GOA Pollock Ecosystem Socioeconomic Profile (ESP)

Review of draft ESP report for Gulf of Alaska pollock including classification, national metrics, ecosystem/socioeconomic processes, indicators, analysis, considerations, data gaps, and future research priorities

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Appendix in SAFE report

1) Intro: justification, data

2) Metrics assessment: national, processes

3) Indicators assessment: time series, analyses

4) Recommendations; data gaps, future priorities

Appendix 1xx. Ecosystem and Socioeconomic Profile of the Walleye Pollock stock in the Gulf of Alaska

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https://meetings.npfmc.org/CommentReview/DownloadFile?p=caaa62af-89e7-4ba7-97a2-f3c06066bc57.pdf&fileName=GOA_Pollock_ESP_Sept_2019.pdf

Justification

- Data classification
  - GOA pollock is a data rich stock at target for catch, size/age, life history
  - Near target for abundance
  - Below target for ecosystem
- AFSC research priorities
  - Recruitment important
  - High trophic interactions

Category	Current	Target	Gap
Catch	5	5	0
Size/Age	5	5	0
Abundance	4	5	1
Life History	5	5	0
Ecosystem	2	4	2

Data

| Title	Description	Years	Extent
EcoFOCI Spring Survey	Shelf larval survey in May-early June in Kodiak to Unimak Pass using oblique 60 cm bongo tows, fixed-station grid, catch per unit effort in numbers per 10 m^2	1978 – present	Western GOA annual, biennial
FBE Summer Survey	Age-0 gadid survey in mid-July through late August on 16 fixed-site stations, northeast Kodiak Island using 36-m demersal beach seine, gadids count, length in mm	2006 – present	Kodiak annual
EcoFOCI Late Summer Survey	Midwater trawl survey of groundfish and forage fish from August-September using Stauffer trawl and bongo tows from Kodiak to Unimak Pass, fixed-station grid	2000 – present	Western GOA biennial
RACE Bottom Trawl Survey	Bottom trawl survey of groundfish in June through August, Gulf of Alaska using Poly Nor'Eastern trawl on stratified random sample grid, catch per unit of effort in mt	1984 – present	GOA tri-, biennial
Seabird Surveys	Ecological monitoring for status and trend of suite of seabird species conducted by Alaska Maritime National Wildlife Refuge (AMNWR) at eight sites throughout Alaska	1991-present	Alaska variable
MACE Acoustic Survey	Mid-water acoustic survey in March in Shelikof Strait for pre-spawning pollock and again in summer for age 1 pollock	1981 - present	GOA annual, biennial
Climate Model Output	Daily sea surface temperatures from the NOAA High-resolution Blended Analysis Data	1977 - present	Central GOA
ROMS/NPZ Model Output	Coupled hydrographic Regional Ocean Modeling System and lower tropic Nutrient-Phytoplankton-Zooplankton dynamics model	1996-2013	Alaska variable
Essential Fish Habitat Models	Habitat suitability MaxEnt models for describing essential fish habitat of groundfish and crab in Alaska, EFH 2016 Update	1970-2016	Alaska
REEM Diet Database	Food habits data collected by the Resource Ecology and Ecosystem Modeling (REEM) Program, AFSC on multiple platforms	1990 – present	GOA biennial
FMA Observer Database	Observer sample database maintained by Fisheries Monitoring and Analysis Division	1988-present	Alaska annual
NMFS Alaska Regional Office	Catch, economics, and social values for fishing industry, data processed and provided by Alaska Fisheries Information Network	1992-2018	Alaska annual
Reports & Online	ADFG Commercial Operators Annual Reports, AKRO At-sea Production Reports, Shoreside Production Reports, FAO Fisheries & Aquaculture Department of Statistics	2011-2018	Alaska, U.S., Global annual

National Metrics

- Ecosystem Metrics

  - Recruitment variability > 0.9, habitat dependence larvae and juveniles stages

  - Key role in ecosystem as prey for broad range of predators

- Socioeconomic Metrics

 - Commercial value, constituent demand for excellence in stock assessment
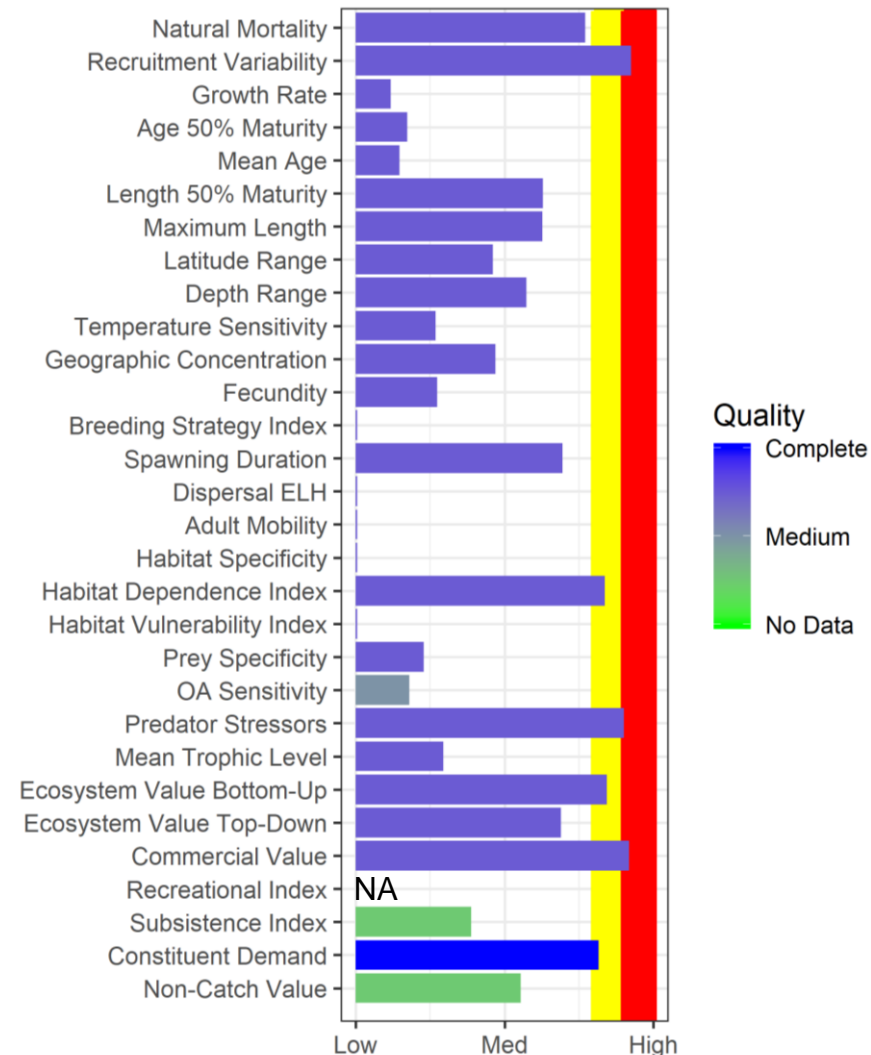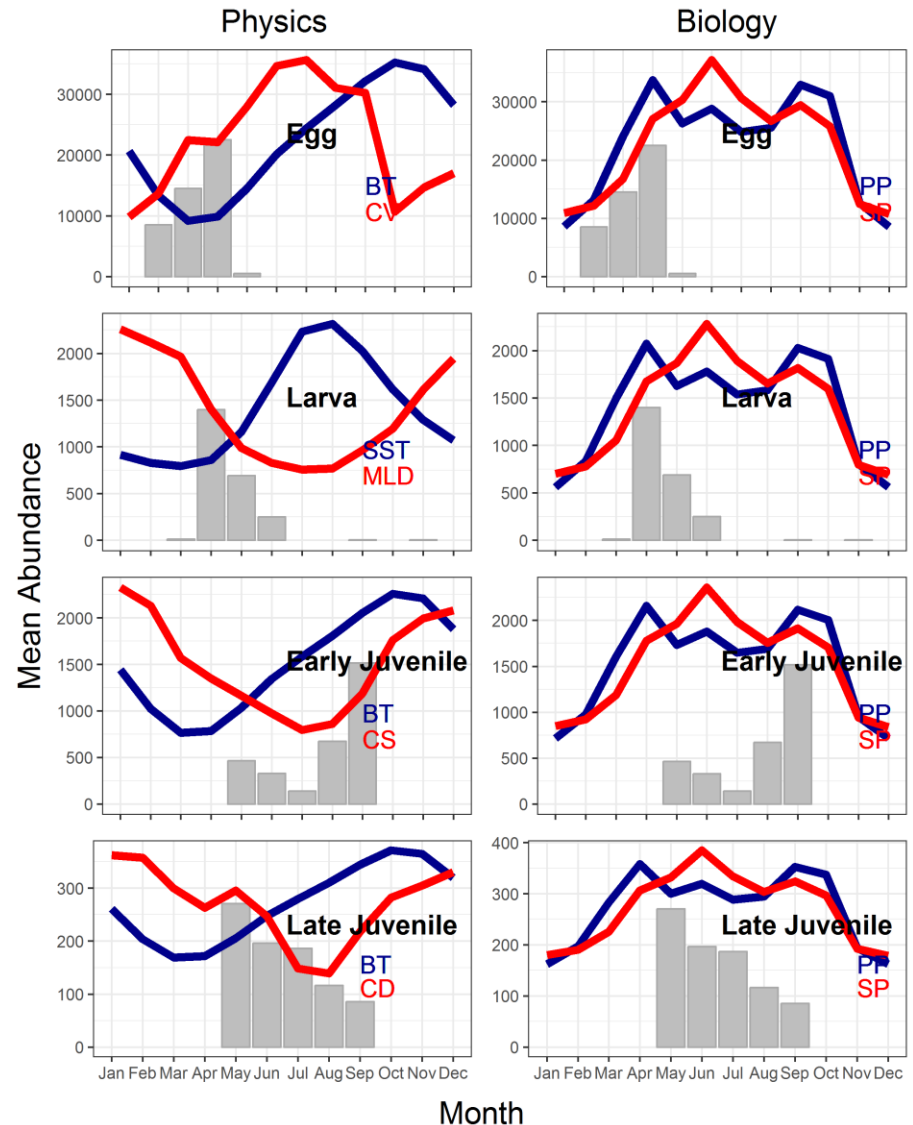
Ecosystem Processes

