

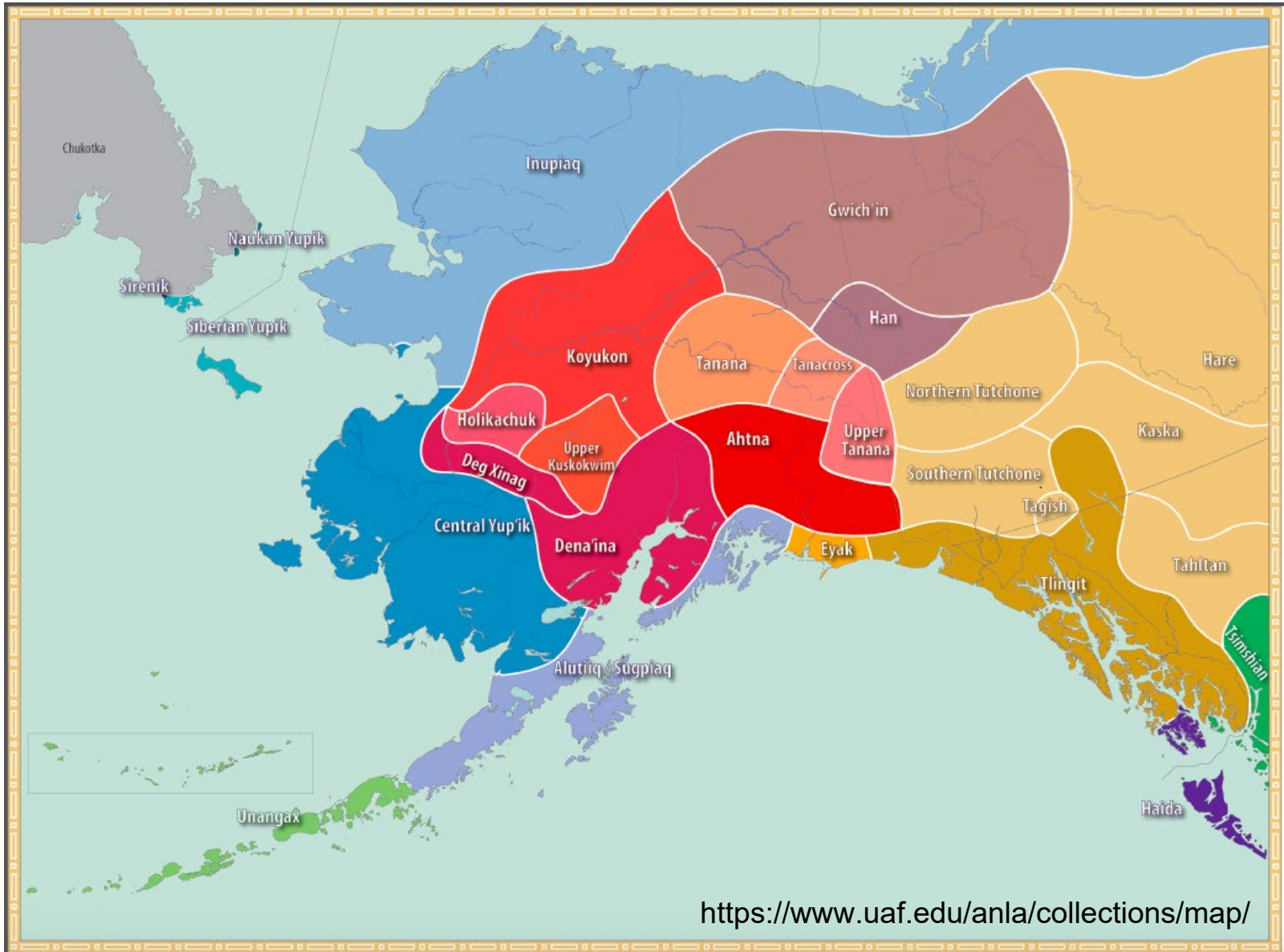
Eastern Bering Sea Ecosystem Status Report

BSAI
Groundfish Plan Team
November 16, 2021



Elizabeth Siddon

Land Acknowledgement



With contributions from:

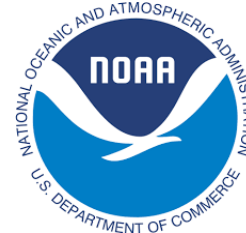
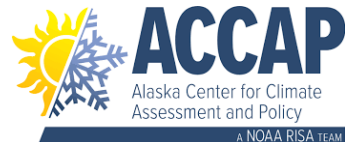
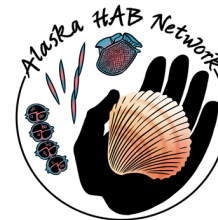
Thank you!

Grant Adams, Don Anderson, Alexander G. Andrews III, Kerim Aydin, Steve Barbeaux, Cheryl Barnes, Lewis Barnett, Sonia Batten, Shaun W. Bell, Nick Bond, Peter Boveng, Lyle Britt, Caroline Brown, Gregory Buck, Matt W. Callahan, Wei Cheng, Bryan Cormack, Jessica Cross, Deana Crouser, Curry J. Cunningham, Seth Danielson, Andrew Dimond, Lauren Divine, Elizabeth Dobbins, Jane Dolliver, Sherri Dressel, Darcy Dugan, Anne Marie Eich, Lisa Eisner, Evie Fachon, Ed Farley, Thomas Farrugia, Sarah Gaichas, Jeanette C. Gann, Sabrina Garcia, Colleen Harpold, Jordan Head, Ron Heintz, Tyler Hennon, Kirstin K. Holsman, Kathrine Howard, Tom Hurst, Jim Ianelli, Tim Jones, Robb Kaler, Kelly Kearney, Esther Kennedy, Mandy Keogh, David Kimmel, Alexander Kitaysky, Christine Kondzela, Joseph Krieger, Kathy Kuletz, Ashley Kushin, Tonia Kushin, Elizabeth Labunski, Geoffrey M. Lang, Ben Laurel, Elizabeth Lee, Jean Lee, Kathi Lefebvre, Aaron Lestenkof, Zachary W. Liller, Jackie Lindsey, Christopher Long, Barbara Mahoney, Sara Miller, Calvin W. Mordy, Jamal Moss, Franz Mueter, James Murphy, Jens Nielsen, Travis Niksik, John V. Olson, Olav Ormseth, Clare Ostle, Jim Overland, Veronica Padula, Emma Pate, Noel E. Pelland, Darren Pilcher, Alexei Pinchuk, Cody Pinger, Bianca Prohaska, Heather Renner, Jon Richar, Sean Rohan, Natalie Rouse, Kate Savage, Sarah Schoen, Gay Sheffield, Punguk Shoogukwruk, Kalei Shotwell, Elizabeth Siddon, Kevin Siwicke, Adam Spear, Ingrid Spies, Phyllis Stabeno, Robert Suryan, Rick Thoman, Grant Thompson, Stacy Vega, Muyin Wang, Jordan Watson, George A. Whitehouse, Alexis Will, and Ellen Yasumiishi.

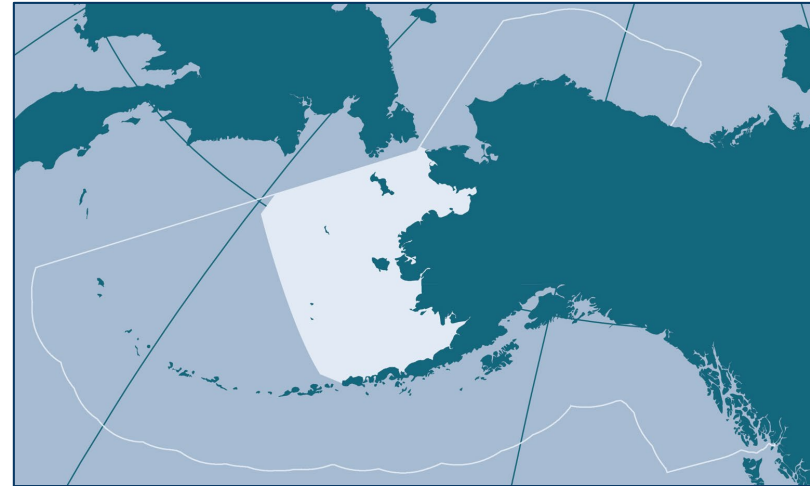
2021 Ecosystem Status Reports

Contributing Partners

COASST



- Summary of BSAI risk tables
- Ecosystem Status: 2021
 - Oceanography
 - Northern Bering Sea
 - Southeastern Bering Sea
- Update on past stories
 - Herring bycatch and PSC limit
 - Ice seal Unusual Mortality Event
 - Gray whale Unusual Mortality Event
 - Seabird bycatch
- SST forecasts
- Summary and Implications



2021 BSAI Risk Tables

7 full assessments for BSAI (+ Alaska-wide Sablefish):

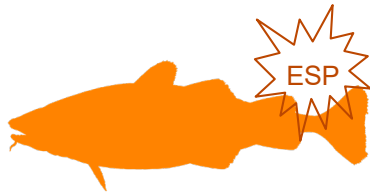
- 4 recommended an ecosystem risk level of 1.
- 4 recommended an ecosystem risk level 2 (details below).



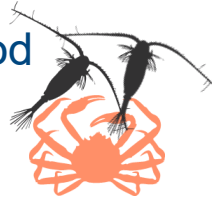
EBS Pollock



Prolonged warm phase, lack of cold pool, and carrying capacity concerns in the NBS



EBS Pacific cod



Prolonged warm phase, reduced prey availability combined with increased metabolic demands, and die-offs in the NBS



AI Pacific cod



Persistent warm conditions and lower prey quality resulting in reduced fish condition



Yellowfin sole



Bottom temps may exceed thermal tolerance, carrying capacity concerns in the NBS, declines in fish condition from 2019



- Moderate impacts to data collection and sample processing in 2021

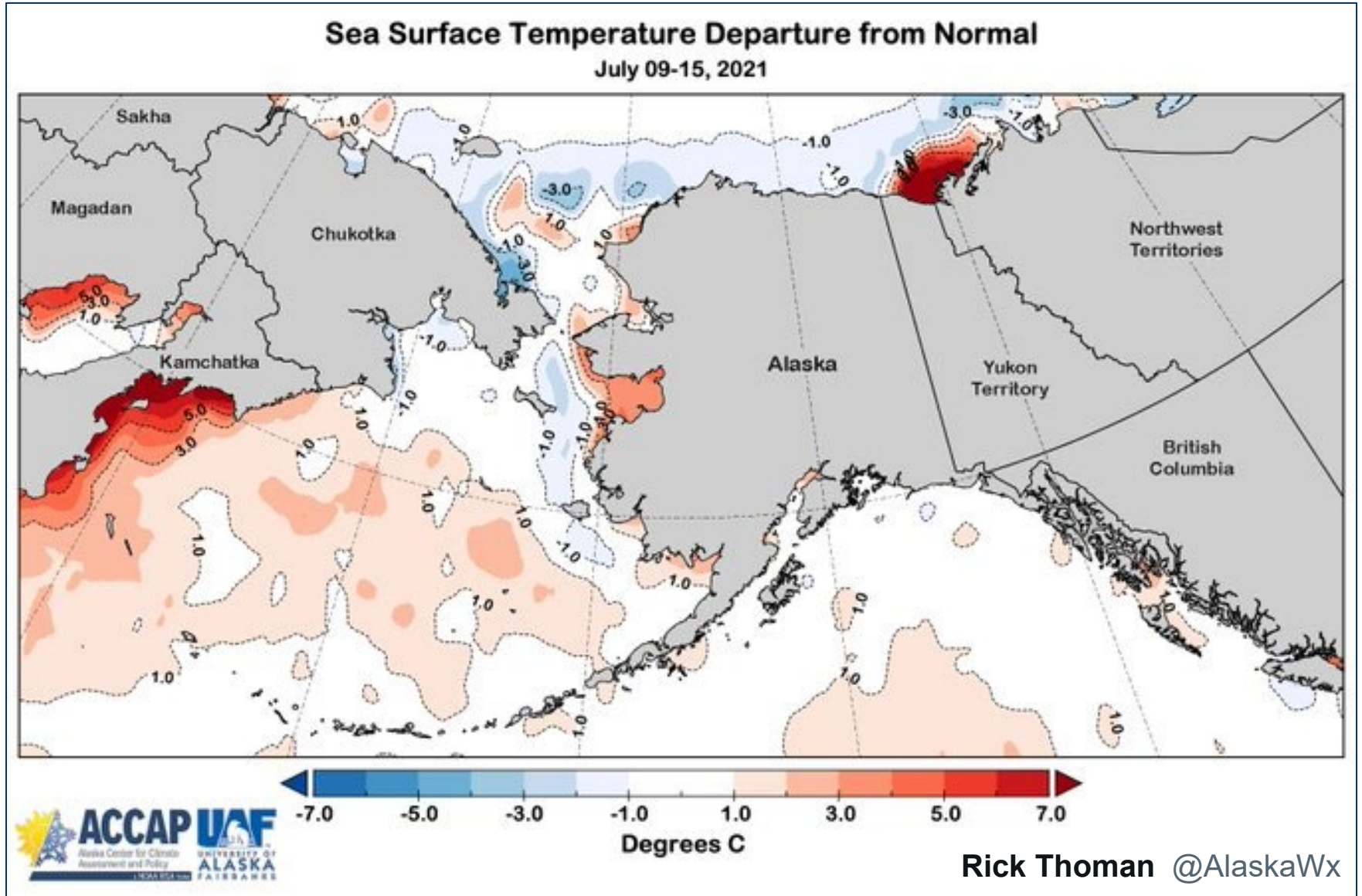


- Survey cancellations
- Lab processing delays due to limited building access over the past ~18 months
- Data processing delays due to surveys logistics



