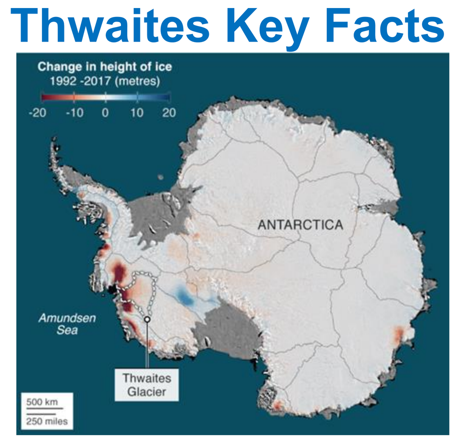
GLACIER GEOENGINEERING

Thwaites Key Facts



Thwaites is one of the world's largest glaciers and is in western Antarctica.

Scientists are worried that Thwaites may collapse in the next twenty years due to the warmer ocean waters melting the Thwaites ice shelf.

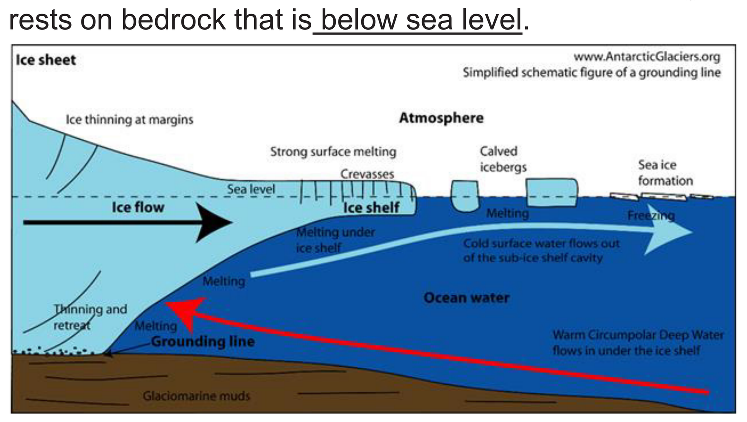
Source: Tom Slater, CPOM

The Thwaites Glacier measures approximately 74,000 sq. miles which is slightly larger than the size of Florida. The Thwaites Glacier is the widest glacier on earth, at approximately 180 miles wide.

Global warming from greenhouse gasses is causing the ocean waters to warm and glaciers to melt.

Why is Thwaites vulnerable?

Thwaites is vulnerable to rapid and extensive melting because the glacier rests on bedrock that is below sea level.



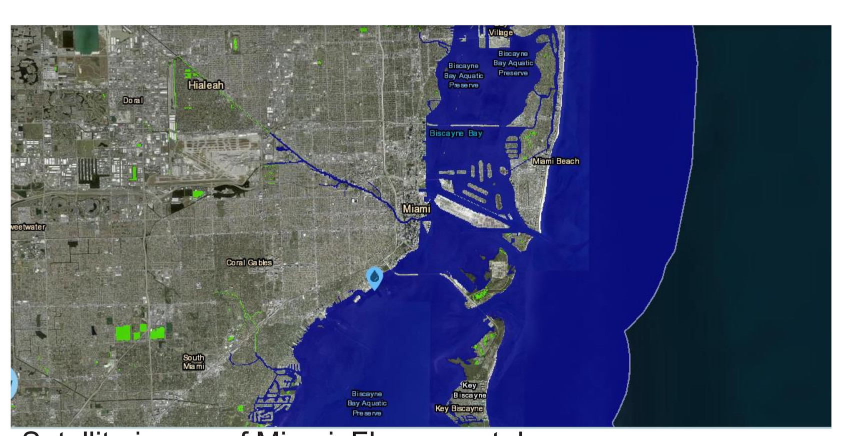
Source: Glacier Antarctica Organization

The warm ocean waters are melting the Thwaites ice shelf and causing the grounding line to retreat. Currently, Thwaites is responsible for 4% of sea level rise. However, if Thwaites collapses and melts entirely, sea levels will rise by more than 2 feet.

