

# Ecosystem Status Report Aleutian Islands 2023 – NPFMC AP Dec 2023

*Thank you!*

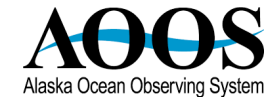
Ivonne Ortiz & Stephani Zador



**With contributions from:**

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photos: [photolib.noaa.gov](https://photolib.noaa.gov)



# 2023 Ecosystem Status Report – Aleutian Islands



## Risk Table

### Environmental/Ecosystem Considerations

#### Level 2

Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)

- AI Pacific cod

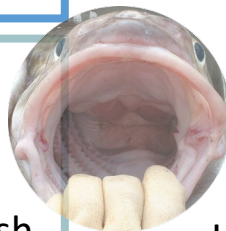
#### Level 1

No apparent environmental/ecosystem concerns

- Northern Rockfish

#### Noteworthy

- Large scale changes SST patterns
- Key temperatures for AI groundfish
- Pcod eating less fish



### Assessment 2023

- Sustained warmer temperature for 10 years
- Warmest winter on record
- Lowest heat and nutrients flux through passes, deeper mixed layer
- Seabirds reproductive success: above mean in EAI; mixed in WAI
- HABs increase EAI: 3,793  $\mu\text{g}/100\text{ g}$  in blue mussels (1000  $\mu\text{g}/100\text{ g}$  potentially fatal)

### Multi-year since ~2013/14 –now linked to regime shift

- Sustained mid-depth & surface warmer temperatures, lower productivity
- Pinks impact: 3rd highest abundance, satellite chla
- Rockfish dominate pelagic foragers - energy banked in little preyed-on, long-lived rockfish (and pink salmon)

### Implications for this year

- SST regime shift implies higher temperatures are the new norm
- sat SST 1-13.4°C, Bottom temperature max 6 - 6.6°C, but is warmer in Sep & <100 m depth
  - fish & invertebrate prey availability expected in EAI, mixed availability in WAI
  - HABs increased risk to human health in EAI



### Cumulative effects

- higher bioenergetic costs
- lower productivity
- zooplankton grow faster
- phenology might start to shift
- changes in prey field timing, composition and location
- rockfish & pink salmon main pathway of zooplankton into foodweb
- past indicators (e.g. PDO) may not be as useful in the future; their relationships with physical and ecological processes may vary as the climate continues to change

## AI Pacific cod

Level 2



- Persistent warm conditions
- Narrow optimal thermal range for >20% egg hatch success
- Single-batch spawners
- Increased bioenergetic costs, increased consumption
- Lower amount of fish in diet since ~2010
- Lower prey quality resulting in reduced fish condition
- Decreased consumption of Atka as prey

## Northern Rockfish

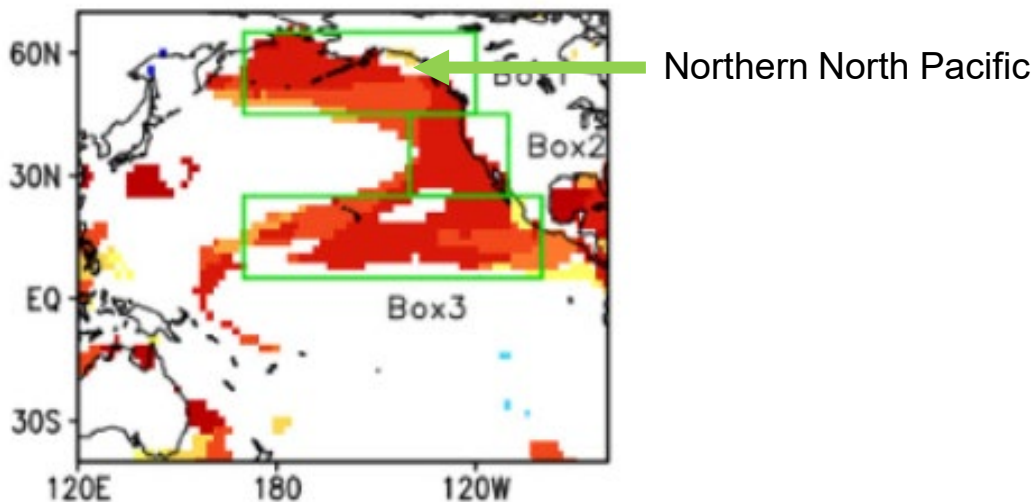
Level 1



- Warm conditions and lower than average fish condition BUT
- Eggs hatch internally – live bearers, parturition April - June
- Long-lived species -each adult cohort's genetic composition is heavily influenced by the environmental conditions experienced during the first year at sea (Maselko et al 2020)
- Genetic portfolio includes the environmental conditions of every cohort's first year
- No apparent effects from Eastern Kamchatka Pink Salmon

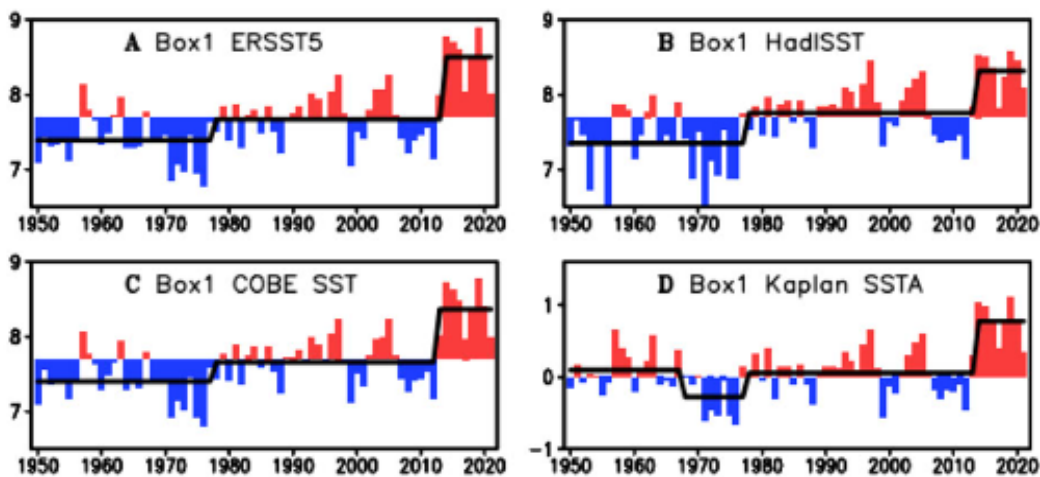
# Noteworthy

# Changes in large scale sea surface temperature patterns

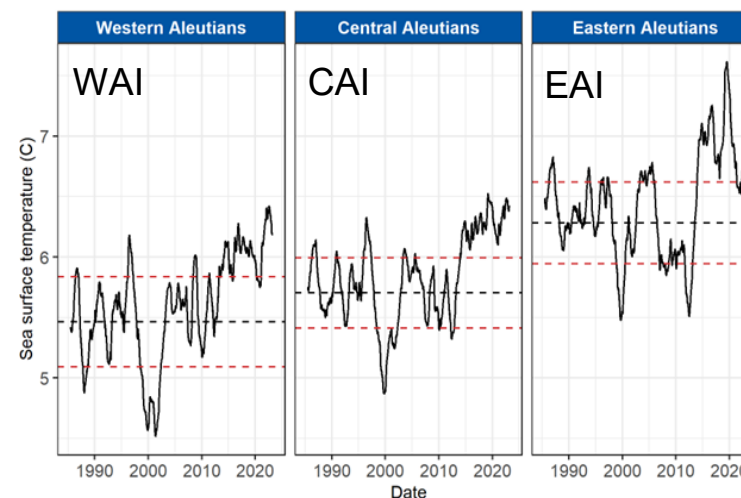


- Thermal regime shift in North Pacific annual mean sea surface temperature 2013/14
- PDO indicator may not be as useful as it used to be
- First mode of variability of SST has changed
- Relationships with physical and ecological processes may vary as the climate continues to change

Lemagie & Callahan



Xiao and Ren, 2023. A regime shift in North Pacific annual mean sea surface temperature in 2013/14. Modified from Figures 1 and 2.

