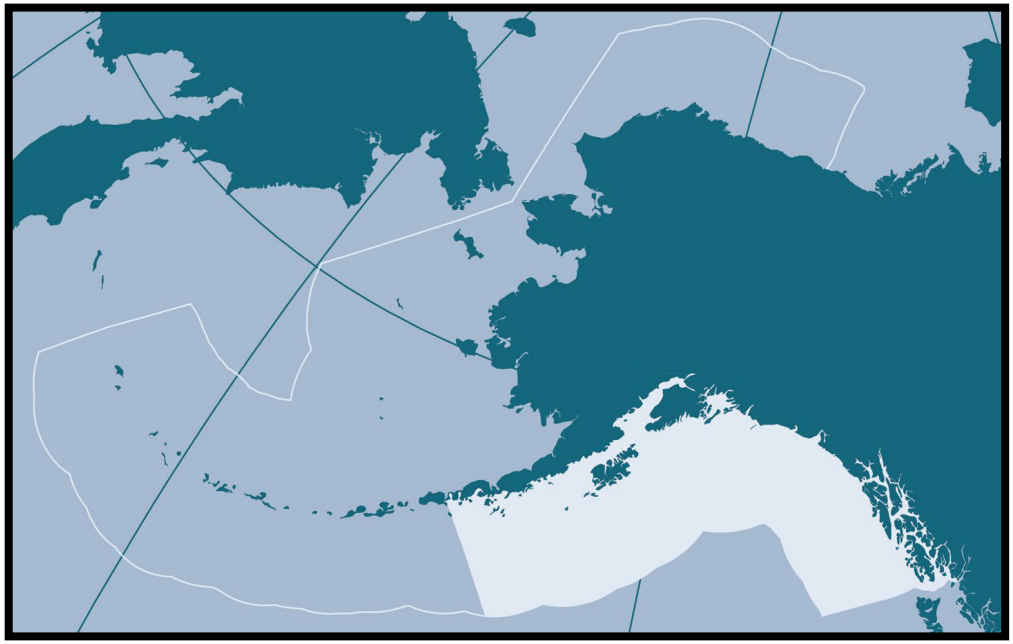
Ecosystem Status Report
Gulf of Alaska
2021

Bridget Ferriss & Stephani Zador



With contributions from:

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Thank you!

2021 Changes to GOA ESR/ Response to SSC

SSC: Synthesize subjects and Continue WGOA/EGOA

1. Oceanography: Combined temperature figures & link to species thresholds
2. Forage Fish: collaboration with Forage Report (Olav Ormseth)
3. Changed WGOA/EGOA boundary in ESR from 144W to 147W

SSC: Continue development of Human Dimensions

Economic and social science ESR contributions paused in 2021 – ongoing AFSC and SSC discussions

Other Changes

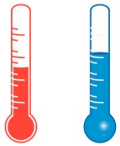
New ESR Contributions:

a. Fisheries-independent Survey-based Indices of Capelin Relative Abundance (D. McGowan)
b. Summary of Forage Conditions (O. Ormseth)
c. Multispecies Model Estimates of Time-Varying Natural Mortality of Groundfish in the Gulf of Alaska
d. Cetacean Distribution in the Gulf of Alaska - The 2021 PacMAPPS Survey (J. Crance)
e. Marine Mammal Strandings in the Gulf of Alaska (M. Keogh)
f. Maturing Coho Salmon Weight as an Indicator of Offshore Prey Status in the Gulf of Alaska (L. Shaul)
g. Seward Line May Phytoplankton Size Index (S. Strom)
h. Bottom Temperature (reanalysis data) (W. Cheng)
i. Spring cross-shelf seabird distribution along Seward Line (D. Cushing)

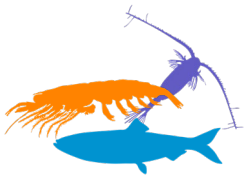
Outreach/Education: GOA 2021 In Brief; GOA ESR 2020 Outreach Video

https://www.fisheries.noaa.gov/media-release/noaa-fisheries-releases-new-video-looking-environmental-conditions-gulf-alaska-2020

GOA 2021: Key Messages

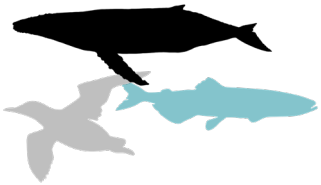


1. 2nd consecutive non-marine heatwave year, with temperatures at surface and depth around long-term averages



2. Mixed trends in prey base
   - Zooplankton: below-average to average (regional)
   - Forage fish: above-average

3. Adult salmon returns improved from the lows of 2020 (pink salmon)



4. Multi-year Trends*:* GOA biological community: some populations remain reduced since the 2014-2016 and 2019 marine heatwave periods but groundfish community, in aggregate, is relatively stable/resilient —

Risk Tables: Environmental/ Ecosystem Considerations

Level 1

(No apparent environmental/ ecosystem concerns)

- Walleye pollock
- Pacific cod
- Sablefish (statewide)
- Pacific ocean perch
- N&S rock sole
- Shallow water flatfish
- Rex sole
- Arrowtooth flounder
- Flathead sole
- Shortraker rockfish
- Demersal shelf rockfish
- Rougheye & blackspotted rockfish
- Skates
- Atka mackerel
- NA: *Octopus, Other rockfish*

