SEDAR 71
South Atlantic Gag Grouper

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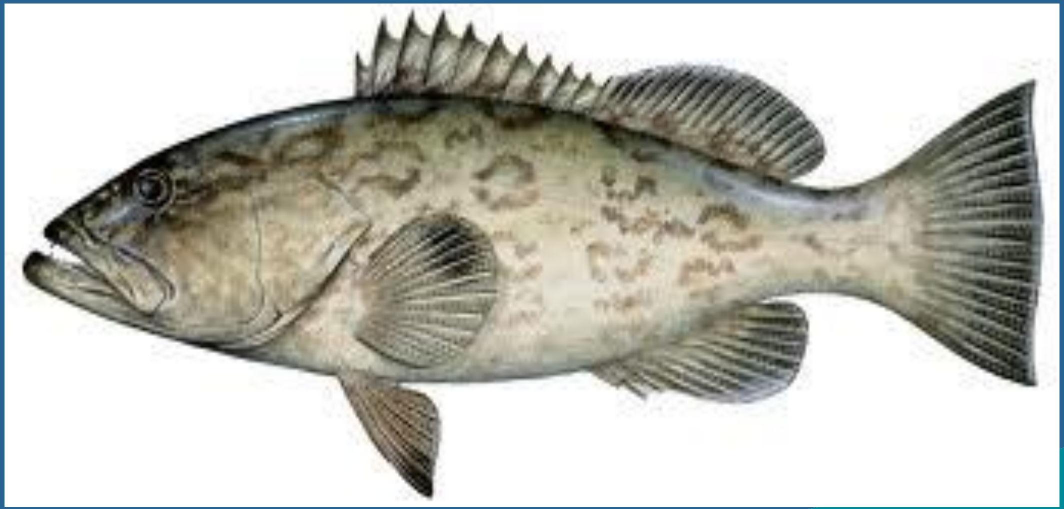
Sustainable Fisheries Branch
Beaufort, NC



SSC meeting

May 03, 2021

Topics

1. Background
2. Data
3. Assessment model
4. Assessment results
5. Projections

SEDAR Assessment History

- SEDAR 10 benchmark: Catch-age model (BAM) with data through 2004
  - F_{2004}/F_{msy} = 1.46 (overfishing); SSB_{2004}/MSST=1.06 (not overfished)
  - Old definition of MSST: $(1\text{-}M)SSB_{msy}$

- 2014 Update: Catch-age model (BAM) with data through 2012
  - $F_{(2010\text{-}2012)}/F_{msy}$ = 1.23 (overfishing); SSB_{2012}/MSST=1.13 (not overfished)
  - New definition MSST: 75%SSB_{msy}

- SEDAR 71 operational assessment:
  - 5 webinars (October 2020-March 2021) plus data scoping
  - Catch-age model (BAM) with data through 2019
  - $F(_{2017\text{-}2019)}/F_{msy}$ = 2.15 (overfishing); SSB_{2019}/MSST=0.2 (overfished)
  - Key features:
    - Added fishery-independent SERFS video index
    - Continued declines in abundance & low recruitment since the 2014 update

Regulatory History

- Size limits (Commercial and Recreational fleets)
  - 20-inch TL minimum size limit (1992-1998)
  - 24-inch TL minimum size limit (1999-present)

- Catch limits
  - Aggregate rec grouper bag limit (5/person/day, 1992)
  - Comm and rec bag limits starting in 1999 (gag or black)
  - Commercial trip limits starting in 2012
  - Spawning season (Jan-Apr) closure 2009-present
  - Comm and Rec ACLs established in 2011 (51% comm, 49% rec)
    - Comm ACL met 2012-2014
    - Rec bag limit reduced to 1 gag/person/day

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Life History

Changes from 2014 update

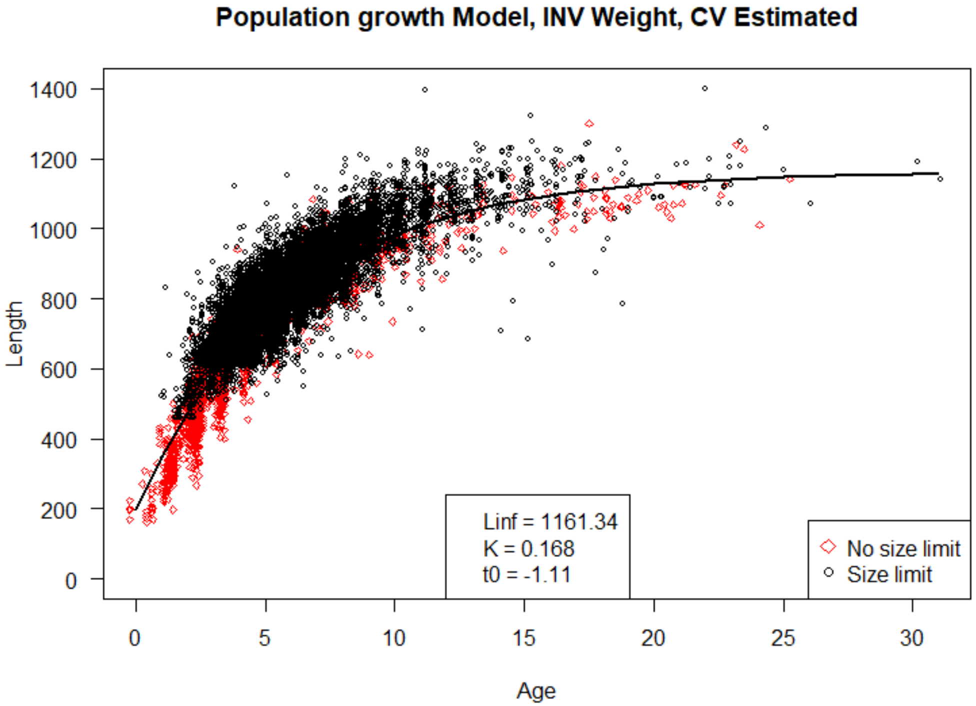
- Updated population growth curve and maturity schedule
- Separate population and fishery growth curves
- Updated natural mortality vector (Lorenzen age-based)
- Time-invariant sex ratio (Age at transition ~ 10.5 yrs, SEDAR71-WP03)

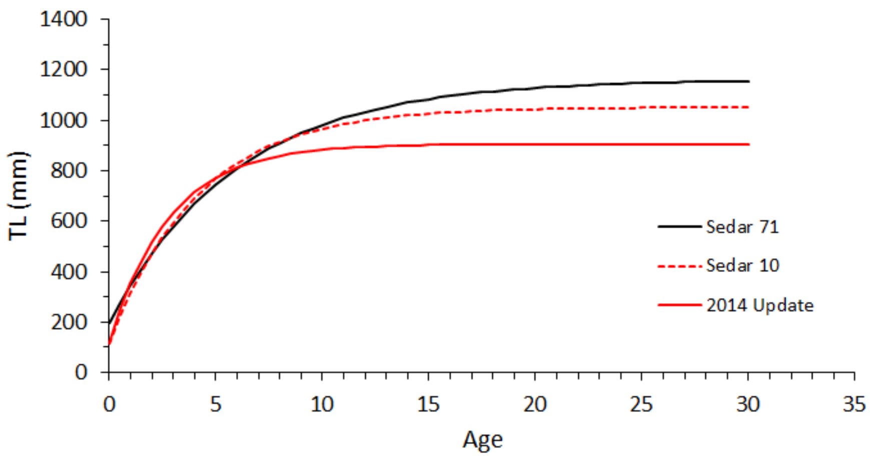
Same as 2014 update

- Discard mortality: 0.4 for cHL, 0.25 for rec fleets
- Model age 1 – 16+ (1 – 12+ for fitting composition data)
- Length-weight and and whole weight-gutted weight conversions
- Peaking spawning mid-April
- Spawning stock modeled as total mature male and female biomass

Life History: Popn Growth Curve

- Updated population growth curve with additional samples

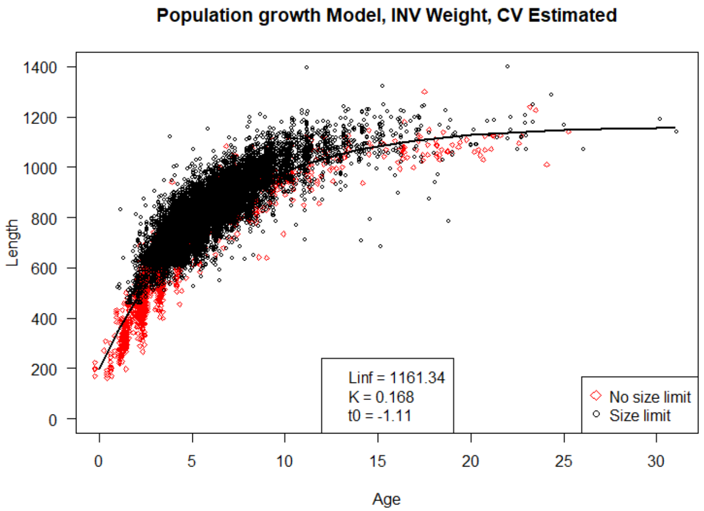


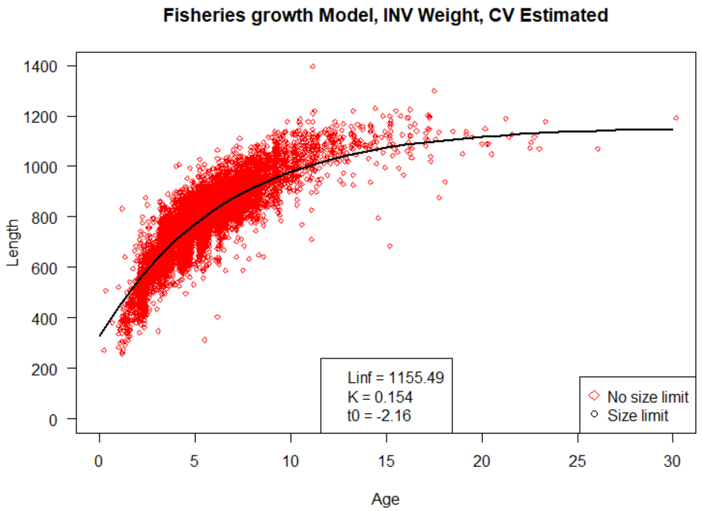


	L_{∞} (mm)	k	t_0
SEDAR 10	1051	0.2	-0.48
2014 Update	905	0.35	0.40
SEDAR 71	1161	0.17	-1.11

Life History: Fishery Growth Curve

- Separate fishery growth curve for landings



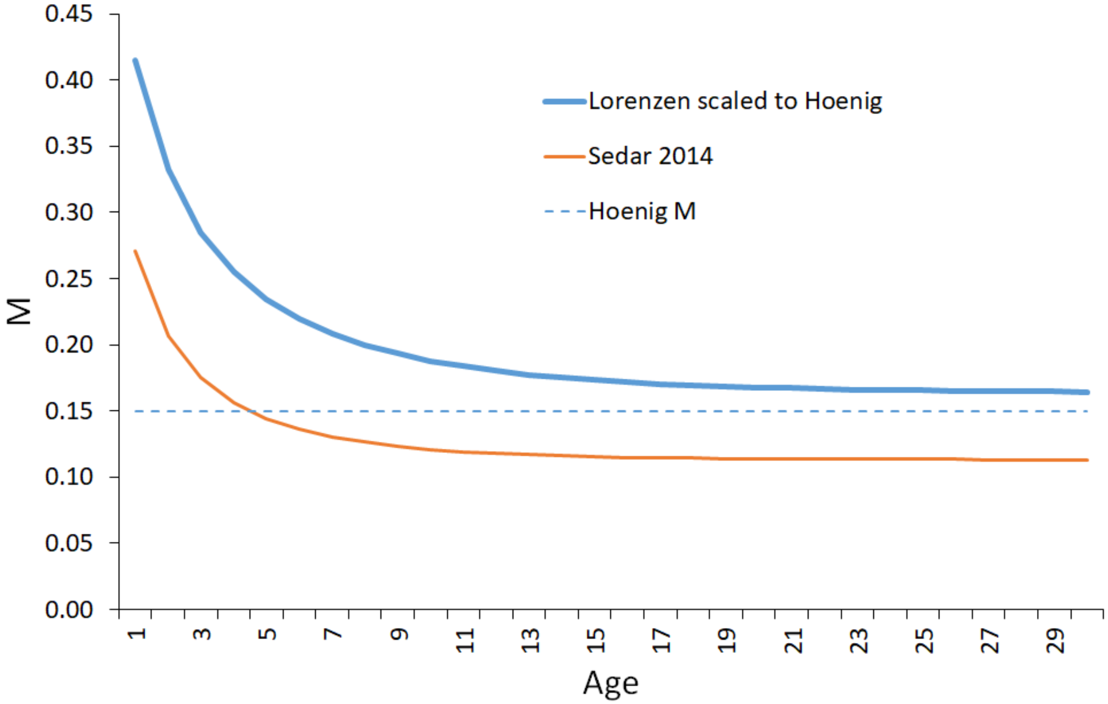


Population growth curve: Linf = 1161 mm, k = 0.168, t0 = -1.11

Fishery growth curve: Linf = 1156 mm, k = 0.154, t0 = -2.16

Life History: Natural Mortality

- Update Lorenzen age-based natural mortality



t_{max} = 30 yrs
Constant M (Hoenig) = 0.15

- Based on update population growth curve (same t_{max})
- Scaled over fully selected ages (5+) rather than all ages (1+)

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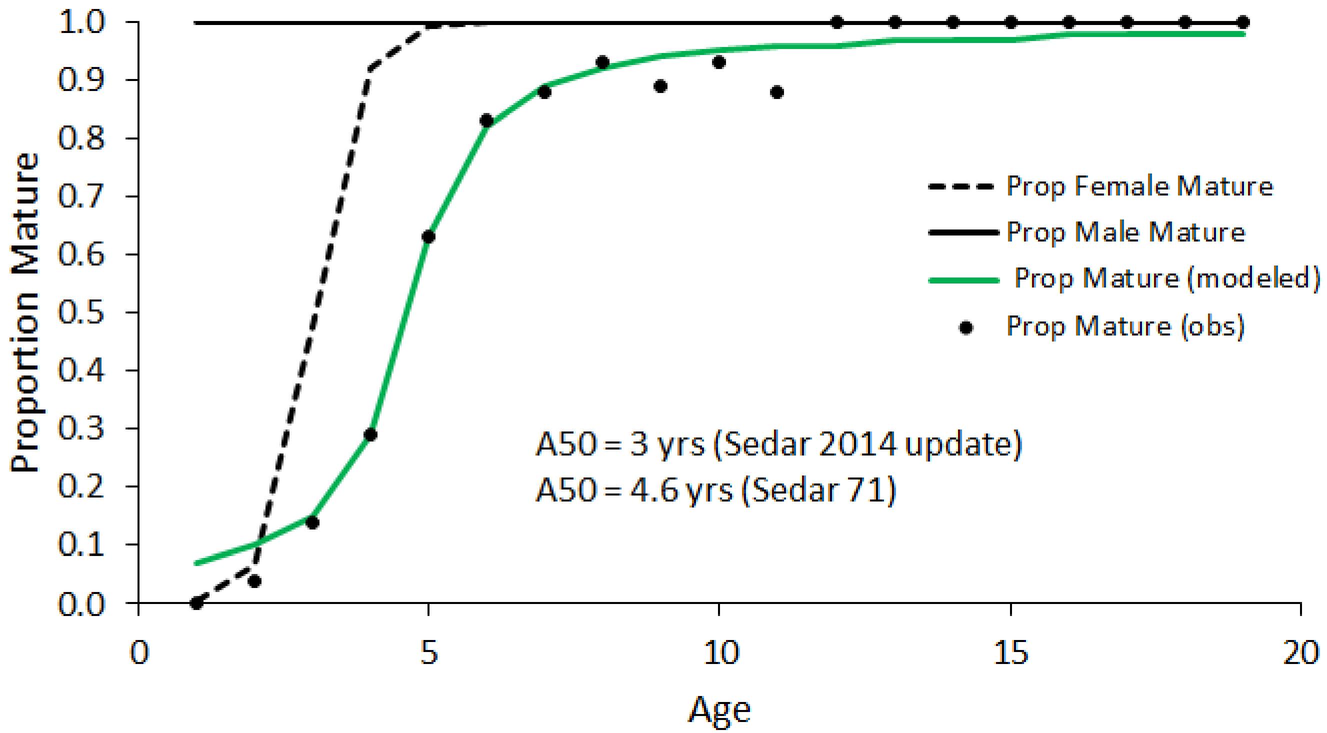
Life History: Maturity

- Updated maturity schedule with additional samples
- Female maturity varies with age, all males assumed mature

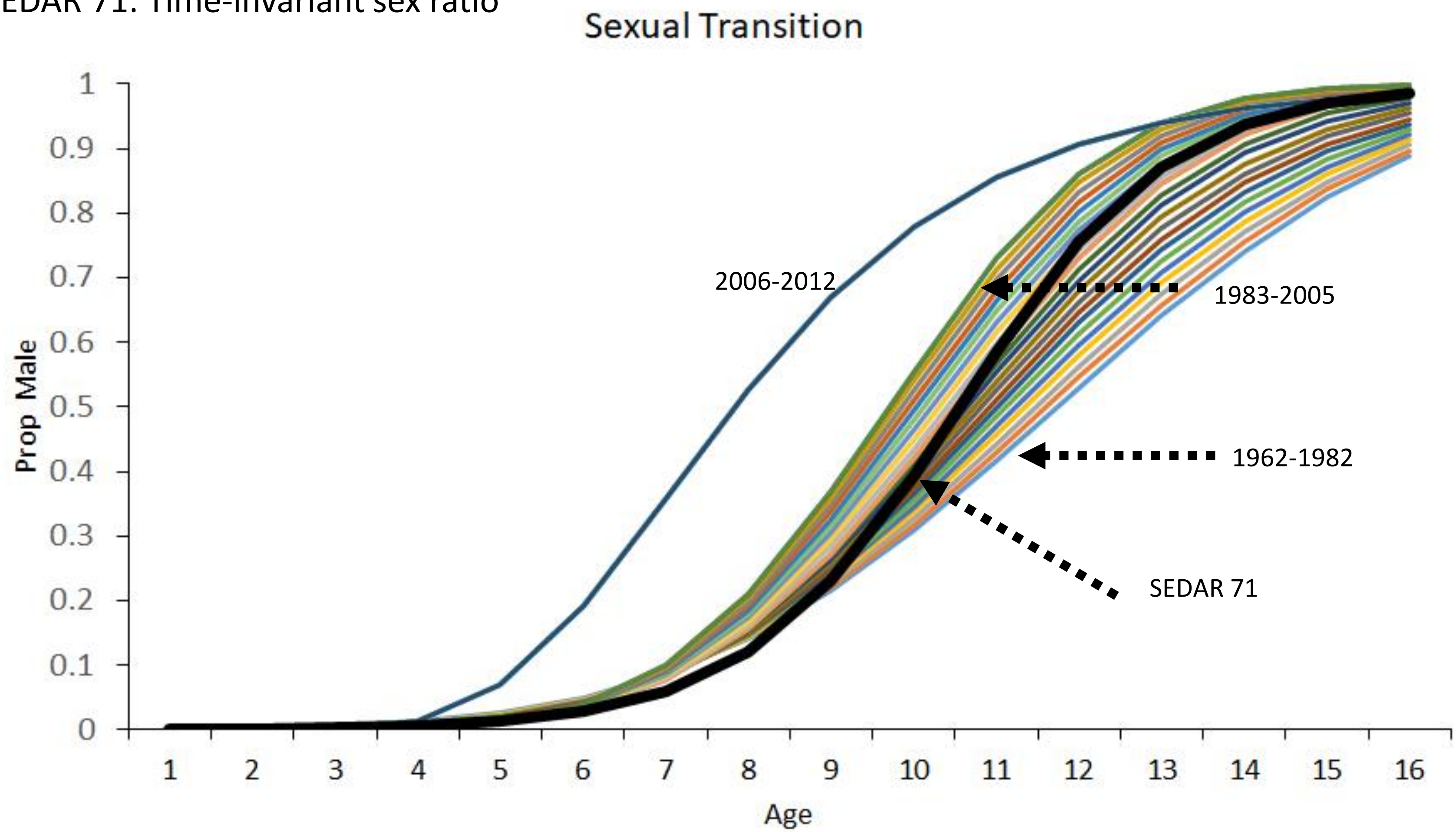


SEDAR71-WP03

Life History: Sex ratio

- Protogynous hermaphrodite (female to male)
- SEDAR 10:
    - Assumed constant sex ratio 1962-1982
    - Annually varying sex ratio 1983-2005
    - Constant sex ratio 2006-2012

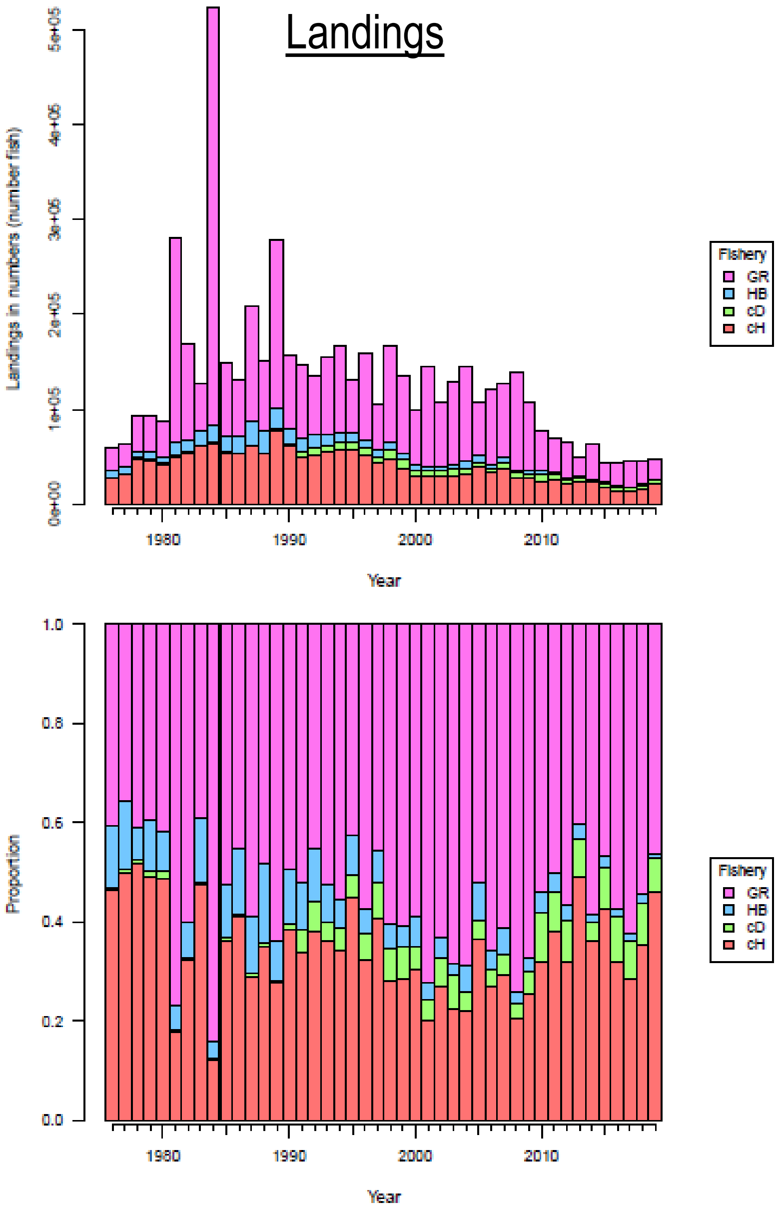
- SEDAR 71: Time-invariant sex ratio

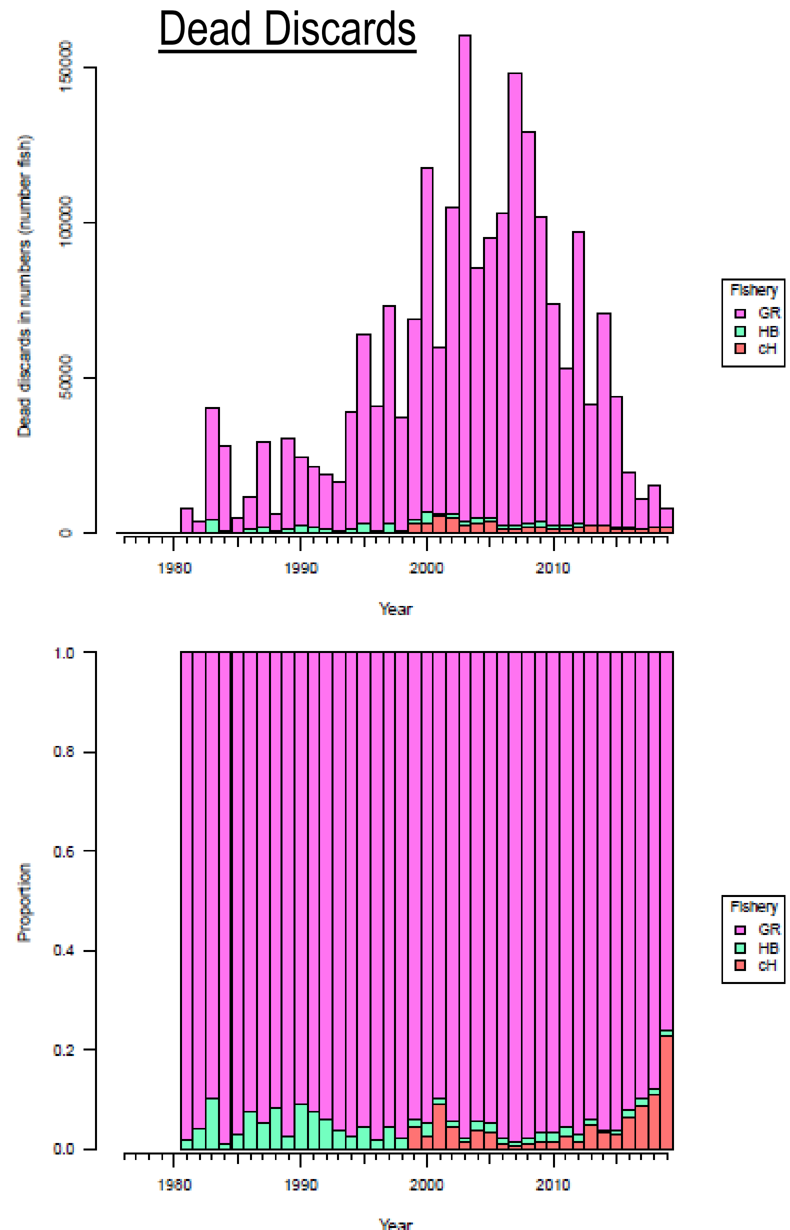


Fleet Structure

- Same as 2014 update
- Commercial handline (pooled with other gears, < 1% landings)
- Recreational headboats
- General recreational (private + charter + shore)
- Landings and dead discards modeled separately for each fleet

Fishery Removals





Composition Data

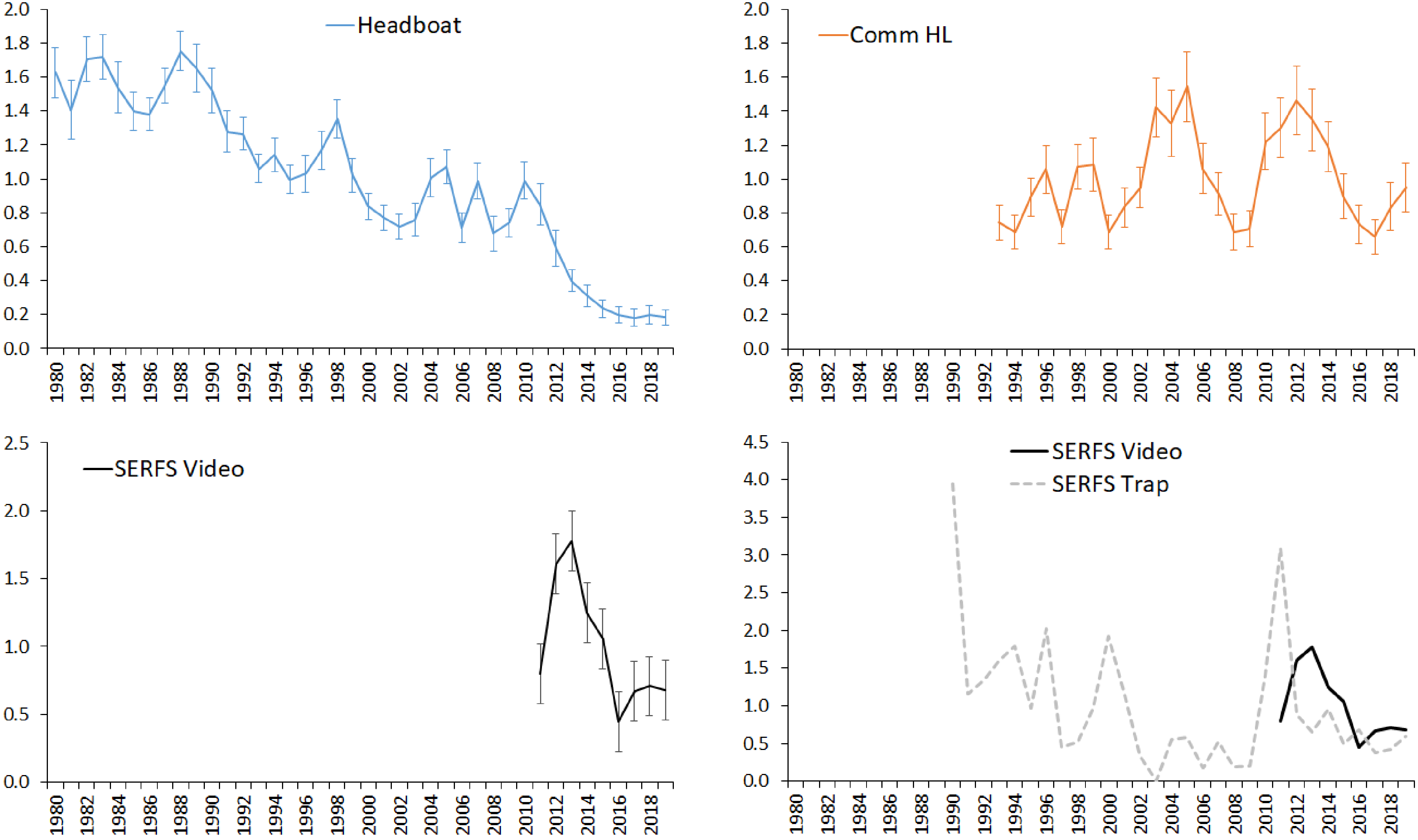
- Age compositions
  - Commercial handline landings (1997, 1999-2019)
  - Commercial dive landings (2009-2011, 2013-2019)
  - Recreational headboat landings (1980-87, 1990-95, 2001-19)
  - SERFS chevron trap (2011-2019)
- Length compositions
  - Headboat landings (1988-1989, 1996-2000)
  - Headboat-at-sea discards (2005-2013)

Indices of Abundance

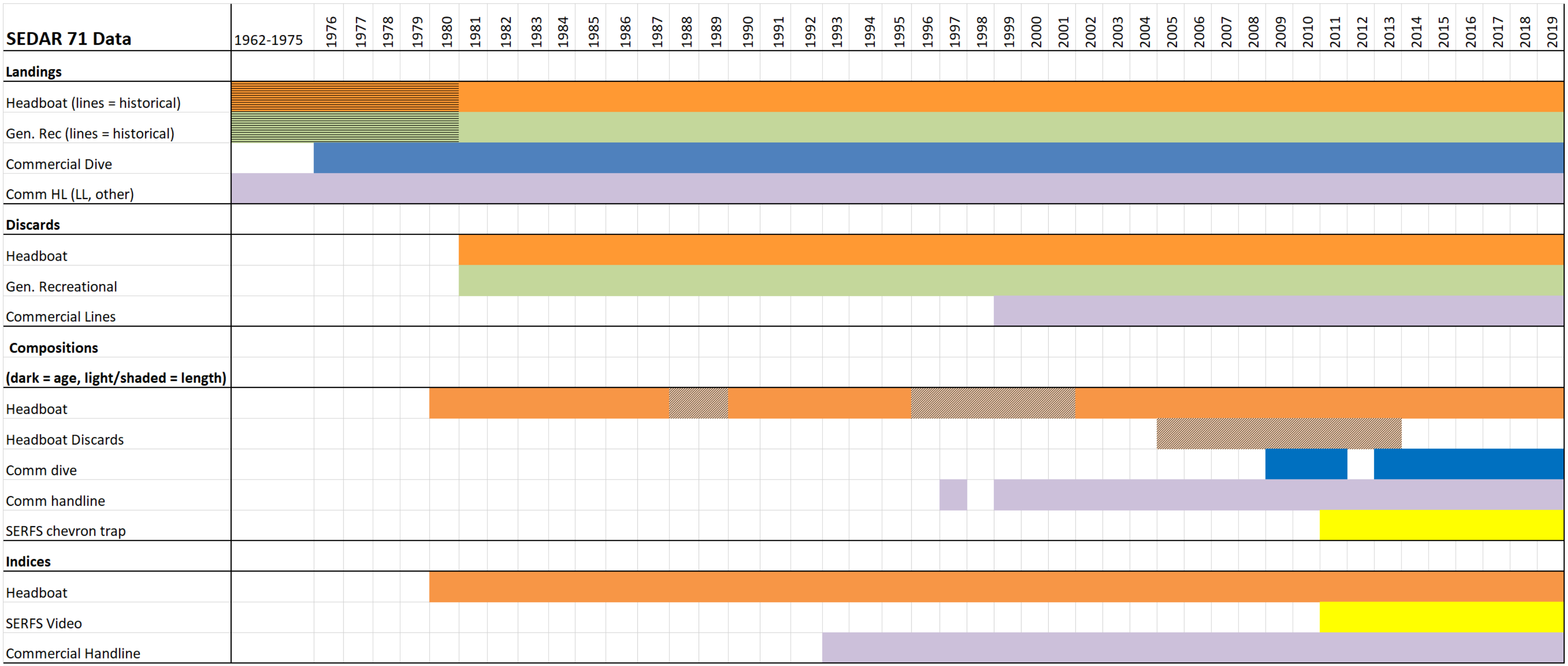
3 indices considered:

- Headboat index (1980-2019)
- SERFS video index (2011-2019)
- Commercial handline index (1993-2019)
  - Excluded due to concerns about hyperstability
  - Conflict with other indices
- MRFSS index from 2014 update (1981-2004) not updated or re-visited for this assessment

Indices of Abundance



Data Summary



Summary of SEDAR 71 Data Updates

- Added 7 additional years of data (2013-2019)
- General recreational landings and discards from current MRIP methods
- Life history:
  - Updated growth curve, maturity schedule, and natural mortality
  - Time-invariant sex ratio
- Separate fishery growth curve for the landings and the fishery
- Length compositions for headboat discards
- Historical recreational landings based on FHWAR method
- SERFS fishery independent video index

Topics

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BAM Base Run

- Same model as in SEDAR 2014 update: Integrated catch-age model (BAM)
- Assessment period 1962-2019
- Assume initial (1962) equilibrium age structure with estimated initial fishing mortality (F_{init})
- Model ages 1-16+ for the population; ages 1-12+ for fitting composition data
- Spawning stock based on total mature male and female biomass
- Separate population and fishery growth curves with constant CV estimated for each
- Lorenzen age-based natural mortality
- Constant catchability (*q*)
- Beverton-Holt stock recruitment relationship; recruitment deviations from 1976 - 2019
- Dirichlet-multinomial for composition data (self weighting); iterative re-weighting on indices

