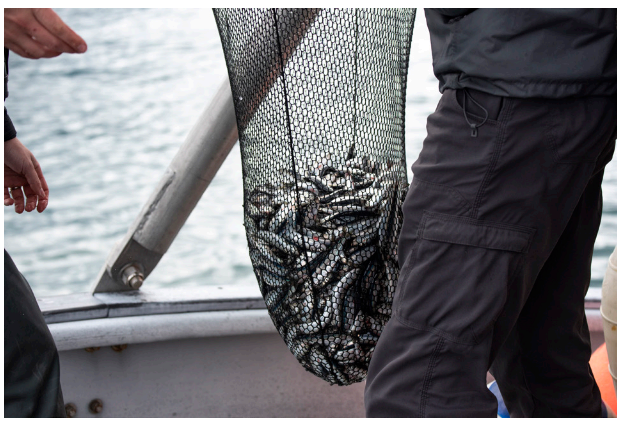
STATE OF KACHEMAK BAY

HIGHLIGHTS FROM LONG-TERM MONITORING AND RESEARCH IN KACHEMAK BAY, ALASKA



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NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

NOAA/NCCOS KASITSNA BAY LABORATORY
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PARTNERS & SUPPORT

The "State of Kachemak Bay" is produced regularly by the NOAA Kasitsna Bay Laboratory, with contributions from many partner organizations, to highlight recent findings from marine ecosystem monitoring, resource management, and research activities in our area. We'd appreciate your comments, suggestions, and additional topics of interest for future editions. Please send questions and comments to Karyn.DeCino@noaa.gov.

Partners who contributed highlights and data from the past couple years to this report include: Kachemak Bay National Estuarine Research Reserve (NERR), NOAA National Weather Service, USDA Natural Resources Conservation Service, US Geological Survey, US National Park Service, University of Alaska Fairbanks, University of Alaska Anchorage, Cook Inlet Aquaculture Association and Center for Alaskan Coastal Studies.

Funding organizations who supported highlighted activities include: Alaska Ocean Observing System, National Science Foundation (Alaska Established Program to Stimulate Competitive Research or EPSCoR, Fire and Ice Project) and Exxon Valdez Oil Spill Trustee Council (Gulf Watch Alaska long-term ecosystem monitoring program).

NOAA KASITSNA BAY LAB: KEEPING TABS ON THE BAY

NOAA Kasitsna Bay Laboratory conducts and hosts research on Gulf of Alaska coastal habitat, ocean and ecosystem changes due to climate change, harmful algal blooms, ocean acidification, oil spills and human activities. We also help synthesize multidisciplinary data from many different organizations, as well as local and traditional knowledge, to help Kachemak Bay communities better understand and respond to marine ecosystem and resource changes. One of our goals is to make coastal data and science results more readily available for decision-making by coastal managers and the public, including through the "State of Kachemak Bay" reports.

NOAA Kasitsna Bay Lab is part of the National Centers for Coastal Ocean Science (NCCOS) under NOAA's National Ocean Service. NCCOS delivers ecosystem science solutions for stewardship of the nation's ocean and coastal resources, to sustain thriving coastal communities and economies. NCCOS partners with the University of Alaska Fairbanks on Kasitsna Bay Lab operations, research and marine education in Kachemak Bay and Cook Inlet.

For more information about NCCOS and Kasitsna Bay Lab: Kris.Holderied@noaa.gov and https://coastalscience.noaa.gov/about/facilities/alaska

Check out the NCCOS Kachemak Bay Ecological Assessment Storymap:
https://storymaps.arcgis.com/stories/7f72bae5d8a34df583a29bac2cec3109

Photo credits cover page: Dr. Brenda Konar, College of Fisheries and Ocean Sciences, University of Alaska Fairbanks; Sarah Schoen, US Geological Survey; NOAA Kasitsna Bay Lab staff

GOING WITH THE FLOW

Satellite-tracked drifter buoys are being deployed by NCCOS Kasitsna Bay Lab researchers to measure surface and subsurface currents in Kachemak Bay. A buoy was deployed at 15 meters (45 foot) depth south of Nanwalek in August 2022, and subsurface currents brought it into the bay, while moving back and forth with the tide. The buoy moved into the bay faster than expected – in the outer bay it moved so fast that it was slowed down, but not turned around by the ebb tide! By contrast, surface waters in the bay tend to flow out of the bay relatively quickly. Learn more: kris.holderied@noaa.gov

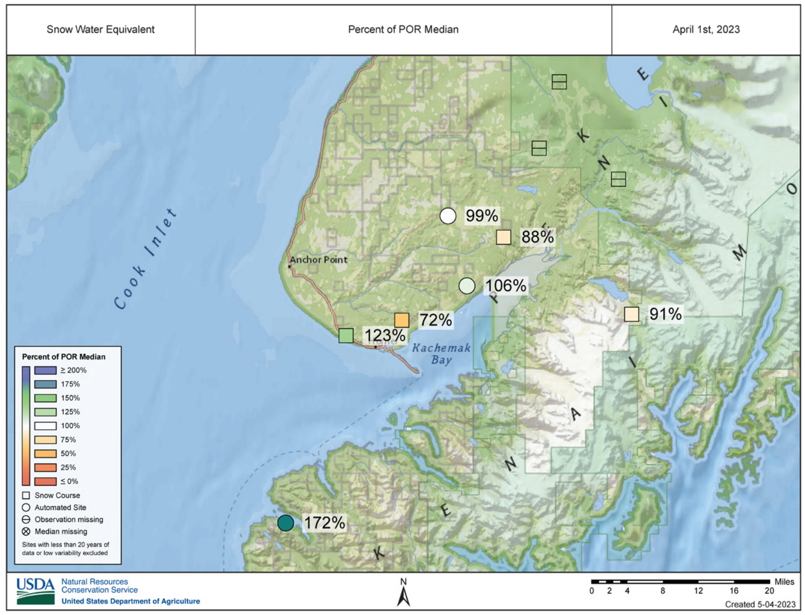
Drifter buoy deployment

Drifter buoy track

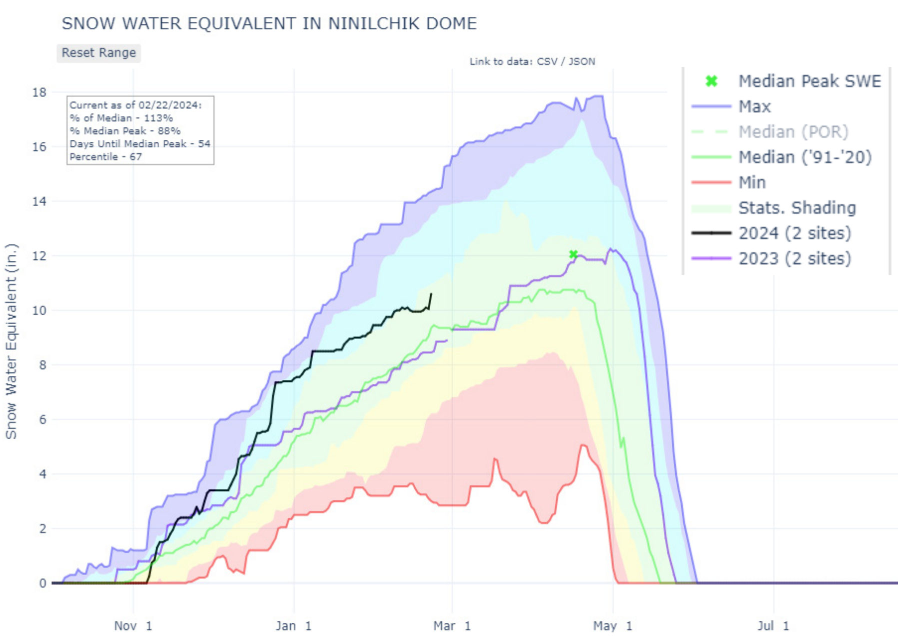
Track of drifter buoy moving into the bay at 15 meters below the surface. Crosses show buoy location every 30 minutes.

