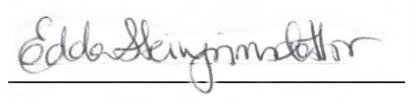
Harnessing Dynamics:
Exploring Scale & Coastal Infrastructure in the Arctic

A Thesis Submitted to the Department of Architecture
Harvard University Graduate School of Design, by

Edda Steingrimsdottir

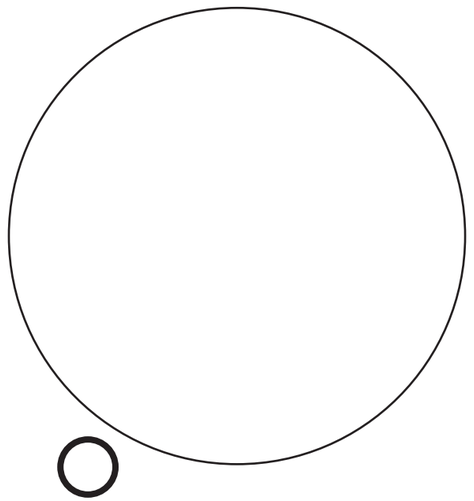
In Partial Fulfillment of the Requirements for the Degree of
[Masterof Architecture]

January 2022
(Month and Year Thesis Submitted)



Edda Steingrimsdottir

Jeannette Kuo



HARNESSING DYNAMICS

Exploring Scale & Coastal Infrastructure in the Arctic

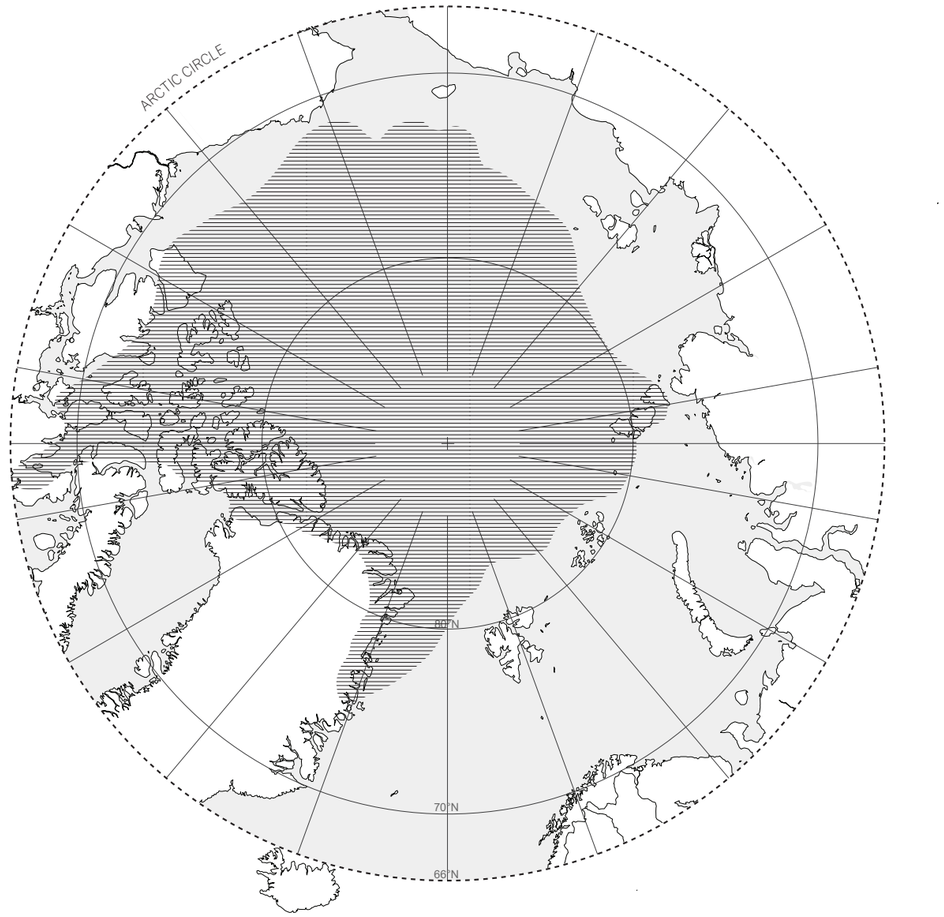
Edda Steingrimsdottir - Fall 2021
Advisor: Jeannette Kuo

contents:

Infrastructure is crucial for survival in extreme environments. However, it is often built with little consideration for its environmental context or the broader needs of the community it serves. In the Arctic, small coastal communities are experiencing accelerating land erosion as a result of climate change. These communities have tight-knit cultures and are surrounded by dominating nature, sublime landscapes, and unpredictable weather. Introducing the coastal barriers necessary to protect these towns must be done with full consideration of the multiple scales at which the infrastructure will operate.

Standard infrastructure neutralizes natural dynamics and separates people from the environment. From large-scale forces such as land erosion to harnessing local atmospheric dynamics such as waves, wind, and fog, architecture must mediate between infrastructure, the natural environment, and the local community to create tangible experiences and meet the community's societal needs. Through the design of a coastal barrier system, this thesis proposes a framework for implementing critical infrastructure that becomes an extension of its surroundings, and harnesses natural dynamics to facilitate experiential opportunities.

INTRODUCTION



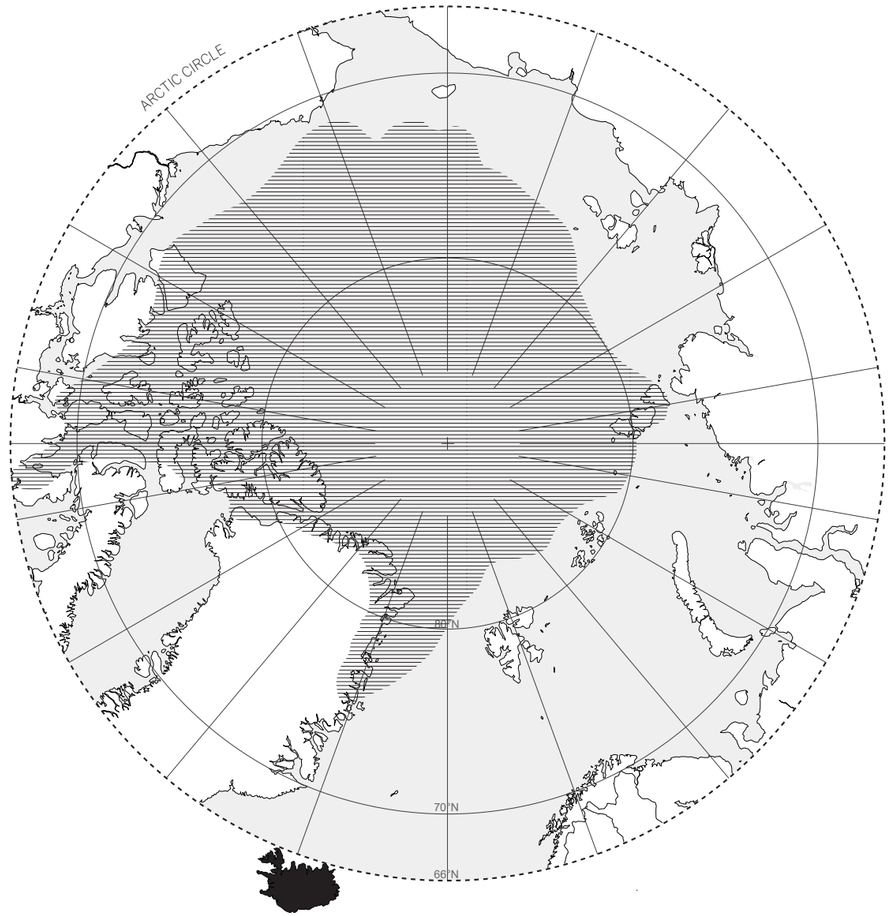
SITE: ARCTIC REGION

THE ARCTIC REGION

INTRODUCTION

SCRIPT:

Tangent to the Arctic Circle, Iceland is an isolated island halfway between North America and Europe.

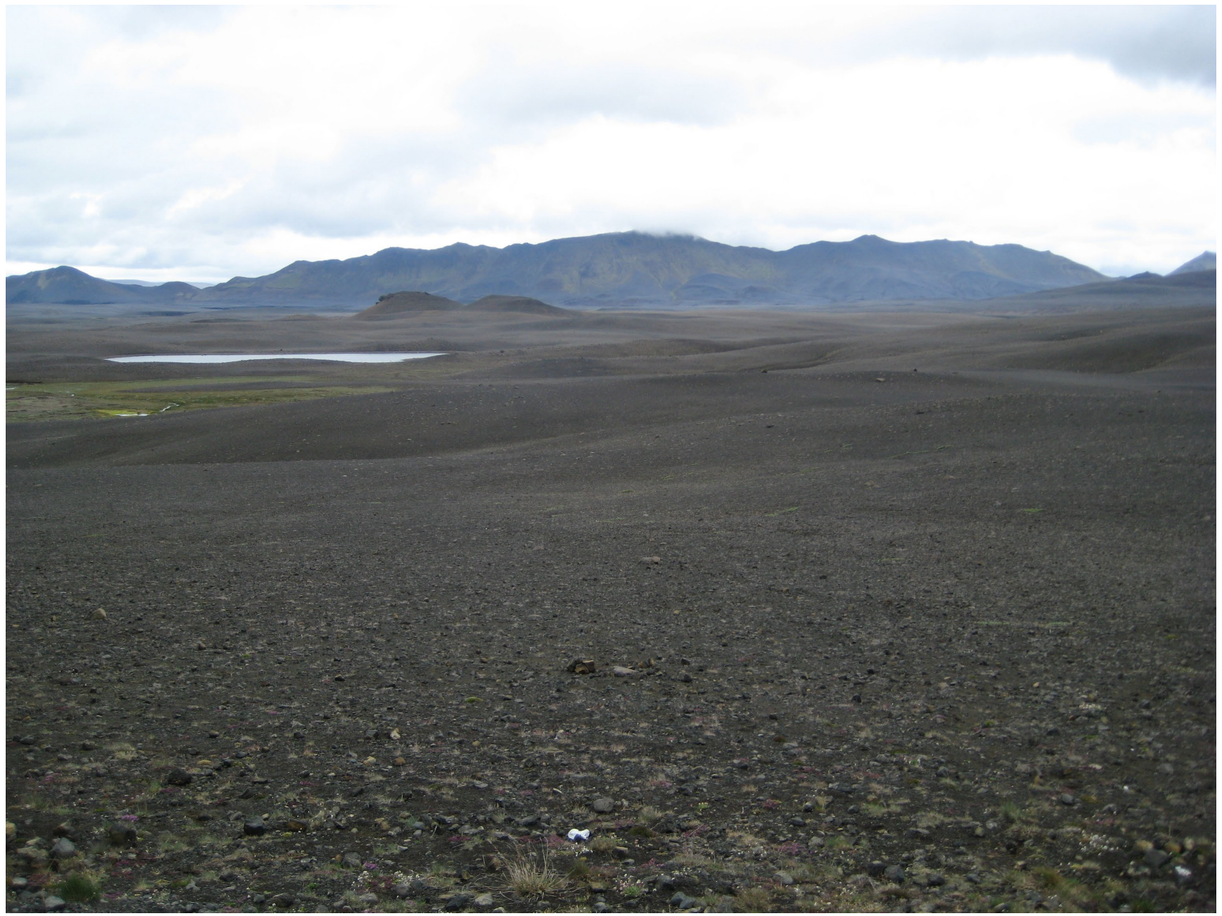


SITE: ICELAND

THE ARCTIC REGION

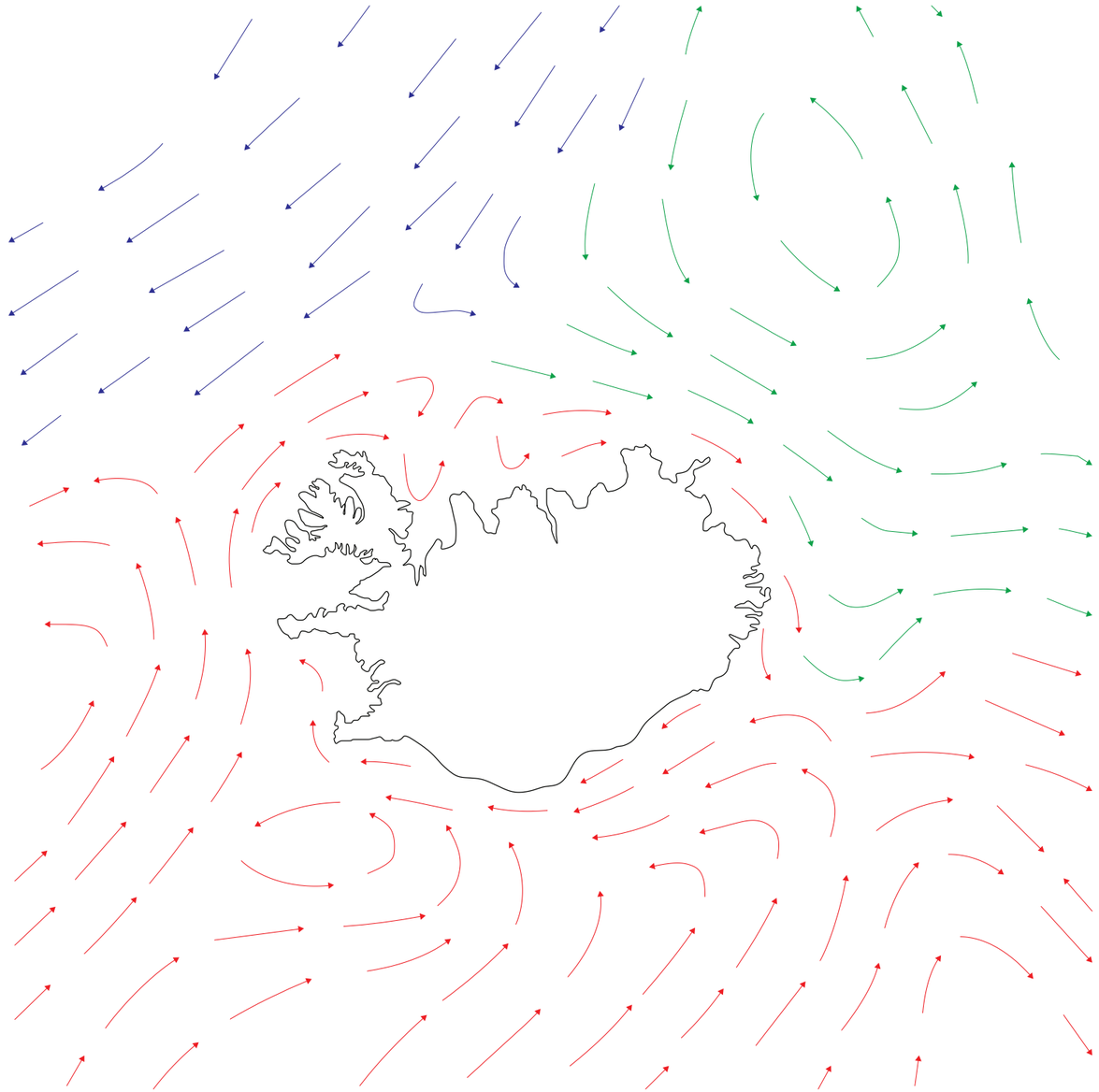
SCRIPT:

It's barren landscape stands exposed to the moist storms of the Gulf Stream, and the cold Arctic blasts from the North.



Barren Landscape.
Sprengisandur.
Iceland.

Image: "Barren Landscape off Route 1 in Southern Iceland." Accessed December 4, 2021. http://www.nothingisreal.com/photos/Iceland/Iceland_2009/tn/img_0321.jpg.index.html.



Ocean Currents.
Warm Salty Atlantic Ocean meets the cold less salty Polar Ocean.

SITE: ICELAND

THE ARCTIC REGION

SCRIPT:

Iceland is a microcosm of the larger Arctic Region.

Jökulsárlón.
Glacial Lagoon.
Iceland.

Image: "Shutterstock_99816977.Jpg (1200×630)." Accessed December 3, 2021. https://traveladestatic.imgix.net/media/original_images/shutterstock_99816977.jpg?fit=crop&w=1200&h=630&format=jpg&q=70.

SCRIPT:

The Arctic is made up of sublime landscapes, fragile nature, natural phenomena, small coastal communities, and vast natural resources.

First map of the Arctic.
Gerardus Mercator.
1595.

Image: "Mercator Map," accessed September 3, 2021. https://library.princeton.edu/visual_materials/maps/websites/north-west-passage/mercator.htm.

Lakagígar.
Sublime landsape.

Image: Hansen, Stian. "Laugavegur." Accessed September 3, 2021. https://www.icelandprotravel.com/individual-tours/special-interest/hiking/laugavegur.html.

Cottongrass.
Svalbard.
Norway.

Image: Jackrel, Rebecca. “Arctic Cottongrass.” Rebecca Jackrel Photograph. Accessed December 4, 2021. https://www.rebeccajackrel.com/image/I0000aVu1rArTTII.

Aurora Borealis.
Frederic Church. 1865.
The aurora borealis and the Arctic expedition of Isaac Hayes.

Image: Frederic Edwin Church, Aurora Borealis, 1865, oil on canvas, Smithsonian American Art Museum, Gift of Eleanor Blodgett, 1911.4.1

NATURAL PHENOMENA

THE ARCTIC REGION

Shishmaref.
Alaska.

Image: Keene, Eli. "Self-Preservation: Amid Debate, An Alaskan Village Decides to Move Inland." The Arctic Institute, July 11, 2017. https://www.thearcticinstitute.org/self-preservation-amid-debate-alaskan-village-decides-move-inland/.

Fishboat
Norway.

Image: The Independent Barents Observer. "When Plastic Becomes Part of Arctic Fish Diets." Accessed November 10, 2021. https://thebarentsobserver.com/en/node/5245.

INTRODUCTION

SCRIPT:

The Arctic is a place that has been frozen in time for thousands of years.

Stranded Iceberg.
Photo by Eliot Porter. 1976.

Image: Porter, Eliot. "Stranded Iceberg, Bismarck Strait, Antarctic Peninsula, Antarctica, February 1976." Artstor. Accessed September 10, 2021. http://jstor.org/stable/community.9845965.

PAST: FROZEN IN TIME

THE ARCTIC REGION

SCRIPT:

Yet over the past decades, it has experienced climate change at twice the rate of any other place on earth.

Ice Watch.
Studio Ólafur Elíasson.

Image: Sutcliffe, Justin. "Olafur Eliasson's Ice Watch Was Slowly Disappearing – Public Delivery." Accessed September 3, 2021. https://publicdelivery.org/olafur-eliasson-ice-watch/.

INTRODUCTION

SCRIPT:

A once impassable ice sheet will soon open up due to the warming temperatures.

'Perilous position of H.M.S. Terror, Captain Back, in the Arctic Regions in the summer of 1837'. William H. Smyth.

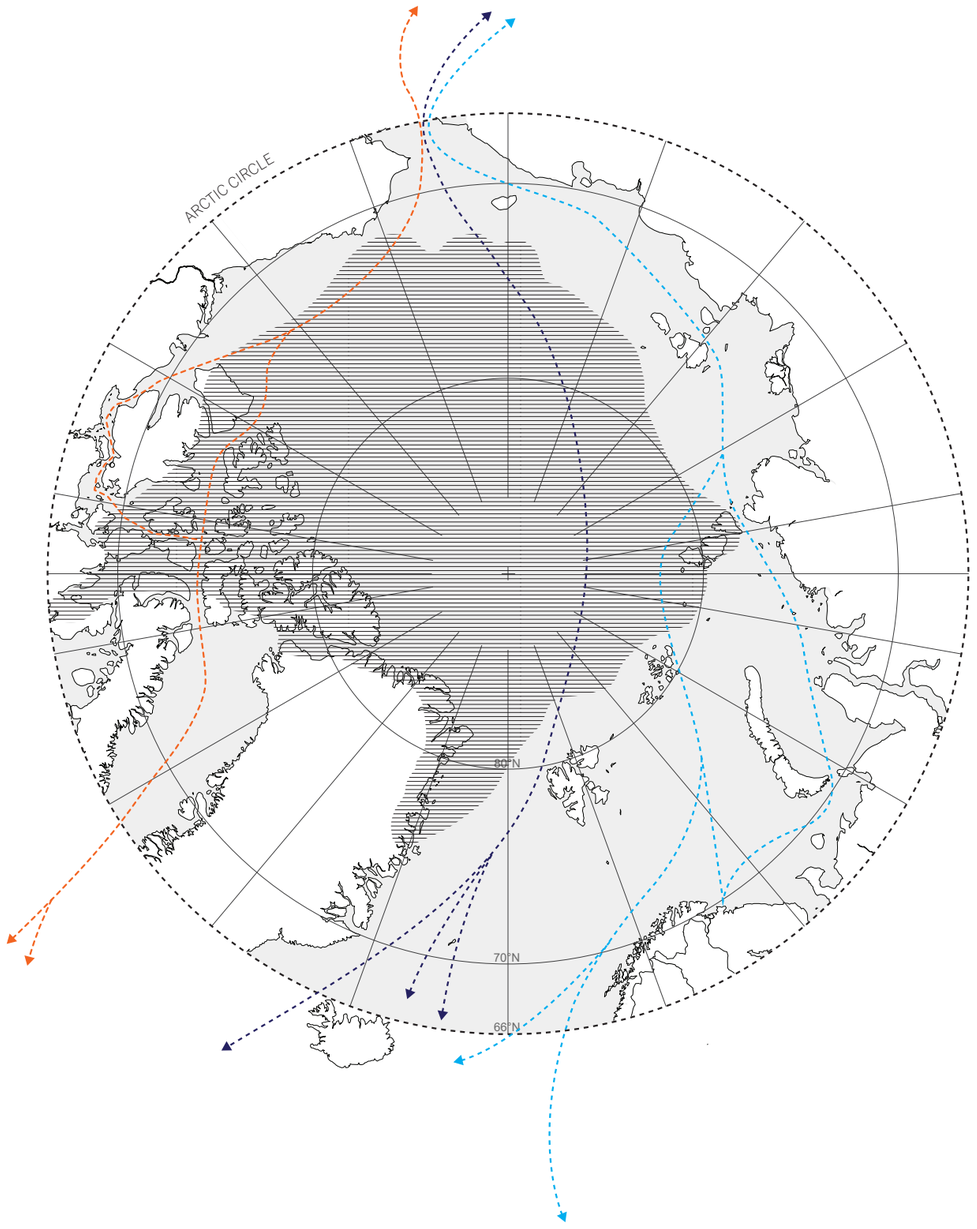
Image: Smyth, William. "Perilous Position of HMS 'Terror', Captain Back, in the Arctic Regions in the Summer of 1837 | Art UK." Art UK - National Maritime Museum. Accessed September 3, 2021. https://artuk.org/discover/artworks/perilous-position-of-hms-terror-captain-back-in-the-arctic-regions-in-the-summer-of-1837-175640.

Cargo.
Arctic Shipping.

Image: Medvedkov, A. Adobe Stock. Arctic Council. "First Arctic Shipping Status Report from PAME Working Group Highlights Increase in Arctic Shipping Traffic." Accessed September 3, 2021. https://arctic-council.org/news/first-arctic-shipping-status-report-increase-shipping-traffic/.

SCRIPT:

Introducing a new way to map the world and bridging together previously disparate continents, a new proximity between Europe and Asia, leading to new relationships and definitions of what is far away.



Nortwest Passage 5225 nautical miles
Northeast Passage 4740 nautical miles
Northern Sea Passage 4170 nautical miles

2010-30
2040-60
2070-90

Diagram by author. Information comes from World Economic Forum.
https://www.weforum.org/agenda/2020/02/ice-melting-arctic-transport-route-industry/

FUTURE: NEW PROXIMITIES

THE ARCTIC REGION

SCRIPT:

It's not just the ice that is melting, the very soil is also dissolving into the ocean.

Coastal erosion
Alaska.

Image: Stratus Consulting/University of Colorado. "NOAA Climate.Gov." Accessed October 5, 2021. https://www.climate.gov/media/7214.

INTRODUCTION

SCRIPT:

Coastal erosion is becoming a major problem for the 4 million Arctic inhabitants as a result of climate change.

Coastal erosion
Siberia.

Image: Oboimov, Alexsander. "Vanishing Arctic: How Warming Climate Leaves Remote Permafrost Islands on the Precipice." Siberian Times. Accessed October 6, 2021. https://siberiantimes.com/other/others/news/n0753-vanishing-arctic-how-warming-climate-leaves-remote-permafrost-islands-on-the-precipice/.

COASTAL EROSION

THE ARCTIC REGION

SCRIPT:

These regions often lack vegetation to bind the soil, and as the ground thaws, it becomes more susceptible to rising tides and increasingly extreme storms.

Coastal erosion
Utiquiagvik. Alaska.

Image: Farquharson, Louise. "Infrastructure and Community Resilience in the Changing Arctic: Status, Challenges, and Research Needs." The Arctic Institute (blog), March 23, 2021. https://www.thearcticinstitute.org/infrastructure-community-resilience-changing-arctic-status-challenges-research-needs/.

Storm.
Reykjavik.

Image: Pjetur. Icelandmag. "Severe Weather Alert for Today, Tomorrow: Dangerously Violent Storm in SE, Parts of W Iceland." Accessed December 3, 2021. https://icelandmag.is/article/severe-weather-alert-today-tomorrow-dangerously-violent-storm-se-parts-w-iceland.

INTRODUCTION

SCRIPT:

A coastal barrier is critical in order to preserve the ground underneath many Arctic towns.

Concrete Seawall.
Coastal Barrier.
Galvestone, U.S.

Image: Speaking of Geoscience. "Coastal Processes and Environments Under Sea-Level Rise and Changing Climate: Science to Inform Management," May 3, 2013. https://speakingofgeoscience.org/2013/05/03/coastal-processes-and-environments-under-sea-level-rise-and-changing-climate-science-to-inform-management/.

SCRIPT:

But these communities are small, they have tight knit cultures, and a very close relationship with the nature that surrounds them.

Raufarhöfn.
Iceland.

Image: "Raufarhöfn." Visit North Iceland. Accessed September 3, 2021. https://www.northiceland.is/en/destinations/towns/raufarhofn.

SCRIPT:

Traditional infrastructure could risk disrupting this in an irreversible way.

Floodwall.
Infrastructure.
Japan.

Image: Ono, Tadashi. FRAC Auvergne. "Coastal Motifs, 2017-2018 – Ryori Bay (1933-1960-2011) – Iwate Prefecture #1167." Accessed September 3, 2021. https://www.frac-auvergne.fr/oeuvre/coastal-motifs-2017-2018-ryori-bay-1933-1960-2011-iwate-prefecture-1167/.

SCRIPT:

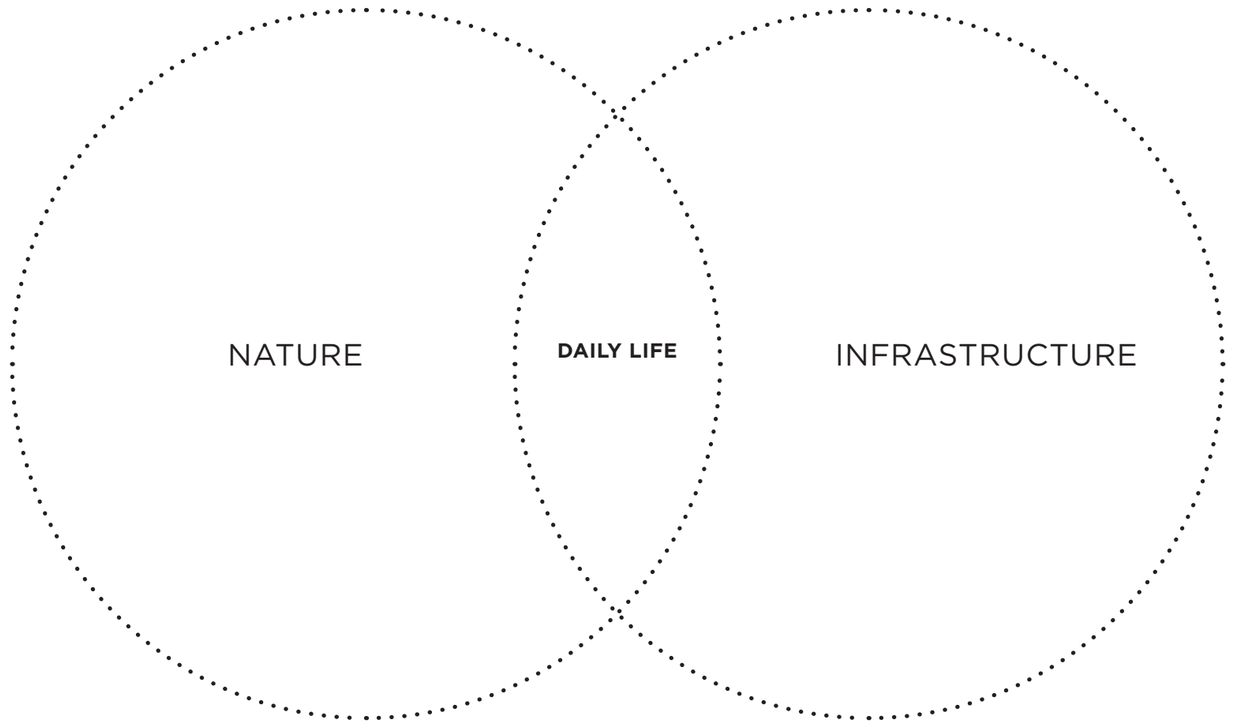
Like the flood walls built to protect Japanese fishing villages that simultaneously protected them from future floods, while blocking the village from it's very livelihood.

Floodwall.
Infrastructure.
Japan.

Image: "After the Tsunami: Japan's Sea Walls – in Pictures." The Guardian, March 9, 2018, sec. World news. http://www.theguardian.com/world/gallery/2018/mar/09/after-the-tsunami-japan-sea-walls-in-pictures.

SCRIPT:

Infrastructure needs to be built to protect against large scale forces, but it should be designed to enhance daily life.

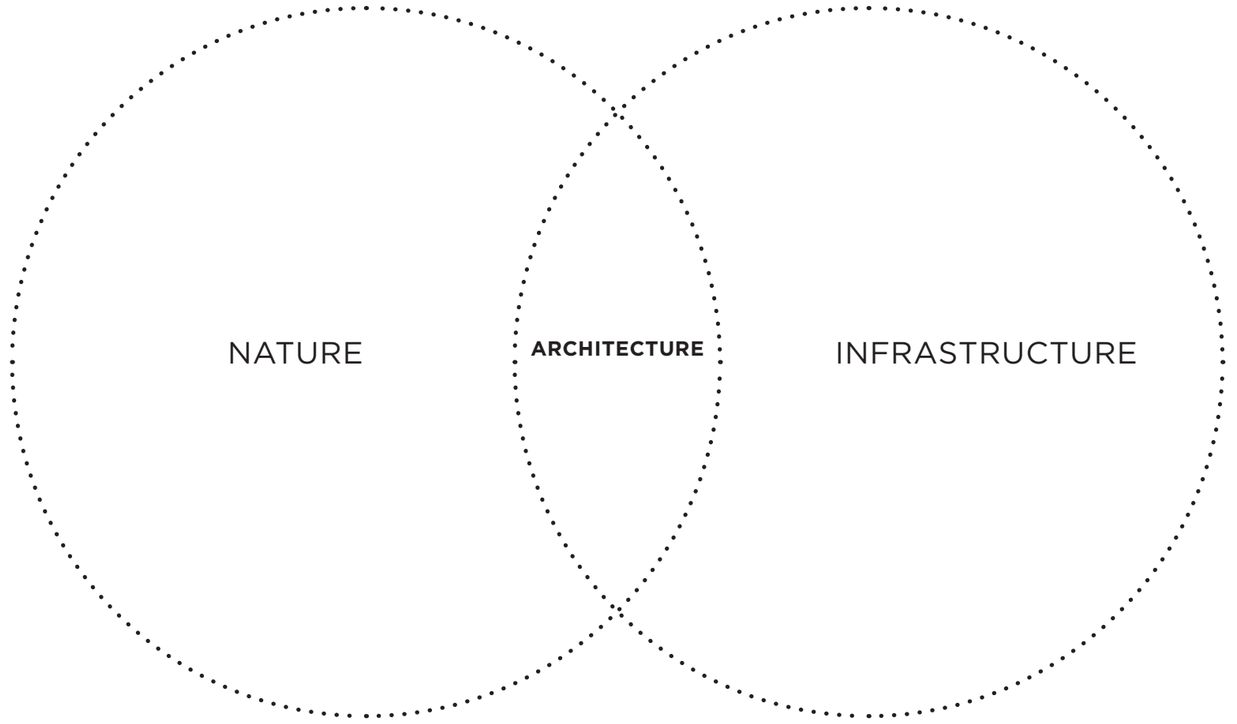


MEDIATOR

APPROACH

SCRIPT:

This thesis explores how architecture can mediate between the functionality of infrastructure and how it can integrate with its environment and the community it serves.

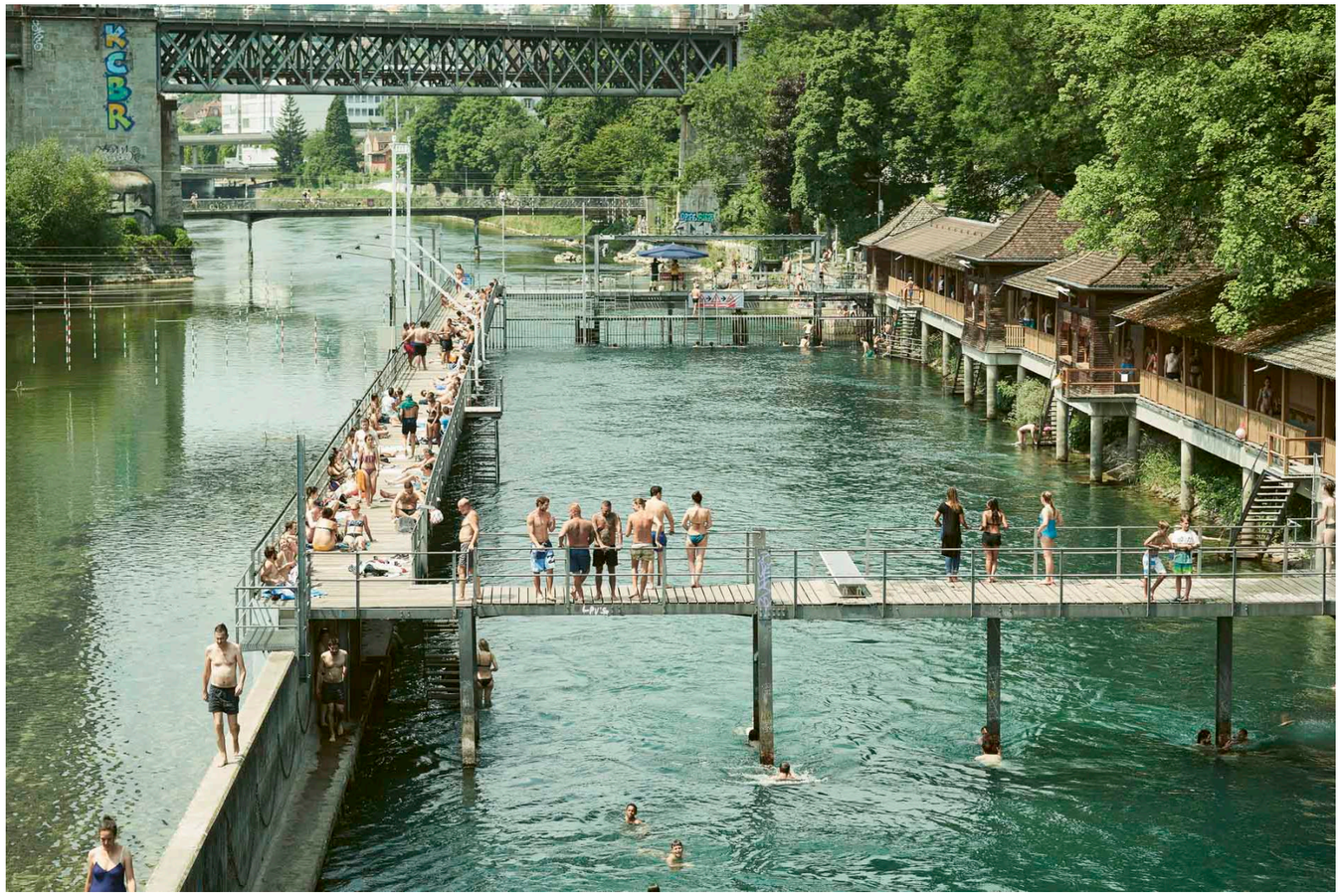


MEDIATOR

APPROACH

SCRIPT:

So, how can infrastructure become an outgrowth of its environment?



Bathing possible due to power station.
Limmat River.
Zurich.

Image: Winter, Magnus. Discovery. "Swim City: Zurich's Unique Summer Scene," August 25, 2017. https://discovery.cathaypacific.com/swim-city-zurichs-unique-summer-scene/.

INTRODUCTION

SCRIPT:

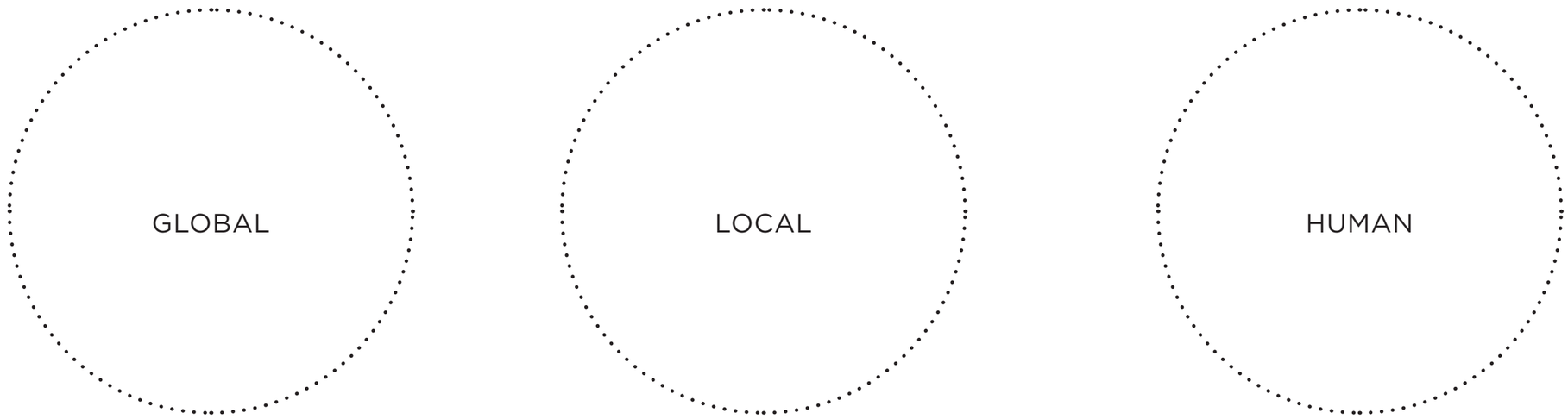
To begin our exploration, we must first break down the interconnected scales at which the design will operate within.

Géographie des plantes Équinoxiales: Section.
Alexander von Humbolt.
1805.

Image: Humboldt, Alexander von. "Géographie Des Plantes Équinoxiales: Tableau Physique Des Andes et Pays Voisins, from Essai Sur La Géographie Des Plantes,." Smithsonian American Art Museum. Accessed September 3, 2021. https://americanart.si.edu/exhibitions/humboldt/online/alexander-von-humboldt-bonpland.

INTERCONNECTED SCALES

APPROACH



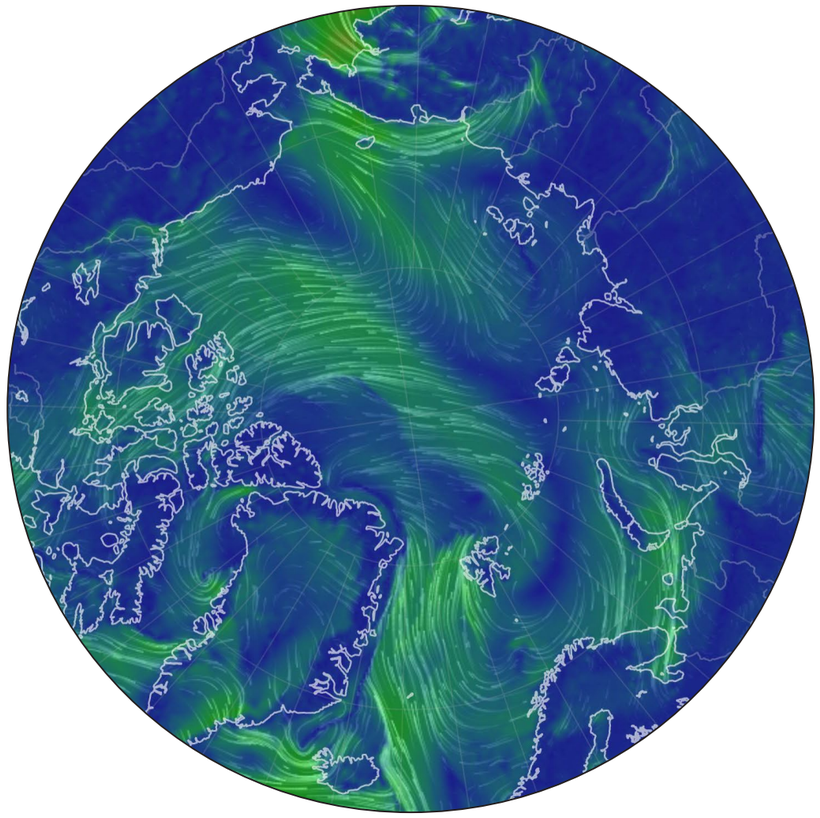
THREE SCALES OF REFERENCE

APPROACH

INTRODUCTION

SCRIPT:

At the highest level is the Global Scale, where the structure itself is responding to the large-scale natural forces that are causing coastal erosion.



Wind in the Arctic.
Screenshot from
https://earth.nullschool.net/

GLOBAL: ARCTIC CONTEXT

APPROACH

INTRODUCTION

SCRIPT:

As we zoom in, we observe the local climate around the structure as it interacts with the dynamics in its surroundings: wind, waves, and fog.

Image: Axelsson, Ragnar. Around Iceland 2015. Accessed January 10, 2022. https://icelandmonitor.mbl.is/news/nature_and_travel/2015/10/01/around_iceland_2015_grindavik_og_vogar/.

LOCAL: COASTAL LANDSCAPE

APPROACH

INTRODUCTION

SCRIPT:

Finally, there is a Human Scale, where the structure responds to an endless variety of potential benefits to the community within which it is built from recreational, to industrial, to tourism applications.

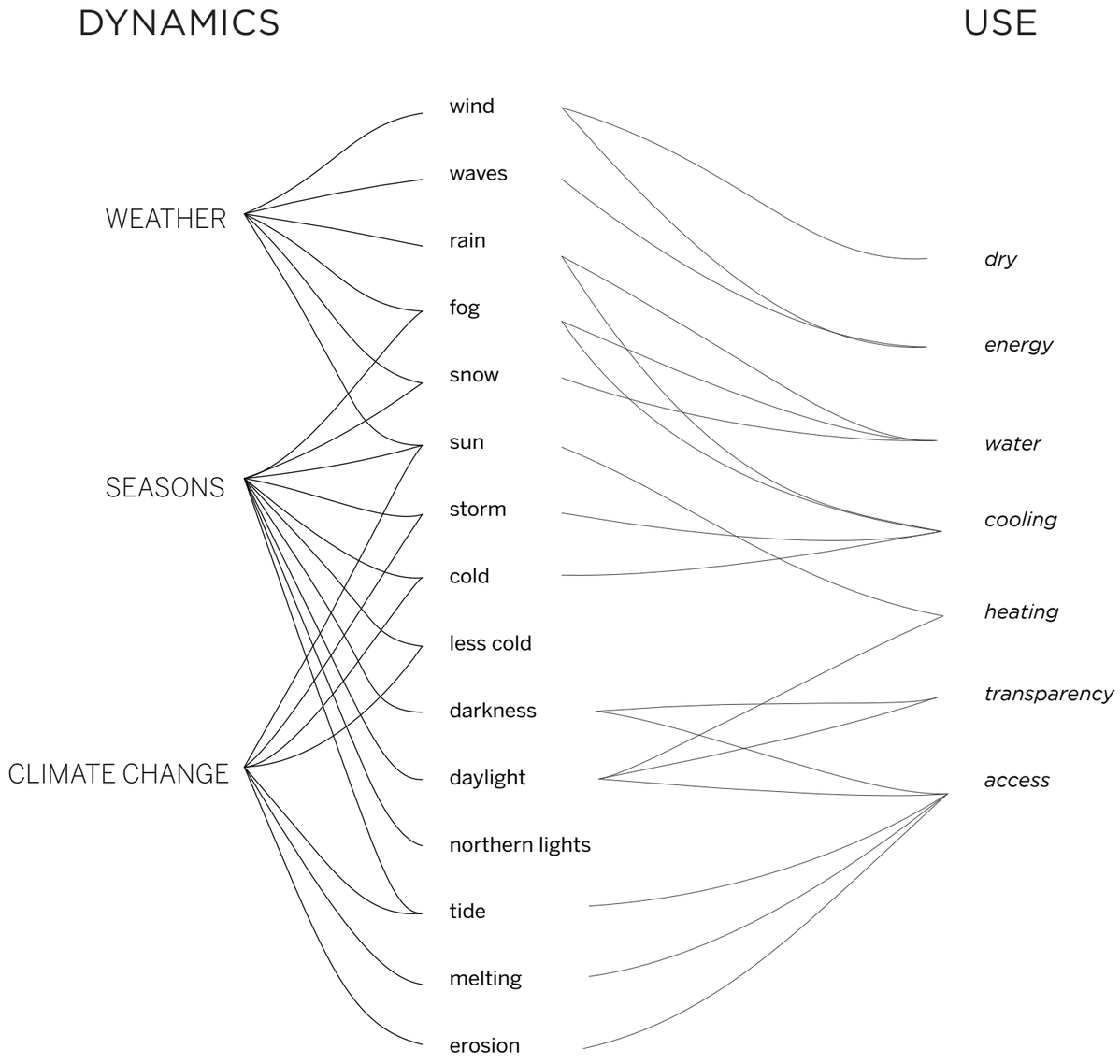
Image: People bathing in Secret Lagoon, Iceland.
http://kaijabeishline.com/wp-content/uploads/2017/01/img_9685-1.jpg

HUMAN INTERACTION

APPROACH

SCRIPT:

By harnessing the natural dynamics of the site, rather than turning them off, we enable the infrastructure to create unique experiences or utility for its visitors. This is critical, especially in places like the Arctic where the connection between people and nature is already so intertwined.



