2023 Black Rockfish Stock Assessments

Panel Members: John Budrick, Joseph Powers (CIE) ,Yong Chen (CIE) and Martin Dorn (UW, AFSC Retired)

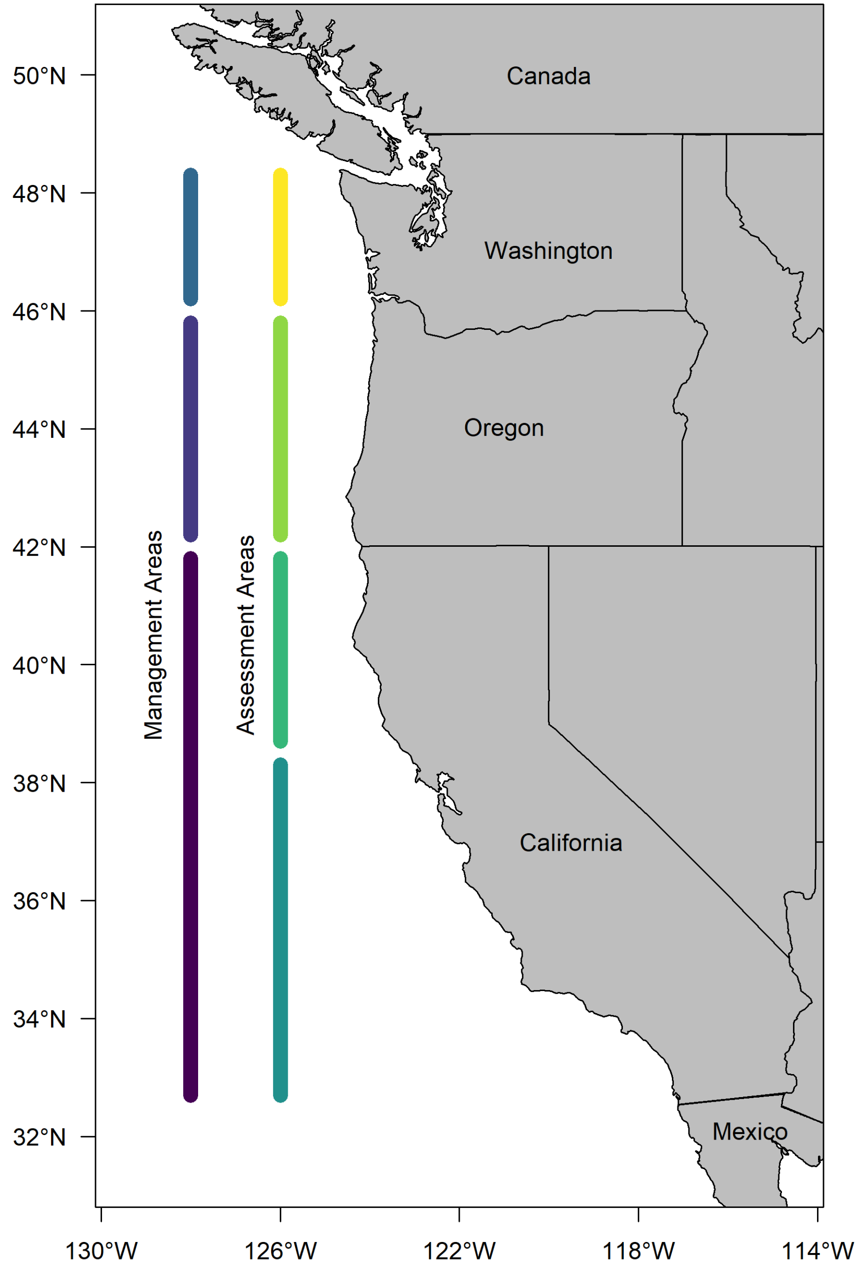
Advisors: Katie Pierson, Oregon Department of Fish and Wildlife, Groundfish Management Team representative

Gerry Richter, B&G Seafoods, Groundfish Advisory Subpanel representative

Marlene A. Bellman, Pacific Fishery Management Council representative

Black Rockfish Ecology

- Distributed from California through Alaska
- Habitat:
  - mostly nearshore (<80m)
  - mid-water
  - aggregating over rocky pinnacles
  - rarely found offshore
- Genetic Structure:
  - Genetic divergence among adults in OR and WA (Miller et al. 2005; Miller and Shanks 2007)
  - Some genetic differences between CA and OR(Sivasundar and Palumbi 2010) and a genetic break at Cape Blanco, OR (Lotterhos et al. 2014)
  - Few long-distance migrants may cause localized discontinuities (Lotterhos and Markel 2012; Hess et al. 2023)
- Movement: Mostly small, but across state and nearshore-offshore of 100s km observed.
- Feeding Habits: Small fish and invertebrates.



California Black Rockfish Stock Assessment

STAT

E.J. Dick (SWFSC, Lead)

Cheryl Barnes (OSU/ODFW)

Julia Coates (CDFW)

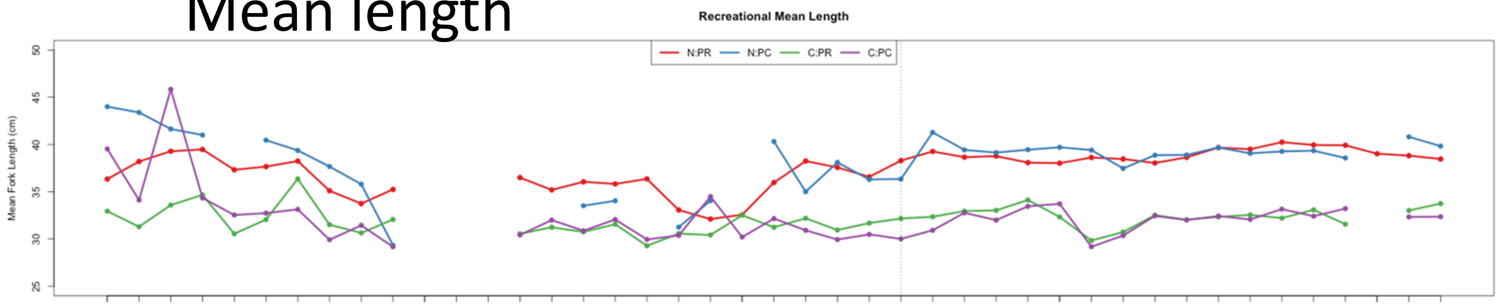
Nick Grunloh (SWFSC)

Melissa Monk (SWFSC)

Tanya Rogers (SWFSC)

Overview of Regional Differences within California

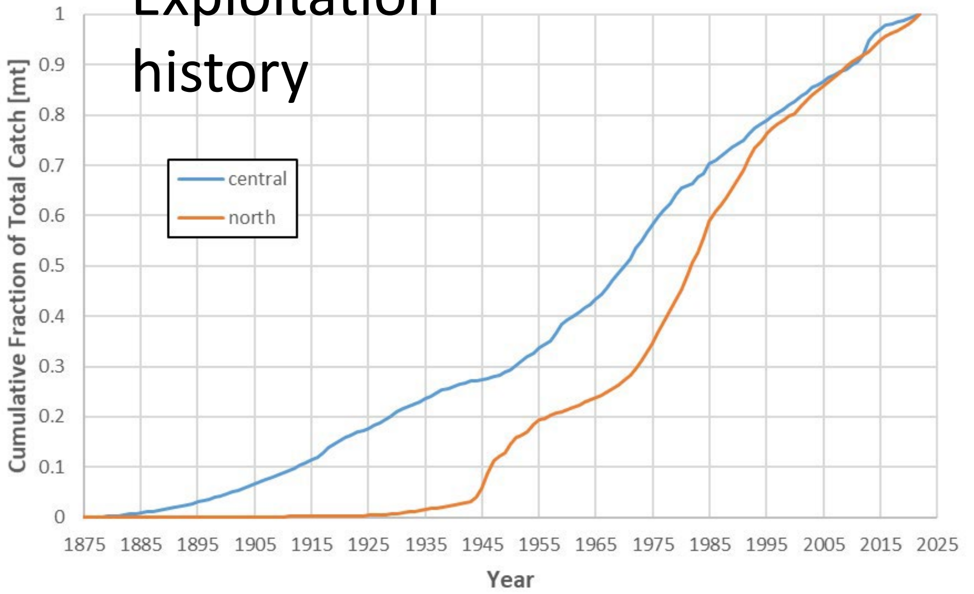
Mean length



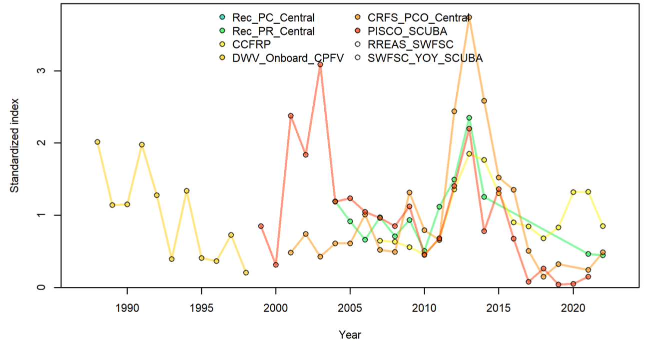
Year:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
#(N:PR):	462	549	610	408	540	836	887	140	126	480				700	808	372	815	173	594	830	517
#(N:PC):	2	33	55	1		40	38	3	10	49						162	379		535	36	
#(C:PR):	166	64	32	25	256	388	142	240	196	352				570	140	172	143	130	71	371	228
#(C:PC):	92	24	7	27	119	365	86	151	56	148				21	2	12	232	1647	705	436	304

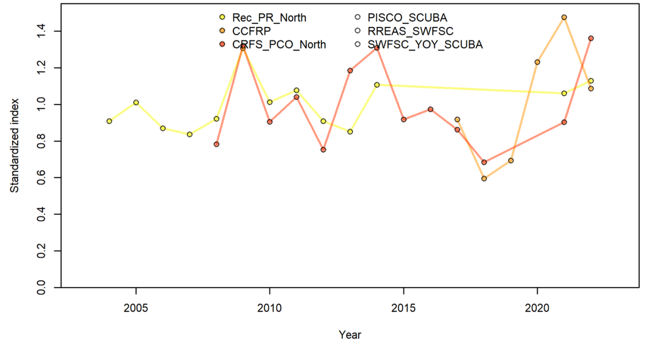
Year:	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
#(N:PR):	175	224	637	518	2381	1705	3308	4195	5844	2580	2244	1980	3436	2869	4989	4333	4126	3658	2741	12	1744	2111
#(N:PC):	52	1	210	97	179	270	834	1225	2243	1428	597	1486	1836	2009	1239	484	390	474	197		307	792
#(C:PR):	232	350	435	1754	2311	2646	2239	2117	2567	1216	2785	4126	7868	4710	4544	2864	784	743	371		611	712
#(C:PC):	628	706	1134	1094	538	717	517	800	728	486	2129	2255	4428	2423	663	1131	295	187	271		295	370

Exploitation history

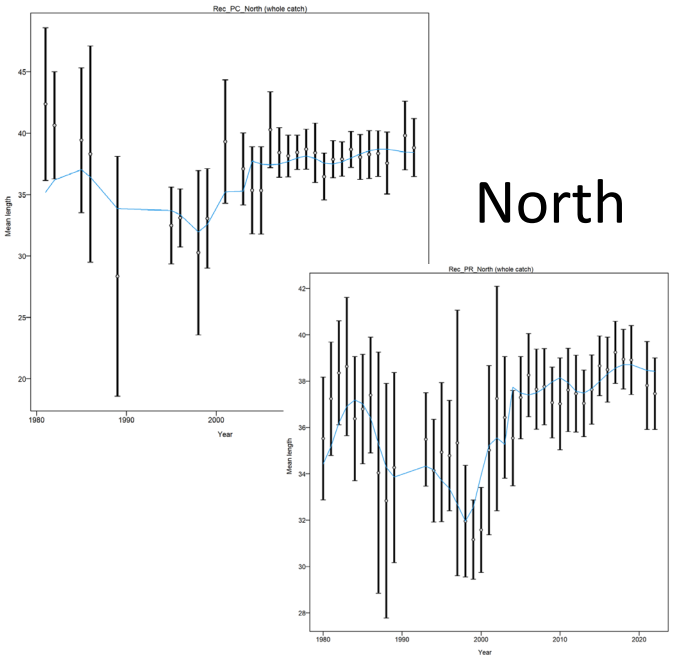


Abundance trends



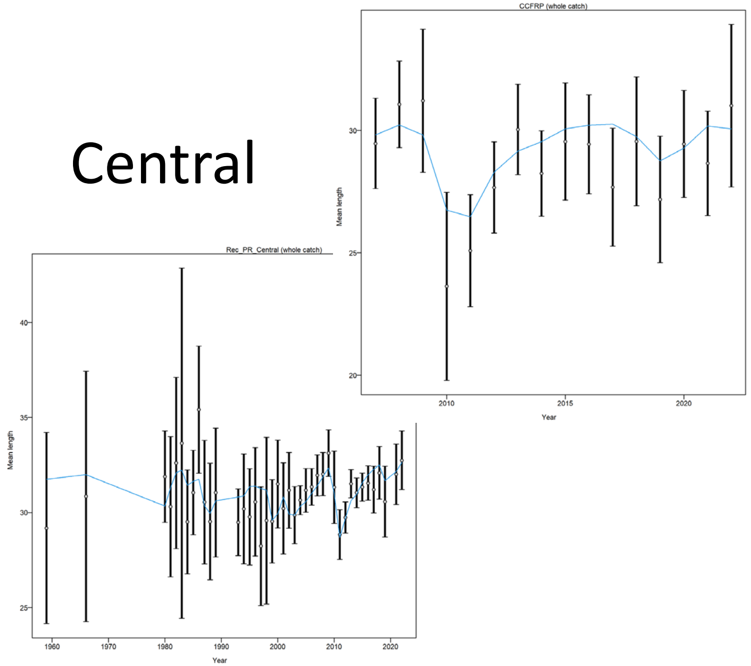


Trends in mean length

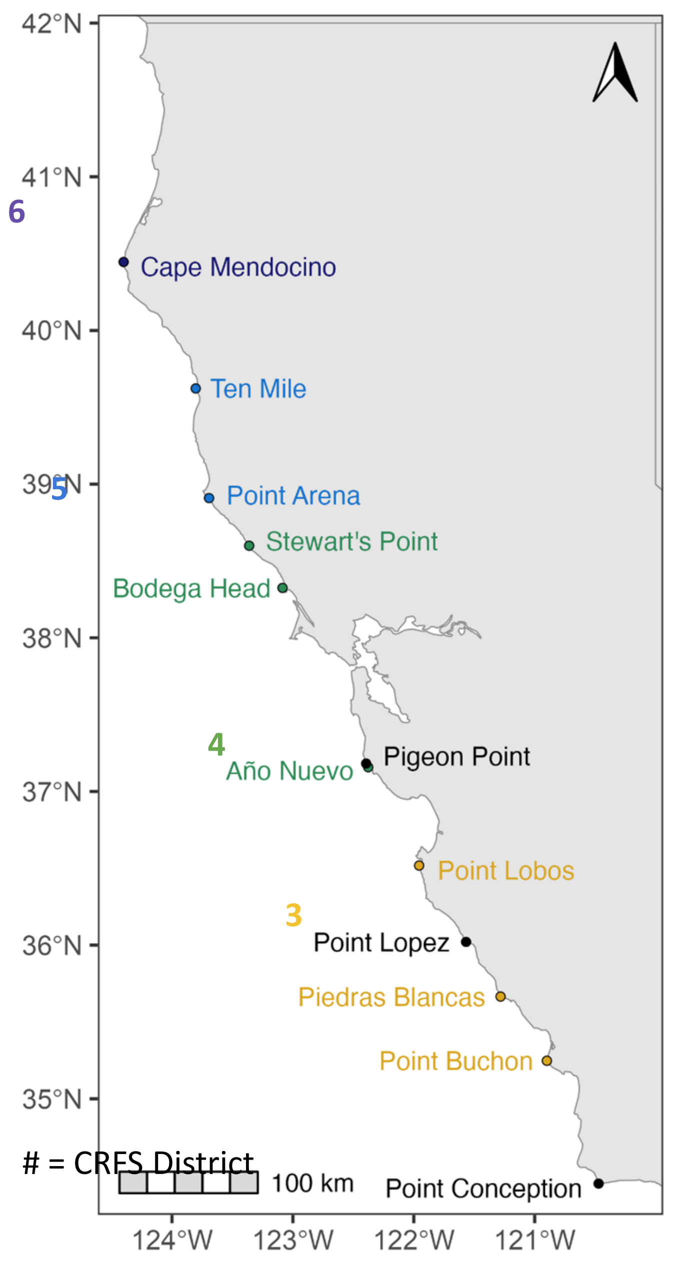


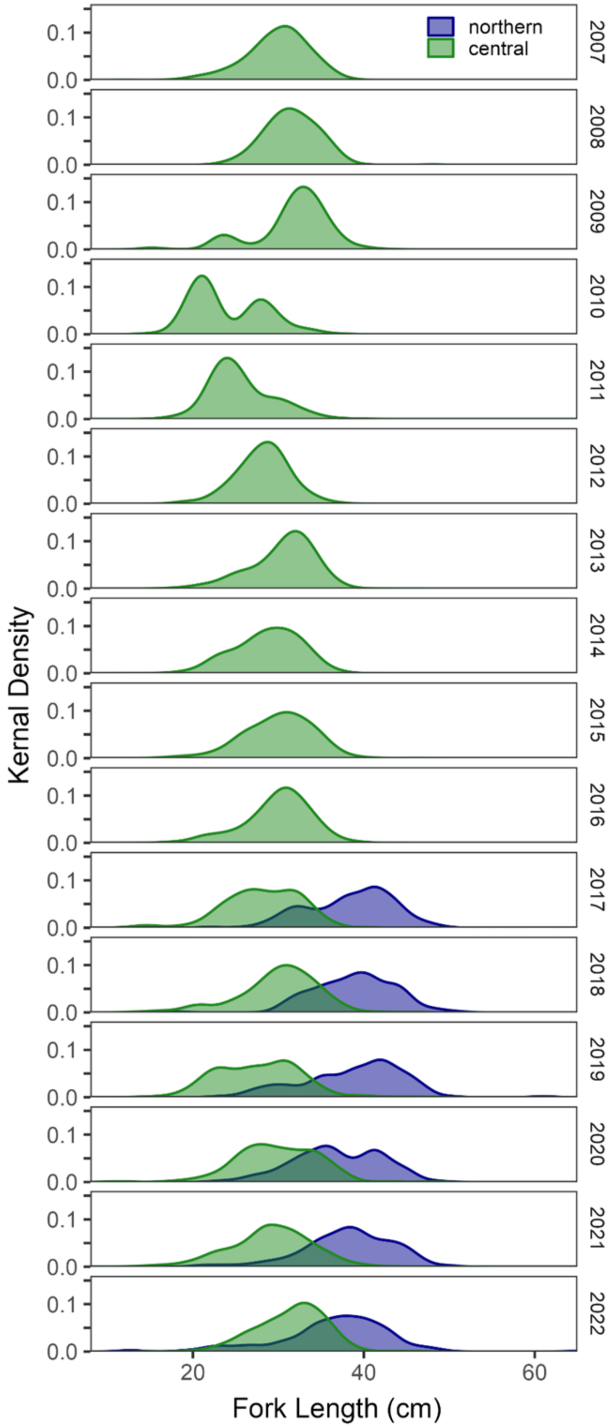
North

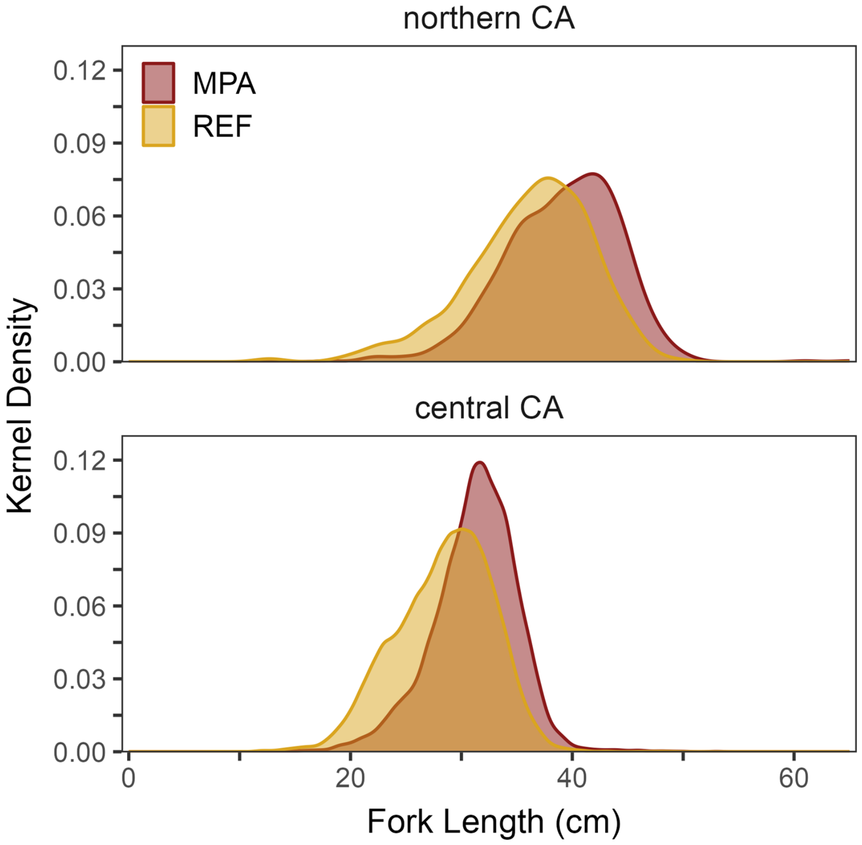
Central



CCFRP Index


42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
124°W
123°W
122°W
121°W
6
5
4
3
Cape Mendocino
Ten Mile
Point Arena
Stewart's Point
Bodega Head
Año Nuevo
Pigeon Point
Point Lobos
Point Lopez
Piedras Blancas
Point Buchon
Point Conception
= CRFS District
100 km


northern
central
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Kernal Density
Fork Length (cm)
20
40
60


northern CA
central CA
MPA
REF
Kernel Density
0.12
0.09
0.06
0.03
0.00
0
20
40
60
Fork Length (cm)

Stock Structure:

genetic differentiation

adult movement

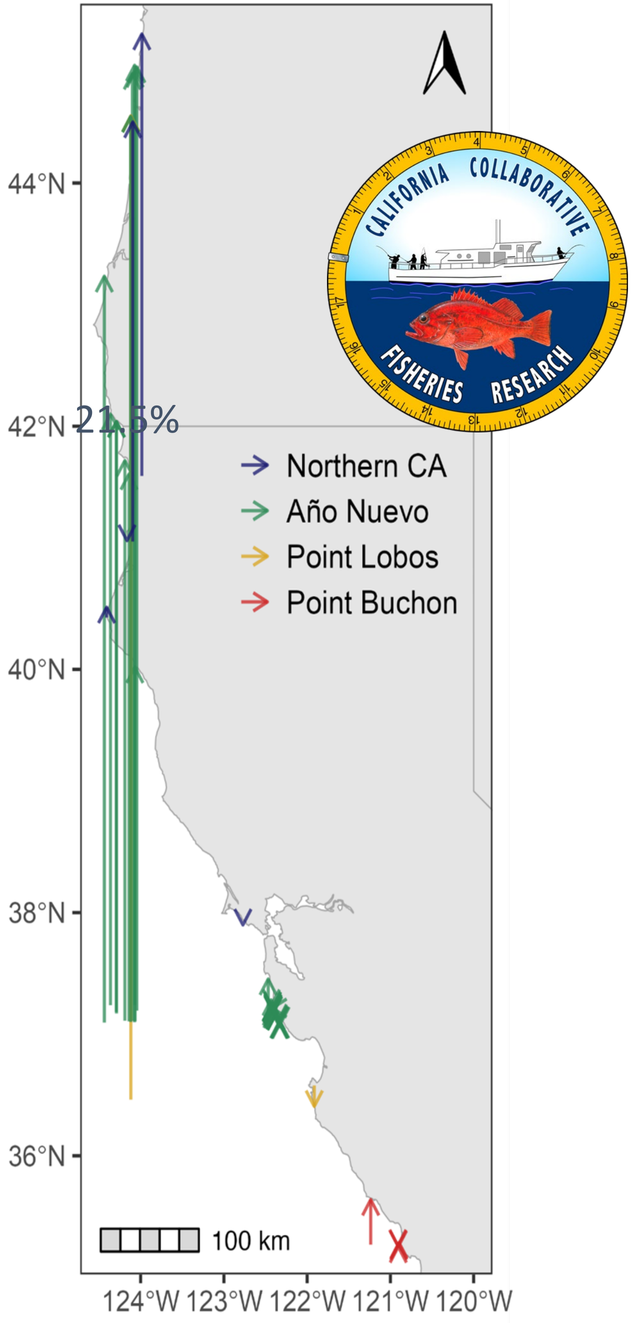
larval dispersal

life history

Net Euclidean Distance

Moved: 0 to 918 km (180 ± 316 km)

Release Site	No. Recaptures
Northern CA	5
Año Nuevo	52
Point Lobos	2
Point Buchon	6
	65



Summary of Previous Assessments

Historical Assessments (Ralston and Dick, 2003; Sampson 2007).

- Single stock south of Cape Falcon, Oregon
- “fleets as areas” approach, with data from each state kept separate.

Full assessment in 2015 (Cope et al. 2016).

- Statewide
- Stock Synthesis
- All recreational modes into a single, statewide fleet
- Commercial fleets into two non-trawl (dead/alive) and one trawl.
- Recovering from an overfished state and was in the precautionary zone as of 2015.
- Basis for current management.

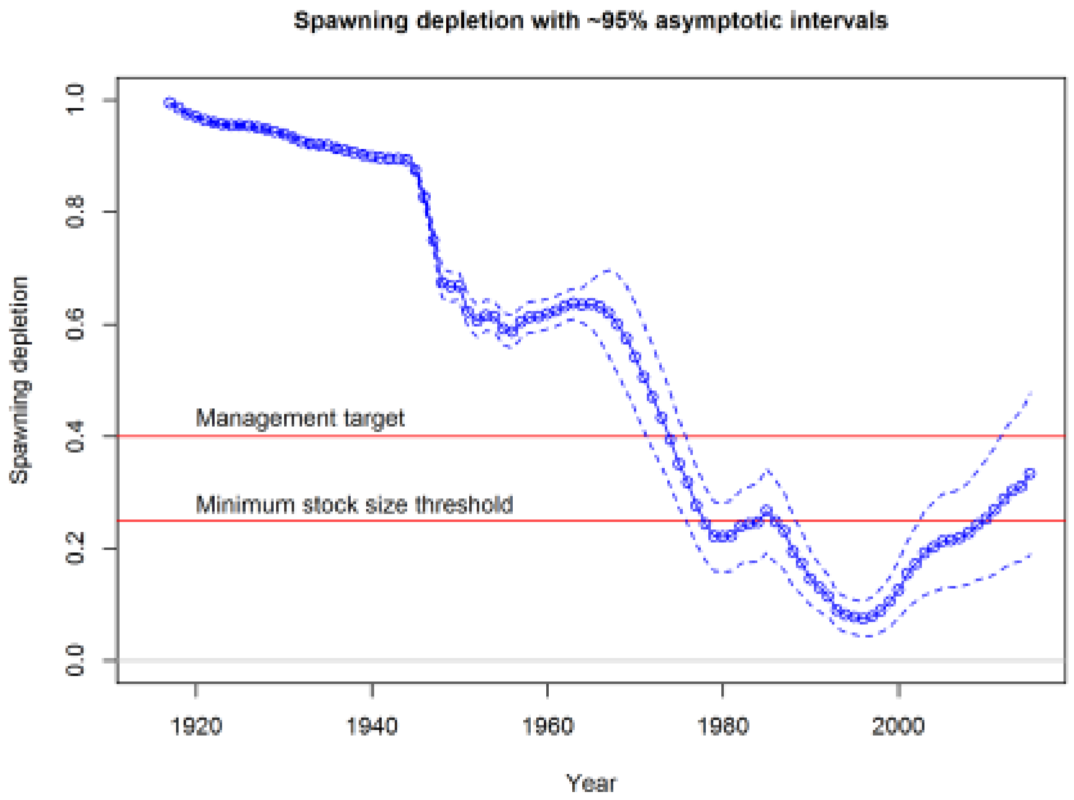
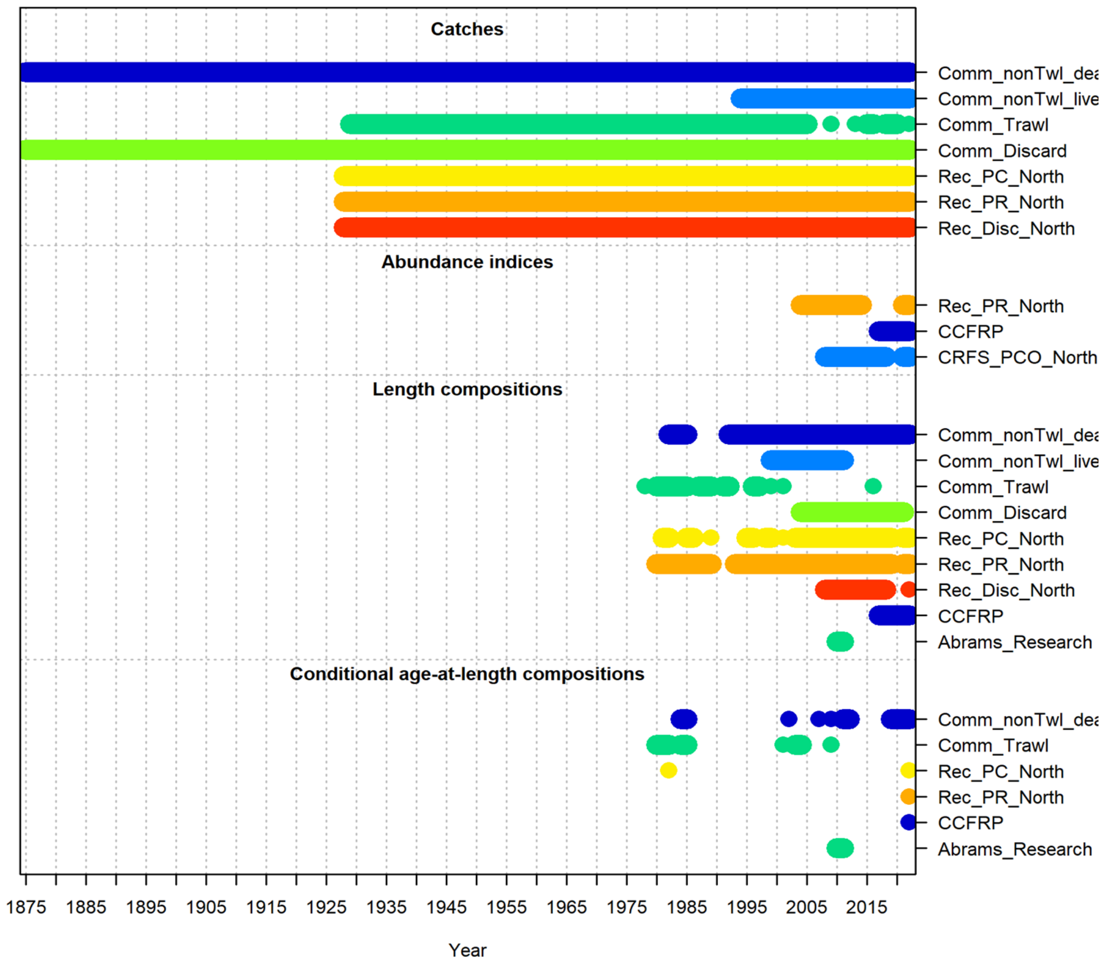


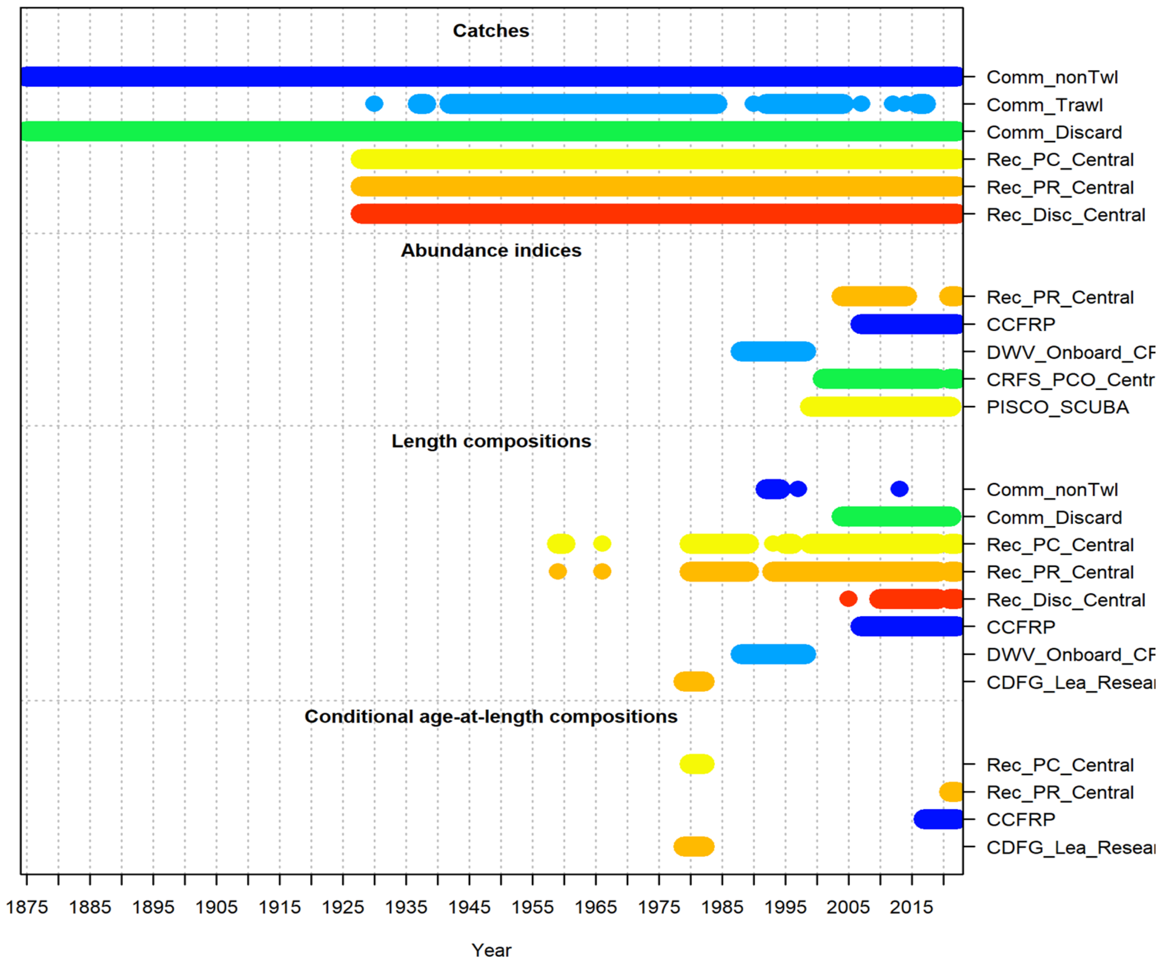
Figure ES-5. Time series of stock status (depletion) of black rockfish in California.

Summary of Data Sources

North



Central



Commercial Fleets by Area

North of Point Arena

- Non-trawl, landed dead
- Non-trawl, landed alive (1994-2022)
- Trawl (avg. <1 mt per year since 2000)
- Discard (1.9% of retained catch, all gears combined)

South of Point Arena

- Non-trawl (minimal live landings)
- Trawl (171 mt, all years combined)
- Discard (1.9% of retained catch, all gears combined)

Photo:
Kenyon Hensel

Estimated Commercial Catch Sources, 1875-2022

- PacFIN (1981-2022)
- CALCOM (1978-1980)
- Ratio estimates (1969-1977)
- California Catch Reconstruction (Ralston et al. 2010); 1916-1968

- Linear interpolation, 1875-1915

- Corrections based on input from CDFW during 2015 assessment
  - Trawl 1981-1982
  - Non-trawl 1983-1985

Recreational Catch Overview

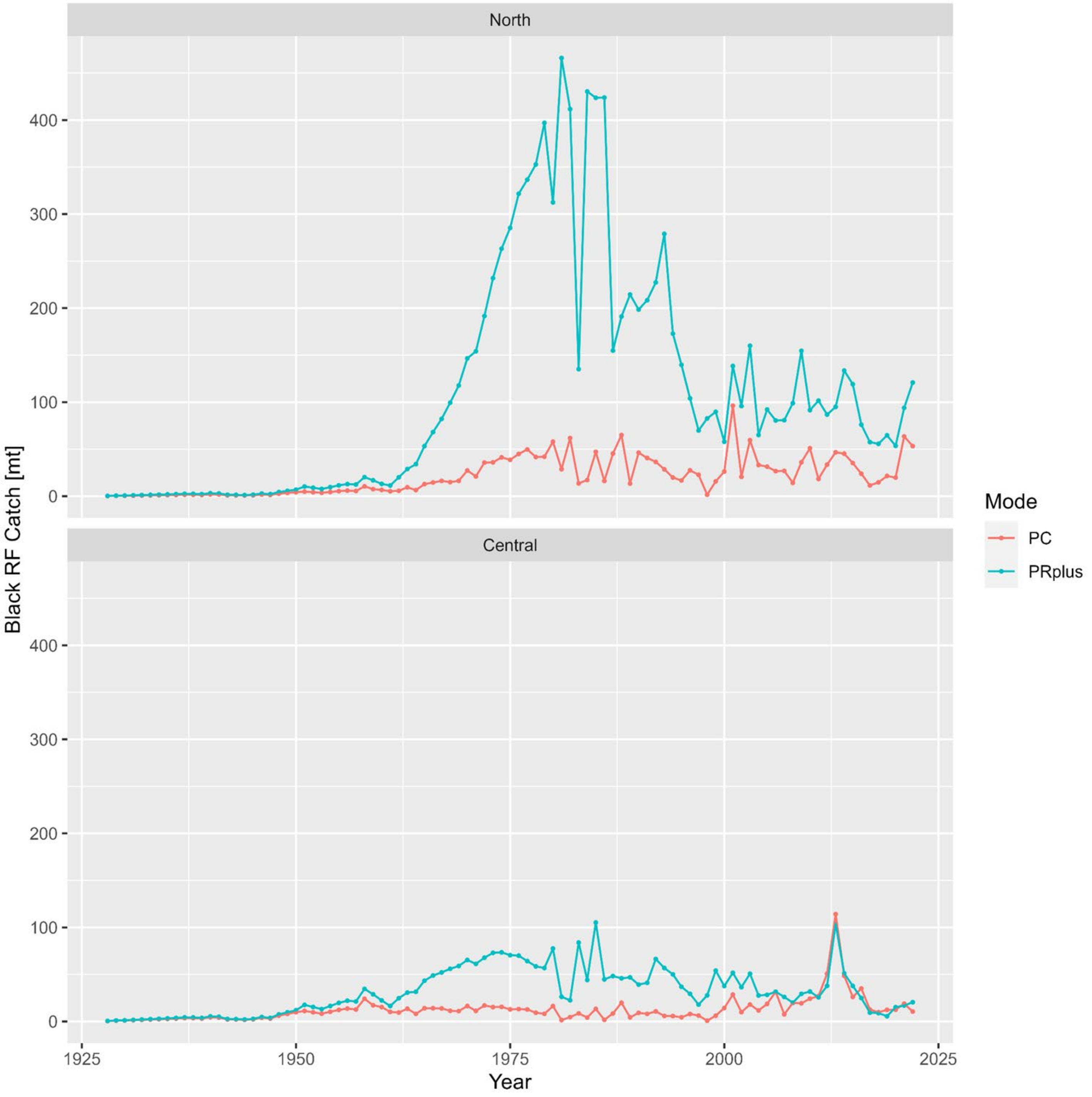
- Boat modes (PC & PR) = ~97% of catch
- Rec catch (numbers) = CPUE * Total Effor
- Catch in weight = Numbers * Mean Weig
- California Recreational Fisheries Survey (CRFS; CDFW survey)
  - 2004-present, 6 “districts”
- Marine Recreational Fisheries Statistics Survey (MRFSS; federal survey)
  - 1980-1989, 1992-2003
    (sampling ‘hiatus’ 1990-1992, all modes)
- California Catch Reconstruction (Ralston et al. 2010; NMFS SWFSC)
  - Applied estimated species compositions tc catch of total rockfish, 1928-1980
  - Stratified N/S of Pt. Conception, boat mod

California Recreational Fisheries Survey (CRFS) Districts

Estimation of Recreational Catch north/south of Pt. Arena

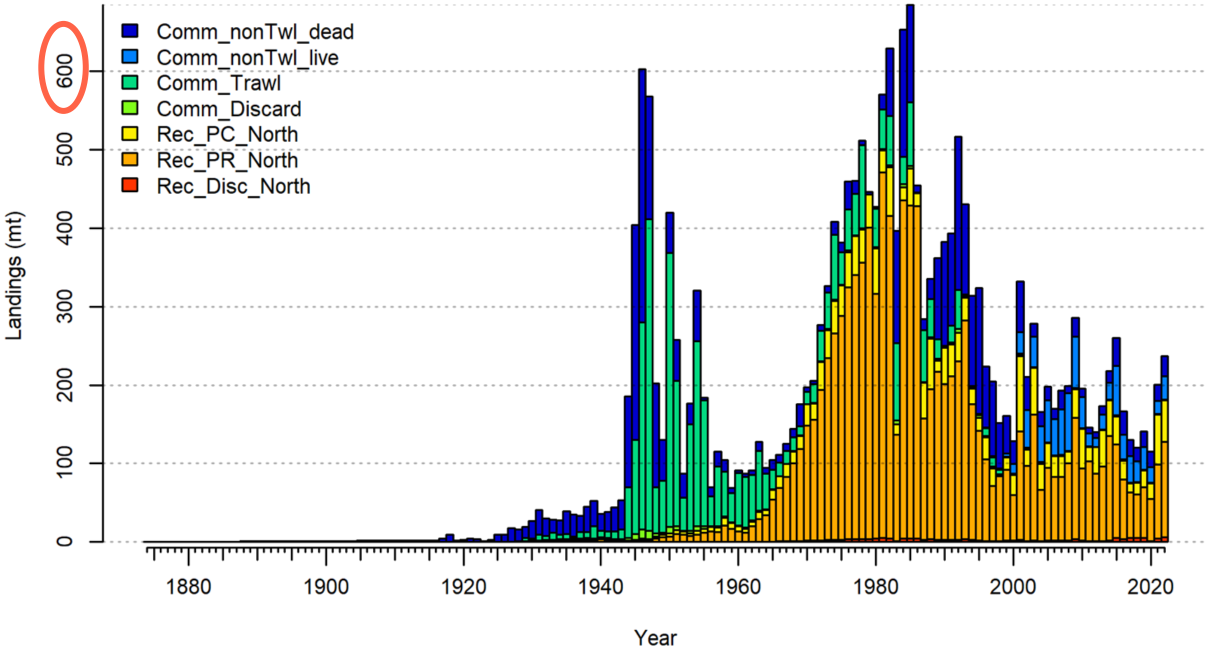
- Catch estimates prior to 2005 only available N/S of Point Conception
- Catch in numbers by mode allocated N/S of Point Arena using coastal county estimates from Albin et al. (1981-86) and CRFS (2005-2007), with interpolated missing years
- Allocation prior to 1960 based on boat mode effort (Miller and Gotshall 1965)
- Average weights estimated from MRFSS length data by year/area/mode
- 1990-1992 PC lengths from CDFW onboard observer survey
- Average weights for unobserved strata (e.g. 1990-1992 PR mode; 1993-1995 PC mode) were borrowed across modes in same year/area

Final estimates of recreational catch in weight [mt] by area, mode, and year

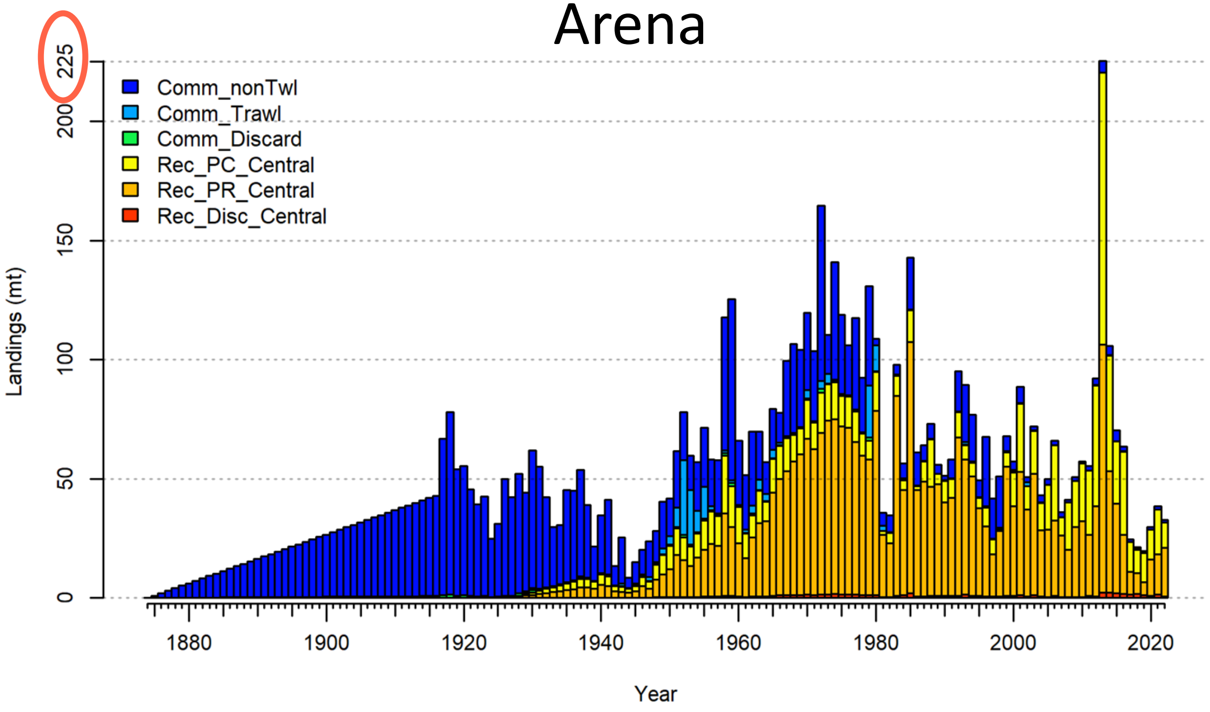


Landings and Discard by Area

North of Point Arena



South of Point Arena



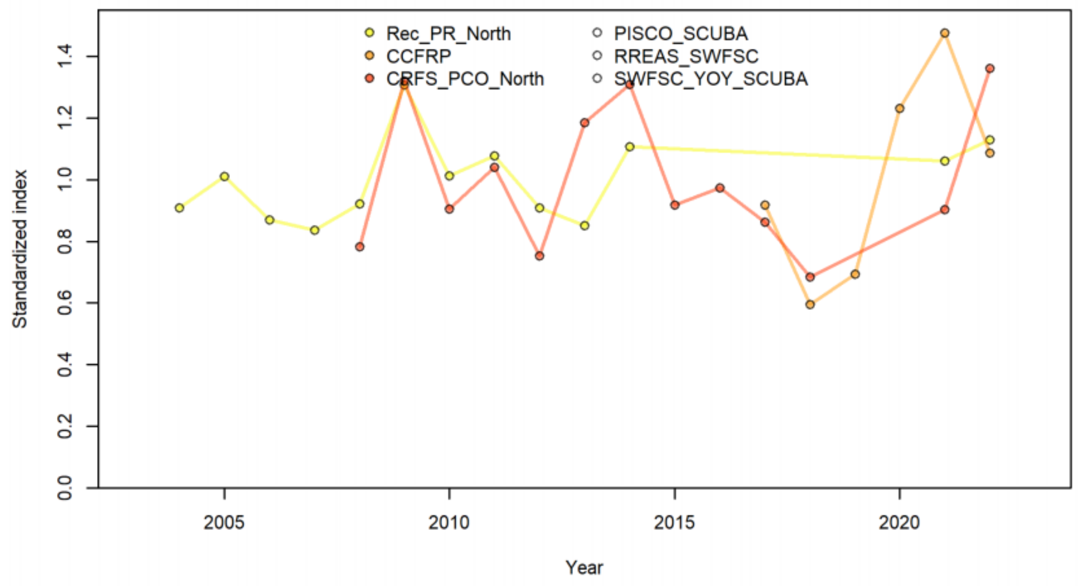
Indices

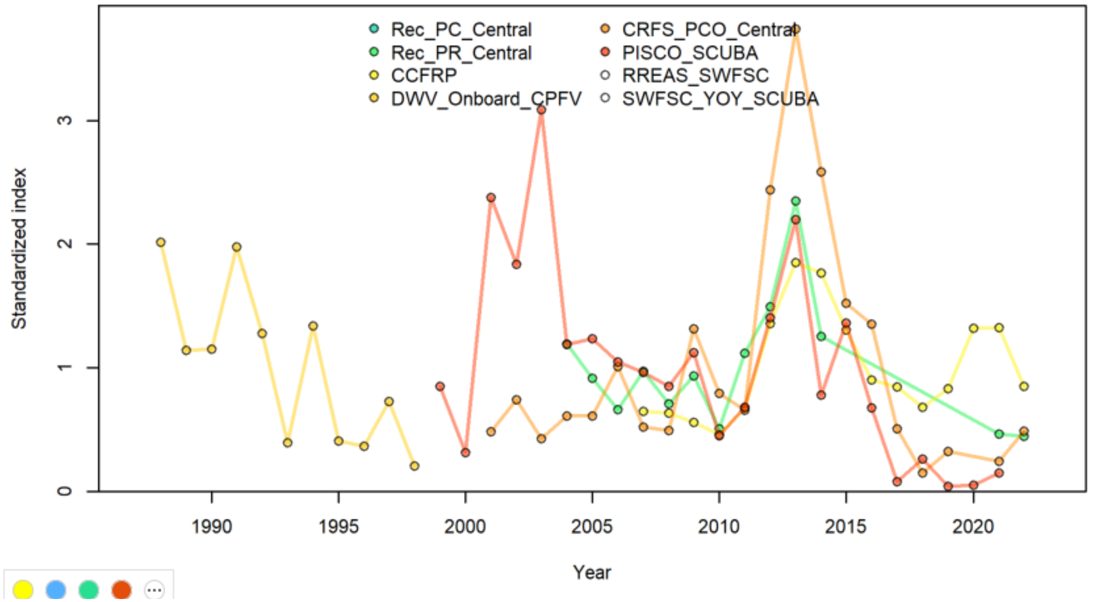
Fishery Dependent

- Private/Rental Dockside Index: Zero inflated negative binomial model.
- CPFV Onboard Index: Retained and discarded counts at drift level.
- DWV Onboard CPFV Index: 1988-1998, retained and discarded mainly central California.

Fishery Independent

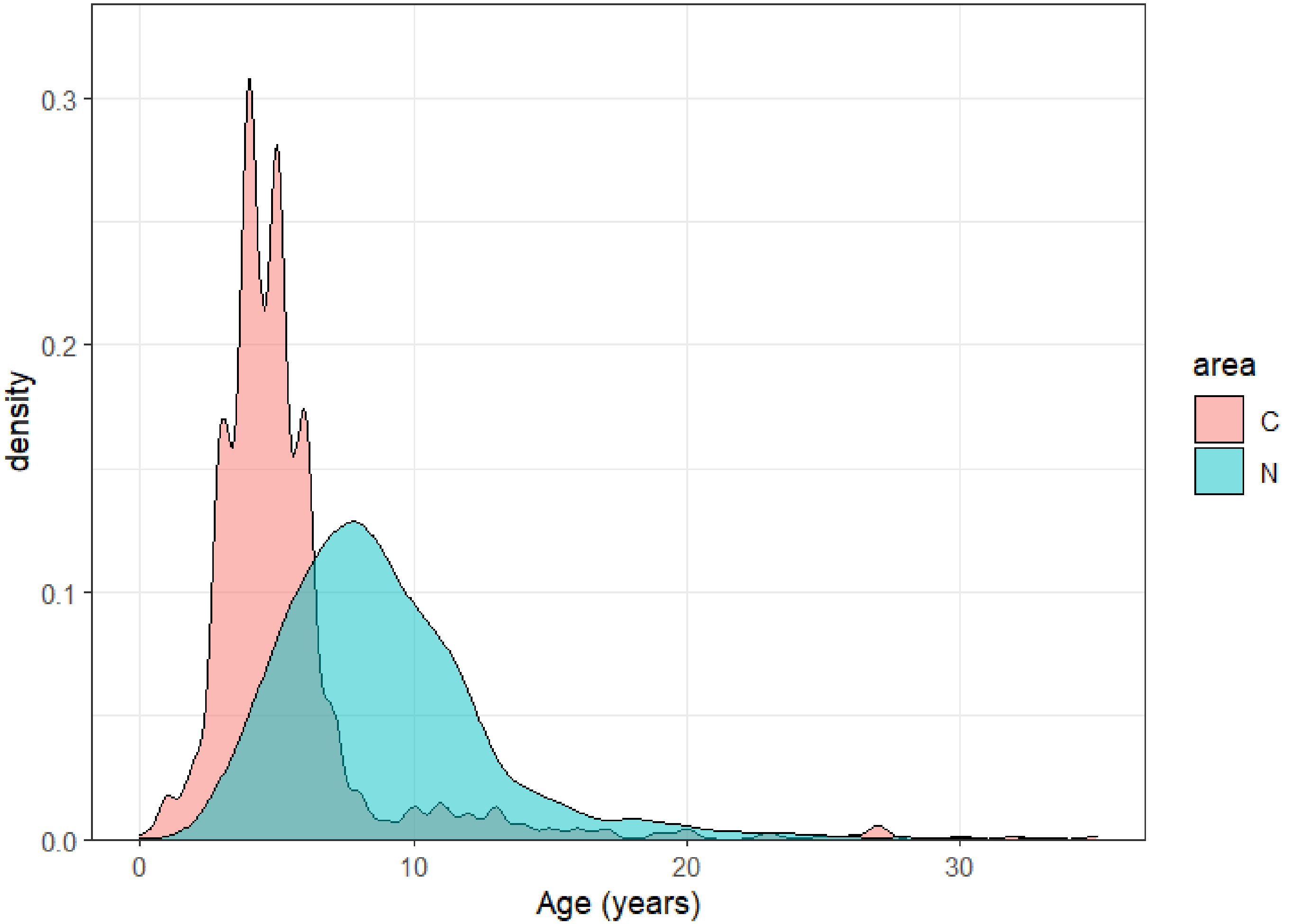
- California Collaborative Fisheries Research Program (CCFRP): Since 2007 in Central Area, 2017 North. Generalized Additive Model.
- Rockfish Recruitment and Ecosystem Assessment Survey (RREAS): Not included, but recruitment index explored in requests/sensitivities.





Summary of age data used in the 2023 assessment

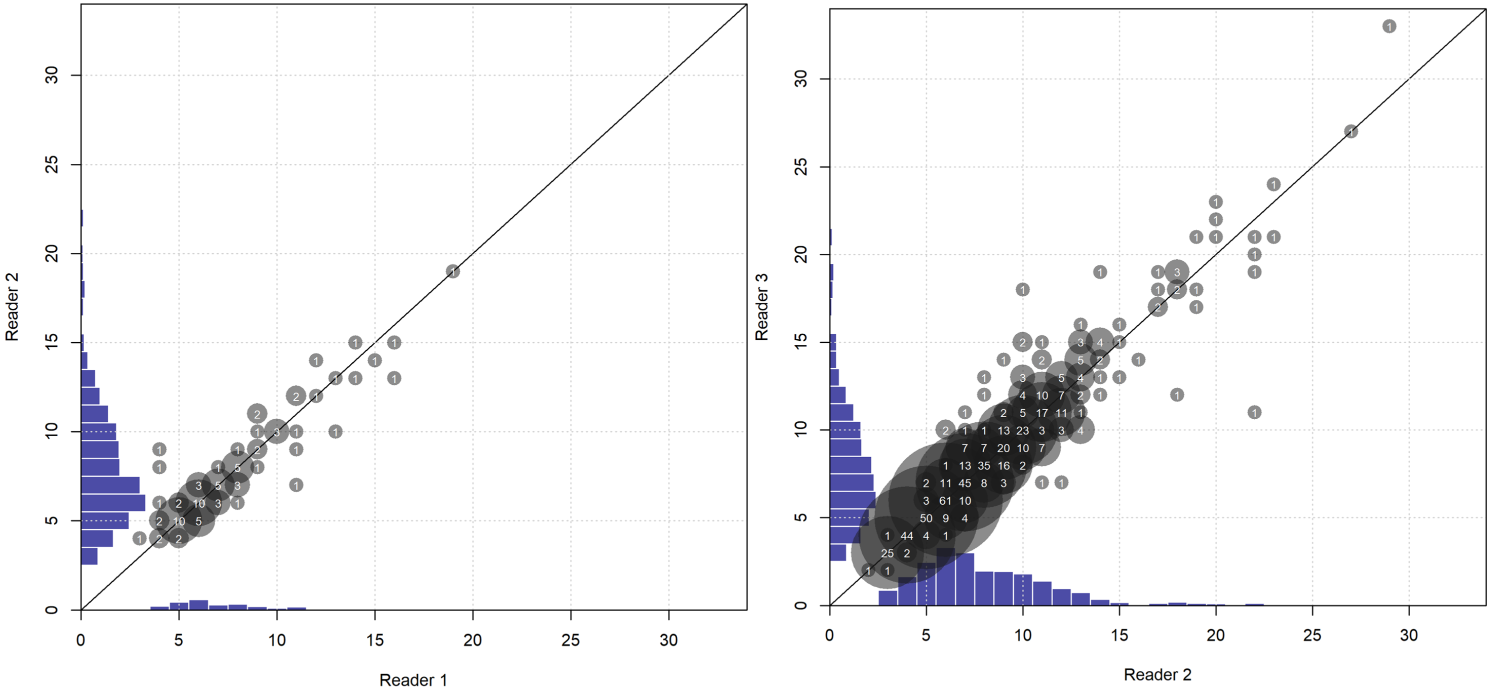
- North of Point Arena = 3,963
- "Central" (S. of Pt. Arena) = 755
- Maximum Observed Ages:
  - Female, 35, central CA
  - Male, 33, northern CA
- Lognormal prior following Hamel and Cope (2022):
  - M = 5.4/35 = 0.154 / yr (median)
  - Log-scale SD(M) = 0.31



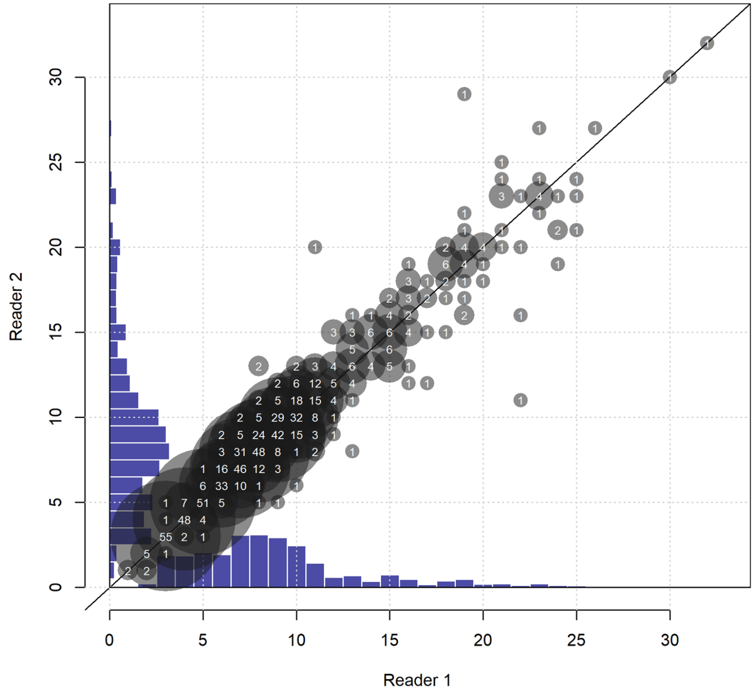
Ageing Error

- Evaluated several models (Punt 2008; Thorson et al. 2012) and selected best using AICc
- 3 readers for otoliths collected after 2015 (plus Abrams 2010-2011 dataset)
  - Best model was unbiased with curvilinear CV
- 2 readers for otoliths collected prior to 2015 (except Abrams dataset)
  - Best model had curvilinear bias and curvilinear CV

After 2015

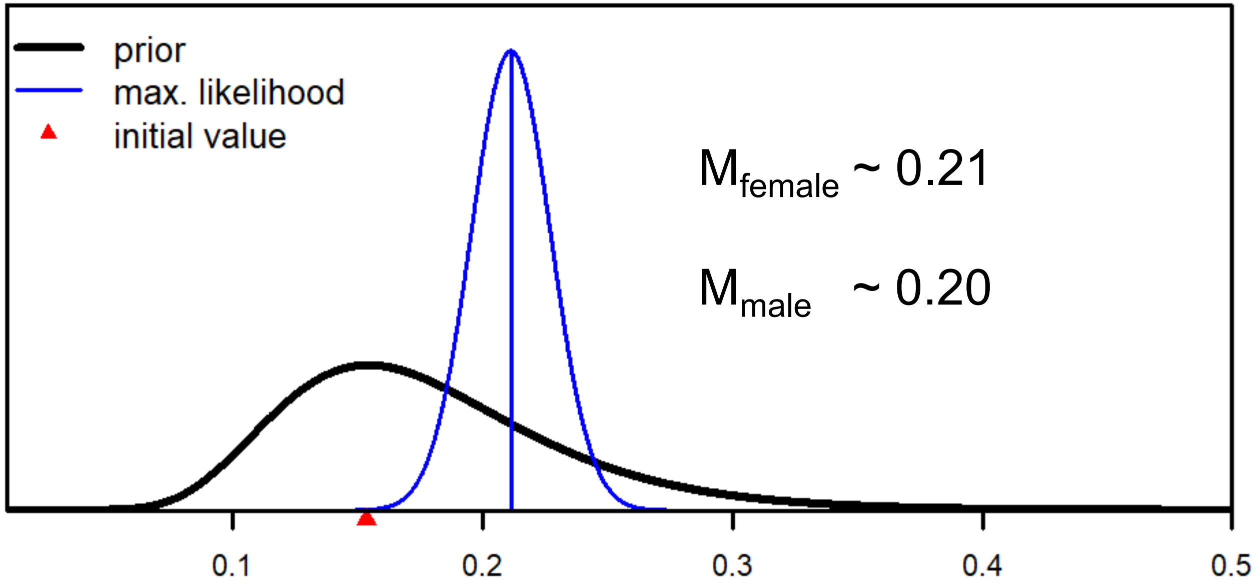


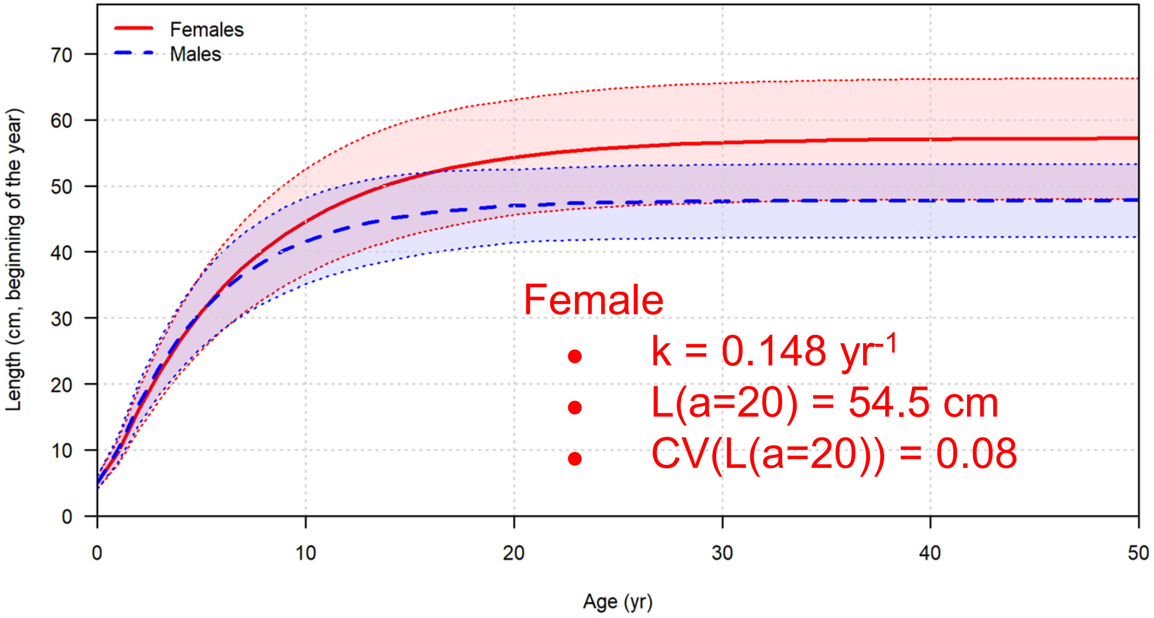
Before 2015

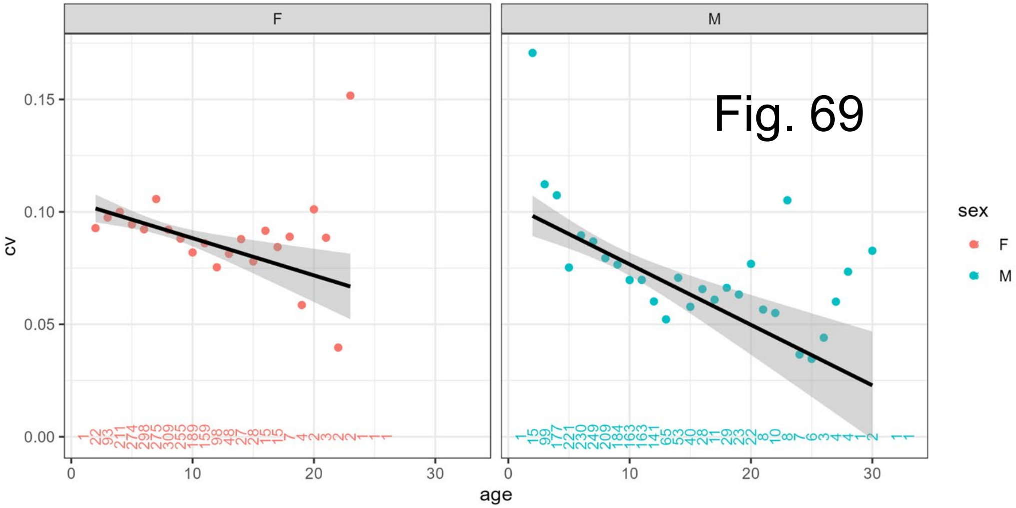


Estimates of natural mortality and growth (Table 37)

Northern California





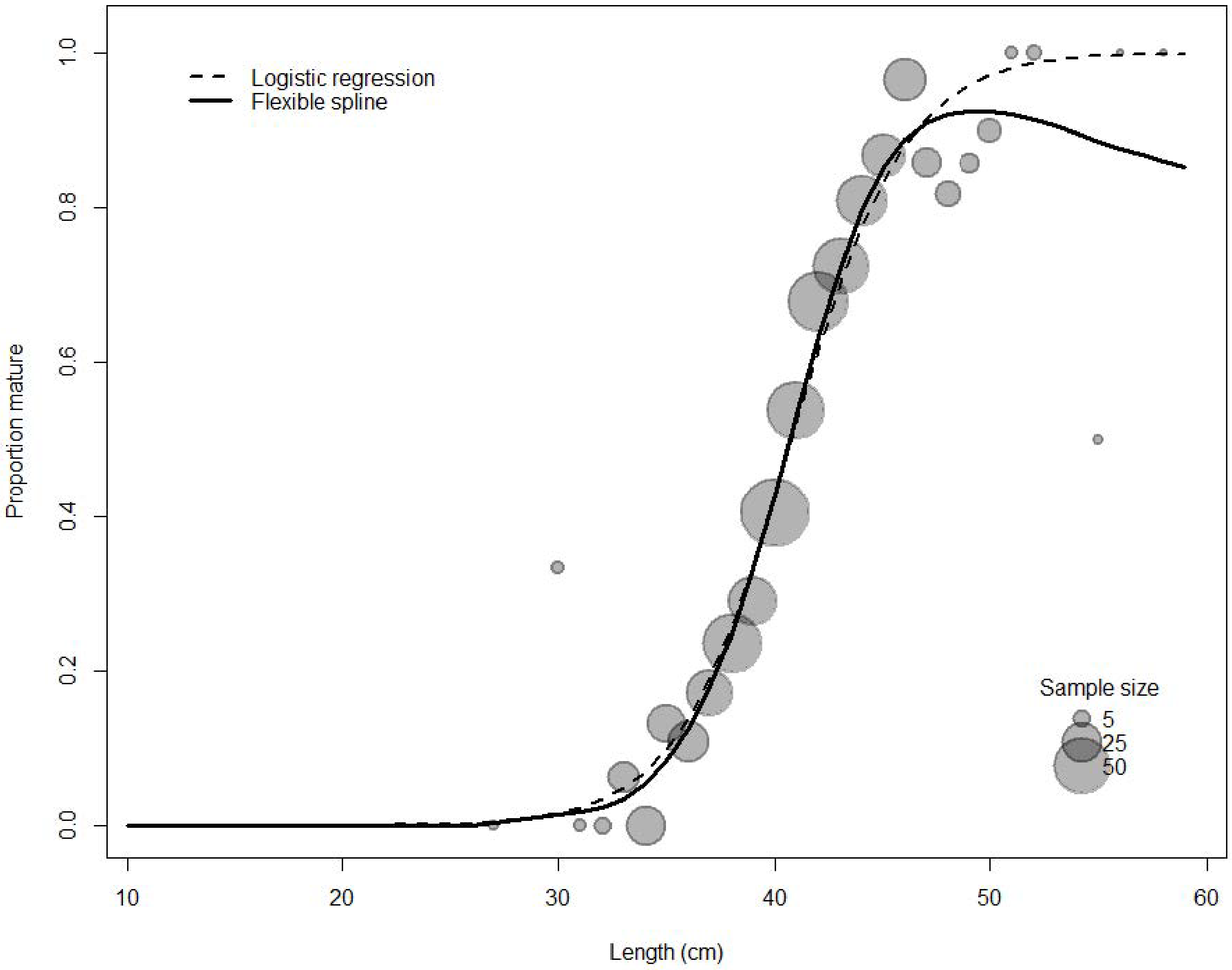


Male

- k = 0.202 yr^{-1}
- L(a=20) = 47.0 cm
- CV(L(a=20)) = 0.068

Maturity and Fecundity

- Female length at 50% maturity
  - Wyllie-Echeverria (1987)
    40 cm (~7 years), California data
  - Claire Rosemond (OSU) and
    Melissa Head (NWFSC)
    "functionally" mature at 40.4 cm
    (~8 years), Oregon data
- Functional maturity accounts for abortive maturation, skipped spawning and follicular atresia
  - biological maturity only considers physiological development
- Fecundity-at-length from *Sebastes* meta-analysis (Dick et al. 2017)
  - $F = aL^b$, b = 4.7
  - Eggs / gram increases with size



Northern California Model Description

- Single, sex-disaggregated population in waters from Pt. Arena to CA/OR border
- Annual time step from 1875-2022, tracking ages 0-50; assumed unfished in 1875
- 1-cm population length bins from 5-70+ cm; 2-cm data bins from 8-60+ cm
- Catch fleets
  - 4 commercial (non-trawl dead, non-trawl live, trawl, discard)
  - 3 recreational (PC boats, PR boats + shore modes, discard)
- “Survey” fleets
  - CCFRP fishery-independent survey
  - Abrams research (included primarily to inform growth)
  - PC onboard index linked to PC fleet selectivity
- Length composition data (all catch fleets, CCFRP, and Abrams)
- Conditional age-at-length (CAAL) data
  - Commercial (non-trawl dead, trawl), Recreational (limited PC & PR)
  - Abrams research, CCFRP

Northern California Model Description (Cont.)

