

# Ecosystem Status Report Gulf of Alaska 2021

Bridget Ferriss & Stephani Zador





PRINCE WILLIAM SOUND  
SCIENCE CENTER



**With contributions from:**

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COASST



**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

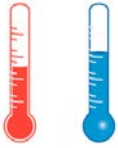
## *SSC: Continue development of Human Dimensions*

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

## *Other Changes*

- a. Added:
  - 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, Nat. Res. Cons.)
  - g. Seward Line May Phytoplankton Size Index (S. Strom, WWU)
  - h. Bottom Temperature (reanalysis data) (W. Cheng)
  - i. Spring cross-shelf seabird distribution along Seward Line (D. Cushing, USFWS)

# GOA 2021: Key Messages



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

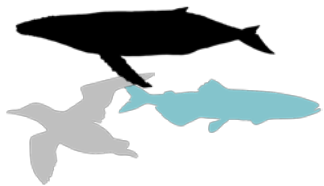
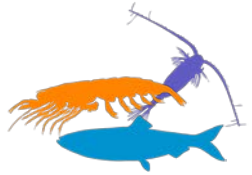
2. Mixed trends in prey base

- Zooplankton: below-average to average (regional)
- Forage fish: more abundant

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

4. Multi-year Trends: GOA biological community is still in transition from 2014-2016 & 2019 heatwave period:

- Cumulative effects of and variable recovery times
- Lower system productivity



# 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. FORAGE CONDITIONS

3. SALMON, MARINE  
MAMMALS, & SEABIRDS

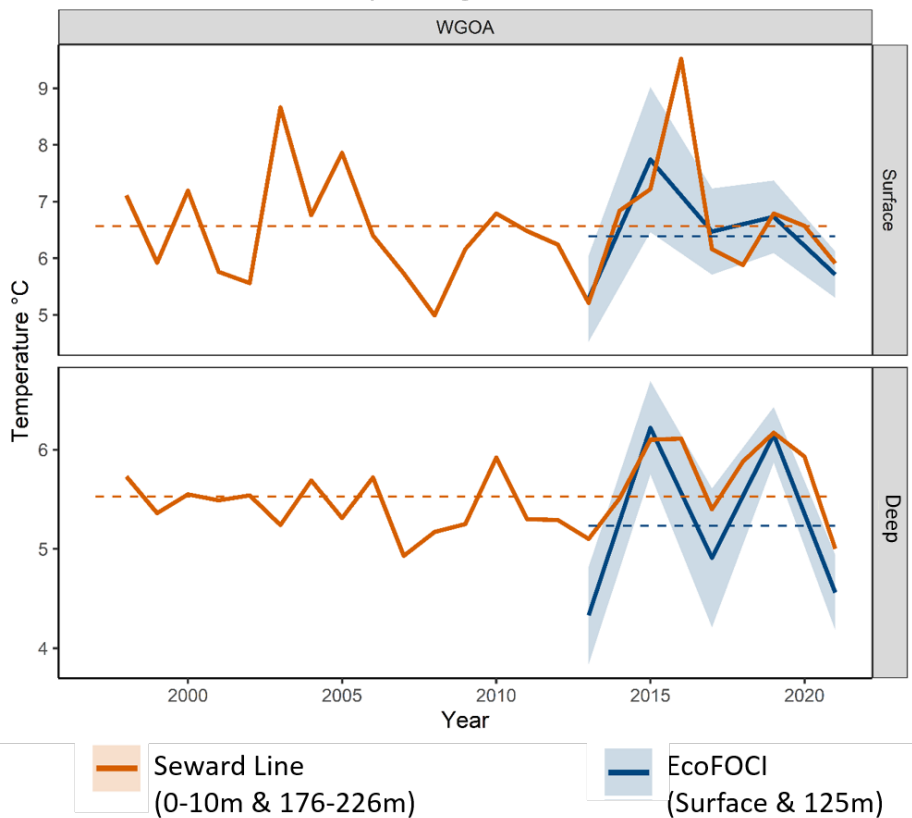
4. MULTI-YEAR TRENDS

# GOA Ocean Temperature

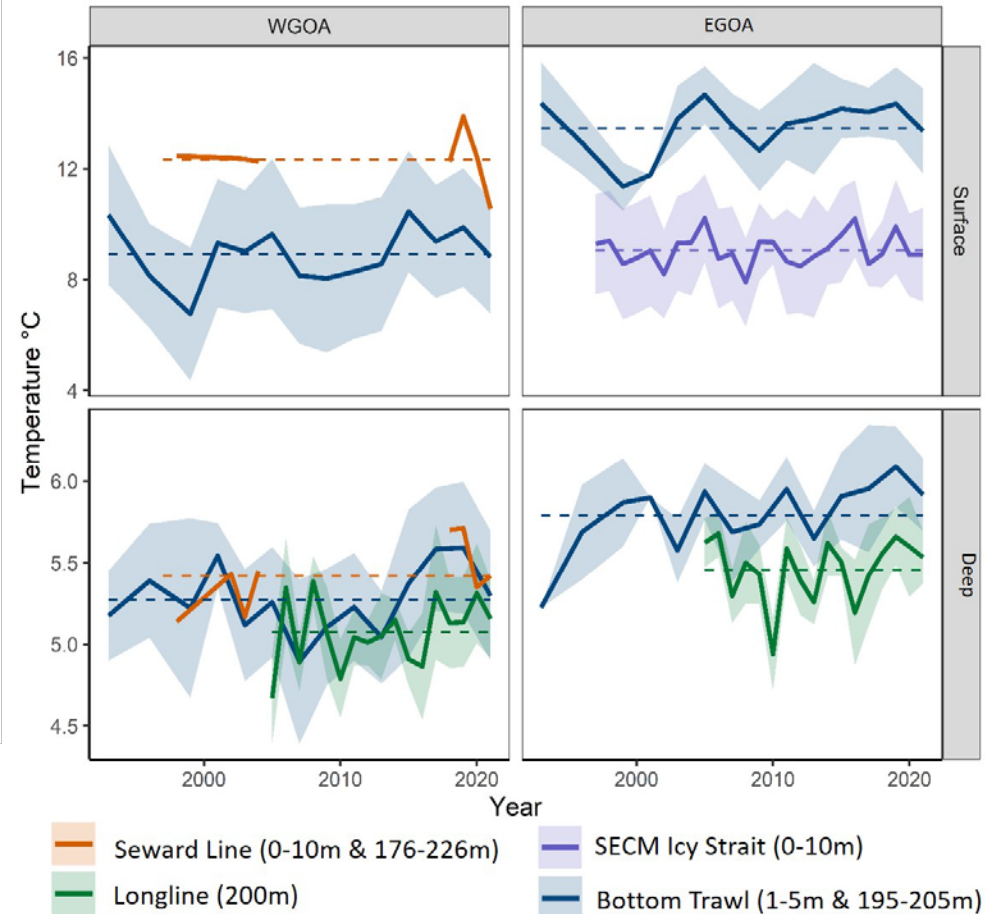
K. Sewicki, N. Laman, E. Fergusson, S. Danielson  
(Thanks to Madison Taylor Weise)

