SEDAR 36 U – U.S. Atlantic Snowy Grouper Update Assessment

SSC meeting

January 11th, 2021

NOAA FISHERIES
Sustainable Fisheries Branch, Beaufort, NC

Background

- Update assessment of SEDAR 36 (2012)
- Terminal year of 2018

- Northern boundary is NC-VA border
- Southern boundary is the Council jurisdictional boundary in the Keys

Background – summary of regulations

- No size limit.

Year effective	Recreational		Commercial	
	Bag limit	ACL (fish)	Trip limit (lbs)	Quota/ACL (klb)
1986	5 grouper/person			
1994			2500	540
1995				442
1996				344
2006	1 snowy/person		275	
2007			175	118
2008			100	84
2009			100	83
2011	1 snowy/vessel	523		
2015		4152	200	
2016		4483		125
2017		4819		135
2018		4983		144
	ACL met 2013, 2014		ACL met every year since 2013	

Outline

- Data Review
  - Life History
  - Removals
  - Indices of abundance
  - Compositions
- Model update
- Base run
- Sensitivities and retrospective
- Uncertainty
- Projections

Life History

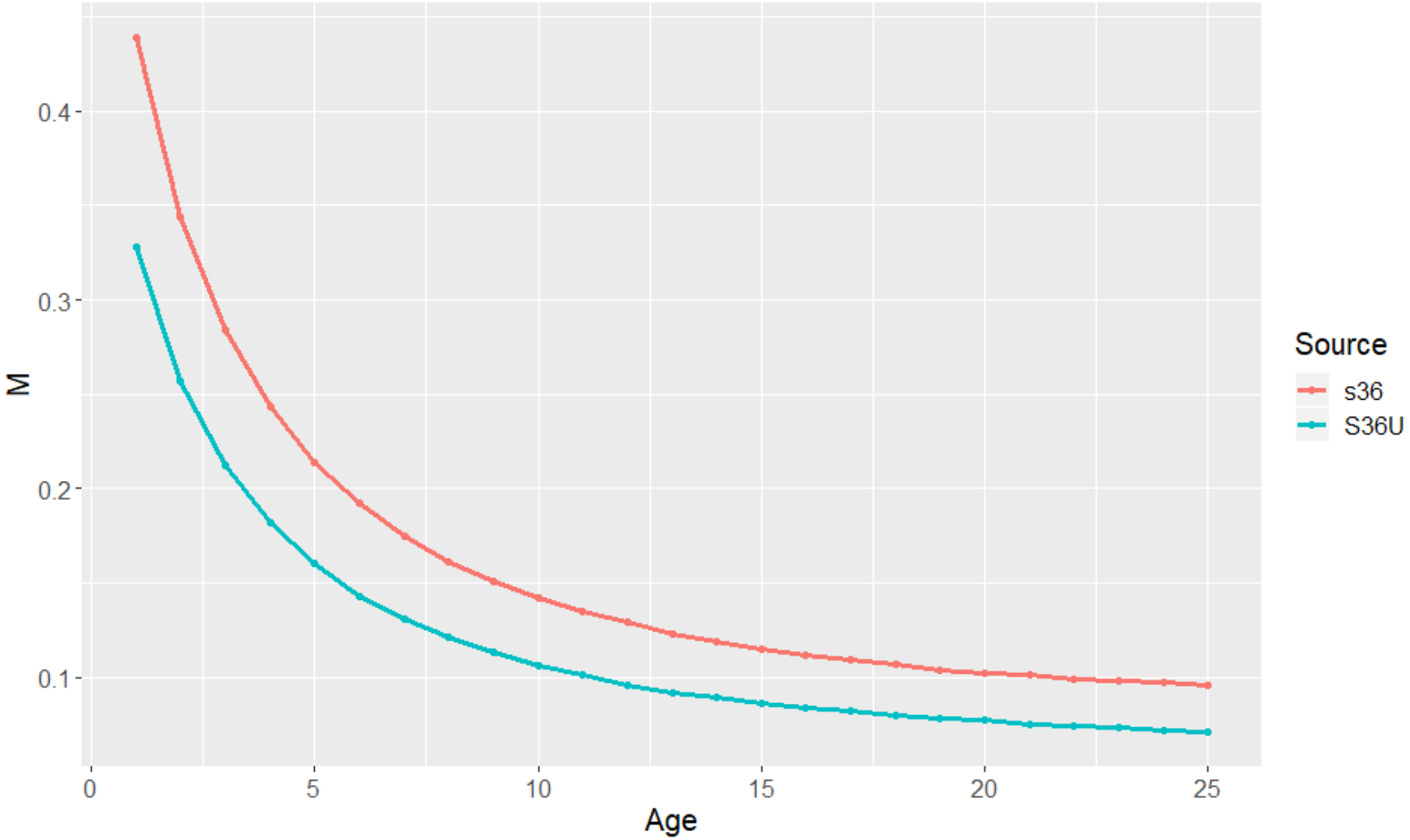
- New information on maximum age
  - SEDAR 36 maximum age of 35
  - SEDAR 36 update >20 fish aged greater than 35 with one fish aged to 80 years
  - Bomb radiocarbon ages to 56
- S36(2012)-Charnov scaled to Hewitt and Hoenig, M=0.12

August 2020 SSC meeting recommendation:

- S36 Update-Charnov scaled to Hewitt and Hoenig, M=0.08
- Range of 0.05 to 0.12 for MCB ensemble
- No update to growth curve

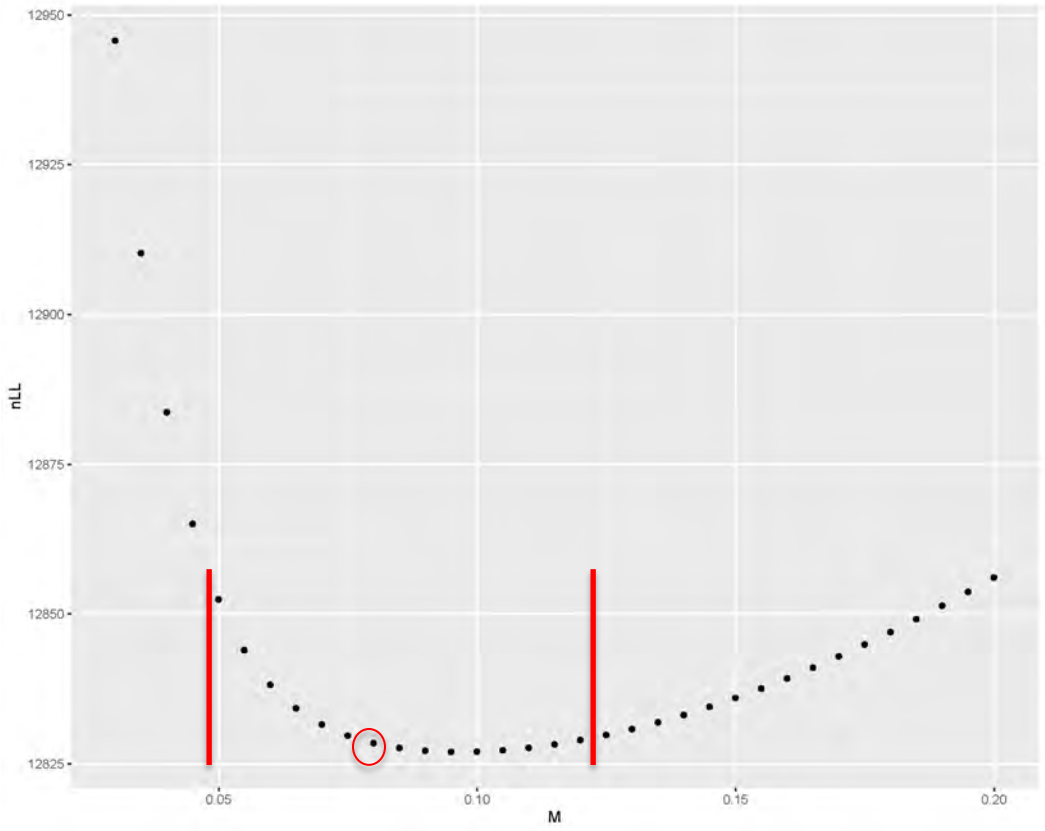
- Assessment team adopted SSC recommendations

Natural Mortality



Likelihood profile – M

- Base run M= 0.08
- Profile to evaluate general consistency



M	nLL
0.05	12865.05
0.055	12852.45
0.06	12843.94
0.065	12838.18
0.07	12834.25
0.075	12831.55
0.08	12829.69
0.085	12828.44
0.09	12827.63
0.095	12827.16
0.1	12826.97
0.105	12827.01
0.11	12827.24
0.115	12827.65
0.12	12828.22

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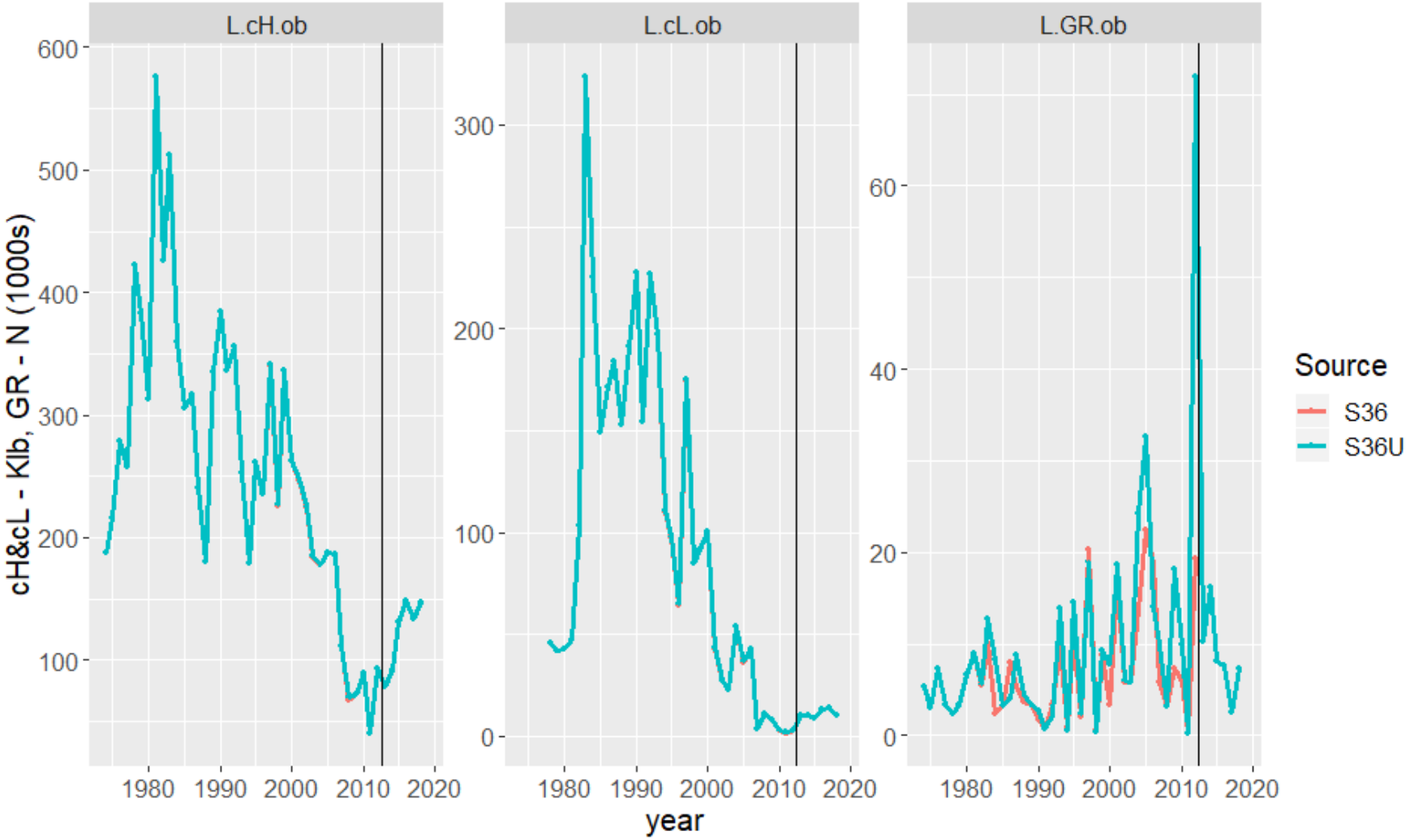
Landings and Discards



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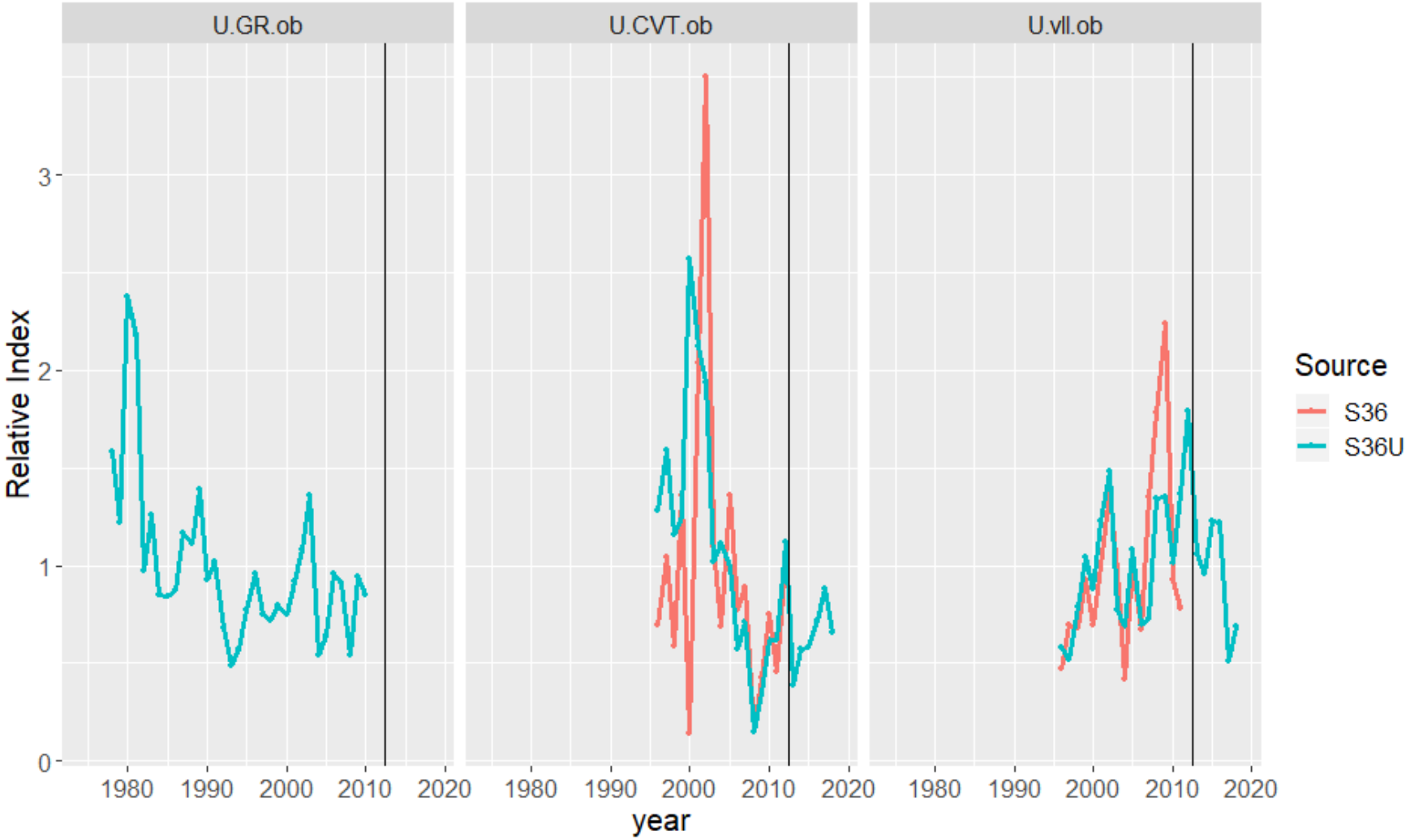
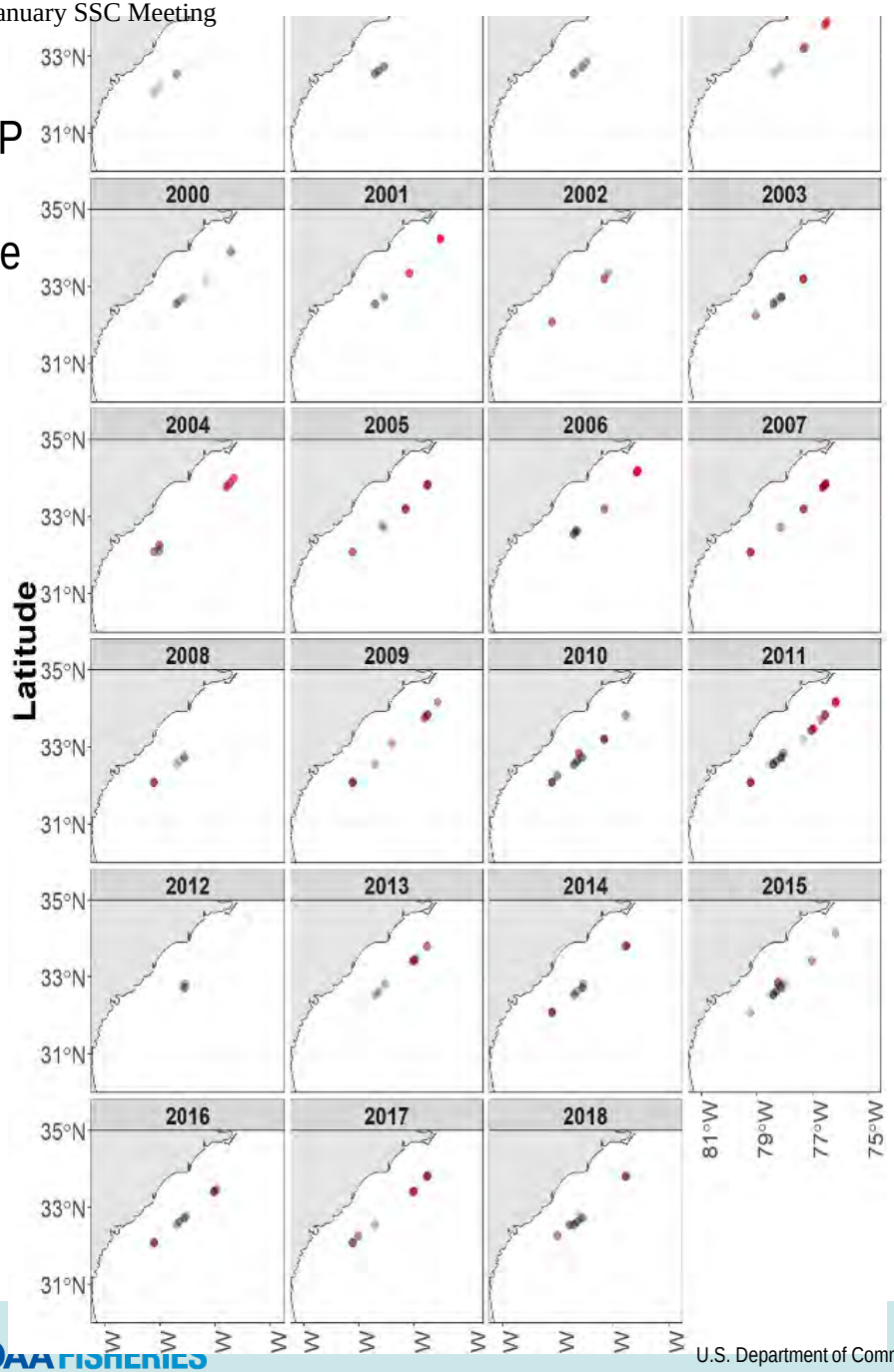
Indices


U.GR.ob
U.CVT.ob
U.vll.ob
Relative Index
0
1
2
3
1980
1990
2000
2010
2020
year
Source
S36
S36U

MARMAP VLL Coverage



Year	index	cv
1996	0.58	0.49
1997	0.52	0.44
1998	0.79	0.36
1999	1.04	0.35
2000	0.88	0.38
2001	1.23	0.23
2002	1.48	0.29
2003	0.77	0.21
2004	0.69	0.56
2005	1.08	0.27
2006	0.70	0.29
2007	0.73	0.35
2008	1.34	0.23
2009	1.35	0.41
2010	1.01	0.22
2011	1.37	0.20
2012	1.79	0.21
2013	1.06	0.45
2014	0.96	0.20
2015	1.23	0.17
2016	1.22	0.20
2017	0.51	0.51
2018	0.69	0.28

Age sample size

Year	sets	fish
1996	9	13
1997	14	38
1998	12	25
1999	14	33
2000	19	36
2001	18	42
2002	10	27
2003	25	52
2004	6	10
2005	19	36
2006	15	30
2007	6	15
2008	20	61
2009	5	21
2010	44	99
2011	57	161
2012	17	73
2013	13	50
2014	29	68
2015	39	102
2016	33	82
2017	7	13
2018	20	43

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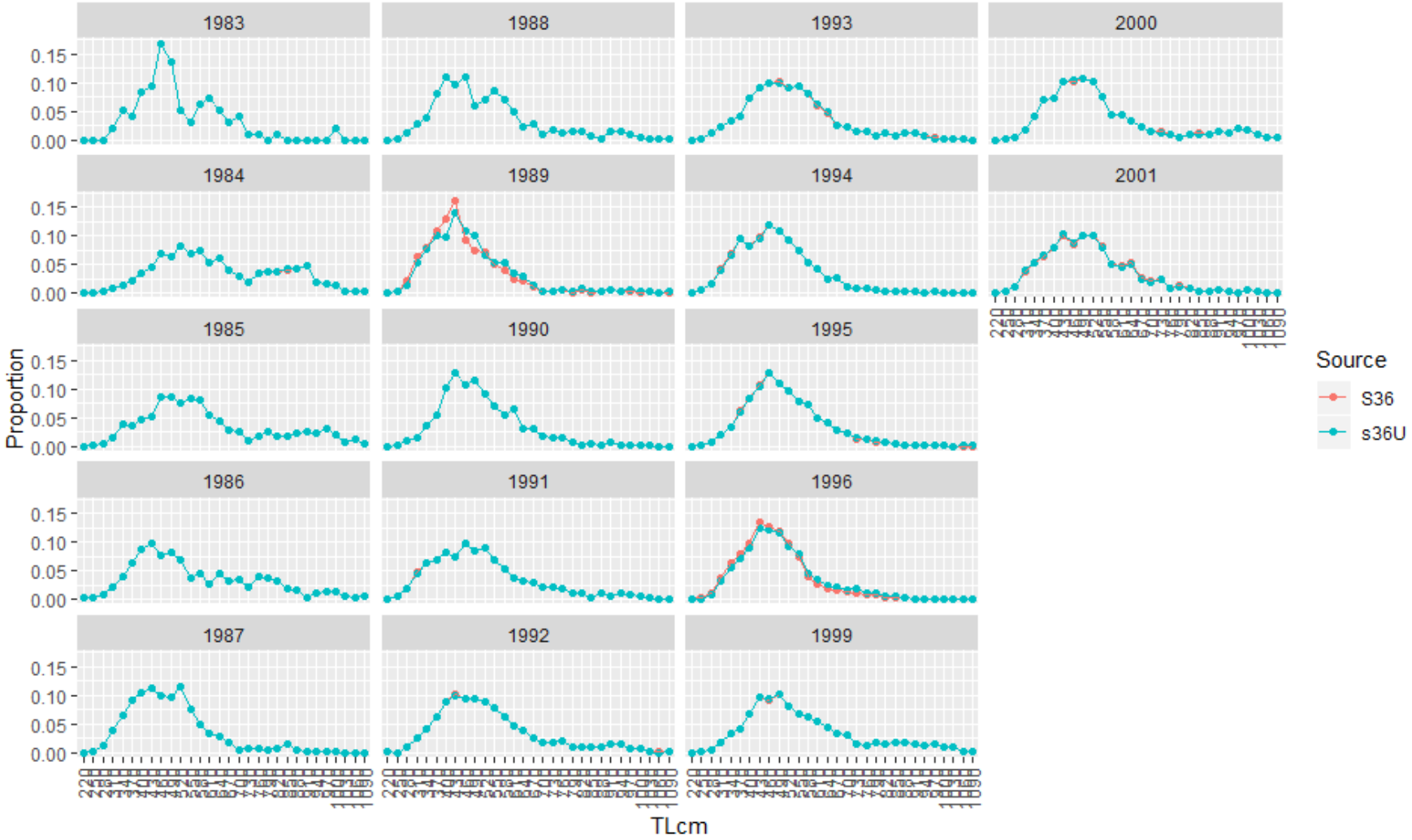
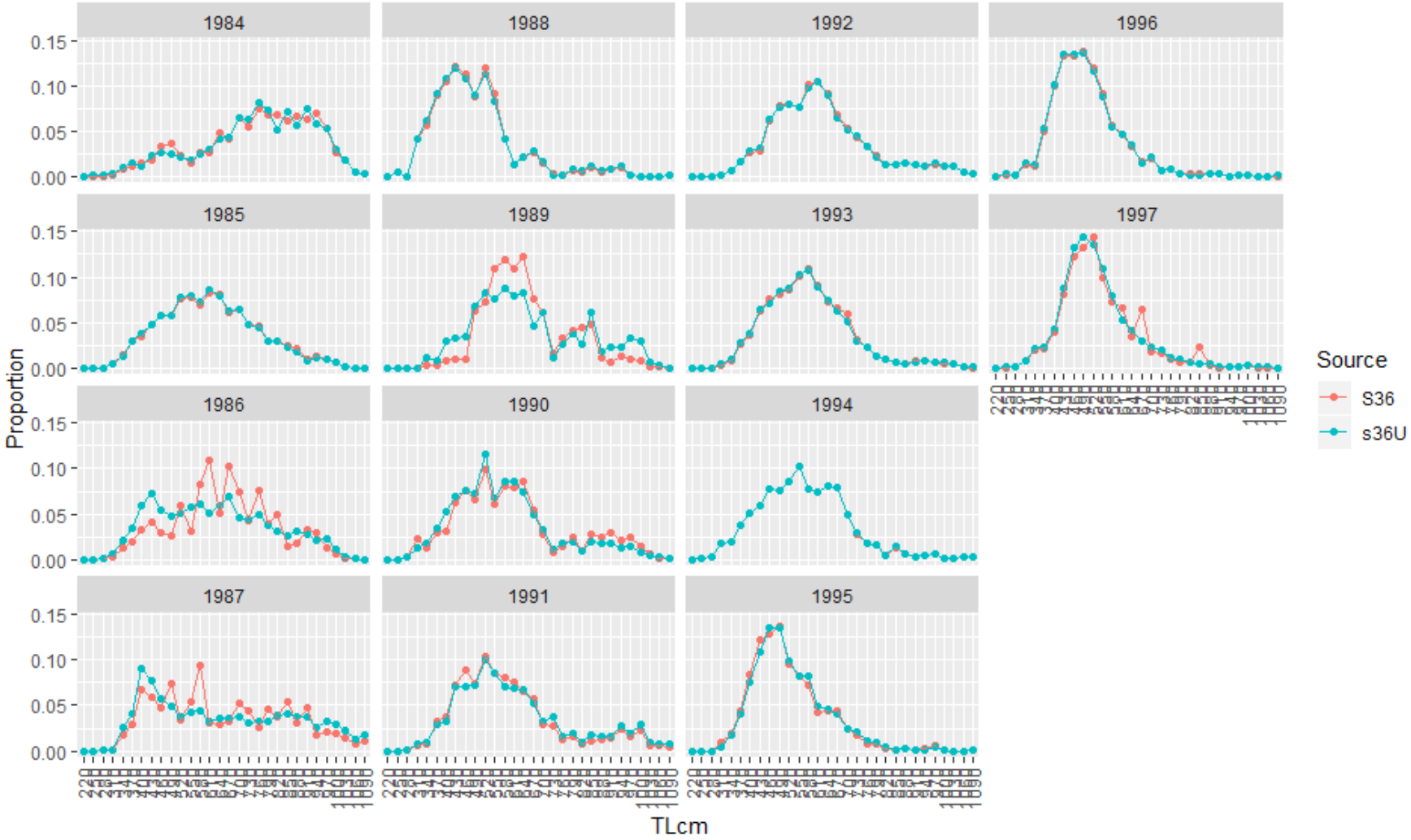
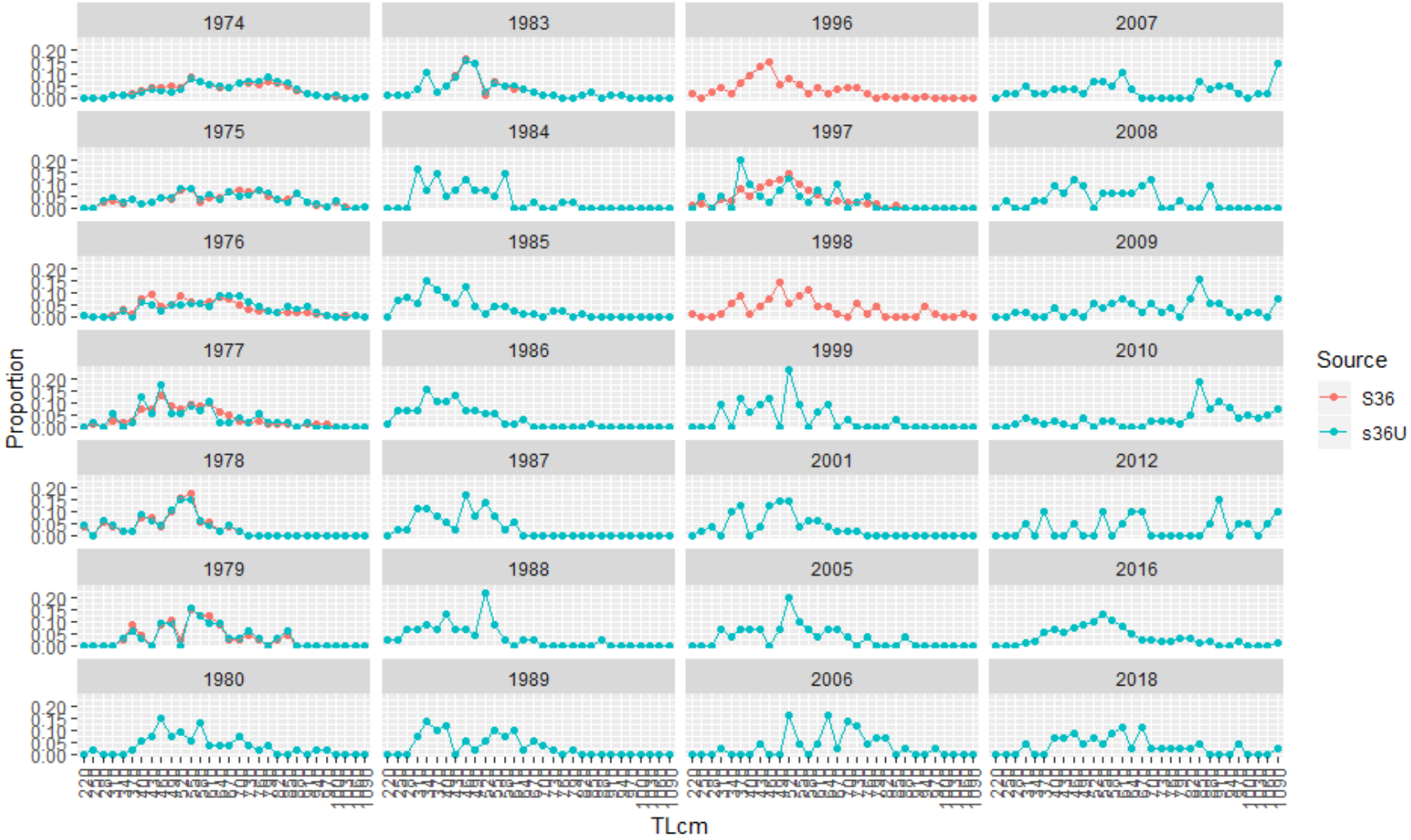
Commercial Handline Length Comp



