# Waves in the Marginal Ice Zone

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## Introduction:

The Marginal Ice Zone (MIZ) is a transitional zone that exists between the vast ocean and very thick, drifting ice (Dumont 2022). This zone is located on the edges of the Arctic and Antarctic pack ice(Horvat 2022). The Marginal Ice Zone plays an essential role in maintaining homeostasis in all of earth's oceans. For example, how the Marginal Ice Zone mediates climate change by shielding larger ice shelves from surface waves is an essential topic to understand for dealing with future climate issues. The purpose of our research was to create a visual representation of the waves that break up the ice in the Marginal Ice Zone and use this to educate middle school students about the Marginal Ice Zone. The importance of this zone is not included in curriculums for students, so many aren't aware of the drastic effect that it has on the rest of the world and ecosystem. By educating the next generation, we wanted them to understand how the Marginal Ice Zone works and how it impacts the entire world. We created a demonstration of how the Marginal Ice Zone works to present to students and determine whether it was effective in educating middle school students. Our hypothesis was that our representation of waves breaking ice in the Marginal Ice Zone would be effective in educating middle school students.

## Methods:

The first step was to create the physical representation of how the Marginal Ice Zone works. The main goal of the demonstration was to convey how waves in the Margina Ice Zone break apart ice, distribute it, and how this affects other parts of the ocean.

Materials Used:

A. 68-quart plastic container
B. Plastic
C. Wood
D. Styrofoam
E. Magnetic stirrer
F. Magnets
G. Gelatin
H. Molds

After creating the demonstration, we made a posterboard, script, and video of our demonstration. We also created a presentation with background information about the Marginal Ice Zone to share with the classroom. We gave our presentation and demonstration to an Earth and Space Science class at Swift Creek Middle School. To analyze whether we were effective in informing the students, the following questions were used to quantitatively evaluate the student's learning:

1. *What is the Marginal Ice Zone (MIZ)?*
   A. The area where ice melts the fastest.
   B. The transitional zone between open sea and dense drift ice.
   C. The coldest part of the ocean.
   D. The area where whales migrate to avoid ice.
2. *Why are larger waves important in the MIZ?*
   A. They freeze the ice faster.
   B. They open gaps in the ice, allowing oxygen to enter the water.
   C. They carry fish away from predators.
   D. They stop carbon dioxide from leaving the water.
3. *What happens when eddies affect the sea ice?*
   A. They push ice together or break it apart.
   B. They make the ice stronger.
   C. They melt the ice faster than waves.
   D. They create more topography under the ice.
4. *Which of these is a factor that affects sea ice distribution?*
   A. Ocean salinity
   B. The season of the year
   C. The color of the ice
   D. Winds that push and pile up ice
5. *Why does melting sea ice matter to ecosystems around the world?*
   A. It lowers the temperature of the ocean.
   B. It provides oxygen to deep waters and helps phytoplankton *spread.*
   C. It changes the color of the water and affects sunlight.
   D. It increases the size of fish populations near the Arctic.

From these questions, we calculated each students average on the pre-test and on the post-test and compared them using an unpaired t-test. We chose to use a p-value of 0.05 to determine statistical significance.

