BERINGSCIENCE

SPRING 2023 | Communicating science in and around the Bering Sea

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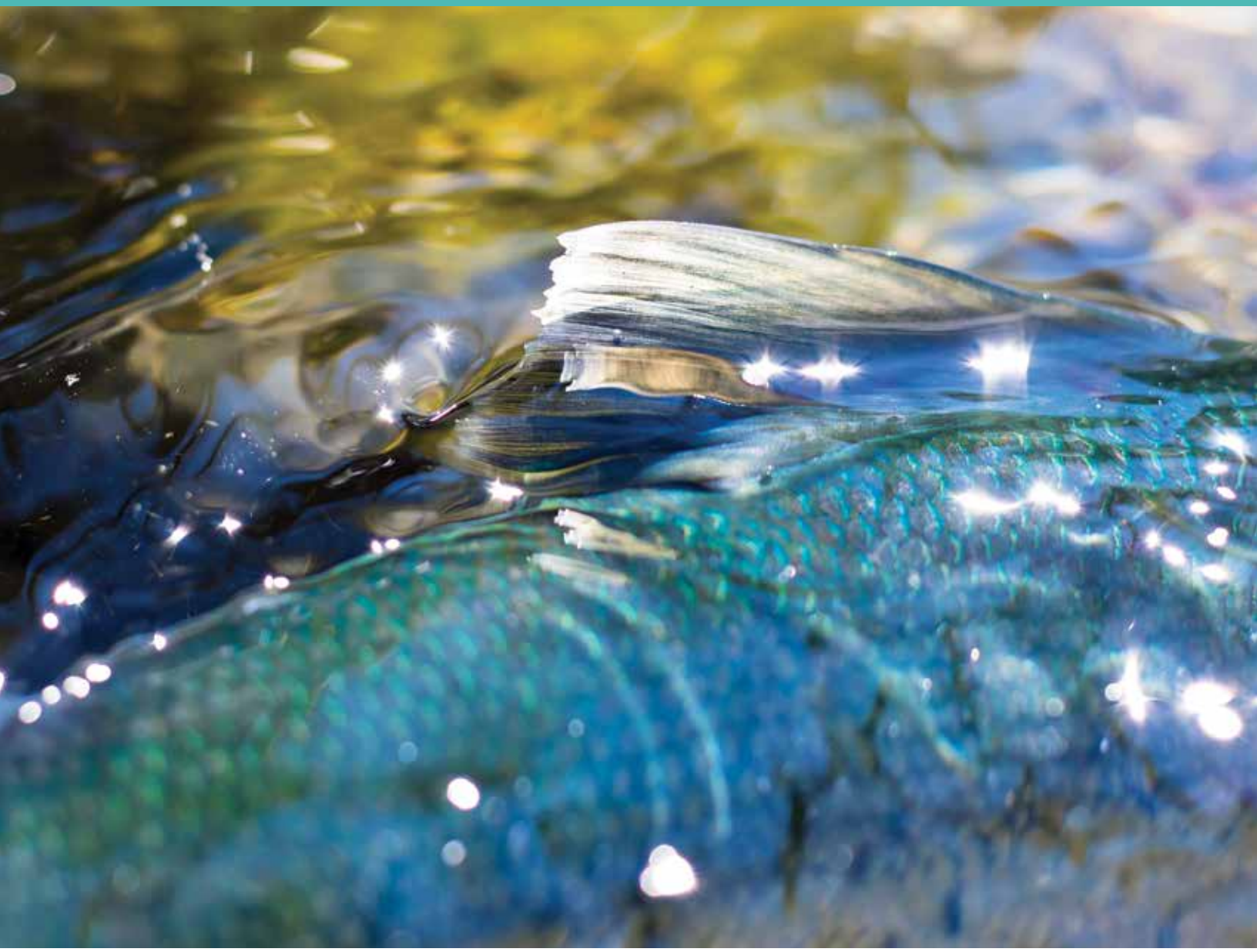

When sockeye salmon first return to a river from their years at sea, their backs are a bright blue-green and their bellies flash pure silver. Credit: Lisa Hupp / US Fish and Wildlife Service

BERING REGION Ocean Data Sharing Initiative

AOOS Alaska Ocean Observing System

International Arctic Research Center

UAF University of Alaska Fairbanks

NOAA

Report background

The Bering Region Ocean Update project began in spring 2020. **Bering Science** is one aspect of the project aimed at increasing regional data sharing among federal, state, community and private sector partners.

This report is a resource for state, federal, community and university partners to share recent observations with community members, other scientists and management agencies.

Read previous reports, and learn how information is gathered and reviewed at **https://aoos.org/beringregion.**

Research contributors

Alaska Department of Fish and Game

Alaska Pacific University

Alaska Ocean Observing System

Coastal Observation and Seabird Survey Team

NOAA Alaska Fisheries Science Center

Qawalangin Tribe of Unalaska

University of Alaska Fairbanks

U.S. Fish and Wildlife Service

U.S. Geological Survey

Woods Hole Oceanographic Institution

Yukon River Drainage Fisheries Association

—and many others, including community members and citizen scientists who contribute to studies in the Bering Sea region

Let's connect

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Cite this report

Bailey, A., C. Rosner, and H.R. McFarland, editors. Bering Science: Spring 2023 Bering Region Ocean Update, Issue 6 [newsletter]. Alaska Ocean Observing System, Anchorage, Alaska.

Feedback, please!

Your opinion is important to us and can help guide future reports. Please share your comments by mailing the postcard in this report, or by completing a short online survey at **www.surveymonkey.com/r/BeringScience2023**. Thank you!

Welcome!

The Bering Sea region is experiencing many changes. Here, you can read about observations and research happening on five topics identified by our Community Advisory Panel.

The Alaska Ocean Observing System (AOOS) and International Arctic Research Center compiled the information from many sources, with funding from the National Oceanic and Atmospheric Administration Alaska Fisheries Science Center (NOAA Fisheries).

Crab

Crab stocks declined in the Bering Sea in 2021 and 2022. What kinds of studies are happening to better understand why? **PAGES 3–5**

Harmful Algal Blooms

Scientists are concerned that warming could lead to more harmful algal blooms in the Bering Sea. How are communites involved in monitoring? **PAGES 6–7**

Seabirds

There is an ongoing seabird die-off. How did it compare to past years? Is avian influenza a threat? **PAGES 8–9**

Weather & Climate

Why was ex-Typhoon Merbok such a severe event for western Alaska, and can we expect more storms like this? **PAGES 10–12**

Salmon

Record sockeye salmon runs contrasted with poorer runs of Chinook and chum. What is being learned about the early lives of salmon? **PAGES 13–15**

Thank you, Community Advisory Panel!

We thank our community advisory panel for providing direction and feedback.

- **Shayla Shaishnikoff,** Qawalangin Tribe of Unalaska
- **Jennifer Hooper,** Association of Village Council Presidents
- **Lauren Divine and Chris Tran,** Aleut Community of St. Paul Island
- **Mellissa Maktuayaq Johnson,** Arctic-Yukon-Kuskokwim Tribal Consortium
- **Craig Chythlook & Connie Melovidov,** University of Alaska Fairbanks (UAF)

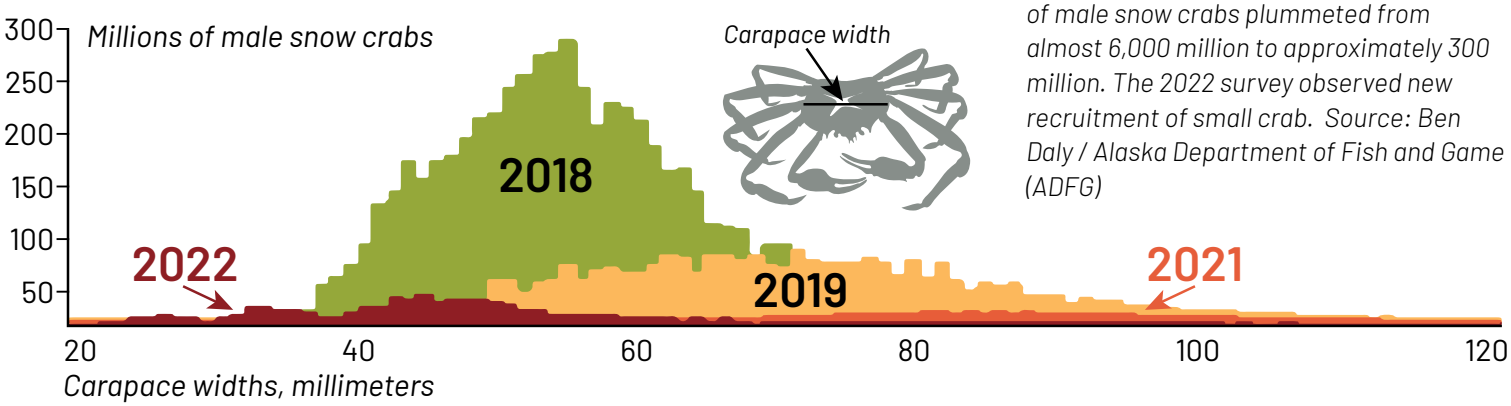
Crab

Closures of two iconic Bering Sea crab fisheries have had a devastating impact on harvesters, industry and communities. In 2022, the Bering Sea snow crab fishery closed for the first time ever after a population-wide collapse the previous year. The Bristol Bay red king crab fishery closed for a second season in a row after more than a decade of gradual decline. In the northern Bering Sea, Norton Sound red king crab abundance increased enough to support a commercial fishery.