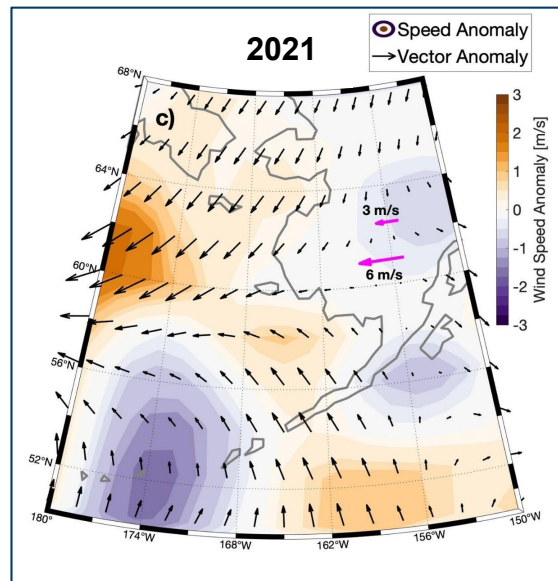
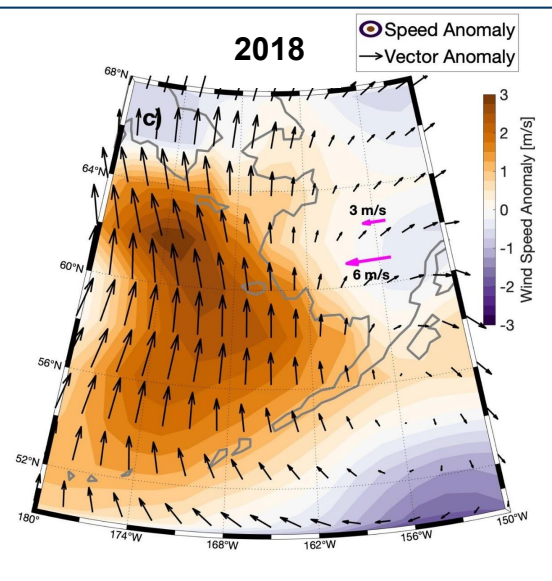
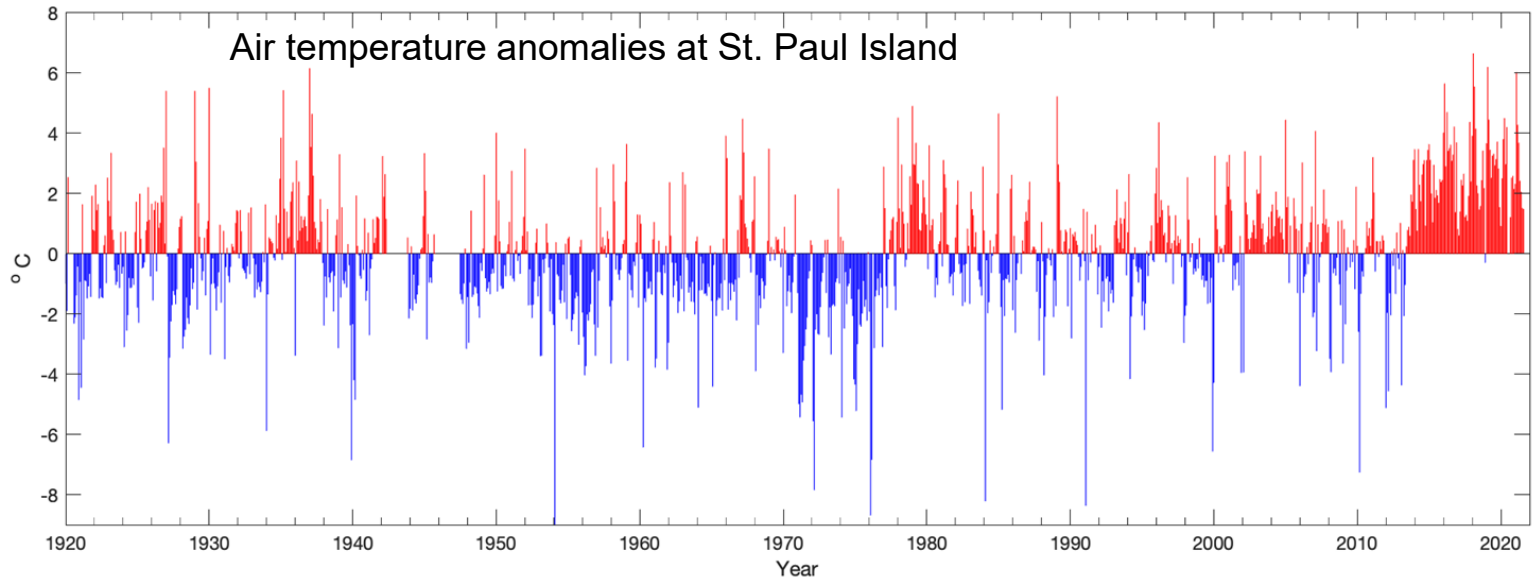
Thank you to all contributors, including NOAA and external partners, who continue to inform our understanding of Alaska's ecosystems!

Ecosystem Status: 2021

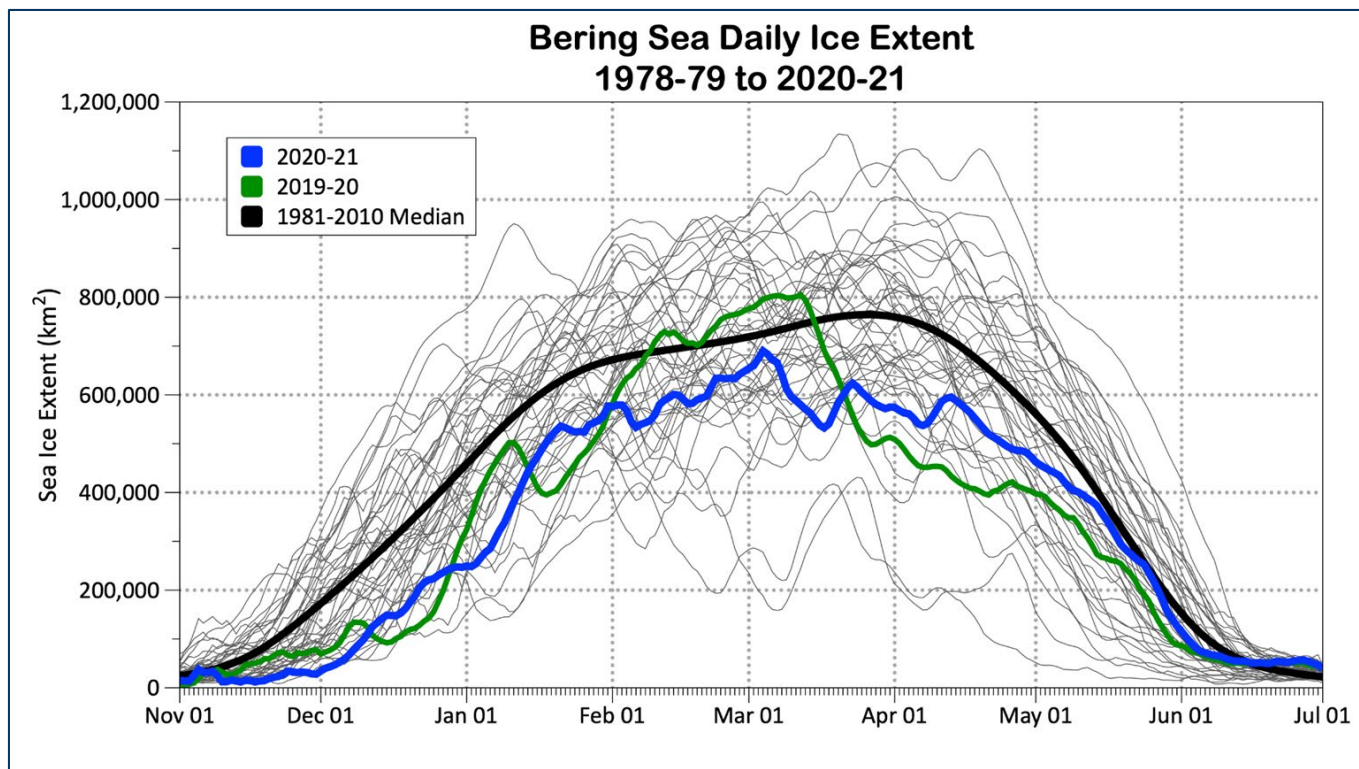


Sea ice dynamics

Overland & Wang, Hennon

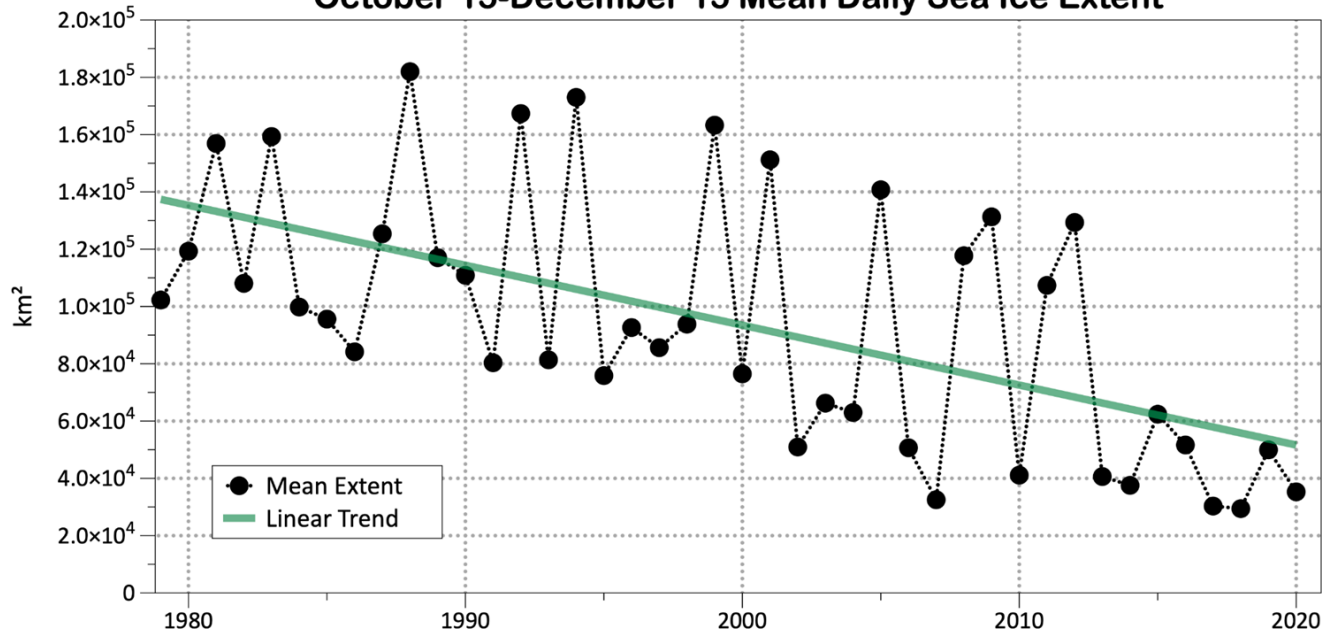


- Persistent warm phase since 2014
- Winds in Feb 2018 and 2019 were from the south
- Winds in Feb 2021 were from north in NBS and from the south in SEBS

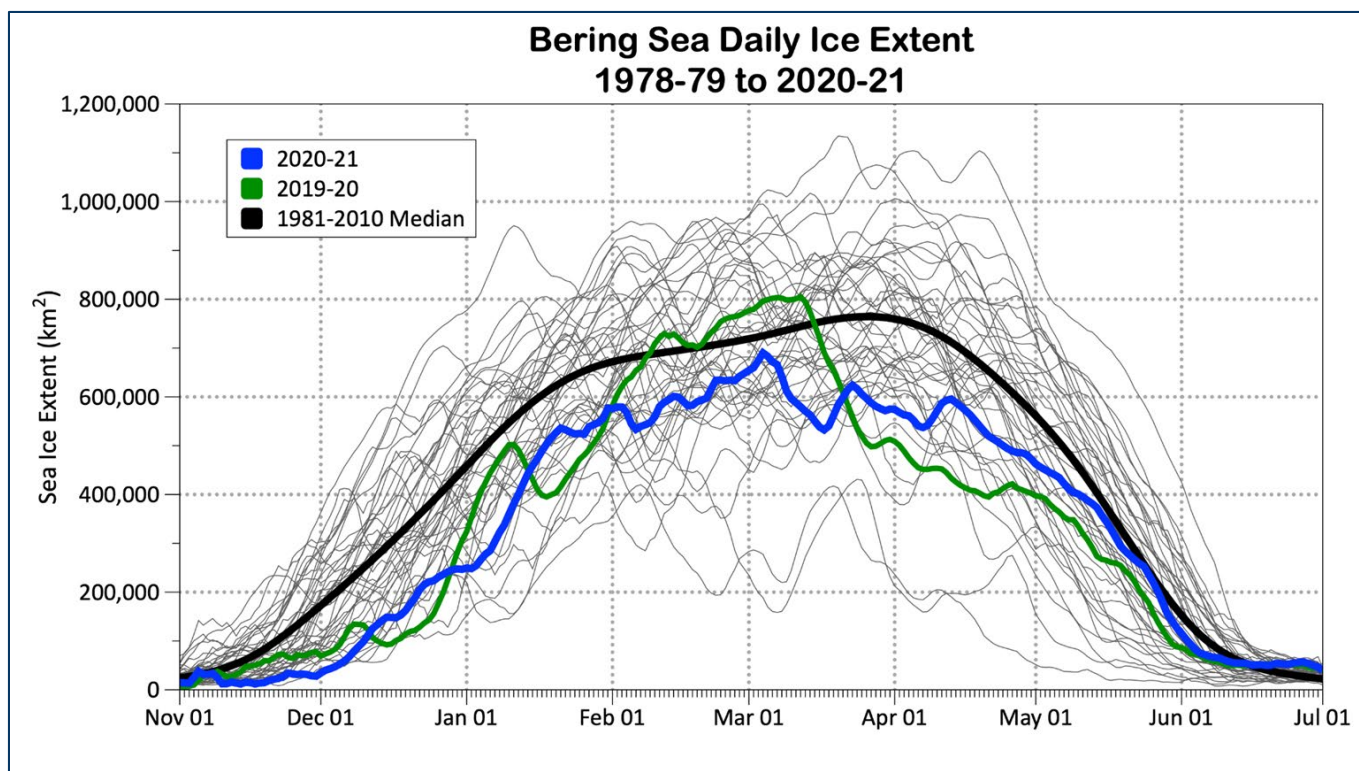


- Delayed freeze-up ('new normal')

Bering Sea, 1979-2020
October 15-December 15 Mean Daily Sea Ice Extent



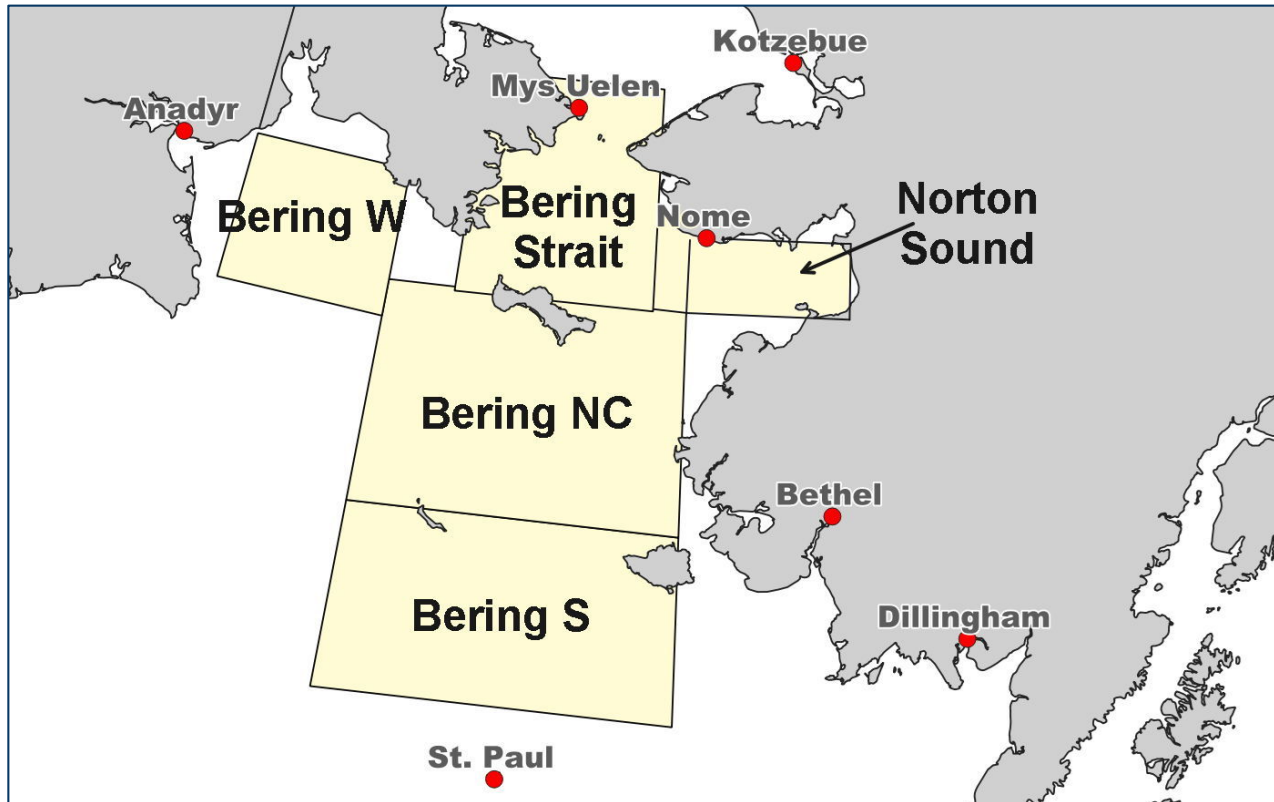
- Delayed freeze-up ('new normal')



