Atlantic States Marine Fisheries Commission

2025 Tautog Regional Stock Assessment Update

Sustainable and Cooperative Management of Atlantic Coastal Fisheries

Atlantic States Marine Fisheries Commission

Tautog Regional Stock Assessment Update

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EXECUTIVE SUMMARY

Tautog is assessed and managed in four stock regions: the Massachusetts-Rhode Island (MARI) region, the Long Island Sound (LIS) region, the New Jersey-New York Bight (NJ-NYB) region, and the Delaware-Maryland-Virginia (DMV) region. This stock assessment is an update to the existing benchmark assessment for tautog (ASMFC 2015, ASMFC 2016); the previous assessment update was completed in 2021 (ASMFC 2021). This assessment updates the accepted statistical catch-at-age model for each region with commercial and recreational fishery catch data and indices of relative abundance from fishery-independent and fishery-dependent data sources through the terminal year of 2024.

Total removals have remained constant or increased since the last assessment update in all regions. The MRIP CPUE index has also shown an increasing trend in the most recent years in all regions. This trend was consistent with the trend in other age-1+ fishery-independent indices in the MARI and LIS regions, but not in the NJ-NYB region, where the signals from the indices were more mixed. No fishery-independent indices were used in the DMV region.

Stock status varied from region to region. Tautog were not overfished in the MARI, LIS, and NJ-NYB regions, but were overfished in the DMV region. Tautog were not experiencing overfishing in the MARI or LIS regions but were experiencing overfishing in the NJ-NYB region and DMV region. Stock status did not change for the MARI or LIS regions from the 2021 update, but did change for the NJ-NYB and DMV regions. The NJ-NYB region went from being overfished but not experiencing overfishing in the 2021 update to not being overfished but experiencing overfishing in this update. The DMV region was previously not overfished or experiencing overfishing, but was considered overfished and experiencing overfishing as a result of the 2025 update.

All regions showed major retrospective patterns in *F* and SSB. The MARI, LIS, and NJ-NYB assessments overestimated *F* and underestimated SSB, while the pattern was reversed in the DMV region. This pattern was also seen in the 2021 update but appeared to have worsened during the 2025 update. The terminal year values of *F* and SSB were no longer within the confidence intervals of the model estimates and stock status did change for some regions for either *F* or SSB if the retrospective pattern was adjusted for. As a result, the SAS adjusted for the retrospective pattern for SSB and *F* in all regions, including in the short-term projections.

Investigating and resolving the worsening retrospective pattern in the assessment should be a high priority for the next benchmark. In addition, several new fishery-independent surveys, including pot-and-trap surveys more appropriate for tautog, have been initiated since the 2016 benchmark and will have long enough time-series if a new benchmark is initiated in 2027 or later.

Table 1. Stock status of tautog in the MARI, LIS, NJ-NYB, and DMV regions.

Spawning Stock Biomass				
Region	**Target**	**Threshold**	**2024**	**Status**
MARI	6,143 mt	4,595 mt	9,572 mt	Not overfished
LIS	9,799 mt	7,349 mt	13,718 mt	Not overfished
NJ-NYB	7,910 mt	5,929 mt	7,900	Not overfished
DMV	4,400 mt	3,236 mt	2,687 mt	Overfished
Retrospective adjustment applied to SSB for all regions				

Fishing Mortality				
Region	**Target**	**Threshold**	**2024**	**Status**
MARI	0.27	0.46	0.26	Not overfishing
LIS	0.25	0.35	0.25	Not overfishing
NJ-NYB	0.20	0.33	0.44	Overfishing
DMV	0.18	0.29	0.36	Overfishing
Retrospective adjustment applied to F for all regions.				

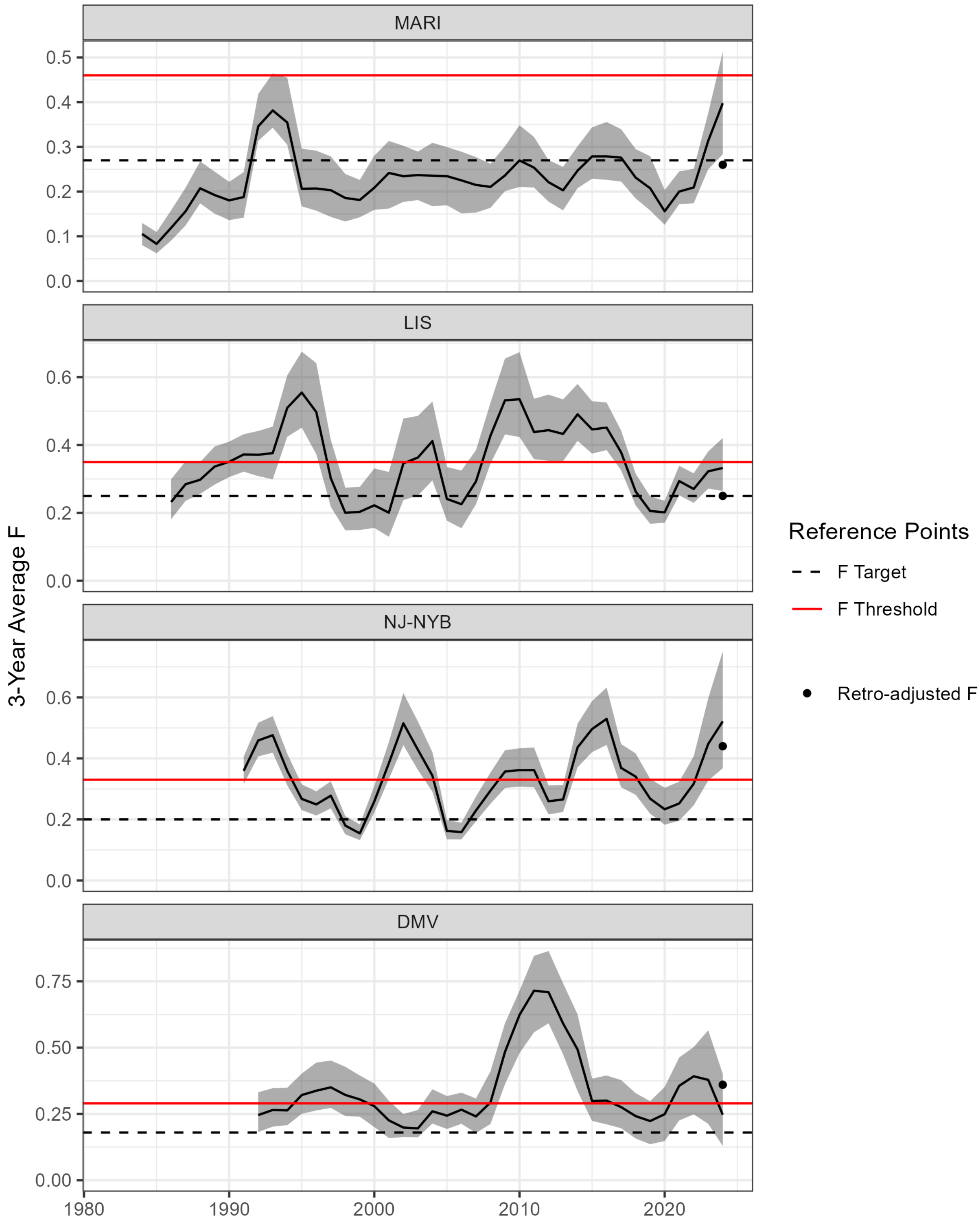

Figure 1. Three-year average fishing mortality rates for tautog in the MARI, LIS, NJ-NYB, and DMV regions plotted with the *F* target and threshold for each region. Shaded areas indicate the 95% confidence interval of the estimates. The retrospectively adjusted values were used to assess overfishing status in 2024.

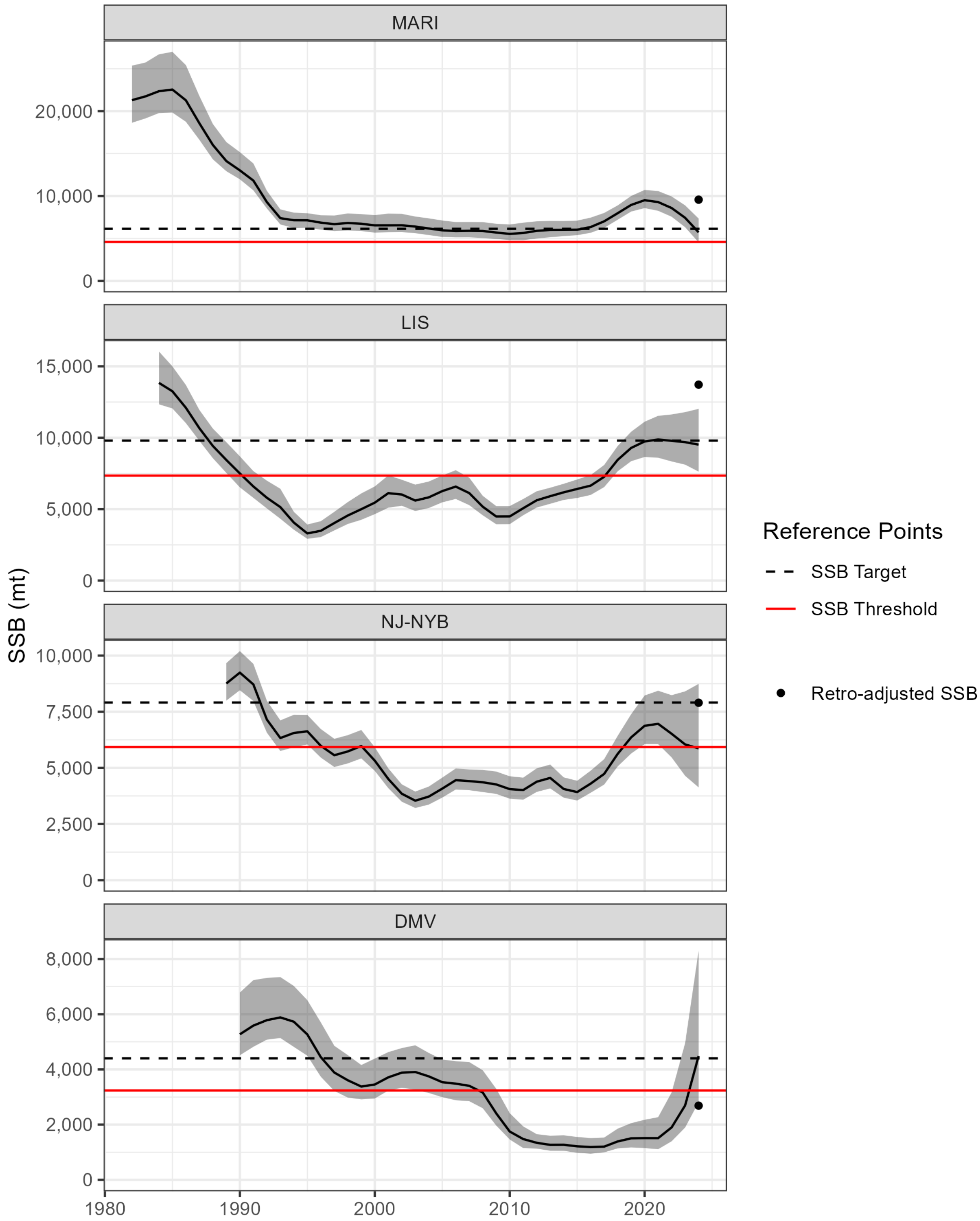

Figure 2. Spawning stock biomass of tautog in the MARI, LIS, NJ-NYB, and DMV regions plotted with the SSB target and threshold for each region. Shaded areas indicate the 95% confidence interval of the estimates. The retrospectively adjusted values were used to assess overfished status in 2024.

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MASSACHUSETTS-RHODE ISLAND REGION

Executive Summary

The 2025 Massachusetts-Rhode Island Region (MARI) stock assessment update used the accepted 2016 benchmark statistical catch-at-age model (ASAP, ASMFC, 2015), adding new years of data since the 2021 stock assessment update. Updated data through 2024 were included for commercial and recreational catch, age and length composition, and fishery-independent indices. No changes to the model occurred during this assessment update and calculations for the biological reference points followed the spawning potential ratio (SPR)-based methods. Model diagnostics showed continued trends in certain residual patterns (e.g., catch and age composition) and a significant retrospective pattern was observed for both three-year averaged fishing mortality rate and spawning stock biomass (Mohn's rho of 0.55 and -0.40, respectively), necessitating an adjustment to the terminal year estimates. The adjusted three-year averaged (2022-2024) fishing mortality rate (F) of 0.26 was below the fishing mortality threshold reference point of 0.46, indicating overfishing is not occurring. The adjusted estimate of spawning stock biomass (SSB) of 9,572 mt was above the threshold of 4,595 mt, indicating that the MARI population is not overfished. Spawning stock biomass has had an increasing trend since 2016, likely due in part to a couple very high recruitment years in 2015-2016. Despite recent lower recruitment likely contributing to a projected decline in SSB from 2025-2027, the three-year projected estimate has a 100% probability of remaining above both the SSB threshold and the SSB target. However, the three-year projection shows fishing mortality continuing to increase through 2027, with a 26% probability of *F* being at or above the *F* threshold in 3 years.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

All datasets included in the 2021 Update Assessment (ASMFC, 2021) were updated to include 2021-2024 data.

Total weight of commercial landings from 1982–2024 were sourced from the Atlantic Coastal Cooperative Statistics Program. The total commercial landings were converted into catch at length using the length frequency distribution of the recreational (MRIP) catch as it is assumed the commercial and recreational length distribution of tautog is consistent between the two fisheries due to similar size regulations, seasons, and gear usage. The catch at length was then multiplied by an age-length key populated by biological data (length/age relationship) from fisheries dependent and independent sources from the MARI region for each year.

Recreational landings in weight and numbers of fish and releases in numbers of fish were retrieved from the MRIP estimates. Recreational landings were converted into catch at age using the same methods as the commercial catch such that the length frequency distribution of the MRIP catch was used to generate catch at length. From there, the catch at length was multiplied by annual age-length keys populated by biological data from the region.

While recreational landings are available in both weight and numbers, the recreational releases are only reported by MRIP in numbers of fish. To determine the total weight of the recreational releases, the length frequency data from the combined MRIP headboat discard data (Type 9) and the American Littoral Society (ALS) volunteer angler survey was applied. By including both these data sources, releases due to length limits as well as other factors (out of season, already reached bag limit, etc.) were accounted for and give an overall makeup of discards in this dataset. The combined length frequencies were used to convert the recreational releases at length into releases at age using the annual age-length keys from the region. The discard mortality rate of 2.5% was then used to obtain the total weight of recreational dead discards and dead discard numbers at age. Total recreational removals by weight and by numbers at age were determined by adding together recreational landings and dead discards.

A single fleet for catch is used in the tautog assessment model, therefore, the total recreational removals in weight and the total commercial removals in weight were combined to represent all removals (converted to metric tons). The total removals at age were also combined (commercial, recreational landings, and recreational discards) into a single fleet.

In the MARI region, the tautog fishery is primarily recreational with recreational removals accounting for 93% of the total removals and a series high of 98% in 2023 (Table 2, Figure 3). From 1982–1992, removals were high, but variable averaging roughly 1.5 million fish per year for the region. Removals have decreased significantly since 1993, averaging roughly 425,000 fish from 1993–2013. Amendment 1 to the tautog FMP was passed in 2017, and from 2018–2024 on average just over 1 million fish have been harvested recreationally in the region per year. This increase is due to recent increases in recreational landings for the region, along with increases in recreational releases. From 2018–2020, recreational landings were closer to 1993–2013 levels averaging approximately 550,000 fish per year. From 2021–2024, recreational landings jumped significantly to an average of 1.3 million fish per year.

The commercial fishery follows a similar trend to the recreational fishery. Landings peaked in 1991 at 329 mt before decreasing in the mid/late 1990s (Table 2, Figure 3). Since the late 1990s commercial landings have remained fairly stable. Since the adoption of Amendment 1, landings have averaged 52.8 mt (2018–2024).

A catch-per-unit-effort (CPUE) index of abundance was used following the same species guild approach as the benchmark assessment. A guild including black sea bass, scup, fluke, and winter flounder was used to identify tautog trips and a generalized linear model (GLM) was used to standardize catch-per-trip as an index of abundance. The same factors were used in the standardization model as in previous assessments (Year, Wave, State, Mode, Angler-Hours) with one addition, Area Fished. The index was also updated to include the data from 2021–2024. The MRIP CPUE index was high and somewhat variable at the beginning of the series before declining through the mid-1990s to lower stable levels throughout the 2000s (Figure 4). The index in recent years (2020–2024) is the highest observed since 1996.

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

There were three fishery-independent indices incorporated in the 2021 Update Assessment that were updated with data from 2021–2024 for this assessment: the Massachusetts Spring Trawl Survey, the Rhode Island Fall Trawl Survey, and the Rhode Island Narragansett Bay Seine Survey (Table 3, Figure 4). The MA and RI trawl survey's age composition information is shown in MARI Appendix 1. The RI seine is a young-of-the-year survey and therefore no age composition is available. Each index was standardized using GLMs to account for factors that may impact the catchability of tautog (such as depth and temperature).

The MA trawl survey uses a stratified random design occurring in the spring and fall of each year, with the exception of 2020 due to COVID-19 restrictions. The 2025 assessment update continued using only the spring survey, similar to previous tautog assessments, for the 2021–2024 data additions. Overall, the survey index peaked in the late 1980s followed by a decline through the 1990s and has since remained at low, relatively stable levels (Figure 4).

The RI trawl survey has operated without interruption since 1979 as a two-season survey (spring and fall) and uses a stratified random design. In 1990, a monthly component was added to the survey that operates year-round under a stratified random design. For this model, only the fall portion of the survey was considered, remaining consistent with the benchmark and 2021 update. Similar to the MA survey, the RI survey index peaked in the mid to late 1980's and then declined to a low level where it has largely remained since (Figure 4).

The RI Narragansett Bay seine survey has operated since 1986 with a consistent standardized methodology since 1988. The survey samples 18 fixed stations throughout Narragansett Bay from June–October annually. The index has been variable over time, increasing through the 2000's before decreasing to a recent low in 2011 of 0.8 fish/seine. The index then increased, hitting a time series high of 16.3 fish/seine in 2022; however, this was followed by a steep decline in 2023 and 2024 (Figure 4).

Age-length data was collected for the MARI region annually in compliance with the tautog FMP. Data collected from 2021–2024 was combined to form annual age-length keys for the region. Samples were collected from both fishery-dependent and fishery-independent sources. This ensures a full sampling of size and age classes as well as provides larger sample sizes for developing the keys. Gaps in the data (i.e., missing length samples) were filled using data from neighboring length bins or using samples from surrounding regions in those missing bins.

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

There were no significant changes to the life history information or model structure since the Benchmark Stock Assessment (Table 4).

This update includes data from 1982–2024. For all datasets, all fish greater than age-12 were combined into a 12+ group. Maturity was set to 0 for age 1 and age 2, 0.8 for age 3 fish, and 1 (fully mature) for all fish age 4 and older across the entire time series. Natural mortality was fixed at 0.16 for all ages and across all years. Release mortality for all age classes across the time series was fixed at 2.5%. Size at age (length at age, weight at age) were developed for each year in the time series, accounting for changes in the biomass over time. The existing sensitivity blocks were maintained through this assessment, with the additional years since the 2021 update included in the final sensitivity block.

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The 2025 assessment update used the accepted 2016 benchmark assessment model (Age Structured Assessment Program from NOAA Fisheries Toolbox), adding data through 2024, to obtain updated estimates of fishing mortality, spawning stock biomass, and recruitment. The updated ASAP model ran successfully, without error, though the model struggled to fit to each index time series precisely, particularly in capturing peaks in abundance early in the MA and RI trawl surveys, or the RI seine in its entirety (see MARI Appendix 1). However, the fits generally matched the trends and were similar to those seen in the 2021 assessment update. Some residual patterns were evident in the age composition diagnostic plots for the indices, similar to the 2021 assessment update (see MARI Appendix 1). Additionally, there was a pattern evident in the total catch residuals, where total catch was largely overestimated prior to 2000 and underestimated thereafter. These patterns were not deemed problematic enough to prohibit the use of this model for assessment or management purposes.

Annual fishing mortality was low through the 1980s (time series low in 1985 of 0.07) then increased to a time series high in 1992 (0.63). Following this peak, annual *F* has varied about a mean of approximately 0.24 through 2024 (Table 5, Figure 5). Spawning stock biomass was above 20,000 mt early in the time series but declined fairly rapidly through the early 1990s and remained at a mean of approximately 6,500 mt from 1992–2017 (Table 5, Figure 6). Recently SSB has shown a slight increase, though it has remained less than 10,000 mt. Recruitment estimates remained largely stable throughout the time series until a marked increase in 2015 and 2016 (Table 5, Figure 7). Estimates of recruitment in recent years have been lower than the time series average and reached a time series low in 2024. High recruitment peaking in 2015 likely contributed to the recent bump seen in spawner biomass (see MARI Appendix 1).

A retrospective analysis was completed using a seven-year peel (i.e., 2017–2024) that showed a significant retrospective pattern for the three-year average *F* (Mohn's rho = 0.55), SSB (Mohn's rho = -0.40), and recruitment (Mohn's rho = -0.34). The model runs tended to overestimate *F* and underestimate SSB and recruitment relative to the terminal year run (Figure 8 - Figure 10). The adjusted estimates of *F* and SSB to account for the retrospective pattern fell outside the confidence intervals of the terminal year estimates for these parameters (MARI Appendix 2

Figure A2.1), warranting the adjustment of *F* and SSB for this assessment (ASMFC 2024). The source of the retrospective pattern is unknown; however, there are several sources of uncertainty in this assessment, and a minor retrospective pattern was observed in the 2021 update. The unadjusted estimates for the 3-year average *F* and SSB were 0.40 and 5,725 mt, respectively. Retrospective adjusted estimates were 0.26 and 9,572, respectively.

Sensitivity analyses were run to look at model dependence on the four survey indices (MA trawl survey, RI trawl survey, RI seine survey, and MRIP CPUE). The final ASAP model chosen for this assessment used adjusted catch and index CVs to correct for Root Mean Square Errors (see MARI Appendix 1); therefore, an additional sensitivity run was completed to look at model performance with the unadjusted CVs. No sensitivity run substantially changed the general trends in fishing mortality or SSB over the time series (MARI Appendix 2 Figures A2.2 and A2.3), though removing the MA trawl survey had a larger impact than the other sensitivity runs. The retrospective error for fishing mortality improved slightly for the runs where the RI trawl and MRIP CPUE indices were removed. The retrospective error for SSB improved in the runs where RI trawl and MRIP CPUE were removed as well as when using the original CVs.

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

The target and threshold levels for fishing mortality (F) were calculated using spawning potential ratio (SPR) reference points. The updated target *F* reference point for 2024, F40%, was 0.27, and the threshold level, F30%, was 0.46, similar values as those estimated for the previous assessment updates (Table 6). The adjusted three-year averaged (i.e., 2022–2024) *F* was estimated to be 0.26 (Table 7). Since the three-year average *F* was below the threshold, the model did not indicate that overfishing was occurring (Figure 11).

Target and threshold spawning stock biomass reference points were calculated by determining equilibrium SSB when assuming fishing at both the target and threshold fishing mortality levels. During these projections, historical recruitment patterns as well as terminal year selectivity, maturity and weight-at-age were assumed. These calculations were conducted using the AgePro program from the NOAA Fisheries Toolbox. The SSB threshold was 6,143 mt and the SSB target was 4,595 mt, similar to the estimates from the 2021 update (Table 6). The adjusted estimated 2024 SSB was 9,572 mt (Table 7). Since the estimated spawner biomass was above both the target and the threshold, the model indicated that the stock was not overfished (Figure 11).

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term, three-year projections (2025–2027) were completed to estimate the probability of overfishing or the stock being overfished during the period. Projections were completed using an assumed constant harvest level equal to the average total removals from 2022–2024 (2,134 mt). All other parameters (life history information and selectivity patterns) were assumed to be the same as used in the ASAP model. Recruitment was randomly drawn from the empirical distribution of recruitment estimated by the ASAP model. Short term projections showed a 100% probability of being at or above the SSB threshold in three years and a 0.3% probability the fishing mortality will be at or below target in three years (Table 8, Figure 12).

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

Fishery-dependent high priorities from the last benchmark assessment focused on biological sampling. There remains a need for expanded sampling of commercial catch, continuation of collecting age structures, increasing catch and discard lengths from commercial and recreational fisheries, and an increase in MRIP sampling to improve recreational catch estimates.

Since the benchmark, the ageing committee has approved the pelvic spine as an appropriate age structure. Since that recommendation, both MA and RI have moved forward with pelvic spines as the primary ageing structure. As in the previous update, differences were seen between MA and RI length-at-age. Moving forward, the observed differences should be investigated to determine if they are naturally occurring (i.e., there are differences in length-at-age between the two states) or if it is a result of differences in ageing techniques.

While improvements to the MRIP sampling have been ongoing since the last benchmark, additional improvements to sampling should be explored. State-level PSEs have improved for Massachusetts and Rhode Island; however, additional sampling at the mode-level would greatly increase the understanding of the recreational fishery as whole.

Fishery-independent priorities include conducting a workshop and pilot studies to design and implement a standardized multi-state fishery survey to monitor tautog abundance and to develop YOY indices, and to enhance age structure collection for smaller fish.

While MARI has the RI seine survey used as a YOY index for the region to fulfill the need locally; working towards a multi-state fishery survey to improve YOY indices will further increase the understanding of recruitment and decrease a source of uncertainty found in the current assessment.

Additional survey methods should be investigated and considered. Outside of the RI seine survey, the other fishery-independent data sources used in the model were trawl surveys. Trawl nets are known to be a sub-optimal method for sampling tautog, as tautog's preferred habitat is rocky areas and reefs, where trawls cannot tow. Alternative survey types, such as fish pot, should be considered to appropriately sample this species.

Though RI and MA have both begun sampling smaller fish for age/length information, increased sample sizes across the entire size range, including these smaller fish, should continue to be a priority for the region to improve the age-length key.

The last benchmark assessment for tautog was completed in 2016. Given that nearly a decade has passed, a new benchmark assessment should be considered. Some considerations for a new assessment should be: reducing uncertainty, managing/improving retrospective patterns seen in both the current (2025) update and the 2021 update, investigating differences in age-length relationships across the region, and to improve the understanding of recruitment within the region.

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MARI Appendix 1: ASAP Input and Diagnostic Plots for the Base Run
MARI Appendix 2: Retrospective Adjustment and Sensitivity Runs

Tables

Table 2. Total removals in metric tons by sector for the MARI region.

Year	Recreational Harvest (mt)	Recreational Release Mortalities (mt)	Commercial Harvest (mt)
1982	2,700.6	2.8	70.6
1983	1,714.1	12.4	90.8
1984	1,761.8	21.6	182.7
1985	603.4	6.9	211.6
1986	4,363.9	25.7	239.9
1987	1,834.5	15.1	304.1
1988	2,905.9	26.6	274.9
1989	1,523.2	8.6	257.1
1990	1,792.2	15.1	226.9
1991	2,502.6	23.7	329.3
1992	4,624.0	15.4	295.8
1993	1,109.0	7.9	164.2
1994	579.8	16.4	76.1
1995	507.1	14.8	59.1
1996	771.0	22.3	44.2
1997	441.9	14.9	47.1
1998	415.7	12.4	50.6
1999	1,033.1	35.2	46.1
2000	903.2	14.0	63.4
2001	655.3	20.0	63.7
2002	788.3	40.6	89.8
2003	868.9	30.3	63.9
2004	818.2	20.7	56.6
2005	1,052.1	29.3	64.5
2006	732.2	31.1	88.4
2007	650.6	27.8	72.2
2008	732.8	22.6	55.3
2009	855.3	35.0	47.9
2010	1,106.9	28.1	54.1
2011	513.7	41.2	47.7
2012	868.9	42.7	53.5
2013	1,571.0	67.6	56.1
2014	1,198.2	104.1	52.9
2015	973.6	72.7	49.4
2016	729.1	55.6	49.3
2017	1,580.3	109.1	54.1
2018	623.8	101.1	51.0
2019	965.8	119.3	51.5
2020	701.3	162.0	52.6
2021	2,049.7	167.5	54.0
2022	1,389.9	114.5	55.9
2023	2,455.8	204.7	50.6
2024	1,911.2	164.5	54.2

Table 3. Indices used in the ASAP model for the MARI region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
MRIP CPUE	Total Catch Per Unit Effort	Stratified Random	Mar-Dec	1982-2024	2+
Massachusetts Trawl Survey	Mean number per tow	Stratified Random	Spring and Fall	1982-2019; 2021-2024	2+
Rhode Island Fall Trawl Survey	Mean number per tow	Stratified Random	September - November	1982 - 2024	2+
Rhode Island Narragansett Bay Seine	Mean number per haul	Fixed	June - October	1988-2024	YOY

Table 4. Model structure and life history information used in the MARI stock assessment.

	Value(s)
Years in Model	1982-2024
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

Table 5. Spawning stock biomass, recruitment, annual F, and 3-year average *F* estimated for the MARI region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual F	3-year Average F
1982	21,294	4.38	0.13	-
1983	21,738	2.86	0.09	-
1984	22,347	2.02	0.09	0.10
1985	22,547	1.74	0.07	0.08
1986	21,276	2.06	0.20	0.12
1987	18,575	2.22	0.20	0.15
1988	16,017	2.46	0.22	0.21
1989	14,118	2.28	0.15	0.19
1990	13,024	1.86	0.16	0.18
1991	11,823	1.86	0.24	0.19
1992	9,292	1.83	0.63	0.34
1993	7,393	1.73	0.27	0.38
1994	7,150	1.64	0.16	0.35
1995	7,141	1.66	0.18	0.20
1996	6,866	1.47	0.27	0.20
1997	6,686	1.57	0.15	0.20
1998	6,827	2.00	0.13	0.18
1999	6,735	2.00	0.26	0.18
2000	6,542	1.72	0.23	0.21
2001	6,544	1.24	0.23	0.24
2002	6,552	1.29	0.23	0.23
2003	6,403	1.44	0.24	0.23
2004	6,177	1.78	0.22	0.23
2005	5,962	1.57	0.23	0.23
2006	5,880	1.39	0.21	0.22
2007	5,906	1.44	0.19	0.21
2008	5,885	1.89	0.22	0.21
2009	5,703	1.80	0.29	0.23
2010	5,538	1.59	0.29	0.27
2011	5,650	1.65	0.17	0.25
2012	5,902	2.09	0.19	0.22
2013	6,003	2.06	0.24	0.20
2014	6,011	2.59	0.30	0.24
2015	6,031	3.58	0.28	0.27
2016	6,349	3.35	0.24	0.27
2017	7,021	2.53	0.29	0.27
2018	7,976	1.85	0.15	0.23
2019	8,952	1.39	0.17	0.20
2020	9,510	1.34	0.14	0.15
2021	9,290	1.30	0.28	0.20
2022	8,588	1.17	0.19	0.20
2023	7,436	1.47	0.45	0.31
2024	5,726	0.57	0.53	0.39
*2024**	*9,572*			*0.26*

**Retrospectively adjusted values*

Table 6. SSB and *F* reference points from 2021 and 2025 updates for the MARI region.

	SSB		F	
	Target	Threshold	Target	Threshold
2021 Update	6,137	4,703	0.28	0.49
2025 Update	6,143	4,595	0.27	0.46

Table 7. Stock status for the MARI region.

	SSB		F	
	Target	Threshold	Target	Threshold
Reference Points	6,143	4,595	0.27	0.46
2024 Estimate	9,572*		0.26*	
2024 Status	Not Overfished		Overfishing is Not Occurring	

*: Retrospectively-adjusted values

Table 8. Short-term projection results for the MARI region under status quo removals.

Landings (mt) for 2025-2027	Probability of being at or above *F* threshold in 3 years	Probability of being at or below SSB threshold in 3 years
Status quo (2022-2024 average)	26%	0%

Figures

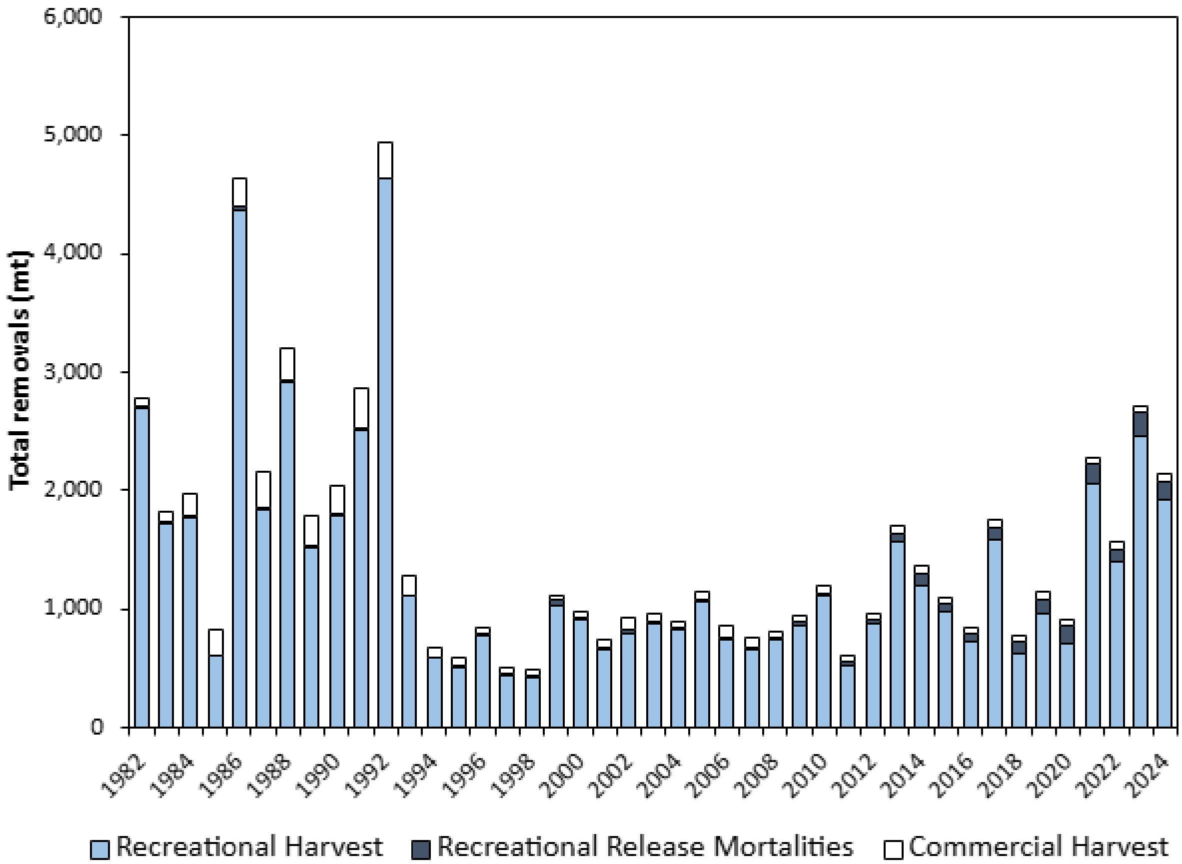


Figure 3. Total removals by sector for the MARI region.

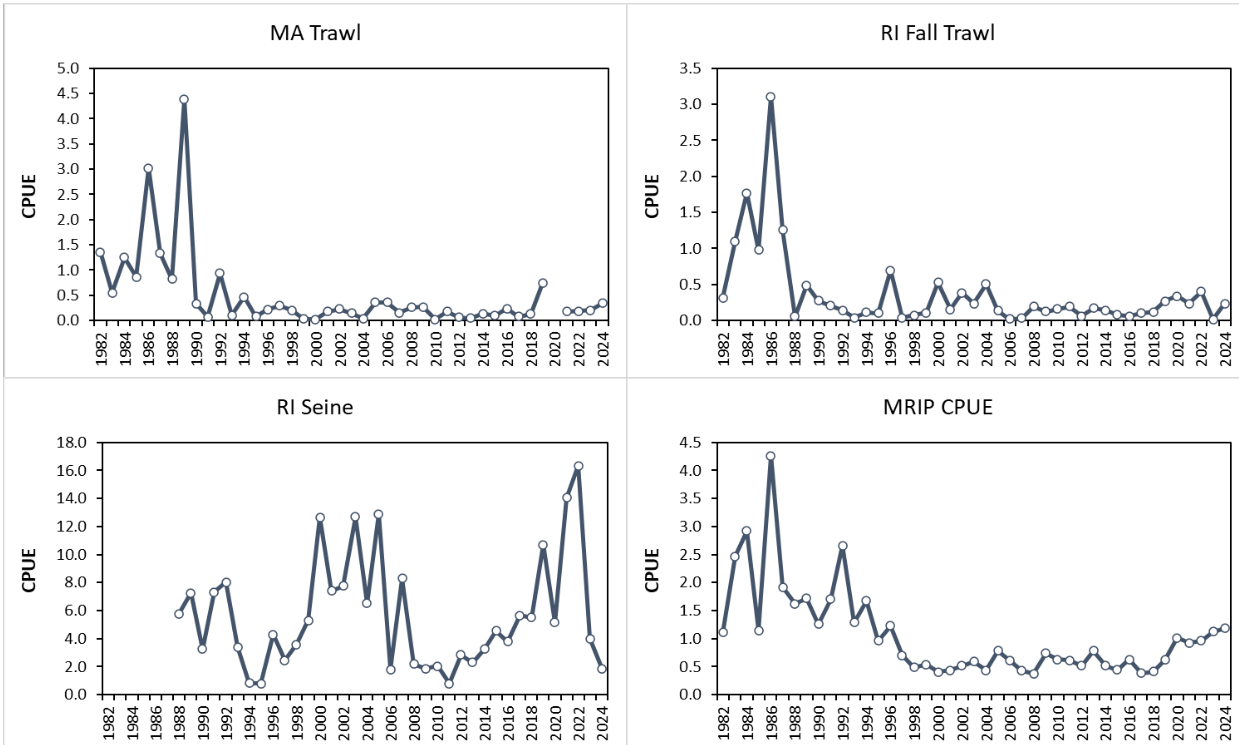


Figure 4. Indices of abundance used in the ASAP model for the MARI region.

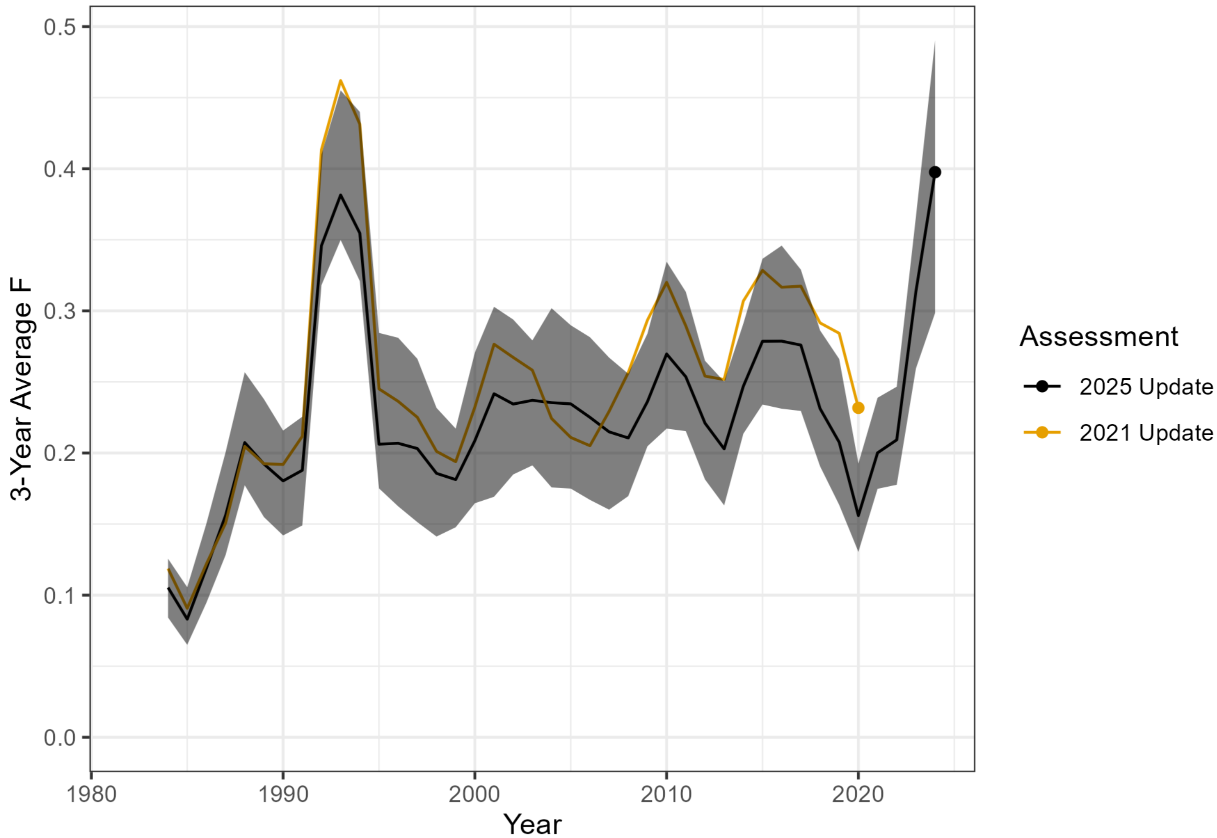


Figure 5. Estimates of the annual full *F* for the MARI region from the 2021 update and the 2025 update.

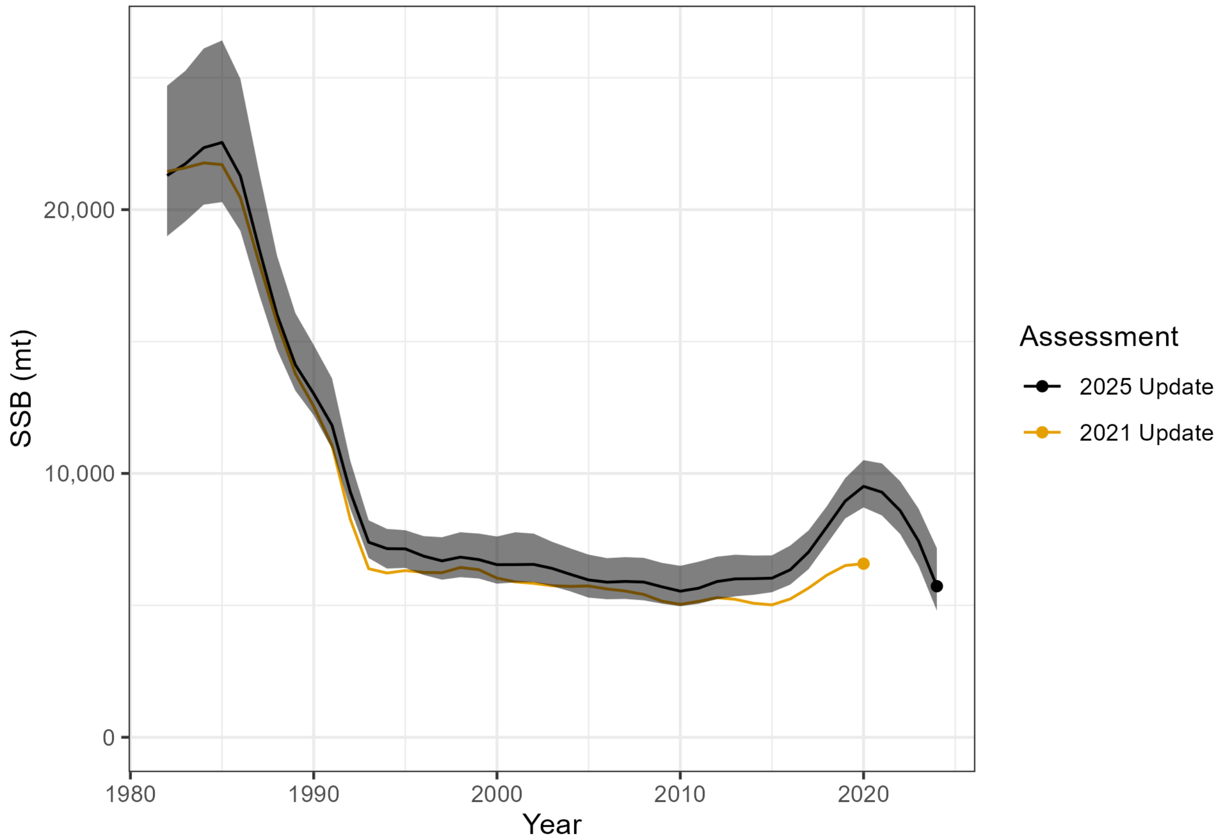


Figure 6. Estimates of spawning stock biomass for the MARI region from the 2021 update and the 2025 update.

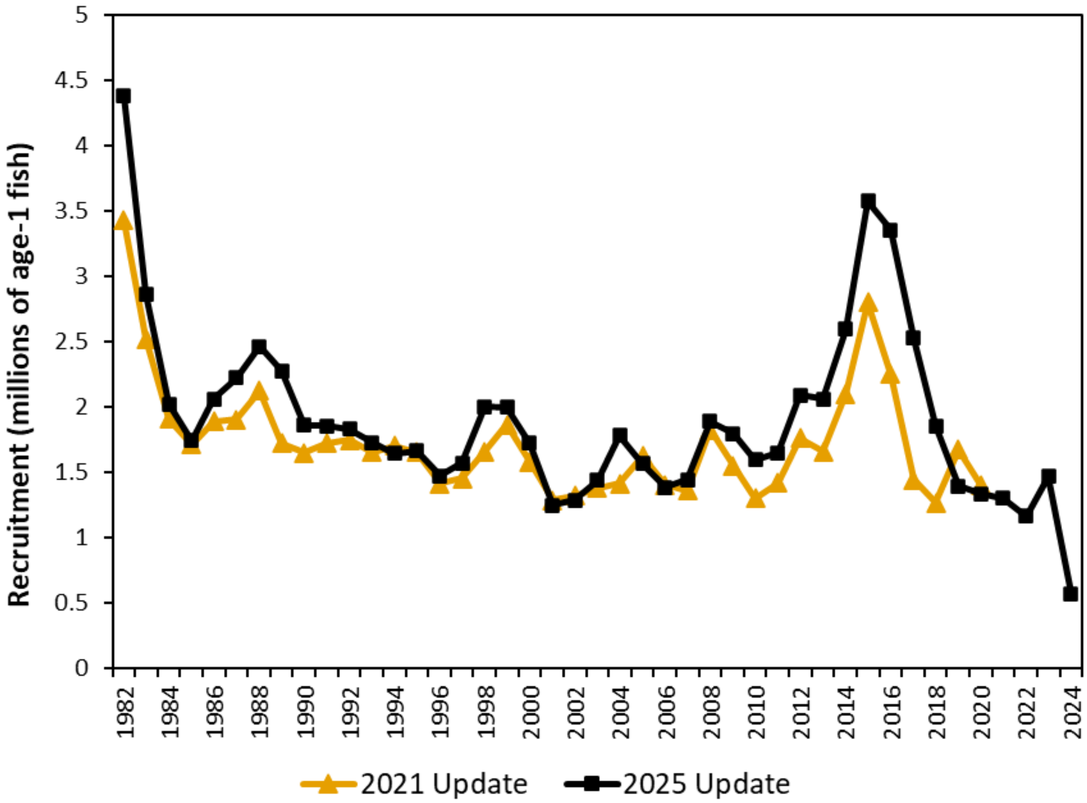


Figure 7. Estimates of recruitment for the MARI region from the 2021 update and the 2025 update.

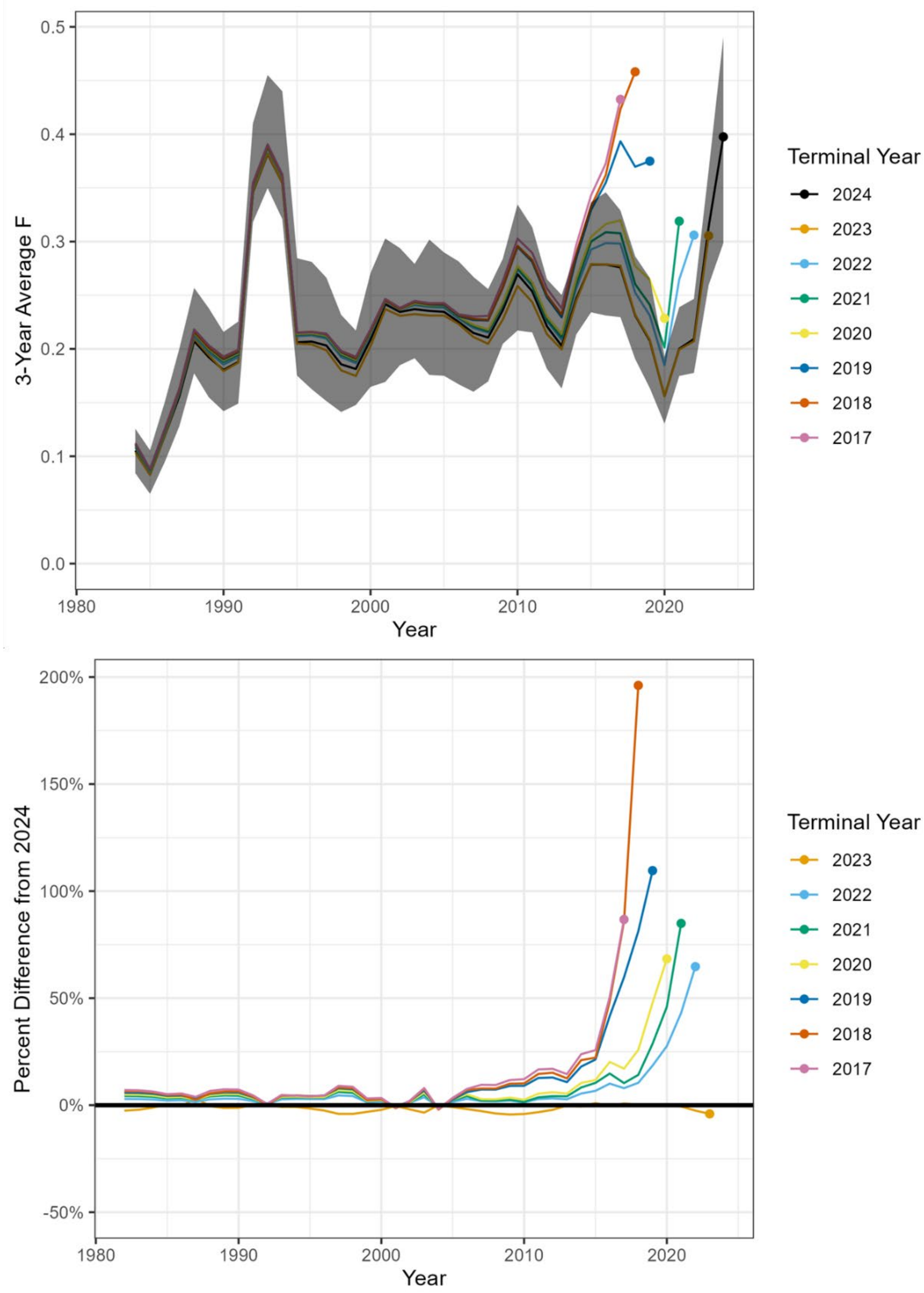


Figure 8. Retrospective analysis for annual *F* for the MARI region in absolute numbers (top) and percent difference (bottom).

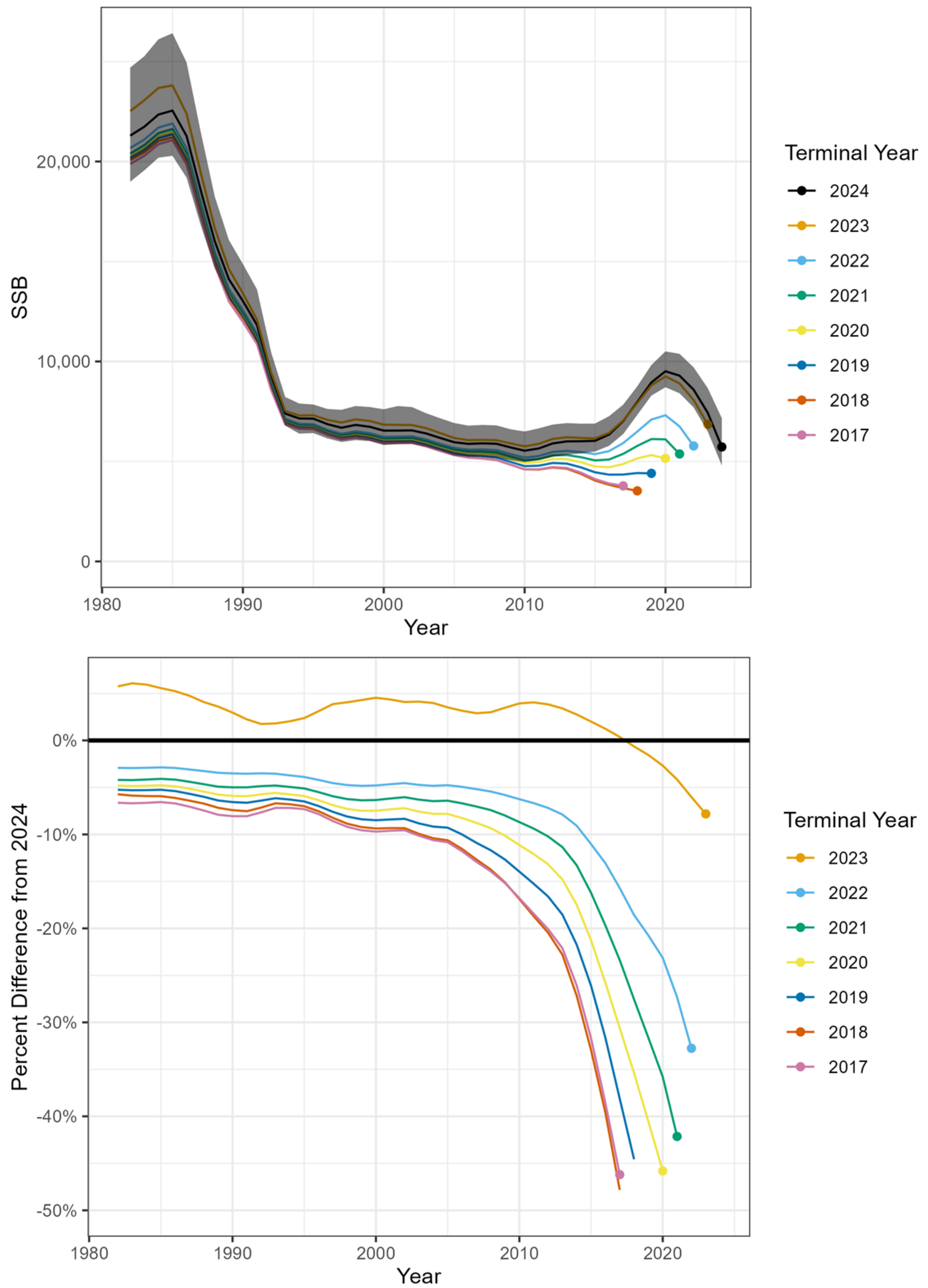
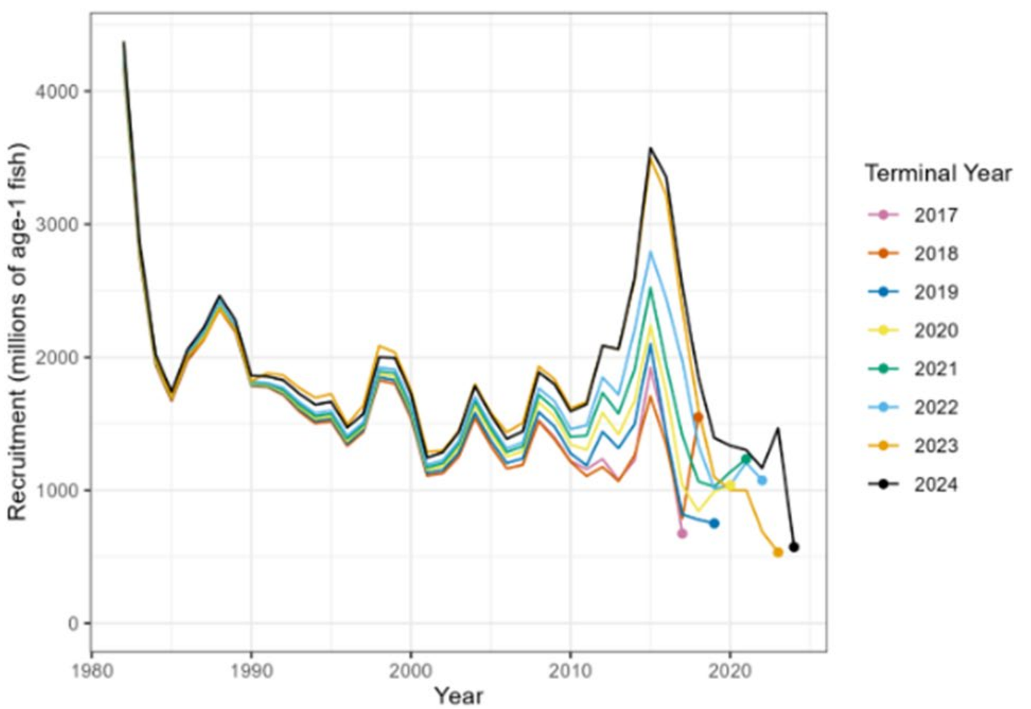


Figure 9. Retrospective analysis for SSB for the MARI region in absolute numbers (top) and percent difference (bottom).



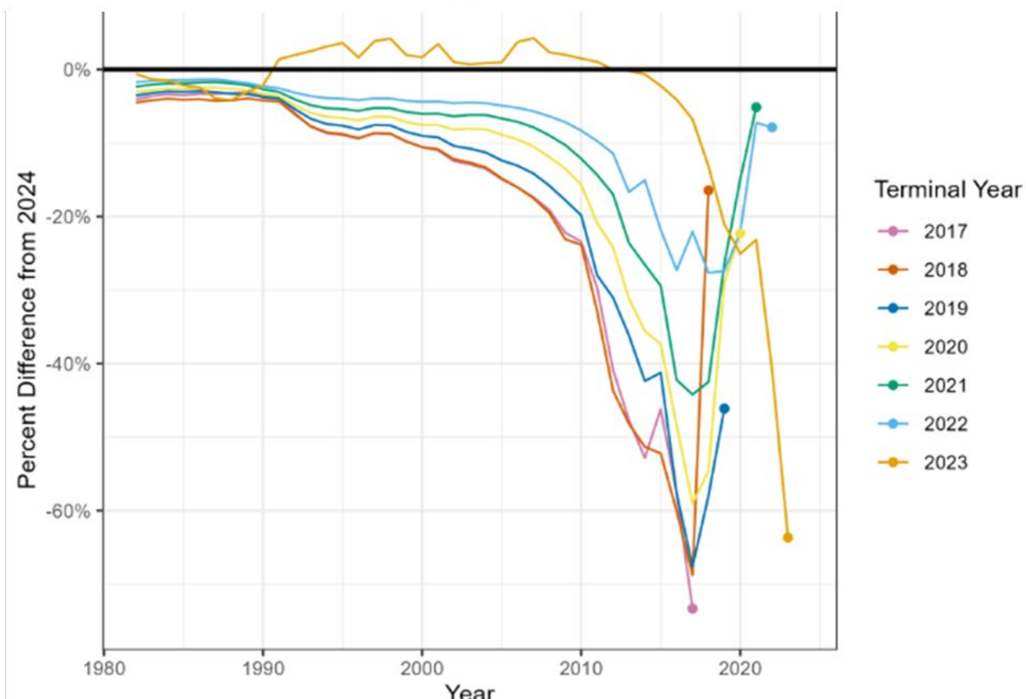


Figure 10. Retrospective analysis for recruitment for the MARI region in absolute numbers (top) and percent difference (bottom).

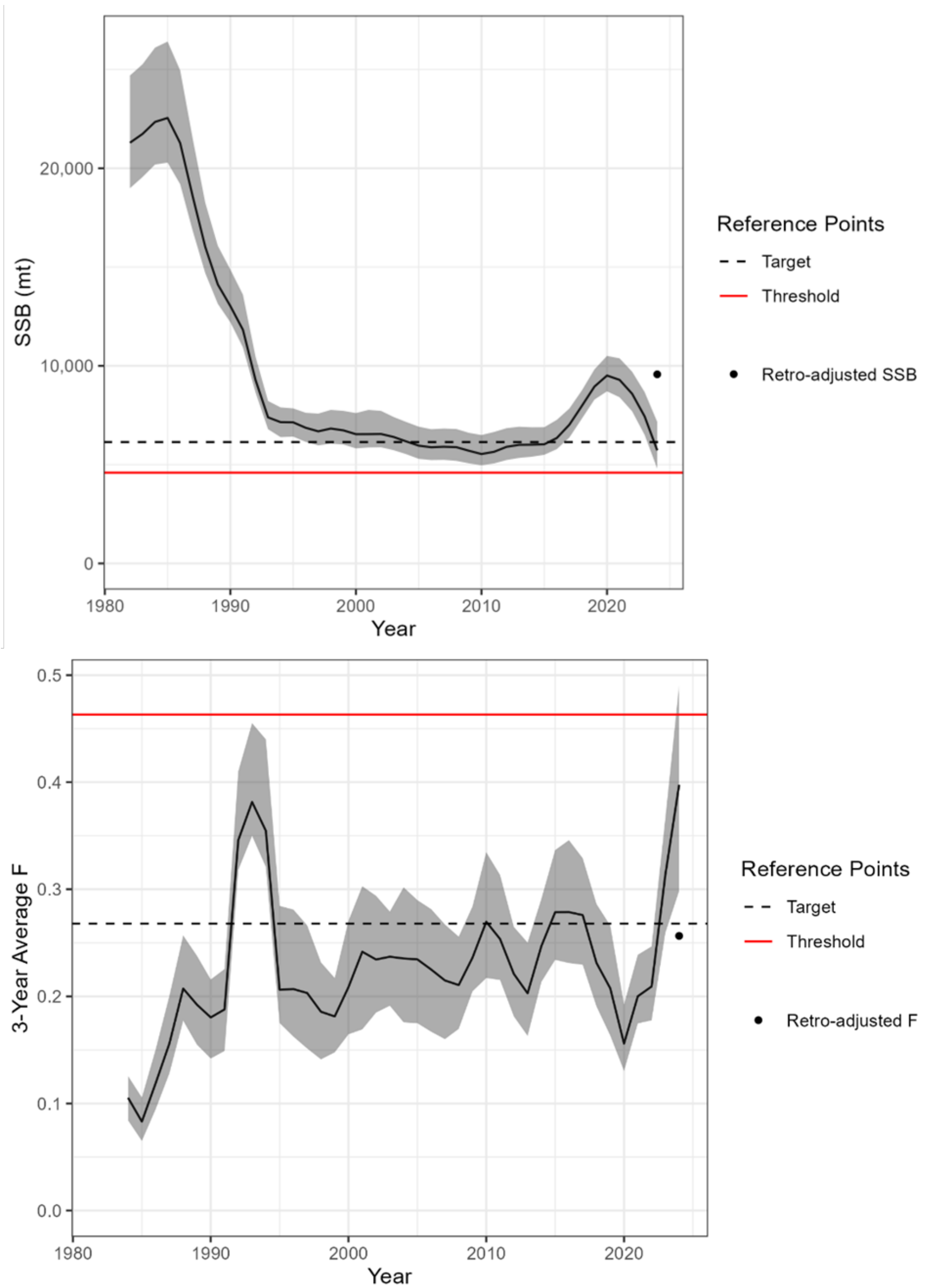


Figure 11. Annual SSB plotted with SSB target and threshold (top) and 3-year average *F* plotted with *F* target and threshold (bottom) for the MARI region.

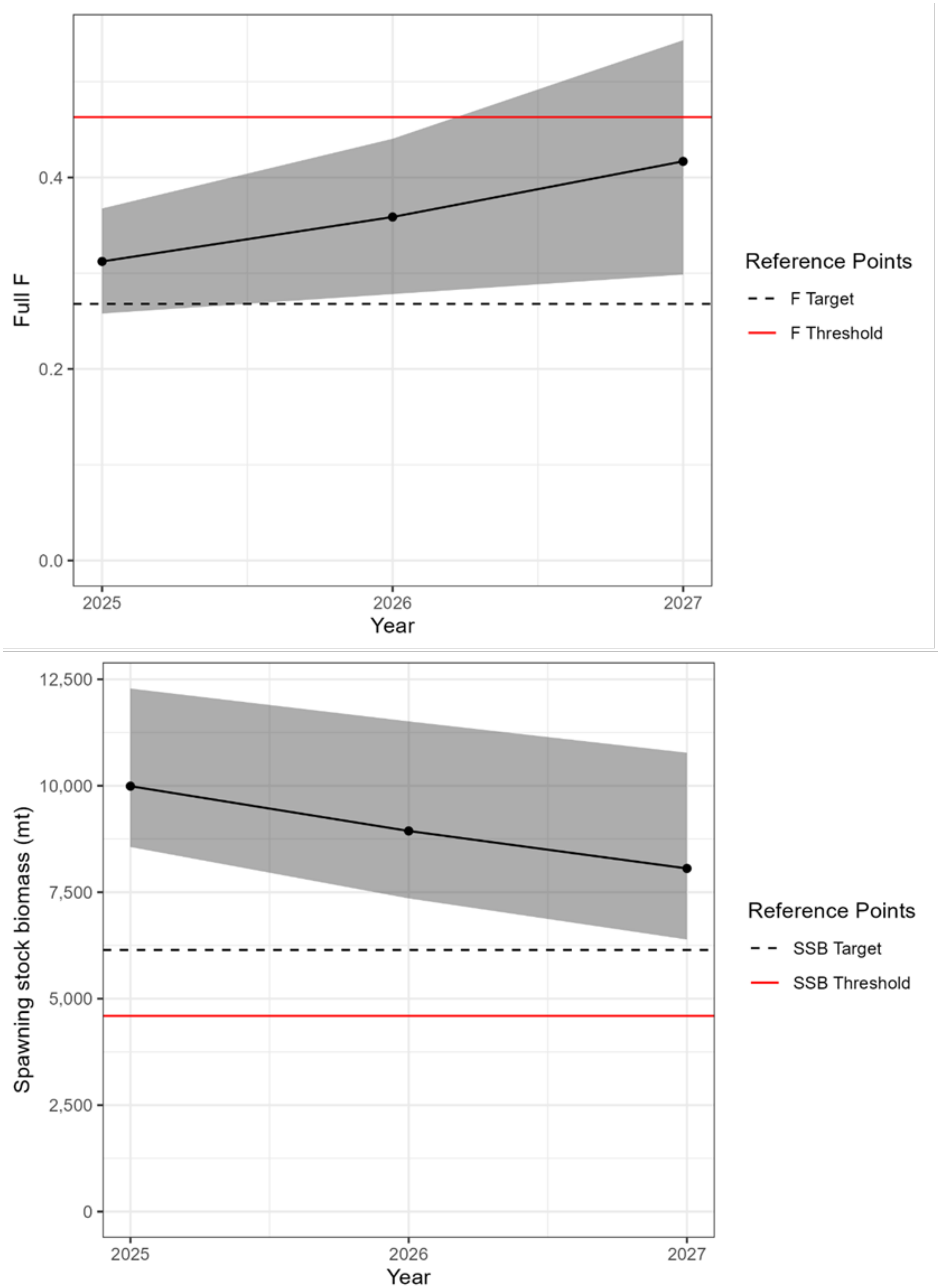


Figure 12. Status quo harvest projections for the MARI region showing the trajectory of annual *F* (top) and SSB (bottom) with their target and threshold reference points.
Shaded areas indicate the 95% confidence intervals of the estimates.

Tautog Stock Assessment Update
LONG ISLAND SOUND REGION

Executive Summary

The 2024 Long Island Sound (LIS) region tautog stock assessment update used the Age Structured Assessment Program (ASAP) version 3.0.17, available through the Northeast Fishery Science Center (NEFSC) National Fishery Toolbox (NFT) which is a “data rich,” forward projecting statistical catch at age program to assess tautog populations. The model incorporated annual harvest estimates, adult fishery-independent and fishery-dependent biomass, available age structure, size-at-age, and juvenile abundance indices from 1984-2024. The fishery-independent surveys were re-standardized to account for new data from 2021-2024. The ASAP model assumed a single fleet with four selectivity periods based on management time blocks. The ASAP model had a strong retrospective pattern that required adjustments for both spawning stock biomass and fishing mortality. Adjusted stock status in 2024 was consistent with the previous update. The current update indicated that the stock is not overfished and not experiencing overfishing. Short-term projections (three years) were conducted to evaluate the risk to the stock for maintaining status quo management. There was no risk that the stock will be overfished or experience overfishing in the near future.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The time series for commercial and recreational removals was extended from the previous assessment update (ASMFC 2021) through 2024, along with the associated age compositions from both sources.

The tautog fishery in the LIS region is predominantly recreational (Table 9, Figure 13). Recreational harvest has remained relatively stable since 2007, with years of low harvest in 2011 and 2018 (Table 1, Figure 13). Recreational release mortality has become a higher proportion of total removals since 2021, with 2024 having the highest number of recreational discard mortality.

Commercial harvest remains a small portion of overall mortality (Table 9, Figure 13). Commercial harvest was highest in the 1980s before declining to a series low in 1999. However, commercial harvest has been higher in 2021-2024, including a 4-year high of approximately 109.5 mt in 2022, which is similar to commercial harvest in the 1980s.

The calibrated MRIP length frequencies were used to calculate the age composition of the recreational harvest and were also used as a proxy for the length composition of the commercial harvest. Data from the MRIP at-sea headboat observer program, the Connecticut Volunteer Angler Survey, and the American Littoral Society (ALS) Volunteer tagging program were used to calculate the age composition of the recreational release mortality based on the methods described in the previous benchmark (ASMFC 2016). Ages 5–7 made up the majority of the total removals over the time series (LIS Appendix 1).

The Tautog TC developed a fishery dependent index of abundance from MRIP recreational survey data, using the same "logical species guilds" from the benchmark assessment to identify tautog trips. The MRIP CPUE index was high and somewhat variable at the beginning of the series before declining through the mid-1990s to lower, stable, levels throughout the 2000s. The index increased from 2021 to 2024 (Figure 14).

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The fishery-independent indices from the LIS consist of the Connecticut Long Island Sound Trawl Survey (CT LISTS), the New York Peconic Bay Trawl Survey, and the New York YOY Seine Survey (Table 10). Age composition information was available for the CT LISTS survey and is shown in LIS Appendix 1. For all indices, statistical model-based standardization of the survey data was conducted to account for factors that affect Tautog catchability.

The CT LISTS is conducted in the spring and fall utilizing a stratified random design and was used to develop an index of age-1+ abundance for tautog. The survey was not conducted in 2020 due to COVID-19 restrictions. This survey is the source of CT's age and length samples for tautog, so as a result, the age-length key for the LIS region did not include CT data for 2020. The model selected with AIC was a zero-altered negative binomial with year, month, and stratum as the explanatory variables. Only categorical parameters were considered because environmental data was not collected in the early years of the time series. The index was highest at the beginning of the time series and declined through the mid-1990s; it rebounded somewhat during the late 1990s and early 2000s and then remained at low, stable levels until 2010. The index increased from 2010 to 2024, by 2024 the index was similar to the late 1980s (Figure 14).

New York YOY Seine Survey operated from 1984 to the present, with a consistent standardized methodology starting in 1987. It is a fixed site survey that is conducted in three separate embayments on Long Island; the data were subset to bays on the north side of Long Island for the LIS region. A subset of 8 stations that were sampled throughout the full time series were used to create the index of abundance. The New York YOY survey was used to develop a YOY index of recruitment for tautog. The New York YOY Seine Survey was conducted in 2020 but the start was delayed due to COVID-19 restrictions. Years with zero catch were not included in the index standardization, including 1985, 1994, and 2009. The best selected model for index standardization was a negative binomial with year and surface temperature as the explanatory variables. The index was variable with periods of higher recruitment including the early 1990s and the early 2000s; in recent years the index has been lower; however 2022, and 2023 were years with high recruitment (Figure 14).

NYDEC Peconic Bay trawl survey operated from 1987 to the present, with a consistent standardized methodology starting in 1991. Sixteen stations are randomly sampled from May to October and target age-1 individuals. The survey was not conducted in 2005, 2006, and 2008. The best selected model based on AIC was a zero-altered negative binomial model with year, station, surface temperature, and surface salinity as explanatory variables. The index is highly variable with a few periods of higher recruitment including the late 1980s and the mid-2010s, but the index increased to its highest value in 2024 (Figure 14).

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

Life history parameters were the same as used in the peer-reviewed benchmark stock assessment (Table 11; ASMFC 2016).

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The model used in the last stock assessment update (1984-2021; ASMFC 2021) was updated with data through 2024. The indices of abundance for the fishery-independent and MRIP surveys were re-calculated and re-standardized for this update, causing some slight deviations between index values for individual years. No other deviations from the 2021 update were made for the 2025 update.

Estimates from the 2025 update were compared to the 2021 update, but not to the benchmark assessment in 2016 because the benchmark did not include the calibrated MRIP estimates. Estimates of fishing mortality were largely similar between the two assessments except between 2000-2010, where the 2025 estimates were higher than the 2021 assessment estimates and in 2016-2021, where the 2025 estimates were lower than the 2021 assessment estimates (Table 12, Figure 15). Estimates of SSB were higher than the 2021 update after 1993 (Table 12, Figure 16). Recruitment estimates for the 2025 update were higher than the 2021 update for most years in the time series (Table 12, Figure 17).

Due to recruitment and SSB estimates being significantly higher compared to the 2021 update, sensitivity runs were conducted to establish what was driving these changes in the model. Runs without the NY Seine Survey and one without the NY Peconic Bay Survey were conducted (LIS Appendix 2 Figure A2.2). Dropping the NY Seine Survey from the model affected the recruitment and SSB estimates greatly, with both values estimated much lower in recent years compared to other model runs. The NY Seine Survey was thus weighted less than others in the final model to offset the extreme influence and high variability in this index.

A retrospective analysis was run from 2019-2024. While there was a strong retrospective pattern, the bias was generally conservative, with fishing mortality being overestimated in all years (Figure 18) and SSB being underestimated in all years (Figure 19). Recruitment was underestimated in all years (Figure 20). Mohn’s rho for *F* (rho=0.56) and SSB (rho=-0.31) were outside the recommended bounds for a long-lived species, and the retrospectively adjusted values for both *F* and SSB were outside of the 90% confidence intervals of the unadjusted values in the terminal year (LIS Appendix 2, Figure A2.1). Therefore, a retrospective adjustment was applied for both metrics (ASMFC 2024).

Fishing mortality has fluctuated throughout the time series, increasing to a high in 1995 before decreasing again through 2001 (Figure 15). In recent years, fishing mortality has declined from 2010 to 2021 but has increased again through 2024. SSB was highest in 1984 but declined to a series low in 1995 (Figure 16). During periods of low F, SSB increased slightly from 1996-2006, before declining again from 2007-2010. SSB increased from 2011-2021 but has declined slightly in the last 3 years, although these years are still some of the highest in the time-series. Recruitment has fluctuated somewhat over time (Figure 17); however, recruitment has generally increased during 2006-2024, with a time-series high recruitment in 2024.

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

The LIS region uses MSY-based reference points for tautog. The SSB target is SSB_{MSY} and the SSB threshold is 75% of SSB_{MSY}. The *F* target is F_{MSY}, and the *F* threshold is the value of *F* that will allow the population to stabilize at the SSB threshold in the long-term. The updated SSB reference points for the LIS region were higher than the values from the 2021 update, but the *F* reference points were similar (Table 13).

The ASAP model runs indicated overfishing was not occurring in the LIS in 2024 relative to MSY reference points. The adjusted 3-year average value of F_{3yr} = 0.25 was below the *F* threshold value of 0.35 (Table 14, Figure 21).

The ASAP model runs indicated the tautog stock was not overfished in the LIS relative to MSY reference points. SSB in 2024 was 13,718 mt, well above the $SSB_{75\%\ MSY}$ threshold of 7,349 mt and SSB_{MSY} target of 9,799 mt (Table 6, Figure 21).

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term, 3-year projections were conducted in AgePro and were used to predict the impact of status quo management on the population. Overall, the stock is not at risk for becoming overfished or for overfishing to occur in the near future. The short-term projection using most recent three-year average of removals indicated there was a 0% probability of being at or above the *F* threshold and less than 10% probability of being at or above the *F* target in 2027 (Table 15, Figure 10). Short term projections showed a 100% probability of being at or above both the SSB threshold and SSB target for 2025-2027 (Table 15, Figure 22).

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

Research recommendations from the benchmark assessment included expanding biological sampling of catch and discards and increased MRIP sampling efforts. Age and length samples in the fishery remain limited leading to age-length borrowing between regions and years. Modeling the harvest and discard at length distributions, rather than using the actual harvest and discard length observations, could potentially help to manage the small sample size for such observations. However, increased monitoring of tautog for both the fishery and fishery-independent survey could increase sample size of age-length data in this region.

Additionally, establishing multi-stage fishery-independent surveys with appropriate gears for structure-oriented species was a high priority documented in the benchmark assessment. In Connecticut, the new Nearshore Survey involving non-trawl gears including pots, seines, and light-traps was initiated in 2025, which may be able to capture young-of-the-year tautog and could be included as a data source in future benchmarks.

The benchmark assessment suggested improved genetic analyses and monitoring of illegal harvest. These recommendations remain high priority for this region and future benchmark assessments. Commercial tagging programs have helped reduce illegal harvest in the commercial sector and improve monitoring of harvest. However, fishers have expressed concern with the current type of tag used (strap tag), suggesting the tag caused lesions on fish and did not stay in place. New York State Department of Environmental Conservation (NYDEC) conducted a feasibility study to evaluate alternative tag types (e.g., Peterson disc, strap, and T-Bar) and tagging locations (NYDEC 2024). NYDEC could not find an alternative to the current tag used for commercial tagging. Due to funding constraints and limited alternative gears to test, the NYDEC has halted additional research.

Age data for the LIS was informed by operculum derived ages for both New York and Connecticut. However, New York anticipates transitioning fully to otoliths in the near future and Connecticut has considered transitioning to spines. Early pair-wise comparisons suggest some bias between otolith and operculum ages, where tautog are estimated one-year older with otolith derived ages compared to operculum derived ages. If otolith or spine ages are to be used in the next benchmark assessment, further pairwise analysis should be conducted to understand how this new age information may affect stock assessment output. Additionally, age composition informed by different structures (spines and otolith) could create disagreement in age information. Future research is needed to understand the impacts of using multiple structures to inform age composition.

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List of Appendices

LIS Appendix 1: ASAP plot outputs from the base run.
LIS Appendix 2: Retrospective Adjustment and Sensitivity Runs.

Tables

Table 9. Total removals in metric tons by sector for the LIS region.

	Recreational Harvest (mt)	Recreational Release Mortalities (mt)	Commercial Harvest (mt)
1984	1,413.1	3	
1985	2,389.6	6.3	
1986	2,179.7	3.2	129.4
1987	2,483.9	5.9	159.1
1988	1,779.0	6	116.9
1989	1,794.0	5.7	140.4
1990	1,518.5	7.8	77.9
1991	1,373.1	8.8	76.2
1992	1,195.2	6.3	74.4
1993	1,254.6	5.1	60
1994	837.0	5.9	33.5
1995	472.1	4.4	11.1
1996	252.1	3.3	51.5
1997	262.3	3.5	31.9
1998	381.5	9.7	26
1999	508.0	8	8.9
2000	154.3	2.5	9.1
2001	151.5	4.8	15.6
2002	1,625.2	19.9	20.4
2003	735.5	9.5	31.9
2004	717.9	10.1	40.8
2005	370.7	5.5	33.6
2006	885.2	13.8	39.3
2007	1,695.5	25.9	54.6
2008	1,371.7	15.5	37.5
2009	1,371.2	14.8	21.5
2010	1,003.7	13.7	25.2
2011	340.7	12.2	33.1
2012	1,224.8	67.6	25.4
2013	972.4	55.2	31.8
2014	1,053.6	93.8	39.6
2015	1,356.3	88.3	29.7
2016	1,519.1	85.3	33.3
2017	833	81.5	47.9
2018	303.2	61.1	38.8
2019	1,550.5	99.2	76.3
2020	1,120.4	96.2	58
2021	1,525.5	92.8	81.6
2022	807.2	87.4	109.5
2023	1,434.8	157.9	77.4
2024	1,388.6	132.4	92.7

Table 10. Indices used in the ASAP model for the LIS region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
MRIP CPUE	Total Catch Per Unit Effort	Stratified Random	Mar-Dec	1982-2024	1+
Connecticut LIS Trawl Survey	Mean number per tow	Stratified Random	April-June	1984-2024	1+
NYDEC Peconic Bay Trawl	Mean number per tow	Stratified Random	May-Oct	1987-2024	1
New York YOY Seine Survey	Mean number per haul	Fixed	July-Nov	1984-2024	YOY

Table 11. Model structure and life history information used in the LIS stock assessment.

	Value(s)
Years in Model	1984-2024
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB calculation	0.42
Number of selectivity blocks	4
Selectivity periods	1984-1986, 1987-1994, 1995-2011, and 2012-2024
Selectivity type	Logistic

	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 12. Spawning stock biomass, recruitment, annual F, and 3-year average *F* estimates for the LIS region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual F	3-year Average F
1984	13,843	2.85	0.18	
1985	13,255	2.27	0.26	
1986	12,096	3.13	0.25	0.23
1987	10,667	2.54	0.34	0.28
1988	9,423	2.59	0.30	0.30
1989	8,441	1.49	0.37	0.34
1990	7,499	1.74	0.38	0.35
1991	6,590	1.79	0.37	0.37
1992	5,799	1.57	0.37	0.37
1993	5,144	1.34	0.39	0.38
1994	4,061	1.41	0.77	0.51
1995	3,301	1.76	0.49	0.55
1996	3,484	1.55	0.22	0.49
1997	4,028	1.77	0.18	0.30
1998	4,555	2.25	0.19	0.20
1999	4,997	2.31	0.23	0.20
2000	5,455	1.98	0.24	0.22
2001	6,119	1.70	0.13	0.20
2002	6,027	1.91	0.66	0.34
2003	5,601	2.16	0.29	0.36
2004	5,826	1.46	0.27	0.41
2005	6,263	1.50	0.15	0.24
2006	6,580	1.44	0.24	0.22
2007	6,125	1.87	0.47	0.29
2008	5,172	2.97	0.55	0.42
2009	4,486	2.53	0.55	0.52
2010	4,490	2.57	0.48	0.53
2011	5,064	2.39	0.27	0.43
2012	5,620	2.24	0.55	0.43
2013	5,908	2.75	0.44	0.42
2014	6,178	2.96	0.42	0.47
2015	6,414	3.09	0.42	0.43
2016	6,647	2.79	0.45	0.43
2017	7,264	2.61	0.22	0.36
2018	8,449	3.27	0.09	0.25
2019	9,287	2.79	0.29	0.20
2020	9,741	2.55	0.21	0.19
2021	9,876	2.70	0.36	0.28
2022	9,785	4.39	0.22	0.26
2023	9,692	4.36	0.36	0.31
2024	9,519	5.21	0.39	0.32
*2024**	*13,718*			*0.25*

**Retrospectively adjusted values.*

Table 13. SSB and *F* reference points from 2021 and 2025 updates for the LIS region.

	SSB		F	
	Target	Threshold	Target	Threshold
2021 Update	6,725	5,044	0.26	0.38
2025 Update	9,799	7,349	0.25	0.35

Table 14. Stock status for the LIS region with adjusted estimates of SSB and F.

	SSB		F	
	Target	Threshold	Target	Threshold
Reference Points	9,799	7,349	0.25	0.35
2024 Estimate	13,718*		0.25*	
2024 Status	Not overfished		Not overfishing	

*: Retrospectively-adjusted value

Table 15. Projection results for the LIS region.

Landings (mt) for 2025-2027	Probability of being at or above the *F* threshold in 3 years	Probability of being at or below SSB threshold in 3 years
Status quo (2021-2024 average)	0%	0%

Figures

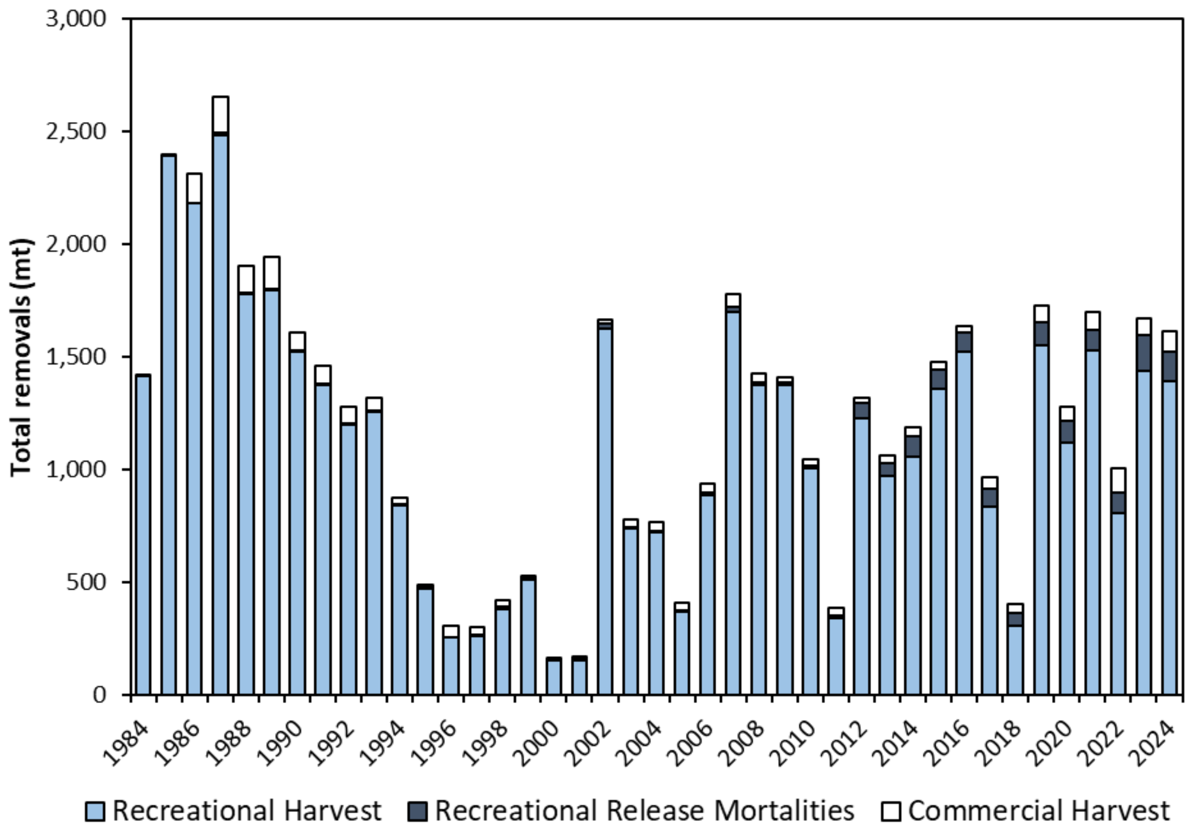

Figure 13. Total removals by sector for LIS region.

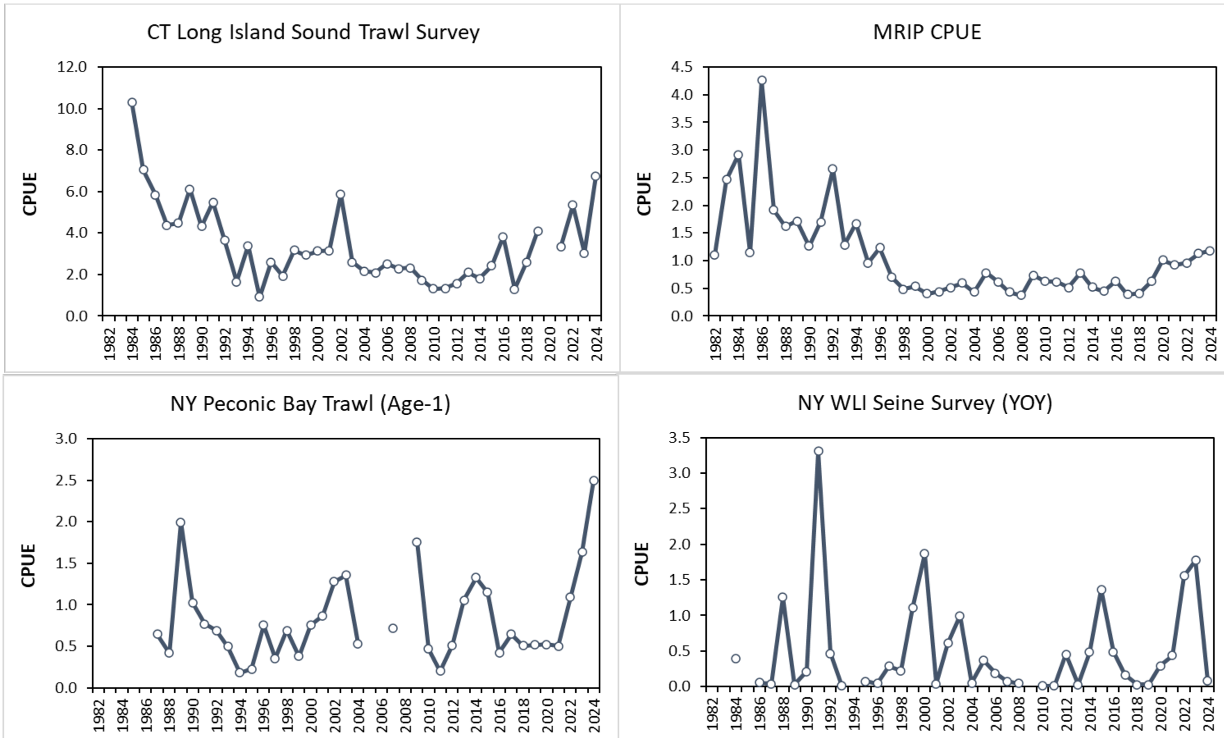

Figure 14. Indices of abundance used for the LIS region.

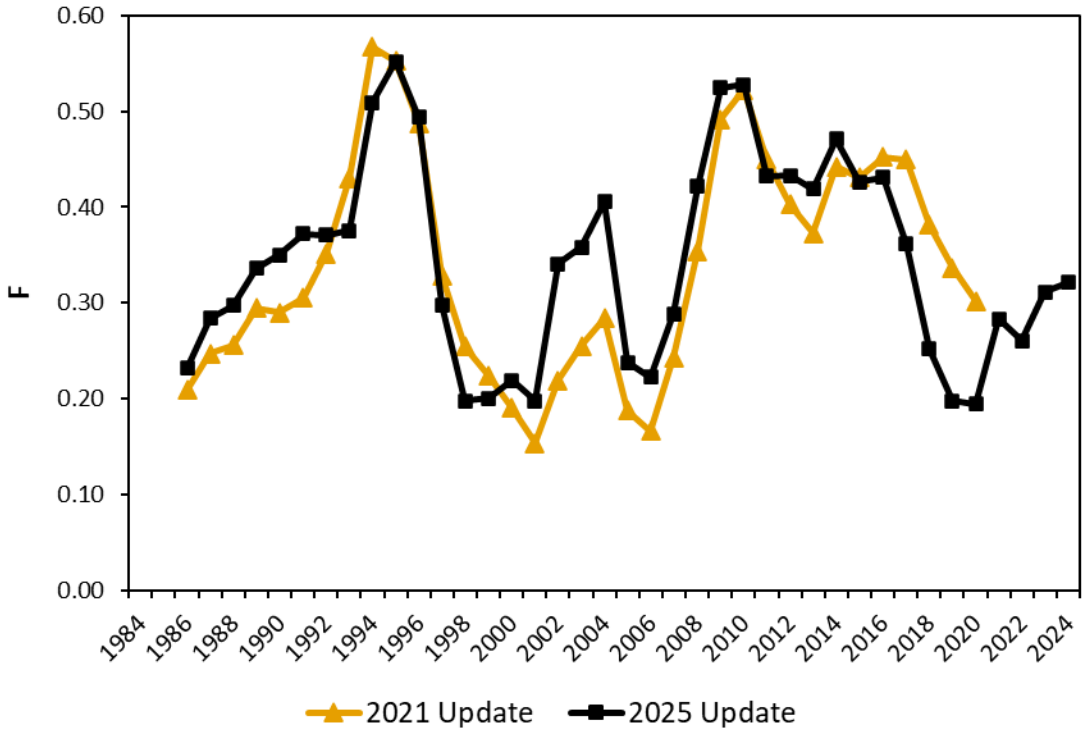

Figure 15. Estimates of the 3-year average *F* for the 2021 update and the 2025 update for the LIS region.

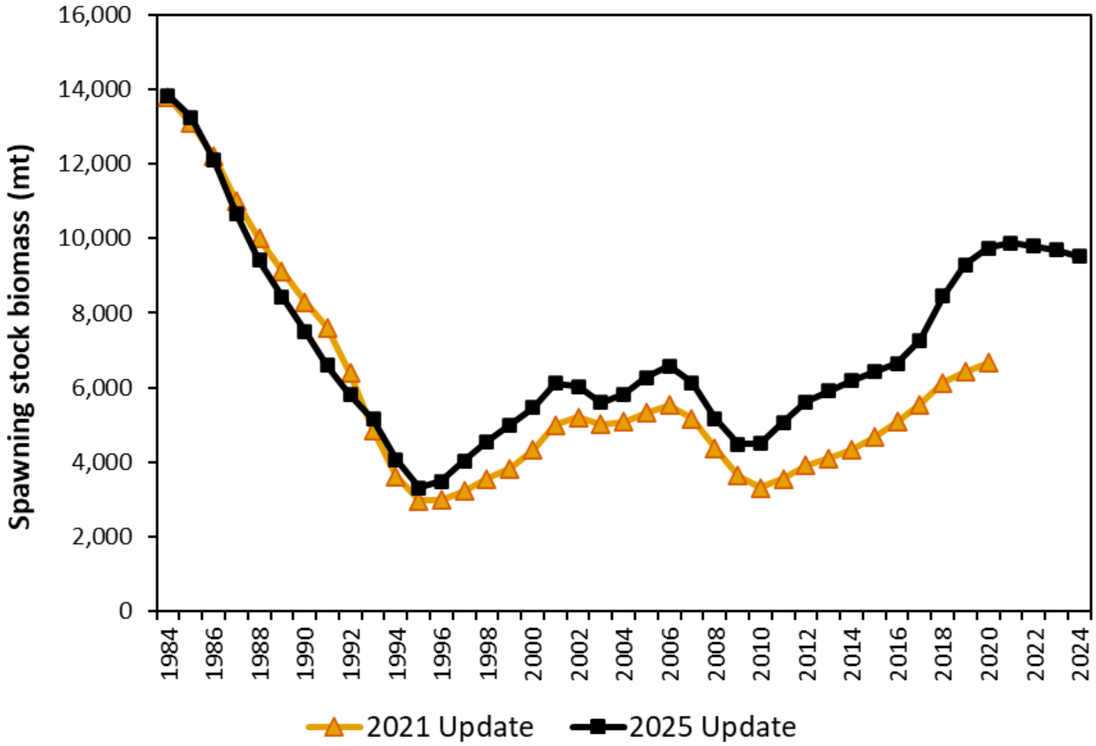

Figure 16. Estimates of spawning stock biomass for the 2021 update and the 2025 update for the LIS region.

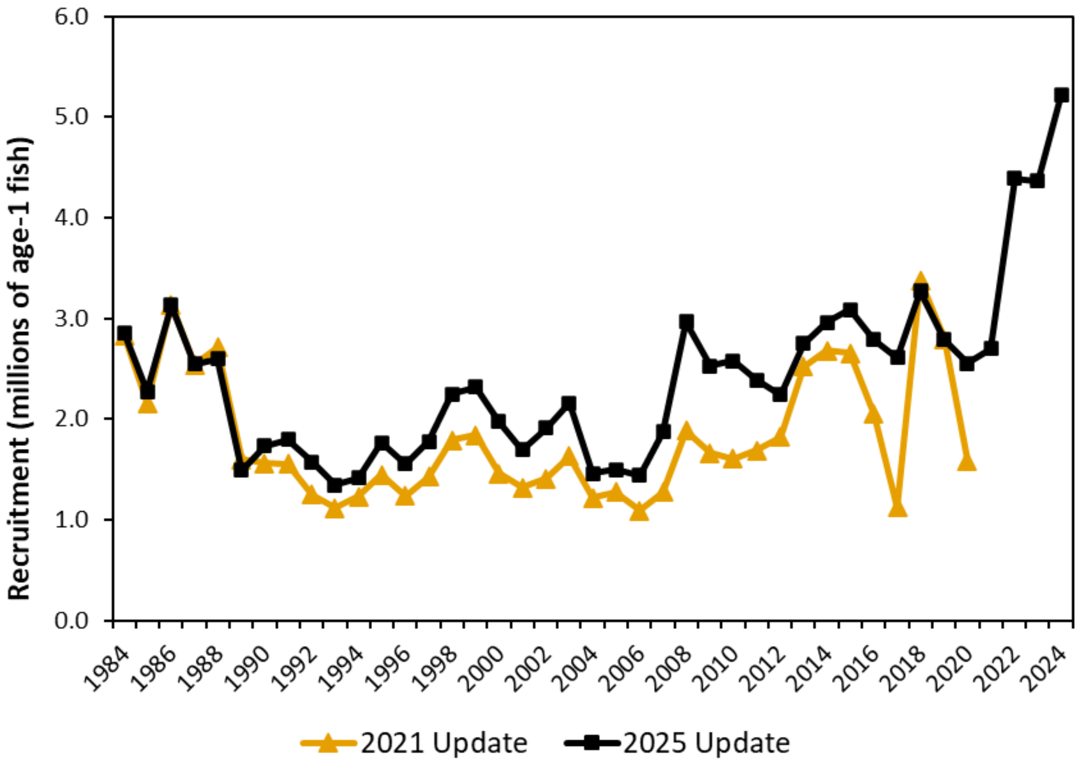

Figure 17. Estimates of recruitment for the 2021 update and the 2025 update for the LIS region.

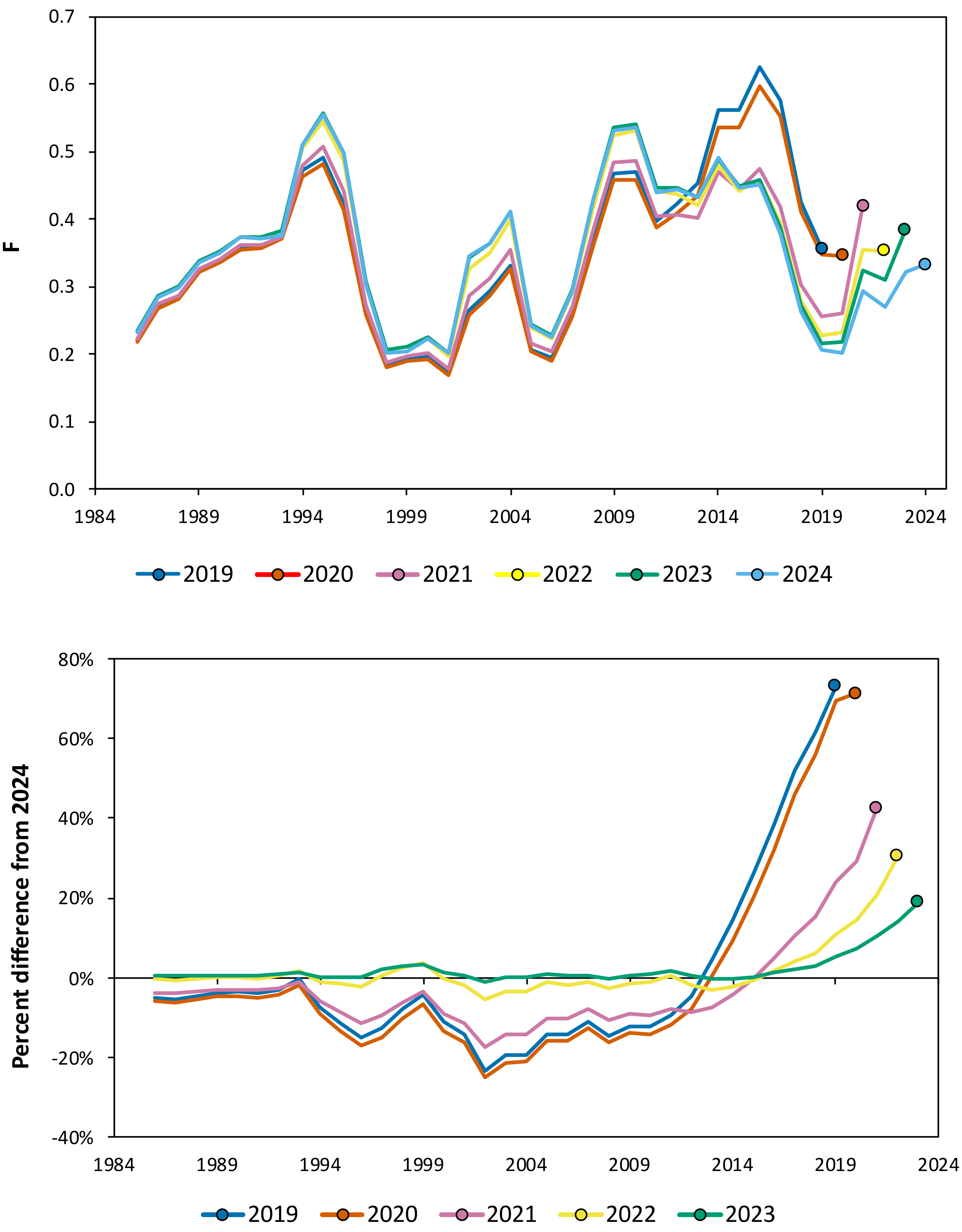

Figure 18. Retrospective analysis for the 3-year average *F* in absolute numbers (top) and percent difference (bottom) for the LIS region.

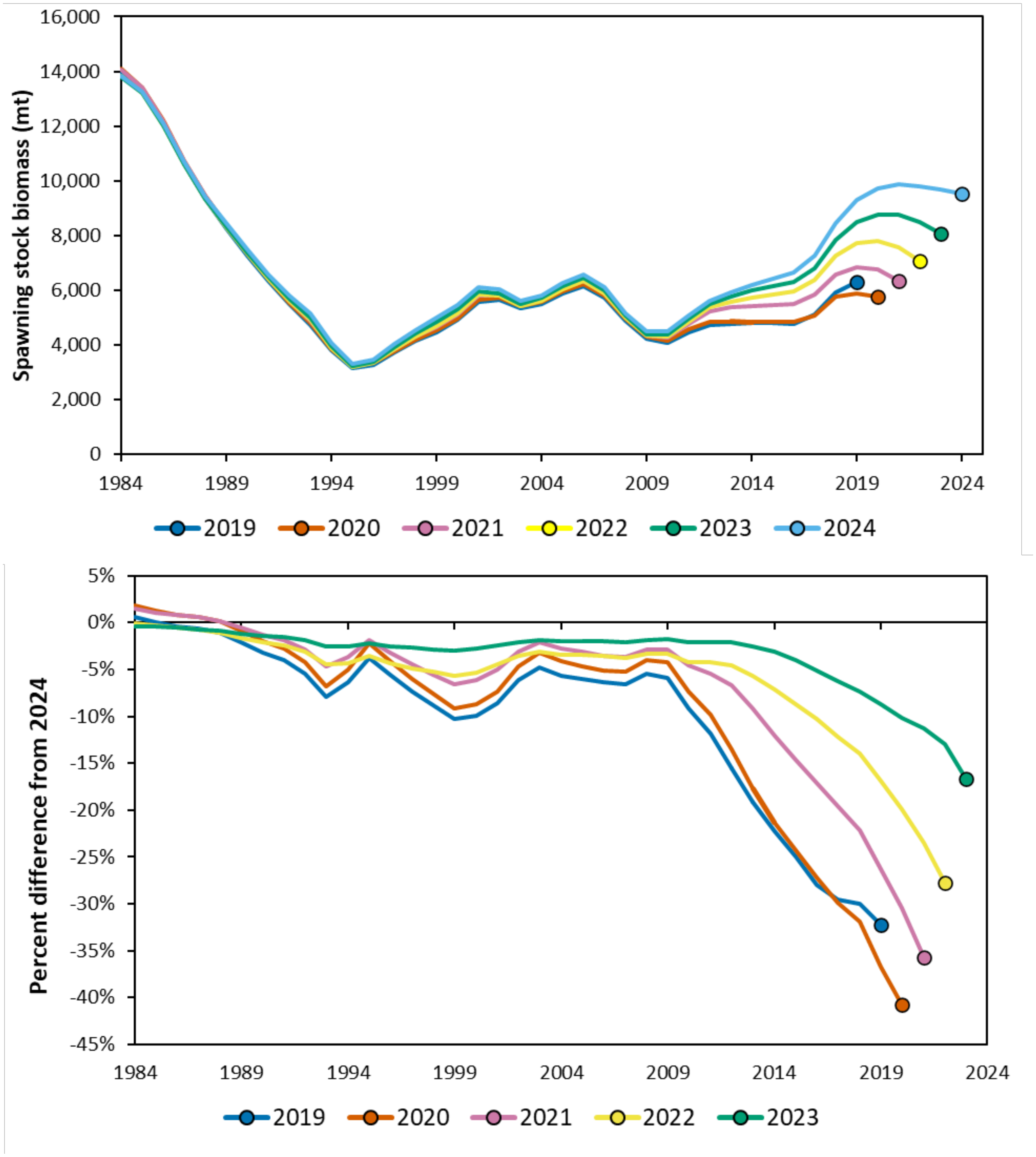

Figure 19. Retrospective analysis for annual SSB in absolute numbers (top) and percent difference (bottom) for the LIS region.

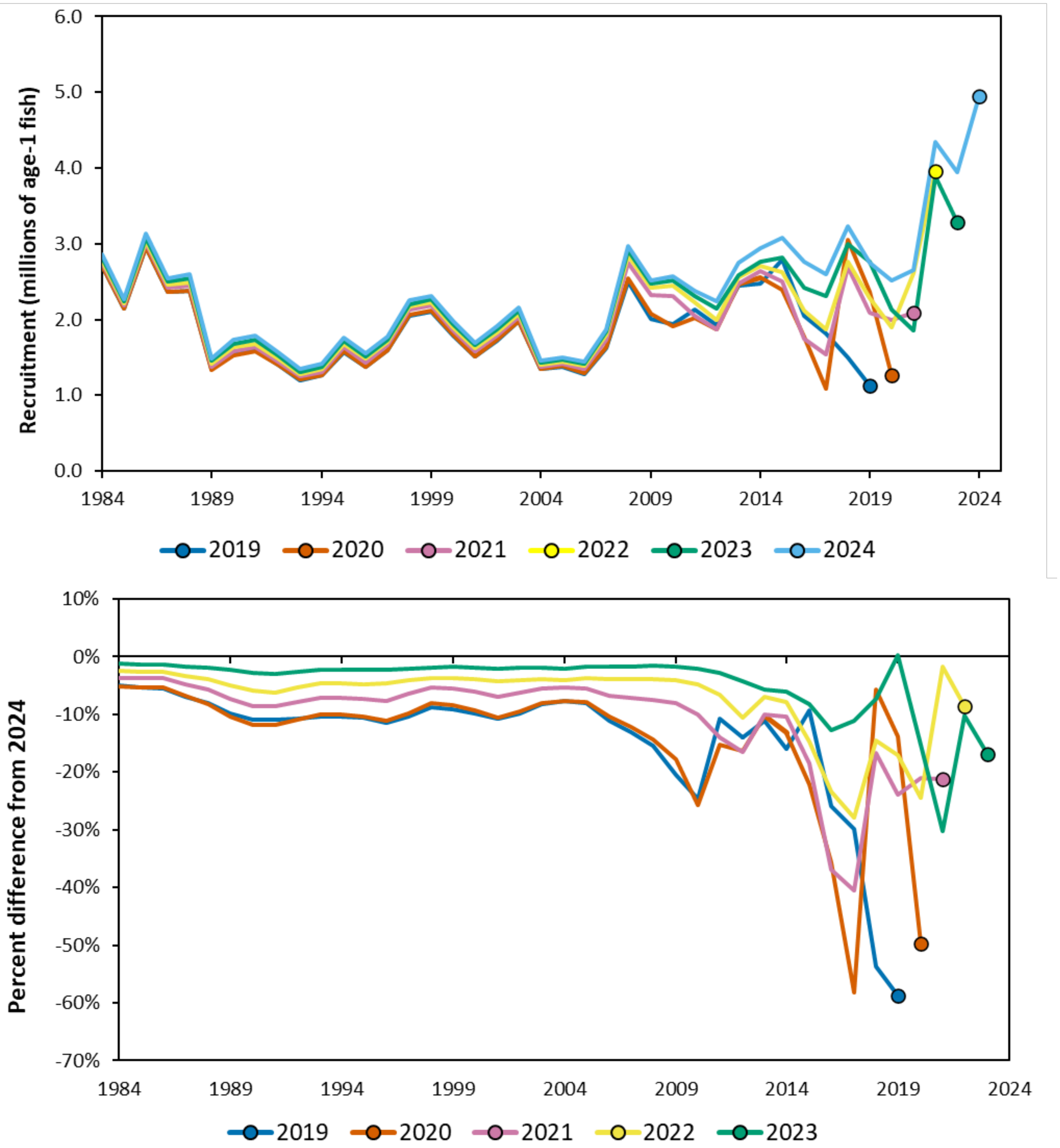

Figure 20. Retrospective analysis for annual recruitment in absolute numbers (top) and percent difference (bottom) for the LIS region.

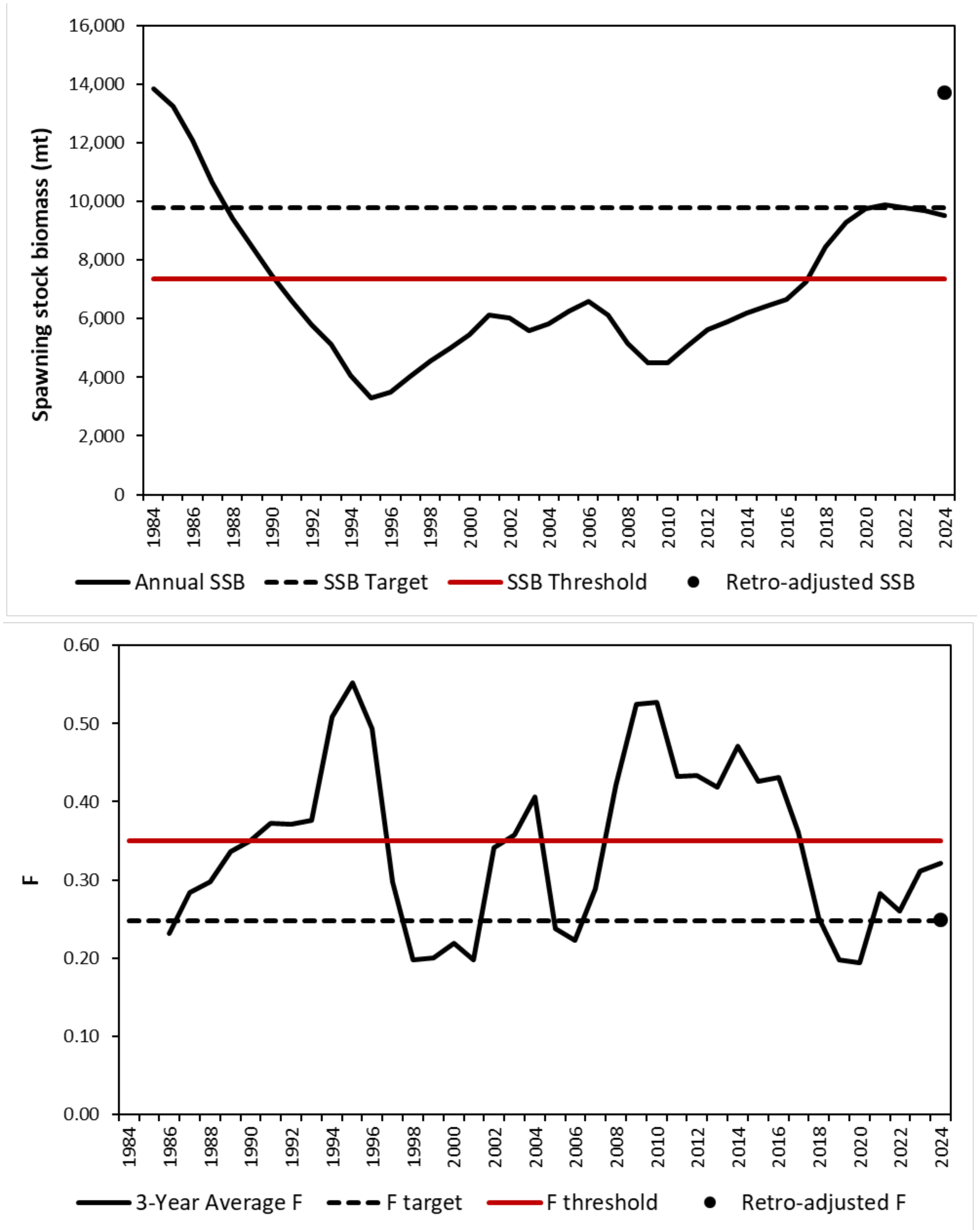

Figure 21. Annual SSB plotted with SSB target and threshold (top), and 3-year average *F* plotted with *F* target and threshold (bottom) for the LIS region.

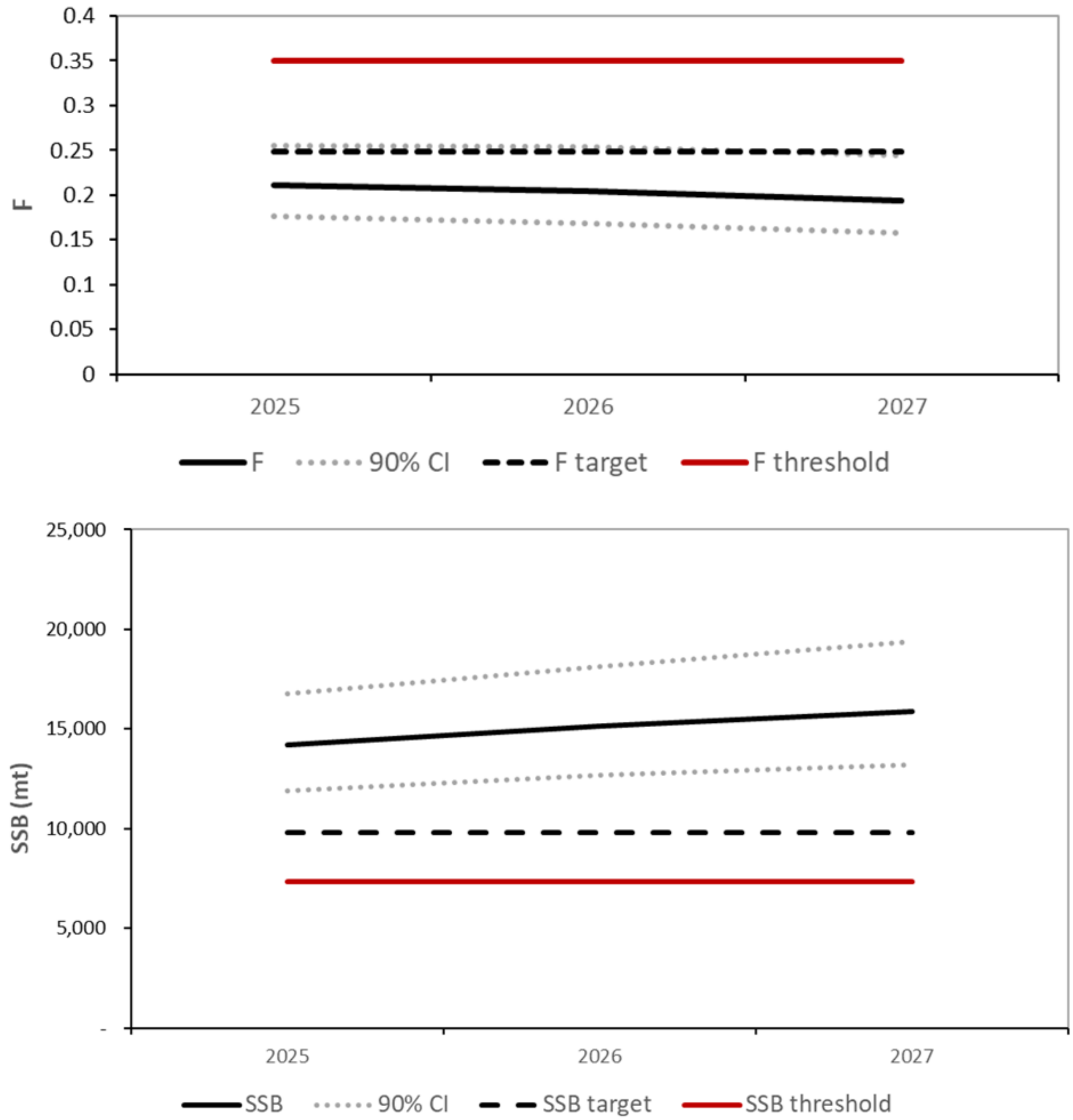

Figure 22. Status quo harvest projections for the LIS region for *F* (top) and SSB (bottom).

