SEDAR 87 : Gulf of America Brown, White, and Pink Shrimp Benchmark Assessments

Gulf Fisheries Branch

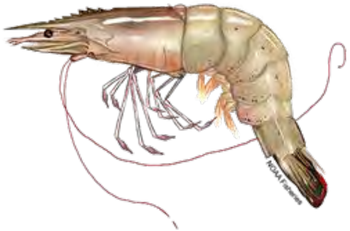
NOAA SEFSC

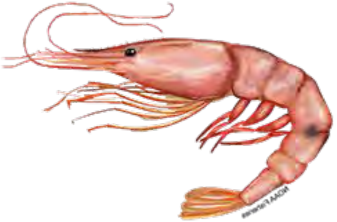
SSC Presentation

Tampa, FL February 24 2026

Presentation Outline*

- Data Inputs
- Brown Shrimp
  - VAST index methodology, results and discussion
  - JABBA methodology, results and discussion
  - EDM methodology, results and discussion
- White Shrimp
  - VAST index results and discussion
  - JABBA results and discussion
  - EDM results and discussion
- Pink Shrimp
  - VAST index results and discussion
  - JABBA results and discussion
  - EDM results and discussion
- Management Benchmark Comparison
- Conclusions and Recommendations





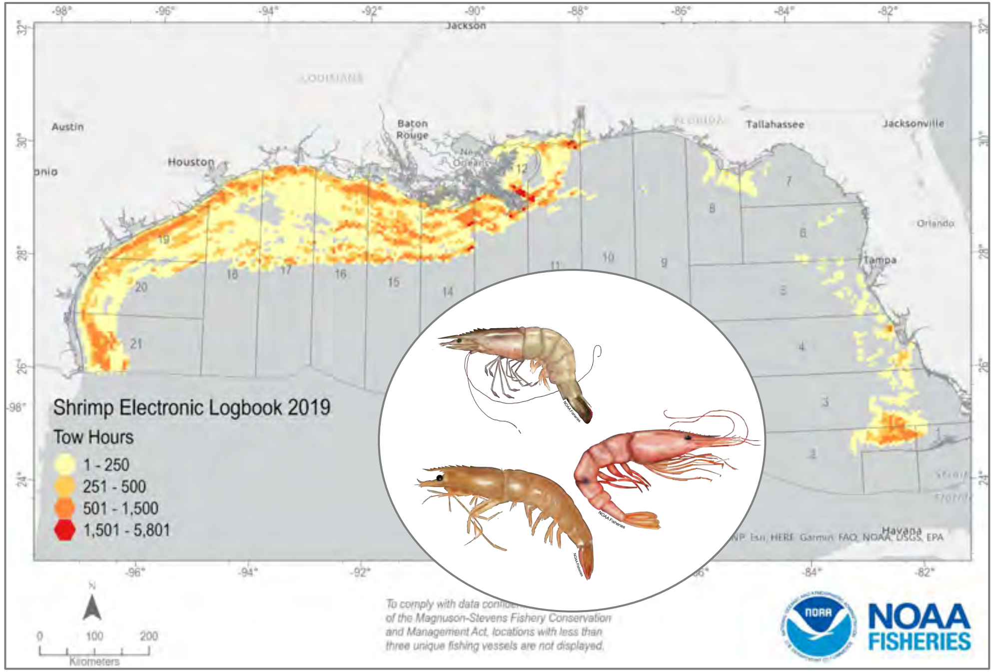
*Reviewer and Stakeholder Concerns and Recommendations addressed throughout presentation

Benchmark Assessment

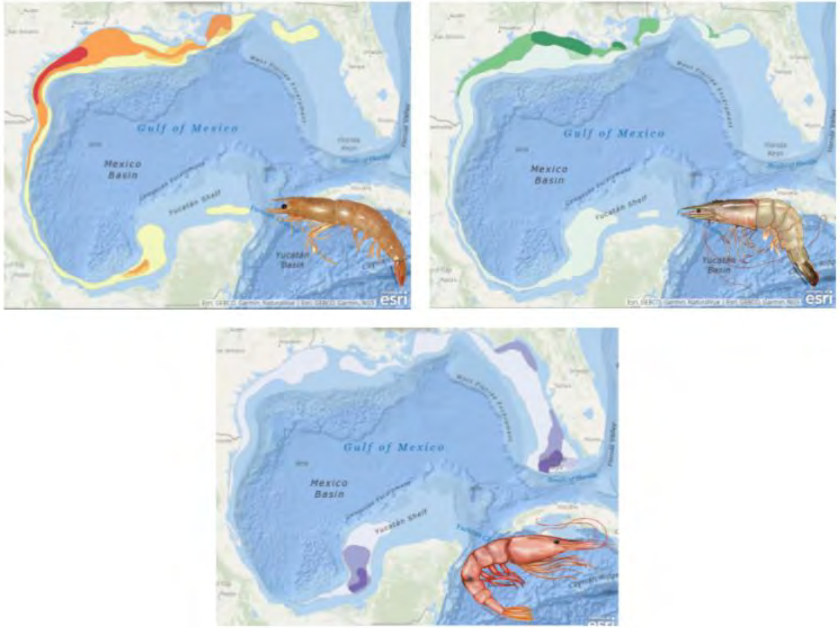
- Opportunity to explore and test alternative stock assessment models
  - **JABBA** : **J**ust **A**nother **B**ayesian **B**iomass **A**ssessment
  - **EDM**: **E**mpirical **D**ynamic **M**odeling
  - **VAST**: **V**ector **A**utoregressive **S**patio-**T**emporal Model *(Index Standardization)*

- Assessment models with simplified dynamics
- Short-lived species (1-2 years) where growth and recruitment are believed to be largely environmentally driven

The Fishery

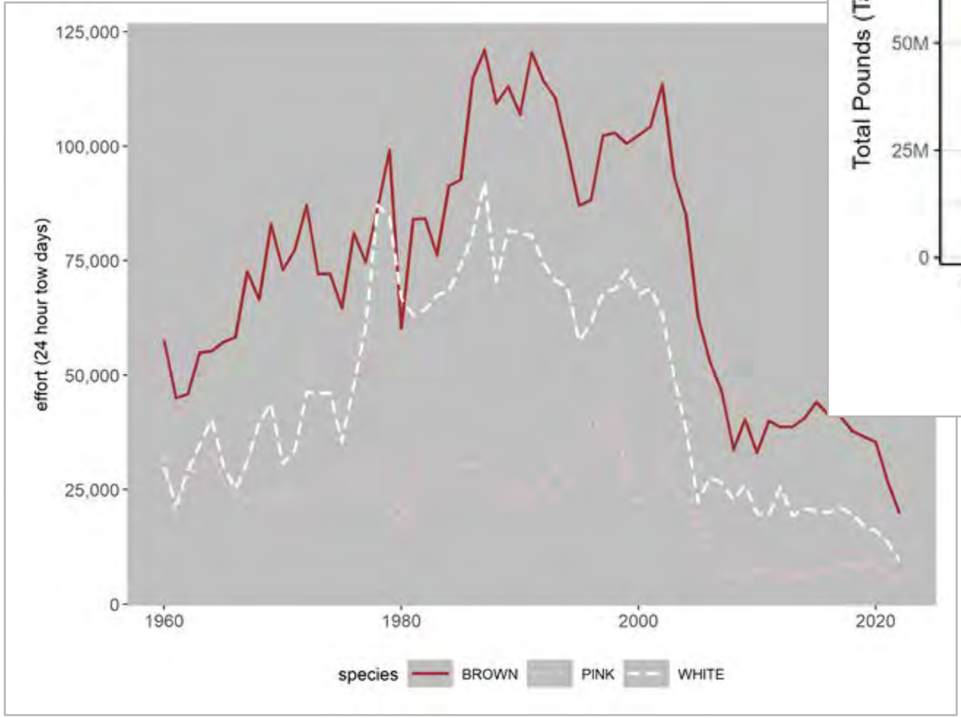


SEDAR87-DW-16

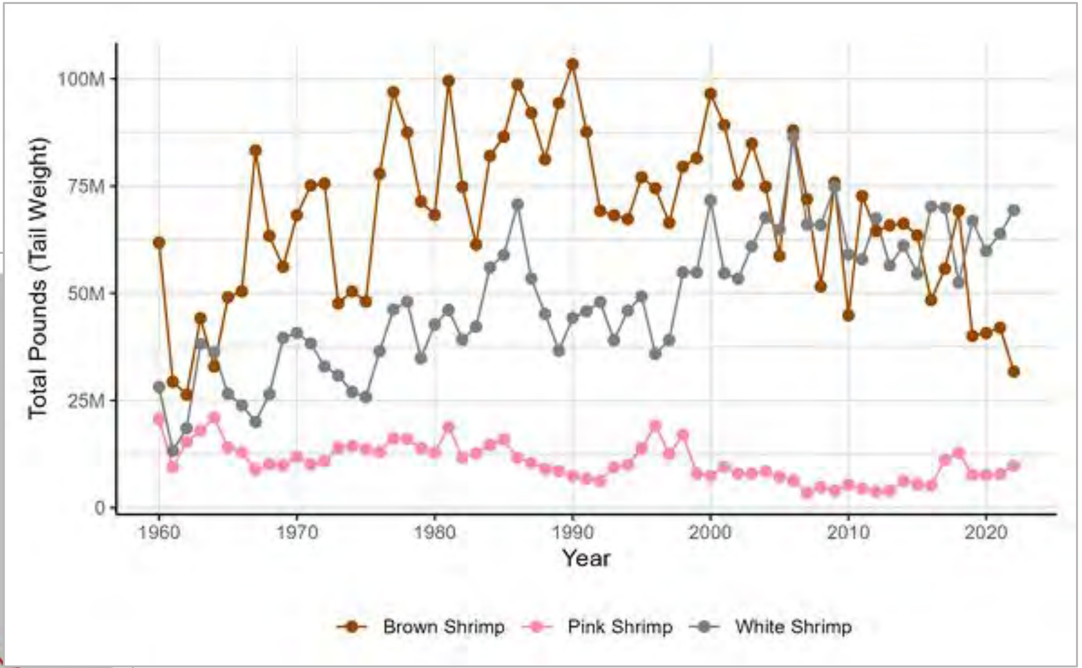


SEDAR87 DW Report, Figure 3.2

The Fishery



SEDAR87-DW-01



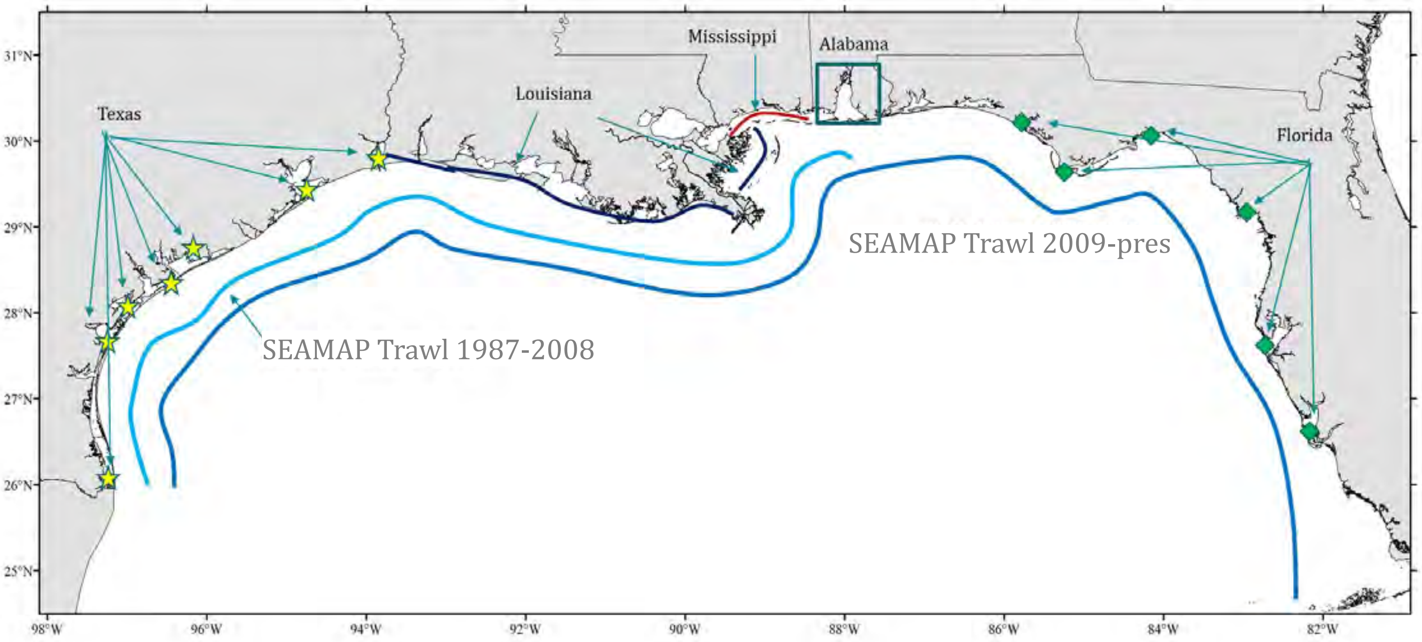
SEDAR87-DW-06

Feedback from Stakeholders Addressed During Process

Why not make use of fishery dependent data for developing the indices given longer time series?

- If FD CPUE data are to be useful they must be weighted by area (not by directed effort as has been done in the past) and the impact of any other variable that impacts catch rates (other than abundance) must be removed through standardization (e.g. time of day, depth, location)
- For shrimp, there is no information on time of day, gear efficiency, depth or precise location associated with the FD CPUE data to properly carry out the standardization process
- Inability to link landings with effort at individual vessel level (e.g. subset of fleet with more precise effort and location information)

Fishery Independent Surveys



man.com/

Fishery Independent Surveys

- SEAMAP (state/federal) – **BSH / PSH**
  - 42 foot otter trawl
- Texas Parks and Wildlife (TPWD)
  - Gulf 20 foot otter trawl (1987) – **BSH VAST Model Only**
- Louisiana Wildlife and Fisheries (LDWF) – **WSH**
  - 16 foot otter trawl (1980)

BROWN SHRIMP

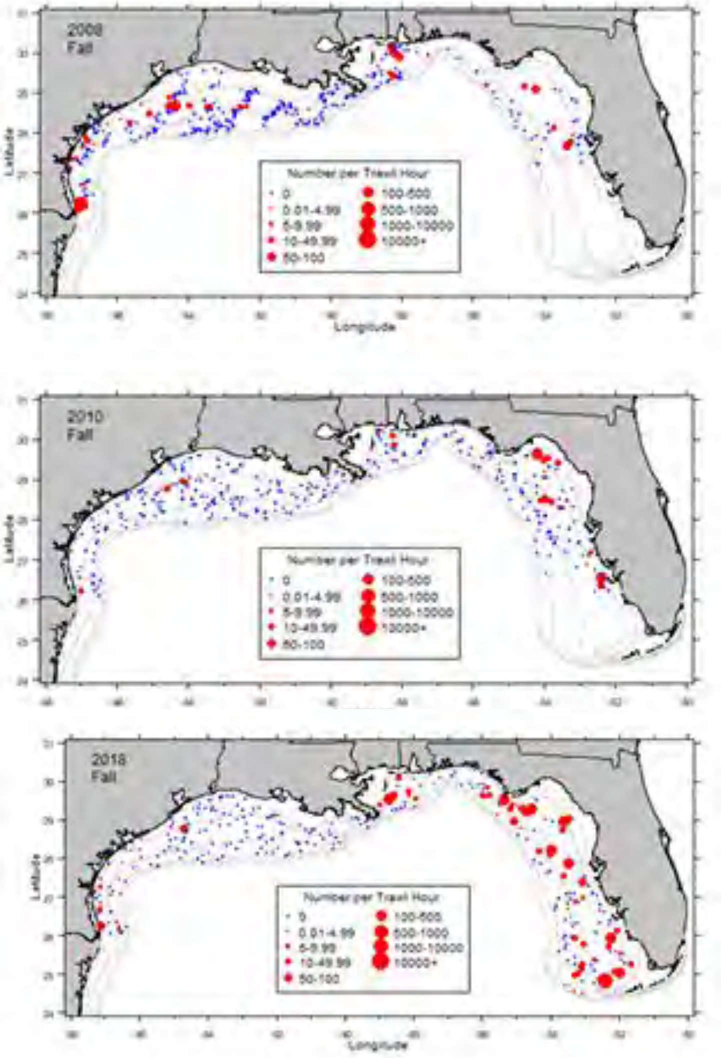
VAST index

VAST (Thorson and Barnett 2017)

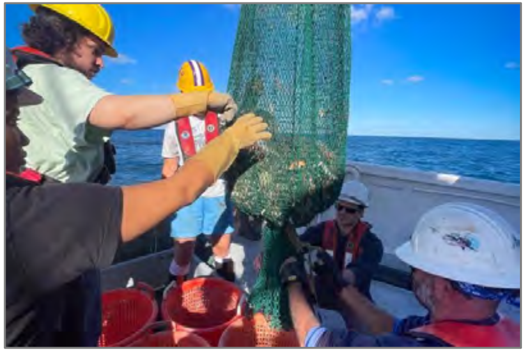
- Delta-generalized linear mixed model used to create species-specific indices of abundance
- Unmeasured processes are approximated through spatial and spatio-temporal random effects.
- VAST "controls for" catchability covariates when calculating an index (i.e., removes their estimated effect) while "conditioning on" density/habitat covariates when calculating an index (i.e., uses them to improve interpolated/extrapolated predictions of density)

VAST - Motivation

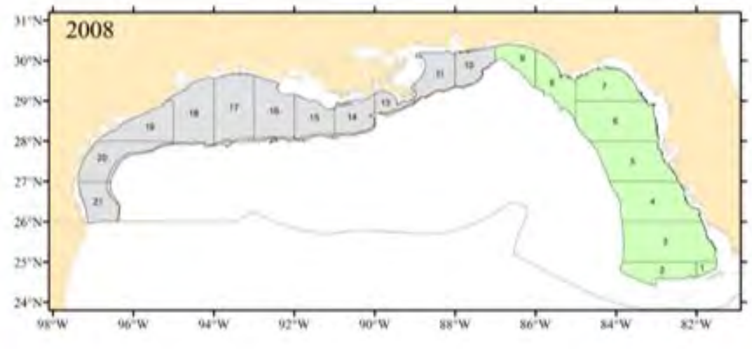
- Develop an index of relative abundance that can control for survey design changes and correct for sampling gaps (e.g., Summer 2020) and delays (e.g., Summer 2022) by using information from a partially overlapping survey.
- Testing impact of Nursery Conditions on abundance (habitat covariates)



SEAMAP Design Change

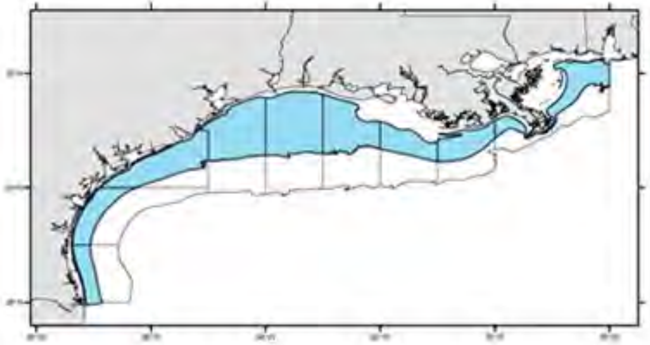


- 1987-2022 (No 2020 Summer)
- 42 ft otter trawl
- Summer and Fall
- Survey design change between 2008 Fall and 2009 Summer surveys (SEDAR87-RD-01)
    - Extend to SSZ 1-9
    - Variable tow time (10-55 min) □ 30 min
    - Across depth strata □ random direction
    - TOD stratification dropped (no longer 1:1)
    - Changes in sampling effort allocation



5 – 20 Fathom Breakdown

Stat Zones	Old Design	Current Design
11	0.13	0.04
13-15	0.13	0.09
16-17	0.13	0.17
18-19	0.13	0.16
20-21	0.13	0.07

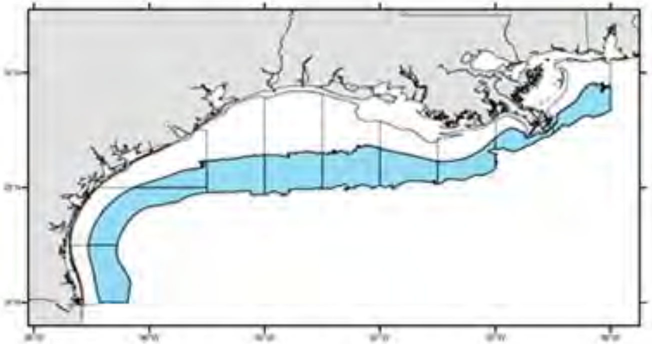


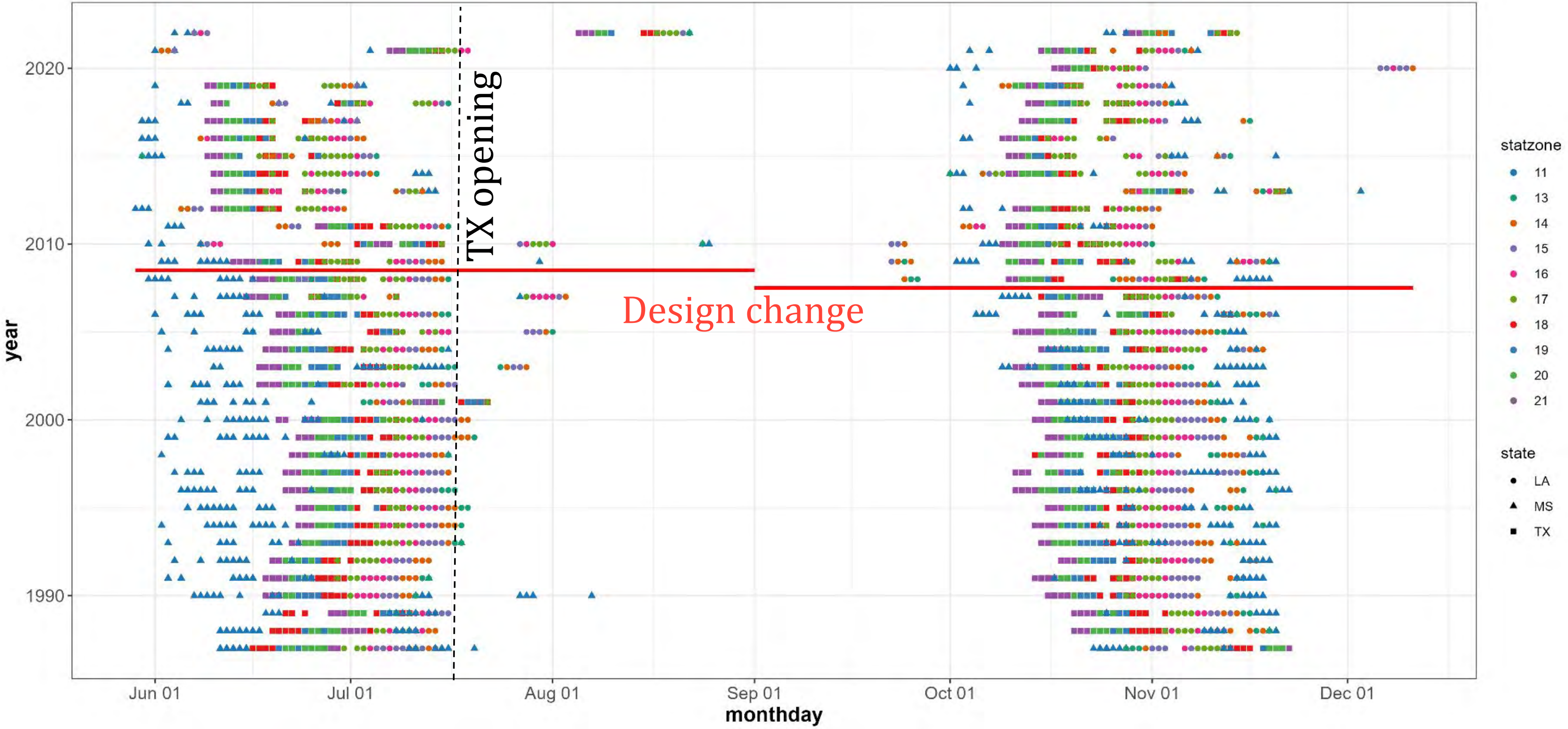
Overall Strata Proportions

Stat Zones	Old Design	Current Design
11	0.2	0.08
13-15	0.2	0.19
16-17	0.2	0.29
18-19	0.2	0.24
20-21	0.2	0.19

20 – 60 Fathom Breakdown

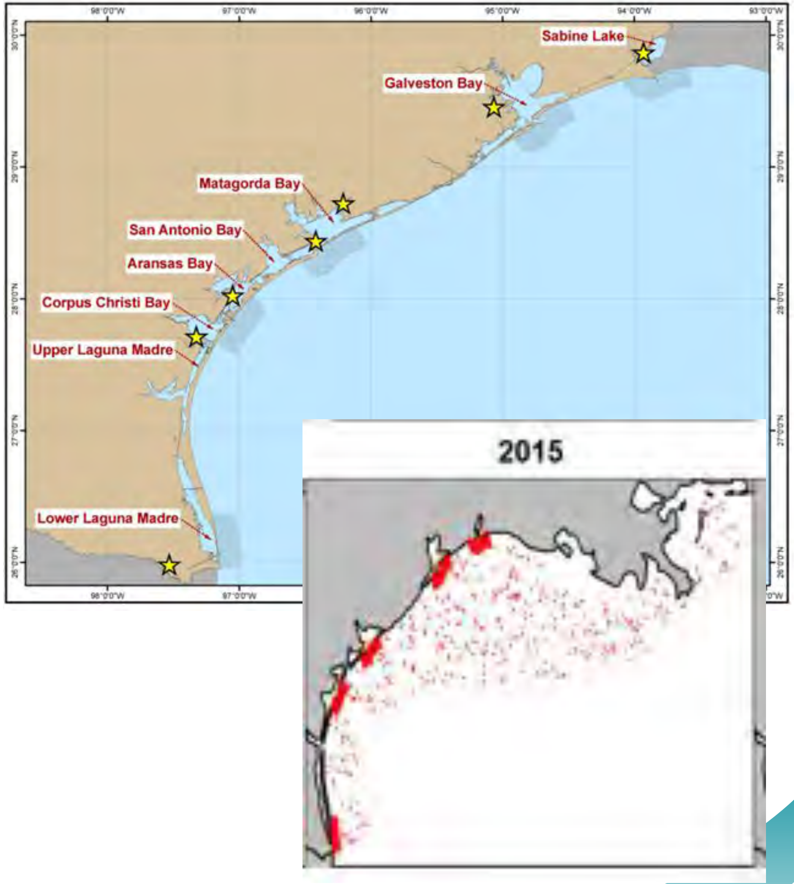
Stat Zones	Old Design	Current Design
11	0.07	0.04
13-15	0.07	0.10
16-17	0.07	0.12
18-19	0.07	0.08
20-21	0.07	0.12




TX opening
Design change
year
2020
2010
2000
1990
Jun 01
Jul 01
Aug 01
Sep 01
Oct 01
Nov 01
Dec 01
monthday
statzone
11
13
14
15
16
17
18
19
20
21
state
LA
MS
TX

TPWD Gulf Survey

- TPWD (SEDAR87-RD-07)
  - 1987-2022
  - 20 ft otter trawls
  - 16 samples / month / area (5 areas)
  - Monthly, daytime
  - Towed parallel to fathom curve
  - 10 min tow



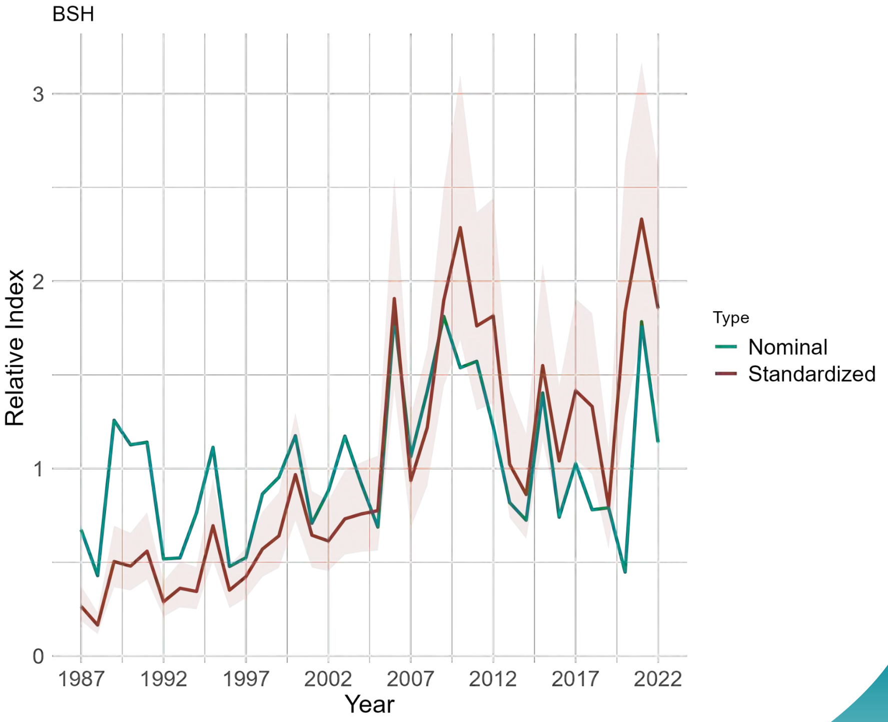
BROWN SHRIMP INDEX RECOMMENDATIONS

Brown Shrimp
SEAMAP (summer and fall) + TPWD
1987-2022

Delta-lognormal
Numbers per tow with effort offset (fish time)
Spatial and spatiotemporal RE (anisotropy)
Catchability covariates :

- time of day
- survey
- month

Index recommended for input into JABBA.