A WINTERY MIX

For the 2023 snow year, which runs from fall 2022 to spring 2023, the snowpack around Kachemak Bay was mixed. Similar to other stations near Cook Inlet in Southcentral Alaska, the stations reporting the most SWE compared to Normal are the ones at lower elevations. Port Graham at 300 feet Above Sea Level (ASL) was reporting 172% Period-of-Record Median on April 1; Demonstration Forest, 780 feet ASL, was measured at 123%. These were the beneficiaries of snow to sea level storms in December and February, and preserved by colder than normal temperatures in February and March. Heading up in elevation and back to the head of the bay, snowpack is less outstanding, with stations reporting Normal to below Normal SWE on April 1. Learn more: https://www.nrcs.usda.gov/wps/portal/nrcs/ak/snow/



April 1, 2023 Snow Water Equivalent (SWE) measurements compared to Period-of-Record Median from all the reporting stations around Kachemak Bay.



2023 and 2024 Snow Water Equivalent measurements for the McNeil Canyon and Anchor River Divide stations. The snowpack for 2024, shown in black, is currently above Normal.

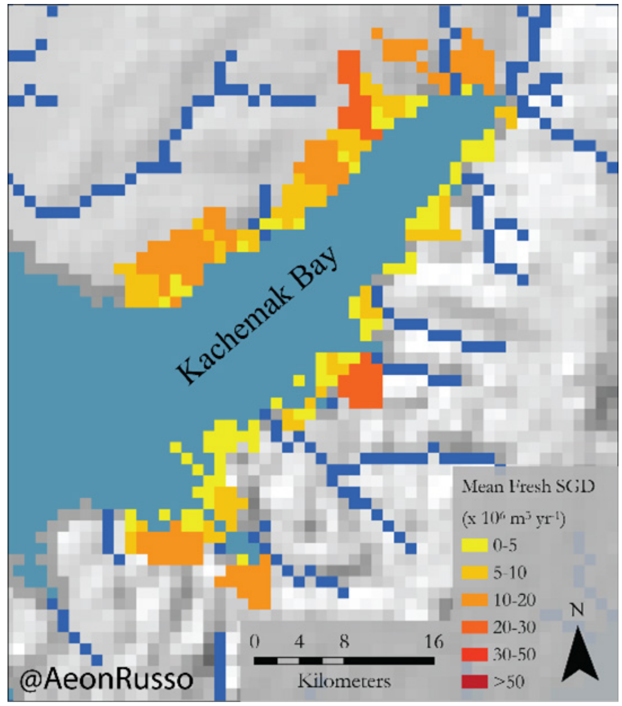
United States Department of Agriculture
Natural Resources Conservation Service

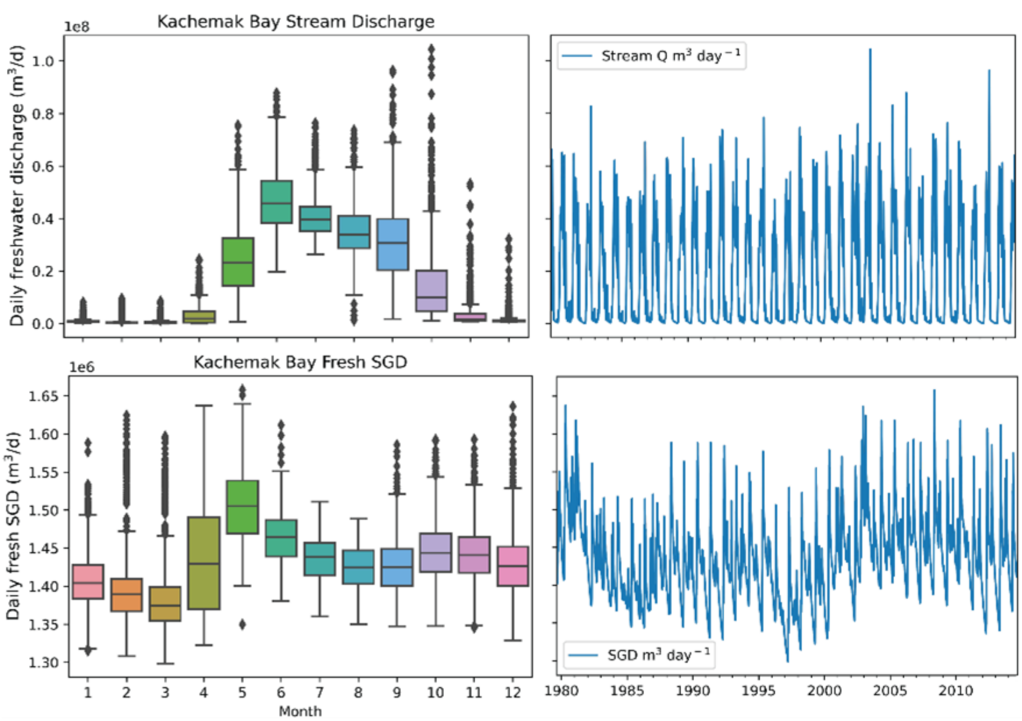
EBiking on trails around Homer.

COASTAL GROUNDWATER

We estimate fresh submarine groundwater discharge (fresh SGD) from coastal catchments along Kachemak Bay using a lumped parameter water balance model that accounts for water budgets within the top soil, sub soil, and aquifer to represent the main processes of soil-aquifer interactions therein. We compare our model results to stream discharge results from the Beamer et al. (2016) Gulf of Alaska freshwater discharge model. We find that fresh SGD contributes 7.7% of the total freshwater flux into Kachemak Bay. Although this may seem like a small contribution, coastal groundwater is known to be enhanced with respect to nutrients and solutes when compared to nearby riverine sources. This suggests that groundwater may be a critical player in near-shore marine chemistry and the ecosystems that thrive from these inputs. Another important finding is that fresh SGD is a sustained contribution throughout the year, whereas rivers mainly contribute during the melt season and into the fall with the onset of the rainy season. Estimates of fresh SGD at high latitudes are currently severely understudied, and Kachemak Bay is an ideal site to begin exploring these coastal groundwater processes. Stay tuned for more!

To learn more, please contact Dr. LeeAnn Munk with the University of Alaska, Anchorage, at lamunk@alaska.edu.





Map and plots showing the relative contributions of freshwater discharge from streams and groundwater seeps to Kachemak Bay, Alaska. Major streams draining from larger watersheds are shown in blue on the map. The areas between these watersheds are the coastal groundwater catchments from which fresh submarine groundwater discharge (fresh SGD, shown in yellow to red) contributes to the freshwater flux. The left panel provides box plots showing the median daily discharge by month, the 25th/75th quartile, and the 10th/90th quartile for both the stream contribution and the fresh SGD contribution. Note the difference in y-axes scale. The right panel provides daily discharge from 1979-2014 for combined streams (top) and combined groundwater seeps (bottom) draining into Kachemak Bay.

TUTKA BAY LAGOON HATCHERY ENVIRONMENTAL OBSERVATIONS

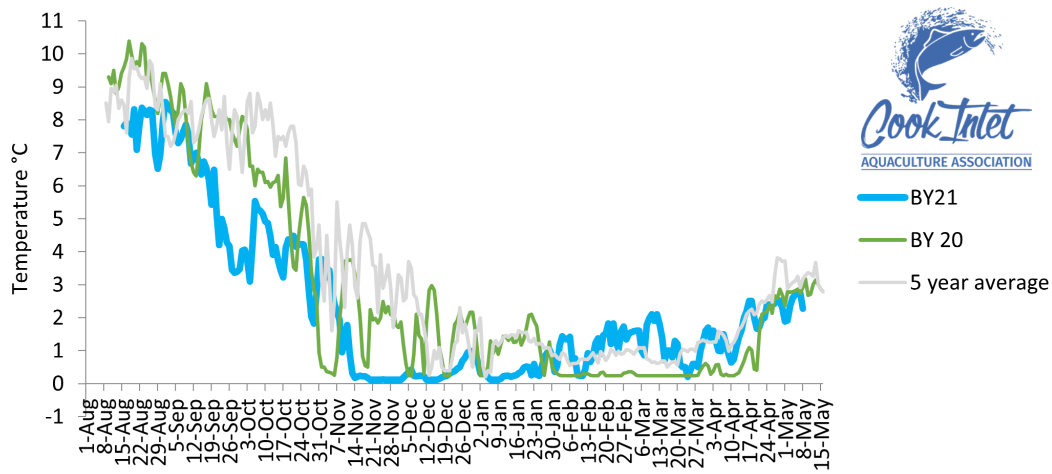
The Cook Inlet Aquaculture Association (CIAA) routinely monitors water temperatures at two sites, as part of hatchery operations. Results from two recent cold winters are shown for Tutka Creek (top plot) and Tutka Bay Lagoon (middle plot), and compared to water temperatures from a Kachemak Bay NERR monitoring station at Seldovia harbor. In the CIAA figures, BY 21 is August 2021 to May 2022, and BY 20 is August 2020 to May 2021.