	Stage	Habitat & Distribution	Phenology	Age, Length, Growth	Energetics	Diet	Predators/Competitors
Adult	**Recruit**	Shelf (0-300 m)	Recruit to survey and fishery ~age 1, length 5-16 cm[19]	Max: 31yrs[AFSC], 105♀/92♂ cm[AFSC] Average: 10 yrs [19] L_inf=65.2cm, K= 0.3 [19]		Euphausiids, shrimp, copepods, juvenile pollock (<1 %) [19]	Arrowtooth flounder, halibut, Pacific cod, steller sea lions, sablefish, shelf pelagic/benthic groundfish, fisheries [17,19]
	Spawning	Shelf (150-300 m, $\bar{x}$ 200 m), Shelikof Strait/Valley [5,9,*11]	February-May, peak mid-March, 13 wks [1,20,25]	1st mature: 3-4 yr [11], 50%: 4.9 yr/44cm [19], ↑ size 50% to 48 since 2008 [19]	Oviparous, high fecundity (385-662·10^3) eggs [11], 1.1-7.2 °C at depth[11]	Euphausiids, shrimp, copepods, juvenile pollock (<1 %) [19]	Arrowtooth flounder, halibut, Pacific cod, steller sea lions, sablefish, shelf pelagic/benthic groundfish, fisheries [17,19]
Offshore to Nearshore Pelagic	**Egg**	Pelagic; shelf (0-200 m, $\bar{x}$ 150-200 m), Shelikof St/Valley, canyons [2,5,6,8-11]	mid-March-April, ~2 wks [10,11,20,25-26]	Egg size: 1.2-1.77 mm [20, RACE]	5.0-5.5°C at 150-250 m depth[10,11]	Yolk [RACE]	Invertebrates, detritivores, pelagic fishes [23,24]
	Yolk-sac Larvae	Pelagic; shelf and coastal areas (0-200 m, primarily upper 50 m), Shelikof St [2,3,5,6-8,10,11]	April [5], peak end April, 1 wk [20,25-26]	3-5 mm SL [2,3,5,6,8,10,11], growth rate 0.12-0.25 mm·day^{-1}[11]	Preferred, 31.5-32.2 ppt, 3.6-7.0 °C [8,10]	Yolk [RACE]	Planktonic predators (zooplankton, birds, fishes), larval groundfishes [5,6,8]
	Feeding Larvae	Pelagic; shelf and coastal areas (0-200 m, primarily upper 50 m), Shelikof St [2,3,5,6-8,10,11]	May-July[5], peak May, 4-5 wks [22,25-26]	30-40 mm SL at transformation [RACE], growth rate 0.12-0.25 mm·day^{-1}[11]	Preferred salinity=31.5-32.2, temperature=3.6-7.0 °C [8,10]	Copepod eggs & nauplii, copepodites [8]	Planktonic predators (zooplankton, birds, fishes), Pollock [17], larval groundfishes [5,6,8]
	Juvenile	Semi-demersal; shelf, coastal areas, bays, fjords, inlets (20-30 m and >30 m with age), mixed substrate [1,3,4,18]	Aug-Mar (1+ yr); 8-24 wks [25,26]	25-40 mm FL (offshore) [5]; >40 mm SL (nearshore) [5]; growth sensitive to diet, competition	Energy density ↑ with length, > over slope, spatial shifts due to +/- *C. marshallae*	Copepods, euphausiids [16]	Arrowtooth flounder, sablefish, cod, pollock [17], juvenile groundfish, macroalgae [12,18], macroinvertebrates [18]
	Pre-Recruit	Semi-demersal; shelf, coastal areas, bays, fjords, inlets, mixed substrate, mud[18]		>250 mm FL[11], age 2+ yrs[10]		Euphausiids, copepods, pollock[16],	Arrowtooth flounder (~50% <20 cm) [19], sablefish, Pacific cod, Pollock [17], juvenile groundfish, macroalgae [12,18], macroinvertebrates [18]