Feedback from Stakeholders Addressed During Process

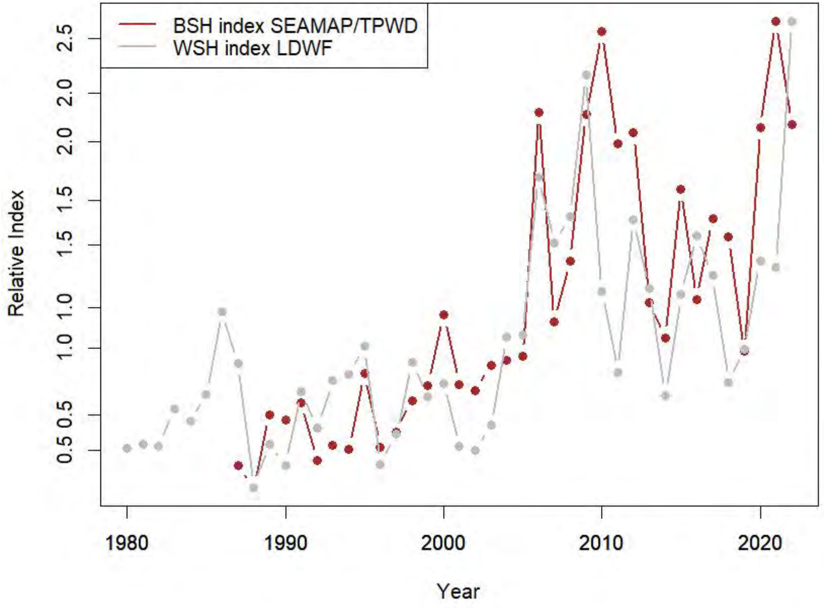
Concern was raised that SEAMAP tow direction might influence CPUE.

- The survey team ran preliminary analyses using tow direction in GAMs : models had very low deviance explained by tow direction
- SEAMAP tows are relatively short so even towing across depth zone results in very little slope (very different from how the fishery operates)

Feedback from Stakeholders Addressed During Process

Concern was raised that the increase in CPUE observed in the SEAMAP data might have been due to a change in captain experience

- The analysts explained that captains follow strict protocols when fishing for a survey to remove any "captain" effect
- Brown (SEAMAP) and white (LDWF) shrimp indices show a similar increase in abundance despite originating from different surveys



NOAA FISHERIES

JABBA

JABBA

Bayesian state-space surplus production model (SPM)

Data inputs

- **Index of abundance** (proportional to the exploitable part of the stock biomass)
- Time series of **fishery removals**.

ELSEVIER

Fisheries Research

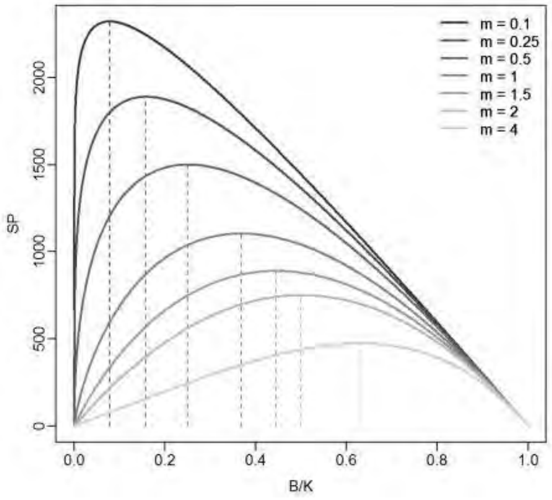
Volume 204, August 2018, Pages 275-288

JABBA: Just Another Bayesian Biomass Assessment

Henning Winker[a b], Felipe Carvalho[c], Maia Kapur[c d]

Parameters

- **r** : intrinsic rate of population change
- **K** : carrying capacity
- **m** : shape parameter that determines at which B/K ratio maximum surplus production is attained; inherently linked with r



$$SP_t = \frac{r}{m-1} B_t \left(1 - \left(\frac{B_t}{K}\right)^{m-1}\right)$$

- **q** : catchability coefficient
- **psi** : initial biomass depletion at start of catch time series
- **process variance** (σ2; fixed or estimated)
- **observation variance** (τ2; fixed or estimated) : input observation error + year to year variation in catchability

Feedback from Reviewers Addressed During Process

When priors are specified for r and m, the Winker parameterization obfuscates the specification of prior distributions: what is r/(m-1) in biological terms when the prior distribution for m spans 1?

$$\frac{dB_t}{dt} = \frac{r}{m-1} B_t \left(1 - \left(\frac{B_t}{K}\right)^{m-1}\right)$$

The priors on r and m cannot be thought of in isolation and m is likely less than 1 for a highly resilient species like shrimp

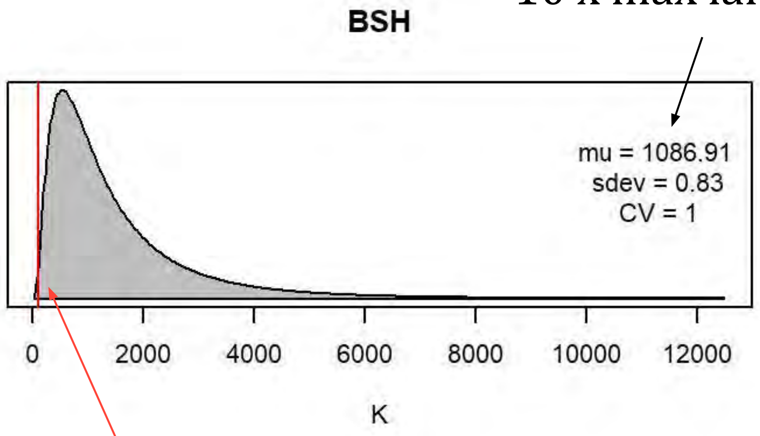
- The analytical team explored two alternative priors for *m*
- Results showed sensitivity of this parameter and that the data are not very helpful in defining it further.

Uncertainty Grid

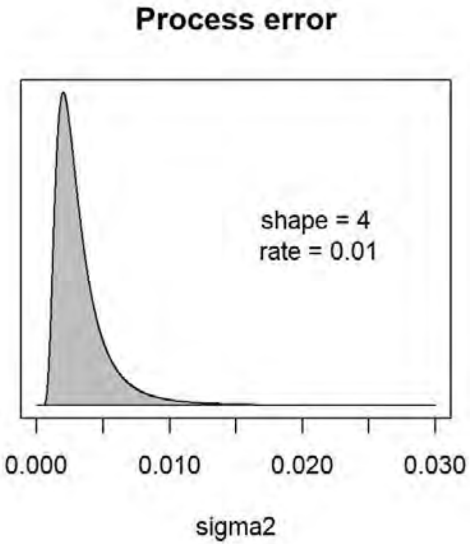
R prior *Medium and High resilience categories in FishBase - Froese et al. 2019*	**Medium** (0.2–0.8)	**High** (0.6–1.5)	**Very high** (1.2–3.0) *(BSH only)*
Initial biomass depletion	**Low** Lognormal (mu=.9, CV=.25)	**High** Lognormal (mu=.25, CV=.5)	
Additional observation error around index	**Yes** Default ~ 1/gamma(0.001, 0.001)	**No**	
B/K ratio at which MSY is attained (prior for shape parameter)	**0.4**	**0.25**	**0.15**

Priors (all runs)

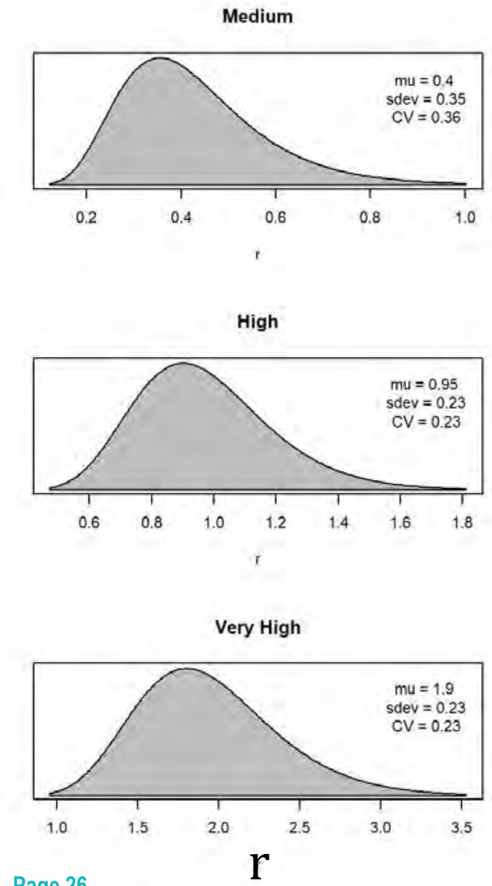
10 x max landings

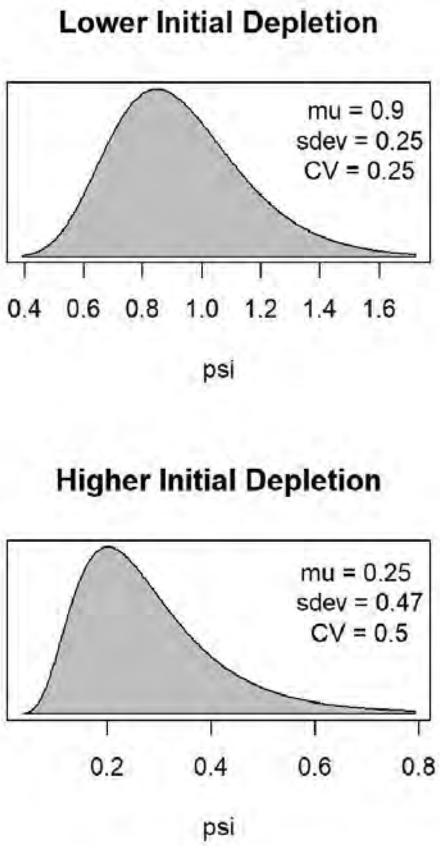


Max landings for the species

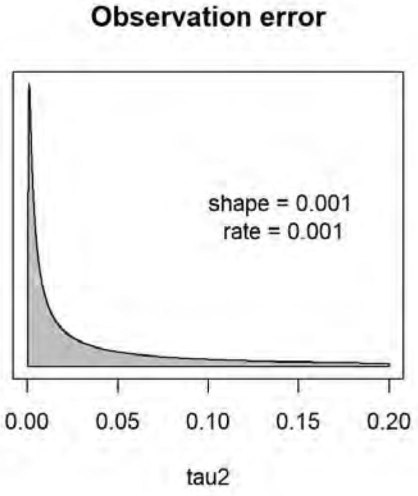


Priors (uncertainty grid)

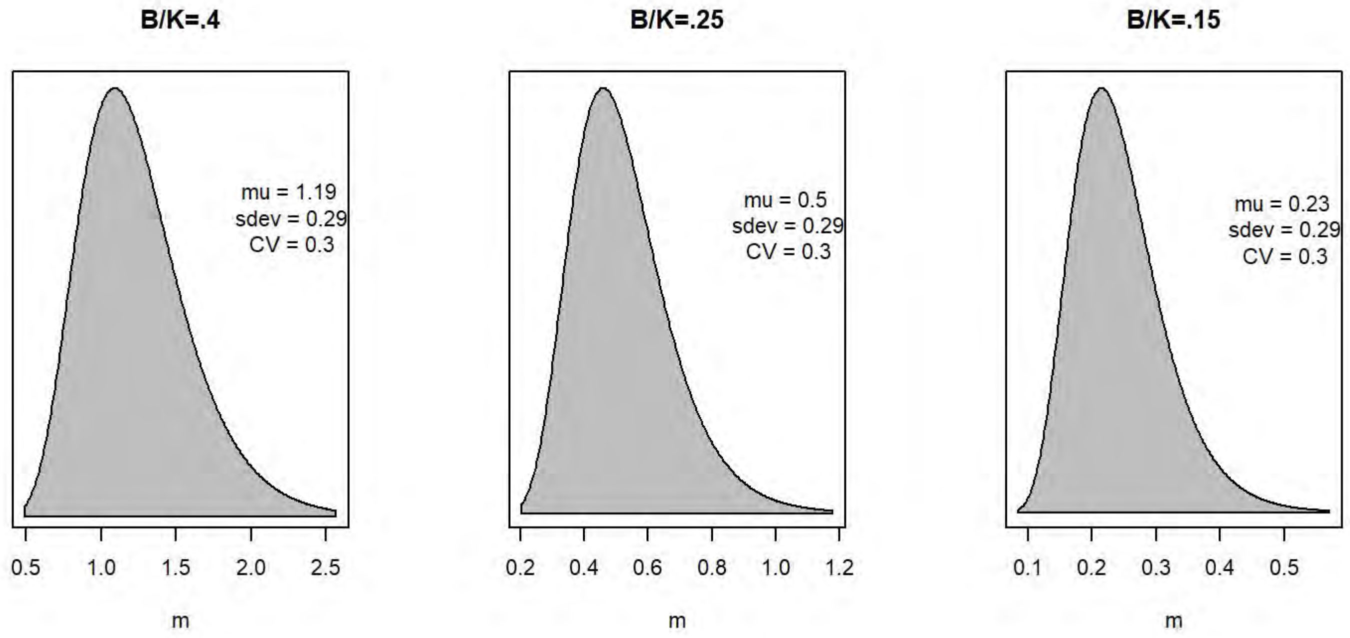




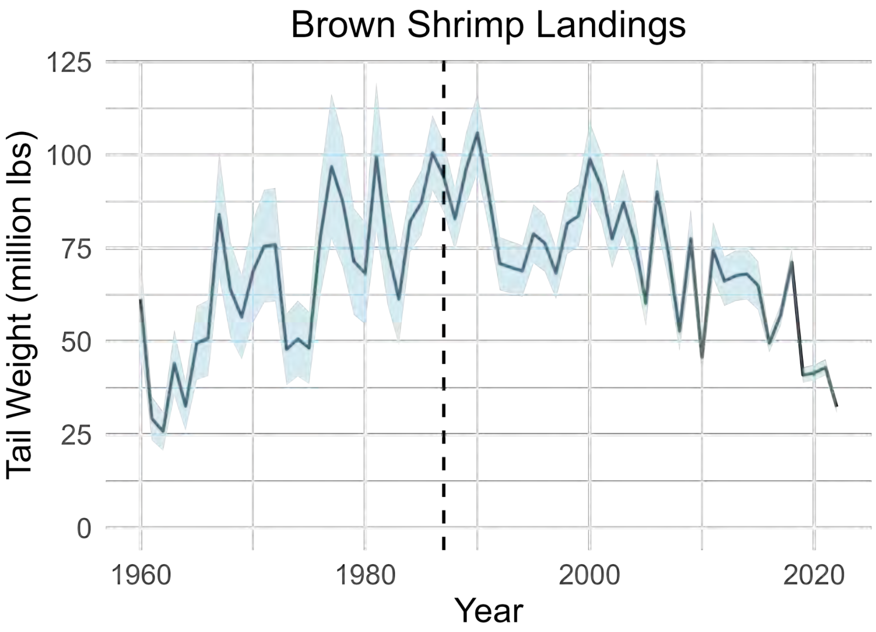
(if estimated)

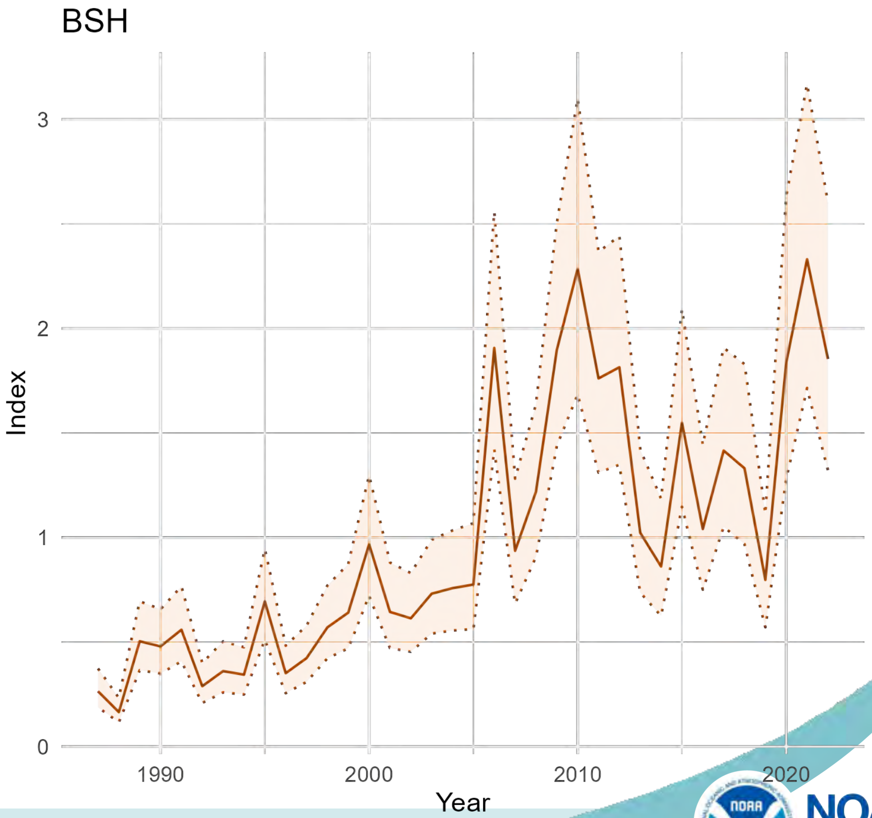


Priors (uncertainty grid)

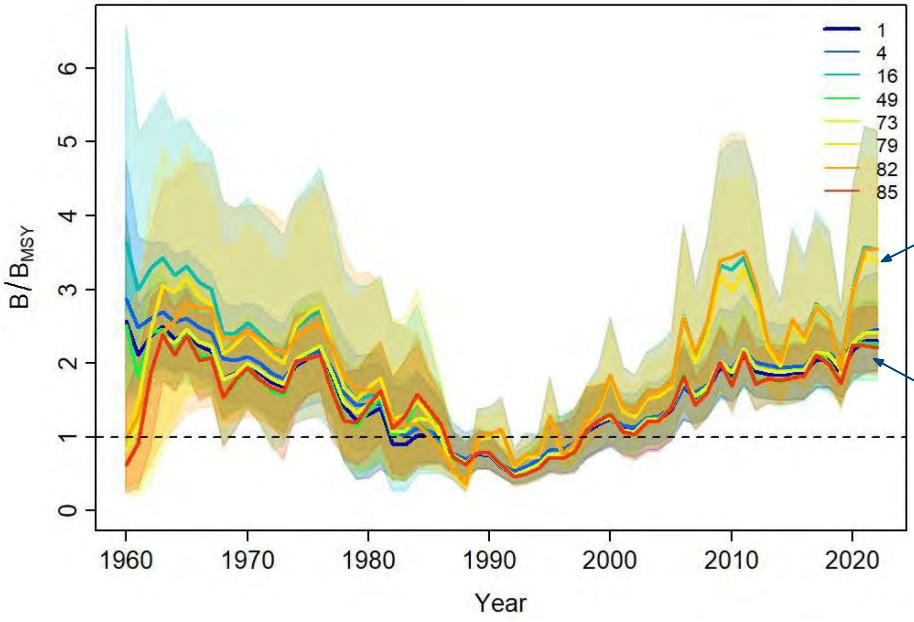


Data - Brown Shrimp





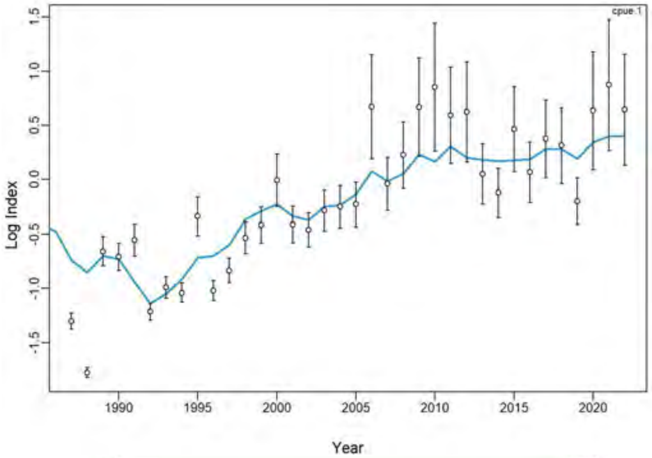
Brown Shrimp Results

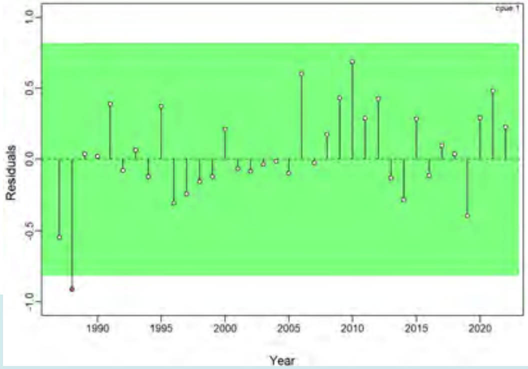


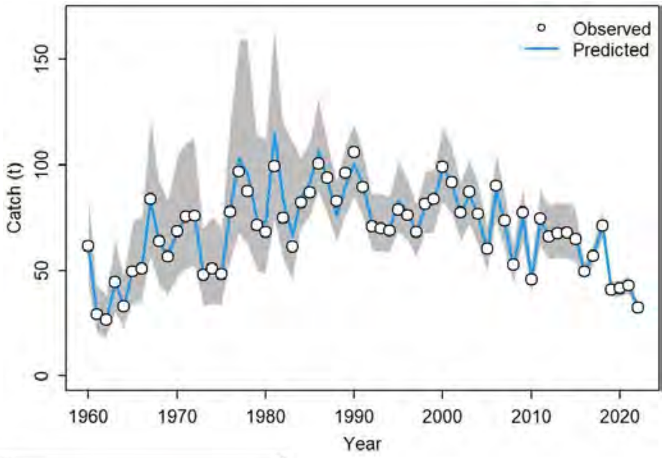
Run	Description
16	Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.
79	Sigma Estimation FALSE. R prior High range. Prior distribution for psi lnorm with mean 0.25.
82	Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.25.
1	Sigma Estimation TRUE. R prior High range. Prior distribution for psi lnorm with mean 0.9.
4	Sigma Estimation TRUE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.
49	Sigma Estimation TRUE. R prior Very High range. Prior distribution for psi lnorm with mean 0.9.
73	Sigma Estimation TRUE. R prior High range. Prior distribution for psi lnorm with mean 0.25.
85	Sigma Estimation TRUE. R prior Very High range. Prior distribution for psi lnorm with mean 0.25.

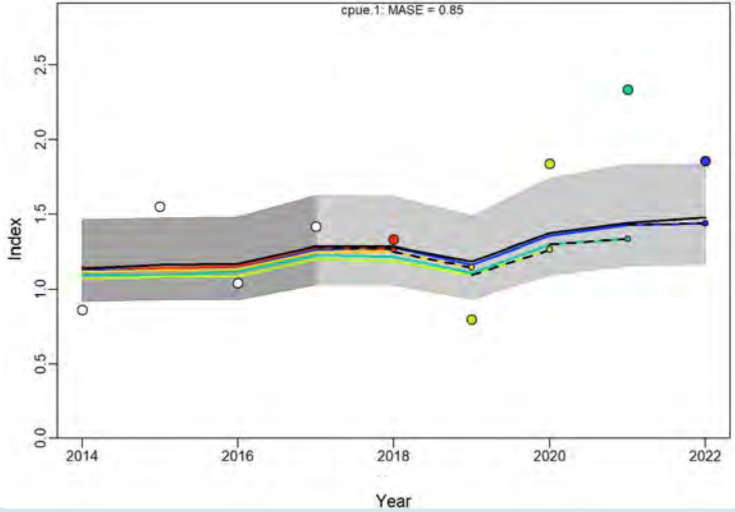
Brown Shrimp - Example Run

1 Sigma Estimation TRUE. R prior High range. Prior distribution for psi lnorm with mean 0.9.



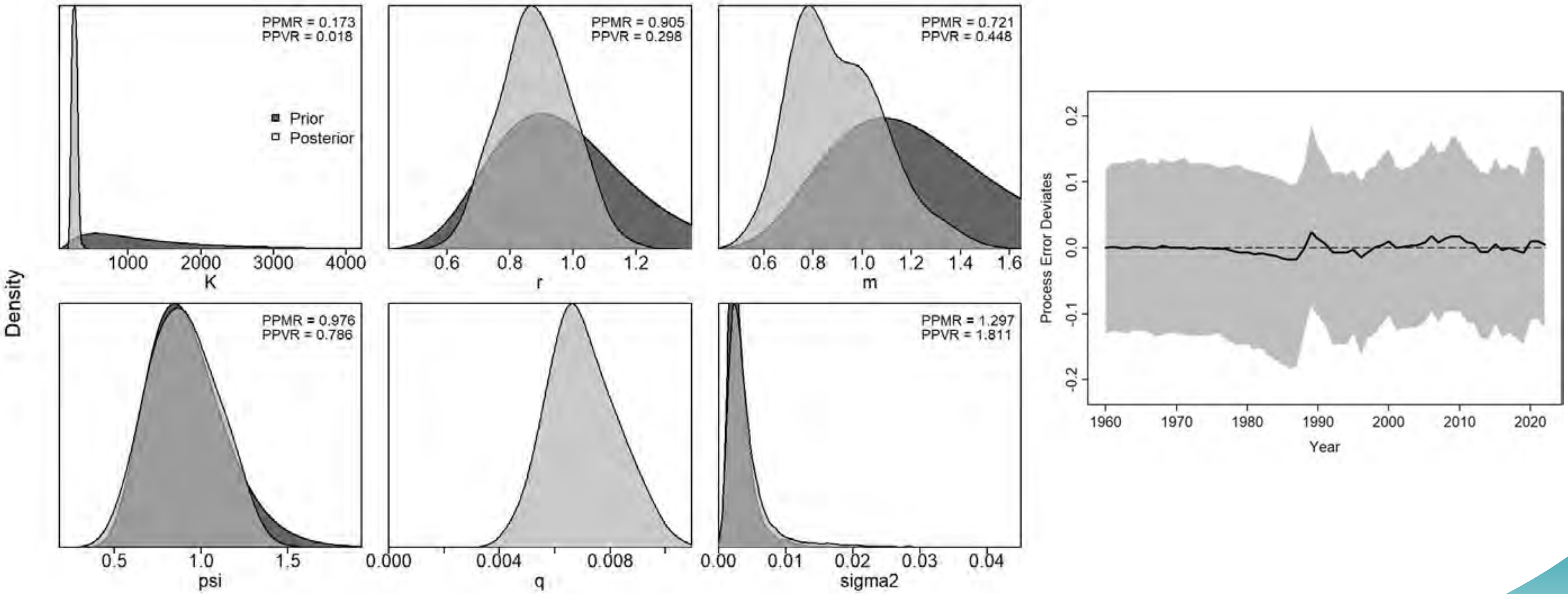






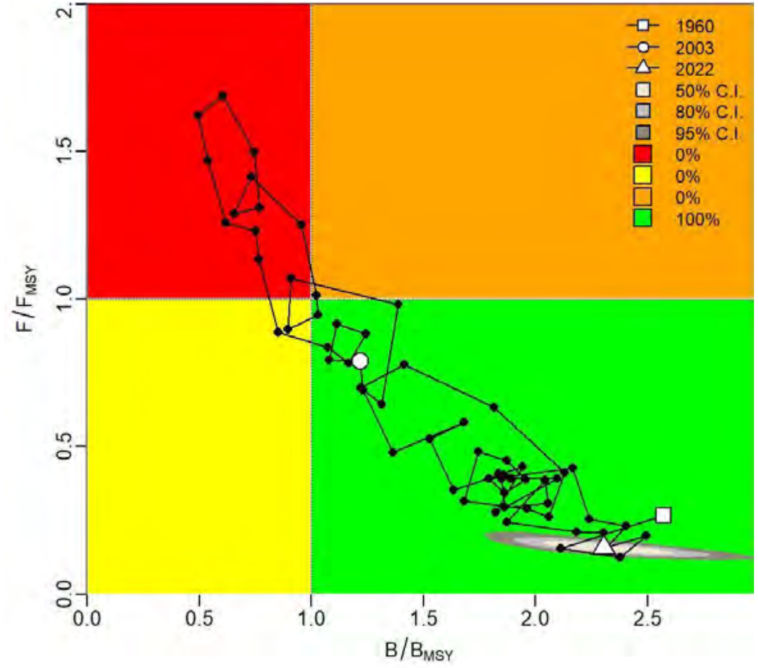
Priors, Posteriors and Process Error

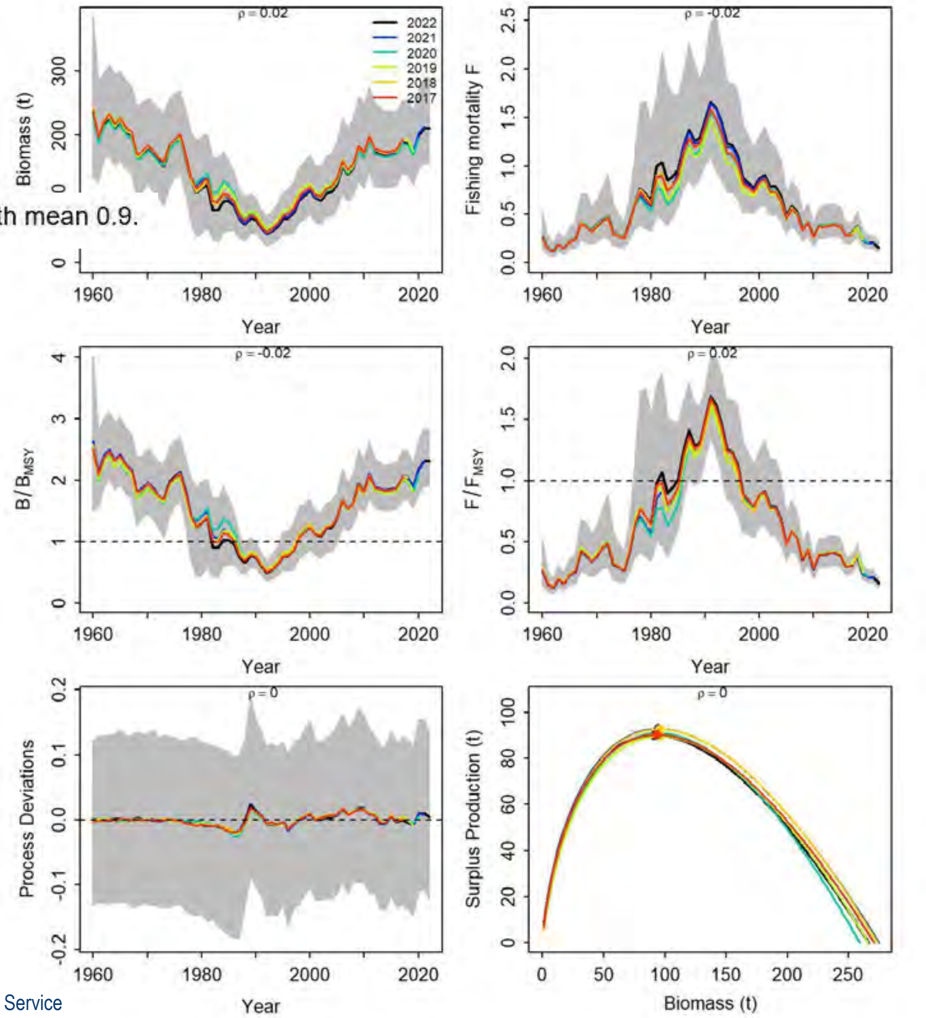
1 Sigma Estimation TRUE. R prior High range. Prior distribution for psi lnorm with mean 0.9.