- 2<sup>nd</sup> 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

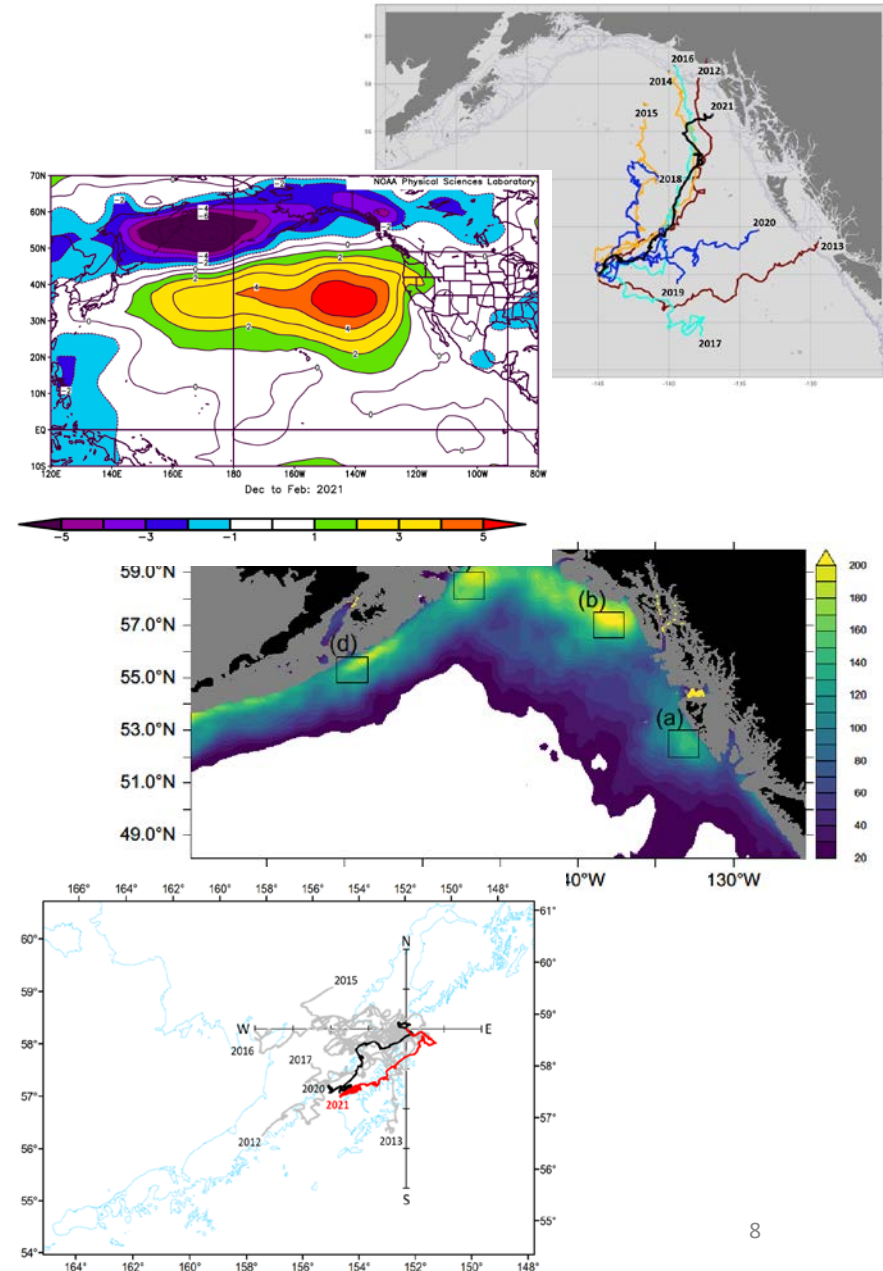


## Summer 2021



# Ocean Transport

- The 2020/2021 winter experienced northward transport (southerly winds) (Papa Trajectory Index/ OSCURS model) (Stockhausen, p.53)
- Westerly winds in the spring and summer reduced the northward transport and created upwelling favorable conditions (Bond, p.32)
- Strong, persistent eddies along the shelf edge of Seward and Kodiak in the winter and spring, indicating greater transport of nutrients across the shelf (Cheng, p.49)
- Spring winds in Shelikof Strait were downwelling-favorable northeasterly winds (conducive to enhanced retention of pollock larvae and juveniles) (Wilson et al., p.56)

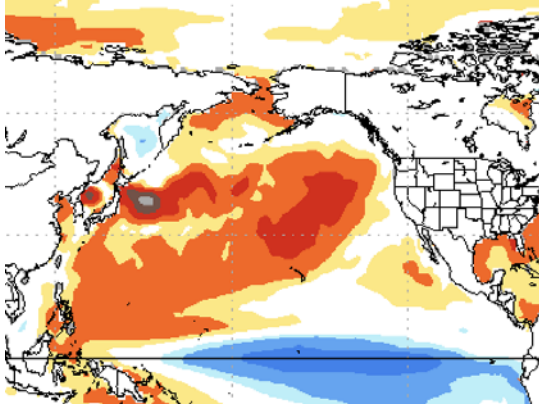




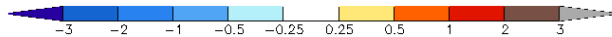
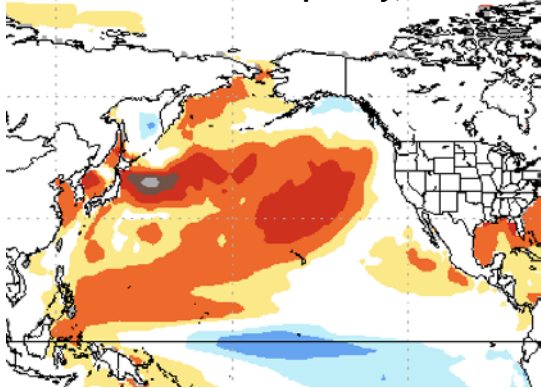
# 2021/ 2022 Climate

N. Bond

Months: Dec-Jan-Feb, 2021



Months: Mar-Apr-May, 2022



- 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



1. OCEANOGRAPHY

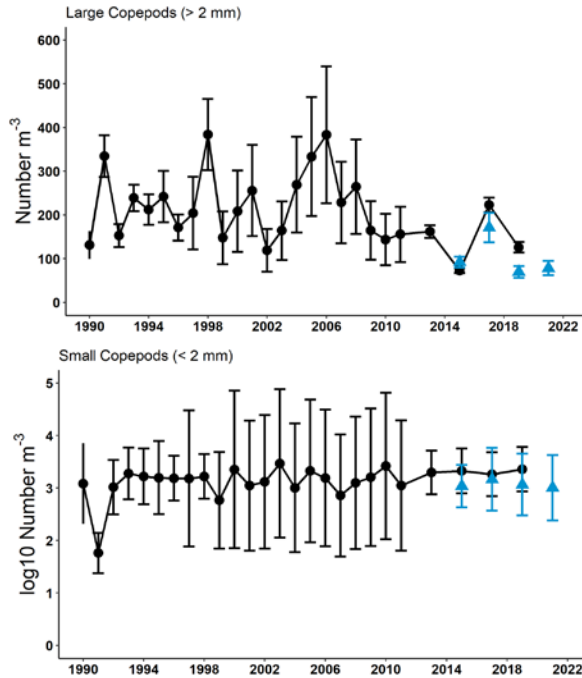
2. FORAGE CONDITIONS

3. SALMON, MARINE  
MAMMALS, & SEABIRDS

4. MULTI-YEAR TRENDS

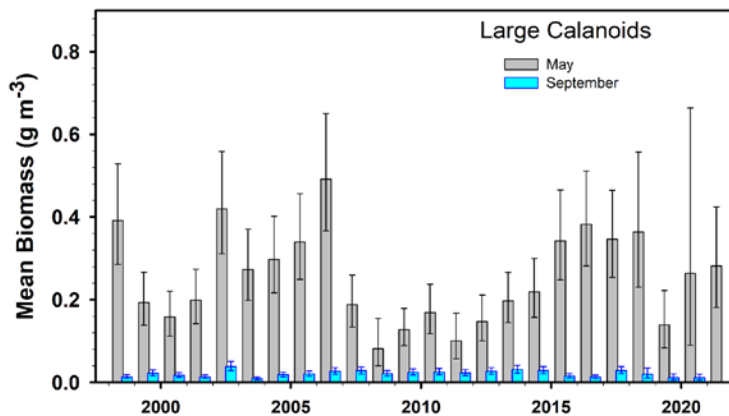
# Copepods

## WGOA: EcoFOCI RZA

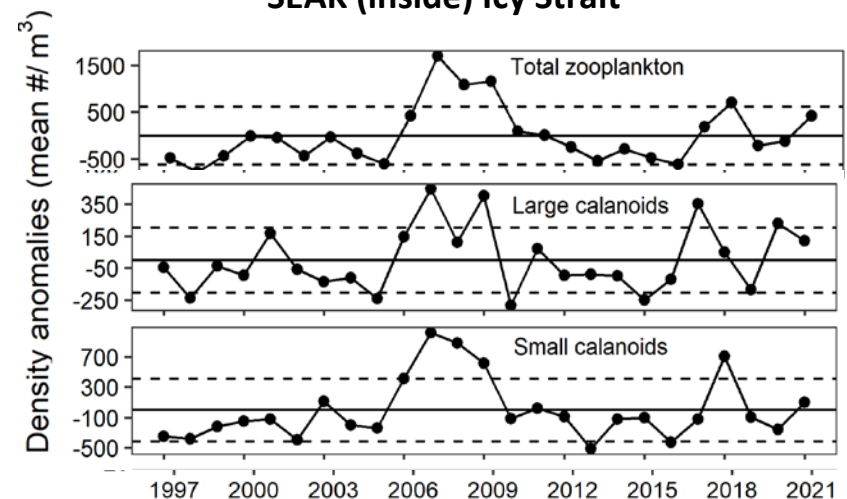


- WGOA (EcoFOCI): large copepod biomass was low in 2021 (similar to 2019, 2015); mainly in Shelikof St. and SW Kodiak; small copepods lower but steady (warm signature)
- W/C GOA (Seward Line): large calanoid copepod biomass in May 2021 was average or slightly above average (similar to 2020)
- SEAK/inside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