Tautog Stock Assessment Update
NEW JERSEY – NEW YORK BIGHT REGION

Executive Summary

This stock assessment is an update to the existing benchmark assessment for tautog (ASMFC 2015, ASMFC 2016); the previous assessment update was completed in 2021 (ASMFC 2021). This assessment updates the accepted statistical catch-at-age model for the New Jersey – New York Bight (NJ-NYB) region with commercial and recreational fishery catch data and indices of relative abundance from fishery-independent and fishery-dependent data sources through the terminal year of 2024.

Total removals have increased since the last assessment, averaging 1,843 mt from 2021-2024 compared to an average of 1,029 mt for 2016-2020. The MRIP CPUE showed an increasing trend since the last update, while the New Jersey Ocean Trawl index showed a declining trend in the most recent years. The NY Seine young-of-the-year index has been highly variable over the time-series, but has shown a number of high values over the most recent years.

Estimates of spawning stock biomass (SSB) from the ASAP model showed that the increasing trend from the 2021 assessment update had been reversed, with SSB declining from a recent high in 2022; the three-year average fishing mortality (*F*) showed the opposite pattern, with *F* increasing since 2021 after a decline from 2016. The model indicated that the stock was not overfished, with SSB being above the threshold and slightly below the target, but overfishing was occurring in 2024. This was a change from the 2016 update, where the stock was overfished, but overfishing was not occurring. Stock status was based on retrospectively adjusted values of SSB and the three-year average *F*, as the 2025 update showed a significant retrospective pattern, with SSB being underestimated and *F* being overestimated.

Short-term projections (2025-2027) based on the 3-year average of recent removals indicated there was a high probability (81%) that the stock would be above the SSB threshold in 2027 but a low probability that *F* would be below the *F* threshold.

It is recommended that the next assessment for this region should be a benchmark assessment, to incorporate a new fishery independent trap survey that should be more appropriate for tautog than the current trawl survey, and to investigate and resolve the worsening retrospective pattern for this region.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The time series for commercial and recreational removals was extended from the previous assessment update (ASMFC 2021) through 2024, along with the associated age compositions from both sources. This assessment update used calibrated estimates of recreational removals from MRIP. The tautog fishery in the NJ-NYB region is predominantly recreational (Table 16, Figure 23). There was a peak in estimated recreational release mortality in 2022, with 2021-2024 overall showing an increased proportion of release mortality to total recreational removal. Commercial landings averaged 69 mt from 2021–2024. Total removals have increased since the last assessment, averaging 1,843 mt from 2021-2024 compared to an average of 1,029 mt for 2016-2020.

The calibrated MRIP length frequencies were used to calculate the age composition of the recreational harvest and used as a proxy for the length composition of the commercial harvest. Data from MRIP and the American Littoral Society (ALS) volunteer tagging program were used to develop the age composition of the recreational release mortality. The MRIP CPUE was updated using the same “logical species guilds” from the benchmark assessment to identify tautog trips. Since the last update, the MRIP CPUE has increased markedly from 2021 onward (Figure 24).

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

Fishery-independent indices from the NJ-NYB region consisted of the NJ Ocean Trawl Survey and the New York Western Long Island Seine Survey (NY WLI; Table 17, Figure 24). Age composition information was available for the NJ Ocean Trawl survey. For all indices, statistical model-based standardization of the survey data was conducted to account for factors that affect tautog catchability.

The NJ ocean trawl survey, which began in 1989, is conducted 5 times annually from January through October utilizing a stratified random design and is used in the assessment as an index of age-1+ tautog abundance. Each sampling period is termed a cruise. Tautog are most abundant on cruises 4-5 (i.e. Aug-Dec), and thus these survey periods were used for the indices. The survey was not conducted in 2020-2021 due to COVID-19 restrictions. Cruise 5 was not completed in 2024 due to boat repairs needed. Since the previous update, while the ocean trawl index indicated an uptick for tautog in 2022, the following years exhibited a decline (Figure 24). The lack of data from an important survey period in 2024 lends uncertainty to this trend.

The NY WLI seine survey has operated from 1984 to the present, with a consistent standardized methodology starting in 1987. It is a fixed site survey that is conducted in three separate embayments on Long Island; the data were subset to Jamaica Bay on the south side of Long Island for the NJ-NYB region. The WLI seine index captures mainly age- 0 fish, so was lagged forward one year and treated as an age-1 index. It was used to develop a YOY index of recruitment for tautog. The NY WLI seine survey was conducted in 2020 but the start was delayed due to COVID-19 restrictions. Since the most recent stock assessment update, the index exhibited its sharpest increase over the time series, only to return to a declining trend as of 2024.

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

Life history data for 2021-2024 was sourced from the New Jersey Ocean Trawl, private charter boats and the Raritan inventory project. The start year was set at 1989 with the terminal year of 2024 which adds 4 additional years of data since the last assessment (Table 18). Natural mortality was set at 0.15 (Table 18). The age plus group included ages 12 and over. The maturity schedule remained the same as the benchmark with 0 for ages 1 and 2, 0.8 for age 3, and 1 for ages 4 through 12 plus. The selectivity blocks remained the same as the last update, as there were no regulatory changes for tautog since the beginning of the most recent block (2018).

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The 2025 assessment update used the accepted 2016 benchmark assessment model (Age Structured Assessment Program from NOAA Fisheries Toolbox), adding data through 2024, to obtain updated estimates of fishing mortality, spawning stock biomass, and recruitment. The catch was generally well fit, with minor patterning in the residuals for total catch and no concerning patterns in the age composition residuals (NJ-NYB Appendix 1). However, the model struggled to fit the NJ Ocean Trawl index in this update and the CV had to be increased compared to the 2021 update in order to have a reasonable RMSE for this index. This was likely due to the change in trend in the NJ Ocean Trawl with the updated standardization, which resulted in a stronger increase in the late 1990s which was not evident in the recruitment index or MRIP CPUE (Figure 24). Some residual patterns were evident in the age composition diagnostic plots for the indices, similar to the 2021 assessment update (see ASMFC 2021, NJ-NYB Appendix 1). These issues were not deemed problematic enough to reject the model.

The three-year average of fishing mortality has been highly variable with no trend over time and has been increasing from a recent low in 2020 to near a time-series high in 2024 (Table 19, Figure 25). The *F* estimates from the 2025 update were similar to the estimates from the 2021 update, and the 2021 *F* estimates were generally within the confidence interval of the 2025 update estimates (Figure 25). SSB peaked at the beginning of the time-series at 9,242 mt and declined through the 1990s, reaching a time-series low in 2003 at 3,539 mt (Table 19, Figure 26). SSB was relatively stable until 2015 before increasing to 6,962 mt in 2021, driven by an increase in recruitment (Table 19, Figure 27) and a decrease in *F* over that time period (Table 19, Figure 25). SSB has declined somewhat since 2021. Estimates of SSB from the 2025 update were generally higher than the estimates from the 2021 update, with most of the 2021 estimates, including the last years of the 2021 update, being outside the confidence intervals of the 2025 update (Figure 26). Recruitment estimates showed a similar trend to SSB, with a period of high recruitment at the beginning of the time-series, a decline to low levels through the late 1990s followed by an increase in the mid-2010s to the mid-2020s (Table 19, Figure 27).

Generally, recruitment estimates since the mid-2010s have been the highest since the early 1990s. Estimates of recruitment from the 2025 update were similar to the estimates from the 2021 update for the early part of the time-series, but have been higher than the 2021 update for the last ten years (Figure 27)

A retrospective analysis was completed using a six-year peel (i.e., 2018–2024) to avoid crossing a selectivity block. A significant retrospective pattern for the three-year average *F* (Mohn's rho = 0.18) and SSB (Mohn's rho = -0.26); the pattern for recruitment was minor (Mohn's rho = 0.06). The model runs tended to overestimate *F* (Figure 28) and underestimate SSB (Figure 29) relative to the terminal year run; there was no consistent pattern for recruitment (Figure 30). The retrospectively adjusted estimates of *F* and SSB were outside the 90% confidence intervals of the terminal year estimates (NJ-NYB Appendix 2 Figure A2.1) and the rho estimates were outside the acceptable limits for a long-lived species (-0.15 < rho < 0.2), warranting the adjustment of *F* and SSB for this assessment (ASMFC 2024). The unadjusted estimates for the 3-year average *F* and SSB were 0.52 and 5,870 mt, respectively. Retrospective adjusted estimates were 0.44 and 7,900 mt, respectively (Table 19).

Sensitivity analyses were run to look at model dependence on the three survey indices (NJ ocean trawl survey, NY seine survey, and MRIP CPUE). The final ASAP model chosen for this assessment used adjusted catch and index CVs to bring the RMSE bounds closer to 1.0; therefore, an additional sensitivity run was completed to look at model performance with the unadjusted CVs. No sensitivity run substantially changed the general trends in fishing mortality or SSB over the time series, or the overall scale of the assessment, although removing the MRIP CPUE resulted in a significantly higher estimate of *F* in the last few years of the time-series and using the original CVs resulted in a significantly higher estimate of SSB and recruitment at the end of the time-series (NJ-NYB Appendix 2 Figures A2.2 and A2.3).

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

The target and threshold levels for fishing mortality were calculated using spawning potential ratio (SPR) reference points. The updated target *F* reference point, $F_{40\%SPR}$, was 0.20, and the threshold level, $F_{30\%SPR}$, was 0.33, similar to those estimated for the previous assessment updates (Table 20). The retrospectively adjusted three-year average (i.e., 2022–2024) *F* was estimated to be 0.44, above both the target and the threshold, indicating overfishing was occurring (Table 6, Figure 31).

Target and threshold spawning stock biomass reference points were calculated by determining equilibrium SSB when assuming fishing at both the target and threshold fishing mortality levels. The projections drew from the empirical distribution of observed recruitment for the full time-series and used the most recent five-year average for selectivity and life history parameters like weight-at-age. These calculations were conducted using the AgePro program from the NOAA Fisheries Toolbox. The SSB threshold was 5,929 mt and the SSB target was 7,910 mt, somewhat higher than 2021 assessment update (Table 20). This was due to the increase in recruitment in recent years which increased the time-series median recruitment. The adjusted estimated 2024

SSB was 7,900 mt, above the threshold and slightly below the target, indicating that the stock was not overfished (Table 21, Figure 31). The retrospective adjustment changed stock status for spawning stock biomass, moving the stock from below the SSB threshold to close to the SSB target. Fishing mortality remained above the *F* threshold after the retrospective adjustment.

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term, three-year projections (2025–2027) were completed to estimate the probability of overfishing or the stock being overfished during the period. Projections were completed using an assumed constant harvest level equal to the average total removals from 2022–2024 (1,843 mt). All other parameters (life history information and selectivity patterns) used the most recent five-year average. Recruitment was drawn from the empirical distribution of the full time-series recruitment estimated by the ASAP model. SSB remained relatively constant over the projections, with a 19% probability of being at or below the SSB threshold in three years (Table 22, Figure 32). Although *F* declines slightly over the projections, there was an 88% probability that fishing mortality would be at or above the threshold in three years (Table 22, Figure 32).

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

In 2016, New Jersey began conducting a ventless trap survey within and around 3 artificial reef sites off the central New Jersey coast. The trap gear is more appropriate for structure-oriented species such as tautog, and the data from this survey may potentially be useful for the next benchmark assessment when the time-series meets the minimum requirement of 10 years.

The retrospective pattern for this region has worsened since the last assessment update, and although the direction is conservative from a management perspective (underestimating SSB and overestimating *F*), this is something that should be investigated during the next benchmark.

References

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List of Appendices

Tables

Table 16. Annual removals by sector (in metric tons) for the NJ-NYB region.

Year	Recreational Harvest	Recreational Release Mortalities	Commercial Harvest
1982	1,162.4	6.8	67.2
1983	1,579.3	13.3	45.6
1984	1,581.0	4.7	58.8
1985	2,798.7	16.7	56.9
1986	2,550.7	10.7	54.8
1987	3,404.6	39.0	58.4
1988	1,895.5	24.1	89.6
1989	1,826.0	19.9	57.9
1990	1,895.6	23.1	86.6
1991	2,767.4	66.5	93.2
1992	2,932.7	53.7	84.8
1993	1,481.2	43.3	89.2
1994	439.9	18.0	92.2
1995	1,616.0	30.3	64.1
1996	1,322.2	37.0	50.7
1997	871.9	39.1	30.9
1998	64.5	14.3	31.5
1999	769.5	77.1	26.5
2000	1,978.2	42.2	30.9
2001	1,313.3	32.6	50.3
2002	1,552.1	71.0	35.9
2003	534.4	30.2	49.5
2004	412.1	27.1	49.5
2005	170.3	10.6	47.4
2006	847.3	28.7	52.2
2007	1,087.5	62.3	58.0
2008	814.7	43.7	57.3
2009	1,241.1	48.6	34.6
2010	1,172.3	53.5	57.4
2011	762.4	49.0	66.8
2012	370.3	18.1	39.9
2013	1,277.8	134.0	52.8
2014	2,609.5	64.3	46.4
2015	820.4	75.2	47.7
2016	1,352.4	189.3	66.2
2017	868.5	82.7	64.1
2018	578.7	17.6	50.0
2019	900.9	84.6	66.3
2020	643.4	147.0	32.1
2021	1,225.2	134.1	59.5
2022	1,587.8	302.2	85.7
2023	1,721.4	257.6	59.6
2024	1,234.8	205.9	72.5

Table 17. Indices used in the ASAP model for the NJ-NYB region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
NY DEC Western Long Island Seine Survey	Mean number per haul	Fixed	May-Oct	1984-2024	YOY
NJ DEP Ocean Trawl Survey	Mean number per tow	Stratified Random	Jan-Oct	1989-2024	1+
MRIP CPUE	Total catch per angler-trip	Stratified Random	Mar-Dec	1981-2024	1+

Table 18. Model structure and life history information used in the NJ-NYB stock assessment.

	Value(s)
Years in Model	1989-2024
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB calculation	0.42
Number of selectivity blocks	5
Selectivity periods	1989 - 1996, 1997 - 2006, 2007 - 2011, 2012 - 2017, 2018 - 2024
Selectivity type	Single logistic

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 19. Spawning stock biomass, recruitment, annual F, and 3-year average *F* estimates for the NJ-NYB region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual F	3-year Average F
1989	8,759	4.04	0.31	
1990	9,242	3.50	0.30	
1991	8,717	3.71	0.47	0.36
1992	7,153	2.72	0.60	0.46
1993	6,329	2.38	0.36	0.48
1994	6,554	1.96	0.12	0.36
1995	6,629	1.64	0.33	0.27
1996	5,982	1.56	0.30	0.25
1997	5,564	1.56	0.20	0.28
1998	5,732	1.83	0.03	0.18
1999	5,974	1.55	0.23	0.15
2000	5,323	1.47	0.52	0.26
2001	4,507	1.52	0.41	0.38
2002	3,850	1.36	0.62	0.51
2003	3,539	1.45	0.26	0.43
2004	3,722	1.99	0.15	0.34
2005	4,076	2.04	0.07	0.16
2006	4,453	2.00	0.25	0.16
2007	4,412	2.03	0.37	0.23
2008	4,359	2.07	0.27	0.29
2009	4,263	1.73	0.44	0.36
2010	4,055	2.02	0.38	0.36
2011	4,013	1.80	0.27	0.36
2012	4,384	2.41	0.13	0.26
2013	4,554	2.32	0.40	0.27
2014	4,061	2.76	0.78	0.44
2015	3,924	2.91	0.31	0.50
2016	4,299	3.26	0.50	0.53
2017	4,732	2.69	0.30	0.37
2018	5,622	2.52	0.22	0.34
2019	6,359	1.74	0.28	0.27
2020	6,874	2.36	0.20	0.23
2021	6,962	3.32	0.28	0.25
2022	6,518	3.04	0.47	0.32
2023	6,044	2.79	0.59	0.45
2024	5,870	3.10	0.50	0.52
*2024**	*7,900*			*0.44*

**Retrospectively adjusted values*

Table 20. SSB and *F* reference points from the 2021 update and the 2025 update for the NJ-NYB region.

	SSB (mt)		F	
	Target	Threshold	Target	Threshold
2021 Update	6,552	4,890	0.19	0.30
2025 Update	7,910	5,929	0.20	0.33

Table 21. Stock status for the NJ-NYB region.

	SSB (mt)		F	
	Target	Threshold	Target	Threshold
Reference Points	7,910	5,929	0.20	0.33
2024 Estimate	7,900*		0.44*	
2024 Status	Not overfished		Overfishing	

*: Retrospectively-adjusted value

Table 22. Short-term projection results for the NJ-NYB region.

Landings (mt) for 2025-2027	Probability of being at or above the *F* threshold in 3 years	Probability of being at or below SSB threshold in 3 years
Status quo (2021-2024 average)	88%	19%

Figures

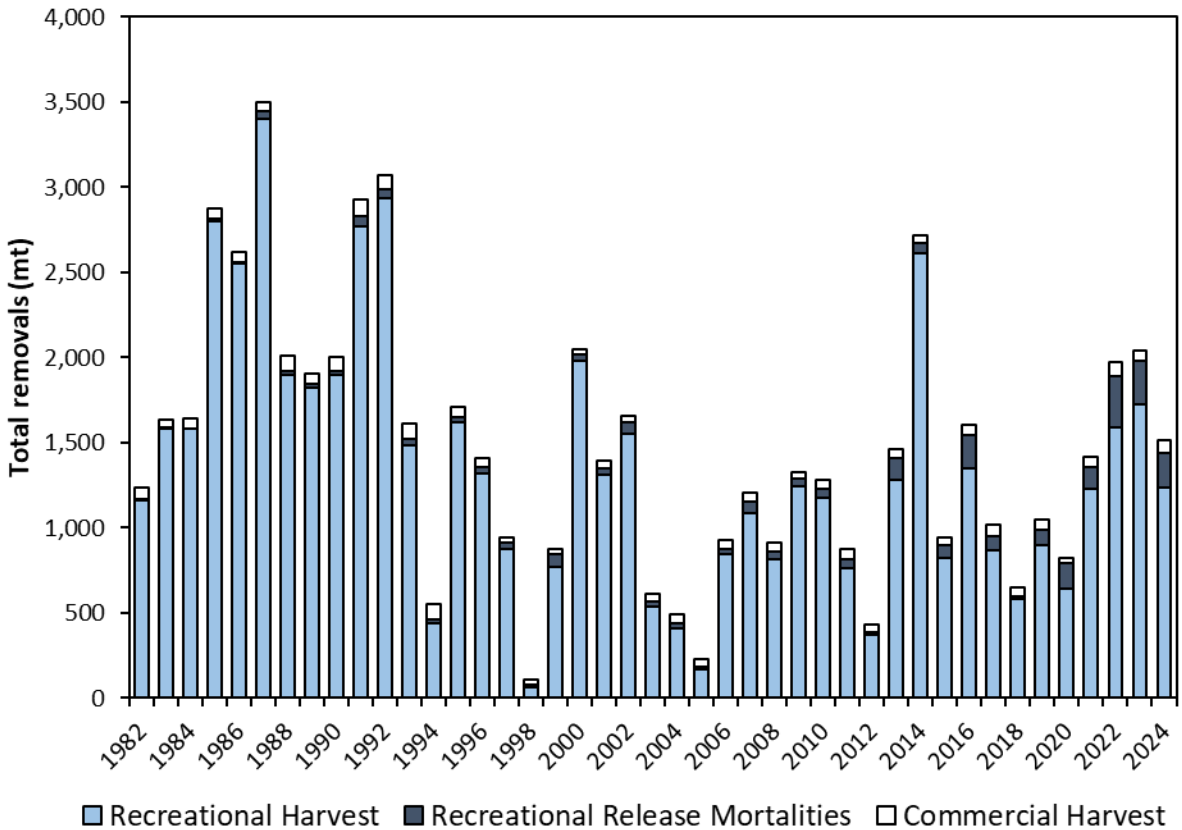


Figure 23. Total removals for the NJ-NYB region by sector.

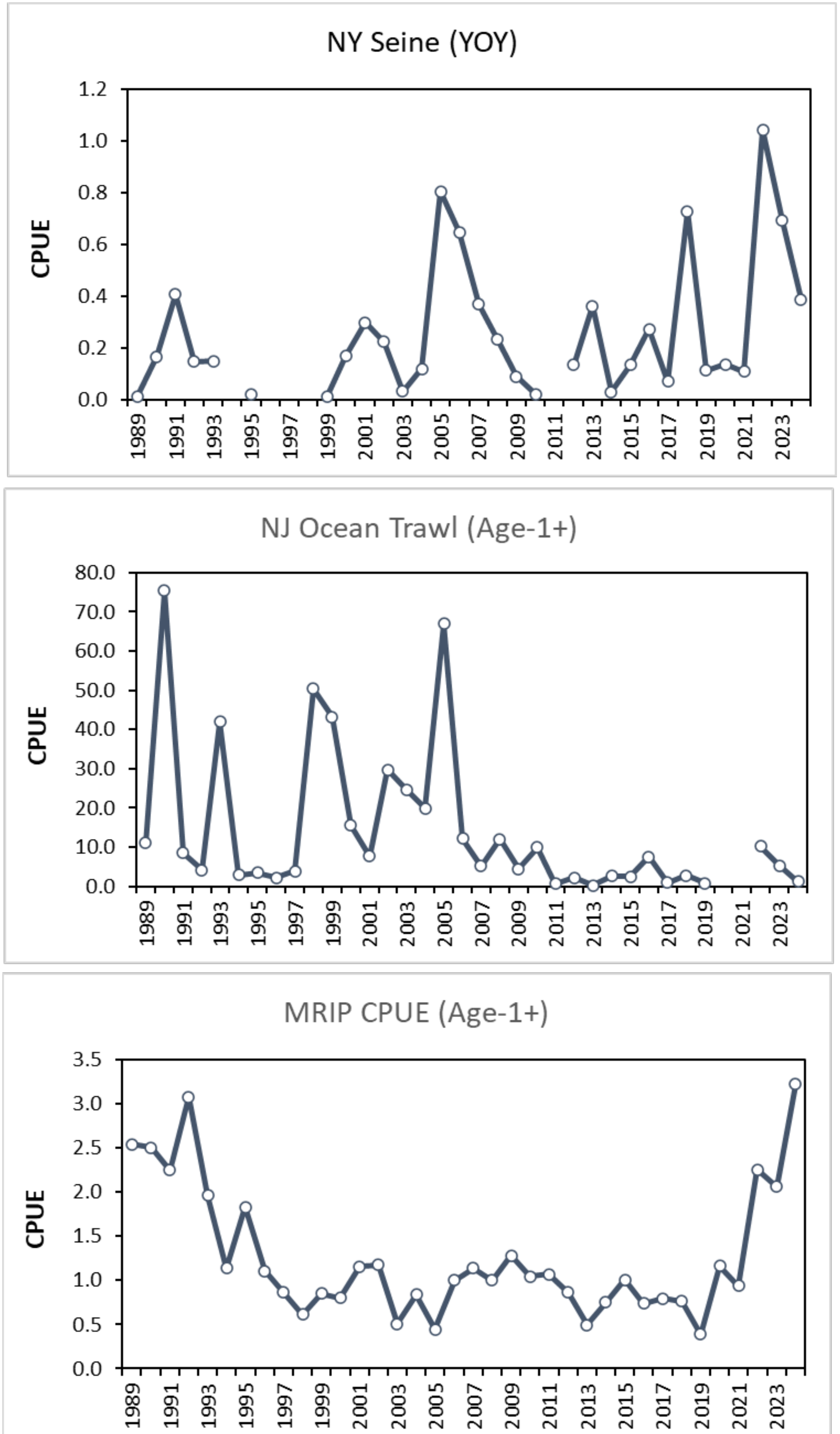


Figure 24. Observed CPUE for each index used in the NJ-NYB region.

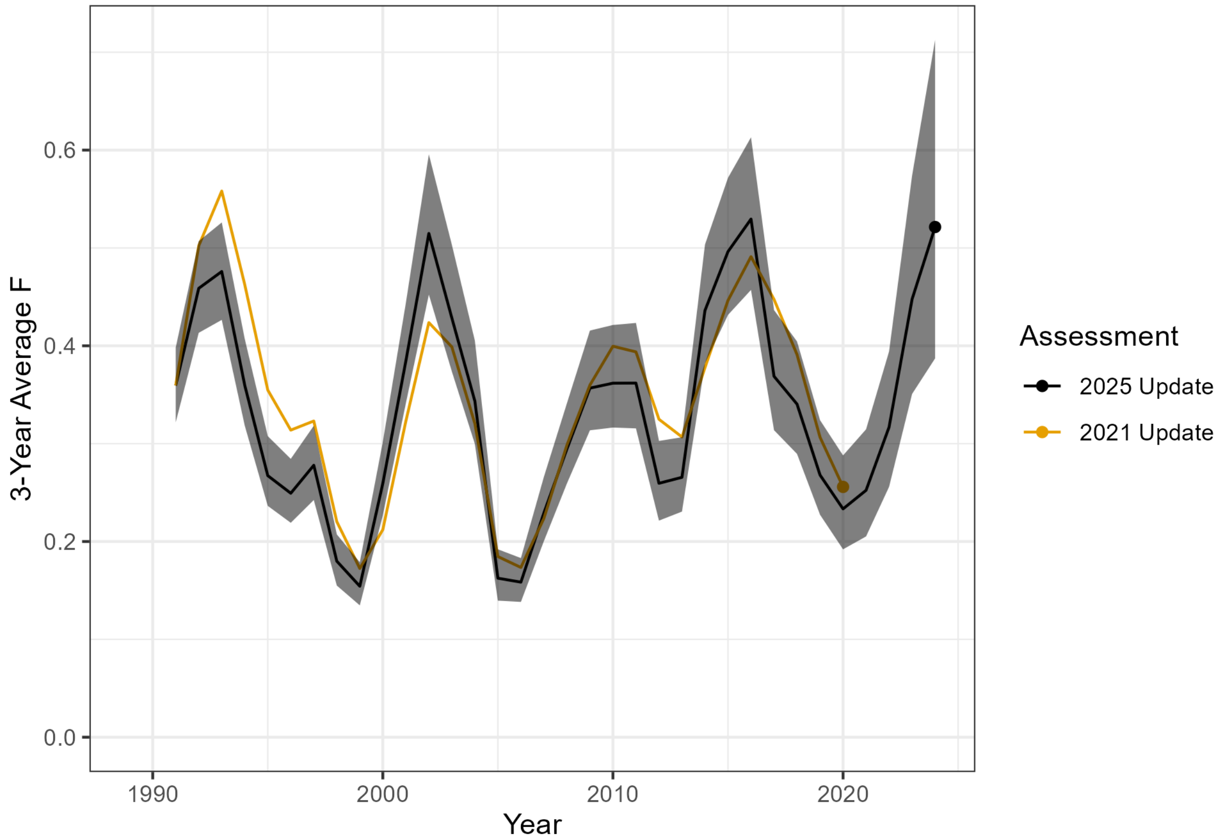


Figure 25. Estimates of the 3-year average of *F* from the 2025 update compared with the 2021 update for the NJ-NYB region. Shaded area indicates the 90% confidence interval of the 2025 update estimates.

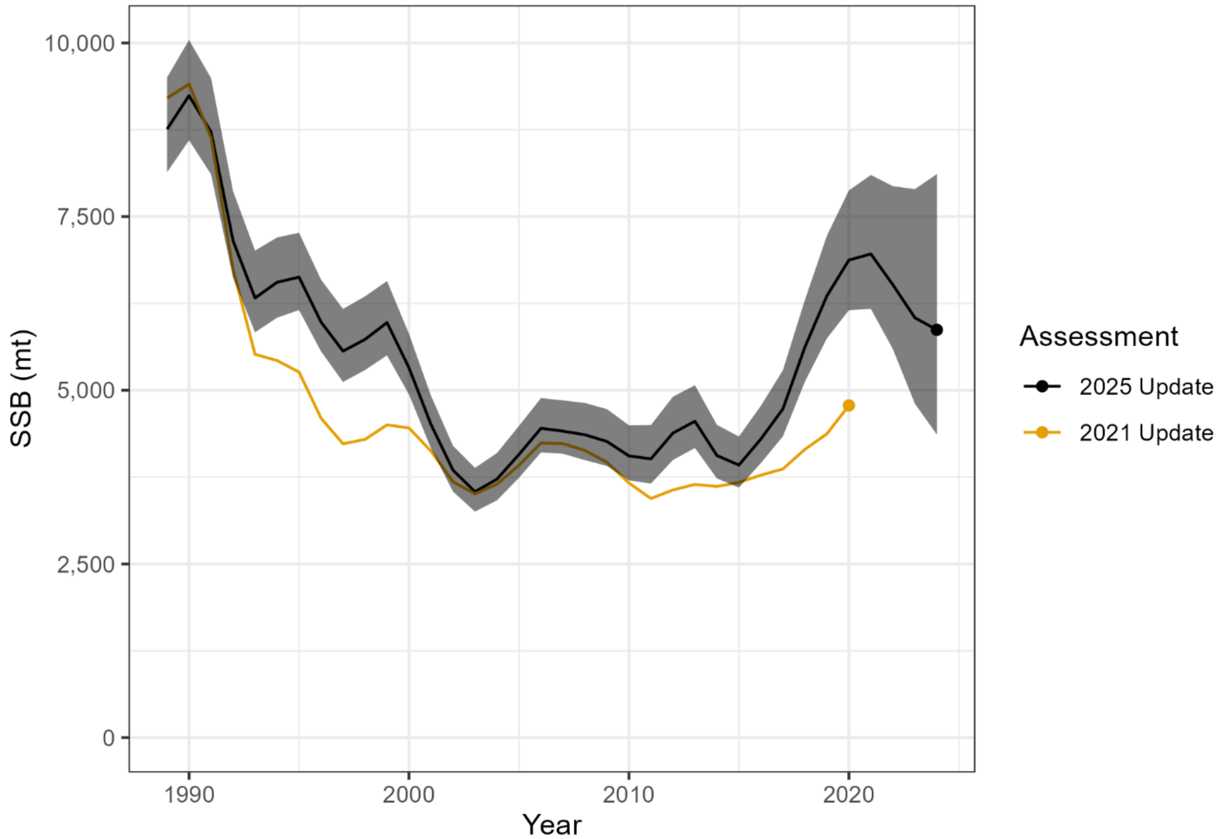


Figure 26. Estimates of spawning stock biomass from the 2025 update compared to the 2021 update for the NJ-NYB region. Shaded area indicates the 90% confidence interval of the 2025 update estimates.

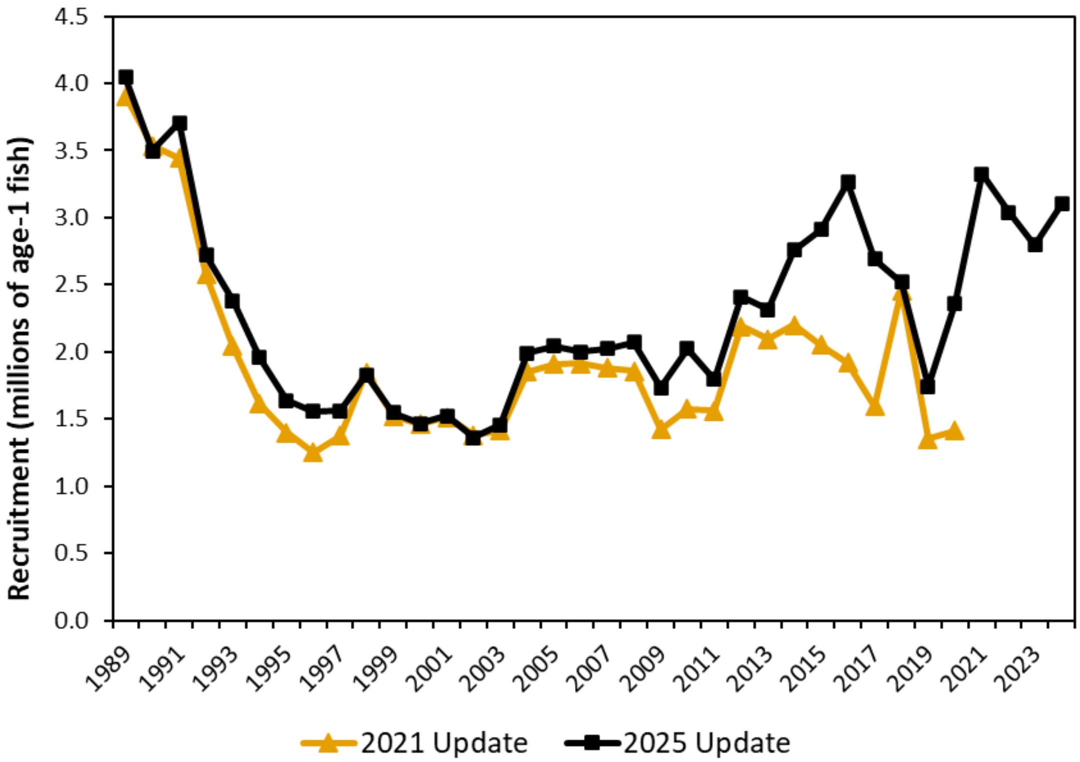


Figure 27. Estimates of recruitment for the 2025 update compared to the 2021 update for the NJ-NYB region.

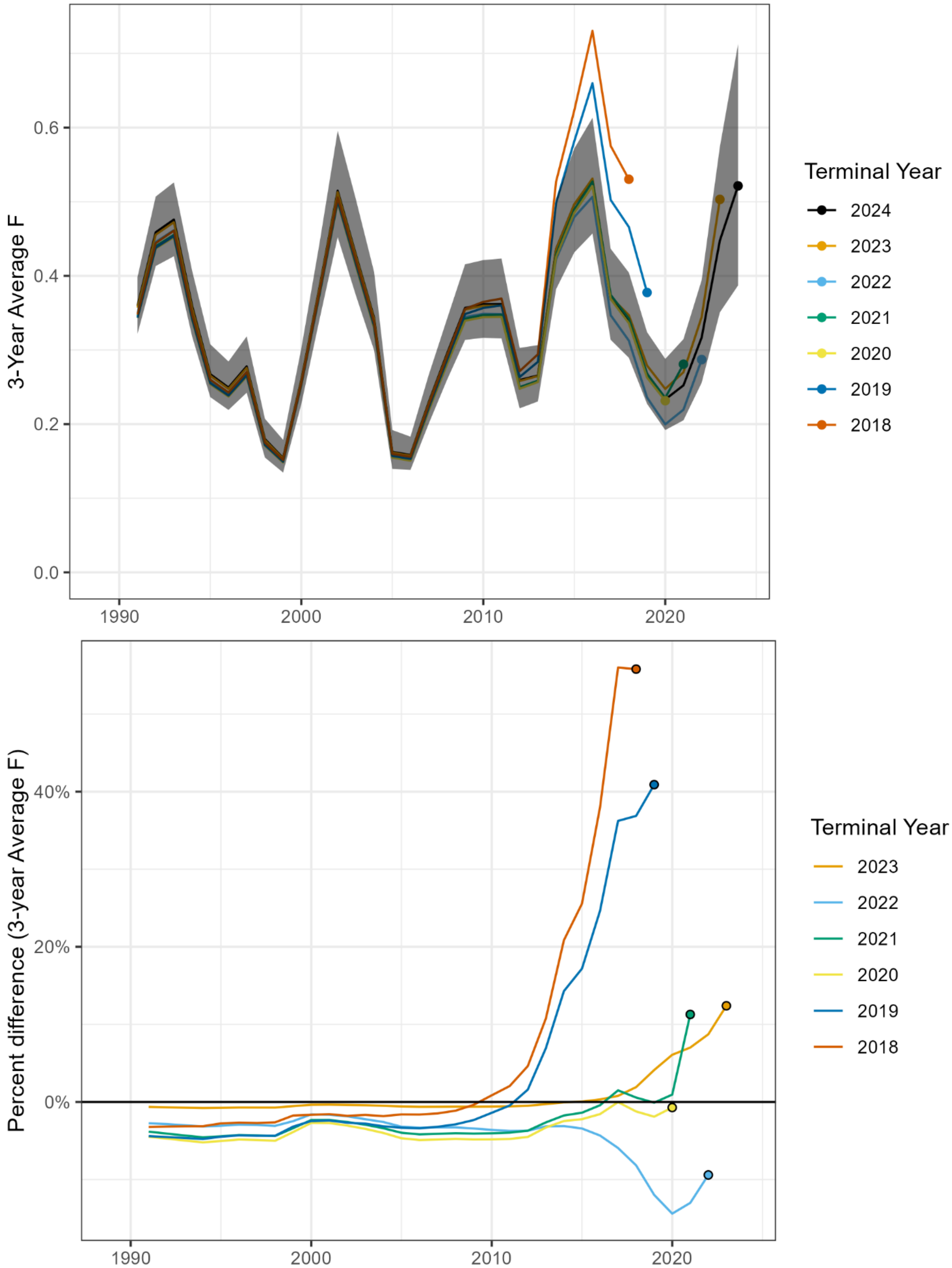
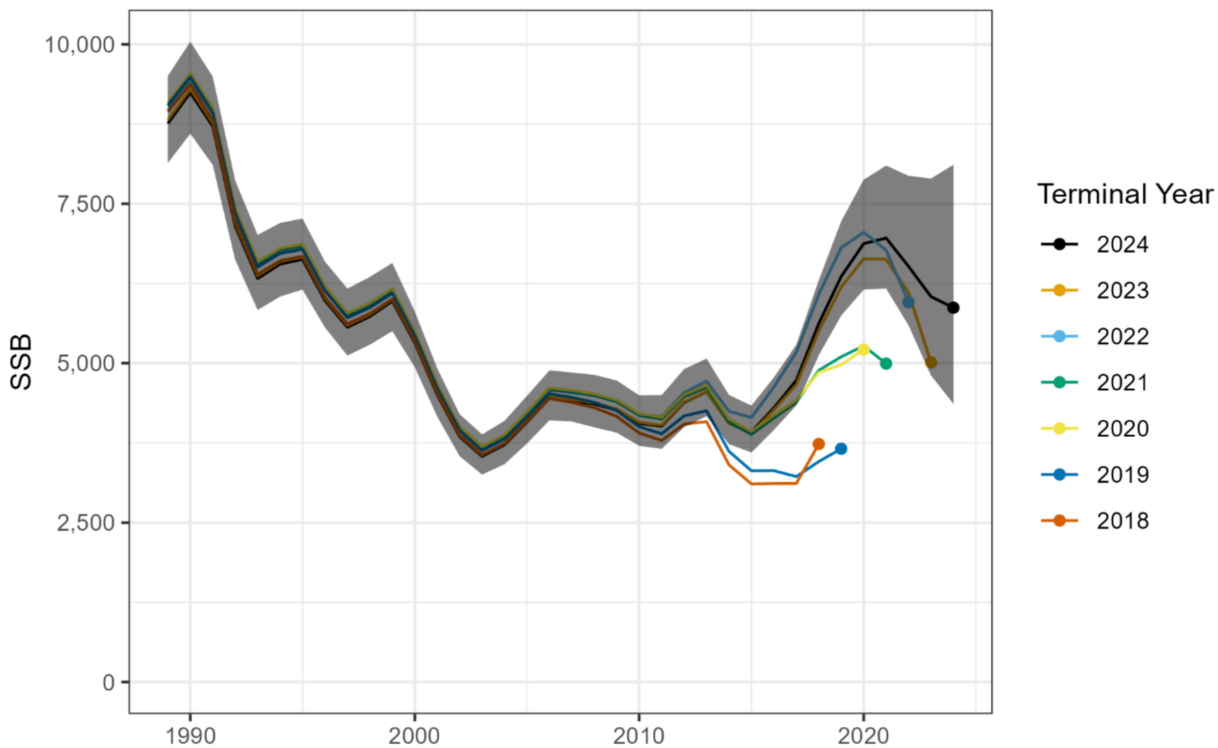


Figure 28. Retrospective analysis for the three-year average *F* in absolute numbers (top) and percent difference (bottom) for the NJ-NYB region. Shaded area indicates 90% confidence interval of base run.



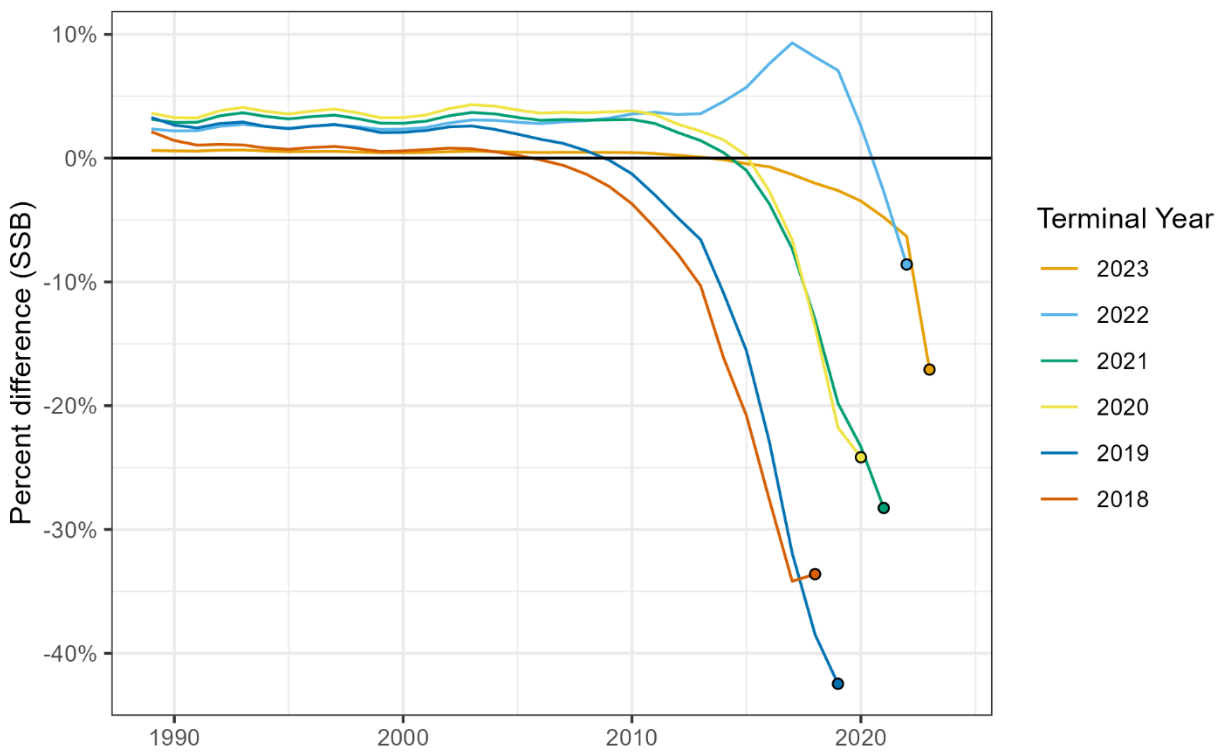
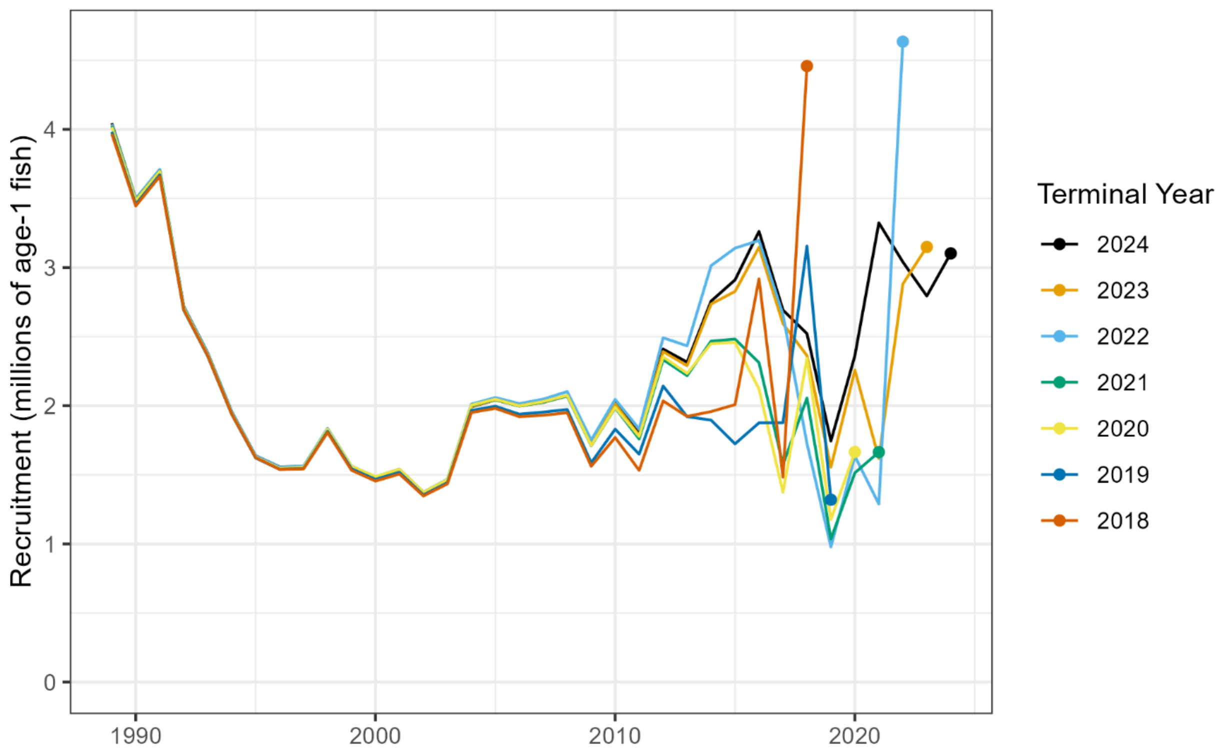


Figure 29. Retrospective analysis for SSB in absolute numbers (top) and percent difference (bottom) for the NJ-NYB region. Shaded area indicates 90% confidence interval of the base run.



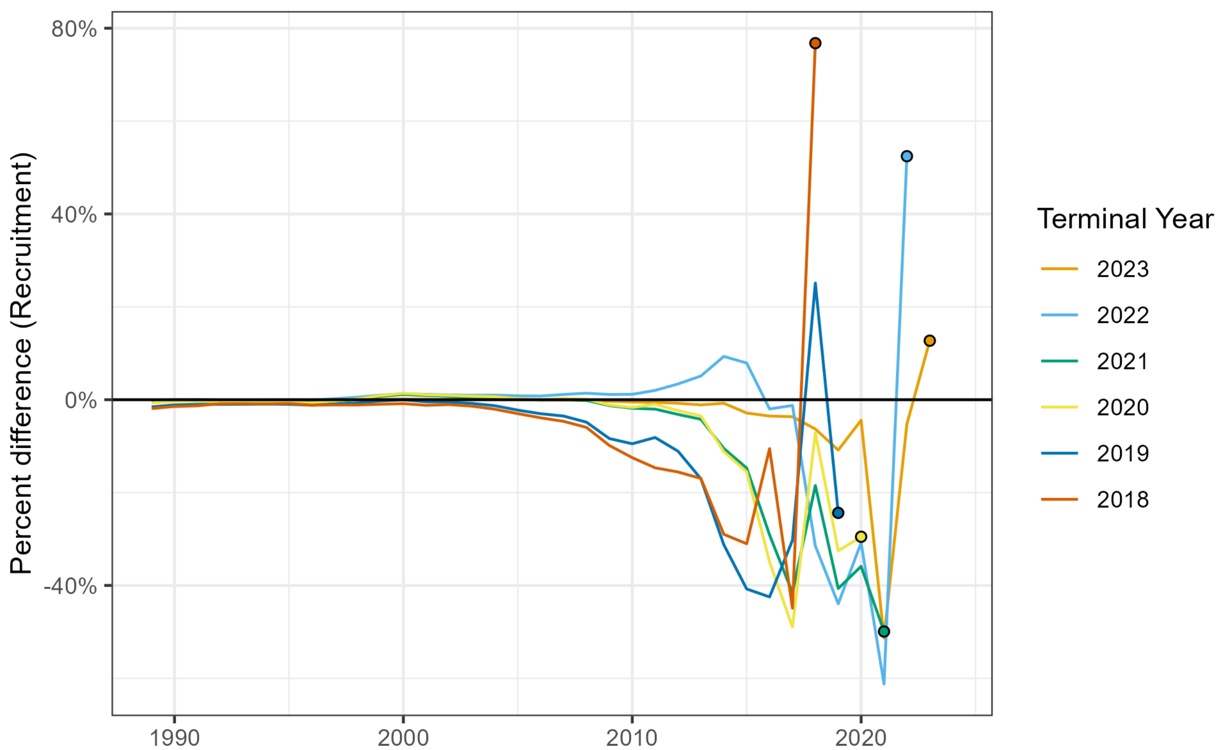


Figure 30. Retrospective analysis for recruitment in absolute numbers (top) and percent difference (bottom) for the NJ-NYB region.

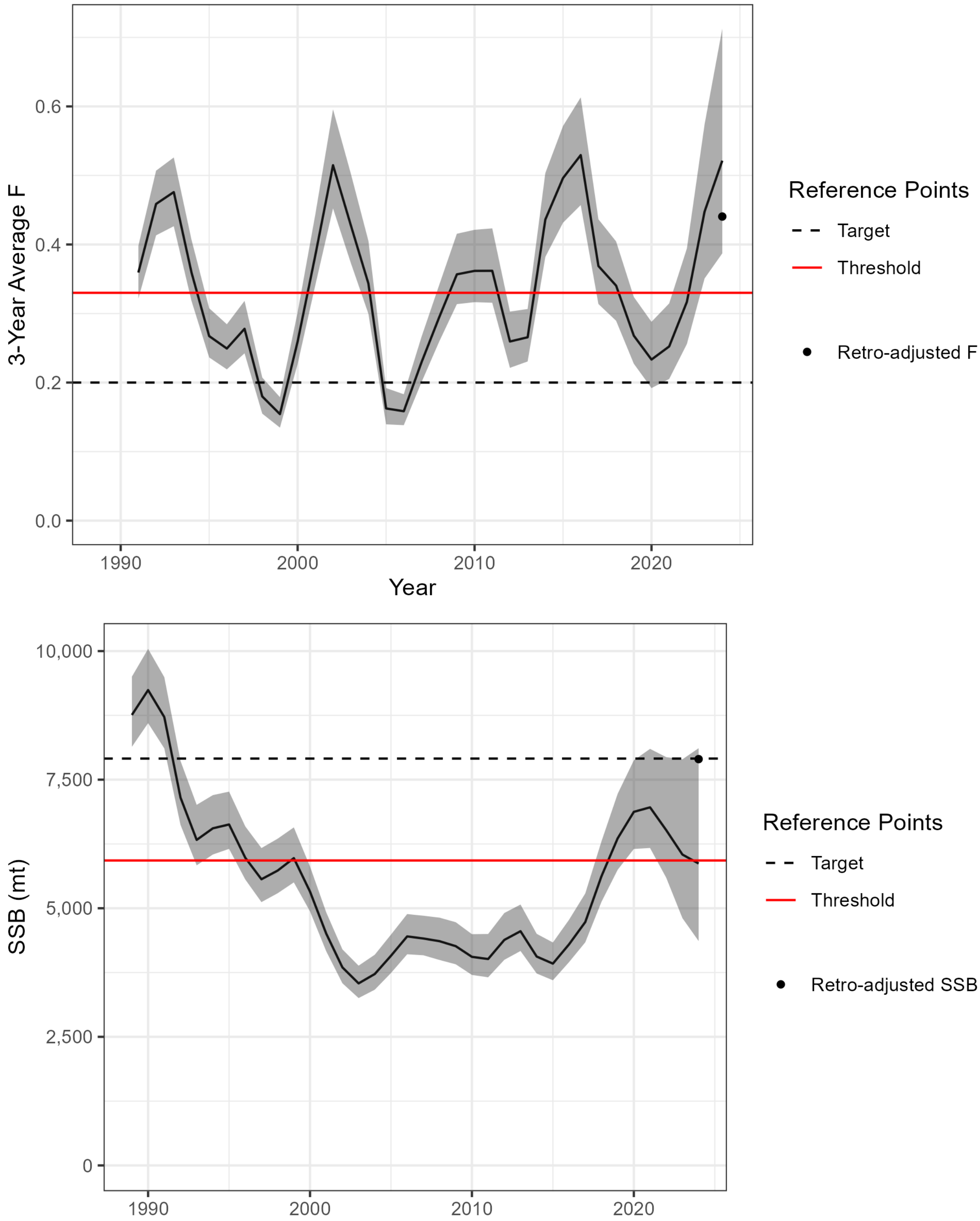


Figure 31. Stock status for the NJ-NYB region. Shaded area indicates the 90% confidence interval of the base run without a retrospective adjustment.

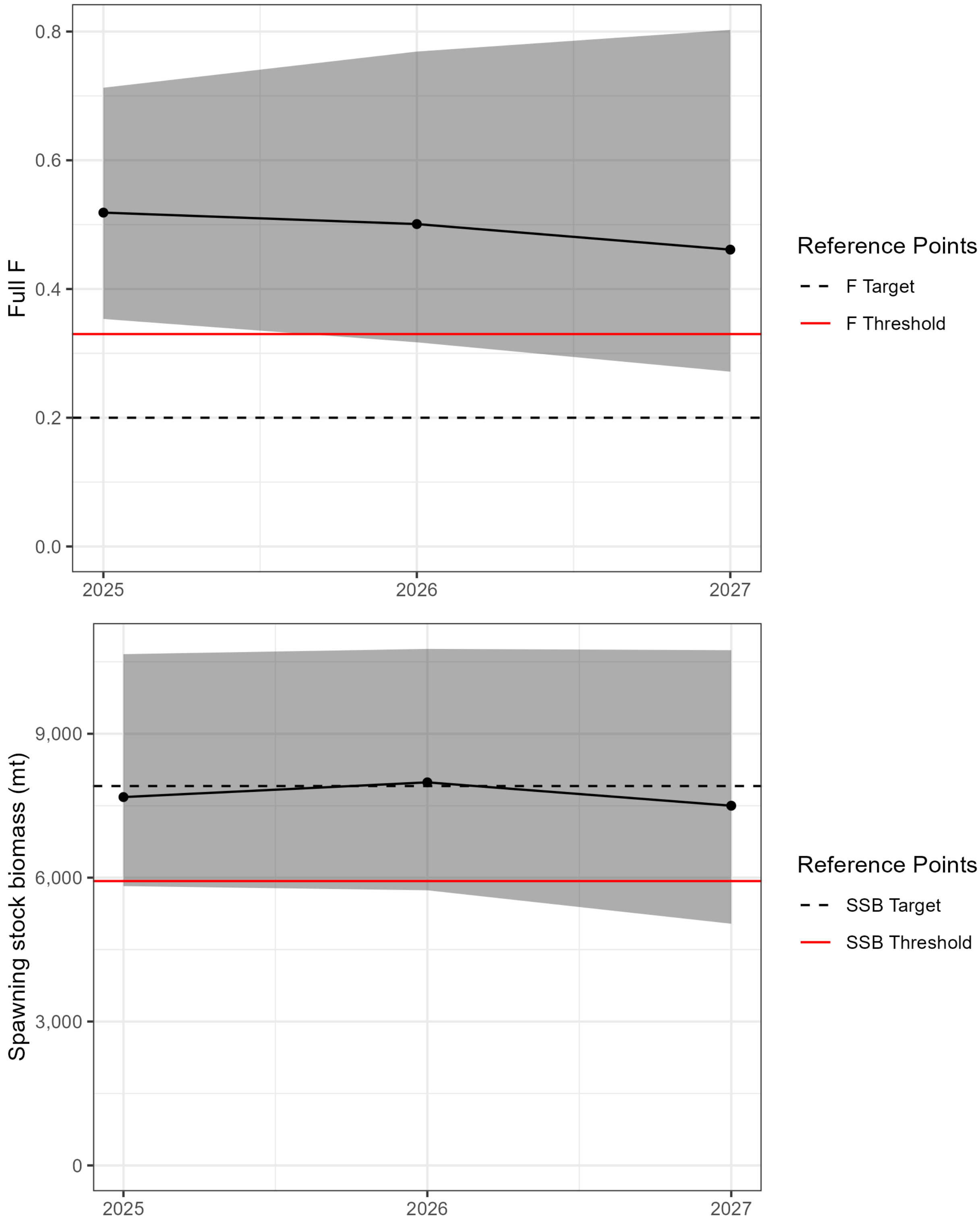


Figure 32. Short-term projection results for the NJ-NYB region using the average of the most recent three years of removals for *F* (top) and SSB (bottom) plotted with the *F* and SSB reference points.

Tautog Stock Assessment Update
DELAWARE-MARYLAND-VIRGINIA REGION

Executive Summary

This stock assessment is an update to the existing benchmark assessment for tautog for the Delaware-Maryland-Virginia (DMV) region (ASMFC 2015, ASMFC 2016); the previous assessment update was completed in 2021 (ASMFC 2021). This assessment updates the accepted statistical catch-at-age model ASAP with commercial and recreational fishery catch data and indices of relative abundance from fishery-independent and fishery-dependent data sources through the terminal year of 2024.

Stock status has changed in this region since the last assessment update. In 2021, the stock for the DMV region was not overfished or experiencing overfishing. The 2025 update of the assessment model initially resulted in a similar conclusion. However, the model shows a strong retrospective pattern, underestimating fishing mortality and overestimating spawning stock biomass in recent years. Based on the observed retrospective pattern and applying ASMFC standardized approach for retrospective correction, the 2024 SSB was adjusted downwards, while fishing mortality was adjusted upwards. As a result of the retrospective adjustment, the 2024 SSB was below the SSB threshold and the fishing mortality was above the *F* threshold, hence the stock status was redefined as overfished and overfishing was occurring.

Short term projections based on the retrospectively adjusted starting values of numbers at age using the average landings from the last three years found that both *F* and SSB will slightly decline by 2027. The probability of the fully-recruited *F* being at or above the *F* threshold is expected to be 22% by 2027, while the probability of SSB being at or below the SSB threshold by the end of the projection is 97%.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

Recreational harvest (A+B1) of tautog for DMV region in 1982 - 2024 varied between 0.35 million and 1.1 million fish, with the overall declining trend through time (Table 23, Figure 33). There was an overall declining trend in recreational harvest, most likely a reflection of the protective regulatory measures (minimum size increase, bag size reduction and seasonal closures) instituted to reduce fishing mortality. Average recreational harvest for the most recent four-year period (2021-2024) was 149,500 fish.

Estimated recreational releases have varied from 15,600 fish in 1984 to 3.59 million fish in 2023. Assuming 2.5% release mortality rate, dead releases varied from 3,910 fish to 898,080 fish (Table 23, Figure 33). There was a general increasing trend for recreational releases through time, with the average for the last four years being 2.58 million fish compared to 0.74 million fish from 1982 to 2020. However, release mortality losses generally were very small relative to the harvest, thus the total recreational losses (A+B1+B2) are only slightly above the recreational harvest (A+B1) as reflected in Figure 33.

Due to low number of intercepted fishing trips that had caught tautog in the most recent decade, annual estimates of recreational landings and discards in MD and VA had low precision. In Virginia Proportional Standard Error (PSE) values exceeded 50% in 5 out of 10 of the most recent years for landings and 4 out of the 10 most recent years for discards. In Maryland, PSE exceeded 50% in 6 out of the 10 most recent years for landings and 4 out of the 10 most recent years for discards. PSEs were all below 50% in Delaware. DMV Regionwide PSE were all below 50%, but in the last 10 years, PSEs of harvest estimates have exceeded 30% five times, and PSEs of live release estimates (B2) have exceeded 30% four times.

Commercial landings reported by each state (DE, MD, and VA) were updated through 2024 and combined to derive region specific landings. Historically, commercial landings peaked at 31,400 pounds (14.2 mt) in 1997 and have declined since (Table 23, Figure 33). Average commercial landings for 2021 - 2024 were 3,953 pounds (1.79 mt). Data on commercial discards were not available, but discards were believed to be minimal. Therefore, estimates of dead discards were not generated.

Biological sampling for tautog is conducted by each state on annual basis with the goal of collecting at least 200 samples per year for each state. Samples for length, weight, sex and age are taken mostly by intercepting the catch of recreational fishermen. However, some samples were taken from commercial fishery as well. Annual age length keys were constructed by combining paired length - age samples from all three states. Age length keys were constructed for years 2021 - 2024 to update age information since 2021 assessment update that had a 2020 terminal year. In instances where there were gaps (i.e., missing length samples) in the data they were filled using either neighboring lengths, adjacent years or using samples in those bins from surrounding regions. On average, 584 samples of age and size samples per year were used to construct annual ALKs for 2021 - 2024, covering 22 - 78 cm size range and ages 1 - 28.

Length frequency of the recreational harvest was characterized using length frequency of the data collected by MRIP combined for all states. MRIP annual harvest estimates were applied to corresponding length frequency of the recreational harvest (A+B1) to obtain harvest in numbers by size. Size frequency of discards (B2) was characterized by combining the raw MRIP Type 9 data and the American Littoral Society (ALS) volunteer tagging data on the size of released fish to obtain regional estimate of discards. Discard lengths were poorly sampled in 2024: sample size =15 as compared to 758, 583, and 158 in 2021-2023, respectively. So instead of using raw length distribution for 2024, we used the average of proportions-at-length from 2021-2024 for the 2024 length frequency.

Due to low or absent commercial fishery size sampling, size frequency of recreational harvest was used to describe commercial catch at size. Recreational harvest, dead releases, and commercial harvest in numbers of fish by size were combined into a total regional estimate and converted into catch at age using regional year-specific age-length keys.

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

There are no fishery-independent indices available for the DMV region. The only index of relative abundance used in the 2015 benchmark assessment and 2016 and 2021 assessment updates was catch per trip derived from MRIP data (Table 24). Total catch per trip was modeled with GLM method using a suite of potentially important covariates (year, state, wave, and mode) with an effort offset based on angler hours for the trip. The MRIP based index was updated through 2024. The MRIP index in 2021-2024 showed a substantial increase compared to the variable but lower average in prior years (Table 25, Figure 34).

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (*M*, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised *M* value) from benchmark.

All regions used ASAP (Age Structured Assessment Program which is included in the NOAA Fisheries Toolbox) as the base model (https://www.fisheries.noaa.gov/resource/tool-app/noaa-fisheries-integrated-toolbox). ASAP is a forward-projecting, statistical catch-at-age model that uses a maximum likelihood framework to estimate annual fishing mortality, recruitment, population abundance and biomass, and other parameters from catch-at-age data and indices of abundance. ASAP provides estimates of the asymptotic standard error for estimated and calculated parameters from the Hessian. In addition, MCMC calculations provide more robust characterization of uncertainty for F, SSB, biomass, and reference points.

Model structure and life history parameters used in the assessment for DMV region are presented in Table 26. Natural mortality was assumed to be a constant value for all years and ages (M=0.16), as estimated in the 2015 benchmark assessment. Tautog were considered to be immature through age 2, 78% mature at age 3, 97% mature at age 4 and 100% mature at age 5. Sex ratio was assumed to be 50:50 and no sexual dimorphism in growth was considered.

The ASAP model was run from 1990 to 2024 based on the catch at age and MRIP index data representing ages 1 - 12, where age 12 was treated as a plus group. Removals were modeled as a single fleet that included total removals in weight and numbers-at-age from recreational harvest, recreational release mortality, and commercial catch. Selectivity of the fleet was described by a single logistic curve. Four selectivity blocks were used: 1982-1996, 1997-2006, 2007-2011 and 2012-2024. The number of selectivity blocks and their definition was similar to the 2021 assessment update, except that the fourth block was extended through 2024 following no change in fishery regulations that could have affected the selectivity parameters. Breaks were chosen based on implementation of fishery regulations. MRIP recreational catch index was split into age specific indices using the recreational catch age structure and the model was fit to index-at-age data assuming a single logistic selectivity curve and constant catchability. No YOY indices are available for DMV region.

All likelihood components weights (lambda values) were similar to the 2021 assessment update. Annual CVs on total catch were set equal to the weighted mean of state specific MRIP

PSE values, while index CVs were based on the GLM-standardized CVs and adjusted upwards to CV=0.6 (constant for all years) to bring the RMSE values for the catch and the index close to one. The input effective sample size (ESS) was set equal to the number of trips intercepted by the MRIP where tautog were measured. ESS values were further adjusted during second model run using ASAP's estimates of stage 2 multipliers for multinomials.

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The previous assessment update completed in 2021 was based on the ASAP model run from 1990 to 2020. The 2025 update included four more years of data on catch, age structure and index of abundance, but otherwise model structure and estimation process have not been modified.

Updated fishing mortality estimates were similar to the 2021 assessment update for most of the historic time series, but in the more recent period appear to be substantially higher, suggesting a presence of retrospective pattern resulting in model underestimation of *F* in most recent years (Figure 35). However, the overall trend of *F* in both cases was very similar (Figure 35).

As in the 2021 assessment update, there was a high peak in fishing mortality in 2010-2012 caused by high recreational harvest estimates for these years (Figure 35). Fishing mortality was in a lower range after 2012 but experienced a recent peak in 2021 (F=0.46) followed by a decline thereafter. The terminal year (2024) *F* was estimated at 0.07, while the three-year average for 2022 – 2024 was estimated as 0.25.

Spawning stock biomass went through two stages of decline during 1990-2010 (Figure 36). The 2025 assessment update indicated SSB was stable between 2010 - 2021, varying within a narrow range of 1,200-1,500 mt (Figure 36). Estimates of SSB from the 2025 update were lower than the estimates of SSB from the 2021 update from about 2000 onwards and did not show the strong increasing trend the 2021 update showed for 2015-2020 (Figure 36). The 2025 update model suggested a strong increase in SSB in 2022-2024 to approximately 4,500 mt. This increase was likely driven by the increase in the MRIP index of tautog abundance (Figure 34). However, this increase is likely to be overestimated as described below in the retrospective section of the report.

Except for the single spike at the beginning of the time series, recruitment appears to have been slowly declining during 1990-2020, varying within the range of 0.3 - 2.1 million fish with an average near 1 million fish (Figure 37). No outstanding year classes were noted aside from the 1990 year-class (age 1 in 1991 on Figure 37). However, the model suggested a striking increase in recruitment in 2022-2023, most likely driven by the trend in the MRIP abundance index because there are no other sources of information on recruitment strength in the most recent years of the assessment (i.e., because those year-classes are not very vulnerable to the fishery, there was very little information on them in the catch-at-age data to date for this region).

Retrospective analyses were performed by shortening (“peeling”) the data time series by one year at a time and comparing the results to the output of the model with full time series (1990-2024). The analysis was completed for time series ending in 2017 (a seven-year peel).

As in the benchmark assessment and 2016 and 2021 assessment updates, the DMV region showed a strong retrospective pattern, consistently underestimating *F* (Figure 38) and overestimating SSB (Figure 39), except for the 2021 time series. Bias in recruitment was not unidirectional, both over and underestimation have occurred (Figure 40). The level of bias ranged from -78 to +90% for *F* (Figure 38), -33 to +10% for SSB (Figure 39) and -83 to +55% for recruitment (Figure 40). The estimates of R, F, and SSB produced by different runs converged more when going back in time.

The decision on whether a retrospective pattern adjustment was needed was based on the procedure developed by the ASFMC Assessment Science Committee (ASMFC 2024).

For long-lived species such as tautog, an adjustment is recommended when the value of Mohn’s rho is outside the recommended bounds (-0.15 – +0.2 for a long-lived species like tautog) and the retrospectively-adjusted values fall outside the uncertainty bounds of the base model estimates for terminal year. For DMV tautog, there was a major retrospective pattern in SSB, where Mohn’s rho = 0.67 exceeded the recommended bounds, and the adjusted value of SSB was outside the 90% confidence interval (DMV Appendix 2 Figure A2.1). Therefore, a retrospective adjustment was applied to SSB.

In case of F, Mohn’s rho (-0.32) was outside of the recommended bounds, while the adjusted value of *F* was still within the 90% confidence interval (DMV Appendix 2 Figure A2.1). However, three out of the last five peels were outside of the confidence interval for the base run (DMV Appendix 2 Figure A2.2), and the terminal year of the previous assessment estimated a 3-year average *F* of 0.06, which was also outside the confidence interval in this year’s assessment. Therefore, a retrospective adjustment was applied to F.

Based on the formal criteria outlined in ASMFC 2023, the terminal year SSB and 3-year average *F* were adjusted using the Mohn’s rho values reported in ASAP for a seven-year peel. The adjusted value of SSB was 2,687 metric tons. The adjusted value of the 3-year average *F* in the terminal year was 0.36.

A limited number of sensitivity runs were conducted to examine the effects of input data and model configuration on model performance and results. The base model results were insensitive to changes in starting values of model parameters (initial numbers at age, steepness, selectivity, catchability, etc.). The model was converging on the same parameters estimates, within a range of initial starting values, indicating stability of model solution.

There is only one index available for the region (MRIP CPUE), therefore removal of the index to investigate its effect was not possible. At the same time, the MRIP index shows a significant increase in abundance in 2022-2024, which has a substantial effect on the model results. An exploratory run was completed by adding a NJ trawl index, assuming there is natural connectivity between DMV and NJ-NYB stocks. However, there was no notable effect of the inclusion of the NJ index on trends or scale of estimated SSB and F. Additionally, the benchmark assessment used only the DMV index for the DMV assessment, hence only DMV MRIP index was kept in the base model run. MRIP survey operations for the DMV region were not significantly affected by COVID pandemic in 2020-2023. Consequently, MRIP index calculated using imputed data was nearly identical to the one that used only non-imputed information.

The most influential parameters to the model were coefficients of variation (CVs) of the index of abundance and catch. Smaller values of CV force the model to fit predicted values of index or total catch closer to the observed and vice versa. To investigate the role of the precision of the estimate of index (MRIP CV), the model was run with the range of estimates of CVs beginning with the original estimates and following with the CVs increased two-fold. Results indicated that overall model fit (objective function value) improves with the increase in CV index, but the RMSE value was still well above 1. The index CVs were then systematically increased with a step of 0.1 and the model was run with the CV ranging from 0.5. to 1.1 (Table A.2.1). High levels of index CV resulted in RMSE values below 1 but at the expense of the modeled index poorly fitting the observed data for both the MRIP Index and Total Catch. For the final run an intermediate CV level of 0.6 for the index was chosen as a balanced value that resulted in RMSE being close to 1 for both catch and an index, and the trend in the modeled index following the observed data reasonably well.

To better characterize the uncertainty in estimates of *F* and SSB, an MCMC procedure was run with the 1000 sampling events and thinning factor of 1000. Results of the MCMC analysis were used to describe the uncertainty in estimates of *F* and SSB as probability density distribution for *F* and SSB for each year of the modeling and in the bootstrapping when doing the short-term projections of the stock using the AgePro software. MCMC results are used to plot the 95% confidence intervals for the time series of *F* and SSB as a measure of the uncertainty (Figure 41).

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

For the DMV stock, SPR-based reference points are used for the stock status determination. Specifically, $F_{40\%SPR}$ was selected as a target reference point and $F_{30\%SPR}$ as a threshold. To calculate corresponding target and threshold level of SSB, the projection model AGEPRO was used to project the population forward in time 100 years under constant fishing mortality ($F_{30\%SPR}$ and $F_{40\%SPR}$) with recruitment drawn from the model-estimated time-series of observed recruitment to develop an estimate of the long-term equilibrium SSB associated with those fishing mortality reference points.

The current (2025) update resulted in similar values for the *F* target ($F_{40\%SPR}$ = 0.18) and *F* threshold ($F_{30\%SPR}$= 0.29) as compared to the 2021 update (Table 28). These slight changes are a result of re-estimation of age specific selectivity for the latest selectivity block (2012-2024).

The SSB target was estimated at 4,400 mt, and the SSB threshold was estimated at 3,236 mt, very close to those obtained from the 2021 update (Table 28).

Based on the formal criteria outlined in ASMFC (2024), the terminal year SSB and 3-year average *F* were adjusted using Mohn's rho values reported in ASAP for a seven-year peel for the determination of stock status. The adjusted value of SSB is 2,687 metric tons, which is less than the SSB threshold of 3,236 metric tons (Table 29, Figure 41). The adjusted value of the 3-year average *F* in the terminal year is 0.36, which is higher than the *F* threshold of 0.29 (Table 29, Figure 41). Therefore, the determination was made that the DMV stock was overfished and that overfishing was occurring in 2024.

Although the formal criteria for a retrospective adjustment are met, the appropriateness of this adjustment is not certain for a number of reasons. Several additional factors are worth considering when discussing the effect of retrospective bias adjustment on determining the stock status in the DMV region. Importantly, the source of the retrospective bias is unknown and future trends in retrospective pattern might change. Indeed, in one year (2021) the direction of the retrospective pattern was reversed with SSB lower and *F* higher than the base model (Figure 38-Figure 39). The direction of the retrospective pattern is a cause for concern because the model tends to underestimate *F* and overestimate SSB and the history of stock status, as the stock was determined to be not overfished and overfishing was not occurring in 2020. The fishery is considered to be stable in terms of regulations (no change). Effective fishing effort may be less stable as an apparent increase in the use of advanced trolling motors with spot lock technology may allow anglers to hold beneficial locations for longer periods of time and fish for tautog more efficiently. Recruitment over the past two decades appears to be stable, while in recent years it has increased significantly according to the model. An increasing trend in recruitment is supported by the MD DNR YOY tautog index for coastal bays seine survey. Since there are no fishery-independent surveys for the DMV region, both the index and the catch data are composed primarily of MRIP data, with its associated uncertainty (see TOR 1). The appropriateness of bias correction therefore can be verified only when additional years of data with the information on catch and the index are accumulated and the assessment model is rerun.

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

A short term, three-year (2025-2027) projection to determine status of the stock and trends in SSB and *F* was completed using AgePro (v. 4.2, NOAA Fisheries Toolbox) model. The projections assumed a constant harvest level equal to the recent three-year average (2022-2024). Biological parameters (maturity, M, weights at age) for the projection model were the same used in the ASAP population model, with the exception that projection catch weights at age were set equal to the average catch weight at age in the most recent selectivity block. Recruitment for the projected years was drawn from the vector of recruitment values estimated by ASAP model in 2021 assessment update. Fishery selectivity at age was set equal to the one estimated by ASAP for the most recent selectivity period. Starting values for the numbers at age were the estimates of number at age calculated for the terminal year of the ASAP model, adjusted for the retrospective bias using the age specific Mohn's rho estimates from the 7-year peel. Harvest for the projected period was assumed equal to the most recent three-year average removals.

If the constant catch of 155.5 mt is maintained during 2025-2027 (status quo scenario), the probability of the fully recruited *F* being at or above the *F* threshold by 2027 is estimated at 22% (Table 30). The probability of SSB being at or above SSB threshold is only 3% (Table 30, Figure 42). Fishing mortality is projected to decline to the *F* target, while SSB is projected to decline slightly by 2027 and remain below the SSB threshold (Figure 42).

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

Developing a fishery independent index for tautog in the DMV is a high priority research recommendation. Since the last benchmark two have been started: MD DNR has started a seagrass survey that has the potential to serve as a YOY index for tautog and DE DFW has started a ventless trap survey that catches fish from a wide size range, which has the potential to serve as an additional index of abundance. The SAS recommends that these surveys be continued and considered for use in the next benchmark.

There is a need to improve the precision of the recreational harvest. Recreational harvest estimates for tautog in the DMV area often have high PSE estimates, which indicates the need for higher sampling rates to intercept more trips that have tautog in the harvest. Winter months are poorly sampled due to the lack of sampling in wave 1 and low sampling effort in waves 2 and 6. For hire trips sampling should be also a high priority during those waves.

There is either no sampling of commercial catch, or very low sampling. There is a need to improve the data on size structure of the commercial catch and the level of discards.

There is a need to update the basic biological information tautog and investigate alternative model structures. Understanding sources of retrospective pattern and eliminating the retrospective is a priority for further model development.

References

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List of Appendices

DMV Appendix 1: ASAP Input and Diagnostic Plots for the Base Run
DMV Appendix 2: Retrospective Adjustment and Sensitivity Runs

Tables

Table 23. Total removals in metric tons by sector for the DMV region.

	Recreational Harvest	Recreational Release Mortalities	Commercial Harvest
1982	1,110.8	0.8	
1983	1,266.9	4.5	
1984	1,158.6	0.4	
1985	927.9	9.5	3.0
1986	1,093.1	3.6	2.3
1987	1,068.5	3.5	3.4
1988	665.1	3.4	4.3
1989	1,758.8	7.5	5.5
1990	532.1	9.5	4.3
1991	1,126.8	14.5	4.3
1992	652.9	13.5	4.3
1993	1,429.3	21.5	3.1
1994	1,249.3	16.5	6.1
1995	1,662.0	21.1	14.1
1996	1,373.5	10.9	13.8
1997	717.8	13.1	14.2
1998	771.9	24.7	10.0
1999	677.5	27.0	12.5
2000	496.7	27.4	8.5
2001	261.9	17.2	8.4
2002	669.1	22.8	12.7
2003	449.8	20.3	8.4
2004	1,010.9	36.7	9.7
2005	539.4	29.2	5.5
2006	709.2	30.8	7.0
2007	676.7	30.6	6.6
2008	709.8	43.4	7.3
2009	999.9	39.1	6.8
2010	1,193.9	47.1	4.2
2011	532.7	18.7	8.1
2012	297.2	7.3	7.4
2013	226.3	16.1	6.8
2014	387.6	23.2	5.0
2015	111.4	23.0	4.6
2016	138.8	15.9	3.6
2017	113.9	29.7	2.7
2018	50.0	15.8	1.0
2019	85.3	13.2	1.2
2020	244.2	10.7	1.3
2021	321.2	100.3	1.2
2022	273.1	62.5	2.3
2023	211.5	119.9	1.6
2024	63.2	31.5	2.0

Table 24. Indices used in the ASAP model for the DMV region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
MRIP CPUE	Total catch per angler-trip	Stratified Random	Mar-Dec	1982-2024	1+

Table 25. Time series of the MRIP index for the DMV region.

Year	CPUE	SE	CV	ESS
1982	1.6263	0.3147	0.1935	17
1983	0.7023	0.0942	0.1342	13
1984	0.9112	0.1501	0.1647	21
1985	0.4262	0.0531	0.1245	18
1986	5.8549	0.5697	0.0973	78
1987	2.1571	0.2897	0.1343	32
1988	1.8500	0.2431	0.1314	33
1989	3.1492	0.3241	0.1029	81
1990	1.3320	0.1623	0.1219	49
1991	1.0838	0.1253	0.1156	54
1992	1.3648	0.1497	0.1097	78
1993	2.6623	0.2925	0.1099	84
1994	2.7895	0.2705	0.0970	75
1995	2.6275	0.2672	0.1017	68
1996	2.5909	0.2737	0.1056	59
1997	1.1610	0.1197	0.1031	40
1998	0.4783	0.0517	0.1081	57
1999	0.8145	0.0898	0.1102	40
2000	0.8409	0.0881	0.1048	27
2001	0.9758	0.0948	0.0972	48
2002	2.0039	0.1836	0.0916	78
2003	1.4193	0.1345	0.0948	99
2004	1.8000	0.1731	0.0961	132
2005	1.8614	0.1740	0.0935	148
2006	2.1948	0.2144	0.0977	174
2007	1.5501	0.1434	0.0925	127
2008	2.6032	0.2275	0.0874	200
2009	1.4090	0.1326	0.0941	157
2010	2.0422	0.1906	0.0933	170
2011	1.7398	0.1812	0.1041	138
2012	1.2304	0.1407	0.1143	93
2013	1.0853	0.1100	0.1014	112
2014	0.8721	0.0940	0.1078	81
2015	0.5923	0.0687	0.1160	51
2016	1.4155	0.1450	0.1024	127
2017	1.4079	0.1428	0.1014	54
2018	1.4719	0.1450	0.0985	60
2019	0.8216	0.0844	0.1027	50
2020	1.3646	0.1582	0.1159	111
2021	2.2522	0.2180	0.0968	104
2022	5.4958	0.5854	0.1065	108
2023	3.4047	0.3506	0.1030	66
2024	3.3876	0.3368	0.0994	21

Table 26. Model structure and life history information used in the stock assessment.

	Value(s)
Years in Model	1990-2024
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB calculation	0.42
Number of selectivity blocks	4
selectivity periods	1990-1996, 1997- 2006, 2007-2011 and 2013-2024
Selectivity type	Single logistic

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

Table 27. Spawning stock biomass in metric tons, recruitment (millions of age-1 fish), annual fishing mortality (*F*), and 3-year average *F* estimates for the DMV region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual F	3-year Average F
1990	5,273	1.82	0.27	
1991	5,588	2.10	0.26	
1992	5,785	1.71	0.21	0.25
1993	5,885	1.29	0.32	0.26
1994	5,729	0.93	0.25	0.26
1995	5,268	0.88	0.39	0.32
1996	4,444	0.94	0.37	0.34
1997	3,887	0.96	0.29	0.35
1998	3,607	1.30	0.30	0.32
1999	3,380	1.12	0.32	0.30
2000	3,454	1.06	0.21	0.28
2001	3,713	1.06	0.14	0.23
2002	3,883	0.93	0.24	0.20
2003	3,907	0.81	0.21	0.20
2004	3,748	0.96	0.33	0.26
2005	3,538	1.07	0.19	0.24
2006	3,485	0.85	0.27	0.27
2007	3,406	0.80	0.26	0.24
2008	3,164	0.83	0.35	0.29
2009	2,408	0.69	0.85	0.48
2010	1,750	0.84	0.68	0.62
2011	1,477	0.46	0.62	0.71
2012	1,341	0.38	0.83	0.71
2013	1,267	0.29	0.32	0.59
2014	1,270	0.39	0.33	0.49
2015	1,214	0.46	0.25	0.30
2016	1,188	0.65	0.33	0.30
2017	1,203	0.46	0.26	0.28
2018	1,390	0.53	0.14	0.24
2019	1,502	0.69	0.27	0.22
2020	1,511	1.55	0.33	0.25
2021	1,510	2.06	0.46	0.36
2022	1,899	3.81	0.38	0.39
2023	2,696	5.66	0.29	0.38
2024	4,489	0.92	0.07	0.25
*2024**	*2,687*			*0.36*

**Retrospectively adjusted values*

Table 28. SSB and *F* reference points from 2021 and 2025 assessment updates for the DMV region.

	SSB		F	
	Target	Threshold	Target	Threshold
2021 Update	4,488	3,355	0.17	0.27
2025 Update	4,400	3,236	0.182	0.288

Table 29. Stock status for the DMV region.

	SSB		F	
	Target	Threshold	Target	Threshold
Reference Points	4,400	3,236	0.18	0.29
2025 retro adjusted	2,687*		0.36*	
2025 Status	Overfished		Overfishing	

**Retrospectively-adjusted value*

Table 30. Projection results for the DMV region.

Landings (mt) for 2022-2024	Probability of being at or above *F* threshold in 3 years	Probability of being at or below SSB threshold in 3 years
Status quo (2022-2024 average)	22%	97%

Figures

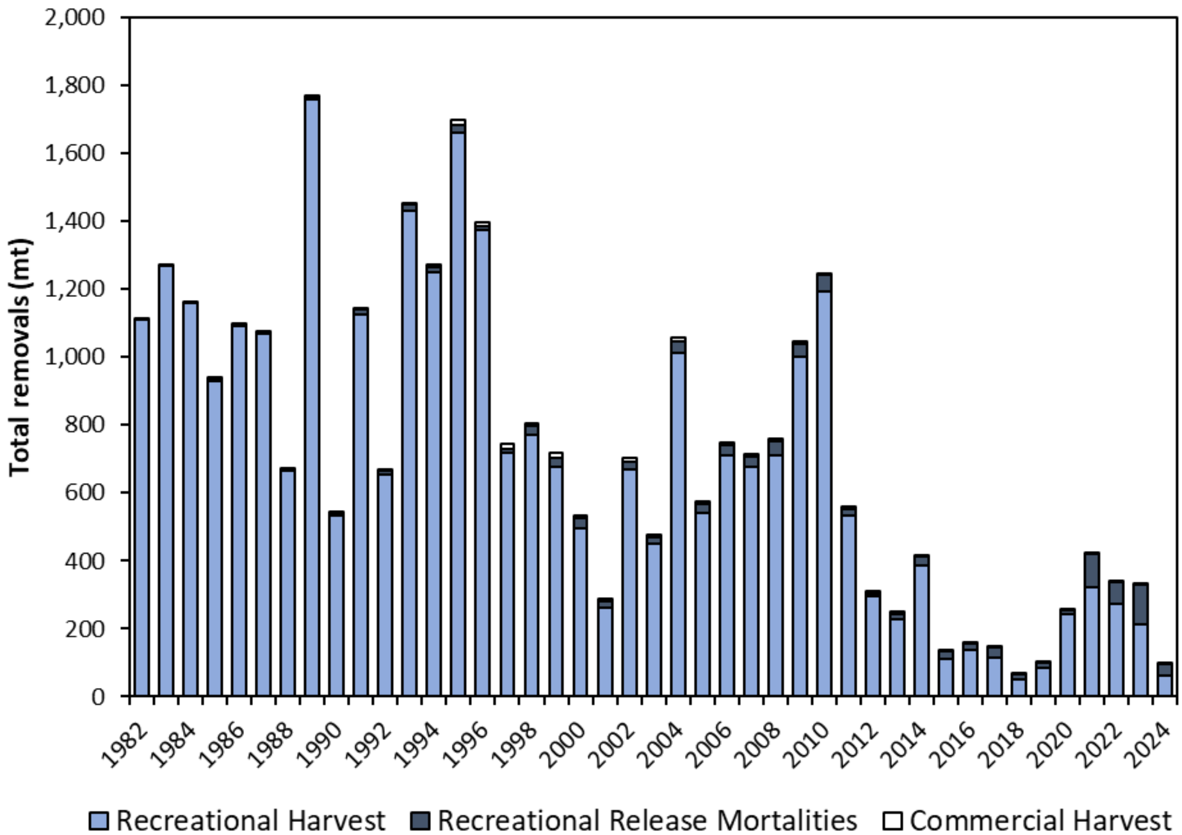


Figure 33. Total removals by sector for the DMV region.

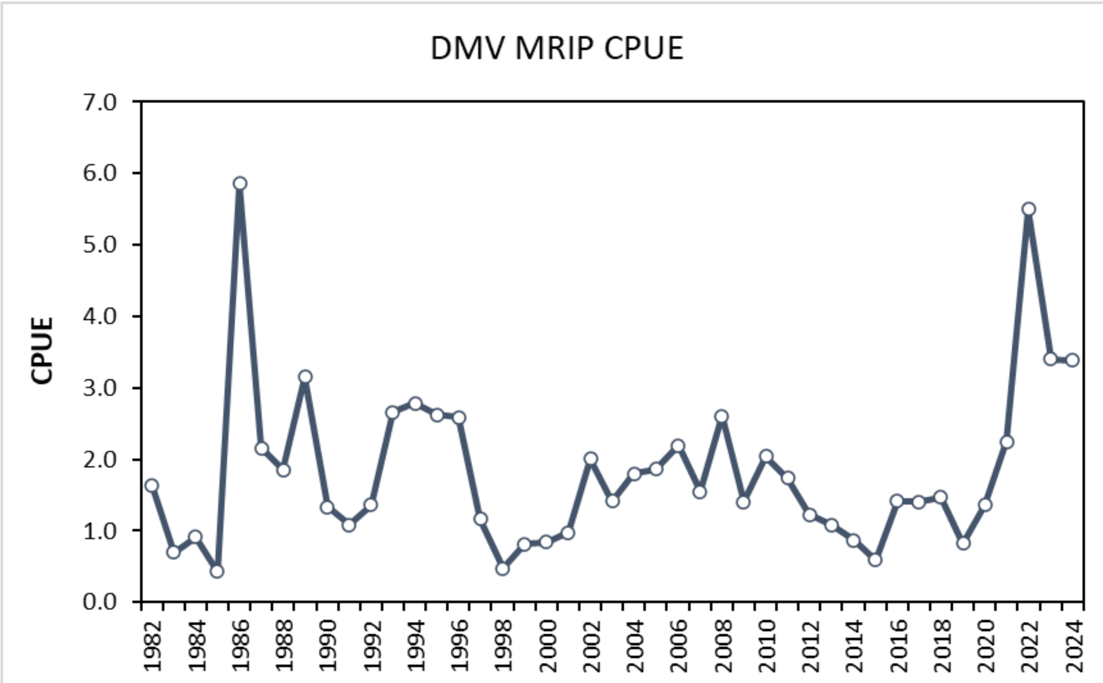


Figure 34. Indices of abundance used for the DMV region.

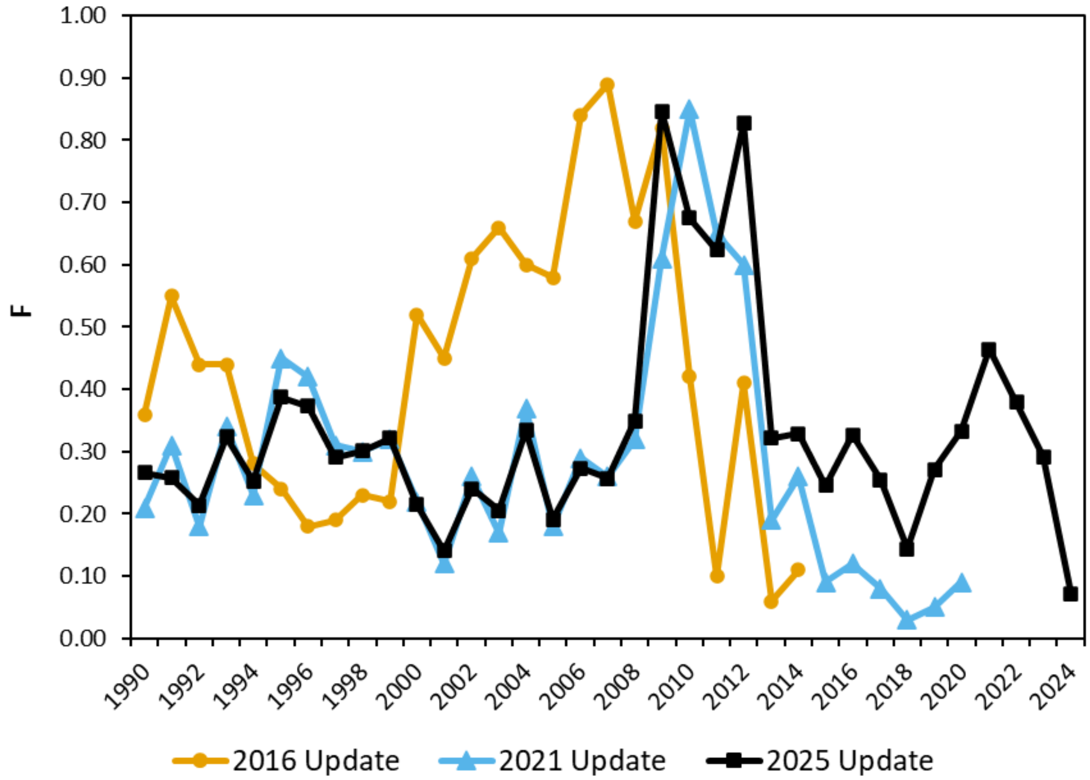


Figure 35. Estimates of the annual full *F* based on the 2016, 2021 and 2025 updates for the DMV region. The estimates from the 2016 update are not directly comparable to the 2021 and 2025 estimates because they are based on the uncalibrated MRIP estimates prior to the transition to the mail-based effort survey.

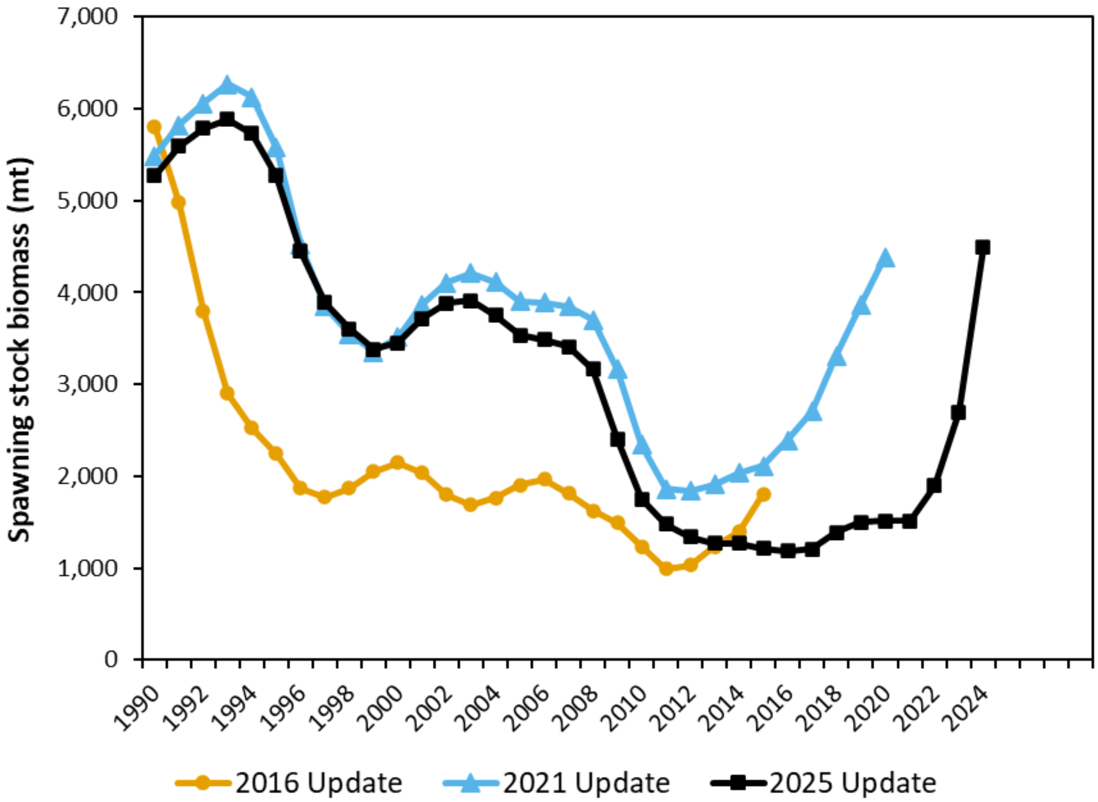


Figure 36. Estimates of spawning stock biomass for the 2016, 2021 and 2025 updates for the DMV region. The estimates from the 2016 update are not directly comparable to the 2021 and 2025 estimates because they are based on the uncalibrated MRIP estimates prior to the transition to the mail-based effort survey.

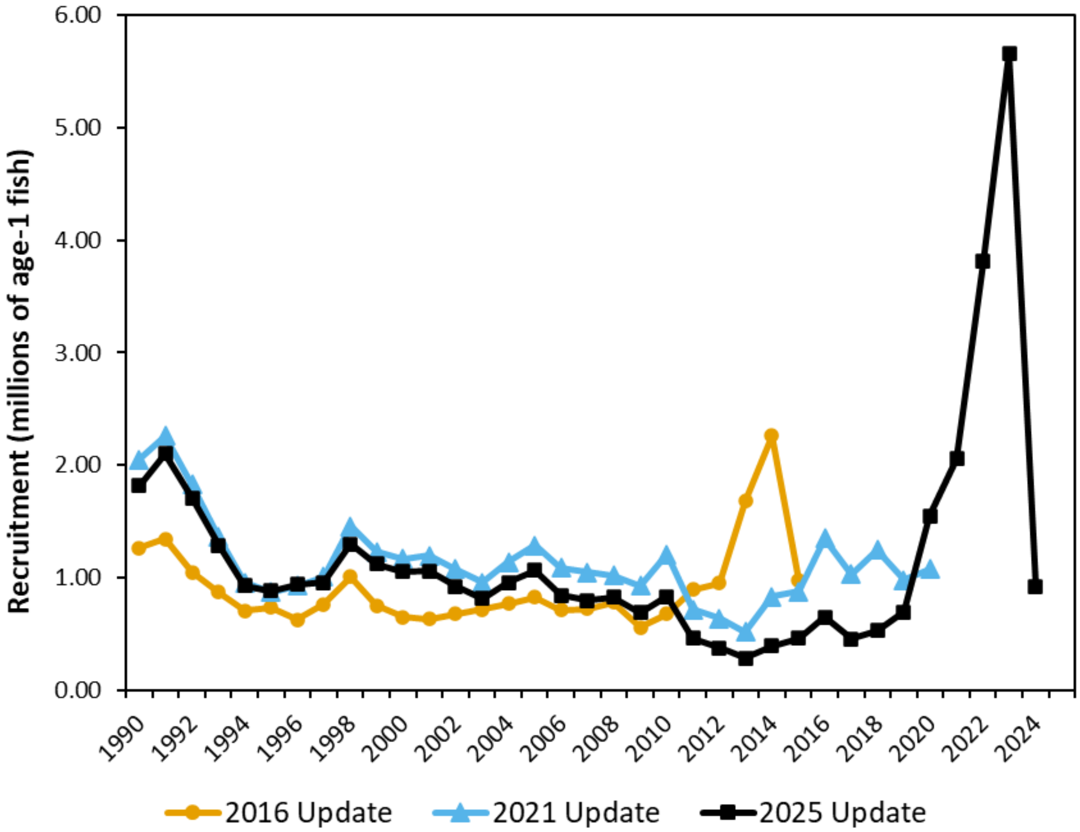


Figure 37. Estimates of recruitment for the 2016, 2021 and 2025 updates for the DMV region. The estimates from the 2016 update are not directly comparable to the 2021 and 2025 estimates because they are based on the uncalibrated MRIP estimates prior to the transition to the mail-based effort survey.

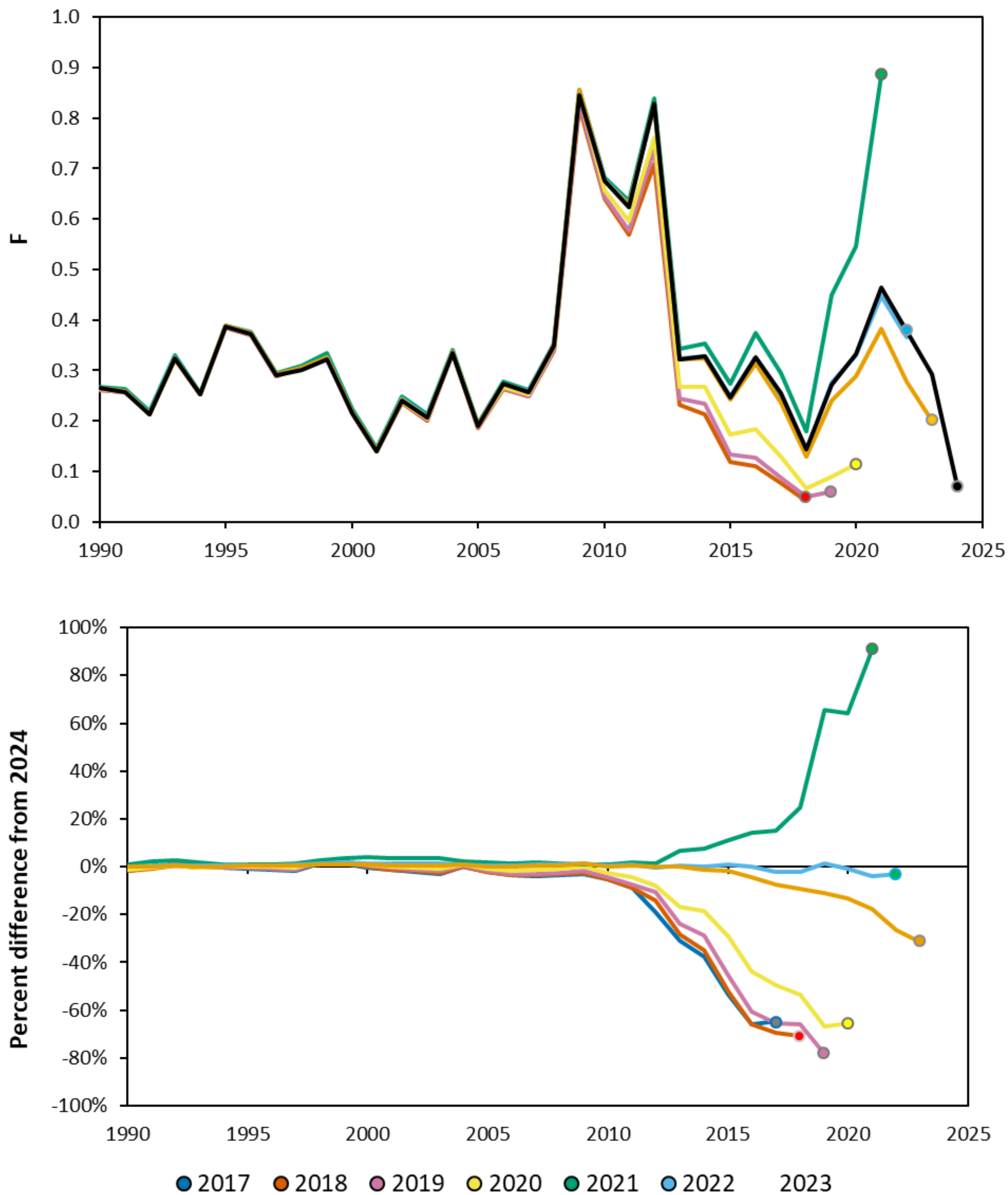


Figure 38. Retrospective analysis for annual *F* in absolute numbers (top) and percent difference (bottom) for the DMV region.

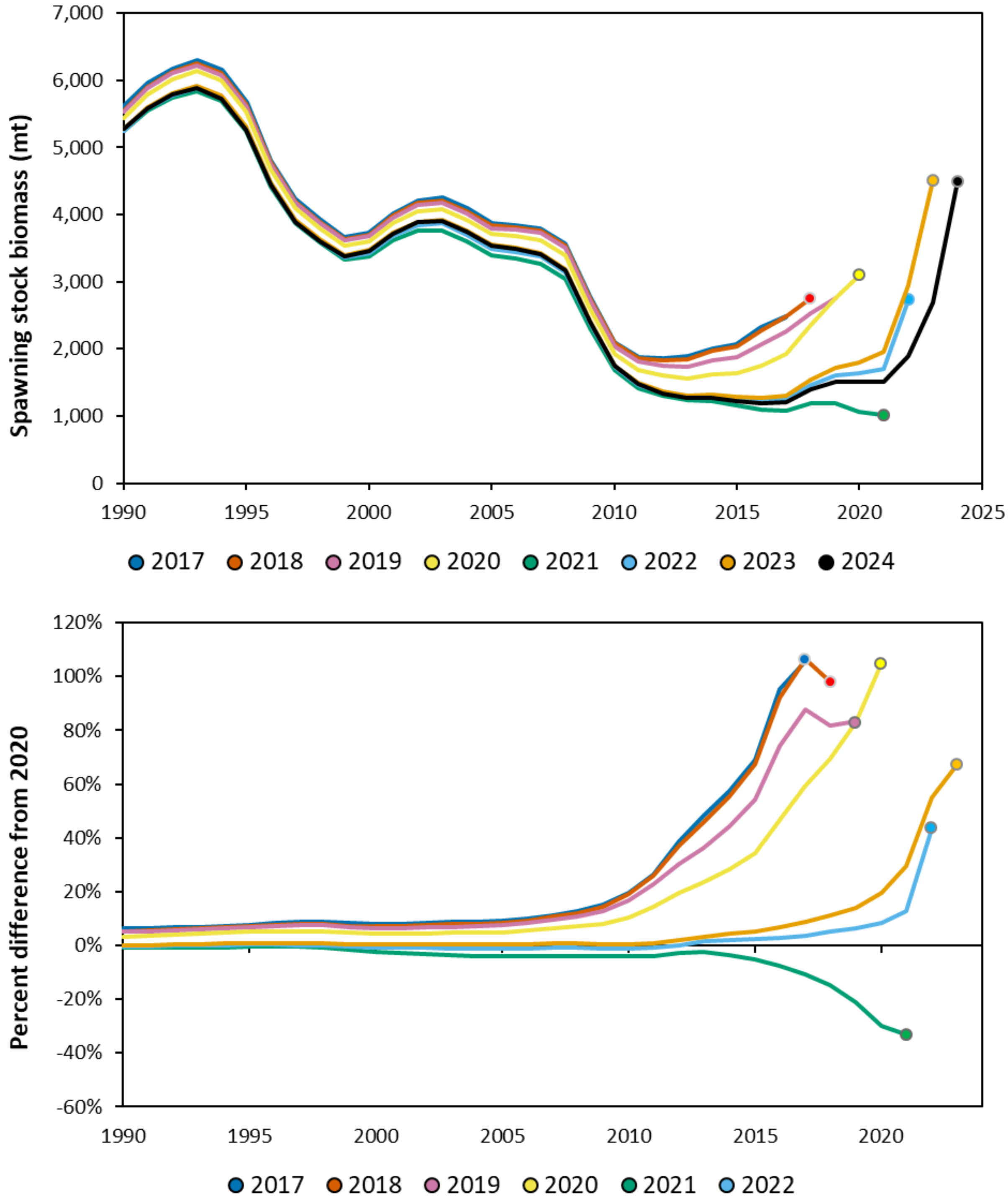


Figure 39. Retrospective analysis for SSB in absolute numbers (top) and percent difference (bottom) for the DMV region.

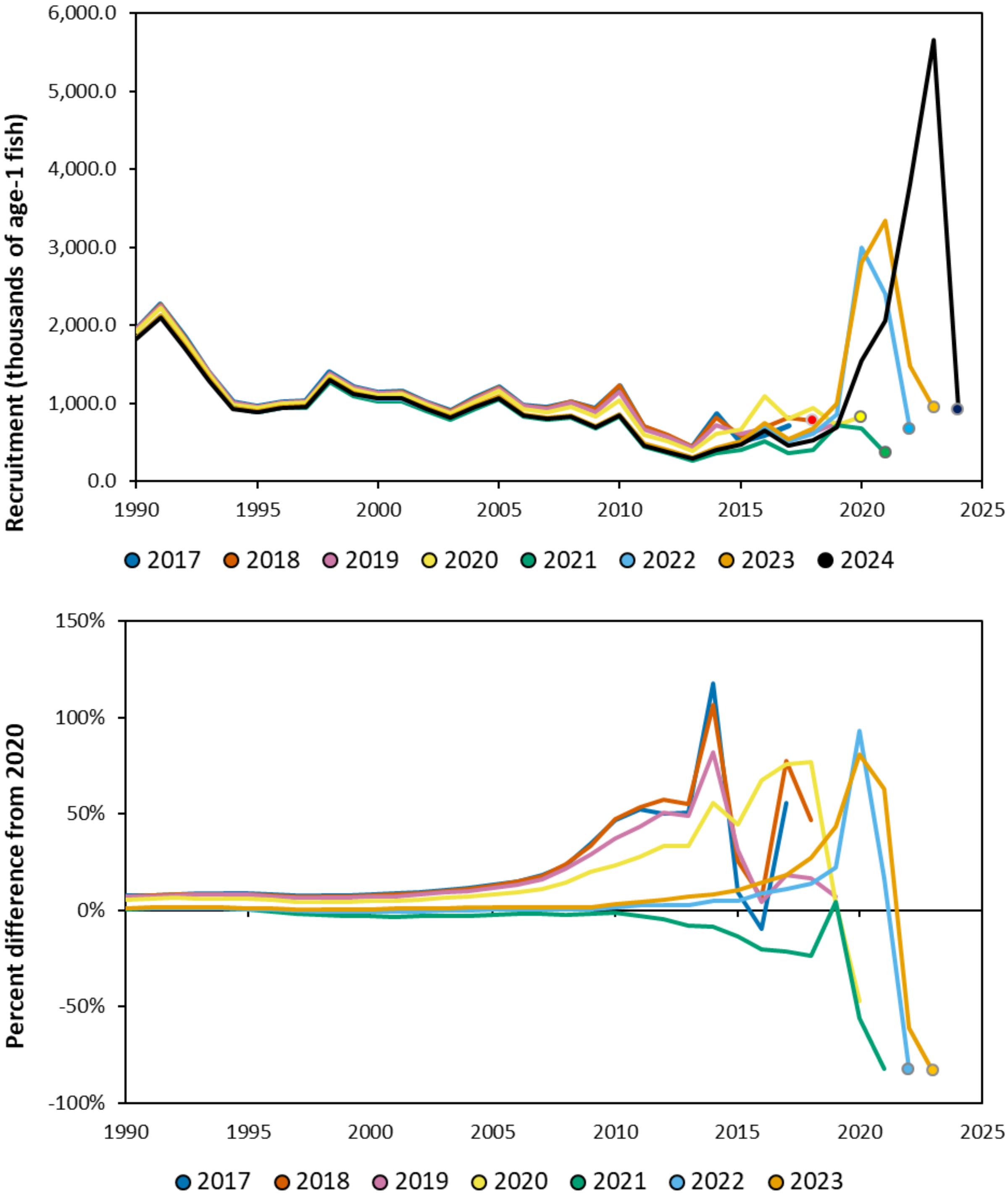


Figure 40. Retrospective analysis for recruitment in absolute numbers (top) and percent difference (bottom) for the DMV region.

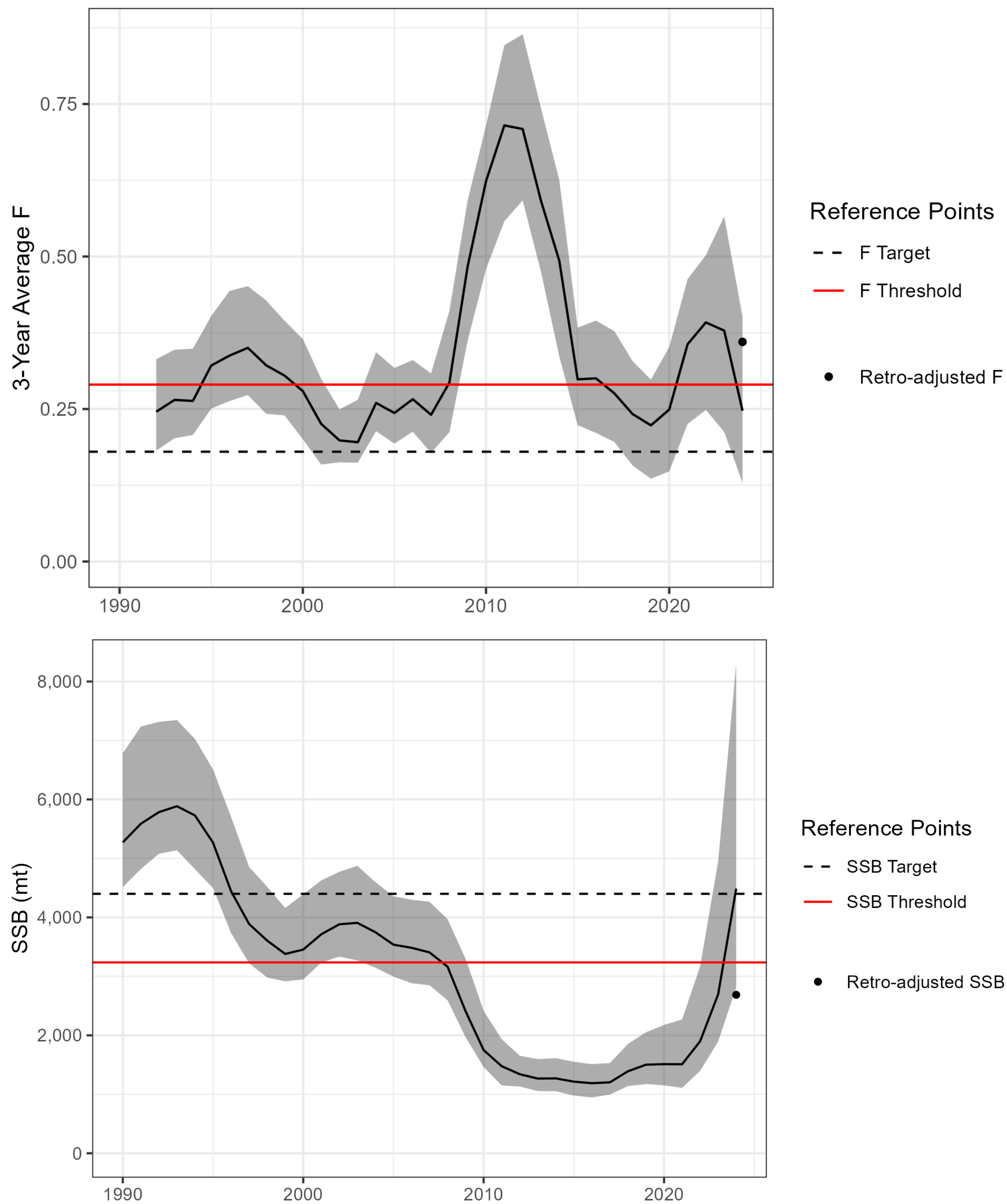


Figure 41. Stock status of tautog in the DMV region. Shaded areas indicate the 95% confidence interval of the estimates. The retrospectively adjusted values were used to assess overfished status in 2024.

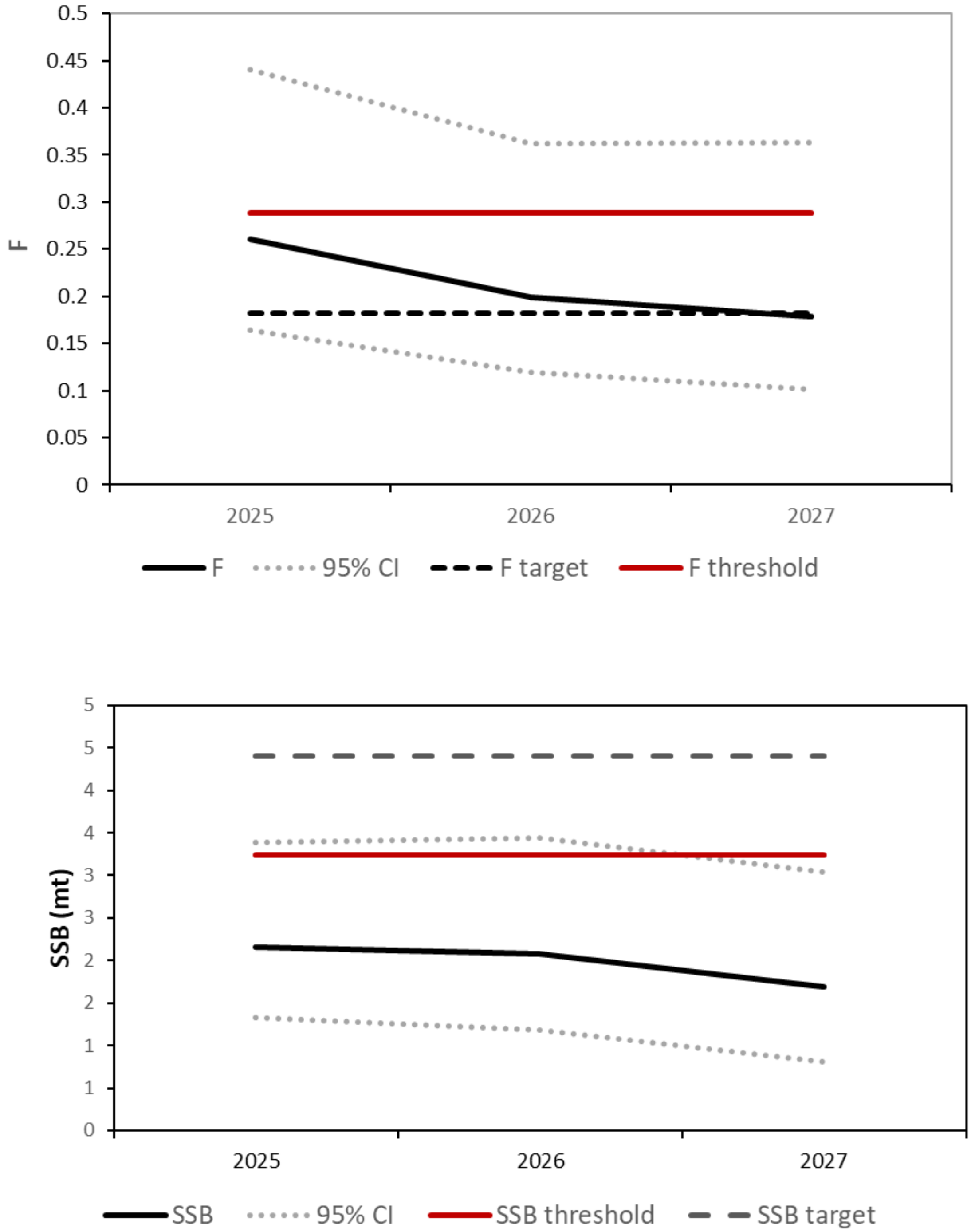


Figure 42. Status quo harvest projections for the DMV region showing the trajectory of annual *F* (top) and SSB (bottom) with their target and threshold reference points. Dotted grey lines indicate the 95% confidence intervals of the estimates.