Seldovia harbor temperatures are warmer than both Tutka sites throughout the year, likely due to a greater influence of the ocean at Seldovia in winter months and the effect of cold freshwater runoff in Tutka Bay in summer months. Interestingly, the fall 2021 waters were relatively cold at both Tutka Creek and Seldovia harbor, but relatively warm in the lagoon, compared to other years.

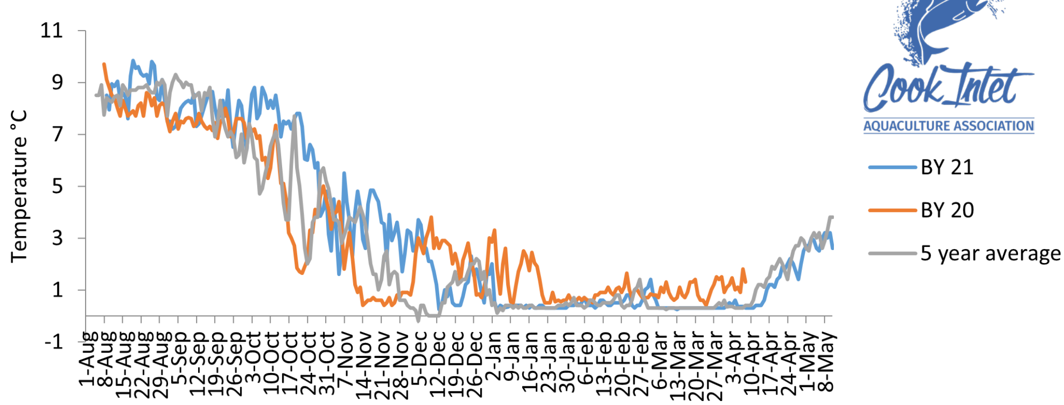
The more normal seasonal temperature patterns of 2022-2023 are also shown for Seldovia.

For more CIAA information, data and reports: https://ciaanet.org/reports/

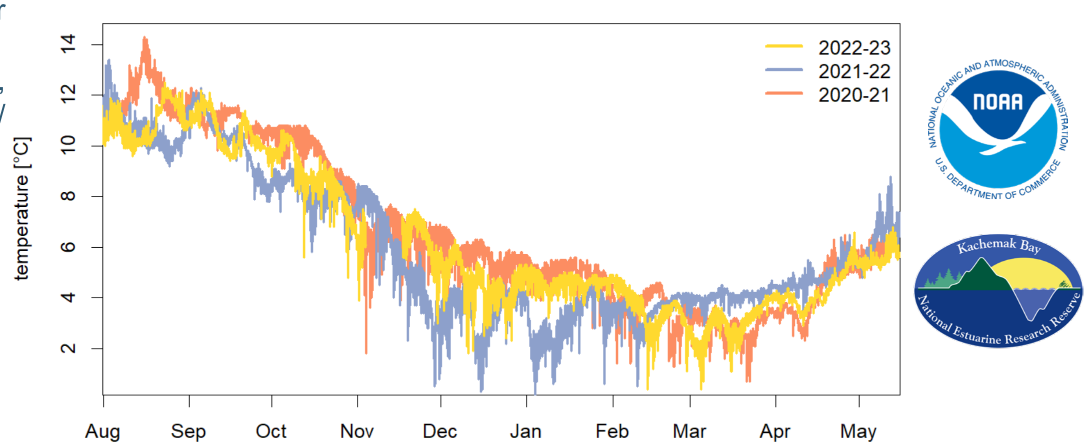
Tutka Creek Temperatures at Tutka Bay Hatchery



Tutka Bay Lagoon Temperatures at Tutka Bay Hatchery



Seldovia Surface Water

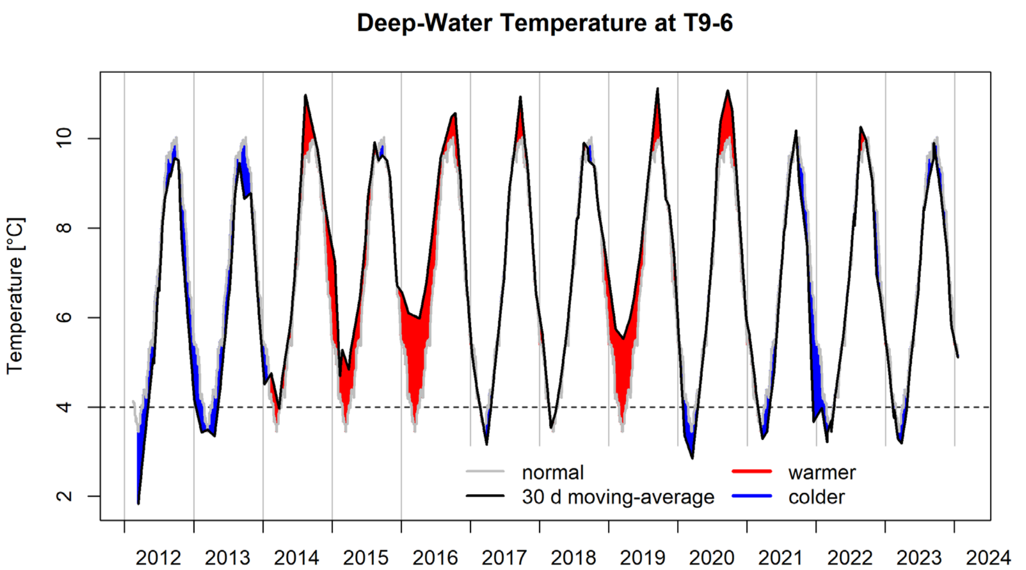


Surface water temperature from Kachemak Bay NERR water quality monitoring station in Seldovia harbor.

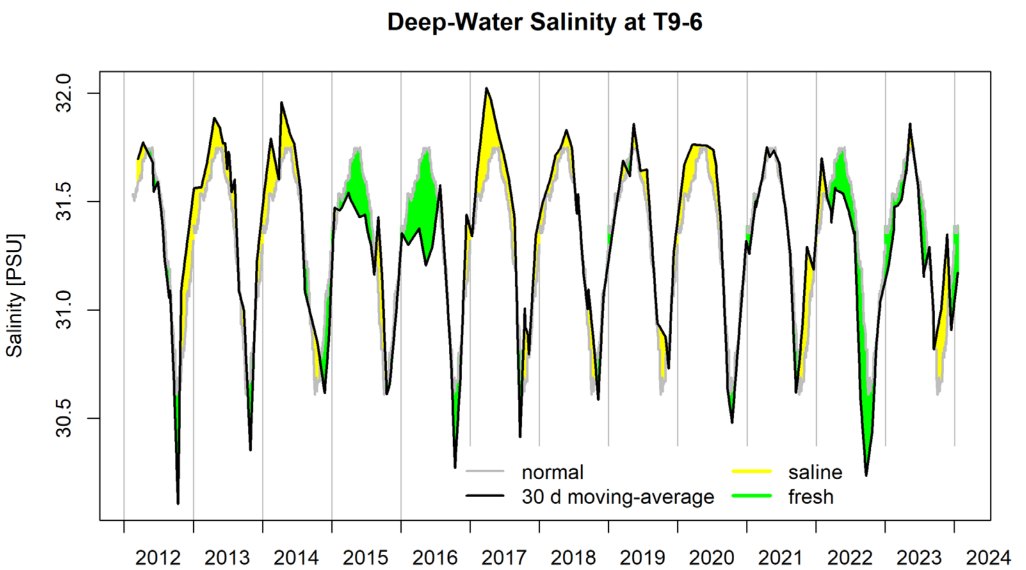
TRACKING CHANGES IN KACHEMAK BAY “WATER HABITAT”

Monthly oceanography surveys are conducted in Kachemak Bay and southeast Cook Inlet by NCCOS Kasitsna Bay Lab researchers, continuing routine “water habitat” monitoring that has been done since 2012. Vertical measurements of water column temperature, salinity and other parameters are made at repeated stations on lines along and across the bay. See the map on the back of this report for sampling locations.