- 98 estimated parameters (including 60 rec. deviations and 2 forecast dev's)
- Natural mortality estimated for females (with prior) and males (offset, flat prior)
- Six estimated parameters of von Bertalanffy growth function
  - Schnute parameterization (A_1 = 0 years, A_2 = 20 years)
  - $L(A_1)$ and $CV(L(A_1))$ fixed at 5 cm and 0.1, respectively, for both sexes
  - $L(A_2)$, *k*, and $CV(L(A_2))$ estimated separately for both sexes
- Beverton-Holt stock-recruitment relationship; steepness fixed at prior mean (0.72)
- Estimated equilibrium unfished recruitment (R_0)
- Recruitment deviations estimated (1963-2022) with $\sigma_R = 0.6$
- All indices assumed proportional to vulnerable biomass
- Added variance parameter for PR mode index
- Length-based selectivity: logistic (commercial) or double-normal (all others)
- Time-blocked selectivity for major rec. fleets (1875-2003; 2004-2022)
- Francis weights applied to all length and age composition data; no upweighting

Central California Model Description

- Single, sex-disaggregated population in waters from Pt. Arena to US/Mex border
- Annual time step from 1875-2022, tracking ages 0-50; assumed unfished in 1875
- 1-cm population length bins from 5-70+ cm; 2-cm data bins from 8-60+ cm
- Catch fleets
  - 3 commercial (non-trawl (dead+live landings), trawl, discard)
  - 3 recreational (PC boats, PR boats + shore modes, discard)
- "Survey" fleets
  - CCFRP fishery-independent survey
  - CRFS PC onboard index (2001-2022) linked to PC fleet selectivity
  - Onboard PC index (1988-1998; "DWV" index)
  - Lea et al. research
- Length composition data (non-trawl, PC, PR, discard, CCFRP, and Lea et al.)
- Conditional age-at-length (CAAL) data
  - Recreational (limited PC & PR)
  - CCFRP, Lea et al.

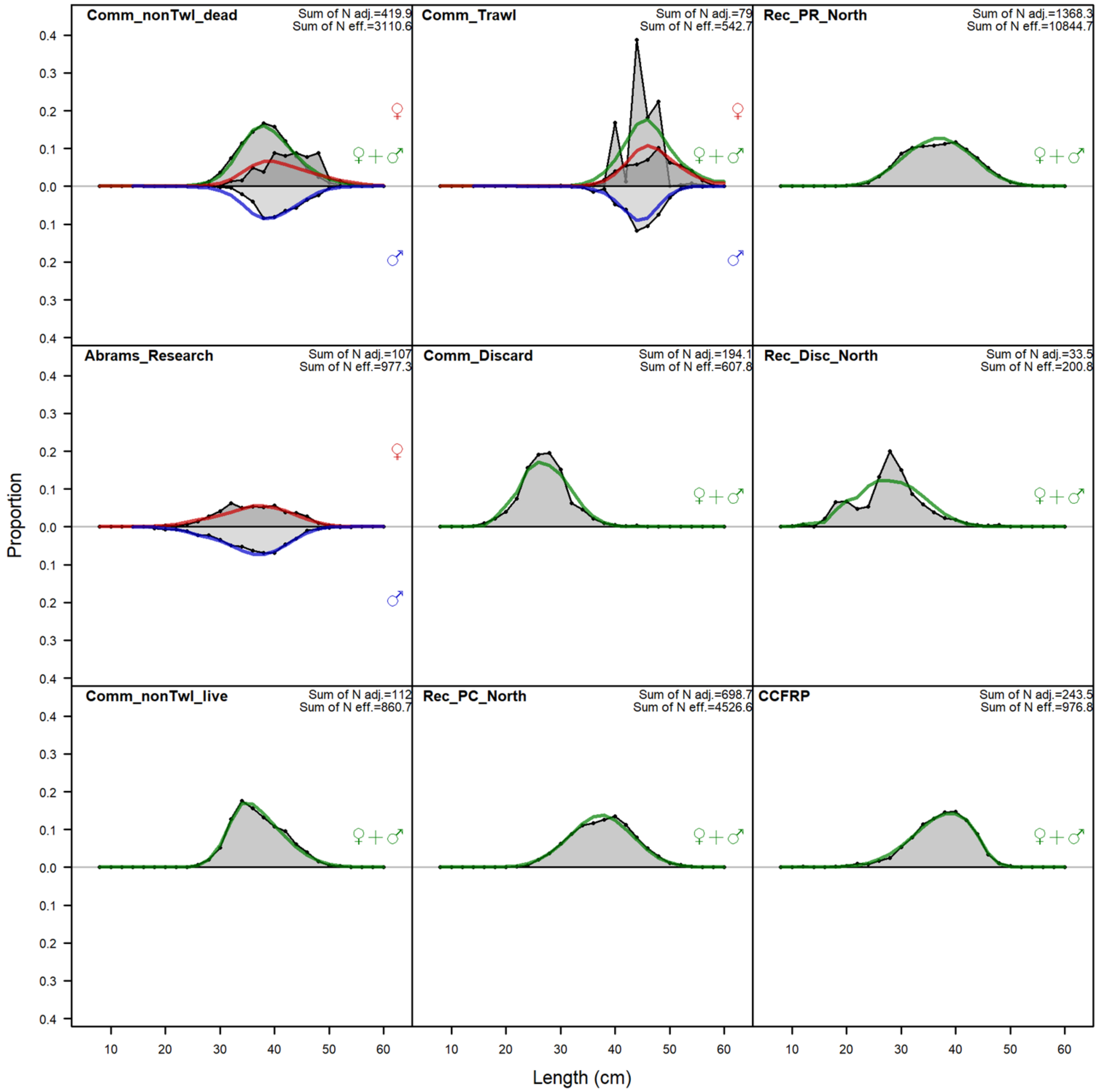
Central California Model Description (Cont.)

- *118 estimated parameters* (including 88 rec. deviations and 2 forecast dev's)
- Natural mortality fixed at sex-specific northern model estimates
- Four estimated parameters of von Bertalanffy growth function
  - Schnute parameterization (A_1 = 0 years, A_2 = 20 years)
  - $L(A_1)$ and $CV(L(A_1))$ fixed at 5 cm and 0.1, respectively, for both sexes
  - $L(A_2)$ and *k* estimated separately for both sexes; $CV(L(A_2))$ fixed (north value)
- Beverton-Holt stock-recruitment relationship; steepness fixed at prior mean (0.72)
- Estimated equilibrium unfished recruitment (R_0)
- Recruitment deviations estimated (1935-2022) with $\sigma_R = 0.6$
- All indices assumed proportional to vulnerable biomass
- Added variance parameter for PR mode index
- Length-based selectivity: logistic (commercial) or double-normal (all others)
- ~~Time-blocked selectivity for major rec. fleets (1875-2003; 2004-2022)~~
- Francis weights applied to all length and age composition data; no upweighting

Model Evaluation

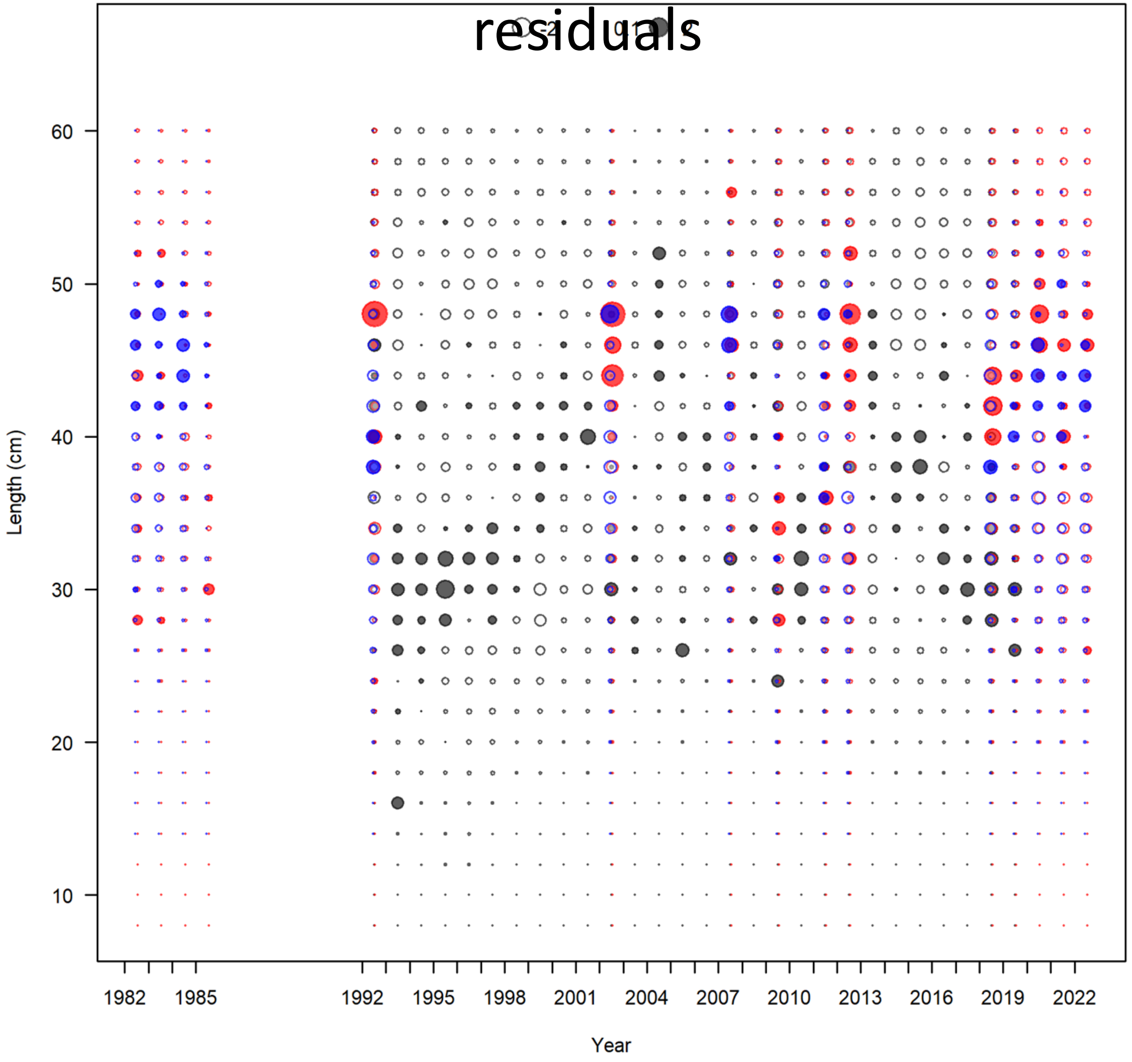
- Attempted fleets as areas, in the end two model areas.
- Bridging results consistent.
- Convergence: Low parameter gradient, no parameters hitting bounds, no improvement in NLL from jitters.
- Reasonable fits to length composition data.
- Poor fit to CCFRP index north of Point Arena, short time series.
- No strong retrospective pattern.
- Sensitivities, drop one (non trawl dead +, drop trawl -), Weighting (base francis) vs MI., etc.

Northern model: fits to length data (aggregated over time)

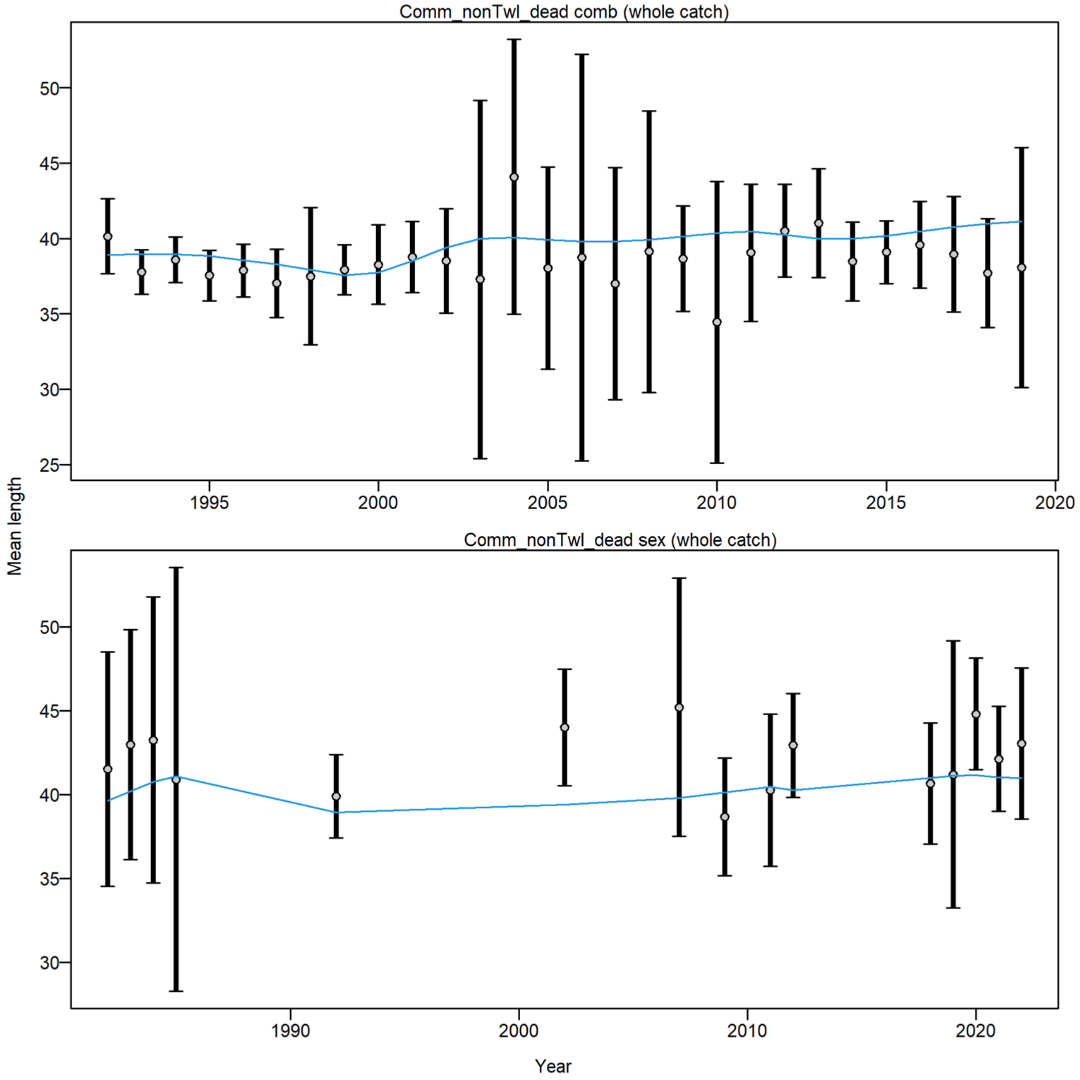


Northern non-trawl fleet (landed dead)

Length composition Pearson residuals

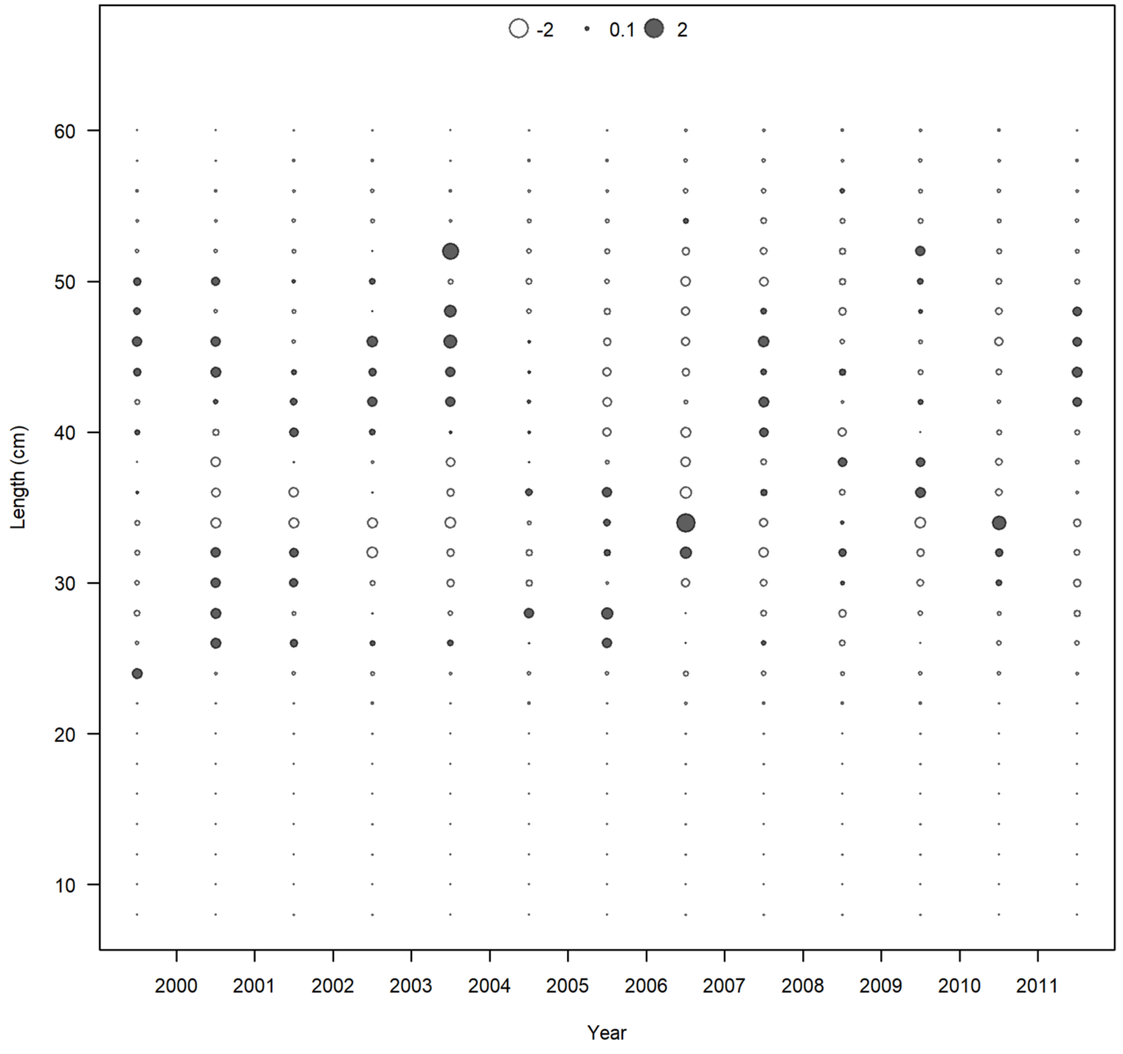


Fits to mean length

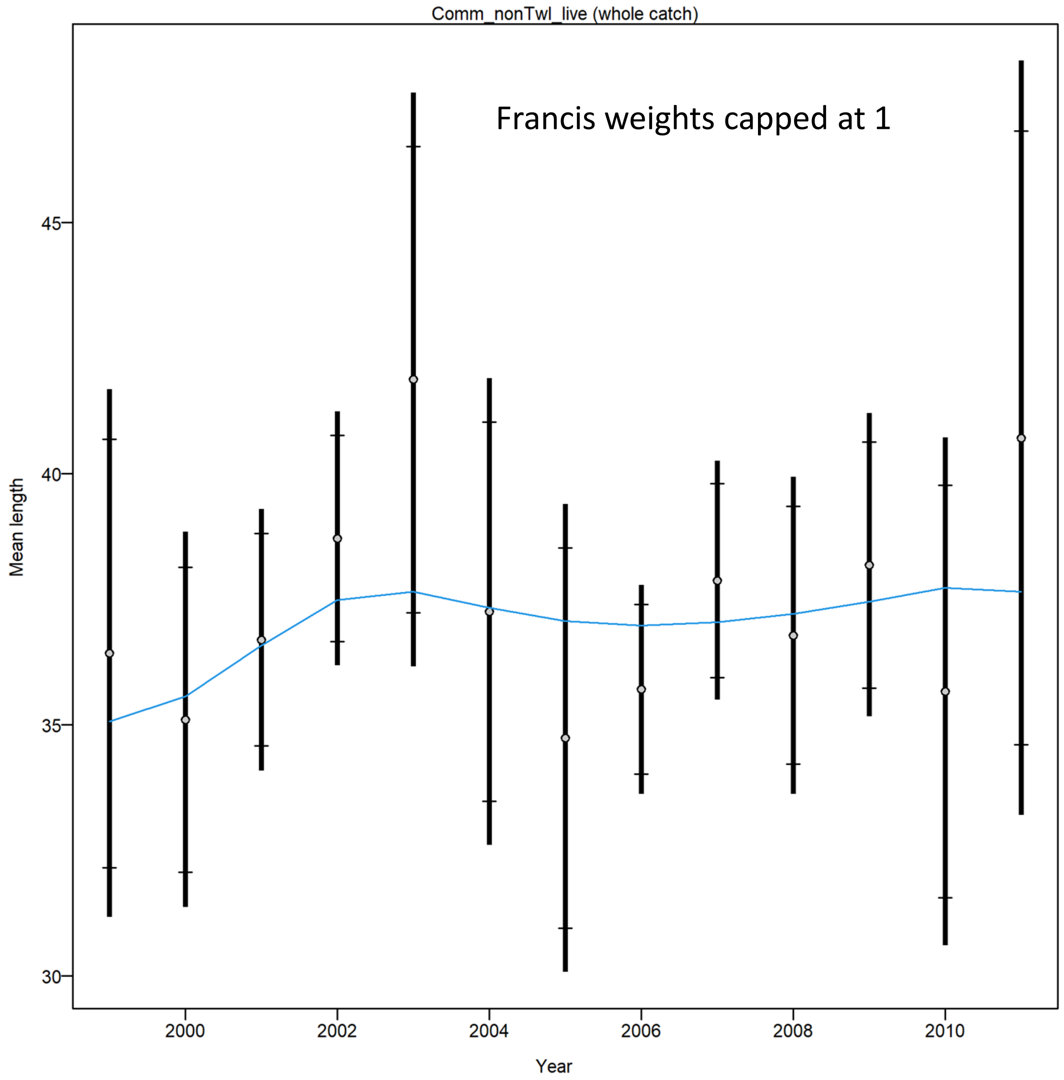


Northern non-trawl fleet (landed alive)

