



POLAR WEEKEND SHRINKING ARCTIC SEA ICE & THE LAST ICE AREA

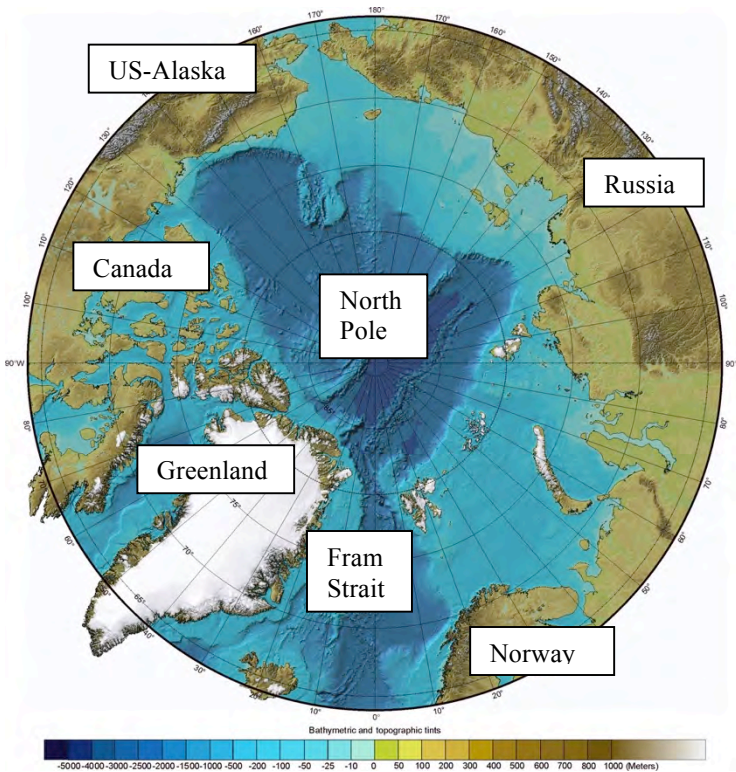
Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE



TOPIC:
Shrinking Arctic Sea Ice and the Last Ice Area

BY:
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PHOTO: Dr. Pfirman dressed in her Arctic gear onboard an ice breaker studying sea ice cover.



WHERE ON THE MAP ARE WE?
The Arctic is at the northernmost end of our planet. Any area north of the 66° 30' N latitude line is considered to be in the Arctic. This latitude line is often referred to as the Arctic Circle (although the circle is imaginary), shown as the outer edge of this map. The Arctic is mainly ocean (shown here in blues), but it includes the northern parts of Alaska, Canada, Russian, Finland, Sweden, Norway, and most of Greenland.

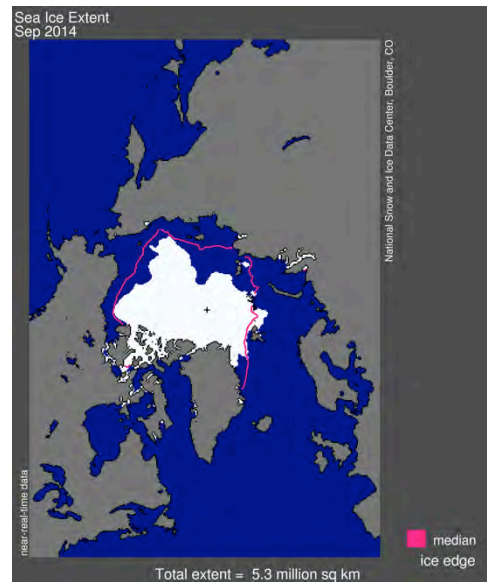
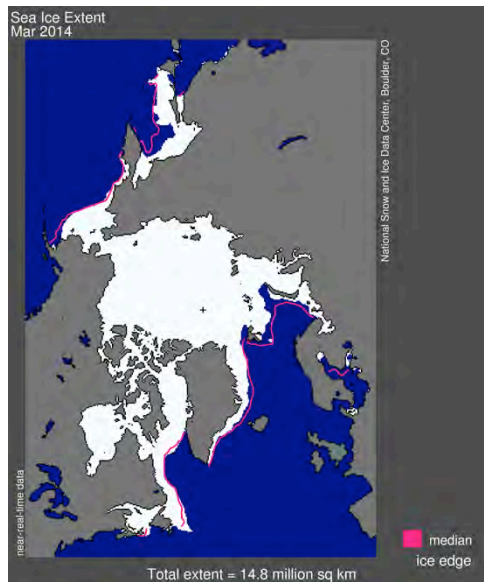
This map is referred to as a 'bathymetric map', meaning its intent is to show the sea floor depth, size and features (topography). While this image is unusual since it does not show the sea ice that covers much of the Arctic Circle all year long, it does clearly show that the Arctic is mainly ocean surrounded by water.

