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Ecosystem & Socioeconomic Profile

Eastern Bering Sea Tanner Crab

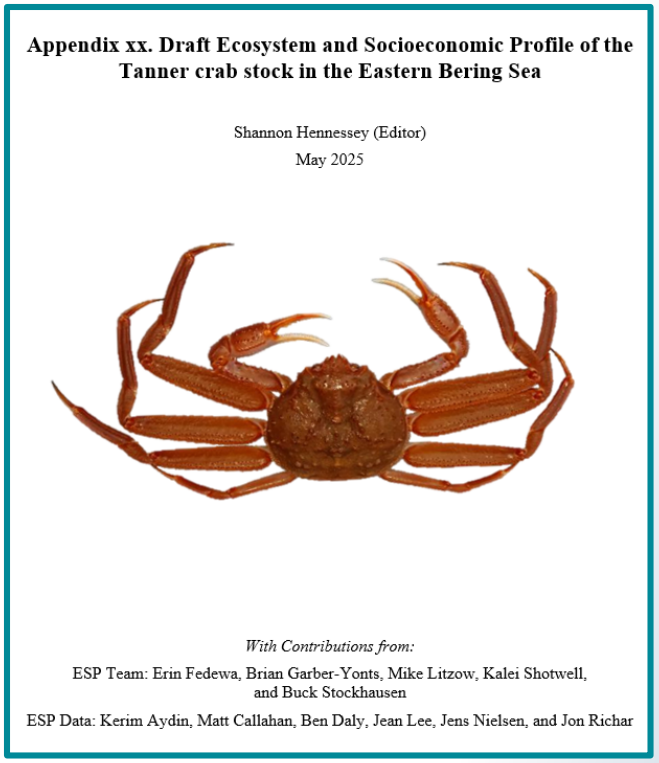
Shannon Hennessey and Brian Garber-Yonts

May 2025

ESP Contributors: Erin Fedewa, Mike Litzow, Kalei Shotwell, Buck Stockhausen, Kerim Aydin, Matt Callahan, Ben Daly, Jean Lee, Jens Nielsen, and Jon Richar

Overview

- May 2025: Draft ESP
  - Introduction
    - Justification, data sources
  - Indicator synthesis
    - Ecosystem processes
  - Indicator assessment
    - Ecosystem indicators
  - Indicator monitoring analysis
    - Traffic light trends
    - Importance analyses



Appendix xx. Draft Ecosystem and Socioeconomic Profile of the Tanner crab stock in the Eastern Bering Sea

Shannon Hennessey (Editor)

May 2025

With Contributions from:

ESP Team: Erin Fedewa, Brian Garber-Yonts, Mike Litzow, Kalei Shotwell, and Buck Stockhausen

ESP Data: Kerim Aydin, Matt Callahan, Ben Daly, Jean Lee, Jens Nielsen, and Jon Richar

- September 2025: Full ESP
  - Updates and current year indicators
  - Socioeconomic indicator synthesis and assessment

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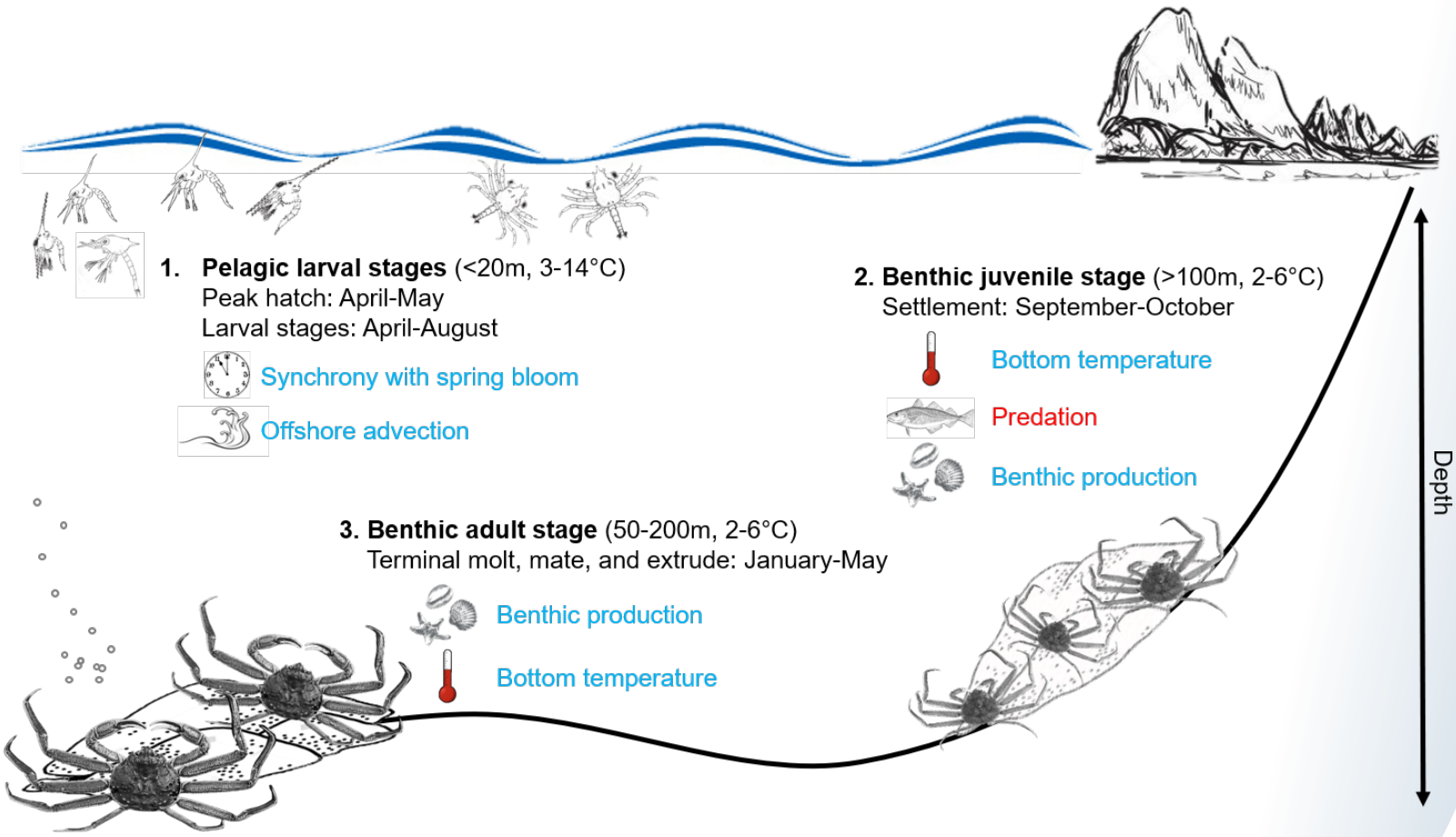
Ecosystem Processes



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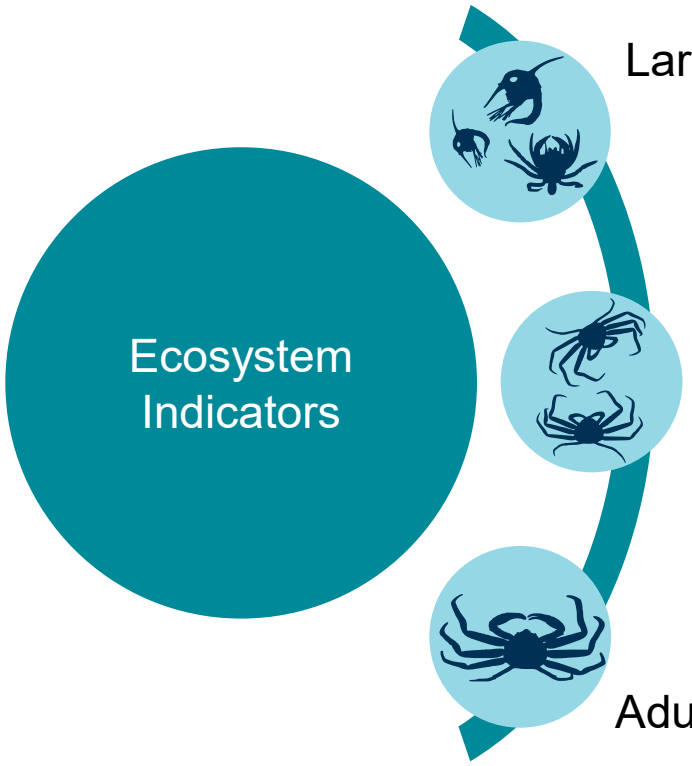
Ecosystem Indicators



Larval

- − Aleutian Low – Beaufort Sea Anticyclone
- + Surface Temperature

Juvenile

- + Chlorophyll-*a* Concentration
- + Juvenile Temperature of Occupancy
- − Benthic Predator Density
- − Pacific Cod Consumption
- − Juvenile Disease Prevalence
- + Benthic Invertebrate Density

Adult

- + Male Size at 50% Terminal Molt
- + Mature Male Area Occupied
- n/a Mature Male Center of Abundance
- + Female Mean Size at Terminal Molt
- + Female Reproductive Potential

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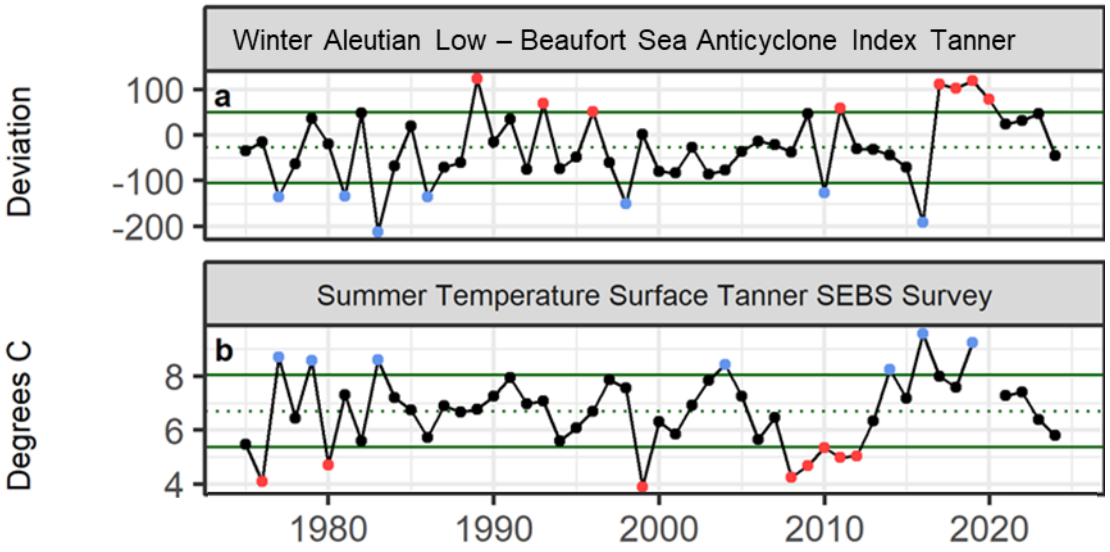
Larval Indicators