BAM Base Run (cont)

- Landings selectivity:
  - cHL: logistic
  - GR and HB: logistic
  - cD: dome-shaped

- Commercial and Recreational discard selectivity:
  - No age comps, 9 yrs headboat-at-sea length comps (2005-2013)
  - P(below the size limit at given age based on growth curve)
  - Headboat-at-sea discard lengths to estimate age-2 selectivity in recent pd (1999-2019)
  - Fleets share the same discard selectivity (as in 2014 update)

- SERFS video selectivity (SEDAR73-WP14):
  - Video assumed logistic, Chevron trap assumed dome
  - Estimate dome-shaped selectivity for Chevron traps based on trap age compositions
  - Ascending limb of Video selectivity same as that of Chevron trap
  - Video selectivity fixed at 1.0 for ages > age maximum selectivity

Assessment Modifications: Selectivity Blocks

- Remove selectivity blocks for commercial fleet (cHL)
  - No shift in length compositions around size limit changes
  - No cHL age compositions prior to 1997

- Reduce selectivity blocks for general recreational (GR) and headboat (HB) fleets
  - Small shift in length and age compositions around 20 inch size lt (1992)
  - No shift in length and age compositions around 24 inch size lt (1999)
  - Pre- and post-size limit blocks (1992)

2014 update:

Selectivity Block	Regulations	Fleet
1962-1991	None	GR, HB, cHL
1992-1998	20 in TL	GR, HB, cHL
1999-2019	24 in TL	GR, HB, cHL

SEDAR 71:

Selectivity Block	Regulations	Fleet
1962-1991	None	GR, HB, cHL
1992-2019	20 in TL	GR, HB

Summary of SEDAR 71 Model Updates

- No selectivity blocks for cHL, pre- and post-size limit blocks for GR and HB
- Include SERFS video index (with selectivity estimated from trap age comps)
- Discards modeled as p(below size limit) at age; age-2 estimated in recent period
- Dirichlet-multinomial for composition data (robust multinomial in 2014 update)
- Iterative re-weighting only for indices (indices and compositions in 2014 update)
- Estimate F_{init} (fixed at 0.03 in 2014 update)
- Estimate steepness (fixed at $h = 0.84$ in 2014 update)

Uncertainty Analysis: Ensemble Modeling

Bootstrap the data:

- Sample from lognormal distn for landings and discards
- Multinomial resampling of observed age and length compositions
- Indices sampled from lognormal distn with CV from iterative reweighting

Monte Carlo draws over key parameters:

- Natural Mortality (M): Truncated normal distribution
    - mean = 0.15 (Hoenig M for max age 30)
    - range = 0.1-0.2 (corresponds to tmax 23 to 45)

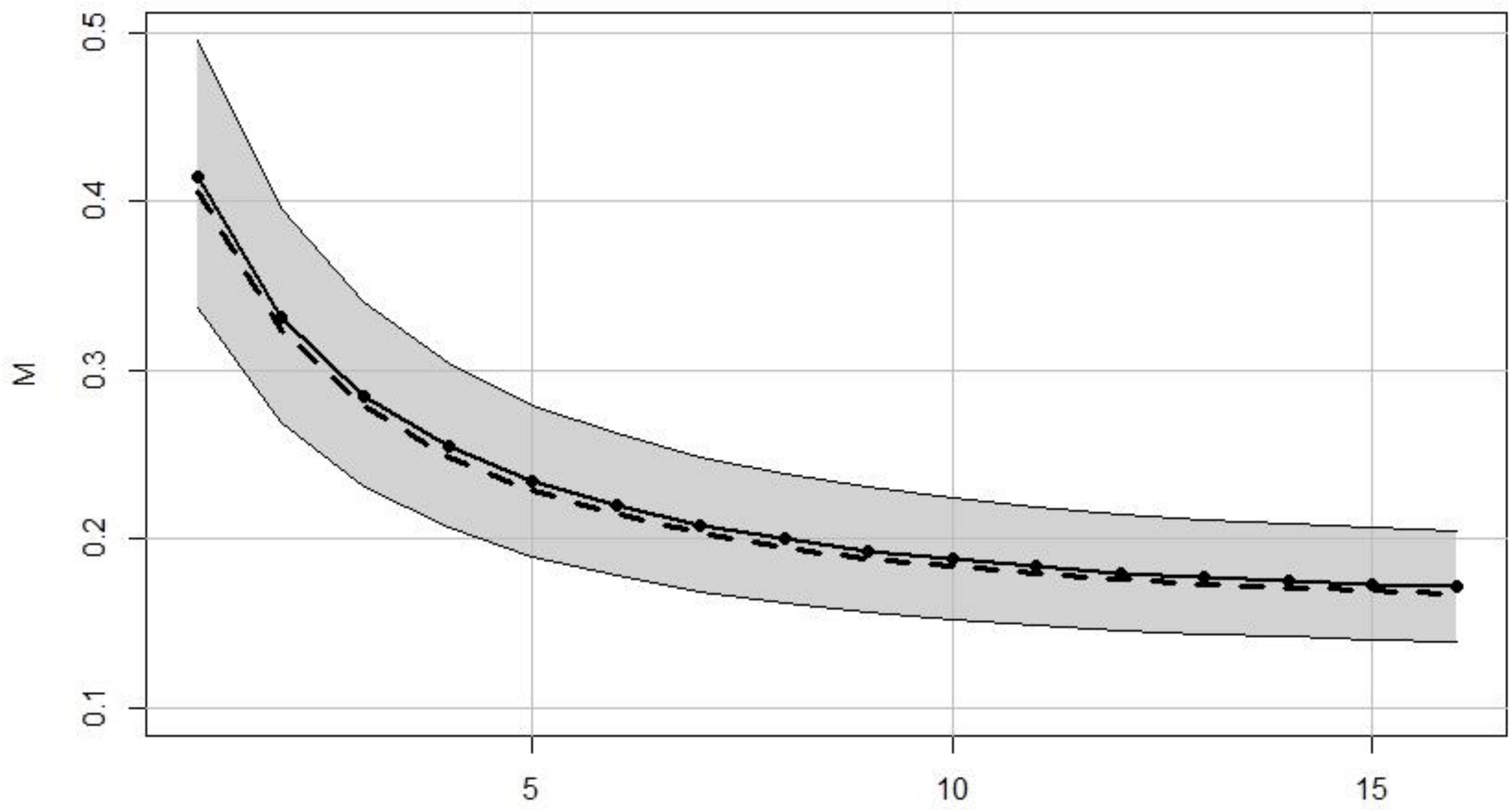
- Discard Mortality: Uniform
    - cHL: 0.3 to 0.5 (0.4 in base)
    - HB and GR: 0.15 to 0.35 (0.25 in base)

- Historical recreational landings (1962-1980)
    - Multiplier: Uniform distribution 0.75-1.25 (+/- 25% of values from FHWAR method)

- Culling: steepness =upper bound, max gradient > 0.1, F_{msy} > 3.0 (4374 runs retained)

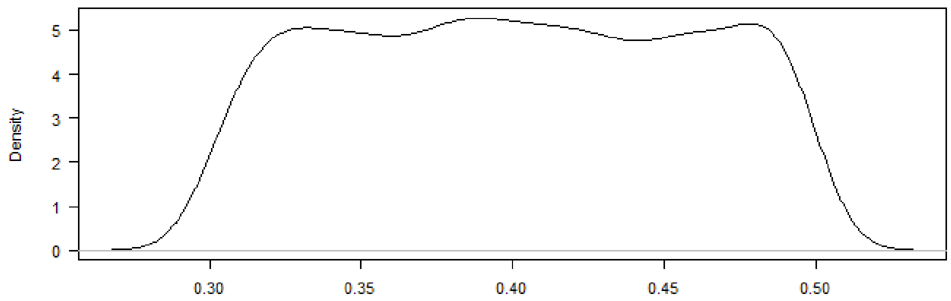
Uncertainty Analysis: Natural Mortality

Solid = MLE (Base)
Dash = Median (MCBE)
Shading = 5th and 95th CIs

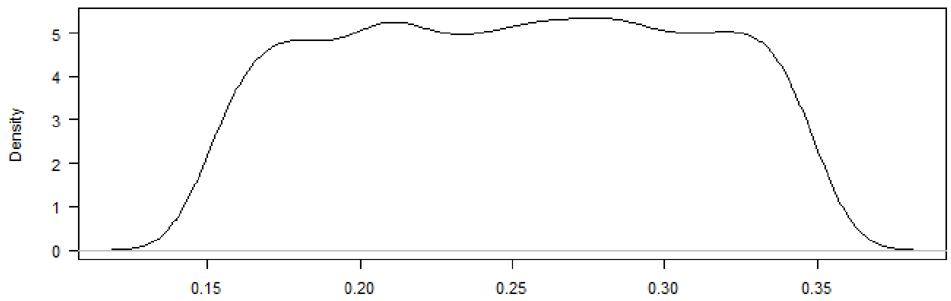


Uncertainty Analysis: Discard Mortality

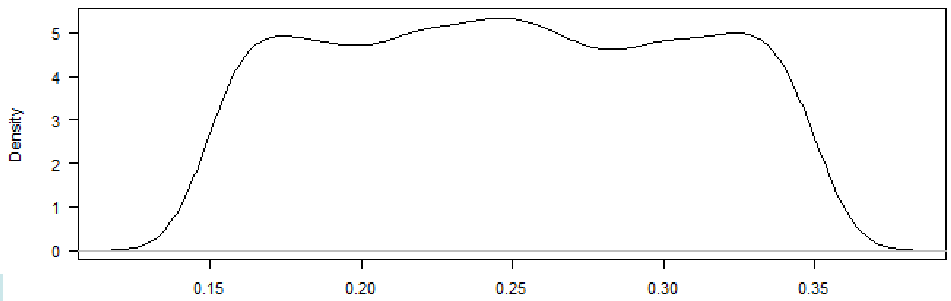
cHL Discard Mortality



HB Discard Mortality

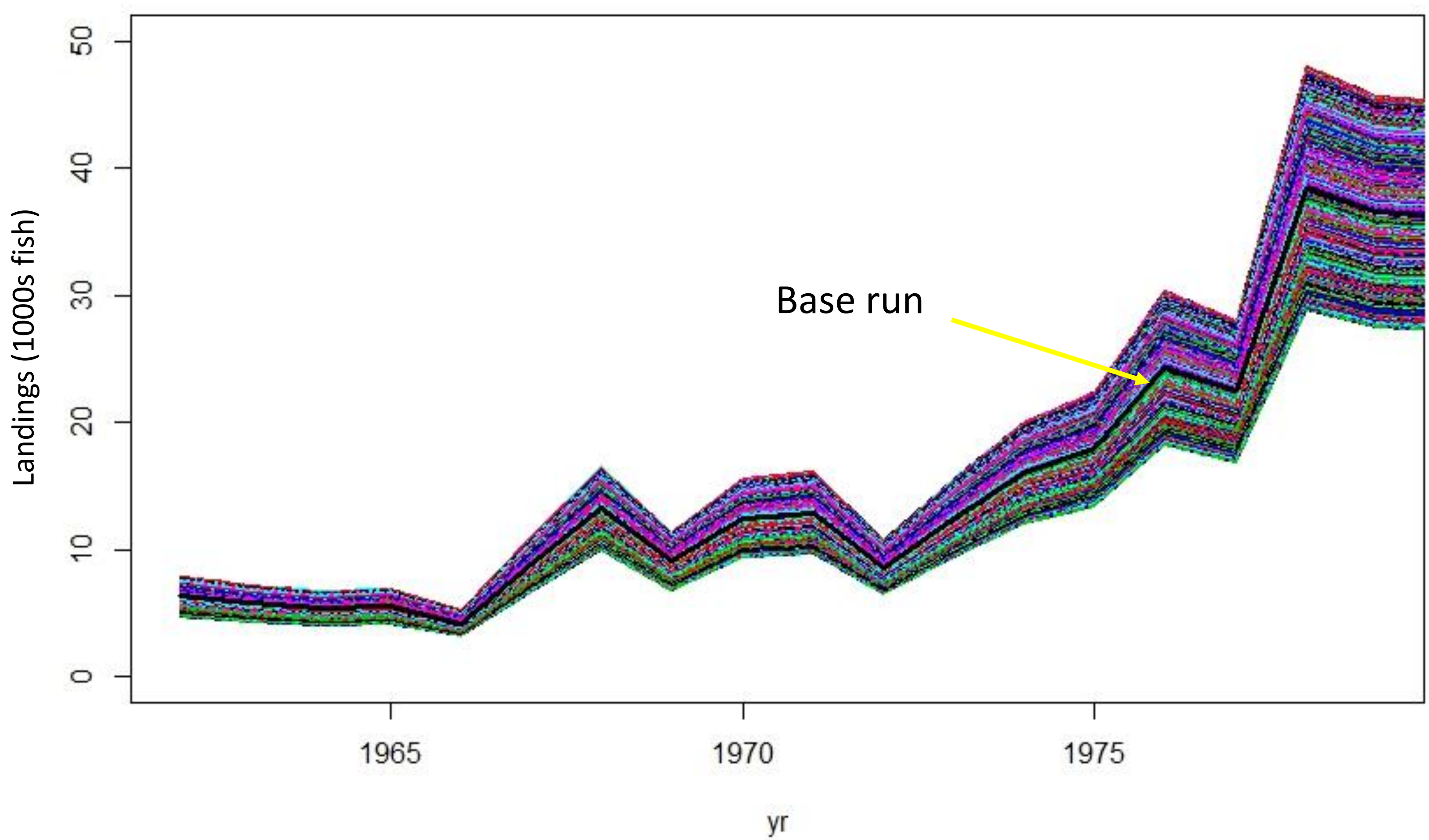


GR Discard Mortality



Uncertainty Analysis: Historic Rec Landings

Historic Period: 1962 – 1980
+ or – 25% of hindcast estimates



Sensitivity Runs

- Steepness
  - low=0.85
  - high=0.95
  - 2014 update=0.84
- Indices-1
  - Headboat (HB) alone
  - Video (VID) alone
  - HB and VID with wgts = 1.0
- Indices-2
  - Truncated HB (retain VID)
  - HB, VID, and comm handline (cHL)
  - HB, VID, cHL-q block
- Indices-3 (random walk on *q* for fish dep indices)
- Finit (+/- 50% estimated value)
- Discard mortality (high = 0.35, low = 0.15 all fleets)
- Selectivity
  - Size limit blocks (as in 2014 update)
  - Video selectivity = trap selectivity (dome-shaped)

continued:

- Natural mortality-1
  - 2014 update M (scaled to ages 1+)
  - SEDAR 71 M (scaled to 1+)
- Natural mortality-2
  - Low M = 0.1 (SEDAR 10)
  - High M = 0.25 (SEDAR 10)
  - Constant M = 0.14 (Hoenig tmax)
- Life history
  - Growth, nat mortality, maturity from 2014 update
- Repro potential = egg production
- 5 year Retrospectives

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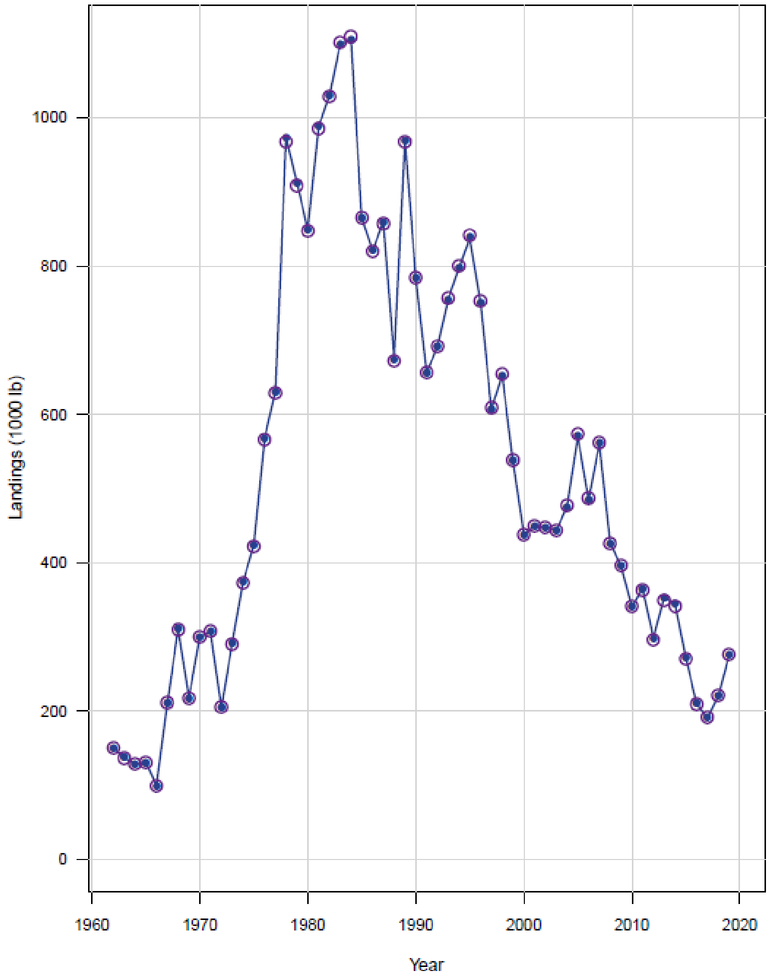
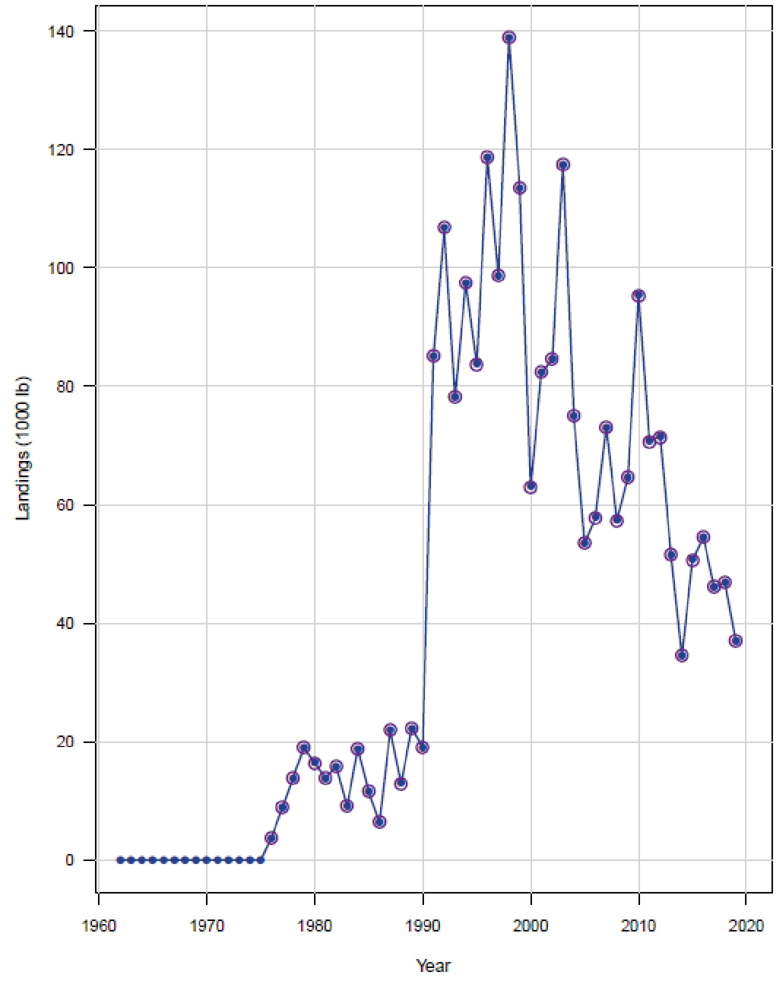
BAM base run: Fit to commercial landings

Commercial Handline (cHL)



Commercial Dive (cD)



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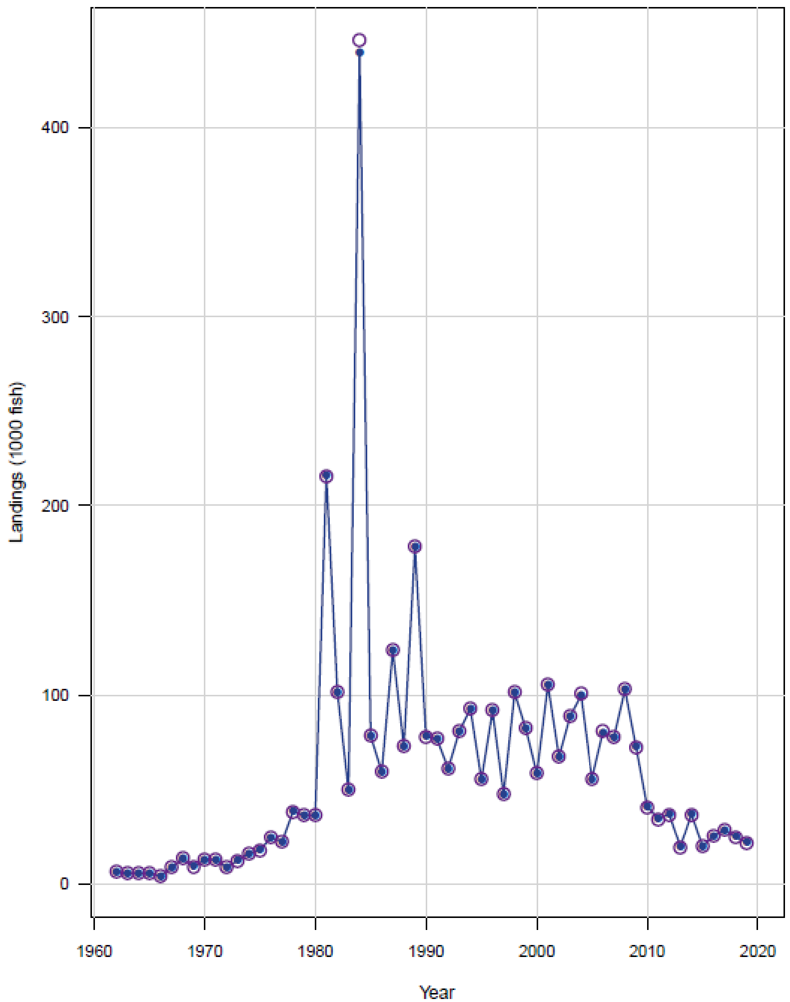
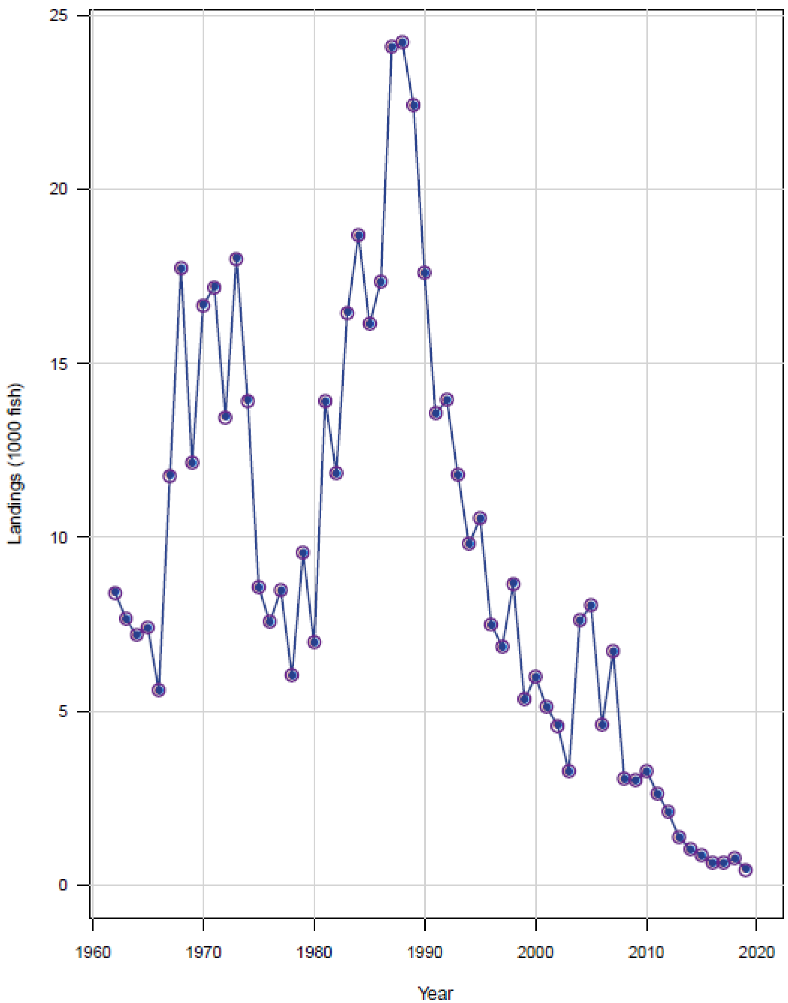
BAM base run: Fit to recreational landings

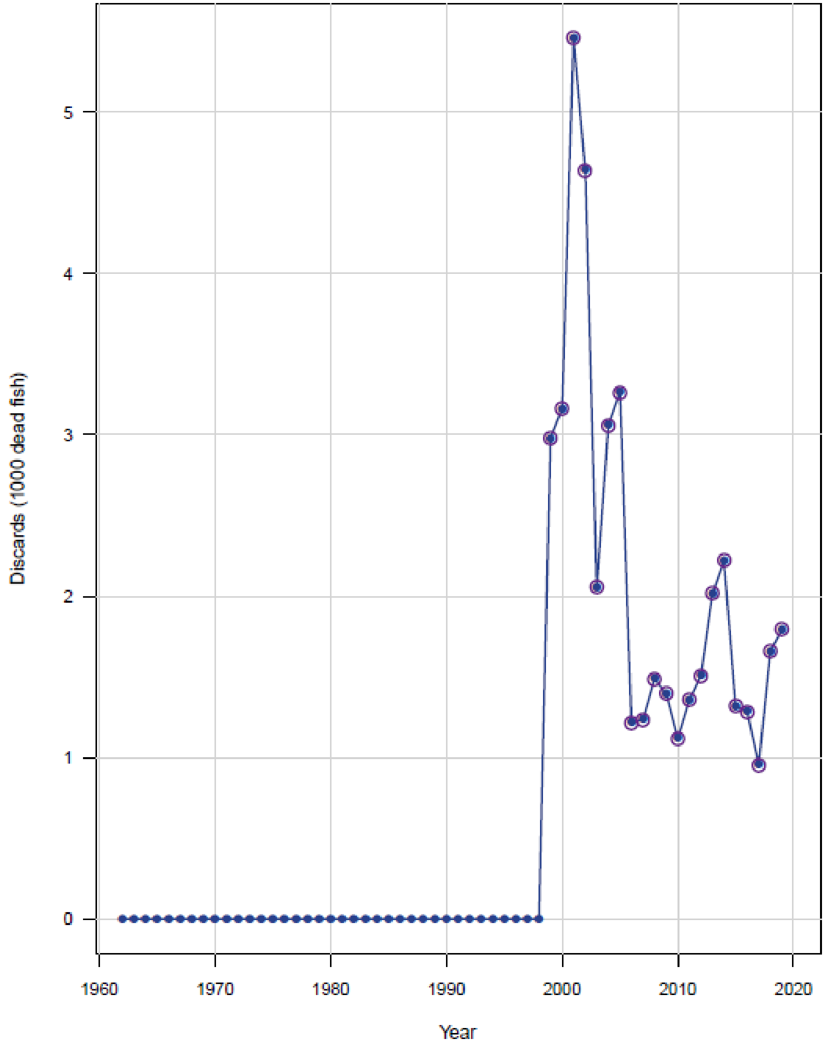
General Recreational (GR)



Headboat (HB)

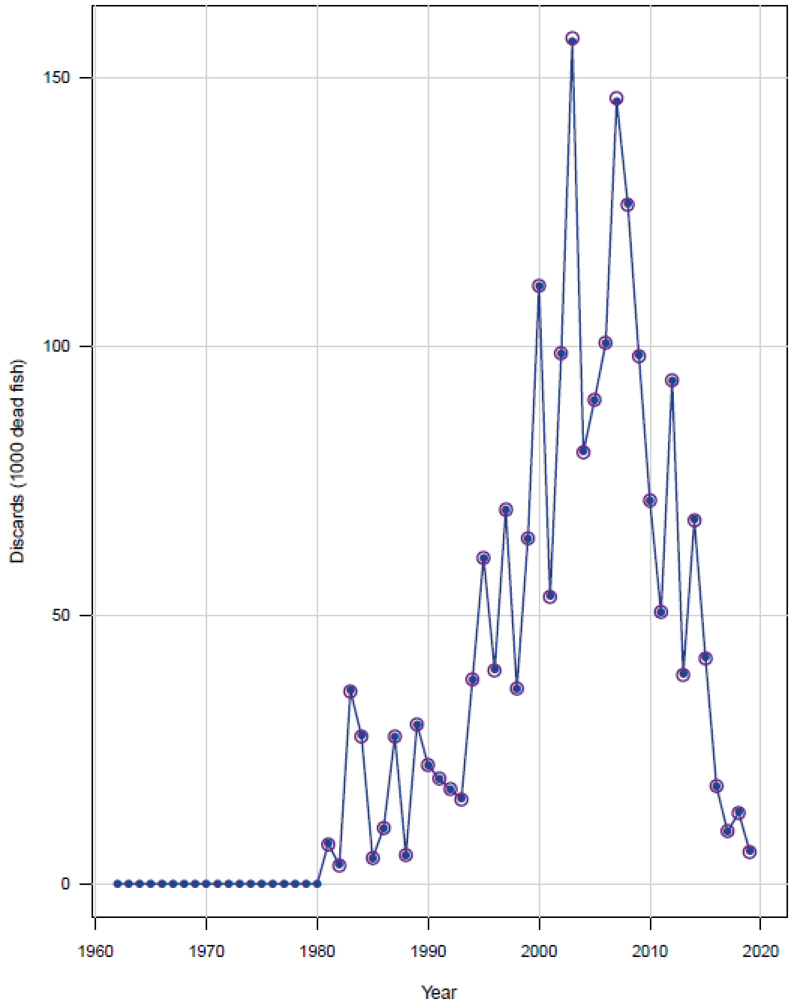


BAM base run: Fit to commercial handline dead discards

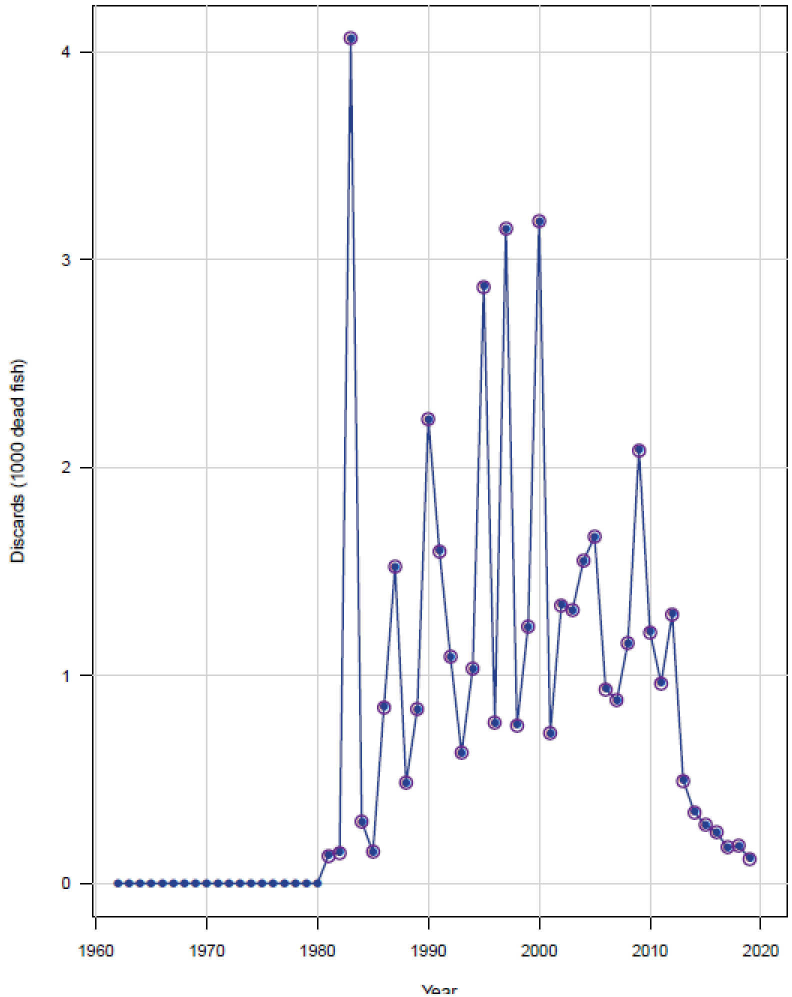


BAM base run: Fit to recreational dead discards

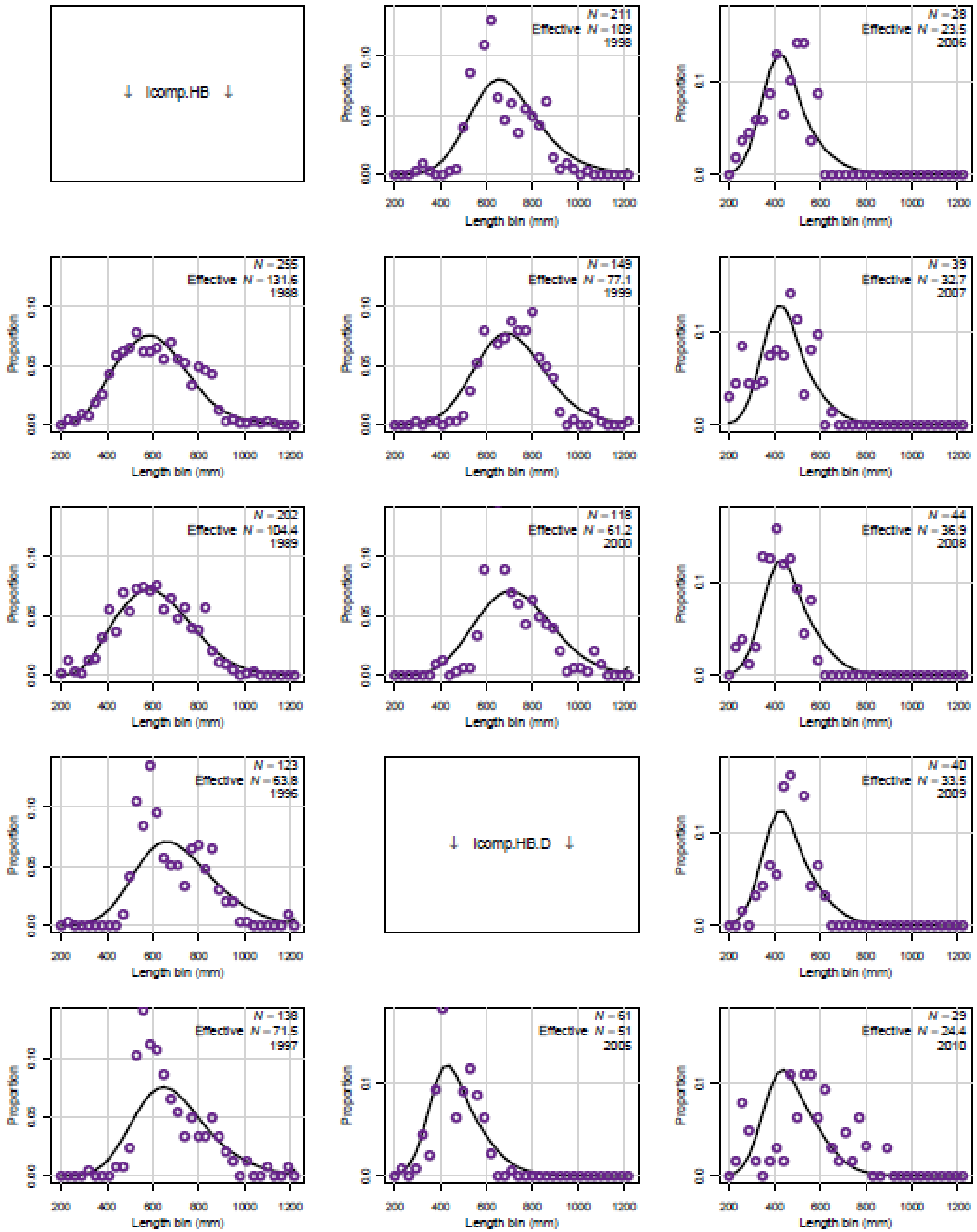
General Recreational (GR)