Length composition Pearson residuals

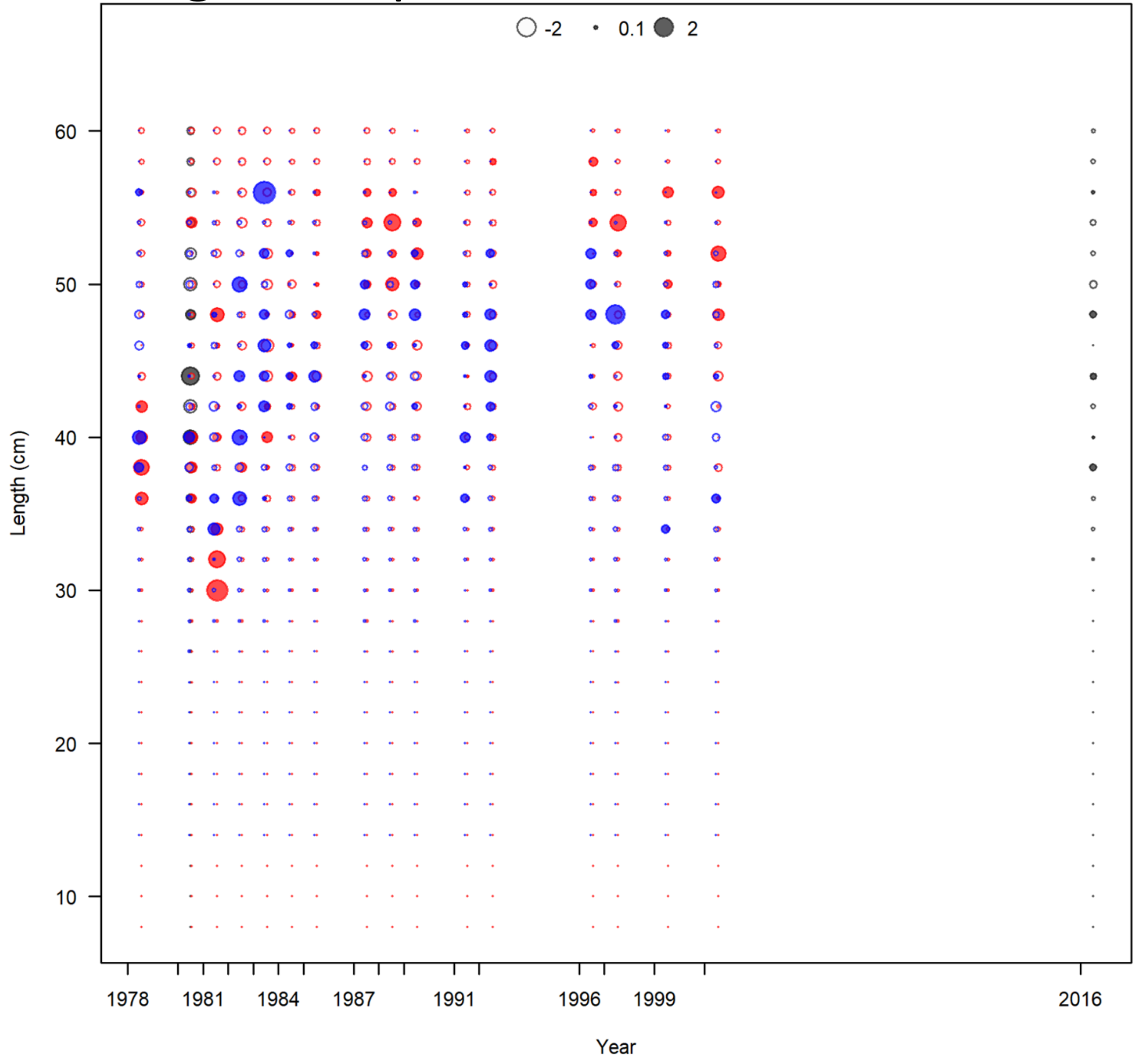


Fits to mean length

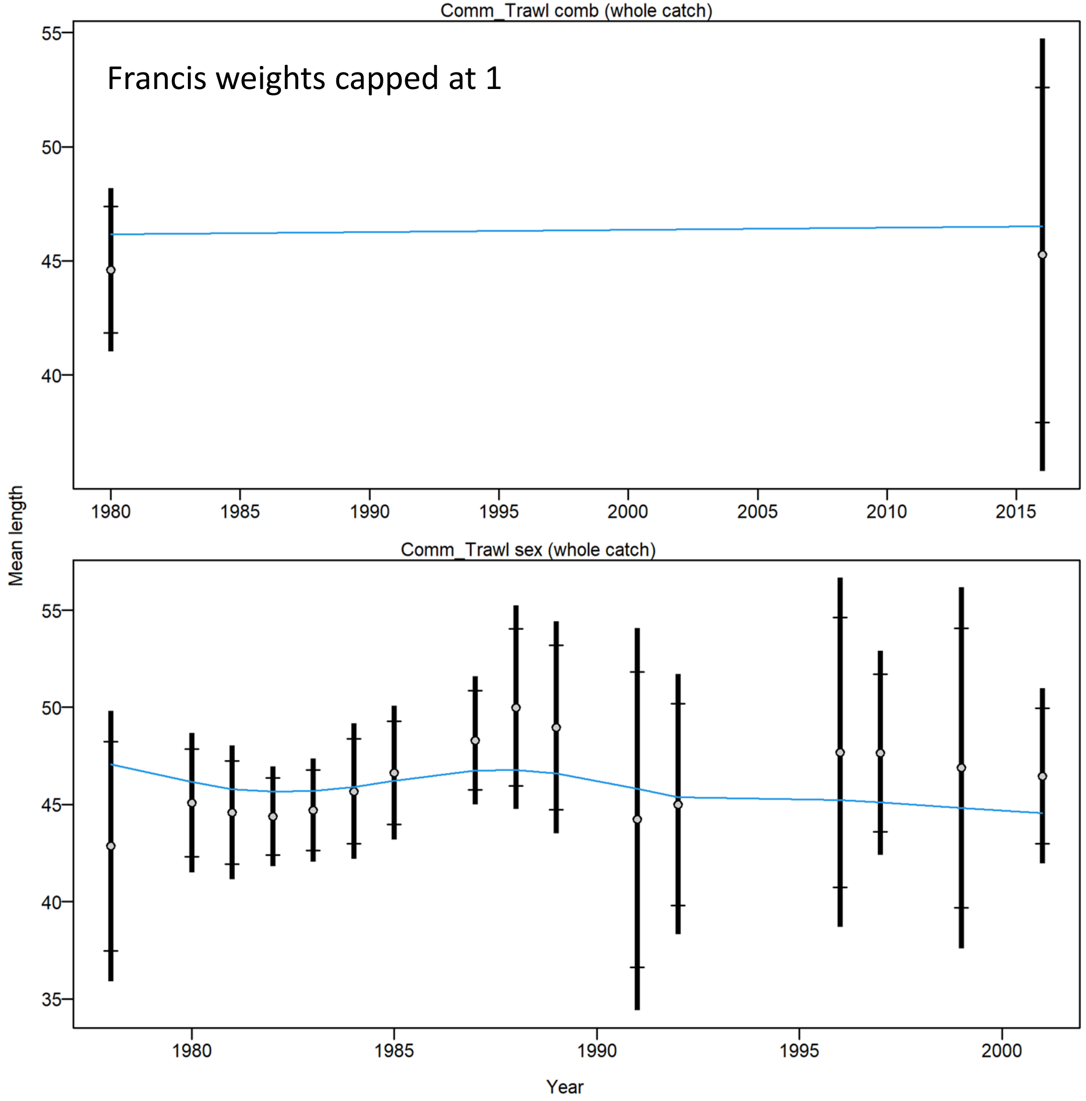


Northern trawl fleet

Length composition Pearson residuals

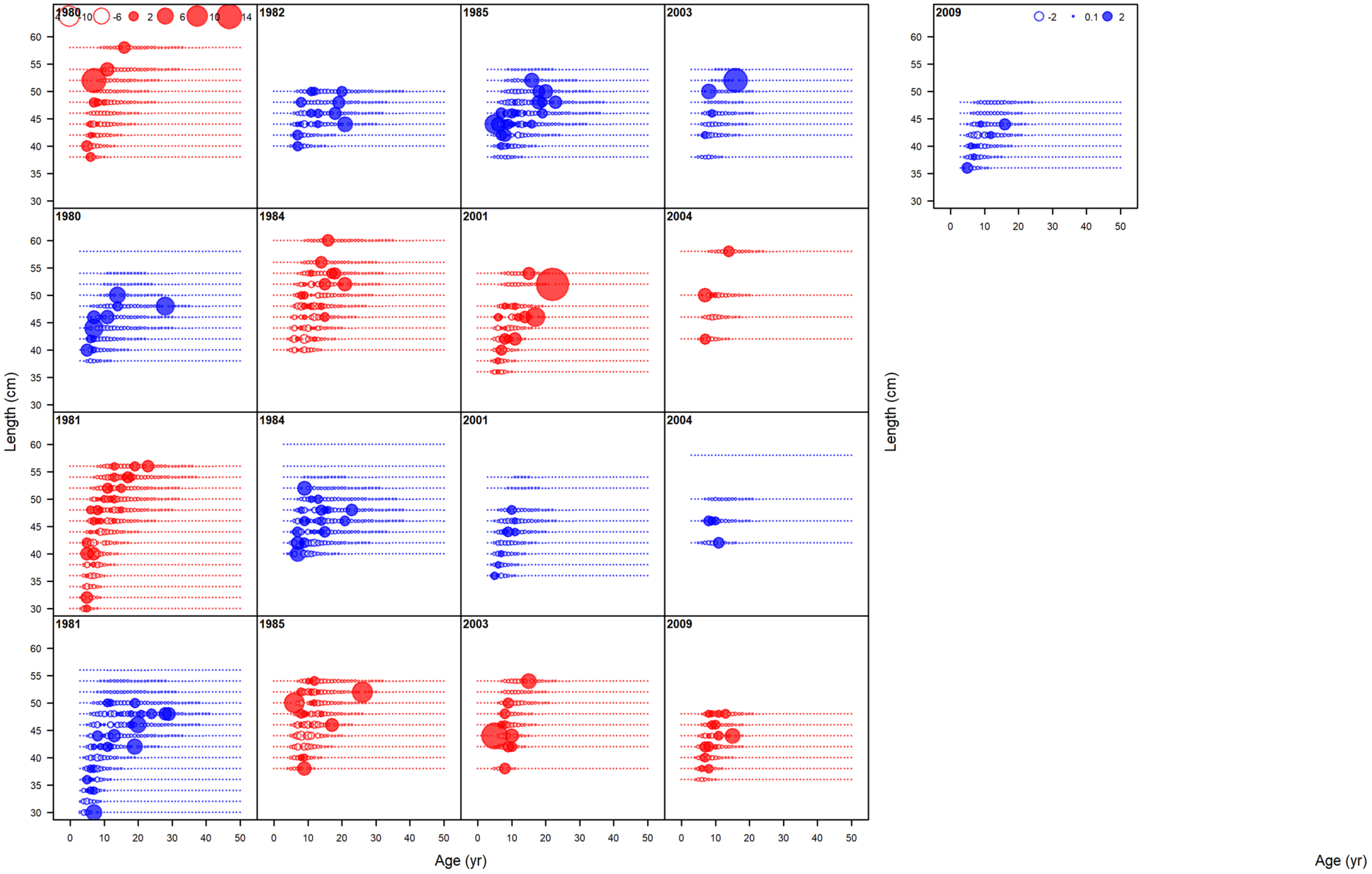


Fits to mean length



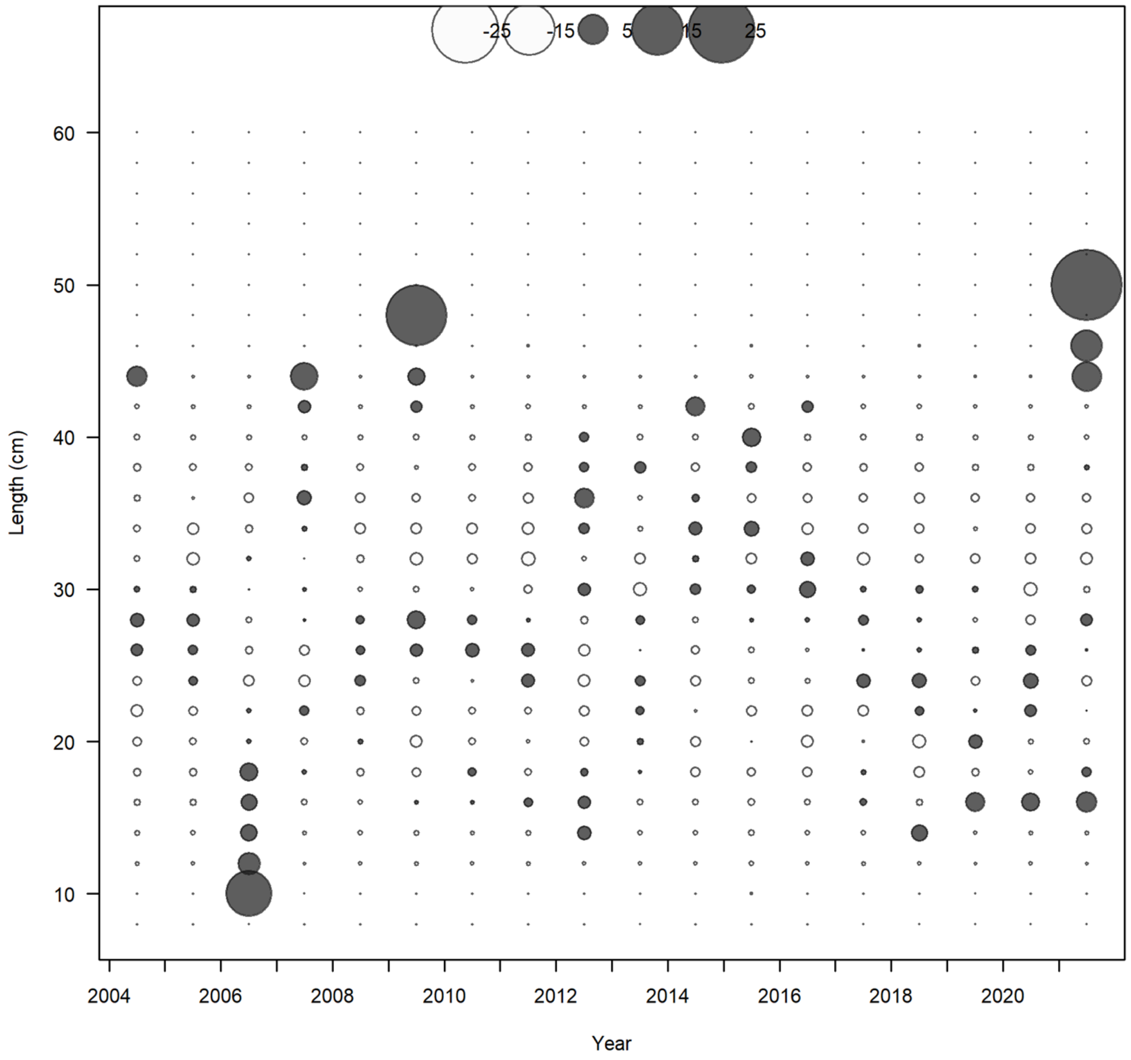
Northern trawl fleet

Age composition Pearson residuals

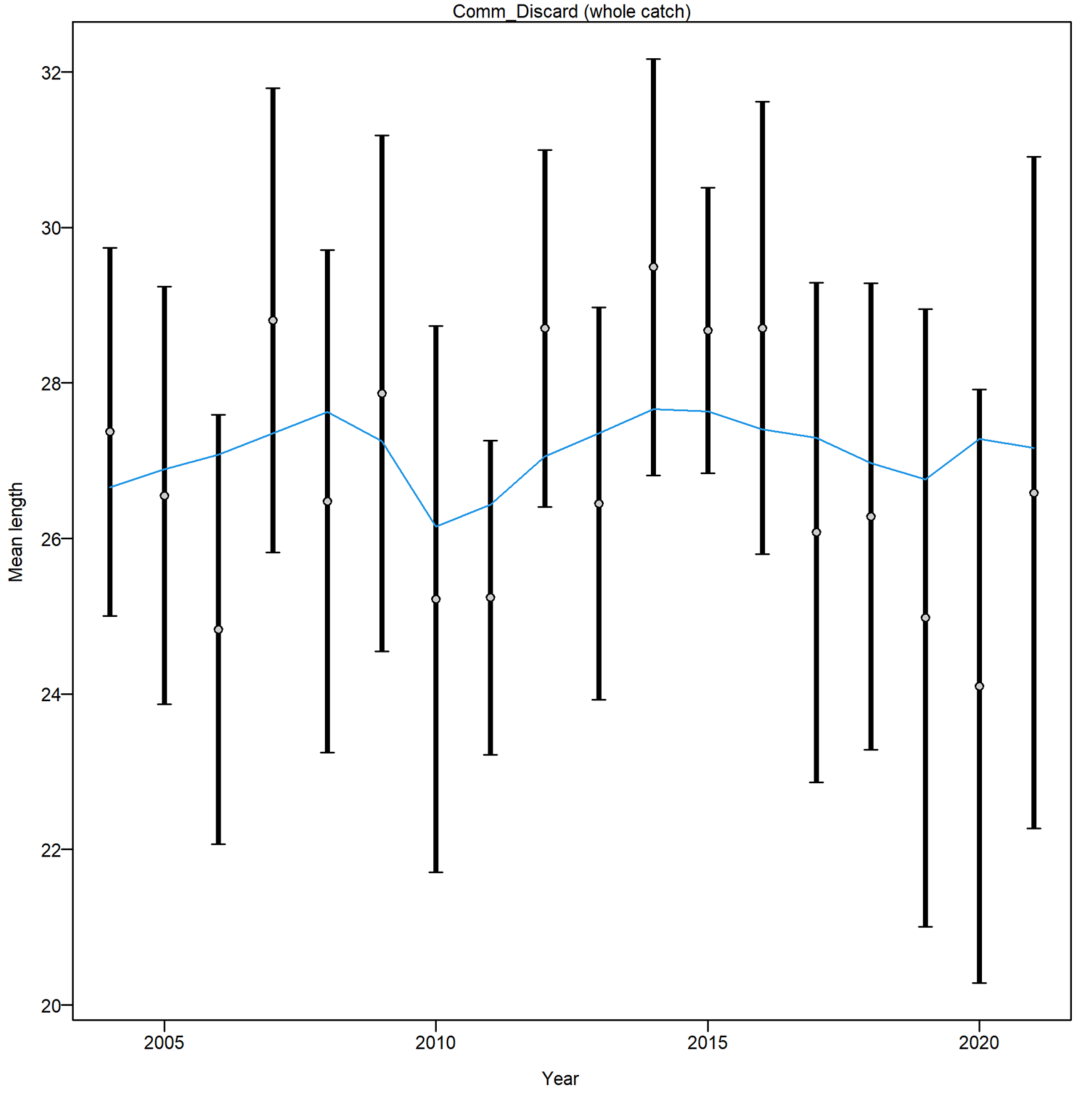


Statewide commercial discard

Length composition Pearson residuals

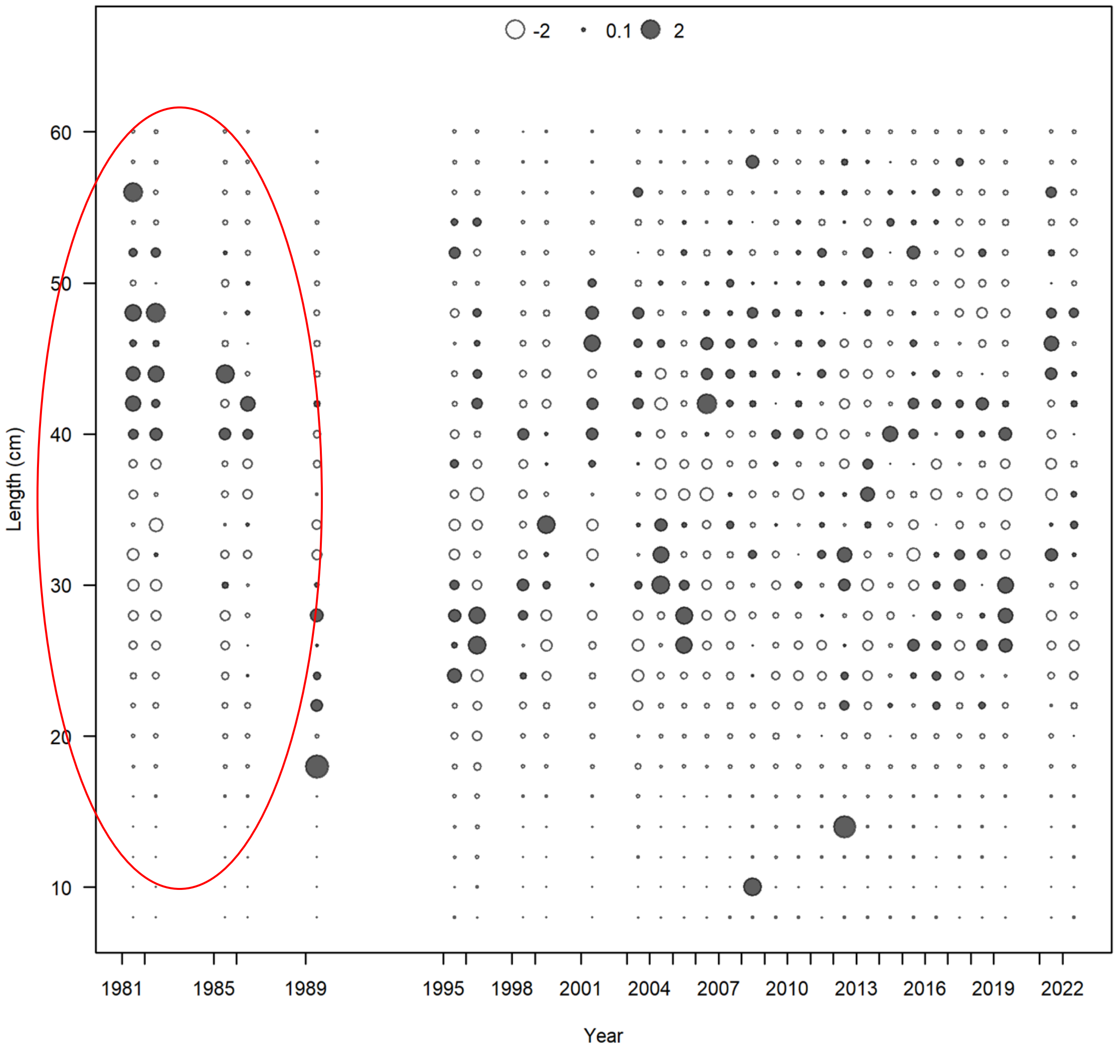


Fits to mean length

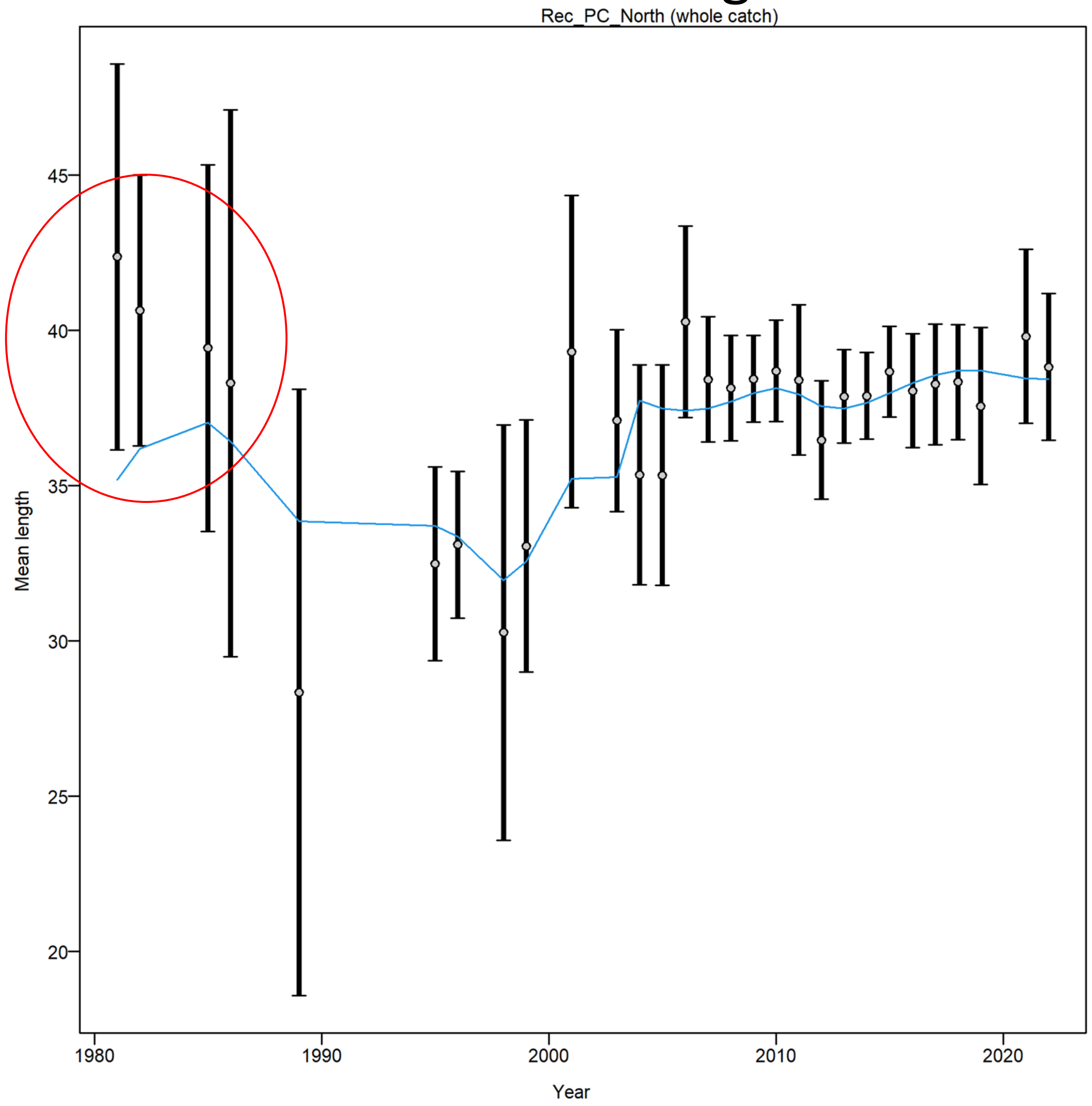


Northern recreational PC fleet

Length composition Pearson residuals

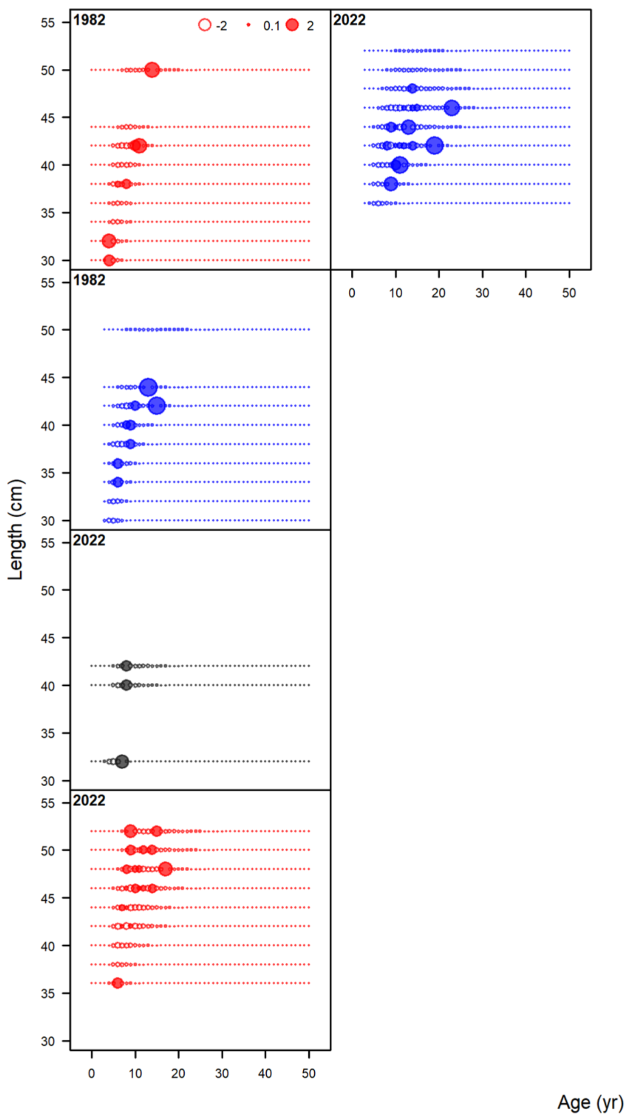


Fits to mean length



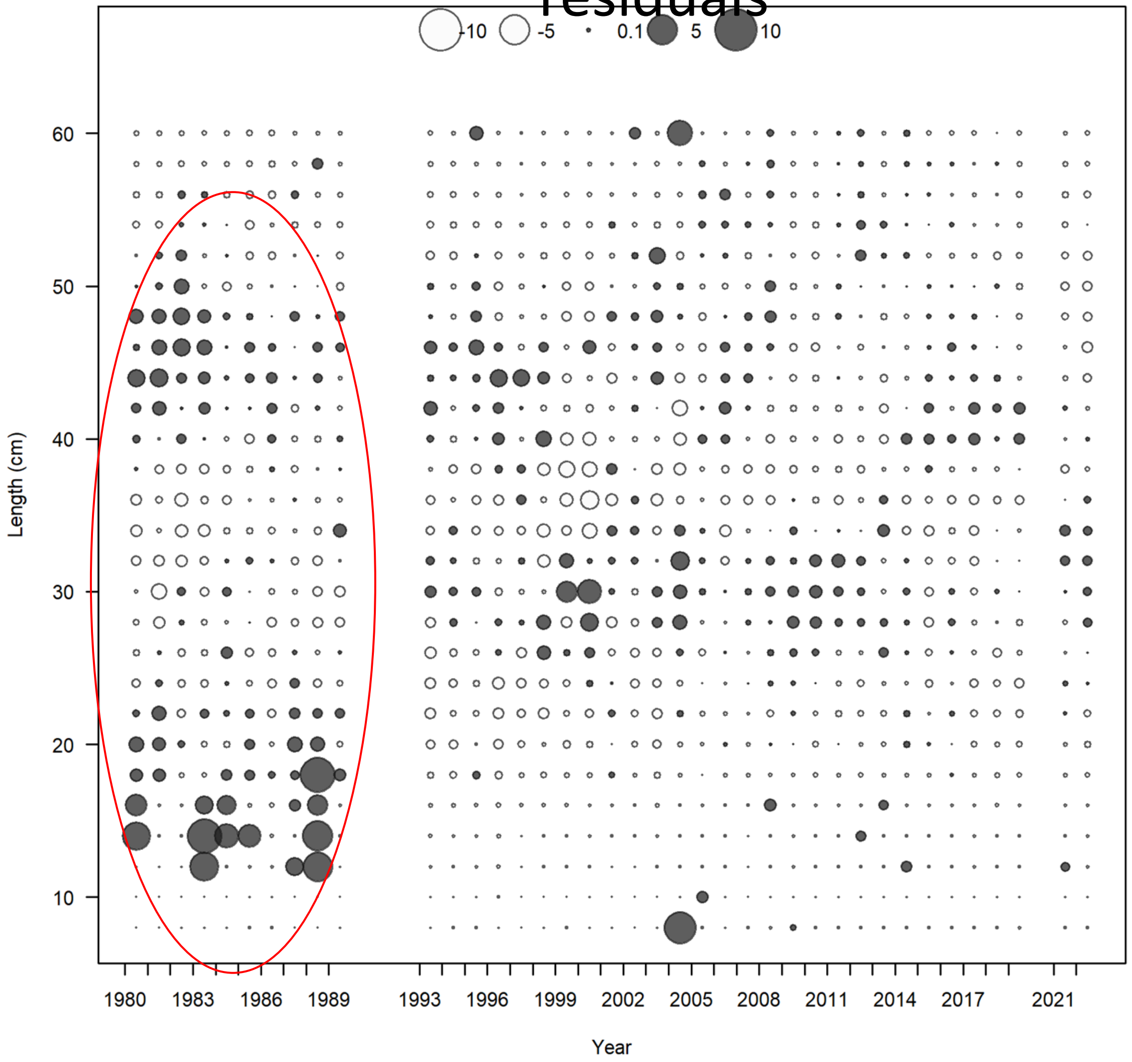
Northern recreational PC fleet

Age composition Pearson residuals

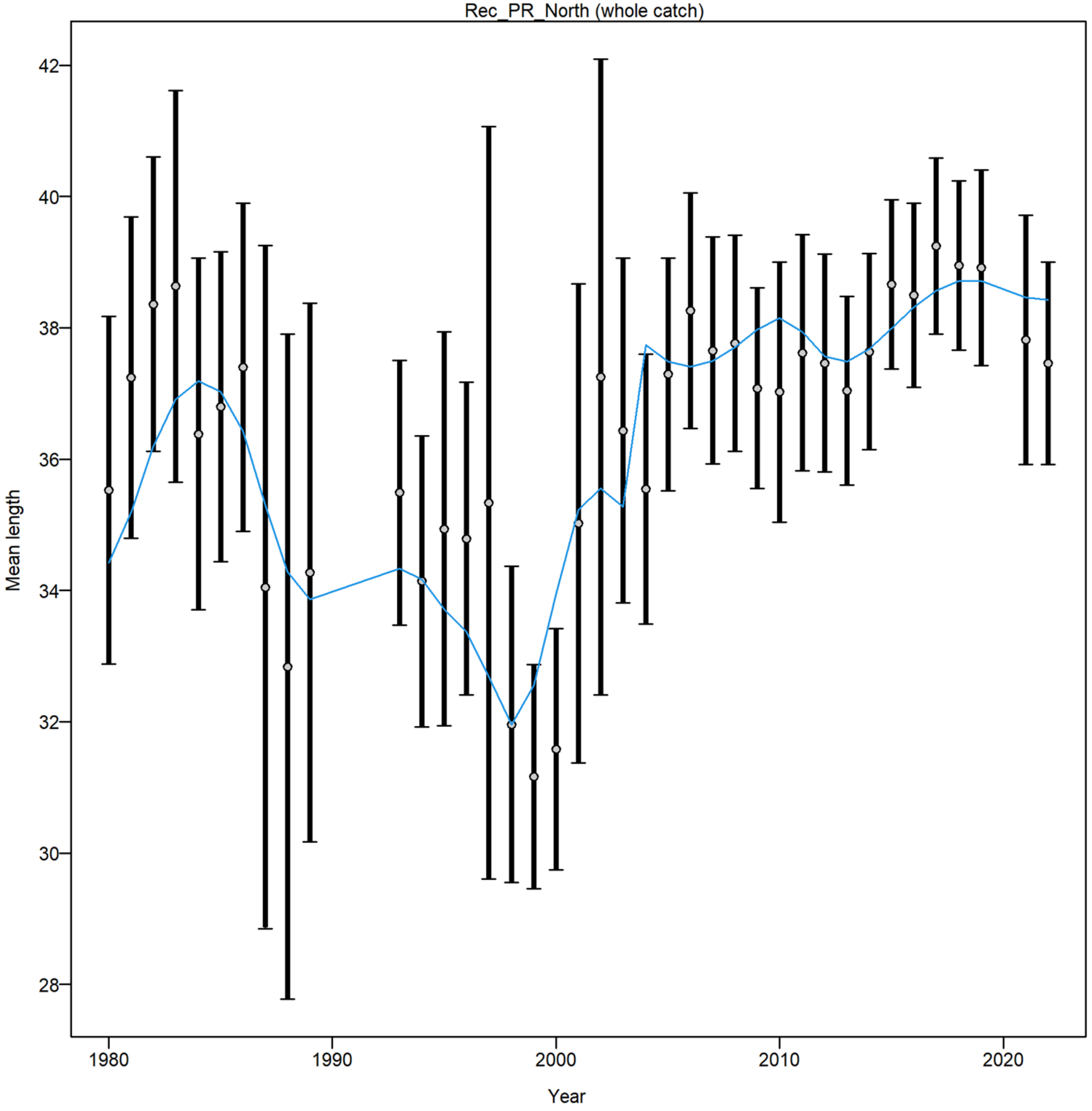


Northern recreational PR fleet

Length composition Pearson residuals

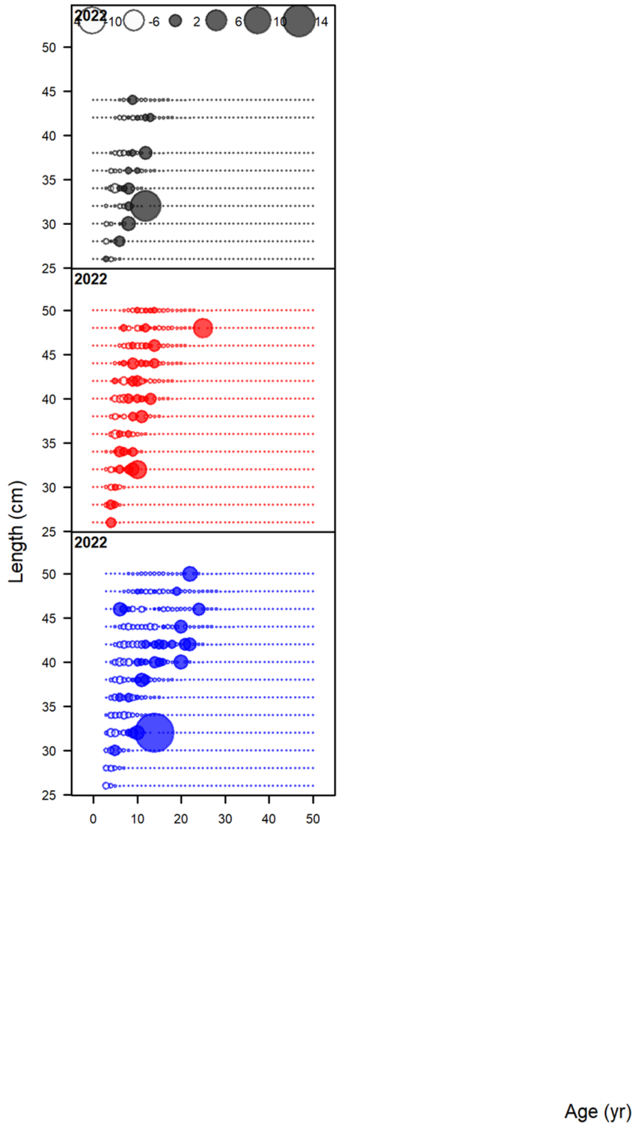


Fits to mean length



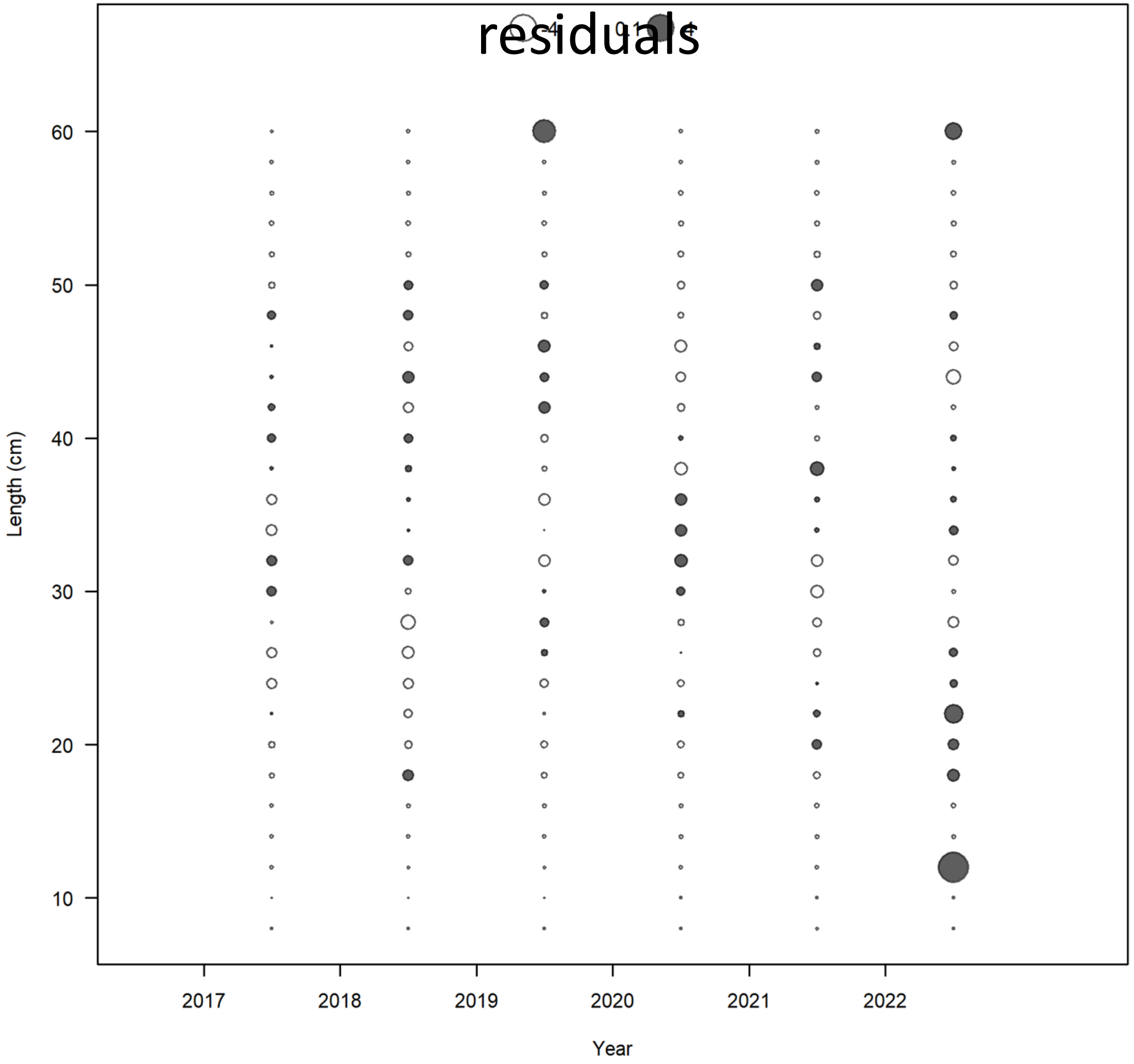
Northern recreational PR fleet

Age composition Pearson residuals

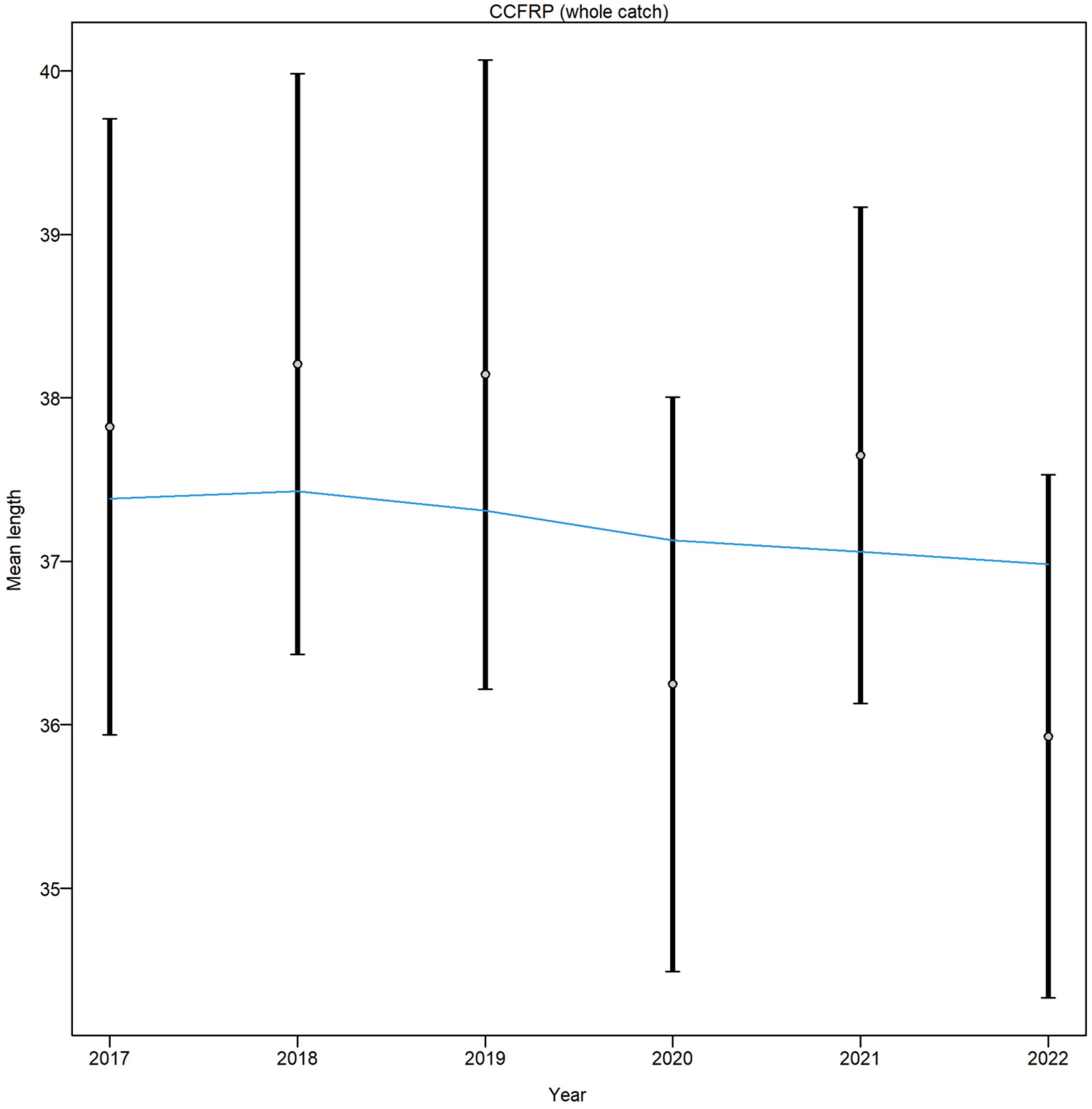


Northern CCFRP survey

Length composition Pearson residuals

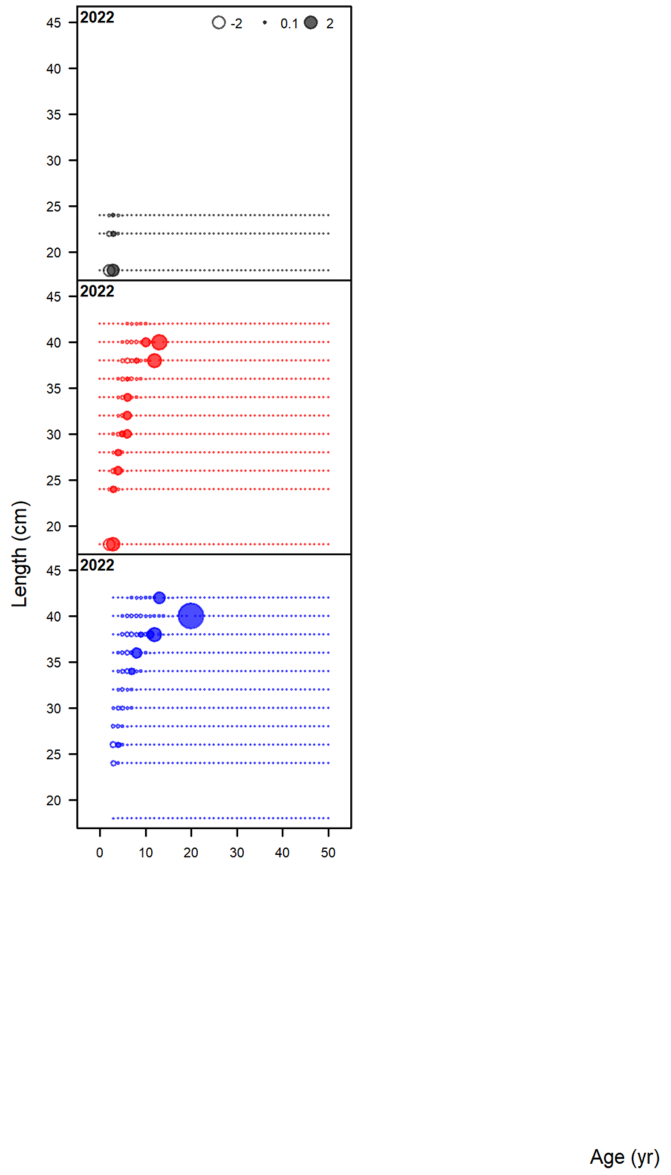


Fits to mean length



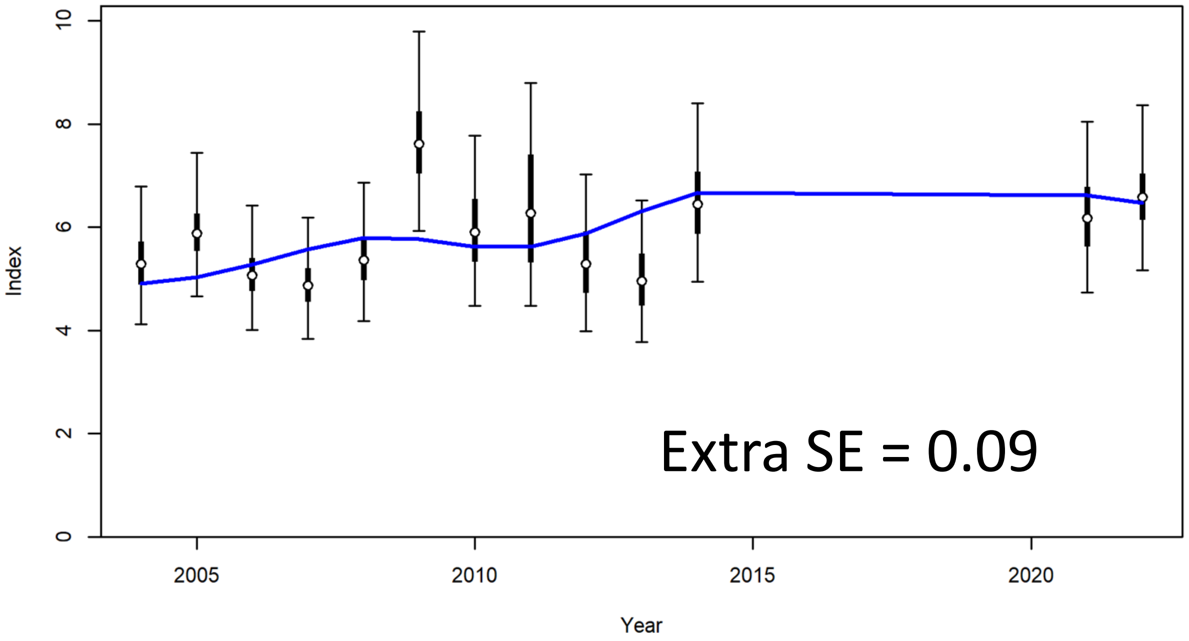
Northern CCFRP survey

Age composition Pearson residuals

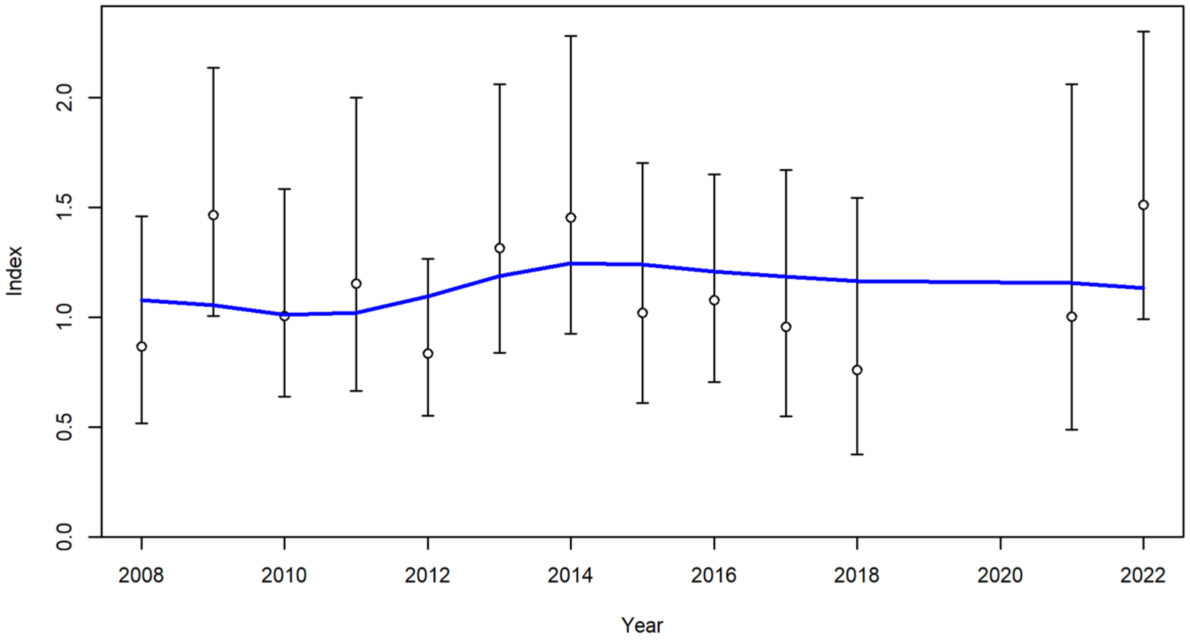


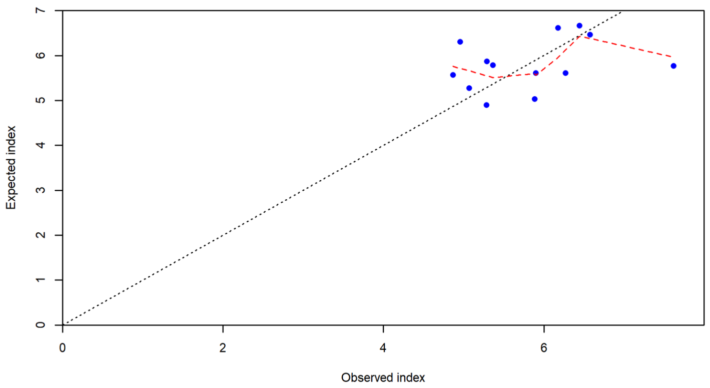
Northern model: fishery-dependent indices of

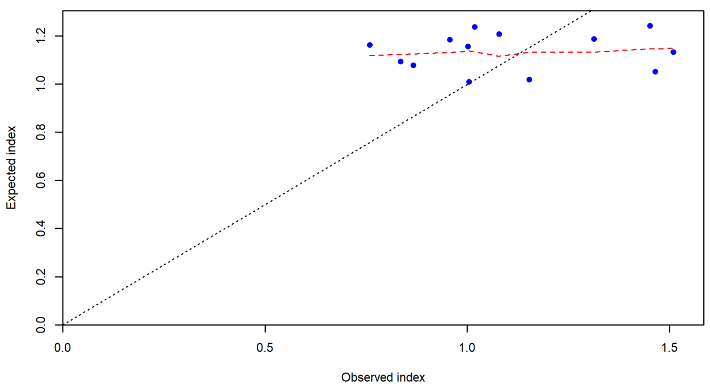
Rec. PR dockside index



Rec. PC onboard index

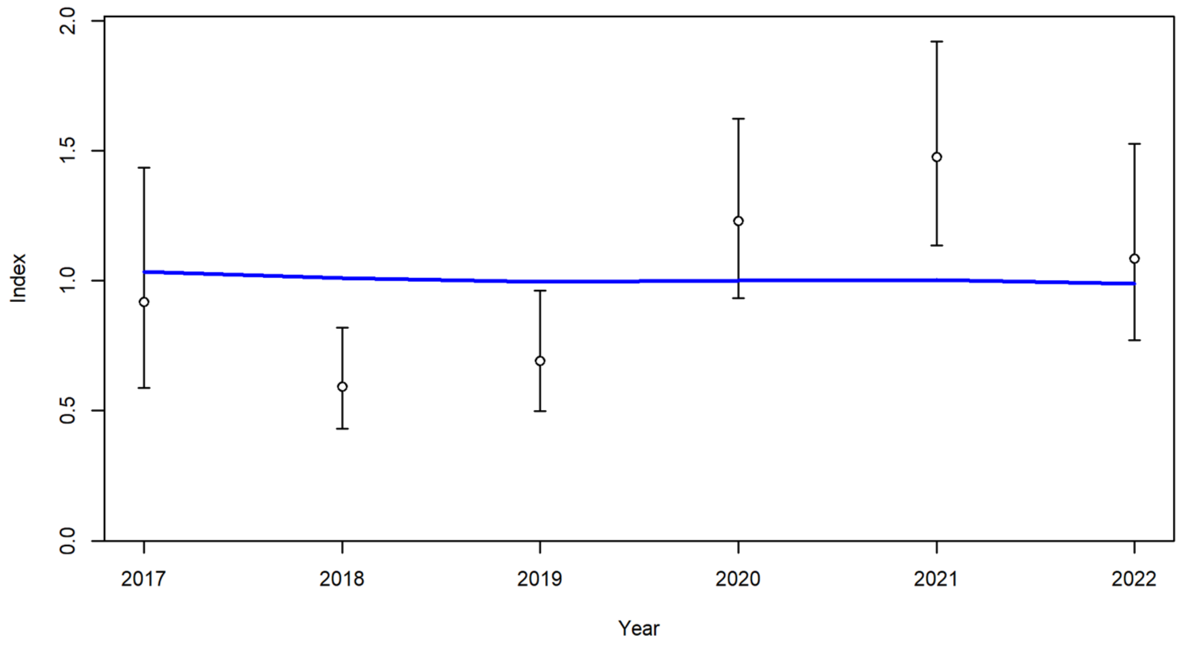


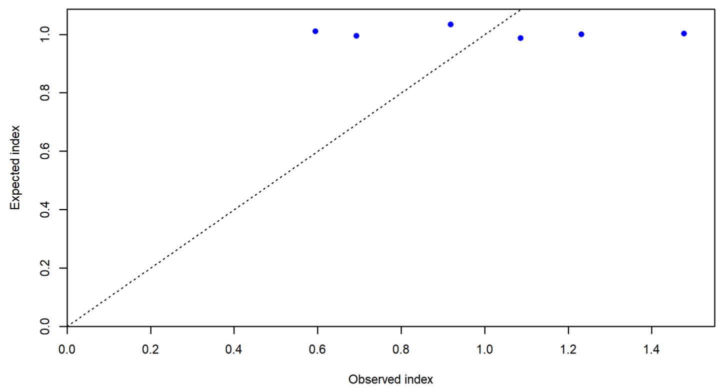




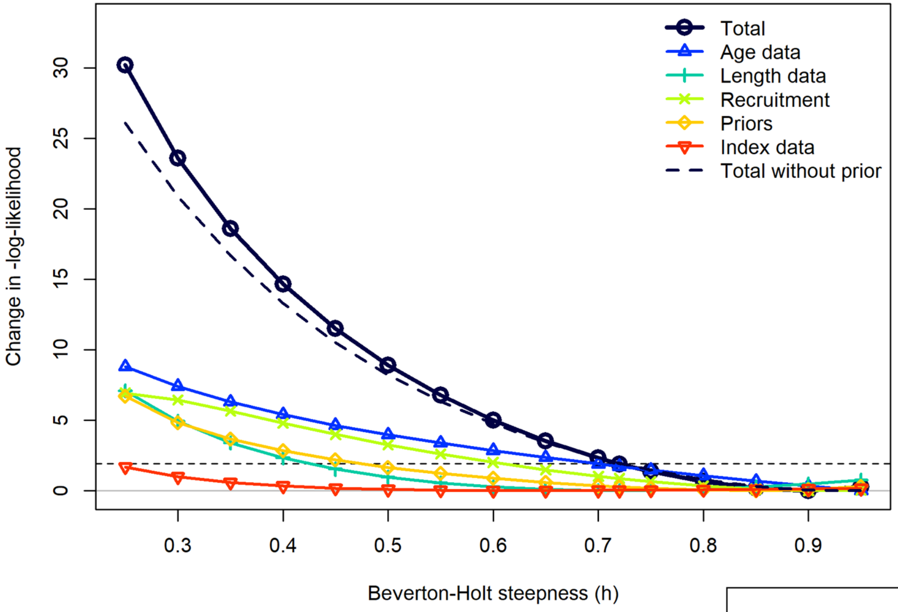
Northern model: fishery-independent indices of

CCFRP index

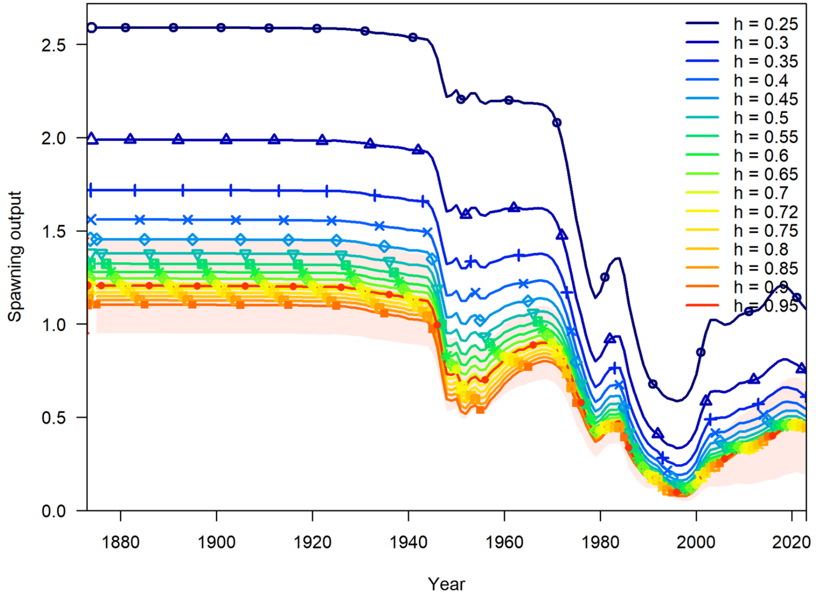


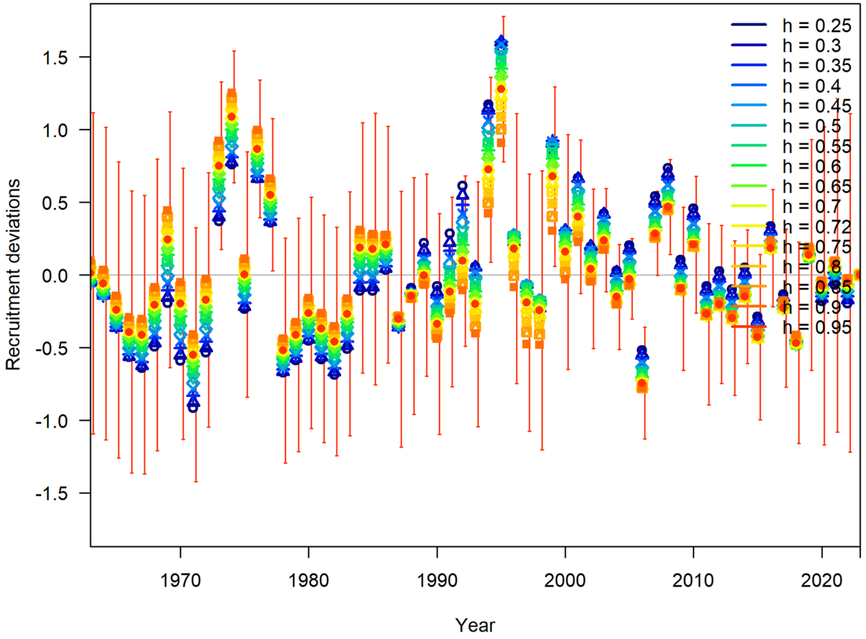


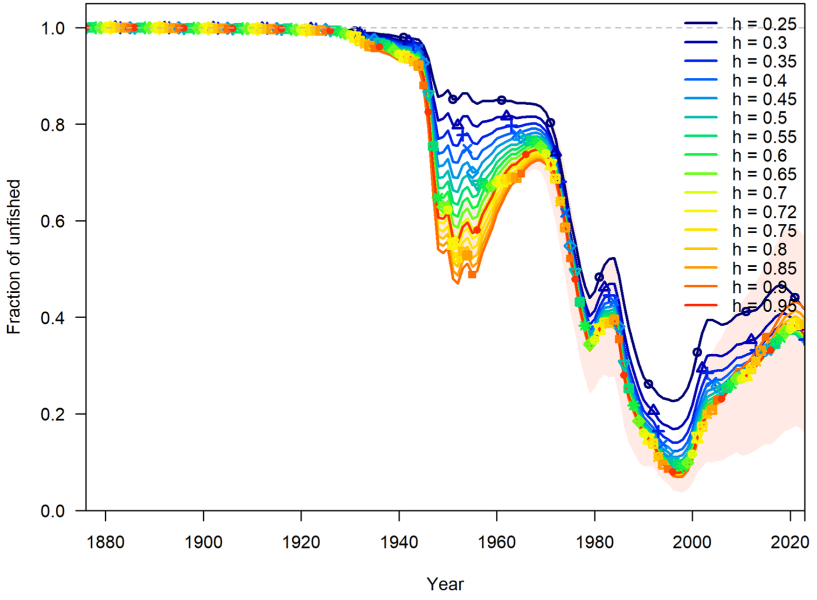
Northern Model Likelihood Profiles: Steepness



Also see Tables 44-45, and Figures 120-122

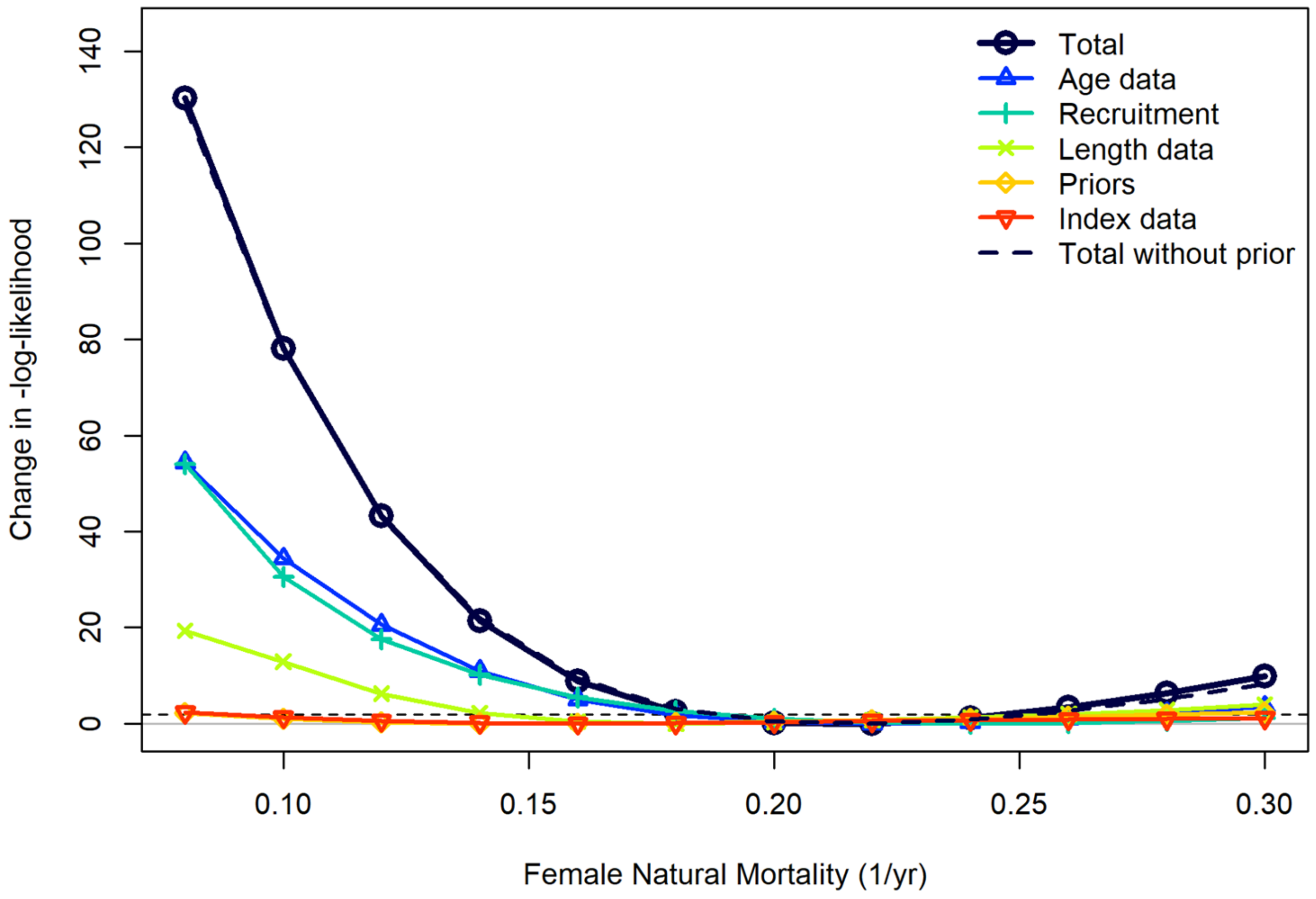


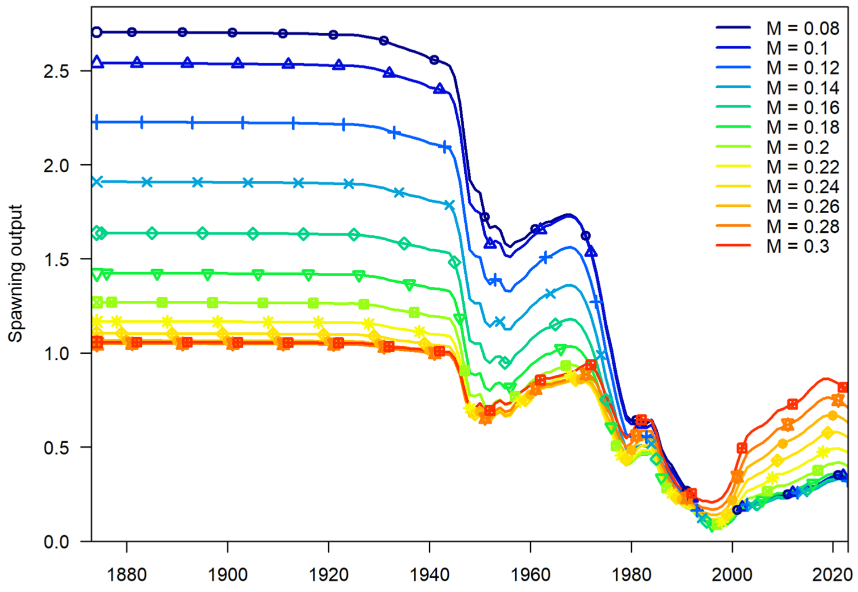


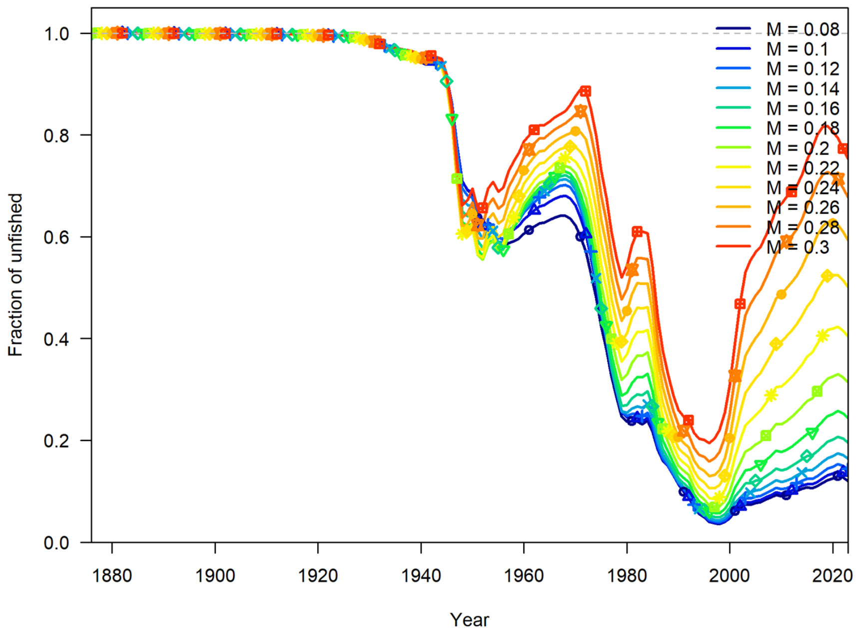


Northern Model Likelihood Profiles: Natural Mortality

Also see Table 46 and Figures 133-135

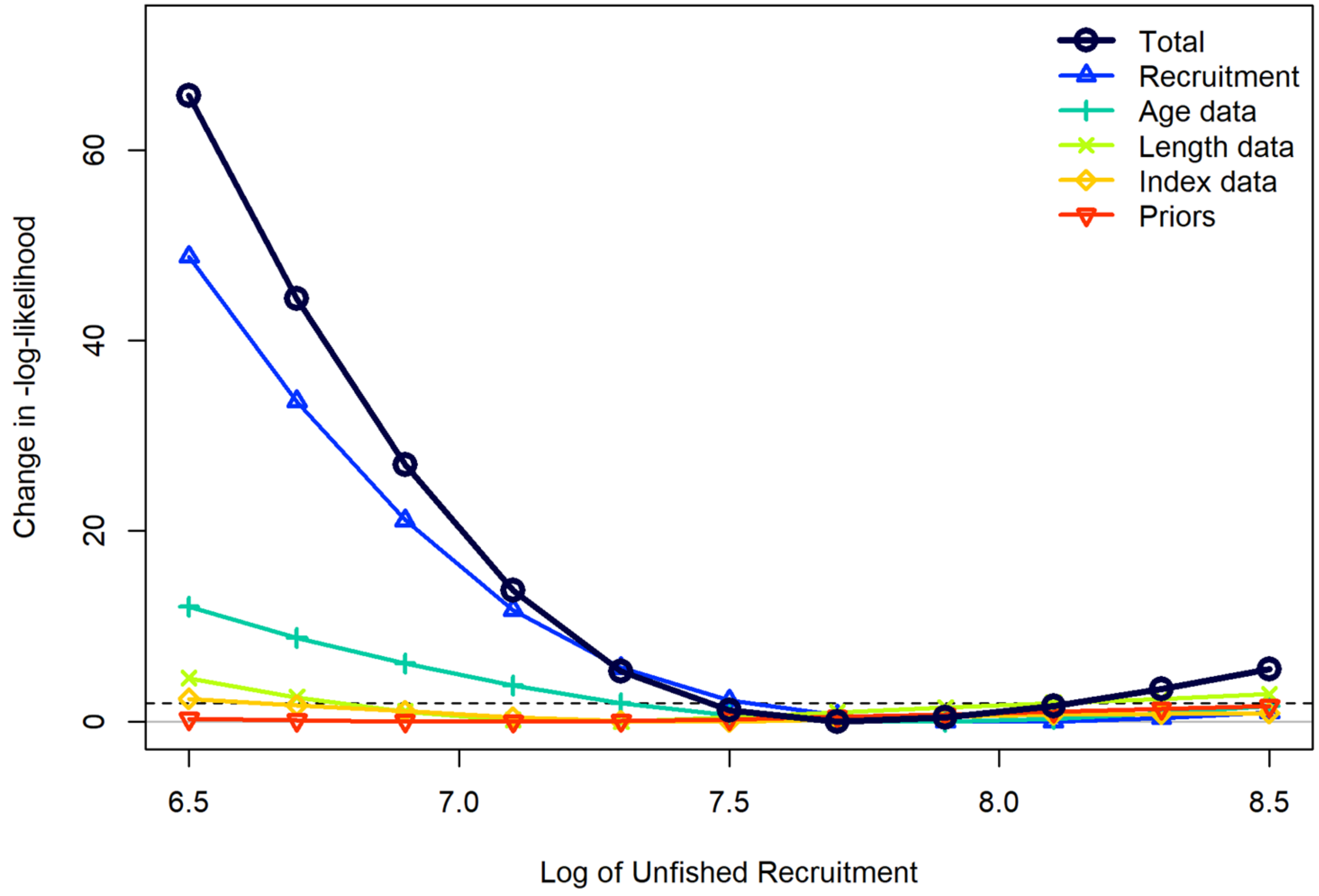


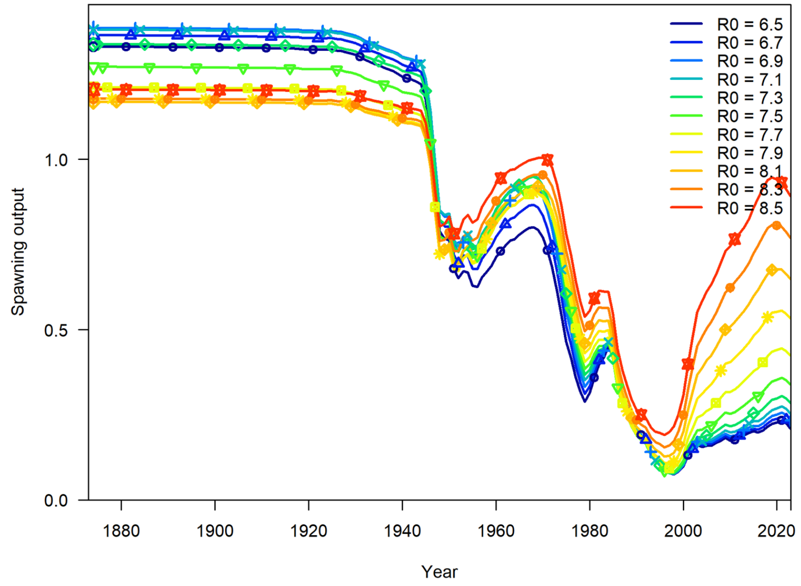


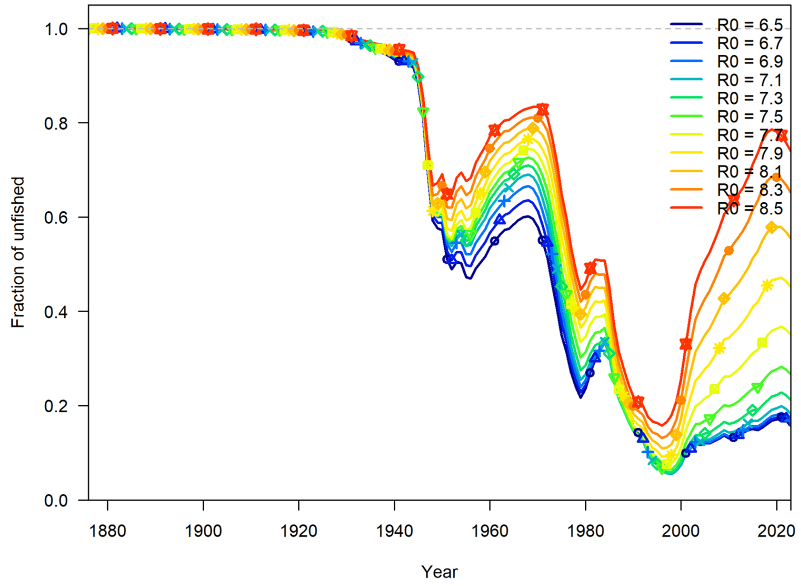


Northern Model Likelihood Profiles: Unfished Recruitment

Also see Table 46 and Figures 127-129







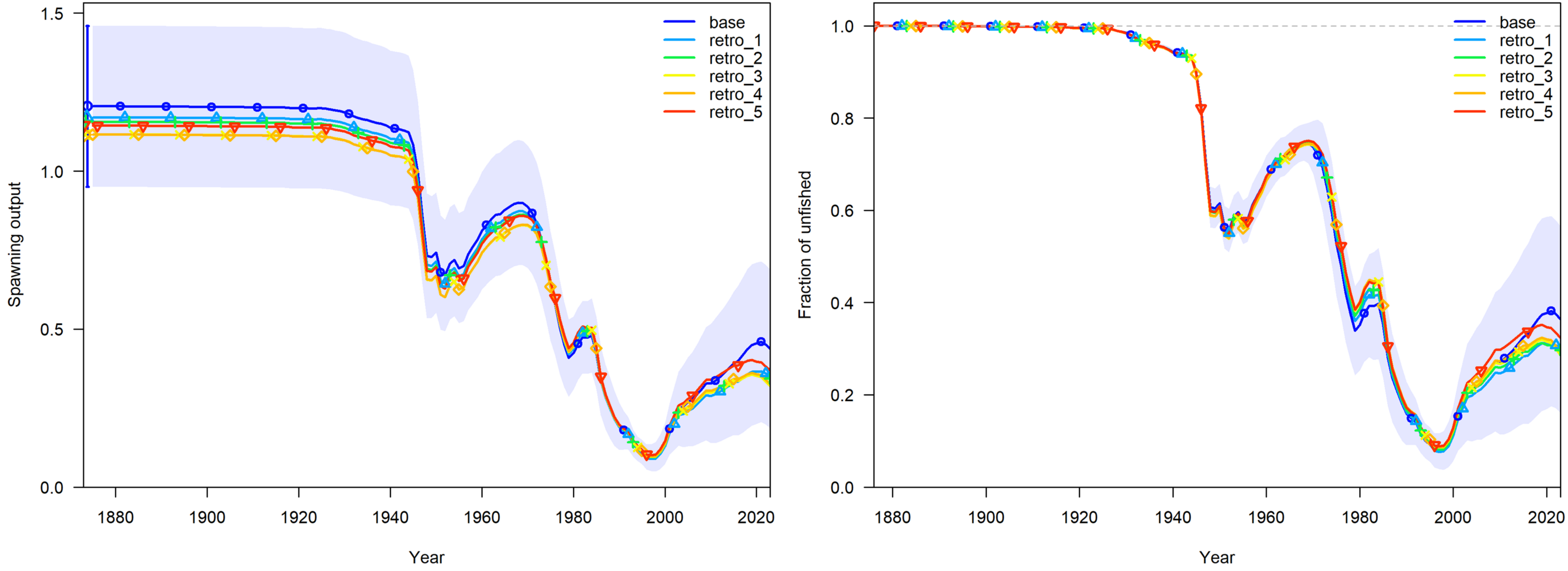
Northern Model Likelihood Profiles: Unfished Recruitment

This table was inadvertently omitted from the draft assessment

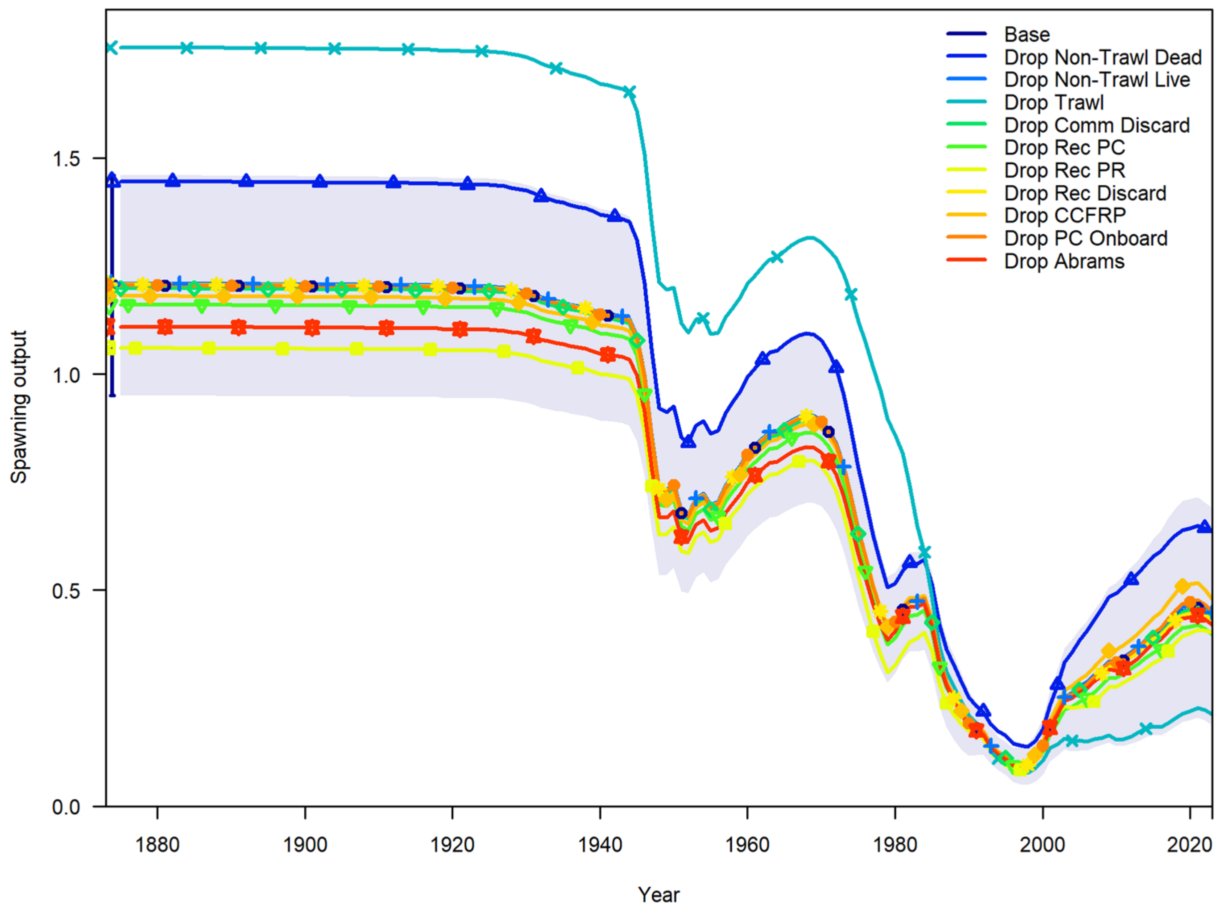
N.Parms	97	97	97	97	97	97	97	97	97	97	97
TOTAL	1171.99	1150.69	1133.24	1120.03	1111.57	1107.45	1106.29	1106.69	1107.91	1109.68	1111.81
Survey	-27.85	-28.52	-29.18	-29.79	-30.20	-30.25	-30.02	-29.74	-29.55	-29.44	-29.36
Length_comp	370.23	368.21	366.71	365.83	365.66	366.06	366.63	367.15	367.60	368.04	368.52
Age_comp	785.64	782.35	779.66	777.36	775.48	774.24	773.64	773.59	773.90	774.46	775.18
Recruitment	43.71	28.55	16.04	6.63	0.55	-2.84	-4.45	-5.05	-5.07	-4.71	-4.14
Parm_priors	0.26	0.10	0.02	0.00	0.08	0.24	0.48	0.75	1.03	1.32	1.61
NatM_uniform_Fem_GP_1	0.123	0.134	0.146	0.159	0.174	0.192	0.209	0.226	0.241	0.255	0.269
L_at_Amax_Fem_GP_1	53.0	53.3	53.6	53.8	54.1	54.4	54.5	54.5	54.5	54.5	54.5
VonBert_K_Fem_GP_1	0.161	0.159	0.156	0.154	0.151	0.149	0.148	0.147	0.147	0.147	0.147
CV_old_Fem_GP_1	0.087	0.086	0.085	0.084	0.083	0.082	0.082	0.081	0.081	0.081	0.081
NatM_uniform_Mal_GP_1	-0.176	-0.144	-0.118	-0.096	-0.077	-0.063	-0.054	-0.049	-0.046	-0.045	-0.045
L_at_Amax_Mal_GP_1	-0.12999	-0.13319	-0.13651	-0.1399	-0.14326	-0.14581	-0.14701	-0.14718	-0.14686	-0.1463	-0.14561
VonBert_K_Mal_GP_1	0.268836	0.277564	0.286394	0.295327	0.303866	0.309783	0.311747	0.310997	0.30914	0.306865	0.304415
CV_old_Mal_GP_1	-0.39403	-0.38302	-0.3709	-0.35786	-0.34383	-0.33068	-0.32024	-0.31342	-0.30988	-0.30891	-0.30992
SR_LN(R0)	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5
Q_extraSD_Rec_PR_North(6)	0.093	0.091	0.088	0.086	0.086	0.087	0.088	0.088	0.087	0.086	0.085

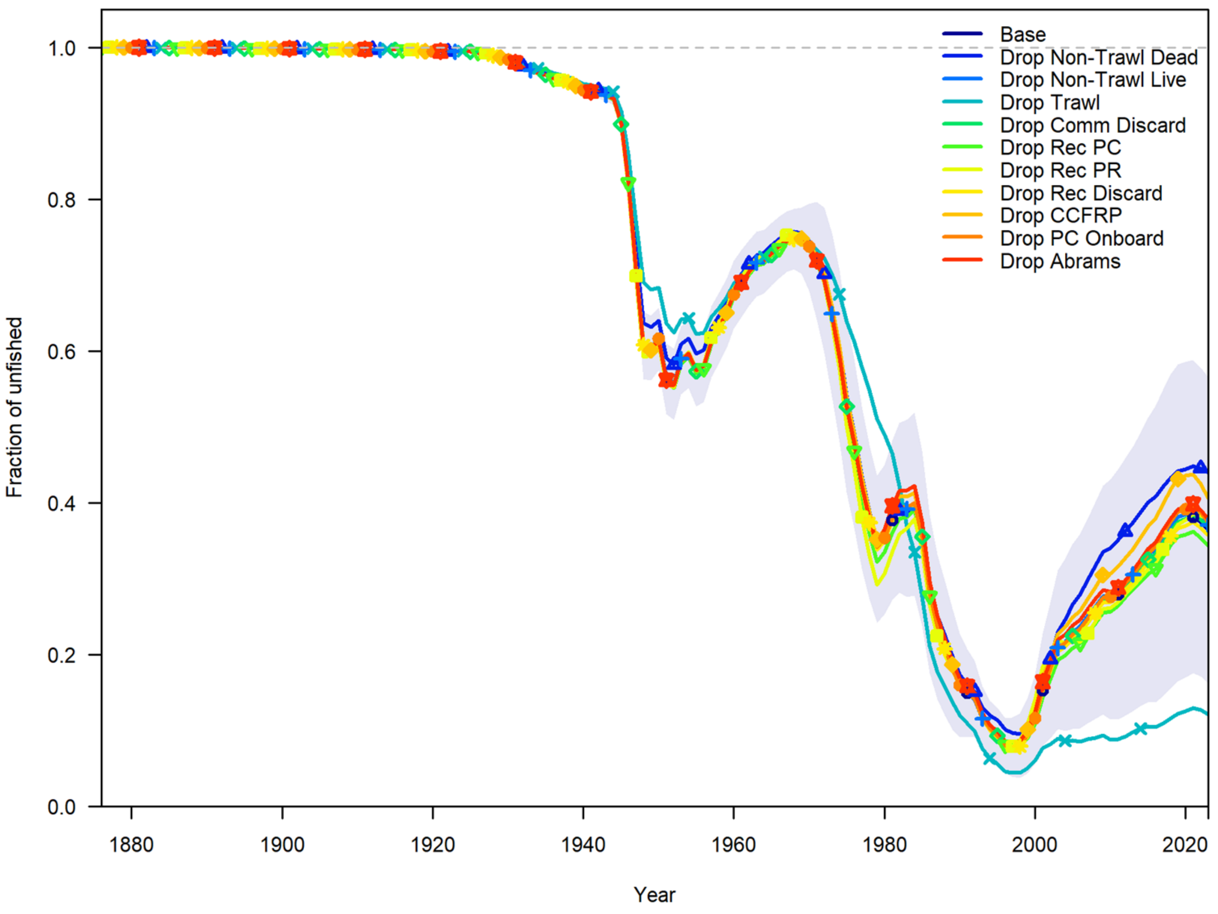
Bratio_2023	0.16	0.16	0.17	0.18	0.21	0.27	0.35	0.45	0.55	0.65	0.74
SSB_unfished	1331	1365	1386	1381	1338	1272	1212	1178	1169	1178	1205
Totbio_unfished	5884	6084	6281	6420	6461	6467	6550	6785	7170	7691	8355
Recr_unfished	665	812	992	1212	1480	1808	2208	2697	3294	4024	4915
Dead_Catch_SPR	164	181	198	216	231	246	262	284	312	345	385
OFLCatch_2023	67	75	84	97	117	149	195	256	328	410	504

Northern model retrospective analysis



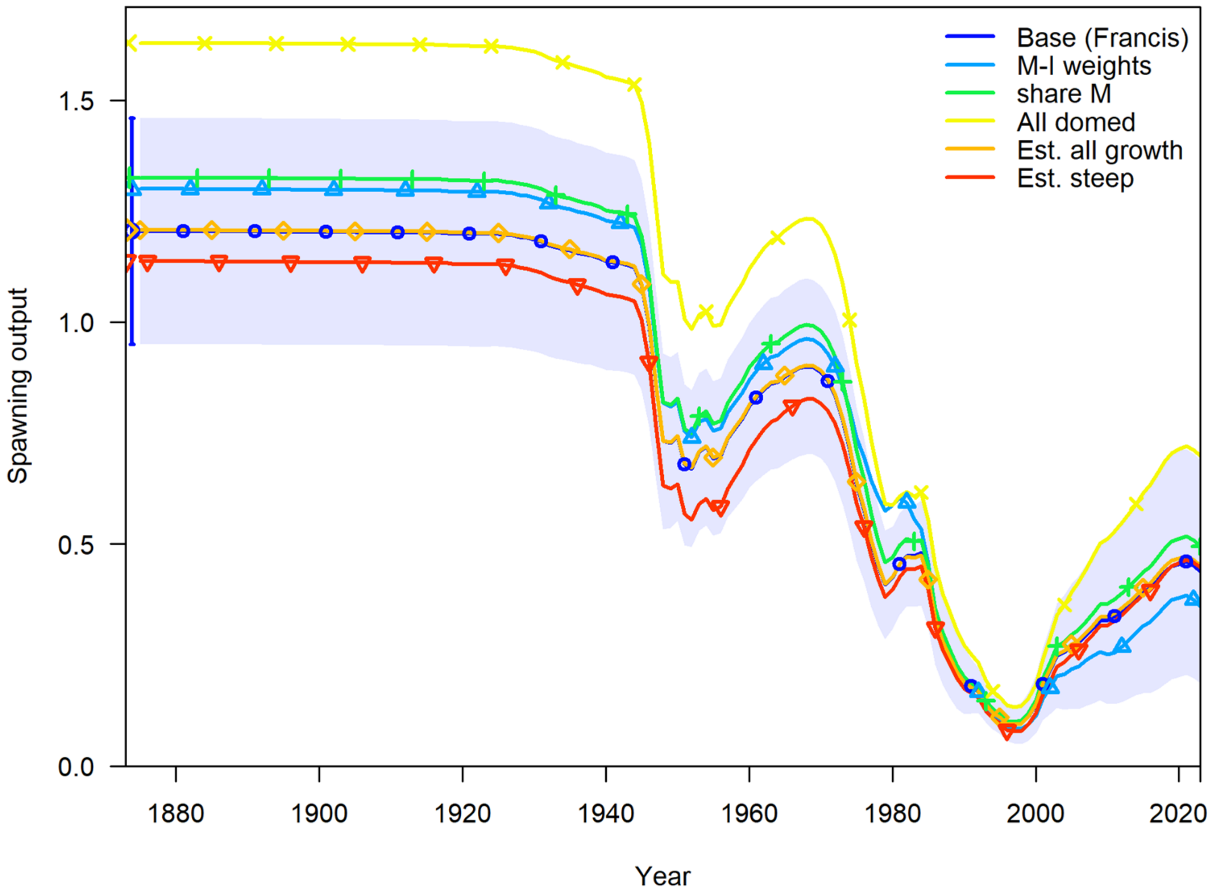
Northern model "drop-one" analysis

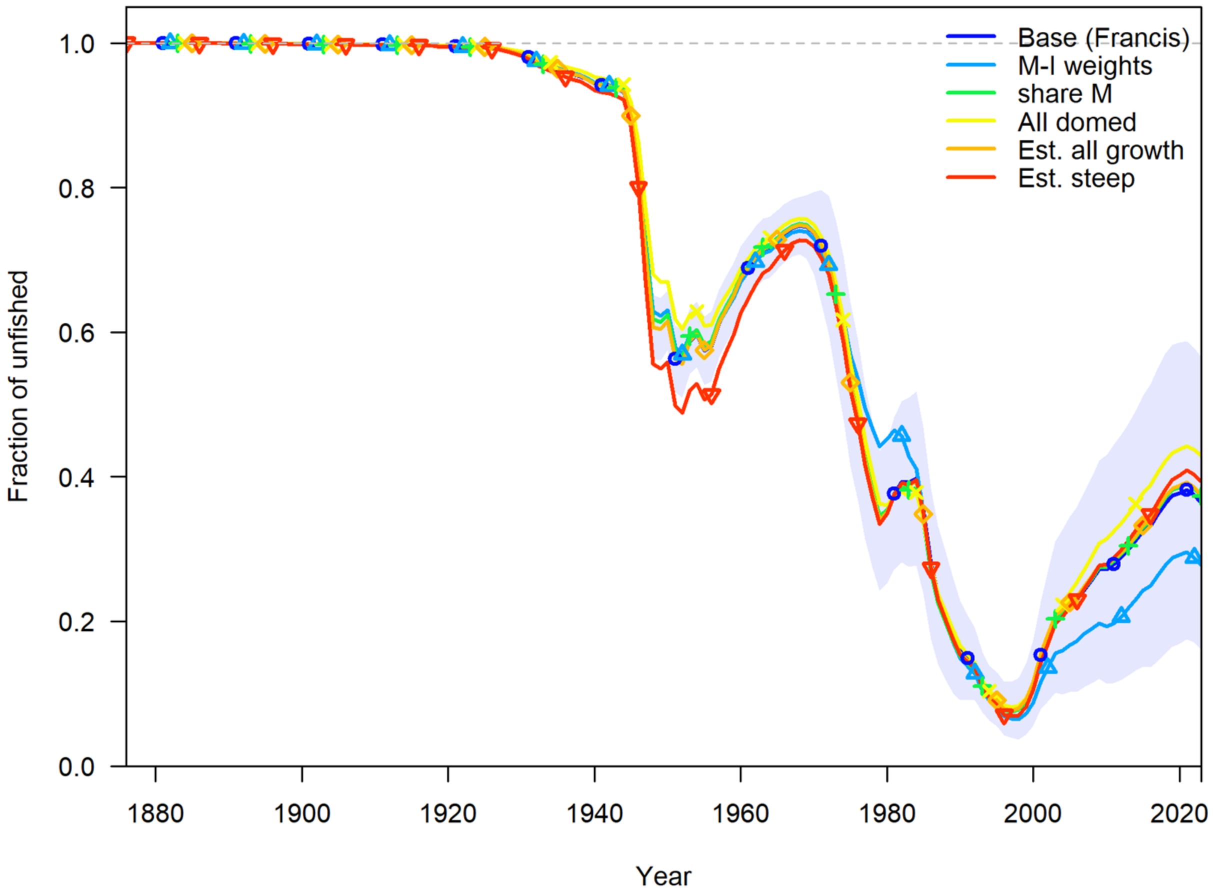




Also see Figs. 113-114 and Tables 41-42

Northern model, additional sensitivity runs





Also see Figs. 117-118 and Tables 36 and 43

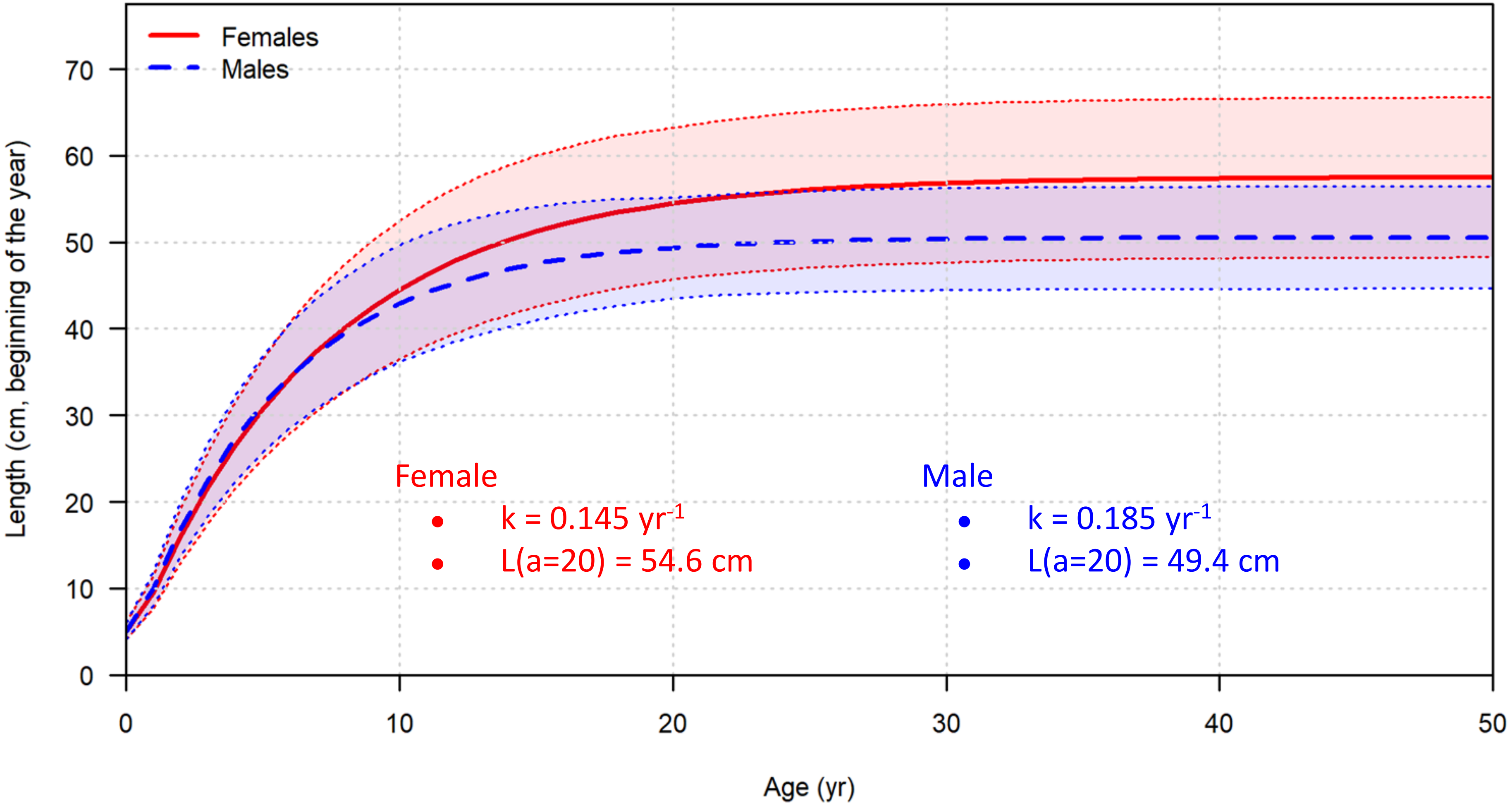
Natural mortality and estimates of growth (Table 48)