Weakening of the ALBSA and declining surface temperatures indicate potential shift towards less favorable larval conditions

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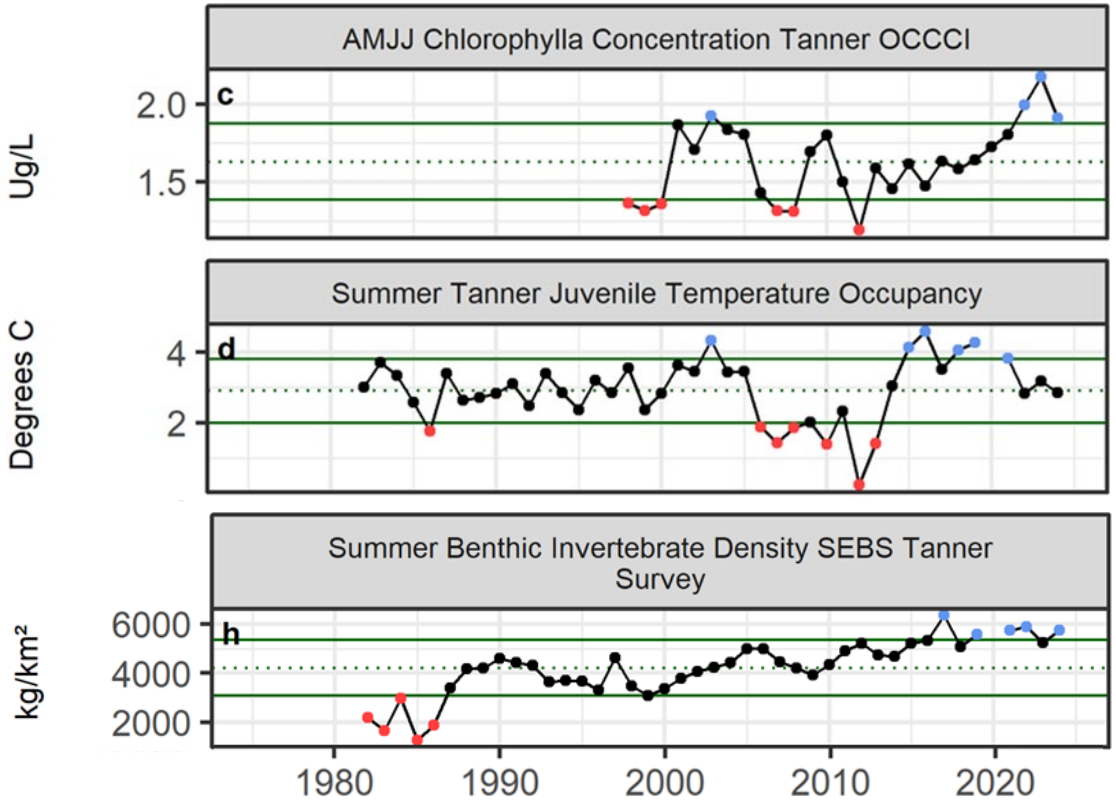
Juvenile Indicators



High chlorophyll-a and benthic invertebrate densities, and average occupancy temperatures, indicate favorable juvenile metabolic conditions

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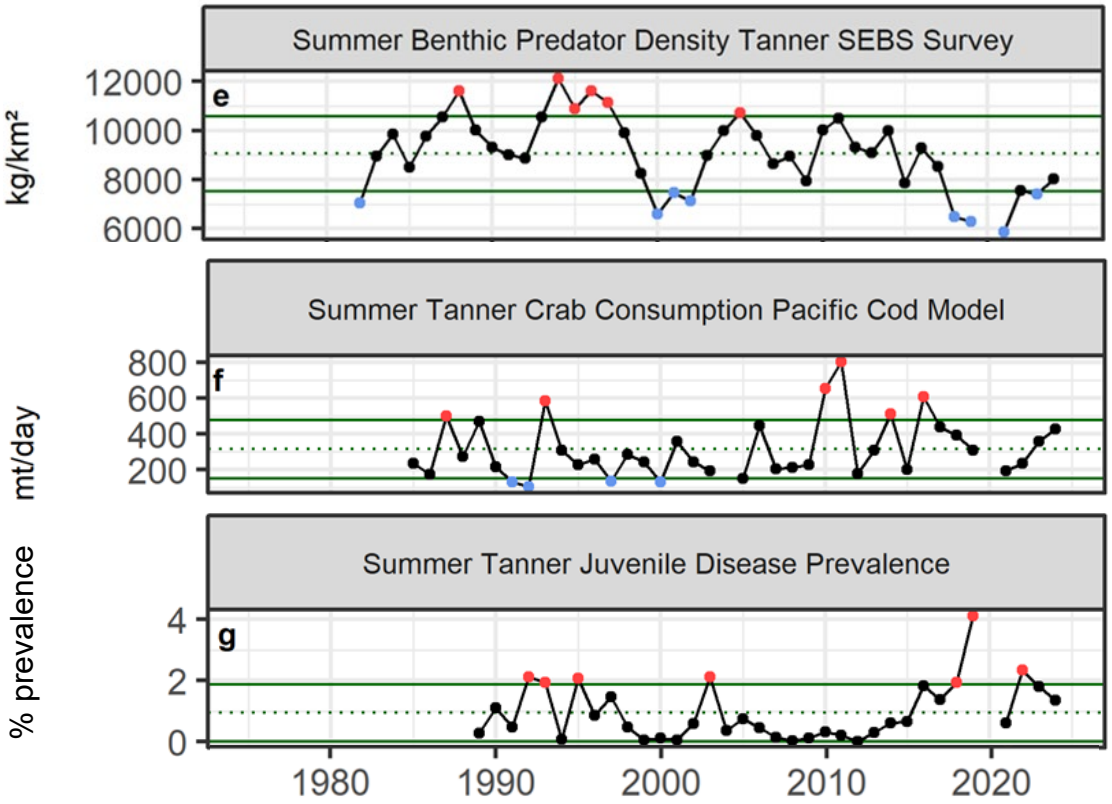
Juvenile Indicators



Increases in predator density and Pacific cod consumption may reflect increased top-down pressure, but coincide with increased recruitment

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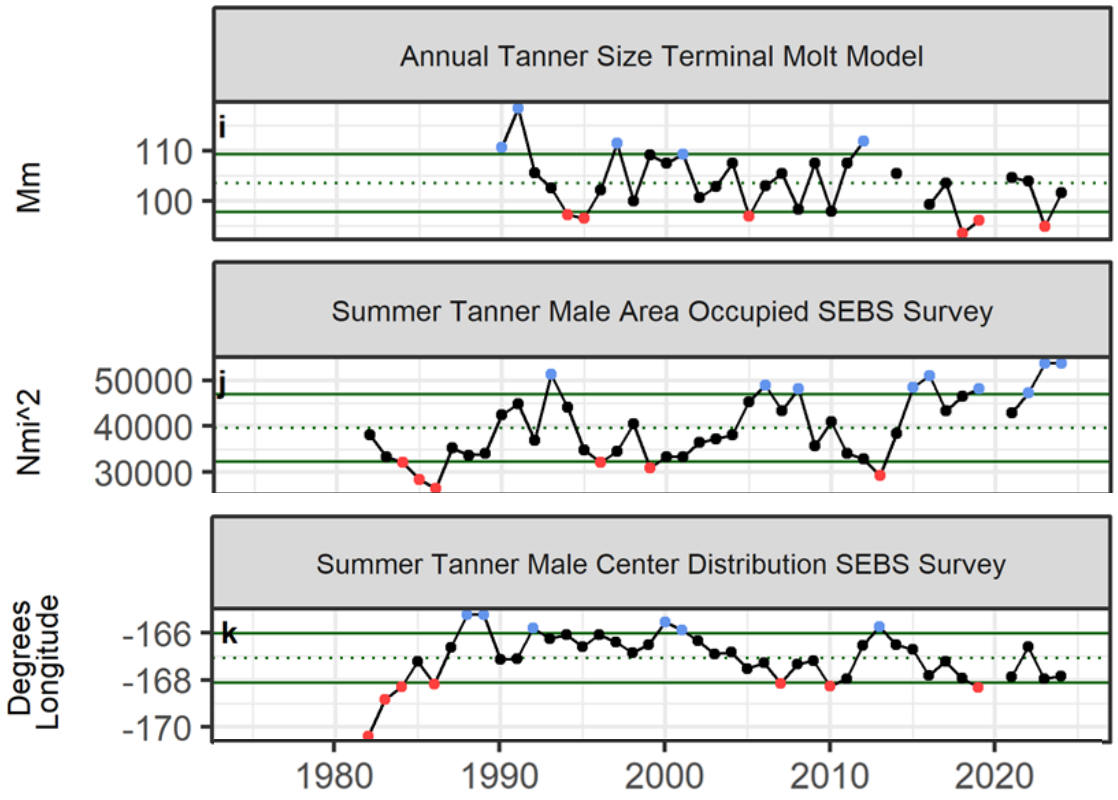
Adult Indicators



All-time high spatial extent of large males coincides with increased stock abundance in 2024, as well as declines in male size at terminal molt. The stock center of distribution has shifted slightly northwest in recent years