Retrospective Analysis & Kobe Plot

1 Sigma Estimation TRUE. R prior High range. Prior distribution for psi lnorm with mean 0.9.





Brown Shrimp Model Diagnostics

	Model Convergence			Model Fit		Model Consistency				Process Error	Prediction Skill	
run	CONV_gw	CONV_hw	CONV_hs	CPUE_rt_rand	CPUE_rt_outl	RETRO_B	RETRO_F	RETRO_B.Bmsy	RETRO_F.Fmsy	ProcB_CI	HX_MASE	DIC
BSH_1_P_rH_psil0.9_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.02	-0.02	-0.02	0.02	PASS	0.85	-469.80
BSH_16_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.29	0.45	0.03	0.00	FAIL	0.82	-525.60
BSH_4_P_rM_psil0.9_sigT_60	FAIL	PASS	PASS	PASS	FAIL	0.21	-0.15	-0.04	0.03	PASS	1.00	-461.50
BSH_49_P_rV_psil0.9_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.03	-0.03	-0.05	0.05	PASS	0.91	-451.60
BSH_73_P_rH_psil0.2_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.15	-0.12	-0.05	0.04	PASS	0.84	-461.30
BSH_79_P_rH_psil0.2_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.34	0.52	0.03	0.01	FAIL	0.73	-524.30
BSH_82_P_rM_psil0.2_sigF_60	FAIL	PASS	PASS	PASS	FAIL	-0.43	0.85	0.03	0.02	FAIL	0.82	-522.80
BSH_85_P_rV_psil0.2_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.10	-0.08	-0.01	0.01	PASS	0.85	-466.90
BSH_1001_P_rH_psil0.9_sigT_60	PASS	PASS	PASS	PASS	PASS	0.02	-0.01	0.01	-0.01	PASS	0.68	-432.20
BSH_1016_P_rM_psib0.5_sigT_60	PASS	PASS	PASS	PASS	PASS	0.24	-0.19	-0.03	0.02	PASS	0.72	-435.60
BSH_1004_P_rH_psib0.5_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.12	0.13	0.01	-0.01	PASS	0.63	-533.40
BSH_1049_P_rM_psib0.5_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.05	0.06	0.01	-0.02	FAIL	0.79	-527.90
BSH_1073_P_rH_psil0.2_sigT_60	PASS	PASS	PASS	PASS	PASS	-0.12	0.14	0.03	-0.03	PASS	0.67	-437.70
BSH_1079_P_rH_psil0.2_sigF_60	PASS	PASS	PASS	PASS	FAIL	0.02	-0.02	0.00	-0.01	PASS	0.62	-528.50
BSH_1082_P_rM_psil0.2_sigF_60	PASS	FAIL	FAIL	PASS	FAIL	-0.05	0.06	0.01	0.00	FAIL	0.73	-533.60
BSH_1085_P_rV_psil0.2_sigT_60	PASS	PASS	PASS	FAIL	FAIL	0.23	-0.19	-0.05	0.05	PASS	0.69	-402.20
BSH_2001_P_rH_psil0.9_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.03	-0.02	-0.01	0.00	PASS	0.64	-386.80
BSH_2016_P_rM_psib0.5_sigT_60	PASS	PASS	PASS	PASS	PASS	0.06	-0.04	-0.01	0.01	PASS	0.77	-433.20
BSH_2004_P_rH_psib0.5_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.25	0.34	0.02	0.01	PASS	0.61	-527.50
BSH_2049_P_rM_psib0.5_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.02	0.02	0.04	-0.04	FAIL	0.73	-534.00
BSH_2073_P_rH_psil0.2_sigT_60	PASS	PASS	PASS	PASS	PASS	0.00	0.00	-0.00	-0.00	PASS	0.68	-400.90
BSH_2079_P_rH_psil0.2_sigF_60	PASS	PASS	PASS	PASS	FAIL	0.01	-0.02	0.04	-0.04	PASS	0.64	-533.90
BSH_2082_P_rM_psil0.2_sigF_60	FAIL	PASS	PASS	PASS	FAIL	-0.04	0.04	-0.02	0.02	PASS	0.74	-518.30

AW

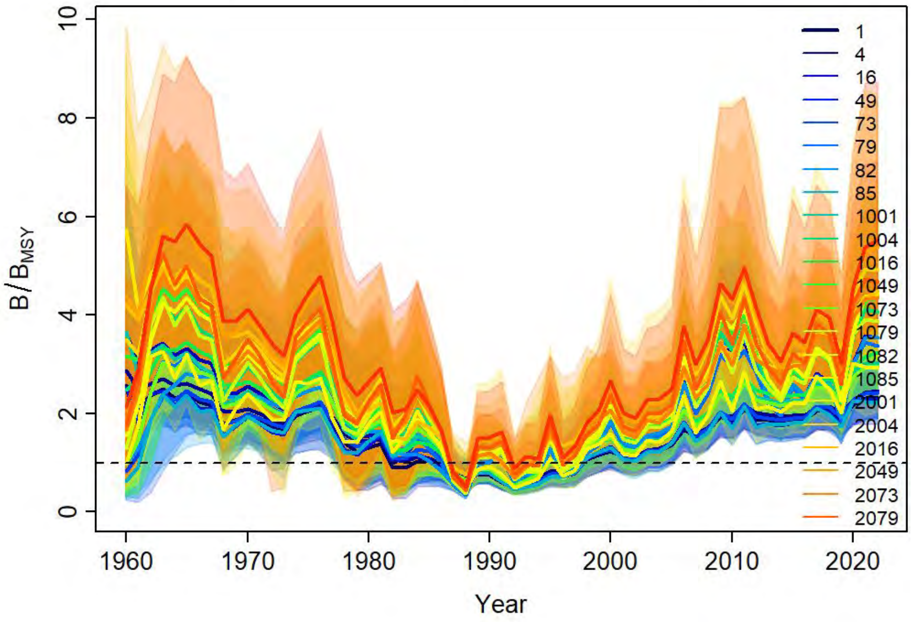
RW

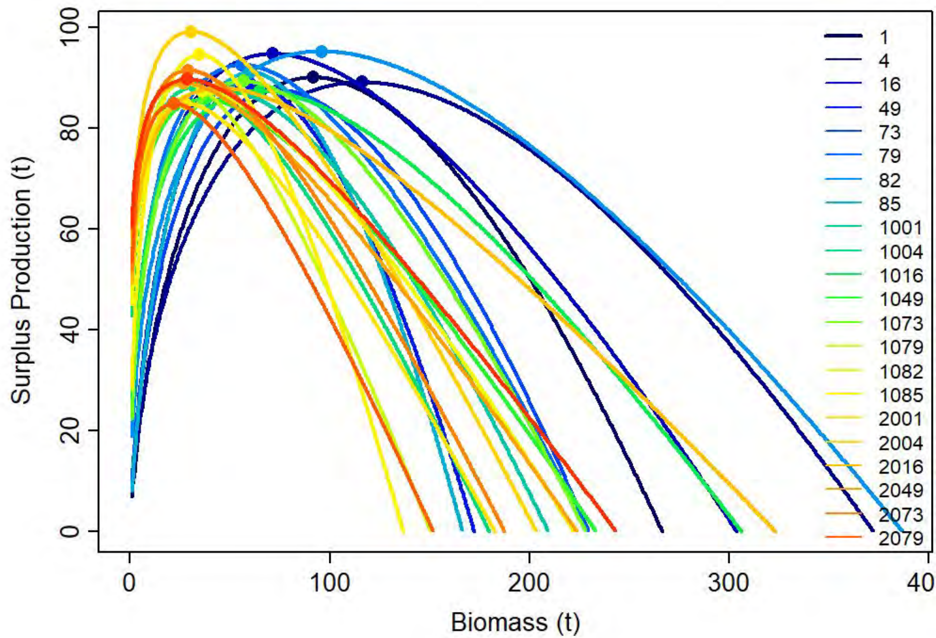
B/K=.40

B/K=.25

B/K=.15

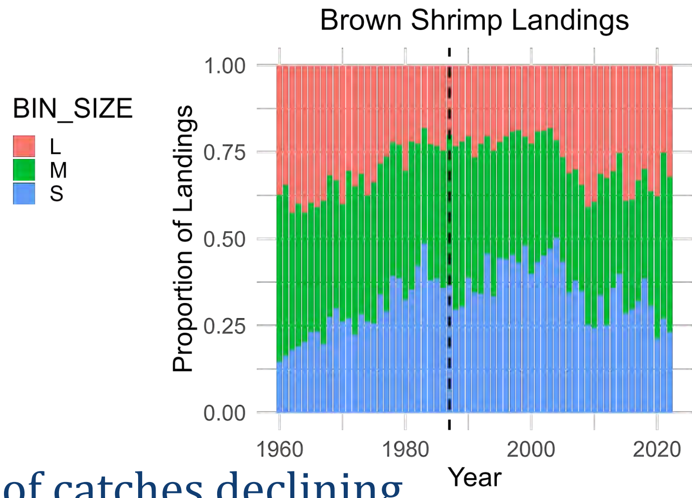
Brown Shrimp Summary Results





NOAA FISHERIES

BROWN SHRIMP JABBA SUMMARY



Strengths

- Data-limited approach with state-space formulation
- Acceptable diagnostics

Weaknesses

- Lack of contrast
  - "One way trip" : index only available over period of catches declining
- Assumptions likely violated
  - SPMs assume that **catch** levels reflect **changes in stock abundance**
  - SPMs assume that the **stock dynamics** are **adequately represented** by the underlying model equations
  - SPMs assume **constant catchability / selectivity** through time
- Current status of population is sensitive to assumptions on m

Empirical Dynamic Modeling (EDM)

Empirical Dynamic Modeling (EDM)

- Lagged abundance data have been used in fisheries for a long time within age-structured models

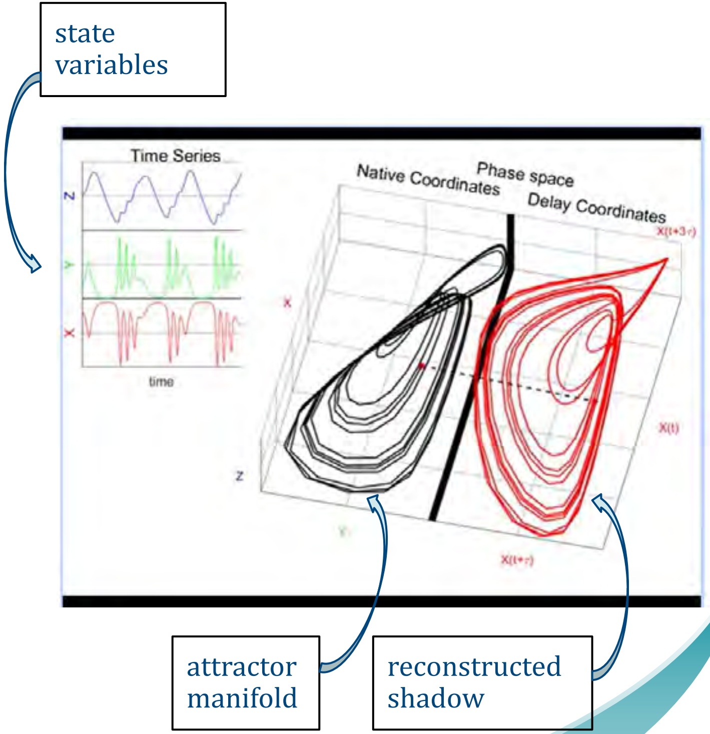
- Takens' Theorem on delay embedding makes this idea more general:

  when there's a system with many variables but only a few are observed, time lags can be used to reconstruct the full system dynamics

  ⟶ don't need data on all variables to make accurate predictions

  ⟶ don't need to specify model form

- Examples of variables not often observed directly: environment, predators, food items, economic influences



Gaussian Process EDM (GP-EDM)

- GP regression can be used to approximate the delay-embedding map ***f***

$$P(y_t \mid f, I_{t-m} - qC_{t-m}, V_e) \sim Normal(\, f(I_{t-m} - qC_{t-m})\, , V_e)$$

$$P(f \mid \phi,\tau) \sim GP(0,\Sigma)$$

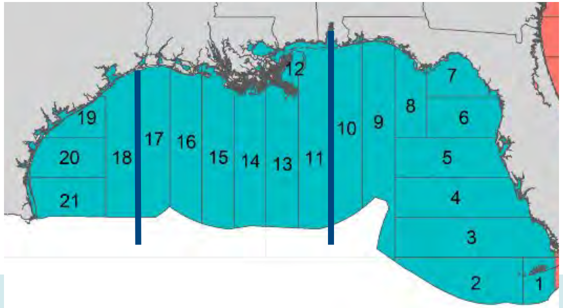
where the probability of observing abundance $\boldsymbol{y}$ at time $\boldsymbol{t}$ is dependent on the function approximation $\boldsymbol{f}$, vector of abundance indices $\boldsymbol{I}$ with $\boldsymbol{m}$ lags ($\boldsymbol{I_{t-m} = \{i_{t-1},\ldots, i_{t-m}\}}$), removals $\boldsymbol{C_{t-m} = \{c_{t-1},\ldots, c_{t-m}\}}$ scaled by catchability coefficient $\boldsymbol{q}$, and process noise $\boldsymbol{V_e}$.
$\boldsymbol{f}$ is dependent on inverse length scales $\boldsymbol{\phi}$ and pointwise prior variance $\boldsymbol{\tau}$, and is assigned a GP prior with mean zero, covariance function $\boldsymbol{\Sigma}$.

- GP-EDM with m=1 can be thought of as a nonparametric production model (Thorson *et al.*, 2014)
    - Abundance next year is dependent on abundance this year

Stratification of Shrimp Data

- **Species:** brown (*Farfantepenaeus aztecus*), pink (*F. duorarum*), white (*Litopenaeus setiferus*)

- **Area:** Gulf fishing areas 1-10, 11-17, 18-21
- **Size Bins:** "Small", "Medium", "Large";
  >67, 67-31, <=30 shrimp tails per pound;
  <129mm, 129mm-166mm, >=167mm total length
- **Season:** Winter (JFMA), Summer (MJJA), Fall (SOND)
- **Year:** 19XX-2022



Model Configuration

- Define the system being modeled
- Stratify data such that system variability can be captured
  - Modeled as "populations" within a hierarchical model
  - Modeled independently with no shared parameters
- ytrans: transformation to apply to y before fitting
- Catchability, q
  - Shared among populations if specified
  - Distinct within populations if specified
- Embedding dimension $\boldsymbol{E}$ approximates system dynamics using lags of the observed states to account for unobserved state variables
  - Limited by time series length $\boldsymbol{T}$, where $\boldsymbol{E} <= \mathrm{sqrt}(\boldsymbol{T})$
- Factorial design was implemented to investigate the impact of each decision

NOAA FISHERIES

Model Performance

- In sample fit statistics
  - R2 - proportion of variance explained by model (independent or hierarchical)
  - R2pop - proportion of variance explained for each population within a hierarchical model
  - R2scaled - proportion of variance explained by a hierarchical model, centered and scaled by population means

- Out of sample fit statistics
  - R2_out - out of sample R2
  - R2_outpop - out of sample R2pop
  - R2_outscaled - out of sample R2scaled

Feedback from Stakeholders Addressed During Process

Stakeholders requested looking into whether or not MSY estimates were stable.

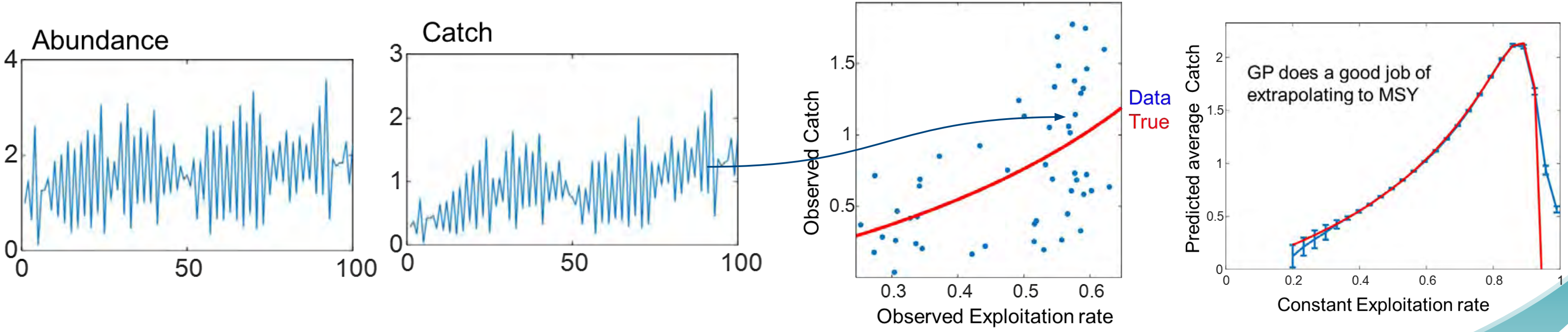
- The survey team ran a retrospective analysis, peeling back up to 5 years of data in each model and comparing estimates to maximum landings.

Model Selection Summary

- Selection decisions focused on models with ‘sequential’ cross-validation considering R2out and R2outscaled metrics
- Test robustness of top performing models’ MSY estimates
  - Filter out unrealistic landings estimates
    - MSY >10x historical landings record
    - MSY at harvest rate U =1 (entire population)
  - Peel back 1:5 time steps and re-estimate MSY
    - If any iteration fails (MSY >10x OR U=1), drop from further consideration
    - Flag any retrospective bias and investigate/drop
- Select final model based on complexity, relative stability

Estimating MSY within EDM

- Maximum Sustainable Yield (MSY) within EDM is defined as the long-run average yield at optimal constant harvest rate
  - EDM captures naturally fluctuating sustainable state of the population
  - MSY is the average of these fluctuations and approximates a static benchmark for management



NOAA FISHERIES

Fishery production model

$B_{t+1} = B_t - C_t + P(B_t - C_t)$

e.g., $P(x) = rx(1 - \frac{x}{k})$ for production function

B: biomass (lbs)
C: catch (lbs)
P: production (lbs)
I: abundance index (#/tow)
q: #/lbs/tow
u: exploitation rate (lbs/lbs)

$I_t = qB_t$

$u_t = \frac{C_t}{B_t}$

Re-write production model in terms of observables

$qB_{t+1} = qB_t - qC_t + qP(B_t - C_t)$

$I_{t+1} = I_t - qC_t + qP[\frac{(I_t - qC_t)}{q}]$

Now we have model linking index and catch
Note that $(I_t - qC_t)$ is proportional to surviving biomass $(B_t - C_t)$

Fishery EDM model

$I_{t+1} = f(I_t - qC_t, I_{t-1} - qC_{t-1}, \ldots, I_{t-E} - qC_{t-E})$

EDM uses $I_t - qC_t$ as proxy for surviving biomass as per fishery production model, but does not assume a known production function, such that the function *f* of time lags allows for unobserved state variables and species interactions

EDM-based MSY

1. Let exploitation rate U_t a controlled variable ranged from zero to one
2. Initialize the history of index I_t and catch C_t and predict the next time step index I_{t+1} using the best-fitted parameters and function *f* iteratively
3. Find the long-run averaged index and catch at MSY given a particular range of exploitation rate

[Tsai, C.-H., Munch, S.B., Masi, M.D. & Stevens, M.H. (2024). Empirical dynamic modeling for sustainable benchmarks of short-lived species. ICES Journal of Marine Science.]

BROWN SHRIMP EDM
Maximum Sustainable Yield

Stratification of Brown Shrimp Data

Goal: Capture reality using the simplest model with the most accurate projection capability. Aggregate where appropriate while still capturing stock dynamics.

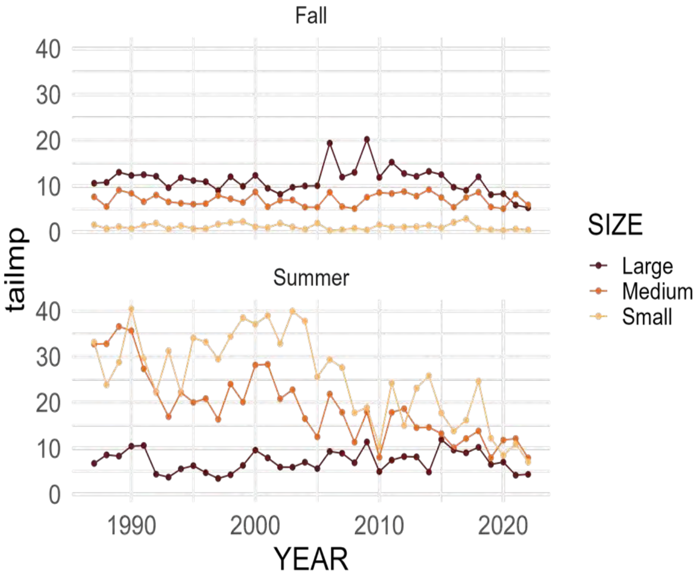
A. **Aggregated:** ANNUAL ; SIZE BINS AGG ; AREA AGG (11:21)
B. **Area:** ANNUAL ; SIZE BINS AGG ; AREA (11:17, 18:21)
C. **Size:** ANNUAL ; SIZE BINS (>67, 67-31, <=30) ; AREA AGG (11:21)
Csm. **Size2:** ANNUAL ; SIZE BINS (>31, <=30) ; AREA AGG (11:21)
D. **Size_Area:** ANNUAL ; SIZE BINS (>67, 67-31, <=30) ; AREA (11:17, 18:21)
Dsm. **Size2_Area:** ANNUAL ; SIZE BINS (>31, <=30) ; AREA (11:17, 18:21)
E. **Season:** SEASONAL (SUMMER, FALL+WINTER) ; SIZE BINS AGG ; AREA AGG (11:21)
F. **Area_Season:** SEASONAL (SUMMER, FALL+WINTER) ; SIZE BINS AGG ; AREA (11:17, 18:21)
G. **Size_Season:** SEASONAL (SUMMER, FALL+WINTER) ; SIZE BINS (>67, 67-31, <=30) ; AREA AGG (11:21)
Gsm. **Size2_Season:** SEASONAL (SUMMER, FALL+WINTER) ; SIZE BINS (>31, <=30) ; AREA AGG (11:21)
H. **Size_Area_Season:** SEASONAL (SUMMER, FALL+WINTER) ; SIZE BINS (>67, 67-31, <=30) ; AREA (11:17, 18:21)
Hsm. **Size2_Area_Season:** SEASONAL (SUMMER, FALL+WINTER) ; SIZE BINS (>31, <=30) ; AREA (11:17, 18:21)

Brown Shrimp EDM Construction

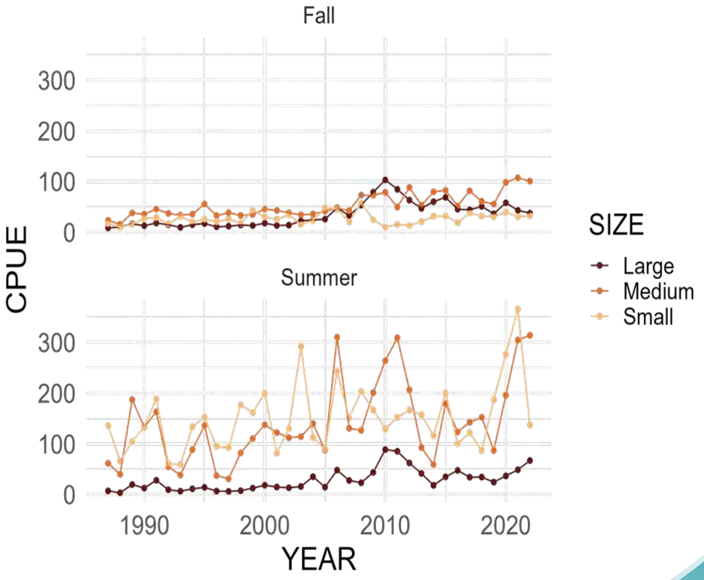
- Brown shrimp
  - SEAMAP, 1987-2022, Fall/Summer
  - Embedding dimension E is m+1 (or m+z+1)
    - $E \leq \sqrt{T}$, where T=36, $E \leq 6$ (up to 5 lags, or 3 lags and 2 covariates, etc) for annual model

Landings and CPUE stratified by Season and Size Class

Landings



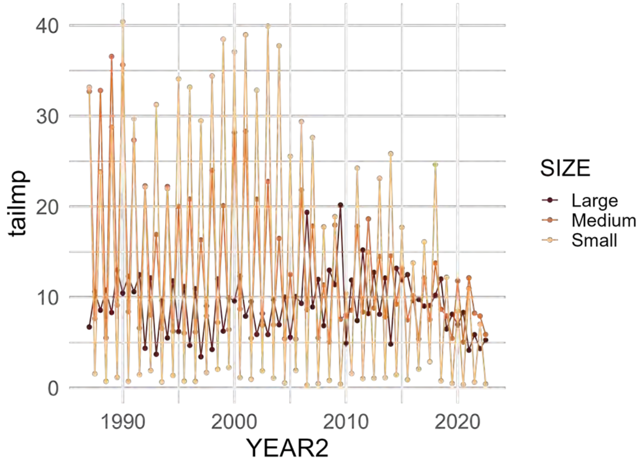
CPUE



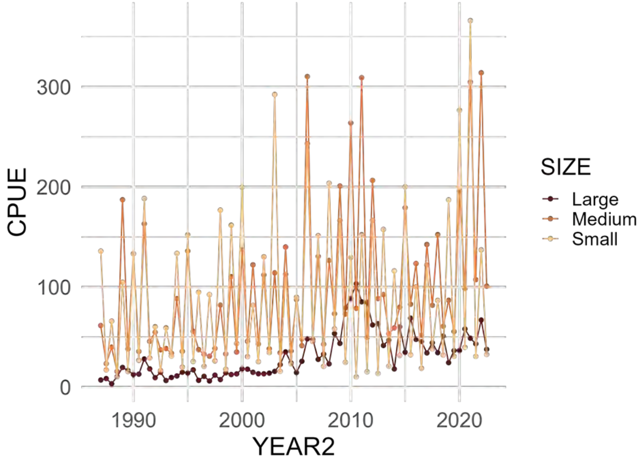
- Visualizes annual trends within season