What happened to the snow crab?

Between 2018 and 2021, snow crab populations dropped. Annual trawl surveys by NOAA Fisheries reported a record high in 2018. In 2019 the abundance of larger crab increased, while smaller crabs dramatically declined. No survey took place in 2020 because of the pandemic. In 2021, the male population estimate was the lowest ever recorded. Legal size crabs continued to decline in 2022, causing the closure of the 2022/23 fishery, but the numbers of small crab increased from 2021.

Researchers and managers agree that the crabs did not move elsewhere, because there was not a population increase in other areas. The peak of the snow crab population occurred during the marine heatwave of 2018–2019, when bottom temperatures rose significantly in the Eastern Bering Sea. The warm water likely stressed the crabs and increased their metabolic needs. Crabs were forced to gather in small areas of cool water at a time when they needed extra food. Scientists hypothesize that they died from starvation.



Snow crab collapse

Surveys by NOAA Fisheries recorded more male snow crabs than ever before in 2018. But between 2018 and 2021, the population of male snow crabs plummeted from almost 6,000 million to approximately 300 million. The 2022 survey observed new recruitment of small crab. Source: Ben Daly / Alaska Department of Fish and Game (ADFG)

Snow crab lesson plans

Students can explore snow crab biology and climate change in the Bering Sea with new lesson plans from NOAA Fisheries.

The curriculum is for 7th grade students but may be adapted for younger or older classrooms. In spring 2023, NOAA Fisheries will expand the curriculum for mixed-grade classrooms in rural Alaska.

Download the materials or request a copy by mail from Erin Fedewa, erin.fedewa@noaa.gov.

Bering Sea snow crab support a valuable commercial fishery. Credit: NOAA Fisheries

Male snow crab movement

Scientists are piloting the use of satellite tags to learn more about where mature male snow crabs go during the year. In 2022, 30 crabs were tagged during the spring commercial fishing season and tracked until July. These crabs moved north to the area surveyed by NOAA Fisheries each year. During that survey, 18 crabs were tagged and tracked for five months and generally moved in a southwesterly direction. The study showed that tagged crabs traveled between three and 80 miles, and that satellite tags may be a good way to investigate their movement and distribution.

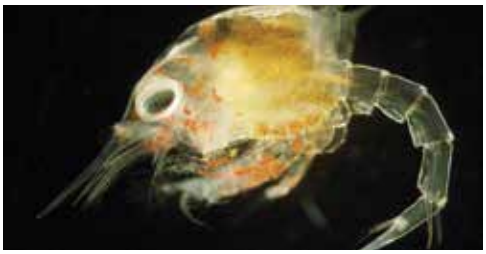
Who is doing this research? University of Alaska Fairbanks (UAF), NOAA Fisheries and ADFG. Additional funders include the Bering Sea Fisheries Research Foundation and the Central Bering Sea Fishermen's Association.

Attaching satellite tracking tags to male snow crabs. Credit: Connie Melovidov / UAF

Crab fishery disaster declarations

ADFG is responding to fisheries disaster requests and developing spending plans for disaster relief funds from NOAA Fisheries.

- **Disasters have been declared and funds have been announced** for 2019 Norton Sound red king crab ($1,433,137) and 2019/2020 Eastern Bering Sea tanner crab ($12,935,199).
- **Fisheries disasters have been declared** for 2020–2021 Norton Sound red king crab, and for 2021–2022 & 2022–2023 Bering Sea crab.



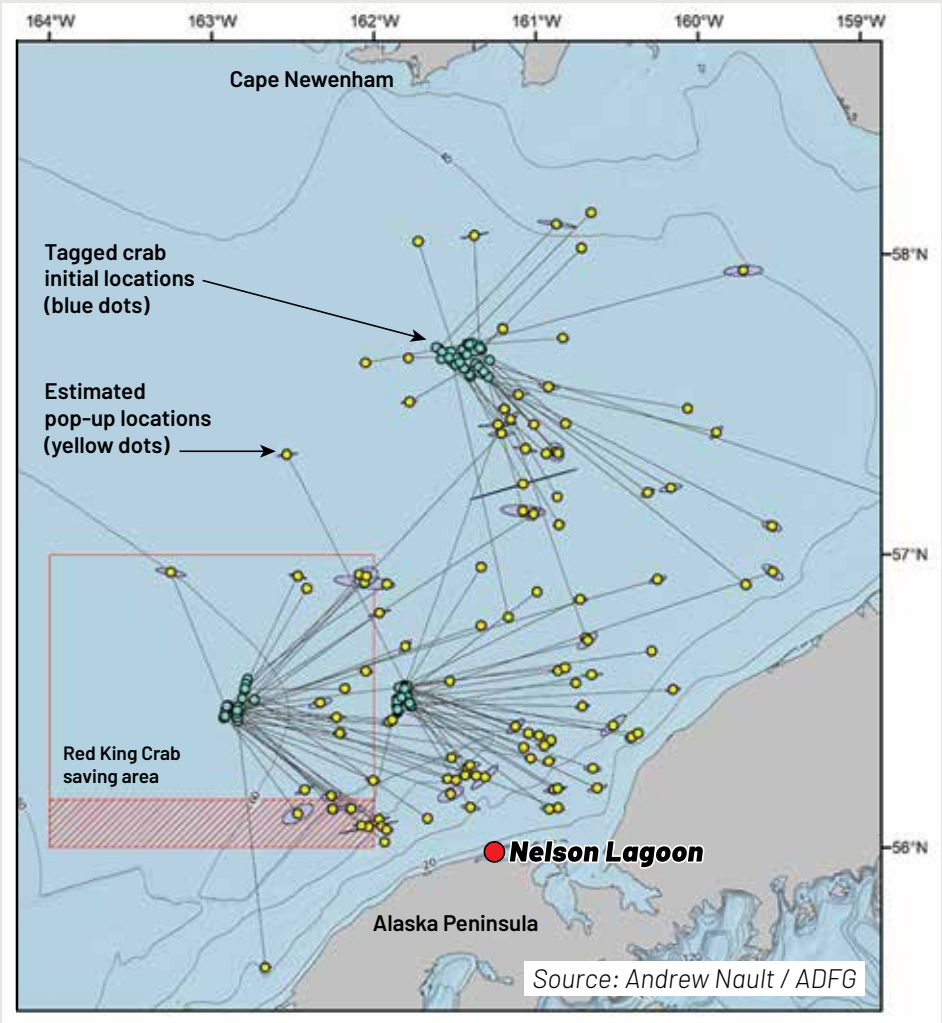
Red king crab larva. Credit: NOAA Fisheries Kodiak Laboratory

Tracking Bristol Bay female red king crab to learn about their early lives

The Bristol Bay red king crab decline is likely related to low survival in early life. To understand where females release larvae in spring, scientists tagged 225 female crabs in fall 2021. Crabs were tracked for six months, moving eastward about a quarter of a mile each day.

Tags popped off in April–May, when they typically molt and release larvae. Tagged crabs reached nearshore areas along the Alaska Peninsula and central Bristol Bay. They were mostly within management areas that protect them from trawling. This research will help future studies determine whether larvae reach good habitat to grow into juveniles.

Who is doing this research? ADFG, NOAA Fisheries and Bering Sea Fisheries Research Foundation.