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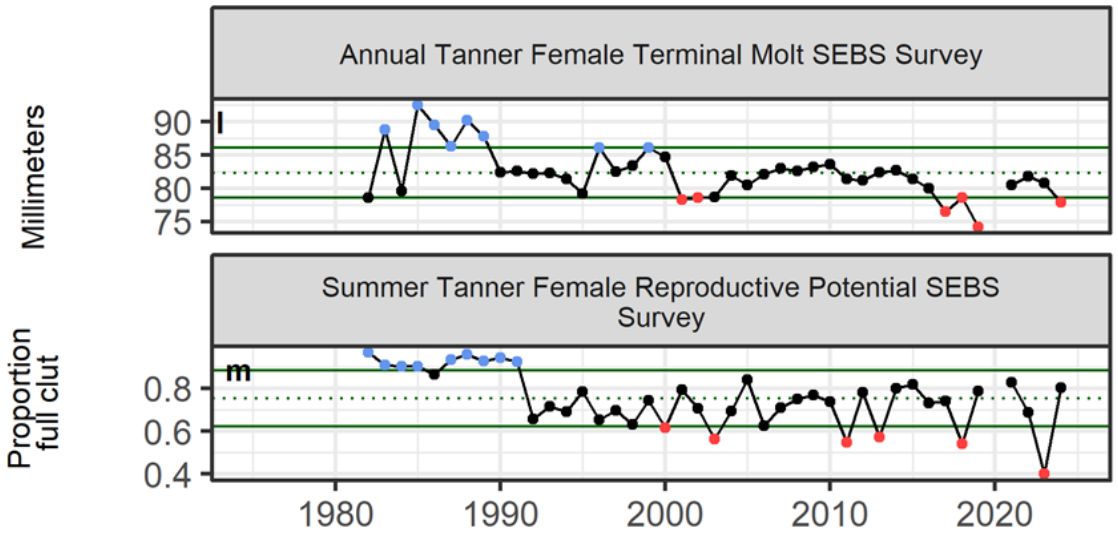
Adult Indicators



Declines in female size at maturity, coupled with increased variation in female reproductive potential, could signify decreased reproductive output. However, recruitment has remained high

Ecosystem Traffic Light Table

Indicator category	Indicator	2020 Status	2021 Status	2022 Status	2023 Status	2024 Status
Larval	* Winter Spring Aleutian Low - Beaufort Sea Anticyclone - Model	**high**	neutral	neutral	neutral	neutral
	Summer Surface Temperature - SEBS Survey	NA	neutral	neutral	neutral	neutral
Juvenile	* Chlorophyll-*a* Concentration SEBS - Satellite	neutral	neutral	*high*	*high*	*high*
	* Juvenile Tanner Crab Occupancy Temperature - SEBS Survey	NA	*high*	neutral	neutral	neutral
	Summer Benthic Predator Density - SEBS Survey	NA	*low*	neutral	*low*	neutral
	* Summer Pacific Cod Consumption	NA	neutral	neutral	neutral	neutral
	* Summer Juvenile Tanner Crab Disease Prevalence - SEBS Survey	NA	neutral	**high**	neutral	neutral
	Summer Benthic Invertebrate Density - SEBS Survey	NA	*high*	*high*	neutral	*high*
Adult	Male Tanner Crab Size at Terminal Molt - Model	NA	neutral	neutral	**low**	neutral
	Summer Male Tanner Crab Area Occupied - SEBS Survey	NA	neutral	*high*	*high*	*high*
	Summer Male Tanner Crab Center of Distribution - SEBS Survey	NA	neutral	neutral	neutral	neutral
	Female Tanner Crab Size at Maturity - SEBS Survey	NA	neutral	neutral	neutral	**low**
	Female Tanner Crab Reproductive Potential - SEBS Survey	NA	neutral	neutral	**low**	neutral

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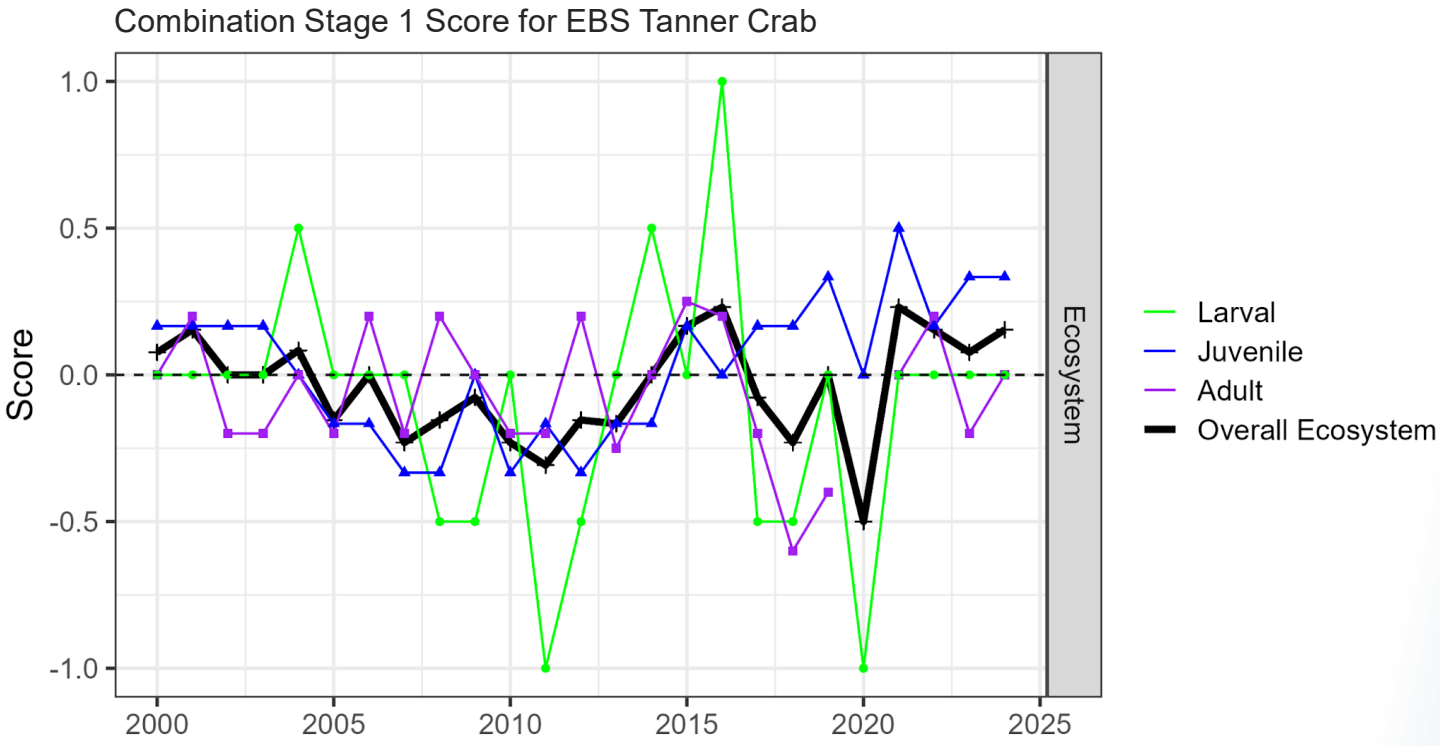
Indicator Analysis: Traffic Light Score



The overall ecosystem score has remained above average since 2021. Larval and juvenile indicators did not change from the previous year, while the adult indicators increased from below average to average

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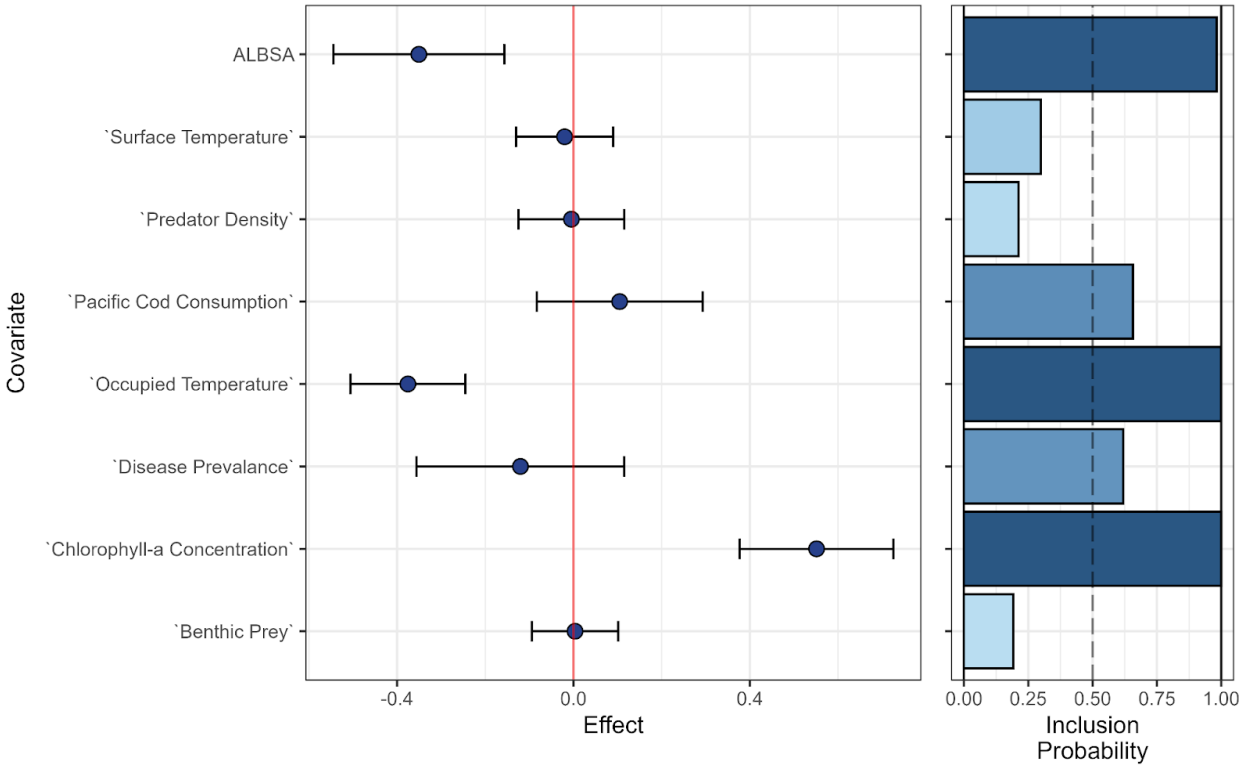
Indicator Analysis: BAS Indicator Importance