Headboat (HB)



BAM base run: Fits to composition data



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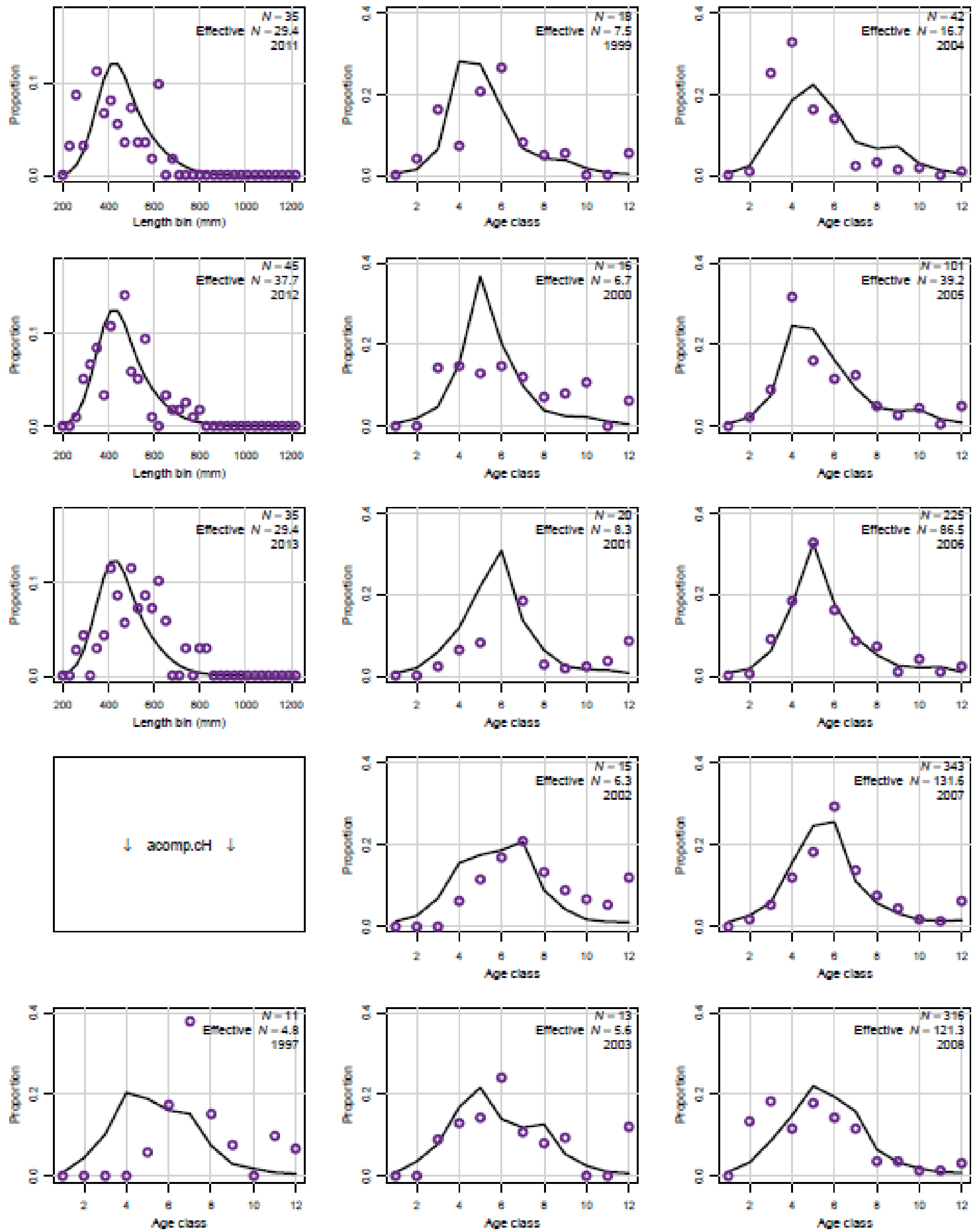
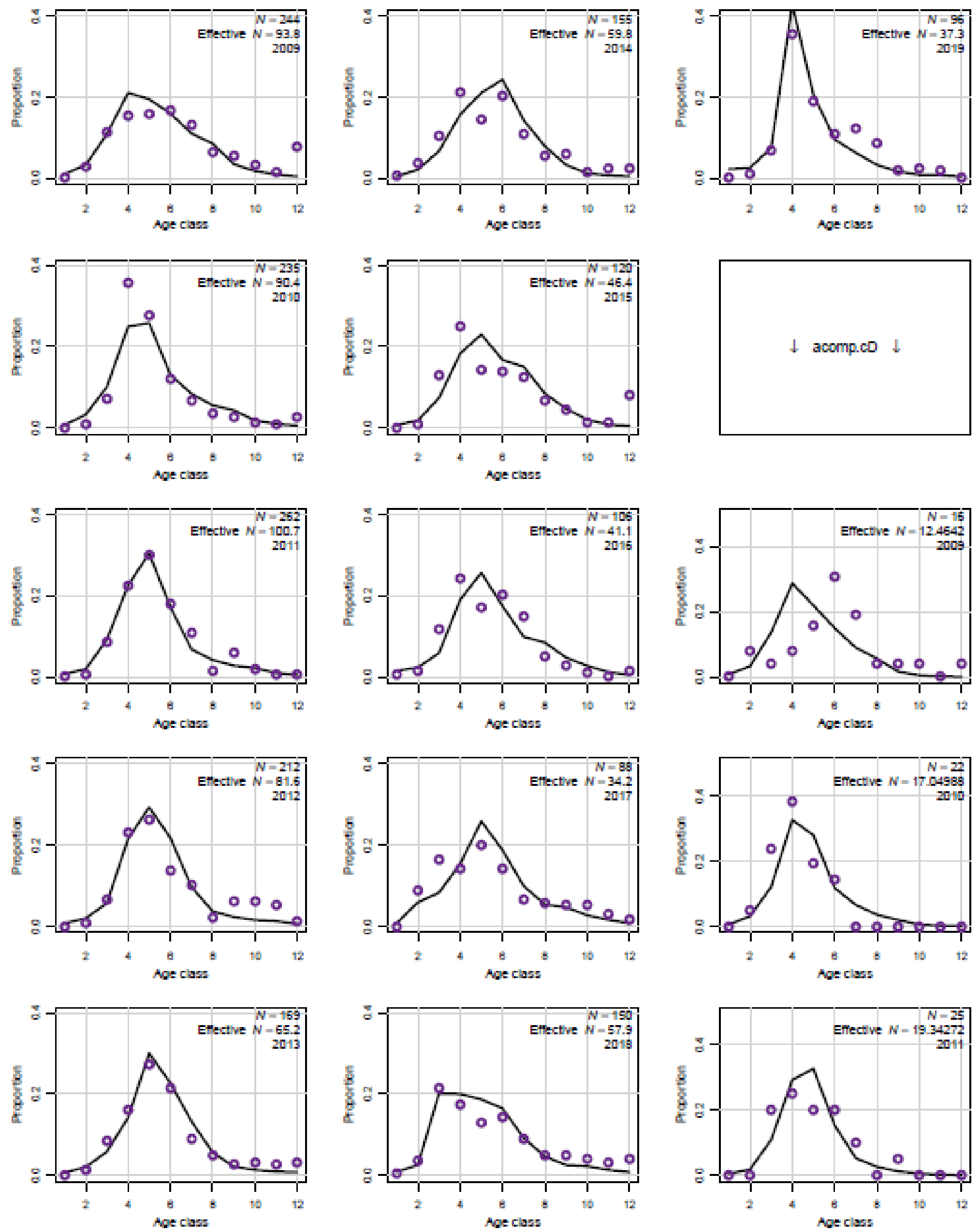
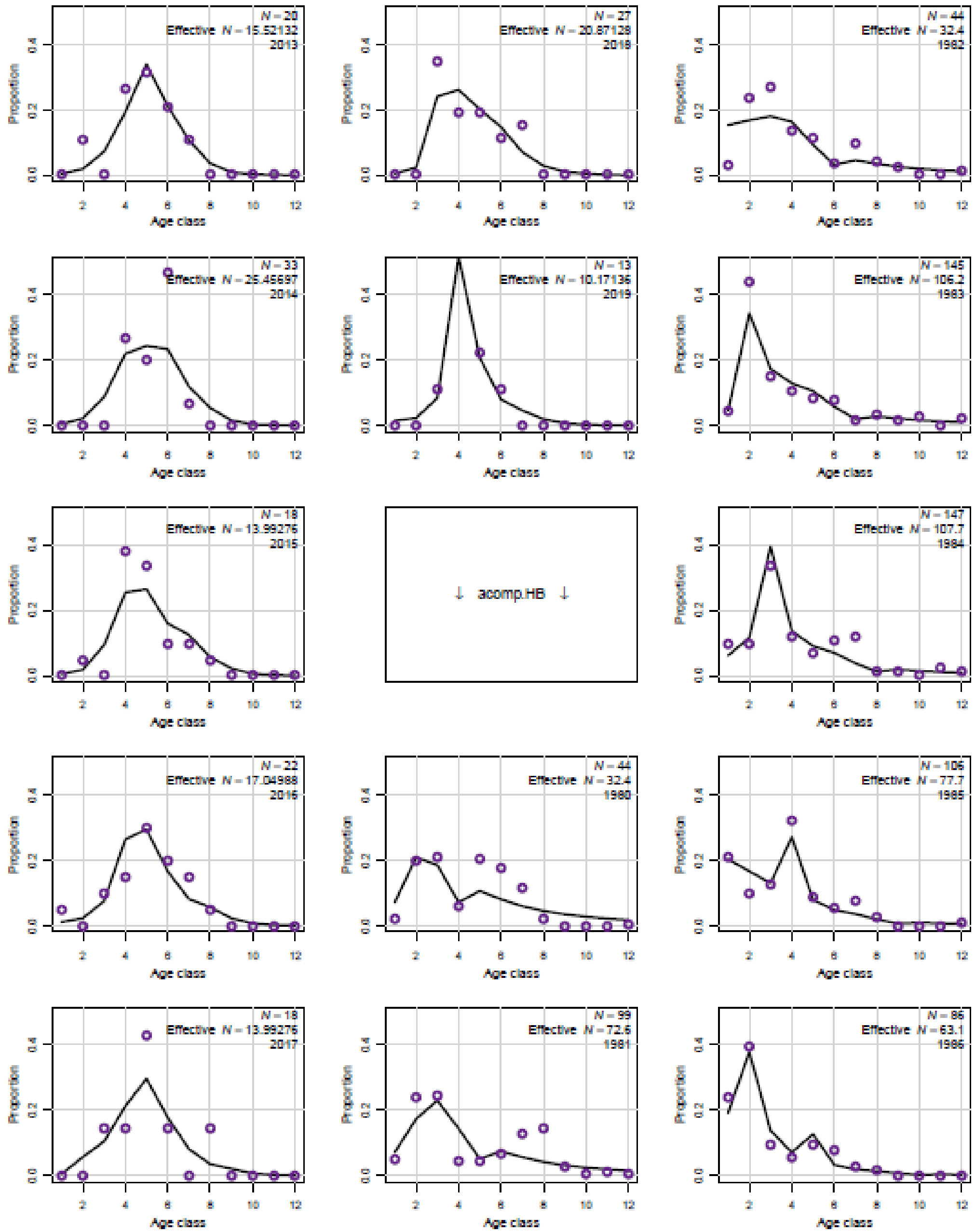
BAM base runs: Fits to composition data