Healthy vs. diseased crabs

A healthy snow crab (top) and a snow crab infected with bitter crab disease (bottom). Infected crabs are pink-orange on the underside and around their joint, and their hemolymph (equivalent to blood in humans) is white instead of clear. Credit: Erin Fedewa / NOAA Fisheries

Warmer water is stressing Bering Sea crabs

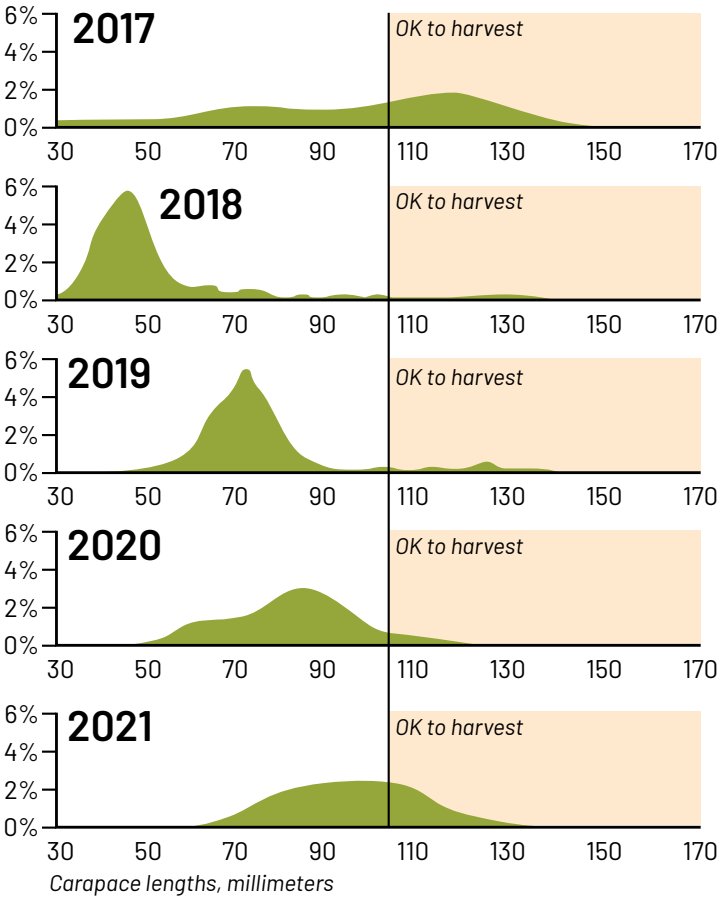
Warm water stresses crabs and makes them more vulnerable to disease. Scientists are analyzing crab blood samples to see if bitter crab disease increased in the Bering Sea before and during the snow crab collapse.

Bitter crab disease can be fatal to crabs. It causes cooked meat to taste bitter (like aspirin) and have a chalky texture. The meat is not toxic to humans, but crabs with the disease cannot be eaten or sold commercially.

Researchers at NOAA Fisheries have been monitoring bitter crab disease in the Bering Sea since 1988. They found the disease in almost 40% of the snow crab samples collected in 2017, which was 25% more than the prior year. Over half of the juveniles sampled near St. Matthew's Island nurseries were infected in 2017, suggesting that the disease may have negatively impacted survival of juvenile snow crab in recent years.

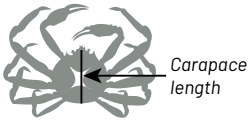
This summer, scientists will process blood samples collected during 2018 and 2019. In the laboratory, they will monitor snow crabs infected with the disease to see how increased temperatures affect survival.

Percentage of male red king crab in Norton Sound trawl survey



King crab sizes over time

Surveys found many king crab in 2018–2020, but most were too small—carapace lengths <105 mm—to legally harvest. 2021 was the first year that crabs would be large enough to legally harvest in 2022. Source: Jenefer Bell / ADFG



Norton Sound red king crab are doing well

In Norton Sound, crab large enough to legally harvest returned to support a commercial fishery in 2022. Trawl surveys found few such crabs beginning in 2018, leading to a low commercial harvest in 2019 and almost no commercial harvest in 2020 and 2021. However, the survey also showed a record number of small crabs in 2018. These crabs have now grown and should support a commercial fishery for the next three years.

Why are Norton Sound crab doing okay, while other crab species are not? The most likely explanation is that Norton Sound is geographically isolated from the southern Bering Sea, so factors causing declining abundances of other crab fisheries are not affecting the Norton Sound population.

Thanks to crab research contributors

- **Jenefer Bell,** ADFG, jenefer.bell@alaska.gov
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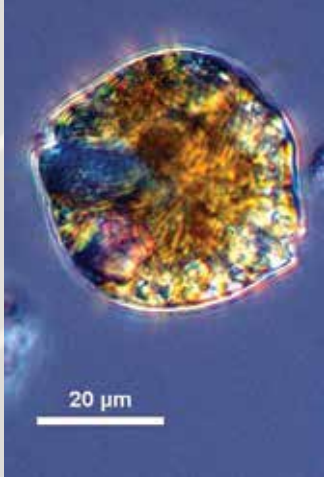
Harmful Algal Blooms

In the Bering Sea, the dinoflagellate *Alexandrium catenella* is the most common harmful algal bloom (HAB) species. HABs are dangerous because *Alexandrium* produces saxitoxin, which can cause paralytic shellfish poisoning (PSP) in animals and humans. The toxin also moves through the food web and affects wildlife at all levels, including those that do not consume shellfish.



How do HABs reach humans?

HAB toxins have been found throughout the Bering Sea food web. Saxitoxins produced by *Alexandrium* are ingested by zooplankton (like copepods) and filter feeders (like mussels, clams and forage fish), then move to the fish, birds and marine mammals that eat them.

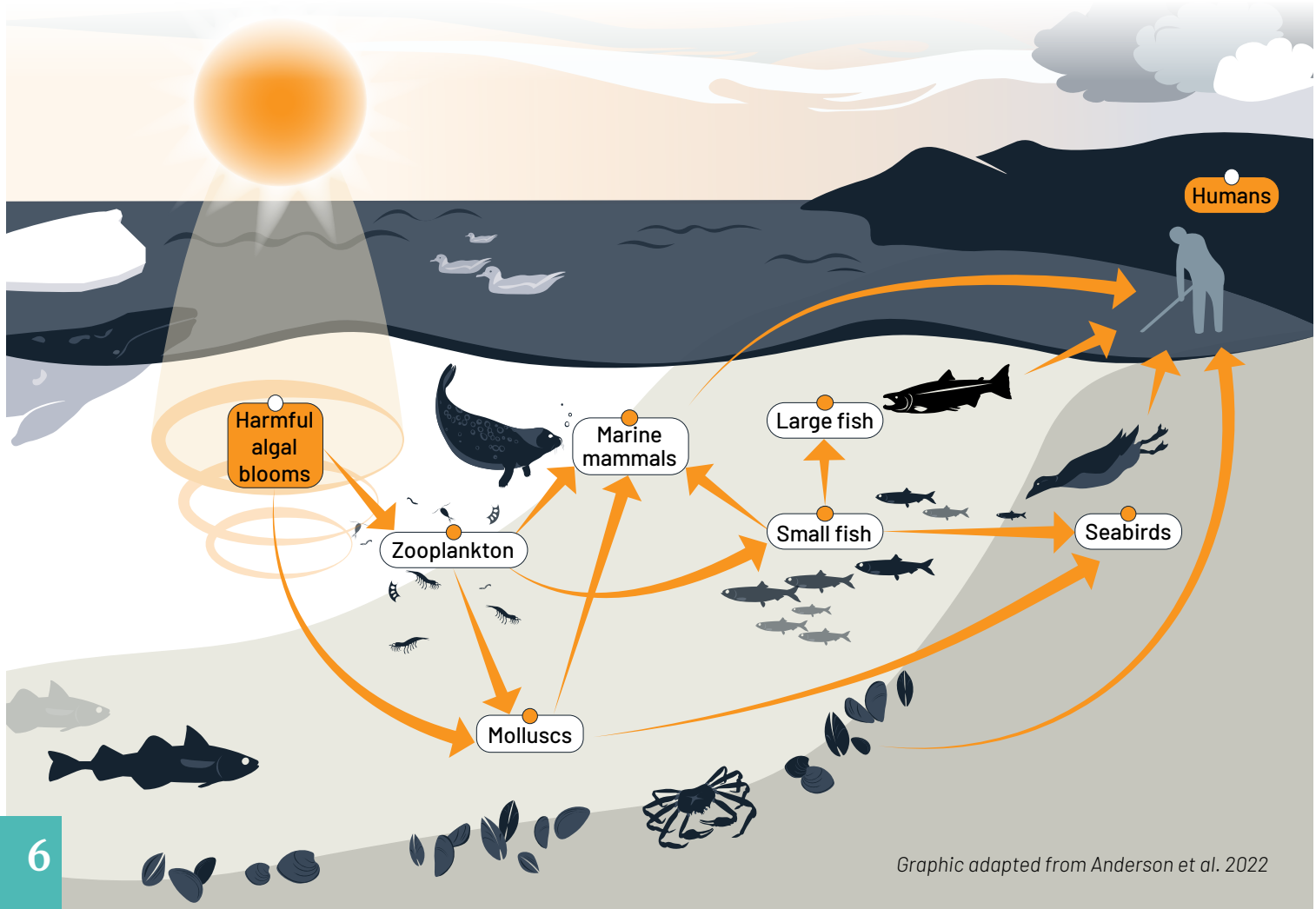
Humans can be exposed to the toxins when they eat these animals, especially shellfish. Researchers are still learning how much HAB toxins impact the behavior and survival of different animals.