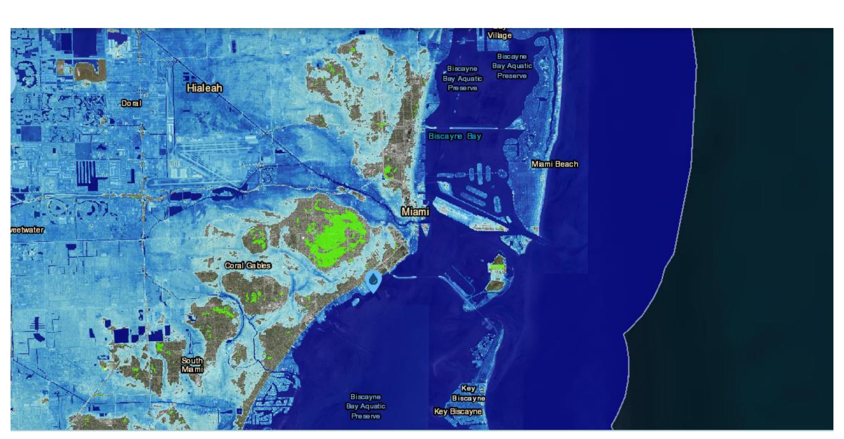
"Doomsday" Glacier

Thwaites is known as the "Doomsday Glacier " because if it collapses, it could trigger other nearby glaciers (in the Western Antarctic ice sheet) to collapse and melt, **raising sea levels by approximately ten feet**. This is why glaciologists are focused on geoengineering solutions, in addition to reducing greenhouse emissions.

If Thwaites collapses, the rise in sea level will cause devastating effects to the planet- wiping out small islands, coastal communities and even very large cities along low-lying areas of the coastline.



Satellite image of Miami, FL, present day:



Satellite image of Miami, FL, if Thwaites and nearby glaciers collapse:

Source: NOAA, screen captures from interactive Sea level Rise Viewer

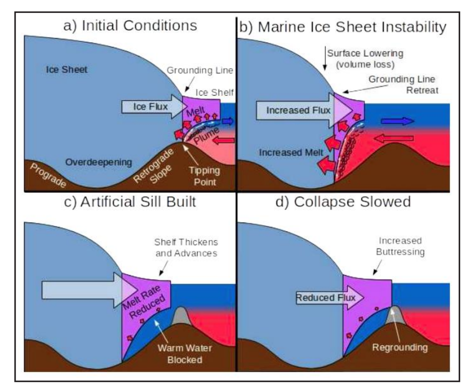
What is Glacier Geoengineering?

Glacier Geoengineering is the deliberate modification of the climate system around a glacier to slow the melt of the ice shelf and reduce sea level rise.

This project focuses on the study of blocking or slowing warm ocean water from reaching the ice shelf extending from the Thwaites glacier, preventing the collapse of the glacier into the ocean.

Thwaites Glacier
Source: Felton Davis / Flicker

Proposed Geoengineered Ideas



Source: Michael Wolovick and John Moore, The Cryosphere.

Glaciologists from Princeton University initially proposed using an artificial sill built on the seafloor to block warm waters. However, the cost and design of a sill was very expensive.

So, the Princeton researchers teamed up with glaciologists from the University of British Columbia. Their idea evolved to a flexible, moving seabed curtain that was anchored instead.

My Geoengineered Design

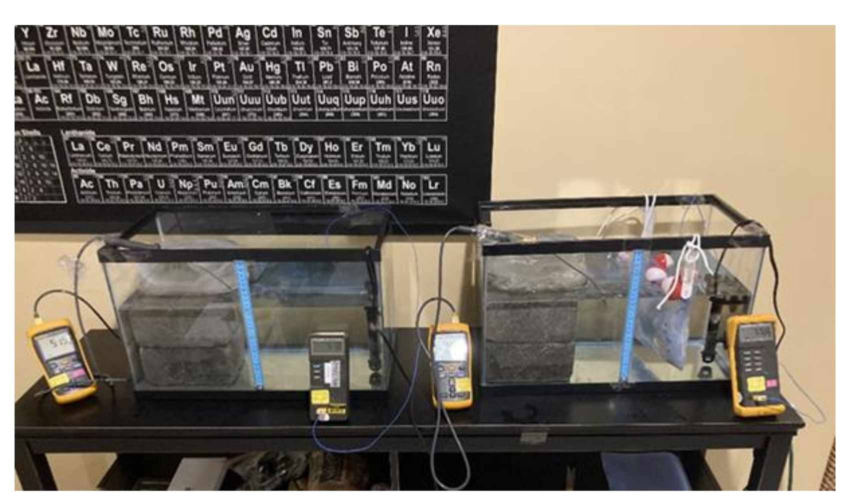
My curtain was constructed with a Ziploc silicone bag, plastic tubes filled with sand, fishing weights, and fishing bobbers. I used a silicone bag because silicone is a very good thermal insulator and the construction of the bag felt sturdier.

Sand is also a good thermal insulator, so I wanted to use that material. Plastic tubes helped structure the sand. One tube was filled with air because I needed to balance the weight of the curtain.