HARNESS DYNAMICS

APPROACH

INTRODUCTION

SCRIPT:

When introducing large infrastructure, the easiest choice might be to create an immutable separation between the community and the large forces it is protecting against.

SHELTER

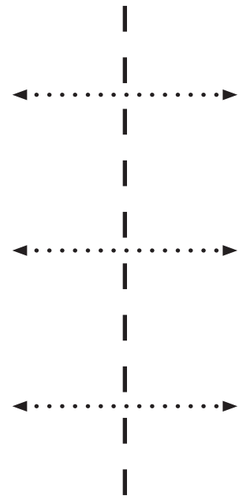
NATURAL FORCES

IMMUTABLE SEPARATION

APPROACH

SCRIPT:

But instead, this project takes it as an opportunity to create overlap within the infrastructure between people and their environment.



CREATING INTERACTIONS

APPROACH

67°
66°
65°
64°
63°
26°
24°
22°
20°
18°
16°
14°
12°

ARCTIC CIRCLE

FLATEYRI

SAUÐÁRKRÓKUR

RAUFARHÖFN

REYKJAVIK

ARCTIC REGION

FJORD
(fjörður)

Flateyri
66.07° N, 23.13° W

BAY
(vík)

Raufarhöfn
66.50° N, 15.40° W

BEACH
(strönd)

Sauðárkrokur
65.74° N, 19.64° W

THREE SITES

APPROACH

SITE 1: FJORD

fjörður

FLATEYRI
66.07° N, 23.13° W

SITE 1: FJORD

67°

66°

65°

64°

63°

26°

24°

22°

20°

18°

16°

14°

12°

ARCTIC CIRCLE

ARCTIC REGION

FLATEYRI

REYKJAVIK

SITE 1: FJORD

67°

26°

24°

22°

20°

18°

16°

14°

12°

ARCTIC CIRCLE

FLATEYRI

66°

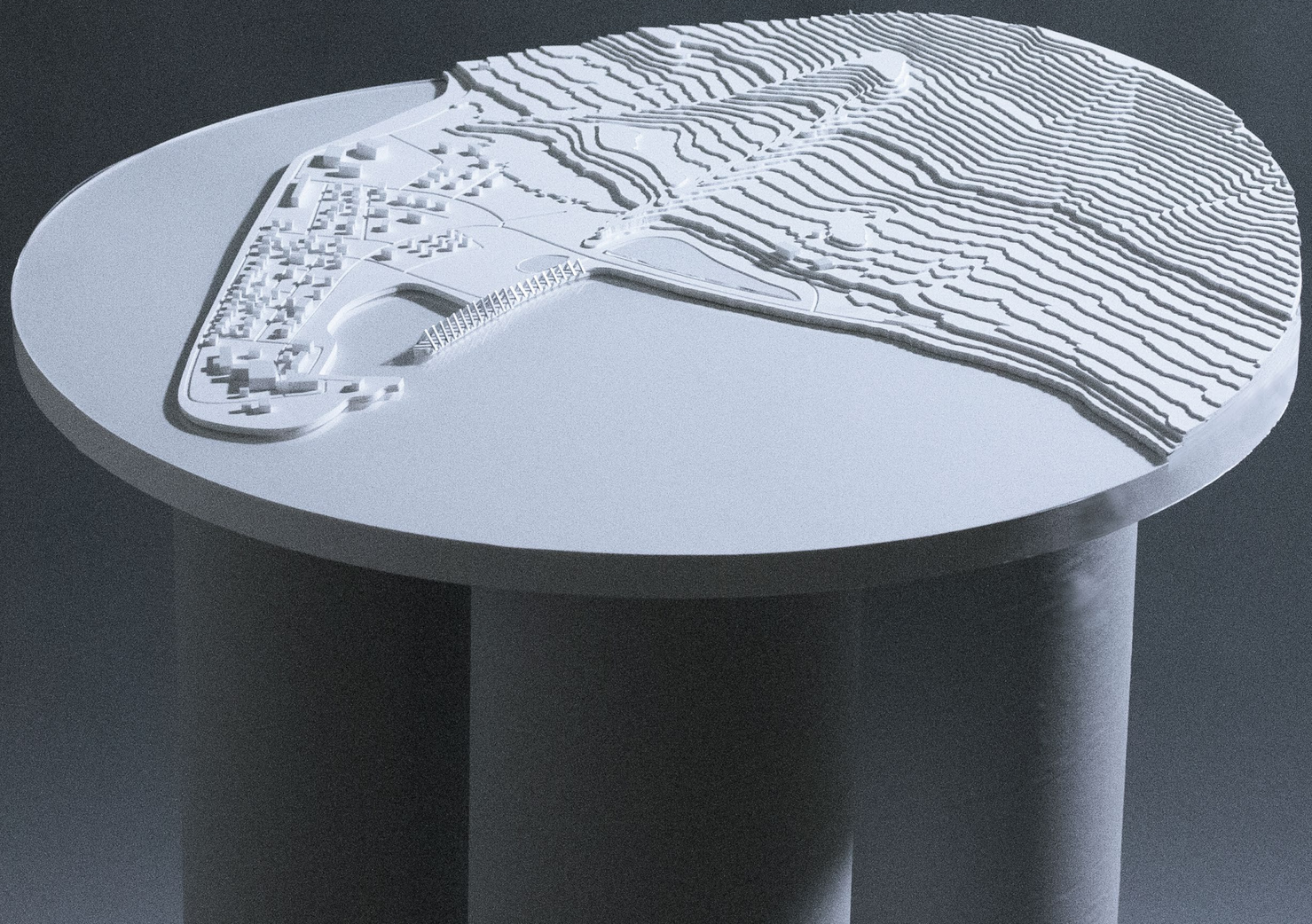
65°

REYKJAVIK

64°

63°

Flateyri, sits in a fjord in western Iceland. It's a small fishing village with a population of 200 people. The harbor is the town's primary economic driver and source of recreation. The steep fjord creates a refuge from the wind and a perfect setup for fog to roll in on the temperature differential between land and sea. The town has struggled to grow its population in recent years. It's off the beaten path for tourists. Little development has taken place in order to attract more people to experience its unique nature and landscapes. The fjords' ocean currents erode away the peninsula the town sits on. As the currents go in and out of the fjord, they excavate the soil and wash it out to sea. A standard coastal barrier would risk creating separation between the community and the harbor, the centerpiece of the town. How could this necessary piece of infrastructure be used to reverse the town's momentum, inviting people towards the harbor, and creating a destination for visitors to experience the town's unique environment?



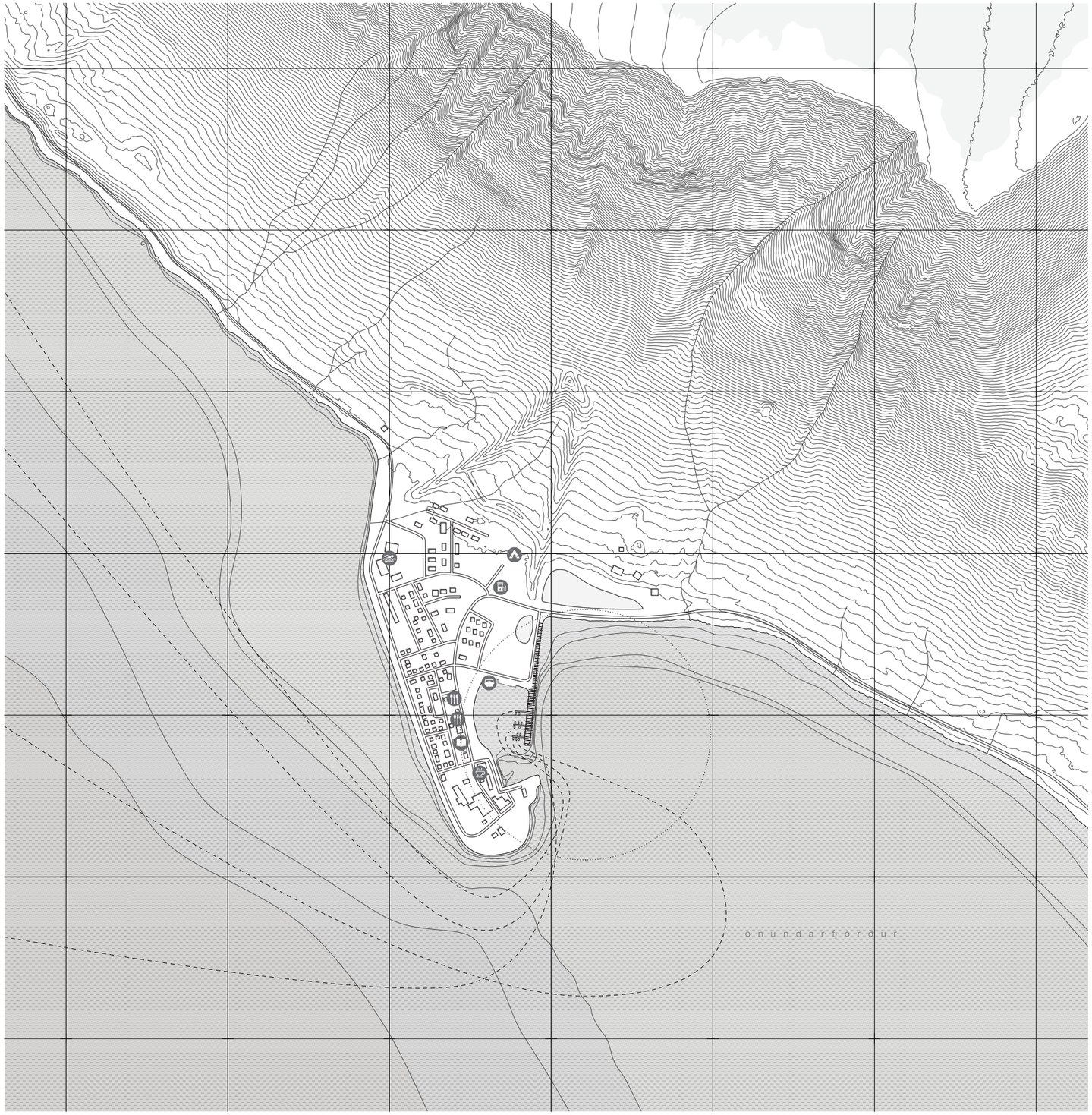
INDUSTRY
fishing boats stored on land

Image: Norstein, Efren. Flateyri Harbour. May 2021.
https://www.google.com/maps/place/Flateyri+Harbor/@66.049445,-23.512849,17z/

RECREATION
kayaking in the fjord

Image: "Kayak Tours / Paddleboarding." Visit Westfjords.
https://www.westfjords.is/en/experiences/tours/kayak-tours-paddleboarding.

SITE 1: FJORD



FLATEYRI 66°07N 23°13W

legend

Avalanches registered since 1997

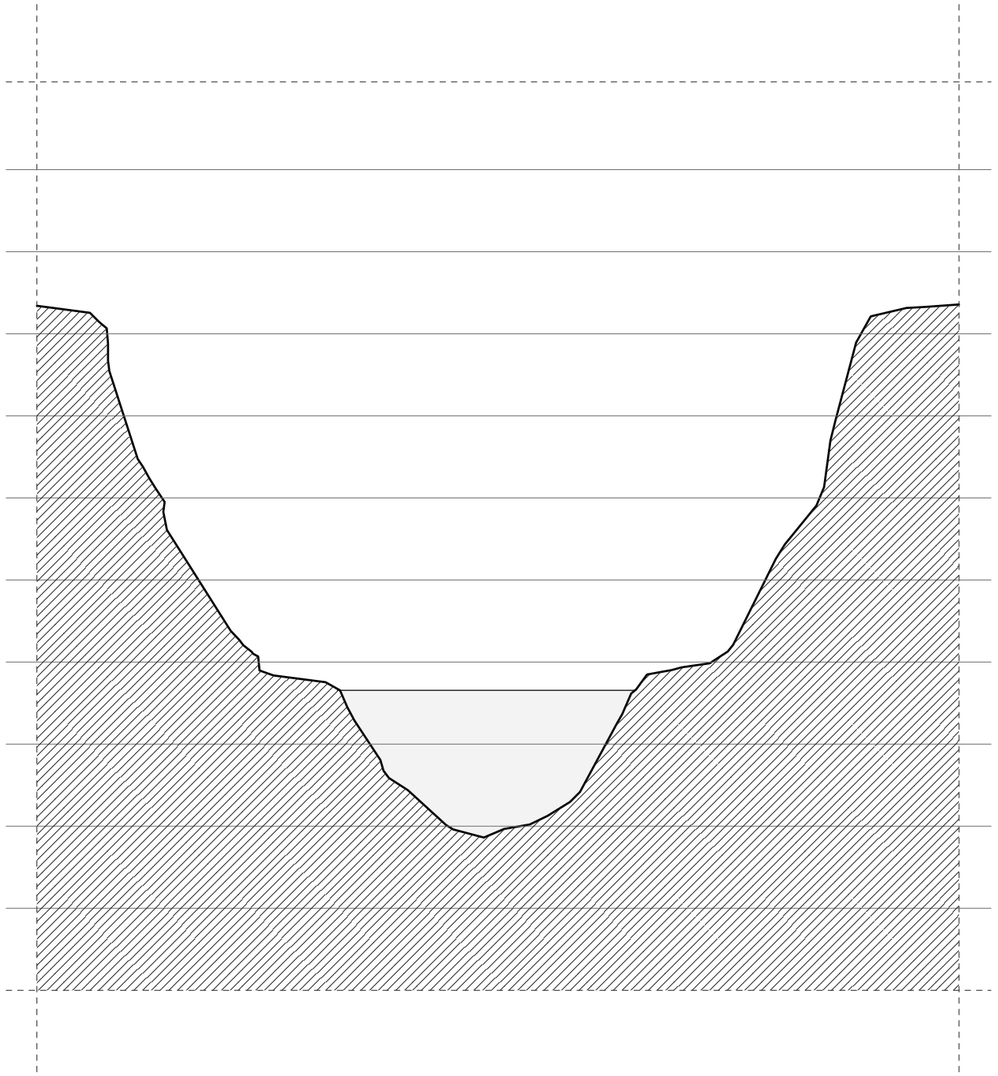
Topography 5m contours

1 : 7000

0 100m 500m

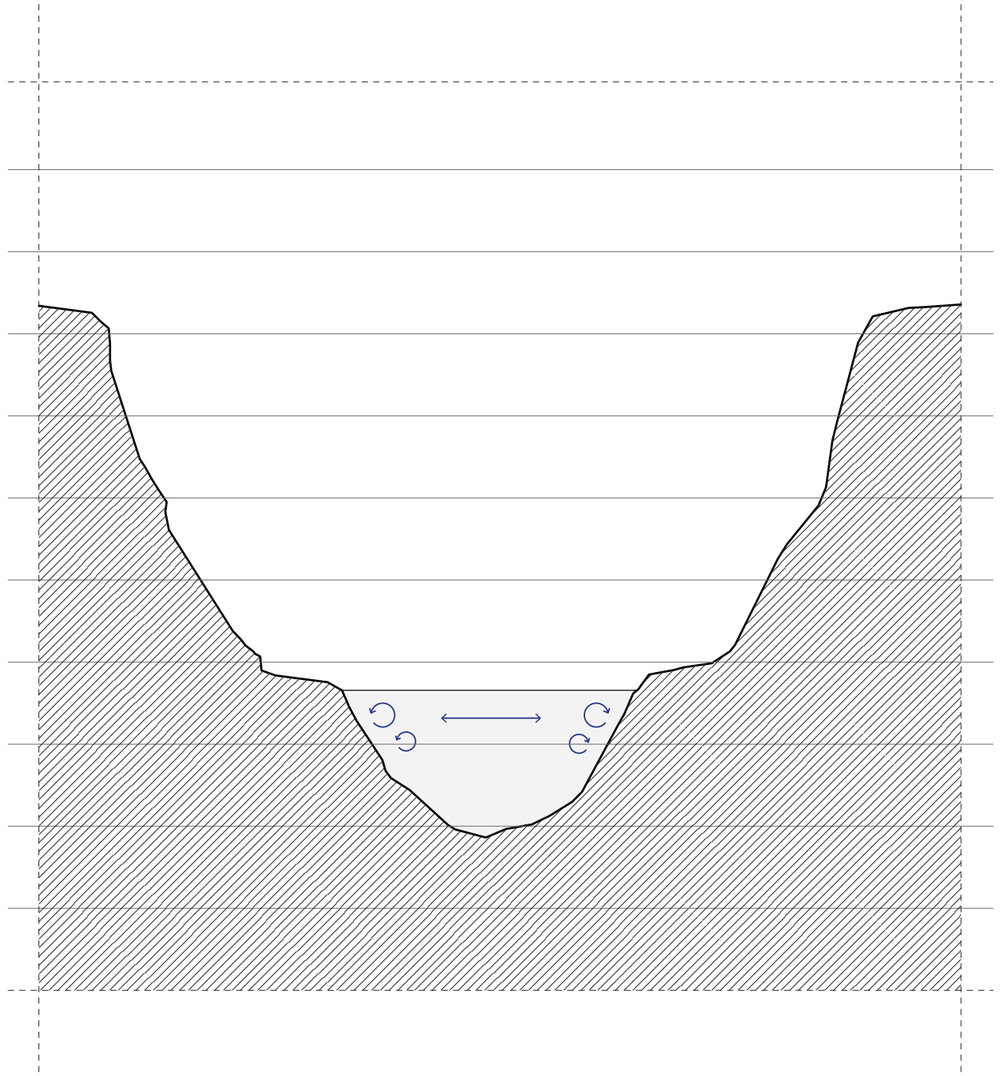
Image: "Lýðskólinn á Flateyri frestar skólastarfi," Bæjarins Besta, April 1, 2020. http://www.bb.is/2020/04/lydskolinn-a-flateyri-frestar-skolastarfi/.

SITE 1: FJORD



CROSS SECTION
shape of a fjord

SITE 1: FJORD



CROSS SECTION
shape of a fjord

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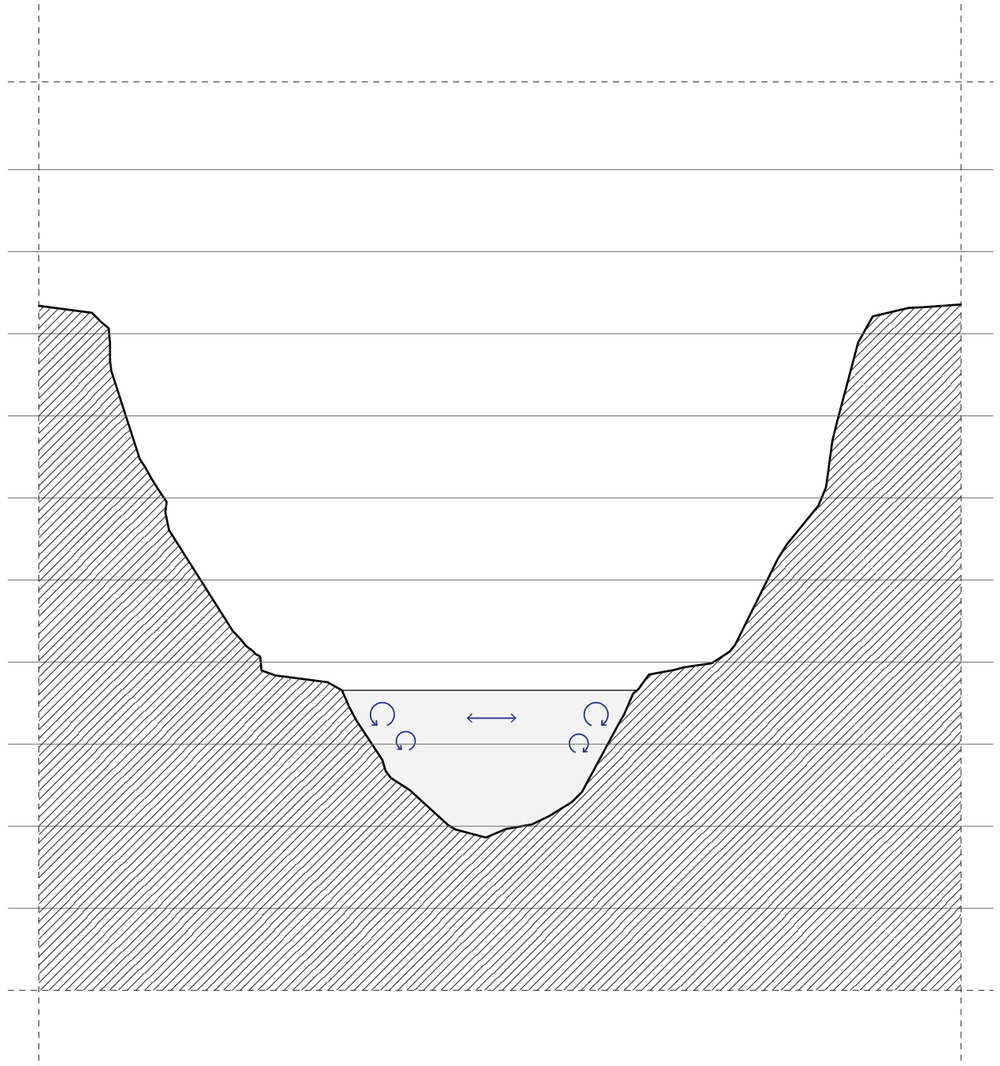

CROSS SECTION
shape of a fjord

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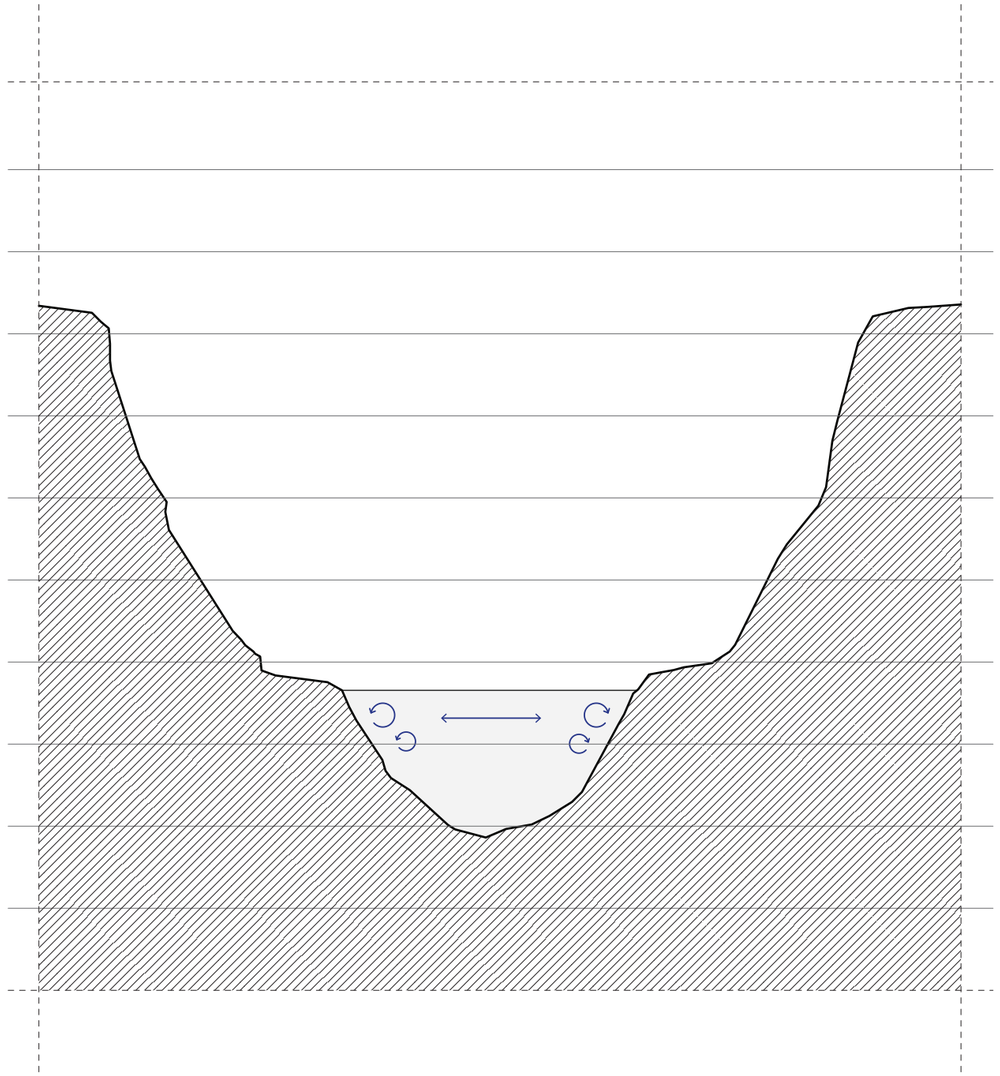

CROSS SECTION
shape of a fjord

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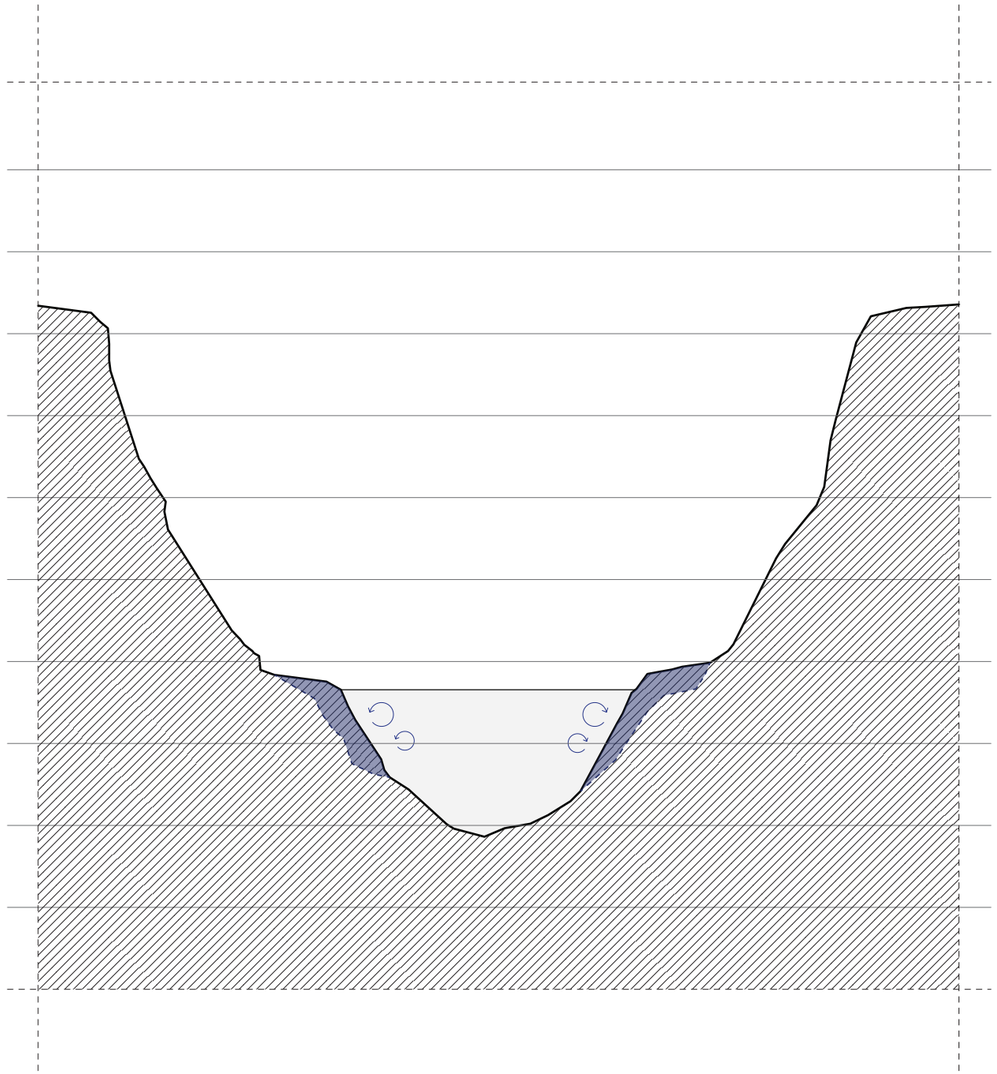
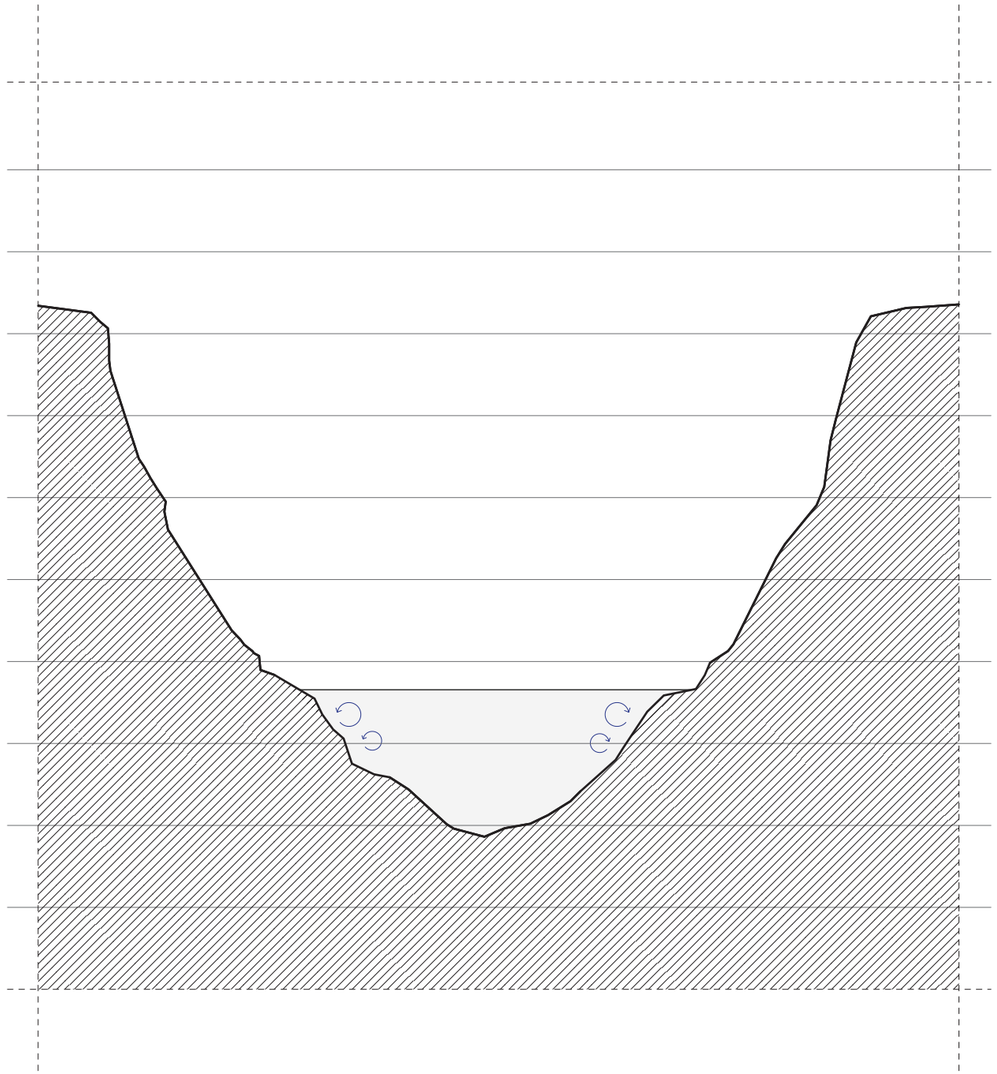


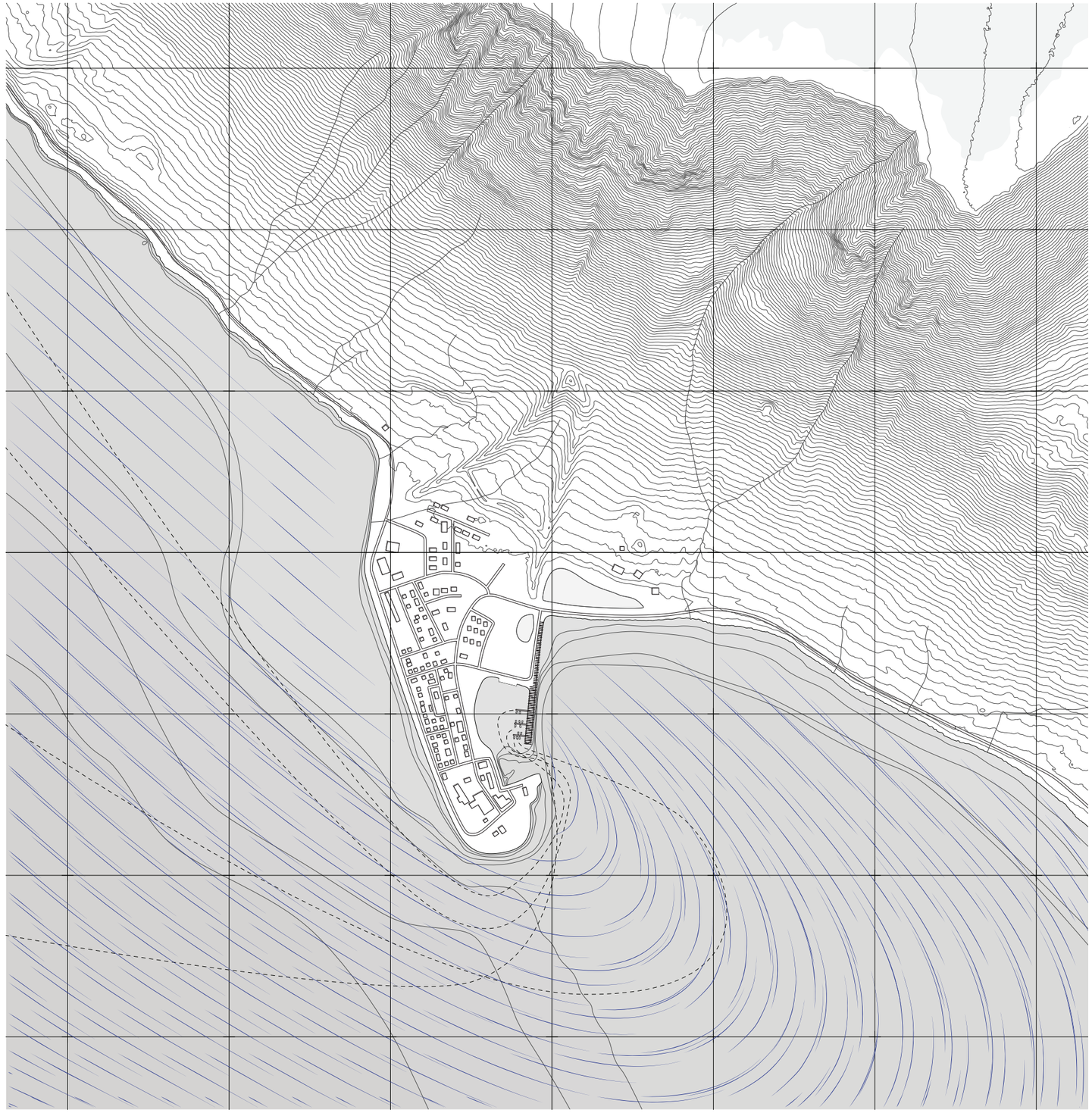
CROSS SECTION
shape of a fjord

SITE 1: FJORD



CROSS SECTION
shape of a fjord

SITE 1: FJORD



FJORD CURRENTS

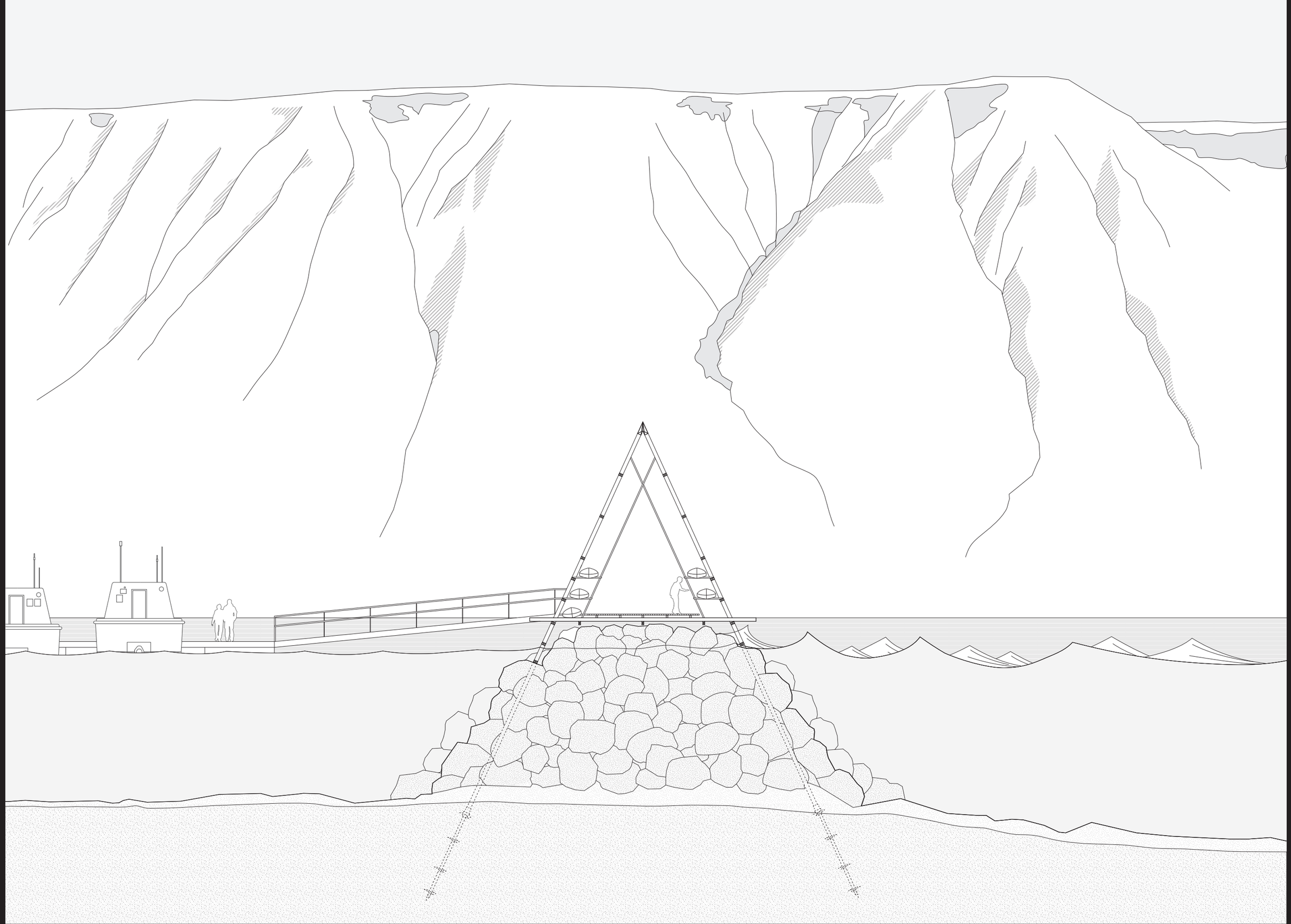
SITE 1: FJORD

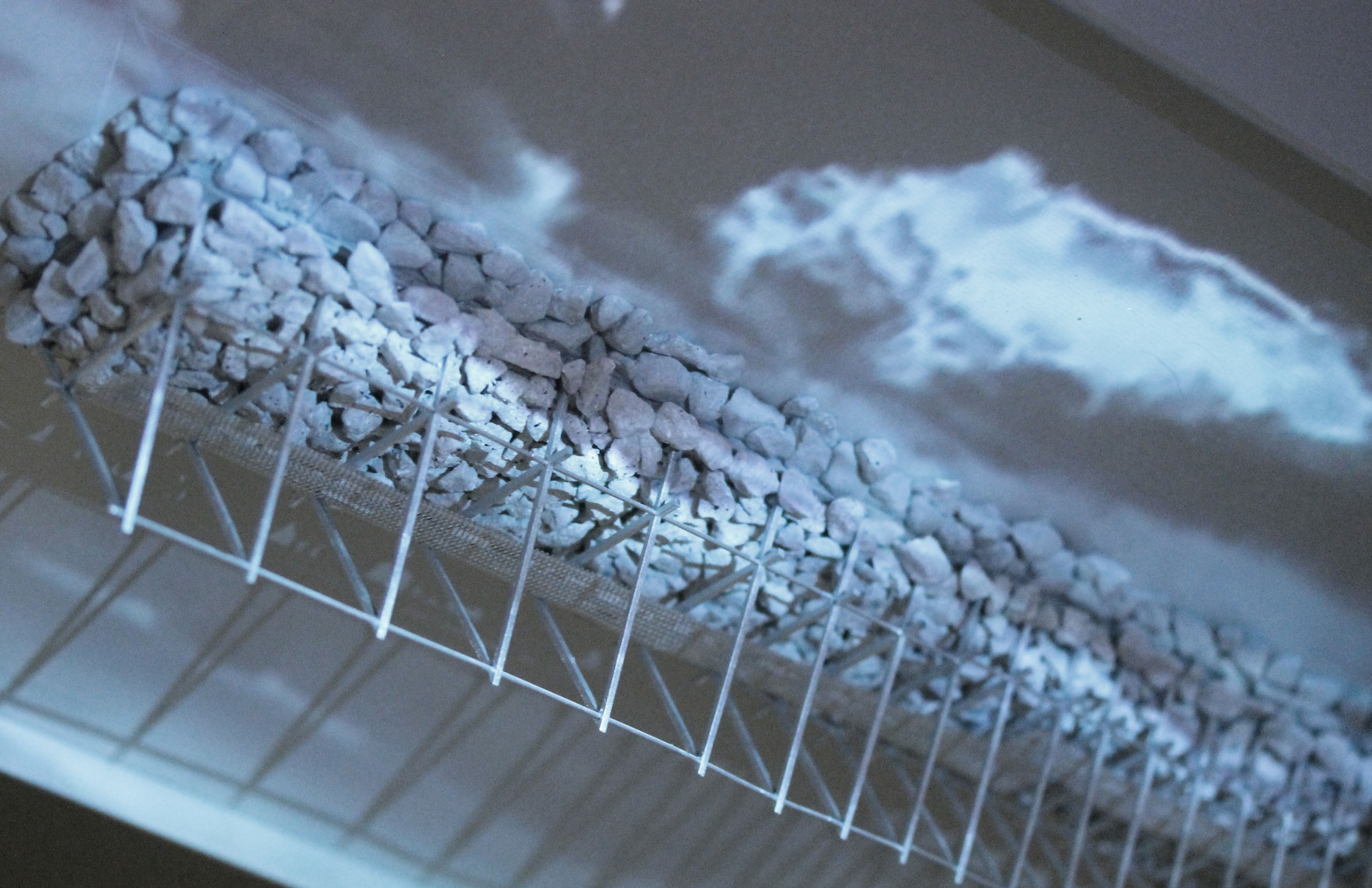
FLATEYRI HARBOUR

Image: Gylfadóttir, Hrefna Björg. "From Iceland — Stranded In Flateyri: Ólafur Arnalds And The Making Of 'Island Songs.'" The Reykjavik Grapevine, July 18, 2016. https://grapevine.is/mag/feature/2016/07/18/9950944/.