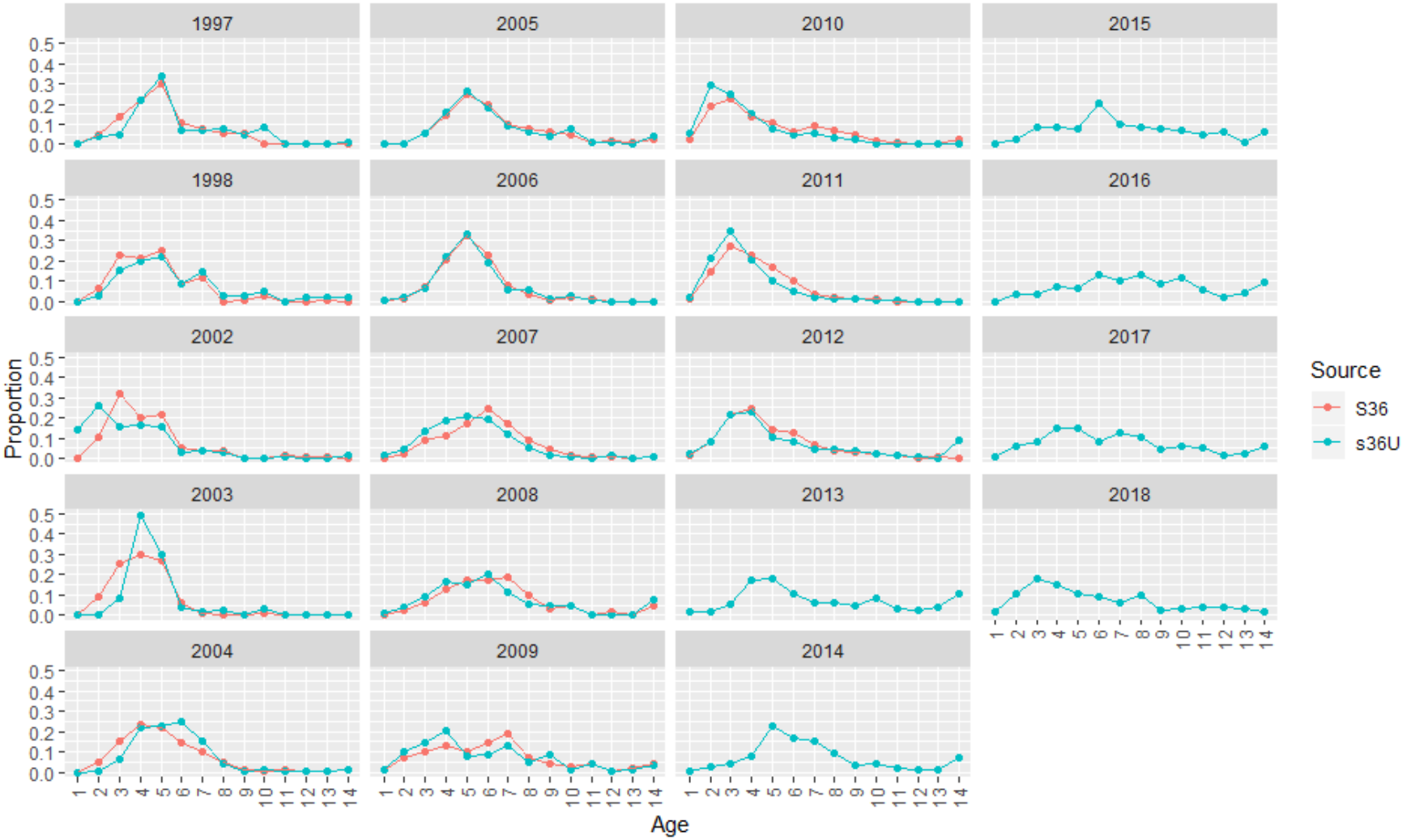
Commercial Longline Length Comp



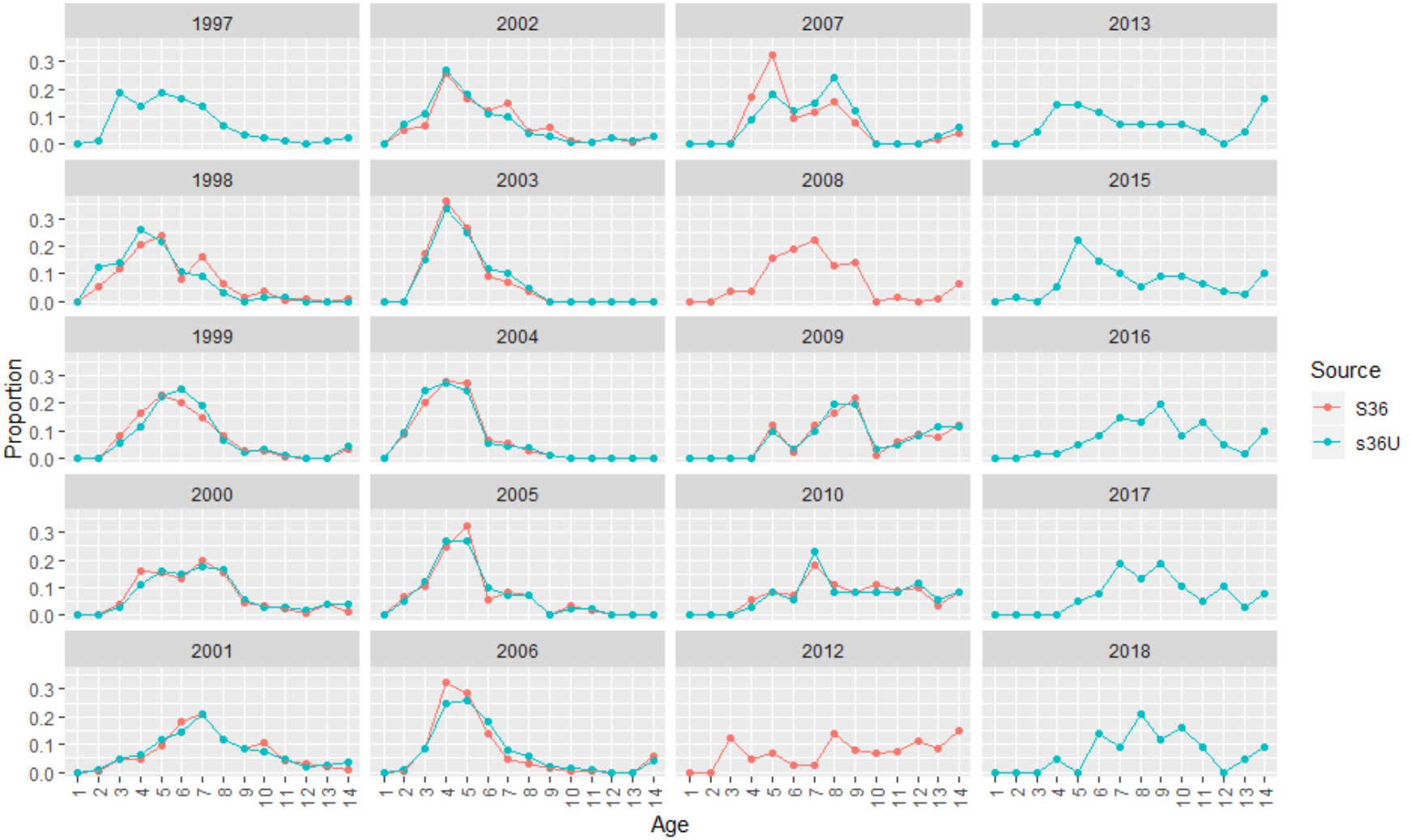
General Recreational Length Comp



Commercial Handline Age Comp

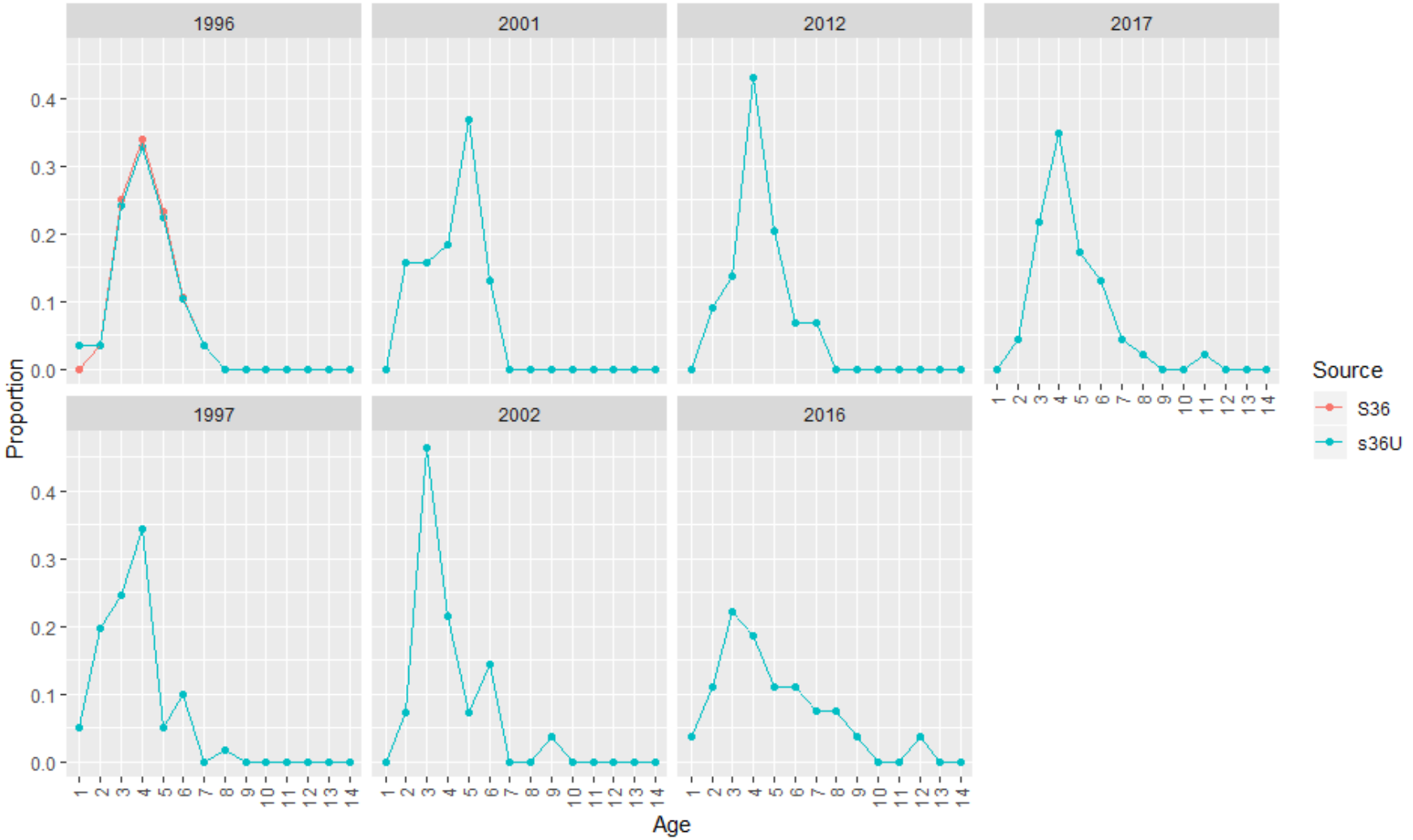


Commercial Longline Age Comp

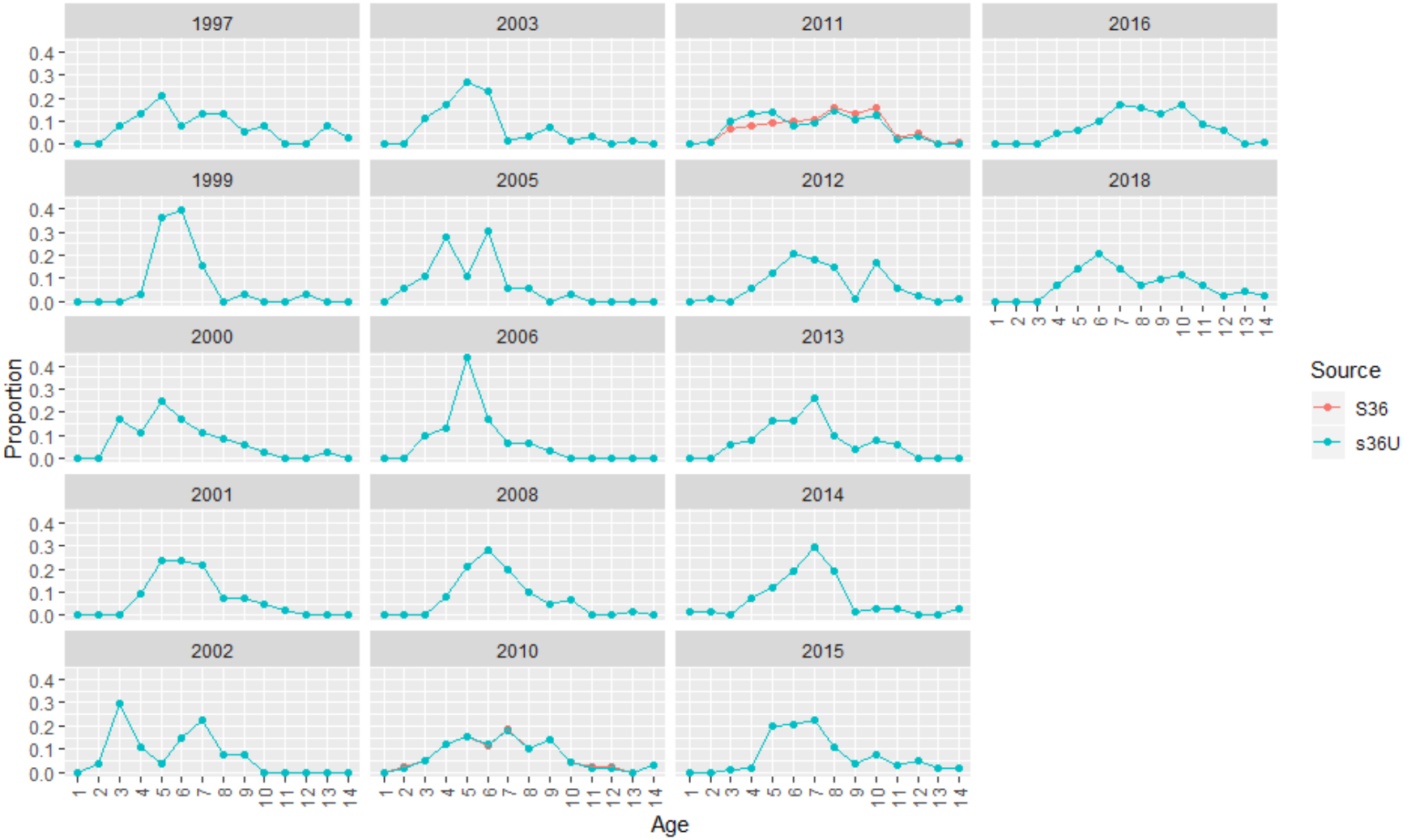


General Recreational Age Comp

MARMAP Chevron Trap Age Comp



MARMAP Vertical Longline Age Comp



Other features, as in SEDAR 36

- Life-history characteristics
  - Length at age (von Bertalanffy growth parameters)
  - Weight at length (power function)
  - Age dependent maturity schedules (male and female)
  - Age dependent sex ratios
- Indices
  - Headboat index unchanged – ends in 2010

Summary of modifications/updates to data

- Six additional years (2013-2018) were added to the end of the time series; start year (1974) unchanged
- Data queries used current methodologies
- Sample size cutoffs (25 fish, 5 trips) for compositions applied by region
- Model-based inputs (commercial discards, indices) were refitted using all relevant data, thus earlier years were subject to modification.
- General recreational fleet represented by latest MRIP methodology. Extremely large 1981 landings excluded as in SEDAR 36.
- Vector of natural mortality at age updated

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BAM: same basic model as in SEDAR36 (1 of 2)

- Catch-age formulation, fit to data using maximum likelihood
- Beverton-Holt spawner recruit model, with lognormal error
- Age-based natural mortality
- Age-based selectivities
  - Logistic (flat-topped) for commercial fleets and MARMAP vll survey
  - Dome-shaped for general recreational and SERFS CVT survey
    - Age at full selectivity fixed
- Baranov catch equation
- Spawning stock based on total mature biomass (males+females)

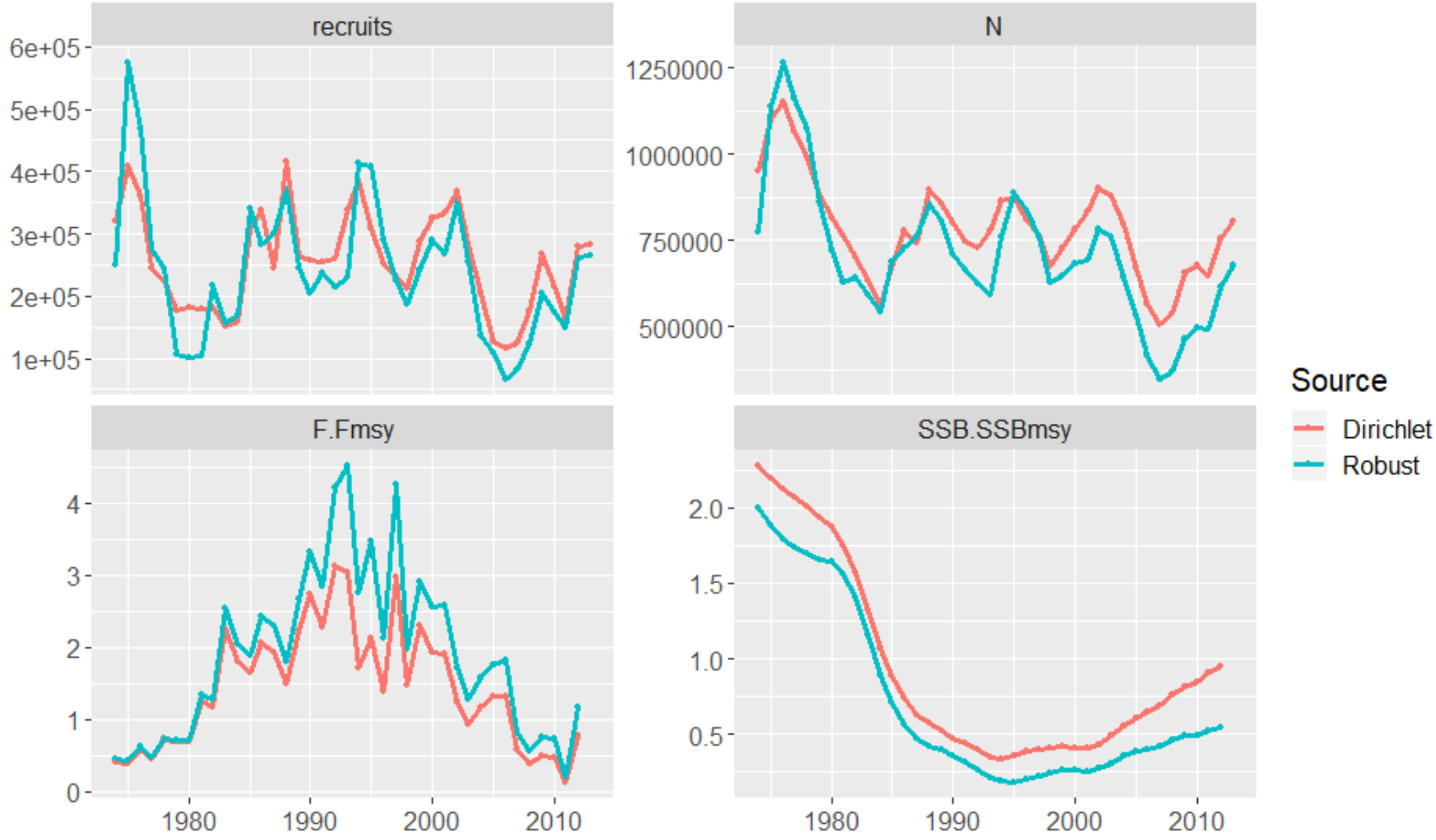
BAM: same basic model as in SEDAR36 (2 of 2)

- Initial age structure in 1974 was estimated
- Recruitment deviations start in 1974
- Ages modeled: 1-25+
- Compositions modeled: 1-14+
- Constant (estimated) CV of size at age
- Uncertainty estimated through Monte/Carlo Bootstrap (MCB) ensemble
- Steepness not estimable, goes to upper bound

Modifications to the SEDAR36 model

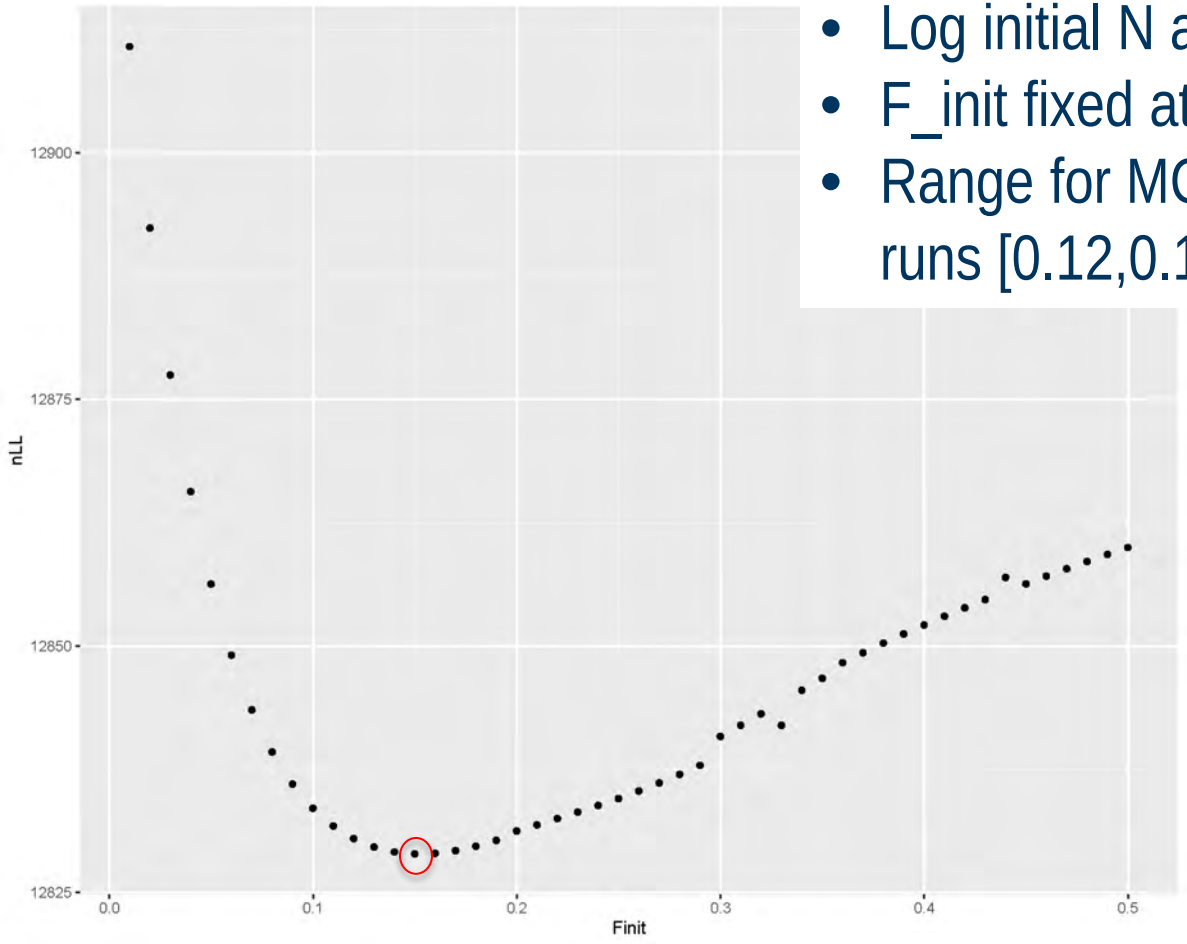
- Latest version of BAM (SEDAR 53)
  - Comp data fit using Dirichlet-multinomial (Robust multinomial used for SEDAR 36)
    - Better accounts for correlation in sampling
    - Self-weighting (no need for iterative reweighting the comps' likelihoods)
    - Allows for zeros in the data

Effect multinomial ⟶ Dirichlet-multinomial (S36 data, S36U model)



Likelihood profile – F_init (evaluate value and range for sensitivities)

- Large plus group in estimated age comps with F_init fixed at S36 value of 0.03
- Log initial N at age deviations all negative
- F_init fixed at 0.15 for base run
- Range for MCB ensemble and sensitivity runs [0.12,0.19] based on +- 2 AIC units



Finit	nLL	deltaAIC
0.1	12834	9.24
0.11	12832	5.64
0.12	12830	3.08
0.13	12830	1.38
0.14	12829	0.38
0.15	12829	
0.16	12829	0.1
0.17	12829	0.64
0.18	12830	1.54
0.19	12830	2.72
0.2	12831	4.62

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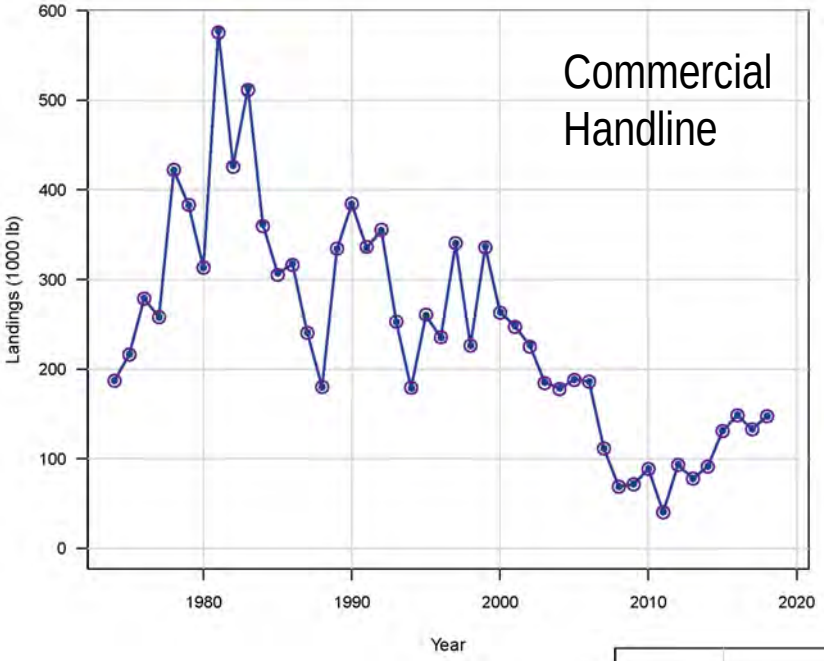
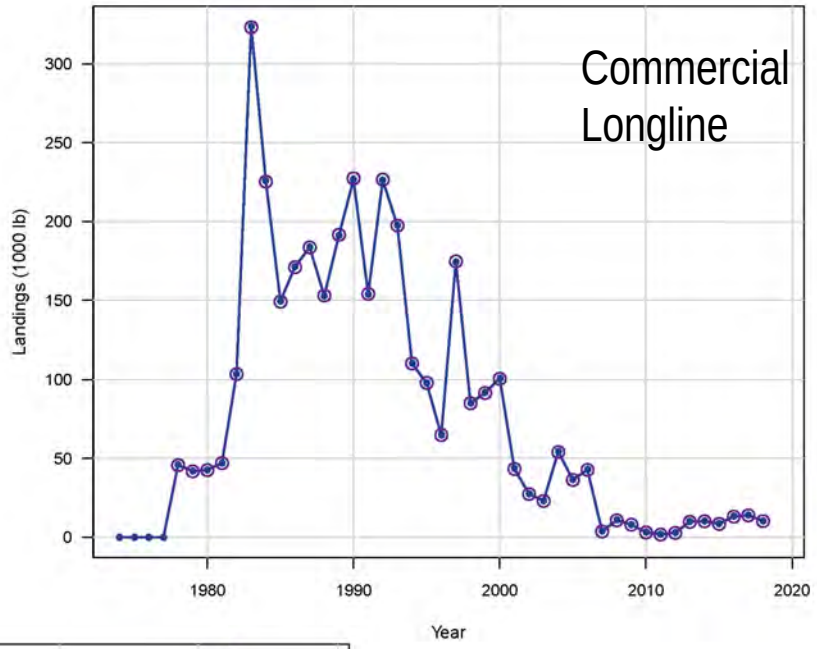
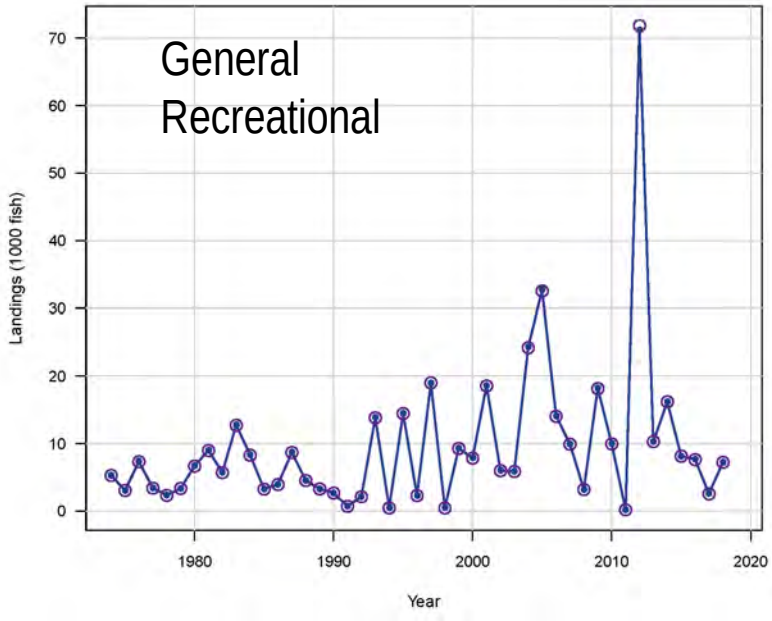
BAM base run – fits to data







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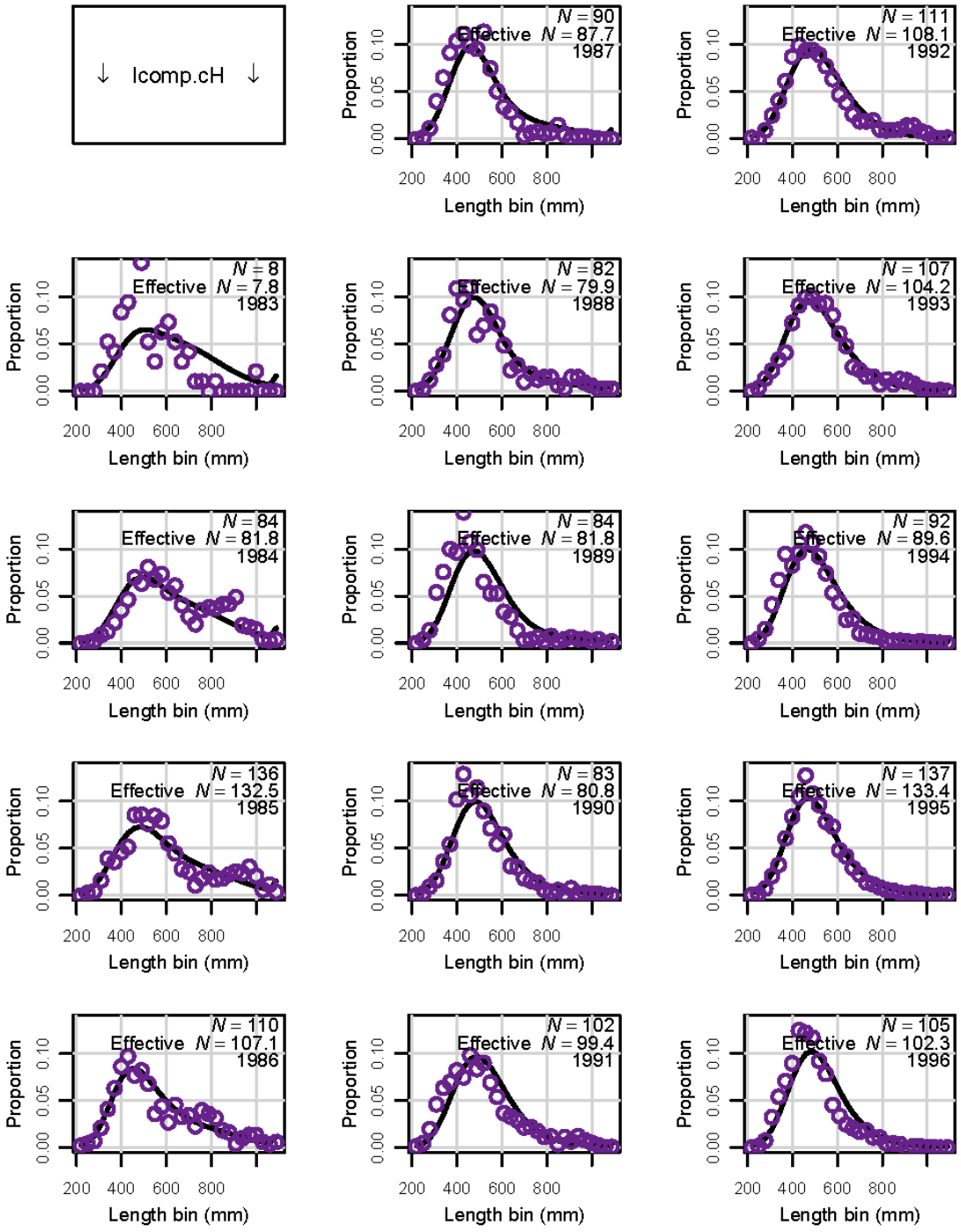