Ecosystem Processes
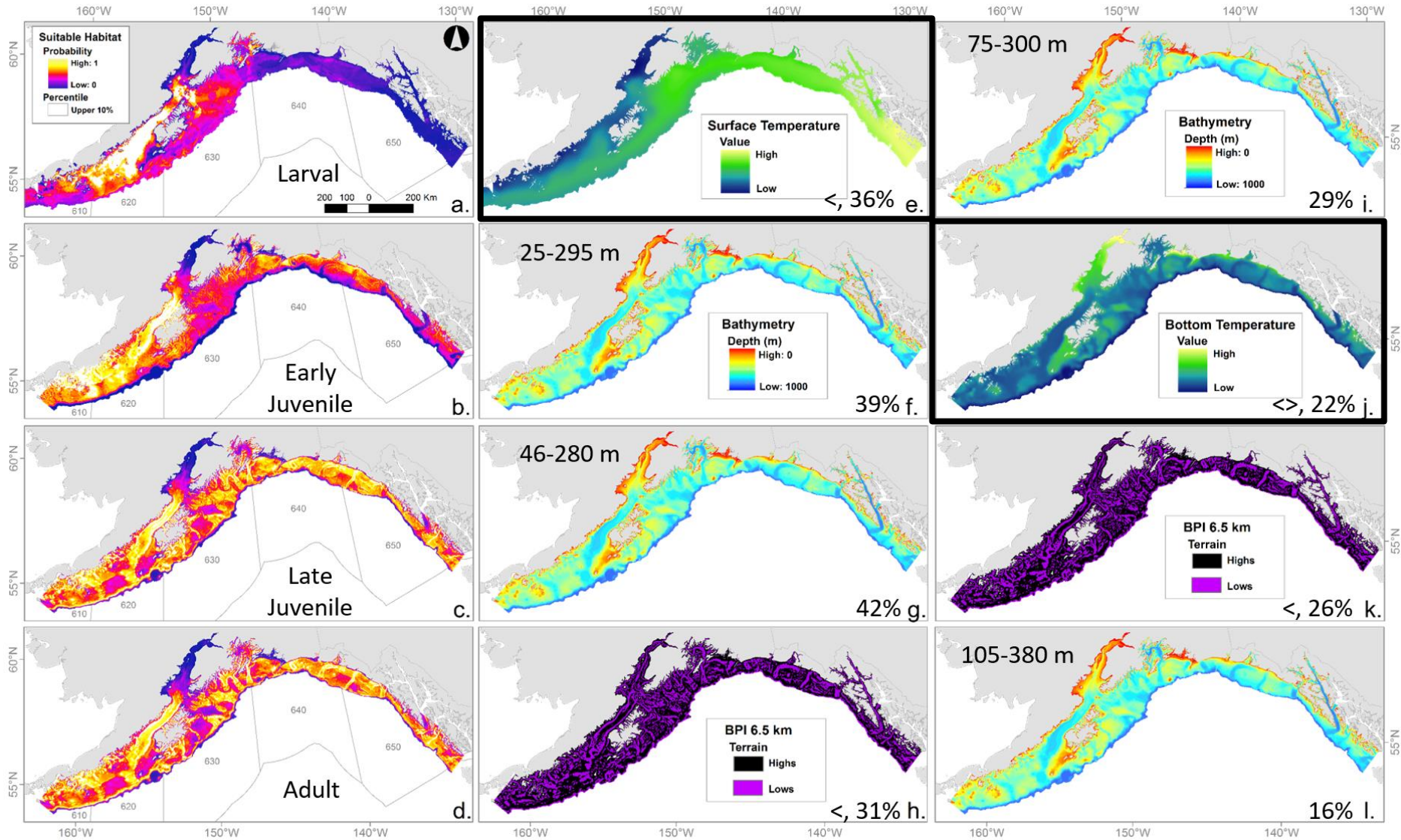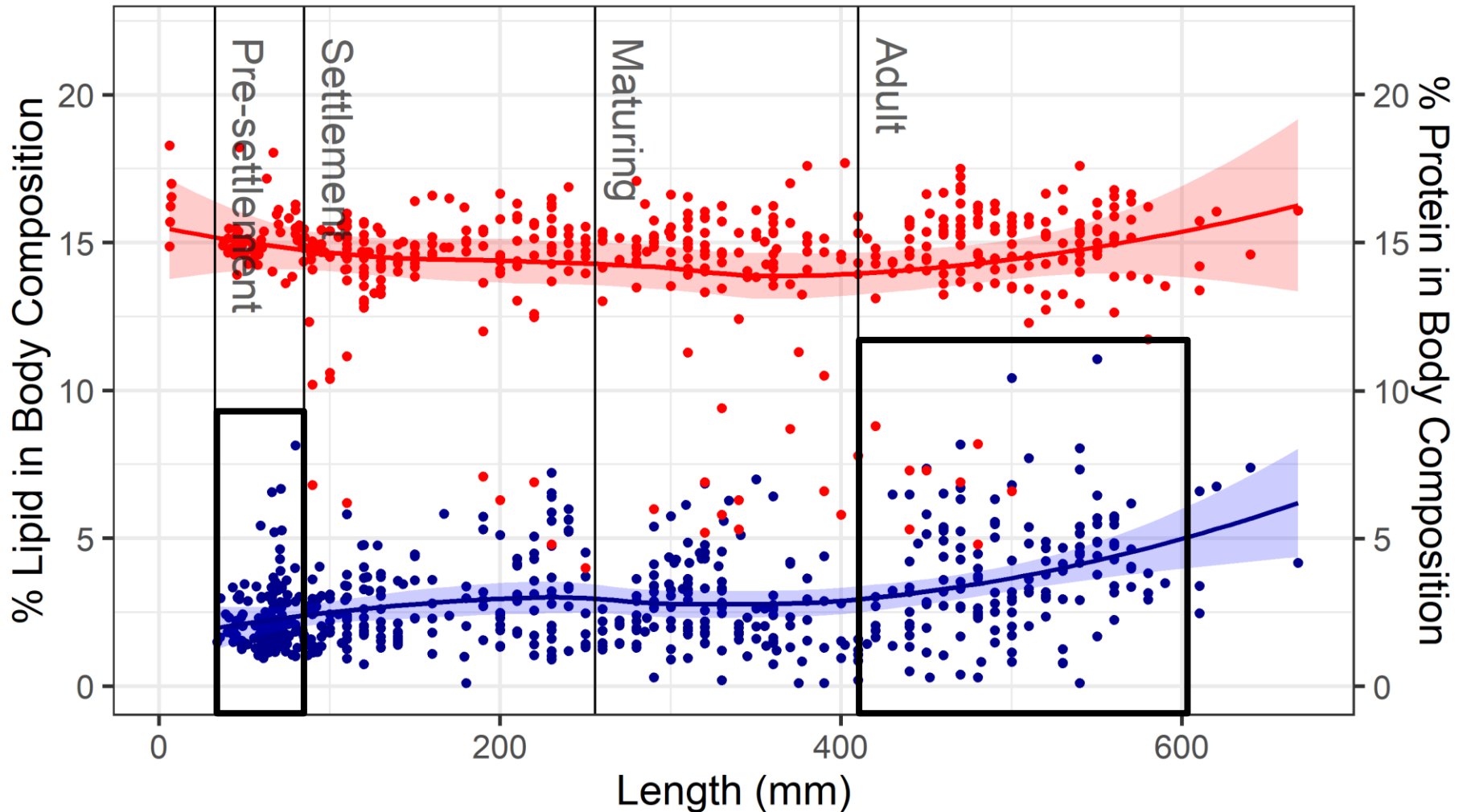
Ecosystem Processes

- Egg and Larvae

  - Pollock eggs pelagic and vulnerable to predators

  - Larvae hatch prior to spring bloom, potential mismatch

  - Cold yrs enhance synchrony

- Juveniles

  - Ubiquitous in epipelagic zone of shelf/slope in E/W GOA, match fall bloom
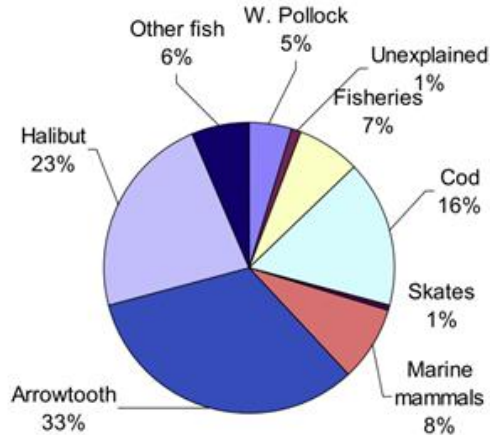
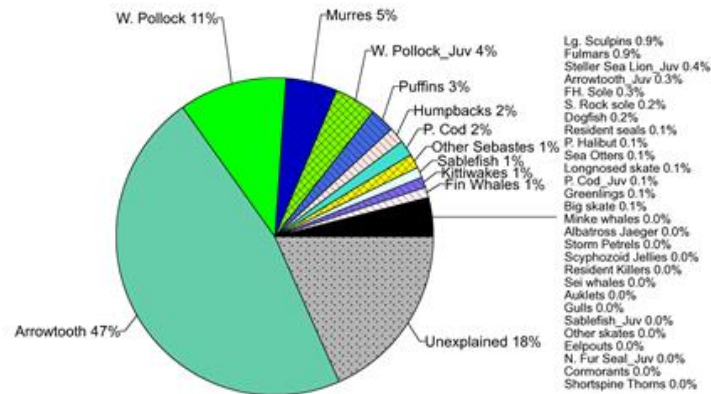# Ecosystem Processes

