NOAA FISHERIES

Northeast Fisheries Science Center

2023 Atlantic mackerel management track assessment

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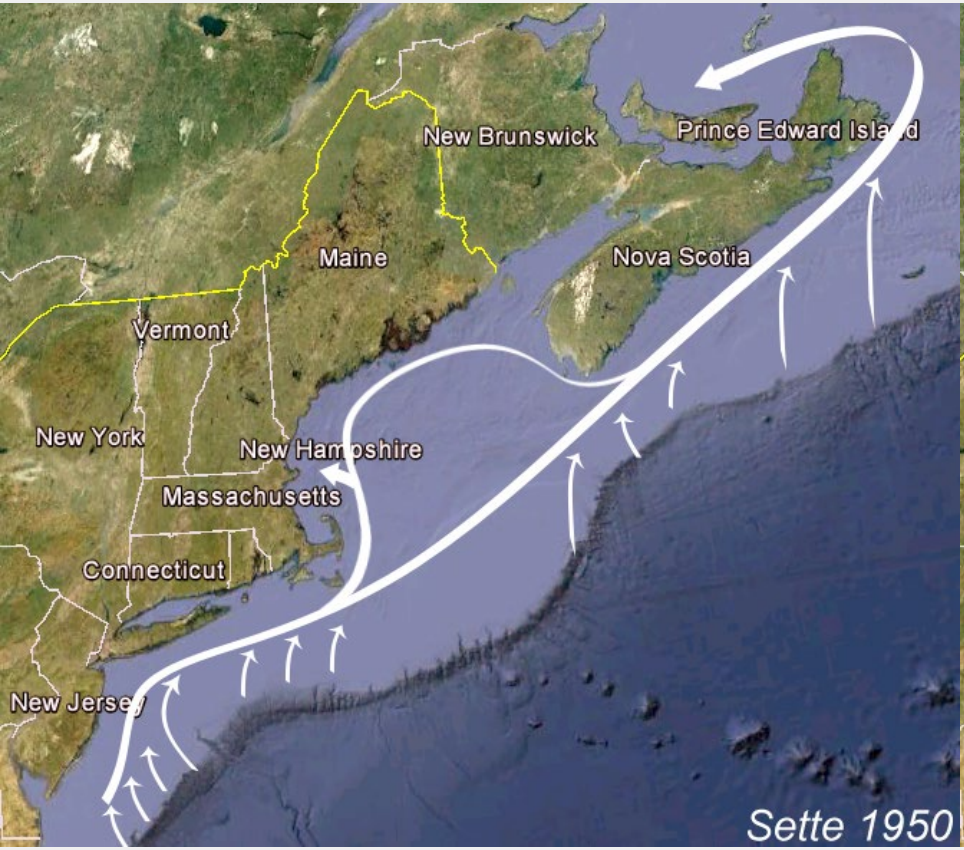
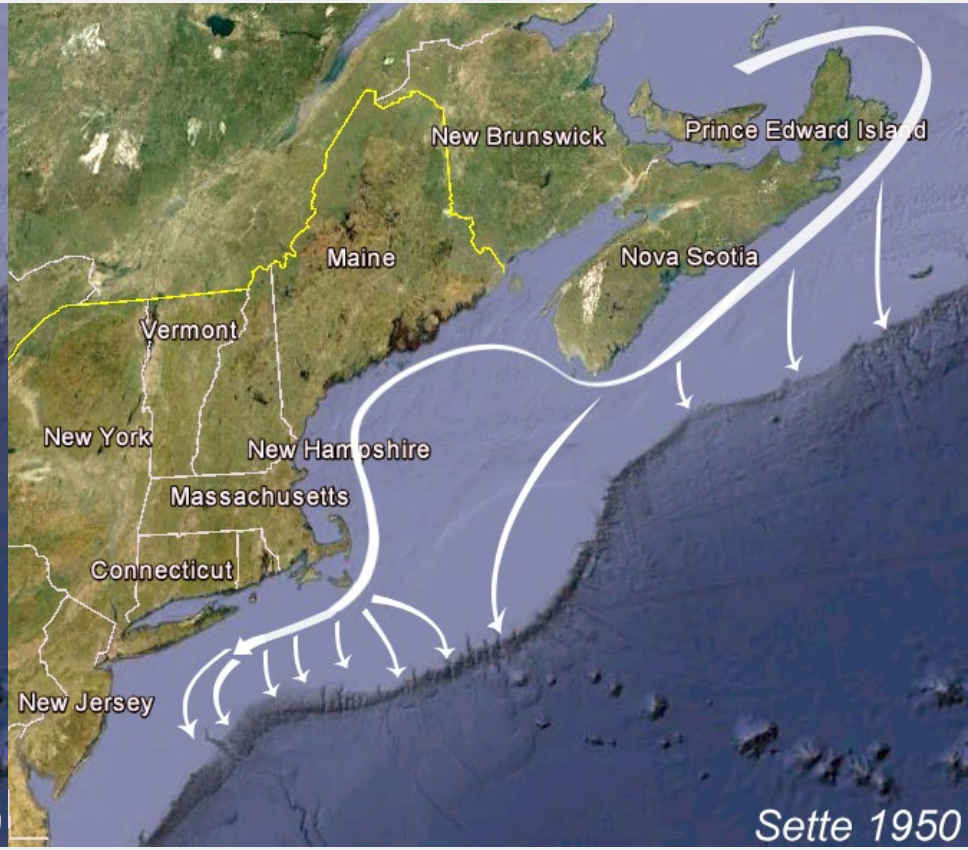
NEFSC, Stock assessment lead
Sept 2023

NW Atlantic mackerel seasonal migration patterns
(Sette 1950)

Spring Migration



Fall Migration



Background

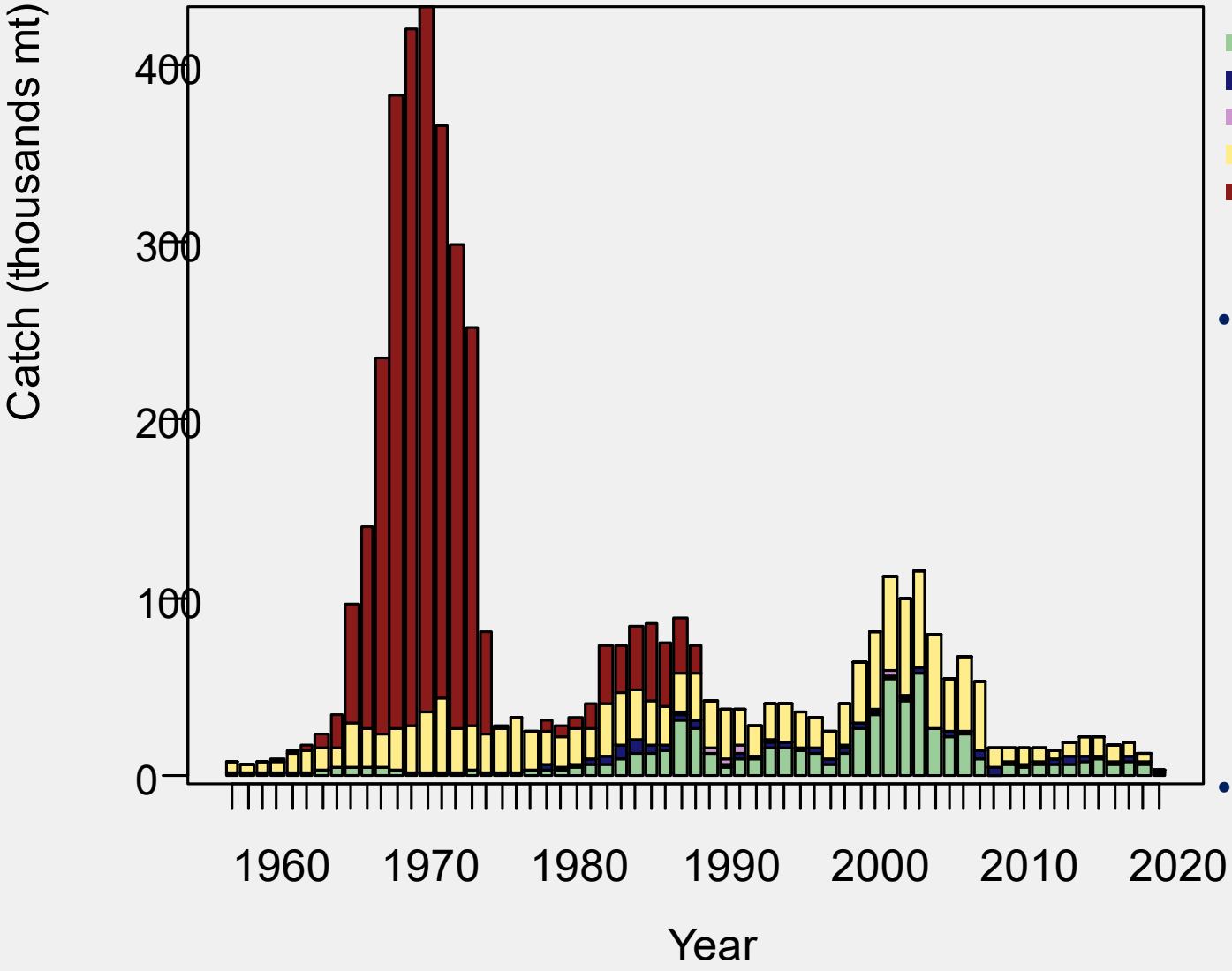
- Last assessed and reviewed in July 2021 (2019 terminal year)
- Primary assessment model = ASAP
  - Ages 1-10^{+}; Constant M = 0.2
  - One fishing fleet, time-invariant flat-topped selectivity (age 6^{+} = 1)
  - Three fishery-independent surveys
    - Range-wide SSB index from egg surveys
    - Spring bottom trawl survey (ages 3^{+}, dome-shaped selectivity)
      - Albatross years (1974-2008)
      - Bigelow years (2009^{+})
  - Long-term projections based on empirical CDF derived using recruitment estimates from 1975 onward
  - BRPs: F40% as Fmsy proxy (0.22)
- Resulting stock status: overfished (24% of SSB msy proxy) with overfishing occurring (208% of Fmsy proxy)
  - Frebuild = 0.12 (F to rebuild stock by 2032, assuming two-stanza recruitment)

Term of Reference 1:

Estimate catch from all sources, including landings and discards

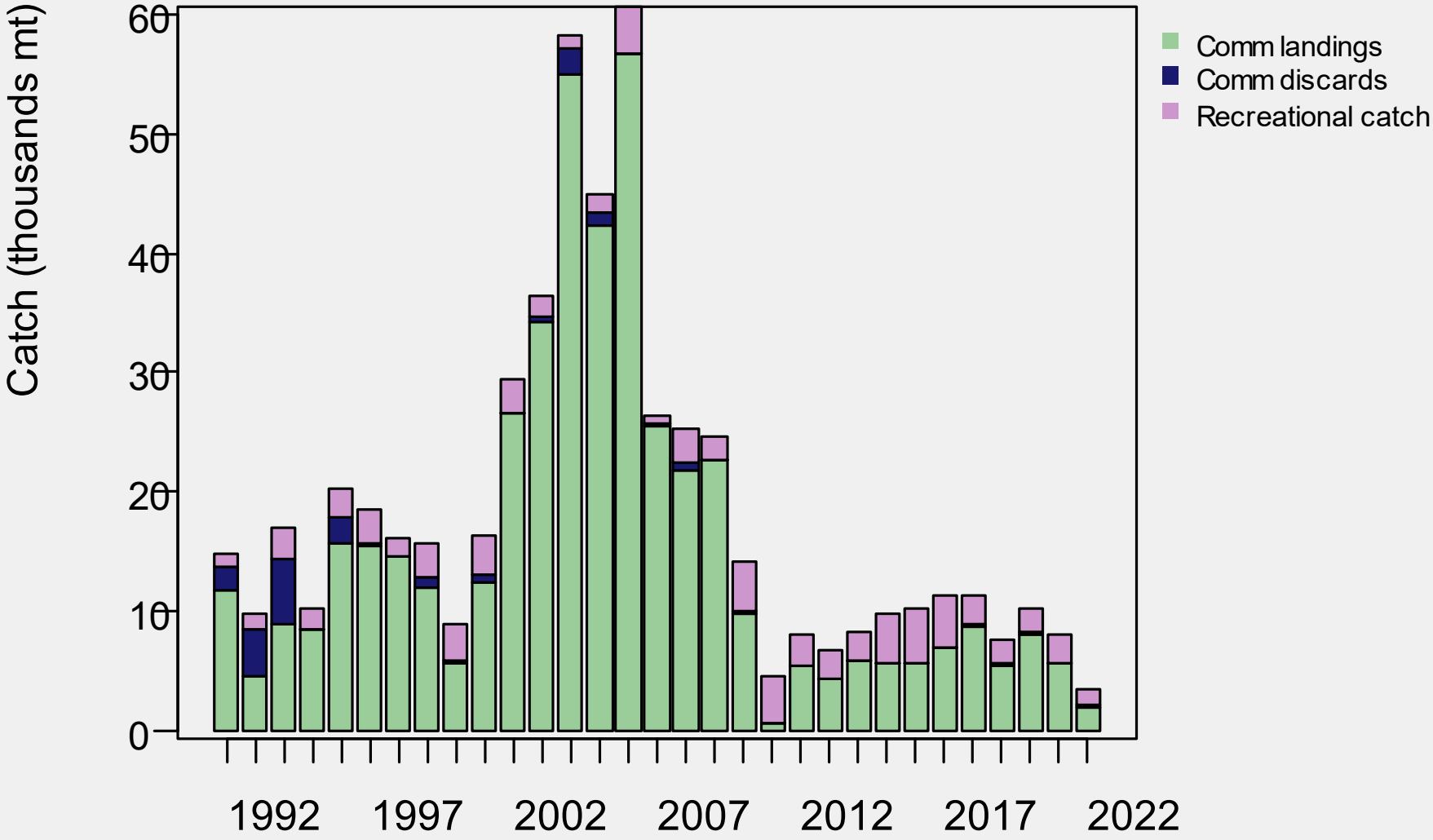
(Canada updated all input data for 2023 assessment)

Total catch (thousands mt)



- Reported Canadian catches represent a subset of total Canadian catch because the bait fishery, recreational fishery and commercial discards are not monitored.
- Canadian directed commercial and bait fisheries closed in 2022

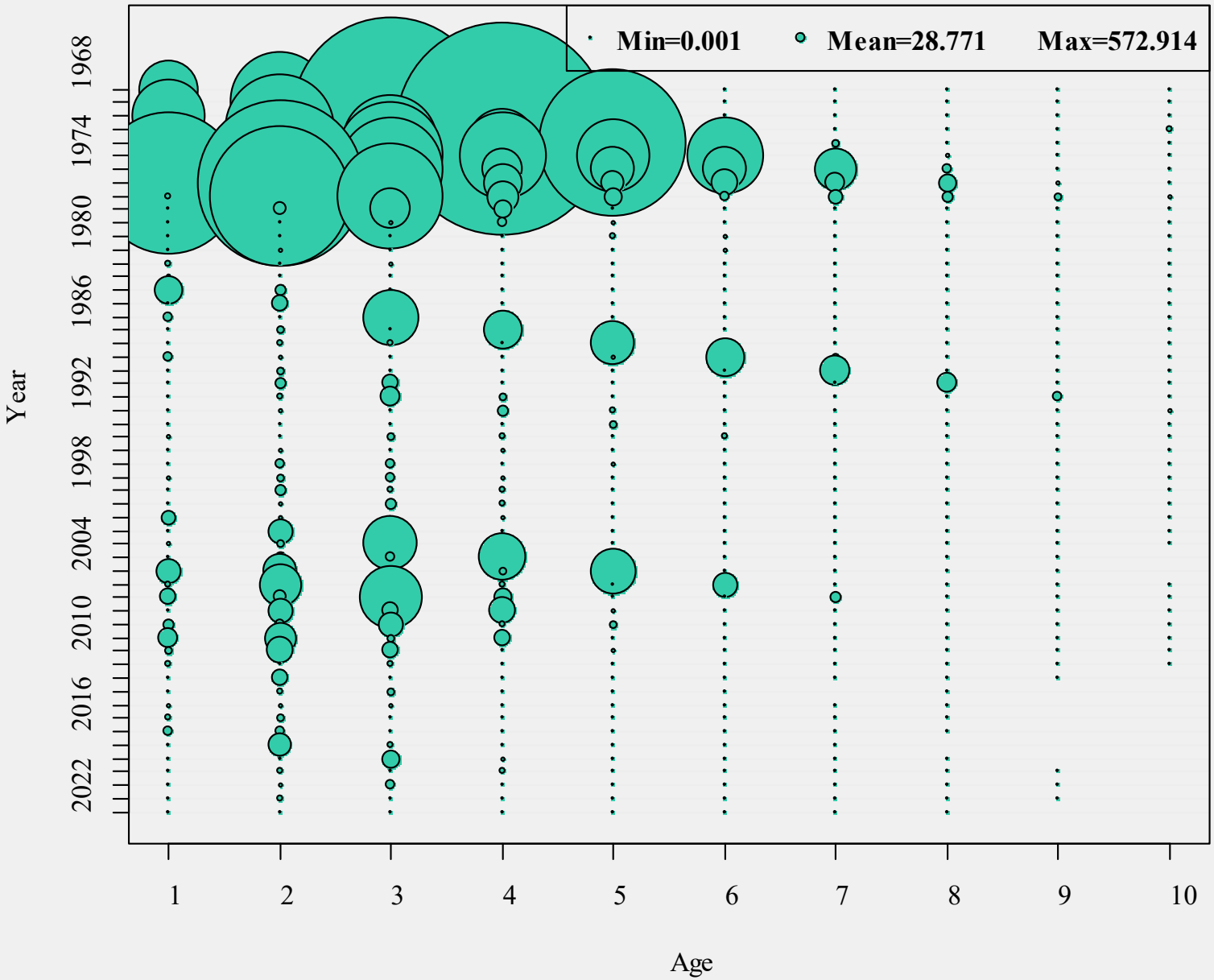
U.S. catch (thousands mt)



Discards estimates comparison

	Combined ratio		CAMS	
	Estimate (mt)	CV	Estimate (mt)	CV
2018	177	0.23	218	0.18
2019	200	0.38	215	0.28

Total catch-at-age (U.S. plus Canada)

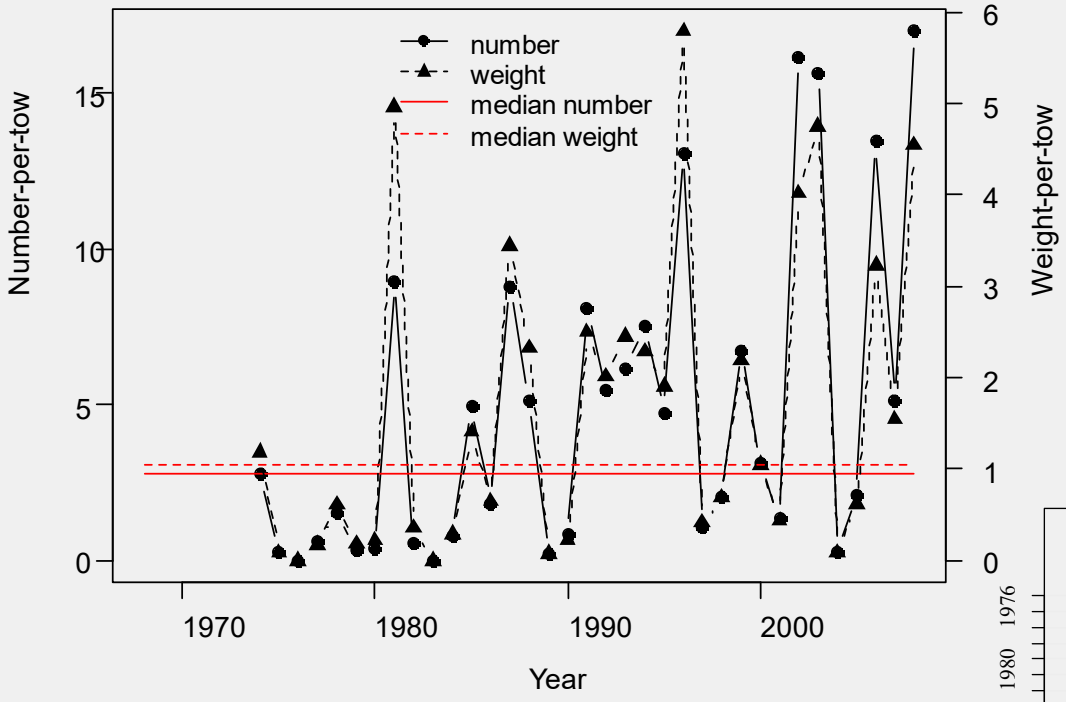


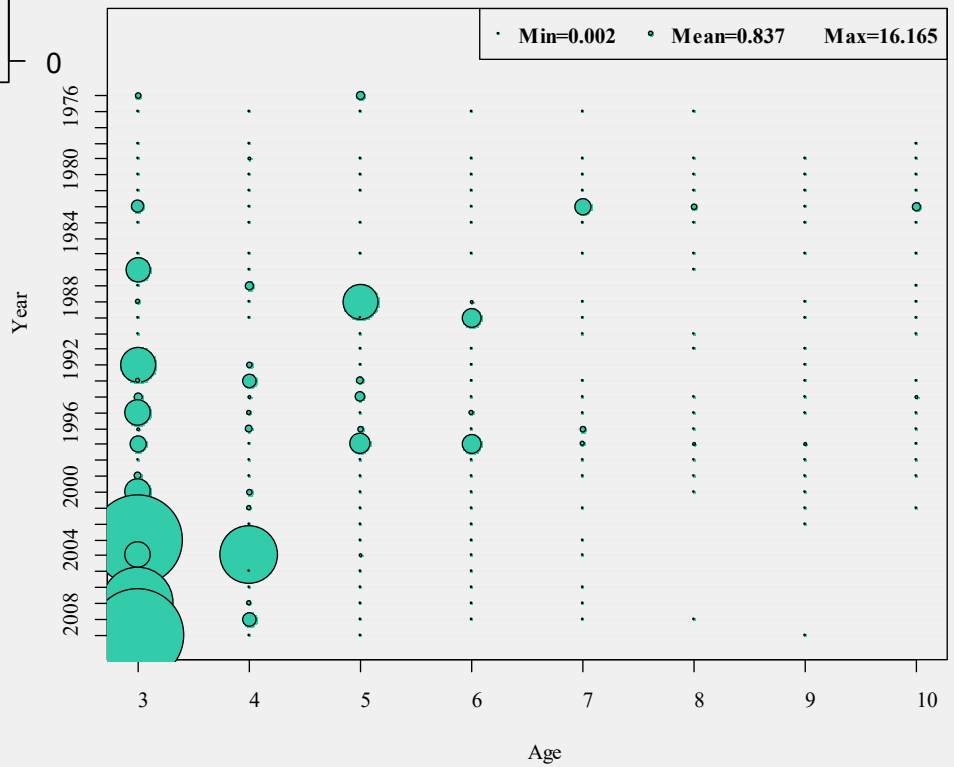
Term of Reference 2:

Evaluate indices used in the assessment

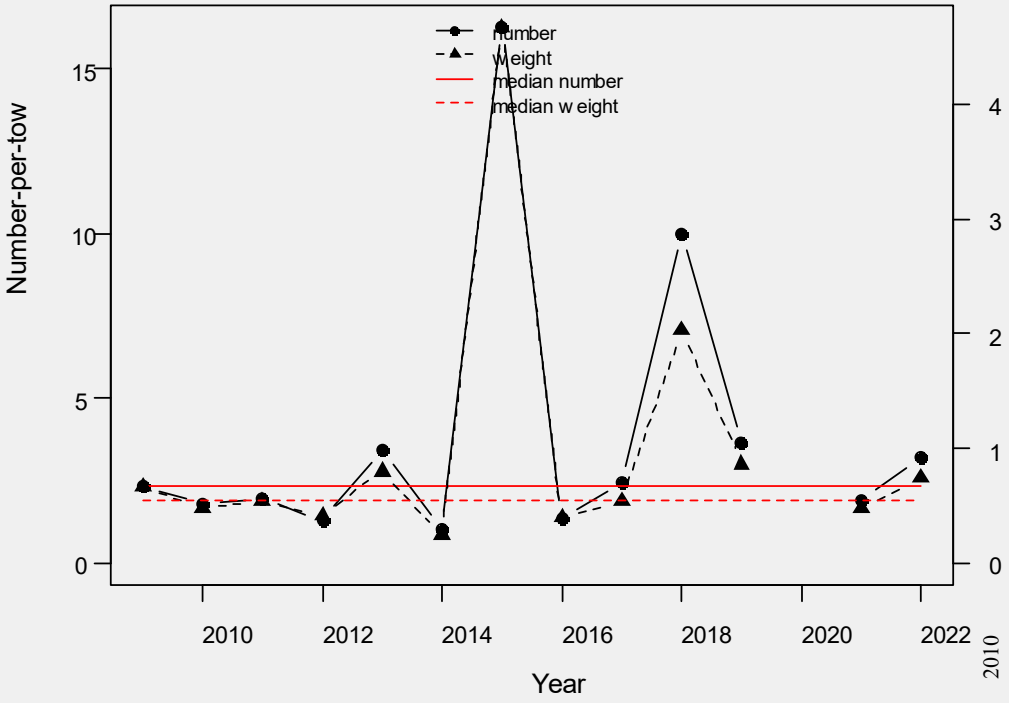
(Canada updated all input data for 2023 assessment)