GENERAL BACKGROUND INFORMATION ON THE SUBJECT:

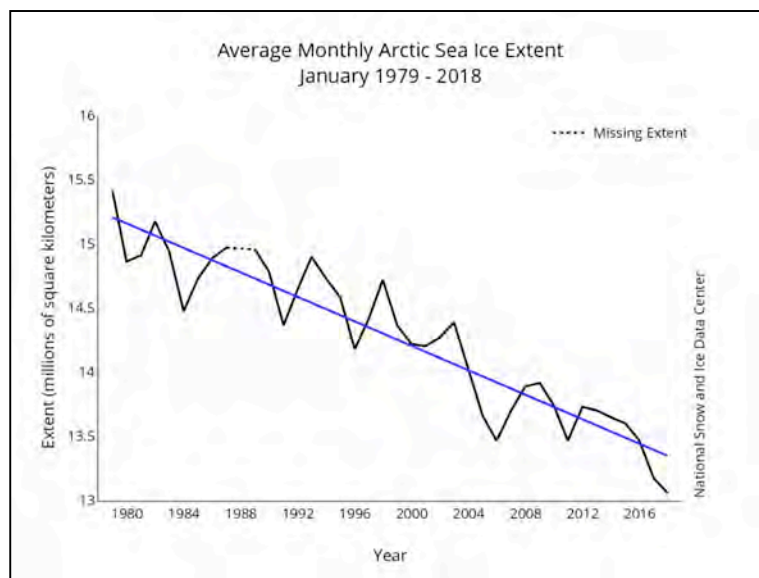
Sea ice is an important part of the Arctic ecosystem. Sea ice forms when the surface of the ocean freezes during fall and winter: air temperatures in the wintertime Arctic average -30°C (-22°F). During summer, the ice melts around the edges of the Arctic Ocean, near the continents. In the past, the sea ice was thick

enough that about half of the ice cover remained in summer, forming what was called multiyear ice, or ice that lasted from one year to the next.

Old ice floes (patches of ice) are thick because each winter freezing ocean surface water adds more ice to the underside of the floe. Floes also thicken when the wind blows one into another and they ride up on top of each other, forming ridges. In the past, old ice in the Arctic used to be more than 3 meters (9 feet) thick. This is different from sea ice in the Antarctic: it forms each winter and then mostly melts the following summer. Antarctic sea ice is just 1-2 meters (3-6 ft) thick.



The two images above are created from actual data. They show Arctic ice cover at two different times in one 'ice season'. The first image is from March, when the ice cover is usually at its maximum extent (largest amount) in the middle of winter. The second is from September, when the ice cover is at its minimum extent (smallest amount) at the end of the summer.



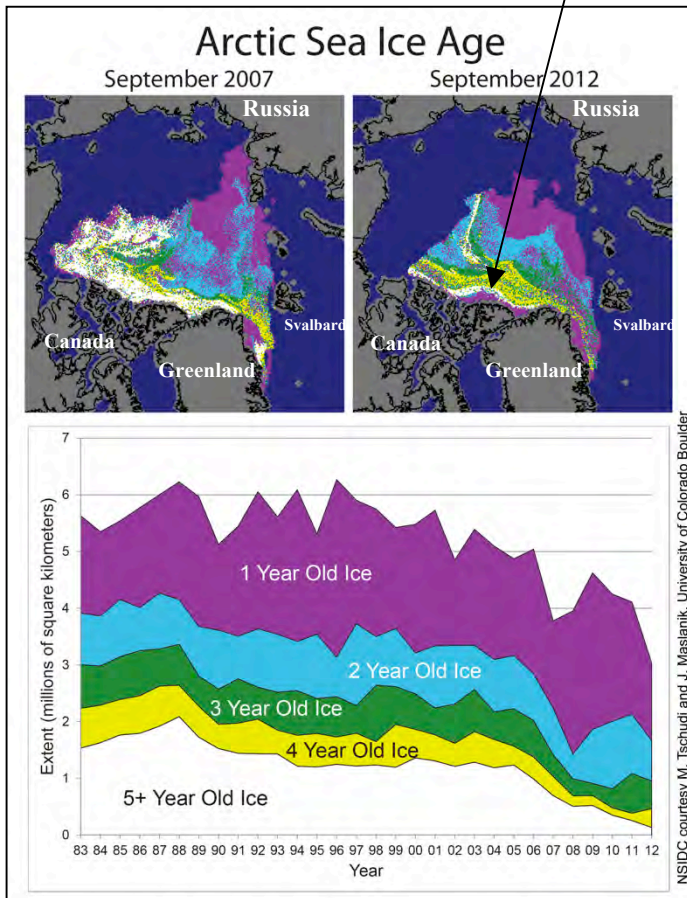
But summer sea ice in the Arctic is disappearing fast! Warm air and ocean temperatures melt the ice during the summer months. Observations from satellites indicate that since 1979, sea ice extent has declined at a rate of more than 11% per decade. The most dramatic decline in ice extent occurred during the summer of 2012. This graph charts the September minimum extent of sea ice from 1979 to 2018. You can see that the amount of ice varies each year but if you follow the blue line (which is called the trend line) you can see that overall the amount of ice is dropping. Now look for the year 2012