Atlantic States Marine Fisheries Commission

Tautog Regional Stock Assessment Update 2025

Regional Appendices

MARI Appendix 1: ASAP Input and Diagnostic Plots for the Base Run

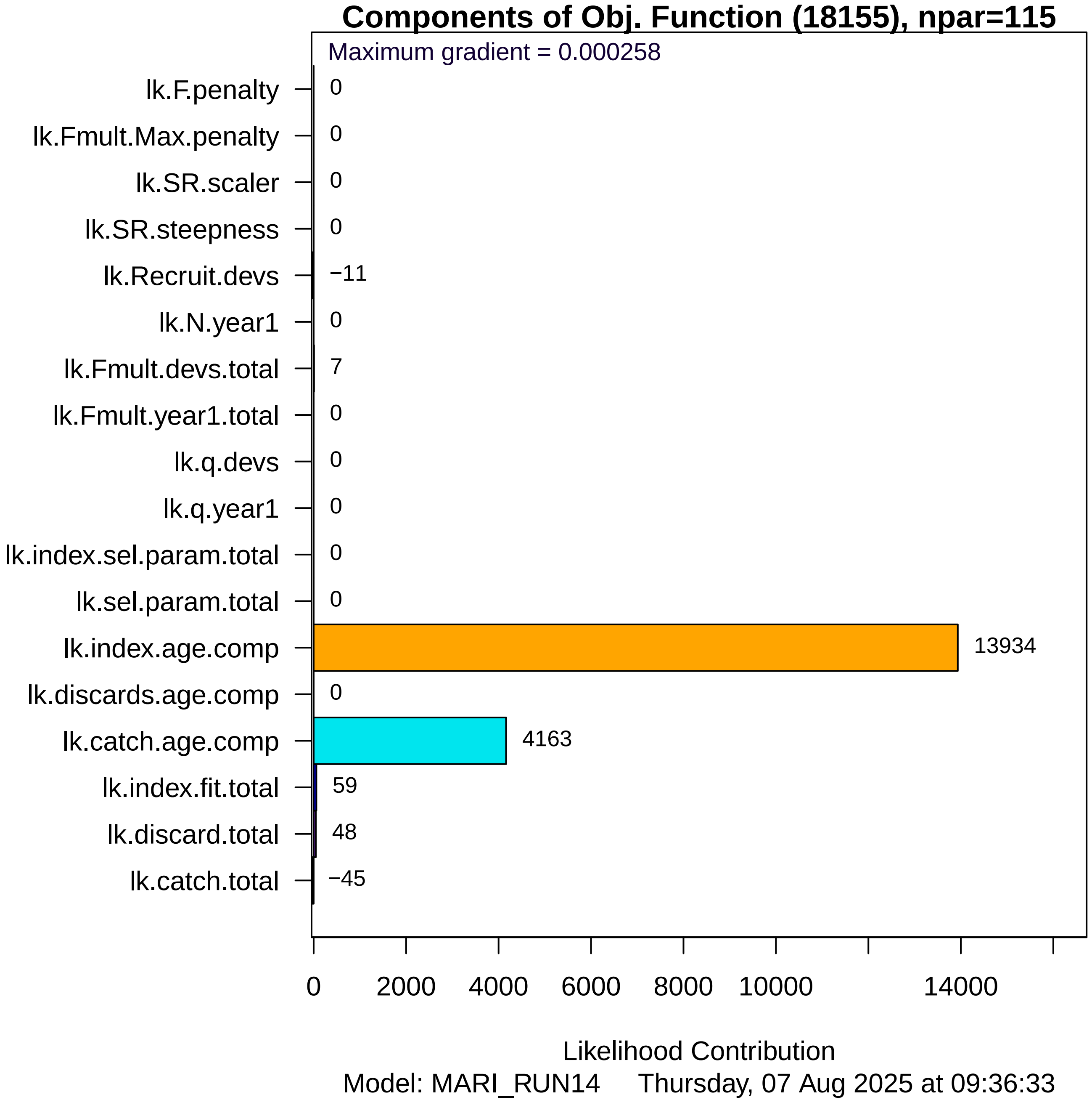
File = MARI_RUN14.dat

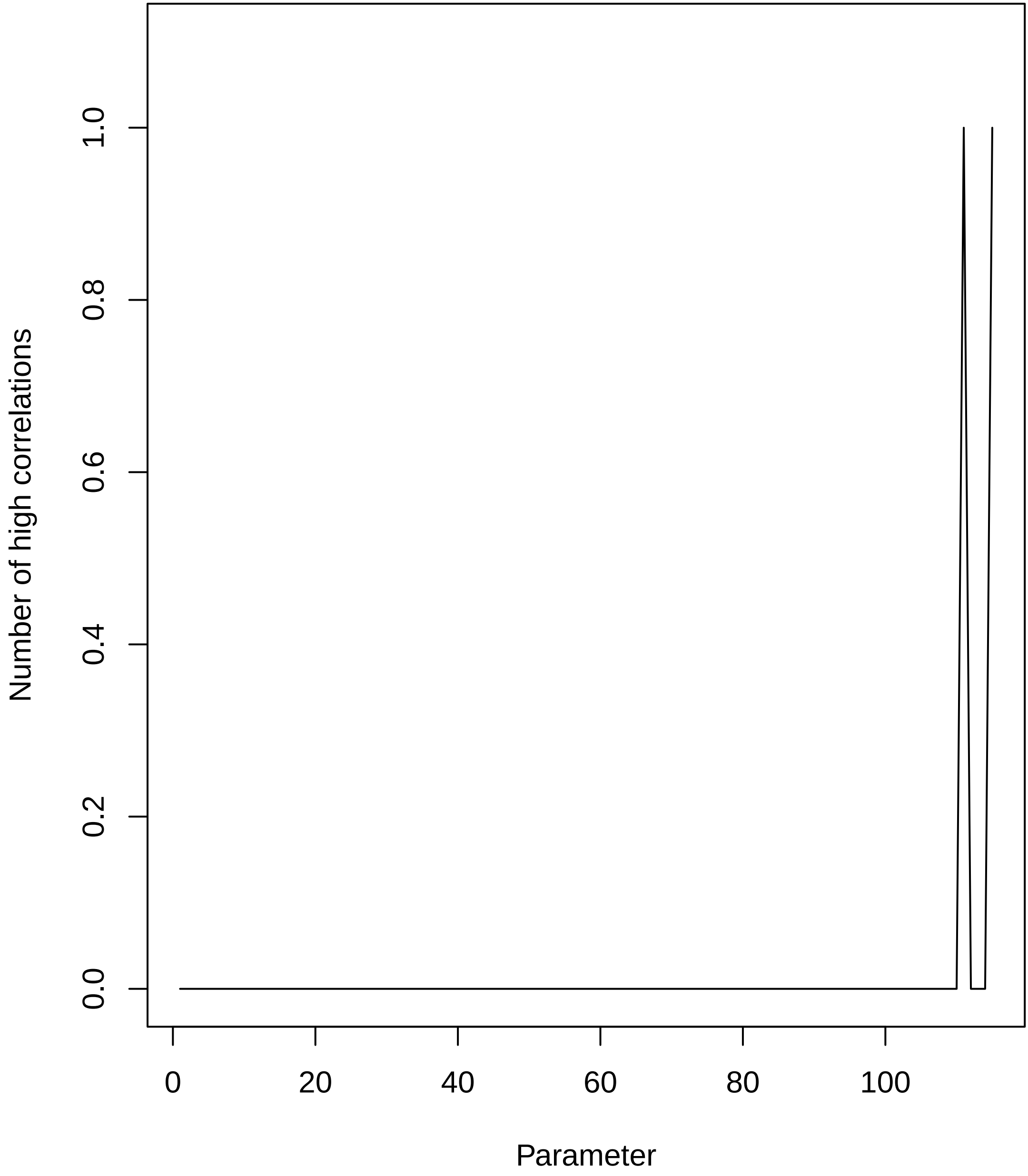
ASAP3 run on Thursday, 07 Aug 2025 at 09:36:33

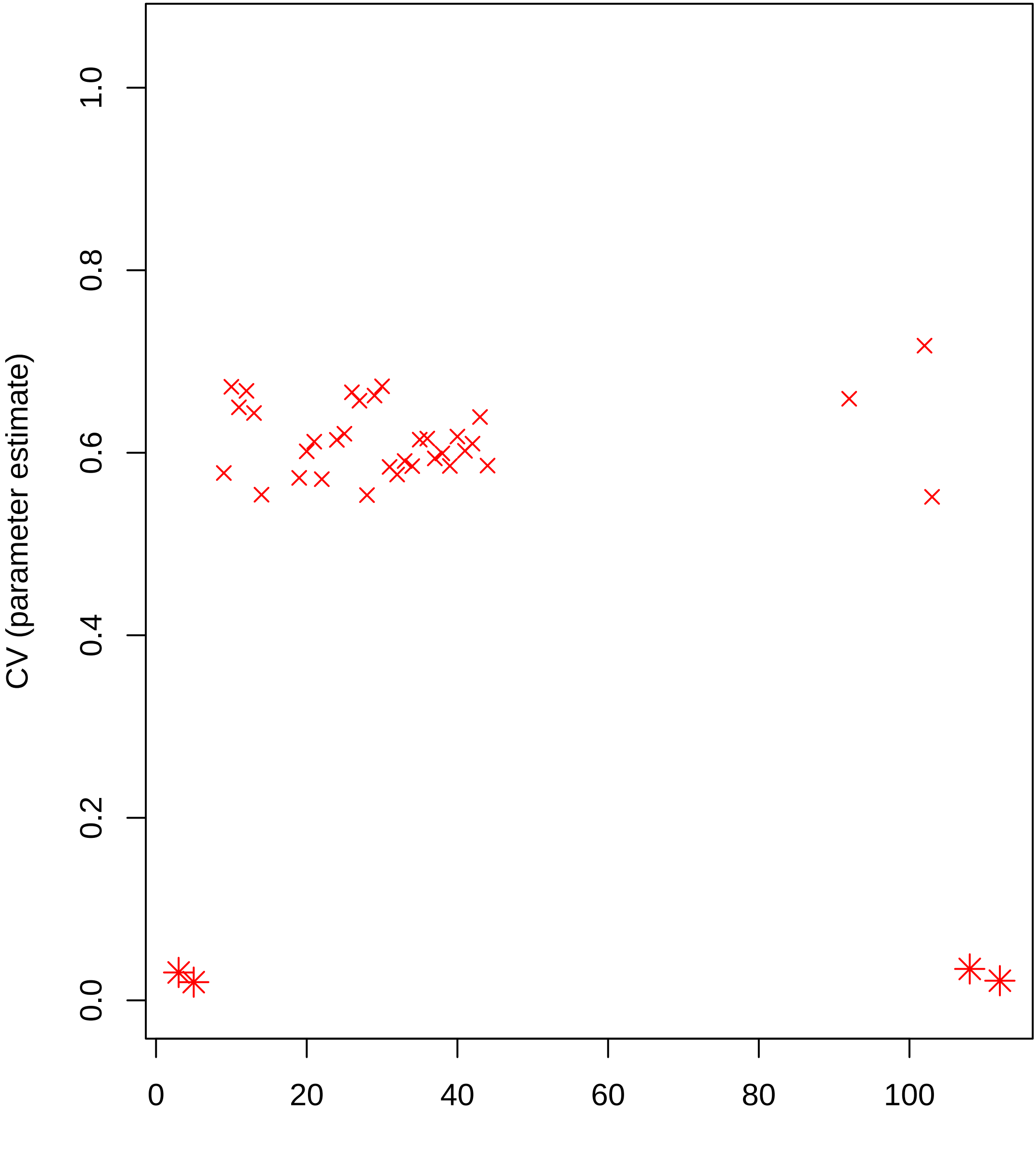
dir = Run14−ScaledTo2021

ASAPplots version = 0.2.18

npar = 115, maximum gradient = 0.000257721


Components of Obj. Function (18155), npar=115
Maximum gradient = 0.000258
lk.F.penalty
lk.Fmult.Max.penalty
lk.SR.scaler
lk.SR.steepness
lk.Recruit.devs
lk.N.year1
lk.Fmult.devs.total
lk.Fmult.year1.total
lk.q.devs
lk.q.year1
lk.index.sel.param.total
lk.sel.param.total
lk.index.age.comp
lk.discards.age.comp
lk.catch.age.comp
lk.index.fit.total
lk.discard.total
lk.catch.total
0
0
0
0
−11
0
7
0
0
0
0
0
13934
0
4163
59
48
−45
0
2000
4000
6000
8000
10000
14000
Likelihood Contribution
Model: MARI_RUN14 Thursday, 07 Aug 2025 at 09:36:33

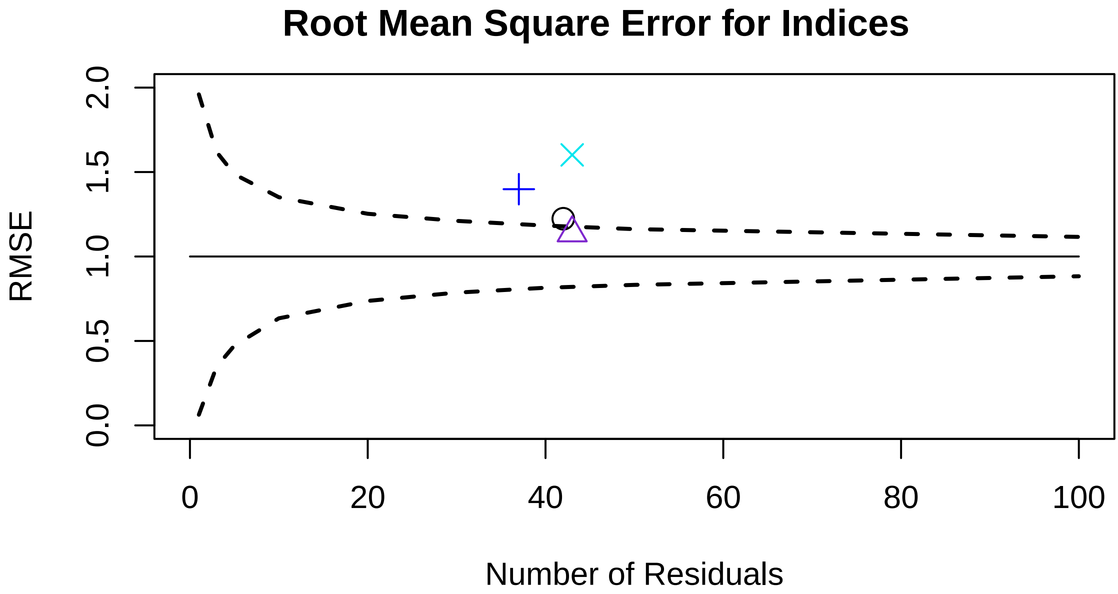

Number of high correlations
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Parameter



CV (parameter estimate)
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Parameter number

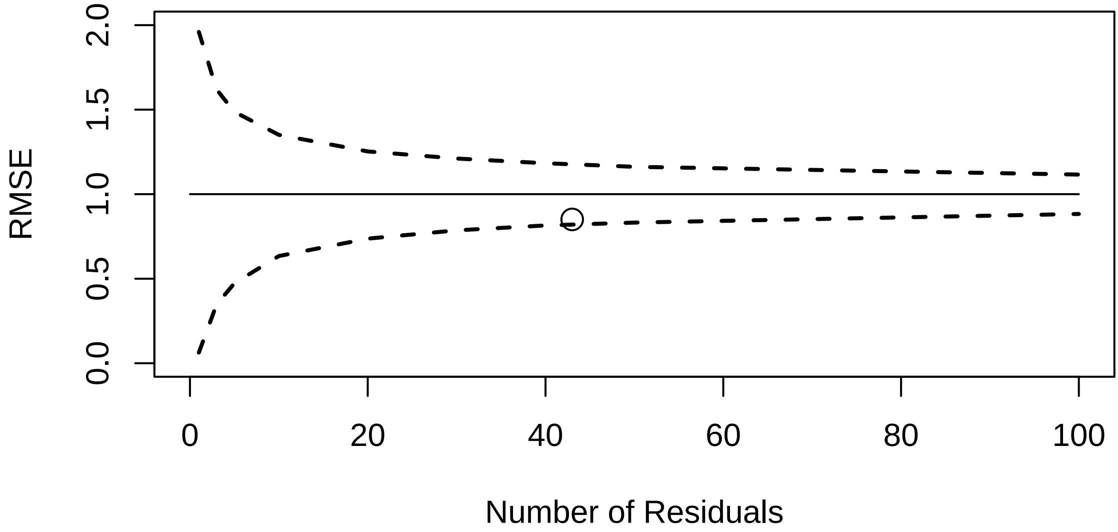
Root Mean Square Error computed from Standardized Residuals

Component	# resids	RMSE
catch.tot	43	0.851
discard.tot	0	0
ind01	42	1.22
ind02	43	1.14
ind03	37	1.4
ind04	43	1.6
ind.total	165	1.35
N.year1	0	0
Fmult.year1	0	0
Fmult.devs.total	42	0.85
recruit.devs	43	0.683
fleet.sel.params	0	0
index.sel.params	0	0
q.year1	0	0
q.devs	0	0
SR.steepness	0	0
SR.scaler	0	0


Root Mean Square Error for Indices
RMSE
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Number of Residuals

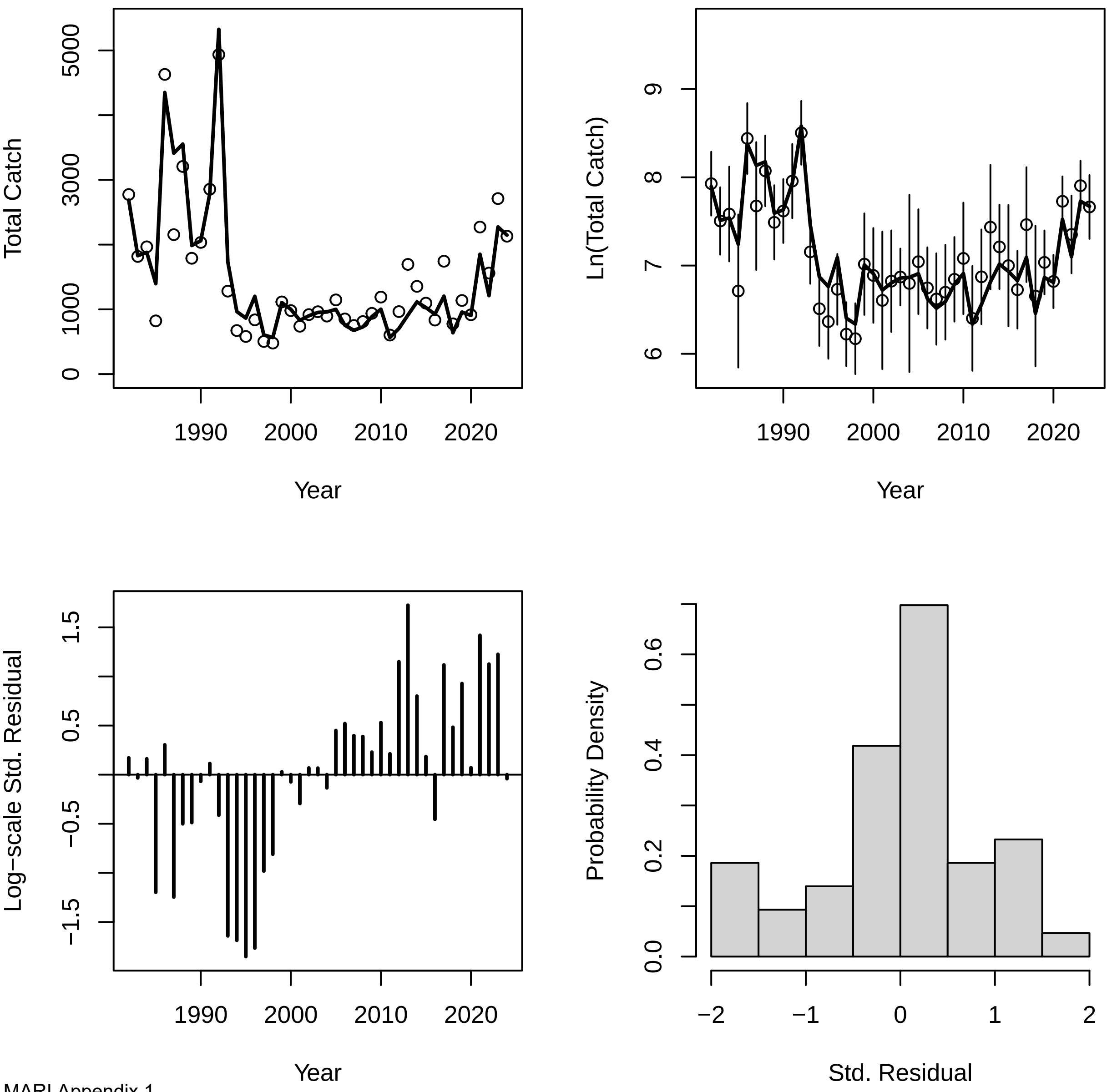

ind.total
MRIP.CPUE
RI Seine
RI Fall Trawl
MA Trawl

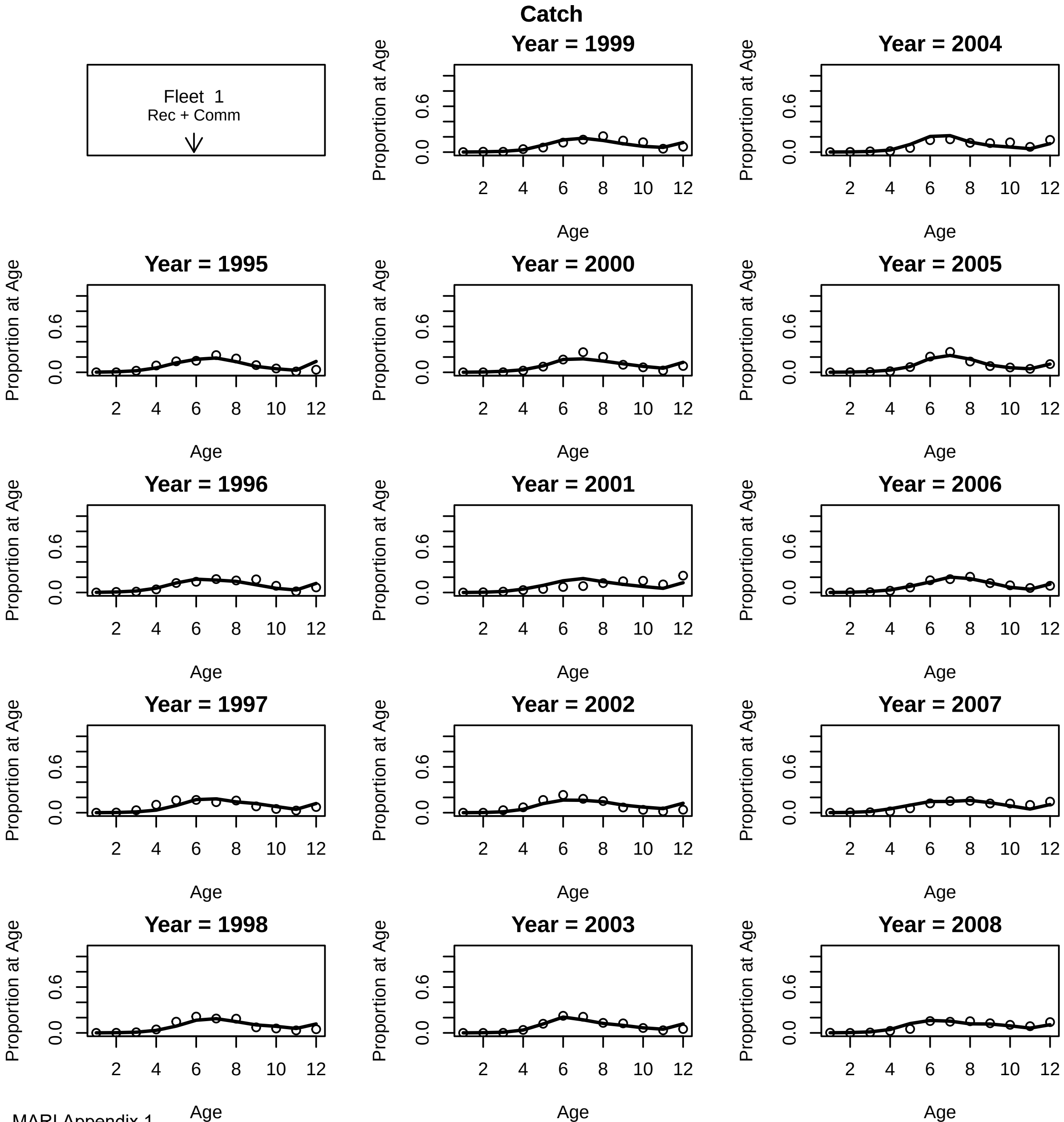
Root Mean Square Error for Catch

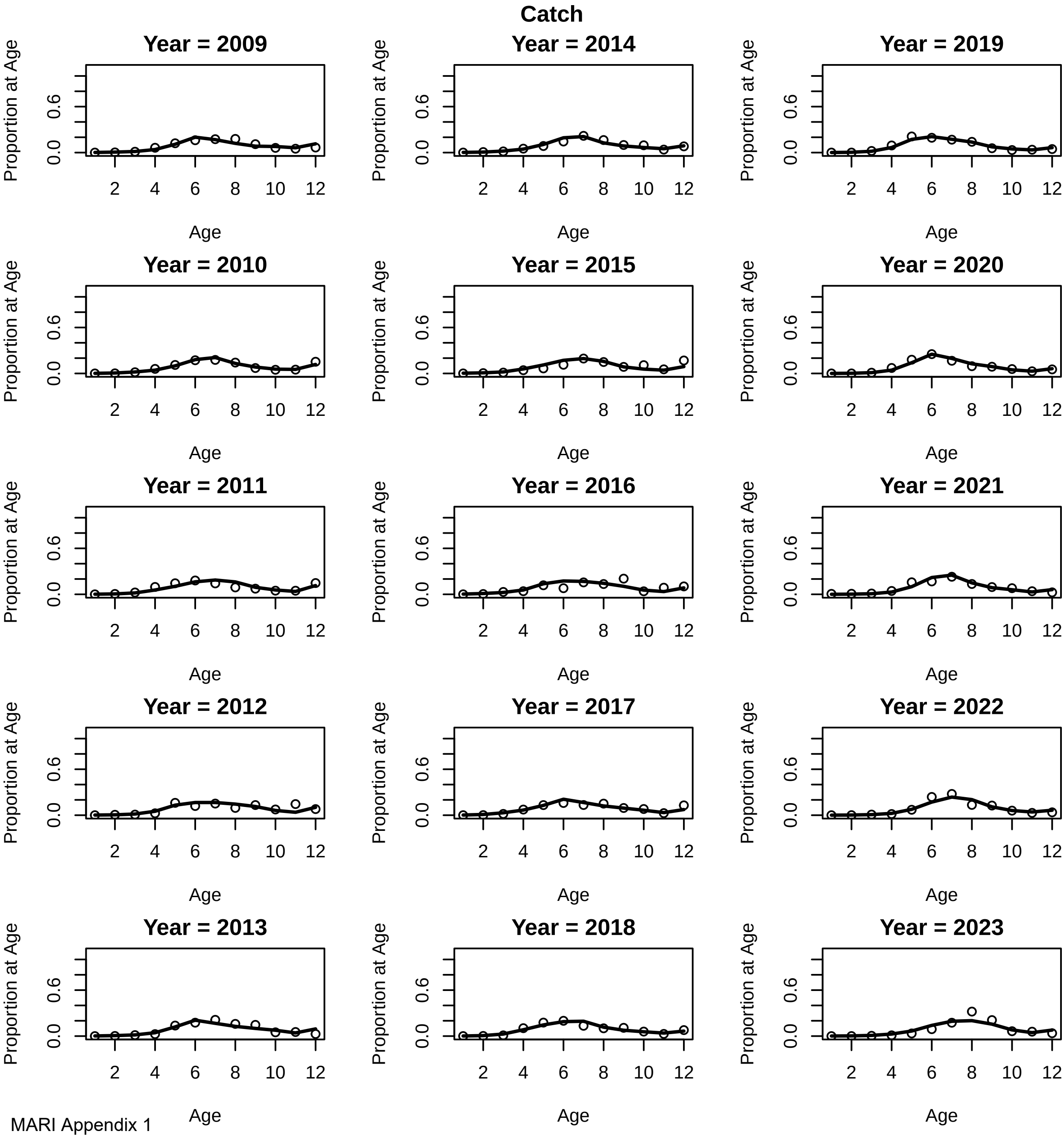


○ catch.tot

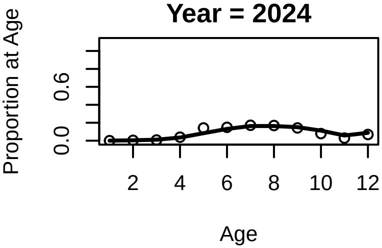
Fleet 1 Catch (Rec + Comm)

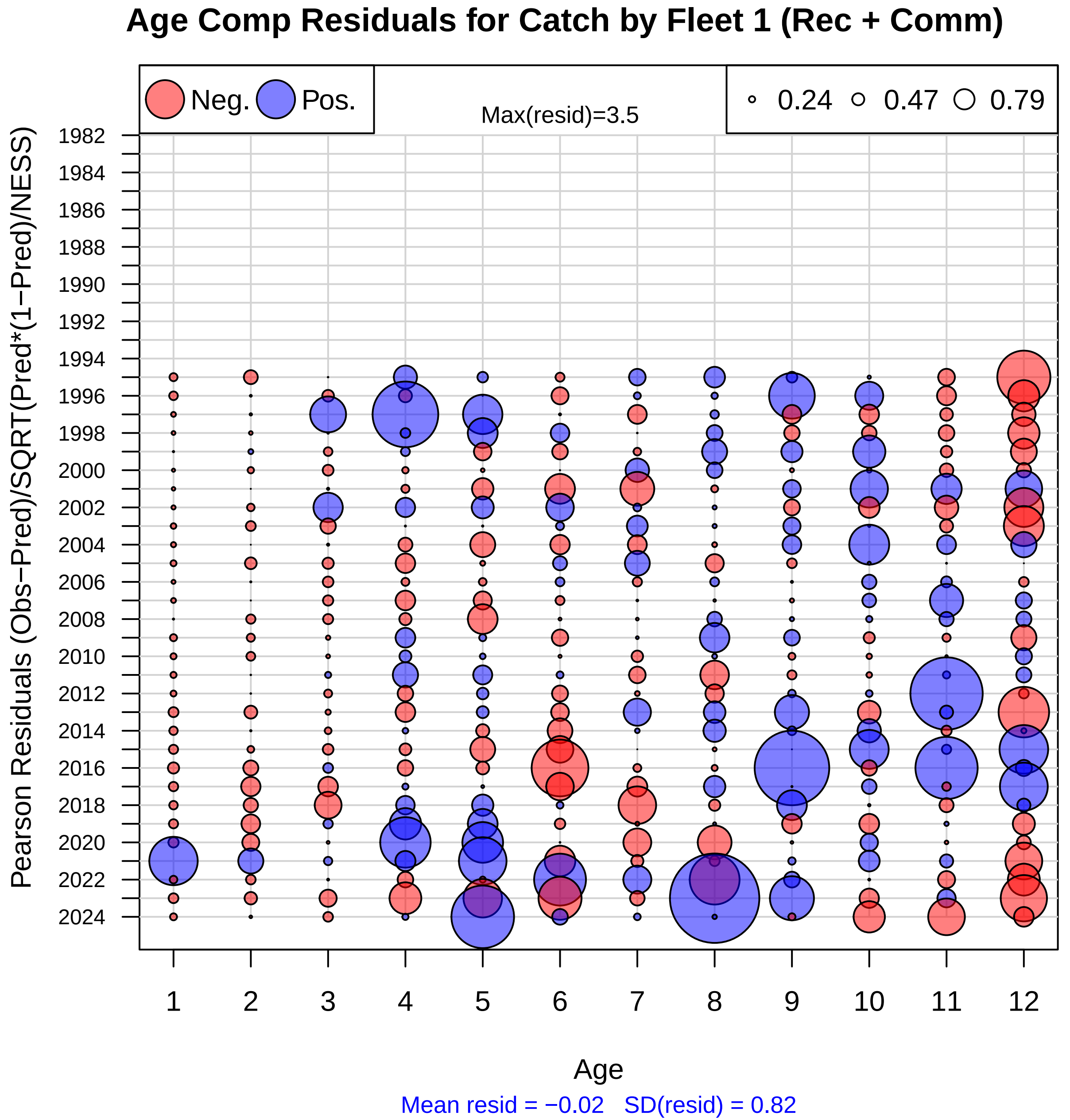


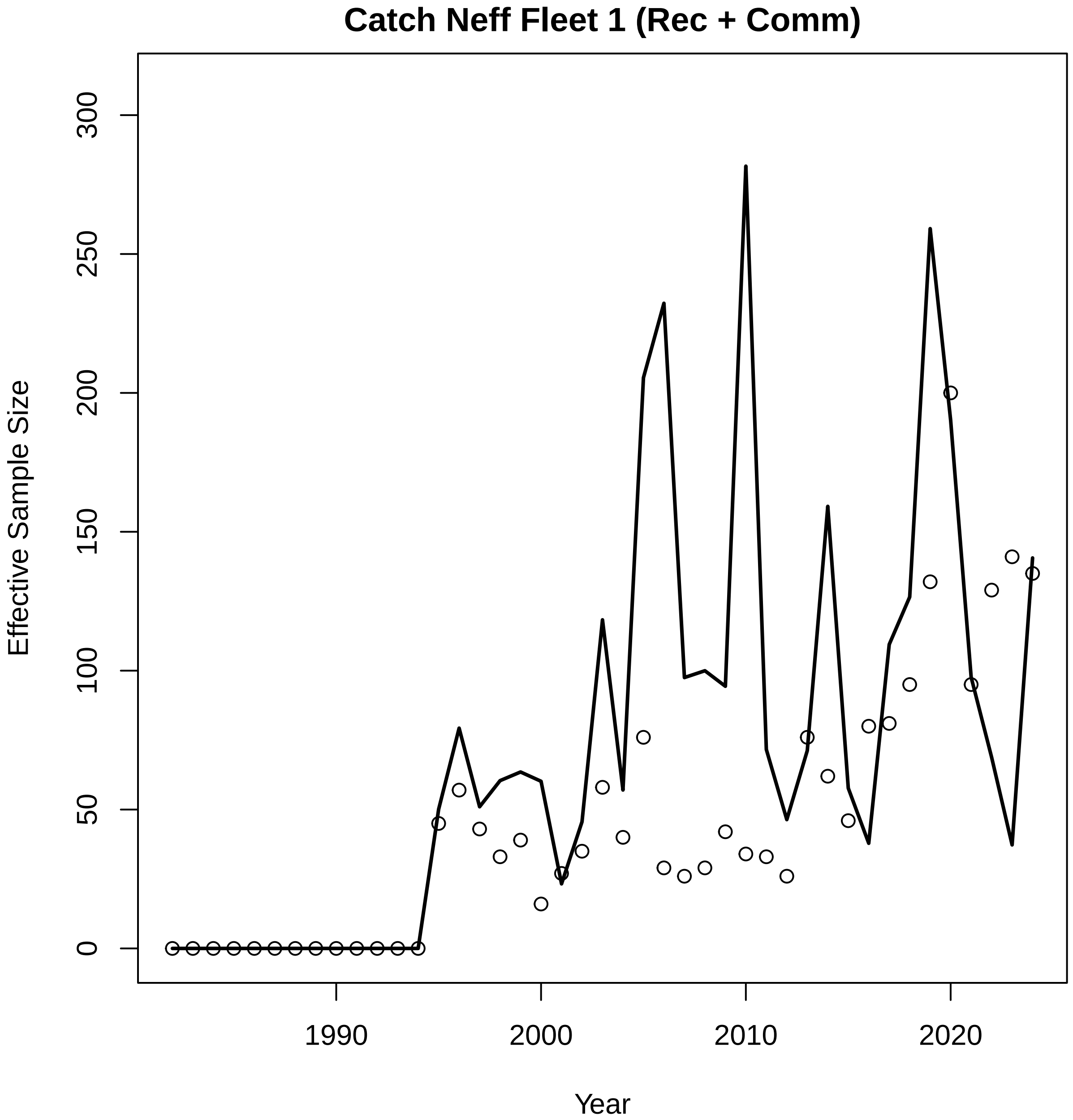

Catch
Fleet 1
Rec + Comm
Year = 1999
Year = 2004
Year = 1995
Year = 2000
Year = 2005
Year = 1996
Year = 2001
Year = 2006
Year = 1997
Year = 2002
Year = 2007
Year = 1998
Year = 2003
Year = 2008
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

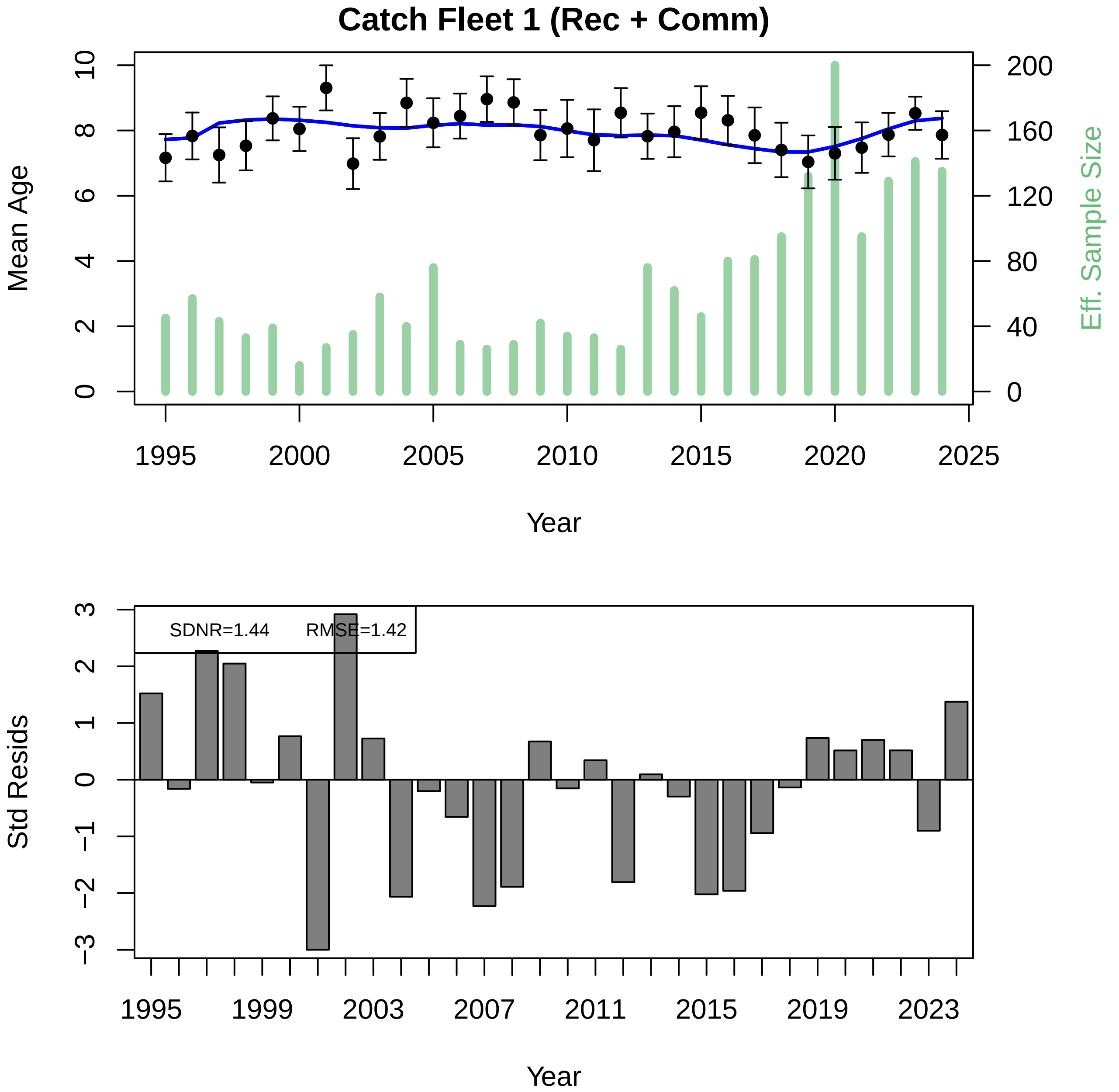

Catch
Year = 2009
Year = 2014
Year = 2019
Year = 2010
Year = 2015
Year = 2020
Year = 2011
Year = 2016
Year = 2021
Year = 2012
Year = 2017
Year = 2022
Year = 2013
Year = 2018
Year = 2023
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

Catch

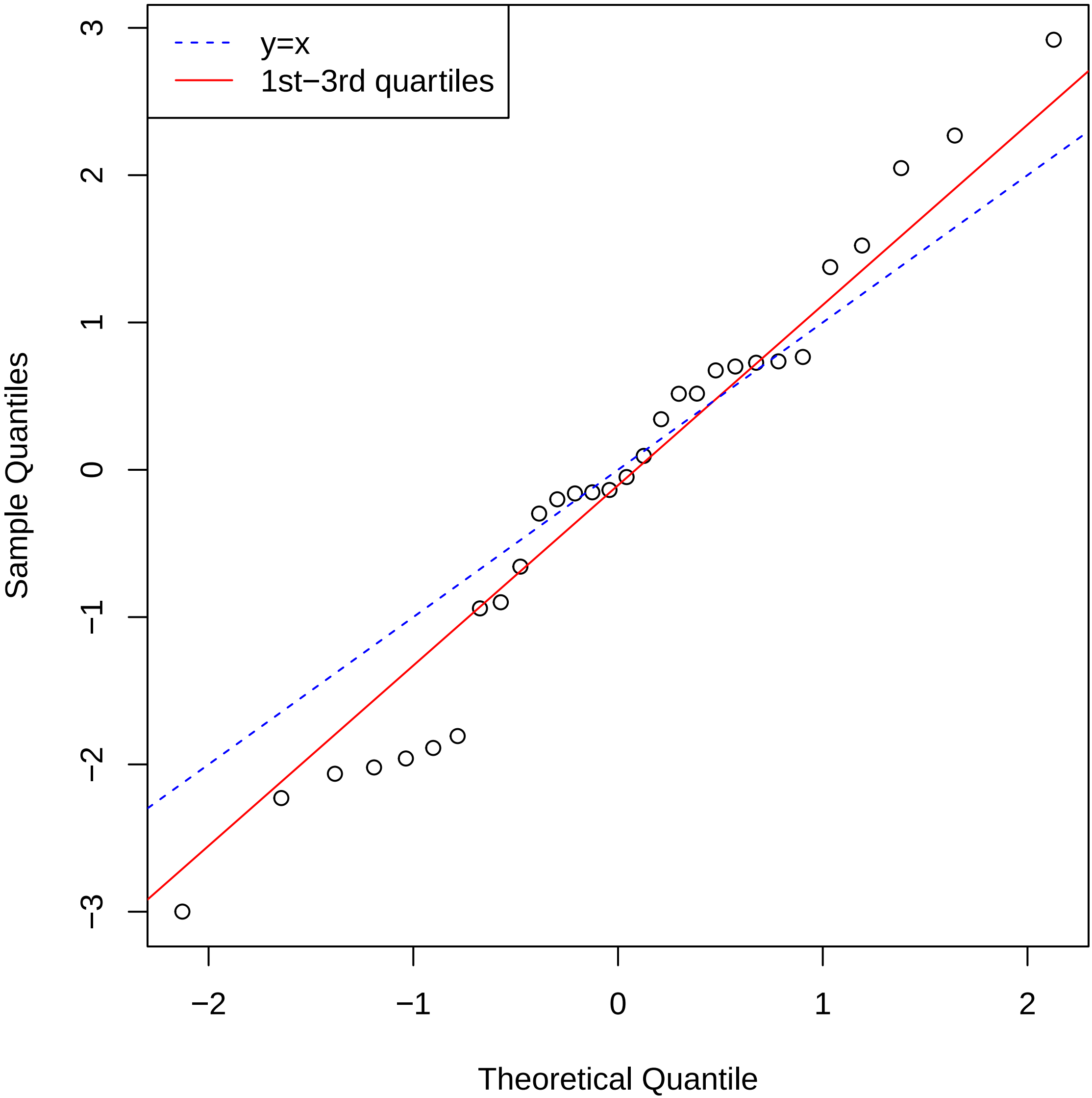



Age Comp Residuals for Catch by Fleet 1 (Rec + Comm)
Neg.
Pos.
Max(resid)=3.5
0.24
0.47
0.79
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
1 2 3 4 5 6 7 8 9 10 11 12
Age
Mean resid = −0.02   SD(resid) = 0.82

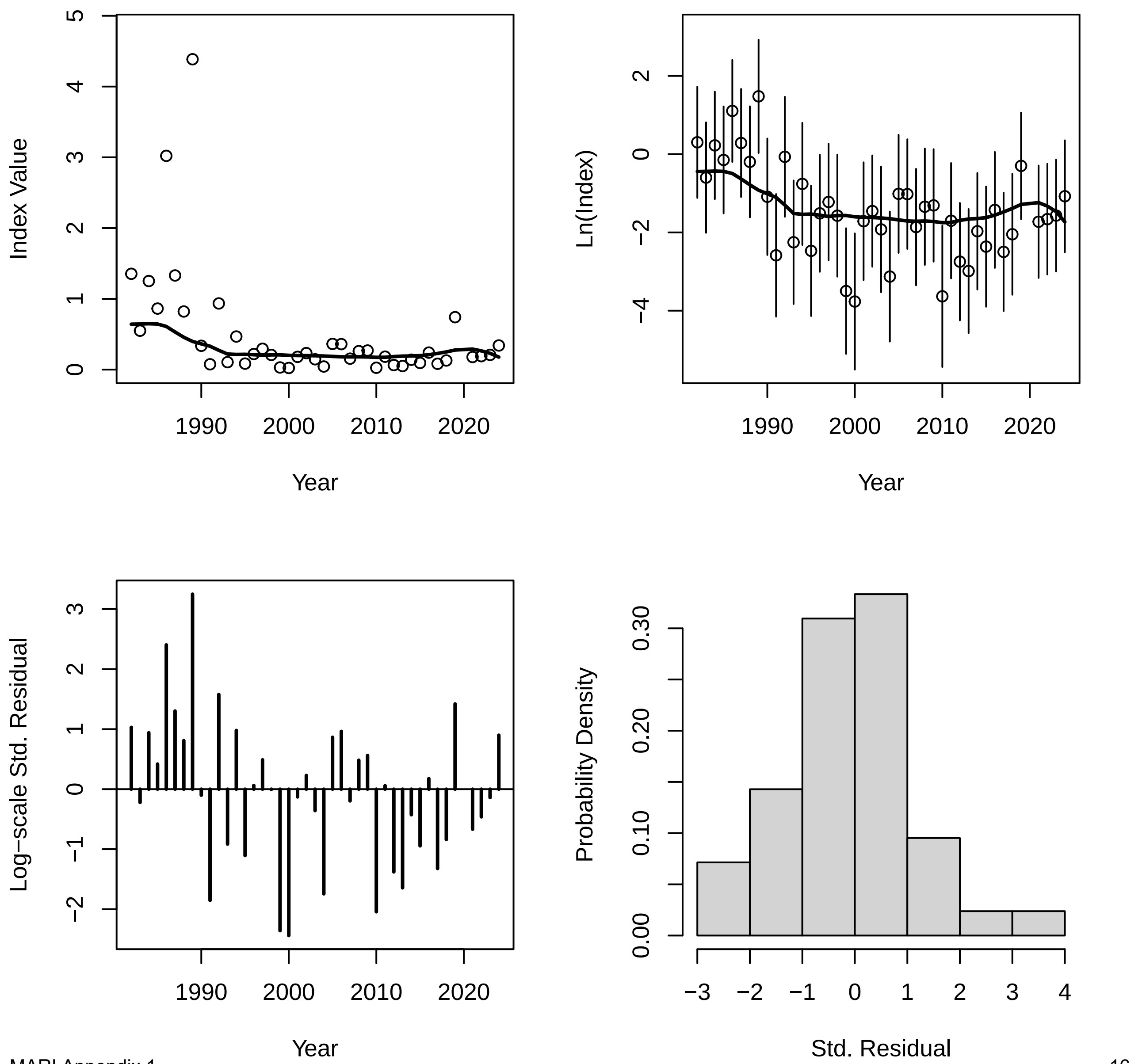

Catch Neff Fleet 1 (Rec + Comm)
Effective Sample Size
0
50
100
150
200
250
300
1990
2000
2010
2020
Year


Catch Fleet 1 (Rec + Comm)
Mean Age
Eff. Sample Size
Year
SDNR=1.44
RMSE=1.42
Std Resids
Year

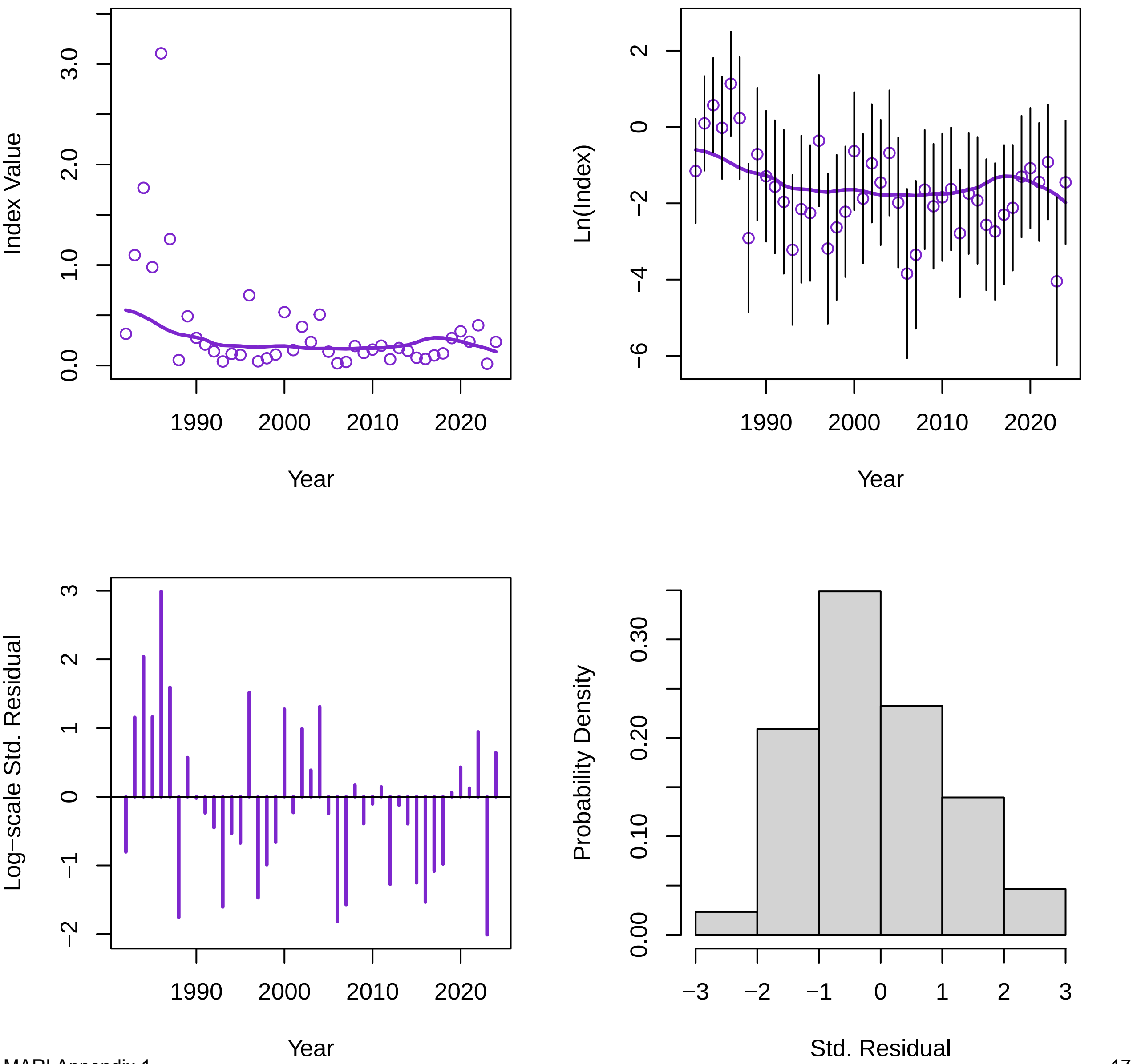
Catch Fleet 1 (Rec + Comm)



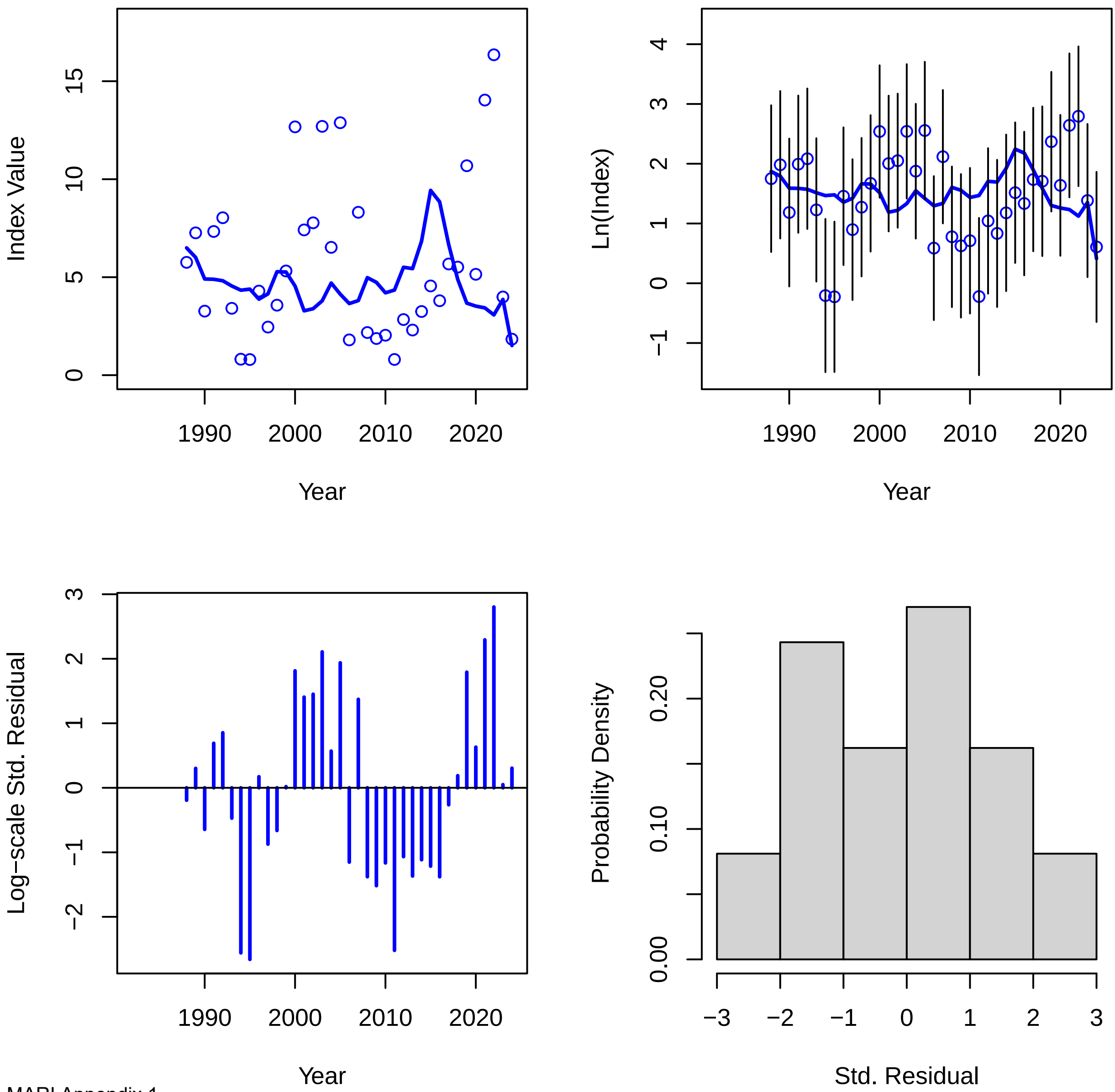
Index 1 (MA Trawl)



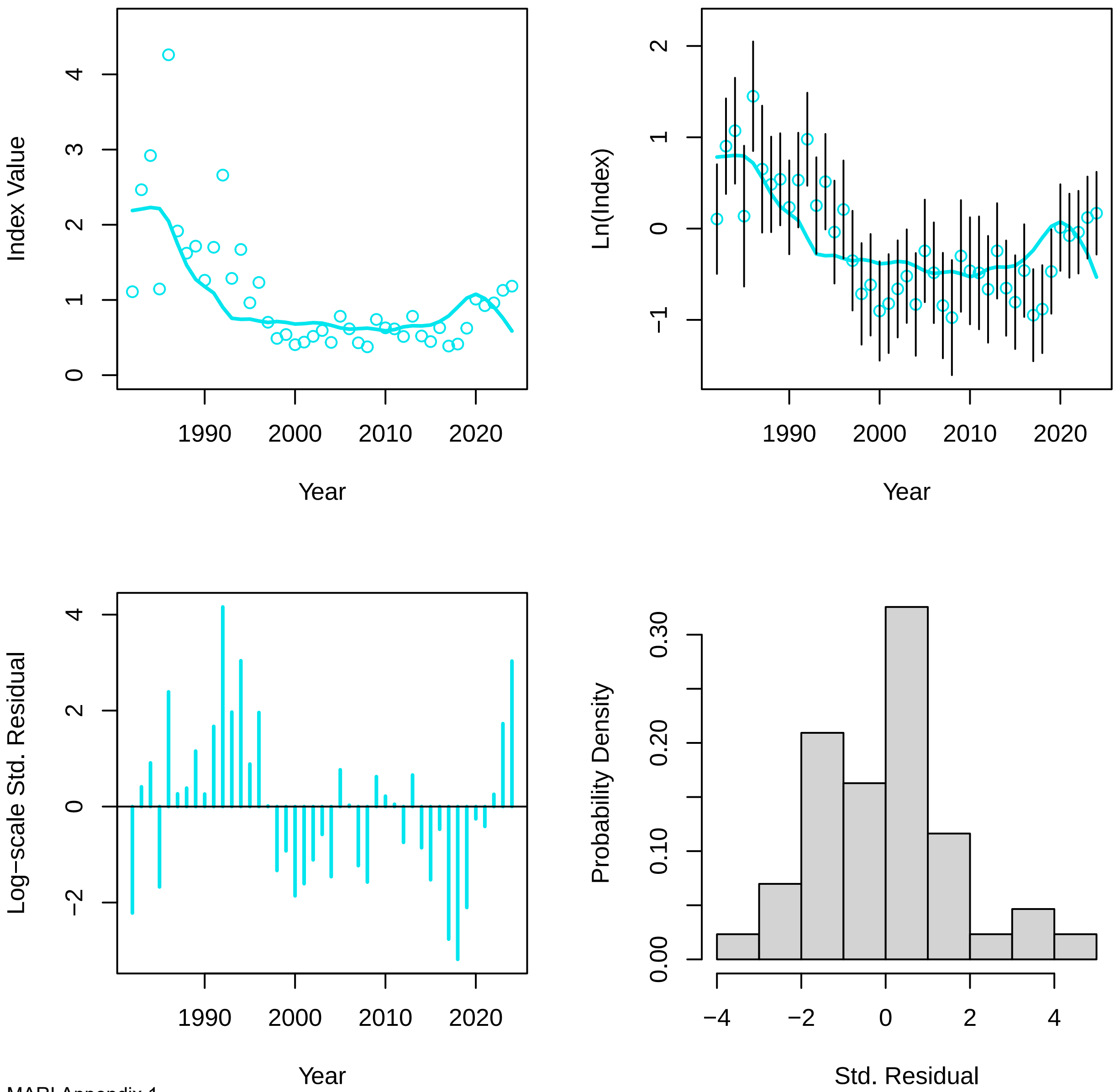
Index 2 (RI Fall Trawl)



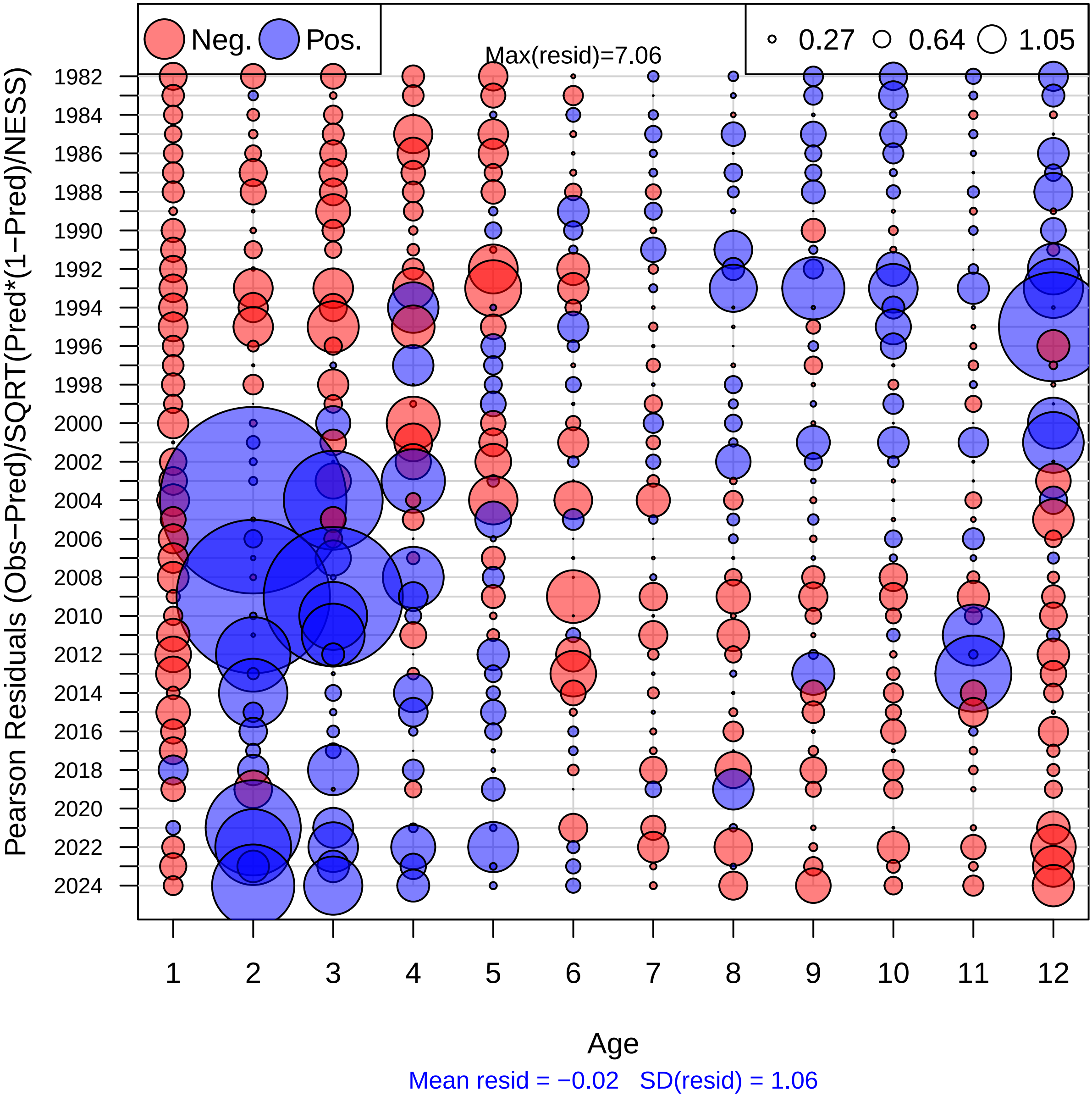
Index 3 (RI Seine)



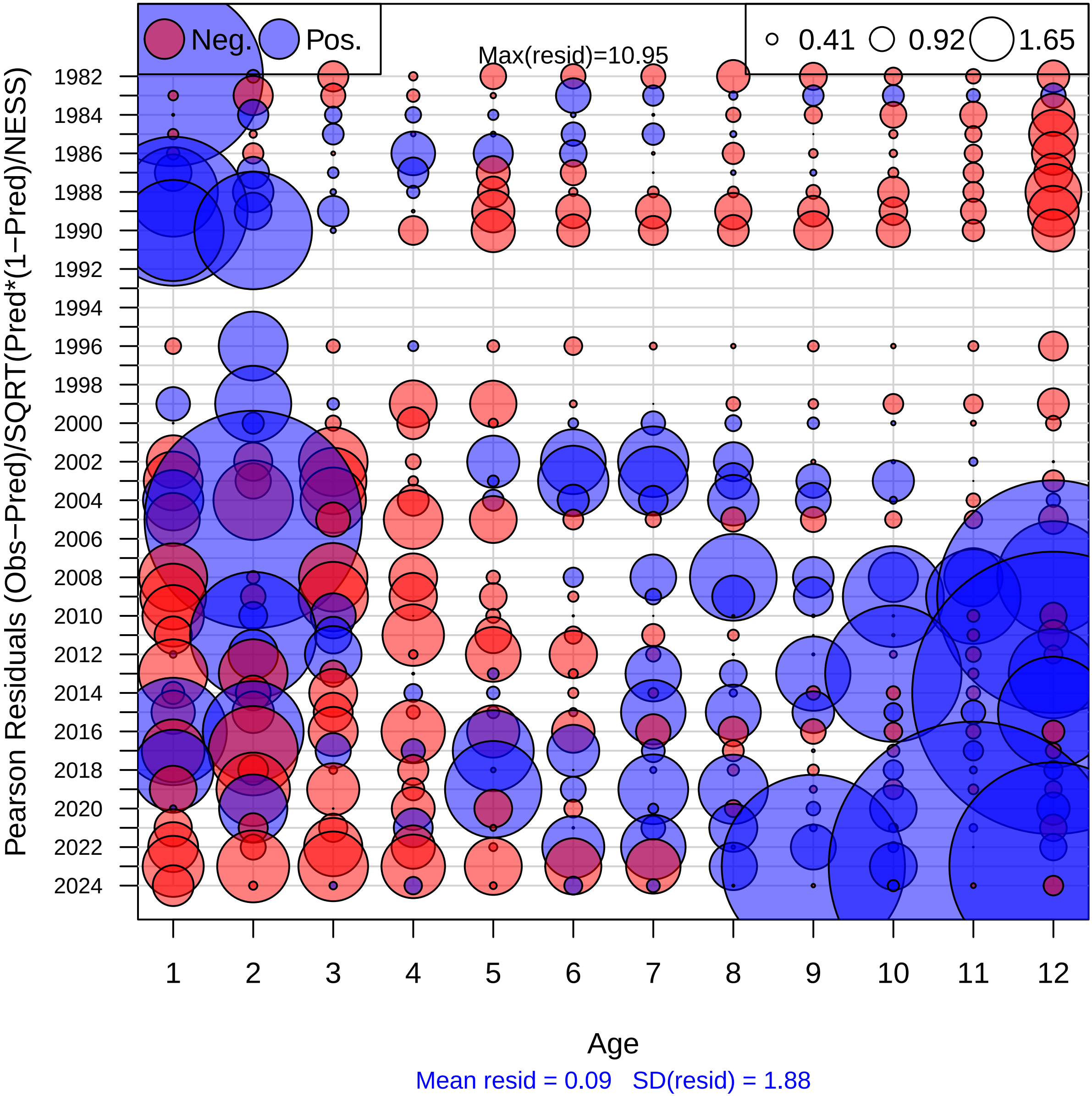
Index 4 (MRIP CPUE)

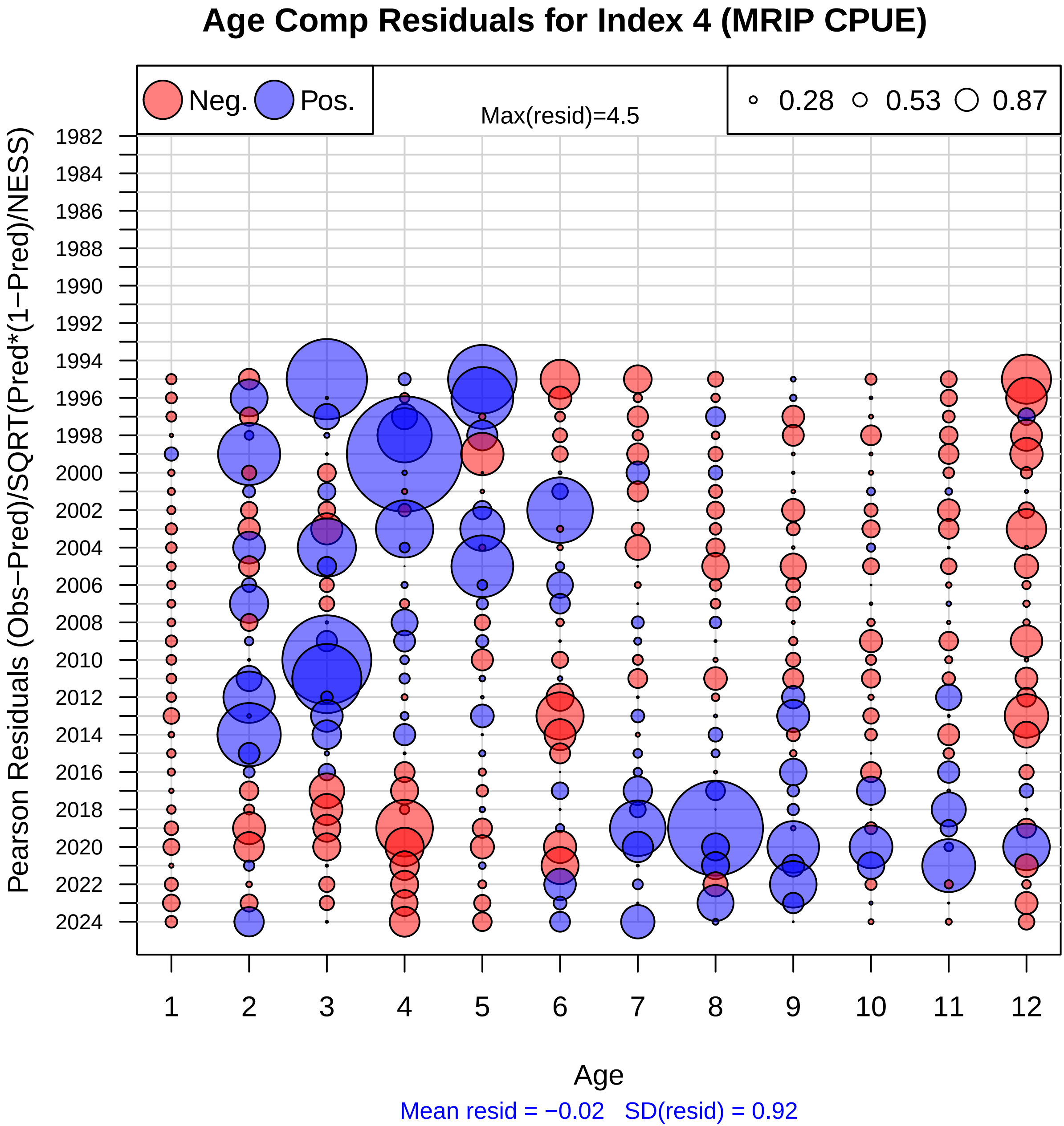


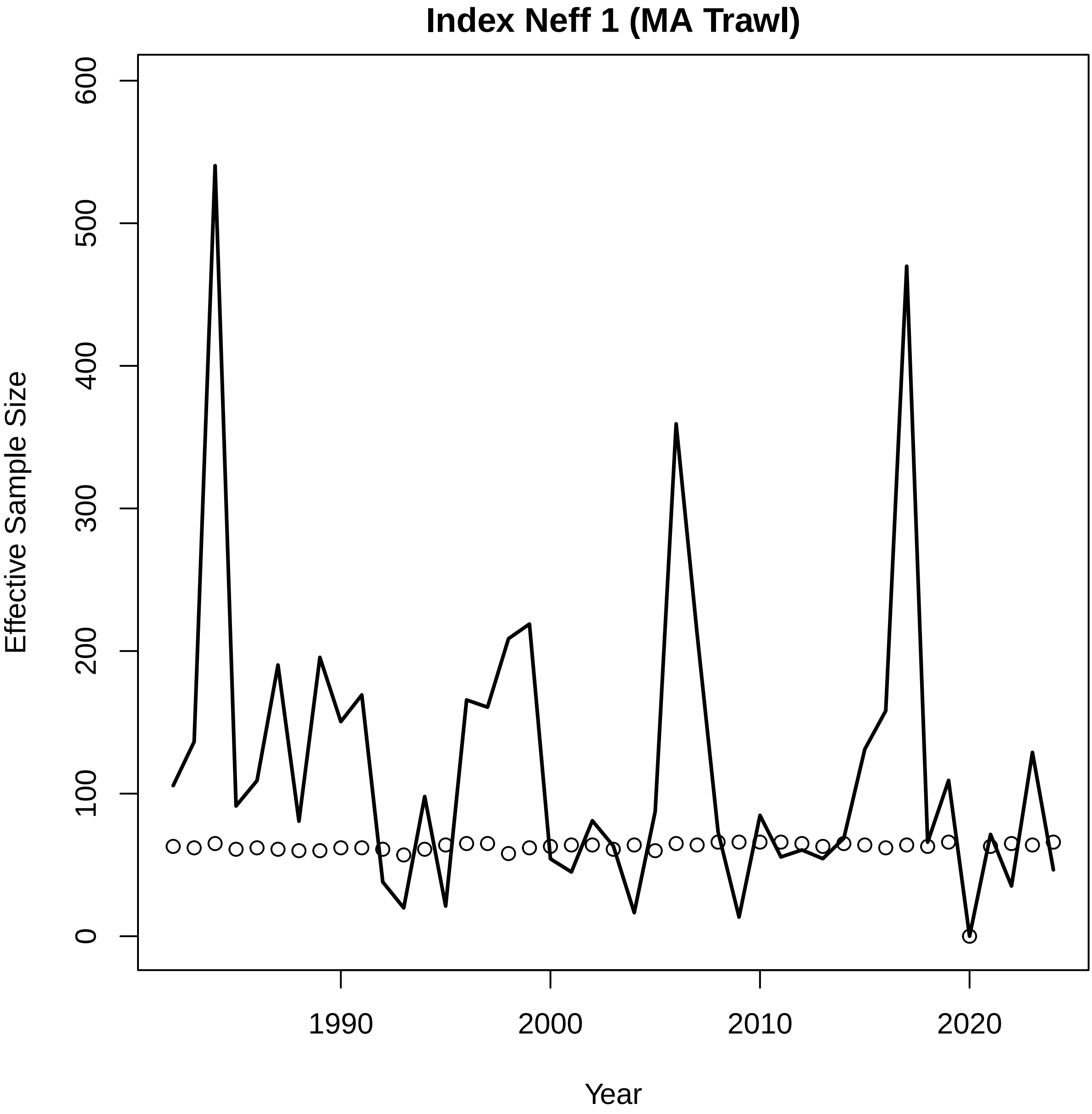
Age Comp Residuals for Index 1 (MA Trawl)

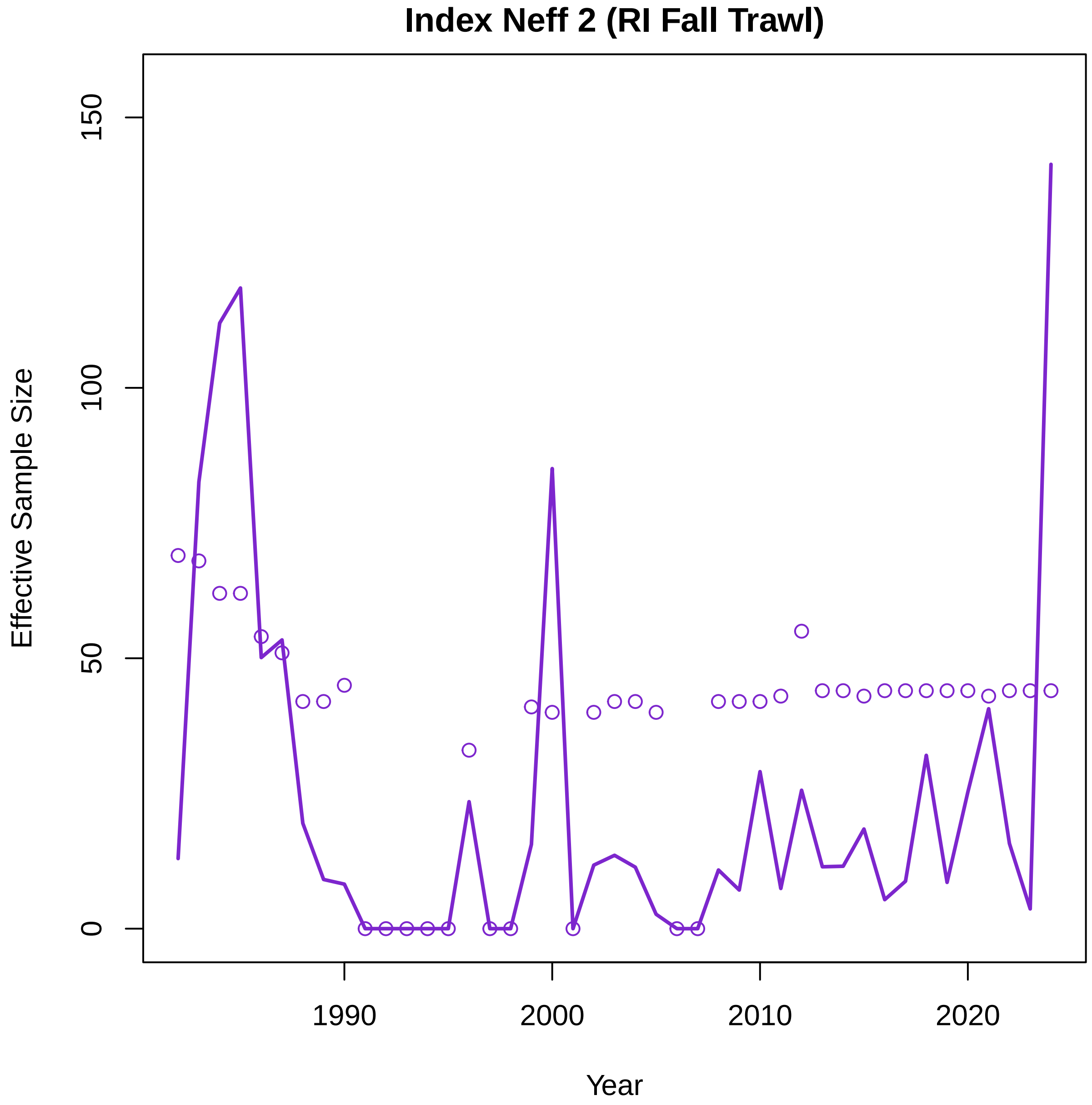


Age Comp Residuals for Index 2 (RI Fall Trawl)

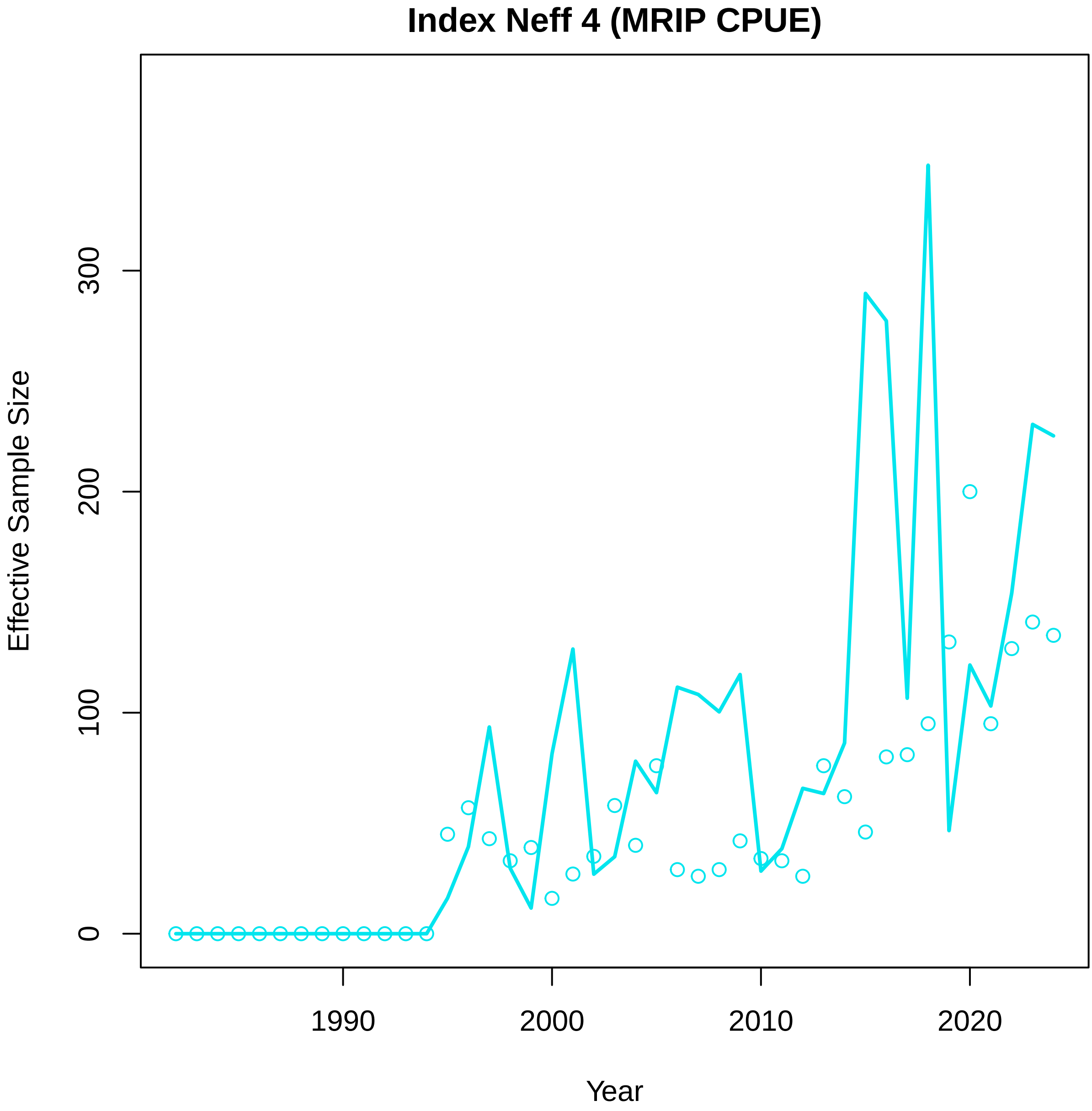


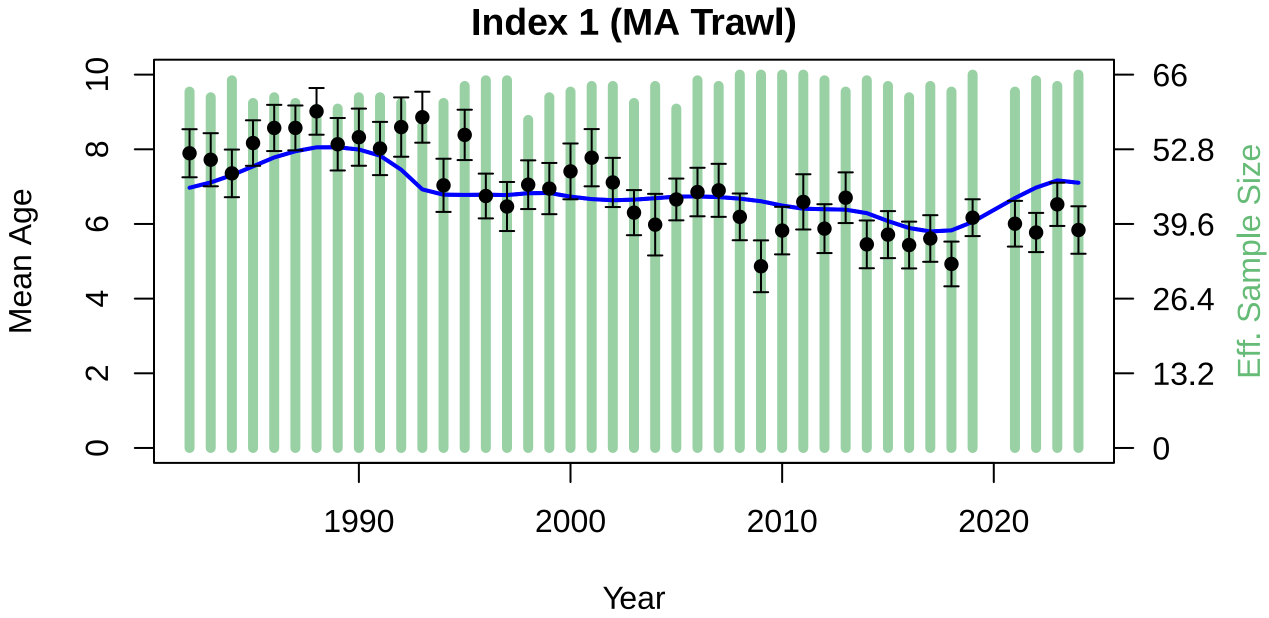

Age Comp Residuals for Index 4 (MRIP CPUE)
Neg.
Pos.
Max(resid)=4.5
0.28
0.53
0.87
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = −0.02 SD(resid) = 0.92

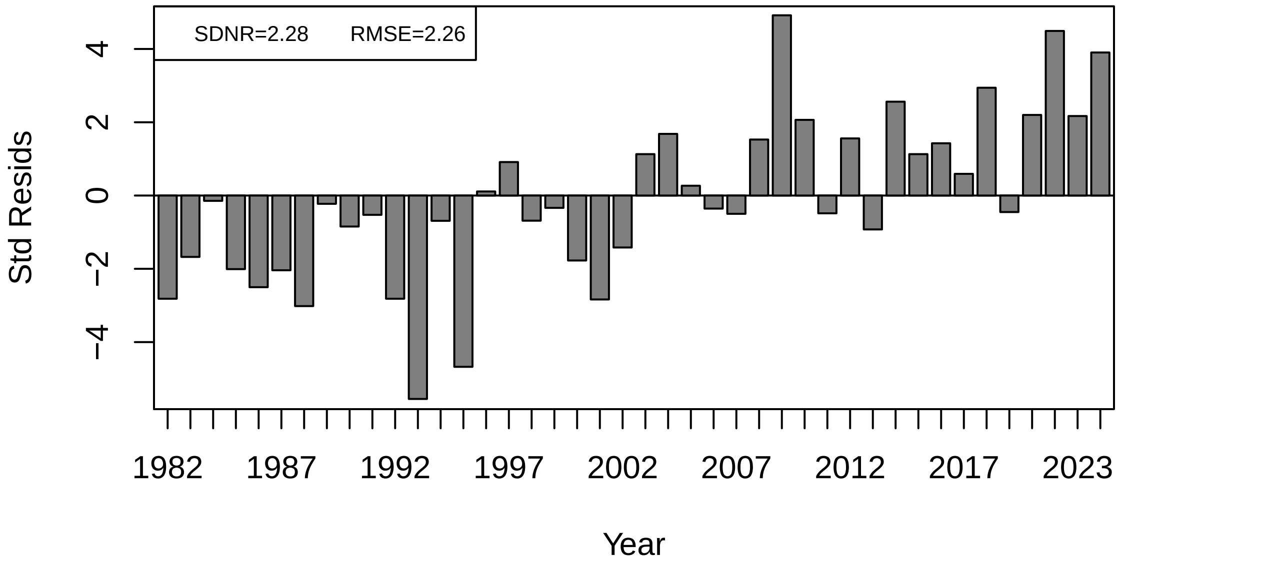

Index Neff 1 (MA Trawl)
Effective Sample Size
0
100
200
300
400
500
600
1990
2000
2010
2020
Year

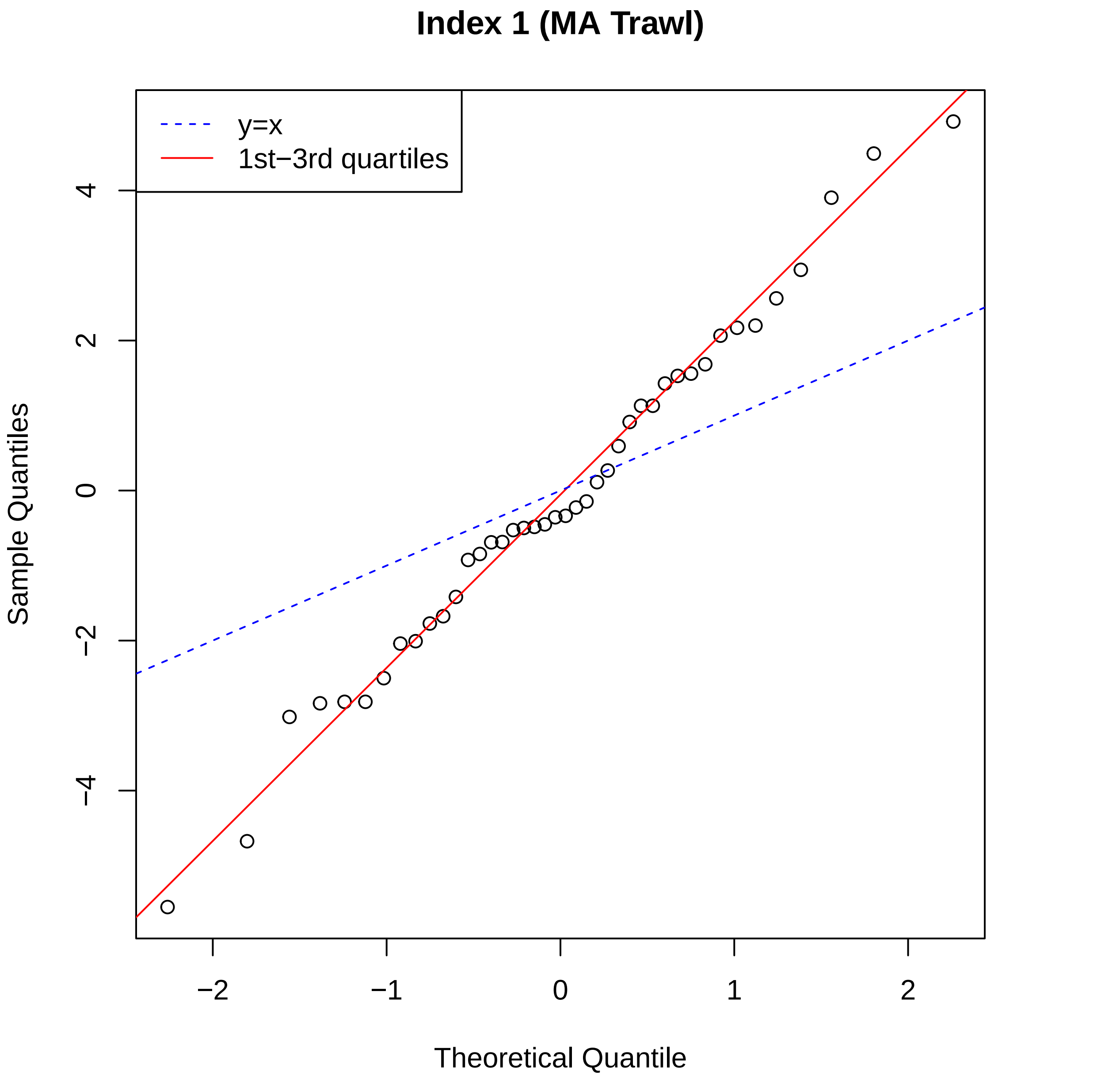


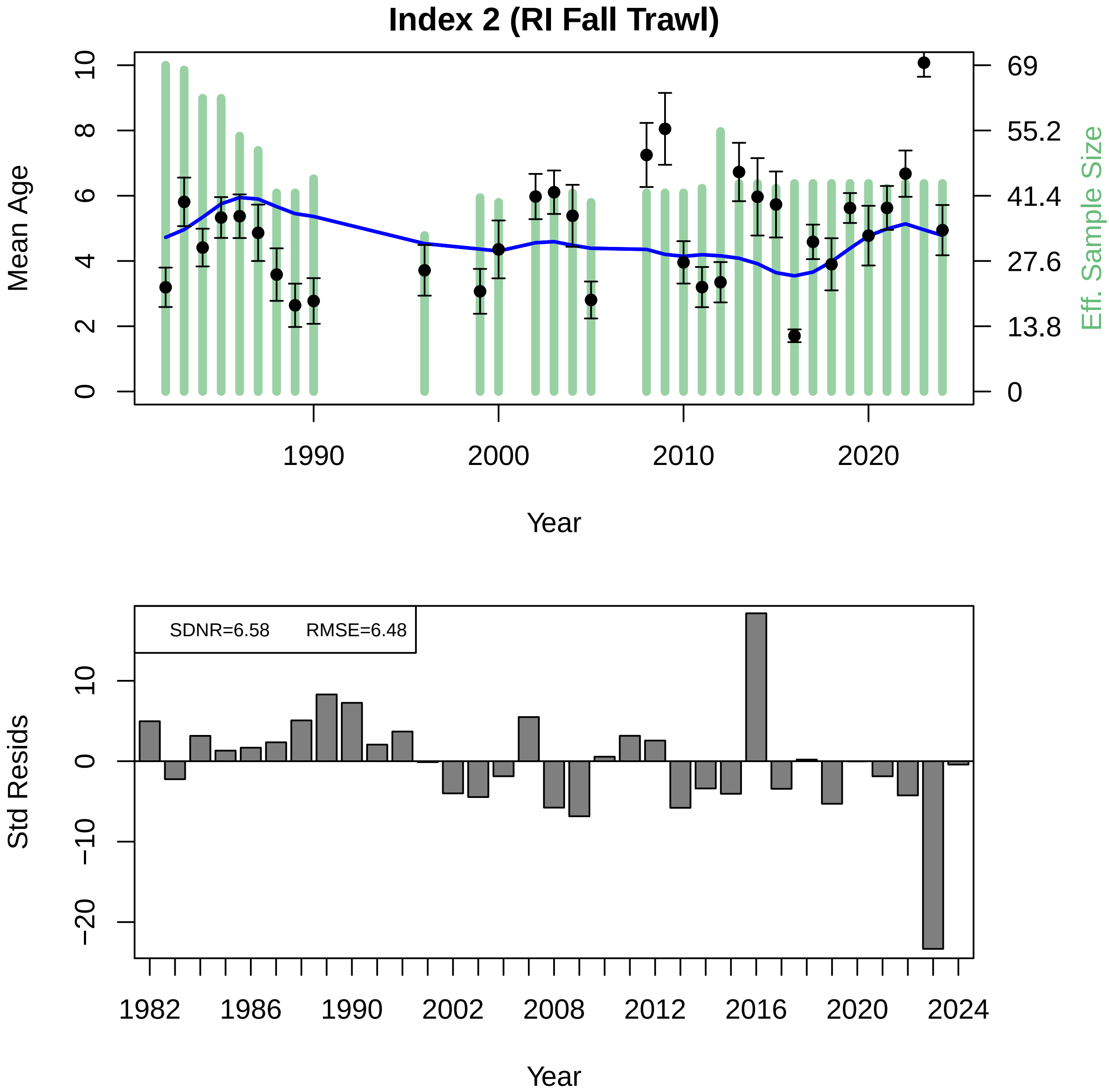
Index Neff 2 (RI Fall Trawl)
Effective Sample Size
0
50
100
150
1990
2000
2010
2020
Year

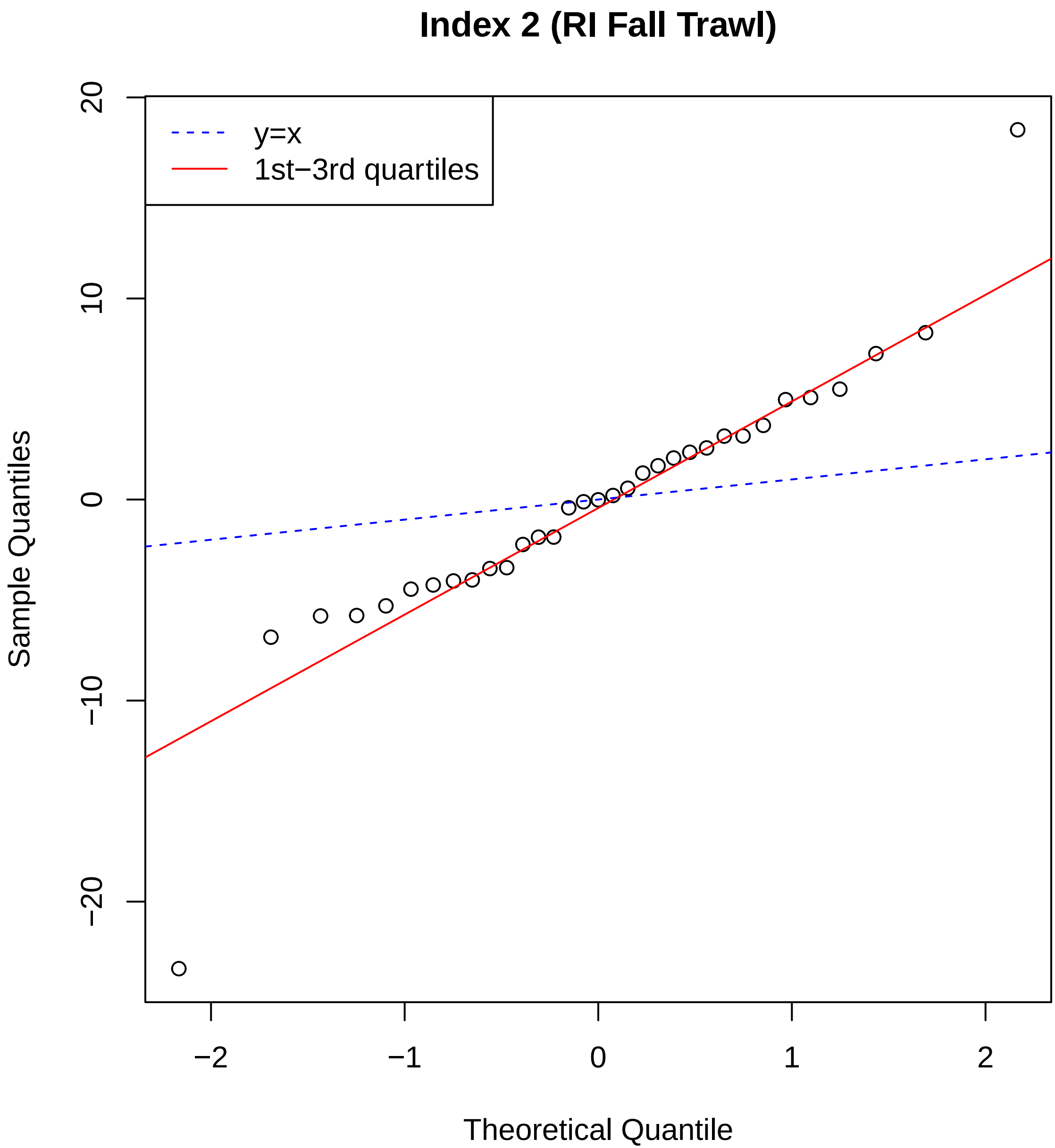

Index Neff 4 (MRIP CPUE)
Effective Sample Size
0
100
200
300
1990
2000
2010
2020
Year


Index 1 (MA Trawl)
Mean Age
Eff. Sample Size
0
2
4
6
8
10
0
13.2
26.4
39.6
52.8
66
1990
2000
2010
2020
Year

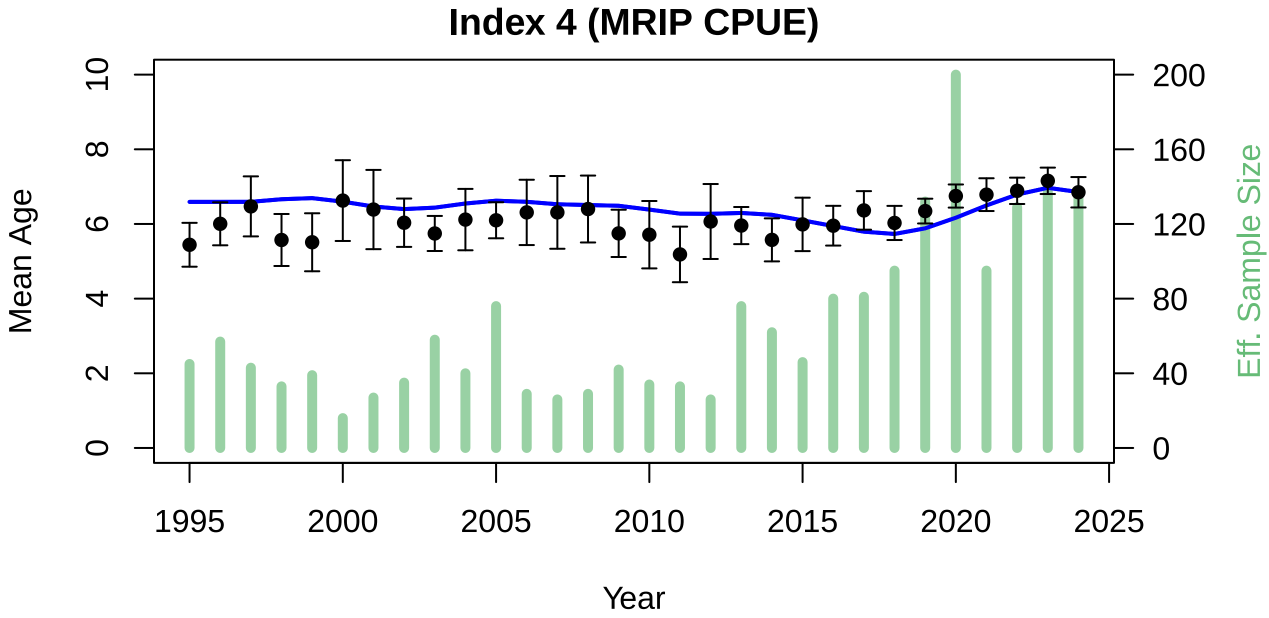

SDNR=2.28
RMSE=2.26
Std Resids
−4
−2
0
2
4
1982
1987
1992
1997
2002
2007
2012
2017
2023
Year


Index 1 (MA Trawl)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
4
2
0
−2
−4
−2
−1
0
1
2

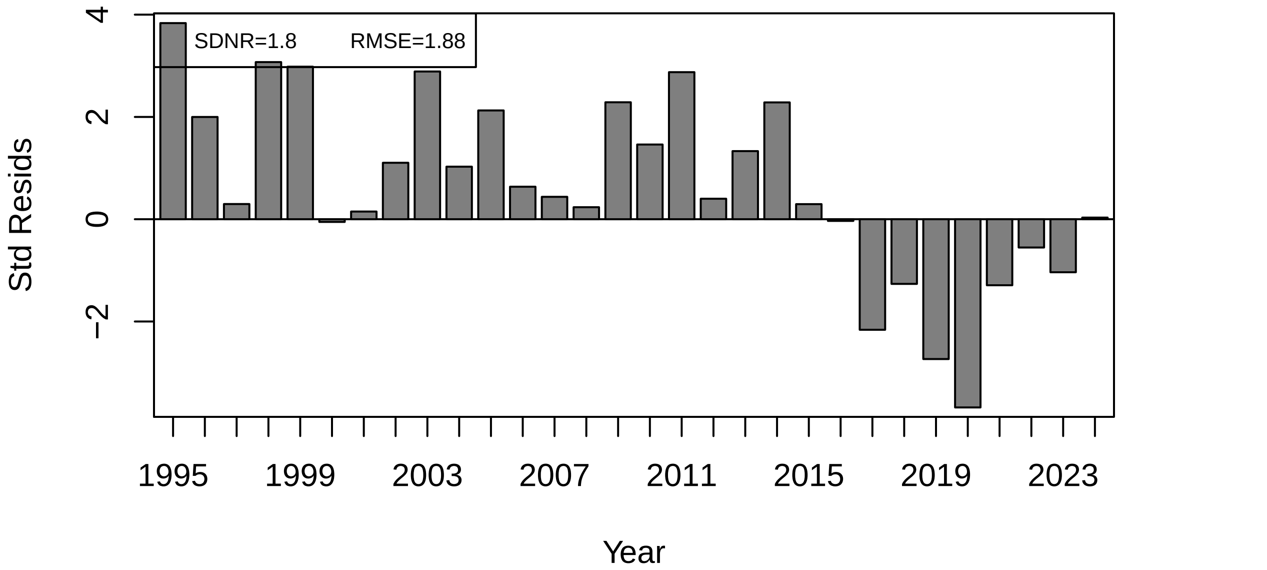

Index 2 (RI Fall Trawl)
Mean Age
Eff. Sample Size
0
2
4
6
8
10
0
13.8
27.6
41.4
55.2
69
1990
2000
2010
2020
Year
SDNR=6.58
RMSE=6.48
Std Resids
−20
−10
0
10
1982
1986
1990
2002
2008
2012
2016
2020
2024
Year



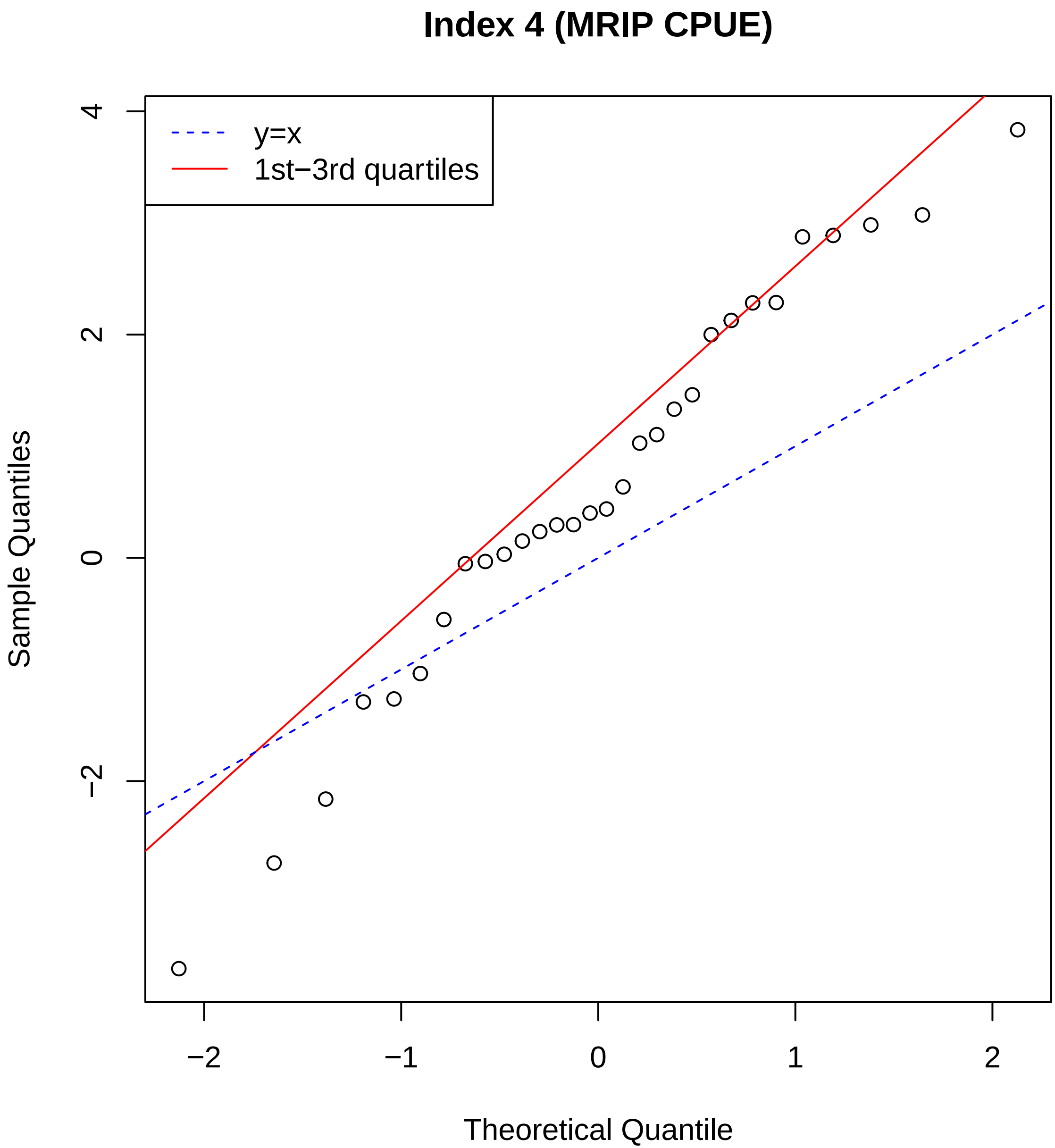
Index 2 (RI Fall Trawl)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
20
10
0
−10
−20
−2
−1
0
1
2

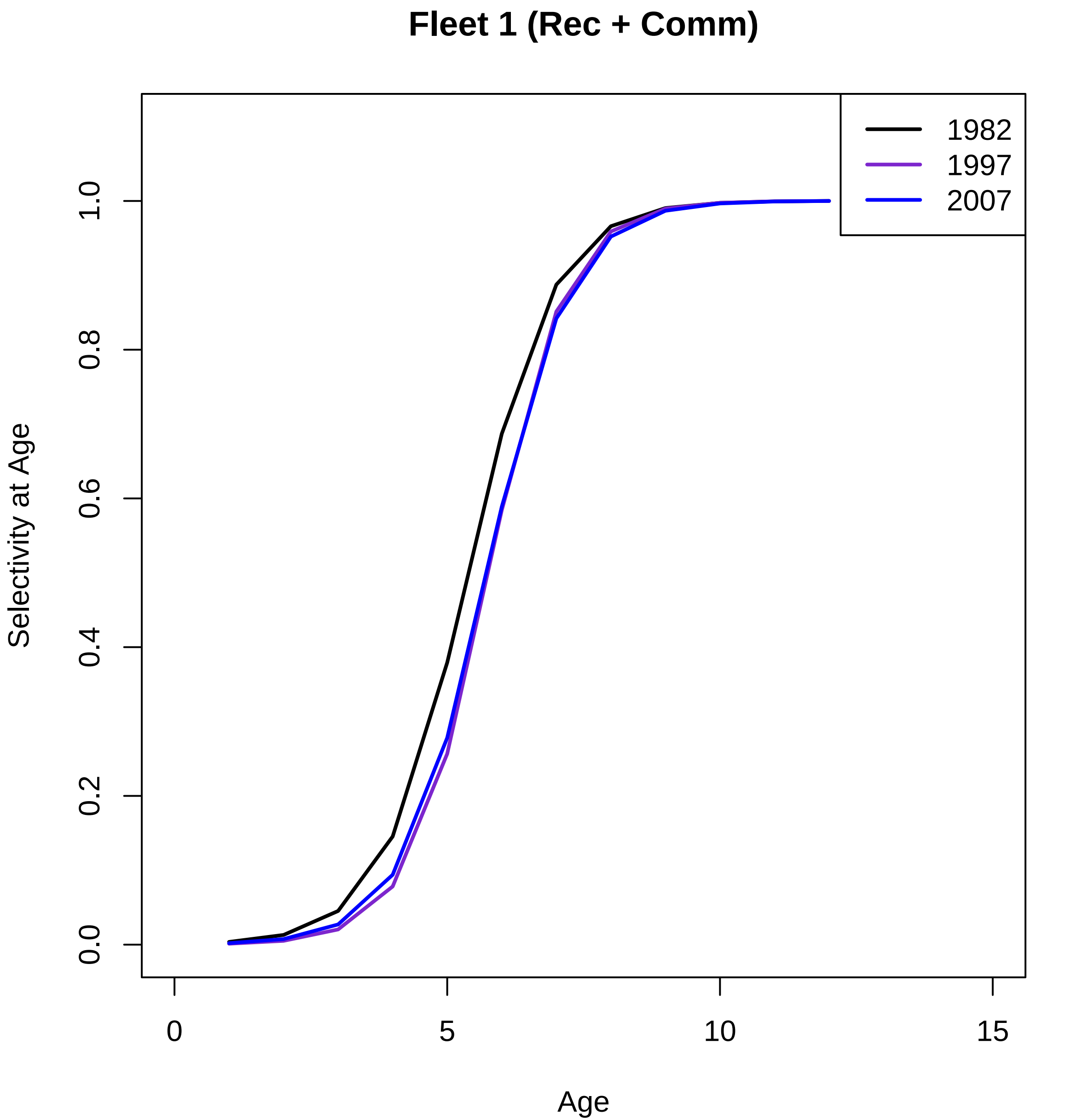


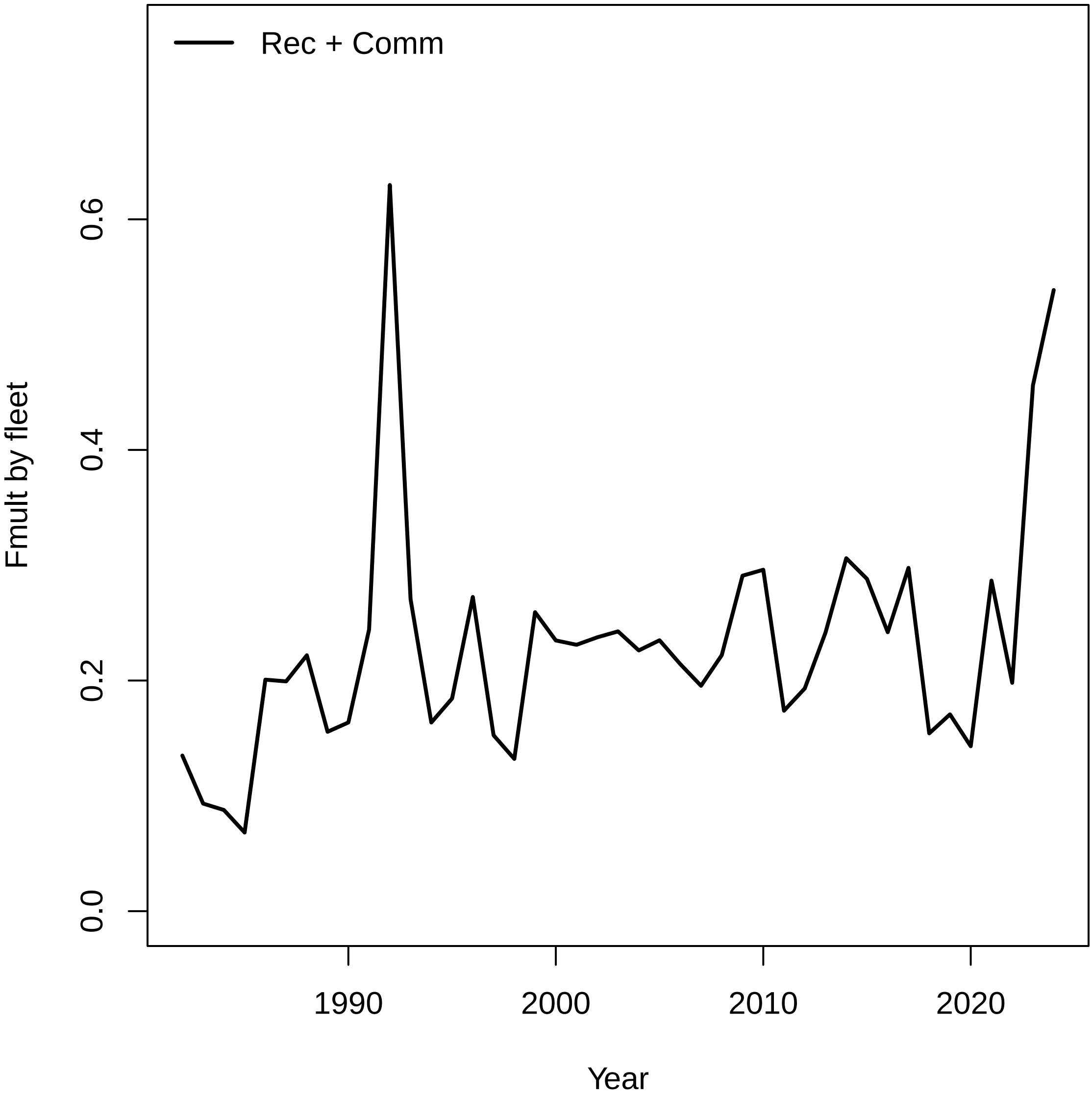
Index 4 (MRIP CPUE)
Mean Age
Eff. Sample Size
Year
0
2
4
6
8
10
0
40
80
120
160
200
1995
2000
2005
2010
2015
2020
2025