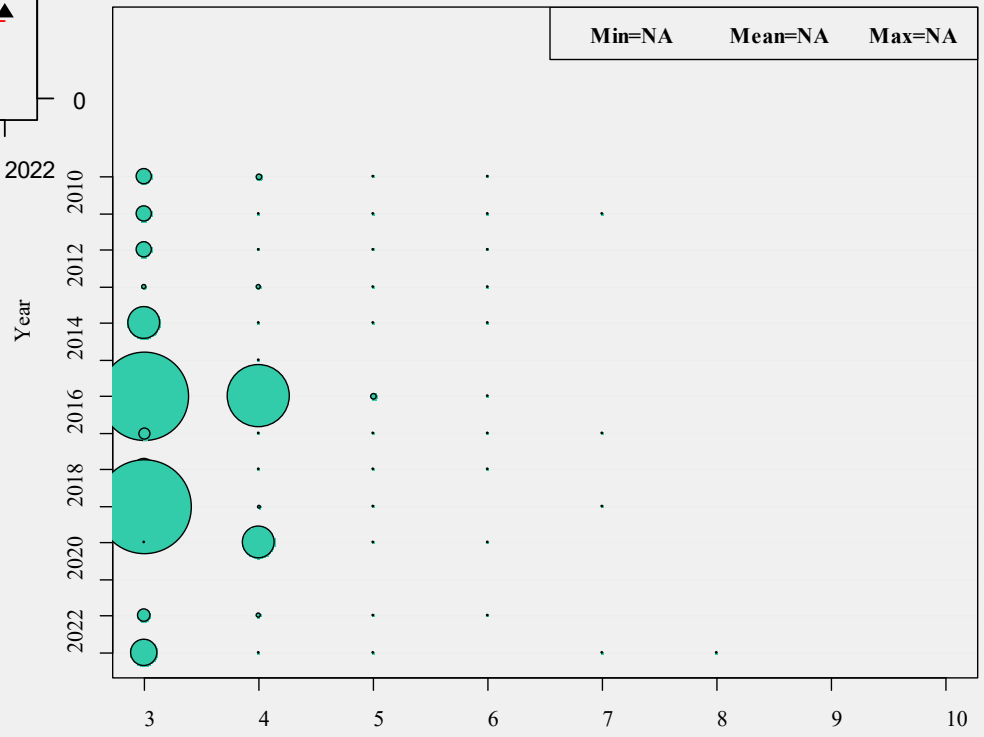
NEFSC spring survey: *Albatross years*



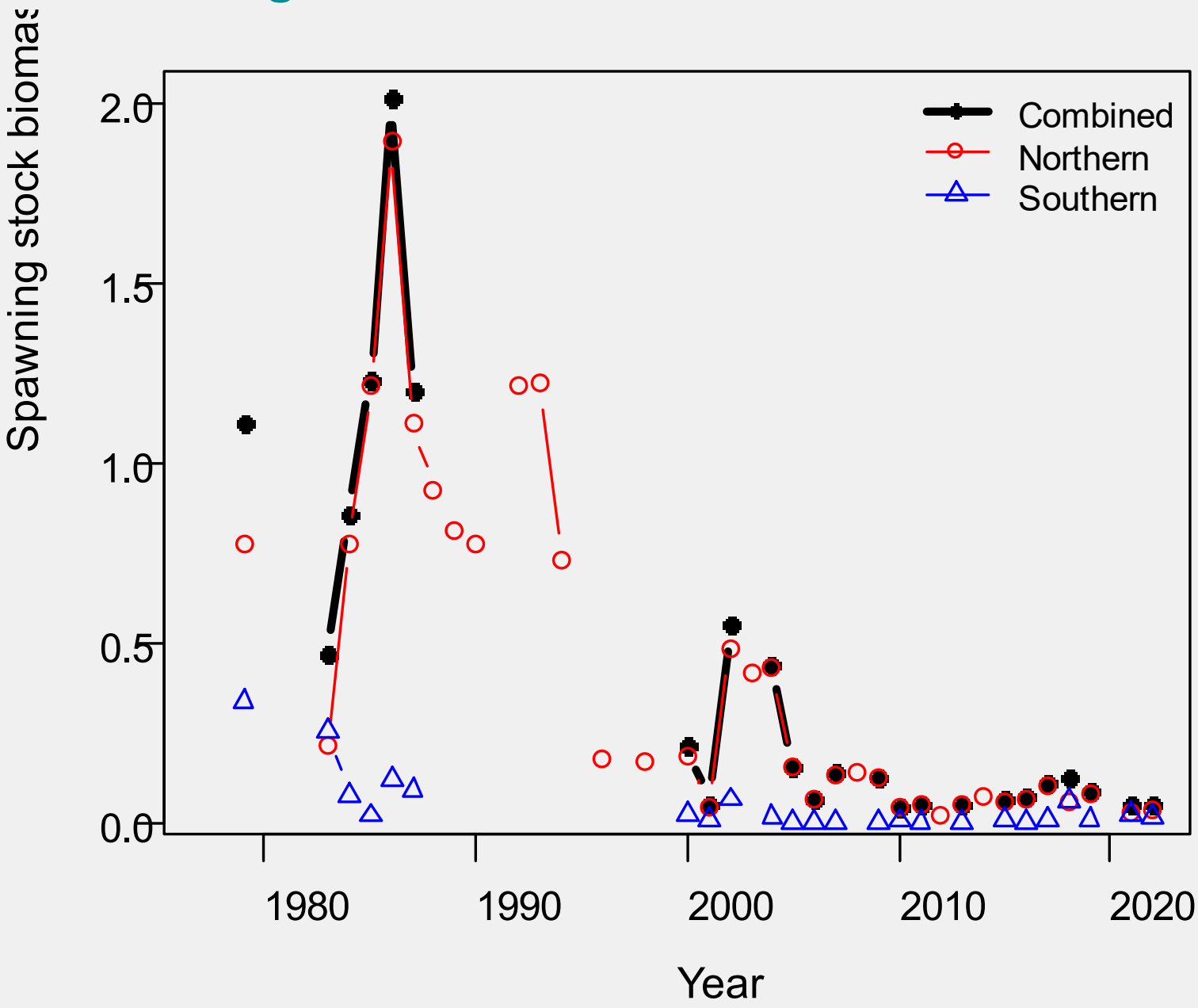


NEFSC spring survey: *Bigelow years*

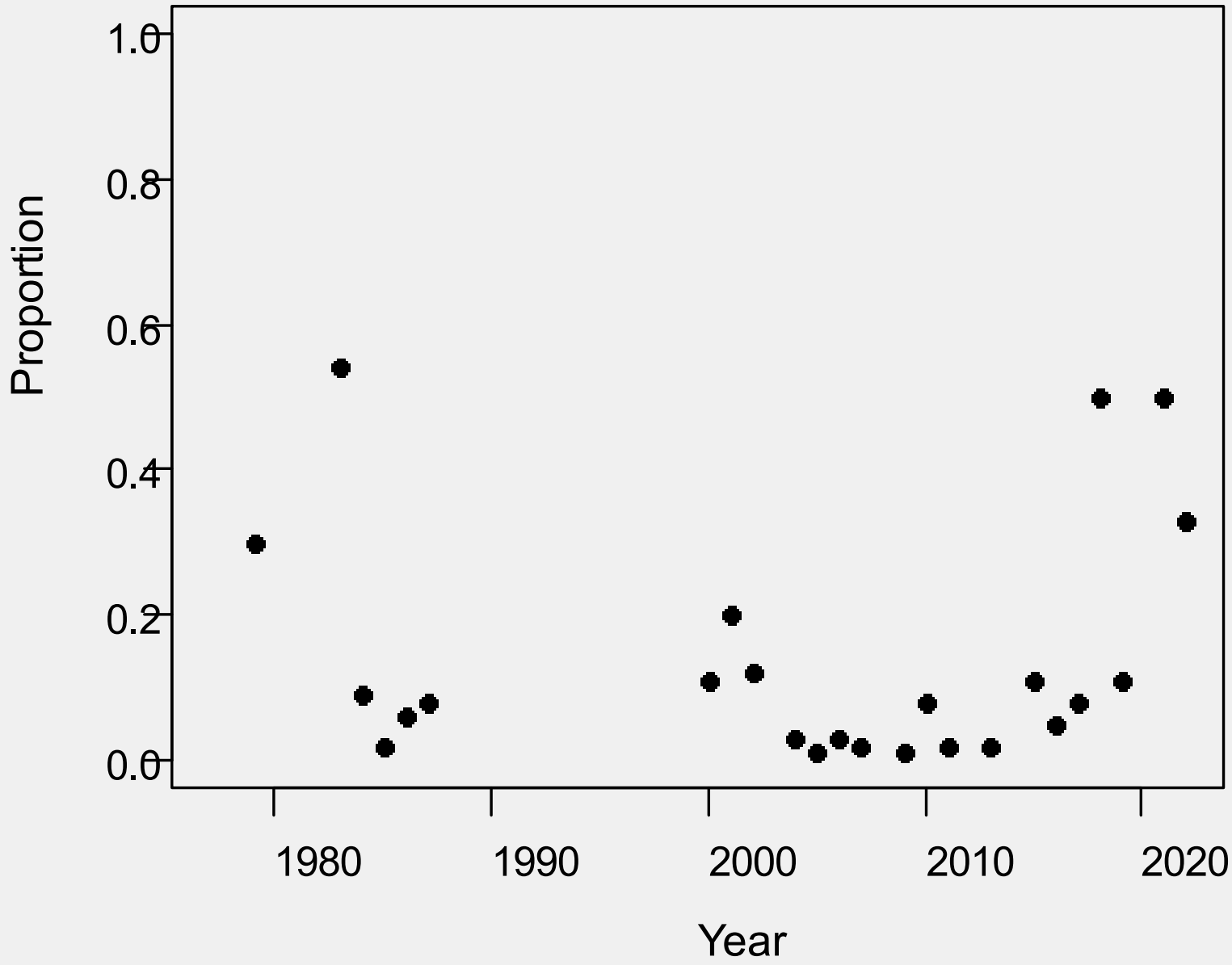




Combined range-wide SSB index (egg and ecosystem surveys)



Contribution of the southern spawning contingent



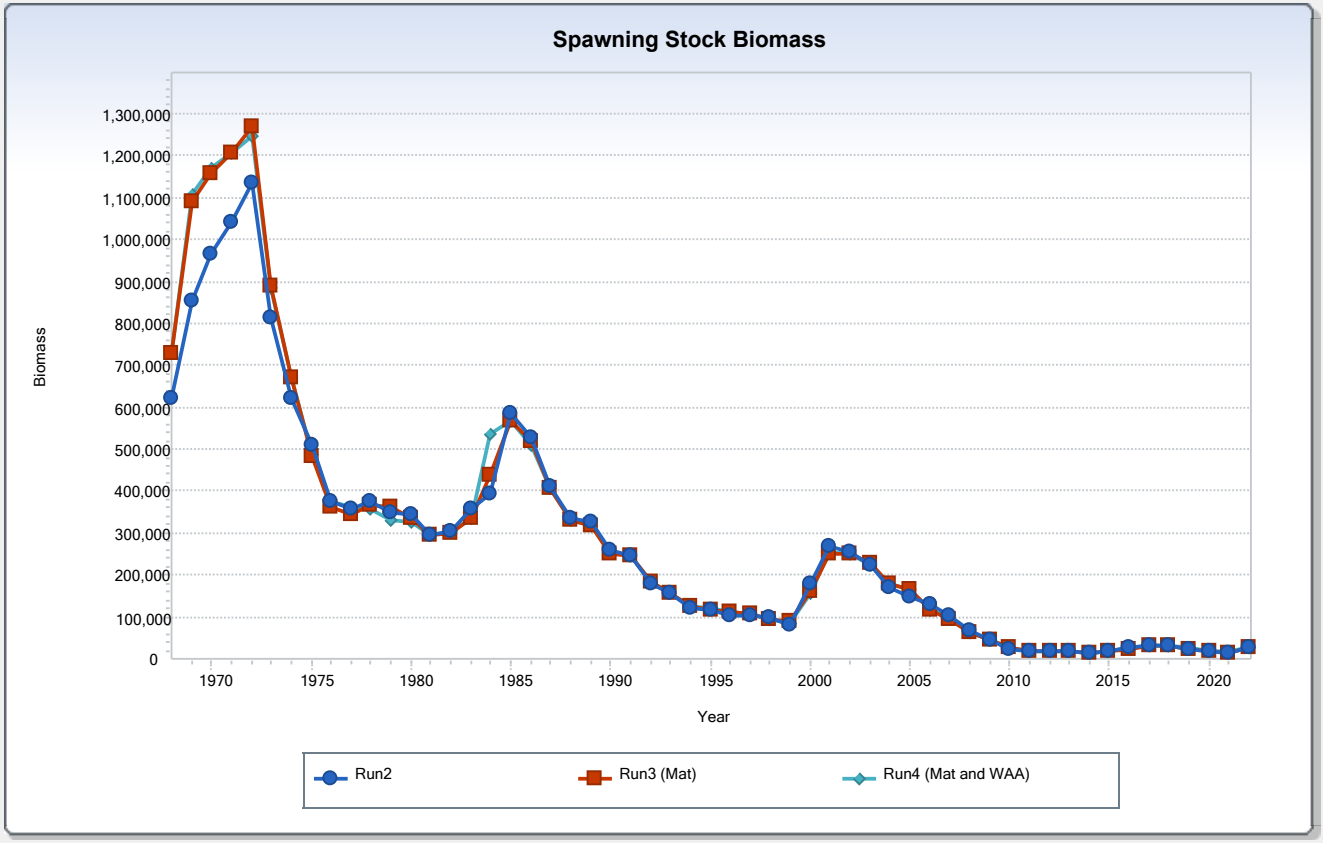
Term of Reference 3:

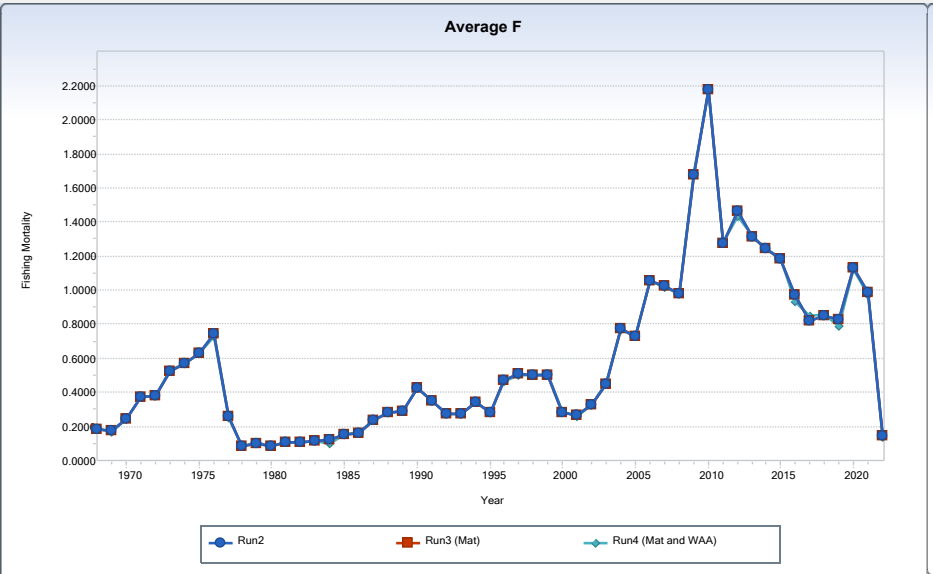
Estimate annual fishing mortality, recruitment and stock biomass for the time series using the approved assessment method and estimate their uncertainty. Include retrospective analyses if possible (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit.

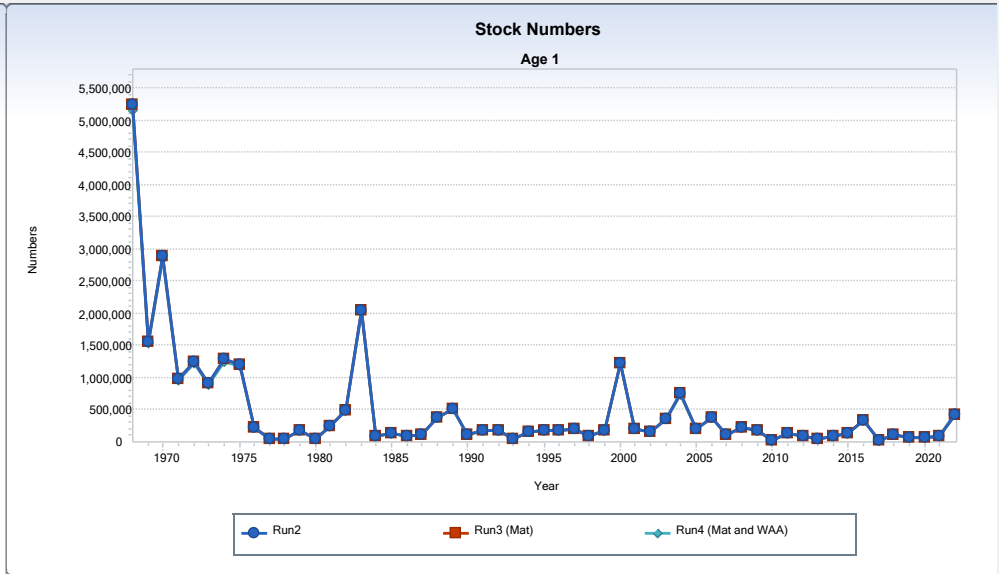
Include bridge runs from the previously accepted model to the updated model proposed for this peer review.

Bridge runs:

2) 2020-2022
3) Maturity
4) WAA

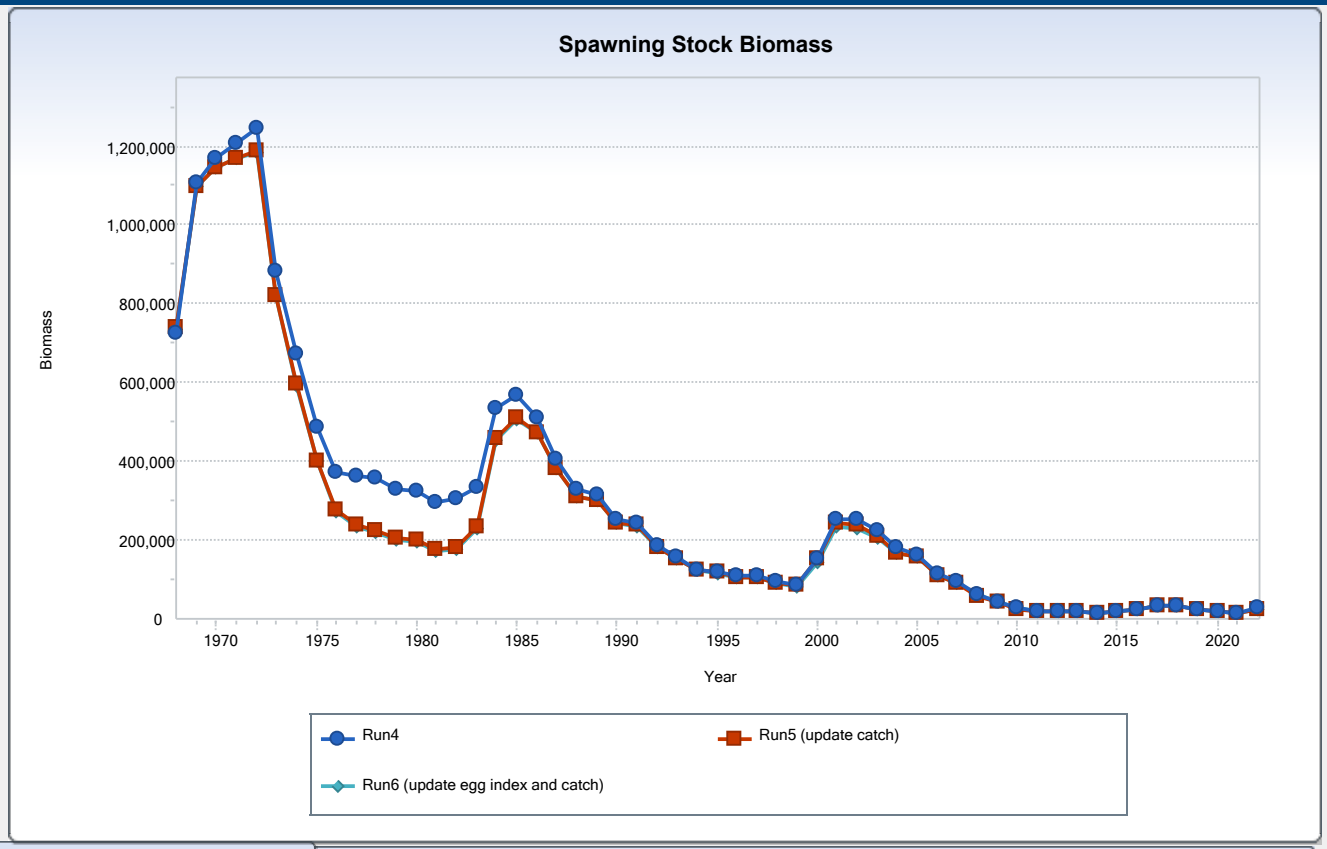


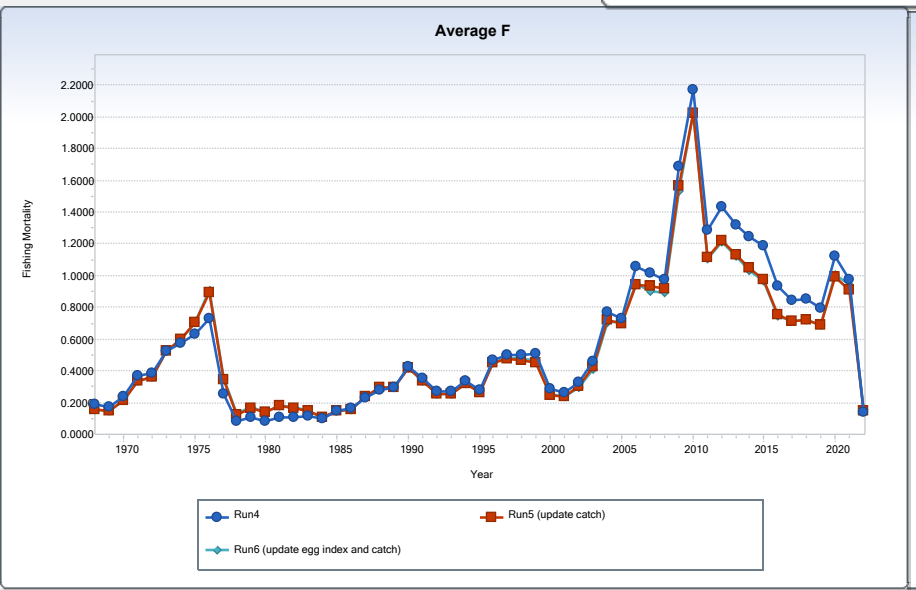


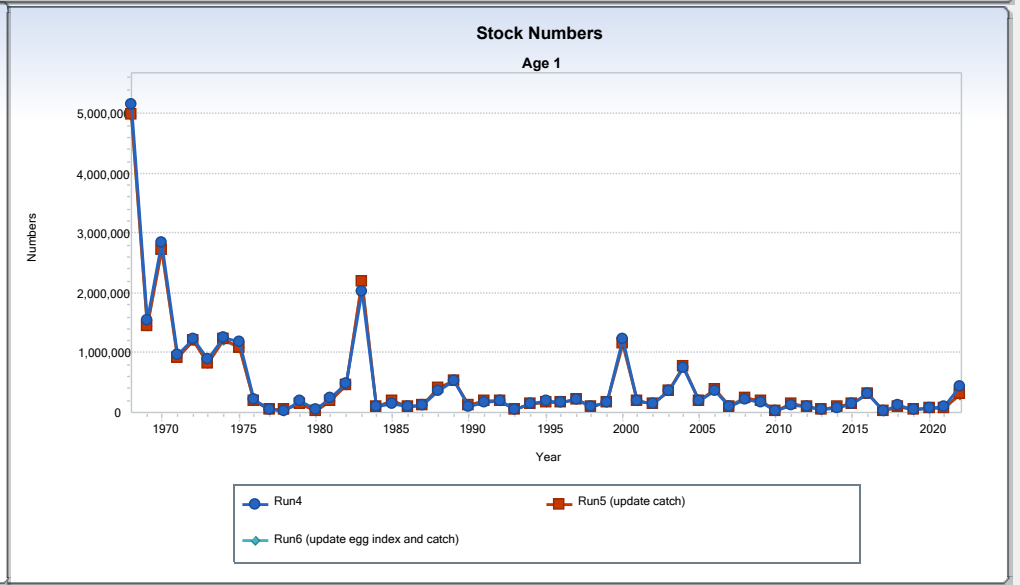


Bridge runs:

5) Fishery catch
6) Egg index

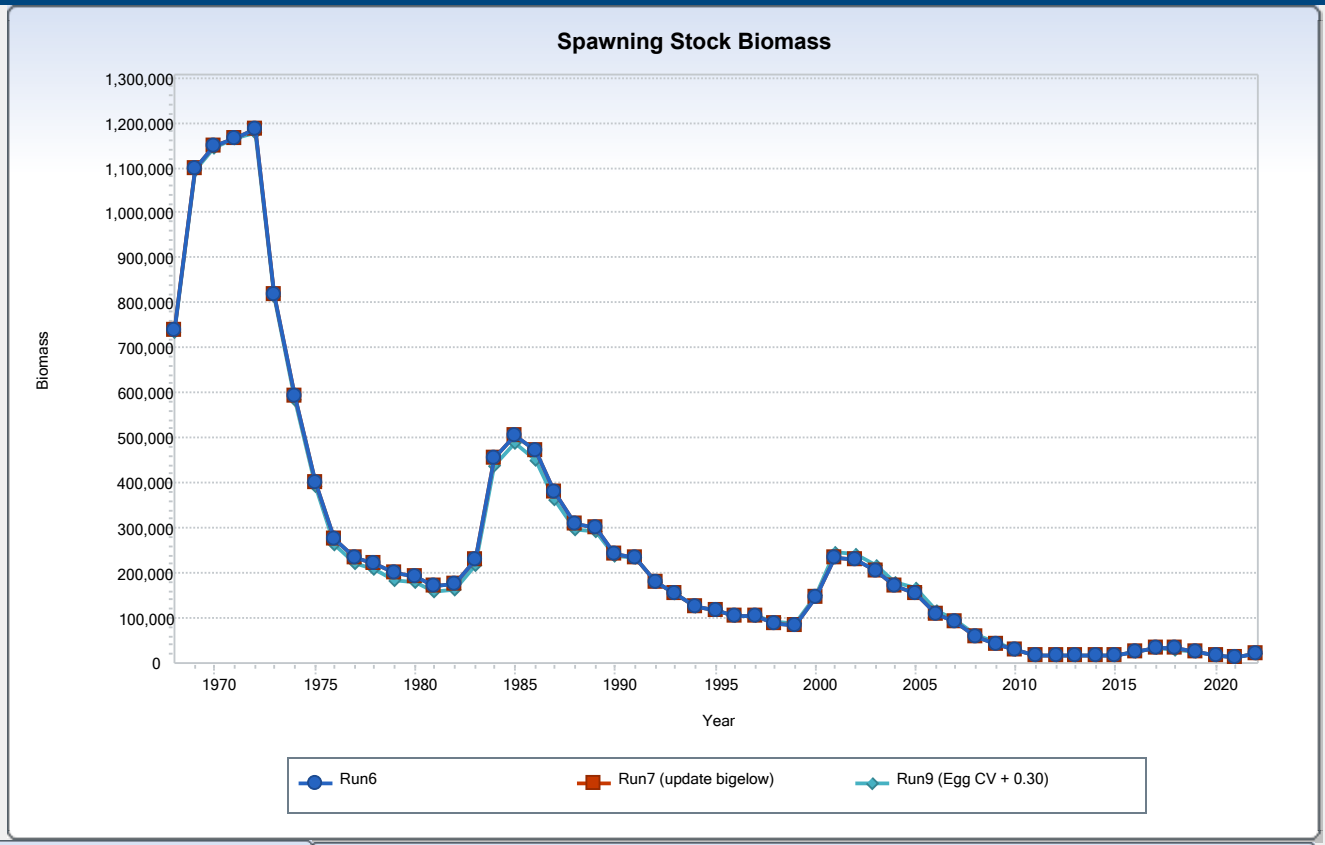


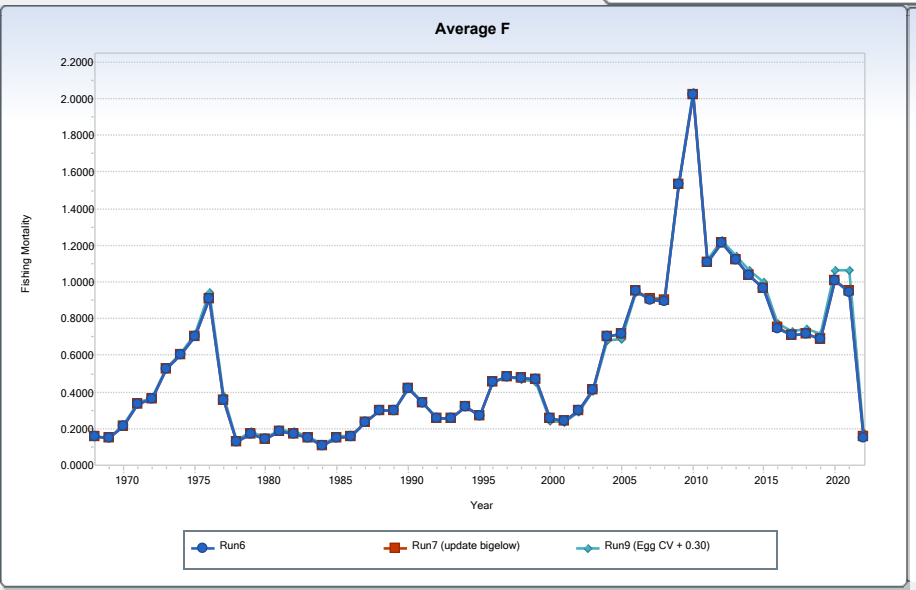


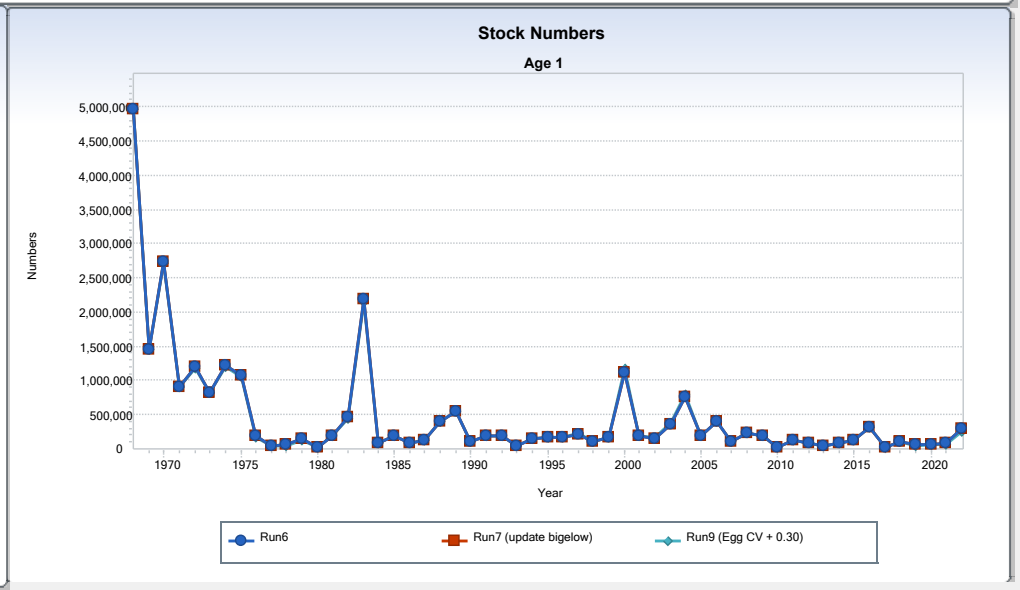


Bridge runs:

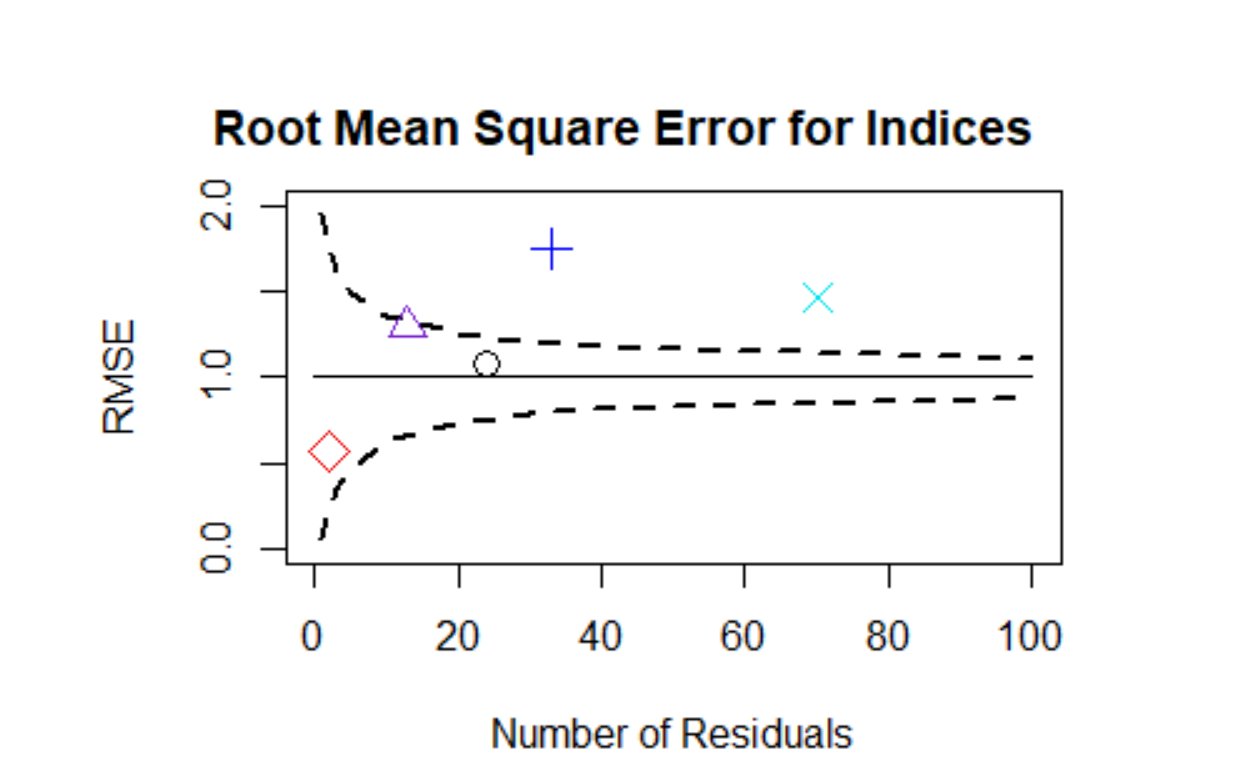
7) Trawl survey
9) Increase egg index CV



