



NOAA
FISHERIES

**Northeast Fisheries
Science Center**

2021 Atlantic mackerel management track assessment

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NEFSC, Stock assessment lead
July 2021

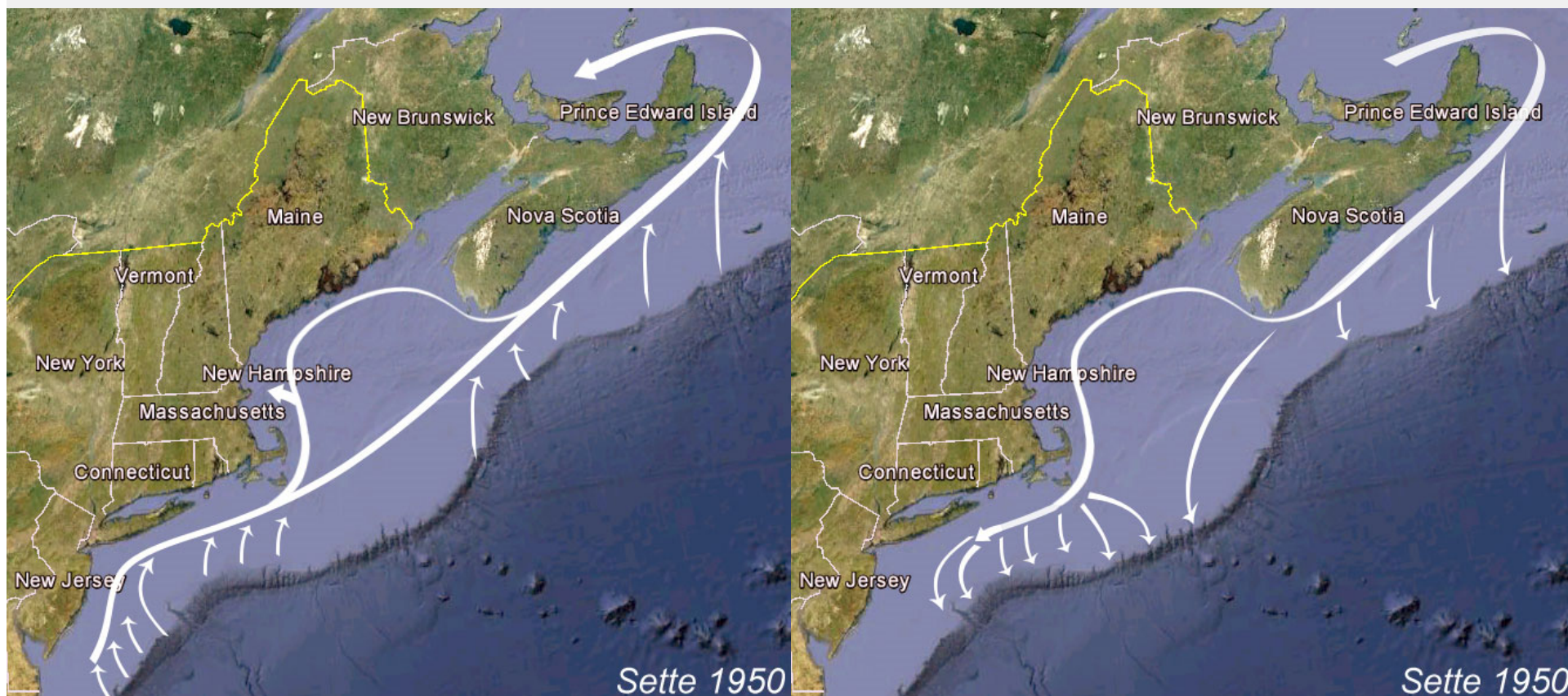


NW Atlantic mackerel seasonal migration patterns

(Sette 1950)

Spring Migration

Fall Migration



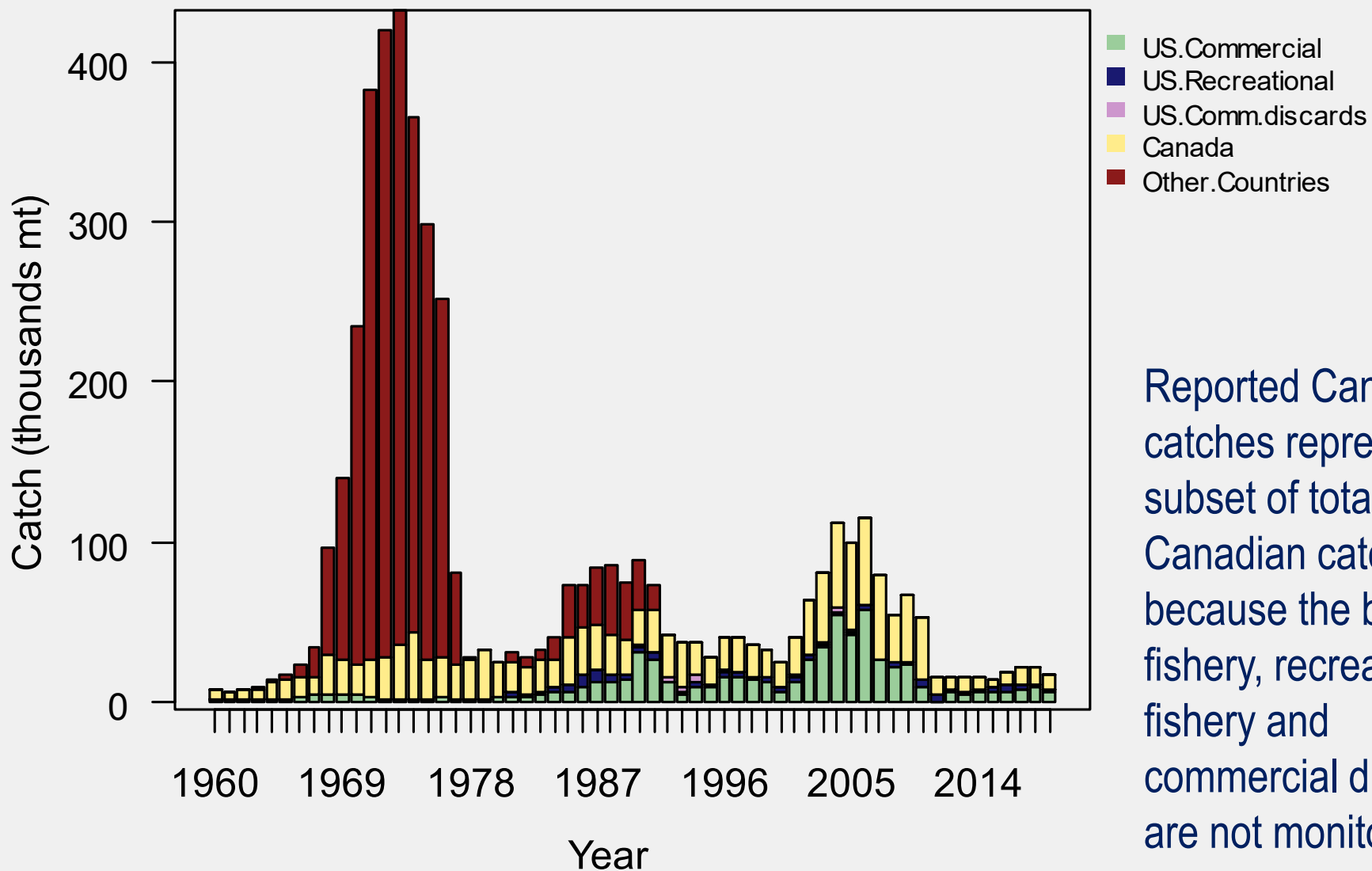
Background

- Last assessed and reviewed in November 2017 (SAW 64)
- Primary assessment model = ASAP (supporting models: censored catch & SAM)
 - 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⁺)
 - Projections based on empirical CDF derived using recruitment estimates from 1975 onward
 - BRPs: F40% as F_{msy} proxy (0.26)
- Resulting stock status: overfished (22.1% of SSB _{msy} proxy) with overfishing occurring (180% of F_{msy} proxy)
 - Frebuild = 0.237 (F to rebuild stock in five years)

Term of Reference 1:

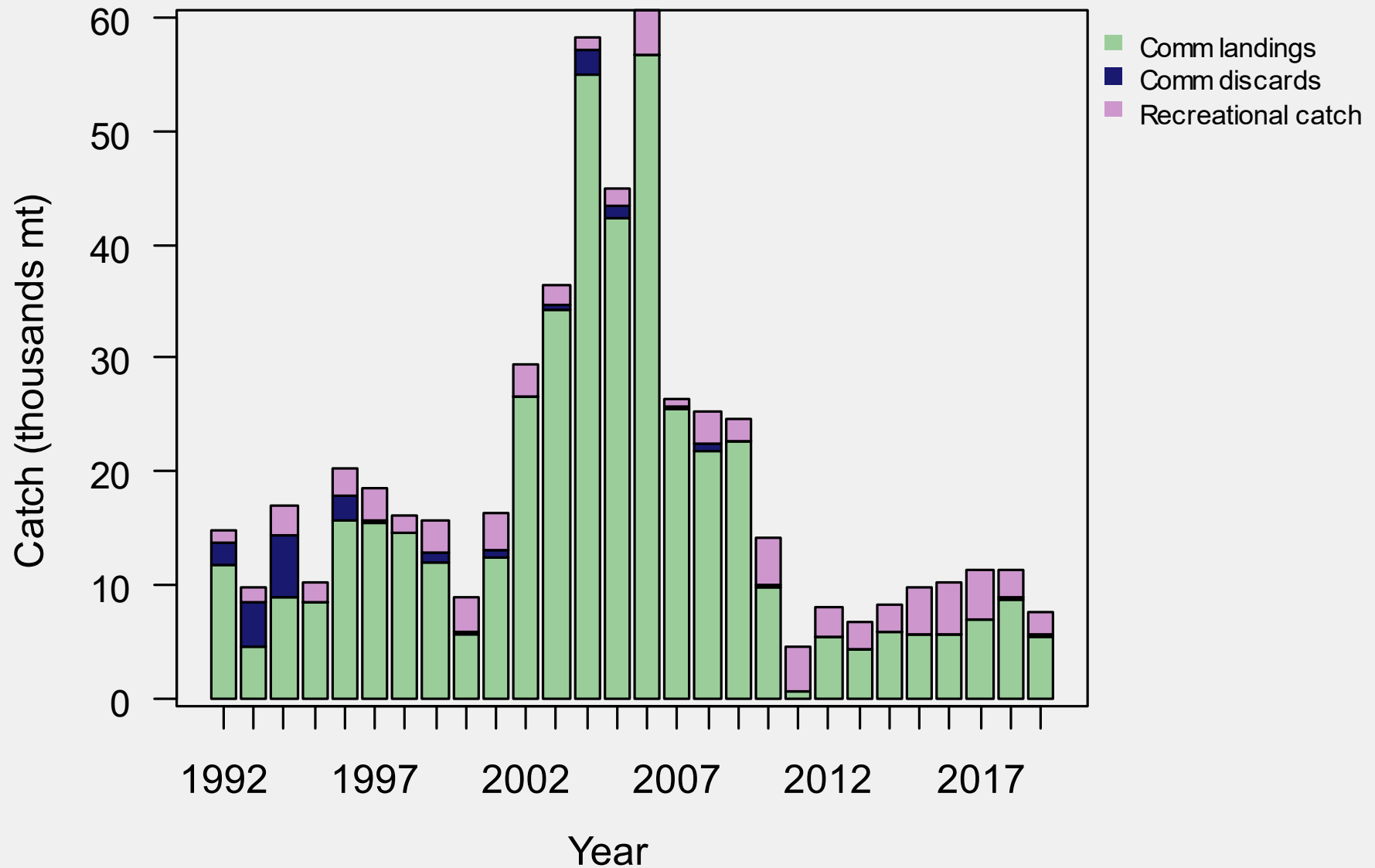
Estimate catch from all sources, including landings and discards

Total catch (thousands mt)

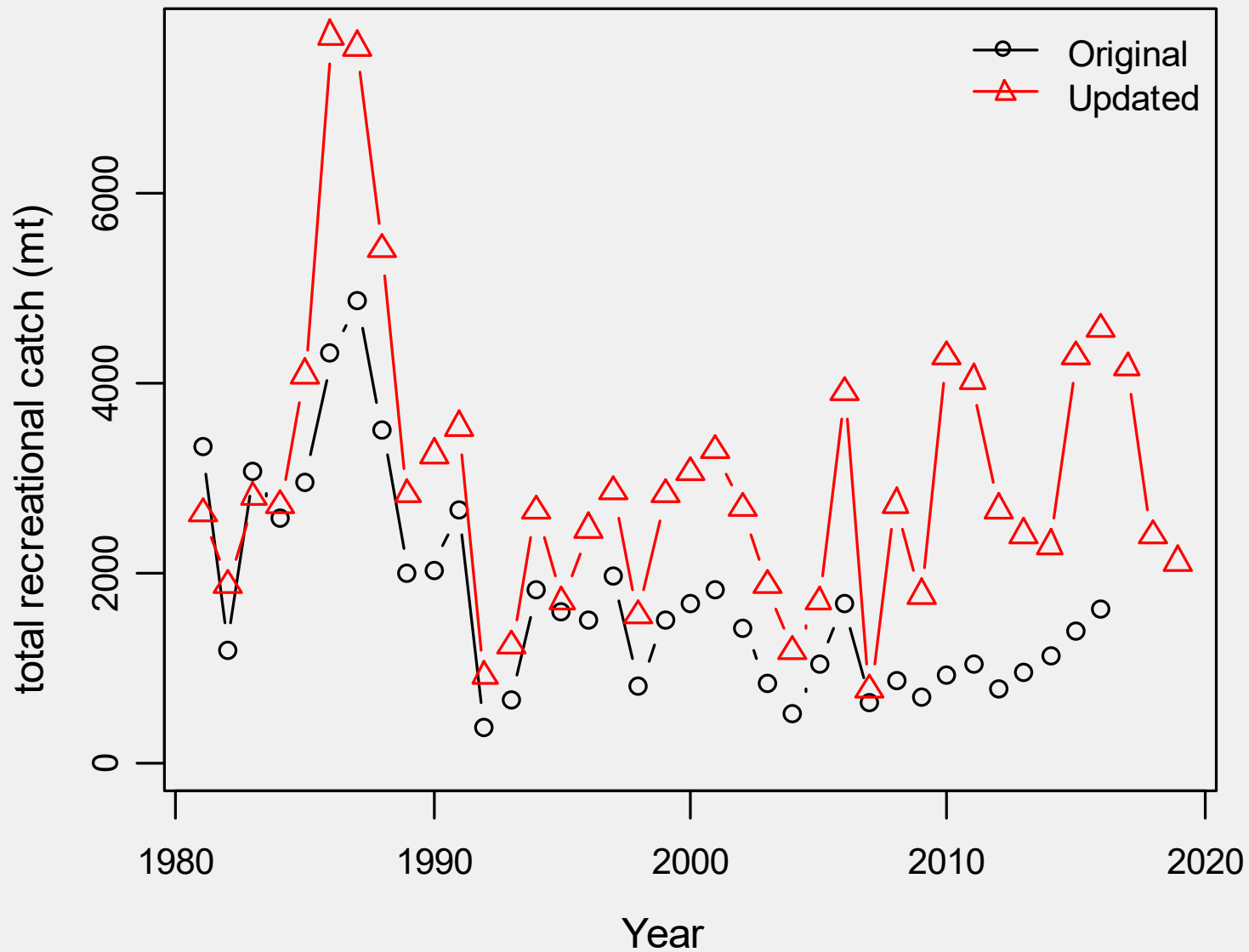


Reported Canadian catches represent a subset of total Canadian catch because the bait fishery, recreational fishery and commercial discards are not monitored.

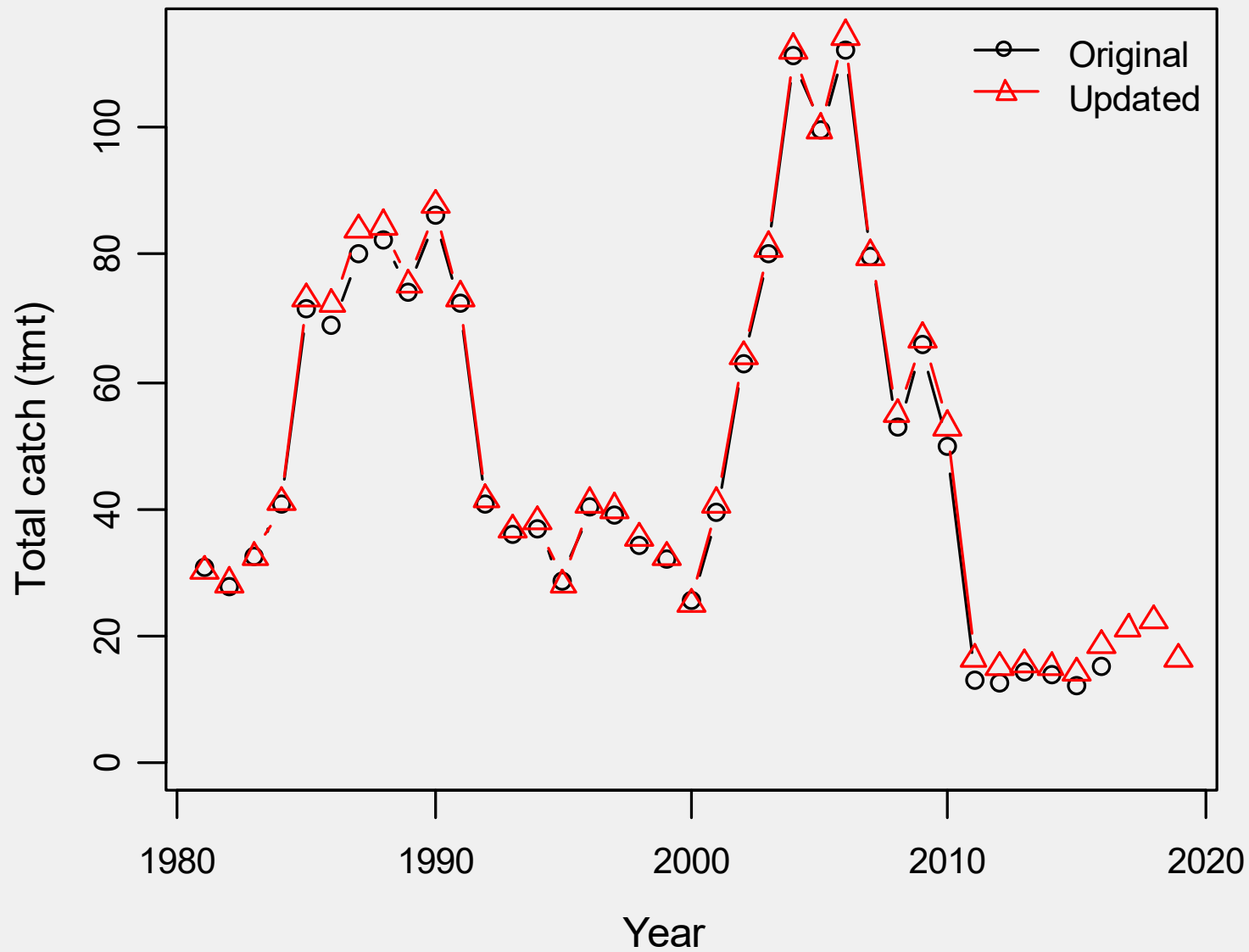
U.S. catch (thousands mt)