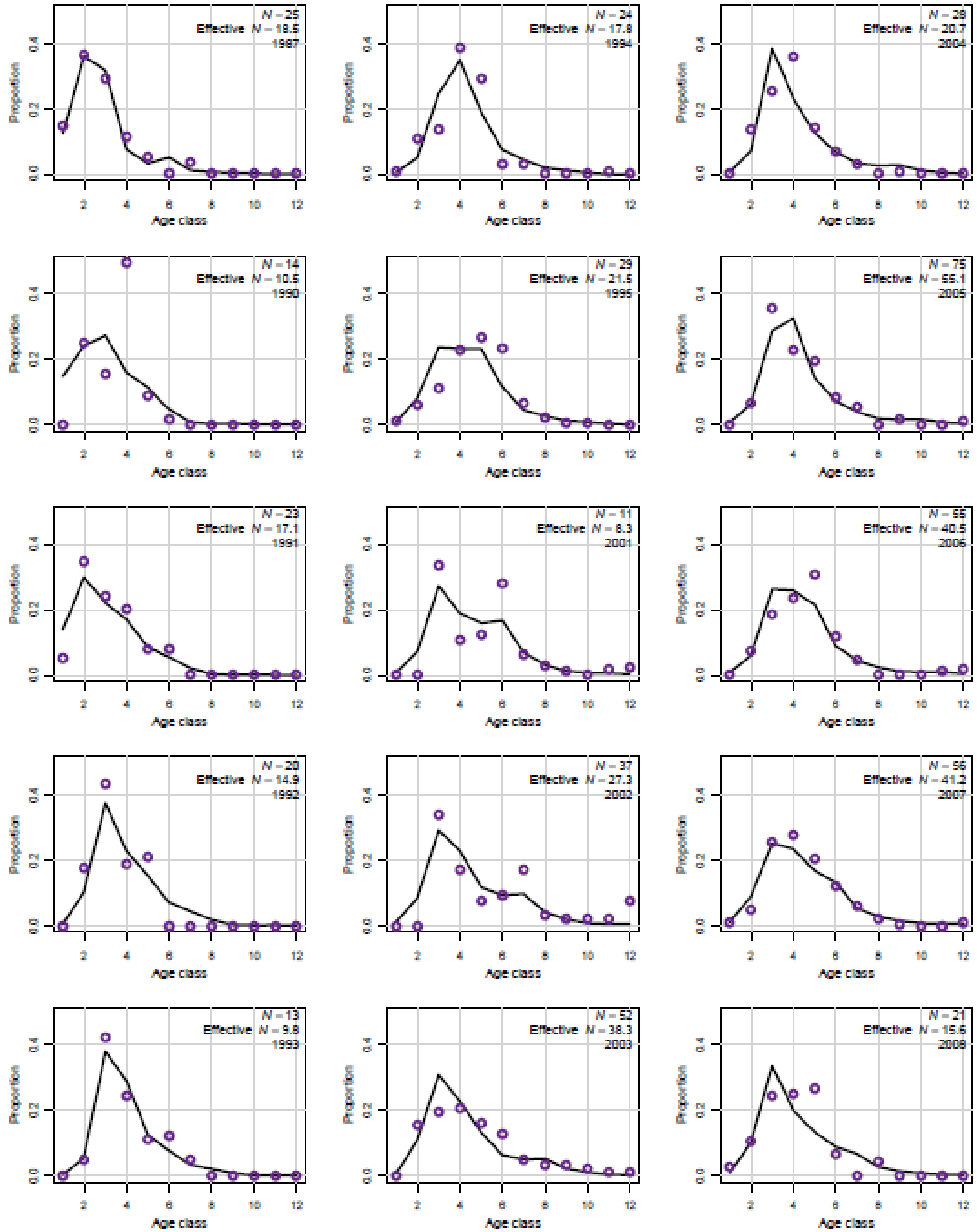
BAM base run: Fits to composition data



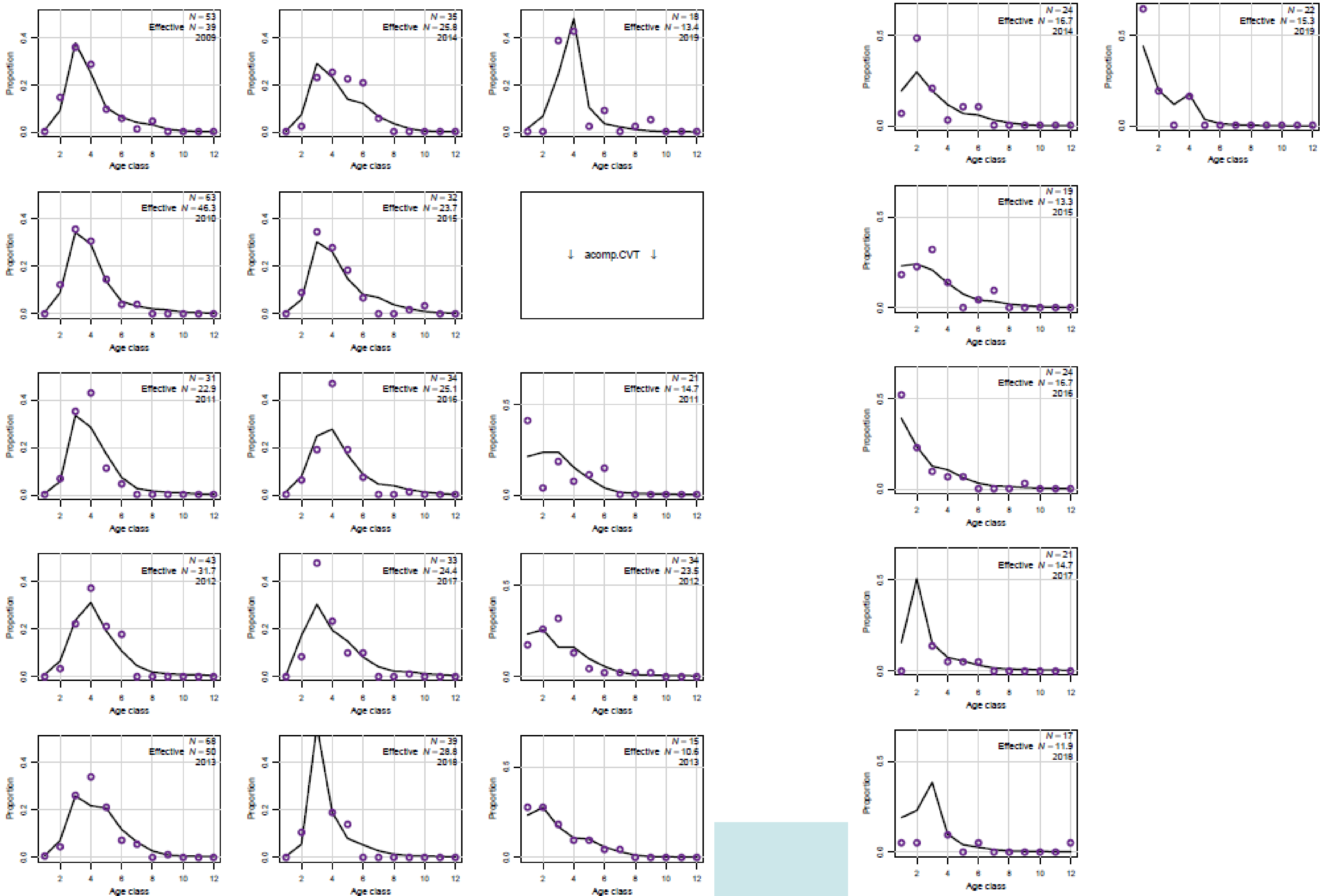
BAM base run: Fits to composition data



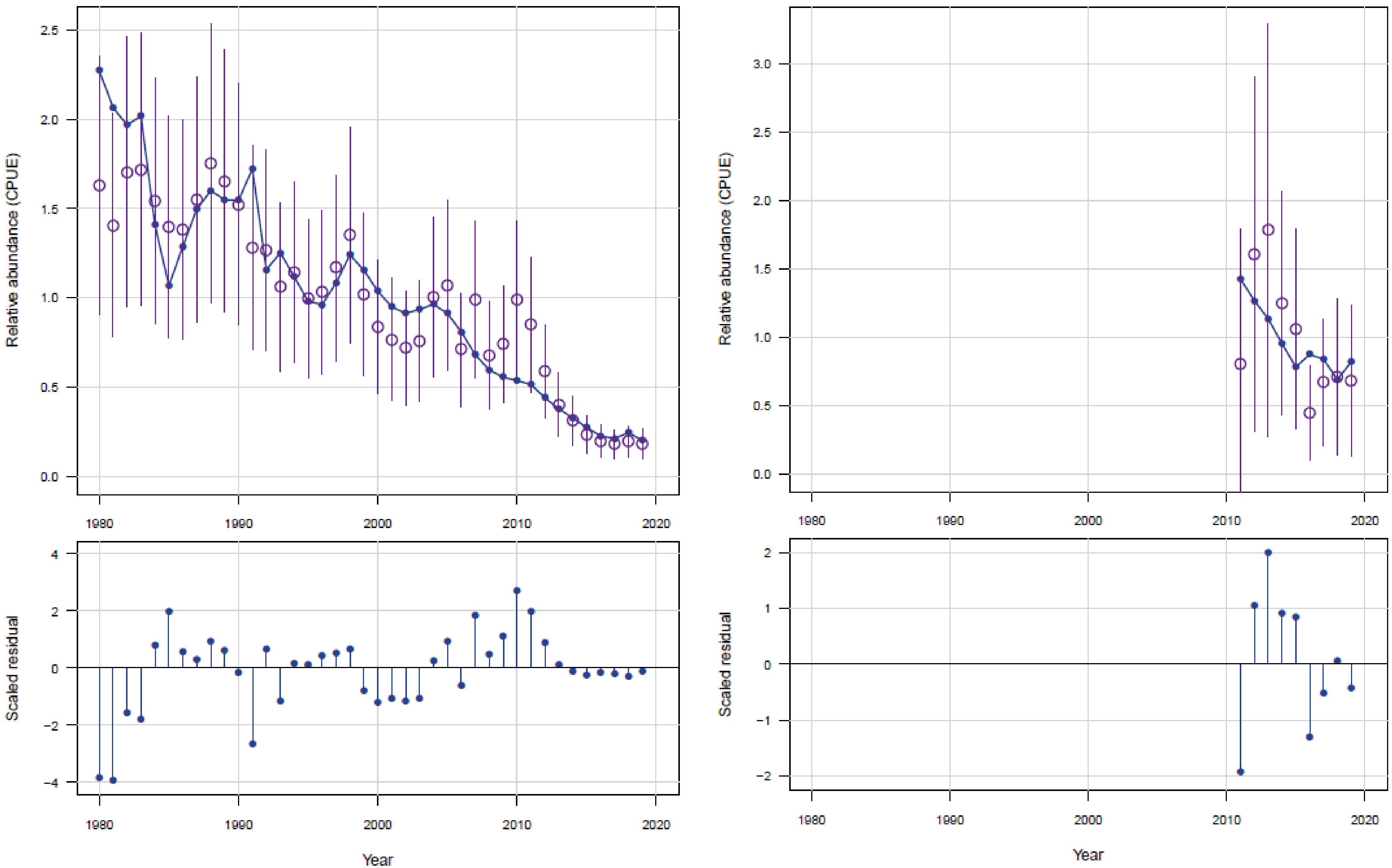
BAM base run: Fits to composition data



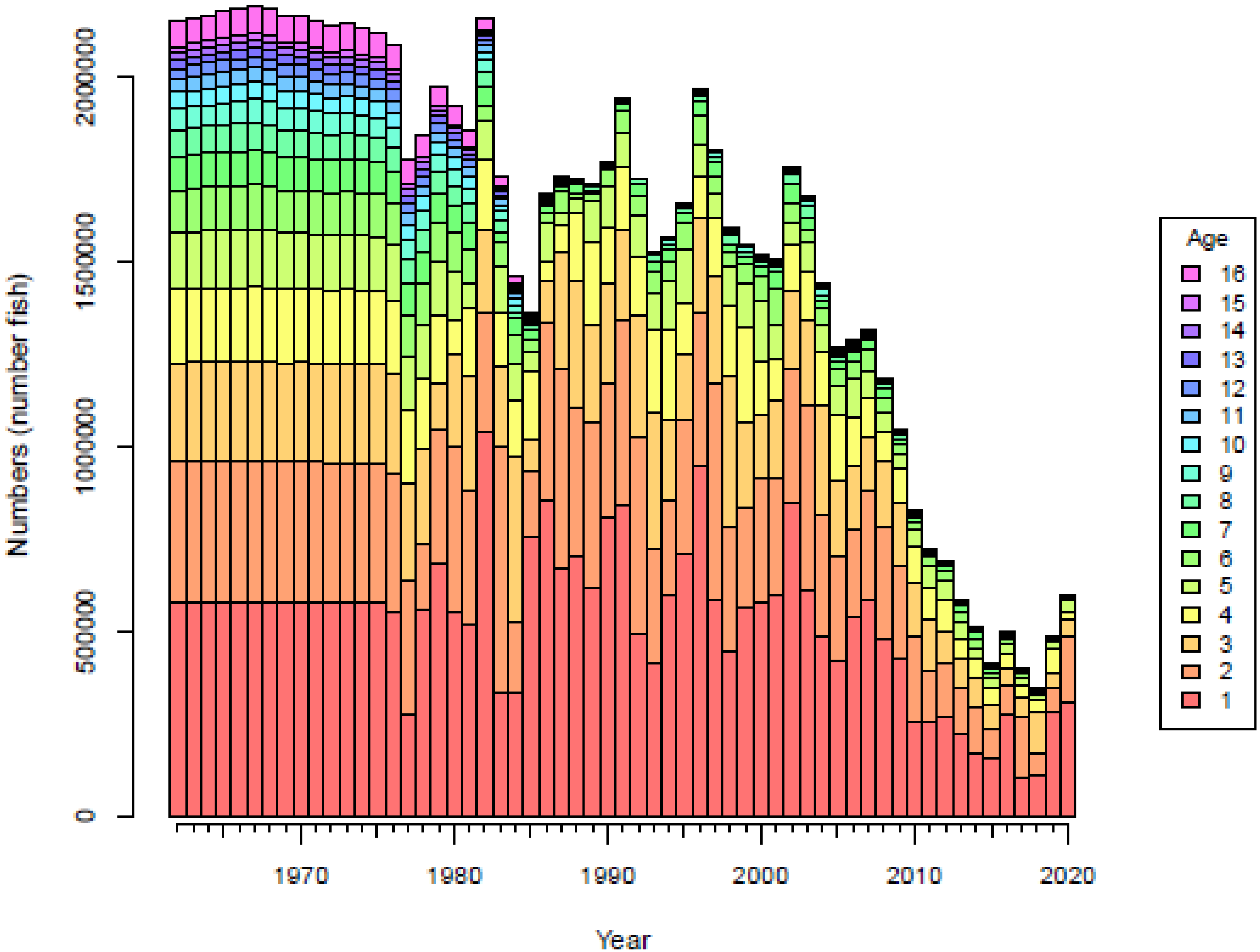
BAM base run: Fits to composition data



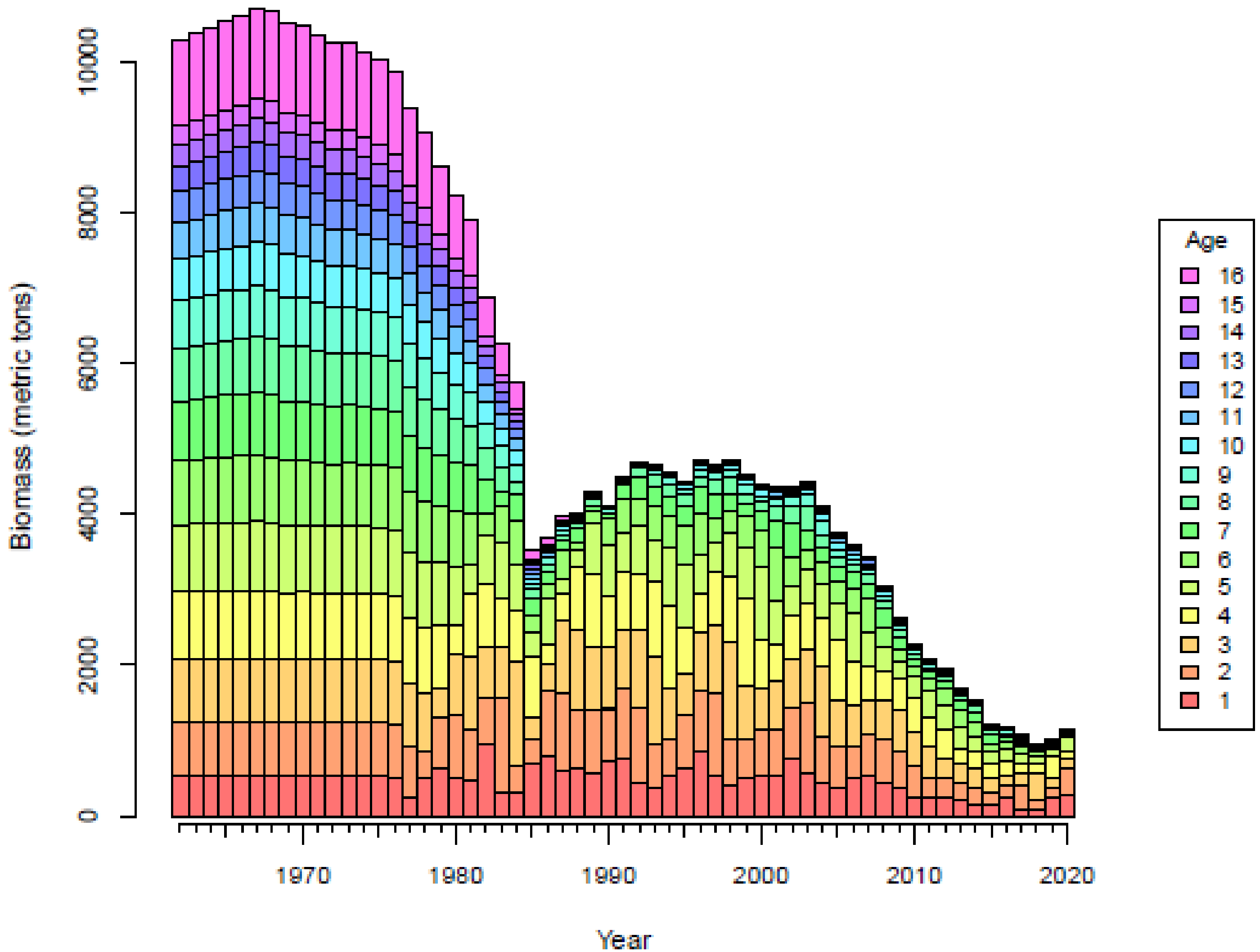
BAM base run: Fits to indices



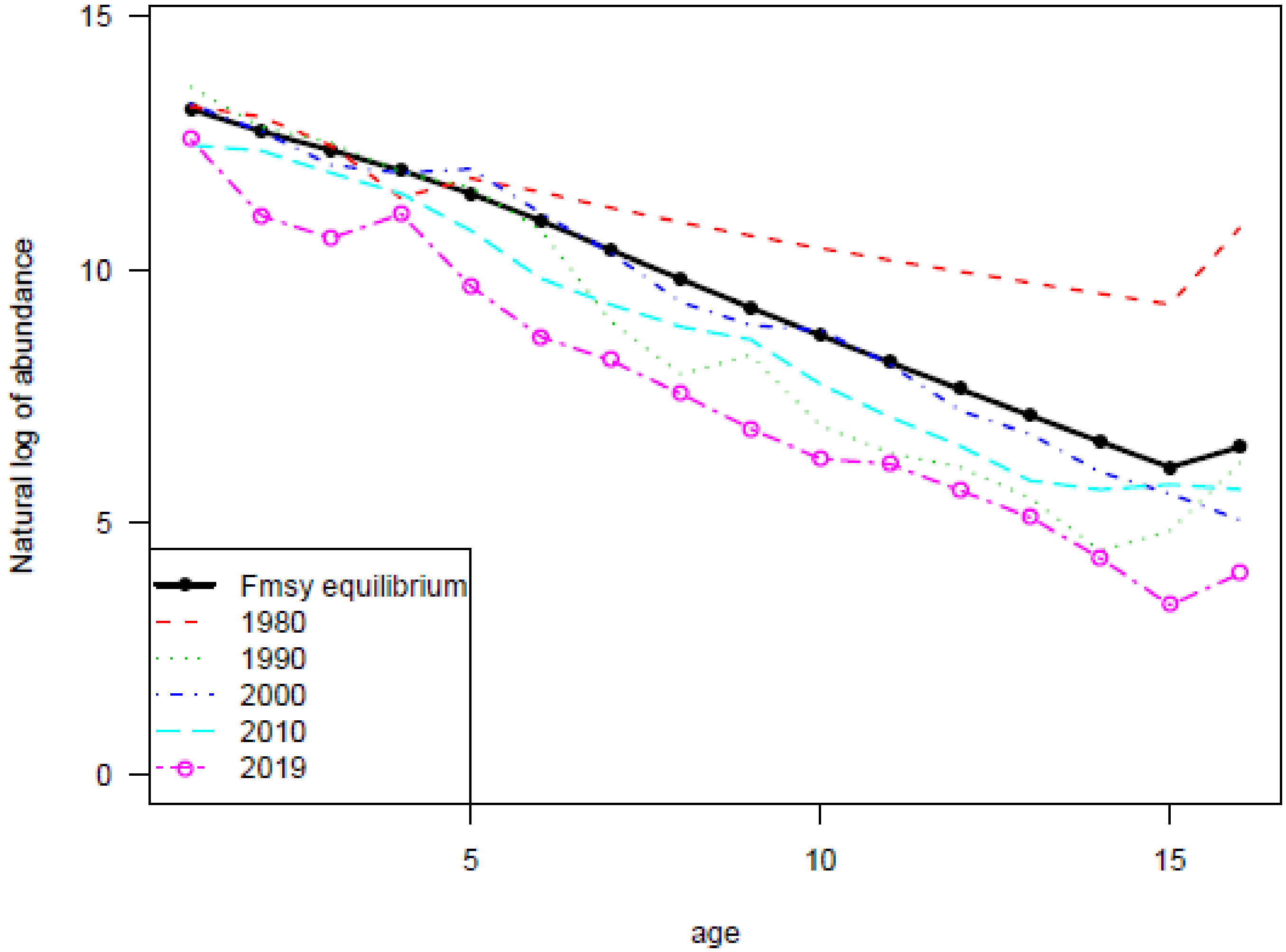
BAM base run: Abundance



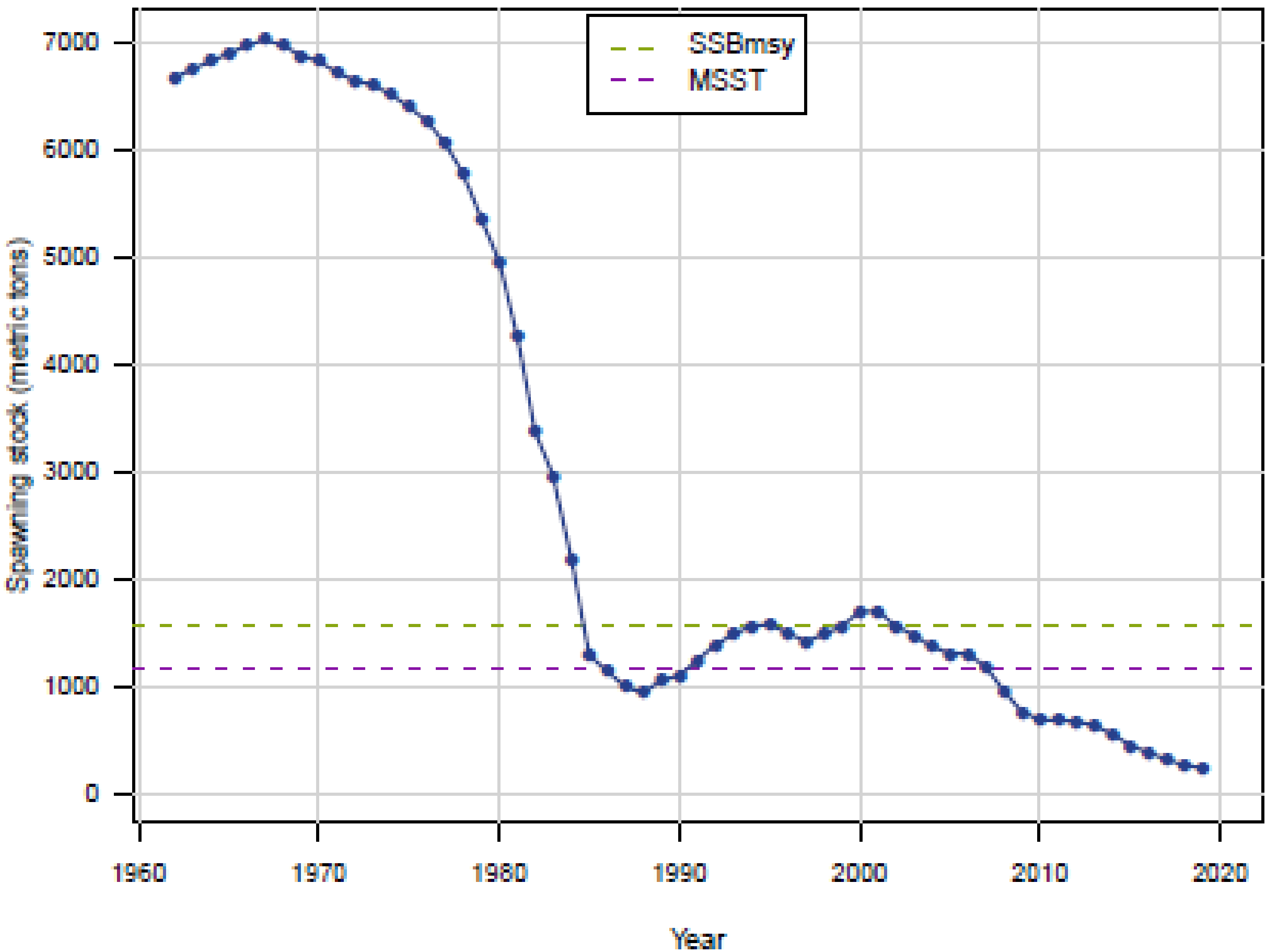
BAM base run: Biomass



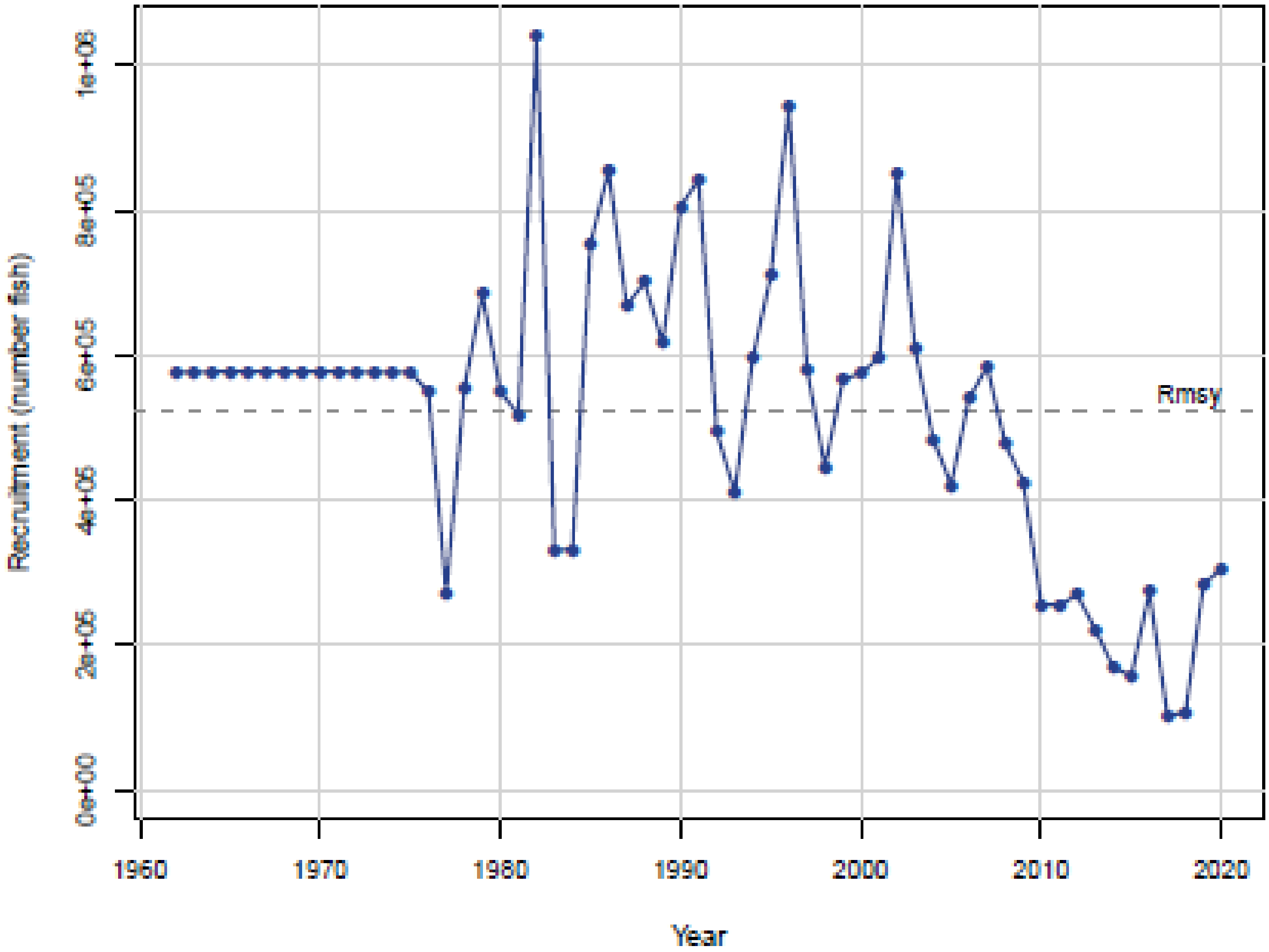
BAM base run: Age structure



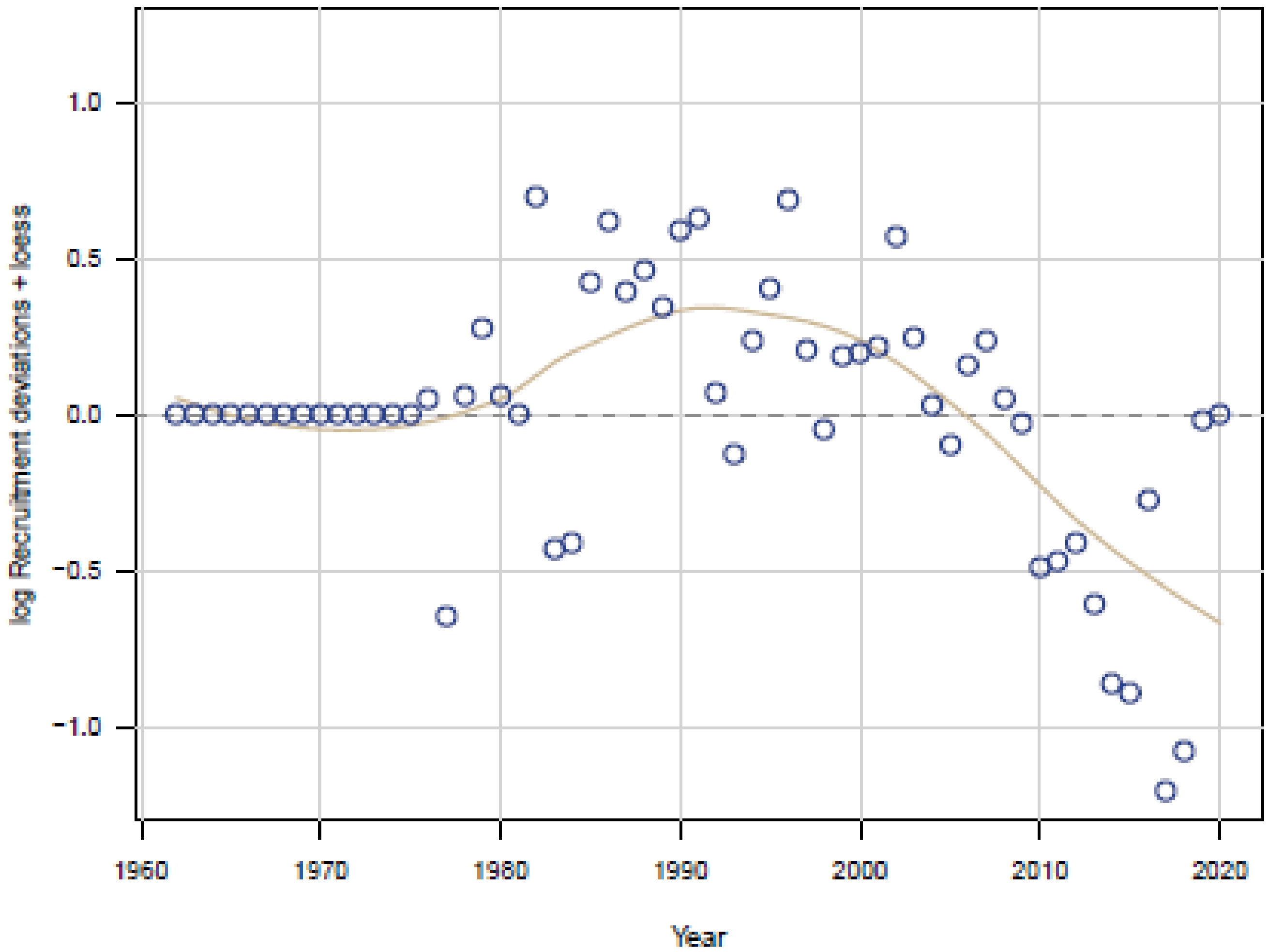
BAM base run: Spawning stock



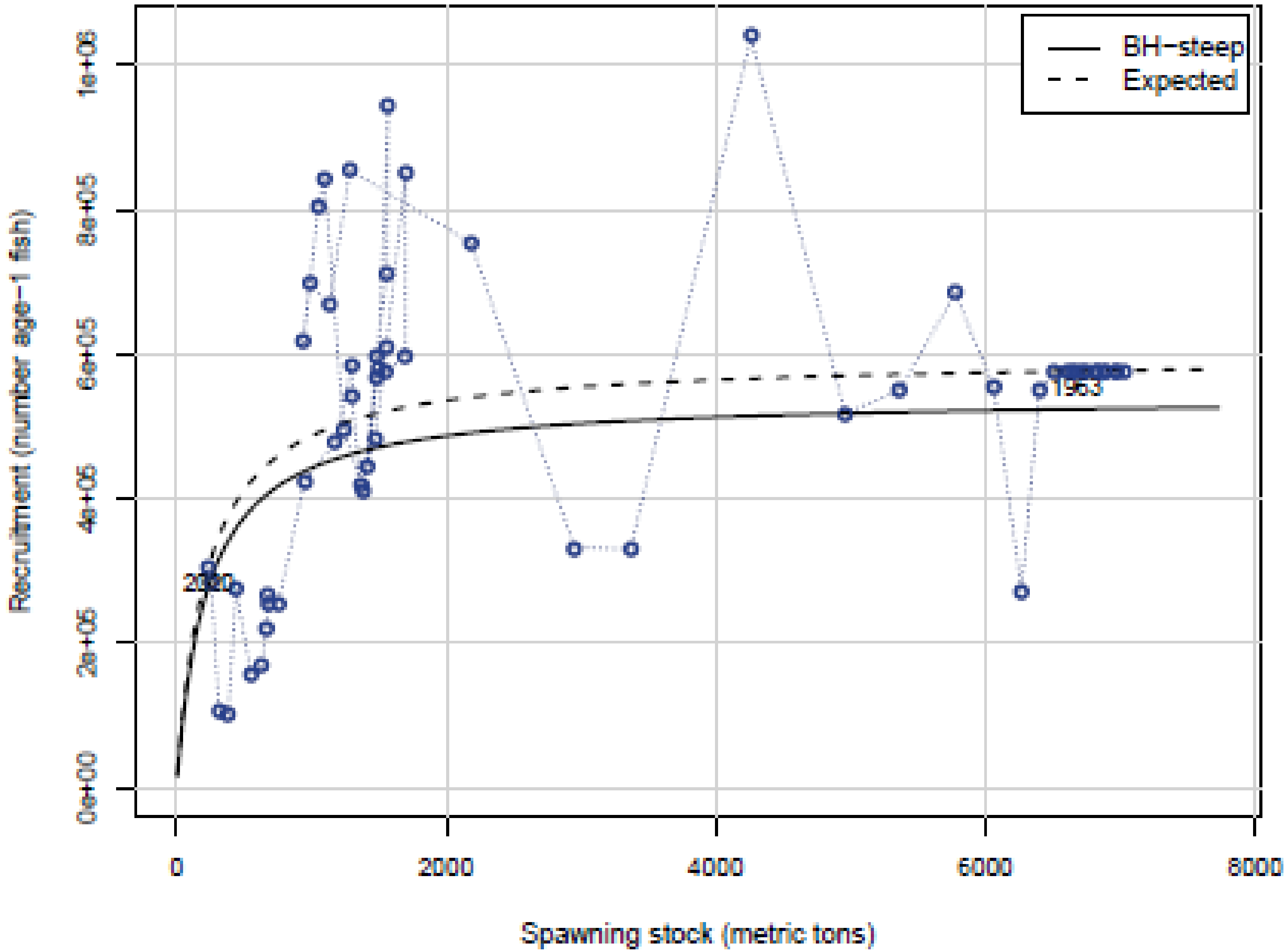
BAM base run: Recruitment



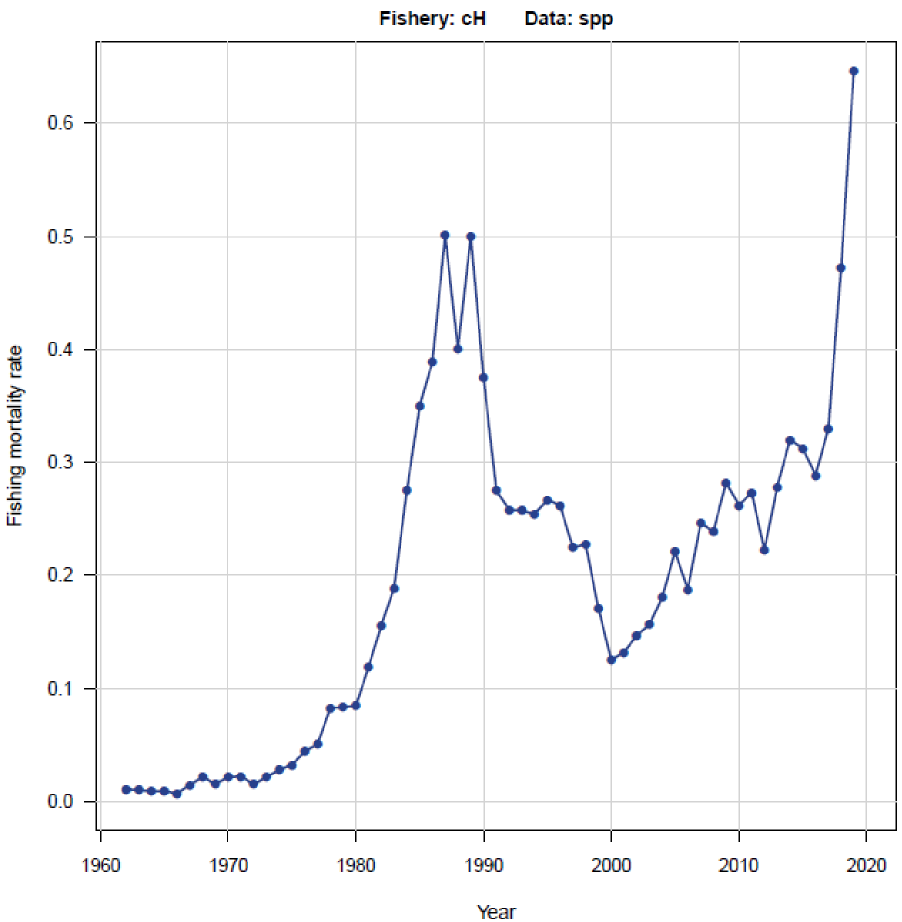
BAM base run: Recruitment deviations

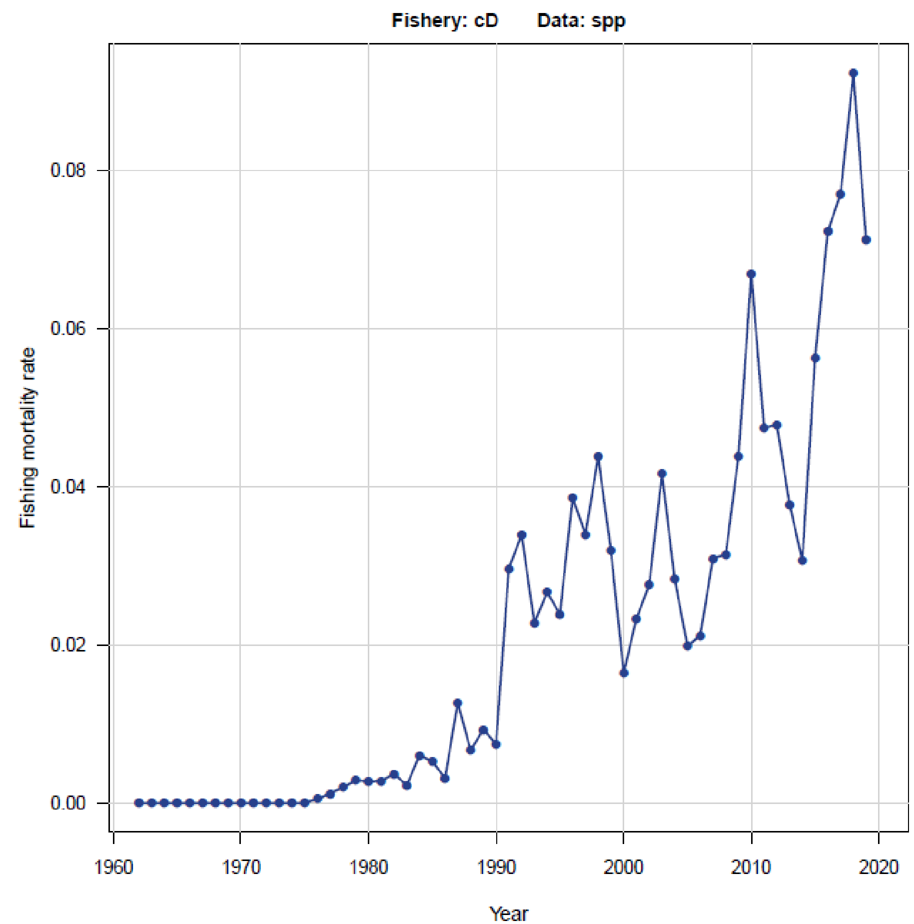


BAM base run: Stock-Recruitment

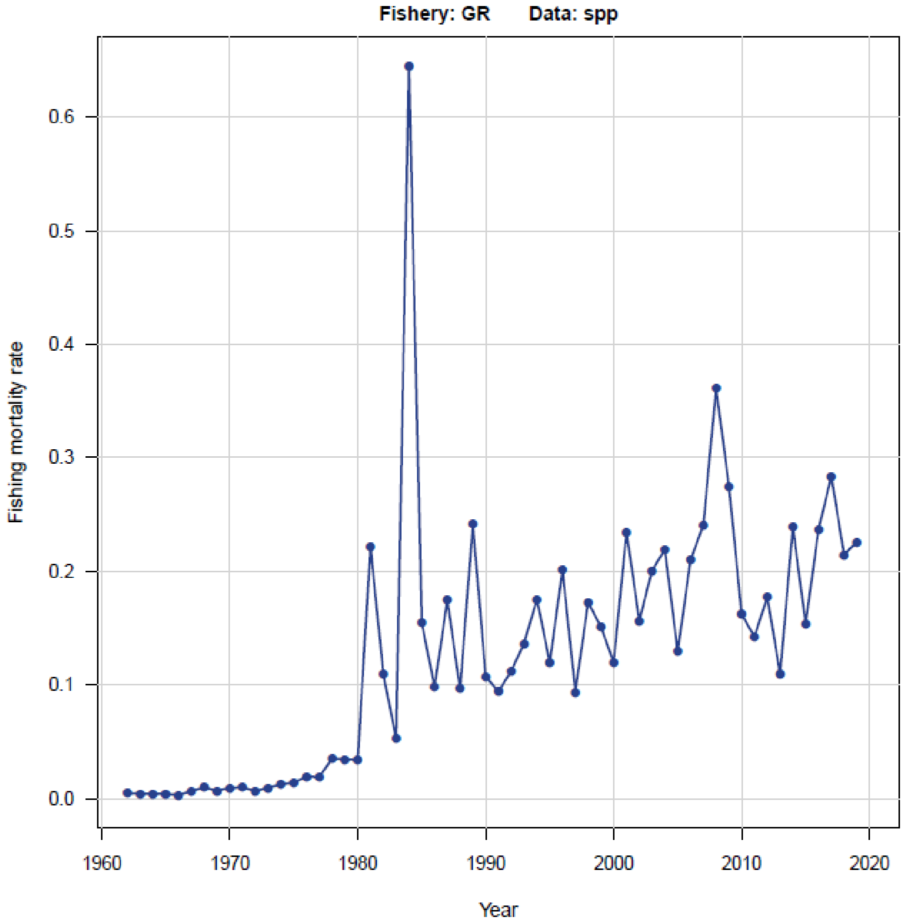


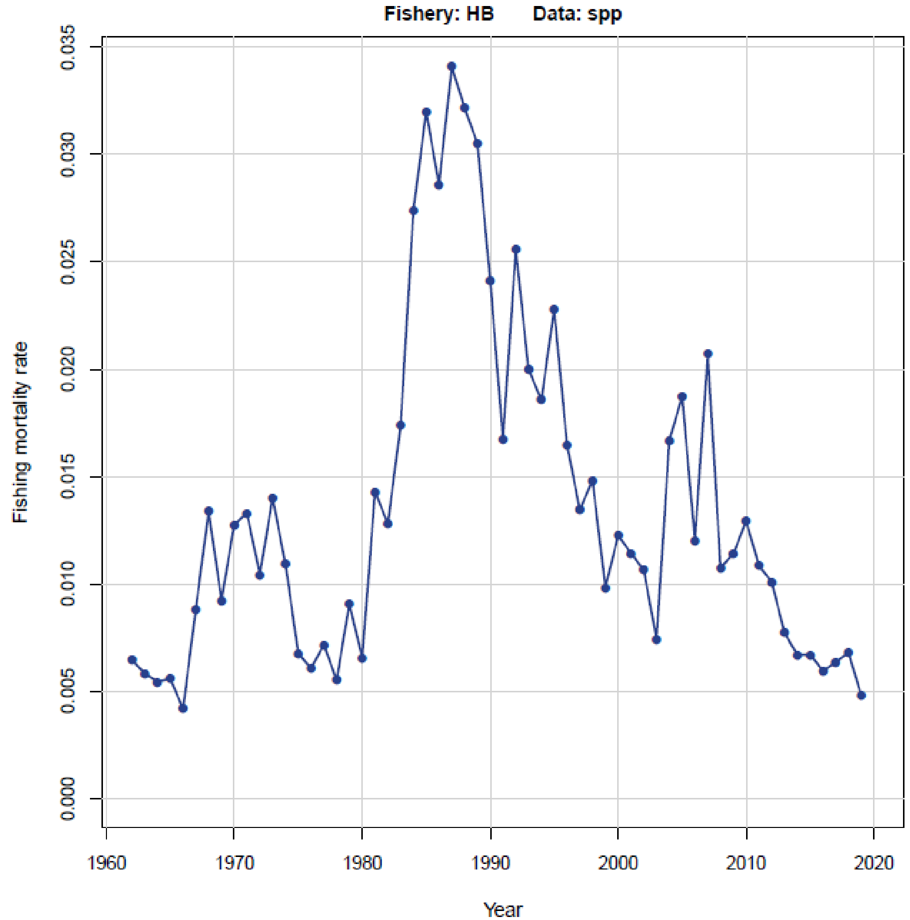
Fishing Mortality: Commercial fleets



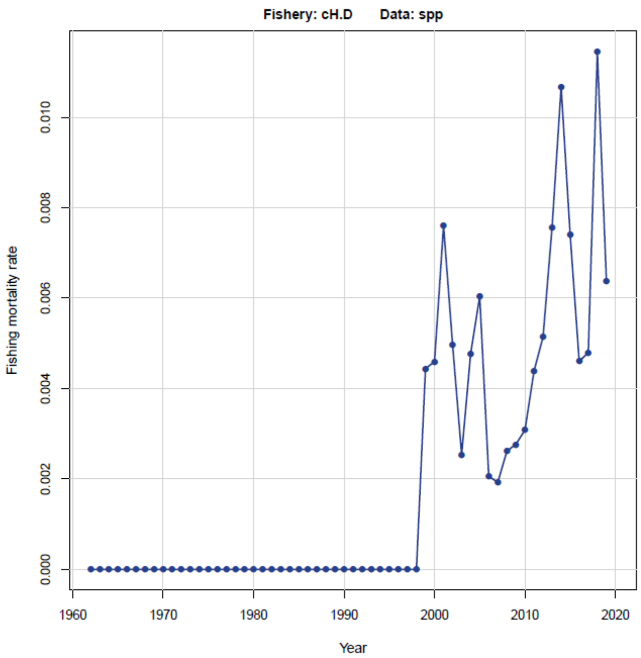


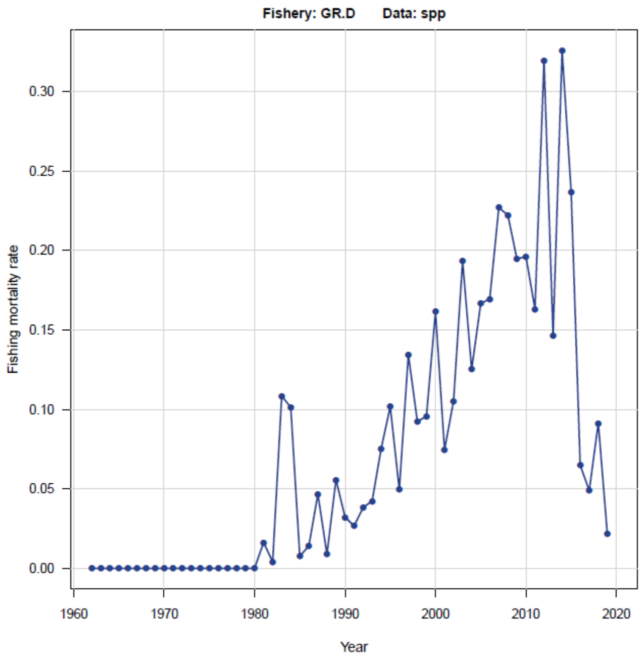
Fishing Mortality: Recreational fleets

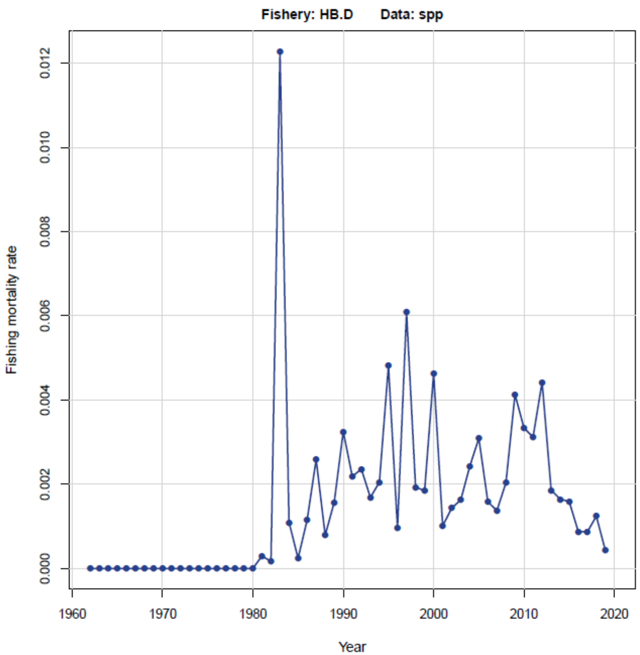




Fishing Mortality: Discards







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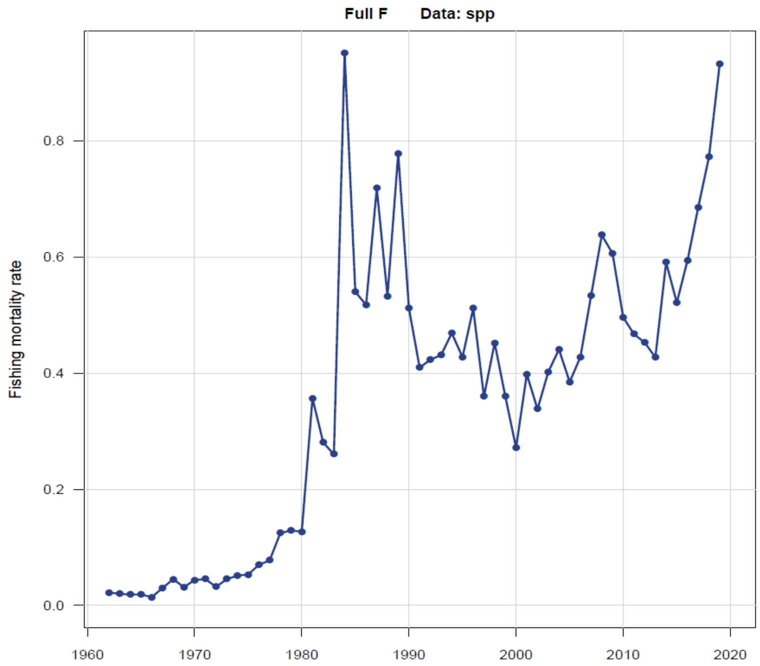
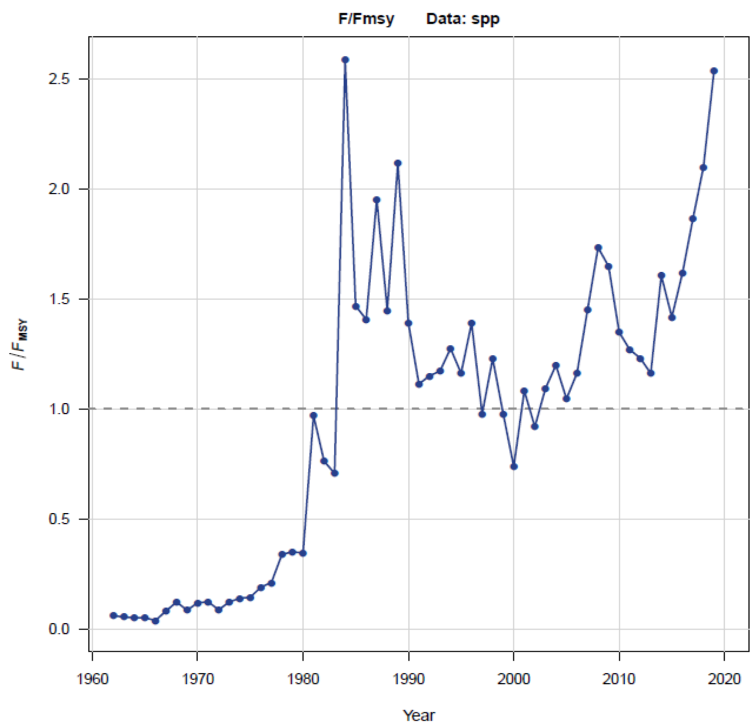
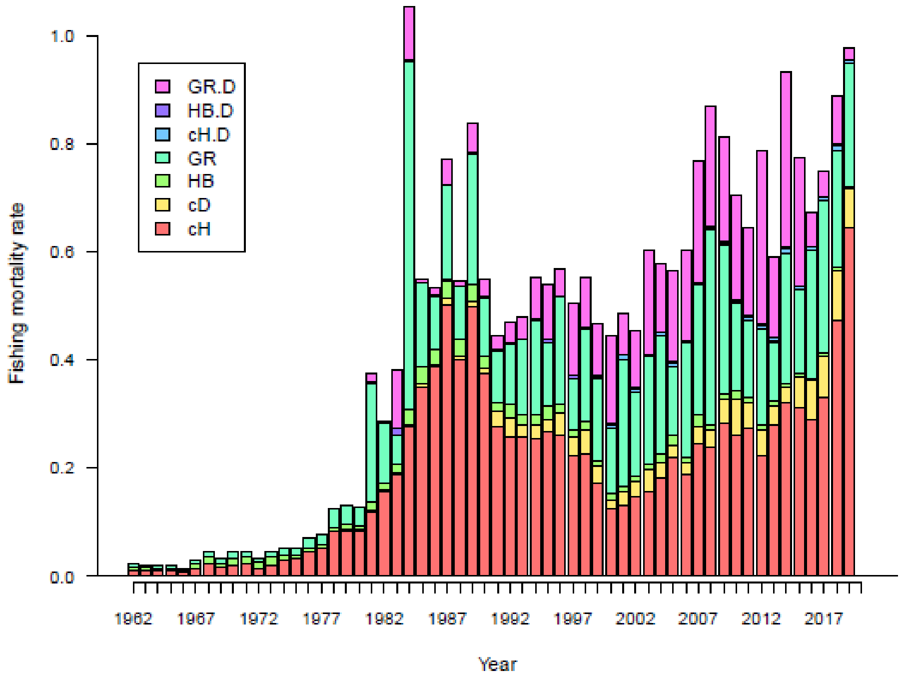
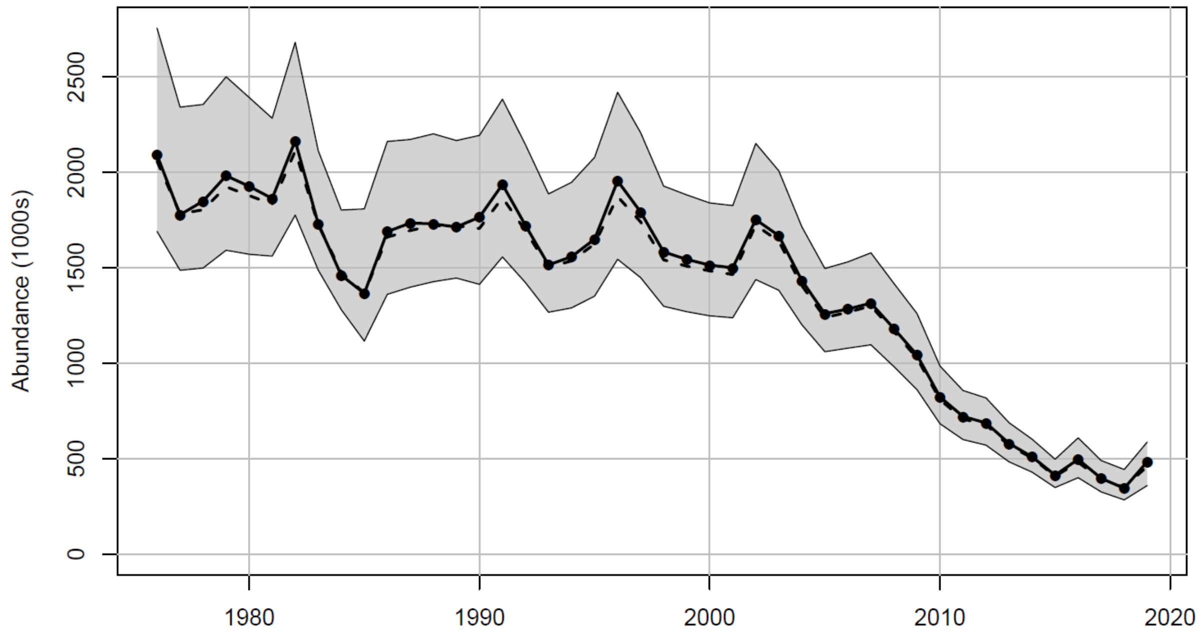
BAM base run: Fishing mortality