2021 Gulf of Alaska

1. OCEANOGRAPHY

2. PREY BASE

3. SALMON, MARINE MAMMALS, & SEABIRDS

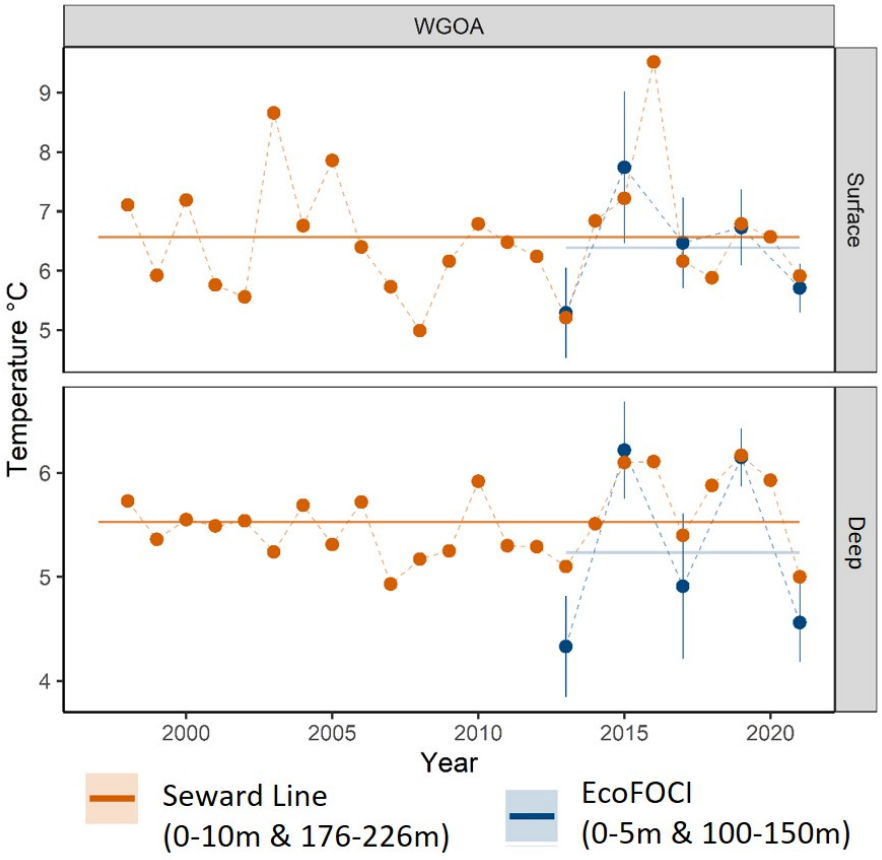
4. MULTI-YEAR TRENDS

GOA Ocean Temperature

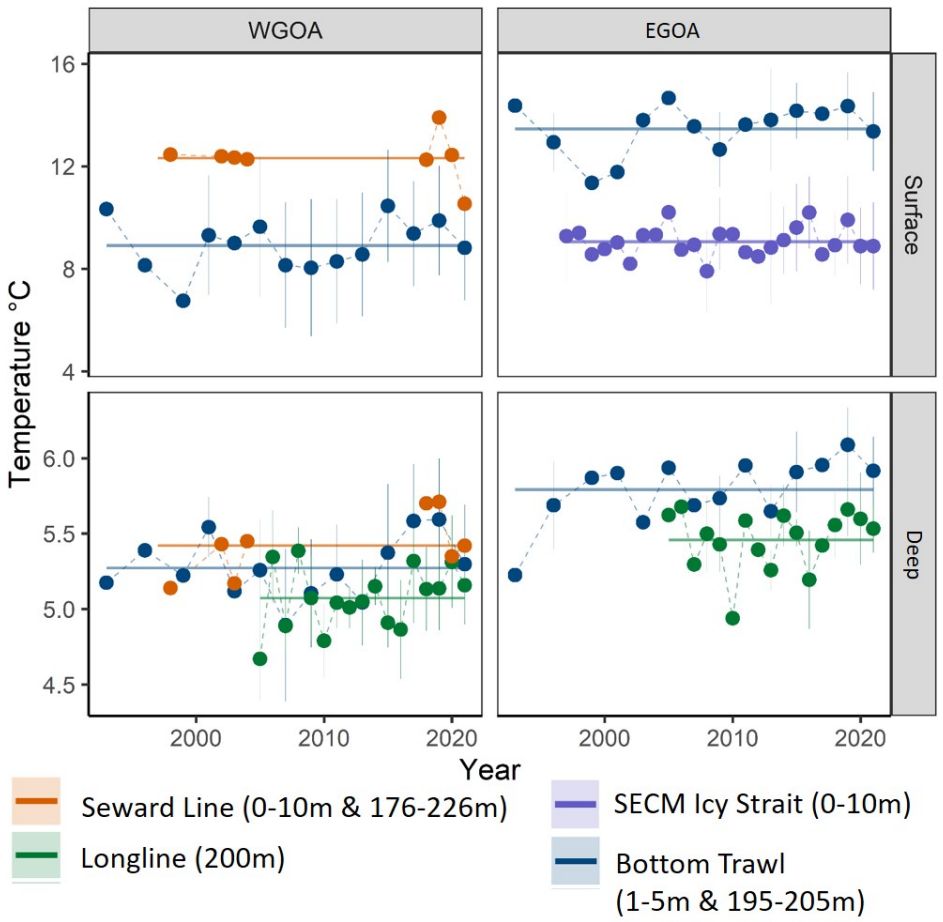
K. Siwicke, N. Laman, E. Fergusson, S. Danielson
(Thanks to Madison Taylor Weise)

- 2nd consecutive non-marine heat wave year
- Surface and depth cooled from 2019
- Spring at or slightly below survey-specific average
- Summer at or slightly above survey-specific average
- All within known optimal ranges for life history stages of major groundfish