U.S. recreational catch: Recalibrated MRIP estimates



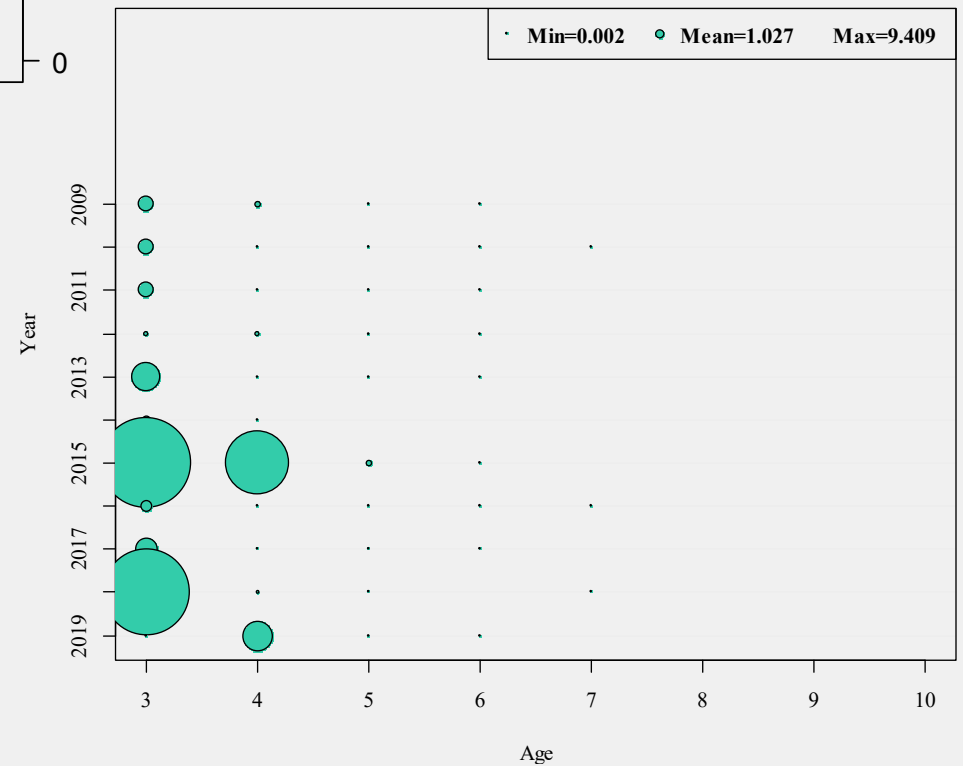
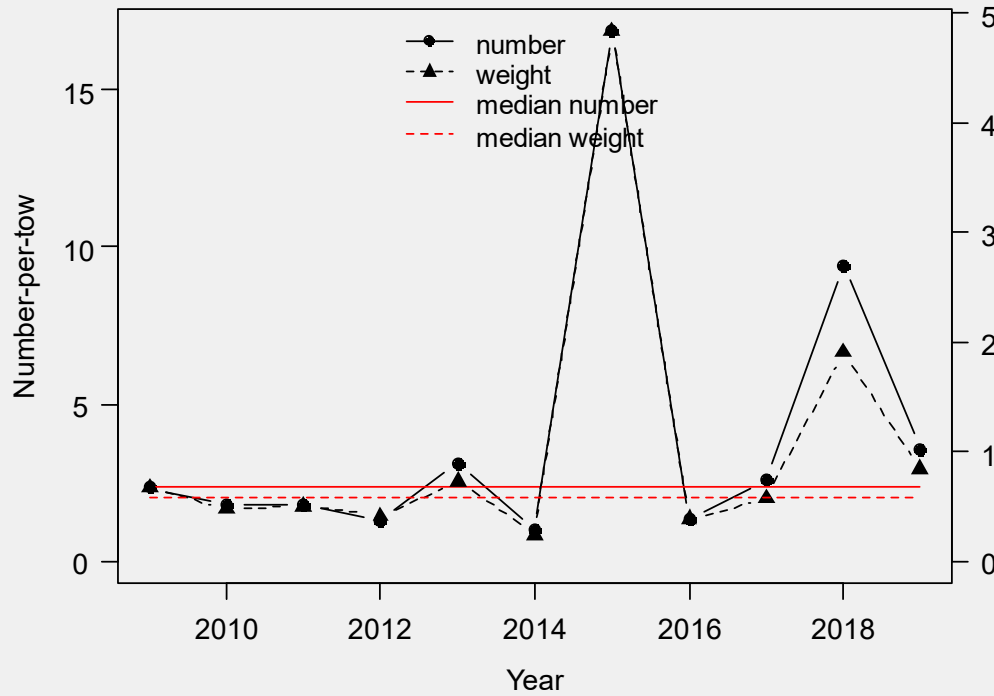
Updated total catch estimates



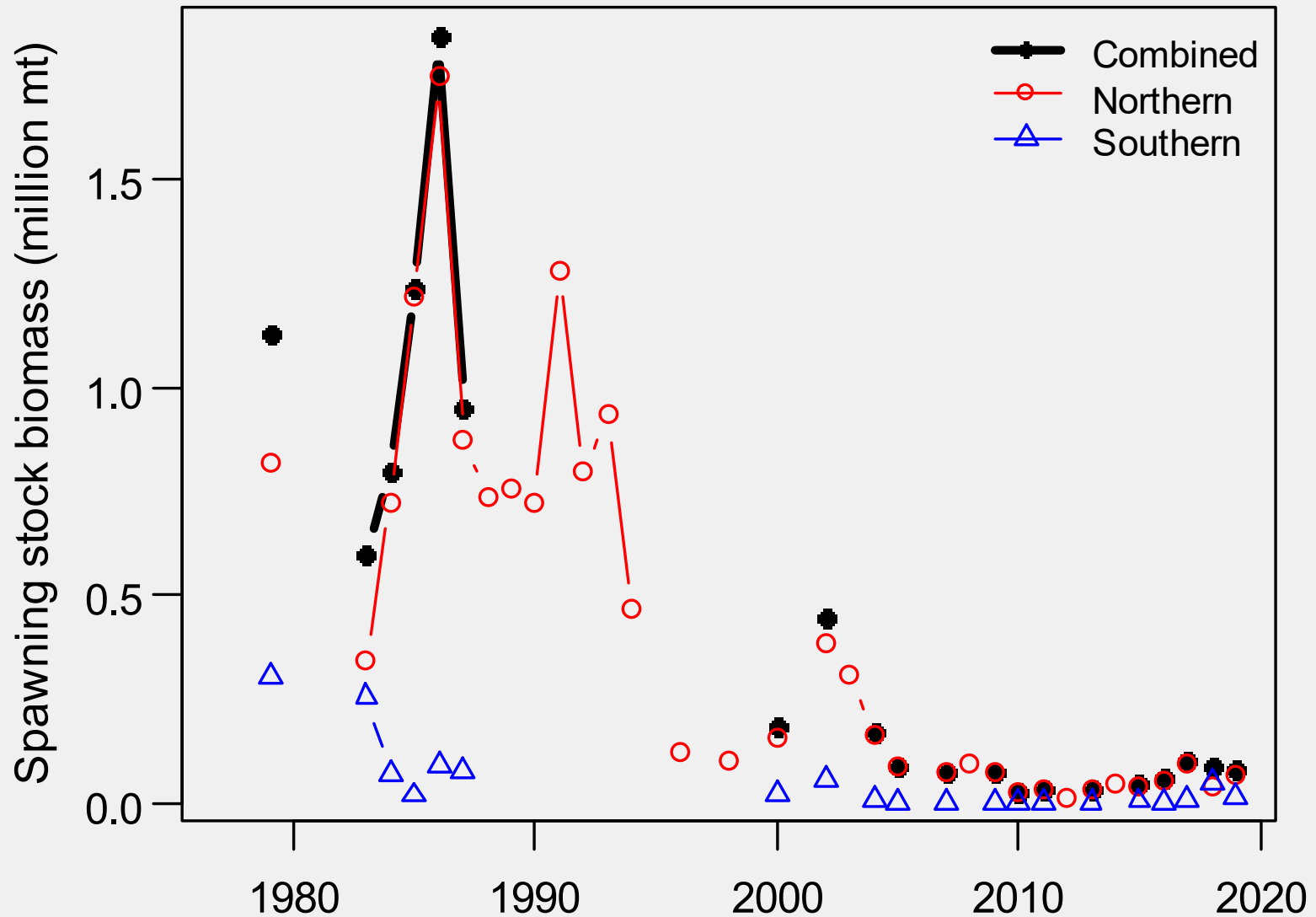
Term of Reference 2:

Evaluate indices used in the assessment

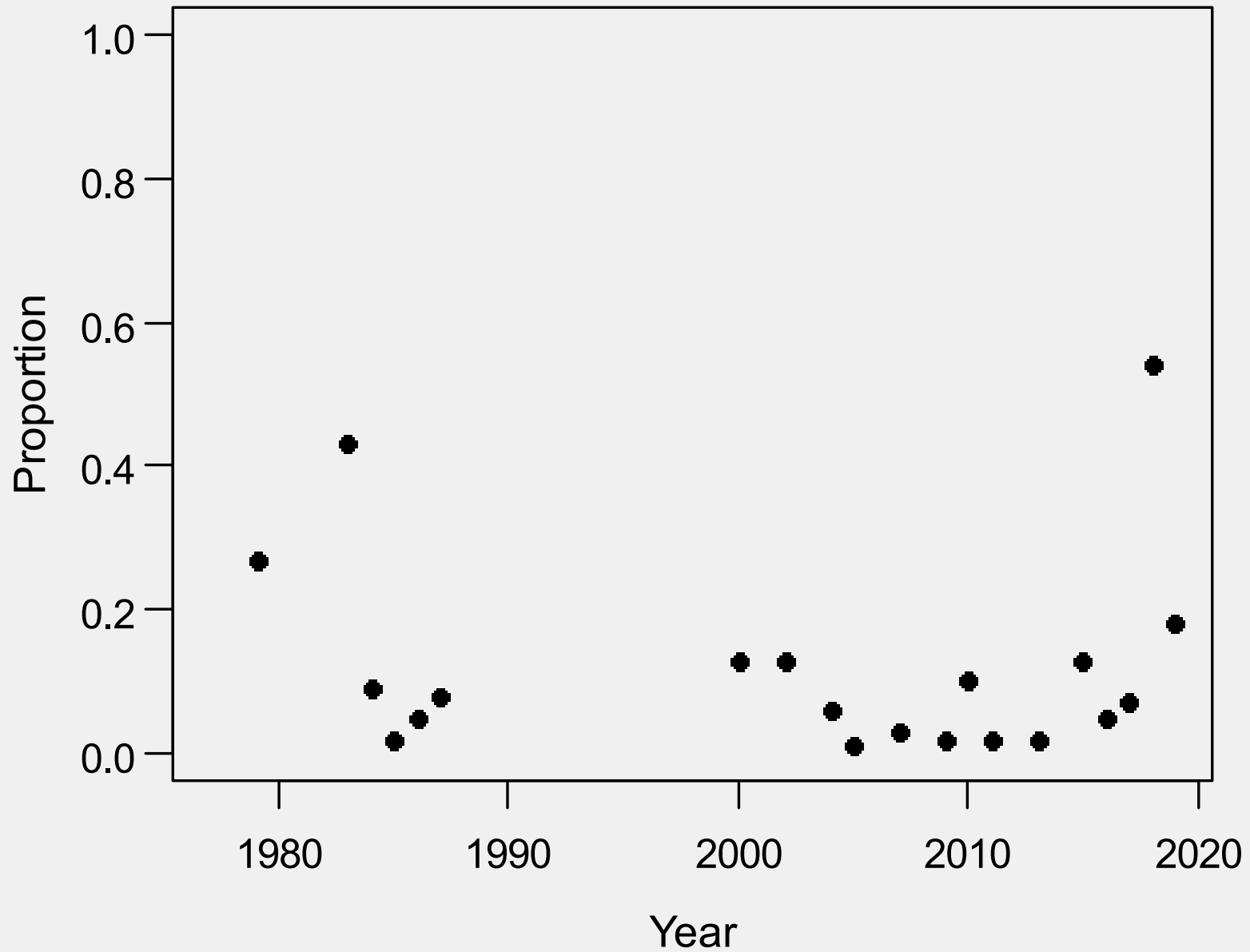
NEFSC spring survey: *Bigelow* years



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



Contribution of the southern spawning contingent



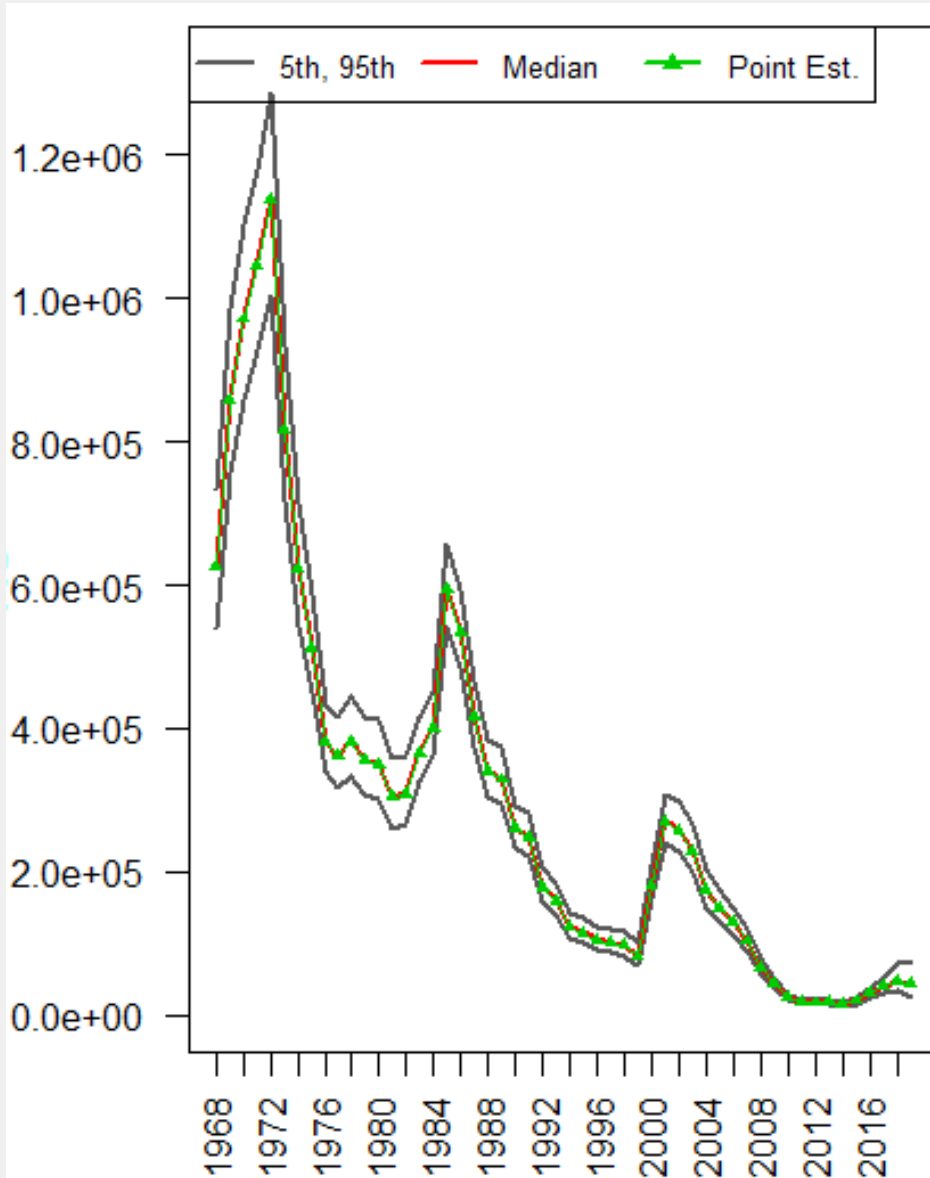
Term of Reference 3:

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.

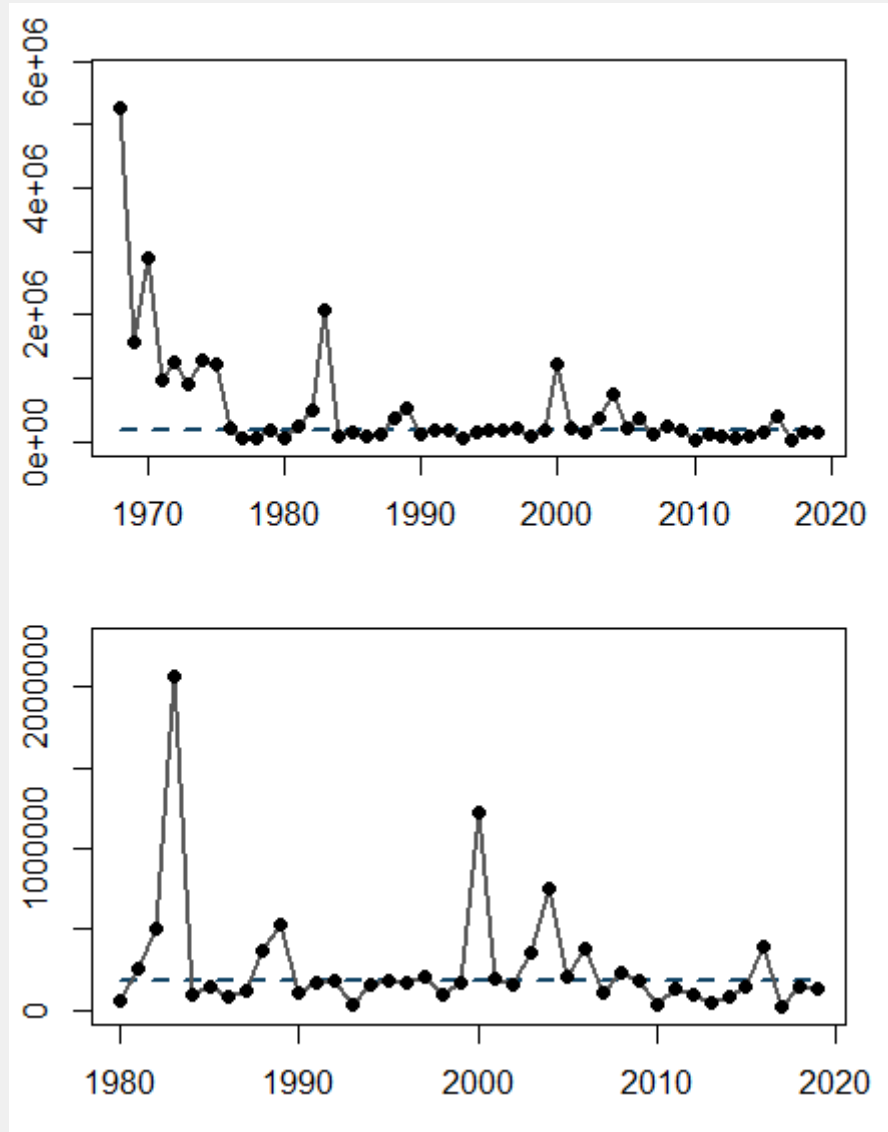
Include bridge runs from the previously accepted model to the updated model proposed for this peer review.