HABs in the Northern Bering Sea

Scientists are concerned that warming conditions could lead to more HABs in the Bering Sea.

In summer 2022, a large bloom of *Alexandrium* moved west past St. Lawrence Island through the Bering Strait. Water samples showed 100,000 *Alexandrium* cells per liter of water (1,000 cells are considered dangerous). Advisories were issued to communities during the event, which lasted six weeks. **No human illnesses were reported.**

How HABs move through the food web



Graphic adapted from Anderson et al. 2022

Community monitoring

The Bering Sea's remote and extensive coastline makes it challenging to study and track HABs. Community monitoring helps alert locals of potential HABs and provides essential data to scientists.

In the Aleutian Islands, the Qawalangin Tribe of Unalaska collects water samples to look for phytoplankton containing HAB toxins. Their data are reported to a national monitoring network. Shellfish samples are sent to Anchorage for toxin testing and the results are posted on the Tribe's website. Several other communities in the Bering Sea are developing similar programs.

Storms like Merbok can wash clams ashore from deep water into areas where they are not usually found, making them available to subsistence harvesters. Shellfish collected after these storms are potentially dangerous, so caution should be exercised. **The Alaska Harmful Algal Bloom network can fund shipping and testing of any samples.** For more information, visit https://ahab.aoos.org/.

TOXINS IN MARINE MAMMALS

HAB toxins have been found in all Alaska marine mammal species. No confirmed die-off events have been reported in the Bering Sea.

Doses of saxitoxin in Bering Sea walruses were recently reported in the range known to impact the health of other mammals. This suggests that walruses may already be vulnerable to poisoning events, especially during warmer years.

TOXINS IN CLAMS

Of all the Bering Sea animals tested, clams had the highest level of toxins. Higher levels occur in warmer waters. Compared to 2019 (the warmest year on record in the Bering Sea), clams in 2022 had low to moderate toxin concentrations.

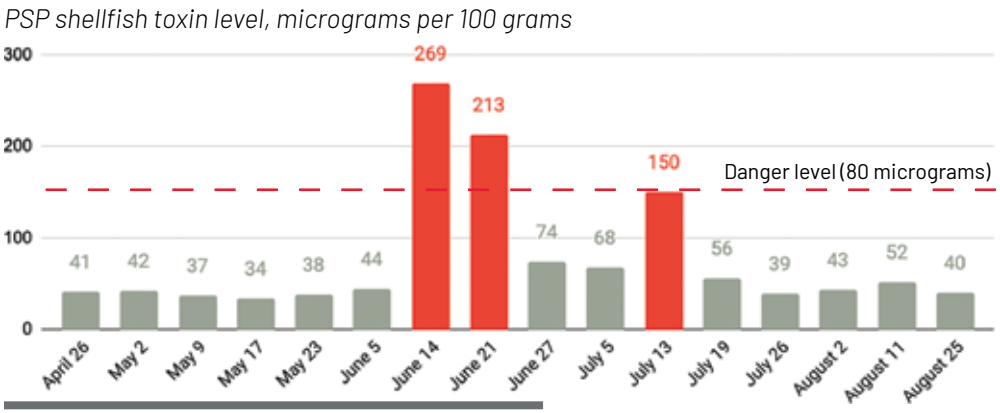
TOXINS IN SEABIRDS

Seabirds feed on small forage fish and marine invertebrates that accumulate HAB toxins.

In recent years, scientists detected saxitoxin in multiple Bering Sea seabird species. The digestive tracts, livers and kidneys contain the most toxins, and muscle the least.

Ongoing research on captive birds aims to better understand the effects of saxitoxin on seabirds.

Left: Qawalangin staff conduct a phytoplankton tow off the Spit Dock in Unalaska. Above: Jenny (left) and Shayla (right) examine their recently collected sample. Credit: Shayla Shaishnikoff



Weekly toxin sampling in mussels in 2022

Sampling was done near Unalaska to monitor for PSP in blue mussels. Red bars indicate toxin levels dangerous to human health. Source: Qawalangin Tribe of Unalaska

THANKS TO HABS RESEARCH CONTRIBUTORS

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- **Shayla Shaishnikoff,** Qawalangin Tribe, shayla@qawalangin.com
- **Caroline Van Hemert,** U.S. Geological Survey (USGS), cvanhemert@usgs.gov

Seabirds

Seabird die-offs and disease are recent hot topics in Alaska. In the Bering Sea, 2022 marked the sixth year of greater than normal seabird mortality, though the die-offs last summer were not as severe as in the past. There has also been recent interest in avian influenza across the United States. Fortunately, few seabirds in the Bering Sea were reported with the disease in 2022.

Seabird status on the Pribilof Islands

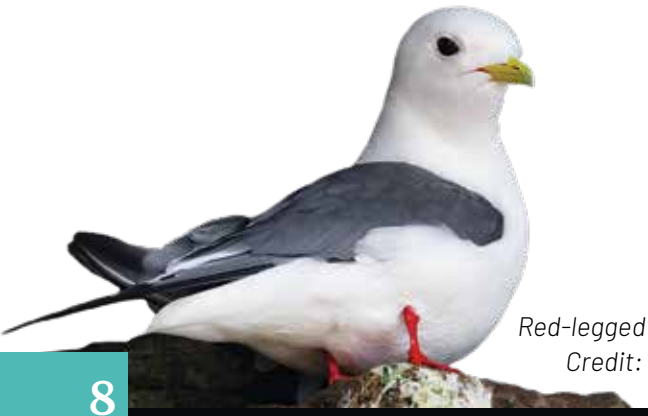
Apart from thick-billed murres, cliff-nesting seabirds had a great year on St. Paul and St. George islands in 2022. Kittiwakes did particularly well, with counts that were higher than in recent years.

In 2015–2016, a heatwave in the Gulf of Alaska killed many seabirds that nest in the Pribilofs. About 75% of common murres from some breeding colonies died during that time. The loss of murres was followed by several years of low breeding success, resulting in egg scarcity. In 2022, murres in Pribilof colonies finally seemed to return to normal breeding activity. Thick-billed murres were the exception—many lost their eggs right after laying.