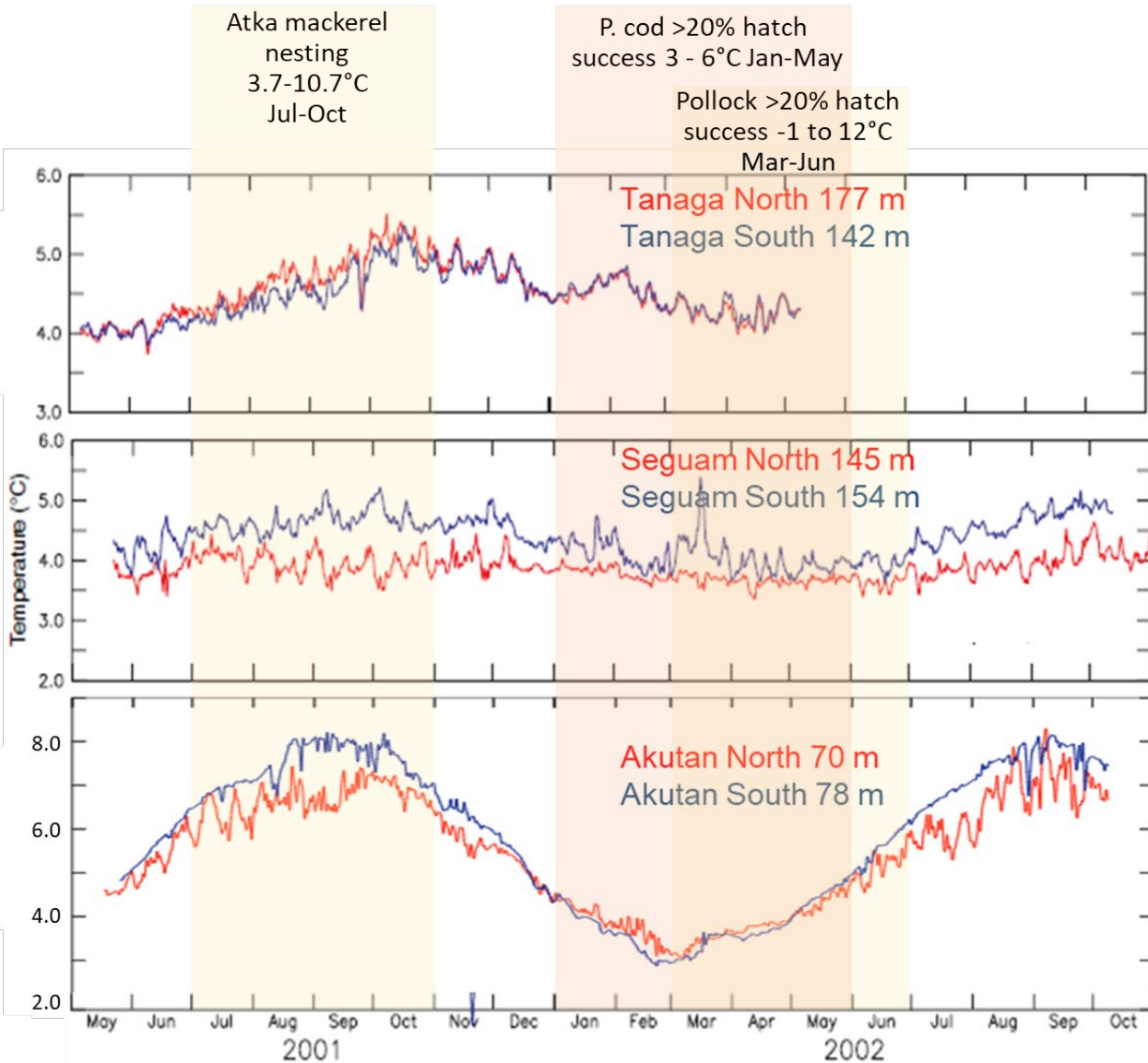


Werb and Rudnick, 2023. Remarkable changes in the dominant modes of North Pacific sea surface temperature. Modified from Figures 1b and 3b.

# Noteworthy

## Key temperature ranges for commercial groundfish species in the Aleutian Islands

Persistent warming conditions: The SSC suggested information on which species are most vulnerable to these persistent conditions would be helpful for understanding ecosystem impact

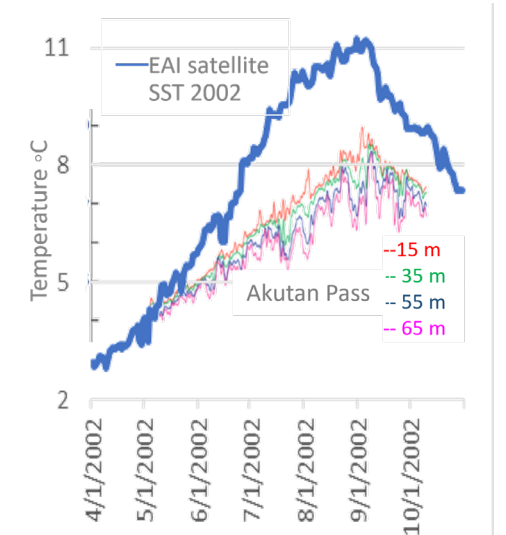


**Most vulnerable: Pacific cod**, narrow optimal temperature for >20% egg hatch success: 3-6°C January to May at 100-200 m. Eggs adhere to seafloor.

Bottom trawl survey max bottom temperature: 6.6°C potentially same temperature in Jan-May in some areas. No. days  $\geq 6^\circ\text{C}$  since 2014: 16 11 times in 2016, depths 68-141m; 6 times depths >100m, across AI

**Second most vulnerable: Atka mackerel**, wide nesting temperature 3.7-10.7°C in July to October, 15°C lethal for eggs, shallowest nests at 34 m depth.

Atka mackerel: Bottom trawl survey max SST: 12.3; twice above 12°C max satellite SST 13.39. Satellite SST No. days  $\geq 12^\circ\text{C}$  since 2014: 79. In WAI & EAI.

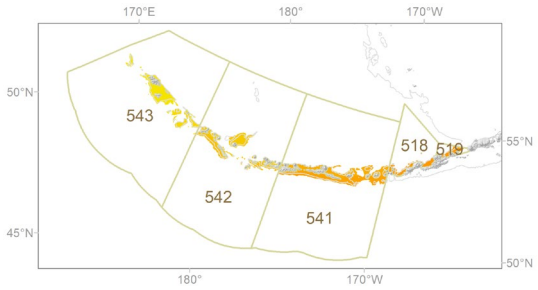


Mooring data: Staben et al 2005; satellite SST Lemagie & Callahan; bottom trawl temperature, O'Leary, .P. cod data: Neidetcher et al. 2014, Laurel, Rogers, Ortiz

# Noteworthy

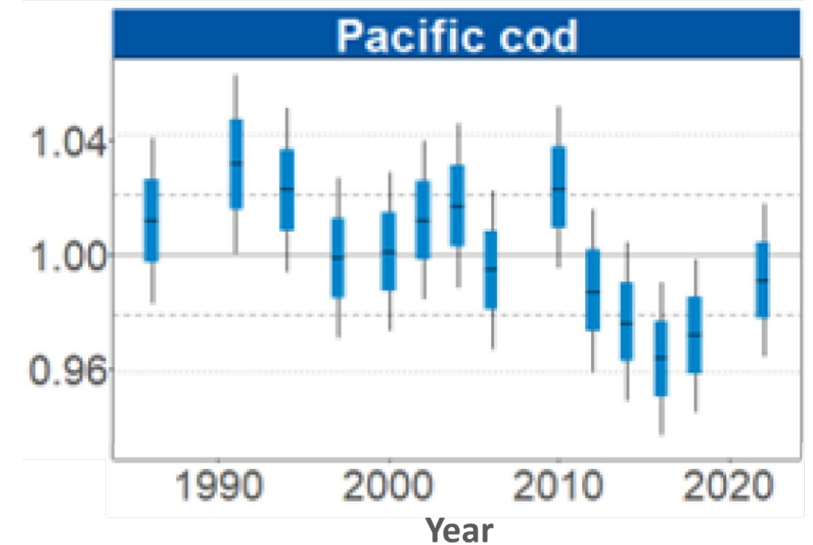
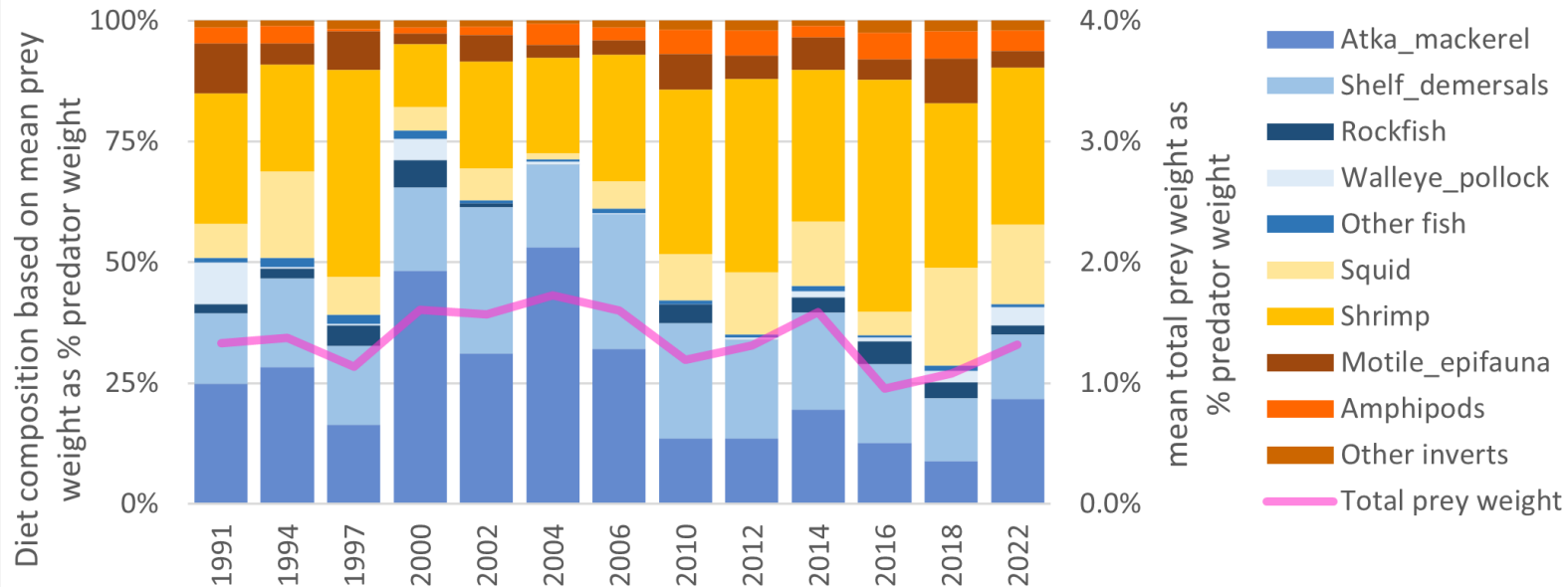
## Changes in Pacific cod diets