Seasonally oscillating Landings and CPUE stratified by Size Class

Landings



CPUE



- Visualizes the full variability in the system
- Real time fluctuations by size class

Top Performing Model Runs

Run	Time	Stratum	Pop	E	rho	R2	R2_out	R2_outscaled	ProcessVar	PriorVar
BSH_G21023	Seasonal	Gsm	SIZE	5	0.67	0.825	0.628	0.511	0.072	0.637
BSH_G10435	Seasonal	Gsm	SIZE	4	0.51	0.918	0.714	0.503	0.189	1.457
BSH_G21031	Seasonal	Gsm	SIZE	5	0.49	0.917	0.706	0.497	0.189	1.478
BSH_G20047	Seasonal	G	SIZE	5	0.96	0.684	0.427	0.416	0.252	0.813
BSH_G10323	Seasonal	Gsm	SIZE	4	0.77	0.797	0.55	0.409	0.086	0.81
BSH_G10890	Annual	Gsm	SEAS_SIZE	4	0.94	0.913	0.808	0.389	0.382	0.698
BSH_G20023	Seasonal	G	SIZE	5	0.96	0.729	0.485	0.364	0.103	0.689
BSH_G10442	Annual	Gsm	SEAS_SIZE	4	0.93	0.903	0.8	0.359	0.412	0.696
BSH_G21040	Annual	Gsm	SEAS_SIZE	5	0.96	0.888	0.786	0.347	0.346	0.632
BSH_G10876	Annual	Gsm	SEAS_SIZE	3	0.95	0.858	0.783	0.342	0.456	0.654
BSH_G21016	Annual	Gsm	SEAS_SIZE	5	0.96	0.861	0.729	0.336	0.602	0.582
BSH_G10554	Annual	Gsm	SEAS_SIZE	4	0.96	0.896	0.791	0.332	0.352	0.624
BSH_G21008	Annual	Gsm	SEAS_SIZE	5	0.95	0.886	0.782	0.318	0.369	0.705
BSH_G10428	Annual	Gsm	SEAS_SIZE	3	0.95	0.831	0.768	0.302	0.493	0.679
BSH_G10106	Annual	Gsm	SEAS_SIZE	4	0.95	0.892	0.785	0.3	0.37	0.631
BSH_G21064	Annual	Gsm	SEAS_SIZE	5	0.87	1	0.771	0.29	0.019	1.335
BSH_G10540	Annual	Gsm	SEAS_SIZE	3	0.93	0.83	0.752	0.278	0.429	0.513
BSH_G21024	Annual	Gsm	SEAS_SIZE	5	0.95	0.874	0.74	0.27	0.378	0.611
BSH_G21032	Annual	Gsm	SEAS_SIZE	5	0.87	1	0.775	0.194	0.017	1.15
BSH_G10092	Annual	Gsm	SEAS_SIZE	3	0.77	0.863	0.732	0.123	0.387	0.701

Filtered by Strata G

20 out of top 54 models

Seasonal Models

- G. Size
- Gsm. Size

Annual Models

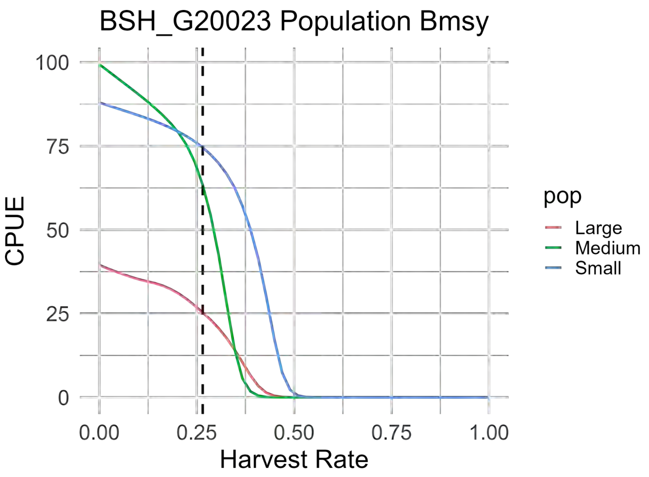
- G. Size_Season
- Gsm. Size_Season

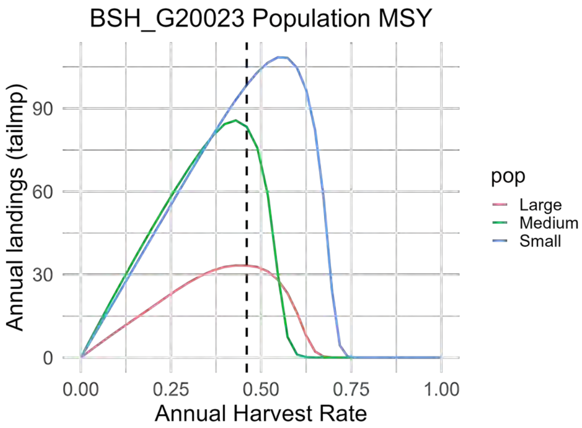
Top 2 Model Runs boxed (e.g. passed MSY checks)

NOAA FISHERIES

Top Performing Models for MSY

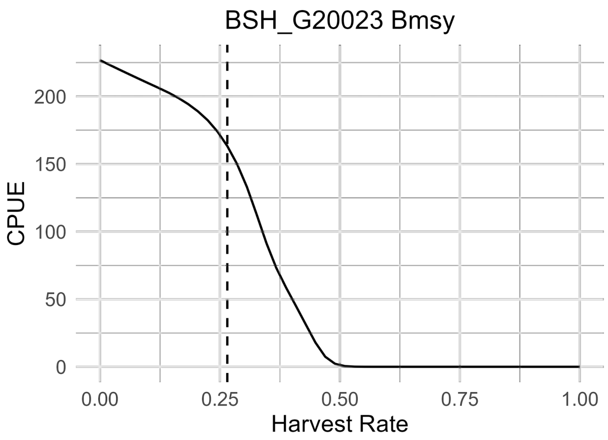
- **Size-structured** (Large, Medium, Small), shared catchability, **seasonal** time steps, E=5, *y* transformation **gr2** ($\log(y_t/(y_{t-1} - qC_{t-1}))$) [G20023]
- **Size-structured** (Large, Smedium), shared catchability, **seasonal** time steps, E=4, *y* transformation **gr2** ($\log(y_t/(y_{t-1} - qC_{t-1}))$) [G10323]

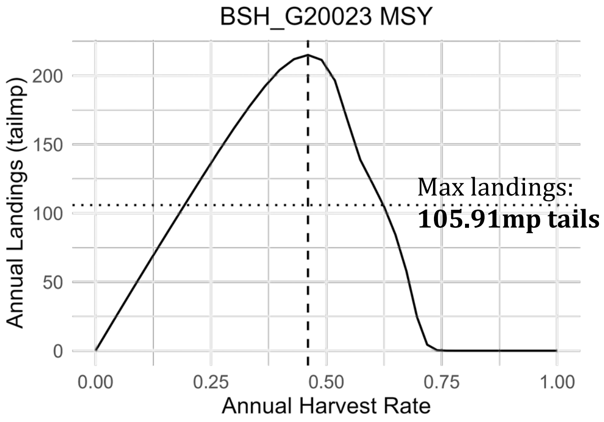




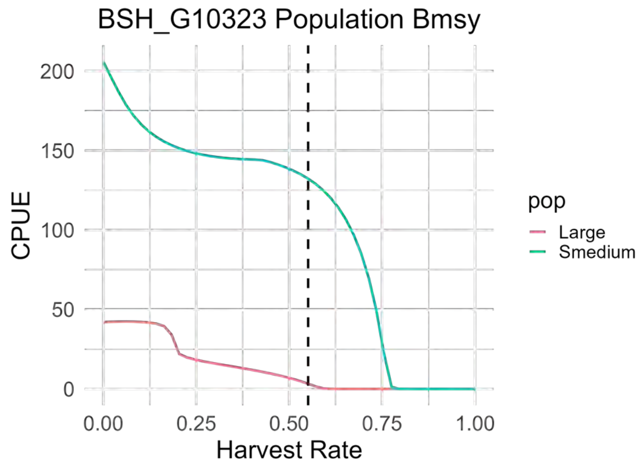
MSY is added across populations

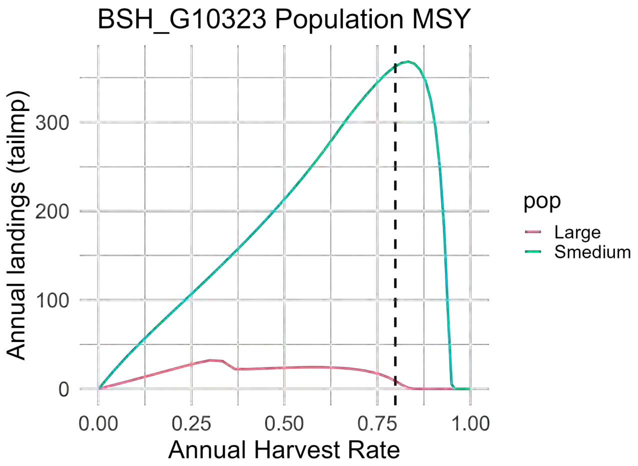
Statistic	BSH_G20023
MSY_mptails	215.069
Fmsy	0.617
Umsy_annual	0.460
Umsy_seasonal	0.265
Bmsy_mp	405.394
df	28.529
R2	0.729
R2Scaled	0.700
R2_outsample	0.485
R2Scaled_outsample	0.364



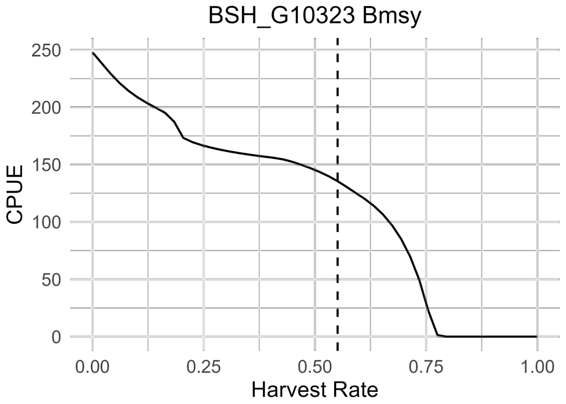


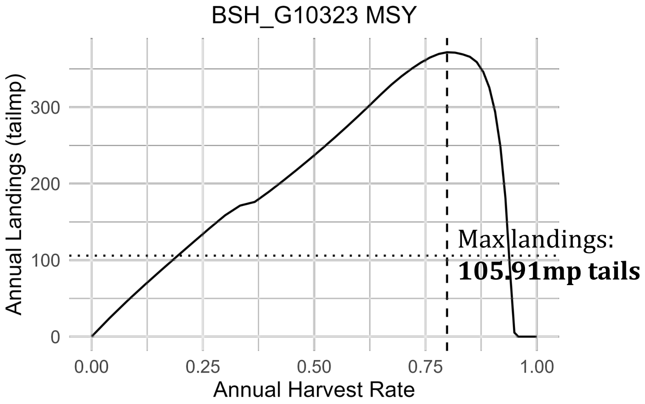
Max landings throughout time series were observed in 1990: **105.91mp tails**





MSY is added across populations





MSY for Smedium is observed at a harvest rate where no Large shrimp are left

Max landings throughout time series were observed in 1990: **105.91mp tails**

NOAA FISHERIES

Model Diagnostics: Retrospective Analysis

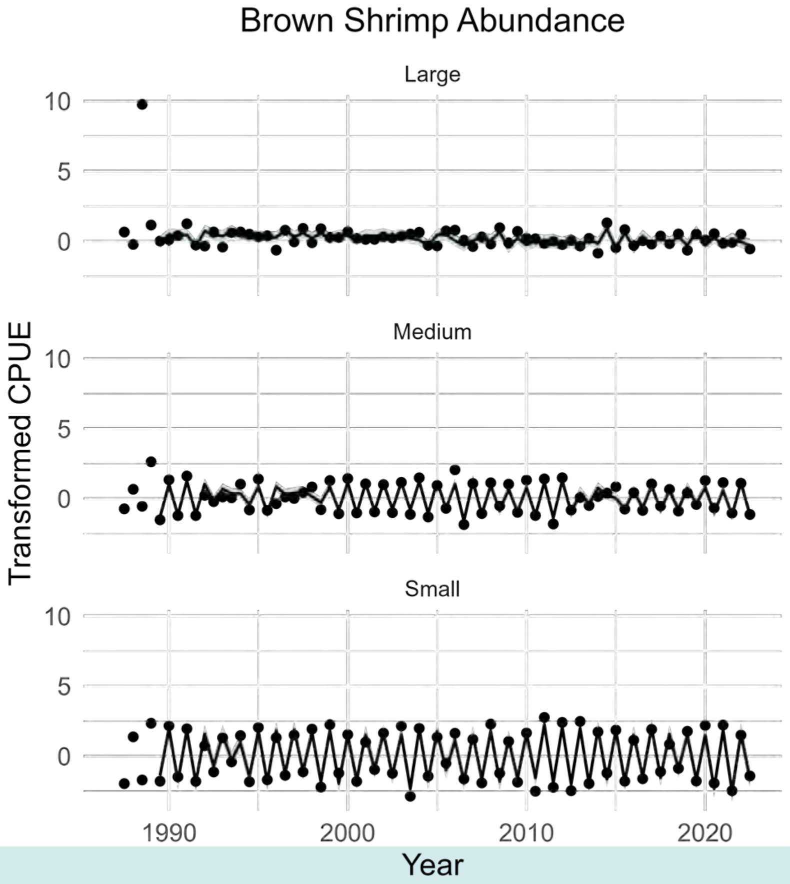
Run	MSY	BMSY_mp	MSY_factor
BSH_G20023_0	215.07	405.39	2.03
BSH_G20023_1	217.66	410.20	2.06
BSH_G20023_2	219.29	383.76	2.07
BSH_G20023_3	233.54	357.61	2.21
BSH_G20023_4	228.08	349.24	2.15
BSH_G20023_5	232.40	379.59	2.19

Top line is MSY estimate from terminal year 2022

_1 means 1 time step peeled back and so forth

Stable model with no apparent retrospective bias

Size-structured (Large, Medium, Small), shared catchability, seasonal time steps, E=5, ytransformation gr2 ($\log(y_t/(y_{t-1} - qC_{t-1}))$) [G20023]



Population	SIZE
Lags	**5**
R2	**0.729**
R2_out	**0.485**
R2_outscaled	**0.365**
R2pop_out_Large	0.345
R2pop_out_Medium	0.331
R2pop_out_Small	0.415
df	28.529
Catchability, *q*	0.402
Dynamic correlation, *ρ*	0.957
Pointwise Prior Variance	0.689
Process Variance	0.103

NOAA FISHERIES

BROWN SHRIMP EDM SUMMARY

- Size structured model (Large, Medium, Small), shared catchability, seasonal time steps, E=5, y transformation gr2 ($\log(y_t/(y_{t-1} - qC_{t-1}))$) [G20023]
- Robust model that captures brown shrimp dynamics
- Provides stable estimates of maximum sustainable yield
  - MSY: 215.07 million pounds of tails
  - U_{MSY}: 0.460 B_{MSY}: 405.39 million pounds of tails
  - U_{2022}: 0.018 B_{2022}: 1,716.53 million pounds of tails
  - U_{2022}/U_{MSY}: 0.039 B_{2022}/B_{MSY}: 4.23

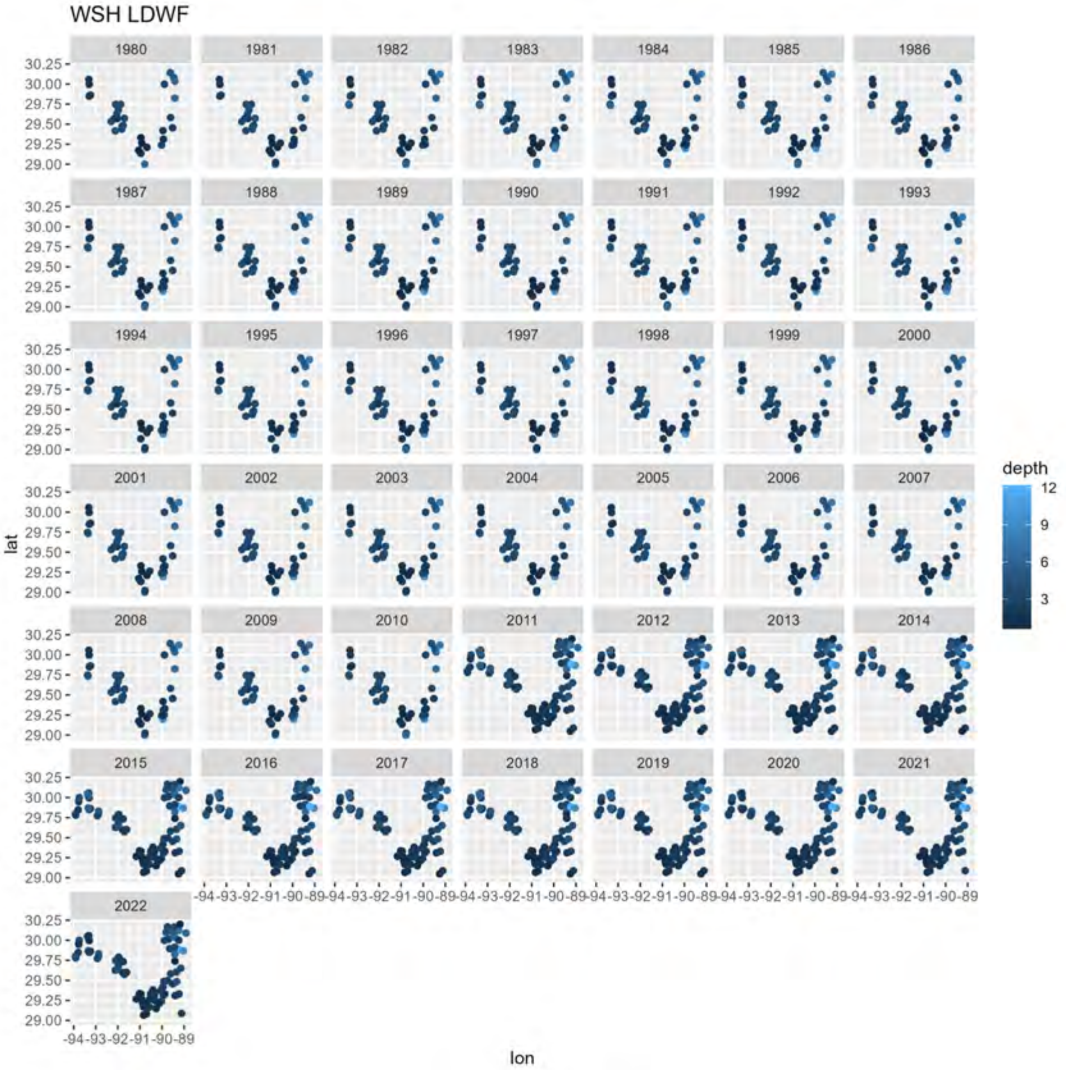
NOAA FISHERIES

WHITE SHRIMP

VAST index

VAST - Motivation

- Develop an index of relative abundance that can control for some of the survey's early changes in spatial footprint
- Testing impact of Nursery Conditions



WHITE SHRIMP INDEX RECOMMENDATIONS

White Shrimp

LDWF

1980-2022

Delta-lognormal

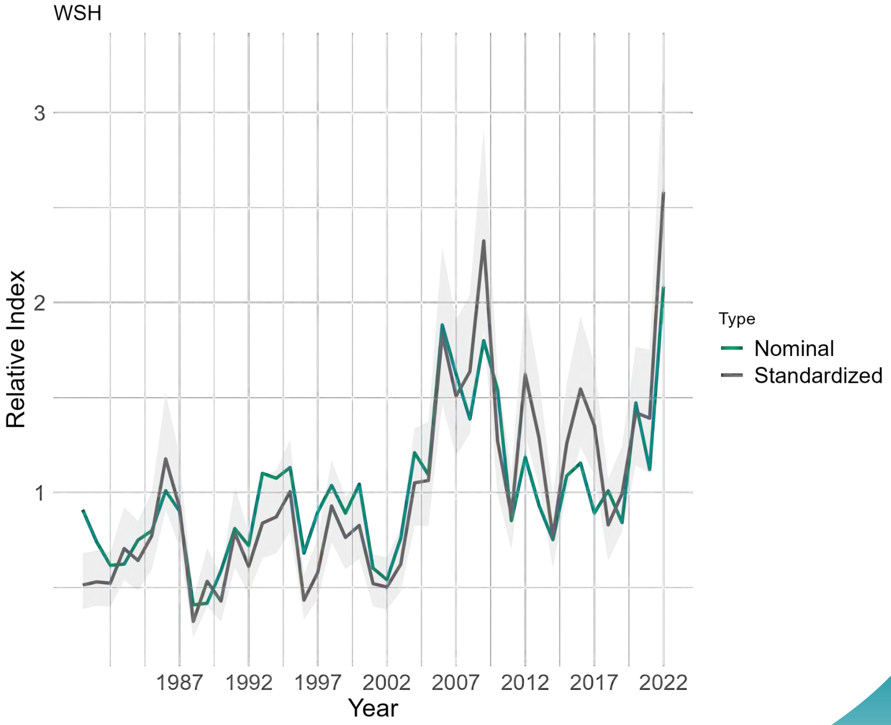
Numbers per tow

Spatial and spatiotemporal RE (anisotropy)

Catchability covariates :

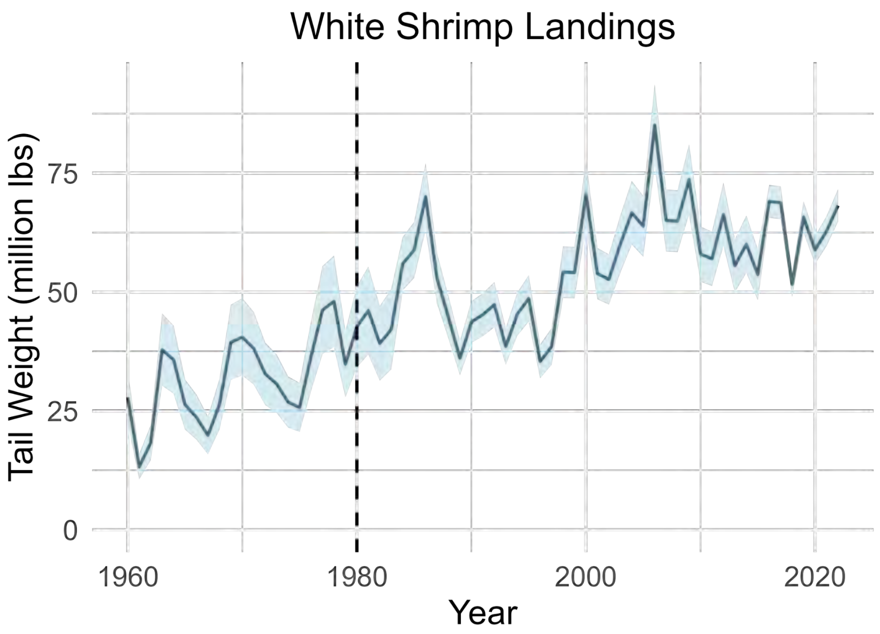
- Month

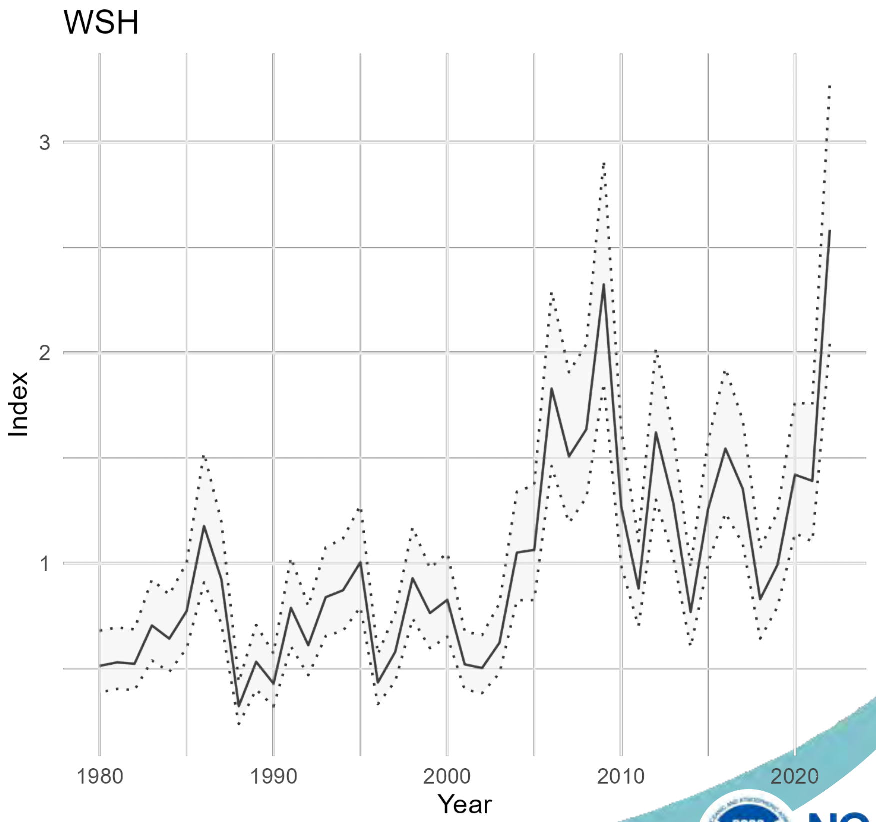
Index recommend for input into JABBA.



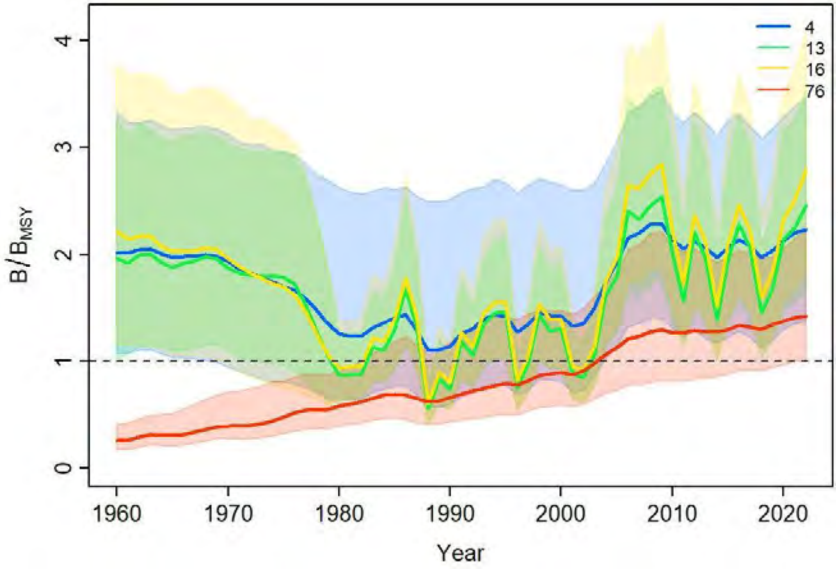
JABBA

Data - White Shrimp





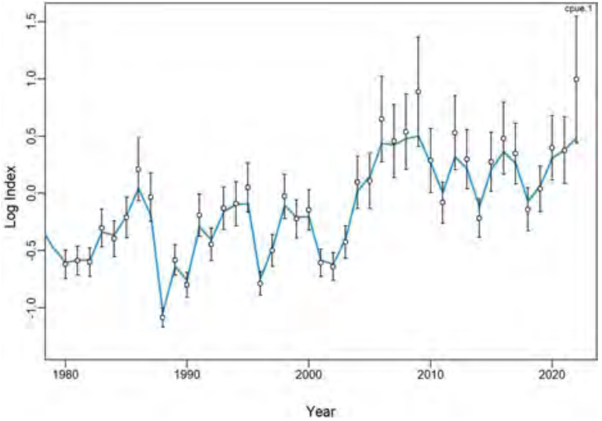
White Shrimp Results

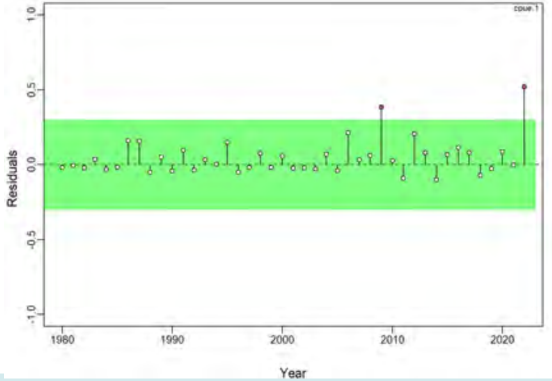


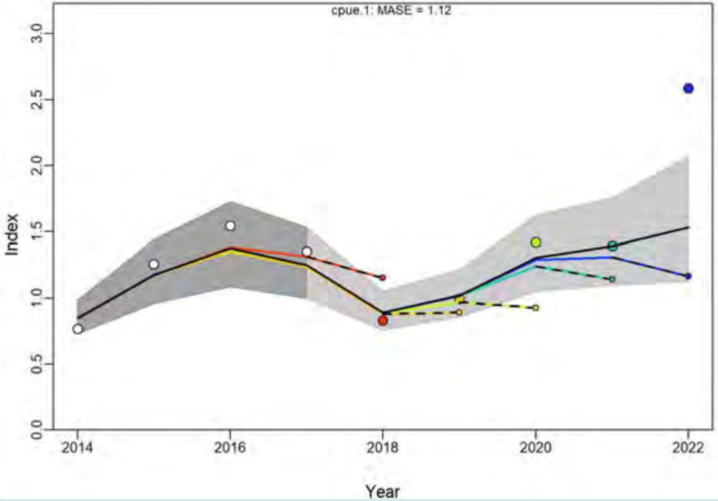
Run	Description
16	Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.
13	Sigma Estimation FALSE. R prior High range. Prior distribution for psi lnorm with mean 0.9.
4	Sigma Estimation TRUE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.
76	Sigma Estimation TRUE. R prior Medium range. Prior distribution for psi lnorm with mean 0.25.