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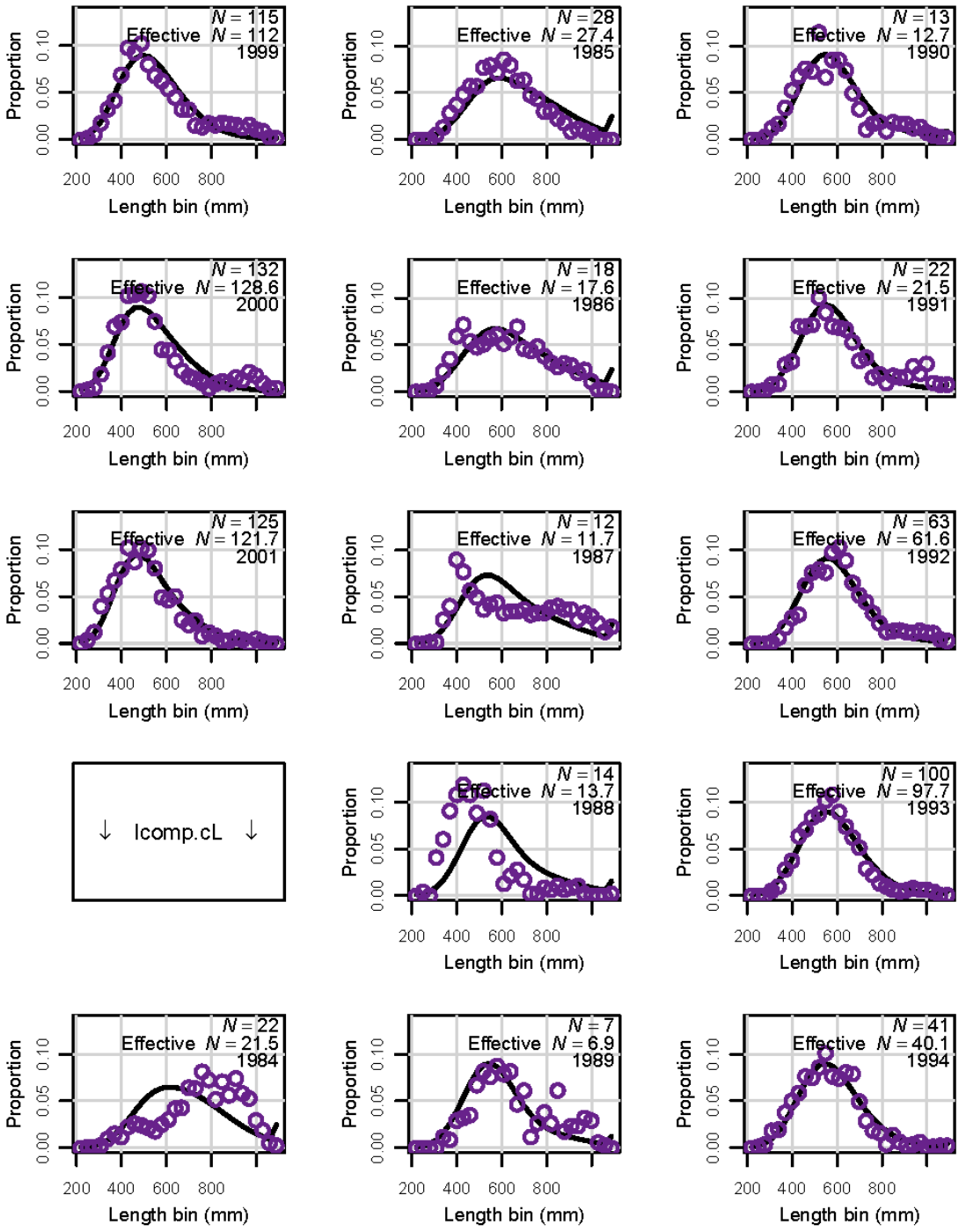

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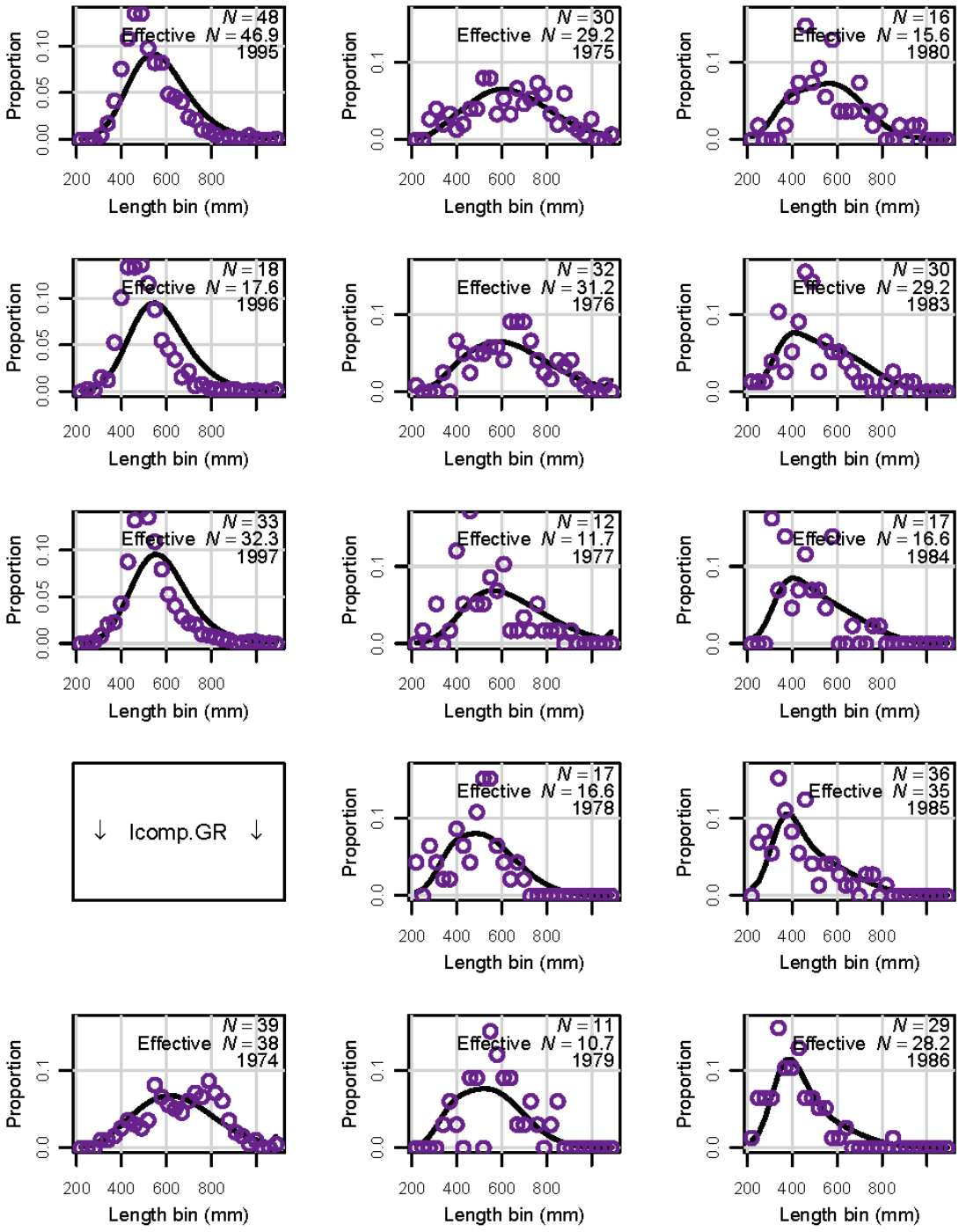

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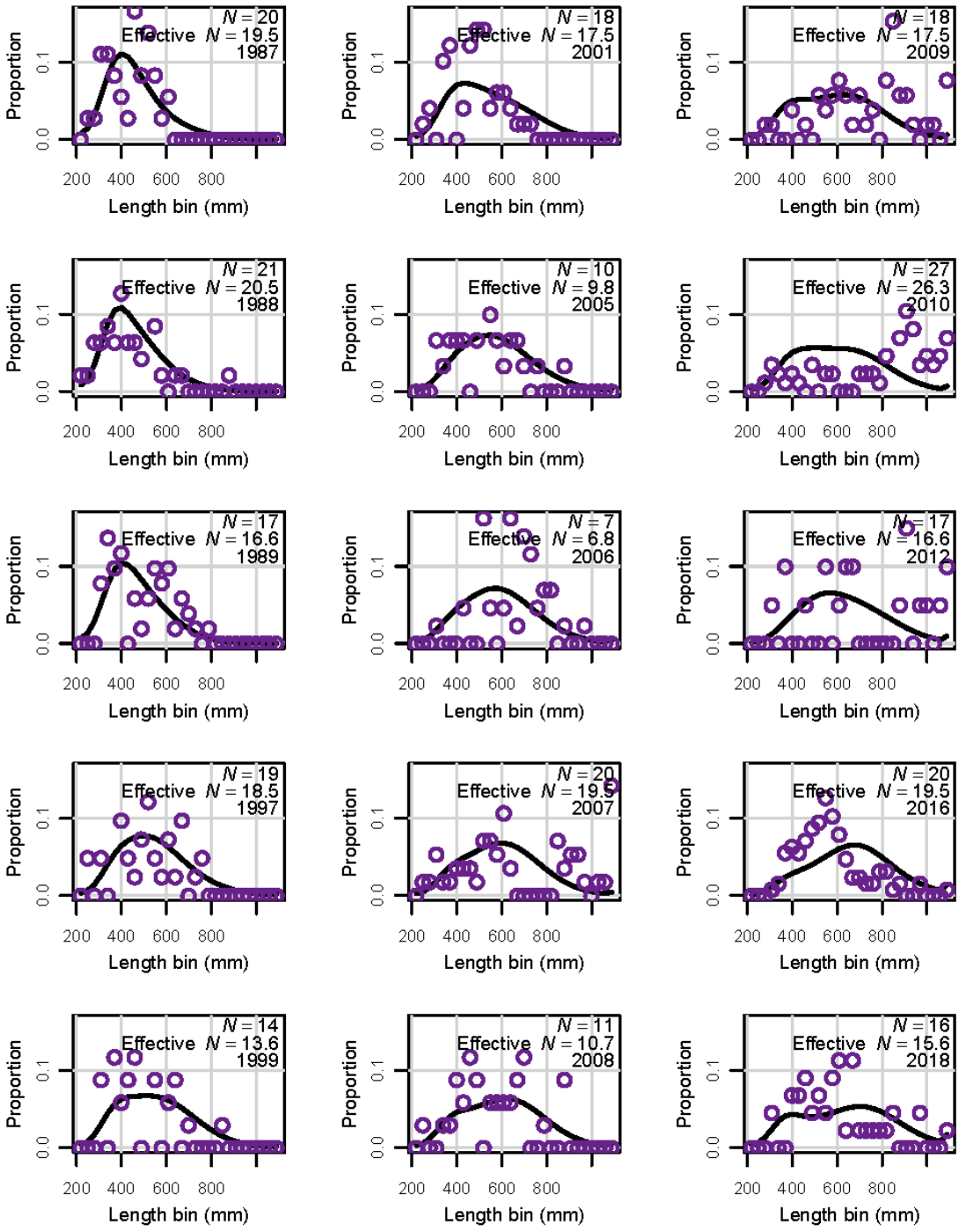

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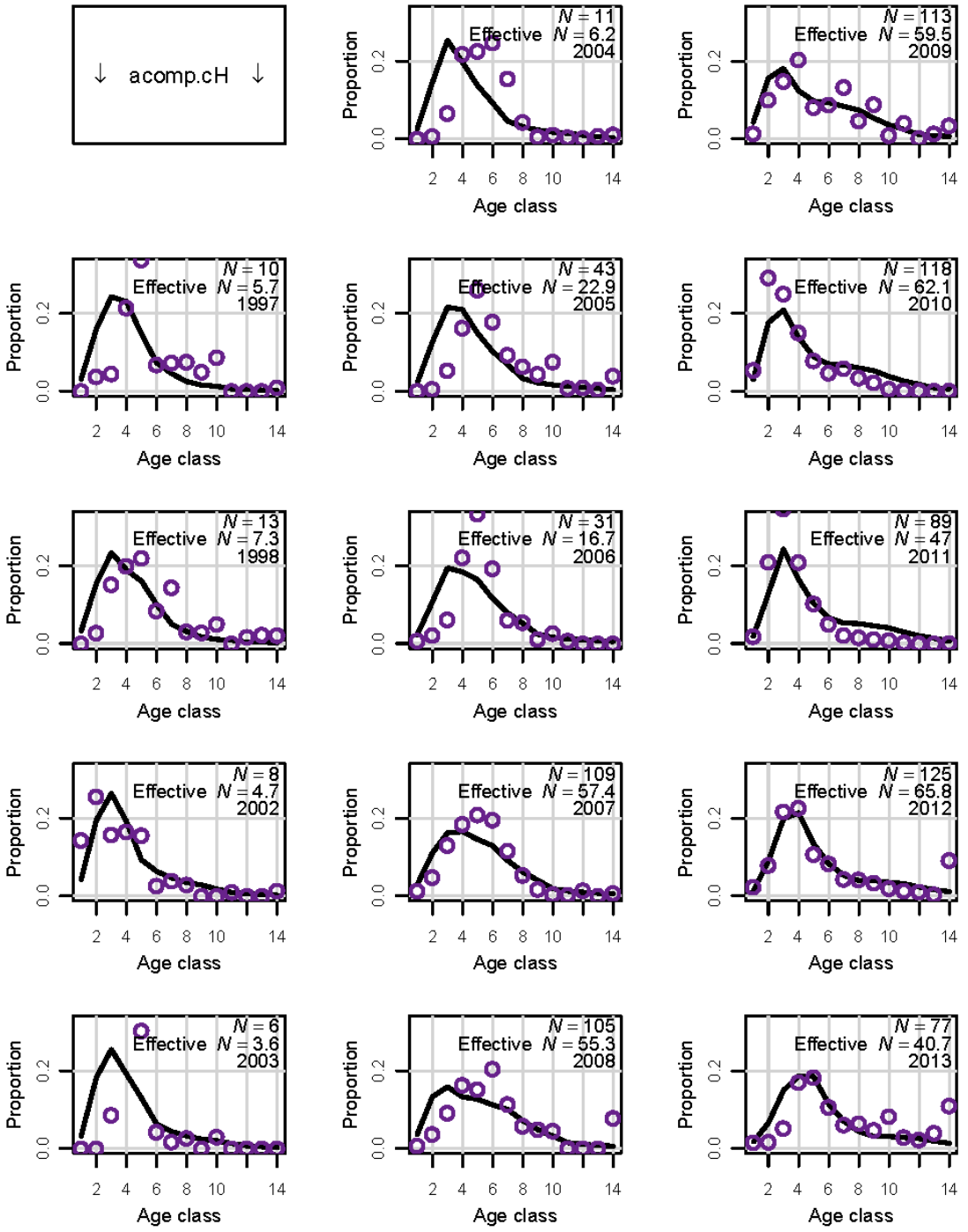

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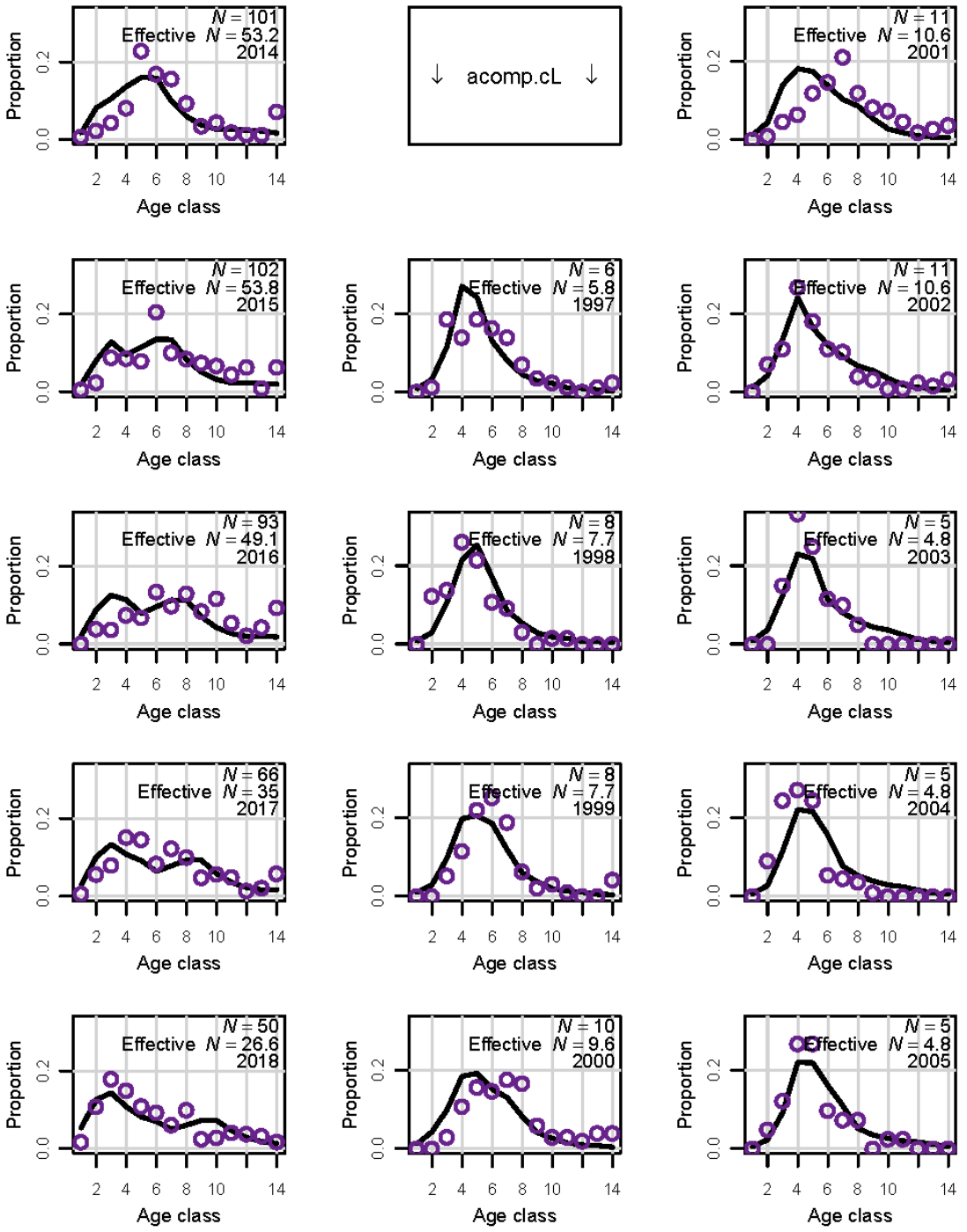

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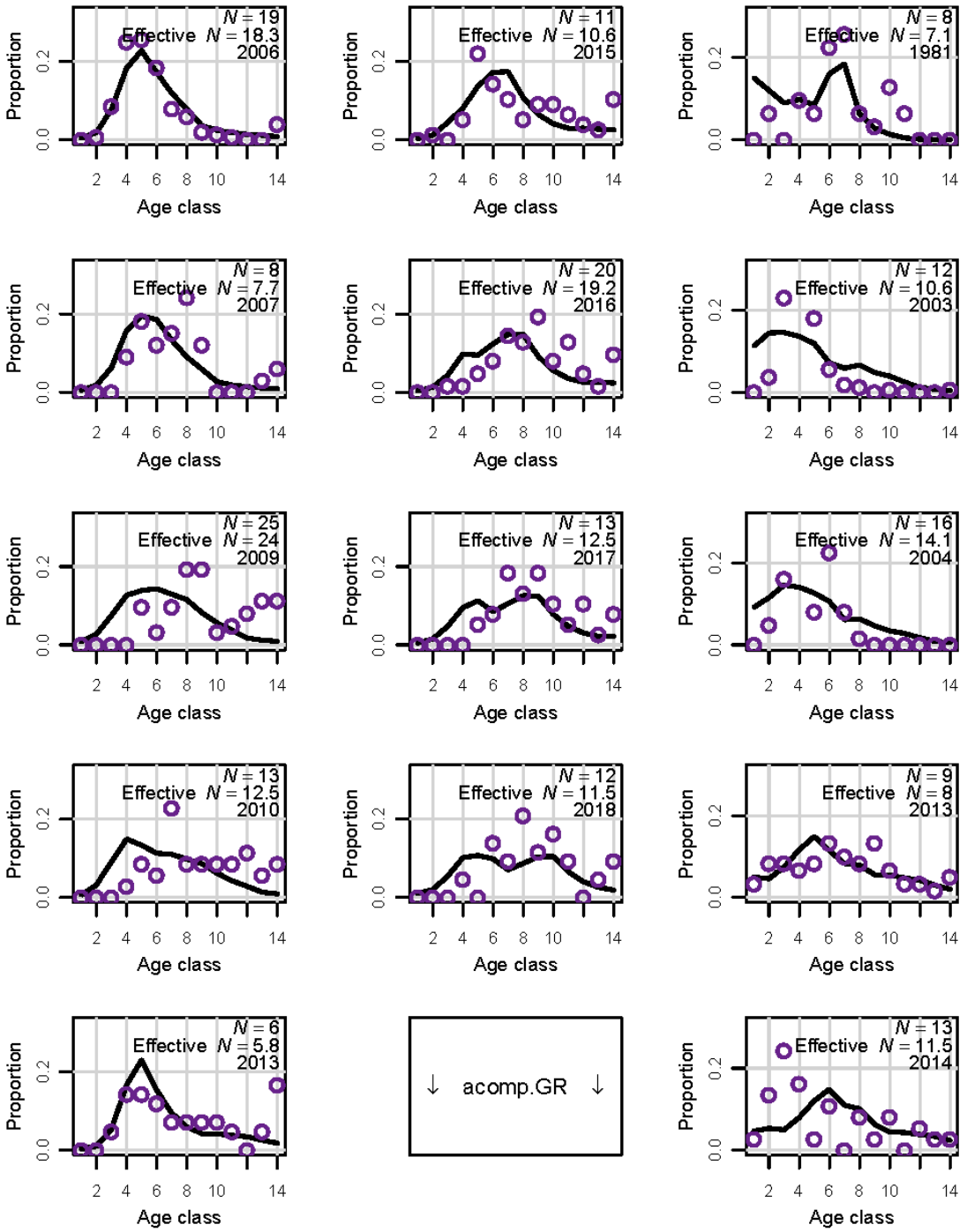

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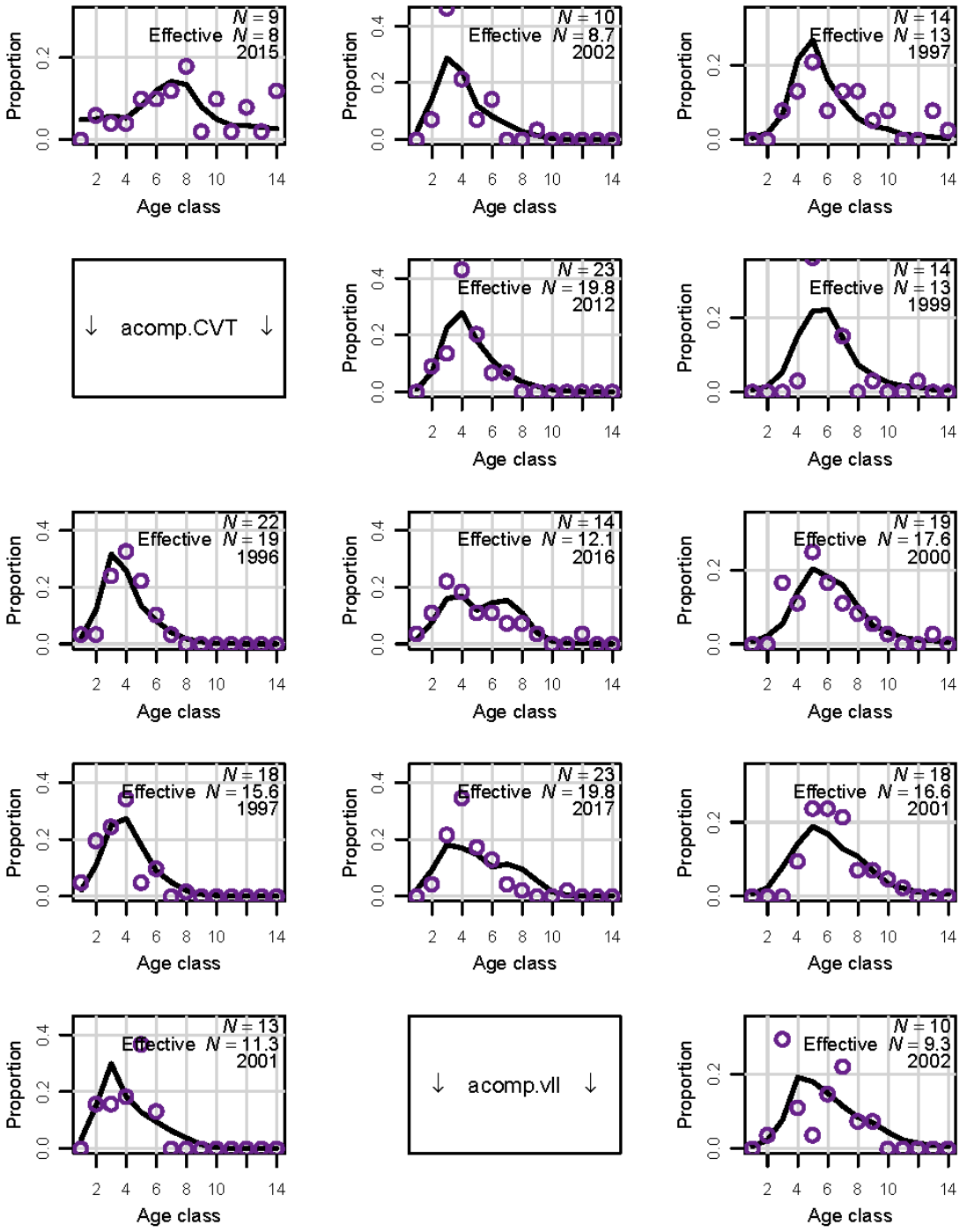
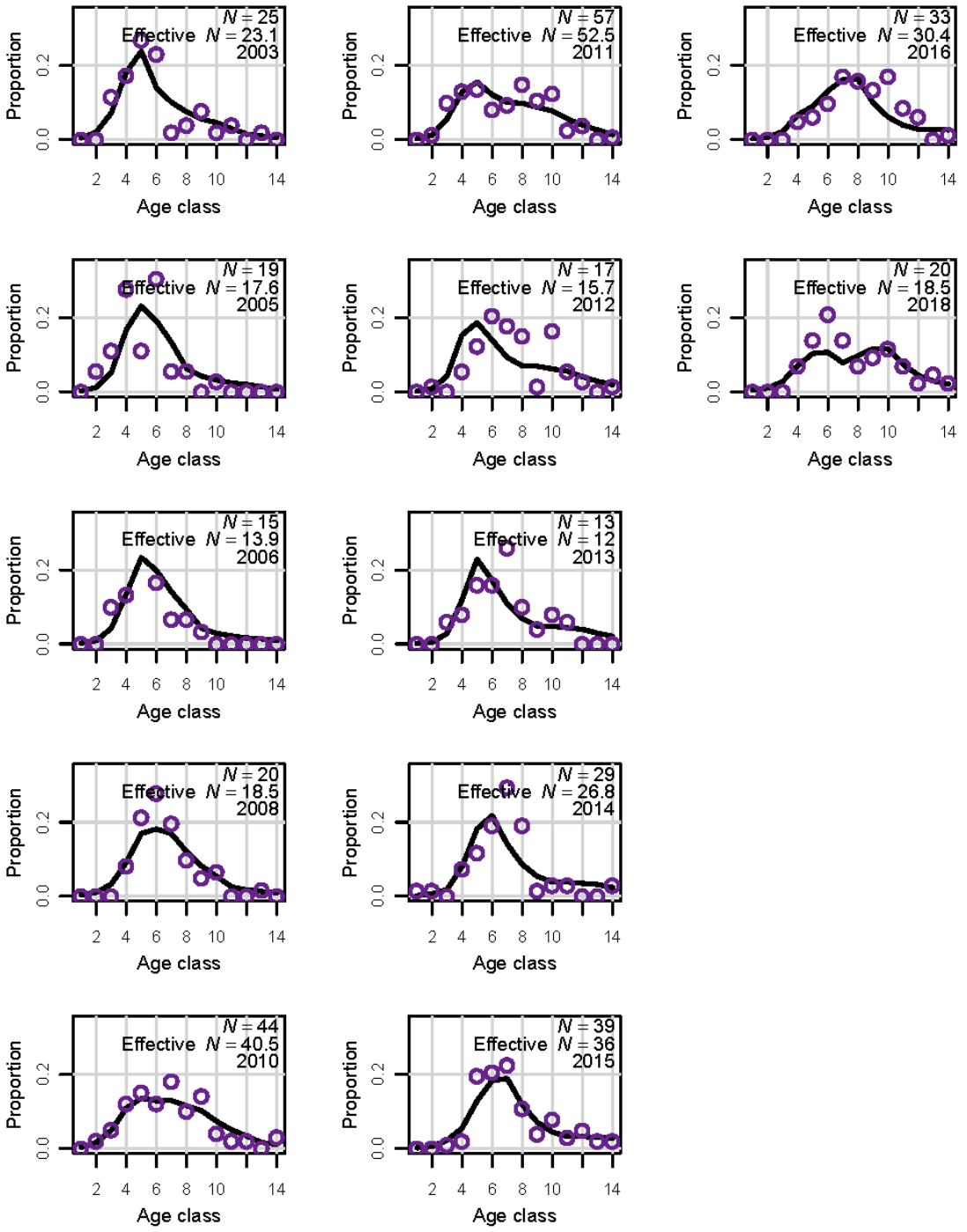


BAM base run – fits to data



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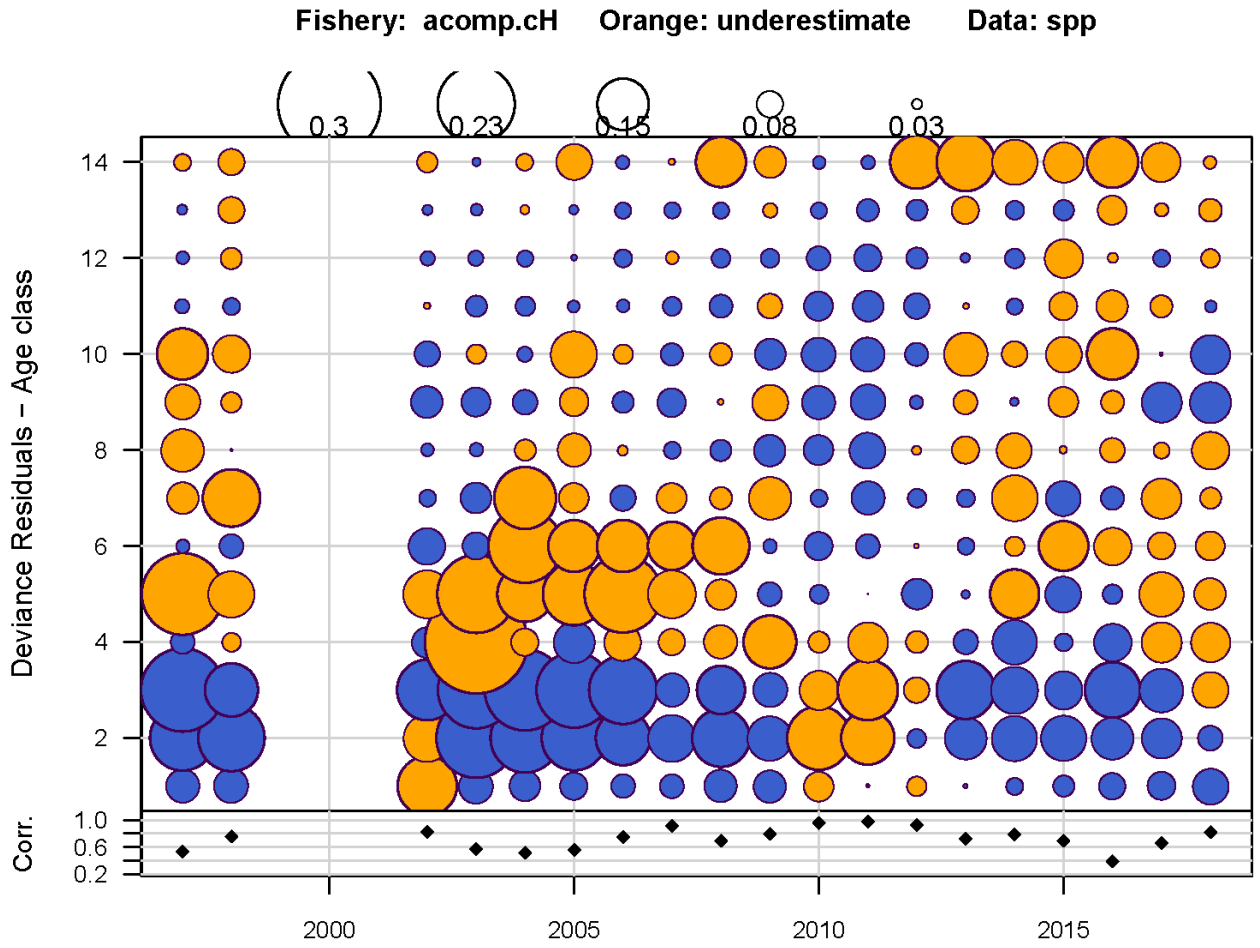