on the graph. See how ice cover drops really low that year?

In summer 2007 (the year with the 2nd record lowest sea ice extent), the ship passageway through the Arctic waters known as the **Northwest Passage** (below) became ice-free for several weeks in August for the first time since 1978, when records when records were first collected. Scientists are concerned that if these trends in sea ice decline continue, the Arctic Ocean could very soon become ice-free in summer.



Sea ice refuge region with oldest and thickest sea ice



The other important change in the Arctic ice cover is that it is getting thinner. There is less and less of the thick, old ice that persisted from one year to the next. Because the ice is thinner, it is easier to melt all the way through, making it more vulnerable to future warming.

The thickest and oldest ice collects north of Canada and Greenland. This is because the winds blow ice from the coast of northern Russia across the Arctic, over the North Pole, towards Greenland – this major current of ice is called the *Transpolar Drift*. While some ice continues out of the Arctic Ocean through Fram Strait between Greenland and Svalbard, a lot of the ice curves around north of Greenland, toward the north slope of Canada.

Models show that in the future, when warming melts ice covering the rest of Arctic Ocean in summer, this one area north of Canada and Greenland is likely to still have ice for a long time. How long? Nobody knows, but it is likely to become a natural refuge for species that either needs sea ice, or just prefer to have it around.

WHAT ABOUT POLAR BEARS?

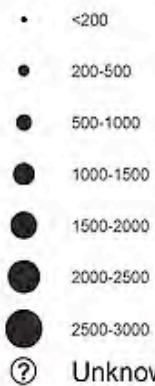


Polar Bears use sea ice for hunting seals, their main source of food. Polar bears know that they can find seals at their breathing holes – which are circular openings that the seals make in the ice. The loss of sea ice is a real threat to the bears, because without it they will have difficulty locating and catching enough high quality food to sustain them and their young.