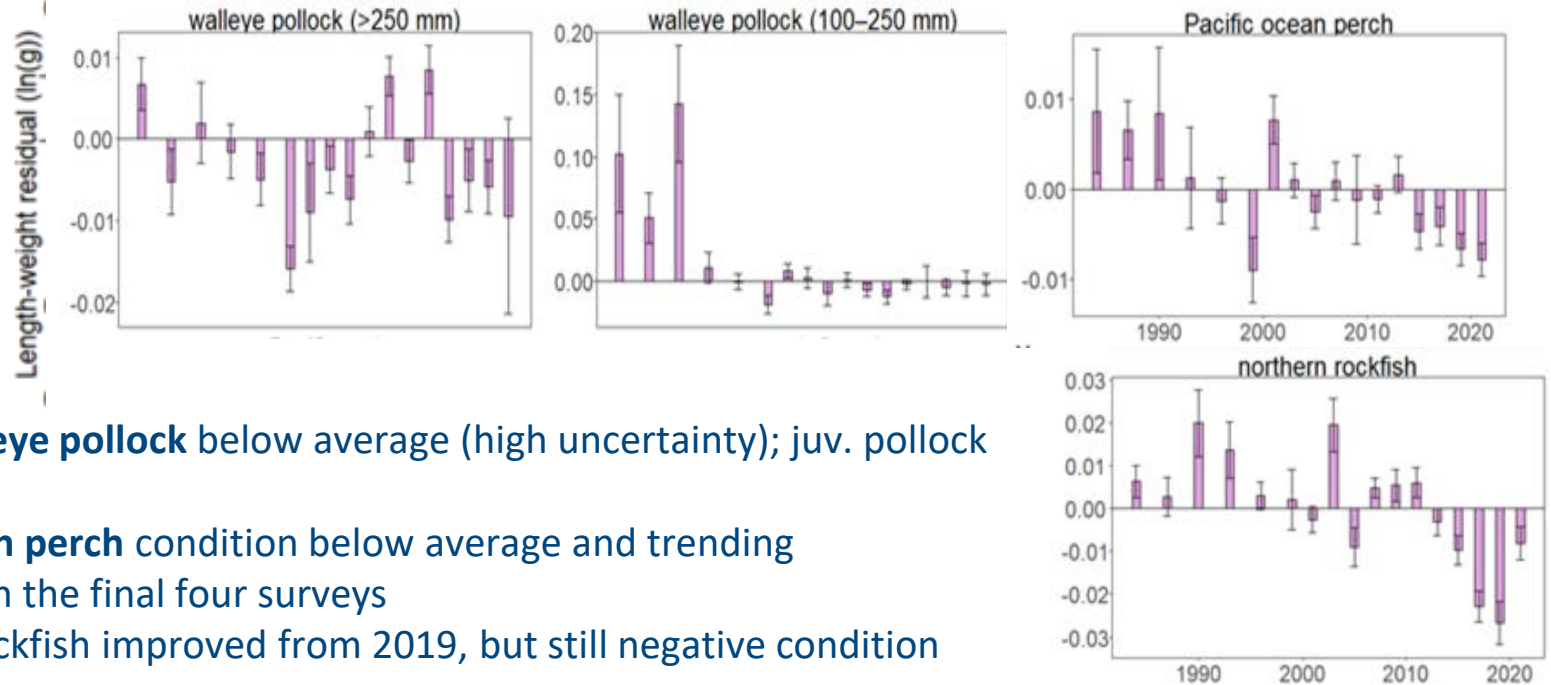
## W/C GOA: Seward Line



## SEAK (inside) Icy Strait

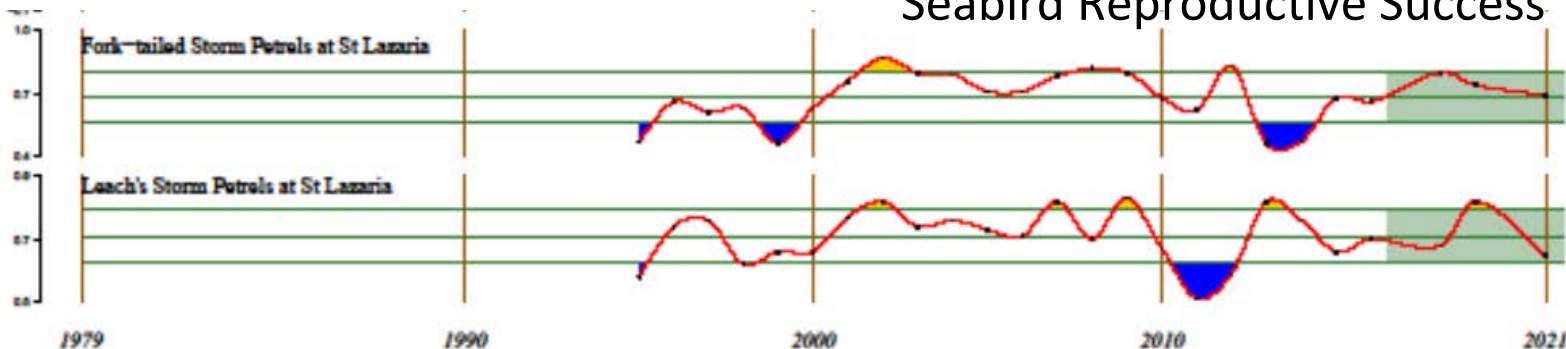


## Groundfish Condition



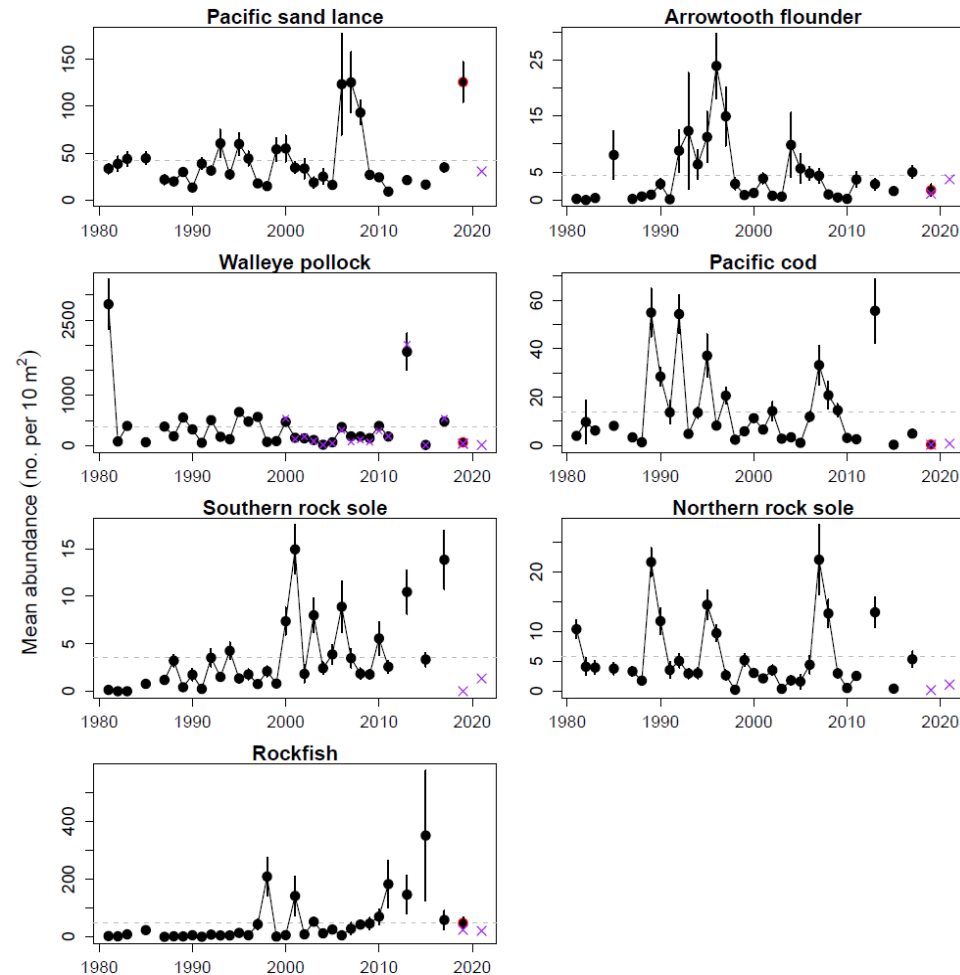
- Age 2+ **walleye pollock** below average (high uncertainty); juv. pollock average
- **Pacific ocean perch** condition below average and trending downward in the final four surveys
- Northern rockfish improved from 2019, but still negative condition
- Planktivorous seabirds had below-average to average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