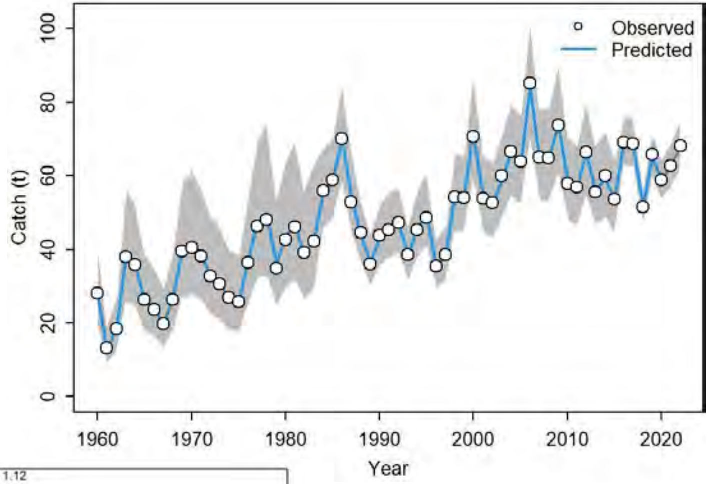
White Shrimp - Example run

16 Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.







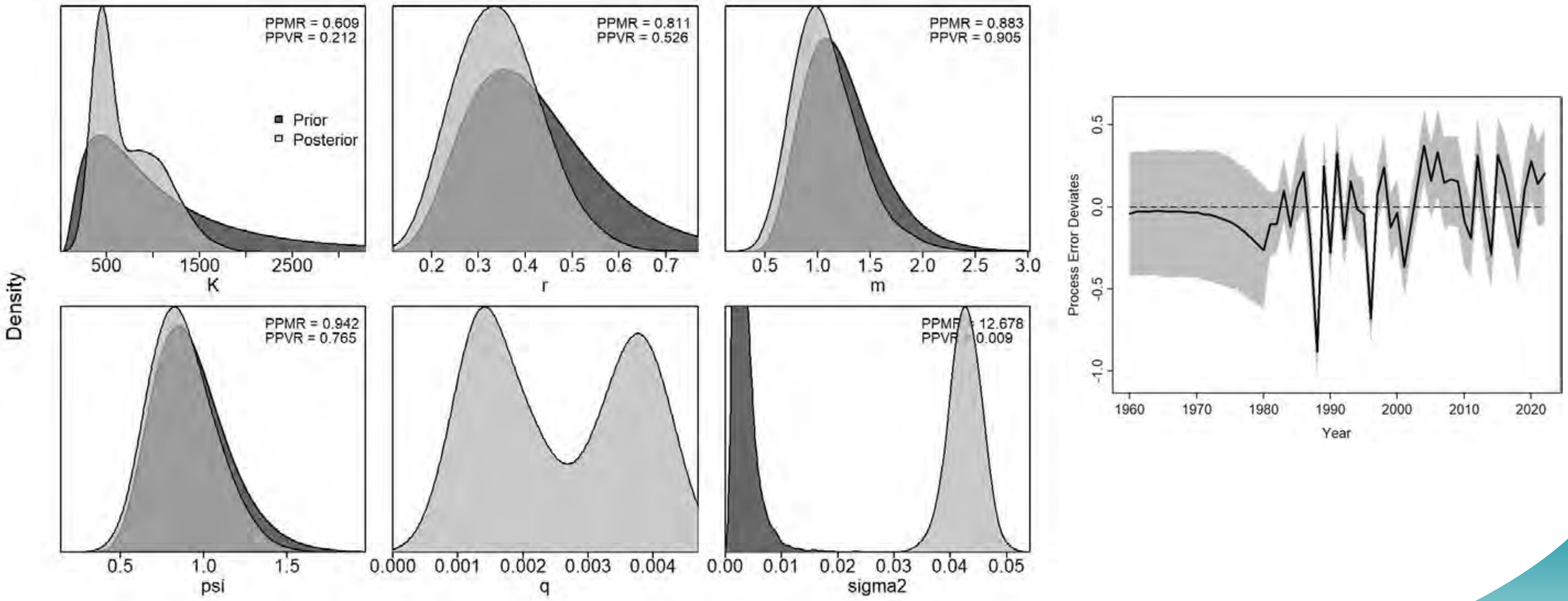


 U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

NOAA FISHERIES

Priors, Posteriors and Process Error

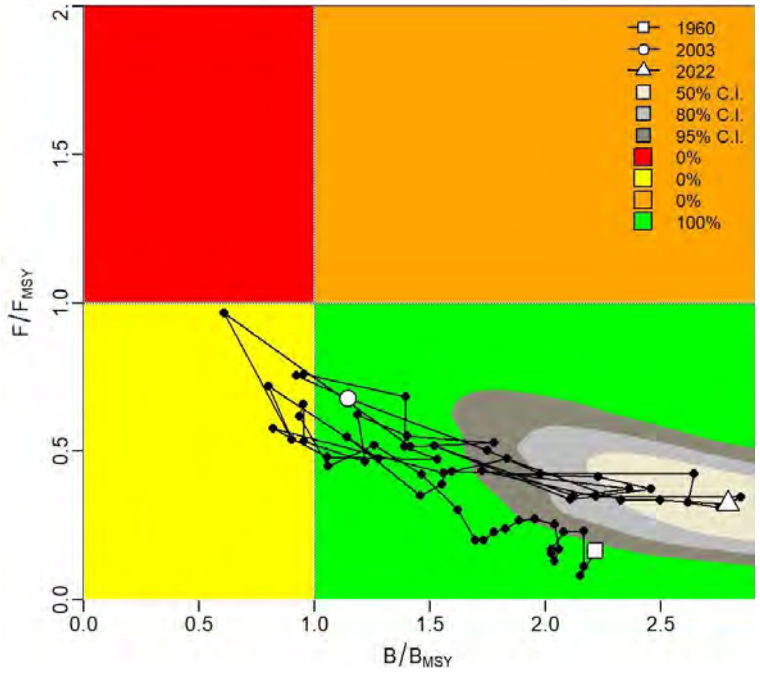
16 Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.

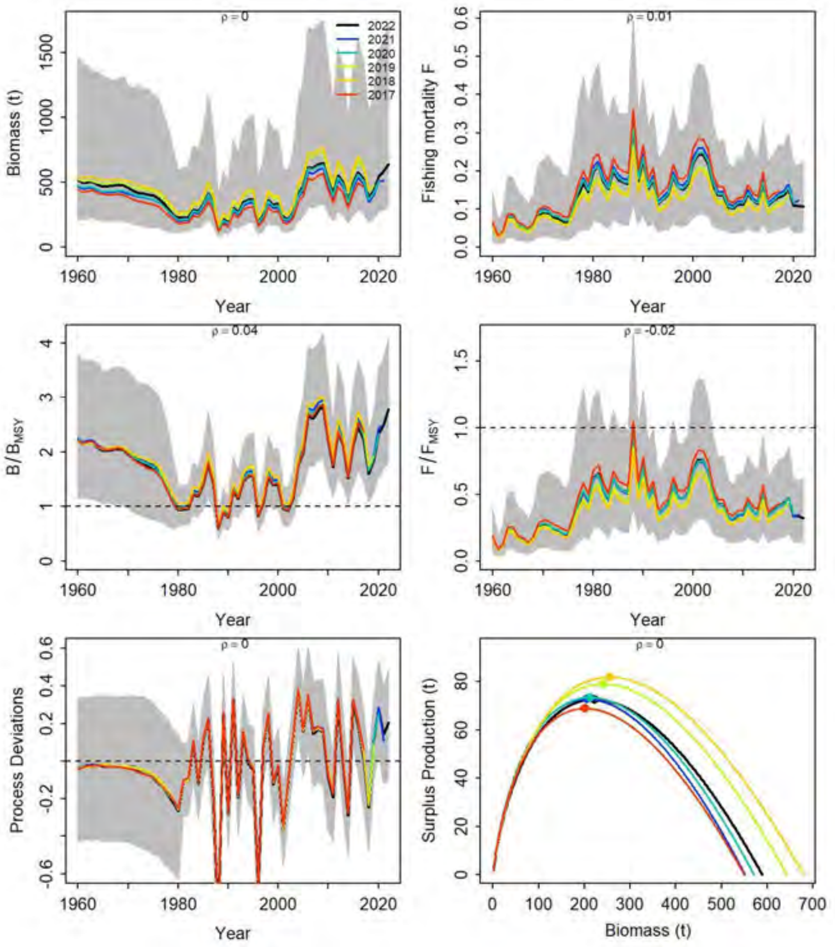


NOAA FISHERIES

Retrospective Analysis & Kobe Plot

16 Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9



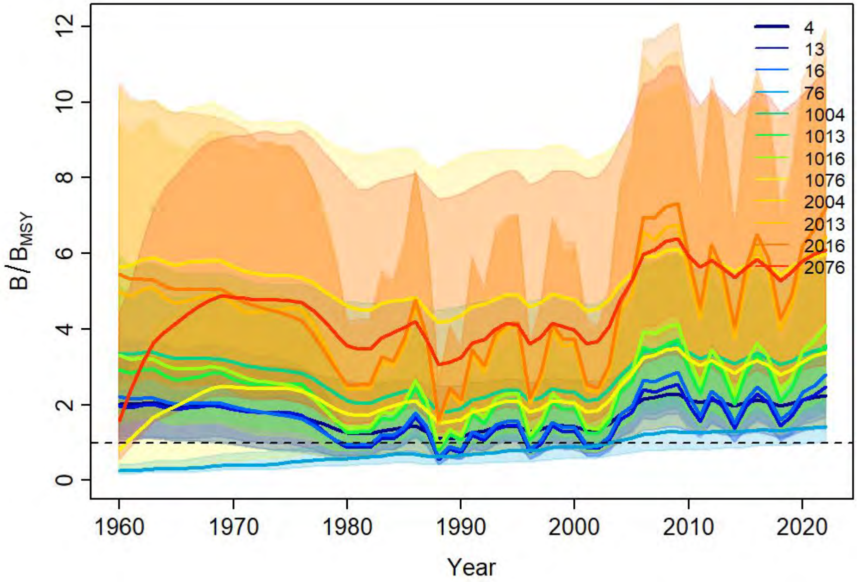


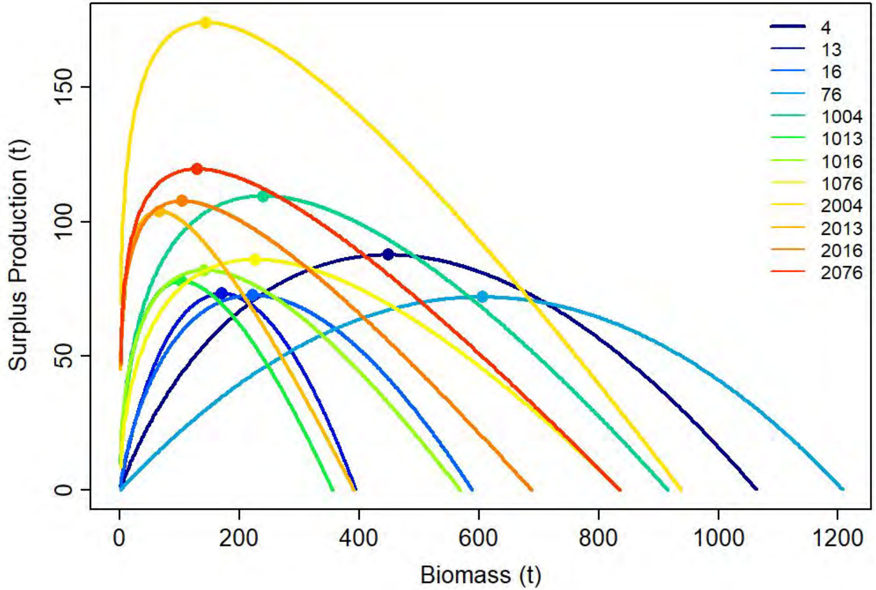
NOAA FISHERIES

White Shrimp Model Diagnostics

		Model Convergence			Model Fit		Model Consistency				Process Error	Prediction Skill		
	run	CONV_gw	CONV_hw	CONV_hs	CPUE_rt_rand	CPUE_rt_outl	RETRO_B	RETRO_F	RETRO_B.Bmsy	RETRO_F.Fmsy	ProcB_CI	HX_MASE	DIC	B/K=
AW	WSH_13_P_rH_psil0.9_sigF_60	FAIL	PASS	PASS	PASS	FAIL	-0.05	0.08	0.01	0.04	FAIL	1.13	-514.90	.40
	WSH_16_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.00	0.01	0.04	-0.02	FAIL	1.12	-518.50	
	WSH_4_P_rM_psil0.9_sigT_60	FAIL	PASS	PASS	PASS	PASS	-0.05	0.09	-0.02	-0.03	PASS	1.17	-369.70	
	WSH_76_P_rM_psil0.2_sigT_60	PASS	PASS	PASS	PASS	PASS	0.01	0.00	0.21	-0.16	PASS	1.10	-462.50	
RW	WSH_1013_P_rH_psil0.9_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.08	0.10	0.03	0.00	FAIL	1.18	-520.80	.25
	WSH_1016_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.10	0.16	0.03	0.02	FAIL	1.15	-519.80	
	WSH_1004_P_rM_psil0.9_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.45	-0.26	0.10	-0.47	PASS	1.28	-286.90	
	WSH_1076_P_rM_psil0.2_sigT_60	FAIL	PASS	PASS	PASS	PASS	0.39	-0.25	0.11	-0.46	PASS	1.24	-406.30	
	WSH_2013_P_rH_psil0.9_sigF_60	FAIL	PASS	PASS	PASS	FAIL	-0.12	0.15	-0.00	0.08	FAIL	1.23	-520.40	.15
	WSH_2016_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	FAIL	-0.23	0.33	-0.02	0.21	FAIL	1.15	-522.00	
	WSH_2004_P_rM_psil0.9_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.12	-0.10	0.01	-0.16	PASS	1.28	-285.40	
	WSH_2076_P_rM_psil0.2_sigT_60	PASS	PASS	PASS	PASS	FAIL	0.46	-0.28	0.04	-0.43	PASS	1.29	-374.30	

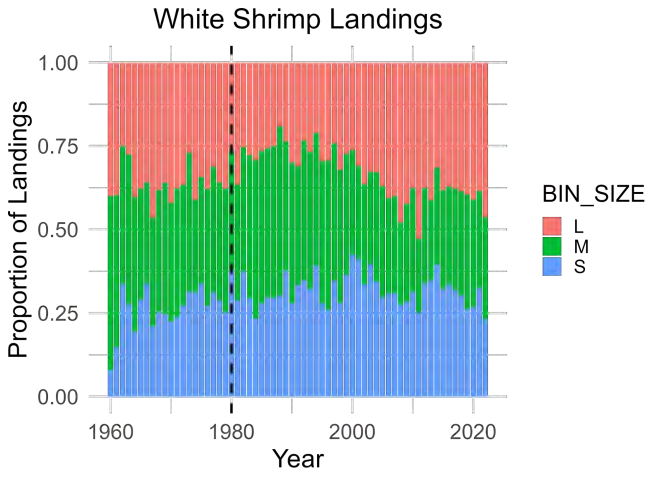
White Shrimp Summary Results





WHITE SHRIMP JABBA SUMMARY

- Similar weaknesses as raised with Brown Shrimp (main assumptions likely violated)
- Non-informative catch rates (CPUE and catches follow same trends)
- Poor diagnostics
    - Sensitive to initial depletion prior
    - Low information (not much departure from priors)
    - Poor prediction skill for the index
- Status of population throughout entire time series is highly sensitive to assumptions on m



Recommendation

- JABBA **not recommended** for White Shrimp

EDM

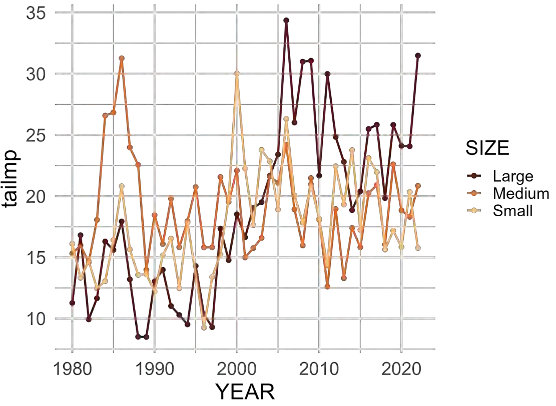
White Shrimp EDM Construction

- White shrimp
  - LA Index, 1980-2022, Quadrimester
    - $E \leq \sqrt{T}$, annual model T=43, $E \leq$6-7 (up to 5-6 lags)
    - T = 43yrs * 3 quadrimesters = 129, E≤11-12, not limited by embedding dimension

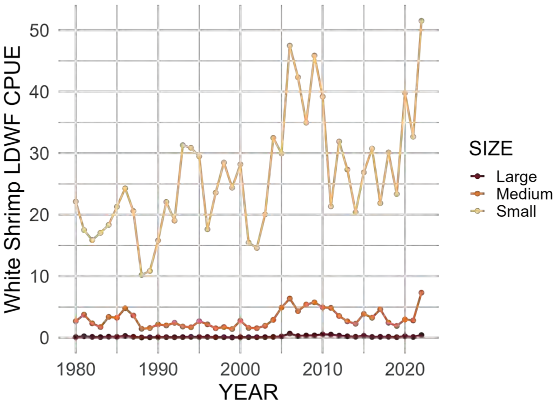
White Shrimp

- Transformed CPUE
  - log: $\log(y_t)$
  - gr1: $\log(y_t/y_{t-1})$
  - gr2: $\log(y_t/(y_{t-1} - qC_{t-1}))$

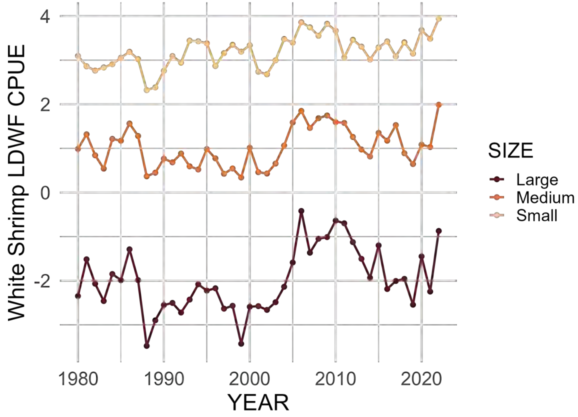
Landings

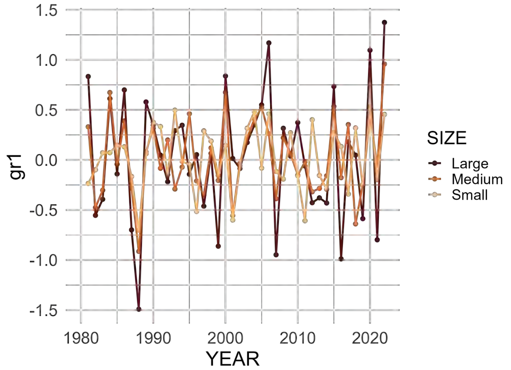


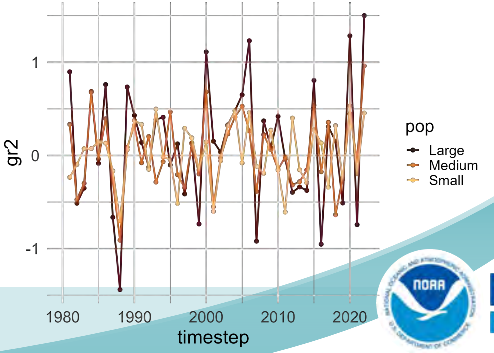
CPUE



↓ log transformed







Constant catchability among populations in hierarchical model may pose a problem for ytrans = none, log

e.g. "Small" is most abundant, but not highest in landings

NOAA FISHERIES

Top Performing Model Runs

Run	Stratum	Pop	E	ytrans	Catchability	LinPrior	rho	R2	R2_out	R2_outscaled	ProcessVar	PriorVar
WSH_C3412	C	SIZE	5	none	Distinct	Yes	0.85	0.949	0.868	0.336	0.642	0.557
WSH_C20072	C	SIZE	6	none	Shared	Yes	0.59	0.944	0.87	0.327	0.714	0.455
WSH_C3368	C	SIZE	3	none	Distinct	Yes	0.74	0.907	0.869	0.301	0.863	0.252
WSH_C3896	C	SIZE	3	gr1	Distinct	Yes	0.6	0.884	0.87	0.298	0.971	0.074
WSH_C3940	C	SIZE	5	gr1	Distinct	Yes	0.76	0.917	0.867	0.298	0.806	0.27
WSH_C2840	C	SIZE	3	gr1	Shared	Yes	0.62	0.885	0.869	0.296	0.967	0.078
WSH_C20120	C	SIZE	6	gr1	Distinct	Yes	0.75	0.914	0.865	0.293	0.834	0.268
WSH_C2862	C	SIZE	4	gr1	Shared	Yes	0.62	0.886	0.867	0.292	0.965	0.089
WSH_C3126	C	SIZE	4	gr2	Shared	Yes	0.62	0.886	0.868	0.279	0.97	0.085
WSH_C3104	C	SIZE	3	gr2	Shared	Yes	0.63	0.885	0.868	0.278	0.969	0.083
WSH_C3148	C	SIZE	5	gr2	Shared	Yes	0.75	0.915	0.865	0.278	0.799	0.274
WSH_C20096	C	SIZE	6	gr2	Shared	Yes	0.74	0.913	0.863	0.273	0.83	0.27
WSH_C244	C	SIZE	5	none	Shared	None	0.95	0.882	0.854	0.245	0.717	1.039
WSH_C20008	C	SIZE	6	none	Shared	None	0.95	0.881	0.847	0.227	0.742	1.037
WSH_C3676	C	SIZE	5	log	Distinct	Yes	0.8	0.922	0.861	0.221	0.748	0.357
WSH_C728	C	SIZE	3	gr1	Shared	None	0.89	0.88	0.865	0.216	0.868	0.448
WSH_C20112	C	SIZE	6	log	Distinct	Yes	0.8	0.922	0.857	0.215	0.755	0.377
WSH_C20128	C	SIZE	6	gr2	Distinct	Yes	0.87	0.895	0.857	0.211	0.828	0.337
WSH_C1828	C	SIZE	5	gr1	Distinct	None	0.87	0.929	0.859	0.203	0.668	0.437
WSH_C1806	C	SIZE	4	gr1	Distinct	None	0.9	0.878	0.863	0.202	0.881	0.487
WSH_C1784	C	SIZE	3	gr1	Distinct	None	0.89	0.879	0.863	0.199	0.869	0.393
WSH_C750	C	SIZE	4	gr1	Shared	None	0.89	0.879	0.863	0.197	0.876	0.463
WSH_C20056	C	SIZE	6	gr1	Distinct	None	0.86	0.927	0.855	0.191	0.689	0.44
WSH_C772	C	SIZE	5	gr1	Shared	None	0.85	0.917	0.852	0.191	0.703	0.391
WSH_C20024	C	SIZE	6	gr1	Shared	None	0.84	0.914	0.848	0.178	0.731	0.386
WSH_C4182	C	SIZE	4	gr2	Distinct	Yes	0.86	0.887	0.856	0.174	0.821	0.416
WSH_C4160	C	SIZE	3	gr2	Distinct	Yes	0.87	0.882	0.857	0.17	0.829	0.502
WSH_C992	C	SIZE	3	gr2	Shared	None	0.89	0.879	0.861	0.057	0.828	0.466
WSH_C1014	C	SIZE	4	gr2	Shared	None	0.89	0.879	0.86	0.044	0.833	0.484
WSH_C1036	C	SIZE	5	gr2	Shared	None	0.89	0.897	0.849	0.008	0.742	0.401

Filtered by Strata C

30 out of top 59 models

Linear Prior, Distinct Catchability preferred

Top 2 Model Runs boxed (e.g. passed MSY checks)

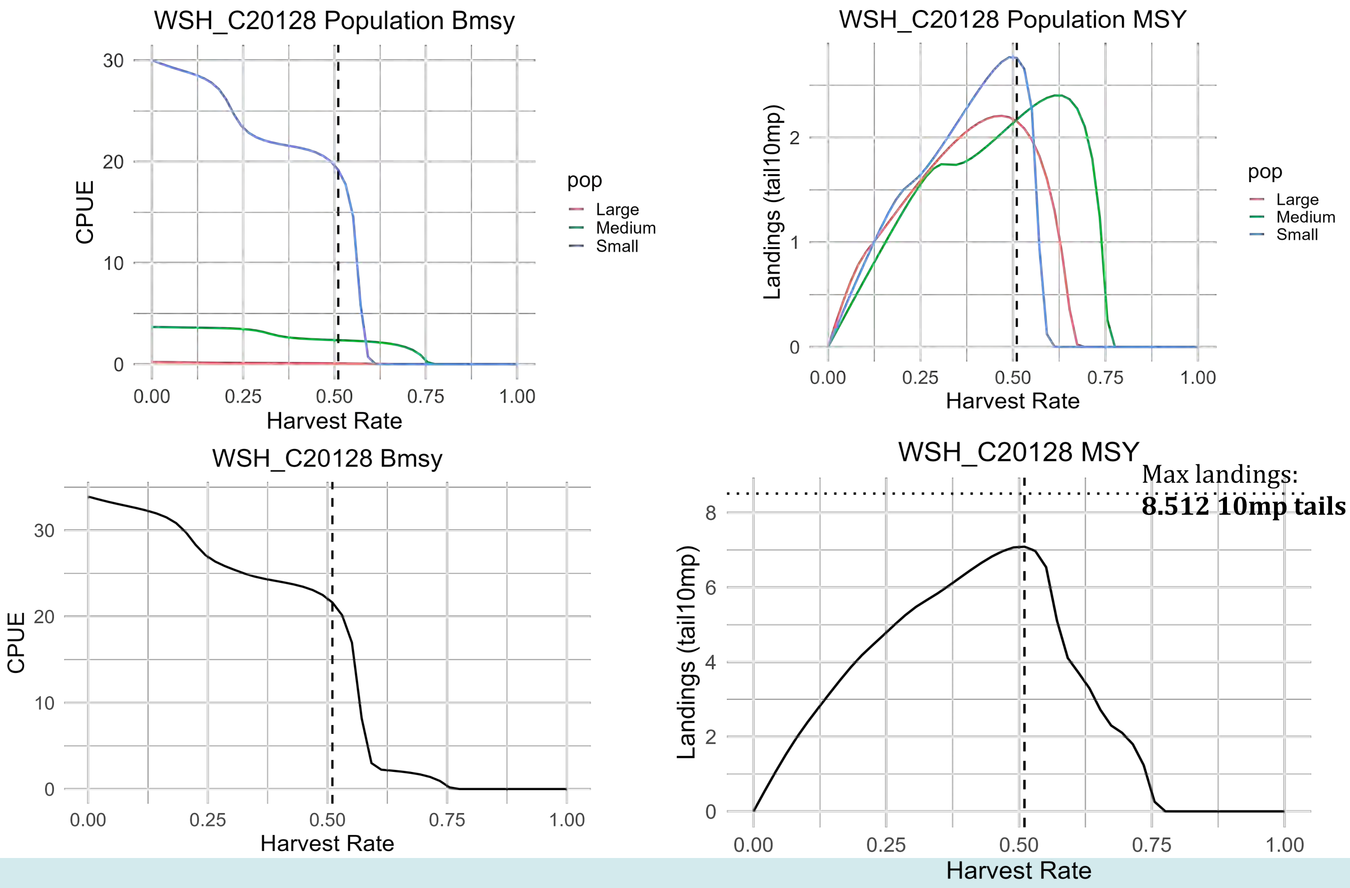
Top Performing Models

- **Size-structured** (Large, Medium, Small), separately estimated catchability, **annual** time steps, **E=6**, y transformation **gr2** ($\log(y_t/(y_{t-1} - qC_{t-1}))$), linear prior [C20128]
- **Size-structured** (Large, Medium, Small), separately estimated catchability, **annual** time steps, **E=4**, y transformation **gr2** ($\log(y_t/(y_{t-1} - qC_{t-1}))$), linear prior [C4182]
- Models have identical parameterizations, except for **complexity** in the embedding dimension