Declines of non-commercial species in WAI: The SSC encourages efforts to explore mechanistic and food-web links for these observed trends, prioritizing diet data when samples are available



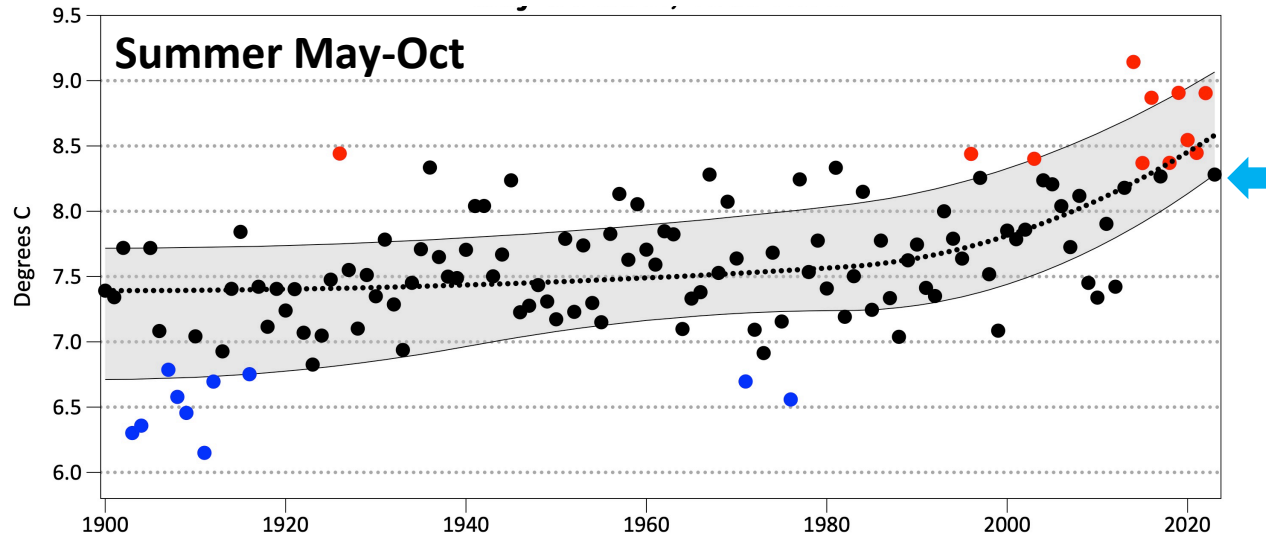
- Less fish in diets
- Even when similar amount of prey was consumed, less fish results in low fish condition
- Lower fish condition potentially due to lower prey quality + potentially higher bioenergetic costs
- Decrease of fish in diet most noticeable in western Aleutian Islands
- Trend not seen east of Samalga where prey consumption was highest in 2022 and condition was (+)

Pacific cod diets in AI areas NMFS 543, 542, 541



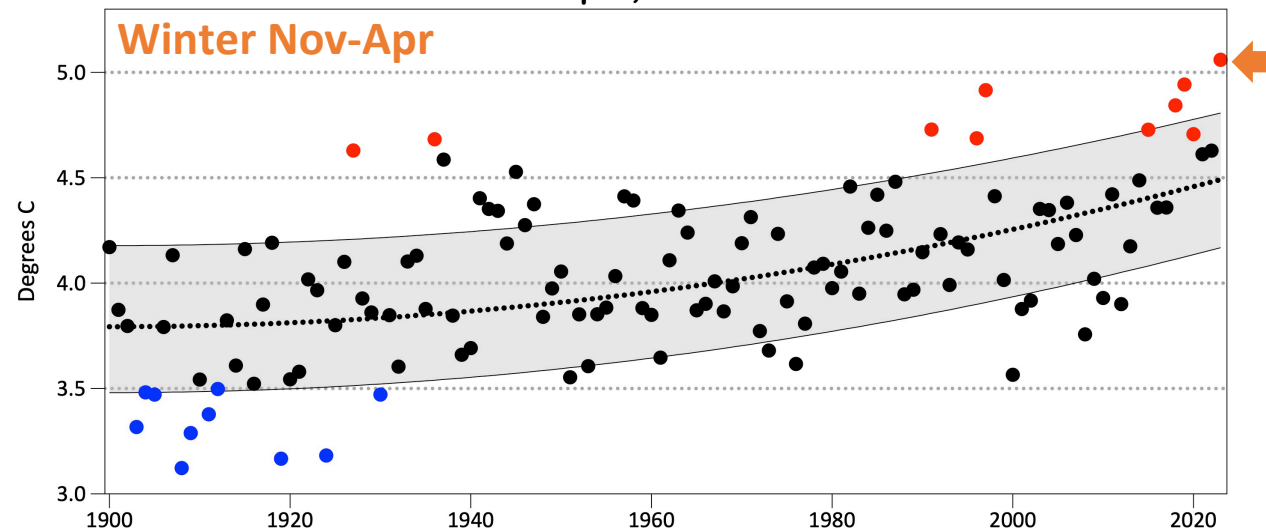
# Current Conditions 2023

Cooling in spring summer, warmest winter



## Long-term Sea Surface Temperature

- 2023 – Cooling of spring and summer
- 2023 – Warmest winter in 124 years
- Warming trend winter and summer