Spring 2021

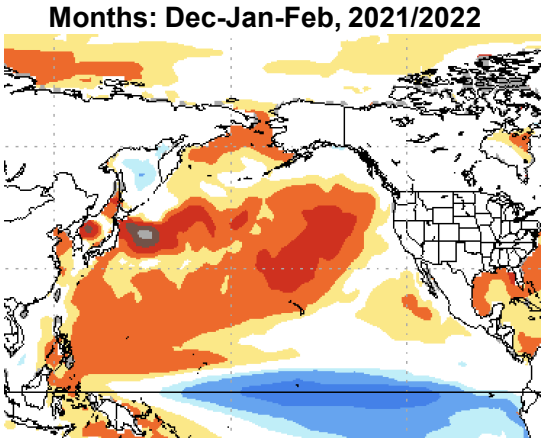


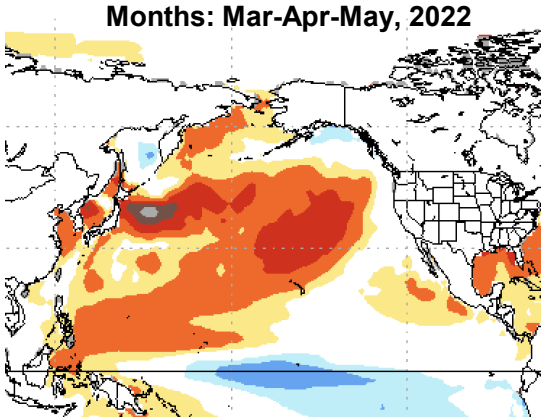
Summer 2021

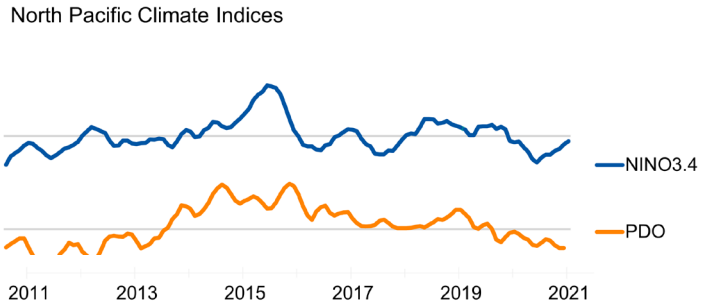


2021/ 2022 Climate

N. Bond







- National Multi-Model Ensemble (NMME)
  - GOA coastal waters predicted to have near average SST (Dec – Feb)
  - Slightly cooler Mar-May
- La Niña (winter)-uncertain strength of response in N. Pacific
- Weaker Aleutian Low
- Positive SLP anomalies south of AK peninsula (similar to winter 2020 but weaker in amplitude)

2021 Gulf of Alaska

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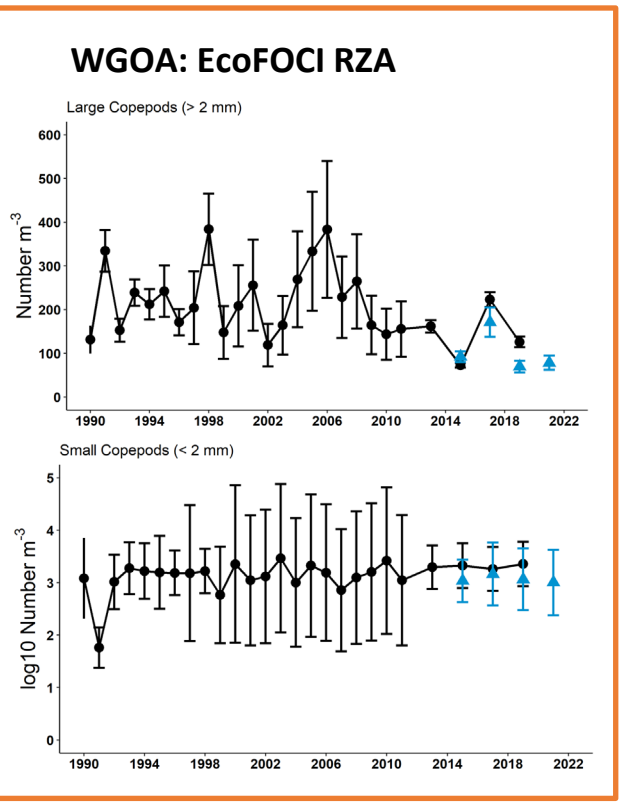
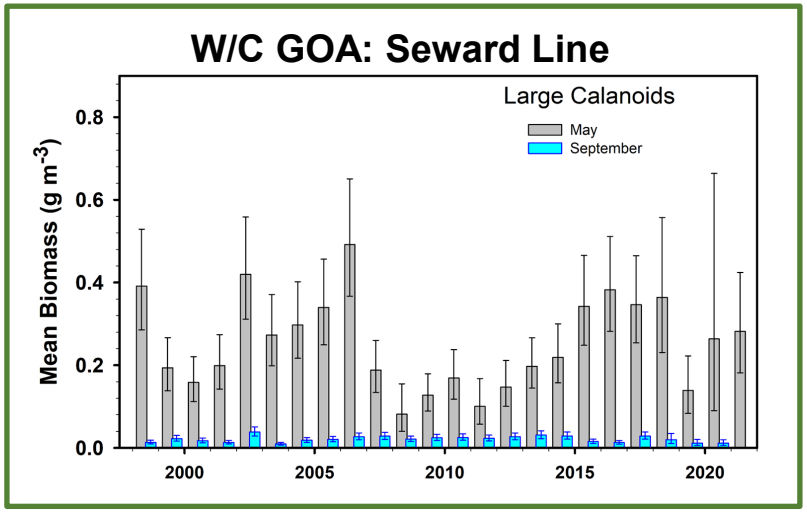
4. MULTI-YEAR TRENDS

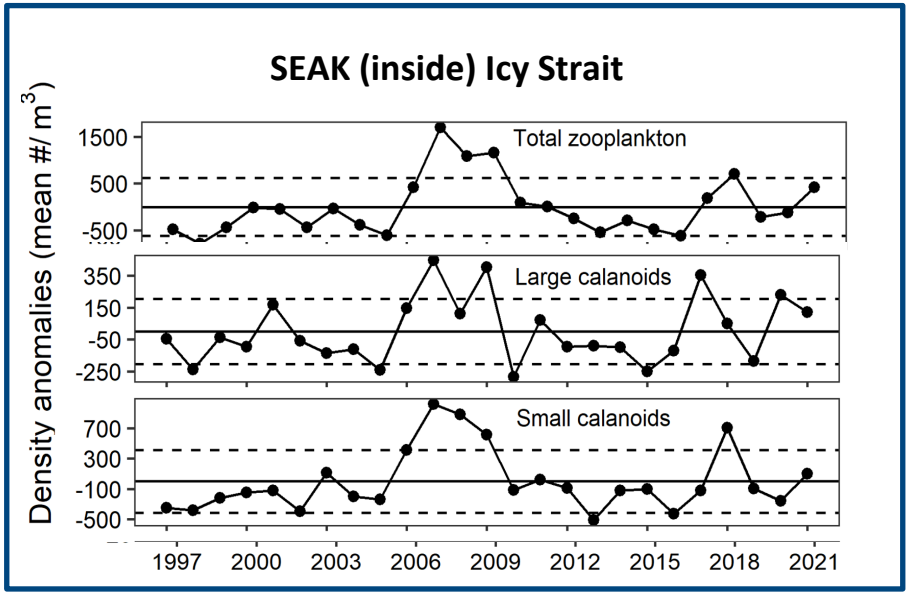
Copepods

D. Kimmel, K. Axler, A. Deary, C. Harpold, D. Crouser, R. Hopcroft, Coyle, E. Fergusson



- **WGOA (EcoFOCI): large copepod biomass was low in 2021 (similar to 2019, 2015); mainly in Shelikof St. and SW Kodiak; small copepods lower but steady (warm signature)**
- W/C GOA (Seward Line): large calanoid copepod biomass in May 2021 was average or slightly above average (similar to 2020)
- SEAK/inside (Icy Strait), the 2021 total density was above average large calanoid copepods slight decrease from 2020 above the long-term average; small copepods approx. average