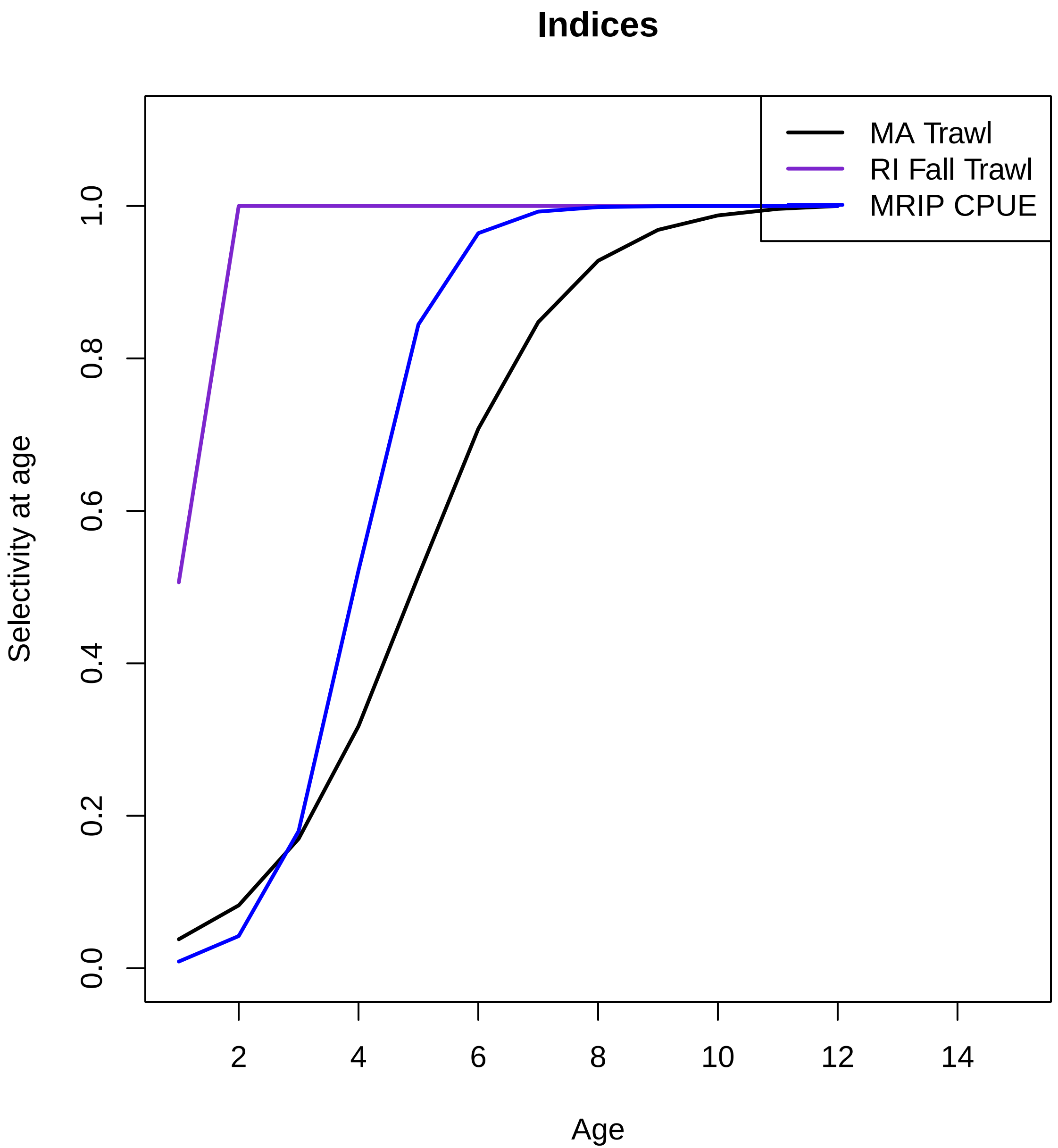
SDNR=1.8
RMSE=1.88
Std Resids
Year
−2
0
2
4
1995
1999
2003
2007
2011
2015
2019
2023

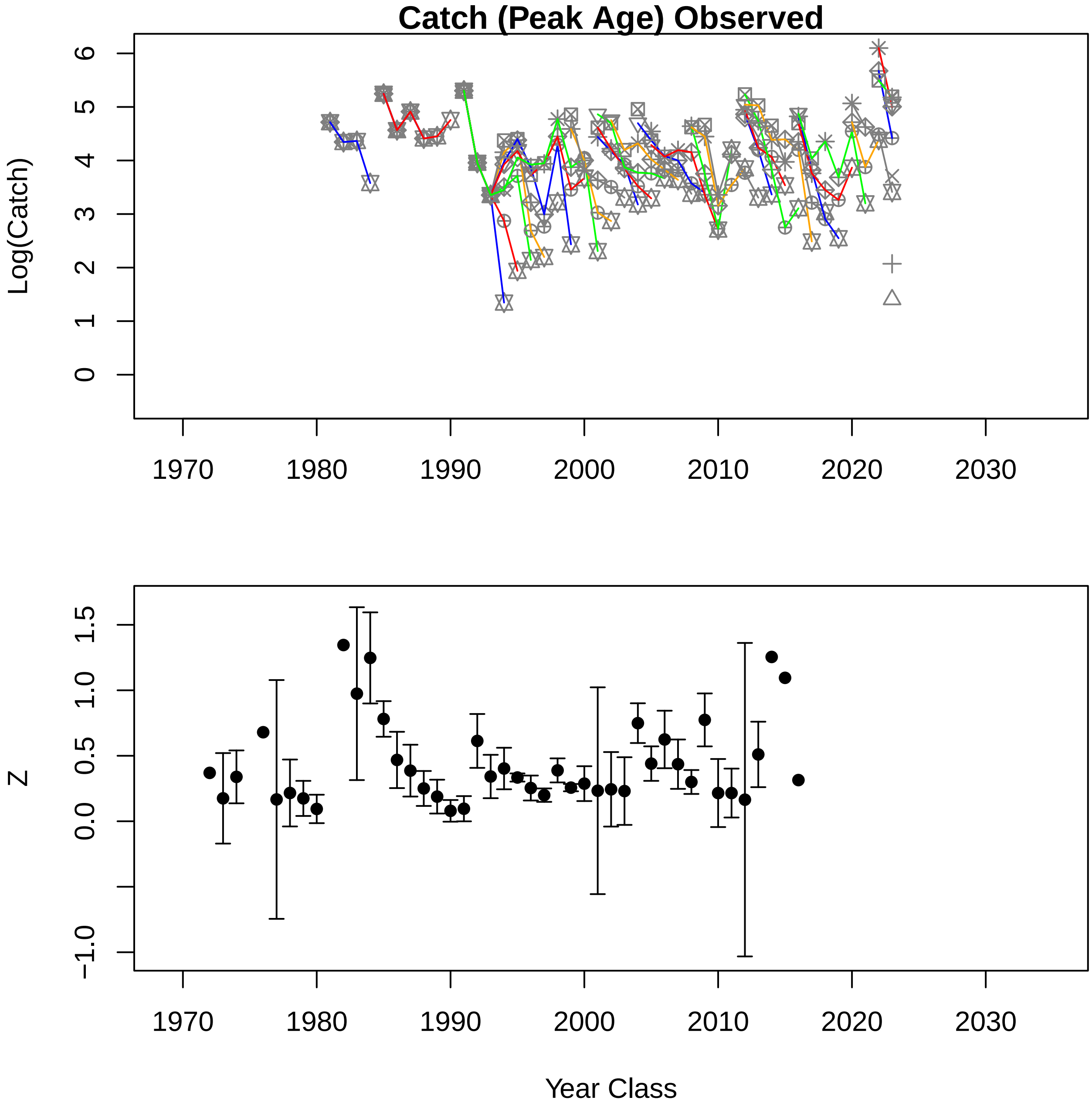

Index 4 (MRIP CPUE)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
4
2
0
−2
−2
−1
0
1
2


Fleet 1 (Rec + Comm)
1982
1997
2007
0.0
0.2
0.4
0.6
0.8
1.0
Selectivity at Age
0
5
10
15
Age

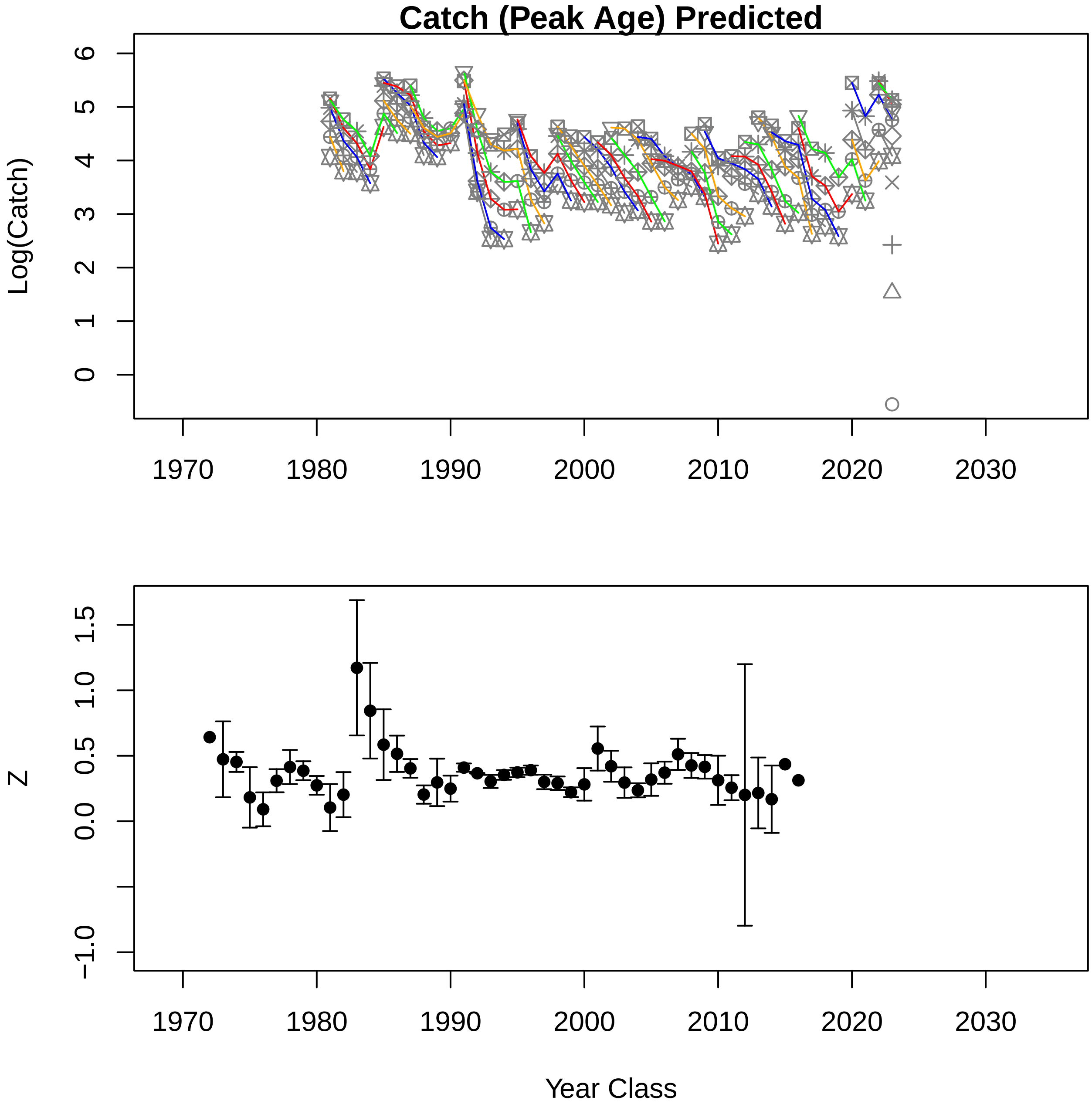


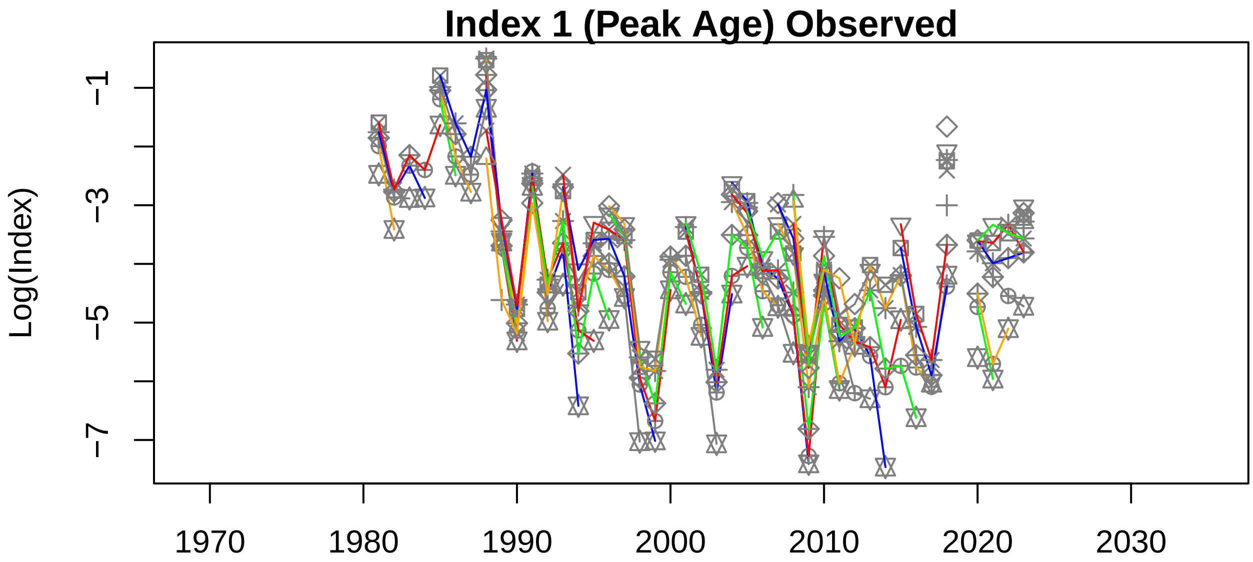
Rec + Comm
Fmult by fleet
0.0
0.2
0.4
0.6
1990
2000
2010
2020
Year


Indices
MA Trawl
RI Fall Trawl
MRIP CPUE
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
14
Age

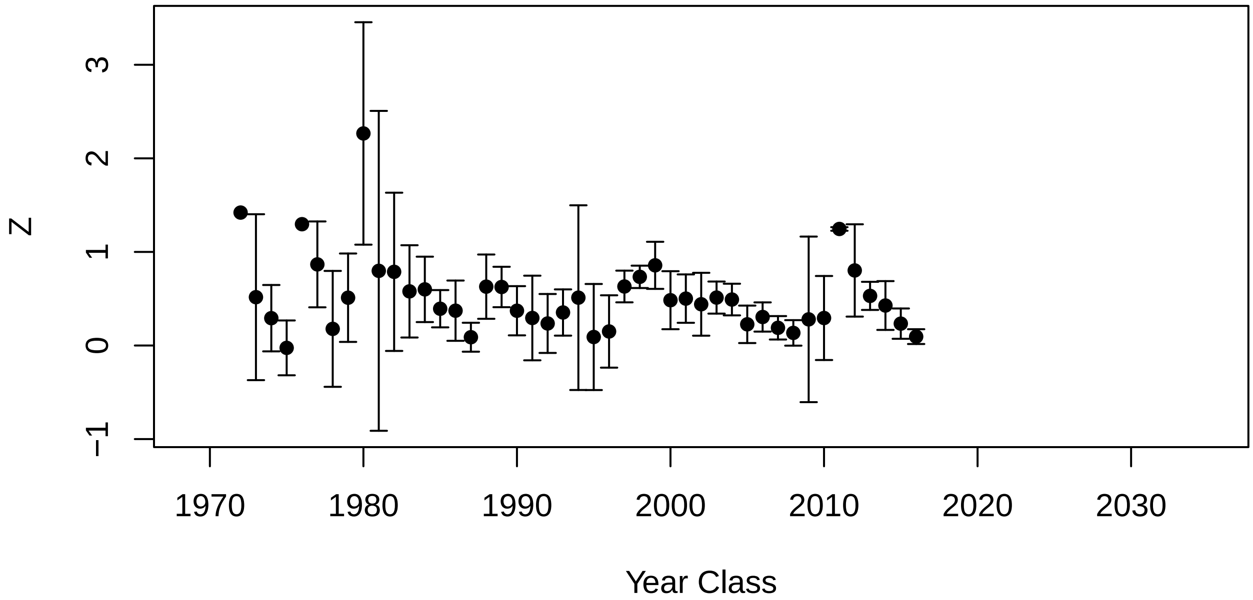


Catch (Peak Age) Observed
Log(Catch)
0
1
2
3
4
5
6
1970
1980
1990
2000
2010
2020
2030
Z
−1.0
0.0
0.5
1.0
1.5
1970
1980
1990
2000
2010
2020
2030
Year Class


Catch (Peak Age) Predicted
Log(Catch)
Z
Year Class

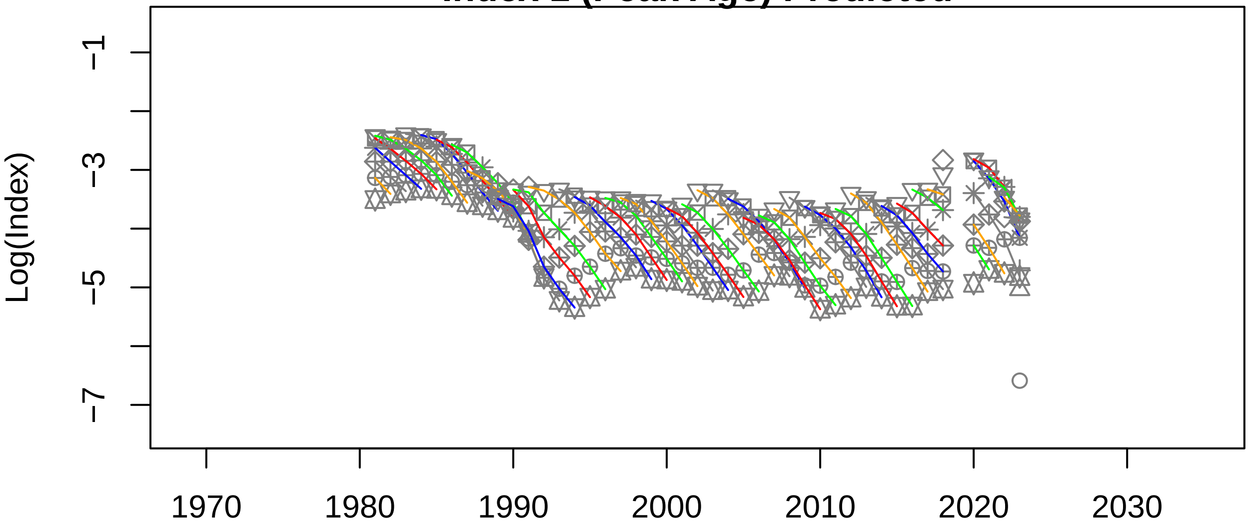


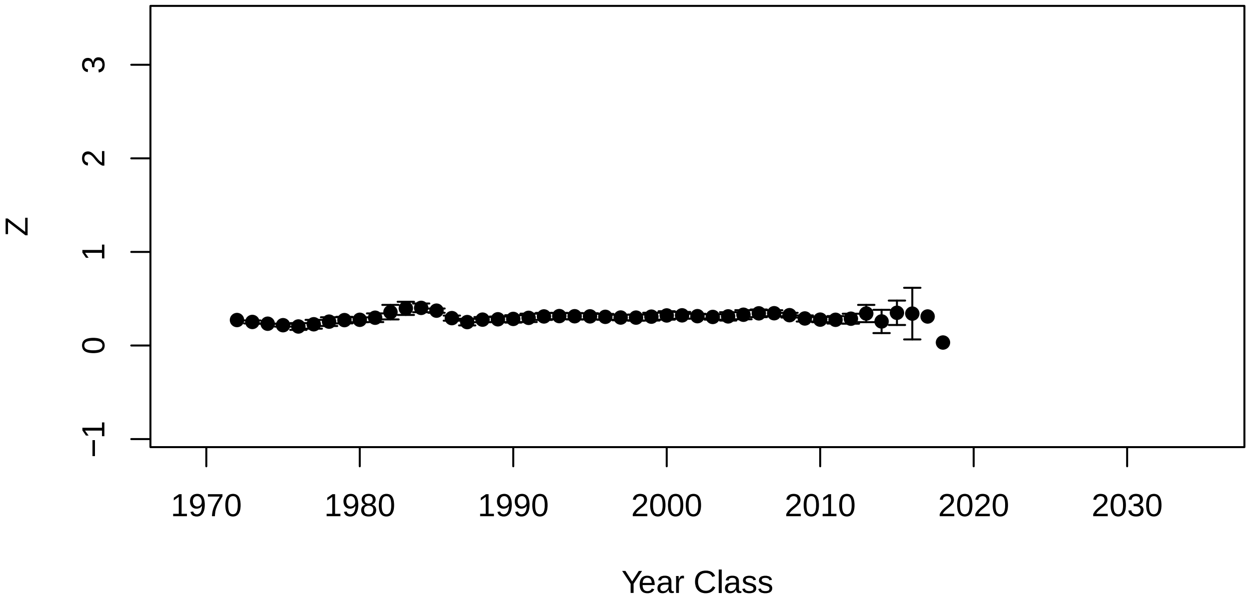
Index 1 (Peak Age) Observed
Log(Index)
−1
−3
−5
−7
1970
1980
1990
2000
2010
2020
2030

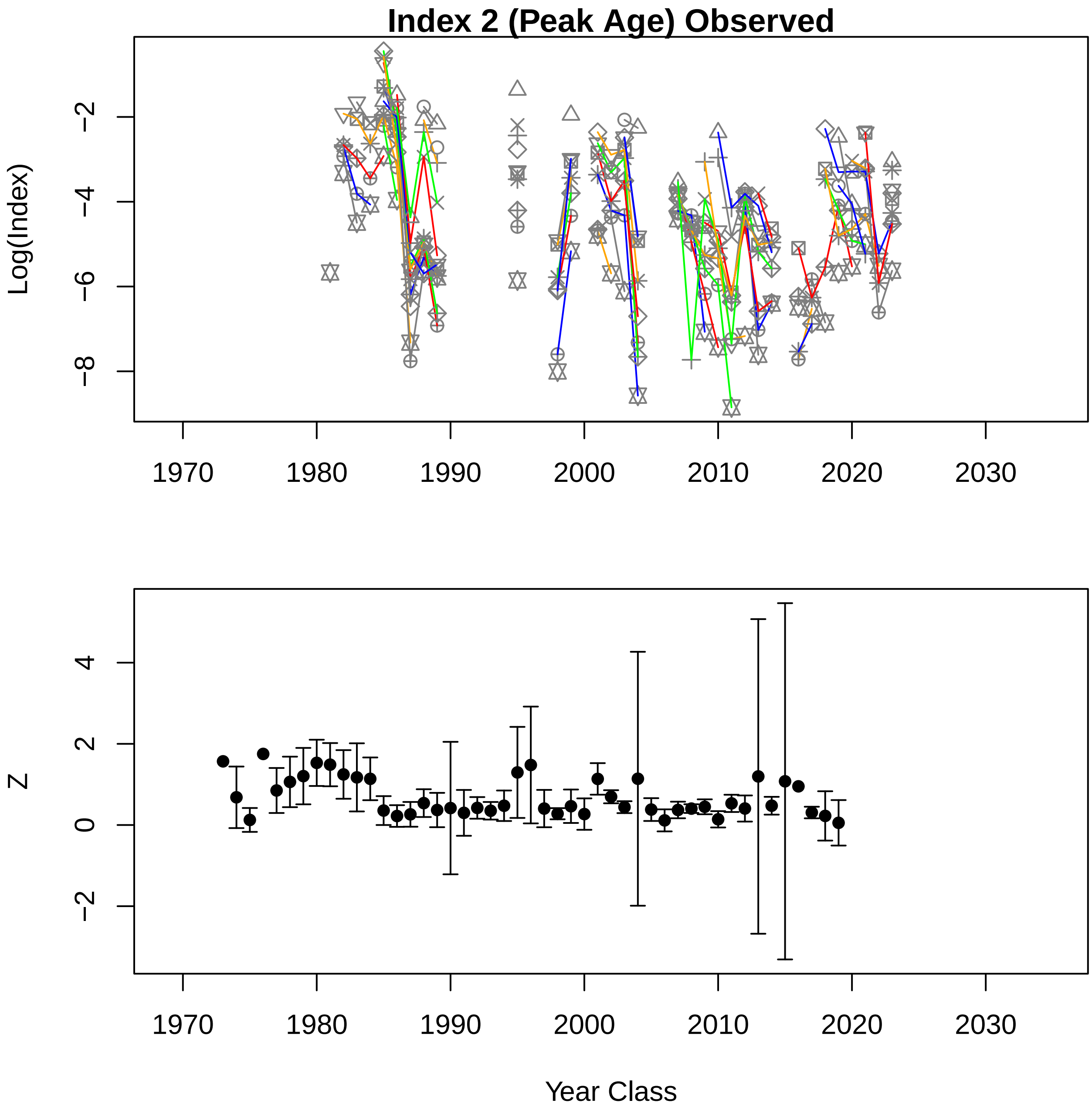


Z
3
2
1
0
−1
1970
1980
1990
2000
2010
2020
2030
Year Class

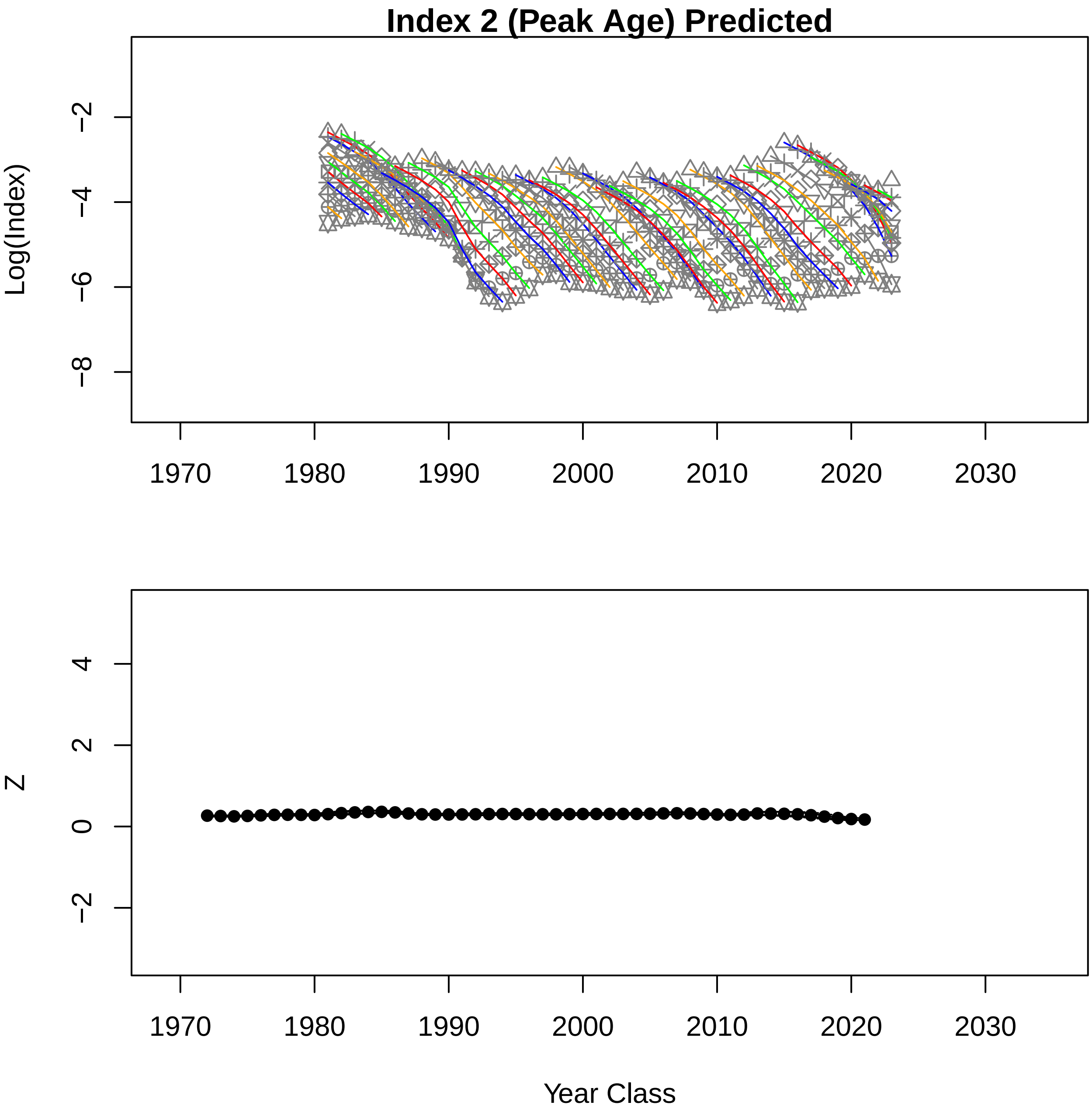
Index 1 (Peak Age) Predicted

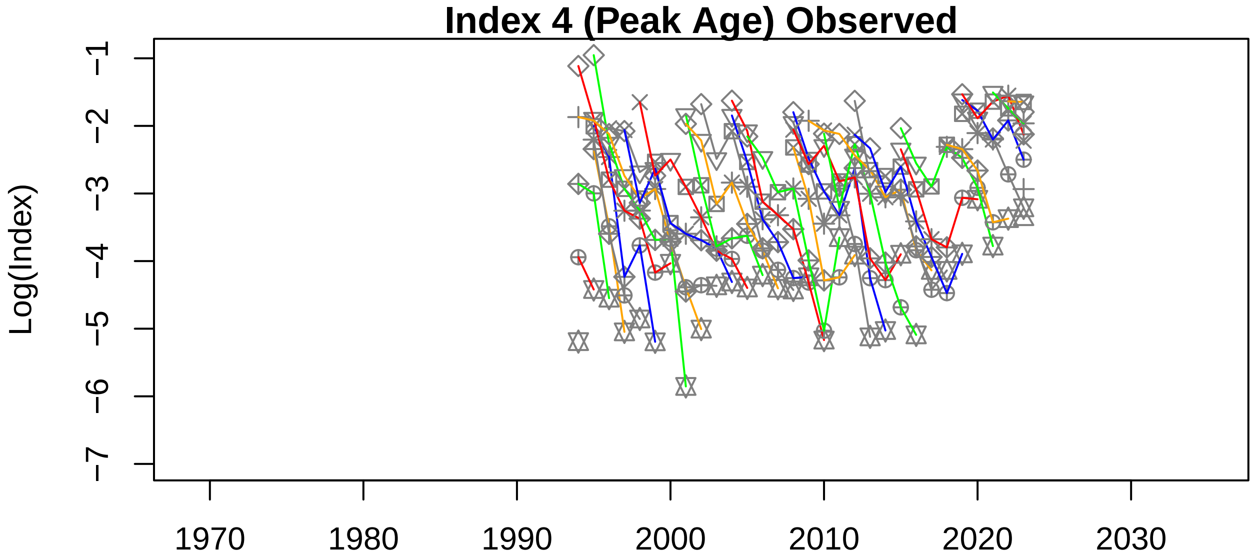


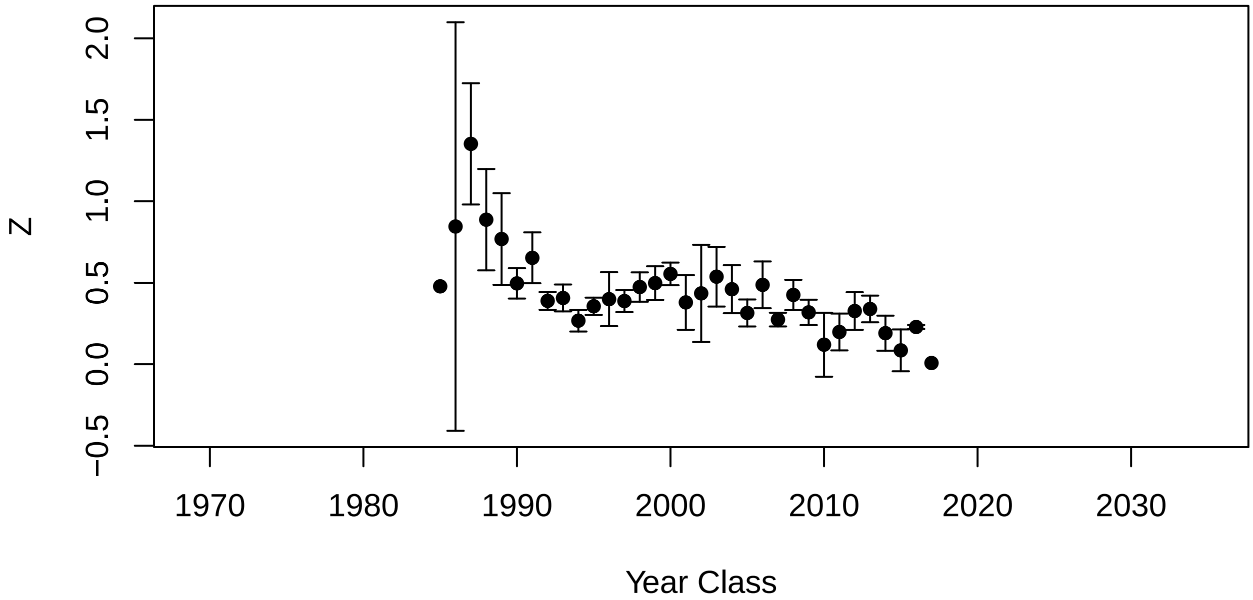


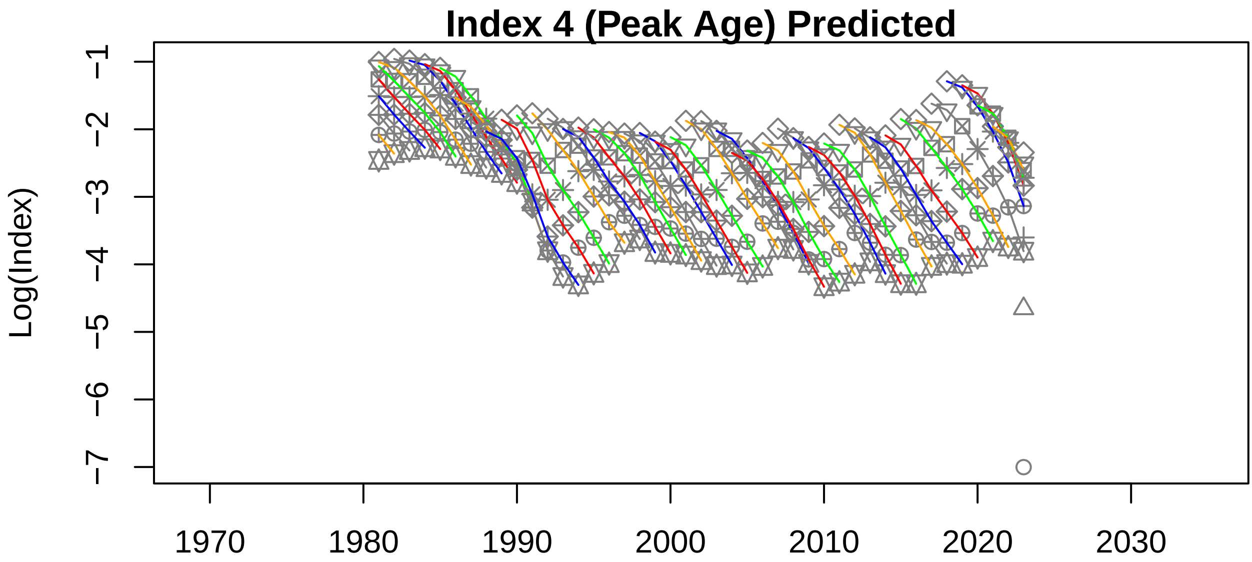


Index 2 (Peak Age) Observed
Log(Index)
−2
−4
−6
−8
1970
1980
1990
2000
2010
2020
2030
Z
4
2
0
−2
1970
1980
1990
2000
2010
2020
2030
Year Class

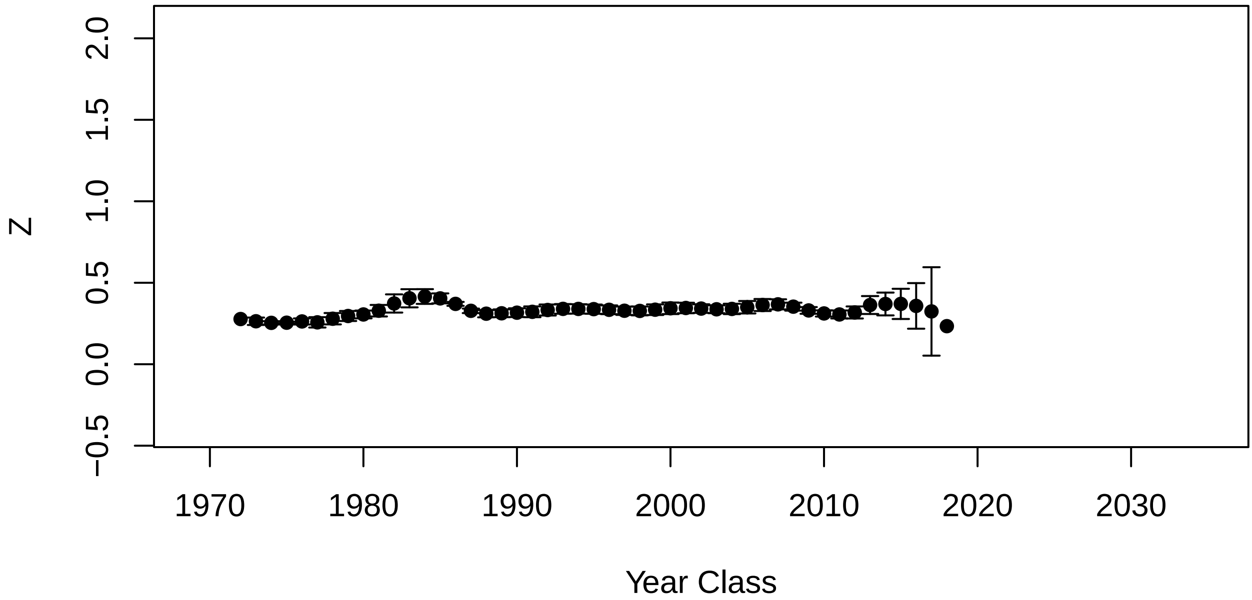

Index 2 (Peak Age) Predicted
Log(Index)
−2
−4
−6
−8
1970
1980
1990
2000
2010
2020
2030
Z
4
2
0
−2
1970
1980
1990
2000
2010
2020
2030
Year Class


Index 4 (Peak Age) Observed
Log(Index)
−1
−2
−3
−4
−5
−6
−7
1970
1980
1990
2000
2010
2020
2030

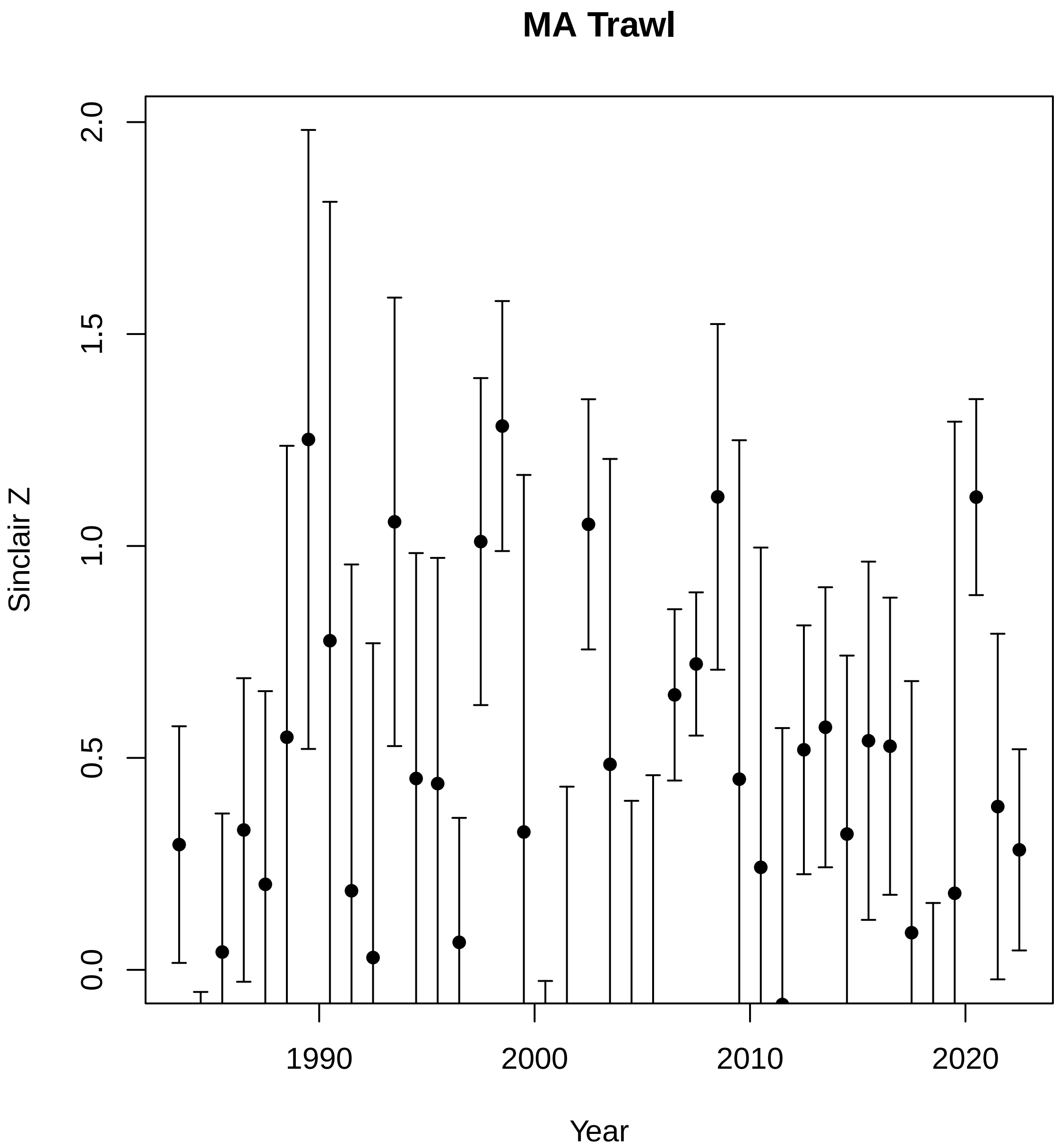

Z
2.0
1.5
1.0
0.5
0.0
−0.5
1970
1980
1990
2000
2010
2020
2030
Year Class

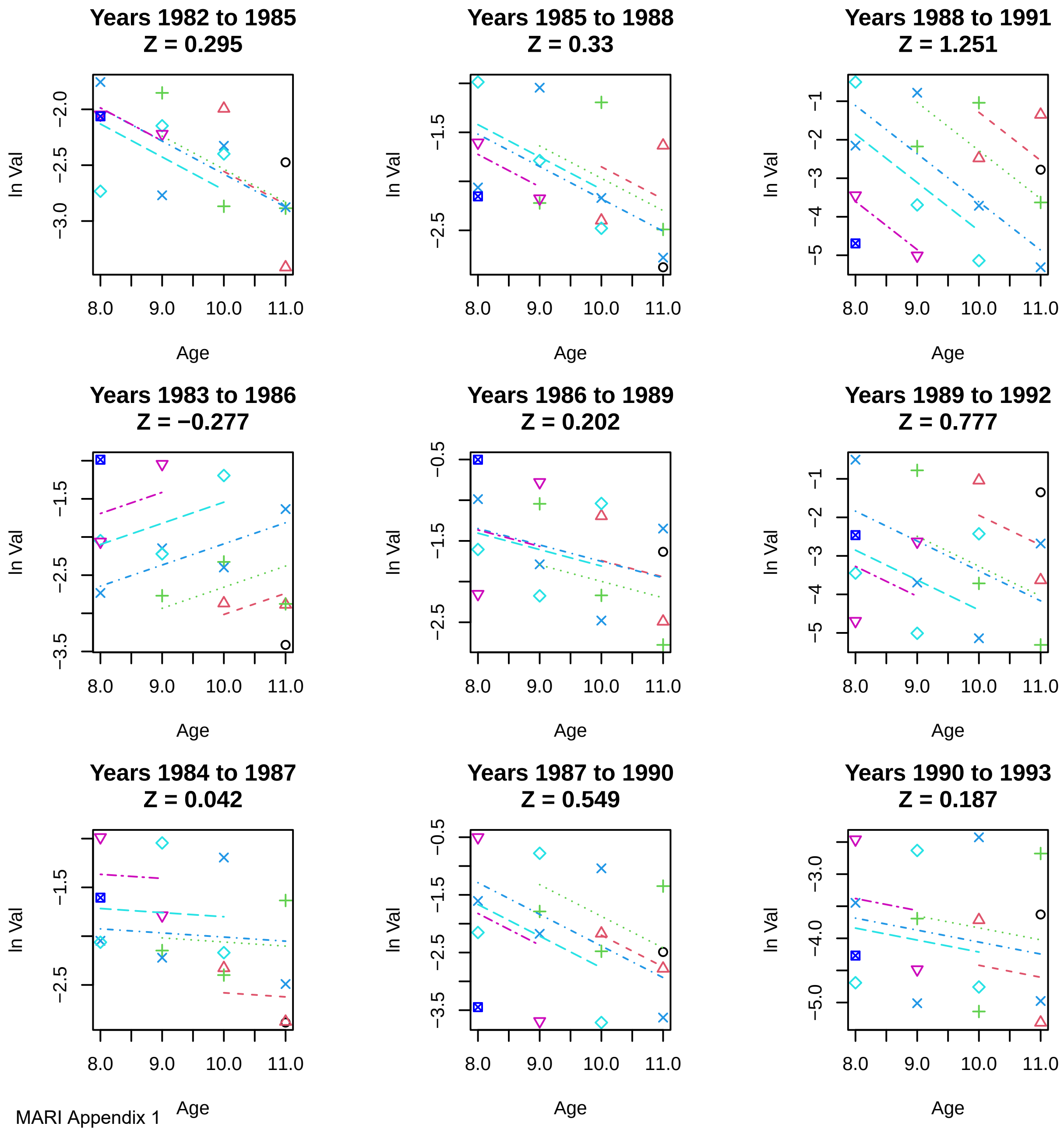


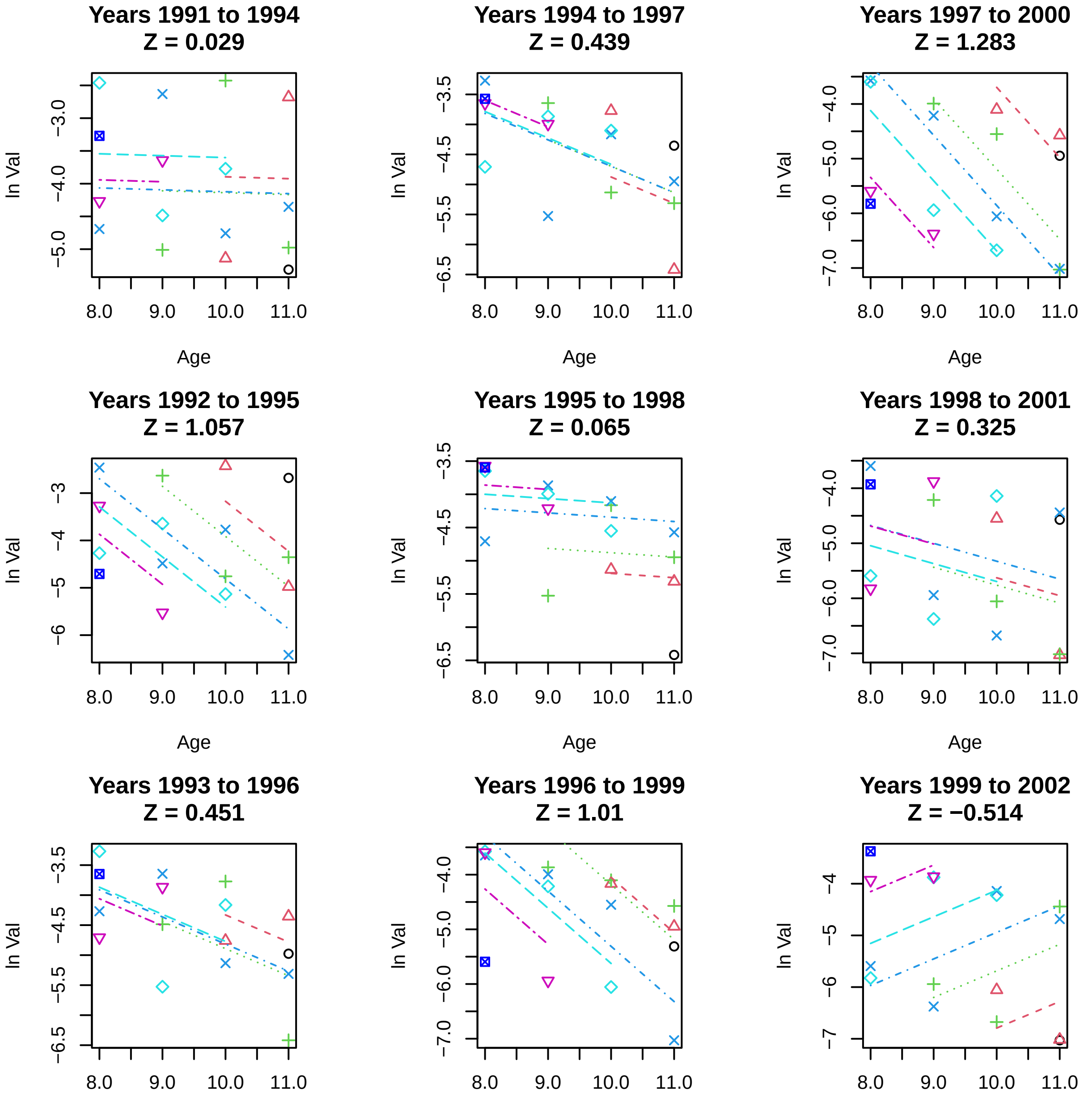
Index 4 (Peak Age) Predicted
Log(Index)
−1
−2
−3
−4
−5
−6
−7
1970
1980
1990
2000
2010
2020
2030

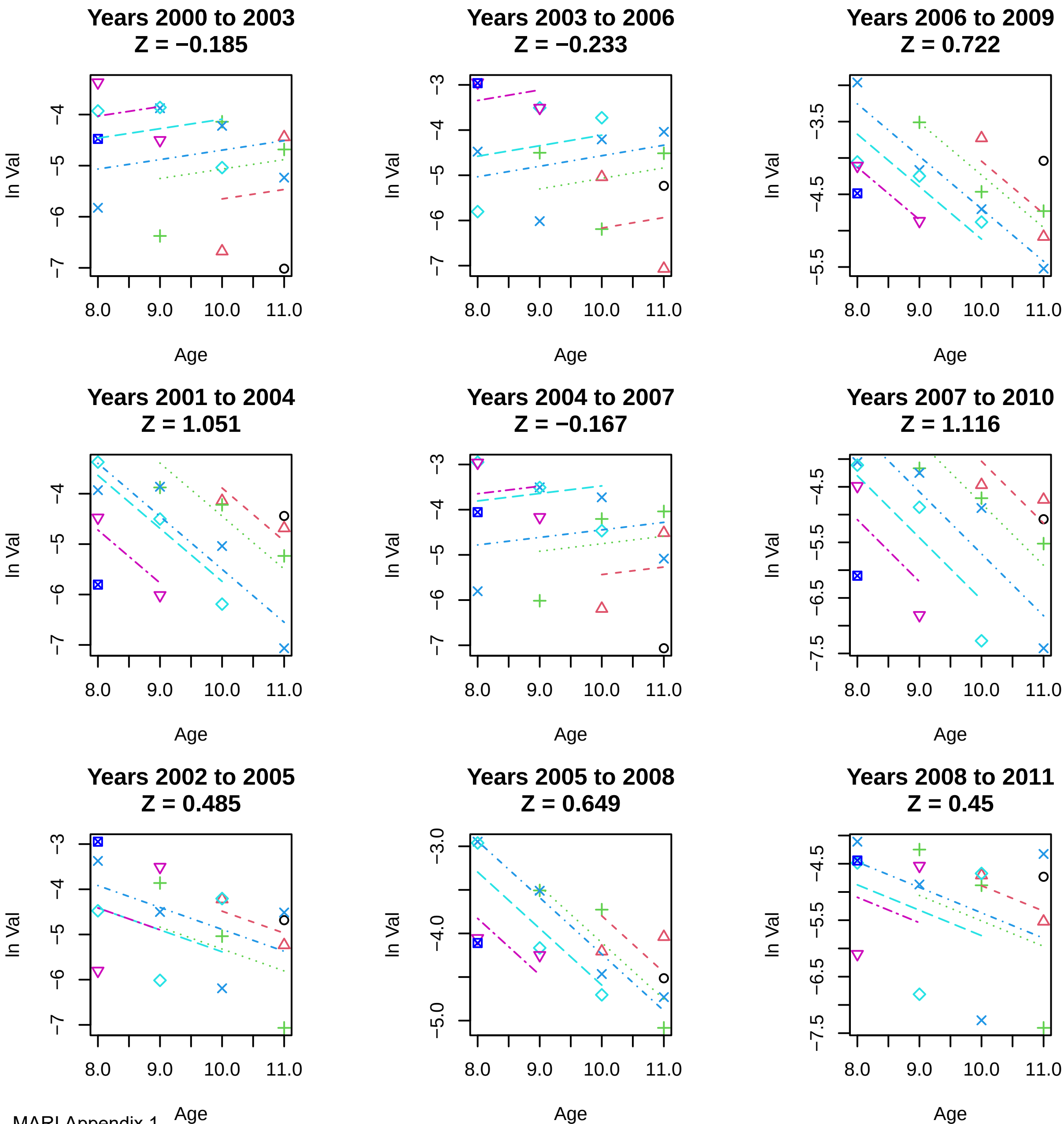


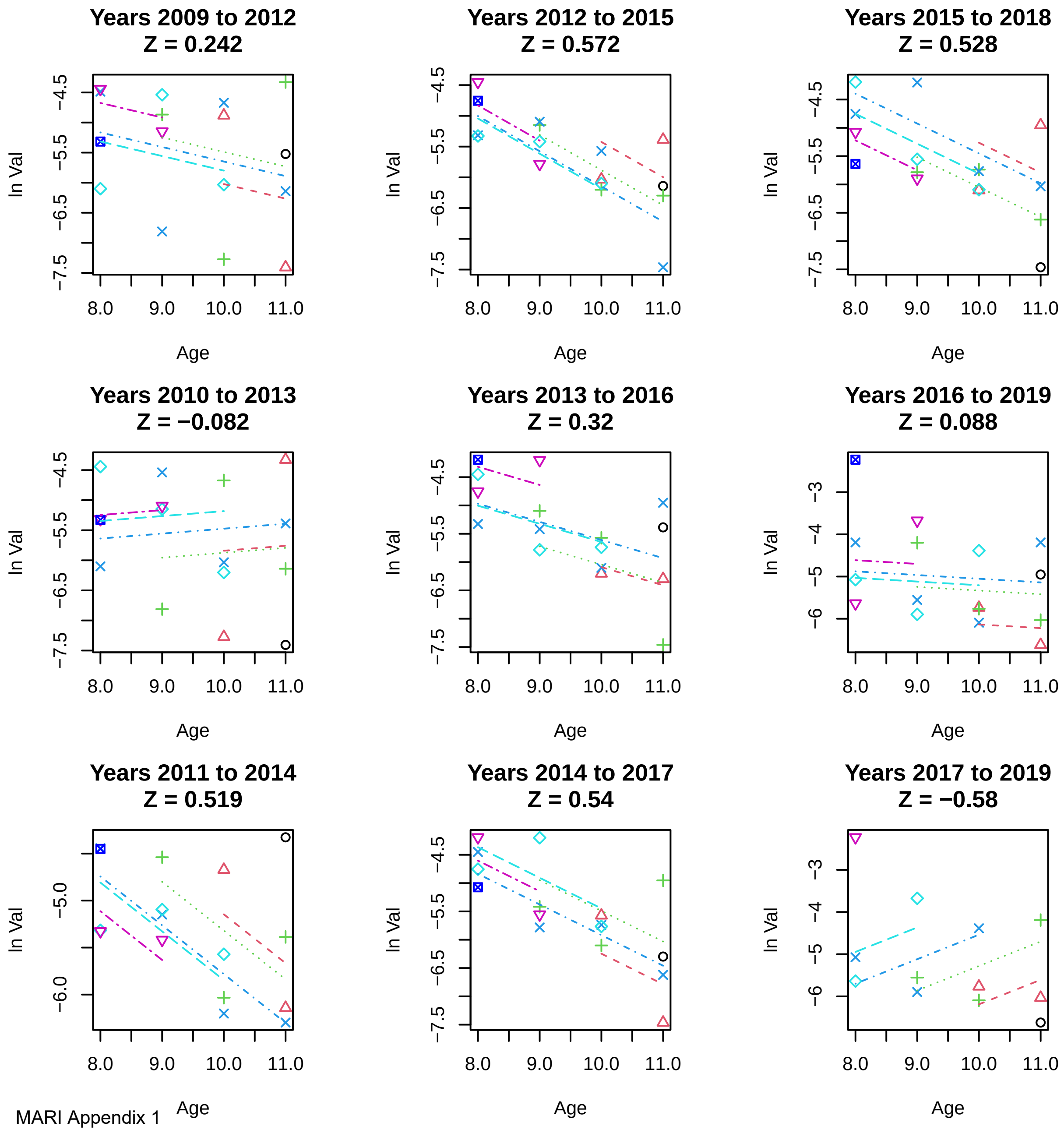
Z
2.0
1.5
1.0
0.5
0.0
−0.5
1970
1980
1990
2000
2010
2020
2030
Year Class

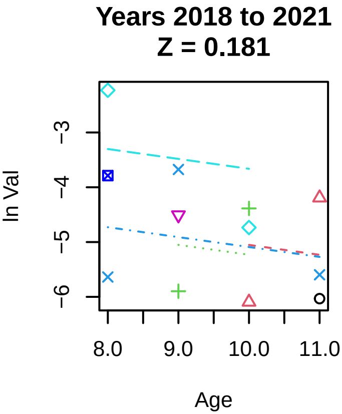

MA Trawl
Sinclair Z
0.0
0.5
1.0
1.5
2.0
1990
2000
2010
2020
Year

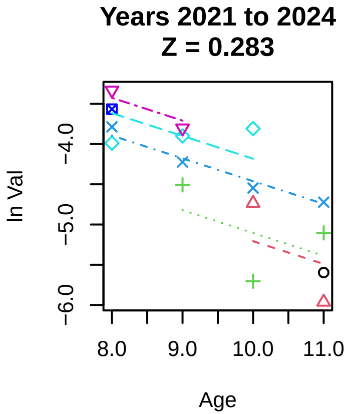

Years 1982 to 1985
Z = 0.295
Years 1985 to 1988
Z = 0.33
Years 1988 to 1991
Z = 1.251
Years 1983 to 1986
Z = −0.277
Years 1986 to 1989
Z = 0.202
Years 1989 to 1992
Z = 0.777
Years 1984 to 1987
Z = 0.042
Years 1987 to 1990
Z = 0.549
Years 1990 to 1993
Z = 0.187
ln Val
Age
8.0
9.0
10.0
11.0

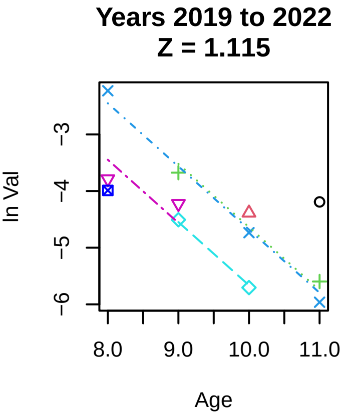

Years 1991 to 1994
Z = 0.029
Years 1994 to 1997
Z = 0.439
Years 1997 to 2000
Z = 1.283
Years 1992 to 1995
Z = 1.057
Years 1995 to 1998
Z = 0.065
Years 1998 to 2001
Z = 0.325
Years 1993 to 1996
Z = 0.451
Years 1996 to 1999
Z = 1.01
Years 1999 to 2002
Z = −0.514
ln Val
Age

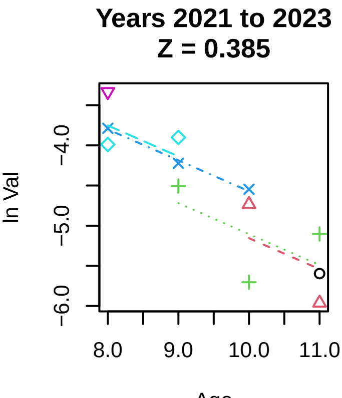

Years 2000 to 2003
Z = −0.185
Years 2003 to 2006
Z = −0.233
Years 2006 to 2009
Z = 0.722
Years 2001 to 2004
Z = 1.051
Years 2004 to 2007
Z = −0.167
Years 2007 to 2010
Z = 1.116
Years 2002 to 2005
Z = 0.485
Years 2005 to 2008
Z = 0.649
Years 2008 to 2011
Z = 0.45
ln Val
Age
8.0
9.0
10.0
11.0

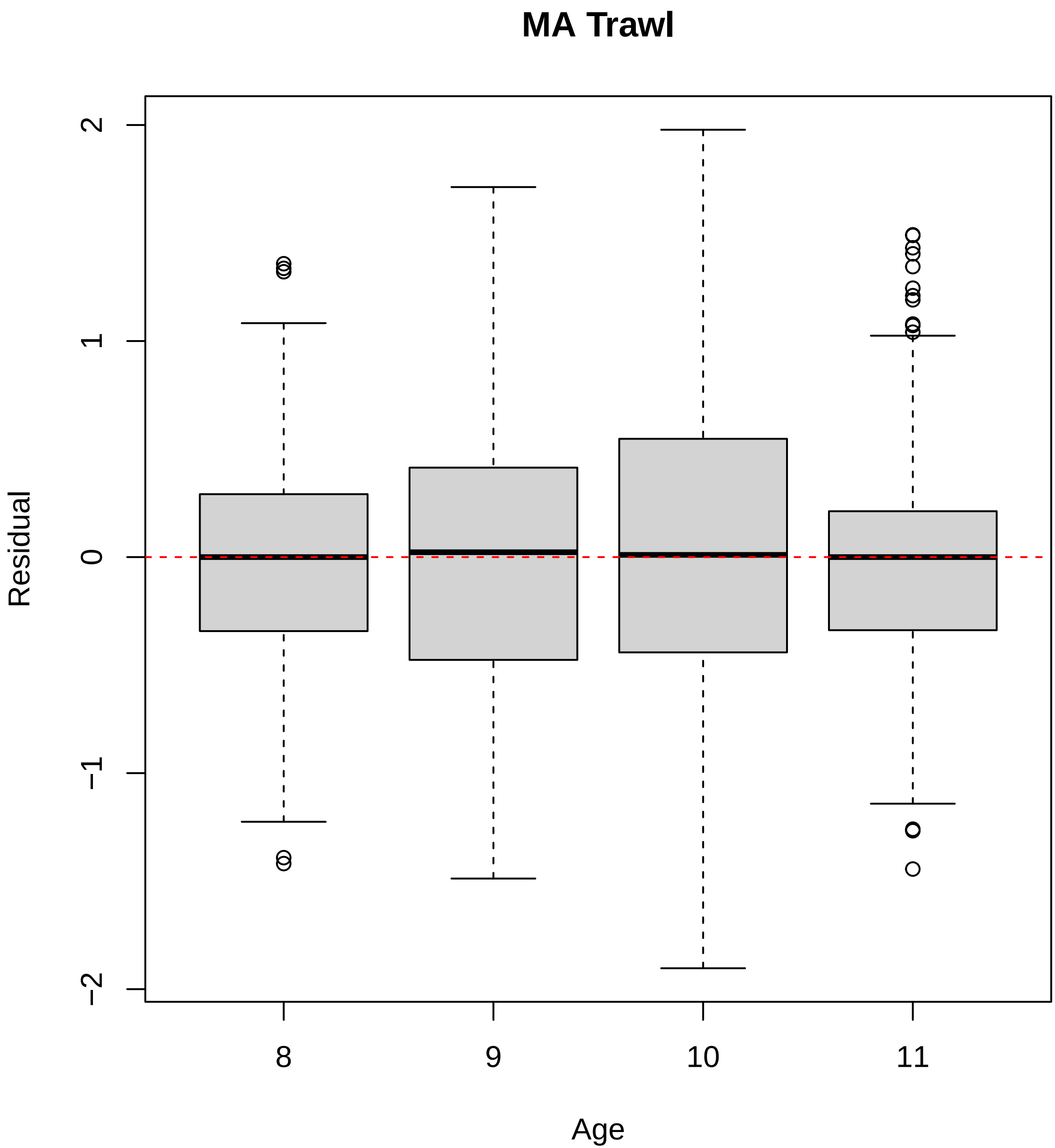

Years 2009 to 2012
Z = 0.242
Years 2012 to 2015
Z = 0.572
Years 2015 to 2018
Z = 0.528
Years 2010 to 2013
Z = −0.082
Years 2013 to 2016
Z = 0.32
Years 2016 to 2019
Z = 0.088
Years 2011 to 2014
Z = 0.519
Years 2014 to 2017
Z = 0.54
Years 2017 to 2019
Z = −0.58
ln Val
Age
8.0
9.0
10.0
11.0

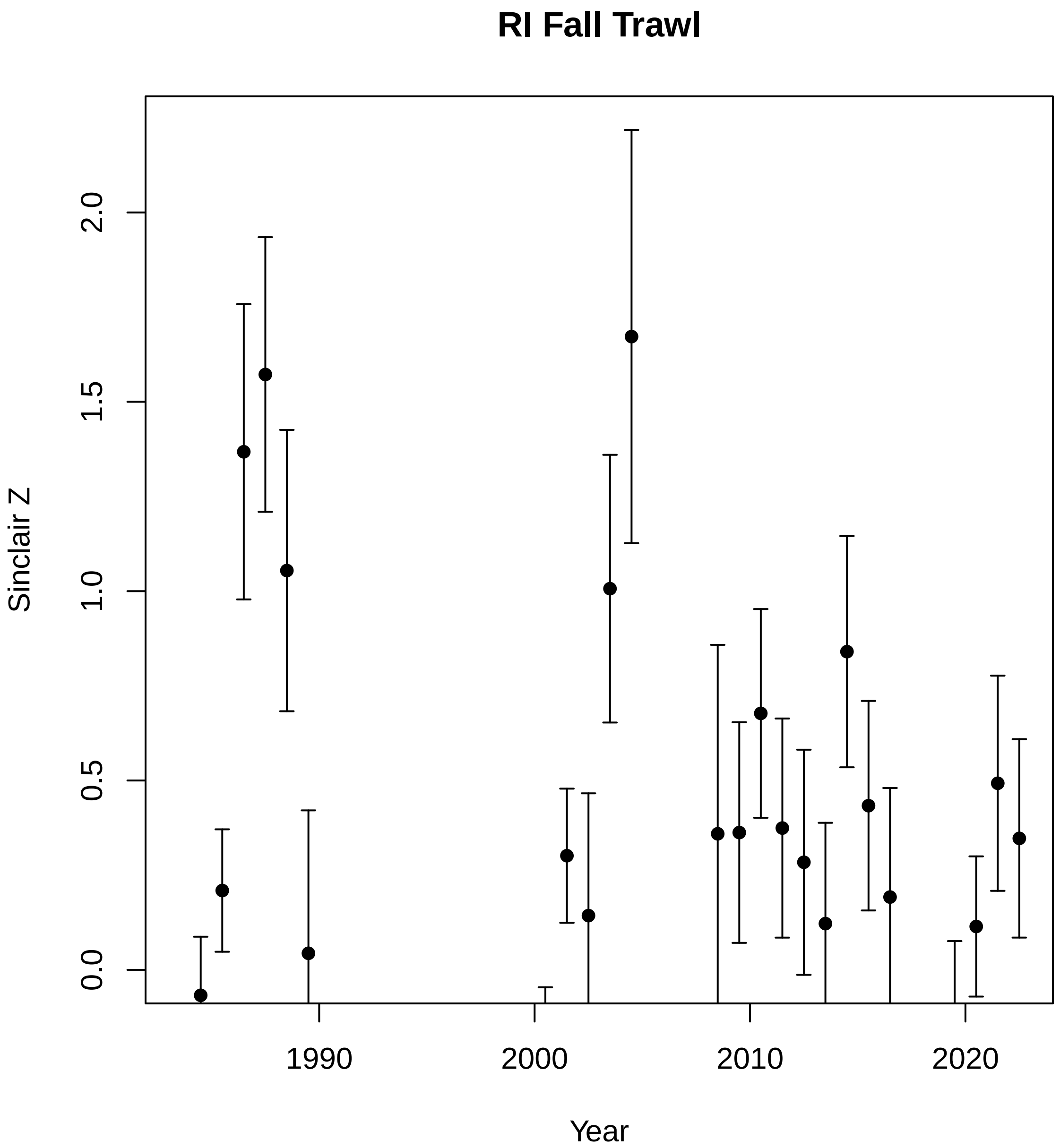

Years 2018 to 2021
Z = 0.181
ln Val
−3
−4
−5
−6
8.0
9.0
10.0
11.0
Age

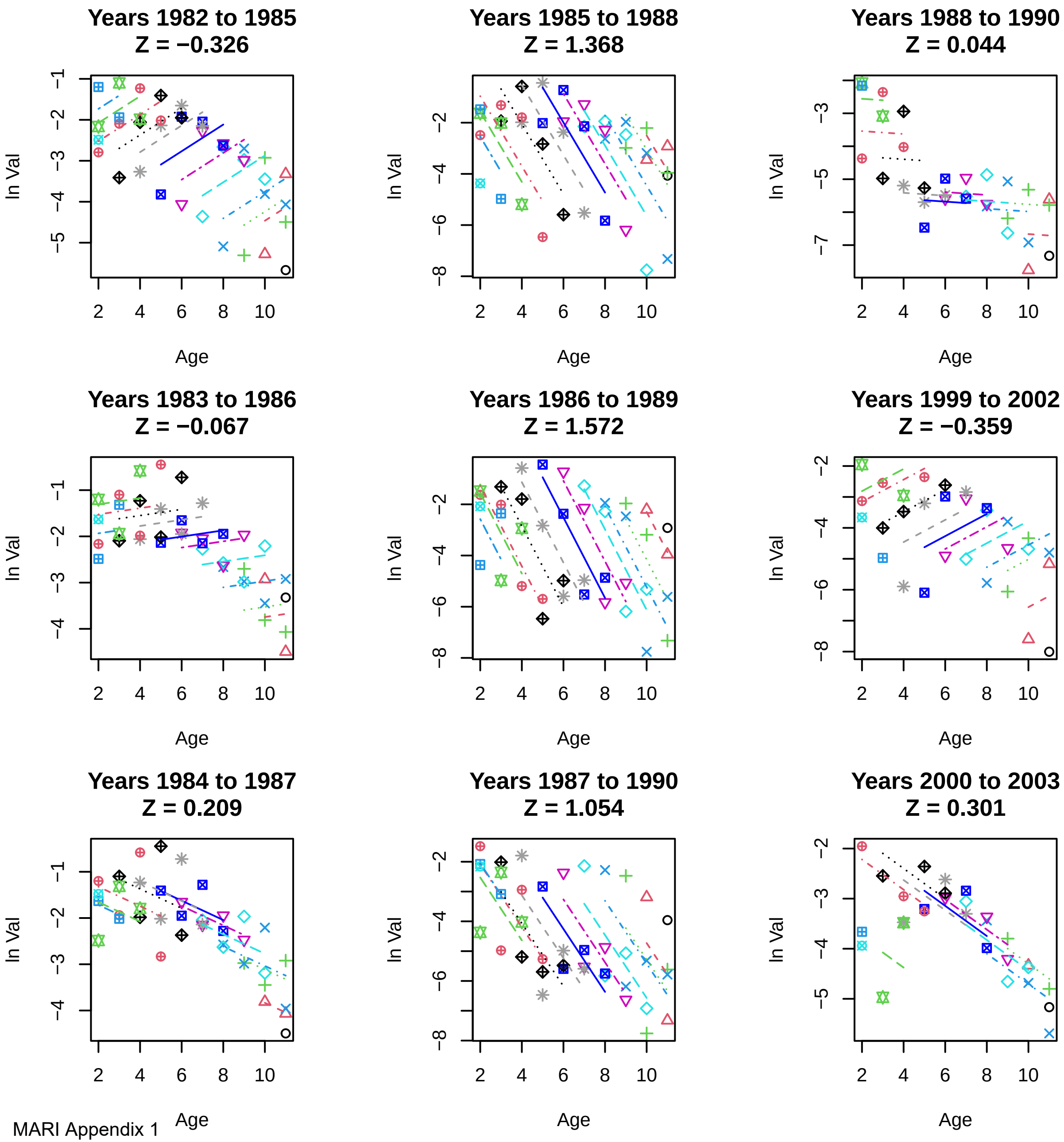

Years 2021 to 2024
Z = 0.283
ln Val
−4.0
−5.0
−6.0
8.0
9.0
10.0
11.0
Age

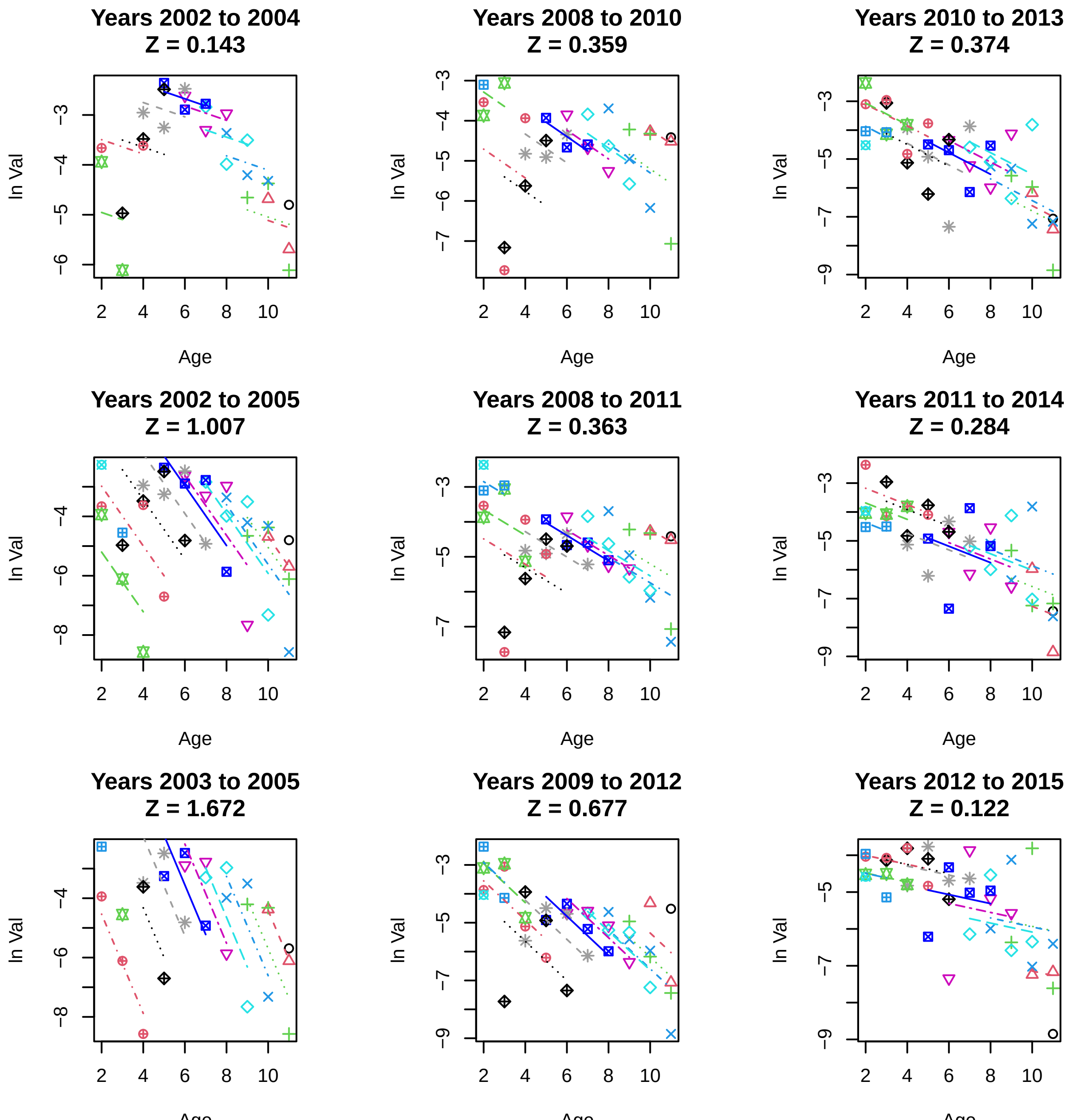

Years 2019 to 2022
Z = 1.115
ln Val
−3
−4
−5
−6
8.0
9.0
10.0
11.0
Age

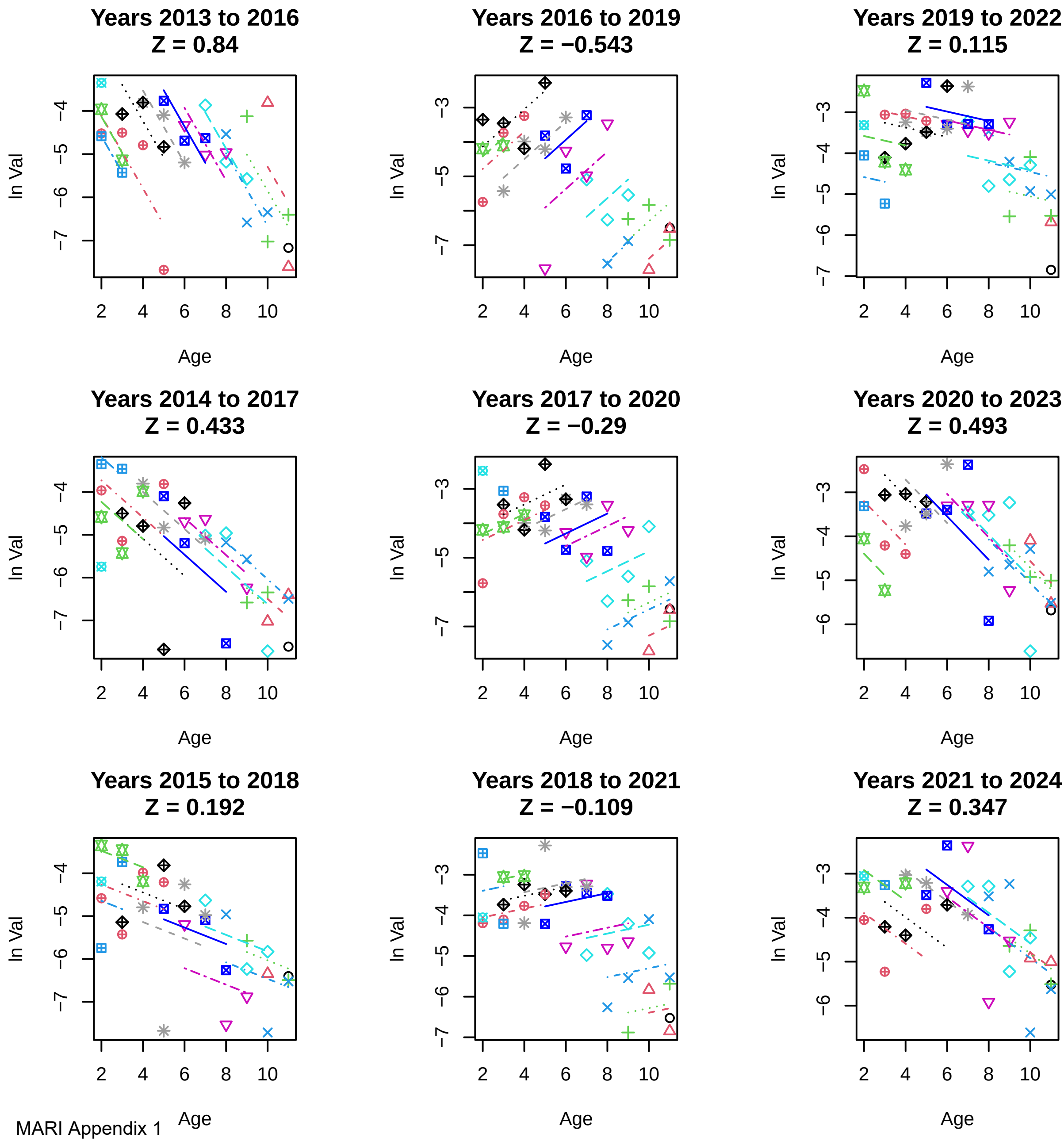

Years 2021 to 2023
Z = 0.385
ln Val
−4.0
−5.0
−6.0
8.0
9.0
10.0
11.0
Age

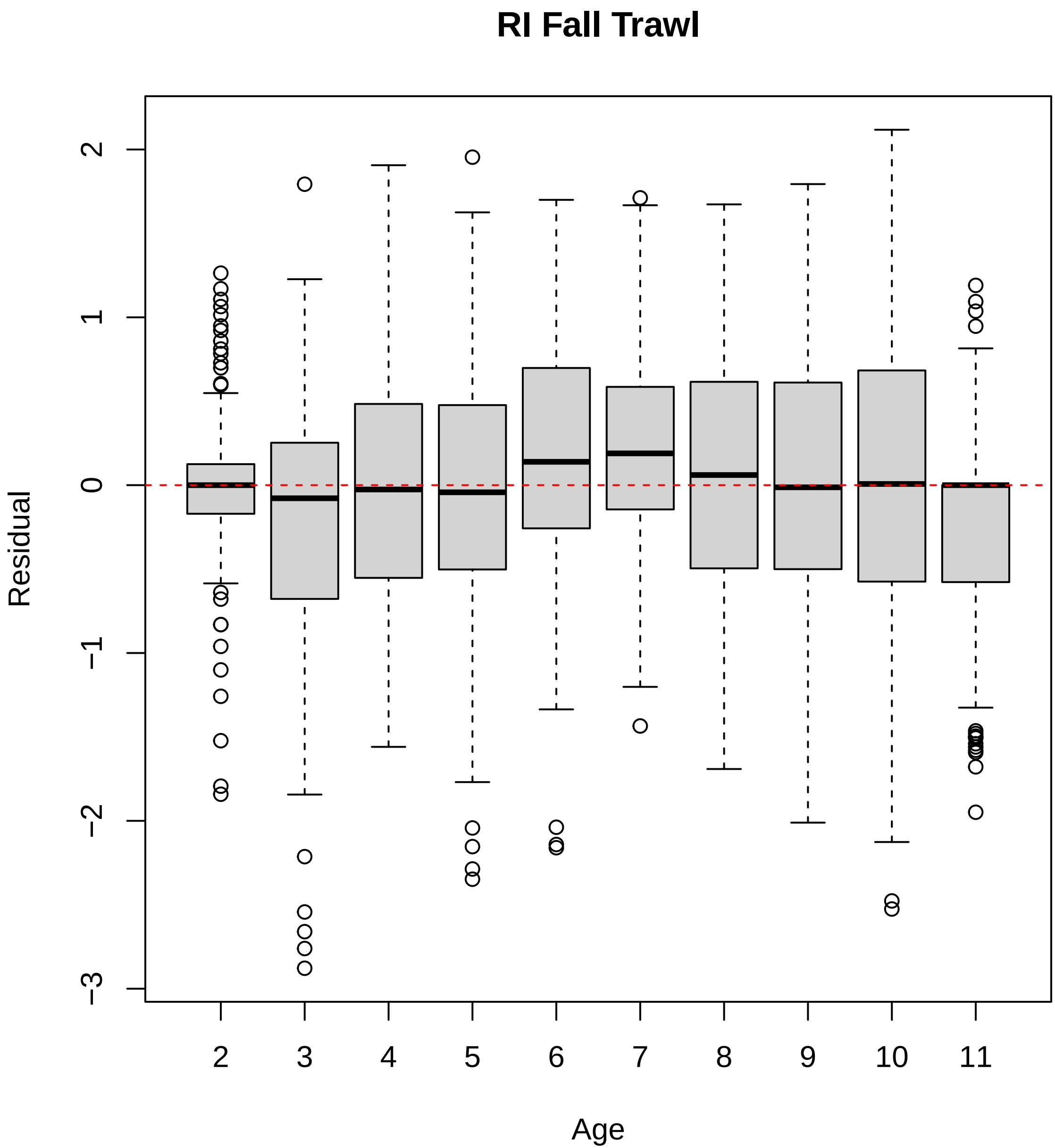

MA Trawl
Residual
2
1
0
−1
−2
8
9
10
11
Age

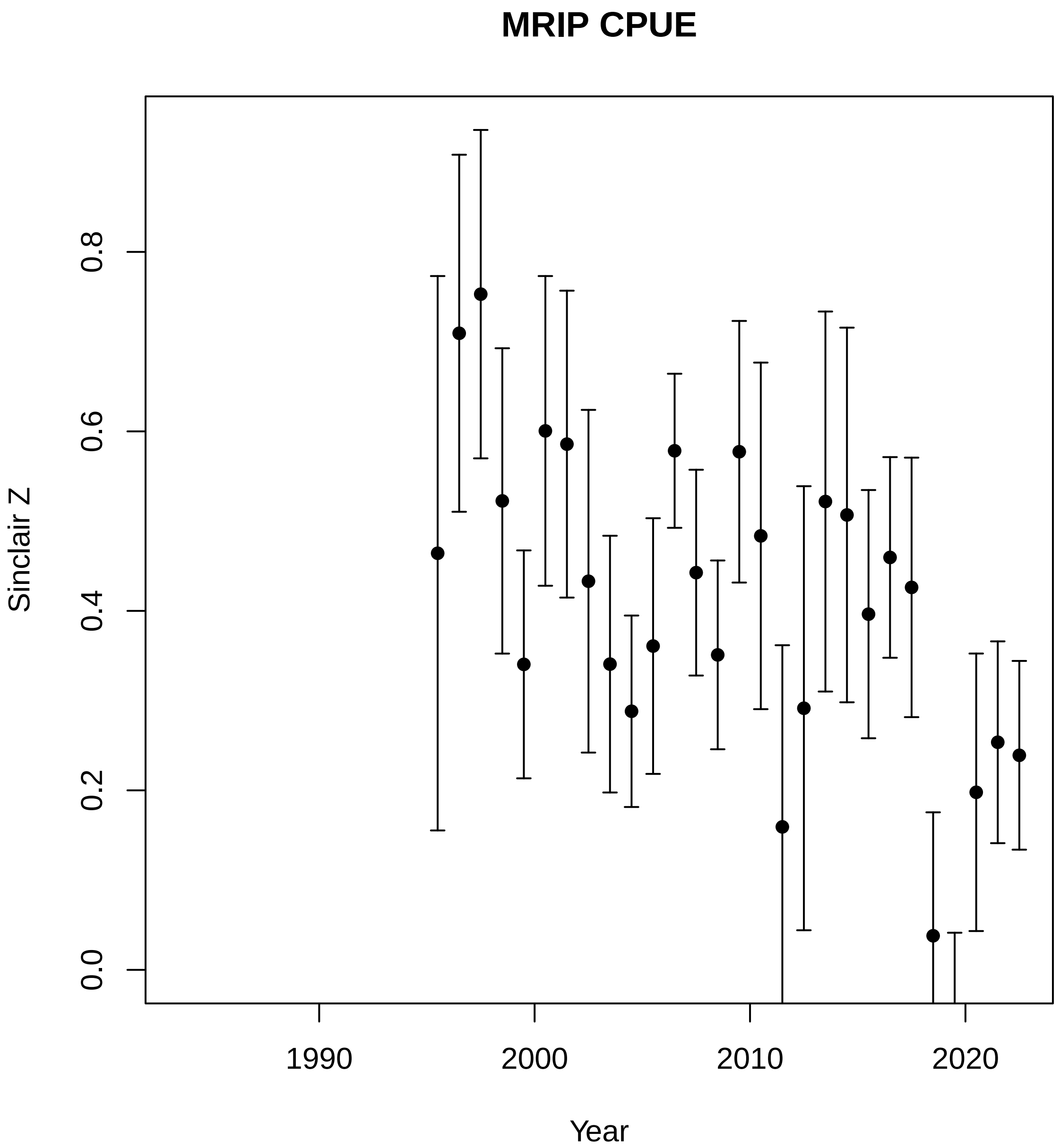

RI Fall Trawl
Sinclair Z
0.0
0.5
1.0
1.5
2.0
1990
2000
2010
2020
Year

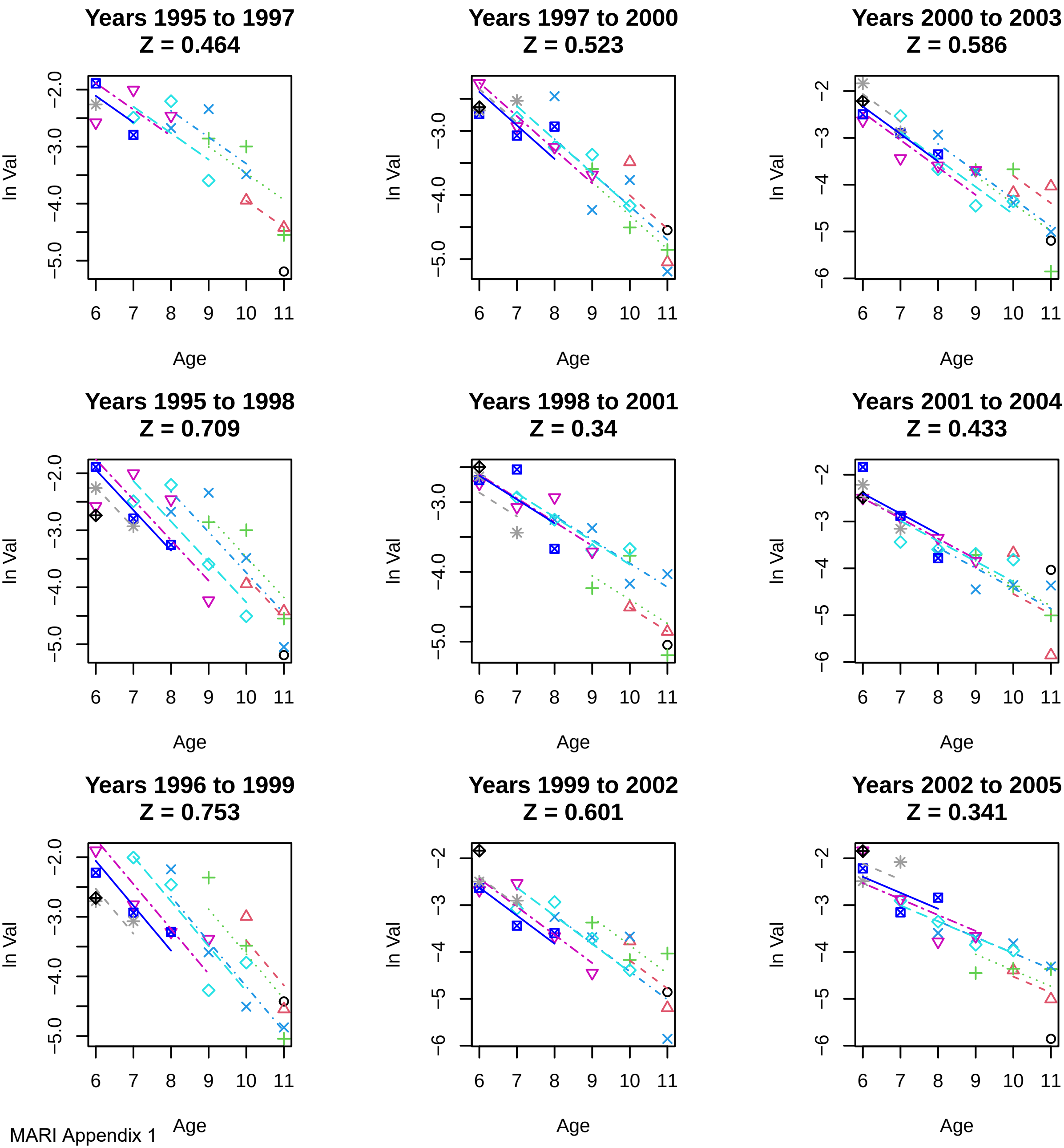

Years 1982 to 1985
Z = −0.326
Years 1985 to 1988
Z = 1.368
Years 1988 to 1990
Z = 0.044
Years 1983 to 1986
Z = −0.067
Years 1986 to 1989
Z = 1.572
Years 1999 to 2002
Z = −0.359
Years 1984 to 1987
Z = 0.209
Years 1987 to 1990
Z = 1.054
Years 2000 to 2003
Z = 0.301
ln Val
Age

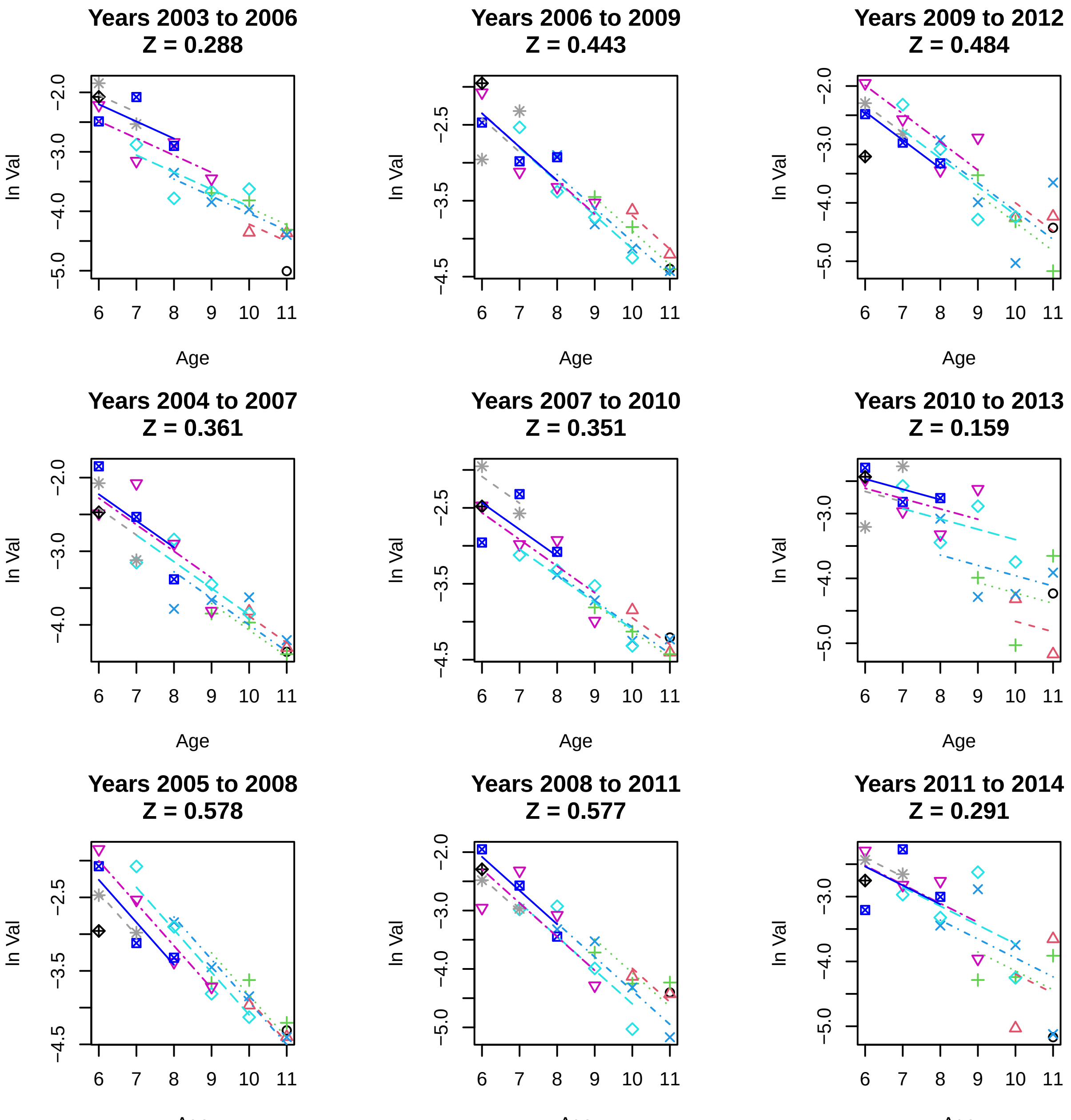

Years 2002 to 2004
Z = 0.143
Years 2008 to 2010
Z = 0.359
Years 2010 to 2013
Z = 0.374
Years 2002 to 2005
Z = 1.007
Years 2008 to 2011
Z = 0.363
Years 2011 to 2014
Z = 0.284
Years 2003 to 2005
Z = 1.672
Years 2009 to 2012
Z = 0.677
Years 2012 to 2015
Z = 0.122
ln Val
Age

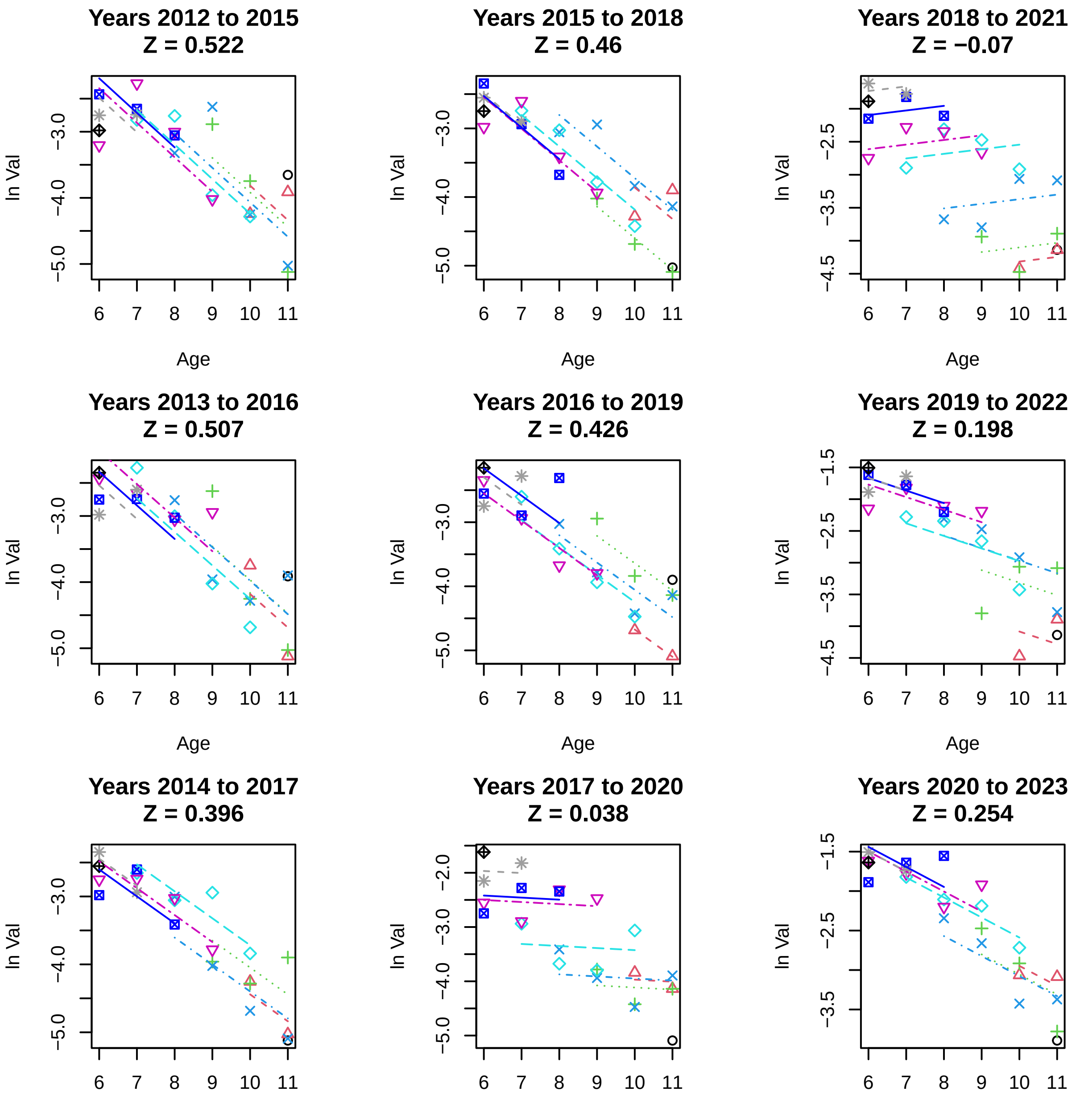

Years 2013 to 2016
Z = 0.84
Years 2016 to 2019
Z = −0.543
Years 2019 to 2022
Z = 0.115
Years 2014 to 2017
Z = 0.433
Years 2017 to 2020
Z = −0.29
Years 2020 to 2023
Z = 0.493
Years 2015 to 2018
Z = 0.192
Years 2018 to 2021
Z = −0.109
Years 2021 to 2024
Z = 0.347
ln Val
Age


RI Fall Trawl
Residual
2
1
0
−1
−2
−3
2
3
4
5
6
7
8
9
10
11
Age

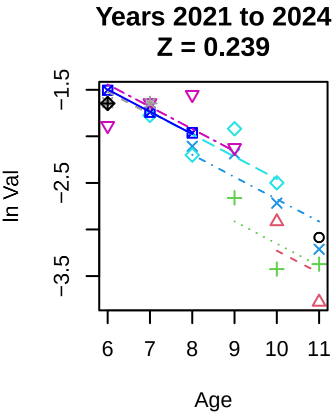

MRIP CPUE
Sinclair Z
0.0
0.2
0.4
0.6
0.8
1990
2000
2010
2020
Year

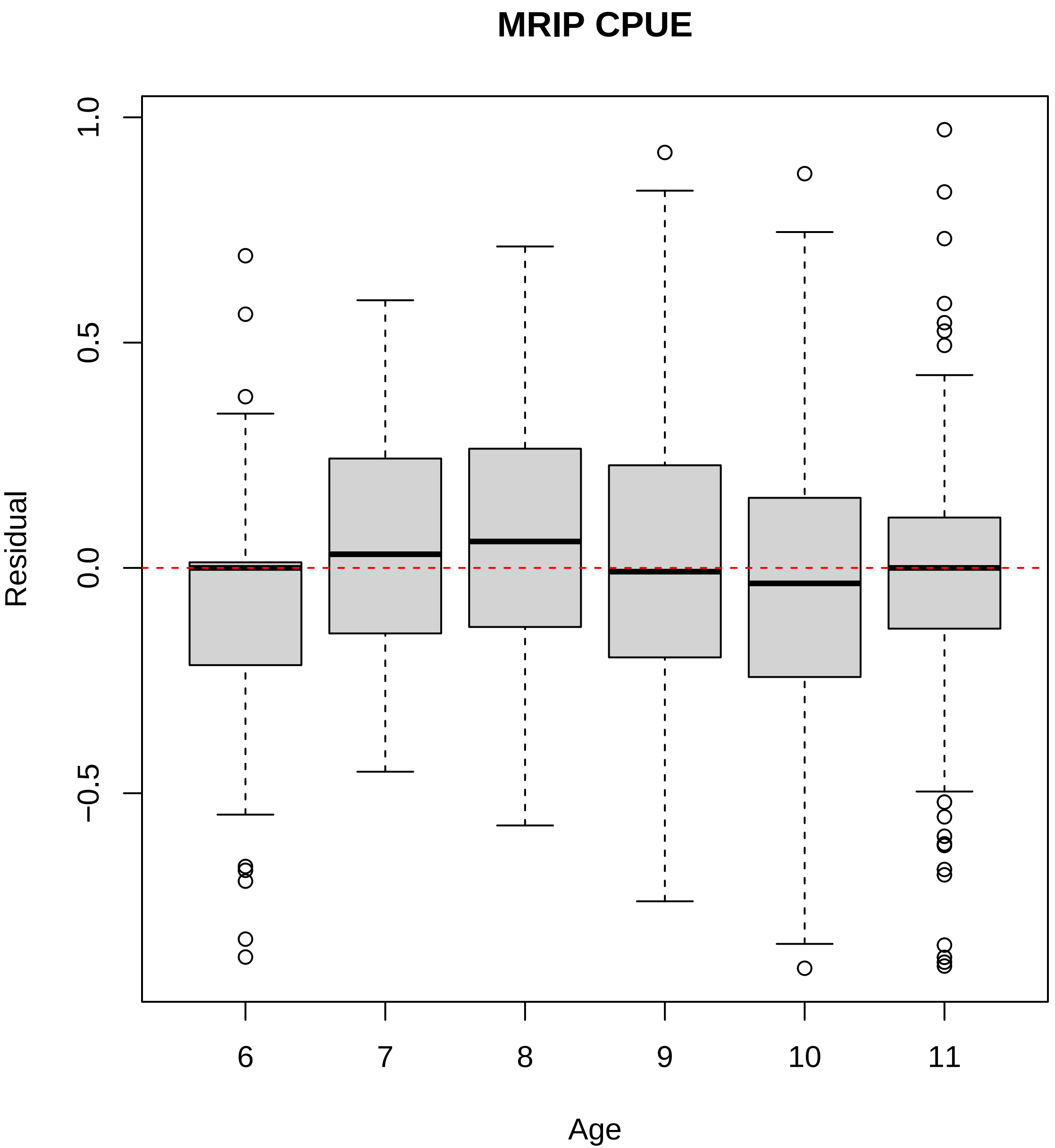

Years 1995 to 1997
Z = 0.464
Years 1997 to 2000
Z = 0.523
Years 2000 to 2003
Z = 0.586
Years 1995 to 1998
Z = 0.709
Years 1998 to 2001
Z = 0.34
Years 2001 to 2004
Z = 0.433
Years 1996 to 1999
Z = 0.753
Years 1999 to 2002
Z = 0.601
Years 2002 to 2005
Z = 0.341
ln Val
Age
6
7
8
9
10
11
−2.0
−3.0
−4.0
−5.0
−2
−3
−4
−5
−6


Years 2003 to 2006
Z = 0.288
Years 2006 to 2009
Z = 0.443
Years 2009 to 2012
Z = 0.484
Years 2004 to 2007
Z = 0.361
Years 2007 to 2010
Z = 0.351
Years 2010 to 2013
Z = 0.159
Years 2005 to 2008
Z = 0.578
Years 2008 to 2011
Z = 0.577
Years 2011 to 2014
Z = 0.291
ln Val
Age
6 7 8 9 10 11

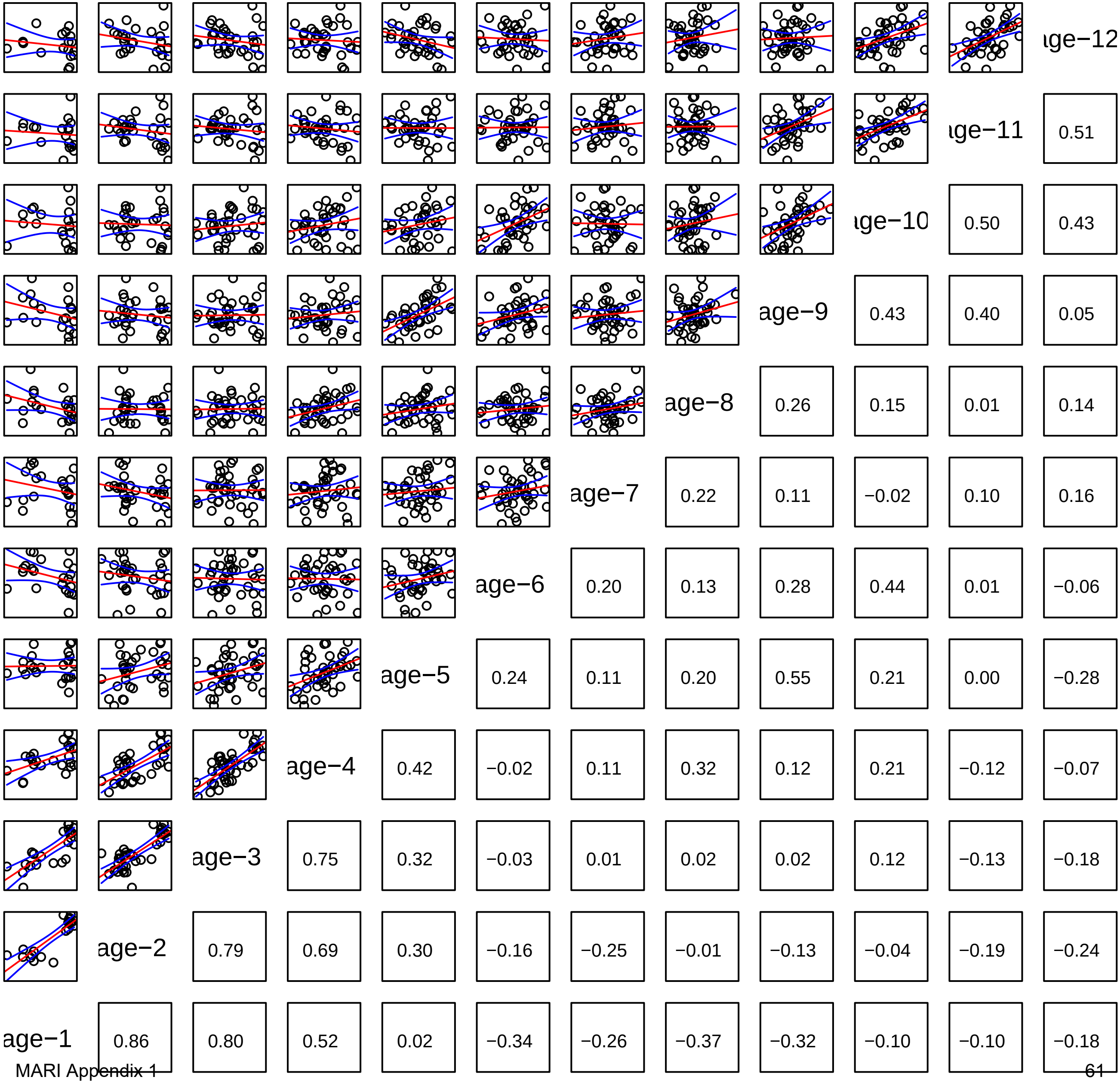


Years 2012 to 2015
Z = 0.522
Years 2015 to 2018
Z = 0.46
Years 2018 to 2021
Z = −0.07
Years 2013 to 2016
Z = 0.507
Years 2016 to 2019
Z = 0.426
Years 2019 to 2022
Z = 0.198
Years 2014 to 2017
Z = 0.396
Years 2017 to 2020
Z = 0.038
Years 2020 to 2023
Z = 0.254
ln Val
Age