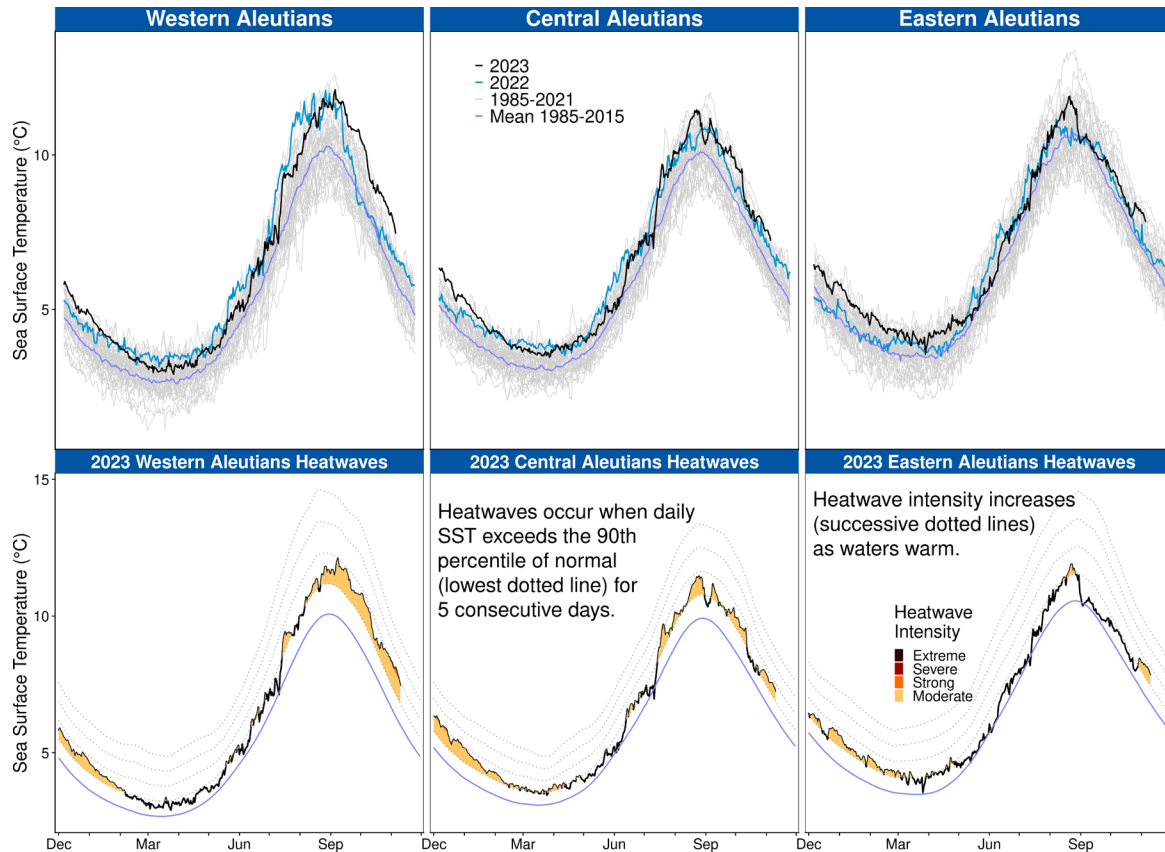
Thoman & Lemagie and Callahan

# Moderate marine heat wave in winter, cooler spring and summer but above long-term average

## Satellite SST

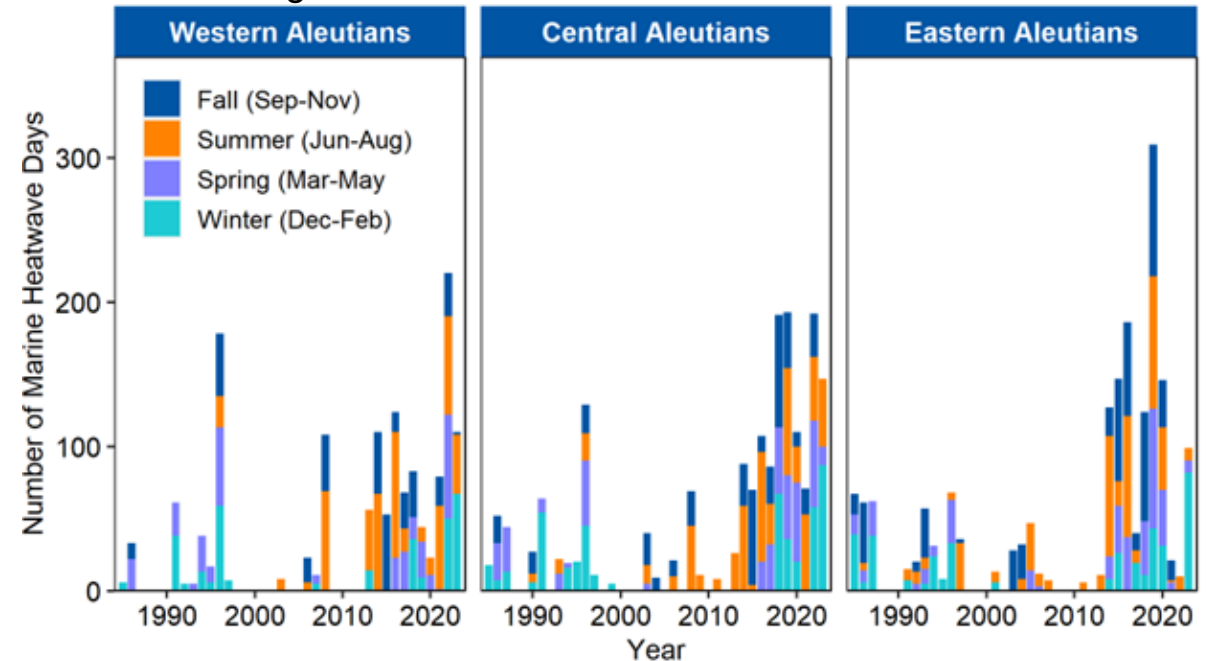
- Warm winter throughout
- Cooler spring & summer but still above 1985-2015 mean
- Current Fall – warmest in WAI

data through 11-12-2023



NOAA Coral Reef Watch data, courtesy National Environmental Satellite, Data, and Information Service (Updated: 11-10-2023)  
Data are modeled satellite products and periodic discrepancies or gaps may exist across sensors and products.  
Contact: matt.callahan@noaa.gov

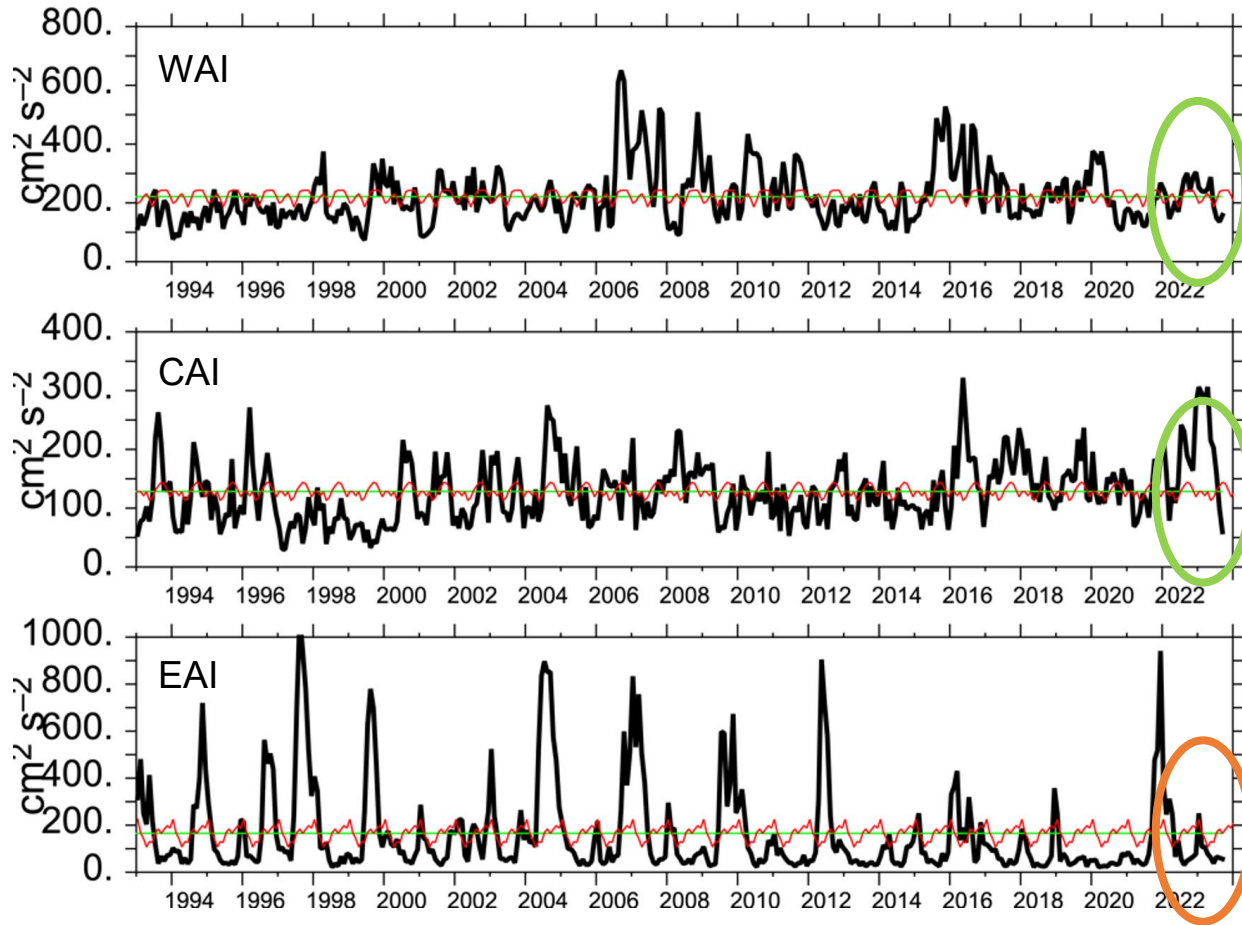
data through 09-02-2023



Lemagie & Callahan



## Lower transport of heat, salt and nutrients through passes across the chain

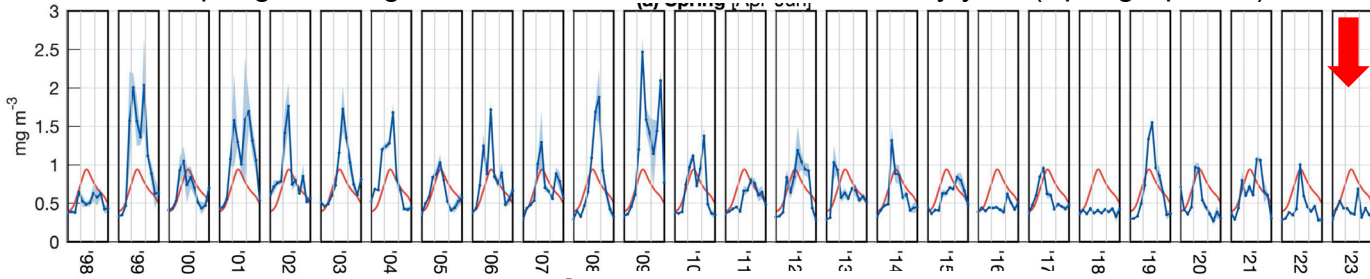


### Eddy Kinetic Energy

- Historical minima in EAI
- Currently below average in all three regions
- Lower transport of heat, salt and nutrients through passes

# Lower than average spring phytoplankton biomass, negative trend across time series

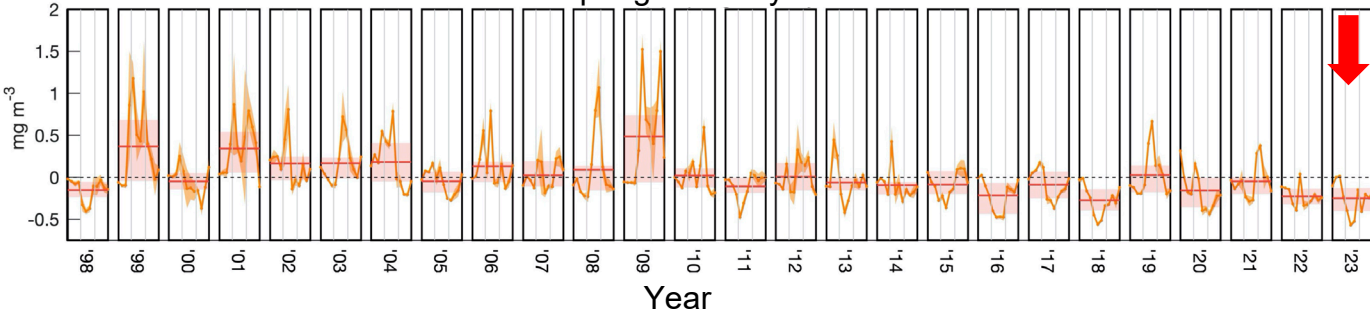
Spring - Average Aleutian Islands Globcolour chl a by year (Spring Apr-Jun)