ASAP estimates:

Spawning stock biomass (mt)

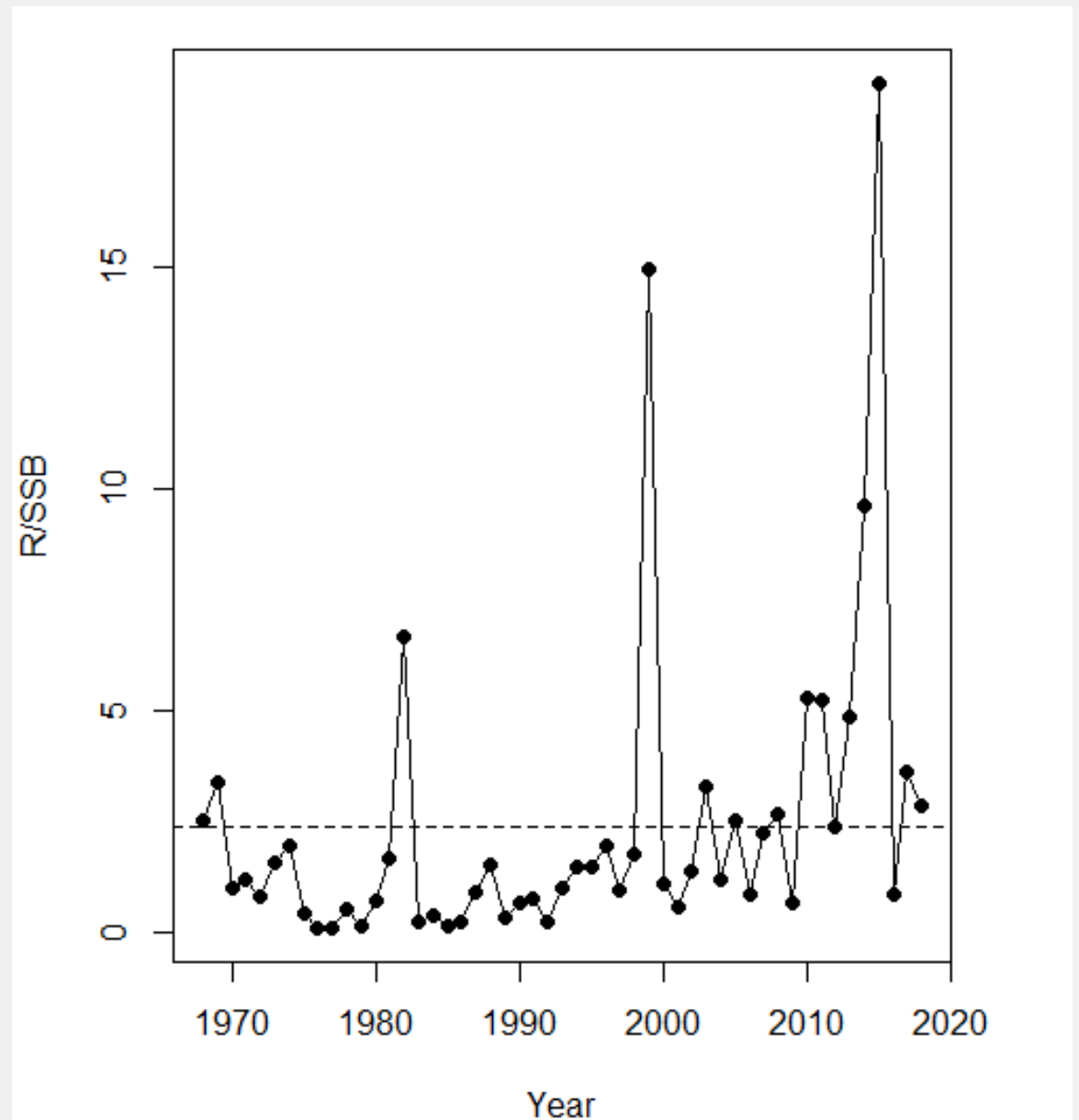


Recruitment (000s)

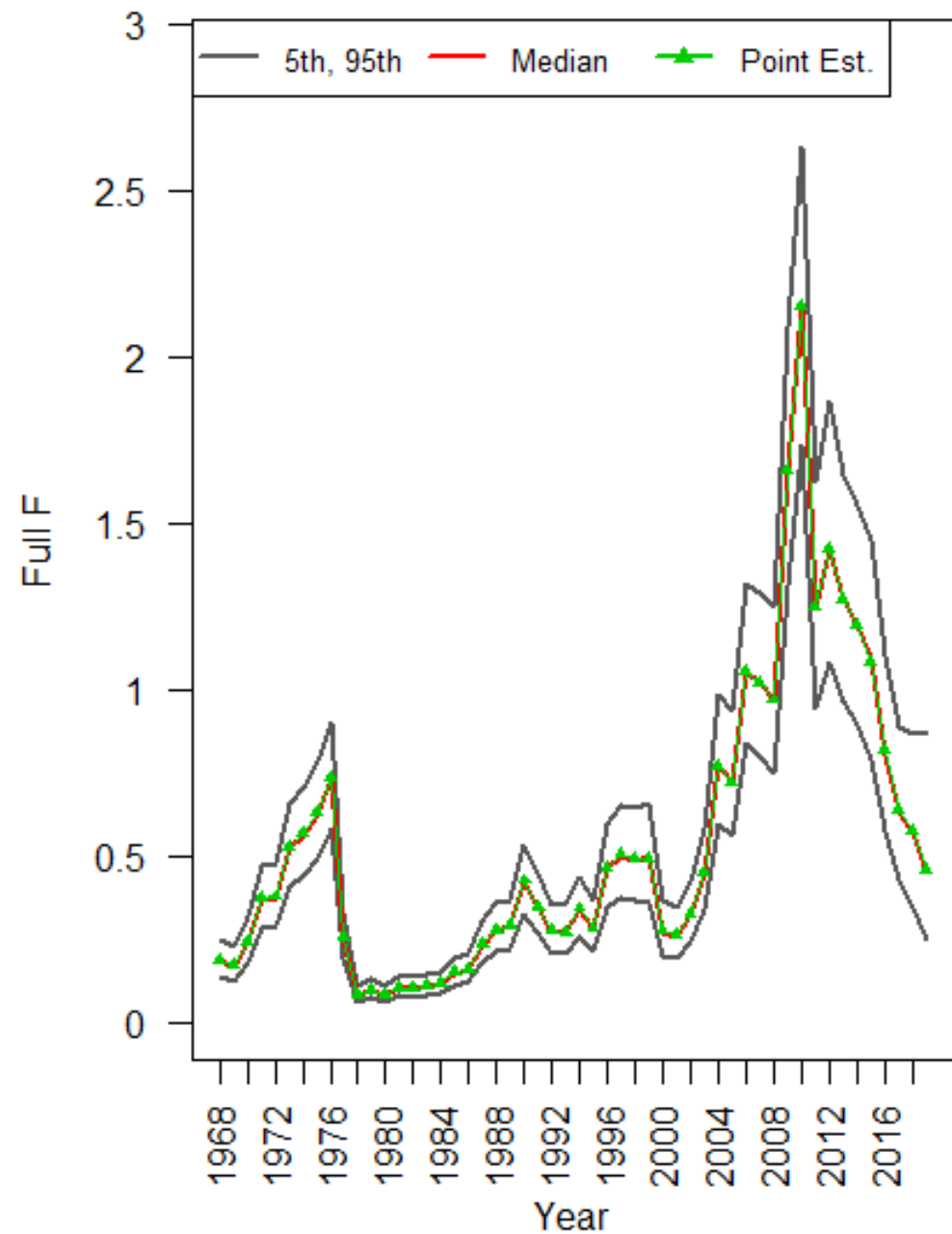


ASAP estimates:

R/SSB

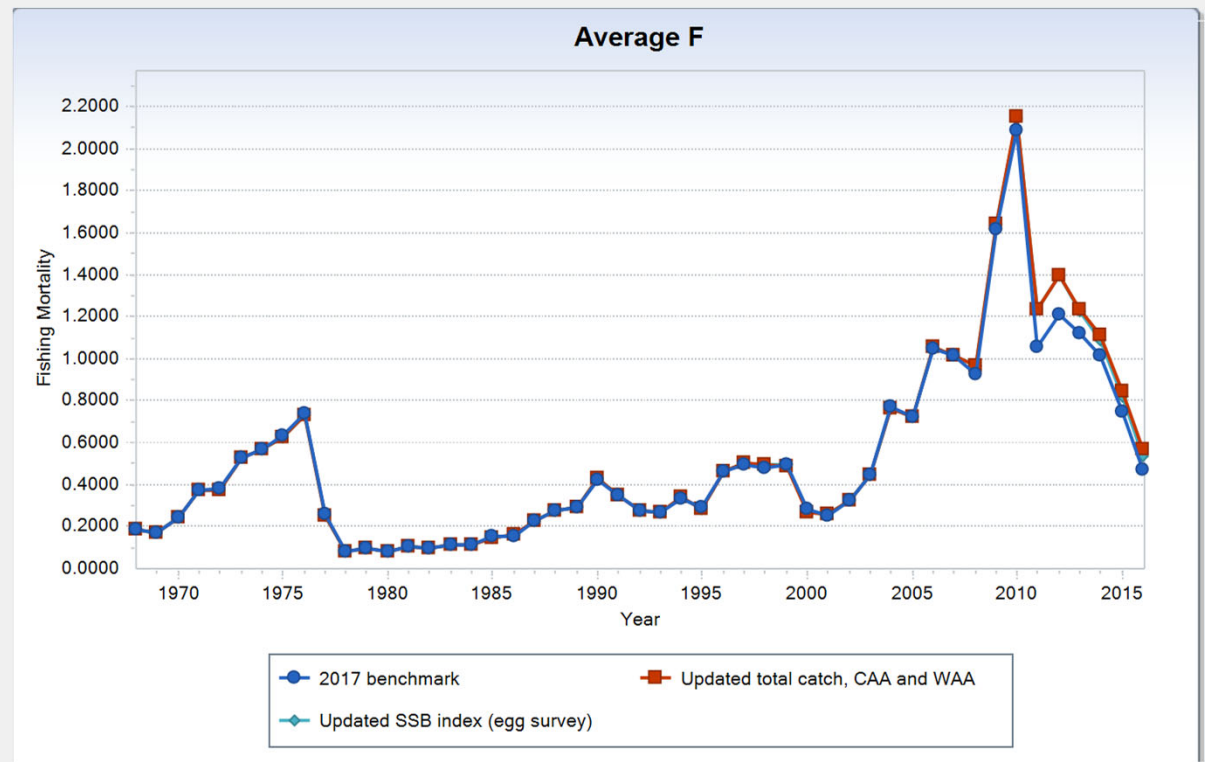
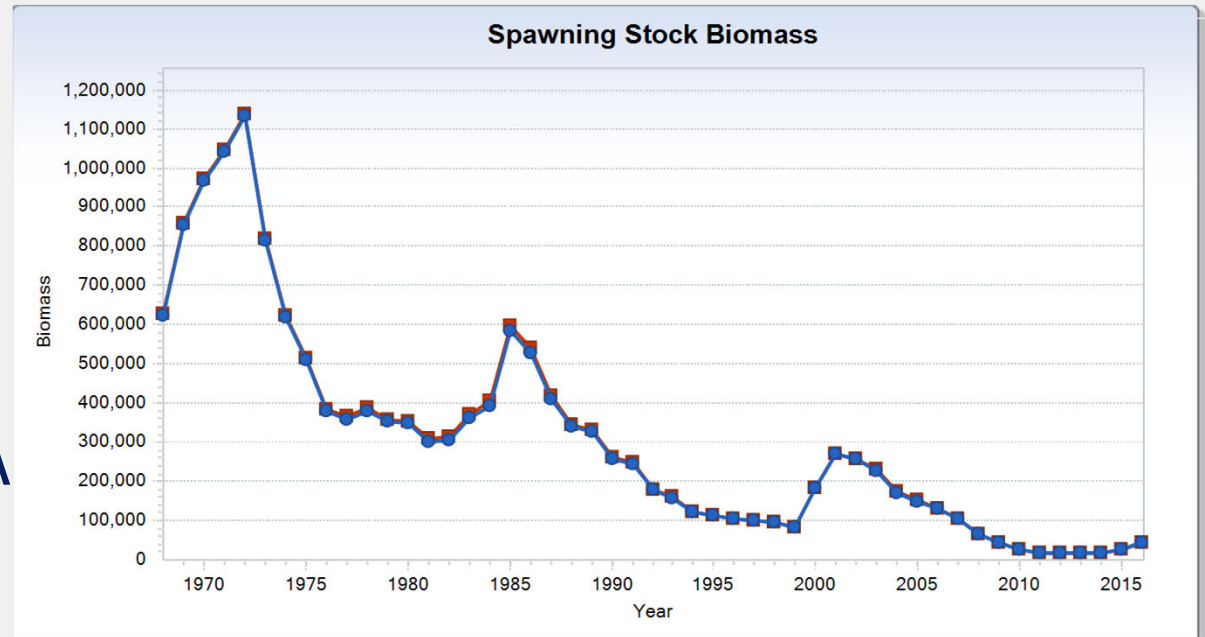


ASAP estimates: Fishing mortality

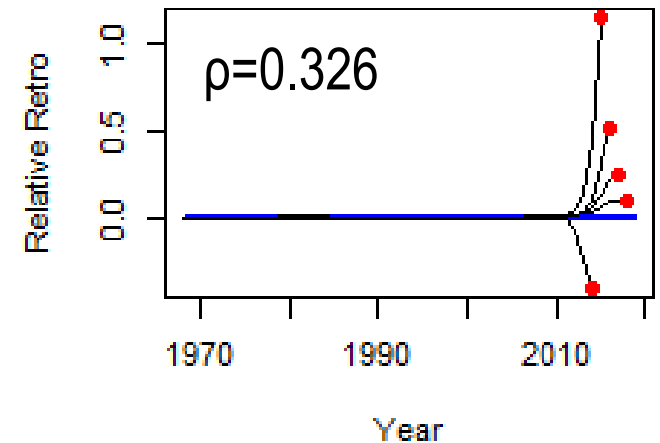
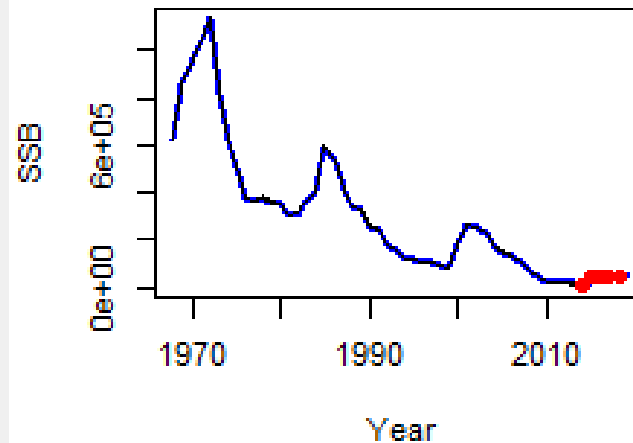
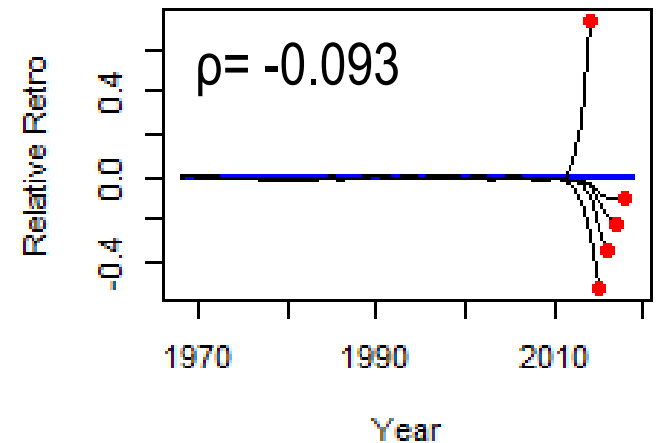
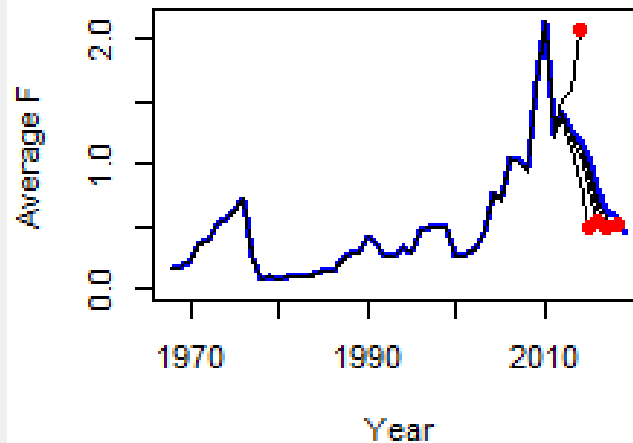


Bridge runs:

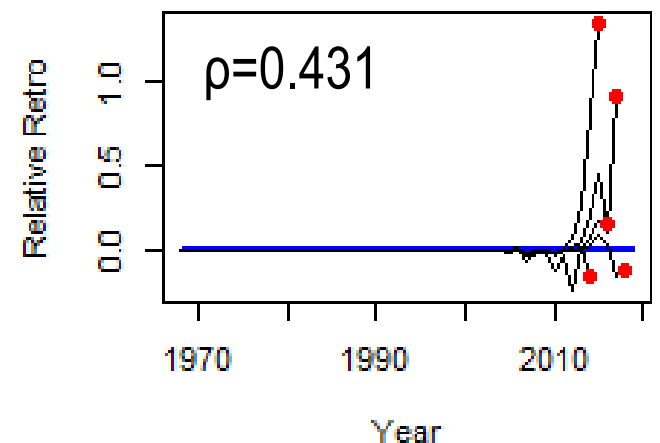
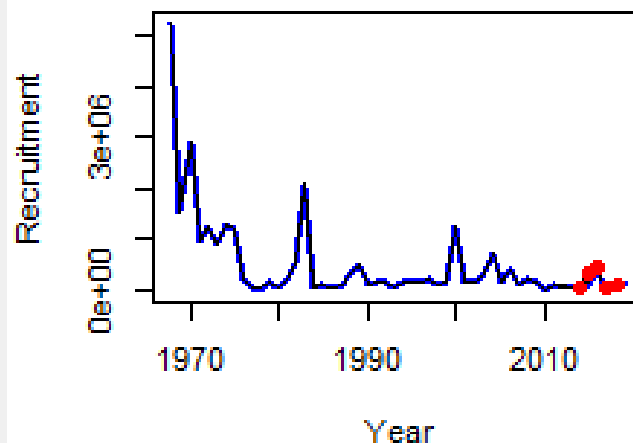
- 1) Revise fishery catch (MRIP, Canadian catch), CAA and WAA
- 2) Revise U.S. egg indices



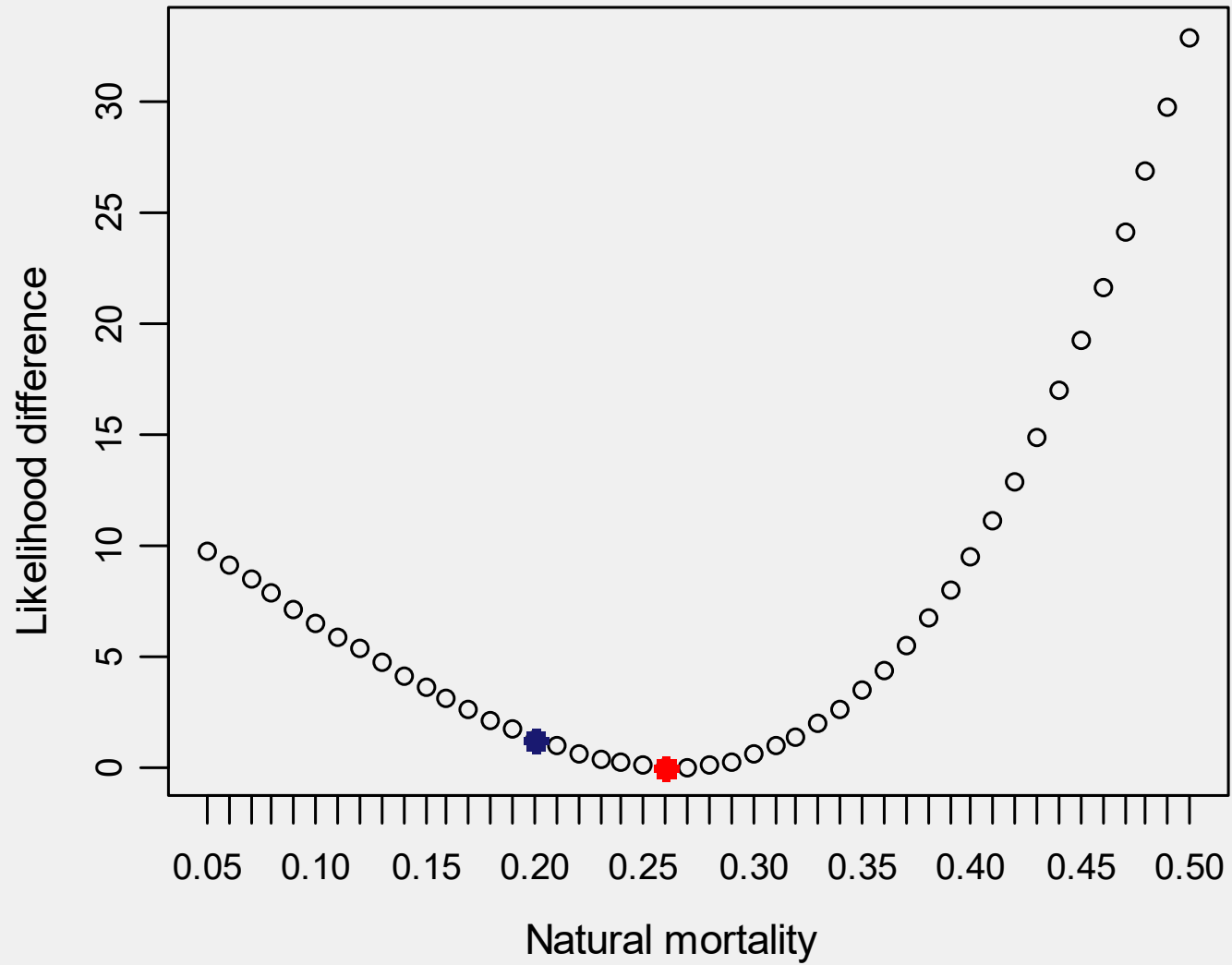
Retrospective analysis: 5 year peels 2014-2018