Pollock Body Composition by Size (Wet Mass)

Ecosystem Processes
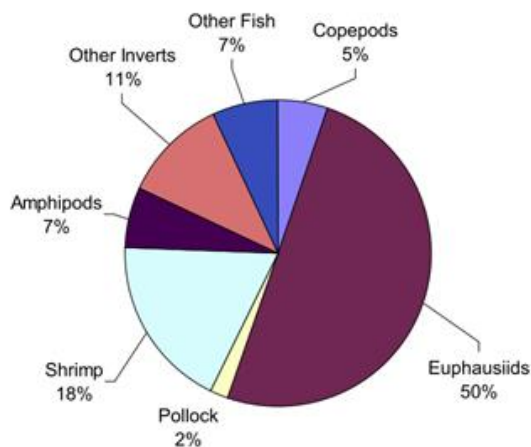

a) GOA pollock mortality sources

b) GOA pollock diet composition

c) GOA pollock juvenile mortality sources

d) GOA pollock juvenile diet composition

Ecosystem Processes

3) Yolk-sac Larvae (0-200, 50 m, 3-7°C)
April
Temperature
Currents
Predation

4) Feeding Larvae (0-200, 50 m, 3-7°C)
May-July
Temperature
Currents
Predation

2) Egg (0-200 m, 5-6°C)
Mid Mar-Apr
Density
Advection/retention
Predation

5) Juvenile (0-30 m, > age)
Aug-1 year old
Prey
Advection/Retention
Predation

6) Pre-recruit (0-300 m)
1-2 years
Prey
Predation

1) Spawning (150-300 m, 1-7°C)
Batches in Feb-May
Temperature
Distribution

7) Recruit (0-300 m)
3 plus years
Predation
Prey

Depth

Ecosystem Processes

	Stage	Processes Affecting Survival	Relationship to GOA Pollock
Adult	**Recruit**	1. Top-down predation increase on age 3+ 2. Bottom-up control on juvenile consumption	Increases in main predator of pollock would be negative but minor predators may indicate pollock biomass increase. Increases in primary prey biomass would be positive for pollock but may increase competition.
	Spawning	1. Distribution 2. Surface and bottom temperature[10]	Increased distribution spread of adult pollock may be negative as pollock would experience non-preferred habitat and potentially lower quality prey options. Increases in temperature may be negative causing early maturation, mismatch with spring bloom.
Offshore to Nearshore Pelagic	**Egg**	1. Water column density 2. Advection/retention 3. Predation	Increases in density, advection, and predation would be negative for egg stage resulting in sinking or dispersal from preferred habitat and adequate zooplankton prey.
	Yolk-sac Larvae	1. Temperature-mediated metabolic rate 2. Currents that facilitate nearshore transport [6,8,10] 3. Predation	Increases in temperature would increase metabolic rate and may result in rapid yolk-sac absorption that may lead to mismatch with prey. Current direction to preferred habitat would be positive for pollock while predation increases would be negative.
	Feeding Larvae	1. Temperature-mediated metabolic rate 2. Currents that facilitate nearshore transport [6,8,10] 3. Predation	Increases in temperature would increase metabolic rate and may result in poor condition if feeding conditions are not optimal. Current direction to preferred habitat would be positive for pollock while predation increases would be negative.
	Juvenile	1. Spring/summer/fall abundance of zooplankton prey [11] 2. Advection/retention (offshore) 3. Predation	Increases in preferred zooplankton prey would be positive for pollock condition and relative biomass of pollock may also be measured by minor predators of pollock. Advection offshore may be positive for pollock to arrive at preferred habitat. Predation would be negative for pollock.
	Pre-Recruit	1. Bottom-up control juvenile consumption 2. Top-down predation increase on age 3+	Increases in main predator of pollock would be negative but minor predators may indicate pollock biomass increase. Increases in primary prey biomass would be positive for pollock but may increase competition.

Socioeconomic Processes

- Economic Performance

  - Paired down version of the EPR from 2018

  - Recent > price, > vessels

  - Roe high priced product

  - Name change to "pollock"

- Tables (national to global)

  - Five year breakdown of various economic metrics

	Avg 11-13	2014	2015	2016	2017	2018
Total Catch K mt	94.0	142.6	167.6	177.1	186.2	158.1
Retained Catch K mt	91.8	141.2	163.0	176.0	184.3	155.7
Ex-vessel Value M $	$ 34.4	$ 37.9	$ 43.6	$ 32.3	$ 35.2	$ 42.2
Ex-vessel Price/lb $	$ 0.169	$ 0.122	$ 0.119	$ 0.083	$ 0.087	$ 0.123
Central Gulf Share of Value	75%	88%	80%	63%	72%	76%
Vessels #	70.0	72.0	65.0	70.0	65.0	71.0

		Avg 11-13	2014	2015	2016	2017	2018
All Products	Volume K mt	36.1	54.7	59.8	75.1	78.1	69.1
All Products	Value M $	$ 84.5	$ 105.8	$ 105.1	$ 106.4	$ 96.7	$ 104.9
All Products	Price lb $	$ 1.06	$ 0.88	$ 0.80	$ 0.64	$ 0.56	$ 0.69
Head & Gut	Volume K mt	18.4	29.7	30.3	27.8	37.4	39.8
Head & Gut	Price lb $	$ 0.68	$ 0.62	$ 0.61	$ 0.38	$ 0.36	$ 0.41
Head & Gut	Value share	33%	38%	39%	22%	31%	35%
Fillets	Volume K mt	5.8	8.2	9.1	14.3	15.7	13.1
Fillets	Price lb $	$ 1.59	$ 1.35	$ 1.30	$ 1.26	$ 1.01	$ 1.17
Fillets	Value share	24%	23%	25%	37%	36%	32%
Surimi	Volume K mt	8.5	12.3	14.7	13.4	10.6	9.8
Surimi	Price lb $	$ 1.19	$ 0.89	$ 0.85	$ 0.97	$ 0.76	$ 0.96
Surimi	Value share	27%	23%	26%	27%	18%	20%
Roe	Volume K mt	1.7	3.5	3.1	0.5	1.1	2.4
Roe	Price lb $	$ 3.07	$ 2.03	$ 1.22	$ 1.39	$ 1.80	$ 1.83
Roe	Value share	14%	15%	8%	2%	4%	9%