Central California

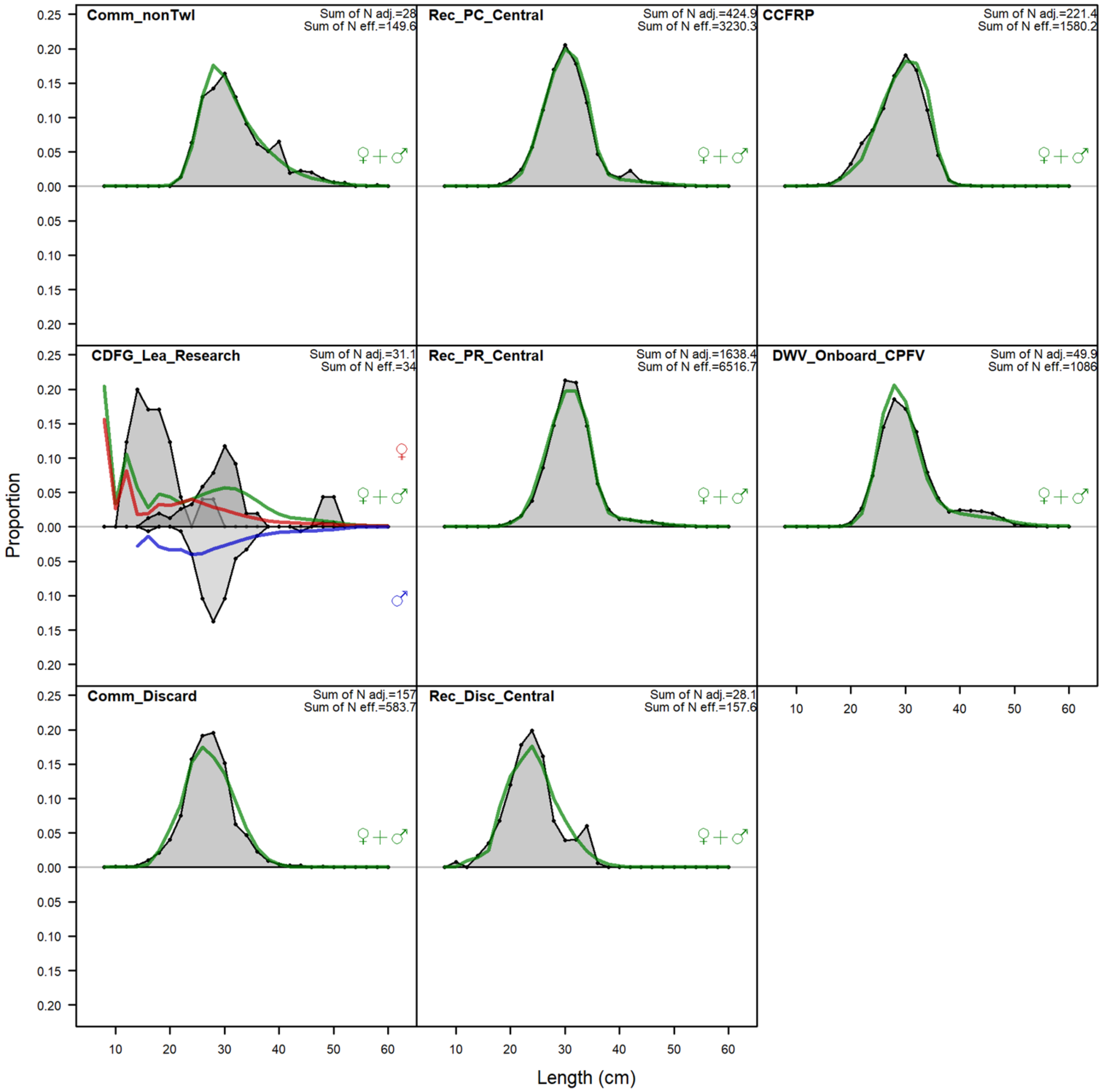
M fixed at northern model estimates:

M_{female} ~ 0.21

M_{male} ~ 0.20

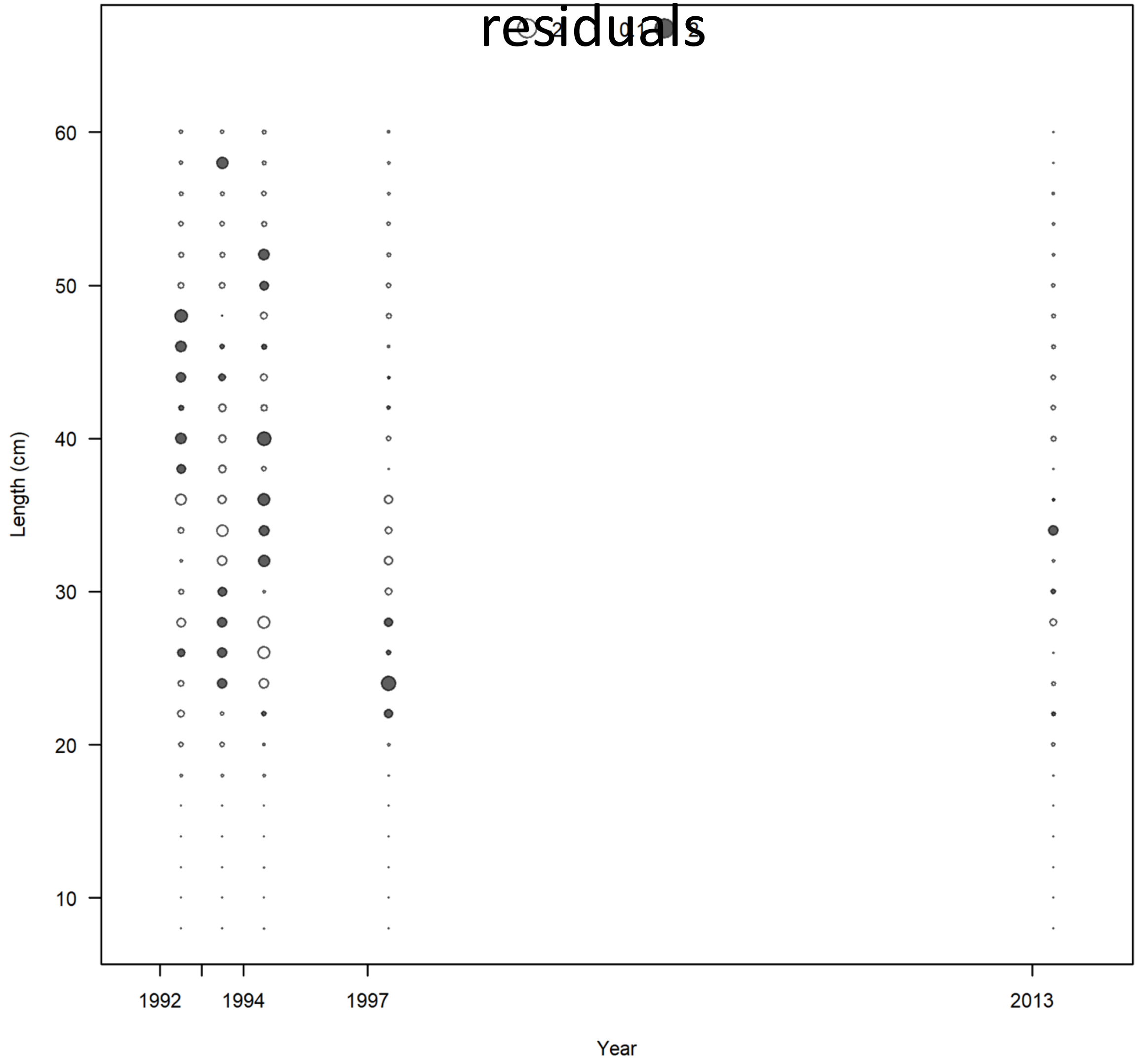


Central model: fits to length data (aggregated over time)

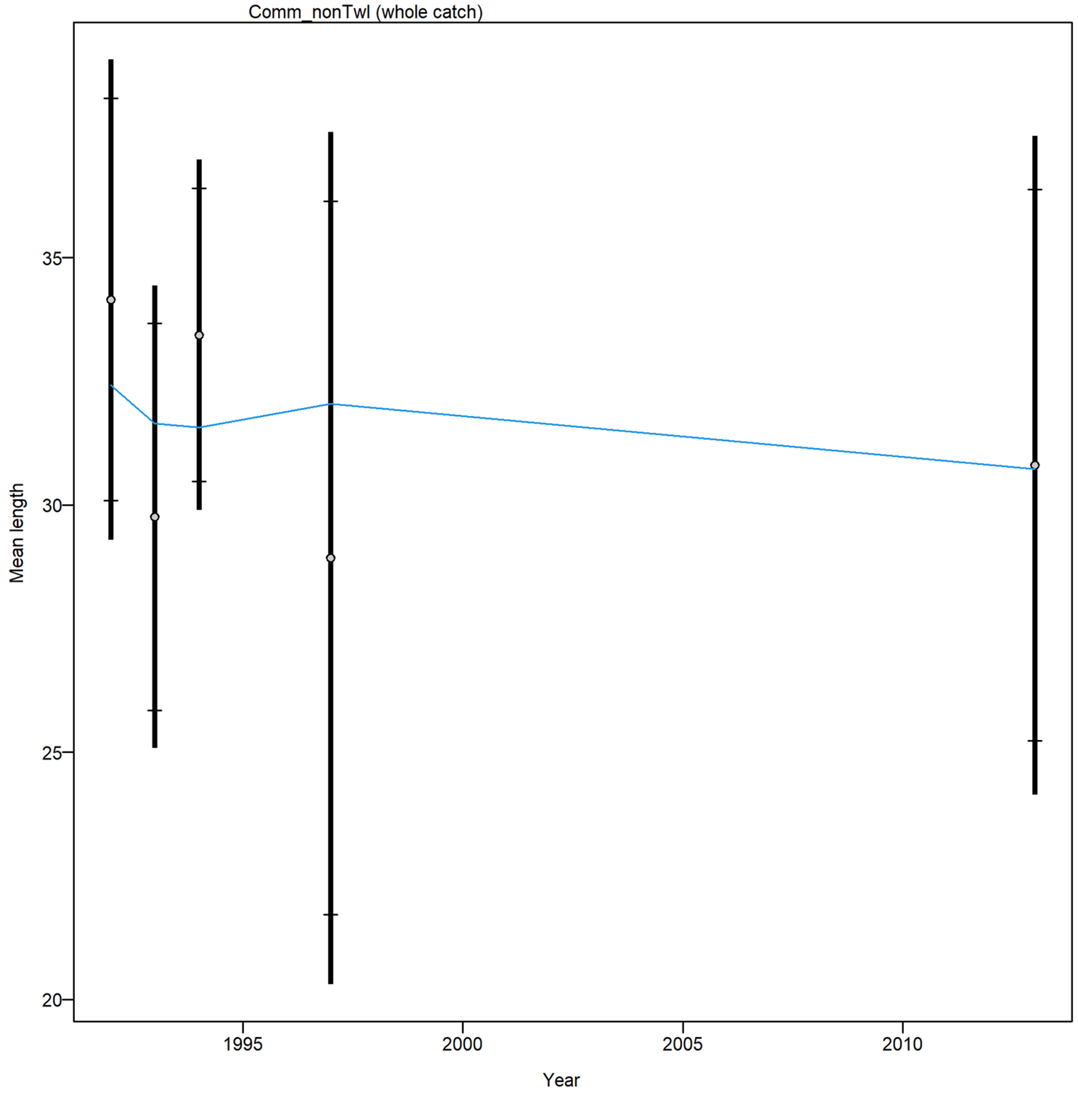


Central non-trawl fleet

Length composition Pearson residuals

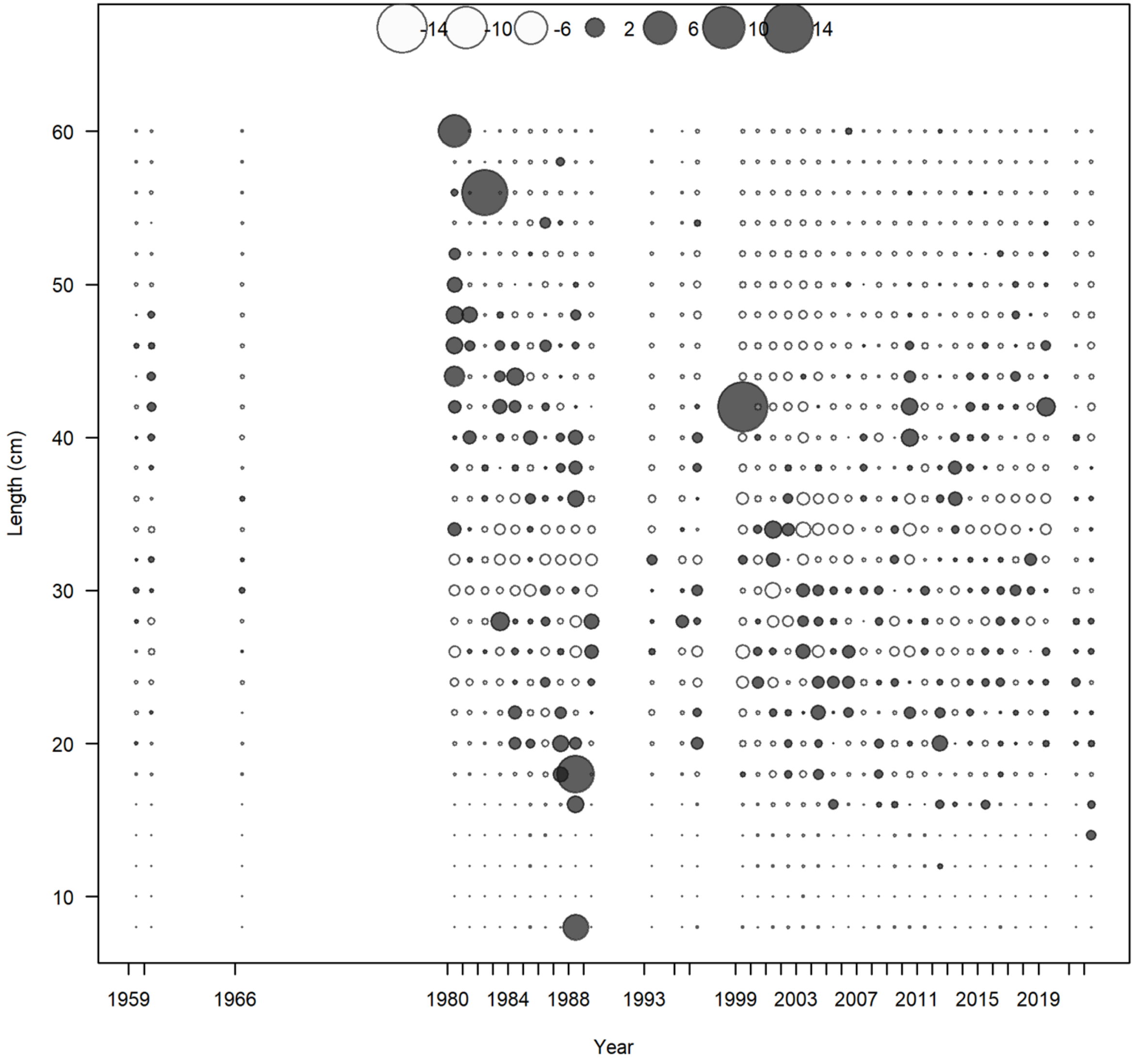


Fits to mean length

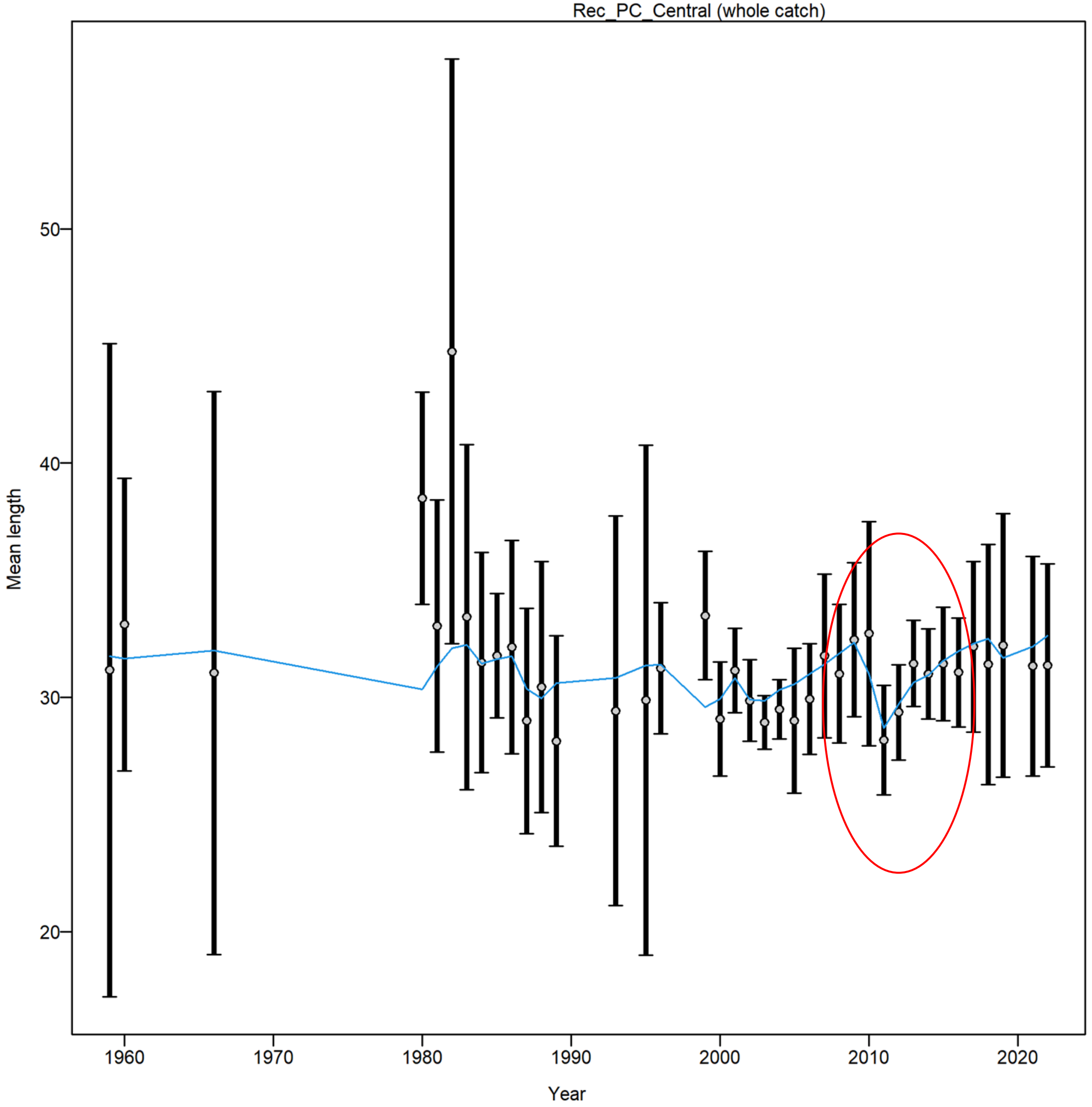


Central recreational PC fleet

Length composition Pearson residuals

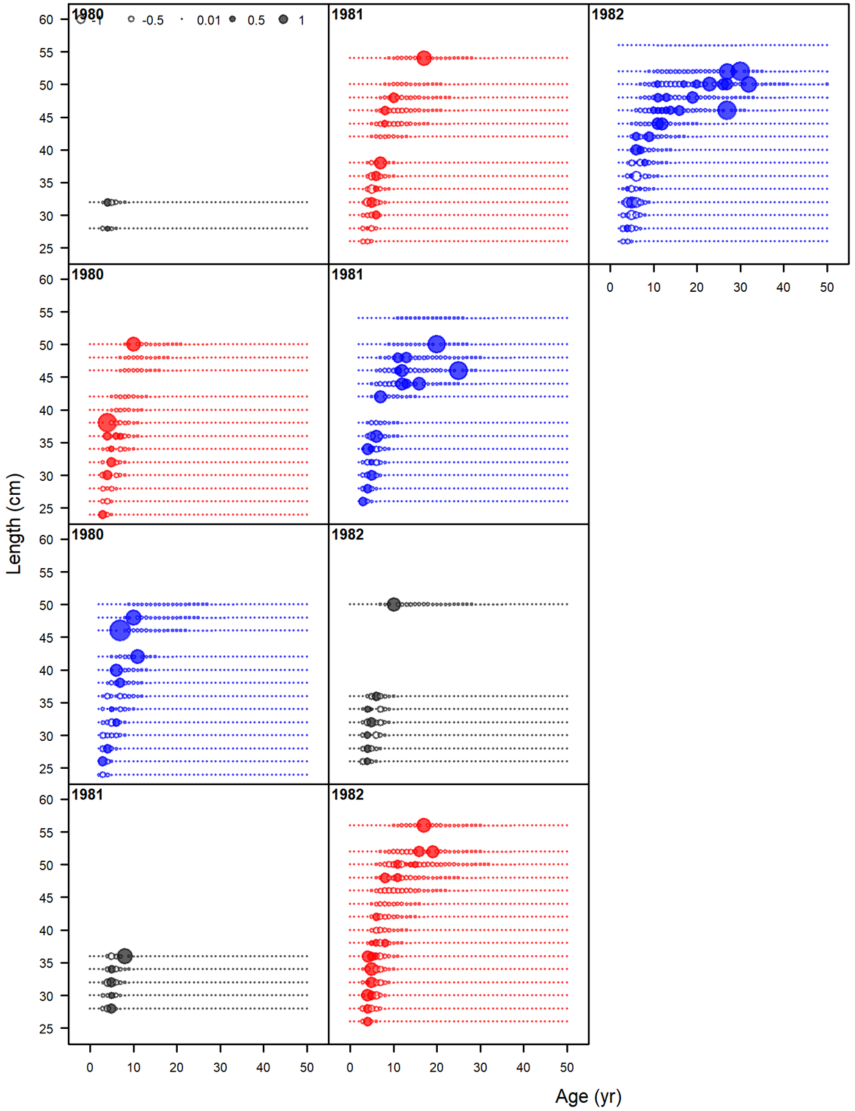


Fits to mean length



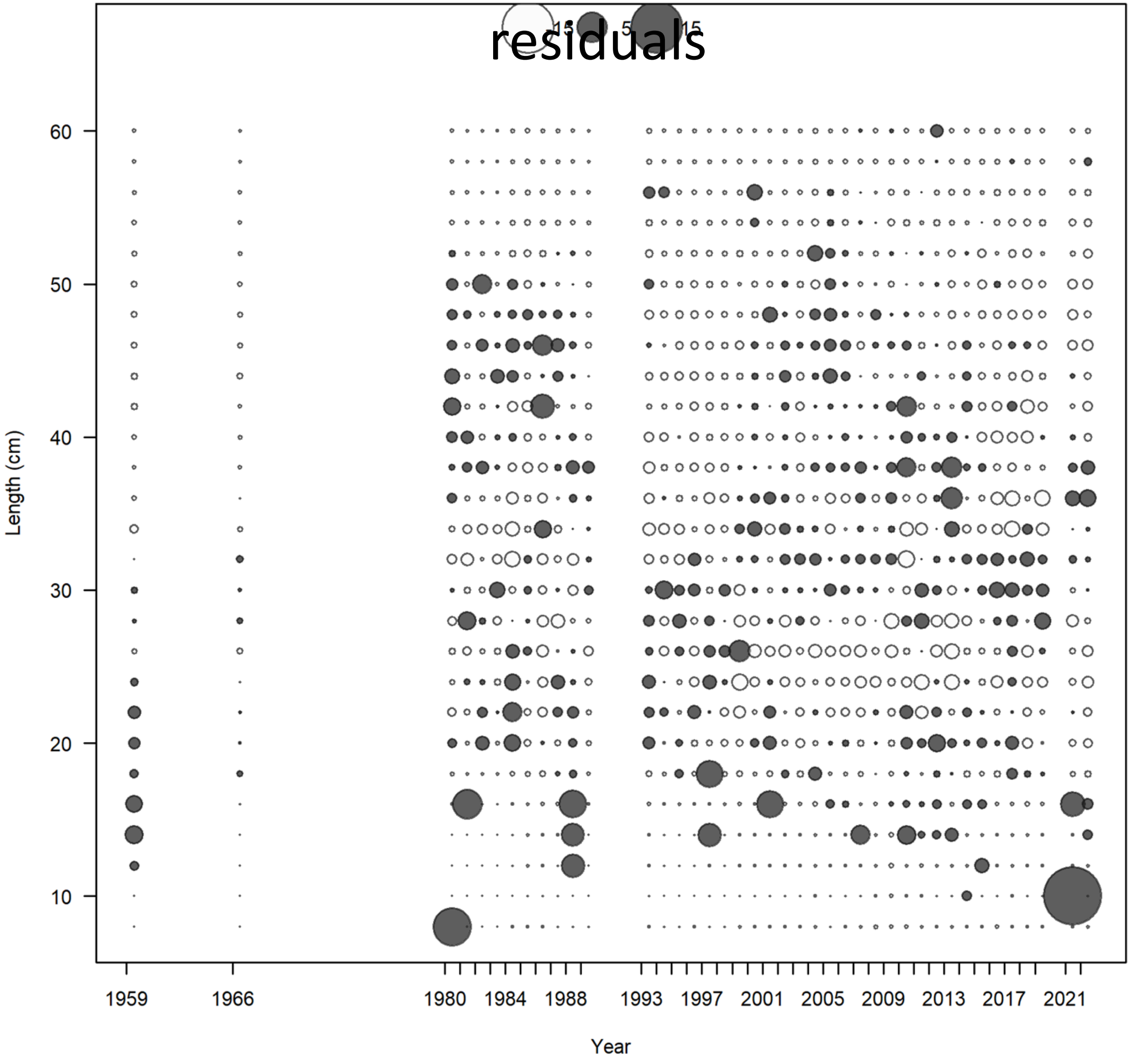
Central recreational PC fleet

Age composition Pearson residuals

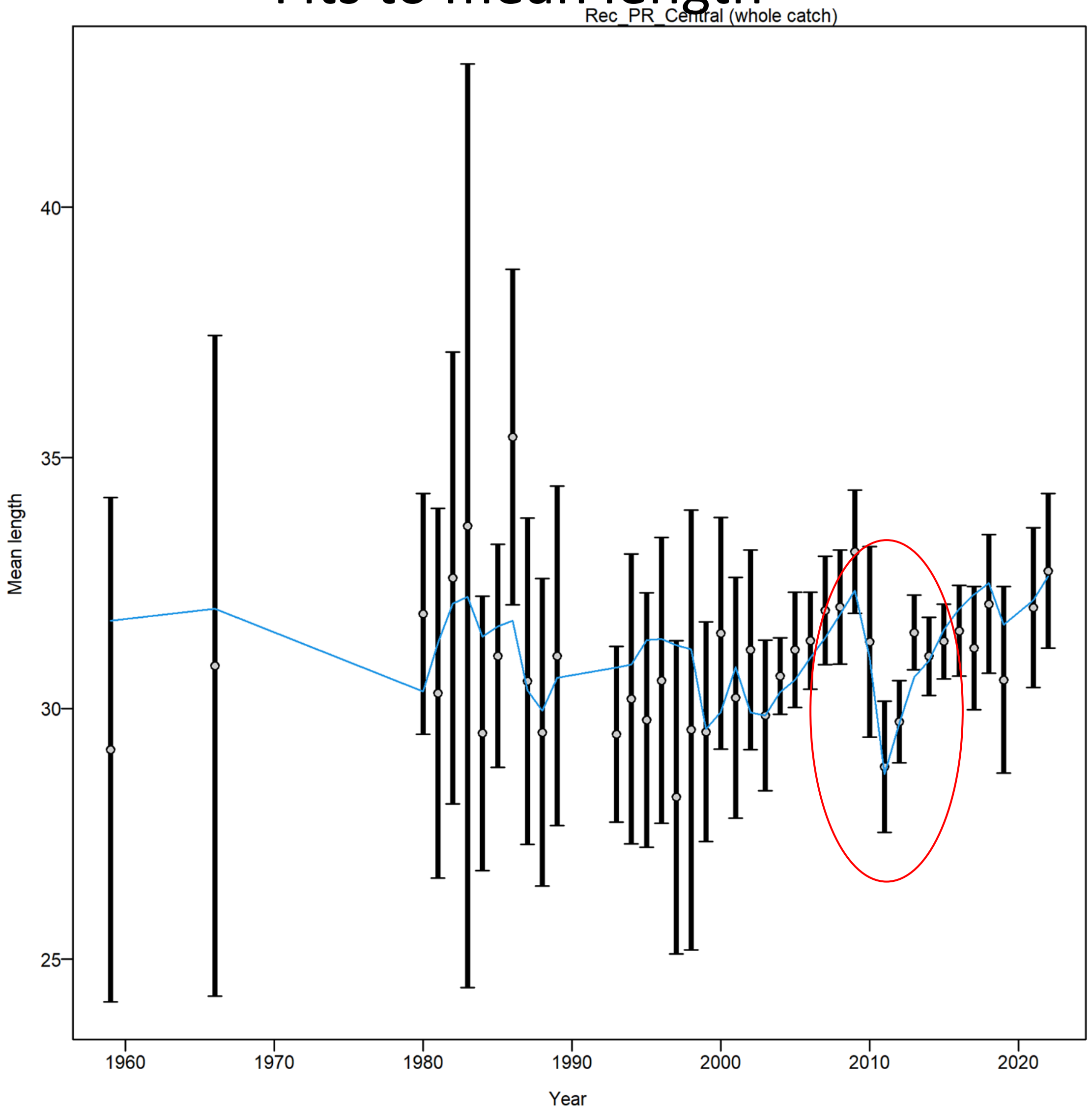


Central recreational PR fleet

Length composition Pearson residuals

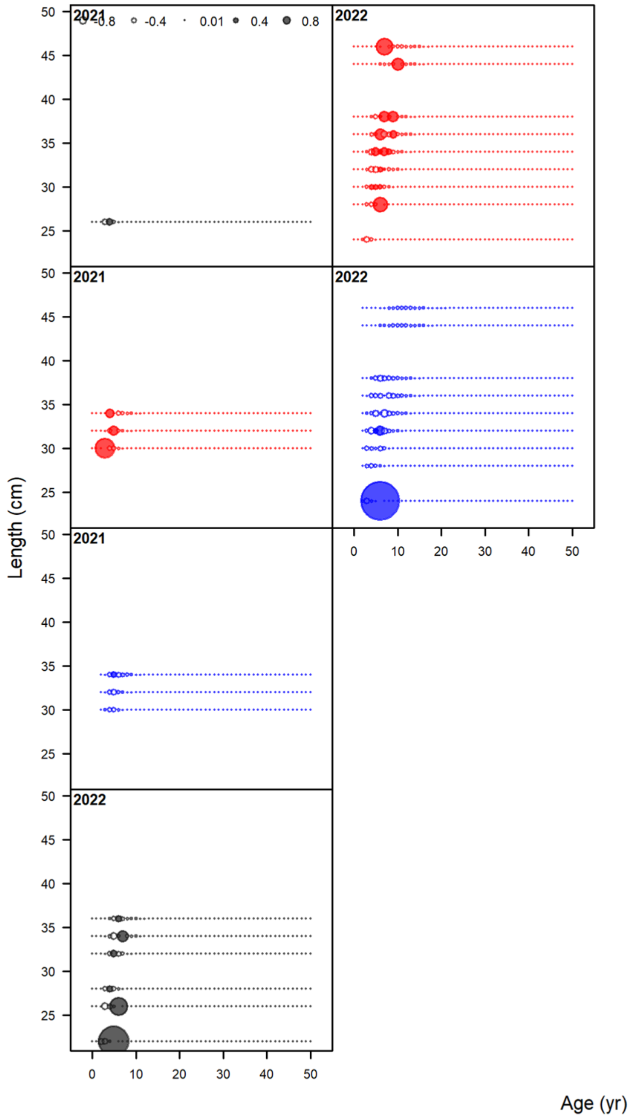


Fits to mean length



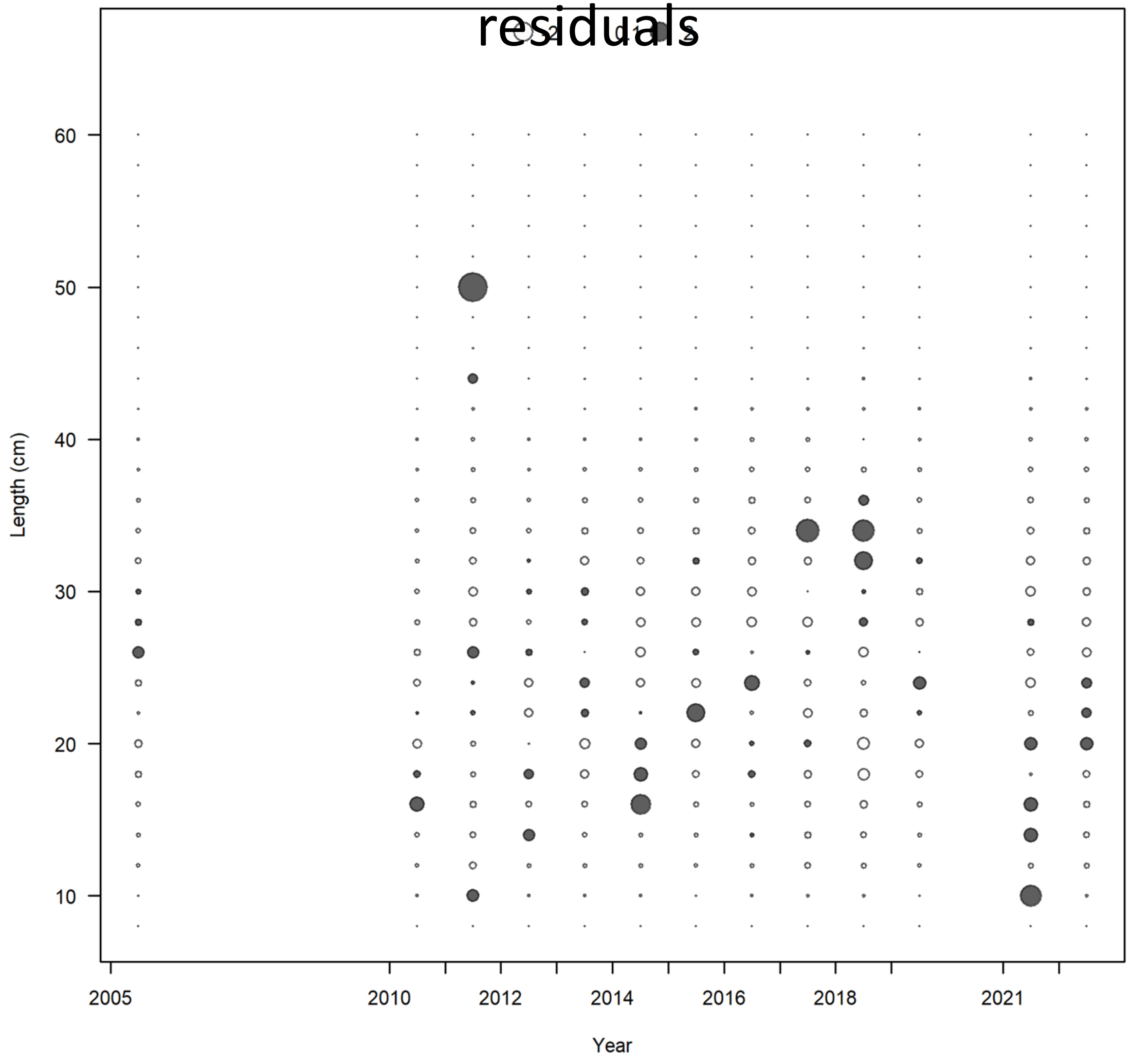
Central recreational PR fleet

Age composition Pearson residuals

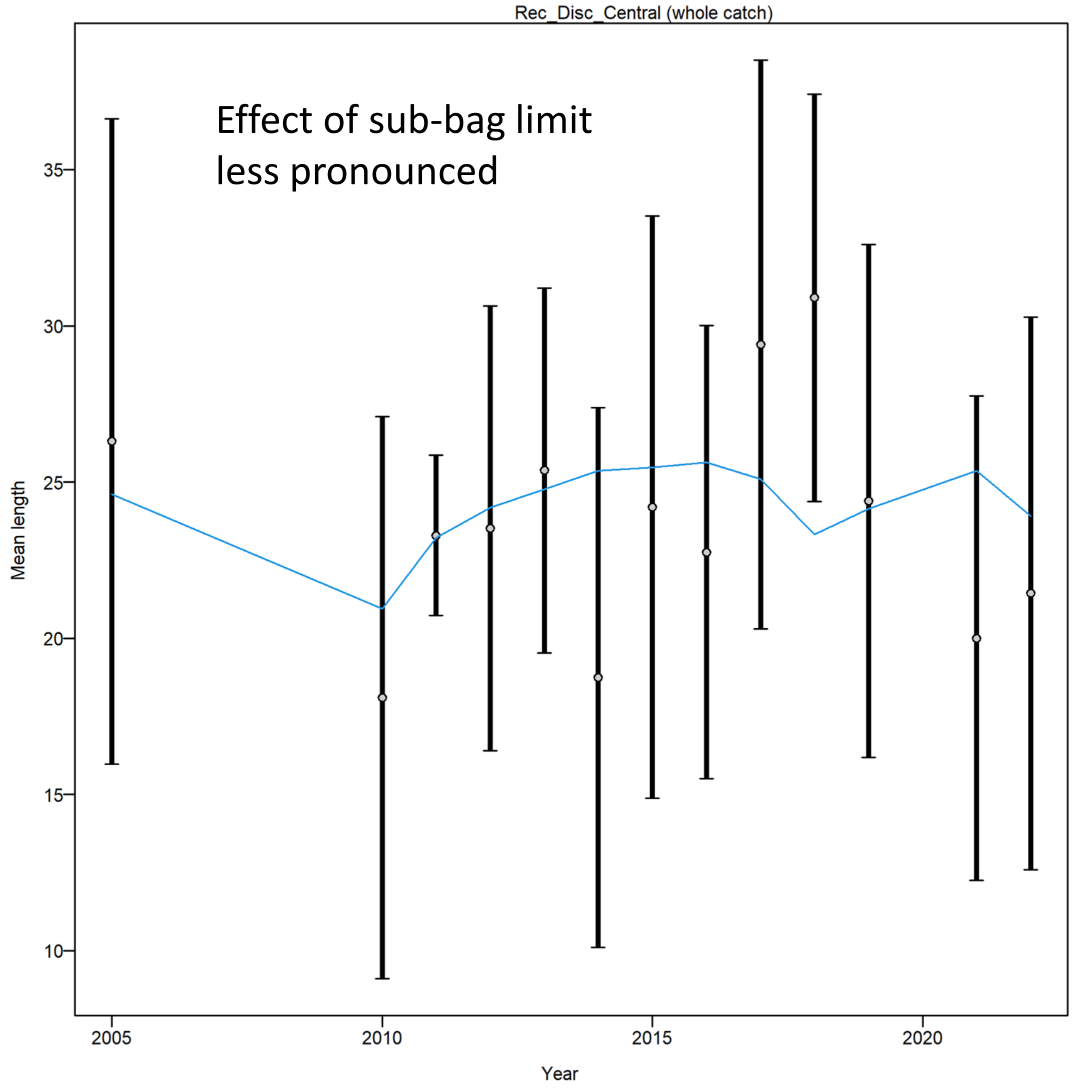


Central recreational discard fleet

Length composition Pearson residuals

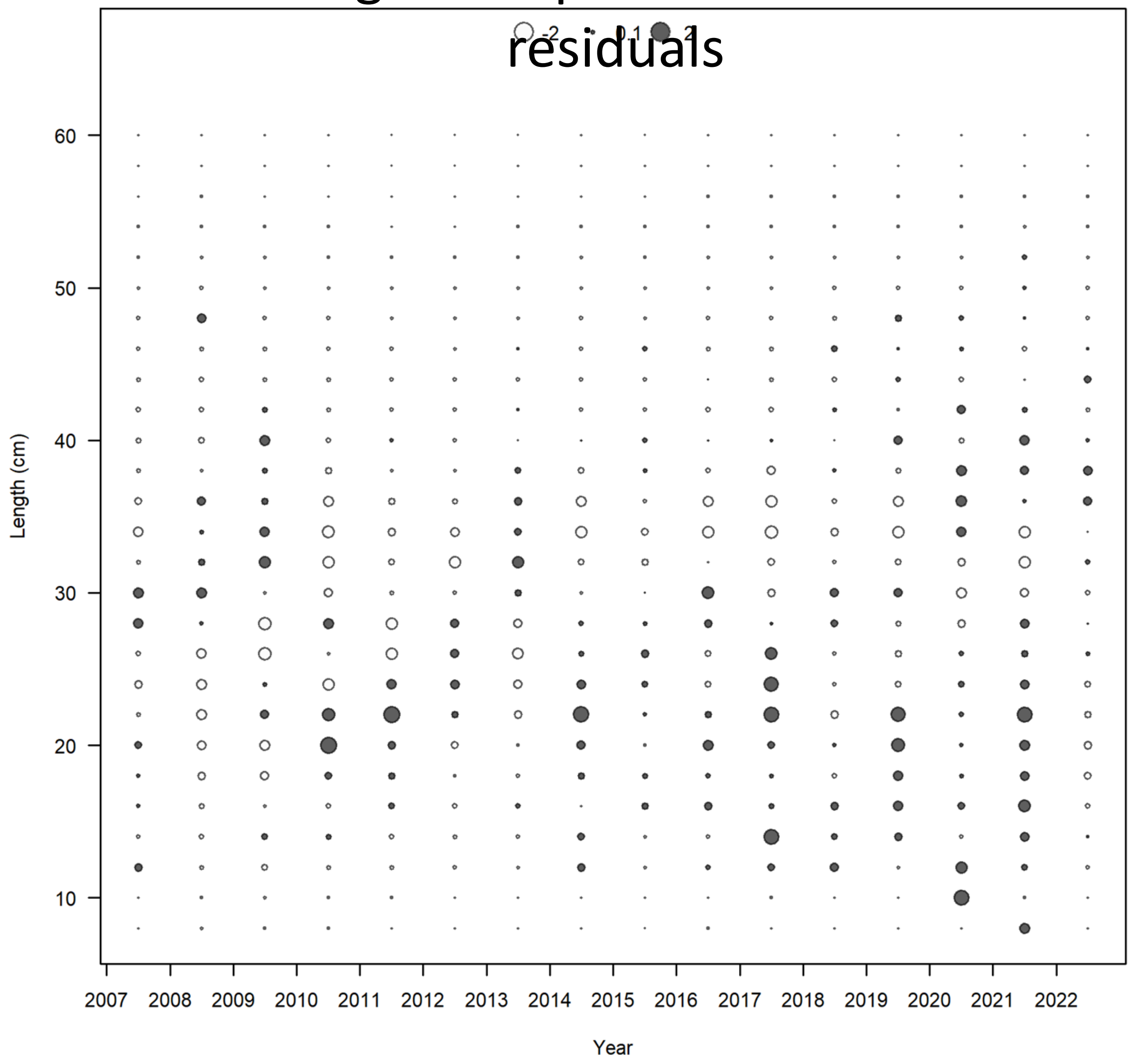


Fits to mean length

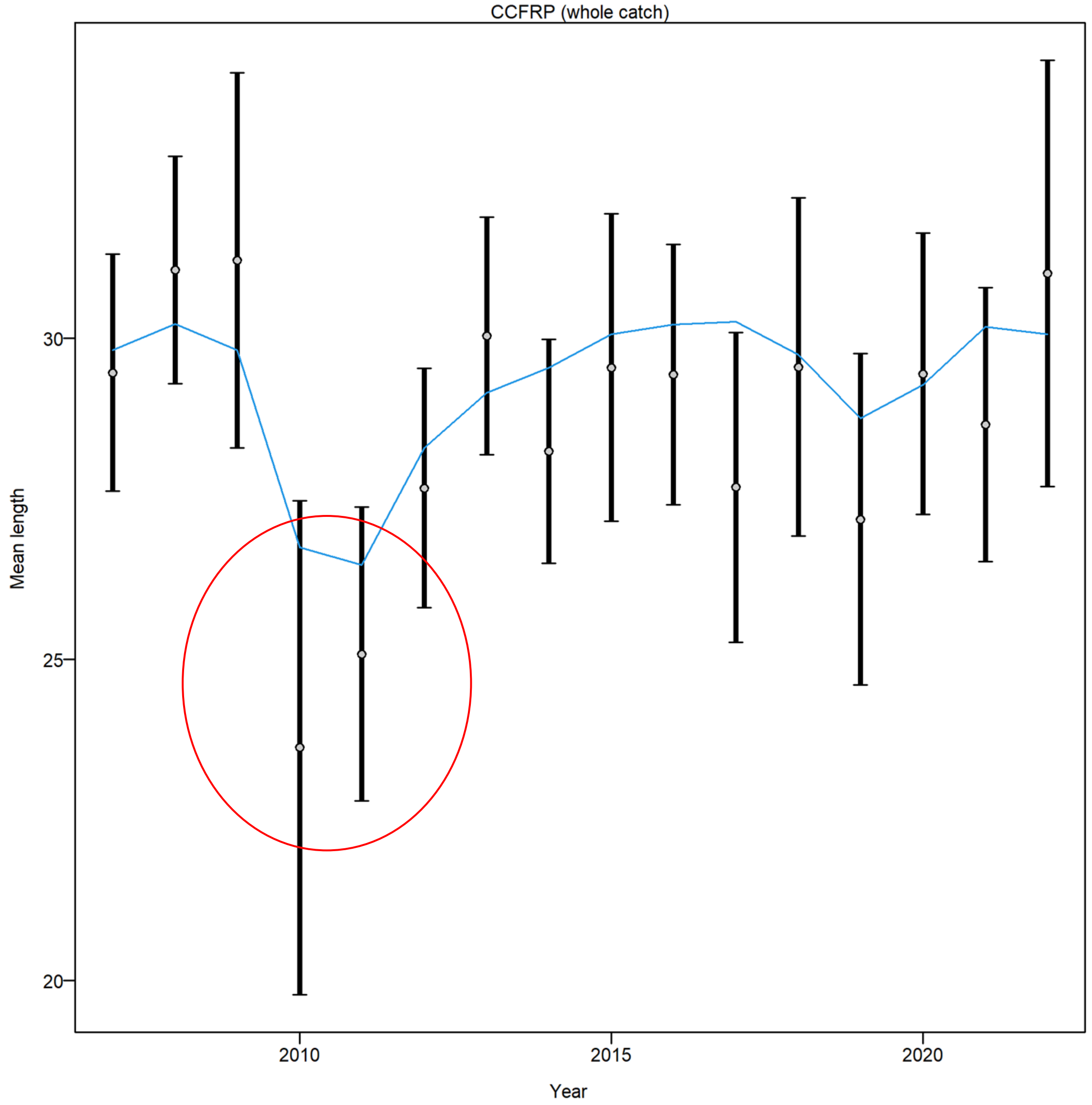


Central CCFRP survey

Length composition Pearson residuals

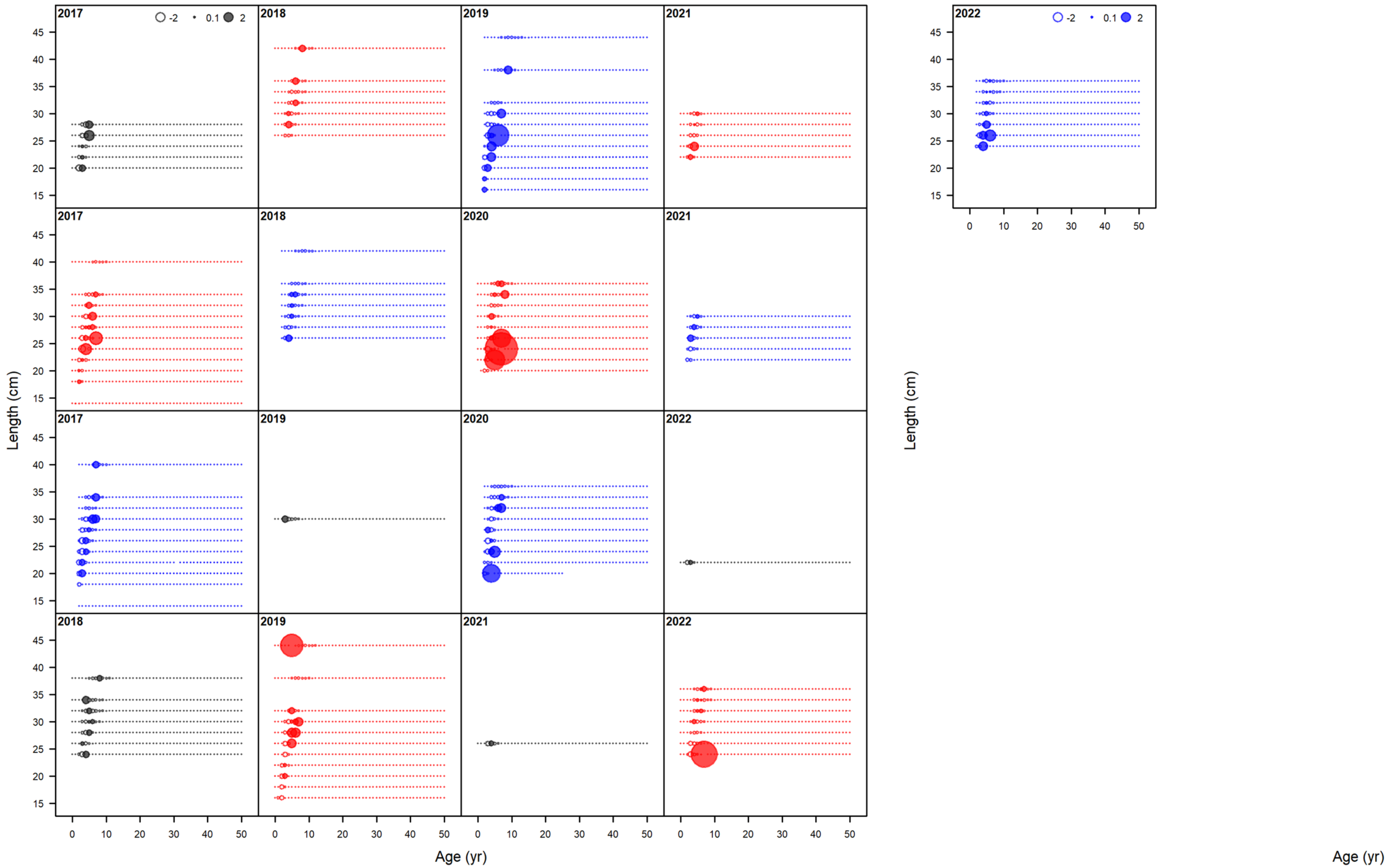


Fits to mean length



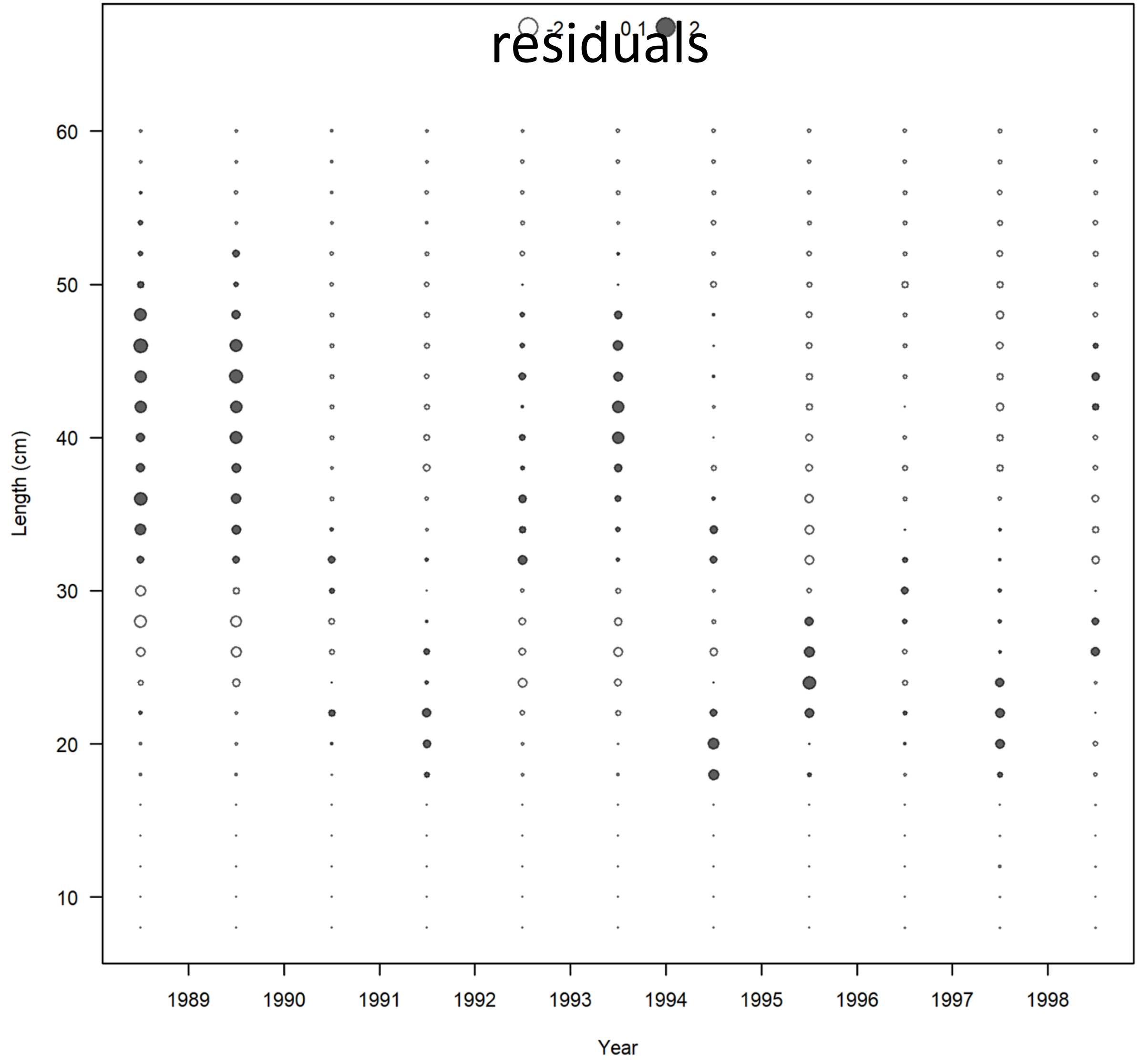
Central CCFRP survey

Age composition Pearson residuals

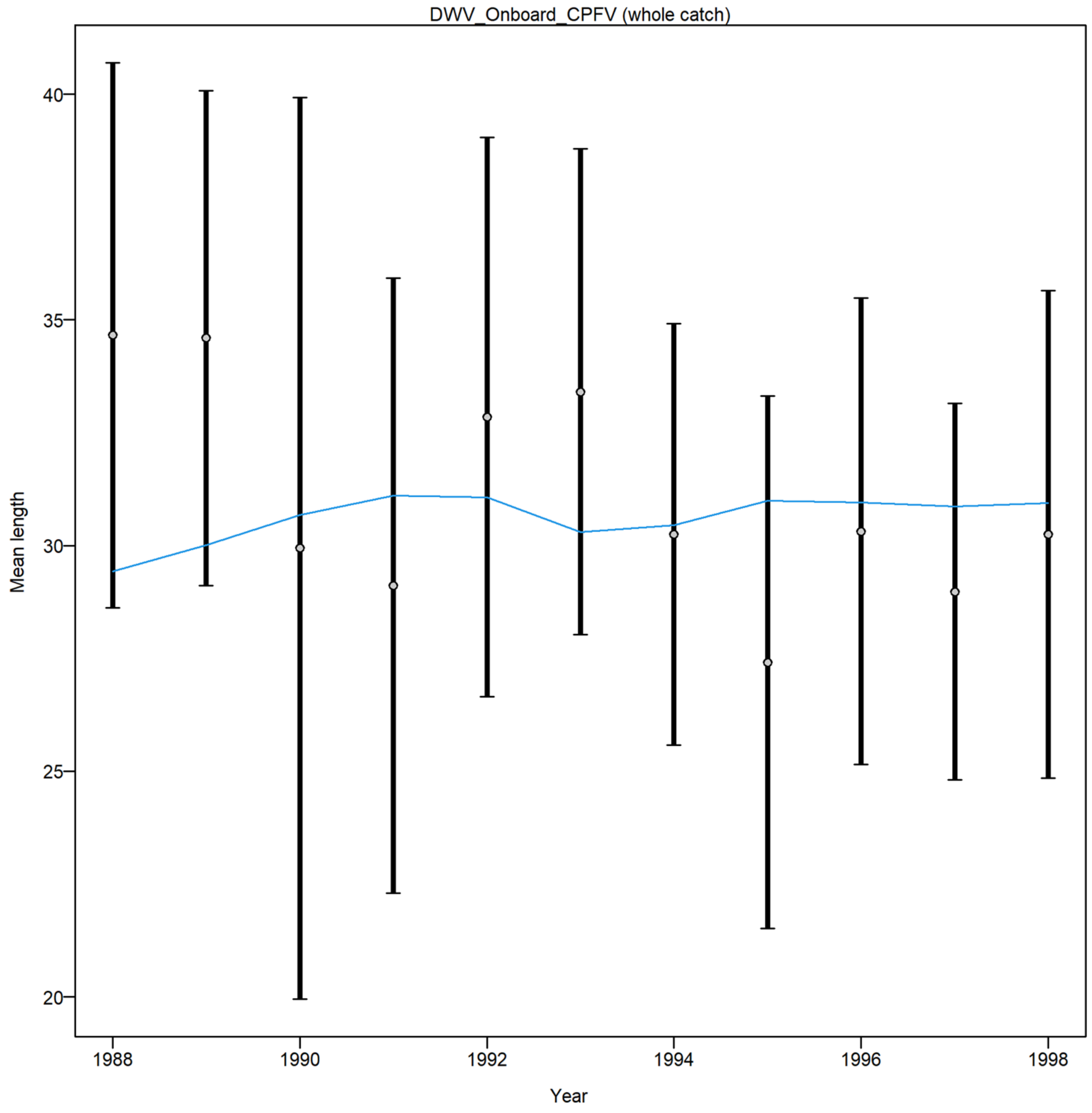


Central PC Onboard (“DWV”) survey

Length composition Pearson residuals

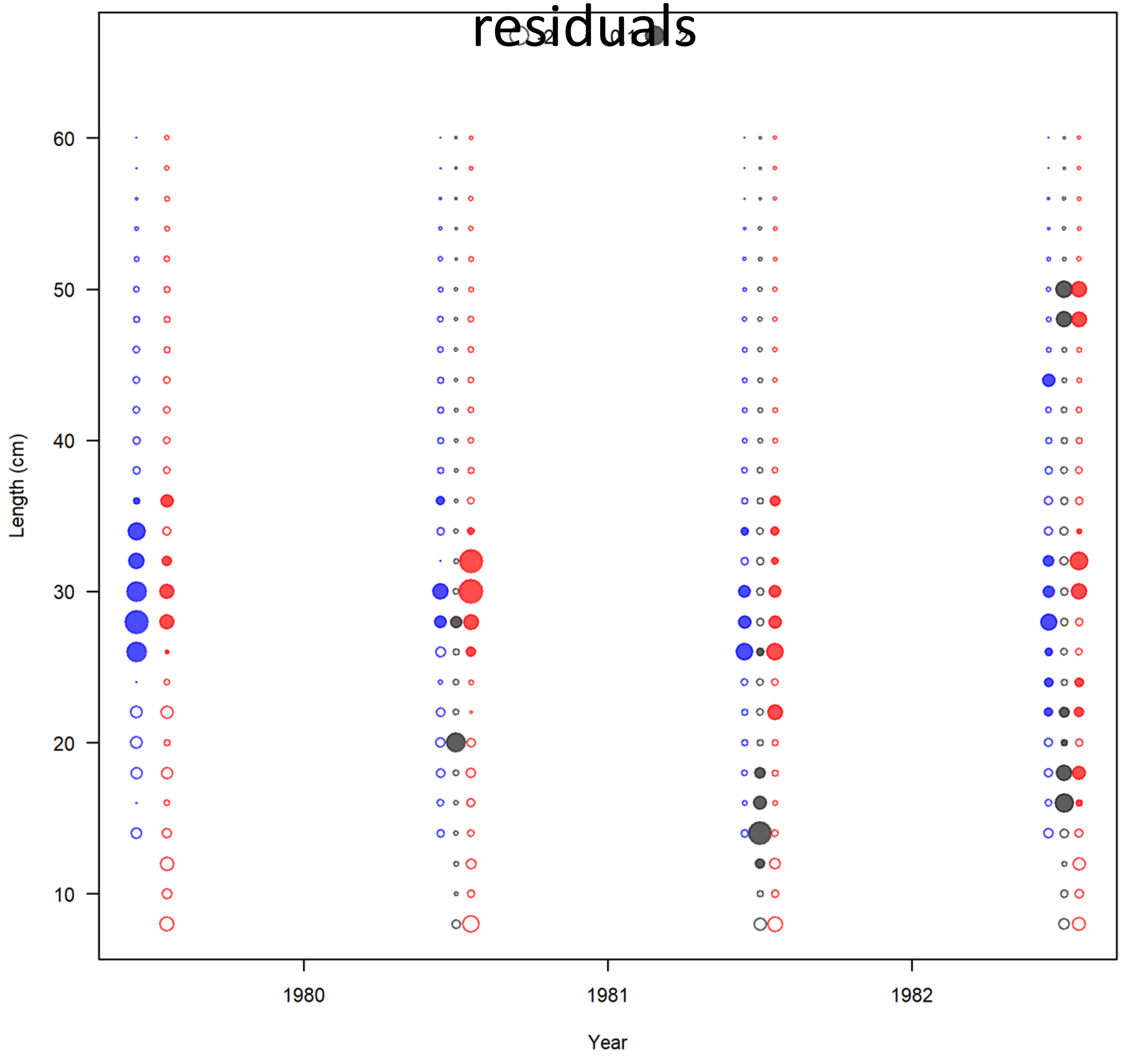


Fits to mean length

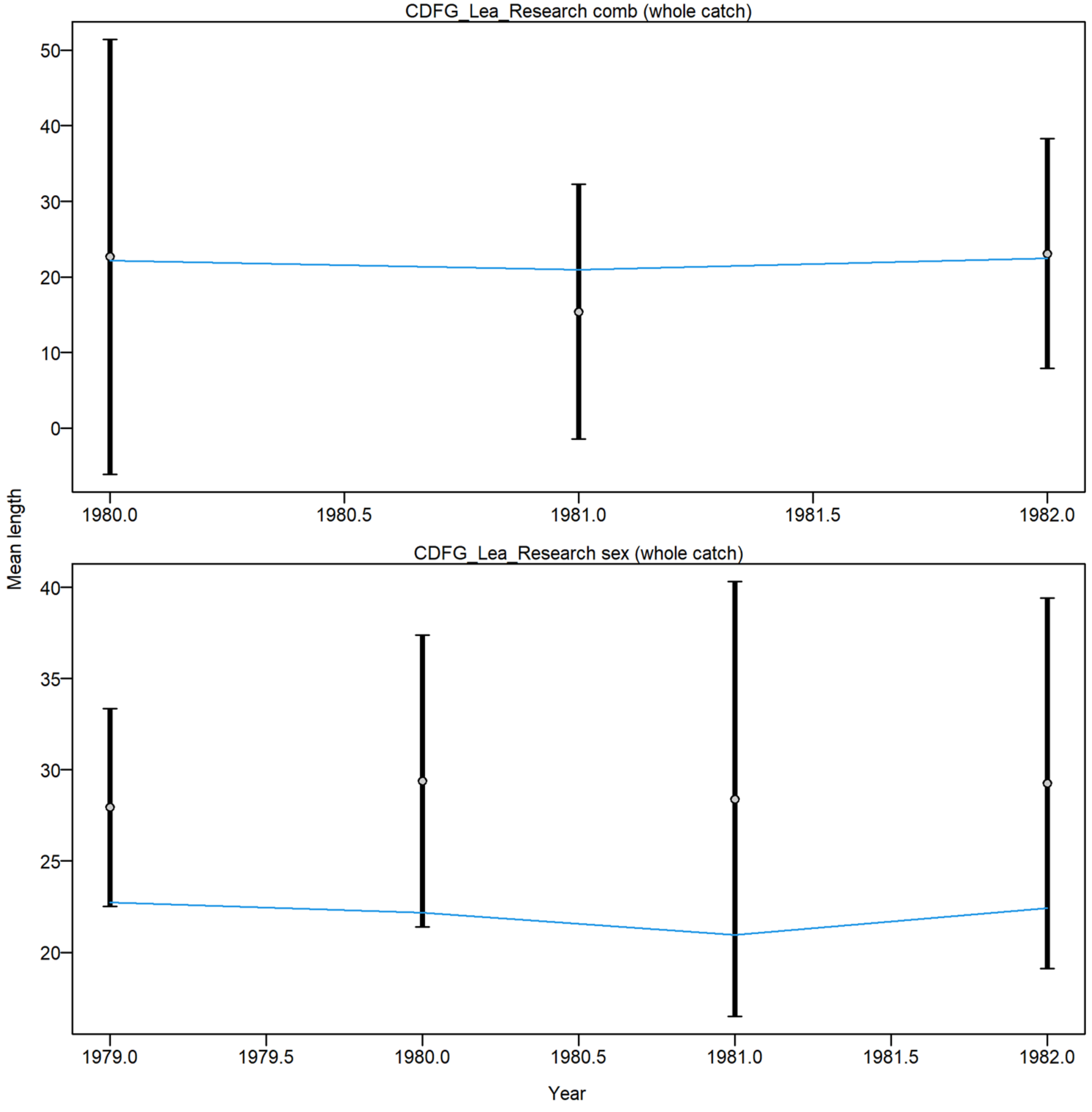


Central Lea et al. research

Length composition Pearson residuals

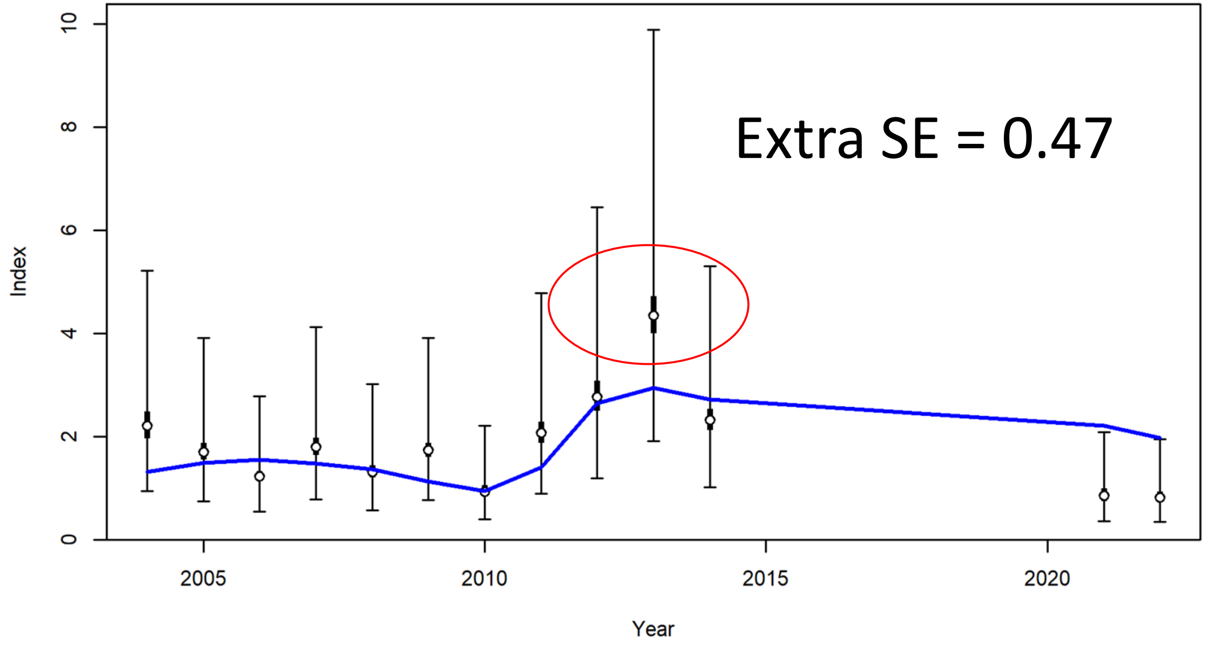


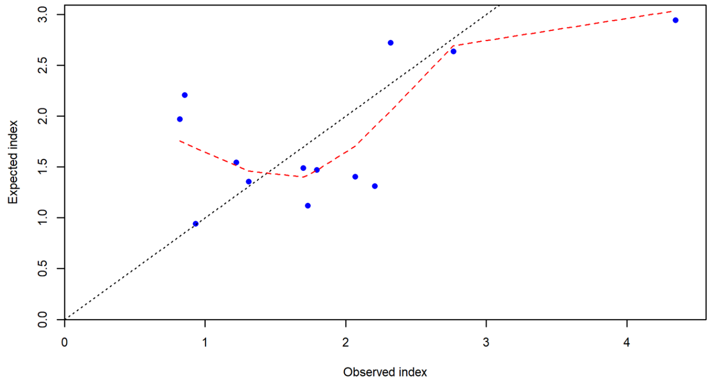
Fits to mean length



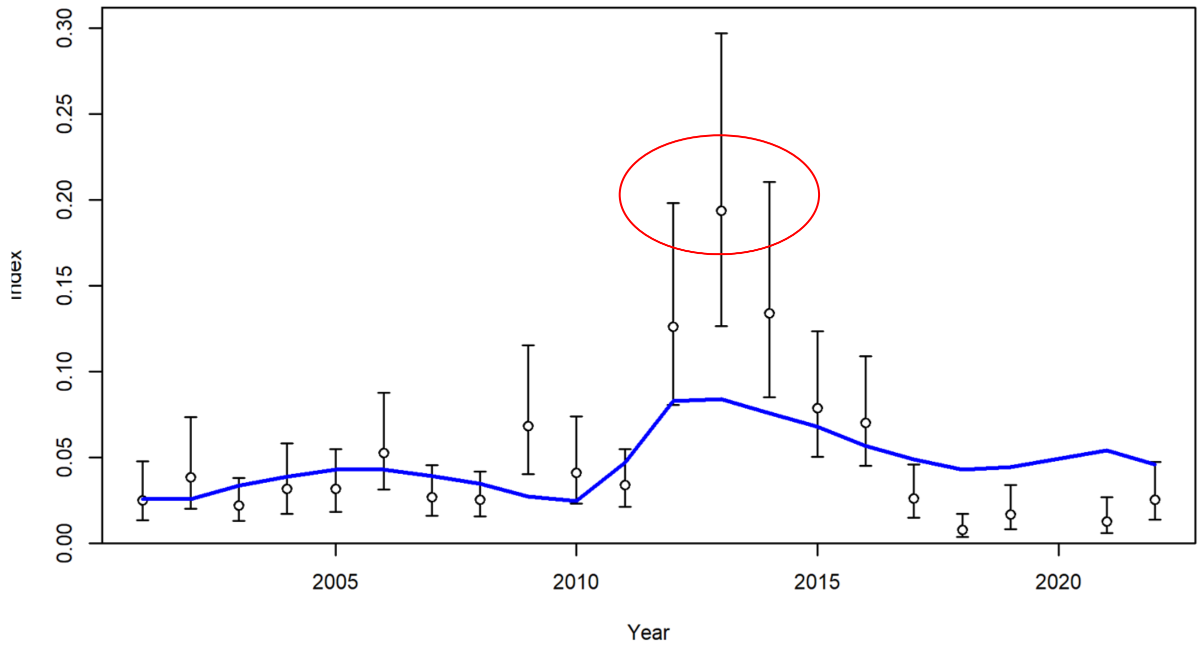
Central model: fishery-dependent indices of abundance

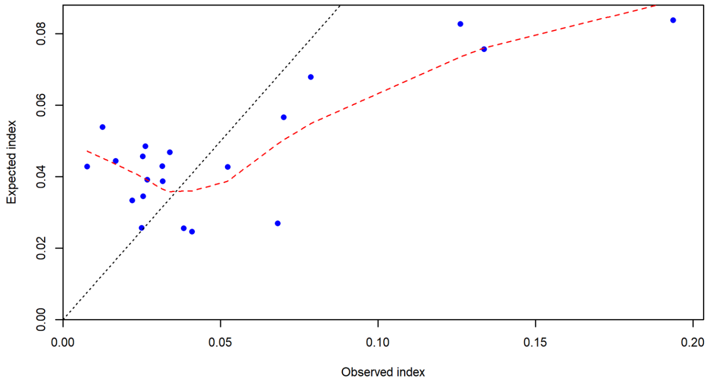
Rec. PR dockside index





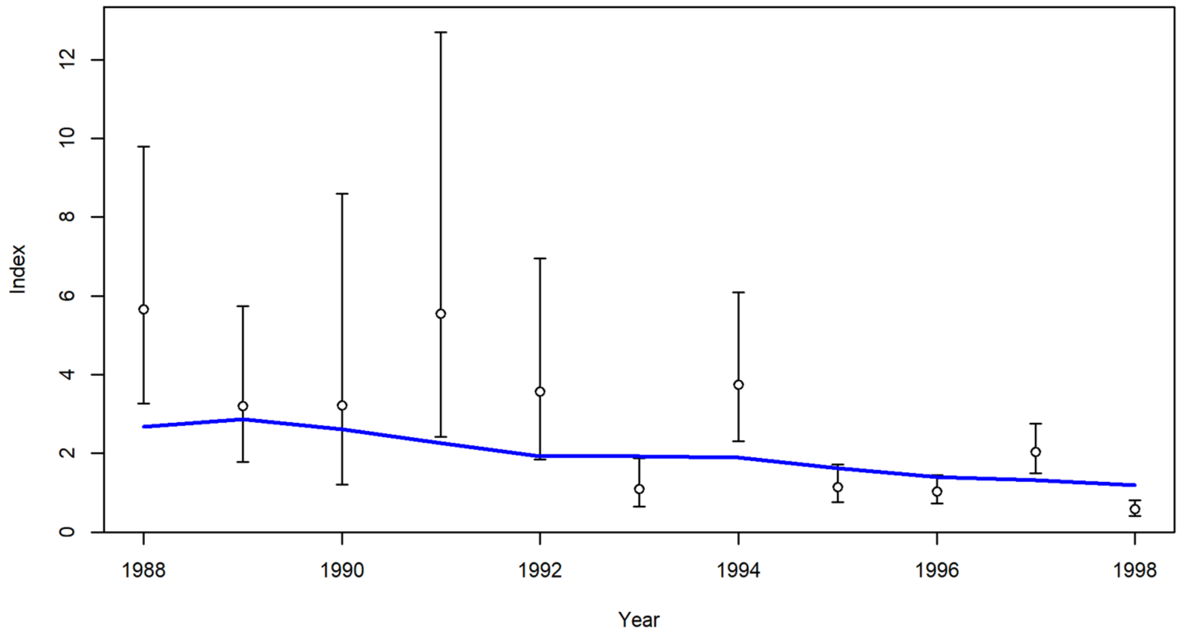
CRFS PC onboard index

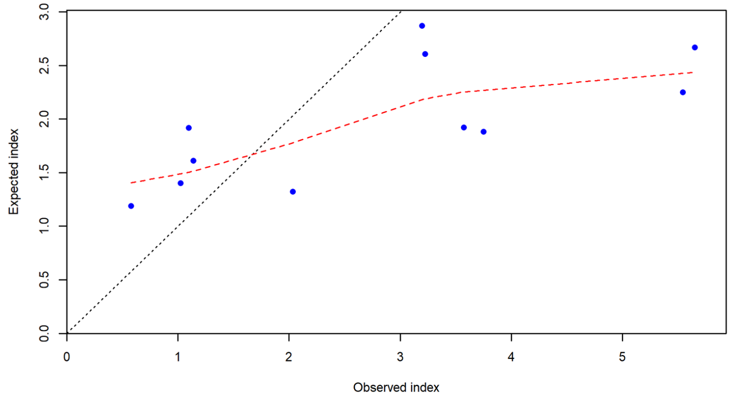




Central model: fishery-dependent indices of abundance (cont.)