	Red-faced cormorants	Glaucous-winged gulls	Common murres	Thick-billed murres	Horned puffins	Tufted puffins	Red-legged kittiwakes	Black-legged kittiwakes	Northern fulmars	Fork-tailed storm-petrels	Leach's storm-petrels	Parakeet auklets	Least auklets
St. George	☺		☻	☹			☻	☻					☻
St. Paul	☻		☻	☹			☻	☻					☺
Buldir		☻		☻	☺	☺	☻	☻		☺	☻	☻	☻
Aiktak		☻	☻	☻	☻	☻				☺	☻		
Chowlet	☺	☻	☻	☻	☻	☻		☻				☹	

☻ Way above average ☻ Average ☹ Below average

Graphic adapted from the Alaska Maritime National Wildlife Refuge



Red-legged kittiwake. Credit: Lisa Hupp

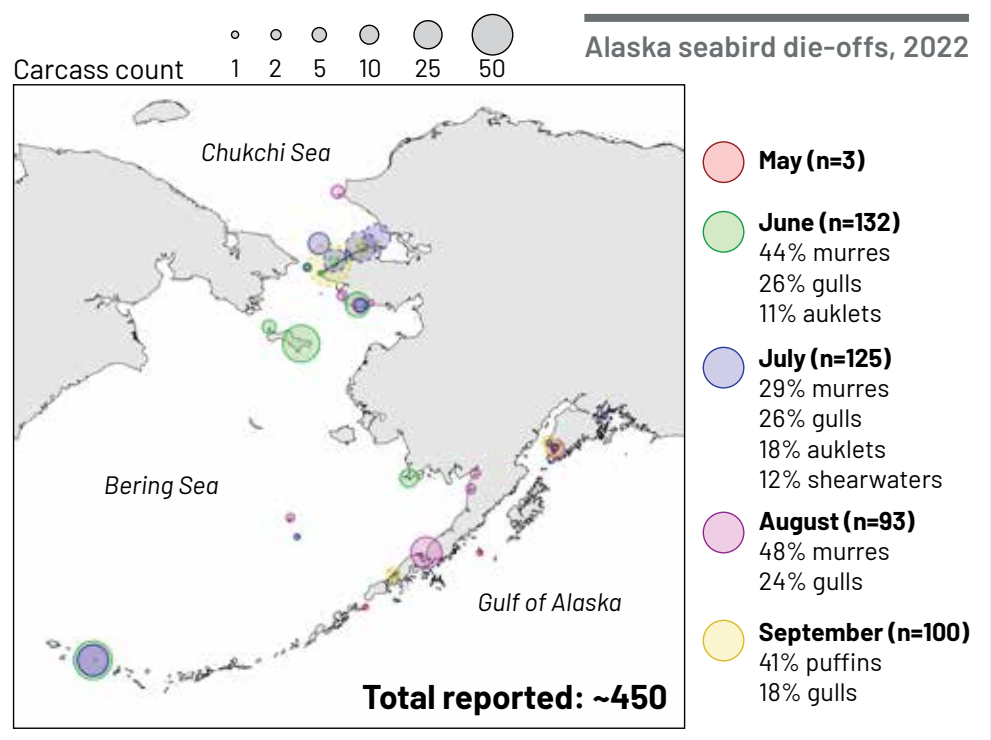
Thick-billed murres. Credit: Greg Thomson

Seabird die-offs

There were fewer reports of die-offs in 2022, but the number of carcasses found on beaches remains higher than expected. Prior to 2015, seabird die-offs were infrequent in Alaska. They usually took place in winter, and were related to disease or large-scale climate events like El Niño.

Since 2017, hundreds to thousands of Bering Sea seabirds have died each summer and fall. The die-offs from 2017 to 2019 corresponded with unusually warm ocean temperatures.

Related ecosystem changes that led to starvation likely caused the die-offs. For instance, warmer temperature and less sea ice may have impacted the zooplankton and forage fish that seabirds eat.



Circle sizes indicate totals of seabird carcasses reported each month. Locations with no reported carcasses may result from remoteness and/or lack of visitation or reporting capacity, rather than a lack of carcasses. Data compilation and map were provided by the Coastal Observation and Seabird Survey Team (COASST; University of Washington, Seattle WA), and uses data collected by Tribal partners, community members, Alaska Sea Grant, National Park Service, U.S. Fish and Wildlife Service and COASST participants.

Avian influenza

In 2022, a highly pathogenic avian influenza (HPAI) outbreak impacted birds across the U.S. and Canada. In the Bering Sea, fewer than 20 seabirds were confirmed to be affected.

The positive cases were in gulls and jaegers, birds that may scavenge on carcasses of infected birds and mammals. Seabirds nesting in dense colonies (like murres and kittiwakes) appeared to be unaffected, although limited seabird carcasses were collected and tested in the Bering Sea region in 2022.

There was only one recent human case of HPAI in North America, and it was associated with exposure to infected poultry. The affected person reported mild symptoms and fully recovered.

Some birds infected with HPAI appear healthy, and others become sick and die. Common signs of disease among affected birds include a lack of coordination, stumbling, inability to stand upright, inability to fly, swimming in circles, a twisted neck and paralysis.

If you observe birds with these signs, please call the U.S. Fish and Wildlife Service Alaska Sick and Dead Bird Hotline.

1-866-527-3358

For information on recent confirmed detections of HPAI in wild birds, visit the U.S. Department of Agriculture at https://tinyurl.com/2p8r3ak8

For information on HPAI and human health, visit the Centers for Disease Control at https://tinyurl.com/35dsp8kp

Hunters: Learn how to limit your exposure to avian influenza at https://tinyurl.com/ysxy3mfe

Thanks to seabird research contributors

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- **Heather Renner,** Alaska Maritime National Wildlife Refuge, heather_renner@fws.gov

Weather & Climate

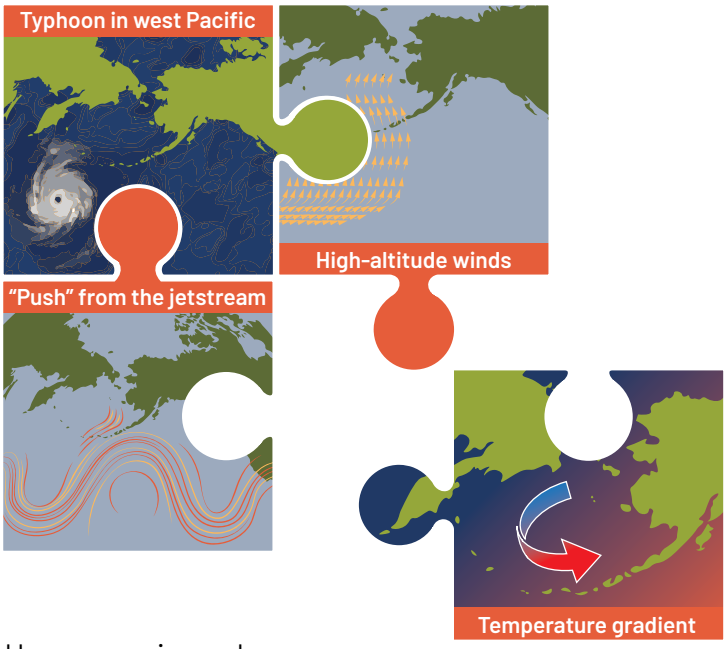
The big news of 2022 was, in a word, Merbok. In September, ex-Typhoon Merbok hammered 1,300 miles of Alaska coastline, with winds and storm surges that impacted communities and coastlines from Bristol Bay to beyond the Bering Strait. Because Merbok hit in early autumn, no sea ice existed to protect the coast.

Merbok: a "perfect storm"

Merbok reached its size and impacted Alaska in the way it did because of how specific atmospheric phenomena lined up.

- A **typhoon** in the far western Pacific Ocean formed where it is normally too cold to support a typhoon.
- Large scale **winds** at upper levels in the atmosphere steered the typhoon toward Alaska.
- A piece of the jetstream broke away from its normal wavy pattern, sending an additional **"push"** of extremely strong winds toward the region that helped strengthen the storm.
- The storm intensified further because of a strong difference in air **temperature** between the western and eastern Bering Sea.

Pieces of the Merbok "puzzle"



If only one or two of these factors had occurred, Alaska would have experienced a more typical early autumn storm with heavy rainfall. **It was the merging of all these pieces that gave Merbok its power.** Though scientists expect storms like Merbok to become more common in the future due to climate change, Merbok-like storms will still be rare since at least three of the four puzzle pieces need to occur simultaneously. This is just one way that powerful storms can come to impact the Bering Sea region.

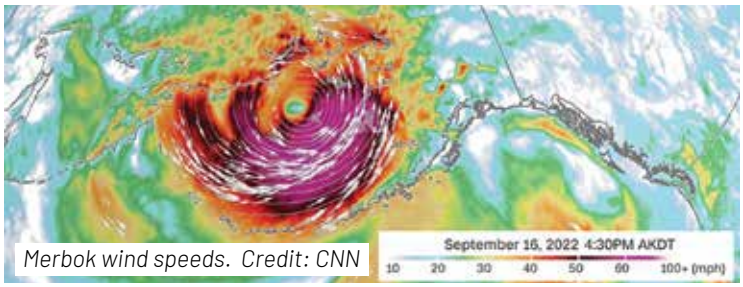
Alaska's most well-documented storm

Organizations collecting data in the Bering Sea region collaborated to provide as much information as possible before, during and in the aftermath of Merbok. As the storm approached, a coordination team and communication pathways were quickly established so that data could be processed and provided to emergency responders and the public. As a result, Merbok was the most well-documented storm event in Alaska history.