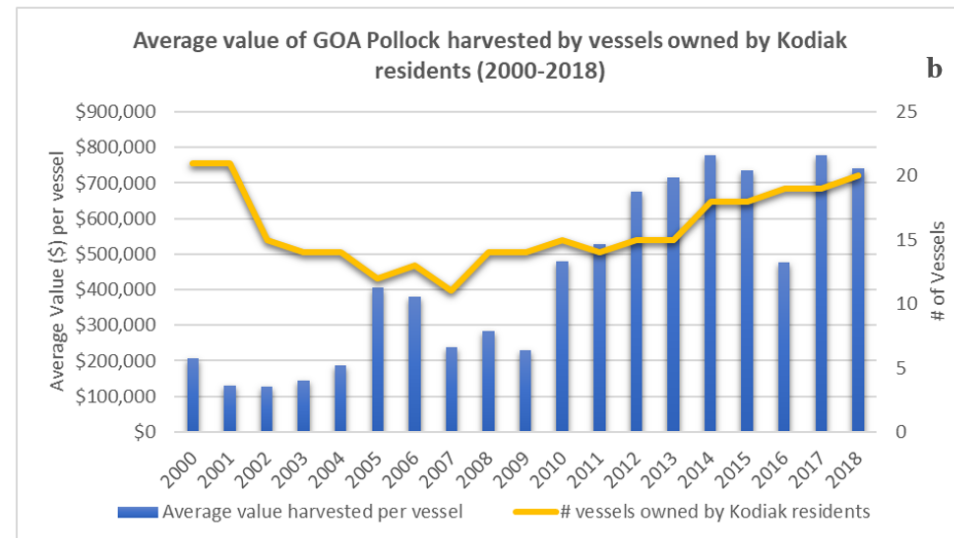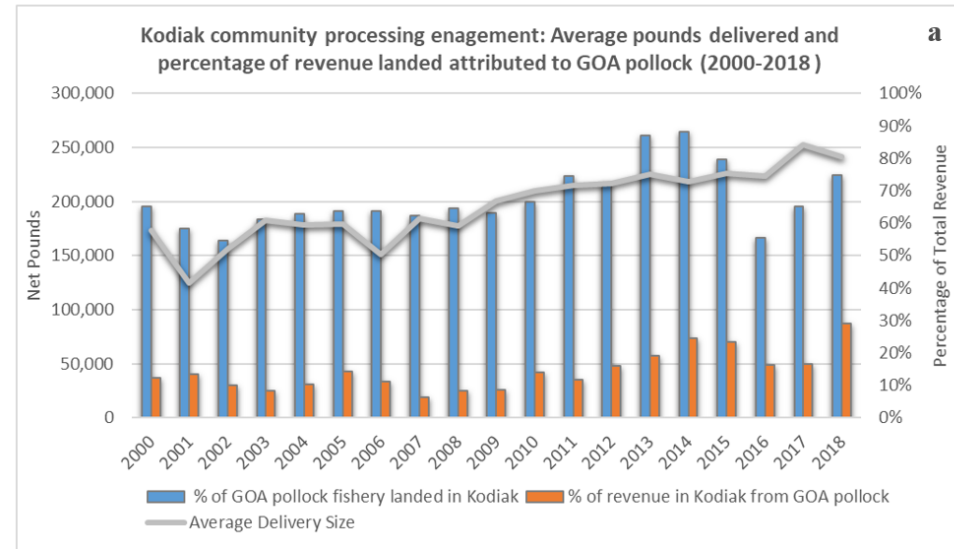|	Avg 11-13	2014	2015	2016	2017	2018
Global Pollock Catch K mt	3,243	3,245	3,373	3,476	3,488	-
U.S. Share of Global Catch	40%	44%	44%	44%	44%	-
GOA share of global	3%	4%	5%	5%	5%	-

Socioeconomic Processes

- Communities
  - Kodiak port accounts for 80% of GOA delivered pollock volume
  - Pollock 16% Kodiak ex-vessel 5 yr avg value
- Engagement metrics
 - Avg delivery, % revenue
  - Avg value/vessel, # vessels

Kodiak community processing enagement: Average pounds delivered and percentage of revenue landed attributed to GOA pollock (2000-2018) **a**

Legend: % of GOA pollock fishery landed in Kodiak | % of revenue in Kodiak from GOA pollock | Average Delivery Size

Average value of GOA Pollock harvested by vessels owned by Kodiak residents (2000-2018) **b**

Legend: Average value harvested per vessel | # vessels owned by Kodiak residents
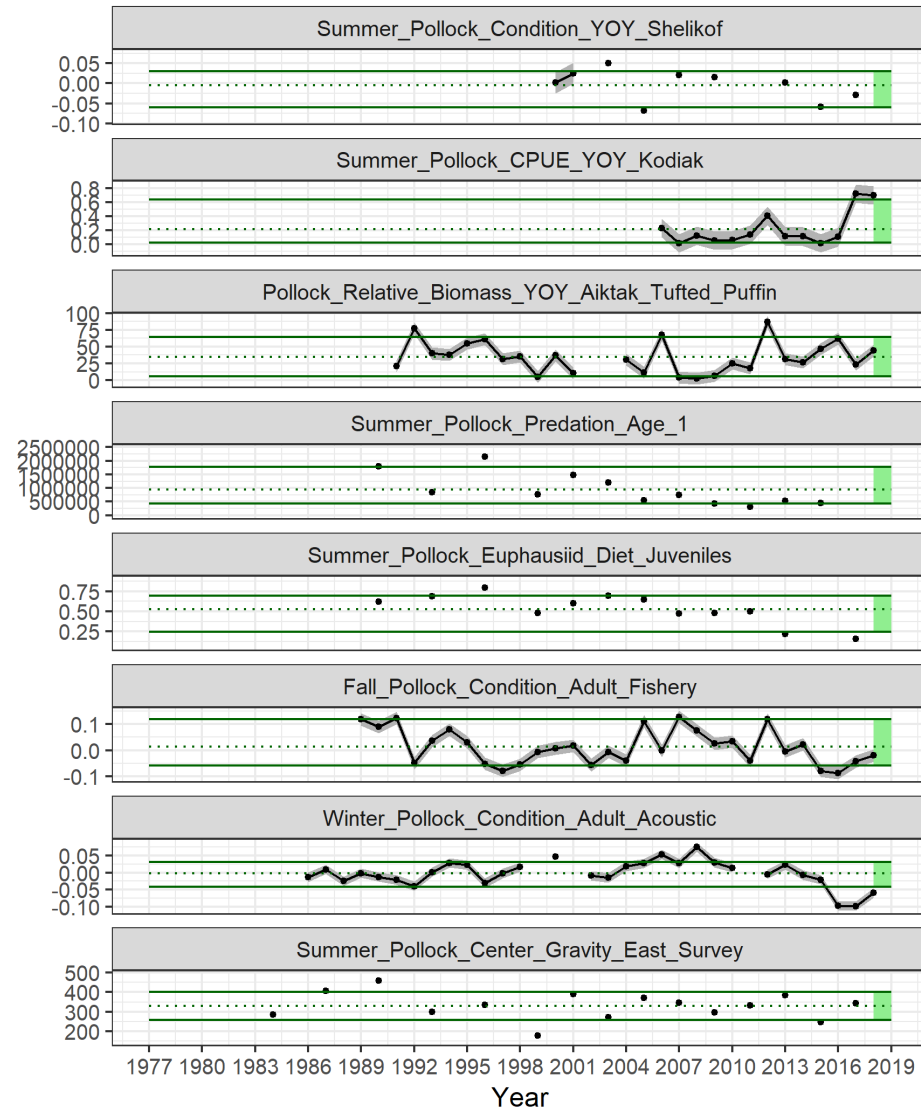
Time Series