- Delayed freeze-up ('new normal')
- Ice advance stalled at end of January
- Ice was steady February through early April
- Wind pattern in Jan-Mar resulted in decoupled ice dynamics between the NBS and SEBS

Sea Ice Thickness

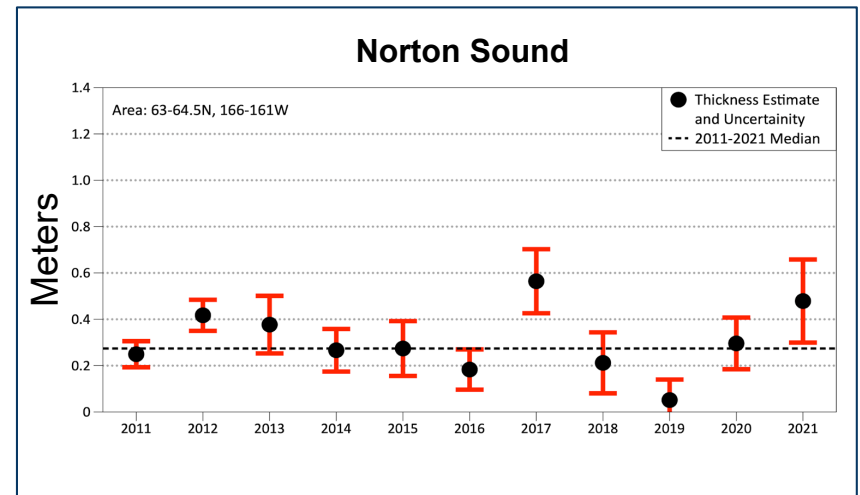
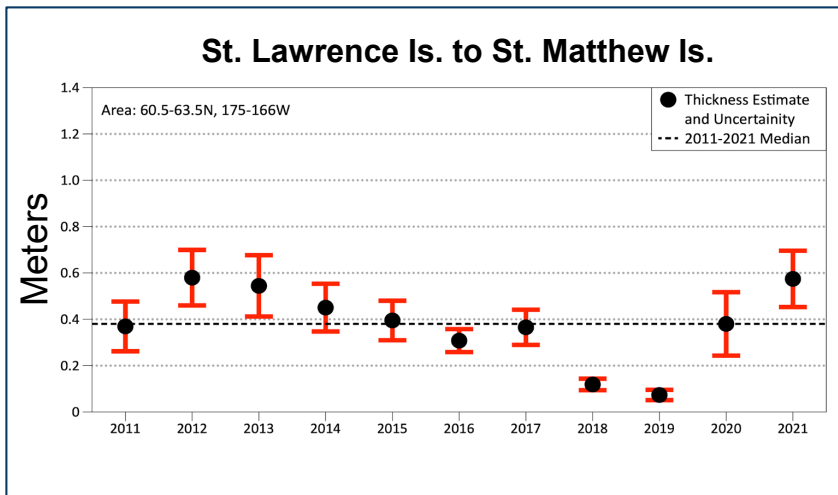
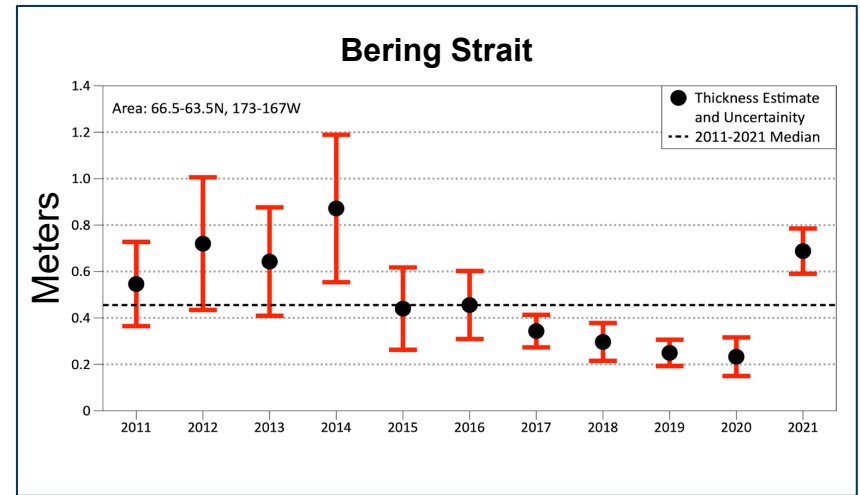
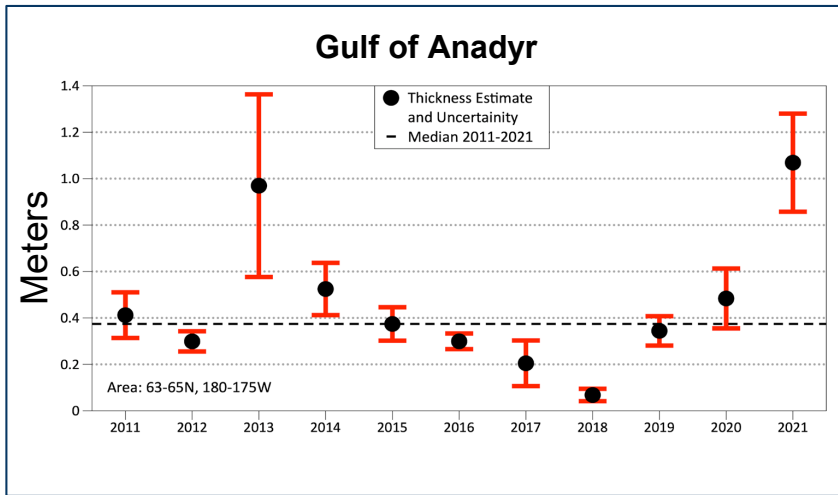
Thoman



- 3rd week of March
- Ice thickness is related to duration of ice over the shelf
- *Implications for:*
 - ice-associated algae
 - stratification
 - cold pool extent

Sea Ice Thickness

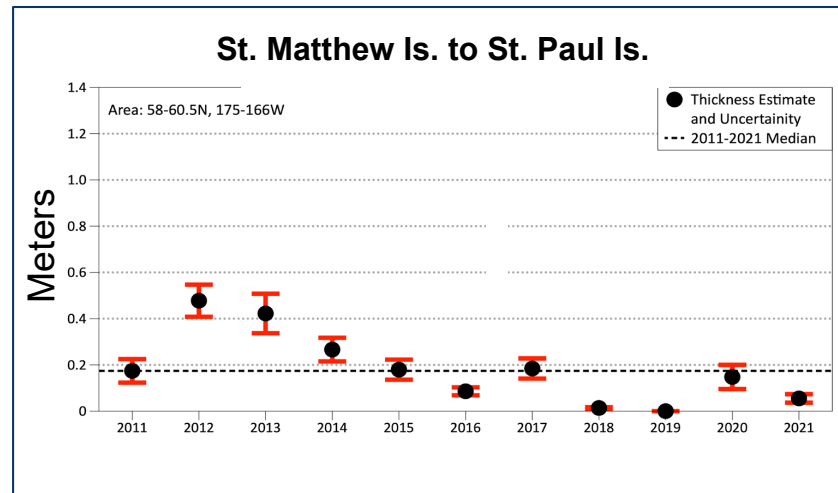
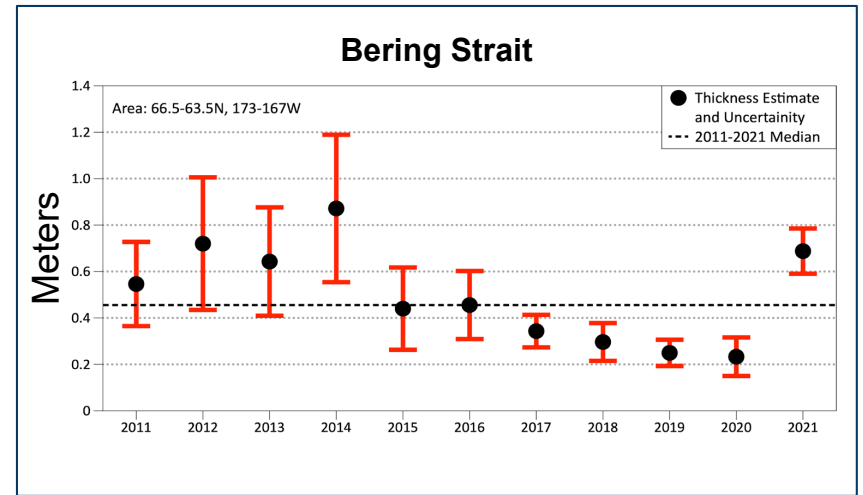
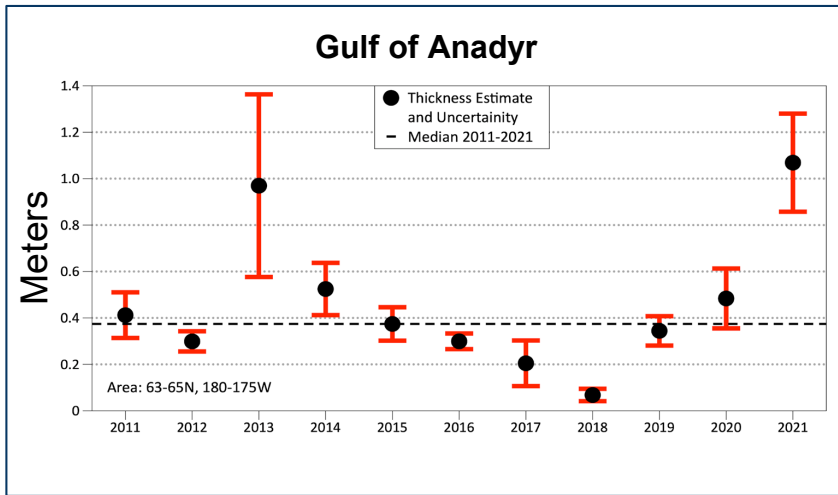
Thoman