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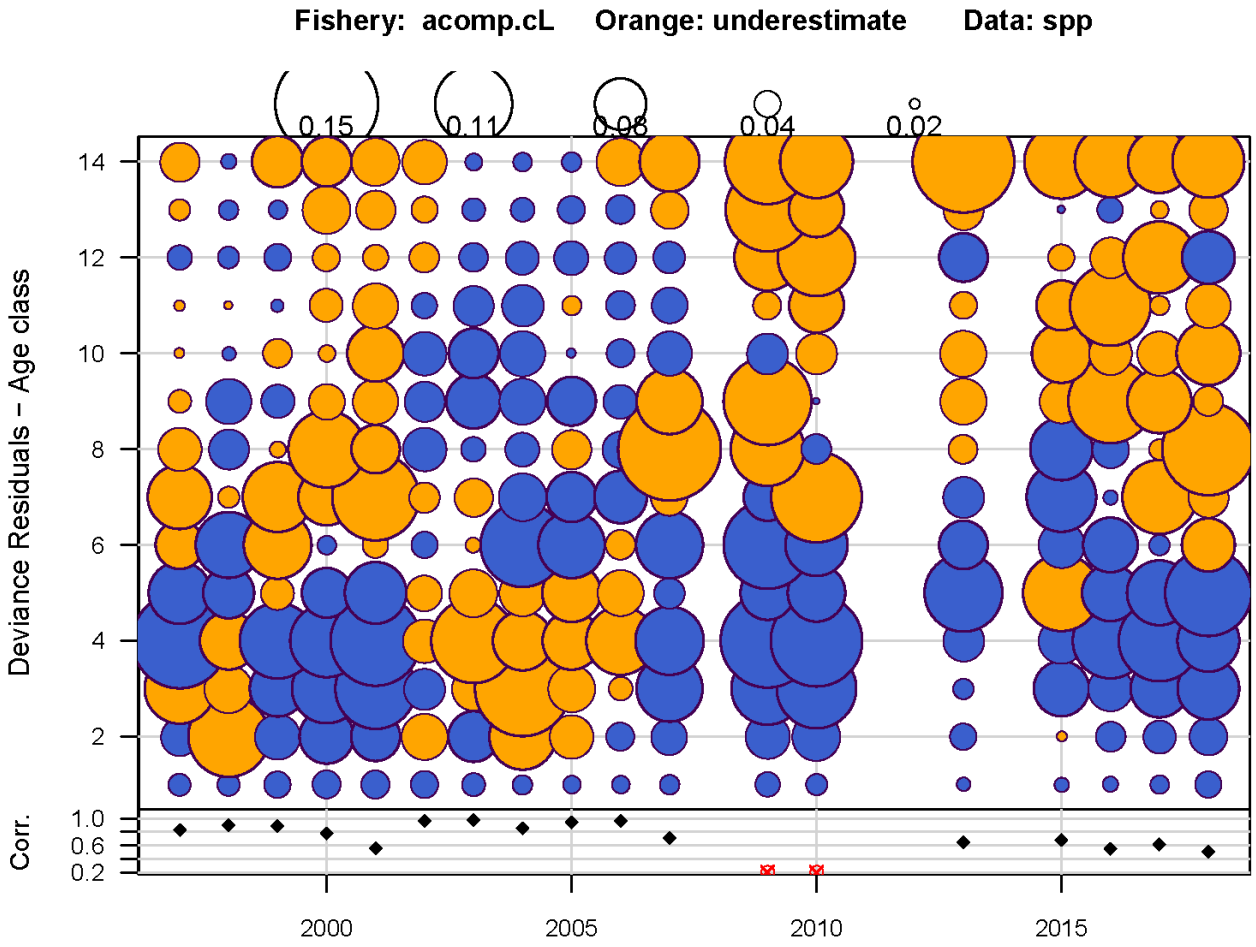

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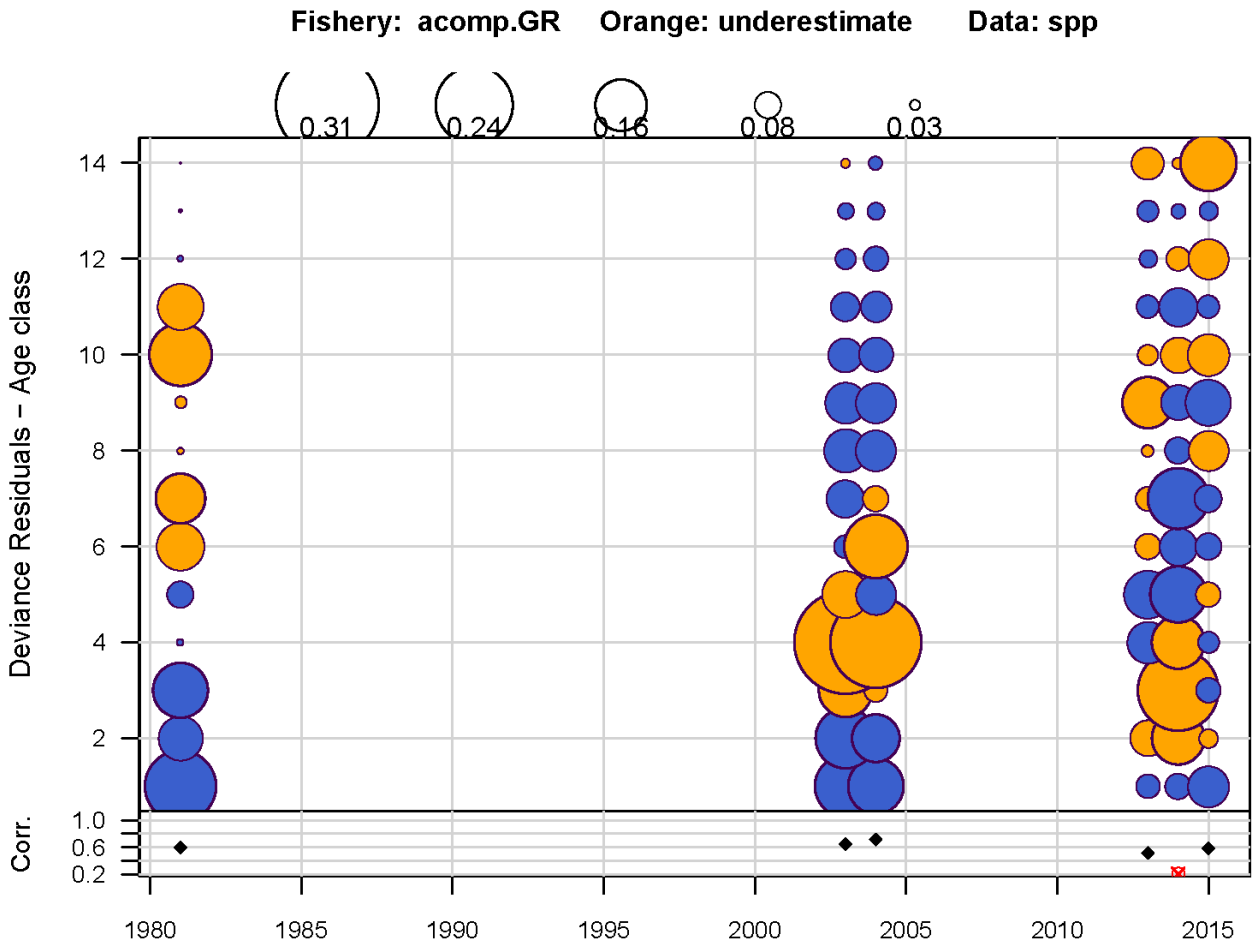

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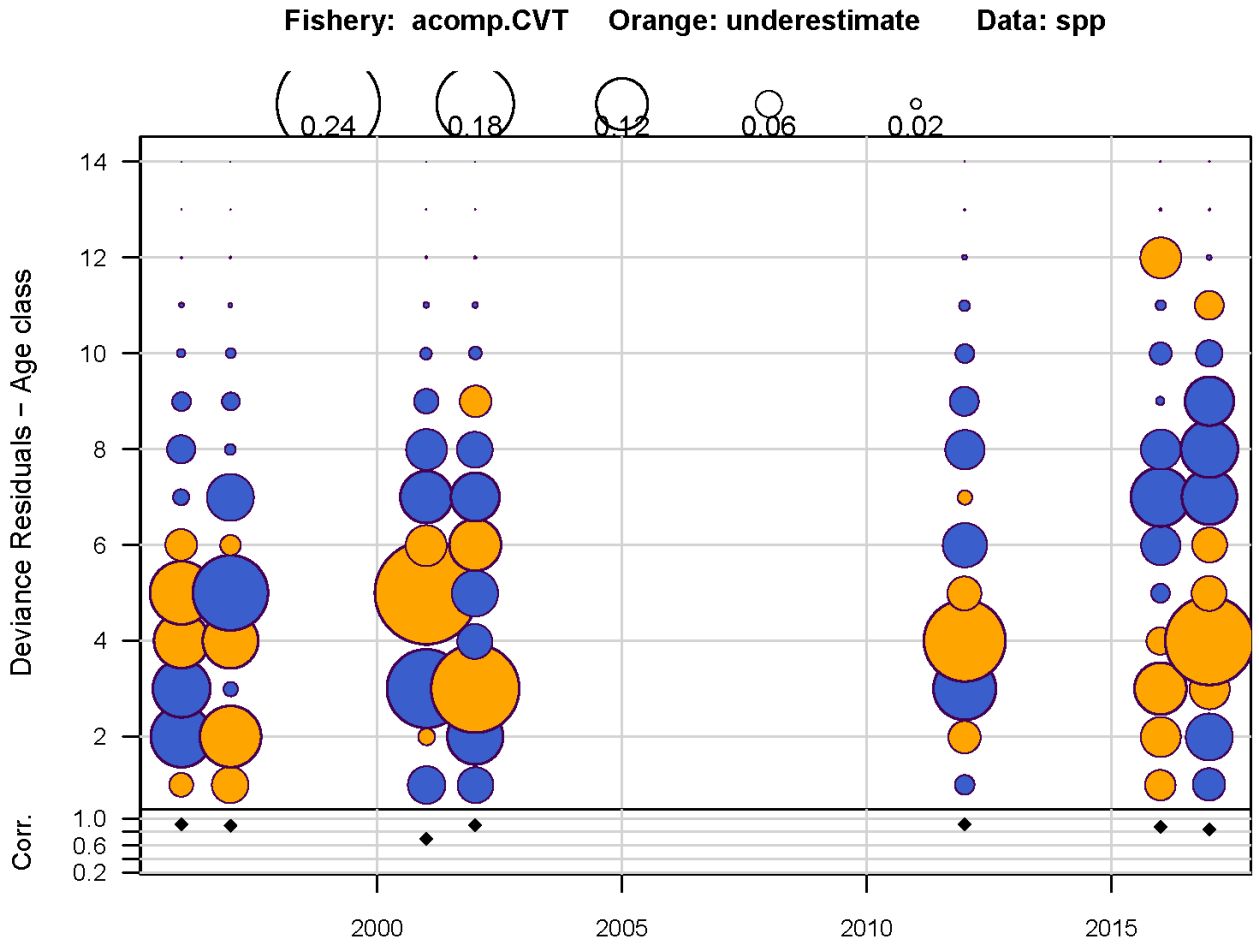

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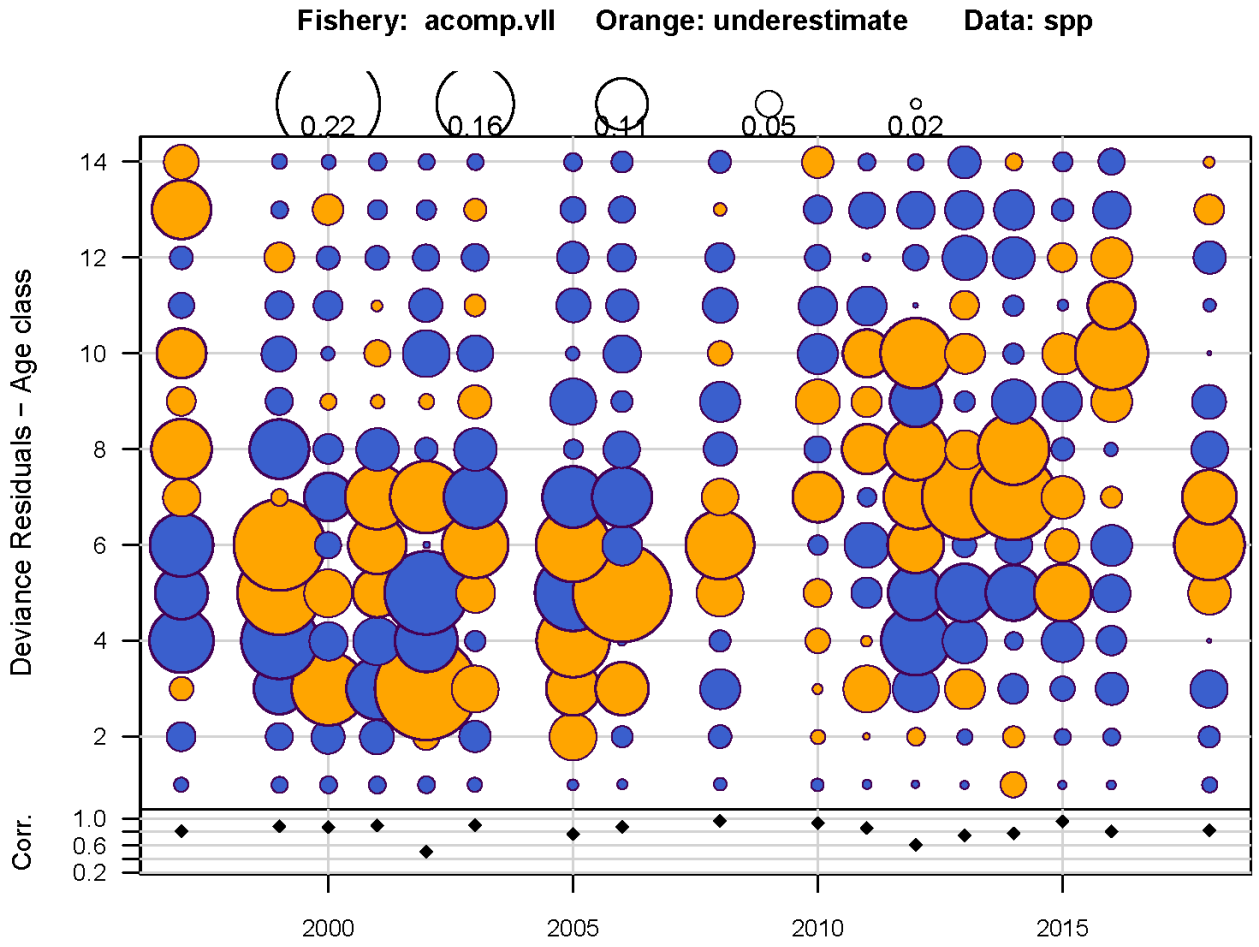

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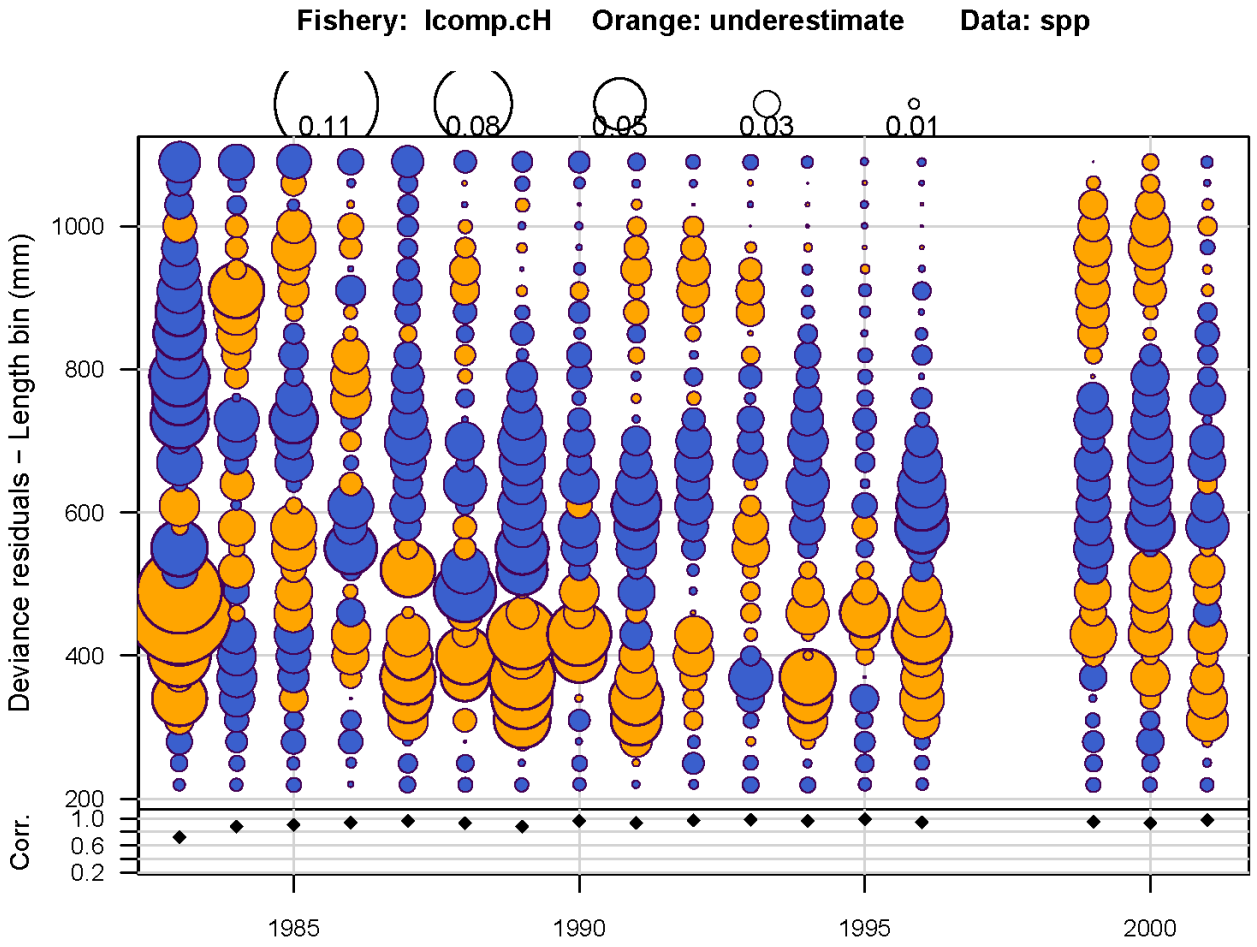

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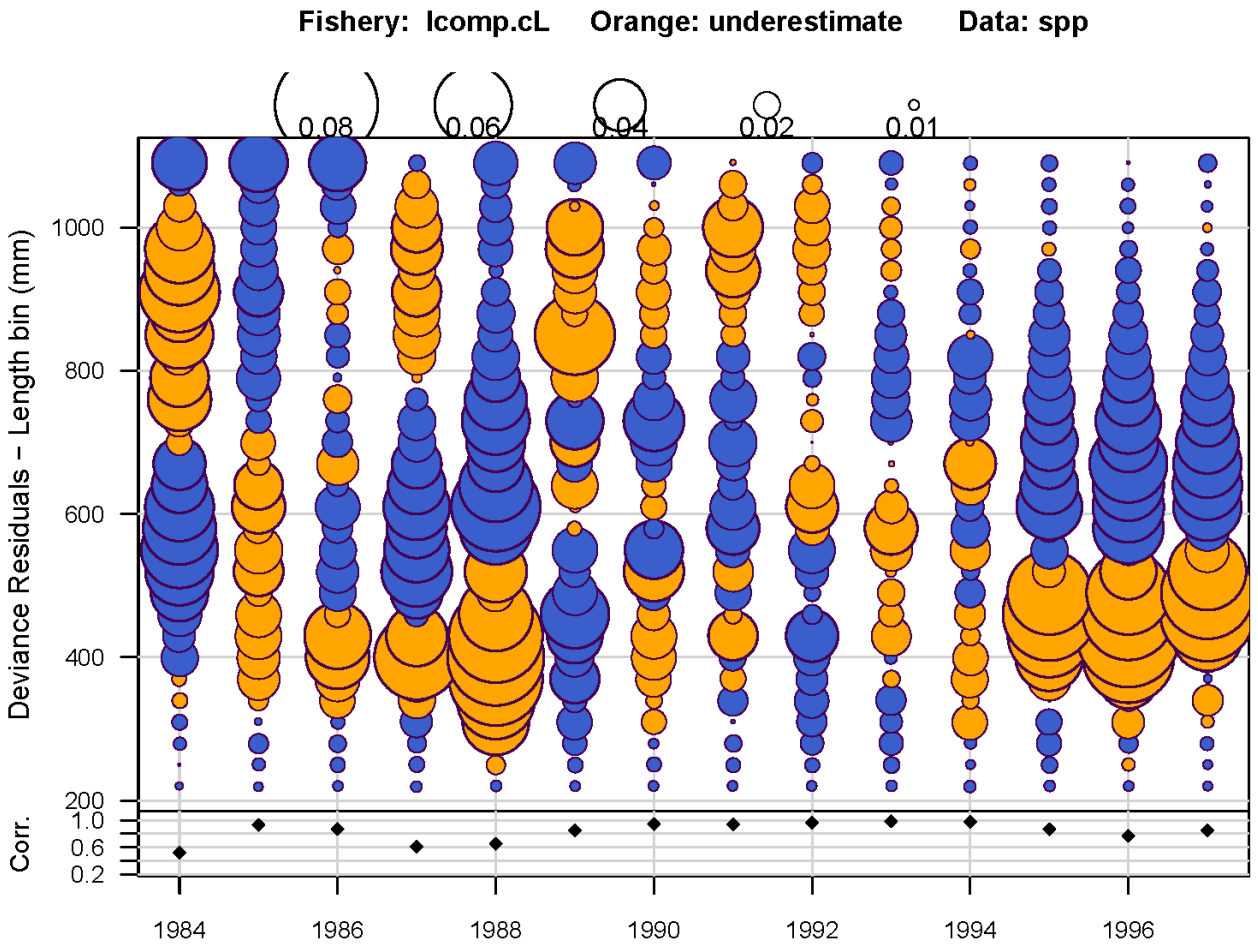

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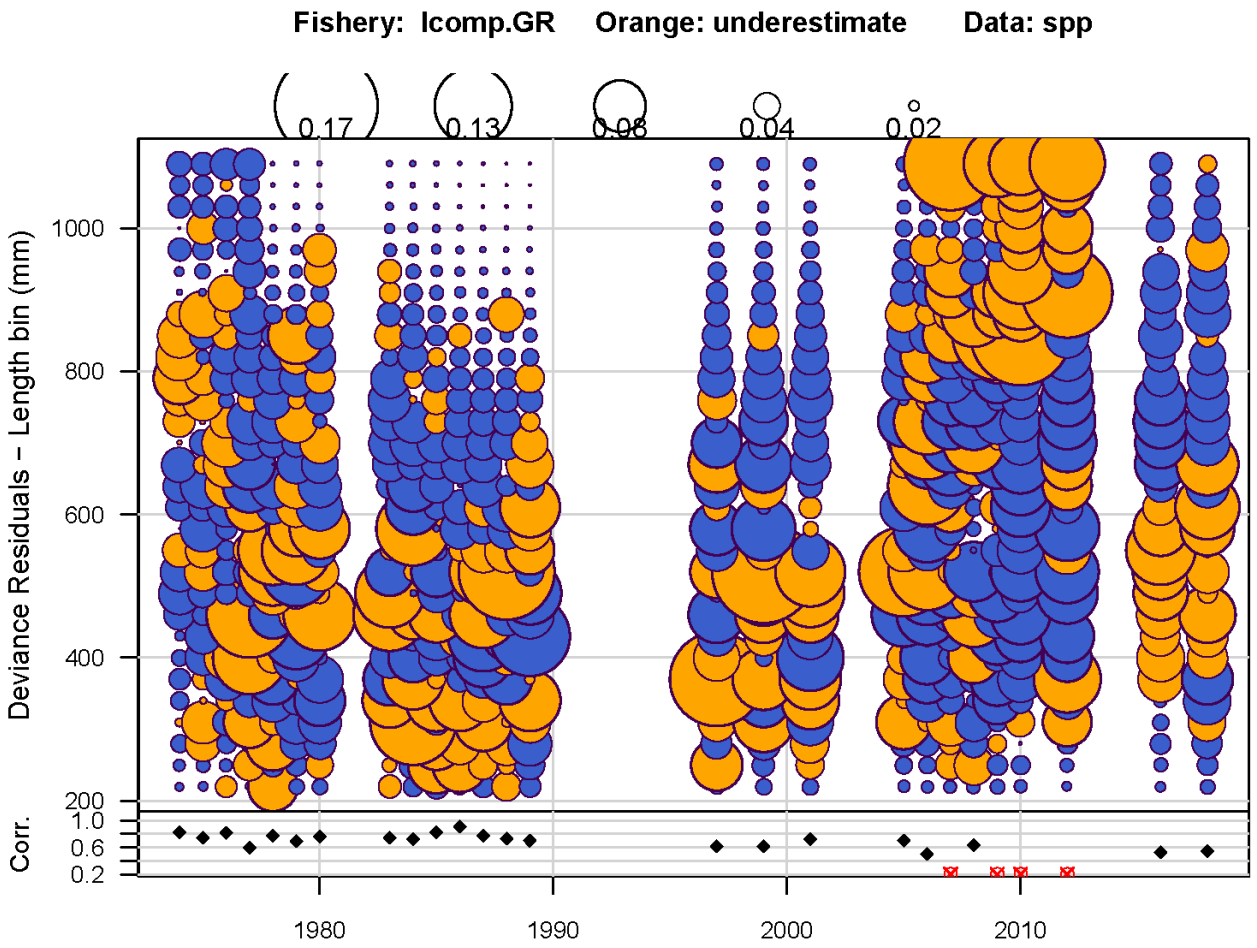
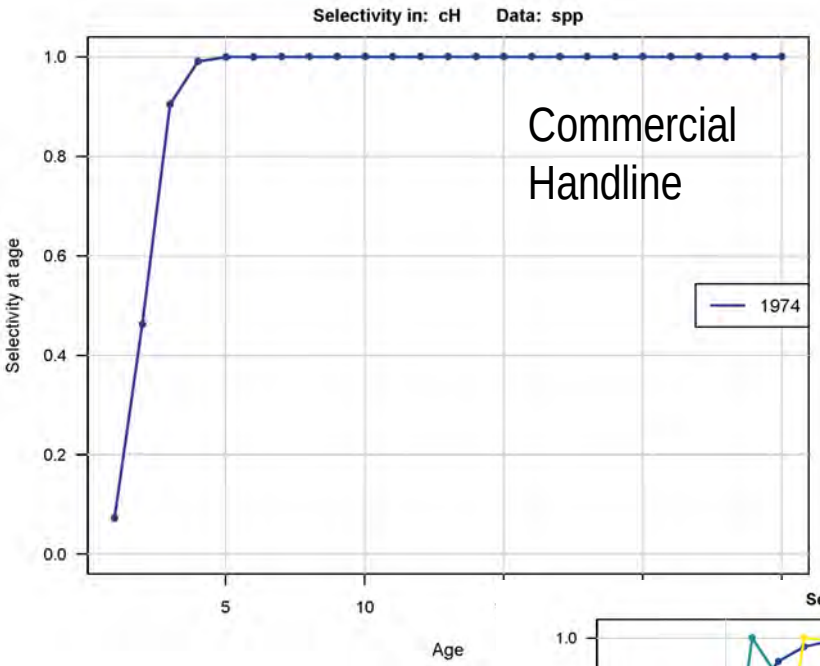
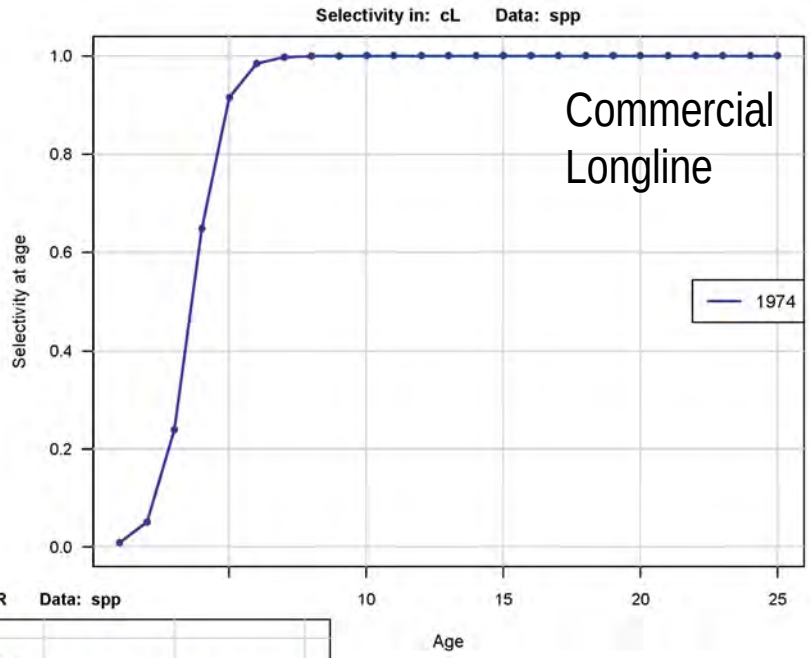