## Seabird Reproductive Success



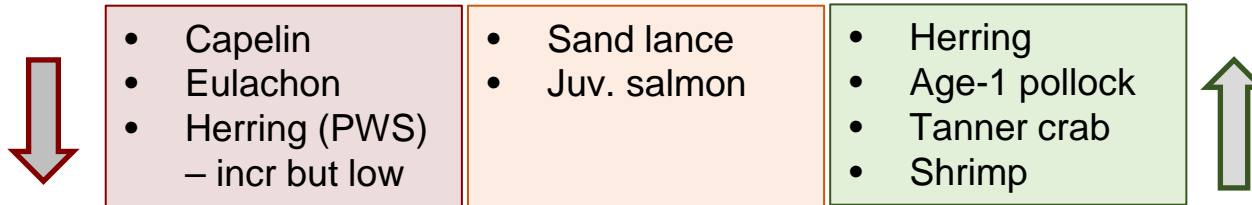
# Larval Fish Abundance

A. Deary, L. Rogers, K. Axler



- Expected average pollock and cod abundance with average temperatures and SW spring 2021 winds (enhances retention)
- BUT Unusually low pollock and cod abundance and caught outside core area (expected average)
- Pacific sand lance have higher recruitment & abundance at higher temperatures (not in 2021- average this year)
- N&S rock sole low abundance (similar to 2019)

# Forage Fish & Other Prey

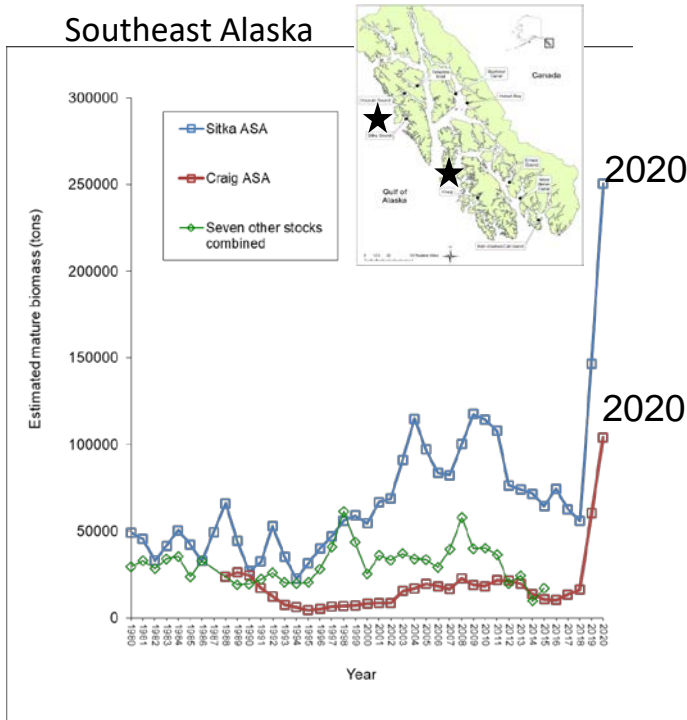


- **\*Capelin** still at reduced abundance (McGowan et al., p.99, Hatch, p.94)
- **Eulachon** biomass dropped following warm years (AFSC Bottom Trawl Survey) (Ormseth, p.87)
- **Sand lance** abundant but patchy; present in Middleton Island seabird diets in moderate proportions (Hatch, p.94)
- **Juvenile salmon** in Icy Strait were less abundance but higher quality prey (Murphy et al., 107, Fergusson et al., p.112)
- **\*Herring** continues to increase abundance (but **PWS** still low) (Hebert et al., p.102, Pagau et al., p.201)
- **Age-1 pollock** were observed in relative high abundances (AFSC 2021 winter acoustic survey)
- **Tanner crab and shrimp** around Kodiak continue to increase (Worton et al., p134, Palsson, p.148).
  
- **\*Piscivorous surface-feeding and diving seabirds** had average to above-average reproductive success (Drummond & Renner p.151).
- **\*Piscivorous groundfish** body condition (weight at length) continued below-average trend since 2015, although some showed signs of improvement in 2021 (O’Leary et al. p.129).



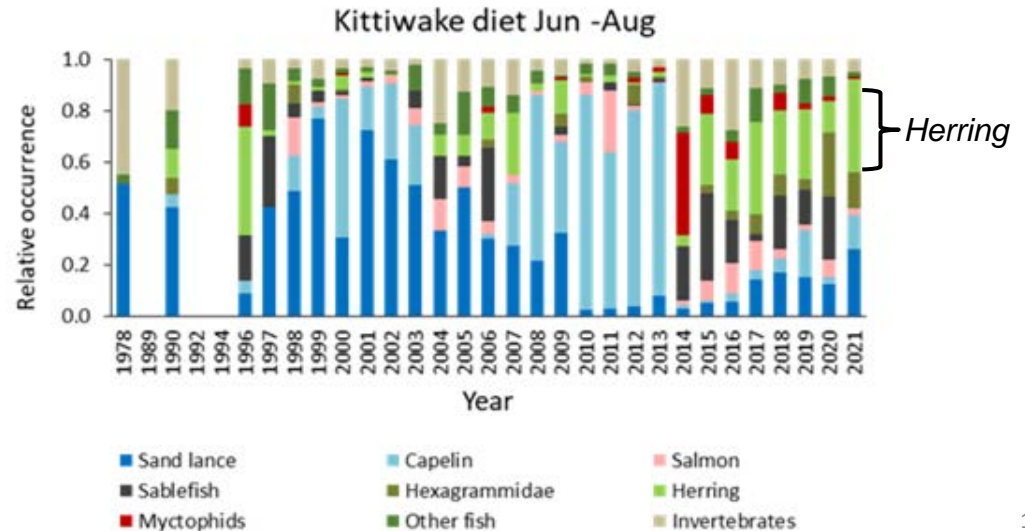
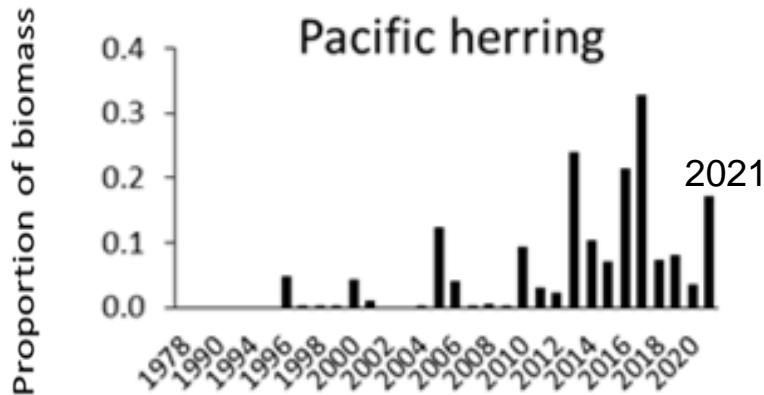
# Herring 2021