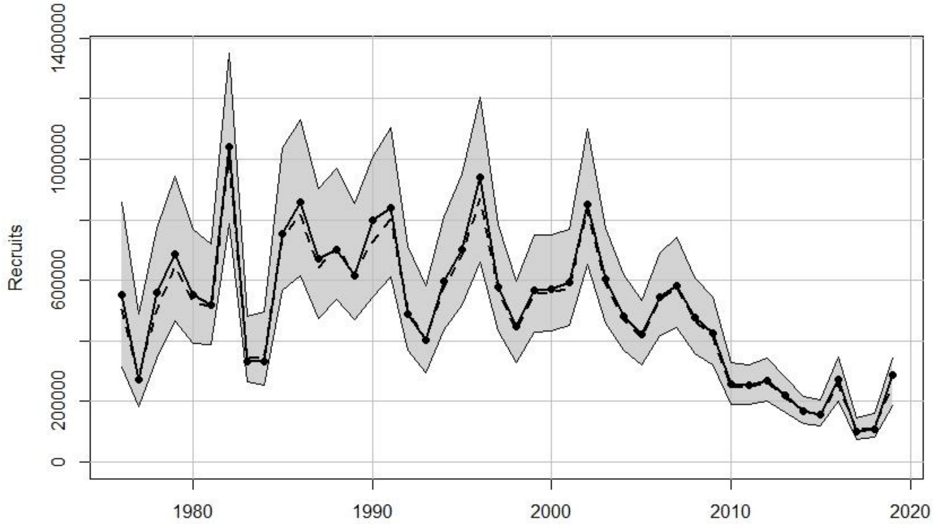


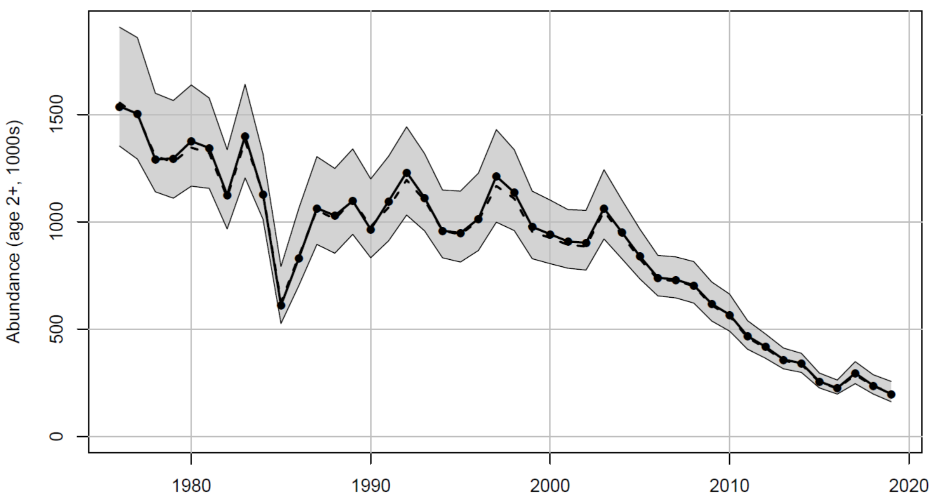




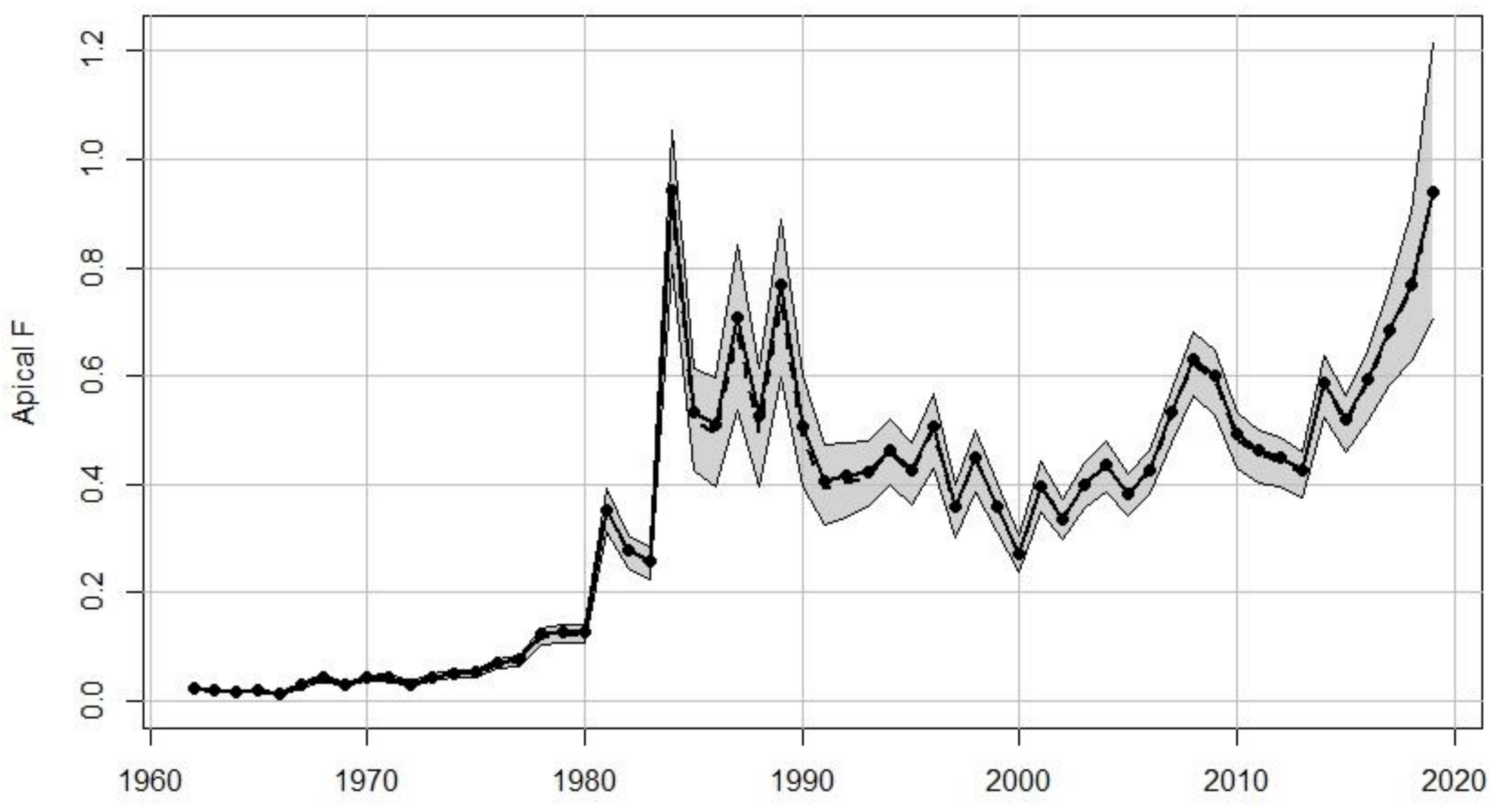
MCBE: Abundance estimates





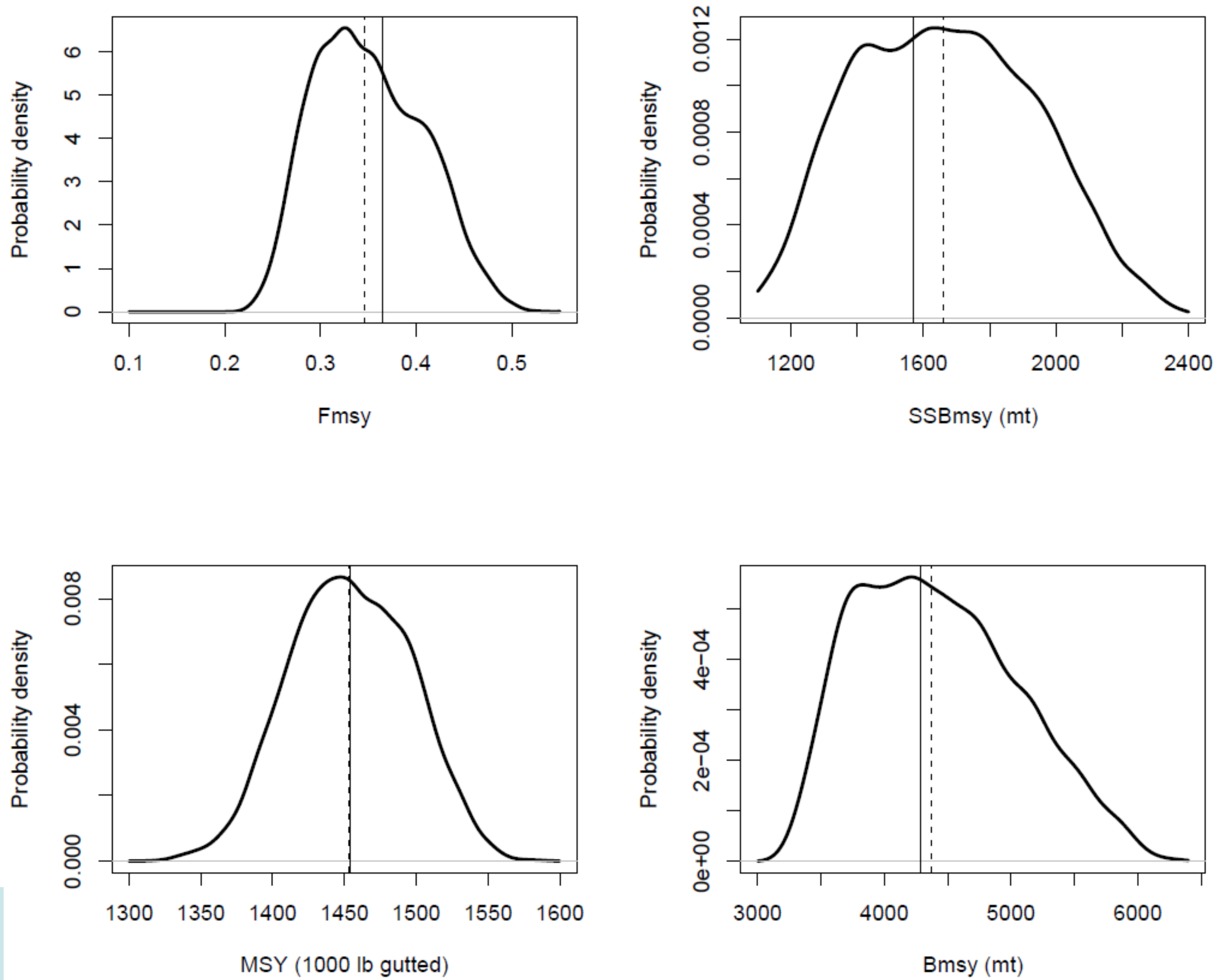


MCBE: Fishing mortality



MCBE: Benchmarks

Solid = MLE (Base)
Dash = Median (MCBE)



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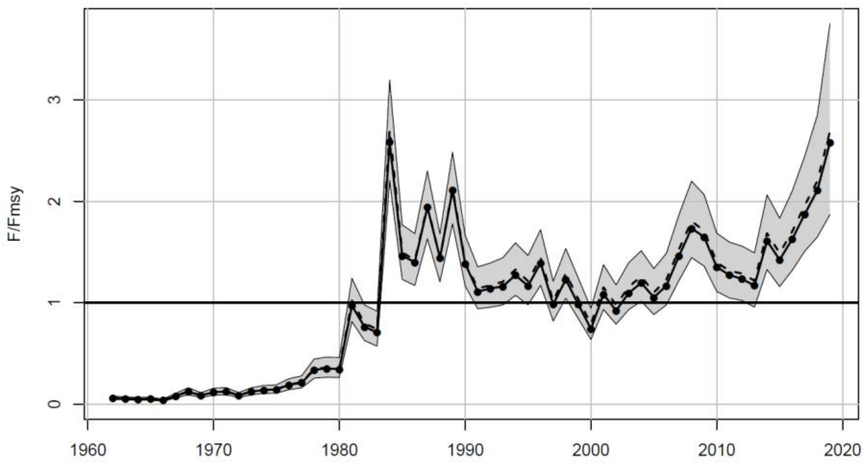
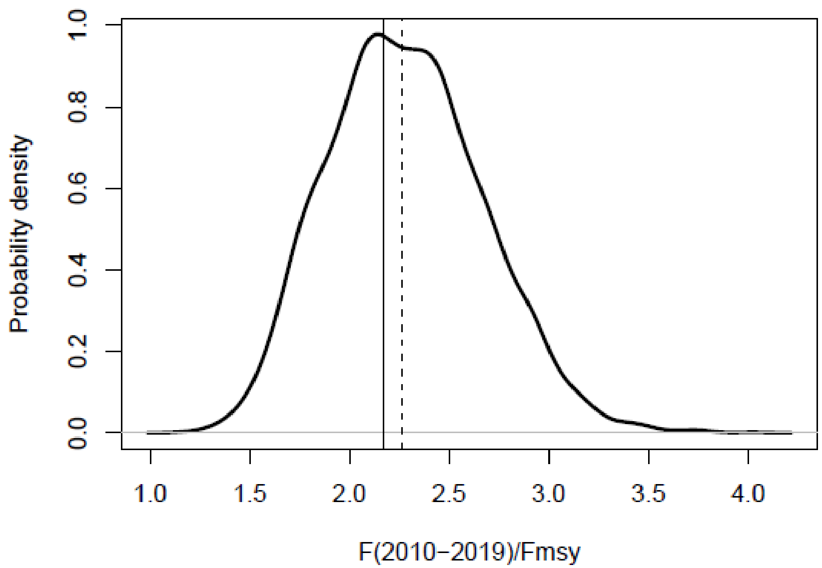
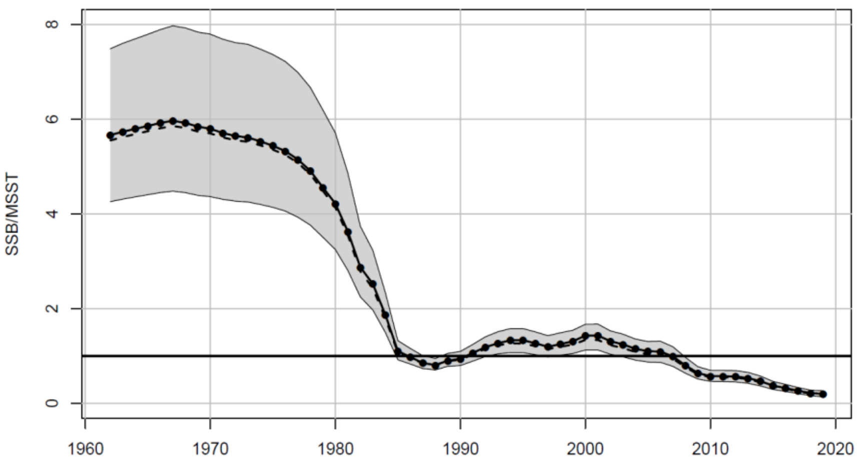
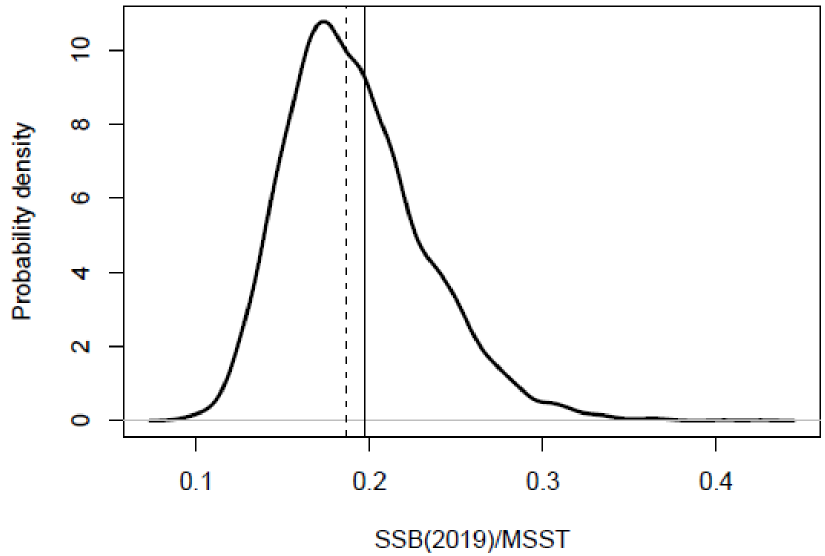
MCBE: Status indicators

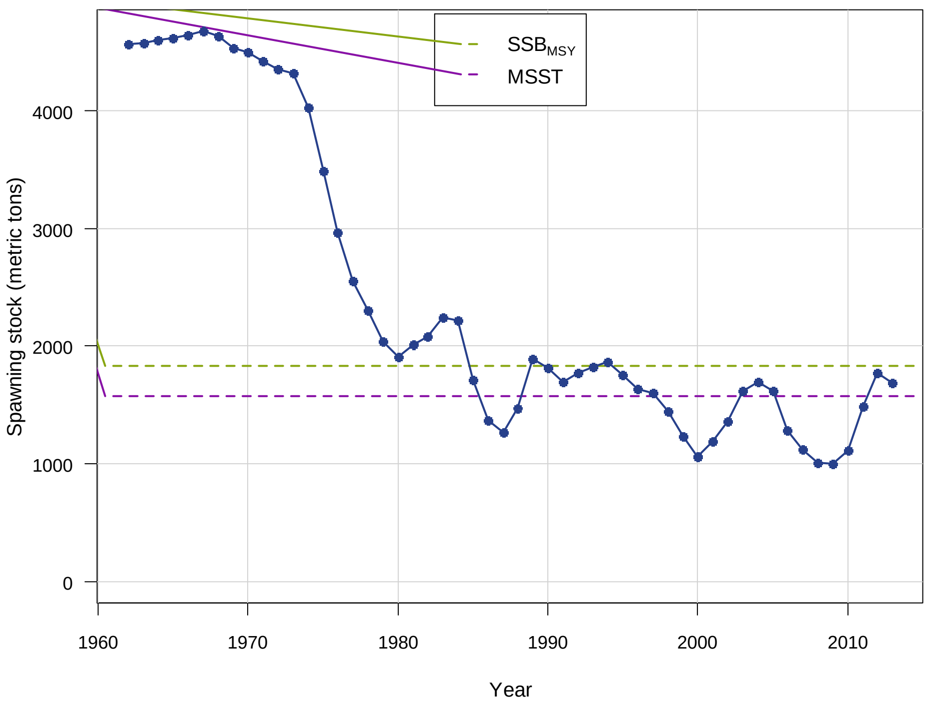


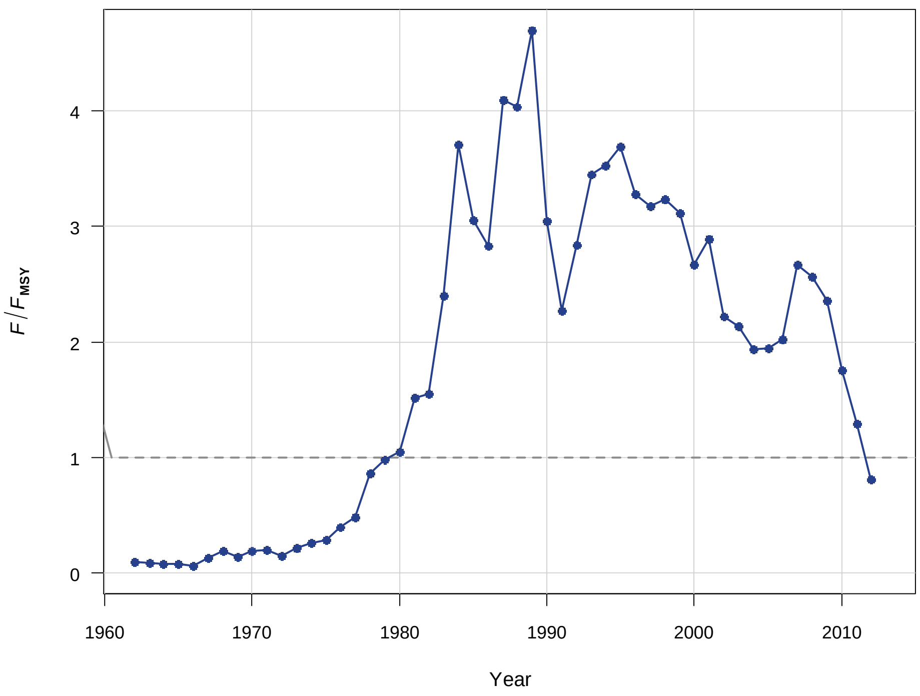




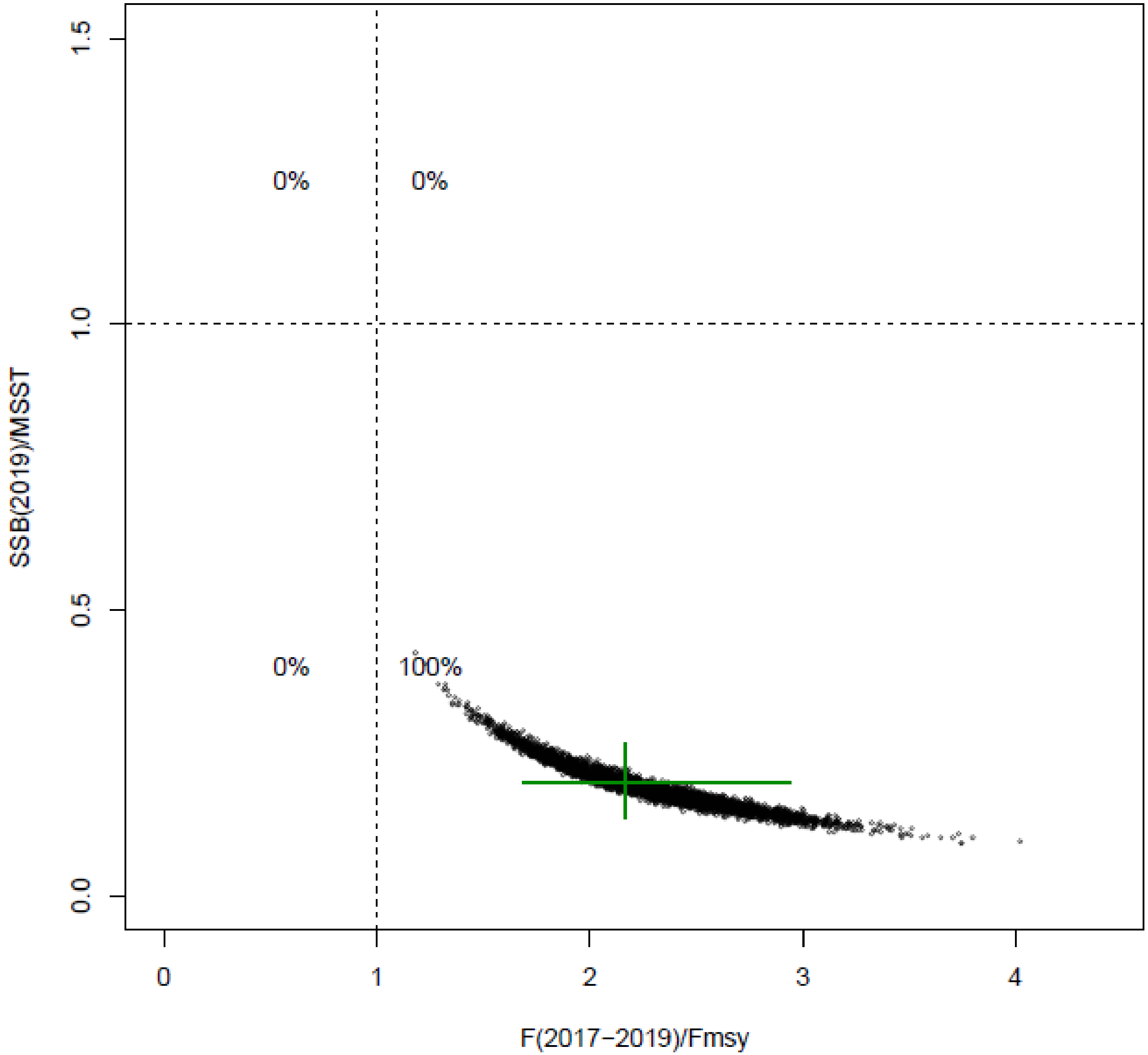


Status from 2014 Update





MCBE: Status indicators



Management Quantities

Table 15 in the report

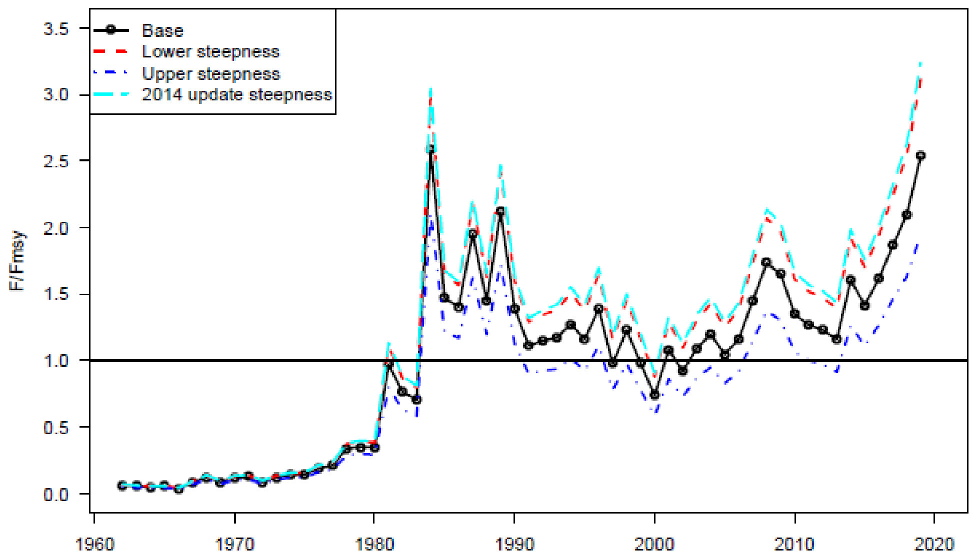
Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.37	0.35	0.06
B_{MSY}	mt whole	4278.4	4368.7	627.2
$\mathrm{SSB}_{\mathrm{MSY}}$	mt whole	1563.9	1659.4	269.7
MSST	mt whole	1172.9	1244.5	202.3
MSY	1000 lb gutted	1455.1	1453.5	41.6
D_{MSY}	1000 fish	17.6	16.7	4.0
R_{MSY}	1000 age-1 fish	521	509	104
$F_{2017-2019}/F_{\mathrm{MSY}}$	—	2.15	2.27	0.38
$\mathrm{SSB}_{2019}/\mathrm{MSST}$	—	0.20	0.19	0.04
$\mathrm{SSB}_{2019}/\mathrm{SSB}_{\mathrm{MSY}}$	—	0.15	0.14	0.03

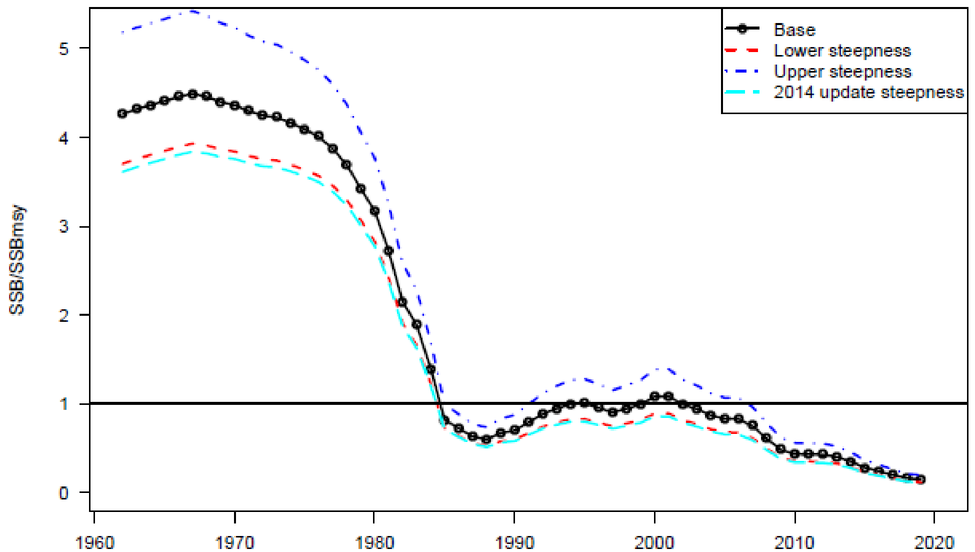
Sensitivity Runs: Steepness

Base h = 0.898 (estimated)

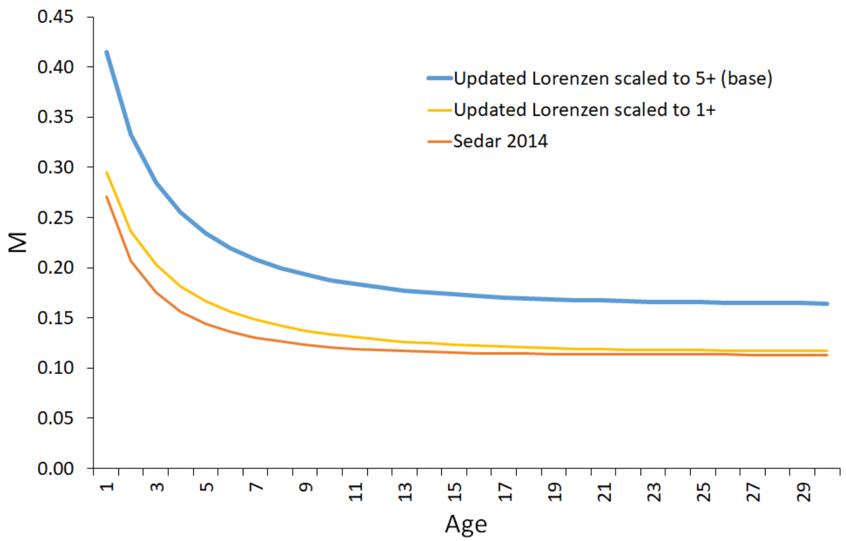
From profiling:
- Low h = 0.85
- High h = 0.95

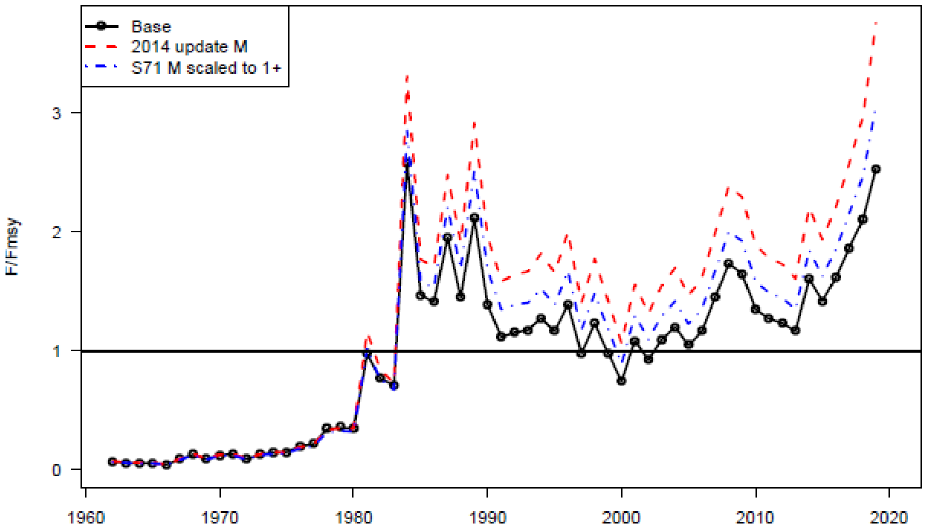
From 2014 update
- Fixed h = 0.84

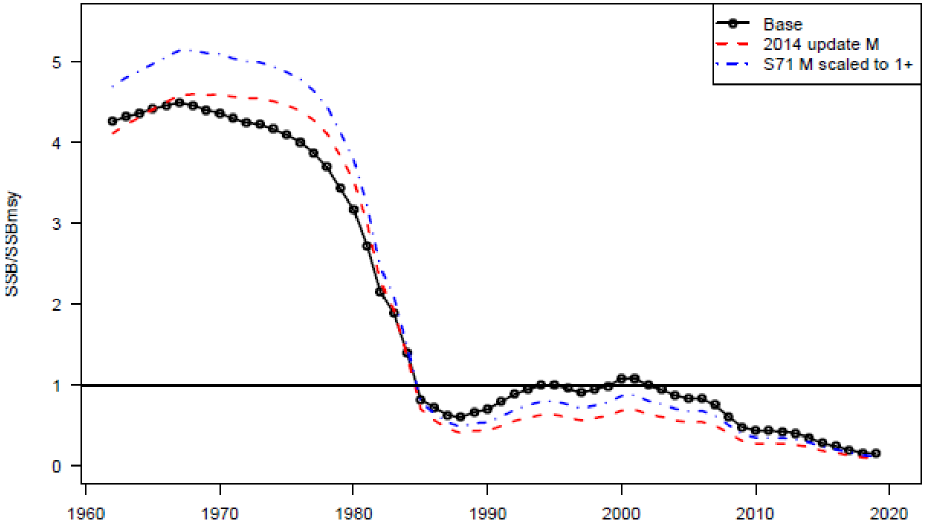




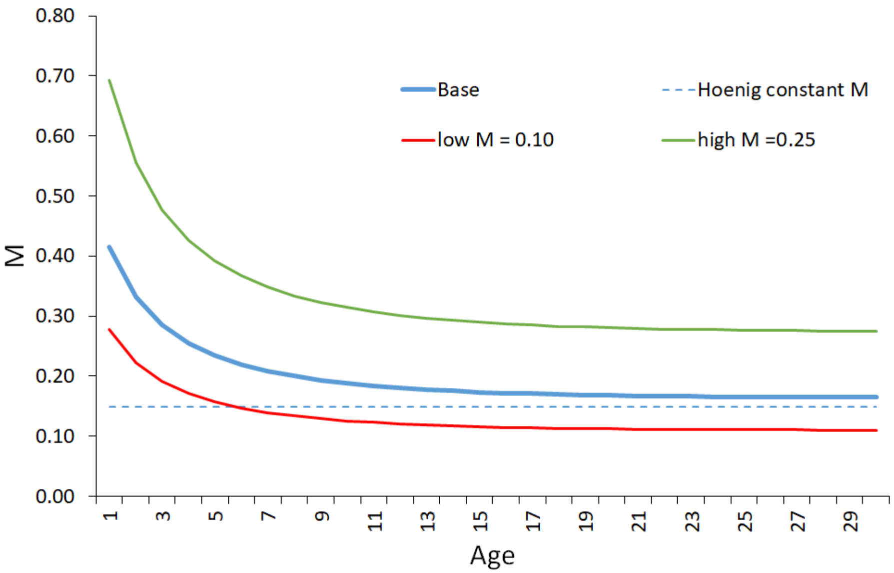
Sensitivity Runs: Natural mortality (scaling)