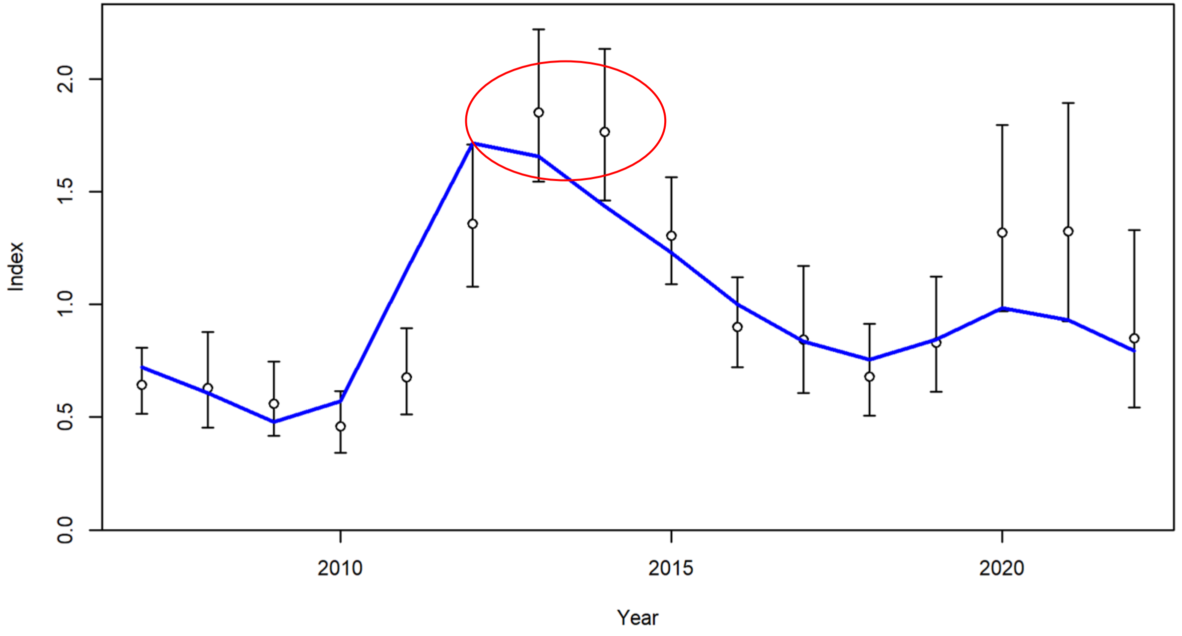
Rec. PC onboard ("DWV") index

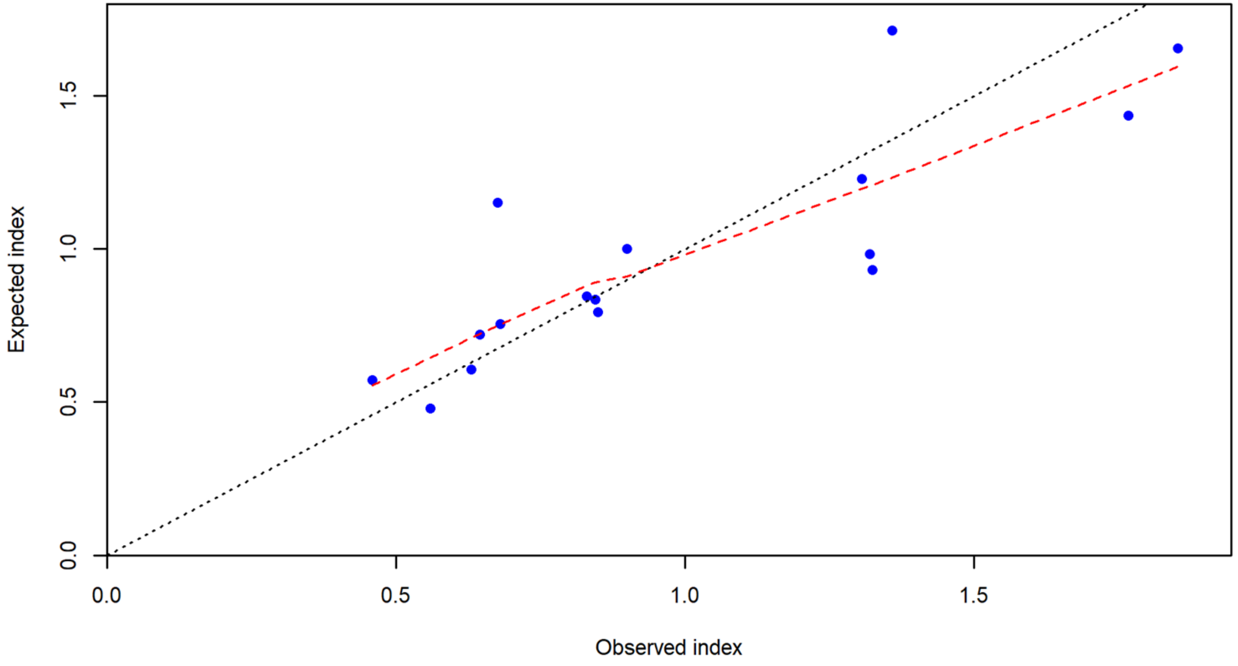




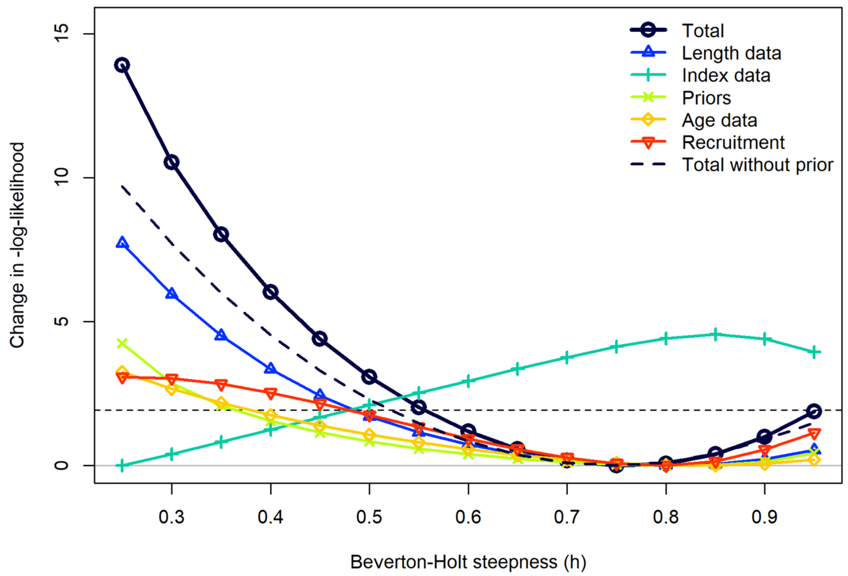
Central model: fishery-independent indices of abundance

CCFRP index

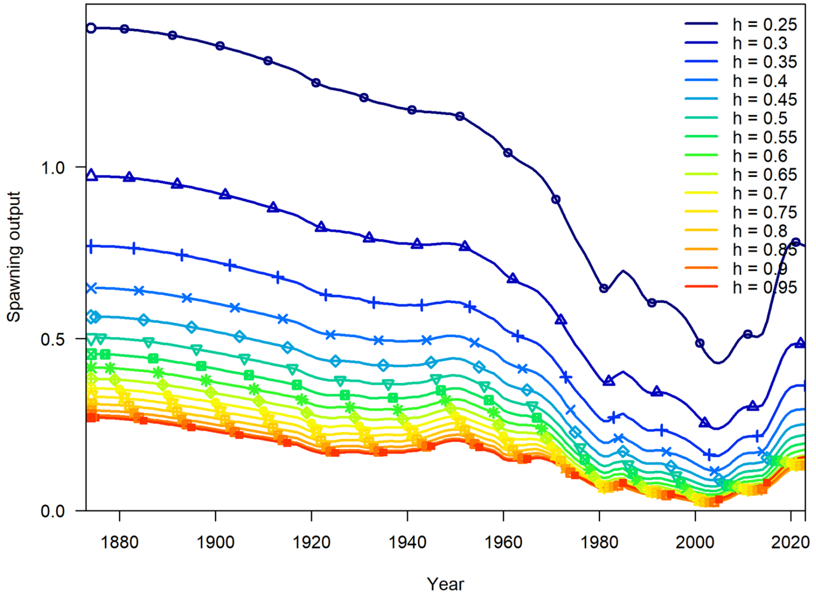


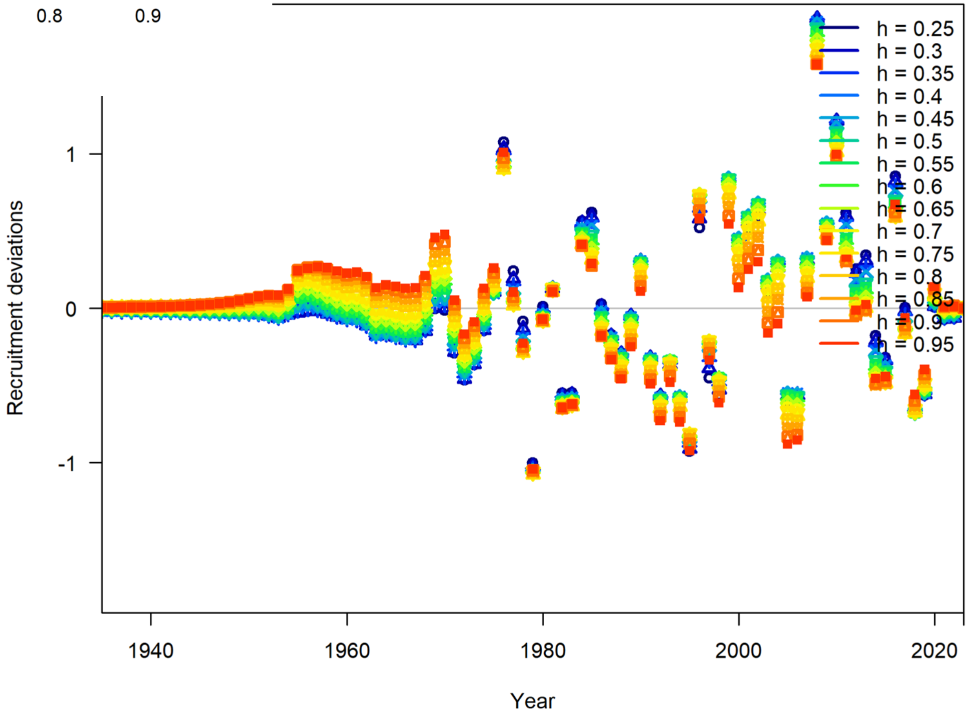


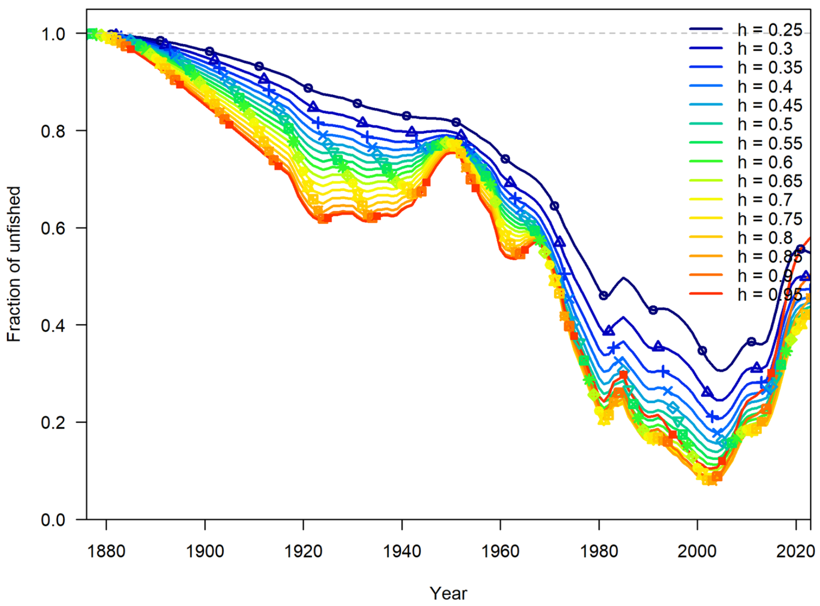
Central Model Likelihood Profiles: Steepness



Also see Tables 55-56, and Figures 176-178

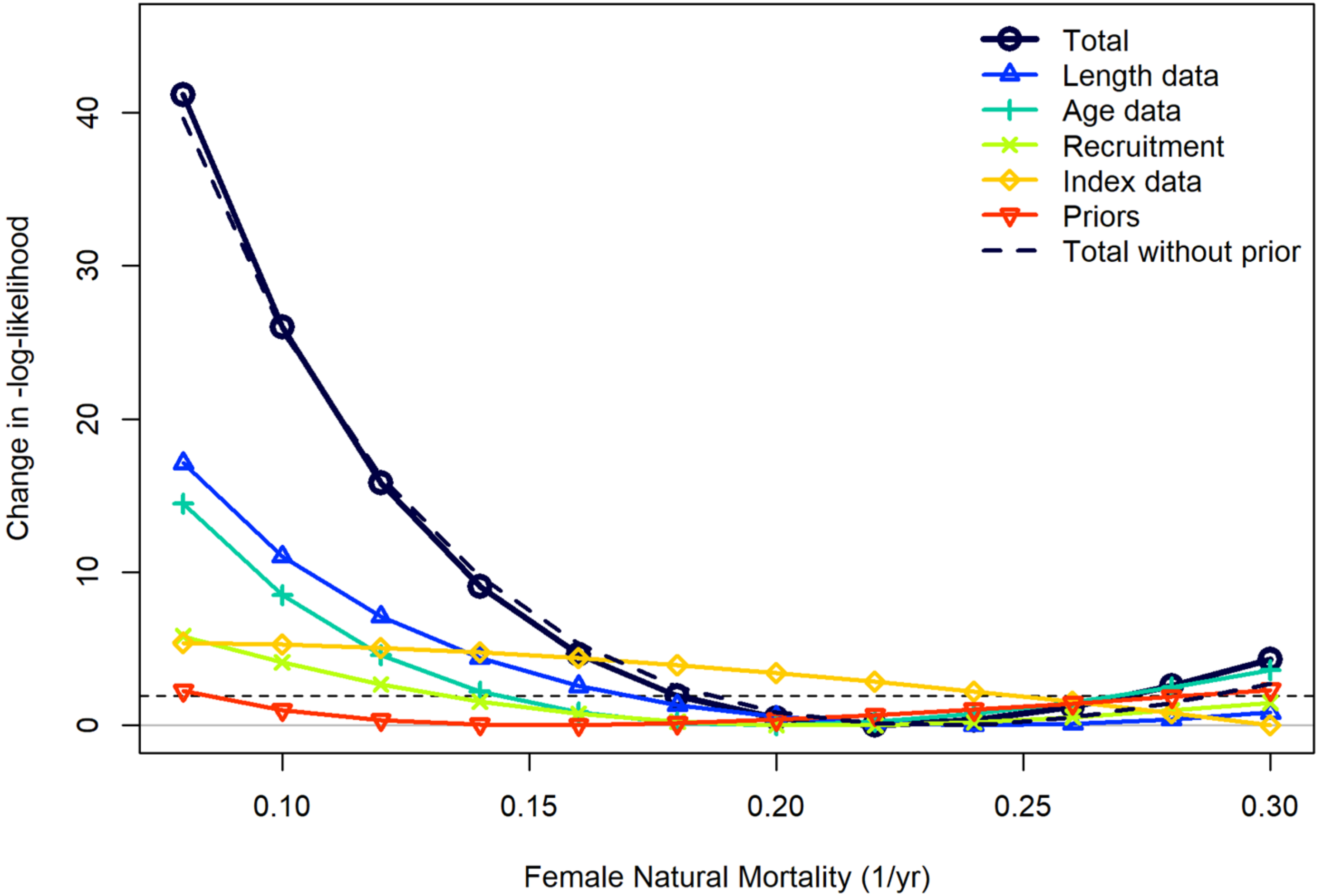


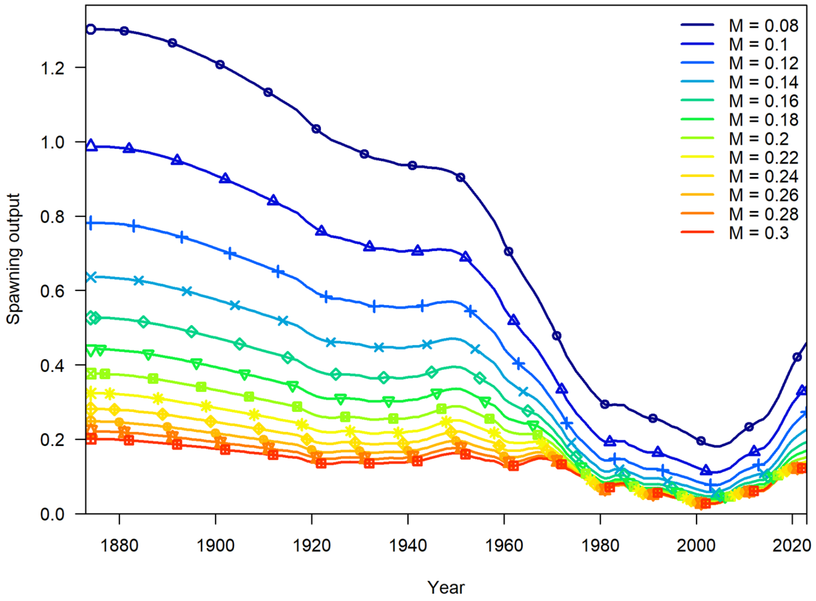


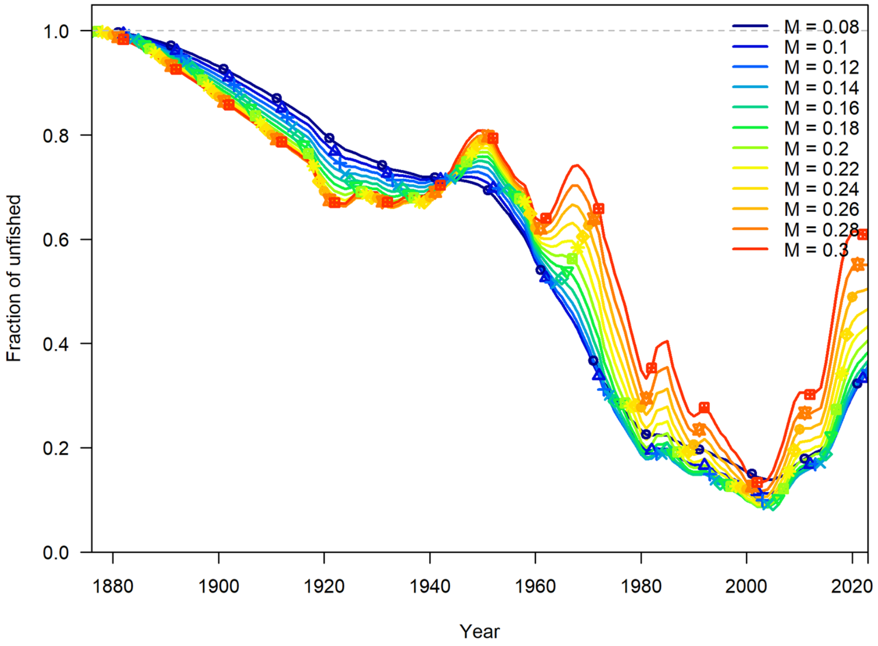


Central Model Likelihood Profiles: Natural Mortality

Also see Tables 59-60 and Figures 189-191

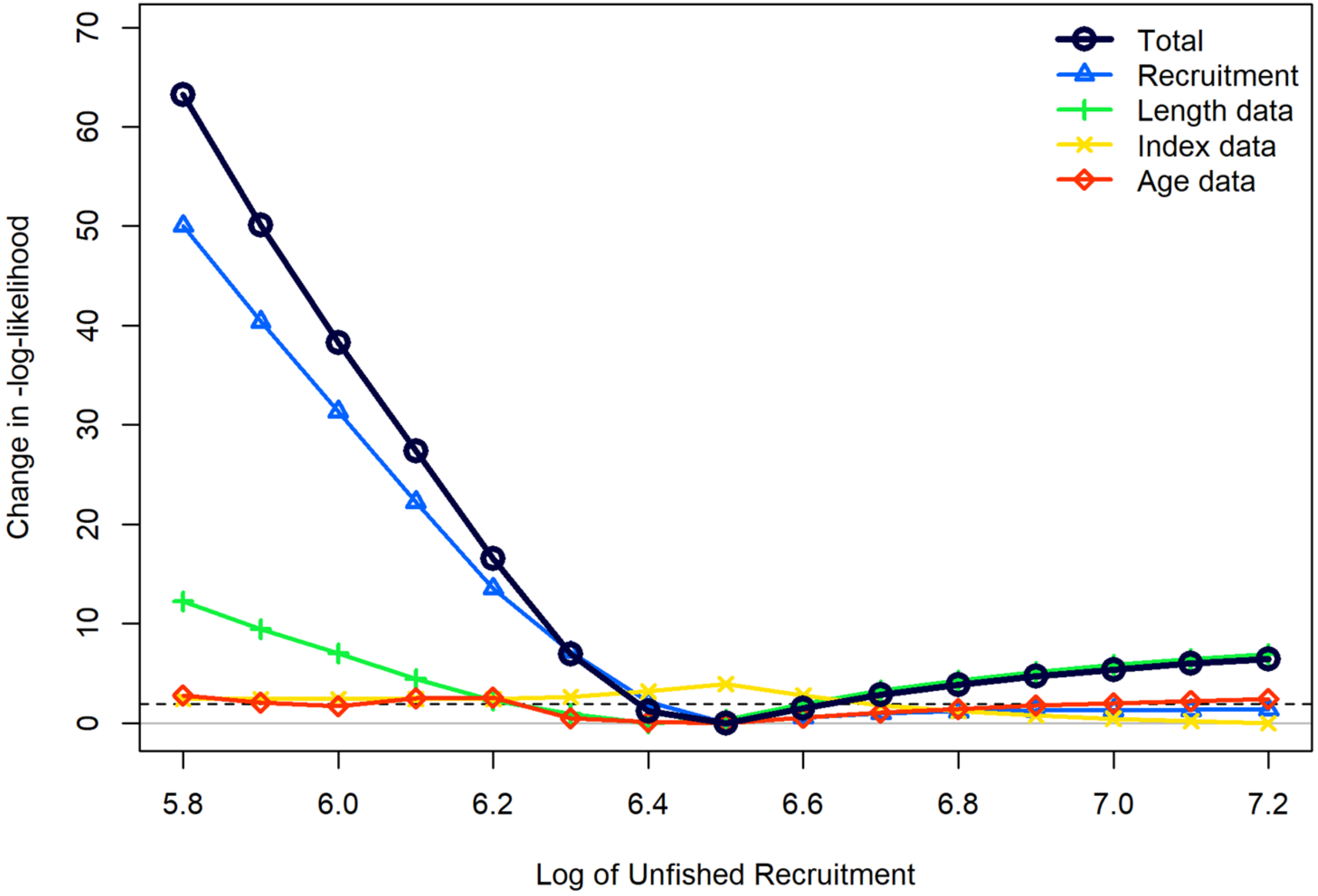


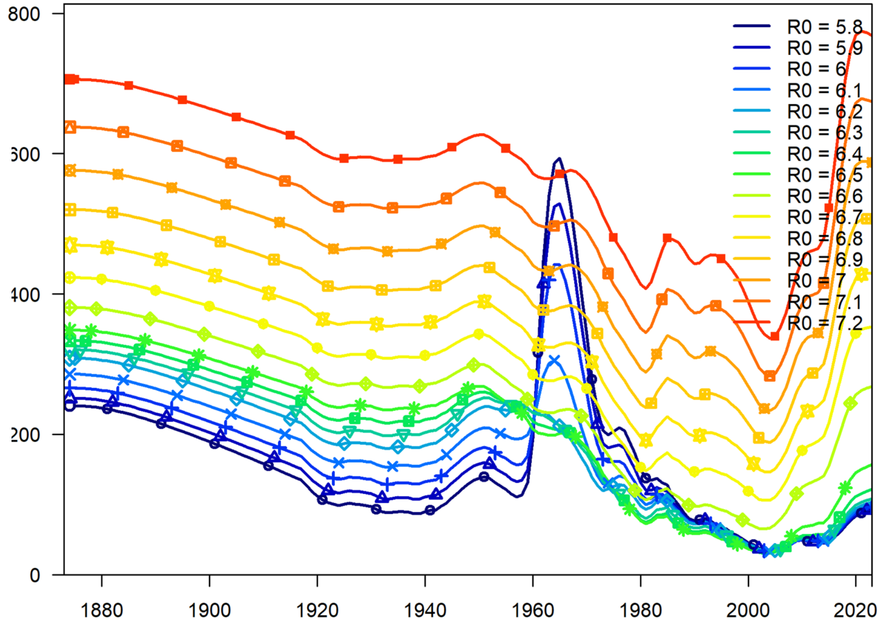


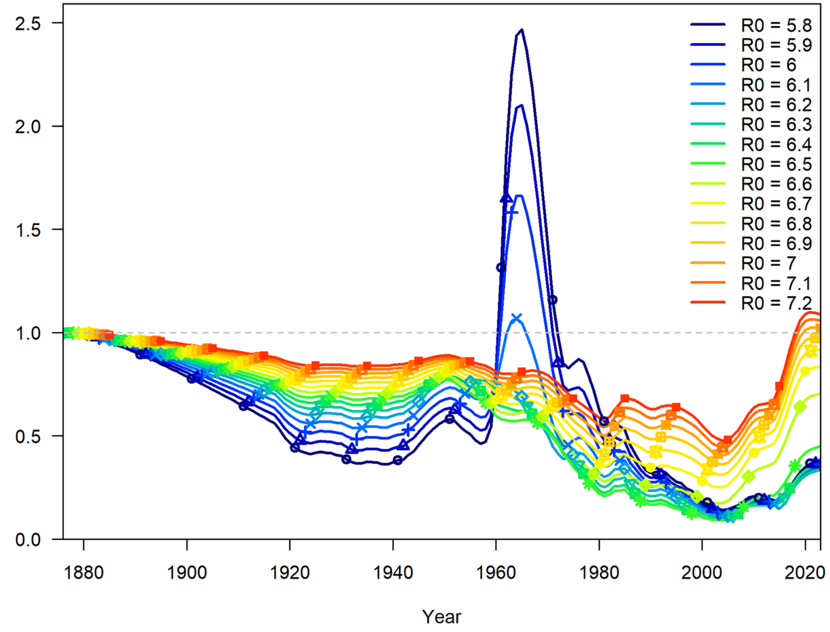


Central Model Likelihood Profiles: Unfished Recruitment

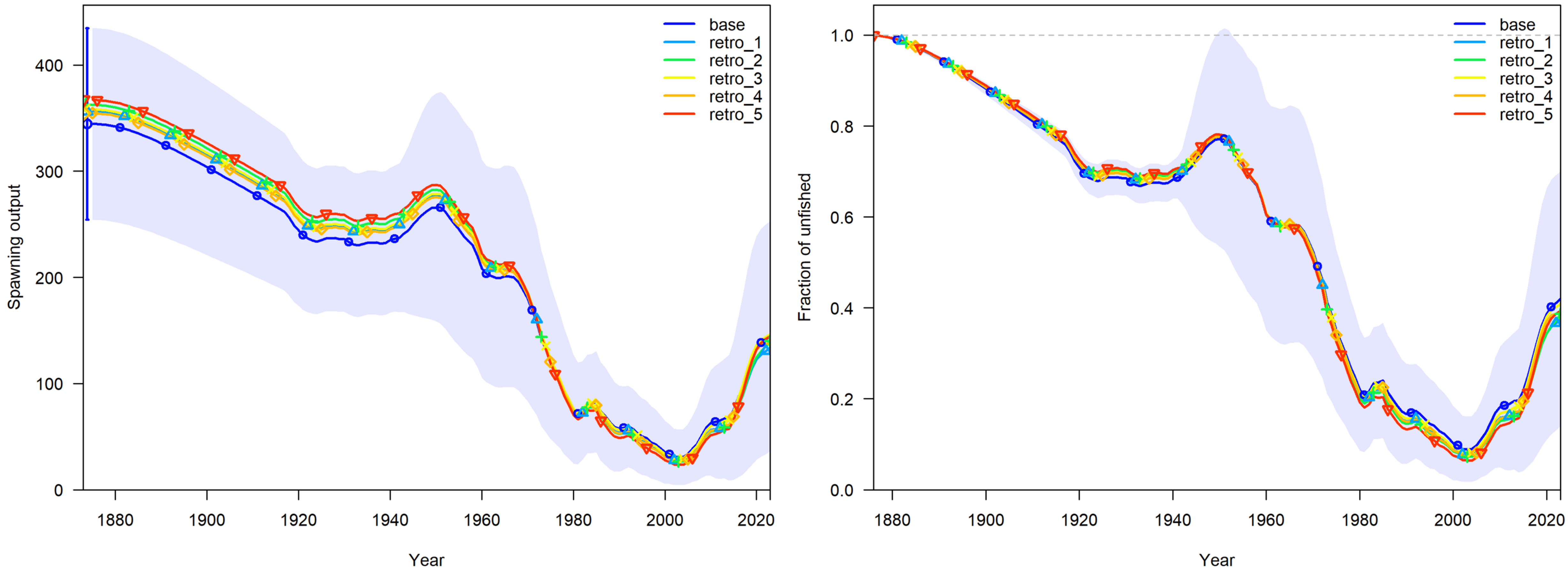
Also see Table 57-58 and Figures 183-185



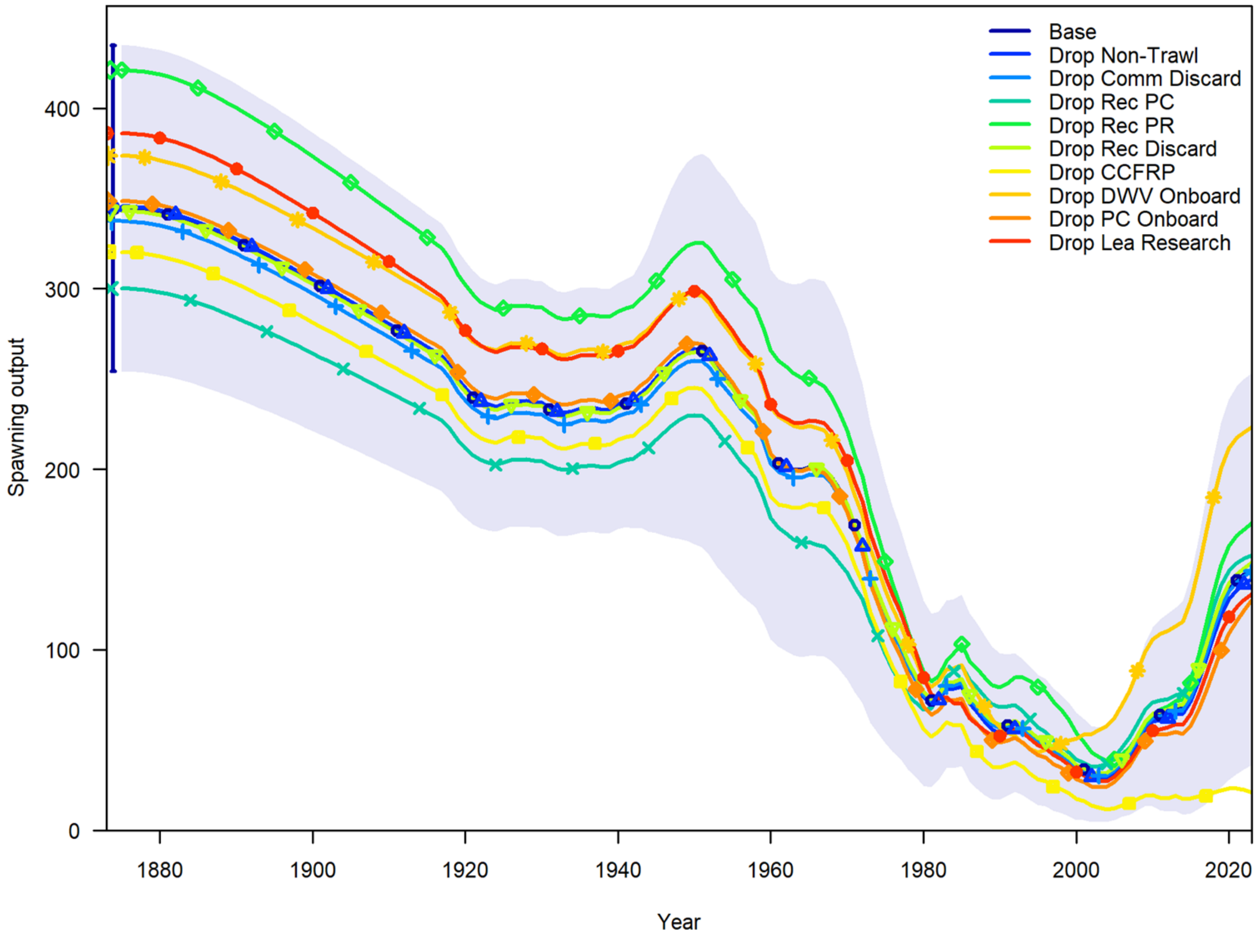


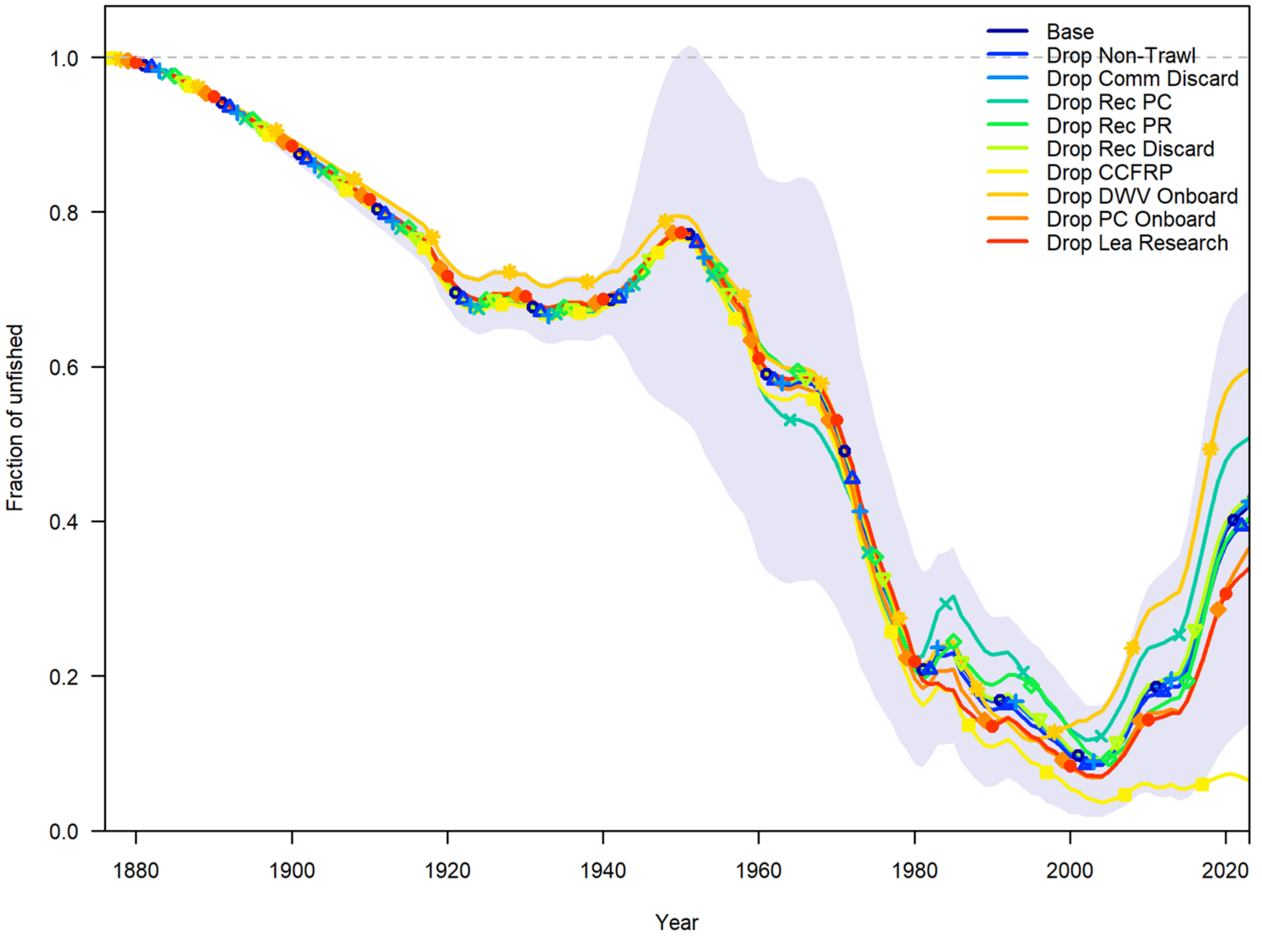


Central model retrospective analysis



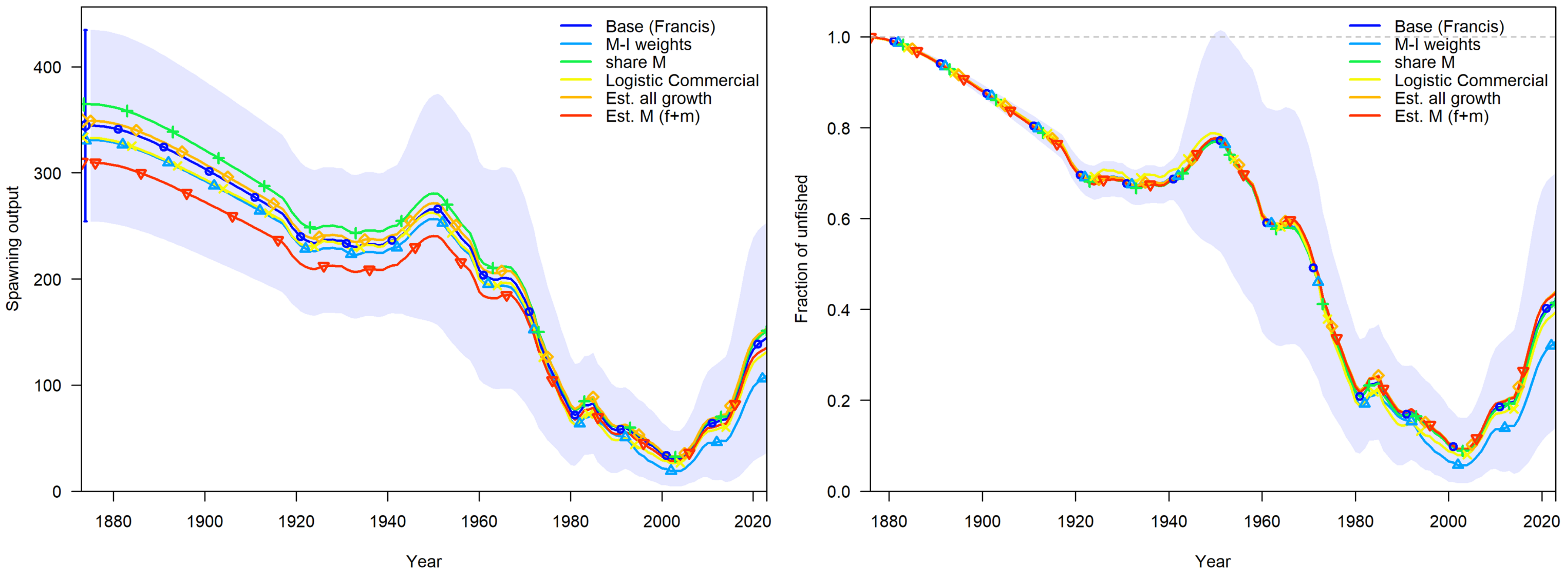
Central model “drop-one” analysis





Also see Figs. 167-170 and Tables 52-53

Central model, additional sensitivity runs



Also see Figs. 173-174 and Table 54

Panel Review Requests of Importance

- Adding ageing error prior to 2015, Request 3.
- Flexible spline fit to functional maturity, Request 4.
- Both incorporated into a revised base model with minimal effect in Request 9 for the north and central.
- Examined potential benefit of recruitment indices from dive surveys and RREAS through squid plots. Consider inclusion in future assessments. Request 8 Central.
  - 4 to 6 years for recruitment devs to stabilize without recruitment indices but 3 to 4 with it.
  - Consider applications in next assessment.

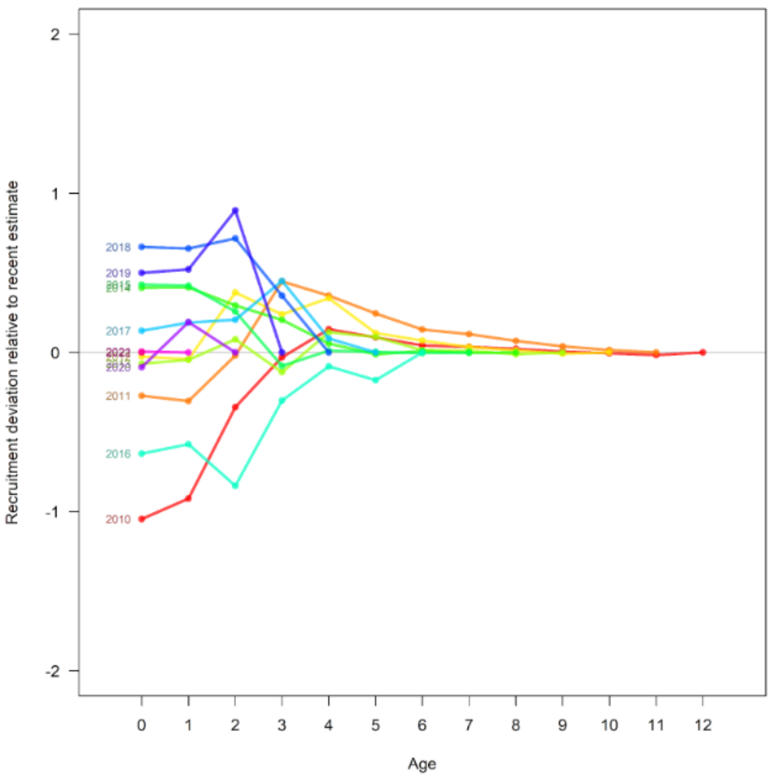


Figure 70. Retrospective analysis of recruitment deviations for the central California model, scaled relative to the most recent recruitment estimate. Convergence of the deviations is represented by the values approaching zero along the vertical axis.

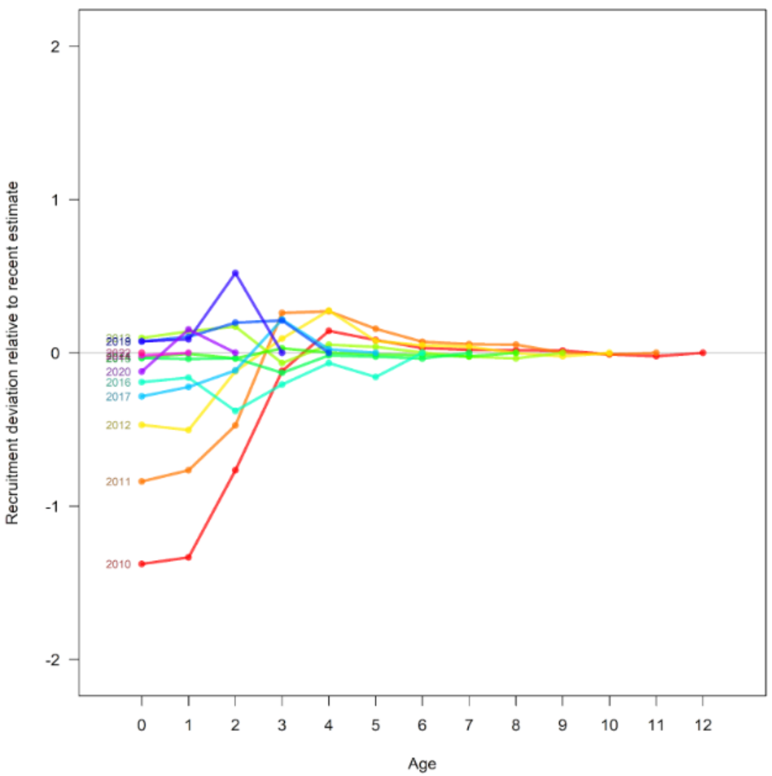


Figure 72. Retrospective analysis of recruitment deviations for the central California model fit with YOY abundance indices, scaled relative to the most recent recruitment estimate. Convergence of the deviations is represented by the values approaching zero along the vertical axis.

Evidence of convergence for northern base model

- Maximum parameter gradient = 6e-5
- No parameters hit bounds (Tables 37 & 38)
- Running base model with ADMB -hess_step option reduced the maximum gradient to zero and only improved neg. log likelihood by -6.8e-13
- 100 jitter runs found no solution with a lower NLL ("jitter fraction" = 0.2)

Technical Merits

- A wide range of available data collected in the fishery-dependent and fishery-independent monitoring programs were examined and well defined protocols were developed for CPUE standardization.

- Age/length data and indices of abundance from various sources were incorporated resulting in a comprehensive evaluation of fish stock dynamics, leading to an improved understanding of the status of the stock and sustainable harvest levels.

- STAT team explored many alternative models with different configurations and parameterizations within the Stock Synthesis framework to check the robustness of the current approach being used for management advice, which improved the quality of the assessment overall and indicated potential solutions to some problems.

- Finer spatial scale stock assessment for black rockfish in California with two assessment areas reduce the uncertainty compared with the 2015 assessment.

Technical Deficiencies

- Concern that primary or secondary trip targets may be too loosely applied to effectively filter out the non-informative data.

- Need to better quantify uncertainties from different model structures that represent plausible fisheries population dynamics. Ensemble modeling approaches may be considered in future to quantify the uncertainty in stock assessment models.

- Current assessment assumes that the assessment areas are closed with no immigration/emmigration, which does not reflect the observed movement in tagging studies.

- No historical functional maturity information available. Recent years of data were used in estimating historical spawning output, though it is likely to vary with biotic and abiotic environmental conditions.

- Lack of explicit consideration of ecosystem dynamics (e.g., climate change) in the stock assessment.

Area Stock Status and Depletion

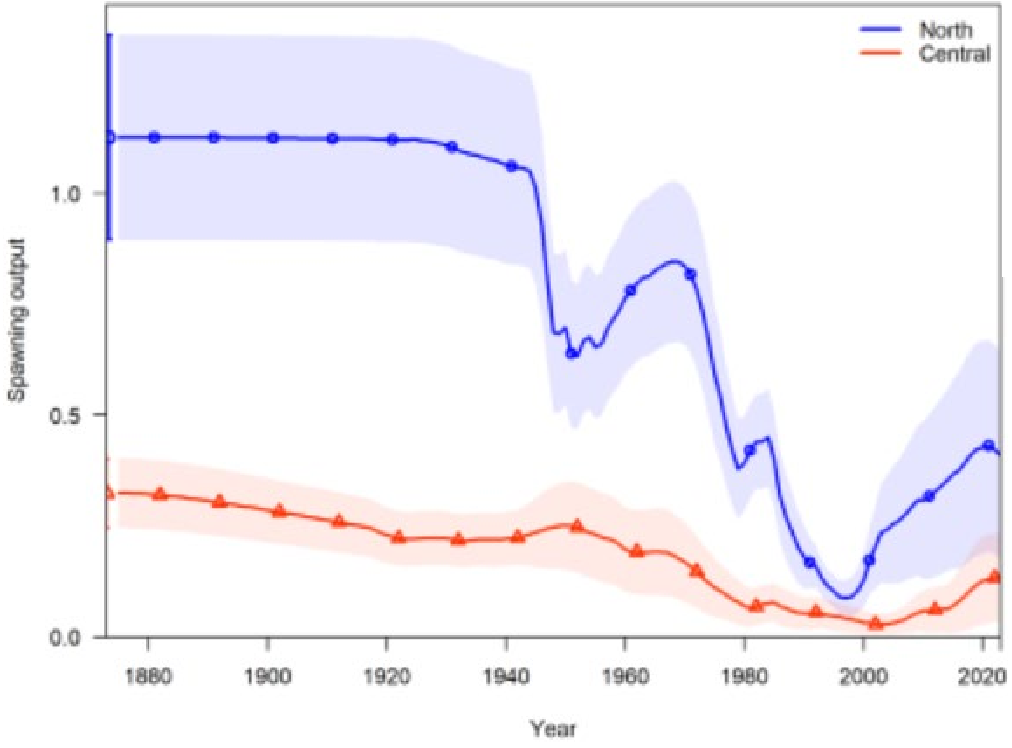


Table ES2. Recent trends in spawning output (billions of eggs) from the northern area base model. Uncertainty intervals are 95% asymptotic estimates.

Year	Spawning Output	Interval	Fraction Unfished	Interval
2013	339	142 - 536	0.301	0.13 - 0.47
2014	352	149 - 556	0.313	0.13 - 0.49
2015	366	154 - 579	0.325	0.14 - 0.51
2016	375	153 - 597	0.333	0.14 - 0.53
2017	393	162 - 624	0.349	0.15 - 0.55
2018	411	174 - 648	0.365	0.16 - 0.57
2019	423	183 - 663	0.376	0.17 - 0.59
2020	427	187 - 667	0.379	0.17 - 0.59
2021	431	193 - 670	0.383	0.18 - 0.59
2022	423	186 - 659	0.376	0.17 - 0.58
2023	410	175 - 645	0.364	0.16 - 0.57

Table ES3. Recent trends in spawning output (billions of eggs) from the central area base model. Uncertainty intervals are 95% asymptotic estimates.

Year	Spawning Output	Interval	Fraction Unfished	Interval
2013	63	10 - 115	0.193	0.04 - 0.34
2014	63	8 - 118	0.194	0.04 - 0.35
2015	70	9 - 131	0.215	0.04 - 0.39
2016	81	11 - 151	0.249	0.05 - 0.45
2017	93	13 - 173	0.287	0.06 - 0.51
2018	107	18 - 195	0.329	0.08 - 0.58
2019	118	23 - 213	0.364	0.1 - 0.63
2020	126	27 - 226	0.390	0.11 - 0.67
2021	131	30 - 232	0.404	0.12 - 0.69
2022	134	32 - 235	0.412	0.13 - 0.69
2023	136	35 - 238	0.421	0.14 - 0.7

Combined Stock Status and Depletion

Table ES4. Recent trends in statewide spawning output (billions of eggs) derived from the northern and central area base models.

Year	Spawning Output	Fraction Unfished
2013	401	0.277
2014	415	0.286
2015	436	0.301
2016	456	0.315
2017	486	0.335
2018	518	0.357
2019	542	0.373
2020	554	0.382
2021	562	0.388
2022	557	0.384
2023	547	0.377

-Statewide Status is in the Precautionary Zone

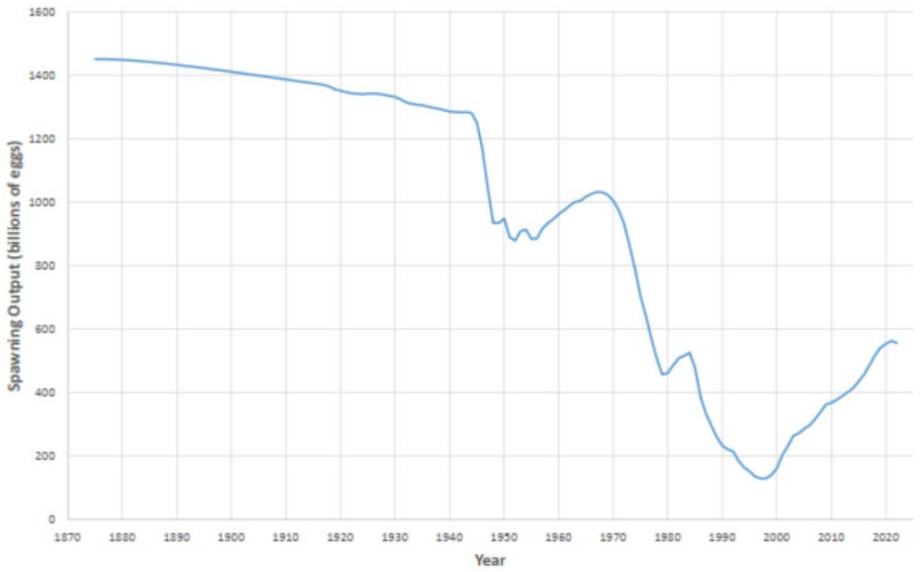


Figure ES4. Combined spawning output (billions of eggs) for the California stock of black rockfish, 1875-2023.

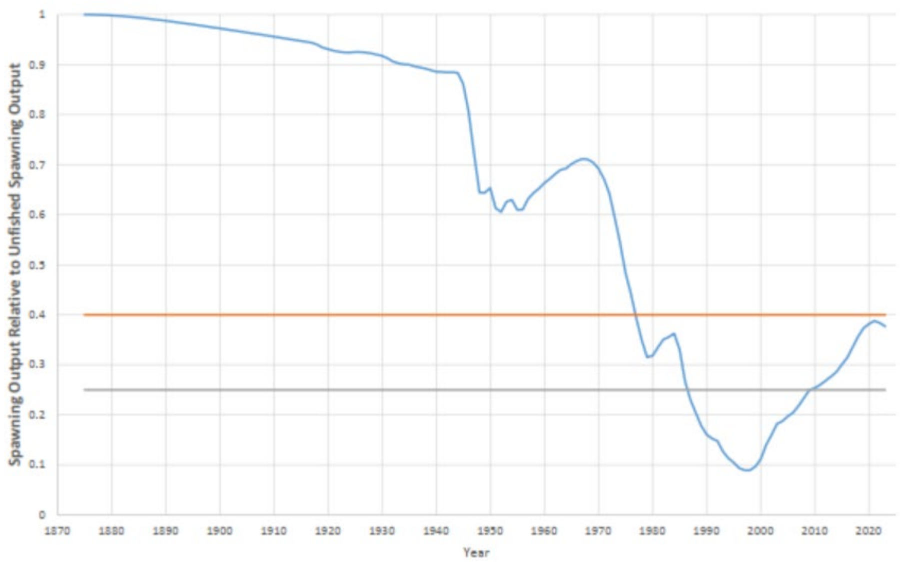
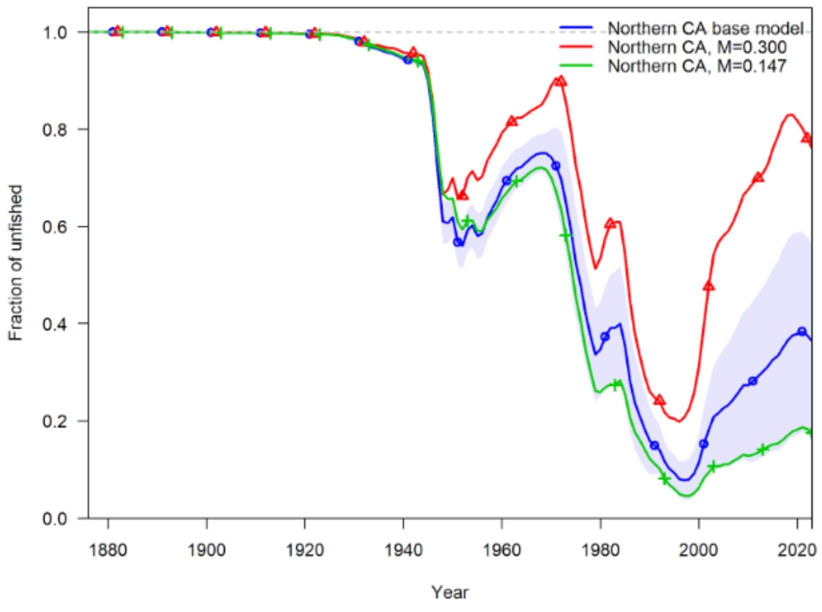


Figure ES5. Spawning output relative to unfished spawning output for the California stock of black rockfish, 1875-2023. The target level of spawning output (40% of unfished) and minimum stock size threshold (25% of unfished) are shown as horizontal lines for reference.