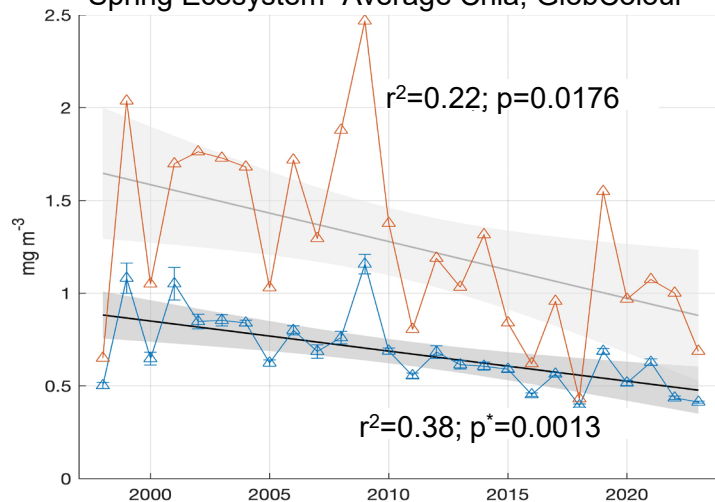
## Satellite chl-a

- Satellite chl-a, spring (Apr-Jun) phytoplankton biomass lower than 1998-2022 spring average
- Evidence for a negative trend in spring AI chl-a across the GlobColour time series
- Low chl-a also in the adjacent off-shelf areas of EBS, shelf areas of GOA in recent years
- Note ratio of small to large phytoplankton fluctuates (next slide)

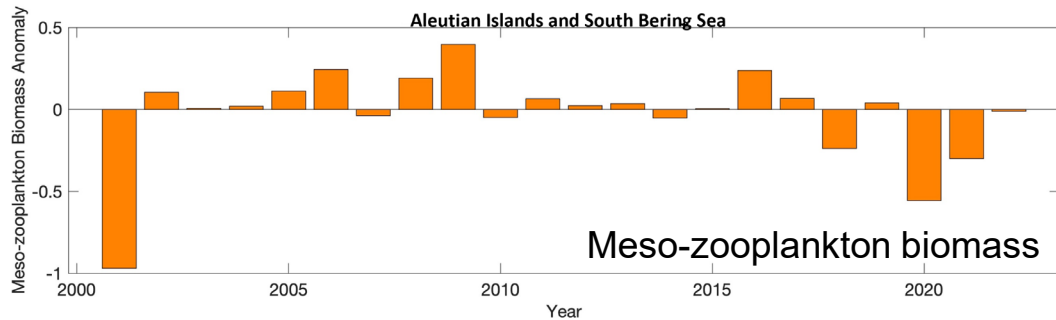
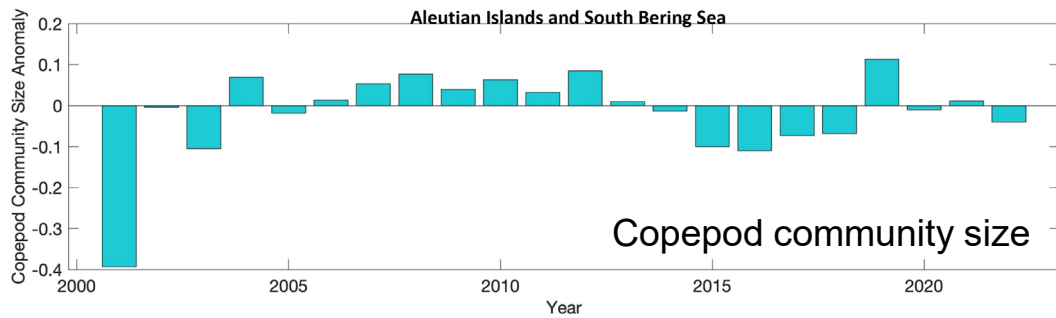
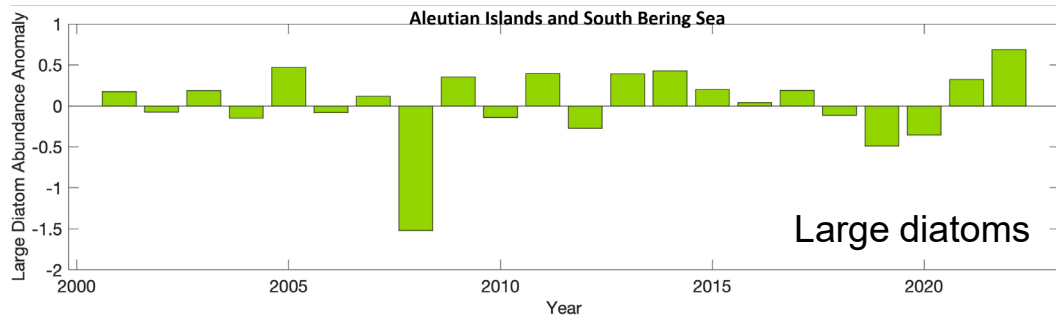
Spring Anomaly



Spring Ecosystem- Average Chla, GlobColour



# More species of smaller size copepods and lower meso-zooplankton biomass

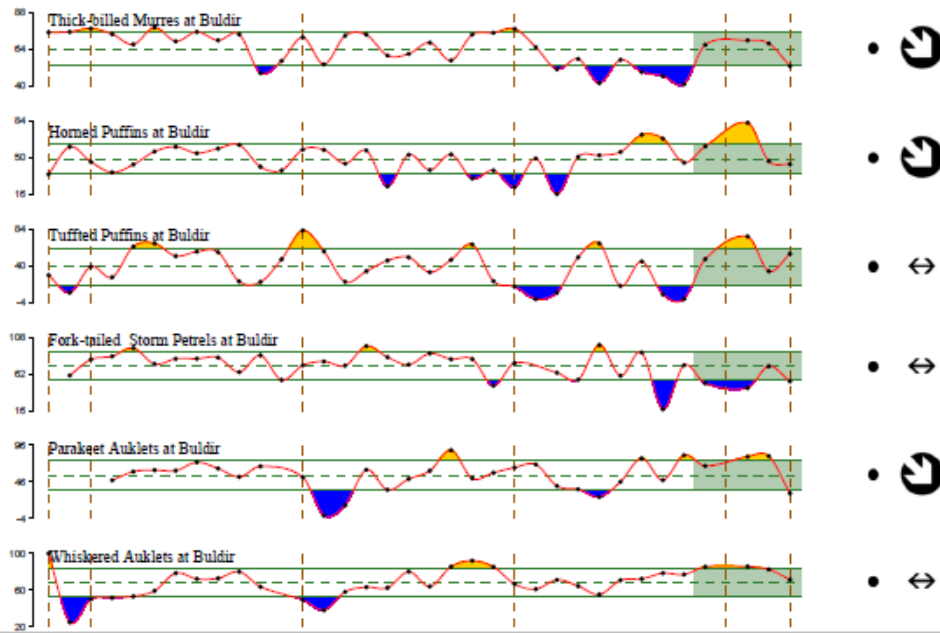


## Continuous plankton recorder

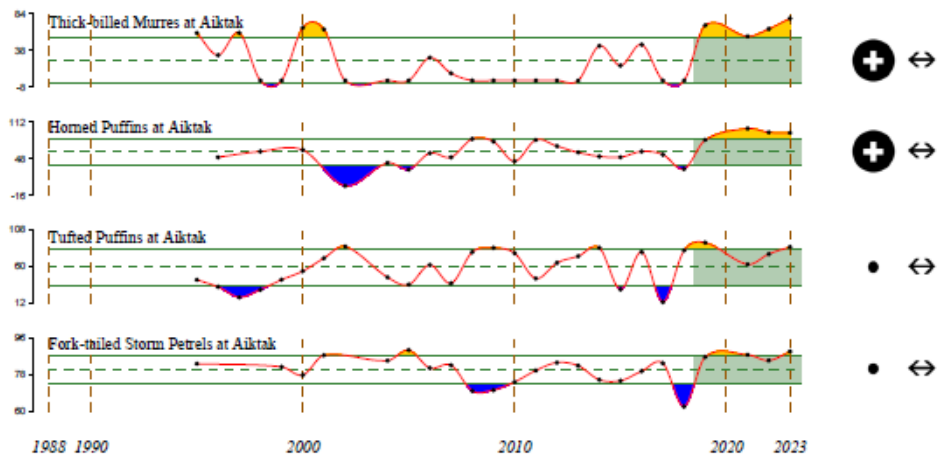
- Large diatom biomass in 2022: higher than 2000-2021 average
- Sustained trend in copepod community size points to smaller size of copepods
- Lower meso-zooplankton biomass than 2000-2021 average in 2022

# Good foraging conditions in eastern Aleutians for all types of prey, mixed in western Aleutians

Western Aleutians



Eastern Aleutians



2019-2023 Mean  
 (+) 1 s.d. above mean  
 (-) 1 s.d. below mean  
 • within 1 s.d. of mean

2019-2023 Trend  
 (bird icon) increase by 1 s.d. over time window  
 (neutral face icon) decrease by 1 s.d. over time window  
 (double arrow icon) change < 1 s.d. over window

## Seabird Reproductive Success

- Average or above for EAI seabirds: **good foraging conditions in summer** for plankton and fish foragers in EAI; mixed in WAI