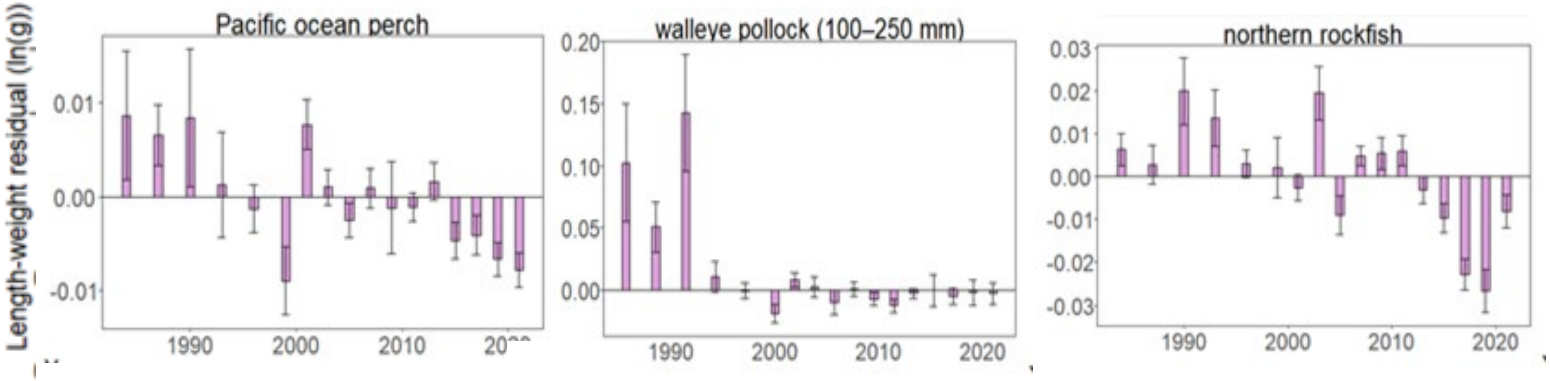




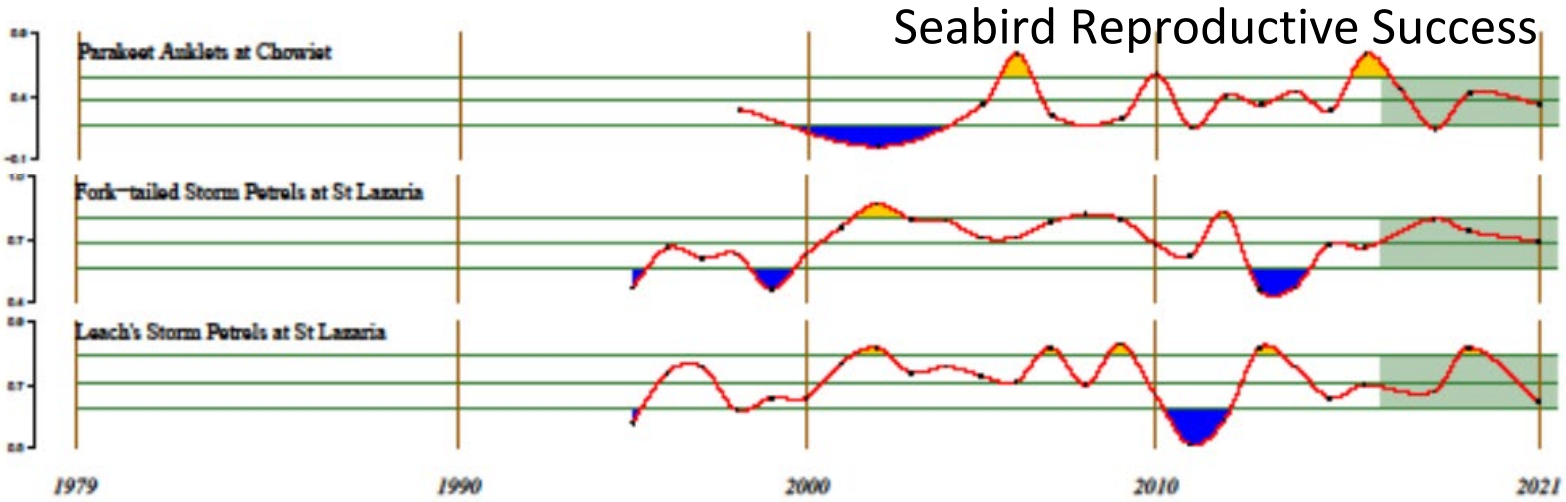
Zooplanktivores

O'Leary, Laman, Rohan, Renner, Drummond

Groundfish Condition



- Age 2+ **walleye pollock** below average (high uncertainty); juv. pollock average
- **Pacific ocean perch** condition below average and trending downward in the final four surveys
- **Northern rockfish** improved from 2019, but still negative condition
- Below-average to average **seabird** reproductive success



Forage Fish & Other Prey

• Capelin • Eulachon • Herring (PWS) – incr. but low	• Sand lance • Juv. Salmon	• Herring • Age-1 pollock • Tanner crab • Shrimp