Hebert, Dressel, Pagau, Trochta, Haight, Arimitsu, Piatt



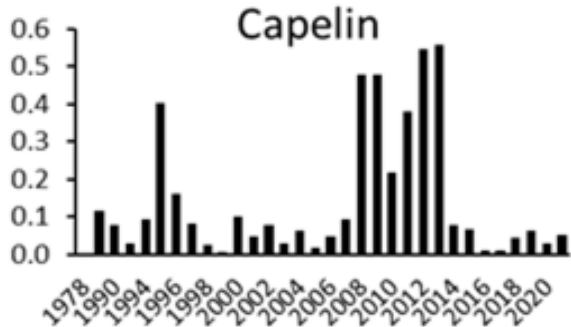
- 2020 SEAK: Increase in populations exposed to ocean influence (Sitka Sound & Craig)
- Large 2016 year class (recruitment event of age-3+ herring observed in 2019 and 2020)
- 2020: PWS: remains low but continued increase – recruitment of large 2016 year class into spawning biomass
- 2021: Increased presences in rhinoceros auklet chick diet (Middleton Island)
- BUT shelf-wide estimates from Bottom Trawl Survey decreased in 2021

Rhinoceros Auklet Chick Diet (Middleton Island)



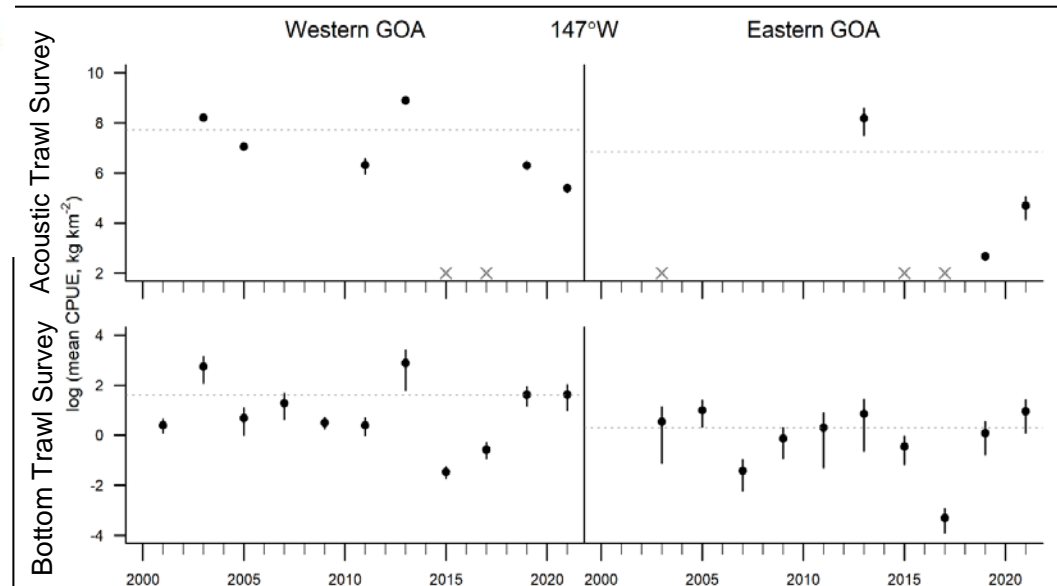
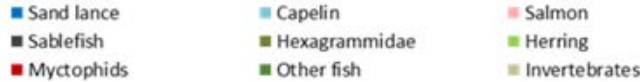
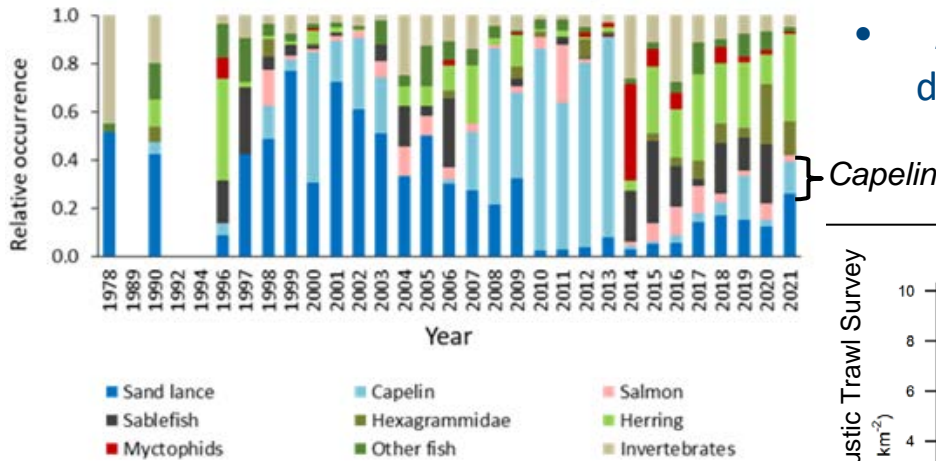
Proportion of biomass

Rhinoceros Auklet Chick Diet  
(Middleton Island)



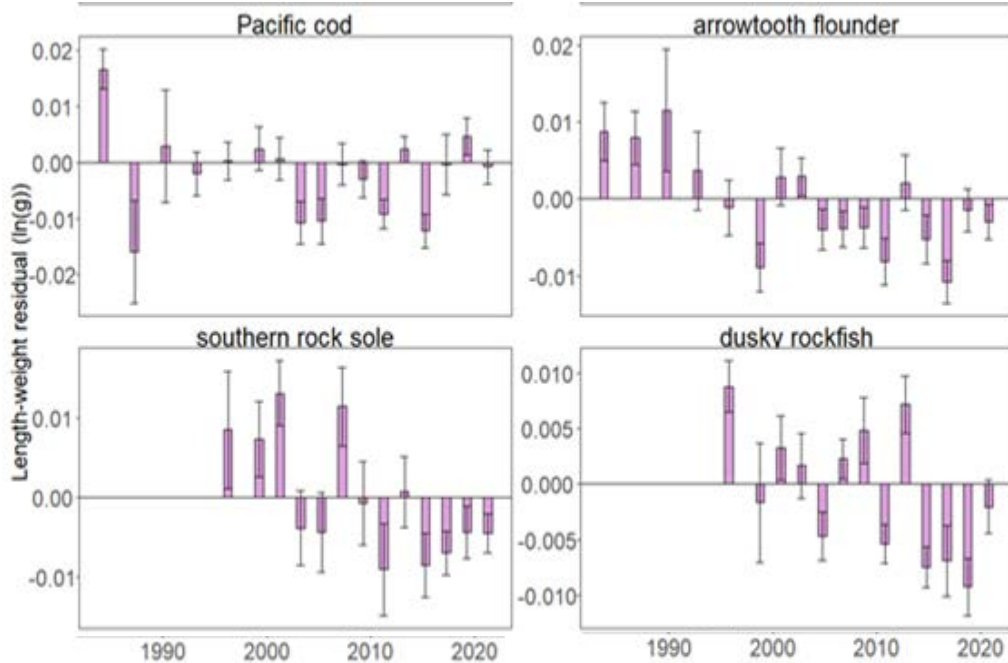
- Capelin abundance still reduced
- Middleton Island (CGOA near edge of shelf) Seabird diets: capelin present but reduced
- Survey indices:
  - EGOA capelin increased from 2019
  - WGOA capelin diverging trends
  - Acoustic Trawl and Bottom Trawl Surveys not designed to sample capelin