Northern and western areas had *increased* ice thickness in 2021

Sea Ice Thickness

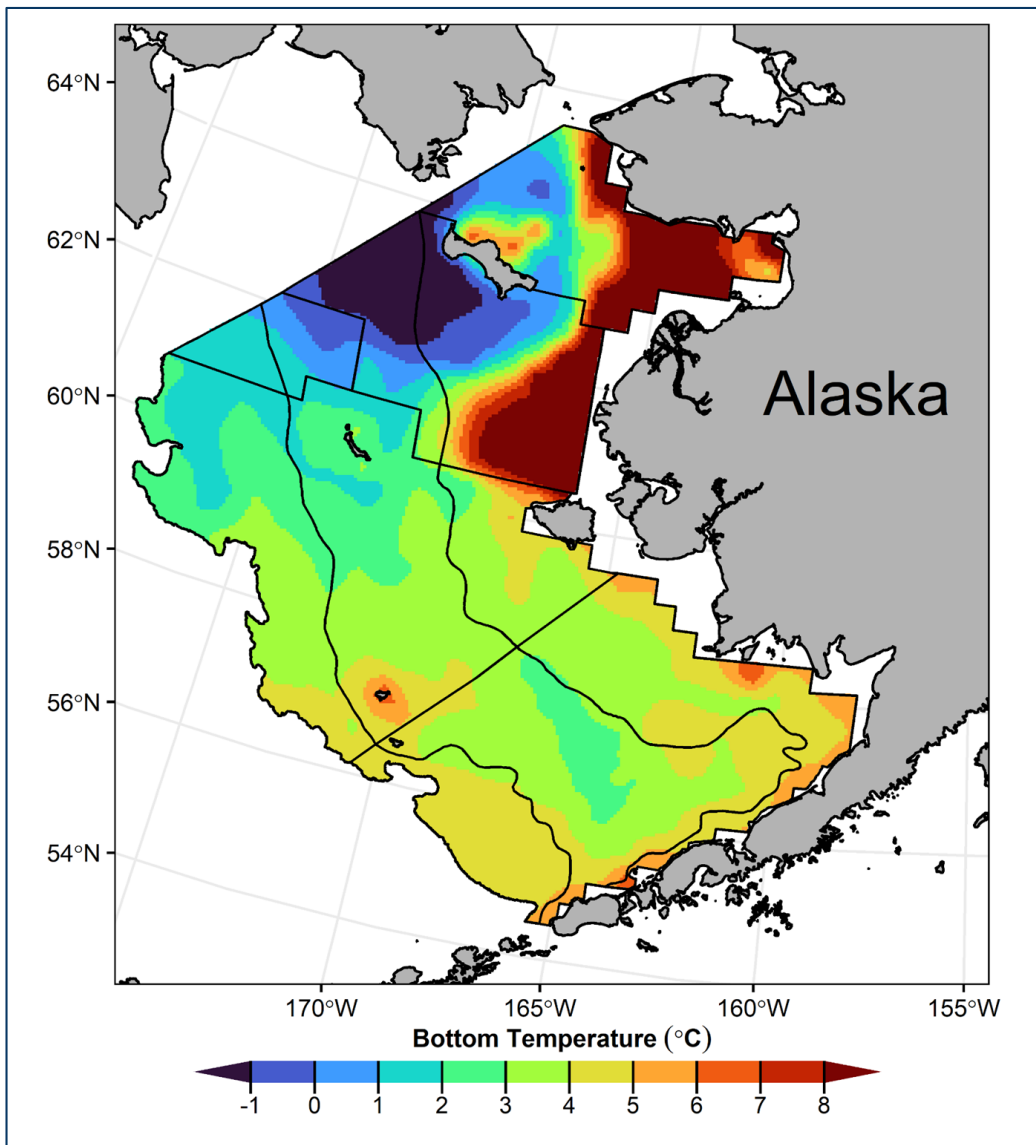
Thoman



South of St. Matthew Is. continued to have **decreased** ice thickness in 2021

2021 bottom temperatures

Rohan & Barnett

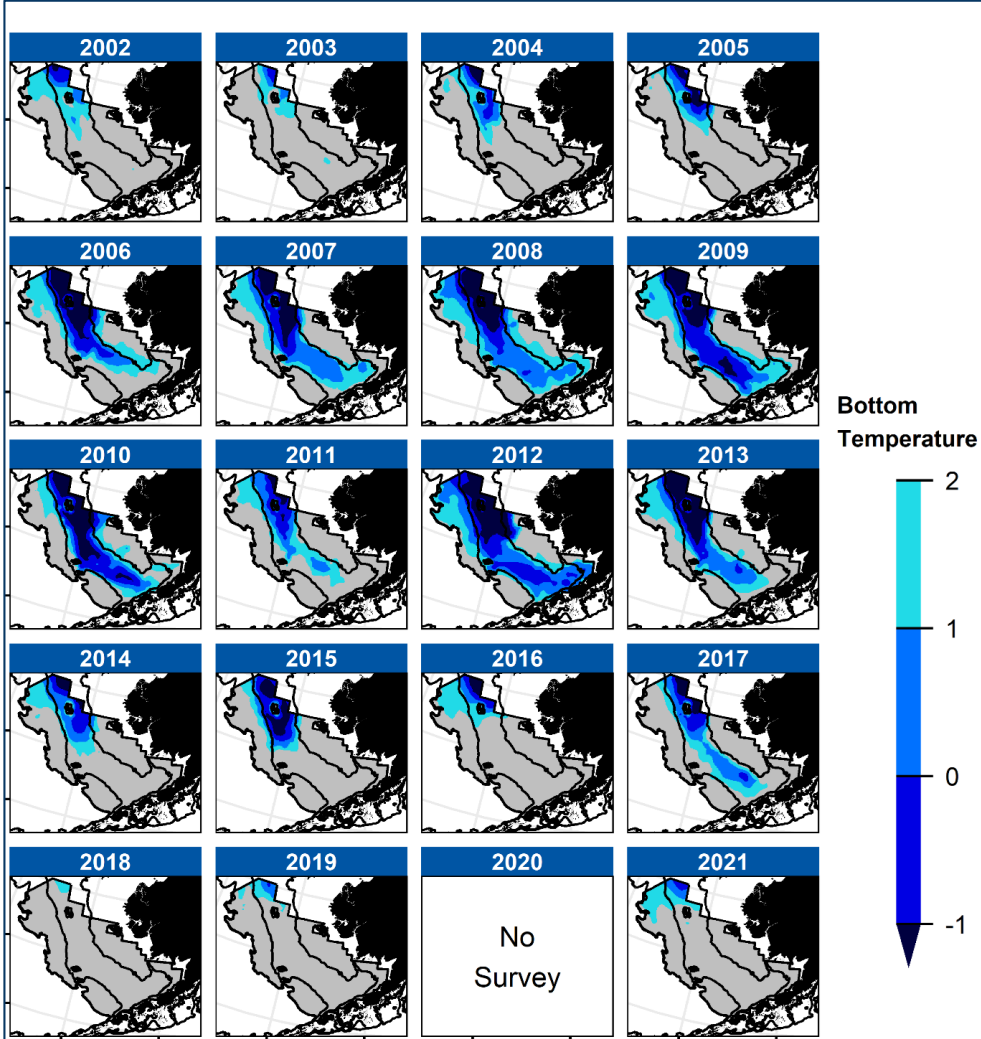
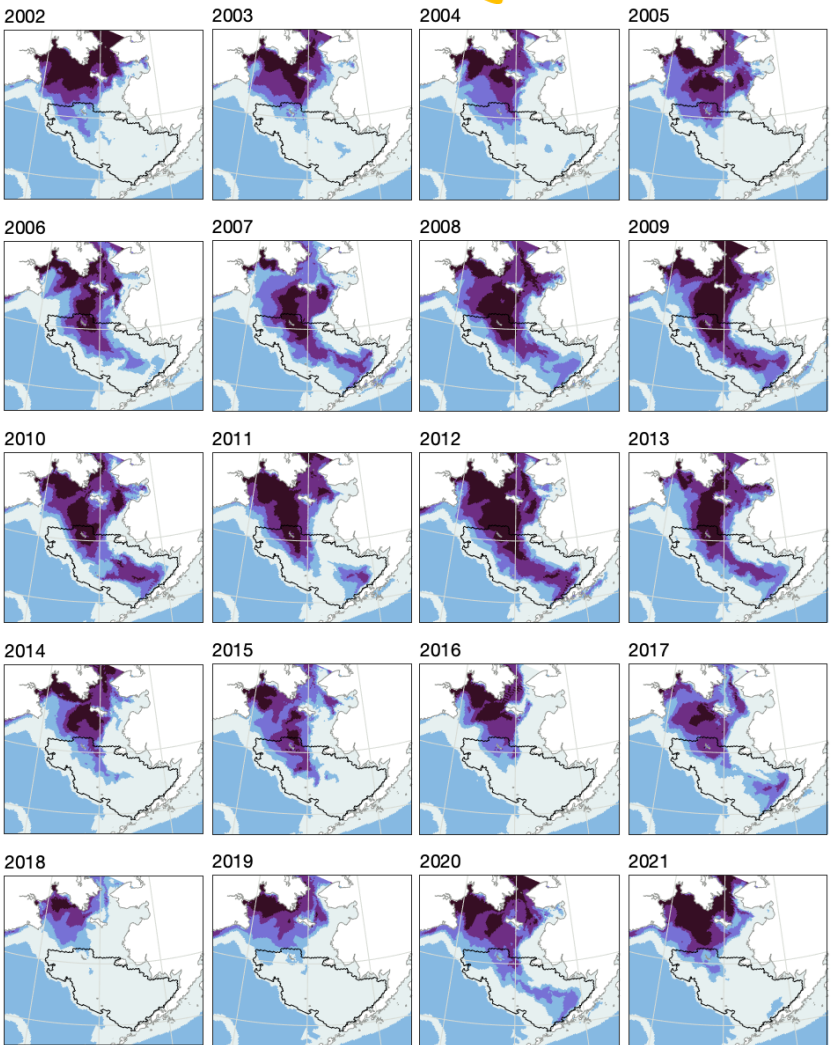
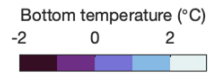


- Cold pool restricted to northwest of survey area
 - May have imposed some barrier to migration
- Extremely warm bottom waters on the northern inner shelf
 - Partially due to survey timing

2021 cold pool

Kearney, Rohan & Barnett

Bering10K ROMS hindcast
Extracted July 1 each year

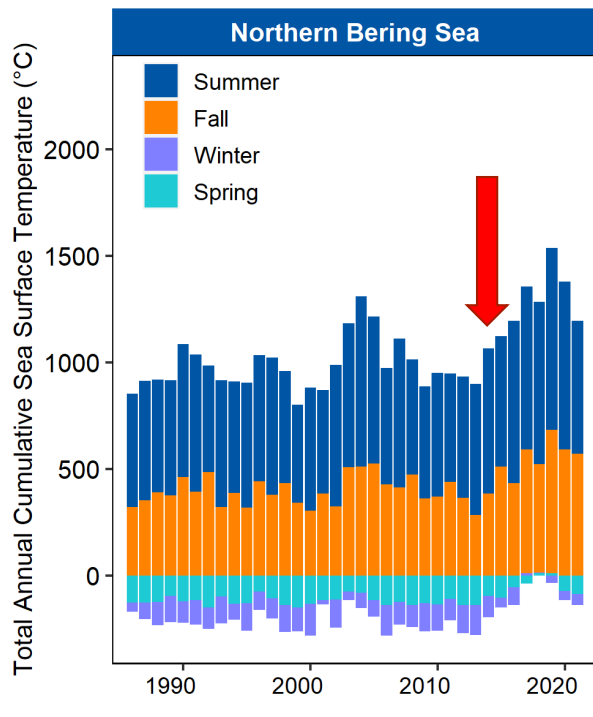
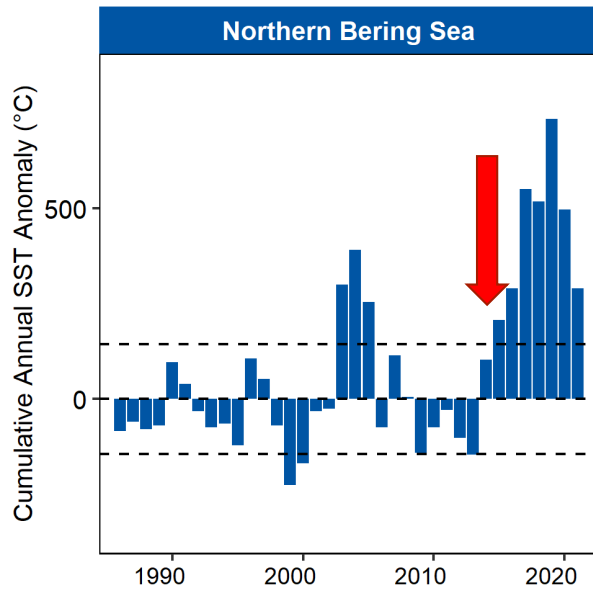


- 2021 resembles 1982 and 2004
- Warmer than average, but not extreme

- 2021 cold pool was 4th lowest on record
- >1SD below the time series mean

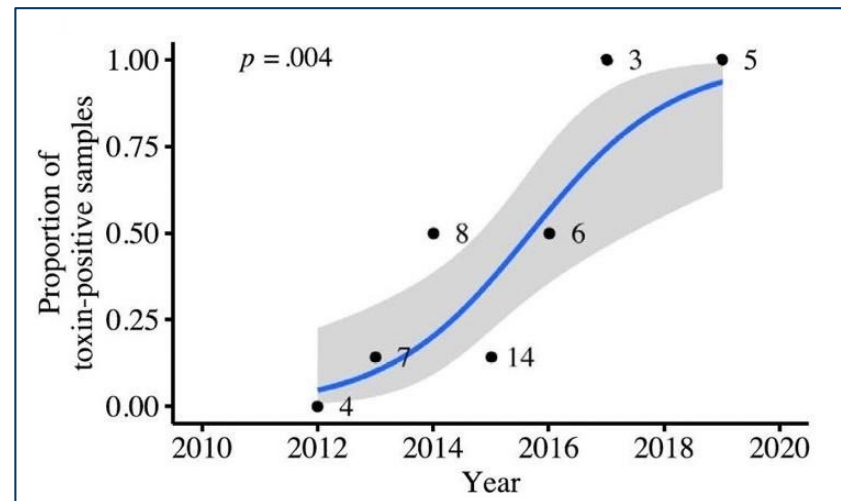
NBS: cumulative impacts

Watson & Callahan, Lefebvre et al.



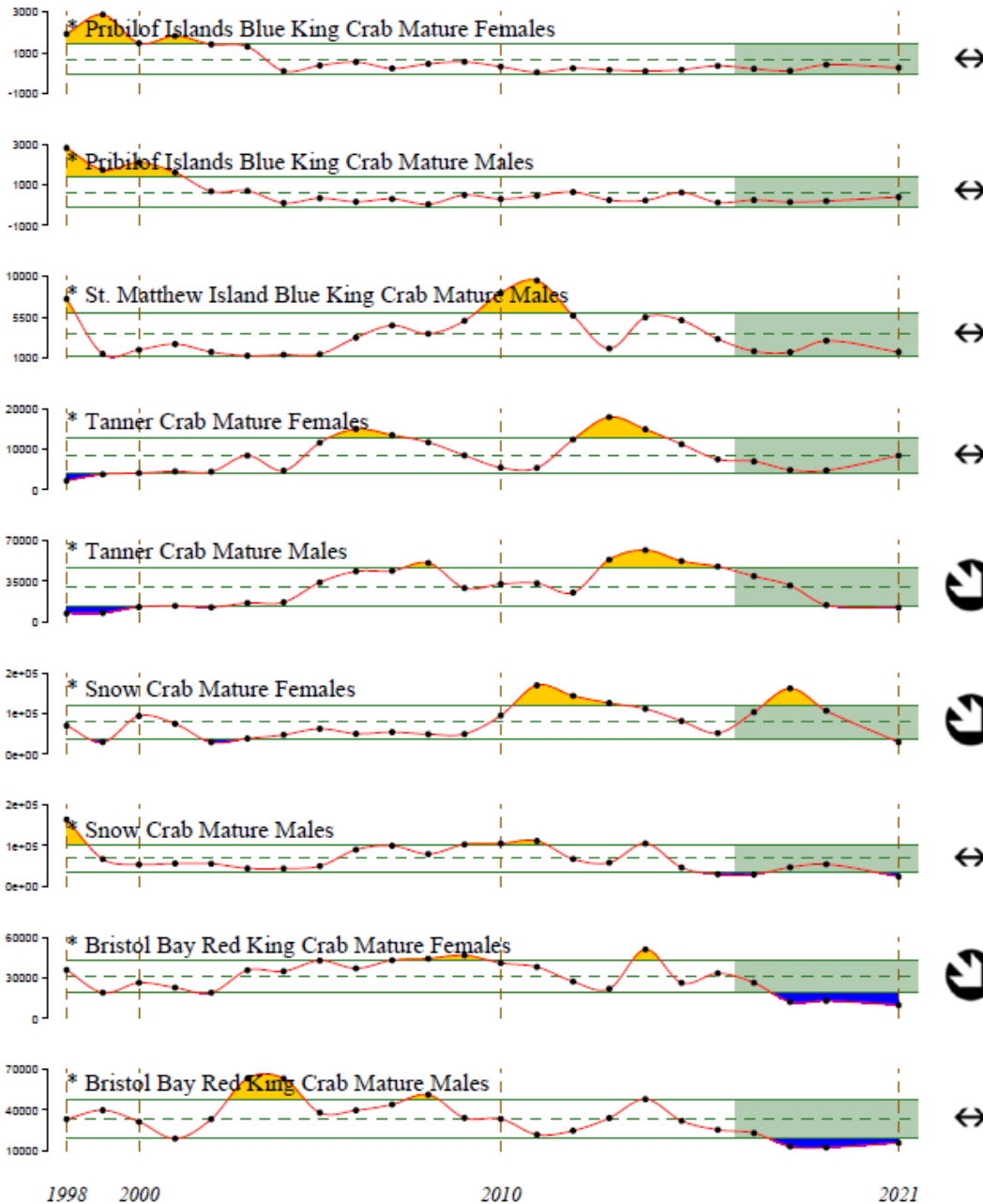
- Cumulative impacts of protracted warm phase
- Ecosystem 'shock' of lack of sea ice in 2017/18 and 2018/19
- Food web dynamics and carrying capacity concerns
 - Shearwaters
 - Gray whales

- Increasing prevalence of HABs in ice seals linked to warming and increased sunlight with loss of sea ice cover