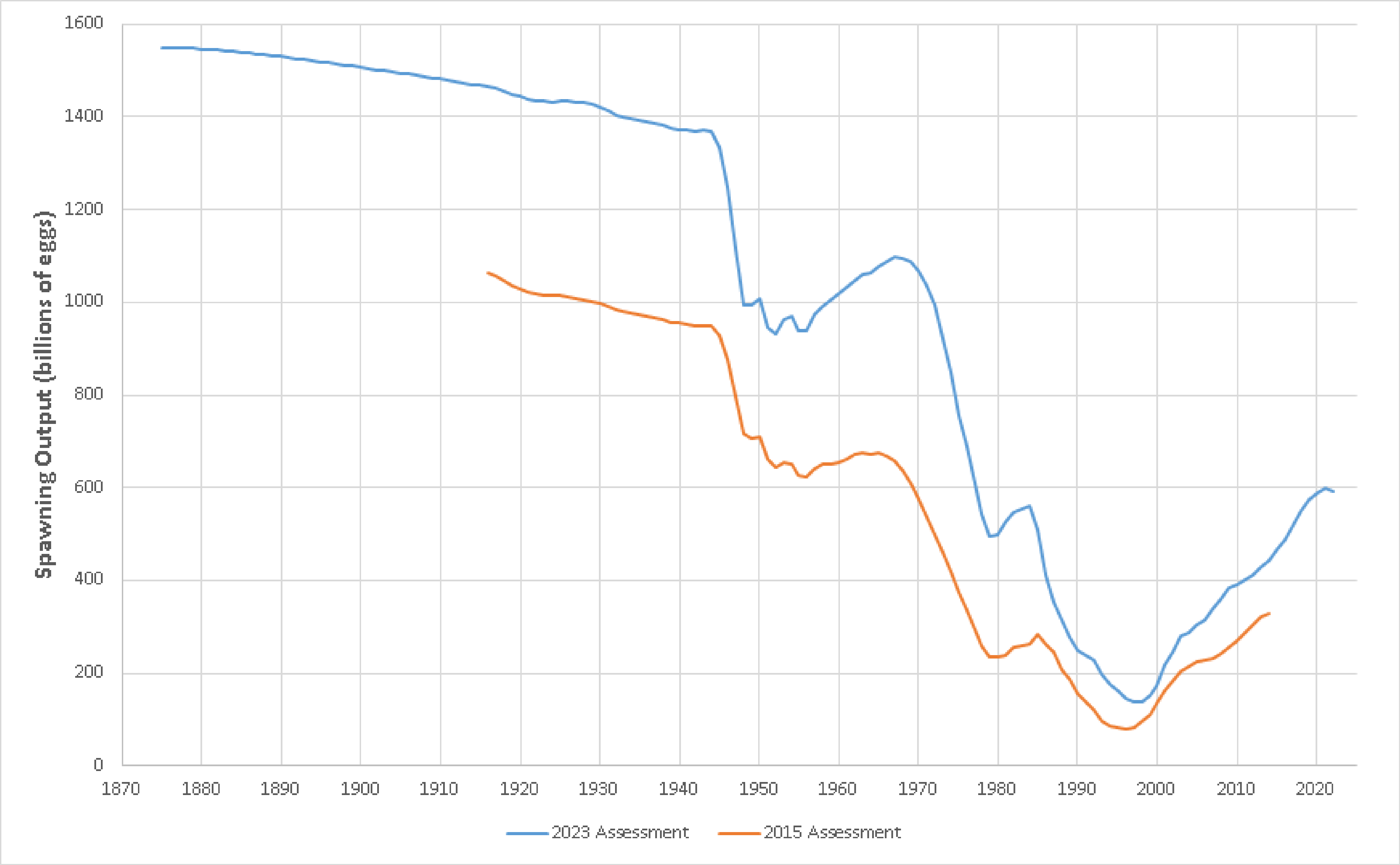
Decision Table - Uncertainties

- Primary Axis of Uncertainty Basis:
  The uncertainty in the prior for natural mortality centered on the point estimate of the base model with the 12.5 and 87.5 percentile of the distribution providing the lower and upper states of nature.
- Full Attainment Assumed
- Base Catch: Healthy by 2032

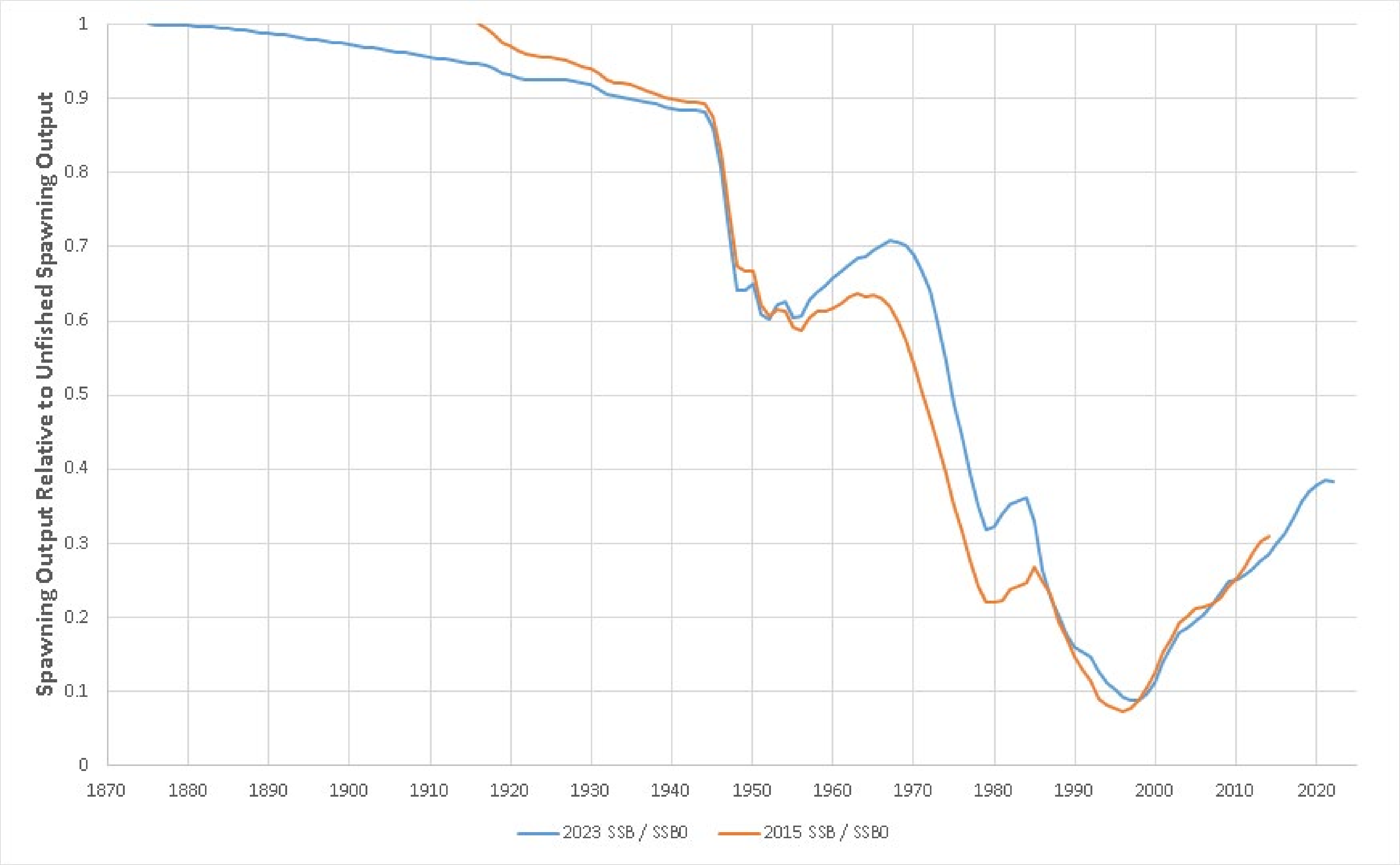


P* = 0.45, sigma = 0.5			State of nature Low Female M = 0.147		Base case Female M = 0.210		High Female M = 0.300	
Management decision	Year	Catch (mt)	Spawning Output	Fraction Unfished	Spawning Output	Fraction Unfished	Spawning Output	Fraction Unfished
Low Catch	2023	334	494	0.222	547	0.377	872	0.736
	2024	329	477	0.215	530	0.365	847	0.716
	2025	86	457	0.205	513	0.354	824	0.696
	2026	96	471	0.212	532	0.367	837	0.707
	2027	109	487	0.219	558	0.384	858	0.725
	2028	122	506	0.227	590	0.407	885	0.748
	2029	135	528	0.237	627	0.432	912	0.770
	2030	148	555	0.249	664	0.458	933	0.788
	2031	160	586	0.263	700	0.483	948	0.801
	2032	171	618	0.278	731	0.504	957	0.808
	2033	181	651	0.293	758	0.523	960	0.811
	2034	189	683	0.307	781	0.539	960	0.811
Base Catch	2023	334	494	0.222	547	0.377	872	0.736
	2024	329	477	0.215	530	0.365	847	0.716
	2025	224	457	0.205	513	0.354	824	0.696
	2026	236	447	0.201	511	0.353	819	0.692
	2027	249	437	0.196	516	0.356	822	0.694
	2028	261	428	0.192	526	0.363	832	0.702
	2029	270	421	0.189	539	0.372	841	0.711
	2030	277	420	0.189	554	0.382	848	0.716
	2031	282	423	0.190	569	0.392	851	0.719
	2032	285	428	0.193	583	0.402	850	0.718
	2033	286	436	0.196	595	0.410	848	0.716
	2034	287	443	0.199	606	0.418	844	0.713
High Catch	2023	334	494	0.222	547	0.377	872	0.736
	2024	329	477	0.215	530	0.365	847	0.716
	2025	580	457	0.205	513	0.354	824	0.696
	2026	566	384	0.173	458	0.316	771	0.652
	2027	555	313	0.141	412	0.284	732	0.618
	2028	543	249	0.112	374	0.258	704	0.594
	2029	529	204	0.092	344	0.237	682	0.576
	2030	518	181	0.081	321	0.221	664	0.561
	2031	507	174	0.078	303	0.209	649	0.548
	2032	498	172	0.077	290	0.200	637	0.538
	2033	491	173	0.078	278	0.192	627	0.530
	2034	485	174	0.078	268	0.185	619	0.523

Total spawning output in California (2023 vs. 2015)



Relative spawning output in California (2023 vs. 2015)



Research and Data Needs

The panel supports the recommendations provided in the pre-STAR draft assessment (reproduced below).

1. Continue to develop the nearshore fishery-independent survey, as the other available surveys provide weak information for the trend in the population.
2. Improve understanding of broader ecosystem considerations within the context of Black Rockfish (and other nearshore species) management.
3. Evaluate and develop linkages between black rockfish population dynamics and environmental, oceanographic, and climate variables. In particular, develop multi-scale models (e.g., species distribution models) that can evaluate spatial patterns (e.g., multi-use areas or closures to fishing) and climate impacts (e.g., growth or distribution shifts) for vulnerable nearshore species. Utilize the growing body of ecosystem information available for the California Current Large Marine Ecosystem, as exemplified in the PFMC Integrated Ecosystem Assessment (IEA) report.

Research and Data Needs (Cont.)

4. Continue work on the investigation into the movement, behavior or mortality of older (> age 10) females to further reconcile their absence in fisheries data. In particular, conduct genetics studies on fish observed off of the continental shelf (middle of the gyre and at sea mounts) to determine their association with the nearshore stocks.

5. Continue to build evidence for appropriate natural mortality values for females and males. This will help resolve the extent to which dome-shaped age-based selectivity may be occurring for each.

6. Design and conduct research studies to better understand the trade-offs revealed in this assessment between black rockfish biology and population scale that seem to be at odds. If discrepancies cannot be uncovered, evaluate management procedures that are as robust as can be to this trade-off.

7. Conduct early life history studies that provide a better understanding of the ecology and habitats of black rockfish from settlement to age-1.

Research and Data Needs (Cont.)

The STAR panel supports the following additional recommendations for future research and data collection.

1. Simulation studies, meta-analyses across species or other research to examine circumstances in which options for treatment sex data for composition data are preferable under Option 1 or 2 treating them as separate or Option 3 treating them as combined. Such studies should aim to provide criteria for their application to inform guidance in the PFMC's Groundfish Terms of Reference and Accepted Practices documents.
2. Further evaluation of temporal and spatial variability in biological and functional maturity may facilitate accounting for uncertainty or help account for trends and identify drivers. Data informing the functional maturity ogive were collected during a period of extreme variability in ocean conditions and further examination of the drivers of variability observed may prove beneficial.
3. Compare trends in abundance and patterns of recruitment across species to examine commonalities, differences and their causes may help inform accounting for environmental determinants.
4. Account for variance in catch history to help reflect the full degree of uncertainty in the assessment.
5. Re-examine methods to generate estimates of abundance from the WDFW Tagging Program using approaches used for similar data sets from analogous studies in Oregon.

Panel Recommendations

- Category: 1b
- Sigma: default 0.5
- Next Assessment: Full assessment to address connectivity between two assessment areas and potential for confounded M for central given migration.
- BSIA recommendation?
- Agreement?

Washington Black Rockfish Assessment

STAT

Jason M. Cope (NWFSC, Lead)

Lisa K. Hillier (WDFW)

Corey B. Niles (WDFW)

Tien-Shui Tsou (WDFW)

Kristen E. Hinton (WDFW)

Fabio P. Caltabellotta (WDFW)

Summary of Previous Assessments

Historical Assessments:

- Wallace and Tagart 1994; Wallace et al. 1999, 1999; Wallace and Tsou 2007.
- Cape Falcon to US/Canada border.
- 2007 assessment used Stock Synthesis 2.
- Included CPUE from tag release trips and Peterson estimates of abundance from tagging as relative abundances.

Full assessment in 2015 (Cope et al. 2016).

- First state-based assessment.
- Stock Synthesis 3
- Recreational, trawl, non trawl, trawl, two surveys.
- Francis weighting, sex specific M (Hide'em or kill'em), estimated rec devs.
- Likelihood components: index, length, age.
- Basis for current management
- 43% of unfished in 2015

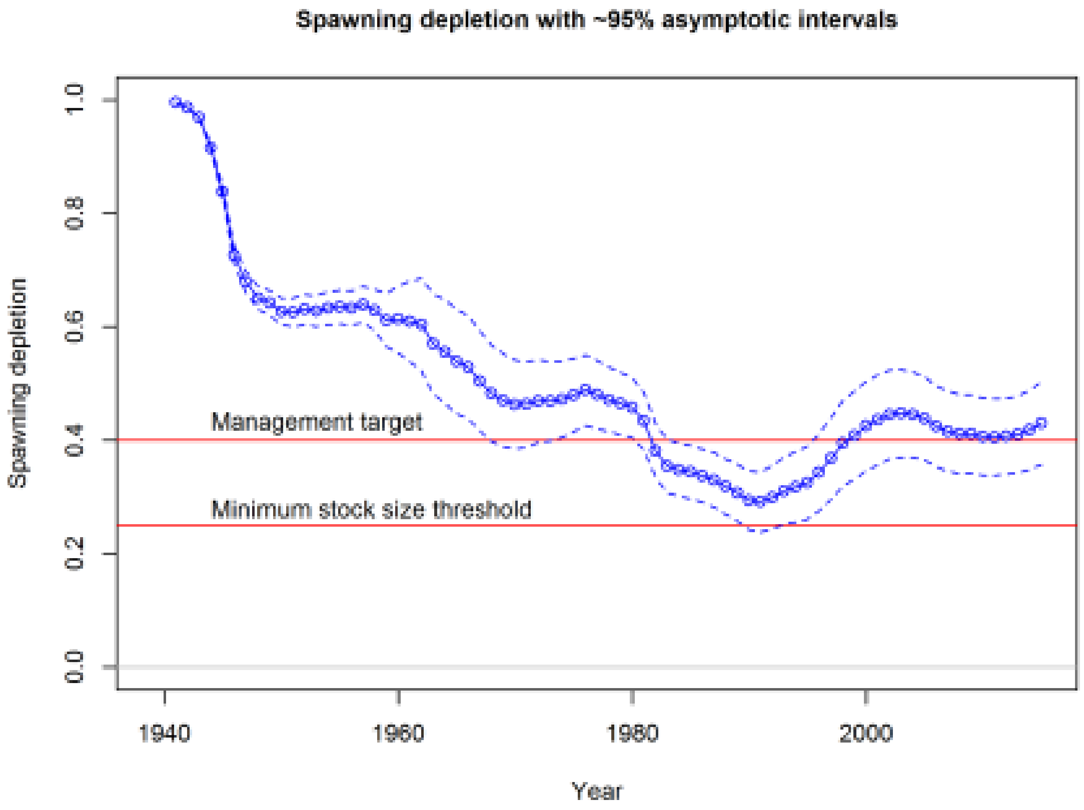
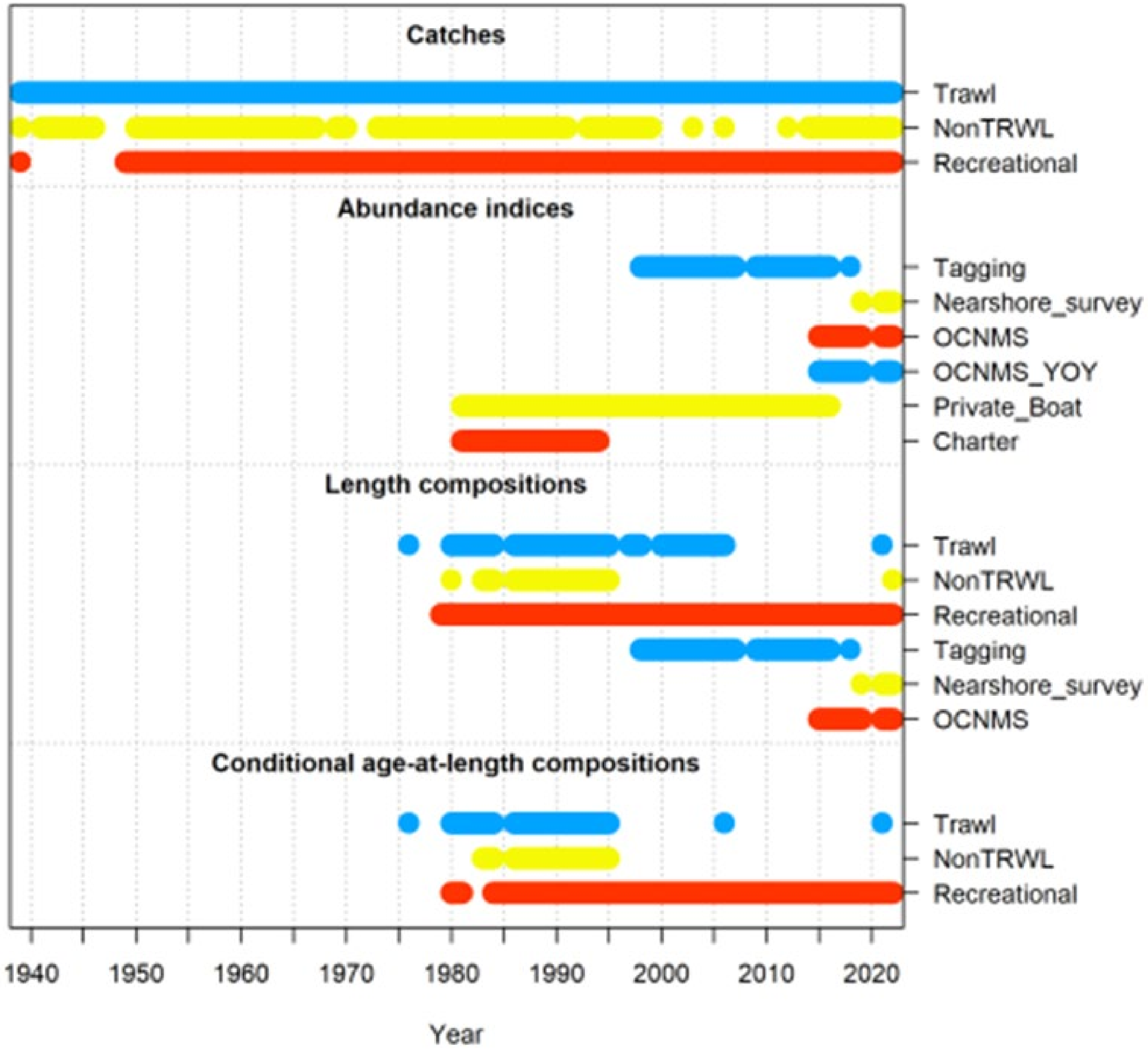


Figure ES-9. Time series of stock status (depletion) of black rockfish in Washington.

Data Sources



Washington Commercial Fisheries

- **Gear grouping**
  - **Trawl: groundfish, shrimp**
  - **Non-Trawl: jig, troll**

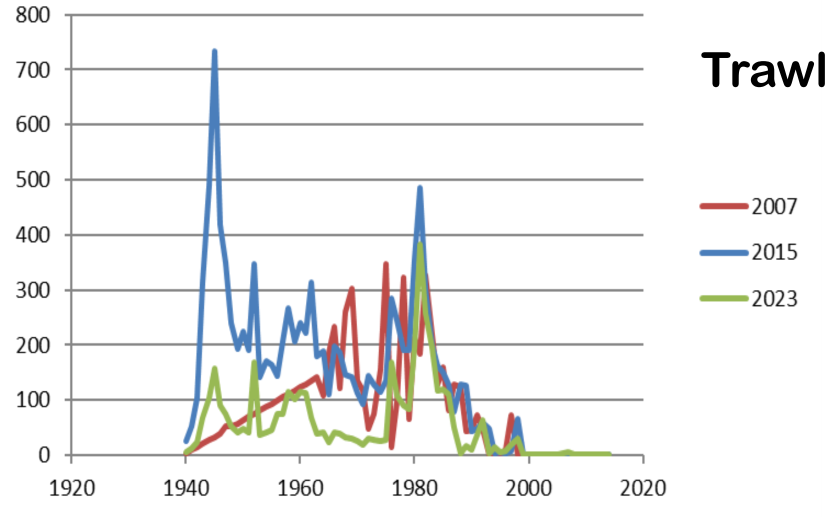
State 3-nmile commercial closure

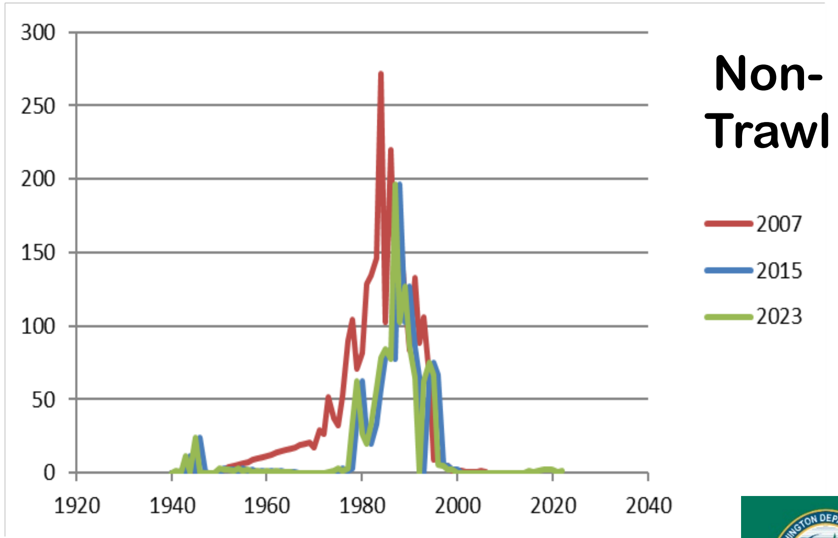
- **1995 – non-trawl**
- **1999 - trawl**

Federal Rockfish conservation area (website): minimum impacts

Commercial Removal - Landings

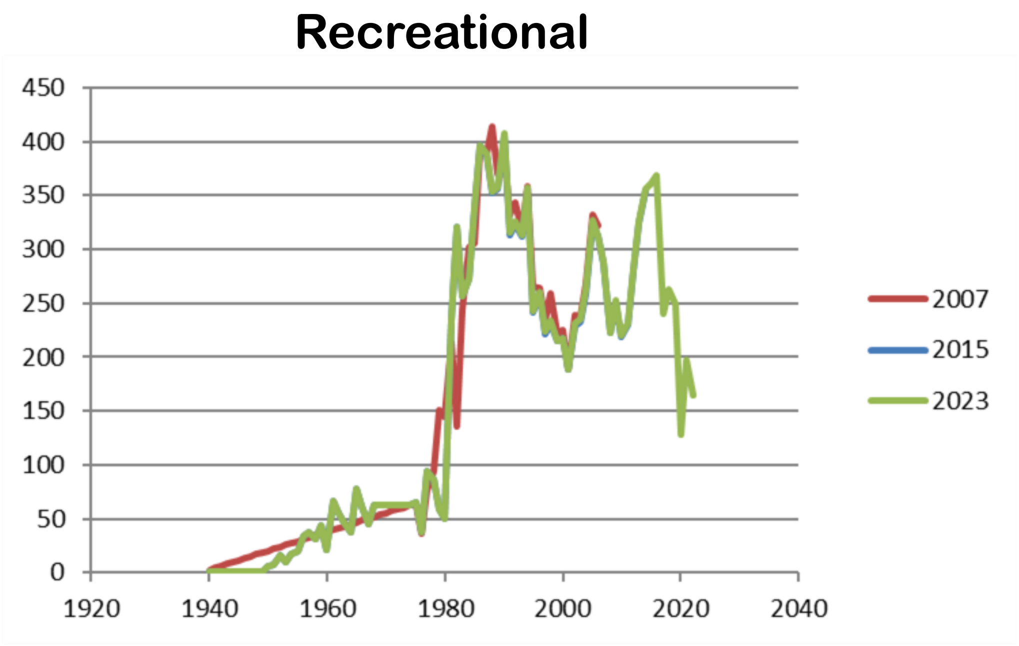
- **WA Landings**
  - ▶ **Pre-2015 landings: same as in 2015 assessment.**
  - ▶ **2015-2022 landings added to this assessment.**
- **Historical Astoria OR landings**
  - ▶ **98.6% of rockfish caught in WA**
  - ▶ **Assume 3% black pre-1981 and 4% for 1981-1986.**
  - ▶ **(Assumed 14.1% in 2015 assessment.)**



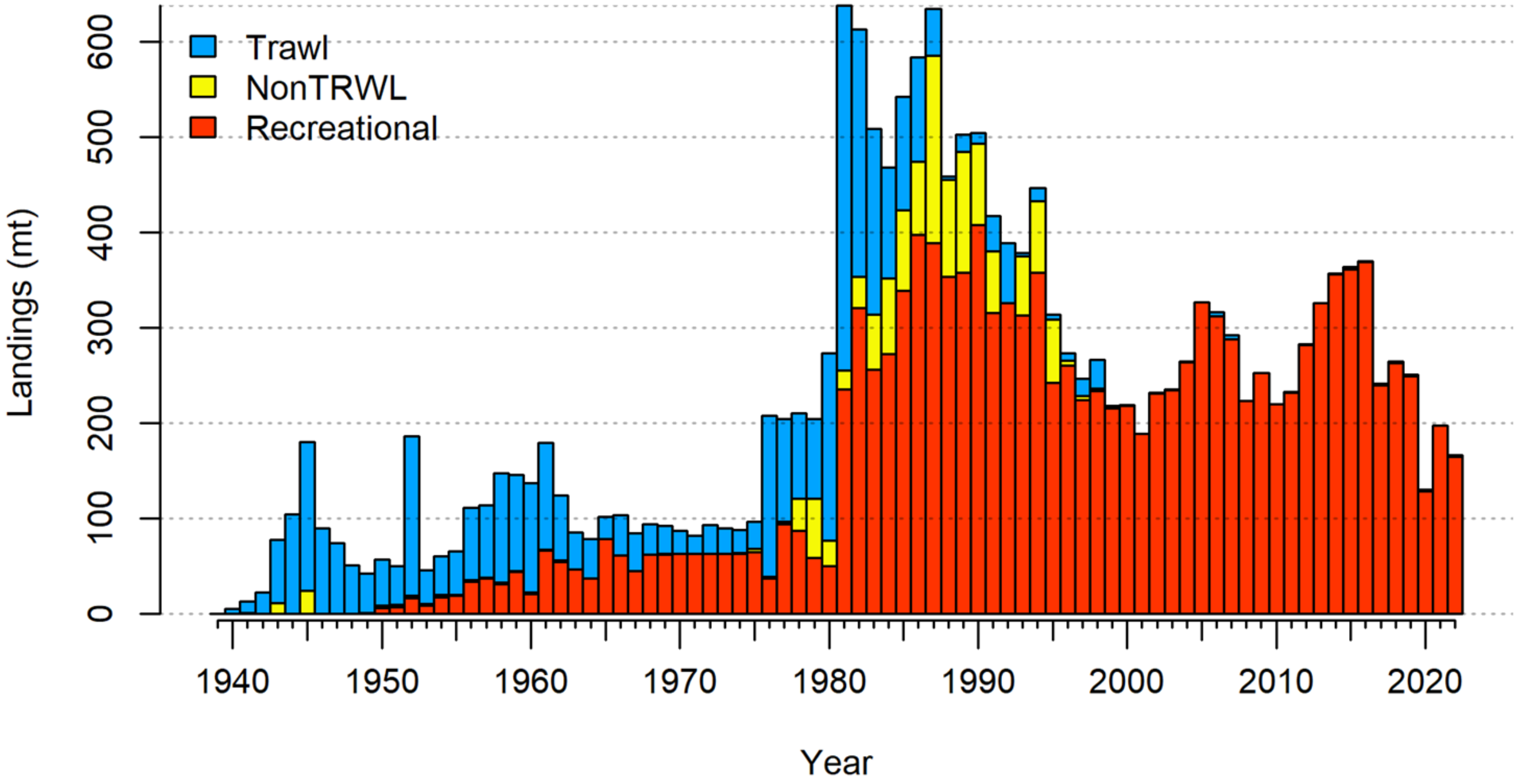


Recreational Removal

- Historical catch reconstruction was conducted in 2015
- Pre-2015 total removal (retained catch and dead releases) same as in 2015 assessment.
- 2015-2022 total removal is added in this assessment.



Washington Total Fisheries Removals



Fishery Biological Samples (Commercial)

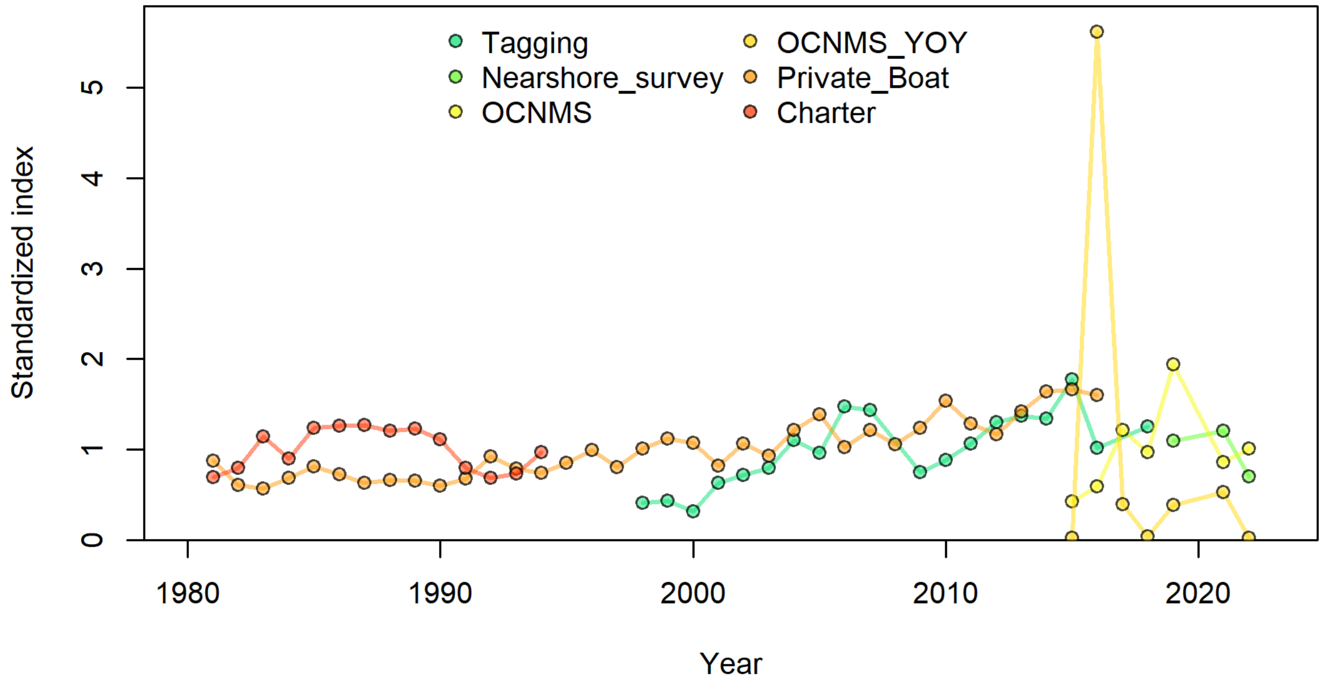
Year	Length		Age	
	Trawl	Non-Trawl	Trawl	Non-Trawl
1976	79		238	
1980	32	14	99	
1981	82		394	
1982	75		295	
1983	135	34	794	100
1984	62	34	298	99
1986	92	152	321	525
1987	108	158	401	620
1988	40	119	99	416
1989	70	89	224	297
1990	70	53	224	125
1991	89	133	301	450
1992	64	88	197	268
1993	46	96	125	320
1994	25	76	48	250
1995	28	71	48	224
1997	6		19	
1998	16		1	
2000	2			
2001	1			
2002	9			
2003	2			
2004	5			
2005	1			
2006	14			
2021	2			
2022		1		

Fishery Biological Samples (Recreational)

Year	Length	Age	Year	Length	Age
1979	508		2001	1777	1773
1980	537	364	2002	2629	1845
1981	1468	71	2003	2323	1841
1982	263		2004	2001	1644
1983	10		2005	2227	1755
1984	834	855	2006	2853	1483
1985	160	160	2007	2929	2169
1986	512	506	2008	2033	1512
1987	645	642	2009	2449	1394
1988	450	448	2010	2301	1310
1989	397	395	2011	2246	934
1990	290	628	2012	2061	770
1991	721	1058	2013	2127	1031
1992	893	999	2014	1928	1213
1993	866	863	2015	2022	1583
1994	868	865	2016	1857	1480
1995	814	812	2017	3206	2248
1996	834	826	2018	2794	1805
1997	900	893	2019	3873	2622
1998	1326	1323	2020	1433	1371
1999	1673	1655	2021	2313	1814
2000	1650	1644	2022	1527	1316

Indices of Abundance

- Fishery Dependent
  - Dockside data: 1981 to present sampled March-October
    - Private boat and charter boat fleets
    - Bag limit reductions, 2003-2011 = 15 fish, 2011-current 12 fish
- Fishery Independent
  - Black Rockfish Tagging Study
    - Marine Area 2, 1995-2018
  - Spring Nearshore Survey
    - Coastwide 125 stations
    - 2019-2022, Mar to May
    - 4 drifts per station 5 fishers 2 flys
- OCNMS
  - SCUBA belt transect, adult and YOY



Model Description:

Structure and data

- 3 fleets
- 6 surveys
- Main likelihood components
  - Surveys
  - Length compositions
  - Conditional age at length data
  - Marginal ages (included but not fit)
- Data weighting
  - Bio: Francis
  - Survey: Additional variance

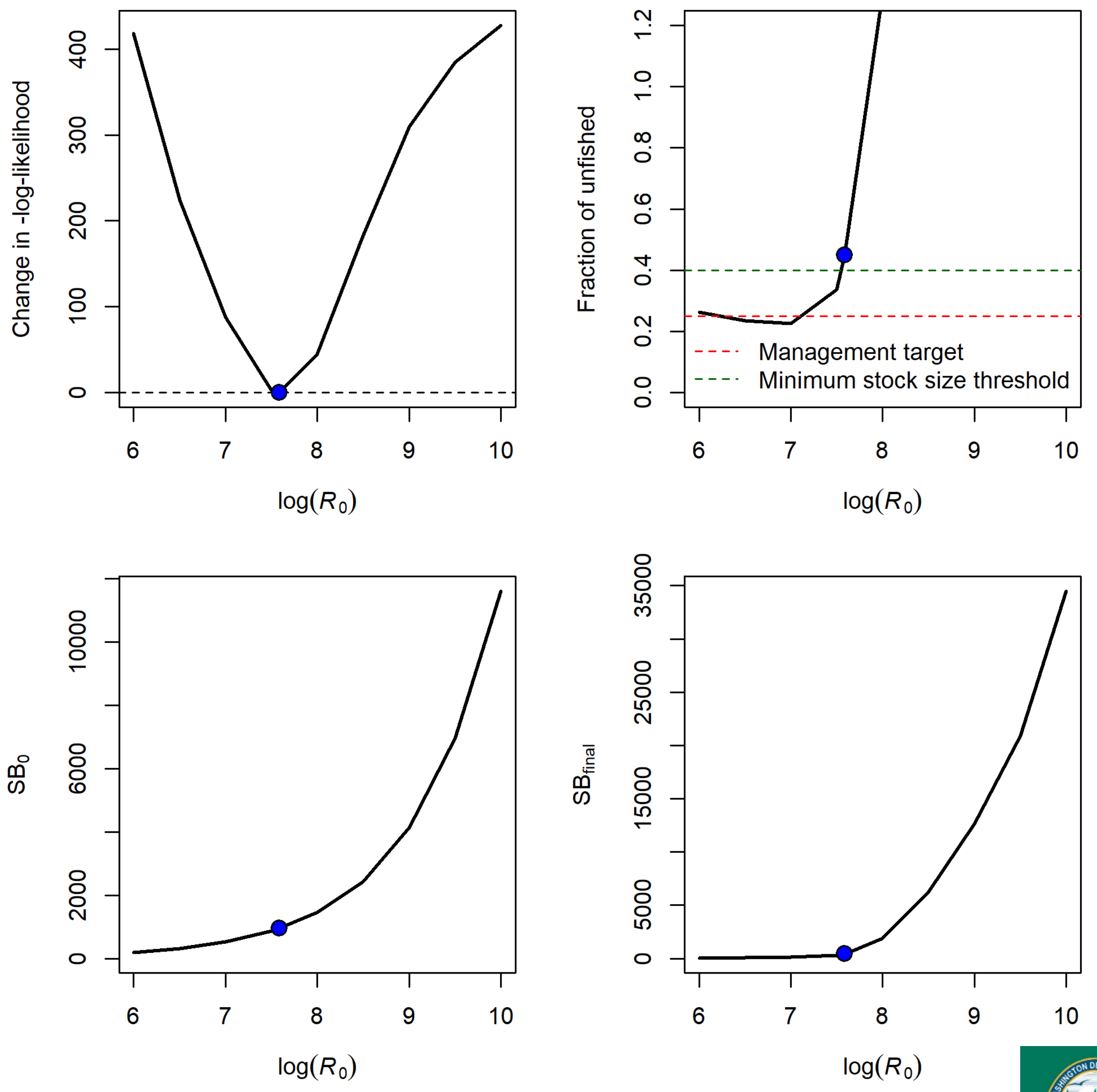
Parameter specification

- Sex-specific
- Estimated
  - L_{Amax}
  - k
  - Recruitment
  - Selectivity
- Fixed
  - Natural mortality
  - L_{Amin}
  - CVs at length
  - Maturity
  - Fecundity
  - Length-weight

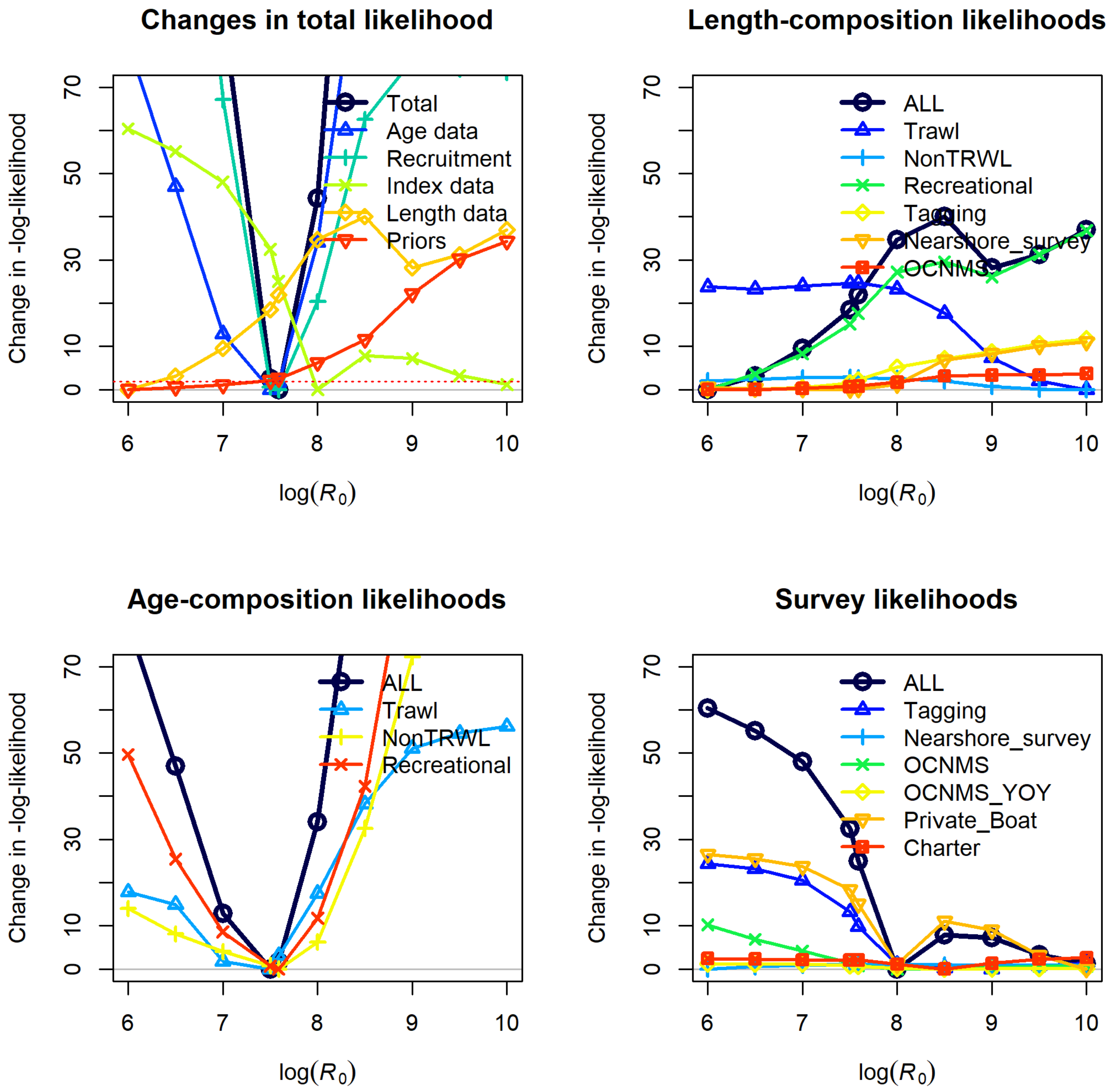
Model Evaluation

- Sensitivities
- Requests from the STAT
- Convergence tests
- Technical merits and deficiencies

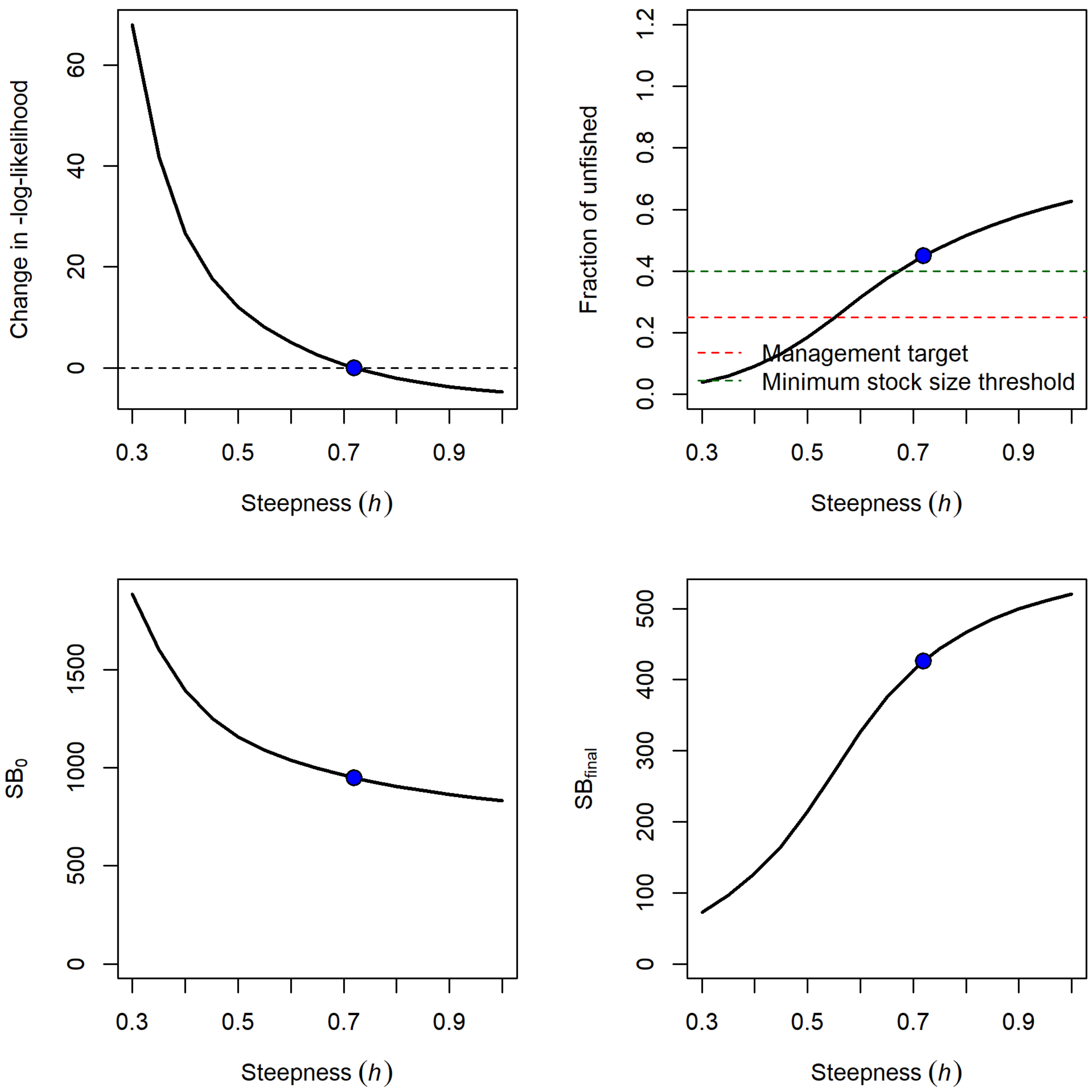
Likelihood profiles: Initial recruitment



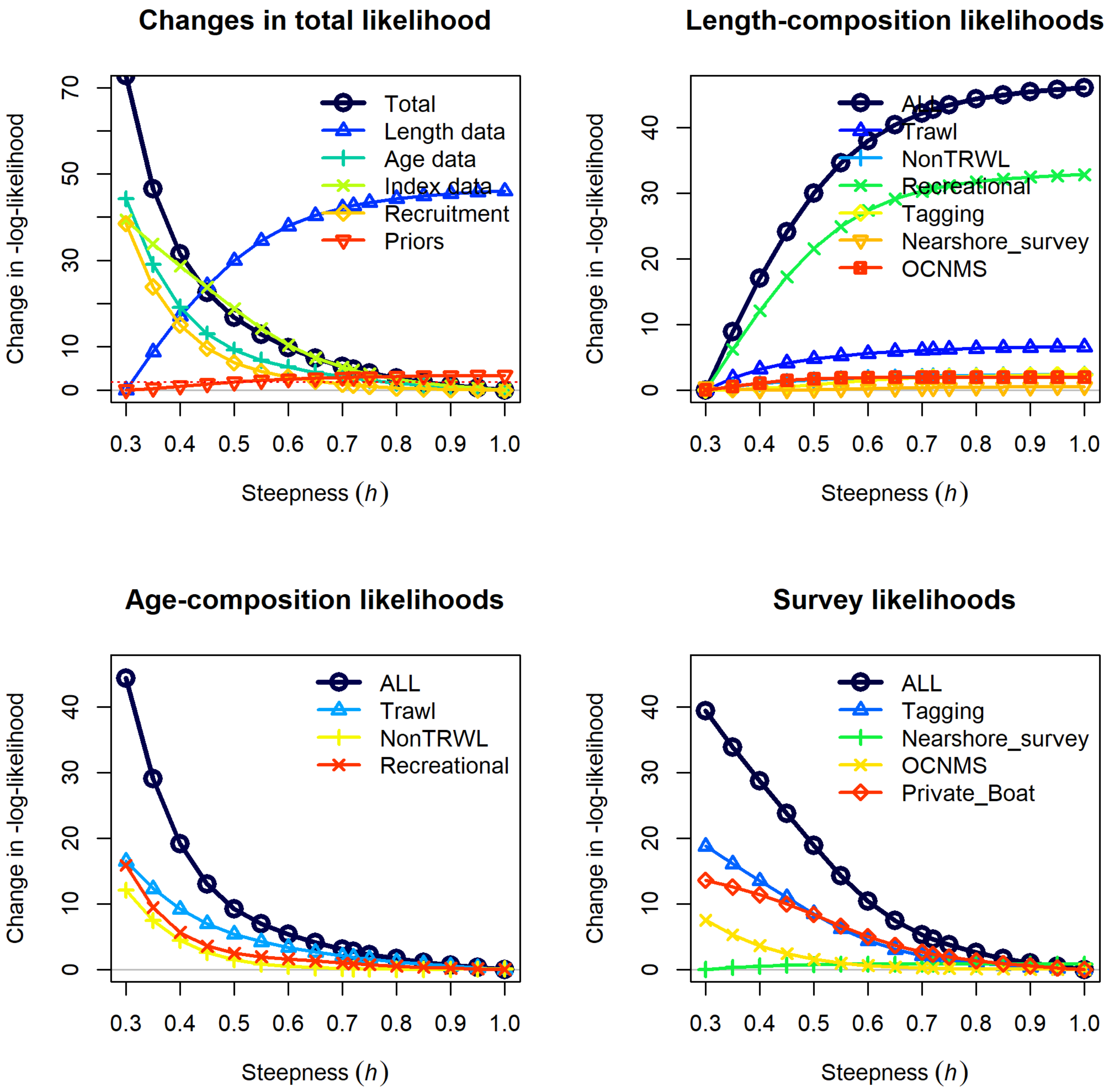
Likelihood components: Initial Recruitment



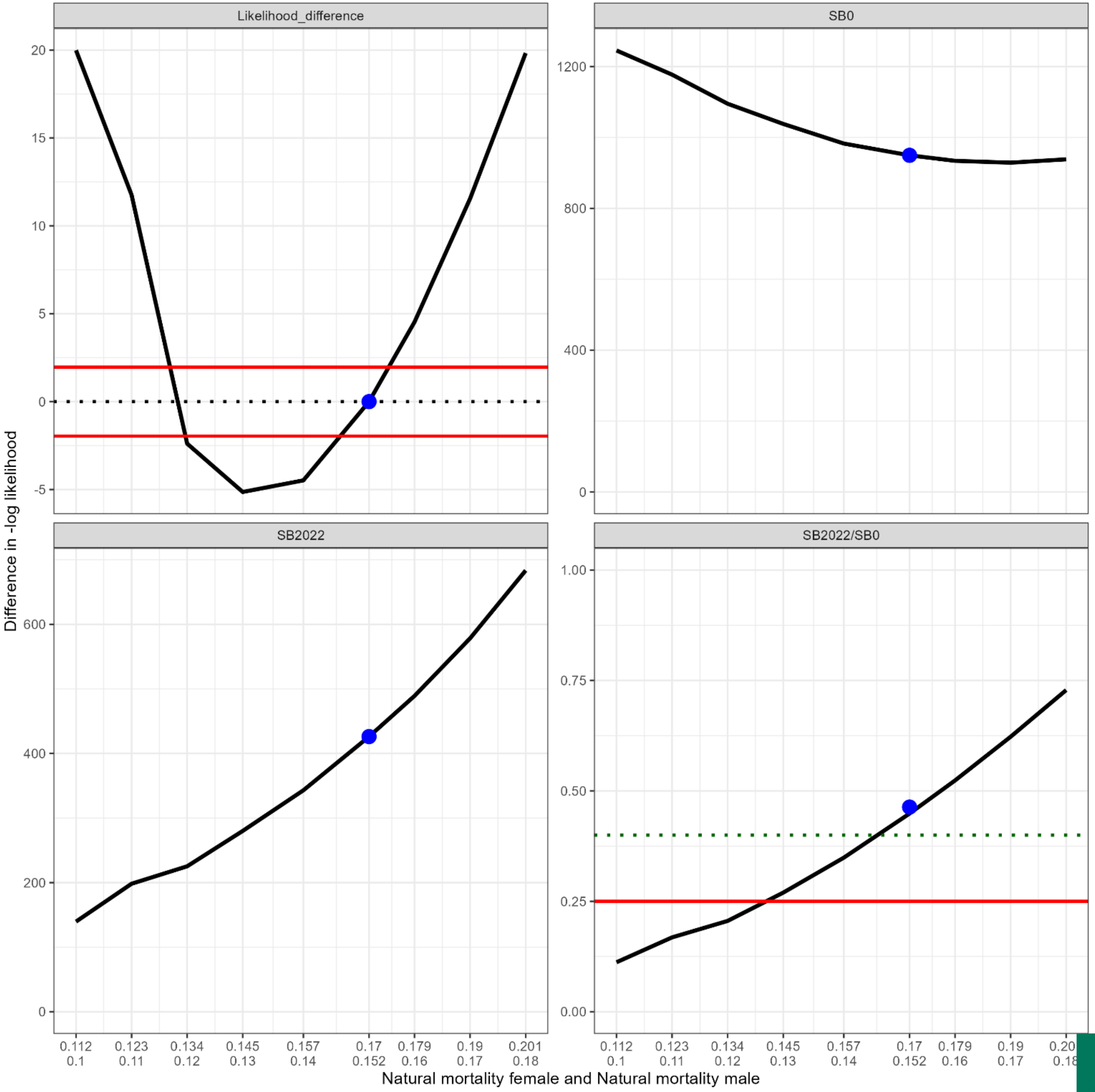
Likelihood profiles: Steepness



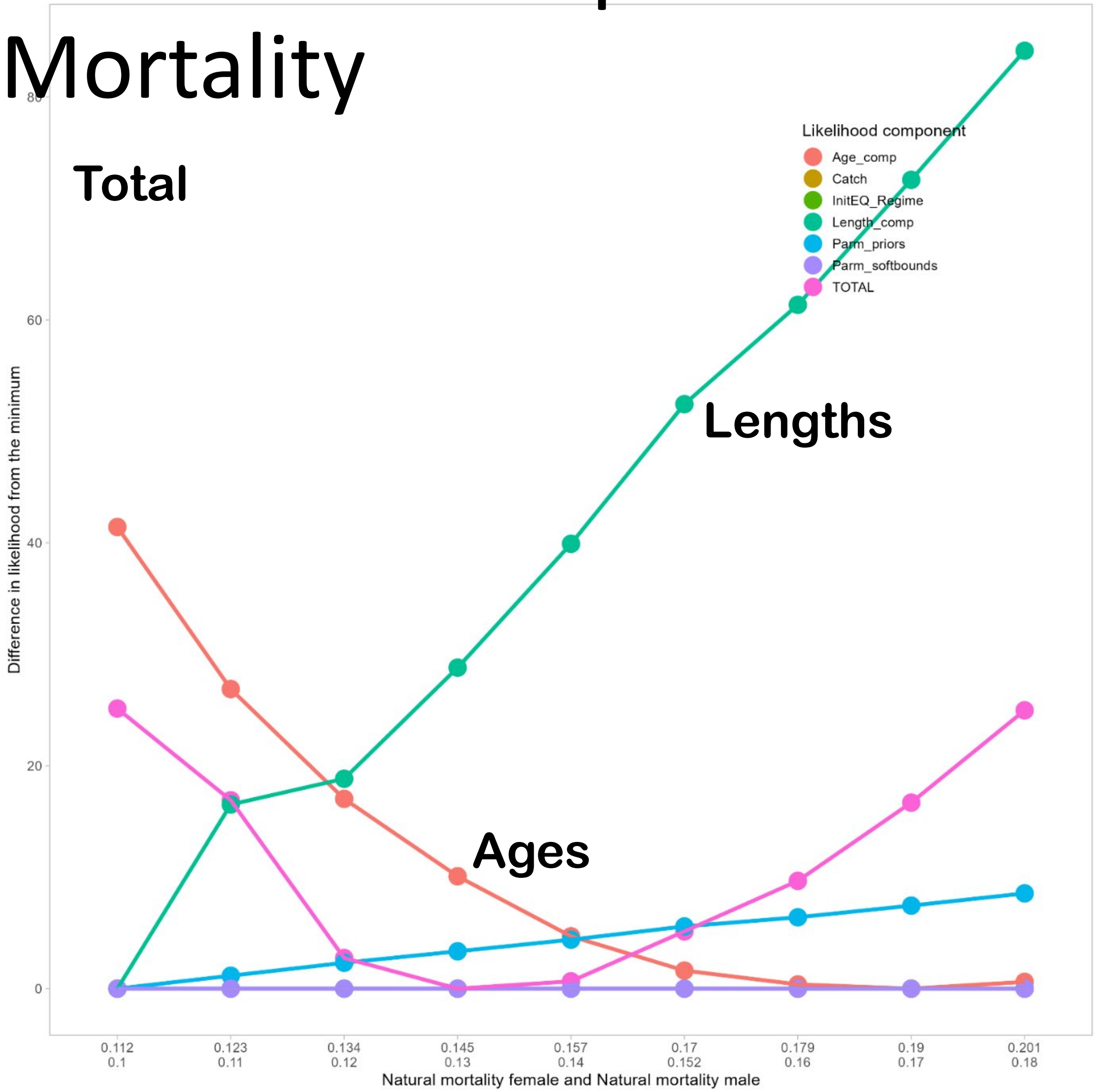
Likelihood components: Steepness

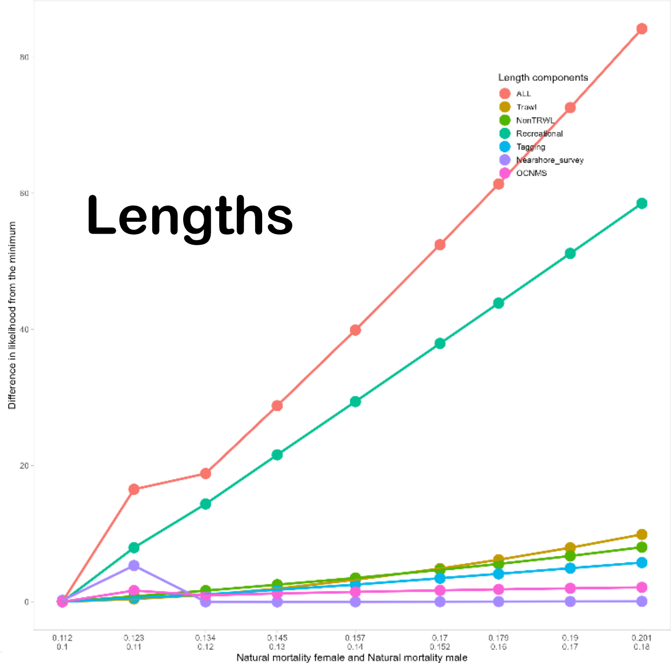


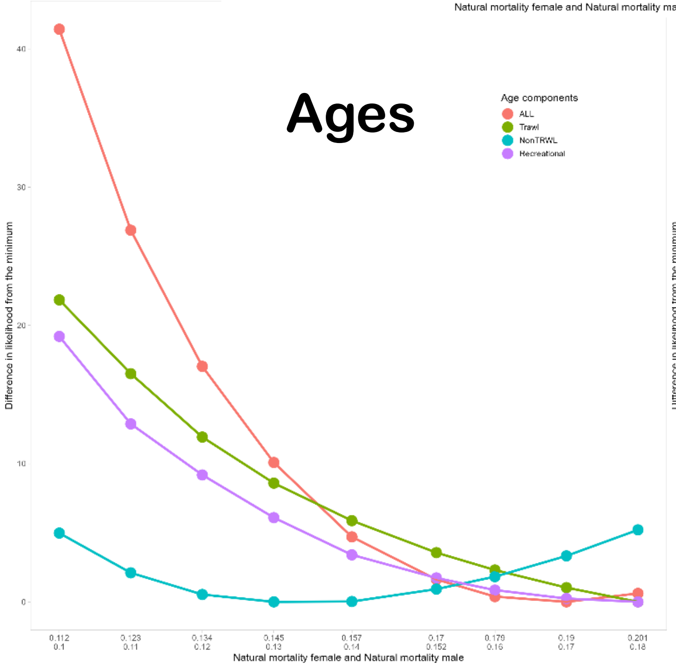
Likelihood profiles: Natural mortality

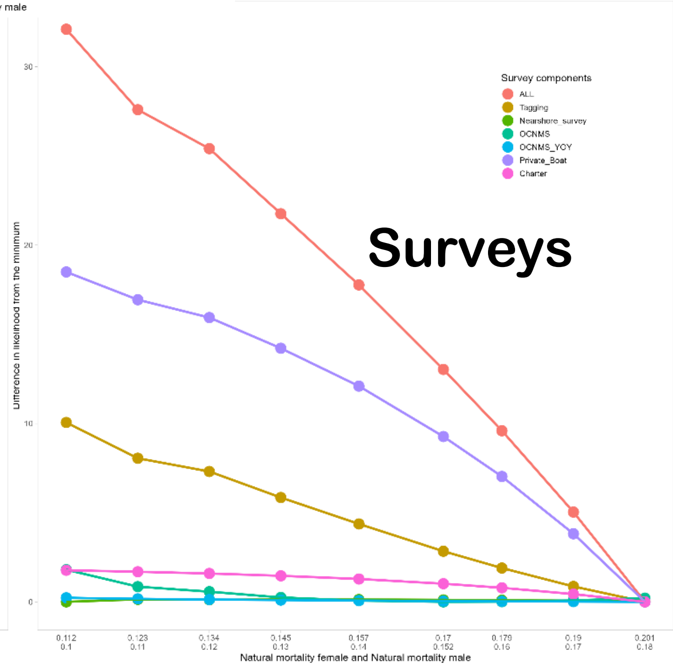


Likelihood components: Natural Mortality

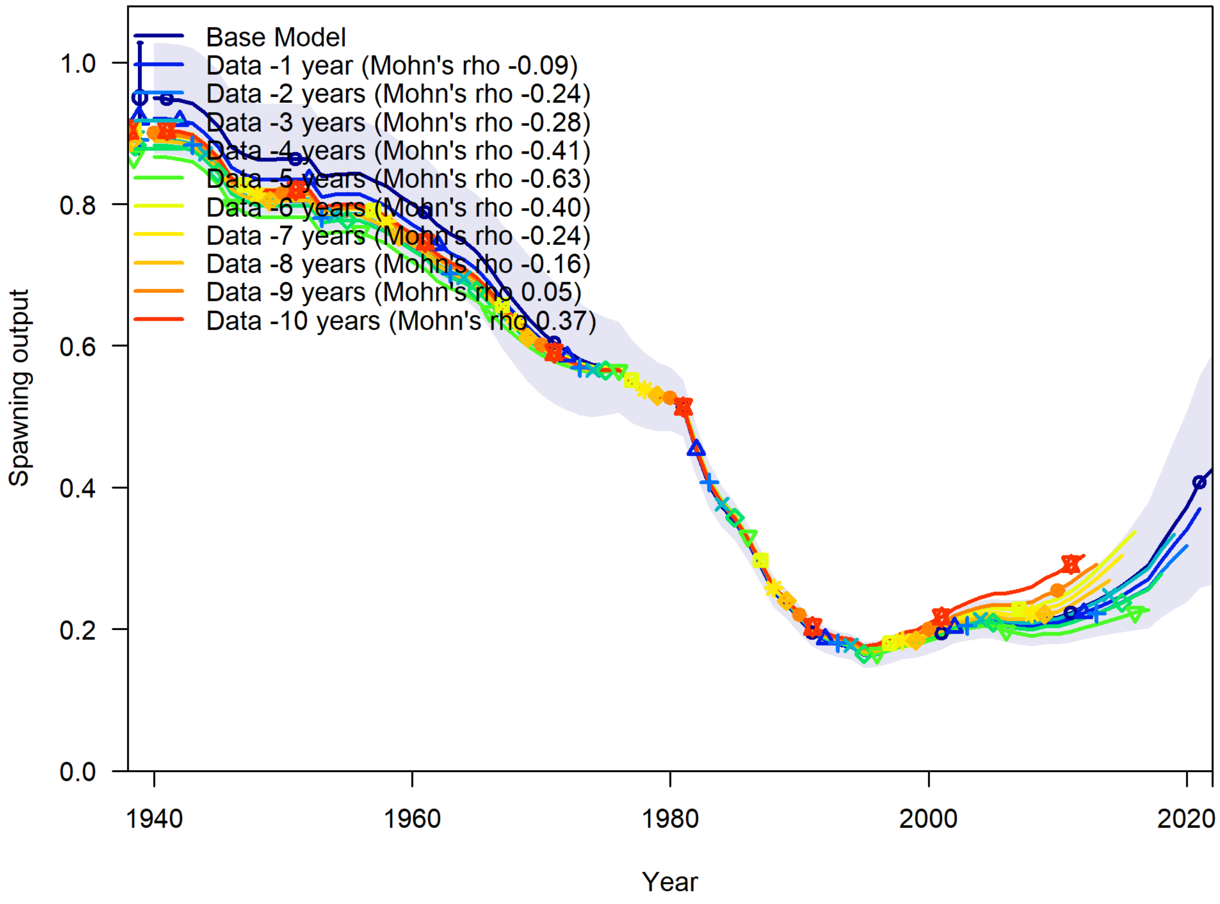


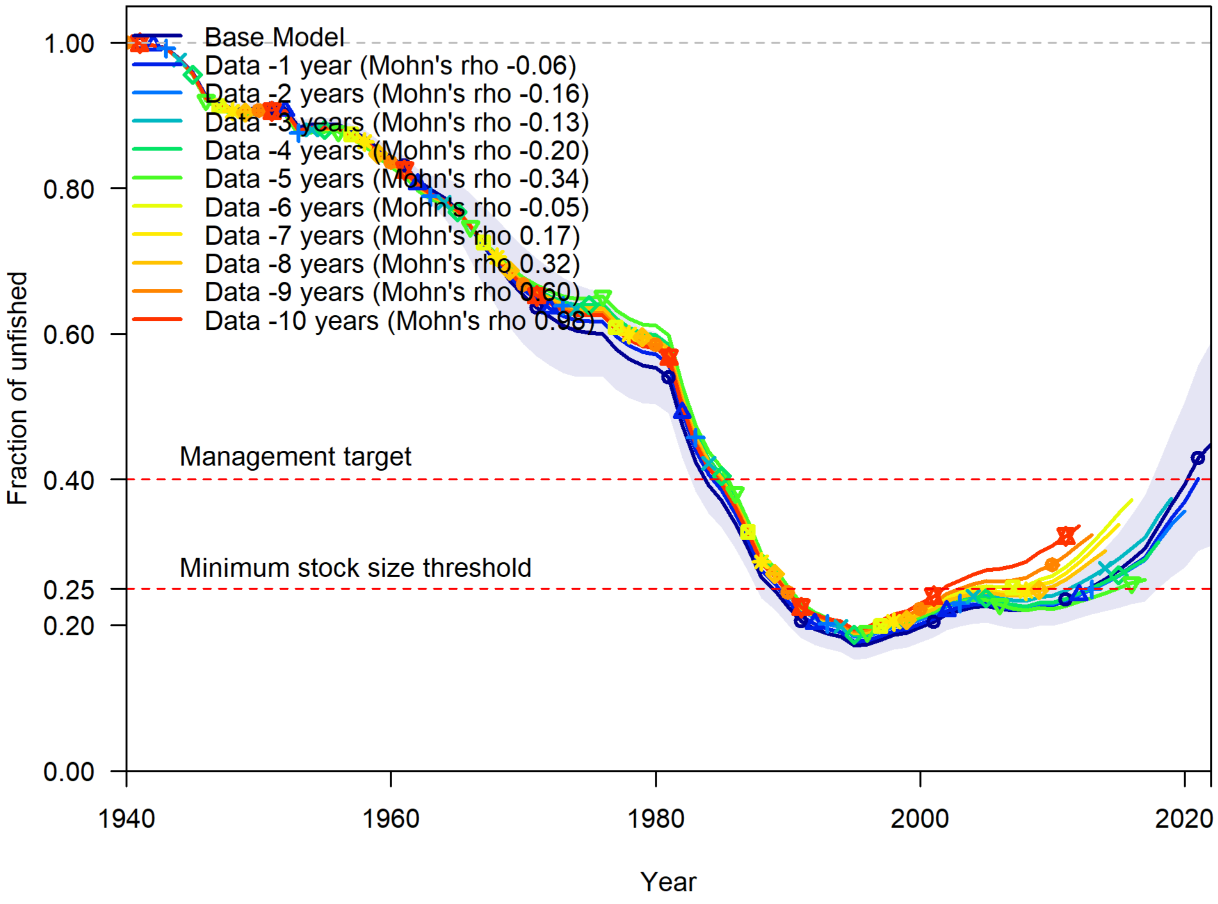






Retrospectives





Washington BRF: Model Building

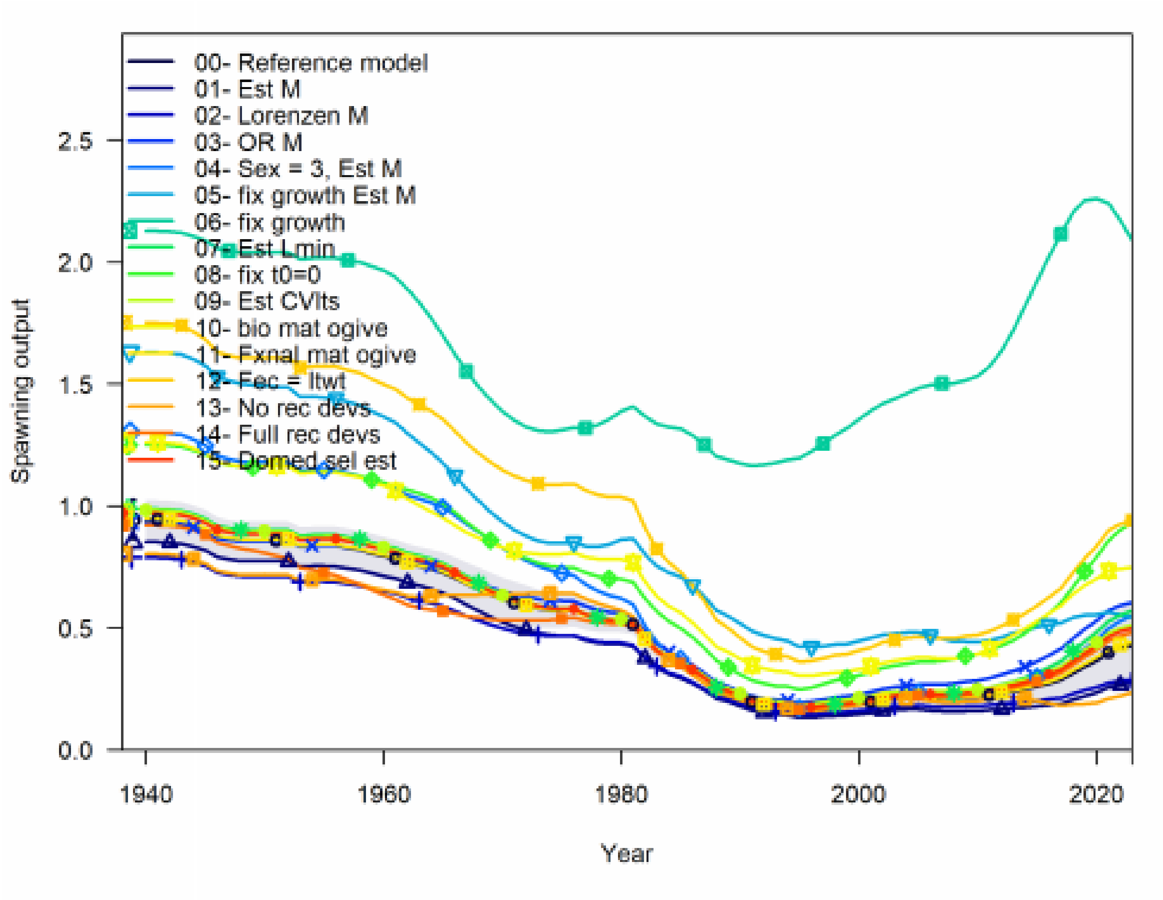


Figure 80: Spawning output (in millions of eggs) time series by model specification scenario compared to the reference model. See 'Sensitivity Analysis' section for more details on each scenario.