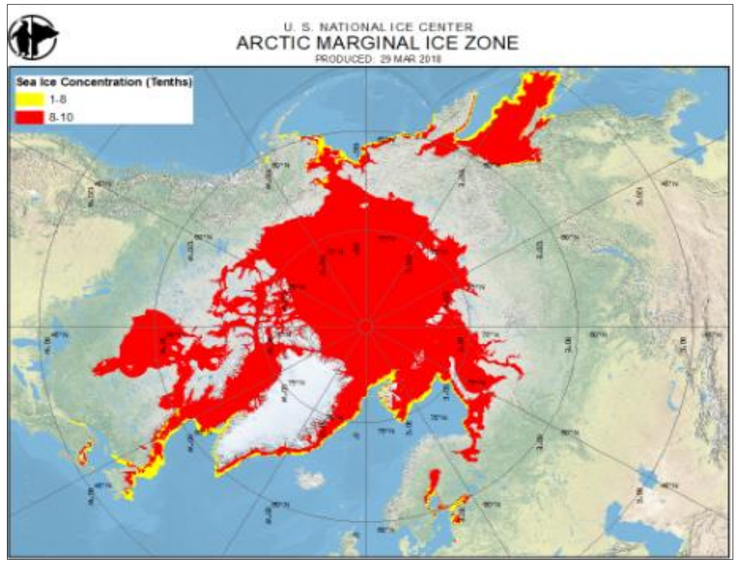


Figure 1: A map of the Marginal Ice Zone and its location. The red portion shows thicker, denser pack ice. The yellow represents the Marginal Ice Zone. We used this image to provide context to our students that we presented to.
Source: U.S. National Ice Center, 29 March, 2018, https://usicecenter.gov/Catalog/ArcticMizChart

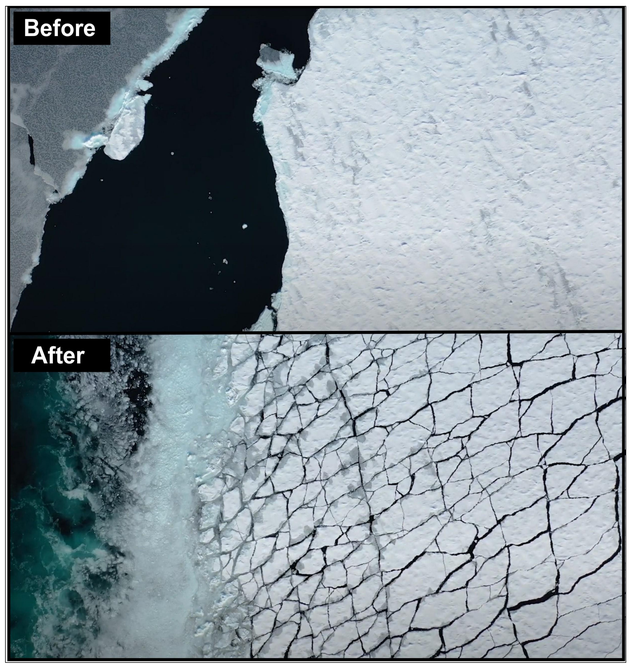


Figure 2: The images above compare a section of the Marginal Ice Zone before increased wave action and after increased wave action. This image provided an idea of how the demonstration would accurately represent how waves break apart ice in the Marginal Ice Zone.
Source: Elie Dumas-Lefebvre/Université du Québec à Rimouski, 20 February, 2023. DOI: 10.5194/tc-17-827-2023, 2023.

## Results:

A t-test was used to compare the results from the pre-tests and post-tests that the students were required to take prior to and after our presentation and showing them the demonstration. The pre-test average was 52.31%. The post-test average was 93.60%.
The p-value calculated was 8E-12.

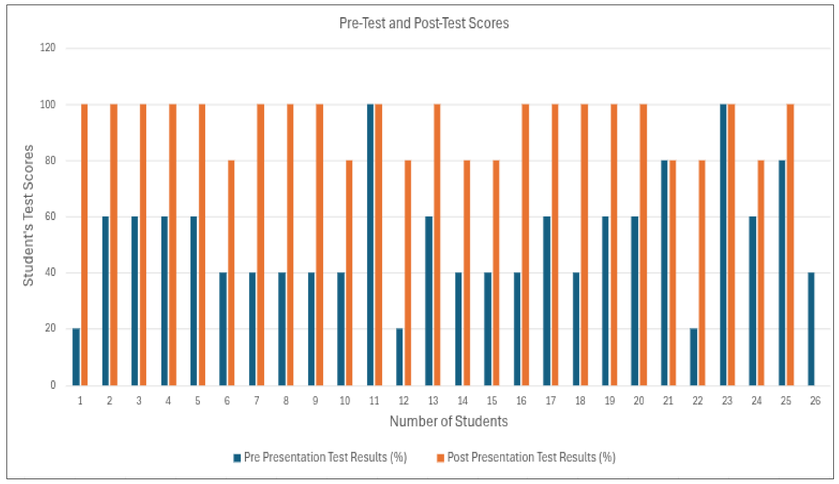


Figure 3: This graph shows the student's individual test scores from the pre-test and post-test. The pre-test scores are shown by the blue bars. The post-test scores are shown by the orange bars. One limitation for this project is that one of the students did not turn his post-test in, which went unnoticed until the data analysis. While this does prove to be a limitation, because the averages were considerably different and the p-value was extremely low, his test would not have changed the data considerably.