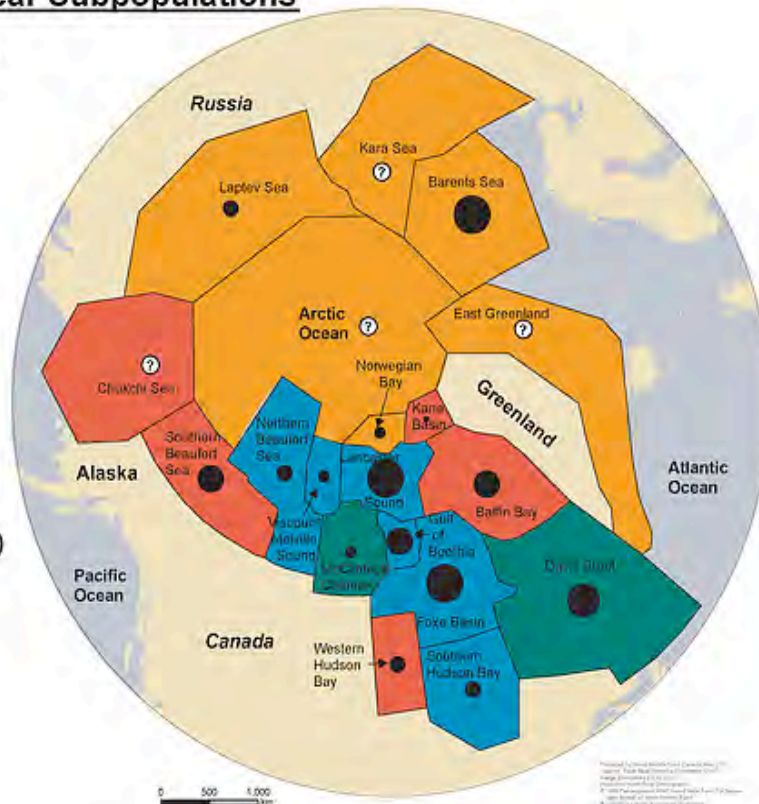
Trends in Polar Bear Subpopulations

Subpopulation size

No. of Bears



Population Trend (2013)



Rapid change is having an impact on the polar bear. Scientists are concerned that the loss of Arctic sea ice due to a warming climate could threaten the survival of the species. Other potential threats to shrinking polar bear habitat include development of oil, gas and mineral production facilities, opening of transportation routes for shipping, and increased traffic associated with tourism. Some scientists are pushing to establish a special sea ice management program in the natural ice refuge, referred to as the Last Ice Area, that could help certain polar bear populations.

TERMS YOU SHOULD KNOW (VOCABULARY):

Arctic - (from Greek arktikos which means northern) northern polar region of the earth which includes almost the whole area of the Arctic Ocean and adjacent areas of Eurasian and North American continents.

Albedo - a measure of how well a surface reflects solar energy.

Drift ice/pack ice – sea ice that moves from winds, currents, or other forces.

Ice floe - an expanse sheet of floating ice.

First-year ice - sea ice of no more than one year's growth.

Multiyear or old ice - ice that has survived at least one melt season; it is typically 2 to 4 meters (6 to 13 feet) thick and thickens by ice growing on its underside.

Sea ice - any form of ice found at sea which has originated from the freezing of sea water.

WHY ARE WE STUDYING ICE IN THE POLAR REGIONS?

Sea ice is an important component of regulating global climate. Bright white ice reflects a lot of incoming solar radiation, while dark waters absorb this heat. Melting and freezing of ice also affects the way water moves throughout the oceans. As sea water freezes, the salt excluded from the crystals makes the ocean water dense. The cold dense water sinks and flows southward as a deep current that continues out of the Arctic Ocean. The water sinking in the north is replaced by warm surface waters from the south. This pattern of ocean currents is called the “ocean conveyor belt” and it influences ocean circulation around the rest of the globe.

Locally, many people who live in Arctic depend on the ice for transportation, as well hunting. Many other animals besides polar bears and seals rely on Arctic sea ice for feeding, breeding, raising young, and transportation.

HOW DOES THIS AFFECT US HERE IN THE UNITED STATES?

The US is an Arctic nation, so changes happening in and around Alaska create challenges and opportunities for our country. Arctic warming also disrupts our planet’s natural air conditioner, leading to greater warming around the rest of the globe.



Dr. Pfirman at a Polar Weekend Fair



The Demonstration Set Up

SHRINKING ARCTIC SEA ICE DEMONSTRATION (see script on pgs. 7-10; suitable for young audiences)

Supplies: This can be done in a large basin, a kiddie pool, a large mixing bowl or casserole dish, or the bathtub! Use pans, smaller dishes, tupperware or old take out containers marked for Svalbard and Greenland can be turned upside down in the container you select. Label these and place them so that they form the Fram Strait. Break up thin flat sections of Styrofoam or packing peanuts to act as sea ice floes. Rubber animals, such as polar bears, seals, and walrus, can be used for fun! However, if you don’t have these specific toy animals, you can use any toy to simulate a polar bear or walrus.

Explain how the Transpolar Drift moves the sea ice from the coast of Russia across the North Pole. Then place the sea ice on the backside of the pool – the pool represents the Arctic Ocean. Now ask the students to blow on the ice as a group and watch how the ice moves toward Greenland and Fram Strait between Greenland and Svalbard. See how some of it flows out Fram Strait into the open ocean where it melts. But also see how much of the ice circles around toward Greenland and collects there – this is the natural ice refuge, where the oldest and thickest ice accumulates.