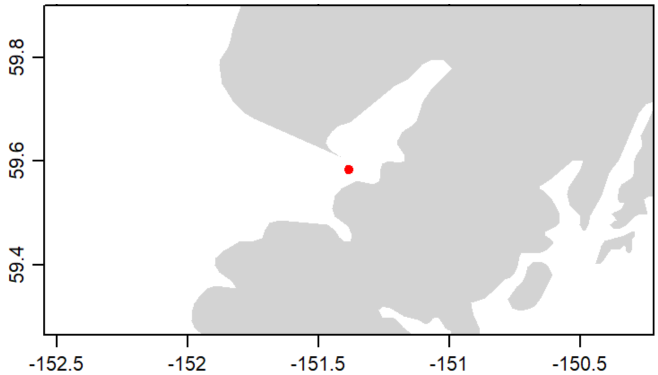
Bay conditions can differ considerably with depth, as freshwater runoff affects the surface layer and intrusions of ocean water keep deeper waters relatively salty all the way to the head of the bay. Shown here are plots of monthly water temperature and salinity for deeper waters at the mid-bay station, as compared to long-term means. The deeper bay water temperatures were remarkably close to average for 2022 and 2023, after often being warmer than normal during 2014-2020. Wet weather in 2022 produced fresher than normal conditions in the bay, while salinities were closer to normal, but also more variable in 2023. Learn more: kris.holderied@noaa.gov, martin.renner@noaa.gov



Mid-bay station time series of temperature with warm (red) and cold (blue) differences from average



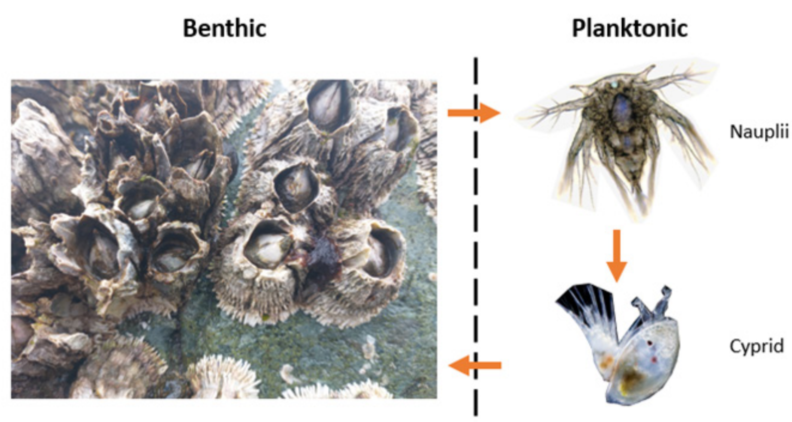
Mid-bay station time series of salinity with salty (yellow) and fresher (green) differences from average



Location of mid-Kachemak Bay oceanography station (T9-6)

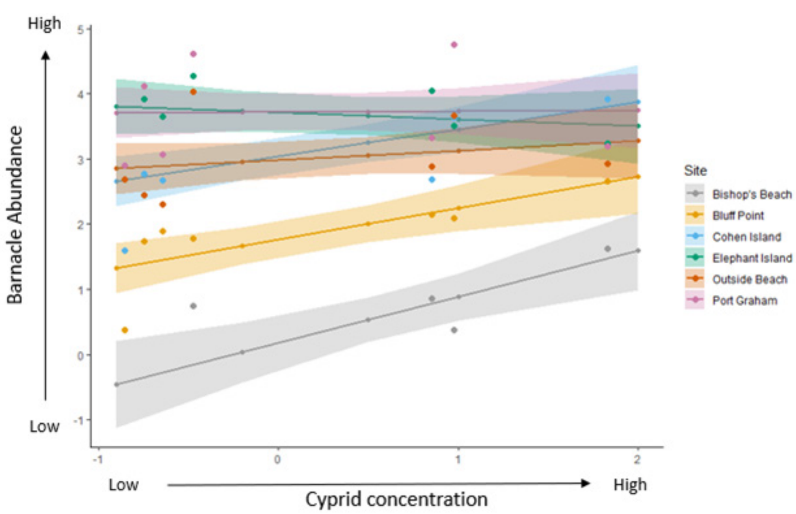
LOCATION, LOCATION, LOCATION: EFFECTS OF LARVAL SUPPLY VERSUS PREDATORS DEPENDS ON WHERE BARNACLES LIVE

Barnacles encrusting rocks in the intertidal are a common sight at many beaches throughout Alaska. However, they also have two microscopic planktonic larval stages: a feeding nauplii stage and a non-feeding cyprid stage. Nauplii hatch out of broods in late winter or spring and float through the water column for a few weeks before transforming into the final cyprid stage, then settling to the bottom and attaching to a rock. Barnacle populations are affected by competition for space to settle, predation by a variety of predators from snails to bears, and by physical stressors that range in scale from oceanic heatwaves to localized ice scour. However, the supply of larvae may also influence the adult barnacle abundance.

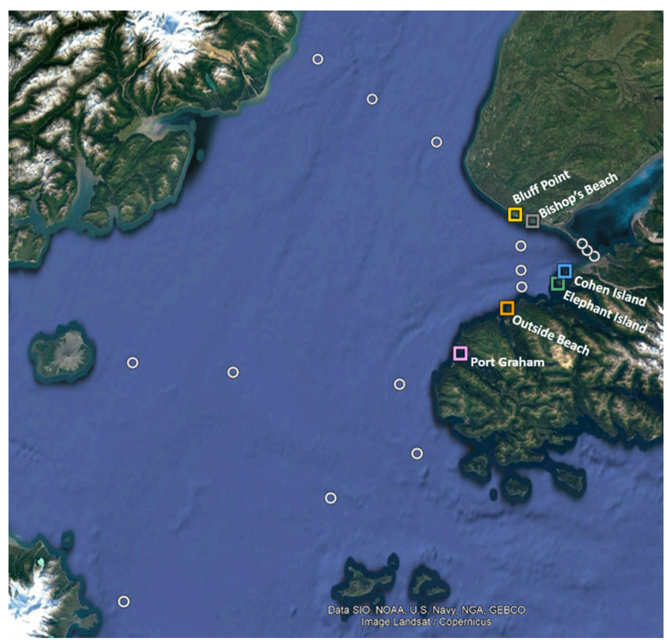


Schematic of barnacle life cycle.

We found that high nauplii concentration in a given year tended to lead to higher barnacle abundance in the following year in the lower intertidal at six sites in Kachemak Bay. However, the effect of cypríd concentration varied among sites. At the two sites on the outer north coast of Kachemak Bay, which generally have low barnacle abundance, there was a strong positive effect of cyprids, meaning that years with higher cyprid concentration were associated with high barnacle abundance. The other four sites on the south coast were not as strongly affected by cyprid concentration. At these sites, predatory snails such as *Nucella* spp. are much more abundant, and they tend to increase in numbers with increased barnacle abundance. It appears that the relative importance of larval supply versus predator abundance varies among locations. Learn more: straiger@usgs.gov