2017 benchmark
Mohns ρ estimates:
F = 0.112
SSB = 0.162
Rect = -0.074

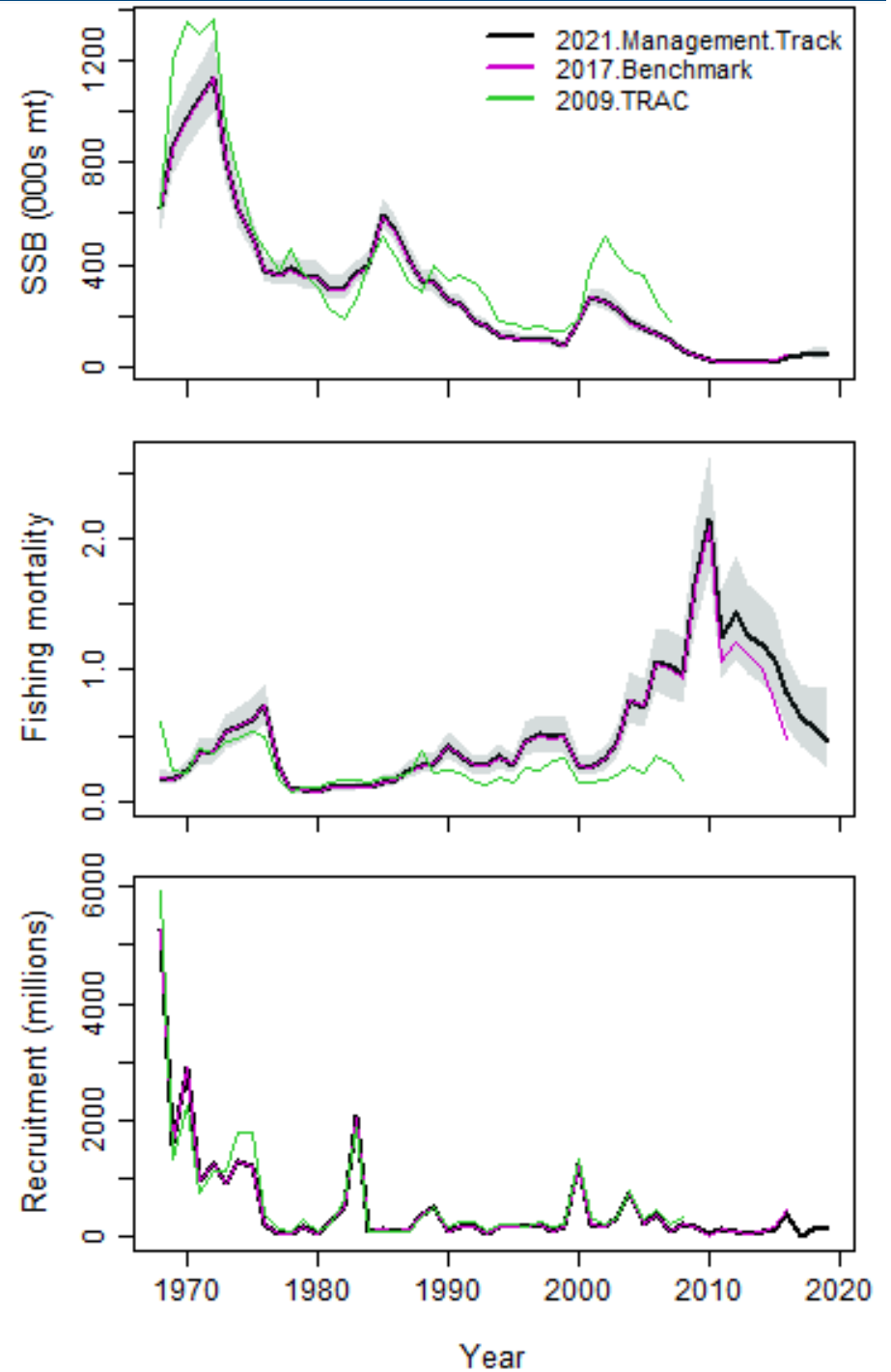


Natural mortality

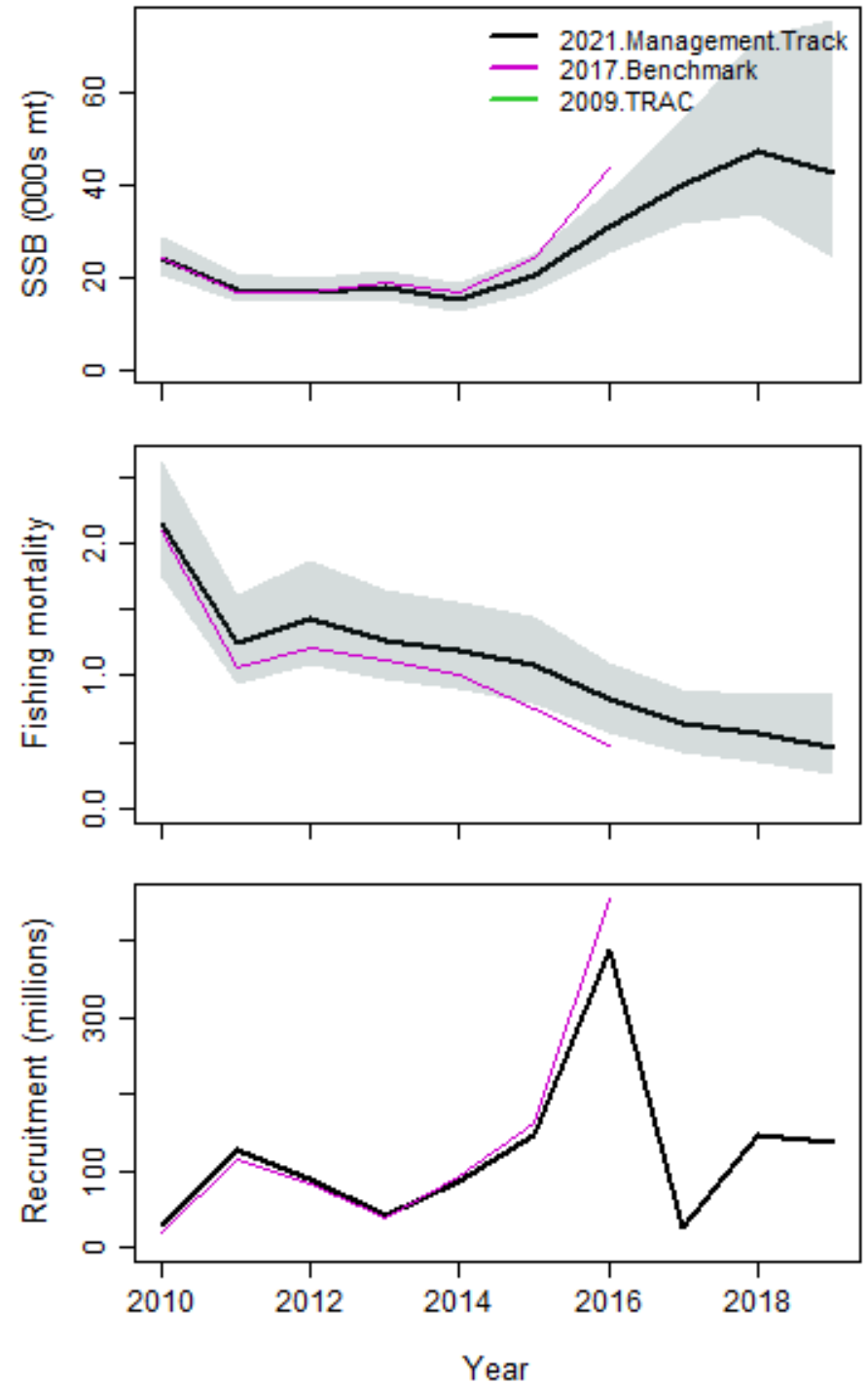


Historical retrospective

* 2009 TRAC did not pass peer review



Historical retrospective



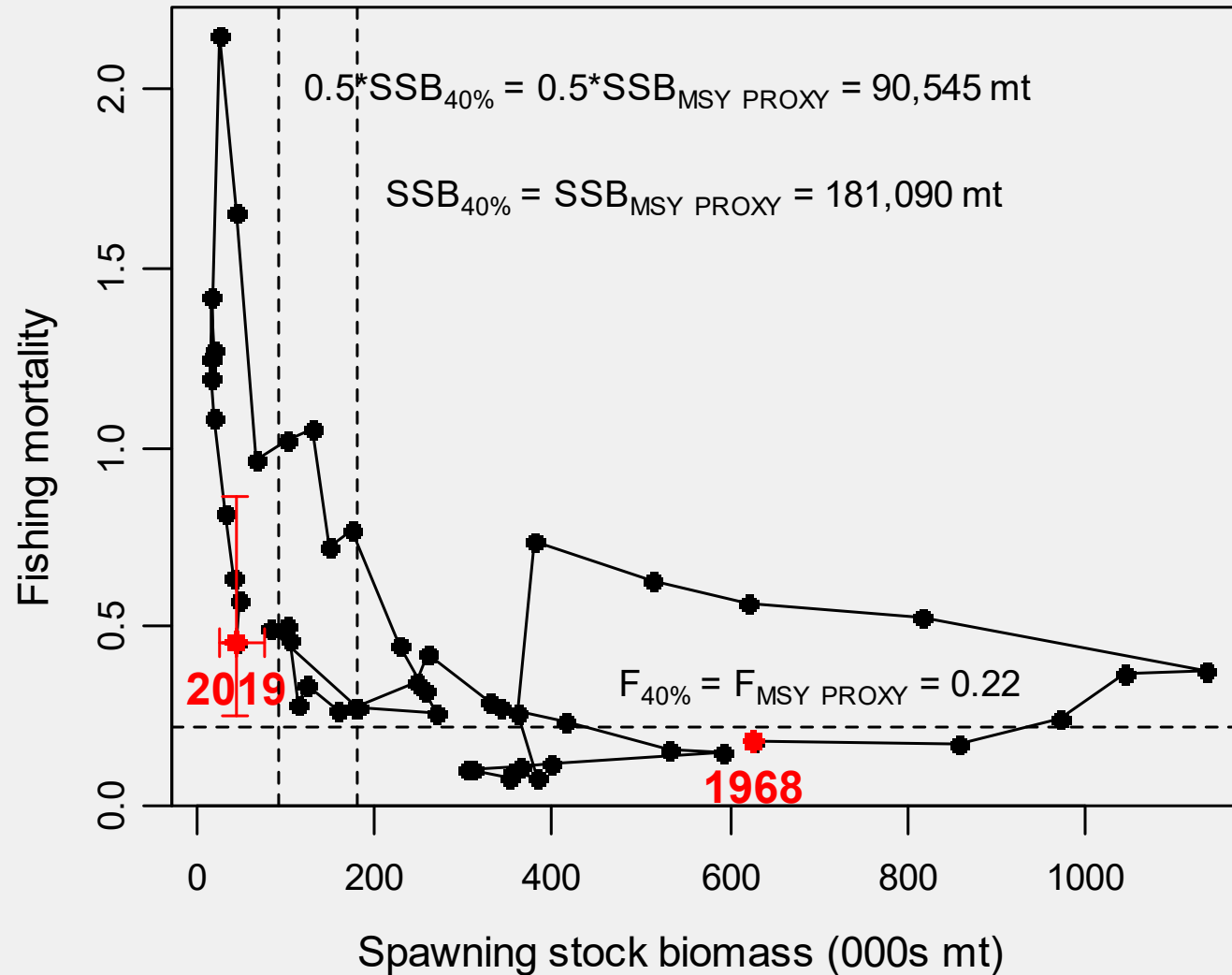
Term of Reference 4:

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

	2017 Bench.	2021 MT
$F_{MSY\ proxy}$	0.26	0.22
$SSB_{MSY\ proxy}$	196,894	181,090 (102,292-386,653)
$B_{MSY\ proxy}$	255,646	237,989 (134,641-486,985)
$MSY\ proxy$	41,334	34,103 (19,404-70,927)

Recommended stock status



2019 estimates:

F: 0.46
(0.25-0.87)

SSB: 42,862
(24,371-75,844)

Overfished (23.7% of SSB msy proxy) with overfishing occurring (208% of Fmsy proxy)

Qualitative stock status metrics

- Age truncation apparent in fishery catches
 - Age-9 fish were observed in 2019 fishery catch for the first time since 2012
- Range-wide SSB estimates from egg surveys have been below the time-series median since 2005
 - Southern contingent egg production was an order of magnitude greater in 2018-2019 compared to the previous decade
- With the exception of the 2015 year class, recruitment estimates have been below the time-series median since 2008
- 2016 year class was the smallest estimate of the time series

2021 Canadian assessment of the northern contingent

- In 2020, SSB was estimated to be 27,599 mt and 23.4% of the SSB msy proxy
- SSB has been in the critical zone since 2011.
- Fully selected fishing mortality was estimated to be 1.30 in 2020 and has been above F40% since 1998
- The 2015 year class was the only year class estimated to be greater than the time-series median since 2009, with this cohort now representing less than 8% of the harvested catch in 2020

Term of Reference 5:

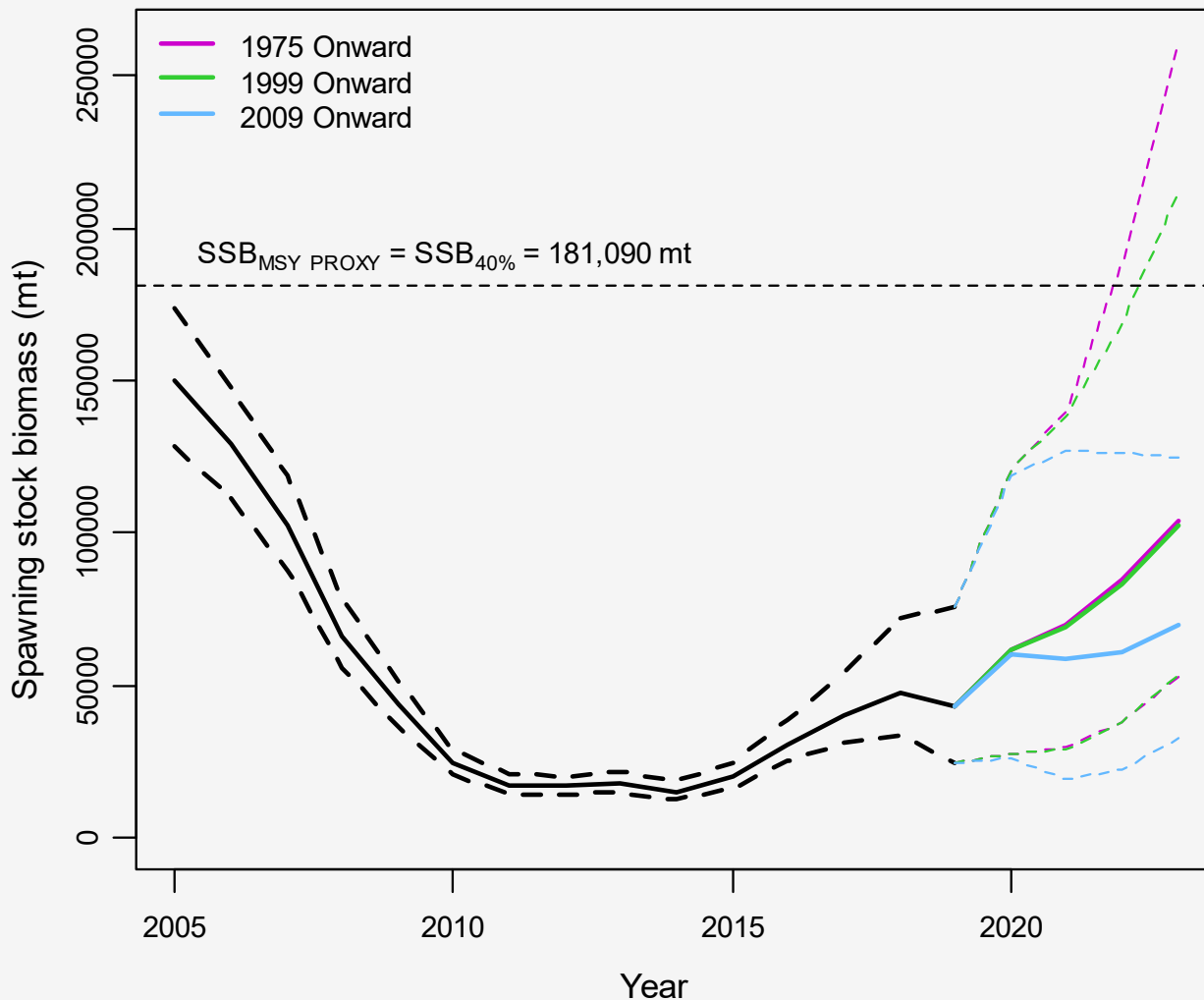
Conduct short-term projections

Short-term projections

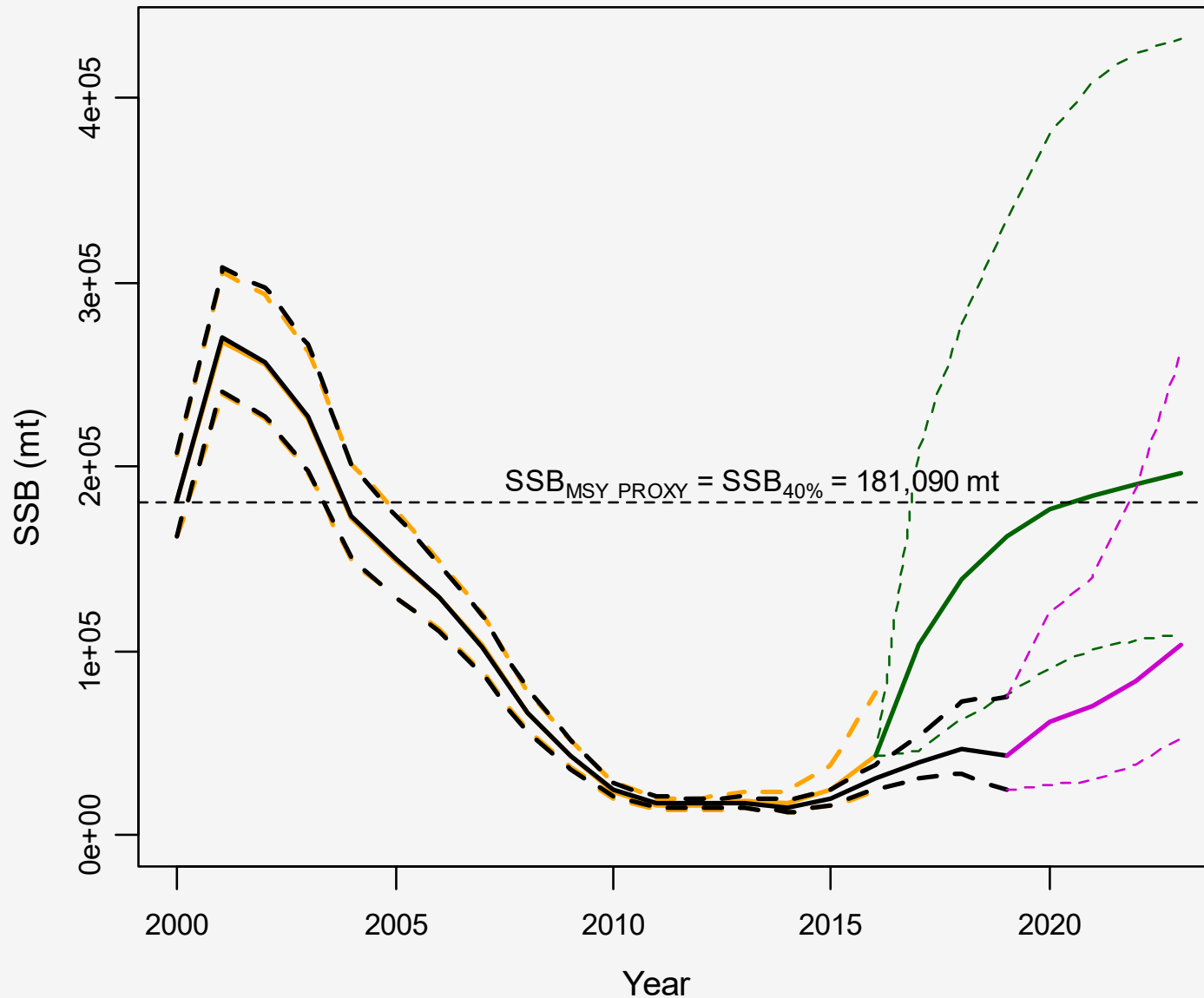
- Following approved methodology, recruitment sampled from an empirical CDF derived using recruitment estimates from 1975 through the terminal year
 - Sensitivity analyses: empirical CDF based on recruitment estimates from 1999 onward and 2009 onward
- Interim catch assumptions
 - 2020: Preliminary US & Canadian catch estimates (18,038 mt)
 - 2021: Sum of U.S. and Canadian ABCs (23,184 mt)
- Canadian assessment:
 - Biological reference points were derived using the full recruitment time series estimated in the model (1968-2020)
 - Short-term projections were derived using 1) the full recruitment time series and 2) the mean recruitment over the last decade

2-year projections, Fmsy SSB (mt)