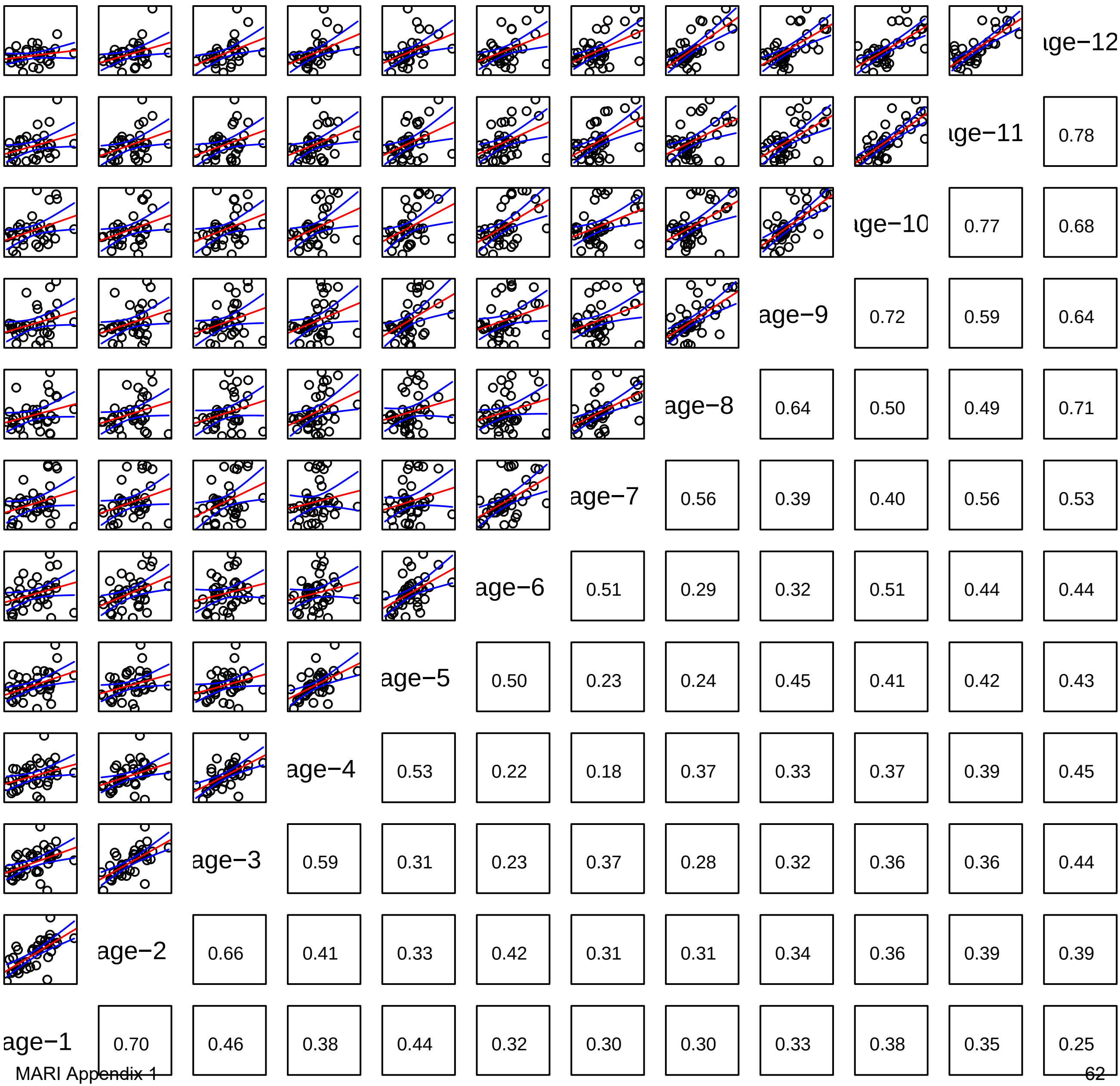

Years 2021 to 2024
Z = 0.239
ln Val
−1.5
−2.5
−3.5
6
7
8
9
10
11
Age


MRIP CPUE
Residual
1.0
0.5
0.0
−0.5
6
7
8
9
10
11
Age

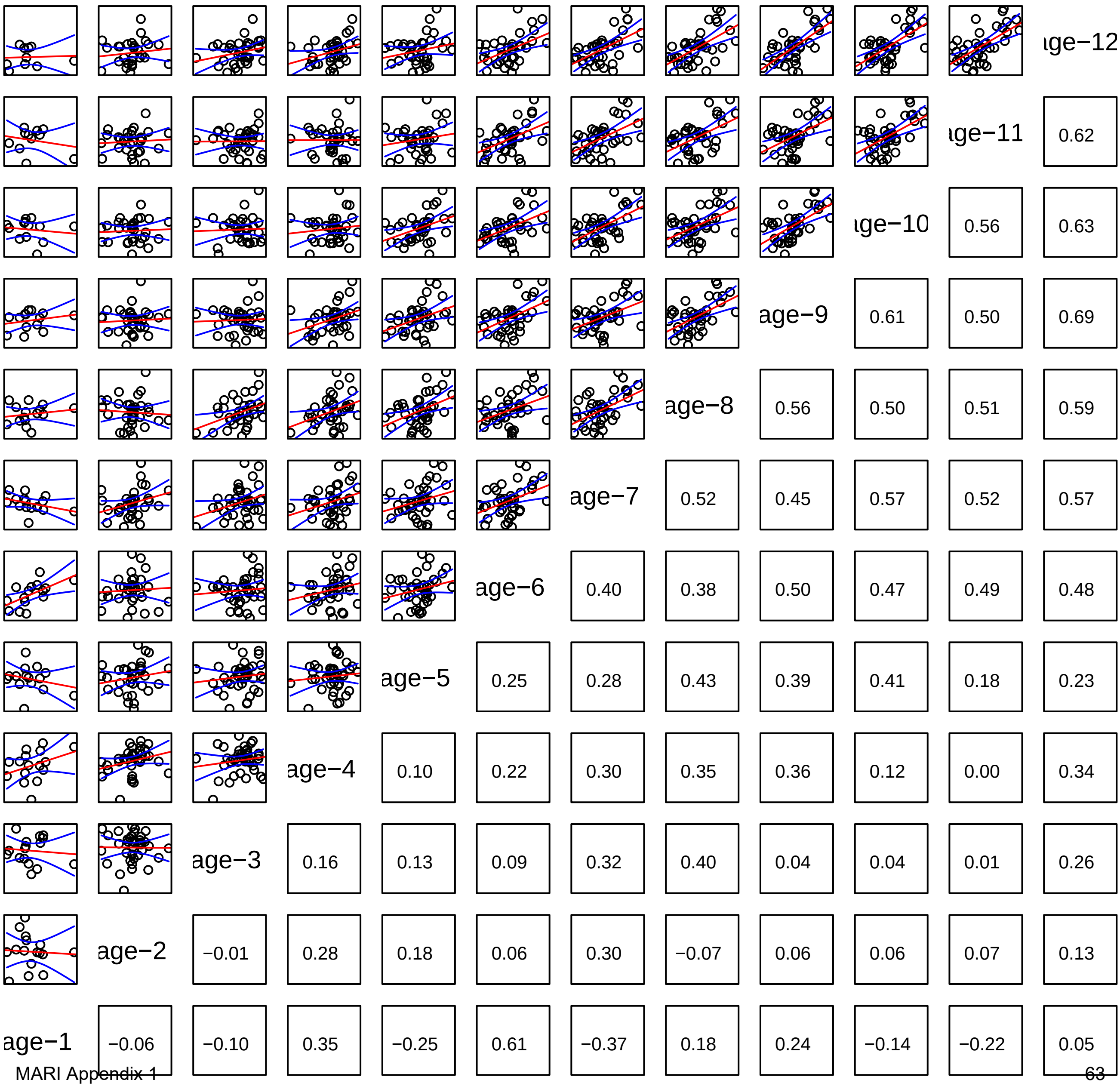
Catch Observed



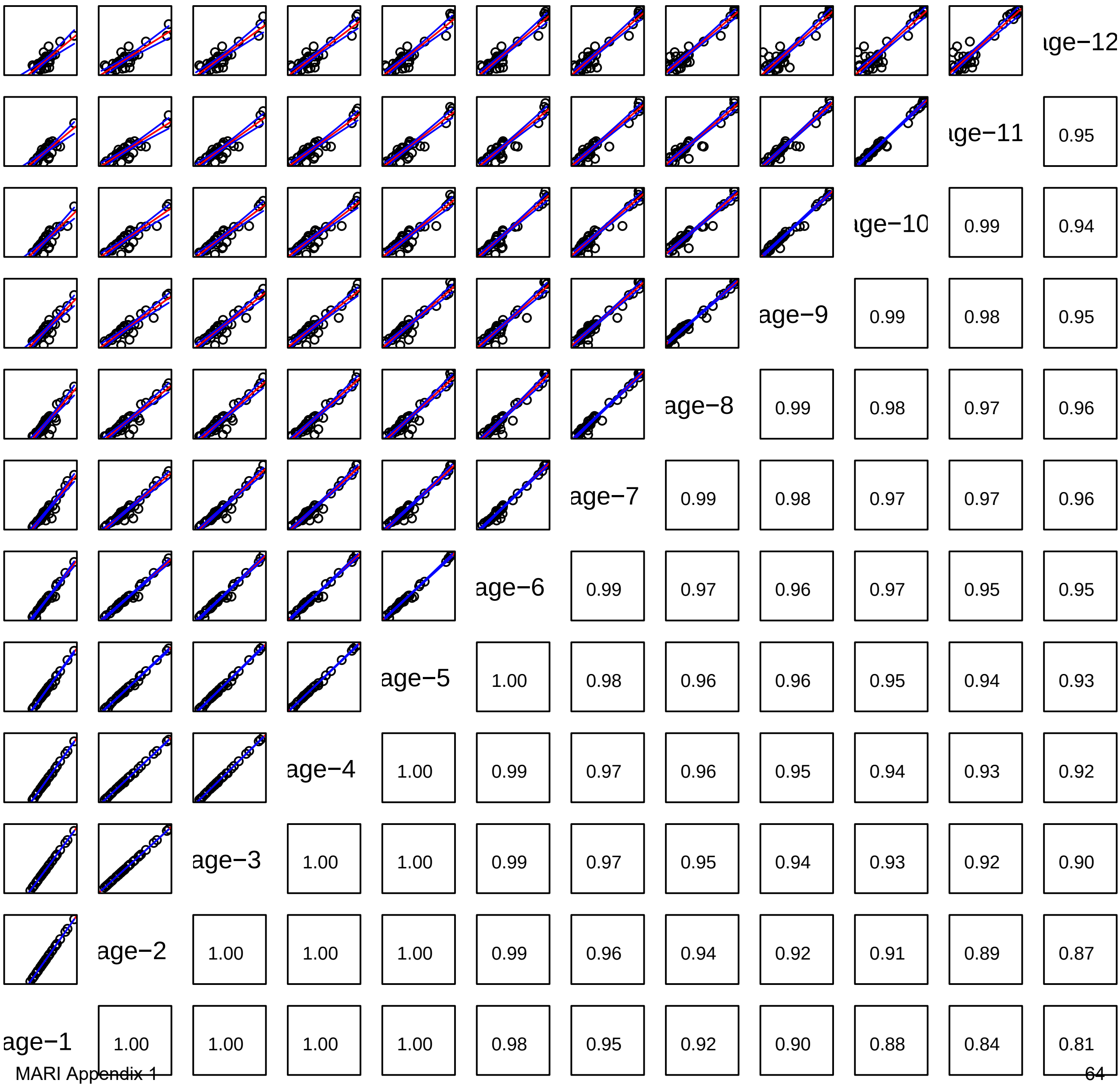
Catch Predicted



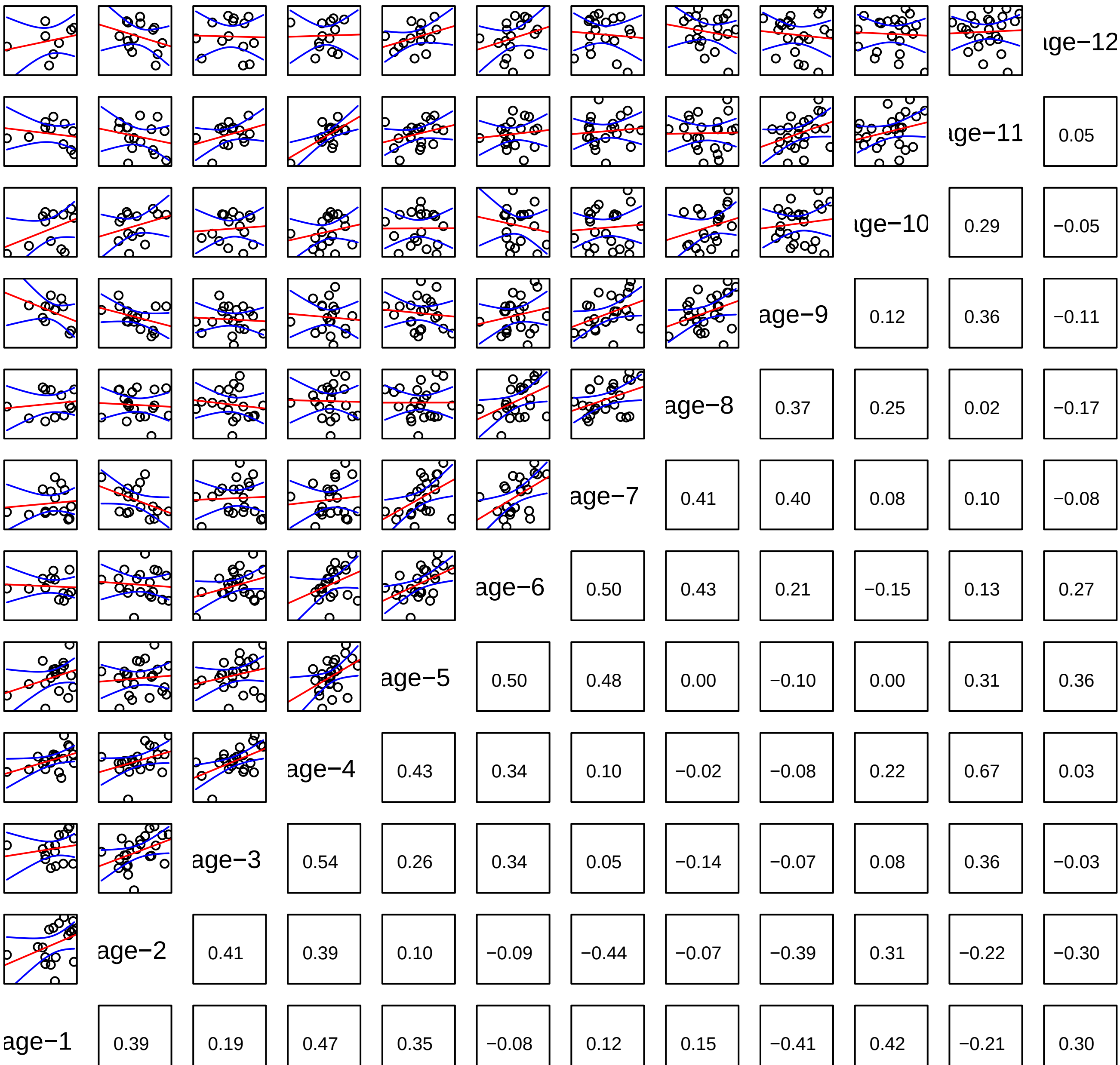
Index 1 (MA Trawl) Observed



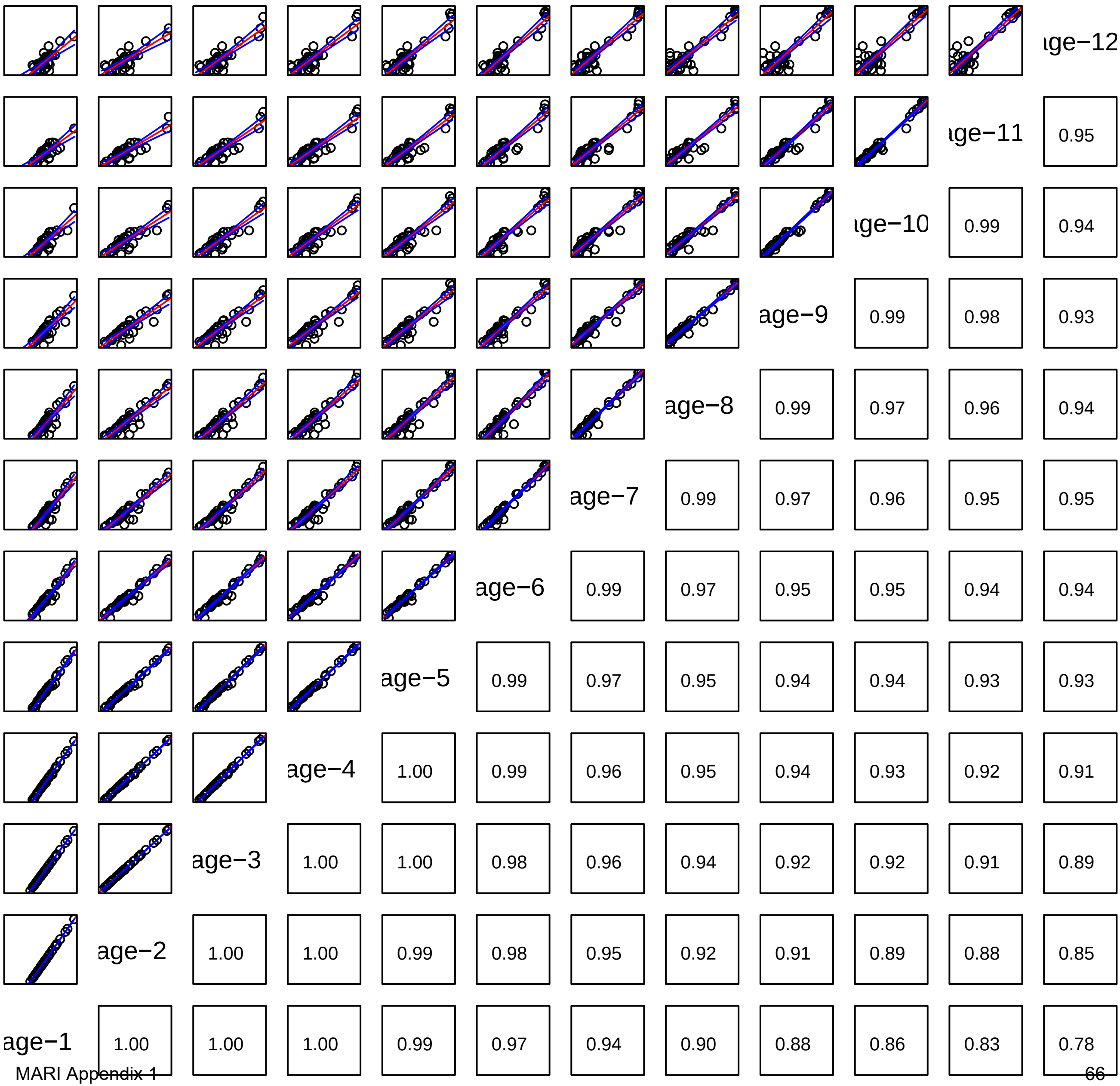
Index 1 (MA Trawl) Predicted



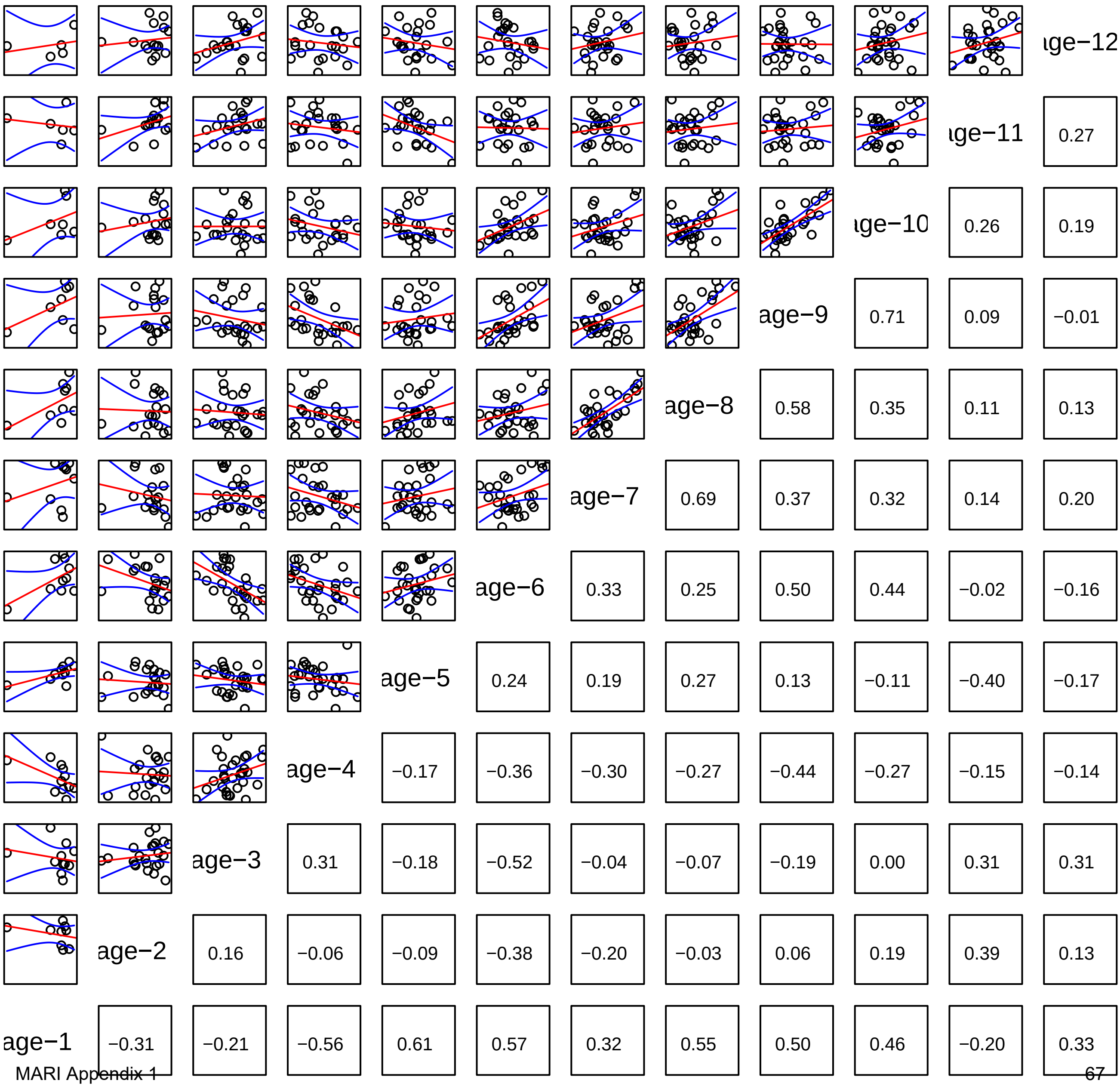
Index 2 (RI Fall Trawl) Observed



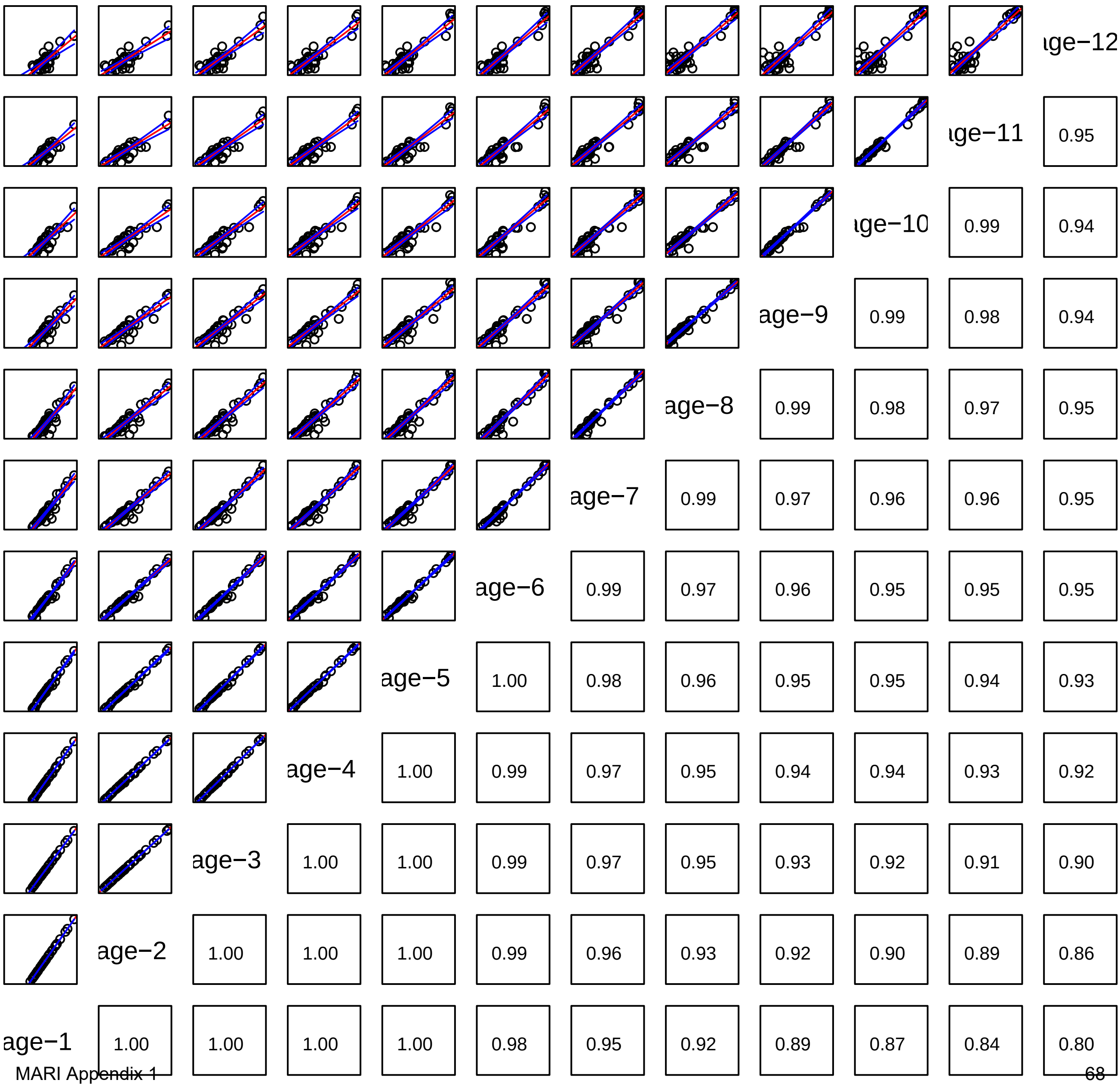
Index 2 (RI Fall Trawl) Predicted

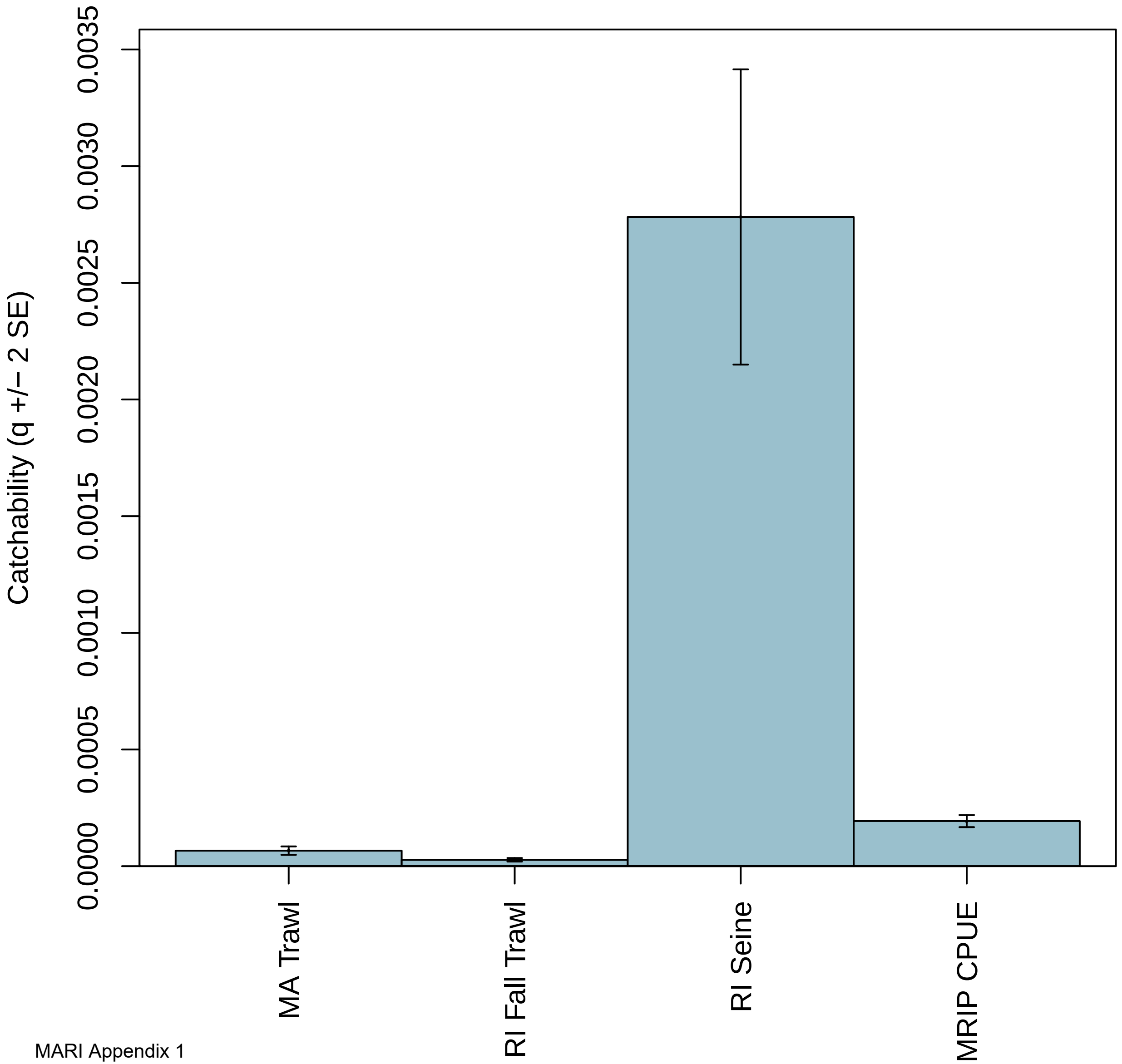


Index 4 (MRIP CPUE) Observed

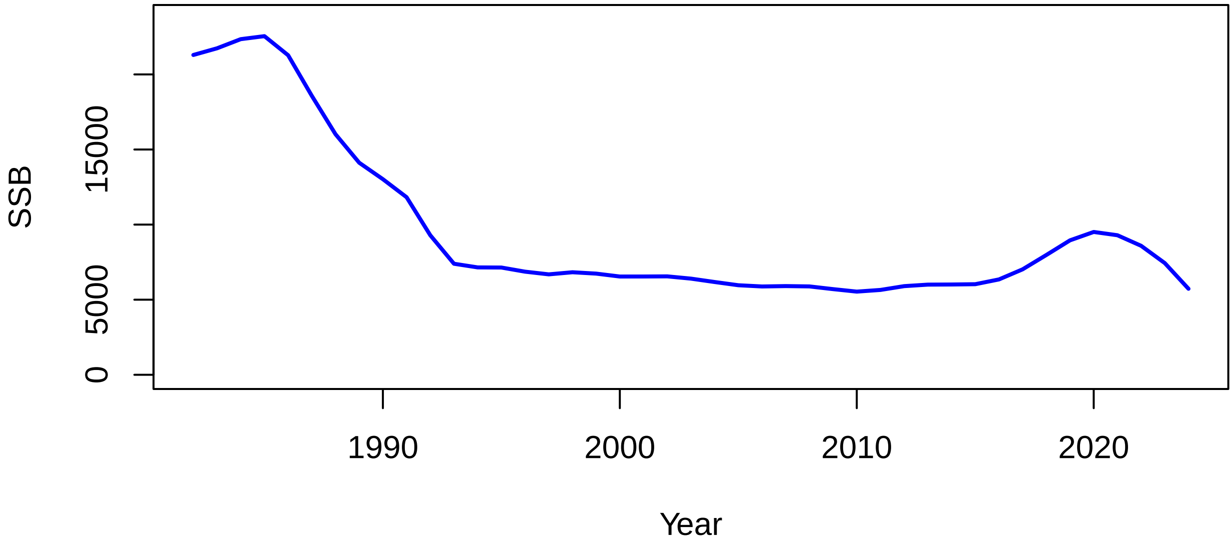


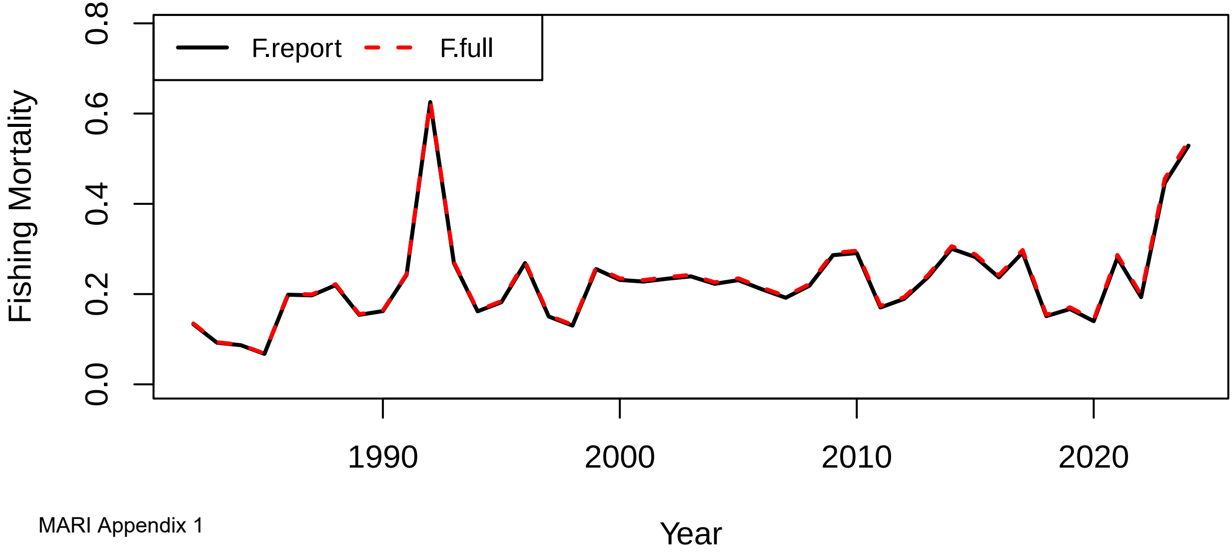
Index 4 (MRIP CPUE) Predicted

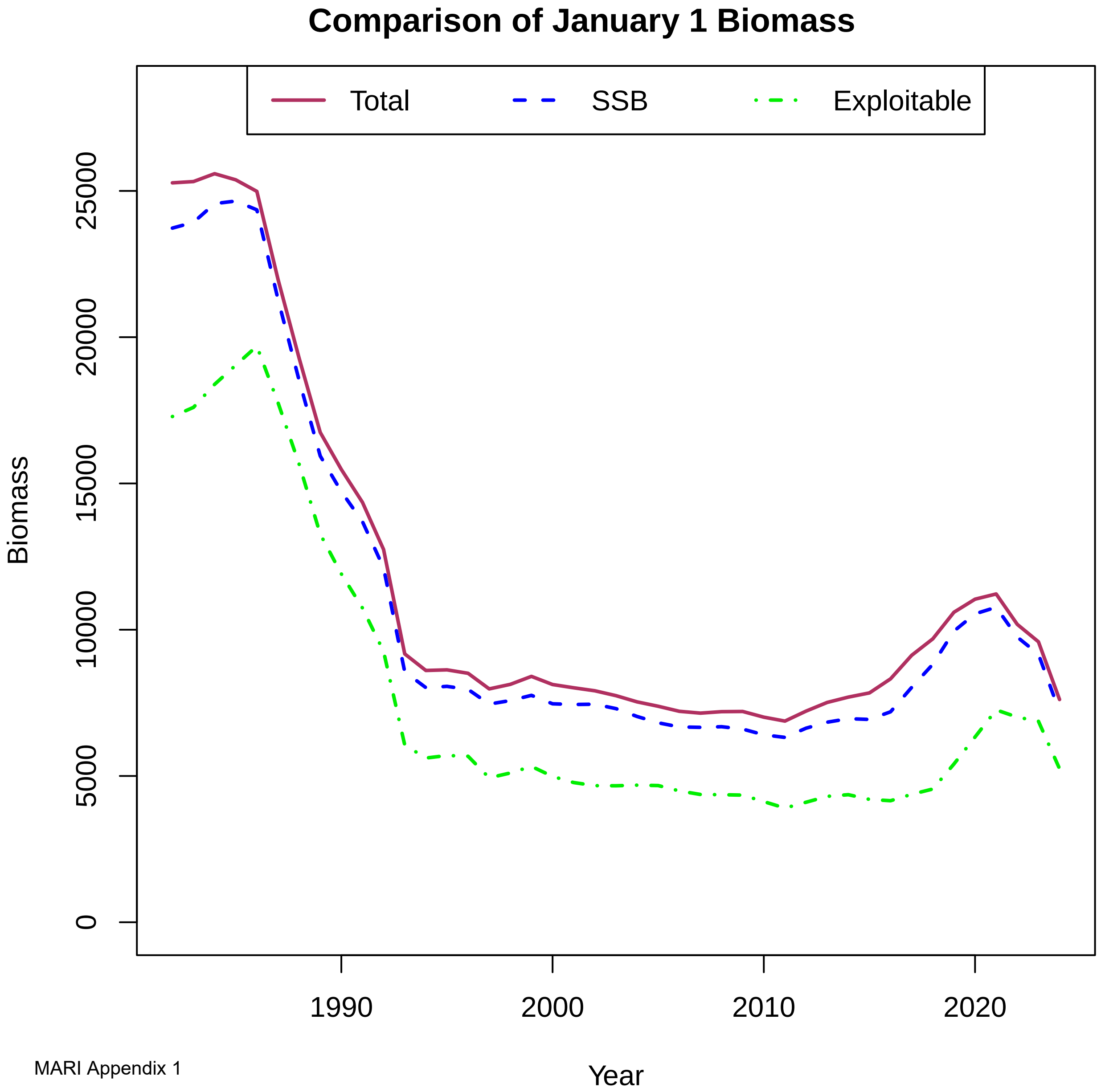




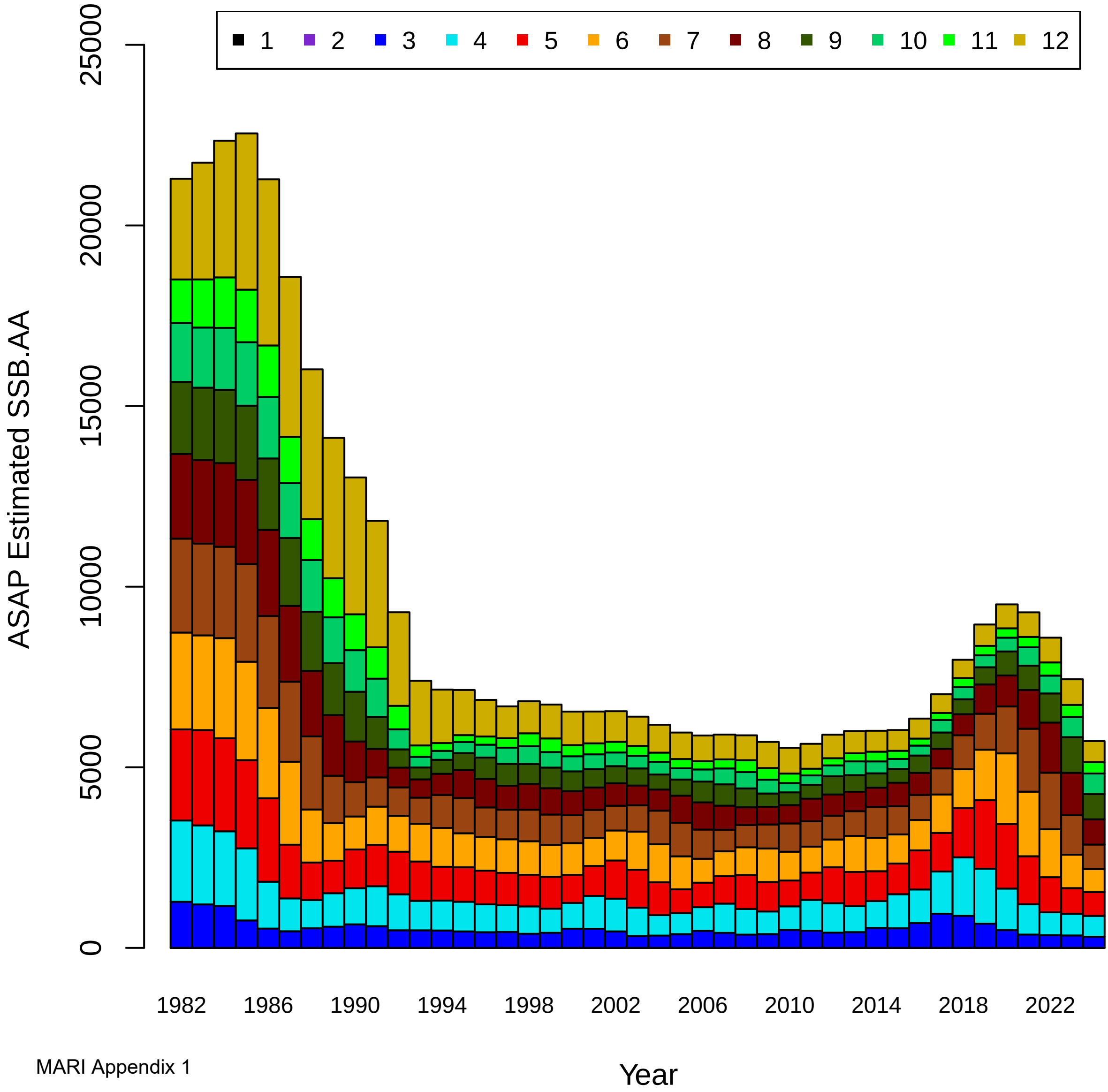
Catchability (q +/− 2 SE)
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035
MA Trawl
RI Fall Trawl
RI Seine
MRIP CPUE


SSB
0
5000
15000
1990
2000
2010
2020
Year

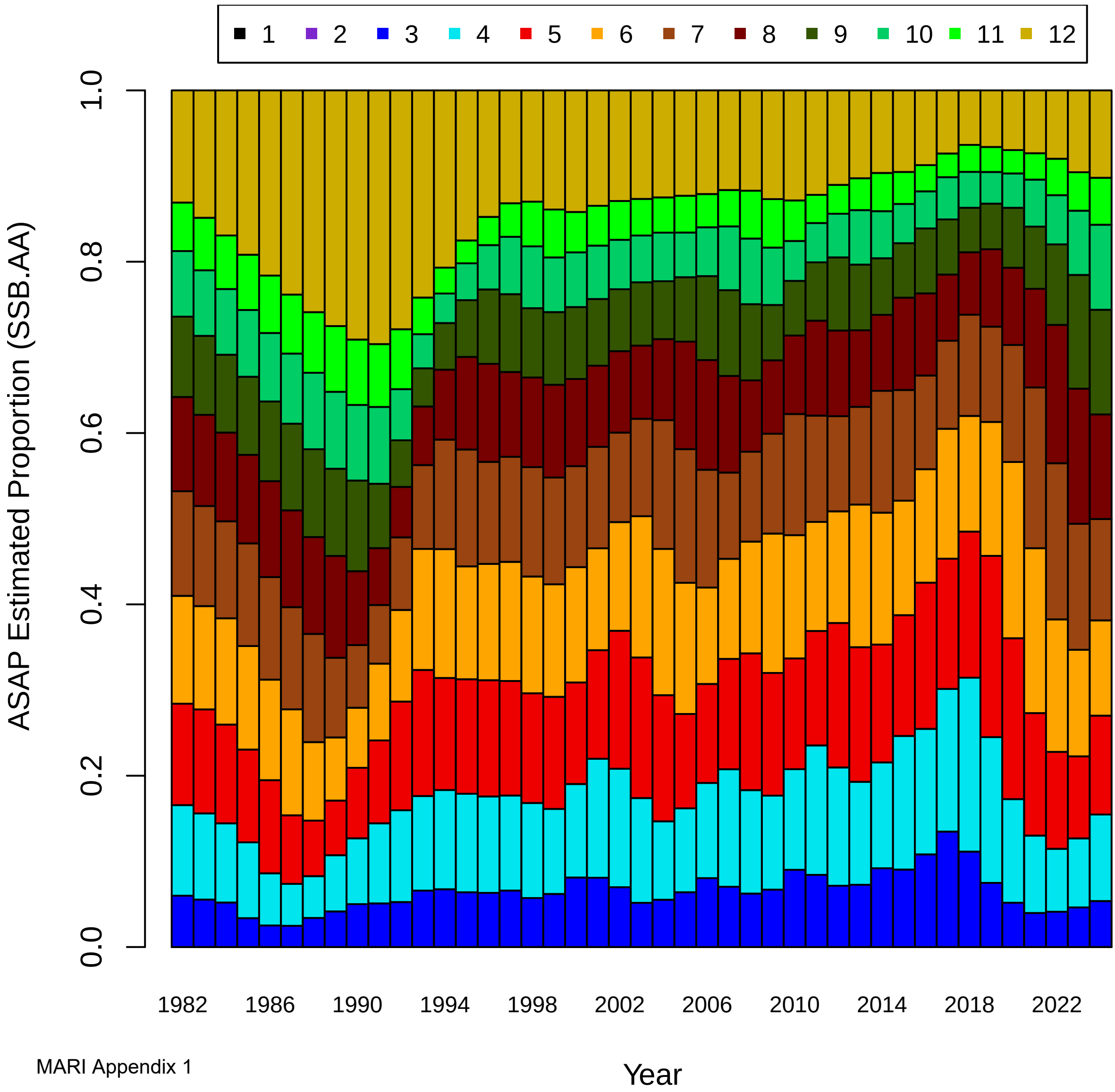

F.report
F.full
Fishing Mortality
0.0
0.2
0.4
0.6
0.8
1990
2000
2010
2020
Year



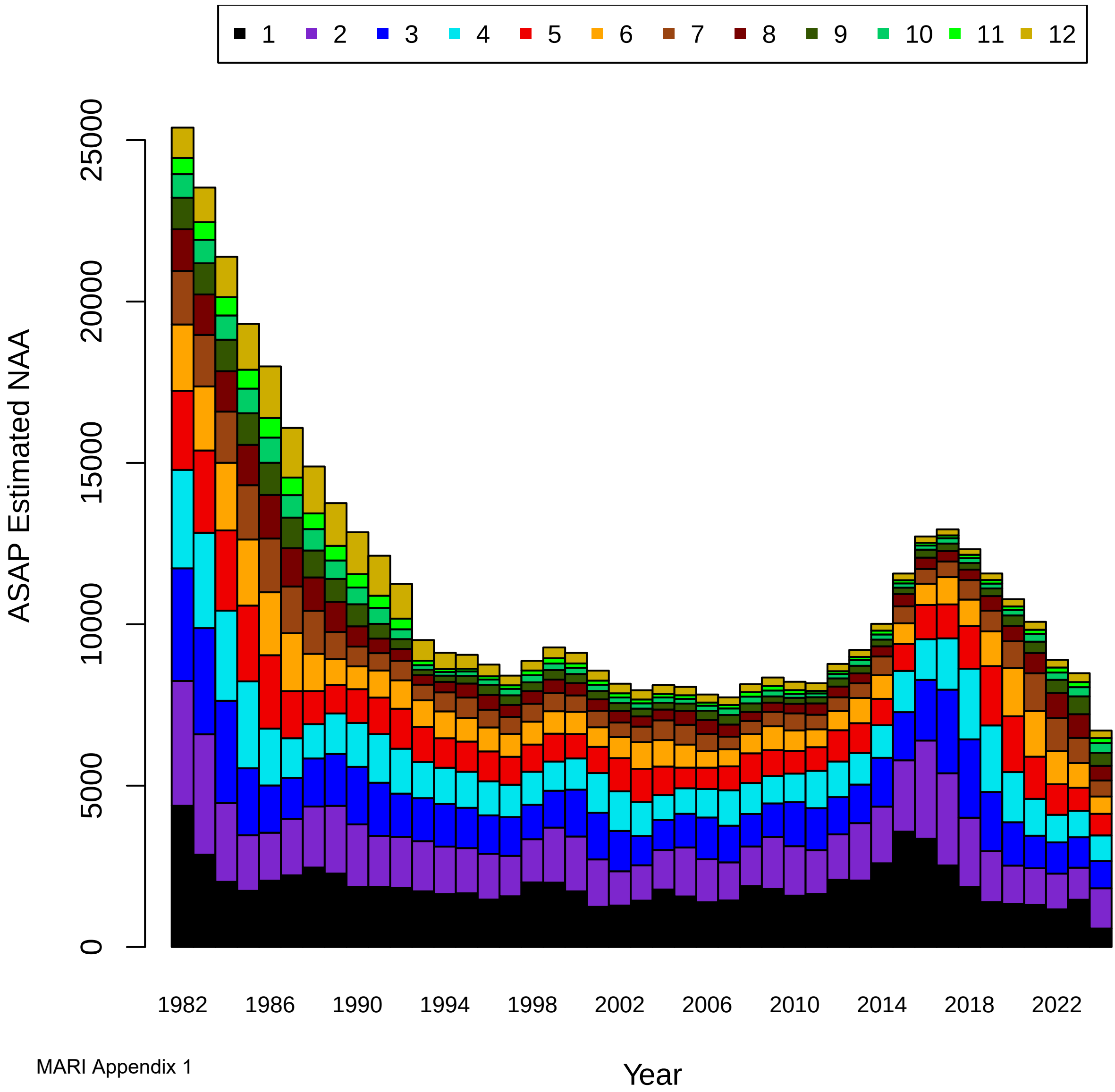
Comparison of January 1 Biomass
Total
SSB
Exploitable
Biomass
Year
0
5000
10000
15000
20000
25000
1990
2000
2010
2020

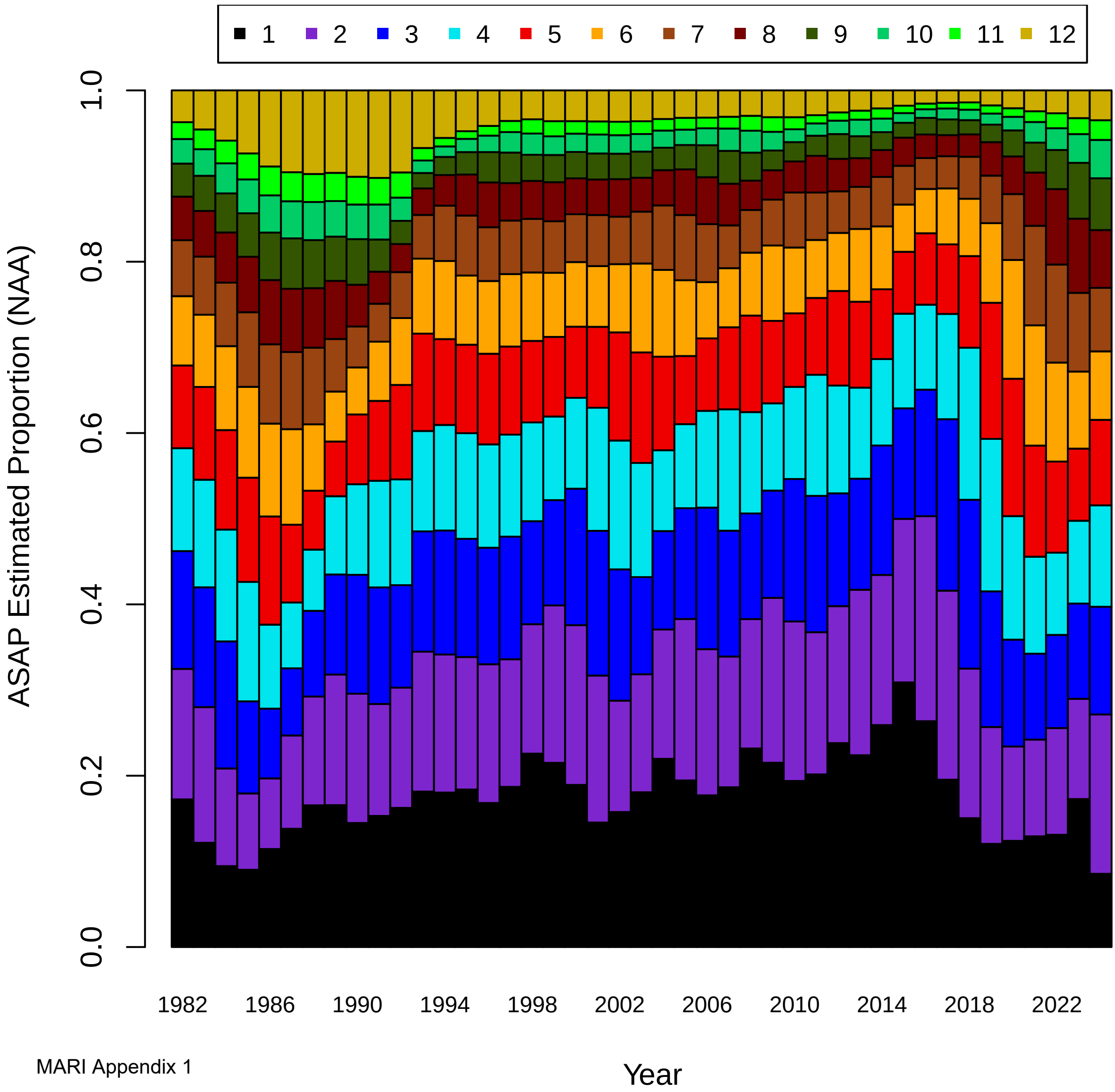


1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated SSB.AA
0
5000
10000
15000
20000
25000
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
Year

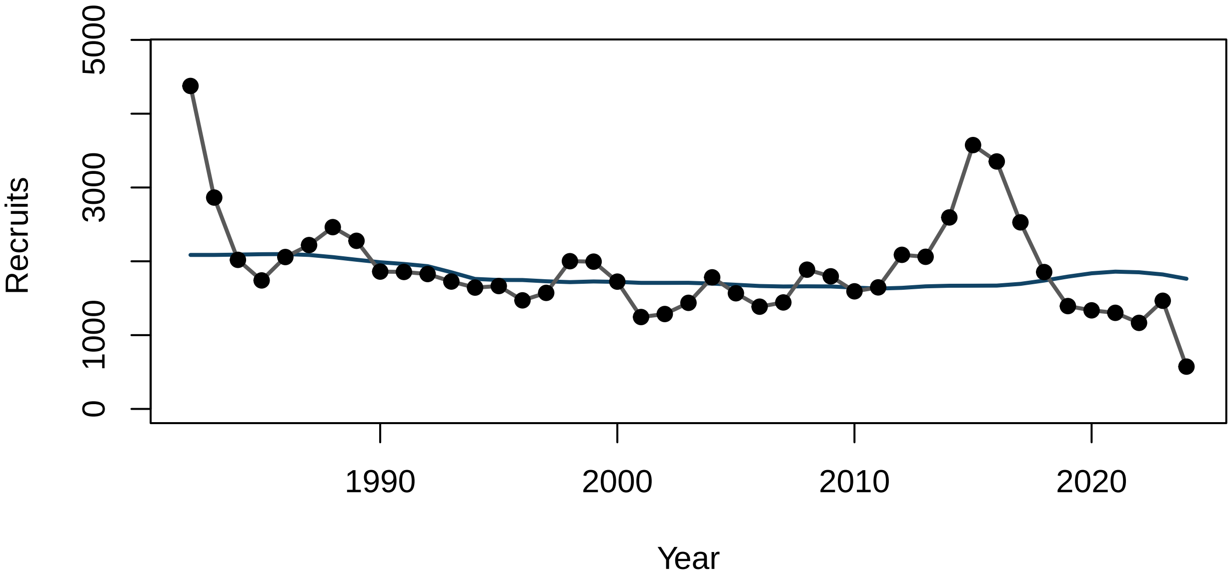


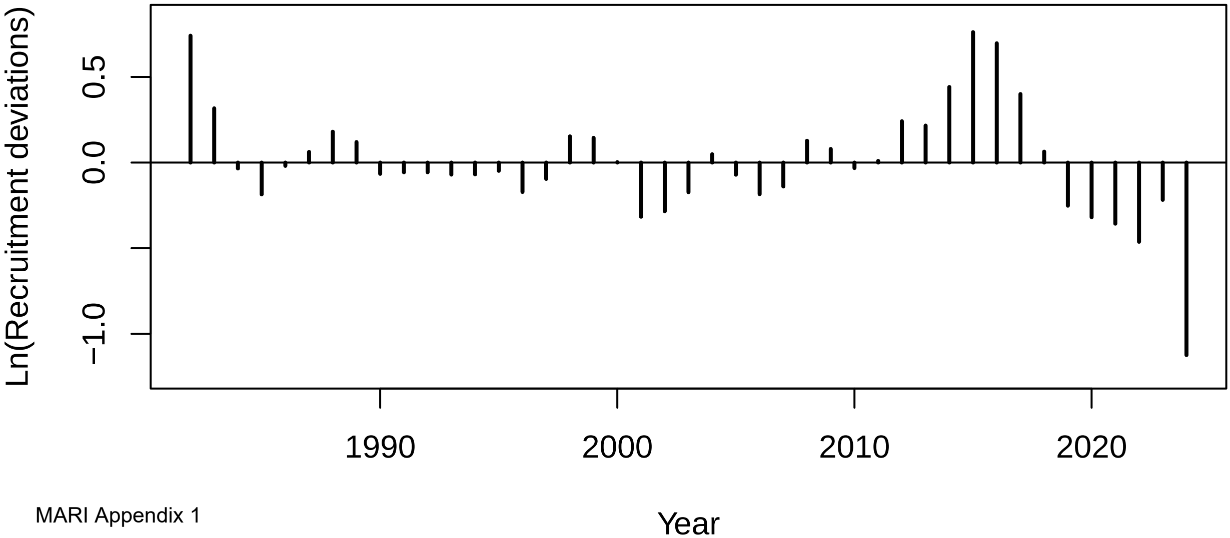
1 2 3 4 5 6 7 8 9 10 11 12
ASAP Estimated Proportion (SSB.AA)
0.0
0.2
0.4
0.6
0.8
1.0
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
Year

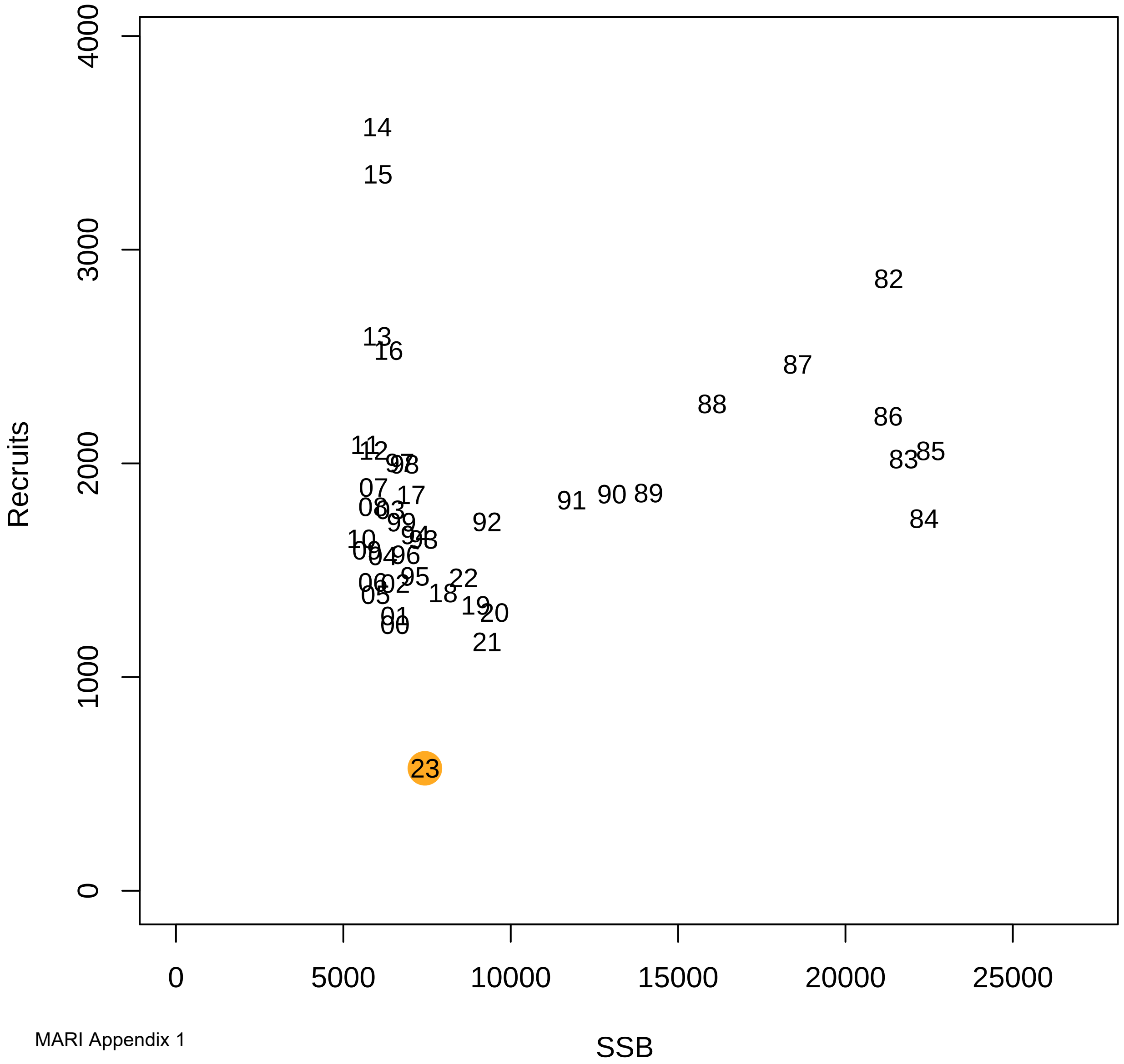

1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated NAA
0
5000
10000
15000
20000
25000
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
Year



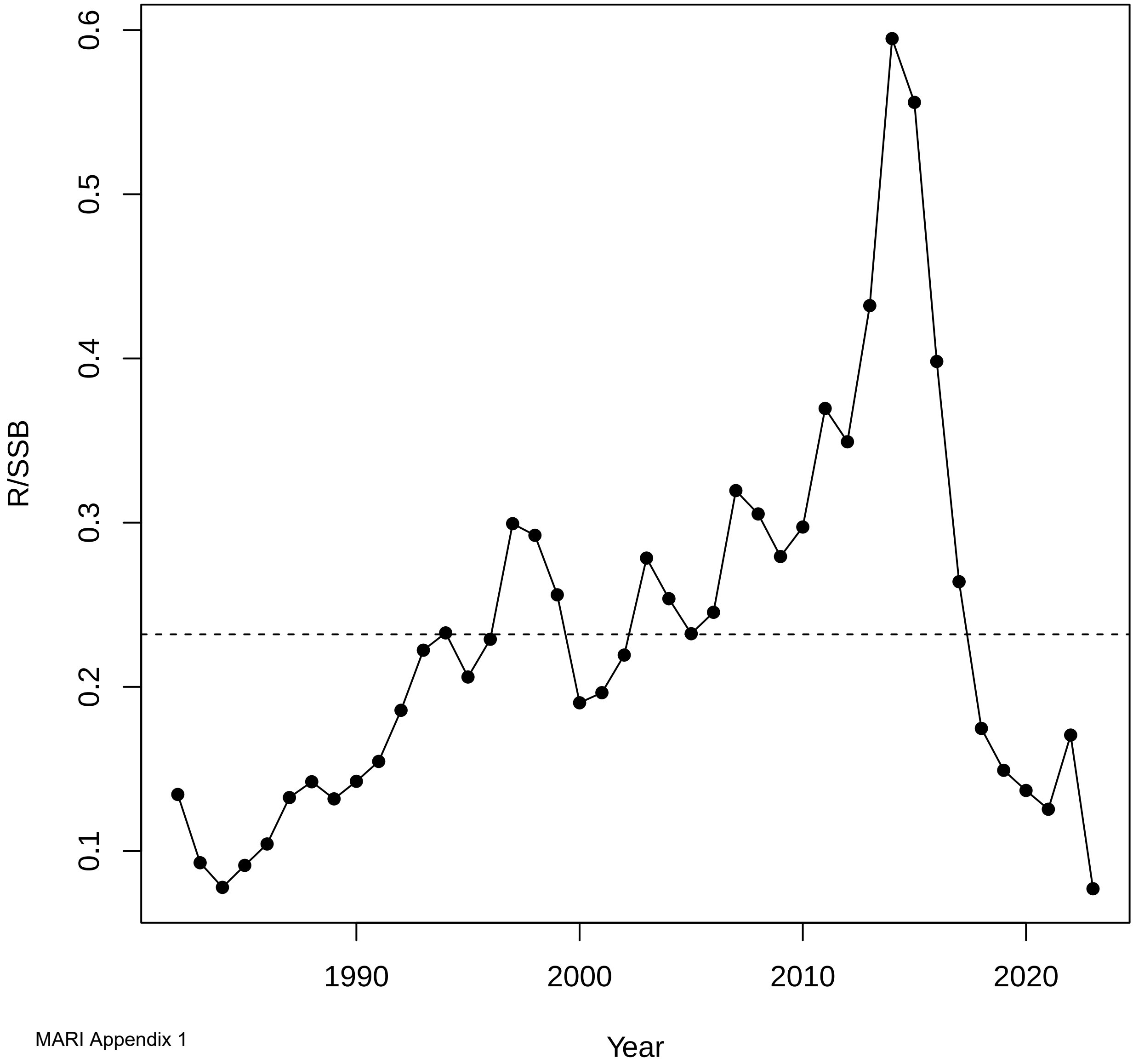
1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated Proportion (NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
Year

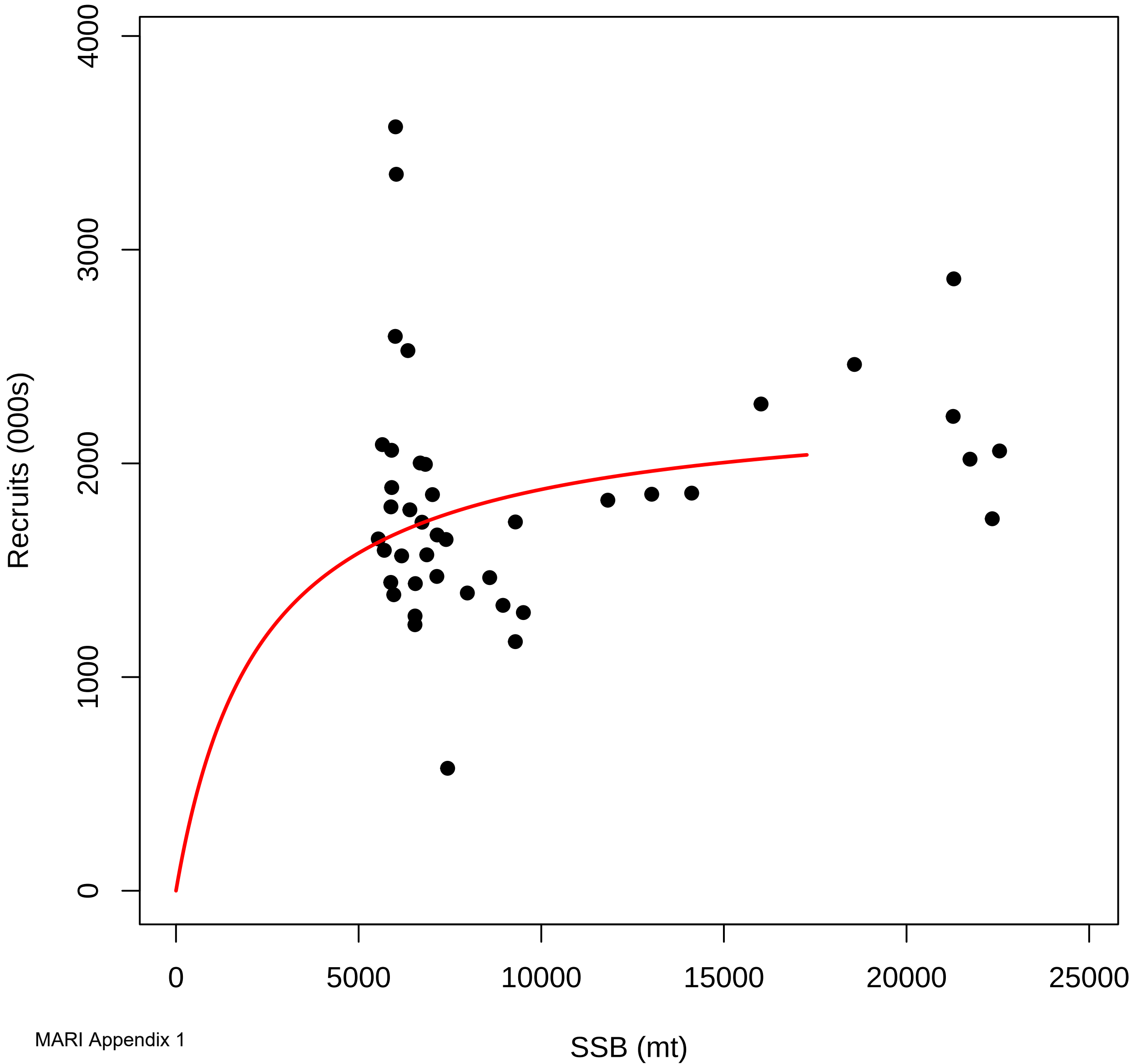

Recruits
0
1000
3000
5000
1990
2000
2010
2020
Year


Ln(Recruitment deviations)
−1.0
0.0
0.5
1990
2000
2010
2020
Year

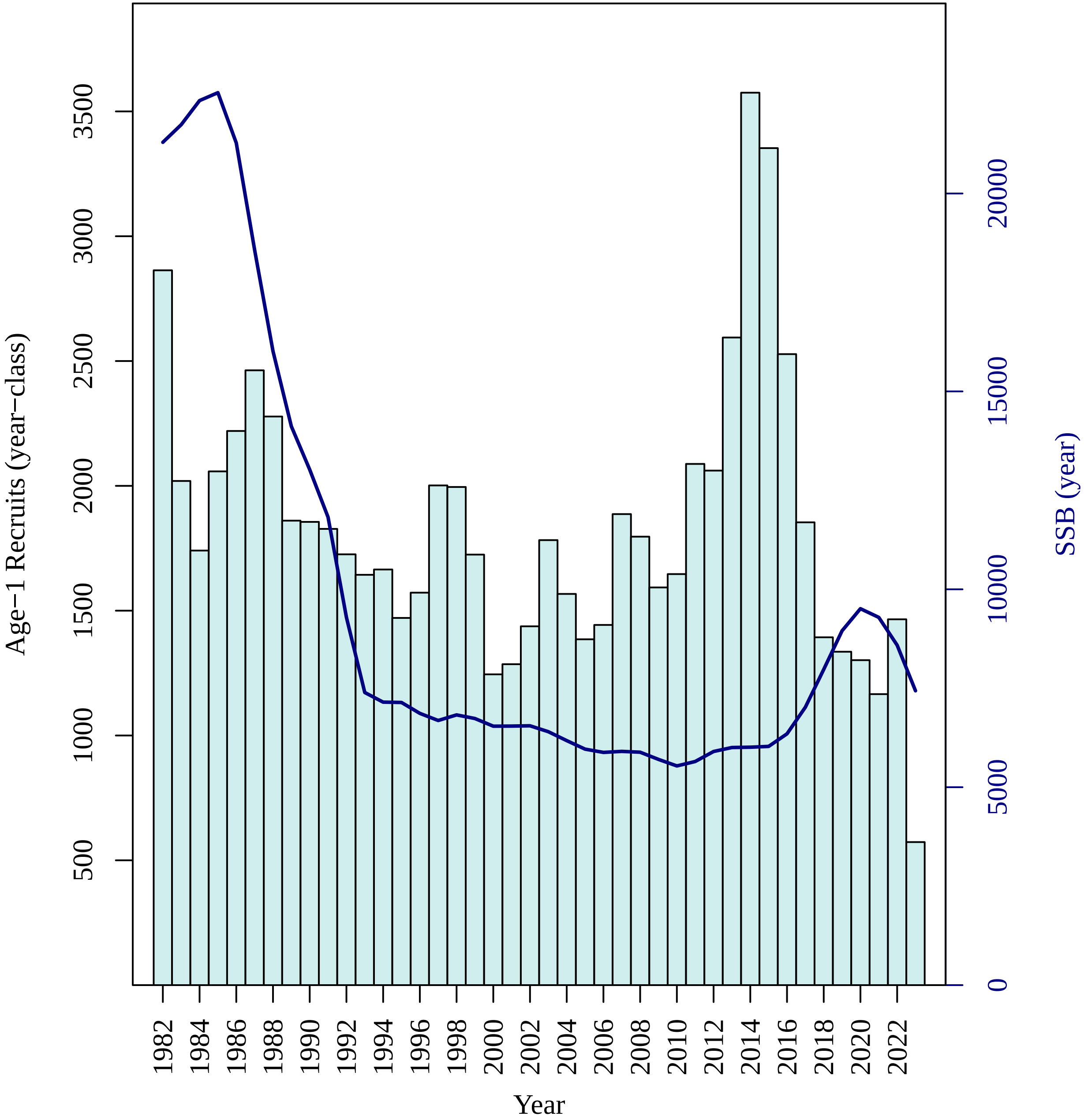


Recruits
SSB
0
1000
2000
3000
4000
0
5000
10000
15000
20000
25000
14
15
82
13
16
87
88
86
11
12
97
98
85
83
07
17
91
90
89
08
03
99
92
84
10
94
93
09
04
96
06
02
95
22
05
18
19
20
01
00
21
23

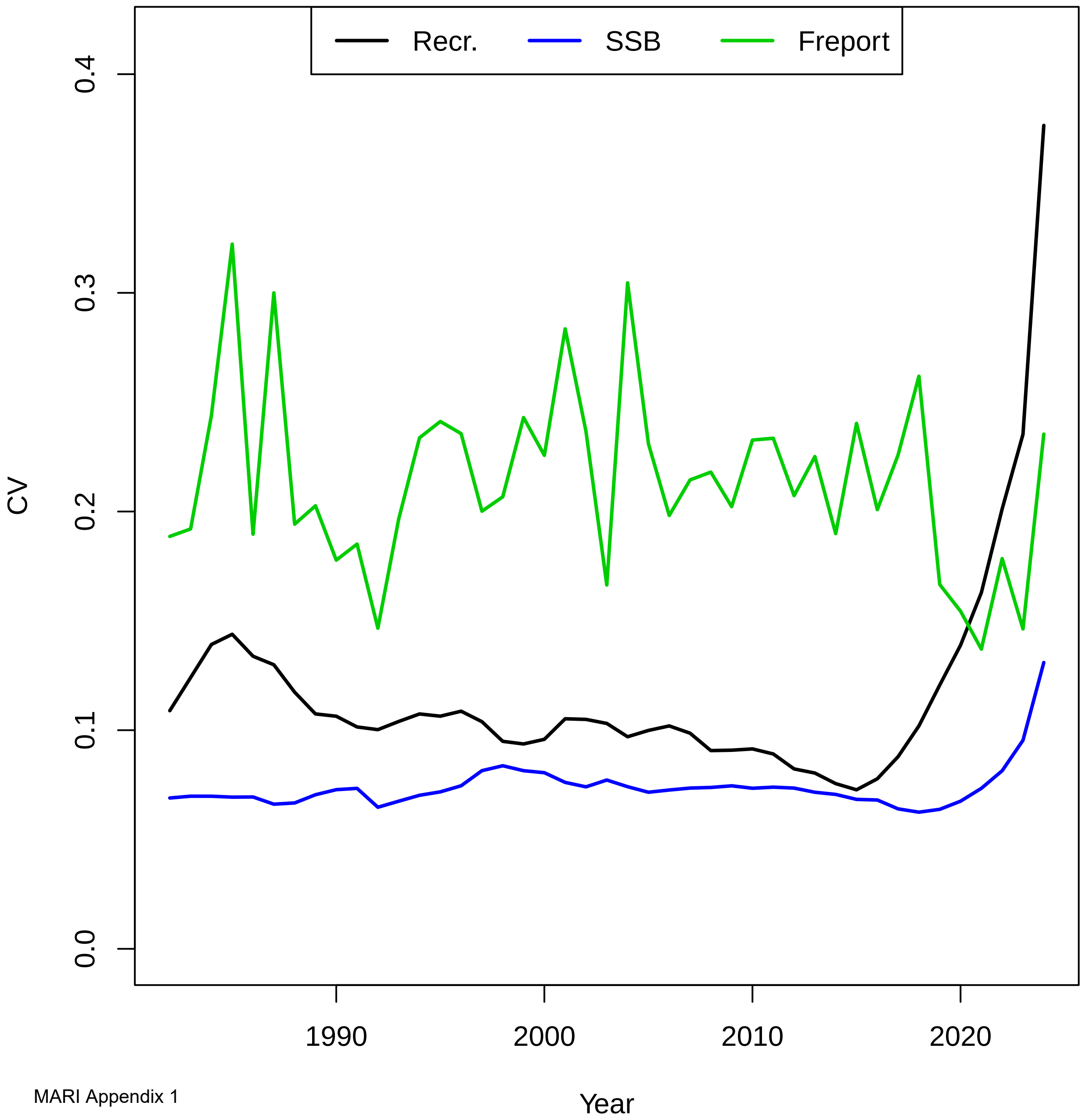

0.6
0.5
0.4
0.3
0.2
0.1
R/SSB
1990
2000
2010
2020
Year



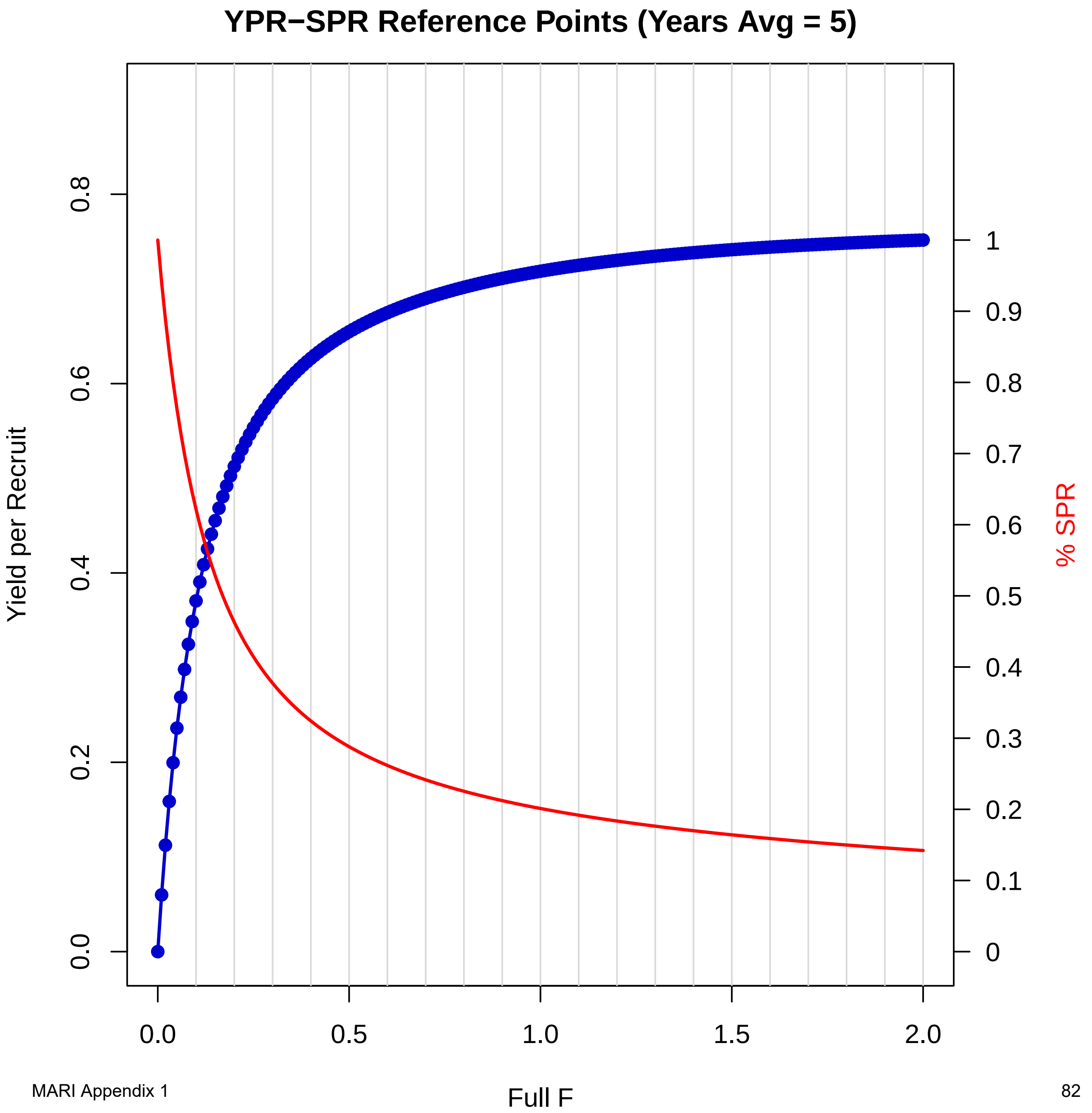
Recruits (000s)
0
1000
2000
3000
4000
0
5000
10000
15000
20000
25000
SSB (mt)



Age−1 Recruits (year−class)
500
1000
1500
2000
2500
3000
3500
SSB (year)
0
5000
10000
15000
20000
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Year



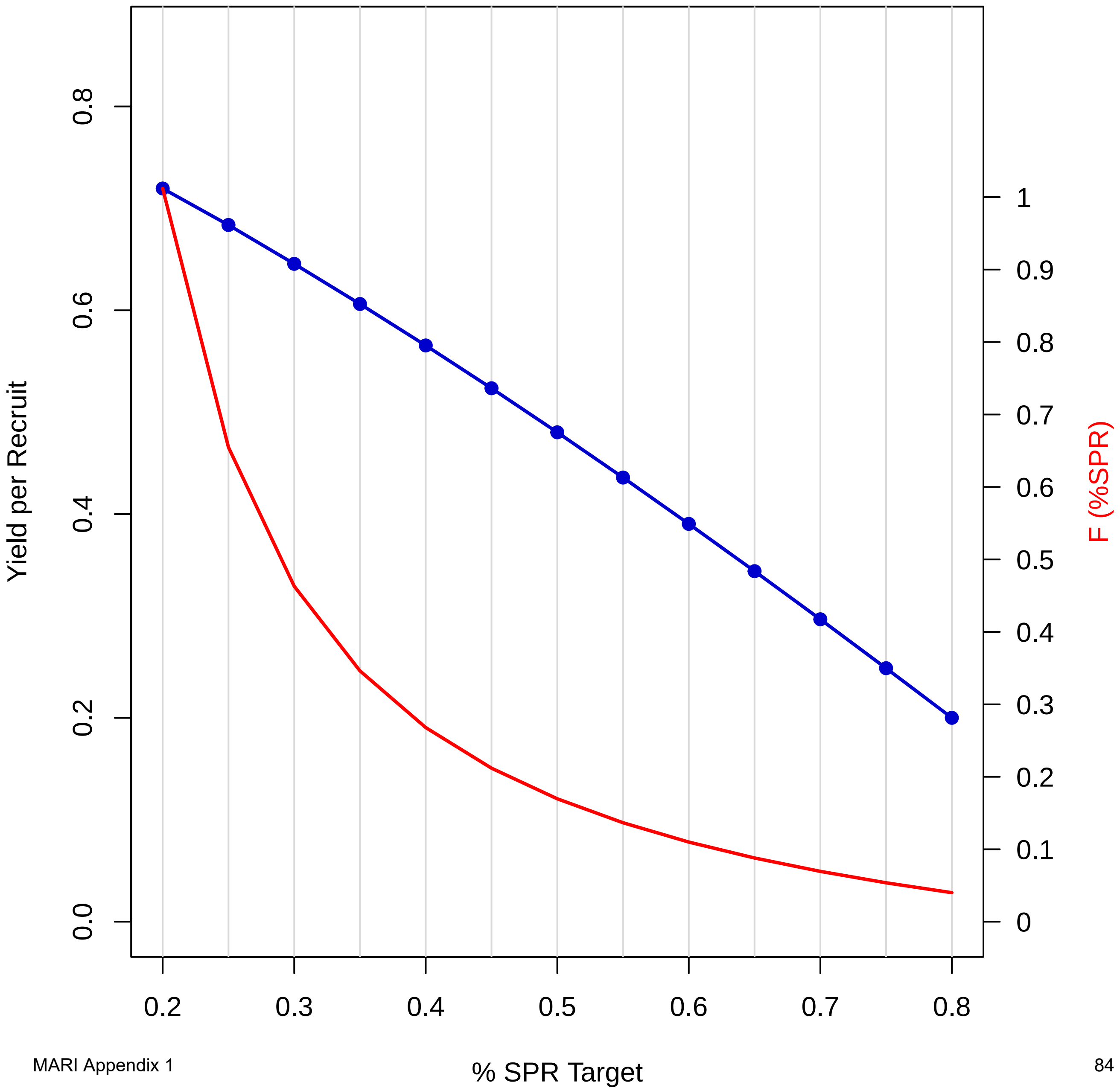
Recr.
SSB
Freport
0.0
0.1
0.2
0.3
0.4
CV
1990
2000
2010
2020
Year


YPR−SPR Reference Points (Years Avg = 5)
Yield per Recruit
% SPR
Full F
0.0
0.2
0.4
0.6
0.8
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.0
0.5
1.0
1.5
2.0

YPR−SPR Reference Points (Years Avg = 5)

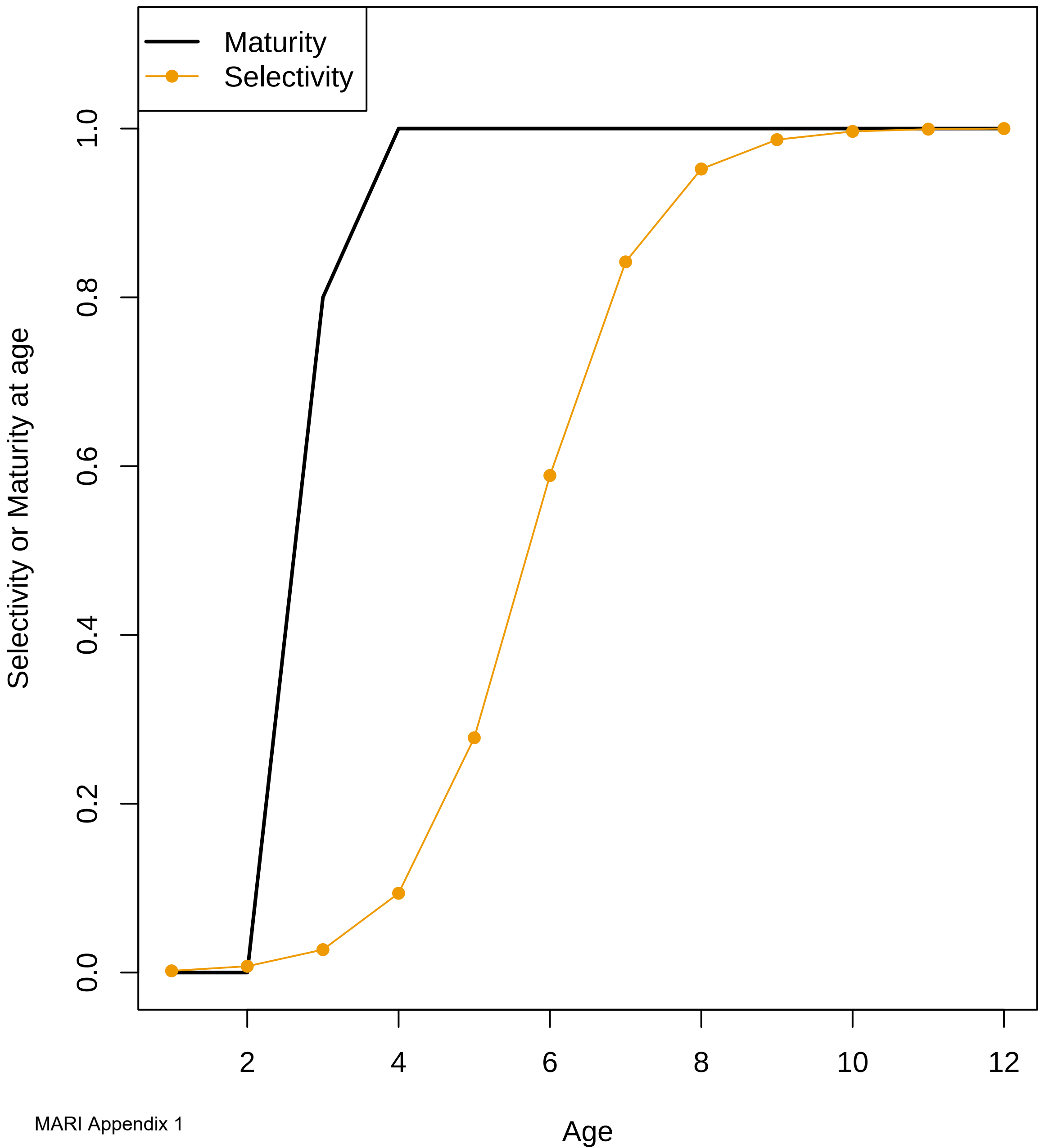
F	YPR	SPR	F	YPR	SPR	F	YPR	SPR
0	0	1	0.35	0.6078	0.348	0.7	0.69	0.2415
0.01	0.06	0.9409	0.36	0.6119	0.3429	0.71	0.6913	0.2397
0.02	0.1124	0.8886	0.37	0.6158	0.3379	0.72	0.6926	0.238
0.03	0.1586	0.8421	0.38	0.6196	0.3332	0.73	0.6938	0.2363
0.04	0.1996	0.8005	0.39	0.6232	0.3286	0.74	0.695	0.2346
0.05	0.2361	0.7631	0.4	0.6266	0.3242	0.75	0.6962	0.233
0.06	0.2687	0.7293	0.41	0.6299	0.32	0.76	0.6974	0.2314
0.07	0.2981	0.6986	0.42	0.6331	0.3159	0.77	0.6985	0.2299
0.08	0.3246	0.6706	0.43	0.6362	0.312	0.78	0.6996	0.2284
0.09	0.3487	0.645	0.44	0.6392	0.3082	0.79	0.7007	0.2269
0.1	0.3705	0.6215	0.45	0.642	0.3046	0.8	0.7017	0.2254
0.11	0.3905	0.5999	0.46	0.6448	0.3011	0.81	0.7028	0.224
0.12	0.4087	0.58	0.47	0.6474	0.2976	0.82	0.7038	0.2226
0.13	0.4255	0.5615	0.48	0.65	0.2943	0.83	0.7048	0.2212
0.14	0.4409	0.5443	0.49	0.6524	0.2911	0.84	0.7057	0.2198
0.15	0.4552	0.5284	0.5	0.6548	0.288	0.85	0.7067	0.2185
0.16	0.4684	0.5135	0.51	0.6571	0.285	0.86	0.7076	0.2172
0.17	0.4806	0.4996	0.52	0.6594	0.2821	0.87	0.7085	0.2159
0.18	0.492	0.4865	0.53	0.6615	0.2793	0.88	0.7094	0.2147
0.19	0.5026	0.4743	0.54	0.6636	0.2766	0.89	0.7102	0.2135
0.2	0.5125	0.4628	0.55	0.6656	0.2739	0.9	0.7111	0.2122
0.21	0.5218	0.452	0.56	0.6676	0.2713	0.91	0.7119	0.2111
0.22	0.5305	0.4418	0.57	0.6695	0.2688	0.92	0.7127	0.2099
0.23	0.5386	0.4322	0.58	0.6714	0.2664	0.93	0.7135	0.2087
0.24	0.5463	0.4231	0.59	0.6732	0.264	0.94	0.7143	0.2076
0.25	0.5535	0.4144	0.6	0.6749	0.2617	0.95	0.7151	0.2065
0.26	0.5603	0.4062	0.61	0.6766	0.2594	0.96	0.7158	0.2054
0.27	0.5667	0.3985	0.62	0.6783	0.2572	0.97	0.7166	0.2043
0.28	0.5728	0.3911	0.63	0.6799	0.2551	0.98	0.7173	0.2033
0.29	0.5786	0.384	0.64	0.6814	0.253	0.99	0.718	0.2022
0.3	0.5841	0.3773	0.65	0.683	0.251	1	0.7187	0.2012
0.31	0.5893	0.3709	0.66	0.6844	0.249	1.01	0.7194	0.2002
0.32	0.5943	0.3648	0.67	0.6859	0.247	1.02	0.72	0.1992
0.33	0.599	0.359	0.68	0.6873	0.2451	1.03	0.7207	0.1982
0.34	0.6035	0.3534	0.69	0.6887	0.2433	1.04	0.7213	0.1973

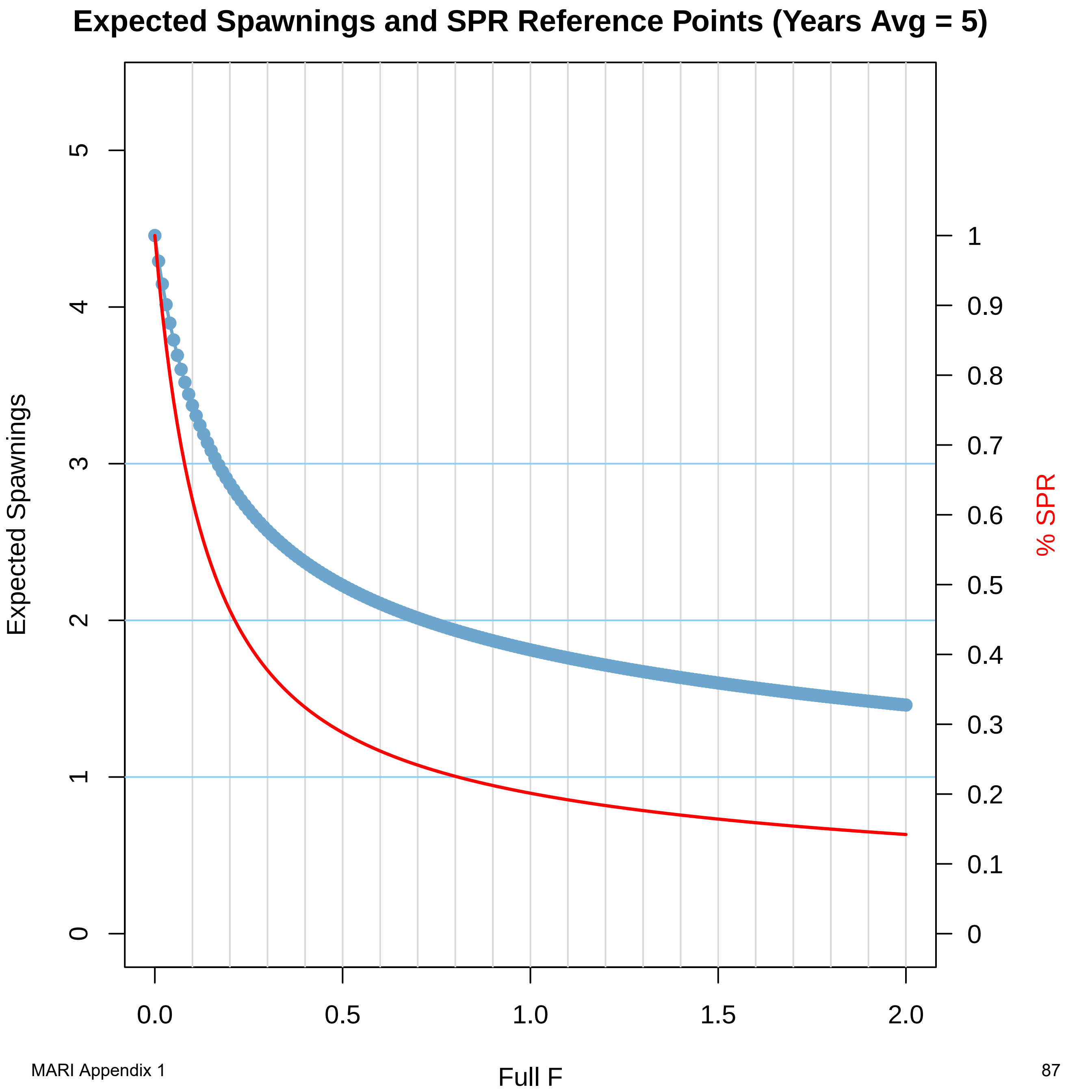
SPR Target Reference Points (Years Avg = 5)



SPR Target Reference Points (Years Avg = 5)

% SPR	F(%SPR)	YPR
0.2	1.0119	0.7195
0.25	0.6548	0.6837
0.3	0.4631	0.6456
0.35	0.3462	0.6062
0.4	0.268	0.5655
0.45	0.2119	0.5235
0.5	0.1697	0.4802
0.55	0.1366	0.4358
0.6	0.11	0.3904
0.65	0.088	0.344
0.7	0.0695	0.2968
0.75	0.0538	0.2488
0.8	0.0401	0.2001

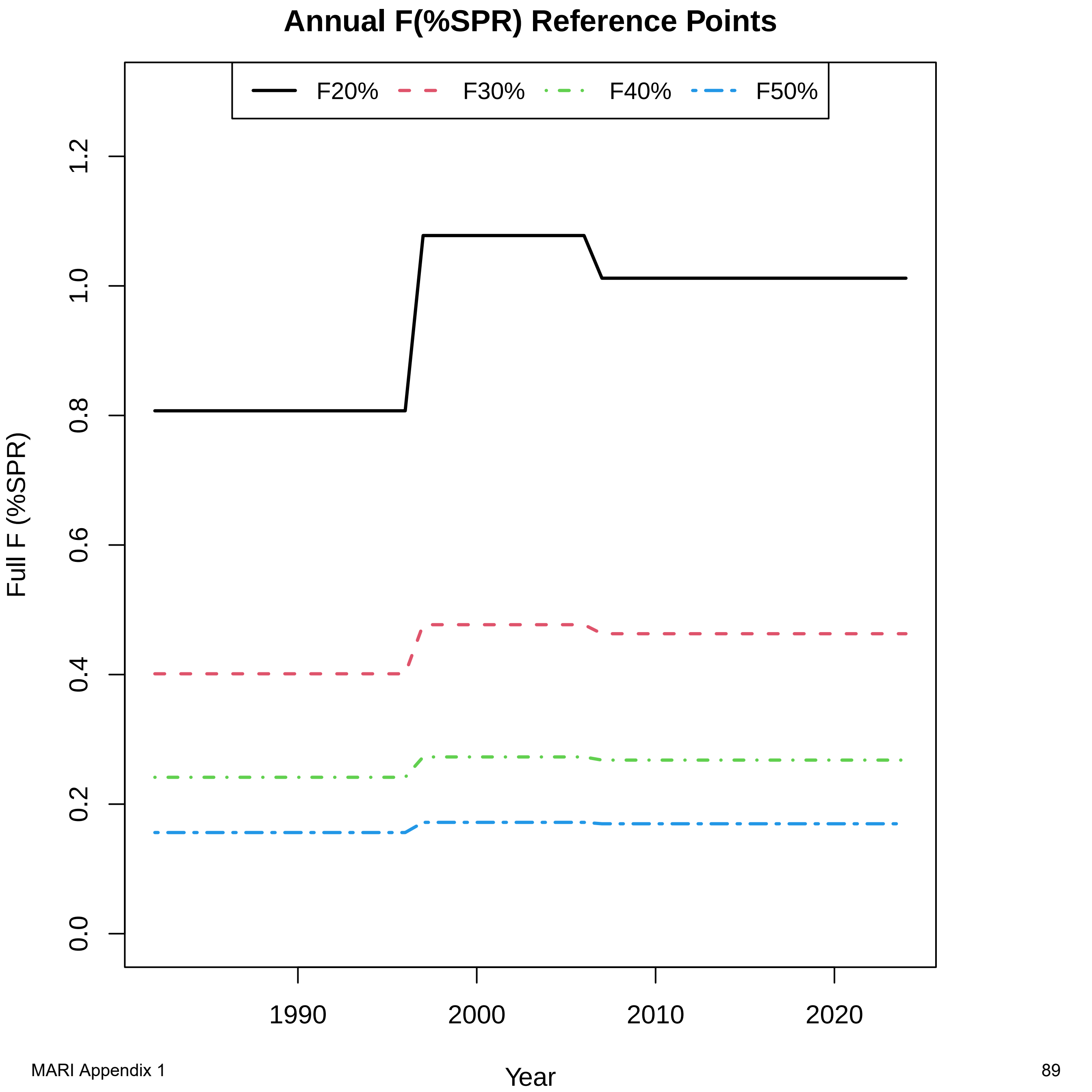

Maturity
Selectivity
Selectivity or Maturity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
Age



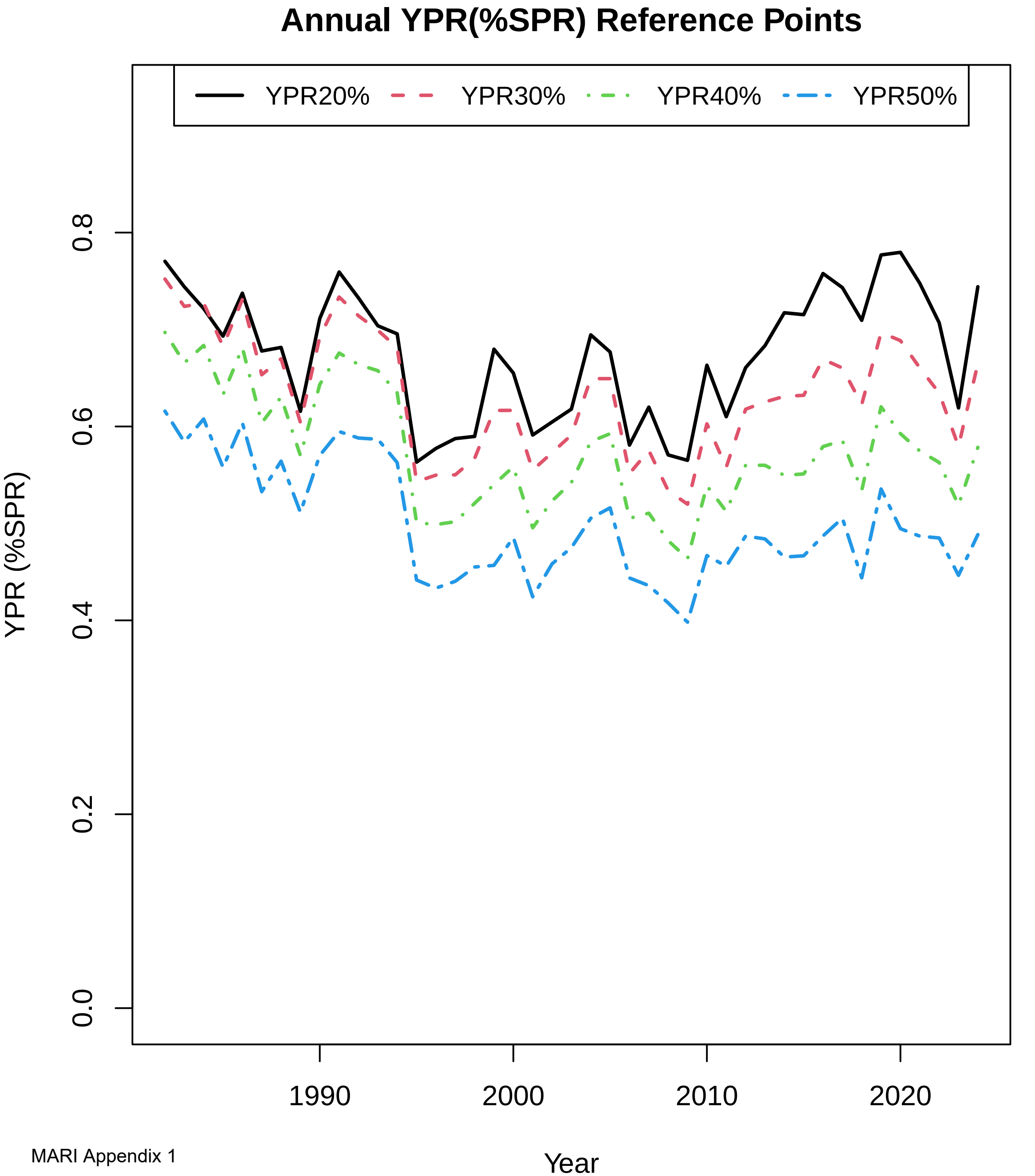
Expected Spawnings and SPR Reference Points (Years Avg = 5)
Expected Spawnings
% SPR
Full F
0
1
2
3
4
5
0.0
0.5
1.0
1.5
2.0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Expected Spawnings & SPR Reference Points (Years Avg = 5)

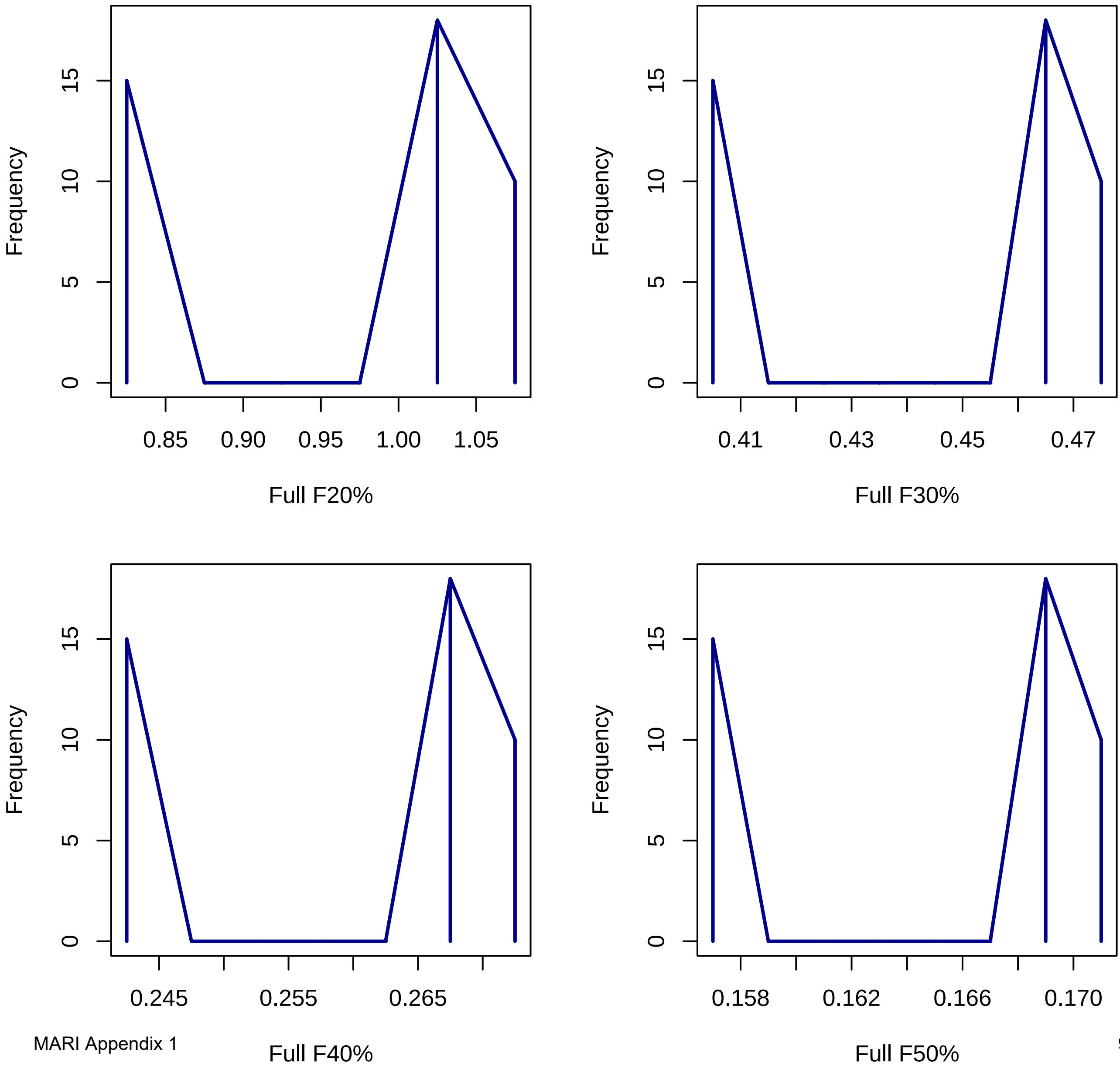
F	E[Sp]	SPR	F	E[Sp]	SPR	F	E[Sp]	SPR
0	4.4562	1	0.35	2.4634	0.348	0.7	2.0144	0.2415
0.01	4.2924	0.9409	0.36	2.4437	0.3429	0.71	2.006	0.2397
0.02	4.1464	0.8886	0.37	2.4247	0.3379	0.72	1.9978	0.238
0.03	4.0154	0.8421	0.38	2.4063	0.3332	0.73	1.9896	0.2363
0.04	3.897	0.8005	0.39	2.3885	0.3286	0.74	1.9817	0.2346
0.05	3.7896	0.7631	0.4	2.3712	0.3242	0.75	1.9738	0.233
0.06	3.6915	0.7293	0.41	2.3545	0.32	0.76	1.9661	0.2314
0.07	3.6017	0.6986	0.42	2.3382	0.3159	0.77	1.9585	0.2299
0.08	3.5191	0.6706	0.43	2.3224	0.312	0.78	1.951	0.2284
0.09	3.4427	0.645	0.44	2.307	0.3082	0.79	1.9437	0.2269
0.1	3.372	0.6215	0.45	2.2921	0.3046	0.8	1.9364	0.2254
0.11	3.3062	0.5999	0.46	2.2776	0.3011	0.81	1.9293	0.224
0.12	3.2449	0.58	0.47	2.2634	0.2976	0.82	1.9223	0.2226
0.13	3.1875	0.5615	0.48	2.2496	0.2943	0.83	1.9154	0.2212
0.14	3.1338	0.5443	0.49	2.2362	0.2911	0.84	1.9086	0.2198
0.15	3.0833	0.5284	0.5	2.2231	0.288	0.85	1.9019	0.2185
0.16	3.0357	0.5135	0.51	2.2103	0.285	0.86	1.8953	0.2172
0.17	2.9909	0.4996	0.52	2.1979	0.2821	0.87	1.8887	0.2159
0.18	2.9484	0.4865	0.53	2.1857	0.2793	0.88	1.8823	0.2147
0.19	2.9082	0.4743	0.54	2.1738	0.2766	0.89	1.876	0.2135
0.2	2.8701	0.4628	0.55	2.1622	0.2739	0.9	1.8697	0.2122
0.21	2.8339	0.452	0.56	2.1508	0.2713	0.91	1.8636	0.2111
0.22	2.7994	0.4418	0.57	2.1397	0.2688	0.92	1.8575	0.2099
0.23	2.7665	0.4322	0.58	2.1289	0.2664	0.93	1.8515	0.2087
0.24	2.7351	0.4231	0.59	2.1182	0.264	0.94	1.8456	0.2076
0.25	2.7051	0.4144	0.6	2.1078	0.2617	0.95	1.8398	0.2065
0.26	2.6763	0.4062	0.61	2.0976	0.2594	0.96	1.834	0.2054
0.27	2.6488	0.3985	0.62	2.0877	0.2572	0.97	1.8283	0.2043
0.28	2.6224	0.3911	0.63	2.0779	0.2551	0.98	1.8227	0.2033
0.29	2.597	0.384	0.64	2.0683	0.253	0.99	1.8171	0.2022
0.3	2.5726	0.3773	0.65	2.0589	0.251	1	1.8117	0.2012
0.31	2.5491	0.3709	0.66	2.0497	0.249	1.01	1.8063	0.2002
0.32	2.5265	0.3648	0.67	2.0406	0.247	1.02	1.8009	0.1992
0.33	2.5047	0.359	0.68	2.0317	0.2451	1.03	1.7956	0.1982
0.34	2.4837	0.3534	0.69	2.023	0.2433	1.04	1.7904	0.1973

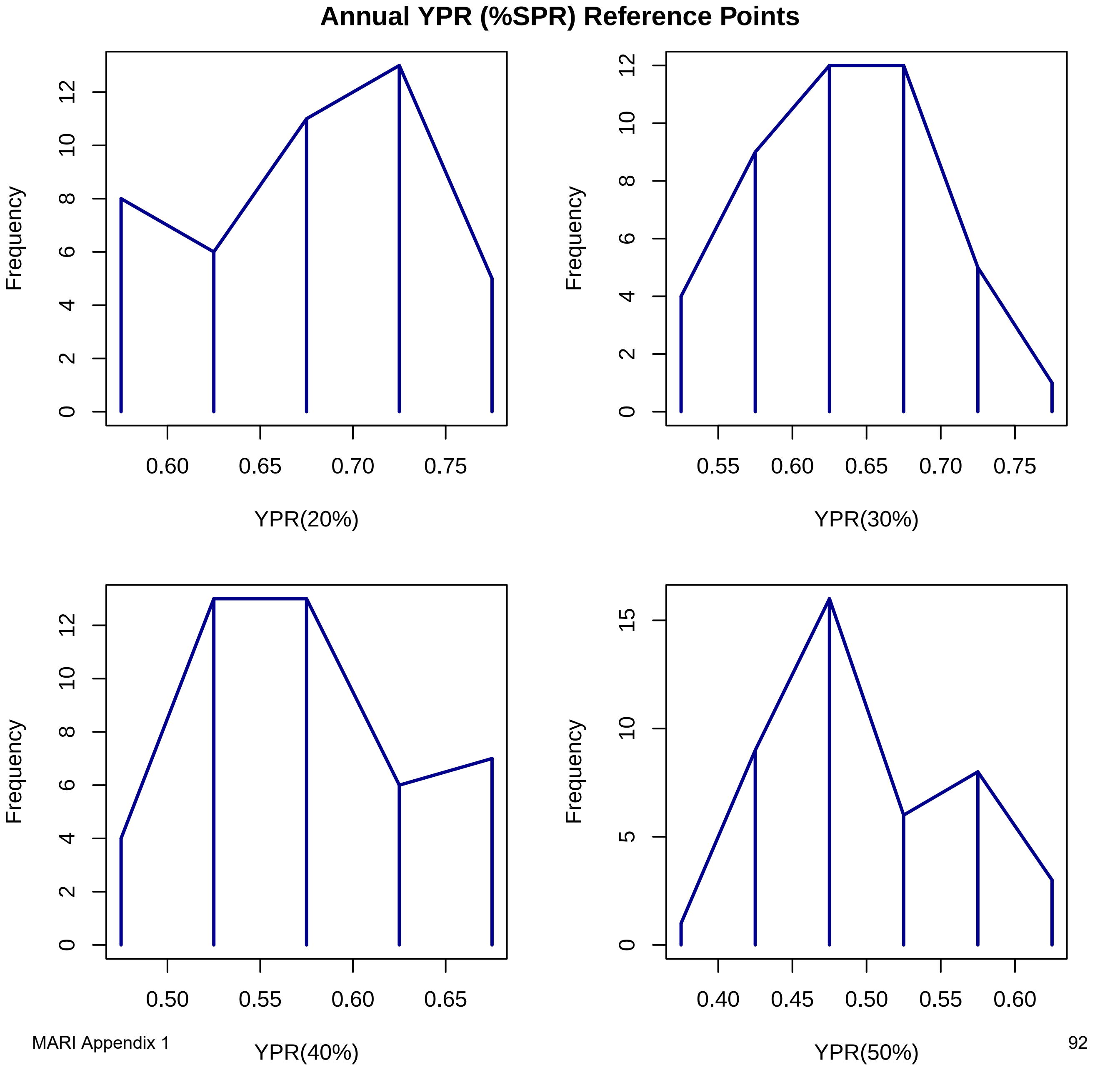


Annual F(%SPR) Reference Points
F20%
F30%
F40%
F50%
Full F (%SPR)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1990
2000
2010
2020
Year

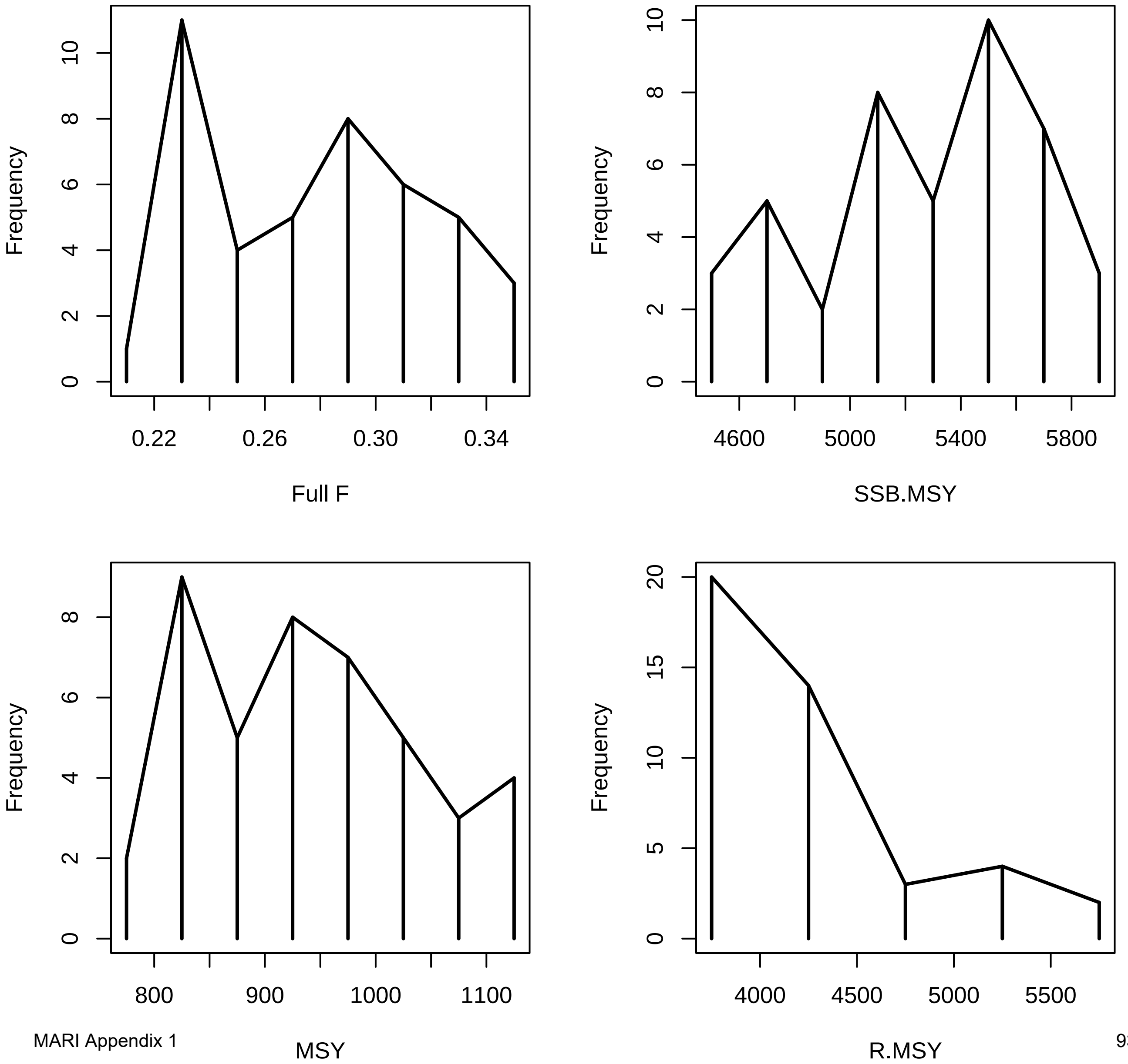

Annual YPR(%SPR) Reference Points
YPR20%
YPR30%
YPR40%
YPR50%
YPR (%SPR)
0.0
0.2
0.4
0.6
0.8
1990
2000
2010
2020
Year