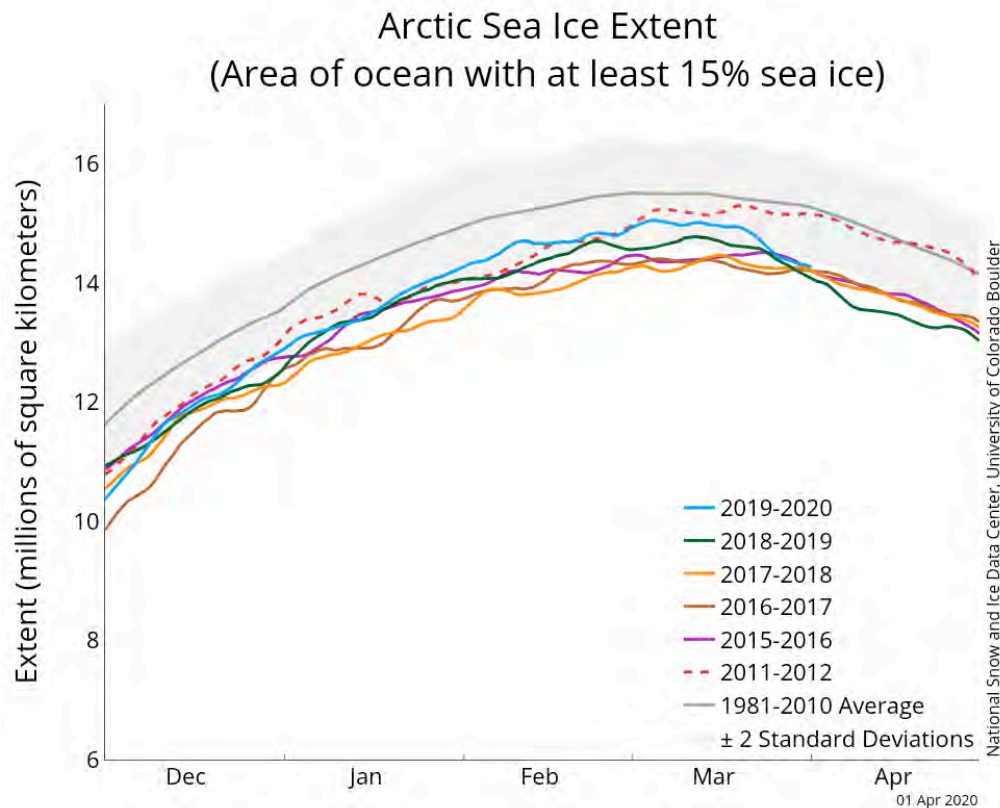
Have students place polar bears, seals and walrus on the Styrofoam ice floes to rest. See how they naturally pick the larger floes because the smaller ones are not as stable. Explain how that is just what Lamont-Doherty Earth Observatory

Arctic animals look for, and how they have trouble when they can't find floes that are large and thick enough to support their weight.

Diving into Arctic Sea Ice Data

Have students examine the Arctic Sea Ice Extent graph below from the NSIDC (or get the most up to date graph and image at <http://nsidc.org/arcticseaicenews/>) and discuss the following. Be sure the students know this is real data:

1. The X-axis on the graph below is labeled with the summer months. The Y-axis is labeled extent cover in square kilometers. What is the graph showing? What do the different lines mean?
2. During what month are they at their lowest point?
3. At what month are they at their highest point?
4. Why do they change over the seasonal cycle?
5. Does 2014's data trend line higher or lower than the average 1981-2010 trend line?



6. How
does the 2019-2020 trend line compare to the data from 2012? Remember 2012 is the recorded low for Arctic Sea Ice Extent.

TO LEARN MORE ABOUT THESE TOPICS:

<http://nsidc.org/arcticseaicenews/>

http://wwf.panda.org/what_we_do/where_we_work/arctic/

http://wwf.panda.org/what_we_do/where_we_work/arctic/last_ice_area/

Script for Shrinking Arctic Sea Ice Demonstration By Stephanie Pfirman

Set up kiddie pool with water, Styrofoam pieces (ca. 3" and some larger, and thicker ca. 5-6" diameter), 2 large solid objects labeled to represent Greenland and Svalbard.

Tips:

When asking questions, respond using phrases such as, "Right", or "Well, actually", or "Good guess/ You're close, but.."

Use the props to help you tell the story, encourage the kids (when appropriate in the script) to swim the seal around or move the walrus/polar bear.

Introduction:

"This exhibit is about melting Arctic ice – have you heard about that before?"

Response...

"Let's see how melting Arctic ice affects life in the North Pole."

Hold out polar bear and walrus and ask, "Do you want to be a polar bear or a walrus?"