Kittiwake diet Jun -Aug





# Groundfish Condition



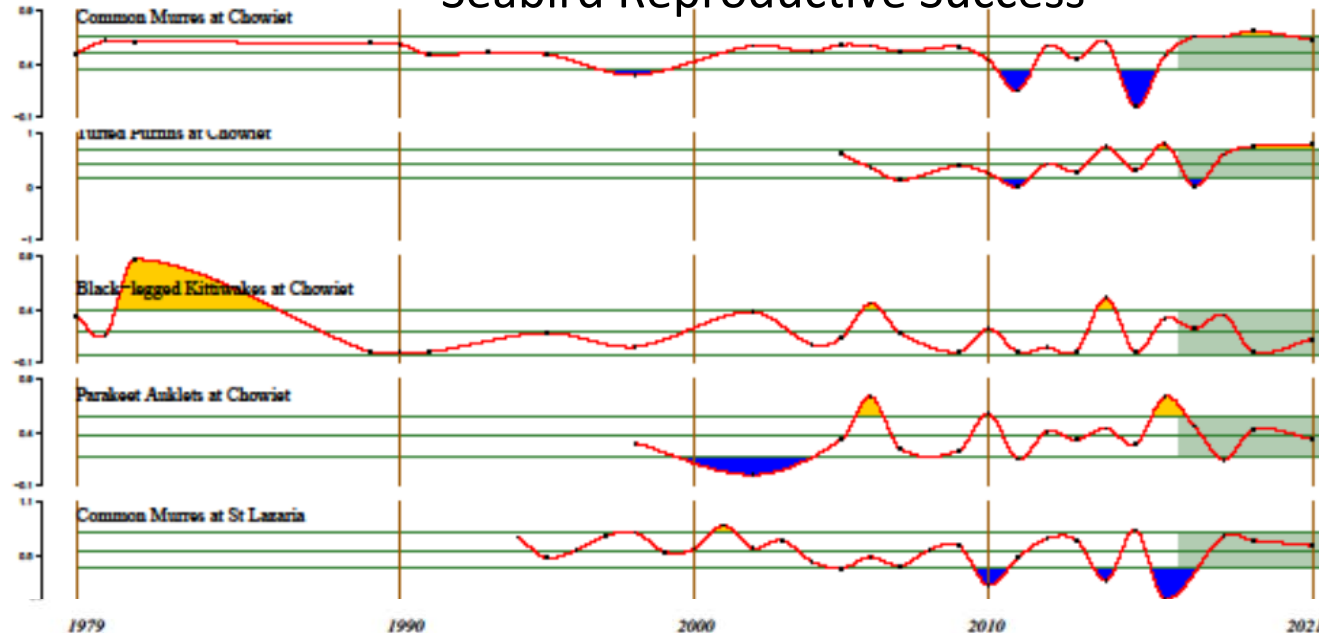
# Piscivores

O'Leary, Laman, Rohan, Drummund, Renner

- **Pacific cod** approx. average
- **Arrowtooth flounder** remained negative
- **Southern rock sole** condition improved over the last 8 years, but the final 4 years remained a constant below average condition
- **Dusky rockfish** also improved, but are still below average

- Piscivorous seabirds average to above-average reproductive success
- Kittiwakes (surface); others (divers)

# Seabird Reproductive Success



# 2021 Gulf of Alaska



1. OCEANOGRAPHY
2. FORAGE CONDITIONS
3. SALMON, MARINE MAMMALS, & SEABIRDS
4. MULTI-YEAR TRENDS

# Ecosystem Impacts of Pink Salmon 2021?

- Large harvest of pinks in GOA (p.106)
- Auke Ck. had 10th highest adult pink returns (high 2020 marine survival) (Vulstek, p.115)

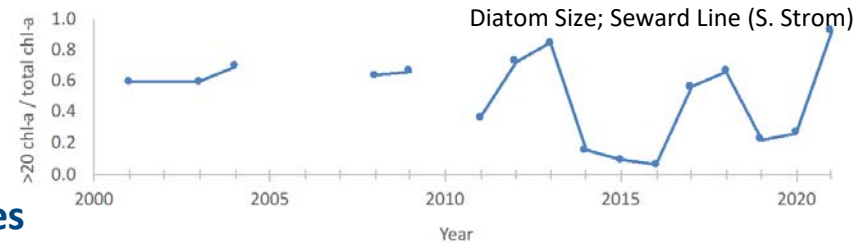
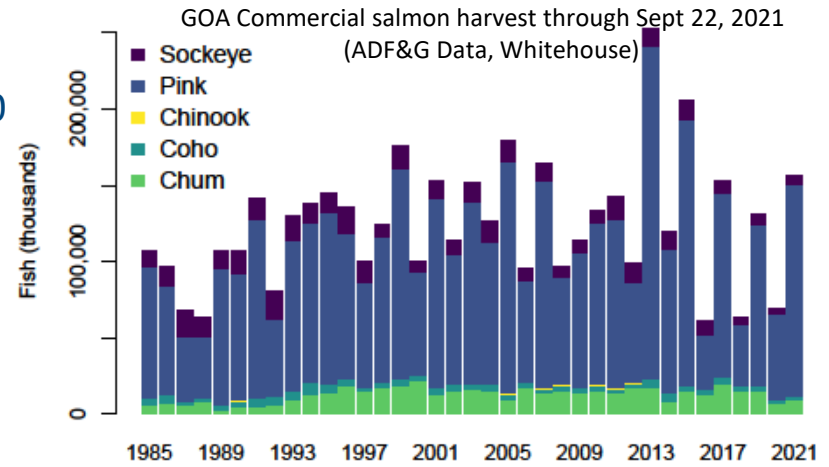
**Reduced abundance of large copepods** (grazing pressure) and increased large diatoms (reduced grazing pressure from copepods) (Batten et al., 2018)

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

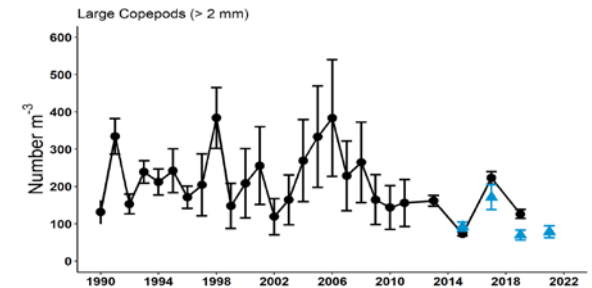
**Reduced reproductive success of black-legged kittiwakes** (Zador et al., 2013)

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

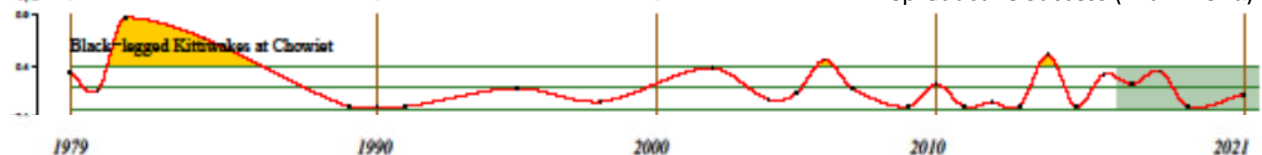
**Changes in diet and reduced size of other salmon species** (Tadokoro et al., 1996; Ruggerone et al., 2003)



Large Copepods (> 2 mm) WGOA: EcoFOCI RZA; Kimmel)























Reproductive Success (Drummond)



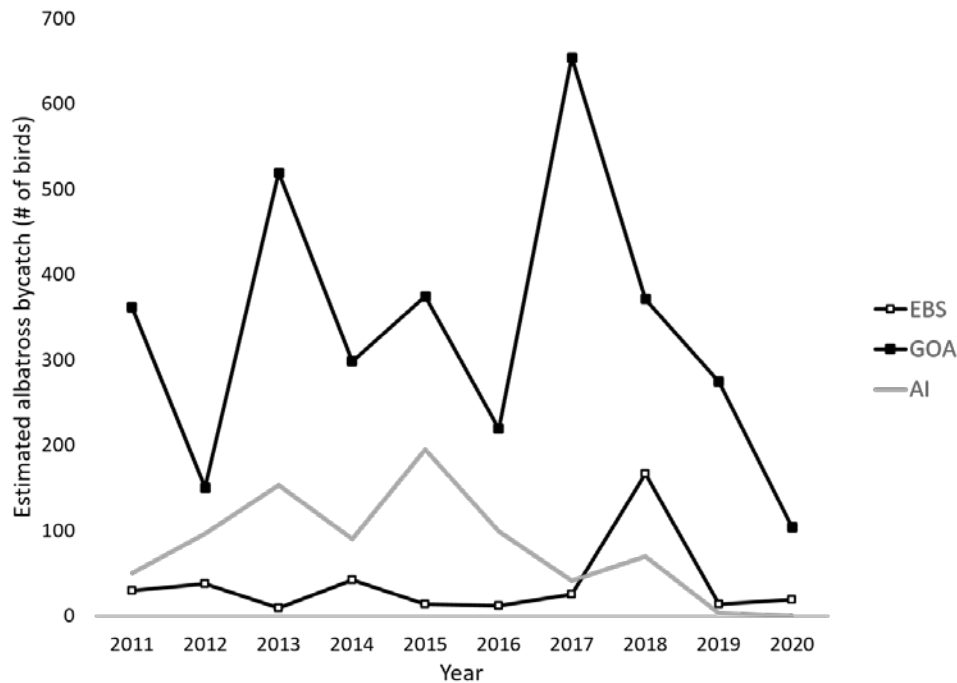
# Seabirds Synthesis

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

	Black-legged kittiwake	Fork-tailed & Leach's storm petrels	
<b>Surface-feeding</b>	 • Breeding timing average  • Reproductive success fair to good  • Middleton Island botulism event  • Gulls had lower densities, middle and outer shelf	 • No information  • Reproductive success poor • Chick growth rates very low  • No unusual mortality detected  • Lower densities across the shelf	 Colony attendance & timing of breeding  Reproductive performance  Mortality index  Distribution
	Common murre, tufted puffin, pelagic cormorant, rhinoceros auklet	Parakeet auklets	
<b>Diving</b>	 • Earlier breeding by cormorants  • Reproductive success good  • No unusual mortality detected  • Alcids had lower densities, even nearshore (preferred habitat)	 • No information  • Reproductive success fair  • No unusual mortality detected  • Alcids had lower densities, even nearshore (preferred habitat)	
	<b>Primarily Fish eating</b>	<b>Primarily plankton eating</b>	