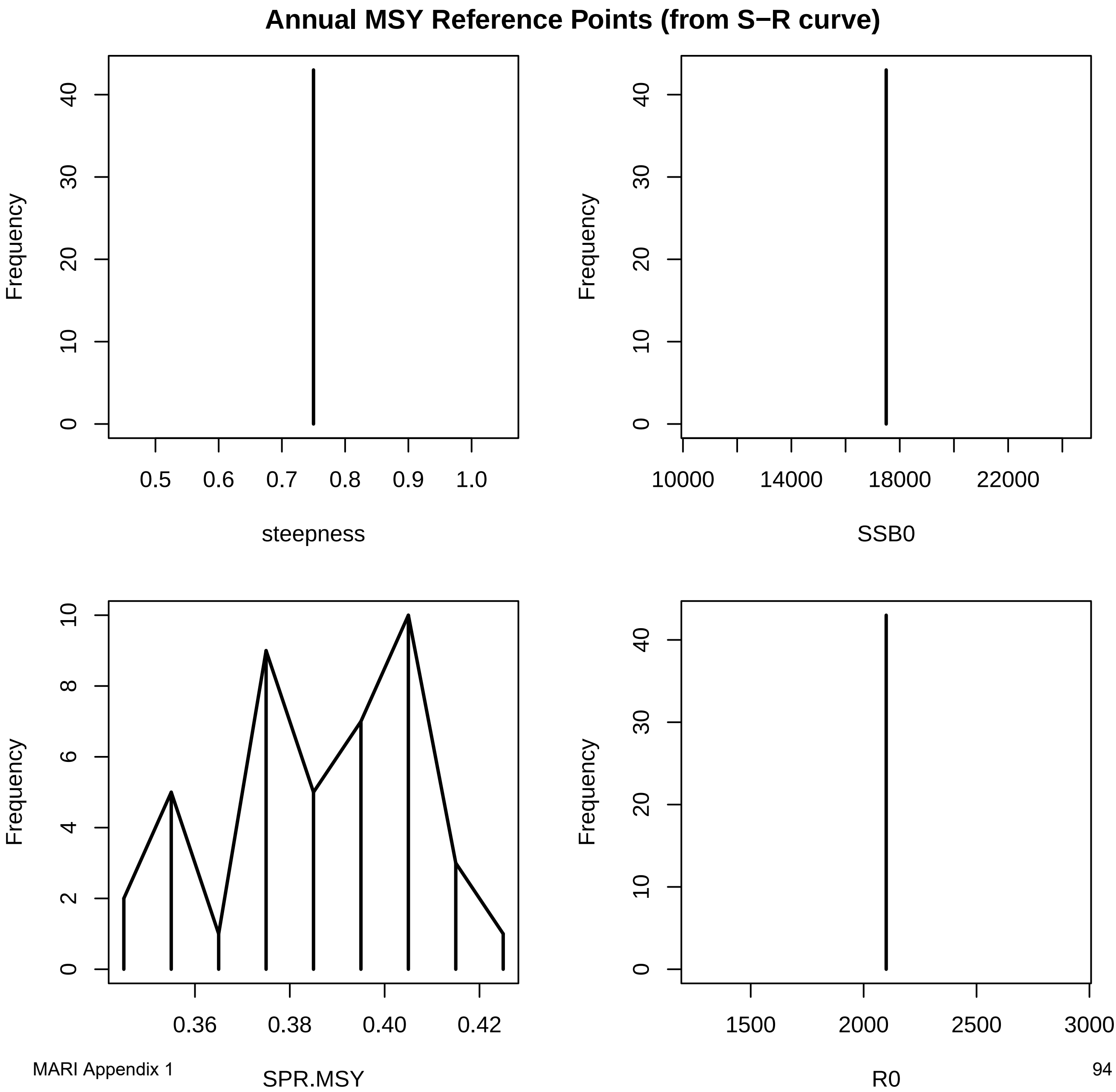
Annual F (%SPR) Reference Points

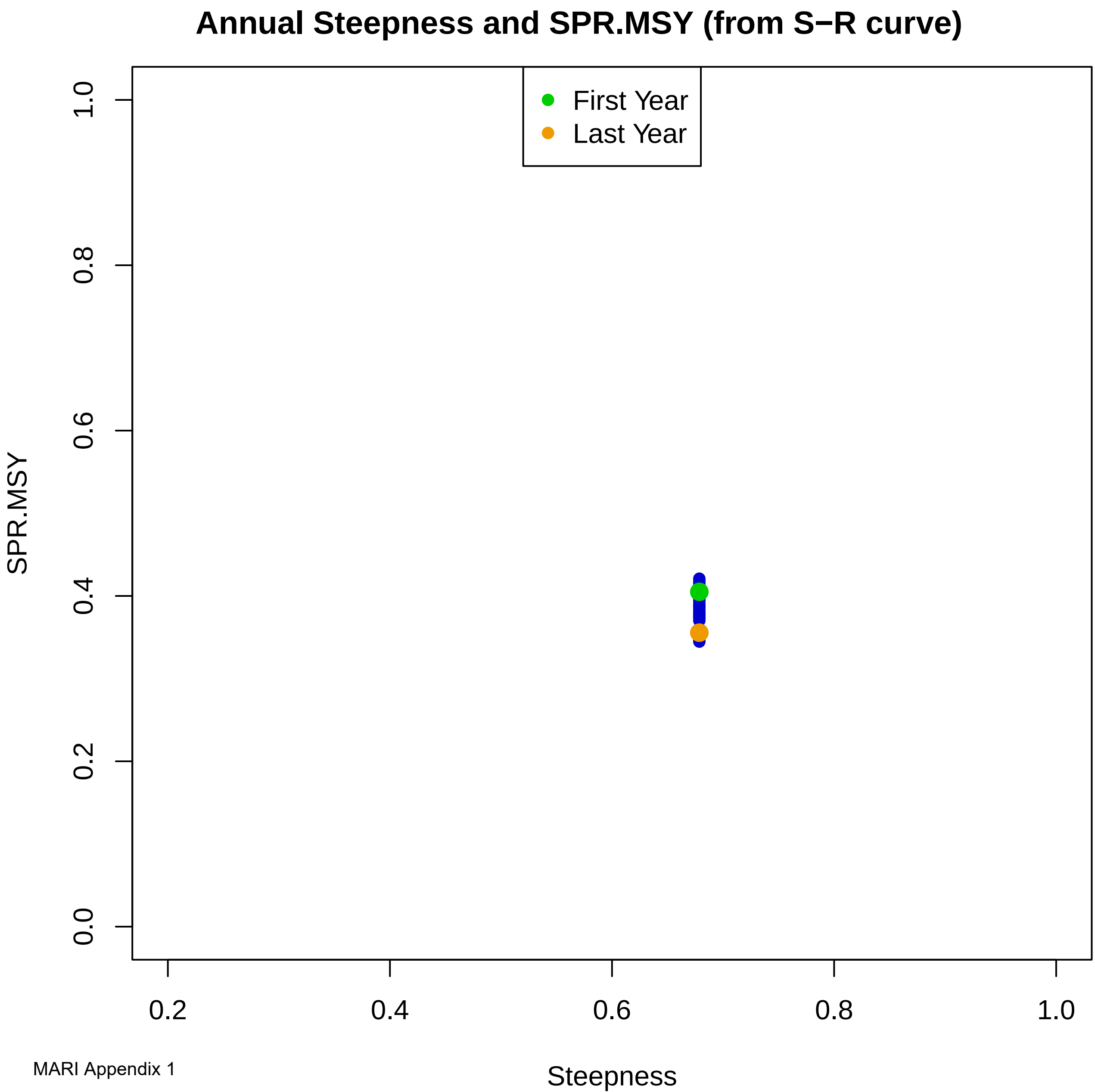


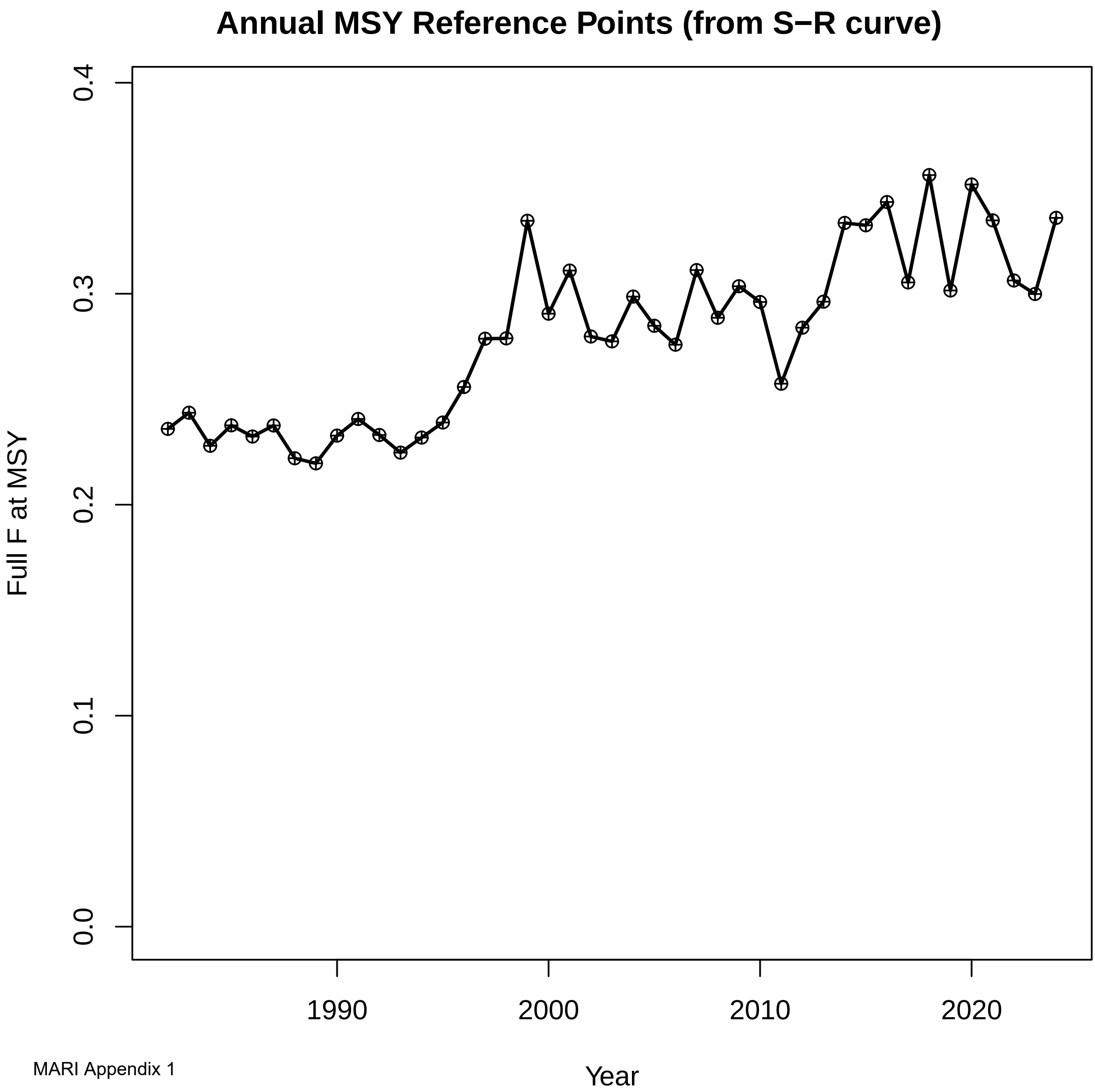

Annual YPR (%SPR) Reference Points
Frequency
0
2
4
6
8
10
12
0.60
0.65
0.70
0.75
YPR(20%)
0.55
0.60
0.65
0.70
0.75
YPR(30%)
0.50
0.55
0.60
0.65
YPR(40%)
0
5
10
15
0.40
0.45
0.50
0.55
0.60
YPR(50%)

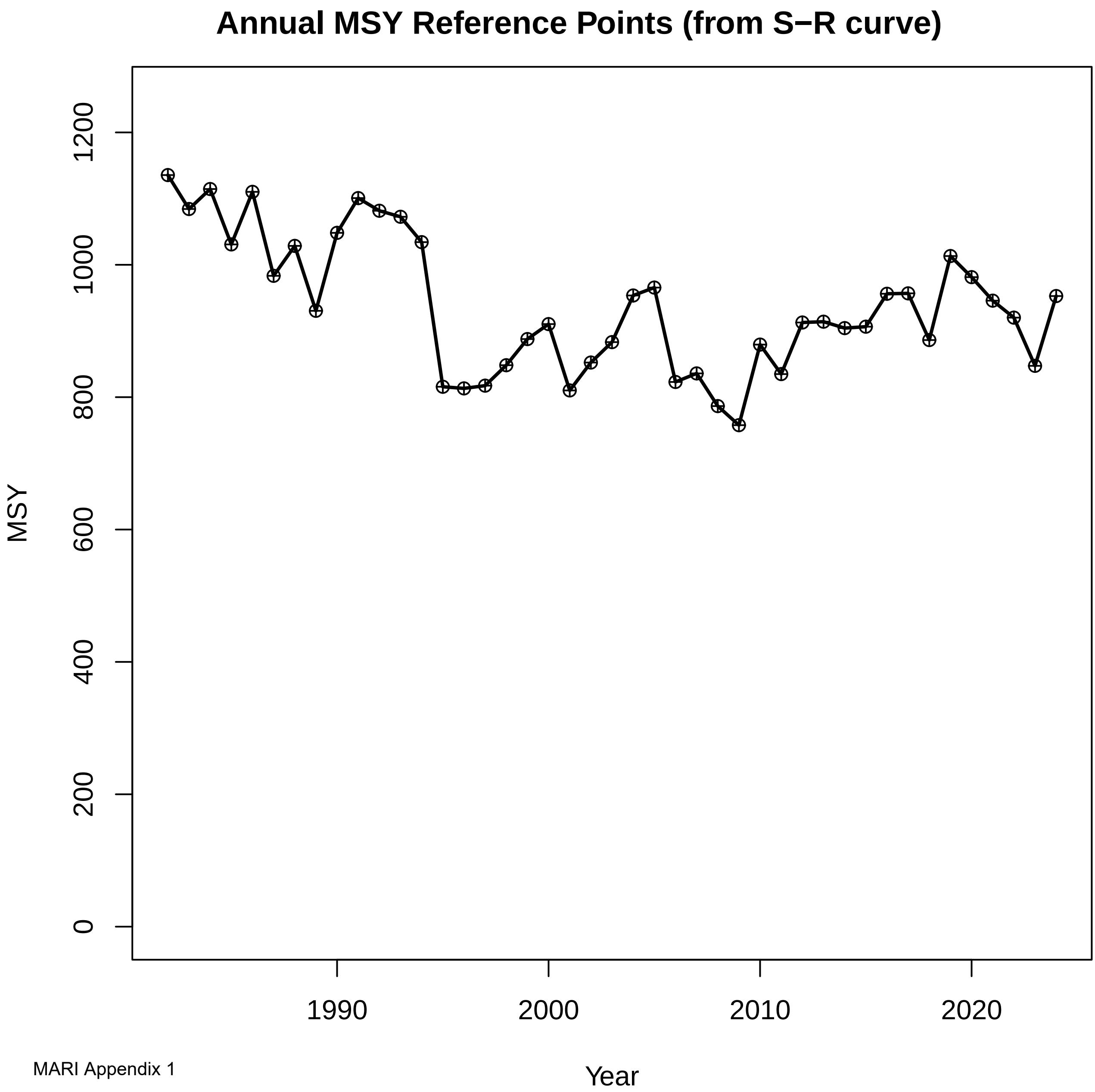
Annual MSY Reference Points (from S−R curve)

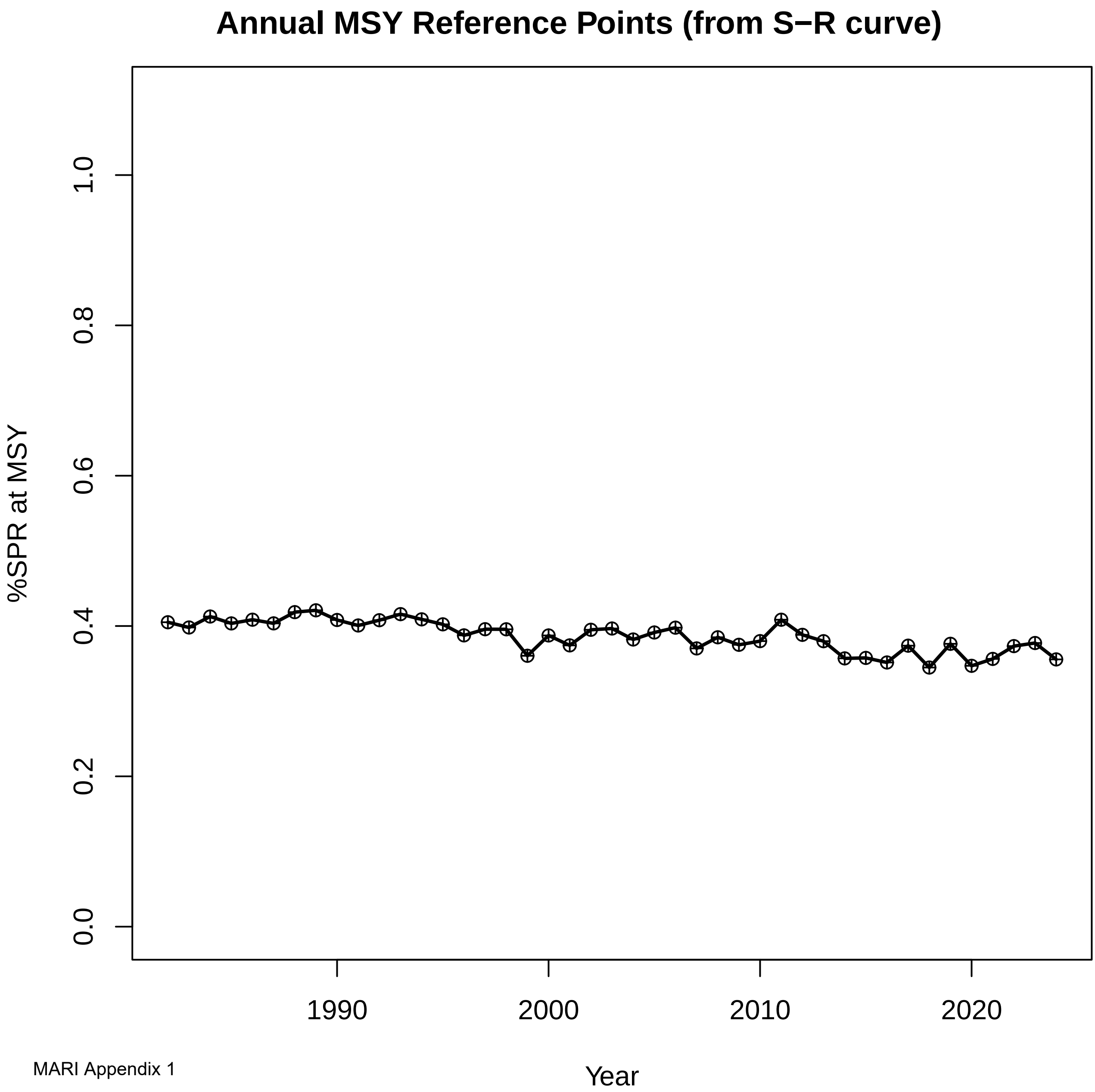



Annual MSY Reference Points (from S−R curve)
Frequency
0
10
20
30
40
0.5
0.6
0.7
0.8
0.9
1.0
steepness
Frequency
0
10
20
30
40
10000
14000
18000
22000
SSB0
Frequency
0
2
4
6
8
10
0.36
0.38
0.40
0.42
SPR.MSY
Frequency
0
10
20
30
40
1500
2000
2500
3000
R0

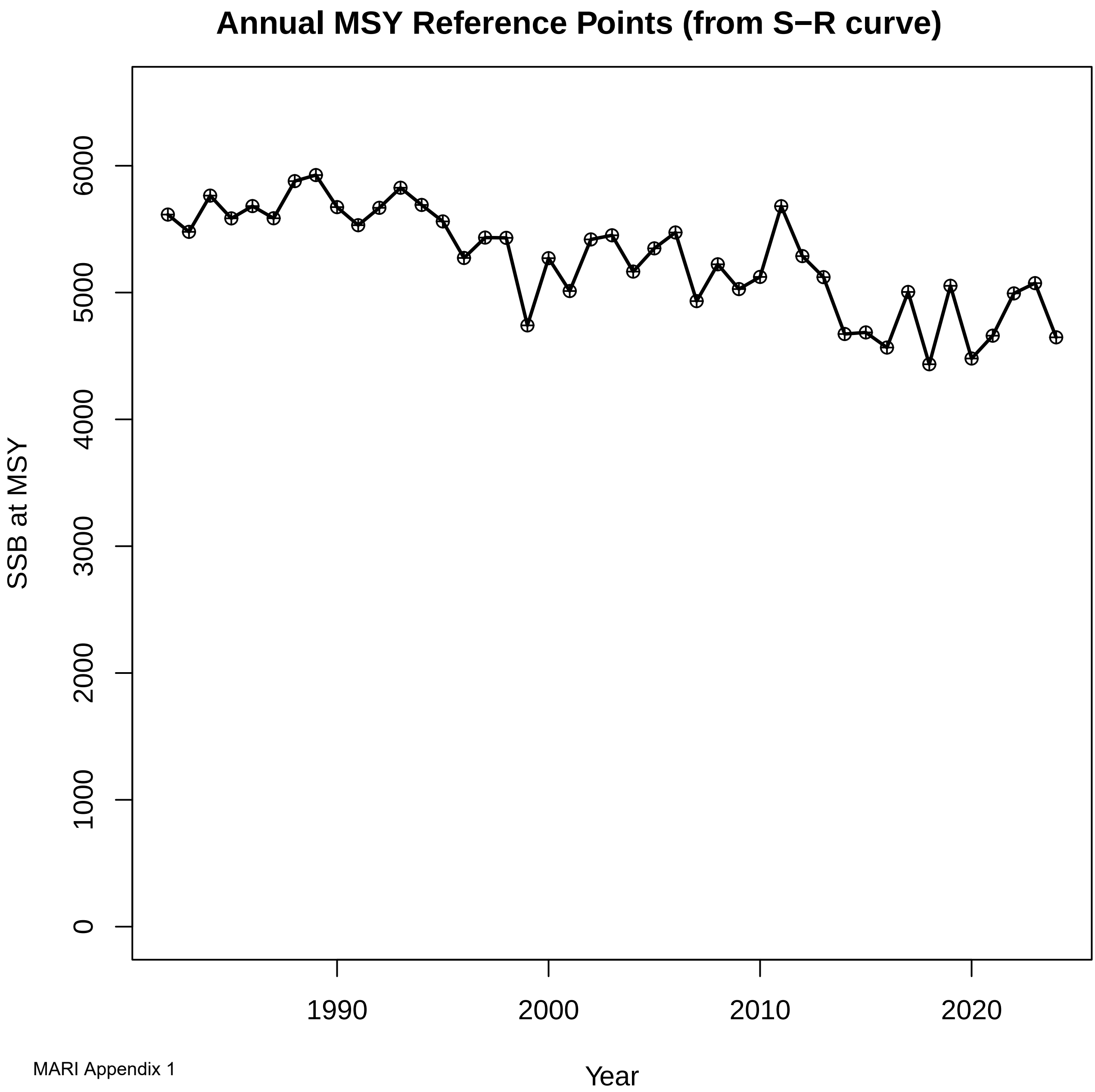

Annual Steepness and SPR.MSY (from S−R curve)
First Year
Last Year
SPR.MSY
0.0
0.2
0.4
0.6
0.8
1.0
Steepness
0.2
0.4
0.6
0.8
1.0

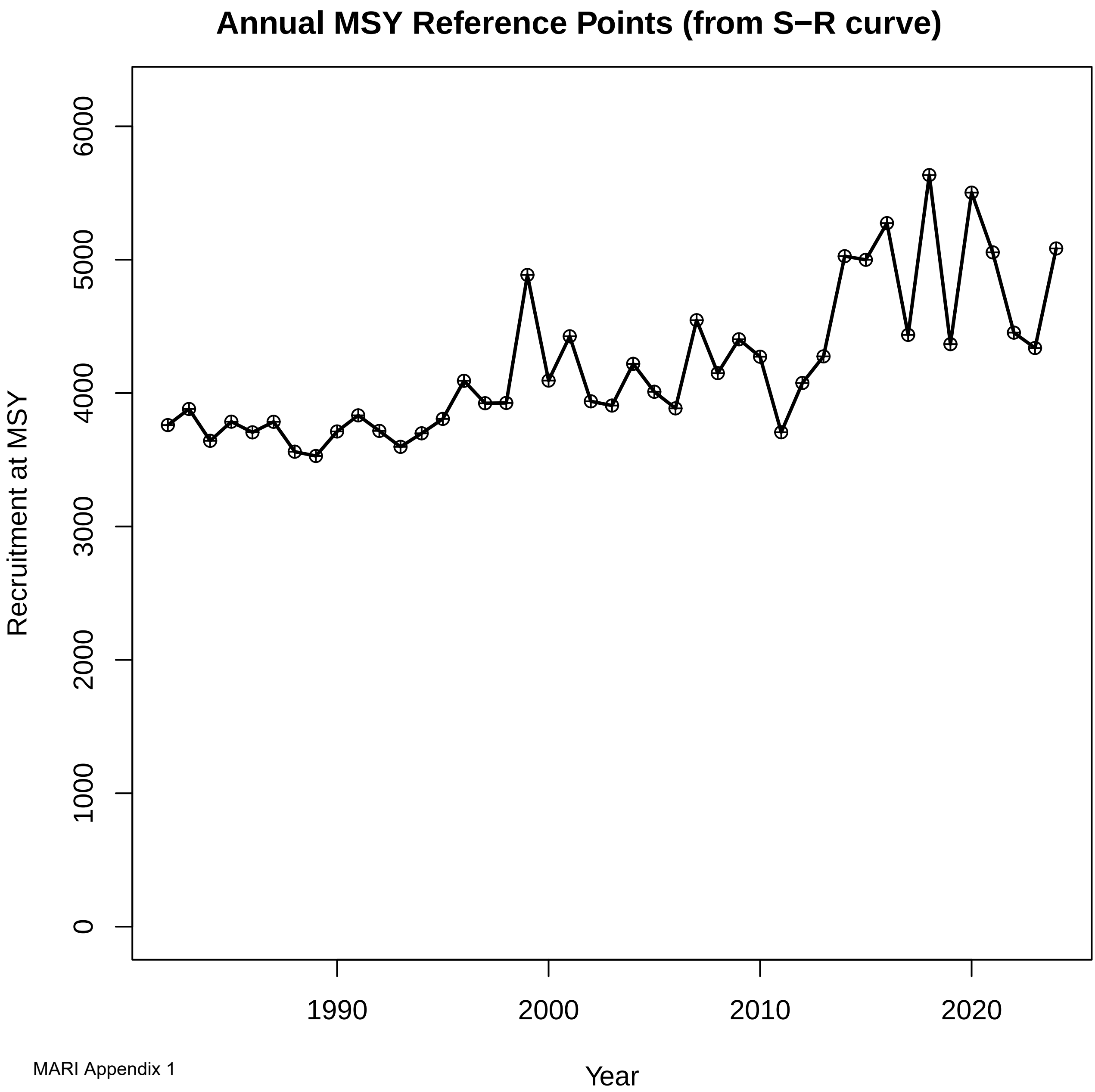

Annual MSY Reference Points (from S−R curve)
Full F at MSY
0.0
0.1
0.2
0.3
0.4
1990
2000
2010
2020
Year

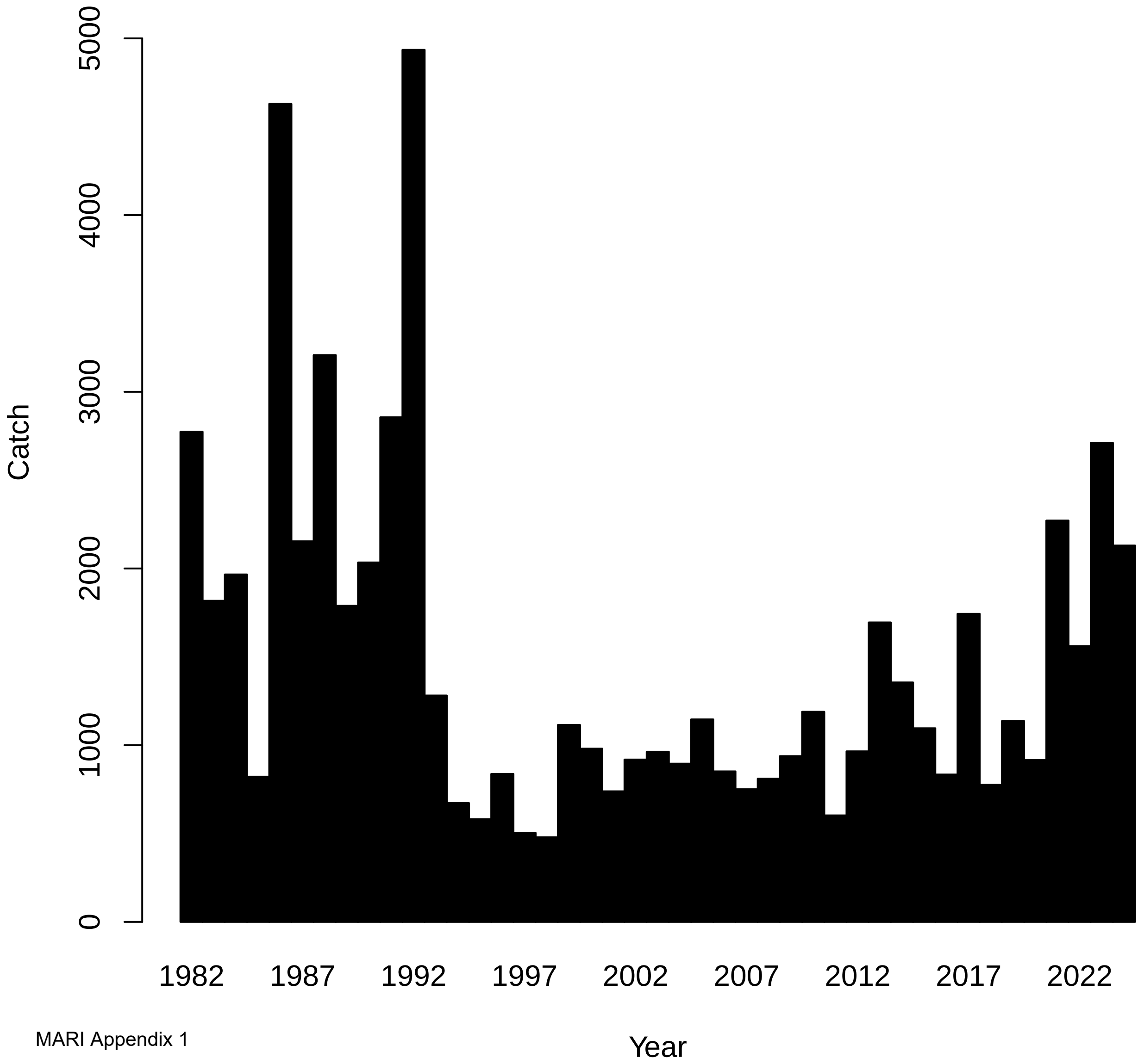

Annual MSY Reference Points (from S−R curve)
MSY
0
200
400
600
800
1000
1200
1990
2000
2010
2020
Year

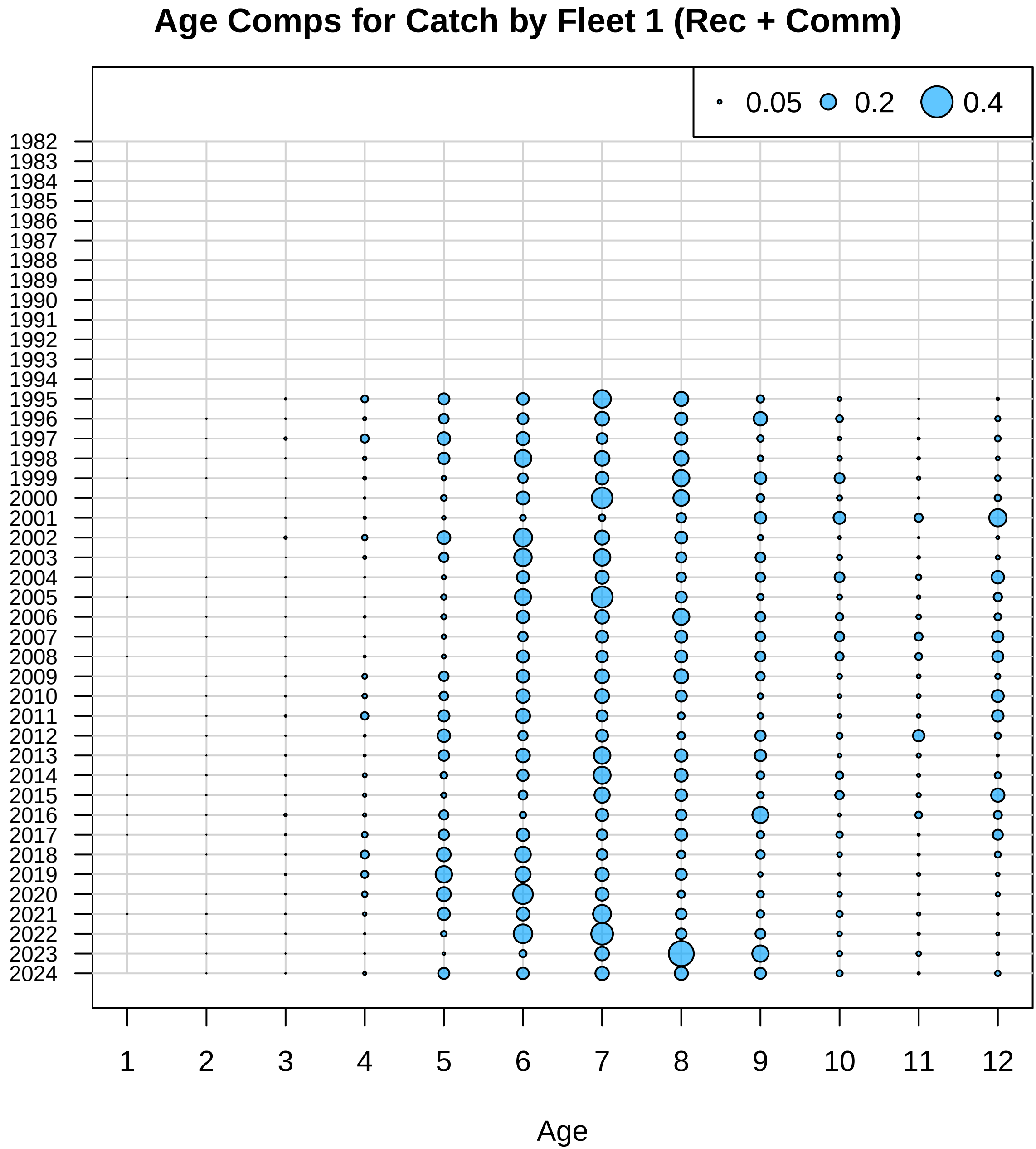


Annual MSY Reference Points (from S−R curve)
%SPR at MSY
0.0
0.2
0.4
0.6
0.8
1.0
1990
2000
2010
2020
Year


Annual MSY Reference Points (from S−R curve)
SSB at MSY
0
1000
2000
3000
4000
5000
6000
1990
2000
2010
2020
Year


Annual MSY Reference Points (from S−R curve)
Recruitment at MSY
0
1000
2000
3000
4000
5000
6000
1990
2000
2010
2020
Year


Catch
0
1000
2000
3000
4000
5000
1982
1987
1992
1997
2002
2007
2012
2017
2022
Year



Age Comps for Catch by Fleet 1 (Rec + Comm)
0.05
0.2
0.4
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
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1998
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2001
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2009
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2011
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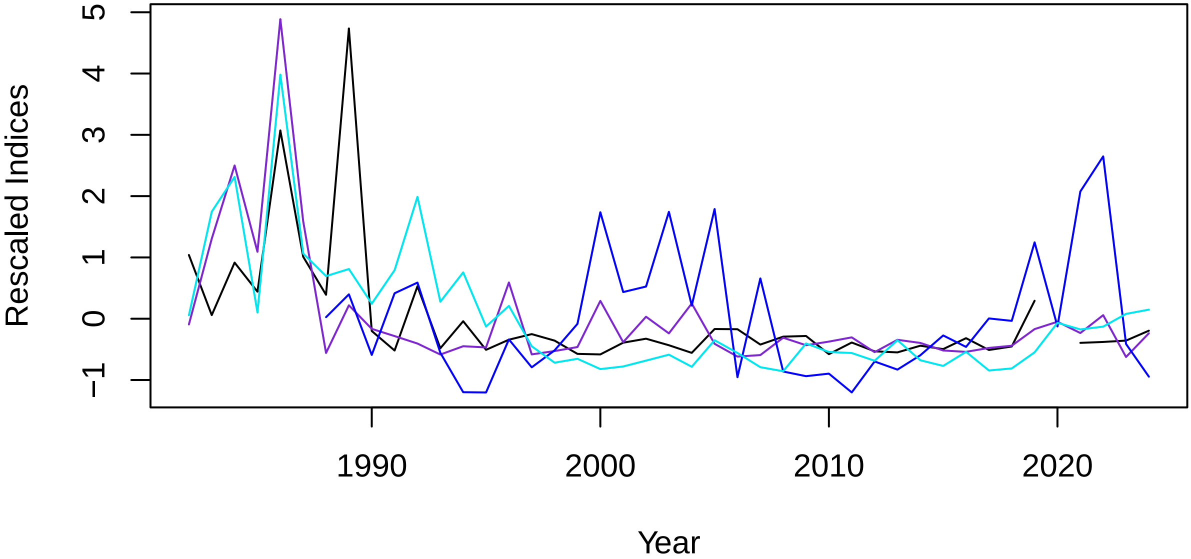
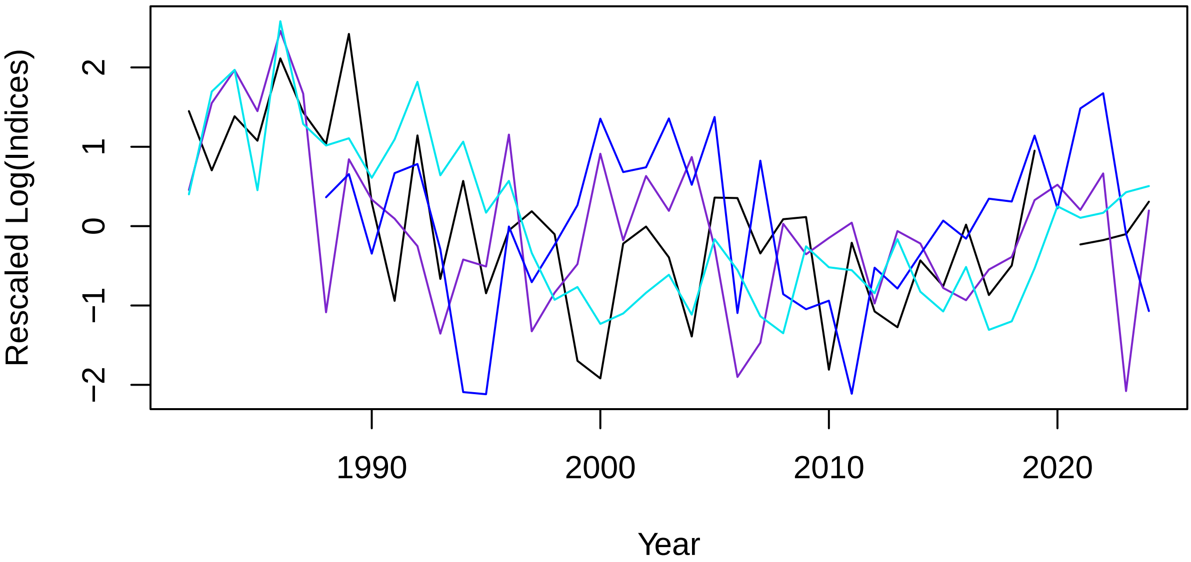
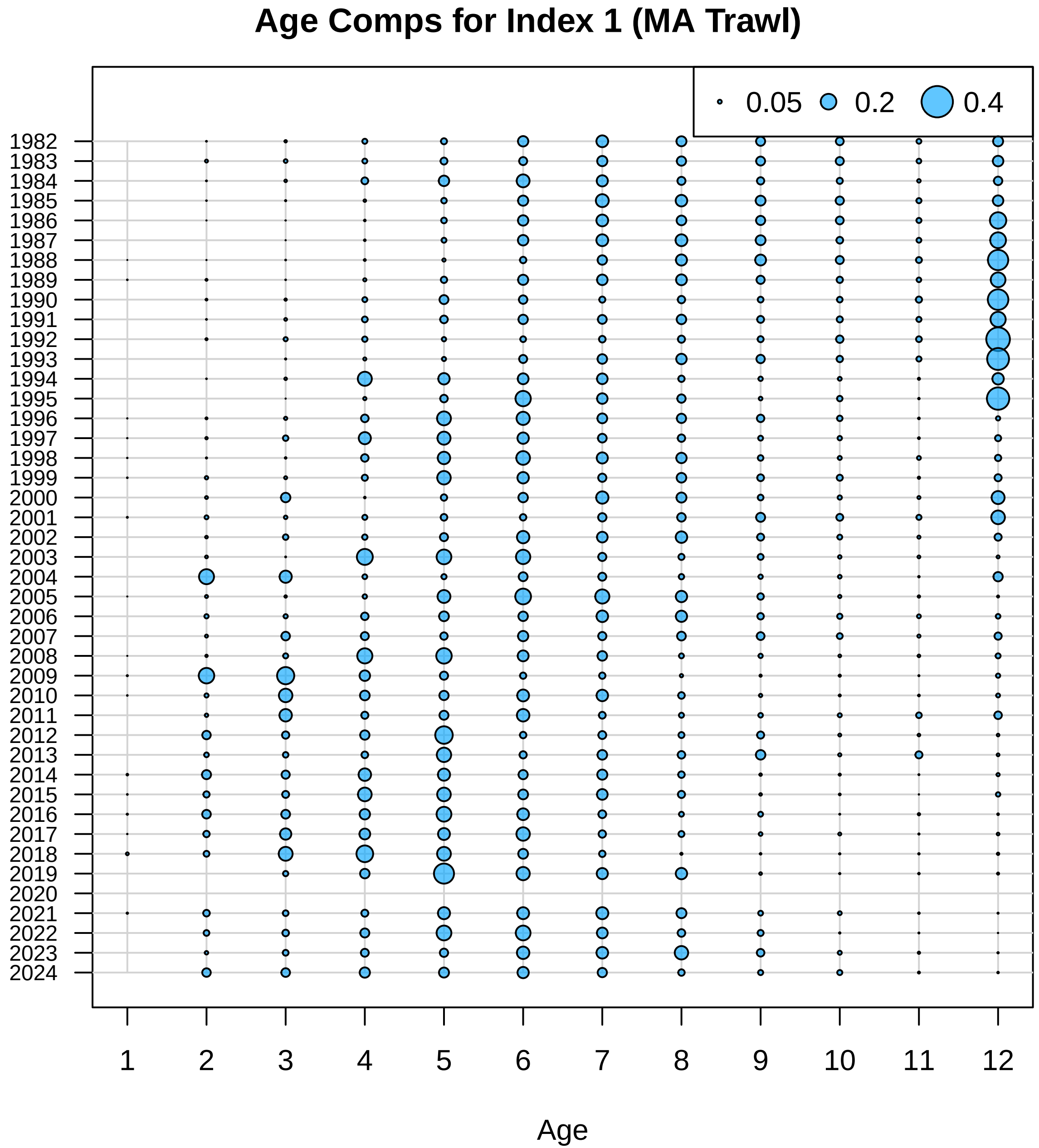
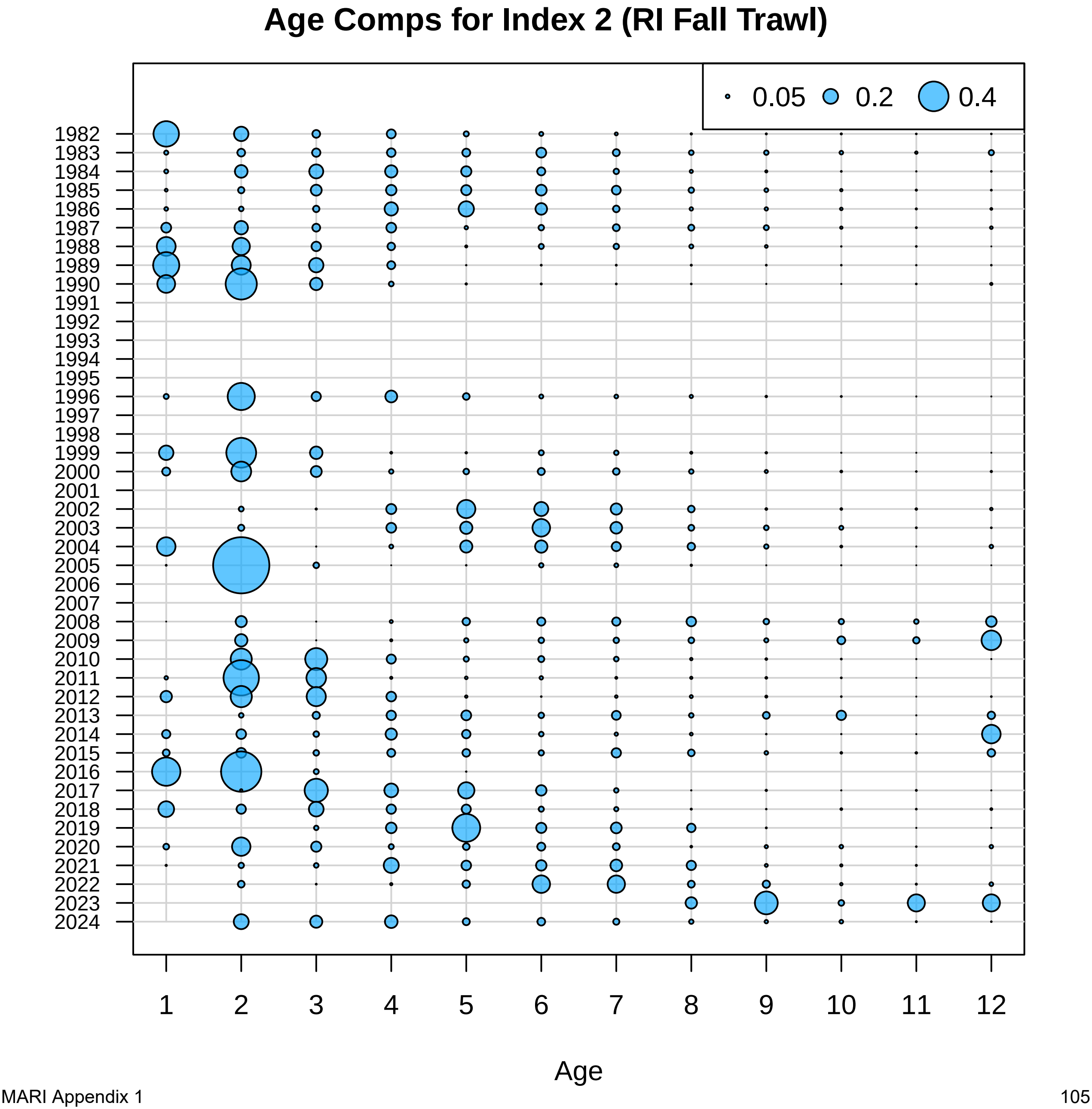
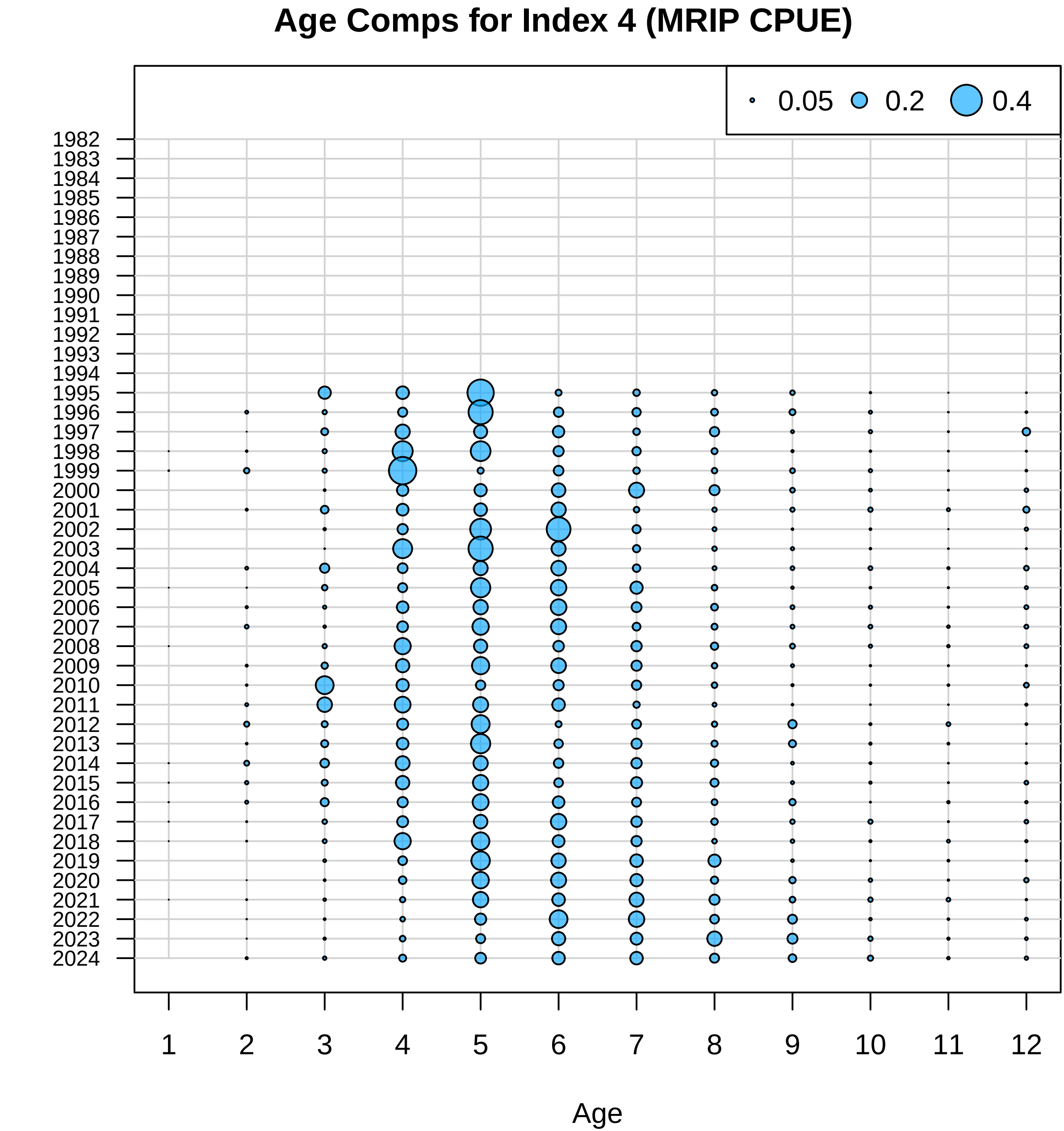
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age


Rescaled Indices
−1
0
1
2
3
4
5
1990
2000
2010
2020
Year

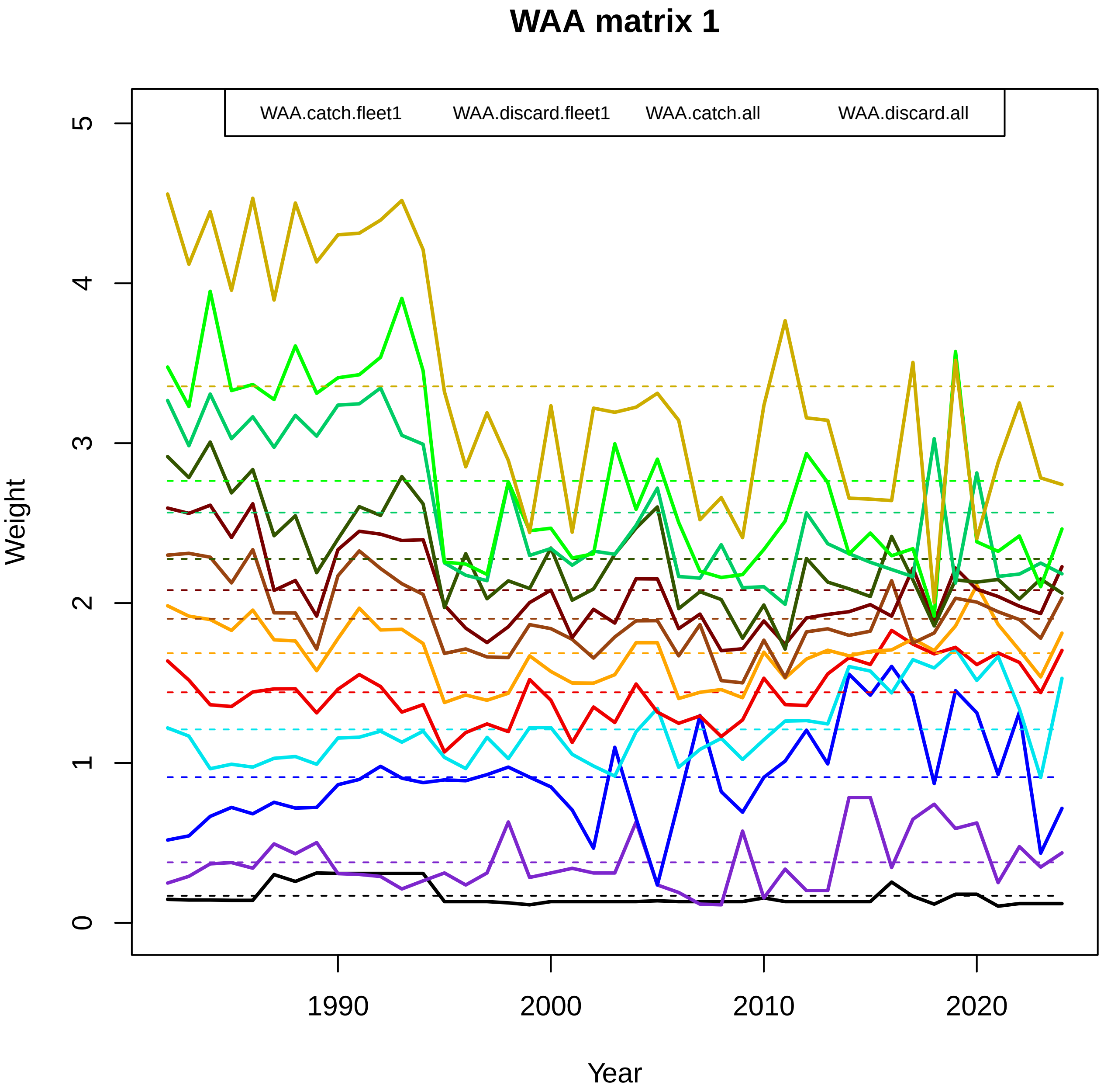

Rescaled Log(Indices)
−2
−1
0
1
2
1990
2000
2010
2020
Year


Age Comps for Index 1 (MA Trawl)
0.05
0.2
0.4
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age

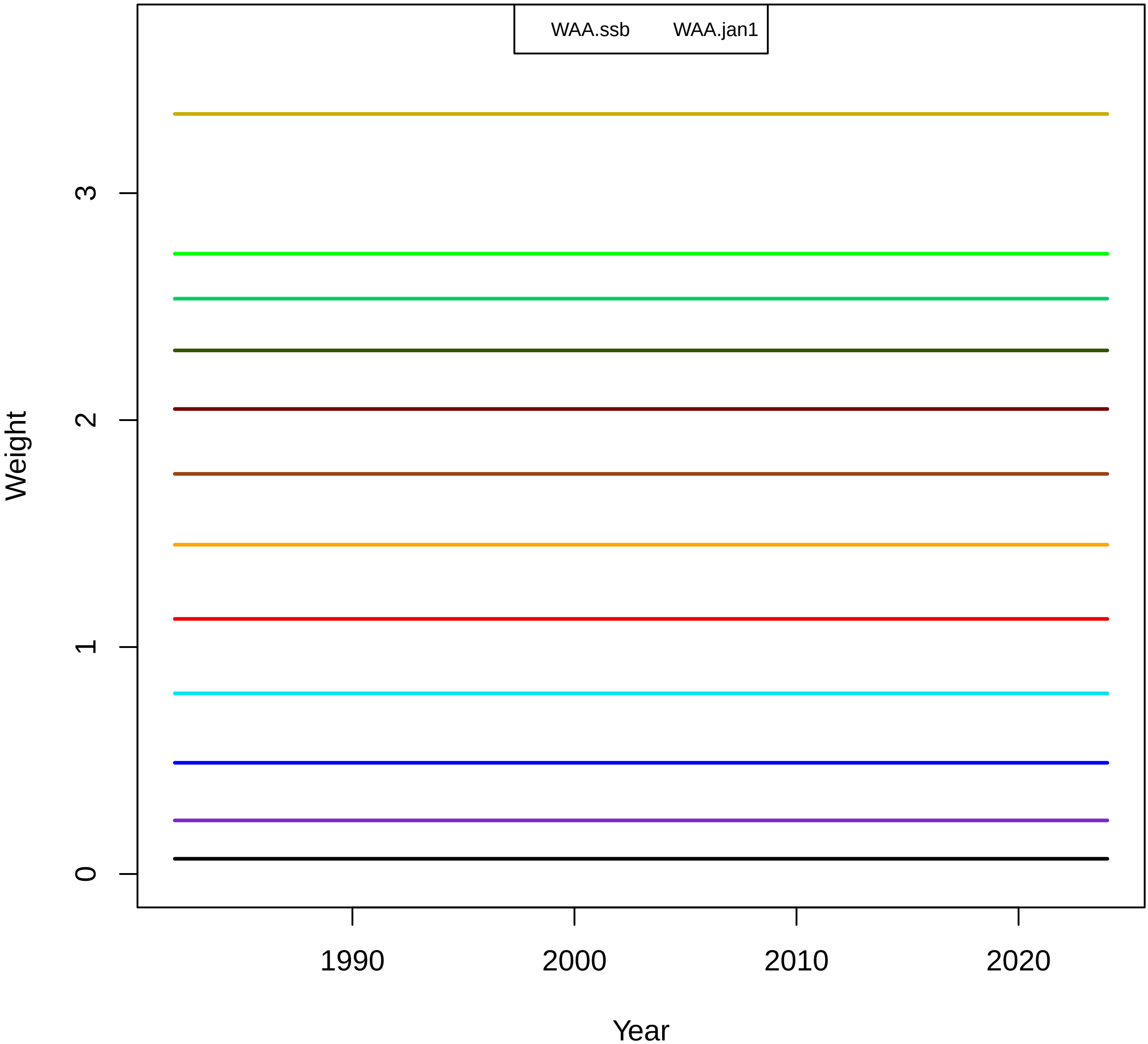

Age Comps for Index 2 (RI Fall Trawl)
0.05
0.2
0.4
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age

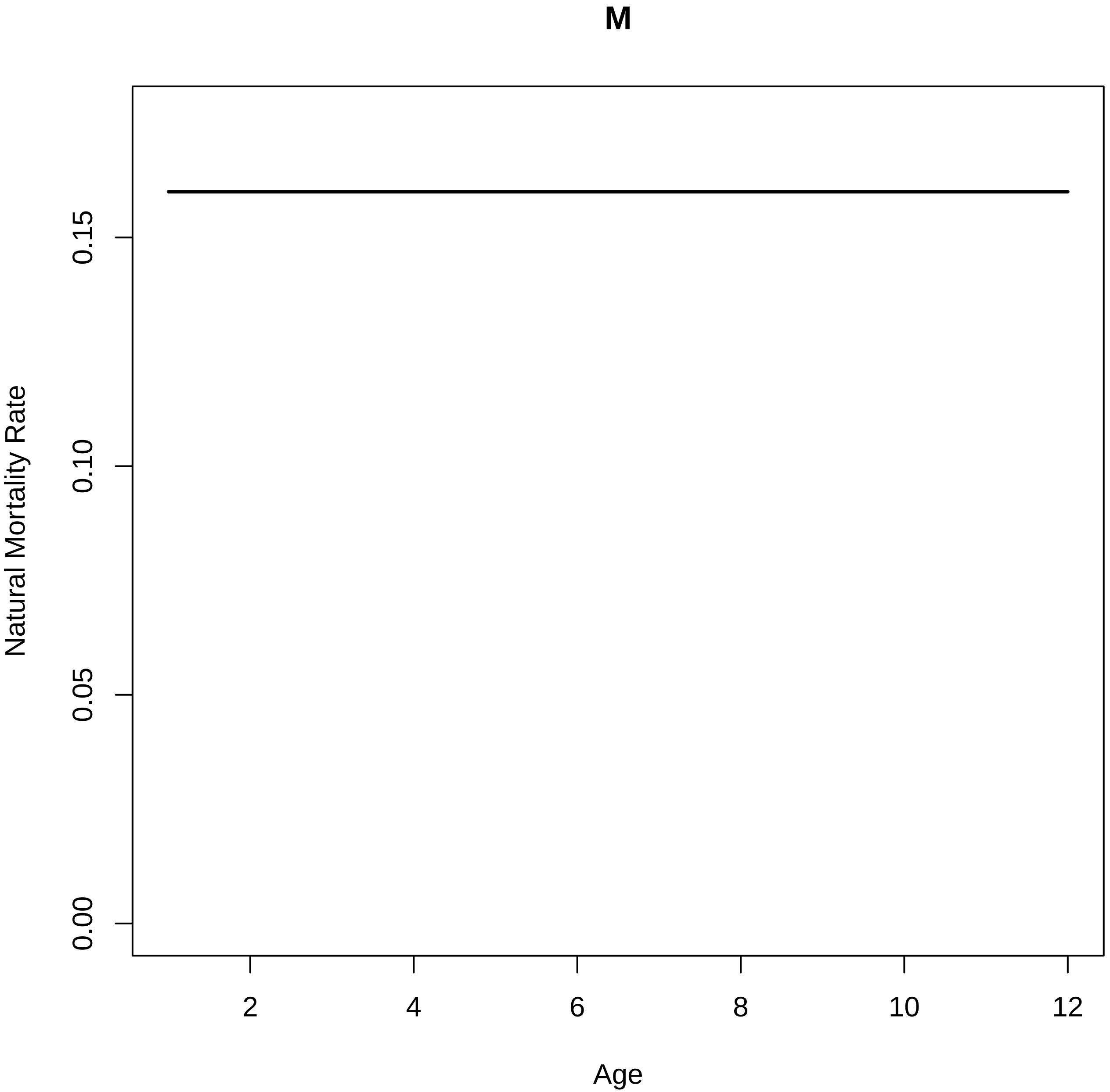


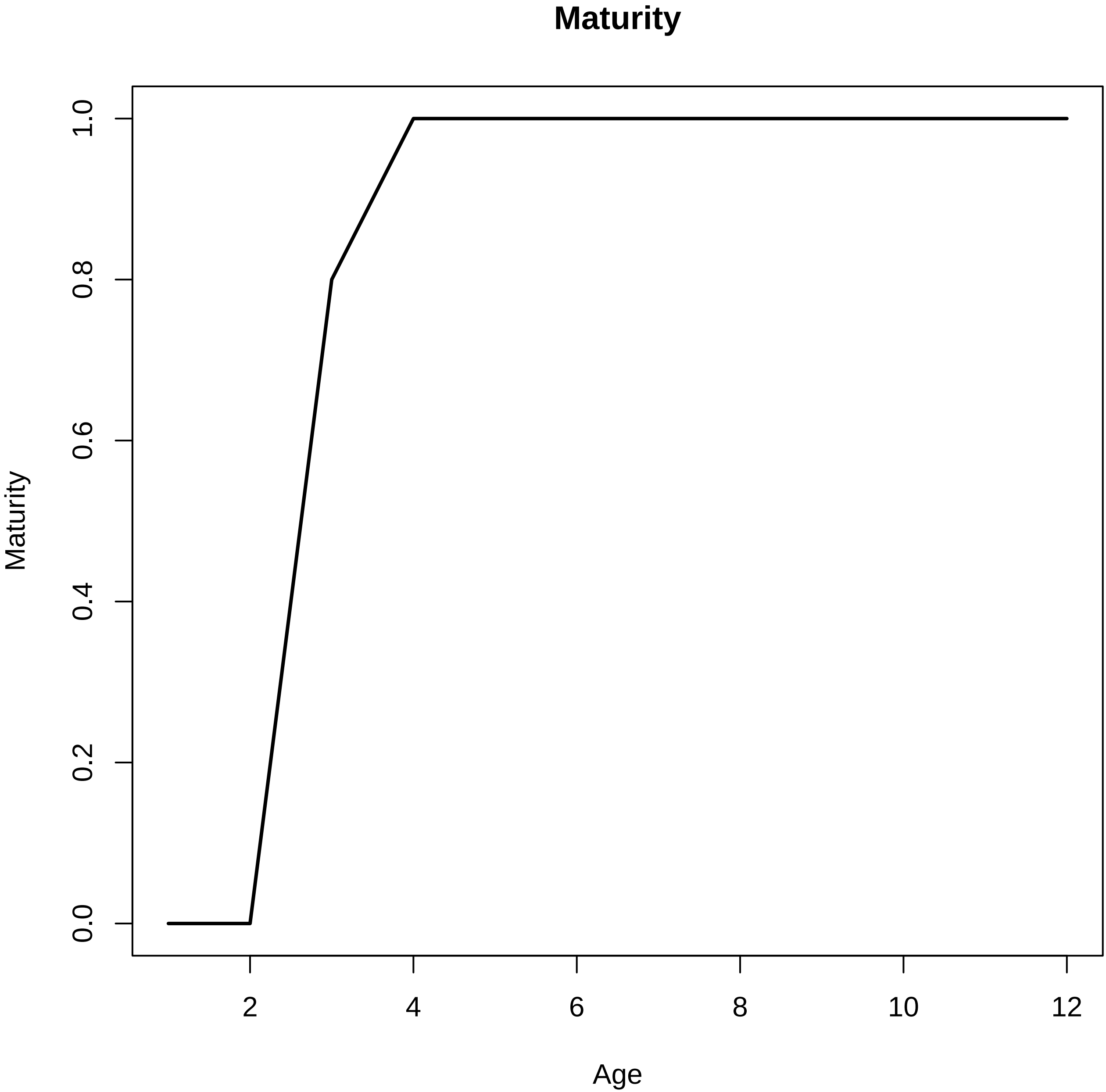
Age Comps for Index 4 (MRIP CPUE)
0.05
0.2
0.4
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age


WAA matrix 1
WAA.catch.fleet1
WAA.discard.fleet1
WAA.catch.all
WAA.discard.all
Weight
0
1
2
3
4
5
1990
2000
2010
2020
Year

WAA matrix 2




M
Natural Mortality Rate
0.00
0.05
0.10
0.15
2
4
6
8
10
12
Age


Maturity
1.0
0.8
0.6
0.4
0.2
0.0
Maturity
2
4
6
8
10
12
Age

MARI Appendix 2: Retrospective Adjustment and Sensitivity Runs

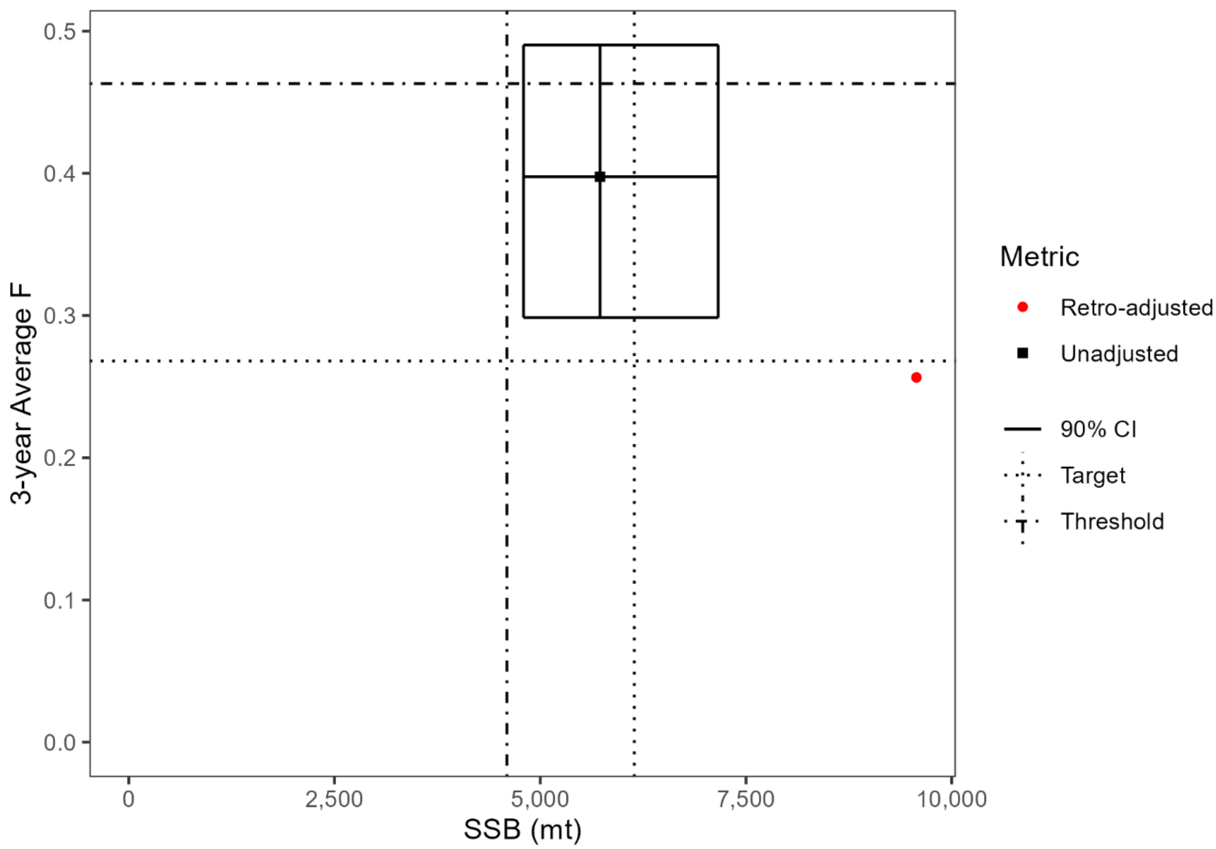


Figure A2.1. Comparison of retrospective adjusted status in 2025 with the base model status. Solid black lines indicate the 90% confidence intervals of the estimates of SSB and F.

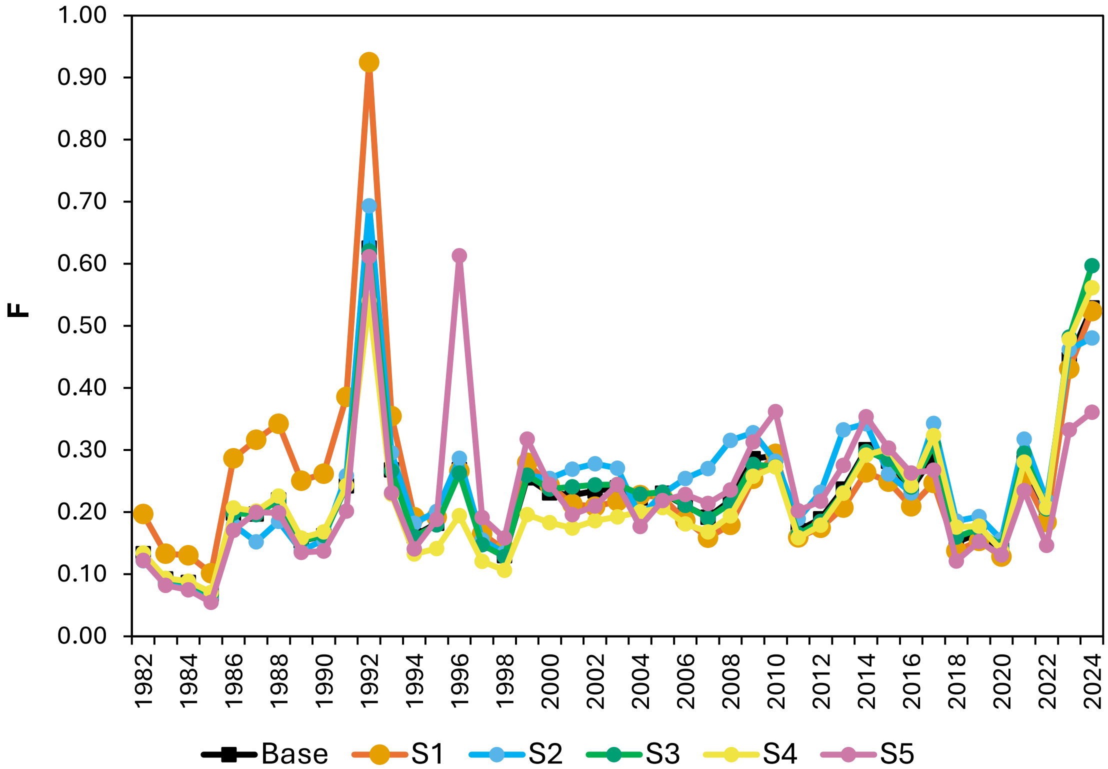


Figure A2.2. Estimates of annual F for sensitivity runs of the ASAP model.

<u>Sensitivity Analysis</u>

Run 1: Exclude MA trawl survey

Run 2: Exclude RI trawl survey

Run 3: Exclude RI seine survey

Run 4: Exclude MRIP index

Run 5: Survey CVs unadjusted for optimizing diagnostic RMSE error

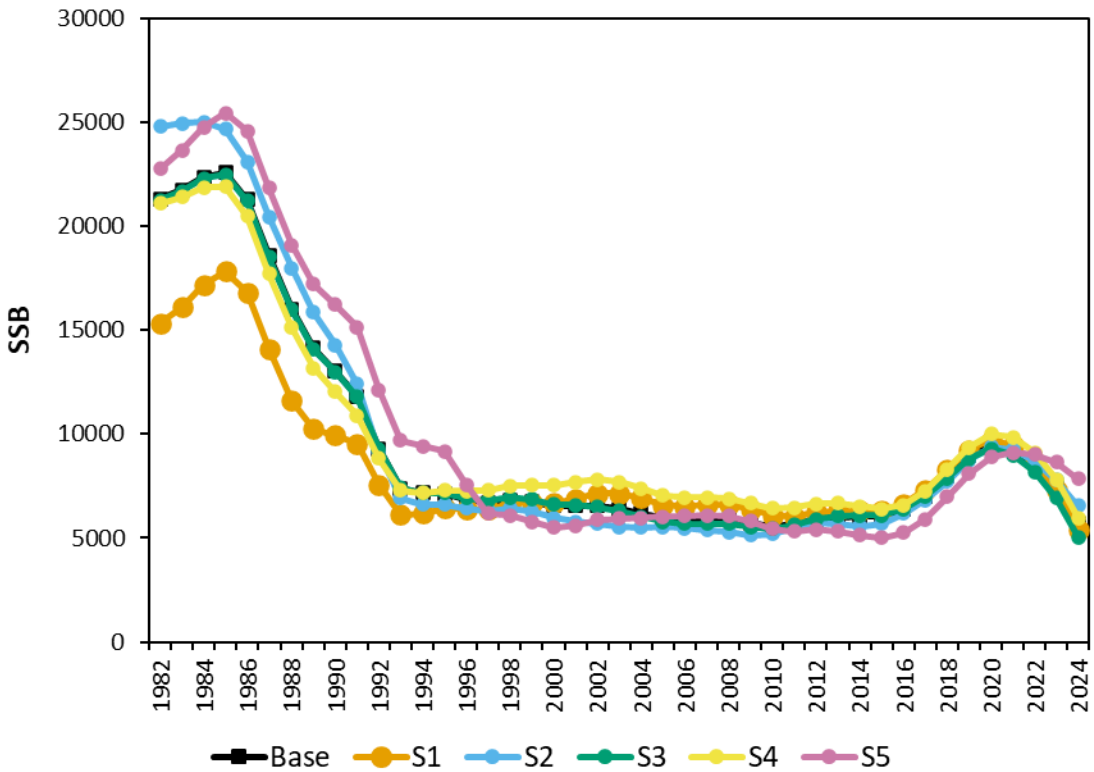


Figure A2.3. Estimates of annual SSB for sensitivity runs of the ASAP model.

<u>Sensitivity Analysis</u>

Run 1: Exclude MA trawl survey

Run 2: Exclude RI trawl survey

Run 3: Exclude RI seine survey

Run 4: Exclude MRIP index

Run 5: Survey CVs unadjusted for optimizing diagnostic RMSE error

LIS Appendix 1: ASAP Input, Diagnostic, and Results Plots for the Base Run

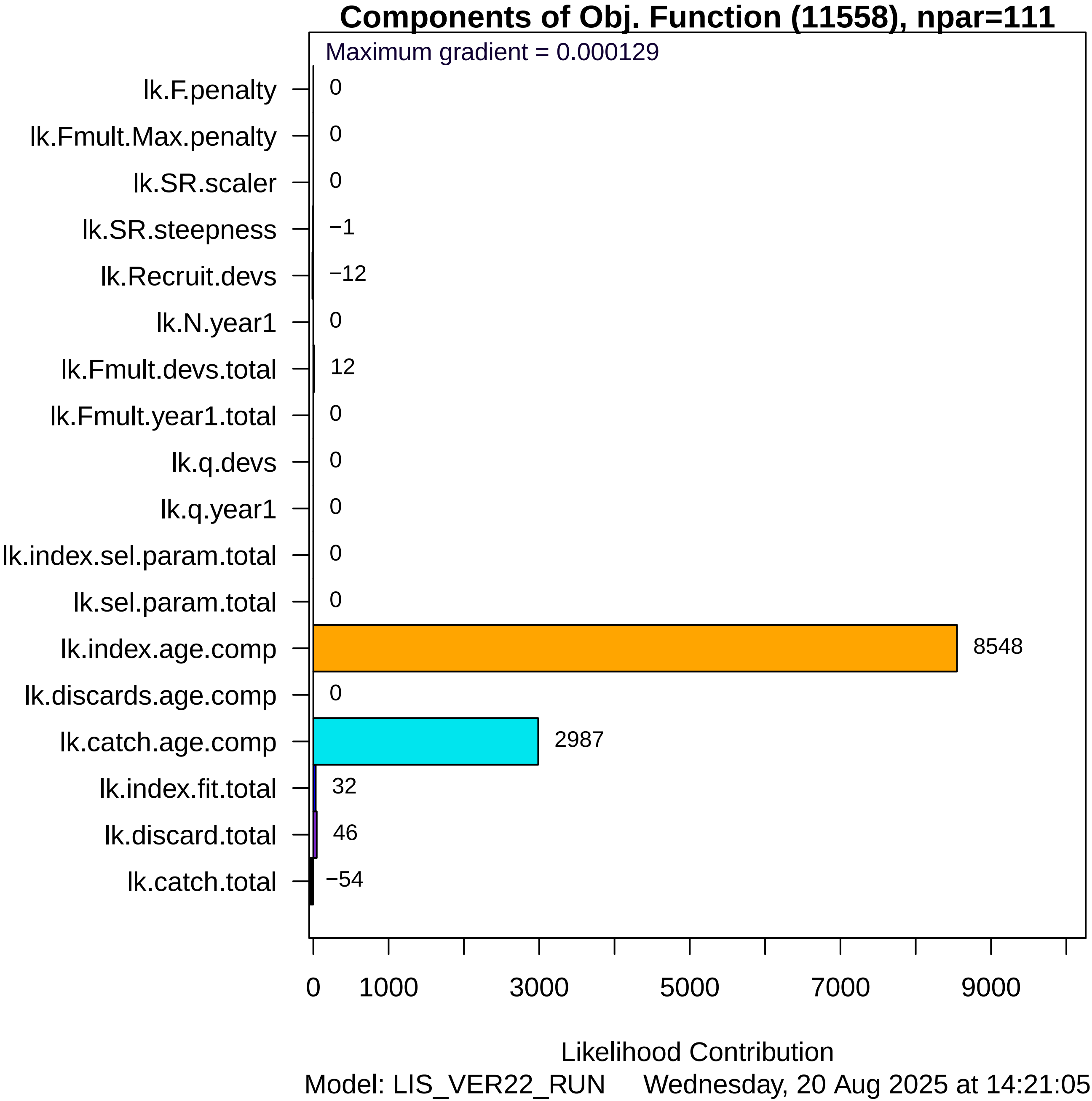
File = LIS_VER22_RUN.dat

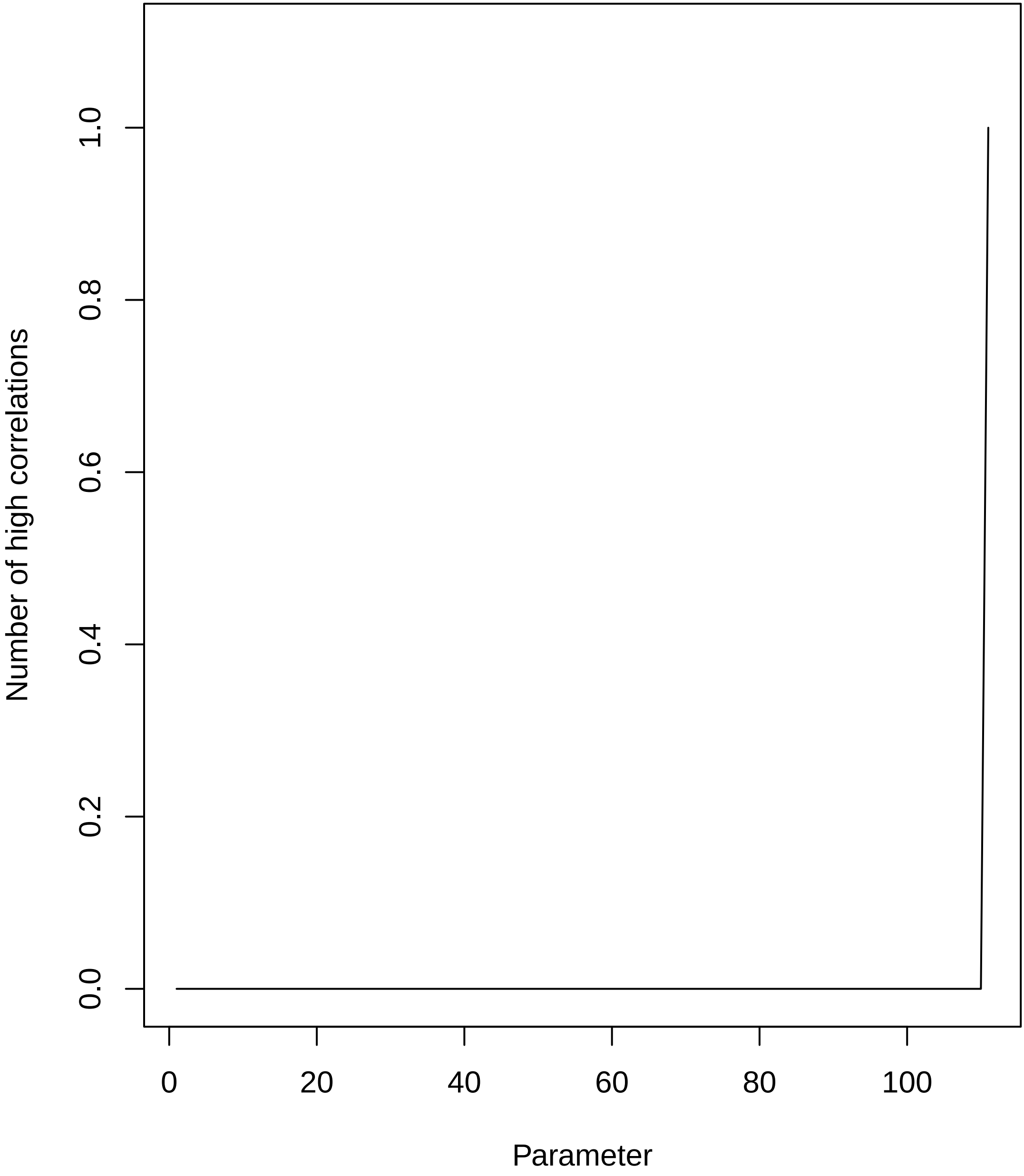
ASAP3 run on Wednesday, 20 Aug 2025 at 14:21:05

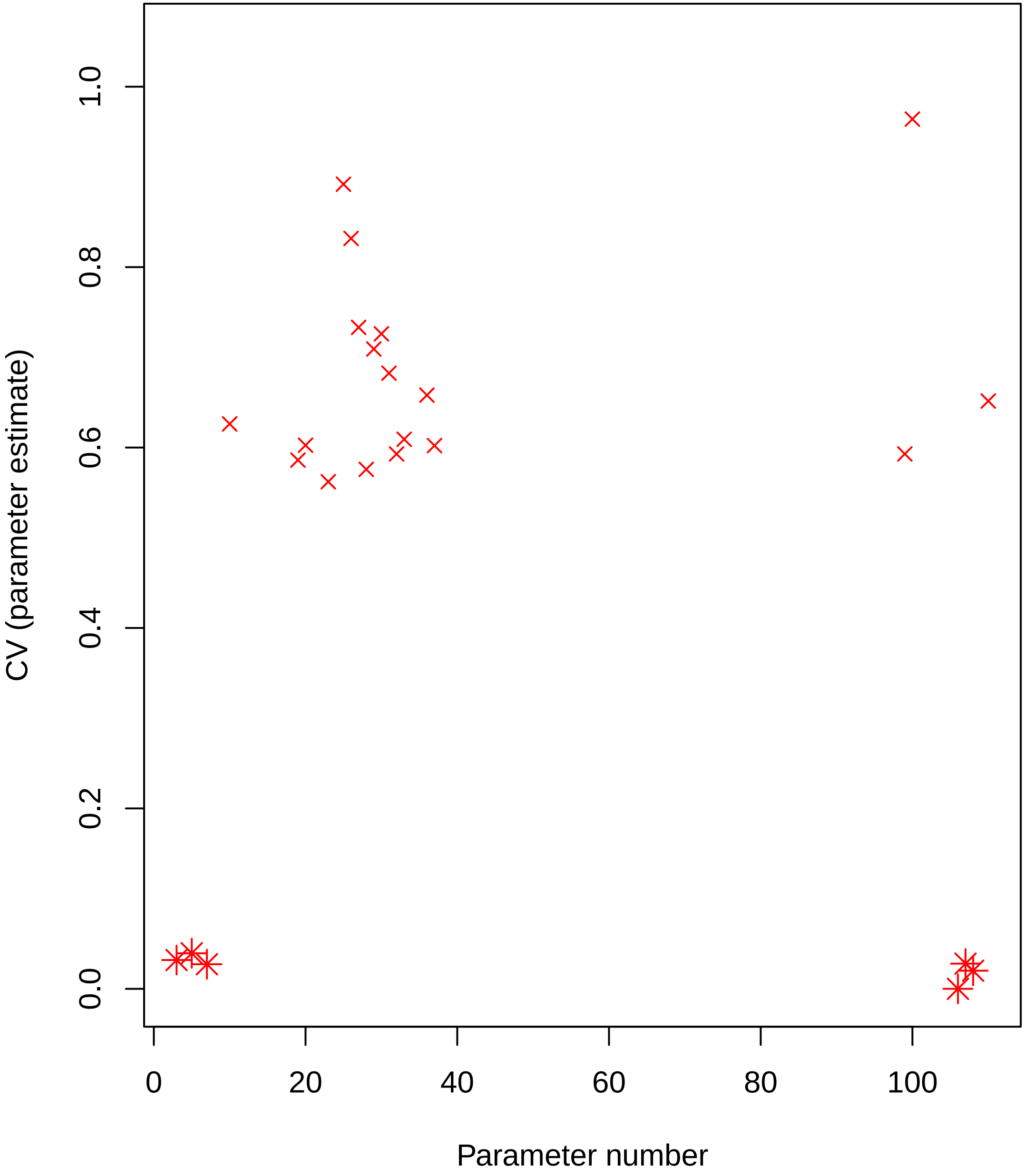
dir = Final_run_ver22\VER22_run

ASAPplots version = 0.2.18

npar = 111, maximum gradient = 0.000128619


Components of Obj. Function (11558), npar=111
Maximum gradient = 0.000129
lk.F.penalty
lk.Fmult.Max.penalty
lk.SR.scaler
lk.SR.steepness
lk.Recruit.devs
lk.N.year1
lk.Fmult.devs.total
lk.Fmult.year1.total
lk.q.devs
lk.q.year1
lk.index.sel.param.total
lk.sel.param.total
lk.index.age.comp
lk.discards.age.comp
lk.catch.age.comp
lk.index.fit.total
lk.discard.total
lk.catch.total
0
0
0
−1
−12
0
12
0
0
0
0
0
8548
0
2987
32
46
−54
0
1000
3000
5000
7000
9000
Likelihood Contribution
Model: LIS_VER22_RUN   Wednesday, 20 Aug 2025 at 14:21:05

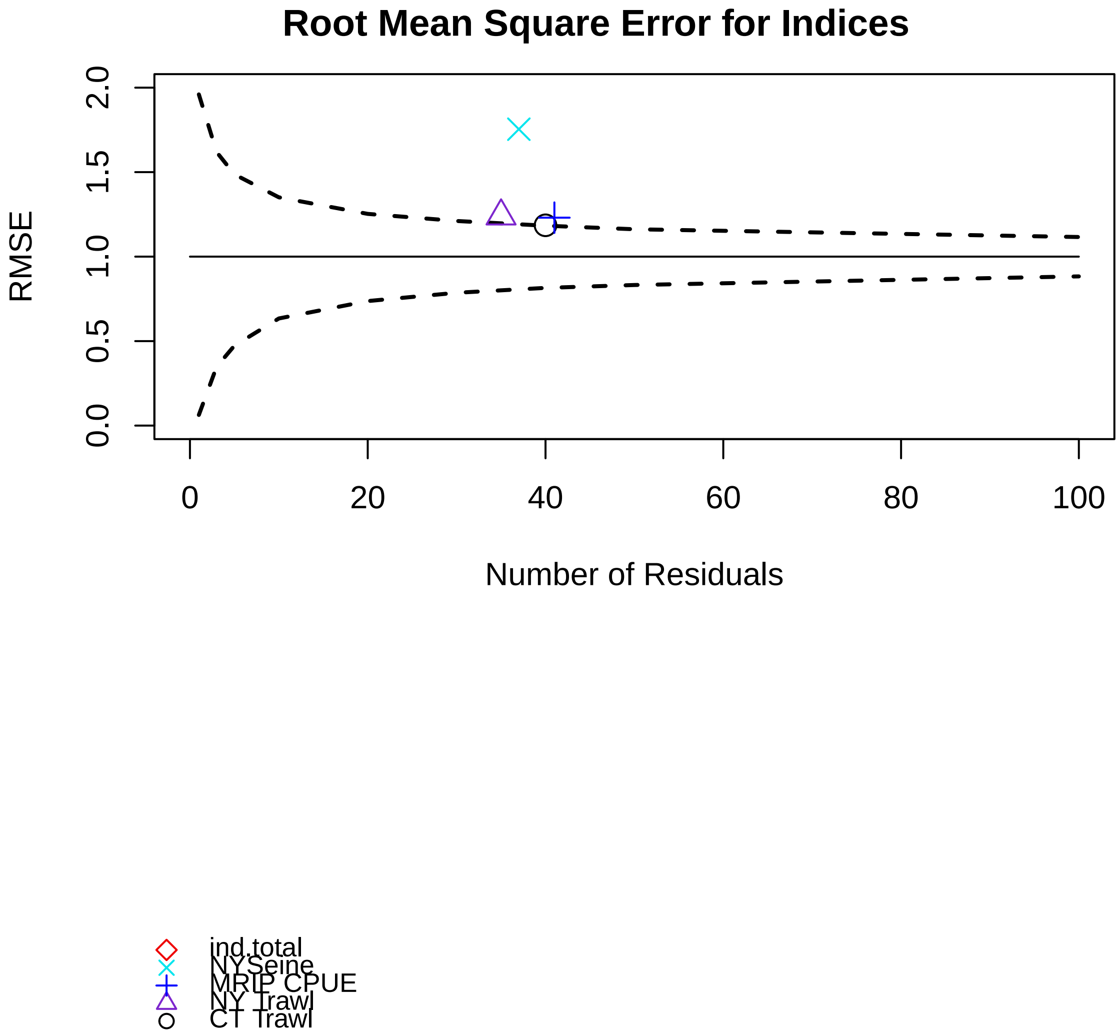

Number of high correlations
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Parameter

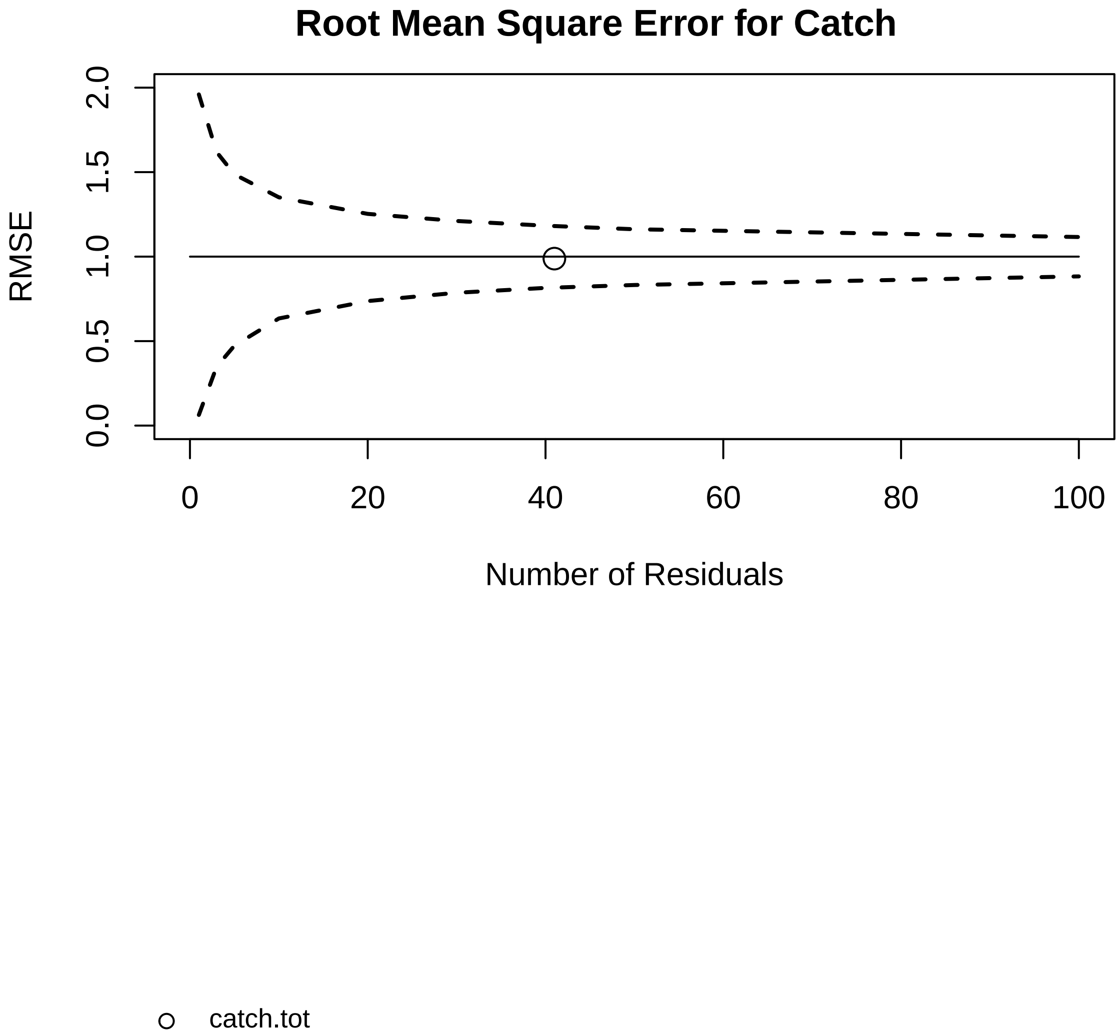


CV (parameter estimate)
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Parameter number

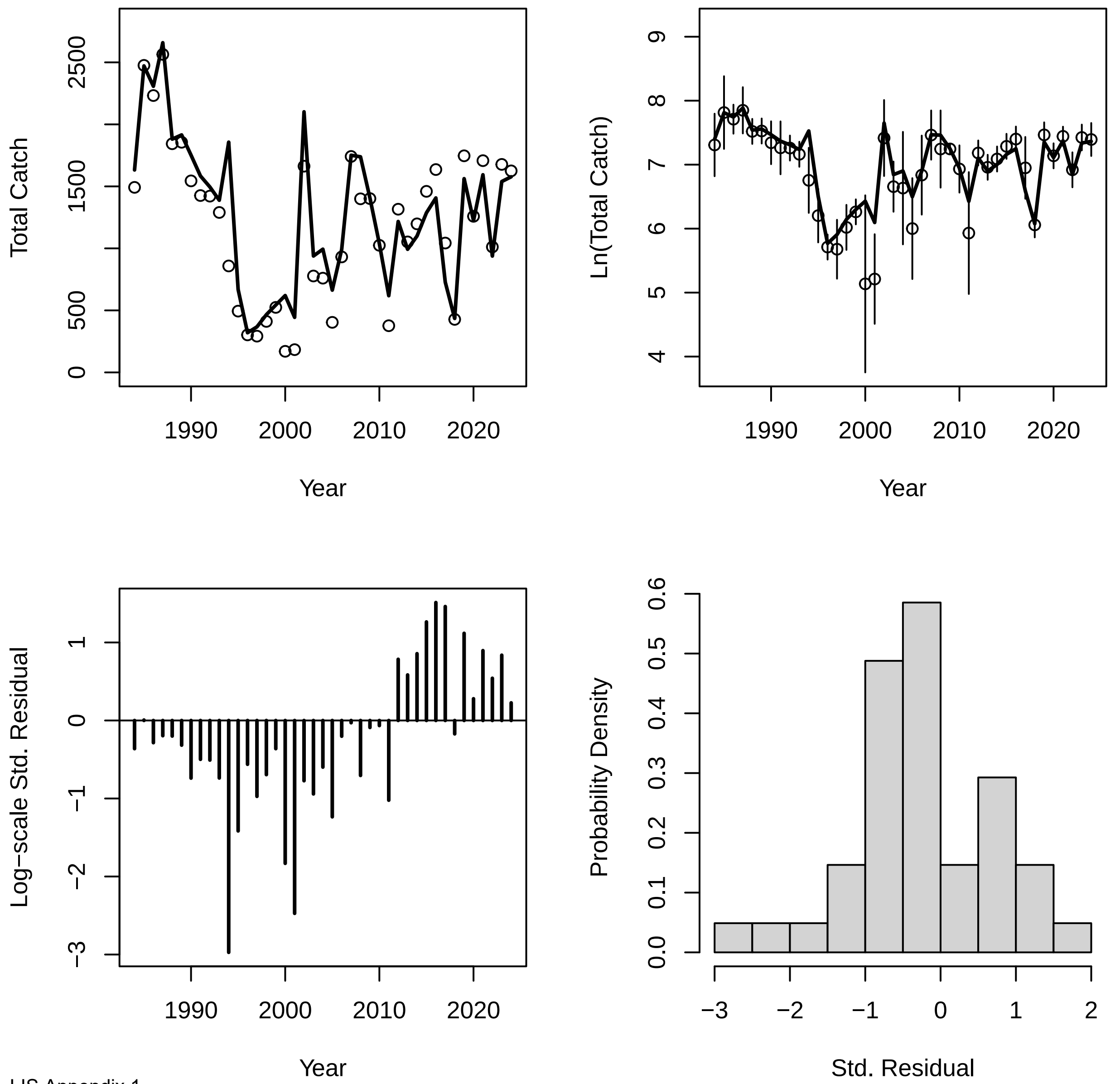
Root Mean Square Error computed from Standardized Residuals

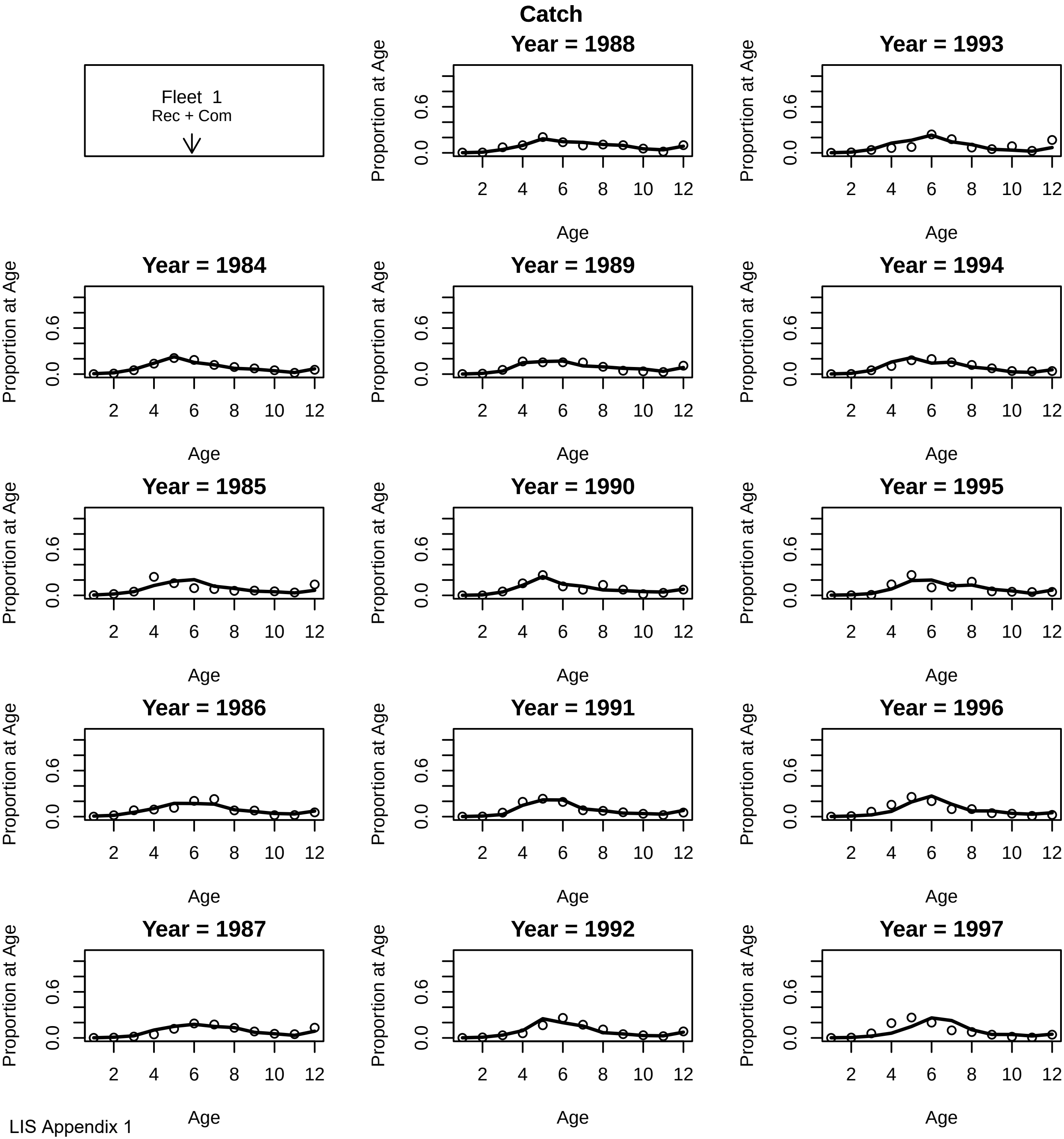
Component	# resids	RMSE
catch.tot	41	0.988
discard.tot	0	0
ind01	40	1.19
ind02	35	1.24
ind03	41	1.23
ind04	37	1.75
ind.total	153	1.37
N.year1	0	0
Fmult.year1	0	0
Fmult.devs.total	40	1.09
recruit.devs	41	0.599
fleet.sel.params	0	0
index.sel.params	0	0
q.year1	0	0
q.devs	0	0
SR.steepness	1	0.0494
SR.scaler	0	0

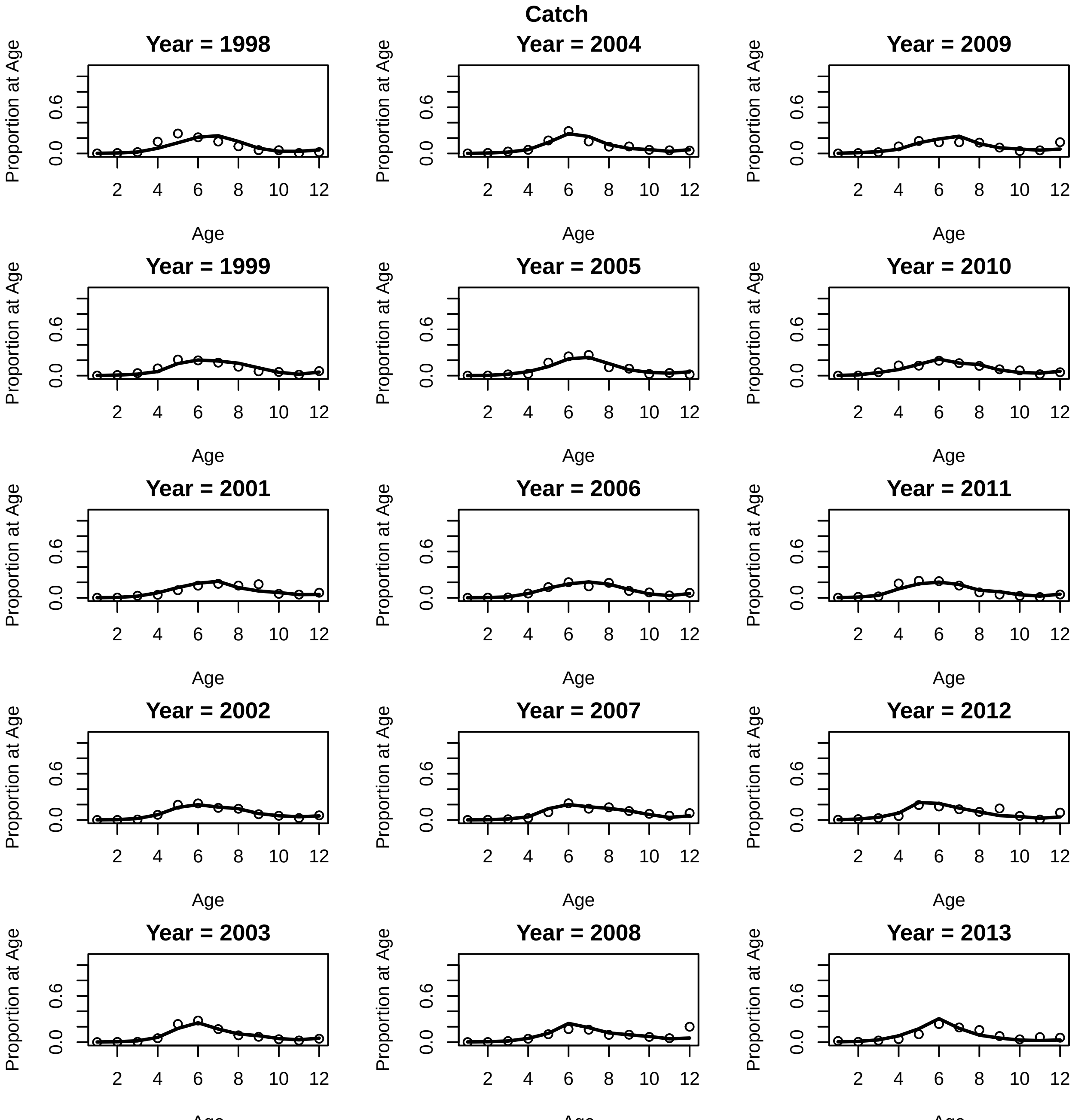

Root Mean Square Error for Indices
RMSE
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Number of Residuals
ind.total
NYSeine
MRIP CPUE
NY Trawl
CT Trawl

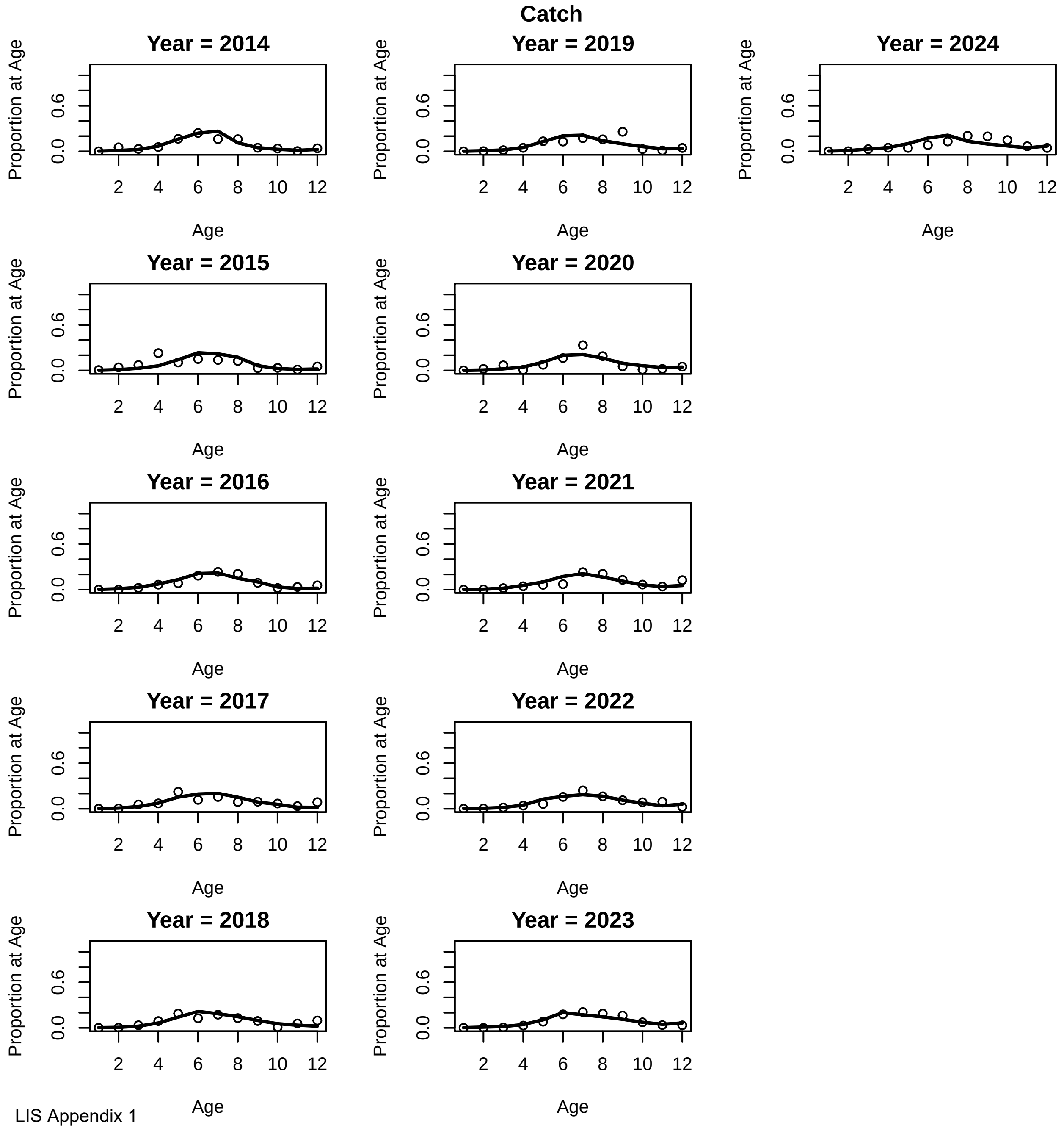

Root Mean Square Error for Catch
RMSE
0.0
0.5
1.0
1.5
2.0
0
20
40
60
80
100
Number of Residuals
catch.tot

Fleet 1 Catch (Rec + Com)

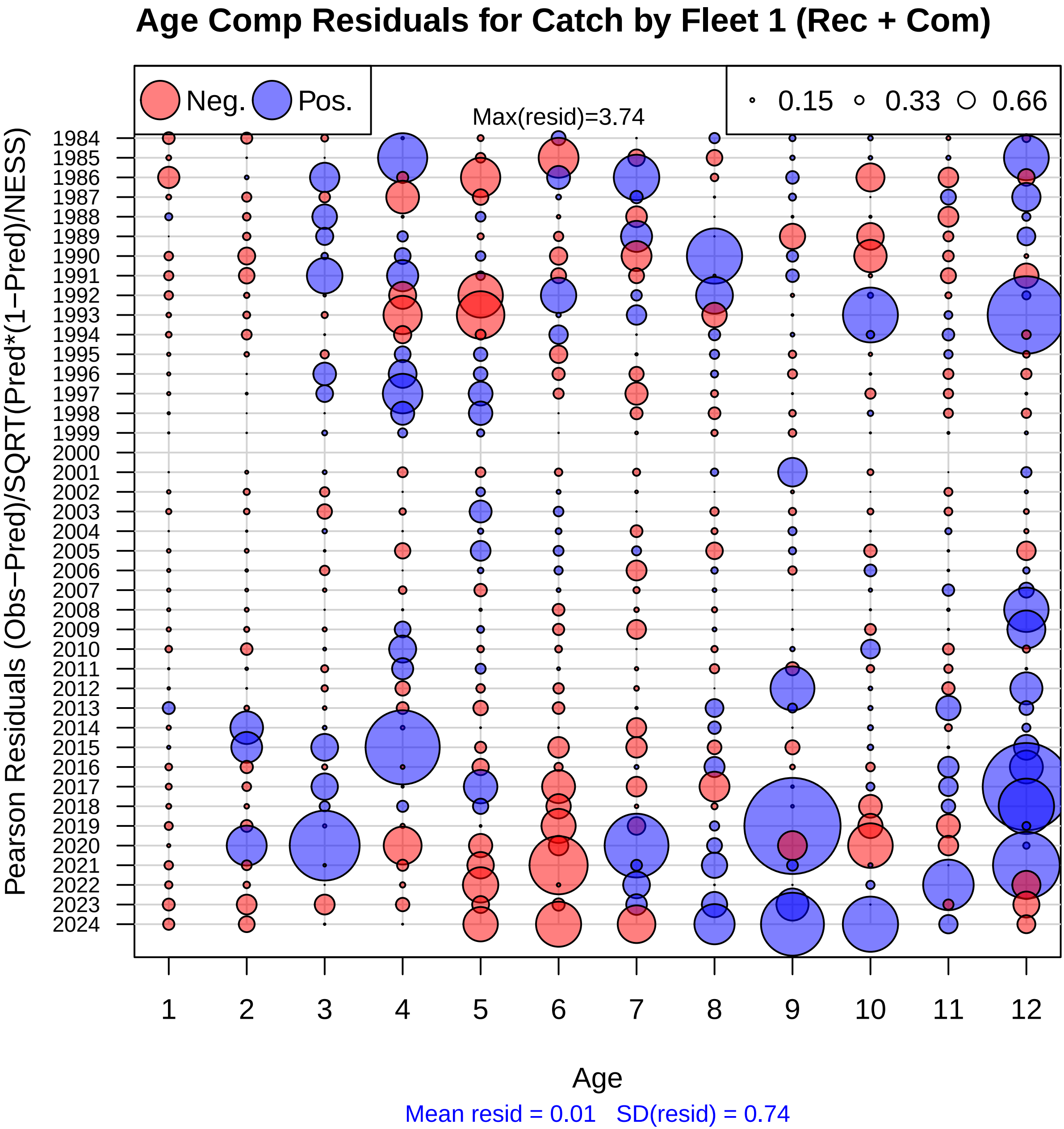


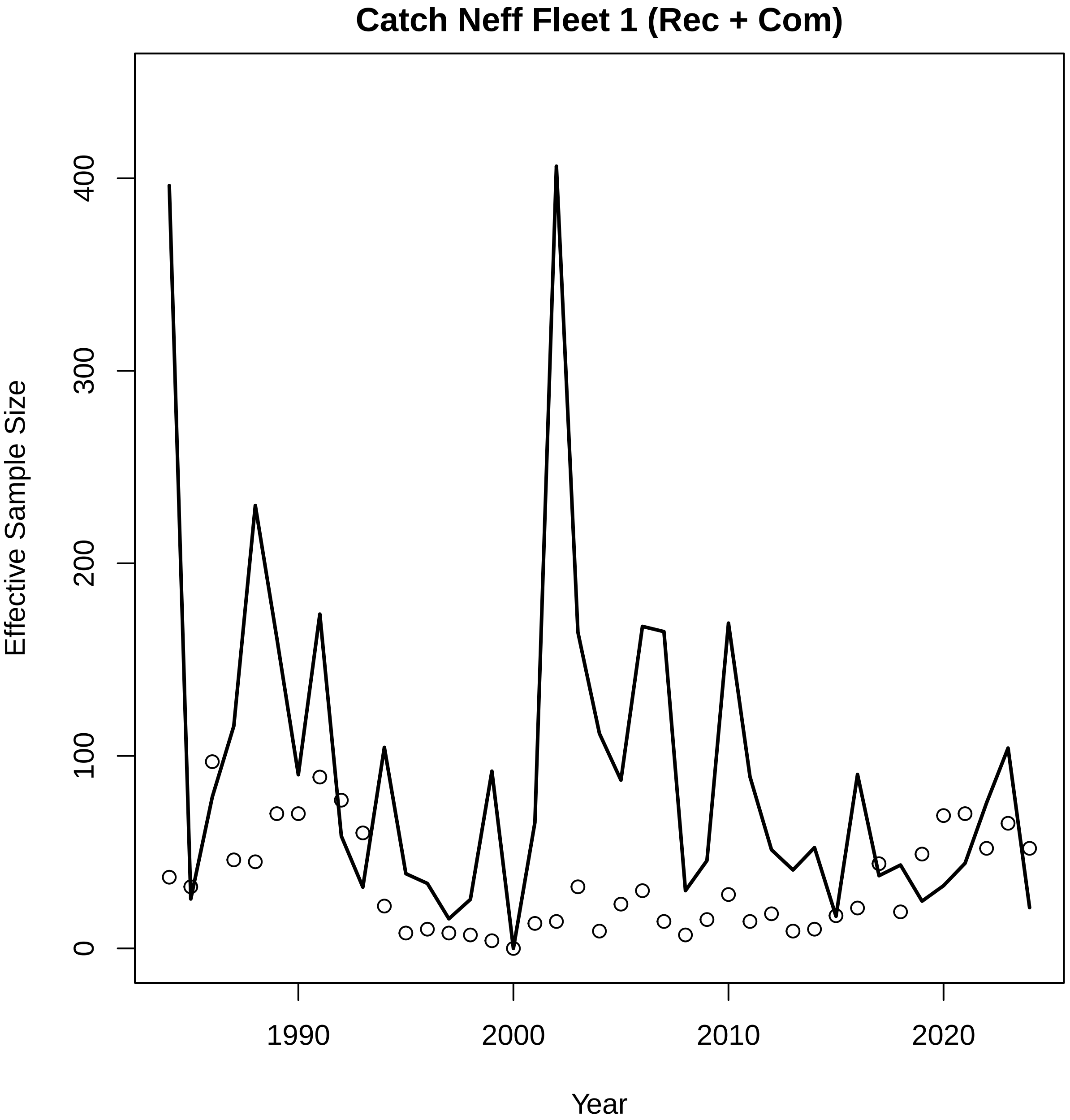

Catch
Fleet 1
Rec + Com
Year = 1984
Year = 1985
Year = 1986
Year = 1987
Year = 1988
Year = 1989
Year = 1990
Year = 1991
Year = 1992
Year = 1993
Year = 1994
Year = 1995
Year = 1996
Year = 1997
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