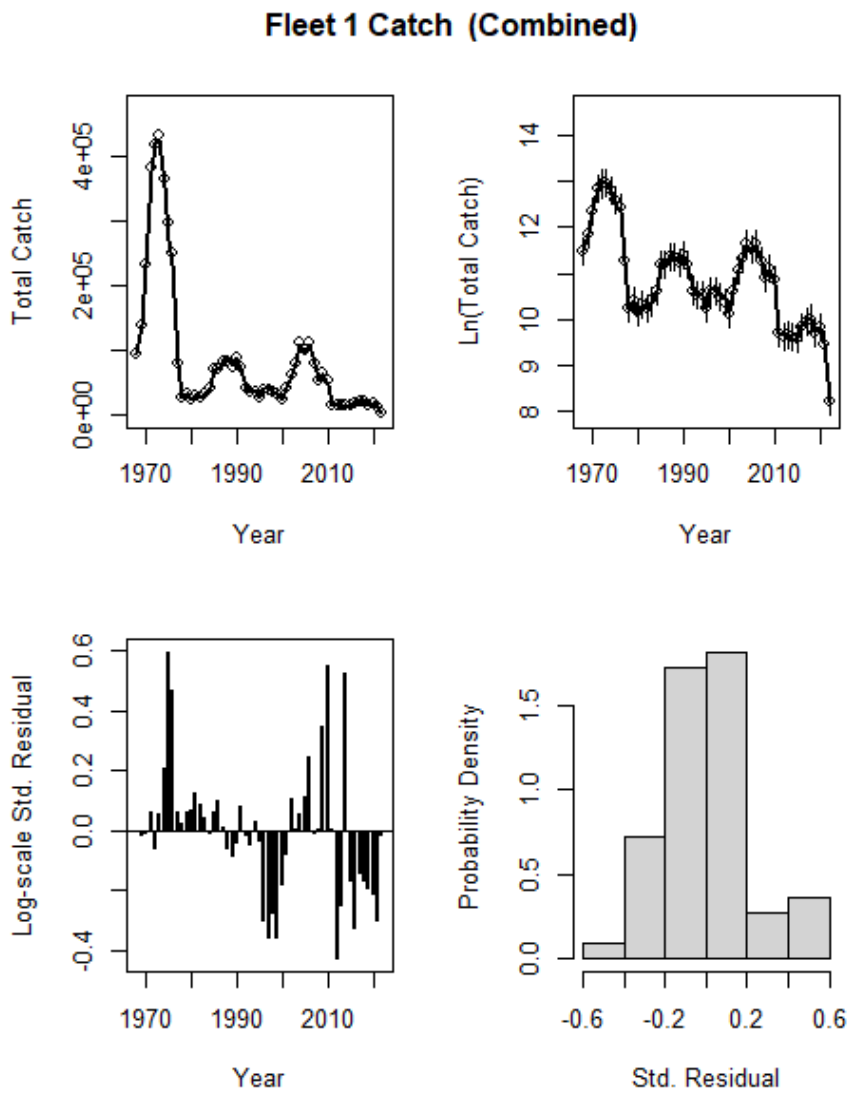


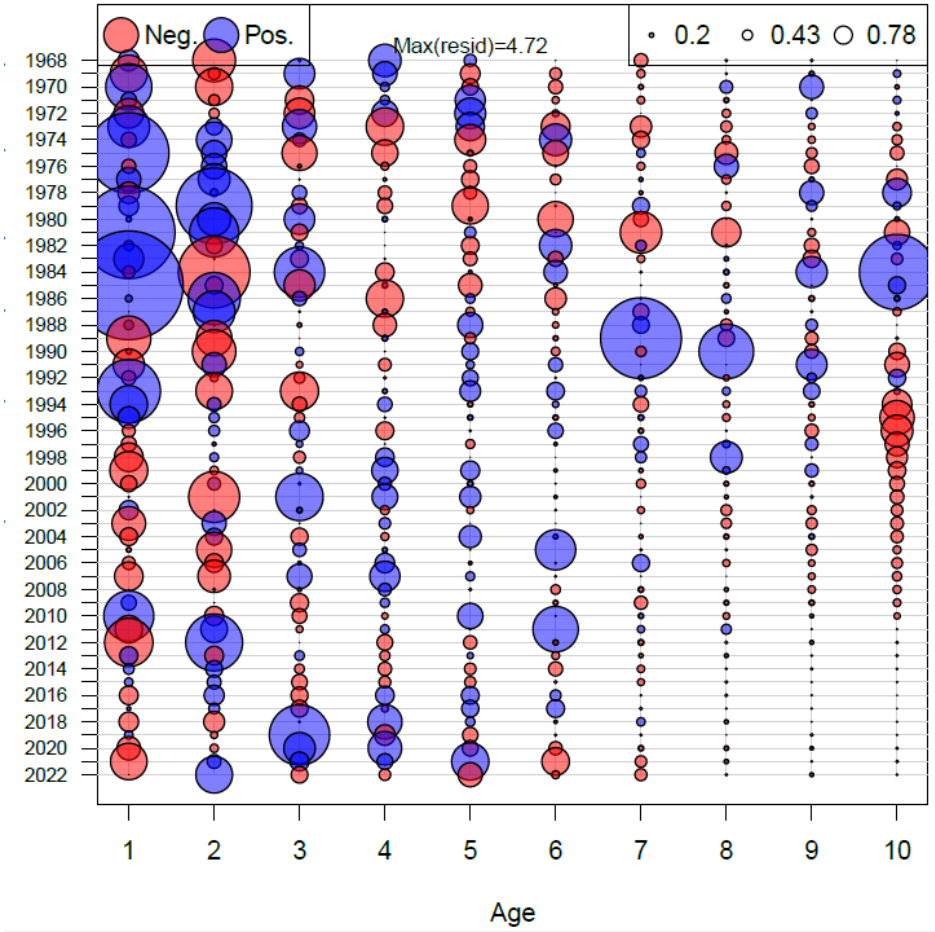


ASAP diagnostics: Index RMSEs

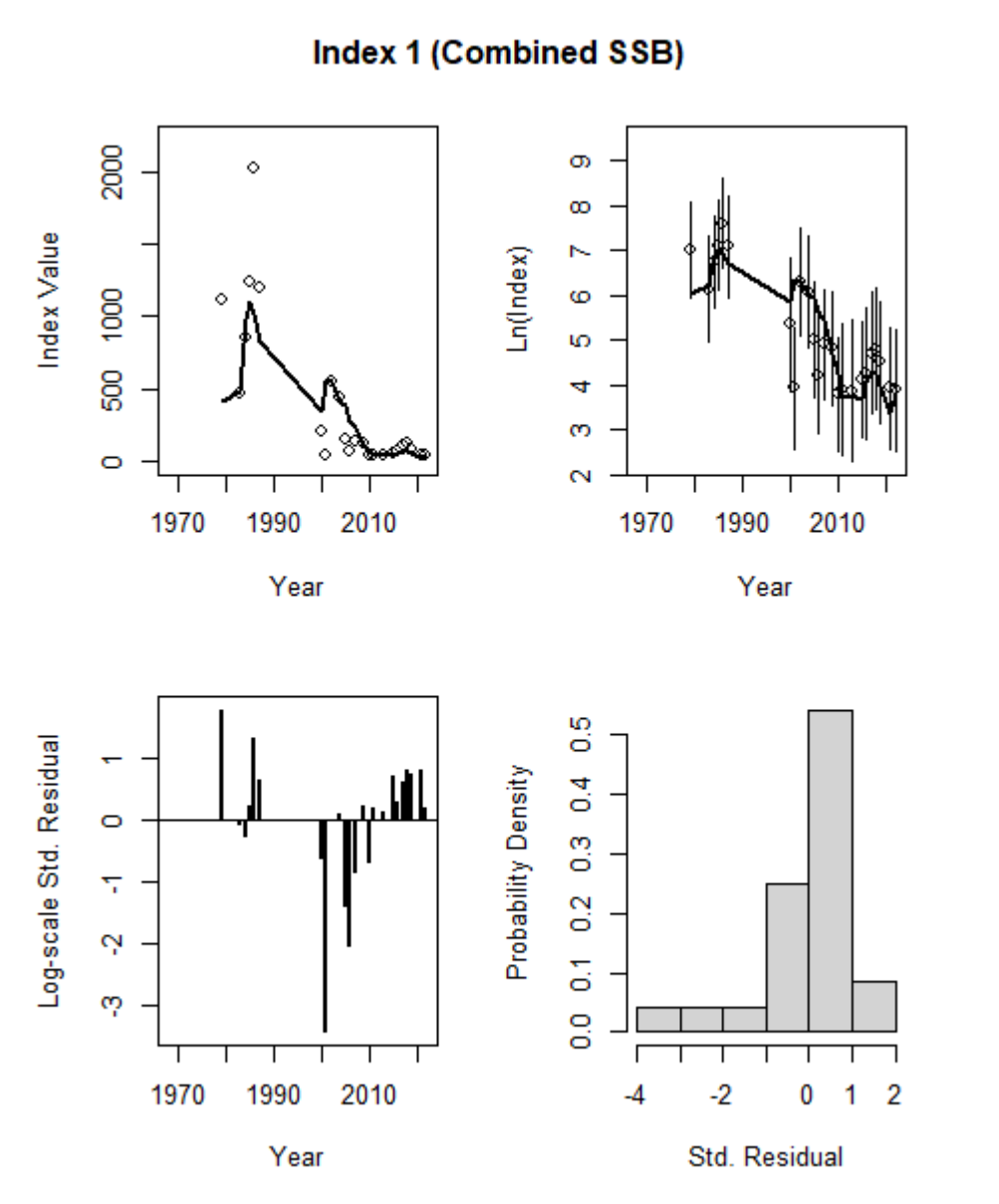


ASAP diagnostics: Fit to fishery catch

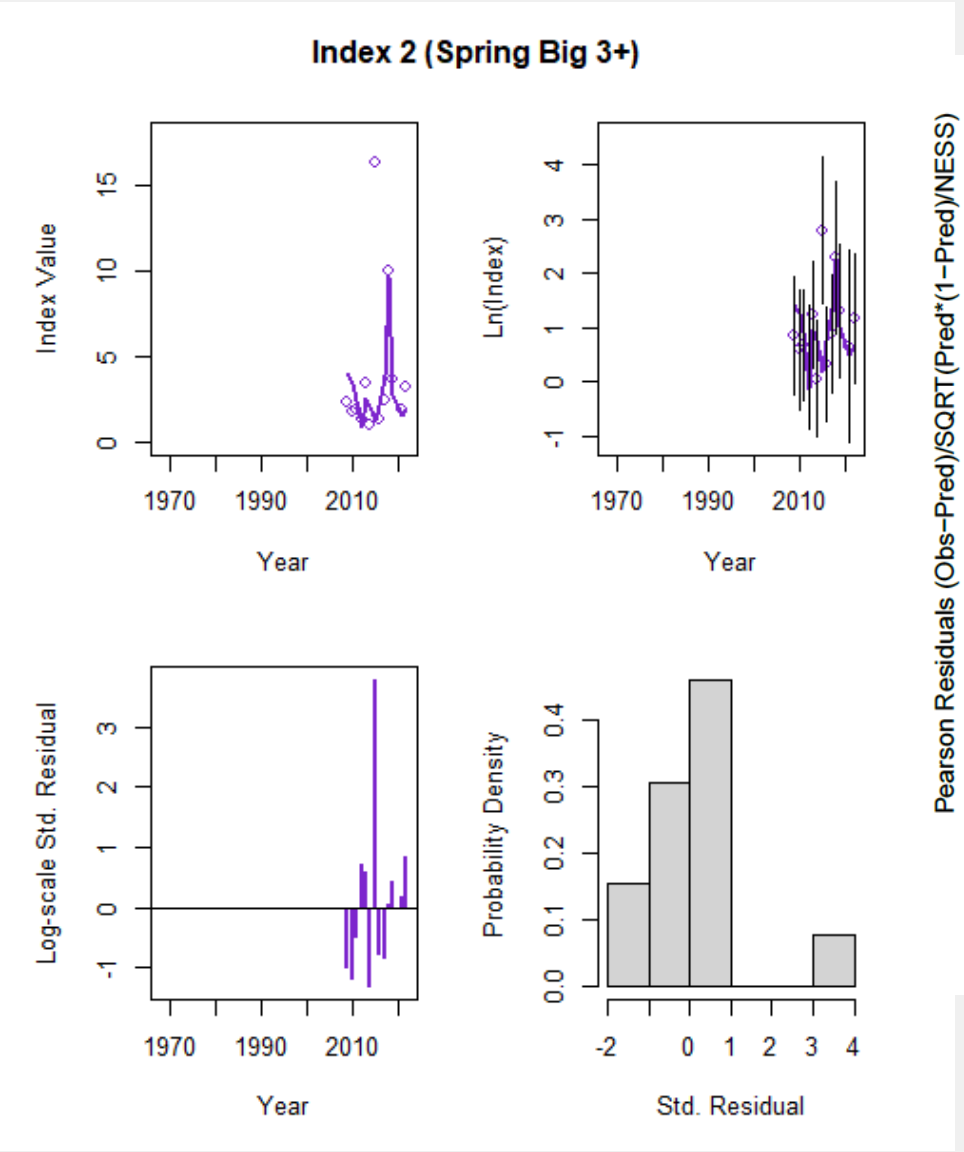


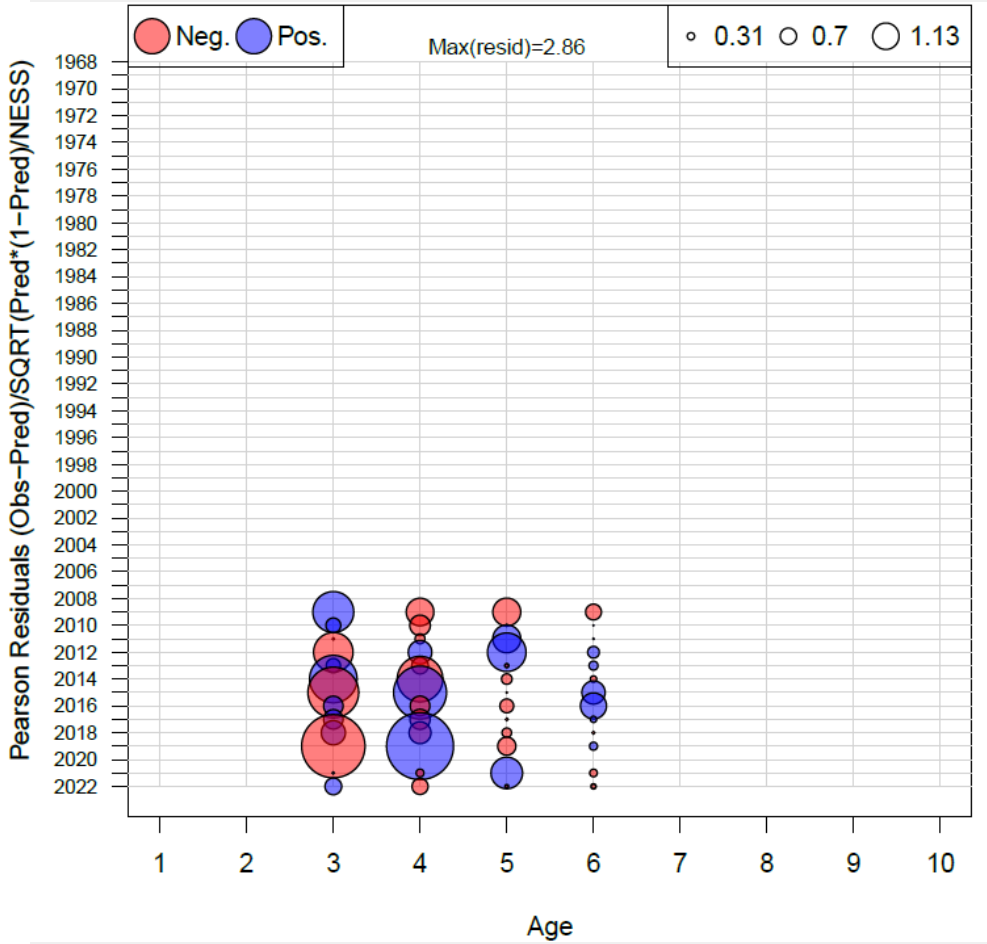


ASAP diagnostics: Fit to range-wide SSB index

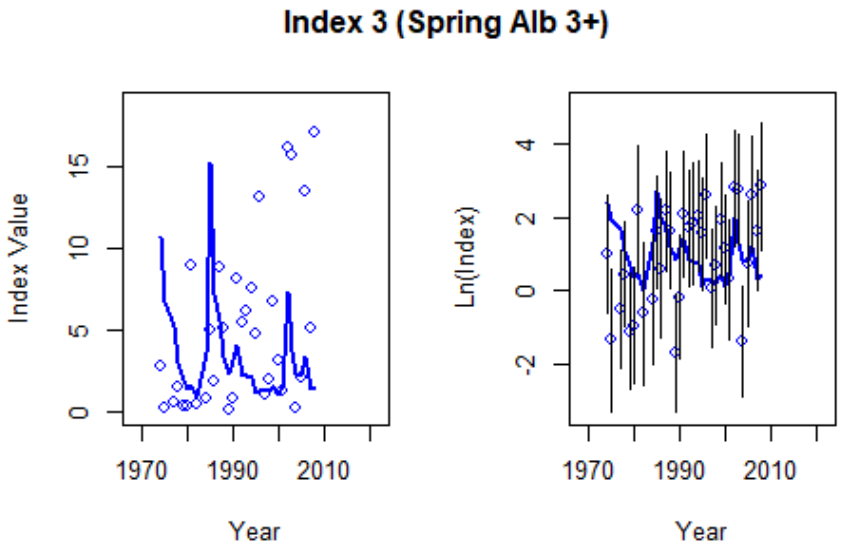


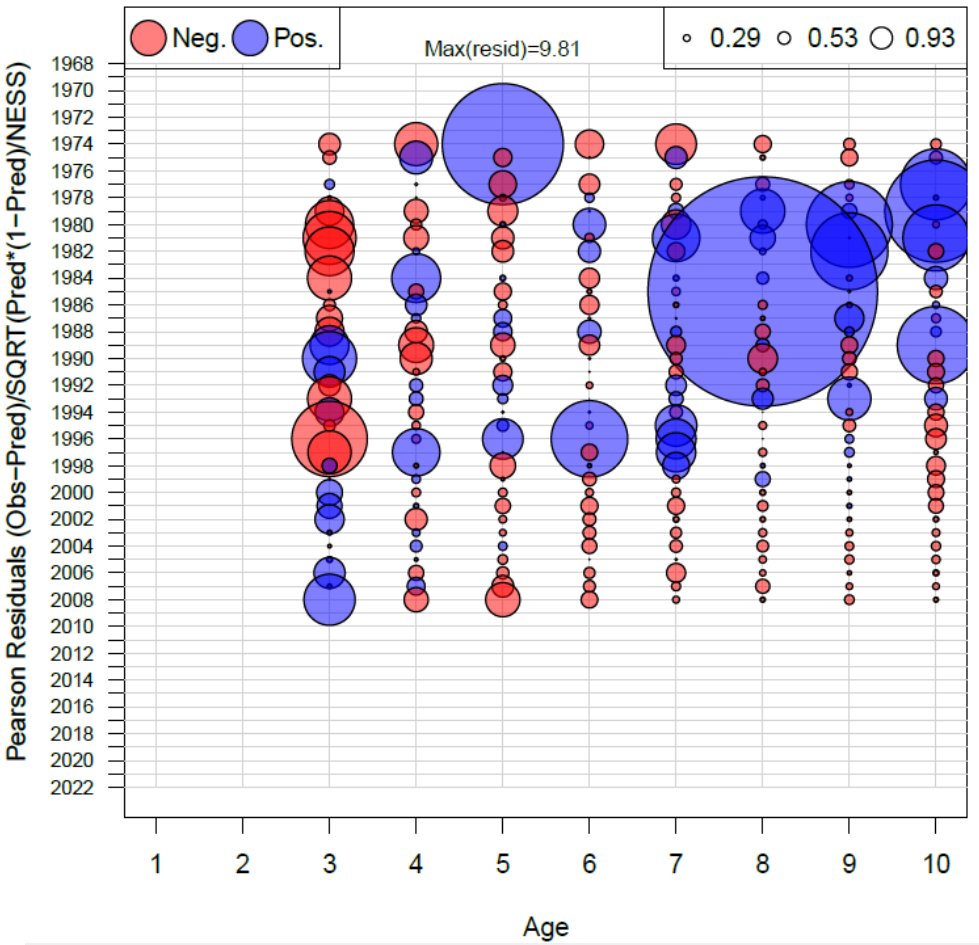
ASAP diagnostics: Fit to *Bigelow* index (2009-2022)





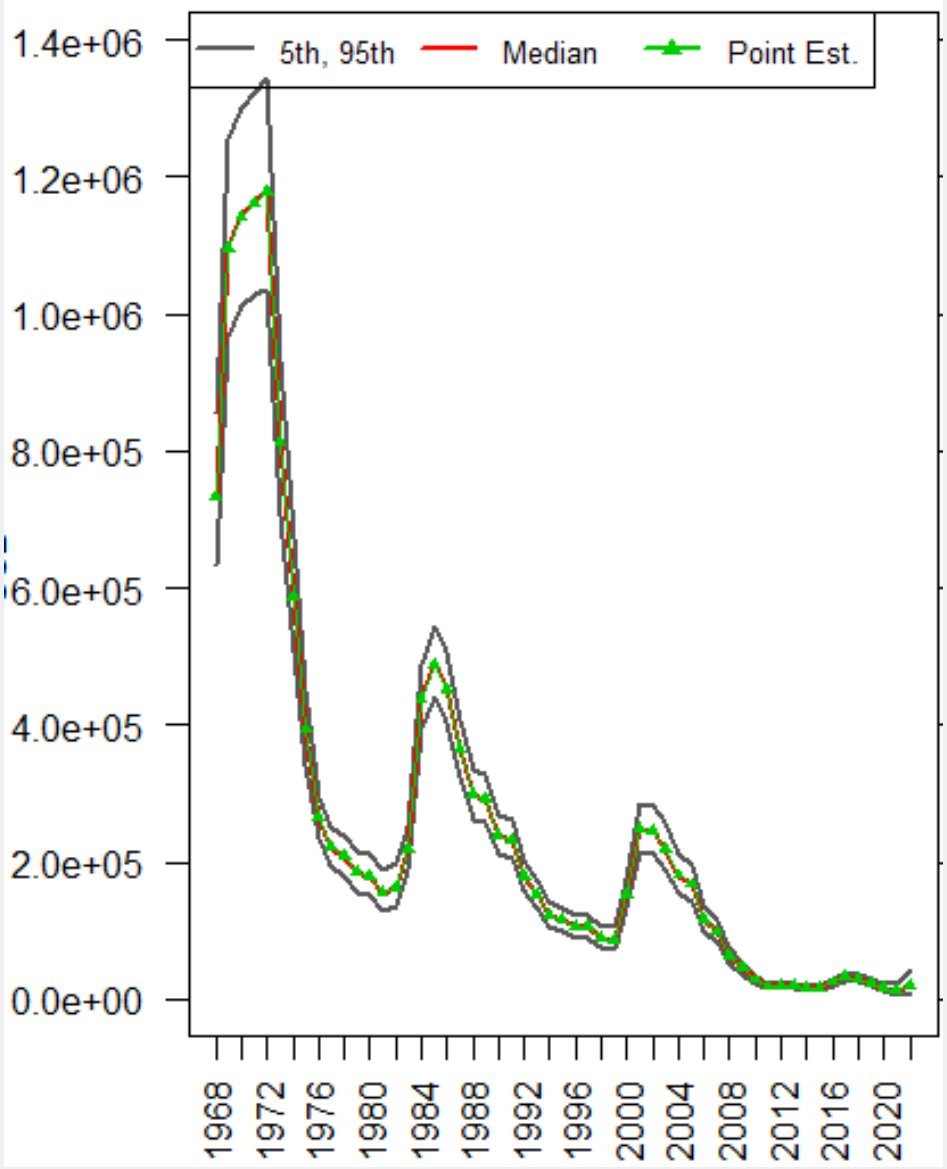
ASAP diagnostics: Fit to *Albatross* index (1968-2008)



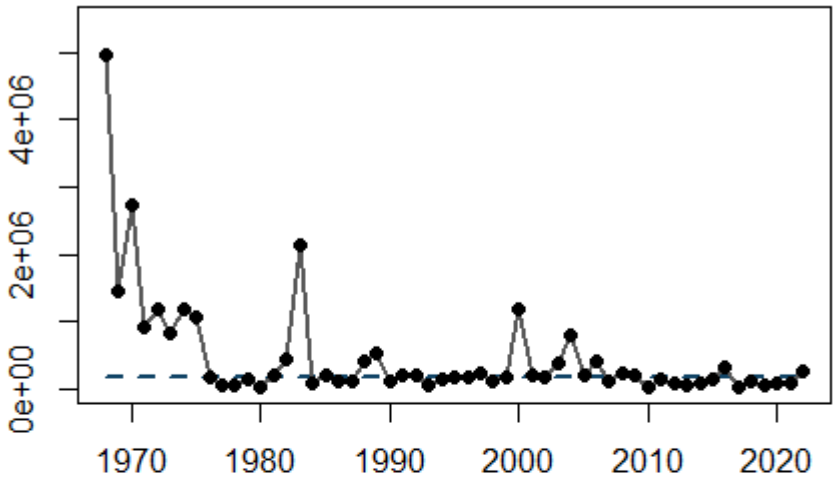


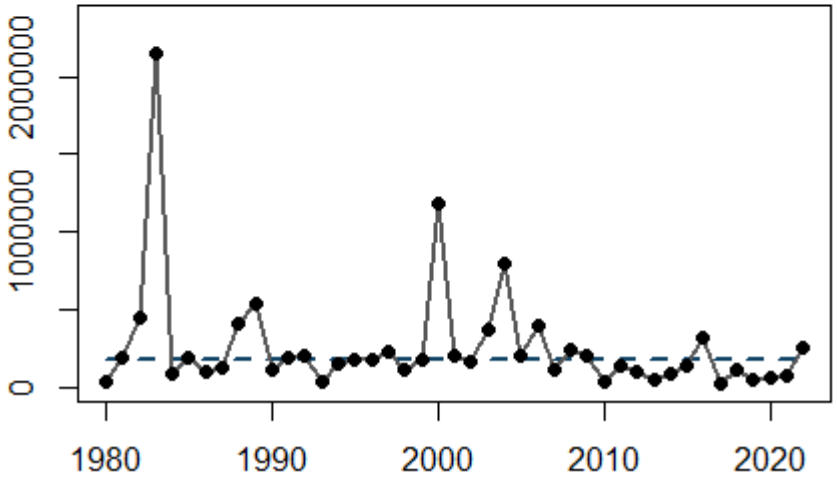
ASAP estimates:

Spawning stock biomass (mt)

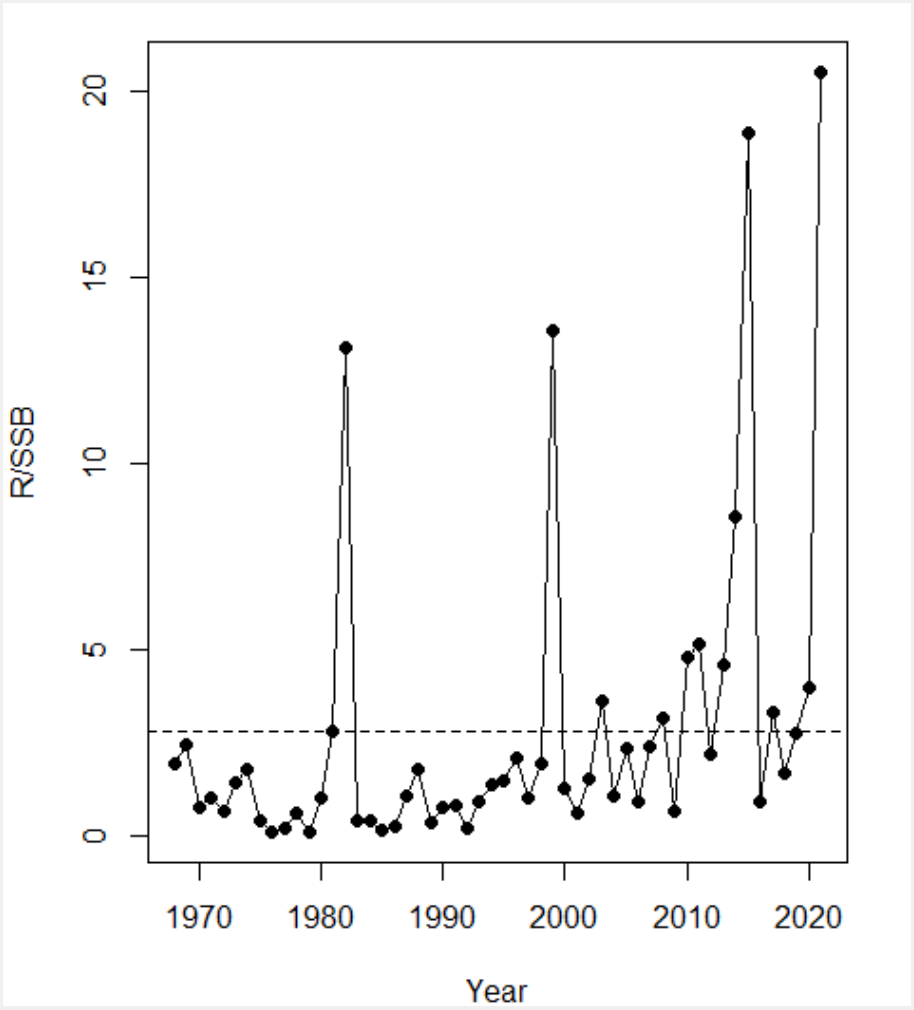


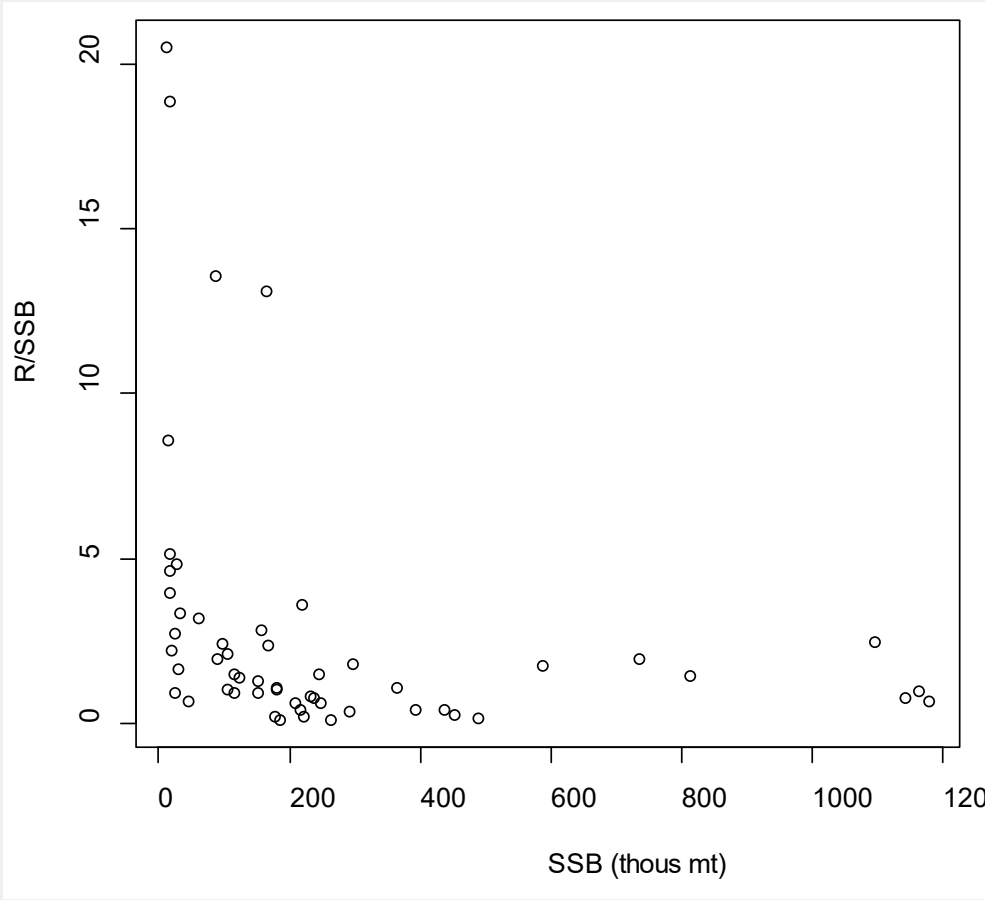
Recruitment (000s)





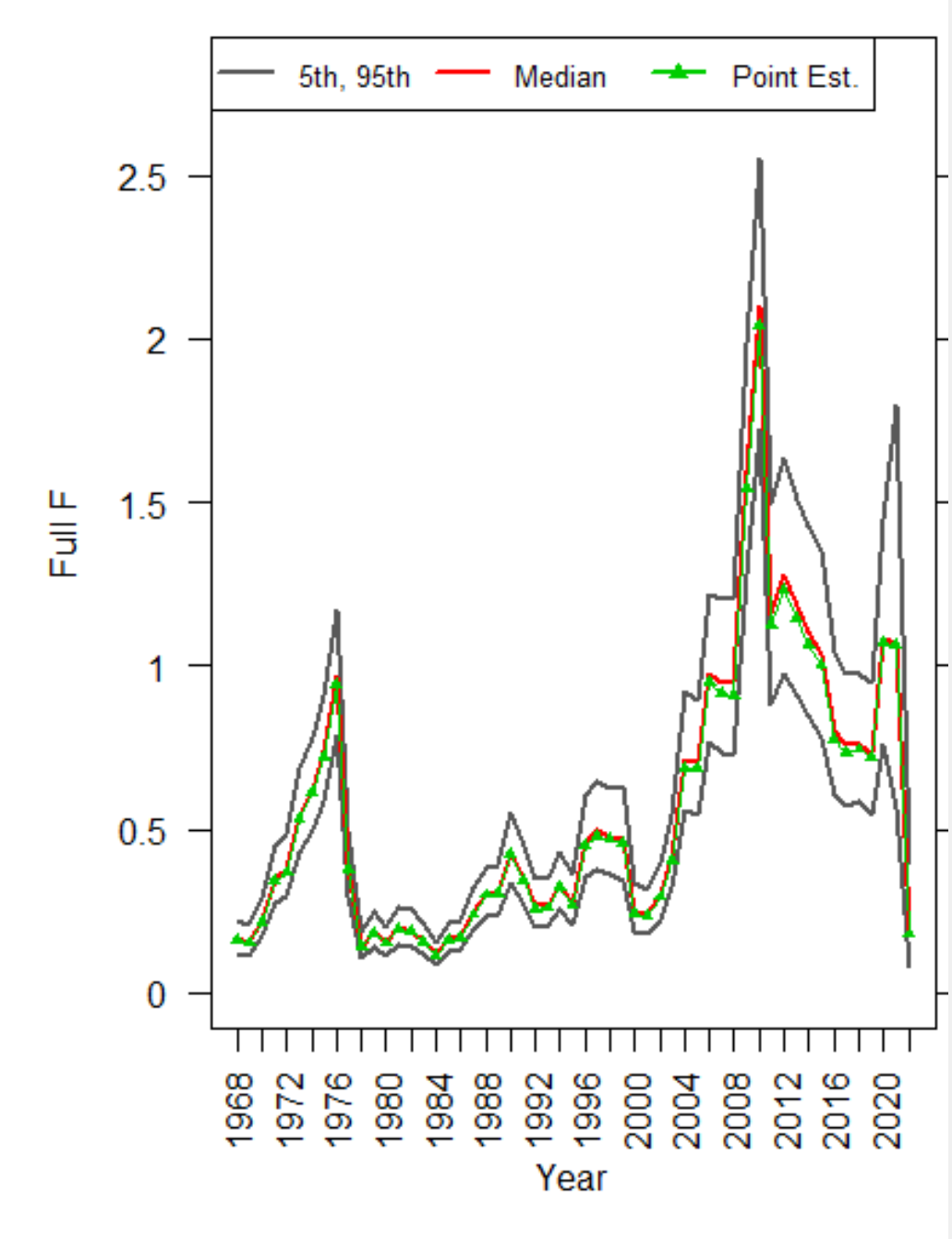
ASAP estimates:
R/SSB





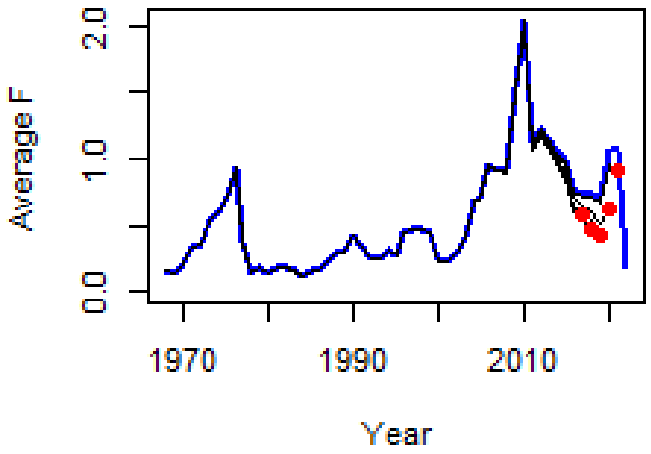
ASAP estimates:

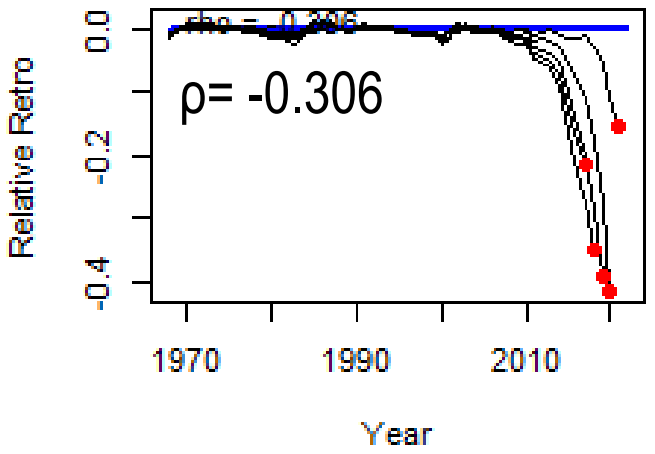
Fishing mortality

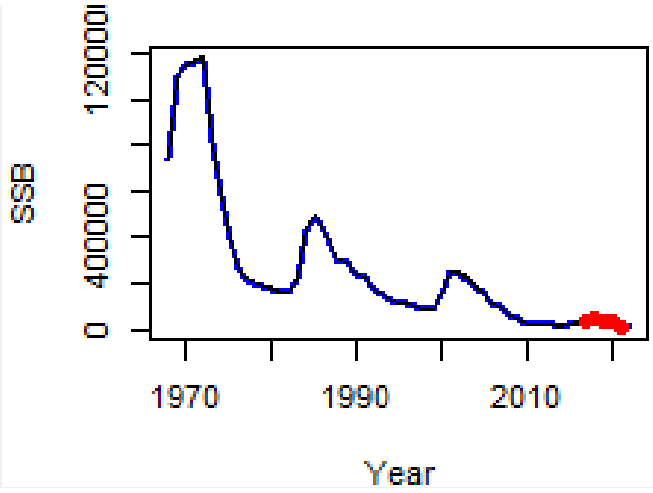


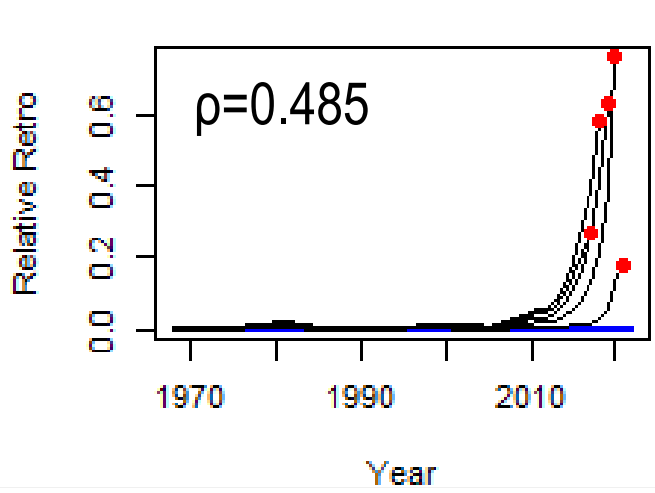
Retrospective analysis:

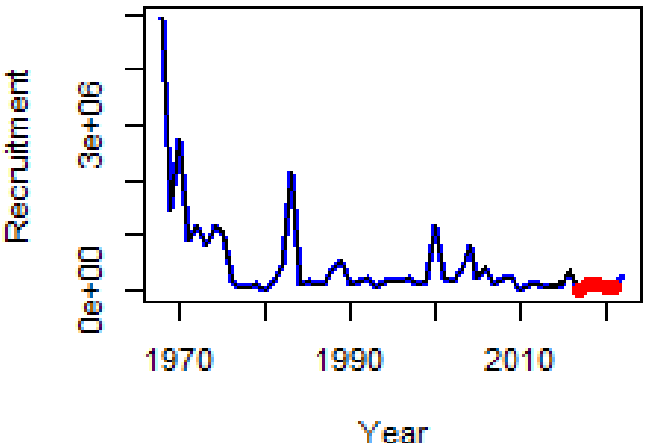
5 year peels
2017-2021

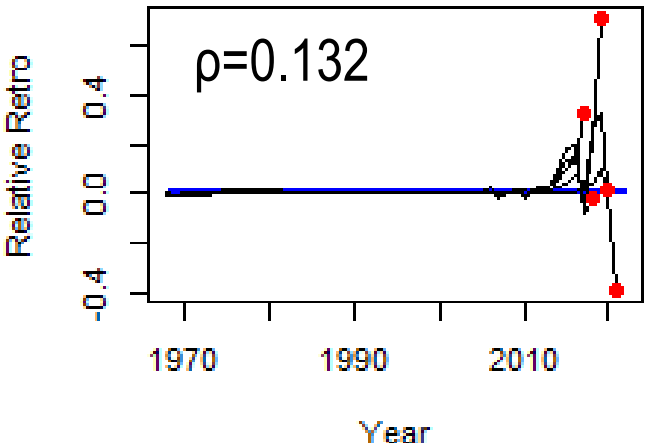








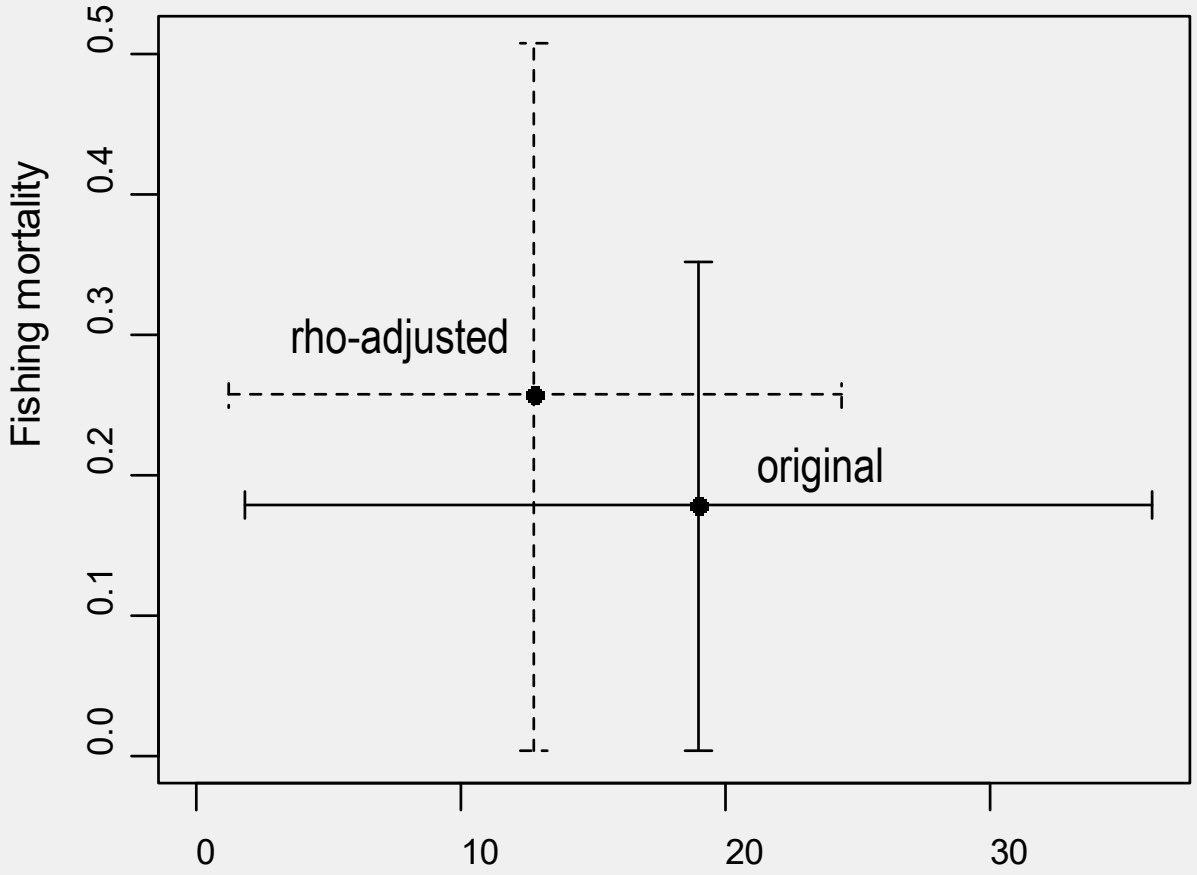




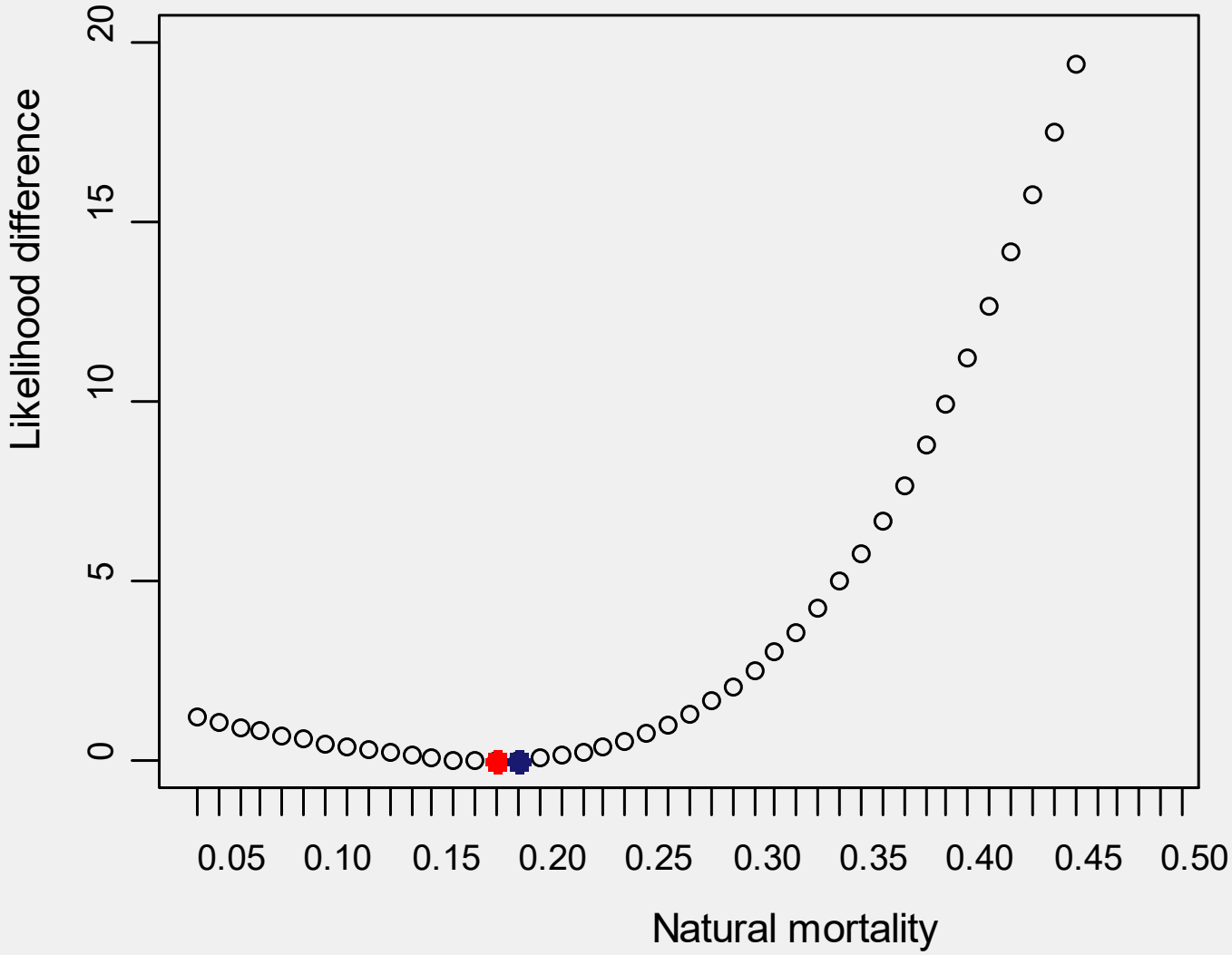
2021 MT
Mohns ρ estimates:
F = -0.093
SSB = 0.326
Rect = 0.431

Retrospective analysis:

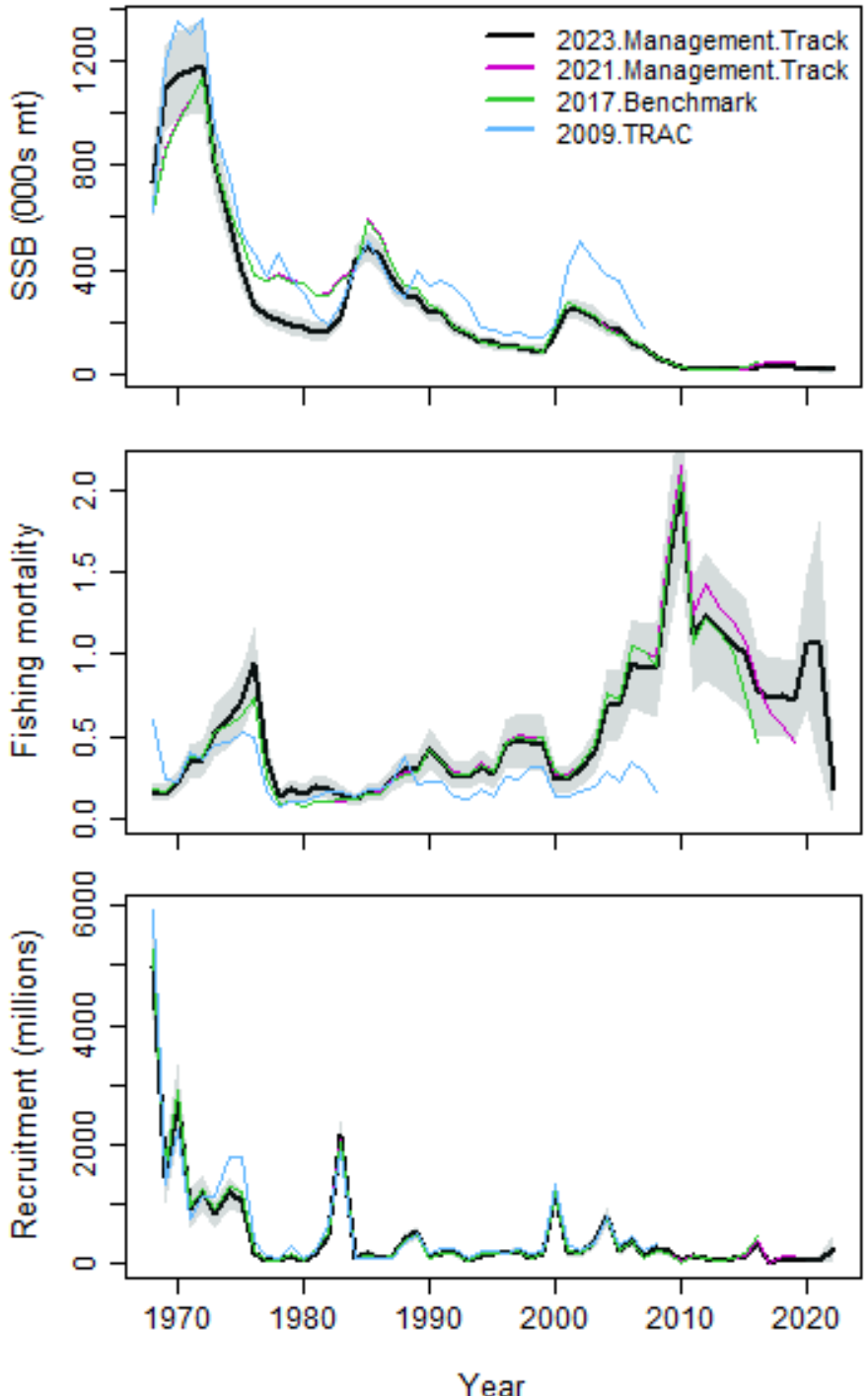
Terminal year estimates with 90% CIs



Natural mortality

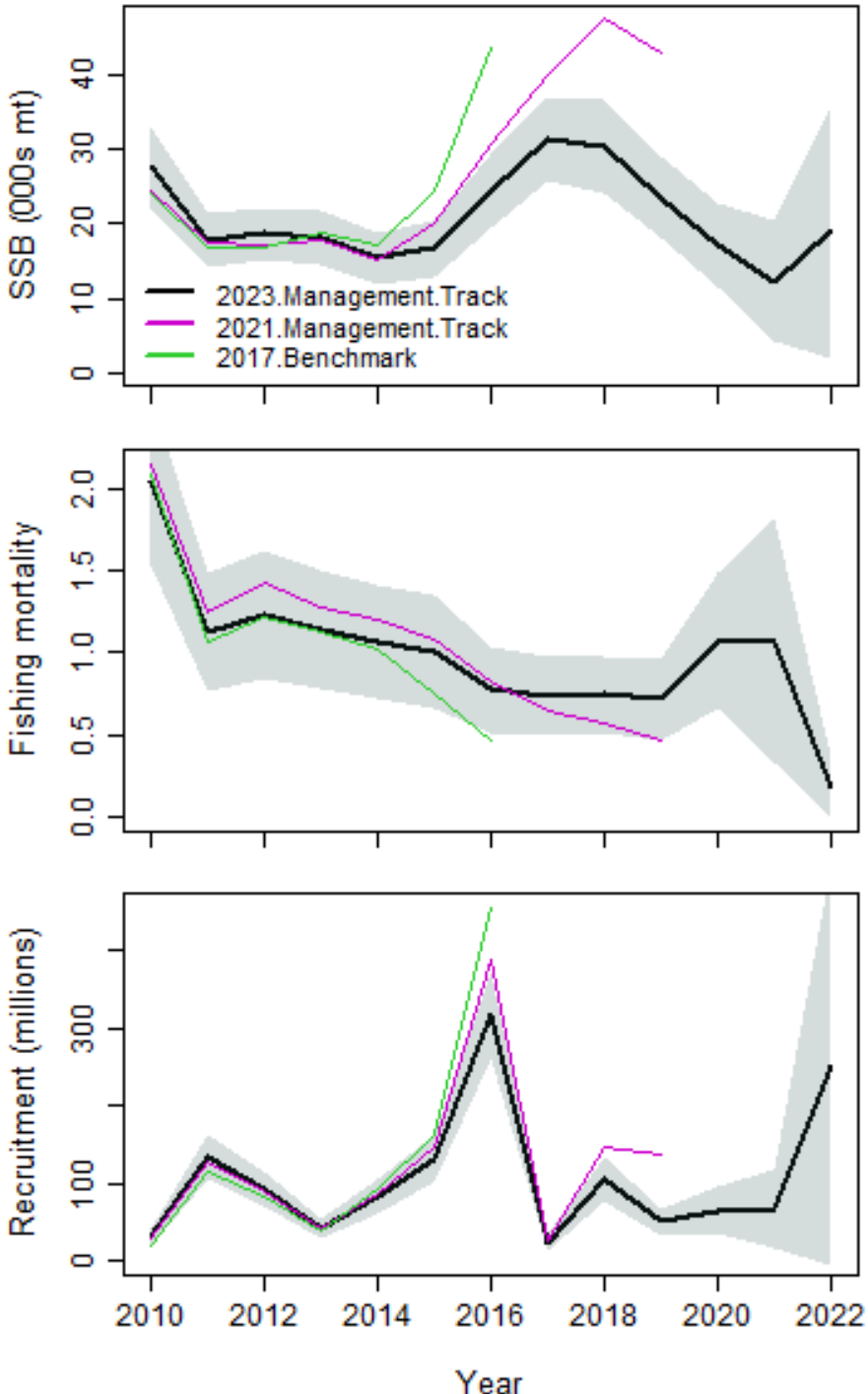


Historical retrospective

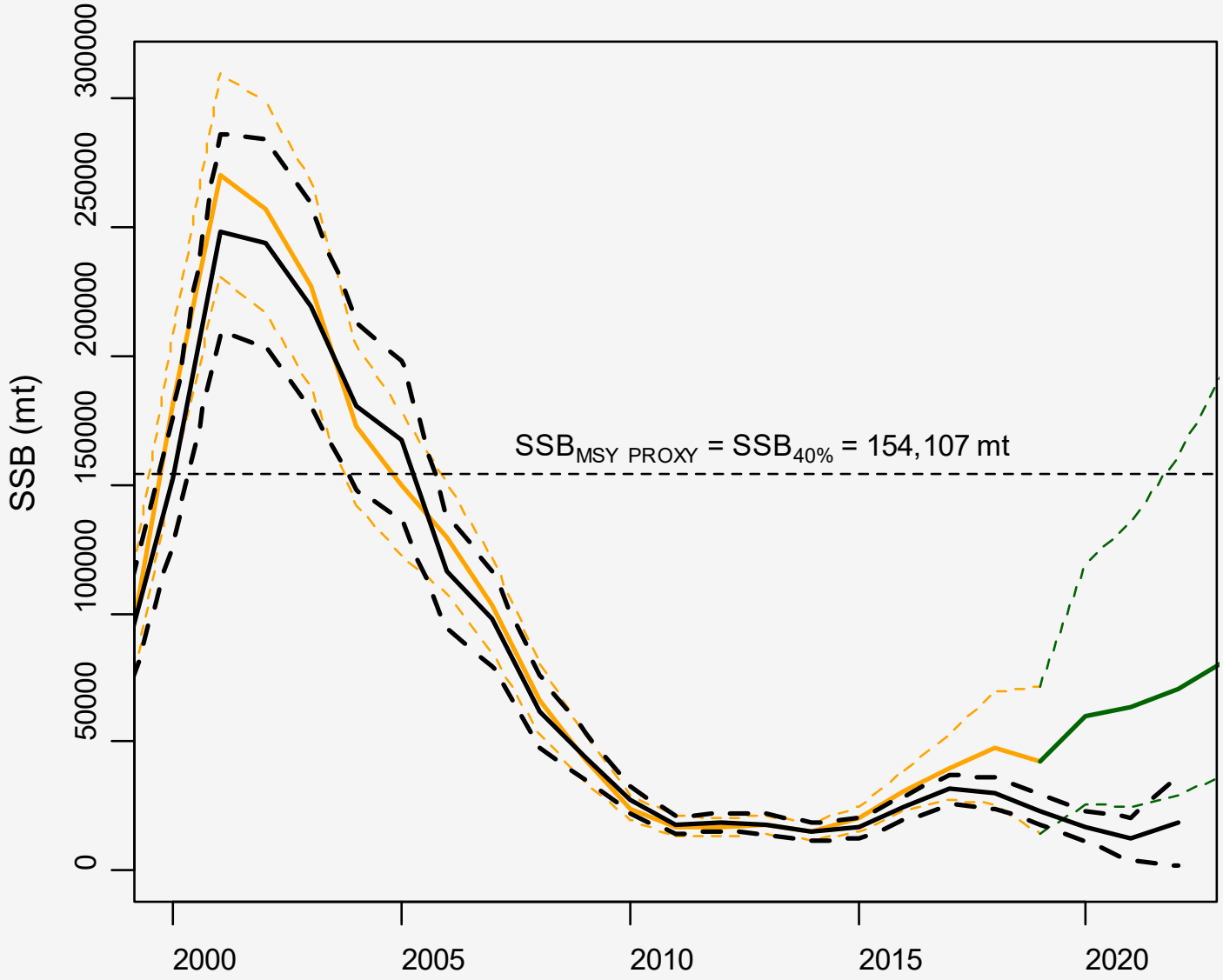


* 2009 TRAC did not pass peer review

Historical retrospective



Comparison with 2021 MT projections



ASAP estimates:

2021 MT

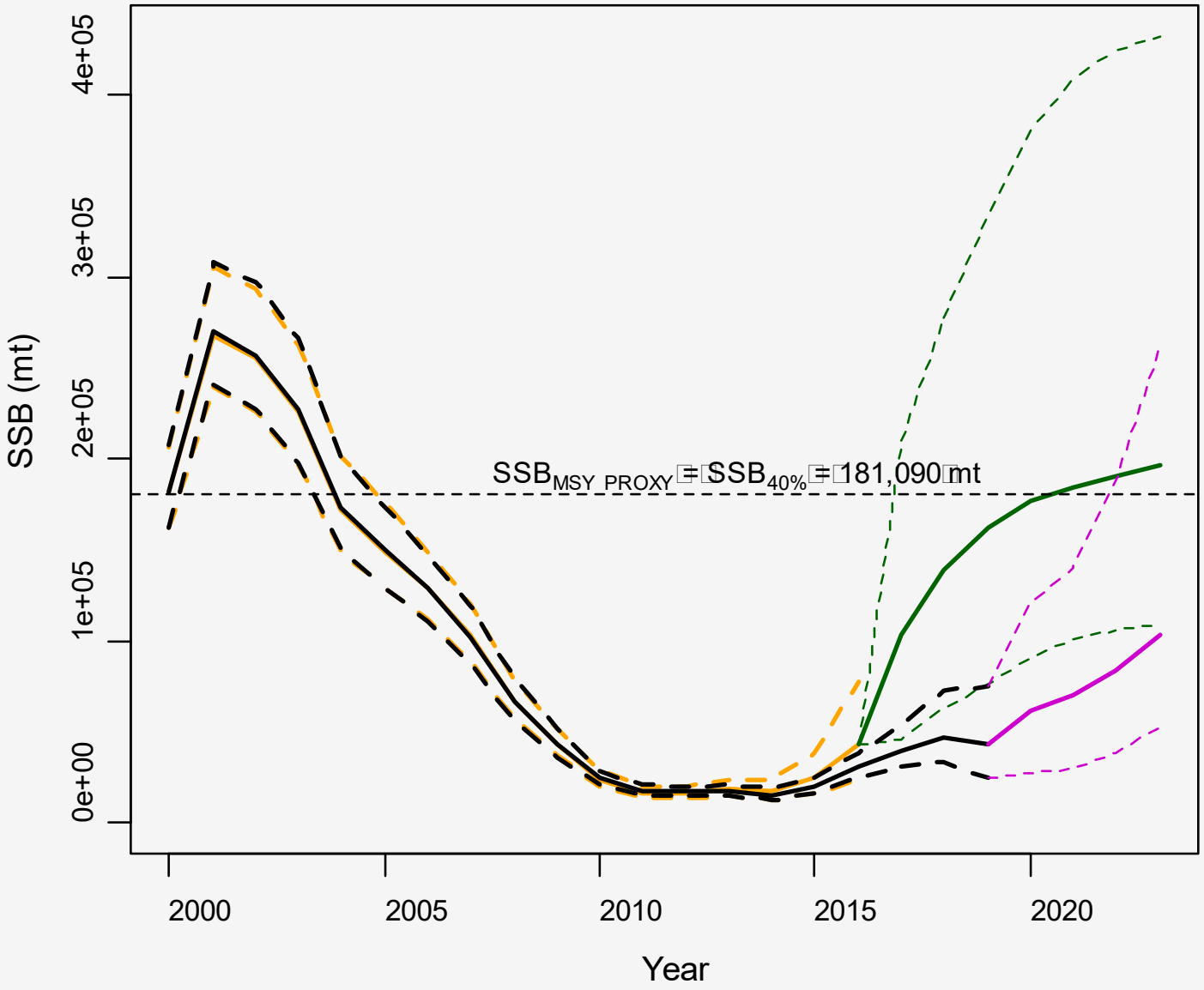
2023 MT

Projections:

2021 MT

(Frebuild, 0.12)

2021 MT comparison with 2017 benchmark projections



ASAP estimates:

2017 Benchmark

2021 MT

Projections:

2017 Benchmark
(Frebuild, 0.237)

2021 MT
(Fmsy, 0.22)

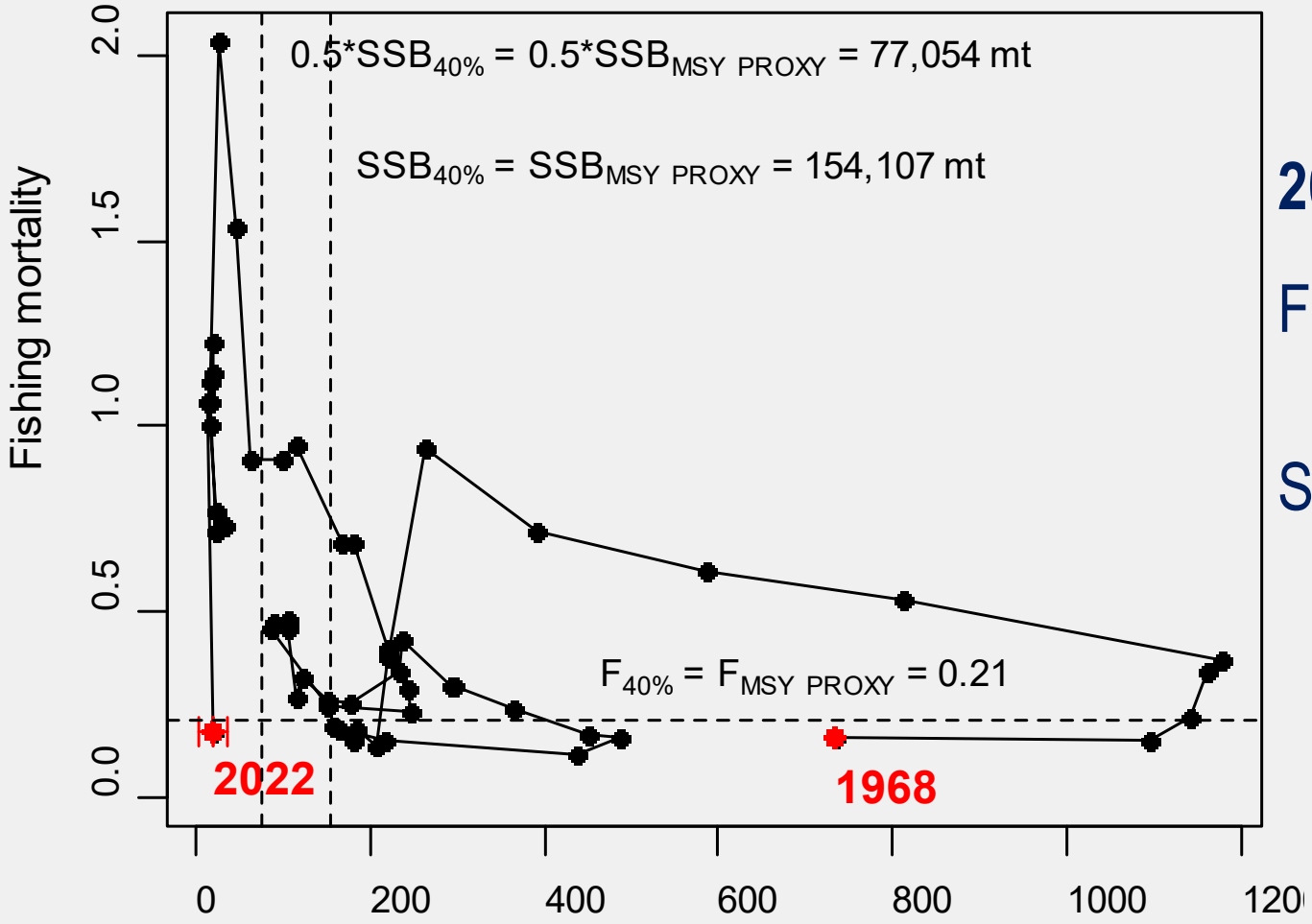
Term of Reference 4:

Re-estimate or updated the BRP's as defined by the management track level and recommend stock status. Provide qualitative descriptions of stock status based on simple indicators/metrics.

Biological reference points

	2021 MT	2023 MT
$F_{MSY\ proxy}$	0.22	0.21
$SSB_{MSY\ proxy}$	181,090	154,107 (86,490-332,677)
$B_{MSY\ proxy}$	237,989	209,952 (118,636-432,417)
MSY proxy	34,103	30,460 (17,321-63,448)

Recommended stock status



2022 estimates:

F: 0.18 (0.003-0.35)

SSB: 19,017 mt (1,835-36,199)

Overfished (12% of SSB msy proxy) but overfishing not occurring (86% of Fmsy proxy)

→ Change in overfishing status

Qualitative stock status metrics

- Age truncation apparent in fishery catches
  - Age-9 fish were observed in 2019-2021 fishery catches for the first time since 2012
- Range-wide SSB estimates from egg surveys have been below the time-series median since 2009
  - Southern contingent egg production has been an order of magnitude greater in since 2018 compared to the previous decade
- With the exception of the 2015 and 2021 year classes, recruitment estimates have been below the time-series median since 2009
- 2016 year class was the smallest estimate of the time series

2023 Canadian assessment of the northern contingent

- DFO revised the full suite of input data for the 2023 assessment (CAA, WAA, egg index, maturity, fecundity)
- SSB has been in or near the critical zone since 2011
- After reaching a time-series minimum in 2021, 2022 SSB was estimated to be 17,649 mt and 42% of the LRP (40% of $SSB_{40\%}$)
- Fully selected fishing mortality was estimated to be 0.42 in 2022 and was below F40% for the first time since 1997
- Estimated recruitment (2012 onward) has been below the time-series median since 2009 and 2022 represented the 3rd lowest estimate of the time series

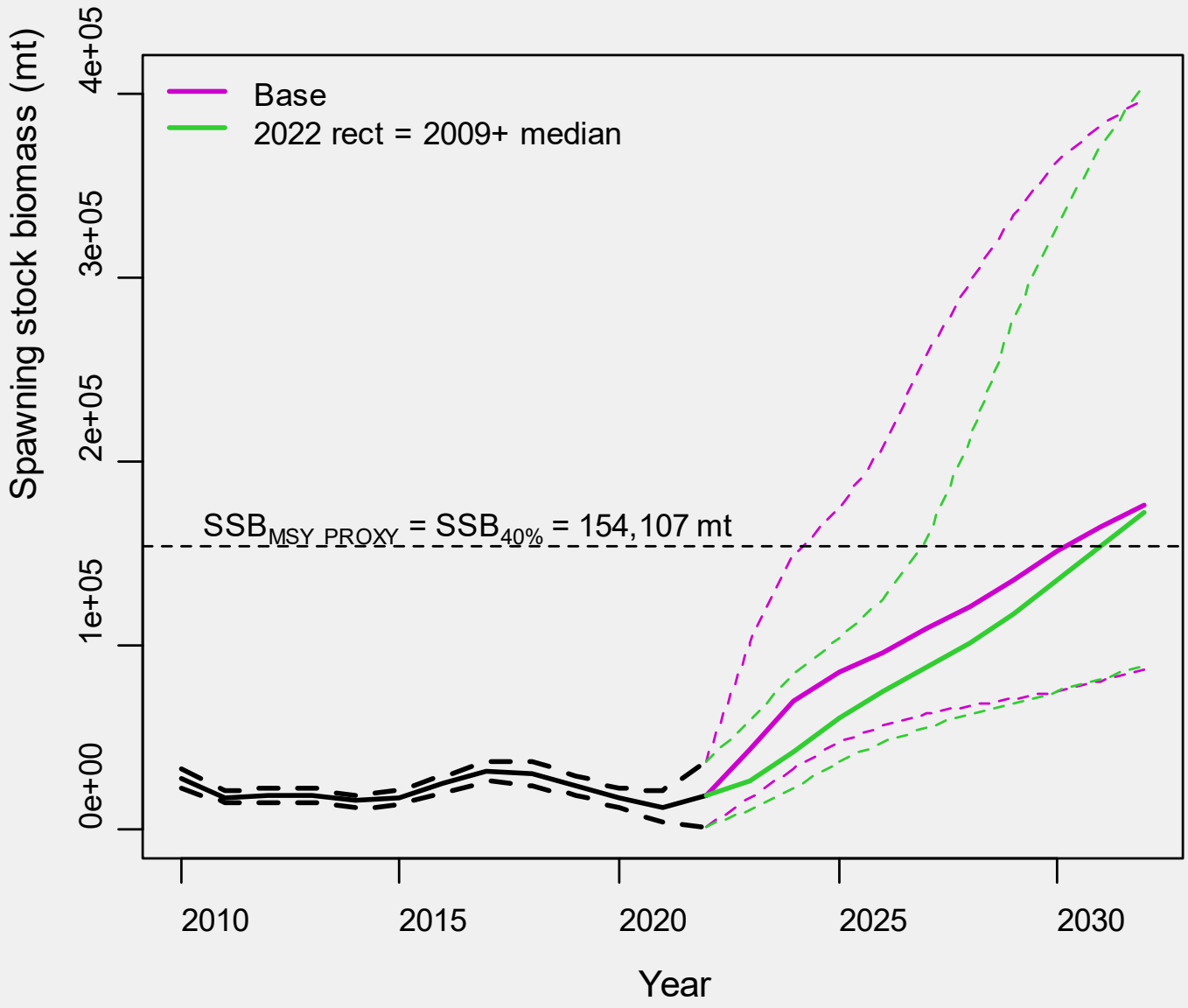
Term of Reference 5:

Conduct short-term projections

Short-term projections

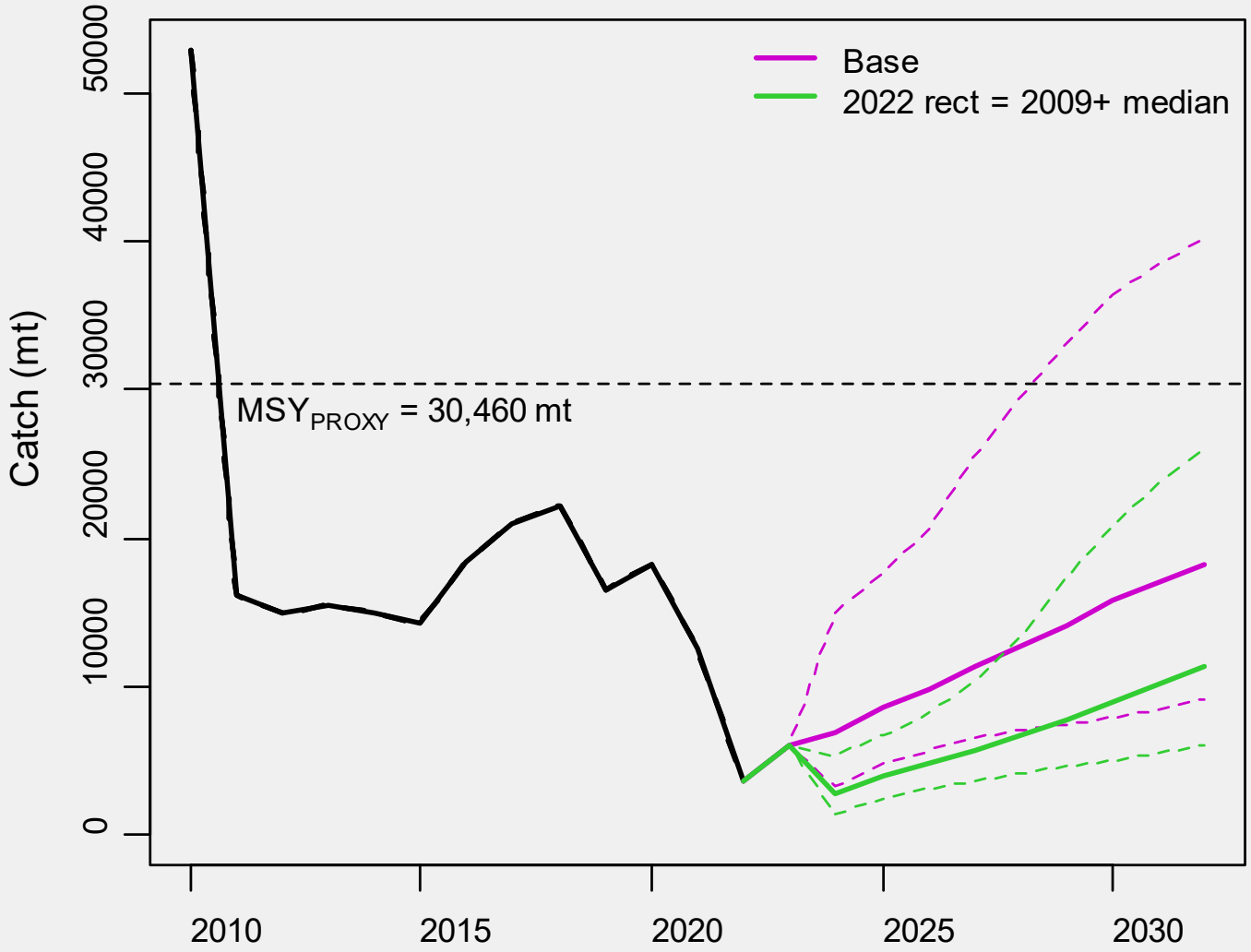
- Following methodology of rebuilding plan, recruitment sampled from empirical CDFs derived assuming two recruitment stanzas
  - When SSB < ½ SSB_{MSY}, CDF based on estimates from 2009 onward
  - When SSB ≥ ½ SSB_{MSY}, CDF based on estimates from 1975 onward
- 2023 catch assumption: 5,953 mt (2023 US ACL + 2022 Canadian catch)
- $F_{rebuild}$ defined as the F that would result in a 61% probability of rebuilding the stock by 2032 ($F_{rebuild}$ updated from 0.12 to 0.11 with this MT)
- Sensitivity analyses per request of MAFMC staff due to poor projection performance
  - 2022 recruitment estimate reduced to median of recent recruitment (2009 onward) ($F_{rebuild}$ reduced from 0.11 to 0.07)
  - Retrospective adjustments made to terminal year NAA estimates
  - 2022 recruitment estimate reduced to median of recent recruitment; retrospective adjustments made to NAA estimates for all other ages

Projections at Frebuild: SSB



	Base	Reduced 2022 Rect
2023	43,721	26,387
2024	69,870	42,756
2025	85,584	61,060
2026	96,586	75,584
2027	109,397	88,050
2028	121,447	101,857
2029	135,534	117,098
2030	151,543	135,003
2031	163,892	153,837
2032	175,493	172,040

Projections at Frebuild: Catch



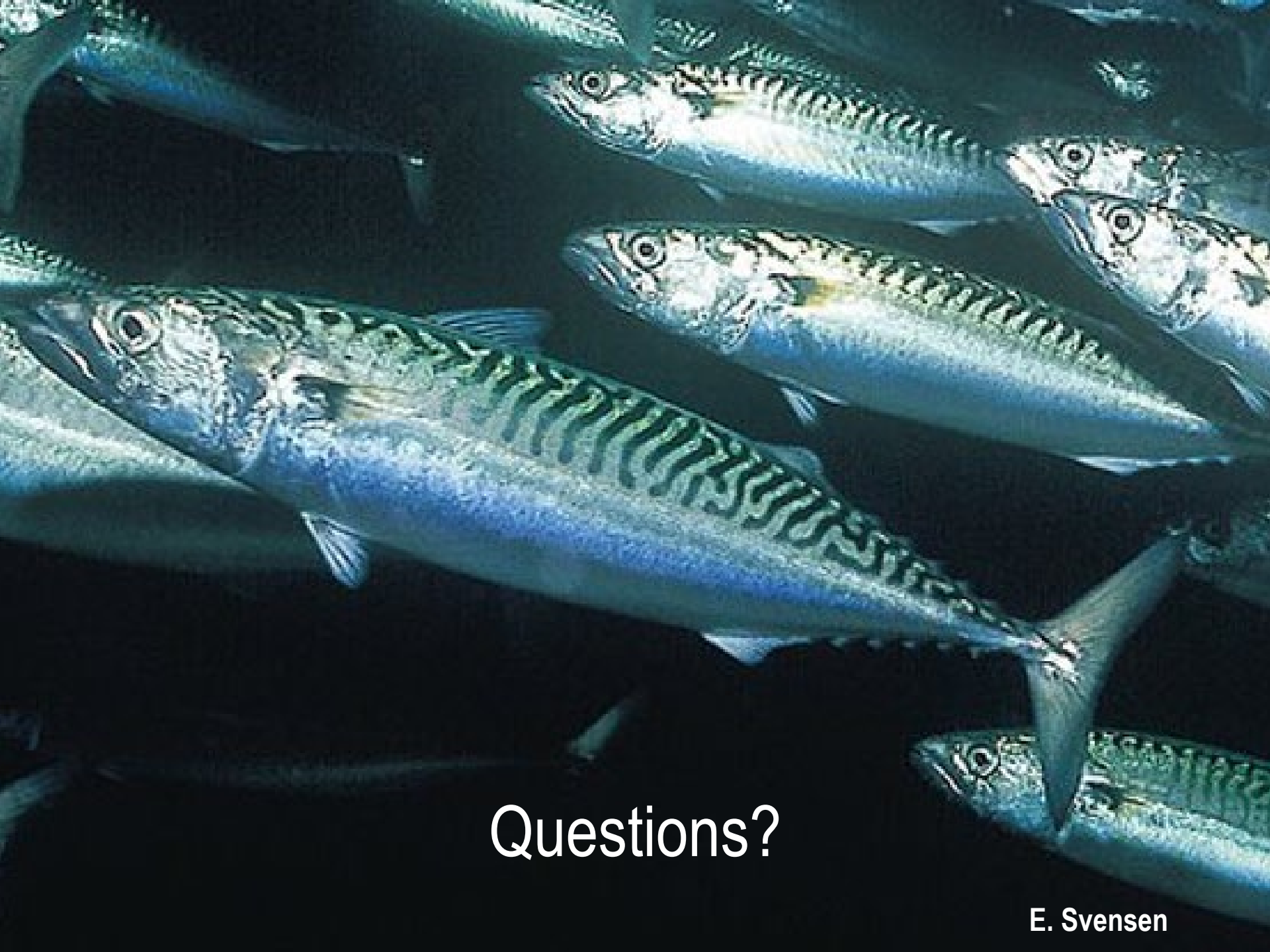
	Base	Reduced 2022 Rect
2023	5,953	5,953
2024	6,864	2,726
2025	8,571	3,900
2026	9,830	4,866
2027	11,417	5,741
2028	12,710	6,760
2029	14,129	7,806
2030	15,764	8,976
2031	17,020	10,200
2032	18,197	11,386

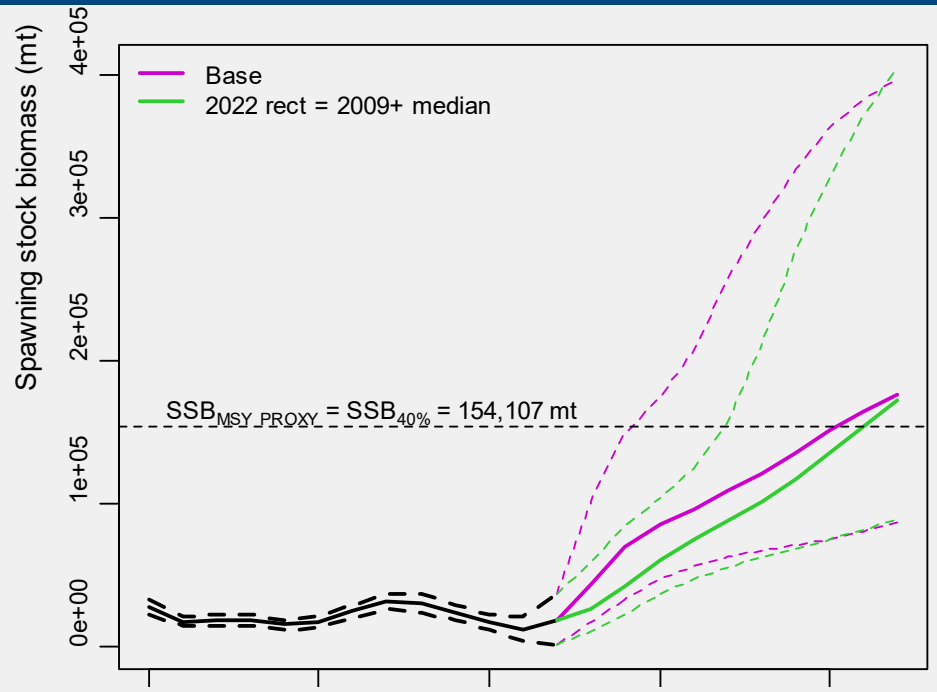
Term of Reference 6:

Respond to any review panel comments or SSC concerns from the most recent prior assessment

Recommendations from 2021 MT peer review

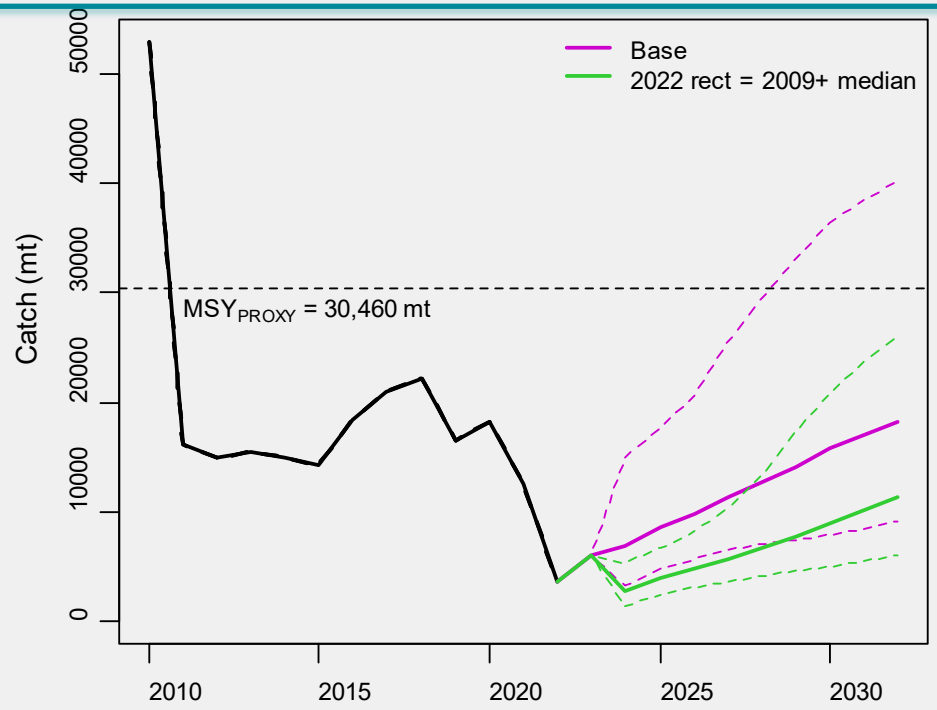
- Panel noted sources of uncertainty related to stock structure and the assumption of a constant, time invariant M
  - Ongoing genetics work indicates small, but potentially significant genetic differentiation between spawning contingents
  - Current work to develop a predation pressure index that estimates temporal trends in natural mortality due to finfish, marine mammals and gannets
- Panel recommend exploration of recruitment dynamics and mechanisms that may explain patterns in recruits-per-spawner
  - Change-point analyses of recruitment, R/SSB and relative condition show greater support for compensation than environmentally-driven shifts


Questions?
E. Svensen



SSB

	Base	Reduced 2022 Rect
2023	43,721	26,387
2024	69,870	42,756
2025	85,584	61,060
2026	96,586	75,584
2027	109,397	88,050
2028	121,447	101,857
2029	135,534	117,098
2030	151,543	135,003
2031	163,892	153,837
2032	175,493	172,040

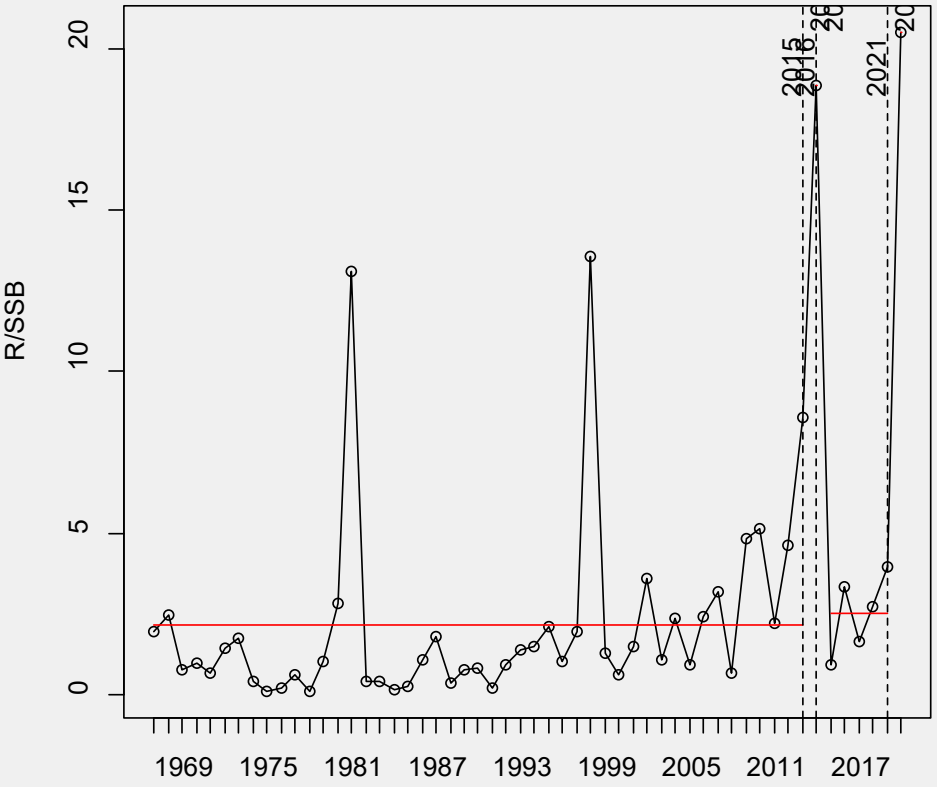


Catch

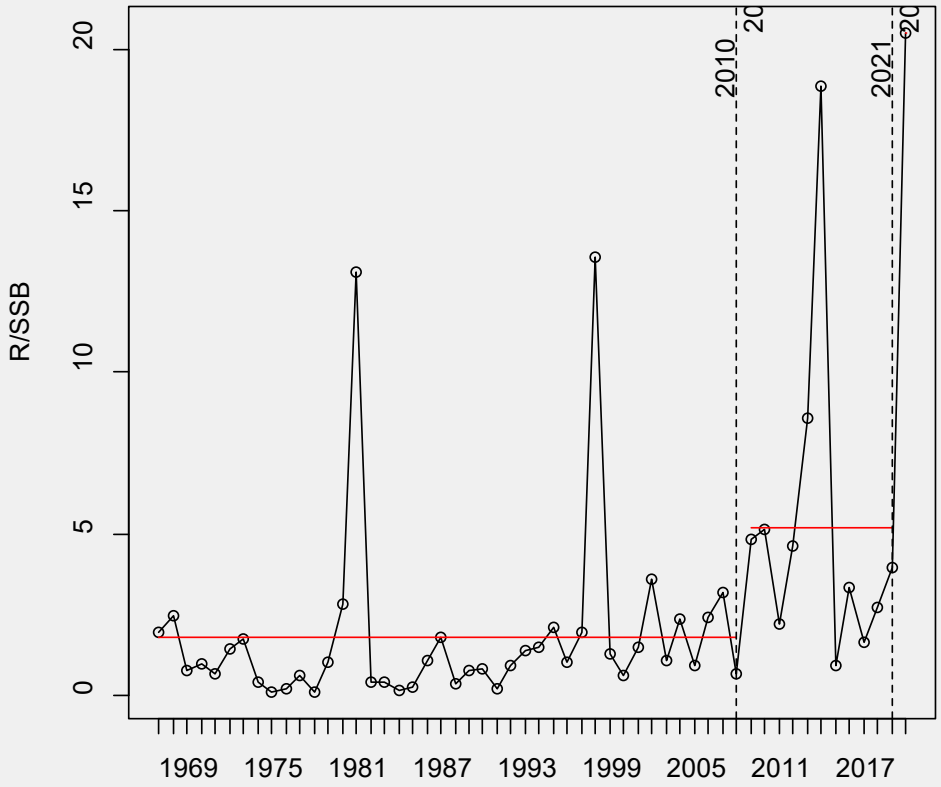
	Base	Reduced 2022 Rect
2023	5,953	5,953
2024	6,864	2,726
2025	8,571	3,900
2026	9,830	4,866
2027	11,417	5,741
2028	12,710	6,760
2029	14,129	7,806
2030	15,764	8,976
2031	17,020	10,200
2032	18,197	11,386

Change-point analysis of R/SSB over time

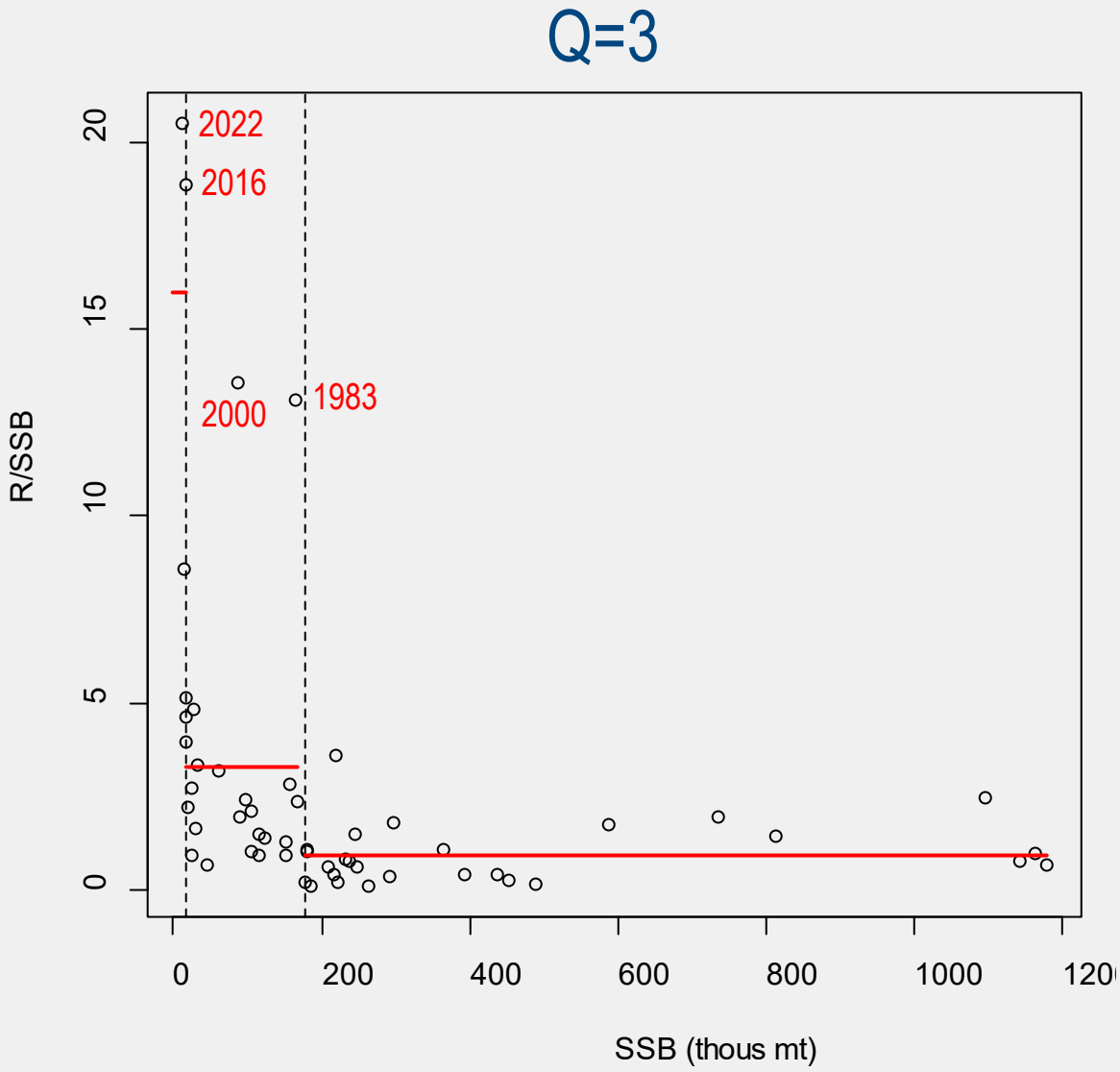
Q=4



Q=3

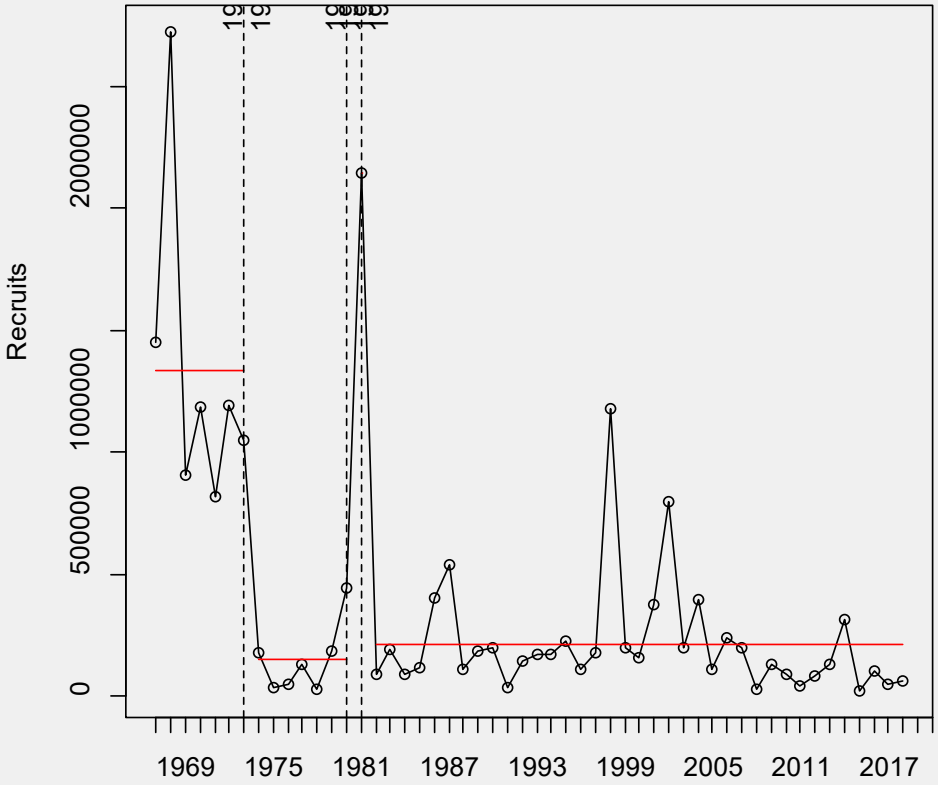


R/SSB sorted by ascending SSB



Recruitment over time

Q=4



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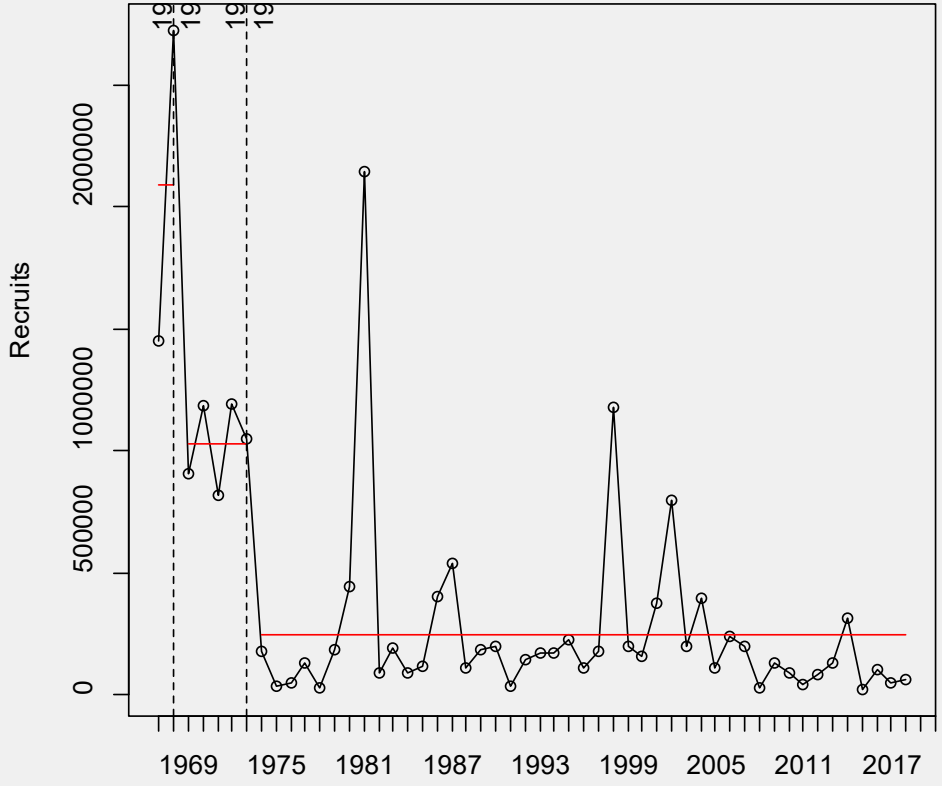
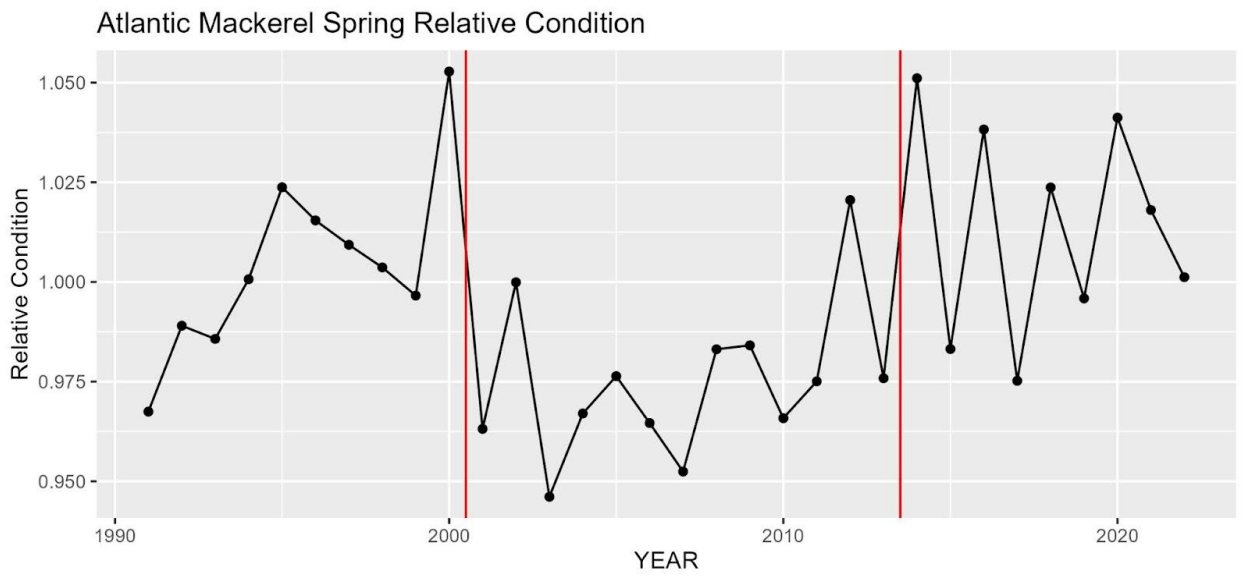
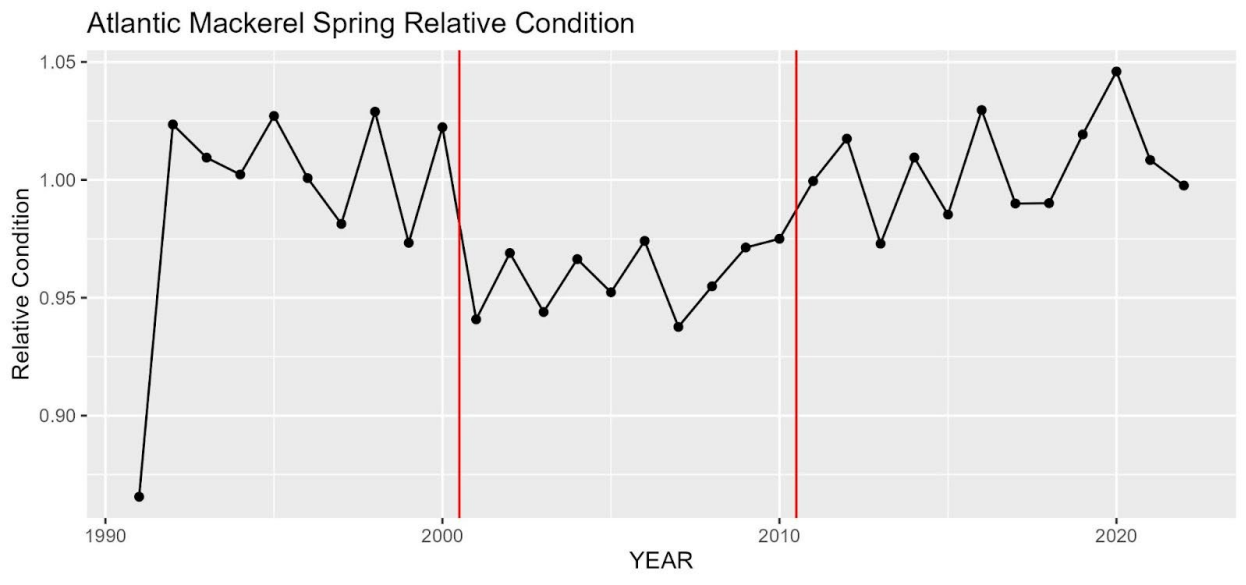


Relative condition

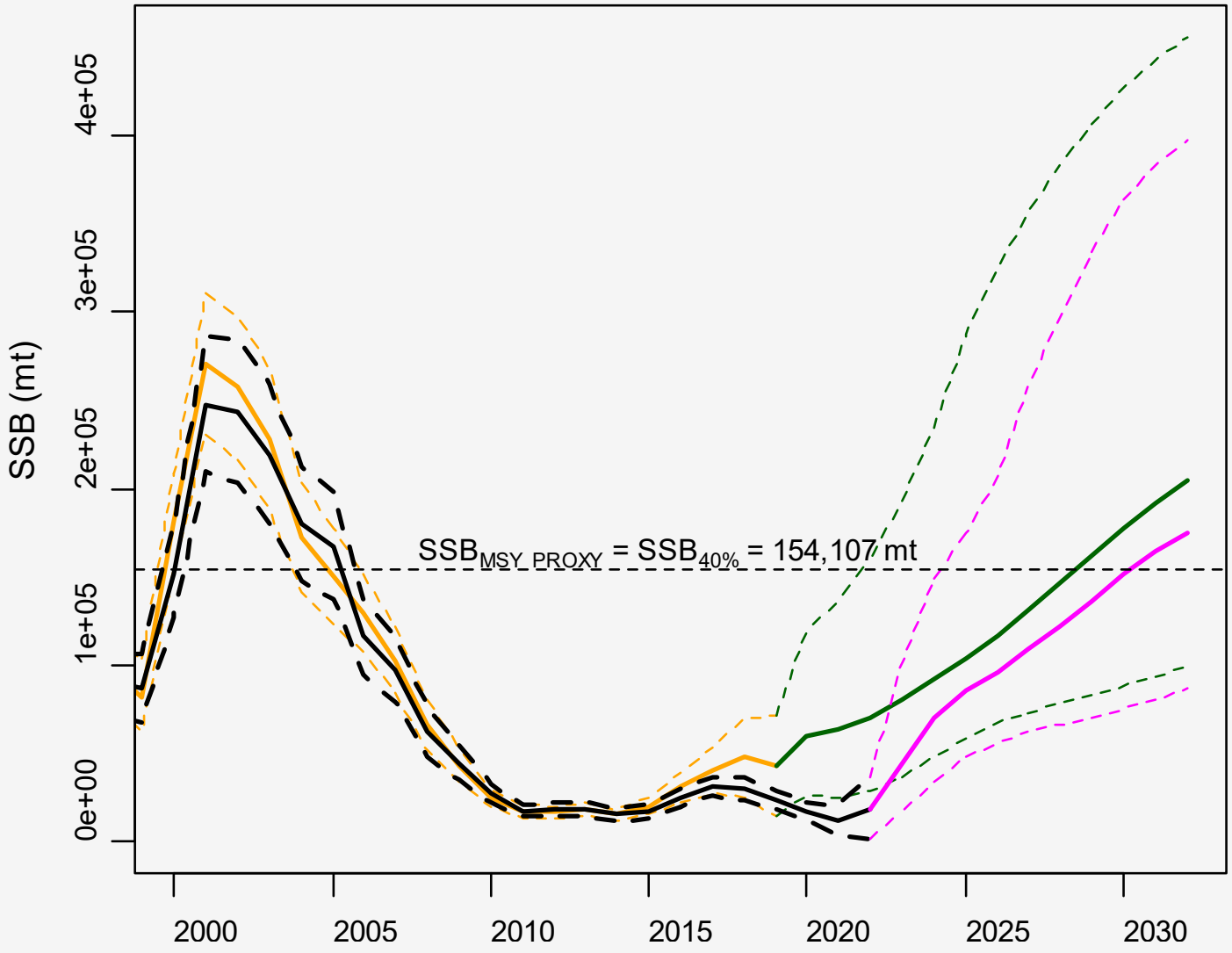


Mature mackerel (>23 cm)