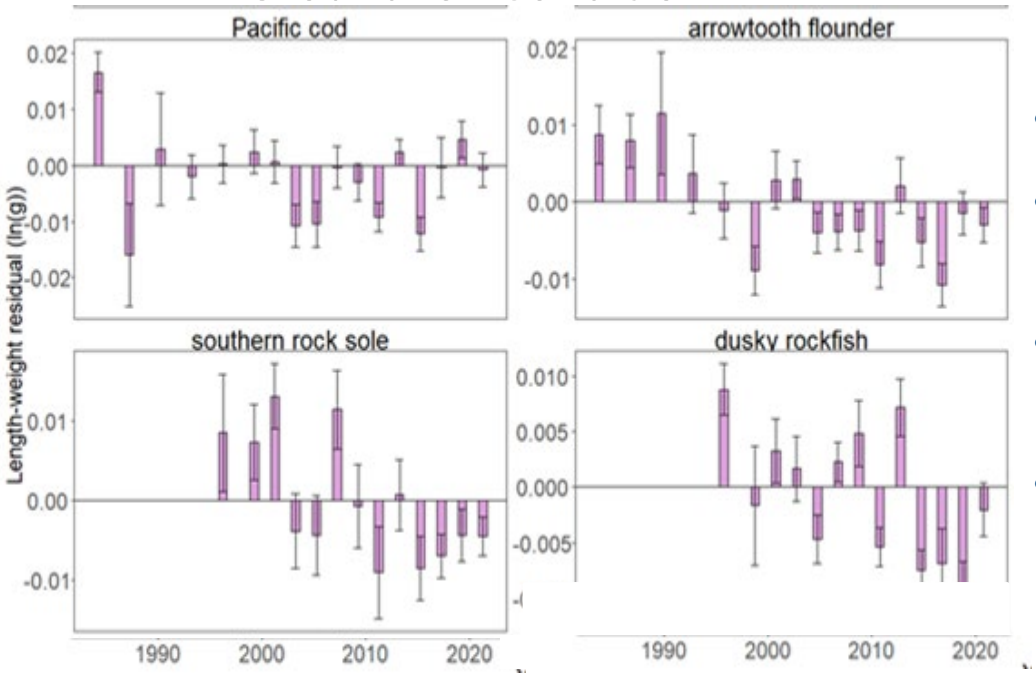
- **Capelin** continued reduced abundance (McGowan, p.99, Hatch, p.94)
- **Eulachon** continued reduced abundance (AFSC Bottom Trawl Survey) (Ormseth, p.87)
- **Sand lance** abundant but patchy; moderate presence in Middleton Island seabird chick diets (Hatch, p.94)
- **Juvenile salmon** less abundant in Icy Strait but higher energy density (Murphy, p.107, Fergusson, p.112)
- **Herring** continues to increase (but **PWS** still low) (Hebert, p.102, Pegau, p.201)
- **Age-1 pollock** relative high abundance (AFSC 2021 winter acoustic survey)
- **Tanner crab and shrimp** continue to increase around Kodiak (Worton, p.134, Palsson, p.148).

- **Piscivorous seabirds** average to above-average reproductive success (Drummond, p.151)
- **Piscivorous groundfish** body condition (weight at length) continued below-average trend since 2015; some signs of improvement in 2021 (O'Leary, p.129).

Piscivores

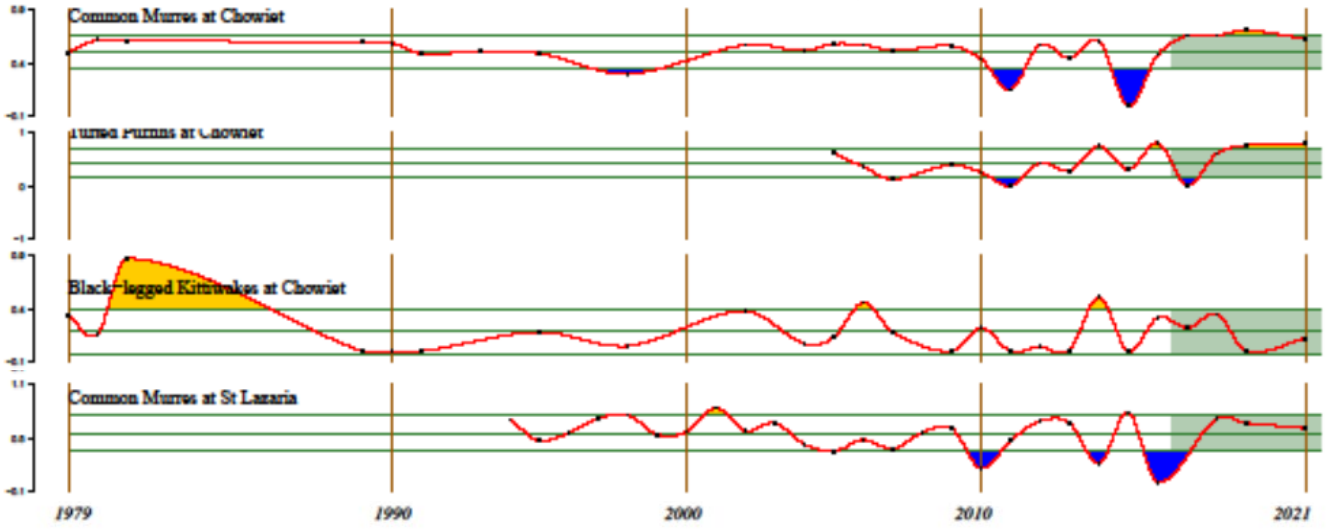
O'Leary, Laman, Rohan, Drummund, Renner

Groundfish Condition



- **Pacific cod** approx. average
- **Arrowtooth flounder** remained negative
- **Southern rock sole** remain negative but improved over the last 8 years
- **Dusky rockfish** improved from 2019 but still below average