Site	Species													EAI	WAI	
	Primarily fish eaters						Primarily zooplankton eaters									
	glaucous winged gull	common murre	thick billed murre	horned puffin	tufted puffin	red-legged kittiwake	black-legged kittiwake	fork-tailed storm-petrel	Leach's storm-petrel	ancient murrelet	parakeet auklet	least auklet	whiskered auklet	crested auklet		
Aiktak	😊	😊	😊	😊	😊	-	-	😊	😊	😊	-	-	-	-	😊	😊
Buldir	😊	-	😊	😊	😊	😞	😊	😊	😊	-	😊	😊	😊	😊	😊	😊

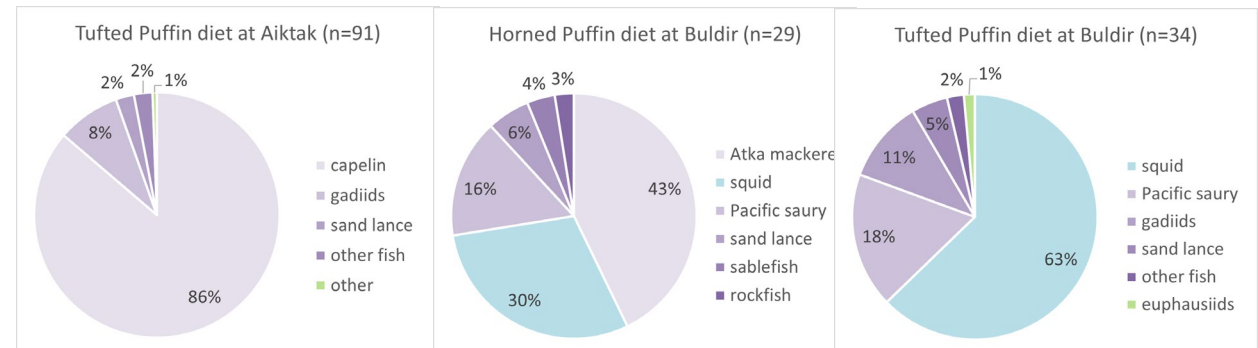
above 😊  
 average 😐

## Seabird Diets

Mostly capelin in the EAI 86% in tufted puffin chick diets

Fish and squid in WAI: 63% squid in in tufted puffin chick diets

Atka mackerel 43% of diet of horned puffins



# Increased PST in June above potentially fatal levels for humans and decreased school enrollment

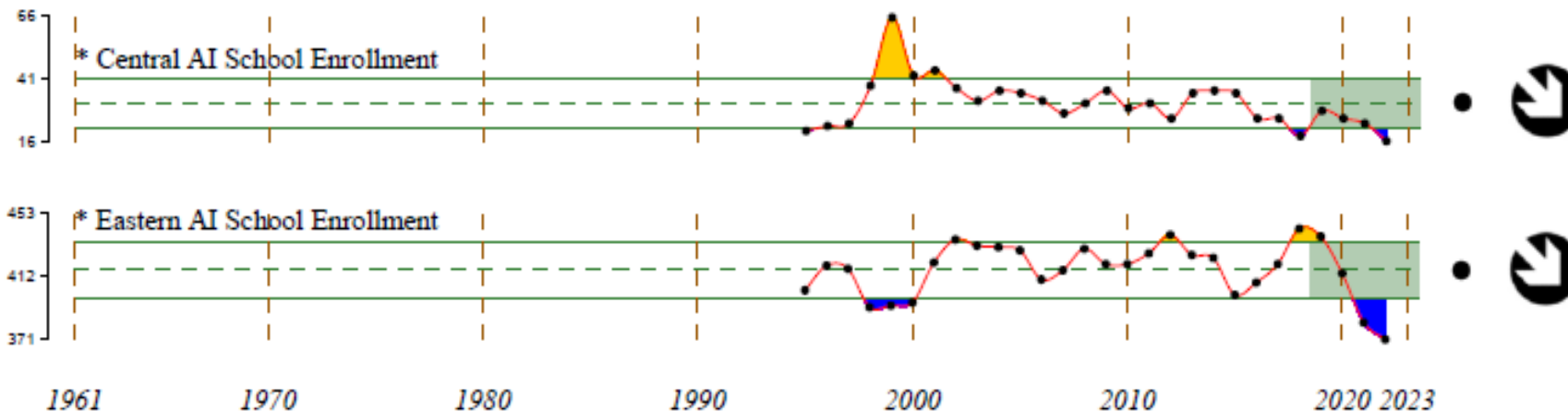


## Harmful Algal Blooms

- Maximum PST recorded in June 15: 3.7x above level considered potentially fatal in humans; 47x above legal limit
- Seabirds (shearwaters) planned to be tested for HABs after over 150 carcasses were reported in Akutan in mid-September; 6 samples tested negative for Highly Pathogenic Avian Influenza

## School enrollment

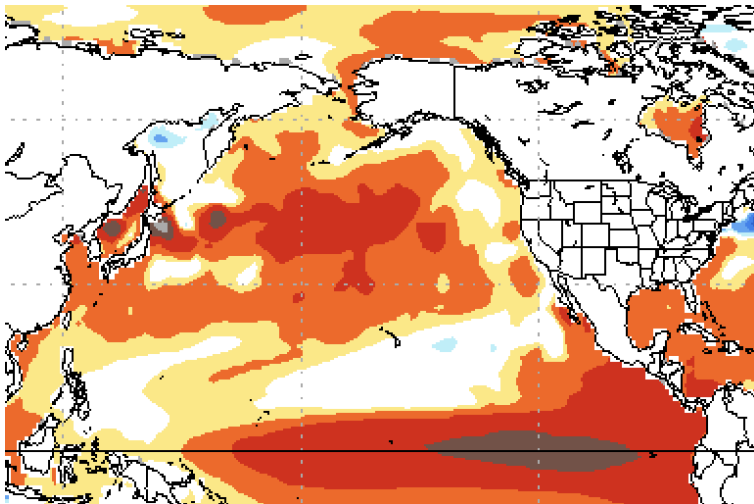
- Decreased school enrollment in 2022-23
  - Central Aleutians: decrease driven by Adak School
  - Eastern Aleutians: decrease driven by Unalaska elementary & high school
- Lower enrollment decreases the stability of the community.
- Enrollment bottomed out in AK in 2021-22 and [has not recovered in the Aleutians.](#)



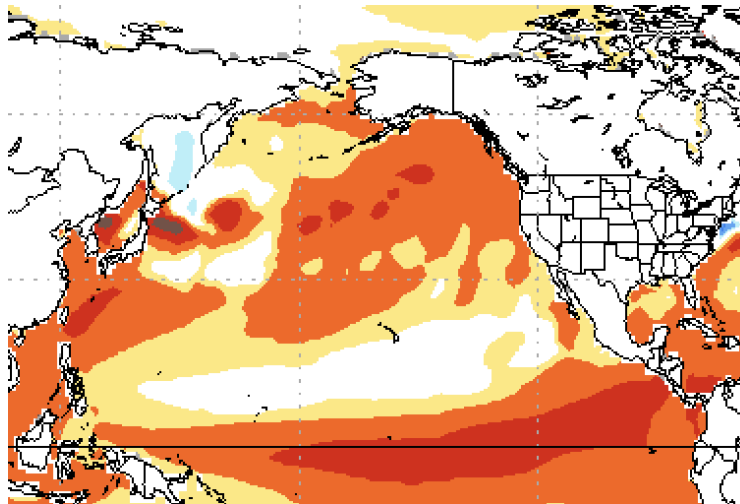
## National Multi-Model Ensemble Forecast 2024

- **62% chance of El Niño** during April – June 2024,
  - Climate prediction center, NOAA [https://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/enso\\_advisory/ensodisc.shtml](https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml)
- **Warm** conditions for western Aleutians (NMME, Bond) for January – March: potential issue for Pacific cod.
- Ensemble indicates conditions should not be extreme relative to the past 20-30 years
- Sea ice should extend south of 60°N perhaps all the way to M2, and as far south as Bristol Bay along the coast