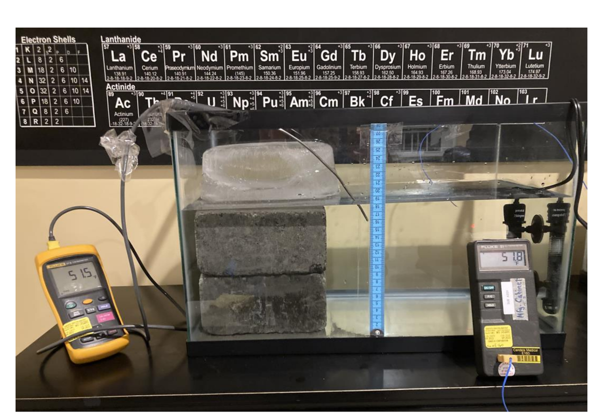
Source: Photo, Stephen Cronin

The silicone bag or flexible curtain was able to float in the water and was anchored to the tank with Command hooks.

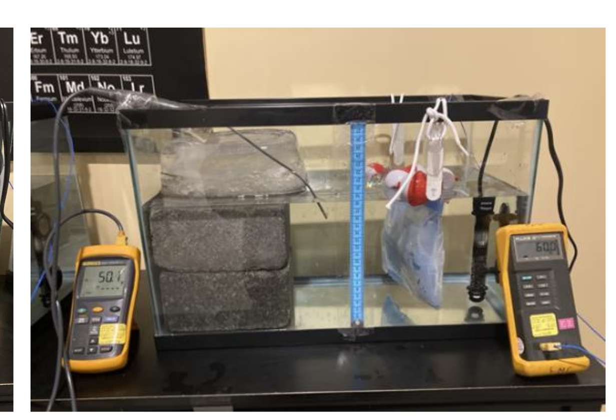
My Experiment Photographs



Front view of experiment running in progress.
Control tank is on the left. Test tank with curtain is on the right.



Control Aquarium with temperature probes measuring 51.5°F near ice shelf and 51.8°F near heater.

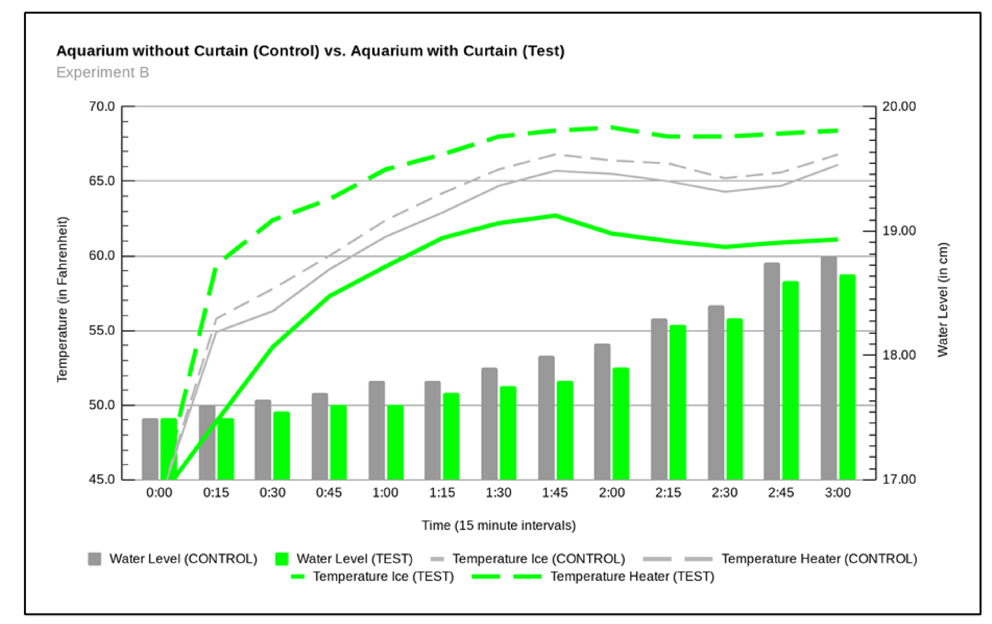


Test Aquarium with temperature probes measuring 50.1°F near ice shelf and 60.0°F near heater.

Source: Stephen Cronin, all photographs

Results

I ran five experiments, and each result supported my hypothesis. Experiment B is shown below.