Seabird Reproductive Success



- Piscivorous **seabirds** average to above-average reproductive success

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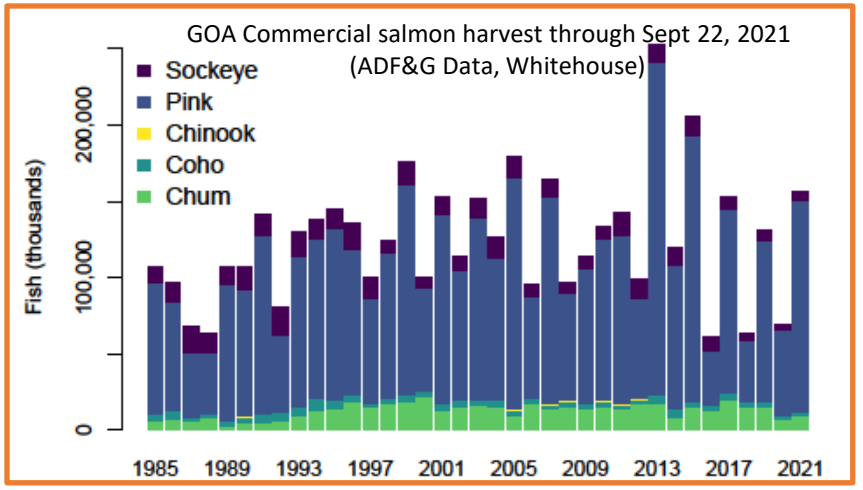
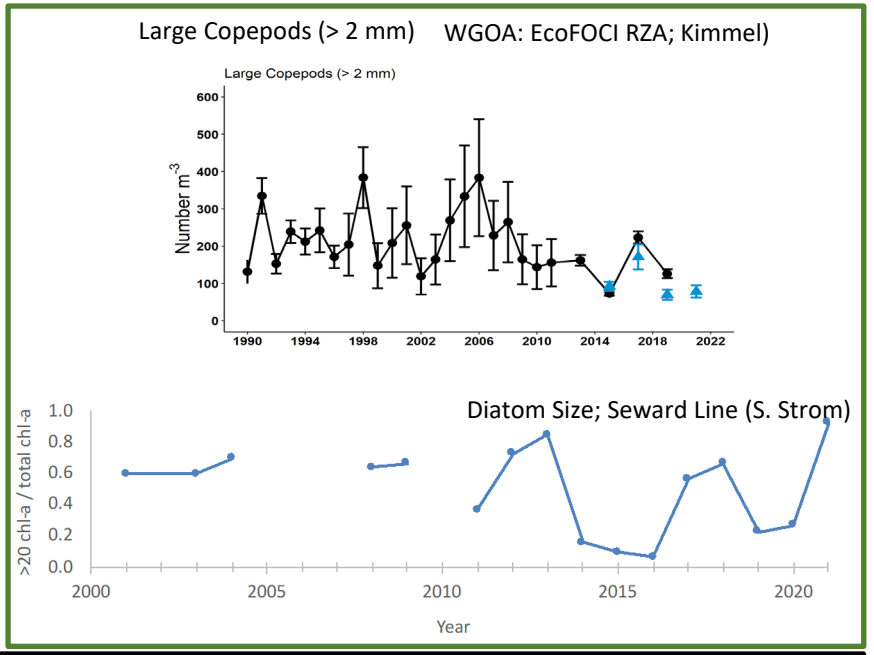
Ecosystem Impacts of Pink Salmon 2021?

Large harvest of pinks in GOA (Whitehouse, p.106, Vulstek, p.115)



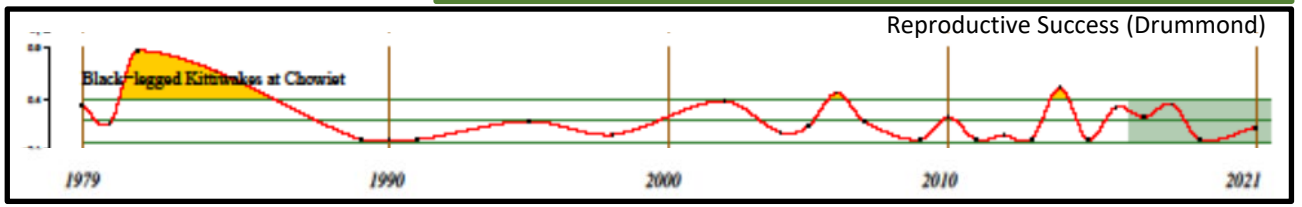
Reduced abundance of large copepods and **increased large diatoms** (Batten et al., 2018)

- ✓ • Increased large diatoms (Seward Line) (Strom,p.65)
- ✓ • Decrease large copepods (WGOA) (Kimmel,p.70)
- ✗ • Average and above-average large copepods on Seward Line & Icy Strait (Hopcroft, p.76 and Fergusson, p.78)



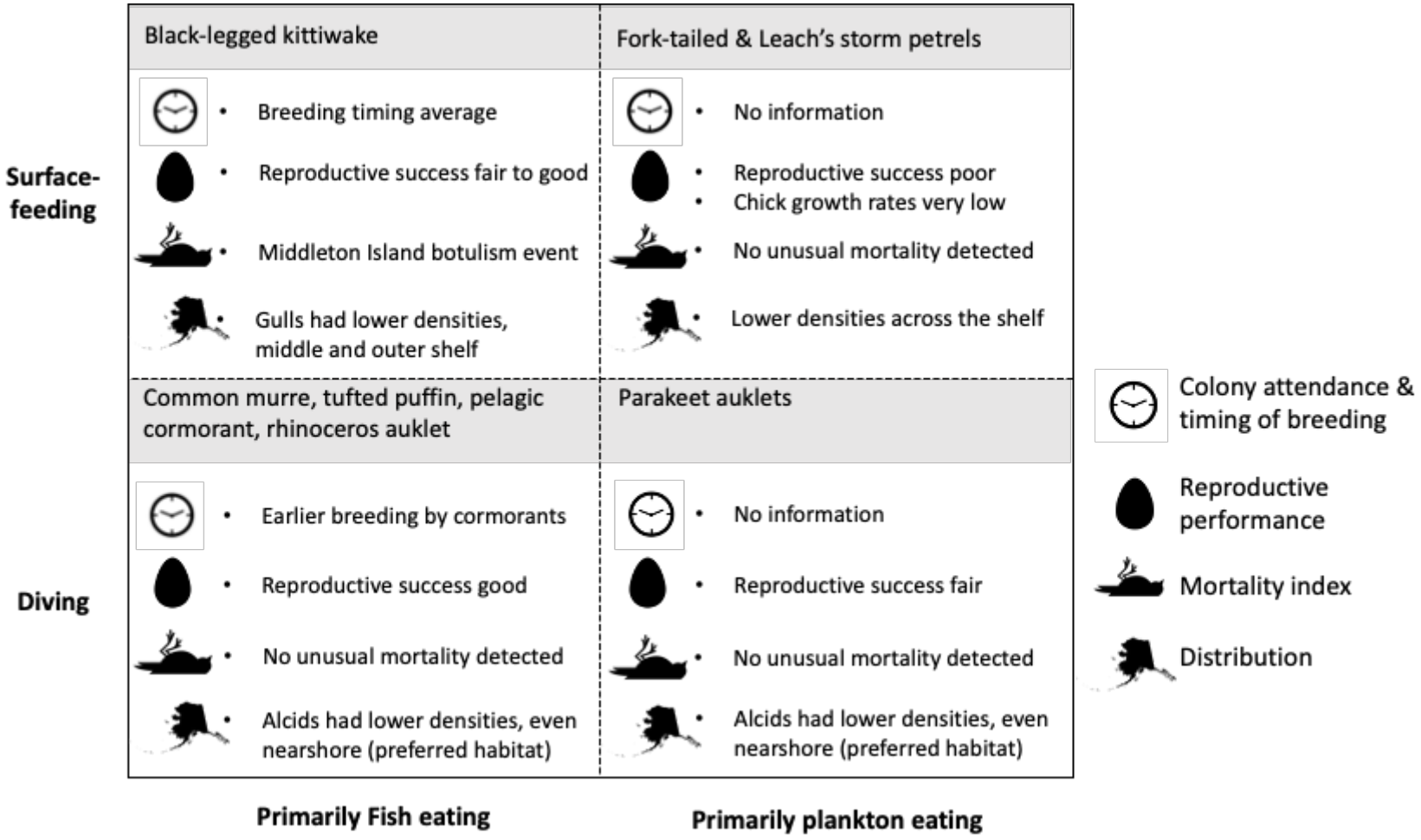
Reduced reproductive success of black-legged kittiwakes (Zador et al., 2013)