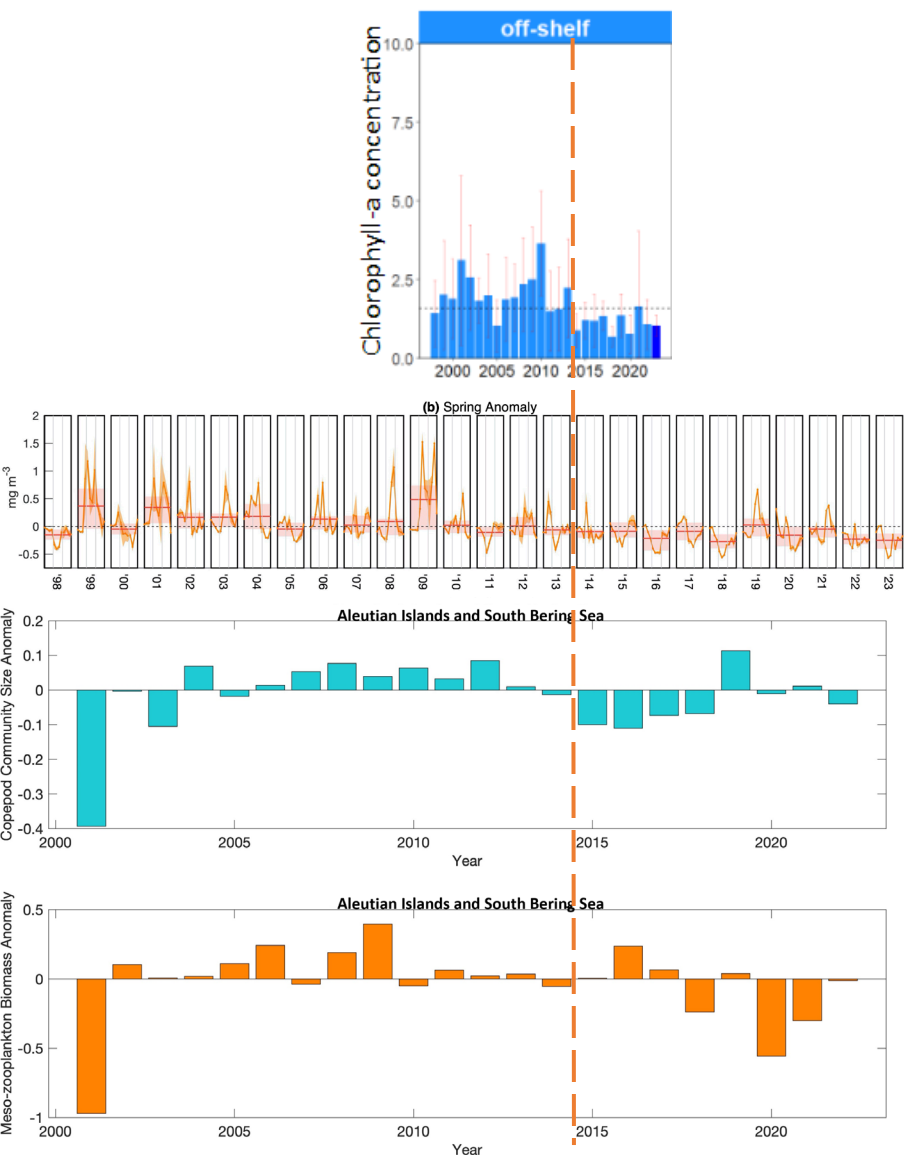
Sea surface anomalies from National Multi-Model Ensemble  
January - March



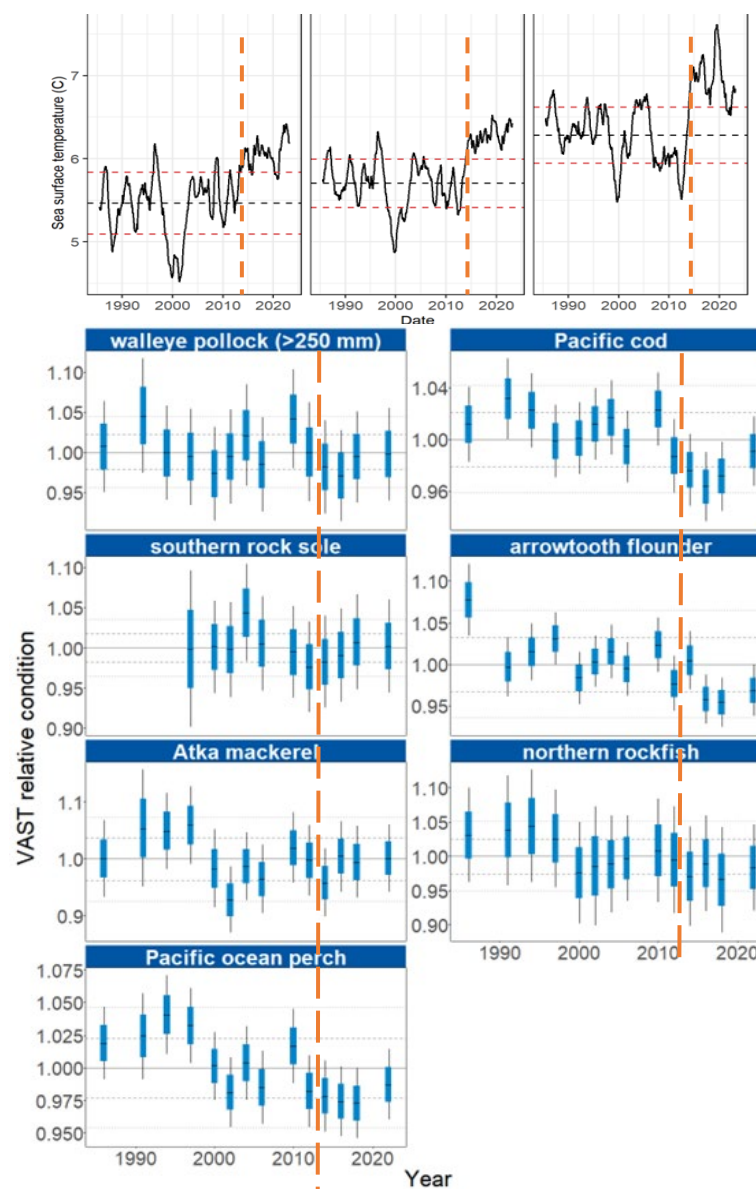
March - May



## Satellite chl-a & Copepods



## Temperature and Fish Condition



## Satellite chl-a, Diatoms & Copepods

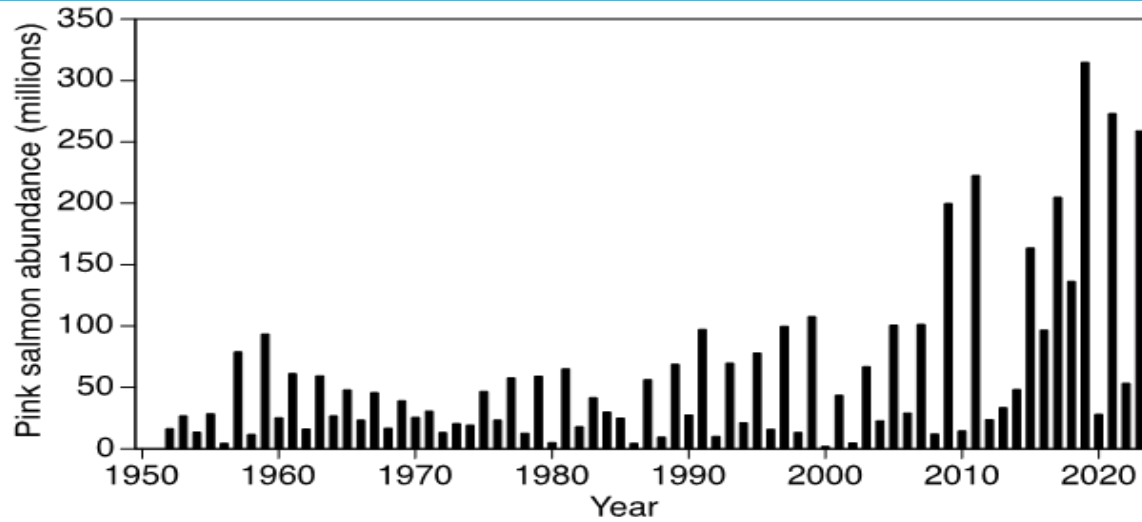
- Satellite-derived chl-a reverted to generally lower than average since 2014.
- Satellite chl-a in EBS off-shelf also decreasing since 2014
- Smaller copepods
- Lower meso-zooplankton biomass

## Temperature and Fish Conditions

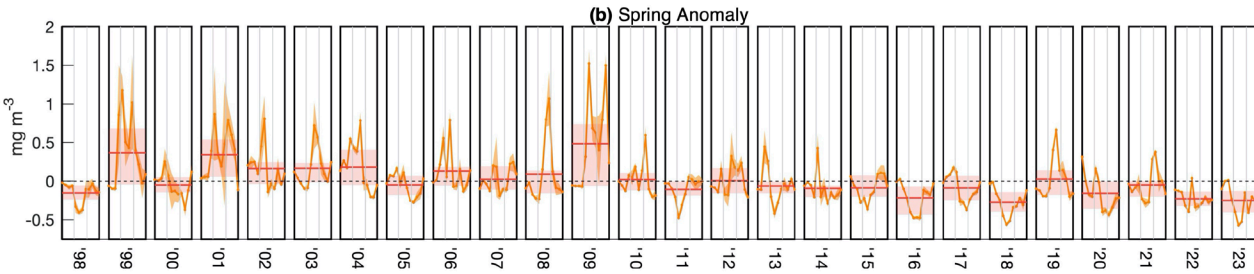
- Warmer temperatures
- Condition factor average or below average since 2014
- Higher energetic costs, increased food consumption

