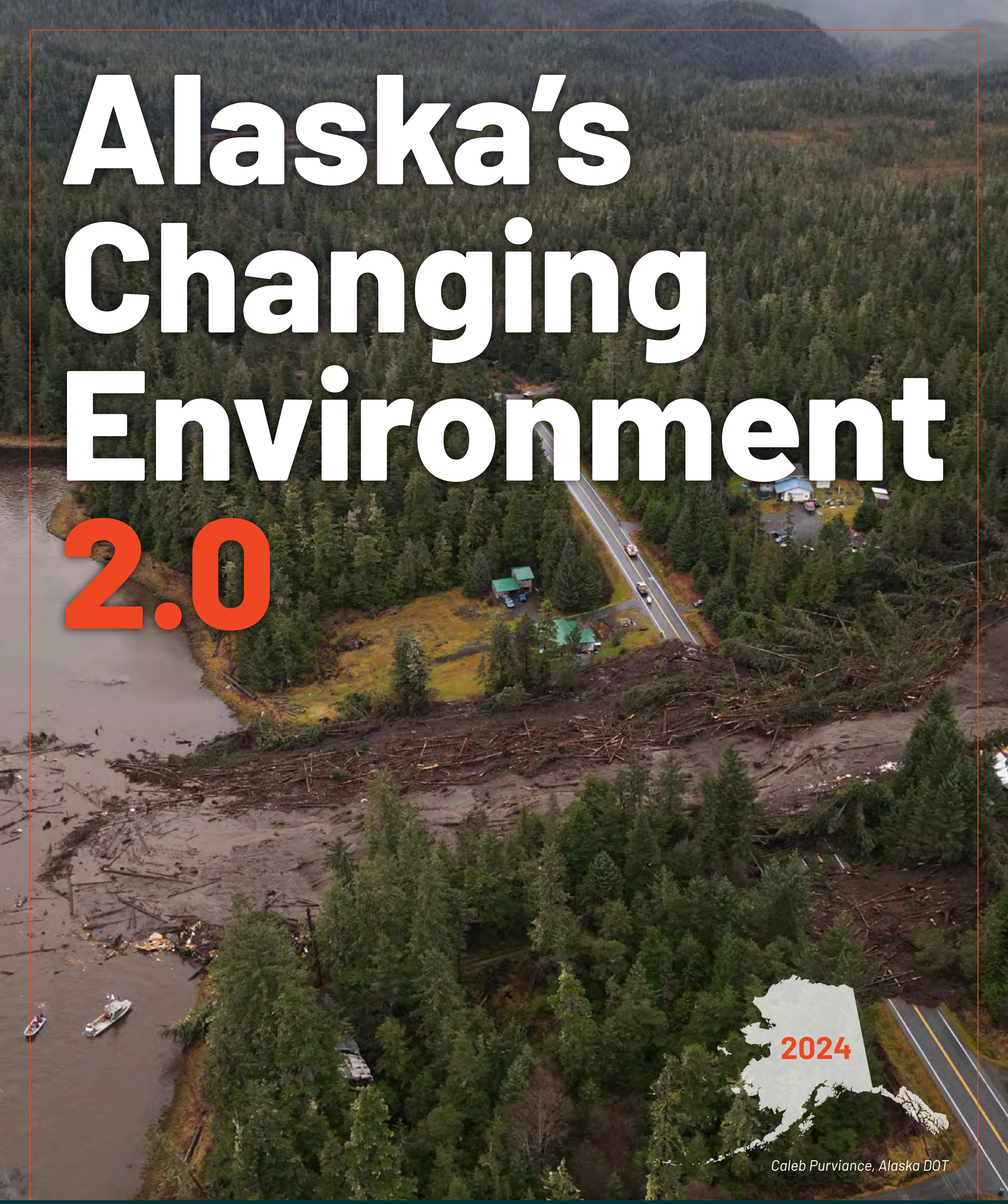
Alaska's Changing Environment 2.0



Caleb Purviance, Alaska DOT

Read it online at uaf-iarc.org/communicating-change

ACCAP Alaska Center for Climate Assessment and Policy
A NOAA CAP team
International Arctic Research Center
UAF University of Alaska Fairbanks

Welcome to Alaska's Changing Environment 2.0

This is the second edition of Alaska's Changing Environment, highlighting environmental changes and extremes that impact Alaskans lives and livelihoods. We published the first Alaska's Changing Environment in 2019, and it was a popular resource that provided Alaskans with timely, reliable and understandable information about climate and environmental changes impacting the state. In the five years since, extreme weather, climate and environmental events have become more frequent. All regions of the state have been impacted, from landslides in Southeast and Typhoon Merbok along the Bering Sea to long-term erosion and permafrost thaw in northwest Alaska. Alaska's Changing Environment 2.0 updates key long-term climate trends and highlights changes and impacts that have emerged or accelerated in recent years.

Read Alaska's Changing Environment online, learn about the series it is a part of, find earlier reports and spinoffs at **uaf-iarc.org/communicating-change**.

Who are we?

This report was led by the UAF Alaska Center for Climate Assessment and Policy with contributions from dozens of scientists and Indigenous experts across Alaska. Send questions to **uaf-accap@alaska.edu.**

\# The number in the red circle near each graphic links to the associated contributor and data source on pages 30–31.

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Featured topics

Disclaimer

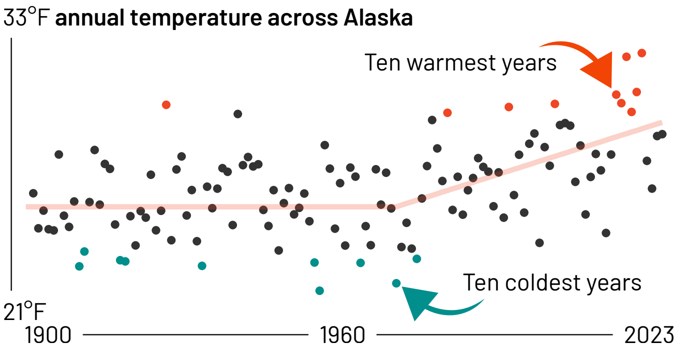
Nearly 40 experts contributed to this report, but it is of course not comprehensive. It is meant to provide accurate and timely information about some of the environmental changes important to Alaskans. We aim to provide a well-rounded and easy to understand perspectives on topics ranging from Alaska climate and extreme events to salmon and polar bears. These synopses should be considered alongside published scientific research, official reports and other sources of information.

Time frames covered in this report vary from topic to topic due to the availability and reliability of datasets, and for maximum consistency with past reports. Email uaf-accap@alaska.edu with questions.

Air temperature

Dramatic temperature increase

There was no overall trend in Alaska temperature for much of the 20th century, despite year-to-year variation. However, starting in the late 1970s temperatures began to climb. The statewide average temperature has increased by more than 3°F in less than 50 years. Now, six of the 10 warmest years since 1900 have occurred since 2010, and there hasn't been a top-ten coldest year since 1975. This is a dramatic change in such a short time given the size and diverse climate across Alaska.



1 WARMING

The pink line in this graph shows how Alaska annual temperature has been trending warmer since the 1970s.

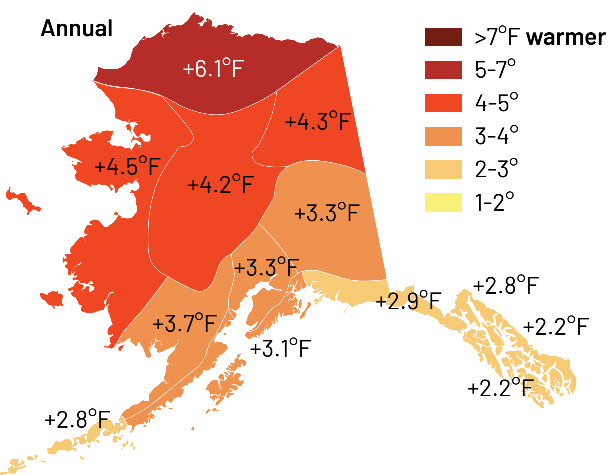
UAF photo

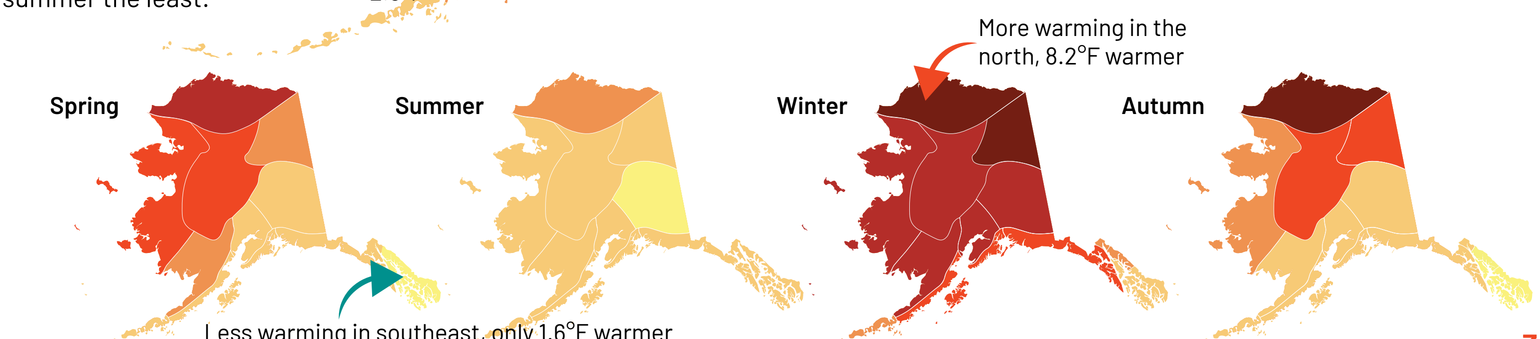
Warmest in the north and winter

Alaska is huge with a wide variety of climates, from temperate rainforest in Southeast to Arctic tundra on the North Slope. So, it's no surprise that regions are warming at different rates. Over the past 50 years, the greatest warming occurred on the North Slope and west coast, where declining sea ice has the most immediate effect. The marine dominated climates of the Aleutians and Gulf of Alaska coast have seen significant but lower rates of warming. Across all regions winter saw the biggest increases ranging from 8.2°F in the north and 2.5°F in Southeast.

2 TEMPERATURE BY REGION & SEASON

These maps show average temperature change across Alaska from 1974 to 2023. The top map shows the annual change, while the bottom four show seasonal changes. Winter warmed the most and summer the least.

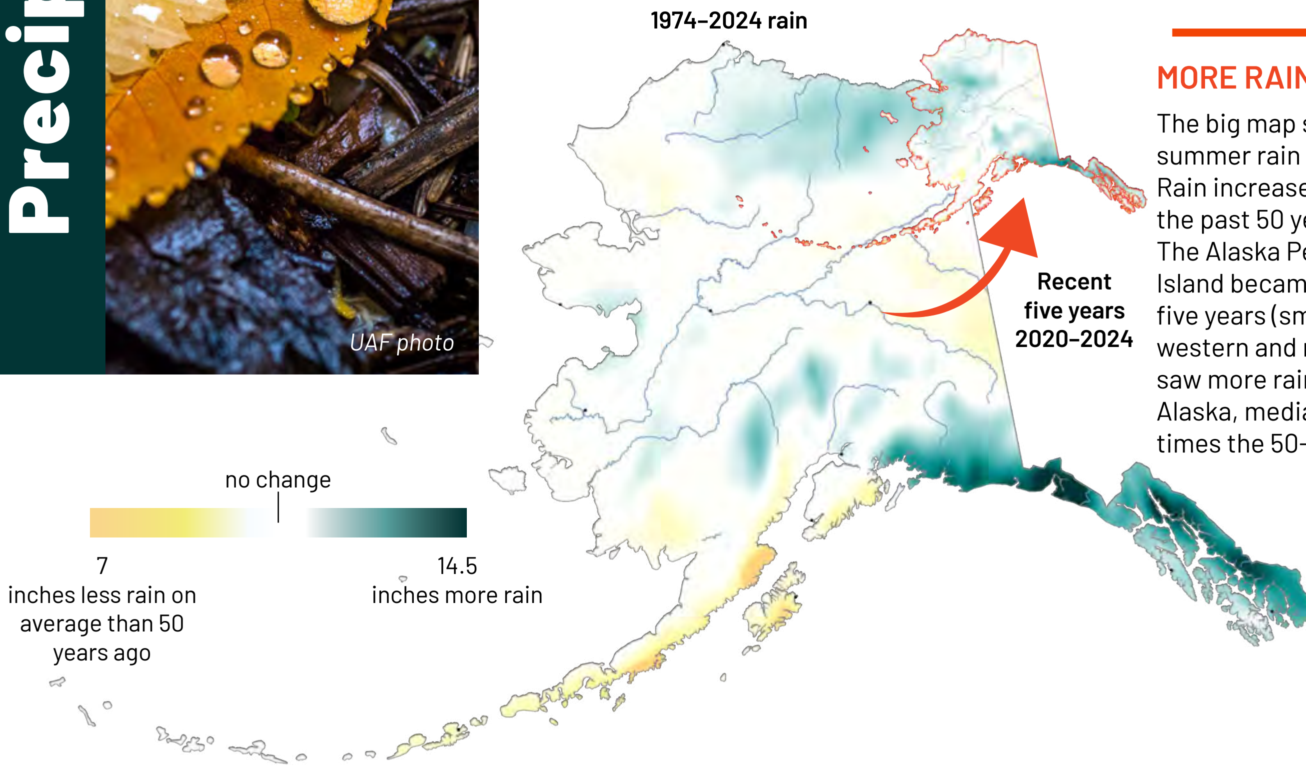




Precipitation

Summer precipitation

The average typical summer precipitation has increased over the past 50 years in much, but not all, of the state. Southeast and the eastern Gulf of Alaska coast saw the largest increases, while the Interior, eastern Kenai Peninsula, Kodiak Island and parts of Southwest trended toward a bit less rain overall. Summer rainfall often varies greatly from one year to the next. In most of Alaska the wettest summers have 5 to 10 times as much rain as the driest. These kinds of swings in precipitation can mask the long-term trend and are an expected part of the past and present climate.



3 MORE RAIN, MOST AREAS

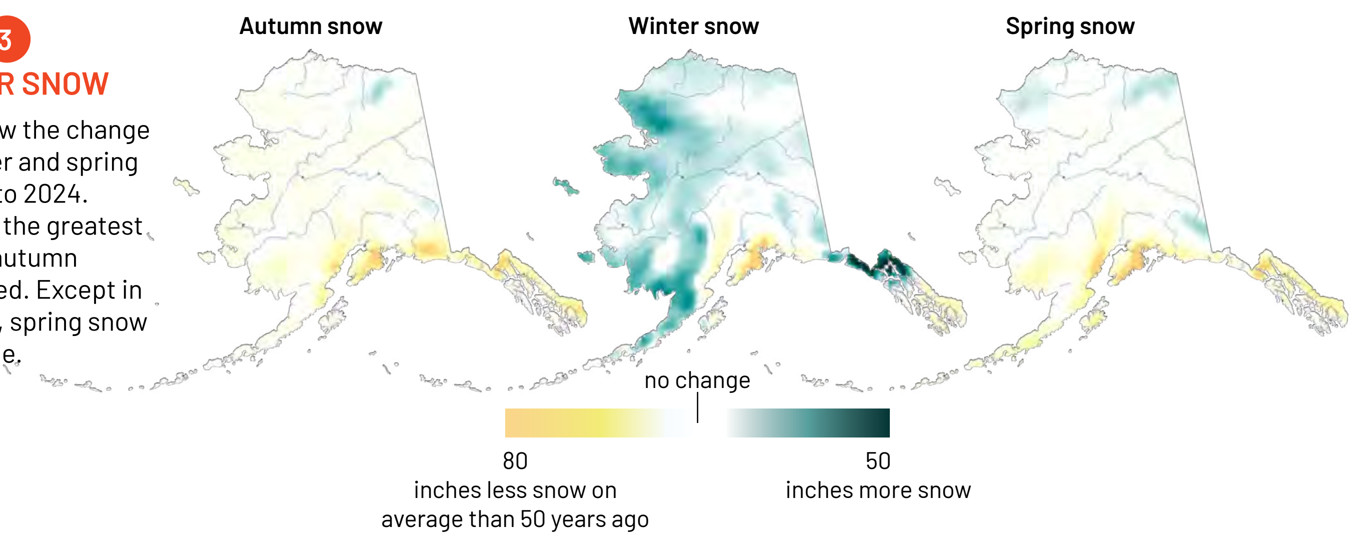
The big map shows change in summer rain from 1974–2024. Rain increased 10+ inches over the past 50 years in Southeast. The Alaska Peninsula and Kodiak Island became drier. Over the past five years (small map), Anchorage, western and northwest Alaska saw more rain. In northwest Alaska, median rainfall was 1.5 times the 50-year average.