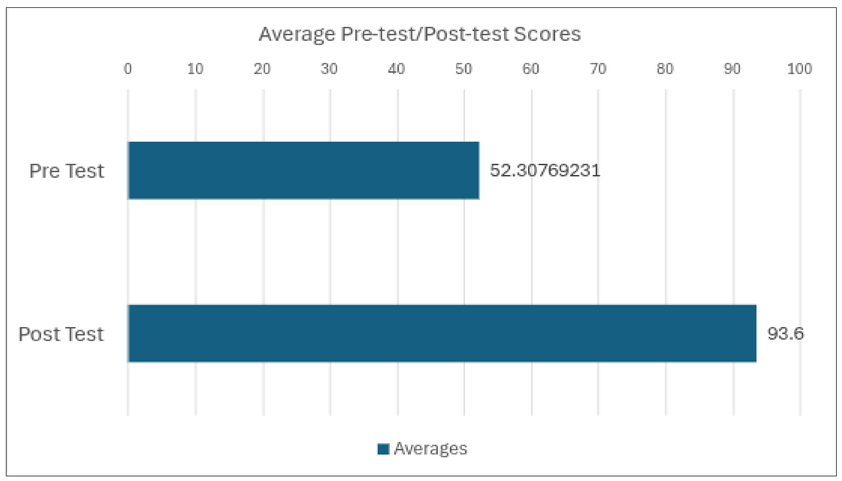


Figure 4: This graph shows the averages of the student's pre-test results and post-test results. the average of the pre-test score was a 52.31%. The average of the post-test score was a 93.6%.

## Discussion:

The results of our experiment strongly indicate that our demonstration and presentation were effective in educating the next generation about the Marginal Ice Zone and its critical importance. Our analysis showed a statistically significant improvement in participants' understanding, as evidenced by a p-value considerably less than 0.05 in the comparison of pre- and post-assessment responses. This statistical significance confirms that our educational approach successfully conveyed key information about the Marginal Ice Zone, reinforcing the value of targeted learning interventions on this topic.

Our findings are particularly important for the future of the next generation, as knowledge about the Marginal Ice Zone remains limited and is not widely included in standard educational curriculums. Despite its crucial role in global ecosystems and climate regulation, this region often goes overlooked in formal education. By addressing this gap, our work contributes to raising awareness about an issue that will increasingly impact the planet.

Understanding the Marginal Ice Zone is more critical now than ever, as environmental challenges in this area are escalating at an alarming rate due to climate change and other human-induced factors. Future generations will face the consequences of these changes, making it essential that they are well-informed and prepared to tackle the associated challenges. Providing students with the necessary knowledge empowers them to engage in meaningful discussions, advocate for policy changes, and contribute to scientific and environmental solutions. Our study highlights the necessity of integrating this topic into broader educational programs, ensuring that the next generation is equipped with the knowledge and tools to address the pressing environmental issues of the future

## Resources:


- Dumas-Lefebvre, E. and Dumont, D.: Aerial observations of sea ice breakup by ship waves, The Cryosphere, 17, 827–842, https://doi.org/10.5194/tc-17-827-2023, 2023.
- Bennetts LG, Bitz CM, Feltham DL, Kohout AL, Meylan MH. 2022 Marginal ice zone dynamics: future research perspectives and pathways.Phil. Trans. R. Soc. A 380: 20210267. https://doi.org/10.1098/rsta.2021.0267
- Dumont D. 2022 Marginal ice zone dynamics: history, definitions and research perspectives.Phil. Trans. R. Soc. A 380: 20210253. https://doi.org/10.1098/rsta.2021.0253
- Horvat C. 2022 Floes, the marginal ice zone and coupled wave-sea-ice feedbacks.Phil. Trans. R. Soc. A 380: 20210252. https://doi.org/10.1098/rsta.2021.0252
- APL-UW. Marginal Ice Zone (MIZ) Program. [Video] YouTube. https://www.youtube.com/watch?v=a_nbMdhS0qE


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