Five indicators had strong inclusion probabilities. ALBSA, juvenile temperature occupied, and chlorophyll-a concentration also had directional effects on recruitment that were distinguishable from zero

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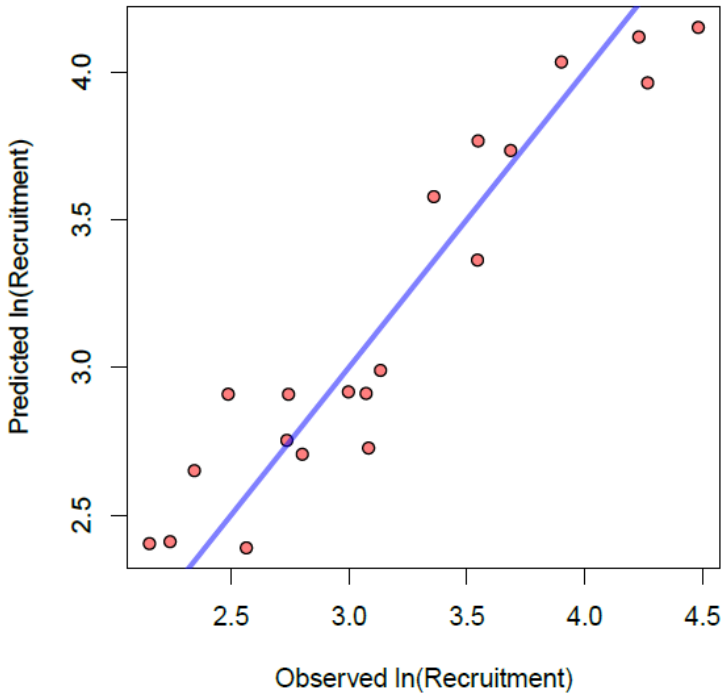
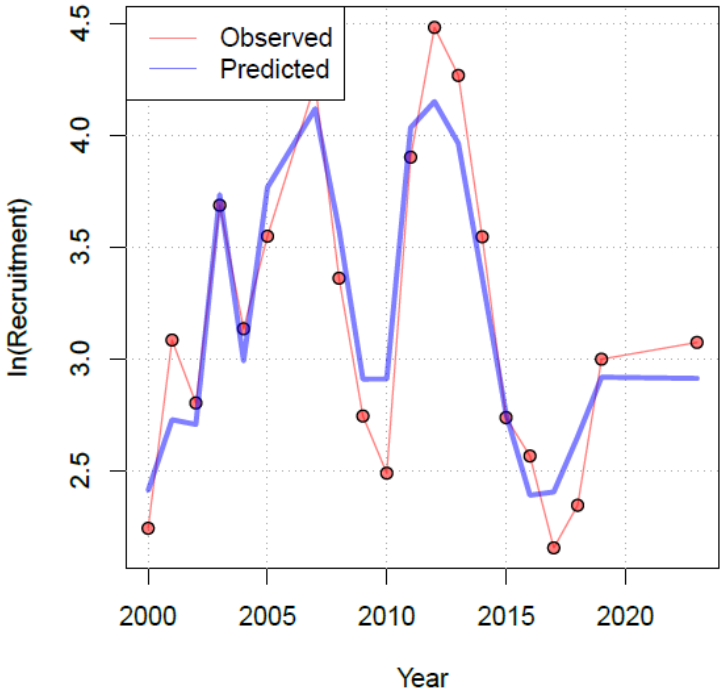
Indicator Analysis: BAS Indicator Importance





The model explained a large amount of variation in “pre-recruits” (70-85mm males) from survey estimates

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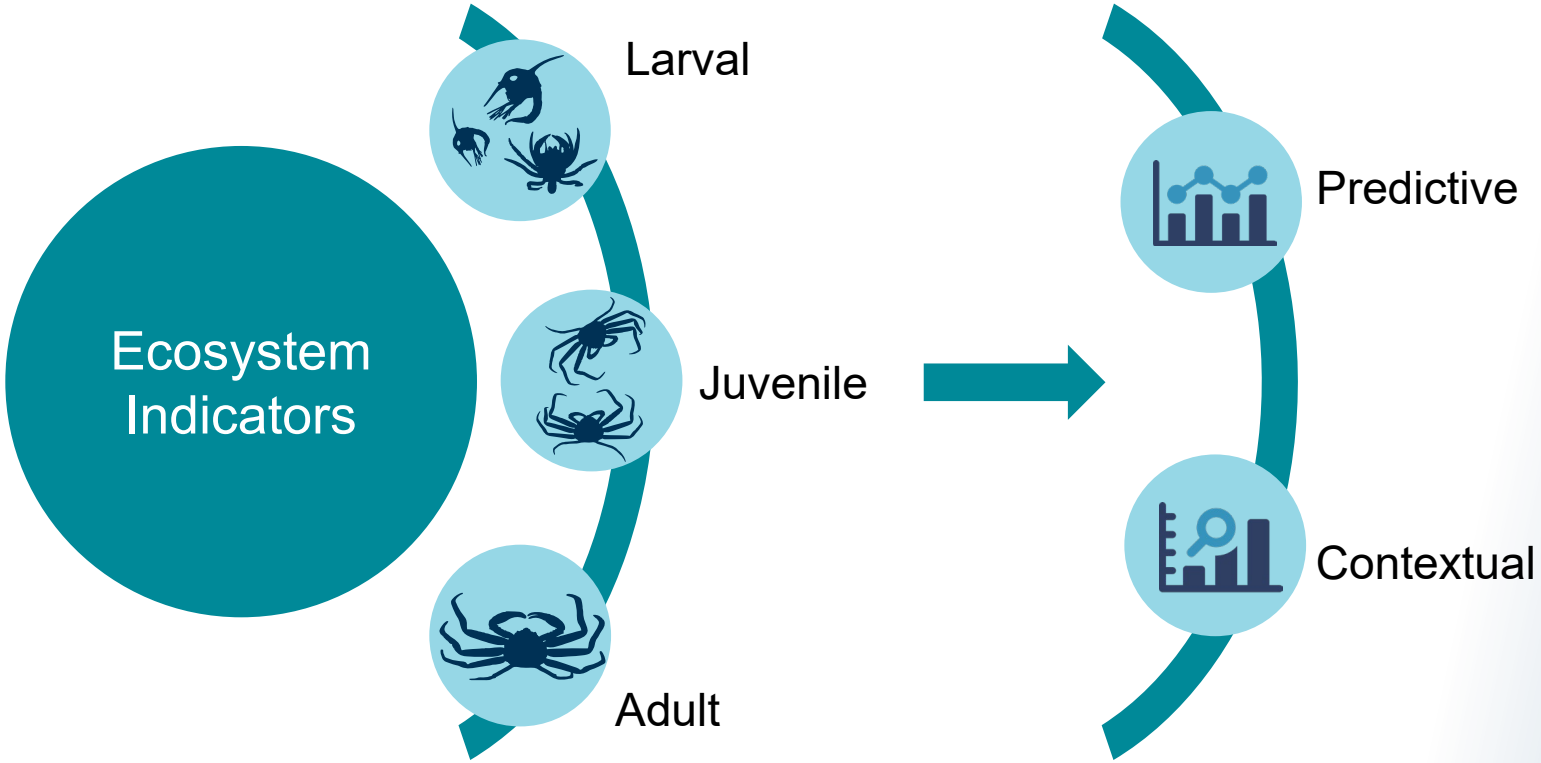
Reframing: Ecosystem Indicators



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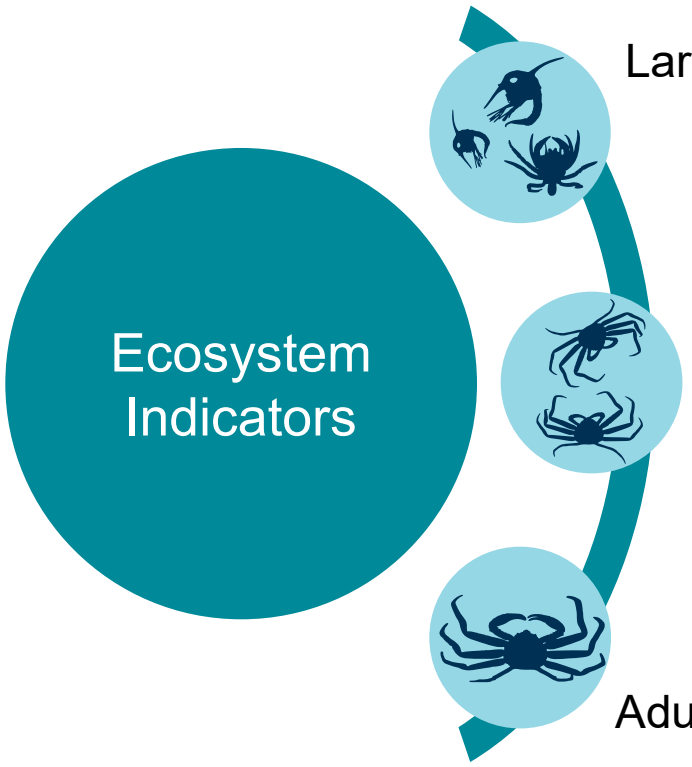
Reframing: Ecosystem Indicators



Larval

- **Aleutian Low – Beaufort Sea Anticyclone**
+ Surface Temperature

Juvenile

+ **Chlorophyll-*a* Concentration**
+ **Juvenile Temperature of Occupancy**
- Benthic Predator Density
- **Pacific Cod Consumption**
- **Juvenile Disease Prevalence**
+ Benthic Invertebrate Density