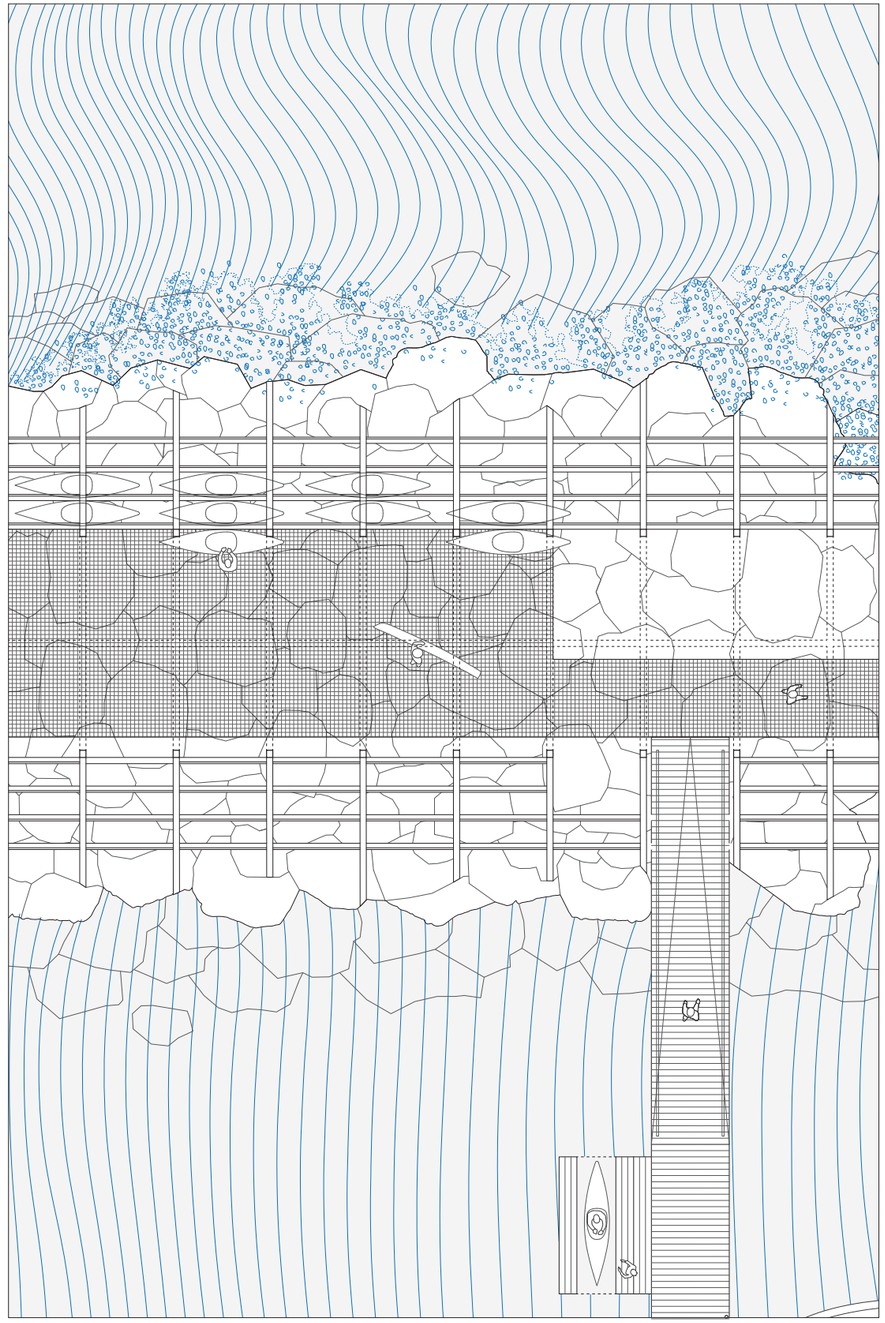
SITE 1: FJORD

A FRAMEWORK FOR FLEXIBILITY
spatial occupation

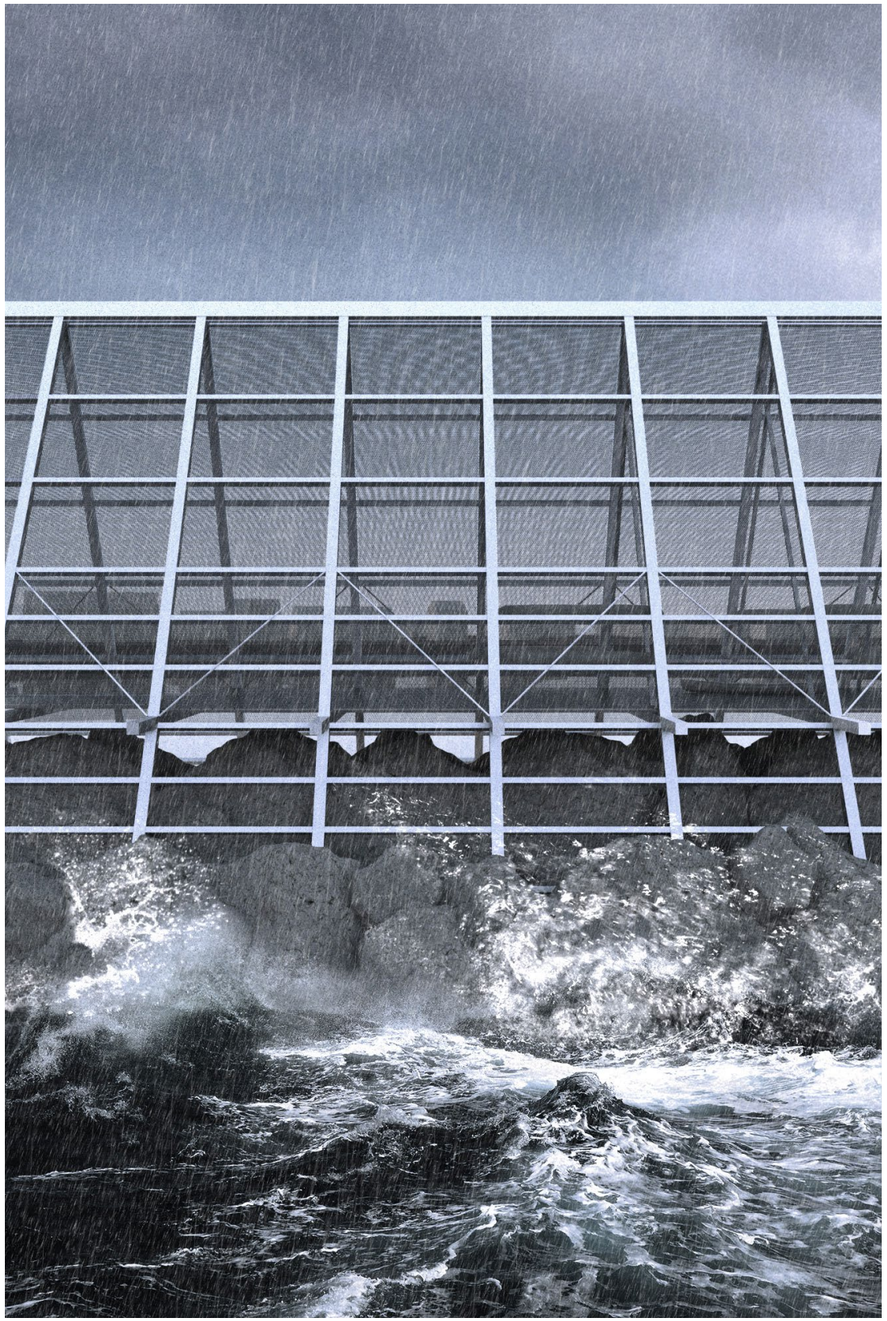




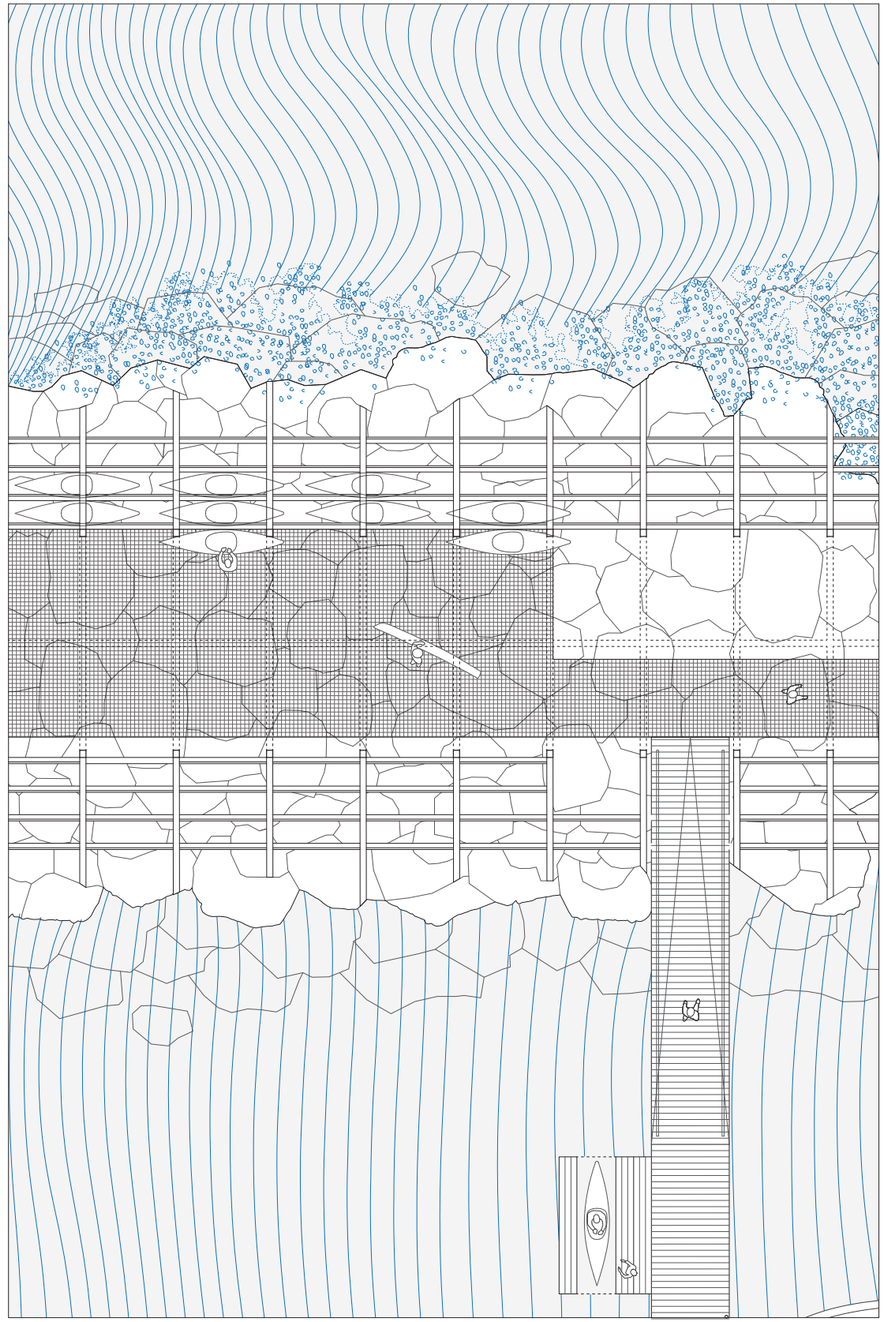
FRAME WORK
a platform for fishermen & recreation



PLAN ZOOM IN:
kayak storage during the summer

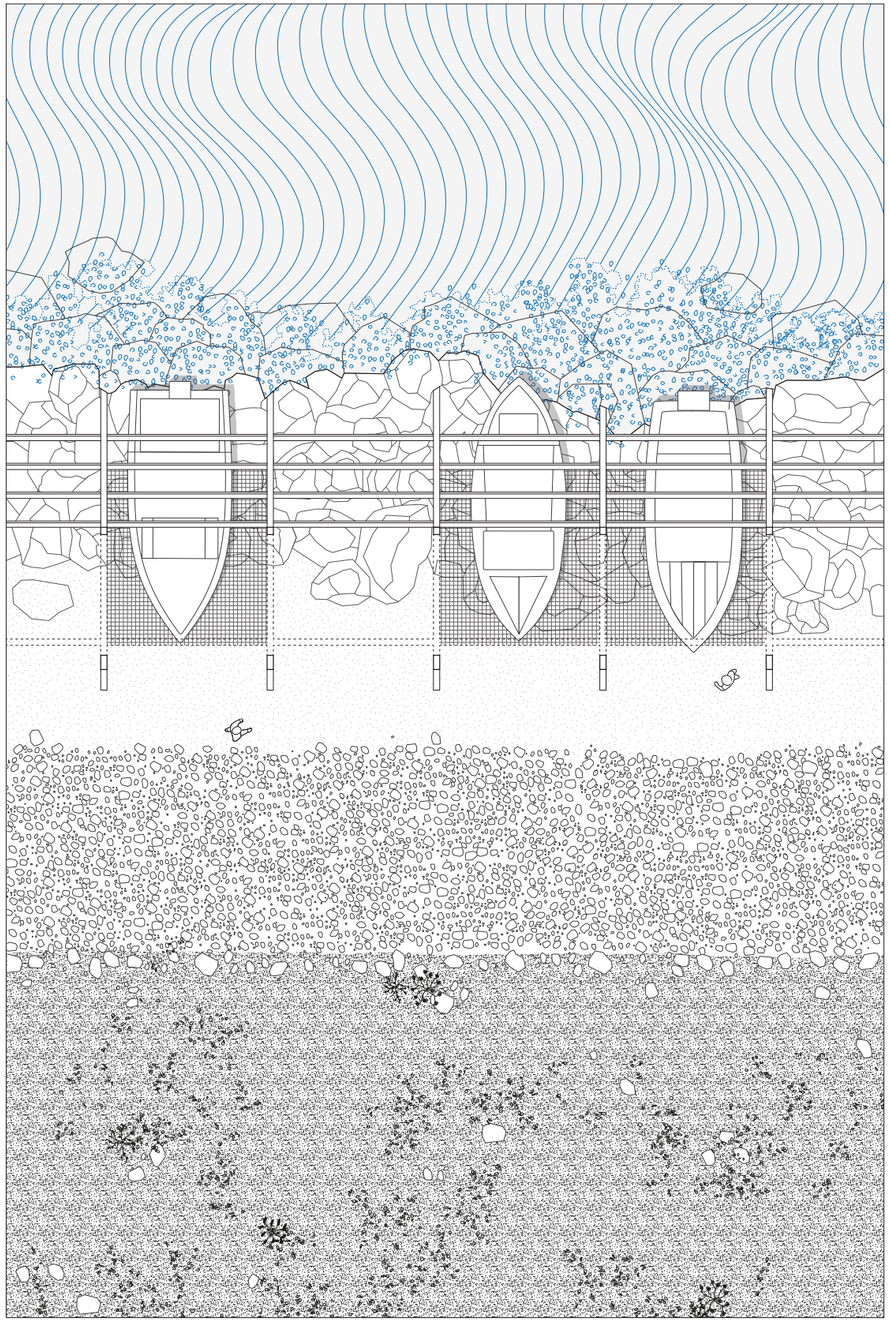


FRAME WORK
a platform for fishermen & recreation

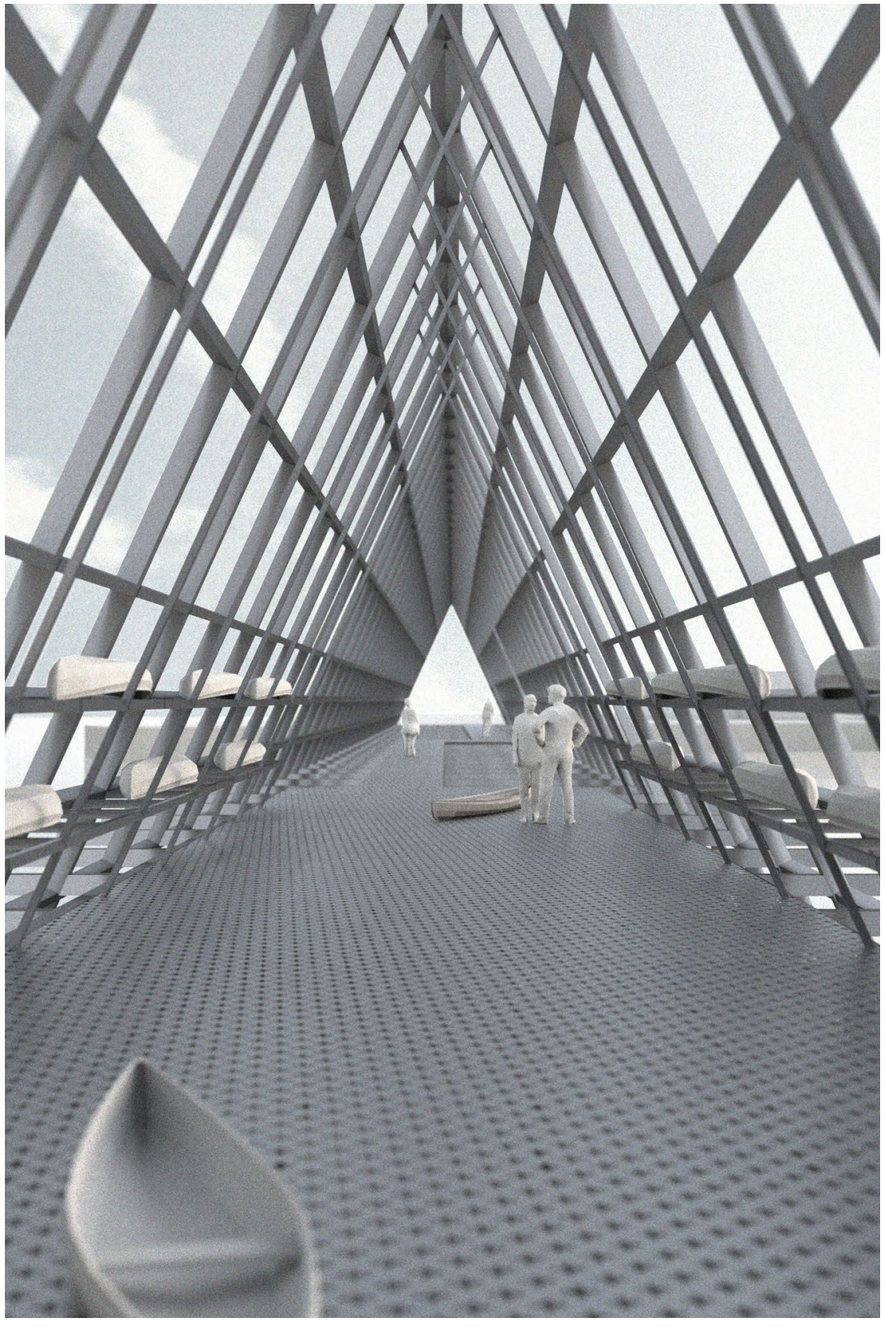


PLAN ZOOM IN:
kayak storage during the summer

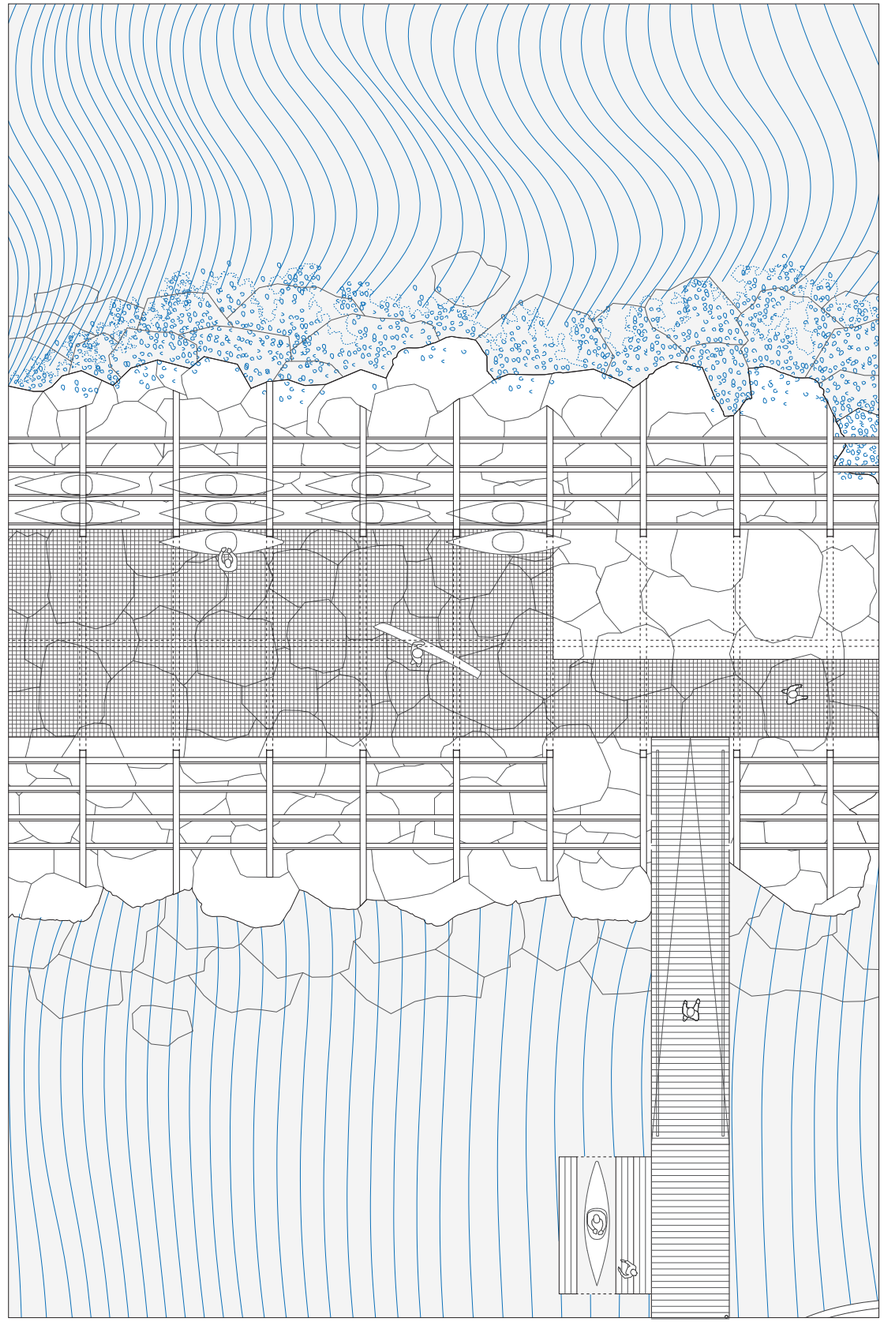
FRAME WORK
boat storage during winter



PLAN ZOOM IN:
boat storage during winter

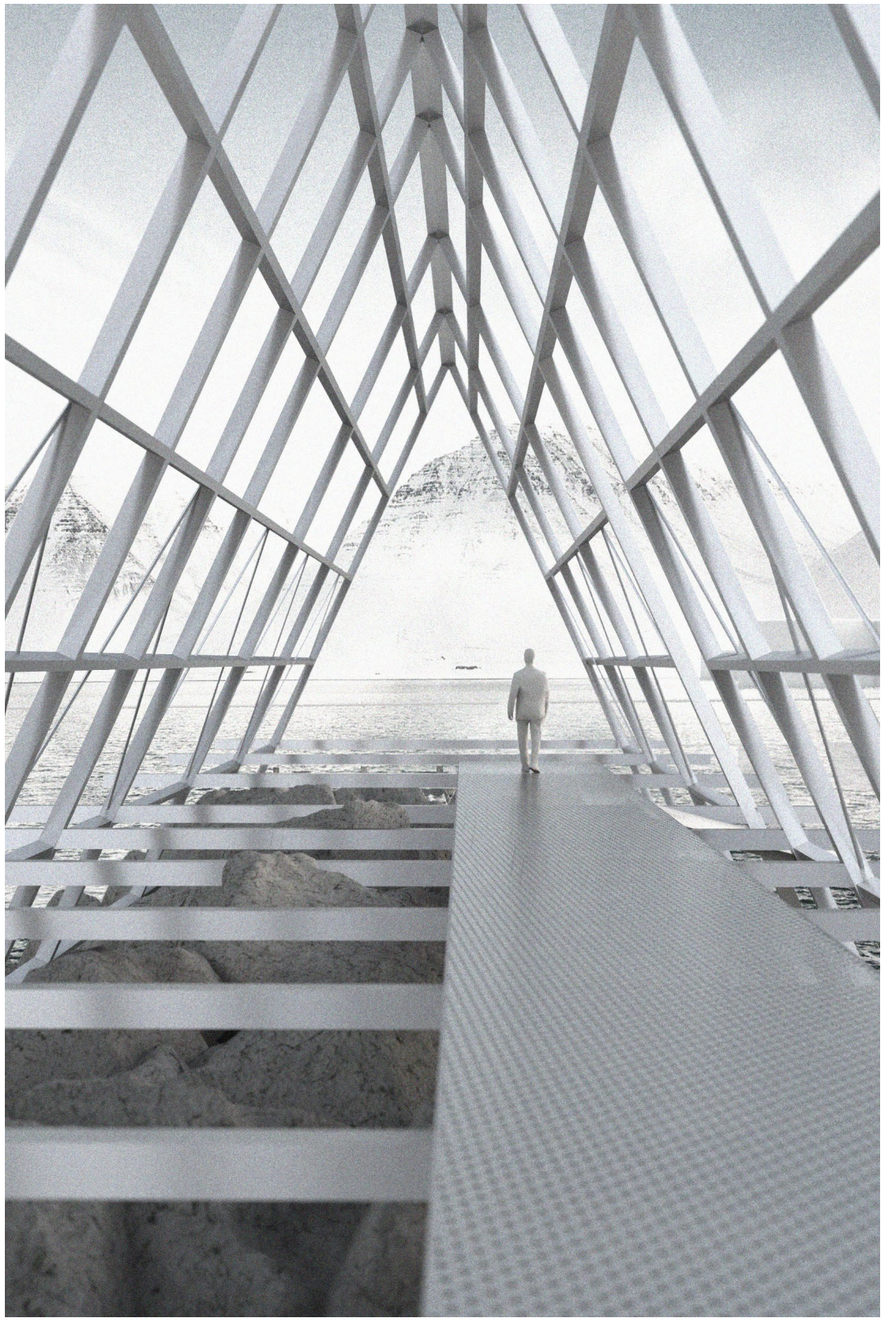


VIEW:
kayak storage

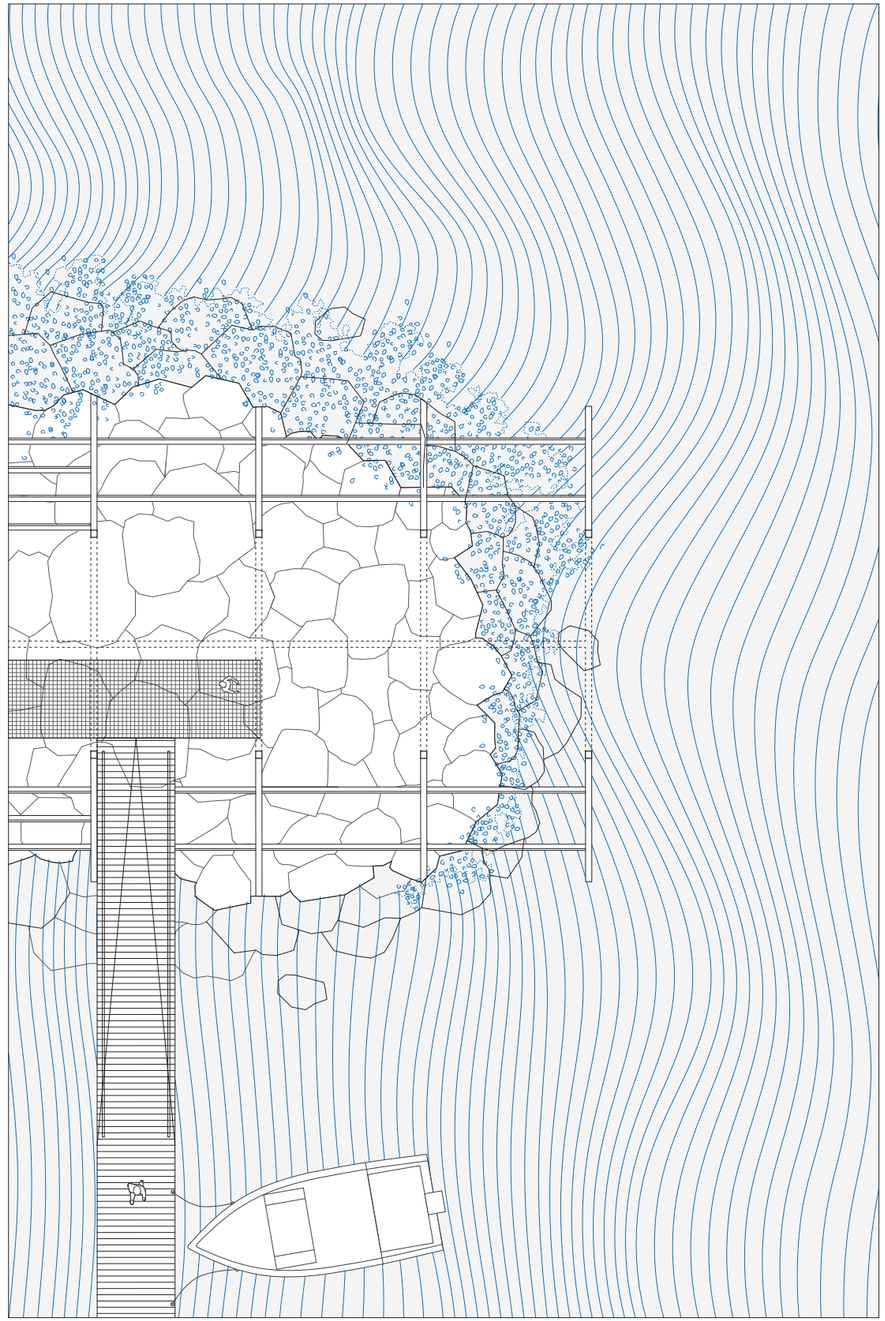


PLAN ZOOM IN:
access to the kayak dock

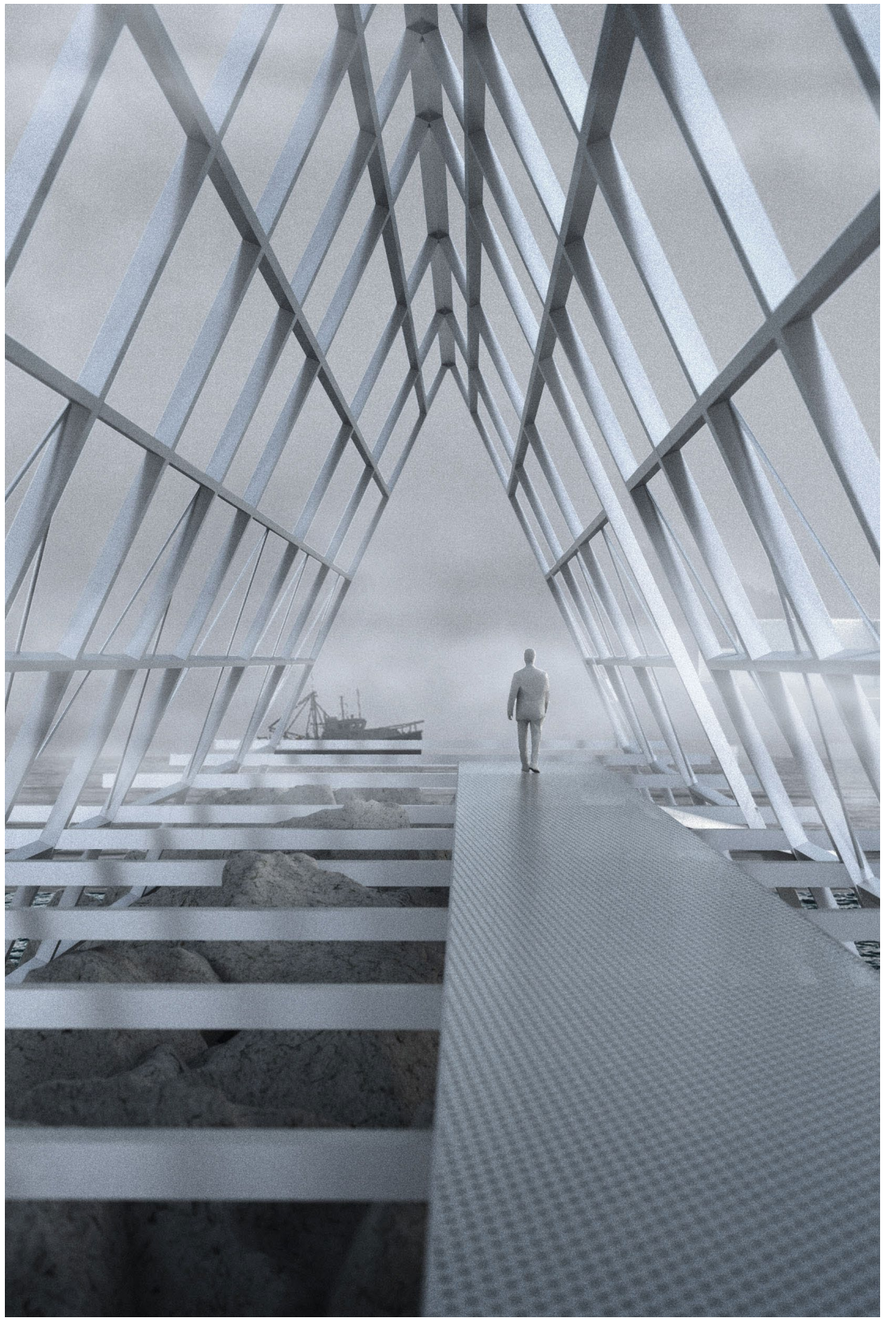
SITE 1: FJORD



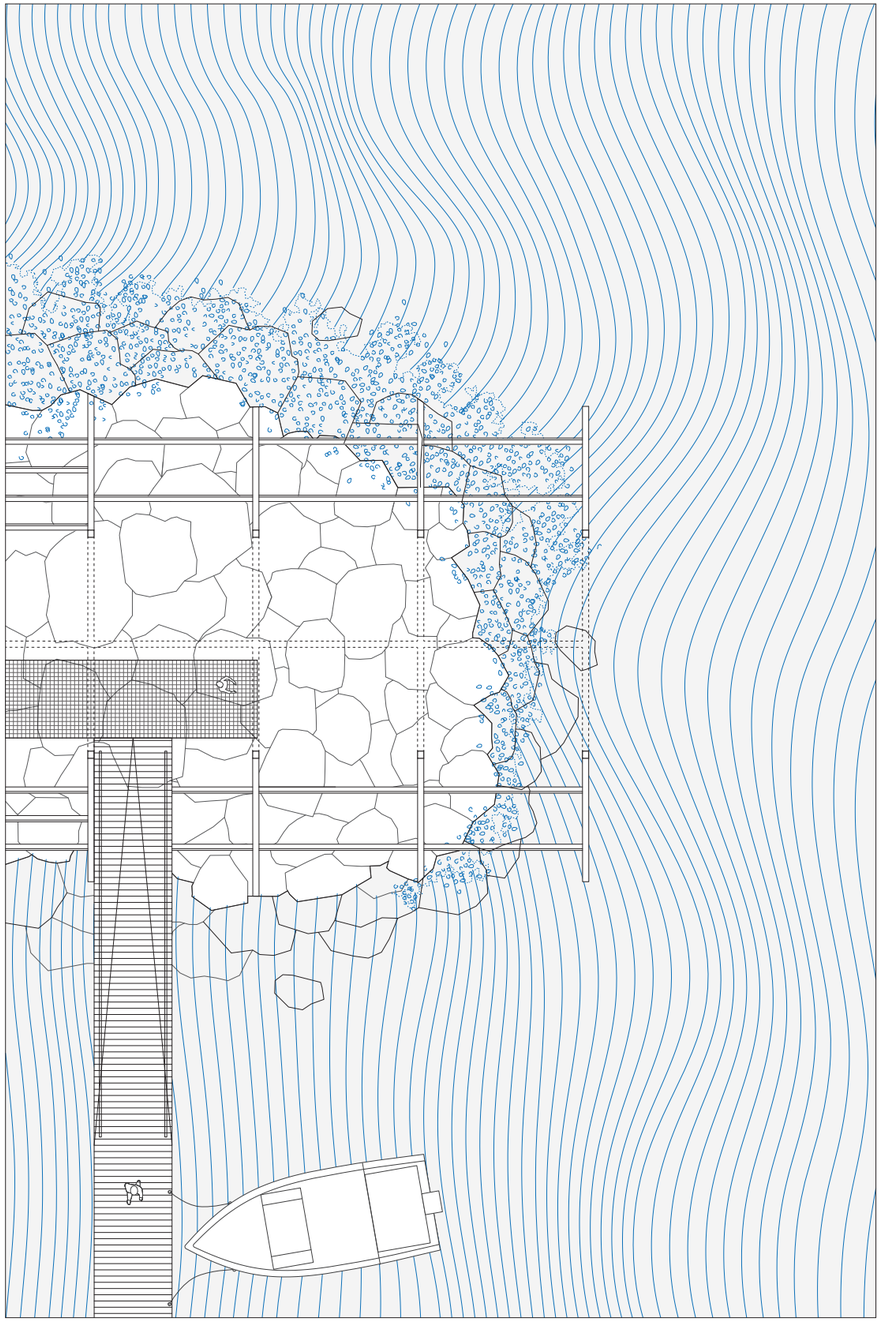
INSIDE THE FRAMEWORK
a view of the fjord



PLAN ZOOM IN:
end of the path



INSIDE THE FRAMEWORK
a view of the fjord



PLAN ZOOM IN
end of the path

SITE 2: BAY

vík

RAUFARHÖFN
66.50° N, 15.40° W

SITE 2: BAY

67°

66°

65°

64°

63°

26°

24°

22°

20°

18°

16°

14°

12°

ARCTIC CIRCLE

RAUFARHÖFN

REYKJAVIK

ARCTIC REGION

SITE 2: BAY

67°

66°

65°

64°

63°

26°

24°

22°

20°

18°

16°

14°

12°

ARCTIC CIRCLE

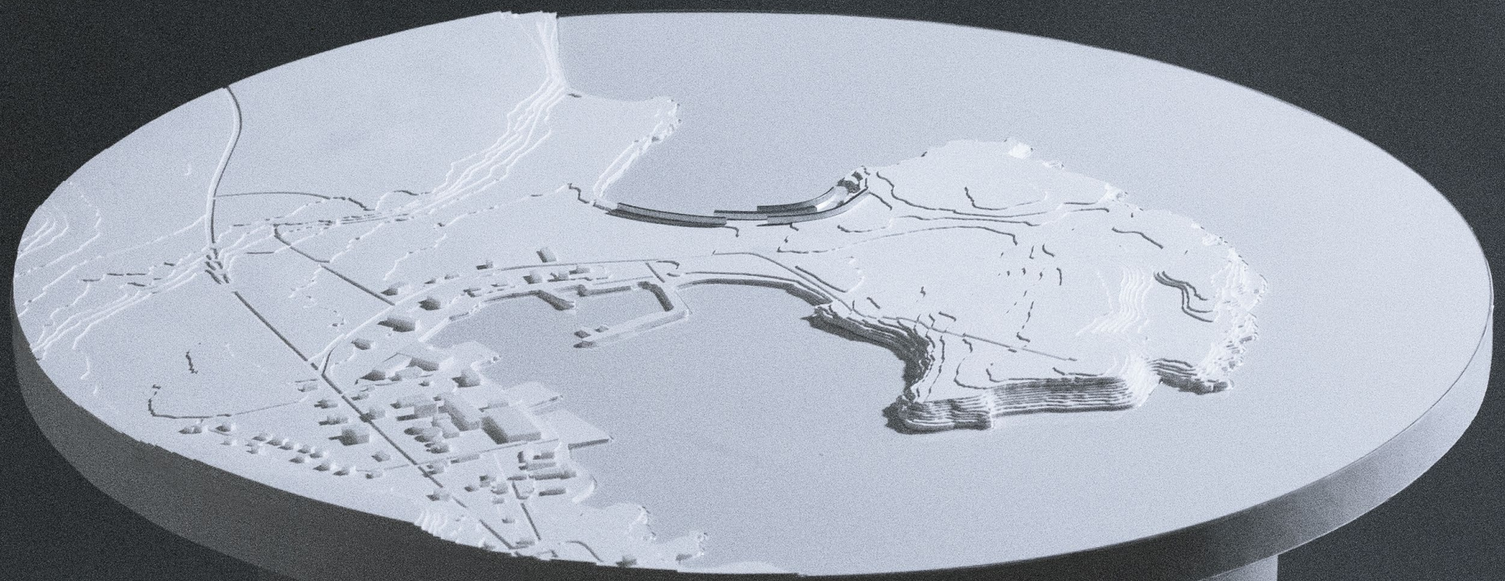
RAUFARHÖFN

REYKJAVIK

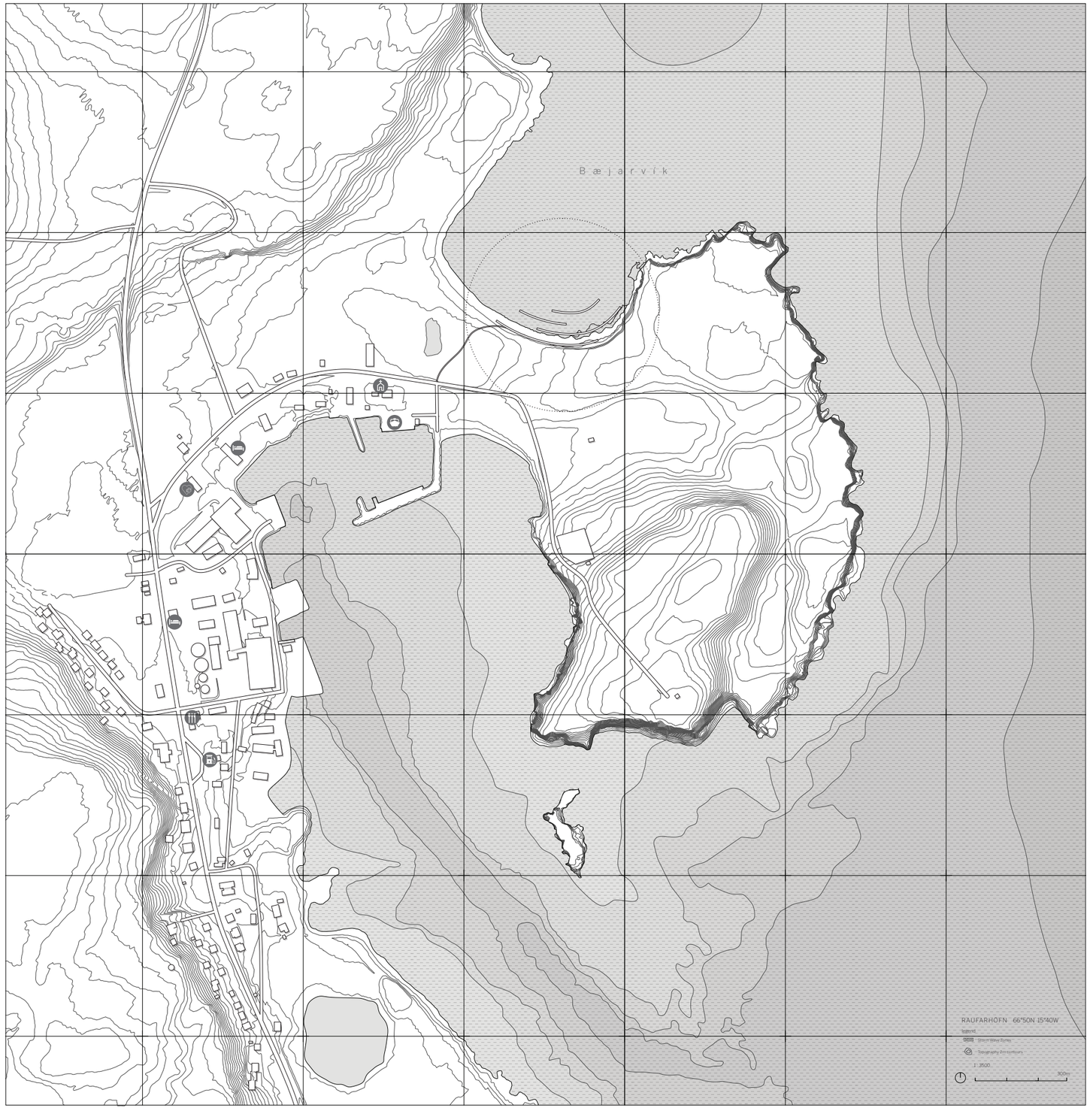
ARCTIC REGION

Raufarhöfn lies in a bay on a barren peninsula on the northernmost tip of Iceland. The bay's natural harbor shields the town's fishing boats from harsh arctic storms. These storms are steadily getting stronger and are chipping away at the side of the bay that protects the town.

Raufarhöfn's population has dwindled to just 189 after being one of the most prosperous towns in Iceland during the 1950's. In recent years, the town has been working to redefine itself as a tourist destination for visitors to experience it's vast ocean views and sublime arctic landscapes. If the walls of the bay erode, the town becomes more exposed to Arctic storms, bringing waves that can easily flood the town. Mitigating the waves is critical for the town to continue to thrive. But how can a coastal barrier simultaneously protect the town and cater to the town's new identity as a place to be immersed in an arctic landscape?