Winter precipitation

Most of Alaska is seeing more mid-winter snow. This increase is driven by warmer temperatures that enable air to hold more water vapor that falls as snow when temperatures are below freezing. Mid-winter snow is decreasing in southern Southeast. Low snow in the region has been linked to environmental impacts including over 1,100 square miles of cedar decline. The trees are dying as insufficient snowpack fails to insulate roots from cold in early spring. Across most of Alaska, snow in autumn is decreasing as more precipitation falls as rain. The North Slope is the only region where snow is increasing across the entire autumn to spring season.

3 MORE WINTER SNOW

These maps show the change in autumn, winter and spring snow from 1975 to 2024. Winter has seen the greatest increase, while autumn snow has declined. Except in southern Alaska, spring snow has changed little.

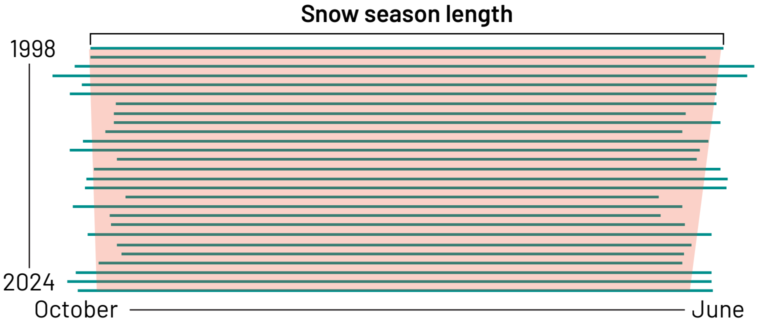


Snow season changes

The snow season is changing across Alaska. It is typically about two weeks shorter than it was several decades ago. The greatest shift occurs in the spring. The spring date when half of the state has no snow is now 11 days earlier compared to only three days later in autumn. As temperatures continue to rise, the numbers of days per year with snow cover will greatly decrease.

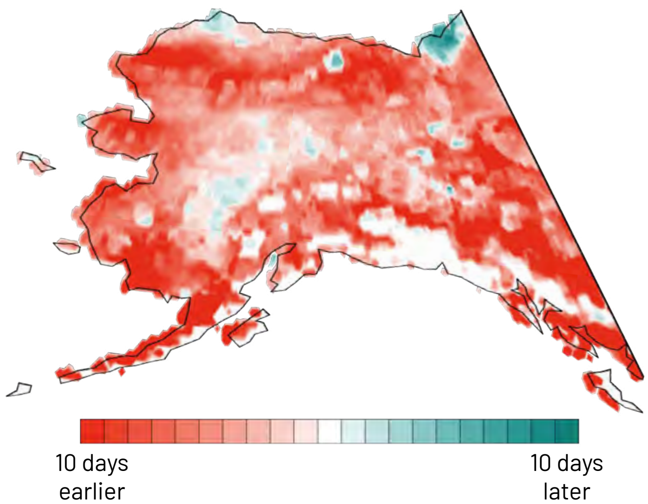
4 SHORTER SNOW SEASON

Over the past 26 years, the number of days when half or more of the state is covered by snow has dropped from 217 to 203 days.



5 REGIONAL SNOW-OFF

This map shows spring snow-off over the past five years (2019–2023) compared to the 40-year average. Across most of Alaska, snow is melting earlier. The largest trends occurred along the Brooks Range and south of the Alaska Range, with the Aleutians and southern Panhandle losing snow up to 6 days earlier than in the past. Even so, snow-off varies greatly from year to year.



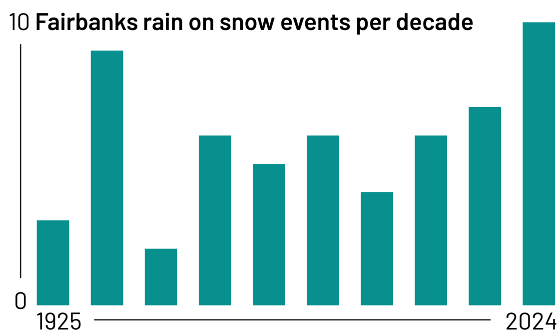
UAF photo

Icing from winter rain

Winter rain is a serious hazard in Alaska. Ice from rain in November may remain on Interior roads until spring. Ice crust over snow can hinder moose movement and seal off vegetation from grazing caribou and other animals.

6 MORE WINTER RAIN IN FAIRBANKS

Over the past 20 years, rain in winter has become more frequent in Fairbanks than any time in the past century. There is now usually at least one rain event each winter, and some winters have two or three. This prompted changes in how roads are treated and the school district built weather days into their calendars.



Storms

Storms in coastal areas

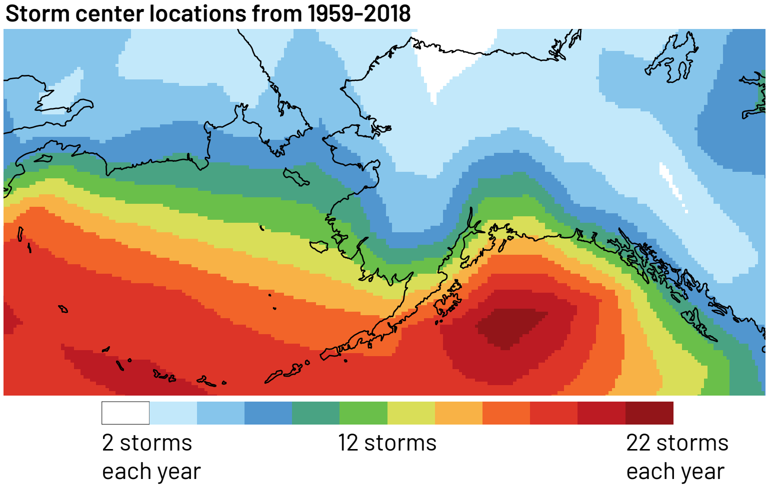
Alaska is located along the North Pacific storm track with storm systems primarily hitting the Bering Sea and Gulf of Alaska regions. These storm systems can significantly impact coastal areas. High winds and waves can cause flooding and erosion that can damage critical infrastructure and endanger the health and wellbeing of coastal communities. In the past five years the western and northern coasts have seen more storms than normal; however, there have been no clear long-term trends in annual storminess since at least 1979. Although the number of storms has not increased, the shorter sea ice season and the protection that ice provides means that there is greater risk of coastal flooding.

7

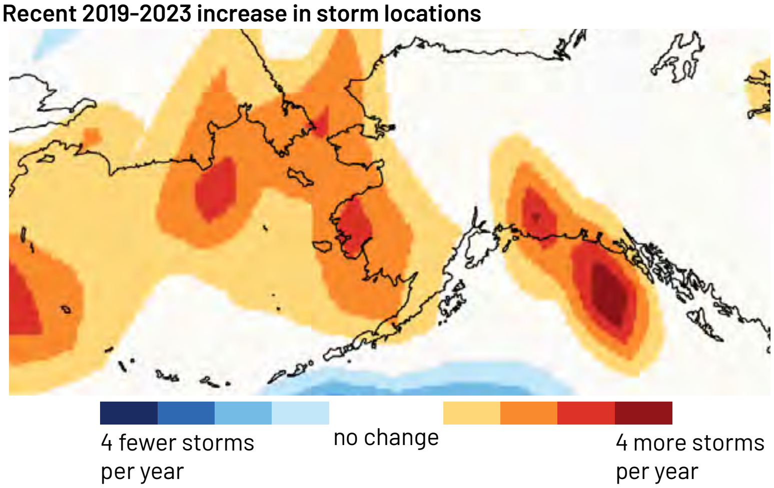
MORE STORMS RECENTLY

The Gulf of Alaska and southern Bering Sea experienced the most storms during the 1959–2018 period (left map). Recently (2019-2023, right map) the eastern gulf and all of Western Alaska have seen an annual average increase of 2–4 moderate to strong storms per year. Note that these maps only show when a storm center directly covered an area; specific locations regularly experience impacts from storm centers that are far away.

Storm center locations from 1959-2018



Recent 2019-2023 increase in storm locations



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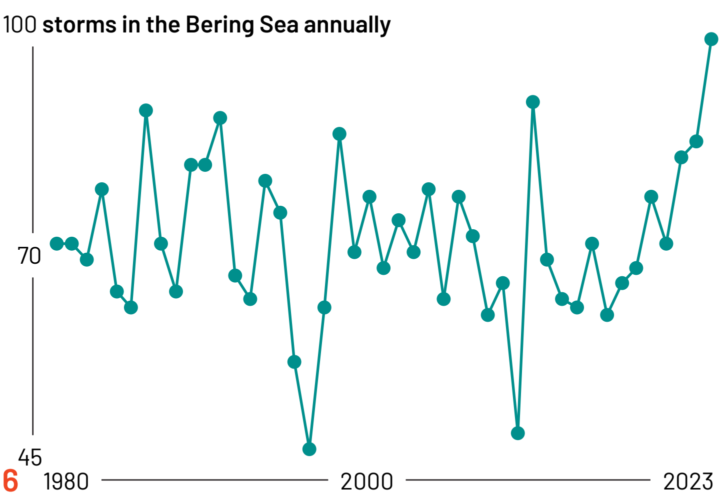
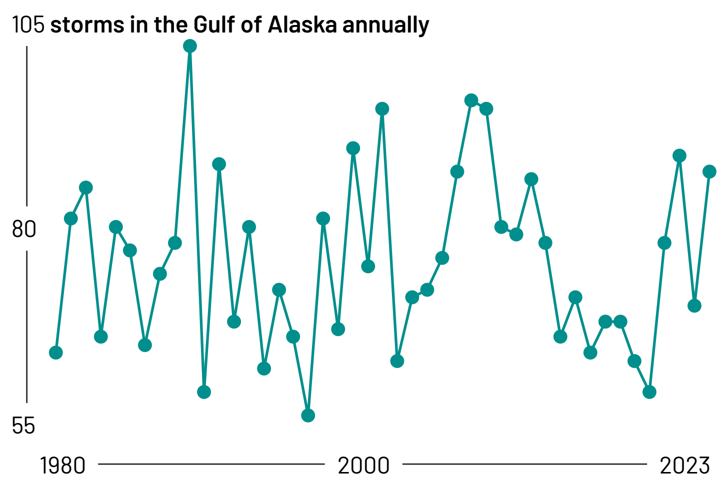
REGIONAL STORMS

The graphs below show the cumulative number of storms in the entire Bering Sea (left) and Gulf of Alaska (right) regions each year. In 2023, the Bering Sea experienced nearly 100 storms, the most since 1980.

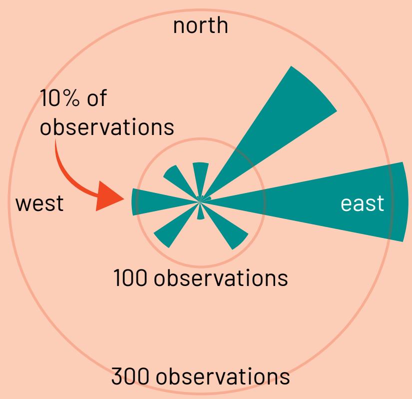




Arctic Iñupiat observers

Across northern and Western Alaska, Iñupiat residents have shared their expertise and knowledge of changing coastal conditions for nearly two decades as part of the Alaska Arctic Observatory and Knowledge Hub. Observations highlight strong variability and decadal shifts in seasonal ocean and weather conditions in Kaktovik, Utqiaġvik, Point Hope, Wainwright and Kotzebue. Warming temperatures, shorter ice seasons and shifting winds affect travel, infrastructure and subsistence hunting.

2006–2014 wind observations



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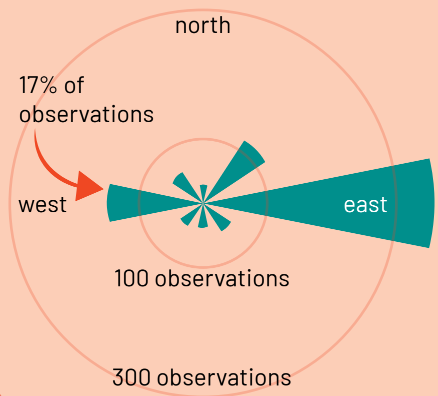
WEST WIND IN UTQIAĠVIK

East winds are most common in Utqiaġvik. But AAOKH observers are seeing more west winds, which are associated with autumn storm impacts and whales further from shore. Since 2015, 17% of observations included west winds, compared to only 10% from 2006-2014.

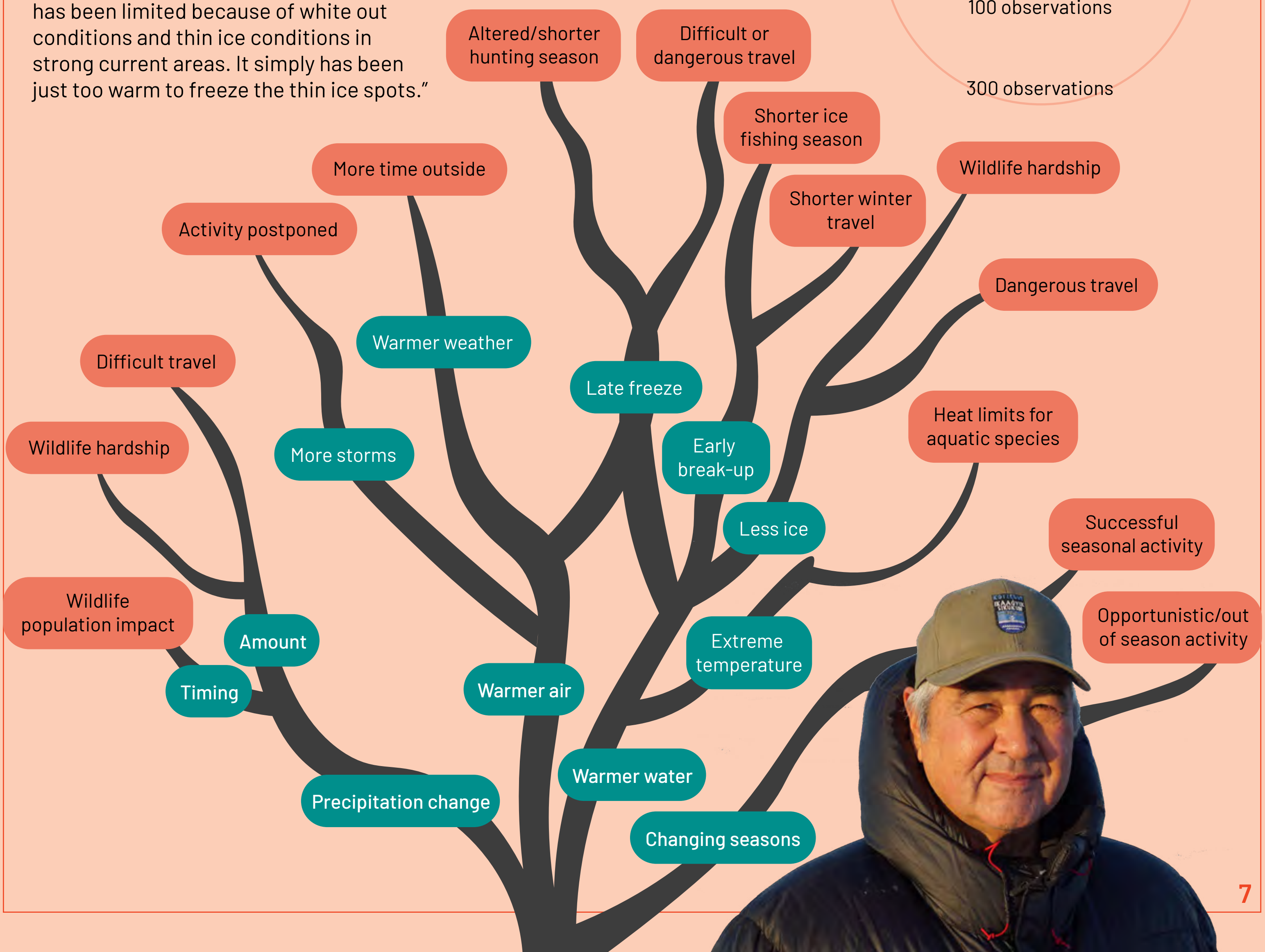
Recent 2015–2024 wind observations



9

KOTZEBUE IMPACTS

This graphic shows climate impacts in Kotzebue based on observations by *Bobby Schaeffer* from 2019-2023. "Difficult or dangerous travel" was reported most often. Example observation from November 23, 2022: "Snowmobile travel has been limited because of white out conditions and thin ice conditions in strong current areas. It simply has been just too warm to freeze the thin ice spots."