NBS: crab declines

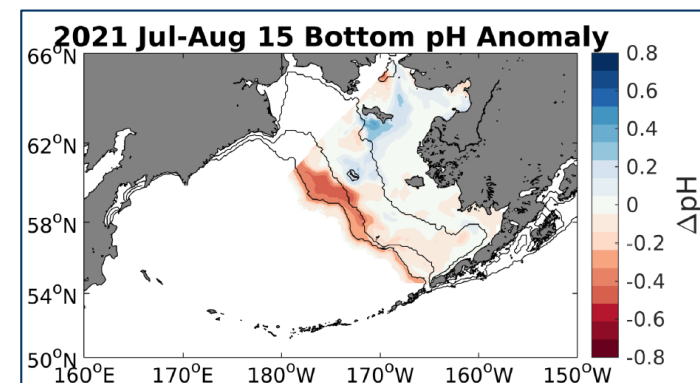
Richar



- Ecosystem explanations:
 - Predation
 - Disease
 - Temperature effects

- Persistent lower pH on outer shelf is result of changes in circulation, not OA

- At this time, no evidence that OA is linked to crab declines

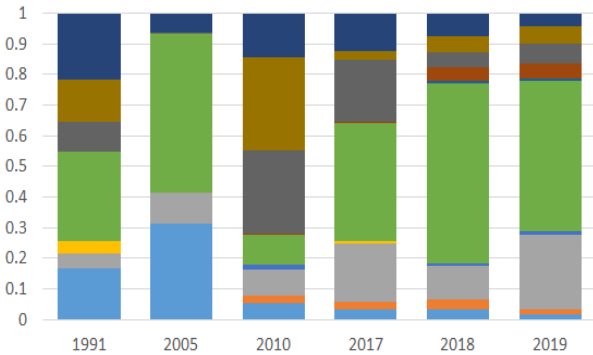




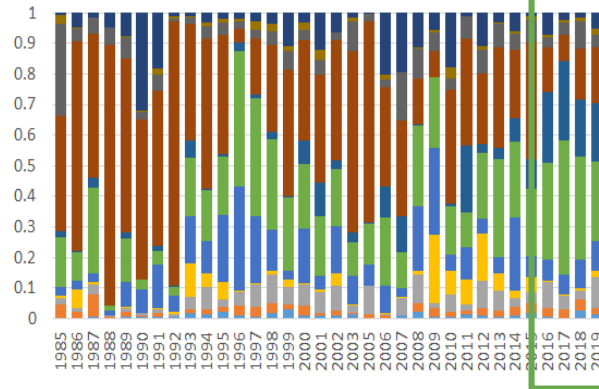
Adult Pacific Cod Food Habits

Aydin

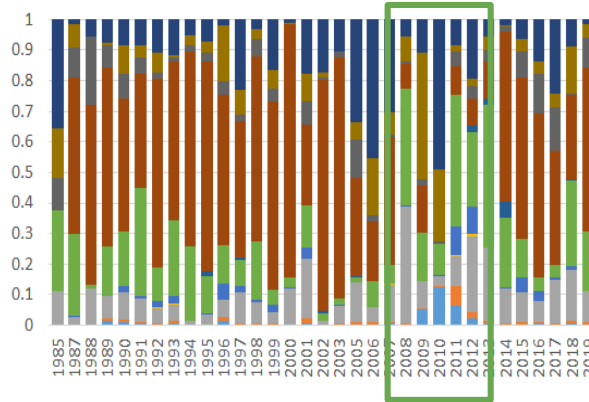
Northern Bering Sea



Northwest outer domain

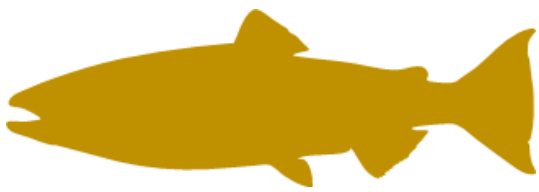


Southeast middle domain



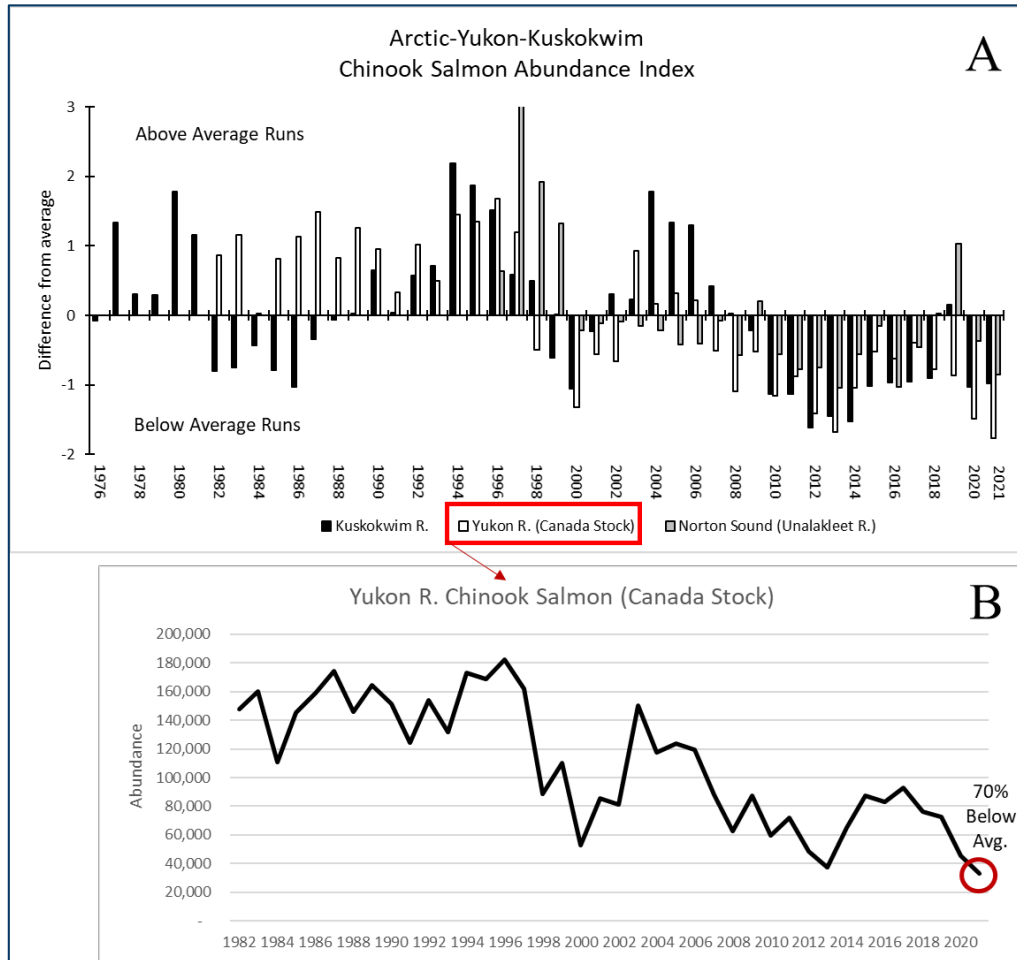
- Other
- Flatfish
- Forage fish
- Pollock
- Octopus
- Chionoecetes
- Eelpouts
- Pandalid Shrimp
- Epifauna
- Polychaete
- Sm. Zooplankton

- Southeast middle: pollock are dominant, except in 2008-2012 when replaced by *Chionoecetes*
- Northwest outer: pollock are dominant, but in 2016-2019 *Chionoecetes* and octopus increased
- NBS: For most years, *Chionoecetes* (primarily ID'd as snow crab) are dominant

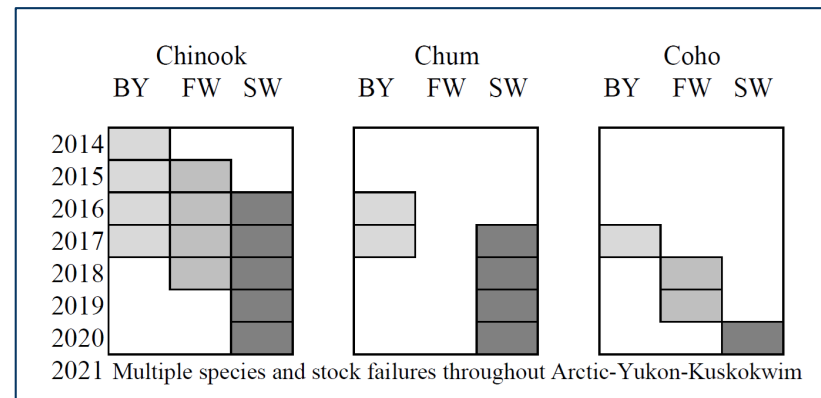


NBS: salmon run failures

Liller



- Chinook, chum, and coho salmon
- Yukon River
 - All directed gillnet fisheries were closed in 2021
- AYK chum run failures portend continued low chum abundance in coming years
- Reflect poor conditions in the marine environment since 2016
- ADF&G addressing through wide range of research initiatives





2021 Seabird Report Card



Region	Annual monitoring site	Red-faced cormorants	Glaucous-winged gulls	Common murre	Thick-billed murre	Horned puffin	Tufted puffin	Red-legged kittiwakes	Black-legged kittiwakes	Northern fulmar	Fork-tailed storm-petrels	Leach's storm-petrels	Parakeet auklets	Least auklets
Chukchi Sea	Cape Lisburne	As part of Covid 19 safety measures, refuge field staff and the R/V Tiglax operated under quarantine and did not visit communities, so we were unable to survey sites in the Pribilof Islands and Cape Lisburne.												
	Pribilofs													
Bering Sea	Hall			☹️	☹️	☹️	☹️	☹️	☹️					☺️

Eggs represent overall productivity relative to the long-term average. White eggs indicate productivity derived from monitoring data; colored eggs indicate productivity based on anecdotal observations.

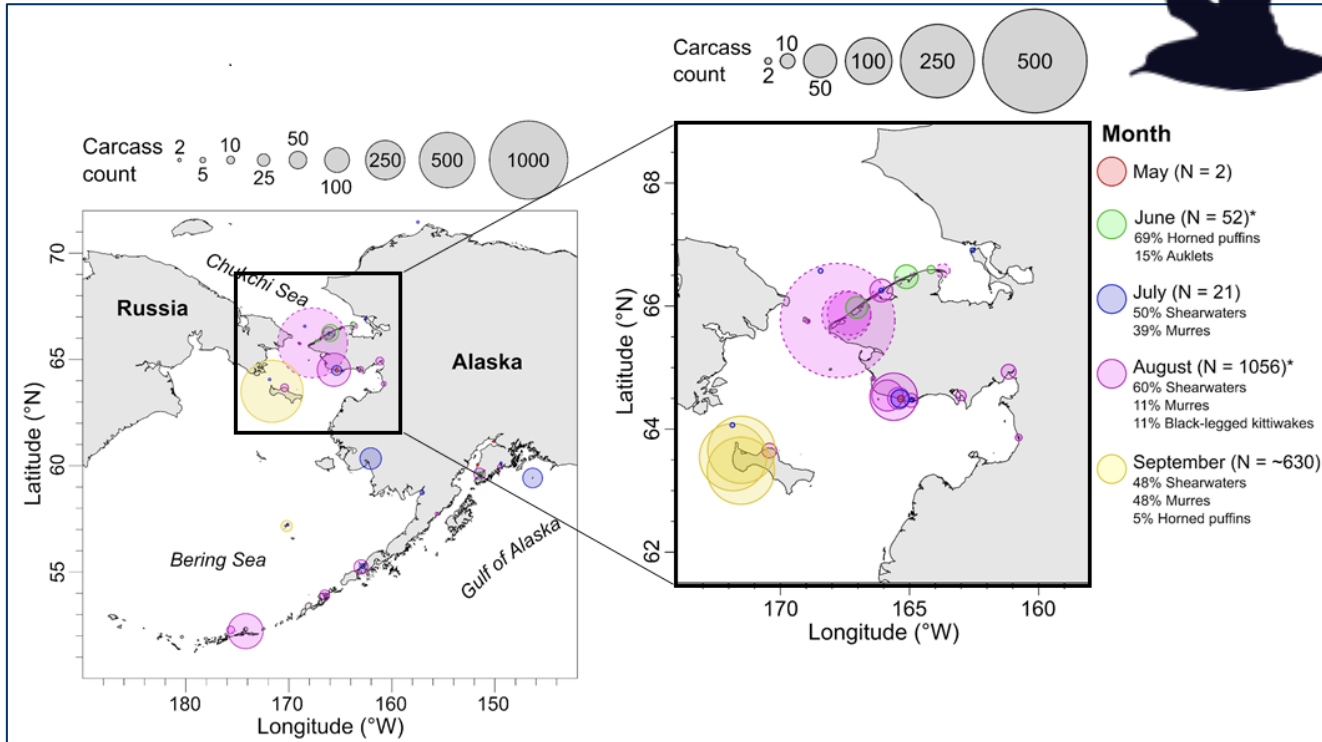
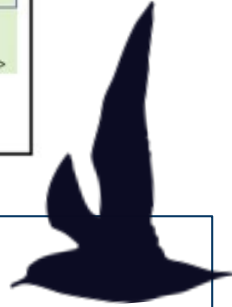
<<< Primarily fish eaters ← → Primarily zooplankton eaters >>>

Way above average! Average Below average Complete failure

NBS: Seabirds

Integrated Seabird Information

- Seabird die-offs highest in the NBS
- Zooplankton-eaters
 - Shearwaters (migrant)
 - Kittiwakes
- Fish-eaters
 - Murres
 - Puffins

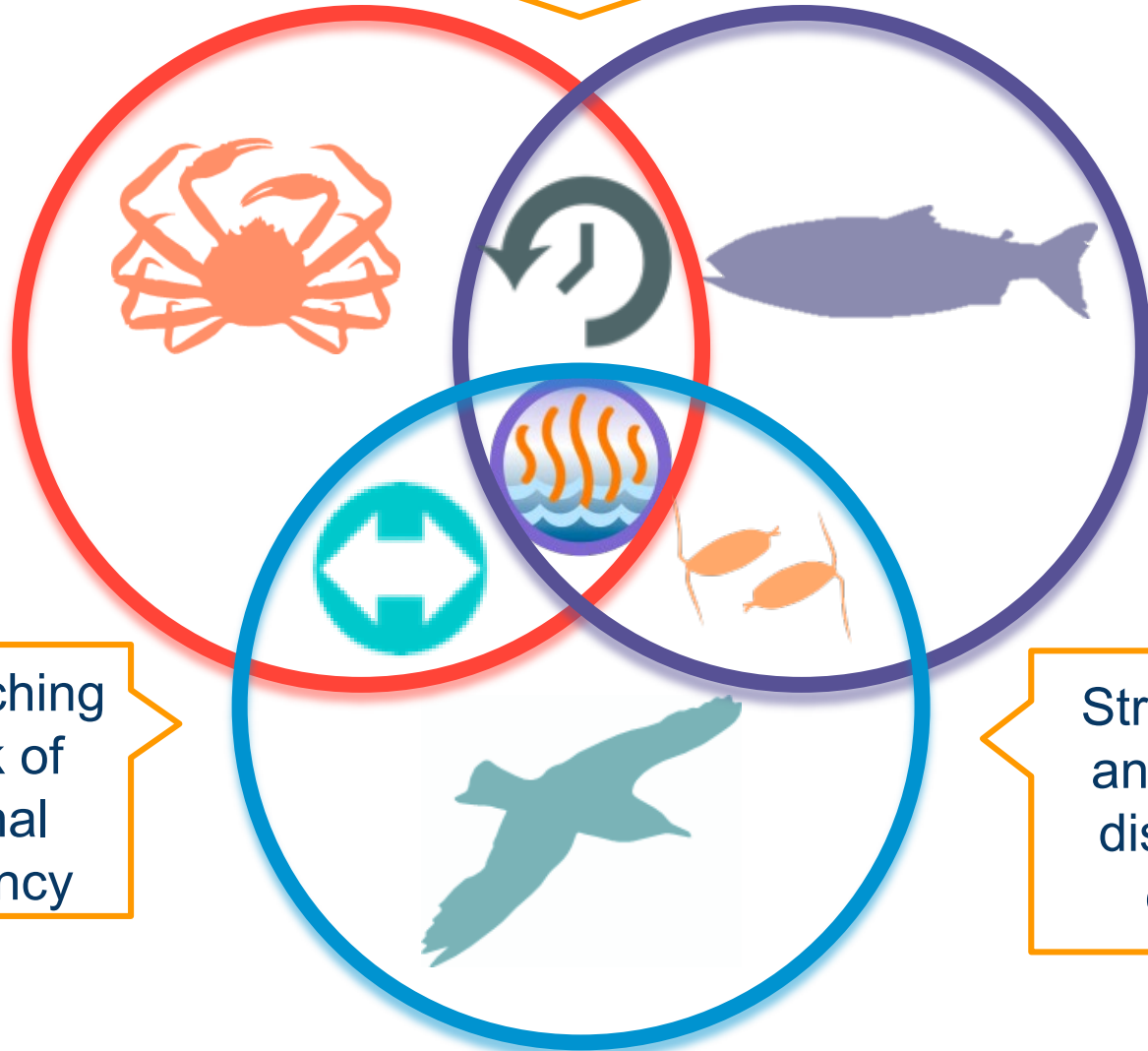


- Reproductive failures for most species
- Least auklets hatched and fledged chicks



Are there common threads?