Adult

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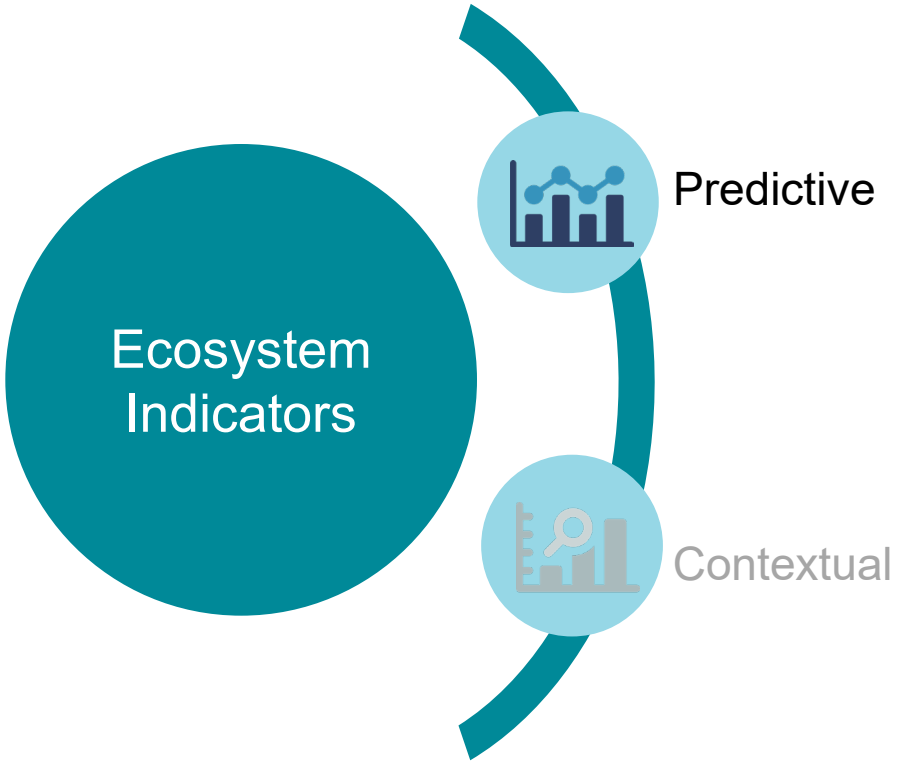
Reframing: Ecosystem Indicators



- Aleutian Low – Beaufort Sea Anticyclone
+ Chlorophyll-*a* Concentration
+ Juvenile Temperature of Occupancy
- Pacific Cod Consumption
- Juvenile Disease Prevalence

Predictive Indicator Evaluation Criteria

- Quantitative, demonstrated relationship with population processes – i.e. recruitment & mortality
  - Evaluated via indicator importance scores, out-of-sample predictive skill, etc.

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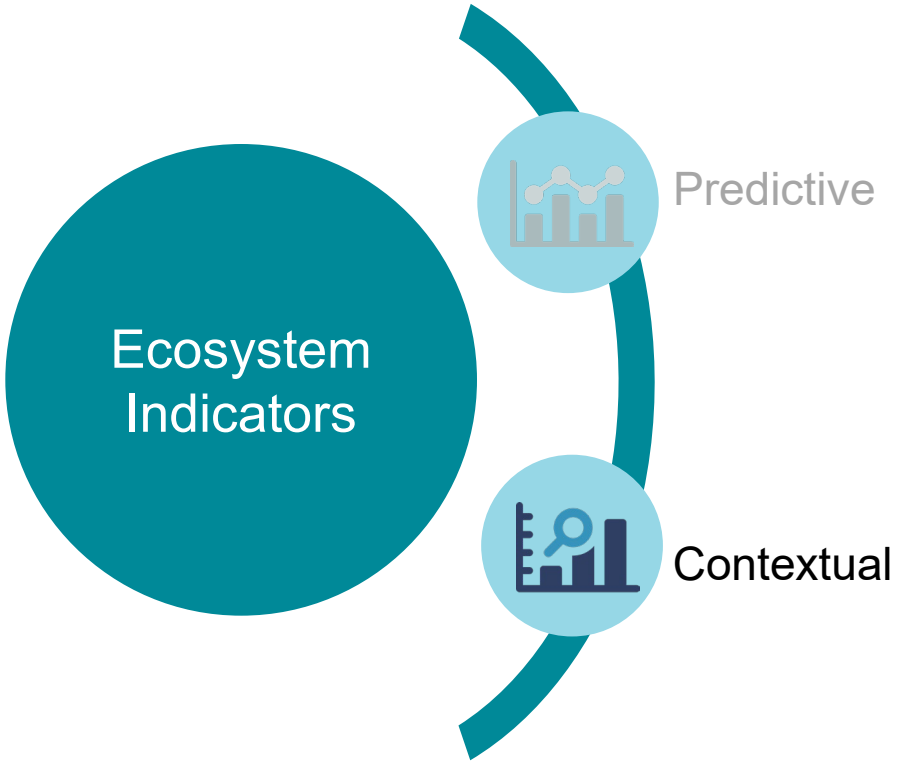
Reframing: Ecosystem Indicators



Contextual Indicator Evaluation Criteria

- Potential red flags related to MMB, but not quantitative driver of recruitment
- Anticipatory information or direct measure of status/health of large immature “pre-recruits” or spawning biomass
- Contextual information for management concern or risk table category

+ Male Size at 50% Terminal Molt
+ Mature Male Area Occupied
n/a Mature Male Center of Abundance
+ Female Mean Size at Terminal Molt
+ Female Reproductive Potential

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Reframing: Ecosystem Indicators

Predictive

- − Aleutian Low – Beaufort Sea Anticyclone
- + Chlorophyll-*a* Concentration
- + Juvenile Temperature of Occupancy
- − Pacific Cod Consumption
- − Juvenile Disease Prevalence

Contextual

- + Male Size at 50% Terminal Molt
- + Mature Male Area Occupied
- n/a Mature Male Center of Abundance
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- + Surface Temperature
- − Benthic Predator Density
- + Benthic Invertebrate Density

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Next Steps

- Refine / develop ecosystem indicators
  - ALBSA → Aleutian Low
  - NE wind stress
  - Juvenile cohort progression
  - Stock spatial patchiness
  - Tanner / snow crab overlap
- Resolving E166/W166 for spatial ecosystem indicators
  - Potential implications for differences in size/maturity
  - Relevance to fishery
- Ecosystem indicator importance
  - Refine BAS model approach – indicator inclusion and lags
  - Dynamic Structural Equation Models
- Reframing ecosystem indicators: predictive vs. contextual

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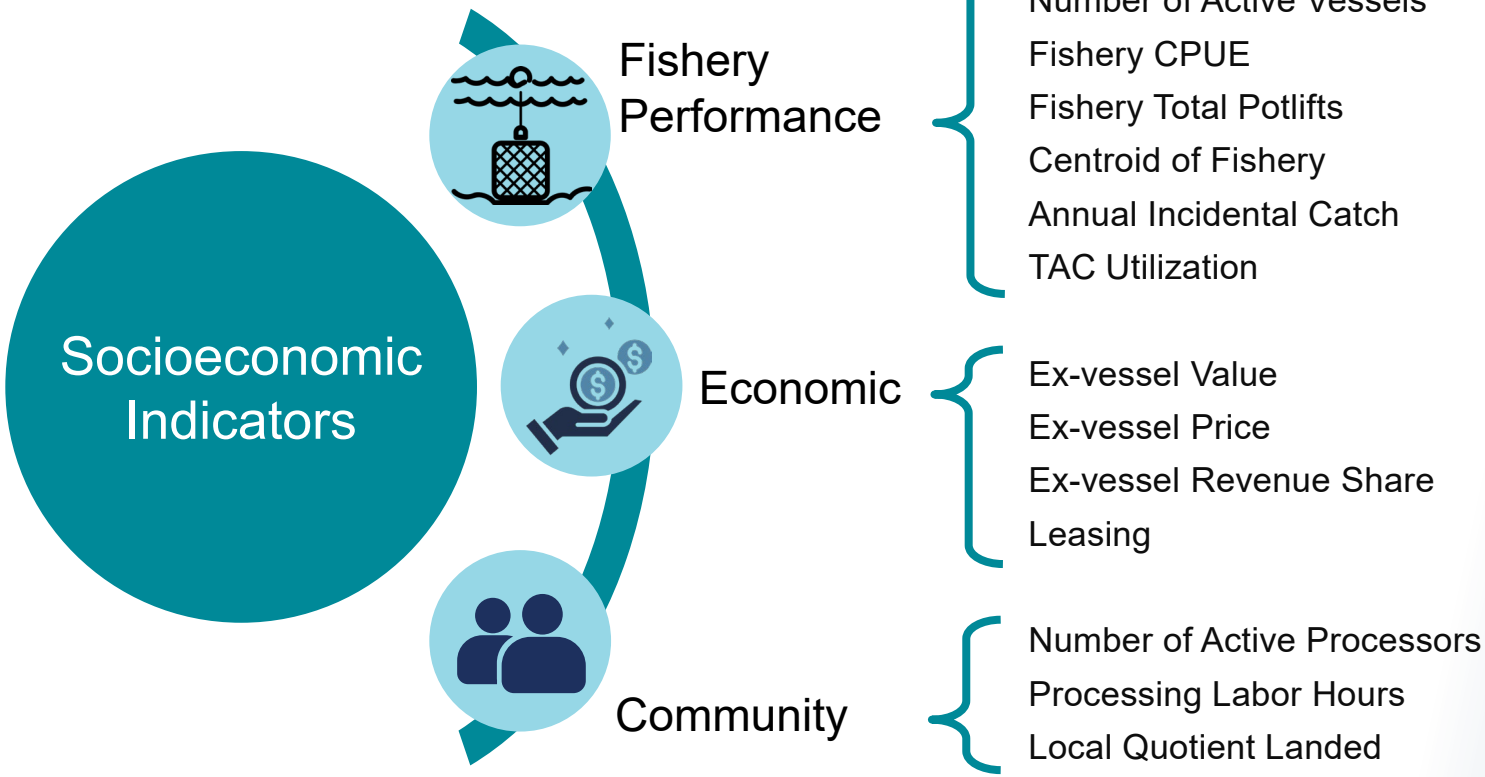
Socioeconomic Indicators



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Questions?