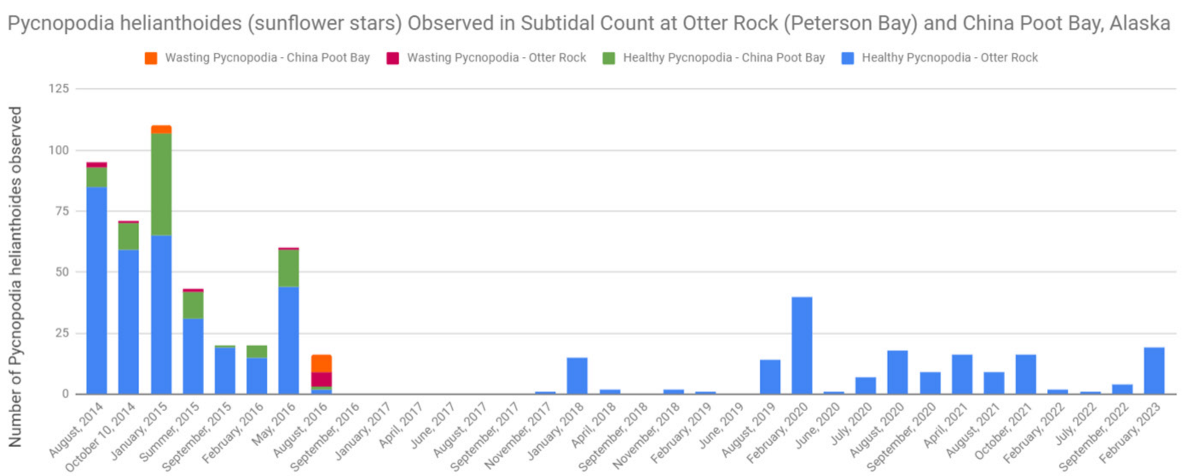
Relationships between barnacle cover and cyprid concentration. Each point represents the barnacle abundance at one site in one year and the corresponding cyprid concentration summed across all stations in that year. The lines on the plot represent the modeled effect of cyprid concentration on barnacle abundance and the shading represents the degree of uncertainty around the estimate. Colors correspond to the intertidal sites on the map.



Barnacle concentrations from all stations (white circles) were summed in each year to compare to barnacle percent cover at the rocky intertidal monitoring locations (colored squares).

HOW ARE SUNFLOWER STARS (*PYCNOPODIA HELIANTHOIDES*) DOING IN KACHEMAK BAY?

Sunflower stars (*Pycnopodia helianthoides*) were recently proposed to be listed as threatened under the Endangered Species Act. These stars have been heavily impacted by sea star wasting syndrome, with the most significant impacts occurring in the southern portion of their range: Mexico, California, and Oregon. In Kachemak Bay, Coastal Studies, along with community members and researchers, noted a major die-off of sunflower stars in August and September of 2017. In addition to the areas that Coastal Studies regularly surveys (China Poot Bay and Otter Rock in Peterson Bay), we have personally observed large *Pycnopodia helianthoides* in Tutka, Jakolof, and Kasitsna Bays in the past year and have heard similar reports from others. Their populations seem to be recovering at a slow to moderate pace in Kachemak Bay, with different recovery trajectories in different areas.



SEA STAR SPECIES COME AND GO?

Each spring, hundreds of K-12 students help Coastal Studies educators to document the presence or absence of various intertidal species using a “biodiversity checklist”. Almost two decades of records illustrate an interesting story of which sea star species have been reasonably common in the Otter Rock and China Poot Bay area over time. Please keep in mind, presence indicates that this sea star species was recorded at least once, in at least one location near the Peterson Bay Field Station in that year. If the species is listed as absent, it was not recorded by students and educators in that year, indicating that it was either truly absent or very uncommon.

Species	Pre-2013	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Dermasterias imbricata	P	P	P	P	P	P	P	P	P	P	P
Henricia spp.	P	P	P	P	P	P	P	P	P	P	P
Leptasterias spp.	P	P	P	P	P	P	P	P	P	P	P
Evasterias troschelii	P	P	P	P	P	P	P	P	P	P	P
Orthasterias koehleri	P	P	P	P	P	A	P	P	P	P	P
Solaster stimpsoni	P	P	P	P	P	P	A	P	P	P	P
Solaster dawsoni	P	P	P	P	P	A	P	P	A	A	P
Crossaster papposus	P	P	P	P	P	A	A	A	A	A	A
Asterias amuerensis	A	A	A	A	A	A	P	A	A	P	P
Pisaster ochraceus	A	A	A	A	A	A	P	P	P	P	P

Three notable stories emerge from these data. First, the impact of the 2016 sea star die-off is apparent in Red-Banded Stars (*Orthasterias koehleri*), Stimpson’s Sun Stars (*Solaster stimpsoni*), and especially Morning Sun Stars (*Solaster dawsoni*). Most dramatically, Rose Stars (*Crossaster papposus*), have not been documented in these locations by Coastal Studies educators or students since 2016. These biodiversity checklists also reveal the consistent occurrence of *Pisaster ochraceus* from 2018-present. This is a dramatic change, as they were not recorded in biodiversity checklists at these locations a single time prior to 2018. Learn more: katieg@akcoastalstudies.org

EXPLORING DRIVERS OF COMMUNITY CHANGE IN ALASKAN INTERTIDAL COMMUNITIES

Ecological communities naturally change over time, but sudden or high magnitude changes in community composition can be an indicator of stress in response to an environmental impact. In Alaska and other high latitude coastal environments, climate warming is causing glaciers to melt faster than they did historically. The resulting increase of cold, sediment-laden freshwater entering nearshore systems can alter a wide array of water characteristics, which will likely have ecosystem-wide impacts. Fluctuation in community composition can be affected by environmental conditions as well as by changes in habitat forming, spatially dominant species (i.e., mussels (*Mytilus trossulus*), barnacles (*Balanus* spp.), and rockweed (*Fucus* spp.)

One study being conducted at nine intertidal sites within two regions in the Gulf of Alaska (Kachemak Bay and Lynn Canal) is investigating which environmental conditions have the greatest effect on community variability in glacially influenced estuaries. Environmental and intertidal community characteristics were recorded at each site monthly from spring to fall for 2019 through 2022, with Kachemak Bay sampling conducted by University of Alaska Fairbanks researchers and graduate students working from NOAA Kasitsna Bay Lab. Preliminary results show that smaller substrates like sand and cobble are associated with higher variability levels. Additionally, communities are less variable when there is a greater coverage of spatially-dominant species like mussels, barnacles, and rockweed. By learning what drives community variability in this region, we can gain a better understanding of how these communities may be affected by the progression of climate change. More information on this five-year University of Alaska project can be found on the project website: https://www.alaska.edu/epscor/fire-and-ice/coastal-margins-team/. Contact: Maddi McArthur, University of Alaska Fairbanks.

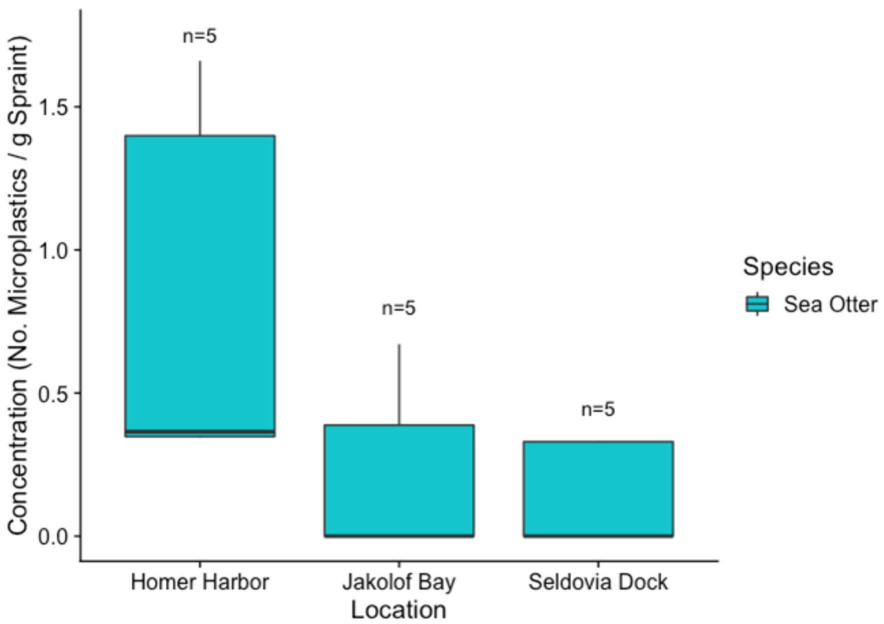
UAF UNIVERSITY OF ALASKA FAIRBANKS

Rocky intertidal environments in Kachemak Bay include changing combinations of rockweed, mussel, barnacle, and bare rock cover in the upper intertidal zone.