SITE 2: BAY



RAUFARHÖFN 66°50N 15°40W

legend

Storm Wave Zones

Topography 2m contours

1 : 3500

300m

A RICH HISTORY
working fish in the 1950's

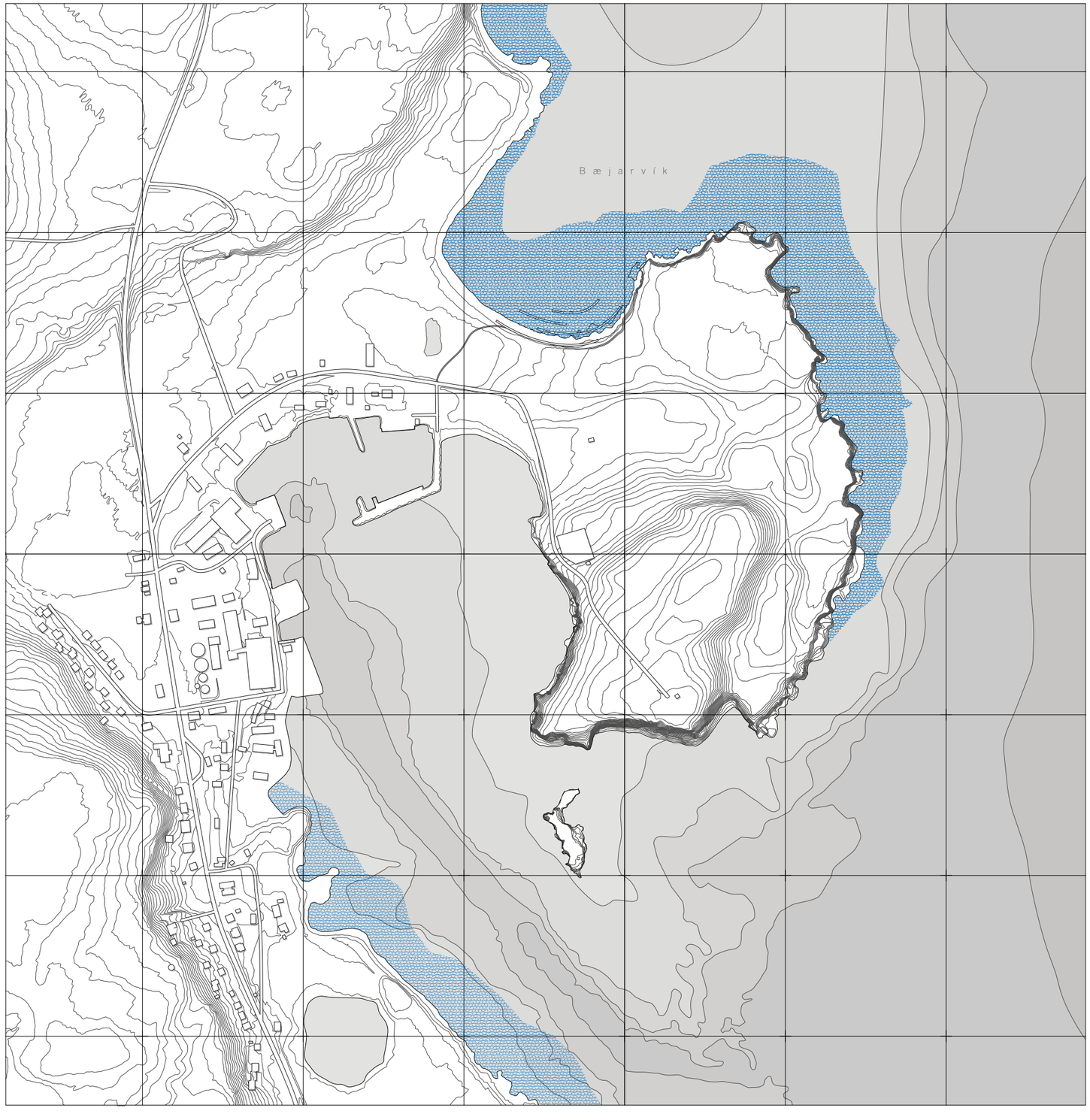
Image: "Sléttunga – Safn til sögu Melrakkasléttu og Raufarhafnar." https://www.bbl.is/frettir/fraedsluhornid/slettunga---safn-til-sogu-melrakkaslettu-og-raufarhafnar.

A DECLINING PRESENT
189 residents

Image: "Raufarhöfn." In Wikipedia, May 5, 2021. https://en.wikipedia.org/w/index.php?title=Raufarh%C3%B6fn&oldid=1021511679.

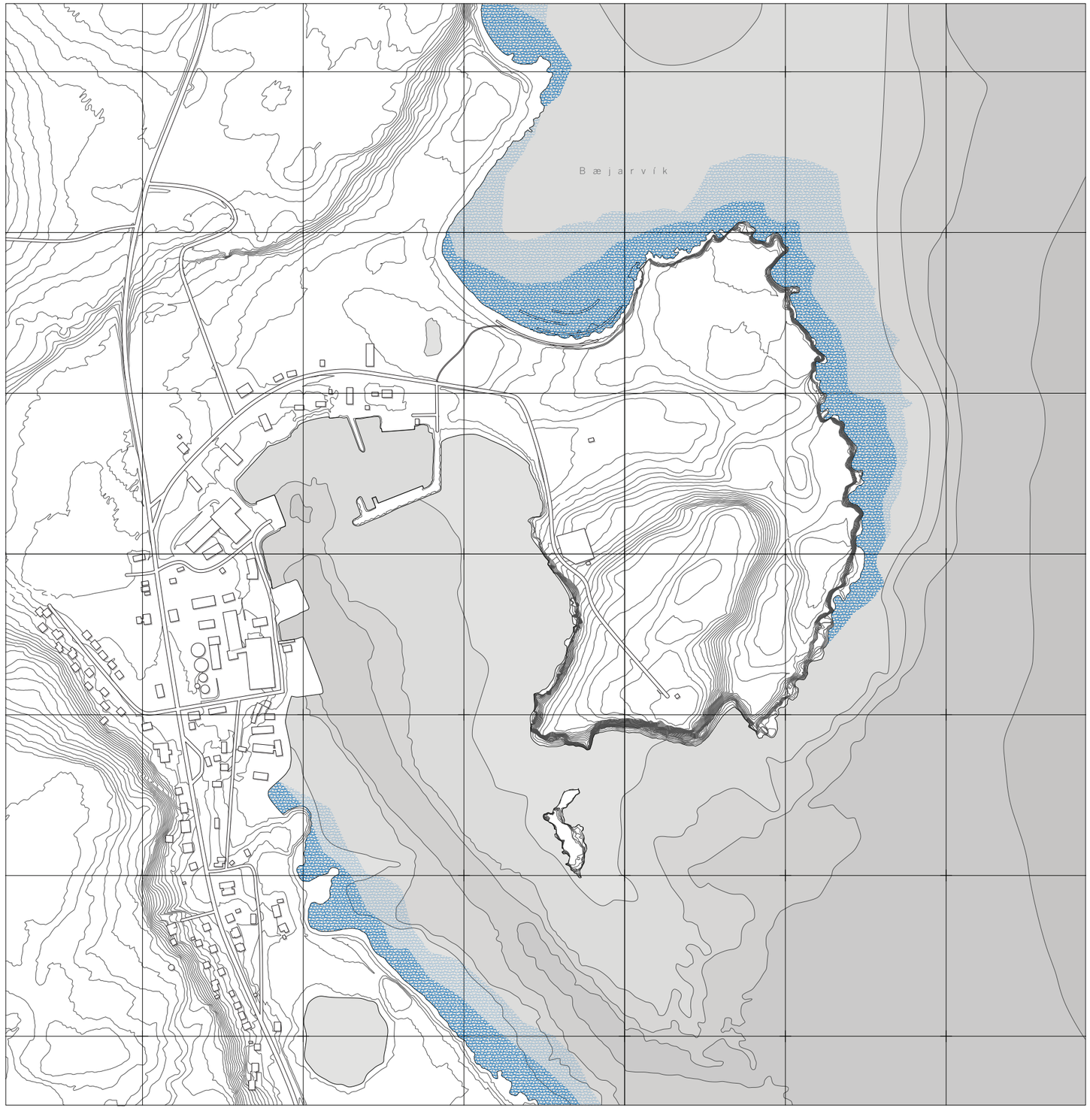
Image: Agnarsson, Ólafur Gísli. Norðurljósin Og Blokkin. November 5, 2015.
Photo. https://www.flickr.com/photos/oligisli/22730596359/.