# Albatross Bycatch

J.Krieger, A. Eich



- Albatross (unidentified, short-tailed, Laysan, black-footed) bycatch continues to decline
- Seabird bycatch is primarily sablefish IFQ fishery (hook and line)
- Reduced interaction with fishery
  - Shift from hook and line to pot gear?
  - Improved forage conditions?

# 2021 Gulf of Alaska

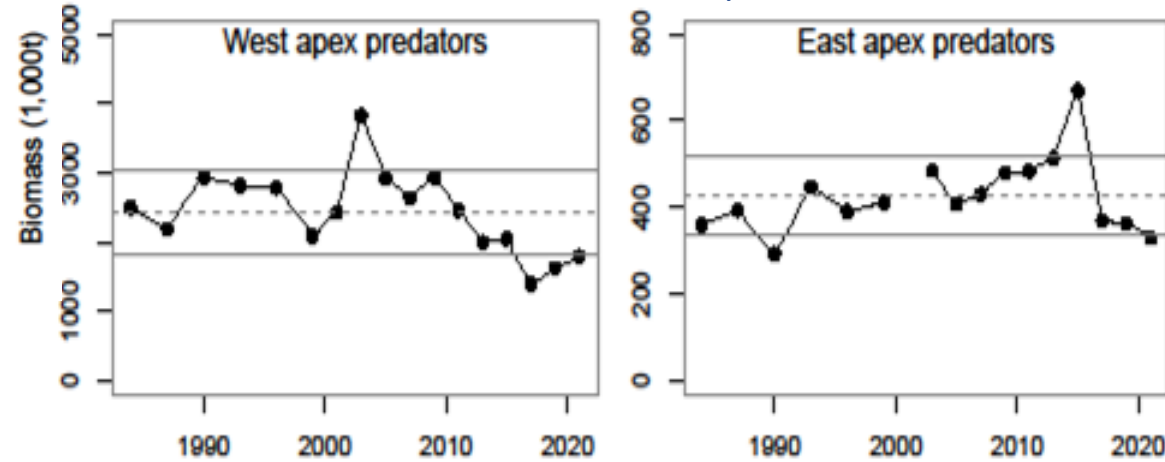


<https://www.nps.gov/gba/learn/nature/humpback-whales-in-glacier-bay.htm>

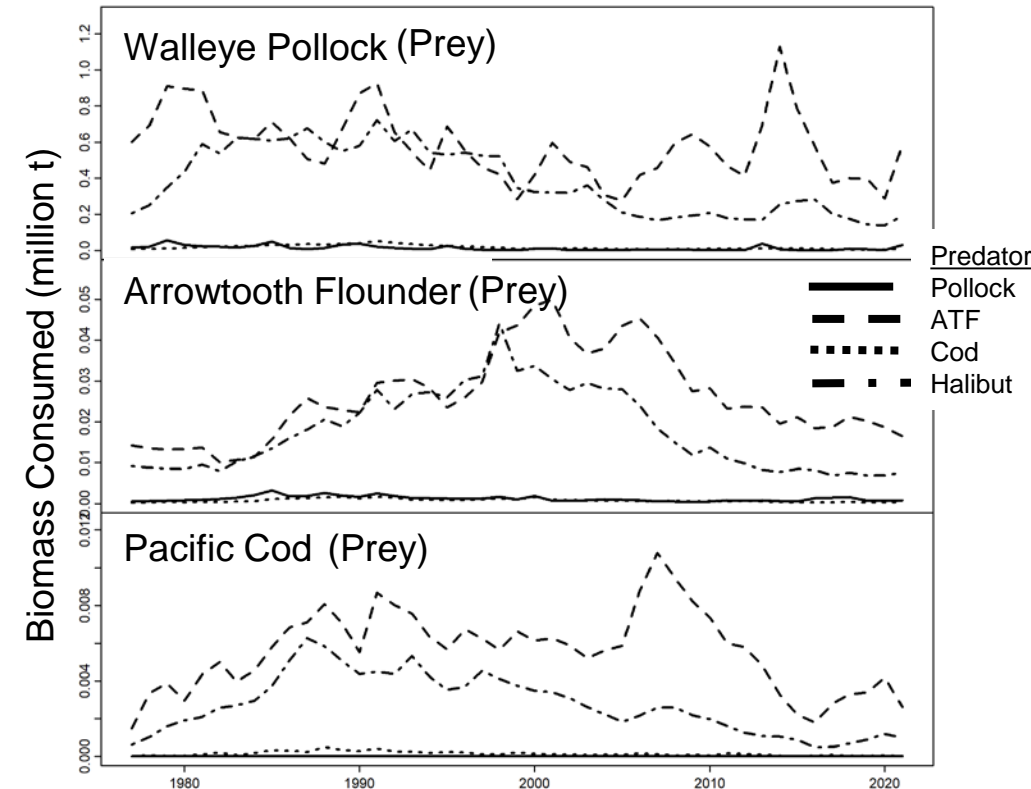
1. OCEANOGRAPHY
2. FORAGE CONDITIONS
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4. MULTI-YEAR TRENDS

# Biomass of Groundfish Apex Predators

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



- AFSC Bottom Trawl Survey Biomass
- Apex predators: primarily driven by arrowtooth flounder, Pacific cod, Pacific halibut, and sablefish.
- 1SD below long-term average

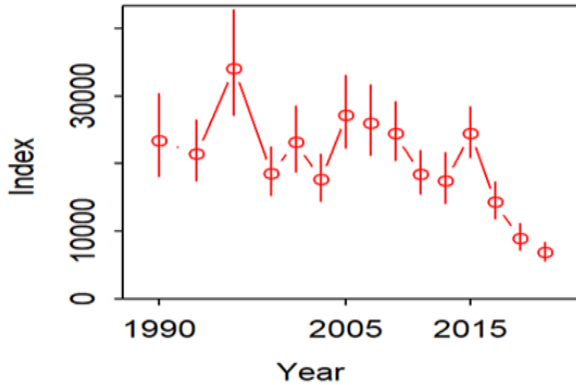


- Multispecies estimates of pollock, Pacific cod, and arrowtooth flounder biomass consumed by predator in the multi-species GOA CEATTLE model.
- Arrowtooth is the primary predator
- All predation mortality between these species has been low
- Pollock predation mortality increased in 2021 due to large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

# Epifauna: Sponges

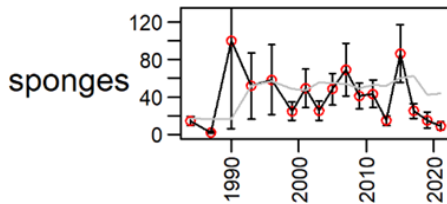
Palsson, von Szalay, Whitehouse, Gaichas

## C. Sponges

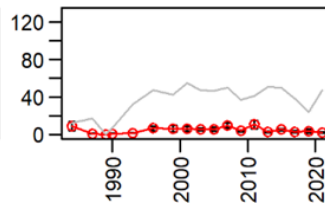


- Sponges are caught in about 50% of bottom trawl survey hauls in all areas of the GOA
- CPUE is generally highest in the Shumagins and lower to the east
- CPUE has substantially declined in the Shumagin and Kodiak regions
- CPUE increasing in Yakutat and Southeastern regions