MICROPLASTICS IN RIVER AND SEA OTTER SPRAINT FROM KACHEMAK BAY

Introduction: Microplastics are a ubiquitous contaminant that is increasing found in both marine and terrestrial ecosystems. Microplastics enter the ocean through a variety of ways where they are ingested by organisms and passed up through the food web. While microplastics are known to cause many negative health effects, no study has been done on northern sea otters (*Enhydra lutris kenoyi*) or North American river otters (*Lutra canadensis*). Otter feces, referred to as spraint, provides a way to assess microplastic ingestion without harming or interacting with the otters. For this project, I aimed to assess microplastic presence in sea otter and river otter spraint.

Methods: I collected spraint samples from four coastal locations of Kachemak Bay (Homer harbor floats, Kasitsna Bay laboratory dock, Jakolov dock, and the Seldovia docks) using metal scoops and glass vials. Once at the laboratory, I weighed and homogenized the samples in a 3:1 ratio of 10% potassium hydroxide solution to break down the spraint sample. The samples were then incubated at 60 ºC for 24 hours before being vacuum filtered onto glass microfiber filters. Finally, I examined the filters with a stereomicroscope at 40X magnification, counted all microplastics, and calculated both frequency of occurrence (FO, percent of samples that contained microplastics) and microplastic concentration.



Results: Sea otters had a microplastic FO of 60% while the FO for river otters was 29%. There was no significant difference in microplastic concentration between sea and river otters. However, sea otters at Homer harbor on the north side of the bay had significantly higher microplastic concentration than those at the Seldovia docks on the south side of the bay (Figure on left).

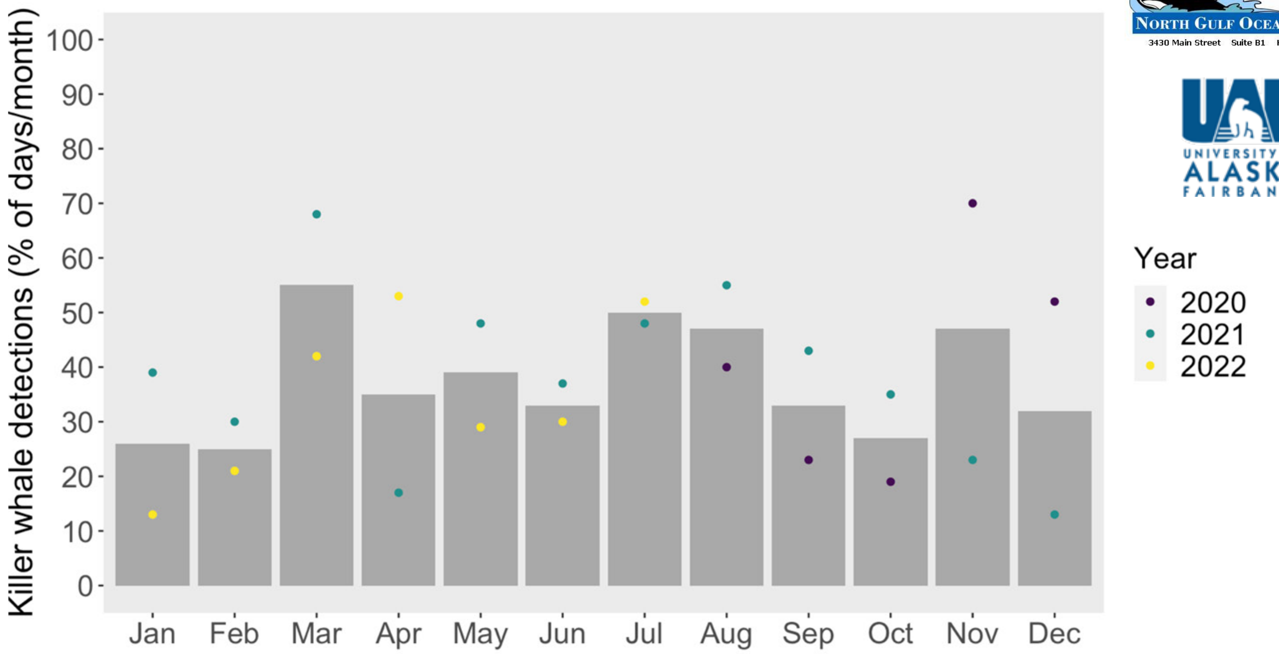
Conclusion: While both sea and river otters in Kachemak Bay are ingesting microplastics, additional sampling is needed with a comparison on prey items ingested to better understand the movement of microplastics through the food web.

Learn more: alsletten@alaska.edu

UNIVERSITY OF ALASKA FAIRBANKS

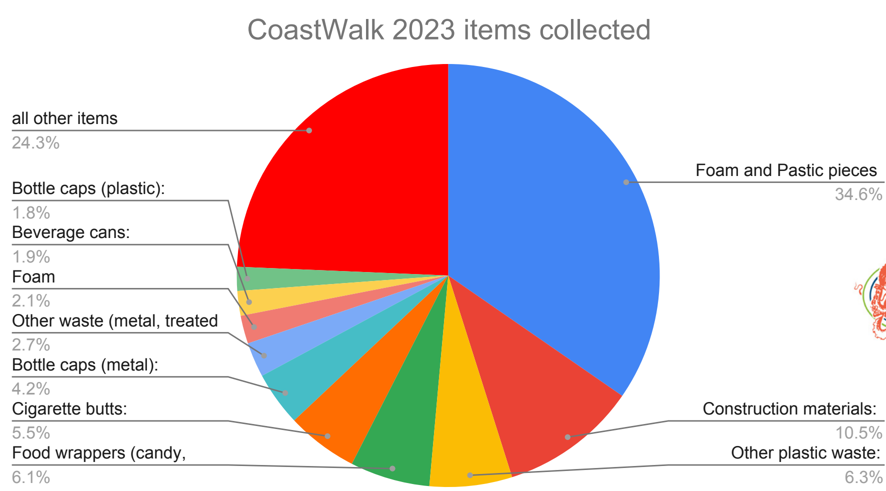
LISTENING FOR KILLER WHALES IN KACHEMAK BAY

Researchers with the University of Alaska Fairbanks and North Gulf Oceanic Society have been listening for killer whales in Kachemak Bay since August 2020 with a hydrophone deployed off the west side of Yukon Island. This figure shows the percent of days per month that killer whales were acoustically detected on average (bars) and for each year (points). Through long-term acoustic monitoring, we plan to uncover seasonal presence and density patterns for fish-eating (resident) and mammal-eating (transient) killer whales in this area.
Learn more: hmyers8@alaska.edu.