Cumulative impacts of thermal exposure and metabolic demands

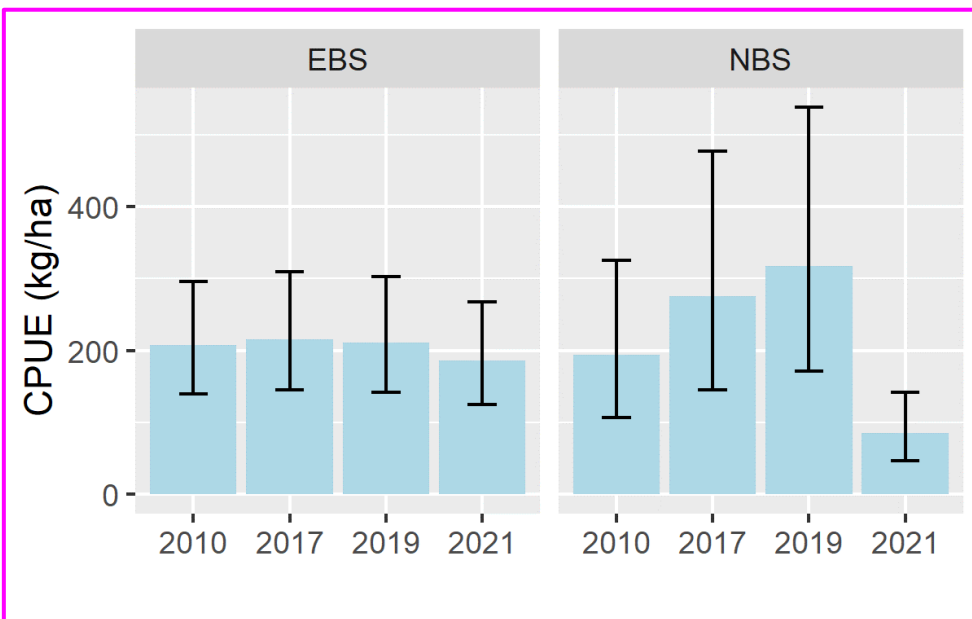
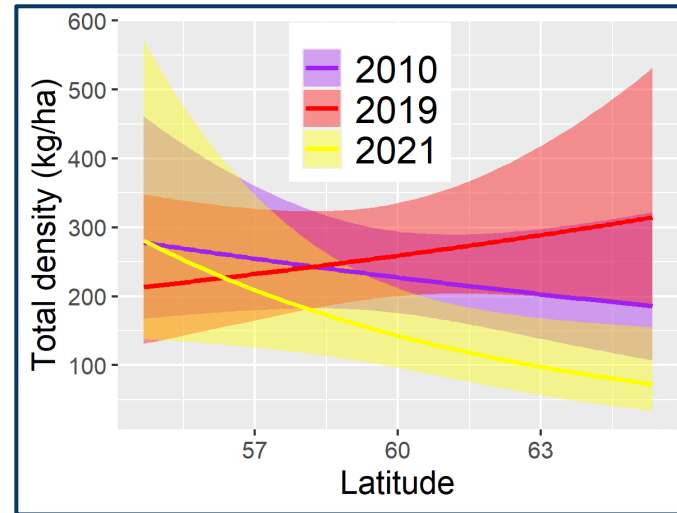
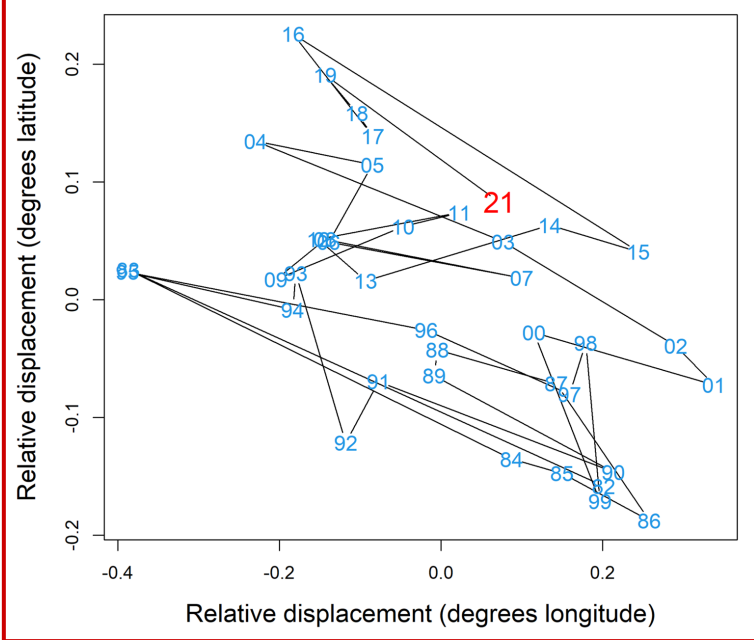


Prey switching and lack of functional redundancy

Stratification and vertical distribution of prey

Shifts in fish distribution

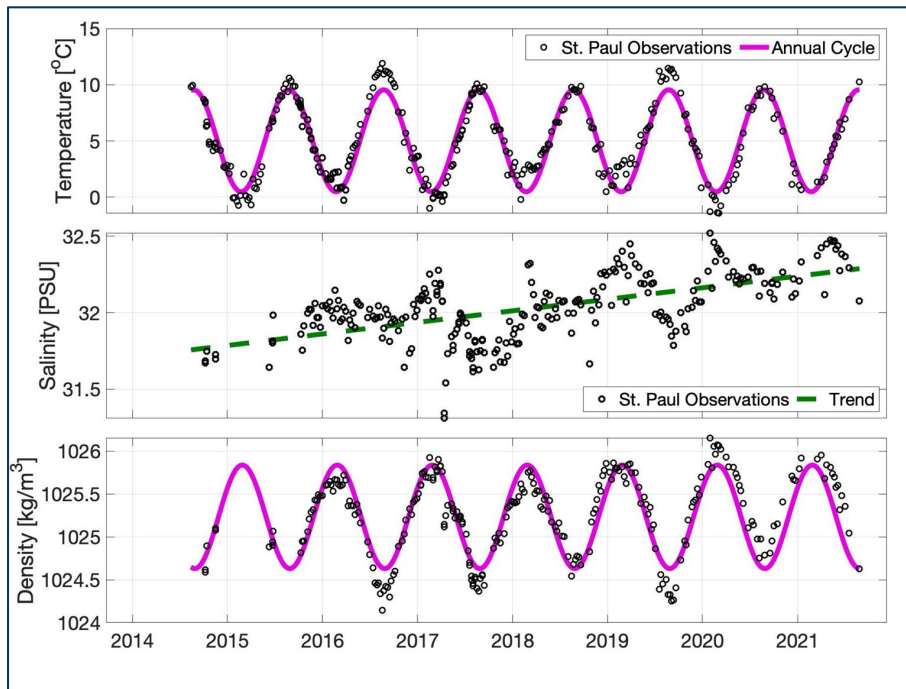
Mueter & Britt



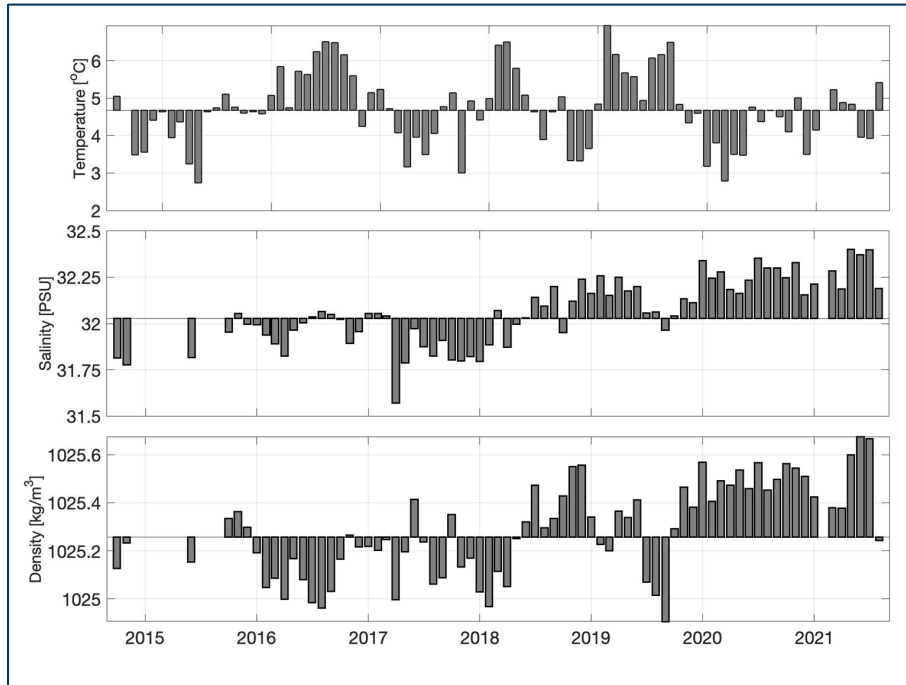
- The distribution of species shifted back to the southeast from 2019 to 2021
- Latitudinal trend had shifted northward, but this reversed in 2021
- Total CPUE in the NBS increased between 2010 and 2019, then decreased substantially between 2019 and 2021

SEBS: physical variables

Danielson et al.

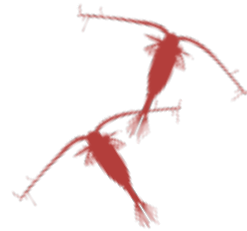
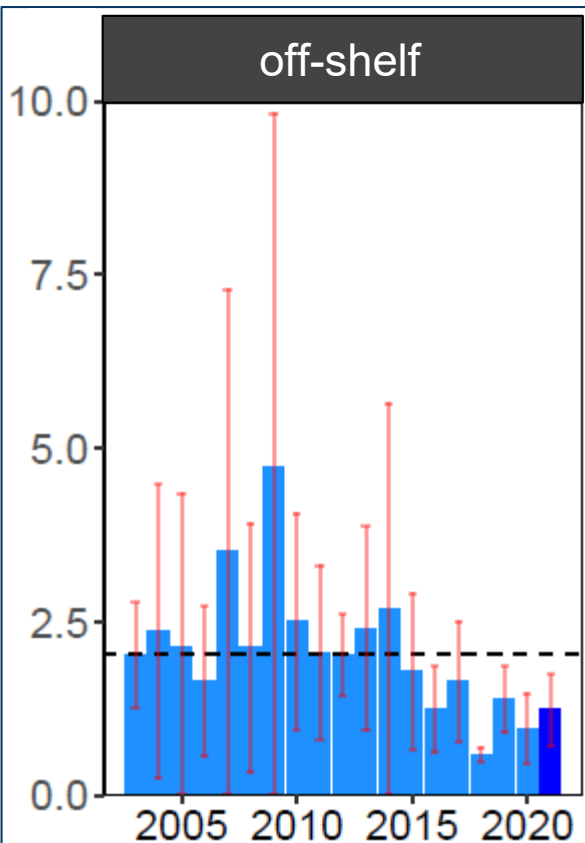
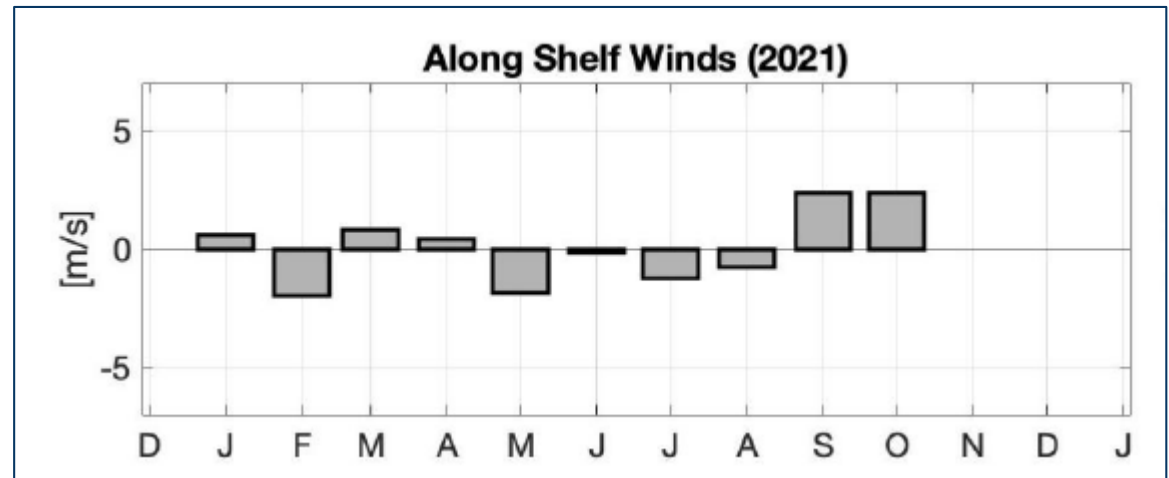
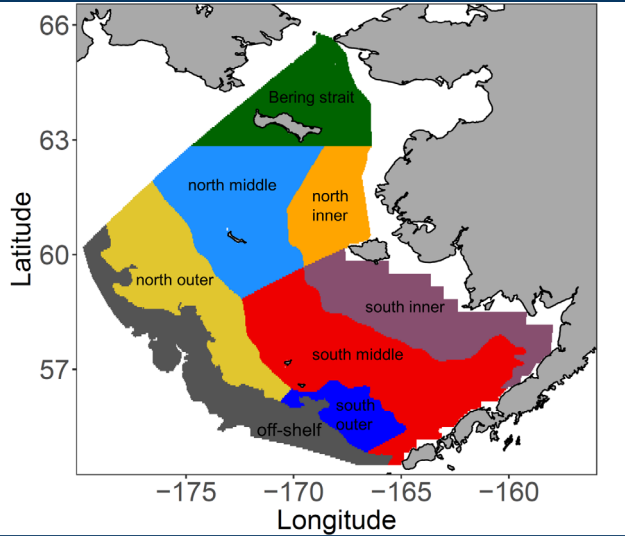