Extreme events

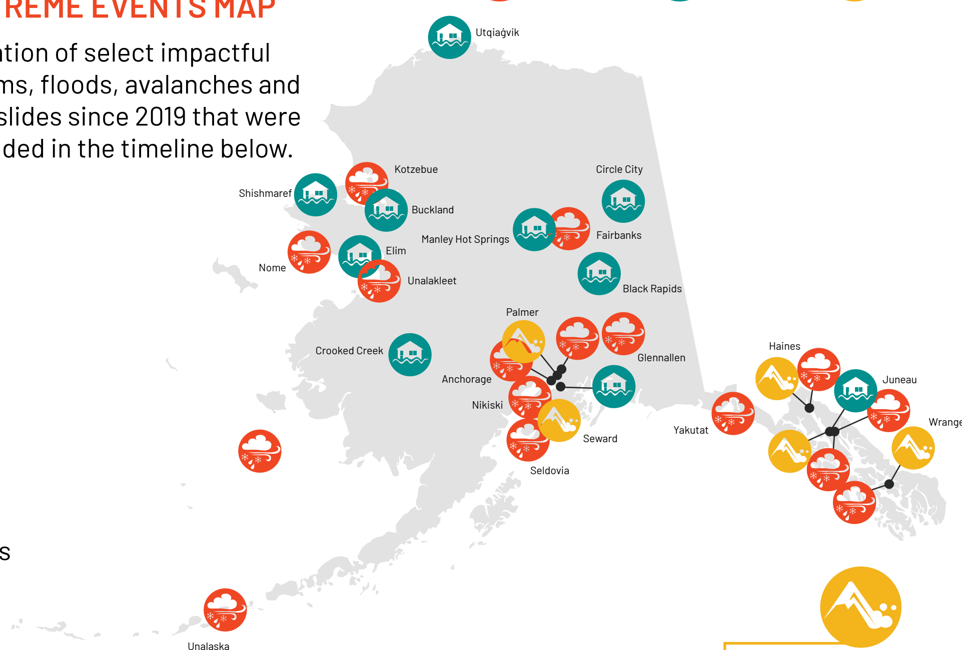

Alaska DOT

More extreme events

The frequency and intensity of extreme events like avalanches, landslides, floods and high impact coastal storms are increasing in Alaska. Since 2020, the State of Alaska declared nearly three dozen weather- or climate-related disasters, about double the 2014-19 total. About a dozen of these were elevated to federal disasters. These events pose great risk to infrastructure, food security, public health and safety. Rural communities, most only accessed by air or water, are especially vulnerable.

10 EXTREME EVENTS MAP

Location of select impactful storms, floods, avalanches and landslides since 2019 that were included in the timeline below.



10 EXTREME EVENTS TIMELINE

Over the past five years Alaska has seen an uptick in fatal landslides, avalanches, strong storms and floods. This timeline is not exhaustive but includes some of the most impactful (excluding wildfire).

2019

- Nov. 2019 — **Strong winds & wet heavy snow;** widespread long-lasting power outages in Nikiski, Seldovia & Kenai Peninsula

2020

- Nov. 2020 — **Flooding** washed out road to landfill at Shishmaref; road washout at Elim
- Dec. 2020 — **Fatal landslide** in Haines; record **24-hour precipitation** in Haines & Juneau

2021

- May 2021 — **Severe ice jam flooding;** state disaster declared in Buckland
- Oct. 2021 — **Flooding** in Girdwood
- Nov. 2021 — **Wind storm;** widespread power outages in Wrangell
  Strong winds; deep Bering Sea storm; damaged infrastructure in Unalaska
- Dec. 2021 — **Freezing rain & snow;** power outages in Interior

2022

- Jan. 2022 — **Wind storm;** widespread damage & power outages at Palmer & Wasilla
  Heavy snow required National Guard in Yakutat
- Feb. 2022 — **Blowing debris;** schools & businesses closed in Nome & Unalakleet
- Mar. 2022 — **Avalanche;** closed Hiland Road; more than 100 homes lost power & access near Eagle River
- May 2022 — **Landslide** cut power & access to Lowell Point near Seward
  Severe break-up flooding at Manley Hot Springs

National Weather Service

Spotlight: Fatal landslides

With the steep mountains and heavy rains of Southeast Alaska, landslides are not new. But they are occurring more often as the region sees more atmospheric rivers and heavy rain events. There have been four fatal slides in the past nine years. An August 2015 slide killed three people in Sitka, a December 2020 slide killed two people near Haines, a November 2023 slide killed six people near Wrangell and an August 2024 slide killed one person and injured three in Ketchikan. All four slides caused extensive property damage. Cleanup took weeks to months and disrupted local economies and road systems.

The factors causing each slide varied. Both Sitka and Haines were triggered by extreme rainfall over a short duration. In Wrangell, the combination of a very wet autumn, heavy — but not record — rain and probably strong winds that rocked trees contributed to the slide. The Ketchikan slide occurred during a relatively dry summer and after the first significant rain (and wind) in weeks.

Jul. 2022
High water washed out Richardson Highway in Black Rapids area

Sep. 2022
Typhoon Merbok; widespread damage to western Alaska

Oct. 2022
Flooding in Utqiaġvik

Dec. 2022
Crippling snow from three big snow storms in 11 days in Anchorage

2023

Mar. 2023
Back-to-back blizzards; drifts blocked buildings & critical infrastructure in Kotzebue; city & state disasters declared & "boil water" advisory

May 2023
Record high rainfall exacerbated ongoing snow melt flooding in Glennallen area

Catastrophic ice jam flooding in Circle City & Crooked Creek

Aug. 2023
Glacier outburst flooding of Mendenhall River near Juneau

Nov. 2023
Fatal landslide; homes destroyed in Wrangell

2024

Jan. 2024
Record 14-day snowfall in Juneau

Aug. 2024
Fatal landslide; homes damaged in Ketchican

Glacier outburst flood near Juneau; coastal & river flooding on lower Kuskokwim

Oct. 2024
Record snow & freezing rain in Interior; flooding in western Alaska

Spotlight event: Typhoon Merbok

Typhoon Merbok pounded Alaska's western coast on September 17, 2022, impacting 1,300 miles of coastline and damaging 40 communities. The storm waters pushed homes off foundations, tore apart protective berms and scattered debris across coastlines.

Though storms are not unusual in the Bering Sea, Merbok developed over unusually warm water. The storm may not have been possible under cooler conditions. Waves reached 50 feet over the Bering Sea, and storm surge sent water into communities at near-record high levels along with near hurricane-force winds. Merbok also hit during the fall subsistence season, when communities gather food for winter, and supplies are brought in and out of rural locations.

State and federal disasters were declared, and FEMA approved $6.68 million for individual assistance and $895,000 for public assistance.

Jeremy Edwards , FEMA

Spotlight event: Outburst flooding

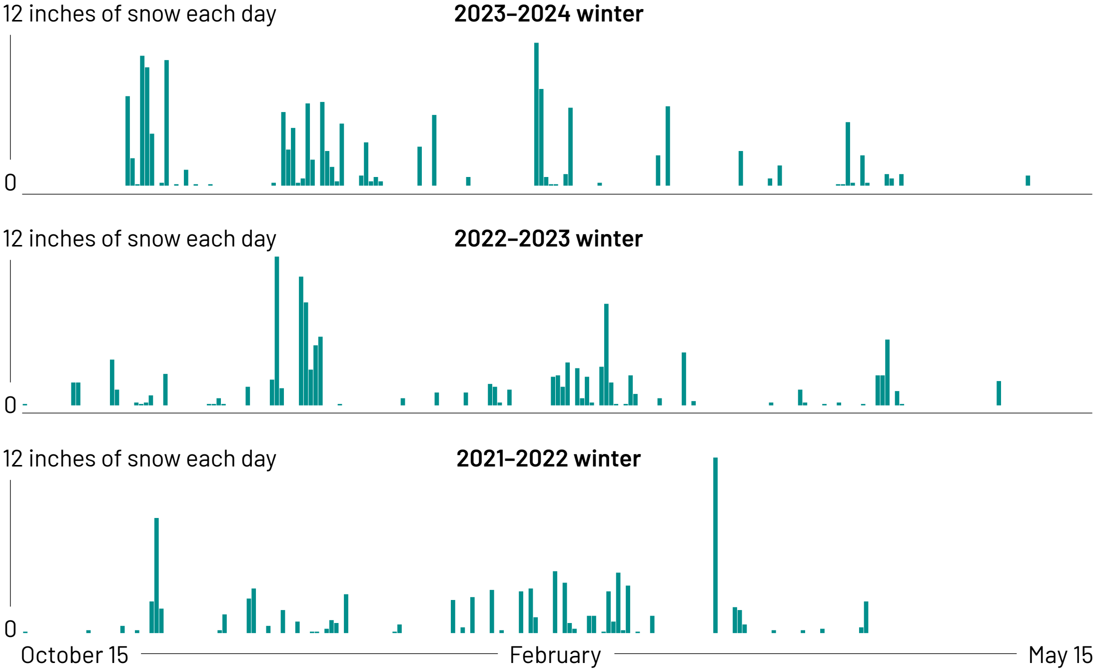
Glacial lake outburst floods are a major and increasing hazard in Alaska. Ice dams often create a lake at the base of a meltwater glacier. Outburst floods occur when the dam breaks, and the lake drains suddenly in a massive pulse. There are often serious downstream impacts.

Beginning in 2011, outburst floods have occurred annually at the Mendenhall River near Juneau. Record-setting floods in 2023 and 2024 inundated Juneau streets and severely damaged homes. The floods caused severe riverbank erosion, and several homes more than 100 feet from the river's edge were swept away. Weather had little to do with the floods. They were instead driven by long-term thinning of the Mendenhall and adjacent glaciers from decades of warming.

Spotlight event: Heavy snow

Winter warming in recent decades has been significant, but so far, much of Alaska remains cold enough for most winter precipitation to fall as snow. With warmer ocean temperatures, more moisture is available to evaporate, and when the ingredients come together, heavy snowfalls can occur.

In Anchorage, the past three winters all had one or more snowstorms producing more than a foot of snow in a 24-hour period. Following heavy snow in November 2023, numerous Anchorage streets went unplowed for days due to a mismatch between city and state road maintenance. Residents were stranded in homes, and businesses were unable to open without employees. In 2024, several dozen roofs collapsed and Anchorage officials warned more than 1,000 commercial property owners that their roofs were at risk due to the heavy snow loads. Impacts from the storm were ongoing for months.



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ANCHORAGE SNOW

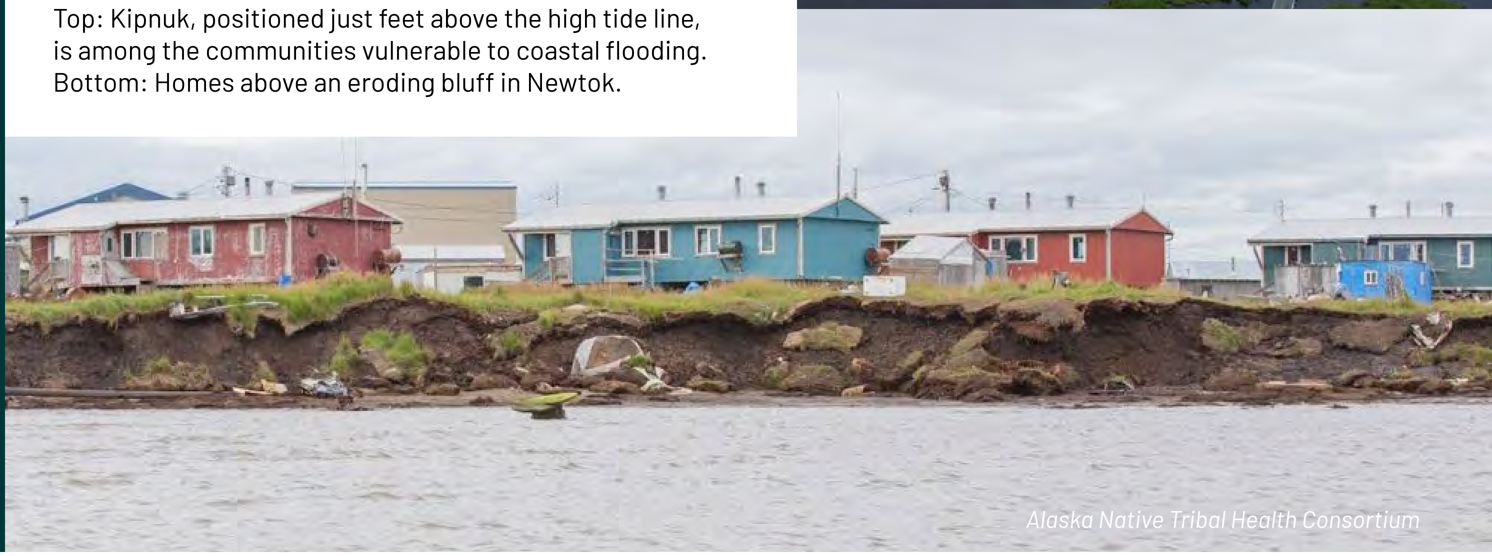
Daily snow for the past three winters in Anchorage. The 2023-24 season produced 133.3 inches of snow and was 0.2 inches shy of the 2011-12 record.

Loren Holmes, Anchorage Daily News

Keith Horen, Alaska Division of Geological & Geophysical Surveys

VULNERABLE COASTAL COMMUNITIES

Top: Kipnuk, positioned just feet above the high tide line, is among the communities vulnerable to coastal flooding. Bottom: Homes above an eroding bluff in Newtok.



Alaska Native Tribal Health Consortium

Coastal flooding 12

Coastal communities in Alaska experience frequent storm surge flooding, and with rapid sea ice loss they are now vulnerable to storms for longer than in the past. Storms can cause widespread damage and cut off parts or entire communities from higher, safer ground because many villages are accessible only by air or water and have isolated utilities and infrastructure.

Kipnuk is one of many communities vulnerable to flooding and expected to suffer damage to critical infrastructure in the short term. Like many western and northern coastal communities, the average ground height in Kipnuk is only a few feet above the high tide line, leaving it vulnerable to flooding during storms and high tides. Between 1979 and 2022, Kipnuk flooded 30 times, six prompting disaster declarations.

The Alaska Division of Geological & Geophysical Surveys assessed flood risk and impacts for Kipnuk and several other communities in an ongoing effort to improve local and statewide flood mitigation decisions.

Coastal erosion 13

Coastal communities in Alaska are also increasingly vulnerable to erosion from flooding, storm impacts and permafrost degradation. In some places, erosion is occurring even without storms. Of 48 communities assessed along the Bering and Beaufort coasts as of 2021, 33 had infrastructure within regions expected to erode in the coming decades. The cost of replacing infrastructure and mitigation — such as protecting bluffs with sand bags or rock rip rap — is in the millions of dollars for most communities.

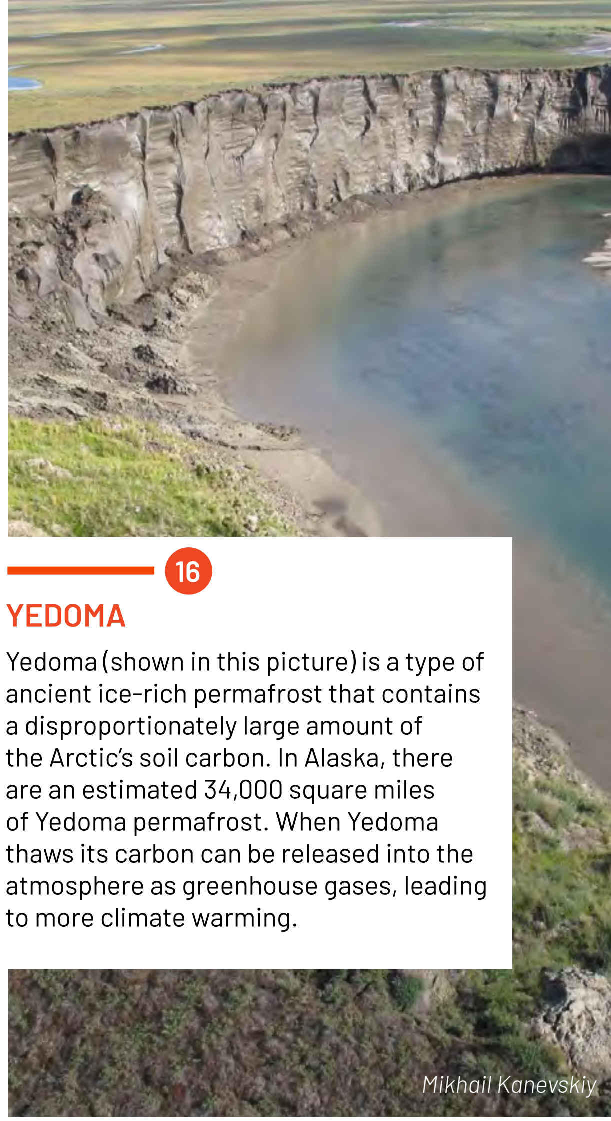
Newtok and Napakiak are perched on thawing permafrost along eroding riverbanks just upstream of the Bering Sea coast. Both communities are relocating. In front of Newtok, the Ninglick River erodes up to 72.8 feet of bank per year. Nearly all the infrastructure is within the area expected to erode by 2075 and could cost $126.4 million to replace.