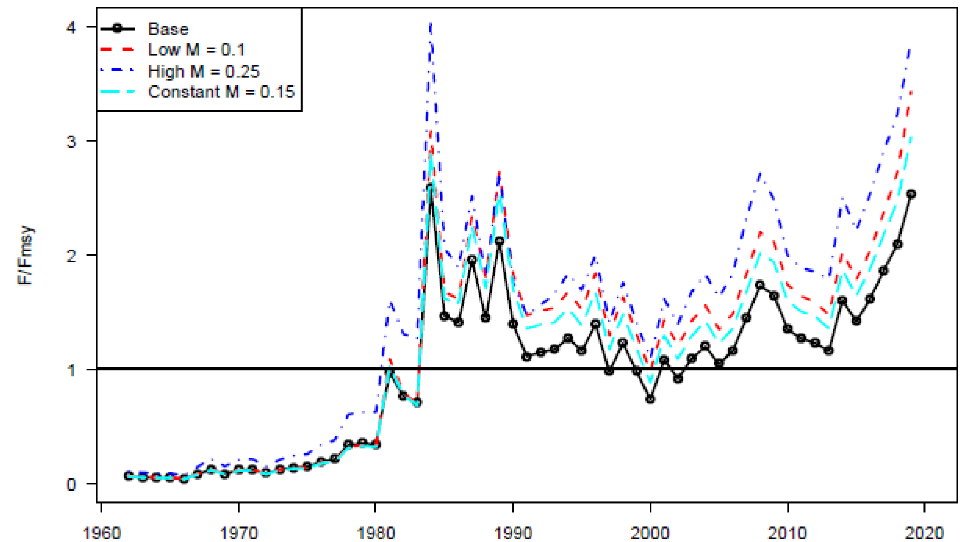


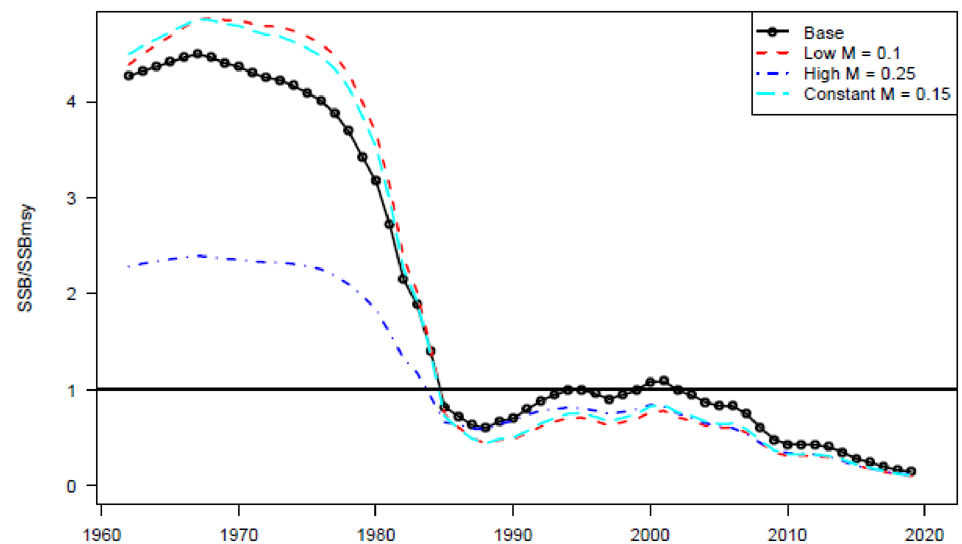




Sensitivity Runs: Natural mortality (magnitude)







- Low M = 0.10 (t_{max} = 45 yr)
- High M = 0.25 (t_{max} = 18 yr)
- Based M = 0.14 (t_{max} = 30 yr)

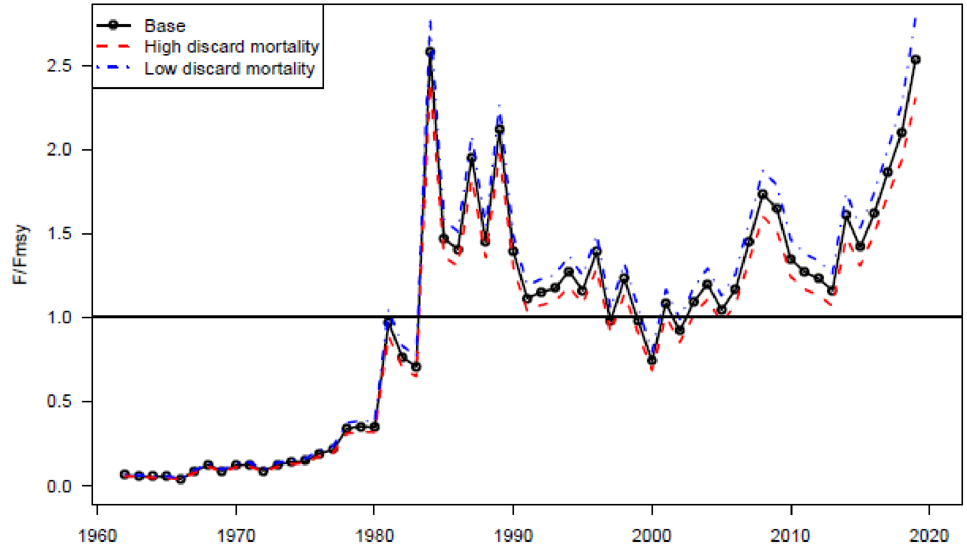
Sensitivity Runs: Discard mortality

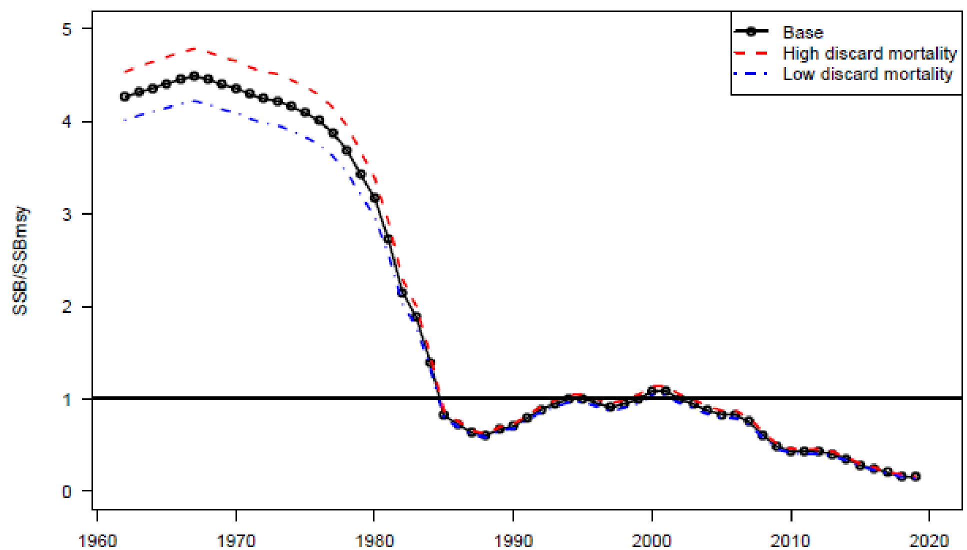
Base Discard Mortality:

- HB and GR = 0.25
- cHL = 0.40

From Sauls et al. (2014):

- Low = 0.15 (all fleets)
- High h = 0.35 (all fleets)



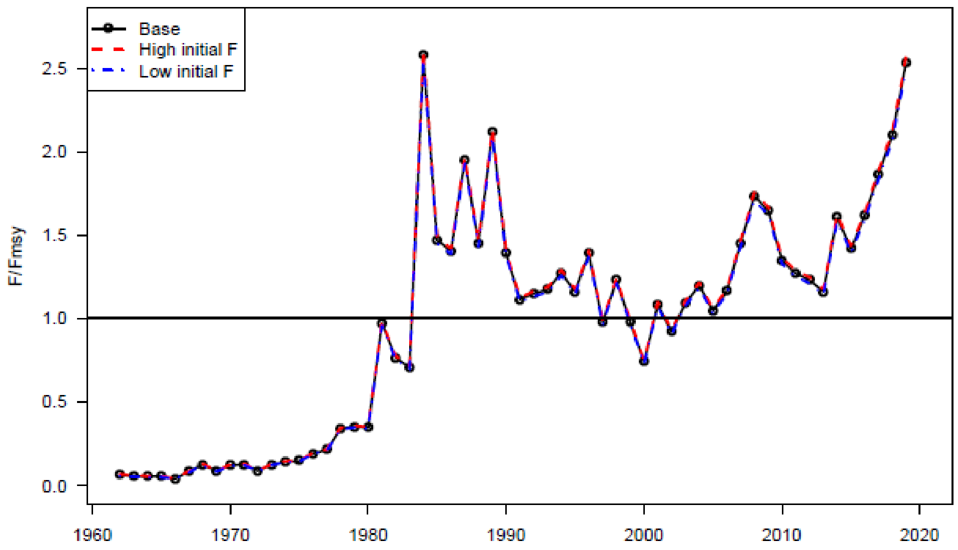


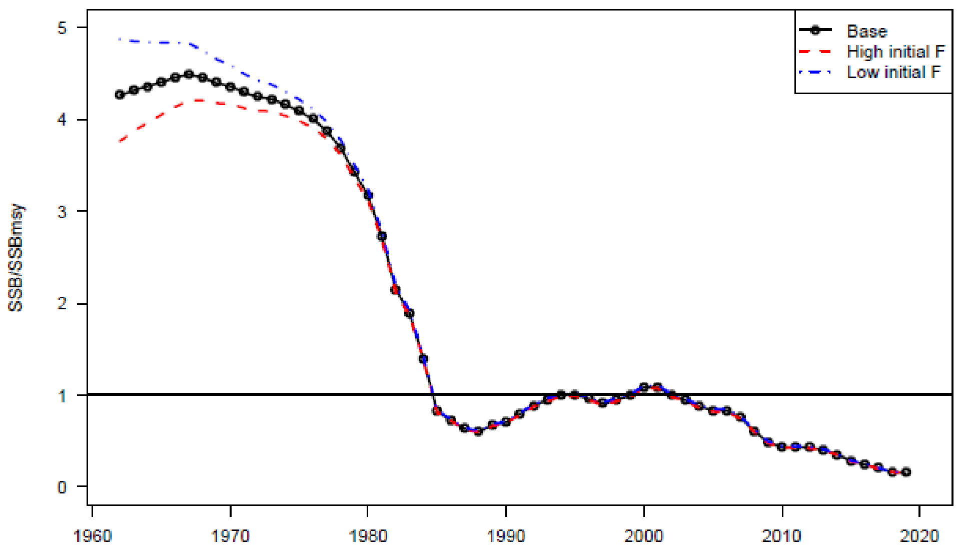
Sensitivity Runs: Initial F

Base F_{init} = 0.032 (estimated)

- Low F_{init} = 0.016 (- 50%)
- High F_{init} = 0.048 (+ 50%)

- Sedar 2014 update: F_{init} = 0.03 (fixed)





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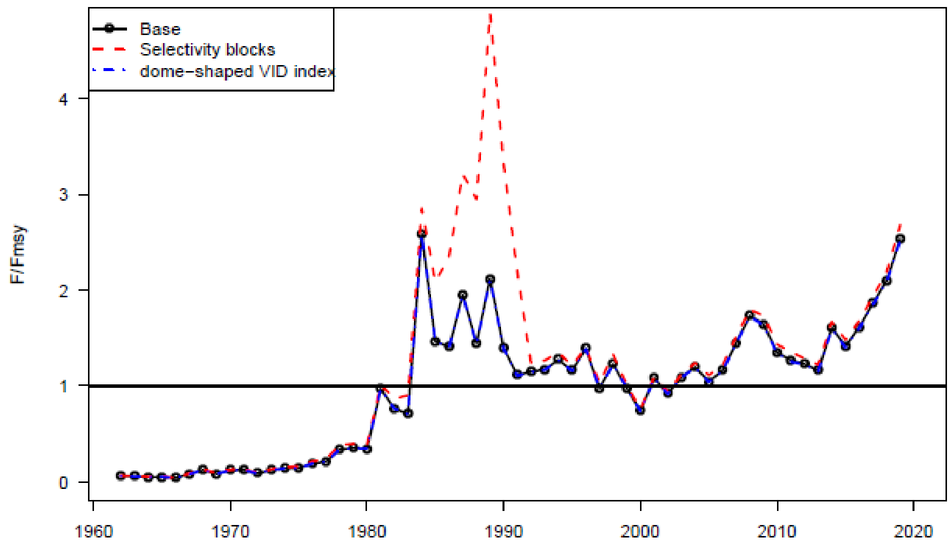
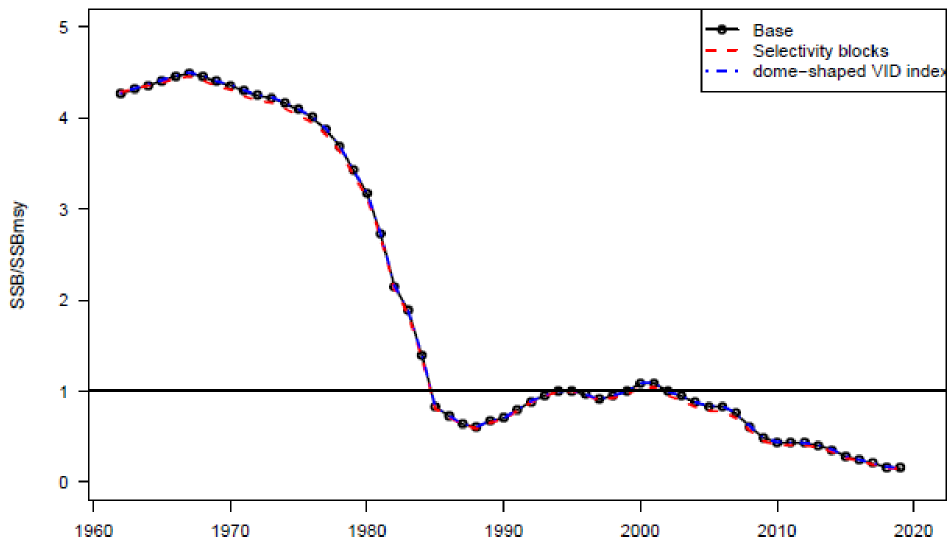
Sensitivity Runs – Selectivity

- Base run:
  - no blocking on cHL
  - 2 blocks on HB and GR
    - Pre size lt: 1962-1991
    - Post size lt: 1992-2019
  - logistic selectivity for Video index
- Sensitivity:
    - 3 blocks on all fleets (as in Sedar 2014 update)
      - 1962-1991 (no size lt)
      - 1992-1998 (24 inch size lt)
      - 1999-2019 (20 inch size lt)
  - Dome-shaped selectivity for Video index

Sensitivity Runs: Selectivity





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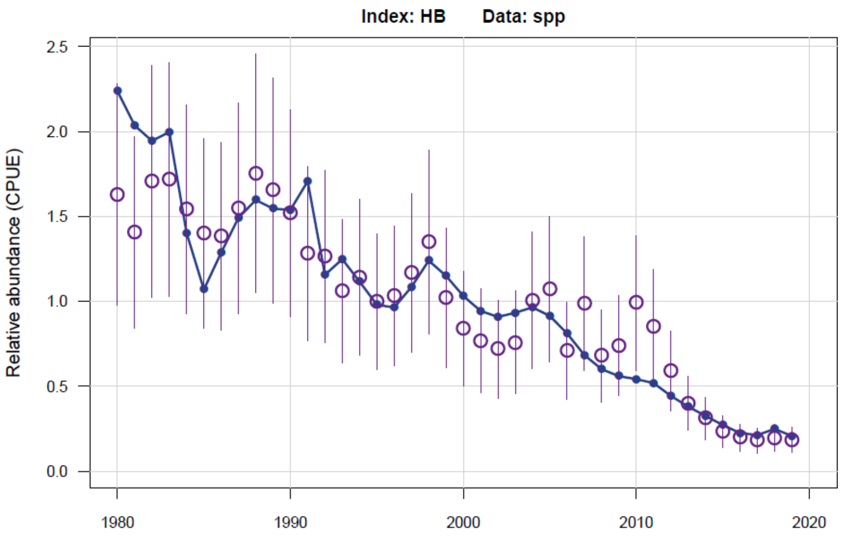
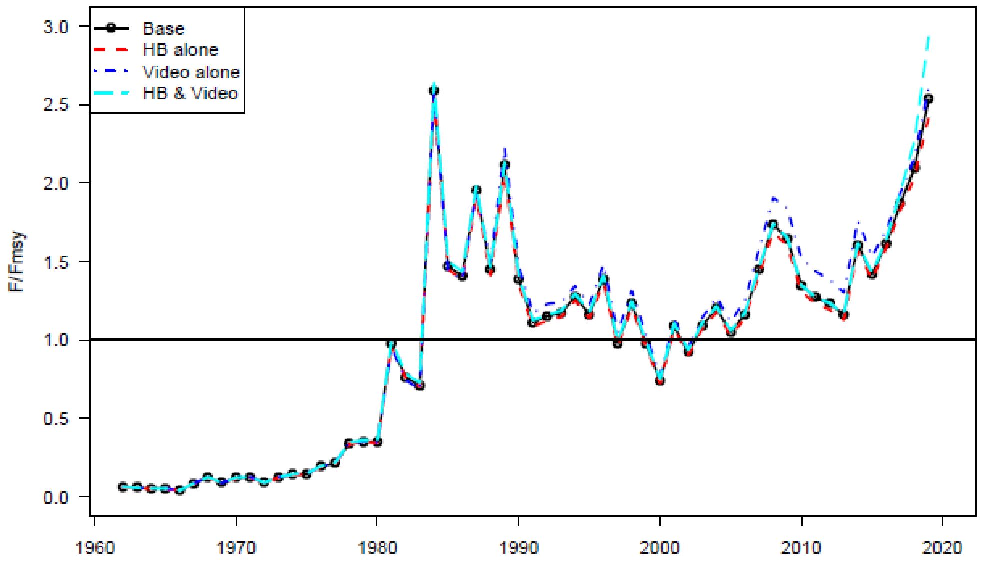
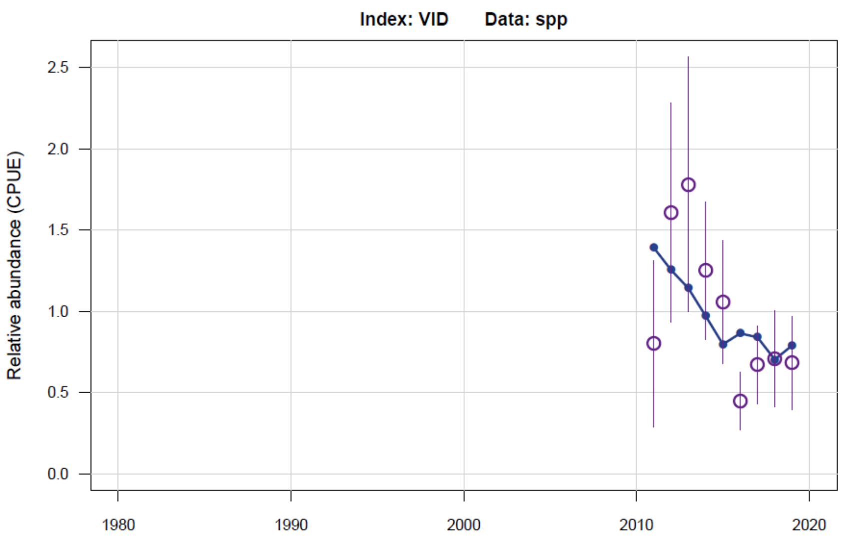
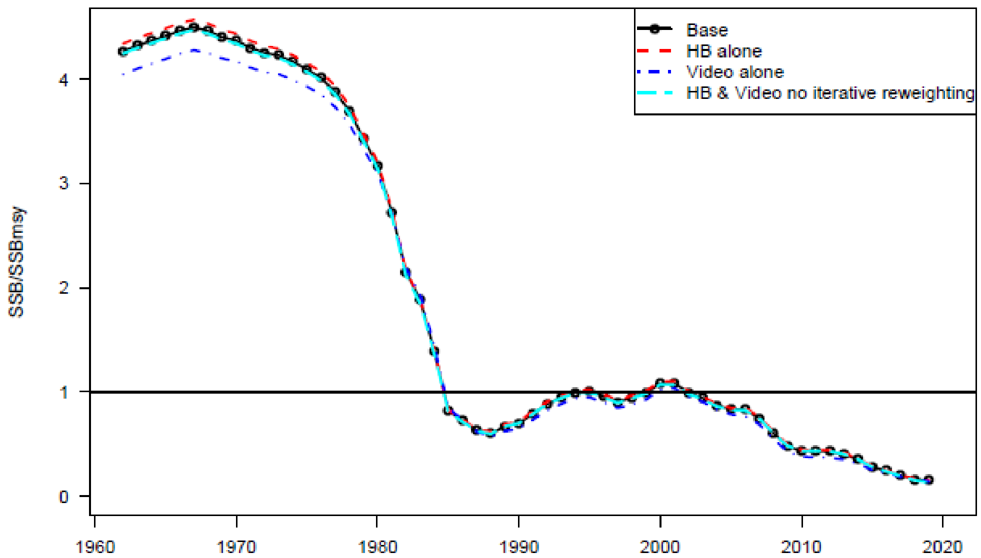
Sensitivity Runs: Indices



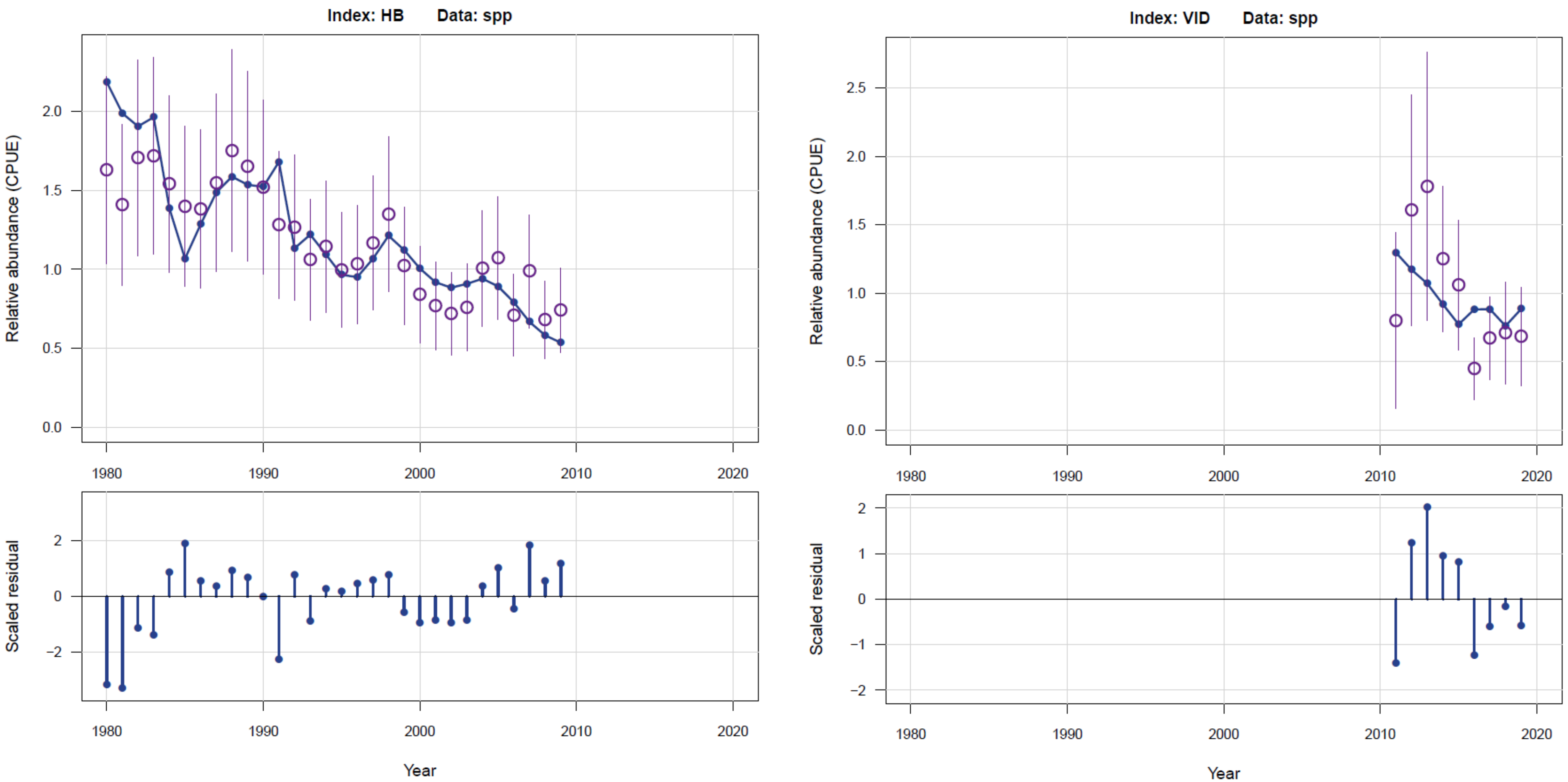






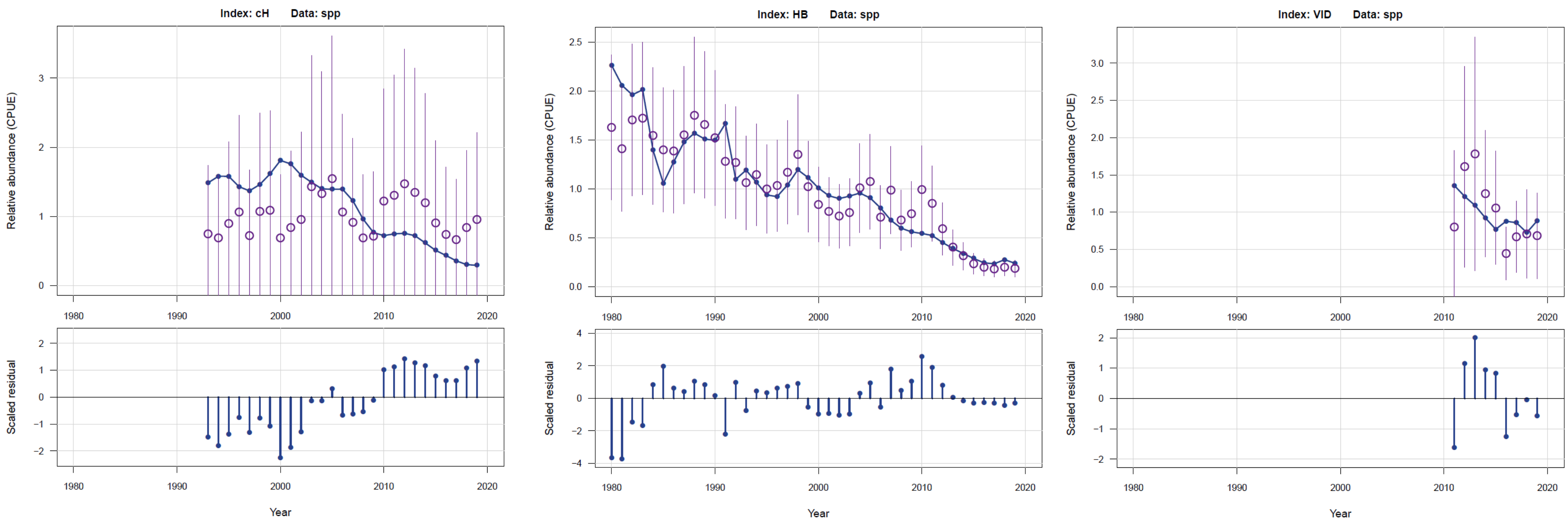
Sensitivity Runs: Alternative index configurations

1. Truncate Headboat in 2009



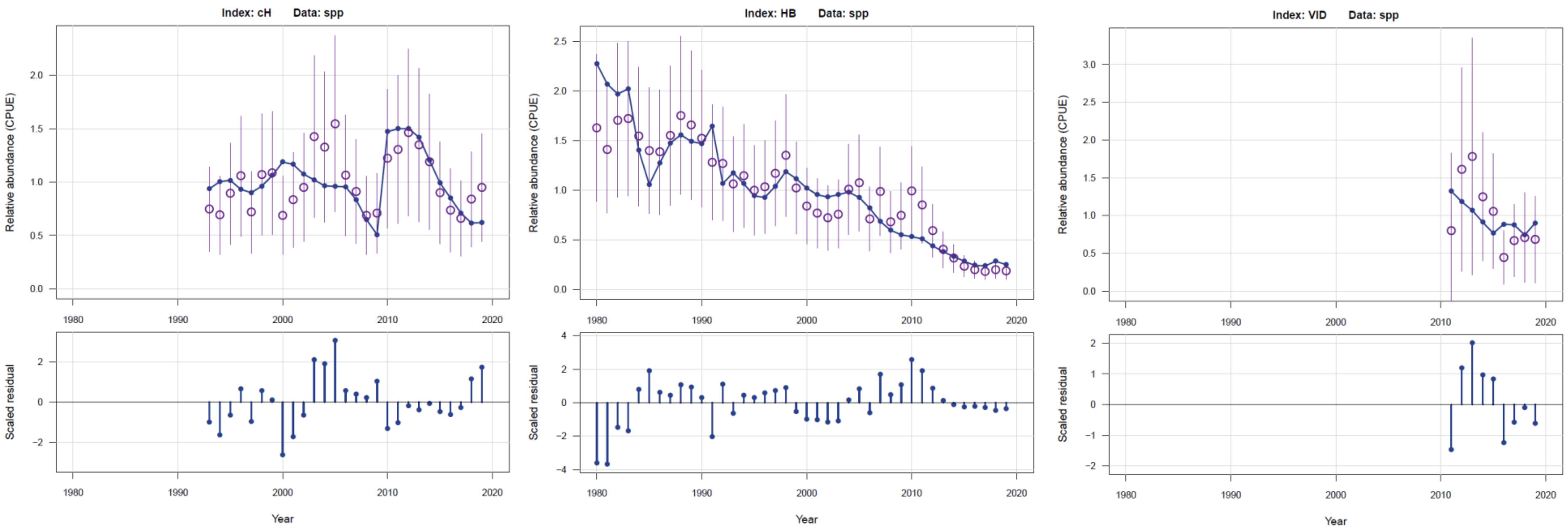
Sensitivity Runs: Alternative index configurations

2. Include Commercial Handline

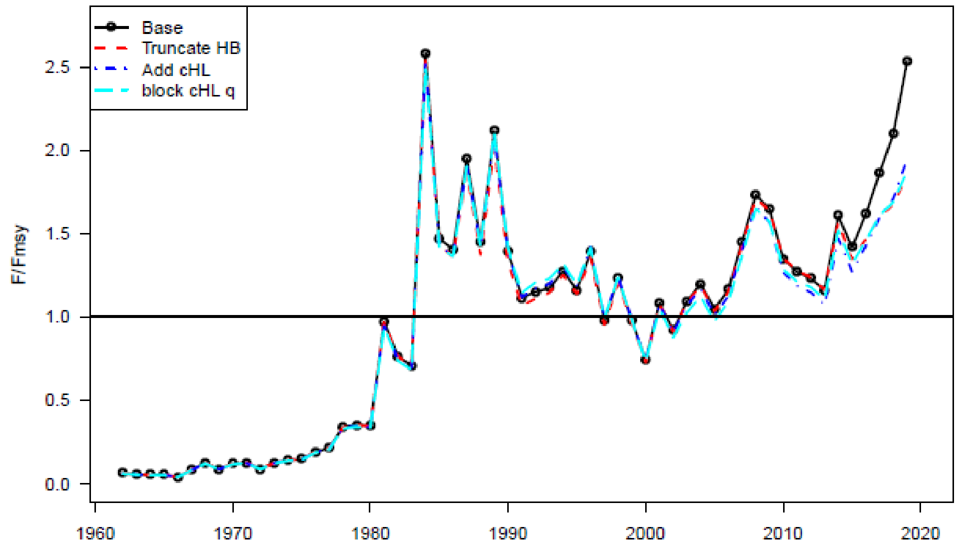


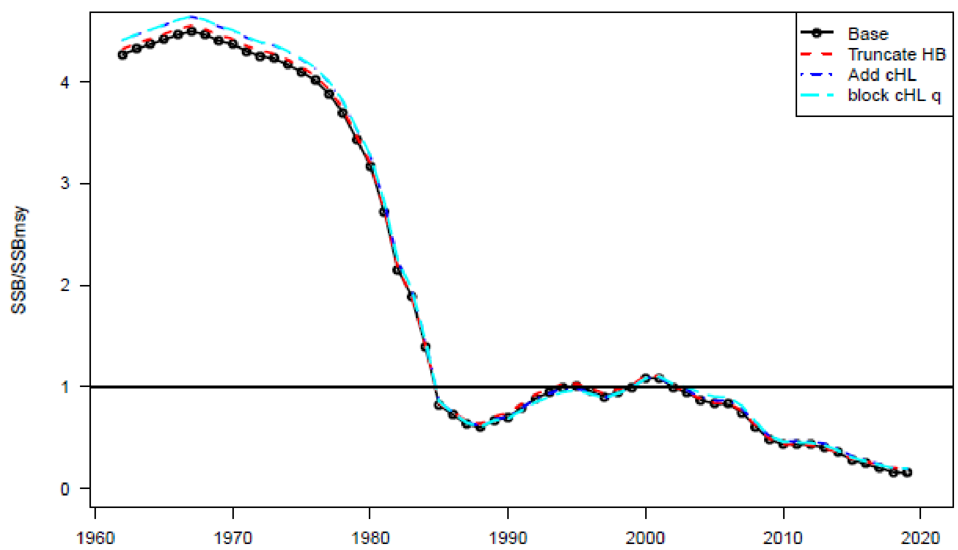
Sensitivity Runs: Alternative index configurations

3. Block q on Commercial Handline

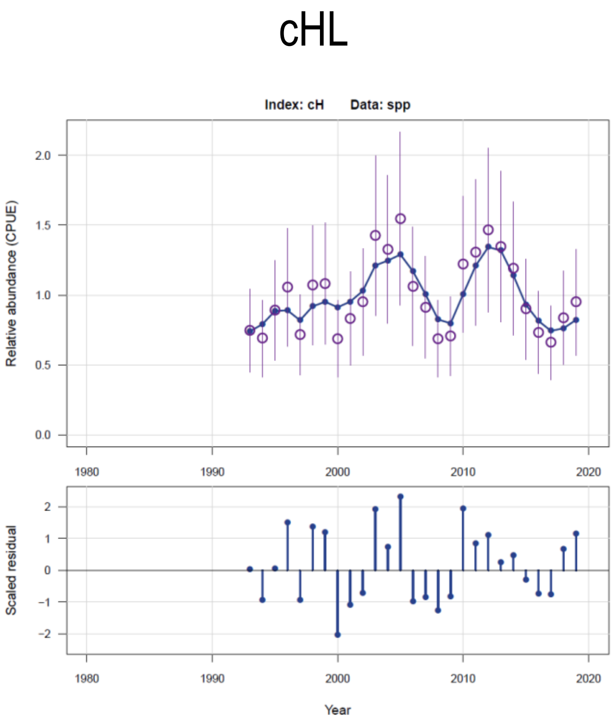


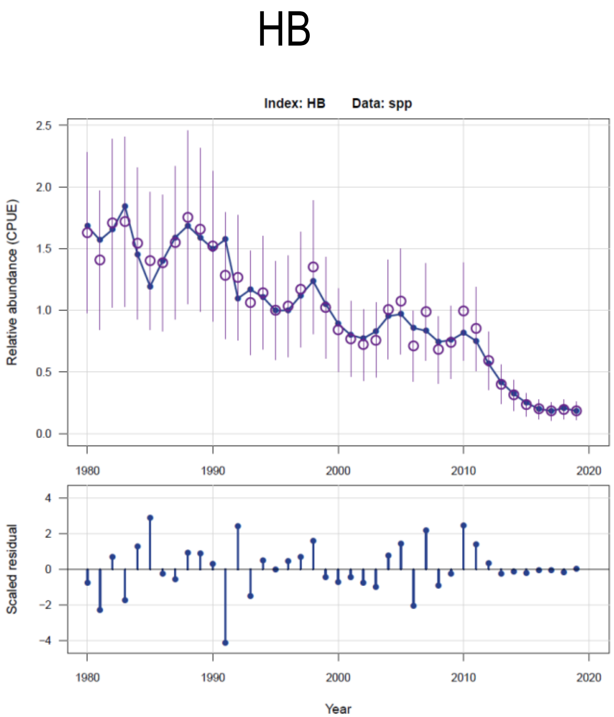
Sensitivity Runs: Alternative index configurations