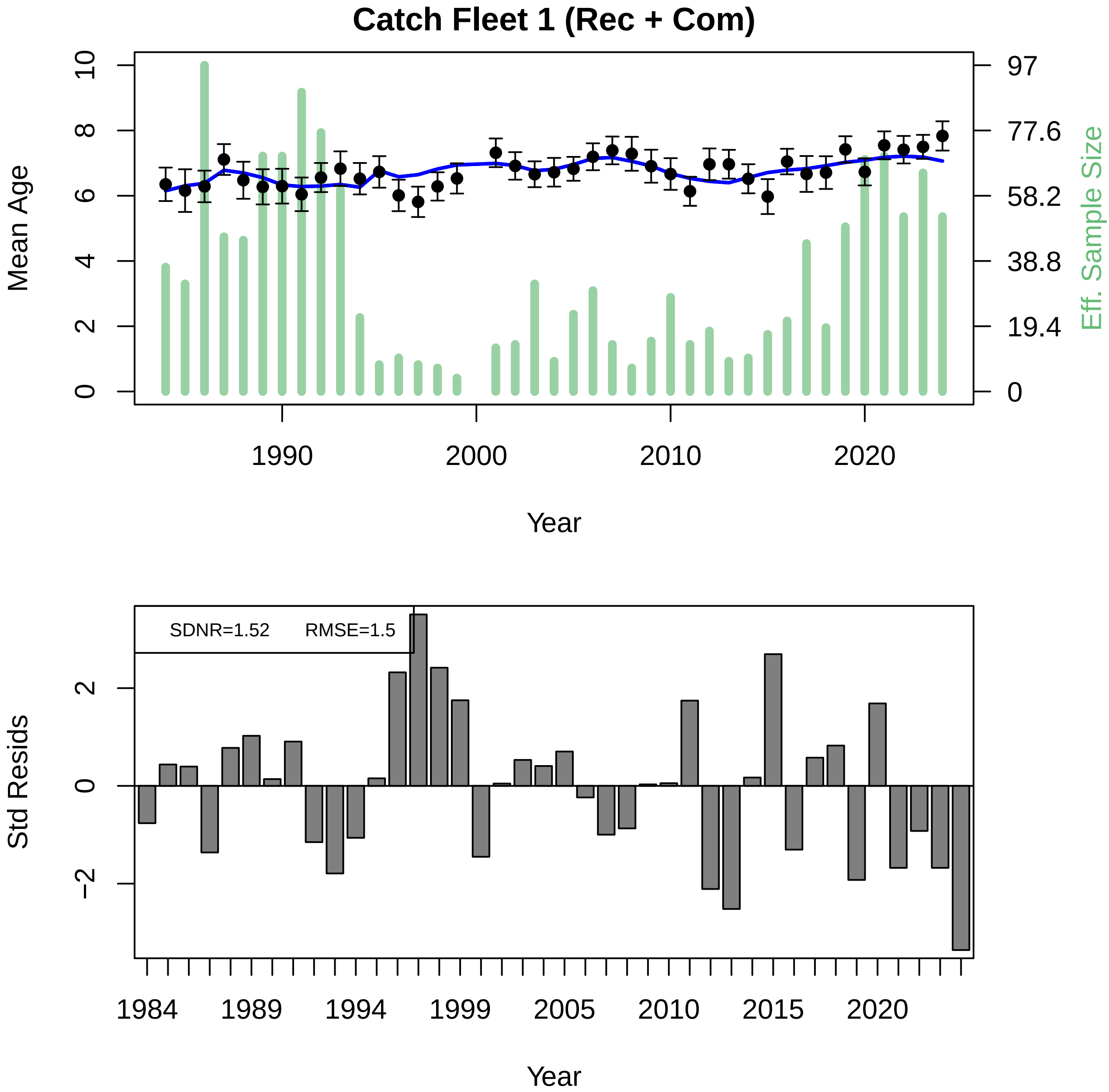

Catch
Year = 1998
Year = 2004
Year = 2009
Year = 1999
Year = 2005
Year = 2010
Year = 2001
Year = 2006
Year = 2011
Year = 2002
Year = 2007
Year = 2012
Year = 2003
Year = 2008
Year = 2013
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

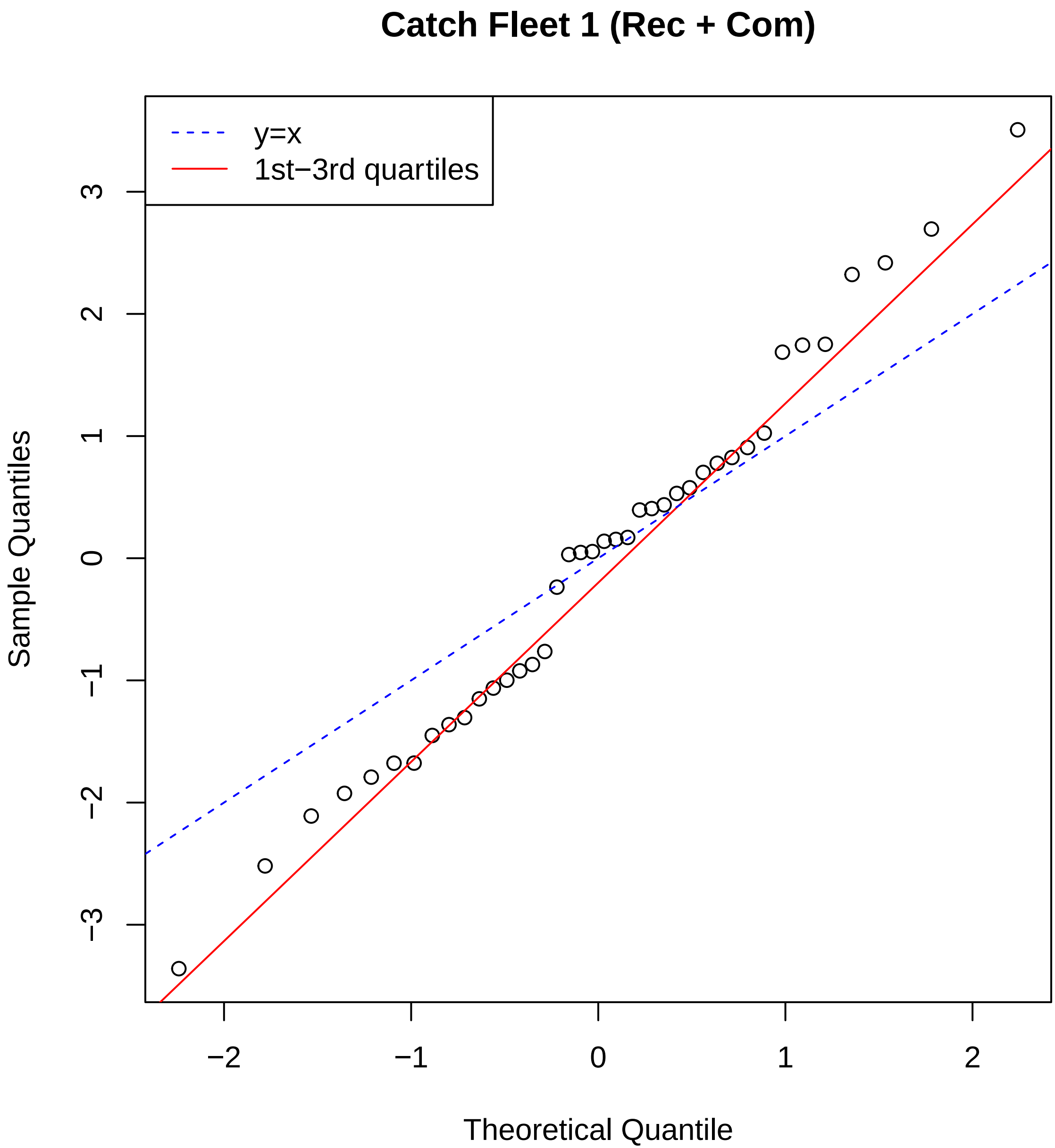


Catch
Year = 2014
Year = 2019
Year = 2024
Year = 2015
Year = 2020
Year = 2016
Year = 2021
Year = 2017
Year = 2022
Year = 2018
Year = 2023
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

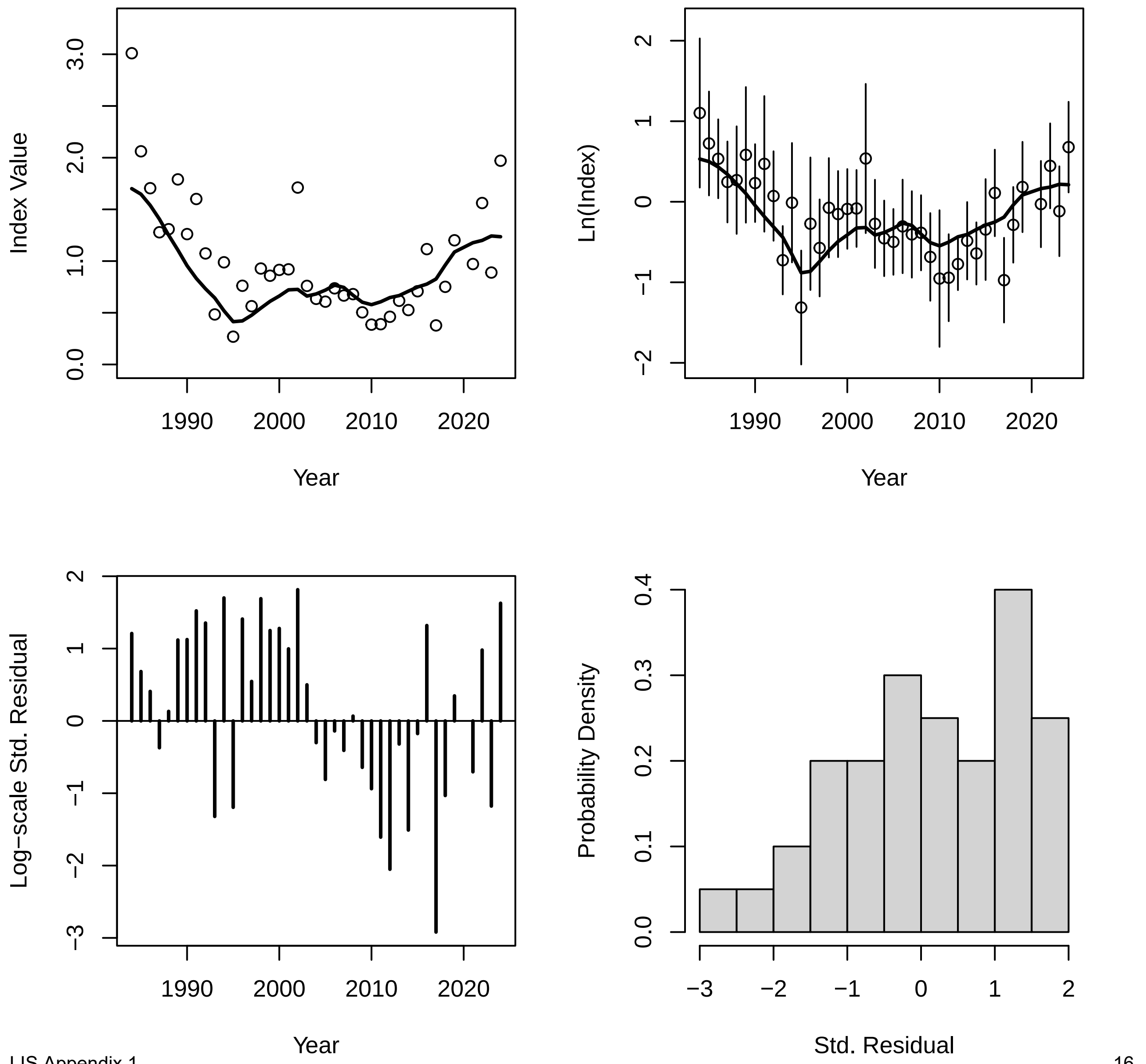

Age Comp Residuals for Catch by Fleet 1 (Rec + Com)
Neg.
Pos.
0.15
0.33
0.66
Max(resid)=3.74
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = 0.01 SD(resid) = 0.74

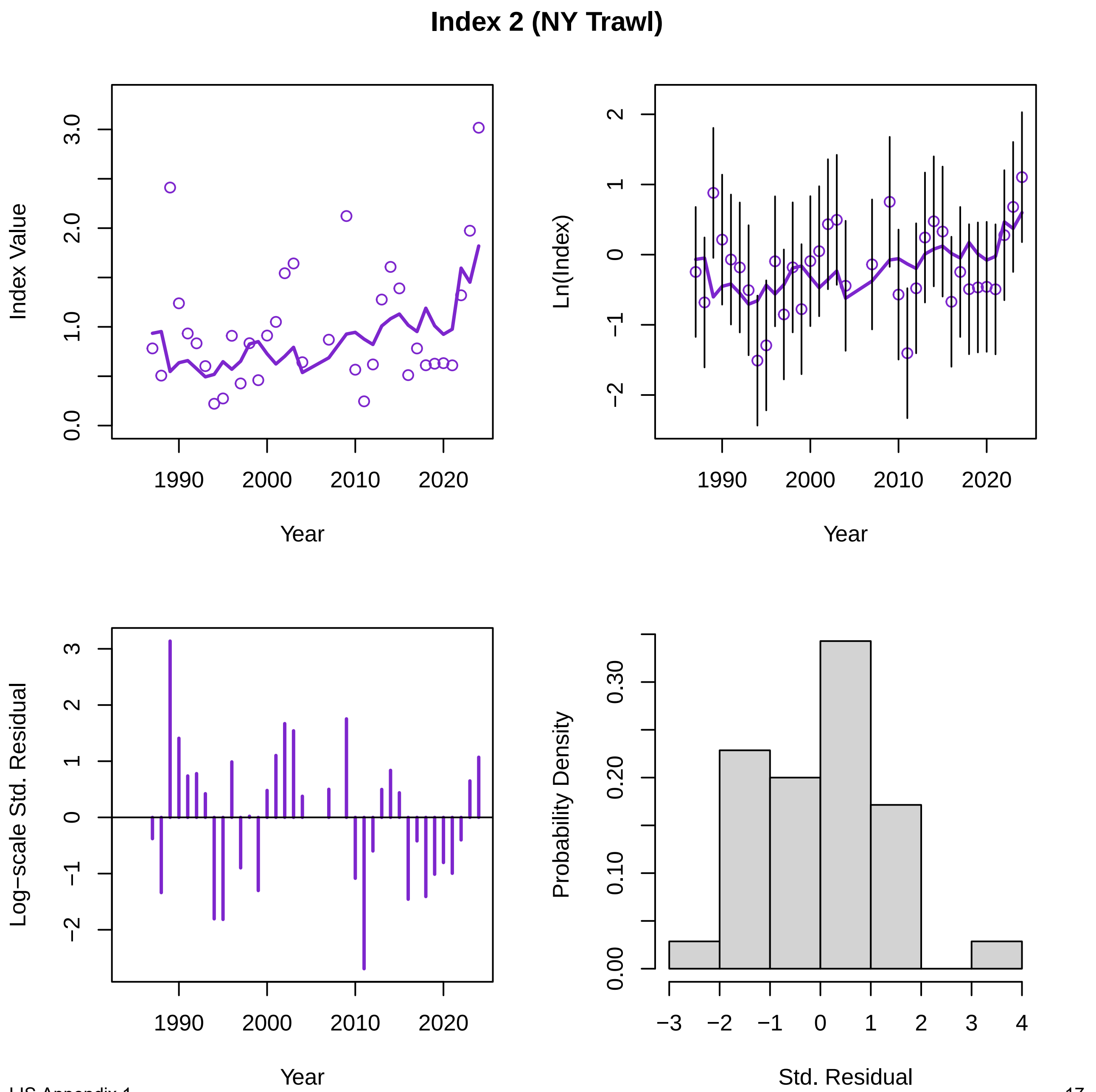

Catch Neff Fleet 1 (Rec + Com)
Effective Sample Size
0
100
200
300
400
1990
2000
2010
2020
Year


Catch Fleet 1 (Rec + Com)
Mean Age
Eff. Sample Size
Year
0
2
4
6
8
10
0
19.4
38.8
58.2
77.6
97
1990
2000
2010
2020
SDNR=1.52
RMSE=1.5
Std Resids
−2
0
2
1984
1989
1994
1999
2005
2010
2015
2020
Year


Catch Fleet 1 (Rec + Com)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
−3
−2
−1
0
1
2
3
−2
−1
0
1
2

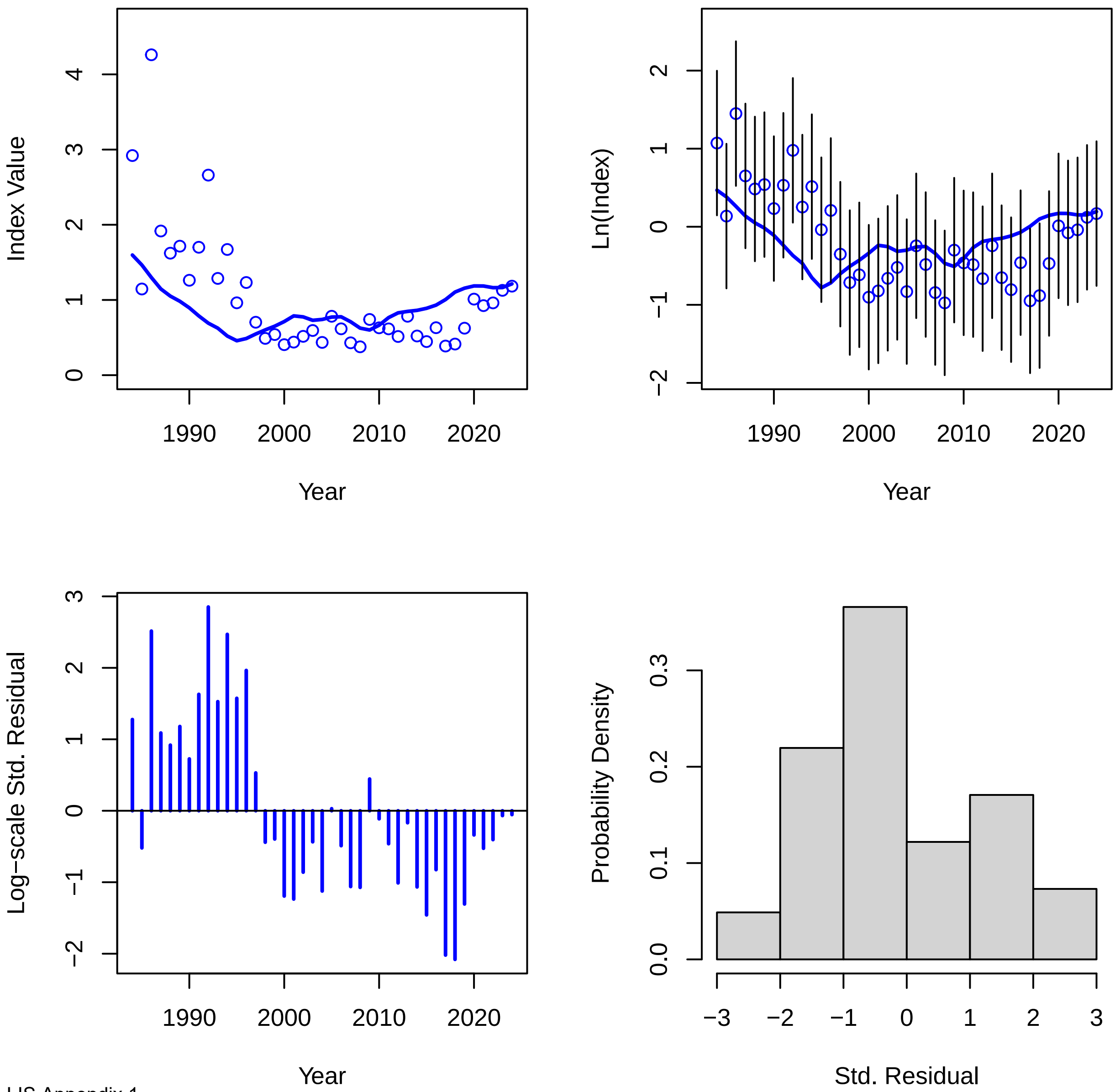
Index 1 (CT Trawl)



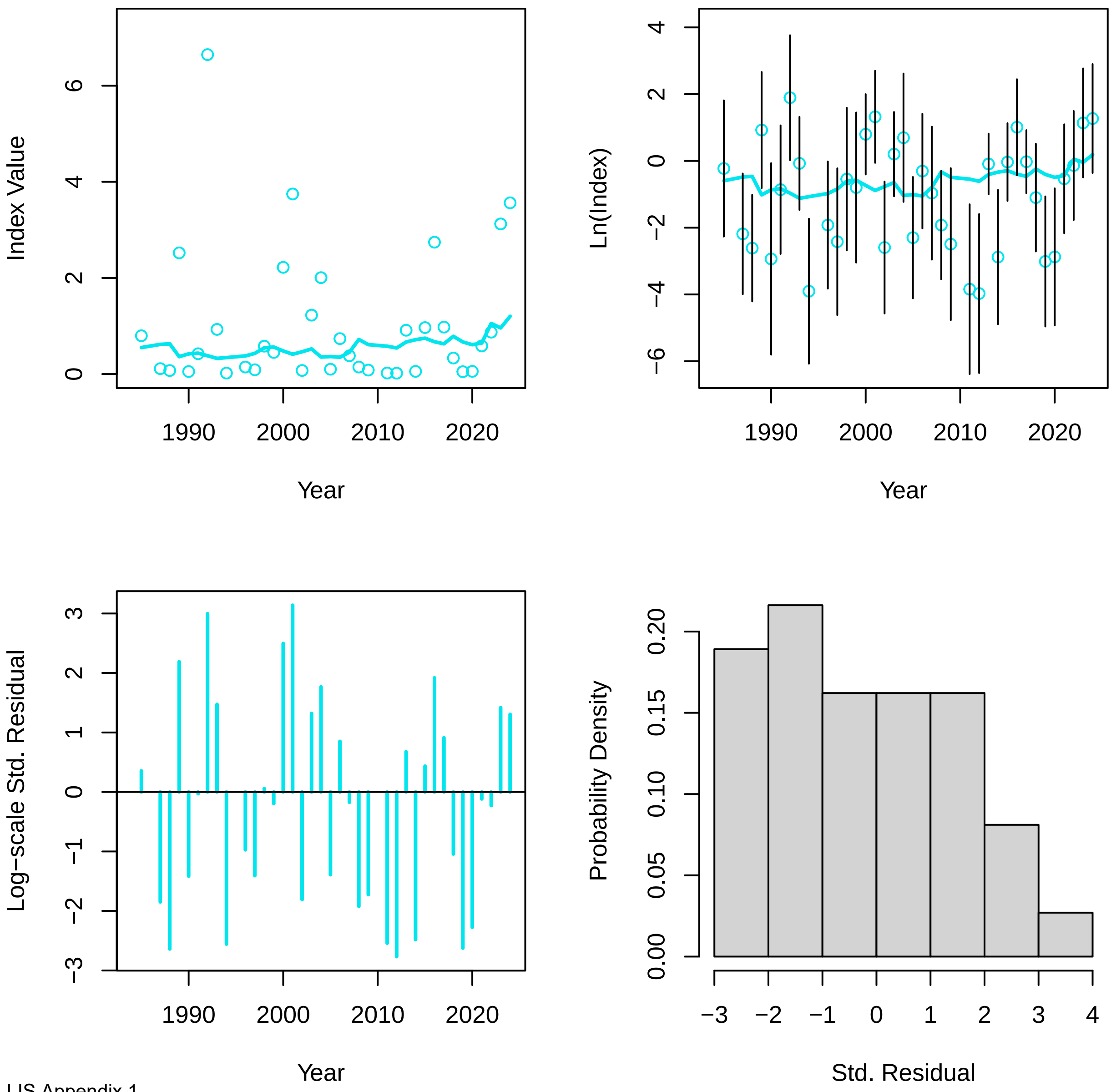


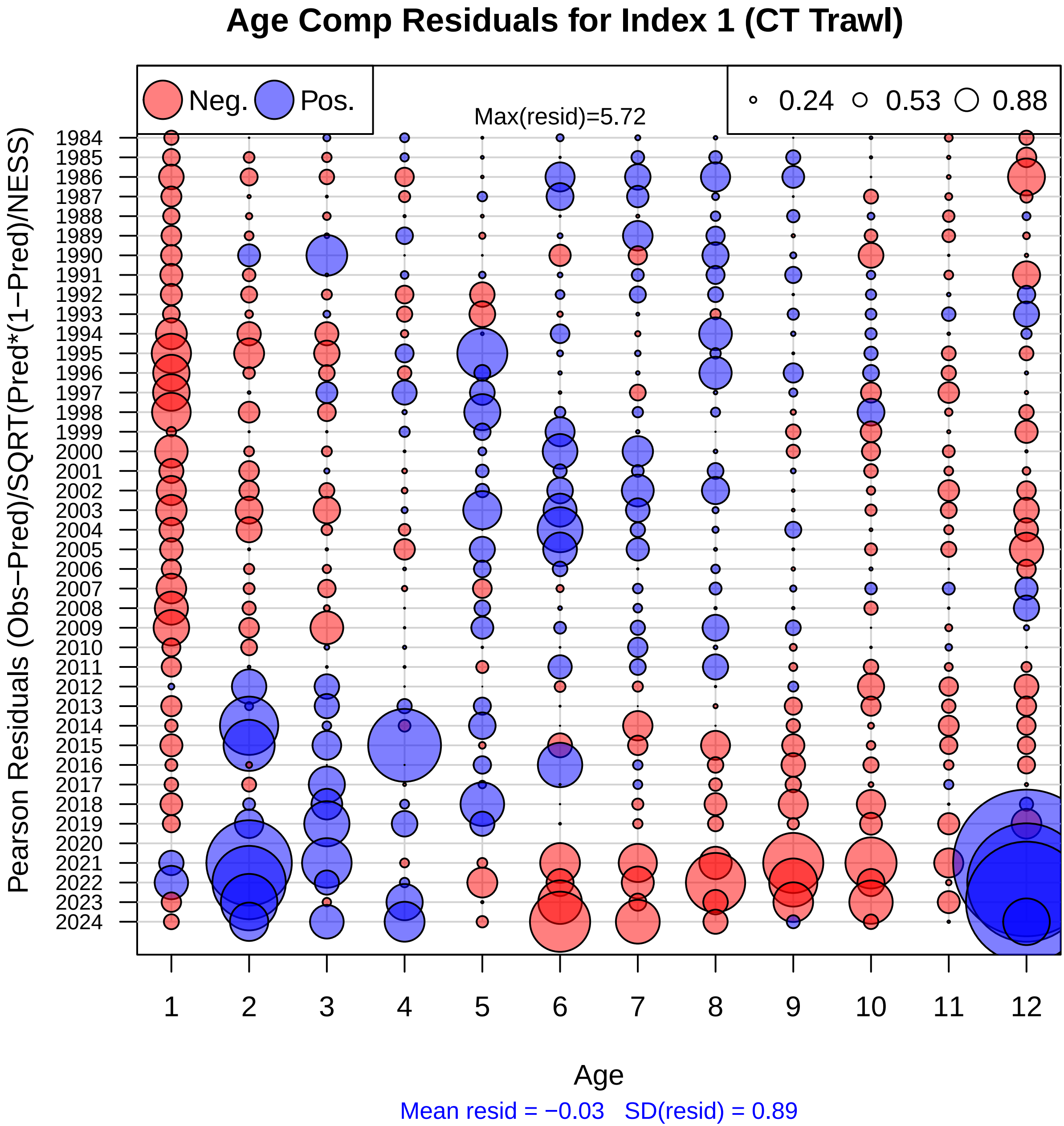
Index 2 (NY Trawl)
Index Value
Year
Ln(Index)
Year
Log−scale Std. Residual
Year
Probability Density
Std. Residual

Index 3 (MRIP CPUE)

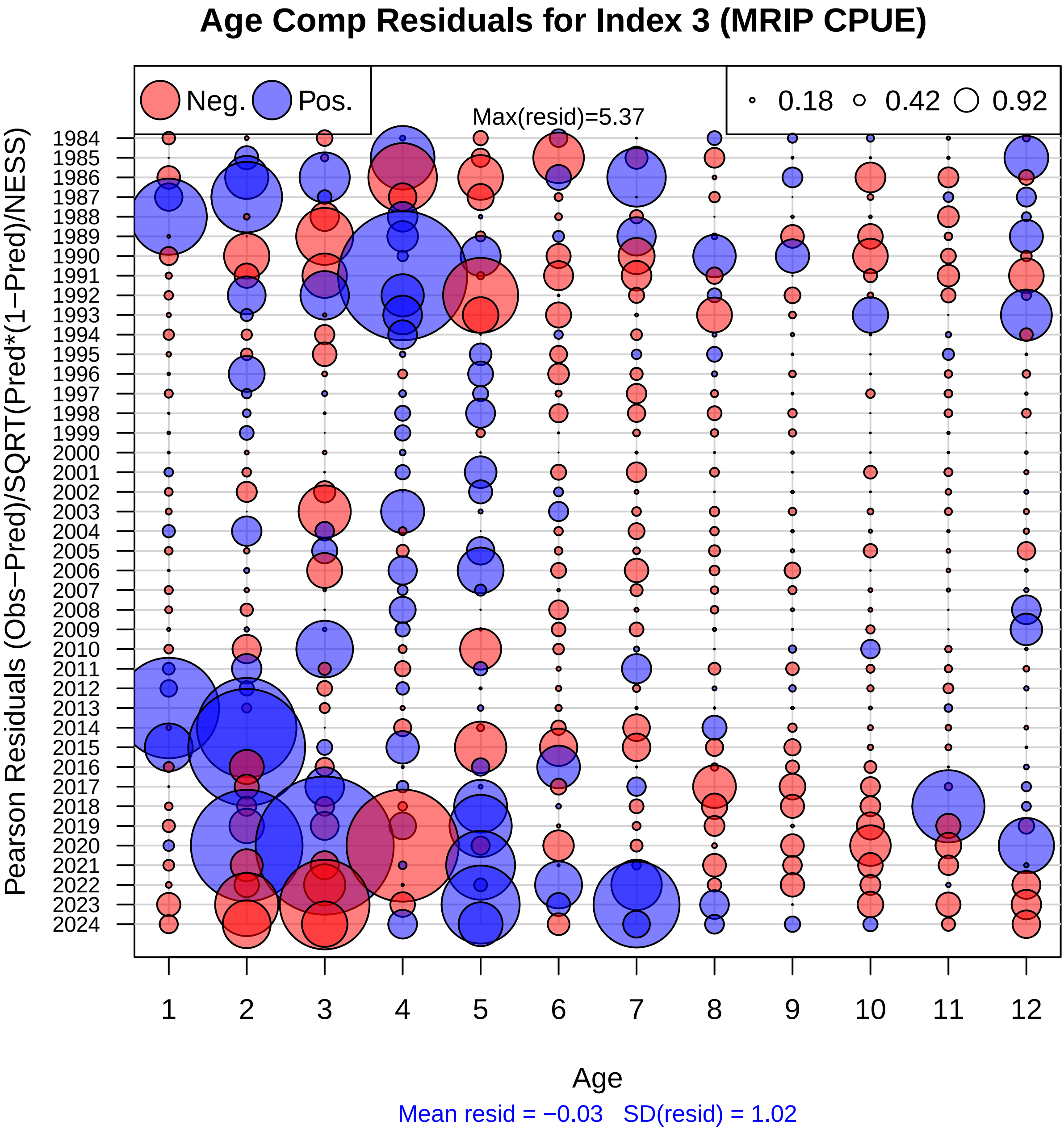


Index 4 (NYSeine)

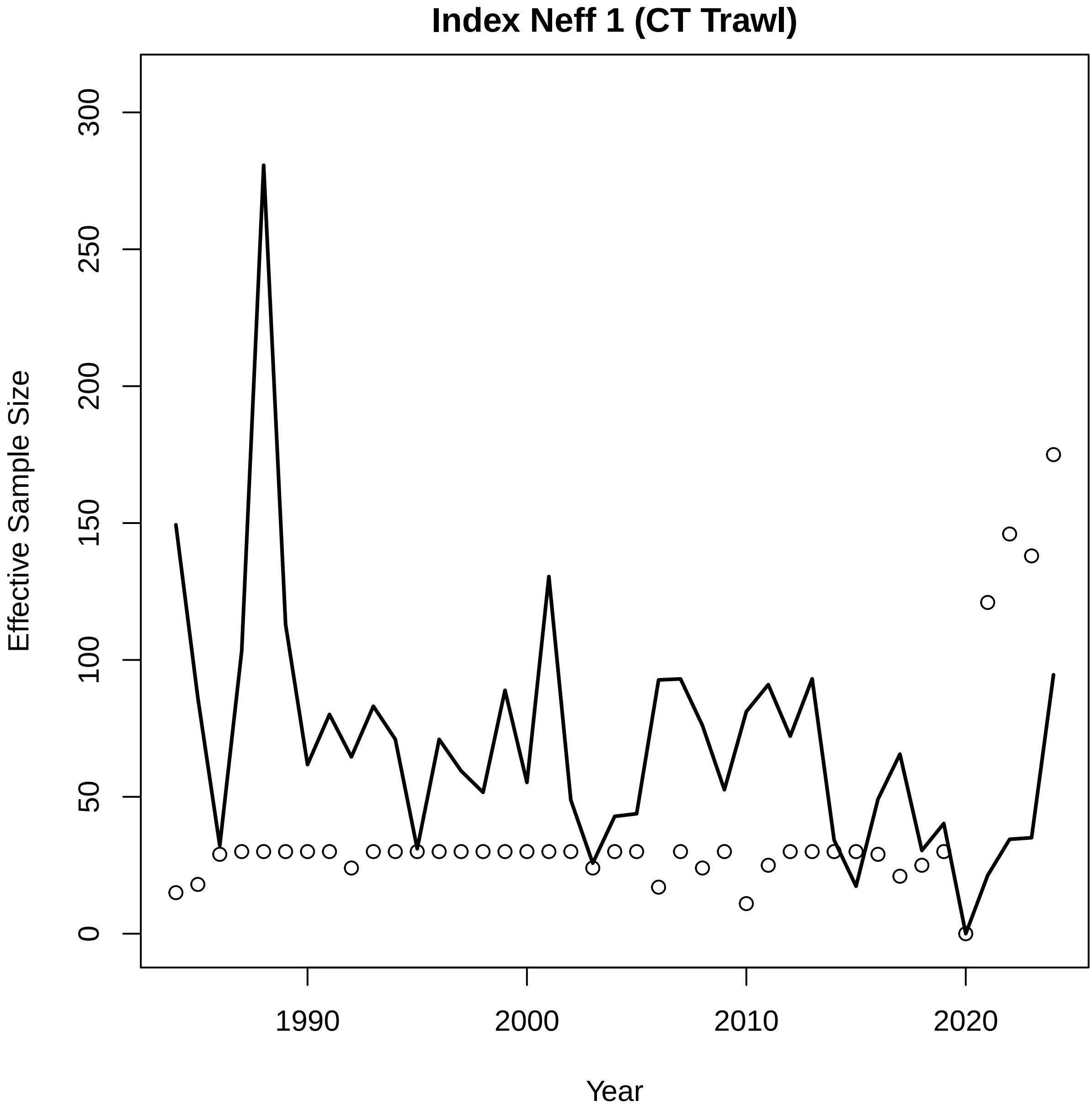


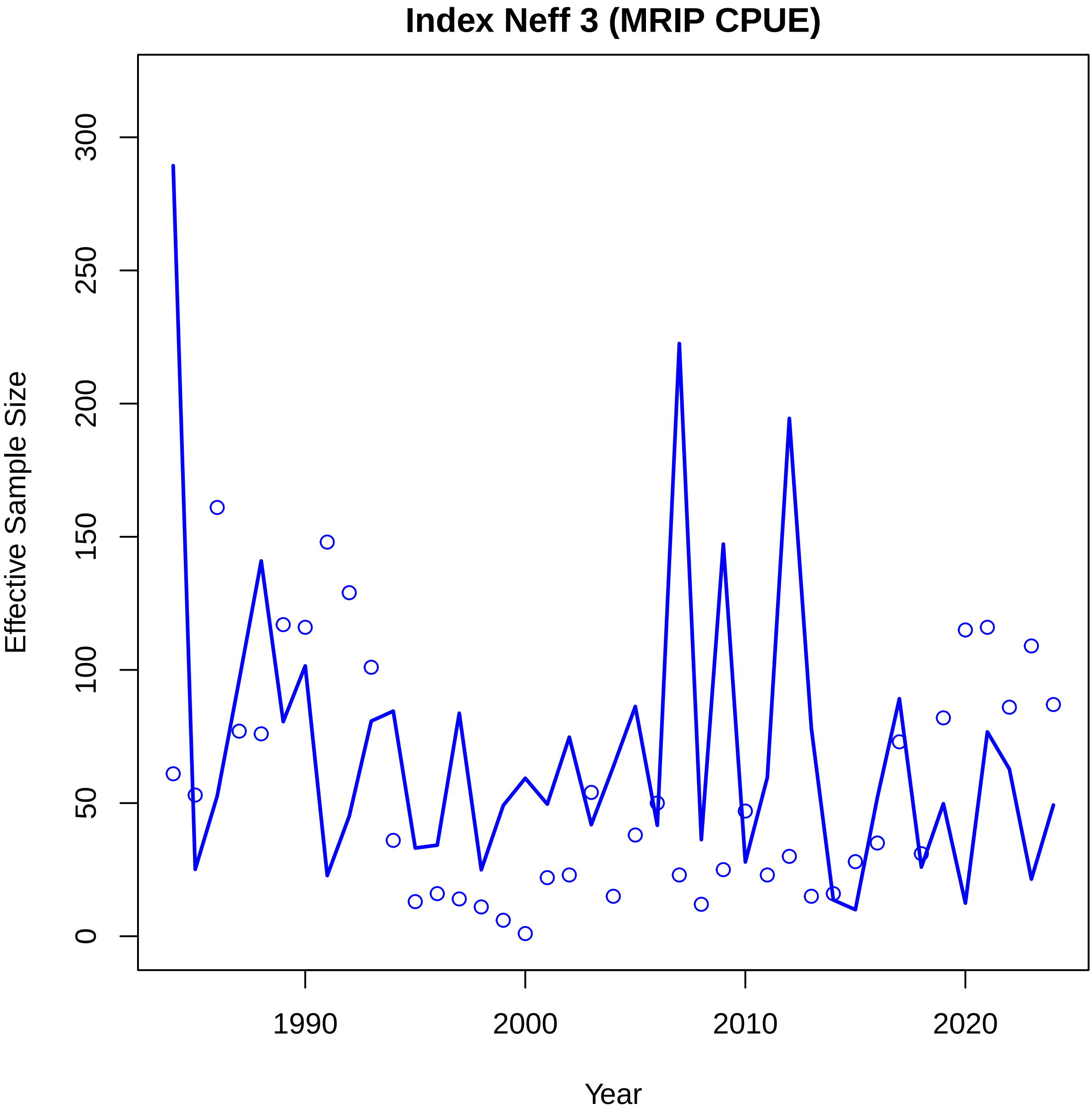


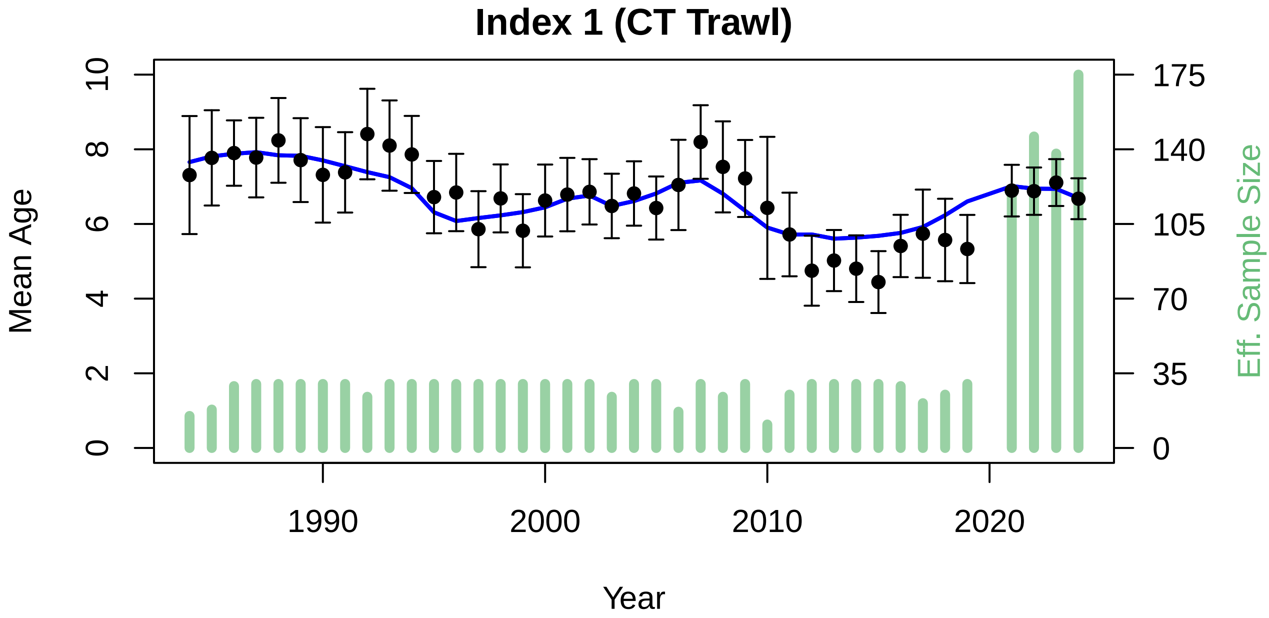
Age Comp Residuals for Index 1 (CT Trawl)
Neg.
Pos.
Max(resid)=5.72
0.24
0.53
0.88
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = −0.03   SD(resid) = 0.89

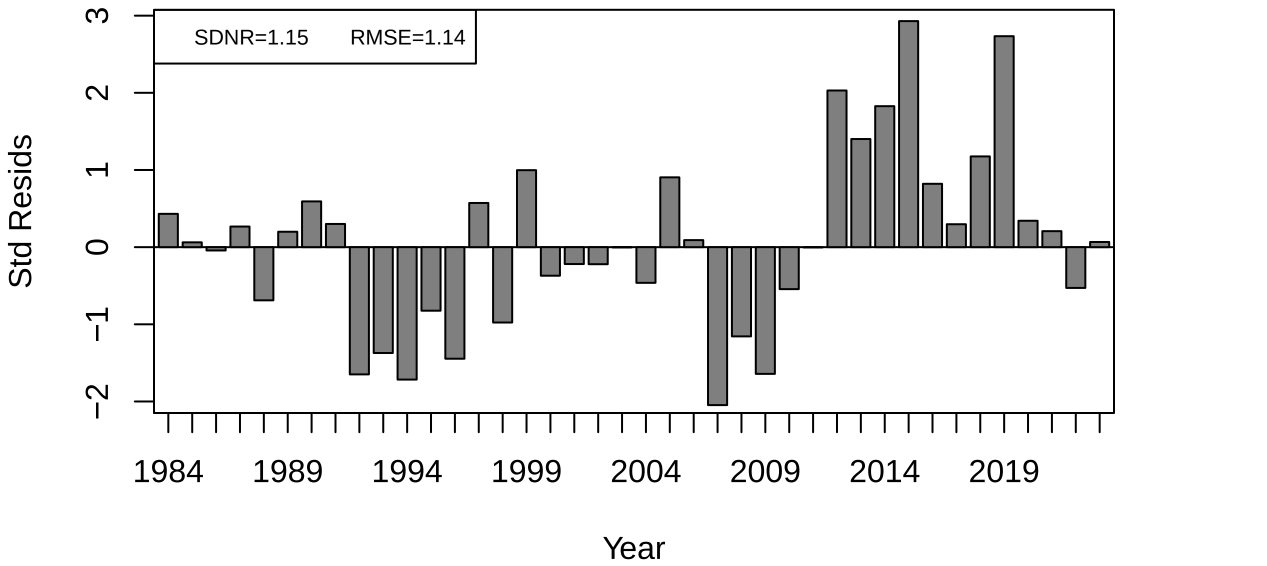


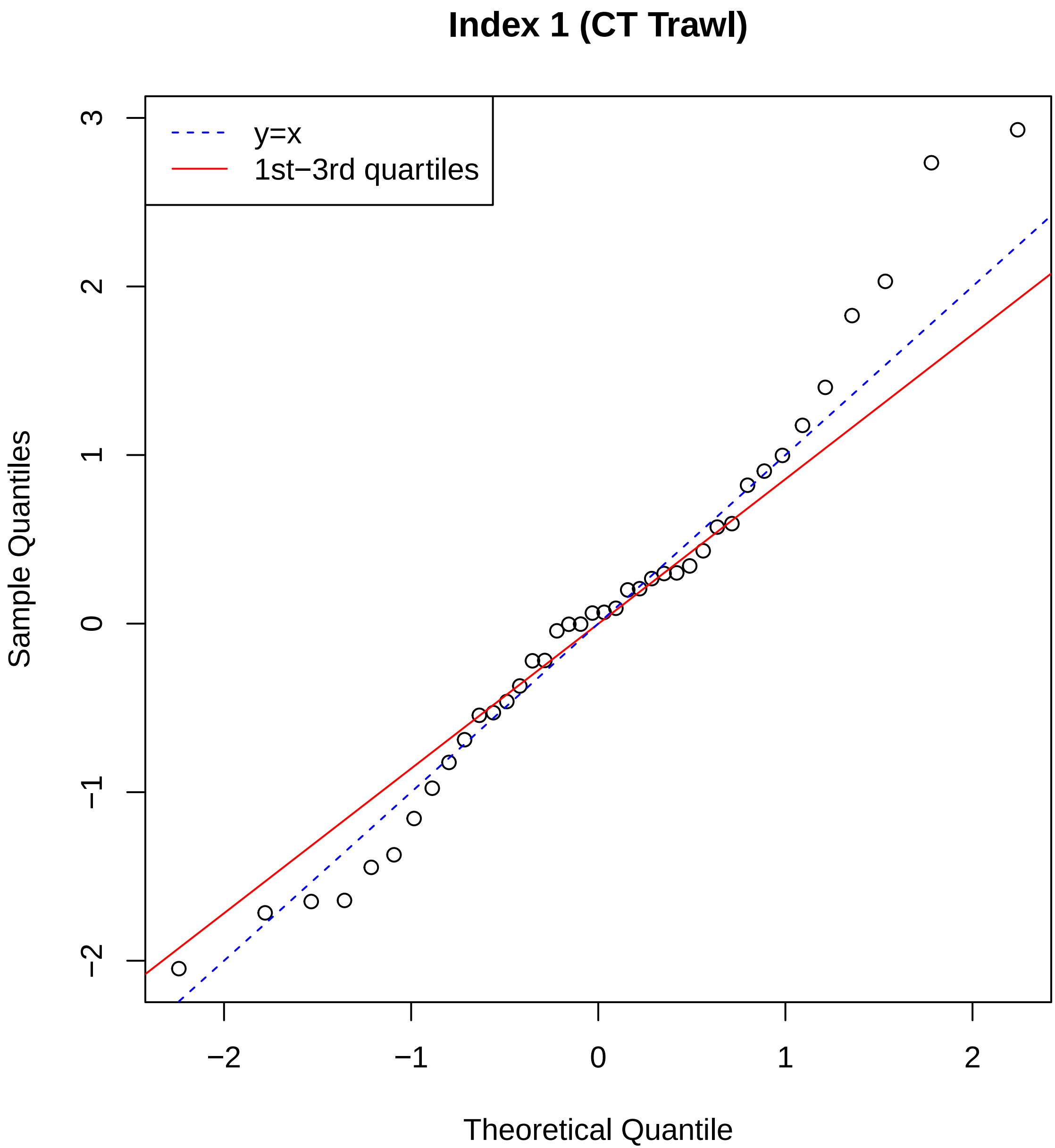
Age Comp Residuals for Index 3 (MRIP CPUE)
Neg.
Pos.
0.18
0.42
0.92
Max(resid)=5.37
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = −0.03 SD(resid) = 1.02

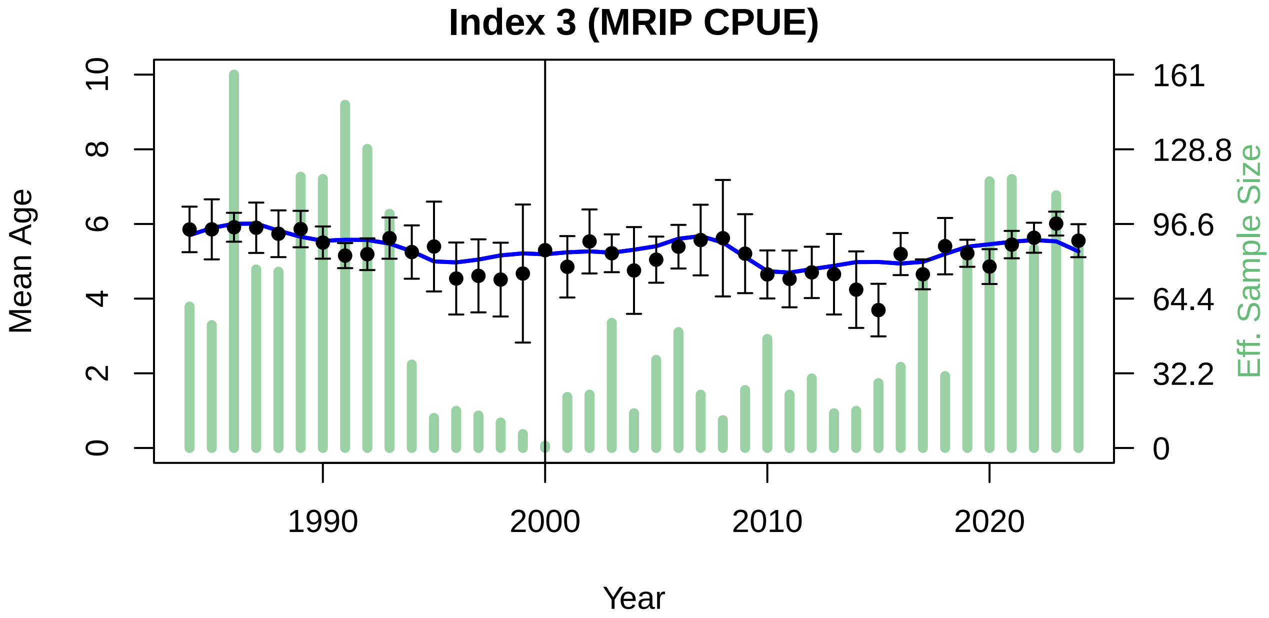

Index Neff 1 (CT Trawl)
Effective Sample Size
0
50
100
150
200
250
300
1990
2000
2010
2020
Year

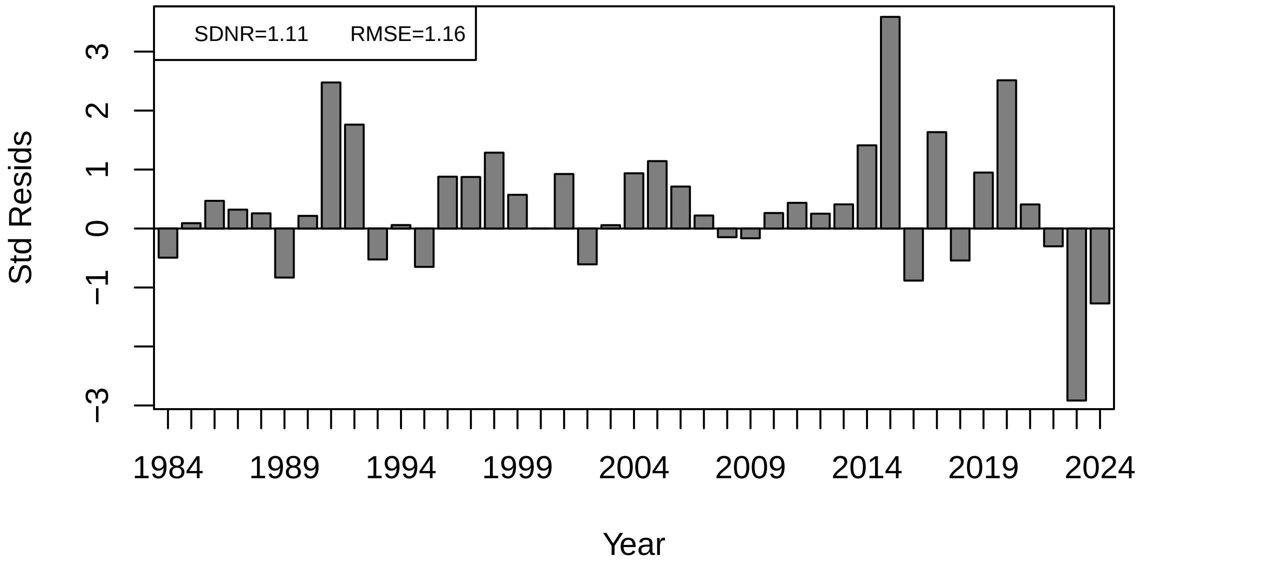

Index Neff 3 (MRIP CPUE)
Effective Sample Size
0
50
100
150
200
250
300
1990
2000
2010
2020
Year

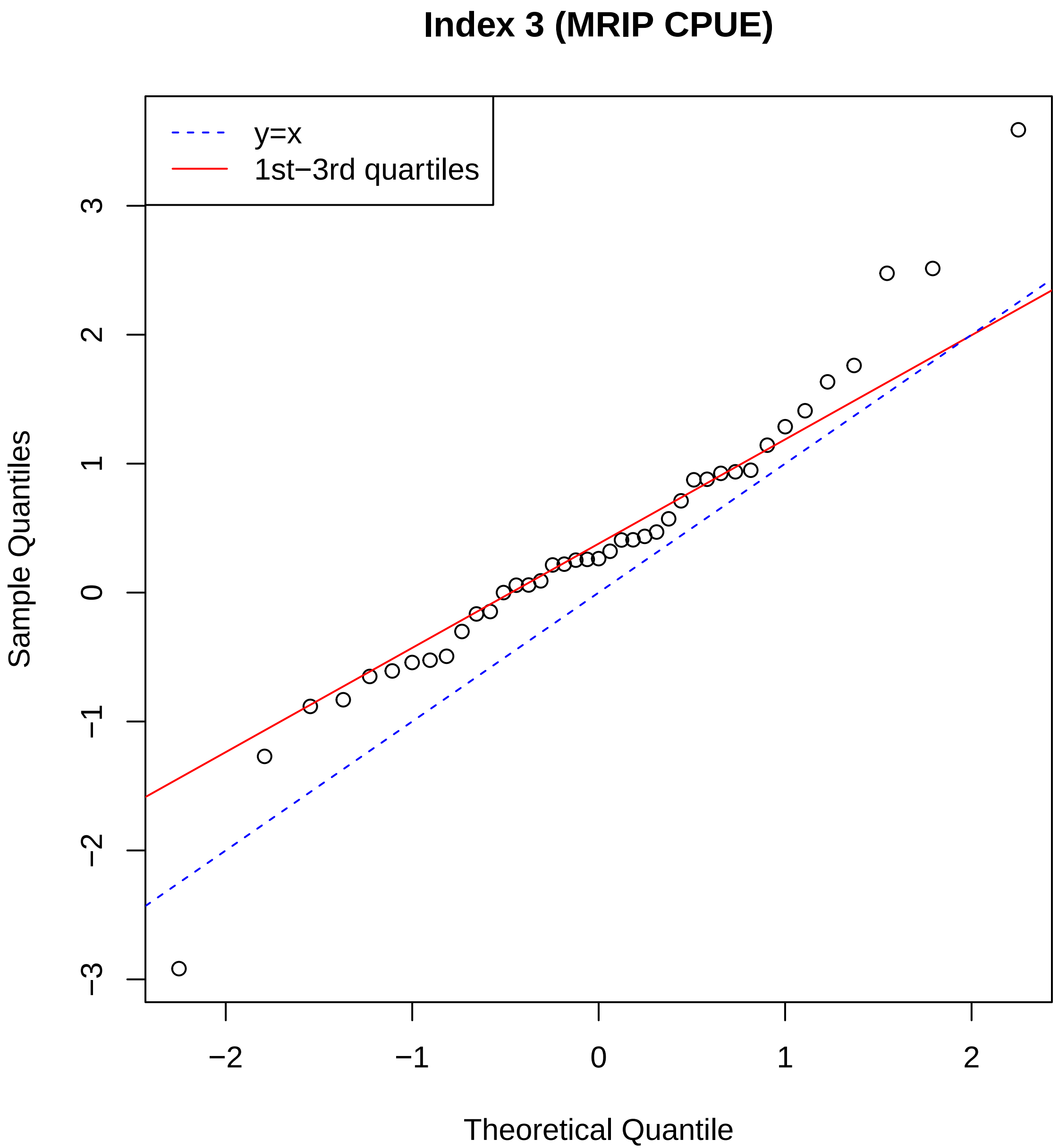

Index 1 (CT Trawl)
Mean Age
Eff. Sample Size
Year
0
2
4
6
8
10
0
35
70
105
140
175
1990
2000
2010
2020

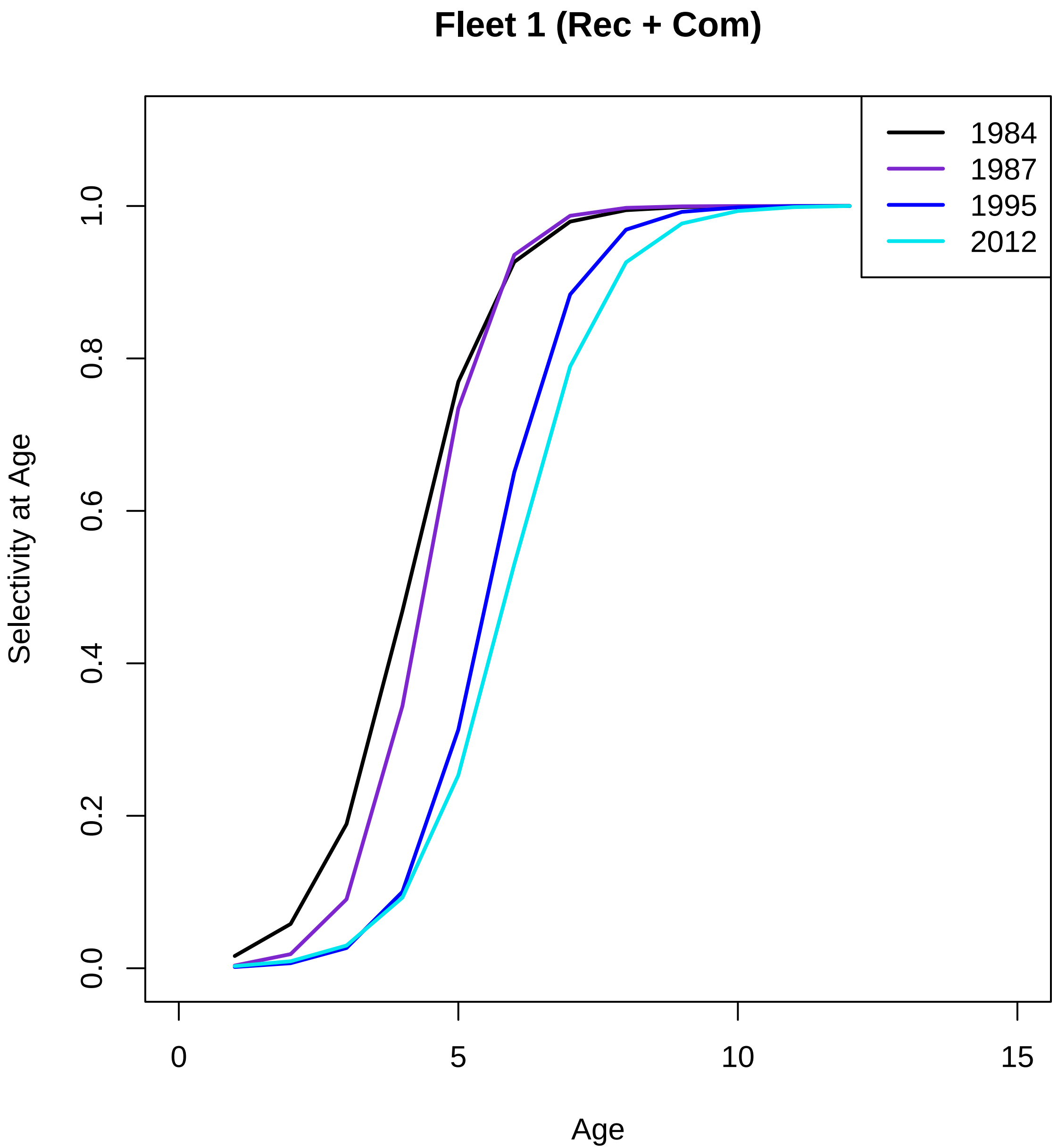

SDNR=1.15
RMSE=1.14
Std Resids
Year
−2
−1
0
1
2
3
1984
1989
1994
1999
2004
2009
2014
2019

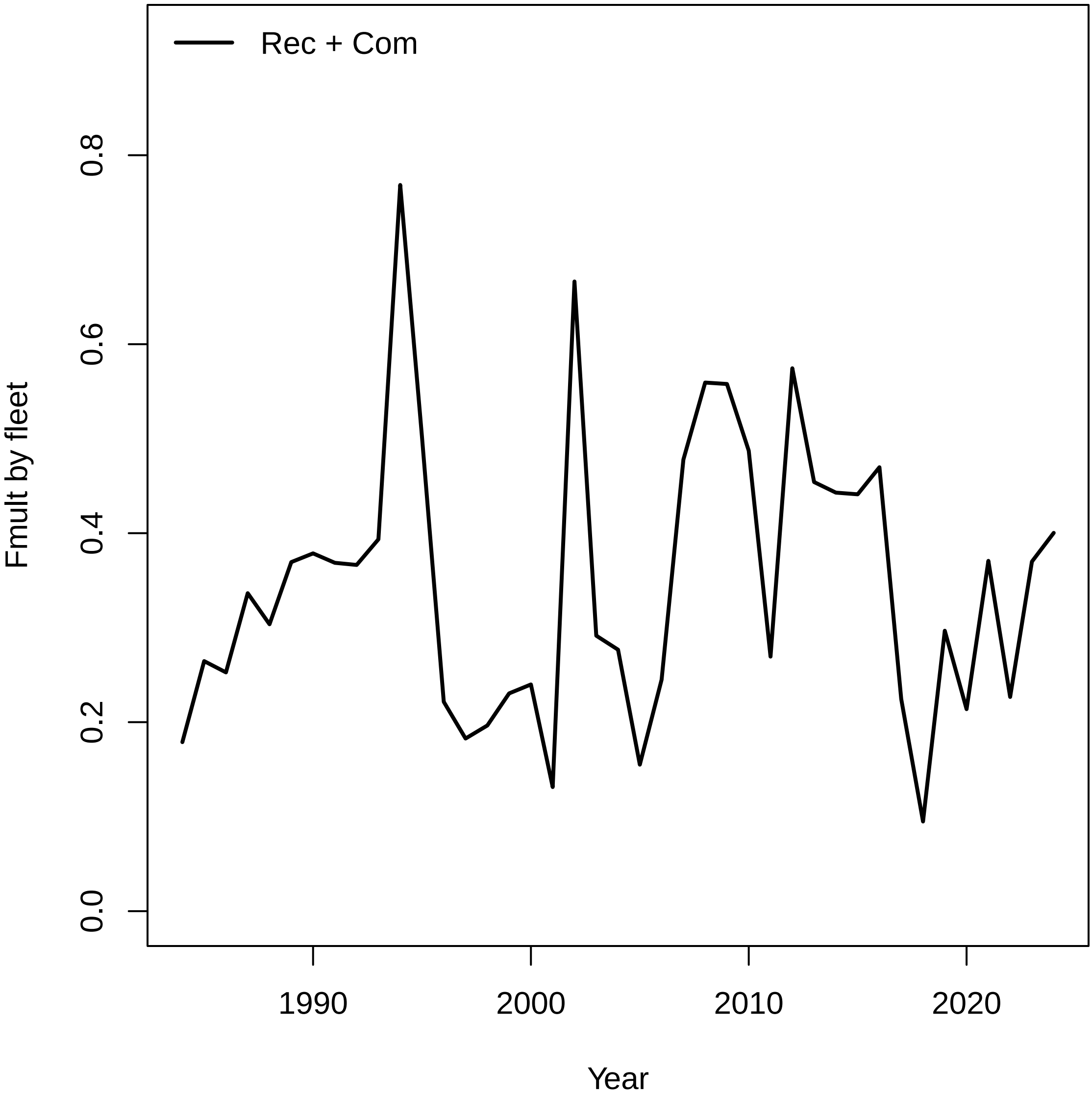

Index 1 (CT Trawl)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
−2
−1
0
1
2
3


Index 3 (MRIP CPUE)
Mean Age
Eff. Sample Size
0
2
4
6
8
10
0
32.2
64.4
96.6
128.8
161
1990
2000
2010
2020
Year

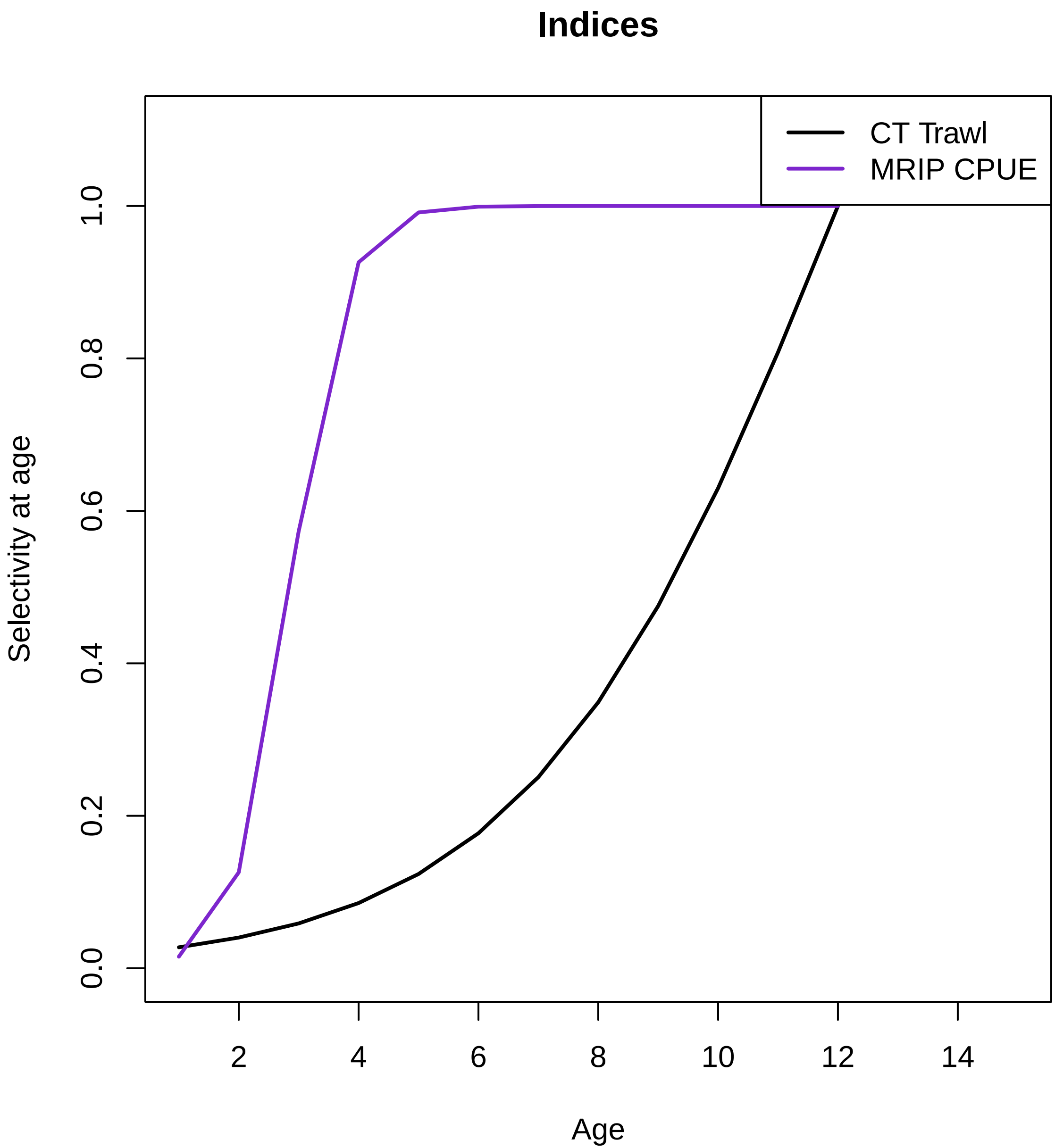

SDNR=1.11
RMSE=1.16
Std Resids
−3
−1
0
1
2
3
1984
1989
1994
1999
2004
2009
2014
2019
2024
Year

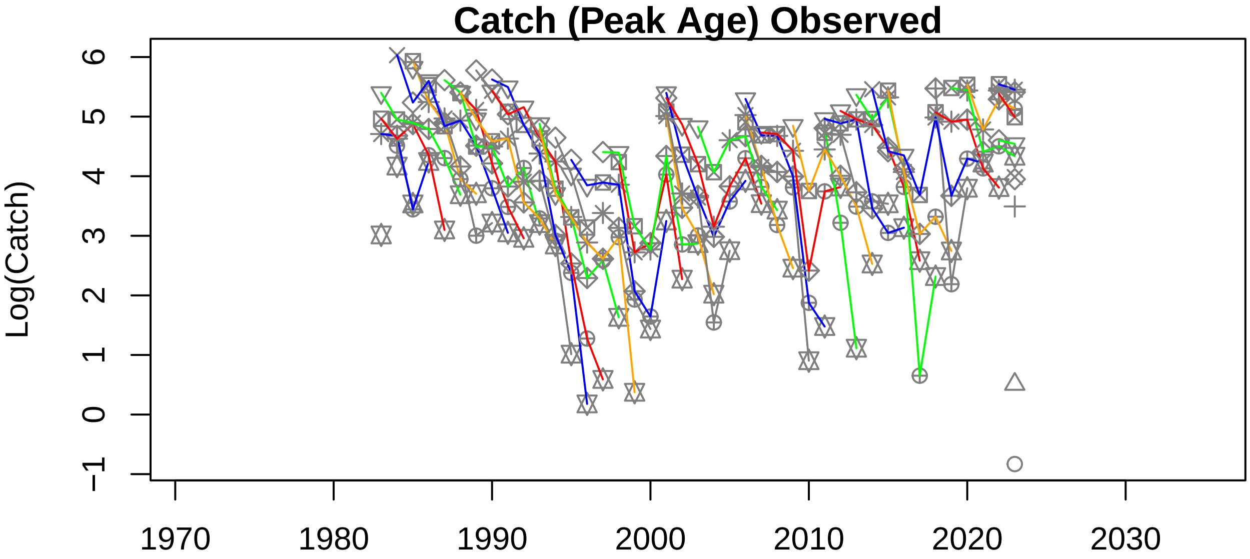

Index 3 (MRIP CPUE)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
−3
−2
−1
0
1
2
3
−2
−1
0
1
2


Fleet 1 (Rec + Com)
1984
1987
1995
2012
Selectivity at Age
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
Age

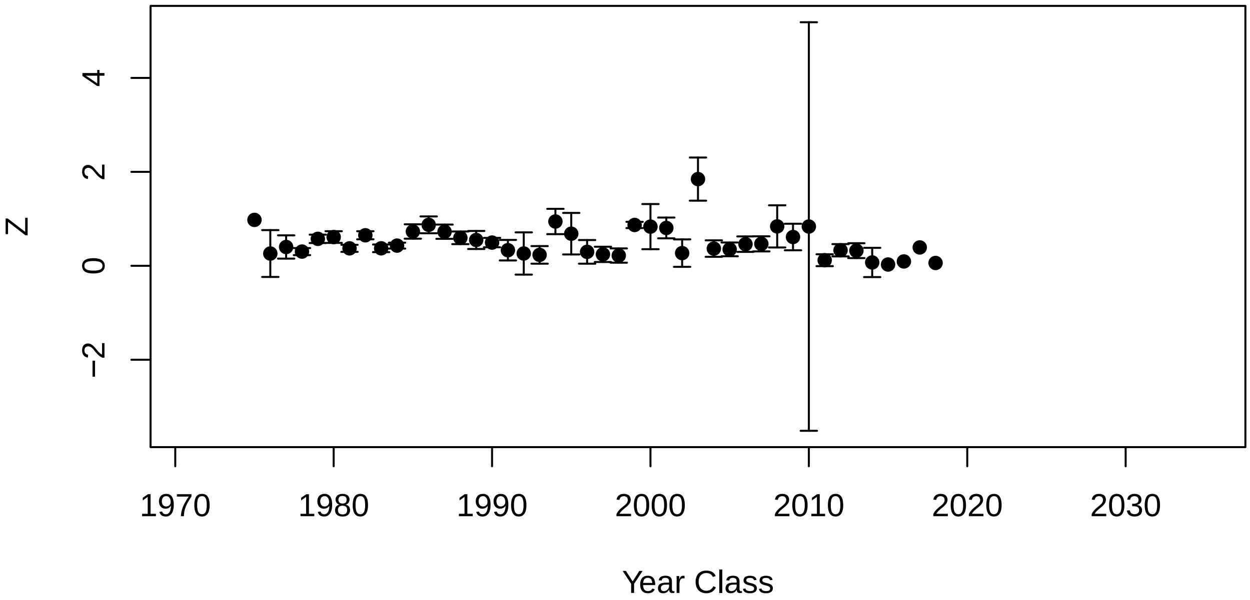


Rec + Com
Fmult by fleet
0.0
0.2
0.4
0.6
0.8
1990
2000
2010
2020
Year


Indices
CT Trawl
MRIP CPUE
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
14
Age

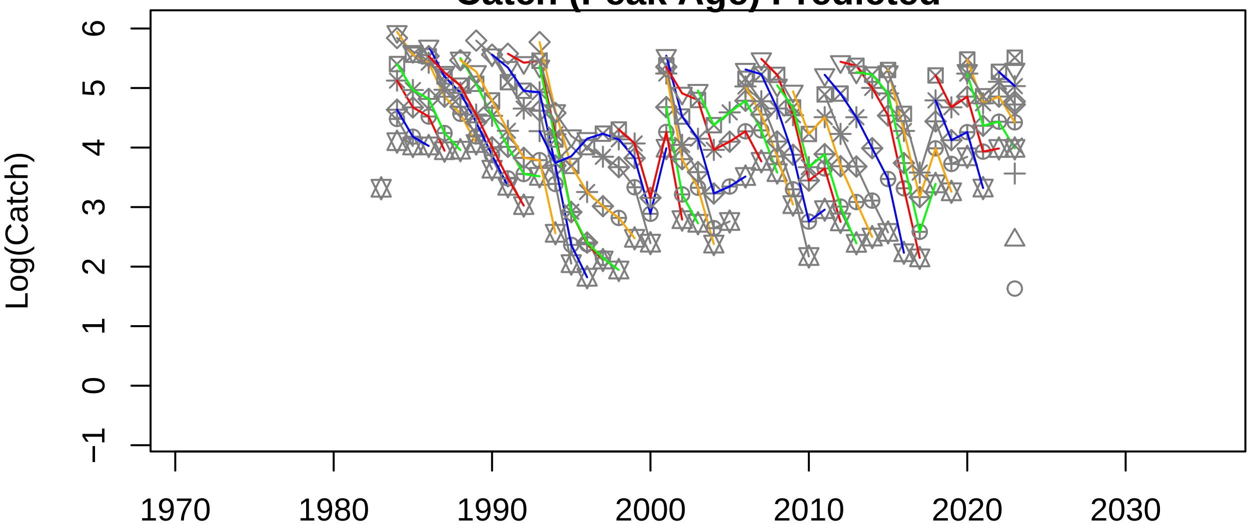


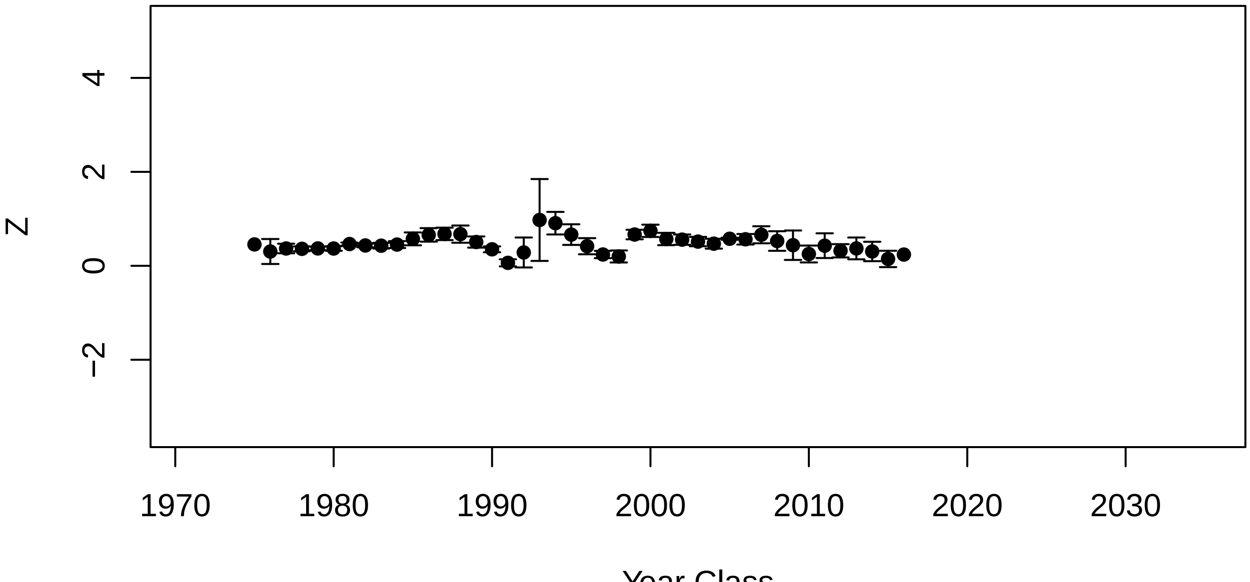
Catch (Peak Age) Observed
Log(Catch)
-1
0
1
2
3
4
5
6
1970
1980
1990
2000
2010
2020
2030

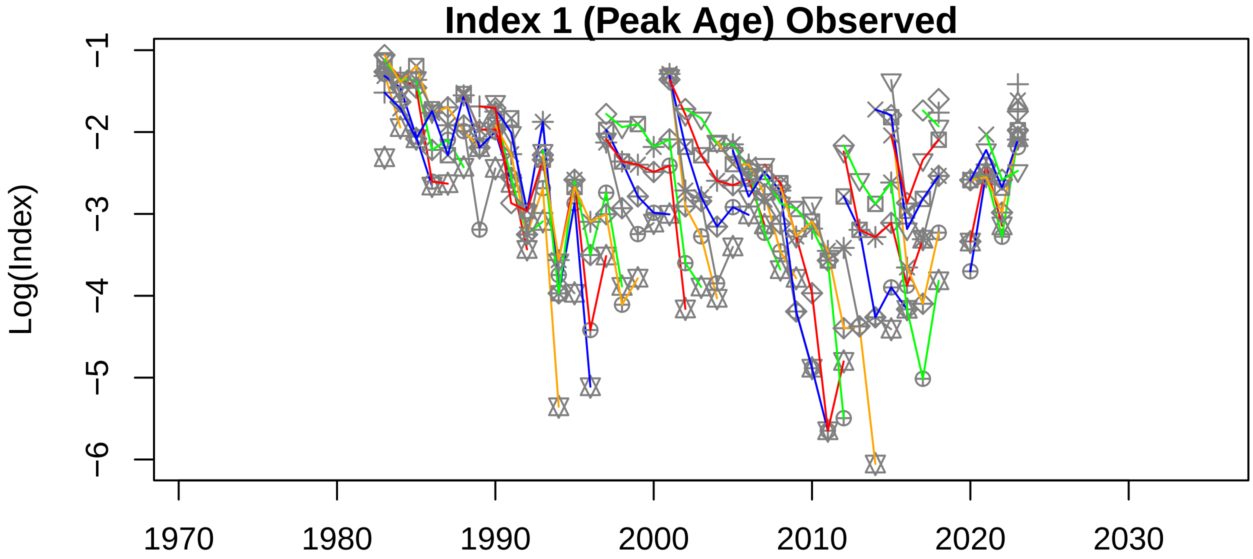


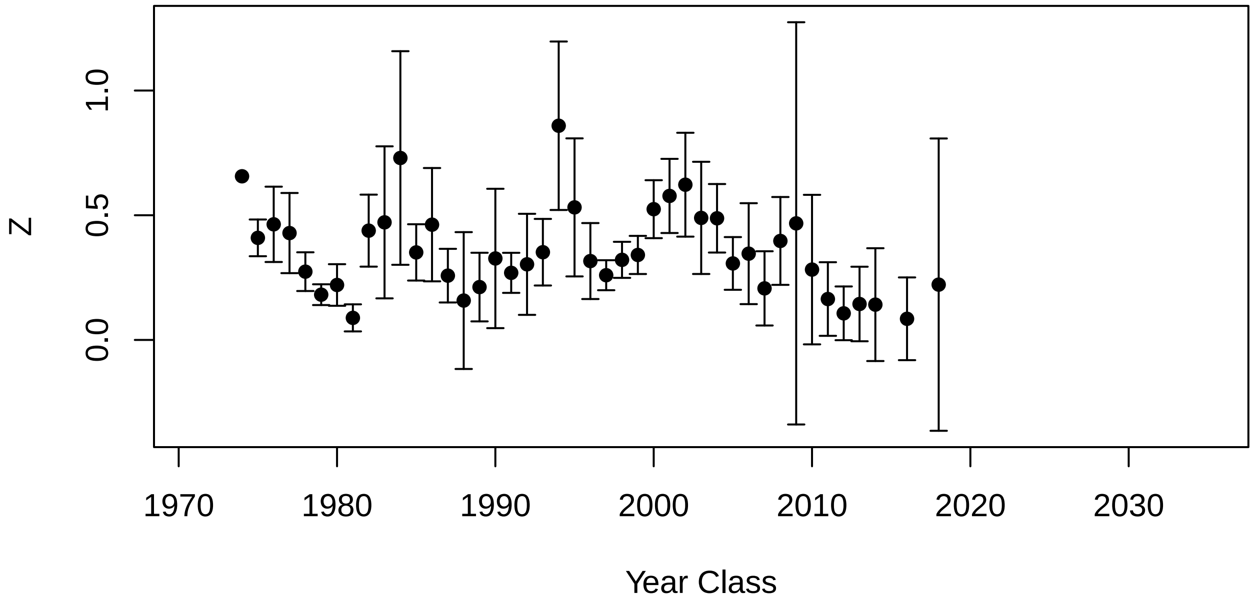
Z
-2
0
2
4
1970
1980
1990
2000
2010
2020
2030
Year Class

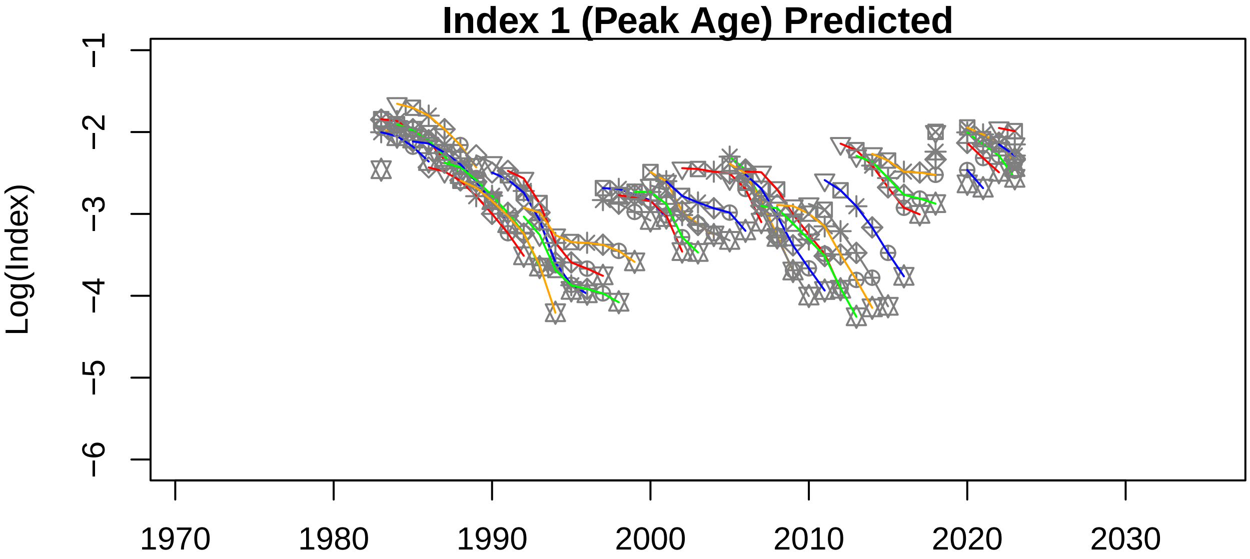
Catch (Peak Age) Predicted



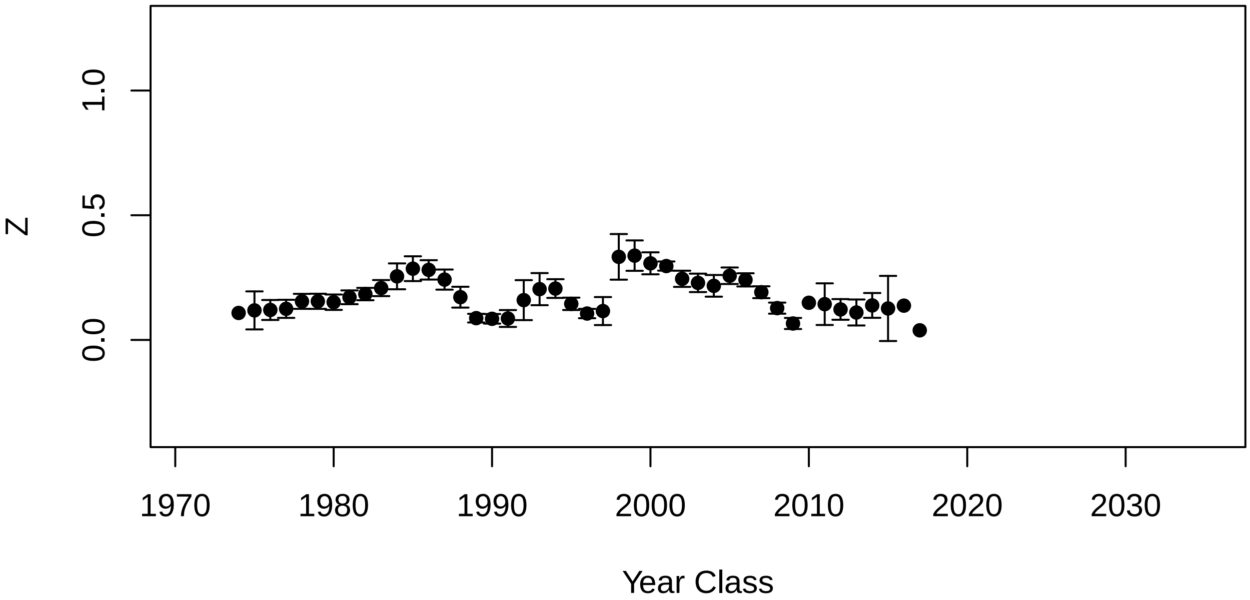



Index 1 (Peak Age) Observed
Log(Index)
−1
−2
−3
−4
−5
−6
1970
1980
1990
2000
2010
2020
2030

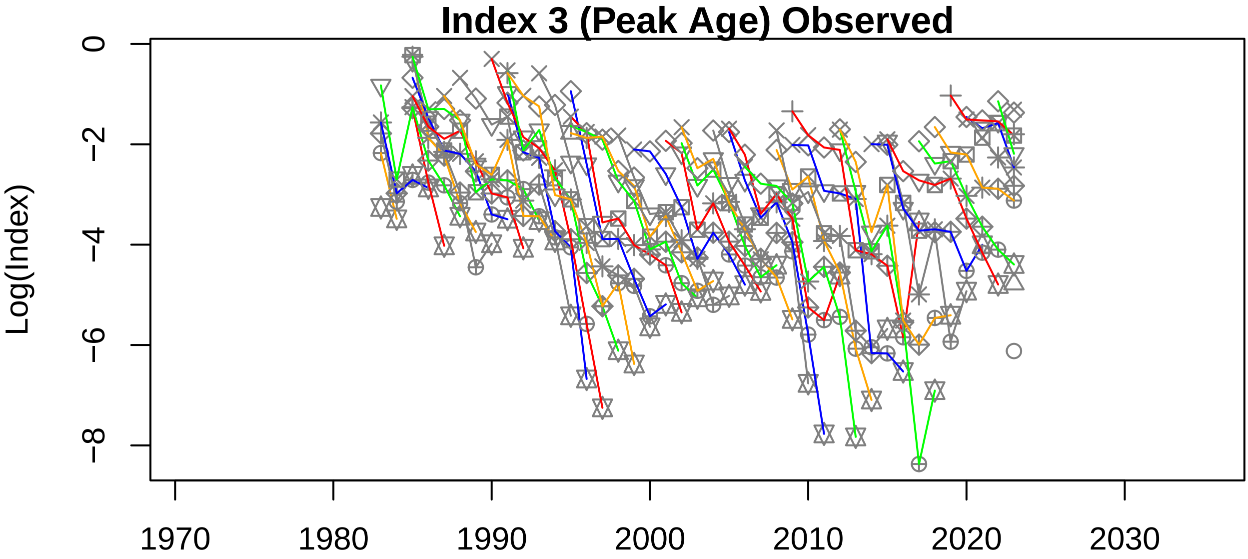

Z
1.0
0.5
0.0
1970
1980
1990
2000
2010
2020
2030
Year Class

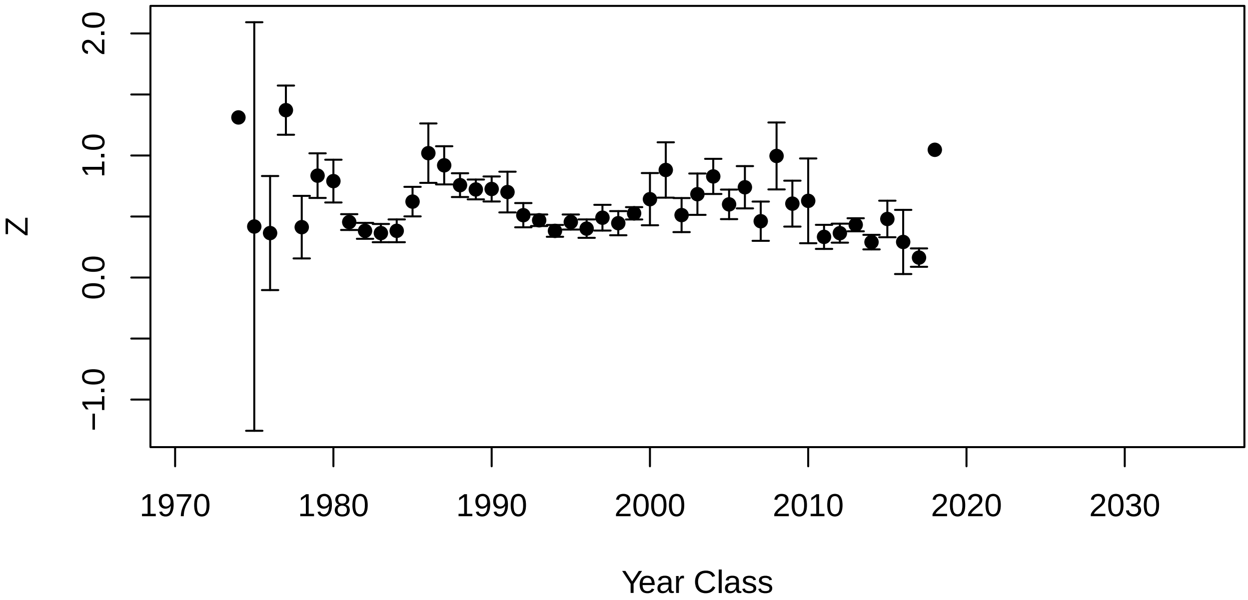


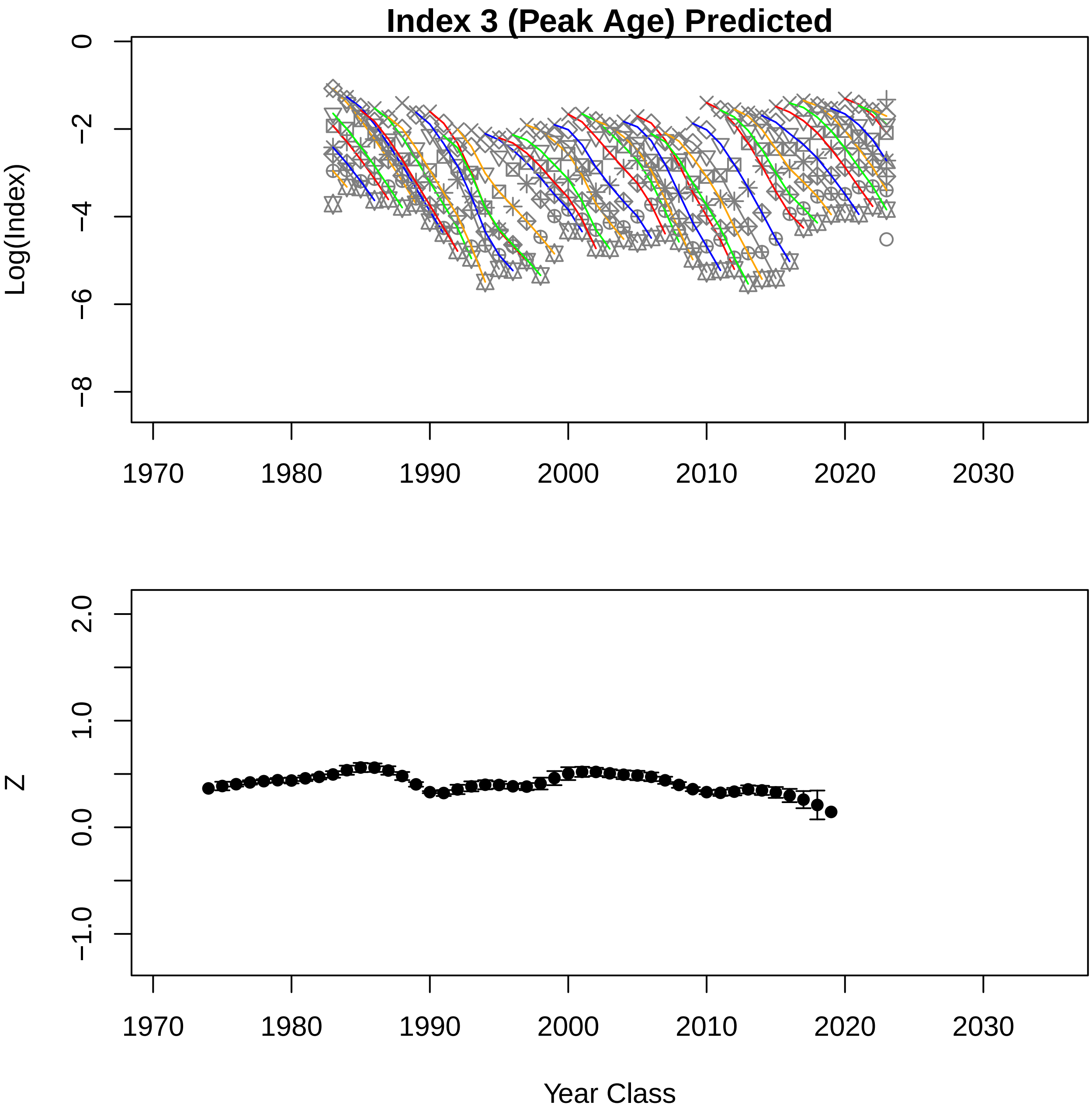
Index 1 (Peak Age) Predicted
Log(Index)
−1
−2
−3
−4
−5
−6
1970
1980
1990
2000
2010
2020
2030

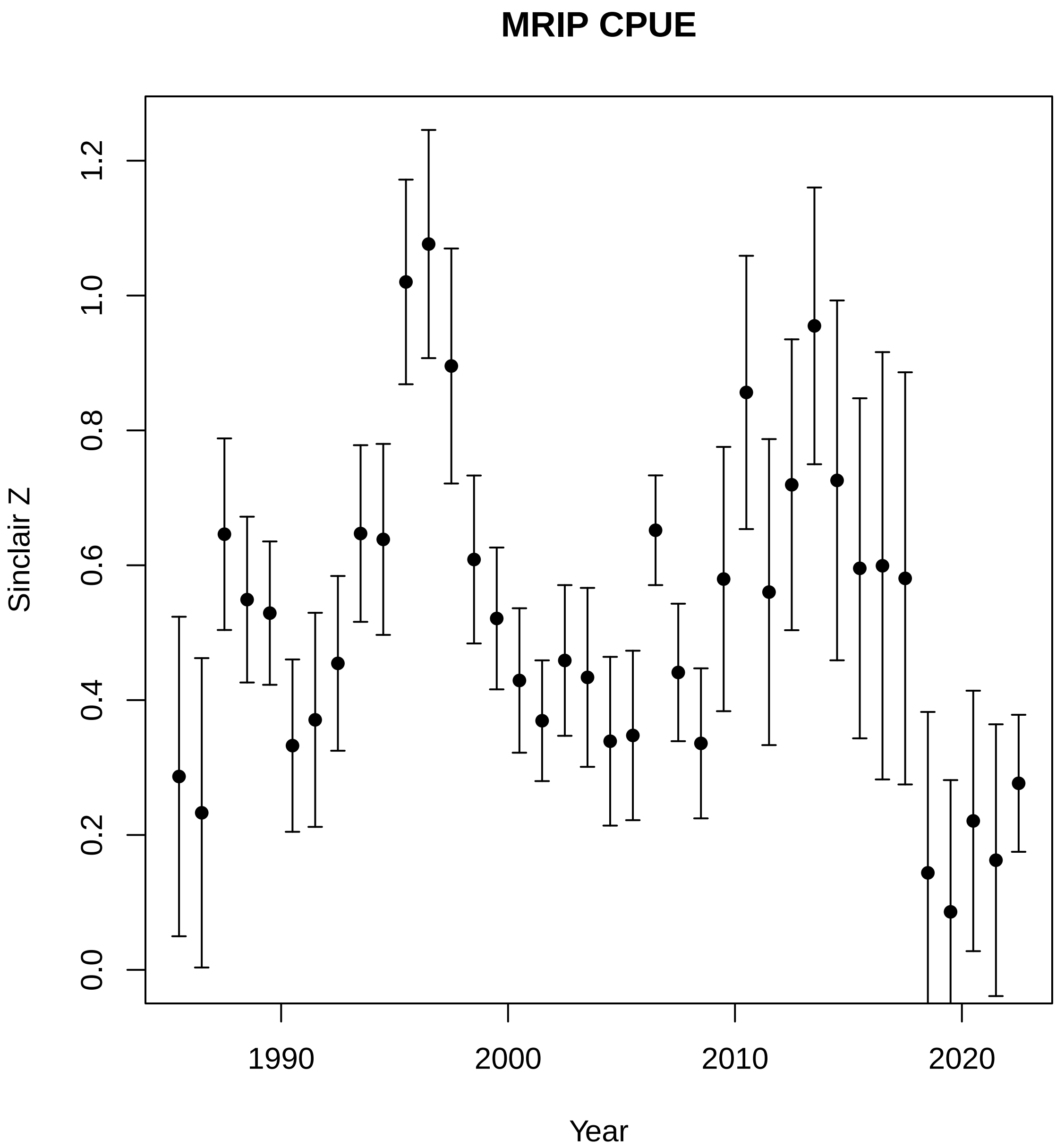


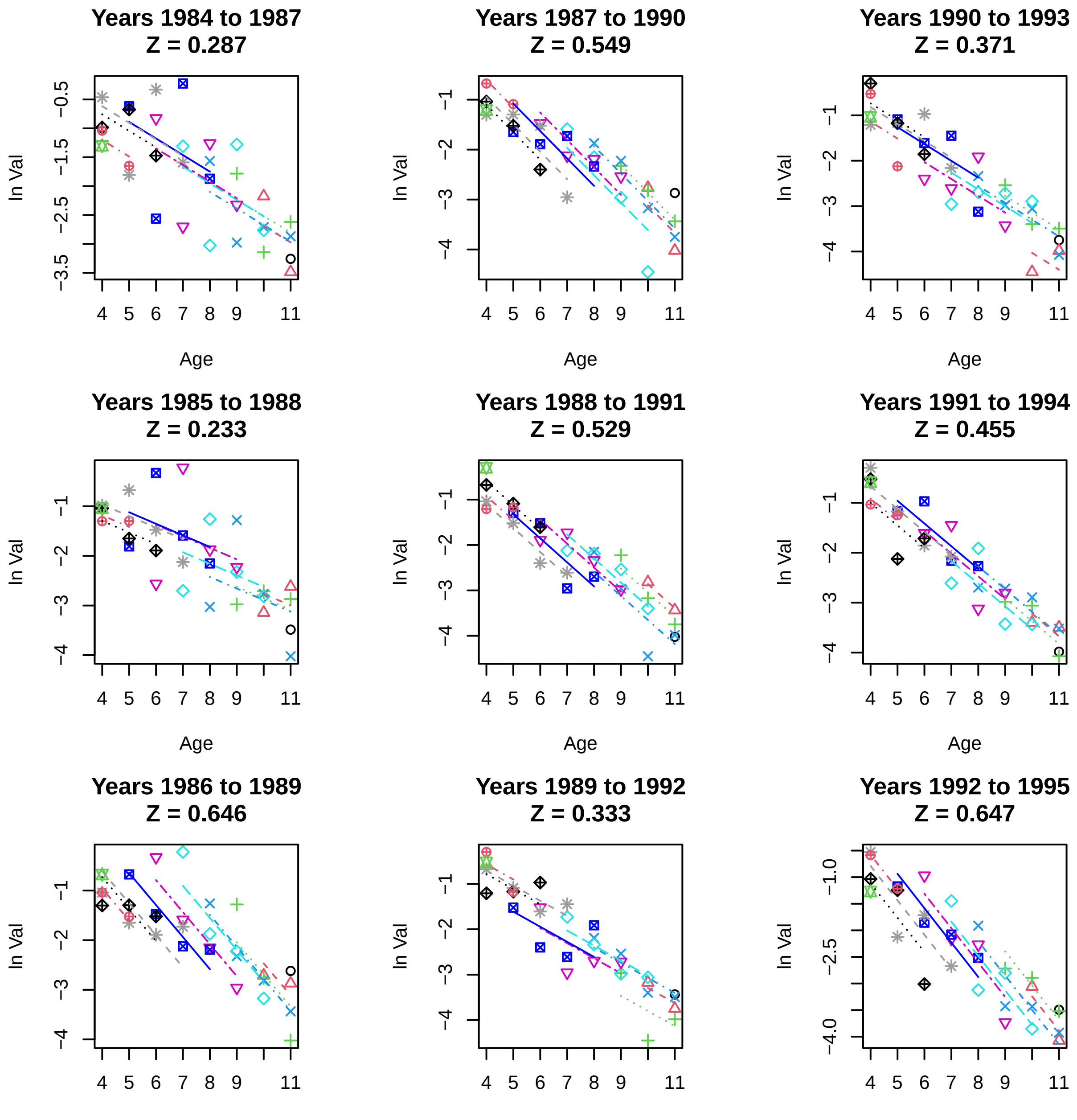
Z
1.0
0.5
0.0
1970
1980
1990
2000
2010
2020
2030
Year Class

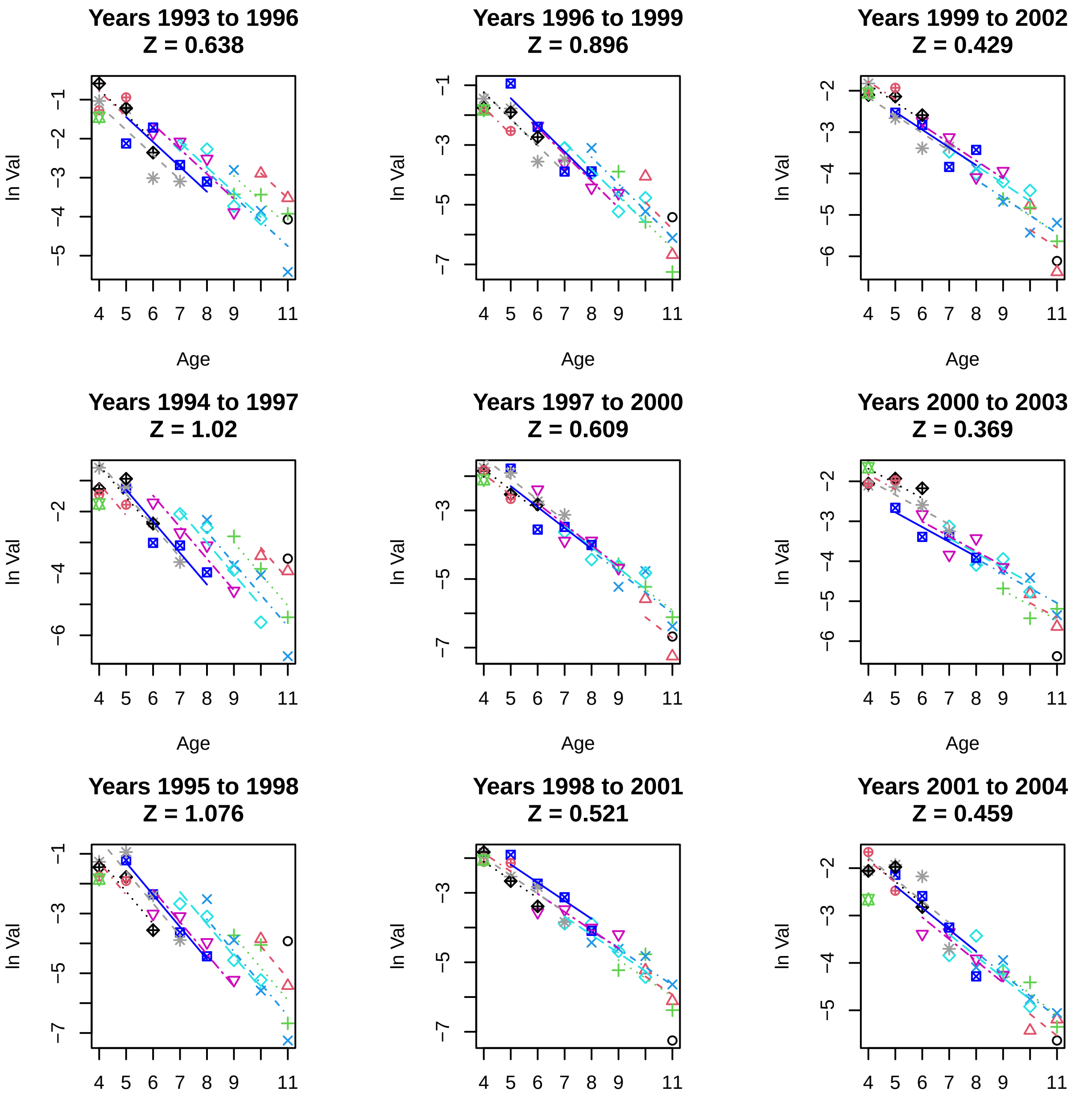

Index 3 (Peak Age) Observed
Log(Index)
0
−2
−4
−6
−8
1970
1980
1990
2000
2010
2020
2030

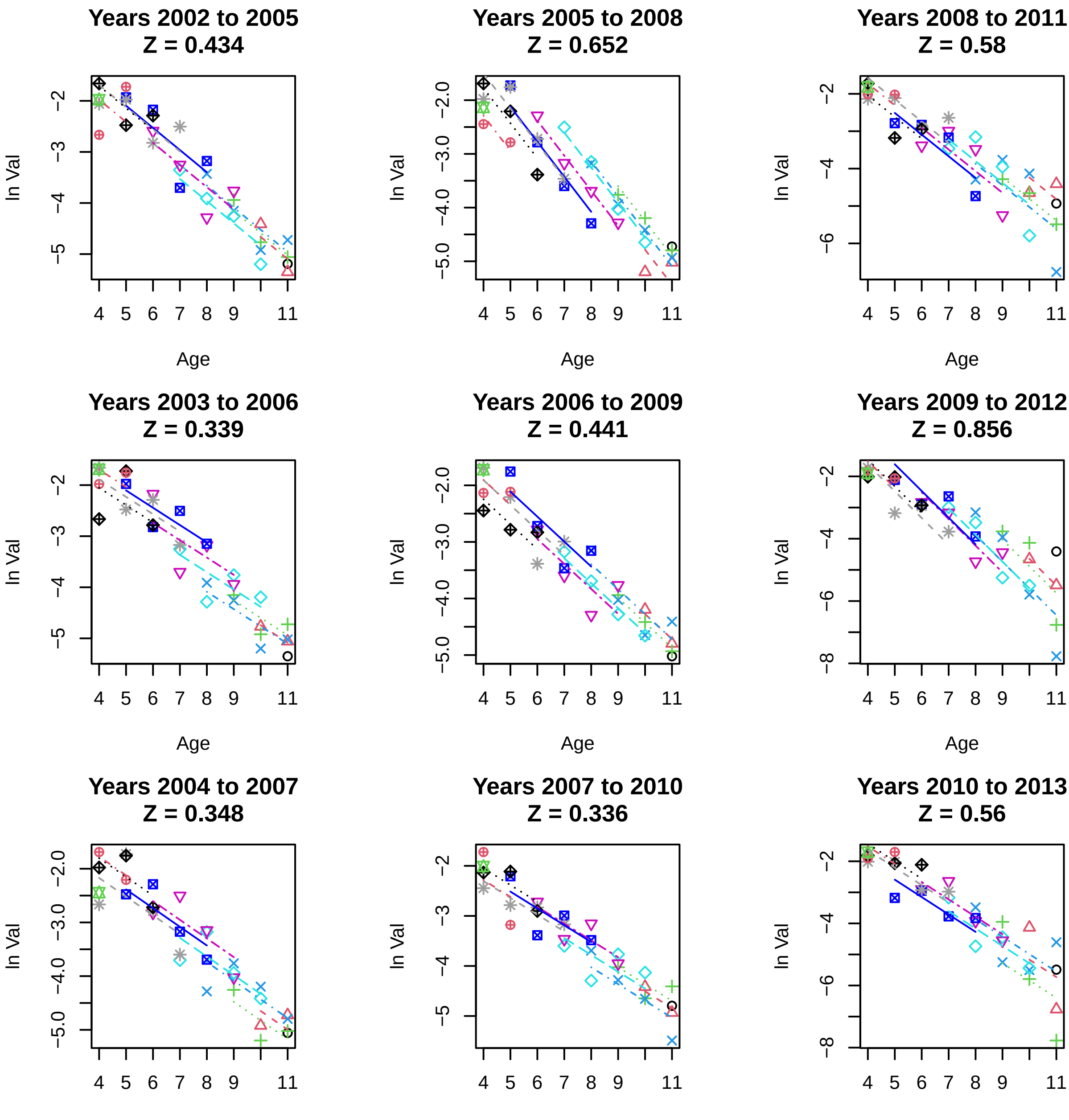

Z
2.0
1.0
0.0
−1.0
1970
1980
1990
2000
2010
2020
2030
Year Class

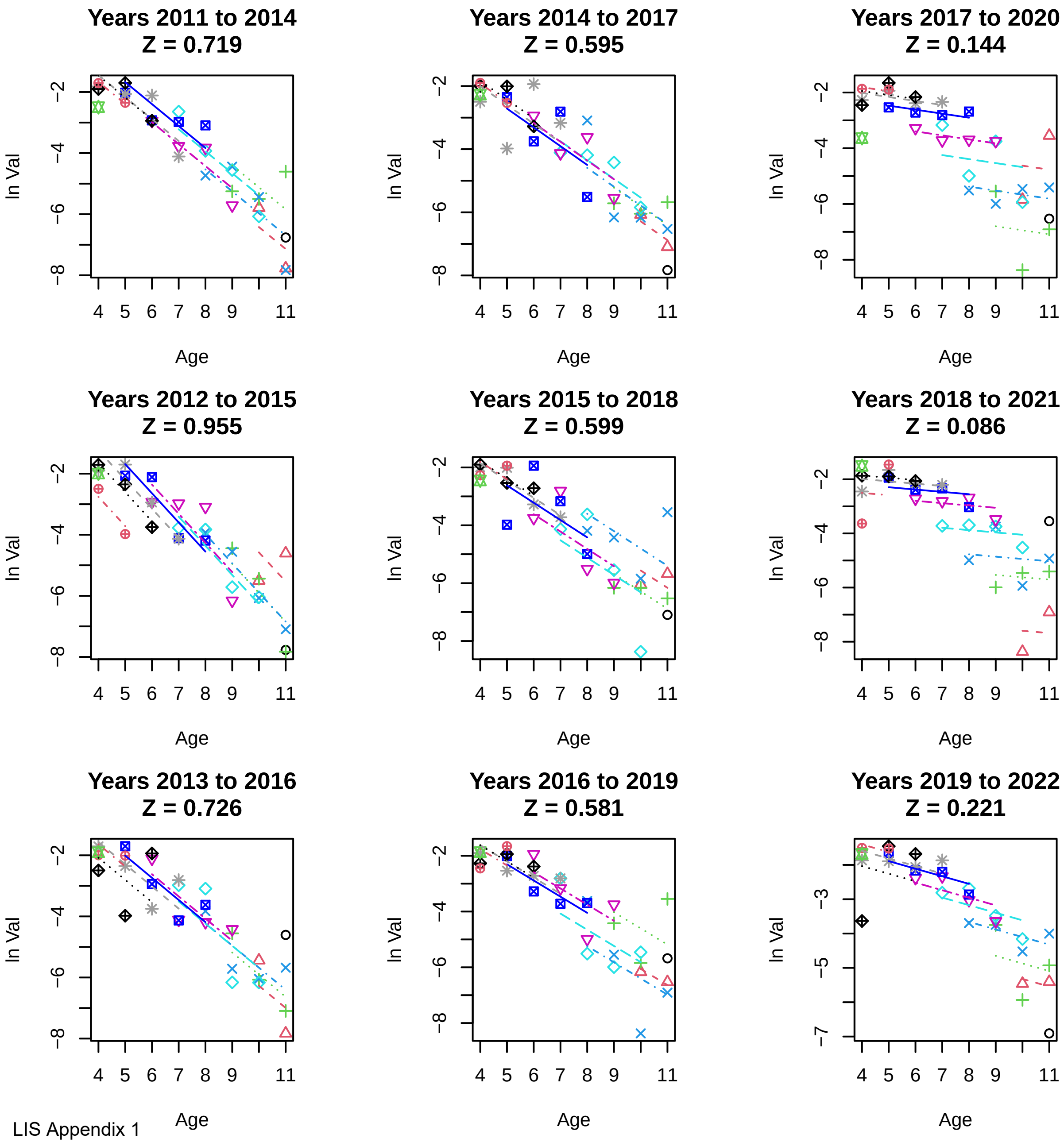

Index 3 (Peak Age) Predicted
Log(Index)
0
−2
−4
−6
−8
1970
1980
1990
2000
2010
2020
2030
Z
2.0
1.0
0.0
−1.0
1970
1980
1990
2000
2010
2020
2030
Year Class