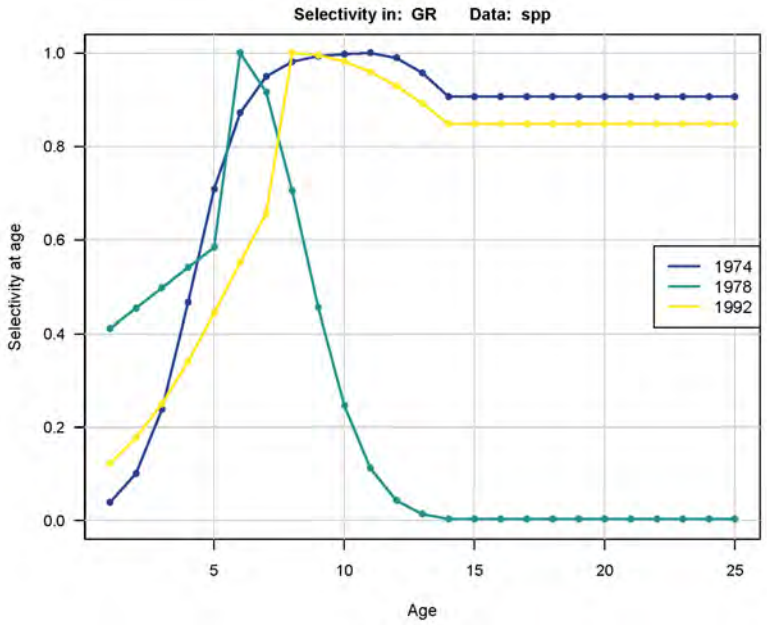
BAM base run – fits to data

Selectivity year = block start year





General Recreational



BAM base run – fits to data

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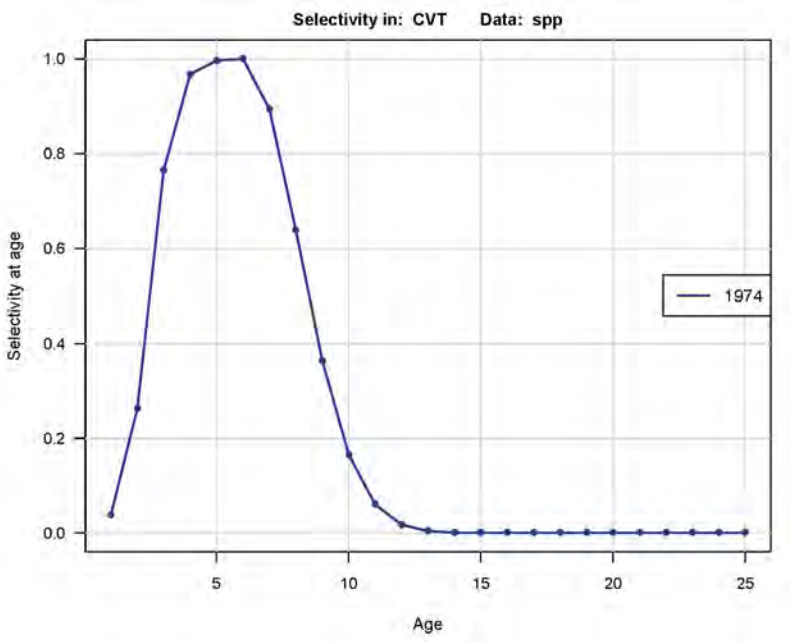
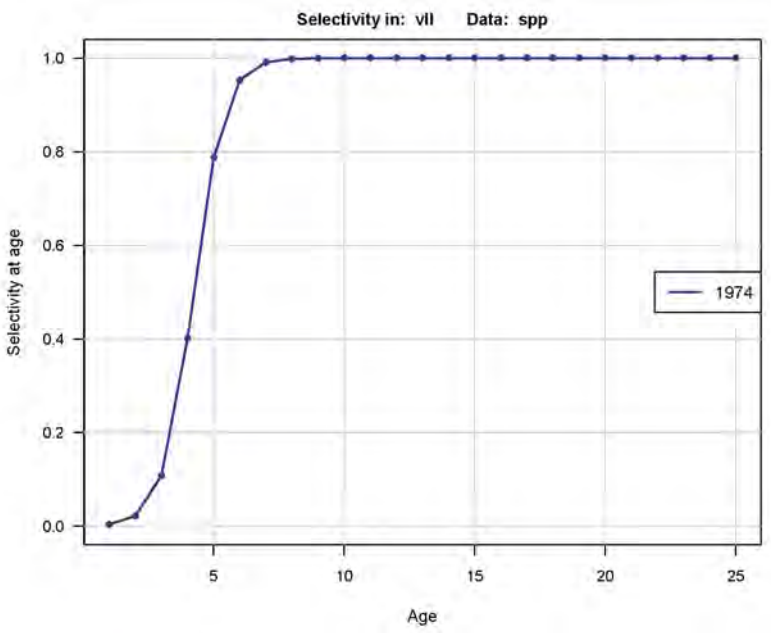
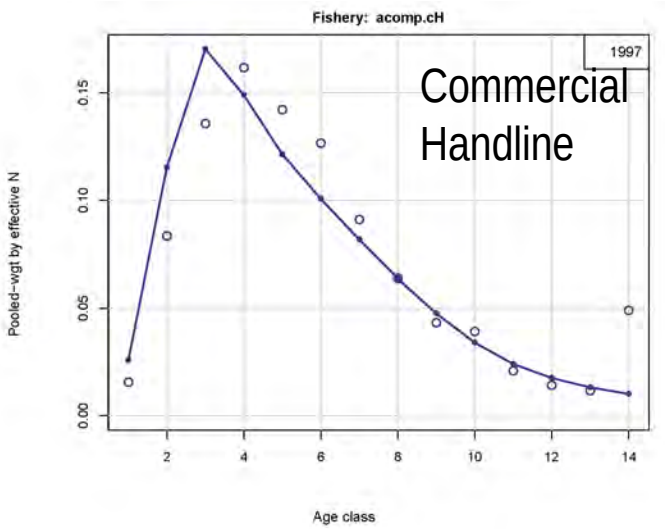
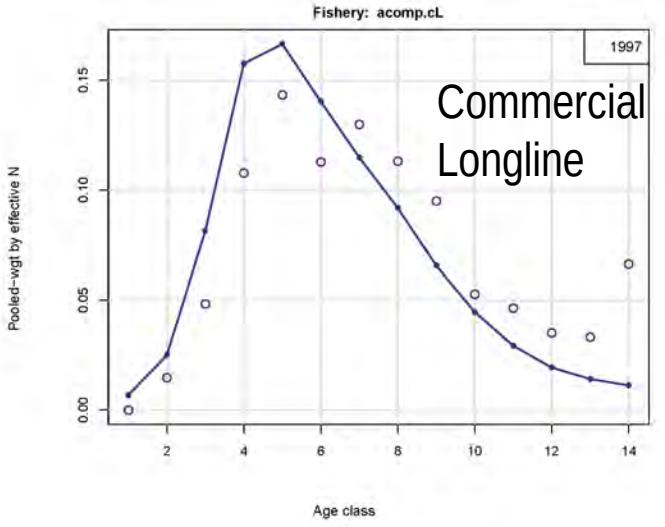


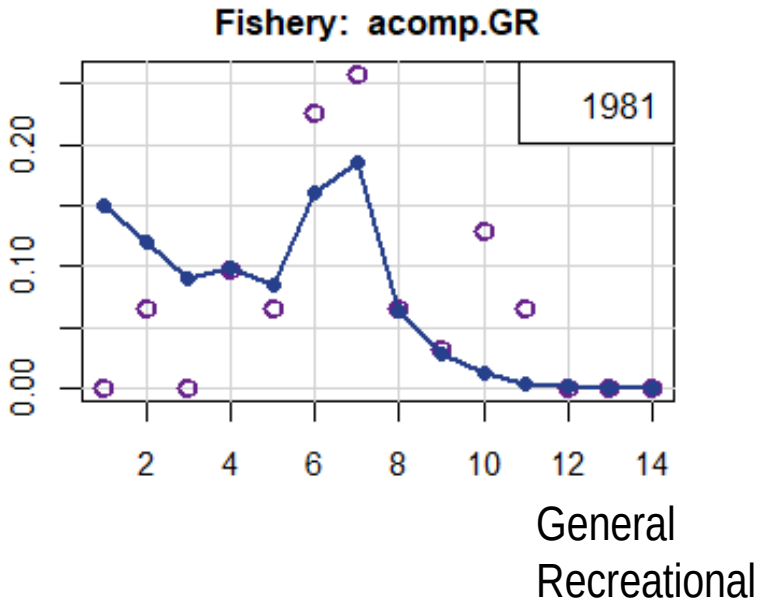


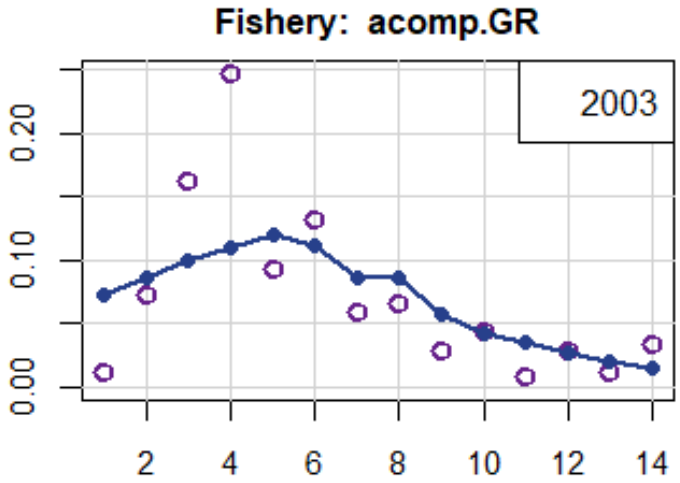
BAM base run – fits to data

Composition year = first year of comps within block







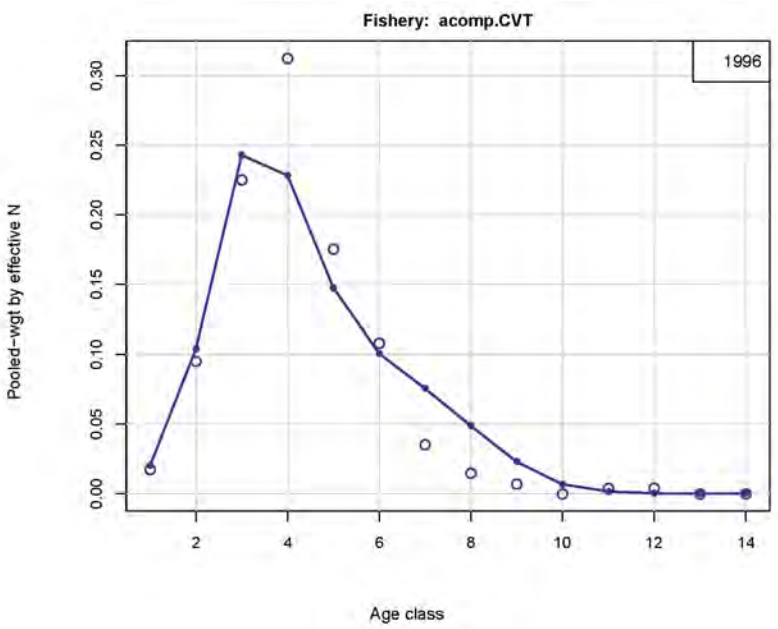


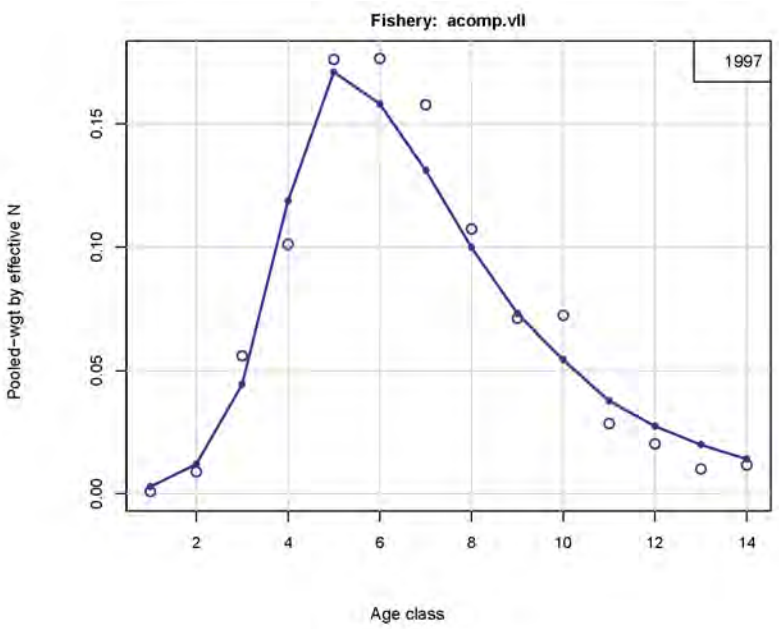
Pooled-wgt by effective N

Age class

BAM base run – fits to data

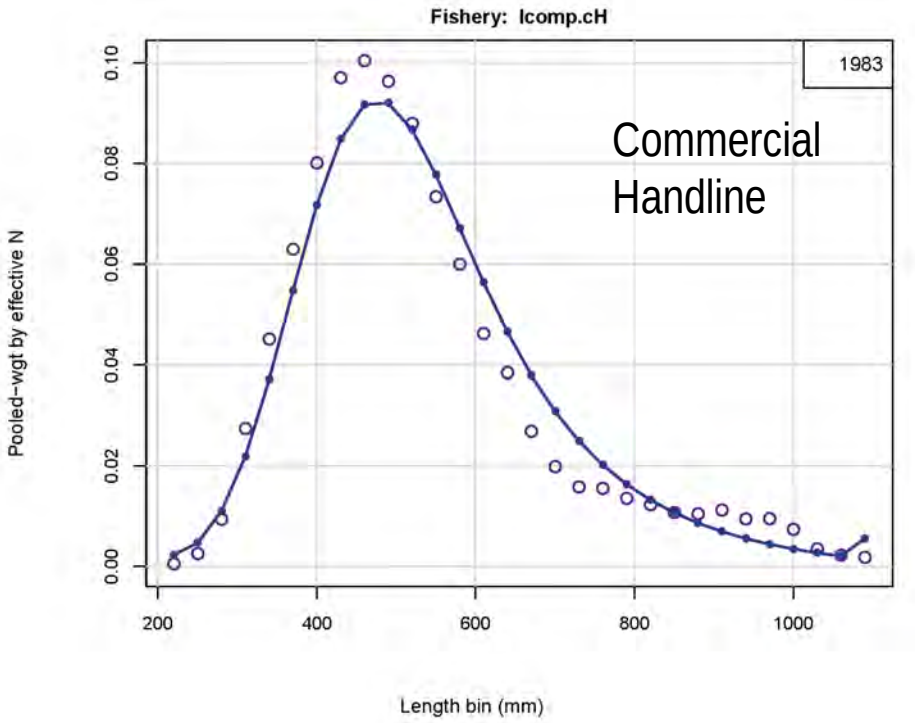
Composition year = first year of comps within block

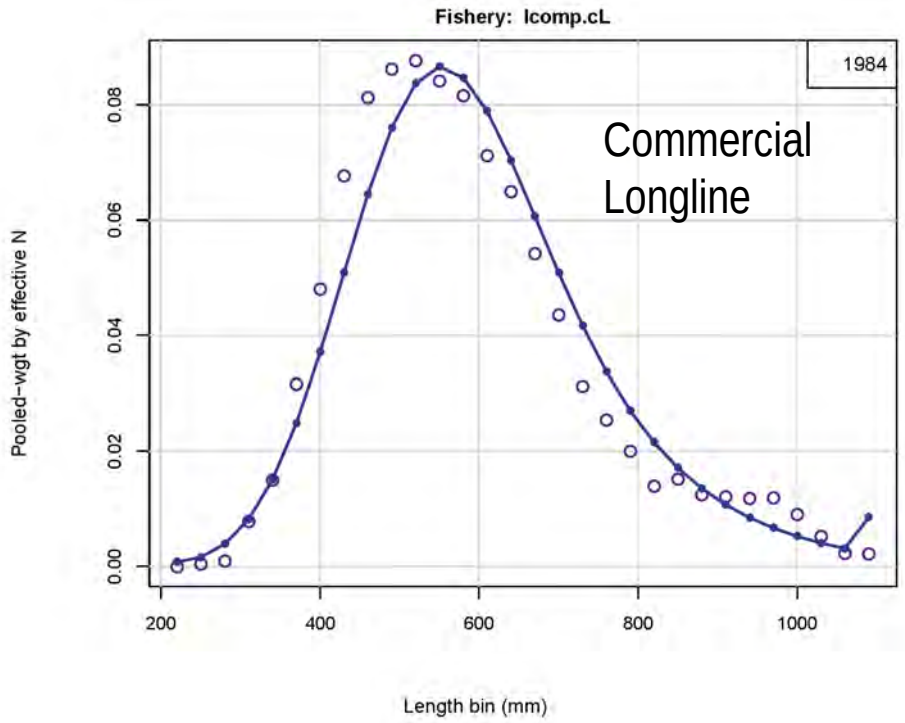




BAM base run – fits to data

Composition year = first year of comps within block

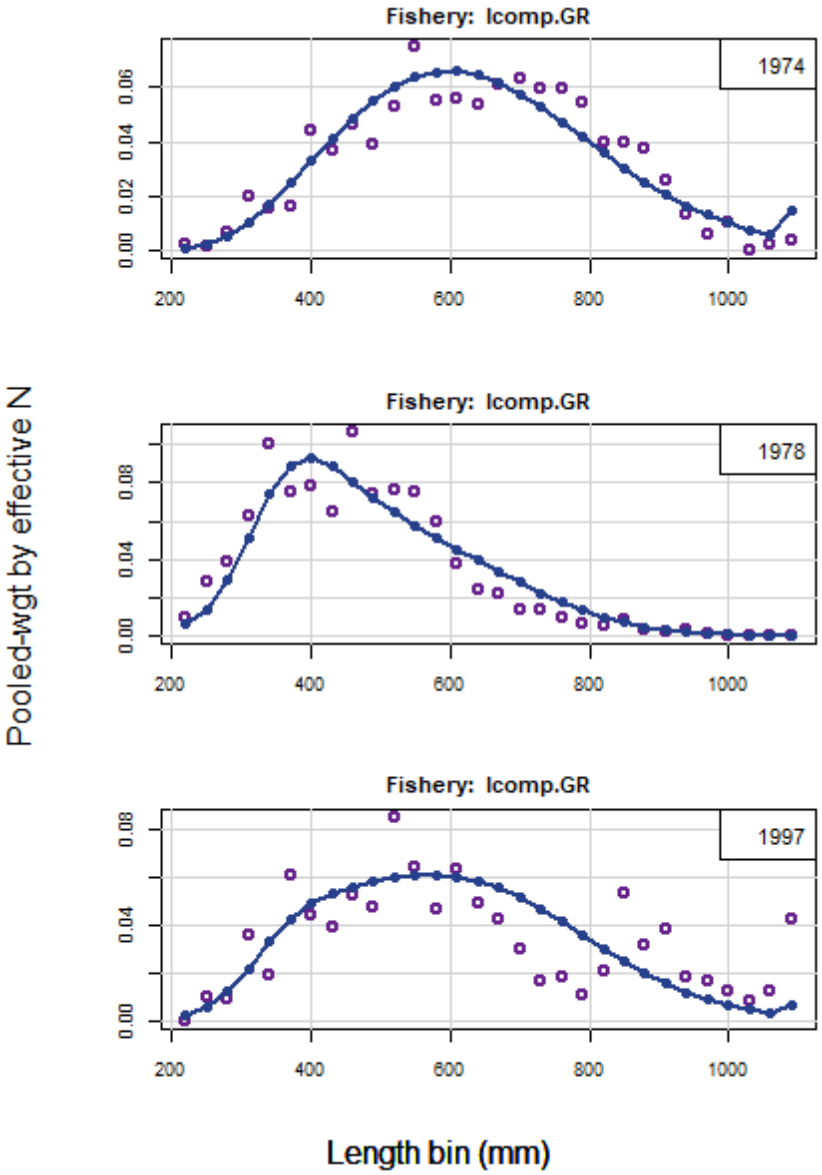




BAM base run – fits to data

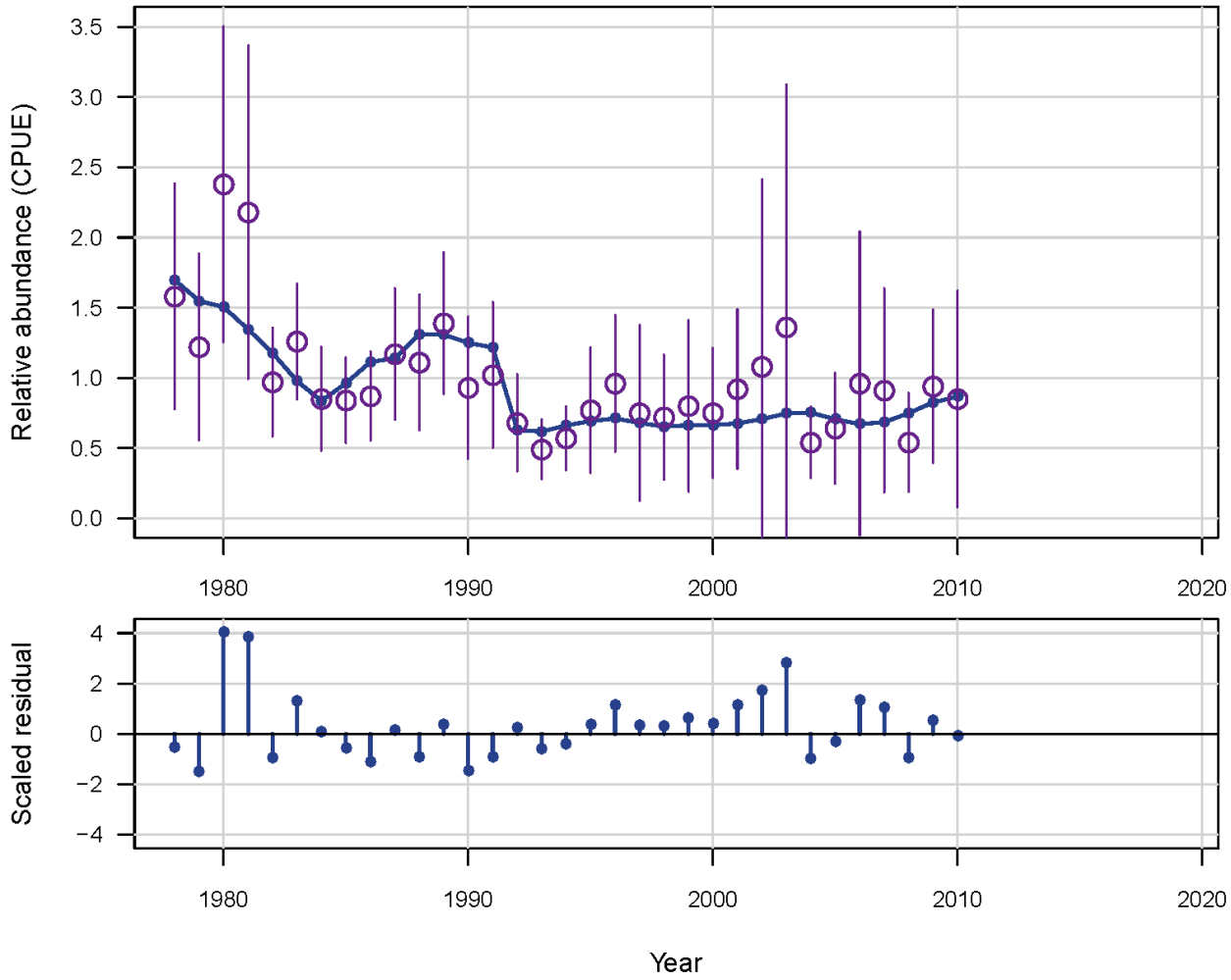
Composition year = first year of comps within block

General
Recreational



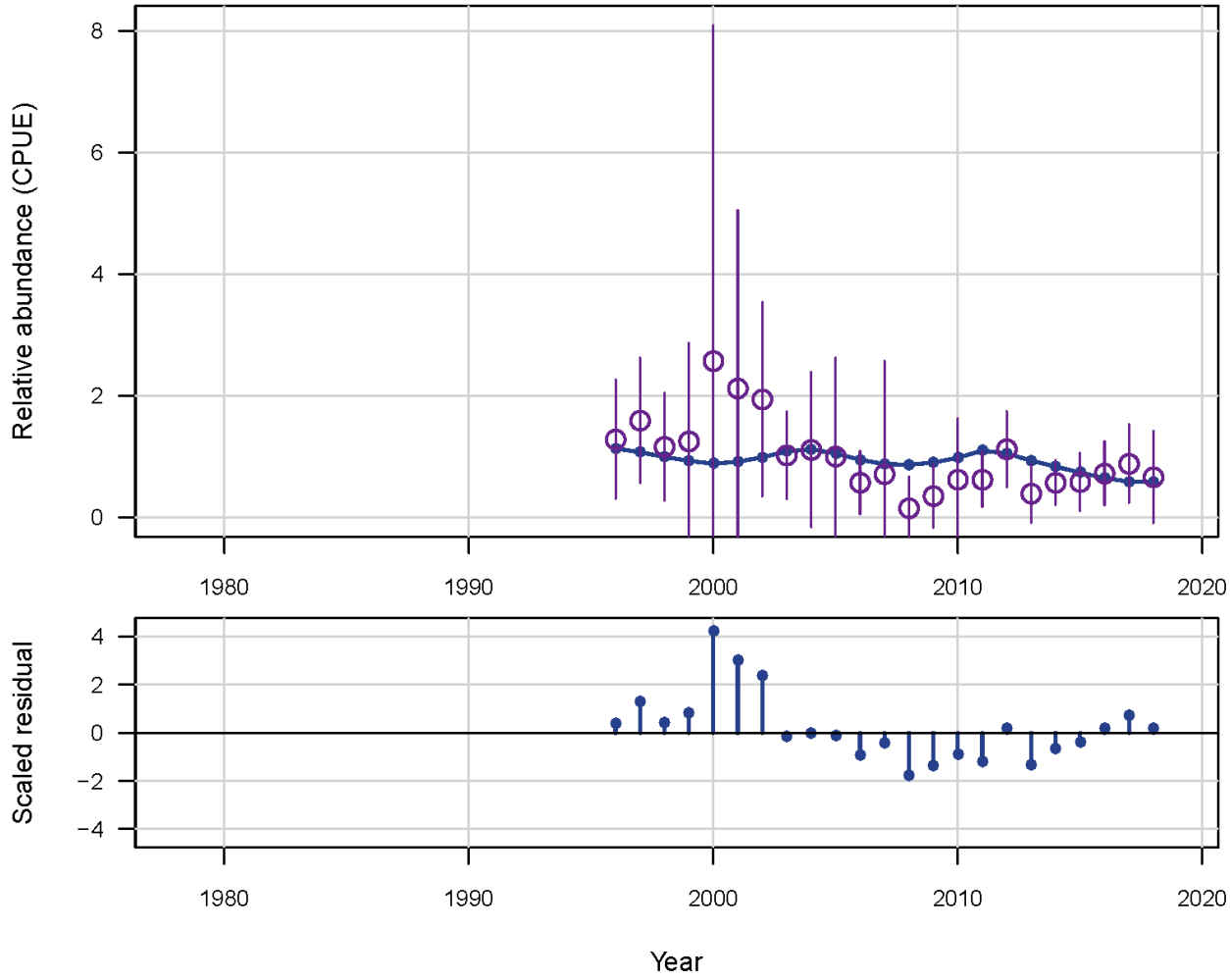
BAM base run – fits to data

Headboat (GR)



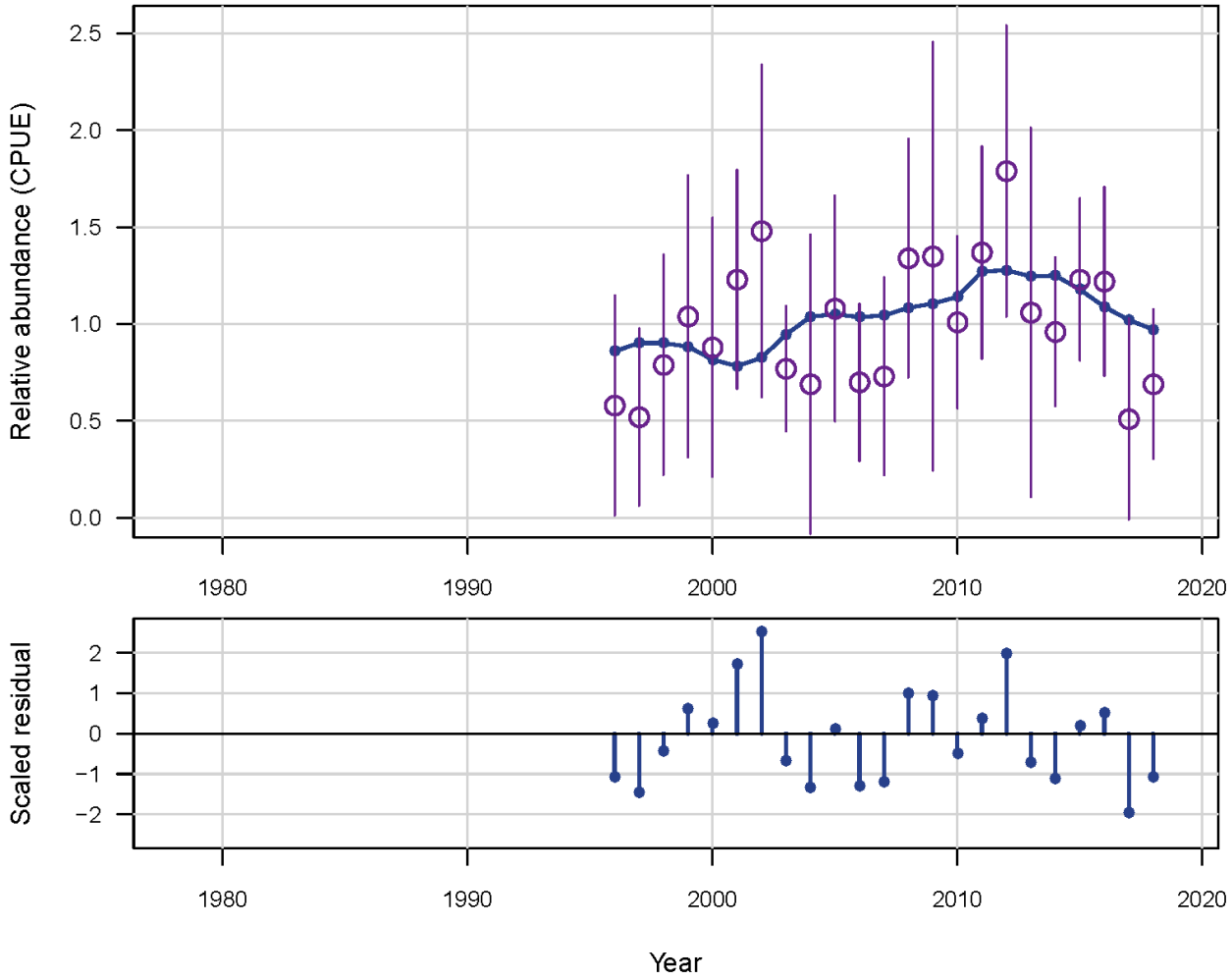
BAM base run – fits to data

SERFS
Chevron Trap (CVT)