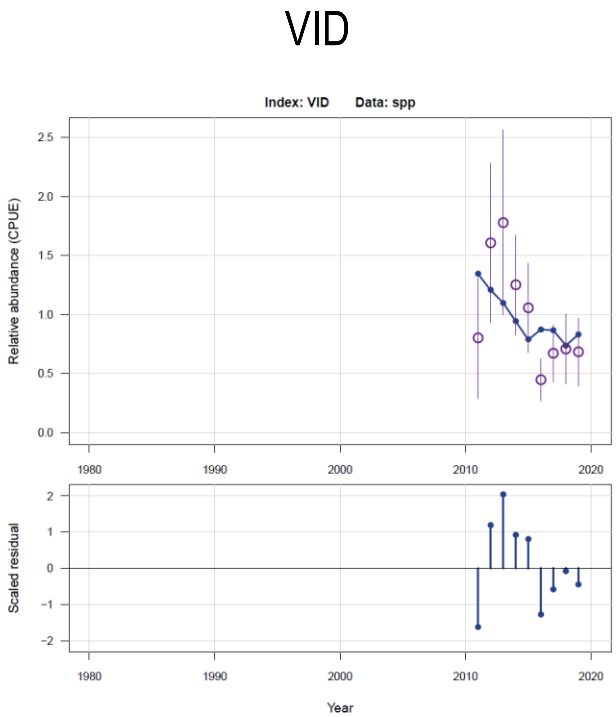




Sensitivity Runs: RW on Fishery Dependent Indices







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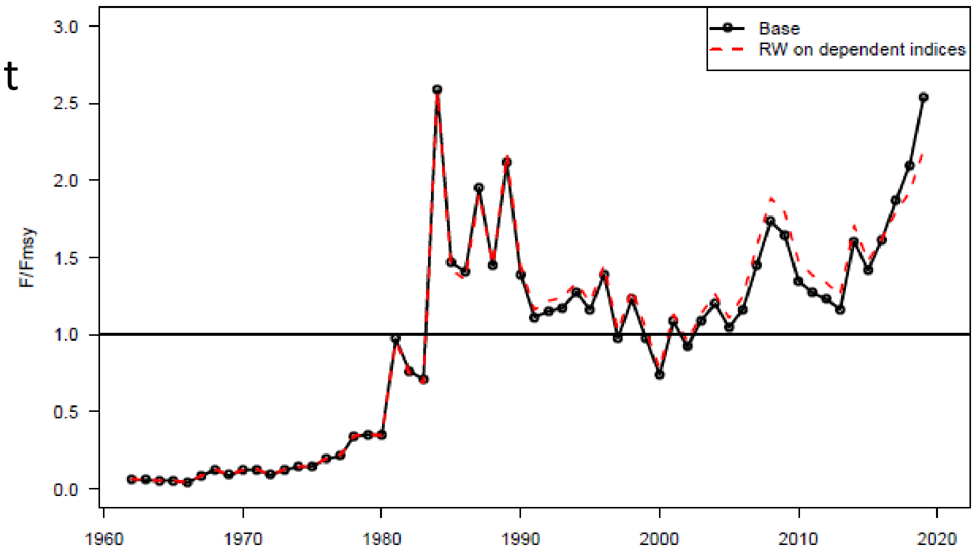
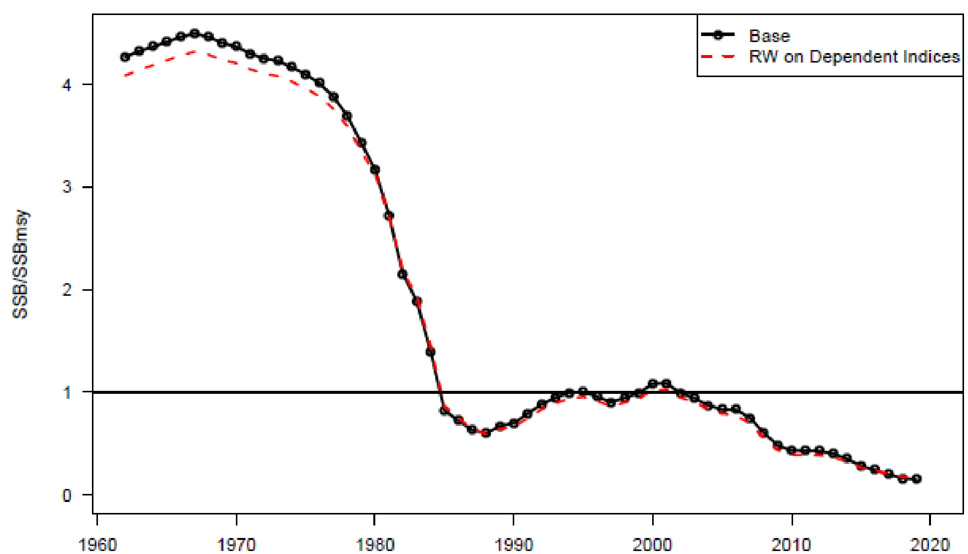
Sensitivity Runs: Time-varying catchability

- Random walk on fishery-dependent indices (cHL and HB)

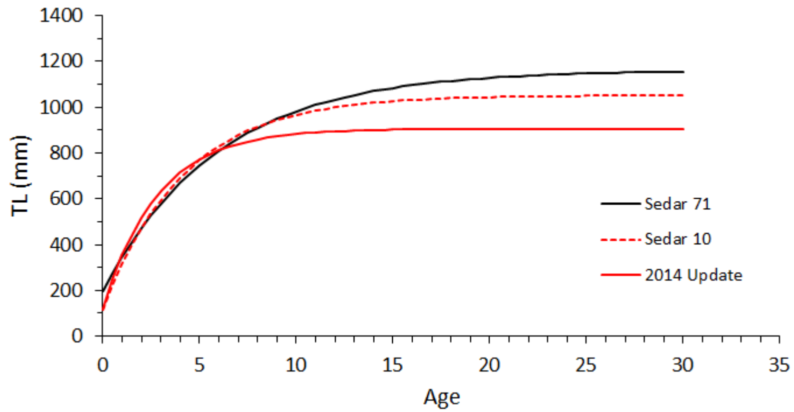




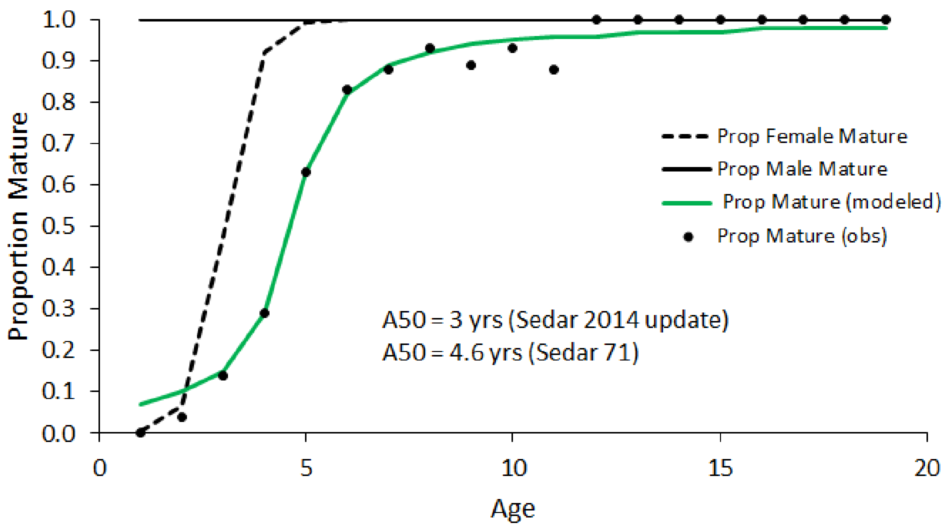
Sensitivity Runs: Life History

2014 Update:
- Growth: faster growth, smaller asymptotic size
- Maturity: younger age at maturity
- Natural mortality: lower M

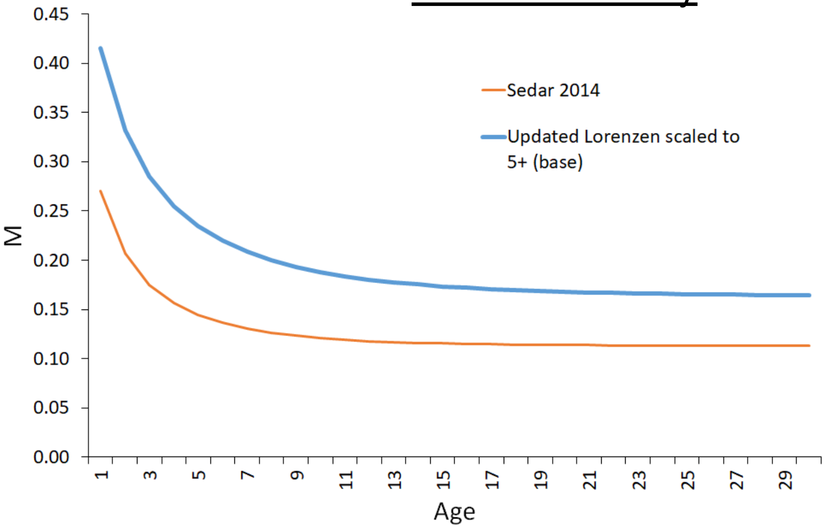
Growth



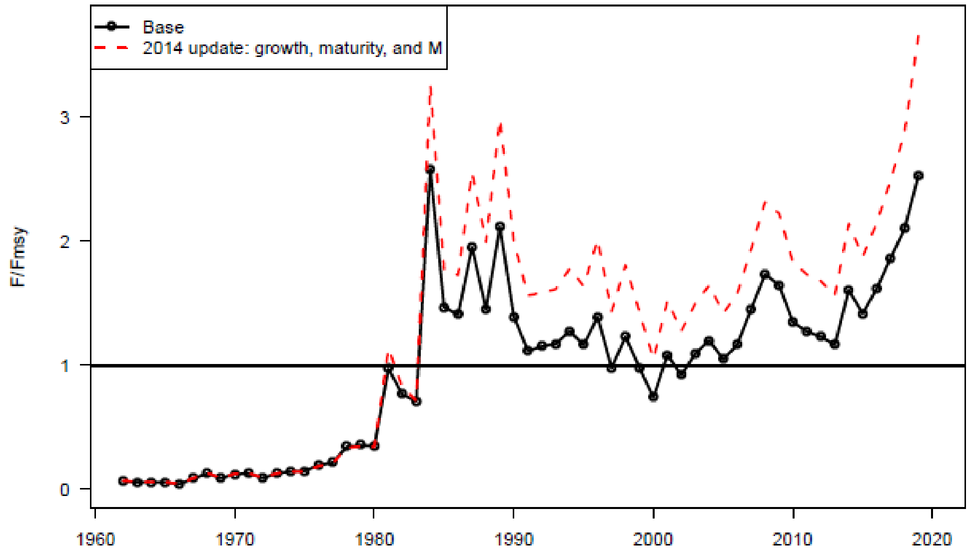
Maturity

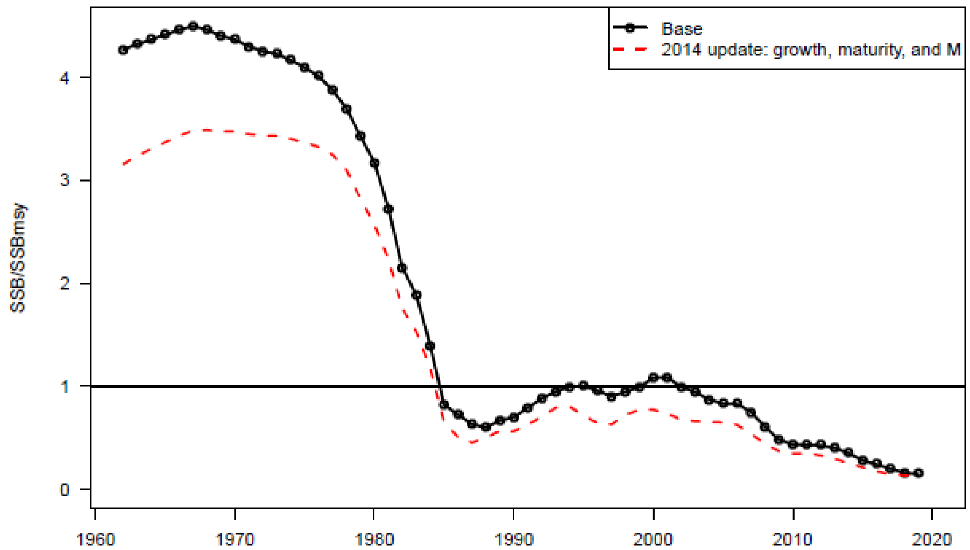


Natural Mortality



Sensitivity Runs: Life history





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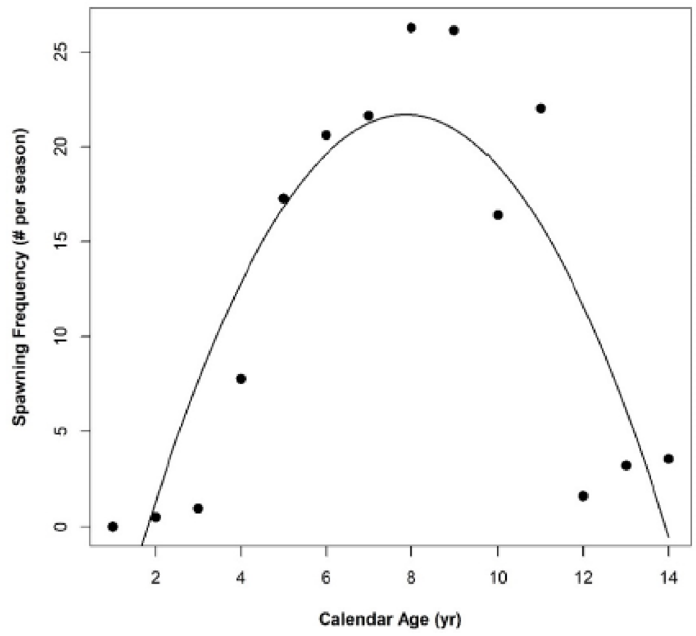
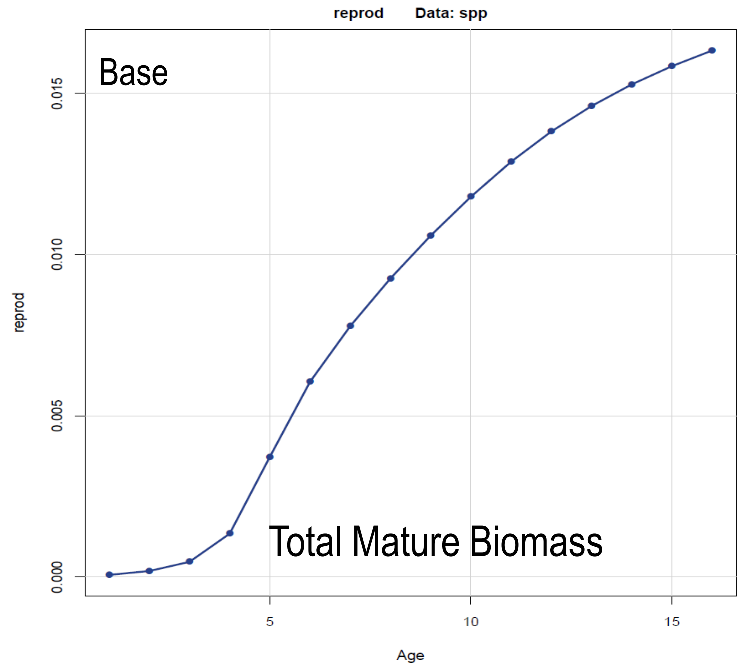
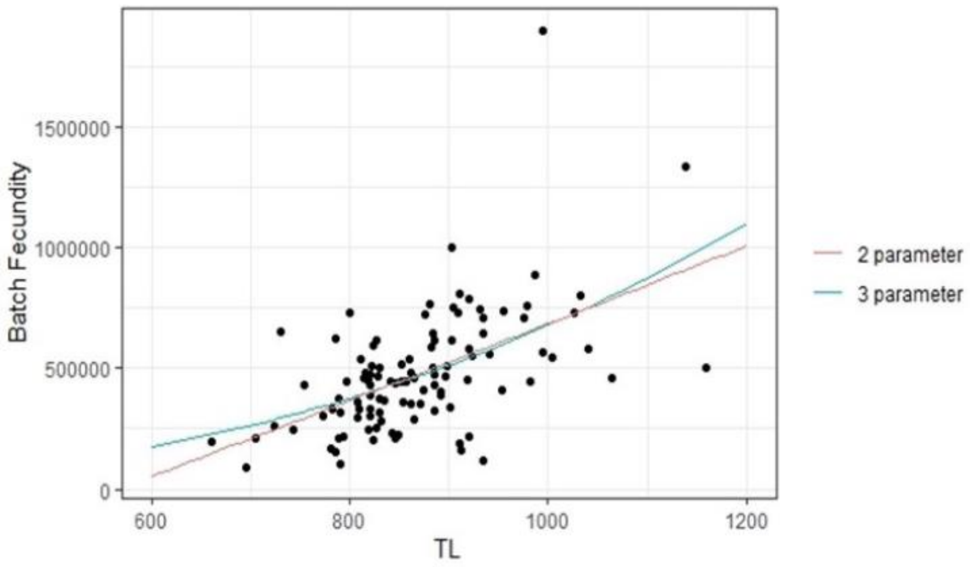
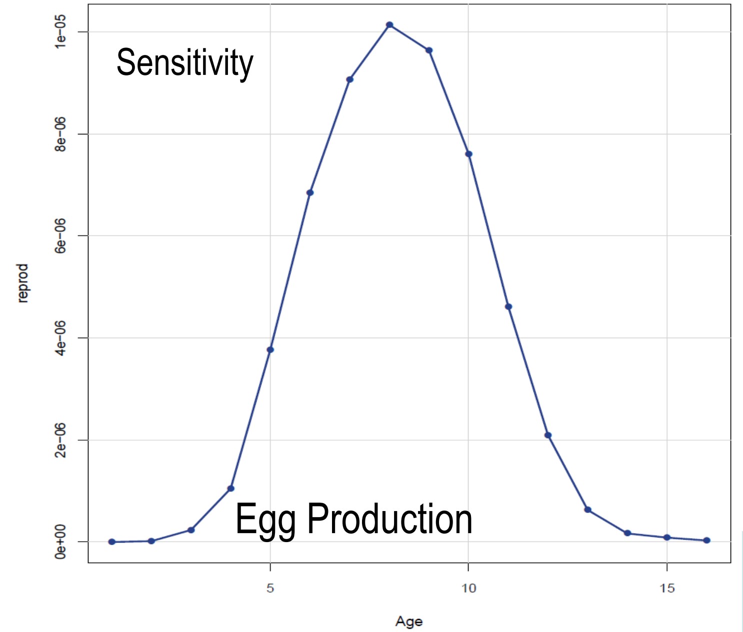
Sensitivity Runs – Reproductive Potential

SEDAR 71-WP03



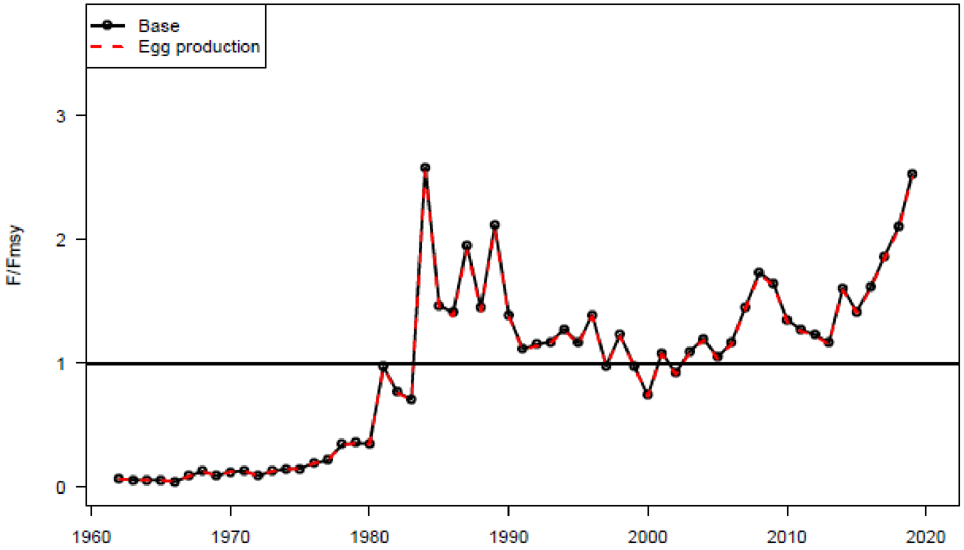


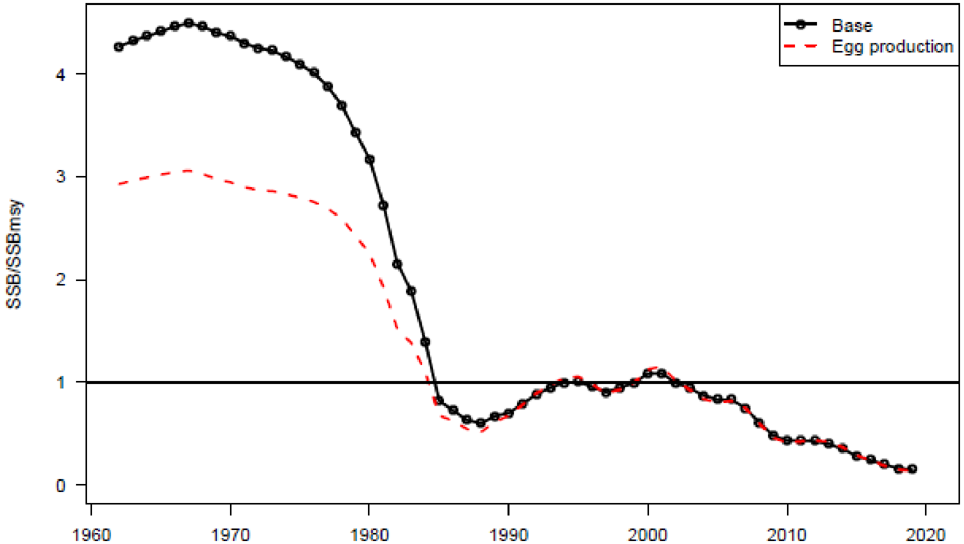




Sensitivity Runs: Reproductive potential

Base run: Total mature male and female biomass
Sensitivity: Female egg production





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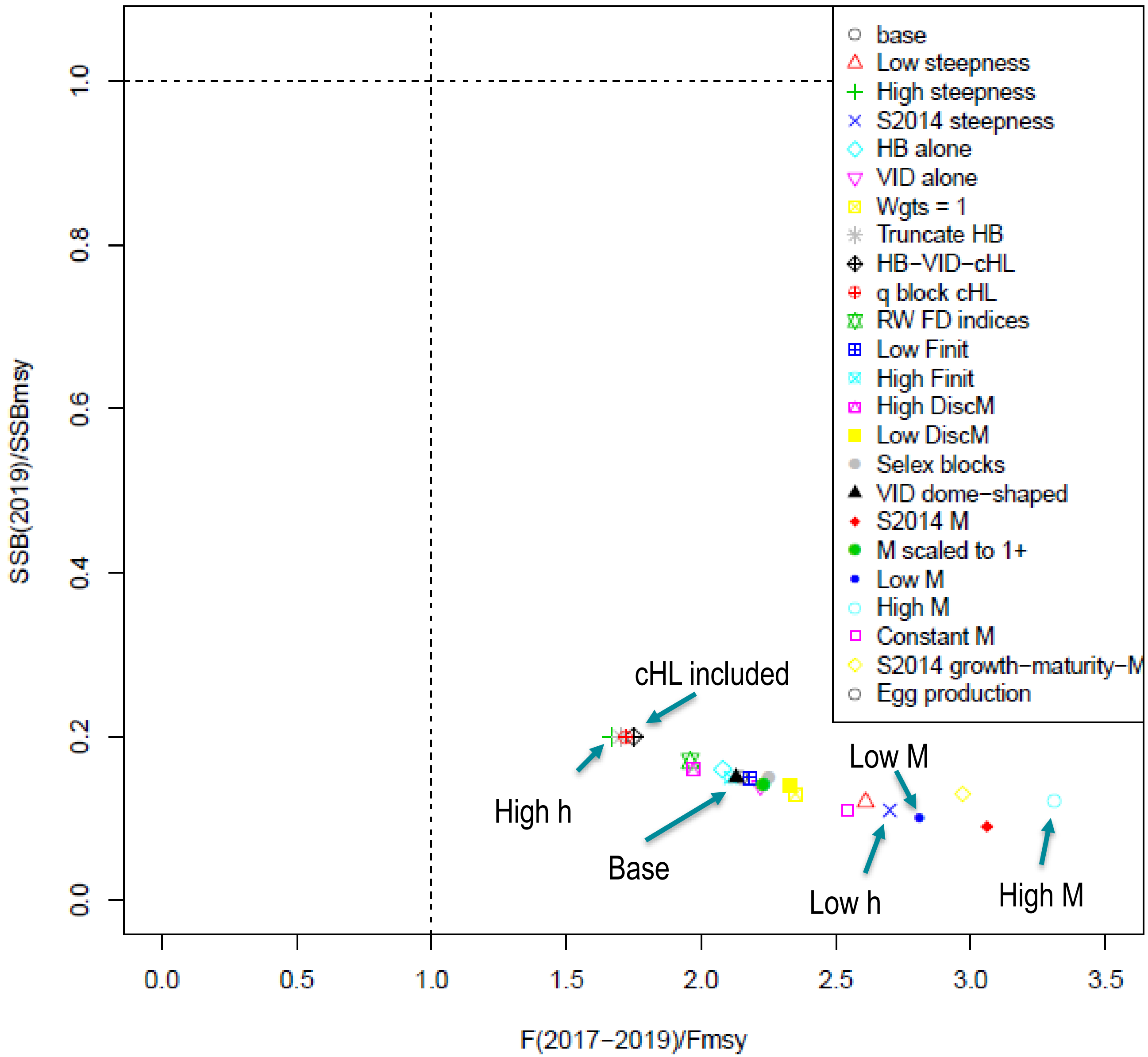
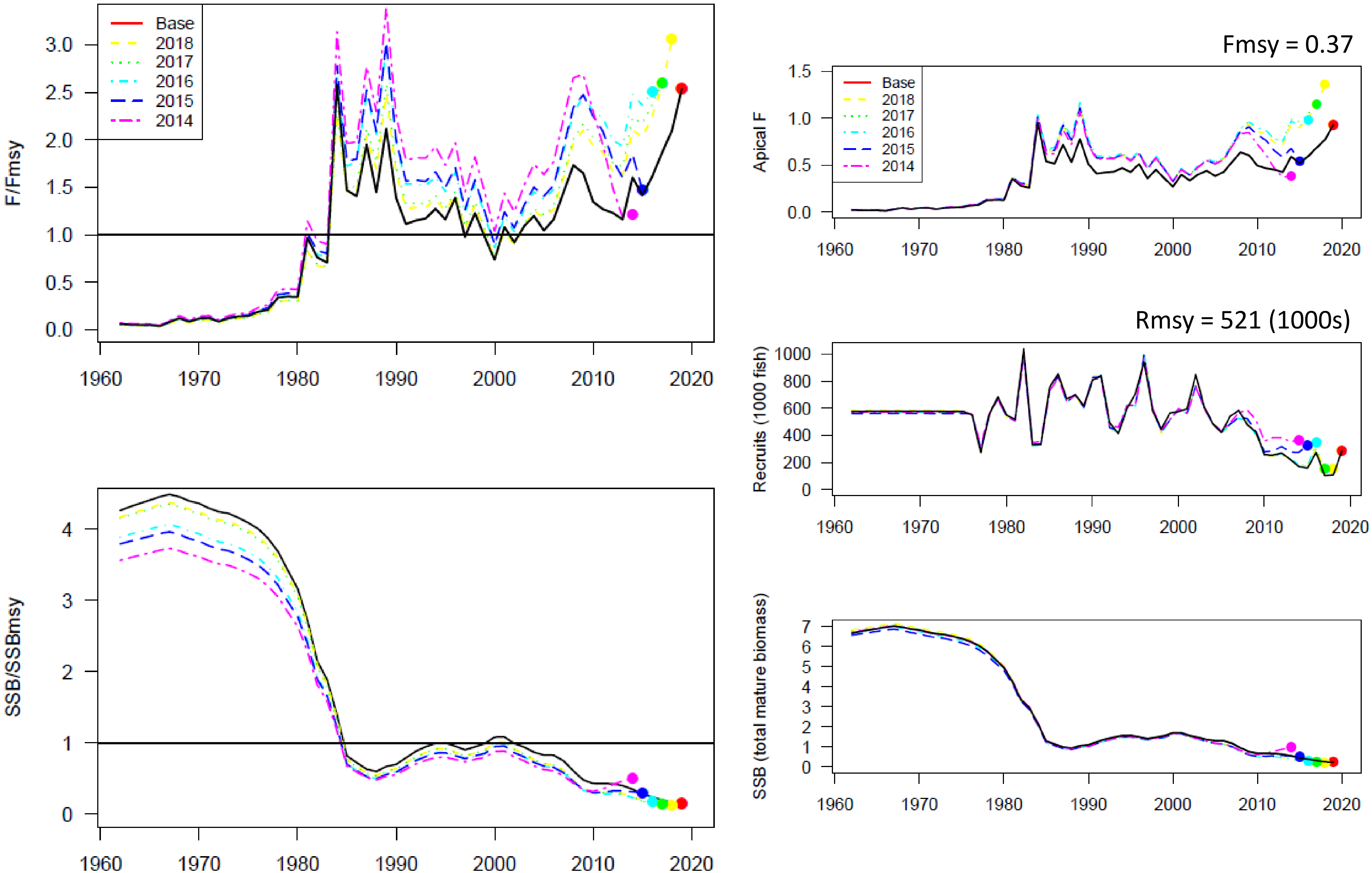
Sensitivity Phase Plot



Retrospective runs (2014-2018)



Summary of Assessment Results

- Gag grouper are overfished and currently experiencing overfishing
- Overfishing has occurred since 1980s (consistent with prior assessments)
- Prior assessments indicate popn has been near stock size threshold until early 2010s; current assessment indicates well below thresholds
- Fishery-dependent and fishery-independent indices indicate 2-3 fold declines in abundance in last 10 years
- Low estimated recruitment in last 10 years of assessment (some modest recruitment in 2016 and 2019, but not well-informed)
- Recent fishing mortality remains high and driven by commercial handline and general recreational fleets

Summary of Assessment Results (cont)

- Assessment results are highly robust to the range of uncertainty considered
- All aspects of SR function estimated for this assessment (R0, h, rec_sigma)
- Fishery-dependent indices should be evaluated for effects of regulatory changes
- Natural mortality (M) was a key source of uncertainty in this assessment (though results were robust to variation in M)
- Potential for sperm limitation, temporal variation in sex ratio, and alternative measures of reproductive potential should be evaluated

Topics

1. Background
2. Data
3. Assessment model
4. Assessment results
5. **Projections**

Projection Methodology

- The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment
- Carry forward uncertainties from ensemble modeling (i.e., 2020 abundance at age, natural mortality, discard mortality, historical recreational removals)
- A single selectivity curve was applied to calculate removals, weighted averaged across fleets using geometric mean *F*s from the last three years of the assessment period
- Initial age structure at the start of 2020 was computed from assessment model
- Constant fishing rates that define the projections were assumed to start in 2022

Projection Configurations

In SEDAR 71 report:

- 10 year projections (2020-2029)

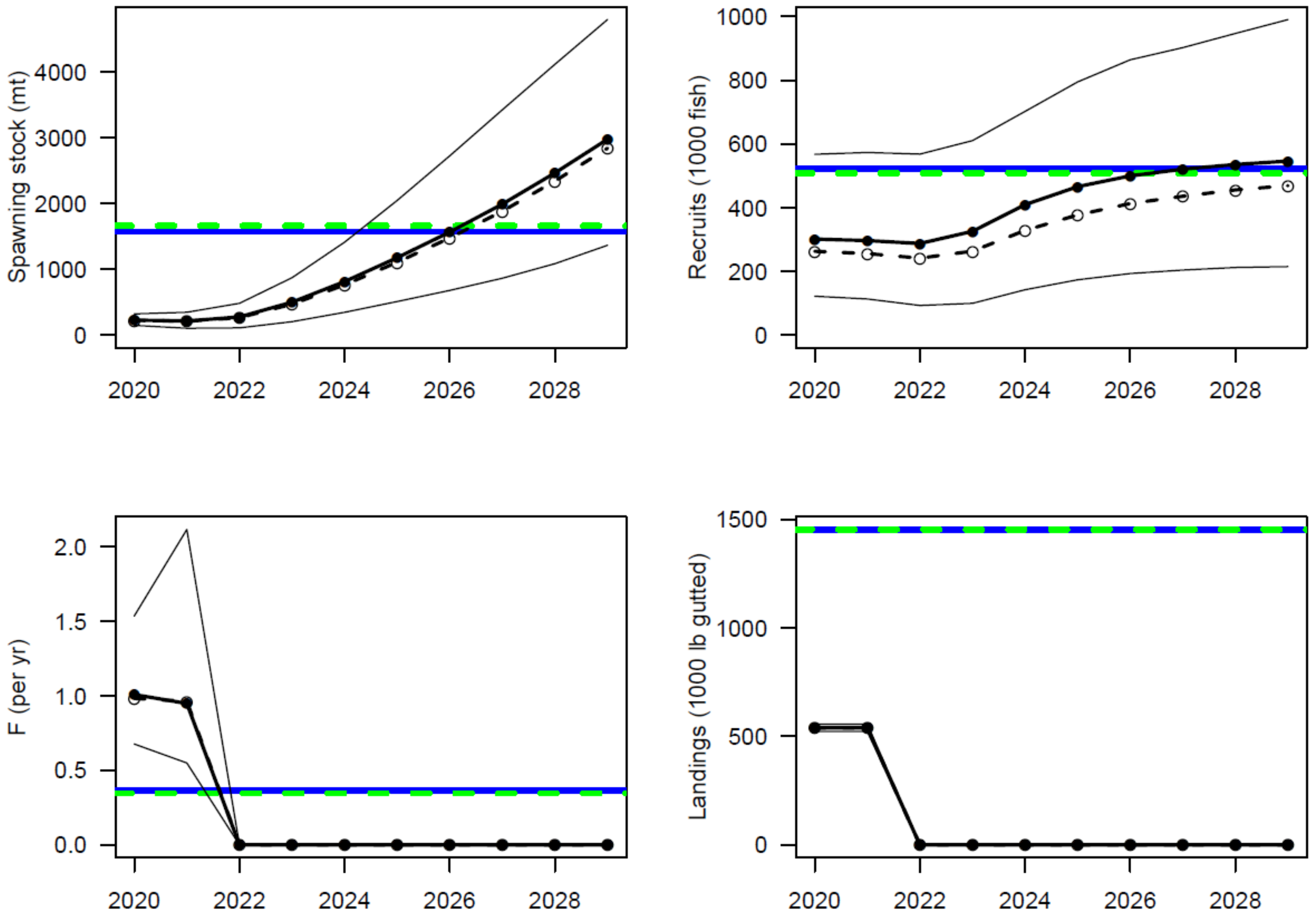
- Interim years
  - 2020 and 2021; first year of management 2022
  - $L_{current}$ (average landings from last 3 years of the assessment)