Immature mackerel (<=23 cm)



Comparison with 2021 MT projections

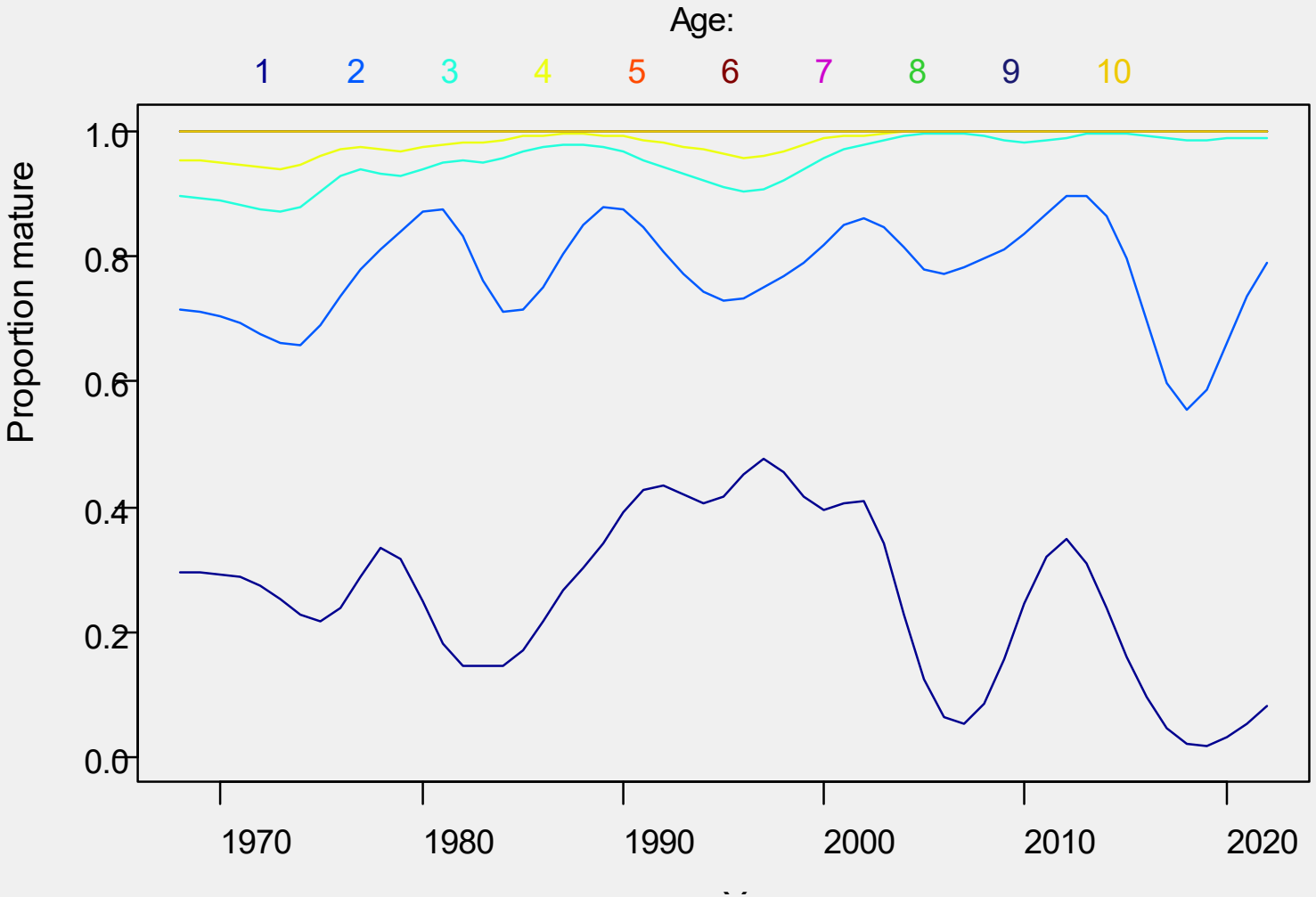


ASAP estimates:
2021 MT
2023 MT

Projections:
2021 MT
(Frebuild, 0.12)

2023 MT
(Frebuild, 0.11)

Maturity



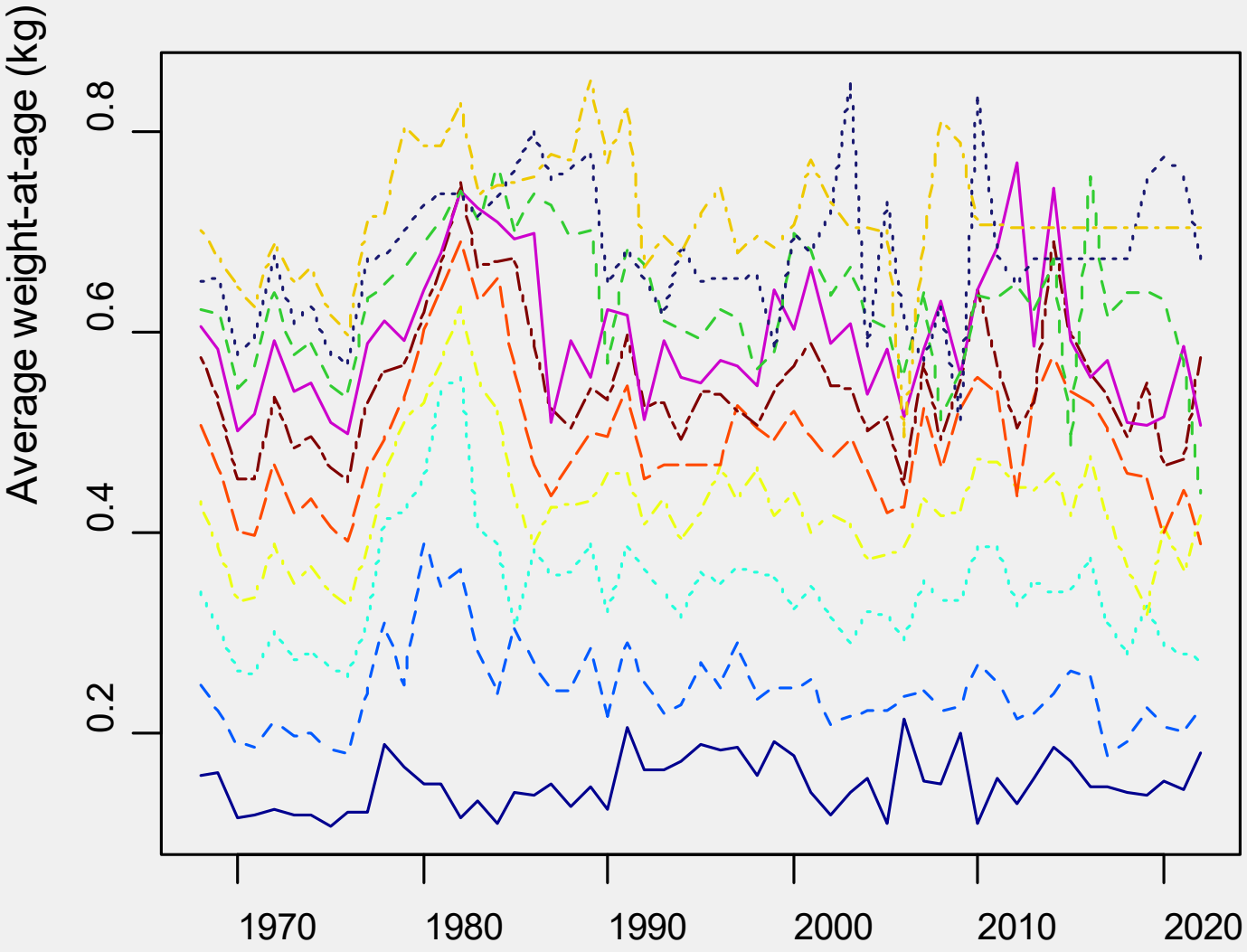
Recent 5-year averages for 2023 MT and 2021 MT

Age-3 = 0.99 (0.94)

Age-2 = 0.67 (0.71)

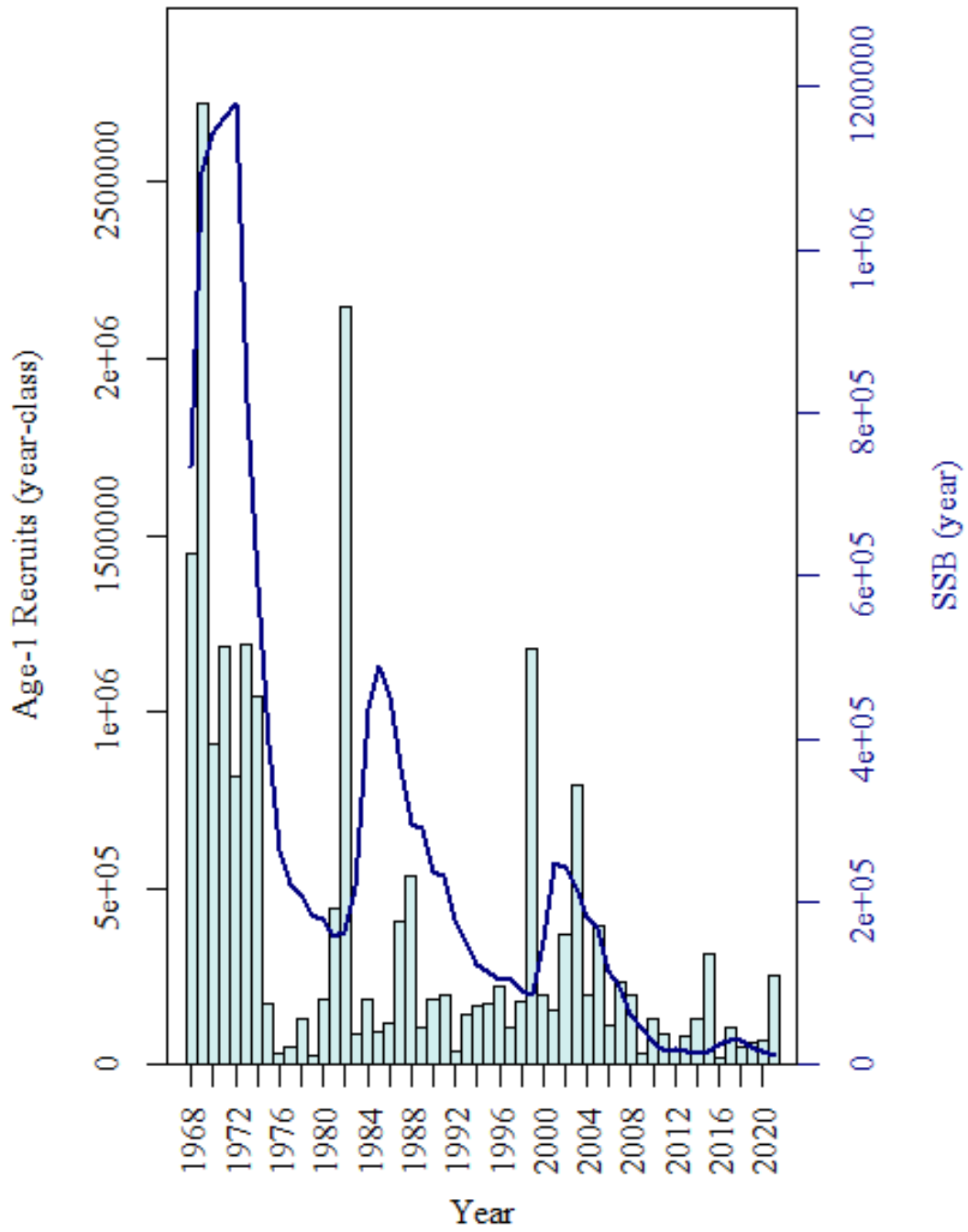
Age-1 = 0.04 (0.18)

SSB Weight-at-age

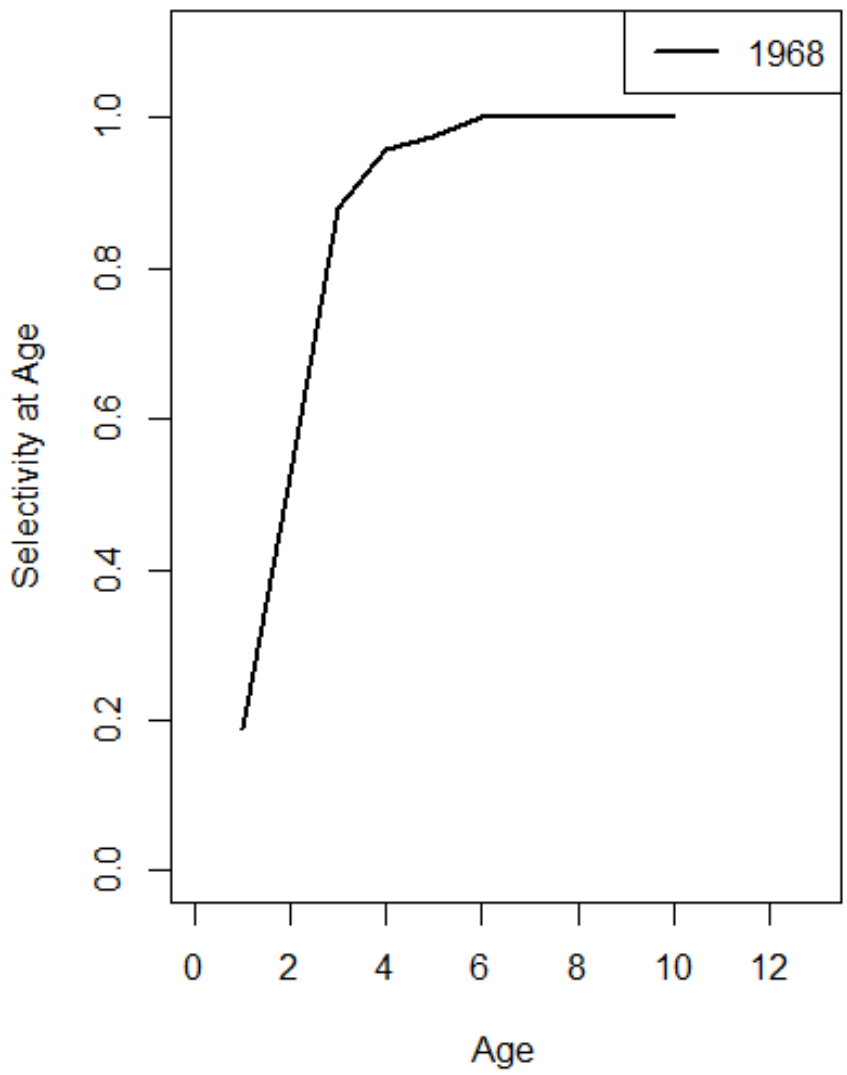


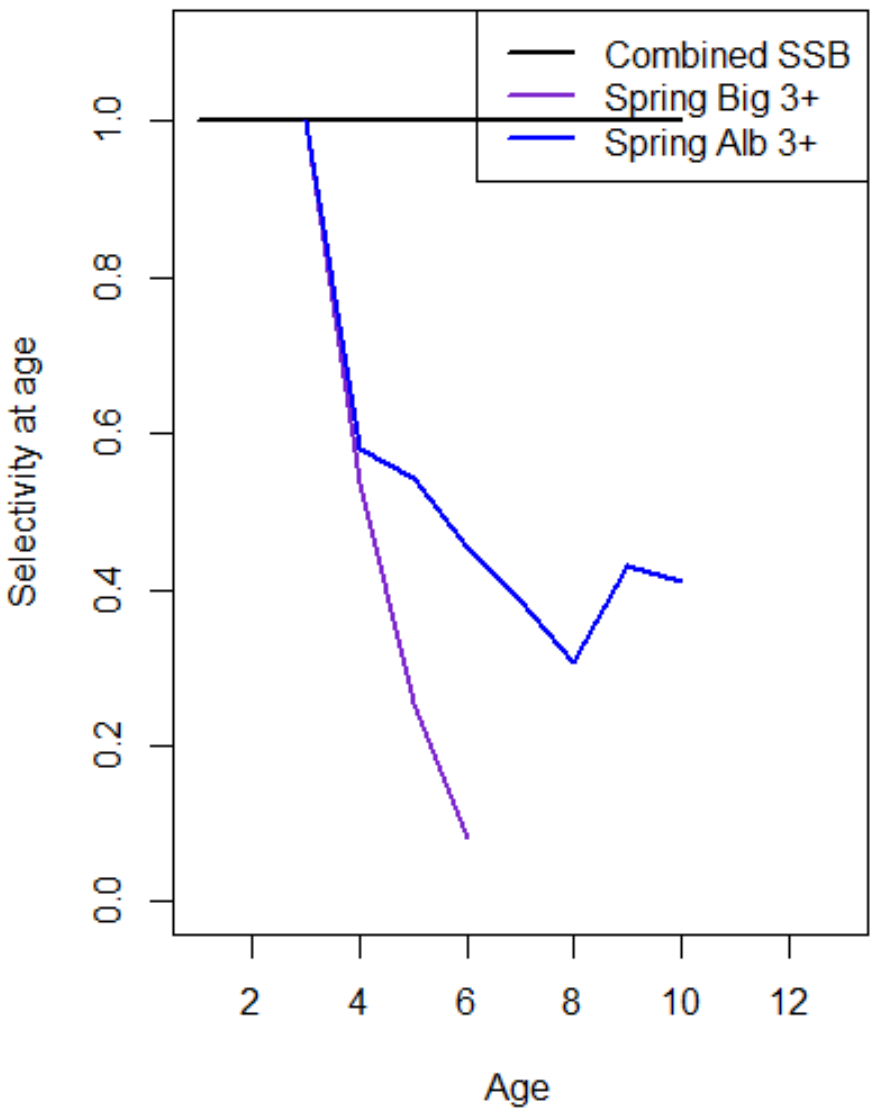
ASAP estimates:

SSB and recruitment time series

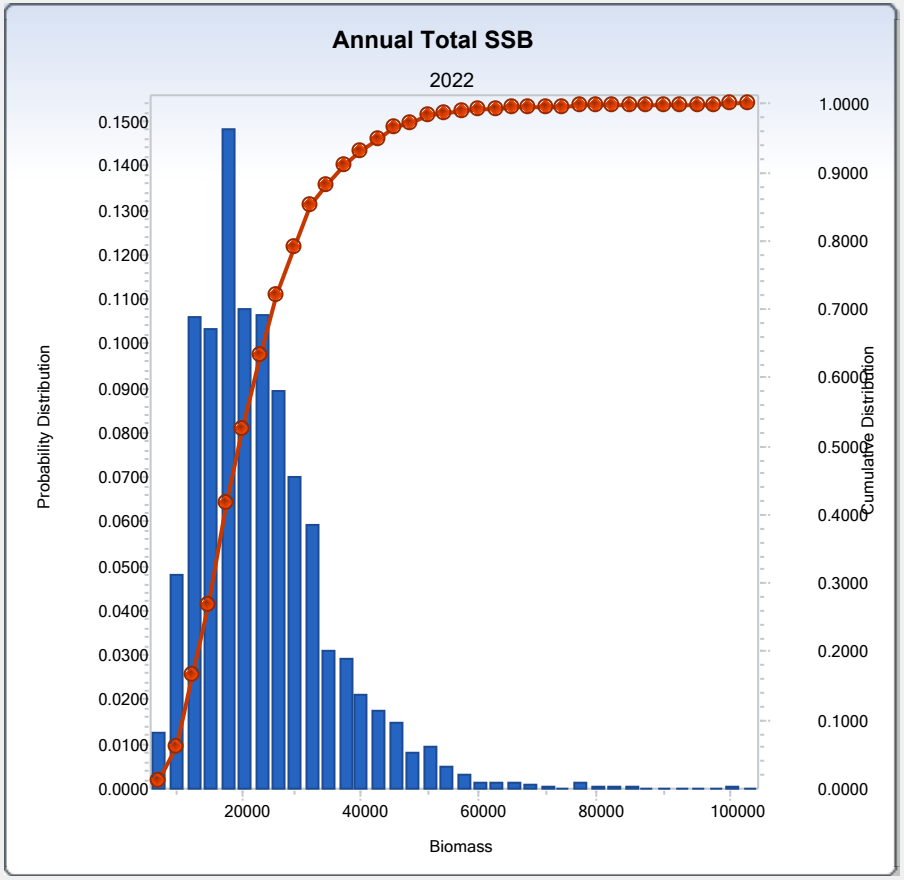


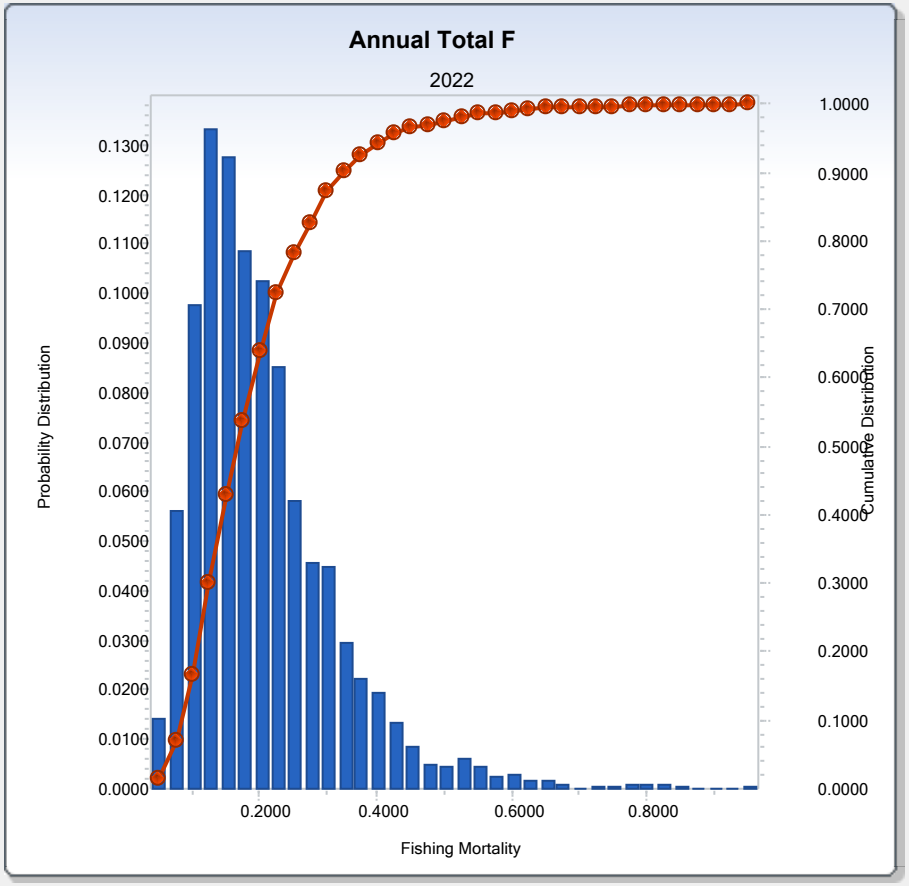
ASAP estimates: Selectivity





ASAP estimates: Terminal year estimates





Long-term projections

- 100-year projections at $F_{40\%}$ (0.21) from 2000 numbers-at-age estimates for 2023 from MCMC simulations
- Recent 5-year averages used for weight-at-age and proportion mature-at-age estimates
- Age-specific fishery selectivity estimates from ASAP model
- Recruitment sampled from an empirical CDF derived from 1975-2019 recruitment estimates of the final ASAP model
- M = 0.2