Merbok data are available to the public and will help with ongoing damage assessment and community assistance. Data will also inform storm modeling, weather forecasting and long-term community planning.

Severe flooding in Golovin after ex-Typhoon Merbok. Credit: Chrystal Fagerstrom / Alaska Division of Geological and Geophysical Surveys (DGGS)

Merbok's impacts on western Alaska



Merbok wind speeds. Credit: CNN

Marine debris washing up on shorelines was a major impact of the storm. Here, volunteers clean a beach at St. Paul Island. Credit: Aaron Lestenkof

KOYUK Ocean 13.7' above highest high tide line

NOME Ocean 9' above highest high tide line
NOME-COUNCIL ROAD Erosion & bridge damage; subsistence camp gear lost

GOLOVIN Houses floated off foundations; ocean 12.2' above highest high tide line

SHAKTOOLIK Lost protective berm; ocean 11' above highest high tide line

CHEVAK Many boats lost in flooding, greatly impacting autumn subsistence

HOOPER BAY Infrastructure damage, including tank farm; houses floated off foundations

NEWTOK Houses floated off foundations; severe erosion and infrastructure damage

Explore Merbok's evolution, flood impacts, high water marks, and data collaboration efforts that were made to aid response and recovery.
https://arcg.is/1umjSH0

A house is stuck under the Snake River bridge in Nome. Credit: Emily Schwing / Alaska Department of Transportation

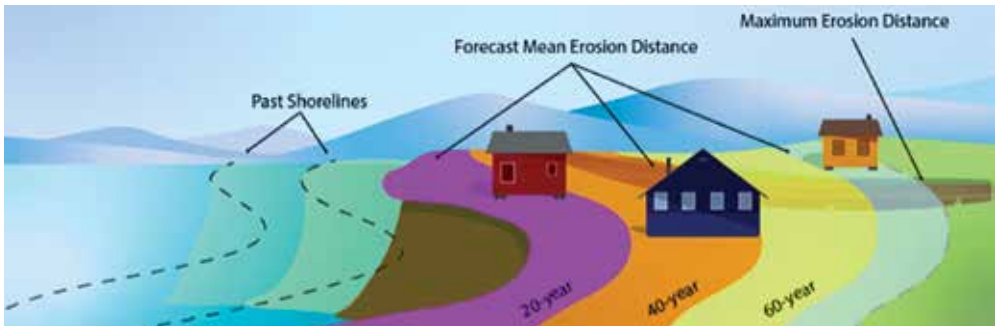
MINOR FLOODING
–Water in yards or under buildings
–Vehicles & other property flooded
–Roads & runway accessible

MODERATE FLOODING
–<1 ft water floods buildings
–People evacuated
–Access cut off to parts of town
–Airstrip closed

MAJOR FLOODING
>1 ft water floods buildings, fuel storage, power generation facilities
–Airstrip completely underwater
–Drinking water & wastewater facilities flooded

Erosion impacts on community infrastructure

Erosion is an ongoing issue for many Bering Sea communities. The erosion caused by ex-Typhoon Merbok is still being analyzed.

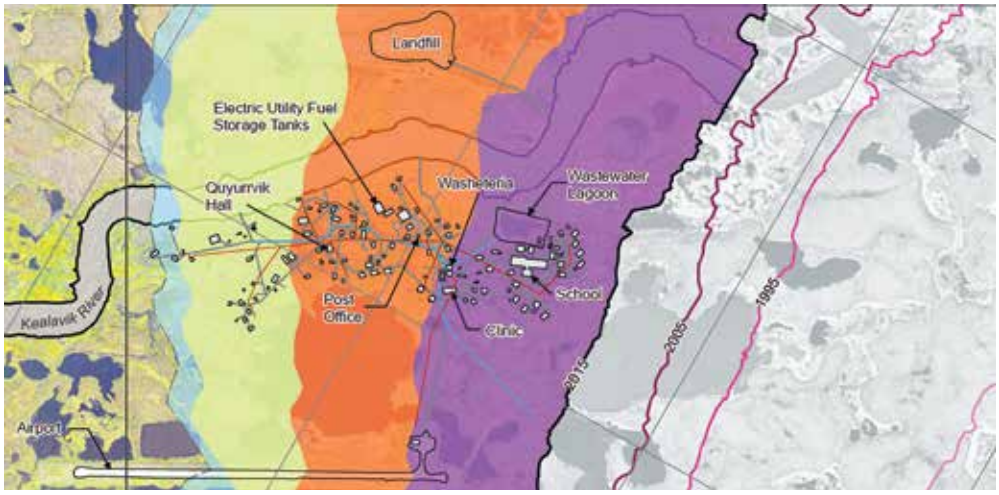


Graphic showing potential future erosion effects and creation of new shorelines over time. Graphics in DGGS reports use this color scheme.

Projected erosion impacts for Newtok

Community reports produced by DGGS contain tables and maps such as these. These tables outline which, and how much, infrastructure may be impacted as the shoreline is projected to recede over the coming decades.

Date Range	Exposed Infrastructure	Date Range	Exposed Infrastructure	Date Range	Exposed Infrastructure
2015 to 2035	**2,007** feet of power line **1,675** feet of water line **6,155** feet of roads & boardwalks **38,850** square feet of barge landing **31** buildings **1** tank facility **69,320** square feet of wastewater lagoon **220** feet of airport	2035 to 2055	**3,373** feet of power line **1,854** feet of water line **10,892** feet of roads & boardwalks **3,480** square feet of barge landing **44** buildings **1** tank facility **730** feet of airport	2055 to 2075	**1,191** feet of power line **254** feet of water line **1,347** feet of roads & boardwalks **9** buildings **1** tank facility **520** feet of airport



Projected erosion forecast map for Newtok.

Thanks to weather & climate research contributors

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Erosion impact reports

The Alaska Division of Geological & Geophysical Surveys (DGGS) has created erosion exposure assessments for the communities below, which may be useful for future infrastructure planning. Information is shown using colors and graphics similar to those on this page.

Download reports here:
https://tinyurl.com/2wvckpr2

- **Alakanuk** *Alarneq*
- **Brevig Mission** *Sitaisaq*
- **Chefornak** *Cevv'arneq / Caputnguaq*
- **Clarks Point** *Saguyaq*
- **Deering** *Ipnatchiaq*
- **Dillingham** *Curyung*
- **Eek** *Ekvicuaq*
- **Egegik** *Igyagiiq*
- **Ekuk** *Ekuk*
- **Elim** *Neviarcaurluq*
- **Emmonak** *Imangaq*
- **Golovin** *Cingik / Siŋik*
- **Goodnews Bay** *Mamterat*
- **Hooper Bay** *Naparyaarmiut*
- **Kaktovik** *Qaaktuġvik*
- **Kipnuk** *Qipnek*
- **Kivalina** *Kivaliñiq*
- **Kongiganak** *Kangirnaq*
- **Kotlik** *Qerrulliik*
- **Kotzebue** *Qikiqtaġruk*
- **Koyuk** *Kuuyuk*
- **Kwigillingok** *Kuigilnguq*
- **Levelock** *Liivlek*
- **Naknek** *Nakniq*
- **Napakiak** *Naparyarraq*
- **Newtok** *Niugtaq*
- **Nome** *Sitŋasuaq*
- **Nunam Iqua** *Sheldon Point*
- **Pilot Point** *Agisaq*
- **Point Hope** *Tikiġaq*
- **Point Lay** *Kali*
- **Port Heiden** *Masrriq*
- **Quinhagak** *Kuinerraq*
- **Scammon Bay** *Marayaarmiut*
- **Shaktoolik** *Saktuliq*
- **Shishmaref** *Qigiqtaq*
- **South Naknek** *Qinuyang*
- **St. Michael** *Taciq*
- **Stebbins** *Tapraq*
- **Teller** *Tala*
- **Togiak** *Tuyuryaq*
- **Toksook Bay** *Nunakauyaq*
- **Tuntutuliak** *Tuntutuliaq*
- **Tununak** *Tununeq*
- **Twin Hills** *Ingricuar*
- **Unalakleet** *Unalaqłiit*
- **Wainwright** *Ulġuniq*
- **Wales** *Kiŋigin*

Salmon

Yukon and Kuskokwim River Chinook and chum runs remained low in 2022, impacting subsistence harvests and food security. Agencies, many organizations and communities are working together to learn how changing environmental conditions—especially warmer temperatures—affect salmon. When possible, sampling efforts are coordinated to minimize how many fish are used for research.