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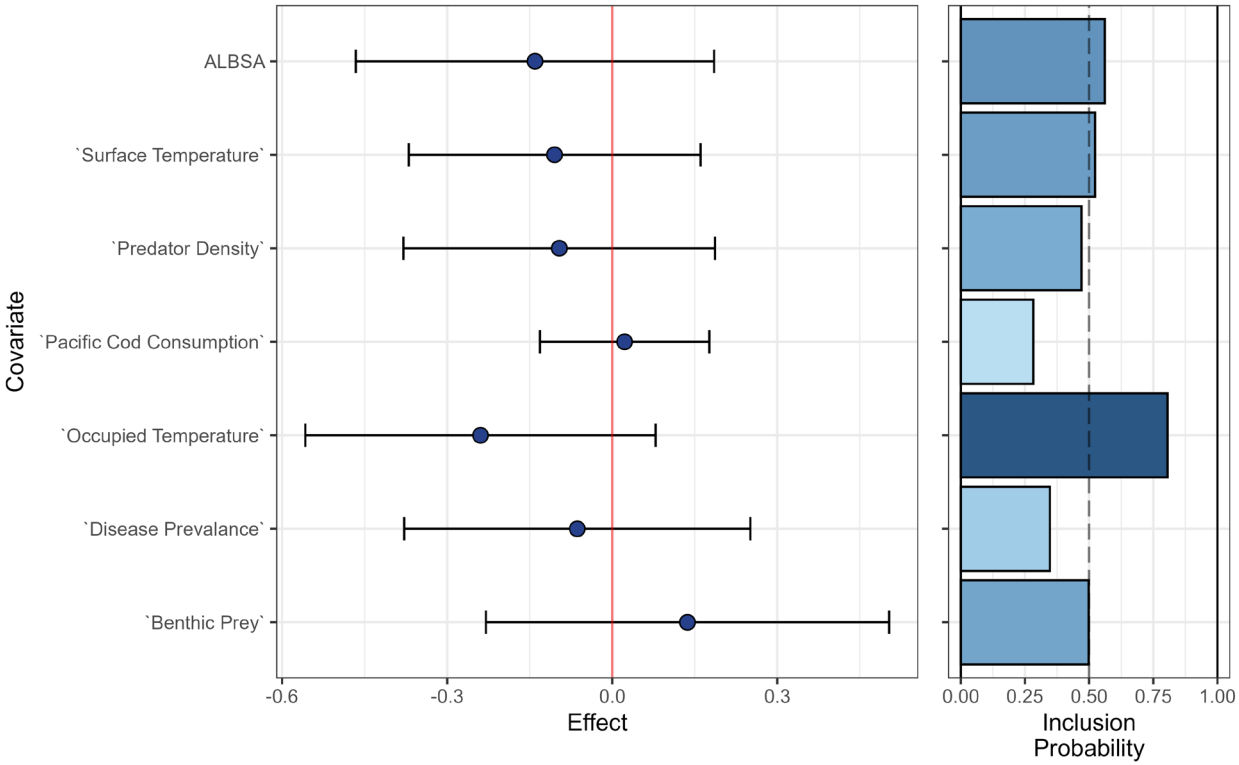
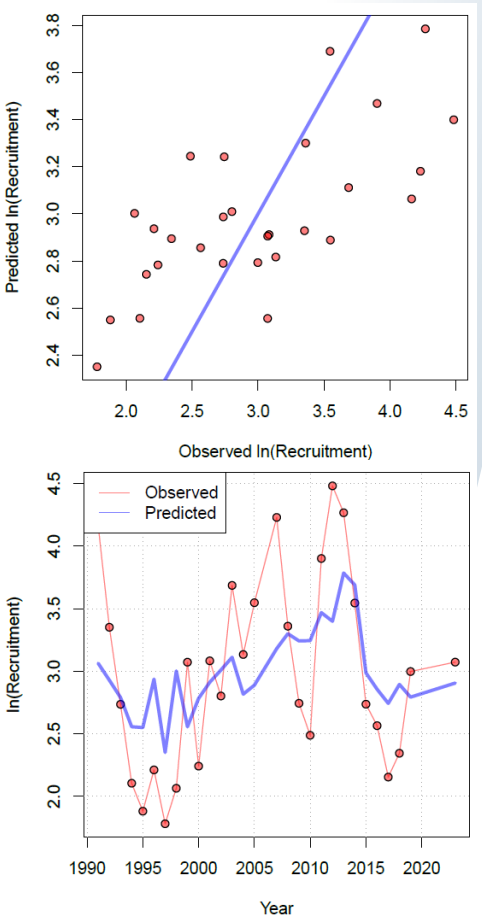
Indicator Analysis: BAS Indicator Importance

BAS model: longer time series, no chlorophyll-a





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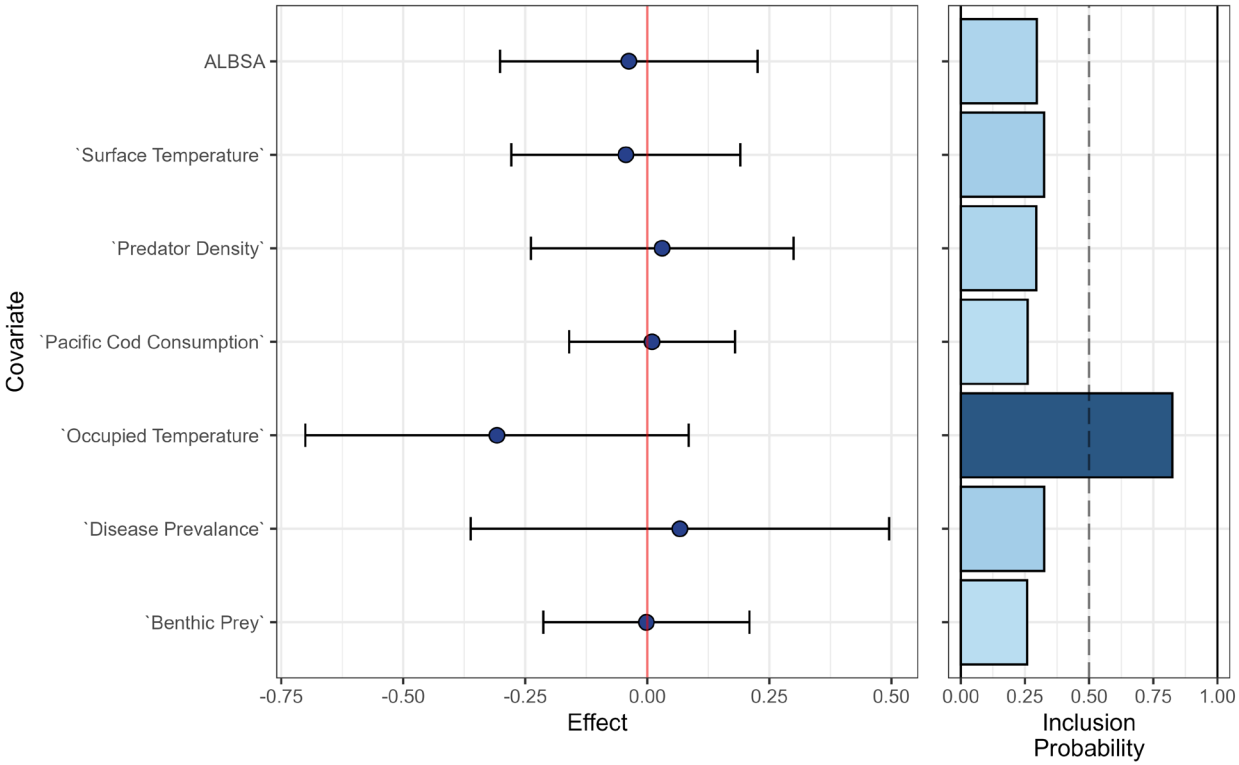
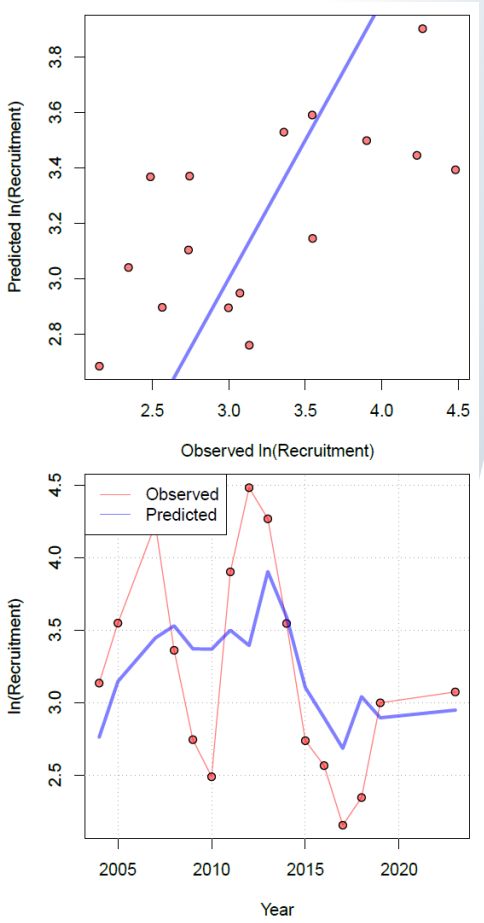
Indicator Analysis: BAS Indicator Importance