	1975 Onward	1999 Onward	2009 Onward
2020	62,039	62,039	60,343
2021	70,137	69,471	58,709
2022	84,382	83,273	60,723
2023	103,970	102,420	69,562



Comparison with 2017 benchmark projections



ASAP estimates:

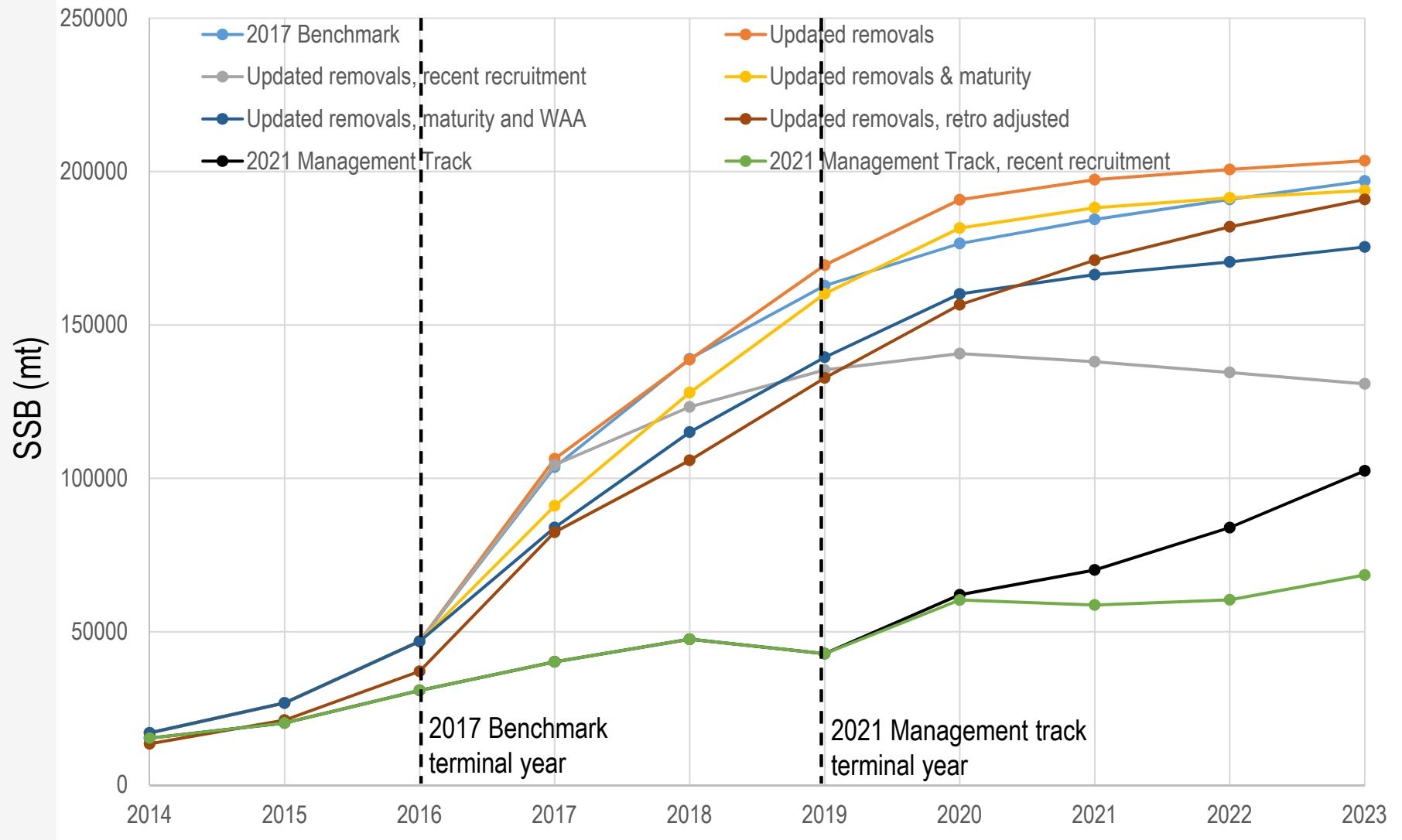
2017 Benchmark
2021 MT

Projections:

2017 Benchmark
(Frebuild, 0.237)

2021 MT
(Fmsy, 0.22)

Comparison with 2017 benchmark projections

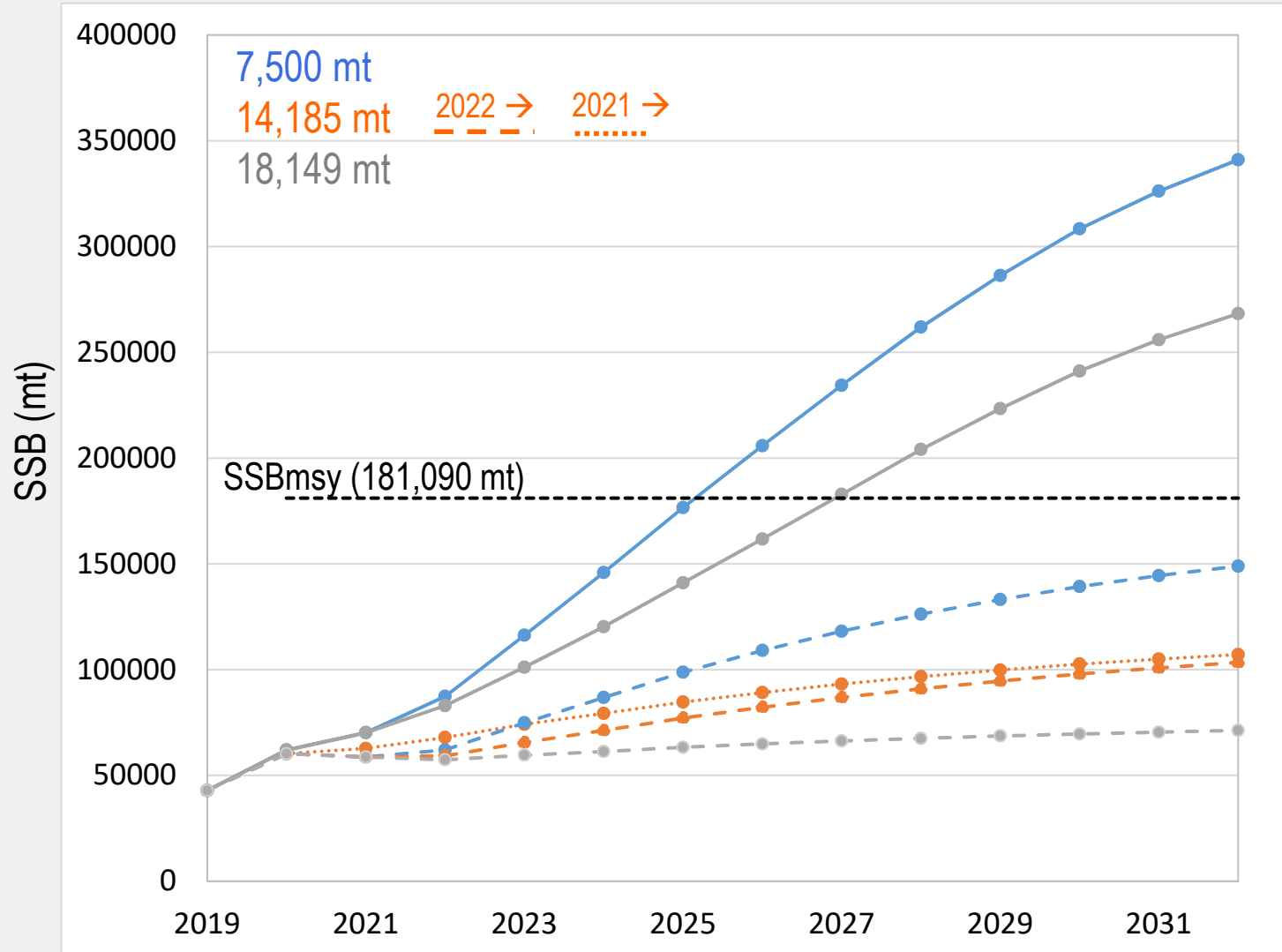


10-year projections for SSC

- Recruitment assumptions: 1975 onward and 2009 onward
- Constant catch scenarios: 7,500mt, 14,185 mt, 18,149 mt
- 25%, 50%, 75%, 90% and 100% of F_{msy} to provide idea of rebuilding timelines
- P^* : 100% and 150% CV using BRPs derived using recruitment estimates from 1975 onward

Constant catch

Rect assumption:



1975 onward

2009 onward

Rebuilding timelines (bracketed using proportion of MSY)

Percent of Fmsy	F	Rect.1975	Rect.2009
100%	0.22	(178,427)	(91,914)
90%	0.2	2030	(97,681)
75%	0.16	2028	(107,590)
50%	0.11	2026	(128,388)
25%	0.06	2025	(156,648)
0%	0	2025	2030

Year rebuilt or **SSB** in 2032

P*: 100%CV, Recruitment 1975 onward

Year	Catch	OFL	ABC	ABC p*	F	SSB	B/Bmsy
2020	18038	N/A	N/A	N/A	0.37	61986	0.34
2021	23184	N/A	N/A	N/A	0.41	70200	0.39
2022	6142	14,886	6,142	0.144	0.09	87874	0.49
2023	9790	20,171	9,790	0.193	0.1	116671	0.64
2024	15113	25,038	15113	0.272	0.13	141934	0.78
2025	20849	29266	20849	0.342	0.15	162759	0.90
2026	26215	32,414	26215	0.399	0.17	177253	0.98
2027	30546	34,681	30546	0.439	0.19	187460	1.04
2028	32840	36,247	32840	0.453	0.2	194878	1.08
2029	34055	37,330	34055	0.456	0.2	199773	1.10
2030	34865	38,045	34865	0.458	0.2	203315	1.12
2031	35304	38,398	35304	0.460	0.2	204821	1.13
2032	35453	38,506	35453	0.460	0.2	205096	1.13

P*: 150%CV, Recruitment 1975 onward

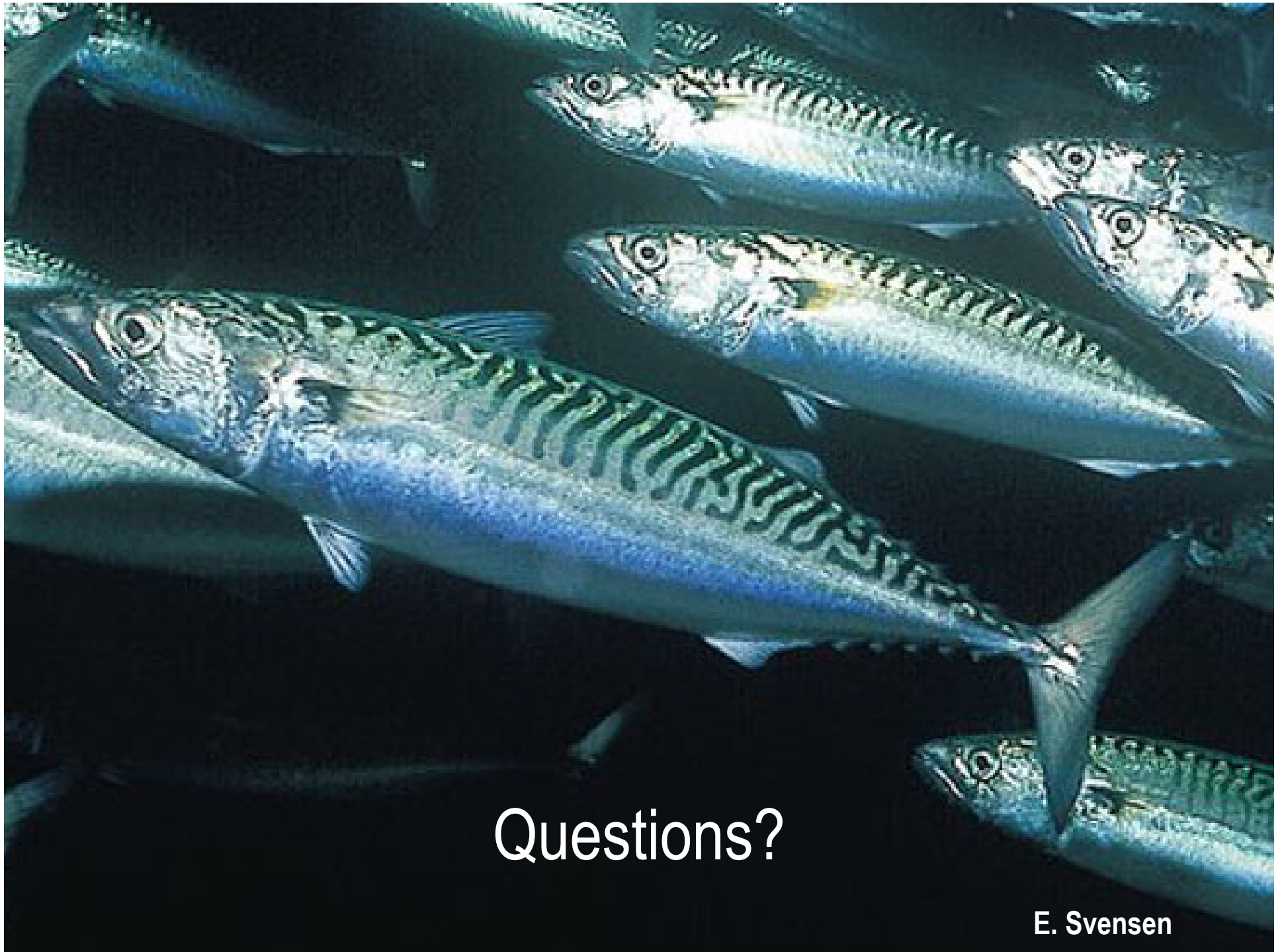
Year	Catch	OFL	ABC	ABC p*	F	SSB	B/Bmsy
2020	18038	N/A	N/A	N/A	0.37	61986	0.34
2021	23184	N/A	N/A	N/A	0.41	70200	0.39
2022	4693	14,886	4,693	0.144	0.07	88427	0.49
2023	8004	20,420	8,004	0.194	0.08	118820	0.66
2024	13510	25,596	13510	0.278	0.11	145753	0.80
2025	19953	30102	19953	0.352	0.14	167712	0.93
2026	26286	33,365	26285	0.413	0.17	182339	1.01
2027	31067	35,554	31067	0.451	0.19	191863	1.06
2028	32668	36,958	32668	0.455	0.19	198734	1.10
2029	33878	38,009	33878	0.458	0.19	203385	1.12
2030	34676	38,687	34676	0.460	0.19	206811	1.14
2031	35104	39,003	35104	0.461	0.2	208140	1.15
2032	35240	39,091	35240	0.462	0.2	208211	1.15

P*: 100%CV, Recruitment 2009 onward

Year	Catch	OFL	ABC	ABC p*	F	SSB	B/Bmsy
2020	18038	N/A	N/A	N/A	0.38	60284	0.33
2021	23184	N/A	N/A	N/A	0.48	58686	0.32
2022	3931	10,817	3,931	0.112	0.08	63502	0.35
2023	5292	13,770	5,292	0.125	0.08	79251	0.44
2024	7345	16,318	7345	0.169	0.09	92411	0.51
2025	9318	18493	9318	0.205	0.11	103372	0.57
2026	11006	20,062	11006	0.235	0.12	110741	0.61
2027	12245	21,150	12245	0.256	0.12	115606	0.64
2028	13088	21,844	13088	0.269	0.13	118692	0.66
2029	13616	22,245	13615	0.278	0.13	120438	0.67
2030	13922	22,477	13922	0.283	0.13	121513	0.67
2031	14099	22,597	14099	0.286	0.13	122023	0.67
2032	14189	22,663	14189	0.287	0.13	122298	0.68

P*: 150%CV, Recruitment 2009 onward

Year	Catch	OFL	ABC	ABC p*	F	SSB	B/Bmsy
2020	18038	N/A	N/A	N/A	0.38	60284	0.33
2021	23184	N/A	N/A	N/A	0.48	58686	0.32
2022	2890	10,817	2,890	0.112	0.06	63911	0.35
2023	4032	13,951	4,032	0.126	0.06	80783	0.45
2024	6009	16,712	6009	0.173	0.07	95168	0.53
2025	8047	19113	8047	0.213	0.09	107286	0.59
2026	9904	20,867	9904	0.246	0.1	115537	0.64
2027	11318	22,086	11318	0.269	0.11	121016	0.67
2028	12305	22,863	12305	0.284	0.11	124453	0.69
2029	12927	23,304	12927	0.294	0.12	126312	0.70
2030	13273	23,546	13273	0.299	0.12	127411	0.70
2031	13465	23,661	13465	0.302	0.12	127891	0.71
2032	13552	23,716	13552	0.303	0.12	128100	0.71

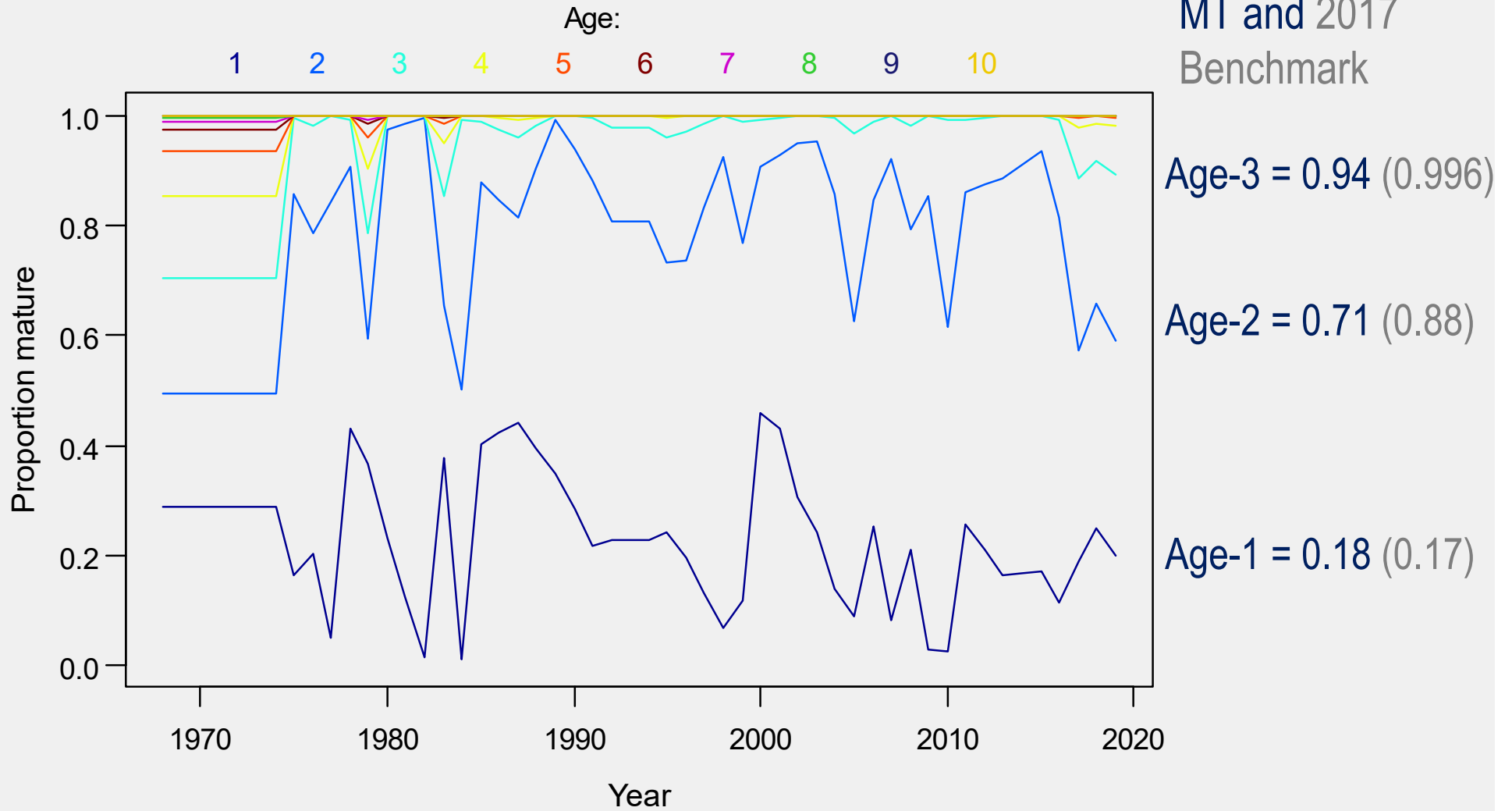


Questions?