SITE 2: BAY



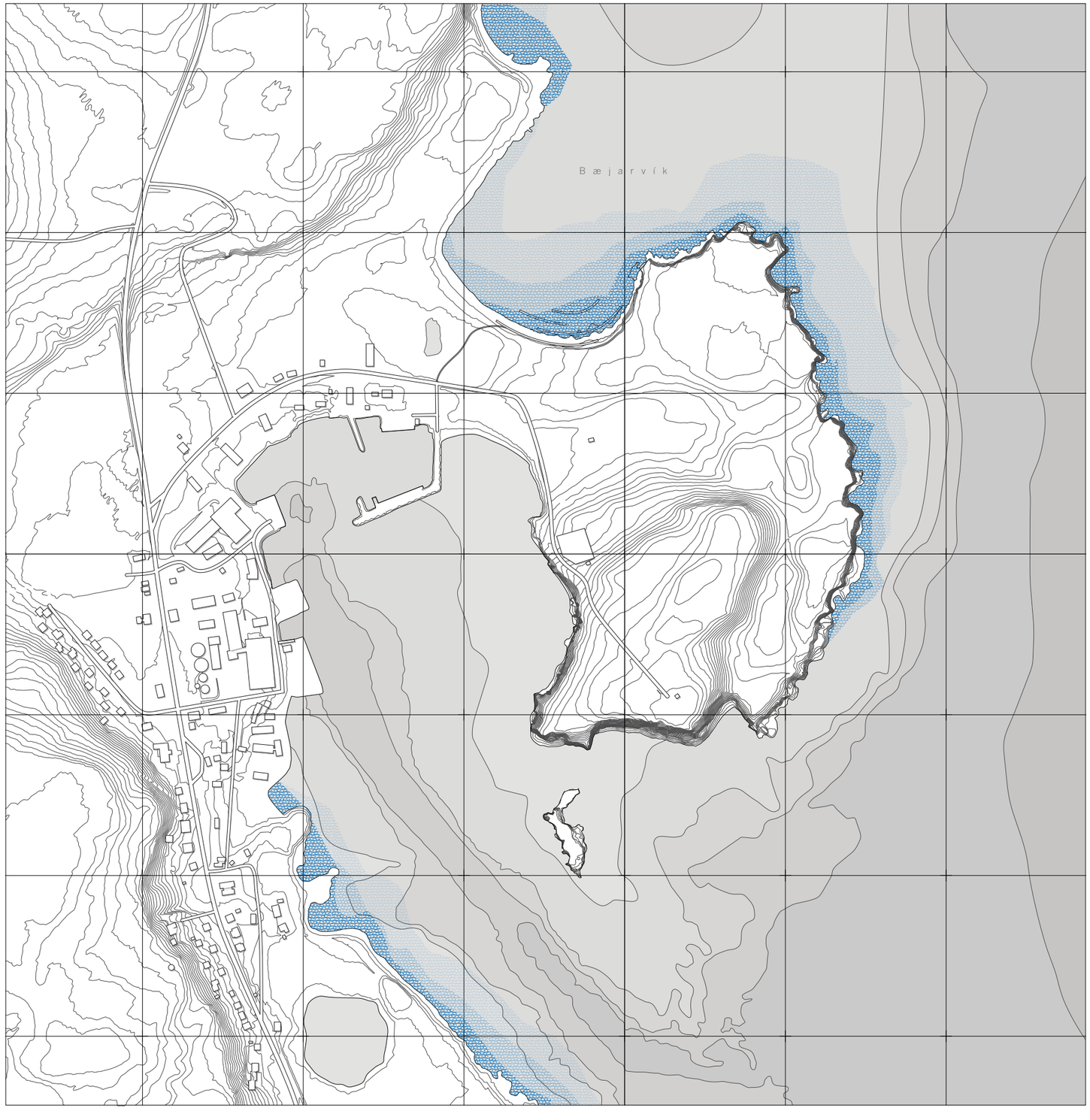
WAVES HITTING THE SHORE

SITE 2: BAY

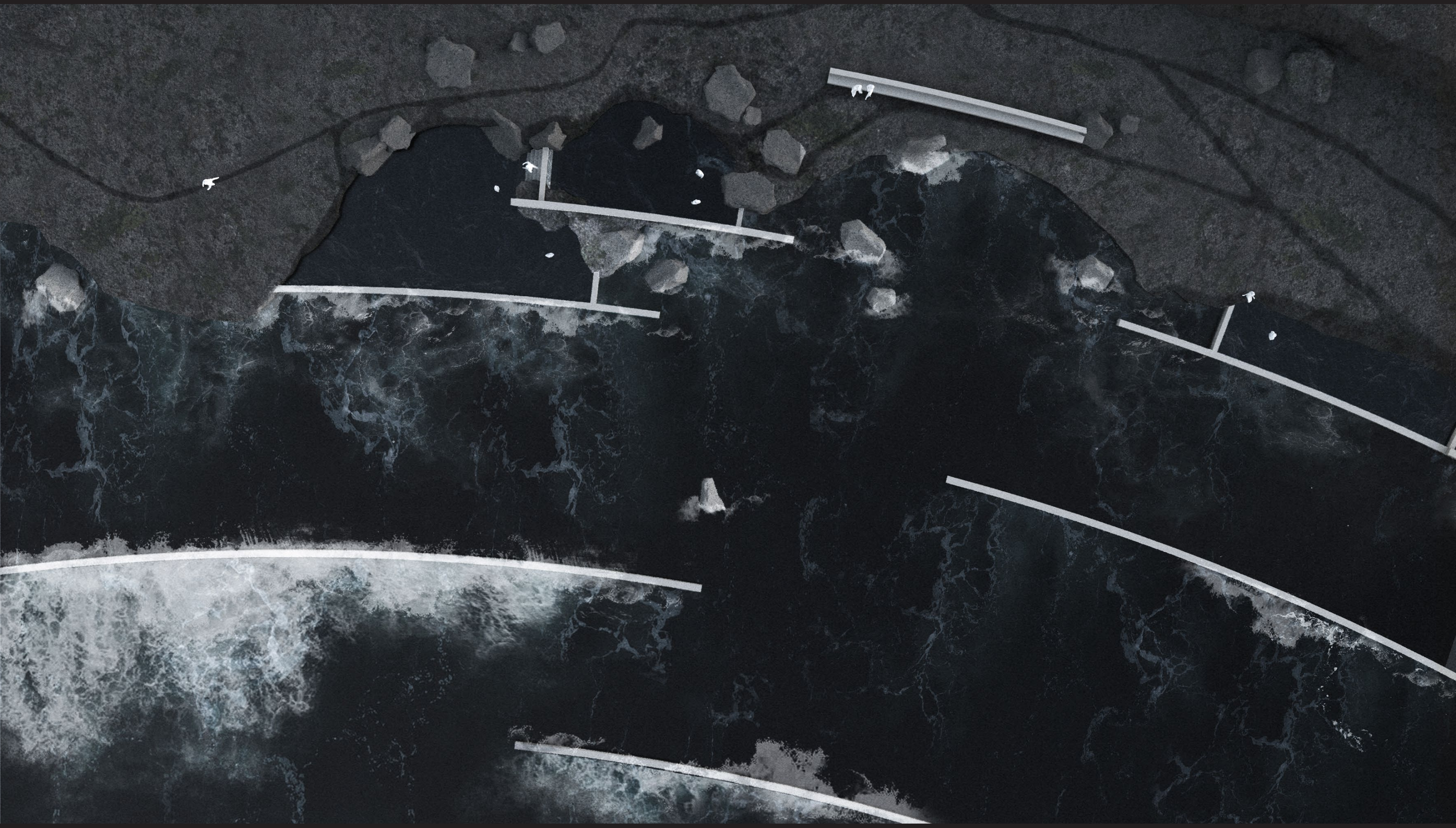


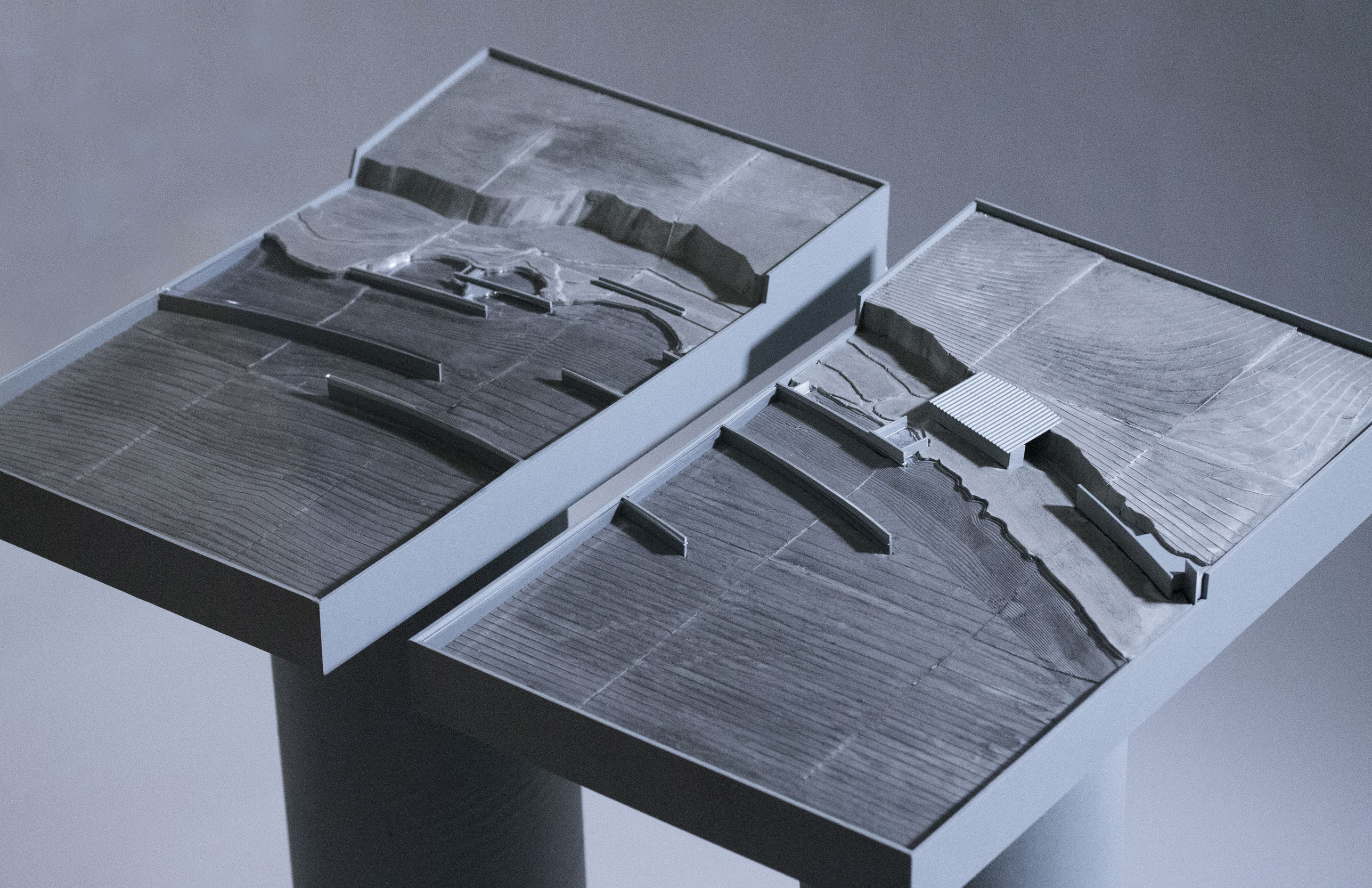
WAVES HITTING THE SHORE

SITE 2: BAY

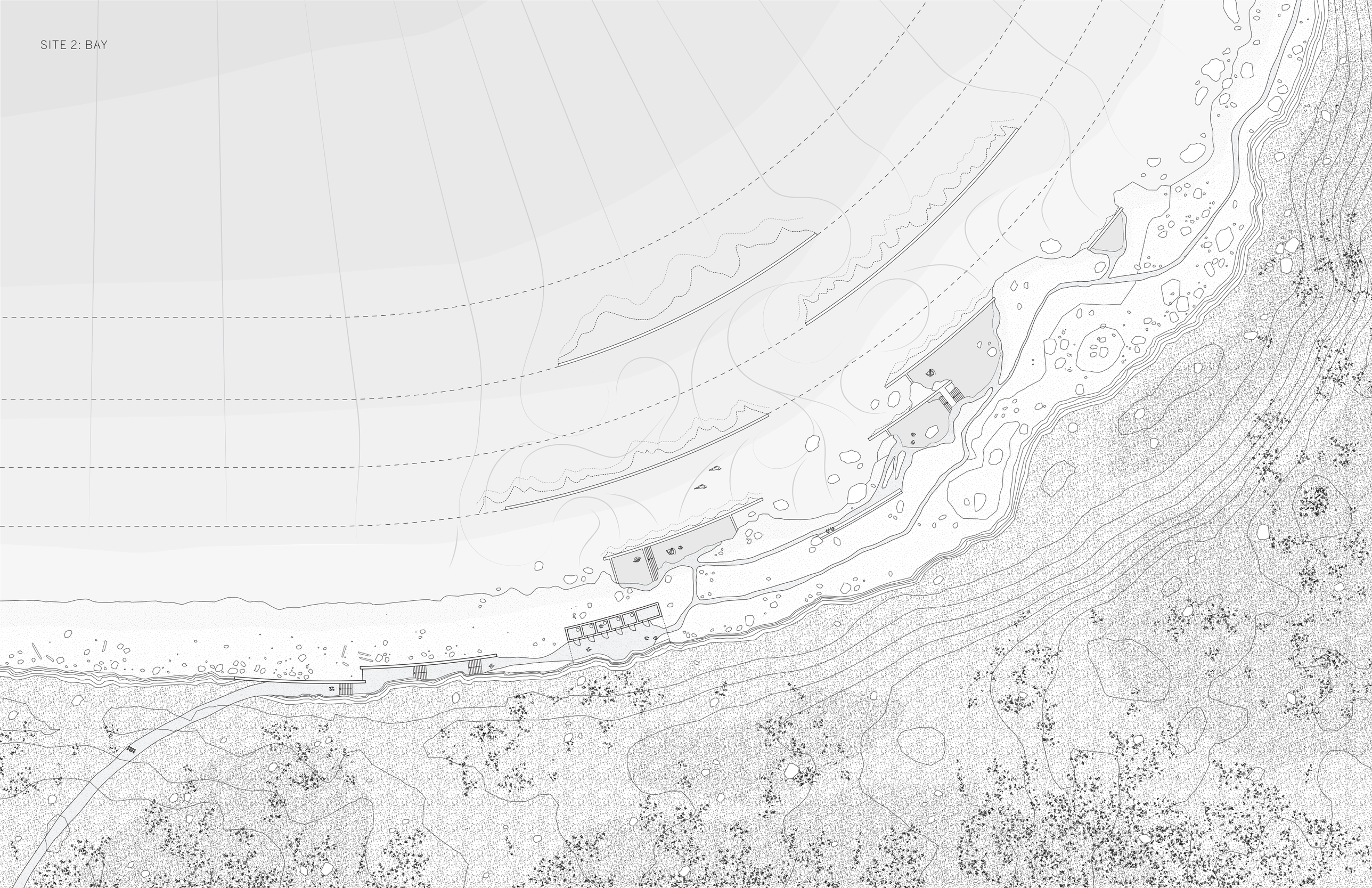


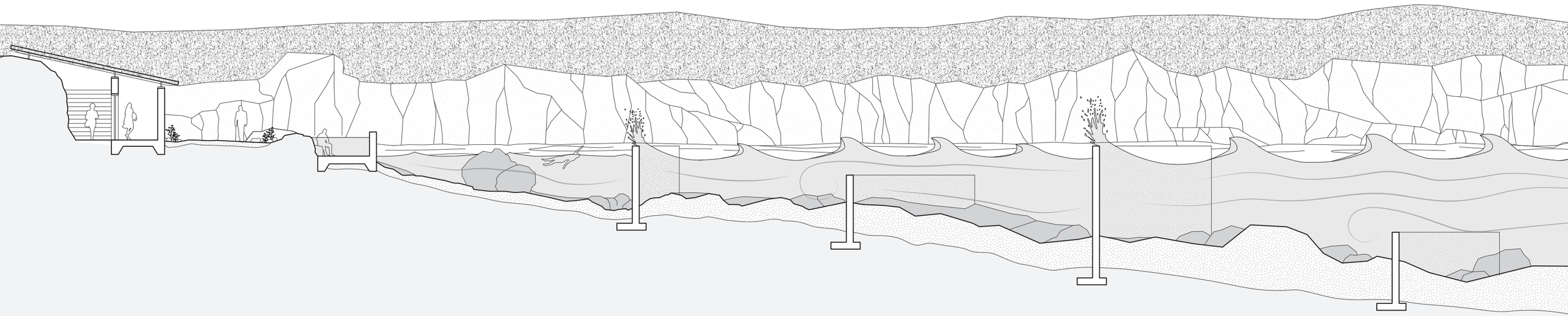
WAVES HITTING THE SHORE





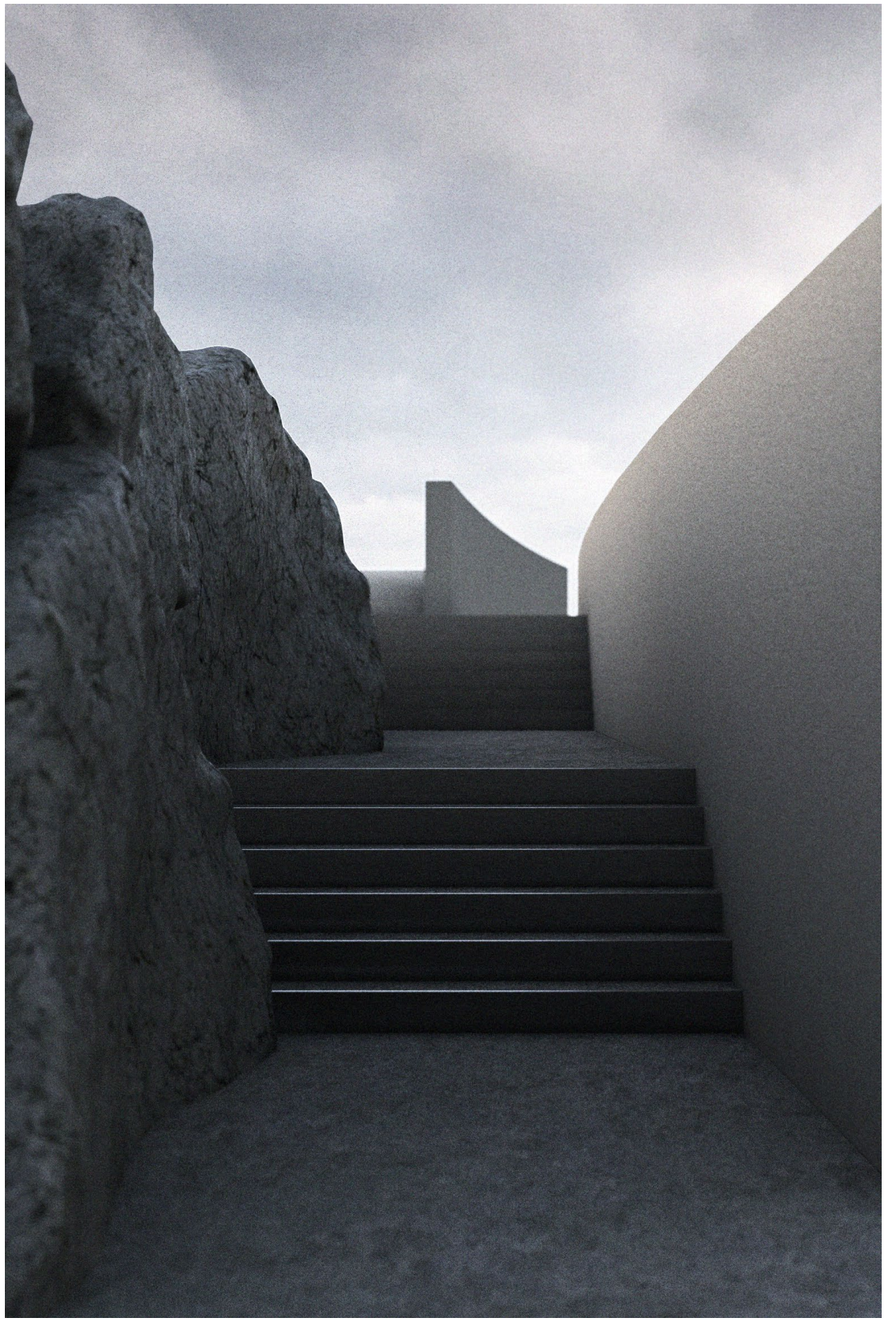
SITE 2: BAY



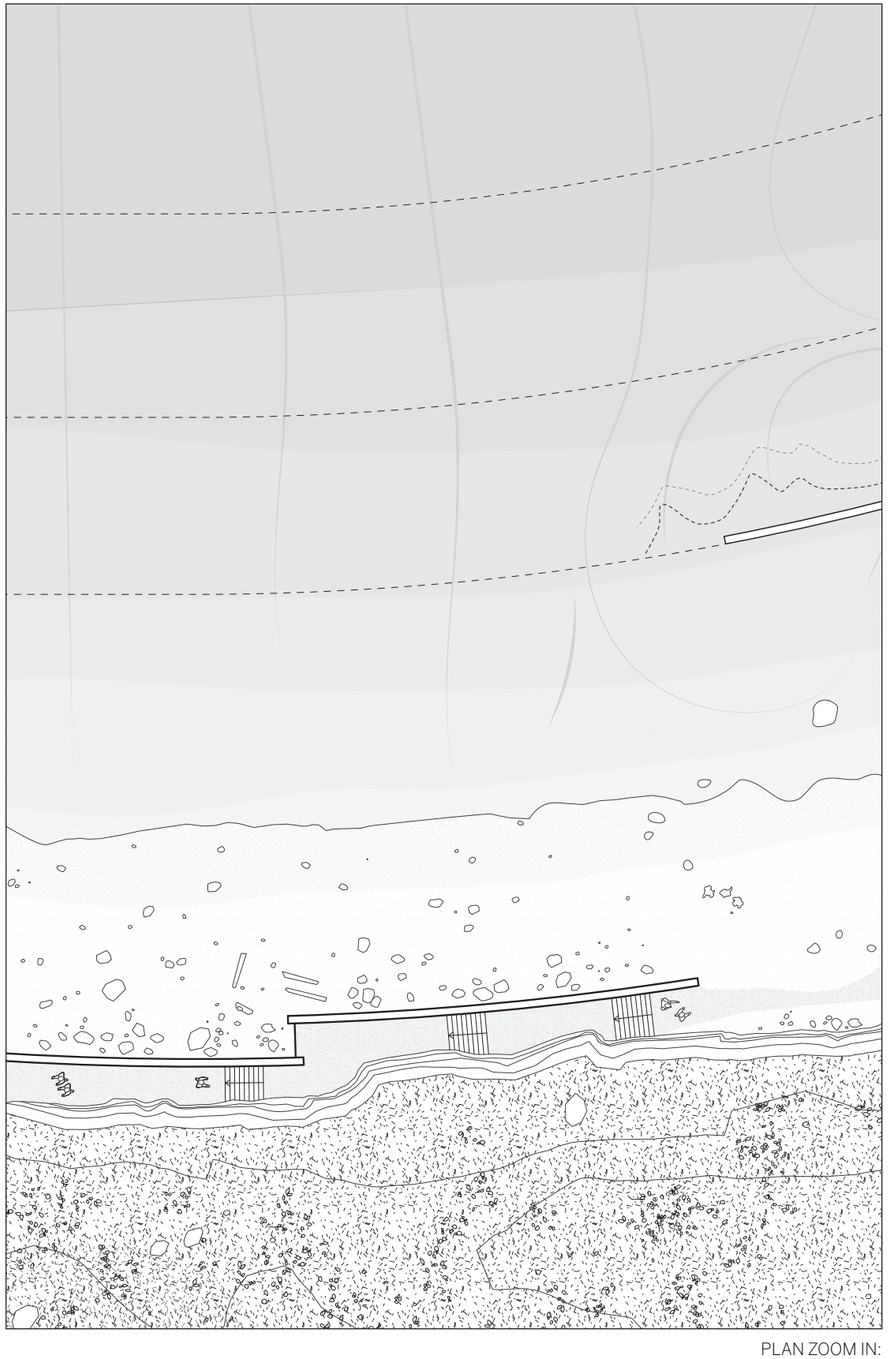


DISSIPATING THE ENERGY

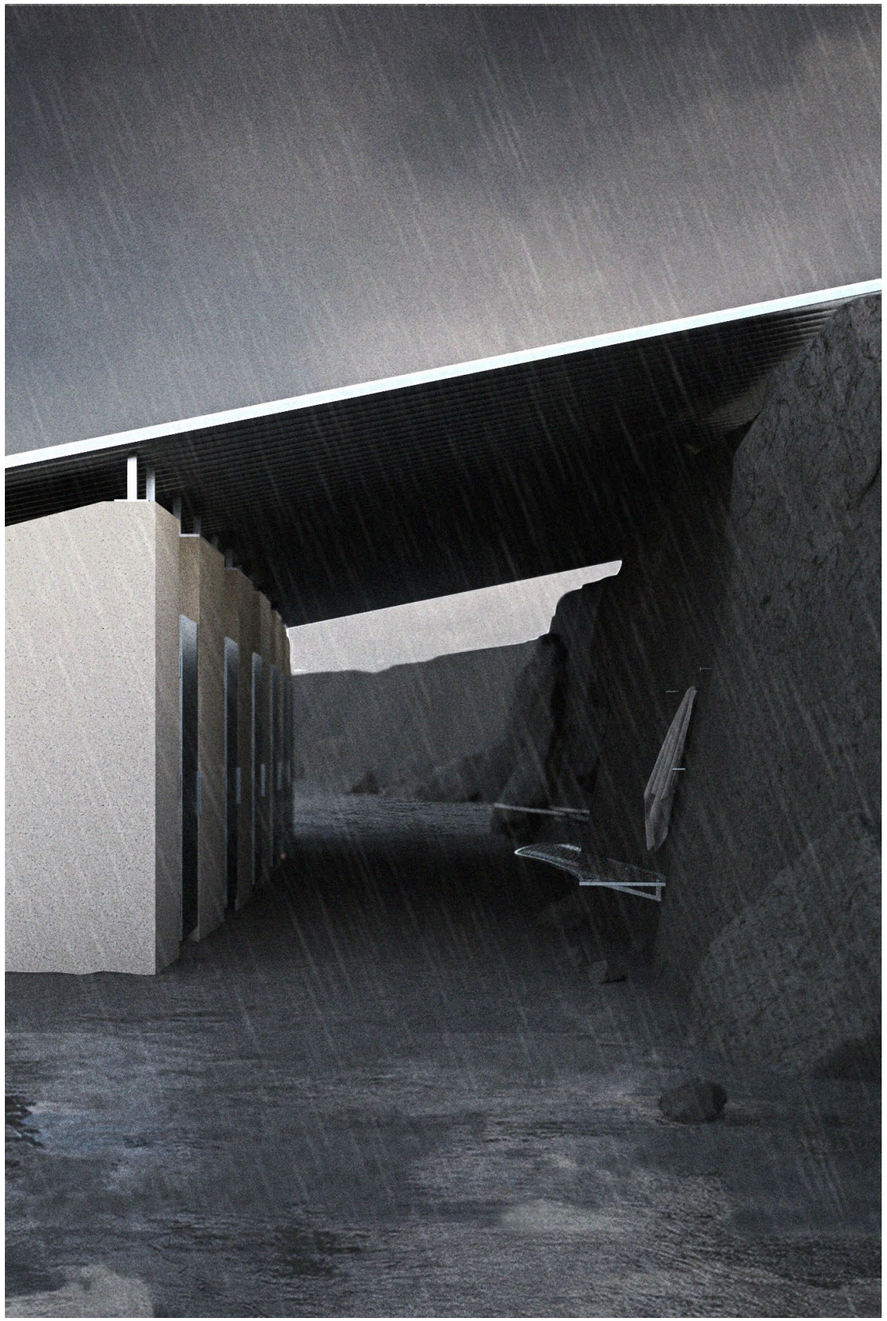
SITE 2 : BAY



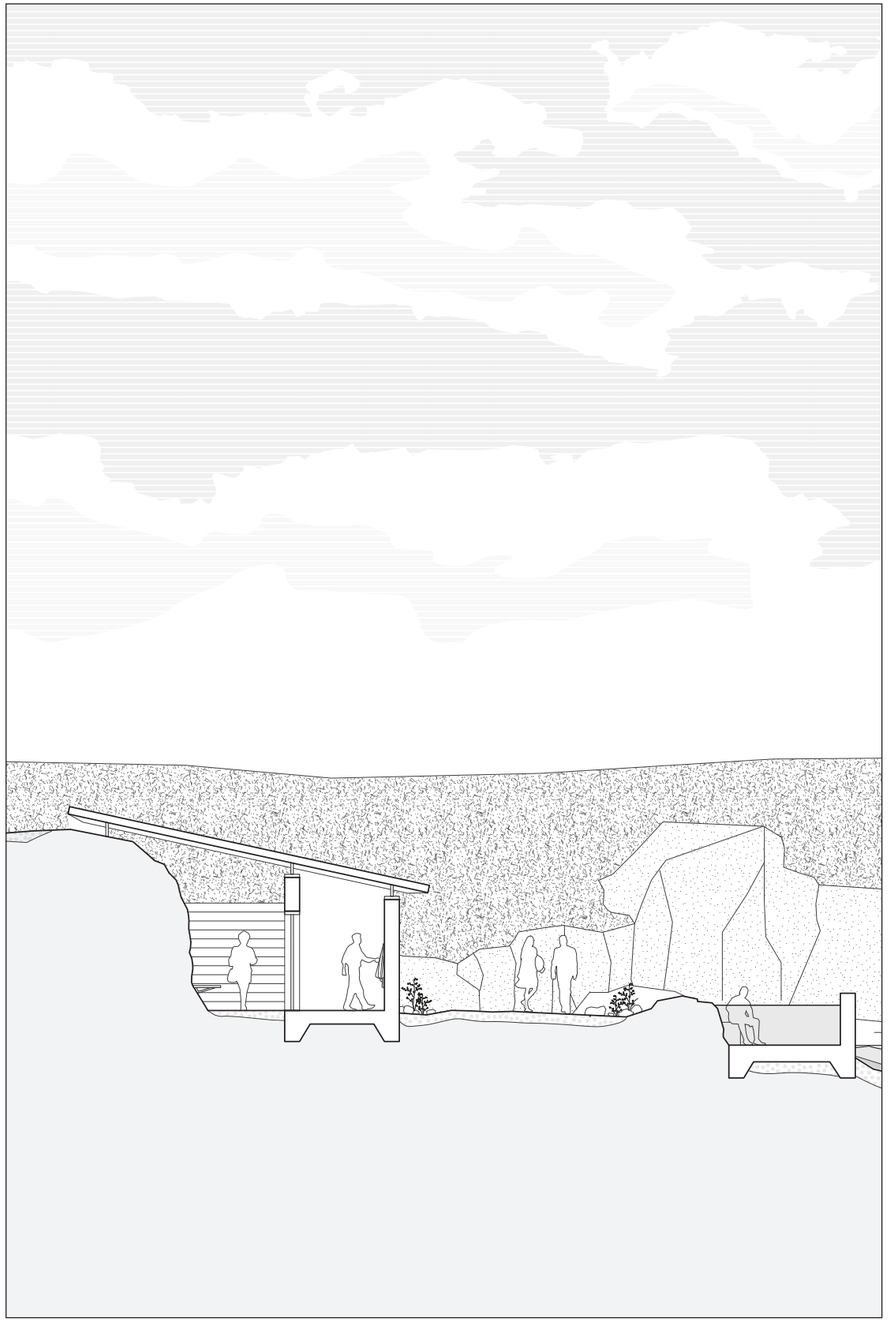
OCCUPIABLE SPACE
access to the bay



PLAN ZOOM IN:
access to the bay

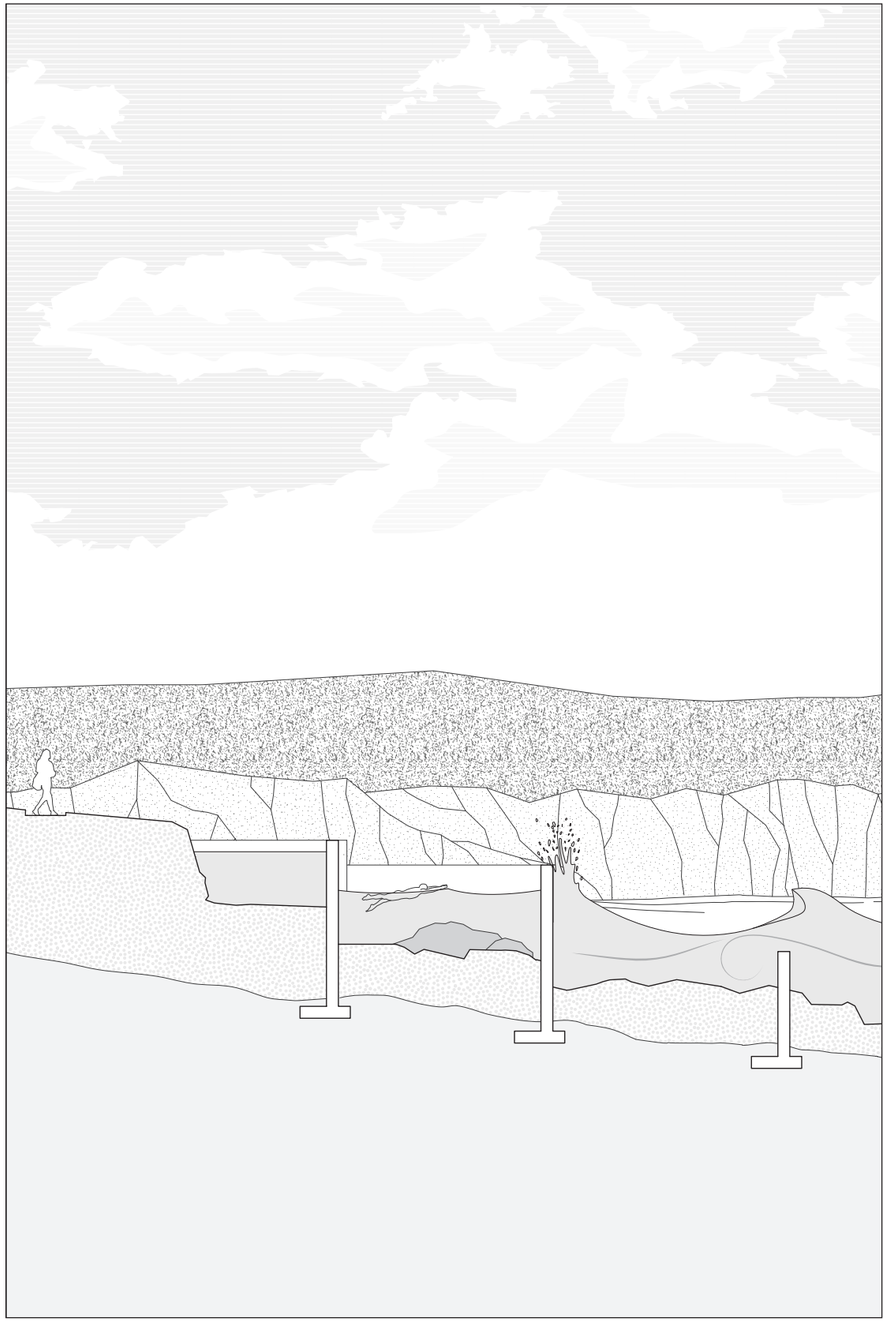


OCCUPIABLE SPACE
sheltered changing room



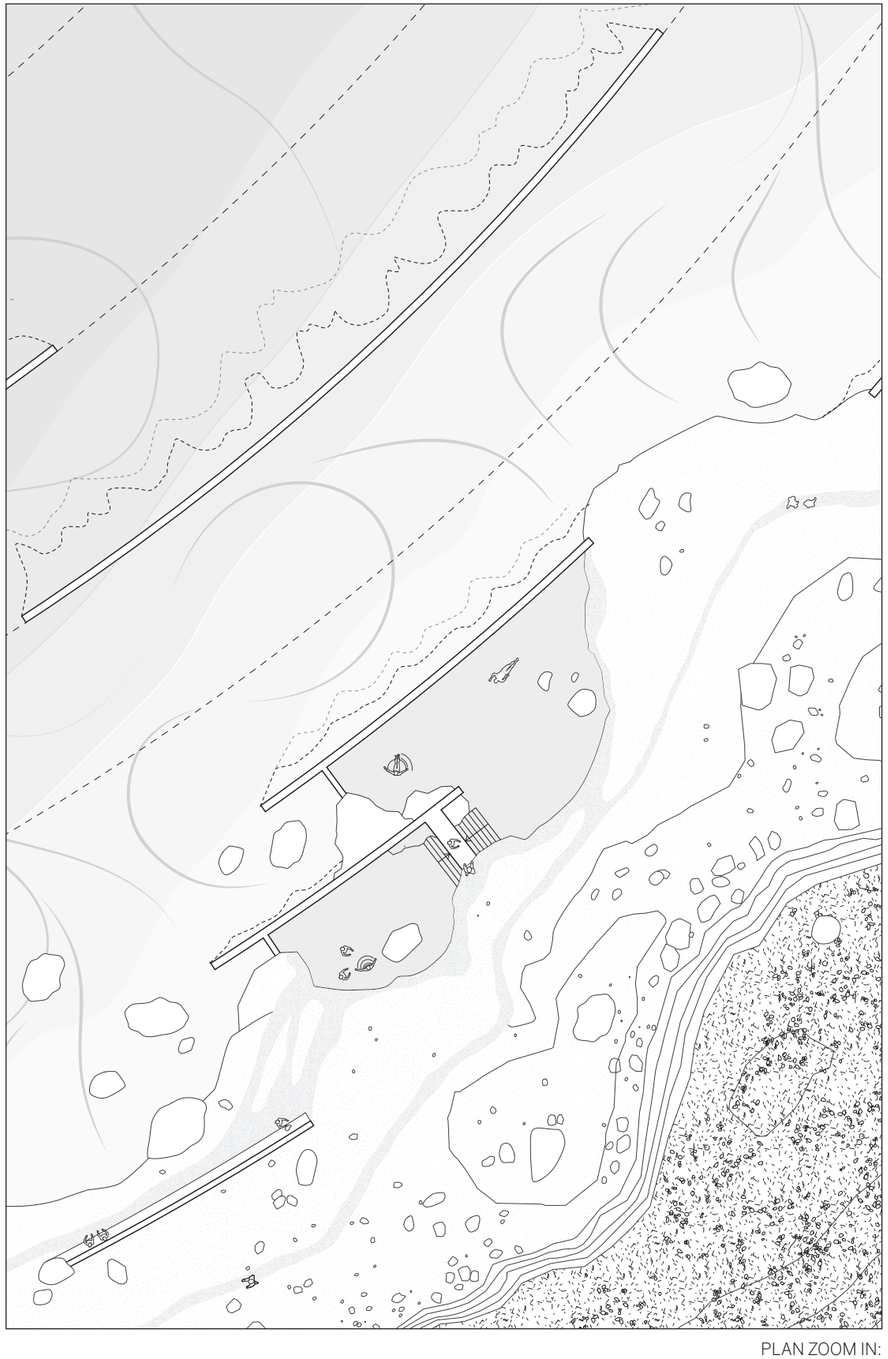
SECTION
sheltered changing room

OCCUPIABLE SPACE
geothermal pool

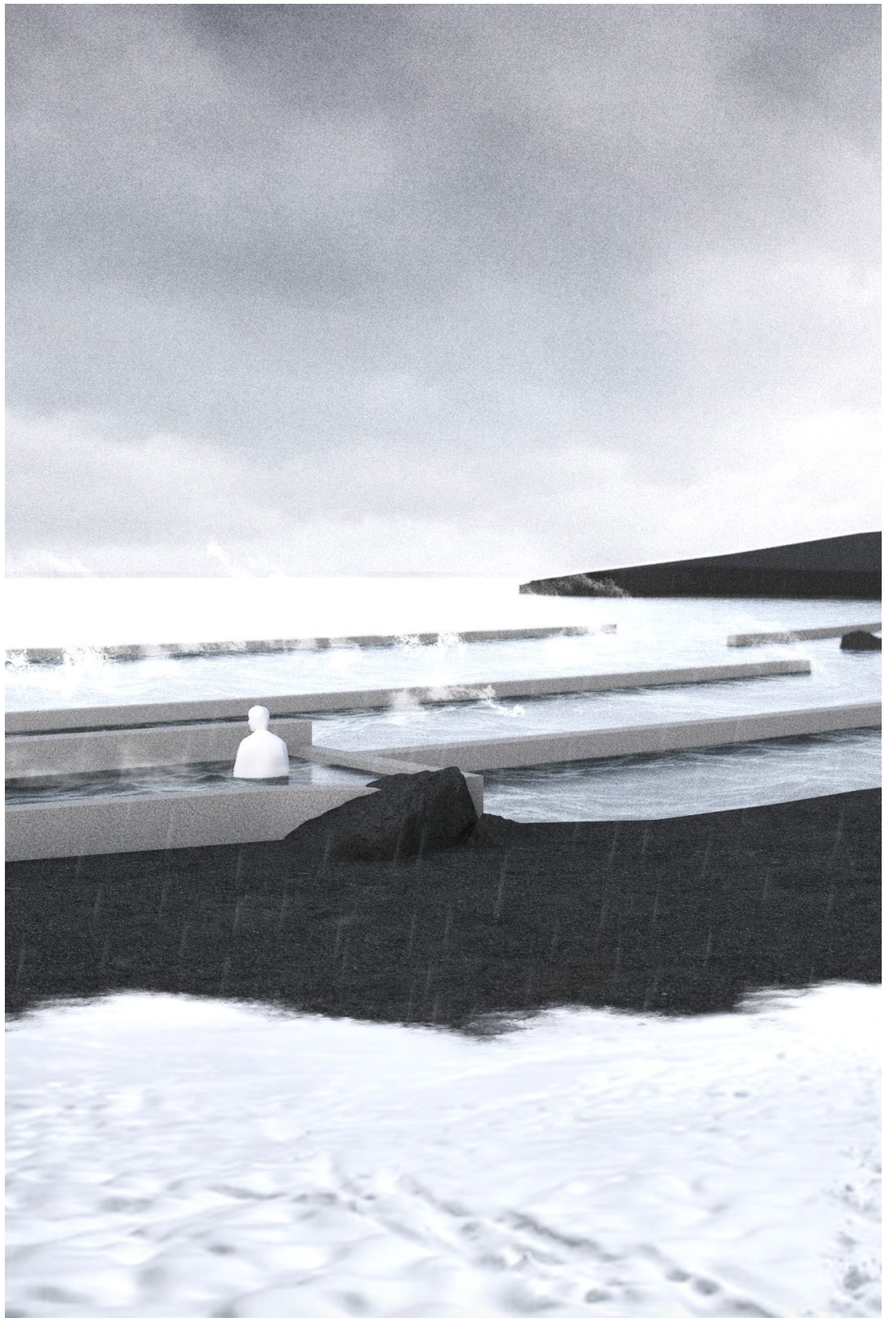


SECTION
series of pools

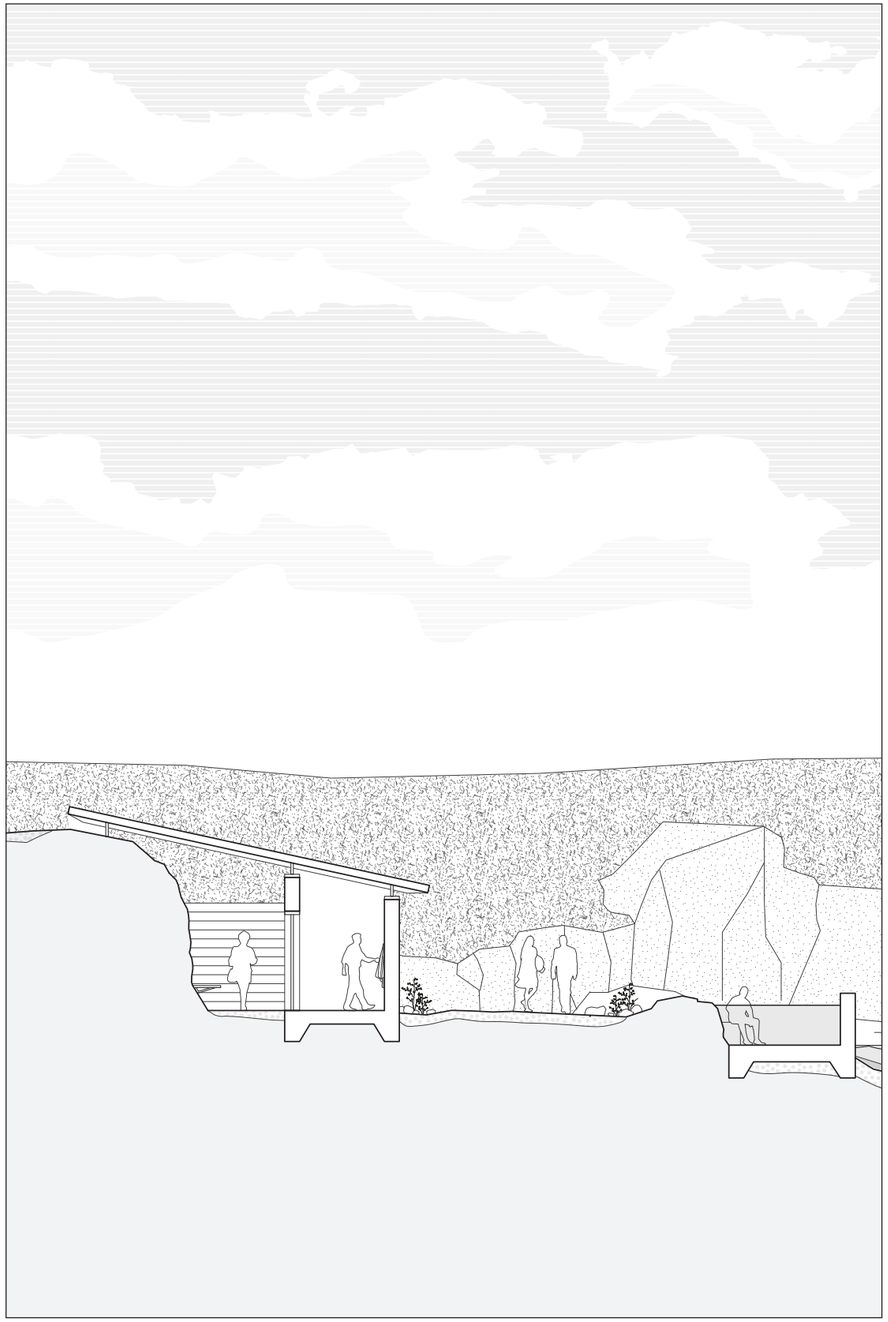
DISSIPATING WAVE ENERGY
how the seawall works



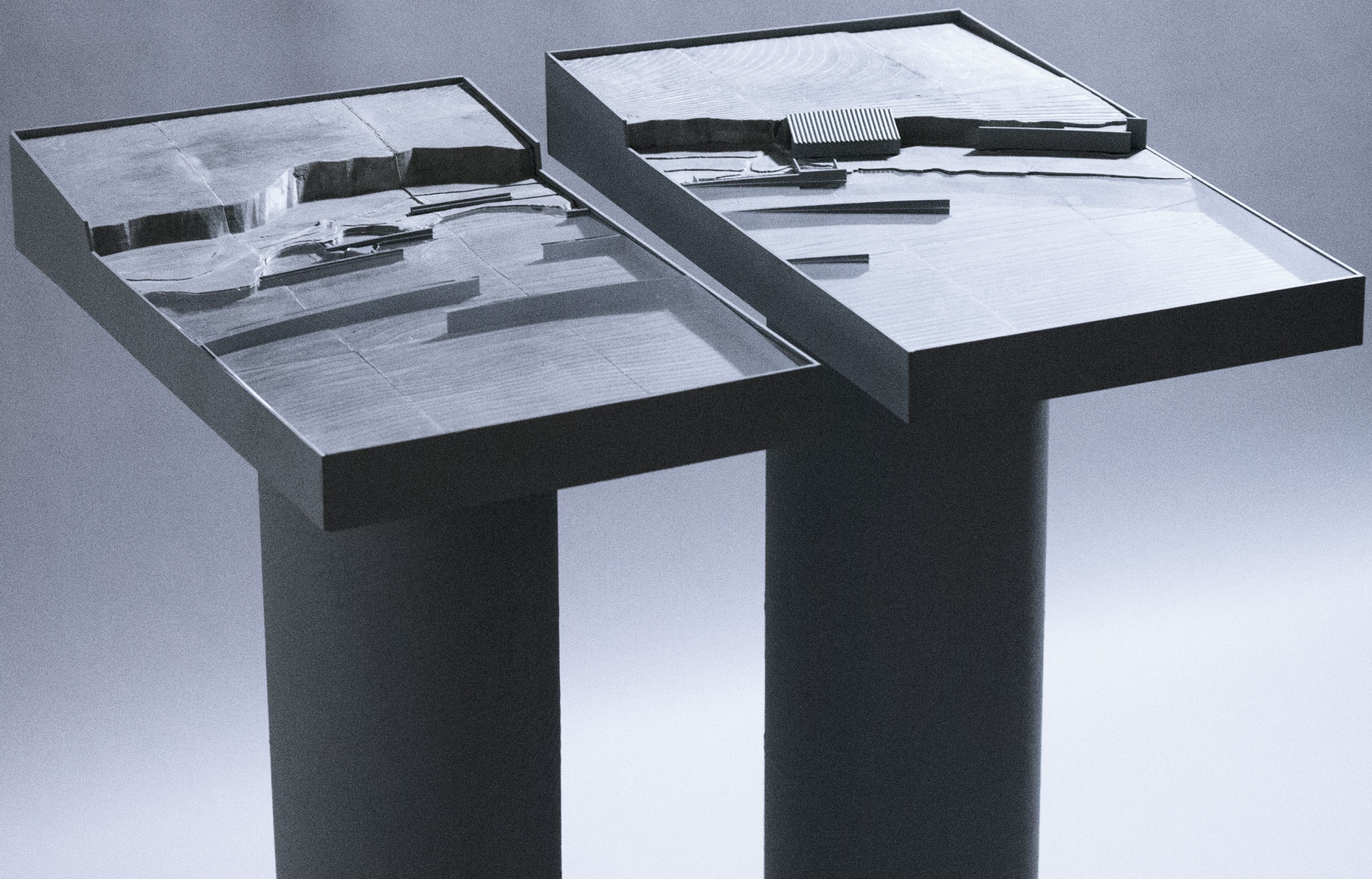
PLAN ZOOM IN:
seawall layout



OCCUPYING NATURE
space for all seasons



SECTION:
occupied space



SITE 3: BEACH

strönd

SAUÐÁRKRÓKUR
65.74° N, 19.64° W

SITE 3: BEACH

67°

26°

24°

22°

20°

18°

16°

14°

12°

ARCTIC CIRCLE

66°

SAUÐÁRKRÓKUR

65°

REYKJAVIK

64°

63°

ARCTIC REGION

SITE 3: BEACH

Located on a black volcanic sand beach on Iceland's north coast, Sauðarkrókur is central to the country's food production infrastructure. The town of 2,500 people is steadily growing and has an increasingly diverse economy. The town is known for its iconic wooden racks that sit on the beach where fish are hung to dry in the salty sea breeze.

Like so many Arctic towns, the rising sea level and intensity of the tides has begun to wash away the sand, threatening the town and the area used to store the drying racks. A coastal barrier system with sand retention traps is necessary to keep the coastline from eroding away. The site faces the northern prevailing winds, located on the beach in the industrial part of town. The structure is made of timber groynes that extend from the beach out into the sea. It traps the sand as it is swept away by the tide, while creating a new datum on the beach.

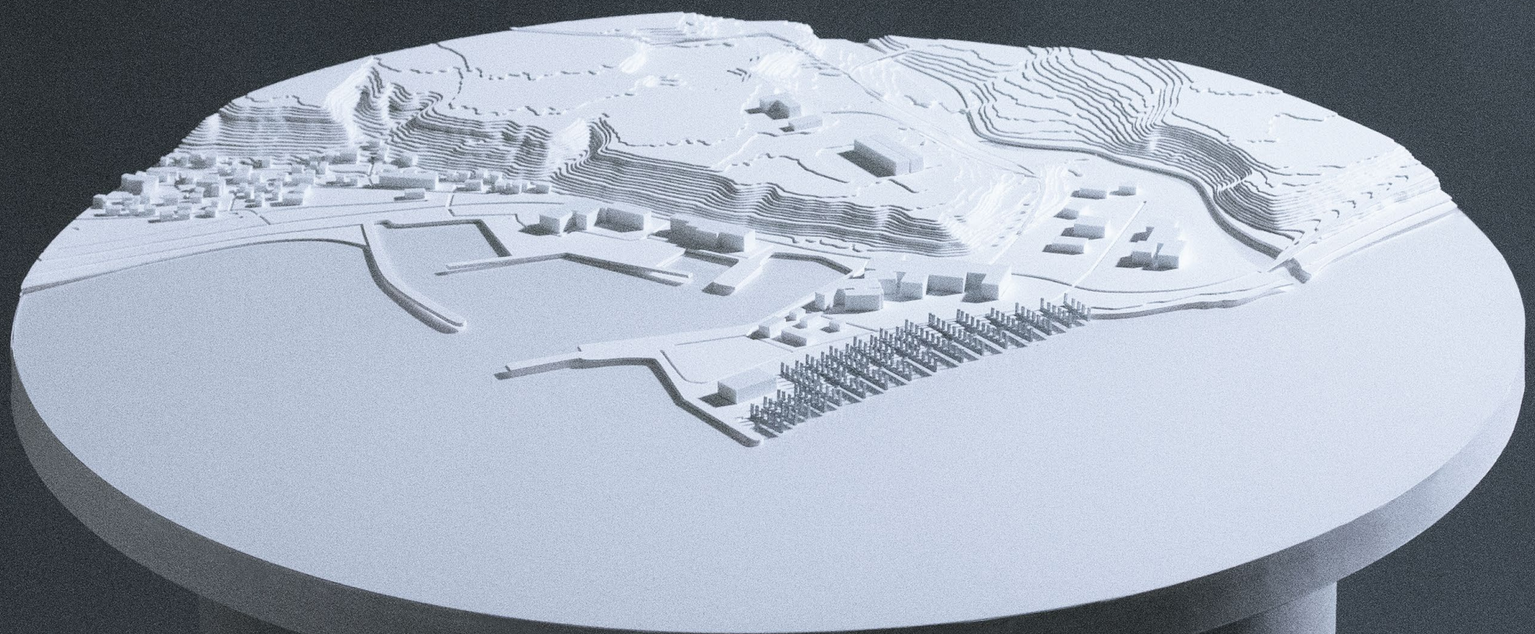
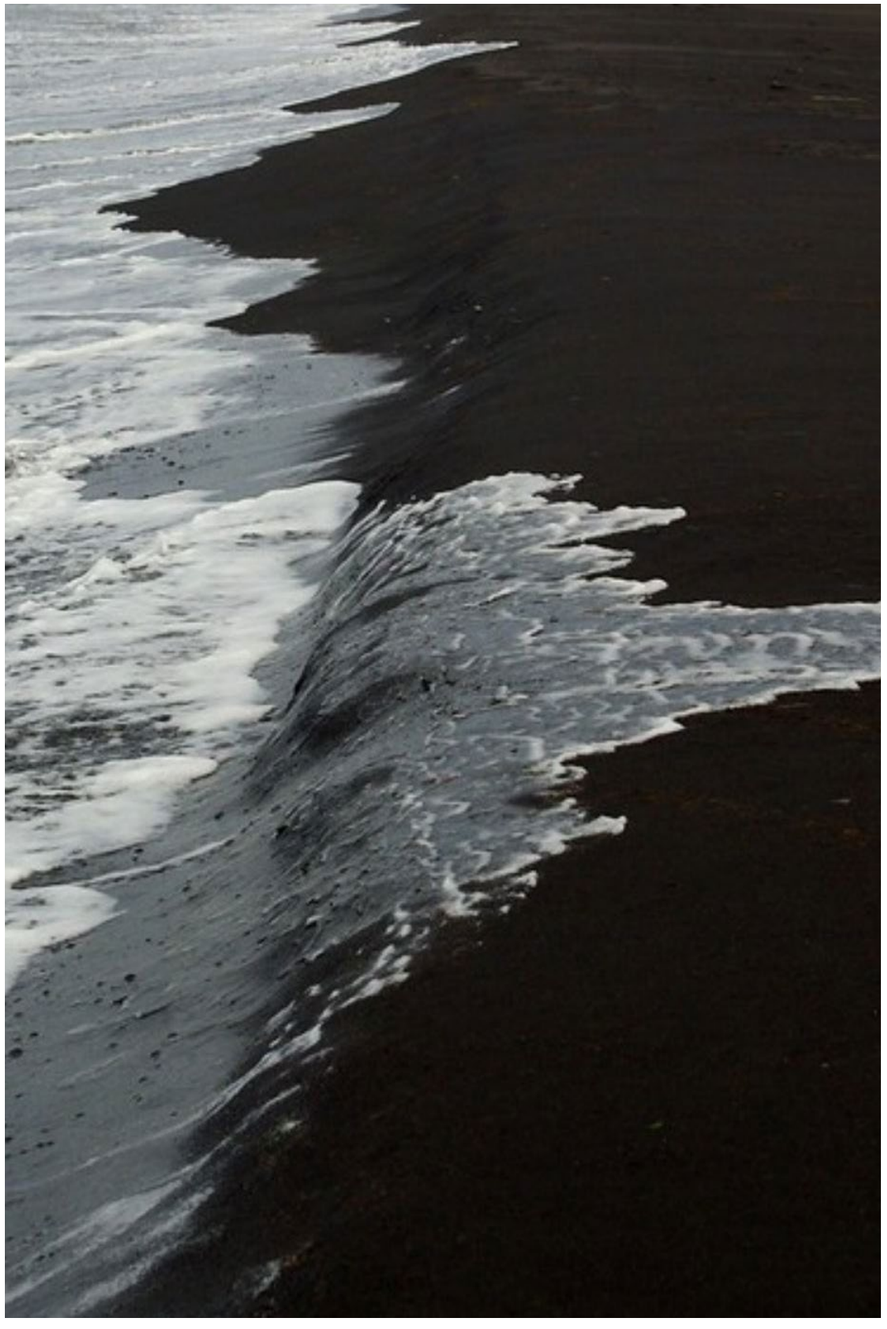
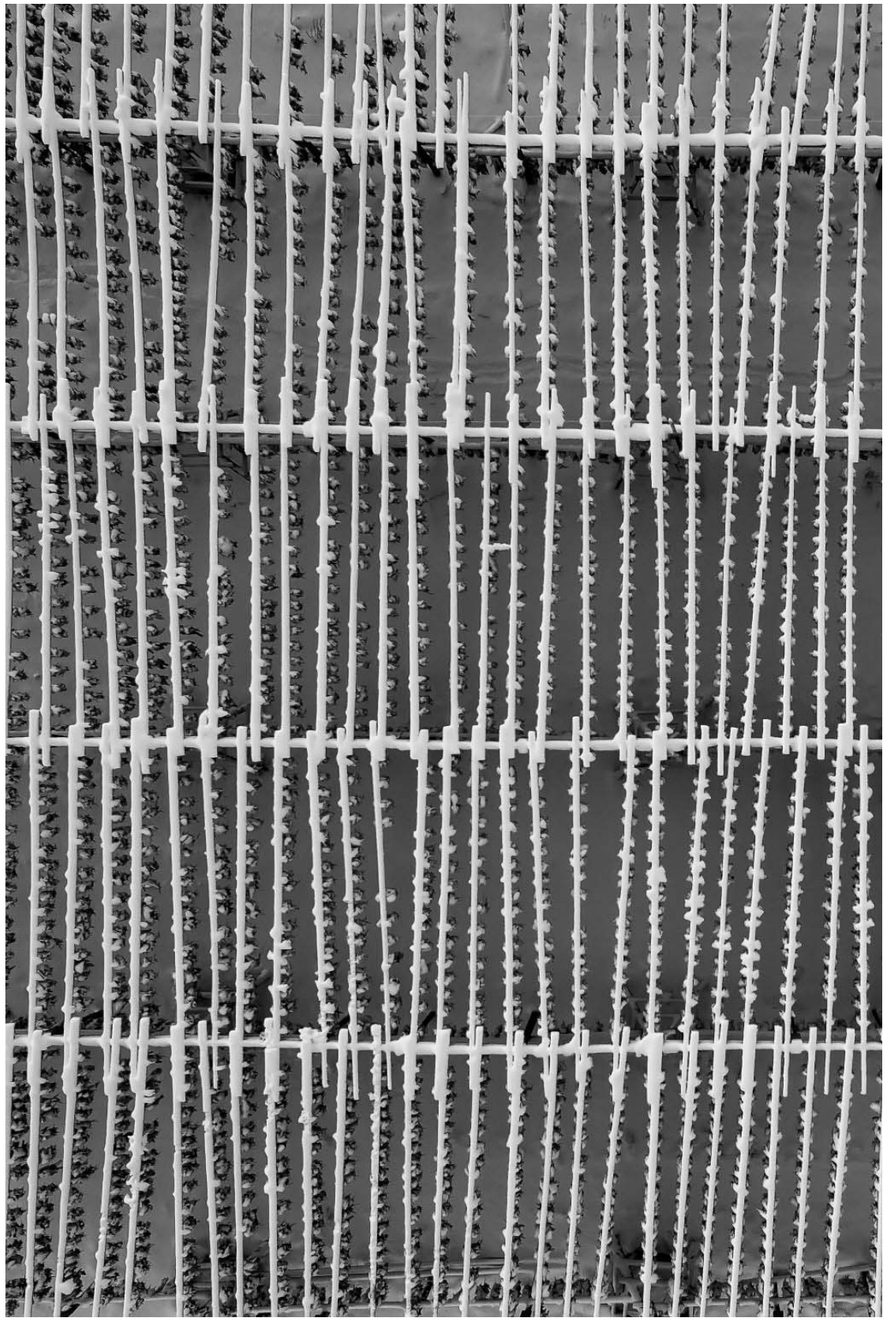


Image: Streetview of Site. Já 360. https://ja.is/kort/?x=470553&y=584577&nz=16.86&ja360=1&jh=314.



SAND EROSION
tides wash the sand away

Image: Hávarðsson, Björgólfur. Caressing the Curves of Mother Earth. July 29, 2009. Photo. https://www.flickr.com/photos/bjorgolfur/3789116105/.



FISH DRYING RACKS
fish are dried in the salty ocean air

Image: Arctic-Images. Getty Images. "Top View of Fish Drying in the Wintertime, Iceland." https://www.gettyimages.com/detail/photo/aerial-snow-covered-metal-racks-with-fish-drying-royalty-free-image/910546940.

SITE 3: BEACH

SAUÐÁRKRÓKUR 65°74N 19°64W

legend

Prevailing Wind Direction

Topography 2m contours

1 : 3500

0 100m 300m

SITE 3: BEACH

SAUÐÁRKRÓKUR 65°74N 19°64W

legend

Prevailing Wind Direction

Topography 2m contours

1 : 3500

0 100m 300m

SITE 3: BEACH

SAUÐÁRKRÓKUR 65°74N 19°64W

legend

Prevailing Wind Direction

Topography 2m contours

1 : 3500

0 100m 300m

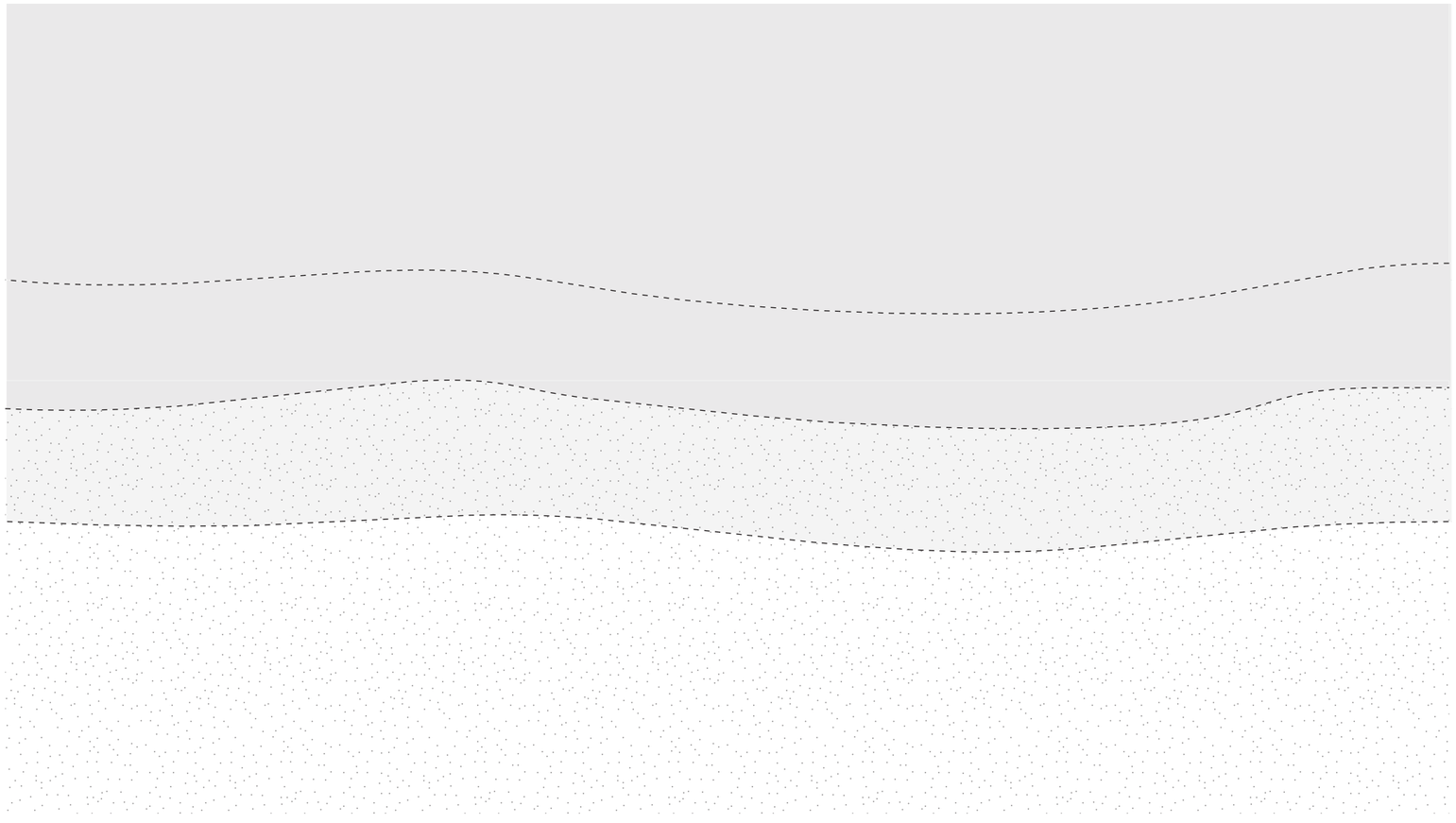


DIAGRAM
timber groyne system

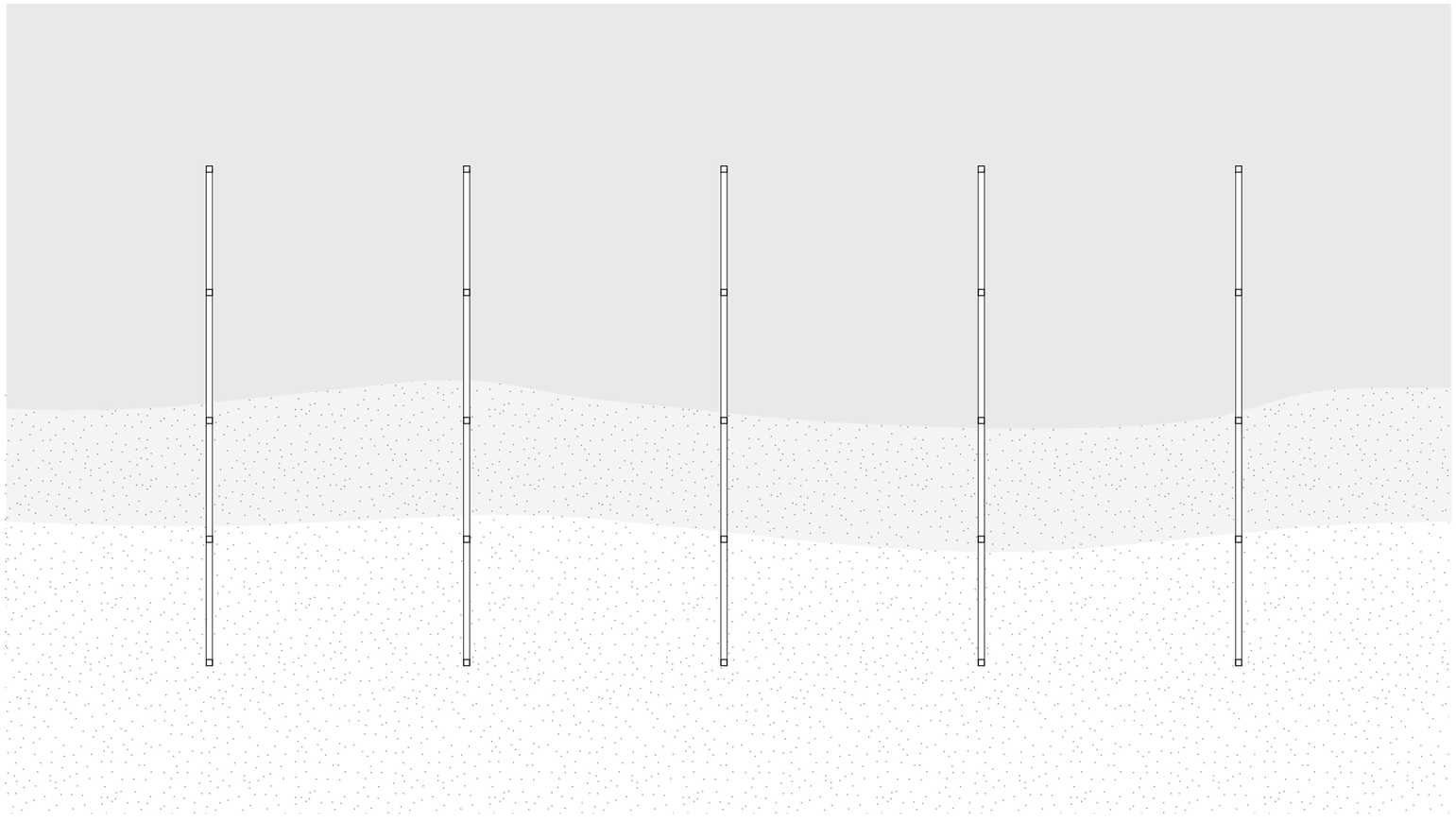


DIAGRAM
timber groyne system

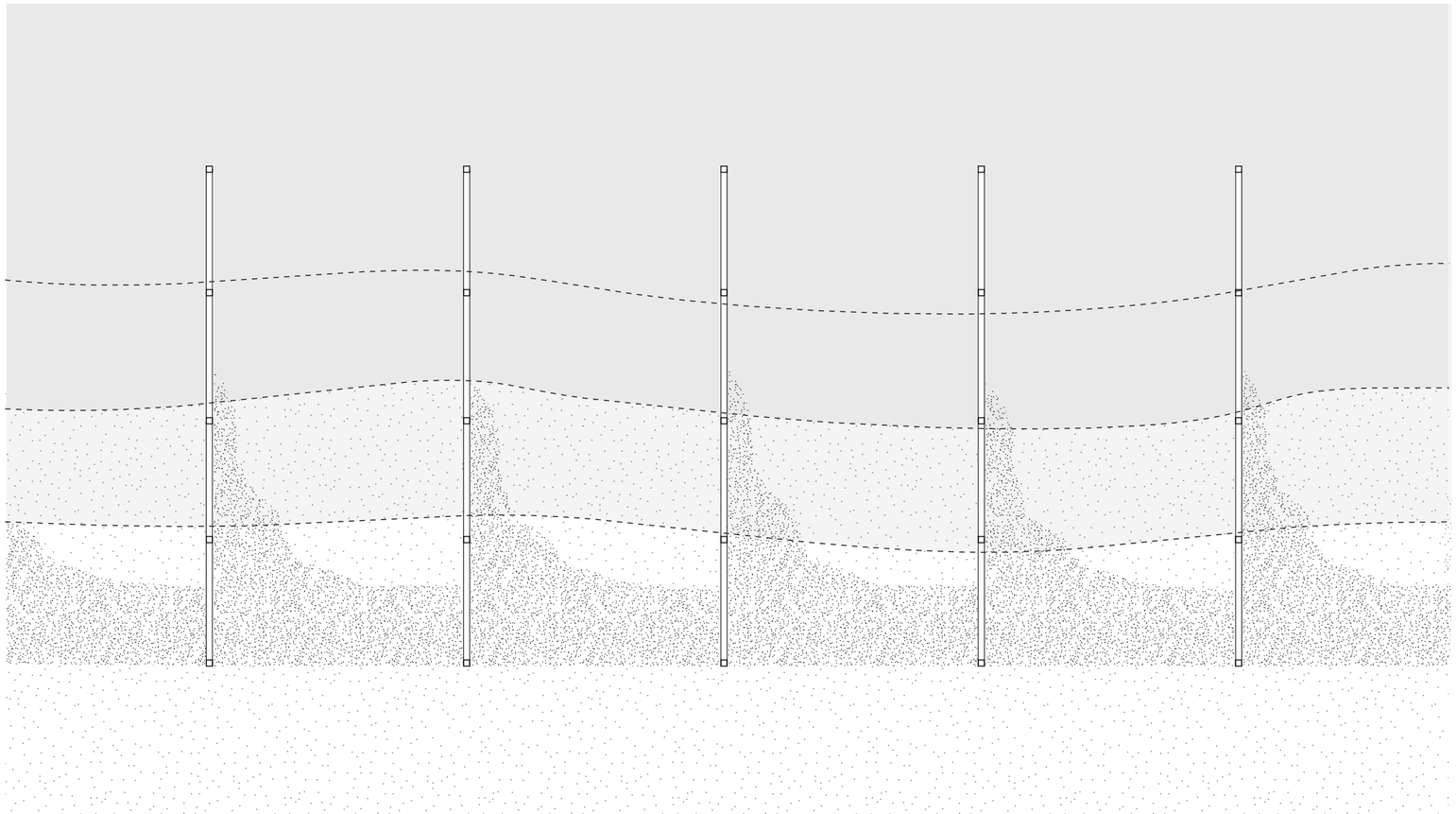


DIAGRAM
timber groyne system

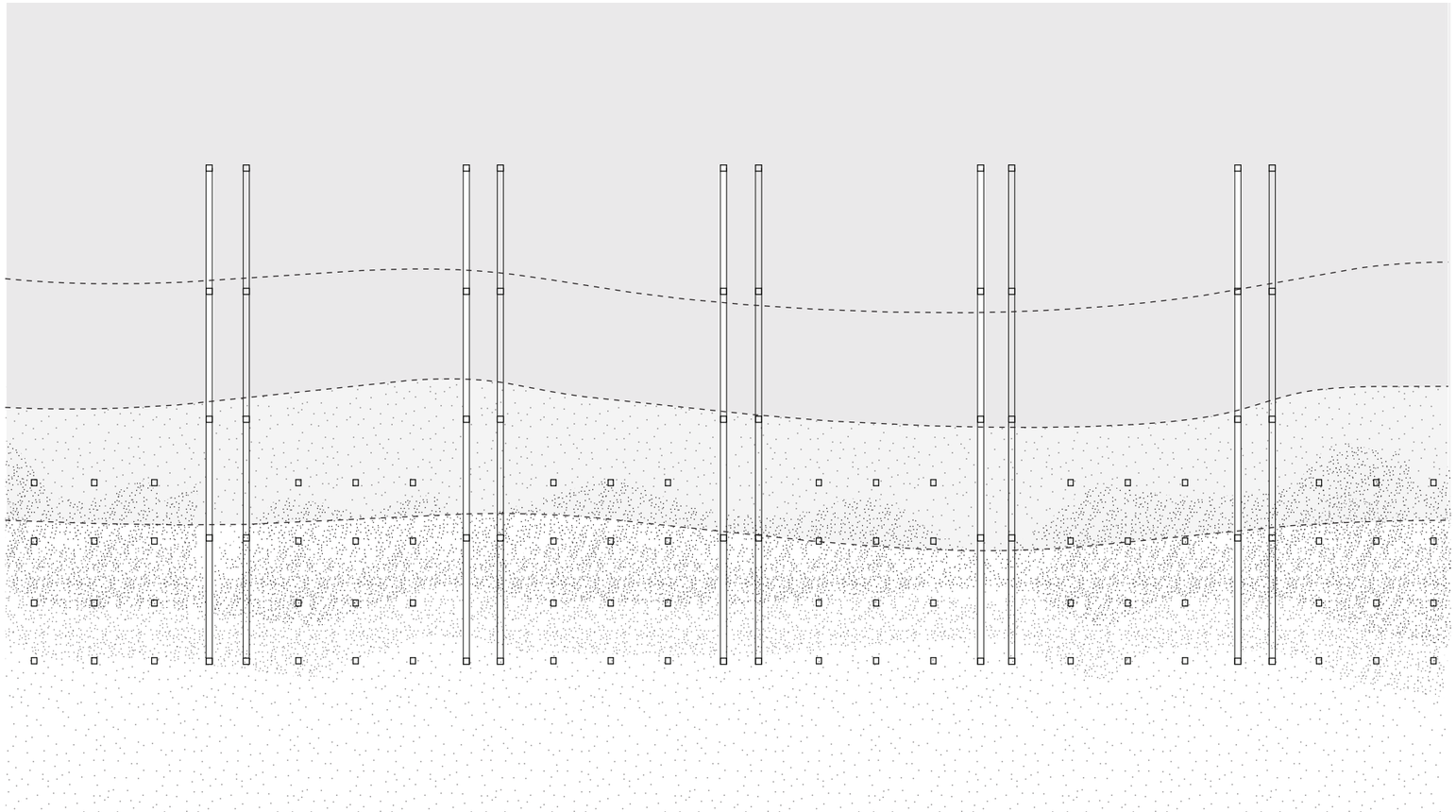


DIAGRAM
timber groyne system

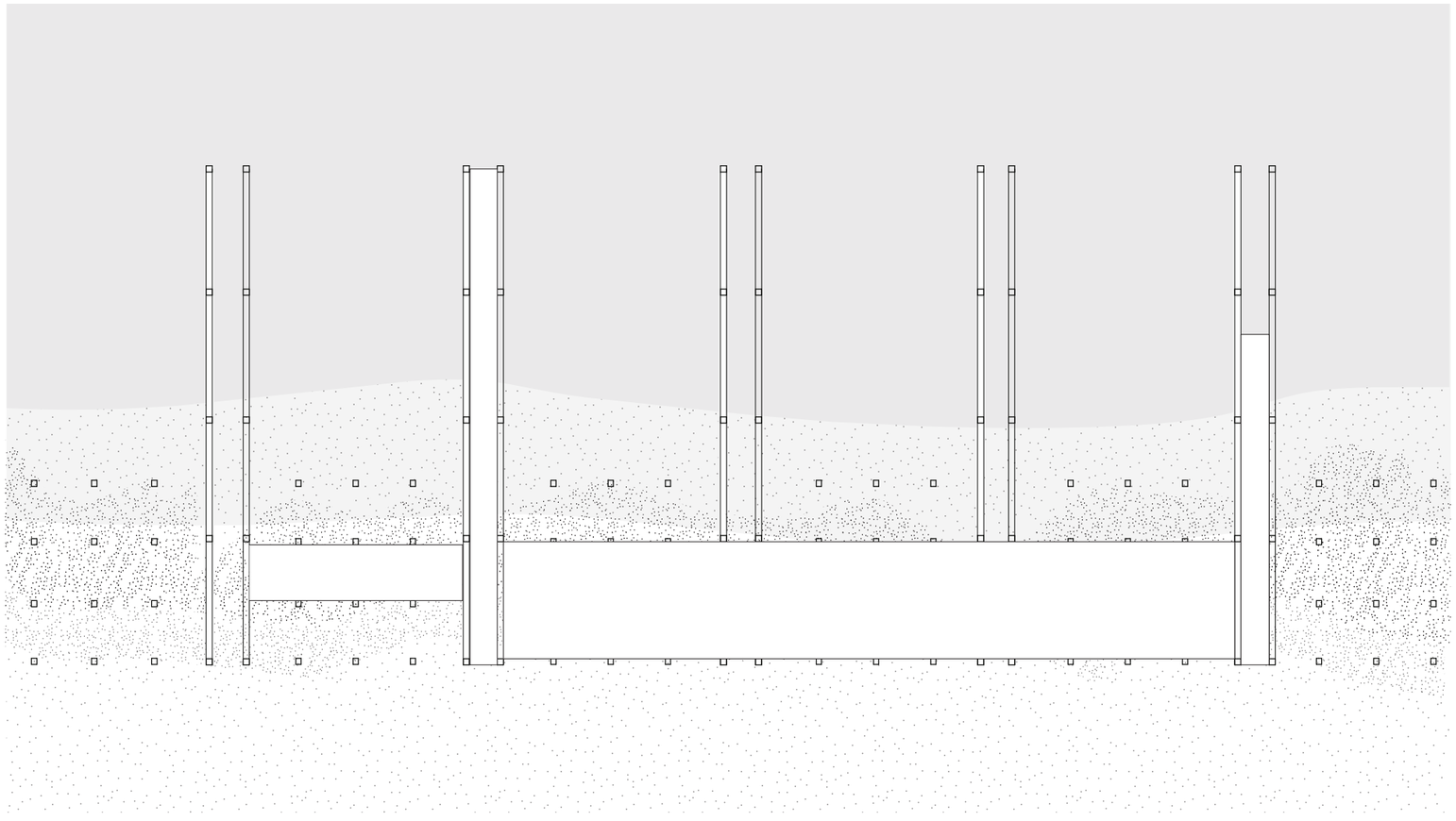
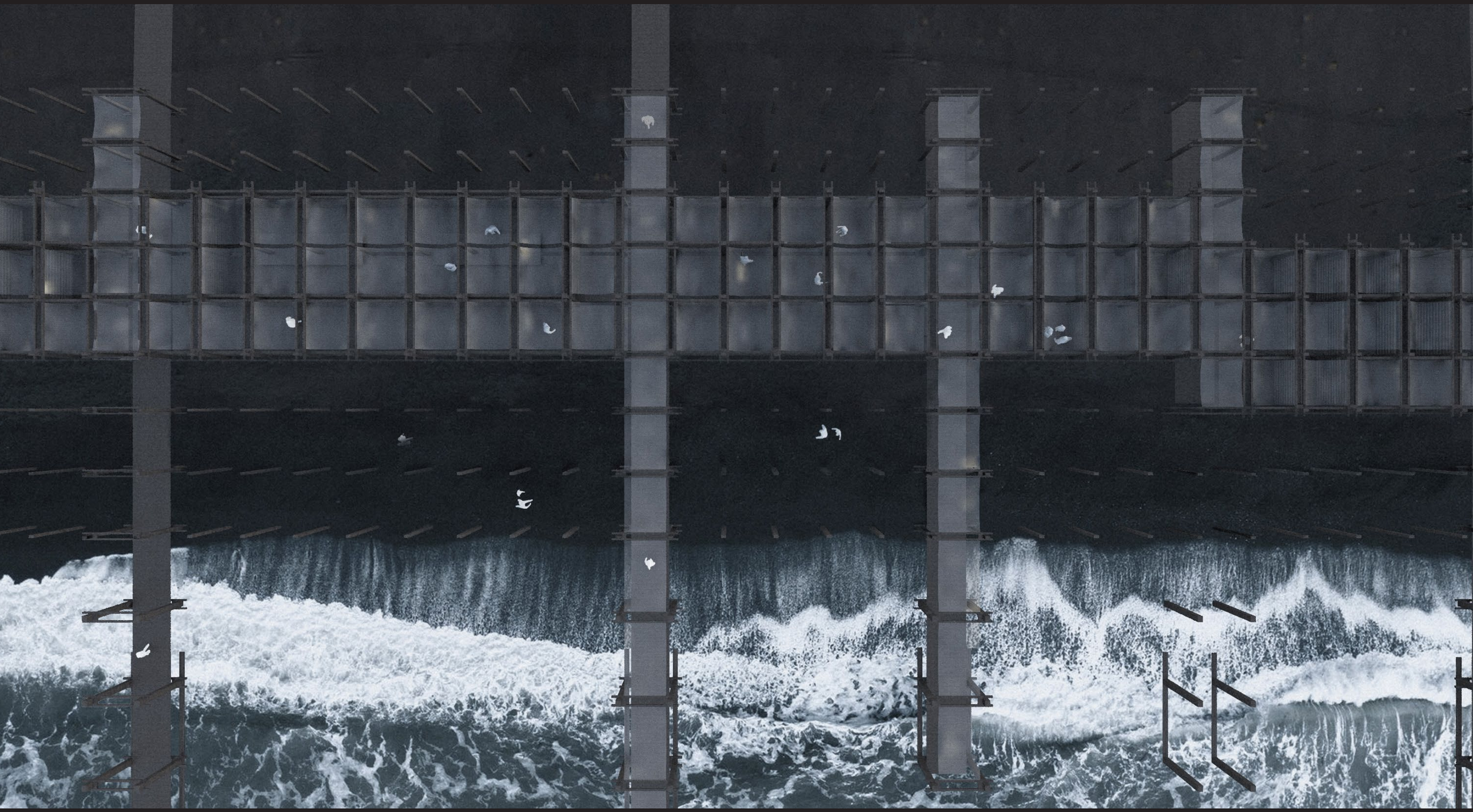