Permafrost degradation

Permafrost thaw is impacting Alaska in many ways including damaging infrastructure, making soils vulnerable to erosion and landslides, and releasing carbon dioxide and methane into the atmosphere, which accelerates climate warming. The rate and timing of permafrost degradation greatly influences how Arctic ecosystems and infrastructure respond to climate warming. Forty years of permafrost and ground temperature observations in Alaska show substantial warming. In interior and northwest Alaska, thawing permafrost has led to permafrost degradation near the surface and a layer of talik — year-round unfrozen ground sandwiched between the permafrost below and the seasonally frozen ground above.

North Slope permafrost warmed most. Record high permafrost temperatures were measured in 2020 at all locations, followed by a slight cooling. This cooling was attributed to lower annual air temperatures from 2020-2022. After 2022, air temperatures were warmer, and scientists expect that permafrost temperatures will continue to rise.

While permafrost warmed near continuously on the North Slope, permafrost temperatures in Alaska's Interior cooled slightly from the 2000s to mid 2010s. Warming resumed in the mid-2010s. By 2020, all locations hit new record highs.



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YEDOMA

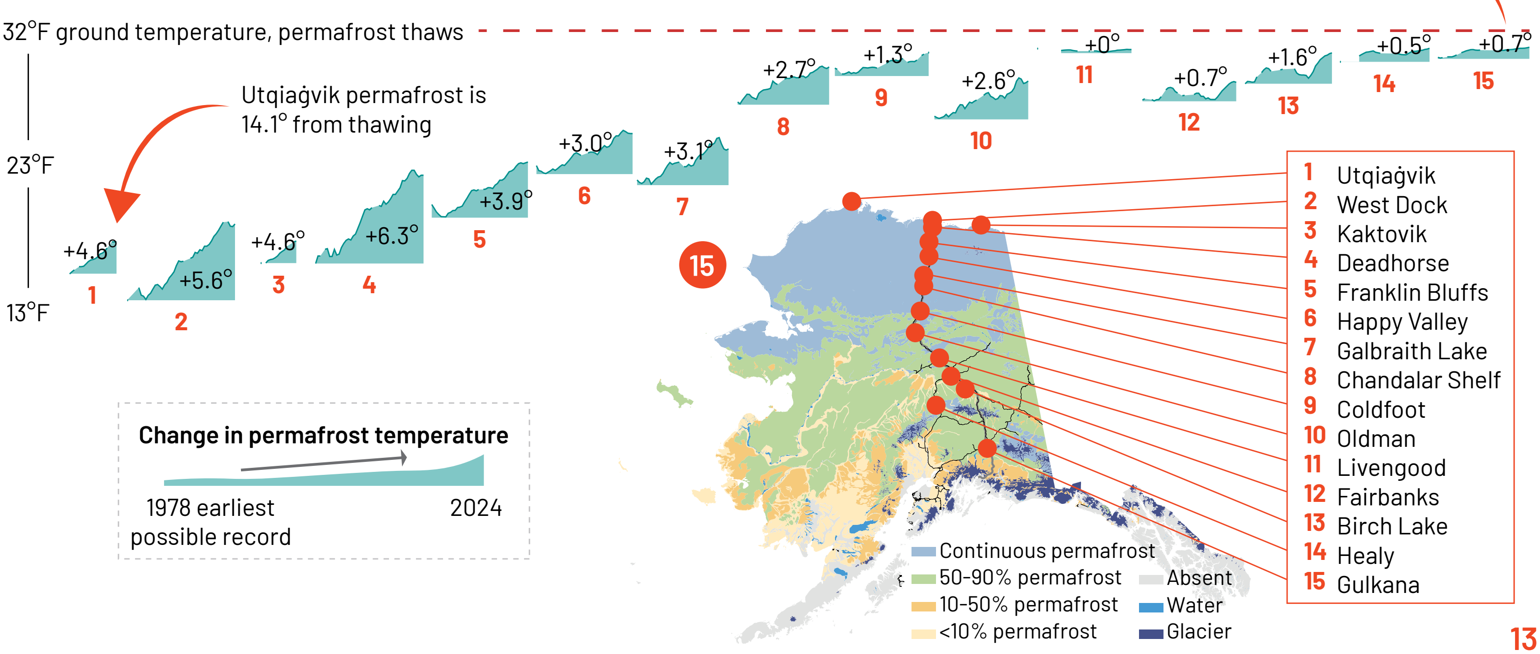
Yedoma (shown in this picture) is a type of ancient ice-rich permafrost that contains a disproportionately large amount of the Arctic's soil carbon. In Alaska, there are an estimated 34,000 square miles of Yedoma permafrost. When Yedoma thaws its carbon can be released into the atmosphere as greenhouse gases, leading to more climate warming.

Mikhail Kanevskiy

14

PERMAFROST IS WARMING

Permafrost around Alaska is warming. These graphics show the change in permafrost ground temperature at 15 sites over several decades (some as early as 1978). Northern sites warmed the most at a rate of between 0.36 to 1.8°F per decade. Though less warming occurred at southern sites, the risk of permafrost thaw is greater since the ground is already close to 32°F.



Wildfire

Paul Ollig, National Park Service

More wildfire

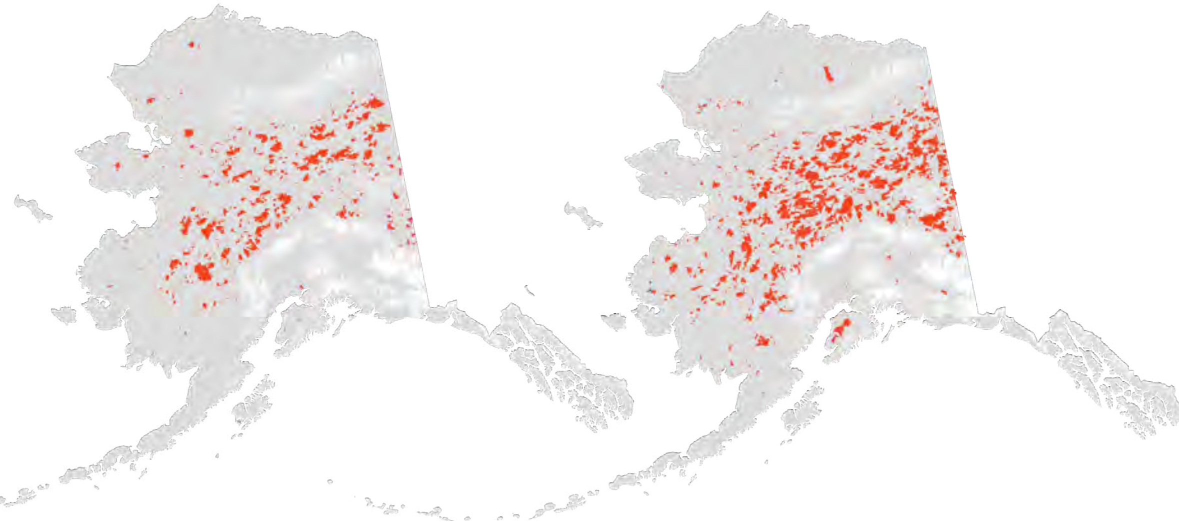
Area burned by wildfire, and severe fire seasons in particular, have increased in Alaska since 1950 (the start of reliable fire data). From 2004–2023, wildfires in Alaska burned over 50 thousand square miles, an area the size of the state of Alabama.

The majority of fire activity in Alaska occurs in the boreal forest between the Alaska and Brooks mountain ranges. In recent years, fires are increasing in tundra areas. Although the fire season in Alaska is short — most activity occurs May to August — it has been growing longer in recent decades, prompting Alaska wildfire management agencies to declare April 1 as the beginning of the Alaska fire season. Wildfire in Alaska is episodic, with low to moderate years interspersed with years with much greater area burned. Seasons that burn in excess of one million acres usually require resources from outside of the state to assist with firefighting efforts.

17

MORE AREA BURNED

Nearly twice as much area burned from 2004–2023 compared to the two decades prior. On average about 2,500 square miles burn each year now compared to about 1,275 square miles during the 1984–2003 period. Over this recent period, Western Alaska and the Kenai Peninsula have seen more fires.



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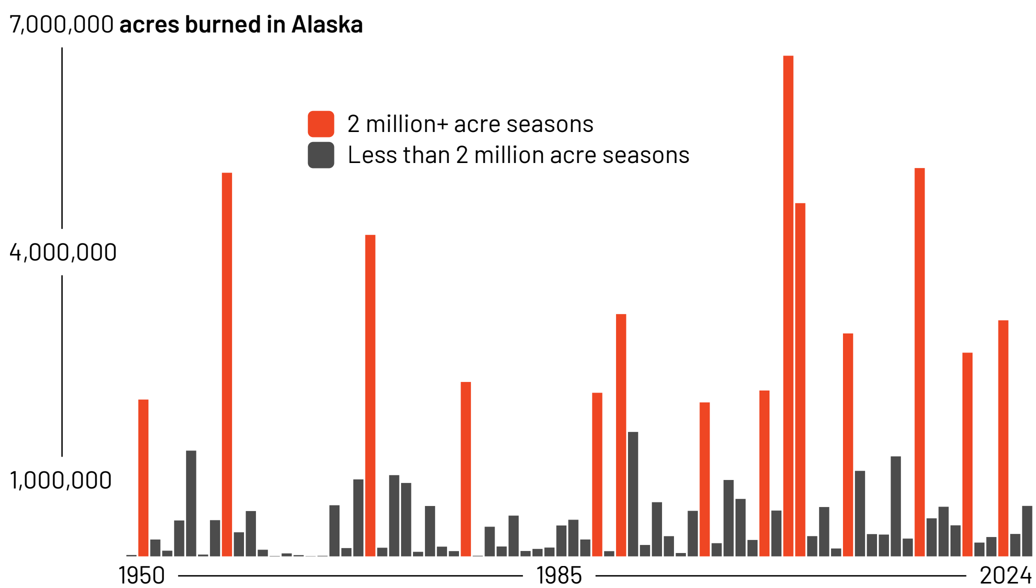
LARGE SEASONS DOUBLED

Alaska is experiencing more wildfire, and severe fire seasons, when over two million acres burn, are twice as common as they were 30 years ago.

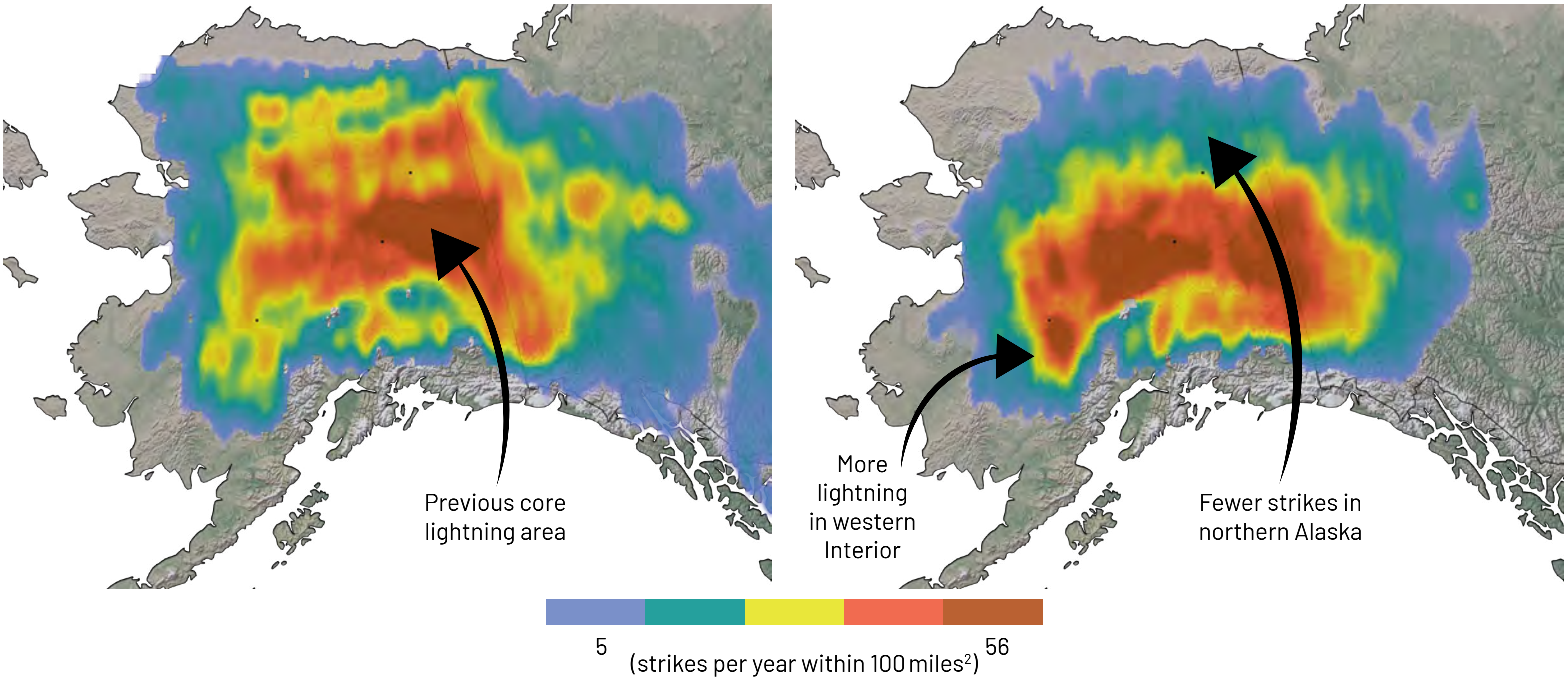


Lightning expanding to new areas

Lightning ignited fires account for the majority of burned area in Alaska. Historically, lightning was most common in the eastern Interior. Now, more lightning is occurring in the western Interior. Over the past 10 years, lightning more than doubled in the region. But during this period, there were also fewer strikes in northern Alaska.

18 LIGHTNING

Left map shows the 2004–2013 period when most lightning was observed in the eastern Interior of Alaska. Lightning in western Interior more than doubled in the recent decade (right map). From 2014–2023, the change in lightning in the eastern Interior varies from region to region.



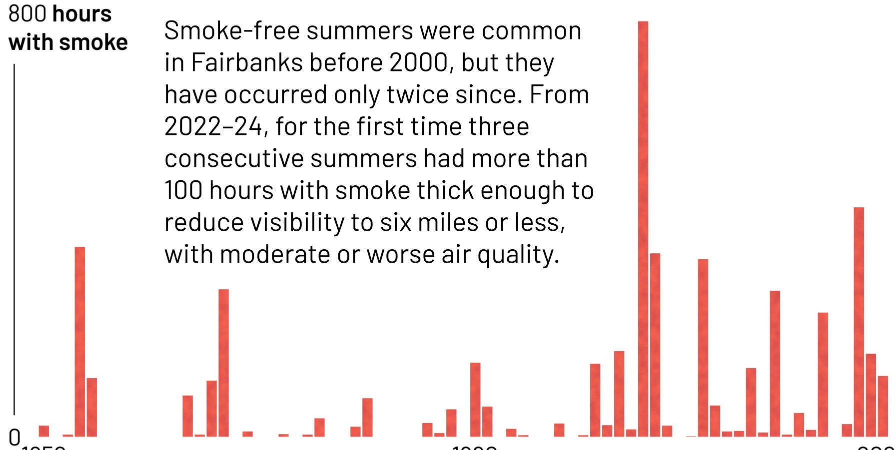

UAF photo

Smoke

Even moderate Alaska wildfire seasons burn hundreds of thousands of acres. Smoke from these fires can be widespread and cause significant human health issues. Smoke often co-occurs with high temperatures, increasing the risk of health impacts in buildings designed to retain heat during Alaska's long winters. Dense smoke can also limit visibility, affecting aviation, which directly impacts remote communities and firefighting operations.