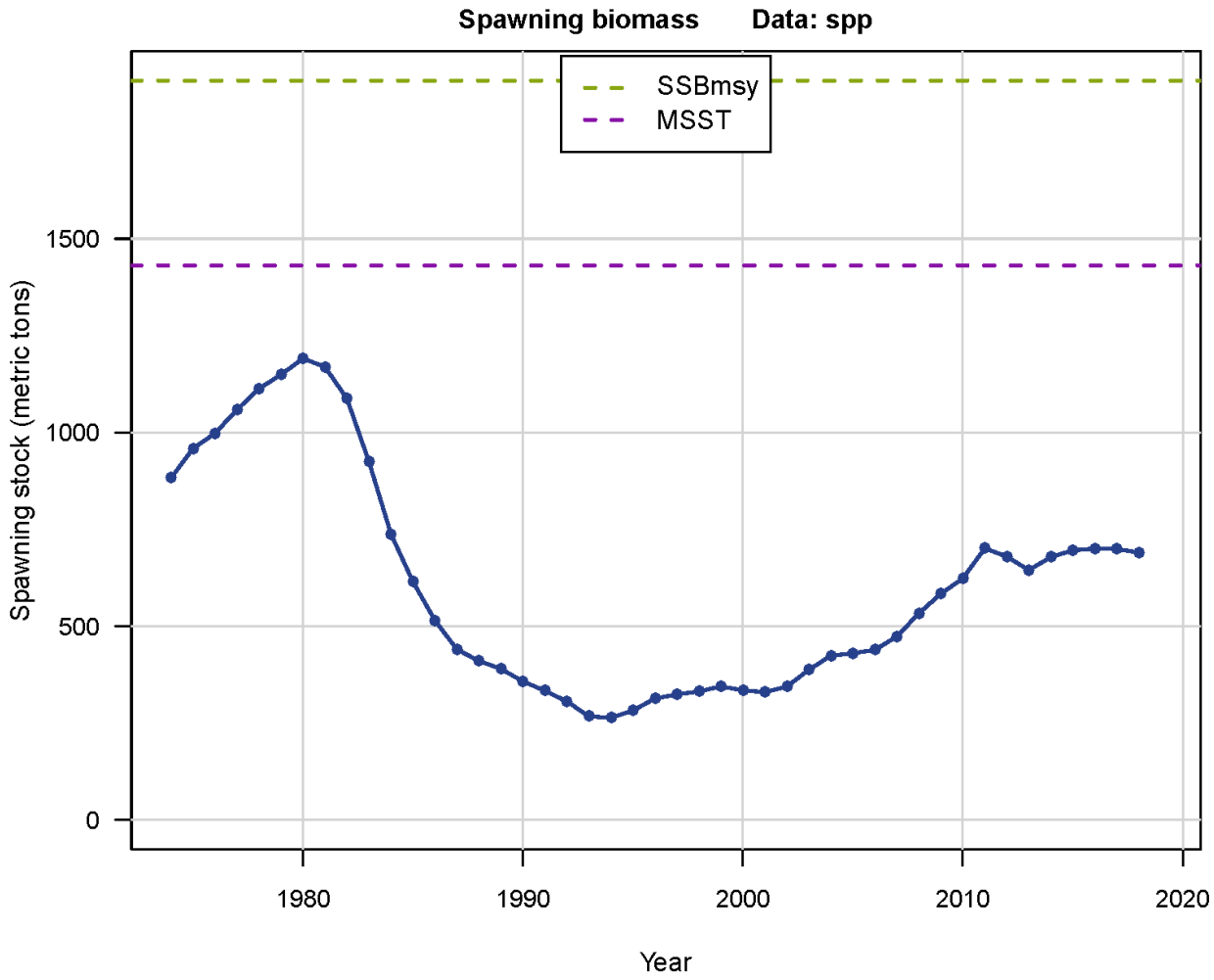


BAM base run – fits to data

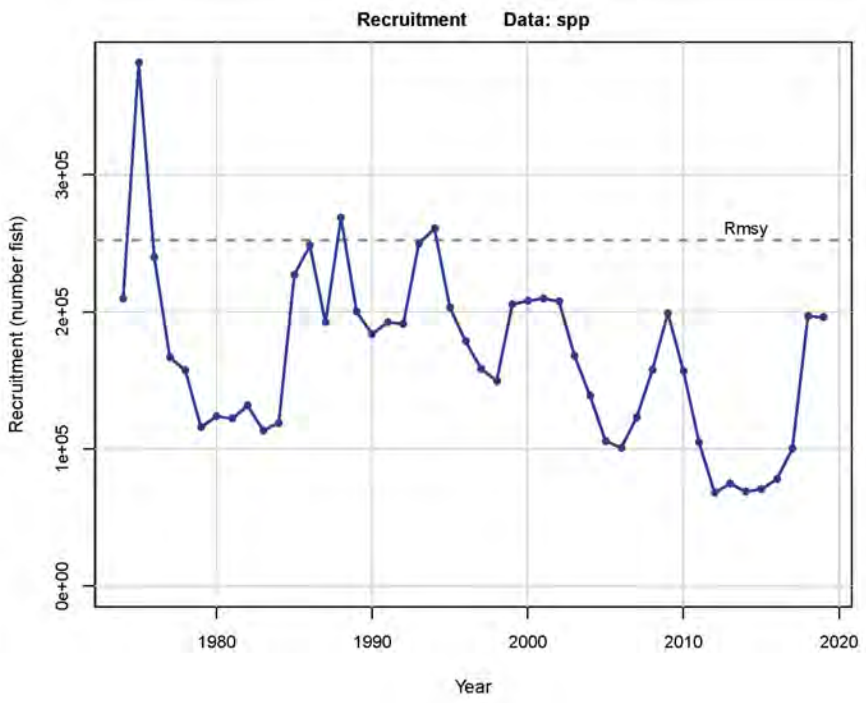
MARMAP
Longline (vll)

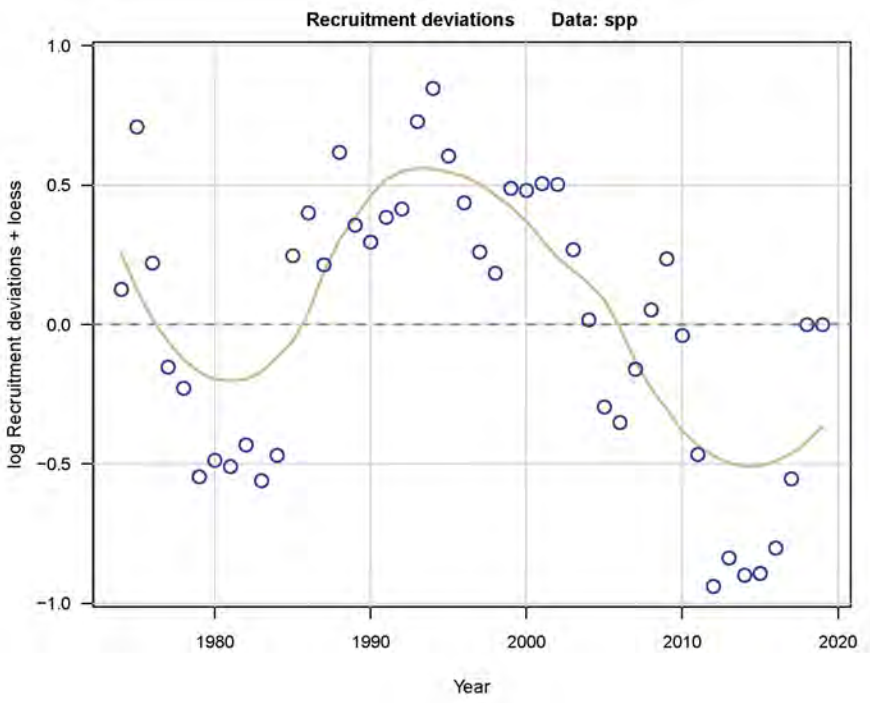


BAM base run – SSB

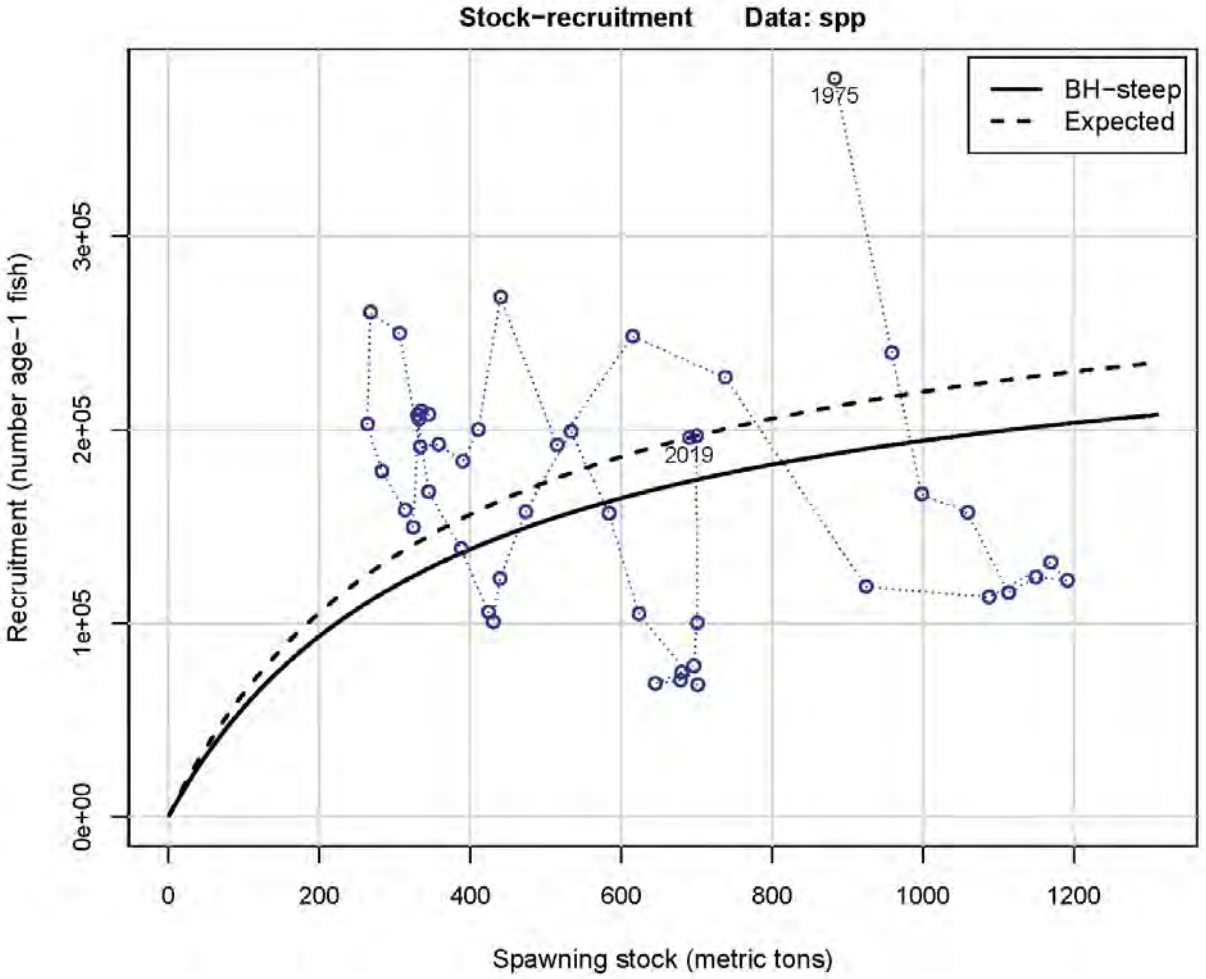


BAM base run – Recruitment

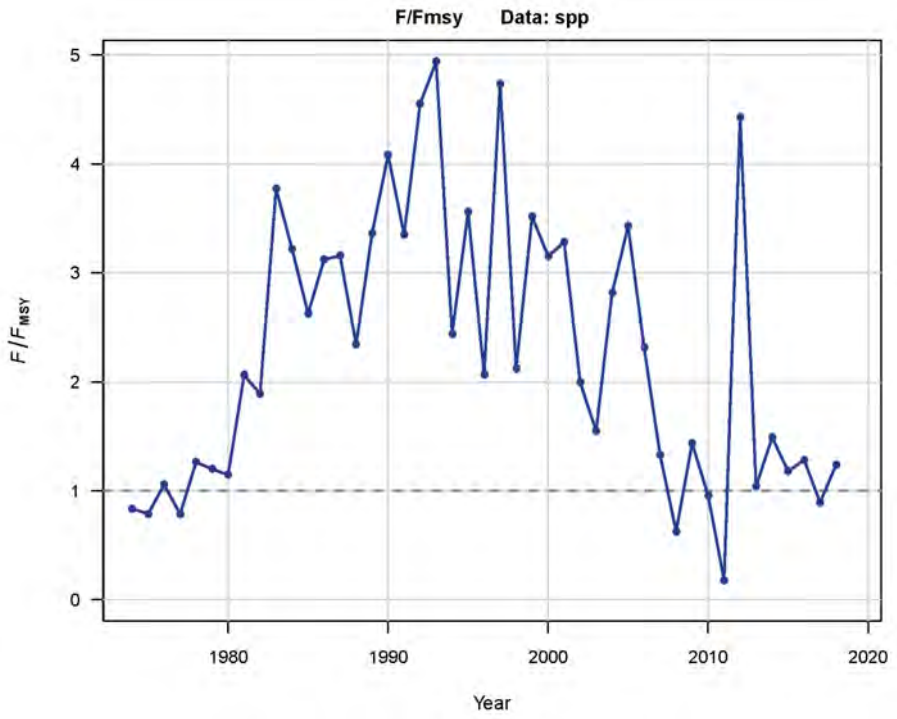


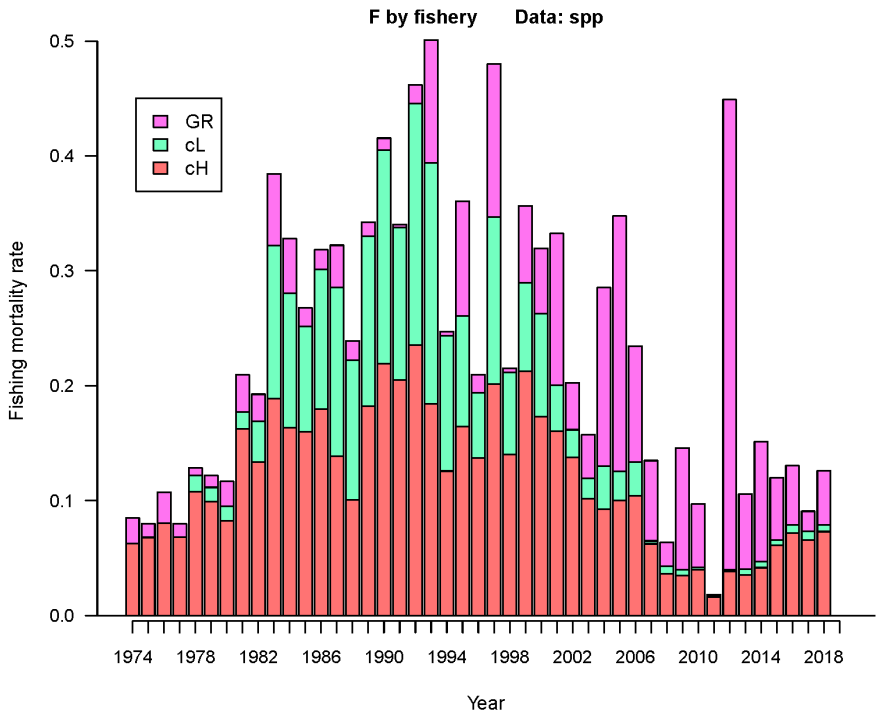


BAM base run – Spawner-recruit curve

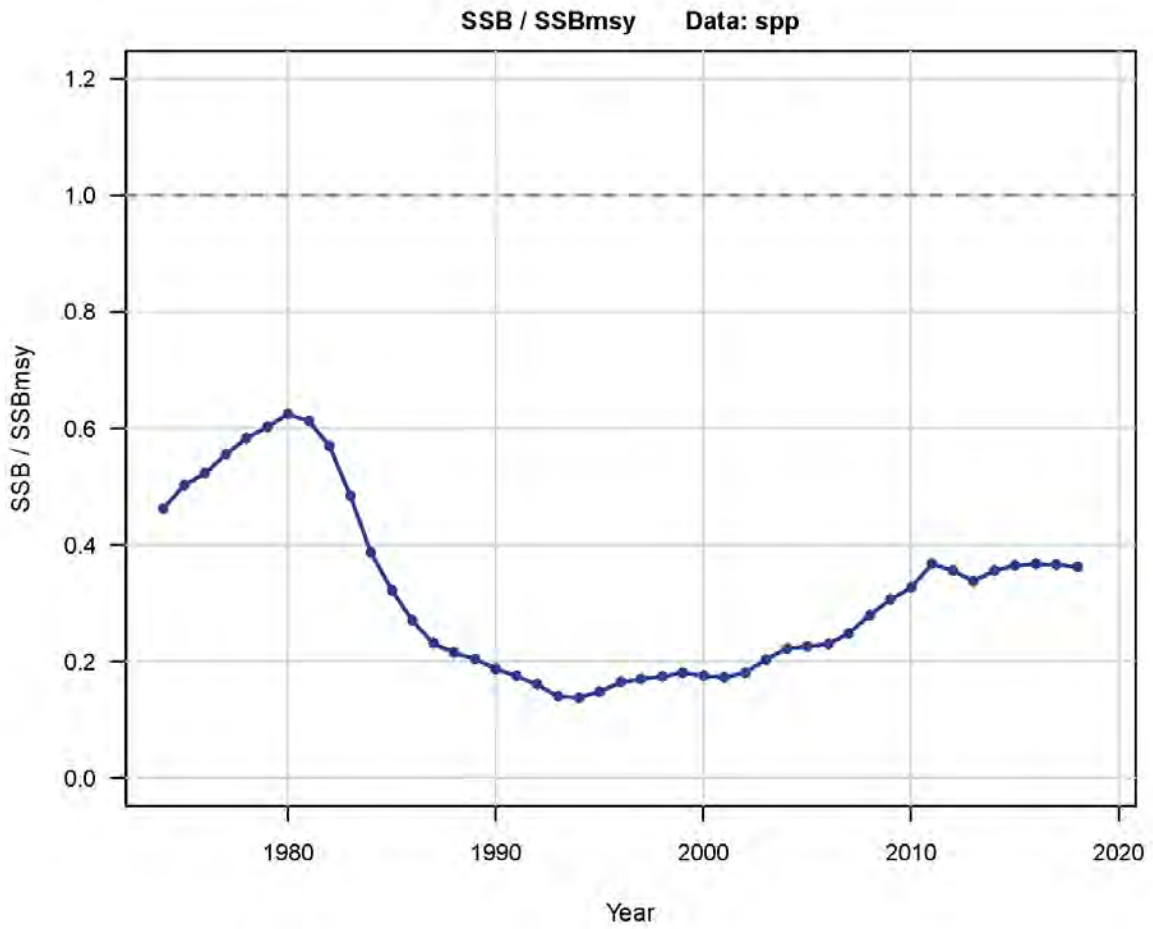


BAM base run – Fishing mortality





BAM base run


SSB / SSBmsy Data: spp
SSB / SSBmsy
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1980
1990
2000
2010
2020
Year

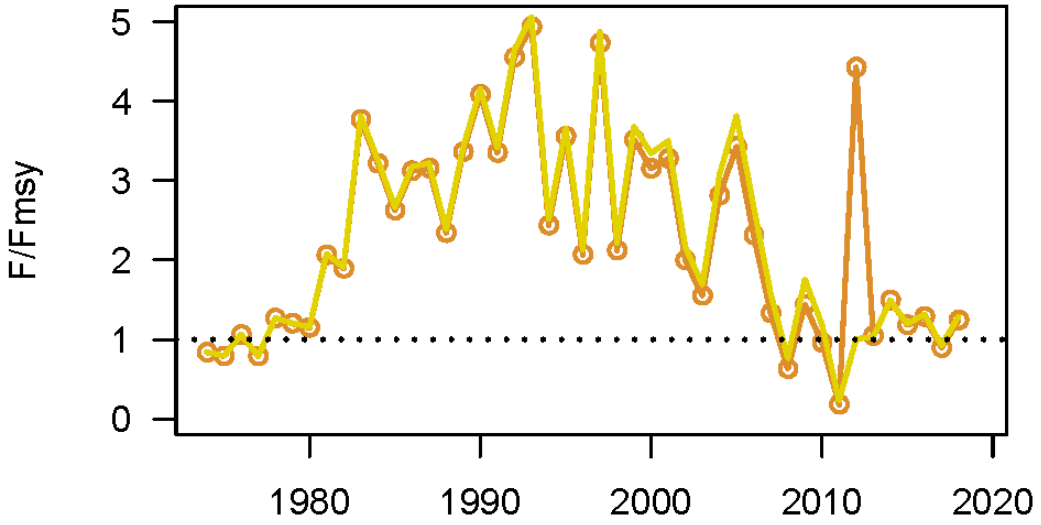
Outline

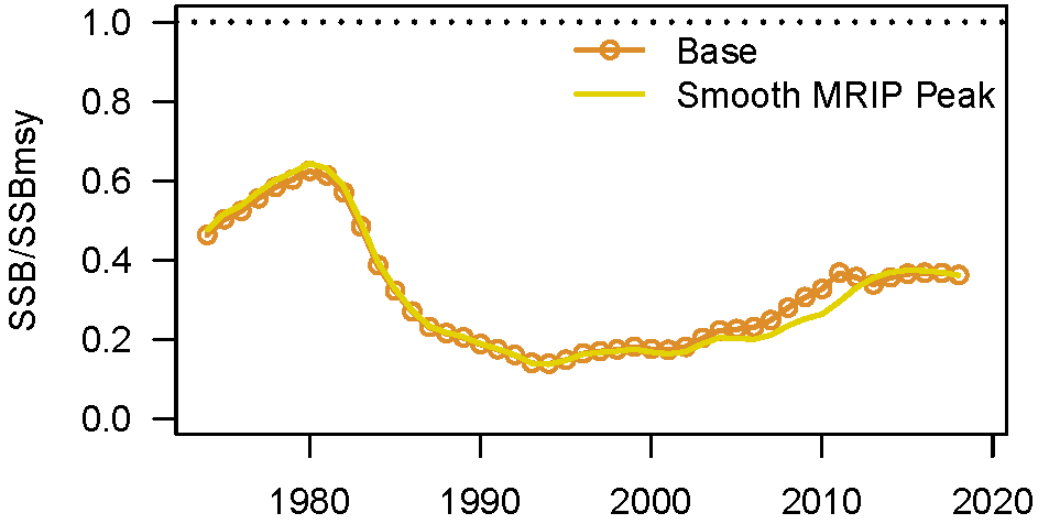
- Model input
  - Life History
  - Removals
  - Indices of abundace
  - Compositions
- Model update
- Base run
- Sensitivities and retrospective
- Uncertainty
- Projections

Sensitivities

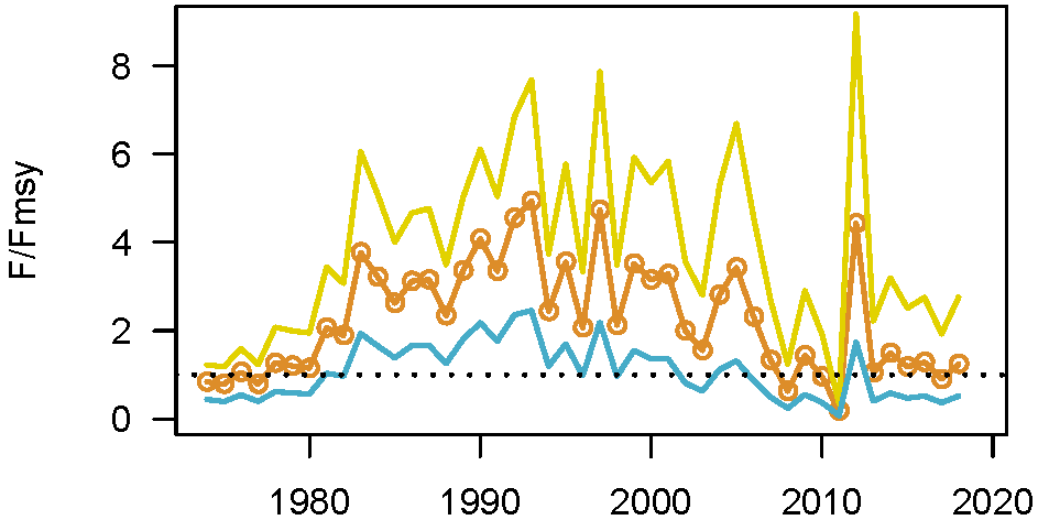
- Smooth MRIP 2012
- Low M=0.05, High M=0.12
- Low F_init=0.12, High F_init=0.19
- Low steepness=0.74, High steepness=0.94

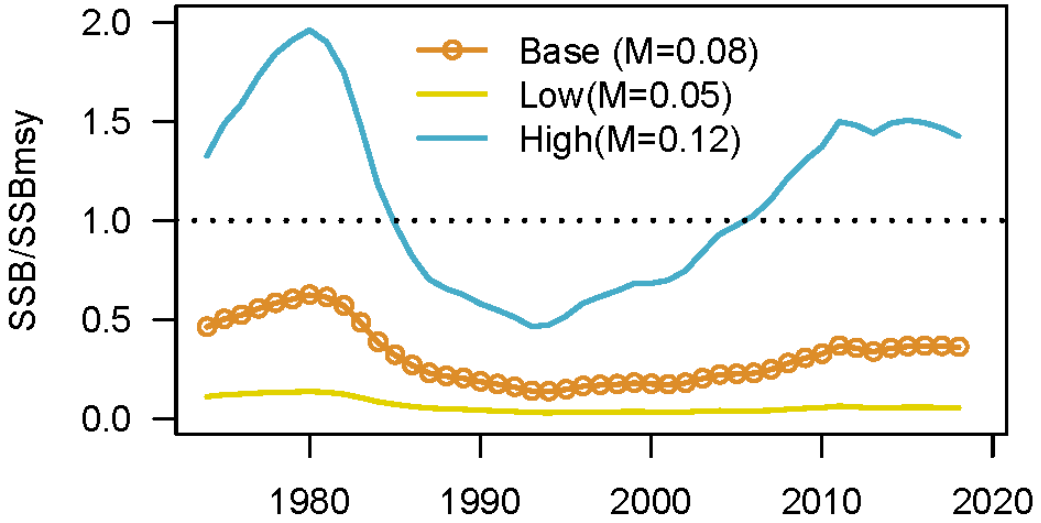
Smooth MRIP 2012



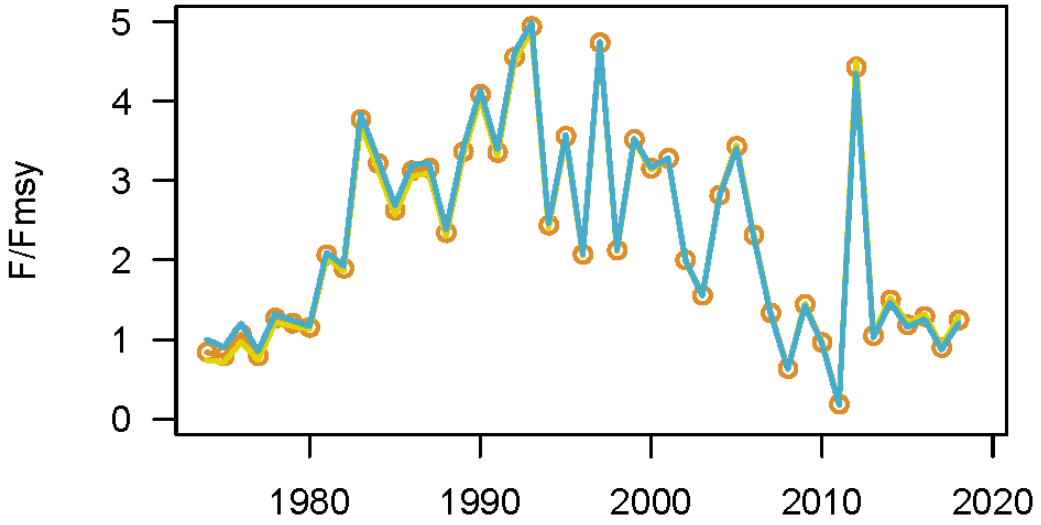


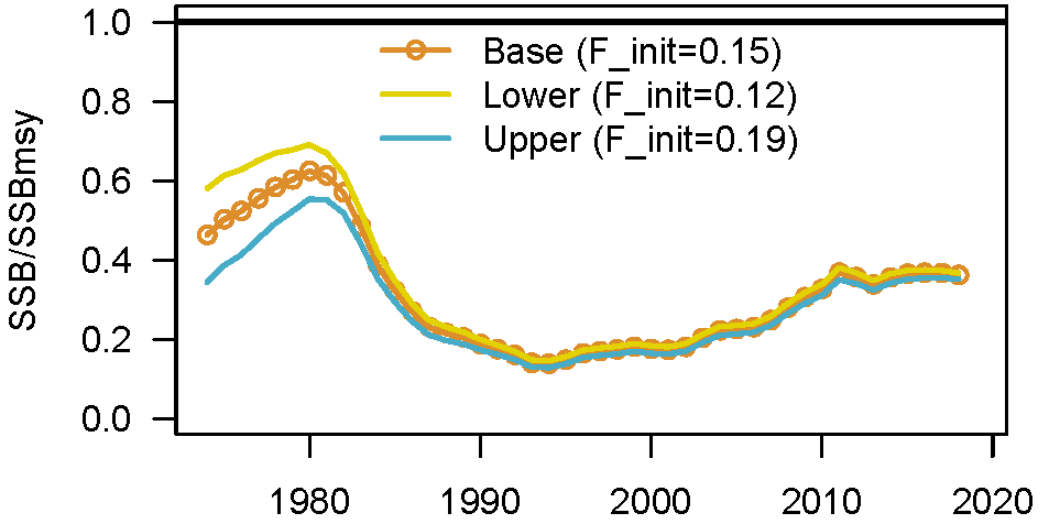
M


F/Fmsy
0
2
4
6
8
1980
1990
2000
2010
2020

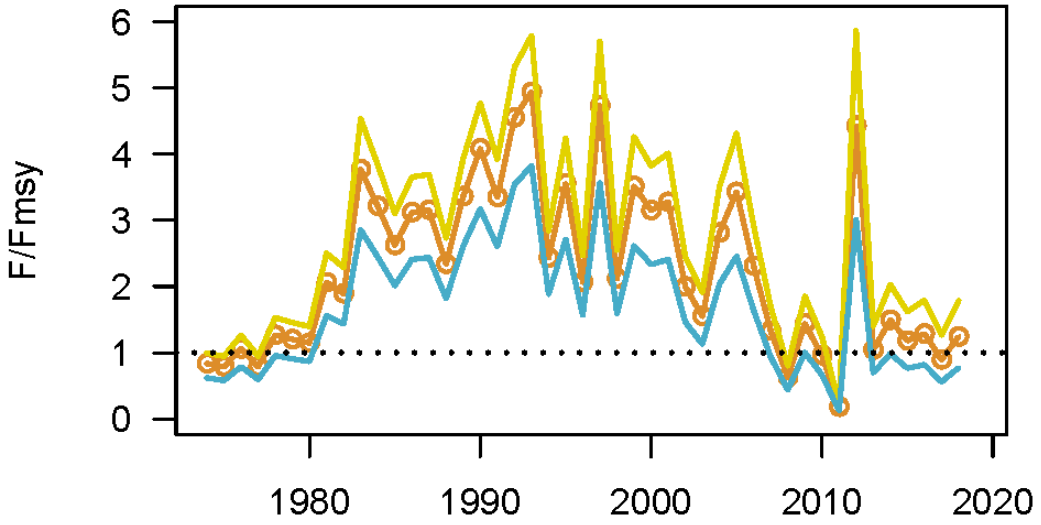

SSB/SSBmsy
0.0
0.5
1.0
1.5
2.0
Base (M=0.08)
Low(M=0.05)
High(M=0.12)
1980
1990
2000
2010
2020