E. Svensen

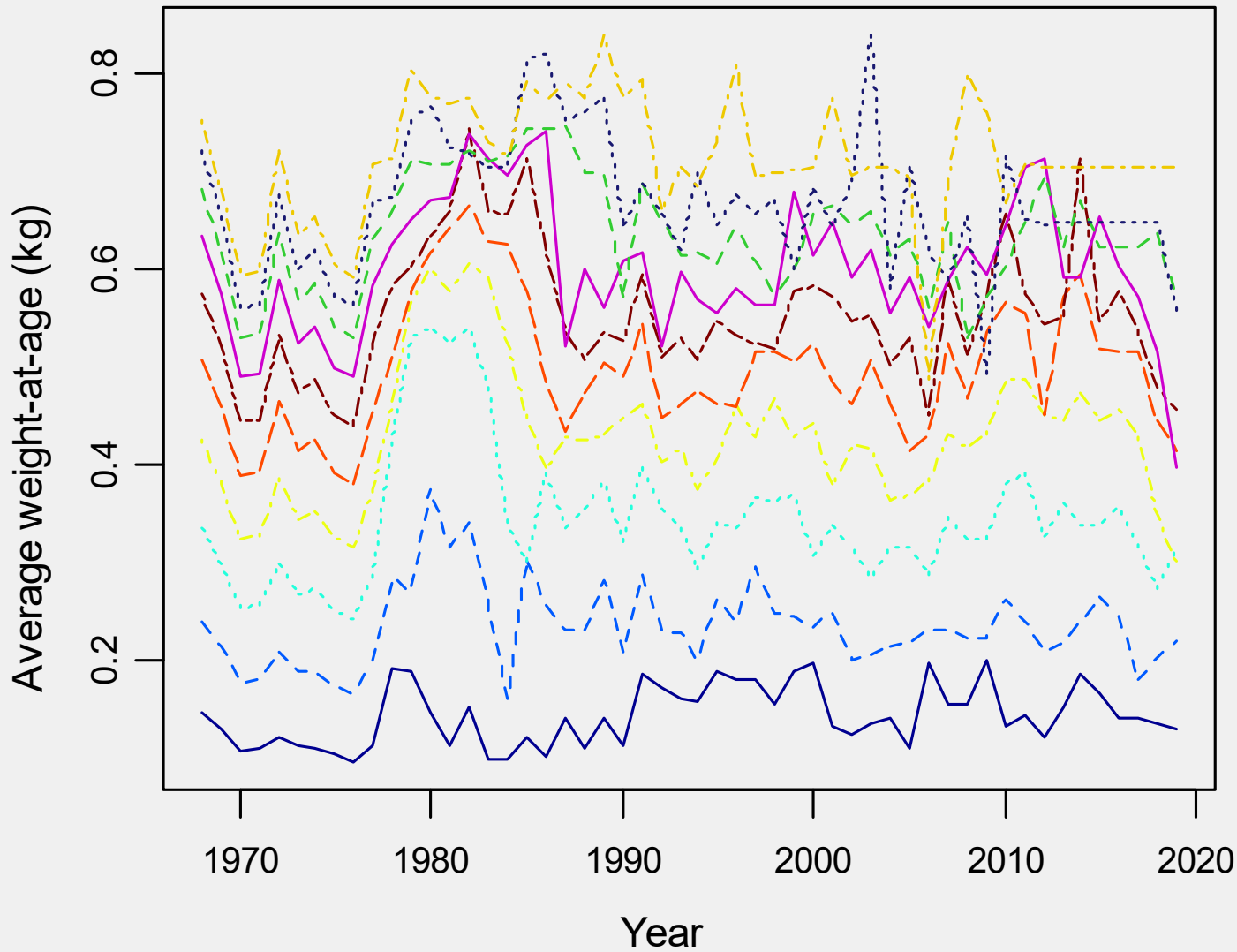
Maturity

Recent 5-year averages for 2021 MT and 2017 Benchmark

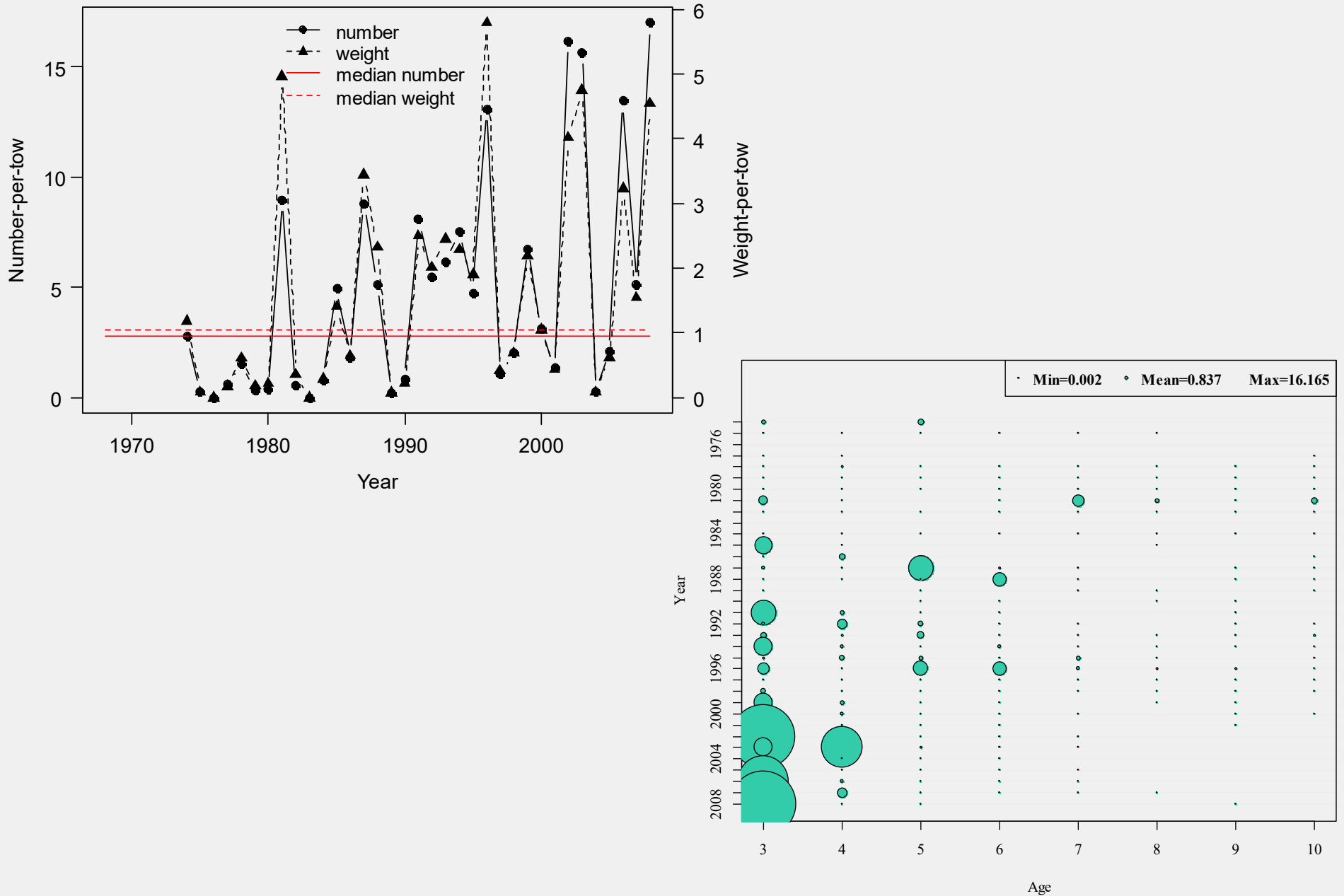


SSB Weight-at-age

Recent 5-year averages for 2021 MT and 2017 Benchmark

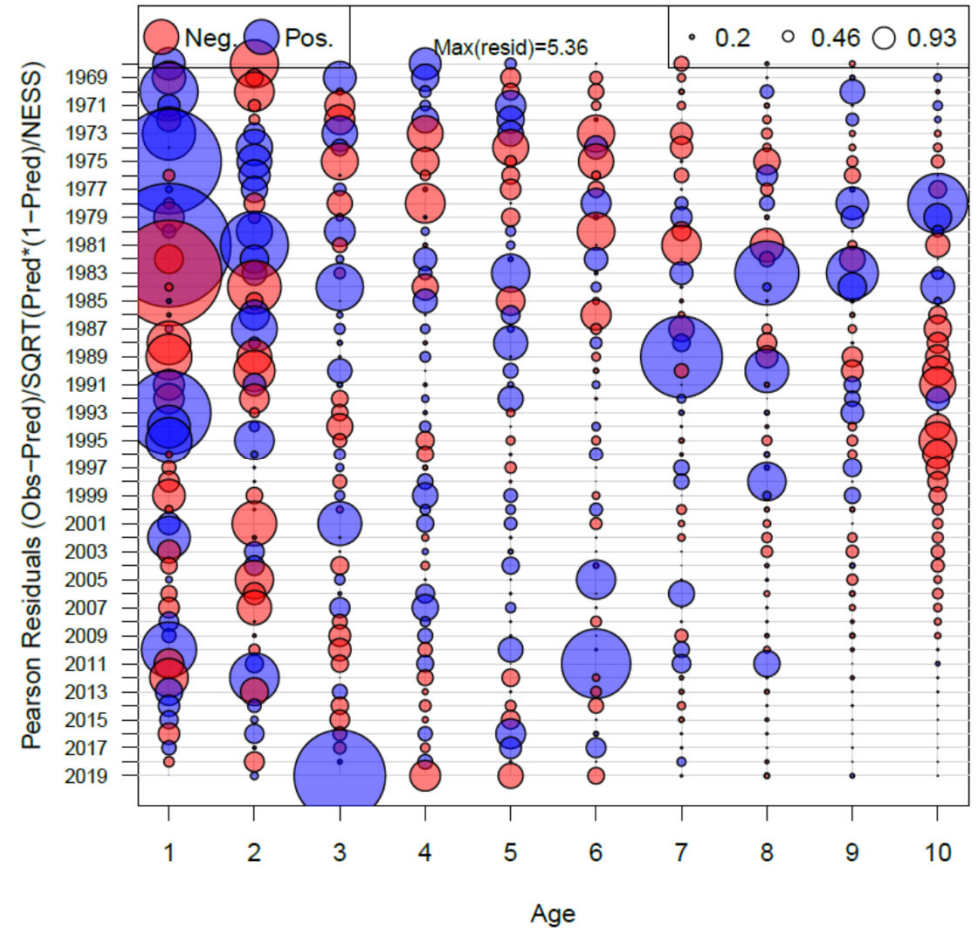
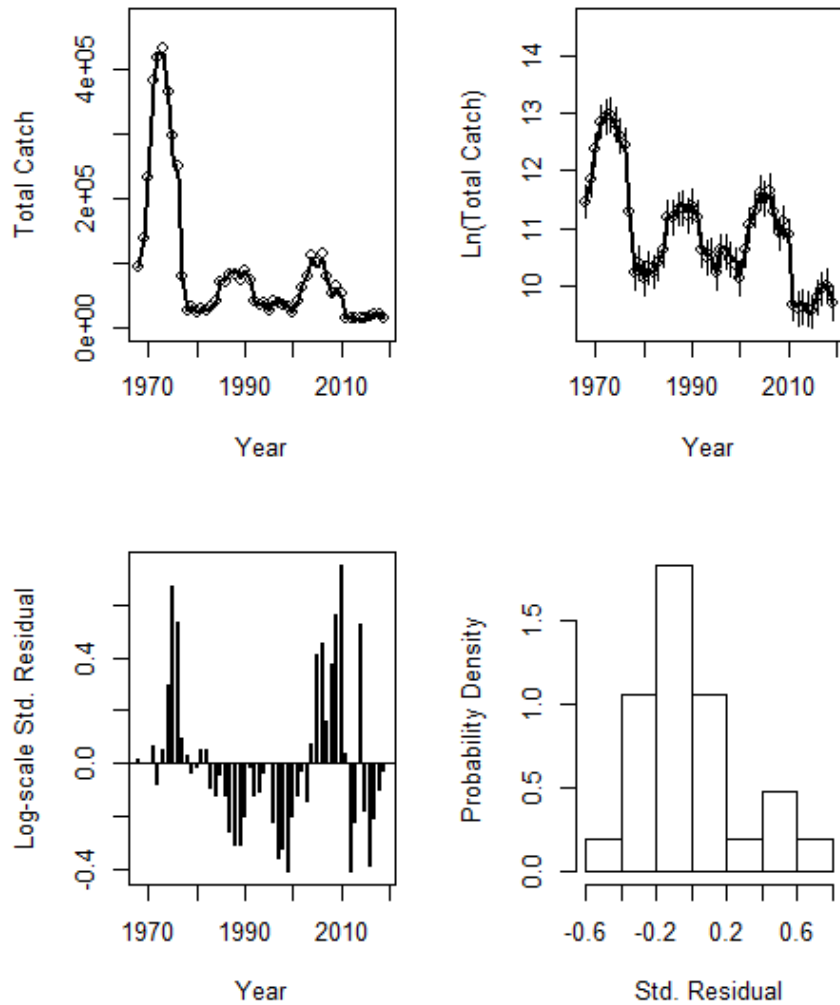


NEFSC spring survey: Albatross years

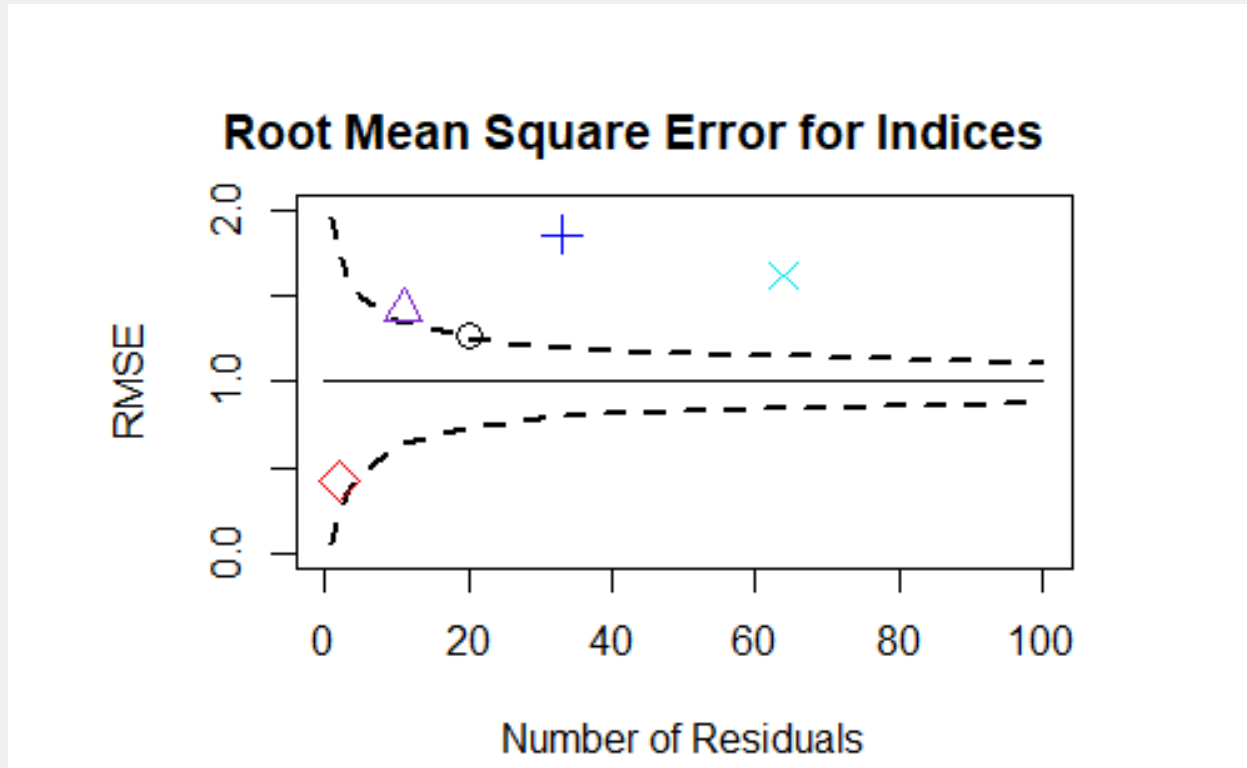


ASAP diagnostics: Fit to fishery catch

Fleet 1 Catch (Combined)

