suitable Ice Floe*
  Use the Ice Floe Identification PPT to introduce students to the term, “ice floe” and to tell the story of the *Polarstern* searching for and attaching to a suitable ice floe.

- *Part 2 - (40 minutes) Find Your Floe Jigsaw*
  Students in a group are individually responsible for developing a specific expertise as it relates to one of three analyst roles (optical satellite imagery, ice thickness, drift). Students then share their expertise with their group and work together to solve a problem.

- *Part 3 - (5 minutes) What’s Next?*
  Preview Day 2: Students will work in their groups to analyze and interpret Arctic sea ice data to select an ice floe to attach an icebreaker to that fulfills certain criteria.

Day 2

- *Part 4 - (40 minutes) Find your Floe*
  Students work in research teams (groups) to analyze and interpret Arctic sea ice data to select a location containing suitable ice floes for attaching an icebreaker to.

- *Part 5 - (10 minutes) Defend your Floe*
  Research teams share which location they selected and justify their selection based on evidence (must consider evidence from satellite imagery, ice thickness, and drift patterns).

- *Part 6 - (10 minutes) Exit Ticket/Update Summary Table*
  Students reflect on their learning by completing an exit ticket and updating the whole class summary table.

Instructional Overview	
Grade Level	Middle/High School
Instructional Time	120 minutes
Standards Alignment	**NGSS Scientific Investigations Use a Variety of Methods:** ● Science investigations use a variety of methods and tools to make measurements and observations. **NGSS Science and Engineering Practices:** ● Analyzing and Interpreting Data ● Engaging in Argument from Evidence
Unit Driving Question	● How have scientific questions, methods, technologies, and our knowledge of the Arctic changed over time?
Driving Question For This lesson	● What do various data tell you about Arctic sea ice conditions, and how can you use this data to identify an ice floe with desired characteristics?
Learning Goals	● Scientific investigations use a variety of methods, and scientists use existing data and evidence to inform and achieve scientific research goals. ● Sea ice in the Arctic is dynamic and not uniform everywhere. It changes seasonally and over longer periods of time due to natural and human-induced forcings. ● We can get information about sea ice using a variety of instruments and methods (satellite, ice cores, drifting buoys, etc.).
Materials	**Day 1:** ❏ Ice Floe Identification PPT ❏ Day 1 Ice Floe Identification Student Worksheet (1 per student)

	❏ Day 1 Student role description sheets (1 set of role description sheet per group) ❏ Optical Satellite Imagery Analyst Role Sheet ❏ Ice Thickness Analyst Role Sheet ❏ Drift Analyst Role Sheet ❏ Day 1 Answer Key ❏ "A Fortress of Snow and Ice" video ❏ Learn MOSAiC: Finding the Floe video **Day 2:** ❏ Ice Floe Identification PPT ❏ Day 2 Ice Floe Identification Student Worksheet (1 per student) ❏ Find Your Floe Data Table (1 per student) ❏ Day 2 Answer Key ❏ Exit Ticket Rubric ❏ Summary Table - *if using entire unit* (large butcher paper or digital copy, 1 per class)
Material Preparation	❏ Cue and test web links ❏ Print student worksheets (1 per student) ❏ Print one set of role sheets (optical satellite imagery analyst, ice thickness analyst, drift analyst) for each group of 3 ❏ Review speaker notes in the Ice Floe Identification PPT ❏ Display summary table - *if using entire unit*
Vocabulary	Ice floe: A large, flat piece of floating ice Icebreaker: A ship that is specially designed to move through ice-covered waters Exclusive economic zone (EEZ): The area from a nation's coastline or some other baseline extending seaward 200 nautical miles (~230 miles) over which the nation has the rights to natural resources
Instructional Strategies	• Jigsaw: Students in a group are individually responsible for developing a specific expertise. They then share their expertise with their group and work together to solve a problem.

Day 1: Ice Floe Identification

Part 1 - Polarstern Searches for a Suitable Ice Floe (15 minutes)

Refer to Part 1 slides included in the Ice Floe Identification PPT. See PPT presenter notes for additional information.

1. Introduce your students to the MOSAiC research expedition. Present the story of the *Polarstern* searching for and attaching to a suitable ice floe (see presenter notes).