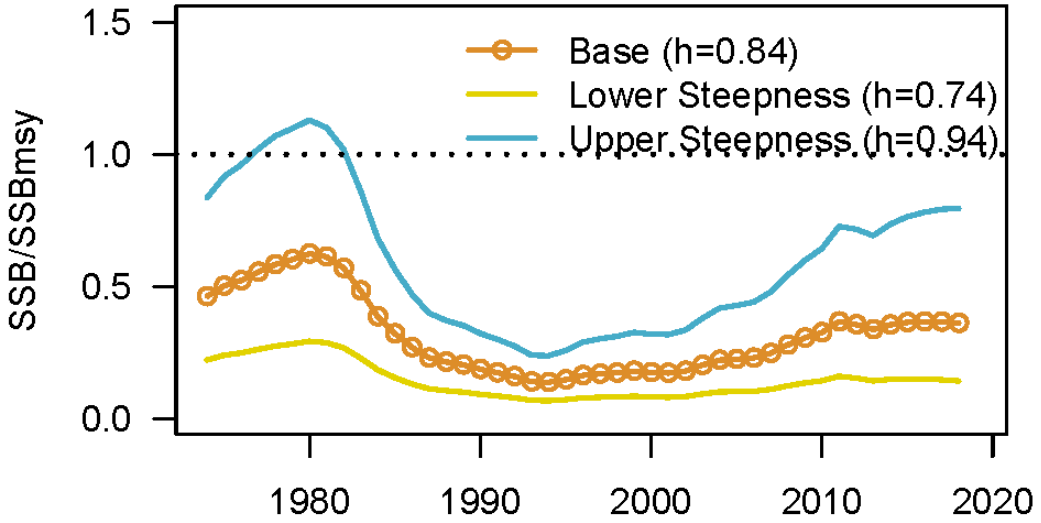
F_init


F/Fmsy
0
1
2
3
4
5
1980
1990
2000
2010
2020

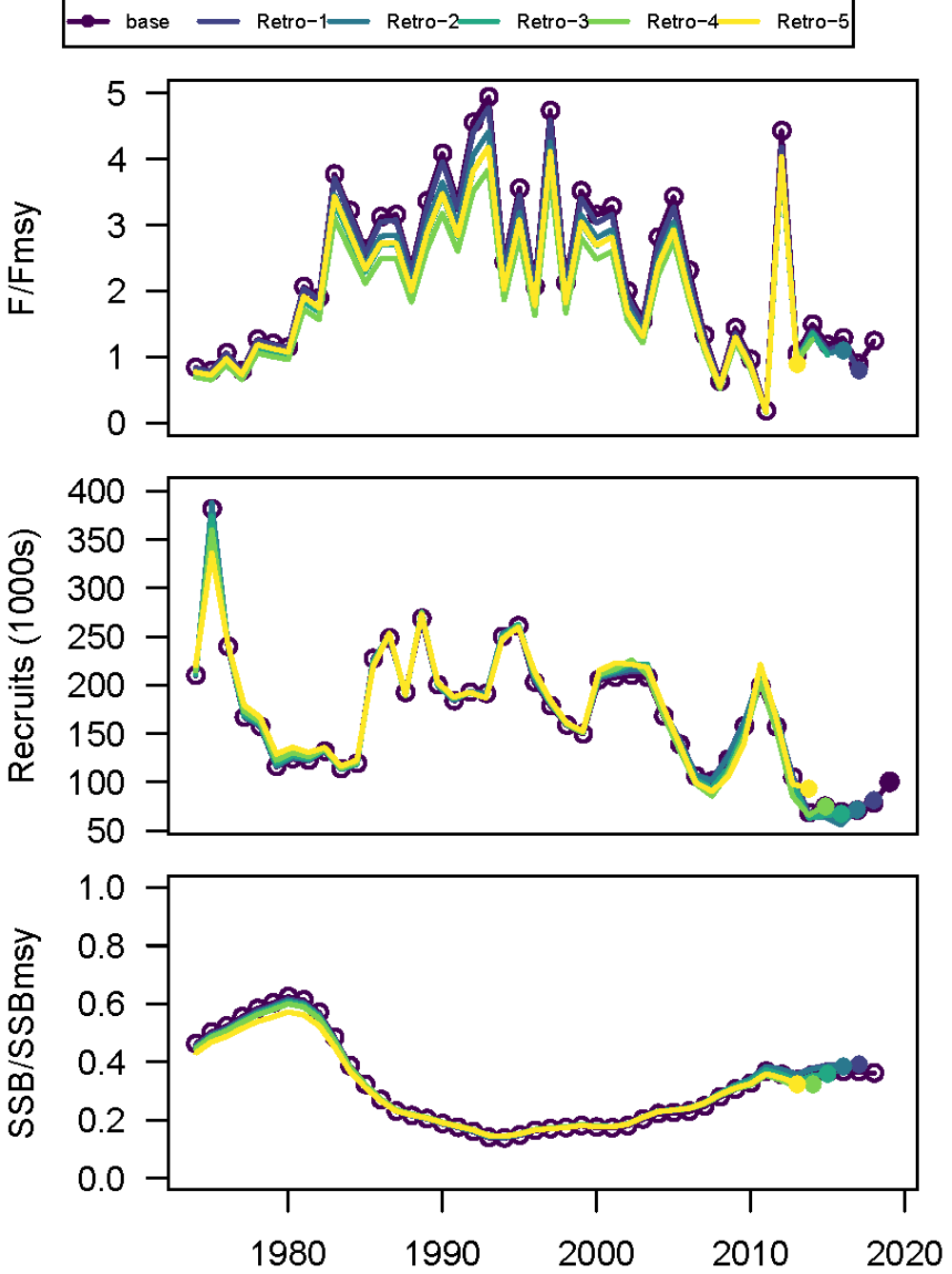

SSB/SSBmsy
0.0
0.2
0.4
0.6
0.8
1.0
Base (F_init=0.15)
Lower (F_init=0.12)
Upper (F_init=0.19)
1980
1990
2000
2010
2020

Steepness


F/Fmsy
0
1
2
3
4
5
6
1980
1990
2000
2010
2020


SSB/SSBmsy
0.0
0.5
1.0
1.5
1980
1990
2000
2010
2020
Base (h=0.84)
Lower Steepness (h=0.74)
Upper Steepness (h=0.94)

Retrospective



Sensitivities

Description	Fmsy	SSBmsy	MSY	F.Fmsy	SSB.SSBmsy	h	R0(1000)	PctSPR
Base	0.101	1907.97	532	1.13	0.36	0.84	254	26
Smooth MRIP 2012	0.102	1845.81	516	1.16	0.36	0.84	245	26
M=0.05	0.066	9039.98	1431	2.44	0.06	0.84	332	28
M=0.12	0.171	682.98	399	0.46	1.42	0.84	384	23
Finit=0.12	0.101	1827.95	509	1.16	0.37	0.84	243	26
Finit=0.19	0.102	2011.11	562	1.1	0.35	0.84	267	26
Steepness=0.74	0.081	4205.61	909	1.59	0.14	0.74	458	32
Steepness=0.94	0.137	1042.38	415	0.71	0.8	0.94	186	19

Outline

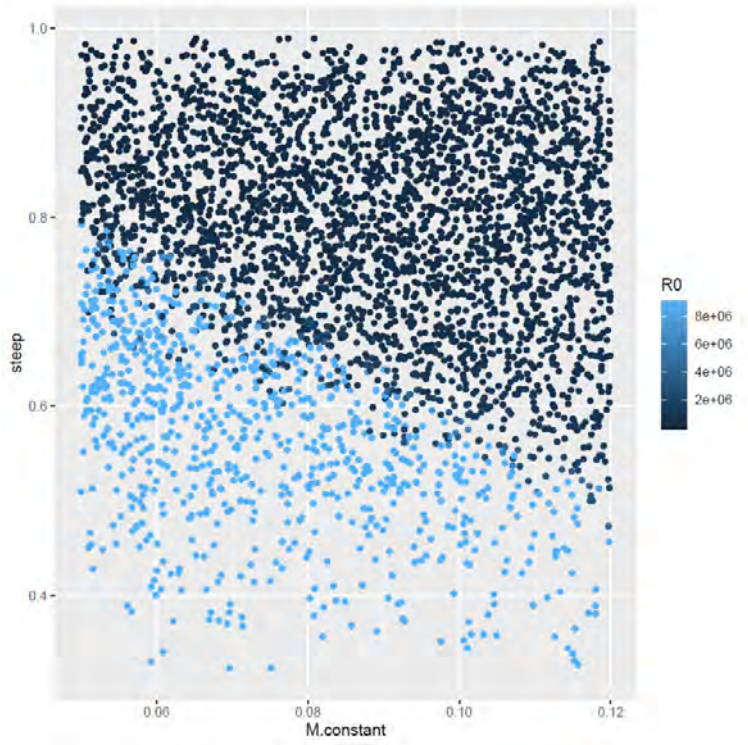
- Model input
  - Life History
  - Removals
  - Indices of abundance
  - Compositions
- Model update
- Base run
- Sensitivities and retrospective
- Uncertainty
- Projections

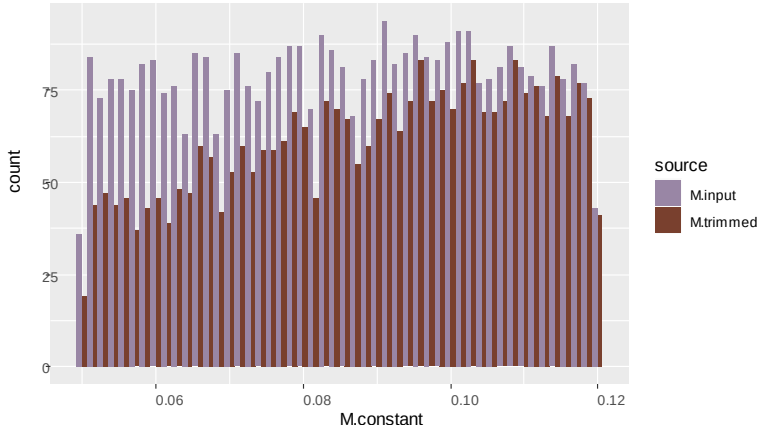
MCB approach

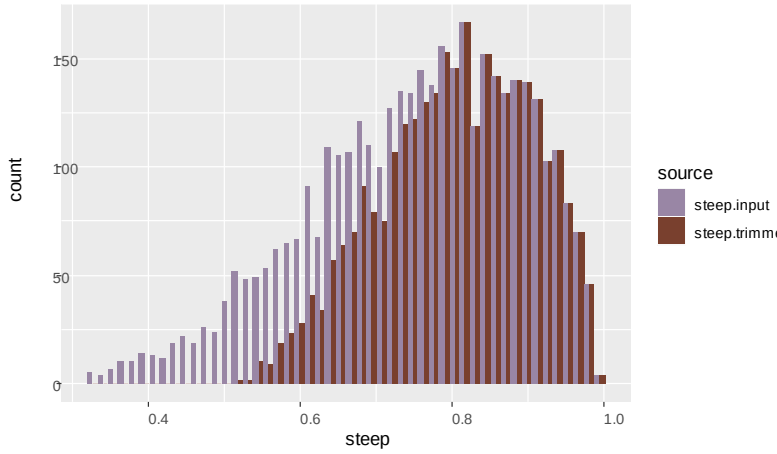
- Monte Carlo components:
  - M: drawn from a random uniform distribution [0.05, 0.12]. Chosen value scales age-based Charnov M.
  - F_init: drawn from a random uniform distribution [0.12, 0.19].
  - Steepness: drawn from a truncated beta distribution [0.32, 0.99]
- Bootstrap components:
  - Landings, discards, and indices: parametric bootstrap of original data, with CVs as applied in the fitting procedure
  - Length and age comps: resample Nfish and assign them to bins with probabilities equal to those from original data

Uncertainty – Combined Monte Carlo and Bootstrap (MCB) ensemble approach

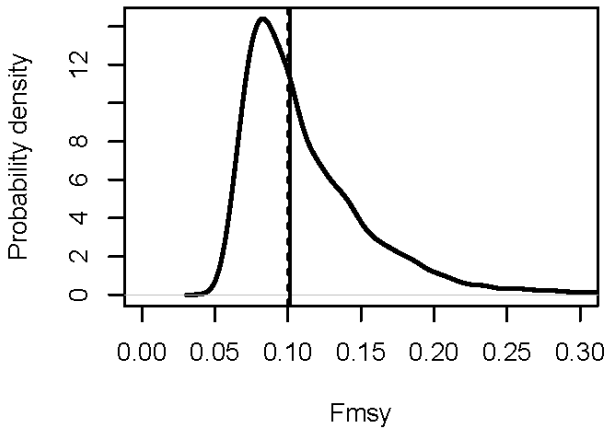
- n=4000 MCB ensemble trials attempted; n=3054 retained
  - N=50 did not converge, n=896 with parameter at bound
  - Distribution of steepness and constant M modified by exclusion

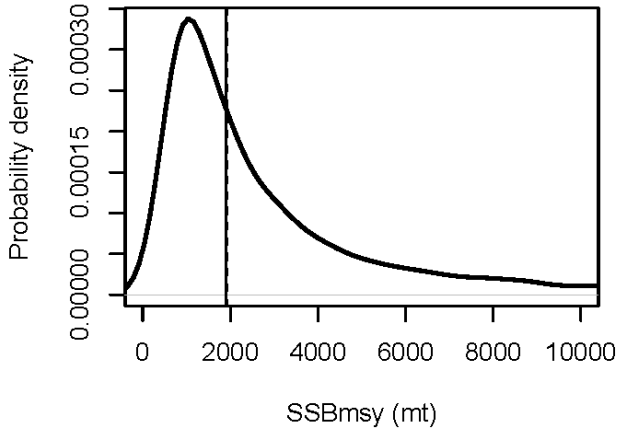




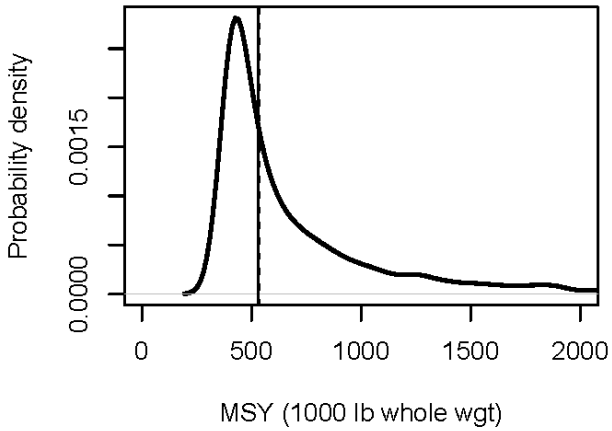


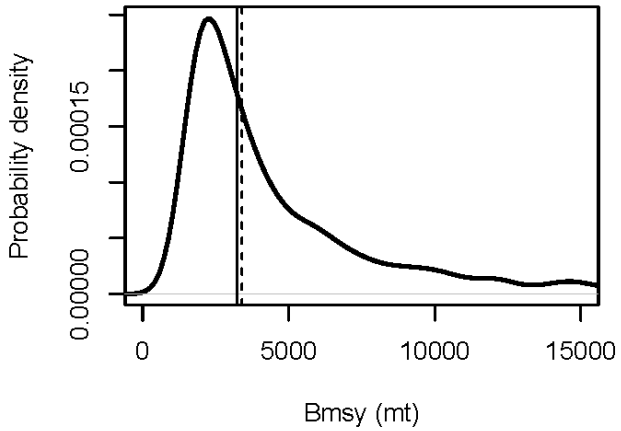
MCB – uncertainty in benchmarks

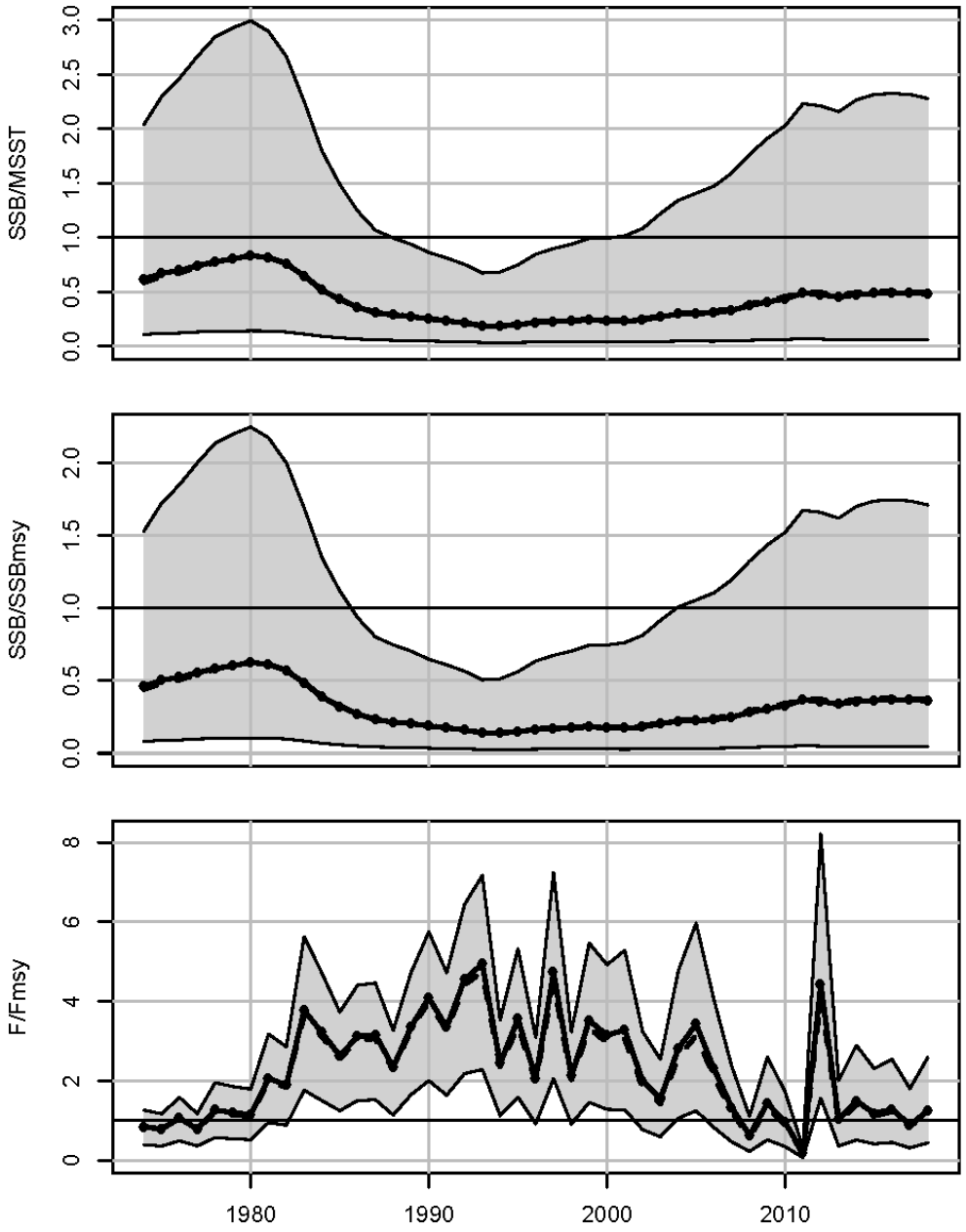


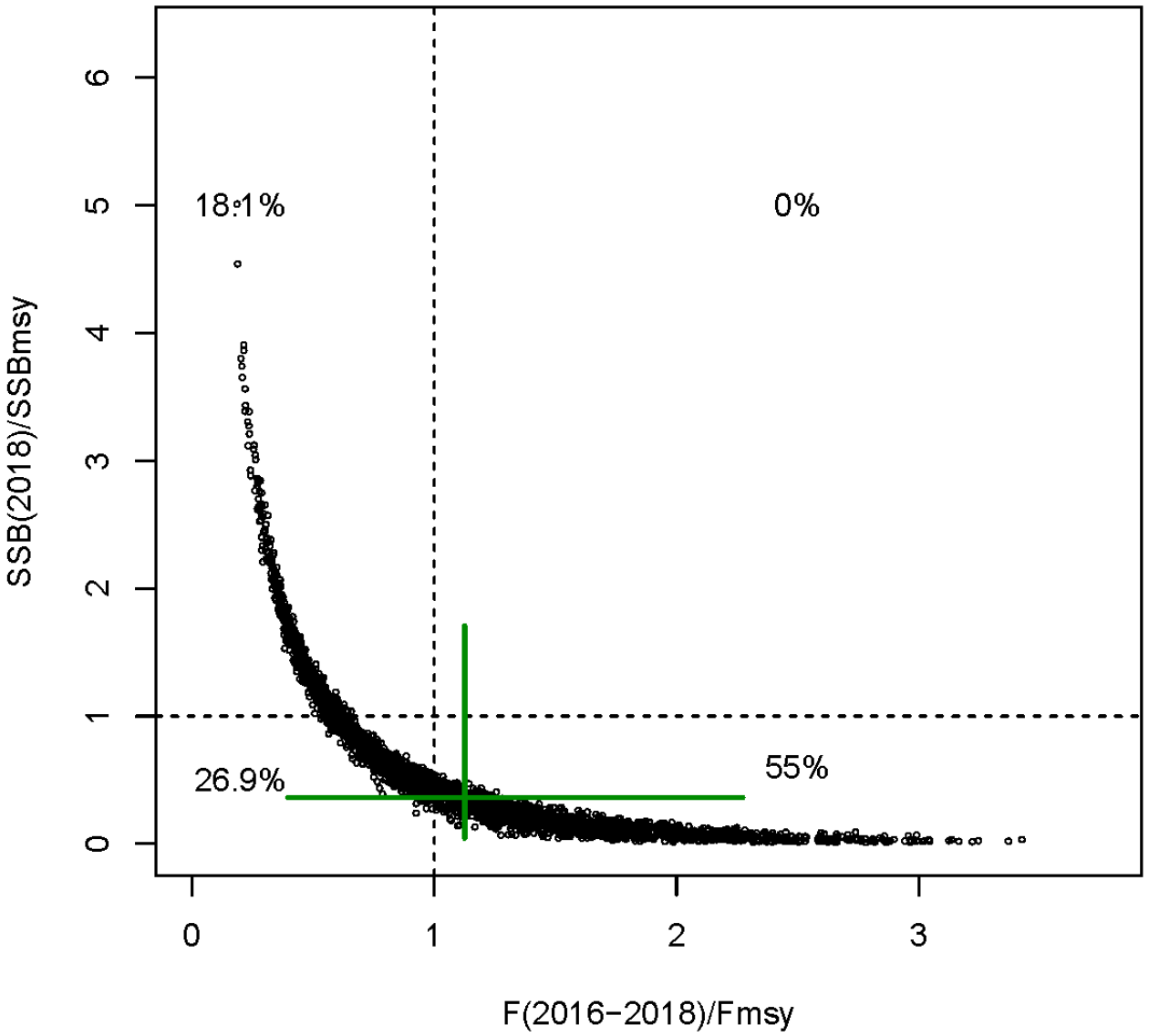


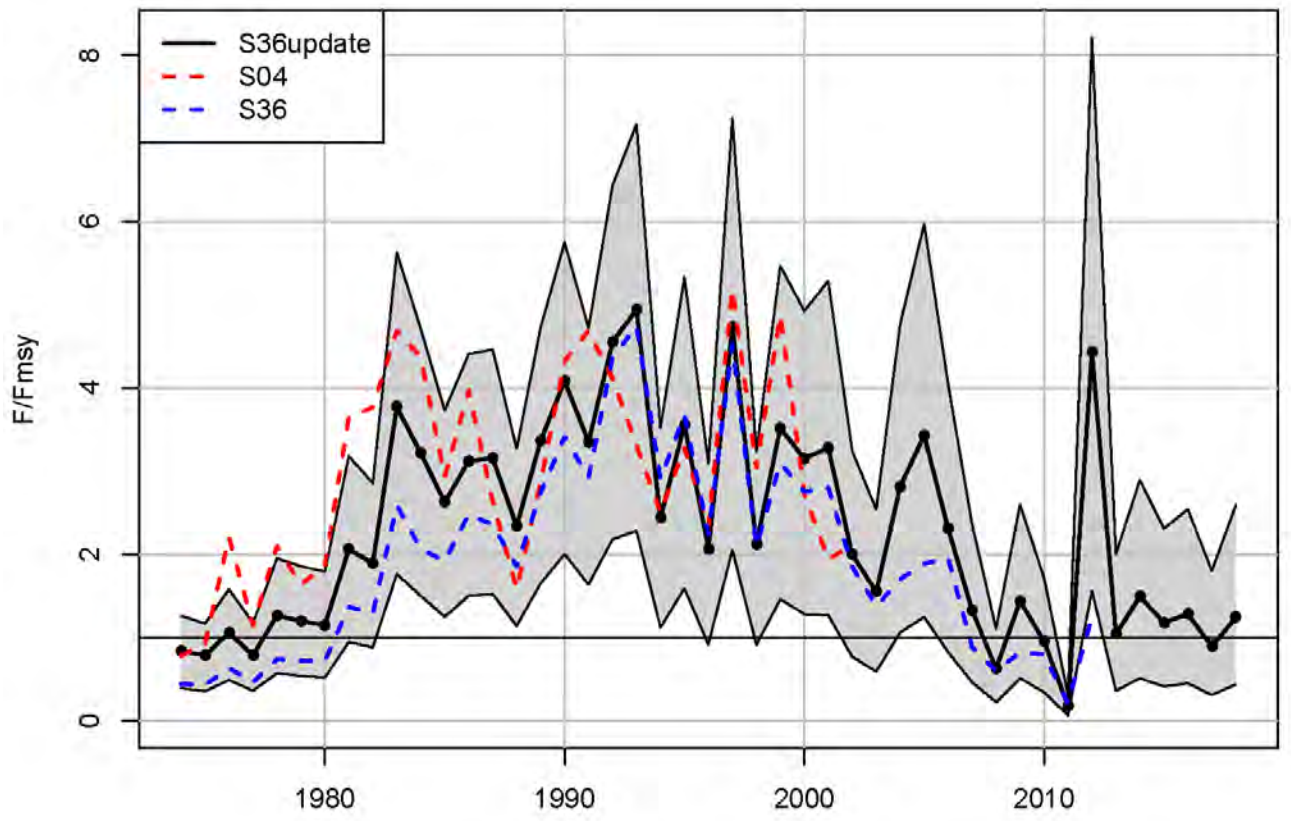
Solid=MLE (base)
Dash=Median

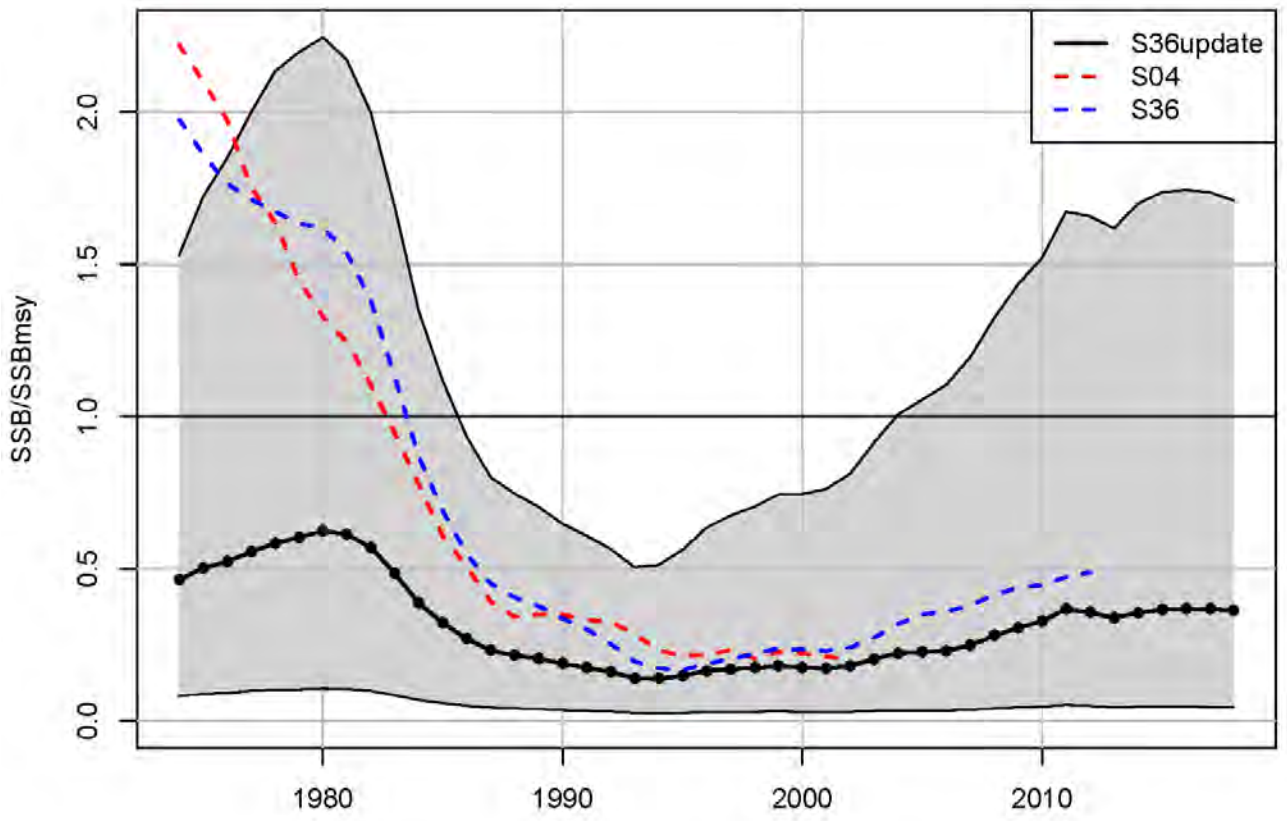





SSB/MSST
0.0
0.5
1.0
1.5
2.0
2.5
3.0
SSB/SSBmsy
0.0
0.5
1.0
1.5
2.0
F/Fmsy
0
2
4
6
8
1980
1990
2000
2010


SSB(2018)/SSBmsy
F(2016−2018)/Fmsy
18.1%
0%
26.9%
55%
0
1
2
3
4
5
6
0
1
2
3


S36update
S04
S36
F/Fmsy
0
2
4
6
8
1980
1990
2000
2010


S36update
S04
S36
SSB/SSBmsy
0.0
0.5
1.0
1.5
2.0
1980
1990
2000
2010

Outline

- Model input
  - Life History
  - Removals
  - Indices
  - Comps
- Model update
- Base run (sg11.pdf)
- Sensitivities and retrospective
- Uncertainty
- Projections

Projections (management in 2023)

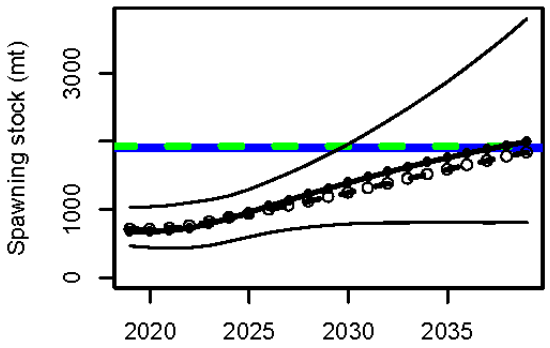
- F = F current
- F = 0
- F = 75% Fmsy
- F = 0.08 (rebuilding probability of 0.5)

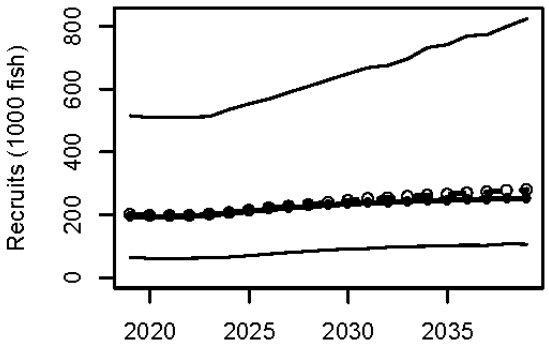
Fix recruitment at recent level (average 2011-2017)

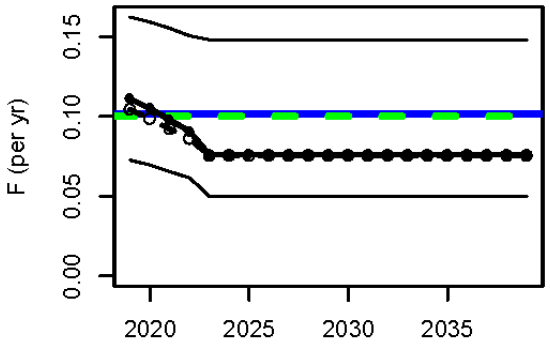
- F = 75% Fmsy
- F = 0

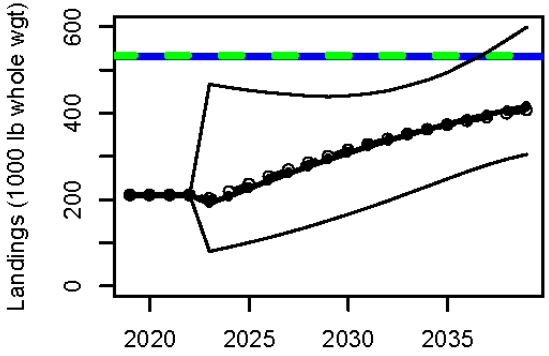
F=75% Fmsy

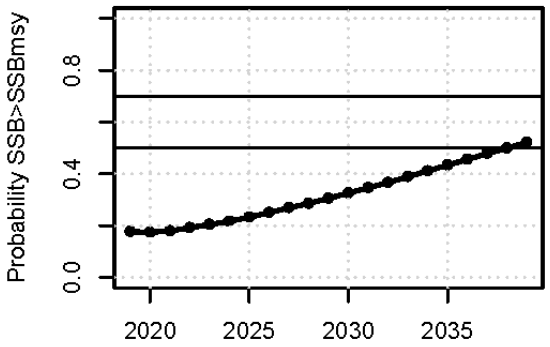
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles