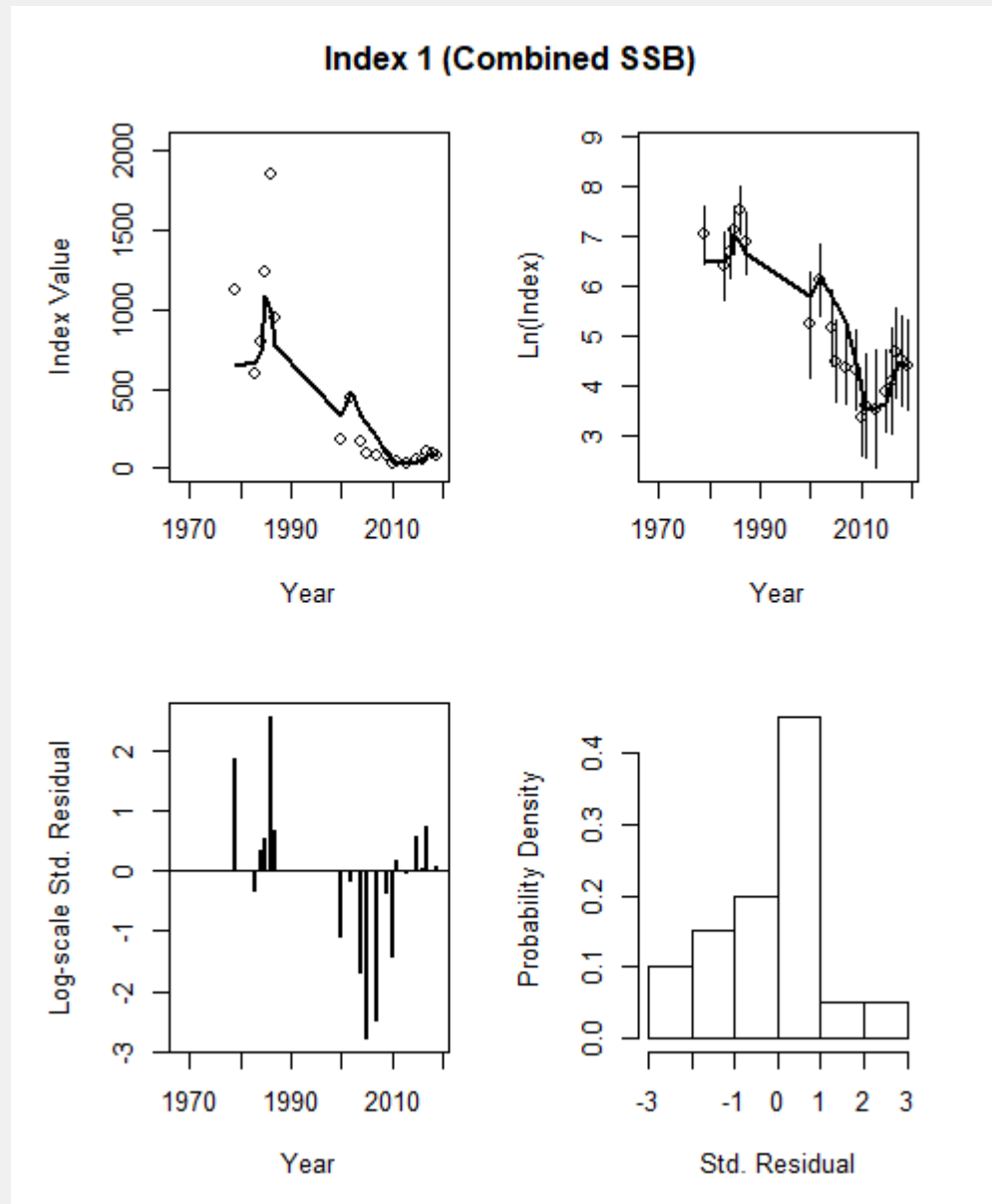


ASAP diagnostics: Index RMSEs



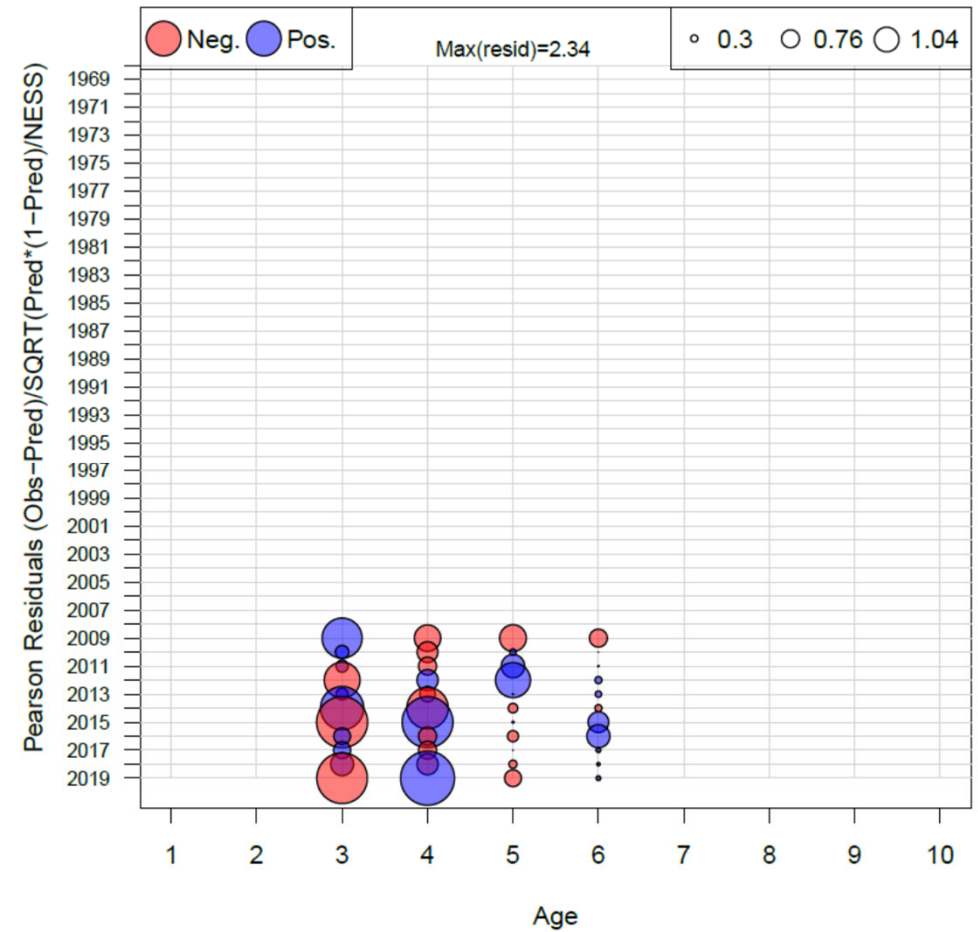
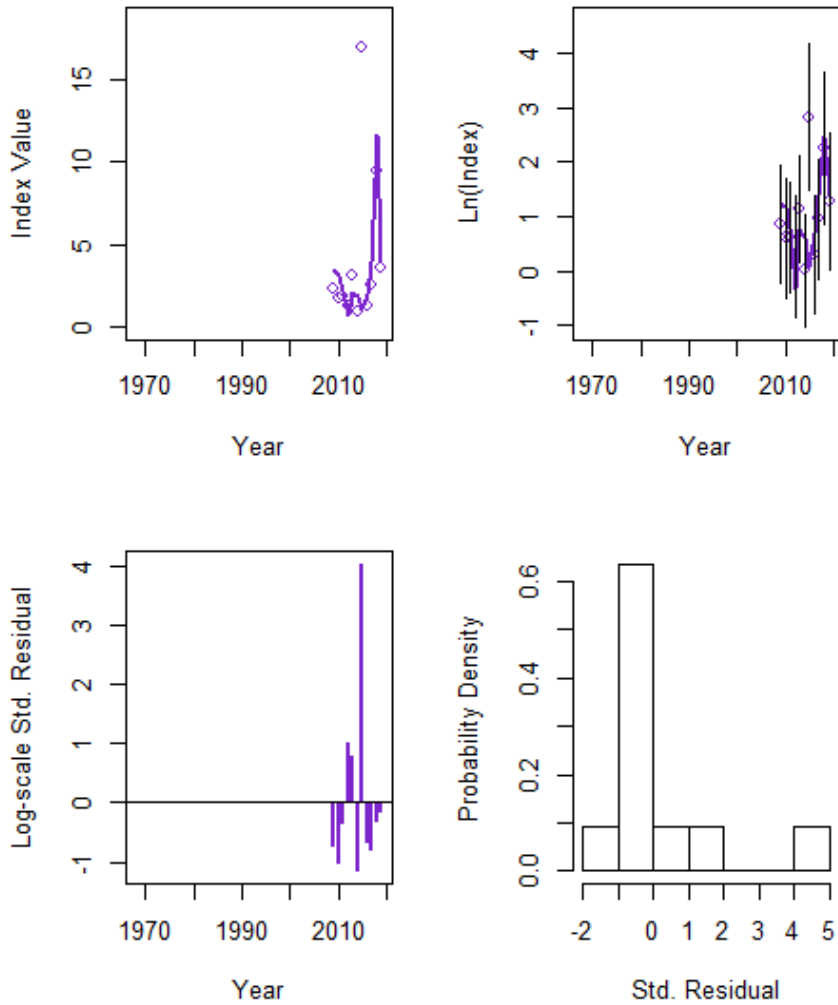
index.sel.params
ind.total
Spring Alb 3+
Spring Big 3+
Combined SSB

ASAP diagnostics: Fit to range-wide SSB index



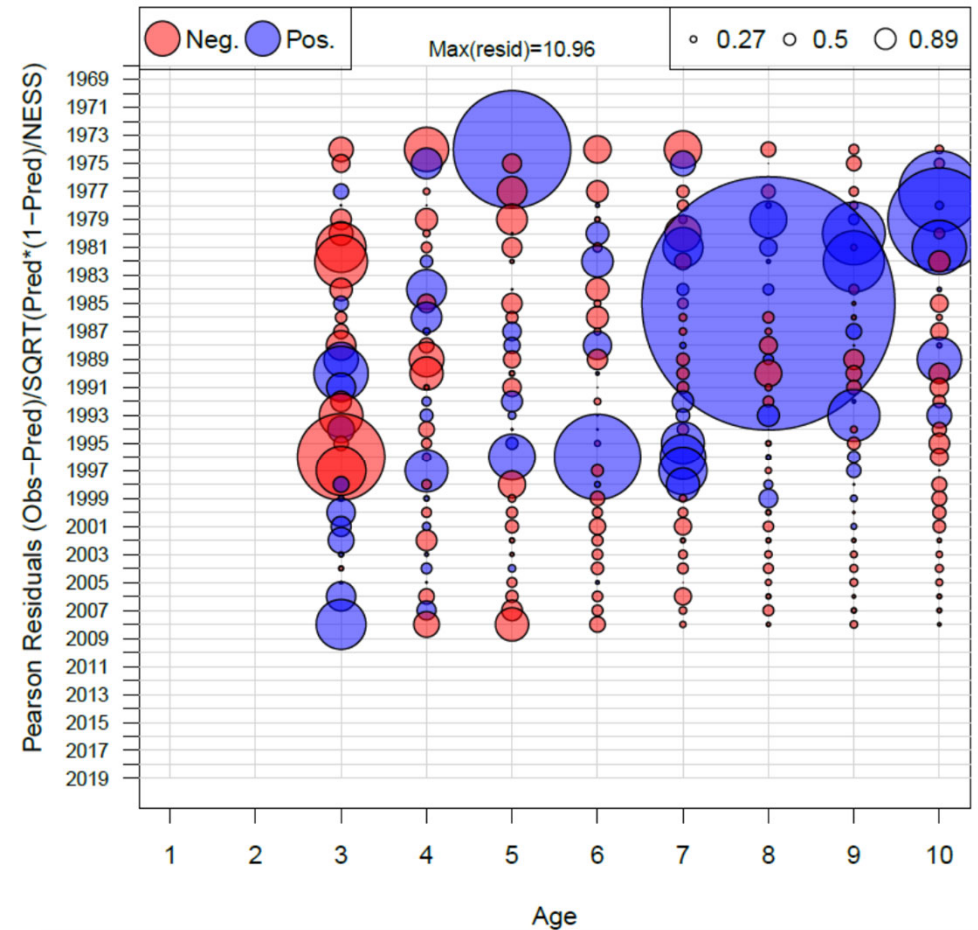
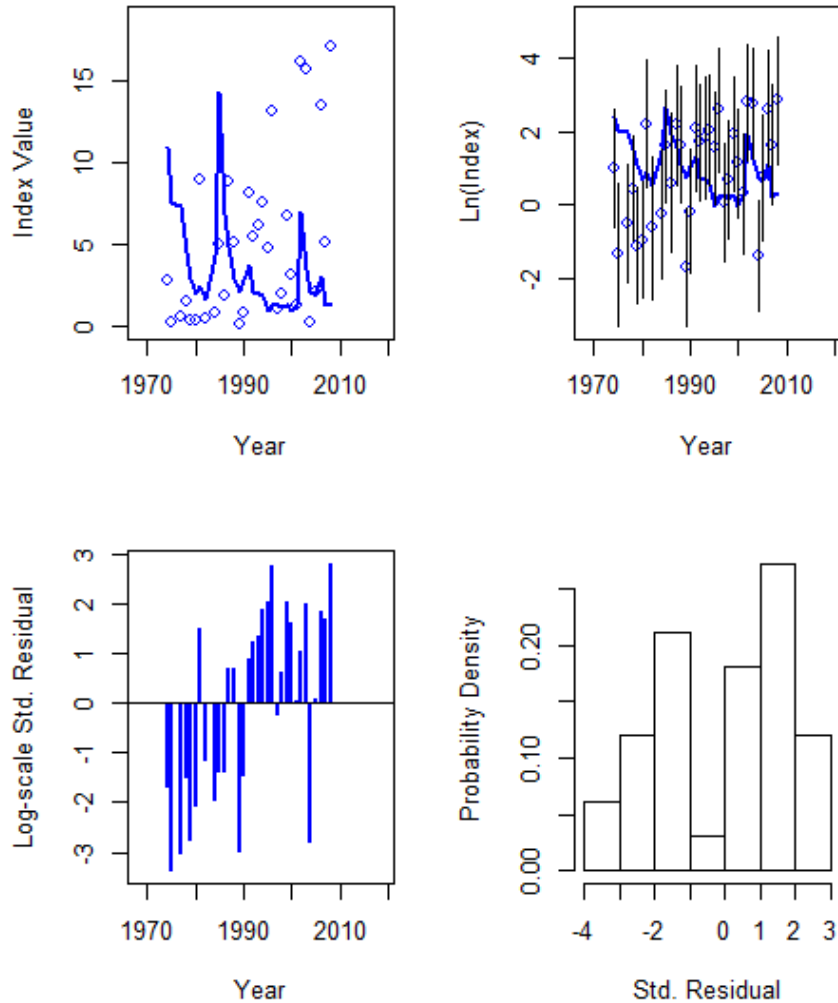
ASAP diagnostics: Fit to *Bigelow* index (2009-2019)

Index 2 (Spring Big 3+)

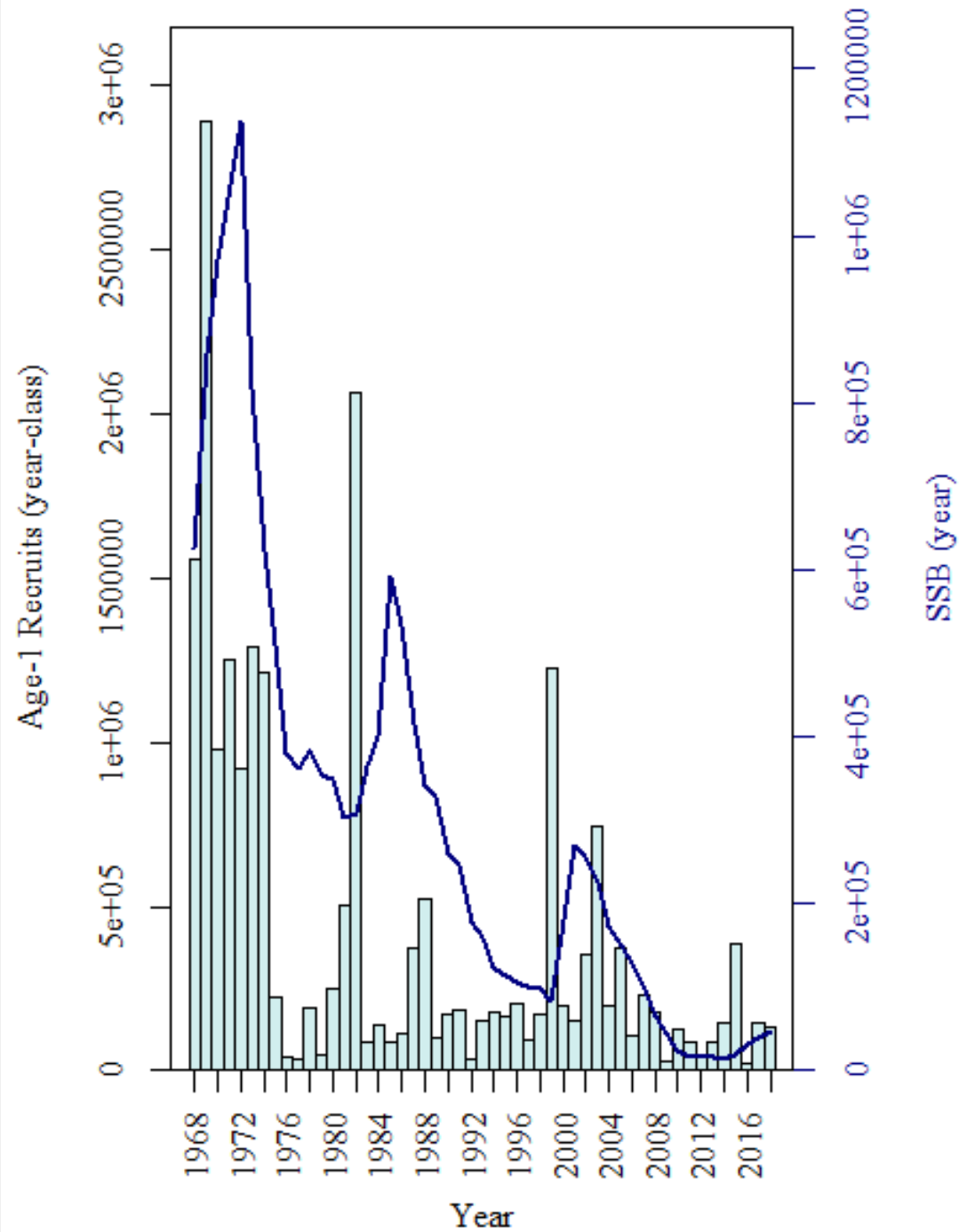


ASAP diagnostics: Fit to *Albatross* index (1968-2008)

Index 3 (Spring Alb 3+)