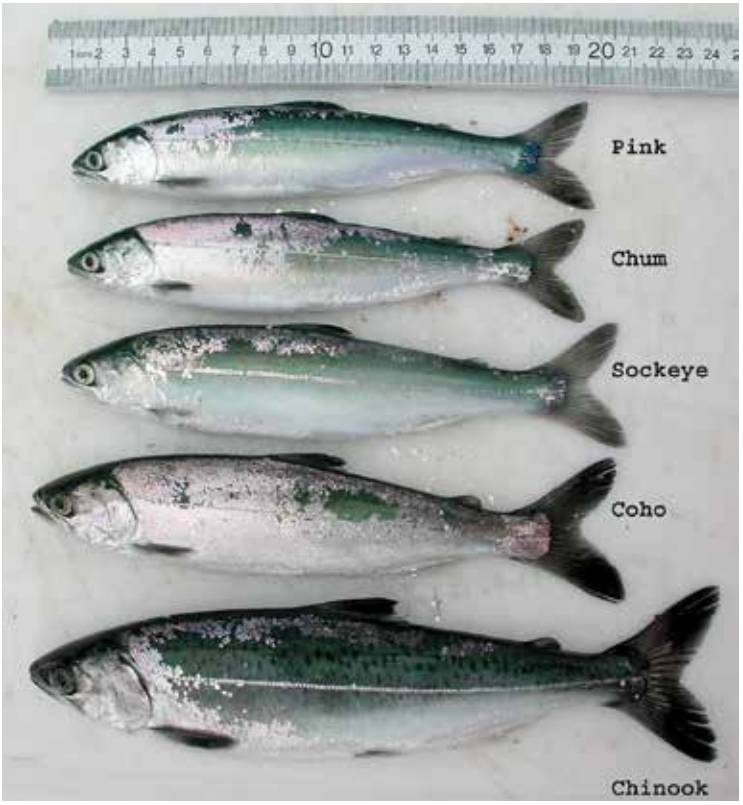
Juvenile salmon surveys

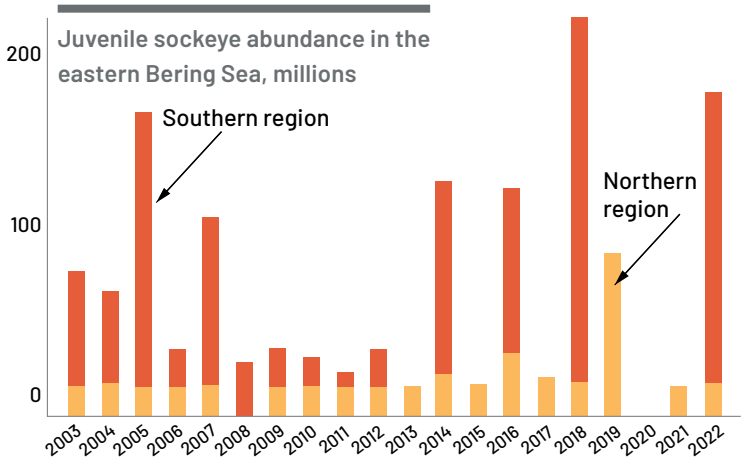
NOAA Fisheries and ADFG monitor juvenile (first year at sea) salmon from Western Alaska in the Bering Sea each September. Chinook, chum and sockeye salmon typically spend two to four years at sea.

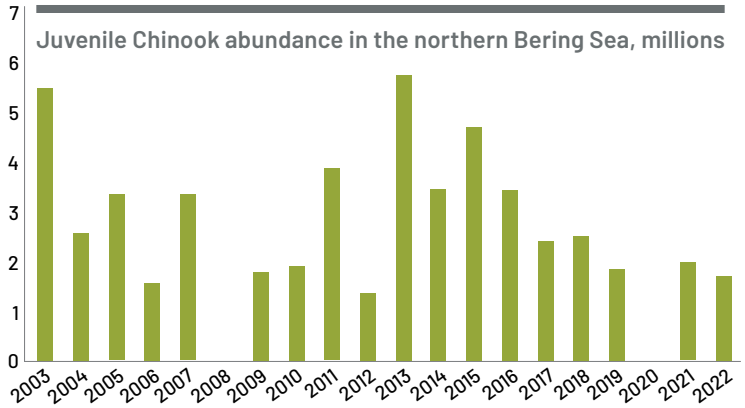
In 2022, abundance of both juvenile Chinook in the northern Bering Sea and juvenile Yukon River Fall Chum was below average. Juvenile sockeye abundance remained high in the southeastern Bering Sea.

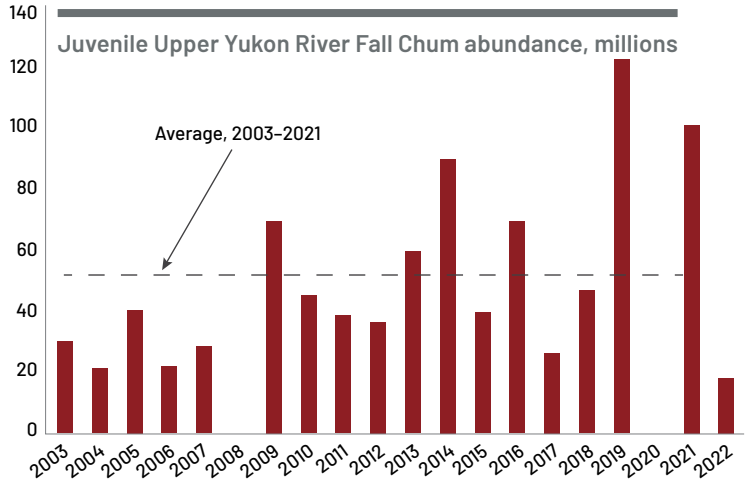
Factors affecting juvenile chum salmon

Yukon Fall Chum spend their first summer in the Bering Sea, then migrate to the Gulf of Alaska for winter. Juvenile chum survival decreased during heat waves in the Bering Sea and Gulf of Alaska. Young chum caught during that time had more empty stomachs and less fat. They were eating jellyfish and other less nutritious prey at a time when the number of high-fat zooplankton in the Bering Sea was low. Researchers are trying to learn more about their early life history to learn how ocean water temperature and prey availability may affect chum runs.









Above: Empty years on graphs mean no data were collected.
Left: Juvenile salmon at the same life stage.
Charts and photo credit: NOAA Fisheries