19 FAIRBANKS SMOKE

Smoke-free summers were common in Fairbanks before 2000, but they have occurred only twice since. From 2022–24, for the first time three consecutive summers had more than 100 hours with smoke thick enough to reduce visibility to six miles or less, with moderate or worse air quality.



Oceans

Mary Ver Hoef

Warmer oceans

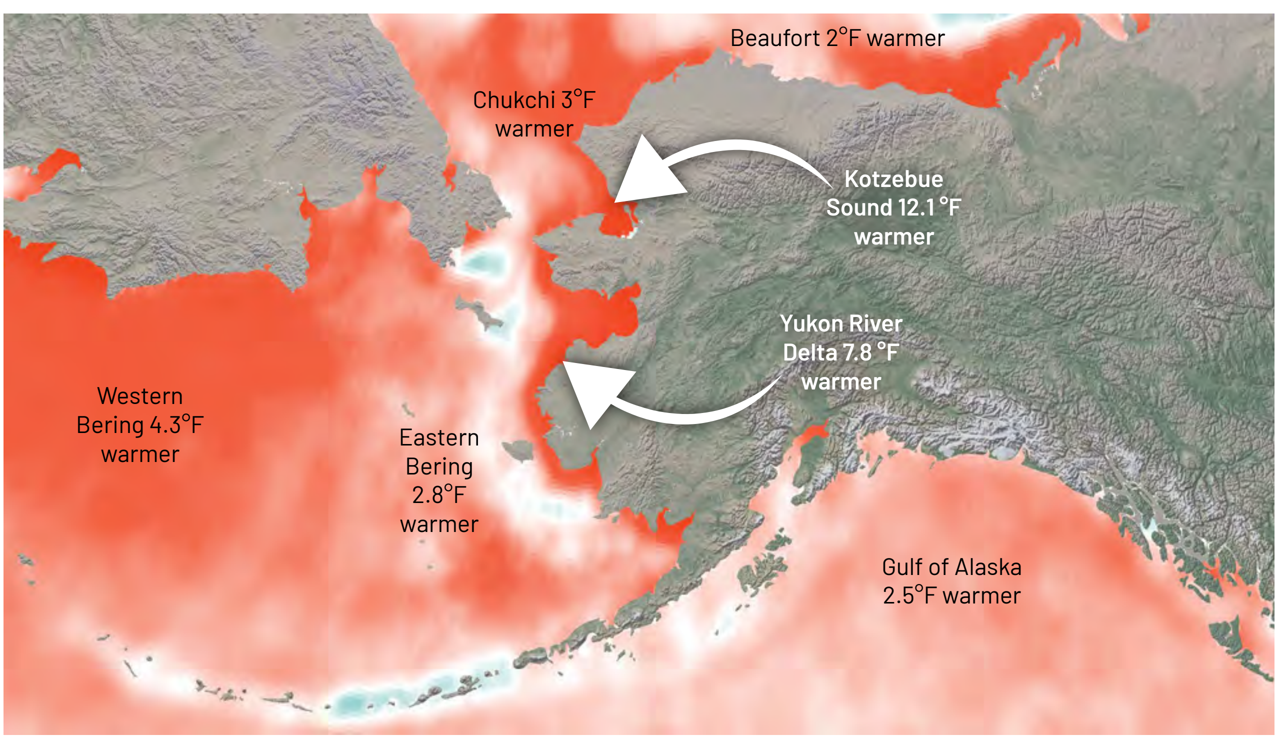
Summer ocean surface temperatures have warmed almost everywhere around Alaska in the past 40 years. The most dramatic changes are in the shallow bays, where ice melts earlier in the spring and rivers dump comparatively warmer water from inland areas. Arctic waters are also warming faster than other areas, driven by earlier sea ice melt. But even well offshore in the Gulf of Alaska, where sea ice does not form in winter, there have been substantial increases. Warmer ocean waters profoundly impact marine ecosystem health and facilitate the increase and spread of hazards such as harmful algal blooms.

20

SEA SURFACE TEMPERATURE

Ocean surface temperatures around the world are warming, and Alaska waters are no exception. Though all of Alaska's oceans have warmed between 1982–2024, the Chukchi Sea has seen the greatest change and is on average 3°F warmer in summer (for the area from shore to 200 miles offshore) than in the 1980s. Kotzebue Sound is an astounding 12.1°F warmer, and the area where the Yukon River dumps into Norton Sound is 7.8°F warmer. A few areas near the eastern Aleutians and Bering Strait have seen little change or even very slight cooling due to local currents.

2°F **colder** 5°F **warmer**

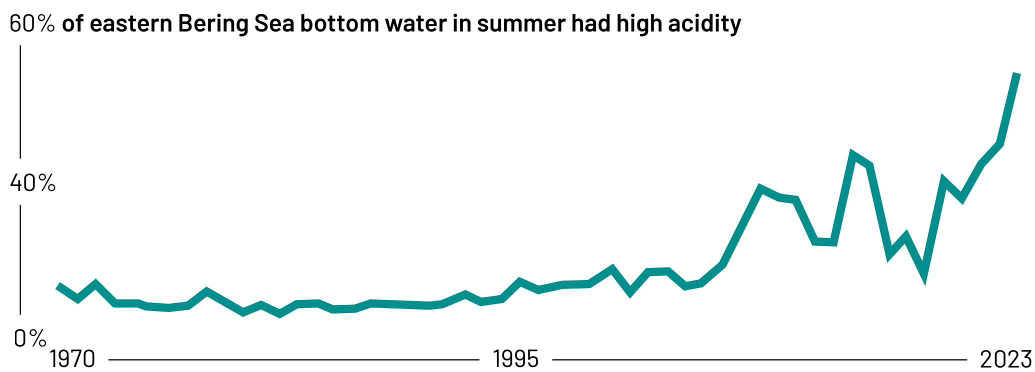


More acidic oceans 21

Alaska is susceptible to ocean acidification. As atmospheric carbon dioxide concentrations increase, the ocean absorbs additional CO_2, making seawater more acidic. Acidity can affect shell formation, growth, behavior and survival of many species ranging from crab and shrimp to salmon. The risks are especially high in polar regions because CO_2 dissolves more readily in cold water. Alaska oceans are becoming increasingly corrosive to shell-building species, and our waters are a hotspot for ocean acidification.

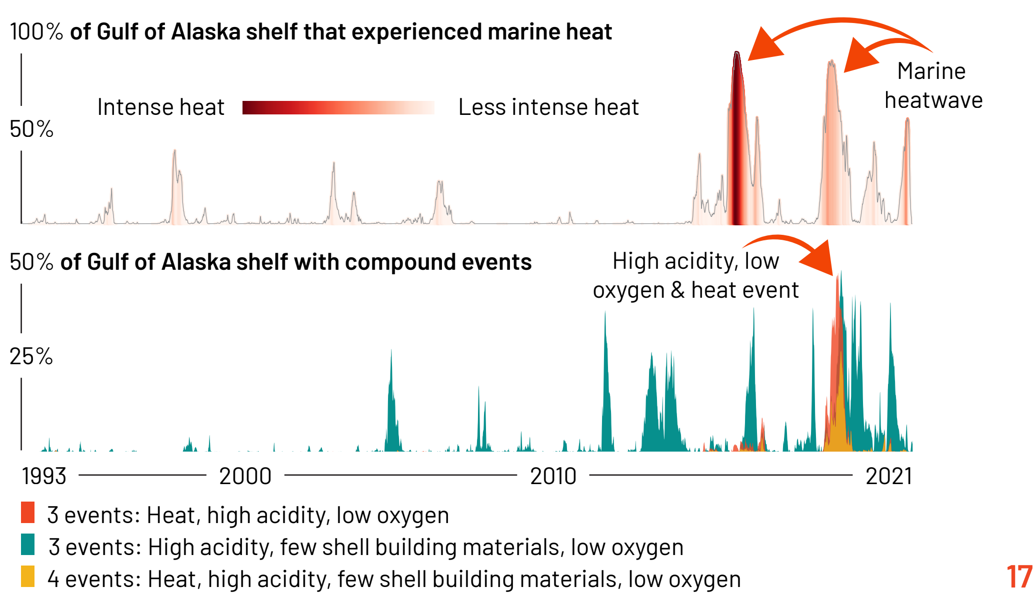
22 CORROSIVE CONDITIONS

Conditions in the Beaufort Sea are now consistently corrosive to shell building species. In the Gulf of Alaska, Bering and Chukchi seas conditions are seasonally corrosive, and the area with corrosive water is expanding. For example in the Bering Sea, ocean models show that 50% of the summer bottom water in 2022 surpassed the threshold where juvenile king crab experience negative effects, compared to only 10% in the 1970s and 1980s.



23 COMPOUND EVENTS

Compound events are occurring more frequently in the Gulf of Alaska. These events occur when multiple environmental conditions reach extreme levels such as simultaneous marine heatwaves, low oxygen and high acidity. Species may bounce back from one of these alone, but when these factors act together impacts to species and their distribution are worsened.



Salmon

Seth Adams

Record highs and lows since 2020

Chinook salmon populations have been declining for decades all over the state. In contrast, pink and sockeye salmon have returned in above-average numbers statewide, but these returns have been highly variable, punctuated by extreme highs and lows. For example, sockeye salmon returned to Bristol Bay in record high numbers in 2022.

Chinook salmon declines in Alaska are linked to climate extremes, including marine heatwaves, high river temperatures during the spawning run, and heavy fall rains when eggs are in the gravel. Population declines are also linked to declining adult body sizes, associated with more competition at sea with highly abundant pink and chum salmon. Climate-linked changes in predators, prey and disease are also likely important factors. The Yukon chum salmon collapse was linked to lower food quality during recent marine heatwaves.

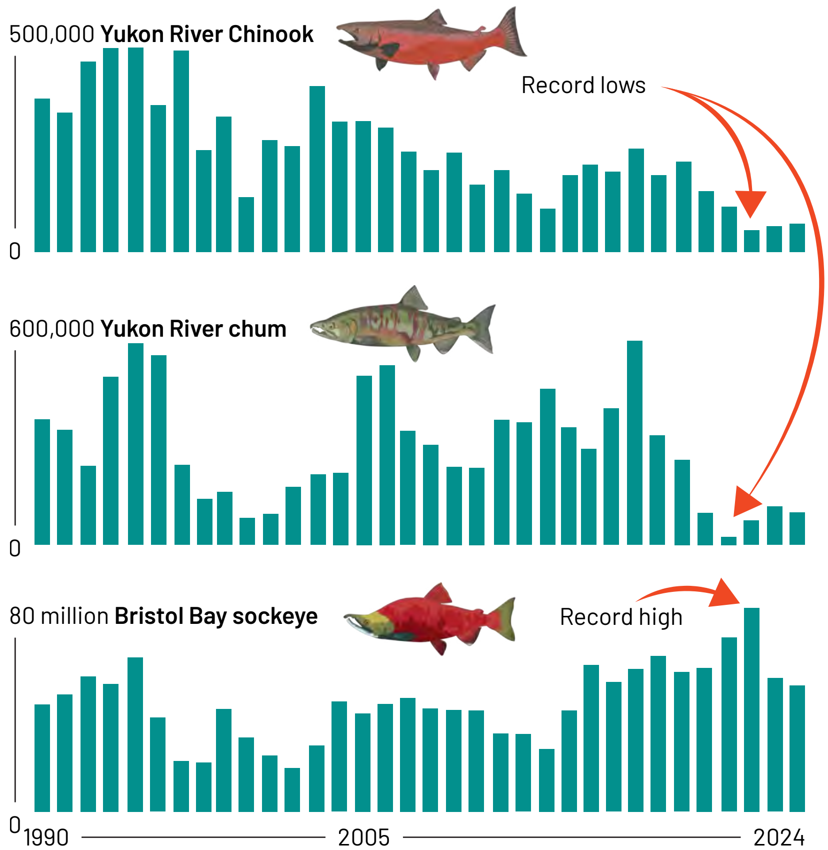
Impacts on fisheries

The combined Chinook and chum declines resulted in the first ever complete closures of subsistence fishing for salmon in the Yukon Basin in 2021 and 2022. The closures were highly disruptive to Indigenous people in the region who have been linked to salmon for thousands of years.

24

SALMON RETURNS

Chinook salmon continued a long-term decline in Western Alaska, reaching a record low return to the Yukon River in 2022 at less than 20% of their 30-year average. Chum salmon abruptly crashed in Western Alaska, bottoming out at less than 10% of their average return. Since, both species rebounded slightly but remain well below average. Meanwhile, sockeye salmon numbers surged in Bristol Bay, with an all-time high in 2022 at nearly double the average return.



The declines also heightened concerns over salmon bycatch in marine fisheries and led to calls for greater inclusion of Indigenous Tribes and organizations in monitoring and management decisions.

Large sockeye and pink runs benefited many fisheries, but even these had disruptive effects. The record high Alaska sockeye salmon harvest in 2022, coupled with large harvests in Russia, led to a global market surplus and price collapse. Some processing plants closed, hurting coastal economies and leaving some fishers without a place to sell their catch. From 2022 to 2023, the Alaska seafood industry suffered a 50% decline in profits and $1.8 billion dollar loss in revenue due in part to the salmon fishery collapse.

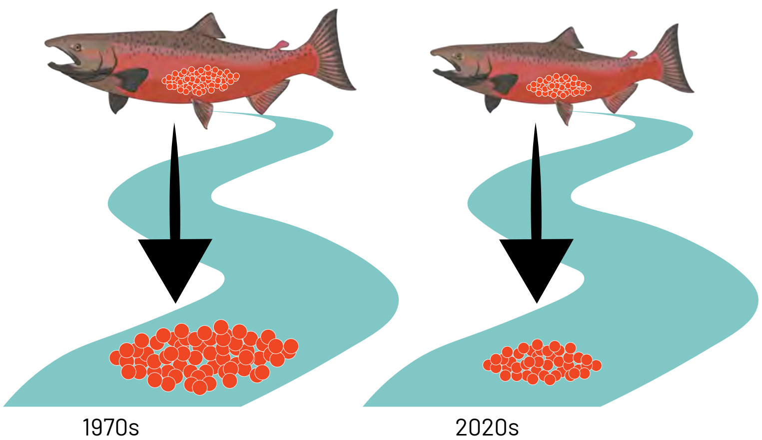
Salmon are getting smaller

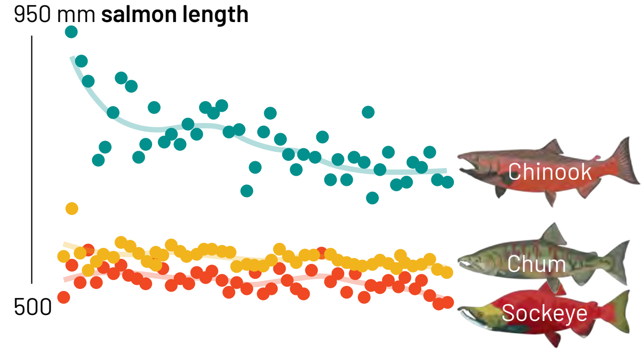
Across the state, all species of salmon are maturing at smaller body sizes. This is especially true for Chinook. Smaller spawners produce smaller and fewer eggs, exacerbating population declines and reducing value of each fish for both subsistence and commercial fisheries. This shift is linked to warmer ocean temperatures, coupled with more competition at sea, lower quality food, and possibly more marine predators selecting the largest fish.

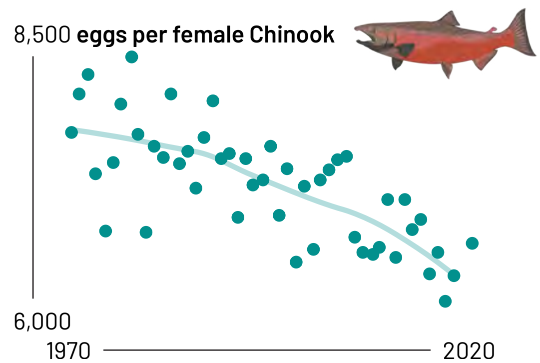
25

FEWER EGGS DEPOSITED IN RIVERS

Chinook salmon — and to a lesser extent chum and sockeye salmon — have become smaller since the 1970s (top right graph). In Chinook, this is associated with 15% fewer eggs per female (bottom left graph) deposited in rivers.







Salmon and well-being 26

Salmon are a keystone of cultural, spiritual, relational, and physical health in Alaska, allowing Indigenous peoples to live their traditional way of life. For many coastal and river communities salmon epitomize well-being.