Ordered by Life Stage

- Physical: heatwave, summer BTS

- Zooplankton: copepods (sm/lg), euphausiids, auklet reprod success

- Pollock larvae: spring

- Pollock YOY: summer offshore
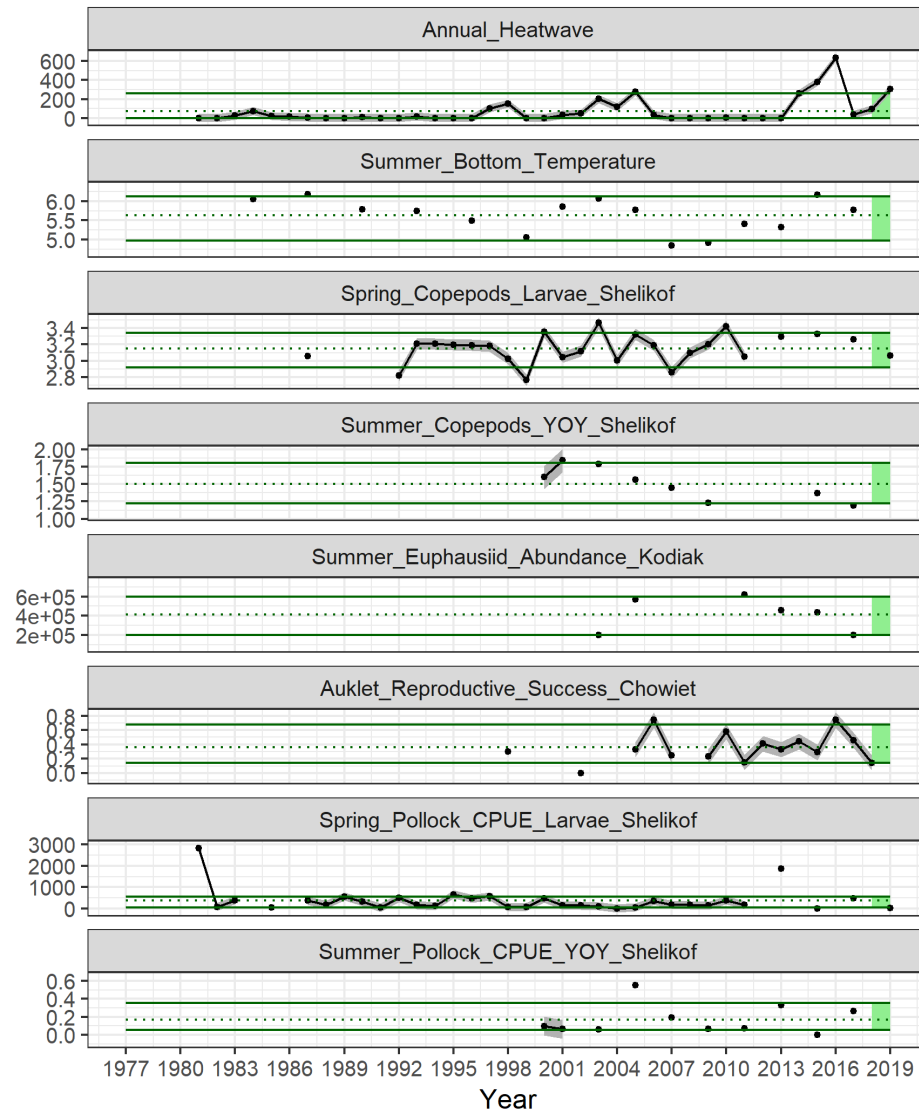
Time Series

Ordered by Life Stage

- Pollock YOY: summer condition, CPUE Kodiak, relative biomass puffins

- Pollock age 1: predation M, prop euphausiid diet

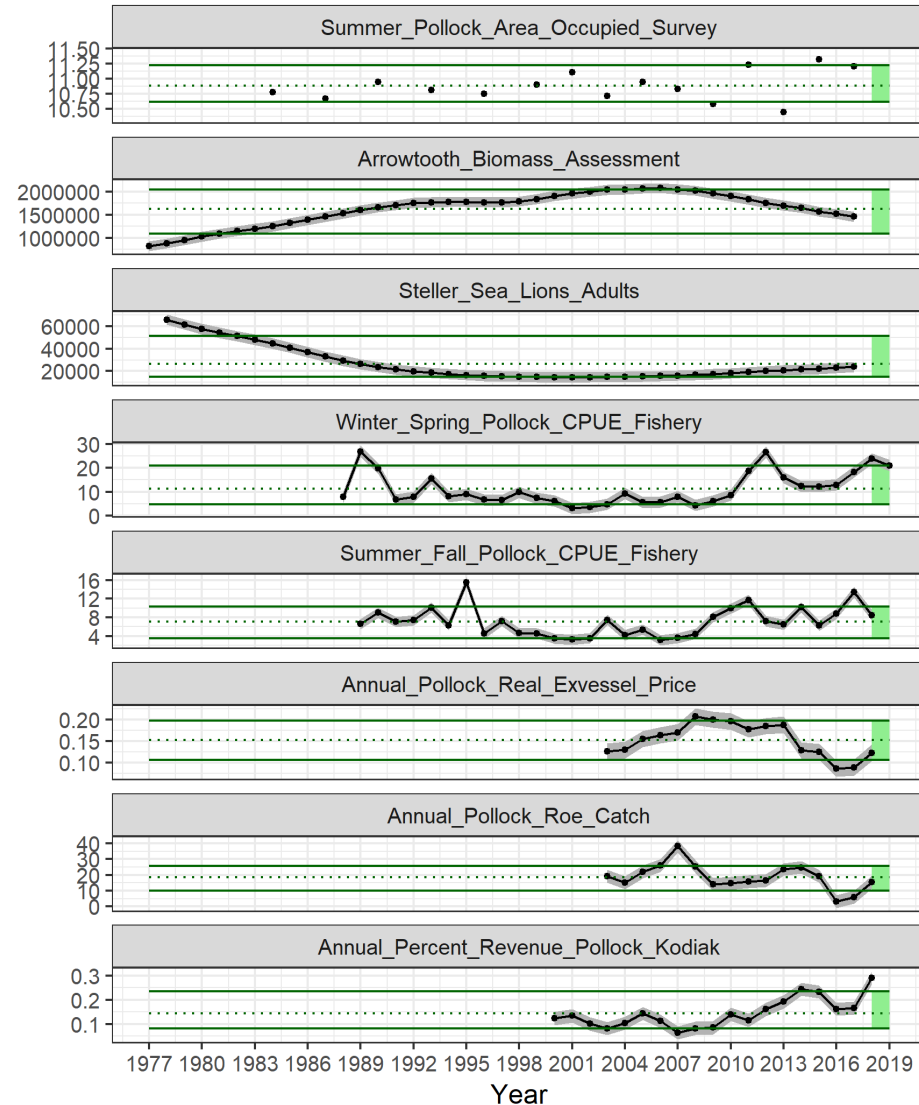- Pollock adult: fall fishery winter survey condition, center of gravity (east)

Time Series

Ordered by Life Stage, Type

- Pollock adult: area occupied, ATF, SSL

- Fishery Performance: CPUE 1,3 trimesters

- Value: real ex-vessel price, roe per unit catch

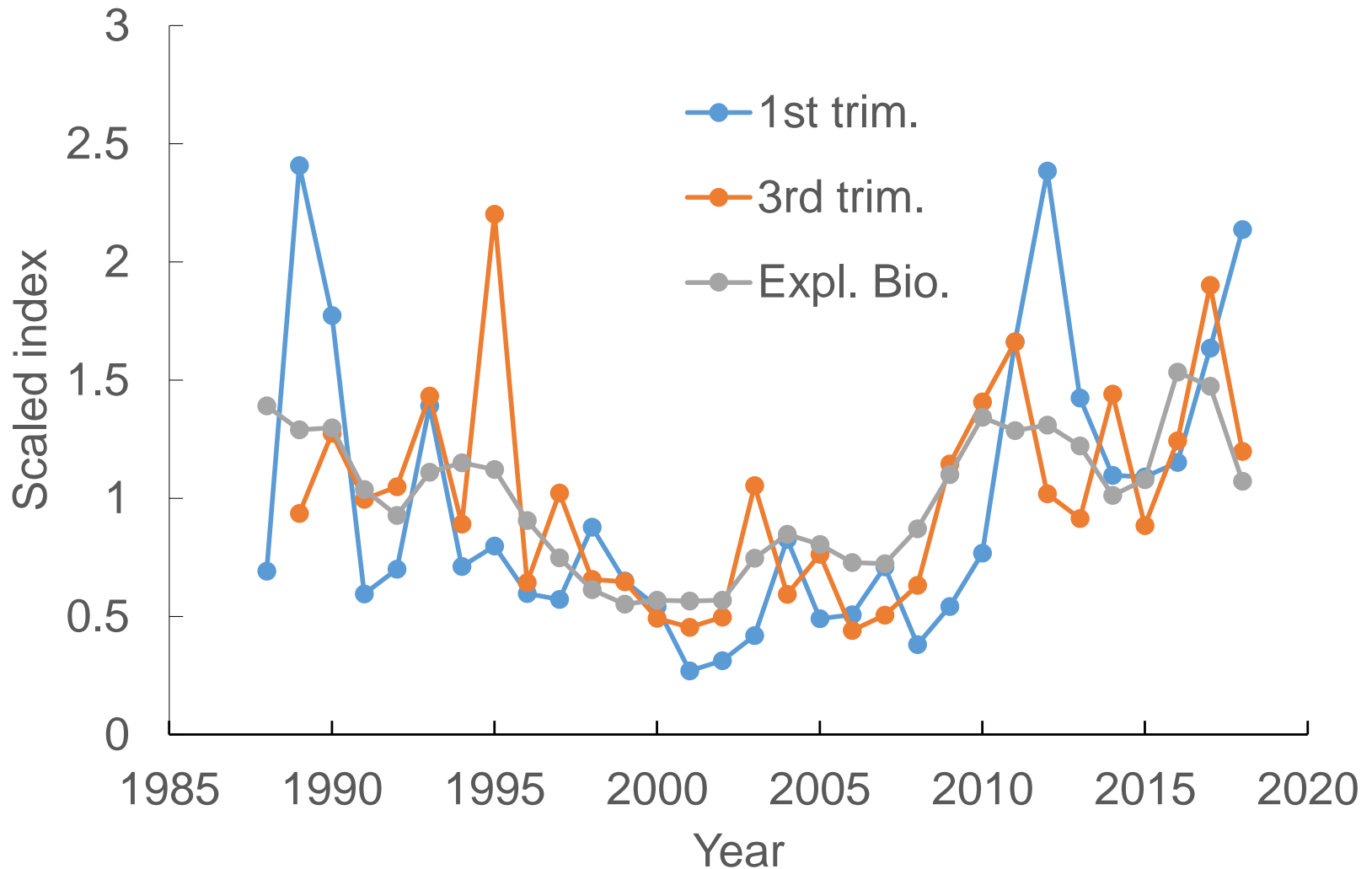- Community: % total revenue Kodiak pollock