- ✓ • Below-average: Middleton Island and Semidi Islands (WGOA) (Hatch and Drummond, p.151)
- ✗ • Above-average on the Barren Islands (WGOA) (Drummond, p.151)



Seabirds Synthesis

M. Arimitsu, D. Cushing, B. Drummond, S. Hatch, T. Jones, J. Piatt, H. Renner
Synthesis compiled by J. Dolliver



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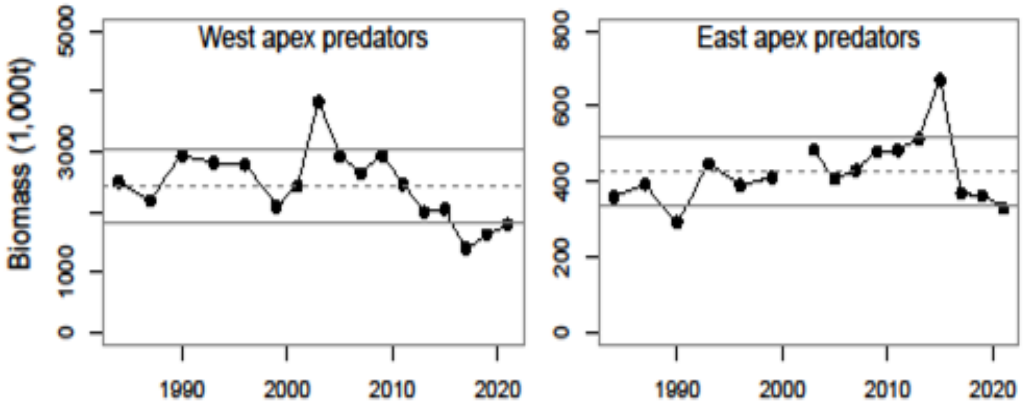
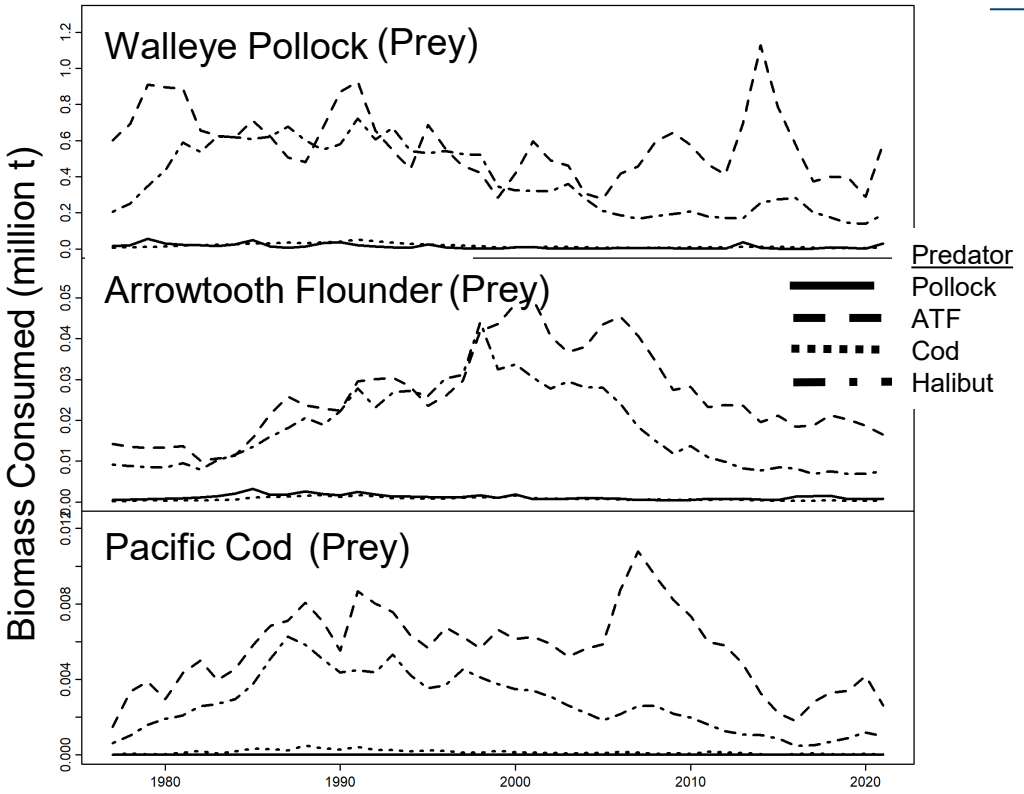
Biomass of Groundfish Apex Predators