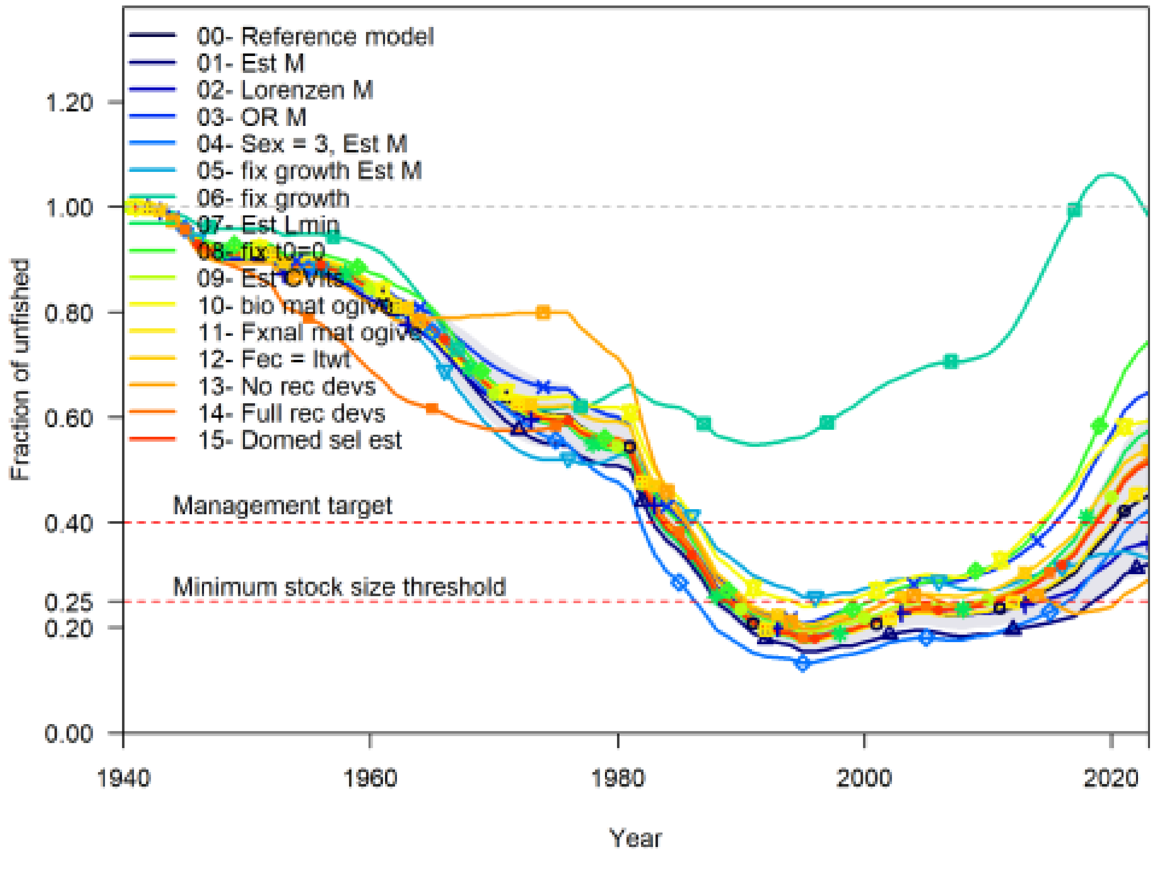


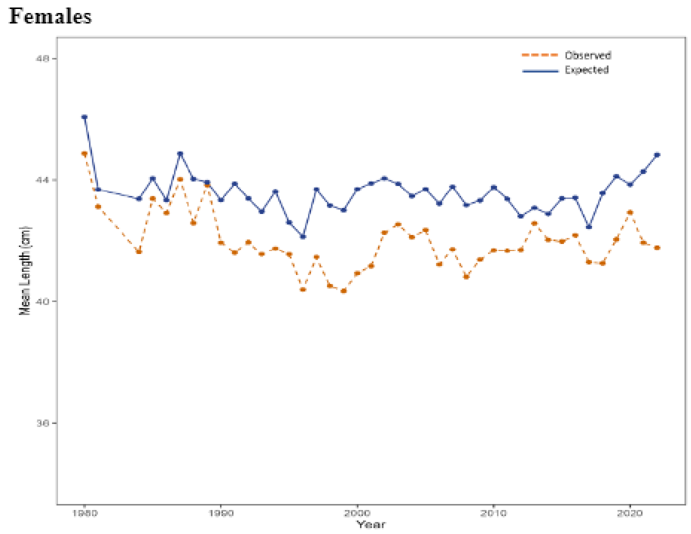
Figure 81: Relative spawning output time series by model specification scenario compared to the reference model. See 'Sensitivity Analysis' section for more details on each scenario.

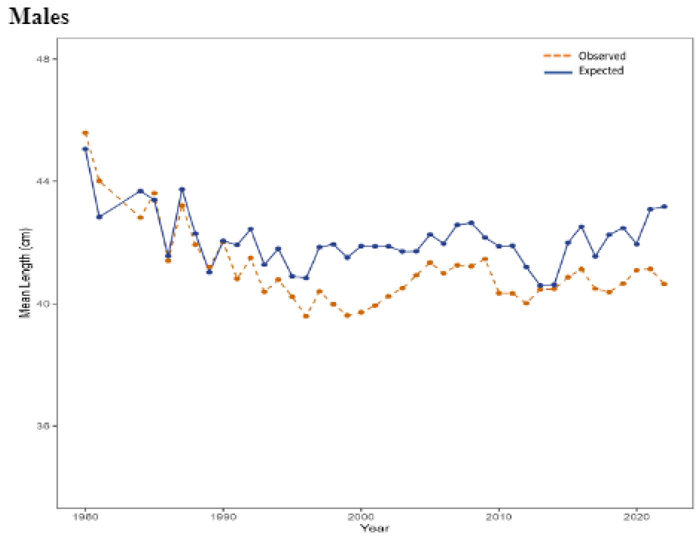
-Fixing growth gives an unrealistically optimistic perspective as does estimating L min to a lesser extent

Panel Review Requests of Importance

- Examination of functional maturity over time, showed variability. If drivers better understood could account for variability. Request 1.
- Differences in lengths and expected lengths given ages explains some tension. Request 3.
- Treating sexes as separate (Option 2) vs combined (Option 3), Request 8.
    - Former was used.
    - The later resulted in higher estimates of M for males.

- No recommended changes to the model.

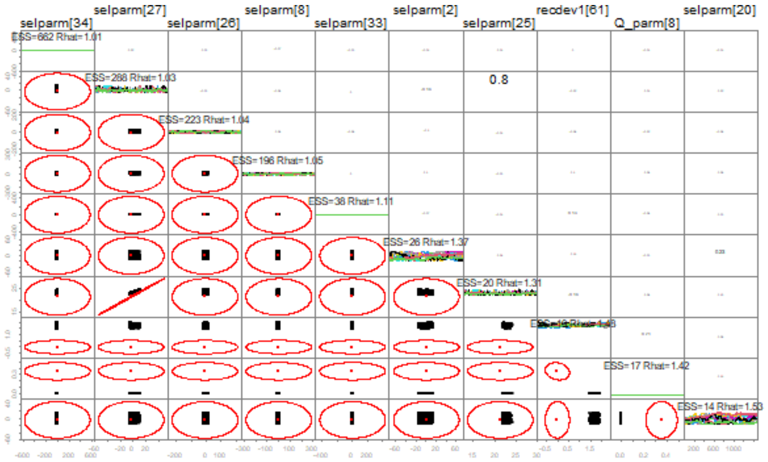


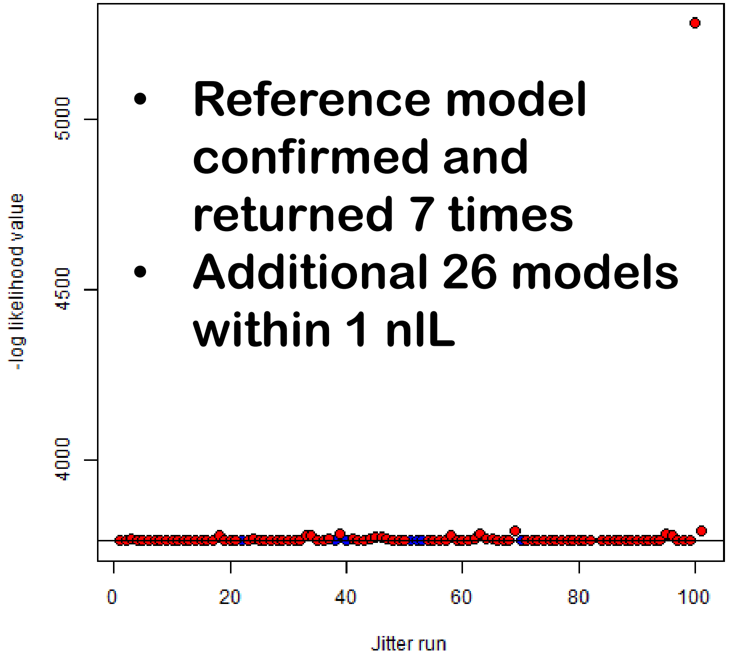


Reference Model:
Efficiency and Convergence

<u>Convergence</u>

- MCMC used to explore parameters “non-dynamic” estimated parameters
- Hessian inversion
- Low maximum gradient
- Sensible parameter values
- Jitter to establish/confirm reference model





- Reference model confirmed and returned 7 times
- Additional 26 models within 1 nlL

Technical Merits

- Black Rockfish Tagging Program conducted from 1981-2022 and nearshore survey data from 2018 to 2022 provide length data and an index of abundance.
- Rod-and-reel survey provide data from 125 fixed stations statewide.
- Substantial age and length data are available from the commercial and recreational fishery with associated sex data.
- Efforts were made to quantify the black rockfish caught in the trawl fishery off of southern Washington by vessels fishing out of Astoria, Oregon.
- Functional maturity was estimated to account for abortive maturation, skipped spawning and follicular atresia as opposed to biological maturity only considering physiological development.
- The assessment is very thorough and carefully done, with a full set of sensitivity runs and model diagnostics.

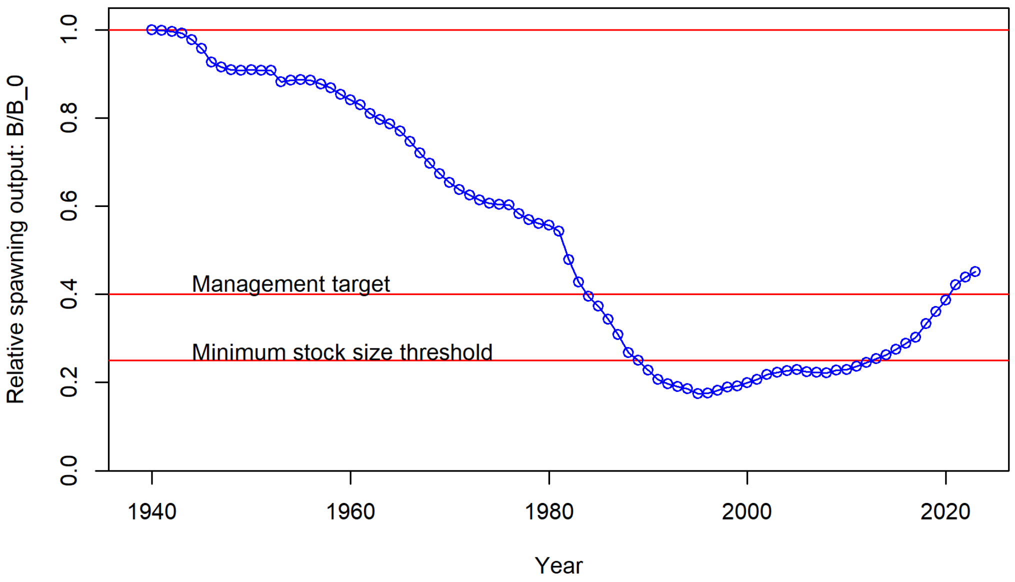
Technical Deficiencies

- Assessment lacks a long-term statewide fishery independent survey. The statewide nearshore survey will become more valuable as the time series is extended.

- Efforts were made to identify ecosystem considerations such as trophic relationships and environmental drivers of recruitment, but there was no direct effort to identify or account for them in the context of the model.

- Functional maturity only in the last decade during a period of extreme variability and further examination of the conditions affecting variation observed in sensitivity analyses may be beneficial.

Depletion and Stock Status



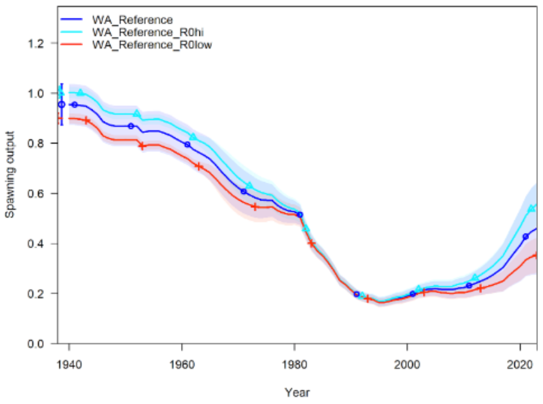
Year	Predicted OFL (mt)	ABC Catch (mt)	Age 0+ Biomass (mt)	Spawning Output	Fraction Unfished
2023	266.12	201.00	5281.08	426.15	0.45
2024	262.96	201.00	5338.69	426.55	0.45
2025	261.56	244.56	5403.93	423.32	0.45
2026	259.38	241.22	5435.74	413.96	0.44
2027	259.53	240.32	5475.13	407.44	0.43
2028	261.24	240.86	5517.01	404.28	0.43
2029	263.84	241.94	5558.01	404.11	0.43
2030	266.80	243.59	5596.37	406.19	0.43
2031	269.76	245.22	5630.98	409.68	0.43
2032	272.50	246.34	5661.74	413.89	0.44
2033	274.94	247.44	5689.26	418.32	0.44
2034	277.03	248.22	5713.83	422.59	0.45

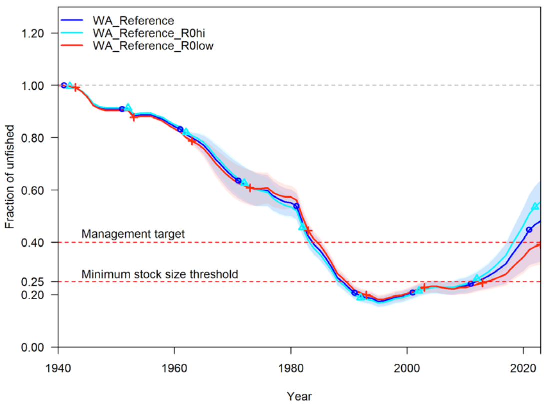
Decision Table - Uncertainties

- **Primary Axis of Uncertainty Basis:**

  A search was conducted across fixed values of *lnR0* to attain the current year spawning output values for the high and low states of nature given by the base model mean plus or minus 1.15 standard deviations (i.e., the 12.5th and 87.5th percentiles).

- **Full Attainment Assumed**





	Year	Catch	Low $\ln(R_0)$		Reference Model		High $\ln(R_0)$	
			Spawning Output	Fraction Unfished	Spawning Output	Fraction Unfished	Spawning Output	Fraction Unfished
	2023	201	352	0.39	426	0.45	557	0.56
	2024	201	348	0.39	427	0.45	562	0.56
	2025	245	343	0.38	423	0.45	562	0.56
	2026	241	333	0.37	414	0.44	552	0.55
	2027	240	326	0.36	407	0.43	543	0.54
P*=0.45	2028	241	325	0.36	404	0.43	537	0.54
sigma=0.5	2029	242	326	0.36	404	0.43	532	0.53
	2030	244	330	0.37	406	0.43	530	0.53
	2031	245	335	0.37	410	0.43	529	0.53
	2032	246	341	0.38	414	0.44	529	0.53
	2033	247	347	0.39	418	0.44	530	0.53
	2034	248	352	0.39	423	0.45	531	0.53
	2023	201	352	0.39	426	0.45	557	0.56
	2024	201	348	0.39	427	0.45	562	0.56
	2025	228	343	0.38	423	0.45	562	0.56
	2026	225	335	0.37	416	0.44	554	0.55
	2027	224	331	0.37	412	0.44	548	0.55
P*=0.4	2028	224	331	0.37	411	0.43	543	0.54
sigma=0.5	2029	225	33	0.37	412	0.44	541	0.54
	2030	226	340	0.38	416	0.44	540	0.54
	2031	227	346	0.39	421	0.45	541	0.54
	2032	228	354	0.39	427	0.45	543	0.54
	2033	228	361	0.40	433	0.46	546	0.54
	2034	226	368	0.41	439	0.48	548	0.55
	2023	201	352	0.39	426	0.45	557	0.56
	2024	201	348	0.39	427	0.45	562	0.56
	2025	279	343	0.38	423	0.45	562	0.56
	2026	279	328	0.36	409	0.43	547	0.55
Equilibrium	2027	279	317	0.35	398	0.42	533	0.53
yield from	2028	279	311	0.35	390	0.41	522	0.52
FMSY proxy	2029	279	308	0.34	386	0.41	513	0.51
of SPR=0.5	2030	279	309	0.34	384	0.41	507	0.50
	2031	279	311	0.35	384	0.41	502	0.50
	2032	279	314	0.35	386	0.41	500	0.50
	2033	279	317	0.35	388	0.41	498	0.50
	2034	279	320	0.36	390	0.41	497	0.50

Research and Data Needs

The panel supports the recommendations provided in the pre-STAR draft assessment (reproduced below).

1. Continue to develop the nearshore fishery-independent survey, as the other available surveys provide weak information for the trend in the population.

2. Improve understanding of broader ecosystem considerations within the context of Black Rockfish (and other nearshore species) management.

3. Evaluate and develop linkages between black rockfish population dynamics and environmental, oceanographic, and climate variables. In particular, develop multi-scale models (e.g., species distribution models) that can evaluate spatial patterns (e.g., multi-use areas or closures to fishing) and climate impacts (e.g., growth or distribution shifts) for vulnerable nearshore species. Utilize the growing body of ecosystem information available for the California Current Large Marine Ecosystem, as exemplified in the PFMC Integrated Ecosystem Assessment (IEA) report.

Research and Data Needs (Cont.)

4. Continue work on the investigation into the movement, behavior or mortality of older (> age 10) females to further reconcile their absence in fisheries data. In particular, conduct genetics studies on fish observed off of the continental shelf (middle of the gyre and at sea mounts) to determine their association with the nearshore stocks.

5. Continue to build evidence for appropriate natural mortality values for females and males. This will help resolve the extent to which dome-shaped age-based selectivity may be occurring for each.

6. Design and conduct research studies to better understand the trade-offs revealed in this assessment between black rockfish biology and population scale that seem to be at odds. If discrepancies cannot be uncovered, evaluate management procedures that are as robust as can be to this trade-off.

7.Conduct early life history studies that provide a better understanding of the ecology and habitats of black rockfish from settlement to age-1.

Research and Data Needs (Cont.)

The STAR panel supports the following additional recommendations for future research and data collection.

1. Simulation studies, meta-analyses across species or other research to examine circumstances in which options for treatment sex data for composition data are preferable under Option 1 or 2 treating them as separate or Option 3 treating them as combined. Such studies should aim to provide criteria for their application to inform guidance in the PFMC's Groundfish Terms of Reference and Accepted Practices documents.

2. Further evaluation of temporal and spatial variability in biological and functional maturity may facilitate accounting for uncertainty or help account for trends and identify drivers. Data informing the functional maturity ogive were collected during a period of extreme variability in ocean conditions and further examination of the drivers of variability observed may prove beneficial.

3. Compare trends in abundance and patterns of recruitment across species to examine commonalities, differences and their causes may help inform accounting for environmental determinants.

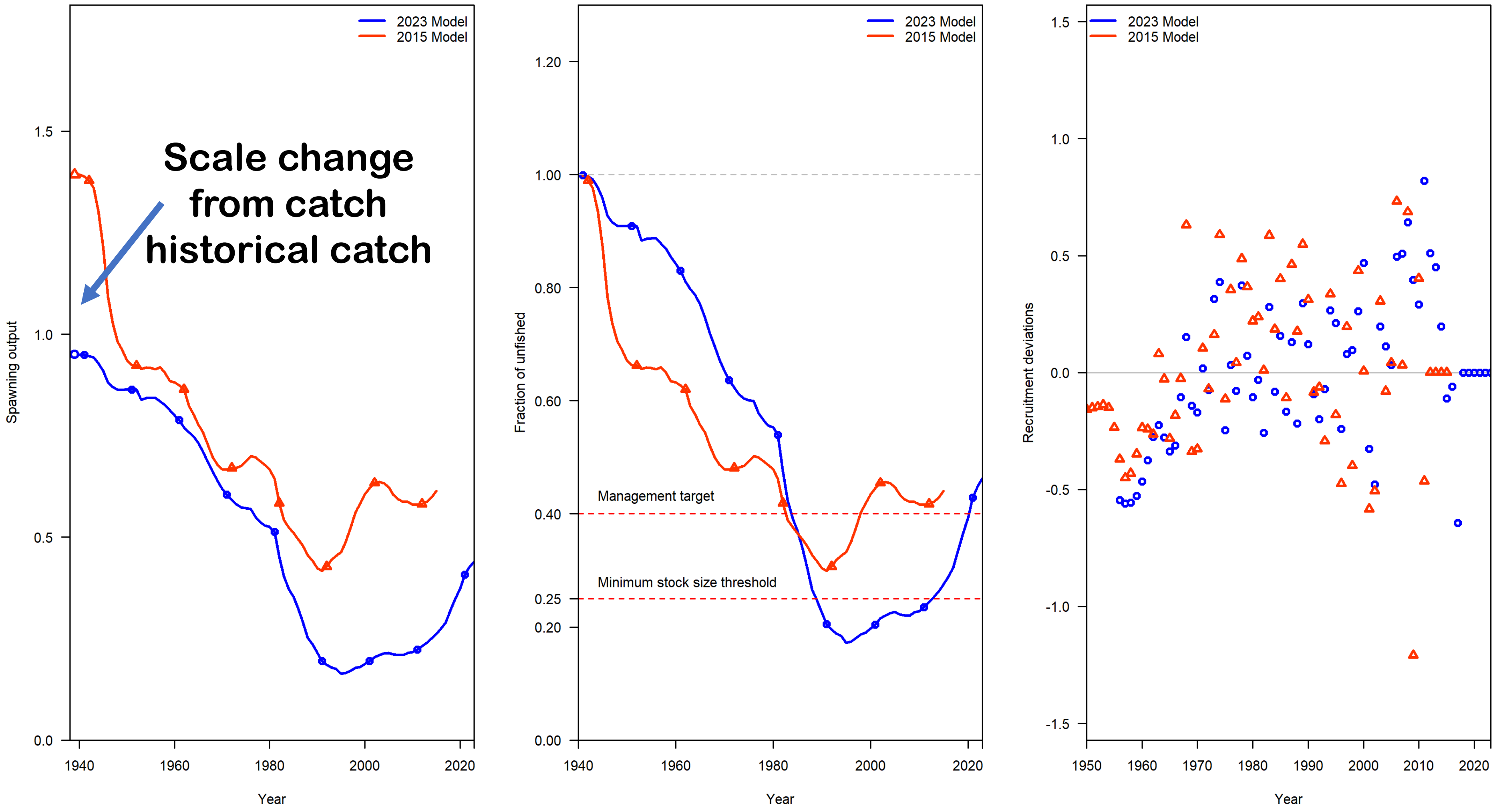
4. Account for variance in catch history to help reflect the full degree of uncertainty in the assessment.

5. Re-examine methods to generate estimates of abundance from the WDFW Tagging Program using approaches used for similar data sets from analogous studies in Oregon.

Washington: 2023 vs 2015 Models

Major changes

- Commercial catch history
- New surveys
  - Nearshore
  - OCNMS



Panel Recommendations

- Category: 1b
- Sigma: default 0.5
- Next Assessment: Update, given the lack of major uncertainties to be resolved in a full assessment and the current model includes all available data sources.

- BSIA recommendation?
- Agreement?

Oregon Black Rockfish Assessment

- Jason M. Cope (NWFSC, Lead)
- Alison D. Whitman (ODFW)
- Aaron M. Berger (NWFSC)
- Leif R. Rasmuson (ODFW)

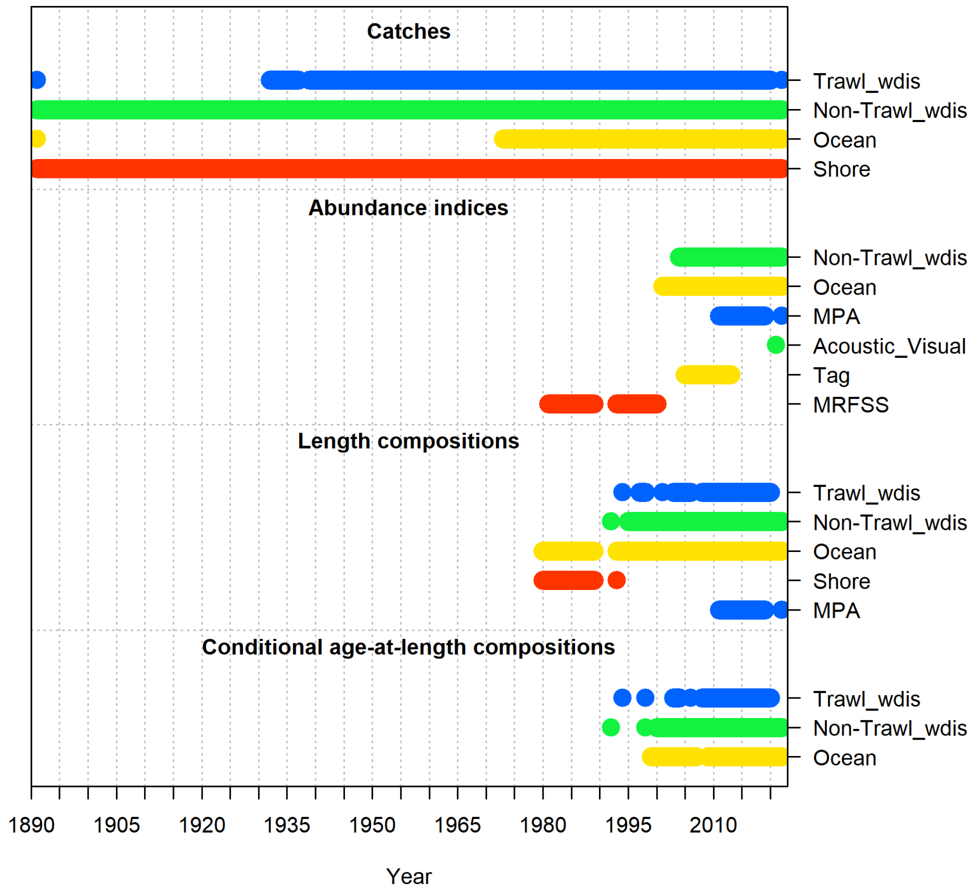
Summary of Previous Assessments

- South of Cape Falcon: Ralston and Dick (2003) developed a statistical catch-at-age model using Stock Synthesis. Sampson (2007) similar model configuration and approach.
  - Hook-and-Line, Trawl, and Recreational
  - Rec CPUE index (fish/trip) combining MRFSS, ORBS and CRFS for PC
  - 2007 used tagging study and juvenile pre-recruit index
  - Differing landings, neither accounted for discards
- North of Cape Falcon: Wallace and Tagart 1994; Wallace et al. 1999, 1999; Wallace and Tsou 2007
  - 1994: Stock synthesis, tagging CPUE and recreational bottomfish effort
  - 1999: AD Model Builder, expected catch at age, tagging data
  - 2007: Stock synthesis 2, tagging release trips and abundance estimates as relative abundance.
- 2015 Assessment: State boundaries, Stock Synthesis 3, 3 commercial/2 recreational fleets/5 surveys, Francis weighting, recruitment devs not estimated, natural mortality constant for males and step function at 10 years for females, domed recreational boat selectivity. 60.4% depletion

Major Changes from 2015 Model

- **Fix q to new AV survey**
- **Estimate recruitment**
- **Constant *M* for female**
- **Length-based selectivity only**
- **Dome-shaped selectivity for ocean boat fleet**
- **Catch history**

Summary of Data Sources



Recreational Ocean Boat/Shore Landings & Discards

- **Ocean boat**
  - **Historic (1979 – 2000) landings – ODFW recreational reconstruction (Whitman 2023)**
    - **Numbers of fish from ODFW ocean salmon sampling program**
    - **Used MRFSS biological data to estimate biomass**
    - **Similar to previous assessment**
  - **Ramp landings from 1973 – 1978 to the 1979 value**
  - **Modern (2001 – 2022) landings – RecFIN**
  - **Discards included modern era landings as estimated by RecFIN**

- **Shore/Estuary**
  - **MRFSS landings from 1980 – 1989 and 1993 – 2003**
  - **SEBS landings from 2003 – 2005**
  - **10 year average from 2006 – 2022**
  - **Assumed a low level of shore/estuary effort historically**
  - **Ramp from 1892 – 1979**
  - **Discards estimated using ocean boat discard rates from RecFIN (0.92%)**
    - **Applied during 2001 – 2022**

Oregon Fish & Wildlife Marine Resources

Historic Commercial Trawl Landings & Discards (1892 – 1986)

- 2015 assessment
  - combination of 1) recent ODFW commercial catch reconstruction (Karnowski et al. 2014) and;
  - 2) reconstructed trawl landings
  - Allocated majority of 3A trawl landings to WA
- Reconstructed trawl landings
  - Statewide rockfish landings from multiple sources (finer spatial scale)
  - Used ODFW species compositions to speciate Black Rockfish and allocate north/south of OR-WA border

- Current assessment uses same approach
  - Allocated unspeciated rockfish to WA
  - Used same species compositions in OR as in 2015
  - Landings identical to 2015 assessment
- 1892 – 1939 = ODFW commercial catch reconstruction (Karnowski et al. 2014)
- 1940 – 1986 = Reconstructed landings from 2015 assessment

OREGON Fish & Wildlife Marine Resources

Commercial Trawl Landings & Discards (1987 – 2022)

- **Landings obtained from PacFIN 1987 – 2022**
- **ODFW URCK/POP reconstruction from 1987 - 1999**

- **Trawl specific discard rate**
  - **Developed using WGCOP data**
  - **4.1% - highly variable**
  - **2002 – 2021**
  - **Applied to trawl landings to obtain total removals**

Marine Resources

Commercial Non-Trawl Landings & Discards

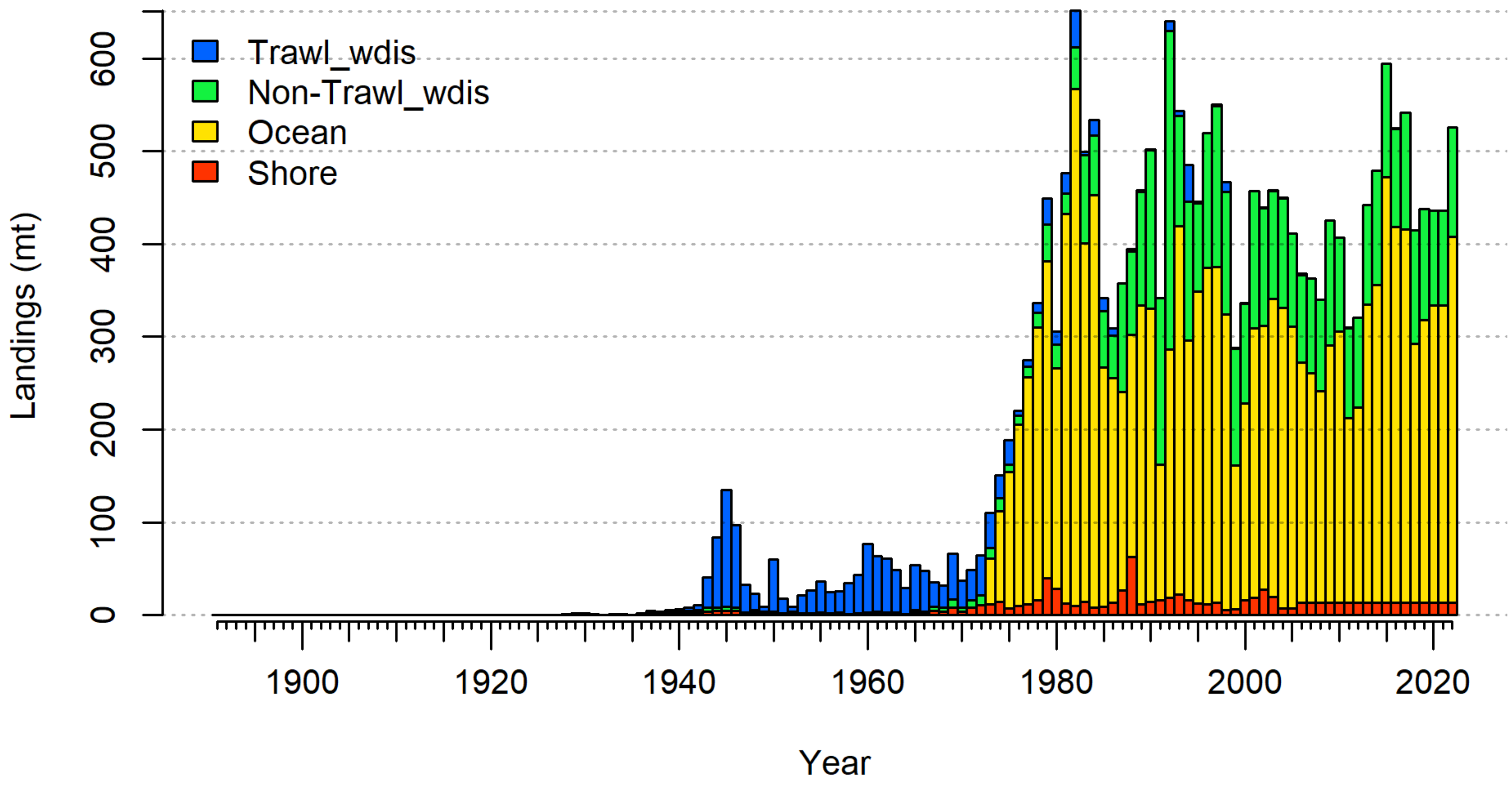
- **1892 – 1986 – ODFW commercial catch reconstruction (Karnowski et al. 2014)**
- **1987 – 2022 – PacFIN**
  - **Plus ODFW URCK/POP reconstruction (1987 – 1999)**

- **Non-trawl specific discard rate**
  - **WCGOP data**
  - **2002 – 2021**
  - **0.9% average rate**
  - **Applied to non-trawl landings to get total removals**

OREGON Fish & Wildlife Marine Resources

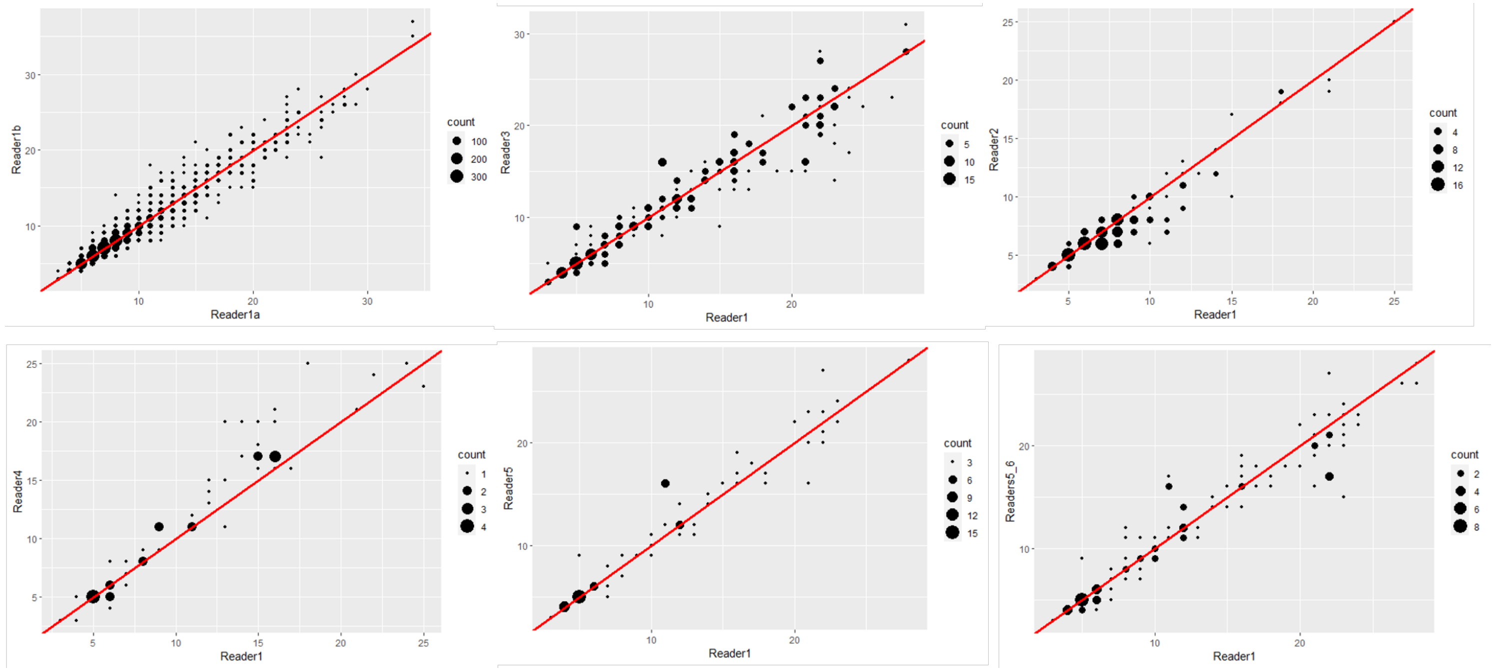
Removals

- Commercial Trawl
- Commercial Non-Trawl
- Recreational Ocean Boat
- Recreational Shore



Age Composition

- Ages = subset of length samples
  - PacFIN and RecFIN
- Majority from the recreational fishery
- Aged by ODFW staff
  - ~41k age samples from 1999 - 2022
  - Multiple readers over the years (addressed using multiple aging error matrices)



OREGON Fish & Wildlife
Marine Resources

Age Composition Sample Sizes

Table 5: Sampled commercial ages by year, fleet and sex. These are equivalent to input sample sizes.

Year	Trawl Female	Trawl Male	Total	Non-trawl Female	Non-trawl Male	Non-trawl Unsexed	Total
1985	283	321	604				
1992				52	91		143
1994	19	22	41				
1995							
1996							
1997							
1998	16	20	36	44	114		158
1999							
2000				134	153		287
2001				99	106		205
2002				172	144		316
2003	18	25	43	218	225		443
2004	38	30	68	206	179		385
2005				132	178		310
2006	83	88	171	286	281	34	601
2007				311	324		635
2008	22	32	54	281	284		565
2009	9	4	13	401	394	31	826
2010	14	14	28	402	369	65	836
2011	31	71	102	440	338		778
2012	15	26	41	376	367	4	747
2013	3	2	5	223	203	5	431
2014	53	14	67	558	299	11	868
2015	14	10	24	492	429	6	927
2016	29	21	50	473	426	1	900
2017	18	6	24	524	456	2	982
2018	2	4	6	570	441	10	1021
2019	3	1	4	406	463	8	877
2020	5	4	9	489	450	13	952
2021				467	440	1	908
2022				479	422		901

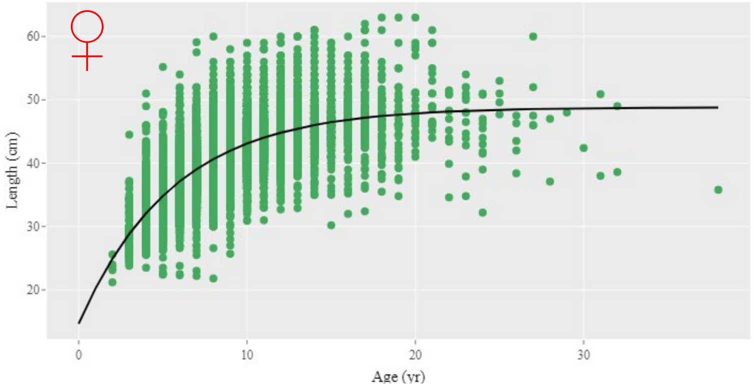
Table 6: Age samples by year and sex for the Ocean Boat fleet (equivalent to input sample sizes). There are no ages for the recreational Shore fleet

Year	Female	Male	Unknown	Total
1999	1804	1806	160	3770
2000	2318	2515	24	4857
2001	1656	1445	57	3158
2002	1966	1791	5	3762
2003	1747	1714	6	3467
2004	1688	1649	0	3337
2005	1538	1587	9	3134
2006	1049	1122	15	2186
2007	1020	1032	9	2061
2009	565	527	0	1092
2010	585	576	17	1178
2011	540	566	22	1128
2012	523	543	25	1091
2013	516	522	10	1048
2014	553	530	10	1093
2015	530	548	11	1089
2016	537	561	3	1101
2017	442	549	2	993
2018	584	619	0	1203
2019	578	576	5	1159
2020	550	560	8	1118
2021	533	562	7	1102
2022	557	592	4	1153

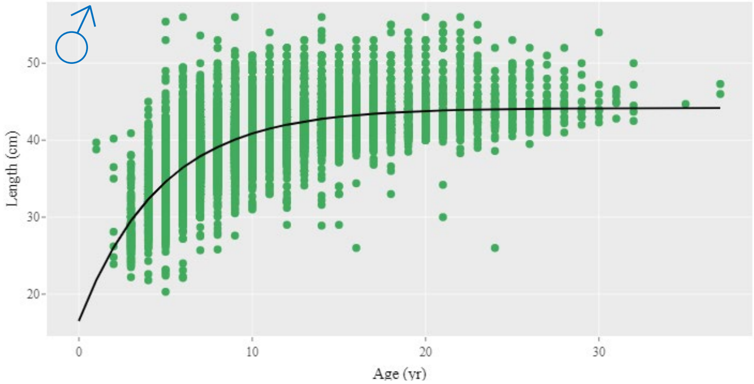
Black Rockfish age and growth

Sex-specific growth

Oregon

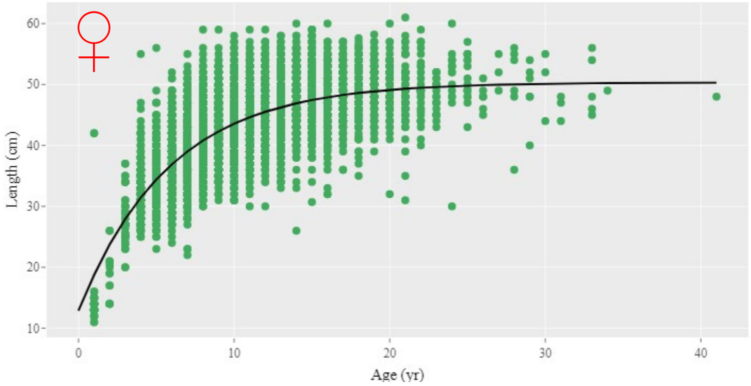


L_∞ = 48.82
k = 0.18
t_0 = -2.00

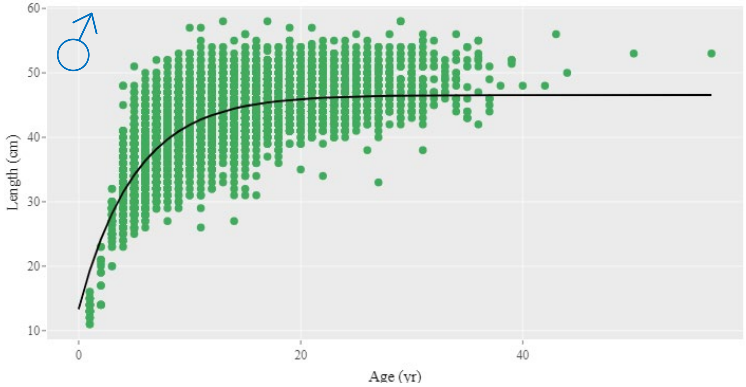


L_∞ = 44.88
k = 0.21
t_0 = -2.21

Washington



L_∞ = 51.19
k = 0.15
t_0 = -2.50



L_∞ = 47.26
k = 0.17
t_0 = -2.99

Big Old Fat Fecund Females (BOFFFs)
What is an "old" female?

CV at length

- 0.7-0.12
- 0.7-0.10

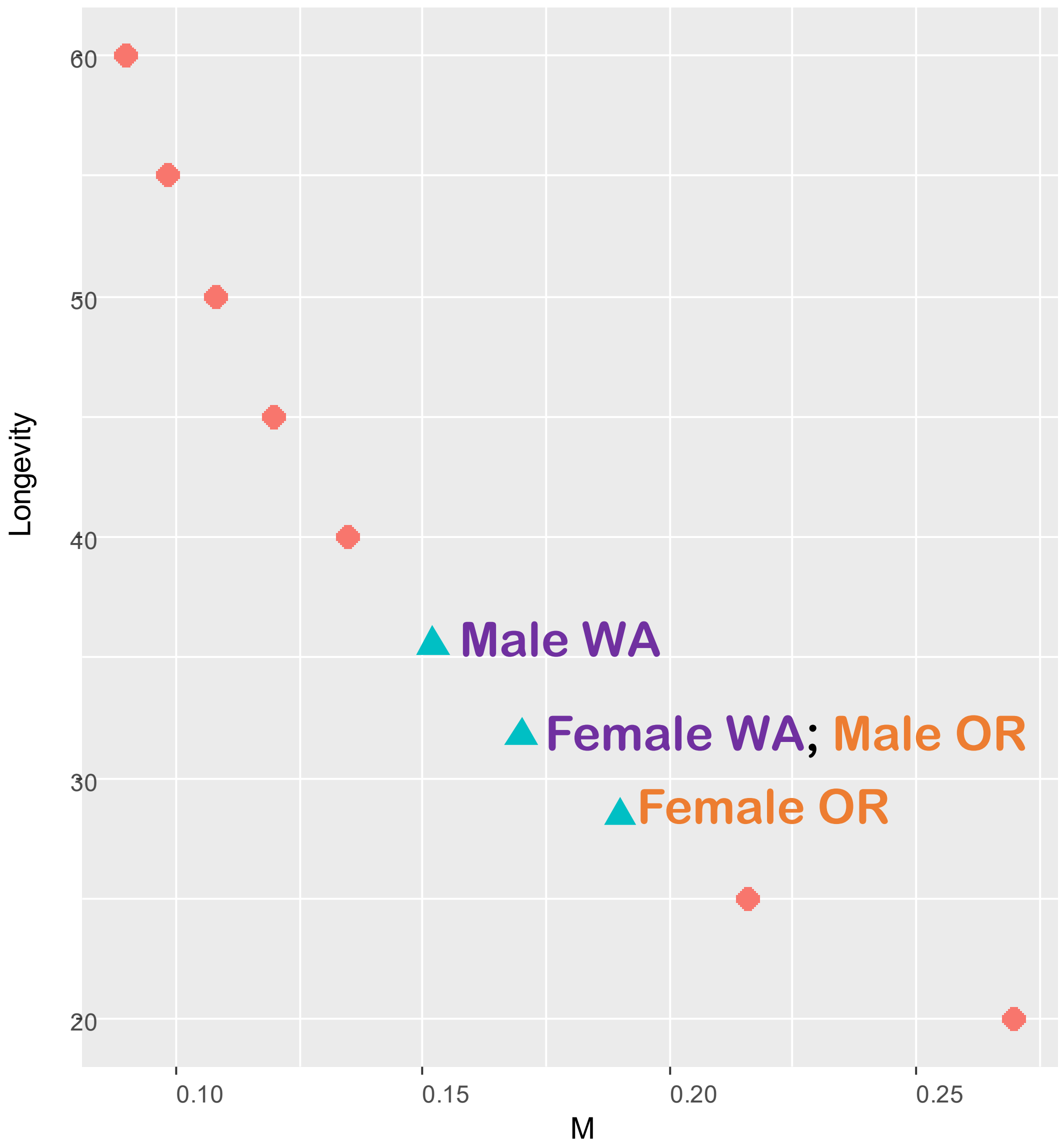
Black Rockfish natural mortality

Longevity not well known

Mortality estimates vary by parameters

Females quickly disappear after

- 20 (Oregon)
- 25 (Washington)



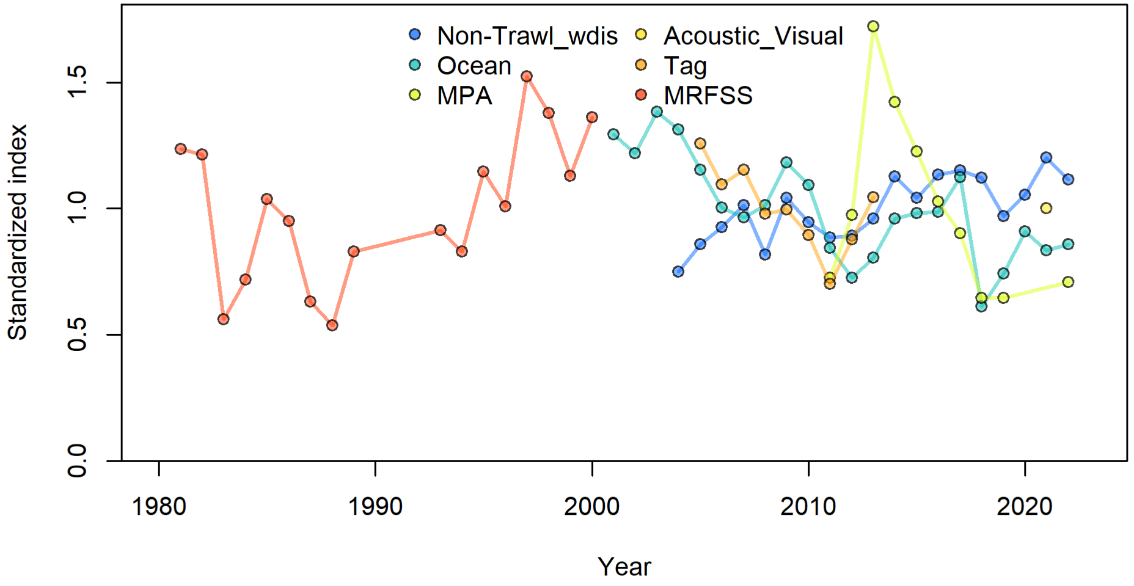
Indices of Abundance

Fishery Dependent

- Nearshore Logbook: Commercial hook and line gear, 2004-2022, fish/hook, filters (missing values, three years logbooks), sdmTMB.
- MRFSS Charter: Previous assessment, 1980-1989, 1993-2000, deltaGLM.
- ORBS: 2001-2022, fish/hour adjusted for travel time, filters (bottomfish trips, closures, bag limit), sdmTMB.

Fishery Independent

- Marine Reserves Hook and Line Survey: 2013-2022 (minus 2020/2021), fish/cell-day, sdmTMB.

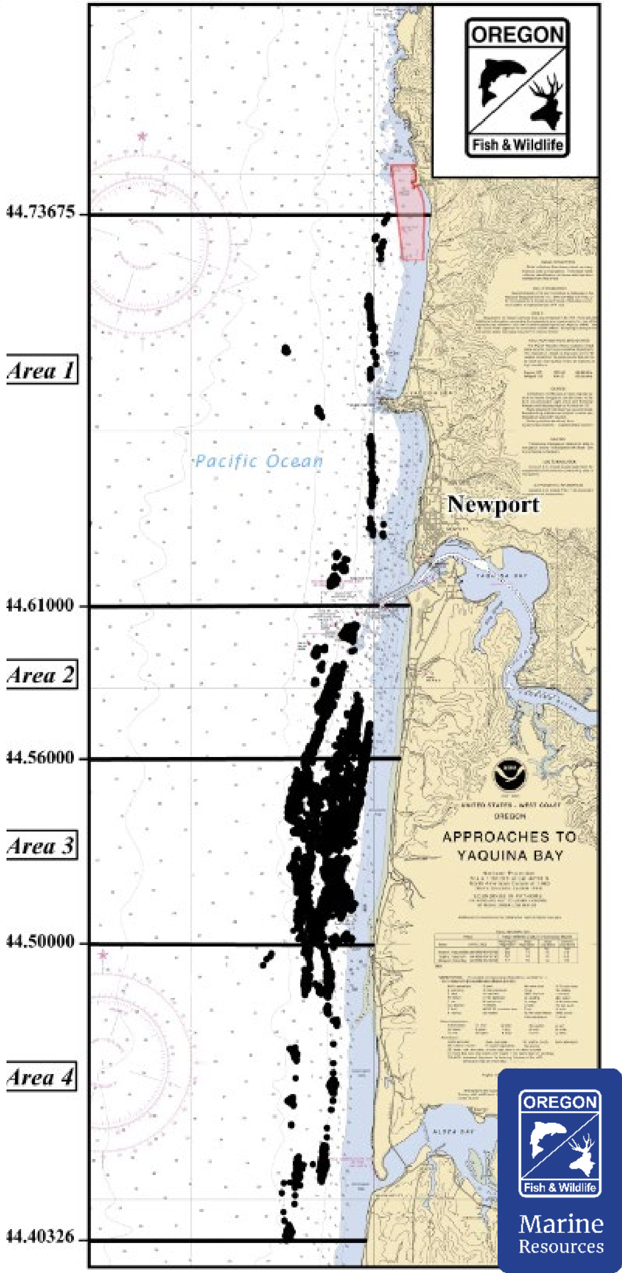


PIT Tagging Project: Areas and Number Tags Deployed

Table 38. Summary of ODFW tagging study off Newport, Oregon.