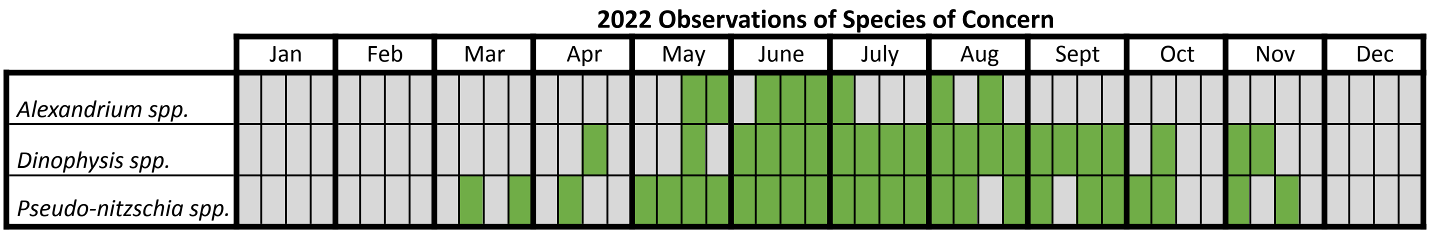
KACHEMAK BAY COASTWALK 2023

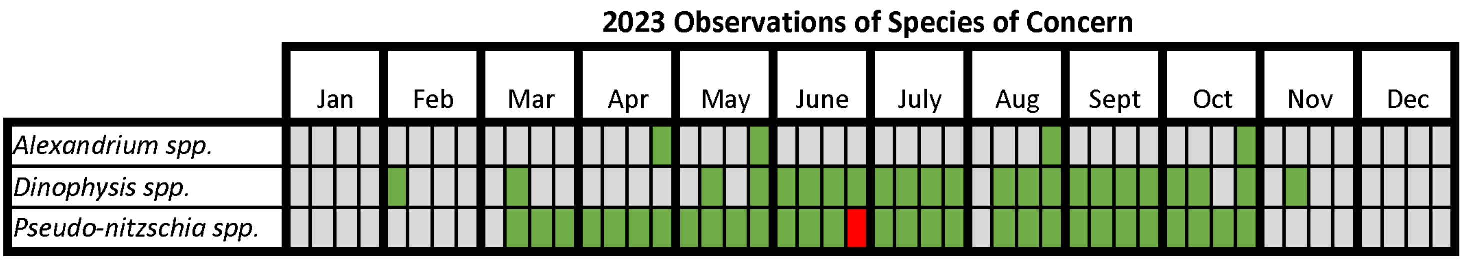
As a part of CoastWalk cleanups in 2023, 454 volunteers removed 1,836 pounds of debris, consisting of 12,778 items, from the beaches of Kachemak Bay. Several cleanups resulted in the removal of over 100 pounds of debris, with cleanups on the Homer Spit, Bishop's Beach, Glacier Spit, and Seldovia being the heaviest cleanups. The heavy cleanups in many cases resulted from large or particularly heavy items being removed, but most cleanups removed numerous small items, with cleanups at Glacier Spit and Diamond Creek recording over 1,000 pieces of Styrofoam. Small pieces, particularly Styrofoam, continue to be a major and difficult source of debris on Kachemak Bay beaches. Learn more: https://www.akcoastalstudies.org/outreach/international-coastal-cleanup.html



HARMFUL ALGAL BLOOMS (HABS)

Phytoplankton are microscopic plant-like organisms that are an essential part of a healthy marine ecosystem. Over 50 phytoplankton species are commonly found in Kachemak Bay, and three of those species can produce toxins that can be harmful to people, birds, and marine mammals. *Alexandrium* species can cause paralytic shellfish poisoning (PSP), *Dinophysis* species can cause diarrhetic shellfish poisoning, and *Pseudo-nitzschia* species can cause amnesiac shellfish poisoning from domoic acid toxin. When these species of concern are abundant, the toxins they produce can accumulate in wild shellfish and can cause illness when toxic wild shellfish are consumed. Commercial shellfish are regulated by AK DEC and considered safe for consumption. In 2023, community monitors and KBNERR staff collected over 210 phytoplankton samples from 24 locations throughout Kachemak Bay to monitor for the presence of harmful phytoplankton.





These charts show the minimum number of months that toxin producing phytoplankton (*Alexandrium, Dinophysis*, and *Pseudo-nitzschia*) were present in Kachemak Bay shown in green. This is the minimum presence throughout the year because not all sites are sampled every week of the year.

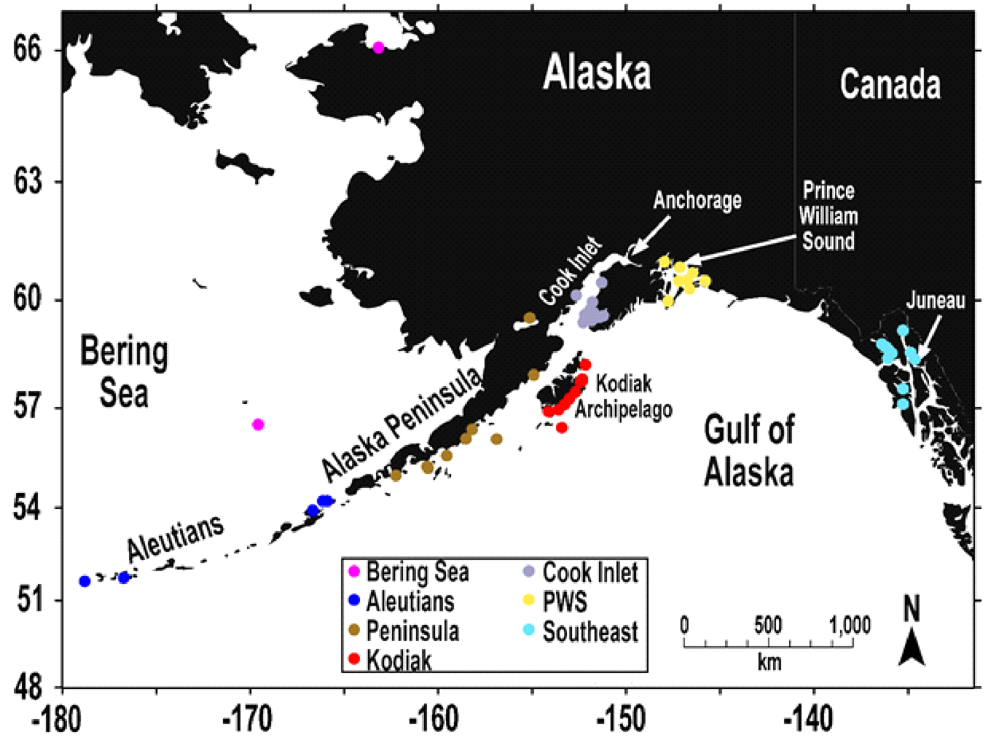
In Kachemak Bay the three species of concern were present in samples throughout the 2023 summer, with *Alexandrium* species seen less frequently than in 2021 or 2022. *Pseudo-nitzschia* species were seen more frequently in 2023, including at high-abundance or "bloom" levels at the end of June. While *Pseudo-nitzschia* species are commonly found in the bay, high levels of domoic acid toxins have not yet been detected. This is similar to results from other Alaska waters, but unlike the amnesiac shellfish poisoning events occurring further south on the U.S. West Coast.

KBNERR staff worked with Fish and Game and AOOS to test razor clams from East Cook Inlet for toxins prior to the opening of the fishery this summer. All samples were below the regulatory limit.

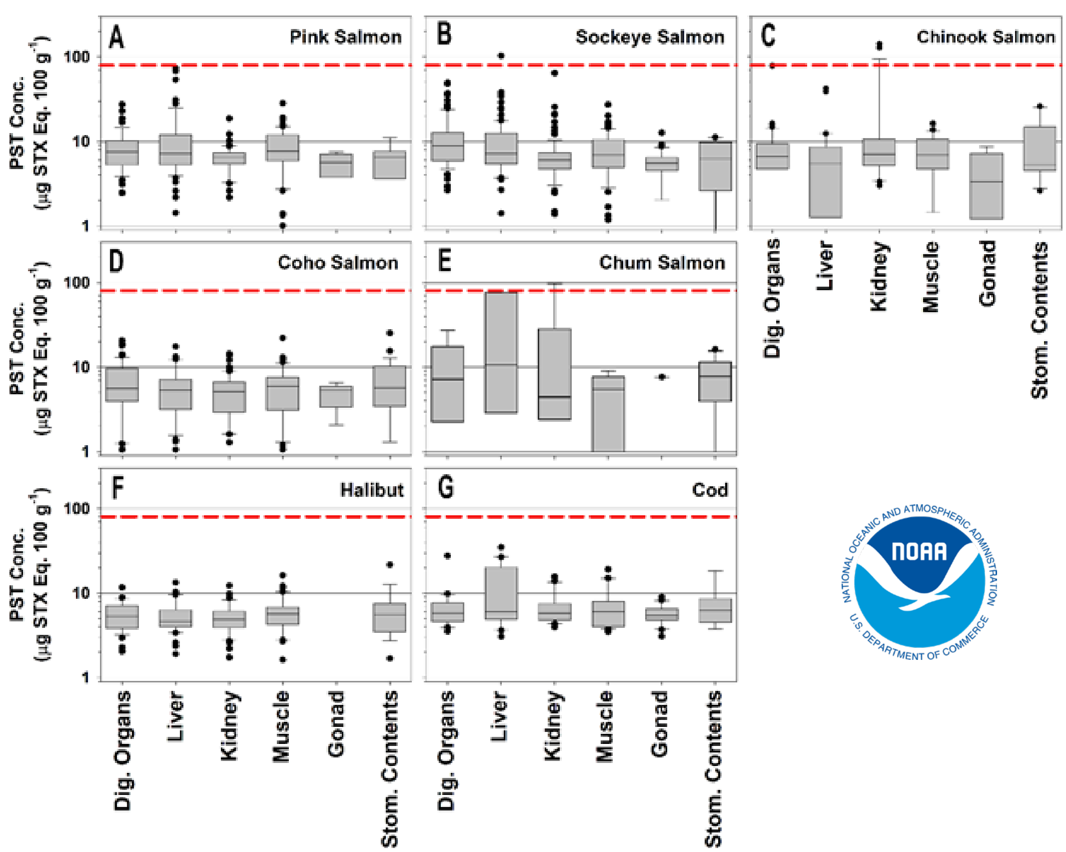
KBNERR IS LOOKING FOR PHYTOPLANKTON COMMUNITY MONITORS! KBNERR is hosting a monitor training on April 18. If you're interested, contact kkschuster@alaska.edu.