A. Whitehouse, K. Aydin, G. Adams, K. Holsman, A. Punt, J. Ianelli, M. Dorn, I. Spies, A. Hollowed



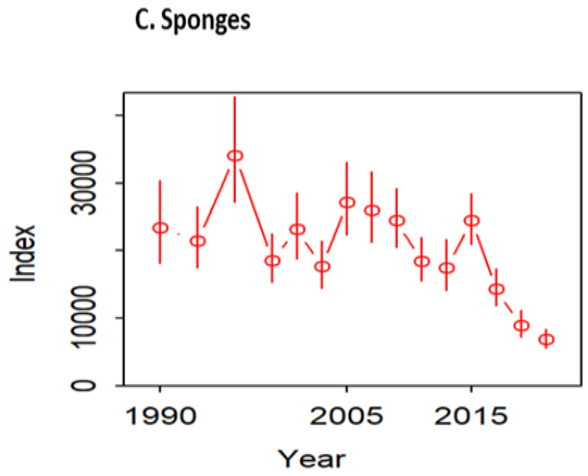
- AFSC Bottom Trawl Survey Biomass
- Low biomass of apex predators: primarily arrowtooth flounder, Pacific cod, Pacific halibut



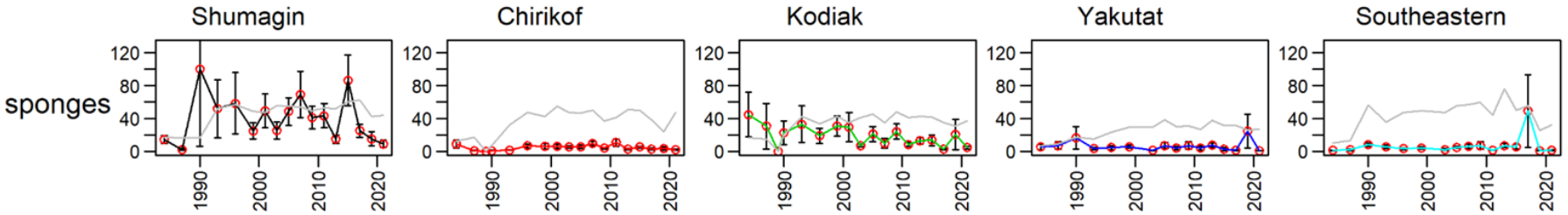
- Multispecies estimates of pollock, Pacific cod, and arrowtooth flounder biomass consumed by predator GOA CEATTLE model.
- Arrowtooth is the primary predator
- All predation mortality between these species has been relatively low
- Pollock predation mortality increased in 2021 large age-1 age class (more available for predation)

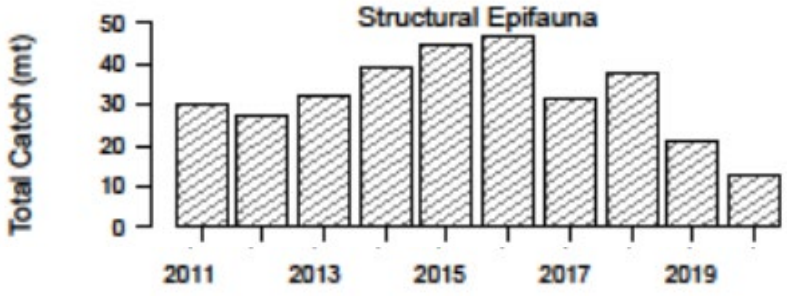
Epifauna: Sponges

Palsson ,von Szalay, Whitehouse, Gaichas



- CPUE is generally highest in the Shumagins and lower to the east
- CPUE has substantially declined in the Shumagin and Kodiak regions
- CPUE increasing in Yakutat and Southeastern regions





- Non-target species in groundfish fisheries
- Decline in structural epifauna: seapens/whips, sponges, anemones, corals, tunicates

Multi-Year Trends in GOA

A. Some populations remain reduced

Reduced populations since 2014-2016 & 2019 marine heatwave periods (capelin, common murres, Prince William Sound humpback whales, some groundfish species)

1. Cumulative Effects & Variable Recovery Time to Marine Heat Wave Years

- Life history
- Changes in age structure or demographics
- Asynchronous recovery in food web
- Changes in epifaunal habitat (7 year decline in sponges)

2. Lower System Productivity in GOA

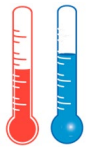
- Below-average chl-a concentration (Watson, p.63)
- Zooplankton community composition (shift to smaller and/or less lipid-rich species)
- Continued below-average groundfish body condition

B. Groundfish community overall relatively stable and resilient

(as sampled by the AFSC bottom trawl)

- Total survey CPUE increased in WGOA and fairly stable in EGOA from 2019 (Mueter, p.183)
- Relatively high species diversity and richness (Mueter, p.186)
- Relatively high mean life span (Whitehouse, p.180)
- Low biomass variability (1/CV biomass) (Whitehouse, p.175)

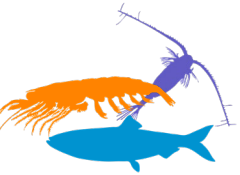
GOA 2021: Key Messages



1. 2nd consecutive non-marine heatwave year, with temperatures at surface and depth around long-term averages — *Continued moderate conditions for growth and physiology*

2. Mixed trends in prey base

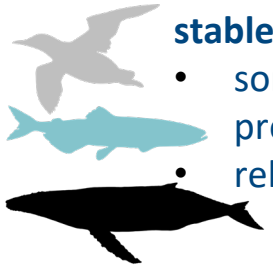
- **Zooplankton: below-ave. to average (regional)**
- below average condition for planktivorous groundfish and reduced reproductive success for some planktivorous seabirds — *lower production at base of foodweb and reduced prey base for planktivorous groundfish (w. pollock, POP, juveniles of other species)*



- **Forage fish: above-average**
- More diverse suite of species; incr. herring, age-1 pollock; moderate sand lance; low capelin — *improved prey base for piscivorous groundfish (P. cod, arrowtooth flounder, sablefish, some rockfish)*

3. Adult salmon returns improved from the lows of 2020 (pink salmon) — *potential evidence of food web impacts in WGOA*

4. Multi-year Trends: GOA biological community: some populations remain reduced since the 2014-2016 and 2019 marine heatwave periods but groundfish community, in aggregate, is relatively stable/resilient —



- some populations remain reduced (e.g., PWS humpback whales, abundance of apex groundfish predators (e.g., P. cod), sponges
- relatively higher stability and resilience metrics across groundfish community in aggregate