Without access to salmon, Indigenous peoples lose more than healthy food in rural villages where groceries are limited and prices are astronomical. There is also less sharing with others, time with family and knowledge passed from generation to generation through the act of catching, preparing and sharing fish. Dramatic salmon changes, and the associated commercial and subsistence fishery closures, have an economic impact in rural Alaska by reducing access to sustainable livelihoods.

These aspects of salmon well-being in an Indigenous context are often under accounted for in fisheries management.

WHAT IS WELL-BEING?

"Well-being is a way of being with others that arises when people and ecosystems are healthy, and when individuals, families and communities equitably practice their chosen ways of life and enjoy a self-defined quality of life now and for future generations."

Rachel Donkersloot and co-authors' definition of well-being from the Alaska Salmon and People Project.

Shrinking glaciers

Alaska is home to more than 27,000 glaciers, covering about 5% of the state. Like much of the world's ice, Alaska's glaciers are melting fast as temperatures rise. Rain also now falls more frequently than snow at high elevations in maritime areas, reducing the snow that accumulates on glaciers in winter.

From 2000 to 2019, Alaska glaciers thinned by an average of three feet per year, with the thinning rate doubling over that time. Nearly 70 billion tons of ice was lost, driving sea level rise and altering streamflow patterns. Interestingly, glaciers ending on land thinned more than those flowing into the ocean.

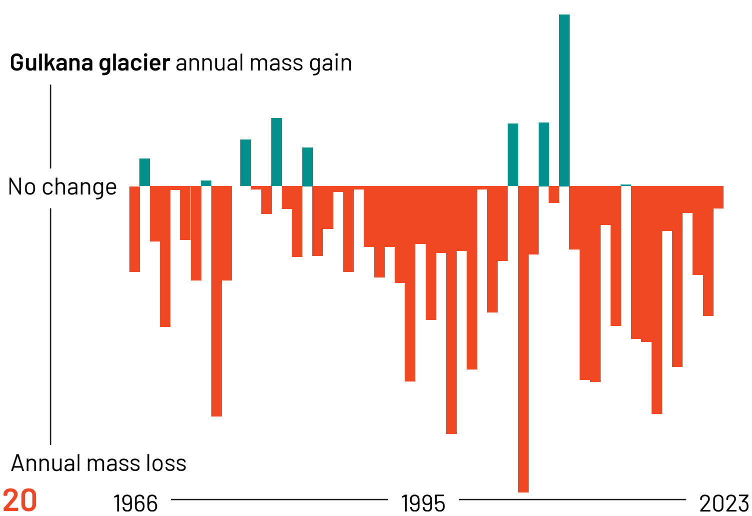
In addition to thinning and mass loss, Alaska's glaciers are also retreating. For example, on the Kenai Peninsula, which hosts over 1,500 square miles of glacier ice, the glacier area shrank by 210 square miles, about 12% of its total area from 1986 to 2016.

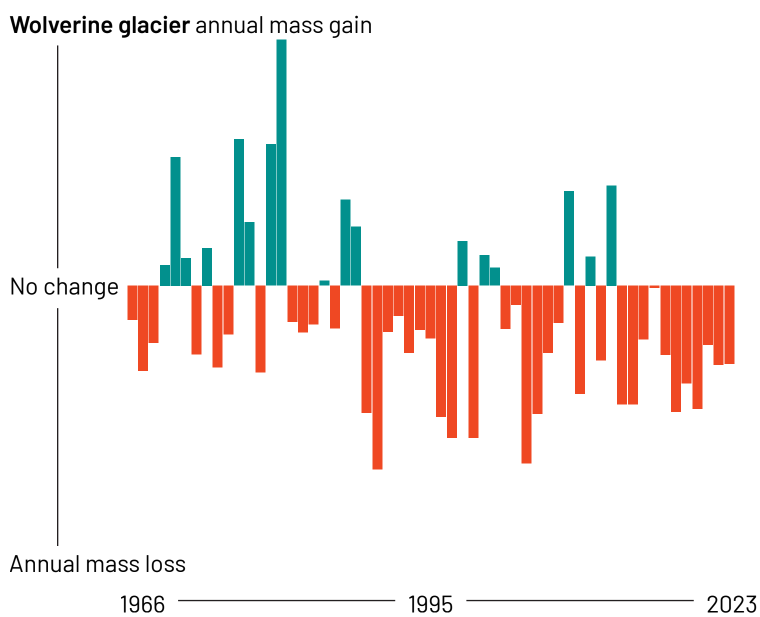
Though these statewide data are several years old, they are the latest available given the amount of time needed to analyze Alaska's many changing glaciers. Recent measurements from individual glaciers show that Alaska glaciers continue to lose mass.

27

BENCHMARK GLACIERS

The Gulkana (left graph) and Wolverine (right graph) glaciers are Alaska's "Benchmark Glaciers" selected for long-term monitoring. Both lost mass since 1966. Gulkana Glacier only grew nine of 57 years. It is one of thousands of Alaska glaciers expected to disappear in the next 80 years.



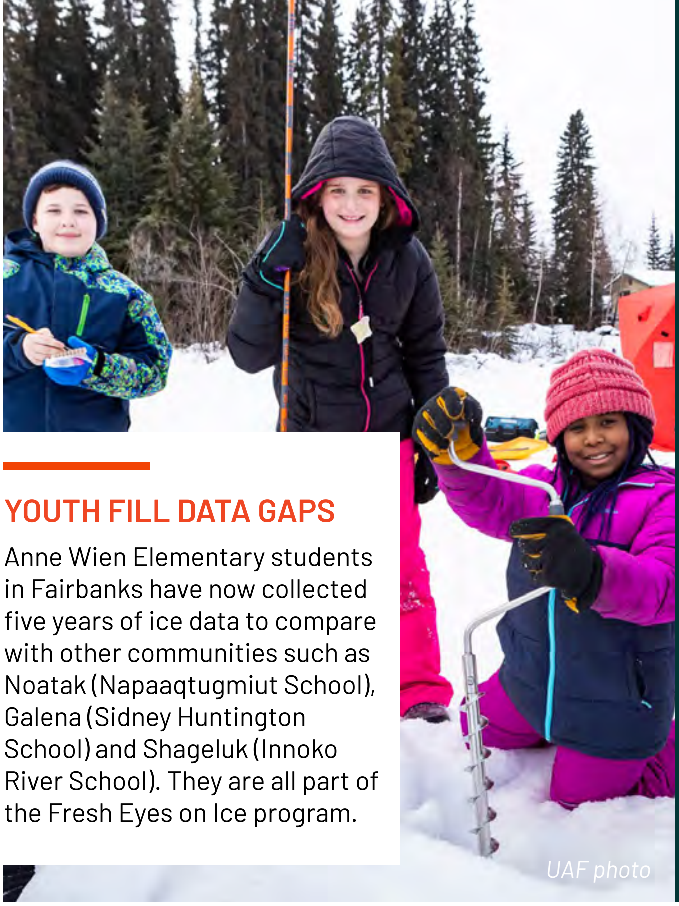


Lake ice varies with snow

Across most of Alaska, there is often not enough long-term data to track lake and river ice change. We do know that ice thickness varies from year-to-year depending on snow. Deep snow can insulate relatively thin ice one year. The next year low snow and/or wind can leave ice bare so ice grows thick.

Studies on the Arctic Coastal Plain show that lake ice is thinning in northern Alaska. Even so, there is variation. For example, lakes in the central Arctic Coastal Plain were very thin in 2012, 2014 and 2018. Yet in 2021, cold temperature, strong winds and low snow allowed ice to grow over 6.5 feet, and many shallow lakes froze solid.

Understanding freshwater ice changes is critical for safe winter travel. To help fill gaps a community-based monitoring program, Fresh Eyes on Ice, partners with schools and community groups around Alaska to collect ice thickness and snow depth data.

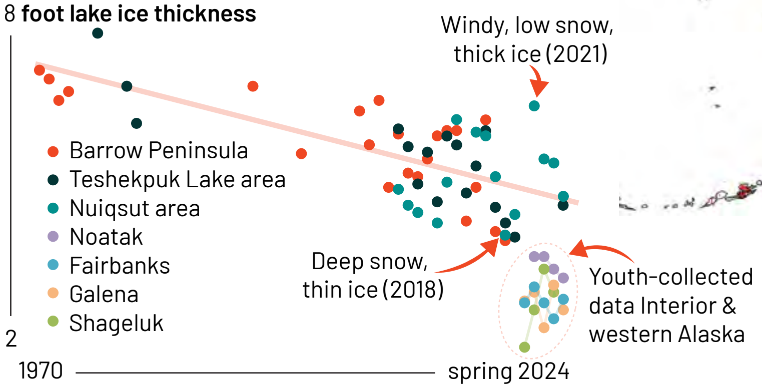


YOUTH FILL DATA GAPS

Anne Wien Elementary students in Fairbanks have now collected five years of ice data to compare with other communities such as Noatak (Napaaqtugmiut School), Galena (Sidney Huntington School) and Shageluk (Innoko River School). They are all part of the Fresh Eyes on Ice program.

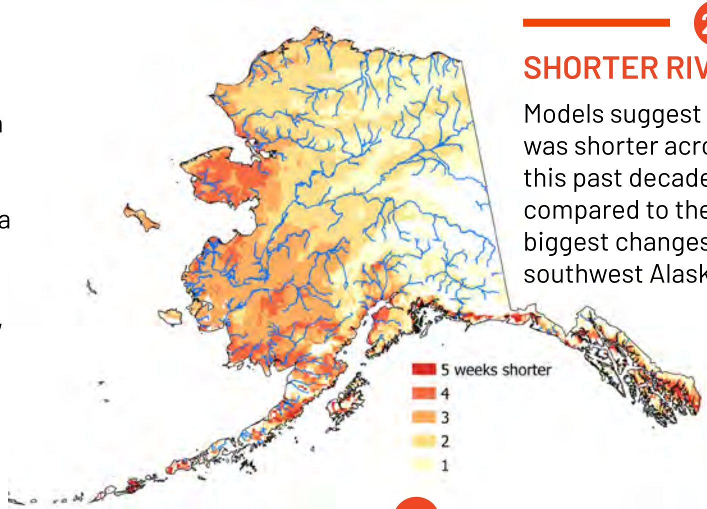
28 LAKE ICE ACROSS ALASKA

This graph shows observations of maximum ice thickness since 1970 in northern Alaska lakes. Though ice has thinned 6 inches per decade, recent dramatic variations are due to changing snow conditions. Measurements by youth in Interior and Western Alaska are building new datasets to detect future trends.



29 SHORTER RIVER ICE SEASON

Models suggest the river ice season was shorter across most of Alaska this past decade (2014-2024) compared to the 1980s, with the biggest changes in western and southwest Alaska.

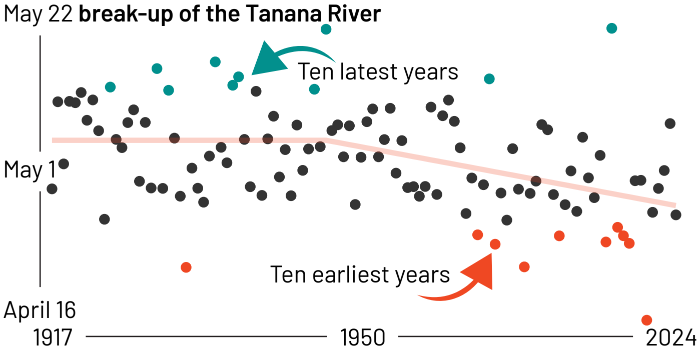


Shrinking river ice season

Ice-covered rivers are the main winter transportation routes for many rural Alaska communities. People have observed, and computer models agree, that rivers are freezing up later and breaking up earlier, reducing the window of safe travel. The shorter ice season affects access to resources and subsistence activities for many Alaskans.

30 EARLIER BREAKUP AT NENANA

The Tanana River boasts one of Alaska's longest records of river breakup. The past 30 years have seen nine of the 10 earliest breakups, and only two of the 10 latest. Even so, there is variability. For example, 2019 was the earliest breakup in 100+ years, while 2023 was late relative to the past 30 years.



Sea ice

Sea ice decline

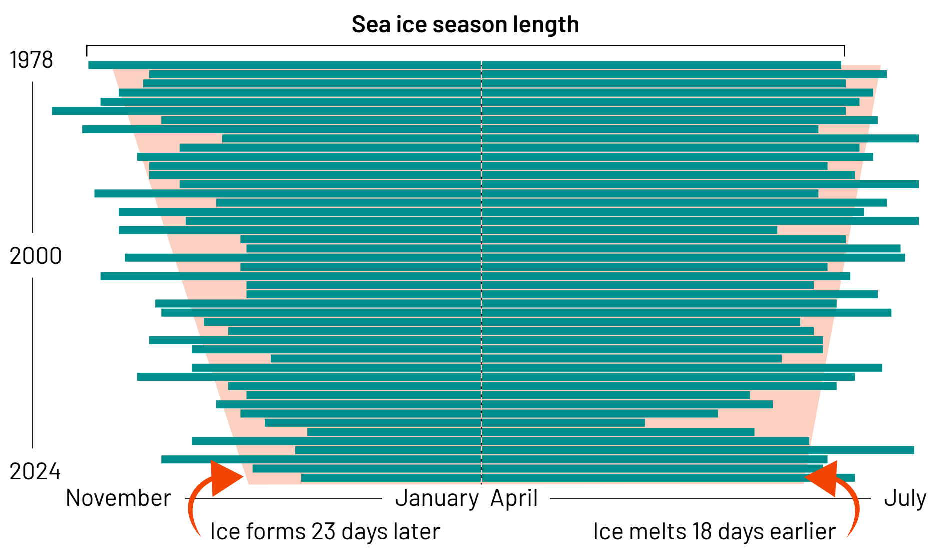
Sea ice is declining around Alaska with some of the most dramatic changes occurring in the Bering Sea. The shrinking ice season has cascading impacts throughout the ecosystem. Fish, birds and marine mammals rely on winter and spring ice. Sea ice also protects coasts from storms, especially in autumn. It also plays an important role regulating the global climate by reflecting sunlight back and insulating the water below.

Historically ice began forming in late October or November in shallow, brackish waters near river mouths and expanded seaward. At the same time, ice developing in the Chukchi Sea pushed south through the Bering Strait. By March, the maximum coverage of sea ice was usually reached. This timing is changing and less predictable.

31

SHRINKING ICE SEASON

The Bering Sea ice season is now 41 days shorter on average than it was in the 1970s. Ice begins forming three weeks later in autumn and melts 2.5 weeks earlier in spring.



INDIGENOUS VOICES

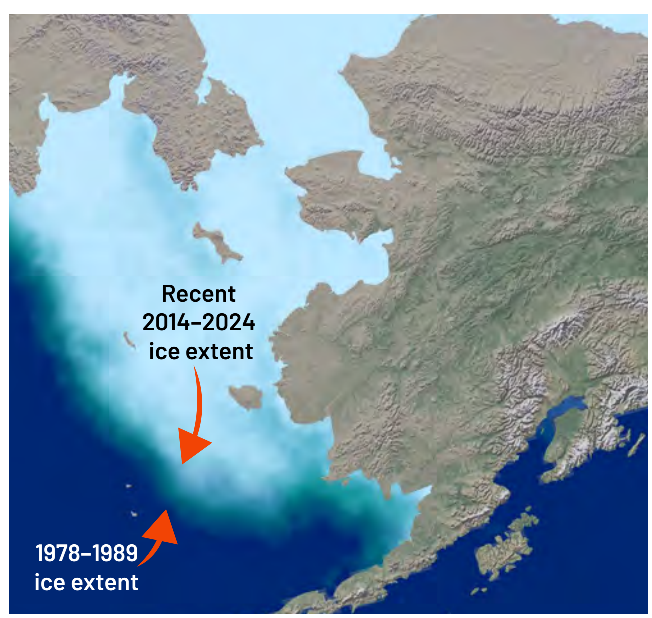
Example observation from February 18, 2024: "5 degrees. North winds 40-45mph, mostly clear. Open water right off the south beach due to the high north winds... We usually have ice this time of year, with recent high north winds it all blew away..."

Guy Omnik, Iñupiaq community-based observer from Point Hope, who is part of the Alaska Arctic Observatory & Knowledge Hub.

32

NOT AS FAR SOUTH

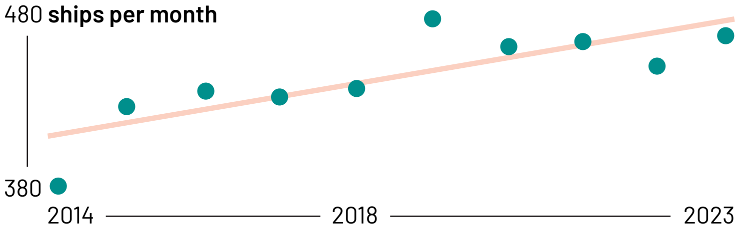
Sea ice doesn't extend as far south, reaching 30-60 fewer miles in the open ocean than it did in the 1980s. Along the coast, ice reached south of Port Heiden to the Aleutians in the 1980s. Now it often stops growing by upper Bristol Bay.