Make them pick one or the other

---Polar Bear/Seal scenario----

"Let's start with the polar bear – what do you think that polar bears eat?"

They often say fish, sometimes they say seals – which is right – *if they say fish, then say "no, fish don't have enough fat to sustain polar bears"* and *see if you can get them to say seals, "Yes, seals!"*

"OK, I'm a seal – see if you can catch me"

Hold the seal underwater. As they try to get you in the water—sometimes they need encouragement to really come after you--wait until they're close and then scoot away underwater really fast with a splash.

This will startle them – which is what you want

"See I'm too fast in the water – you need to find some way to slow me down."

Pick up a piece of Styrofoam that has a premade small hole in it and poke the head of the seal up through, then put that in the water and tell them to "catch me again."

"See, you wait for me to come up and breathe through this hole in the ice, and then you can catch me. You need the ice to slow the seals down."

Then make the point again – **"So in the future, if there isn't a lot of sea ice, what might happen to the seals?"**

Response...

"Since there is less sea ice, the seals can breathe anywhere by coming up to the surface of the water. The seals can also escape from the polar bears more quickly, because they can swim away faster"

Show them the difference by taking the Styrofoam out of the water and using the seal and polar bear to aid in the visual.

“However, how might this affect the polar bears?”

Response...

“The ice helps to slow down the seals, so the polar bears can catch them. Without the ice, it will be harder for the polar bears to find food.”

-----Walrus Scenario-----

“OK, what about the walrus, what do you think they eat? I’ll give you a hint.”

“Walrus are big animals, right? They don’t like to move around too much because they want to save their energy. What type of animal do you think they would eat, something slow and easy to catch?”

People often have lots of answers, including plants (not enough protein), but don’t come close – you can *give another hint*, “When you think of a slow animal, what do you think of?”

Usually they say turtle or snail – *if they say turtle, you can say even slower and smaller.*

“*Really close*, their favorite food is actually clams!”

“Do you know how many clams they eat in 1 day? I’ll give you another hint – it is a lot -- each walrus weighs about 1 ton.”

See what they guess – go around to whoever is there and have them guess. It is nice to include parents/guardians as well.

“right – **they eat 5000 clams in 1 day!** (p. 28-29 Walrus book) Really emphasize the 5000, as most people are surprised.

“How do you think they find the clams?”

Response...

“They dive down to the seabed and use their whiskers to find the food. Then they create a water jet from their mouth and use their flippers to push away the mud to find the clams.”

While talking, take the walrus along the pool floor, searching for clams.

“Do you think they eat the whole entire clam, including the shell? That would be 5000 clam shells in one day!”

They all say no ...

“Right all those shells in their belly would give them a bad stomach ache. They actually suck the meat out of each shell and then move on to the next.”

“On each 5 minute dive, they can eat about 50 clams, so how many clams can they eat in 1 minute?”

... wait for them to calculate

“10, right... OK, now if they have to eat 5000 clams in 1 day, and they can only eat 50 clams on 1 dive, how many dives do they need to make?”

... wait for them to calculate

“100, right ... do you think that would make them tired?”

... they say yes

“So they need to find a place to rest – where would you rest if you were up in the Arctic?”

Sometimes they choose the land/glaciers and sometimes they choose the ice – which is correct, they haul out on land as well as ice – but you can say, “If you found a good clam bed, would you want to swim all the way back to shore to rest or would you rather find someplace close by to take a nap and then continue?”

Get them to pick a piece of ice to rest on – they will pick a large piece and then say

“Why did you choose a large piece of ice?”

They’ll say because otherwise the ice won’t support them

“That was a smart choice -- that’s exactly what the walrus look for too – they need a large, thick floe, which is a sheet of floating ice, that is sturdy enough for them to rest on.

“But there’s another reason why they need the ice – What would happen to a clam bed, if a whole herd of walrus came to it and each walrus wanted to eat 5000 clams a day?”

Everyone says it will be gone ...

“Right – so they need to find a way to get to a new clam bed – and remember I said that they are really slow and need to save their energy for finding food? Can you think of any way they can get to a new clam bed without swimming?”

Often they say the ice

“Yes -- they can hitch a ride on an ice floe and drift to another area with more clams to eat.”

Show, using the walrus and Styrofoam, how the “ice” facilitates the process of getting food.

“What might happen if there is no sea ice?”

Response...

“They can’t chill out and rest, and it will be harder for them to get to new clam beds.”