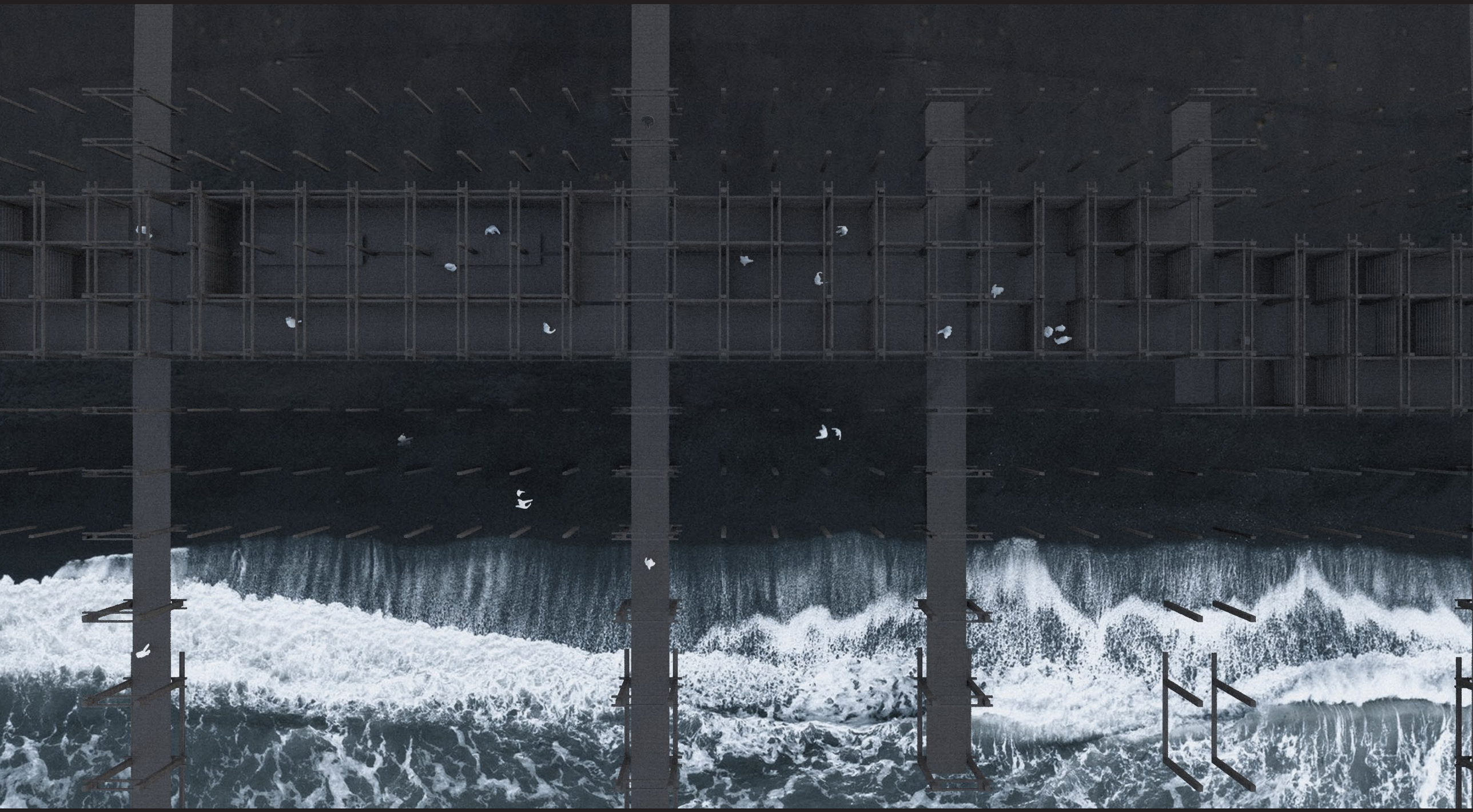
DIAGRAM
timber groyne system

SITE 3: BEACH

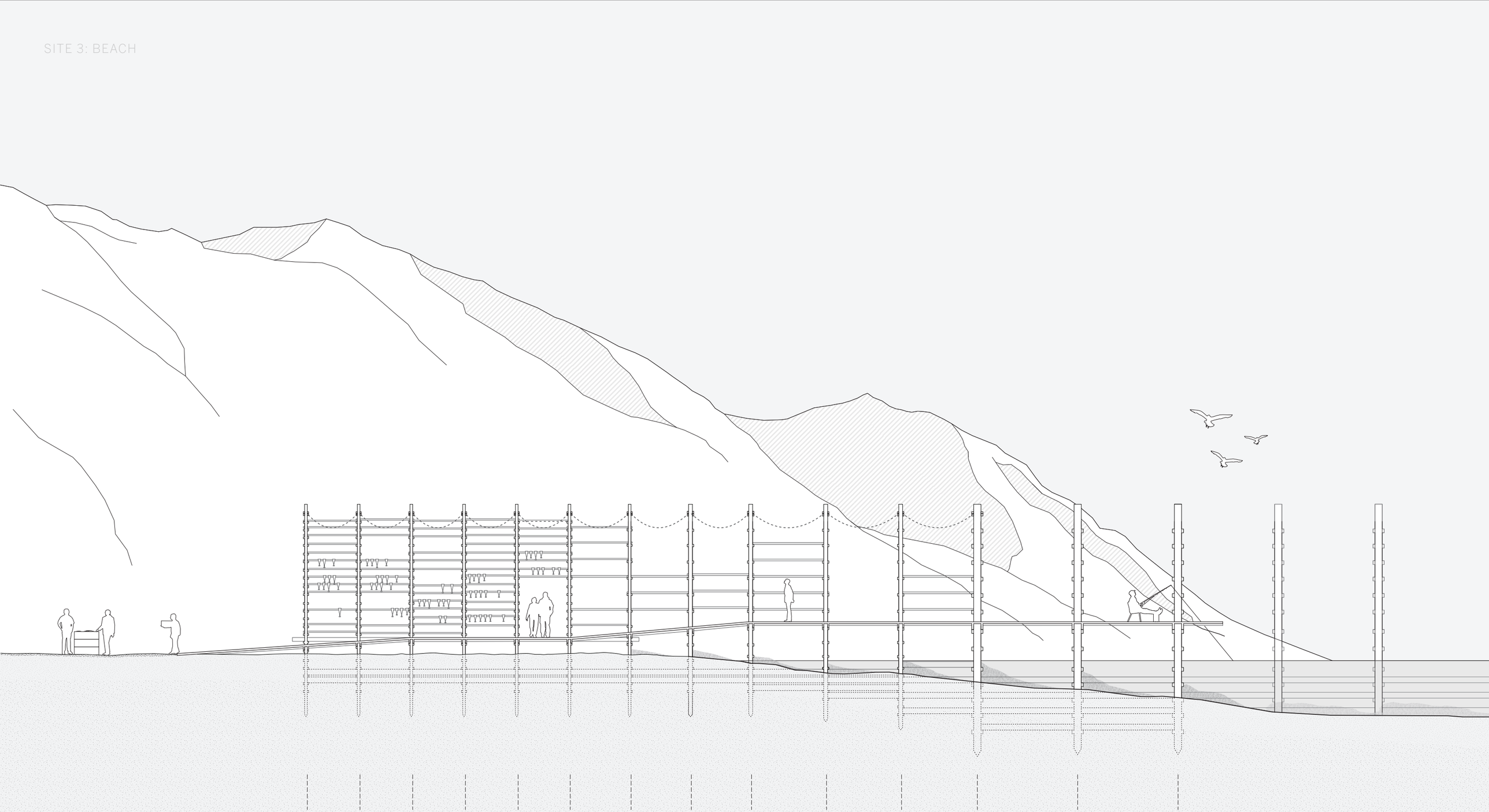
A FRAMEWORK FOR FLEXIBILITY

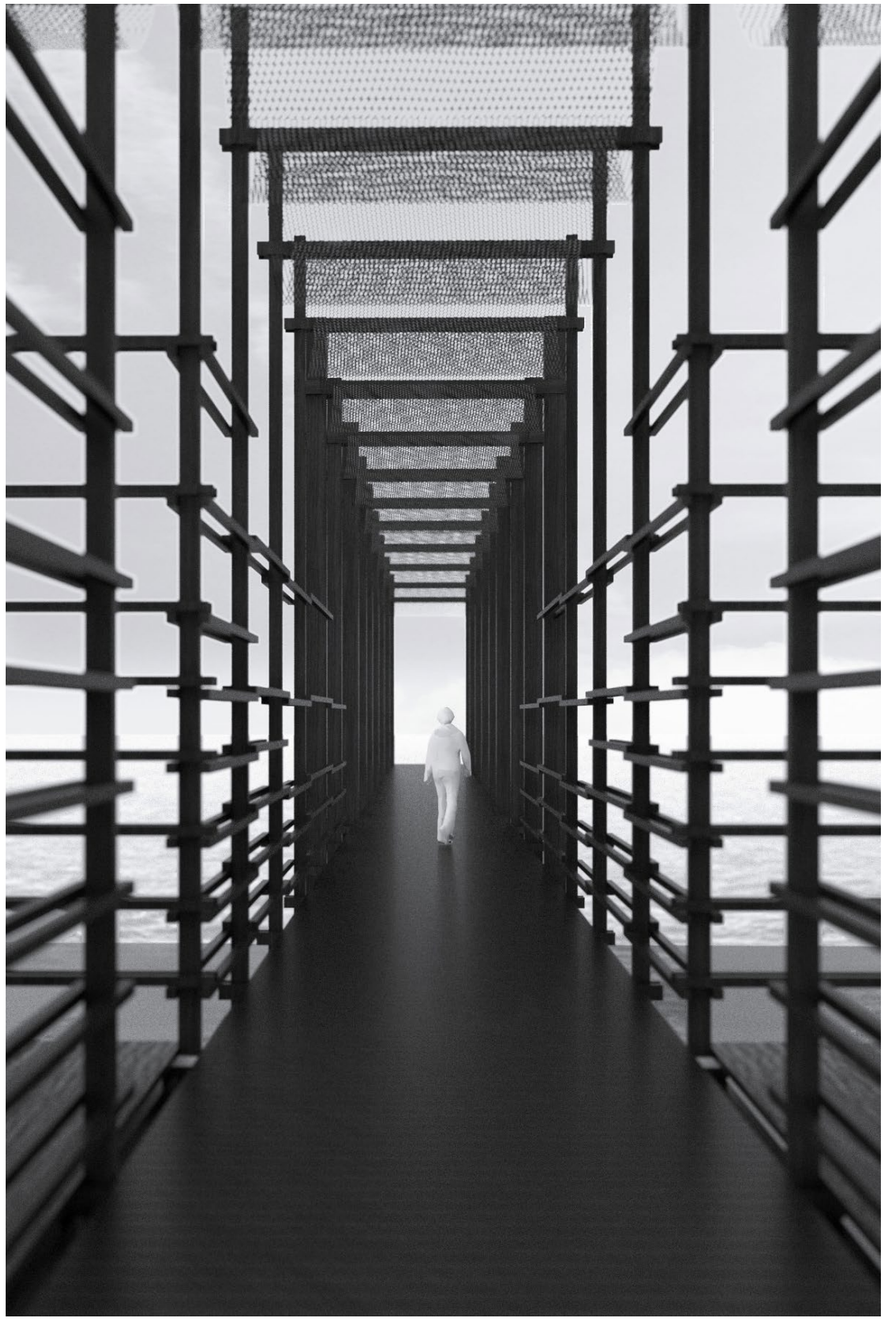
SITE 3 : BEACH



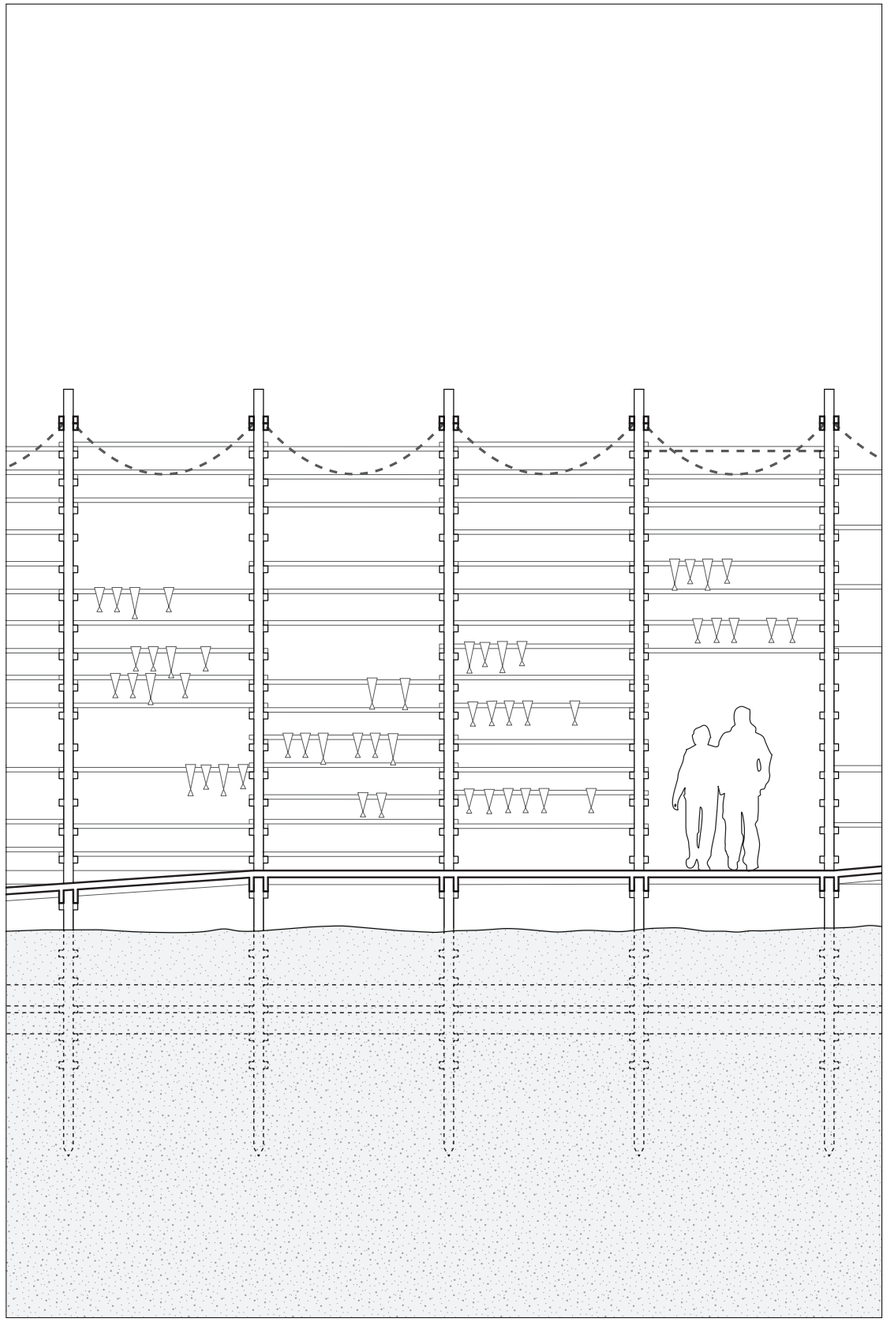


SITE 3: BEACH



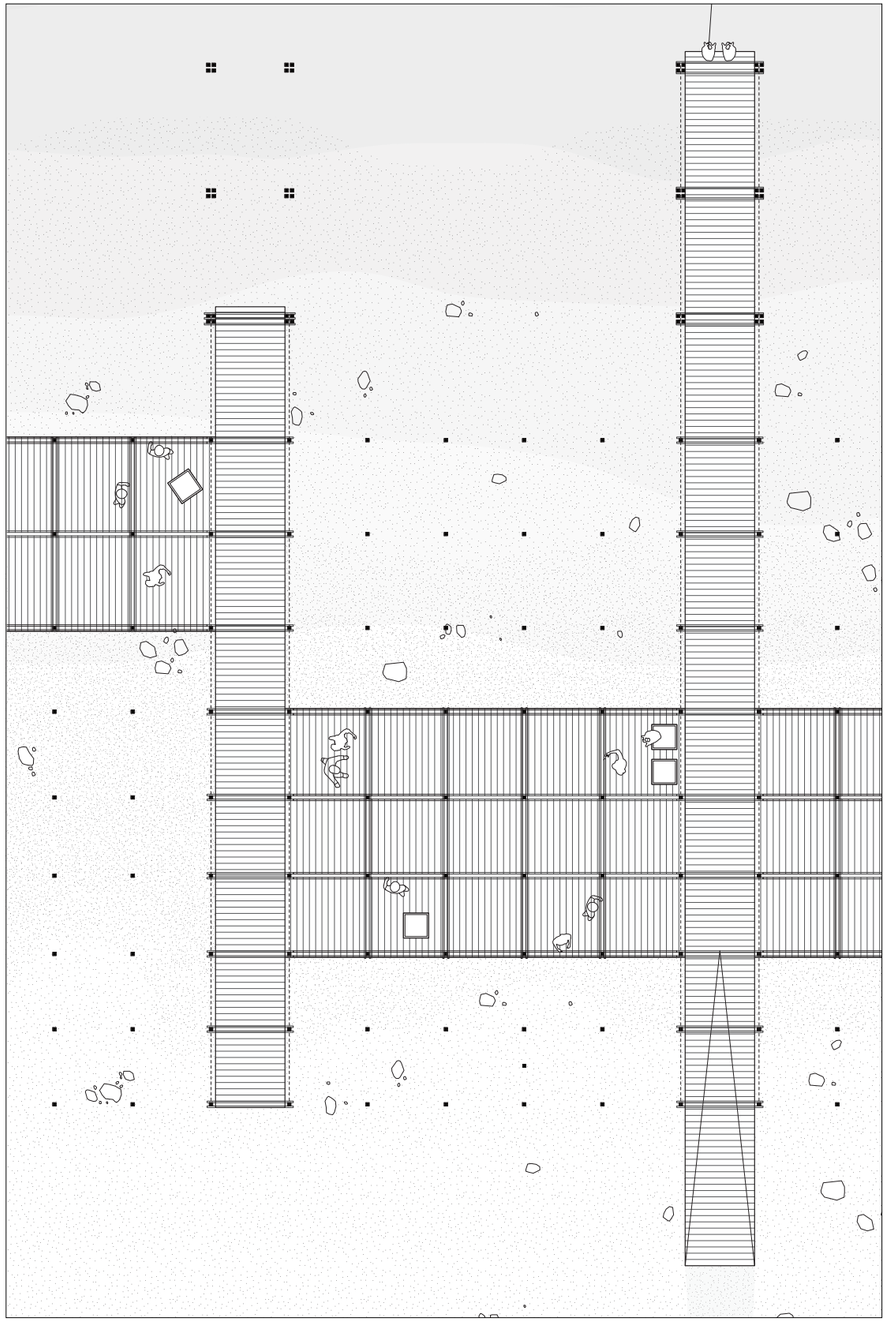


VIEW:
under the canopy



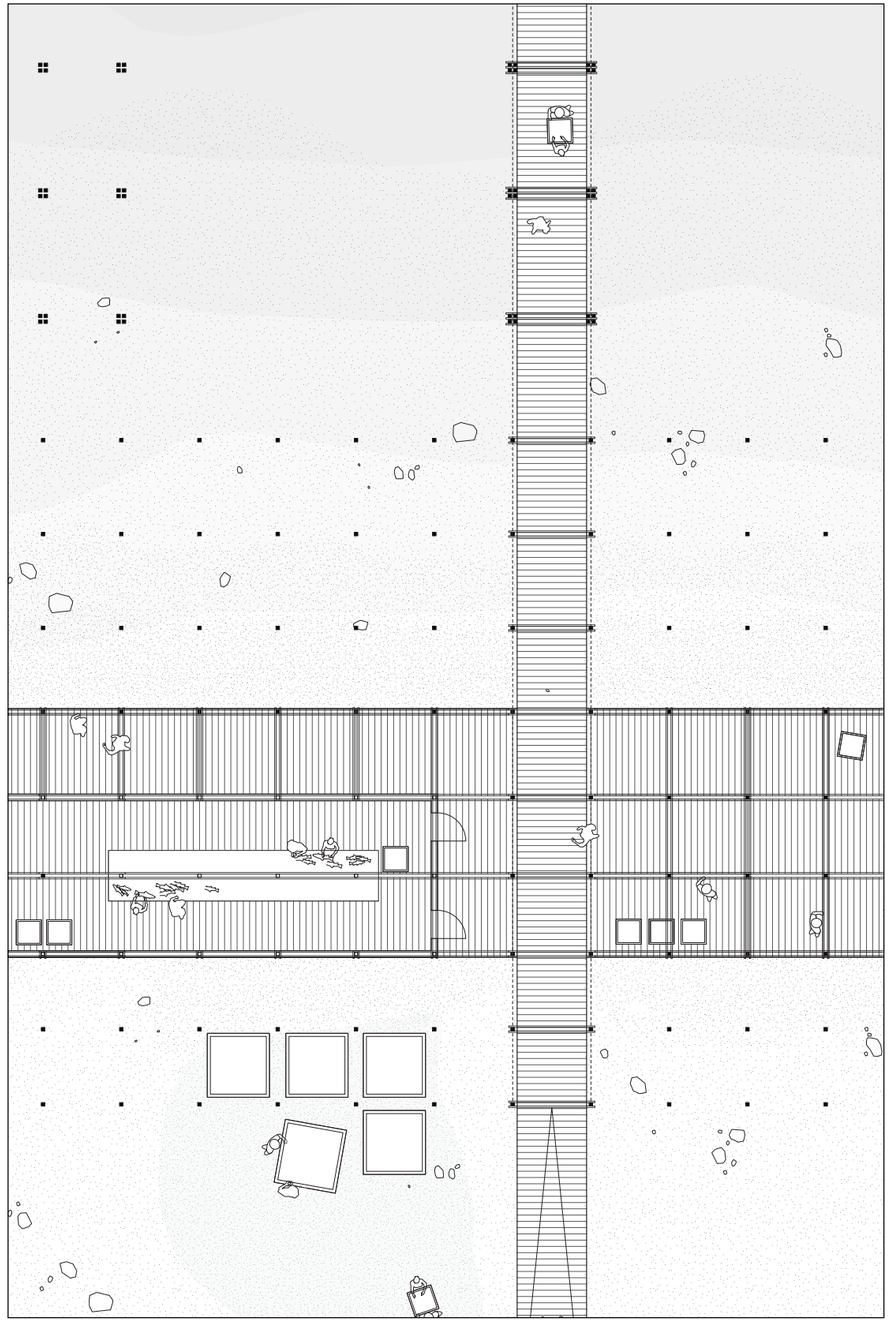
SECTION
canopy & fish drying

VIEW:
under the canopy

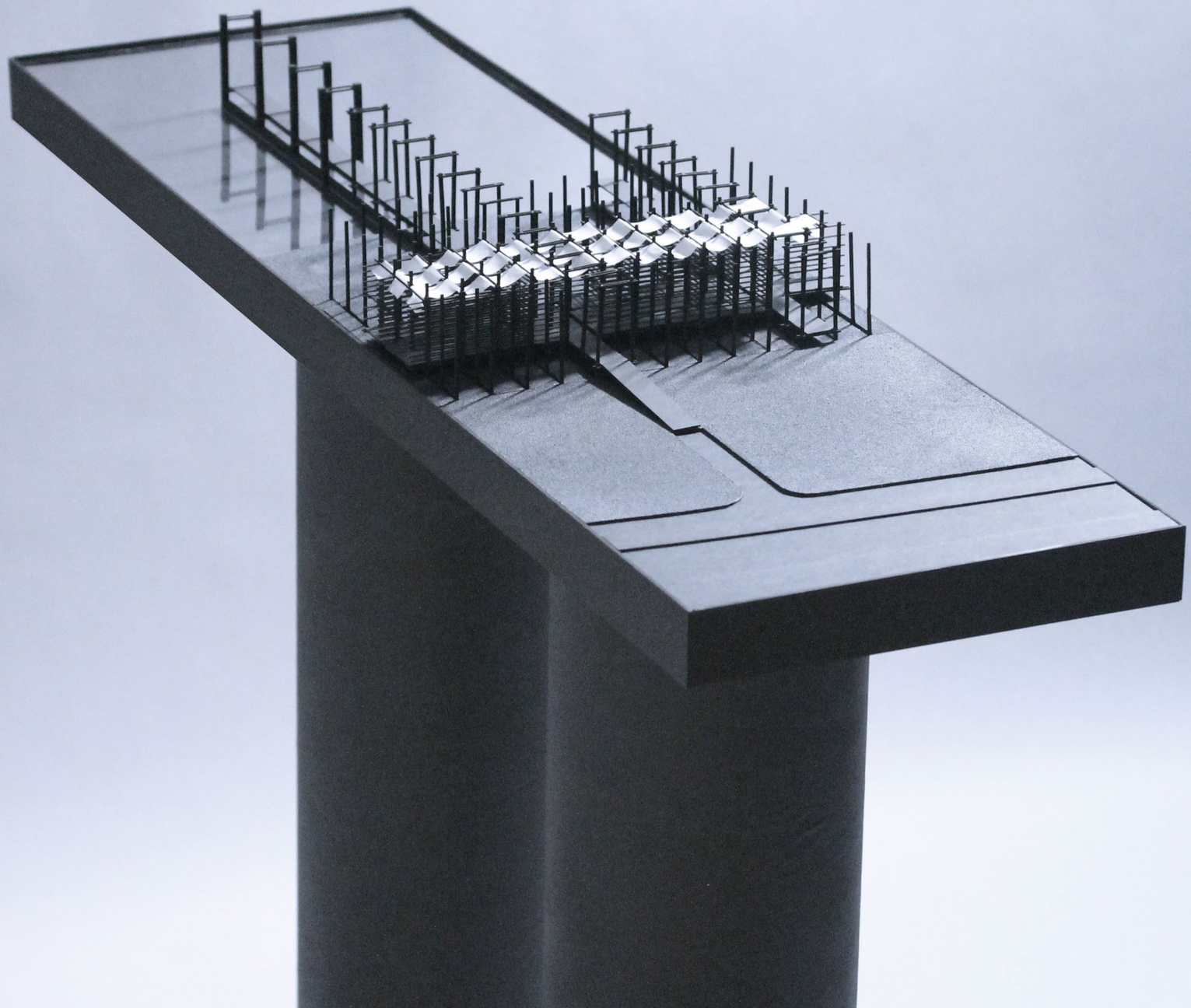


PLAN ZOOM IN:
fish drying

VIEW
fishing off the dock



PLAN ZOOM IN:
fish drying area



67°
26°
24°
22°
20°
18°
16°
14°
12°
ARCTIC CIRCLE
66°
65°
64°
63°
FLATEYRI
SAUÐÁRKRÓKUR
RAUFARHÖFN
REYKJAVIK
ARCTIC REGION

SUMMARY

SCRIPT:

Zooming back out, these designs have explored how coastal infrastructure can be built to protect against large scale forces, while being designed to enhance daily life. As climate change accelerates across the Arctic, and the world, the need for critical barriers to protect communities will increase.

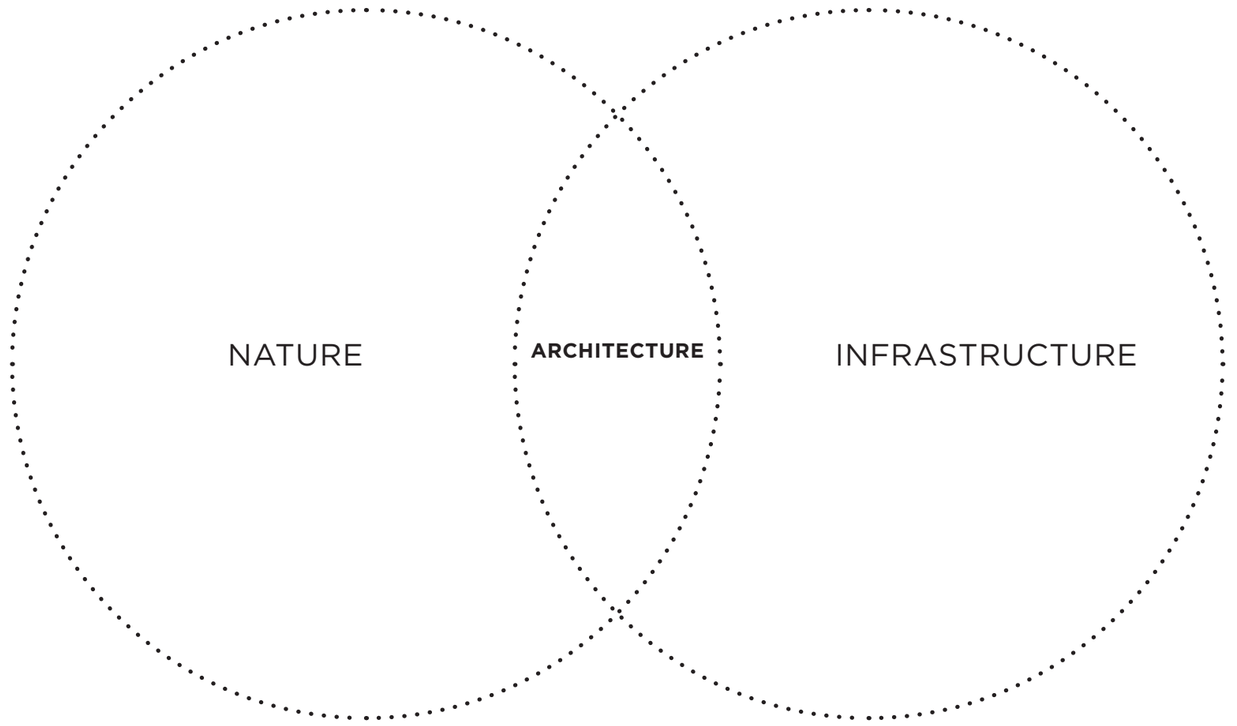
Glacial Comparison
Svalbard.
Christian Åslund.

Image: Åslund, Christian. Glacier Comparison on Svalbard, Climate Change. Accessed September 10, 2021. http://www.christian.se/global-warming-retreating-glaciers.

SUMMARY

SCRIPT:

We must ask how these structures will integrate with their surrounding nature and the communities within which they are built.



MEDIATOR

APPROACH

SUMMARY

SCRIPT:

To explore this I chose exposed coastal towns in sublime natural environments. These sites provided the context to consider the interconnected scales at which they must operate within to successfully become an extension of their environment.

SITE 1
(FJORD)

Flateyri
66.07° N, 23.13° W

SITE 2
(BAY)

Raufarhöfn
66.50° N, 15.40° W

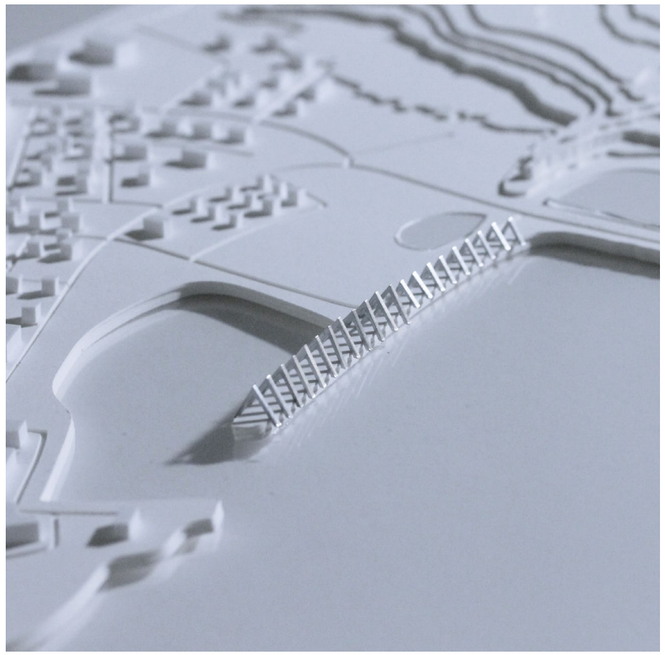
SITE 3
(BEACH)

Sauðárkrokur
65.74° N, 19.64° W

SUMMARY

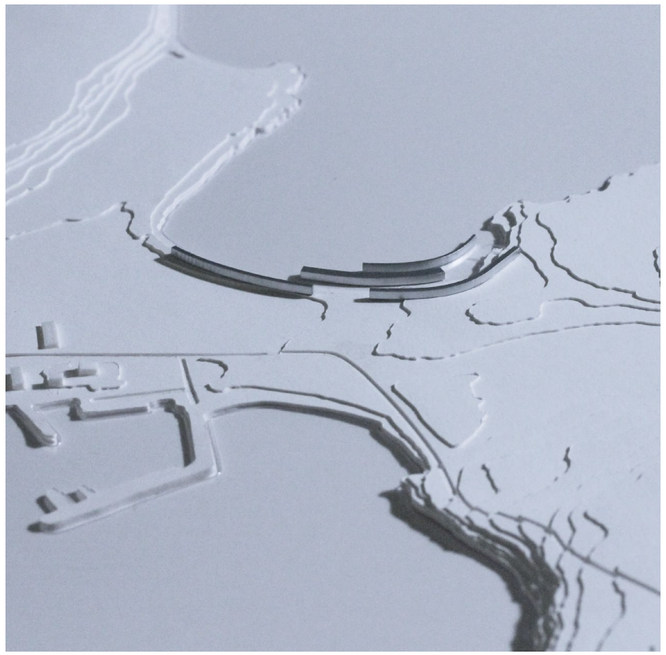
SCRIPT:

From the Global Scale where they fend
off land erosion



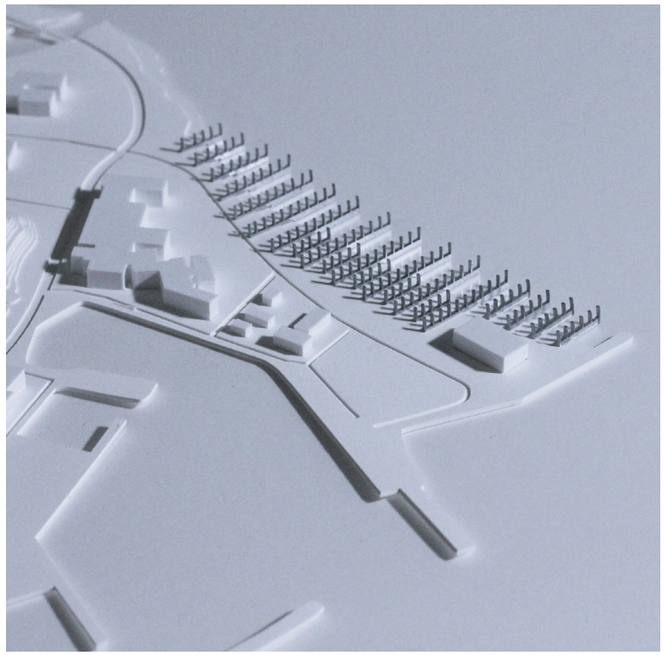
SITE 1
(FJORD)

Flateyri
66.07° N, 23.13° W



SITE 2
(BAY)

Raufarhöfn
66.50° N, 15.40° W



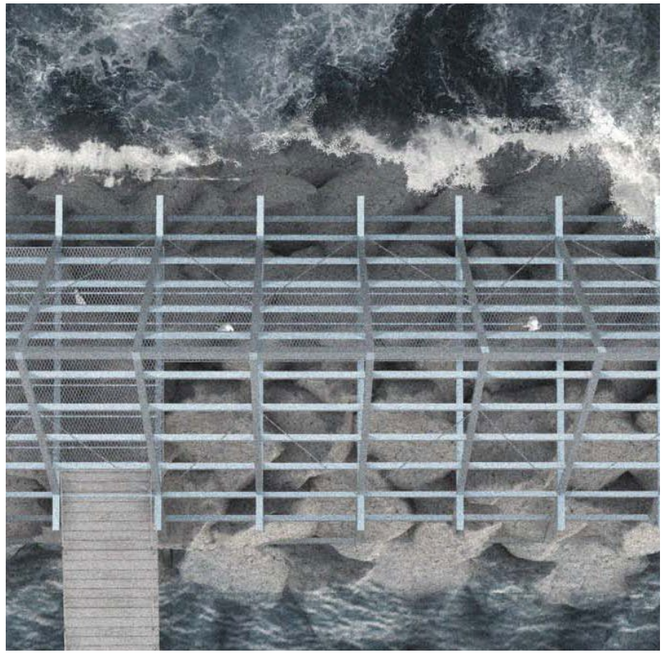
SITE 3
(BEACH)

Sauðárkrokur
65.74° N, 19.64° W

SUMMARY

SCRIPT:

To the Local Scale as it interacts with each sites natural dynamics of waves, wind, and fog



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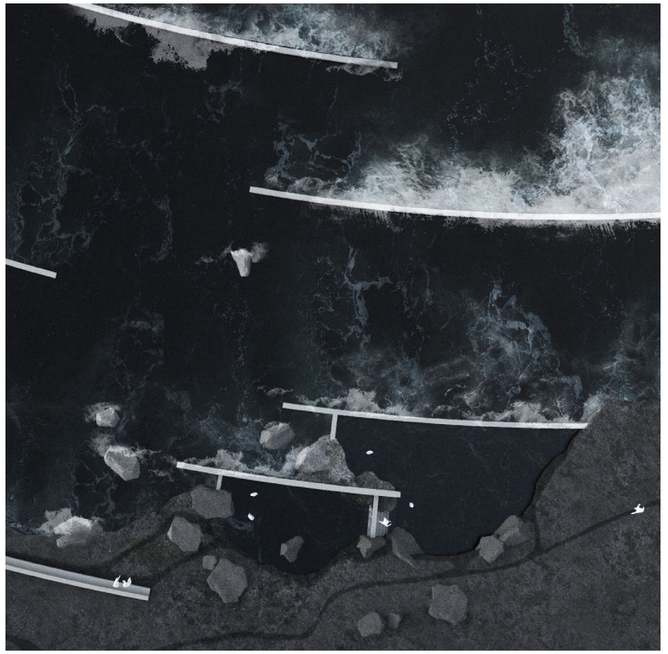

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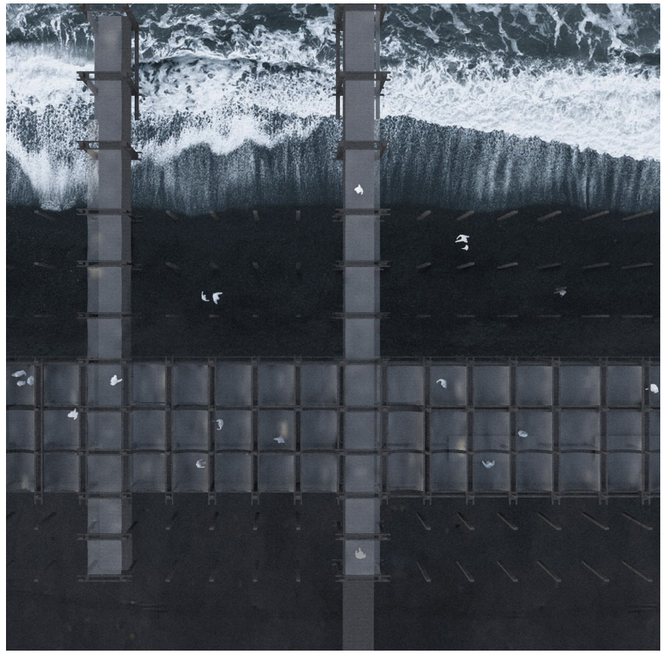


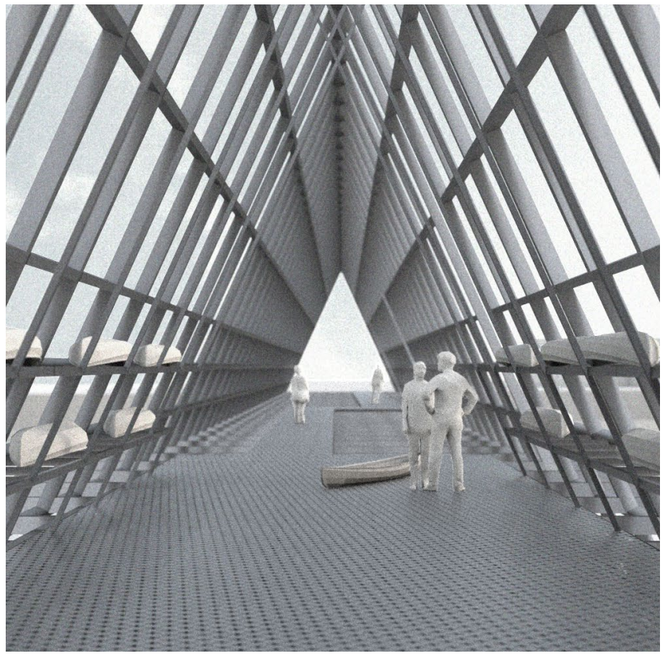
SITE 3
(BEACH)

Sauðárkrokur
65.74° N, 19.64° W

SITE 3: BEACH

SCRIPT:

And finally the Human Scale, to create immersive experiences and a platform for which the community can engage with the structure.



SITE 1
(FJORD)

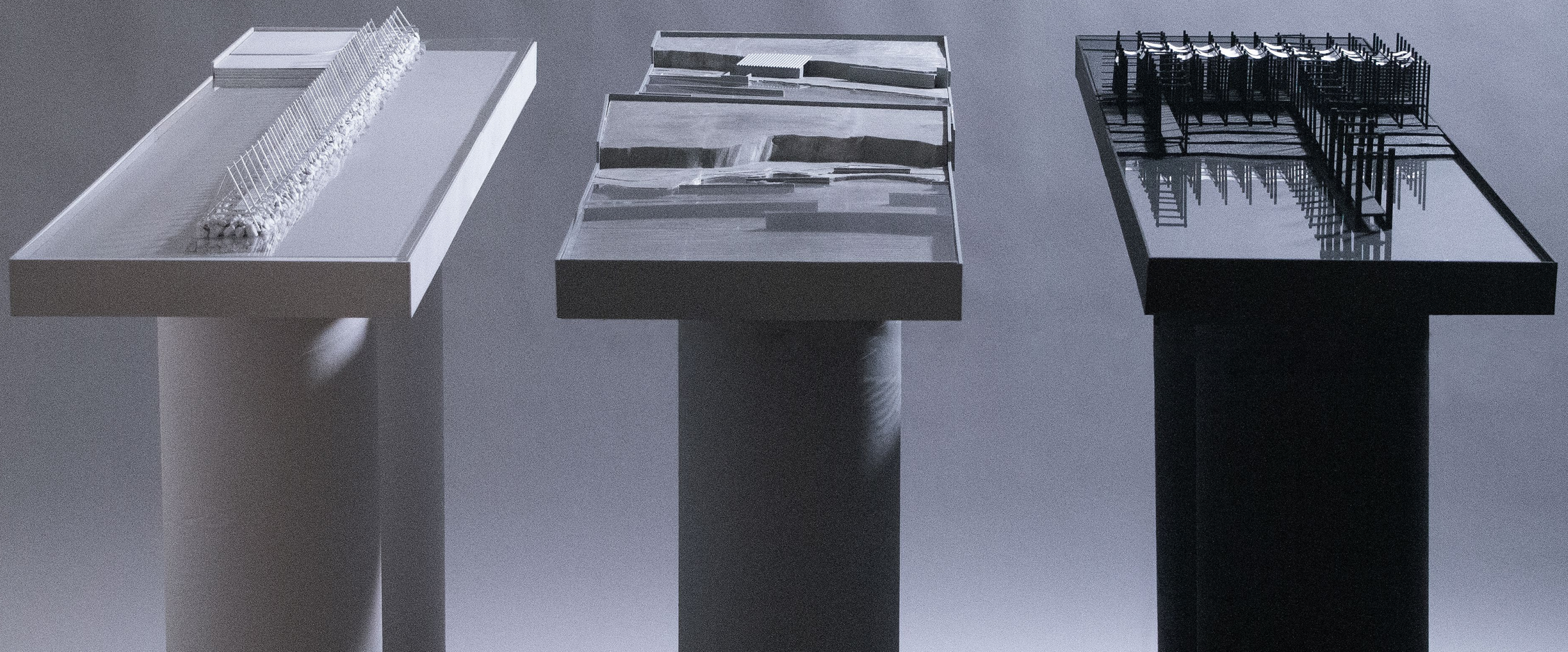
Flateyri
66.07° N, 23.13° W

SITE 2
(BAY)

Raufarhöfn
66.50° N, 15.40° W

SITE 3
(BEACH)

Sauðárkrokur
65.74° N, 19.64° W



RESEARCH BOOKLET

FIG. 1
Ice Watch.
Studio Ólafur
Elíasson.