33

MORE SHIP TRAFFIC

As sea ice declines, more ships are passing through the Bering, Chukchi and Beaufort seas along Arctic sea routes. Since 2014, the Pacific Arctic has seen about seven more ships per month each year. Ships are also undertaking longer voyages in the region. More vessels use the region in summer, but there is also an increase in ice breaking vessels moving through dense pack ice in winter, particularly along the Russia coast in the Northern Sea Route.

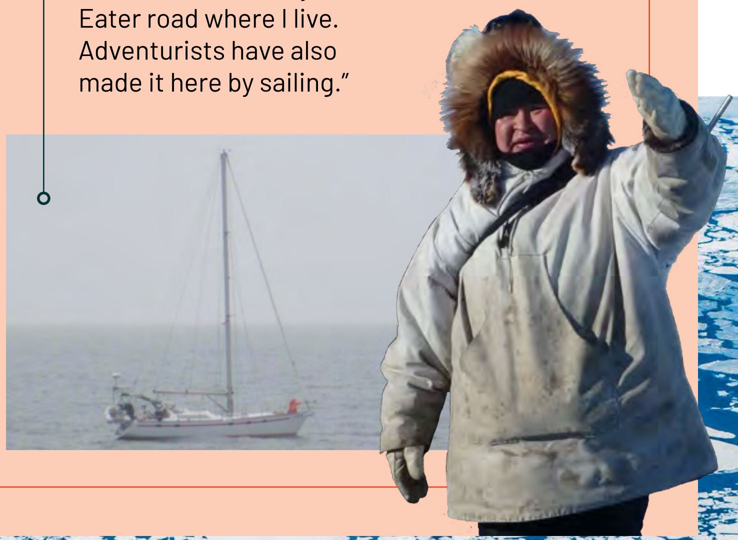


INDIGENOUS VOICES

"[We] are concerned about ships. We are seeing shipping happening year-round, going to Russia. [Ships] can be harmful for animals. We don't know what wastes there are. These are things we are observing."

Billy Adams, Iñupiaq community-based observer from Utqiaġvik, who is part of the Alaska Arctic Observatory & Knowledge Hub.

Example observation from July, 26 2022: "It rained upon us for a couple days in Barrow, then it turned to snow last night 32°F this morning. The plant life grew and bushes have made their way to Cake Eater road where I live. Adventurists have also made it here by sailing."



UAF photo

USFWS

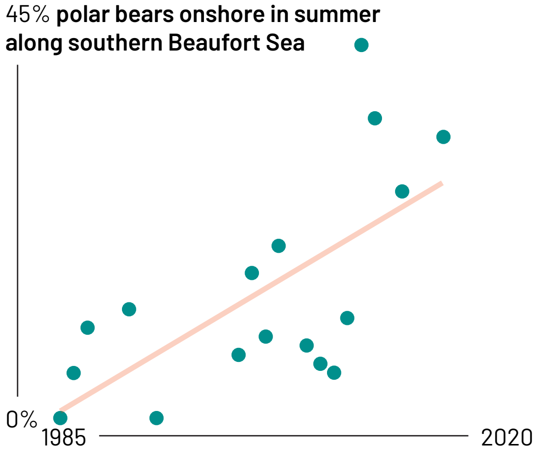
Less ice, polar bears move onshore

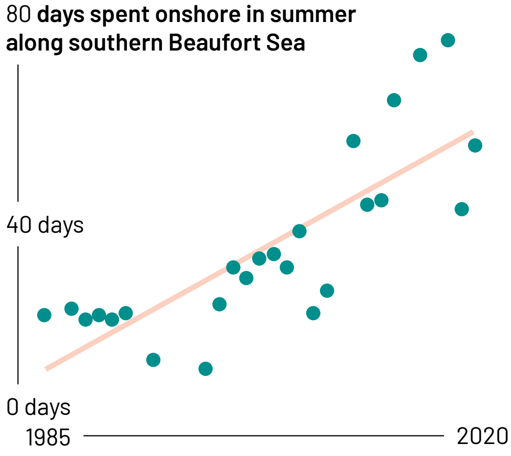
As sea ice declines, a larger proportion of the Alaska polar bear population spends more time on land. This major shift in habitat use may negatively impact polar bear diet and energy use. When bears are on land or near the coastline, they have much greater chances of interacting with people, communities and industry infrastructure. This could create more opportunities for a growing polar-bear tourism industry, but also lead to more human-bear conflict and disturbance to bear populations during critical times of the year. For example, with unreliable sea ice conditions, a greater proportion of pregnant females are denning on land.

34

TIME SPENT ONSHORE

The percentage of polar bears summering onshore increased from 5 to 30% in the southern Beaufort Sea (left graph) and 10 to 50% in the Chukchi Sea. Both populations spent 60-70 days onshore by 2020 (right graph), an increase of more than 30 days since the 1980s.





INDIGENOUS VOICES

In Kaktovik, *Carla SimsKayotuk, an Iñupiaq community-based observer with the Alaska Arctic Observatory and Knowledge Hub*, has been reporting more polar bears near town than the community has seen in the past. Example observation from September 6, 2024:

"It has been windy the last few days, the whalers went out for couple hours and had to come back home due to the waves. Today has been damp, windy and foggy off and on. There are over 60 polar bears around our area."

Spotted seals. NOAA Fisheries

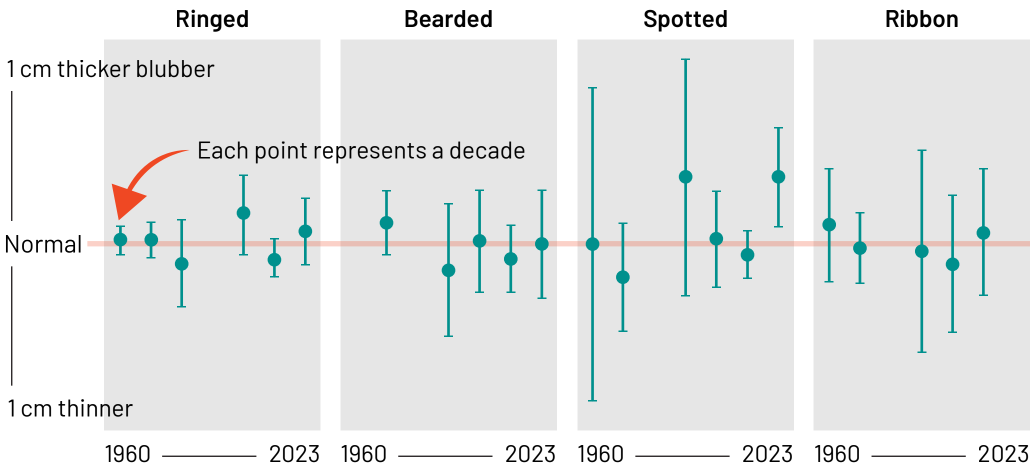
Healthy ice seals

Ice seal populations along Alaska's coast appear to be healthy despite concerns that sea ice loss limits platforms for resting, pupping, pup rearing and molting. The four species of ice seals found in the Bering, Chukchi and Beaufort seas — ringed, bearded, spotted and ribbon — have been sampled during the annual subsistence harvest since the 1960s. Based on this monitoring there has been no long-term negative impacts to body condition, age of maturity, pregnancy rates or pup survival past weaning. This is good news, given that in addition to ongoing sea ice loss there was an unusual mortality event in 2018–2019 when 275 seals were found dead on beaches. That event was attributed to malnutrition related to extremely warm ocean temperatures in the Bering Sea.

35

ICE SEAL BLUBBER

Blubber thickness is an indication of ice seal health. Average thickness each decade has not changed for seals harvested along Alaska's coast between the 1960s and 2023. In the 2010s, thickness of ringed, bearded and spotted seal blubber dipped below average but rebounded in the 2020s, and was above average for spotted seals.

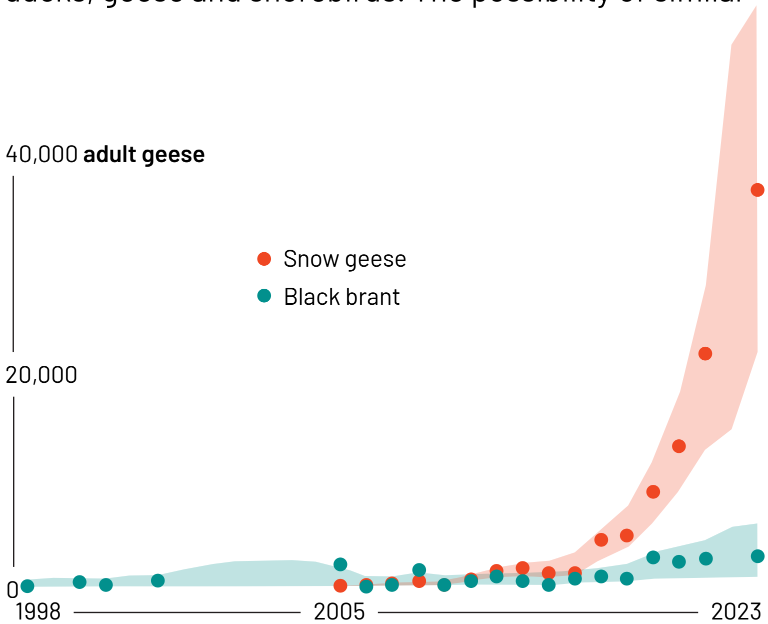


Ryan Askren, U.S. Geological Survey

Snow geese population explosion

Snow geese populations in Alaska are rapidly increasing with dense nesting colonies near the Ikpikpuk and Colville river mouths on the Beaufort Sea coast. Fewer than 500 adults nested on the Colville River Delta when long-term monitoring began in 2005. By 2019, the population had grown to 20,000 adults and doubled to approximately 40,000 adults between 2019 and 2023.

In other parts of North America, abundant snow geese led to overgrazing and nesting habitat loss for other ducks, geese and shorebirds. The possibility of similar outcomes in Alaska is concerning, especially on the Colville River Delta which supports the largest Arctic-breeding population of black brant, another colonial-nesting goose. The brant population on the Colville was growing in 2023, but at a much slower rate than the snow geese. Despite this positive growth, there was less grass and sedge cover and more bare ground in areas used by nesting snow geese on the Colville in 2022 compared to 2016. Snow goose grazing effects may become more severe and widespread across Alaska's North Slope if the population continues growing at its current pace.



36

GEESE POPULATION GROWTH

Population explosion of nesting snow geese compared to growth of black brant populations on the Colville River Delta. Dots are counts from aerial photographic surveys. Shaded areas show possible population size based on model estimates.

Seabird die-offs

Since 2015, large numbers of dead seabirds have washed up on Alaska beaches. Though seabird die-offs occurred sporadically in the past, recent die-offs were more frequent, widespread, impactful and longer-lasting. The die-off stretched from California to the Bering Sea, centering in the Gulf of Alaska.

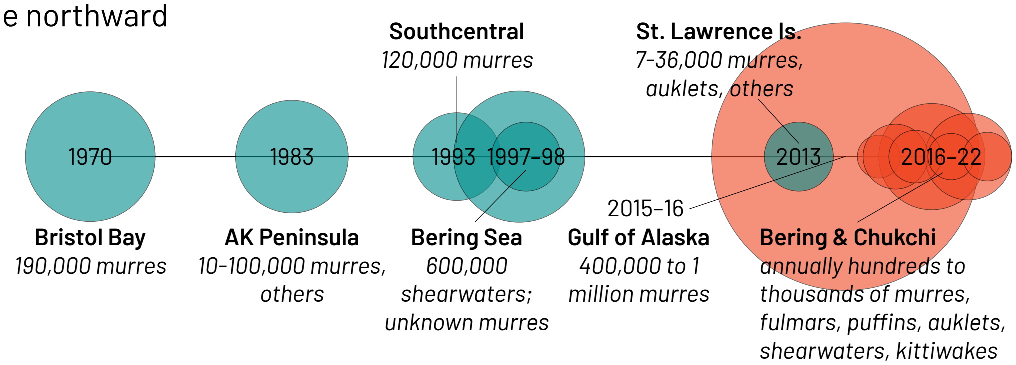
Starvation was the cause of most seabird deaths. Less and lower quality prey associated with warmer oceans likely explains some of the deaths. The warm water conditions also allowed the northward migration of predatory fish (walleye pollock, Pacific cod), increasing competition with seabirds.

Harmful algal bloom biotoxins were detected in seabird tissues in the Bering and Chukchi seas, though starvation still seemed to be the cause of death. Highly Pathogenic Avian Influenza was not confirmed in seabird carcasses except for murres, gulls and jaegers.

37

3 MILLION DEATHS

This timeline shows the magnitude of Alaska seabird die-offs from 1970–2022. Starting in 2015, as many as 3 million birds died (mostly murres), marking the largest seabird die-off ever recorded in the Pacific Ocean. These recent die-offs are in red on the timeline. Since 2022, the die-off has slowed.

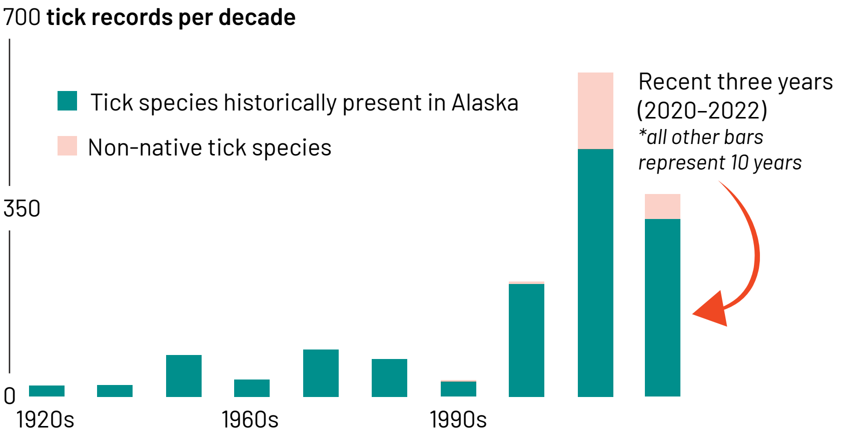


New tick species documented in Alaska

Ticks and the diseases they can spread have not historically been a concern in Alaska. While several species of ticks are common in the state, these ticks have limited potential as vectors for human or wildlife disease. In recent decades, several new species that can spread disease have been documented in Alaska. Evidence from the Alaska Submit-a-Tick Program suggests that these non-native ticks have not established wild populations here, but surveillance is critical.

A moose calf with hair loss from winter tick in Canada. Photo by Bill Samuel

While the risk of being bitten by a tick in Alaska is currently low, warmer conditions may improve habitat for ticks that transmit infections to humans and wildlife. A related concern is the introduction and establishment of the winter tick. Although winter ticks are not a direct threat to human health, they can heavily infest moose and have led to a significant decrease in moose populations in the Lower 48 and Canada. Submit any tick you find to the Alaska Submit-A-Tick program. Report moose with hair loss, if between December to March and in the pattern pictured, to the Alaska Department of Fish and Game.

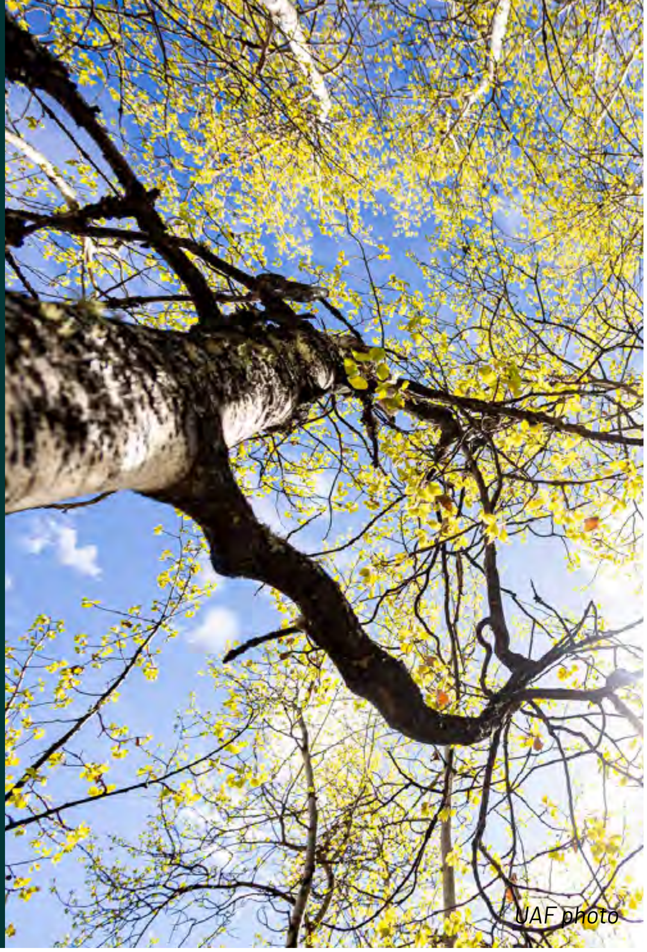


38

TICK RECORDS SINCE 1909

This graph shows the number of tick records in Alaska between 1909–2022. In recent decades, several non-native tick species that can spread disease have been documented. Though the increase in tick records is due in part to more public awareness of ticks, the increasing proportion of non-native tick records suggests recent introductions of these species.