BAS model: truncated time series, no chlorophyll-a





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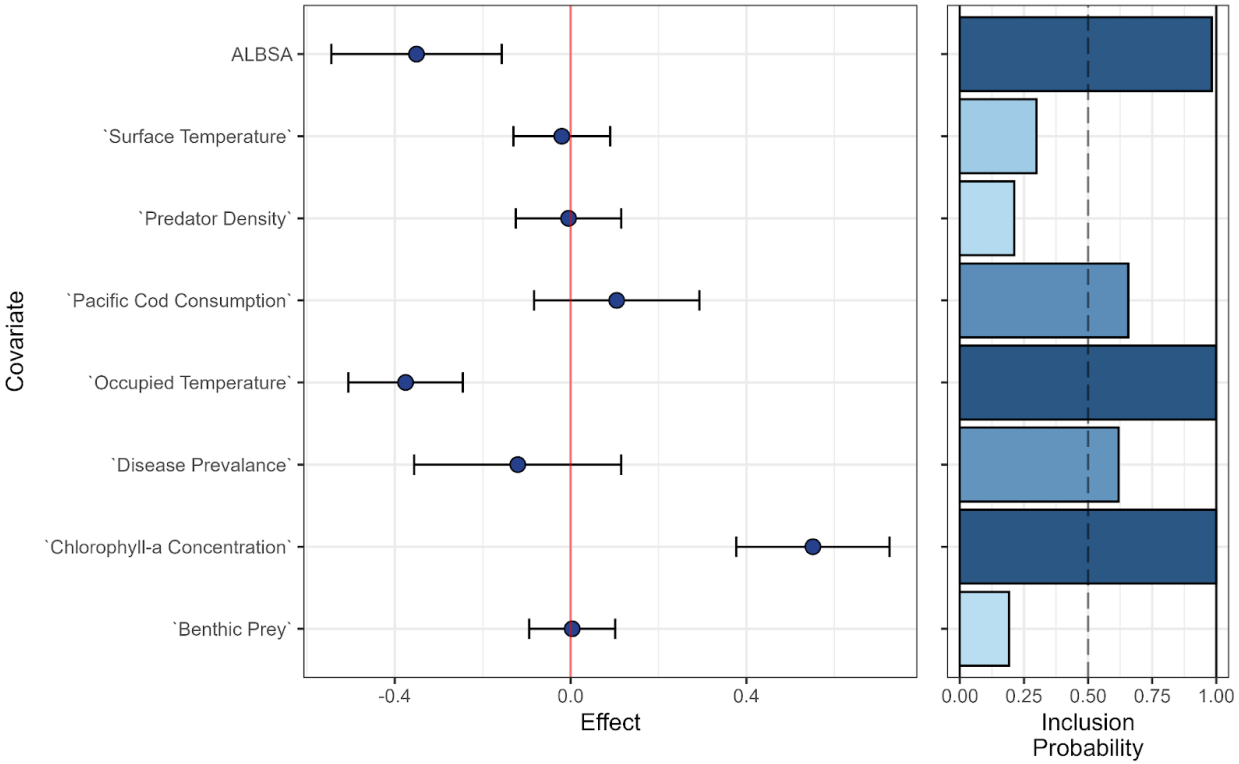
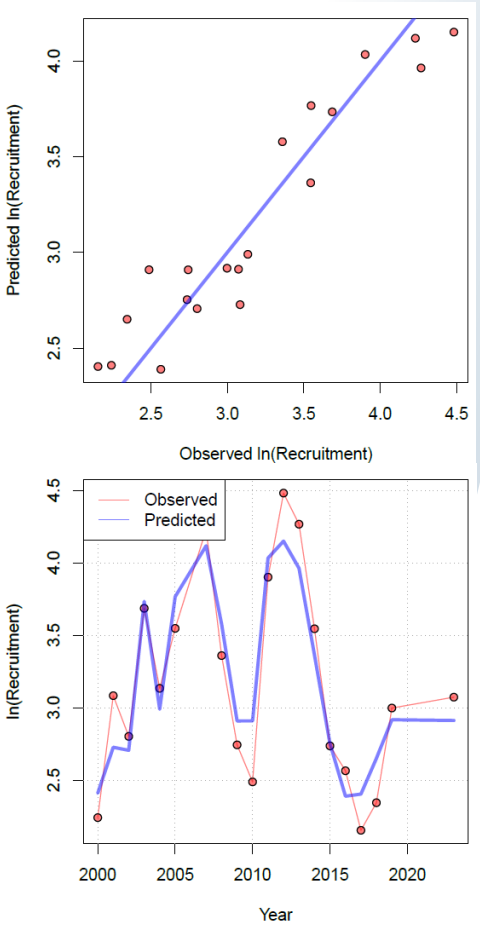
Indicator Analysis: BAS Indicator Importance

Current BAS model





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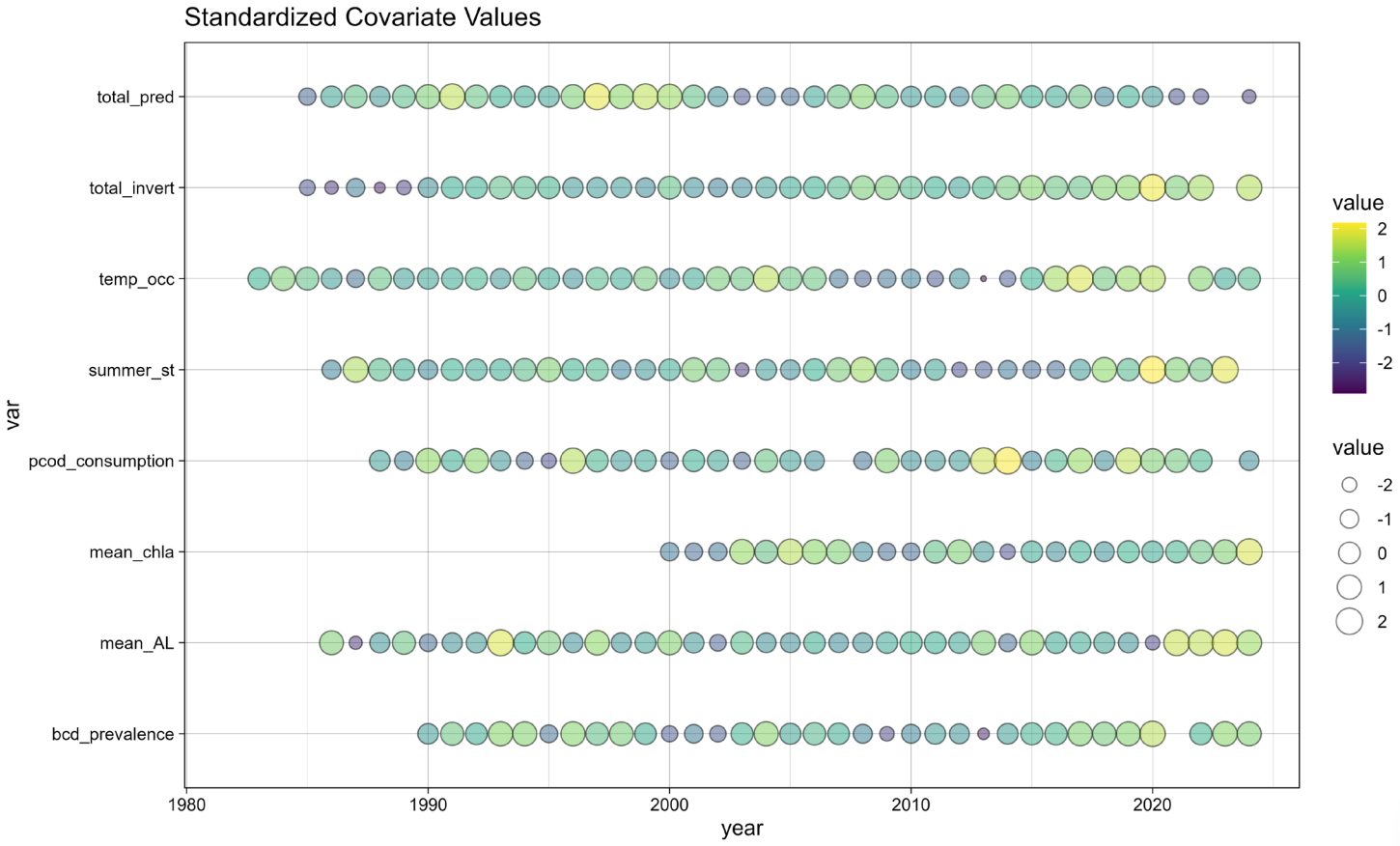

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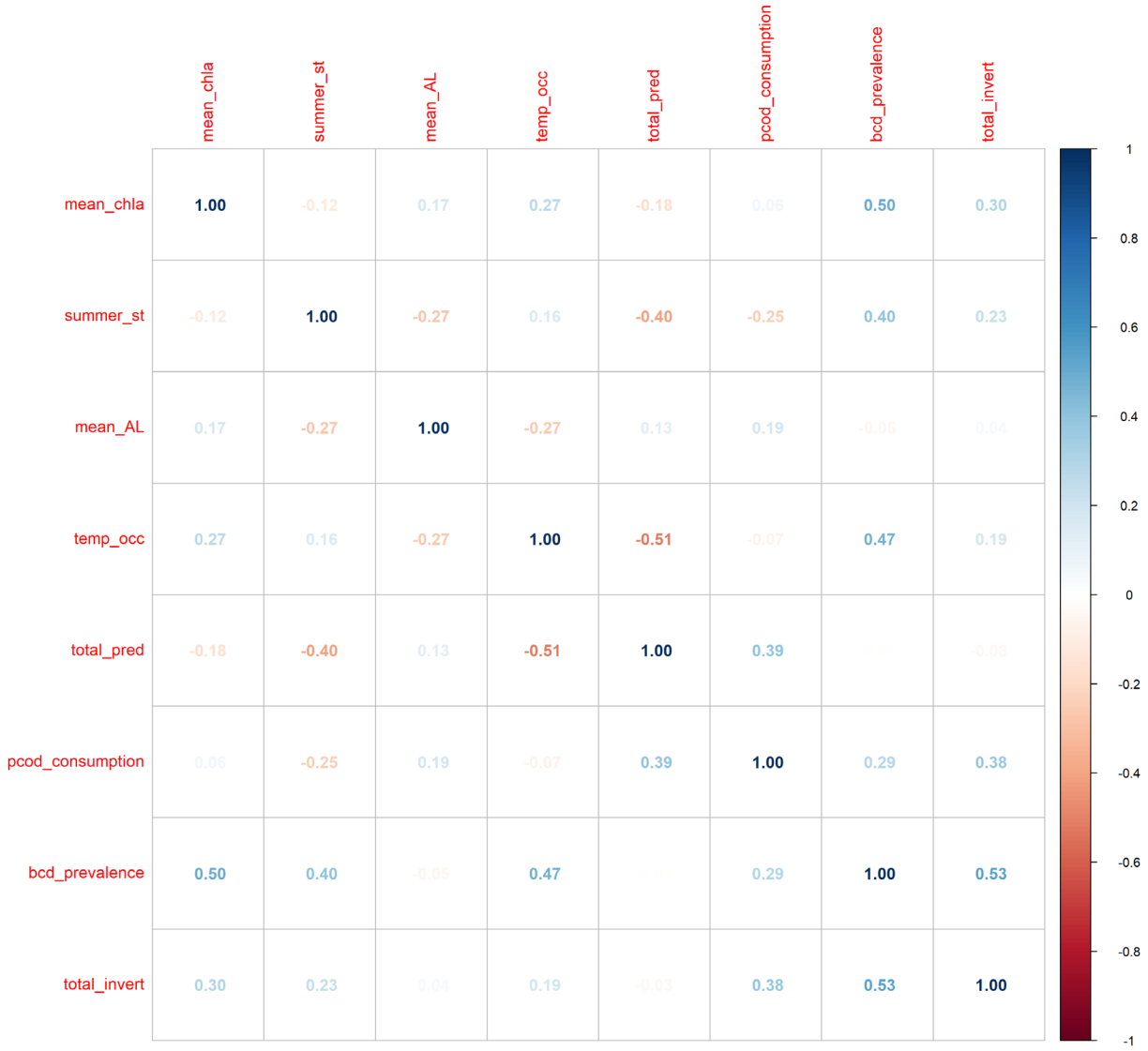
Indicator Analysis: BAS Indicator Importance