HARMFUL ALGAL BLOOMS (HABS)

NCCOS researchers from the Beaufort Lab in North Carolina conduct research in Kachemak Bay and across many Gulf of Alaska communities on how harmful algal bloom toxins may be transferred to fish and invertebrates through the marine food web. Results from paralytic shellfish poisoning toxin testing of salmon, halibut and cod are shown in plots below, with red lines marking the regulatory limit for safe consumption. While toxins were present at low levels in many fish tissues, levels near or above regulatory limits were only found in liver, kidney and digestive organs of some species. Learn more: Steve Kibler (steve.kibler@noaa.gov) or Dominic Hondolero (dominic.hondolero@noaa.gov).



Map with coastal Alaska showing HAB sample collection sites (colored dots) located in the Bering Sea, Aleutians, Alaska Peninsula, Kodiak Archipelago, Cook Inlet, Prince William Sound and Southeast Alaska.



EUROPEAN GREEN CRAB REACHES ALASKA

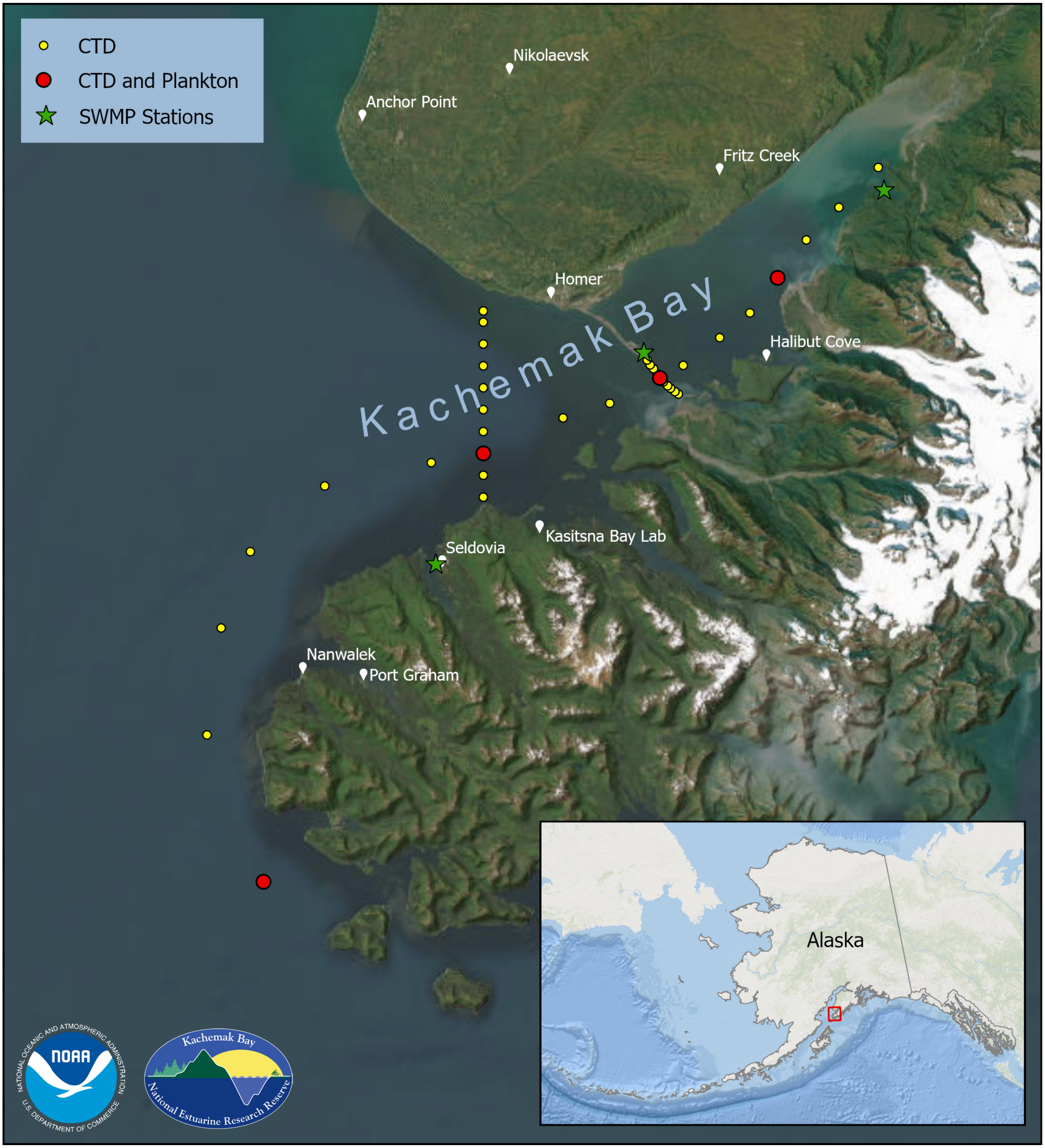
Invasive European green crabs were detected on Annette Island in June of 2022 by Metlakatla Indian Community Fish and Wildlife Biologists. Since the first detection, the Metlakatla Fish and Wildlife have removed over 750 invasive green crabs. This species is a highly invasive ecosystem engineer capable of increasing coastal erosion and destroying eelgrass beds. An agile and voracious predator, invasive green crabs consumes native shellfish and juvenile crab species at a rate that can lead to their total exclusion from the nearshore; they are also agile enough to catch and eat juvenile salmon. KBNERR is one of many partners of the Alaska Invasive Species Partnership Marine Invasives Committee, together we are building capacity through early detection training events for new monitors, collaborative and standard early detection protocols, development of education and outreach materials and a rapid response plan. In 2021 the Alaska Invasive Species Partnership Marine Committee received funding to update Alaska's European green crab Rapid Response Plan originally written in 2009. As part of the update process a rapid response exercise was conducted in Kachemak Bay to delineate roles and responsibilities, test the plan in a realistic scenario and identify next steps. Watch the video highlighting the exercise: https://youtu.be/6ddpeY7IQDY

KBNERR Harmful Species Program is looking for interested and curious community members to join our volunteer and community monitor programs this summer. There are a variety of ways to get involved, learn collection and monitoring techniques that support a better understanding of natural variability in Kachemak Bay in addition to providing early detection for harmful algal blooms and marine invasive species. If you are interested in peering into Kachemak Bay phytoplankton communities, or seeing who is crawling or swimming around in our nearshore environments or supporting student participation in local science activities consider joining us for one or both of our spring 2024 Community Monitor Trainings.

Community monitor training for early detection of European green crab will be Friday May 24th. Any interested person should contact Jasmine Maurer at jrmaurer@alaska.edu, they will learn how to; identify invasive green crabs and native nearshore fish and crab species, measure and properly handle animals caught, deploy traps and record data, and conduct a molt walk survey. We will help with site selection for Community Monitors that want to adopt a site to monitor. Monitoring for the early detection of invasive green crabs is once a month seasonally from May to September/October.

Photos this page courtesy of A. Lutto, USFWS.

NCCOS KASITSNA BAY LAB AND KACHEMAK BAY NERR OCEANOGRAPHIC SAMPLING LOCATIONS



CTD: Conductivity-temperature vs depth vertical station
SWMP: System-wide Monitoring Program water station