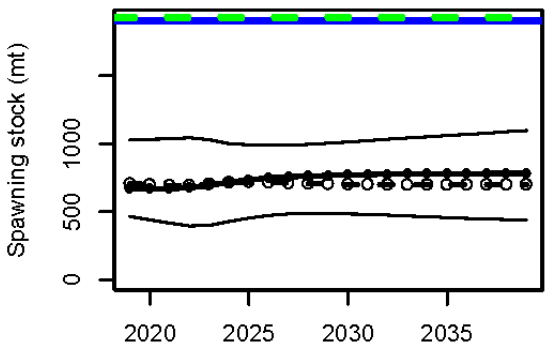


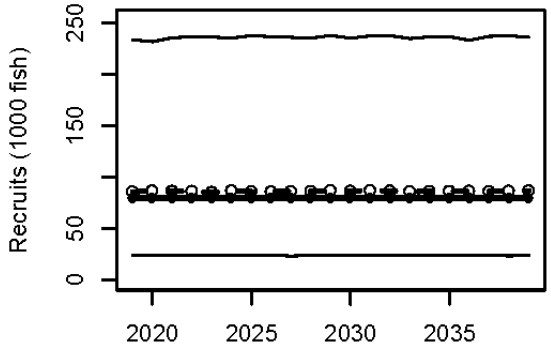
F=75% Fmsy

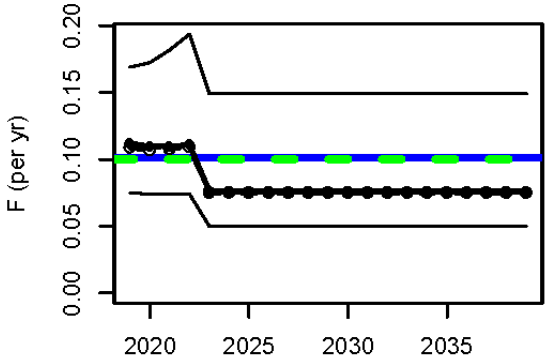
year	pr.rebuild	F.base	F.med	S.base(mt)	S.med(mt)	Rm.base(1000)	Rm.med(1000)	Rm.base(1000 lb)	Rm.med(1000 lb)
2019	0.177	0.11	0.1	672	711	25	24	210	210
2020	0.174	0.1	0.1	673	709	27	26	210	210
2021	0.18	0.1	0.09	690	722	28	27	210	210
2022	0.192	0.09	0.09	728	762	28	28	210	210
2023	0.204	0.08	0.08	790	819	25	27	192	202
2024	0.216	0.08	0.08	871	881	27	29	208	218
2025	0.232	0.08	0.08	959	939	29	30	226	236
2026	0.25	0.08	0.08	1049	998	31	32	244	253
2027	0.269	0.08	0.08	1138	1058	32	34	261	269
2028	0.285	0.08	0.08	1225	1119	34	35	277	285
2029	0.305	0.08	0.08	1309	1184	35	37	293	300
2030	0.325	0.08	0.08	1391	1247	36	38	308	315
2031	0.346	0.08	0.08	1471	1313	37	39	323	328
2032	0.366	0.08	0.08	1548	1381	38	40	337	340
2033	0.388	0.08	0.08	1622	1451	39	42	350	352
2034	0.411	0.08	0.08	1692	1517	40	43	363	362
2035	0.433	0.08	0.08	1759	1586	41	43	375	373
2036	0.455	0.08	0.08	1823	1652	42	44	386	382
2037	0.478	0.08	0.08	1883	1715	43	45	397	390
2038	0.499	0.08	0.08	1940	1779	43	46	407	399
2039	0.521	0.08	0.08	1993	1838	44	47	416	407

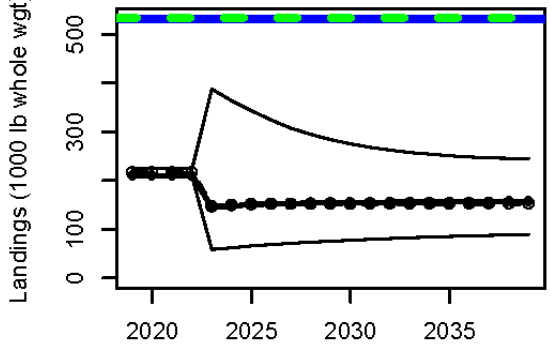
F = 75% Fmsy and continued low recruitment (average 2011 – 2017)

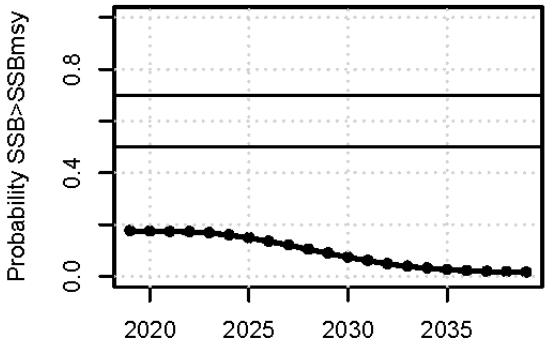
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles











Summary

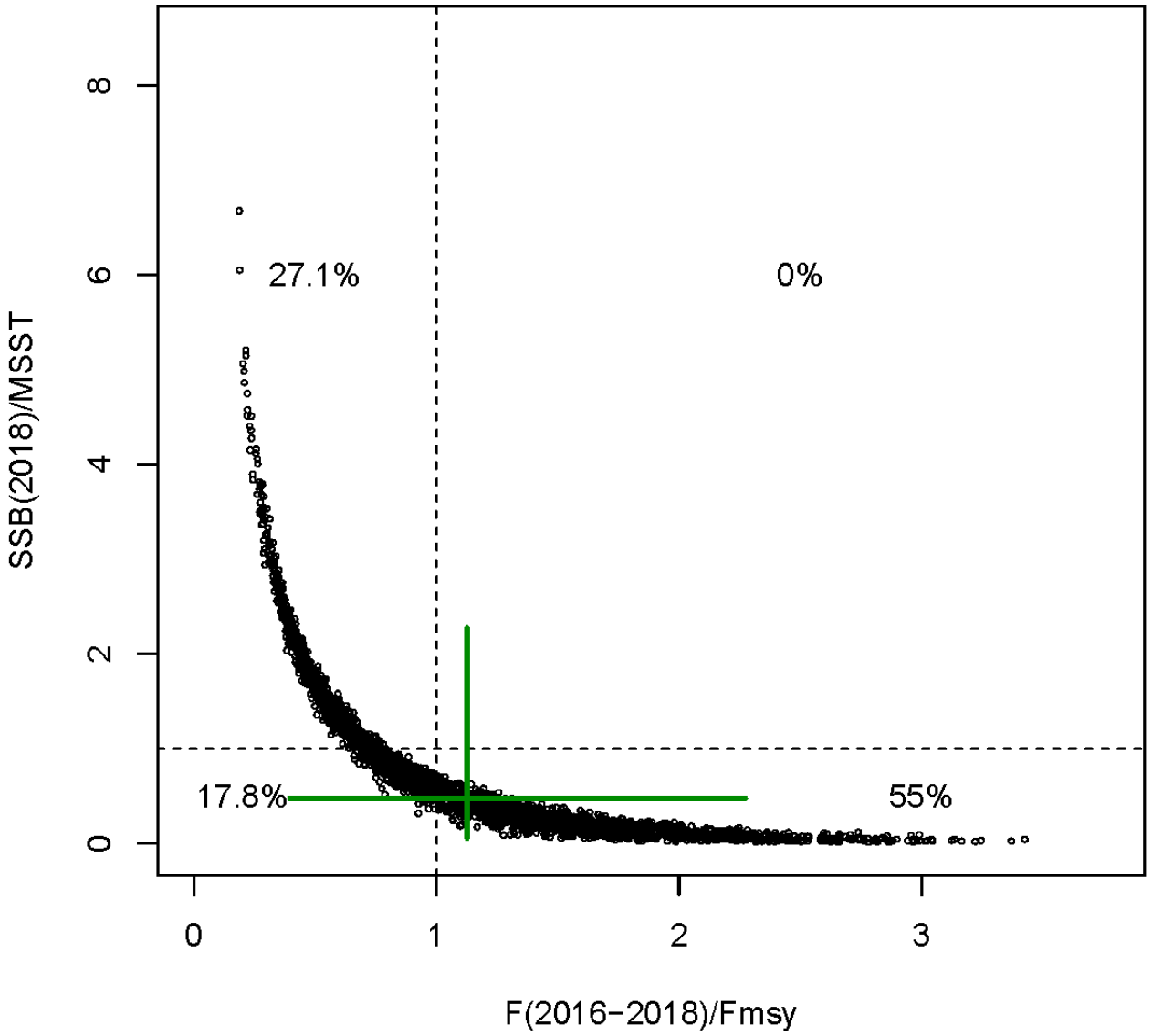
- Snowy grouper is currently overfished and overfishing
- This finding is partially attributable to change in natural mortality based on new information on maximum age
- Low recruitment levels since 2011 are limiting rebuilding progress

Recommendations

- Assess MRIP removal estimates over time series
- Evaluate basis for commercial selectivity block for recent period (fishing behavior)
- Investigate recent methods for natural mortality as discussed in SEDAR 68 and SEDAR 73
- Need for robust deepwater survey

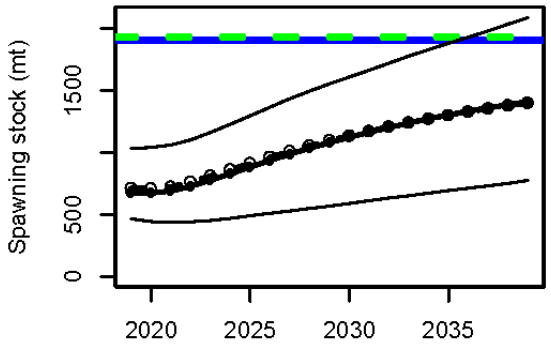
Questions?

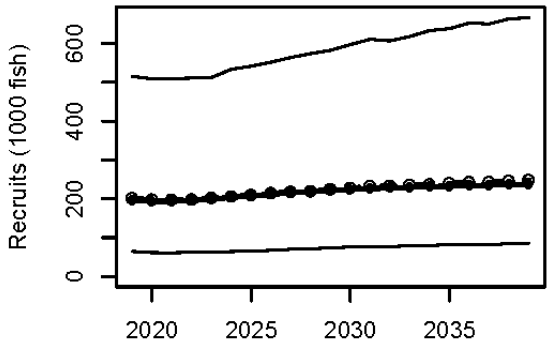
Extra slides

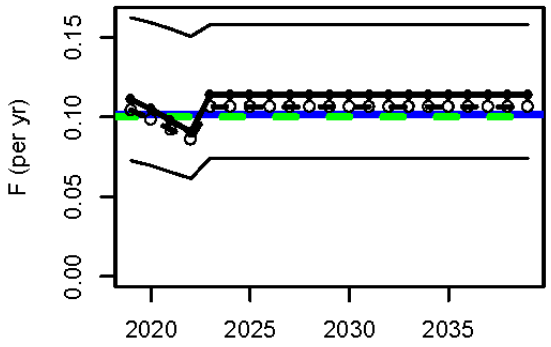

SSB(2018)/MSST
F(2016−2018)/Fmsy
27.1%
0%
17.8%
55%
0
2
4
6
8
0
1
2
3

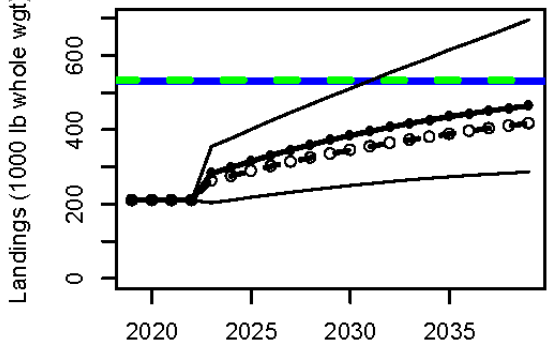
F Current

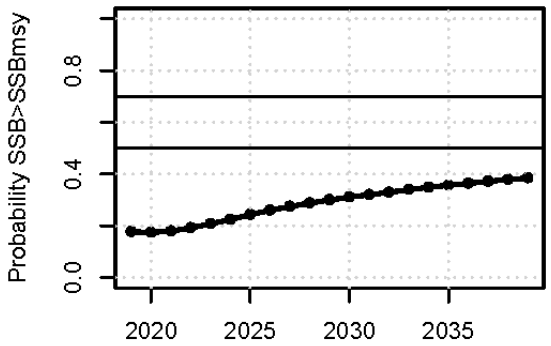
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles









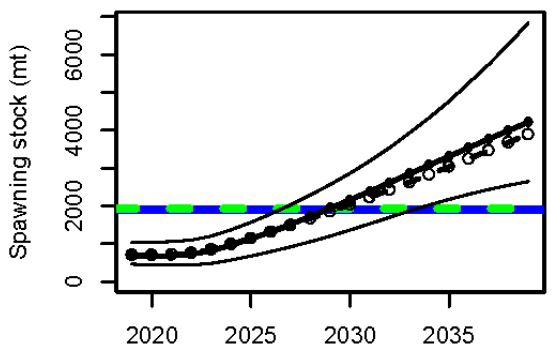


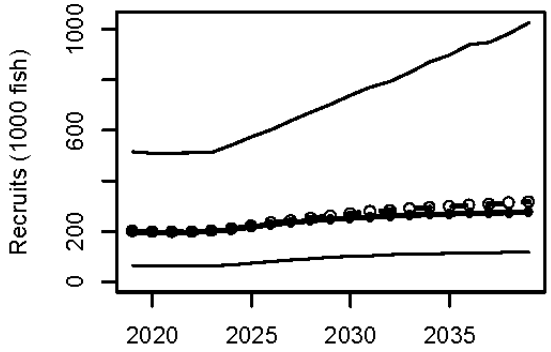
F= F current

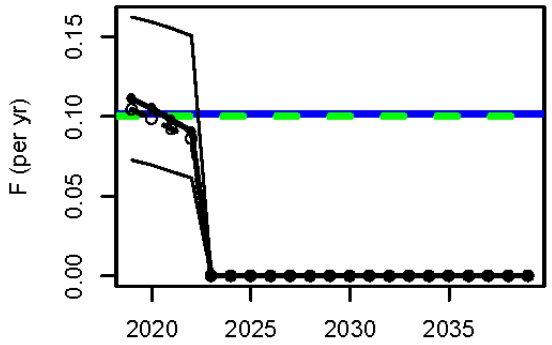
year	pr.rebuild	F.base	F.med	S.base(mt)	S.med(mt)	Rm.base(1000)	Rm.med(1000)	Rm.base(1000 lb)	Rm.med(1000 lb)
2019	0.177	0.11	0.1	672	711	25	24	210	210
2020	0.174	0.1	0.1	673	709	27	26	210	210
2021	0.18	0.1	0.09	690	722	28	27	210	210
2022	0.192	0.09	0.09	728	762	28	28	210	210
2023	0.208	0.11	0.11	777	811	38	35	283	263
2024	0.224	0.11	0.11	828	861	39	36	299	276
2025	0.243	0.11	0.11	882	912	41	37	315	289
2026	0.259	0.11	0.11	936	963	43	39	331	302
2027	0.274	0.11	0.11	987	1009	44	40	346	314
2028	0.287	0.11	0.11	1035	1054	45	41	360	325
2029	0.3	0.11	0.11	1080	1096	46	42	373	336
2030	0.31	0.11	0.11	1122	1135	48	43	385	346
2031	0.32	0.11	0.11	1163	1171	48	44	396	355
2032	0.329	0.11	0.11	1201	1207	49	45	407	365
2033	0.339	0.11	0.11	1237	1240	50	46	417	373
2034	0.349	0.11	0.11	1271	1271	51	46	427	381
2035	0.356	0.11	0.11	1303	1299	52	47	435	389
2036	0.363	0.11	0.11	1332	1327	52	48	444	397
2037	0.371	0.11	0.11	1360	1353	53	48	451	404
2038	0.379	0.11	0.11	1385	1377	53	49	458	411
2039	0.384	0.11	0.11	1409	1399	54	49	464	417

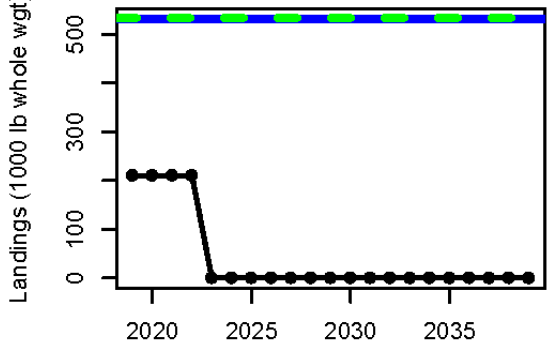
F=0

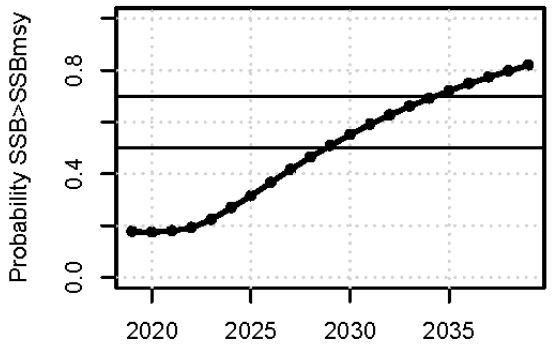
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles









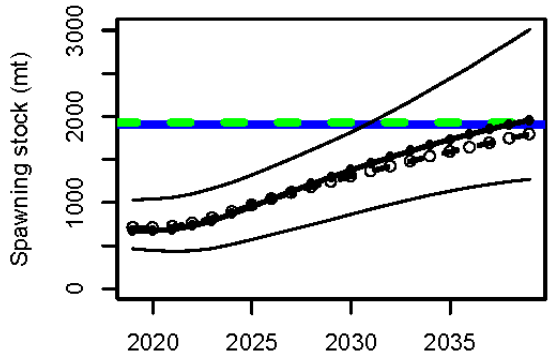


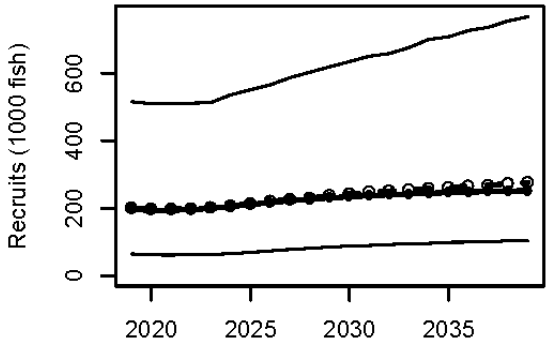
F = 0

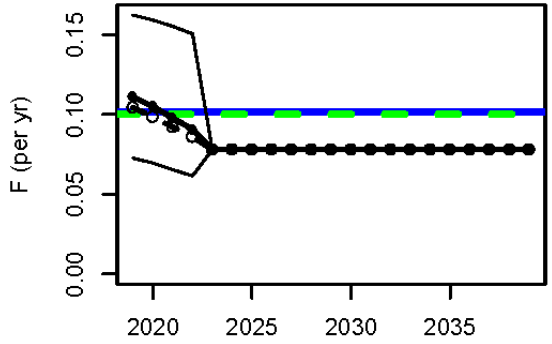
year	pr.rebuild	F.base	F.med	S.base(mt)	S.med(mt)	Rm.base(1000)	Rm.med(1000)	Rm.base(1000 lb)	Rm.med(1000 lb)
2019	0.177	0.11	0.1	672	711	25	24	210	210
2020	0.174	0.1	0.1	673	709	27	26	210	210
2021	0.18	0.1	0.09	690	722	28	27	210	210
2022	0.192	0.09	0.09	728	762	28	28	210	210
2023	0.223	0	0	819	851	0	0	0	0
2024	0.268	0	0	965	993	0	0	0	0
2025	0.314	0	0	1134	1149	0	0	0	0
2026	0.366	0	0	1319	1317	0	0	0	0
2027	0.416	0	0	1517	1492	0	0	0	0
2028	0.464	0	0	1725	1672	0	0	0	0
2029	0.508	0	0	1940	1854	0	0	0	0
2030	0.55	0	0	2161	2041	0	0	0	0
2031	0.591	0	0	2387	2233	0	0	0	0
2032	0.626	0	0	2617	2427	0	0	0	0
2033	0.66	0	0	2850	2628	0	0	0	0
2034	0.69	0	0	3082	2832	0	0	0	0
2035	0.72	0	0	3314	3039	0	0	0	0
2036	0.748	0	0	3544	3251	0	0	0	0
2037	0.773	0	0	3772	3467	0	0	0	0
2038	0.796	0	0	3995	3682	0	0	0	0
2039	0.819	0	0	4214	3895	0	0	0	0

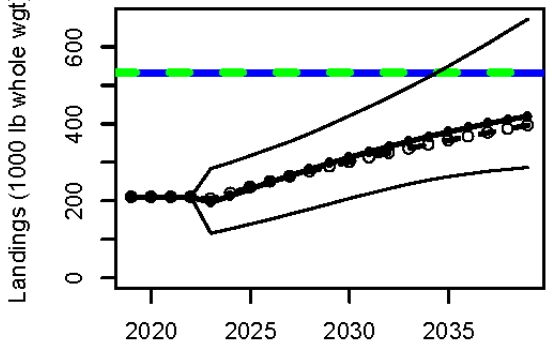
F =0.08 (F to achieve rebuilding probability of 0.5 by 2039)

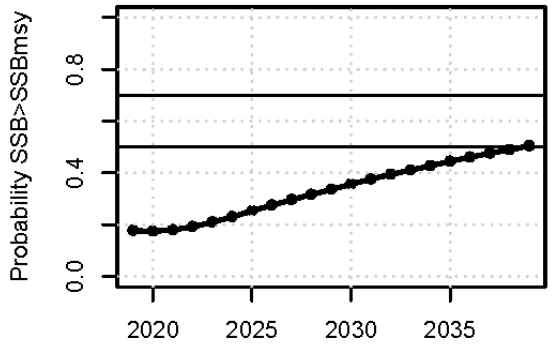
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles









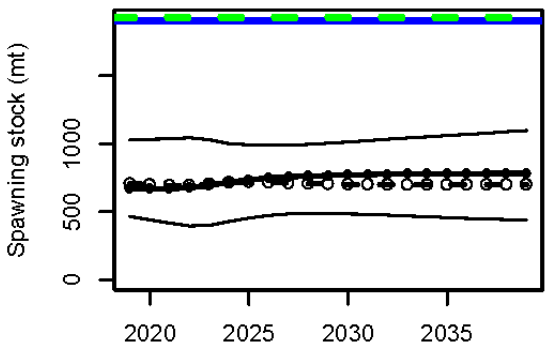


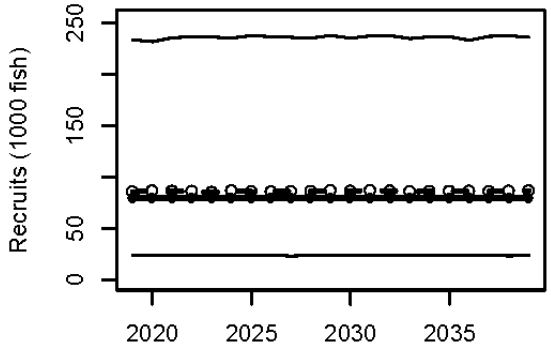
F =0.08 (F to achieve rebuilding probability of 0.5 by 2039)

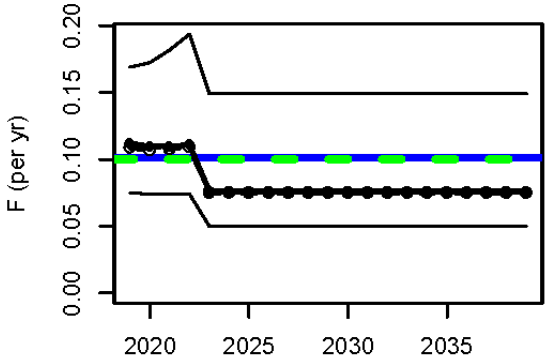
year	pr.rebuild	F.base	F.med	S.base(mt)	S.med(mt)	Rm.base(1000)	Rm.med(1000)	Rm.base(1000 lb)	Rm.med(1000 lb)
2019	0.177	0.11	0.1	672	711	25	24	210	210
2020	0.174	0.1	0.1	673	709	27	26	210	210
2021	0.18	0.1	0.09	690	722	28	27	210	210
2022	0.192	0.09	0.09	728	762	28	28	210	210
2023	0.209	0.08	0.08	790	821	26	27	196	205
2024	0.23	0.08	0.08	869	894	28	28	213	220
2025	0.253	0.08	0.08	955	968	30	30	231	236
2026	0.275	0.08	0.08	1043	1042	31	31	249	250
2027	0.296	0.08	0.08	1130	1112	33	33	266	264
2028	0.316	0.08	0.08	1214	1179	34	34	282	277
2029	0.335	0.08	0.08	1296	1242	36	35	298	289
2030	0.356	0.08	0.08	1376	1304	37	36	313	301
2031	0.375	0.08	0.08	1453	1364	38	37	327	313
2032	0.394	0.08	0.08	1528	1421	39	38	341	325
2033	0.41	0.08	0.08	1599	1479	40	39	355	336
2034	0.427	0.08	0.08	1667	1535	41	40	367	347
2035	0.444	0.08	0.08	1732	1590	42	41	379	357
2036	0.46	0.08	0.08	1794	1640	43	42	390	367
2037	0.475	0.08	0.08	1852	1693	43	43	401	378
2038	0.488	0.08	0.08	1906	1745	44	43	411	387
2039	0.504	0.08	0.08	1957	1793	45	44	420	396

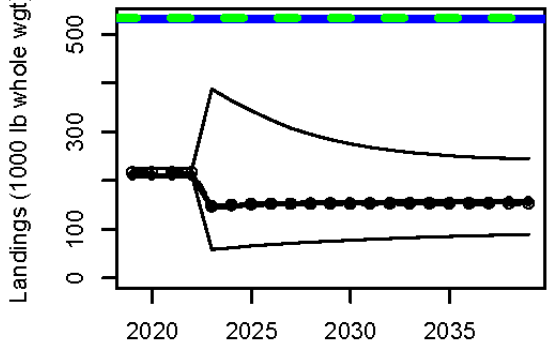
F = 75% Fmsy and continued low recruitment (average 2011 – 2017)

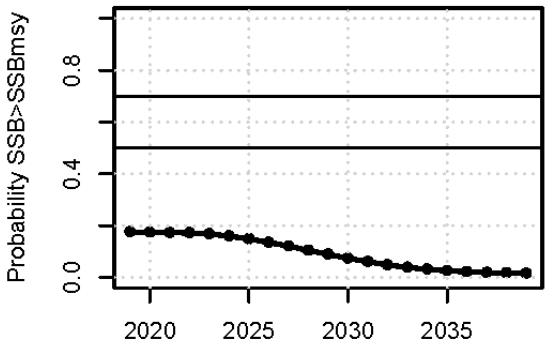
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles









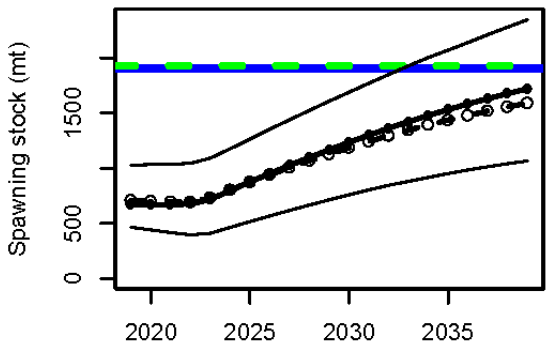


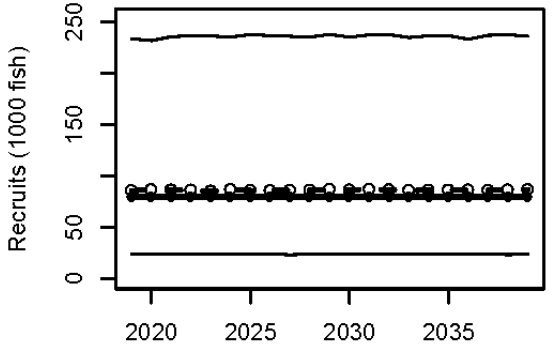
F=75% Fmsy and continued low recruitment (average 2011 –2017)

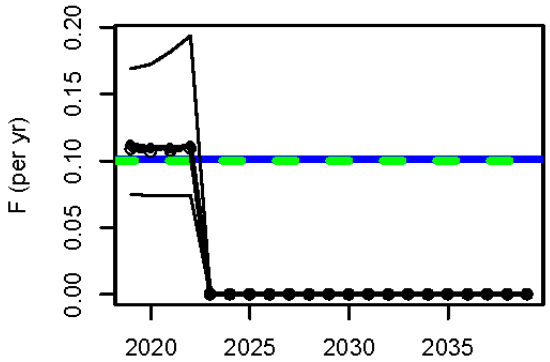
year	R.base(1000)	R.med(1000)	F.base	F.med	S.base(mt)	S.med(mt)	L.base(1000)	L.med(1000)	L.base(1000 lb)	L.med(1000 lb)	pr.rebuild
2019	80	85	0.11	0.11	672	707	24	25	210	216	0.176
2020	80	86	0.11	0.11	671	699	24	25	210	216	0.174
2021	80	86	0.11	0.11	670	694	23	24	210	216	0.172
2022	80	86	0.11	0.11	676	694	23	23	210	216	0.172
2023	80	85	0.08	0.08	693	704	15	16	145	147	0.167
2024	80	87	0.08	0.08	717	717	15	16	148	149	0.159
2025	80	86	0.08	0.08	736	720	15	16	151	151	0.148
2026	80	86	0.08	0.08	748	717	15	16	152	152	0.135
2027	80	86	0.08	0.08	757	710	15	15	153	152	0.121
2028	80	86	0.08	0.08	763	706	15	15	154	152	0.104
2029	80	87	0.08	0.08	767	704	15	15	154	152	0.089
2030	80	86	0.08	0.08	771	702	15	15	155	152	0.074
2031	80	87	0.08	0.08	774	701	15	15	155	152	0.06
2032	80	86	0.08	0.08	776	699	15	15	155	153	0.048
2033	80	86	0.08	0.08	778	699	15	15	156	153	0.039
2034	80	86	0.08	0.08	779	699	15	15	156	153	0.031
2035	80	86	0.08	0.08	780	699	15	15	156	153	0.025
2036	80	86	0.08	0.08	781	699	15	15	156	153	0.021
2037	80	86	0.08	0.08	782	700	15	15	156	153	0.018
2038	80	86	0.08	0.08	782	700	15	15	156	153	0.017
2039	80	86	0.08	0.08	782	701	15	15	156	153	0.015

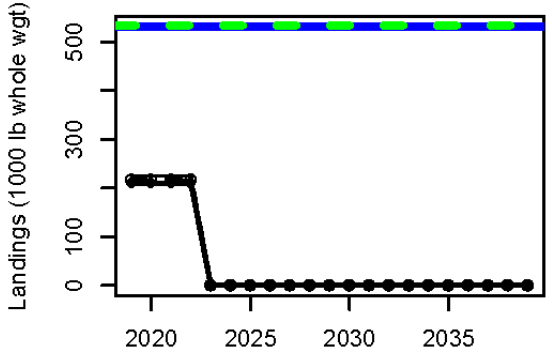
F = 0 and continued low recruitment

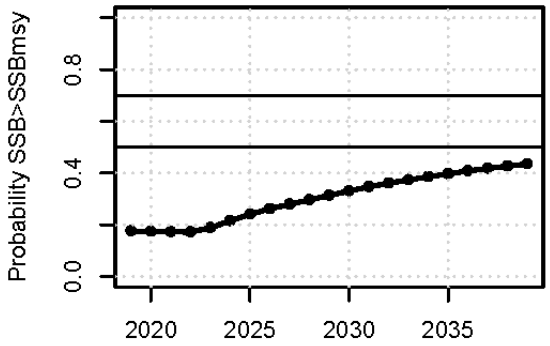
Thick blue solid=base benchmark
Thick green dash=median benchmark
Thin solid, closed circles=deterministic
Thin dash, open circles=median
Thin solid=5th and 95th percentiles











F = 0 and continued low recruitment (average 2011 –2017)

year	R.base(1000)	R.med(1000)	F.base	F.med	S.base(mt)	S.med(mt)	L.base(1000)	L.med(1000)	L.base(1000 lb)	L.med(1000 lb)	pr.rebuild
2019	80	85	0.11	0.11	672	707	24	25	210	216	0.176
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2022	80	86	0.11	0.11	676	694	23	23	210	216	0.172
2023	80	85	0	0	718	730	0	0	0	0	0.188
2024	80	87	0	0	797	802	0	0	0	0	0.215
2025	80	86	0	0	875	874	0	0	0	0	0.24
2026	80	86	0	0	952	942	0	0	0	0	0.261
2027	80	86	0	0	1025	1007	0	0	0	0	0.279
2028	80	86	0	0	1097	1068	0	0	0	0	0.296
2029	80	87	0	0	1167	1128	0	0	0	0	0.313
2030	80	86	0	0	1235	1186	0	0	0	0	0.33
2031	80	87	0	0	1300	1242	0	0	0	0	0.347
2032	80	86	0	0	1362	1295	0	0	0	0	0.36
2033	80	86	0	0	1422	1345	0	0	0	0	0.374
2034	80	86	0	0	1479	1393	0	0	0	0	0.385
2035	80	86	0	0	1532	1436	0	0	0	0	0.396
2036	80	86	0	0	1583	1478	0	0	0	0	0.408
2037	80	86	0	0	1632	1519	0	0	0	0	0.417
2038	80	86	0	0	1677	1556	0	0	0	0	0.426
2039	80	86	0	0	1721	1590	0	0	0	0	0.434