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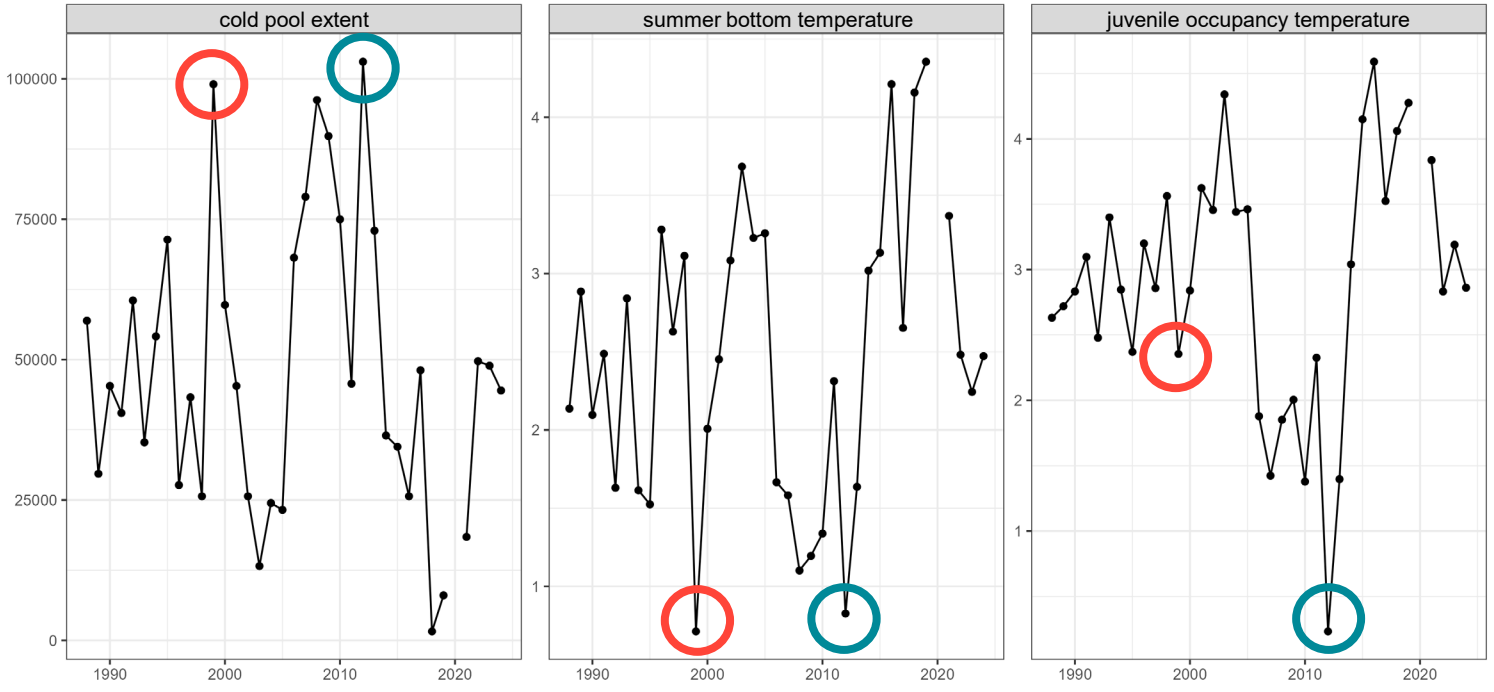
Juvenile Temperature

Bottom temperature, cold pool extent, juvenile occupancy temperature
→ highly correlated



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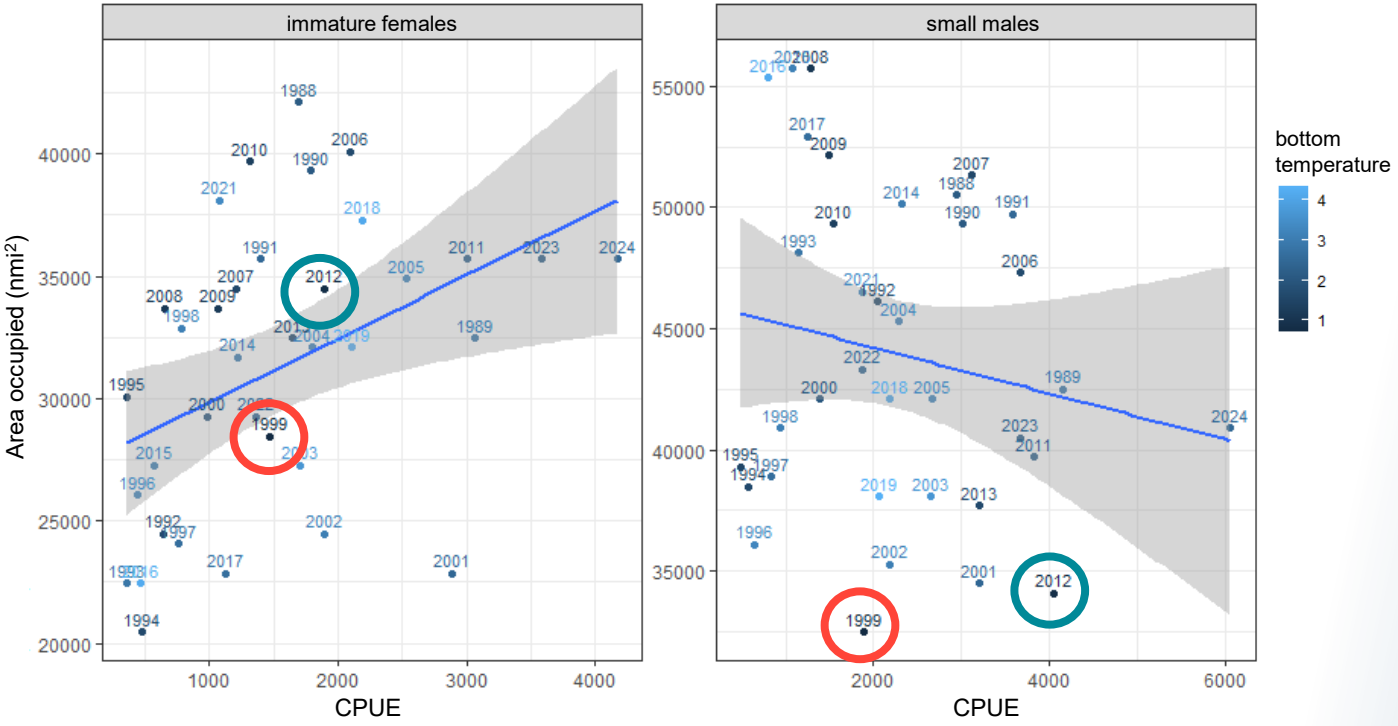
Juvenile Temperature

Bottom temperature, cold pool extent, juvenile occupancy temperature → highly correlated

- 2012 small male density ~2x 1999 density, similar area occupied



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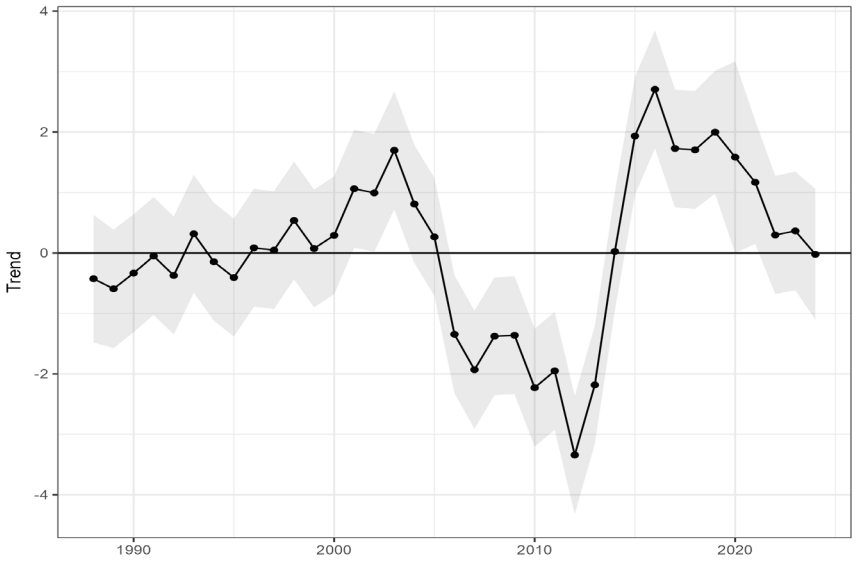
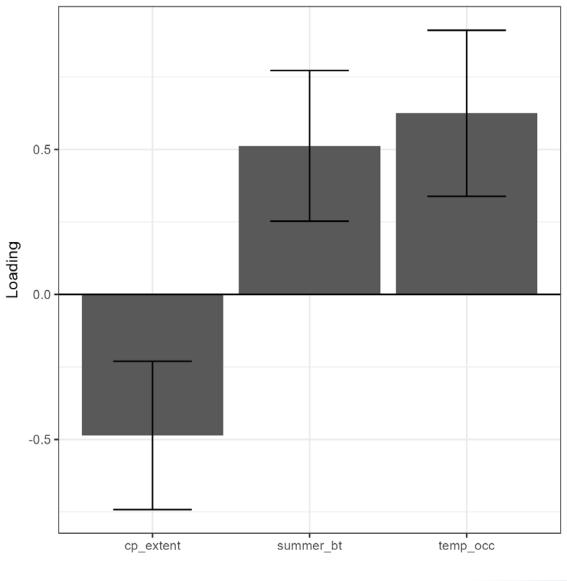
Juvenile Temperature

Bottom temperature, cold pool extent, juvenile occupancy temperature → highly correlated

- Dynamic factor analysis – trend similar to occupancy temperature
- Reduced interpretability as indicator





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