Linear Prior

- Assumes a relationship between biomass and harvest rate
- The model returns to the mean of the prior outside of the range of the data, which can be nonsensical for harvest rate simulations
- Can aid in grounding the population to 0 as the harvest rate, $\boldsymbol{U}$, approaches 1 (i.e. the entire population is harvested)
- Introduces more biological realism where we don’t have data to inform the model

Size-structured (Large, Medium, Small), separately estimated catchability, annual time steps, E=6, y transformation gr2 (log(yt/(yt-1 - qCt-1)), linear prior [C20128]

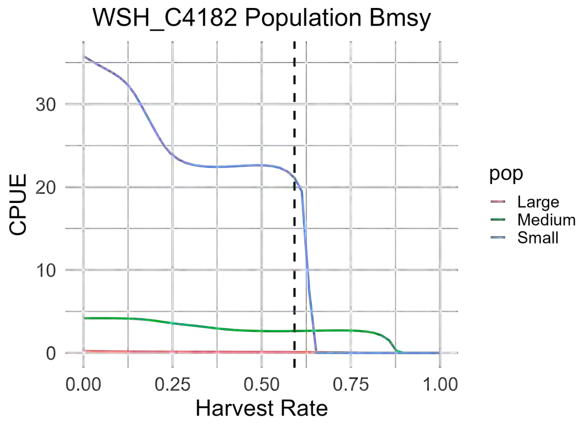


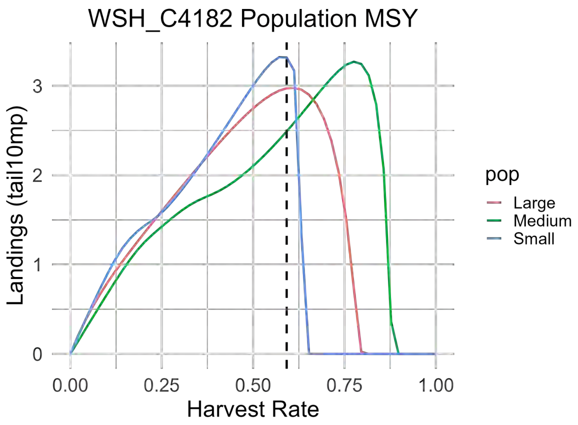
MSY is added across populations

More complex (larger embedding dimension) compared to similarly performing model

MSY estimate 70.9mp tails is less than the max landings observed in 2006, 85.12mp tails

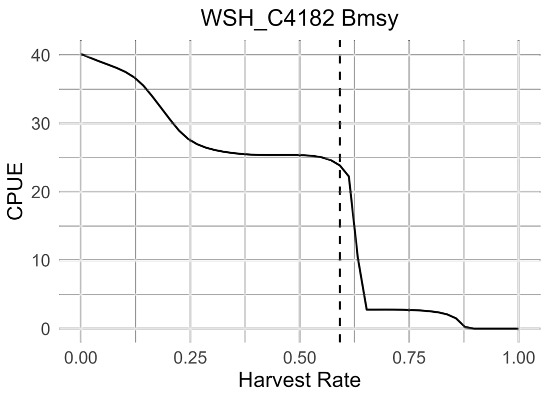
Size-structured (Large, Medium, Small), separately estimated catchability, annual time steps, E=4, y transformation gr2 (log(yt/(yt-1 - qCt-1)), linear prior [C4182]

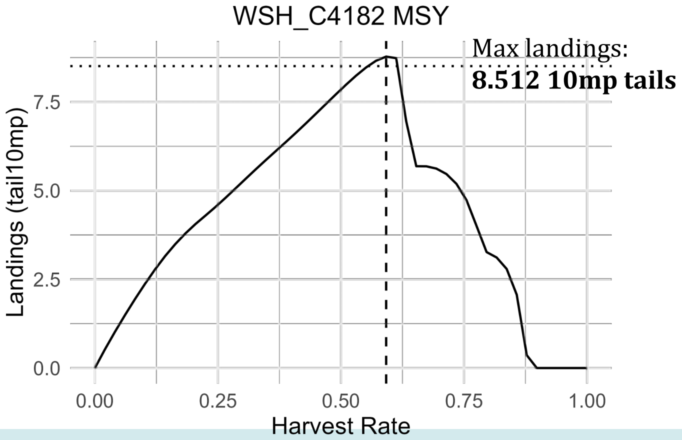




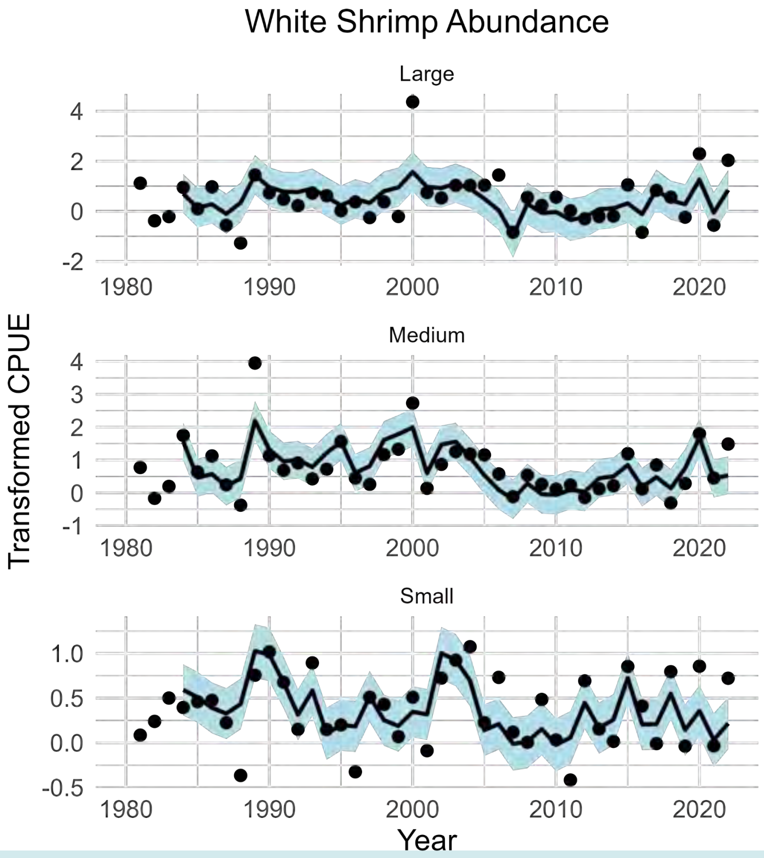
MSY is added across populations

Statistic	WSH_C4182
MSY_10mptails	8.780
Fmsy	0.896
Umsy_annual	0.592
Bmsy_10mp	14.835
df	9.579
R2	0.887
R2Scaled	0.312
R2_outsample	0.856
R2Scaled_outsample	0.174





Size-structured (Large, Medium, Small), separately estimated catchability, annual time steps, E=4, y transformation gr2 ($\log(y_t/(y_{t-1} - qC_{t-1}))$), linear prior [C4182]



Parameter	WSH_C4182
CatchabilityLarge	0.021
CatchabilityMedium	0.627
CatchabilitySmall	3.767
DynamicCorrelation	0.864
LengthScale1	1.216
LengthScale2	0.039
LengthScale3	0.000
LengthScale4	0.000
PointwisePriorVariance	0.416
ProcessVariance	0.821

Model Diagnostics: Retrospective Analysis

Run	MSY	BMSY_mp	MSY_factor
WSH_C4182_0	8.78	14.84	1.03
WSH_C4182_1	9.05	11.37	1.06
WSH_C4182_2	8.91	14.55	1.05
WSH_C4182_3	8.62	11.12	1.01
WSH_C4182_4	8.66	11.16	1.02
WSH_C4182_5	8.85	11.11	1.04

Top line is MSY estimate from terminal year 2022

_1 means 1 time step peeled back (e.g. data through 2021) and so forth

Stable model with no apparent retrospective bias

Max landings were observed in 2006:
85.12mp tails (**8.512 tail10mp**)

WHITE SHRIMP EDM SUMMARY

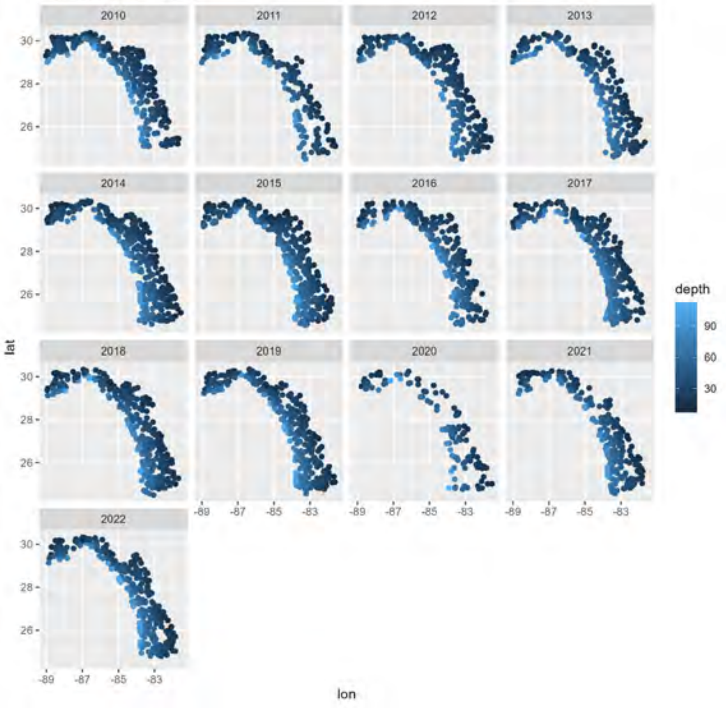
- Size-structured (Large, Medium, Small), separately estimated catchability, annual time steps, E=4, y transformation gr2 ($\log(y_t/(y_{t-1} - qC_{t-1}))$), linear prior [C4182]
  - Similar parameterization as next best model, but smaller embedding dimension and fewer degrees of freedom
- Robust model that captures white shrimp dynamics
- Provides stable estimates of maximum sustainable yield
  - MSY: 87.80 million pounds of tails
  - U_{MSY}: 0.592 B_{MSY}: 148.35 million pounds of tails
  - U_{2022}: 0.123 B_{2022}: 449.9 million pounds of tails
  - U_{2022}/U_{MSY}: 0.209 B_{2022}/B_{MSY}: 2.48

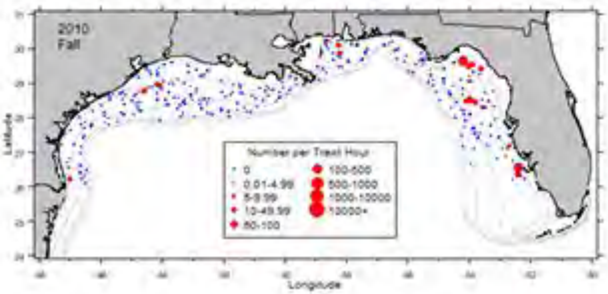
PINK SHRIMP

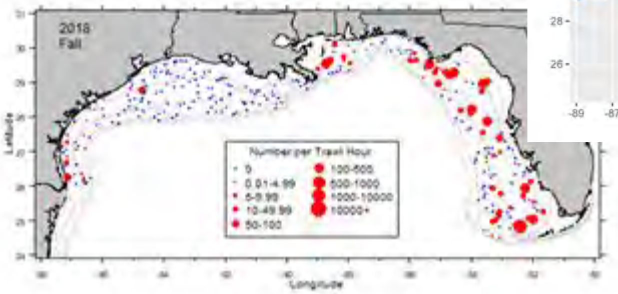
VAST index

VAST - Motivation

- Develop an index of relative abundance that can control for some of the survey's early changes in spatial footprint
- Testing impact of nursery conditions







PINK SHRIMP INDEX RECOMMENDATIONS

Pink Shrimp
SEAMAP (summer and fall)

2010-2022

SSZ 2-10

Zero-inflated negative binomial

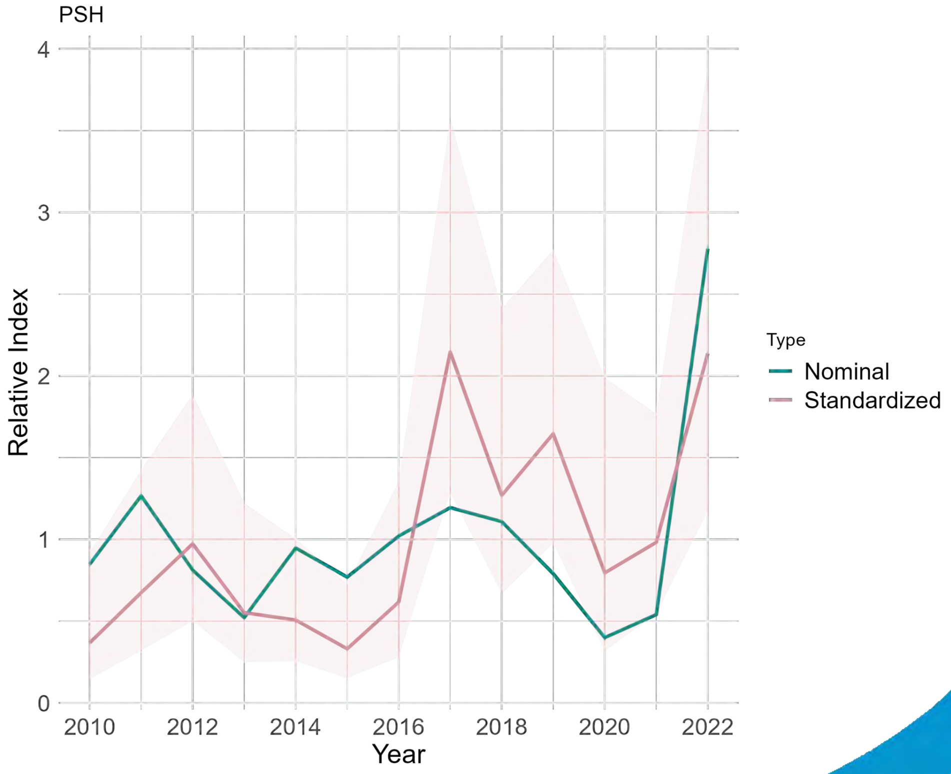
Numbers per tow

Spatial RE (anisotropy)

(no spatiotemporal RE)

Catchability covariate: time of day

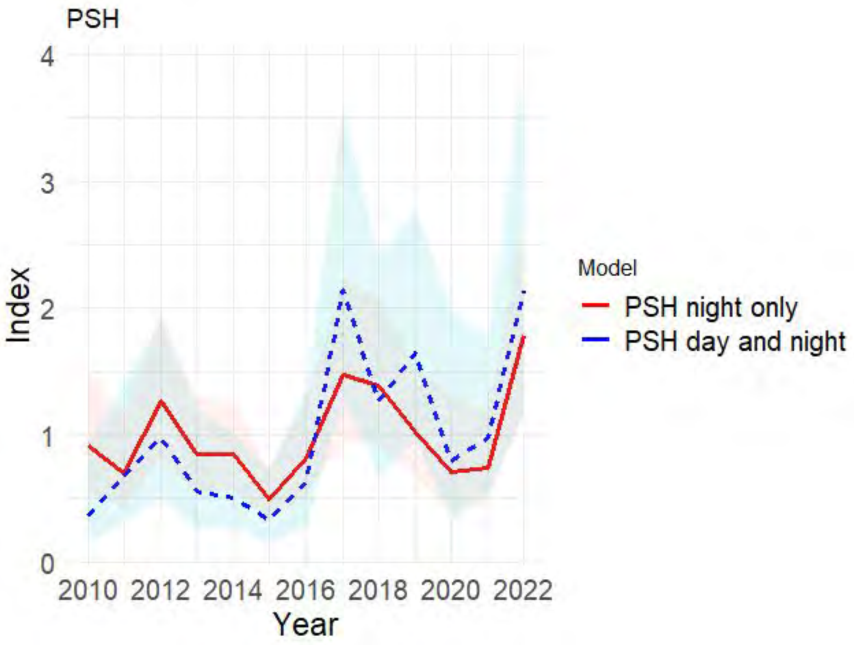
Index used for input into JABBA.



Feedback from Reviewers Addressed During Process

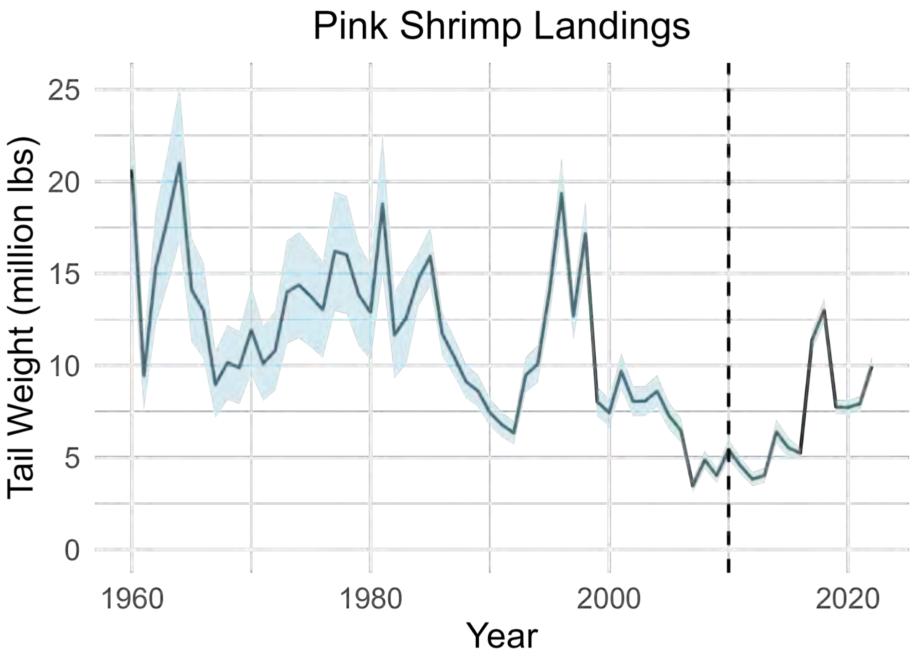
Removing day trawls from dataset will reduce proportion of zeros and likely result in a more precise standardized index of abundance

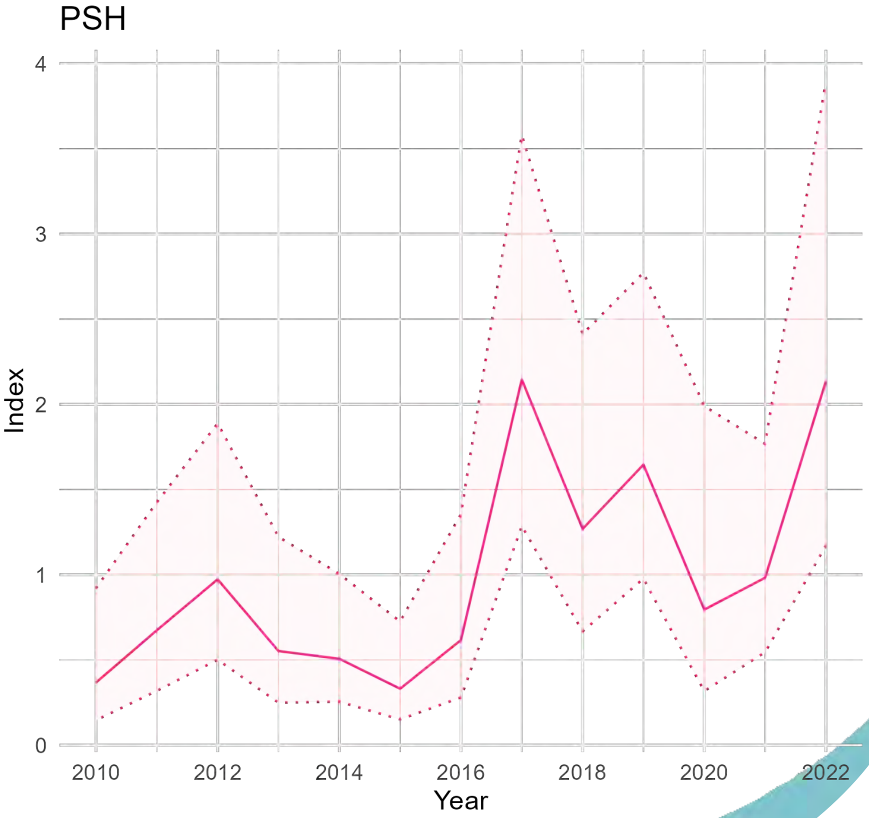
- Analyses were rerun with night only samples and resulted in a more precise index
- JABBA was not updated since not recommended for providing management advice.



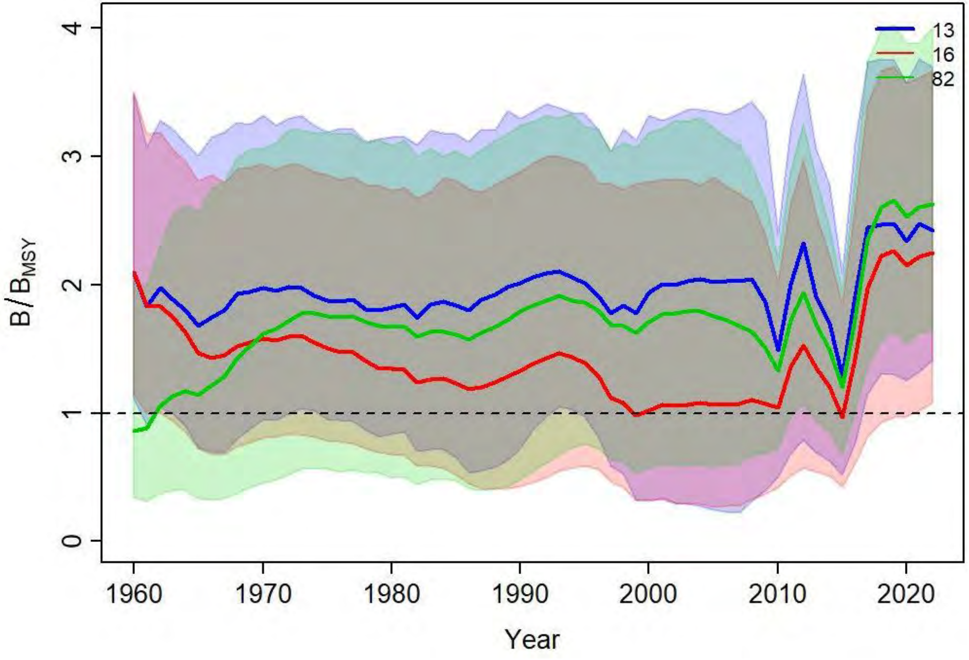
JABBA

Data - Pink Shrimp





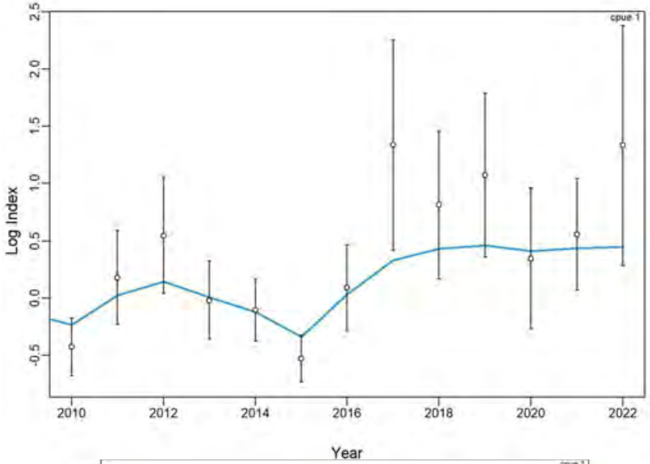
Pink Shrimp Results

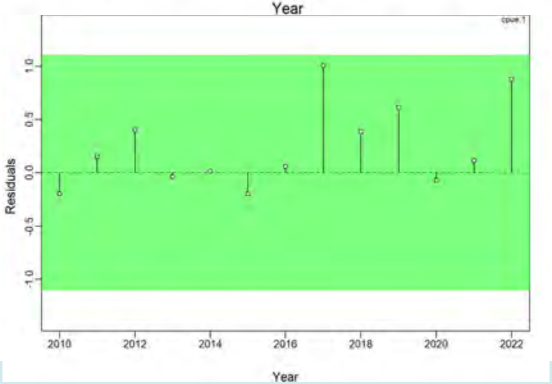


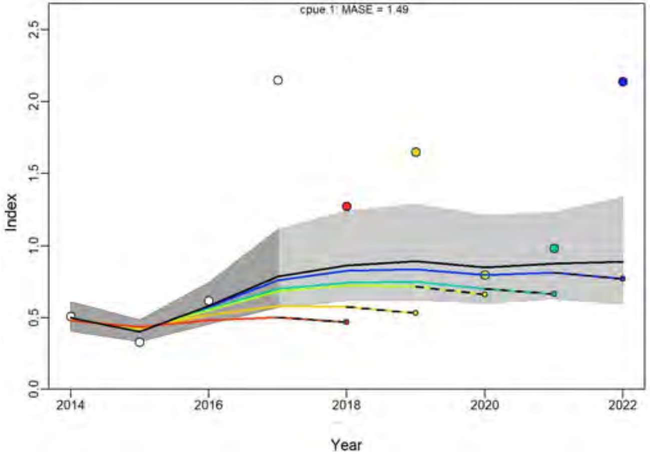
Run	Description
13	Sigma Estimation FALSE. R prior High range. Prior distribution for psi lnorm with mean 0.9.
16	Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.9.
82	Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.25.

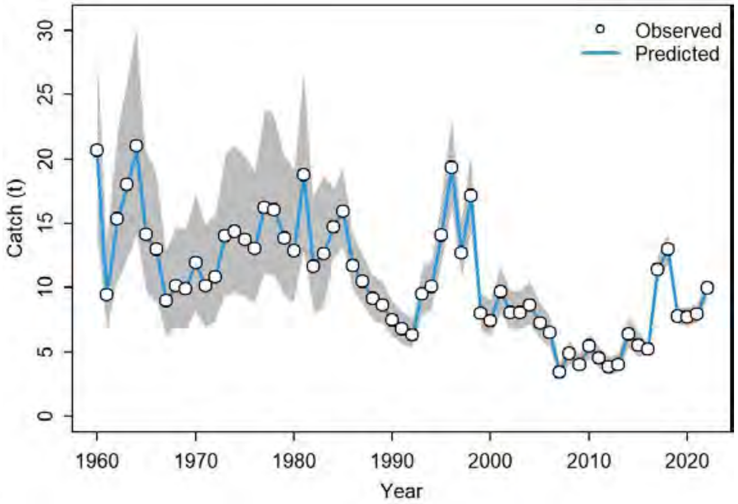
Pink Shrimp - Example run

82 Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.25.