- Projection scenarios:
  - $F = 0$
  - $F = F_{current}$ (geometric mean last 3 yrs, 2017-2019)
  - $F = F_{msy}$ (equivalent to $P^* = 0.5$)
  - $F = F_{rebuild}$
    - Rebuilding time frame = 2040 (generation time of 11 yrs + 10 years)

- 3 additional rebuilding projections (not in SEDAR 71 report

Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

F = 0



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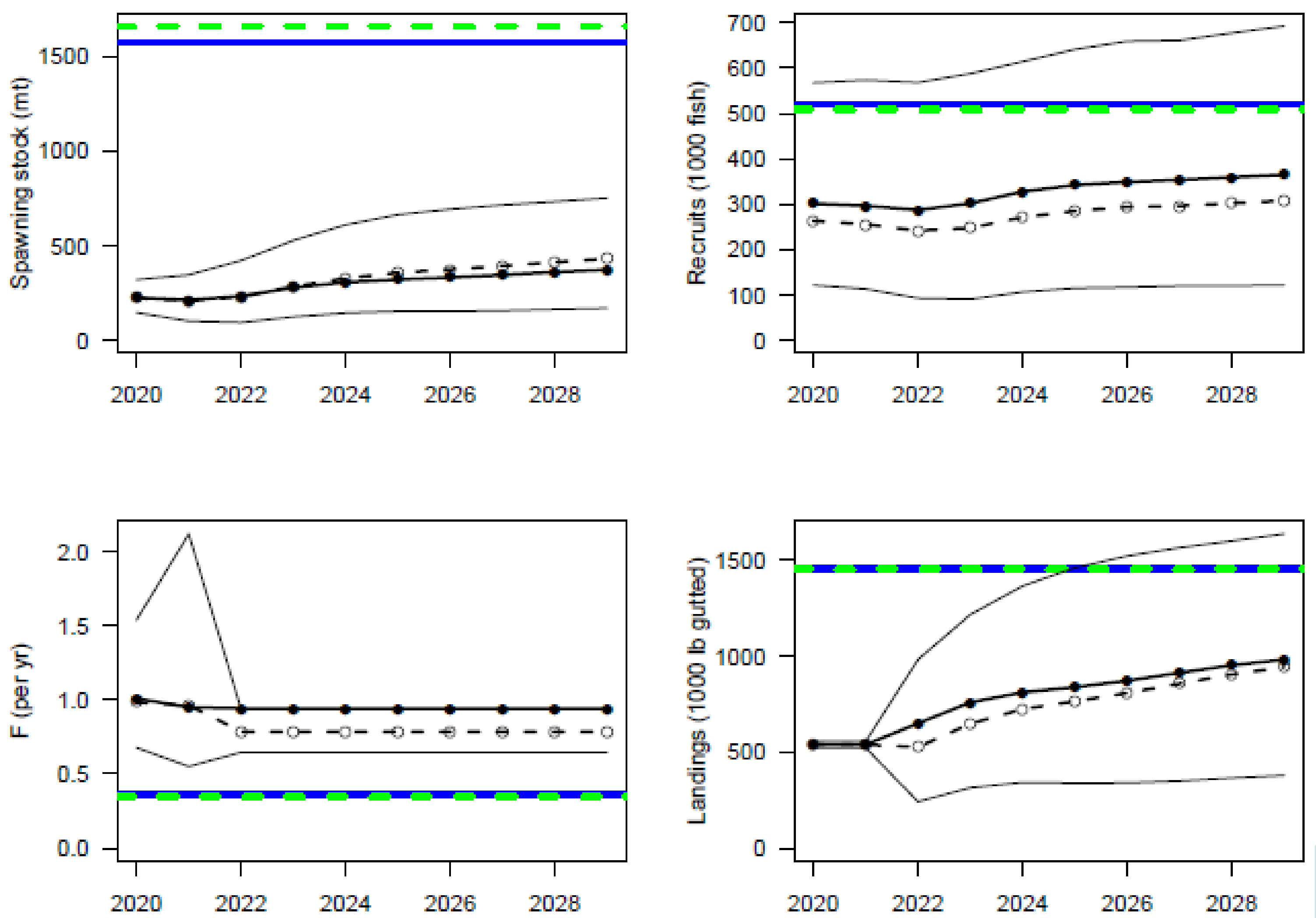
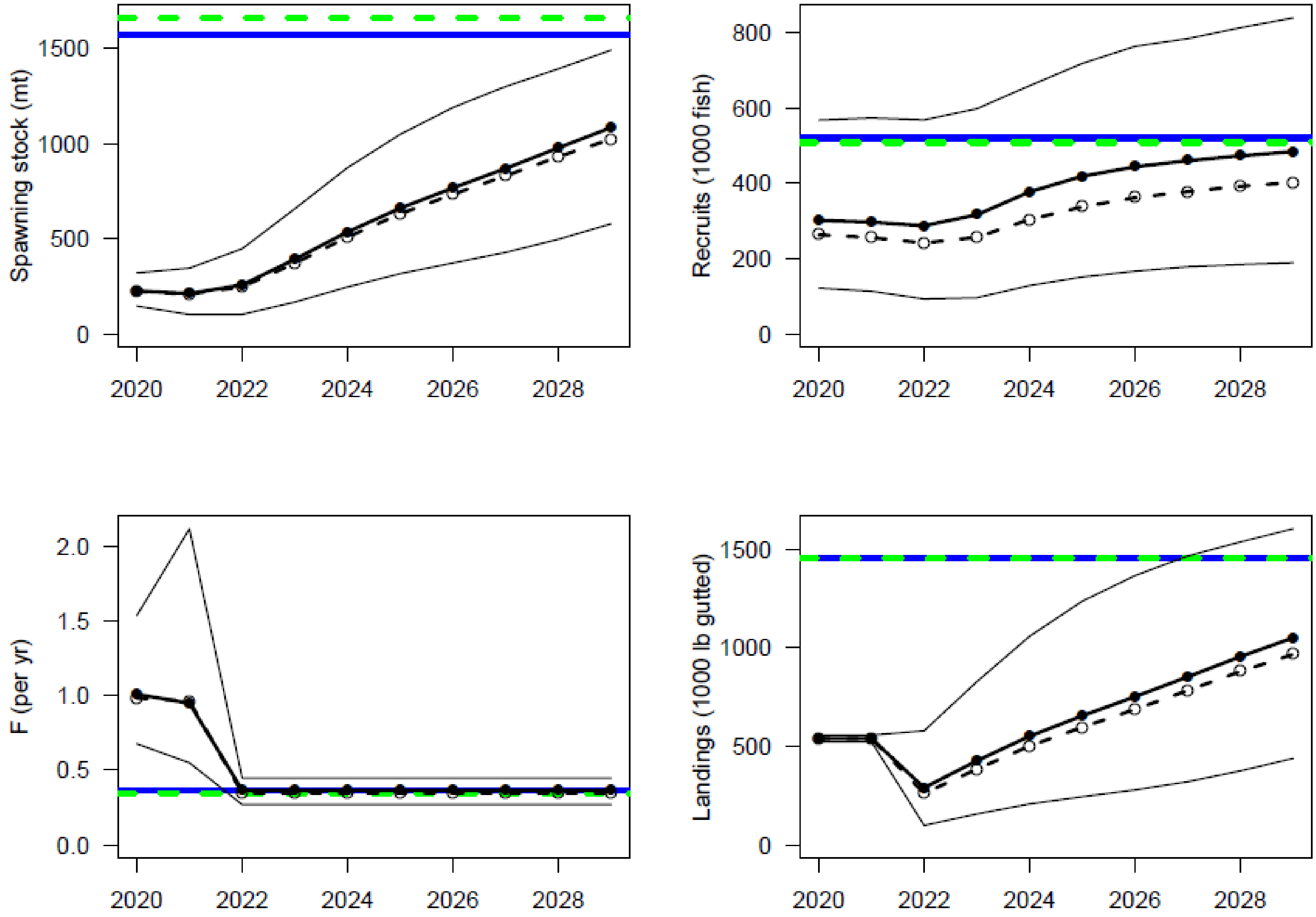
Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

$F = F_{current}$



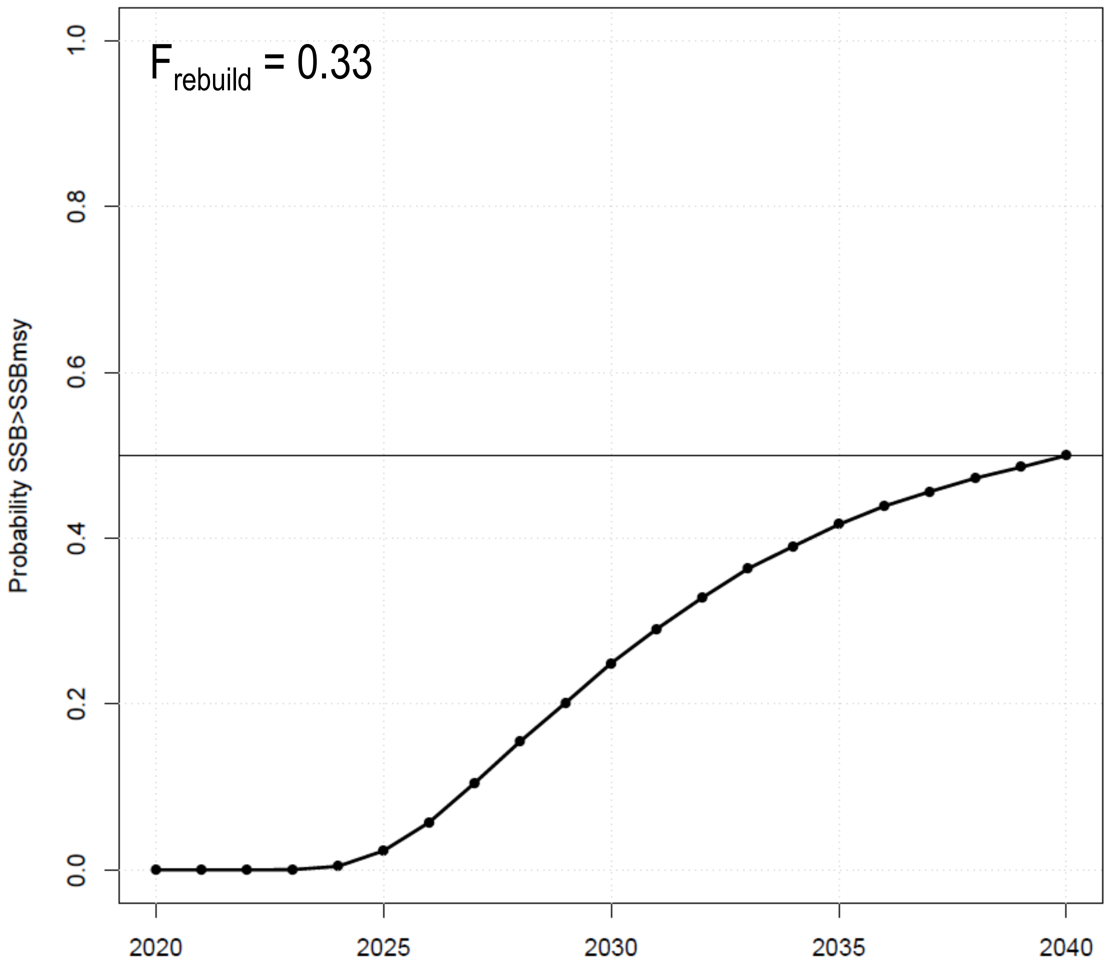
Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

$F = F_{MSY}$



NOAA FIS

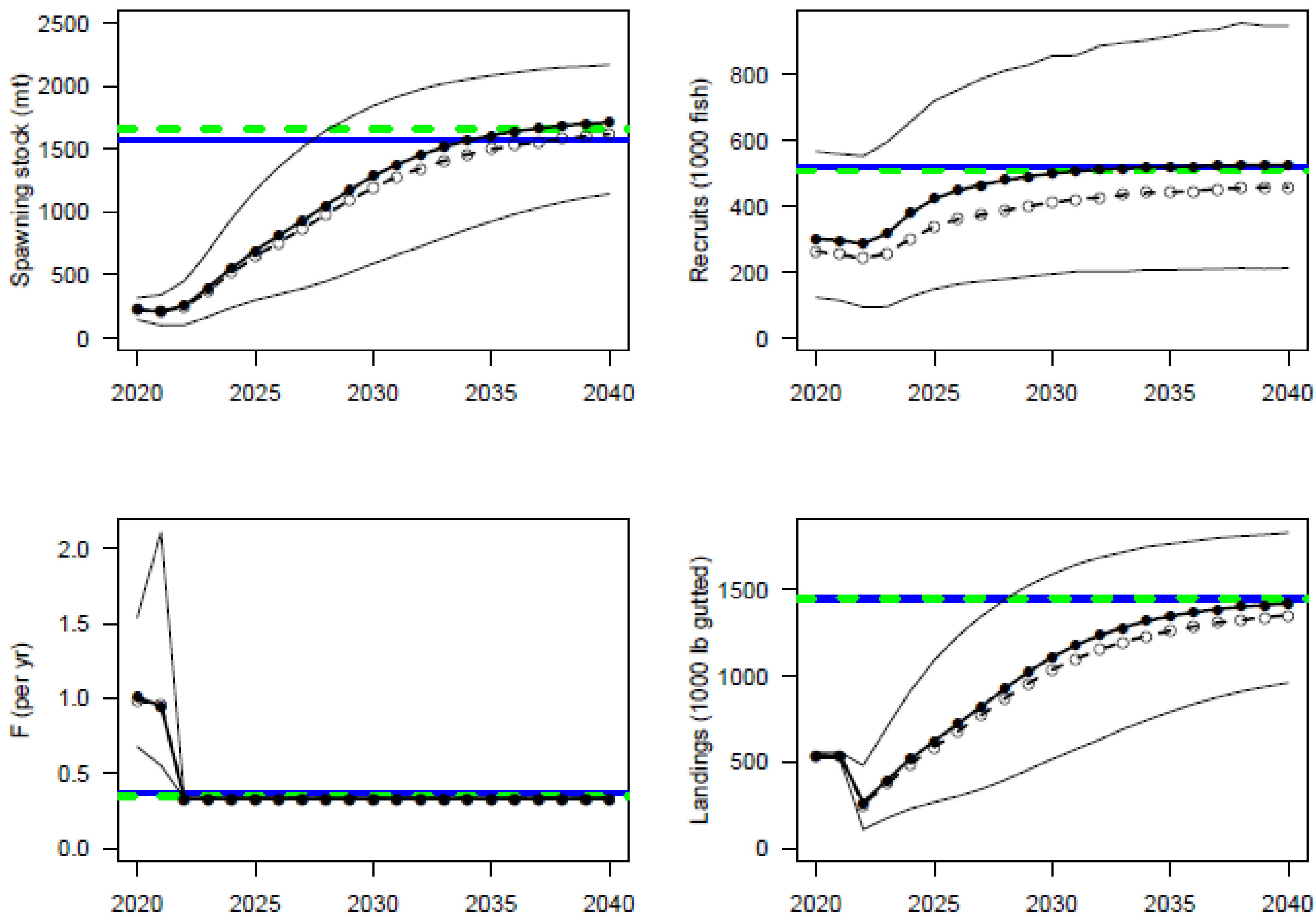
Projections – Probability of Rebuilding (10 years)



Rebuilding time frame: 21 years
Generation time: 11.3 years + 10 years (2040)

Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

$F = F_{Rebuild}$



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Additional Rebuilding Projections

- Scenario 1: T_{max} = T_{min} plus one generation time
  - T_{min} = time to rebuild when F =0 (8 years)
  - Generation time = 11 years
  - T_{max} = 19 years (rebuilding time frame)
  - Projection period 2020 – 2038
  - $F_{rebuild}$ = 0.325

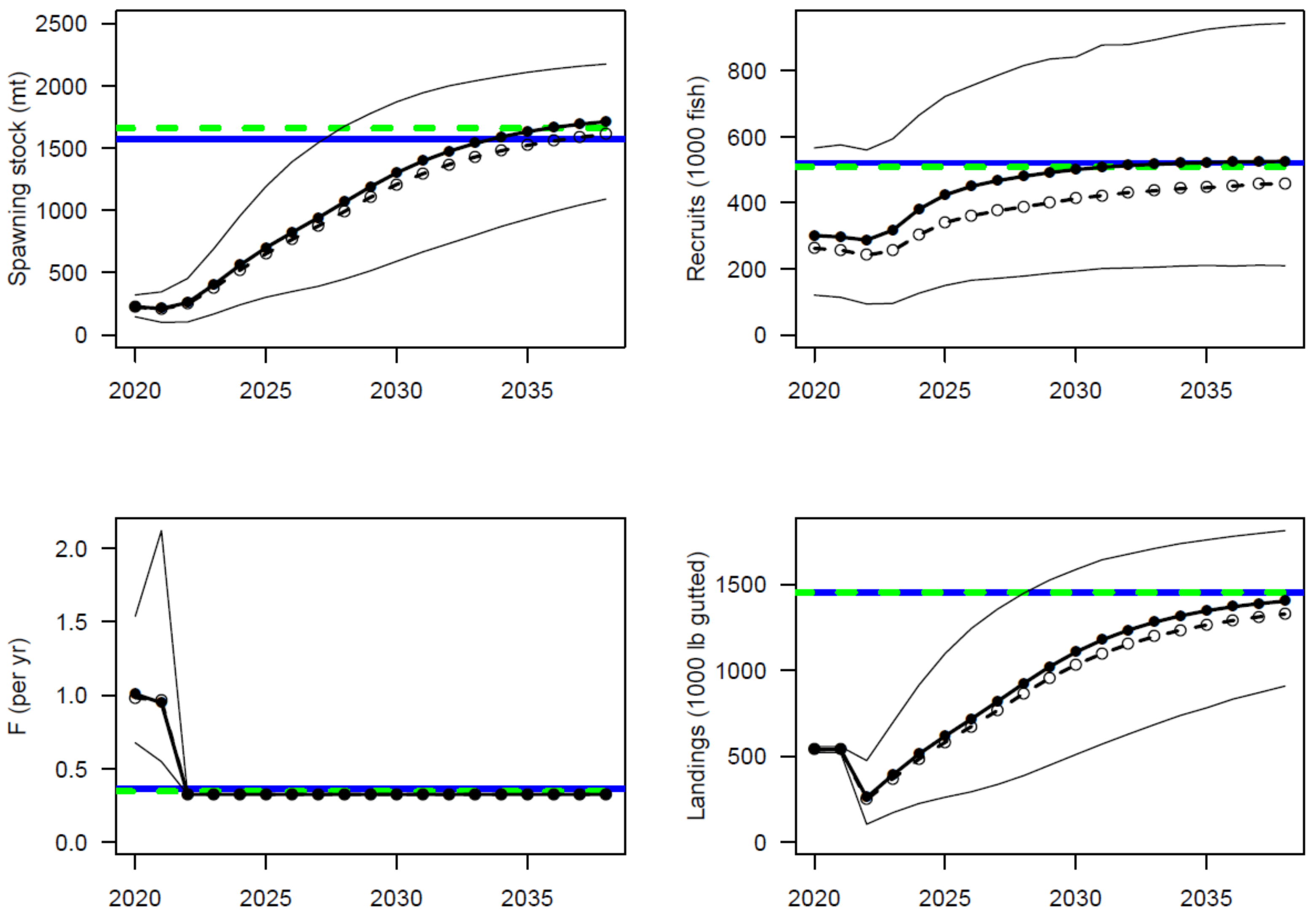
- Scenario 2: Amount of time to rebuild to SSB_{msy} if fished at 75% of MFMT (F_{msy} = 0.37)
  - In 2032 SSB > SSB_{msy} (with 50% probability)
  - T_{max} = 13 years (rebuilding time frame)
  - Projection period = 2020 – 2032
  - $F_{rebuild}$ = 0.278

- Scenario 3: T_{min} x 2
  - T_{min} = 8 years
  - T_{max} = 16 years (rebuilding time frame)
  - Projection period = 2020 – 2035
  - $F_{rebuild}$ = 0.307

Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

Scenario 1

$T_{max} = T_{min}$ plus one generation time



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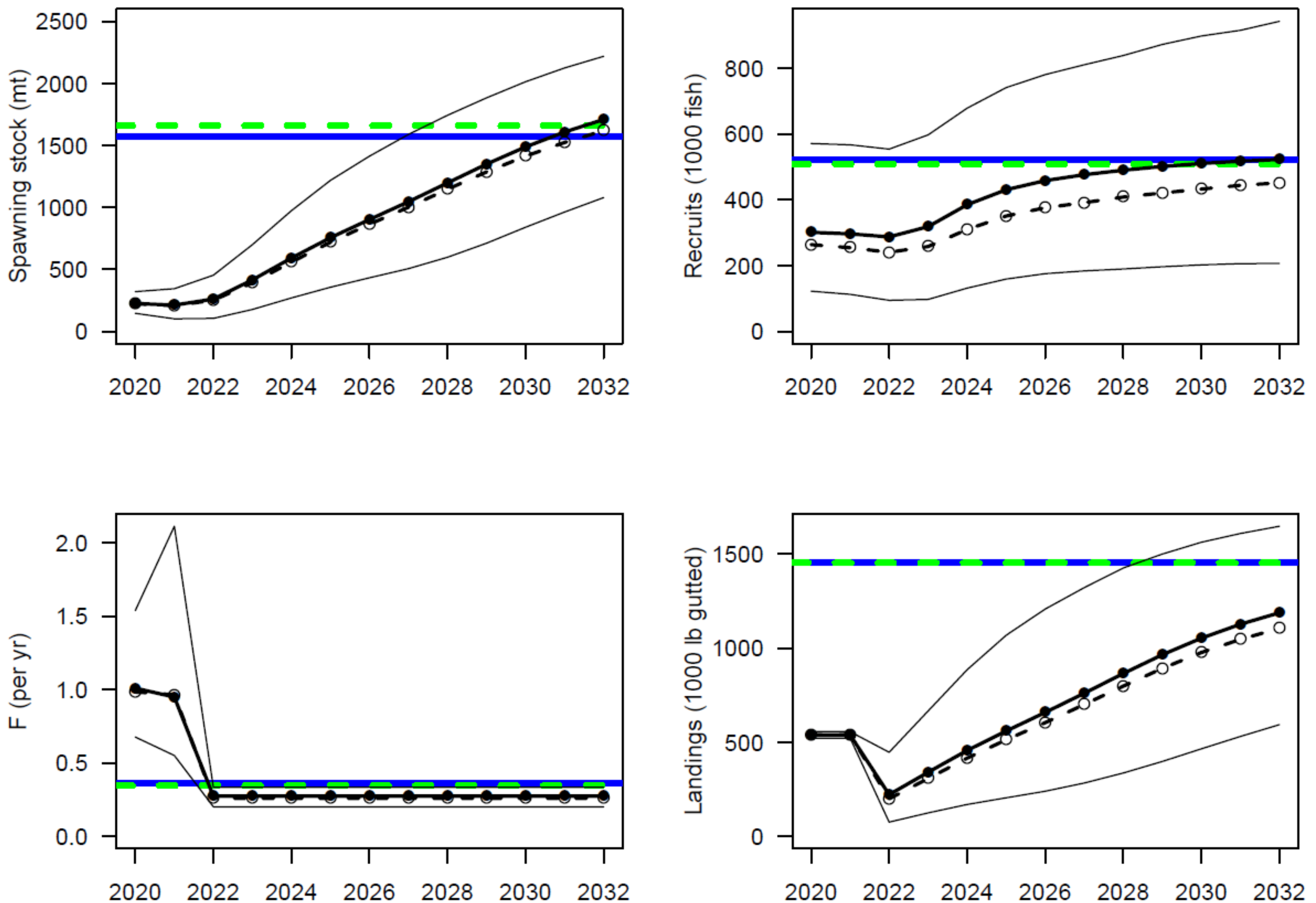
Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

Scenario 2

T_{max} = time to rebuild to SSB_{msy} if fished at 75% of MFMT

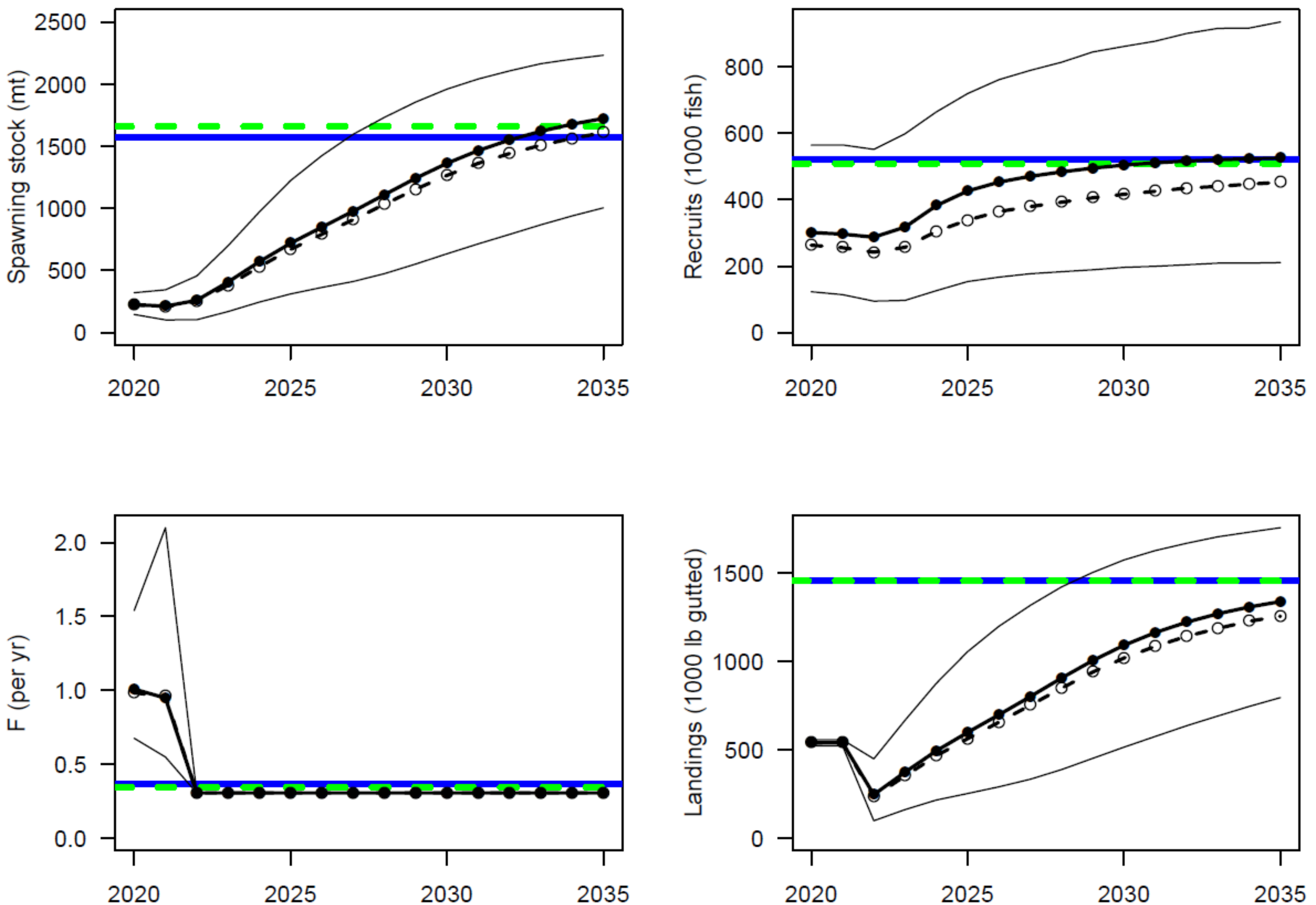


NOAA FIS

Thick blue solid=base run
Thick green dash=ensemble median
Thin solid, closed circles=base (deterministic)
Thin dash, open circles=ensemble median (stochastic)
Thin solid=5th and 95th percentiles (stochastic)

Scenario 3

$T_{max} = T_{min} \times 2$



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Scenario 1

$T_{max} = T_{min}$ plus one generation time

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 gut)	L.med (1000 lb gut)	D.base (1000)	D.med (1000)	D.base (1000 lb gut)	D.med (1000 lb gut)	pr.recover
2020	301	262	1.01	0.98	225	223	49	49	539	539	25	22	104	92	0
2021	296	257	0.95	0.96	212	208	56	55	539	539	24	23	104	97	0
2022	287	241	0.32	0.32	259	248	26	25	260	248	8	8	37	33	0
2023	317	255	0.32	0.32	402	376	37	35	391	369	9	8	39	35	0
2024	381	303	0.32	0.32	559	519	45	43	513	483	11	9	45	39	0.005
2025	424	340	0.32	0.32	700	651	52	49	617	581	12	10	51	44	0.025
2026	450	361	0.32	0.32	822	766	60	56	716	672	13	11	56	48	0.065
2027	467	375	0.32	0.32	940	874	68	63	818	766	14	12	60	51	0.114
2028	480	388	0.32	0.32	1066	990	75	70	923	864	14	12	62	53	0.165
2029	491	399	0.32	0.32	1189	1104	82	76	1021	954	15	12	64	55	0.216
2030	501	413	0.32	0.32	1301	1208	87	81	1106	1032	15	13	65	56	0.261
2031	508	422	0.32	0.32	1395	1293	92	85	1176	1096	15	13	66	58	0.304
2032	513	431	0.32	0.32	1473	1367	95	89	1233	1151	15	13	67	59	0.345
2033	517	436	0.32	0.32	1537	1428	98	91	1279	1196	15	14	68	60	0.378
2034	520	443	0.32	0.32	1589	1478	100	94	1317	1233	16	14	68	61	0.411
2035	522	446	0.32	0.32	1631	1521	102	95	1346	1263	16	14	69	62	0.438
2036	524	451	0.32	0.32	1664	1556	103	97	1370	1289	16	14	69	62	0.46
2037	525	456	0.32	0.32	1691	1586	104	98	1388	1311	16	14	69	63	0.481
2038	526	457	0.32	0.32	1711	1610	105	99	1402	1327	16	14	69	63	0.497

R = age-1 recruits (1000 fish)
F = fishing mortality rate (per yr)
S = spawning stock (metric tons)
L = landings (1000 fish and in 1000 lb gutted wgt)
D = dead discard (1000 fish, 1000 lb gutted wgt)
pr.recover = proportion stochastic projections with SSB > SSB_{msy}
extension 'b' = deterministic value from base run
extension 'med' = median of stochastic runs

Scenario 2

T_{max} = time to rebuild to SSB_{msy} if fished at 75% of MFMT

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 gut	L.med 1000 lb gut	D.base (1000)	D.med (1000)	D.base 1000 lb gut	D.med 1000 lb gut)	pr.recover
2020	301	264	1.01	0.98	225	223	49	49	539	539	25	22	104	92	0
2021	296	254	0.95	0.96	212	208	56	55	539	539	24	23	104	97	0
2022	287	240	0.27	0.26	261	251	23	20	222	200	7	6	31	27	0
2023	318	258	0.27	0.26	415	392	32	29	341	308	8	6	33	28	0
2024	385	310	0.27	0.26	592	559	40	36	457	416	9	7	38	32	0.004
2025	431	351	0.27	0.26	756	719	47	43	560	513	10	9	44	37	0.024
2026	458	376	0.27	0.26	902	864	54	49	659	604	11	9	48	41	0.063
2027	476	391	0.27	0.26	1046	1002	62	56	761	701	12	10	51	43	0.126
2028	490	408	0.27	0.26	1197	1146	69	63	866	799	12	10	54	45	0.197
2029	501	421	0.27	0.26	1349	1286	76	70	965	893	13	11	55	47	0.276
2030	510	433	0.27	0.26	1488	1413	81	75	1053	977	13	11	56	48	0.359
2031	517	444	0.27	0.26	1608	1523	86	79	1127	1047	13	11	57	49	0.444
2032	523	452	0.27	0.26	1708	1618	89	82	1188	1105	13	11	58	50	0.52

R = age-1 recruits (1000 fish)
F = fishing mortality rate (per yr)
S = spawning stock (metric tons)
L = landings (1000 fish and in 1000 lb gutted wgt)
D = dead discard (1000 fish, 1000 lb gutted wgt)
pr.recover = proportion stochastic projections with SSB > SSB_{msy}
extension 'b' = deterministic value from base run
extension 'med' = median of stochastic runs

Scenario 3

$T_{max} = T_{min} \times 2$

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 gut	L.med 1000 lb gut	D.base (1000)	D.med (1000)	D.base 1000 lb gut	D.med 1000 lb gut)	pr.recover
2020	301	263	1.01	0.98	225	223	49	49	539	539	25	22	104	92	0
2021	296	255	0.95	0.96	212	208	56	55	539	539	24	23	104	97	0
2022	287	242	0.31	0.31	260	249	25	24	247	235	8	7	35	31	0
2023	318	257	0.31	0.31	407	380	35	33	374	352	9	7	37	33	0.001
2024	382	305	0.31	0.31	570	530	43	41	494	466	10	9	43	37	0.007
2025	426	339	0.31	0.31	719	669	50	48	598	563	11	10	49	42	0.028
2026	453	364	0.31	0.31	849	791	58	54	698	656	12	11	54	46	0.075
2027	470	379	0.31	0.31	976	908	66	61	800	751	13	11	57	49	0.129
2028	484	392	0.31	0.31	1109	1032	73	68	905	848	14	12	59	51	0.191
2029	495	406	0.31	0.31	1242	1154	80	74	1004	939	14	12	61	52	0.246
2030	504	416	0.31	0.31	1362	1265	85	79	1090	1018	14	12	62	54	0.3
2031	511	425	0.31	0.31	1465	1362	90	84	1162	1084	14	12	63	55	0.349
2032	516	435	0.31	0.31	1550	1441	93	87	1220	1141	15	13	64	57	0.392
2033	520	440	0.31	0.31	1620	1508	96	90	1268	1185	15	13	65	58	0.43
2034	523	447	0.31	0.31	1677	1563	98	92	1306	1225	15	13	65	58	0.466
2035	525	452	0.31	0.31	1723	1609	100	94	1337	1254	15	13	66	59	0.499

R = age-1 recruits (1000 fish)
F = fishing mortality rate (per yr)
S = spawning stock (metric tons)
L = landings (1000 fish and in 1000 lb gutted wgt)
D = dead discard (1000 fish, 1000 lb gutted wgt)
pr.recover = proportion stochastic projections with SSB > SSB_{msy}
extension 'b' = deterministic value from base run
extension 'med' = median of stochastic runs

The End