- Community-led monitoring at St. Paul Island since 2014, start of current protracted warm period
- Salinity shows an increasing trend over the time period, in part due to lack of ice melt
- The long-term increase in density at St. Paul Island is driven by the increase in salinity
- *Implications* for water column stratification and vertical mixing



SEBS: lower trophic dynamics

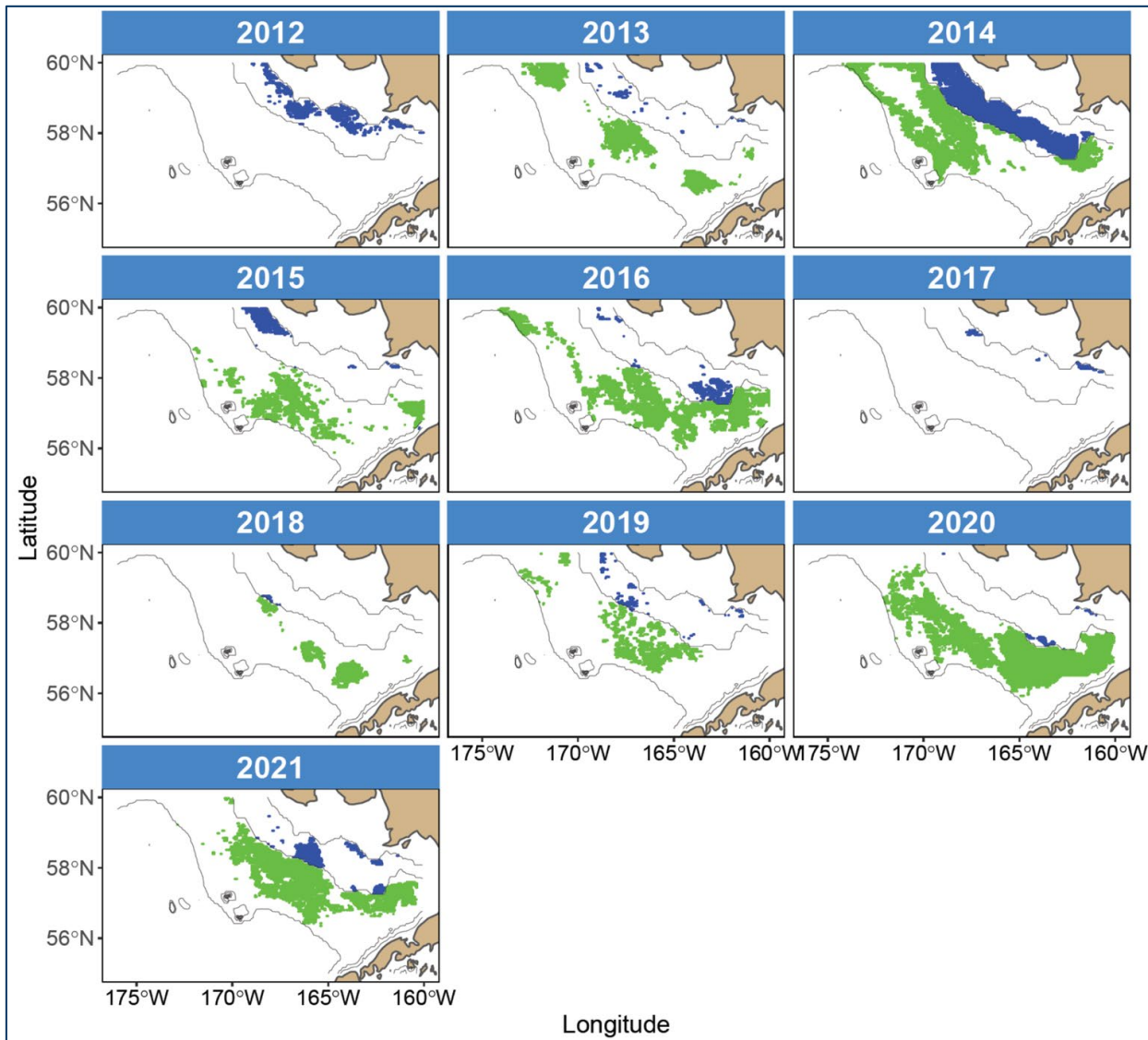
Nielsen et al., Hennon, Kimmel et al.



- Southern shelf had below-average chlorophyll-a biomass
- The off-shelf region had below average values, continuing a trend since 2014
- Along-shelf winds through 2021 were variable (i.e., not consistently upwelling or downwelling favorable conditions)
- *Calanus* spp. appeared to be developing more slowly due to the relative colder temperatures
- May have resulted in higher availability later in the year

SEBS: lower trophic dynamics

Nielsen et al.



- Cocolithophore bloom index was low in 2018 and 2019, but higher in 2020 and 2021
- Density stratification determines bloom strength
- Higher during years with very low **or** very high stratification
- *Implications:* cocolithophores result in longer trophic chains, may be a less desirable food source, and can reduce foraging success for visual predators

SEBS: Seabirds

Integrated Seabird Information

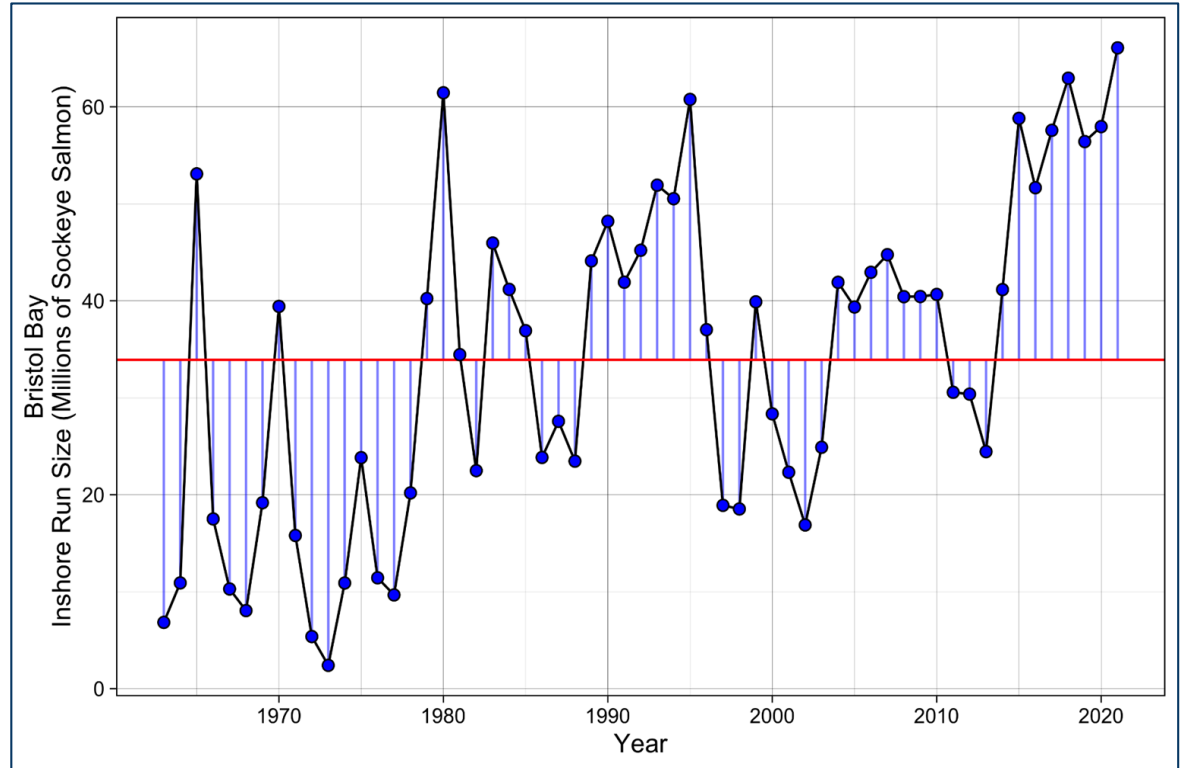


- On St. Paul Island, the timing of breeding and abundance of fish-eating birds (e.g., murrelets, puffins) appeared average
- Plankton-eating bird abundance (e.g., least auklets) was lower than average
- Parakeet auklets have been declining; none were observed in 2020, but some were observed in 2021
- Offshore surveys by USFWS were minimal in 2021, but those indicated average or slightly above average densities across the SEBS
- Low-to-average encounter rate of carcasses (i.e., die-offs) at the Pribilof Islands in 2021

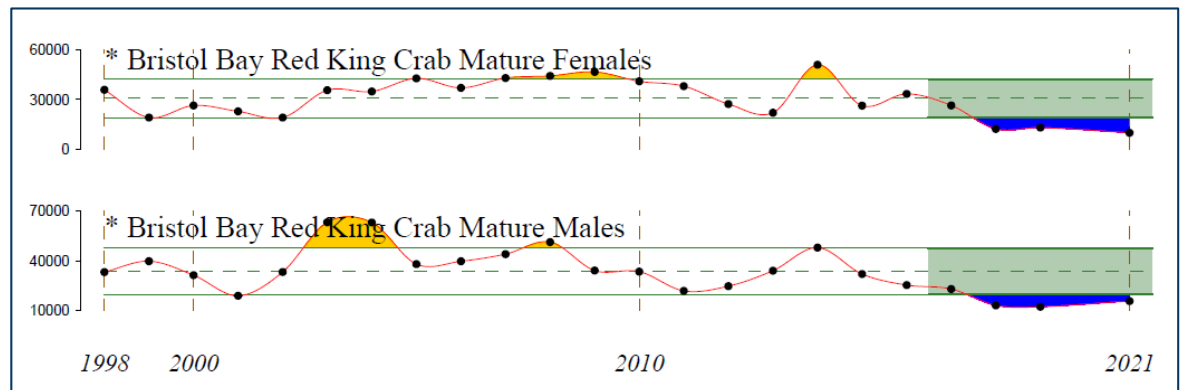
SEBS: Bristol Bay sockeye salmon

Cunningham

- 2021 is the largest inshore run on record.
- Juvenile sockeye feed on zooplankton and age-0 pollock in warm years; adults feed on zooplankton and krill.

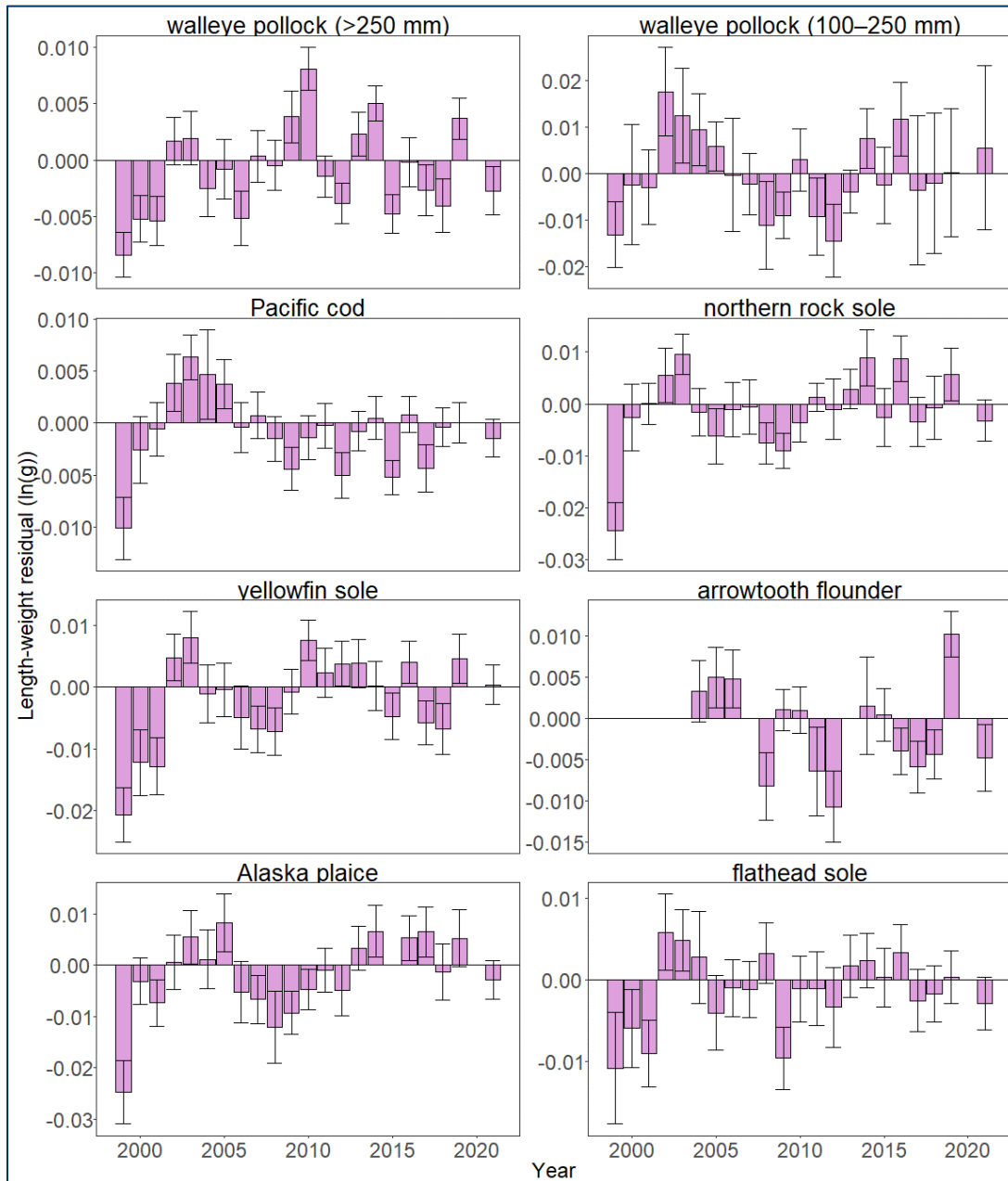


- Are there system-wide impacts?