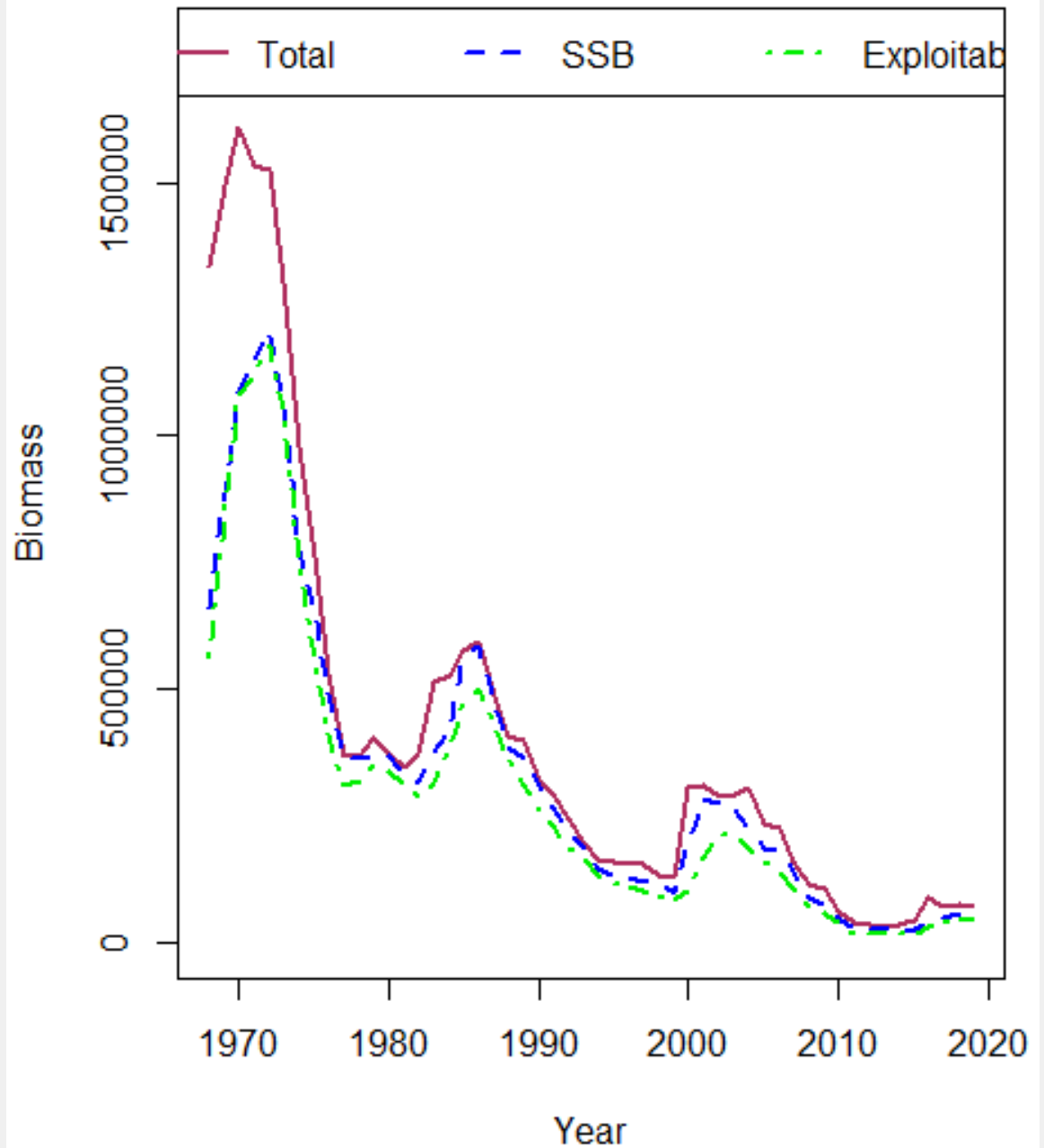


ASAP estimates: SSB and recruitment time series

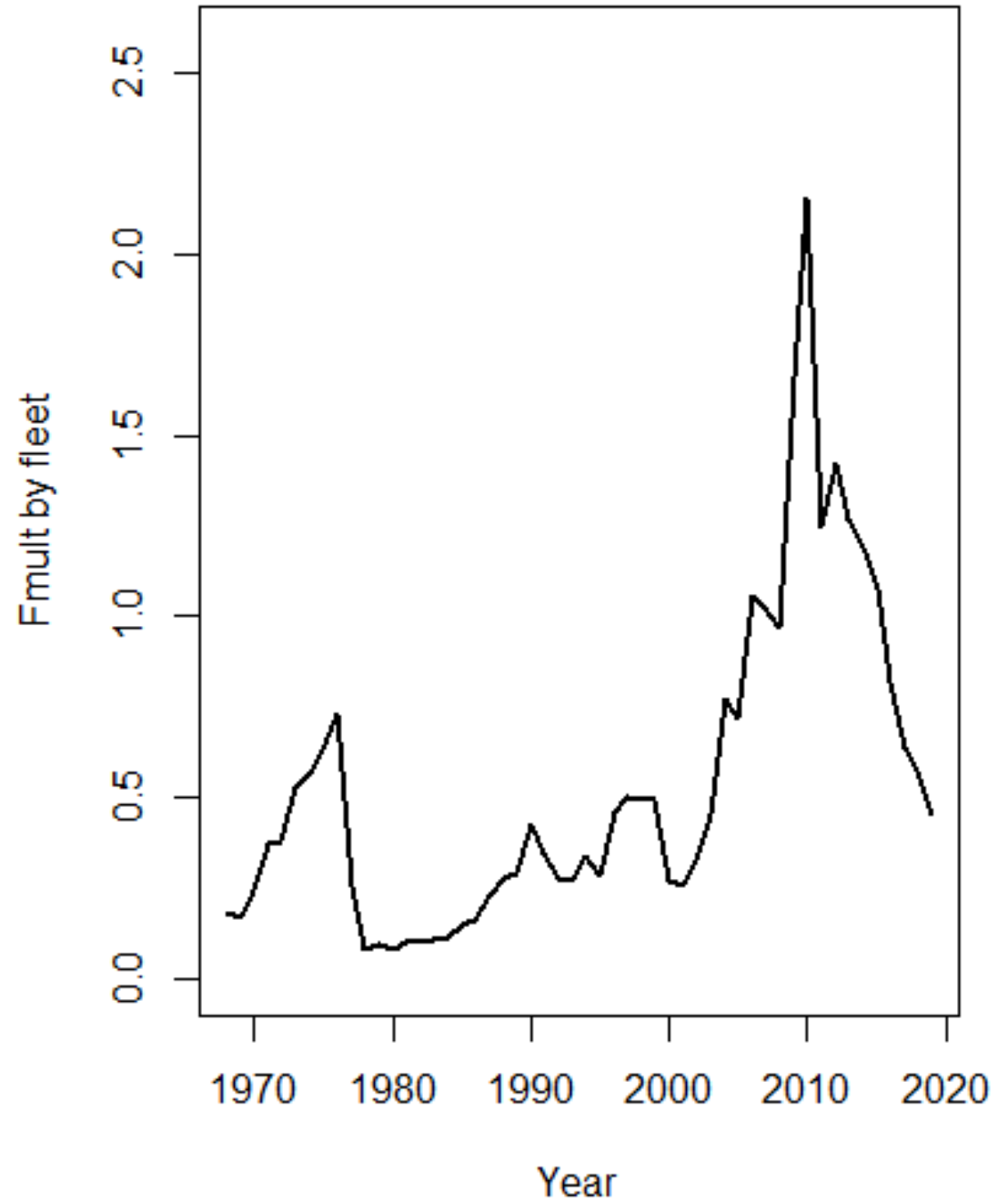


ASAP estimates: Biomass

Comparison of January 1 Biomass

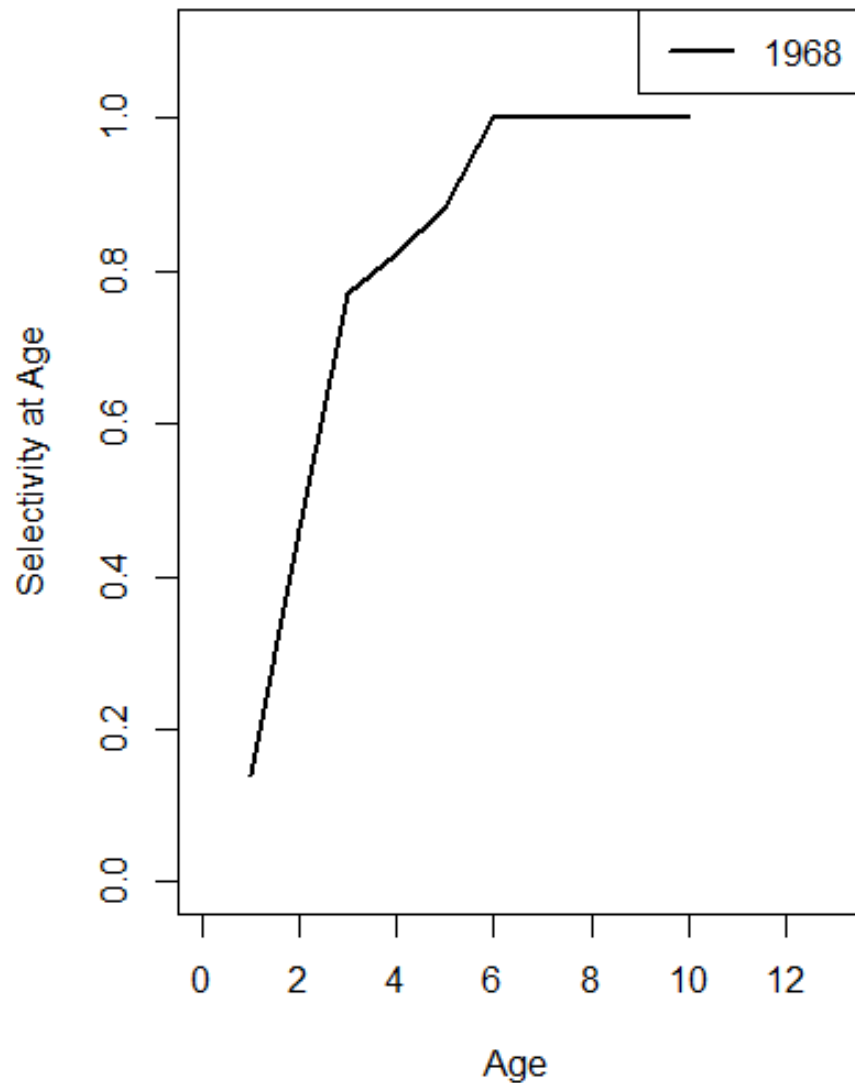


ASAP estimates: Fishing mortality

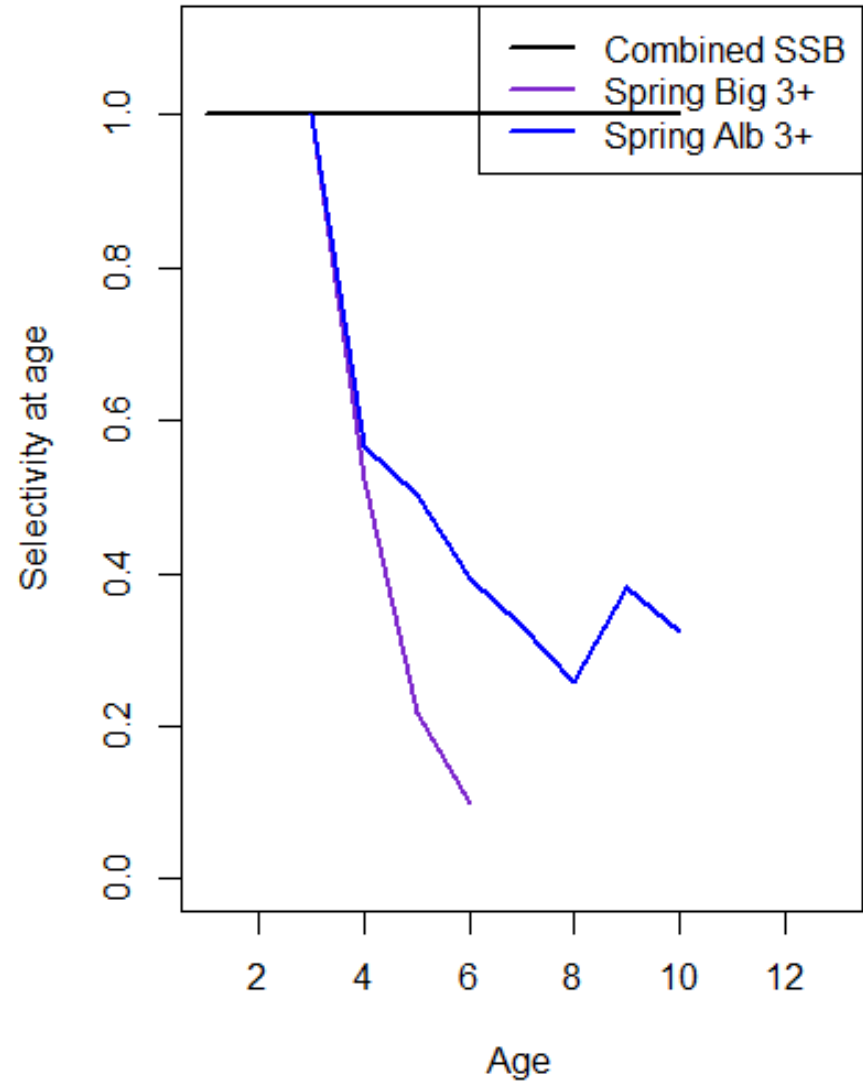


ASAP estimates: Selectivity

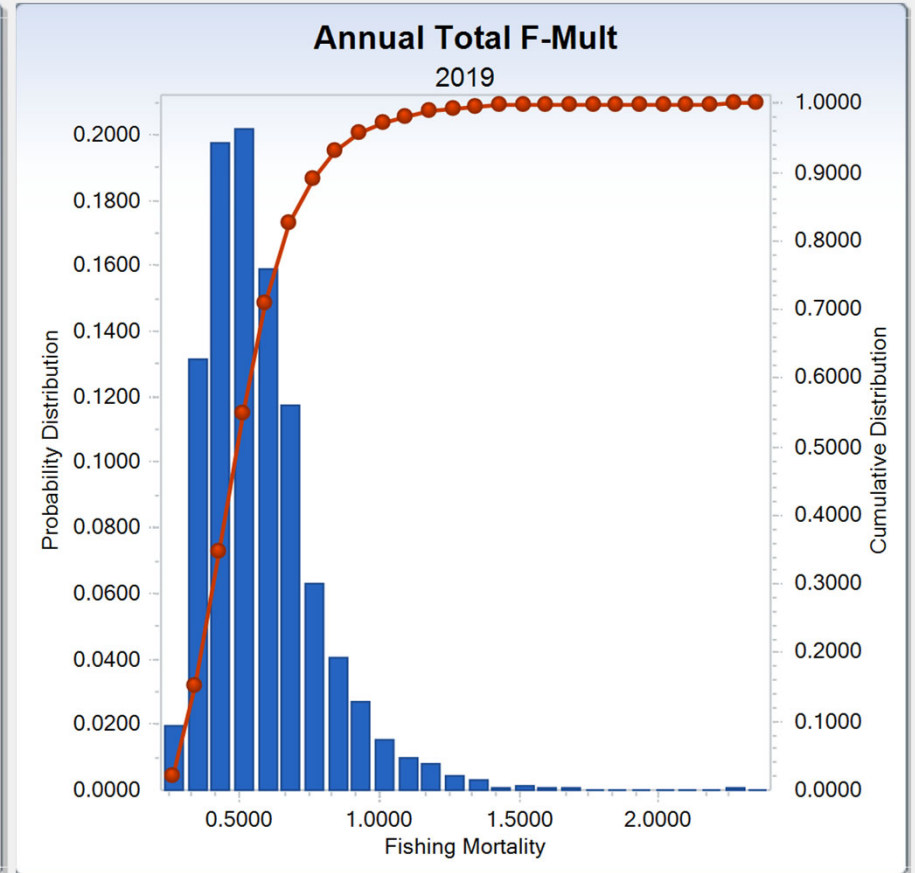
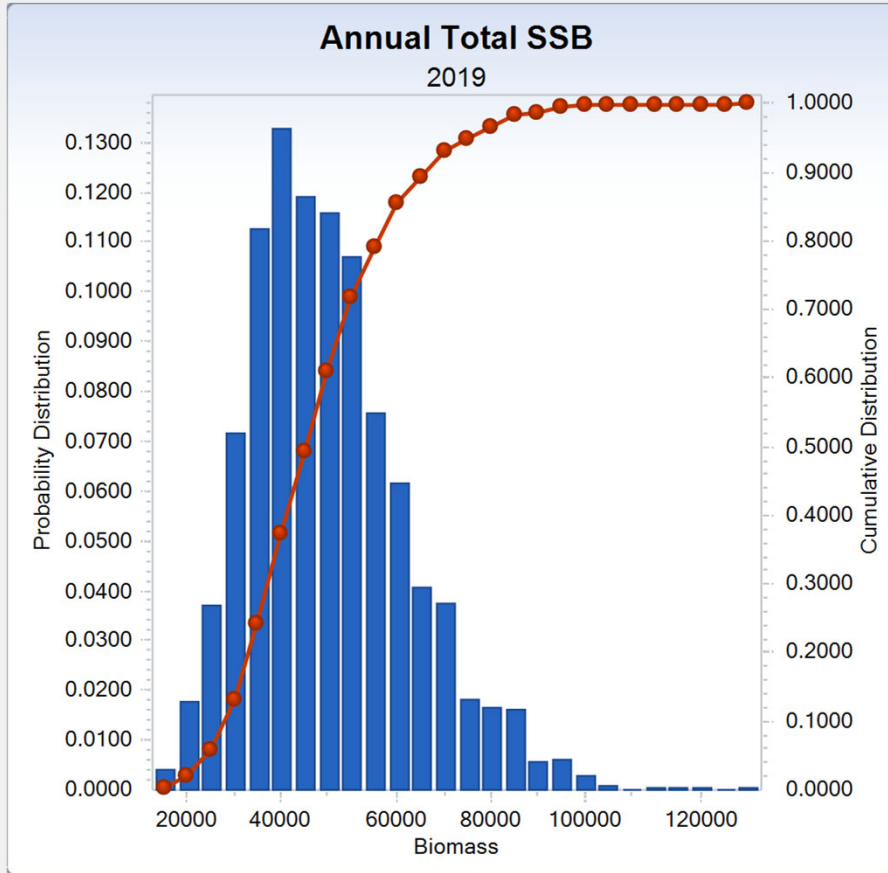
Fleet 1 (Combined)



Indices

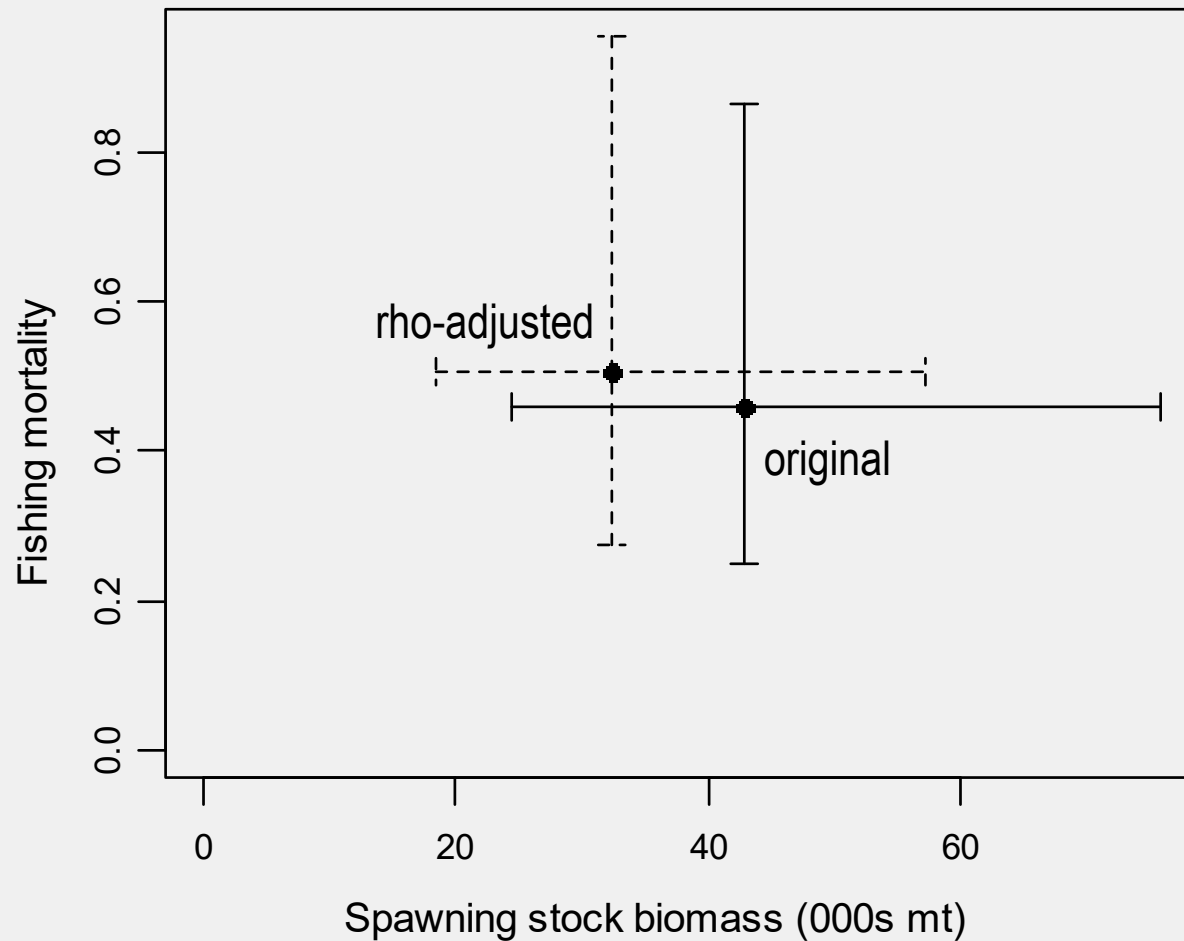


ASAP estimates: Terminal year estimates

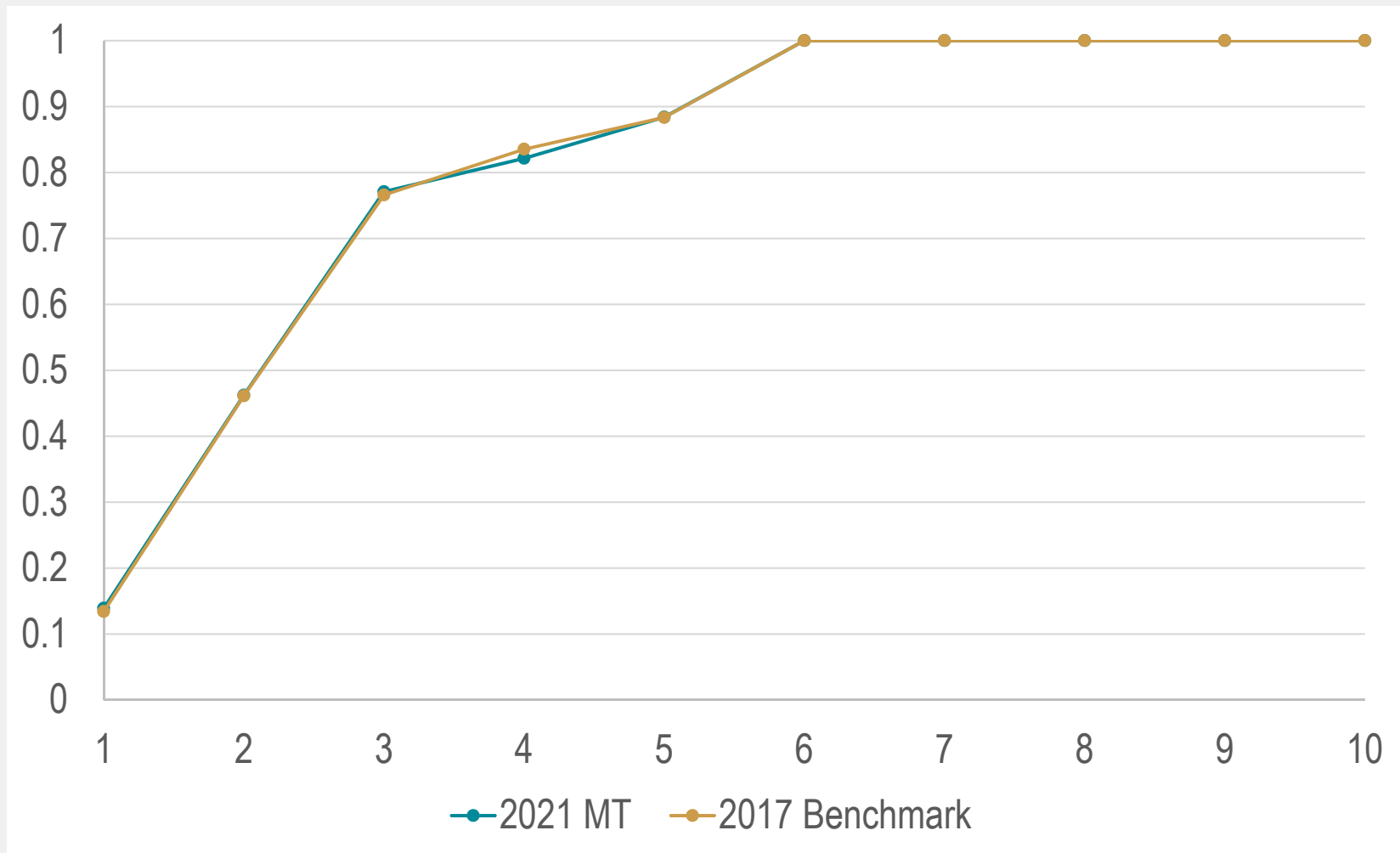


Retrospective analysis:

Terminal year estimates with 90% CIs



Fishery selectivity



Long-term projections

- 100-year projections at $F_{40\%}$ (0.22) from 2000 numbers-at-age estimates for 2019 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
- $M = 0.2$

2-year projections: F=0

SSB (mt)

	1975 Onward	1999 Onward	2009 Onward
2020	62,039	62,039	60,343
2021	70,137	69,471	58,709
2022	90,149	88,968	65,054
2023	126,431	124,505	85,280