----Ice movement scenario-----

“The projection for the future is that we will keep losing sea ice as global warming proceeds, causing problems for walrus, polar bears, and seals, as well as the Arctic indigenous communities that depend on these animals for food and cultural practices.”

But there is 1 place where we might have ice for a long time and we are working to protect that area.

“Do you know where it is?”

... usually they say at the North Pole –

“Let’s see how the ice moves in the Arctic region.”

Position the kids by Siberia (name is marked on the pool).

“Okay now, we are going to pretend we are the cold north polar wind. Blow onto the ice, and let’s see where it goes.”

As you’re saying the above, move all the ice up close to them, and on the opposite side of Greenland

“Now blow!”

What will happen is that the ice will move across the pool toward Greenland and cluster there

“See what happened? All the ice moved across the Arctic to the region north of Greenland and that’s exactly what will happen in the future.

When there is less and less ice, the wind will blow the ice that is left across the Arctic and it will build up in this one spot, so we are trying to keep good quality – thick – ice there.”

Shift now to talk to the parents

You can point out where the last ice area is on the poster.

“There is a lot of oil and gas in the Arctic” – here you can point to the poster showing where the oil and gas development may be. Mention something about current developments taking place in the area due to oil companies and certain national policies.

“So it could be that the region becomes more polluted in the future. We’re trying to make sure that this one region is managed so that animals like polar bears and walrus that need ice can survive for as long as possible into the future.”

“What are ways you and your community can help to reduce global warming so that sea ice stays for longer ...”? Brainstorm some ideas. Examples; taking public transportation/carpooling, using eco-friendly appliances, recycling, etc...

References:

Born, E.W. (2005). *The Walrus in Greenland*.

Pfirman, S., Tremblay, B., Newton, R., Fowler, C. (2009). *The Arctic Sea Ice Refuge*.

The Arctic's Last Ice Area

Stephanie Pfirman^{1,2}, Bruno Tremblay^{3,2}, Robert Newton²
¹Barnard College, Columbia University
²Lamont-Doherty Earth Observatory of Columbia University
³McGill University, Canada

Summary: As global warming reduces the summer sea-ice in the Arctic Ocean, ecosystems requiring ice year round are likely to survive longest in the region immediately north of Canada and Greenland. Models and satellite data indicate that summer sea ice will persist longer in this region than any anywhere else in the Arctic. Analysis of models and satellite data indicate that ice in this natural refuge will come from both locally created sea ice, as well as drifting ice that forms originally over the central Arctic. Depending on future changes in melt patterns and sea ice transport rates, the Siberian shelf seas may also be a source of ice to the refuge.

On August 1, 2019, Canada stepped up and, working the Qikiqtani Inuit Association and WWF, established the **Tuvaijuittuq Marine Protected Area**. Tuvaijuittuq translated into English is "the place where the ice never melts". While this is a major step, because Arctic sea ice is in constant motion, protecting this region will not protect the ice habitat: we also need to manage its 'ice shed' or the area that creates the ice that moves into this area. The Last Ice Area will persist precisely because it accumulates ice from remote areas.

Walrus Need Sea Ice to Rest

Biggest Walrus Gathering Recorded as Sea Ice Shrinks
More than 35,000 of the marine mammals have congregated in Alaska.



http://www.sdsbg.com/frontier_scientists/files/Walrus_sittingNOAA.jpg

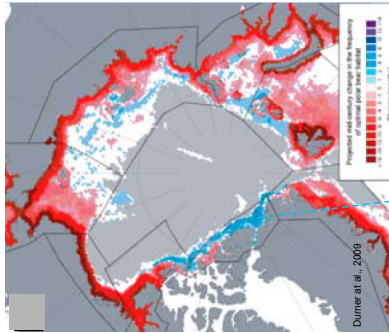
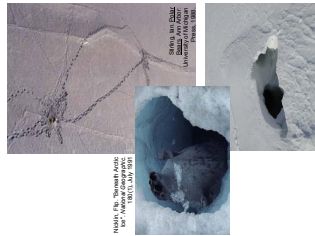


Over a thousand walruses gather on the northwestern coast of Alaska on September 23, 2014.