F/V Novarupta, July 2022. Credit: Brad Angasan

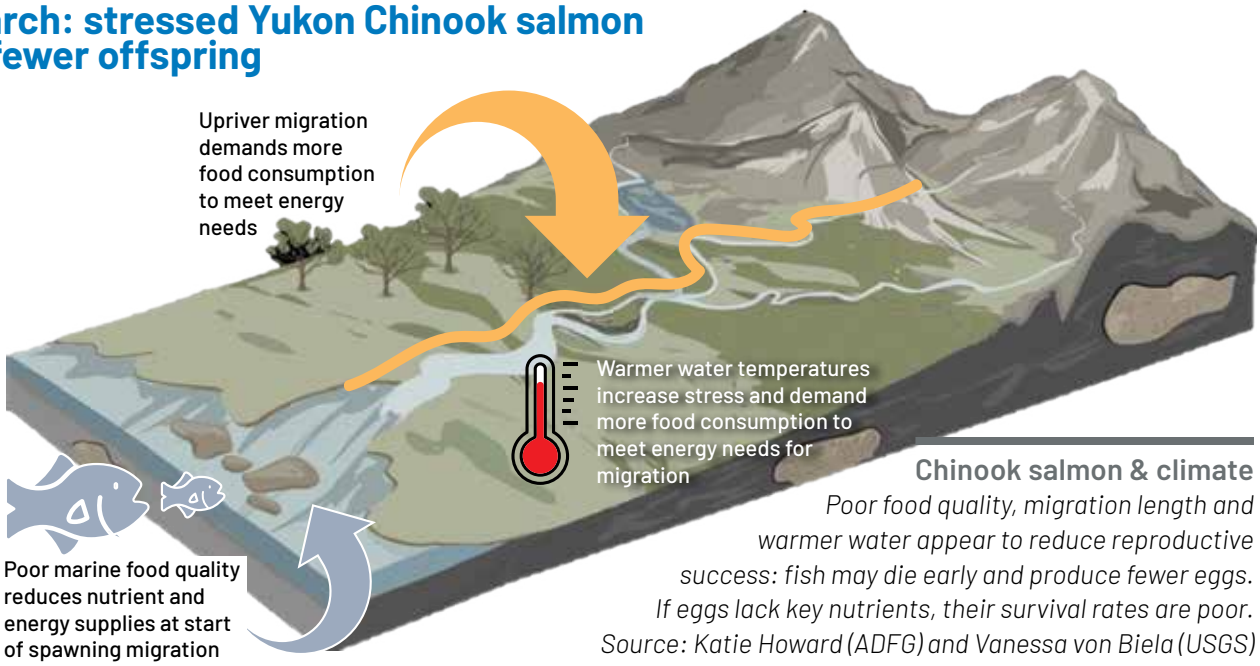
Record Bristol Bay sockeye runs in 2022

Over 79 million sockeye salmon returned to Bristol Bay in 2022—the largest run on record. Average runs in the last 20 years have been about 44 million fish. This record run size provided more than enough fish for the spawning grounds, harvest by subsistence and sport fisheries, and a commercial harvest of 60 million sockeye salmon that exceeded the previous record by 16 million fish.

Why are sockeye doing relatively well?
Juvenile sockeye use lakes—cold, deep water and more food (due to a shorter ice season) help grow healthy salmon.

Ongoing research: stressed Yukon Chinook salmon may produce fewer offspring

Warmer ocean temperatures, extremely warm river temperatures and lower river flows can affect how well salmon can acquire, store and use energy—and, ultimately, reproduce.



Chinook salmon & climate
Poor food quality, migration length and warmer water appear to reduce reproductive success: fish may die early and produce fewer eggs. If eggs lack key nutrients, their survival rates are poor.
Source: Katie Howard (ADFG) and Vanessa von Biela (USGS)

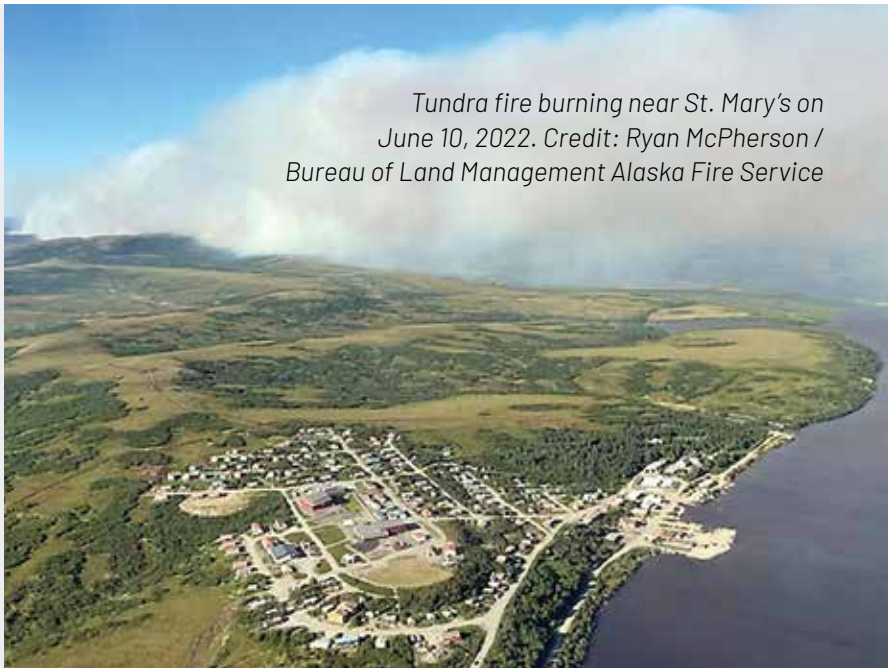
Scientists and local people are working together to test these ideas and gain a better picture of Chinook salmon declines. This work involves sampling at sea and across the Yukon basin with team work of ADFG, USGS, the Yukon River Drainage Fisheries Association (YRDFA) and NOAA Fisheries. Other collaborators include Tribal councils in Emmonak, Alakanuk, St. Mary's and Huslia, as well as Canadian partners.

Wildfire impacts on salmon?

Western Alaska had a record wildfire season in 2022. The East Fork Fire in the Andreafsky River watershed near St. Mary's was the largest wildfire in the Yukon Delta region in recorded history.

In the years following a wildfire, sunlight penetrates to ground level into burn scars, warming land and water. Warming effects are large—several degrees Fahrenheit—and last for over a decade.

On the Andreafsky River, water temperatures were already high enough to cause heat stress in Chinook salmon before the wildfire, so further warming could reduce the survival of spawning adults or eggs in coming years.



Tundra fire burning near St. Mary's on June 10, 2022. Credit: Ryan McPherson / Bureau of Land Management Alaska Fire Service

Ichthyophonus infecting salmon

Ichthyophonus has infected many species of fish worldwide, including Yukon River Chinook salmon. The disease is caused by a parasite. Infected fish have white lesions on their flesh and hearts. Subsistence fishers reported increasing presence of Ichthyophonus in 2020 and in 2021, prompting a study to better understand how many fish could be dying from the disease prior to spawning. Preliminary results from fish sampled on the Yukon River show an increase in Ichthyophonus in 2022. The study will continue for two more years.

White spots of Ichthyophonus on a salmon heart. Credit: Jayde Ferguson / ADFG

Credit: Bering Sea Fishermen's Association

Local knowledge of Yukon River salmon

Projects that share western science and Indigenous knowledge will help us better understand how climate impacts Chinook and chum. In a new study, YRDFA will facilitate interviews with experienced fishers and processors in Emmonak and Alakanuk. They will be asked about their observations of Chinook and chum harvested at the mouth of the river. Their knowledge of the health, condition and run timing of the fish will help us better understand the historic and current health of Chinook and the effects of their marine diet.

YRDFA is also working with residents of St. Mary's and Huslia to develop community capacity to help in understanding the decline in Yukon River salmon. This includes water temperature monitoring, coordinating local data collection for annual carcass surveys, and creating a rapid community response plan to assess salmon die-off during a heat event. This work will increase local hire and training on salmon related research.

Thanks to salmon section contributors

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- **Vanessa von Biela,** USGS, vvonbiela@usgs.gov

Fisheries disaster declarations

ADFG is responding to fisheries disaster requests and developing spending plans for federal disaster relief funds.

Disasters have been declared and funds announced for:

- 2019 Norton Sound red king crab ($1,433,137)
- 2019/2020 Eastern Bering Sea tanner crab ($12,935,199)
- 2020 Norton Sound, Yukon River, Kuskokwim River and Chignik salmon; and 2021 Yukon River salmon (part of $55,928,849 for statewide salmon disasters)

Disasters have been approved for:

- 2020 and 2021 Norton Sound red king crab
- 2021 Kuskokwim River, Norton Sound and Chignik salmon
- 2021–2022 and 2022–2023 Bering Sea crab

A request for the 2022 Yukon River salmon fishery is pending. Find updated information at these websites:

- ADFG Federal Fisheries Disasters
- NOAA Fisheries Fisheries Disaster Determinations

Fishing boats wait for an opener in Chignik's city harbor in 2019. The 2020 Chignik salmon fishery was one of 14 Alaska fisheries disasters declared by the federal government. Credit: Alex Hager / KDLG

Disclaimer

We have done our best to provide balanced, synthesized and easy to understand current perspectives on crab, HABs, seabirds, weather & climate, and salmon in the Bering Sea Region. We provide a "sampler" of research happening on each topic, though much more work is being done than can be covered here.

Although state and federal management agencies, Tribal and science organizations generously contributed research information to this report, *Bering Science* is primarily meant for science outreach and is not part of any official management process. It is not comprehensive and does not take the place of official documents like the NOAA Ecosystem Status Reports.

Your opinion is important to us and can help guide future reports.
Please share your comments by mailing the postcard in this report, or by completing a brief online survey at www.surveymonkey.com/r/BeringScience2023. Thank you!

A vast slough in the Yukon Delta National Wildlife Refuge.
Credit: Fred Broerman / U.S. Fish and Wildlife Service