# Eastern Kamchatka pink salmon in odd years

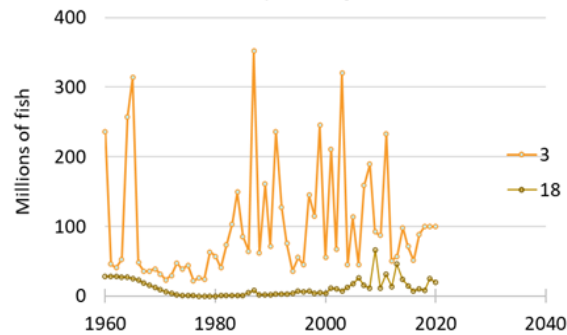
# Multi-year patterns



Spring (Apr-Jun) satellite chla anomaly GlobColour, Pelland



Pacific Ocean perch Age 3 and 18

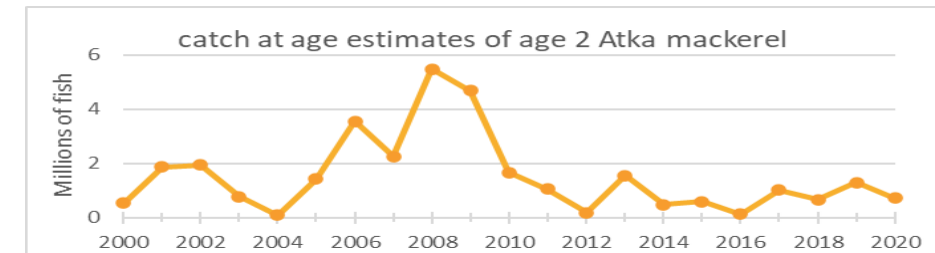
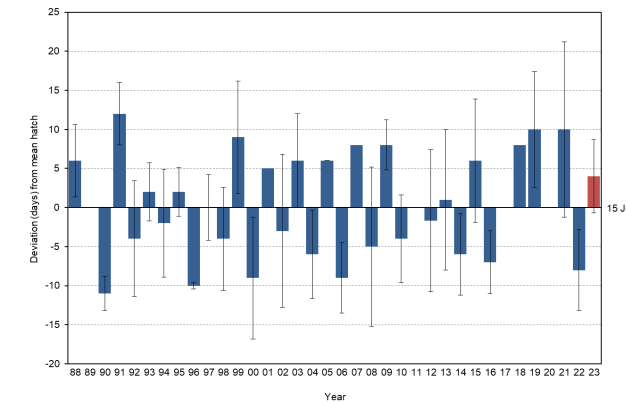


Spencer et al. 2020

## Eastern Kamchatka pink salmon

- Continued high level for a low abundance year
- Biennial pattern at several trophic levels from diverse sources
- No statistical analysis has been conducted
- Potential thresholds: 2009 for high abundance years

Tufted puffin hatch date anomaly at Buldir, Rokek et al.  
no effect on reproductive success

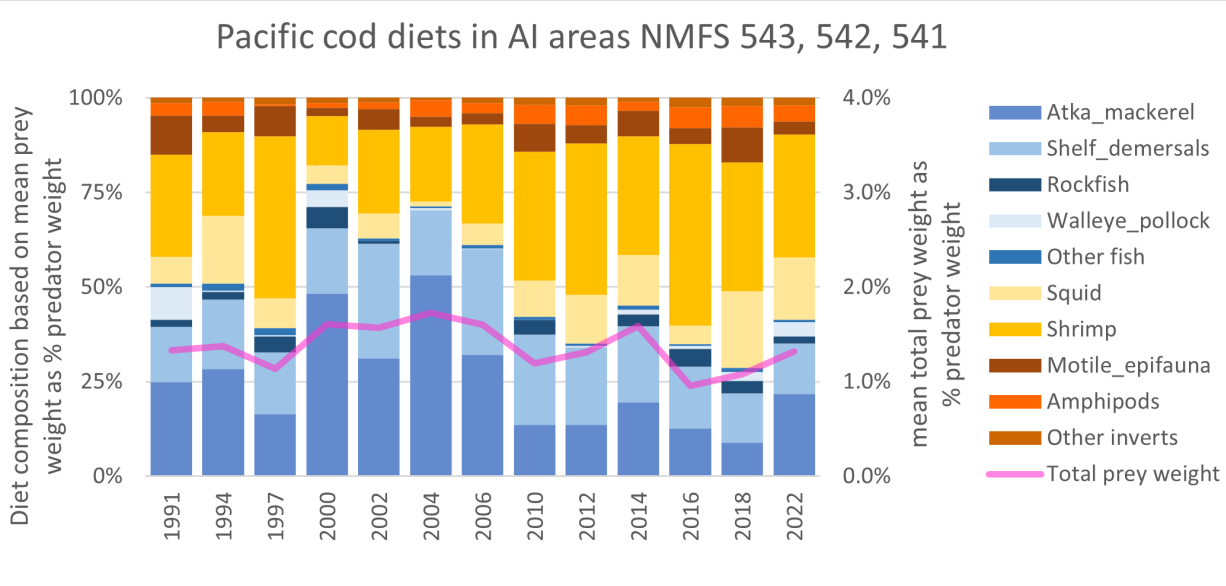


Lowé et al. 2021

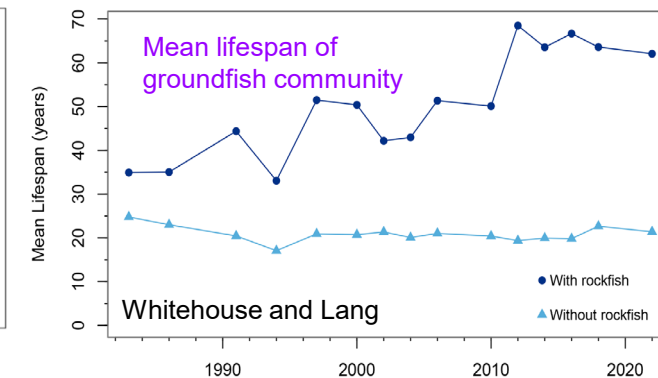
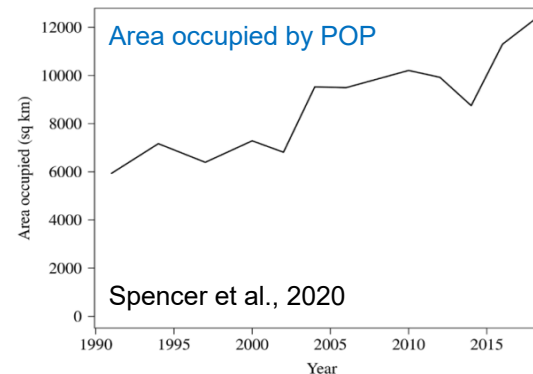
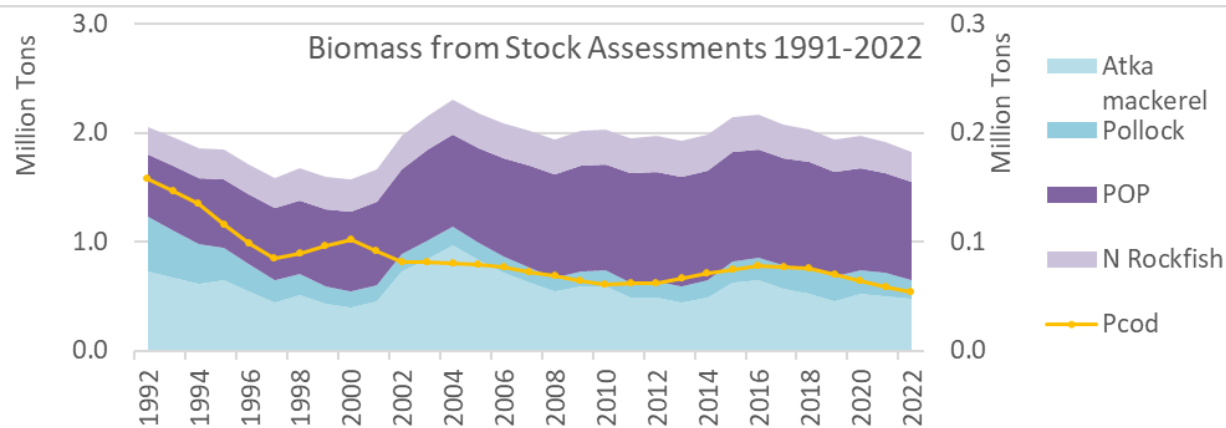


# POP and Northern Rockfish as main pelagic foragers

# Multi-year patterns



- Increased competition with other fish feeding on zooplankton, changes in cod diet may be due to decreasing Atka mackerel
- POP expanding area occupied
- Longer mean lifespan of groundfish community (35 to 60 years) means a slower turnover rate & dampened effects of environmental variability (increased ecological stability)
- Spatial competition with Atka mackerel, pollock?

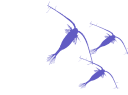


# Summary and implications



Jan – Mar warmest winter on record, sustained warmer temperatures and large-scale changes in SST

*Potential concern for higher bioenergetic costs, changes in phenology (timing and success of egg development, growth rates, and utility of past indicators (e.g. PDO may not be as useful in the future)*



Lower than average phytoplankton biomass (sat chl-a) and small copepod size

*Decreased primary production/ lower availability of large copepods as prey, despite favorable climatological conditions for zooplankton*



Seabird reproductive success above average in EAI for plankton and fish-eating seabirds; mixed for WAI

*Indicates potential availability of prey and good foraging conditions for both plankton and fish eating groundfish in EAI, but mixed availability in prey in WAI*



HABs increased to 47x FDA limit in June

*Indicates potential seasonal risk to human health and risk to predators in the ecosystem*



Pacific cod diets

*Decreased availability of fish in diets, available prey of lower quality and/ or increased bioenergetic costs and consumption.*



Rockfish dominance of pelagic forage fish biomass

*Potential for increased competition for zooplankton and decreasing availability of Atka mackerel and pollock as prey for fish and marine mammals. Rockfish are long-lived and are not a preferred prey item, but may increase resilience of ecosystem*



Increasing Eastern Kamchatka pink salmon during both low abundance and high abundance years

*Potential biennial pattern cascading to fish and combined with increased temperatures since 2014. Eastern Kamchatka pink salmon export energy from the system*

*The persistent warm conditions + rockfish dominance + increasing pink salmon abundance jointly might indicate*

***transition of the ecosystem to a state where rockfish and pink salmon are the main pathway of zooplankton into food web***

## Additional Information Available

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Ecosystem Status Reports through 2022 are available [here](#):



ESR Reports (1999-2022)