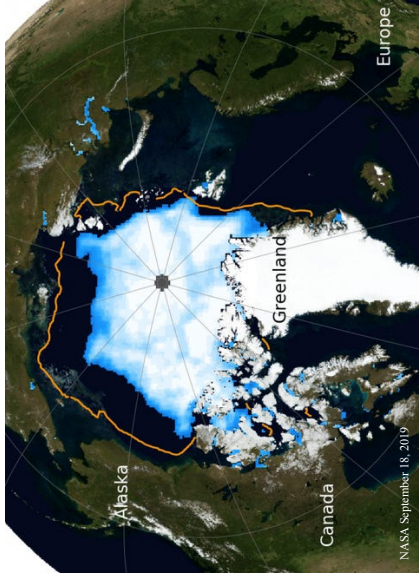


Stephanie Pfirman doing research in the Arctic.

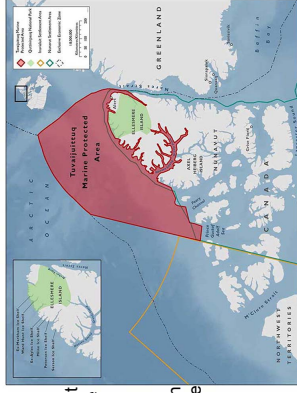
Polar Bears Need Sea Ice to Catch Food



Projected changes in optimal polar bear habitat for 2050



The Tuvaijuittuq Marine Protected Area is set aside for a 5 year period limiting human use of the area with allowances for Inuit access. It is 322,000 sq. km., about the size of Norway and is one of the largest marine protected areas in the world, ranking 10th, just slightly smaller than the Great Barrier Reef Marine Park. However, it is only about 50% the area of the scientifically defined Last Ice Area, which extends to the west, as well as to the east, into the waters offshore Greenland.



<https://www.fishbase.org/locations/area/atlantic-ocean/atlantic-ocean.html>

When Could We Lose the Sea Ice?

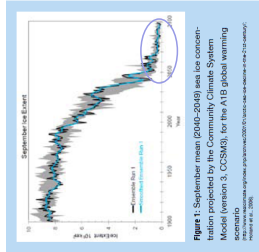
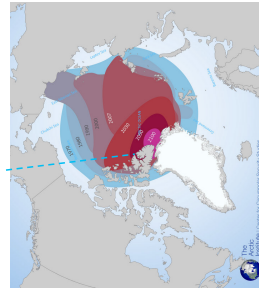


Figure 1: September mean (2010-2019) sea ice concentration projected by the Community Climate System Model (version 3, CCSM3), for the A1B global warming scenario (IPCC 2007). Source: https://www.cesm.ucar.edu/models/cesm1.0/ocs/figures/ocs_fig1.html

Most models project rapid summer ice loss followed by some sea ice through ca. 2075

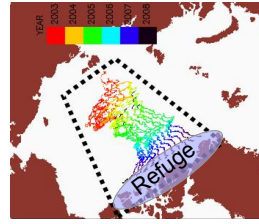
Where Will Sea Ice Last the Longest?



<https://www.ccmr.noaa.gov/sites/default/files/seaice/future/map2.jpg>

Need to manage the ice shed where sea ice forms that supplies the refuge as well as the September ice refuge area

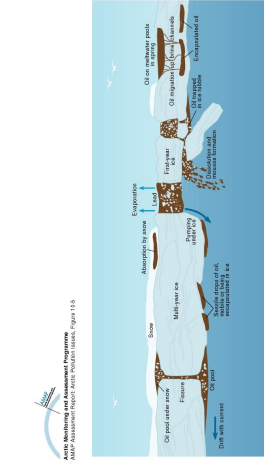
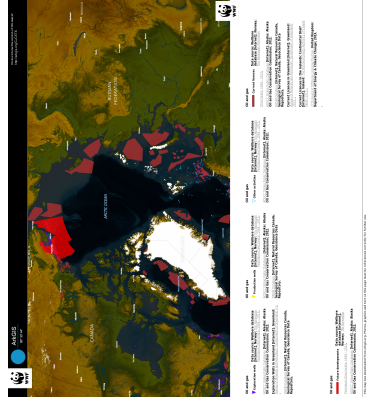
Where is the "Ice Shed"?



Pfirman et al. 2008, Arctic Circle

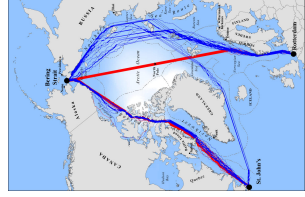
Potential Pressures on the Refuge and its Ice Shed

Oil/Gas/Mineral Production



Very Difficult to Clean Up Spills in Icy Waters

Transportation



Smith and Stephenson, 2013