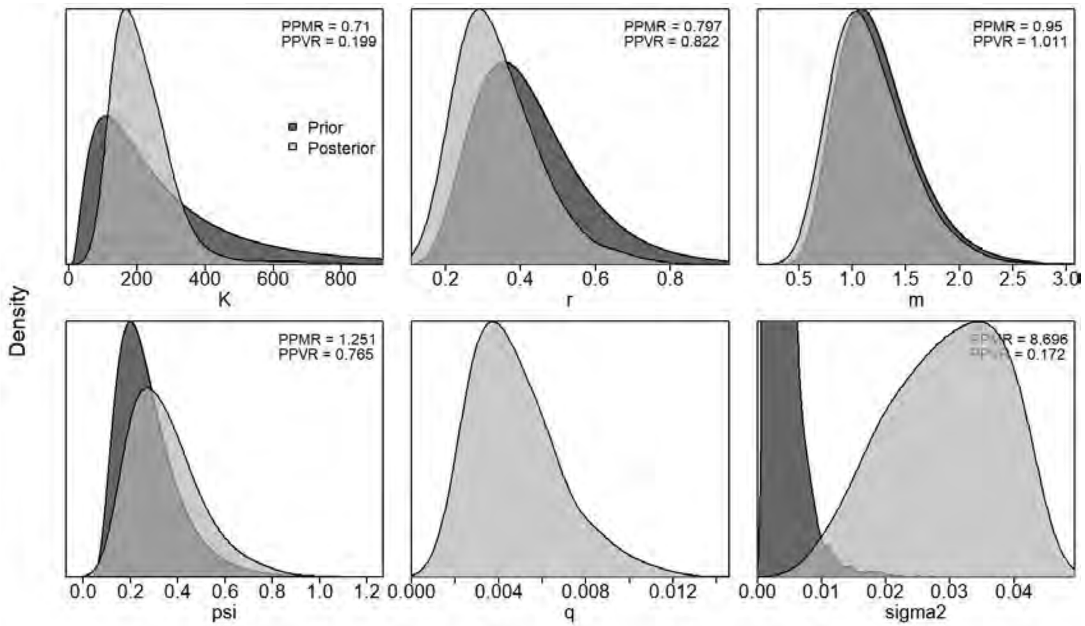


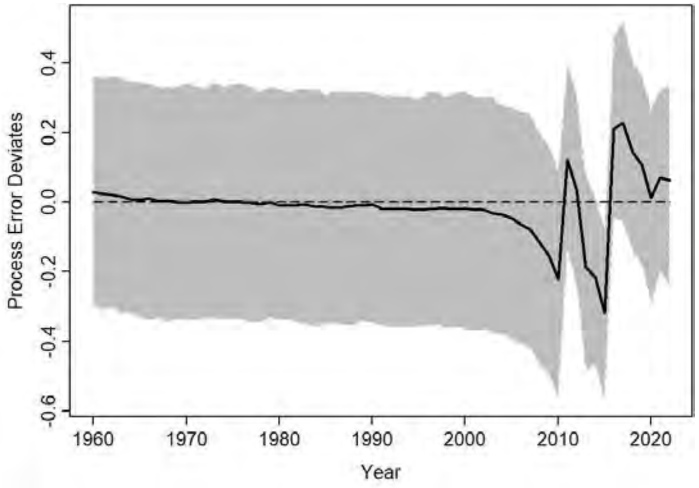
 U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

NOAA FISHERIES

Priors, Posteriors and Process Error

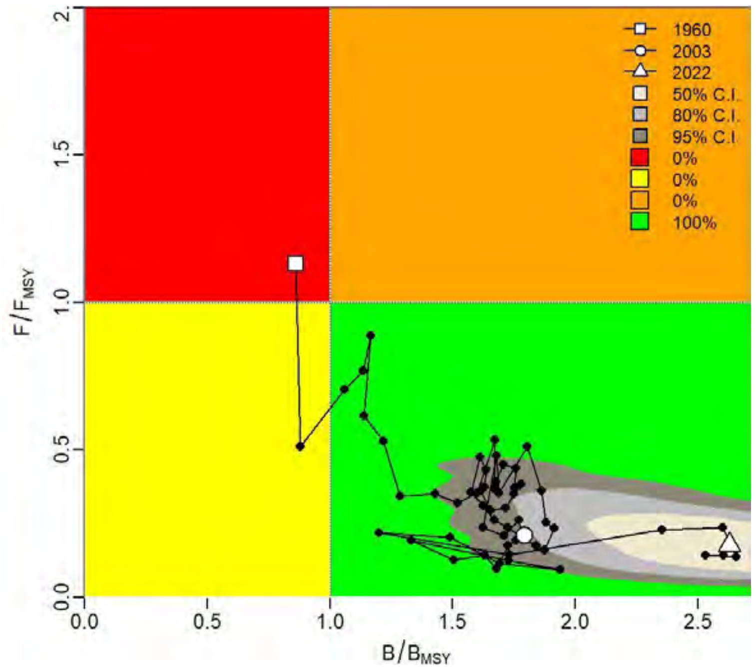
82 Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.25.

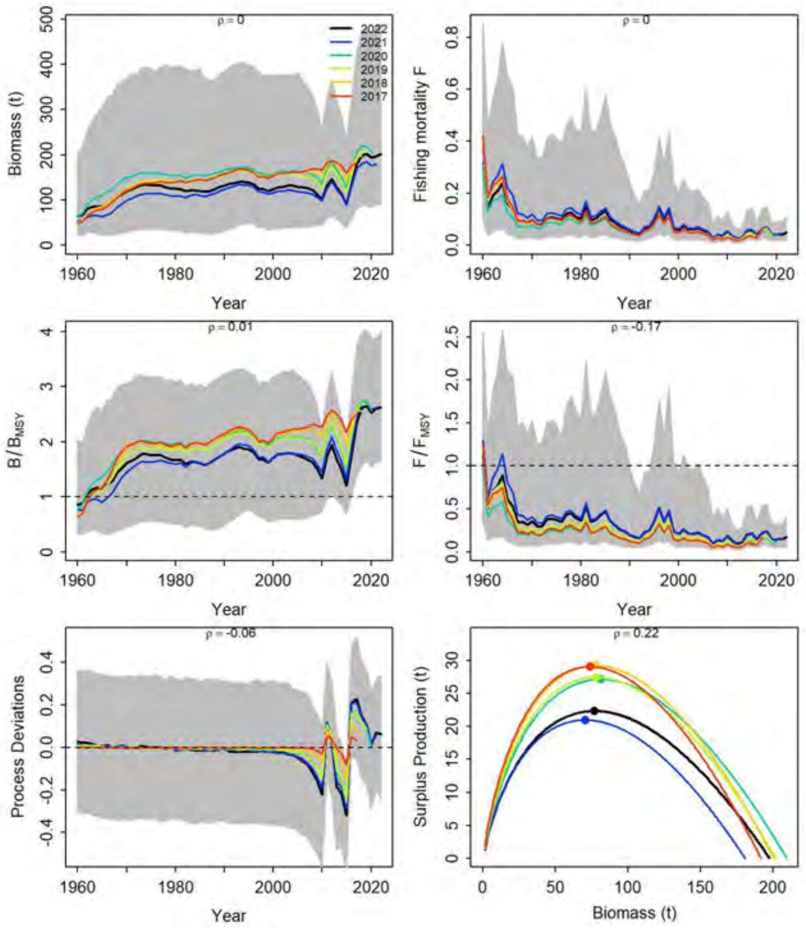




Retrospective Analysis & Kobe Plot

82 Sigma Estimation FALSE. R prior Medium range. Prior distribution for psi lnorm with mean 0.25.



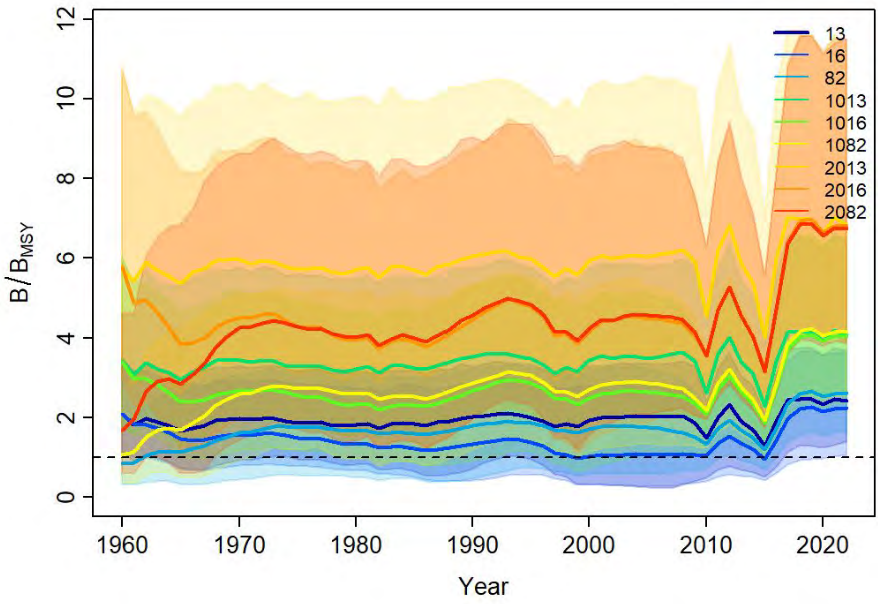


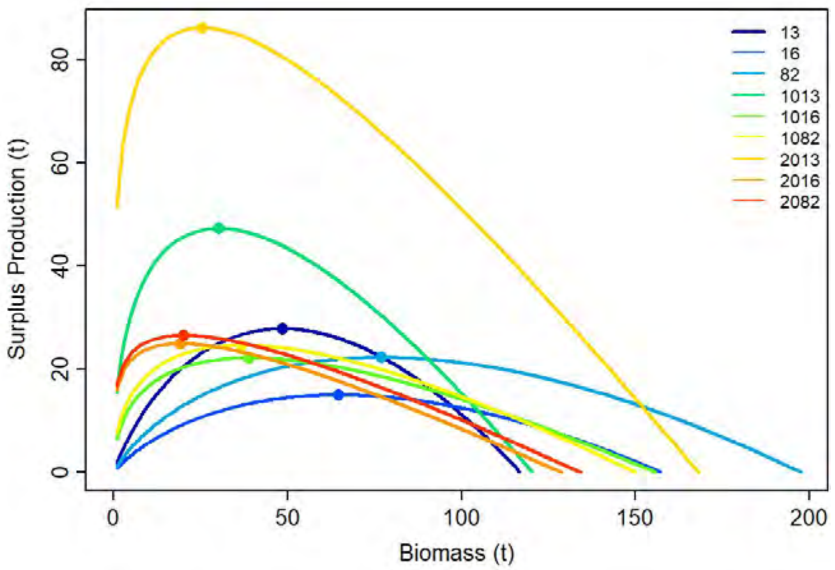
NOAA FISHERIES

Pink Shrimp Diagnostic Summary

		Model Convergence			Model Fit		Model Consistency				Process Error	Prediction Skill		B/K=
	run	CONV_gw	CONV_hw	CONV_hs	CPUE_rt_rand	CPUE_rt_outl	RETRO_B	RETRO_F	RETRO_B.Bmsy	RETRO_F.Fmsy	ProcB_CI	HX_MASE	DIC	
AW	PSH_13_P_rH_psil0.9_sigF_60	FAIL	PASS	PASS	FAIL	PASS	0.11	-0.06	0.02	-0.30	FAIL	1.76	-456.30	.40
	PSH_16_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	PASS	0.29	-0.21	0.16	-0.41	FAIL	1.49	-466.80	
	PSH_82_P_rM_psil0.2_sigF_60	PASS	PASS	PASS	PASS	PASS	0.00	-0.00	0.01	-0.17	FAIL	1.49	-472.80	
RW	PSH_1013_P_rH_psil0.9_sigF_60	FAIL	PASS	PASS	FAIL	FAIL	0.10	-0.05	-0.03	-0.17	FAIL	1.80	-448.70	.25
	PSH_1016_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	PASS	-0.06	0.09	0.01	-0.23	FAIL	1.55	-469.30	
	PSH_1082_P_rM_psil0.2_sigF_60	PASS	PASS	PASS	PASS	PASS	0.07	-0.04	-0.01	-0.17	FAIL	1.53	-472.70	
	PSH_2013_P_rH_psil0.9_sigF_60	PASS	PASS	PASS	FAIL	FAIL	-0.18	0.25	-0.04	0.06	FAIL	1.79	-435.20	.15
	PSH_2016_P_rM_psil0.9_sigF_60	PASS	PASS	PASS	PASS	PASS	0.06	-0.03	-0.02	-0.21	FAIL	1.54	-475.10	
	PSH_2082_P_rM_psil0.2_sigF_60	PASS	PASS	PASS	PASS	PASS	-0.01	0.05	-0.02	-0.13	FAIL	1.54	-471.90	

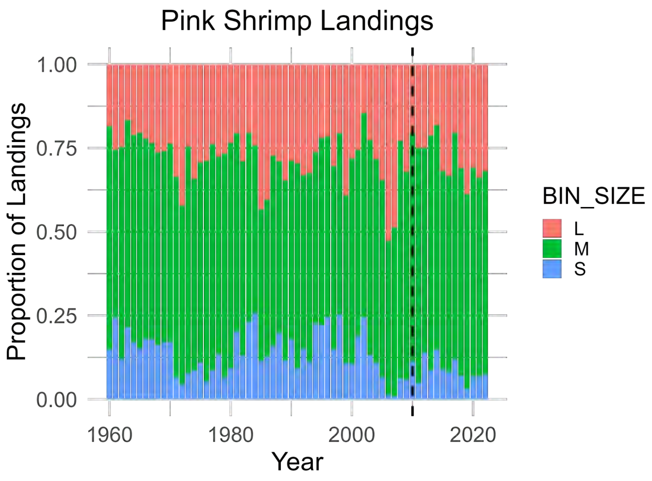
Pink Shrimp Summary Results





PINK SHRIMP JABBA SUMMARY

- Similar weaknesses as raised with brown and white shrimp (some of the main assumptions likely violated)
- Non-informative catch rates (CPUE and catches both follow same trends)
- Short index time series
- Poor diagnostics
  - Poor prediction skill for the index
  - **Minimal information in data (not much departure from priors)**
- Status of population throughout entire time series is highly sensitive to assumptions on m



Recommendation

- JABBA **not recommended** for pink shrimp

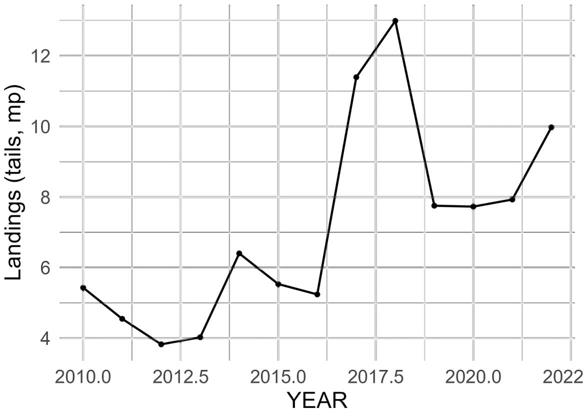
EDM

Pink Shrimp EDM

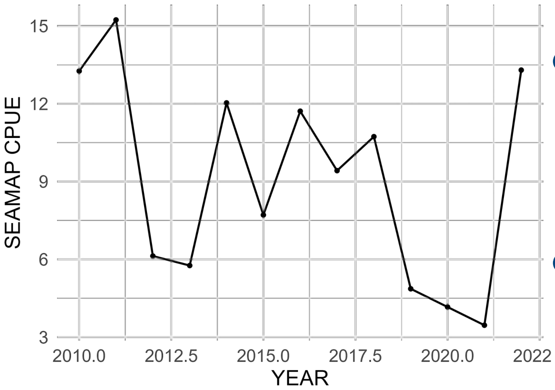
- Pink shrimp
  - SEAMAP, 2010-2022, Summer only (Fall unavailable until 2014)
    - $E \leq \sqrt{T}$, where T=13, $E \leq$ 3-4 (up to 2-3 lags, or 1-2 lags and 1 covariate, etc)
    - Pushing limits for time series length

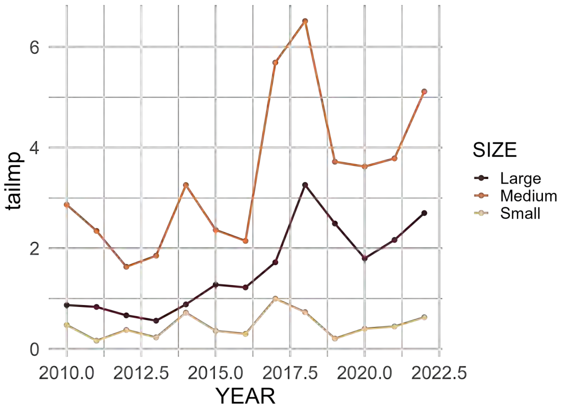
Pink Shrimp

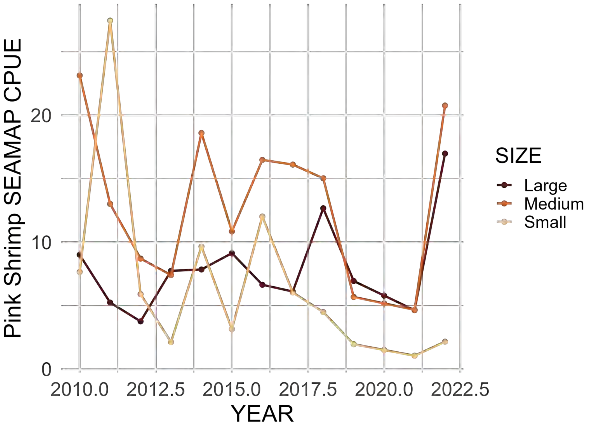
Landings



CPUE







- Model structure options
  - Individual models
  - Hierarchical to share length scales
- Size model hypotheses (Pop=Size)
  -

Year	State	Total Landings (tails, mp)	Landings Missing Size (tails, mp)	Percent Missing Size
2010	FL	5.434	1.218	22.4%
2011	FL	4.552	1.207	26.5%
2012	FL	3.830	1.153	30.1%
2013	FL	4.030	1.386	34.4%
2014	FL	6.404	1.542	24.1%
2015	FL	5.537	1.535	27.7%
2016	FL	5.243	1.575	30.0%
2017	FL	11.394	2.984	26.2%
2018	FL	12.989	2.484	19.1%
2019	FL	7.755	1.337	17.2%
2020	FL	7.730	1.904	24.6%
2021	FL	7.931	1.532	19.3%
2022	FL	9.975	1.530	15.3%

NOAA FISHERIES

Top Performing Model Runs

Run	Stratum	Pop	E	ytrans	Catchability	LinPrior	rho	R2	R2_out	R2_outscaled	ProcessVar	PriorVar
PSH_A20051	A	GULF	4	none	Distinct	Yes	0.5	0.641	0.128	0.128	0.583	1.595
PSH_C1035	C	SIZE	3	log	Distinct	None	0.67	0.485	0.327	0.016	0.766	0.45
PSH_C20039	C	SIZE	4	none	Distinct	None	0.76	0.682	0.297	0	0.544	0.615
PSH_C859	C	SIZE	3	none	Distinct	None	0.73	0.536	0.279	0	0.629	0.468
PSH_C10155	Csm	SIZE	3	none	Shared	None	0.37	0.561	0.235	0	0.774	0.399
PSH_C309	C	SIZE	2	log	Shared	None	0.62	0.282	0.221	0	0.957	0.298
PSH_C1013	C	SIZE	2	log	Distinct	None	0.62	0.282	0.221	0	0.957	0.298
PSH_C10133	Csm	SIZE	2	none	Shared	None	0.56	0.312	0.16	0	0.92	0.766
PSH_C21069	Csm	SIZE	4	none	Shared	Yes	0.49	0.855	0.154	0	0.277	1.416
PSH_C1519	C	SIZE	3	none	Shared	Yes	0.45	0.47	0.15	0	0.546	0.927
PSH_C89	C	SIZE	2	none	Shared	None	0.52	0.316	0.132	0	0.548	0.934
PSH_C793	C	SIZE	2	none	Distinct	None	0.52	0.316	0.132	0	0.548	0.934
PSH_C1695	C	SIZE	3	log	Shared	Yes	0.44	0.382	0.12	0	0.584	1.124
PSH_C21037	Csm	SIZE	4	none	Distinct	None	0.38	0.896	0.12	0	0.169	1.281
PSH_C1497	C	SIZE	2	none	Shared	Yes	0.51	0.312	0.115	0	0.596	0.949
PSH_C10815	Csm	SIZE	3	none	Distinct	None	0.36	0.902	0.114	0	0.135	1.331
PSH_C265	C	SIZE	2	log	Shared	None	0.49	0.265	0.114	0	0.654	1.206
PSH_C10969	Csm	SIZE	2	log	Distinct	None	0.5	0.248	0.097	0	0.645	1.336
PSH_C10265	Csm	SIZE	2	log	Shared	None	0.5	0.248	0.097	0	0.645	1.336
PSH_C10111	Csm	SIZE	3	none	Shared	None	0.37	0.899	0.094	0	0.141	1.318
PSH_C10793	Csm	SIZE	2	none	Distinct	None	0.51	0.305	0.093	0	0.491	1.213
PSH_C10089	Csm	SIZE	2	none	Shared	None	0.51	0.305	0.093	0	0.491	1.216
PSH_C12223	Csm	SIZE	3	none	Distinct	Yes	0.36	0.898	0.089	0	0.192	1.788
PSH_C20069	C	SIZE	4	none	Shared	Yes	0.47	0.416	0.084	0	0.63	0.89
PSH_C11695	Csm	SIZE	3	log	Shared	Yes	0.49	0.649	0.077	0	0.51	1.965
PSH_C11519	Csm	SIZE	3	none	Shared	Yes	0.37	0.894	0.077	0	0.196	1.764
PSH_C12399	Csm	SIZE	3	log	Distinct	Yes	0.49	0.645	0.074	0	0.512	1.906
PSH_C21045	Csm	SIZE	4	log	Distinct	None	0.42	0.713	0.066	0	0.397	1.619
PSH_C287	C	SIZE	3	log	Shared	None	0.3	0.596	0.062	0	0.42	0.983
PSH_C21109	Csm	SIZE	4	log	Distinct	Yes	0.49	0.643	0.052	0	0.578	1.935

Top 30 Models

None have any predictive capabilities

Top Performing Models

- No pink shrimp models passed the selection criteria
- Insufficient time series length to accurately projection pink shrimp population and landings

Alternate Management Benchmarks

- Top 3 highest catches
  - 1964 21.0mp
  - 1960 20.7mp
  - **1996 19.3mp ← MSY proxy of 3rd highest catch**
- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 19.3mp = 0.400
  - 2021 7.93mp / 19.3mp = 0.401
  - 2022 9.98mp / 19.3mp = 0.516
- Recent (2020-22) Average: 8.55mp / 19.3mp = 0.422
- Catch_Recent / MSYproxy < 1 ⟶ **Not** Undergoing Overfishing

Alternate Management Benchmarks

- Top 3 highest catches
  - 1964 21.0mp
  - 1960 20.7mp
  - **1996 19.3mp ← MSY proxy of 3rd highest catch**
- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 19.3mp = 0.400
  - 2021 7.93mp / 19.3mp = 0.401
  - 2022 9.98mp / 19.3mp = 0.516
- Recent (2020-22) Average: 8.55mp / 19.3mp = 0.422
- Catch_Recent / MSYproxy < 1 → **Not** Undergoing Overfishing

Alternate Management Benchmarks

- Tier 3a approach :

  MSY proxy = mean recent 10 years landings + 2* SD(landings)

  = mean(**2013-2022**) + **2*SD(2013-2022**)

  = 7.90 + 2*2.83 = **13.57 mp**

- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 13.57mp = 0.57
  - 2021 7.93mp / 13.57mp = 0.58
  - 2022 9.98mp / 13.57mp = 0.74

NOAA FISHERIES

Alternate Management Benchmarks

- Tier 3a approach :

  MSY proxy = mean recent 10 years landings + 1.5* SD(landings)

  = mean(**2013-2022**) + **1.5*SD(2013-2022)**

  = 7.90 + 1.5*2.83 = **12.15 mp**

- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 12.15mp = 0.64
  - 2021 7.93mp / 12.15mp = 0.65
  - 2022 9.98mp / 12.15mp = 0.82

NOAA FISHERIES

Alternate Management Benchmarks

- Tier 3a approach :

  MSY proxy = mean recent 10 years landings + 2* SD(landings)

  = mean(**2013-2022**) + **2*SD**(**1960-2022**)

  = 7.90 + 2*4.36 = **16.62 mp**

- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 16.62mp = 0.47
  - 2021 7.93mp / 16.62mp = 0.48
  - 2022 9.98mp / 16.62mp = 0.60

NOAA FISHERIES

Alternate Management Benchmarks

- Tier 3a approach :

  MSY proxy = mean recent 10 years landings + 1.5* SD(landings)

  = mean(**2013-2022**) + **1.5*SD(1960-2022**)

  = 7.90 + 1.5*4.36 = **14.44 mp**
- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 14.44mp = 0.54
  - 2021 7.93mp / 14.44mp = 0.55
  - 2022 9.98mp / 14.44mp = 0.69

Alternate Management Benchmarks

- Tier 3a approach :

  MSY proxy = mean 10 years landings + 2* SD(landings)

  = mean(**1990-1999**) + **2*SD**(**1990-1999**)

  = 11.14 + 2*4.52 = **20.18 mp**
- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 20.18mp = 0.38
  - 2021 7.93mp / 20.18mp = 0.39
  - 2022 9.98mp / 20.18mp = 0.49
- 1990s were investigated as a recent interval before the economic collapse of the fishery

Alternate Management Benchmarks

- Tier 3a approach :

  MSY proxy = mean 10 years landings + 2* SD(landings)

  = mean(**1990-1999**) + **1.5*SD**(**1990-1999**)

  = 11.14 + 1.5*4.52 = **17.92mp**
- 3 most recent years' catches / MSYproxy
  - 2020 7.73mp / 17.92mp = 0.43
  - 2021 7.93mp / 17.92mp = 0.44
  - 2022 9.98mp / 17.92mp = 0.57
- 1990s were investigated as a recent interval before the economic collapse of the fishery

PINK SHRIMP CONCLUSIONS

- Insufficient time series length to accurately project pink shrimp population and landings within EDM framework
- Neither EDM nor JABBA are recommended
- Monitor status with the alternate management benchmark, third highest catch
- Potential to monitor abundance using VAST into the future

Recommendations from Reviewers

Short-Term Recommendations from Reviewers Addressed during Review

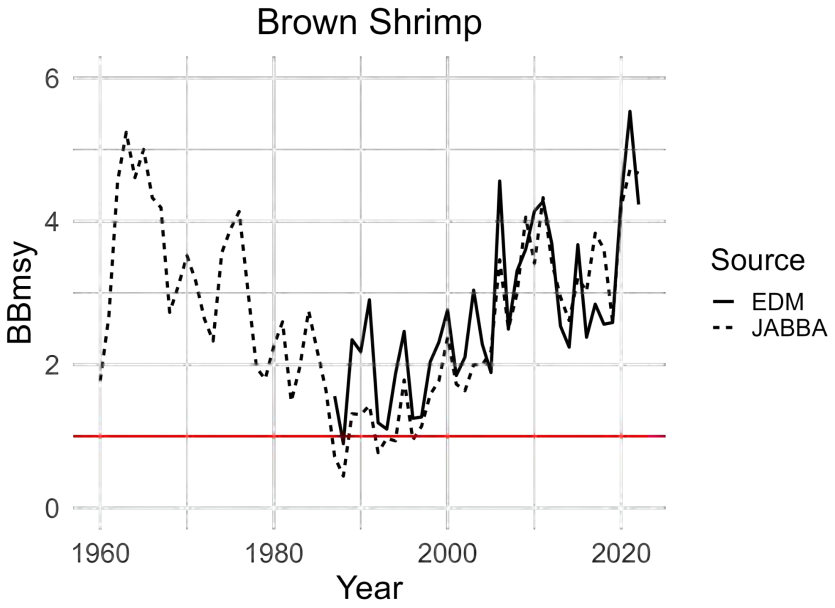
- Truncating survey data in VAST to reduce percent zeros
- Exploring impact of shape parameter *m* in JABBA
- Comparing index trends between surveys and species
- Converting SEAMAP index into absolute measure of biomass for comparison
- Clarifying EDM concepts including catchability, escapement, population scale
- Comparing Benchmarks between model types
- Use Harvest Rate (U) in lieu of F in EDM for reporting

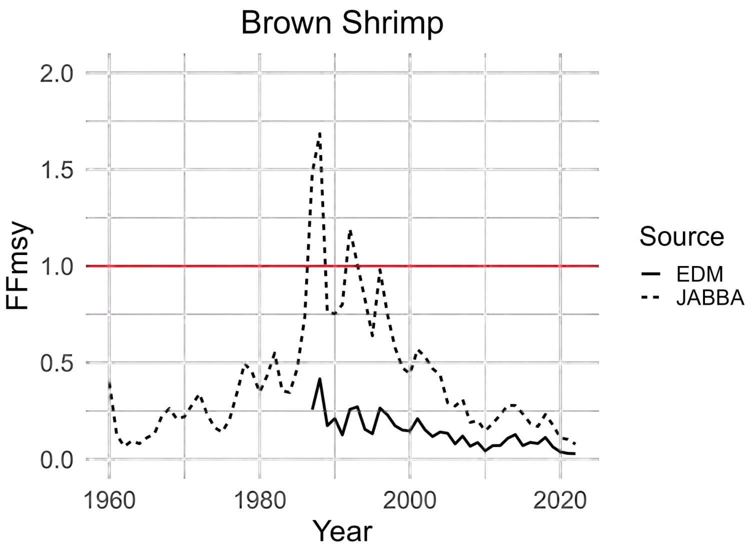
Benchmark Comparisons

Feedback from Reviewers Addressed During Process

The Review Panel requested plots and analyses to ground truth the scale of the assessment results. EDM estimates for MSY exceeded anything the fishery has landed in the past, drawing scrutiny to the scale of these models.