SEBS: fish condition

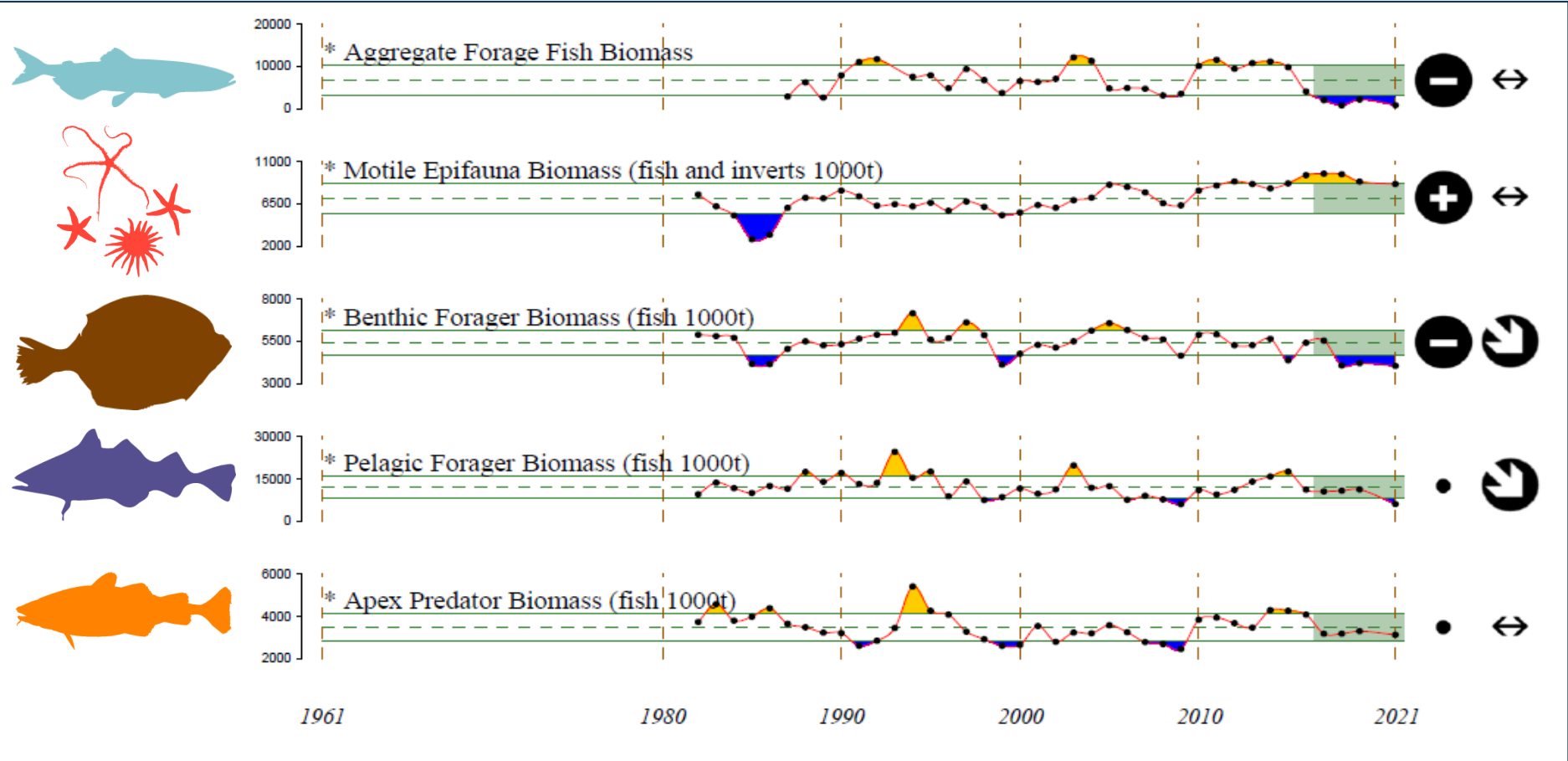
Rohan & Prohaska



- In 2019, an upward trend in condition was observed for most species relative to 2017-2018
- In 2021, negative residuals were observed for all species shown, except small pollock

SEBS: functional guilds

Whitehouse



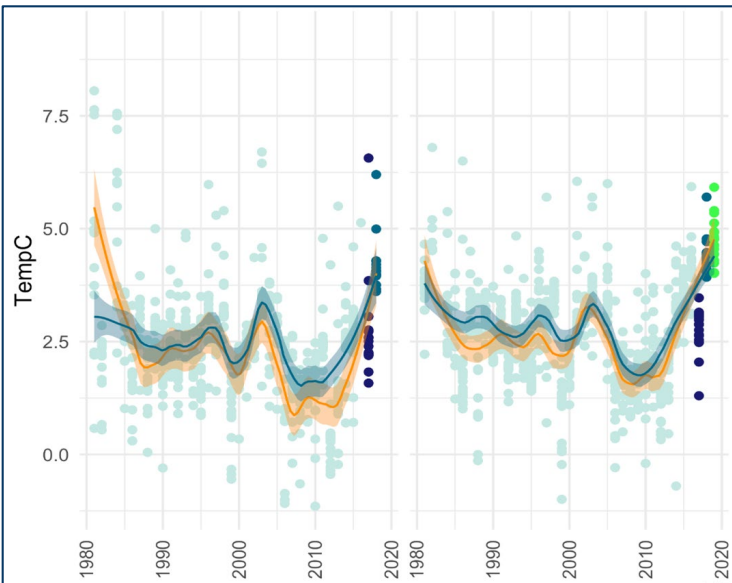
- Forage fish declined steeply between 2015-2017 and remain below their long term mean
- Motile epifauna peaked in 2017 and remain above their long term mean
- Benthic foragers are at lowest level over the time series
- Pelagic foragers dropped in 2021 to their second lowest value (driven by pollock)
- Apex predators was within normal limits in 2021

SEBS: bioenergetics

Holsman et al.

Walleye pollock

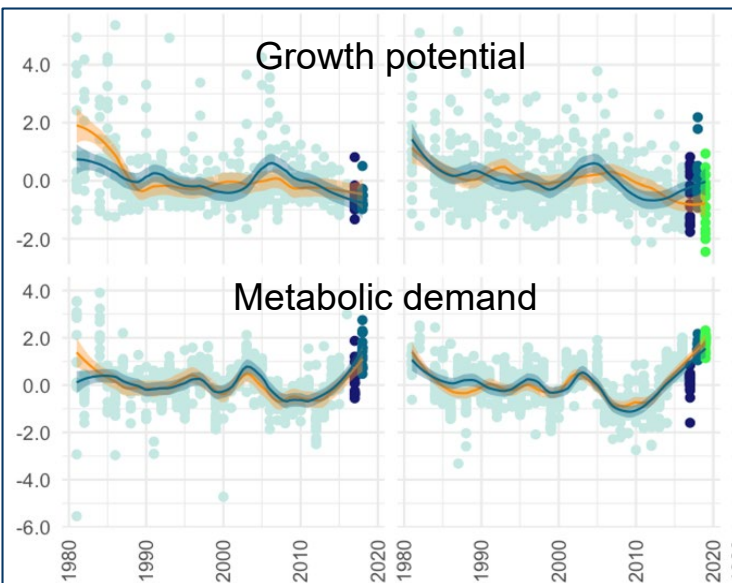
Pacific cod



- The thermal experience has increased in recent years, especially for Pacific cod
- Metabolic demand has increased while foraging rates and prey energy have decreased
- *Implication:* combined, this has led to a decline in growth potential, especially for juvenile and adult pollock and juvenile Pacific cod

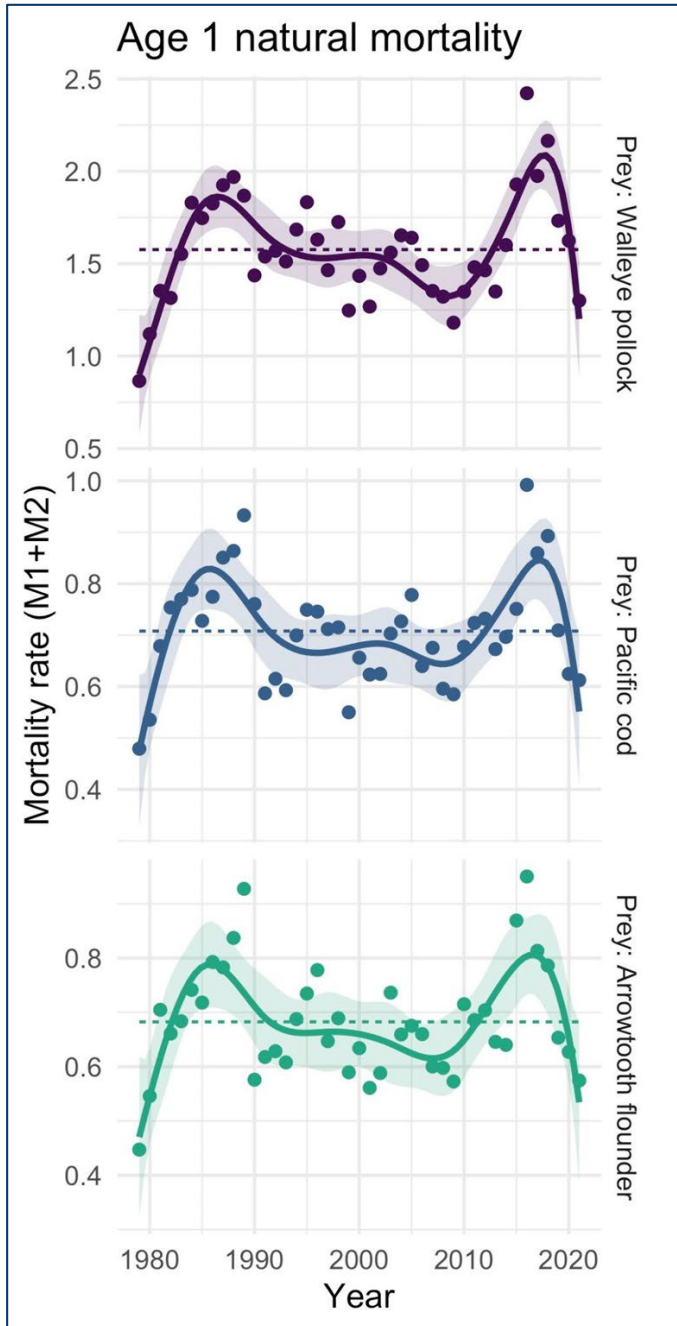
Growth potential

Metabolic demand



Southeastern Bering Sea

Holsman et al.



- Estimates of age-1 natural mortality continue to decline from the peak in 2016, and remain below the long-term mean
- Warm temperatures lead to high metabolic demand of predators
- But declines in total predator biomass result reduced predation relative to 2016
- *Implication:* improved top-down conditions for juvenile groundfish survival in 2020

Update on past stories

● Herring bycatch and PSC limit (Buck et al.)



- The 2016 year class is estimated to be the largest since 1982
- The 2020 pollock A season may have encountered these age-4 Togiak fish, partially explaining the increase in incidental catch

● Ice seal Unusual Mortality Event (Mahoney et al.)



- Increased mortality in 2018-2019 coincided with reduction in sea ice habitat and potential competition for prey

● Gray Whale Unusual Mortality Event (Keogh & Savage)

- Gray whales strandings dropped ~50% in 2021
- Closure of the UME has been discussed; will reassess in early summer 2022



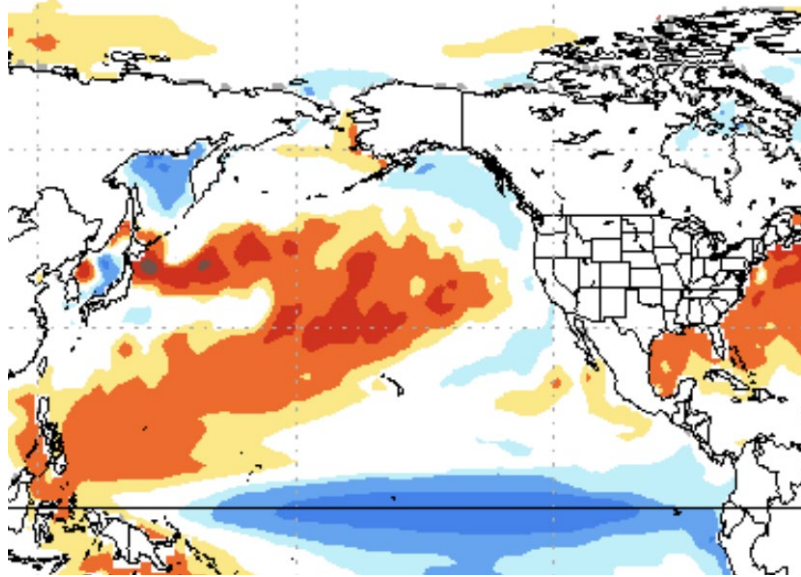
● Seabird bycatch (Krieger & Eich)

- Bycatch decreased 52% from 2019 to 2020, but...
 - COVID-19 reduced fishing days
 - Shift from hook-and-line to pot gear
- Spectacled and Steller's eiders takes
 - Result of species' shifts in response to warming waters?



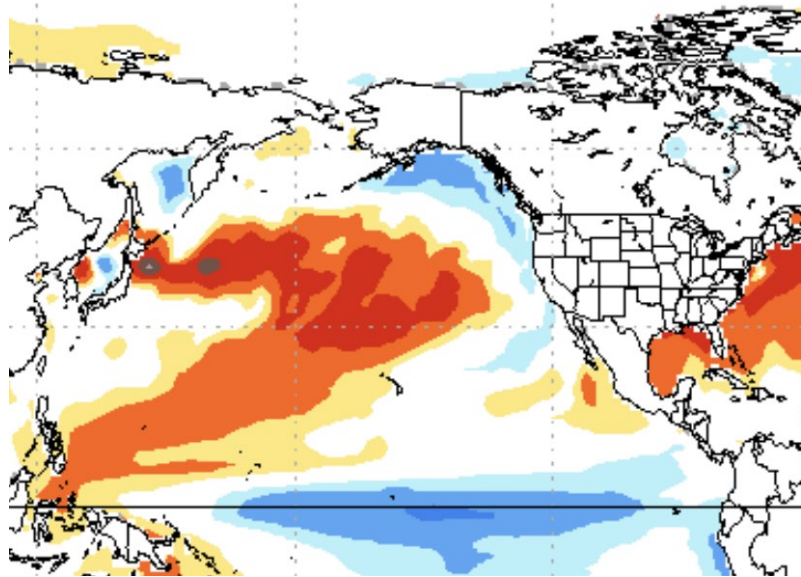
SST projections from NMME

Bond



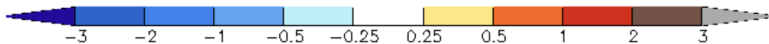
December 2021 - February 2022

- High SLP over western Bering Sea resulting in decreased warmth over SEBS; consistent with La Niña winters.



February - April 2022

- Near-normal temperatures in the Bering Sea and Aleutian Islands with neutral La Niña conditions.



2021 Summary and Implications



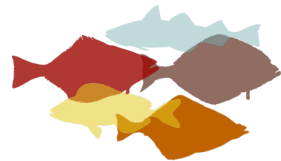
The eastern Bering Sea has been in a persistent warm phase since 2014; 2021 sea ice extent was near-normal, with thicker ice in the NBS and thinner/less ice in the SEBS; cold pool extent was 4th lowest of the time series.

Implications: Cumulative impacts of continued warm conditions over the shelf



Crab population declines, salmon run failures, and seabird die-offs & reproductive failures all connected to the NBS marine environment.

Implications: Concerns about carrying capacity of the NBS

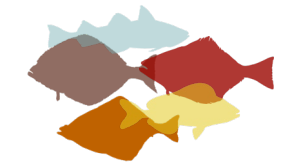


Groundfish shifted to the southeast between 2019 and 2021, with the latitudinal trend reversing to the south in 2021. Total CPUE in the NBS decreased substantially between 2019 and 2021.

Implications: Changes in fish distributions may result in biomass outside the shelf ecosystem and may indicate limitations of productivity in the NBS



Lack of sea ice over the southern shelf contributed to salinization with *impacts to stratification and vertical mixing*. Reduced chl-a biomass and weak upwelling conditions may limit productivity and combined with an above-average coccolithophore bloom in 2021 *suggests poor bottom-up trophic pathways to support juvenile and forage fishes*. Indications that *Calanus* spp. were developing slowly *indicating lipid-rich prey may have been available in late summer*



Groundfish condition was negative for all species, except small pollock; guilds for forage fish, benthic foragers, and pelagic foragers all below their long term means; thermal experience has increased resulting in increased metabolic demands.

Implications: cumulative impacts of continued warmth evident across indicators; fish will need to eat more prey, use energetic reserves, or move to energetically favorable foraging grounds.