Arctic History

The Arctic is defined by the Arctic Circle, indicating the approximate southern limit of the midnight sun and the polar night. Through time, this northernmost part of the planet has been thought of as a place of terra incognita, of far away expeditions, myths and danger. Today, a once frozen in time landscape, is rapidly changing due to the effects of climate change.

The North Pole is perhaps the most famous place in the Arctic region. Defined as the point in the Northern Hemisphere around which the Earth's axis rotates on a daily basis. Geographically, the North Pole is 4621 m below sea level, on an undersea mountain range, the Lomonosov Ridge. Above it, sea ice is generally dense with occasional large cracks and areas of open water. The ice moves erratically about 1 km a day westwards.[1] For a long time, the location of the North Pole was believed to be fixed, but due to the tilting of the Earth's axis, the precise location of the North Pole is not an exact place. It's lateral dimension cannot be defined. Nevertheless, the North Pole is important to map makers and has also had a symbolic meaning in the public mind for centuries.[2] Along with the Arctic, the North Pole has been labeled as everything from hell to heaven, and is now under the radar of scientists as a testing ground for what impacts climate change has in store for us.

[1] Roots, "Why the North Pole Matters."
[2] Roots, "Why the North Pole Matters."

Ancient References

First accounts of the Arctic date as far back as the Ancient Greek. Around 330 BC, the Greek explorer Pytheas was the first to record a description of the midnight sun, the aurora borealis and the polar ice. This he encountered on his trip sailing north for six days from the British Isles to an island he referred to as “Thule”, the most northerly land in the world. It is unknown where exactly he reached, it could have been e.g. Norway, Iceland or Faroe Islands. There, Pytheas found what he describes as a frozen ocean, a place that man could “neither sail nor walk.”[3] Thule was one of three names the Greek gave the North. The second name was Arktikos (of the great bear), referring to the circumpolar constellation in the Northern skies, the Ursa Major, and which we use today when referring to the Arctic. The third name was Hyperborea, referring to the region beyond the kingdom of Boreas, god of the north wind. According to the Greeks, a northern paradise of perpetual sunlight lay there, with fertile soil and warm breezes.[4] Almost in parallel with this utopian vision of the Arctic was a darker history of Vandals, Goths and Vikings deriving from the north, attacking southerly lands. The north was even referred to as Hell and the home to Gog & Magog, allies of Satan.

The name Arctic comes from the Greek word Arktos, which means bear. This refers to the constellations the Great and the Little Bear, which are only visible in the Northern Hemisphere.

[3] Blind, “The Earliest Traveller to the High North.” p.212

[4] Schulz, “Literature’s Arctic Obsession.”

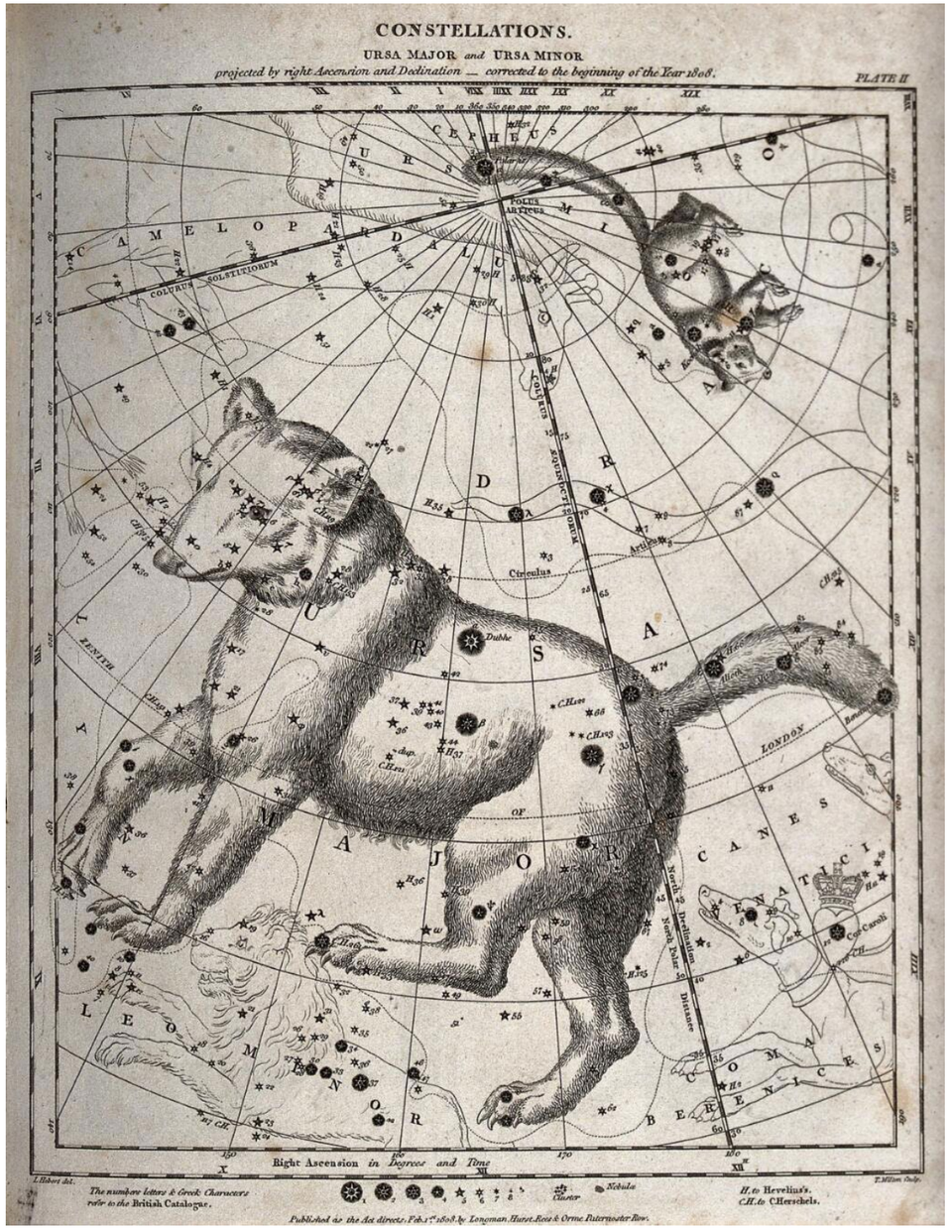
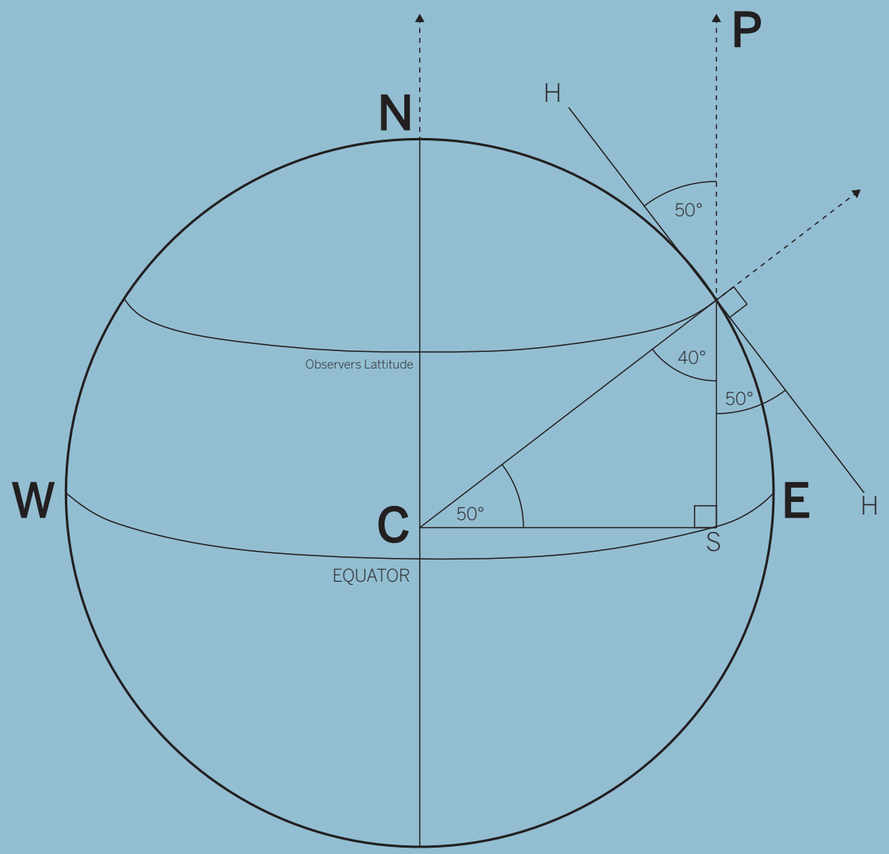


FIG. 3 Astronomical chart of the constellations of Ursa Major and Ursa Minor.
Copperplate engraving by Milton after a drawing by L. Hebert from Abraham Rees' Cyclopedia or Universal Dictionary of Arts, Sciences and Literature, London, 1820

THE NORTH STAR

What makes the North Star important is that the axis of Earth is pointed almost directly at it. This means that during the course of the night and the year, the North Star stays put in almost the same spot above the northern horizon while the other stars circle around it. This makes the North Star a good wayfinding tool in the Northern Hemisphere, since no matter the time of the night or year, the North Star is always in the same spot, indicating North.[5]



[5] By Preston Dyches, “What Is the North Star and How Do You Find It?,” NASA Solar System Exploration, accessed August 12, 2021, https://solarsystem.nasa.gov/news/1944/what-is-the-north-star-and-how-do-you-find-it.

First Maps & Trips

Today, scientists are trying to map the transformation of the Arctic and its ice, making projections and estimates to predict what will happen to the region in the future. With the help of satellites, polar explorations and scientific research we know what the North Pole looks like today. Despite our current knowledge, the Arctic still has a sense of mystery and uncertainty to it because of its unknown future. In the 16th century, explorers put little thought into the future of the Arctic, but were trying to find out and map what was there. To them, the Arctic was a mysterious place, an unknown territory yet to be mapped. [6] Initial maps of the area bear a strong mark of improvisation and try to put together pieces of information about the area coming from various sources, some more inventive than others. Not many had ventured north at this point in time, and no man was to reach the North Pole itself until in 1909.

The Arctic can first be seen on Johannes Ruys' world map of 1507. Around the north pole, Ruysch drew islands, based on reports in the book Inventio Fortunata of the English friar Nicholas of Lynne.

The first known map focusing primarily on the Arctic, The Septentrionalium Terrarum, dating from 1595, was drawn by the Flemish cartographer Gerard Mercator, who is known for inventing the Mercator Projection for mapping the world.[7] This first Arctic map shows the pole made up of four islands, which according to the myth were separated by four strong flowing rivers. These carried the oceans of the world towards a giant whirlpool at the

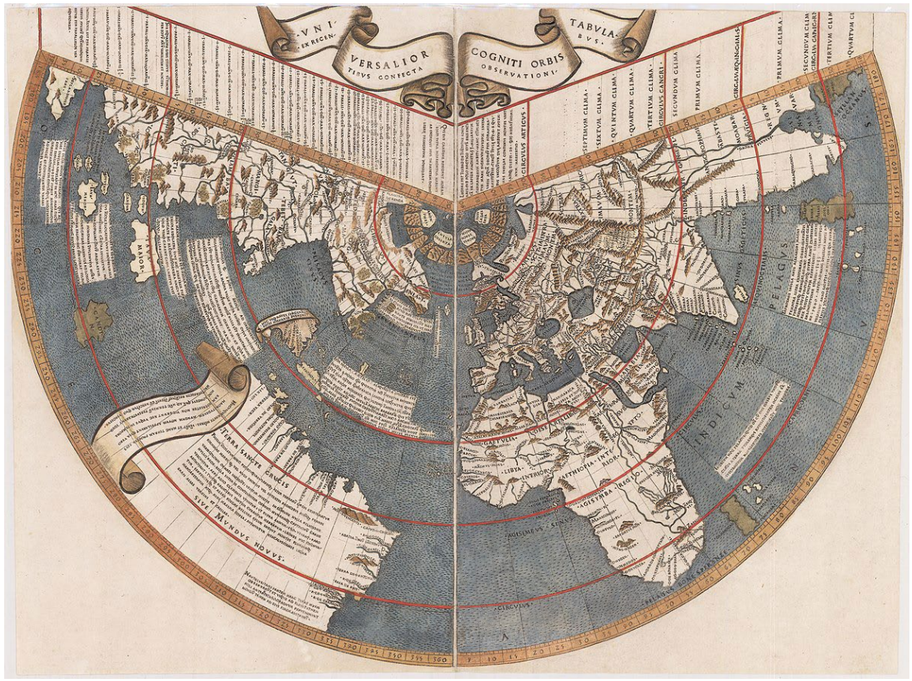


FIG. 5 **The World. Historical Map. Johannes Ruysch. 1507.**
Shows the Arctic as four islands with a rock in the centre.

[6] Schulz, "Literature's Arctic Obsession."

[7] Britannica, T. Editors of Encyclopaedia. "Mercator projection."

FIG. 6 **The Arctic. Historical Map. Gerardus Mercator. 1595.**
Was among the first to indicate an all-water route across the top of North America.

pole where there stood a large rock, labeled as "Rupes Nigra et Altissima" (Black Very High Cliff). At this time there was a general assumption that the North Pole was made up of a magnetic rock and was considered the reason why compasses turn North. Despite this, Mercator disagreed and placed a second rock labelled "Magnetic Pole" in the top left corner of the map, potentially as an explanation to magnetic variation.[8]

The first maps of the Arctic came hand in hand with the first Arctic Journeys. European exploration of the Arctic regions began in the 16th century, with searches for new sea routes to reach the Pacific.[9] The goal was to simplify trading with Asia by finding a shorter path connecting the continents. Today, these routes are referred to as the Northeast and Northwest passages. Despite several efforts, it took four centuries to successfully find a route and cross the Arctic from Europe to Asia. It was in 1878 that the Finnish-Swedish scientist Adolf Erik Nordenskiöld successfully crossed the Northeast Passage. Crossing the Northwest Passage proved to be more difficult and was achieved in 1903-06 by the Norwegian explorer Roald Amundsen.

[8] Giaimo, "The Mysteries of the First-Ever Map of the North Pole."
[9] "Arctic Study & Exploration."

THE SUBLIME

In aesthetics, the sublime is the quality of greatness to the extent that it cannot be calculated, measured or imitated. The theory of sublime art was put forward by Edmund Burke in 1757, where he defined sublime as an artistic effect productive of the strongest emotion the mind is capable of feeling.[10]

FIG. 7 Aurora Borealis. Frederic Church. 1865.

[10] "Sublime," Tate, accessed August 12, 2021, https://www.tate.org.uk/art/art-terms/s/sublime.

Arctic Hype

During the Victorian Era, the Arctic went from being a place of darkness and evil to be one of curiosity and desire. Several Arctic expeditions were made with the prime goal to find the passage between Europe and Asia. The aim was to ease trade between the east and west and it was believed that a shorter shipping route could be found across the Arctic. These expeditions were often funded by the governments, who saw opportunities in staying ahead when it came to Arctic exploration.[11] The British Navy made several attempts from 1818-1845 to find the Northwest Passage, all without success. The most famous one is perhaps the ill-fated journey of Sir John Franklin, who's ship and crew were lost in 1845 and a total of 15 rescue expeditions did not succeed in finding them. The Franklin expedition remnants were not found until in 2014, more than 150 years after their disappearance. The stories told by the expeditions that returned and the unknown fates of those who didn't, sparked an appetite in society for polar adventure.[12] Tales about the North pole were countless and some expeditions even published their own news journals, such as "The Illustrated Arctic News" published on board HMS Resolute: Captain Horatio T. Austin, which was searching for the Franklin Expedition, 1850-51. Such containing articles, sketches and drawings of the events in the Arctic.

The U.S. joined the Arctic scene when in 1867 it purchased Alaska from Russia for $7.2 million. The gain was to search for whale oil off the Alaskan coast, a desirable resource at the time. The indigenous population was not consulted nor informed of this trade.

[11] Cacho, "The History of North Pole Expeditions."

[12] Schulz, "Literature's Arctic Obsession."

FIG. 8
The Iceberg.
Frederic Church.
1875.

FIG. 9

Frederick Cook and Robert Peary both claimed they discovered the North Pole.

Race for the North Pole

During the centuries of Arctic hype it also became a matter of interest to some nations to be the first to reach the North Pole, a question of superiority of one nation over another. It came to represent the ultimate challenge, to reach the inaccessible North Pole and stand at the centre of Earth's rotation.[13]

The first claimed journey to reach the North Pole was in 1909 by Robert E. Peary. The first claimed flight over the Pole was made on 9 May 1926 by US naval officer Richard E. Byrd in a Fokker tri-motor aircraft. Although verified at the time by a committee of the National Geographic Society, this claim has since been undermined. The first consistent, verified, and scientifically convincing attainment of the North Pole was on 12 May 1926, by Norwegian explorer Roald Amundsen and his US sponsor Lincoln Ellsworth from the airship Norge. Norge, though Norwegian-owned, was designed and piloted by the Italian Umberto Nobile. The flight started from Svalbard in Norway, and crossed the Arctic Ocean to Alaska.

Alongside the race of reaching the North Pole, what can be considered a more important aspect of Arctic exploration was getting increased interest as well. This was the scientific knowledge that could be gained by exploring the landscape, ocean and climate of the Arctic.[14] This led to the first 'International Polar Year' (1882-83), which resulted in scientific observation stations being placed throughout the Arctic.

[13] Solomon, "To the Ends of the Earth."

[14] Cacho, "The History of North Pole Expeditions."

If the 20th century recorded the many firsts of exploring the North Pole, the 21st century has so far been recording the many firsts of warmest temperature, decreasing ice and changing scenery. Is a new type of race for the North Pole ahead of us? A race to retain it. Can protecting the North Pole become a matter of interest that transcends nations? Recent years have seen an increase in polar tourism. The undertone is that now is the last chance to see it before it's gone.

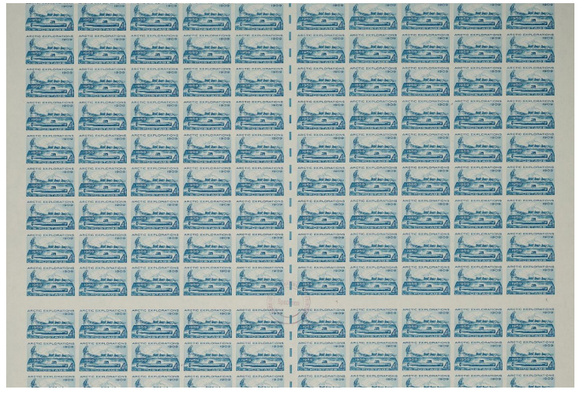


FIG. 10
U.S. Post Stamps marking the 1909 Arctic Expedition.

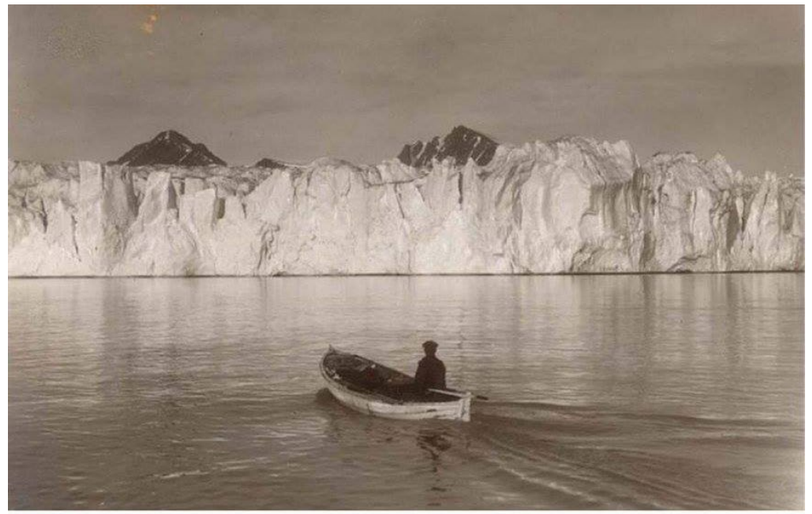


FIG. 11
Glacial Comparison Svalbard. Christian Åslund.

FIG. 13

First flight to the North Pole.
The New York Times
1909

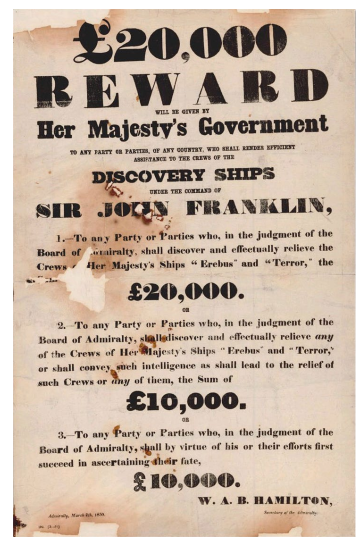


FIG. 14

Reward advertisement.
Search for the
Franklin Expedition.

FIG. 15

Awareness of Climate
Change impacting
the Arctic.

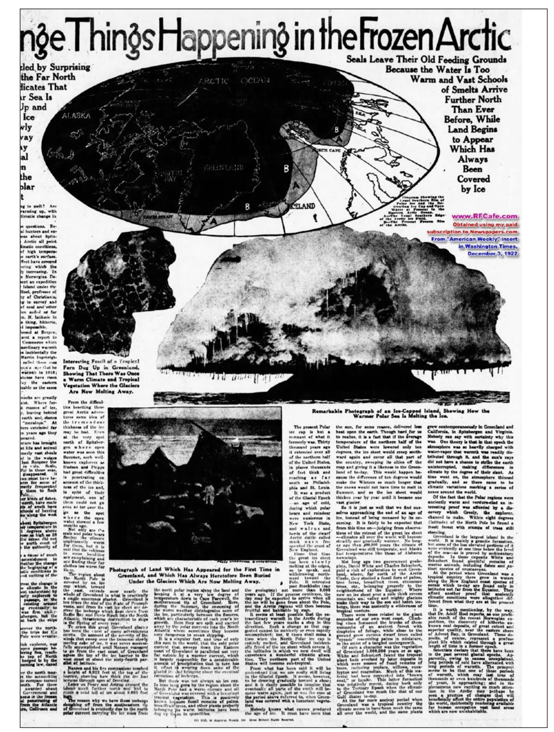
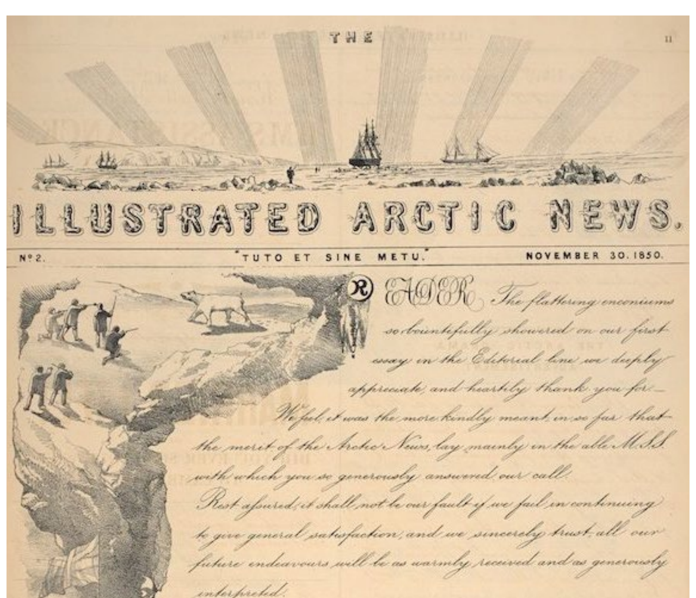


FIG. 17

What if an ancient story about the far north came true? An Iceless Arctic. Arcticle in the New Yorker.
Kathryn Schulz.

FIG. 12

Some Arctic
Expeditions published
their own newsletters



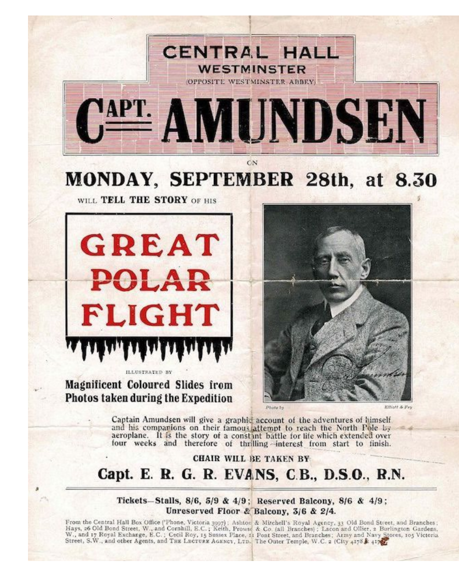


FIG. 16

Roald Amundsen
crossed the North
Pole in an airship
in 1926.

The Arctic of Tomorrow

As the twentieth century picked up its pace, the Arctic gradually lost society's interest. Other political and cultural stakes were more important and attention turned to industrialisation, mass production, technological advancements, wars, the air and reaching space. A century later, it might be turning and stories and news about the Arctic gaining interest once again. With increased impact of Climate Change and the rapid transformations it has and is foreseen to have on the Arctic, the region is changing. The North Pole as we know it might disappear for good. As Kathryn Schulz points out in her article Literature's Arctic Obsession: "once the ice disappears ... the Pole will become once again what it was long ago: a place we know only through stories."[15]

FIG. 19
Crossing the Arctic Ocean.

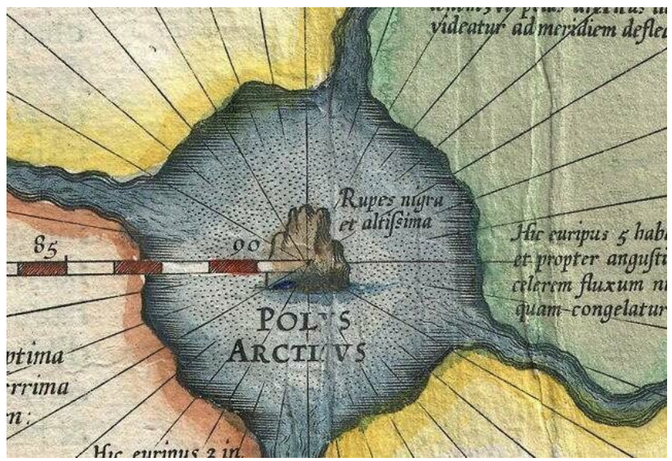


FIG. 18
An icefree Arctic.
Part of Historical Map.
Gerardus Mercator. 1595.

[15] Schulz, "Literature's Arctic Obsession."

First Settlemt
Paleo-Arctic culture

12.000 BC

Thule
Hyperborea
Arktikos
Ancient Greek

325 BC

Gog & Magog
Goths

300 AD

heaven or hell?

Vikings

1000

First map of the North Pole

Arctic Explorations
Victorian Era

1595

Denmark takes over
Greenland from Norway

1814

USA purchases Alaska
from Russia

1867

Santa Claus moved to
North Pole

Race for the North Pole

1906

First Northwest Crossing
Roald Amundsen

1909

First man on the North Pole
Robert E. Peary

Oil is found

1968

Monitoring of the
Ice begins

1970

Irreversible
melting begins

1996

Arctic Council founded

Franklin Expedition
Shipwreck Discovered

2012

**Climate Change
Political Interest**

who ownes what?

Russia puts their flag on
the seabed of North Pole

Record Warm Summer

Denmark claims the
North Pole

2020

Trump want's to buy
Greenland

The New IPCC Report

New definitions?

2120

Communities & the Arctic Council

Communities living within the Arctic Circle span the globe, despite the differences in language and culture, they are all accustomed to unpredictable weather and immeasurable landscapes. With only 4 million people spread out over an area two times the size of the USA, the region represents one of the least populated areas in the world, with sparse nomadic communities and few large cities and towns. Typical Arctic societies are small, remote, and located within fragile nature. In addition to the threats of climate change, the arctic must also contend with the reality of new shipping lanes opening up, and untapped natural resources becoming accessible. The arctic societies will be under pressure to grow and adapt to their new economic and environmental circumstances.[16]

Approximately half of the Arctic population lives in Russia, where the three largest towns above the Arctic Circle are located: Murmansk (300,000 inhab.), Norilsk (170,000 inhab.), and Vorkuta (60,000 inhab.). Tromsø in Norway has about 71,000 inhabitants, and Reykjavík in Iceland has more than 120,000. No permanent settlements are located above 78° north latitude. Most of the communities live along the coast, bordering the Arctic Ocean. [17]

[16] Crump, "Arctic Change = Global Change or, What Happens in the Arctic Doesn't Stay in the Arctic."

[17] "Population."

The Arctic Council was founded in 1996 as a response to the growing pressure and attention the Arctic Region was facing. The council is a forum for promoting cooperation, coordination, and interaction among the Arctic states: Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden & the United States. These eight countries have Arctic Ocean coastlines and, under international conventions, have rights to economic zones within 200 miles of their shores. However, no country owns the North Pole or the region of the Arctic Ocean surrounding it. Nevertheless, some hints of claims have been made in the past.[17] The goal of the Arctic Council is to focus on the opportunities of transnational and intercultural cooperation and discussing military security is off limits.

In recent years, other countries that are not geologically located within the Arctic have been paying more attention to the region. This has resulted in thirteen Non-Arctic States having been approved as 'Observers to the Arctic Council'. These include China, France, Germany, Italy, Japan, Netherlands, Poland, India, Korea, Singapore, Spain, Switzerland and the U.K.

FIG. 21 **The Arctic Council Meeting,**
Eight nations make up the members of the council. The chairmanship rotates between the countries every 3 years.

[18] McCown, "Who Really Owns The North Pole?"

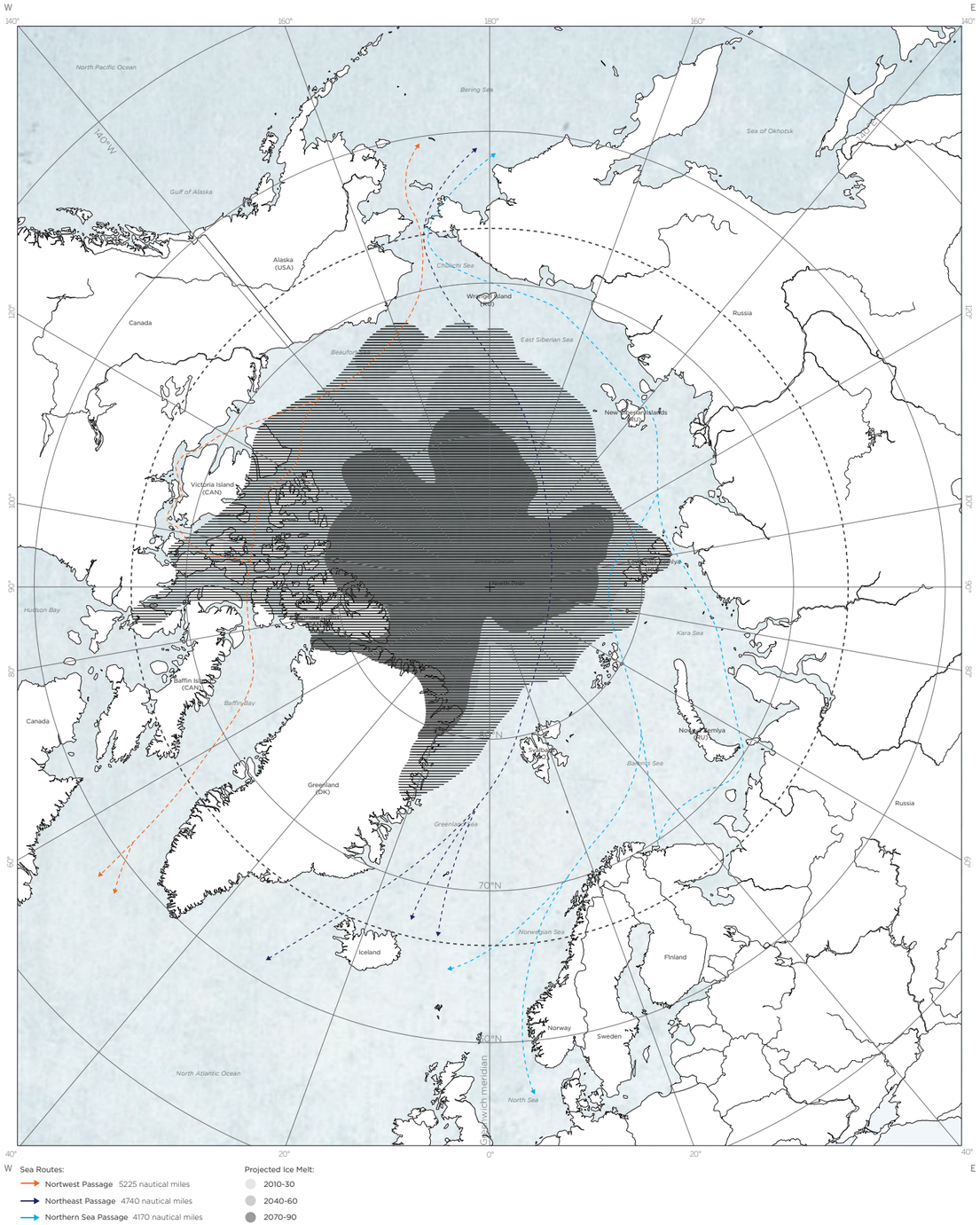
DAYLIGHT & DARKNESS

Polar nights: when it is dark for 24h/day. This happens at the poles due to the earth's axial tilt and takes place from September to March.

Midnight Sun: when it is daylight 24h/day. The sun remains above the horizon continuously. This happens from April to August.

FIG. 22

Polar night in Utqiagvik, Alaska,



New Relationships

According to the newly released IPCC report, the Arctic Northwest passage will be ice-free during the summer months by 2050. The Arctic is warming twice as fast as the rest of the planet. In recent years, record warm summers have repeatedly been registered. Seasonally, the ice in the Arctic reaches its max in March and min in September. Looking back at records, there is no precedent in the past 150 years where the sea ice extent is as small as it has been in recent years.[20]

FIG. 23
Cargo Passing Through the North Sea.

[20] "Sea Ice Extent (Arctic Only) - 1850 - Present."

The New York Times | https://www.nytimes.com/2019/05/24/climate/china-arctic.html

Latest Arena for China's Growing Global Ambitions: The Arctic

By Somini Sengupta and Steven Lee Myers

May 24, 2019

*Want climate news in your inbox? Sign up here for **Climate Fwd:**, our email newsletter.*

ROVANIEMI, Finland — The Arctic is thawing, and China is seizing the chance to expand its influence in the north.

For China, the retreating ice potentially offers two big prizes: new sources of energy and a faster shipping route across the top of the world. To that end, the country is cultivating deeper ties with Russia.

More than 3,000 miles from home, Chinese crews have been drilling for gas beneath the frigid waters of the Kara Sea off Russia's northe coast. Every summer for the last five years, Chinese cargo ships have maneuvered through the ice packs off Russia's shores — a new passage that officials in Beijing like to call the Polar Silk Road. And in Shanghai, Chinese shipbuilders recently launched the country's second icebreaker, the Snow Dragon 2.

China's ambitions in the Far North, said Aleksi Harkonen, Finland's ambassador for Arctic affairs, mirror its ambitions everywhere else "It's after global influence," he said, "including in the Arctic."

The China-Russia partnership advances both countries' agendas in the region, at least for now. It also comes against a background of rising hostilities between China and the United States over issues like trade, territorial claims and allegations of espionage.

That tension is spilling over into the Arctic.

In April, the Pentagon, in its annual report to Congress on China's military power, included for the first time a section about the Arctic ar warned of the risks of a growing Chinese presence in the region, including the possible deployment of nuclear submarines in the future.

And this month, Secretary of State Mike Pompeo used a meeting of foreign ministers here in Rovaniemi, just a few miles south of the Arctic Circle, to assail China for what he called its "aggressive behavior" in the region and pointed to Beijing's actions in other parts of tl world.

Projection: Changing Landscape.

The New York Times Magazine | ProPublica | Pulitzer Center

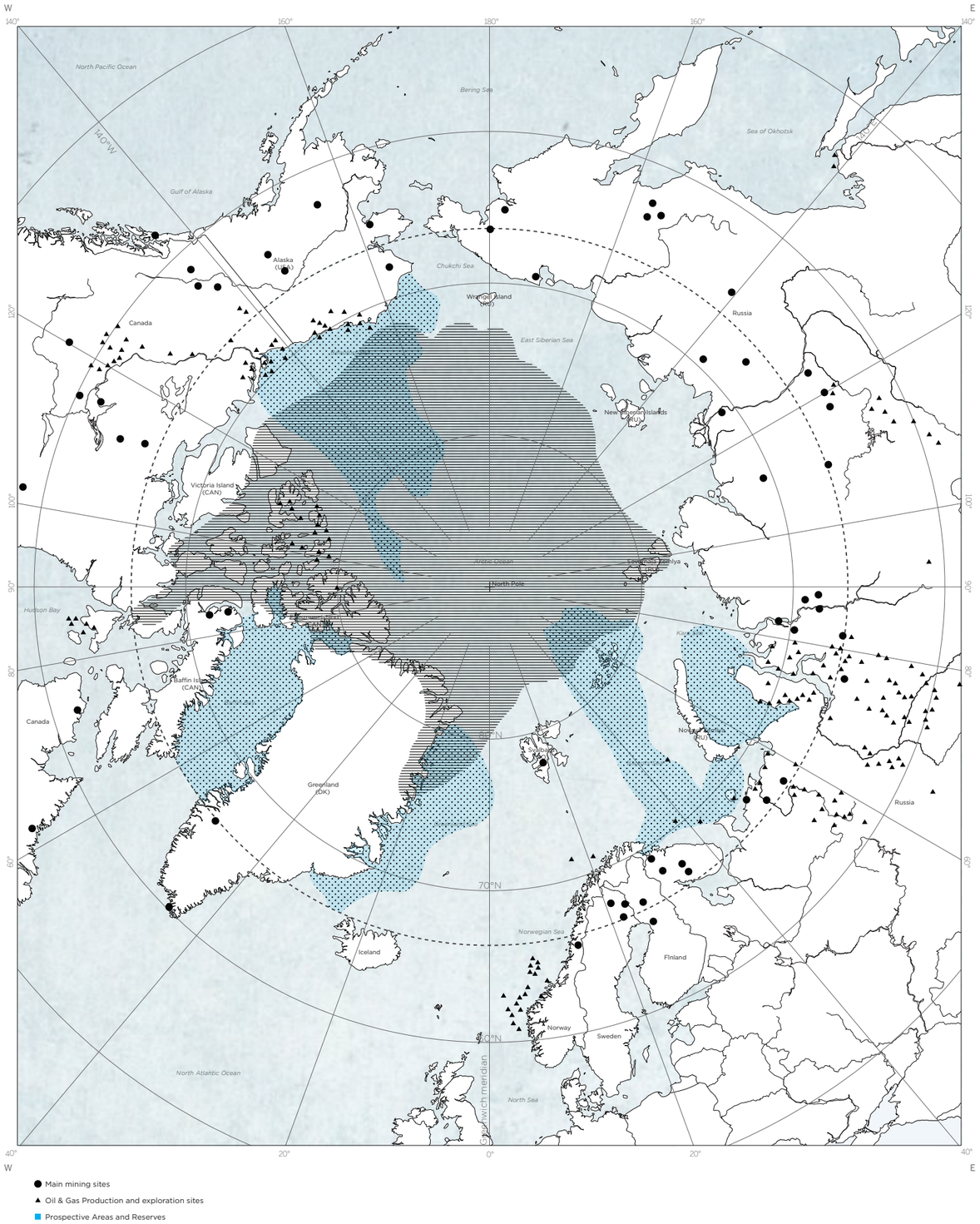
"The Great Climate Migration" by Abrahm Lustgarten

Part 2:

For most of human history, people have lived within a surprisingly narrow range of temperatures, in the places where the climate supported abundant food production. But as the planet warms, that band is suddenly shifting north. According to a pathbreaking recent study in the journal Proceedings of the National Academy of Sciences, the planet could see a greater temperature increase in the next 50 years than it did in the last 6,000 years combined. By 2070, the kind of extremely hot zones, like in the Sahara, that now cover less than 1 percent of the earth's land surface could cover nearly a fifth of the land, potentially placing one of every three people alive outside the climate niche where humans have thrived for thousands of years. Many will dig in, suffering through heat, hunger and political chaos, but others will be forced to move on. A 2017 study in Science Advances found that by 2100, temperatures could rise to the point that just going outside for a few hours in some places, including parts of India and Eastern China, "will result in death even for the fittest of humans."

People are already beginning to flee. In Southeast Asia, where increasingly unpredictable monsoon rainfall and drought have made farming more difficult, the World Bank points to more than eight million people who have moved toward the Middle East, Europe and North America. In the African Sahel, millions of rural people have been streaming toward the coasts and the cities amid drought and widespread crop failures. Should the flight away from hot climates reach the scale that current research suggests is likely, it will amount to a vast remapping of the world's populations.

Projection: Changing Demographic.



Resources & Energy Production

Another reason countries are increasingly looking towards the Arctic is the amount of untapped resources that presumably can be found under the Arctic Sea Ice.[21] The primary energy resources exploited in the Arctic have been hydroelectric power, oil and gas, and coal. Remote Arctic communities depend 80% on diesel as the primary energy source.

FIG. 24
Oil drilling in the Arctic.

[21] Dillow, "Russia and China Vie to Beat the US in the Trillion-Dollar Race to Control the Arctic."

Oil

Currently being extracted.

Natural Gas

Currently being extracted.

Coal

Currently being extracted.

Hydro

Currently being emploid in some parts of the Arctic.

Wind Turbines

Currently being emploid in some parts of the Arctic.

Tidal

Could be a future opportunity for the area.

Documentation

Scientists study the Arctic to learn more about how climate and weather are changing. They investigate how Arctic climate and weather interact with the rest of the world, and how climate change will affect the region. A number of governments maintain permanent research stations in the Arctic. Also known as Arctic bases, polar stations or ice stations, these bases are widely distributed across the northern polar region of the earth.[22]

Most of these stations have been temporary, either being abadoned after a research project is complete or due to lack of funding to continue.

Some of the reserach stations are built on land or ice covered land, while other are ‘Drifting Ice Stations’ located on the sea ice of the Arctic Ocean.

FIG. 25
Drift Ice Stations.
Arctic.

[22] Kubny. “Drift Ice Stations Are Russian Tradition.”

FIG. 26
Weather Station.
Canada.

FIG. 28
Tiski Weather Station.
Russia.

FIG. 30
Svalbard Satelite Station.
Norway.

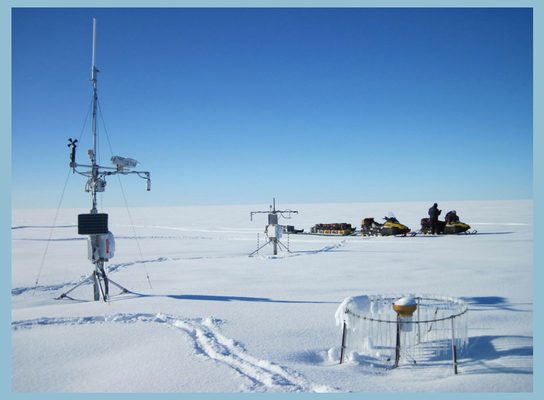


FIG. 27
Weather Station.
Greenland.

FIG. 29
Igloolik Research Station.
Canada.