Distribution Indicators

- Spatio-temporal model

  - Recommended settings

  - GOA grid west 140°W

- Indicators

  - Evaluate center of gravity in a northeast direction?

  - Increasing trend in effective area occupied possibly into poor habitat, Nov. = dist'n at age-1
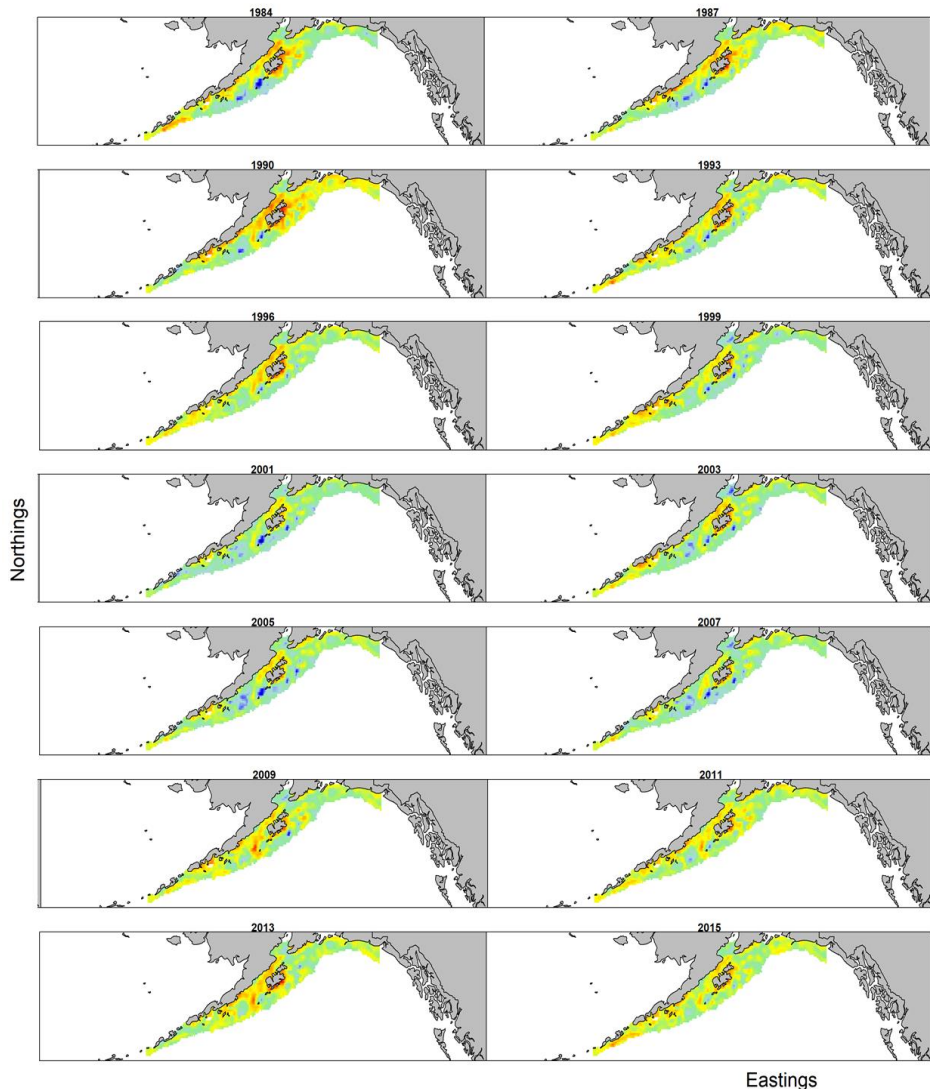
Performance Indicators

Ecosystem Traffic Light

- 2012 year class

  - Supported by larval/YOY surveys and puffin diet

  - Heatwave influence and prey indicators low

  - Poor condition 2015-18

  - Spatial distribution spread out and eastward shift

  - Major predator biomass decreasing trend

Title	Description	Recent
Annual Heatwave	Regional daily mean sea surface temperatures from NOAA climate model processed following Hobday et al., 2016 to obtain marine heatwave cumulative intensity. Please contact S. Barbeaux for more details.	+
Summer Bottom Temperature	Average summer bottom temperature (ºC) over all hauls of the RACE GOA shelf bottom trawl survey. Available from AKFIN or online survey database.	●
Spring Copepods Larvae Shelikof	Mean abundance of small copepods (< 2 mm) in core Shelikof area measured in log scale numbers per meter cubed with associated rapid zooplankton assessment (Kimmel et al., 2019)	●
Summer Copepods YOY Shelikof	Mean abundance of large copepods (> 2 mm) in core Shelikof area measured in log scale numbers per meter cubed with associated rapid zooplankton assessment (Kimmel et al., 2019)	-
Summer Euphausiid Abundance Kodiak	Acoustic backscatter per unit area classified as euphausiids and integrated over the water column and across Kodiak core survey area from MACE summer survey (Ressler et al., 2019)	-
Auklet Reproductive Success Chowiet	Proportion of parakeet auklet nest sites with fledged chicks from total nest sites with eggs laid from Chowiet Island (Higgins et al., 2018)	●
Spring Pollock CPUE Larvae Shelikof	Mean abundance of larval pollock taken in bongos from core sampling area in Shelikof Strait during EcoFOCI spring survey with rapid assessment (Rogers et al., 2019)	-
Summer Pollock CPUE YOY Shelikof	Mean abundance of YOY pollock taken in midwater trawl from core area in WGOA area during EcoFOCI summer survey with rapid assessment (Rogers et al., 2019)	+
Summer Pollock Condition YOY Shelikof	Body condition of YOY pollock taken in midwater trawl from core area in WGOA area during EcoFOCI summer survey with rapid assessment (Rogers et al., 2019)	●
Summer Pollock CPUE YOY Kodiak	Catch per unit effort of YOY pollock in beach seine from fixed sites in nearshore Kodiak survey (Laurel et al., 2019)	+

Ecosystem Traffic Light

- Current conditions

  - Entering another heatwave, weak/mod ENSO, < storms

  - 2018 yr class experience similar conditions to 2012

  - Poor 2019 larvae/YOY in all surveys and PWS

- Traffic light (update)