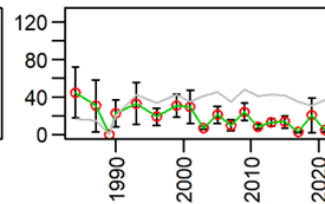
## Shumagin



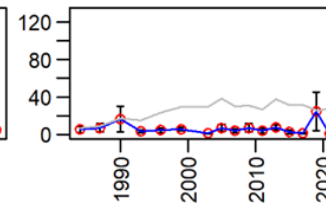
## Chirikof



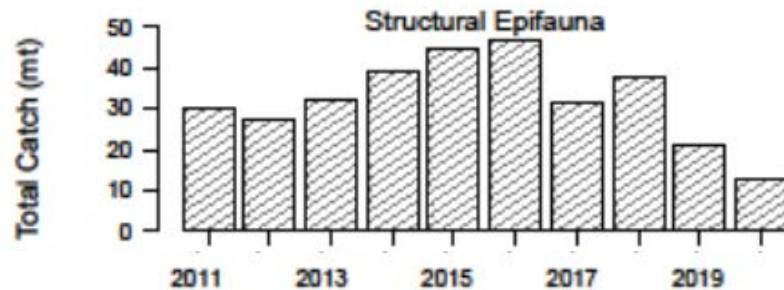
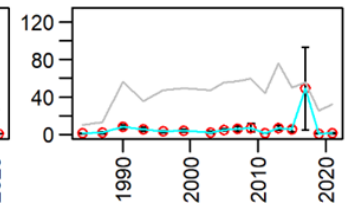
## Kodiak



## Yakutat



## Southeastern



- Non-target species in groundfish fisheries
- Structural epifauna: seapens/whips, sponges, anemones, corals, tunicates
- Decline from high in 2016 to low in 2020



## GOA still in transition from marine heat waves

Reduced populations since 2014-2016 marine heatwave period (capelin, common murre, Prince William Sound humpback whales, some groundfish species (e.g., Pacific cod), apex groundfish predators (P. cod, arrowtooth flounder, P. halibut))

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

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



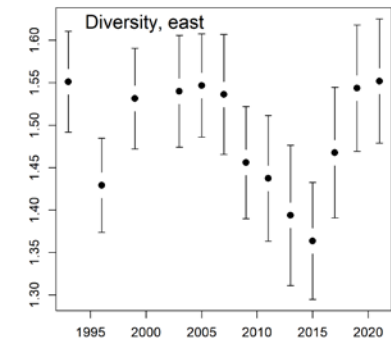
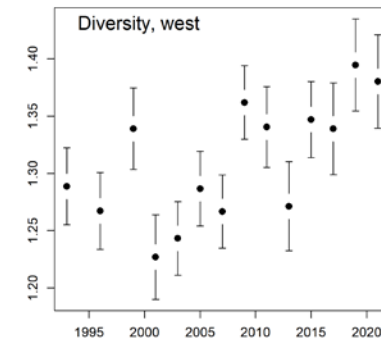
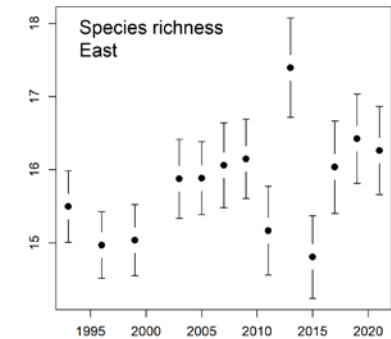
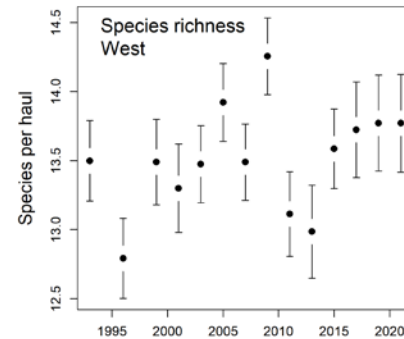
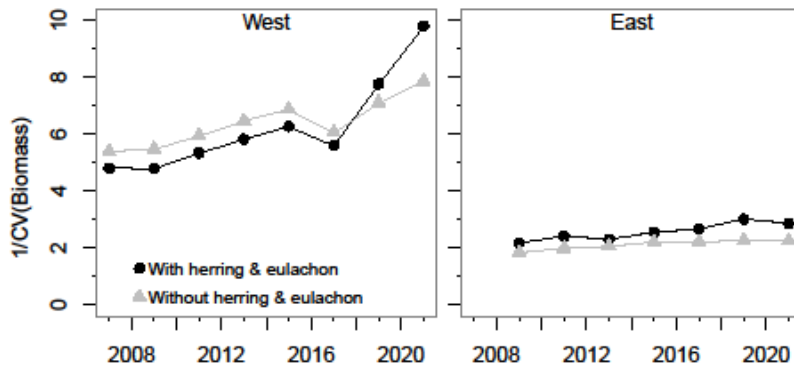
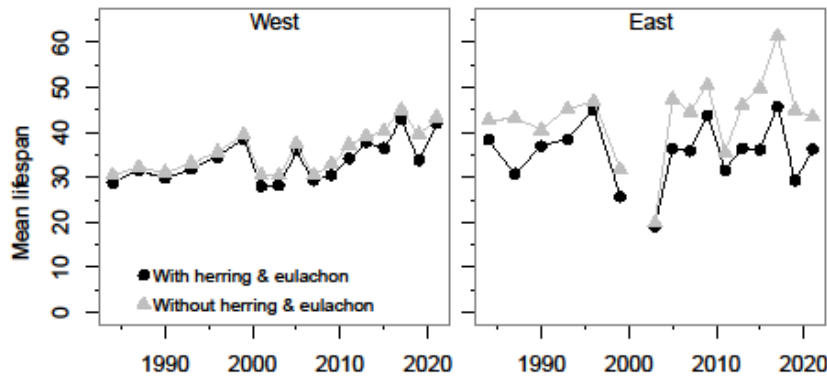
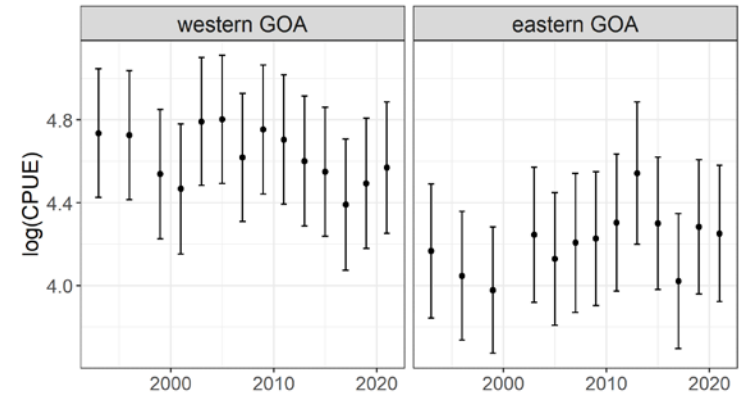
### 2. Lower System Productivity in GOA

- Below-average chl-a concentration (EGOA since 2016-2021; WGOA 2016, 2019, 2021)
- Zooplankton community composition (shift to smaller and/or less lipid-rich species)
- Continued below-average groundfish body condition
- Juvenile sablefish are shifting their distribution deeper

# Stability and Resilience of Groundfish Community

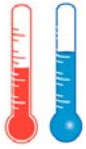
A. Whitehouse, F. Mueter

- Total AFSC bottom trawl survey CPUE increased in WGOA and fairly stable in EGOA from 2019 (p.183)
- Low biomass variability ( $1/CV$  biomass) (p.175)
- Species diversity and richness high
- High Mean life span (p.180)
- Relatively stable exploitation rates of total groundfish (2.5-7.2%)[up to 2017] (p.230)



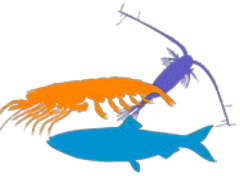
# GOA 2021: Key Messages

1. **2<sup>nd</sup> 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: higher abundance**
- 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 is still in transition from 2014-2016 heatwave period:** (PWS herring and humpback whales, groundfish condition, abundance of apex groundfish predators (e.g., P. cod, arrowtooth flounder), sponges

- **Cumulative effects of and variable recovery times Lower system productivity** (chl-a, zooplankton, groundfish condition)

— *will trends recover in another cool year (2022) or continue on alternate path?*