Plants



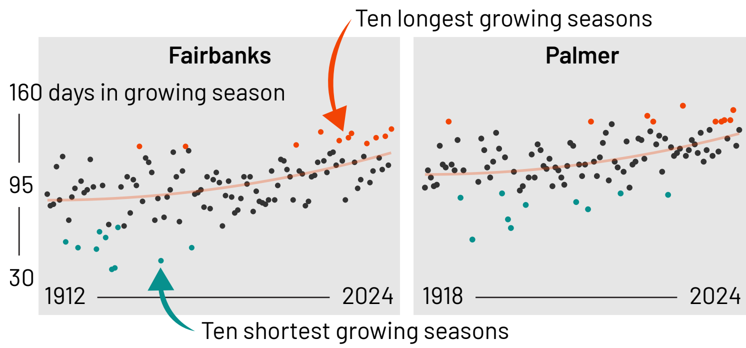
Longer growing season

Alaska's growing season — the number of summer days when temperatures stay above freezing — is increasing over most of the state. The Interior and southcentral can now consistently grow crops like wheat that take 90 days of above freezing temperatures to mature.

39

FAIRBANKS AND PALMER GROWING SEASON

The growing season in Fairbanks and Palmer is on average four weeks longer than it was in the early 1900s. This change is based on data gathered at the Agricultural and Forestry Experiment Stations in both locations, two of Alaska's longest operating climate stations.



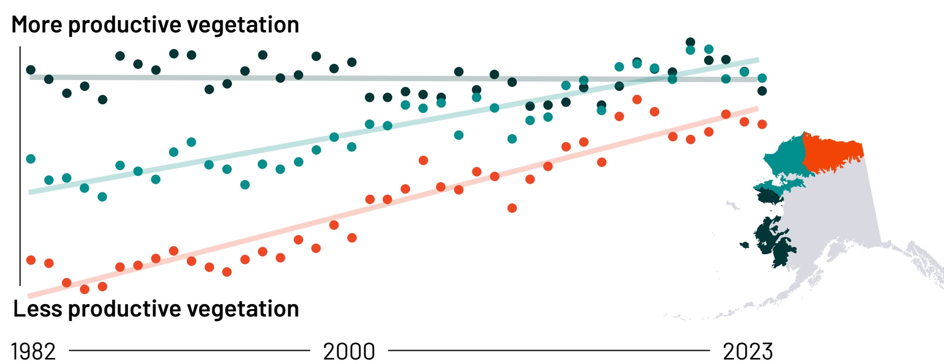
Greener, more productive vegetation

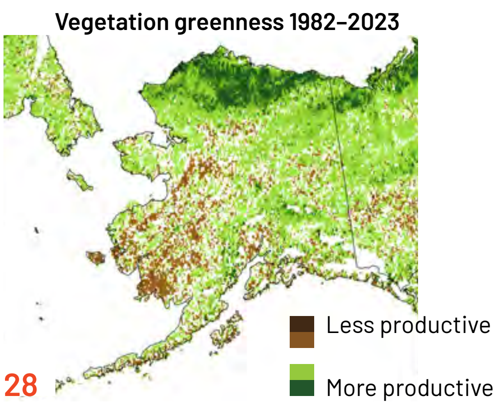
Since the 1980s, satellite observations of plant color show that vegetation in Alaska has been "greening," except in the southwest. This trend is primarily driven by warmer summers, which make vegetation more productive. Greening is also associated with the expansion of shrubs into areas where small tundra plants once dominated. While the long-term trend shows increasing vegetation productivity, climate and environmental factors create short-term fluctuations. Periods with cooler summers can temporarily reduce vegetation growth, reducing the greenness for a short time.

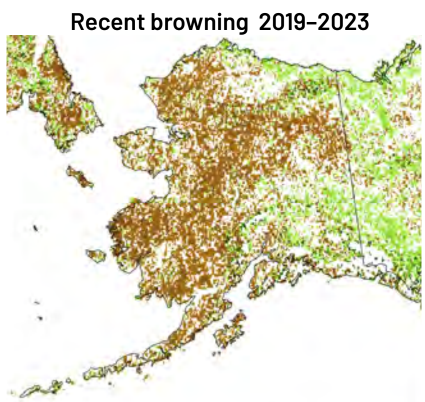
40

NORTHERN TUNDRA GREENING

Productivity of tundra vegetation along the Alaska coasts since 1982. The tundra along the Beaufort coast (red on the map and graph) has greened the most.







41

RECENT "BROWNING"

Though the long-term 1982–2023 trend shows more greenness (left), since 2019 (right) plants across most of Alaska were less productive, except on the North Slope. This recent "browning" may be related to cooler summers, insect infestations that damaged vegetation, or spring snow conditions that shortened or disrupted the growing season.

UAF photo

Berry concerns as temperatures rise 42

Berries are a critical resource to many Alaskans. One study found that families in Tribal communities picked at least five gallons of berries each year, with some picking up to 20 gallons. An analysis of 29 Alaska adaptation plans and risk assessments found that changing or increased variability in berry abundance was the top berry concern. Other concerns included precipitation changes that impact berries, changes in distribution of berries, and changes in timing of flowering, fruiting and harvest.

Despite rising temperatures, the available data do not show that blueberry and cranberry form or ripen earlier. Snow depth and the date in spring when the snow melts are strong predictors of flowering times. Even so, the conditions in prior years also impact timing. Most berry plants in Alaska, including blueberry and lowbush cranberry, start their buds one or two years before the berry forms. During especially warm summers some berry species become stressed and their buds don't develop as far during autumn. The following spring — even if snow melts early — the buds may be behind and berries may emerge late.

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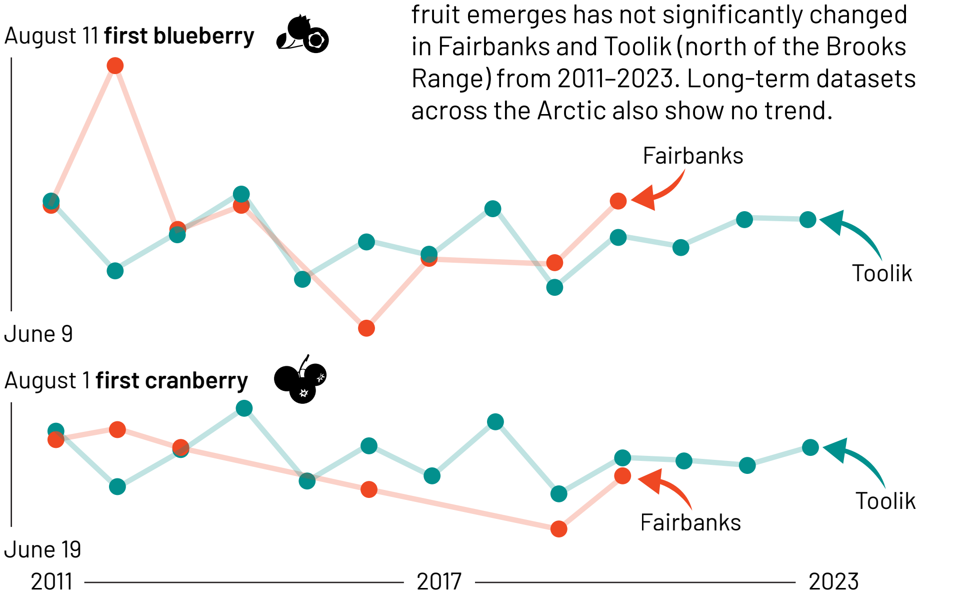
FIRST BERRY

The date when the first blueberry and cranberry fruit emerges has not significantly changed in Fairbanks and Toolik (north of the Brooks Range) from 2011–2023. Long-term datasets across the Arctic also show no trend.



INDIGENOUS VOICES

"Berries at times are so much smaller, and there are at times no berries at all, and then at times an abundance of berries."

Annie Fredericks, Chuathbaluk

"Elders also say to wait to pick until after first frost, but now the berries are ripe before that point."

Stephen Payton, Seldovia

Quotes gathered during listening sessions in 2021 and 2022 for the Alaska Berry Futures project.

Contributors & data sources

Throughout the report the number in the red circle near each graphic links to the associated contributor and data source on these pages.

Air temperature

Contributor: Rick Thoman, UAF Alaska Center for Climate Assessment and Policy

1. Warming • Data source Berkeley Earth
2. Temperature region & season • Data source NOAA NCEI

Precipitation

3. More rain, most areas & More winter snow • Contributors: Rick Thoman, Zav Grabinski , UAF Alaska Center for Climate Assessment and Policy. Data source ERA5
4. Shorter snow season • Contributor: Brian Brettschneider, National Oceanic and Atmospheric Administration. Data source NSIDC
5. Regional snow-off • Contributors: Uma Bhatt, UAF Geophysical Institute; Chris Waigl, UAF International Arctic Research Center. Data source DOI:10.5281/zenodo.13988930
6. More winter rain in Fairbanks • Contributor: Rick Thoman, ACCAP. Data source NOAA/NCEI & NWS

Storms

Contributor: Peter Bieniek, UAF International Arctic Research Center

7. More storms recently & regional storms • Data source ERA5, algorithm "Climatology and interannual variability of Arctic cyclone activity," Zhang et al (2004)

Indigenous voices

Quote contributors: Guy Omnik (page 22), Billy Adams (page 23), Carla SimsKayotuk (page 24), UAF Alaska Arctic Observatory and Knowledge Hub; Annie Fredericks, Intertribal Agriculture Council (page 29); Stephen Payton, The Seldovia Village Tribe (page 29)

8. West wind in Utqiaġvik • Contributors: Billy Adams, Joe Mello Leavitt, Lease Paton, Roberta Glenn-Borade, Donna Hauser, UAF Alaska Arctic Observatory and Knowledge Hub
9. Kotzebue impacts • Contributors: Bobby Schaeffer, Alex Ravelo, Roberta Glenn-Borade, Donna Hauser, AAOKH

Extreme events

10. Extreme events timeline & map • Contributors: Rick Thoman, Heather McFarland, UAF Alaska Center for Climate Assessment and Policy
11. Anchorage snow • Contributor: Rick Thoman, ACCAP. Data source NOAA/NCEI

Flooding and erosion

Contributor: Nora Nieminski, Alaska Division of Geological & Geophysical Surveys

12. Coastal flooding • Data source "Coastal flood impact assessments for Alaska communities" (DGGS RI 2021-1)
13. Coastal erosion • Data source "Erosion exposure assessment of infrastructure in Alaska coastal communities" (DGGS RI 2021-3)

Permafrost

Contributor: Vladimir Romanovsky, UAF Geophysical Institute

14. Permafrost is warming • Data sources GI Permafrost Lab Thermal State of Permafrost database, National Science Foundation, "Permafrost" Smith et al in 2022 State of the Climate
15. Inset map • Data source "Permafrost characteristics of Alaska," Jorgenson et al (2008)
16. Yedoma • Data source "Circum-Arctic map of the Yedoma permafrost domain," Strauss et al (2021)

Wildfire

17. More area burned & Large seasons doubled • Contributor: Zav Grabinski, UAF Alaska Fire Science Consortium. Data source Alaska Interagency Coordination Center
18. Lightning • Contributors: Joshua Hostler, Uma Bhatt, UAF Geophysical Institute; Zav Grabinski, AFSC. Data source Alaska Lightning Detection Network
19. Fairbanks smoke • Contributor: Rick Thoman, ACCAP. Data source NOAA/NCEI & NWS

Oceans

20. Sea surface temperature • Contributors: Rick Thoman, Zav Grabinski, ACCAP. Data source OISSTv2.1 courtesy of NOAA/PSL/ESRL
21. More acidic oceans • Contributors: Darcy Dugan, Alaska Ocean Observing System; Darren Pilcher, NOAA Northwest Fisheries Science Center

22. Corrosive conditions • Data source "Ocean acidification," Pilcher et al in 2022 Eastern Bering Sea Ecosystem Status Report. Crab sensitivity thresholds based on studies at the NOAA lab in Kodiak

23. Compound events • Contributors: Claudine Hauri, UAF International Arctic Research Center. Data source "More than marine heatwaves: A new regime of heat, acidity, and low oxygen compound extreme events in the Gulf of Alaska," Hauri et al (2024)

Salmon

24. Salmon returns • Contributor: Erik Schoen, UAF International Arctic Research Center. Data source ADF&G; "Divergent responses of Western Alaska salmon to a changing climate," Schoen et al in 2023 Arctic Report Card; "Body size and early marine conditions drive changes in Chinook salmon productivity across northern latitude ecosystems," Feddern et al (2024)

25. Fewer eggs deposited in rivers • Contributor: Erik Schoen, IARC. Adapted from "The reproductive value of large females: consequences of shifts in demographic structure for population reproductive potential in Chinook salmon," Ohlberger et al (2020)

26. Salmon and well-being • Contributor: Harmony Wayner, UAF International Arctic Research Center. Data sources "State of Alaska salmon and people;" "Assessing the sustainability and equity of Alaska salmon fisheries through a well-being framework," Donkersloot et al (2020)

Glaciers

27. Benchmark glaciers • Contributor: Regine Hock, UAF Geophysical Institute. Data source U.S. Geological Survey

Lake and river ice

28. Lake ice across Alaska • Contributor: Chris Arp, UAF Institute of Northern Engineering. Interior data source Fresh Eyes Ice Community-based Monitoring Teams in Arctic Data Center; northern data source Arp et al in Arctic Data Center

29. Shorter river ice season • Contributor: Dana Brown, UAF International Arctic Research Center. Data source ERA5, U.S. Geological Survey Landsat, accessed via Google Earth

30. Earlier breakup at Nenana • Contributor: Rick Thoman, ACCAP. Data source NOAA/NWS Alaska-Pacific RFC

Sea ice

31. Shrinking ice season • Contributor: Rick Thoman, ACCAP. Data source NSIDC Sea Ice Index, Version 3

32. Not as far south • Contributors: Rick Thoman, Zav Grabinski, ACCAP. Data source National Snow and Ice Data Center

33. More ship traffic • Contributors: Donna Hauser, UAF International Arctic Research Center; Greta Ferloni, IARC/Durham University. Data source Arctic Ship Traffic Database

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Contributor: Todd Brinkman, UAF Institute of Arctic Biology

34. Time spent onshore • Data source "Forecasts of polar bear (Ursus maritimus) land use in the southern Beaufort and Chukchi Seas, 2040–65," USGS Open-File Report 2023–1048

Healthy ice seals

35. Ice seal blubber • Contributor: Lori Quakenbush, Alaska Department of Fish and Game. Data source "Ice seals of Alaska," Quakenbush et al in 2024 Arctic Report Card

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Contributors: Vijay Patil, Daniel Ruthrauff, U.S. Geological Survey Alaska Science Center. Data source DOI:10.5066/P13PPHS2

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Wildlife & ticks

Contributors: Micah Hahn, UAA Institute for Circumpolar Health Studies; Kimberlee Beckmen, Alaska Department of Fish and Game

38. Tick records since 1909 • Data sources "Ticks as a potential public health concern in Alaska, 2010–2022," Hahn (2023) & "Establishing a baseline for tick surveillance in Alaska: Tick collection records from 1909-2019," Hahn et al (2020)

Plants

39. Fairbanks and Palmer growing season • Contributor: Rick Thoman, ACCAP. Data source NOAA NCEI

40. Northern tundra greening • Contributor: Uma Bhatt, GI. Data source AVHRR GIMMS3g+ NDVI

41. Recent "browning" • Contributor: Uma Bhatt, GI. Data source NASA GSFC

Changing berries

Contributors: Katie Spellman, UAF International Arctic Research Center; Christa Mulder, UAF Institute of Arctic Biology

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Read Alaska's Changing Environment online

uaf-iarc.org/communicating-change