  - Multiple red indicators, few stable, several not updated

| Title	Description	Recent
Pollock Relative Biomass YOY Aiktak	Relative biomass of pollock measured from screening burrows of tufted puffins diets at Aiktak Island (Youngren et al., 2019)	●
Summer Pollock Predation Age-1	Predation mortality estimates of age-1 pollock from multiple data sources and models (Barnes et al., *In Review*)	●
Summer Pollock Euphausiid Diet Juvenile	Proportion-by-weight of pollock taken from summer bottom trawl survey samples in GOA (K. Aydin, *pers. commun.*)	-
Fall Pollock Condition Adult Fishery	Length-weight regression of pollock sampled by observers in the fall pollock fishery (M. Dorn, *pers. commun.*)	●
Winter Pollock Condition Adult Acoustic	Length-weight regression of pollock sampled in Shelikof Strait during the late winter MACE acoustic survey (M. Dorn, *pers. commun.*)	-
Summer Pollock Center of Gravity East	Biomass-weighted average of the location of extrapolation-grid cells in northings or eastings from spatio-temporal model of pollock in the summer bottom trawl survey (Thorson and Barnett, 2017)	●
Summer Pollock Area Occupied	Area required to contain the population at its average biomass from spatio-temporal model of pollock in the summer bottom trawl survey (Thorson and Barnett, 2017)	+
Arrowtooth Biomass Assessment	Total biomass estimates from arrowtooth flounder stock assessment model output (Spies et al., 2017)	●
Steller Sea Lion Adult Counts	Non-pup estimates of Steller sea lions from the GOA portion of the western Distinct Population Segment (ESR GOA 2018)	●

Socioeconomic Traffic Light

- Performance/Price
  - CPUE increasing since 2008
  - Price & roe catch down, but increasing in 2018, concurrent with condition
- Engagement up in Kodiak
- Traffic light (update)
  - CPUE indicators good
  - Price avg, community good

Title	Description	Recent
Winter-Spring Pollock CPUE Fishery	Catch of pollock in tons/hour from the winter-spring (first trimester) of the pollock fishery (M. Dorn, *pers. commun.*)	+
Summer-Fall Pollock CPUE Fishery	Catch of pollock in tons/hour from the summer-fall (third trimester) of the pollock fishery (M. Dorn, *pers. commun.*)	●
Annual Pollock Real Ex-vessel Price	Estimate of real ex-vessel value in price per pound inflation adjusted to 2018 USD (B. Fissel, *pers. commun.*)	●
Annual Pollock Roe per unit Catch	Roe per-unit-catch calculated as 1000*(roe production)/(retained catch) (B. Fissel, *pers. commun.*)	●
Annual Percent Revenue Pollock in Kodiak	Percentage of the total revenue Kodiak gets from the GOA pollock fishery (aka, local quotient) (S. Wise, *pers. commun.*)	+

Based on recent year or current year?

Modeling Application

Standardized Covariate Values

Bayesian Adaptive Sampling
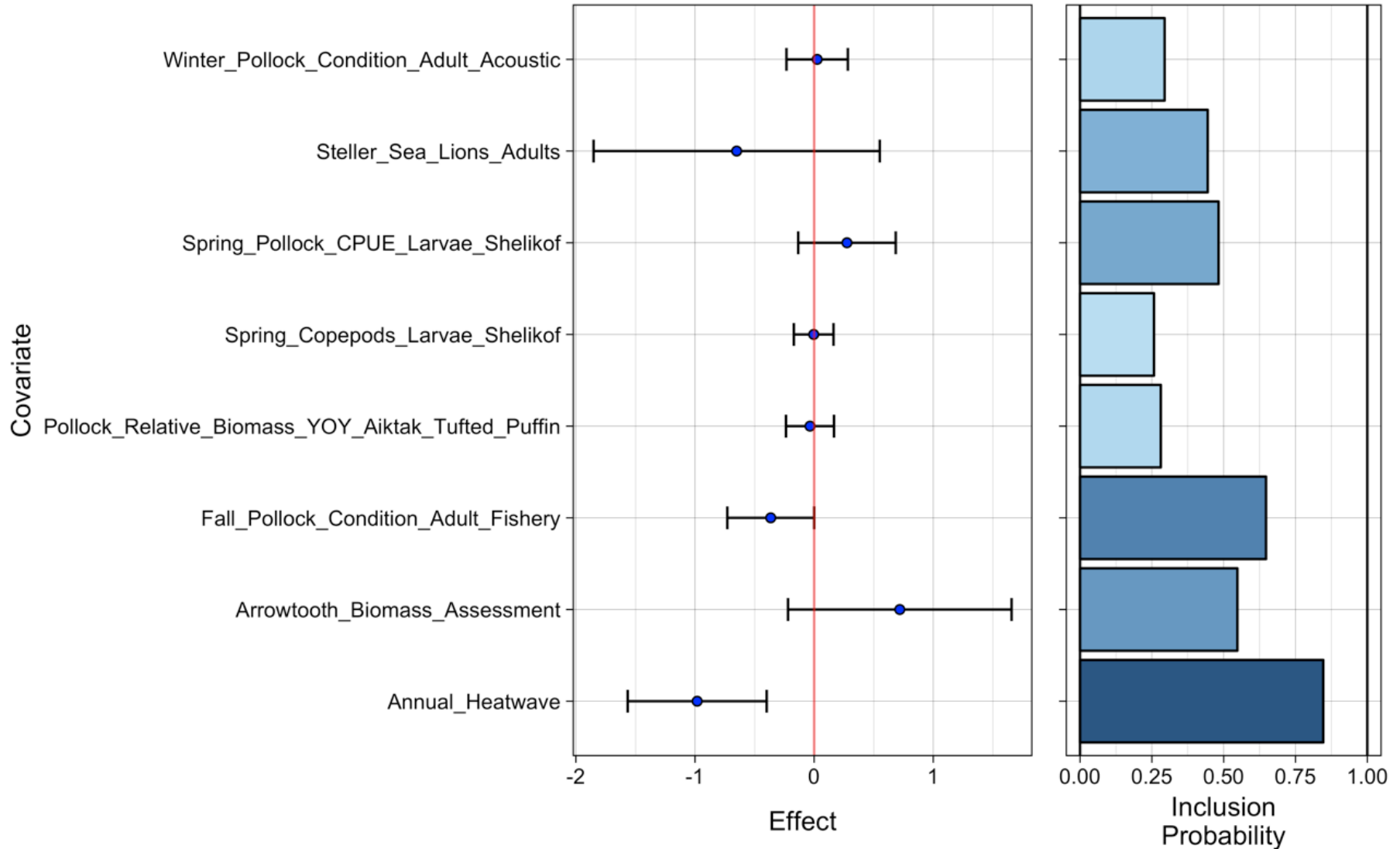
Metric Considerations

- Ecosystem

  - Ontogenetic habitat shift in distribution, batch spawning may mitigate vulnerability, spawn timing impacted by spawner age and temperature

  - Degree larval mismatch may be critical with cold years enhancing synchrony with optimal prey

  - Juvenile pollock sensitive to foraging conditions, spatial distribution may influence encounter of optimal prey

- Community engagement was added to EPR

Indicator Considerations

- Ecosystem

  - Return to heatwave conditions, decreased storminess

  - Early indicators suggest weak 2019 year class following apparent average or above average in 2017 and 2018

  - Euphausiids declining, smaller % of diet, body condition of juveniles and adults low since 2015

  - Prey for 2018 year class similar to that of 2012 year class and may result in smaller size@age and poor condition when it enters the fishery

- Socioeconomic
  - Fishery CPUE above average since 2016, consistent with stock biomass levels
  - Precipitous drop in roe-per-unit-catch in 2016-17 that rebounded in 2018 and may be related to poor body condition of adult pollock since 2015
  - Percent revenue in Kodiak from GOA pollock reached high in 2018, suggesting high level of reliance on GOA pollock fishery by Kodiak residents

Gaps & Future

- Indicator Gappiness
    - Investigate remote sensing, climate model options
    - Refinement of GOA CEATTLE model

- Alternative Indicators
    - Upcoming competitors (sablefish, POP)
    - Condition, energy density at edges of range

- Next Steps – November SAFE Appendix
    - Update ESP with new survey data, age-1 VAST
    - Include recommendations from PT review

Questions?