Arctic Research Stations:

Station name	Location	Operating country	Year opened	Year closed
Abisko Scientific Research Station	Abisko, Sápmi	Sweden	1903	Active
Adam Mickiewicz University Polar Station	Petuniabukta, Svalbard, Norway	Poland	2011	Active
Alomar Observatory[2]	Andøya Space, Andøya, Svalbard	Norway	1994	Active
Arctic Yellow River Station	Ny-Ålesund, Svalbard, Norway	China	2003	Active
AWIPEV Arctic Research Station	Ny-Ålesund, Svalbard, Norway	France Germany	2003	Active
Barrow Observatory[3]	Point Barrow, Alaska	United States	1973	Active
Begichev Polar Station	Maly Begichev Island, Krasnoyarsk Krai	Soviet Union Russia	NA	Abandoned
Bolshoy Lyakhovsky Polar Station[4]	Bolshoy Lyakhovsky Island. Sakha	Soviet Union Russia	NA	Abandoned
Brønlundhus	Peary Land, Greenland	Denmark	1947	Transformed into a museum
Buor-Khaya Polar Station[5]	Buor-Khaya Gulf, Sakha	Soviet Union Russia	NA	Abandoned
Canadian High Arctic Research Station[6] (CHARS) campus	Cambridge Bay, Nunavut	Canada	TBA	Active
Centrumsø Research Station	Centrum Lake, Greenland	Denmark	1954	Abandoned
Chelyuskin Polar Station[7]	Cape Chelyuskin, Krasnoyarsk Krai	Soviet Union Russia	1932	Active
Chetyrokhstolbovoy Polar Station[8]	Medvezhyi Islands, Sakha	Soviet Union Russia	1933	Active
Churchill Northern Studies Centre[9] (CNSC)	Churchill, Manitoba	Canada	1976	Active
Czech Arctic Research Station	Longyearbyen and Petuniabukta, Svalbard, Norway	Czechia	2014	Active
Daneborg	Wollaston Foreland, Greenland	Denmark	1944	NA
Danmarkshavn	Dove Bay, Greenland	Denmark	1906	Active
Dirigibile Italia Arctic Station	Ny-Ålesund, Svalbard, Norway	Italy	1997	Active
Dr. Neil Trivett Global Atmosphere Watch Observatory	Alert, Nunavut	Canada	1986	Active
Dye 3	Four different locations in southern Greenland	United States	1971	1991
Ernst Krenkel Observatory	Heiss Island, Arkhangelsk Oblast	Soviet Union	1956	1980
Flashline Mars Arctic Research Station	Devon Island, Nunavut	Canada	2001	Active
Golomyanniy Island Polar Station[10][11]	Sredniy Island, off Severnaya Zemlya	Soviet Union Russia	1954	NA
Heiberg Polar Station[12]	Heiberg Islands, Krasnoyarsk Krai	Soviet Union Russia	1940	1995
Himadri[13]	Ny-Ålesund, Svalbard, Norway	India	2008	Active
Igloolik Research Centre[14]	Igloolik, Nunavut	Canada	1975	Active
IndARC[15]	Kongsfjorden, Svalbard, Norway	India	2014	Active
International Biological Station Lena-Nordenskiöld[16]	Tiksi, Sakha	Russia	1995	Active
Iqaluit Research Centre[17][18]	Iqaluit, Nunavut	Canada	1978	Active
Isachsen Station	Ellef Ringnes Island, Nunavut	Canada	1948	1978
Izluchin Polar Station	Komsomolets Island, Severnaya Zemlya, Krasnoyarsk Krai	Soviet Union Russia	NA	Abandoned
Kap Harald Moltke	Peary Land, Greenland	Denmark	1972	NA
Kevo Research Station[19]	Kevo	Finland	1958	Active
Kigilyakh Research Station[20]	Kigilyakh Peninsula, Bolshoy Lyakhovsky Island, New Siberian Islands	Soviet Union Russia	NA	NA
Kilpisjärvi Biological Station[21][22]	Kilpisjärvi	Finland	1964	Active
Kiruna Observatory	Kiruna	Sweden	NA	NA
Kluane Lake Research Station[23]	Kluane Lake, Yukon	Canada	1961	Active
Koldewey Station	Ny-Ålesund, Svalbard, Norway	Germany	1991	Active, part of APIWEV station
Kolyuchin Polar Station	Kolyuchin Island, Chukotka	Soviet Union Russia	NA	Abandoned in the 1990s
Labytnangi Ecological Research Station[24]	Labytnangi, Yamalo-Nenets	Soviet Union Russia	1954	Active

Station name	Location	Operating country	Year opened	Year closed
Lavrentiya Research Station	Lavrentiya, Chukotka	Soviet Union Russia	NA	NA
McGill Arctic Research Station[25]	Axel Heiberg Island, Nunavut	Canada	1960	Active
Mestersvig	Scoresby Land, Greenland	Denmark	1956	Active
Mývatn Research Station	Mývatn	Iceland	1975	Active
NEEM Camp	Northern Greenland ice sheet, Greenland	Denmark	2008	2015
Netherlands Arctic Station, Univ Groningen[26]	Ny-Ålesund, Svalbard, Norway	Netherlands	1995	active
Nicolaus Copernicus University Polar Station	Kaffiøyra, Svalbard, Norway	Poland	1975	Active
North Ice	Northern Greenland ice sheet, Greenland	United Kingdom	1952	1954
Northeast Science Station[27]	Chersky, Sakha	Soviet Union Russia	1977	Active
Ny-Ålesund[28]	Spitsbergen, Svalbard	Norway	1967	Active
Peschanny Polar Station	Cape Unslicht, Bolshevik Island, Severnaya Zemlya	Soviet Union Russia	NA	Abandoned
Polar Environment Atmospheric Research Laboratory[29][30] (PEARL)	Eureka, Nunavut	Canada	1993	Active
Polish Polar Station	Hornsund, Svalbard, Norway	Poland	1957	Active
Popov Polar Station[31]	Bely Island, Yamalo-Nenets	Soviet Union Russia	November 1, 1933	March 2001
Preobrazheniya Polar Station	Preobrazheniya Island, Sakha	Soviet Union Russia	NA	Abandoned
Prima Polar Station[32]	Cape Baranov, Bolshevik Island, Severnaya Zemlya	Soviet Union Russia	NA	Active
Provideniya Research Station	Provideniya, Chukotka	Soviet Union Russia	NA	NA
Resolute Nunavut Station[33]	Resolute, Nunavut	Canada	1947	NA
Russky Island Arctic Station[34]	Russky Island, Nordenskiöld Archipelago, Krasnoyarsk Krai	Soviet Union Russia	1935	1999
Samoylov Station[35]	Lena Delta Wildlife Reserve, Sakha	Russia	1998	Active
Samuila Polar Station	Samuila Island, Komsomolskaya Pravda Islands, Krasnoyarsk Krai	Soviet Union Russia	NA	Abandoned
Sermilik Station	Ammassalik Island, Greenland	Denmark	1970	Active
Sodankylä Arctic Research Centre[36]	Sodankylä	Finland	NA	NA
Solnechny Polar Station[37]	Solnechny Bay, Bolshevik Island, Severnaya Zemlya	Soviet Union Russia	1952	Abandoned
Stanisław Baranowski Spitsbergen Polar Station	Werenskioldbreen, Svalbard, Norway	Poland	1971	Active
Station Nord	Princess Ingeborg Peninsula, Greenland	Denmark	1952	Active
Stolbovoy Meteorological Station[38]	Stolbovoy Island, Sakha	Soviet Union Russia	NA	Abandoned
Summit Station	Near summit of the Greenland ice sheet, Greenland	United States	April 1989	Active
Thule Research Station[39]	Pituffik, Greenland	Denmark	1995	Active
Toolik Field Station[40]	Toolik Lake, Alaska	United States	1975	Active
Troynoy Island Polar Station[41]	Izvestiy TSIK Islands, Krasnoyarsk Krai	Soviet Union Russia	1953	Active
Tuktoyaktuk Station[42]	Tuktoyaktuk, Northwest Territories	Canada	NA	1997
Tundra Ecosystem Research Station[43][44] (TERS)	Daring Lake, Northwest Territories	Canada	1994	Active
Tyrtov Island Polar Station	Tyrtov Island, Nordenskiöld Archipelago, Krasnoyarsk Krai	Soviet Union	1940	1975
Uedineniya Polar Station	Uyedineniya Island, Krasnoyarsk Krai	Soviet Union Russia	NA	1996
University of Copenhagen Arctic Station	Qeqertarsuaq, Greenland	Denmark	1906	Active
Ushakov Island Polar Station	Ushakov Island, Krasnoyarsk Krai	Soviet Union	1954	1980s
Vavilov Meteorological Station[45]	October Revolution Island, Severnaya Zemlya	Soviet Union	1974	1988
Villum Research Station[55]	Station Nord, North Greenland	Denmark	1990	Active
Vize Island Arctic Research Station	Vize Island, Krasnoyarsk Krai	Soviet Union Russia	November 1. 1945	NA
Ward Hunt Island Observatory Research Station[46]	Ward Hunt Island, Nunavut	Canada	1957	Active
Western Arctic Research Centre[47]	Inuvik, Northwest Territories	Canada[48]	1964	Active
Whapmagoostui-Kuujjuarapik Research Complex[49]	Whapmagoostui, Quebec	Canada	1971	Active
White Sea Biological Station[50] (WSBS MSU)	Chupa, Republic of Karelia	Soviet Union Russia	1938	Active
Willem Barents Biological Station[51]	Meduza Bay, Krasnoyarsk Krai	Soviet Union Russia	NA	NA
Wrangel Island Cape Blossom Station[52]	Cape Blossom, Wrangel Island, Chukotka	Soviet Union Russia	NA	NA
Wrangel Island Ushakovskoye Station[53]	Ushakovskoye, Wrangel Island, Chukotka	Soviet Union Russia	NA	NA
Yenisei Ecological Station[54]	Mirnoye, Turukhansky District, Krasnoyarsk Krai	Soviet Union Russia	NA	NA
Zackenberg Station	Wollaston Foreland, Greenland	Denmark	1997	Active
Zeppelin	Zeppelinfjellet, Svalbard	Norway	1990	Active

SOURCE: "List of Research Stations in the Arctic," in Wikipedia, August 11, 2021, https://en.wikipedia.org/w/index.php?title=List_of_research_stations_in_the_Arctic&oldid=1065025012.

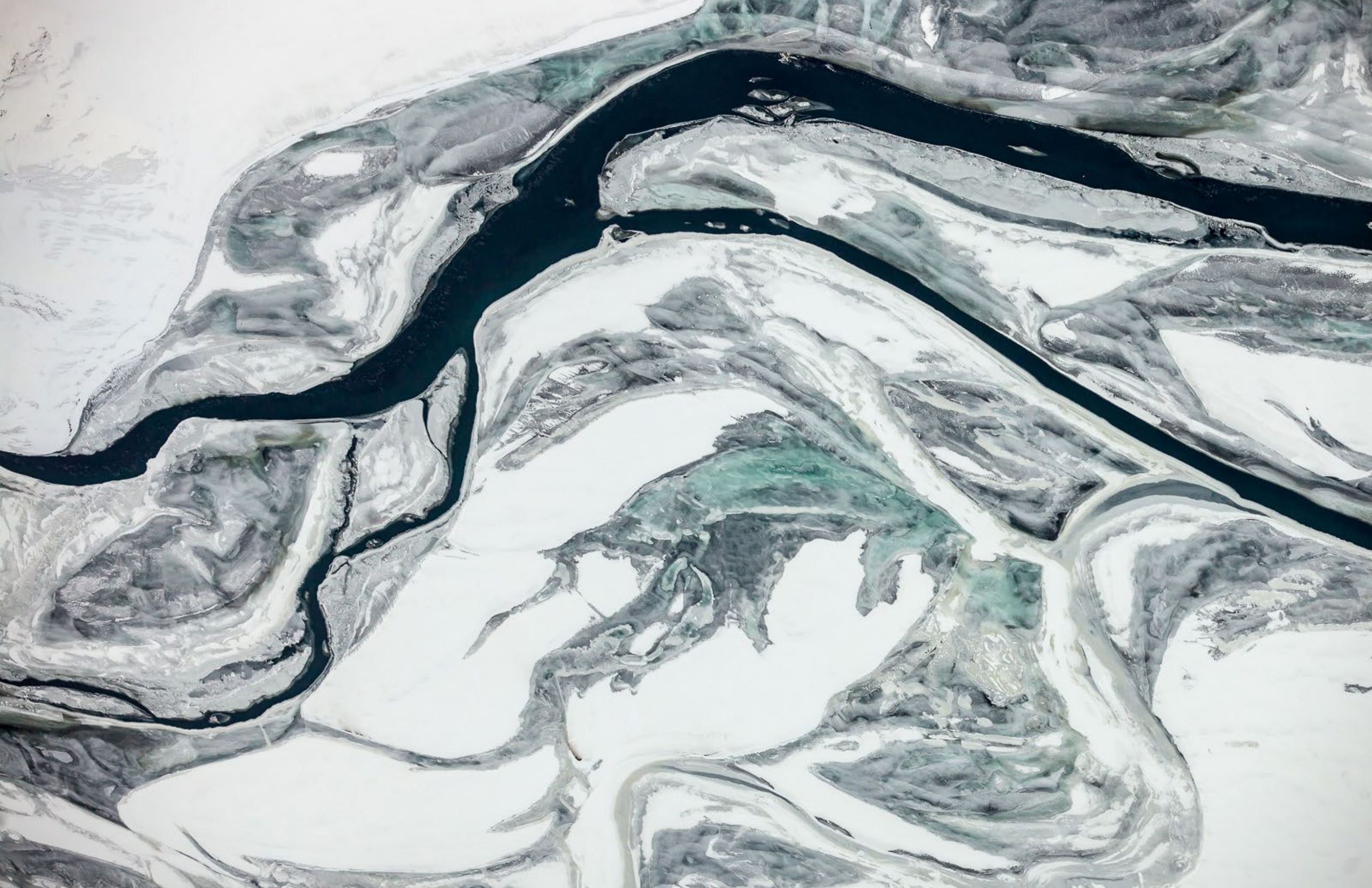


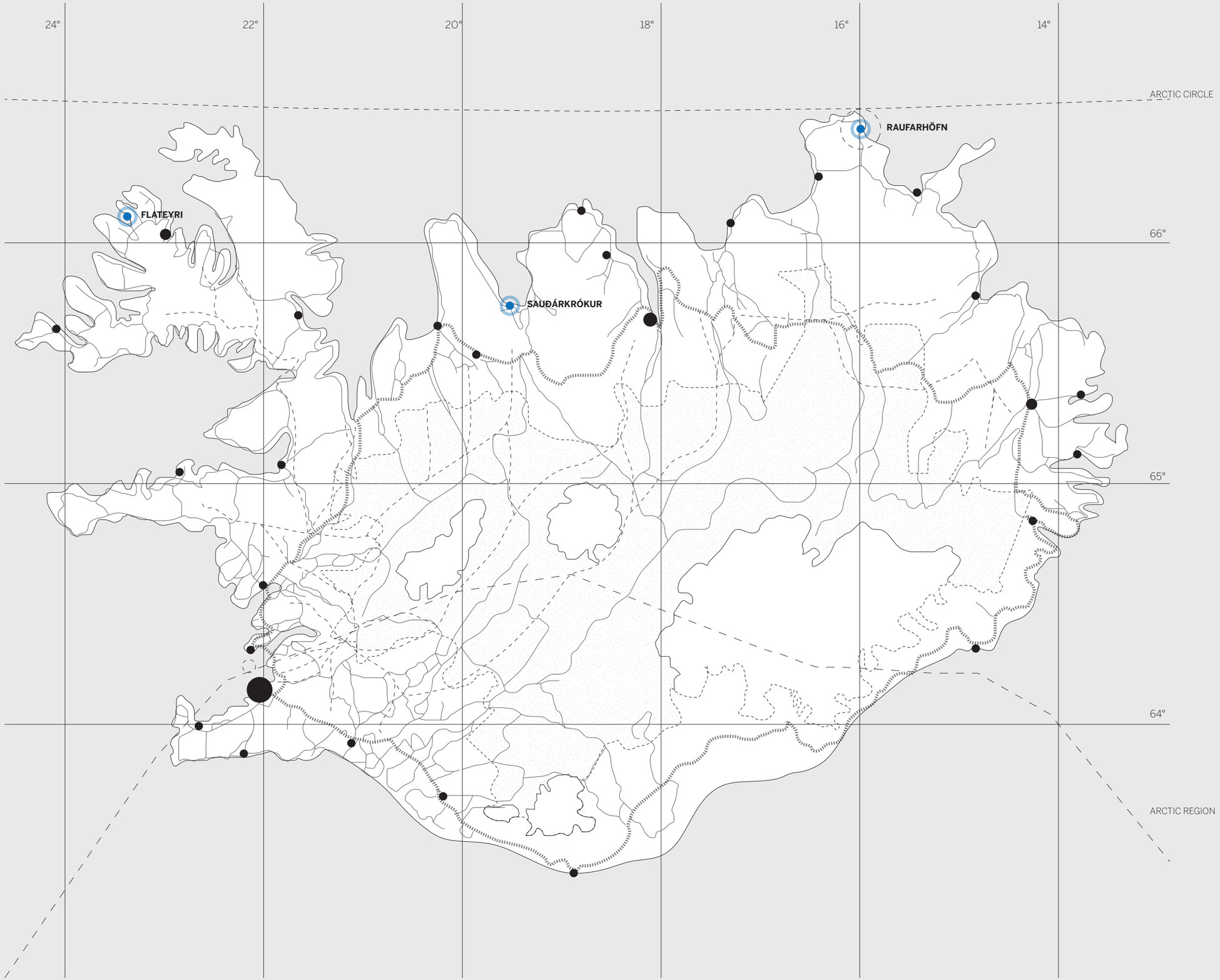
FIG. 32
Map of Iceland.
Abraham Ortelius.
1590.

An island along the Arctic

Located in the North Atlantic Ocean, between 60°- 66° N, Iceland is an island tangent to the Arctic Circle. Iceland is considered to be a part of Europe, not of North America, though geologically, the island belongs to both continents. Iceland was still uninhabited long after the rest of Western Europe had been settled. First records of settlements date back to 874 AD when Vikings arrived from Norway. According to the Landnámabók (“Book of Settlements”) Iceland was discovered by Naddodd, who lost his way sailing from Norway to the Faroes and drifted to the east coast of Iceland. Naddodd named the country Snæland “Snowland” because of the snowcovered mountains he encountered.[F] The first permanent settlers were Ingolfur Arnarson and his wife Hallveig Fróðadóttir. They deliberately set sail for Iceland and settled in the bay that now is Reykjavik.

Iceland was an independent commonwealth until 1262 when it went under Norwegian Rule. It wasn’t until in 1944 that the country gained full independence again, after centuries of belonging to Norway and later Denmark. The twentieth century proved influential for the country’s development. This was a decade of many firsts; the university was founded, a proper hospital built and networks such as roads, water and and a central heating systeWm set up. It is commonly said that Reykjavik went from being a farmstead to a city in the course of those 100 years. The population also grew exponentially, from 20.000 in 1900 to 360 000 in 2021. Overall, the 20th century was when Iceland caught up with the western world and became categorized as a first world country.

[23] Vilhjálmsson, “Ingólfur Arnarson á að hafa fundið Ísland en hafði enginn komið til Íslands áður?”


24°
22°
20°
18°
16°
14°
ARCTIC CIRCLE
66°
65°
64°
ARCTIC REGION
FLATEYRI
SAUÐÁRKRÓKUR
RAUFARHÖFN

Declining Countryside

Settlements in Iceland thread the coast. For centuries, these coastal settlements thrived on what the ocean had to offer. In the later part of the 19th century, some of them prospered and grew into fishing towns. For the first half of the 20th century, a large part of the country's population lived in these towns. They offered plenty of jobs and opportunities. This has turned drastically around. Today, two thirds of Iceland's population lives in the capital region Reykjavik. The countryside is in decline.

One of the main reasons for the decline of the countryside was the centralisation of the fishing industry. This resulted in many smaller villages being left out, suddenly having to find a new way to make an income, all while looking out onto the ocean that once had been their bread and butter.[24]

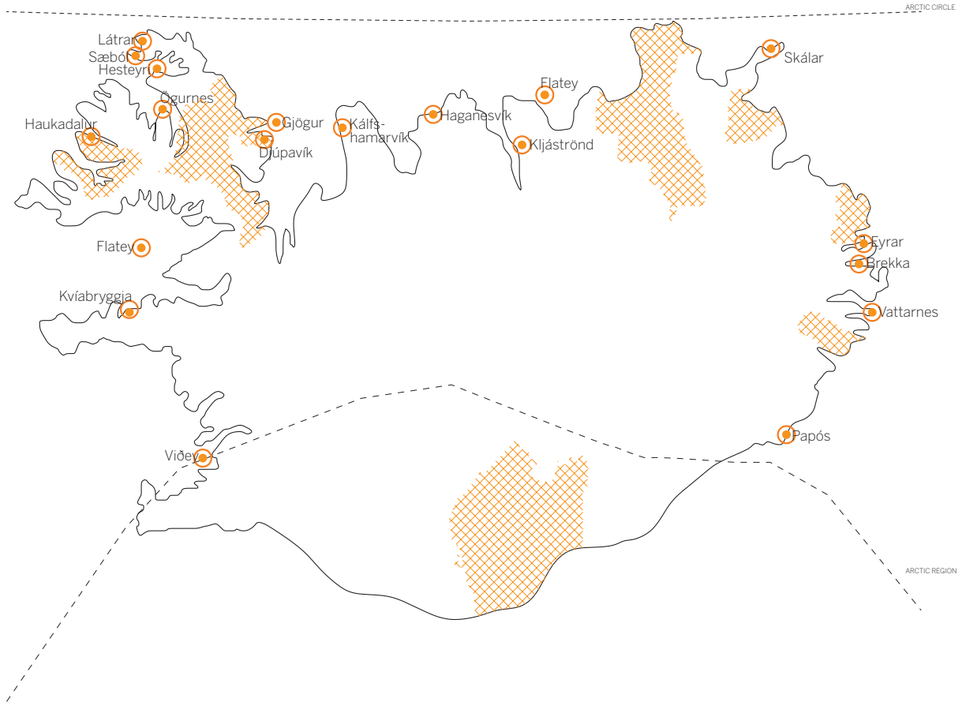
Due to harsh winters, the center of the country, the "Highland", is inaccessible and untraversable during large parts of the year. The roads that cross the Highland typically open in the later half of June and close in the middle of September.

FIG. 33
Siglufjörður.
Small fishing town.
Population:
2021: 1208 inhab.
1955: 3000 inhab.

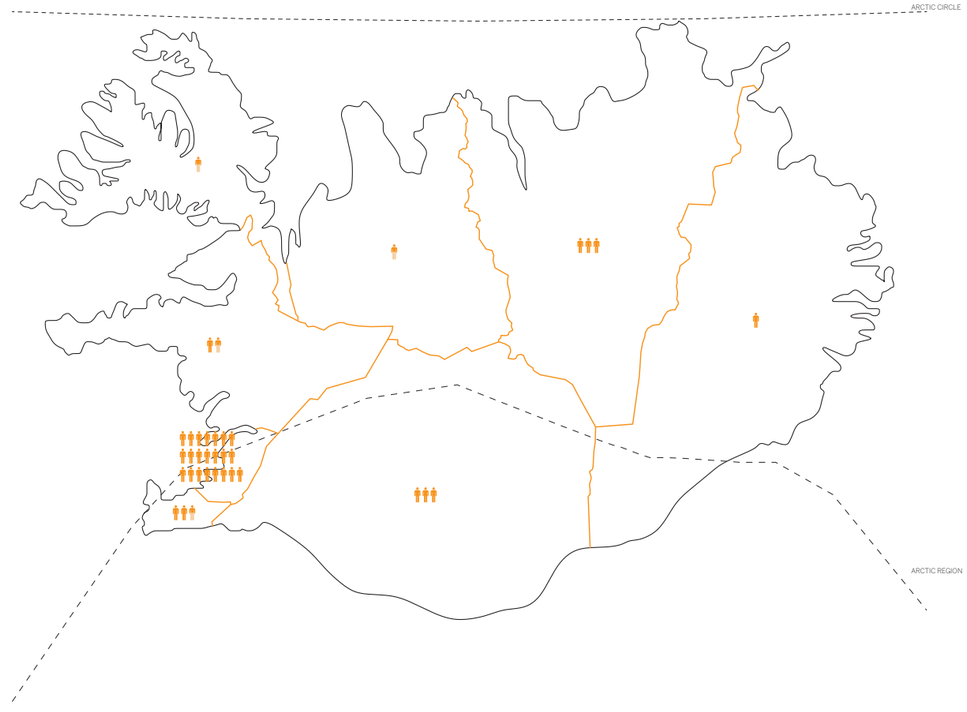
(Village)Þorp: > 200
(Town)Bær: < 200

Reykjavik is the only city in Iceland.

[24] Baldursdóttir and Halldórsson, "The Fragile Communities Program."



Most of the declining towns are located above the Arctic Region



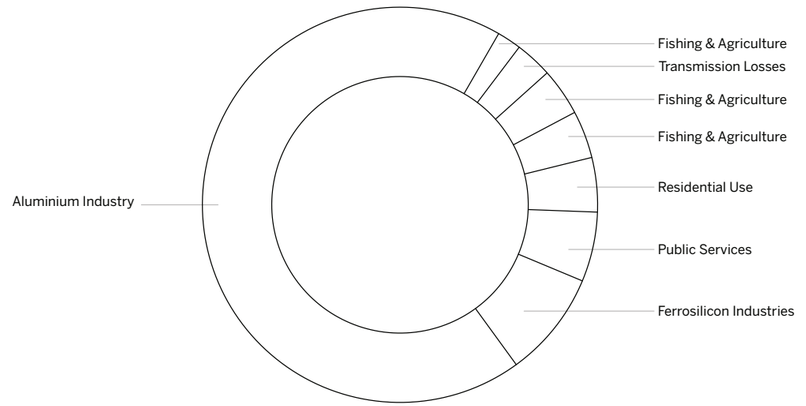
Iceland is divided into 8 regions.

FIG. 34
Large scale industry.
Aluminium Plant.
Alcoa. Reyðarfjörður.

Large-scale Industry

Recent years have seen an increase in international companies benefiting from the country's inexpensive and clean energy. This interest has been considered an opportunity to revitalize the declining countryside, offering jobs and boosting their economy.[25]

However, the reality is also that this large scale industry has required more energy to be produced in order to serve them. This has resulted in power stations being built solely to serve large scale industries. Today, over 60% of the nation's electricity production goes to the aluminium smelters. These large scale industries ship raw products across the globe, benefit from the inexpensive energy, ship their products back out and leave little of value behind in the country.



Electricity
Consumption
Breakdown

[25] Gunnarson and Gunnarson, Wilderness in the Circumpolar North. p.58.

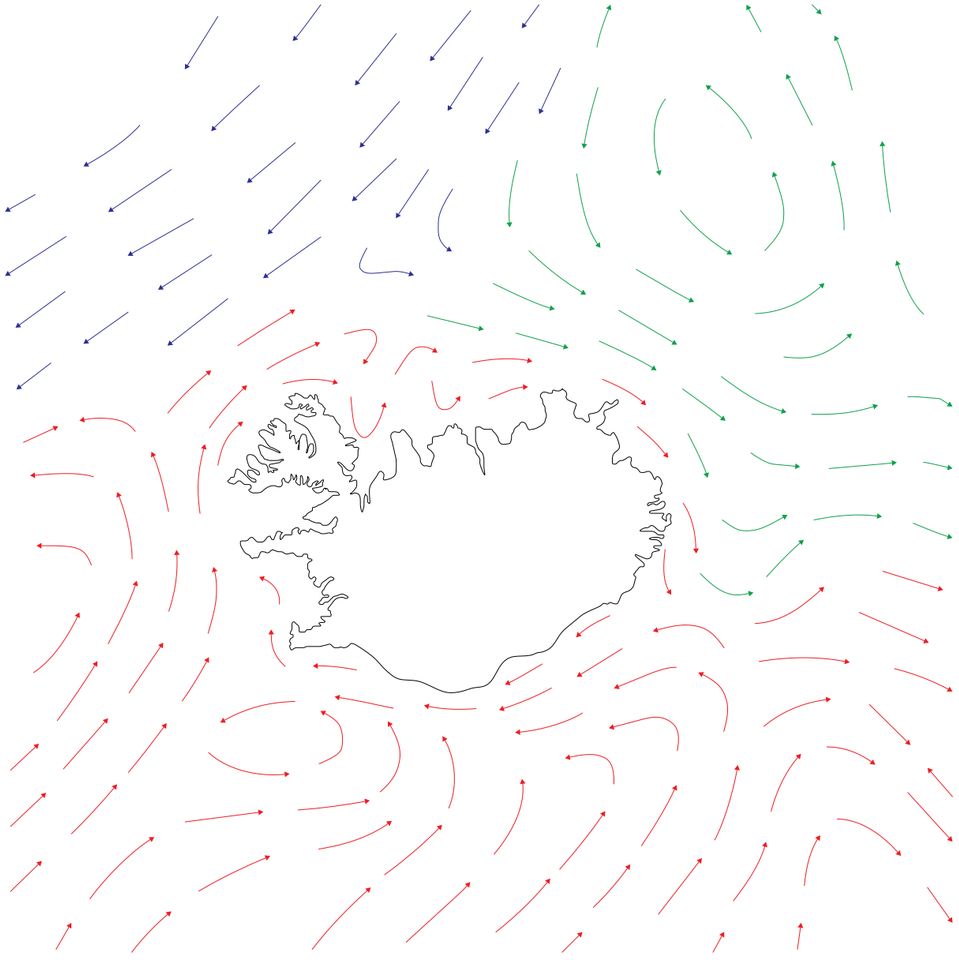
Resource: Water / Ocean

Water in its many forms is Iceland's main resource. The ocean offers the fish that has fed the population and been the main export product for decades, the rivers and waterfalls offer hydroelectricity and the warm water found below ground heats up the nation's homes. It also plays an important part in the social and cultural identity of the nation. It can be summarized that without the presence of this resource in all its formats, life on the isolated Arctic island would be almost impossible, or at least a lot less pleasant.

However, in recent decades an awareness has been raised to the fact that Iceland cannot take this resource for granted and its future is far from certain. One of the impacts of global warming is increased acidity of the ocean. Along with rising sea levels, this is what will likely have the biggest impact on northern coastal settlements such as Iceland. [26]

FIG. 35
Places named
after bad weather

[26] "Climate of Iceland."



Ocean Currents. Warm Salty Atlantic Ocean meets the cold less salty Polar Ocean.

Ocean Acidification

As the amount of carbon dioxide in the atmosphere rises, the oceans absorb a lot of it. In the ocean, carbon dioxide reacts with seawater to form carbonic acid. This causes the acidity of seawater to increase.

Ocean acidification is already impacting many ocean species, especially organisms like oysters and corals that make hard shells and skeletons by combining calcium and carbonate from seawater.[27]

[27] Osterloff, "What Is Ocean Acidification?"

FIG. 36
Icelandic Winter Storm

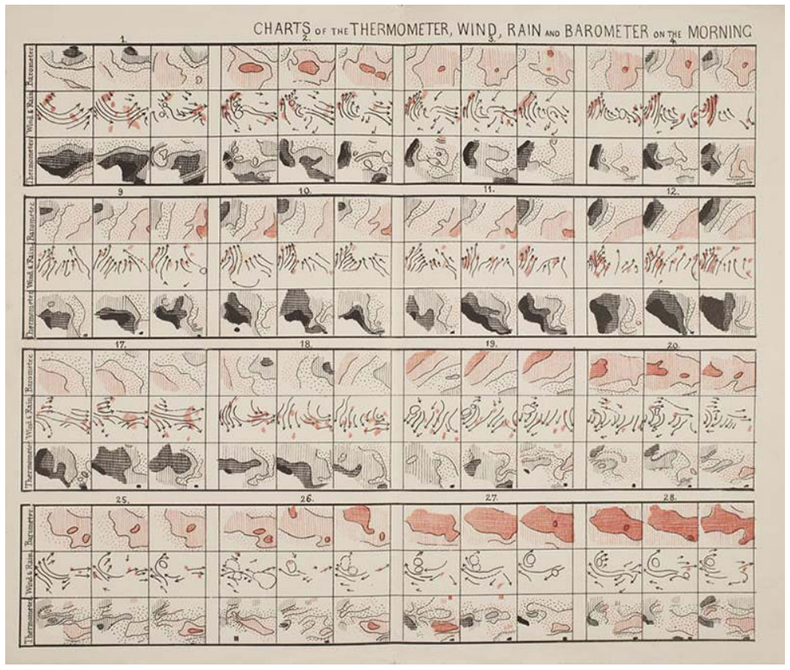
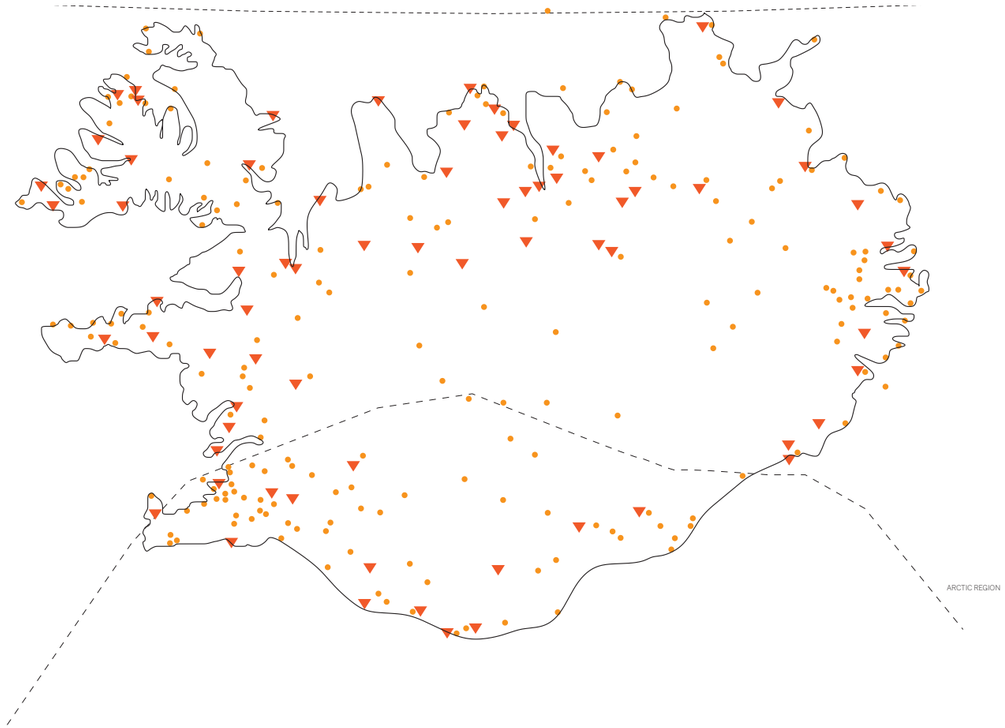


FIG. 37
Francis Galton
Weather Mapping



Weather Obsession

On RAS1, Iceland's national radio station, the weather report is read several times over the course of a day. The weather forecast is on average the most watched tv program.[28] The Icelandic language has an extensive vocabulary for the weather, with over 70 words describing snow and 200 for wind. Everyone has something to say about the weather. It is one of the most popular discussion topics in Iceland.It serves as an icebreaker, a topic that can always be tapped into for a courteous chit-chat.

This obsession is perhaps not strange given the extremities and unpredictabilities that the weather has on people's lives in the Arctic. Despite this obsession with the weather, the history of meteorological observations in Iceland is not long. The first instrumental observations were carried out from 1749-51 near Reykjavik and later similar observations were made temporarily at several locations. The first meteorological station with systematic and continuous weather observations was established at Stykkisholmur in 1845 and has been in operation ever since.

[28] Háskólabókasafn, "Tímarit.is."

FIG. 39
Turf arranged into herringbone pattern.

Local Construction

With most of Iceland's development happening during the 20th century, the country does not have a long story of architectural heritage. Reykjavik went from a farmstead to a city in the course of the twentieth century.

Iceland lacks local construction materials. Almost all building materials have to be imported, making them expensive. Due to poverty and lack of construction materials, the vernacular building style of the past relied on stacking layers of turf to create shelter and insulative mass. Known as turf houses, these buildings were damp and had to be returfed at regular intervals.

Harsh weather conditions mean that buildings need to be well insulated and any exposed material must tolerate weathering. This has led to the trend of cladding buildings in corrugated aluminium.[29] Additionall, buildings in Iceland must meet certain seimsic codes since all of the country is located in an earthquake zone.

[29] O'Sullivan, "How Reykjavik's Sheet-Metal Homes Beat the Icelandic Winter."

FIG. 40
Conflict.
Wilderness &
Infrastructure.

FIG. 41
Building in
Fragile Nature.

FIG. 42
Drying Fish Racks.
Iceland.

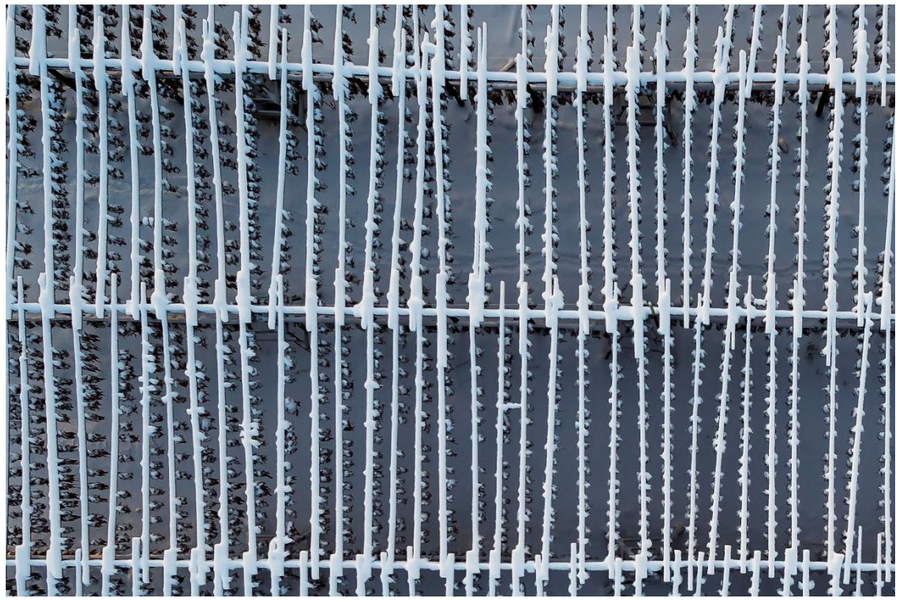


FIG. 43
Drying Fish Racks.
Iceland.

FIG. 44
Drying Fish Shed.
Iceland.

FIG. 45
Drying Fish Shed.
Iceland.

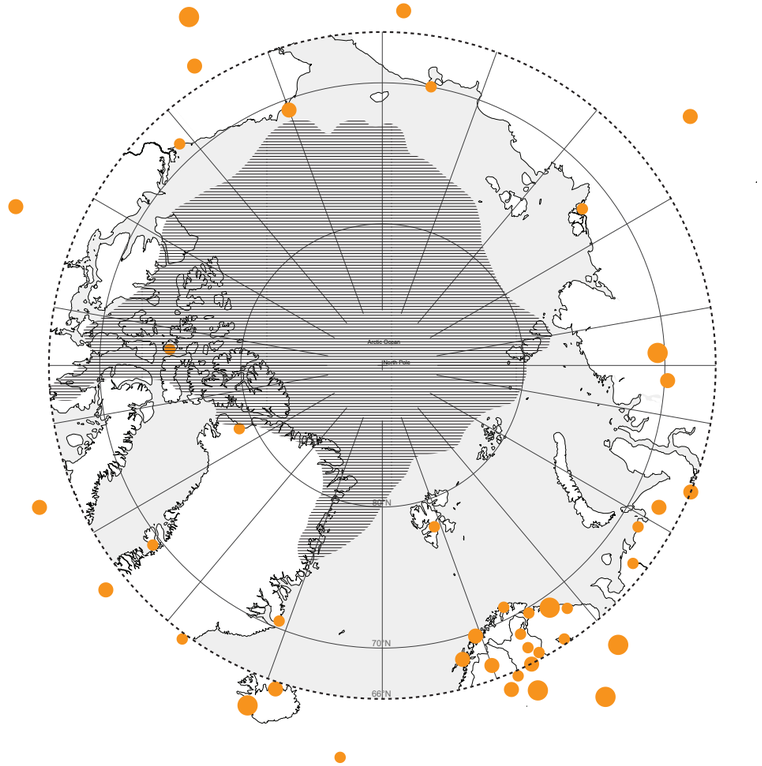


FIG. 46
Coastal erosion
Utiquiagvik. Alaska.

FIG. 47
Coastal erosion
Alaska.

FIG. 48
Coastal erosion
Siberia.

FIG. 49
Floodwall.
Japan.

static

FIG. 50
Sand Dunes.

dynamic

seawalls

floodwalls

walls

groynes/jetties

movable surge barriers

tide gates

static

dynamic

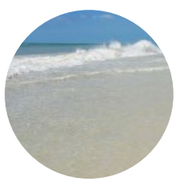
dikes

sand dunes

breakwaters

landform

marshes

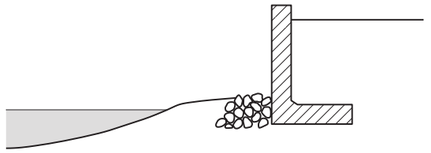


beaches

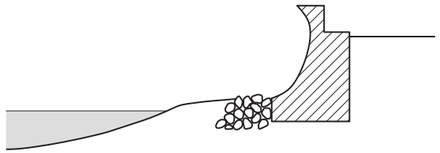
FIG. 51

Curved Concrete
Coastal Infrastructure

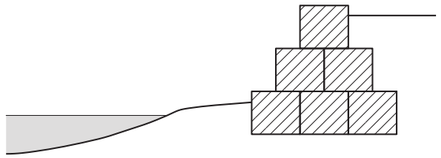
seawalls



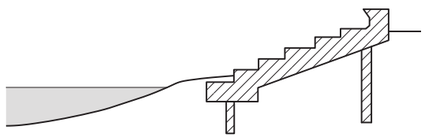
SEAWALL



CURVED
SEAWALL



GABION
SEAWALL



STEPPED
SEAWALL

FIG. 52
Seawall.
Ofunato Bay,
Iwate prefecture, Japan.

FIG. 53
Seawall.
Ryori Bay.
Iwate prefecture, Japan.

floodwalls

FIG. 54
Seawall.
Miyako Bay,
Iwate prefecture, Japan.

FIG. 55
Seawall.
Kesennuma Bay.
Miyagi prefecture, Japan.

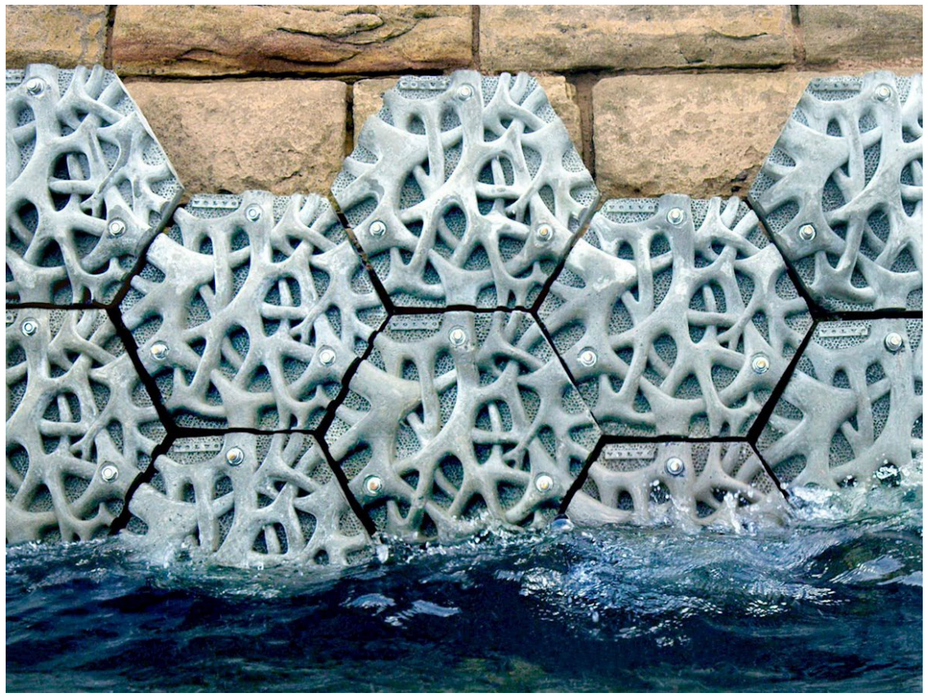


FIG. 56
Living Seawall.
Designed by Volvo.

FIG. 57
Living Sea Wall.

Images:

FIG.1:
Sutcliffe, Justin. “Olafur Eliasson’s Ice Watch Was Slowly Disappearing – Public Delivery.” Accessed September 3, 2021. https://publicdelivery.org/olafur-eliasson-ice-watch/.

FIG.2:
Graham, Ken. “Midnight Sun.” Britannica. Accessed August 13, 2021. https://www.britannica.com/science/midnight-Sun.

FIG.3:
Astronomy: a chart of the constellations Great Bear and Little Bear. Engraving.. Engravings.. Place: <A HREF=https://wellcomecollection.org/>Wellcome Collection</A>. https://library.artstor.org/asset/24856593.

FIG.4: Diagram

FIG. 5:
Library of Congress. “Johannes Ruysch World Map (1507-1508)” Accessed September 10, 2021. https://www.loc.gov/exhibits/treasures/images/vc00map.jpg.

FIG. 6:
“Mercator Map.” Accessed August 8, 2021. https://library.princeton.edu/visual_materials/maps/websites/northwest-passage/mercator.htm.

FIG. 7:
Smithsonian American Art Museum. “Aurora Borealis.” Accessed September 3, 2021. https://americanart.si.edu/artwork/aurora-borealis-4806.

FIG. 8:
Frederic Edwin Church (American, 1826-1900). c. 1875. The Iceberg. PAINTINGS. Place: Terra Foundation for American Art, Daniel J. Terra Collection. https://library-artstor-org.ezp-prod1.hul.harvard.edu/asset/TERRA_DB_103997338.

FIG. 9:
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Labor:

Help assembling models Flateyri & Sauðárkrókur: Mari Bjerknes & Svanhildur Vilhelmsdottir

Help assembling model of Raufarhöfn: Arnar Larusson

Photoshopping model photos: Stephanie Lloyd & Mari Bjerknes

Help assembling Site Models 1&3: Stephanie Lloyd

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