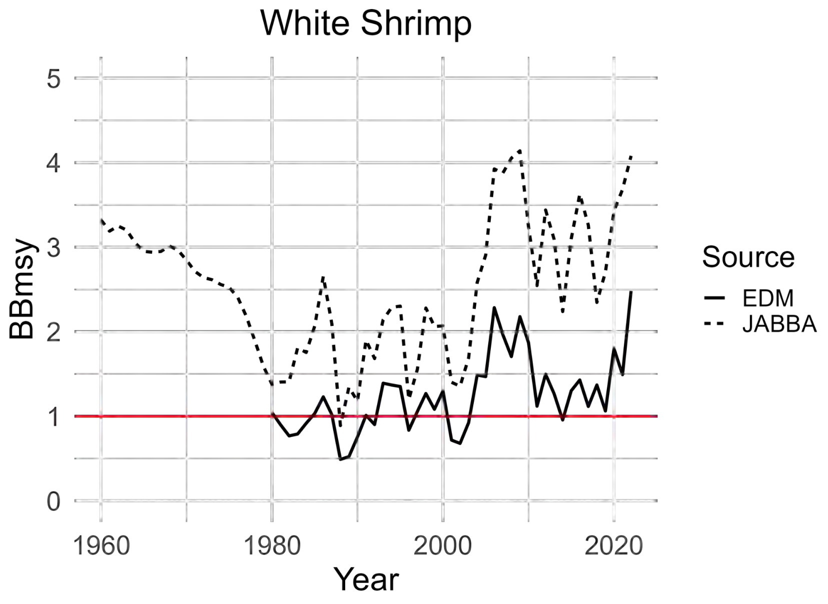
- The analytical team provided figures compiling JABBA and EDM model estimates for biomass and mortality alongside landings
- Results showed that EDM population scales were more in line with the relative habitat extents of brown and white shrimp

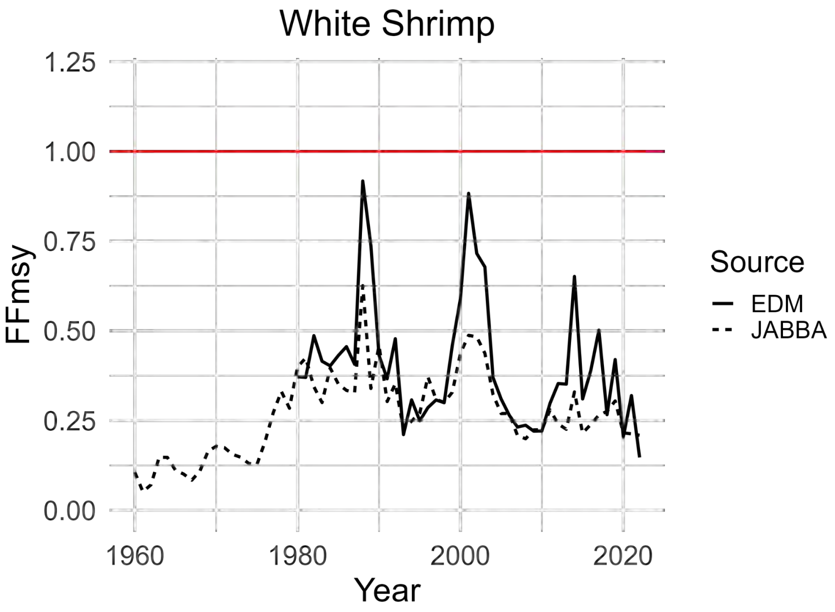




When the index time series comes into JABBA in 1987, the model attributes the change in abundance to the fishing fleet, resulting in a large estimate of F.

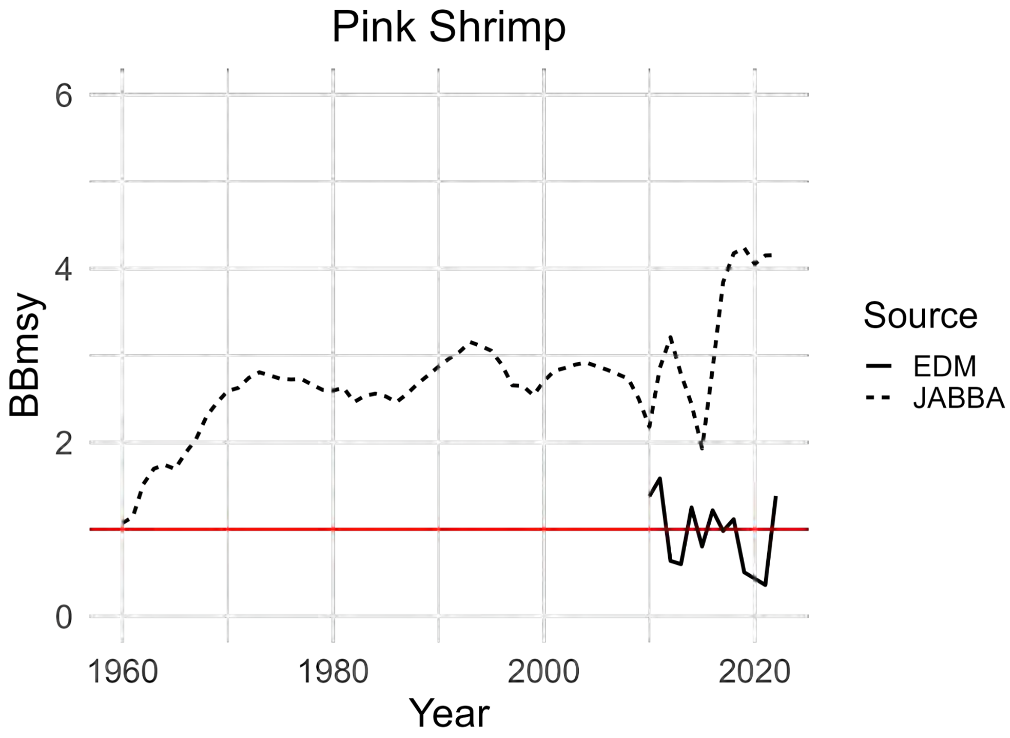
EDM accounts for changes in abundance (e.g. mortality) through lags of abundance, where multiple drivers (environment, predator abundance, etc) are accounted for, more appropriately measuring the effect of the fishing fleet and resulting harvest rate.





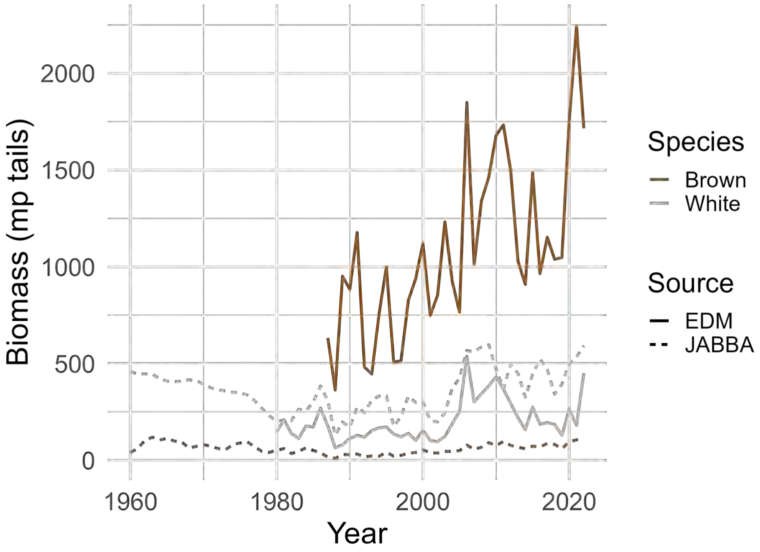
Note: JABBA not recommended for white shrimp; lower Bmsy/K had better diagnostics, but shifted B/Bmsy up for all years

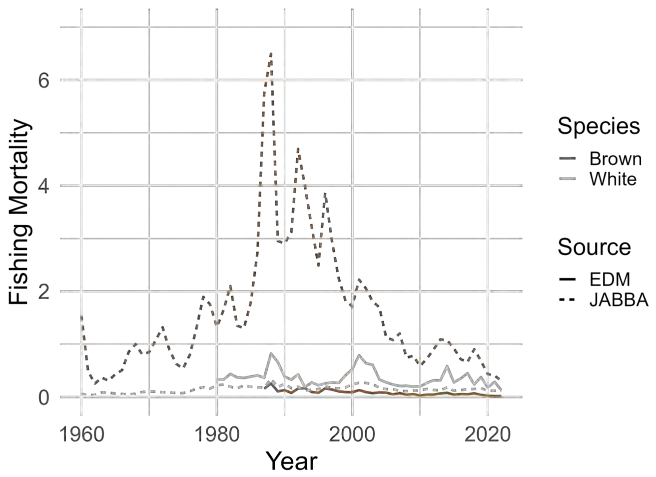
Height of B/Bmsy is highly sensitive to the m prior



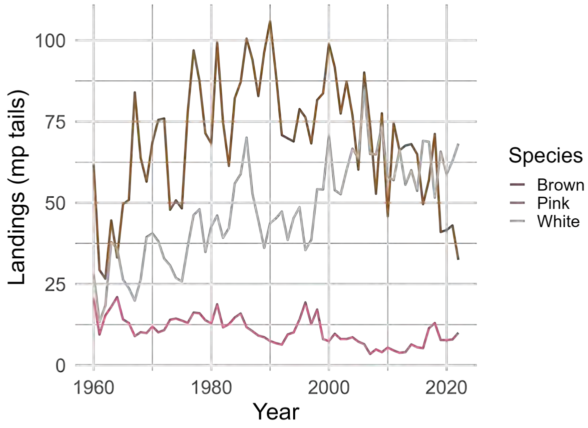
Fmsy infinity for EDM

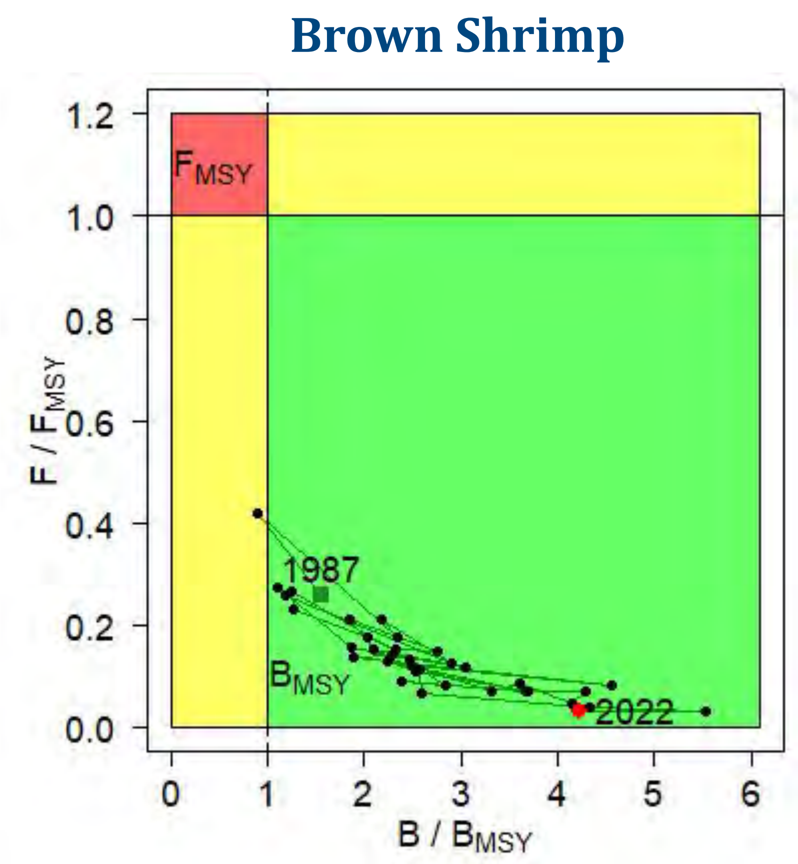
F/Fmsy=0 for all years

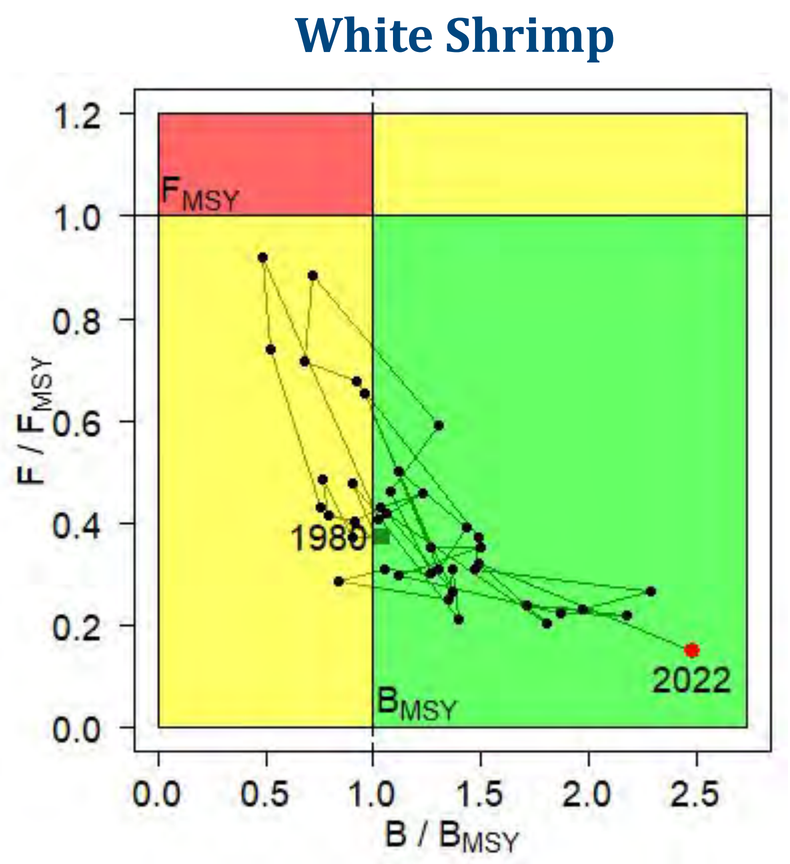


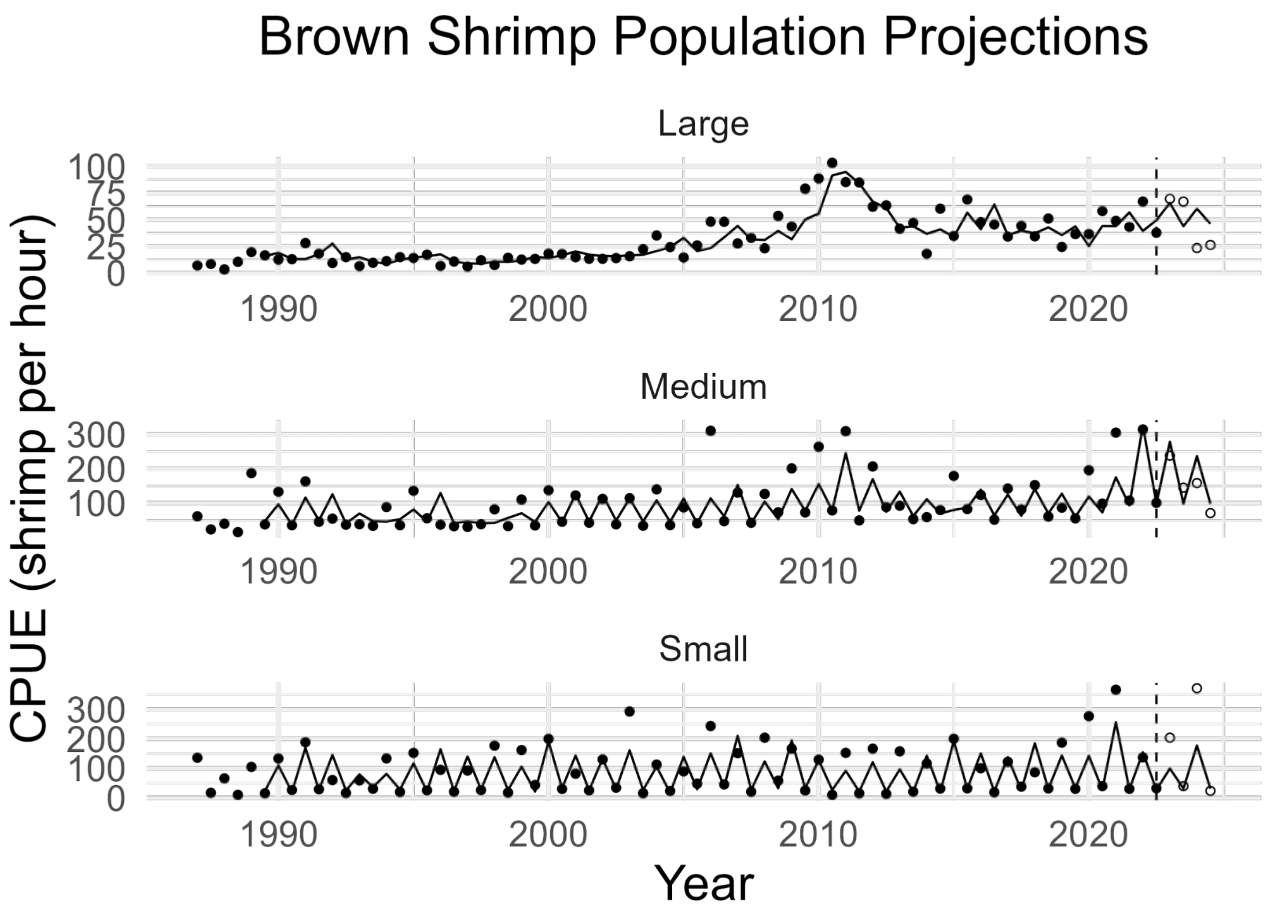


Brown Shrimp	White Shrimp
Bury day, emerge night	In water column day & night
Higher salinity / offshore	Lower salinity / coastal
Deeper, 27-73m (up to 183m)	Shallower (0-35m)
Muddy	Marsh




Brown Shrimp
F / FMSY
1.2
1.0
0.8
0.6
0.4
0.2
0.0
FMSY
1987
BMSY
2022
0
1
2
3
4
5
6
B / BMSY


White Shrimp
F / FMSY
1.2
1.0
0.8
0.6
0.4
0.2
0.0
FMSY
1980
BMSY
2022
0.0
0.5
1.0
1.5
2.0
2.5
B / BMSY



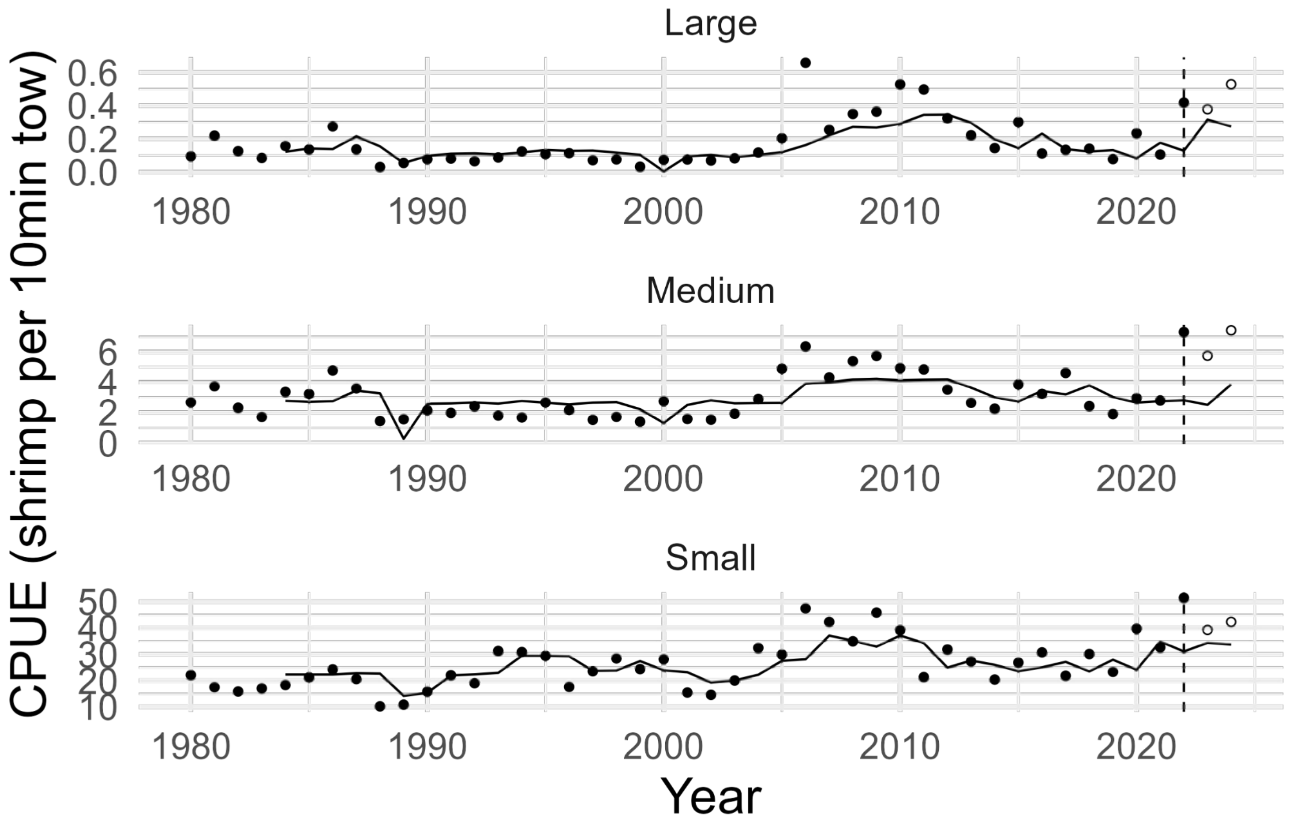
Solid line is model estimates + projections (U=2020-2022 avg)

Dashed line is terminal year of model (Fall 2022)

Observed data in the model are solid dots

Updated data are open dots (Summer 2023 - Fall 2024)

White Shrimp Population Projections



Solid line is model estimates + projections (U=2020-2022 avg)

Dashed line is terminal year of model (2022)

Observed data in the model are solid dots

Updated data are open dots (2023-2024)

Conclusions & Recommendations

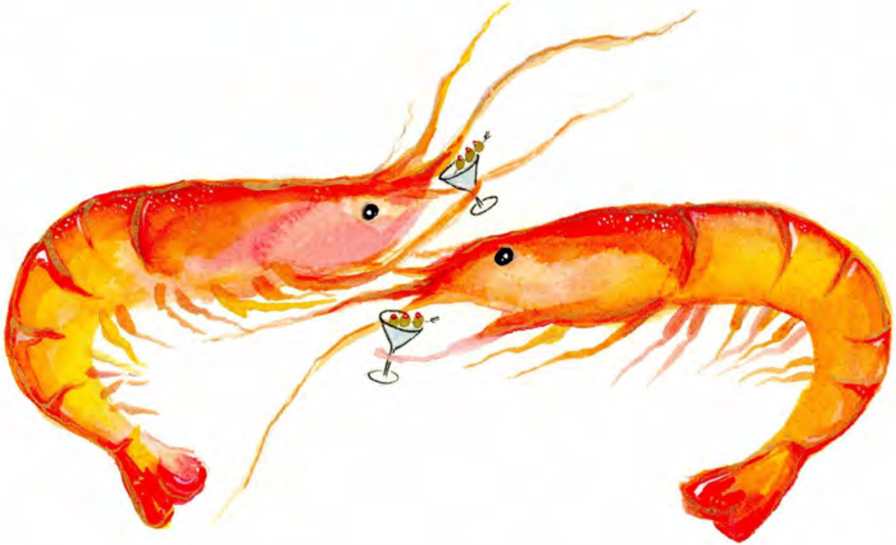
Benefits of EDM in Stock Assessment

- Short-lived species with chaotic dynamics are better modeled using EDM compared to traditional stock assessment models
  - Does not require life history data or any functional form
  - Captures large fluctuations in biomass and accurately projects into the future if state space is mapped with appropriate time series length
  - Does not require direct measurements of information driving fluctuations
- Improved model fits and predictive capability over traditional stock assessment models
- Accommodates benchmark estimation for management

SUMMARY OF RECOMMENDATIONS

- Brown Shrimp - EDM summary
  - MSY: 215.07 million pounds of tails
  - U_{MSY}: 0.460, B_{MSY}: 405.39 million pounds of tails
  - U_{2022}/U_{MSY}: 0.039, B_{2022}/B_{MSY}: 4.23
- White Shrimp - EDM summary
  - MSY: 87.80 million pounds of tails
  - U_{MSY}: 0.592, B_{MSY}: 148.35 million pounds of tails
  - U_{2022}/U_{MSY}: 0.209, B_{2022}/B_{MSY}: 2.48
- Pink Shrimp
  - Data-limited management with VAST available for monitoring trends if requested
  - Use data-limited approach for setting management benchmarks

Questions?



@CorrineCroneArt

References

Browder, J.A. and Robblee, M.B., 2009. Pink shrimp as an indicator for restoration of everglades ecosystems. ecological indicators, 9(6), pp.S17-S28.

Cao, J., Thorson, J.T., Richards, R.A. and Chen, Y., 2017. Spatiotemporal index standardization improves the stock assessment of northern shrimp in the Gulf of Maine. Canadian Journal of Fisheries and Aquatic Sciences, 74(11), pp.1781-1793.

Cao, J., Chen, Y. and Richards, R.A., 2017. Improving assessment of Pandalus stocks using a seasonal, size-structured assessment model with environmental variables. Part I: Model description and application. Canadian Journal of Fisheries and Aquatic Sciences, 74(3), pp.349-362.

Costello, T.J. and Allen, D.M., 1966. Migrations and geographic distribution of pink shrimp, Penaeus duorarum, of the Tortugas and Sanibel grounds, Florida. Fishery Bulletin, 65(2), pp.449-459.

Hart, R. A. 2018a. Stock assessment for pink shrimp (Farfantepenaeus duorarum) in the U.S. Gulf of Mexico for the 2017 fishing year. NOAA Fisheries, Southeast Fisheries Science Center. Gavelston, Texas.

Hart, R. A. 2018b. Stock assessment update for white shrimp (Litopenaeus setiferus) in the U.S. Gulf of Mexico for the 2017 fishing year. NOAA Fisheries, Southeast Fisheries Science Center. Gavelson, Texas.

Hart R. A. 2018c. Stock assessment update for brown shrimp (Farfantepenaeus aztecus) in the U.S. Gulf of Mexico for the 2017 fishing year. NOAA Fisheries, Southeast Fisheries Science Center. Gavelson, Texas.

References

Hart, R. A. 2012a. Stock Assessment of Pink Shrimp (Farfantepenaeus duorarum) in the U.S. Gulf of Mexico for 2011. NOAA Technical Memorandum NMFS-SEFSC-639, 12 p.

Hart, R. A. 2012b. Stock Assessment of Brown Shrimp (Farfantepenaeus aztecus) in the U.S. Gulf of Mexico for 2011. NOAA Technical Memorandum NMFS-SEFSC-638, 37 p.

Hart, R. A. 2012c. Stock Assessment of White Shrimp (Litopenaeus setiferus) in the U.S. Gulf of Mexico for 2011. NOAA Technical Memorandum NMFS-SEFSC-637, 36 p.

Hart, R. A., and J. M. Nance. 2010. Gulf of Mexico Pink Shrimp Assessment Modeling Update: From a Static VPA to an Integrated Assessment Model, Stock Synthesis. NOAA Technical Memorandum NMFS-SEFSC-604, 32p.

Hein, S. and Meier, P., 1995. Skimmers: Their development and use in coastal Louisiana.

Munch, S.B., Poynor, V. and Arriaza, J.L., 2017. Circumventing structural uncertainty: a Bayesian perspective on nonlinear forecasting for ecology. Ecological Complexity, 32, pp.134-143.

Nance, J. M. 1989. Stock assessment for brown, white, and pink shrimp in the U.S. Gulf of Mexico, 1960-1987. NOAA Technical Memorandum, NMFS-SEFC-221.

Nichols, S. 1986. Stock assessment of brown, white and pink shrimp in the U.S. Gulf of Mexico, 1960-1985. NOAA Tech. Memo. NMFS-SEFC-179.

Nichols, S. 1984. Updated assessments of brown, white and pink shrimp in the U.S. Gulf of Mexico. Paper presented at the Workshop on Stock Assessment. Miami, Florida, May 1984.

References

SEDAR. 2024. Gulf of Mexico White, Pink, and Brown Shrimp Data Workshop Report. North Charleston, SC.

O'Leary, C.A., Thorson, J.T., Ianelli, J.N. and Kotwicki, S., 2020. Adapting to climate-driven distribution shifts using model-based indices and age composition from multiple surveys in the walleye pollock (Gadus chalcogrammus) stock assessment. Fisheries Oceanography, 29(6), pp.541-557.

Shelton, A.O., Thorson, J.T., Ward, E.J. and Feist, B.E., 2014. Spatial semiparametric models improve estimates of species abundance and distribution. Canadian Journal of Fisheries and Aquatic Sciences, 71(11), pp.1655-1666.

Thorson, J.T., Shelton, A.O., Ward, E.J. and Skaug, H.J., 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes. ICES Journal of Marine Science, 72(5), pp.1297-1310.

Thorson, J.T., Ianelli, J.N. and Kotwicki, S., 2017. The relative influence of temperature and size-structure on fish distribution shifts: A case-study on Walleye pollock in the Bering Sea. Fish and Fisheries, 18(6), pp.1073-1084.

Thorson, J.T. and Barnett, L.A., 2017. Comparing estimates of abundance trends and distribution shifts using single-and multispecies models of fishes and biogenic habitat. ICES Journal of Marine Science, 74(5), pp.1311-1321.

Thorson, J.T., Ono, K. and Munch, S.B., 2014. A Bayesian approach to identifying and compensating for model misspecification in population models. Ecology, 95(2), pp.329-341.

References

Tsai, C., S.B. Munch, M.D. Masi, A.G. Pollack. 2023. Predicting nonlinear dynamics of short-lived penaeid shrimp species in the Gulf of Mexico. Can. J. Fish. Aquat. Sci. 80: 57–68.

Tsai, C.-H., S. B. Munch, M. D. Masi, and M. H. Stevens. 2024. Empirical dynamic modeling for sustainable benchmarks of short-lived species. ICES Journal of Marine Science 81:1–12.

Turley, Brendan, Lisa Ailloud, and Molly Stevens 2023. Development of estuarine environmental indices for SEDAR 87 Gulf of Mexico White, Pink, and brown shrimp stock assessment. SEDAR87-AP-01. SEDAR, North Charleston, SC. 15 pp.

NOAA FISHERIES