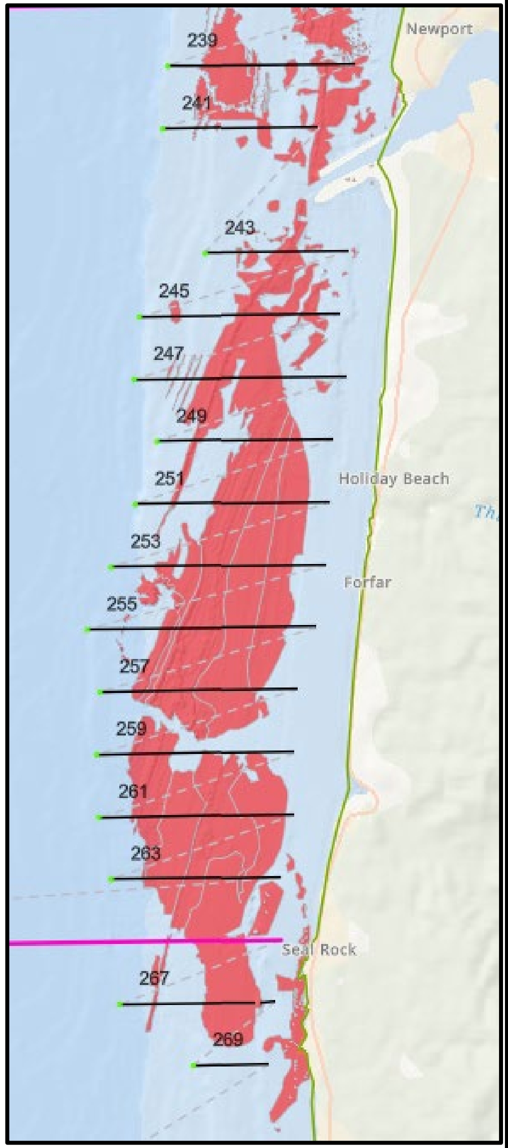
Tag year (i)	i	Number tagged	j =	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
				Recapture year (j)											
			j =	1	2	3	4	5	6	7	8	9	10	11	12
2002	1	2304		44	50	43	25	17	19	12	8	14	7	5	9
2003	2	2459			41	55	48	53	35	21	19	12	8	8	7
2004	3	2523				60	74	54	61	32	21	18	10	11	5
2005	4	2621					56	60	53	42	36	20	10	12	10
2006	5	2572						90	76	54	59	31	26	15	9
2007	6	2935							58	52	58	59	18	24	13
2008	7	3902								96	95	79	38	41	26
2009	8	3891									114	104	55	53	28
2010	9	3967										76	73	72	49
2011	10	4033											78	99	73
2012	11	2920												62	61
2013	12	2663													44
Estimated no. fish landed =				60977	74620	60951	63948	64101	62113	55829	59147	51903	39843	51921	85978
No. fish scanned (cs_j)=				50029	51940	44499	54892	54315	51373	43683	46778	39861	30444	40032	47050
Sampling rate =				82.0%	69.6%	73.0%	85.8%	84.7%	82.7%	78.2%	79.1%	76.8%	76.4%	77.1%	54.7%
<u>Brownie model results</u>:															
Estimated recovery rate, f_j =				0.01910	0.02510	0.02889	0.02904	0.03304	0.02965	0.02966	0.03125	0.02964	0.02892	0.03033	0.02995
Estimated survival rate, S_j =					0.6506	0.7457	0.8812	0.7185	0.9427	0.6933	0.8179	0.7789	0.5812	0.8729	0.6670
<u>Derived abundance</u>:															
Est. abundance (1000s), N_j =				2619.7	2069.59	1540.43	1889.9	1644.15	1732.61	1472.65	1496.70	1344.71	1052.76	1319.81	1570.71
Est. coeff. variation [N_j] =				5.92%	5.69%	4.17%	4.03%	3.62%	3.88%	3.76%	3.41%	3.53%	3.48%	3.34%	3.48%

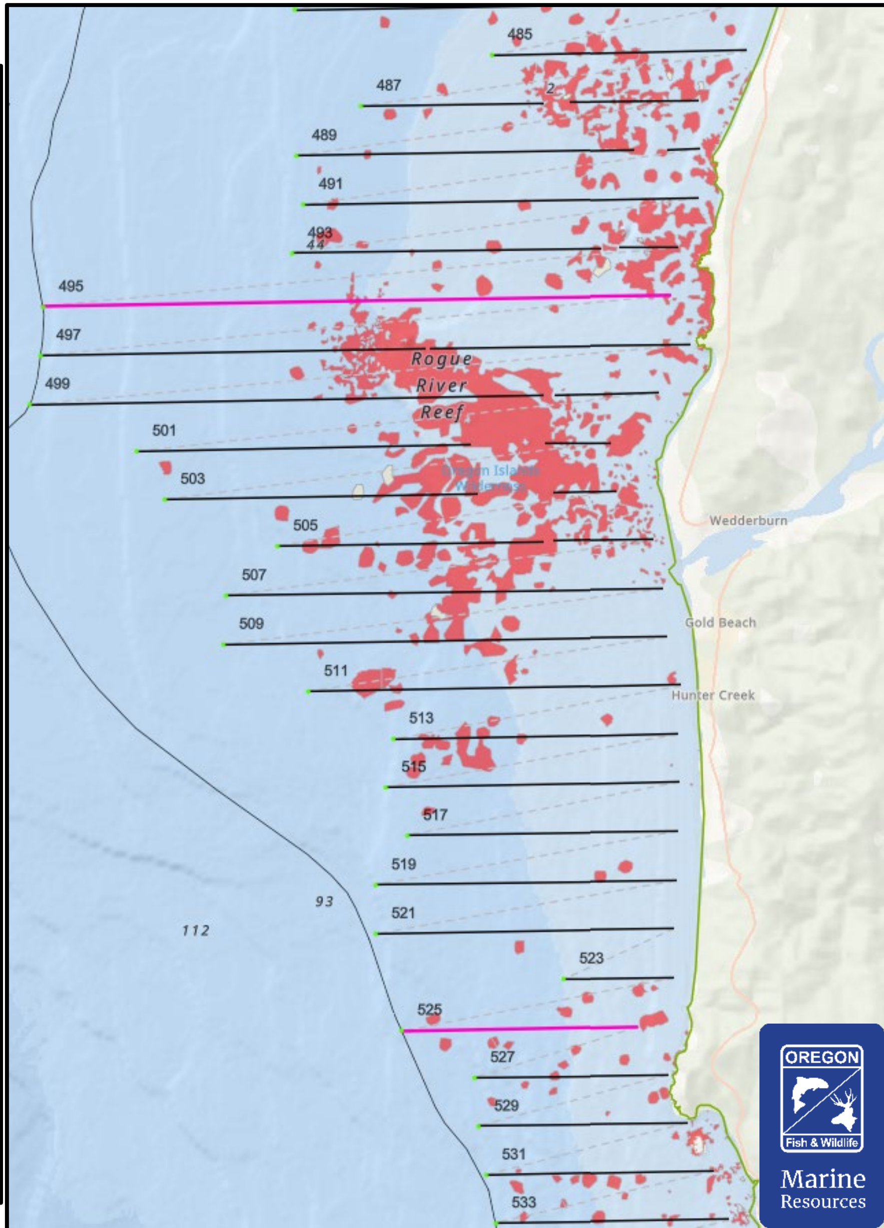
2002 - 2012 Black Rockfish PIT Tagging Locations



Acoustic Visual Survey: Survey Design

- Best available habitat data
- Transects every 15 km regardless and every 1 if rocky
- Conducted summer 2021, reviewed by SSC and CIE fall 2022





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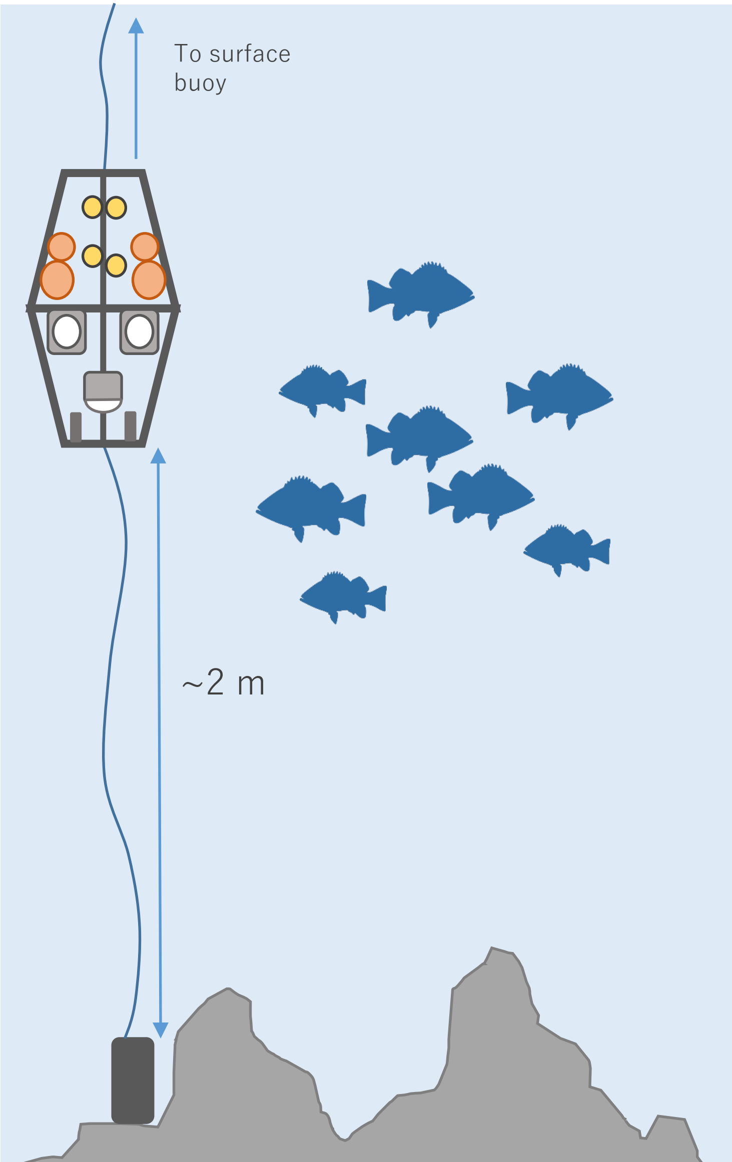
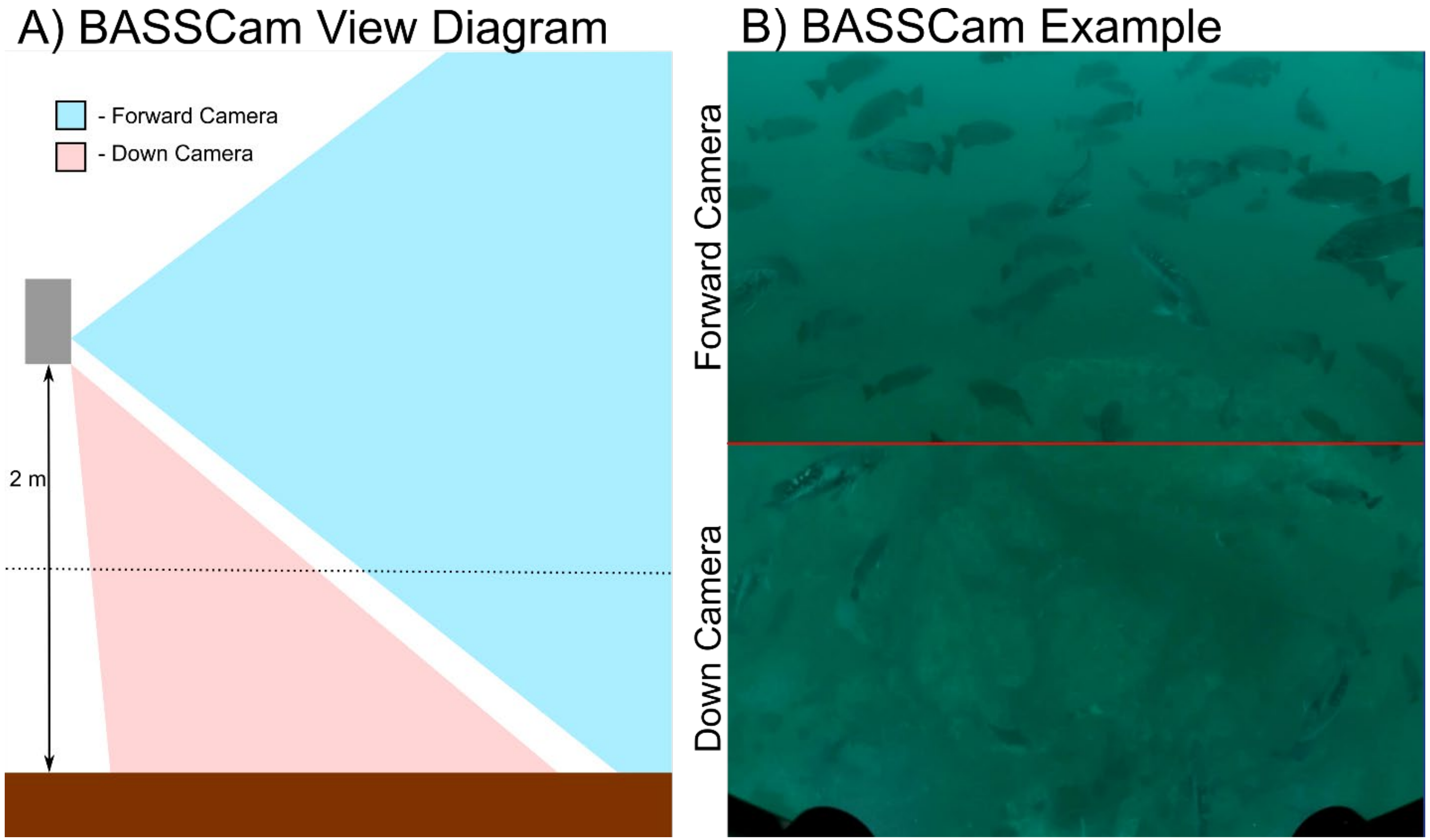
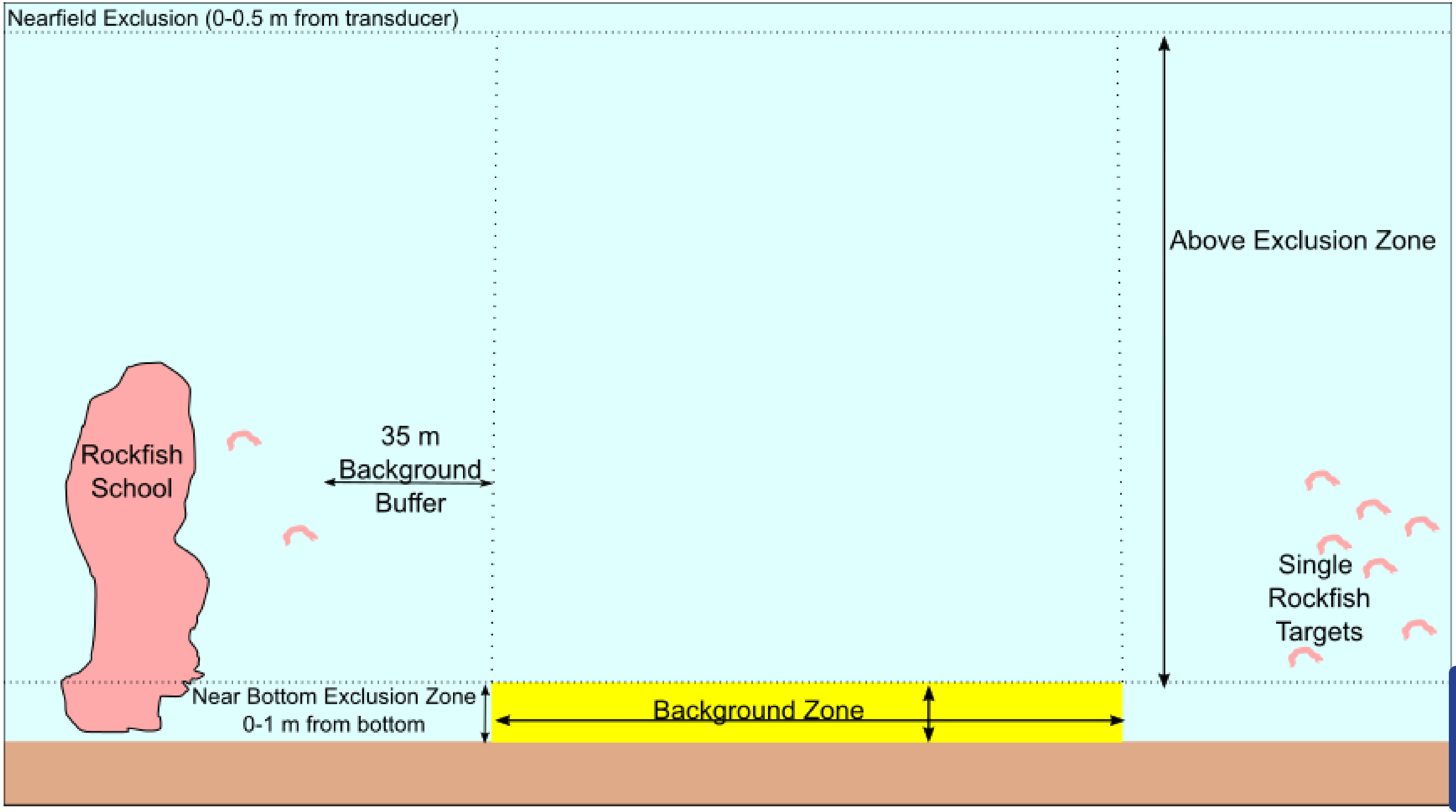
Acoustic Visual Survey: BASSCam





Acoustic Visual Survey: Different Zones for Acoustic Analysis



Acoustic Visual Survey Estimates

Region	Biomass	Standard Deviation	CV
North	3,307.97	1,838.75	55.59
Central	101.94	126.74	124.32
South	9,635.67	5,647.01	58.61
Statewide-Combined Regions	13,045.59	5,939.92	45.53

Region with PIT tagging

Oregon Fish & Wildlife Marine Resources

Model Description

Structure and data

- 4 fleets
- 6 surveys
- Main likelihood components
  - Surveys
  - Length compositions
  - Conditional age at length data
  - Marginal ages (included but not fit)
- Data weighting
  - Bio: Francis
  - Survey: Additional variance

Parameter specification

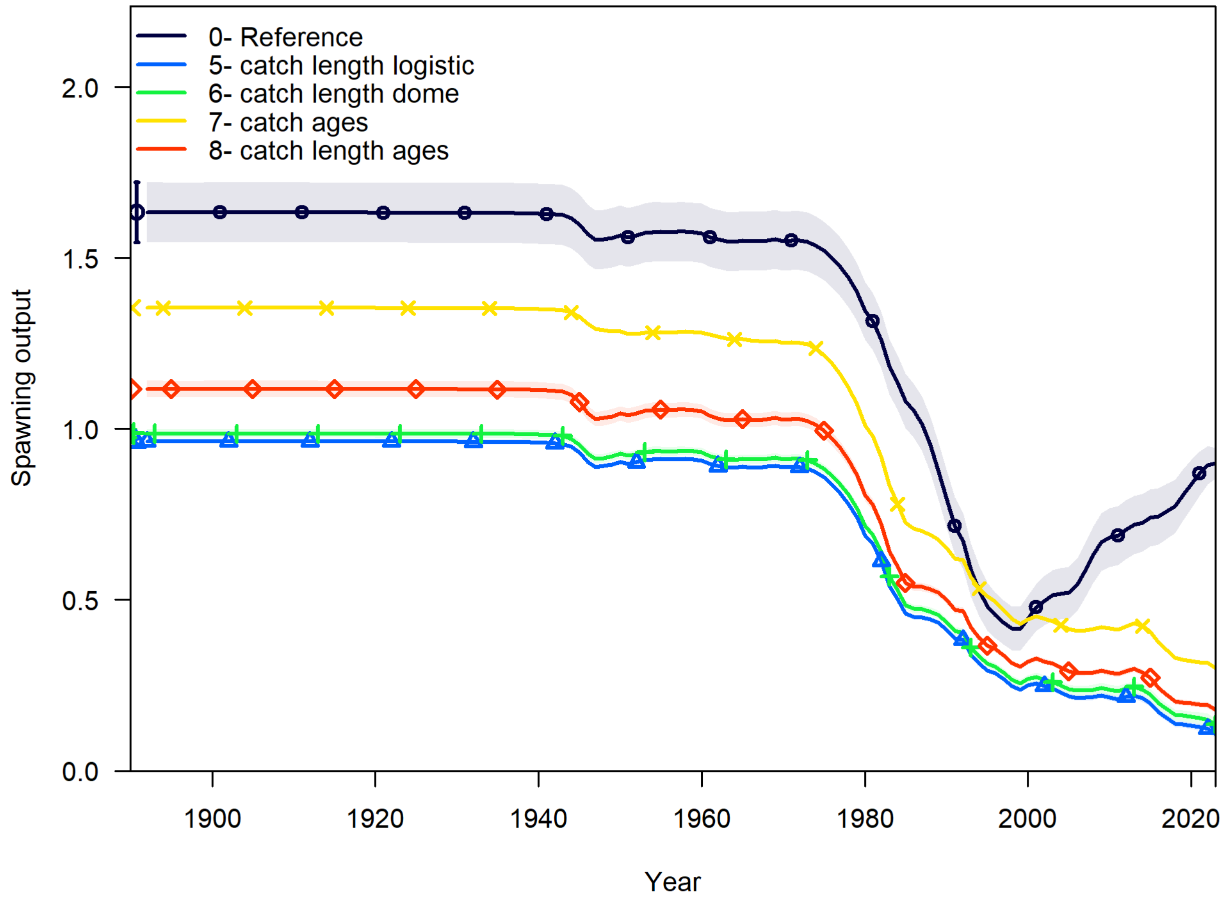
- Sex-specific
- Estimated
  - L_{Amax}
  - k
  - Recruitment
  - Selectivity
- Fixed
  - Natural mortality
  - L_{Amin}
  - CVs at length
  - Maturity
  - Fecundity
  - Length-weight
  - AV q

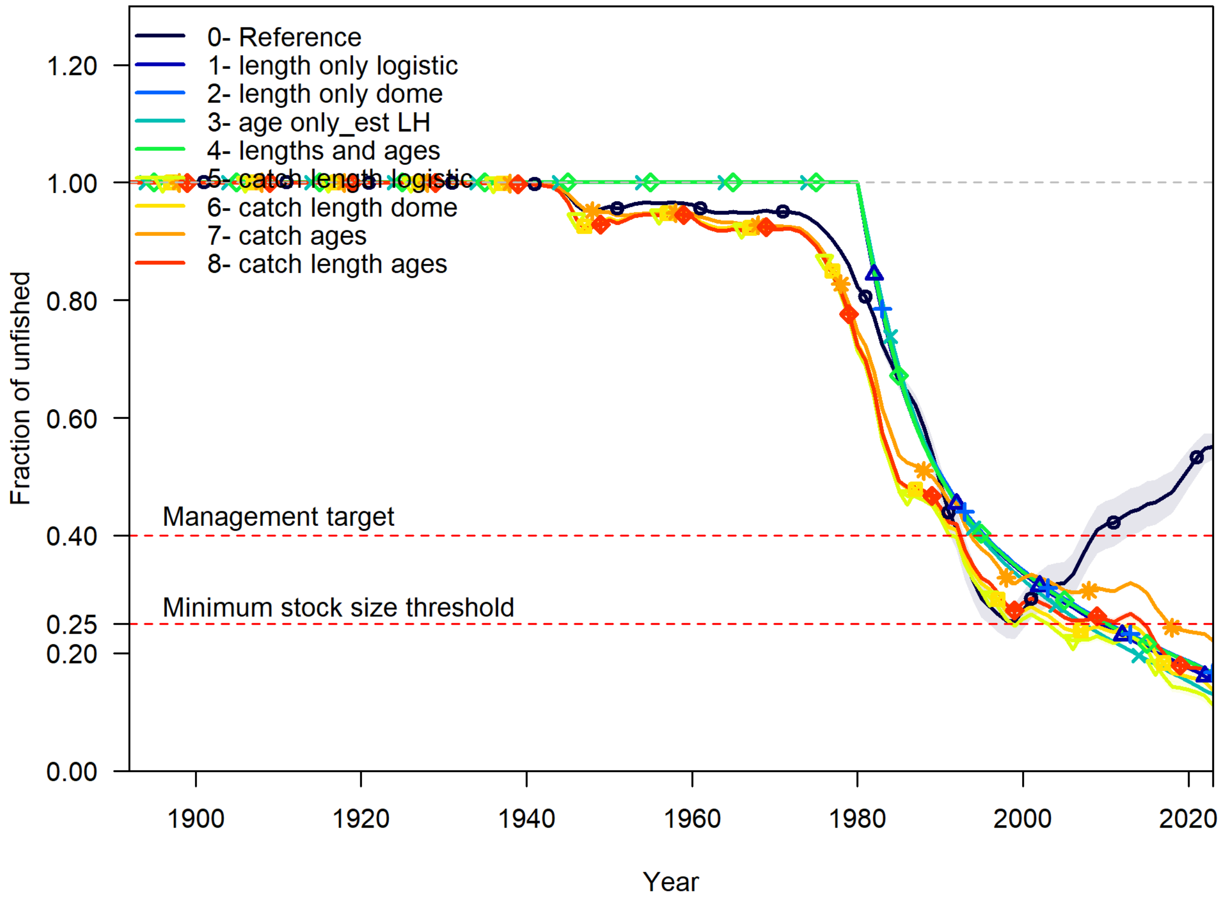
Marine Resources

Model Evaluation

- Sensitivities
- Requests from the STAT
- Convergence tests
- Technical merits and deficiencies

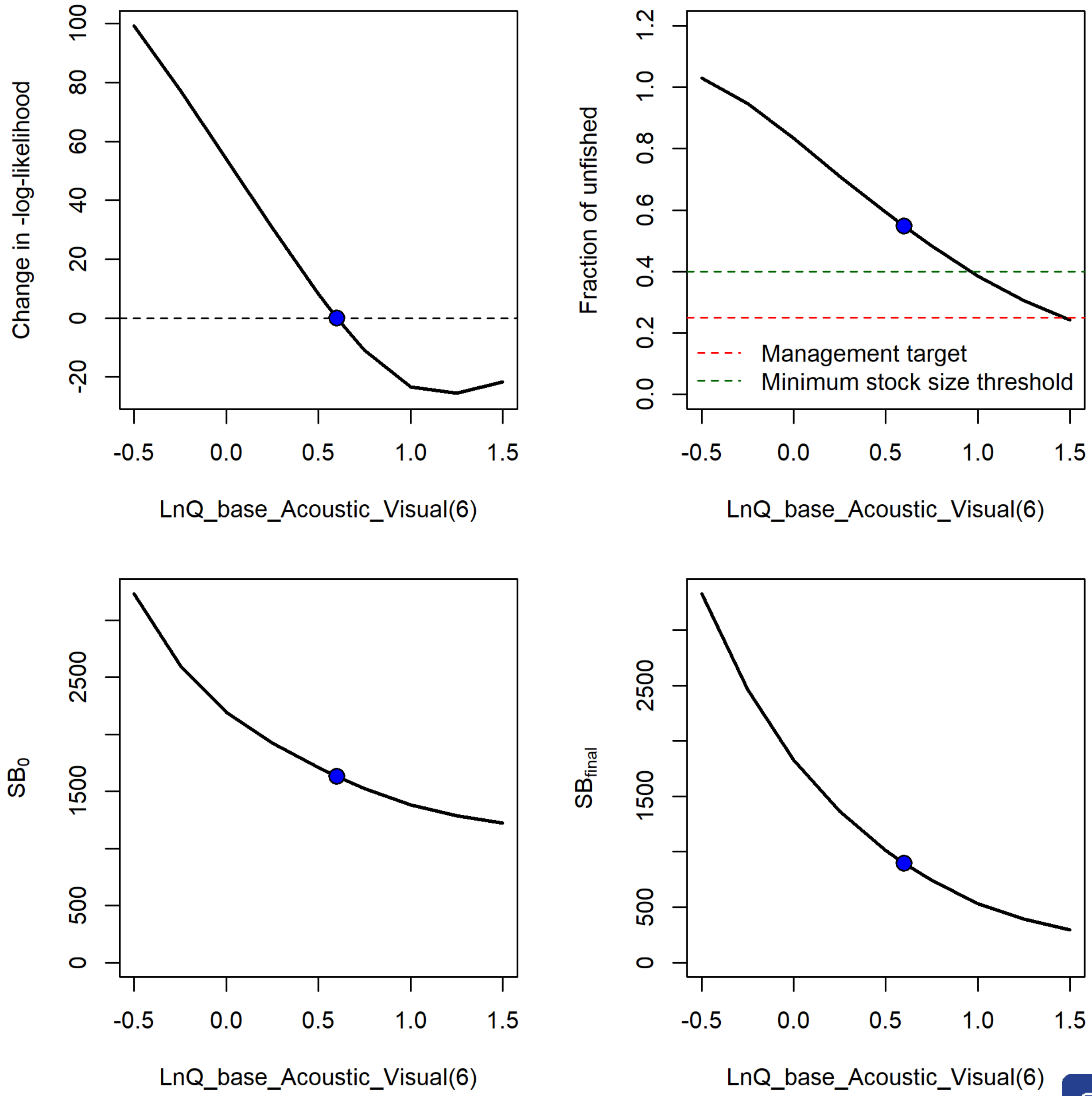
Model Building Sensitivities





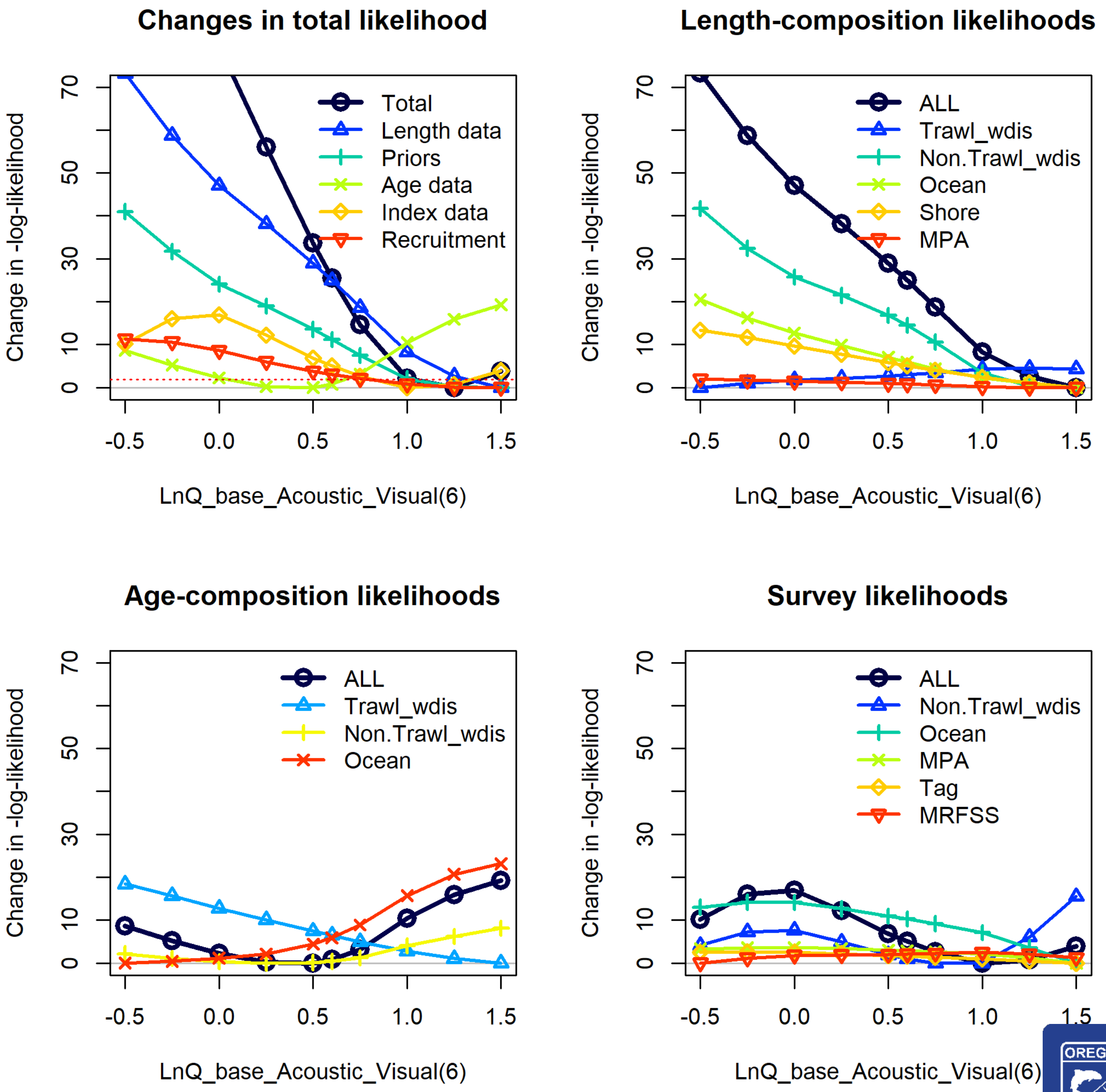
Marine Resources

Likelihood profiles: Acoustic Visual q

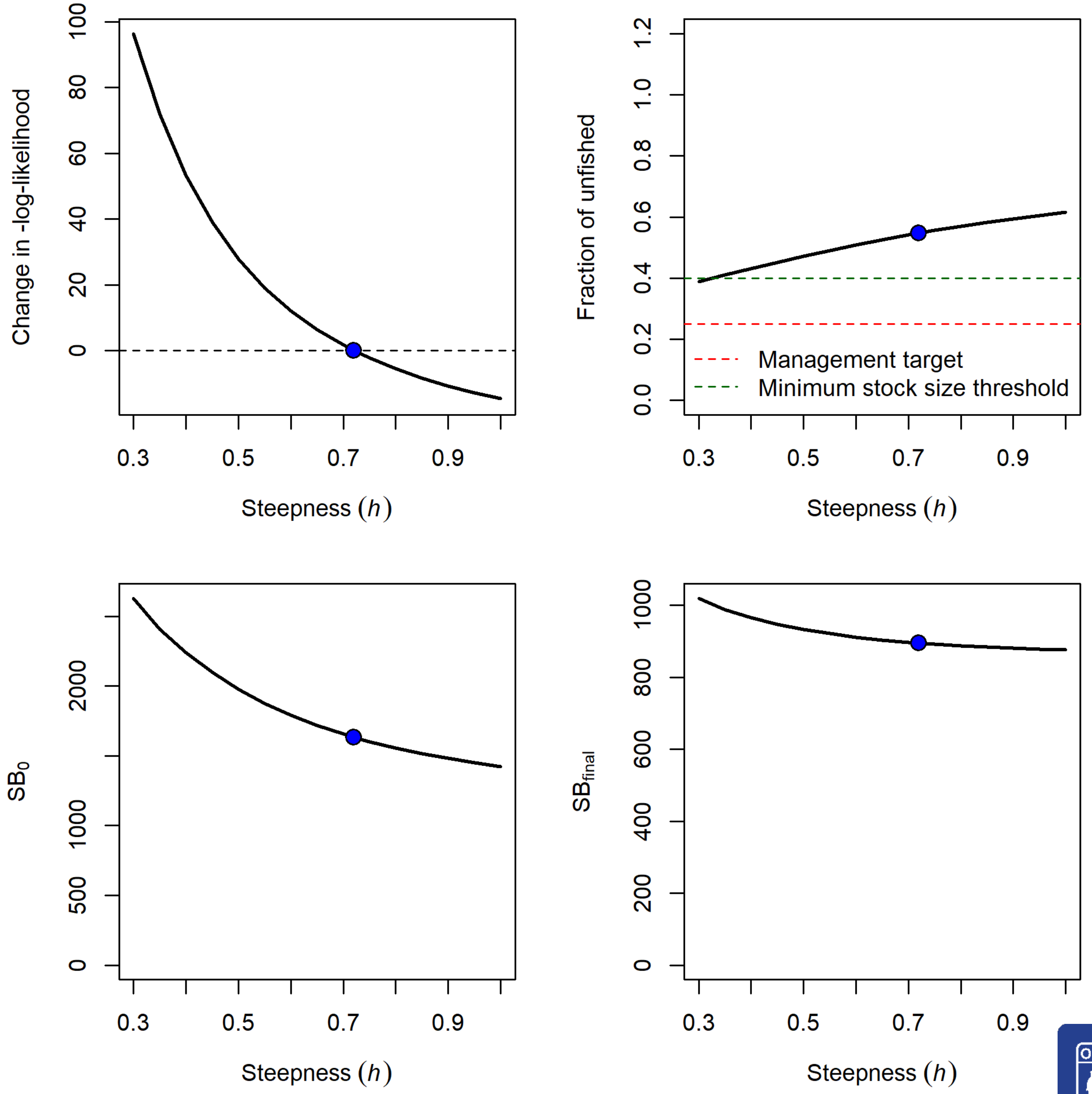


OREGON Fish & Wildlife Marine Resources

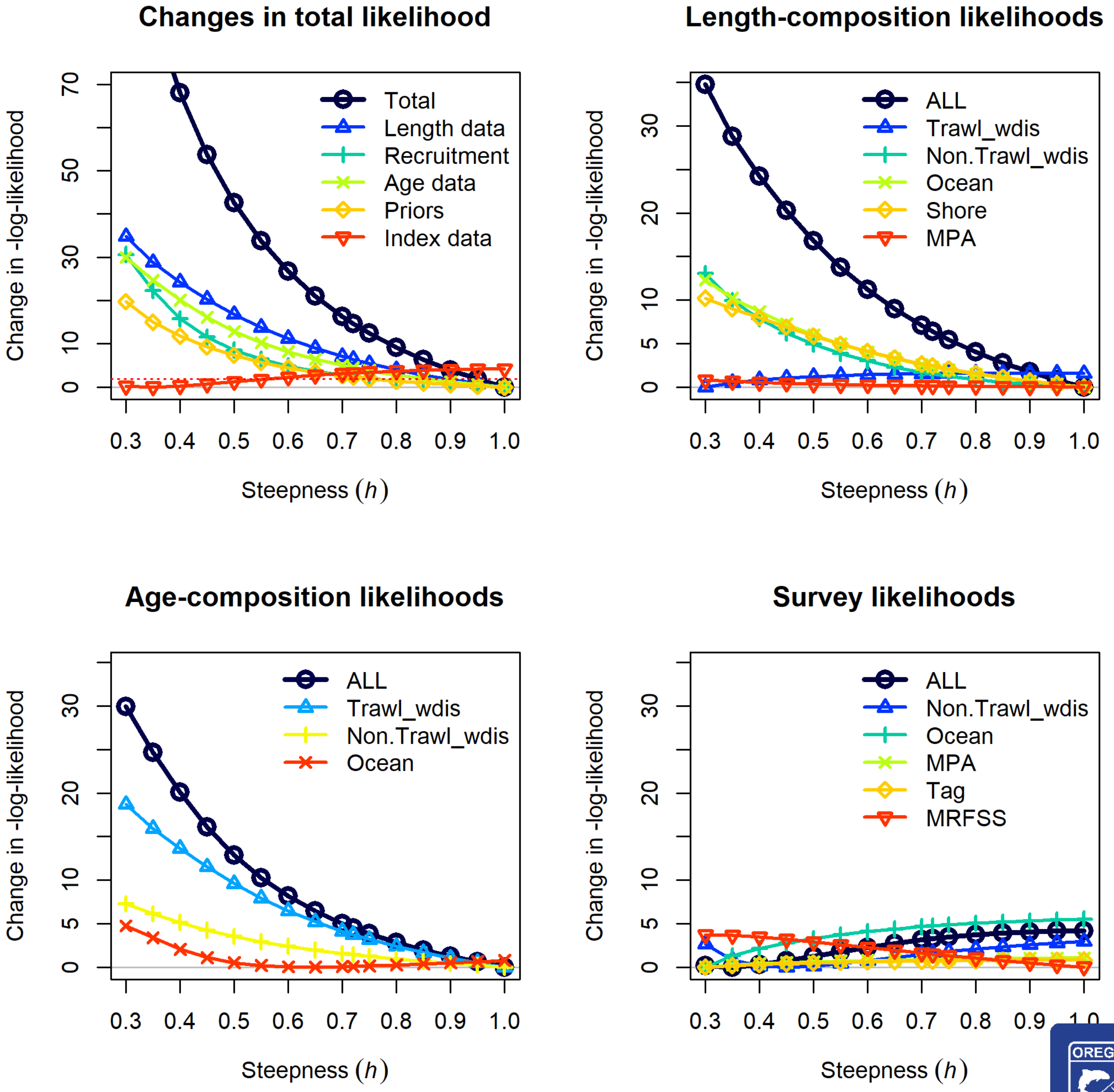
Likelihood profiles: Acoustic Visual q



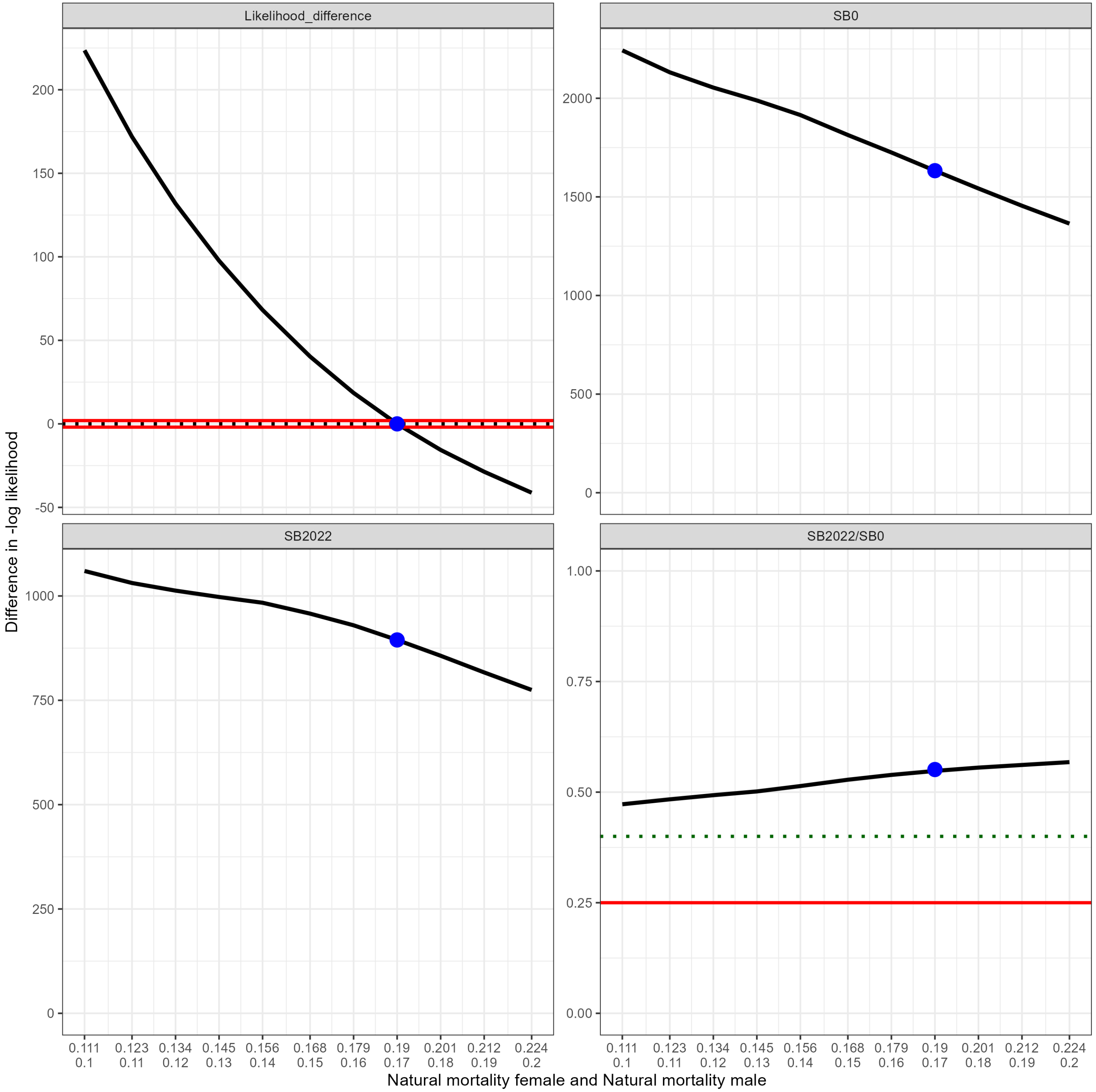
Likelihood profiles: Steepness



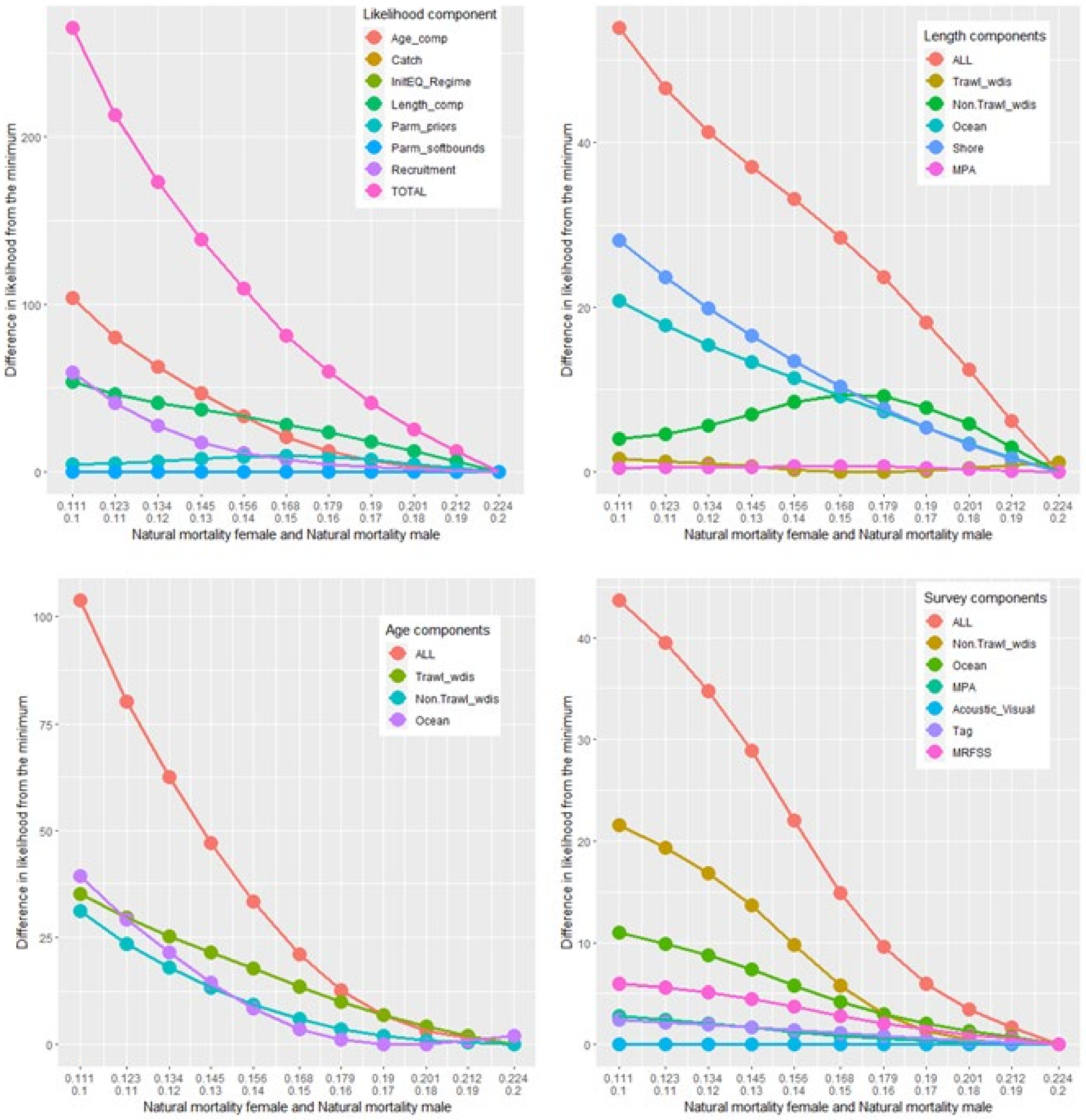
Likelihood components: Steepness



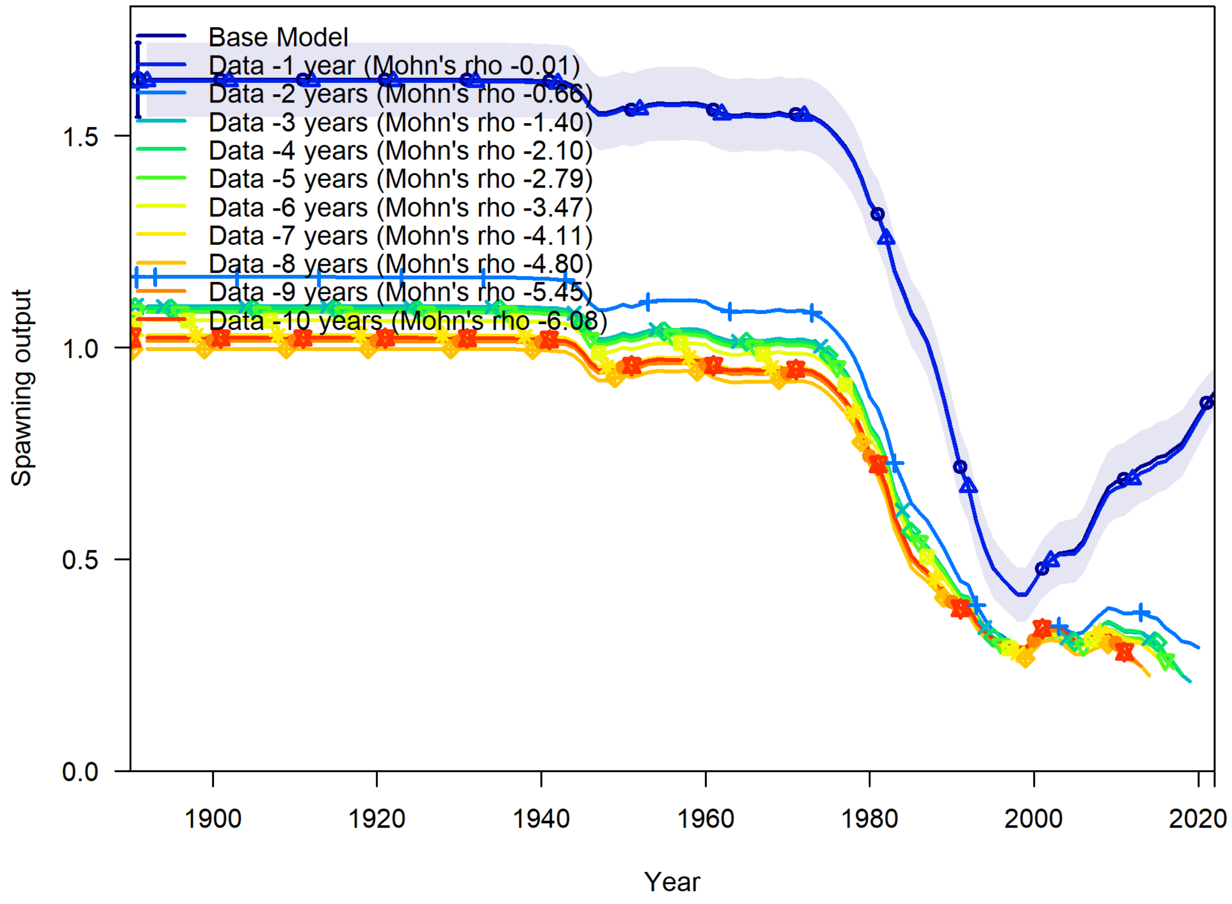
Likelihood profiles: Natural mortality

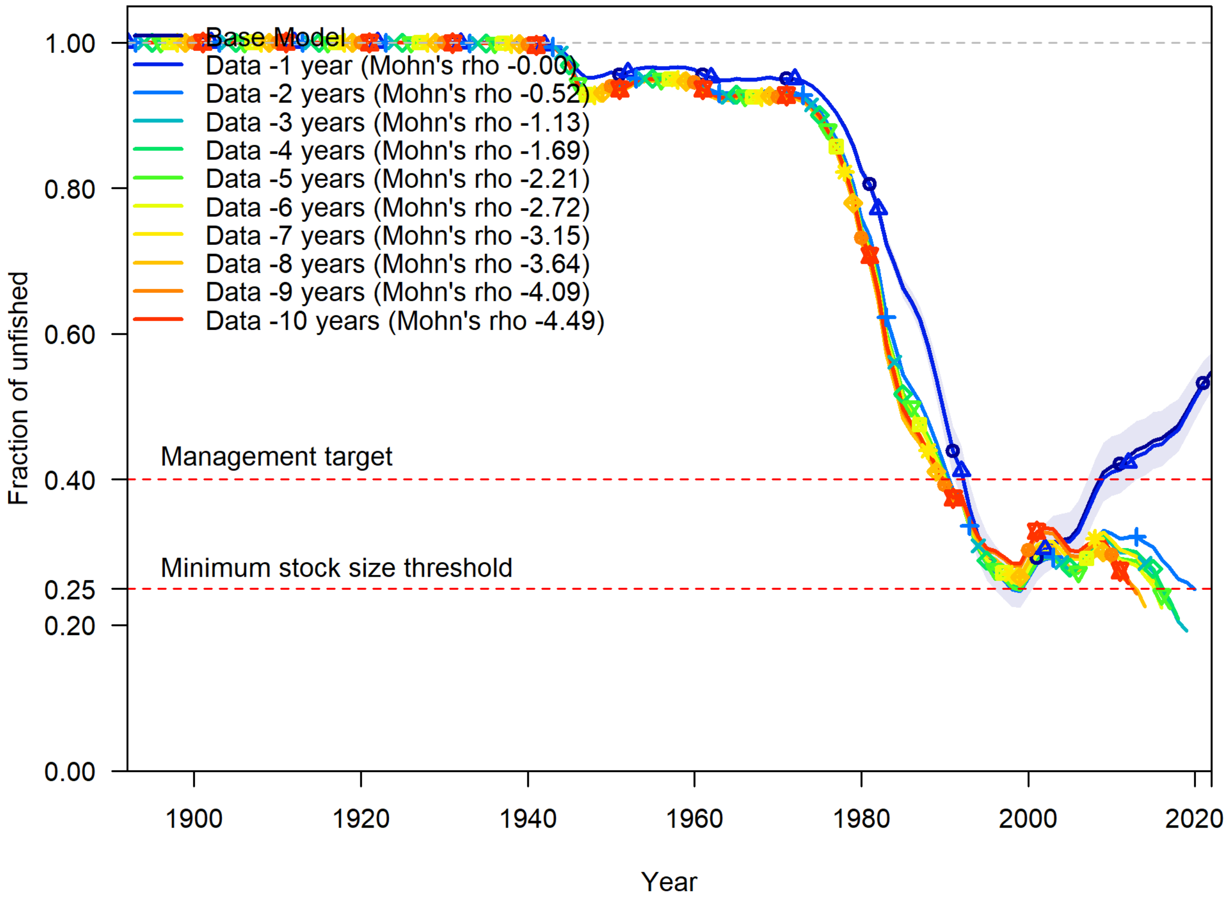


Likelihood components: Natural mortality



Retrospectives





OREGON Fish & Wildlife Marine Resources

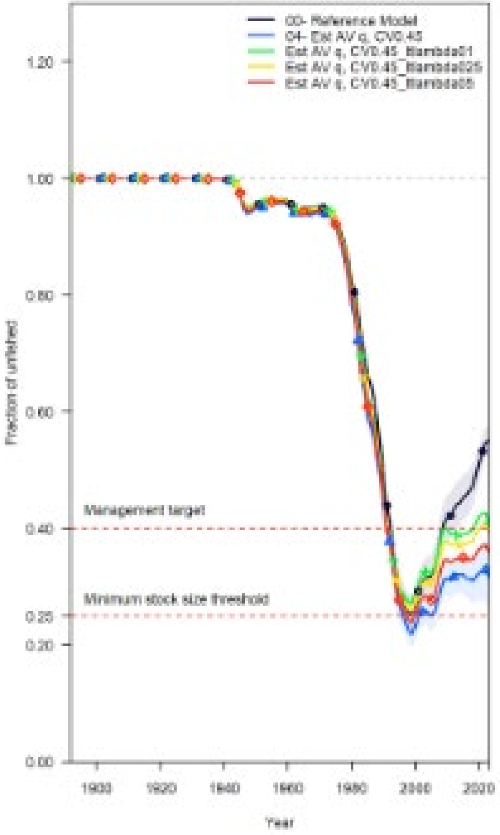
Panel Requests of Importance

Base model estimates of AV Survey q are implausibly high (~4) from influence of length composition.

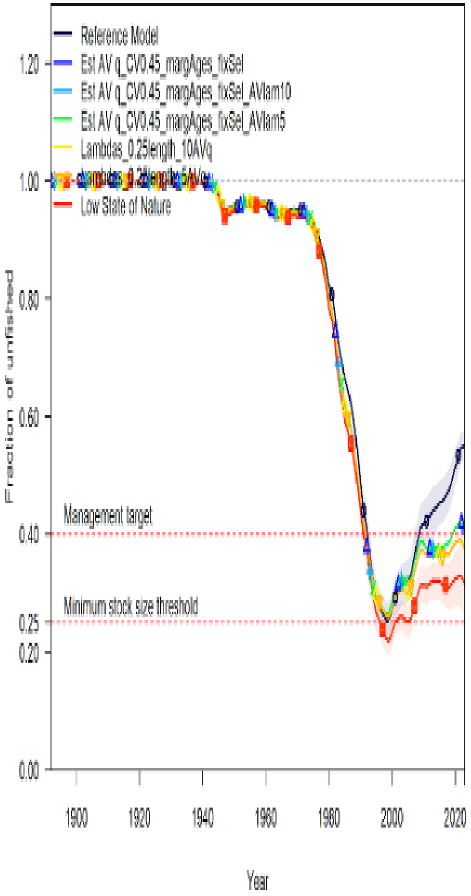
- Examining alternative lambda weighting.
  - Down weighting lengths 0.1 and 0.5. Request 5.
  - Up weighting AV survey 5, 10, 25. Request 9.
- Fixing selectivity, turning off lengths and use marginal ages. Request 15. Preferred model given:
  - High sample size of ages
  - Subjective lambda weighting
  - AVq = 2.6, more reasonable

Request 5

Request 9



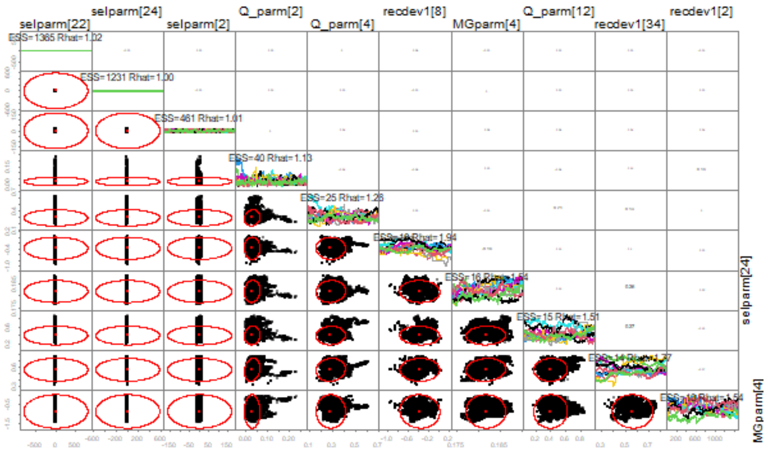
Request 15

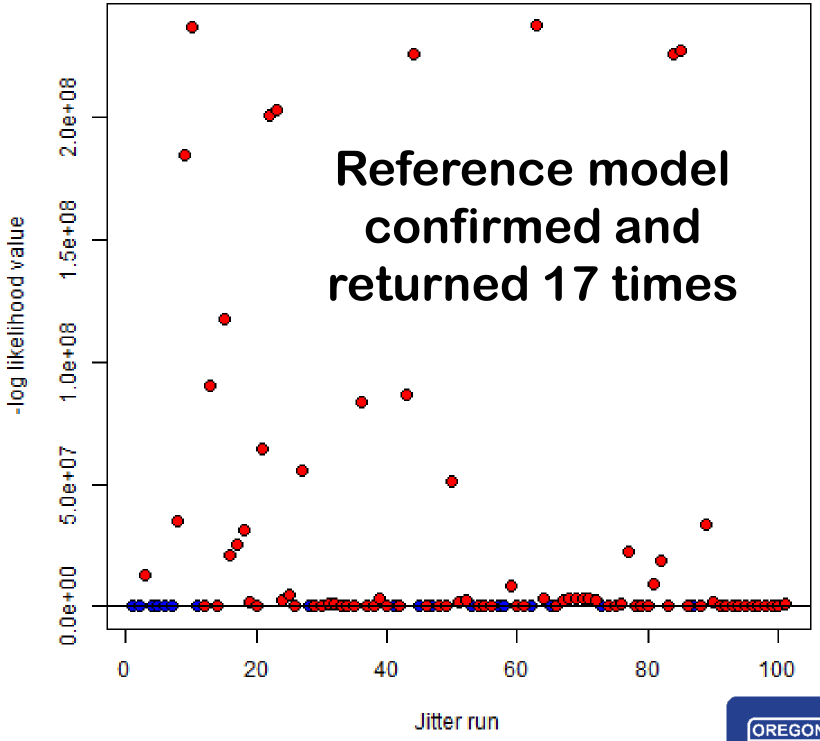


Reference model: Efficiency and convergence

Convergence

- **MCMC used to explore parameters "non-dynamic" estimated parameters**
- **Hessian inversion**
- **Low maximum gradient**
- **Sensible parameter values**
- **Jitter to establish/confirm reference model**





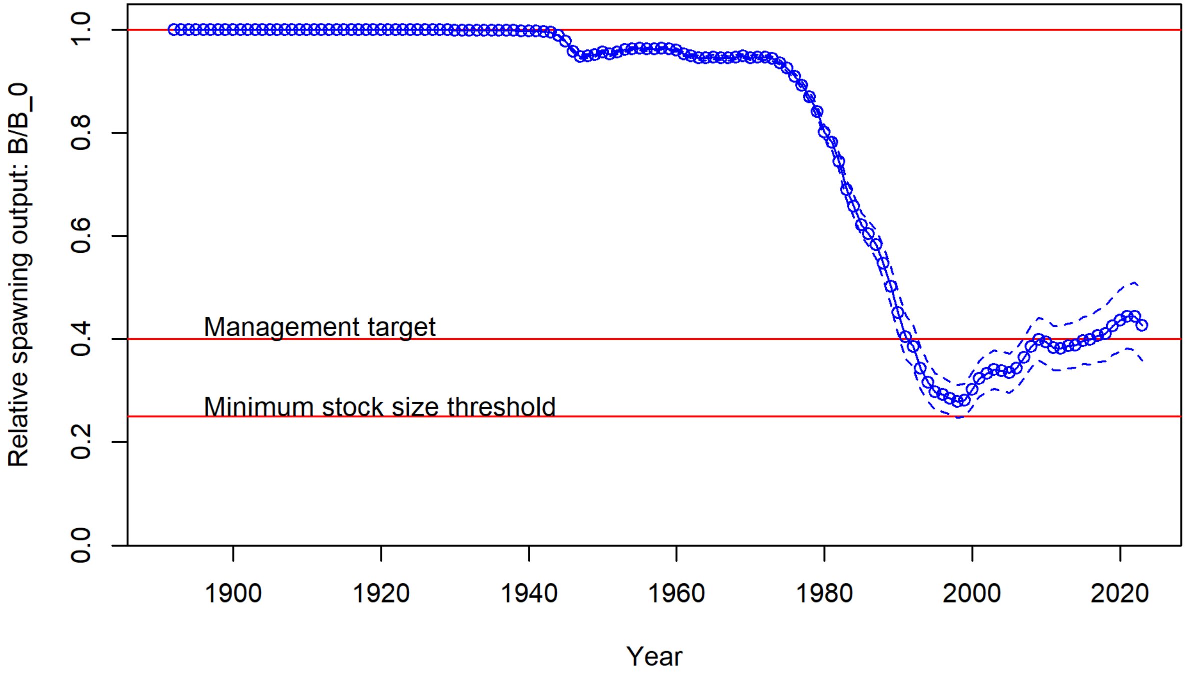
Technical Merits

- Large quantity of length and age data available for the assessment.
- Considerable number of indices available to inform the assessment, including several based on long-term monitoring of the fishery.
- Several fishery-independent surveys available, including a recent acoustic-visual survey that, at least in theory, provides an absolute measure of abundance.
- Assessment incorporated estimates of functional maturity that took into account skipped spawning, which was considered an improvement overestimates of physiological maturity, as is usually done.
- Assessment is very thorough and was carefully done.
- Full set of sensitivity runs and model diagnostics.

Technical Deficiencies

- Only one acoustic visual survey estimate is available because the full survey has been conducted only once. Additional acoustic-visual surveys are needed to address this deficiency.
- The reliability of the acoustic-visual survey could be improved by in-situ transducer calibration, and use of a species-specific target strength for black rockfish.
- Information on functional maturity is only available in the last decade, which has been a period of extreme environmental variation in Oregon waters.
- It is unclear how representative these estimates are of the long-term average.
- While several long-term fishery-dependent indices are available, in general, they do not appear to be highly informative about the assessment.

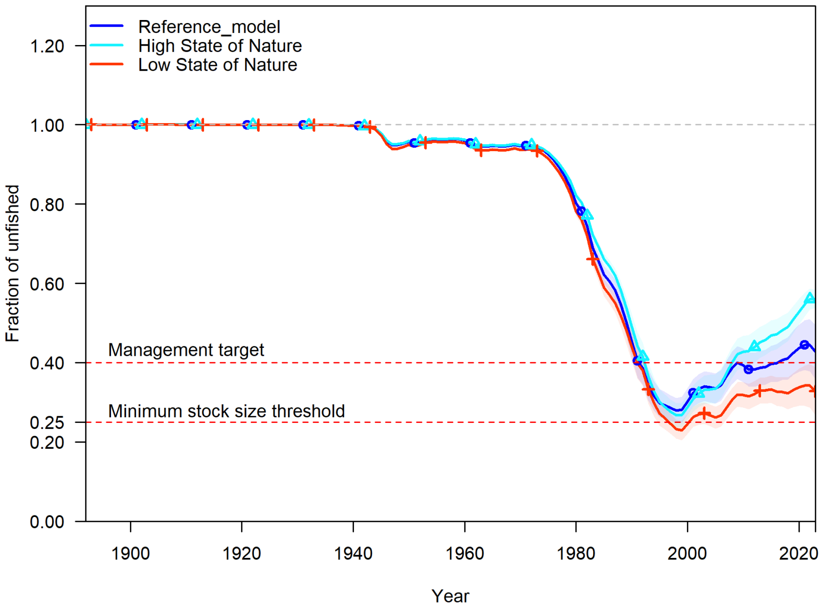
Depletion and Stock Status



Year	Predicted OFL (mt)	ABC Catch (mt)	Age 0+ Biomass (mt)	Spawning Output	Fraction Unfished
2023	372.04	511.90	5693.59	617.27	0.43
2024	353.84	511.90	5583.11	584.86	0.40
2025	343.62	316.33	5505.53	551.50	0.38
2026	354.15	324.45	5631.88	552.31	0.38
2027	366.05	335.46	5749.79	560.00	0.39
2028	376.87	346.33	5849.97	572.15	0.40
2029	385.48	353.48	5930.24	586.06	0.41
2030	391.80	357.71	5994.58	599.87	0.42
2031	396.23	360.17	6047.55	612.38	0.42
2032	399.40	361.06	6092.92	623.01	0.43
2033	401.93	361.74	6134.00	631.84	0.44
2034	404.20	362.16	6172.26	639.19	0.44

Decision Tables - Uncertainties

The high state of nature was given by a model that pinned the acoustic-visual catchability (q) to 1.8 by reducing the CV of the survey to a small value (original base model). The lower state of nature was given by a model in which the acoustic-survey catchability is freely estimated.



	Year	Catch	Est. AV q		Reference Model		AV ln(q) =1.82	
			Spawning Output	Fraction Unfished	Spawning Output	Fraction Unfished	Spawning Output	Fraction Unfished
	2023	512	426	0.33	617	0.43	907	0.56
	2024	512	403	0.31	585	0.40	896	0.55
	2025	316	378	0.29	551	0.38	875	0.54
	2026	324	384	0.30	552	0.38	878	0.54
	2027	335	394	0.30	560	0.39	882	0.54
P*=0.45	2028	346	408	0.31	572	0.40	886	0.55
sigma=0.5	2029	353	422	0.32	586	0.41	891	0.55
	2030	358	435	0.33	600	0.42	895	0.55
	2031	360	447	0.34	612	0.42	899	0.56
	2032	361	456	0.35	623	0.43	903	0.56
	2033	362	464	0.36	632	0.44	906	0.56
	2034	362	470	0.36	639	0.44	909	0.56
	2023	512	426	0.31	617	0.43	907	0.56
	2024	512	403	0.29	585	0.40	896	0.55
	2025	295	378	0.30	551	0.38	875	0.54
	2026	303	387	0.31	555	0.38	881	0.54
	2027	314	400	0.32	566	0.39	888	0.55
P*=0.4	2028	323	416	0.33	581	0.40	895	0.55
sigma=0.5	2029	329	433	0.35	598	0.41	903	0.56
	2030	332	450	0.36	615	0.43	911	0.56
	2031	333	464	0.37	631	0.44	918	0.57
	2032	334	476	0.37	645	0.45	925	0.57
	2033	334	487	0.38	656	0.45	931	0.58
	2034	330	496	0.38	667	0.46	936	0.58
	2023	407	426	0.33	617	0.43	907	0.56
	2024	407	403	0.31	585	0.40	896	0.55
	2025	407	378	0.29	551	0.38	875	0.54
	2026	407	372	0.29	539	0.37	865	0.53
Equilibrium	2027	407	372	0.29	536	0.37	856	0.52
yield from	2028	407	376	0.29	538	0.37	850	0.52
FMSY proxy	2029	407	383	0.29	544	0.38	847	0.52
of SPR=0.5	2030	407	390	0.30	551	0.38	845	0.52
	2031	407	396	0.30	559	0.39	844	0.52
	2032	407	402	0.31	566	0.39	844	0.52
	2033	407	406	0.31	571	0.40	844	0.52
	2034	407	409	0.31	576	0.40	844	0.52

Research and Data Needs

The panel supports the recommendations provided in the pre-STAR draft assessment (reproduced below).

1. Continue work on the investigation into the movement, and behavior or mortality of older (> age 10) females to further reconcile their absence in fisheries data.

2. Conduct population genetics studies on fish observed off of the continental shelf (middle of the gyre and at sea mounts) to determine their association with the nearshore stocks.

3. Continue to build evidence for appropriate natural mortality values for females and males.

4. Improved historical catch reconstructions. Specifically, the historic trawl fishery catches (pre-1987) in particular require particular attention. A synoptic catch reconstruction is recommended, where states work together to resolve cross-boundary state catch issues as well as standardize the approach to catch recommendations to the extent possible.

Research and Data Needs

5. Stock structure for black rockfish is a complicated topic that needs further analysis. How this is determined (e.g., exploitation history, genetics, life history variability, biogeography, etc.) and what this means for management units needs to be further refined. This is a general issue for all nearshore stocks that likely have significant and small-scale stock structure among and within states, but limited data collections to support small-scale management.

6. Continue acoustic-visual fisheries independent coastwide survey to develop a time series. Further refine the survey by addressing the recommendations of the SSC methodology review from 2022. Examine the potential of using spatial modeling to reduce the uncertainty in the population estimates from the acoustic-visual fisheries independent coastwide survey.

7. Reconcile contradictory signals in the black rockfish biology versus the population scale.

8. Better understand the ecology and habitats of black rockfish from settlement to age 4. Further development of surveys aimed specifically at recruitment or settlement rates of nearshore species, such as OSU's Standard Monitoring Units for the Recruitment of Fishes (SMURF) collections, that are not frequently encountered in offshore federal age-0 surveys is needed.

•

Research and Data Needs

The STAR panel supports the following additional recommendations for future research and data collection.

1. With respect to the STAT's recommendation No. 6 above on the acoustic-visual survey, the Panel recommends that the survey team focus on improving the survey estimates by a) obtaining a target strength estimate for black rockfish, b) developing a method for in-situ transducer calibration, and c) improving backscatter identification using visual surveys and other methods as appropriate. Concentrating on the echo integration component of the survey seems warranted given that methods are well developed and widely used, and it is regarded as a reliable and robust acoustic survey technique.

2. Develop additional capacities in stock synthesis to model marine reserves (i.e., closed to fishing) and areas that are open to fishing.

3. Explore tradeoffs between the different options to fitting sex-specific composition data in stock synthesis and develop recommendations for acceptable practices.

4. Using acoustic visual survey data to develop an informative prior for the PIT tag survey was considered during the STAR panel meeting, but there was insufficient time to fully explore this approach. Future assessments should continue to develop and evaluate this approach.

5. Continue to collect functional maturity information and evaluate the role of geography, environmental forcing, and density dependence on functional maturity estimates for black rockfish.

Panel Recommendations

- Category: 1b
- Sigma: default 0.5
- Next Assessment: Full to address inclusion of AV survey.

- BSIA recommendation?
- Agreement?

Comparisons Across Assessments

Table 1. Parameters and management reference points across black rockfish assessment areas. Values in standard text are estimated and those in italics are fixed. The natural mortality parameters for Central California are fixed at the estimated values from the northern California model (the assessment with the majority of available age data).

Model Parameters	Washington	Oregon	Northern California	Central California
M_female	*0.17*	*0.19*	*0.210*	*0.210*
L_inf Female	*52.73*	*51.00*	*57.073*	*57.577*
VonBert_K_Fem	*0.12*	*0.182*	*0.148*	*0.145*
M_male	*0.152*	*0.17*	*0.200*	*0.200*
L_inf Male	*47.65*	*46.04*	*47.762*	*50.542*
VonBert_K_Male	*0.14*	*0.220*	*0.202*	*0.186*
LN(R0)	7.58	8.104	7.718	6.473
h	*0.72*	*0.72*	*0.72*	*0.72*
sigma_R	*0.6*	*0.6*	*0.6*	*0.6*
Derived Parameters				
B0	943.88	1445.09	1126	324
FracUnfished (2023)	45%	43%	36%	42%
OFL_FSPR (2023)	266.12	372.05	204	48.5
MSY_SPRproxy	275.88	406.67	265	65

Comparison of Recruitment and Relative Abundance Trends