Experiment B						
	Control			Test		
	Aquarium without Curtain			Aquarium with Curtain		
Time	Water Level (cm)	Ti (F)	Th (F)	Water Level (cm)	Ti (F)	Th (F)
0:00	17.50	43.6	43.6	17.50	43.8	43.8
0:15	17.60	54.9	55.8	17.50	48.9	59.4
0:30	17.65	56.3	57.8	17.55	53.9	62.4
0:45	17.70	59.1	60.0	17.60	57.3	63.8
1:00	17.80	61.3	62.4	17.60	59.3	65.8
1:15	17.80	62.9	64.2	17.70	61.2	66.8
1:30	17.90	64.7	65.8	17.75	62.2	68.0
1:45	18.00	65.7	66.8	17.80	62.7	68.4
2:00	18.10	65.5	66.4	17.90	61.5	68.6
2:15	18.30	65.0	66.2	18.25	61.0	68.0
2:30	18.40	64.3	65.2	18.30	60.6	68.0
2:45	18.75	64.7	65.6	18.60	60.9	68.2
3:00	18.80	66.1	66.8	18.65	61.1	68.4

Ice shelf completely melted in Control by 3:00 hours

Source: Graph and Table, Stephen Cronin

Key Observations

1. **The curtain prevented the warm waters from reaching the ice block.** In the test aquarium, the temperature near the heater was significantly warmer (6-9 °F) than the temperature near the ice block.

   The green lines above show the temperature difference between the two temperature probes in the test aquarium. This happened in each experiment.

2. **The water level in the control aquarium was higher than the test aquarium** (except for Experiment C). This most likely was because there was no curtain in the control aquarium, **allowing the heated water to mix with the cooler water.**

   The gray lines above show that heat transfers easily from the heater to the ice shelf without the use of a curtain.

Problem Statement

How Can Geoengineering Slow The Melt Of An Ice Shelf?

Hypothesis

My hypothesis is that a geoengineered wall (or curtain) will prevent warmer ocean waters from reaching the ice shelf, slowing the melt rate of the ice shelf.

In my experiment, an aquarium with a geoengineered wall will prevent warmer waters from reaching the ice block. The geoengineered wall (or curtain) slows the rate of ice melt compared to the aquarium without a wall.

Independent Variable

The aquariums will simulate the Antarctic ice shelf and ocean waters.

One aquarium will have a geoengineered wall (or curtain) that will slow the warmer waters from reaching the ice block. This is the "**Test**".

The other aquarium will have no wall and simulate the Antarctic ice shelf as it is today. This is the "**Control**."

The **independent variable** is the geoengineered wall (or curtain).

Dependent Variables

1. **Temperature in both aquariums**, measured in Fahrenheit. Temperature is recorded from two locations: (1) near the ice shelf/block and (2) near the heater.
2. **Amount of ice melted**, measured (in cm) by an increase in rising water level in the aquarium. The rise in water level simulates the rise of ocean levels.

Materials

I used the following materials in my experiment:

1. **Aquariums** - qty. 2, 10 gallon, approx. 20.1'' L x 10.1'' W x 12.5'' H
2. **Ice Blocks** - qty. 2, approx. 8.5''L x 5.75''W x 3.5''H. A mold was used to ensure the ice was approximately the same size.
3. **Temperature Probes** - qty. 4, two probes in each tank to record temperature near the ice block and near the heater.
4. **Concrete Blocks** - qty. 2, approx. 7''W x 7''Dx 3.5''H
5. **Water** - approx. 4.5 gallons per aquarium, refrigerated to 37℉
6. **Aquarium Heaters** - qty. 2, 150 Watts to heat the water.
7. **Geoengineered Curtain**
   a. qty. 1 Ziploc silicone bag measuring 8.6'' H x 9'' W x 1.65'' D.
   b. qty. 3 plastic tubes measuring 7.5'' L x 1'' Dia
   c. Sand approx. ½ cup
   d. qty. 5 fishing bobbers
   e. qty. 5 safety pins
   f. qty. 4 fishing weights
   g. qty. 2 command hooks and string to anchor

The ice blocks simulate the Thwaites' ice shelf. The concrete blocks simulate the Antarctic bedrock resting underneath the glacier. Finally, the heaters simulate the warming ocean waters due to global warming.

Conclusion

The results from the five repeated experiments support my hypothesis.

The temperature difference between the two probes in the aquarium with the geoengineered curtain was significant and ranged between 6-10℉. This difference in temperature slowed the melt of the ice block.

This suggests that a geoengineered structure, like a flexible moving curtain, could slow the rate of glacial melting and the devastating effects from climate change. It would help buy more time, as the world transitions to renewable energy.