2. Introduce vocabulary terms: ice floe, icebreaker, and exclusive economic zone (EEZ). Students record definitions onto their student worksheets.

3. Watch "A Fortress of Ice and Snow" video to learn more about how MOSAiC scientists identified the ideal ice floe to attach the *Polarstern* to.

> **Optional:** Watch the "Learn MOSAiC: Finding the Floe" video to learn how MOSAiC scientists use satellite information to identify suitable ice floes in the Arctic.

4. Discuss the 6 characteristics of a "suitable" ice floe MOSAiC scientists considered when searching for an ice floe to attach the *Polarstern* to (see PPT slide #7).

Part 2 - Find Your Floe Jigsaw (40 minutes)

Refer to Part 2 slides included in the Ice Floe Identification PPT. See PPT presenter notes for additional information.

1. Separate students into research teams (groups of 3). Each team member is assigned a specific analyst role to help find an ice floe to attach a ship to: optical satellite imagery analyst, ice thickness analyst, drift analyst.
    a. Teacher: Distribute "Role Description" sheets to each research team.

2. Jigsaw: Students review individual Role Description sheets and answer the analyst questions before coming back together to share their expertise with the group/class.

3. Discuss the exercise as a class:
    a. *What does it mean to collaborate? Why do you think scientists collaborate or work in teams?*

Part 3 - What's Next? (5 minutes)

Refer to Part 3 slides included in the Ice Floe Identification PPT. See PPT presenter notes for additional information.

1. Preview Day 2: Students will work in their same groups and use their same analyst roles to analyze and interpret Arctic sea ice data to select an ice floe to park an icebreaker that fulfills certain criteria.

Day 2: Ice Floe Identification

Part 4 - Find Your Floe (40 minutes)

Refer to Part 4 slides included in the Ice Floe Identification PPT. See PPT presenter notes for additional information.

1. Distribute Day 2 student worksheet.
    a. Students will refer to their "Role Description" sheets (distributed Day 1) in this activity.

2. Warm up: Why is collaboration (working together) so important in science? (Reflect on your experience as part of your research team).
    a. Use this warm up as an opportunity to review Day 1 including the 6 ice floe characteristics suitable for attaching an icebreaker to and each of the analyst roles: optical satellite imagery analyst, ice thickness analyst, drift analyst.

3. Divide students into their research teams established in Day 1 and introduce them to their task:

    "*You are now in research teams who will be conducting a research expedition similar to MOSAiC. As a team, you need to identify an ice floe that is suitable to park/attach your icebreaker in. You will be using data and the ice floe guidelines from MOSAiC to do this. Each team member will take on a specific role and expertise and be individually responsible for analyzing specific datasets. You will share what you've learned with your team members to decide on a suitable ice floe together. Be prepared to justify your decision with data and evidence.*"

4. Students work as a research team, using their role description sheets (distributed on Day 1), to complete the "Find Your Floe Data Table" and determine which of the 5 locations contains ice floes suitable for attaching an icebreaker to.

Part 5 - Defend Your Floe (10 minutes)

Refer to Part 5 slides included in the Ice Floe Identification PPT. See PPT presenter notes for additional information.

1. Defend your Floe: Ask each group to briefly explain which location contains ice floes best suited for parking their icebreaker in and why.
    a. Discuss the exercise as a class:
        i. *What does it mean to collaborate? Why do you think scientists collaborate or work in teams?*
        ii. *Could you have chosen a suitable ice floe on just the information you had for your specific role? Why or why not?*

Part 6 - Exit Ticket/Update Summary Table (10 minutes)

Refer to Part 6 slides included in the Ice Floe Identification PPT. See PPT presenter notes for additional information.

1. Exit Ticket - Students provide a short explanation and create an annotated sketch to address the prompt, “Explain how you used each group member’s expertise to choose an ice floe for your expedition.”
    a. Project and describe the Exit Ticket Rubric to the class before they begin the assessment as this is what you will use to grade their exit tickets.

2. Update Summary Table ***(if using entire unit)*** - Gather student ideas to update the MOSAiC Navigation/Technologies box in the summary table (see Answer Key).