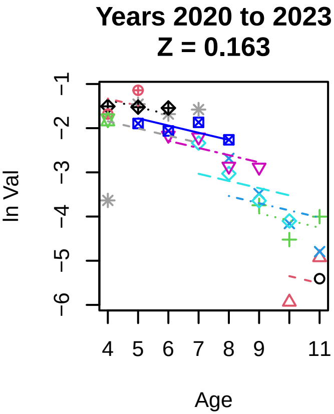

MRIP CPUE
Sinclair Z
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1990
2000
2010
2020
Year

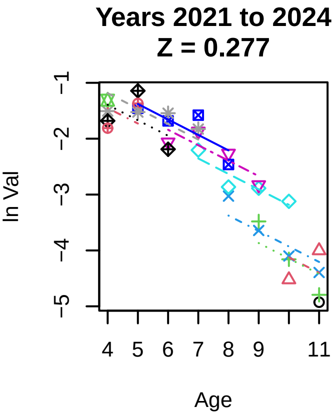

Years 1984 to 1987
Z = 0.287
Years 1987 to 1990
Z = 0.549
Years 1990 to 1993
Z = 0.371
Years 1985 to 1988
Z = 0.233
Years 1988 to 1991
Z = 0.529
Years 1991 to 1994
Z = 0.455
Years 1986 to 1989
Z = 0.646
Years 1989 to 1992
Z = 0.333
Years 1992 to 1995
Z = 0.647
ln Val
Age

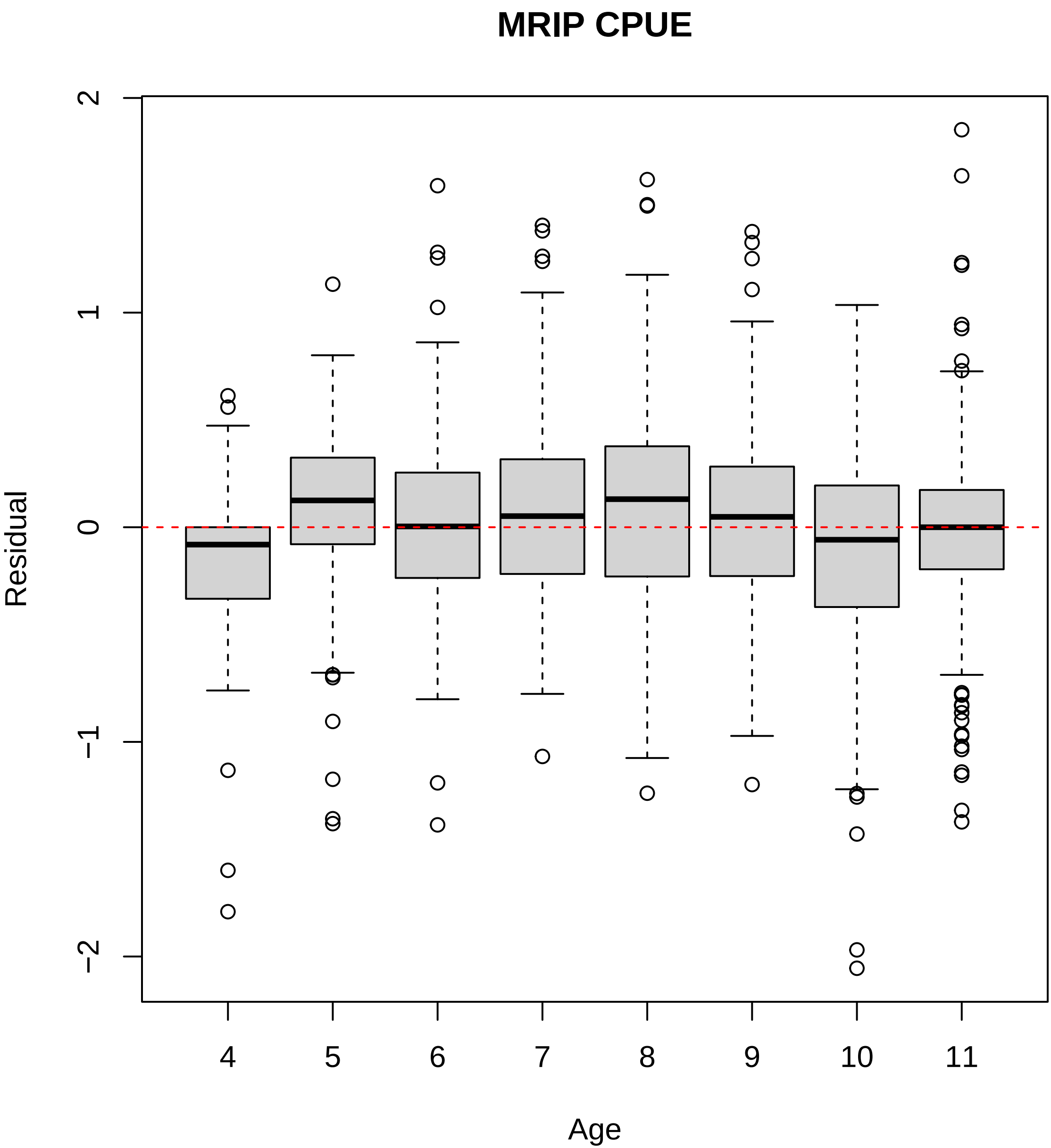

Years 1993 to 1996
Z = 0.638
Years 1996 to 1999
Z = 0.896
Years 1999 to 2002
Z = 0.429
Years 1994 to 1997
Z = 1.02
Years 1997 to 2000
Z = 0.609
Years 2000 to 2003
Z = 0.369
Years 1995 to 1998
Z = 1.076
Years 1998 to 2001
Z = 0.521
Years 2001 to 2004
Z = 0.459
ln Val
Age
4 5 6 7 8 9 11


Years 2002 to 2005
Z = 0.434
Years 2005 to 2008
Z = 0.652
Years 2008 to 2011
Z = 0.58
Years 2003 to 2006
Z = 0.339
Years 2006 to 2009
Z = 0.441
Years 2009 to 2012
Z = 0.856
Years 2004 to 2007
Z = 0.348
Years 2007 to 2010
Z = 0.336
Years 2010 to 2013
Z = 0.56
ln Val
Age


Years 2011 to 2014
Z = 0.719
Years 2014 to 2017
Z = 0.595
Years 2017 to 2020
Z = 0.144
Years 2012 to 2015
Z = 0.955
Years 2015 to 2018
Z = 0.599
Years 2018 to 2021
Z = 0.086
Years 2013 to 2016
Z = 0.726
Years 2016 to 2019
Z = 0.581
Years 2019 to 2022
Z = 0.221
ln Val
Age

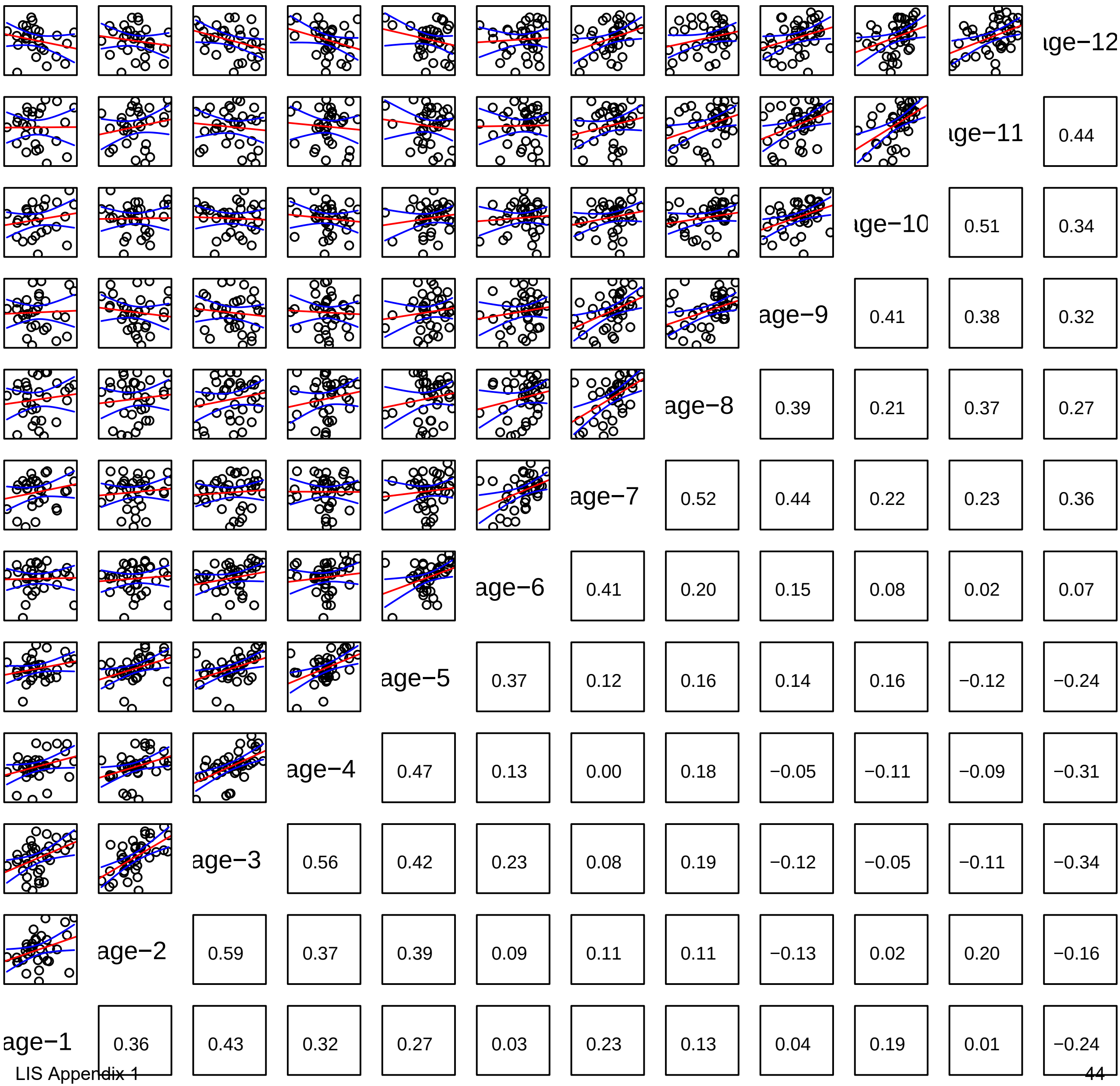

Years 2020 to 2023
Z = 0.163
ln Val
Age
−1
−2
−3
−4
−5
−6
4
5
6
7
8
9
11


Years 2021 to 2024
Z = 0.277
ln Val
Age
−1
−2
−3
−4
−5
4
5
6
7
8
9
11

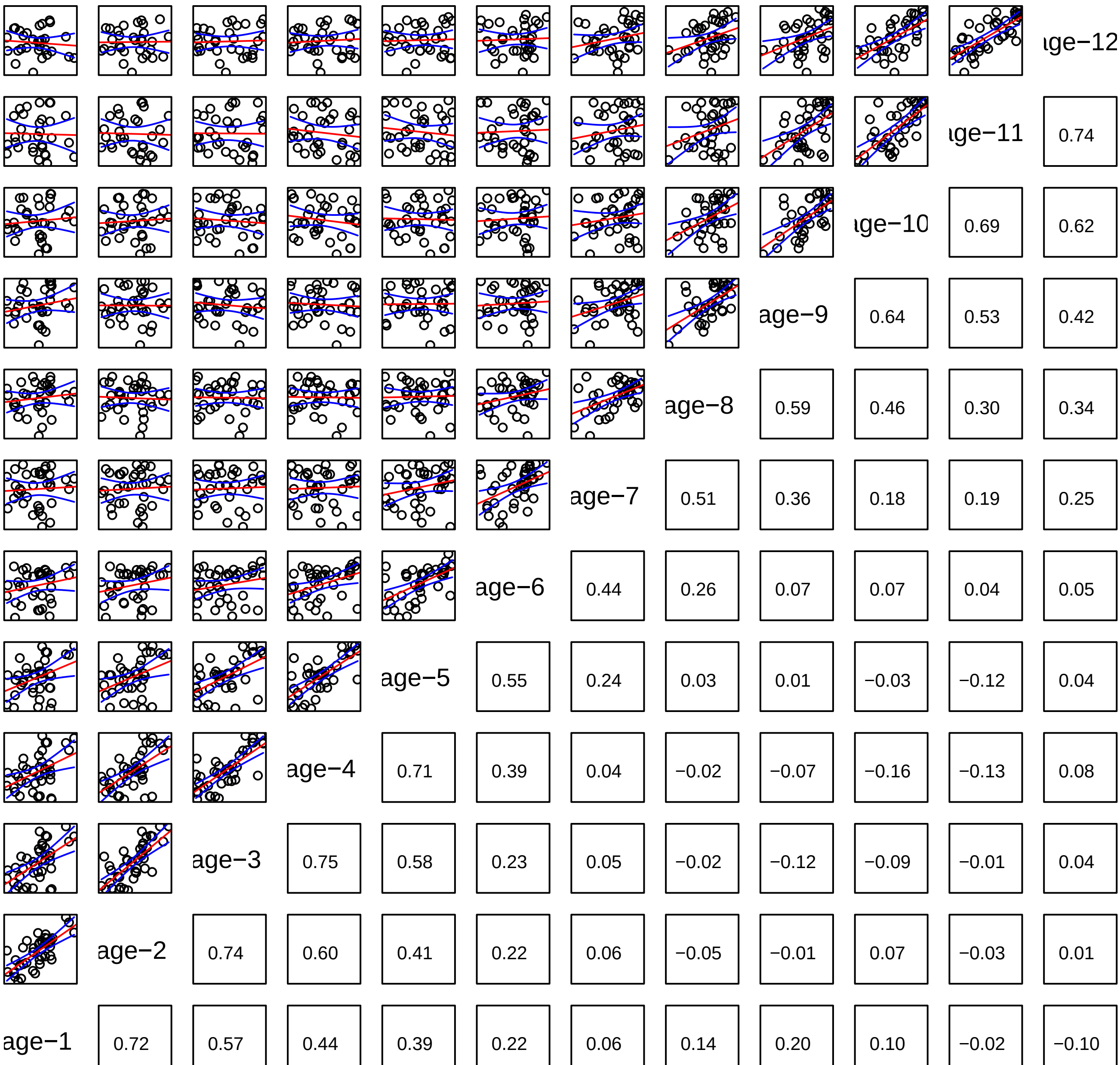


MRIP CPUE
Residual
2
1
0
−1
−2
4
5
6
7
8
9
10
11
Age

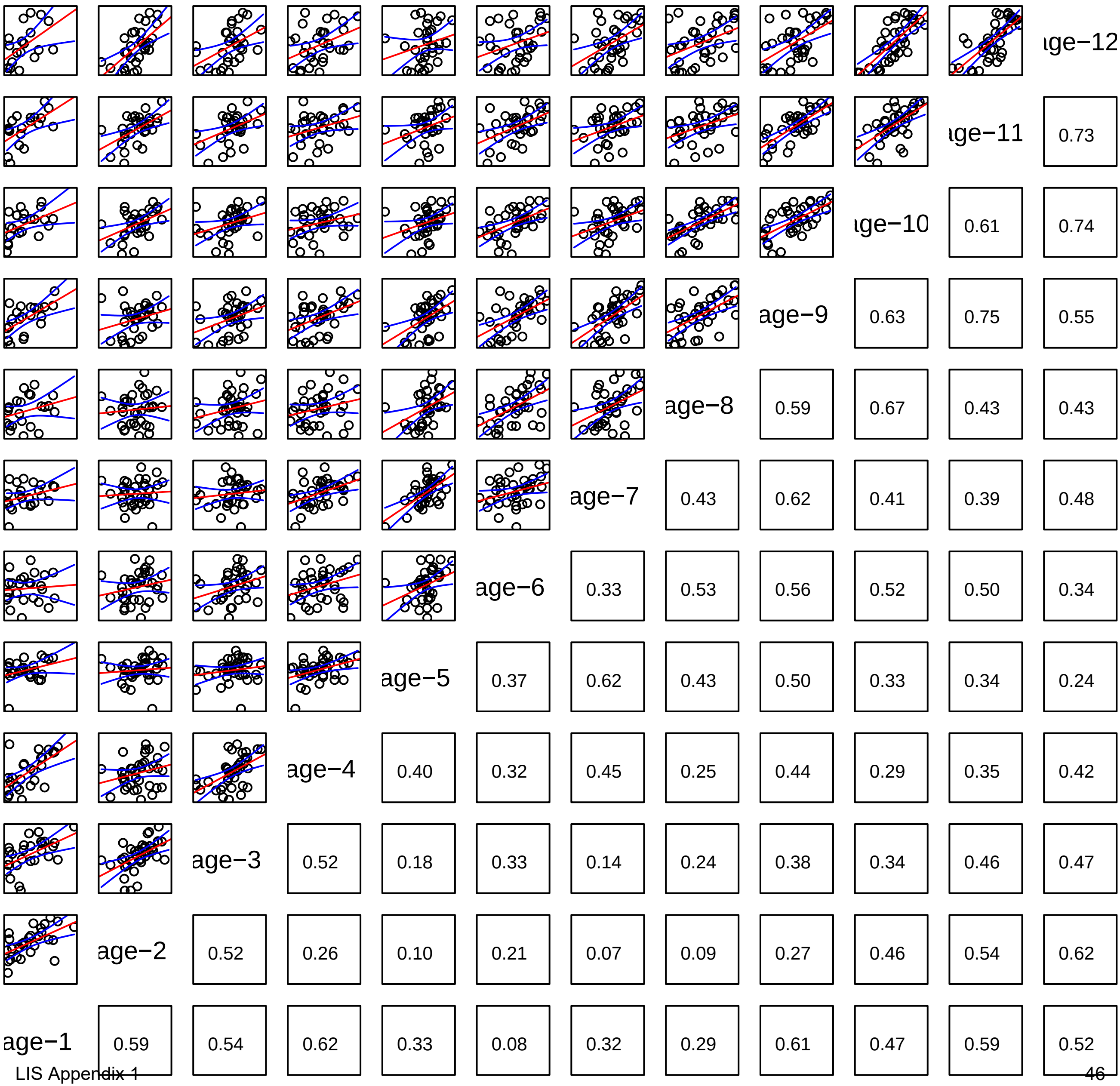
Catch Observed



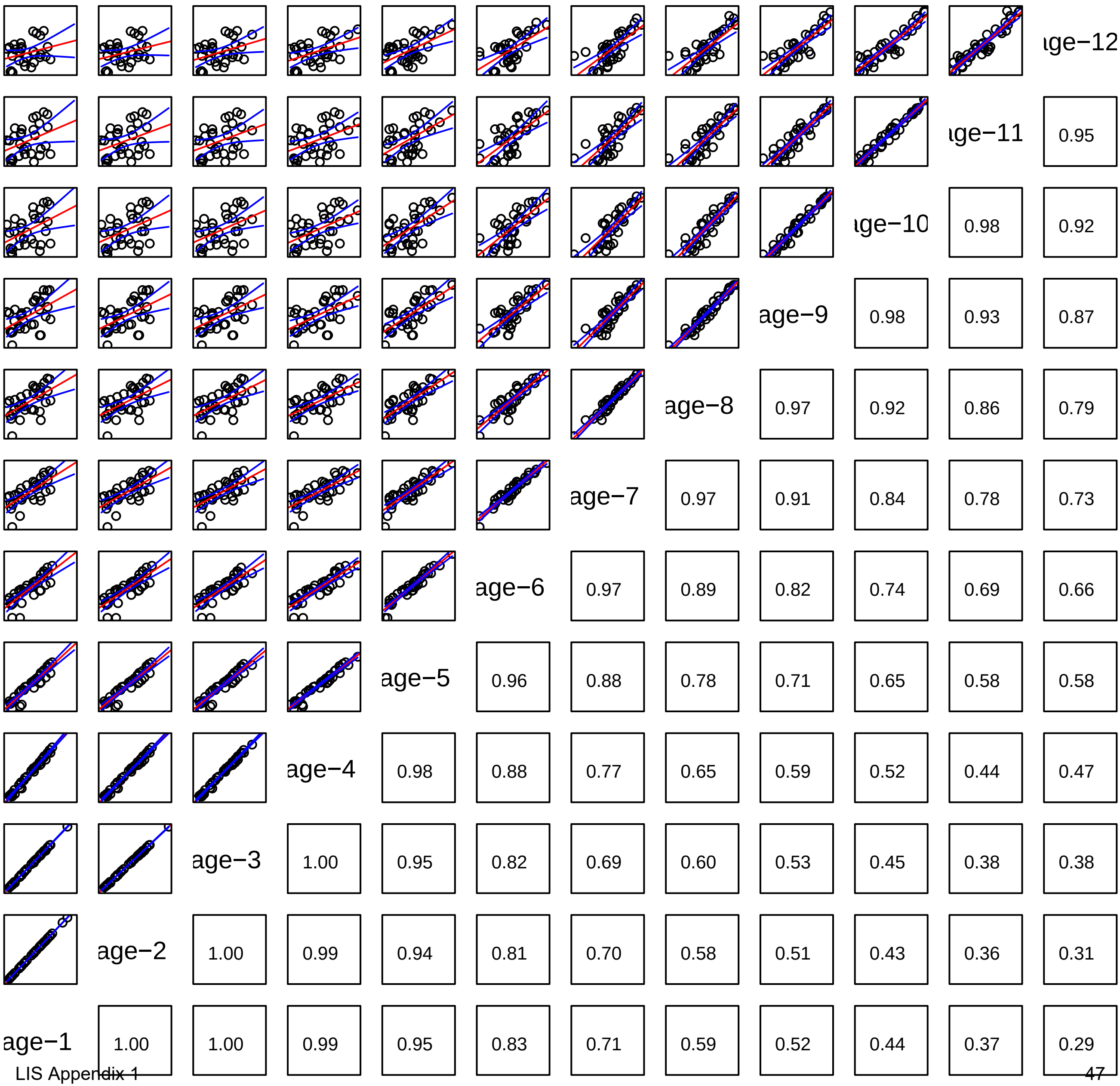
Catch Predicted



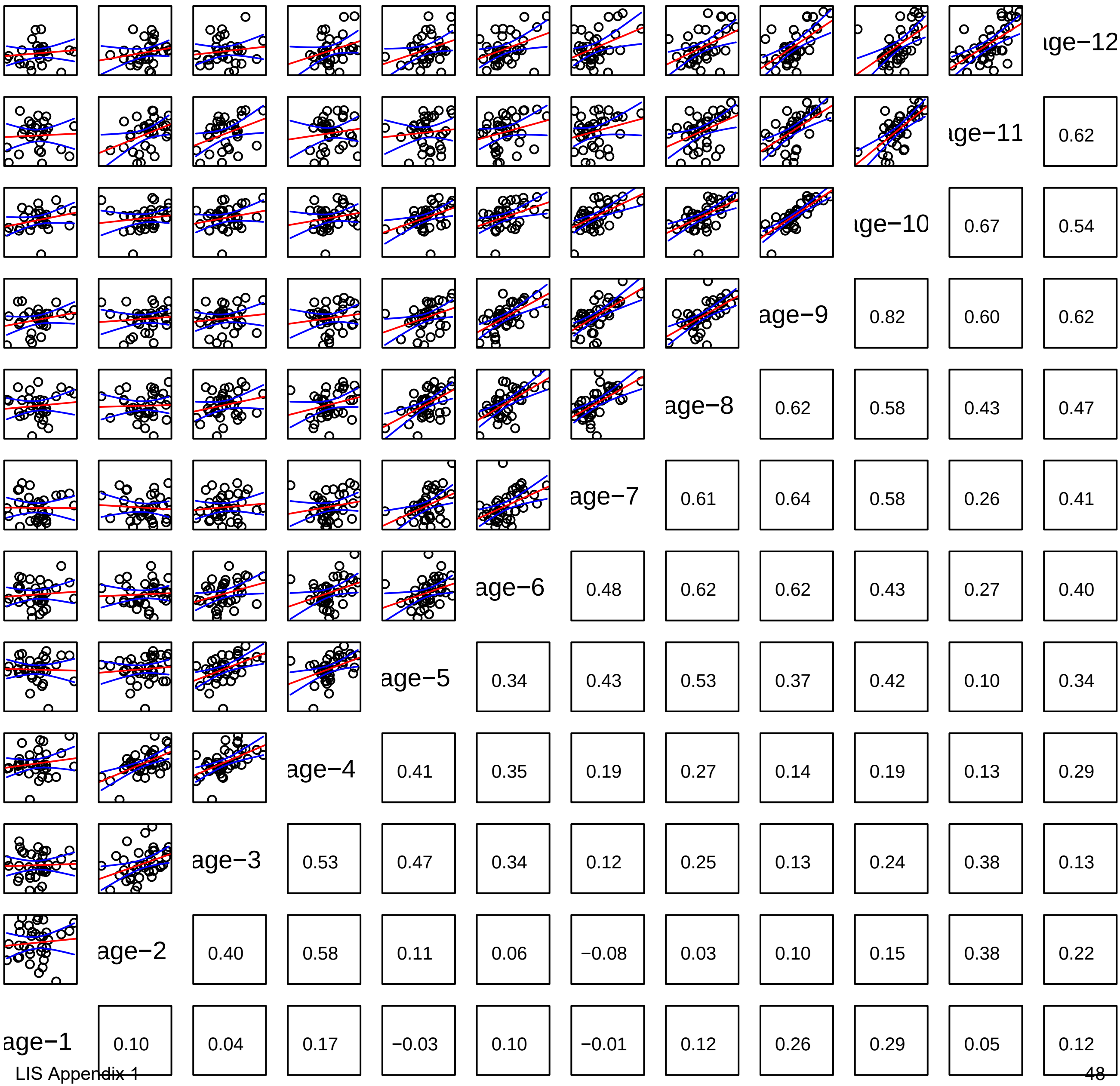
Index 1 (CT Trawl) Observed



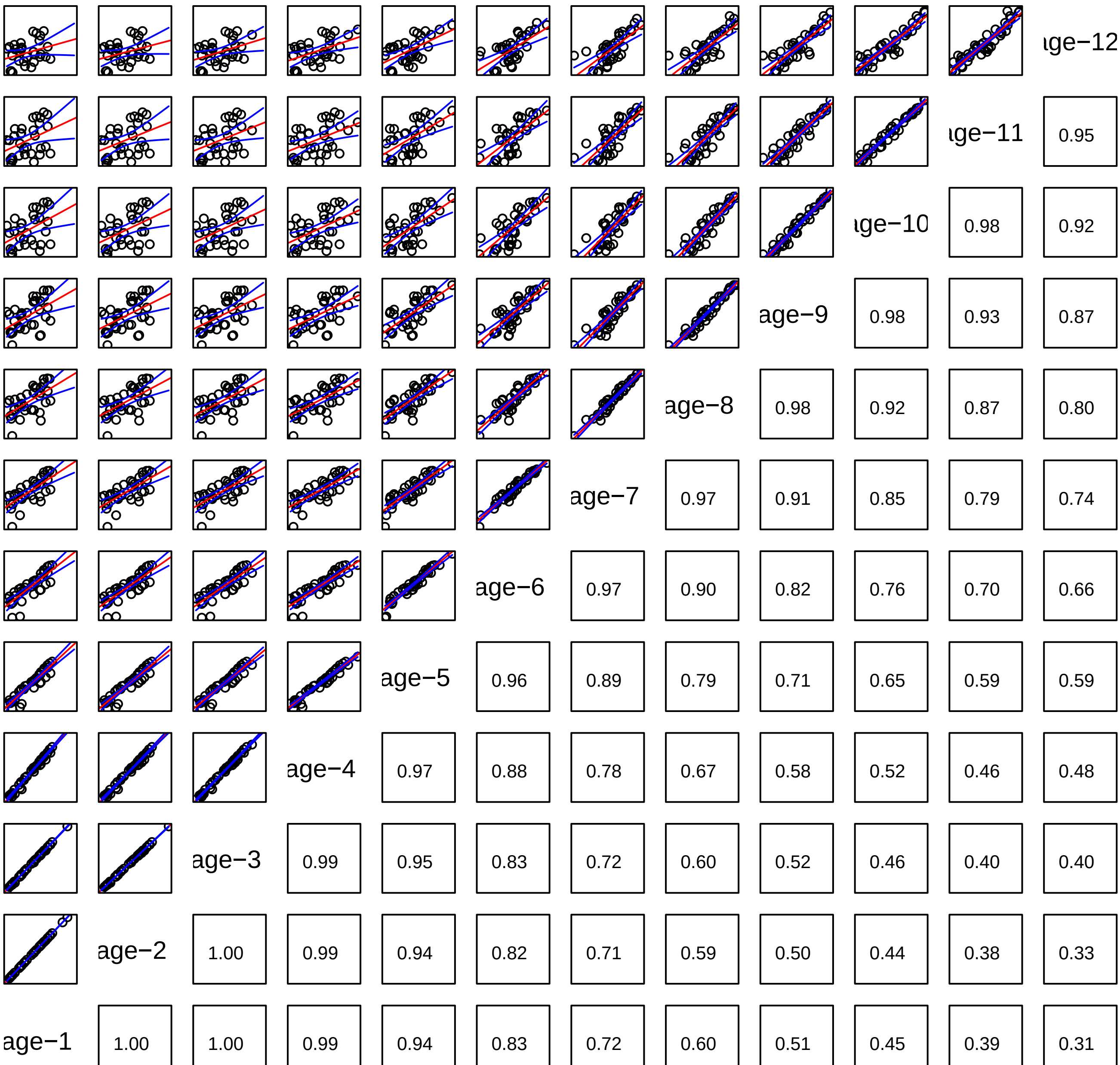
Index 1 (CT Trawl) Predicted

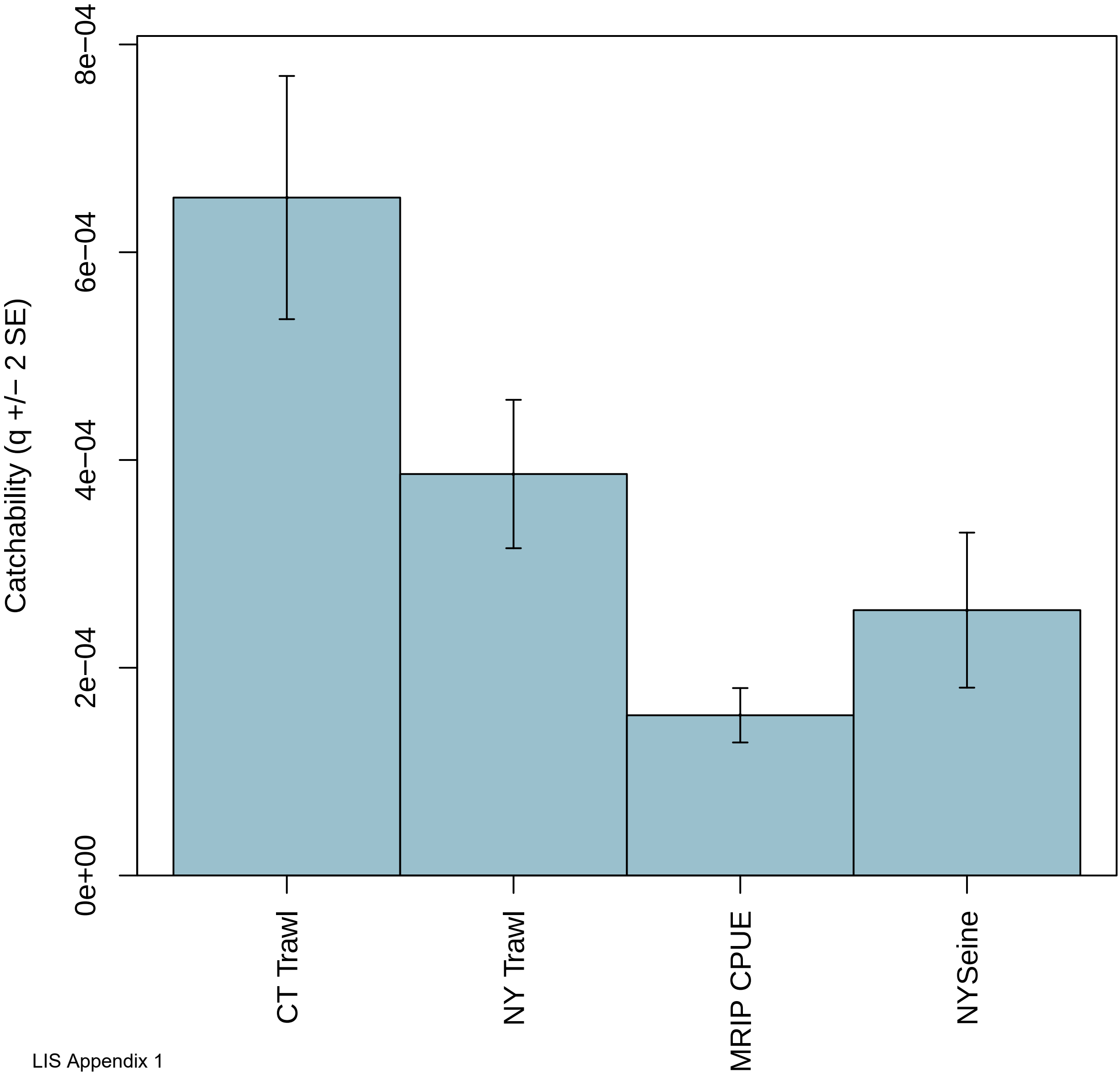


Index 3 (MRIP CPUE) Observed

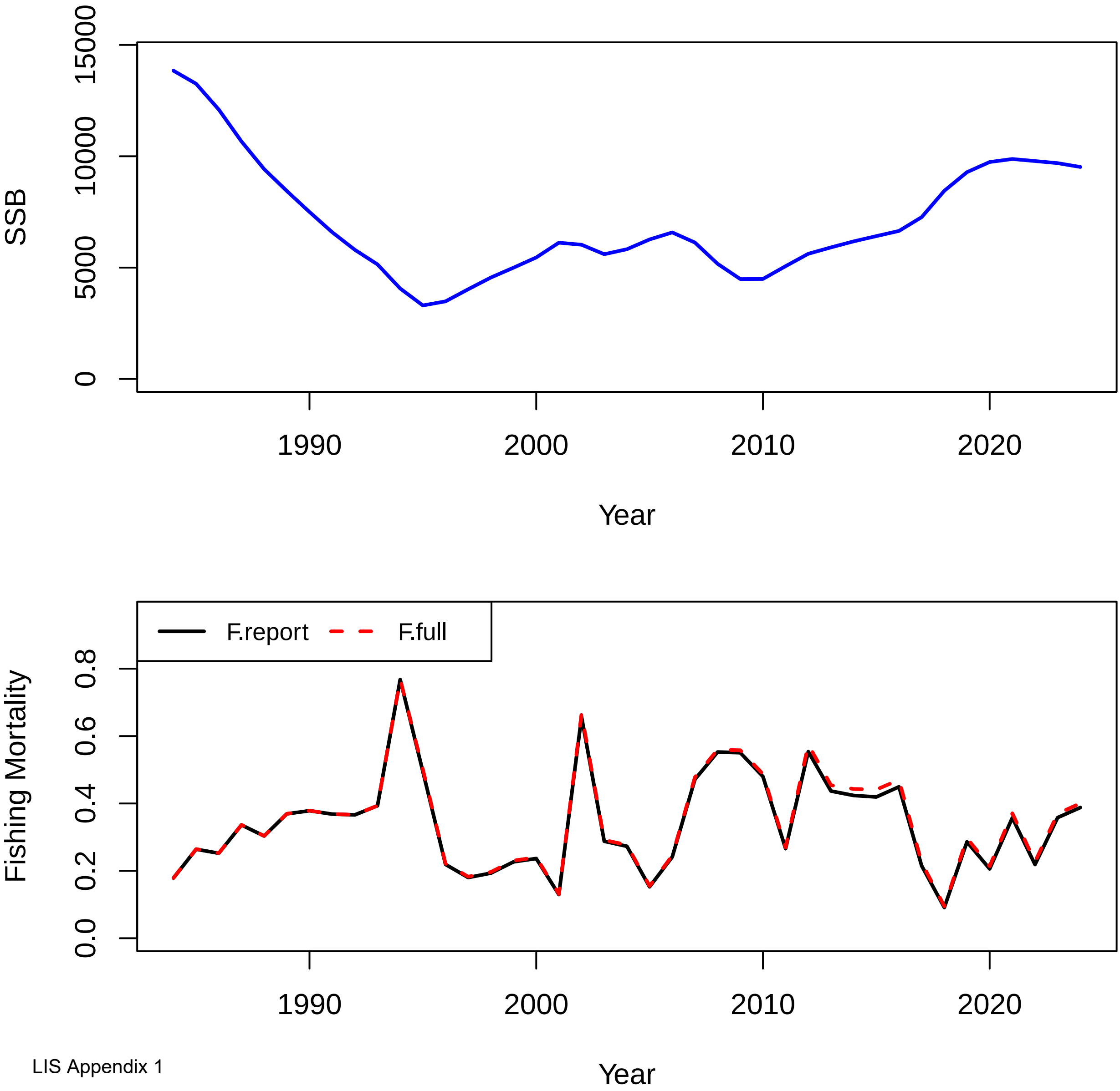


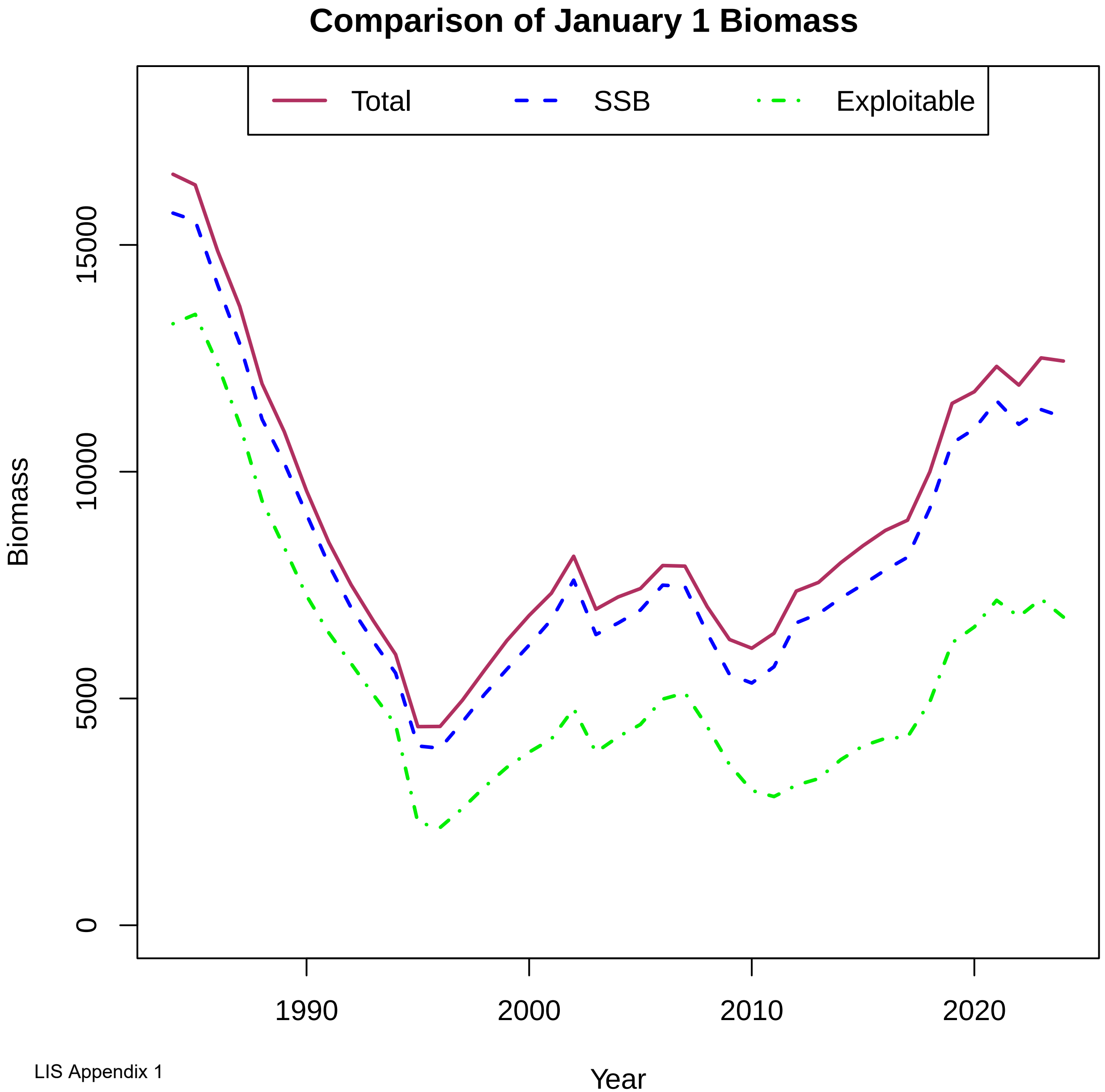
Index 3 (MRIP CPUE) Predicted



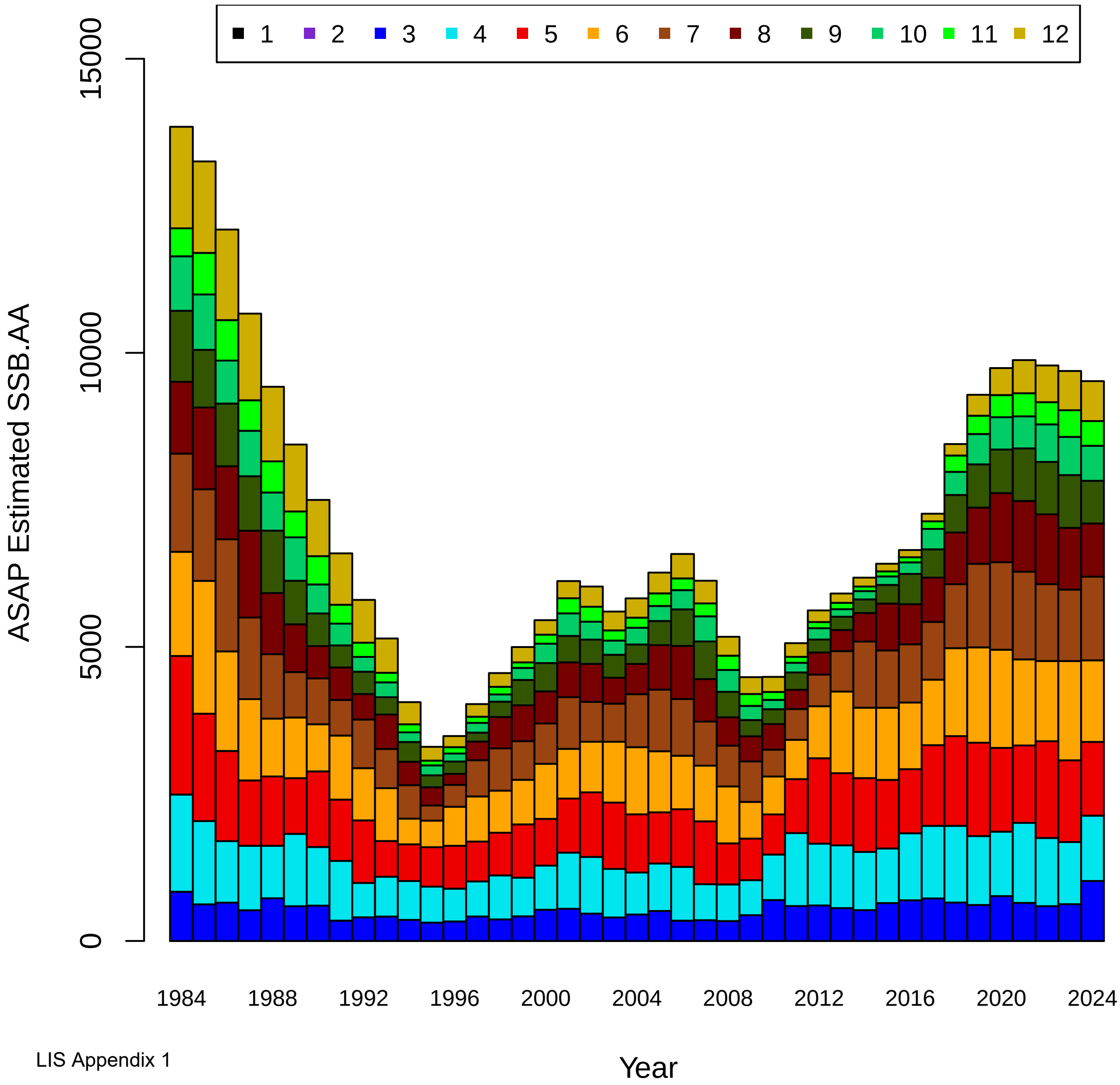


Catchability (q +/− 2 SE)
8e−04
6e−04
4e−04
2e−04
0e+00
CT Trawl
NY Trawl
MRIP CPUE
NYSeine

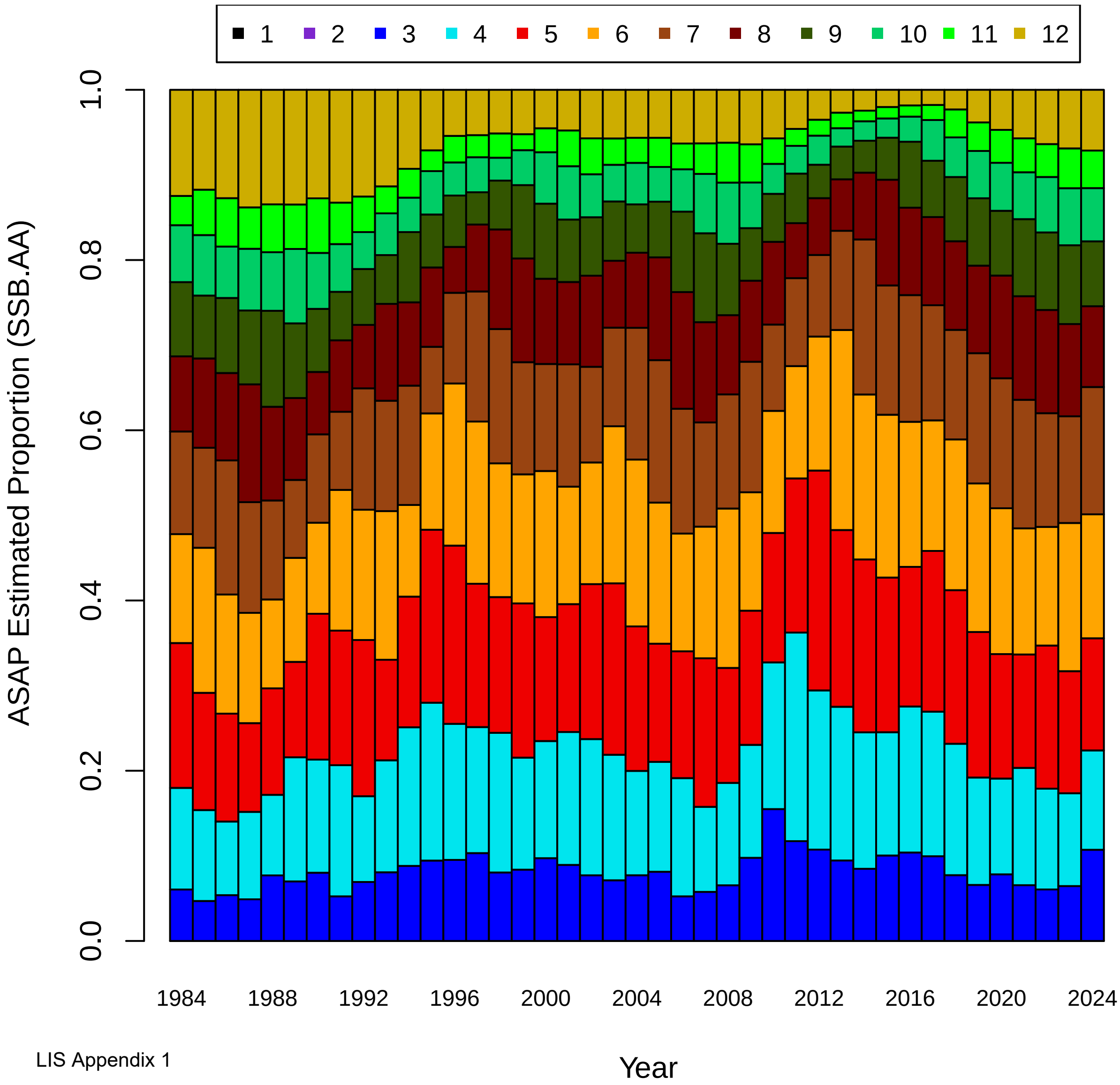

SSB
0
5000
10000
15000
1990
2000
2010
2020
Year
Fishing Mortality
0.0
0.2
0.4
0.6
0.8
F.report
F.full
1990
2000
2010
2020
Year

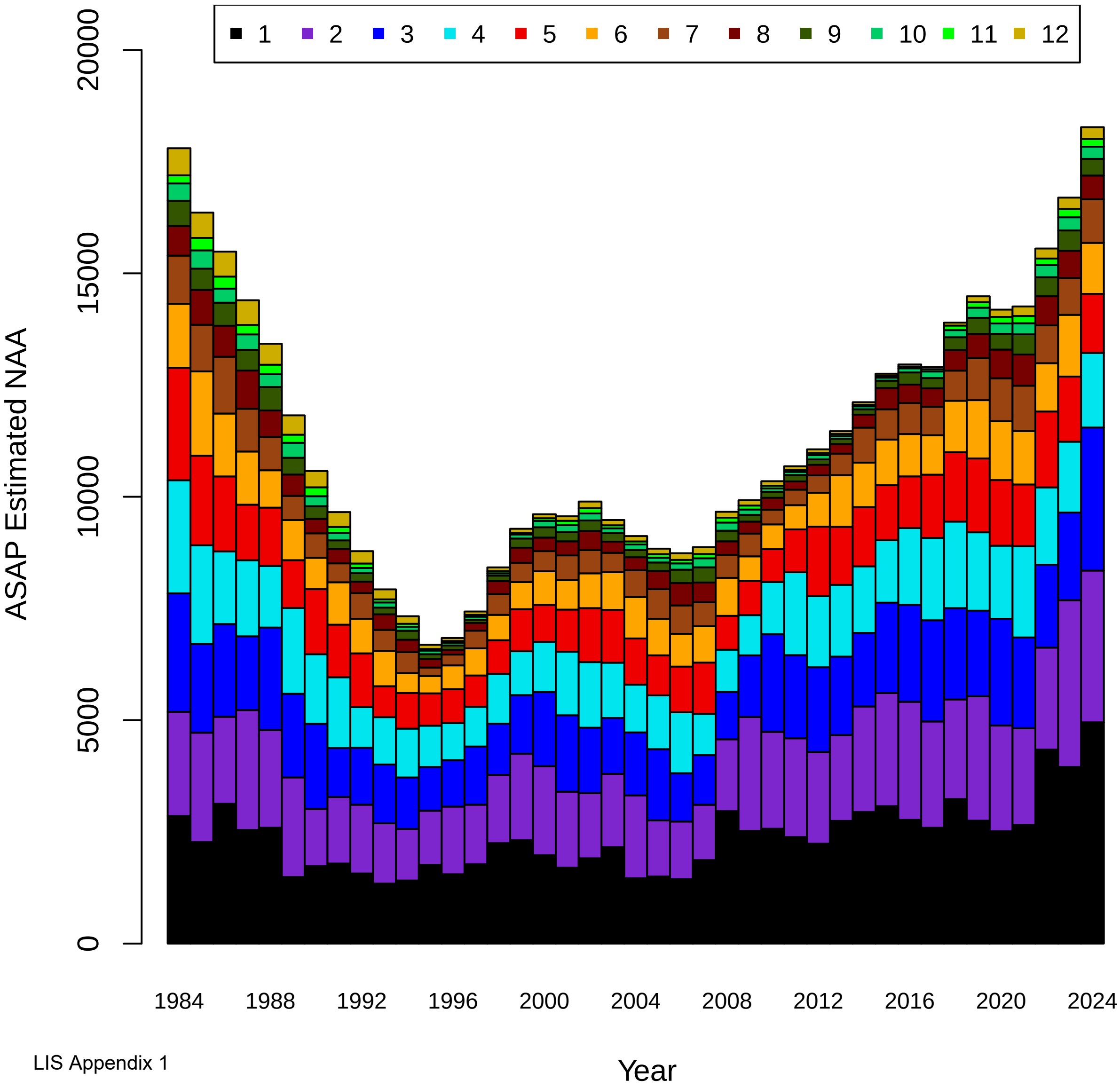


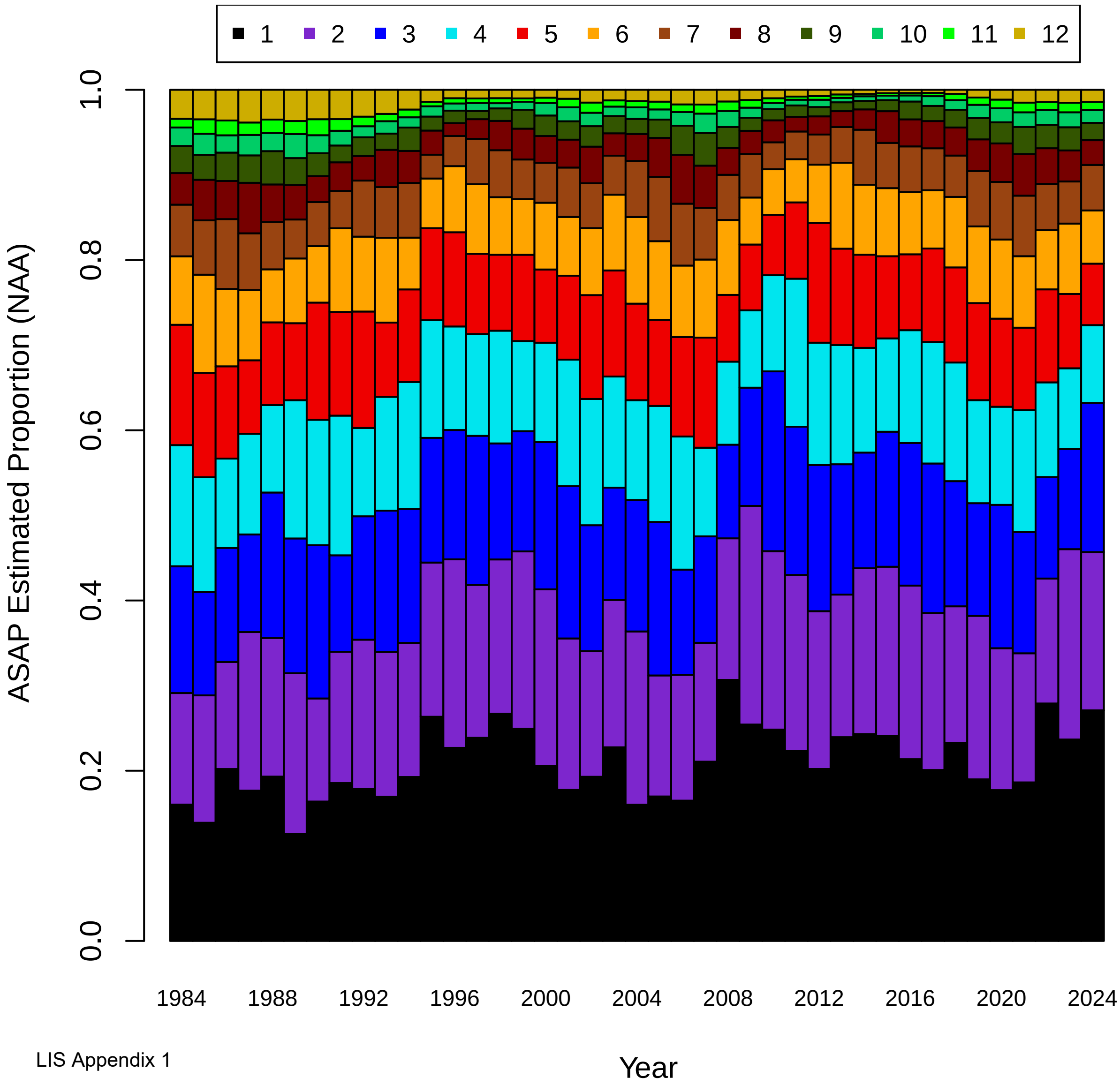
Comparison of January 1 Biomass
Total
SSB
Exploitable
Biomass
0
5000
10000
15000
1990
2000
2010
2020
Year

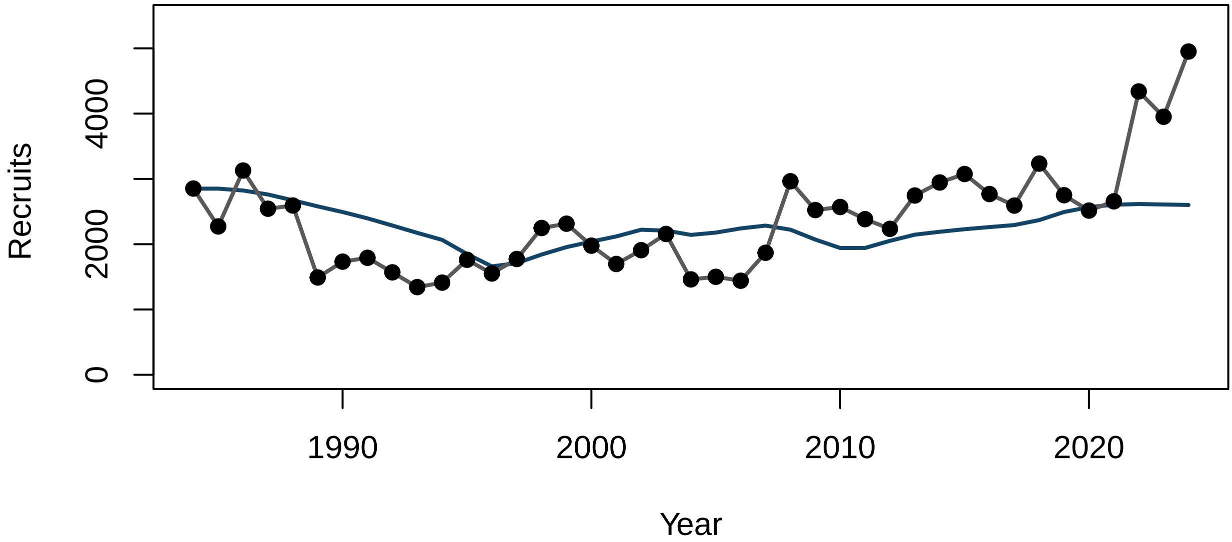


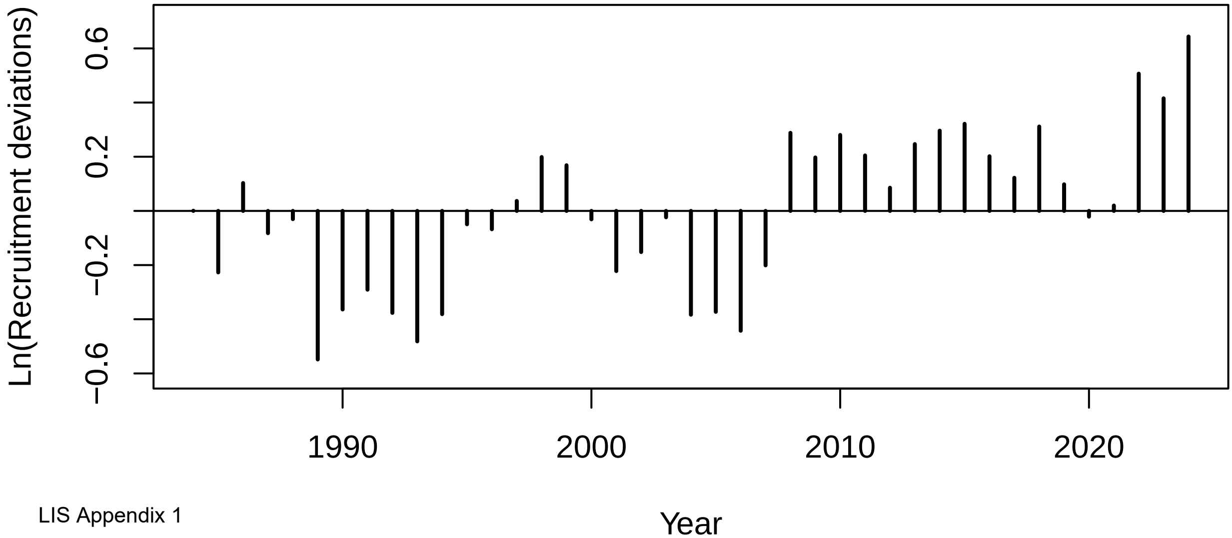
1
2
3
4
5
6
7
8
9
10
11
12
15000
10000
5000
0
ASAP Estimated SSB.AA
1984
1988
1992
1996
2000
2004
2008
2012
2016
2020
2024
Year

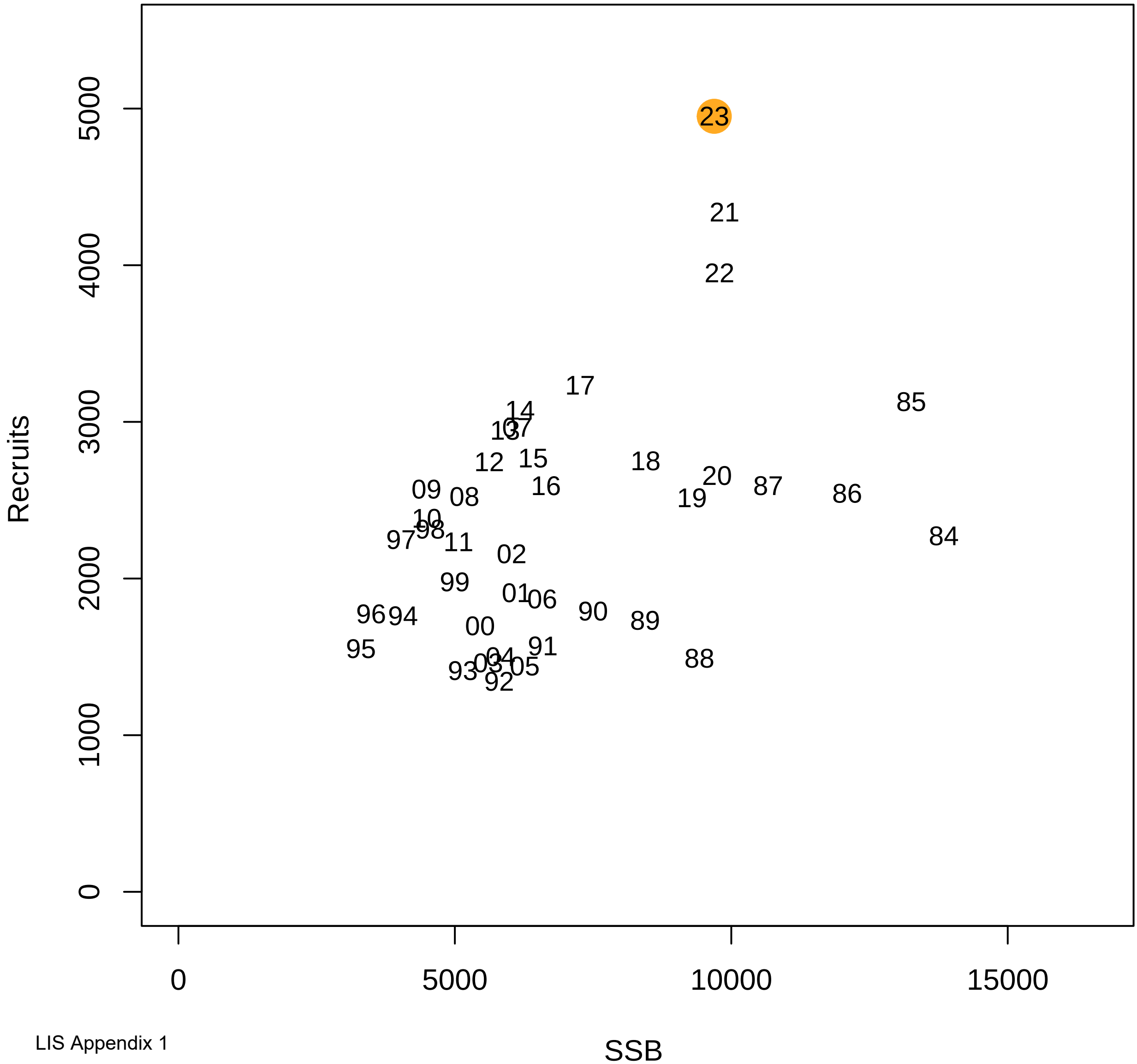

1 2 3 4 5 6 7 8 9 10 11 12
ASAP Estimated Proportion (SSB.AA)
0.0
0.2
0.4
0.6
0.8
1.0
1984
1988
1992
1996
2000
2004
2008
2012
2016
2020
2024
Year


1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated NAA
0
5000
10000
15000
20000
1984
1988
1992
1996
2000
2004
2008
2012
2016
2020
2024
Year

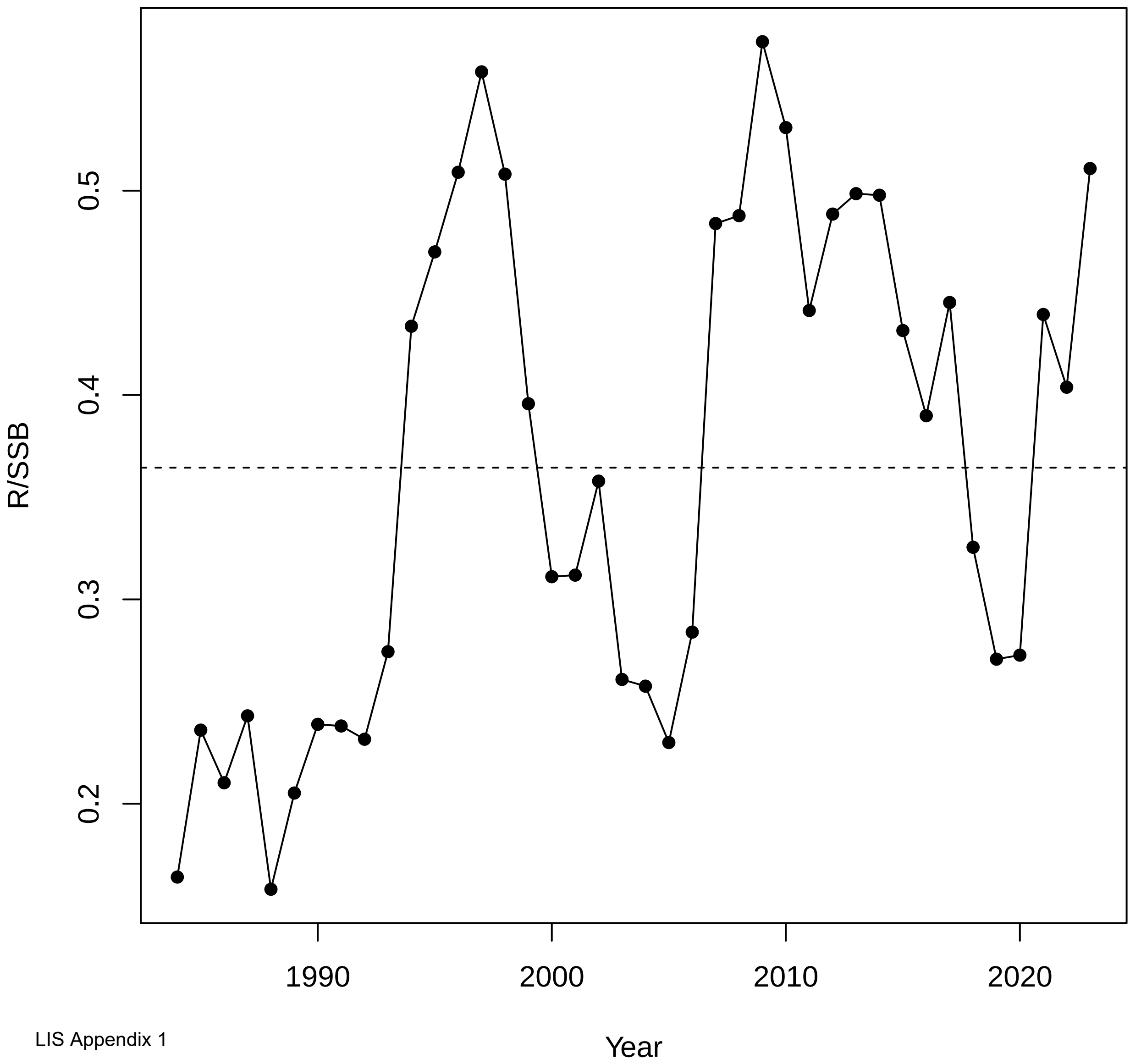

1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated Proportion (NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1984
1988
1992
1996
2000
2004
2008
2012
2016
2020
2024
Year

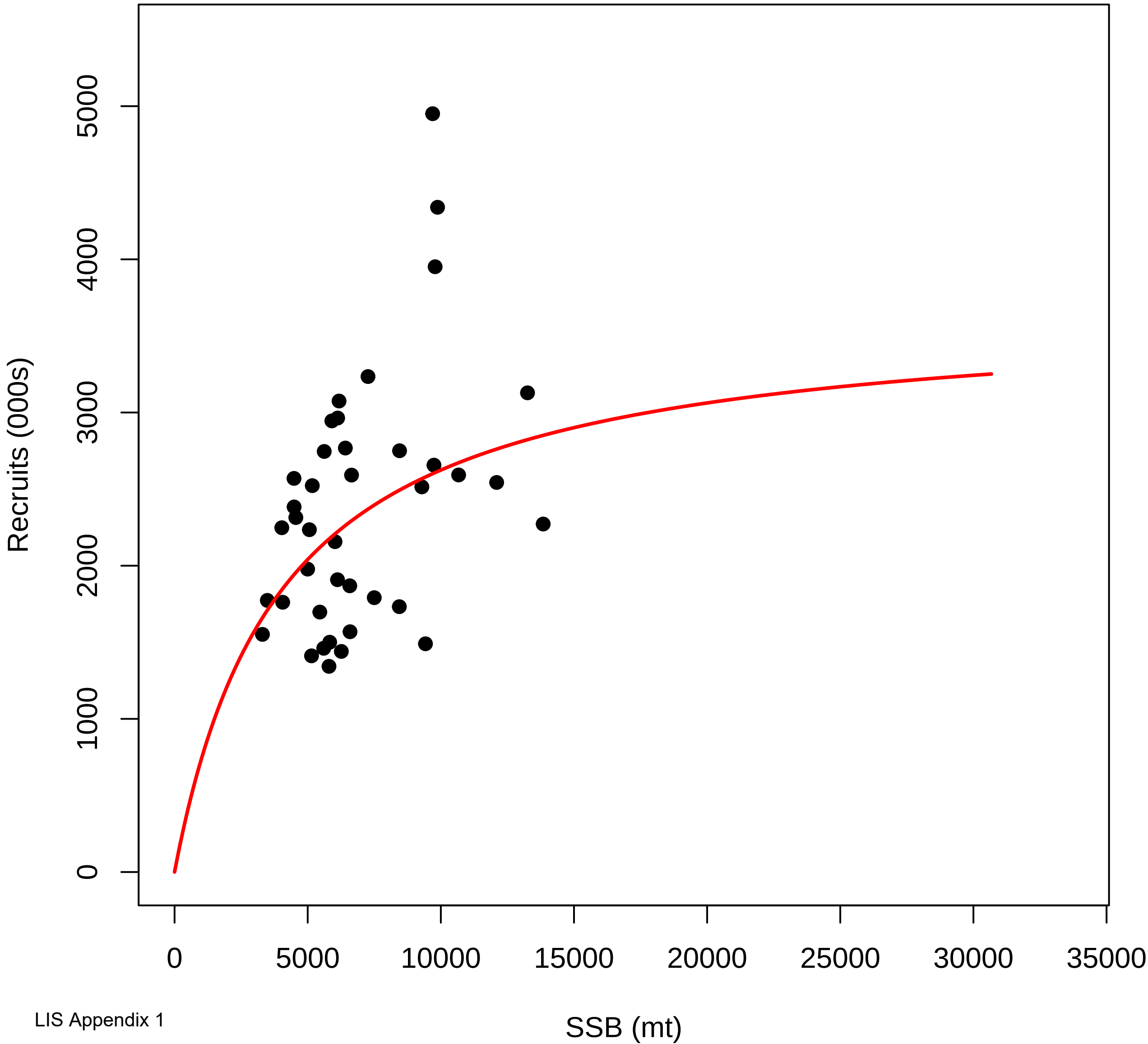

Recruits
0
2000
4000
1990
2000
2010
2020
Year


Ln(Recruitment deviations)
−0.6
−0.2
0.2
0.6
1990
2000
2010
2020
Year

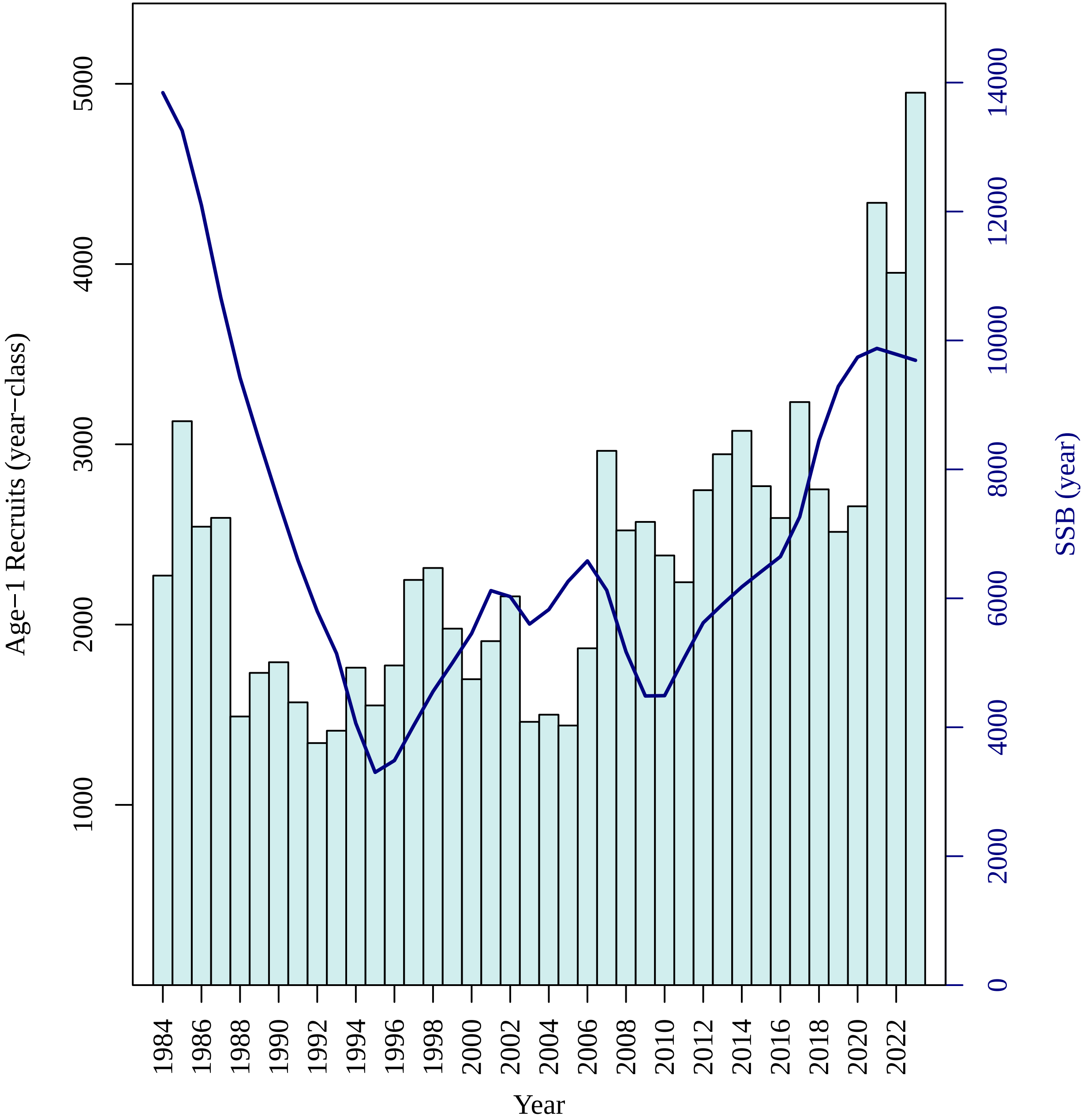


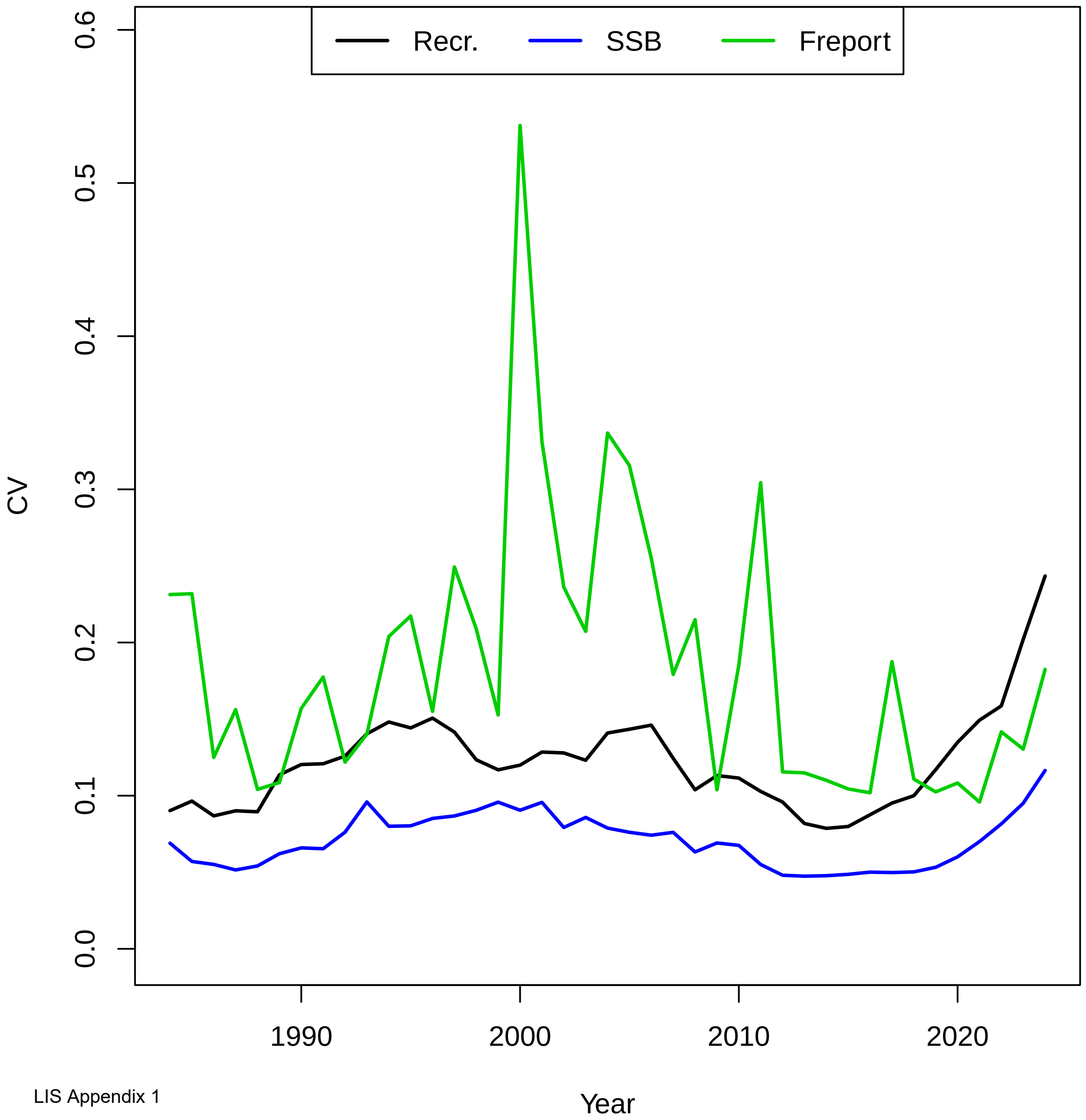
Recruits
SSB
0
1000
2000
3000
4000
5000
0
5000
10000
15000
23
21
22
17
85
14
13
07
12
15
18
20
87
86
16
09
08
19
10
98
97
11
84
02
99
01
06
90
89
96
94
00
95
91
04
03
05
88
93
92

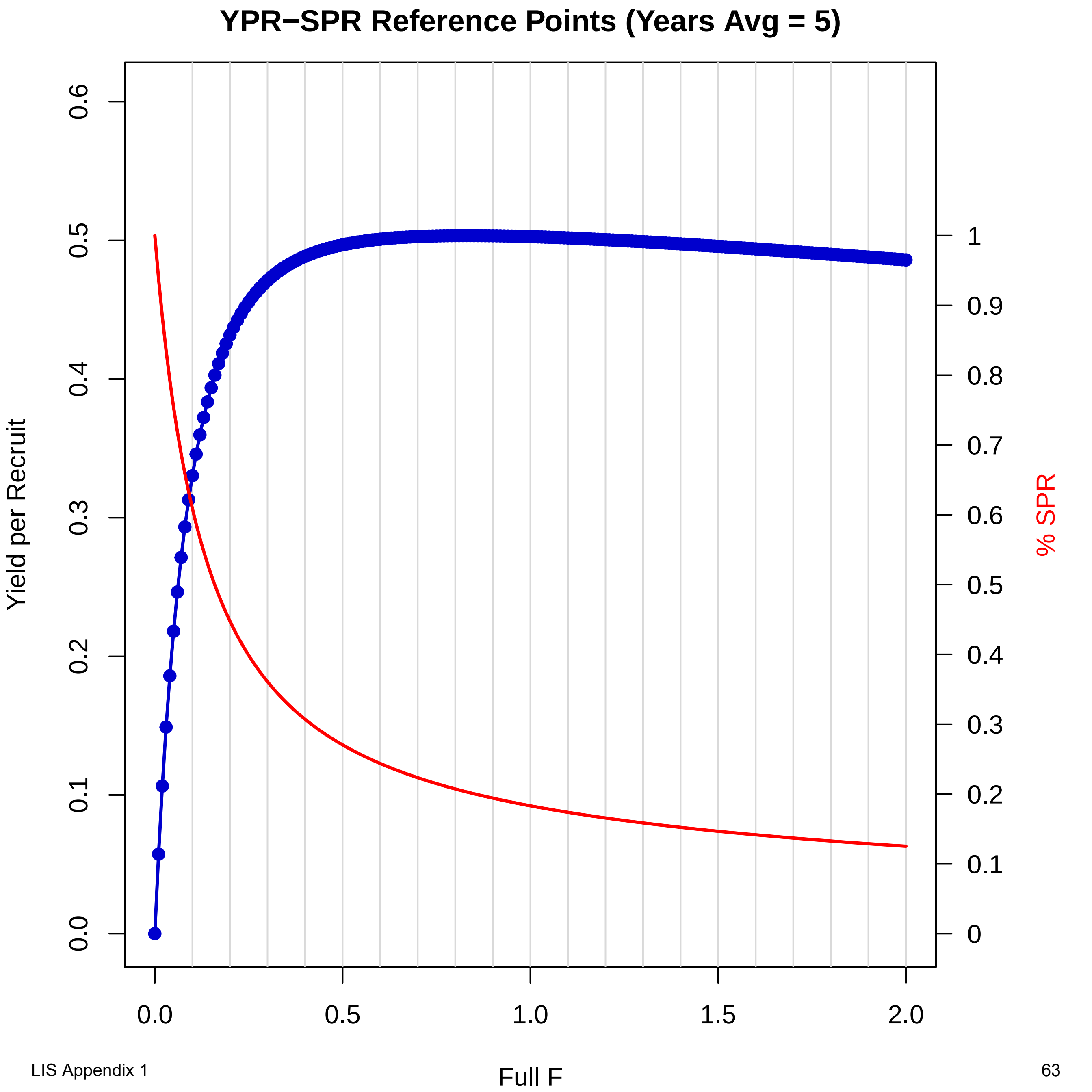

R/SSB
0.2
0.3
0.4
0.5
1990
2000
2010
2020
Year



Recruits (000s)
0
1000
2000
3000
4000
5000
0
5000
10000
15000
20000
25000
30000
35000
SSB (mt)

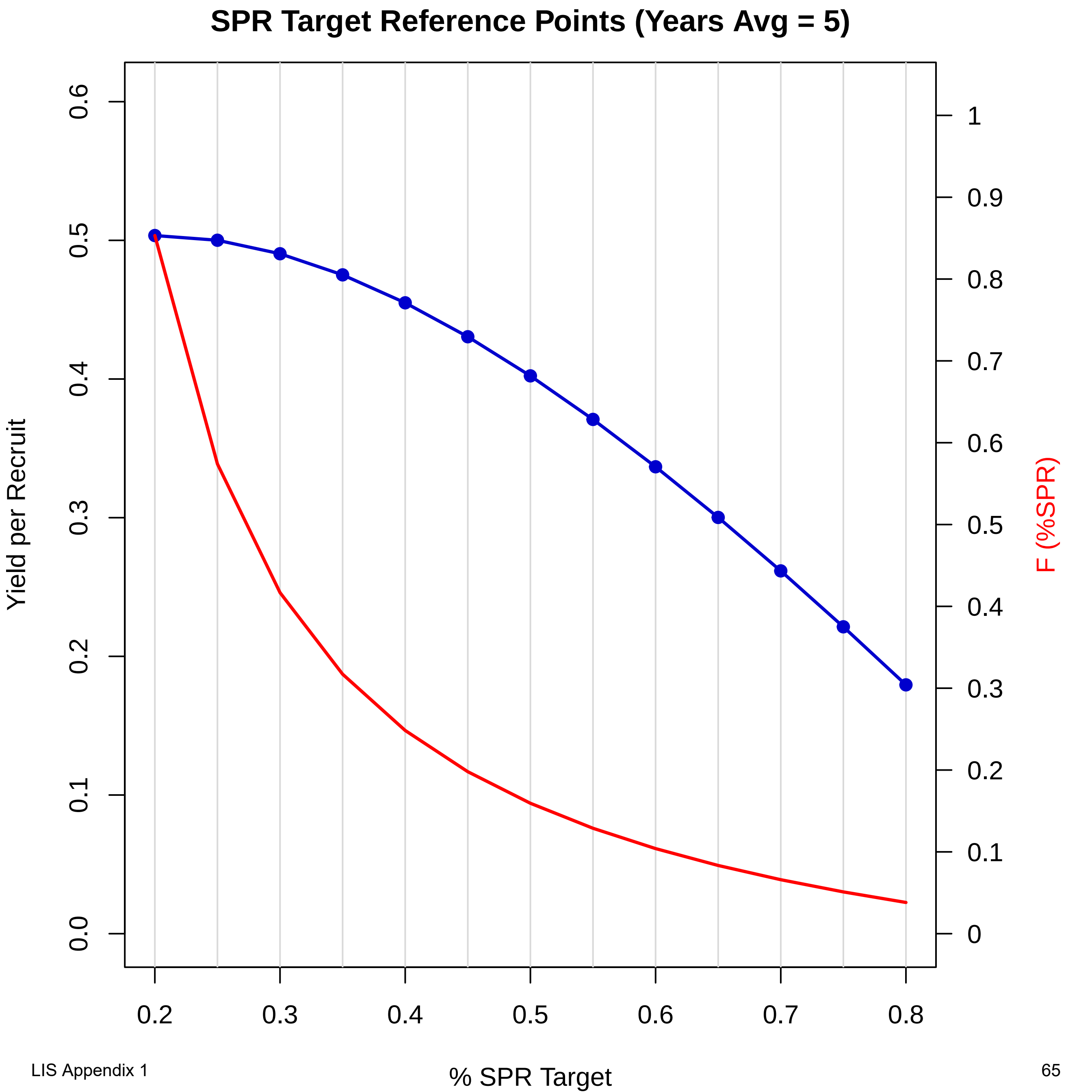

Age−1 Recruits (year−class)
1000
2000
3000
4000
5000
SSB (year)
0
2000
4000
6000
8000
10000
12000
14000
Year
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022


Recr.
SSB
Freport
CV
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1990
2000
2010
2020
Year


YPR−SPR Reference Points (Years Avg = 5)
Yield per Recruit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
% SPR
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.0
0.5
1.0
1.5
2.0
Full F

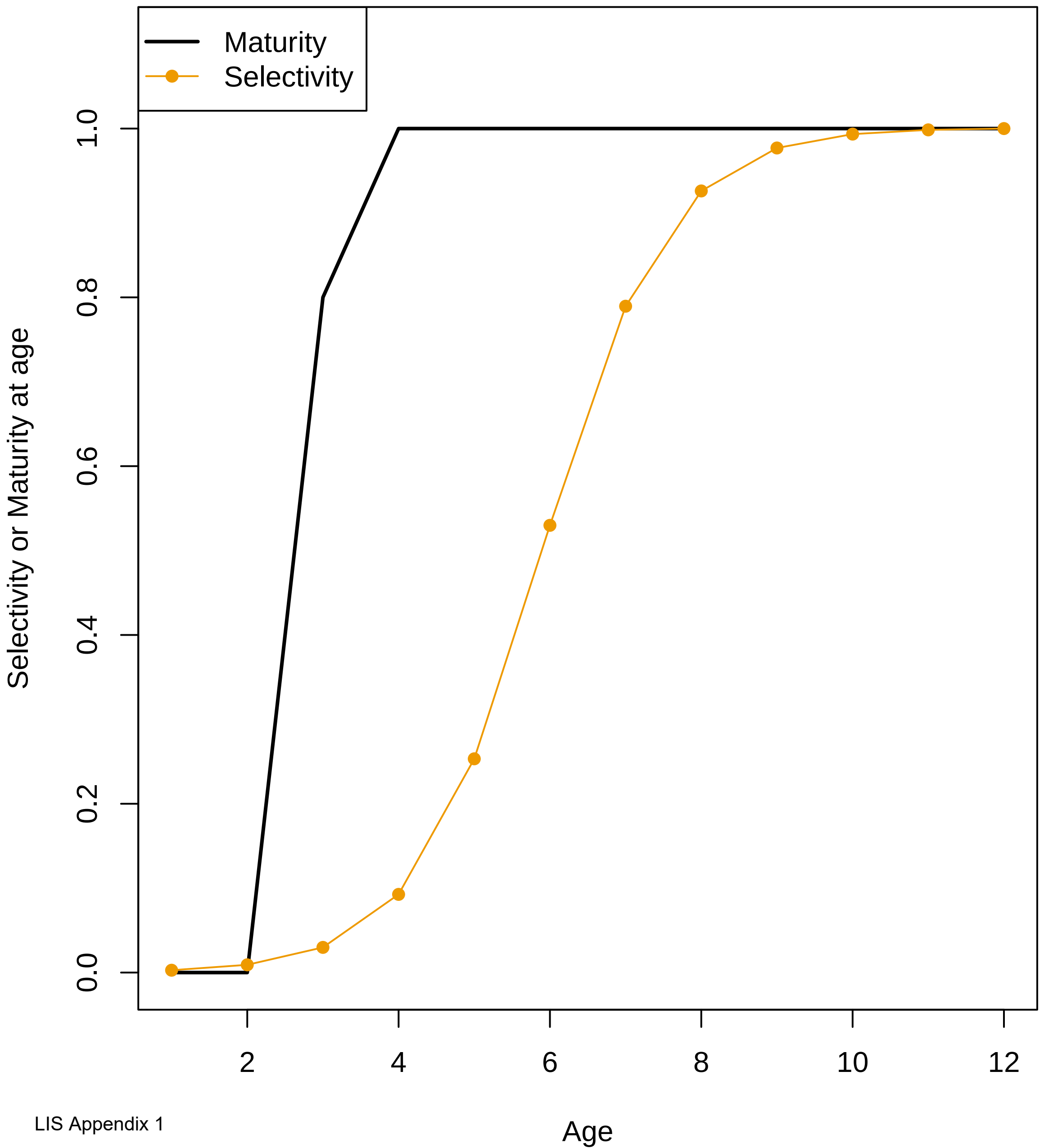
YPR−SPR Reference Points (Years Avg = 5)

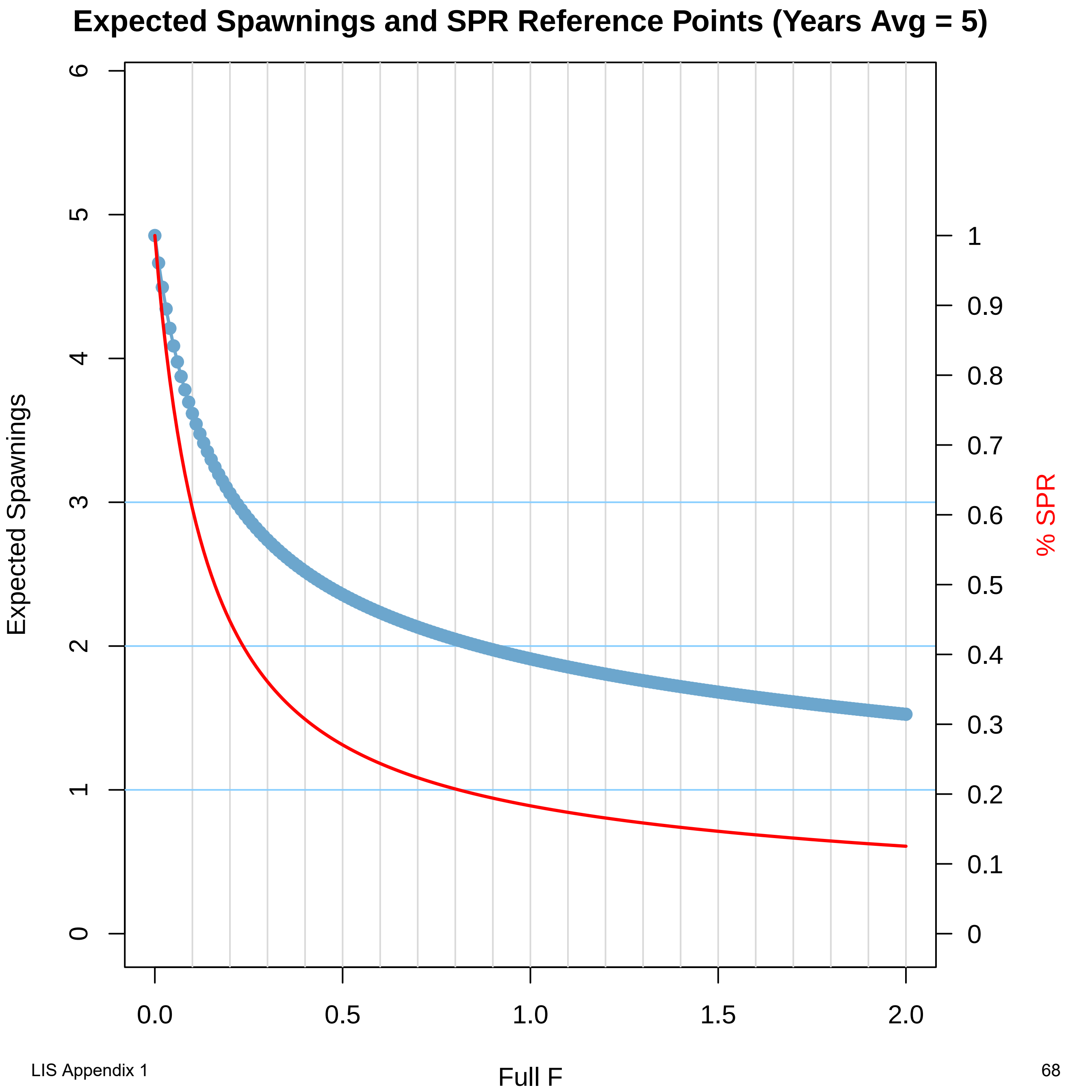
F	YPR	SPR	F	YPR	SPR	F	YPR	SPR
0	0	1	0.35	0.4814	0.3312	0.7	0.5028	0.2234
0.01	0.0573	0.9381	0.36	0.4831	0.326	0.71	0.5029	0.2217
0.02	0.1065	0.8836	0.37	0.4846	0.321	0.72	0.503	0.2199
0.03	0.149	0.8354	0.38	0.486	0.3162	0.73	0.5031	0.2182
0.04	0.1859	0.7924	0.39	0.4873	0.3116	0.74	0.5032	0.2166
0.05	0.2181	0.7539	0.4	0.4885	0.3071	0.75	0.5032	0.2149
0.06	0.2464	0.7192	0.41	0.4896	0.3028	0.76	0.5033	0.2133
0.07	0.2713	0.6877	0.42	0.4907	0.2987	0.77	0.5033	0.2118
0.08	0.2933	0.6591	0.43	0.4916	0.2947	0.78	0.5034	0.2103
0.09	0.3129	0.6329	0.44	0.4925	0.2909	0.79	0.5034	0.2088
0.1	0.3303	0.609	0.45	0.4934	0.2872	0.8	0.5034	0.2073
0.11	0.3458	0.587	0.46	0.4942	0.2836	0.81	0.5035	0.2059
0.12	0.3598	0.5667	0.47	0.4949	0.2802	0.82	0.5035	0.2045
0.13	0.3723	0.5479	0.48	0.4956	0.2768	0.83	0.5035	0.2031
0.14	0.3835	0.5304	0.49	0.4962	0.2736	0.84	0.5035	0.2017
0.15	0.3937	0.5142	0.5	0.4968	0.2704	0.85	0.5035	0.2004
0.16	0.4028	0.4991	0.51	0.4973	0.2674	0.86	0.5035	0.1991
0.17	0.4111	0.485	0.52	0.4979	0.2645	0.87	0.5034	0.1978
0.18	0.4186	0.4717	0.53	0.4983	0.2616	0.88	0.5034	0.1966
0.19	0.4255	0.4593	0.54	0.4988	0.2588	0.89	0.5034	0.1954
0.2	0.4317	0.4477	0.55	0.4992	0.2561	0.9	0.5033	0.1941
0.21	0.4374	0.4367	0.56	0.4996	0.2535	0.91	0.5033	0.193
0.22	0.4426	0.4264	0.57	0.4999	0.251	0.92	0.5033	0.1918
0.23	0.4473	0.4166	0.58	0.5003	0.2485	0.93	0.5032	0.1907
0.24	0.4516	0.4073	0.59	0.5006	0.2461	0.94	0.5031	0.1895
0.25	0.4556	0.3986	0.6	0.5009	0.2438	0.95	0.5031	0.1884
0.26	0.4592	0.3903	0.61	0.5011	0.2415	0.96	0.503	0.1873
0.27	0.4626	0.3824	0.62	0.5014	0.2393	0.97	0.503	0.1863
0.28	0.4657	0.3749	0.63	0.5016	0.2371	0.98	0.5029	0.1852
0.29	0.4685	0.3678	0.64	0.5018	0.235	0.99	0.5028	0.1842
0.3	0.4711	0.361	0.65	0.502	0.233	1	0.5027	0.1832
0.31	0.4735	0.3545	0.66	0.5022	0.231	1.01	0.5026	0.1822
0.32	0.4757	0.3483	0.67	0.5024	0.229	1.02	0.5026	0.1812
0.33	0.4778	0.3423	0.68	0.5025	0.2271	1.03	0.5025	0.1802
0.34	0.4797	0.3366	0.69	0.5026	0.2252	1.04	0.5024	0.1792


SPR Target Reference Points (Years Avg = 5)
Yield per Recruit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
F (%SPR)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
% SPR Target

SPR Target Reference Points (Years Avg = 5)

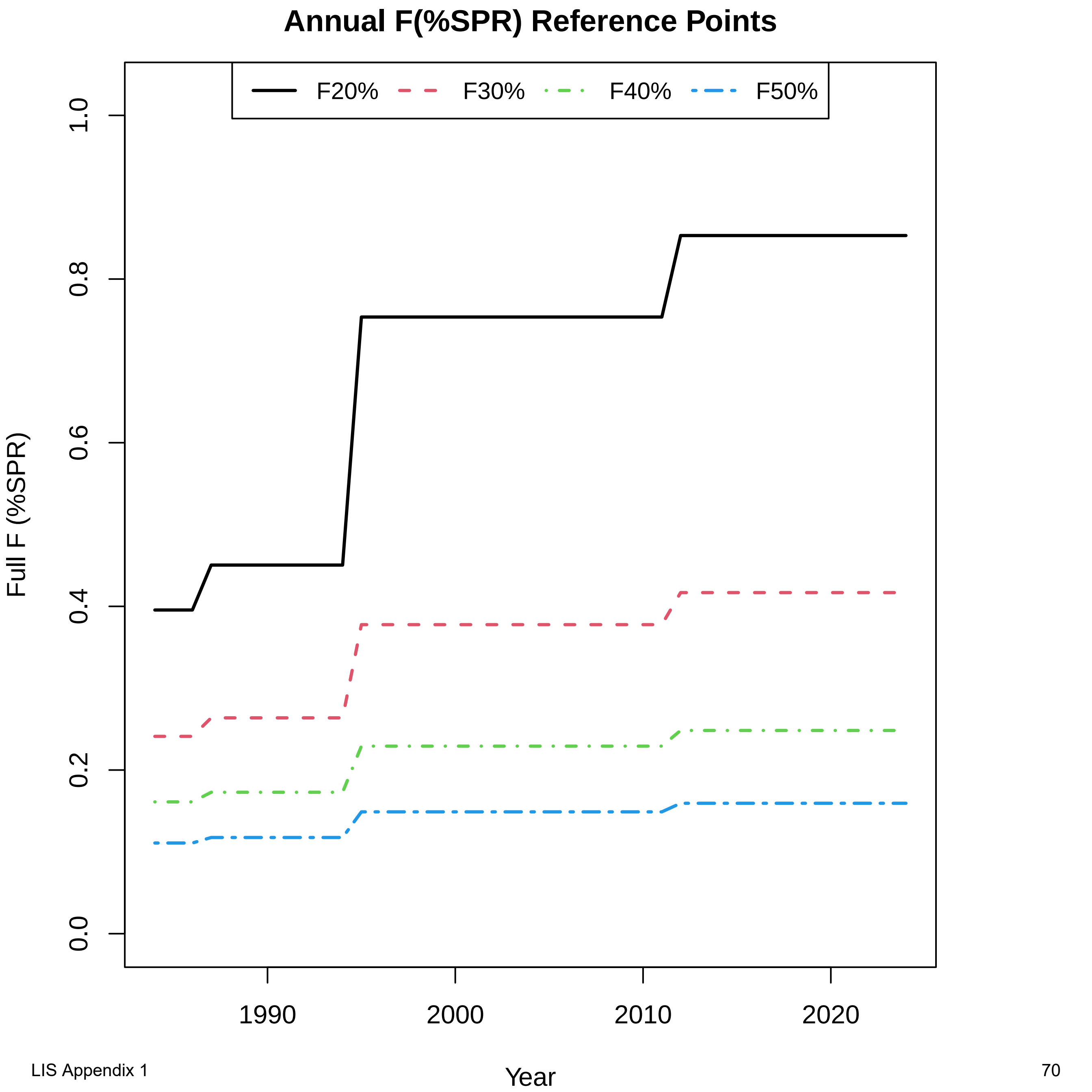
% SPR	F(%SPR)	YPR
0.2	0.8532	0.5035
0.25	0.574	0.5001
0.3	0.4168	0.4903
0.35	0.3171	0.4751
0.4	0.2484	0.455
0.45	0.198	0.4305
0.5	0.1594	0.4023
0.55	0.1288	0.3709
0.6	0.104	0.3367
0.65	0.0834	0.3002
0.7	0.066	0.2616
0.75	0.0511	0.2213
0.8	0.0382	0.1794

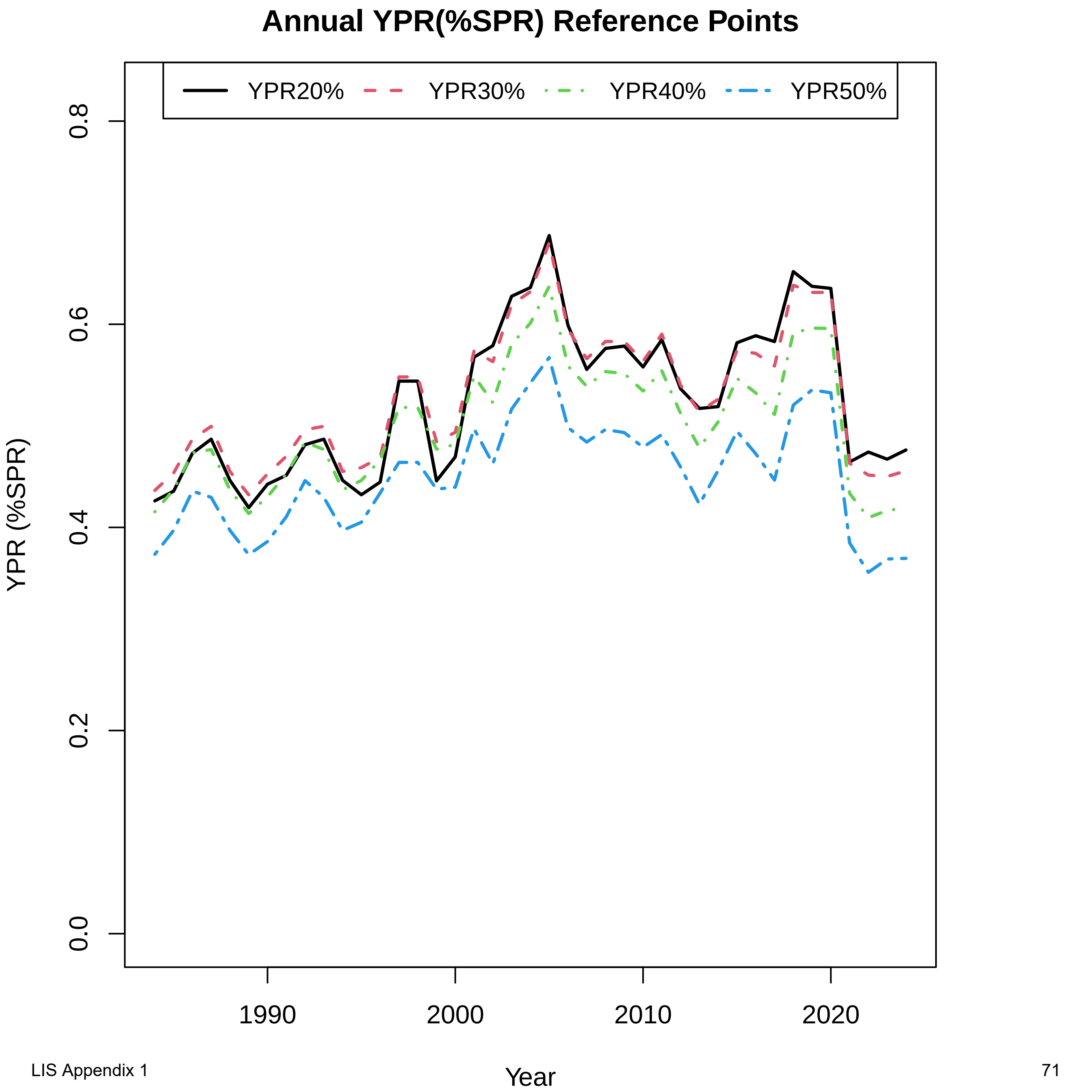

Maturity
Selectivity
Selectivity or Maturity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
Age


Expected Spawnings and SPR Reference Points (Years Avg = 5)
Expected Spawnings
% SPR
Full F
0
1
2
3
4
5
6
0.0
0.5
1.0
1.5
2.0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

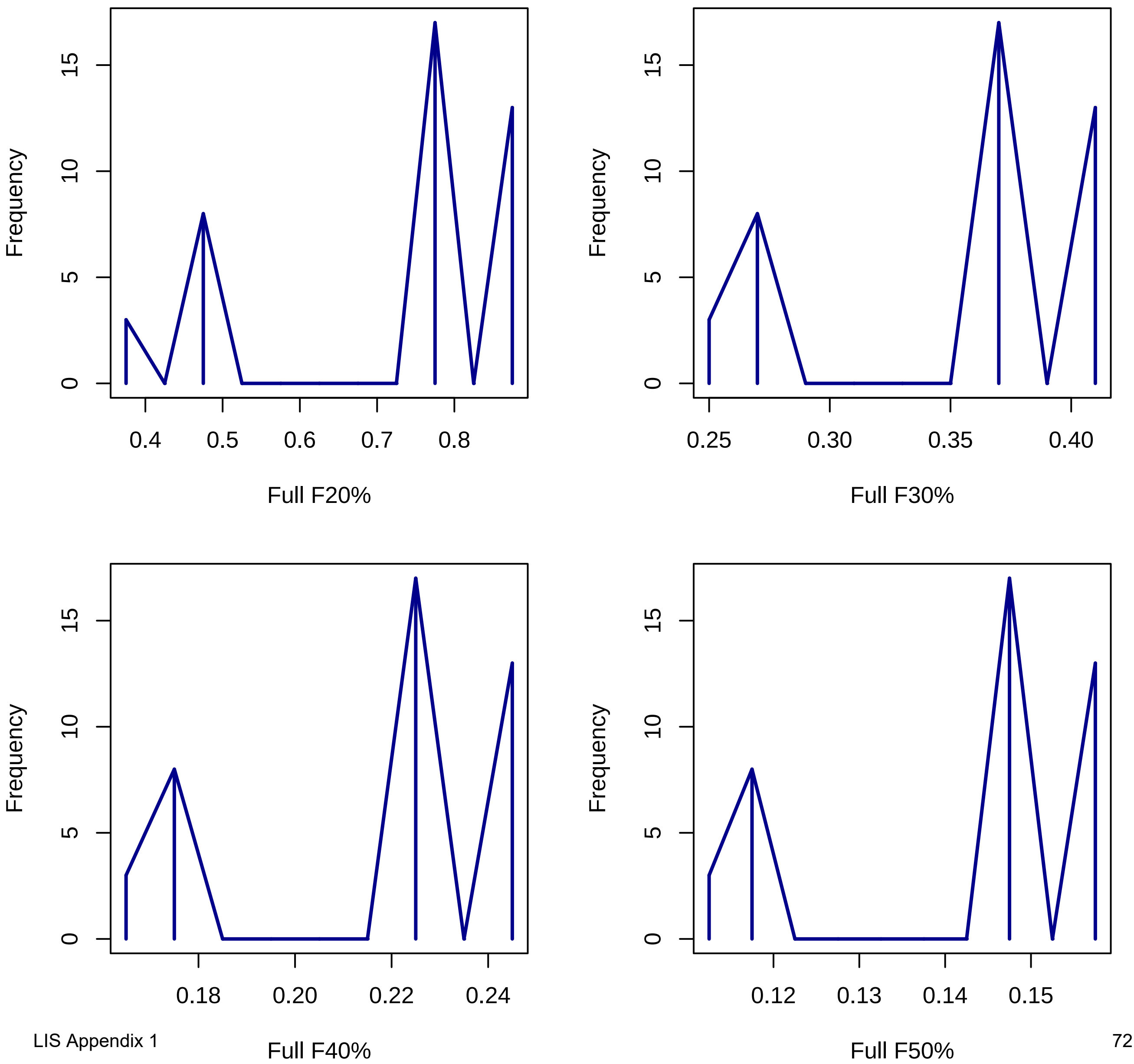
Expected Spawnings & SPR Reference Points (Years Avg = 5)

F	E[Sp]	SPR	F	E[Sp]	SPR	F	E[Sp]	SPR
0	4.8546	1	0.35	2.6187	0.3312	0.7	2.1315	0.2234
0.01	4.6639	0.9381	0.36	2.5974	0.326	0.71	2.1224	0.2217
0.02	4.495	0.8836	0.37	2.5767	0.321	0.72	2.1134	0.2199
0.03	4.3444	0.8354	0.38	2.5567	0.3162	0.73	2.1046	0.2182
0.04	4.2091	0.7924	0.39	2.5374	0.3116	0.74	2.0959	0.2166
0.05	4.0869	0.7539	0.4	2.5186	0.3071	0.75	2.0874	0.2149
0.06	3.9759	0.7192	0.41	2.5004	0.3028	0.76	2.079	0.2133
0.07	3.8746	0.6877	0.42	2.4828	0.2987	0.77	2.0708	0.2118
0.08	3.7817	0.6591	0.43	2.4656	0.2947	0.78	2.0627	0.2103
0.09	3.6962	0.6329	0.44	2.449	0.2909	0.79	2.0547	0.2088
0.1	3.6172	0.609	0.45	2.4328	0.2872	0.8	2.0468	0.2073
0.11	3.5439	0.587	0.46	2.417	0.2836	0.81	2.039	0.2059
0.12	3.4757	0.5667	0.47	2.4017	0.2802	0.82	2.0314	0.2045
0.13	3.4122	0.5479	0.48	2.3867	0.2768	0.83	2.0239	0.2031
0.14	3.3527	0.5304	0.49	2.3721	0.2736	0.84	2.0165	0.2017
0.15	3.2969	0.5142	0.5	2.3579	0.2704	0.85	2.0092	0.2004
0.16	3.2444	0.4991	0.51	2.3441	0.2674	0.86	2.002	0.1991
0.17	3.195	0.485	0.52	2.3306	0.2645	0.87	1.9949	0.1978
0.18	3.1484	0.4717	0.53	2.3174	0.2616	0.88	1.9879	0.1966
0.19	3.1042	0.4593	0.54	2.3045	0.2588	0.89	1.981	0.1954
0.2	3.0624	0.4477	0.55	2.2919	0.2561	0.9	1.9742	0.1941
0.21	3.0227	0.4367	0.56	2.2796	0.2535	0.91	1.9675	0.193
0.22	2.9849	0.4264	0.57	2.2675	0.251	0.92	1.9609	0.1918
0.23	2.9489	0.4166	0.58	2.2557	0.2485	0.93	1.9544	0.1907
0.24	2.9146	0.4073	0.59	2.2442	0.2461	0.94	1.948	0.1895
0.25	2.8818	0.3986	0.6	2.2329	0.2438	0.95	1.9416	0.1884
0.26	2.8505	0.3903	0.61	2.2219	0.2415	0.96	1.9353	0.1873
0.27	2.8205	0.3824	0.62	2.211	0.2393	0.97	1.9291	0.1863
0.28	2.7917	0.3749	0.63	2.2004	0.2371	0.98	1.923	0.1852
0.29	2.764	0.3678	0.64	2.19	0.235	0.99	1.917	0.1842
0.3	2.7375	0.361	0.65	2.1798	0.233	1	1.911	0.1832
0.31	2.7119	0.3545	0.66	2.1698	0.231	1.01	1.9051	0.1822
0.32	2.6874	0.3483	0.67	2.16	0.229	1.02	1.8993	0.1812
0.33	2.6636	0.3423	0.68	2.1503	0.2271	1.03	1.8935	0.1802
0.34	2.6408	0.3366	0.69	2.1408	0.2252	1.04	1.8878	0.1792

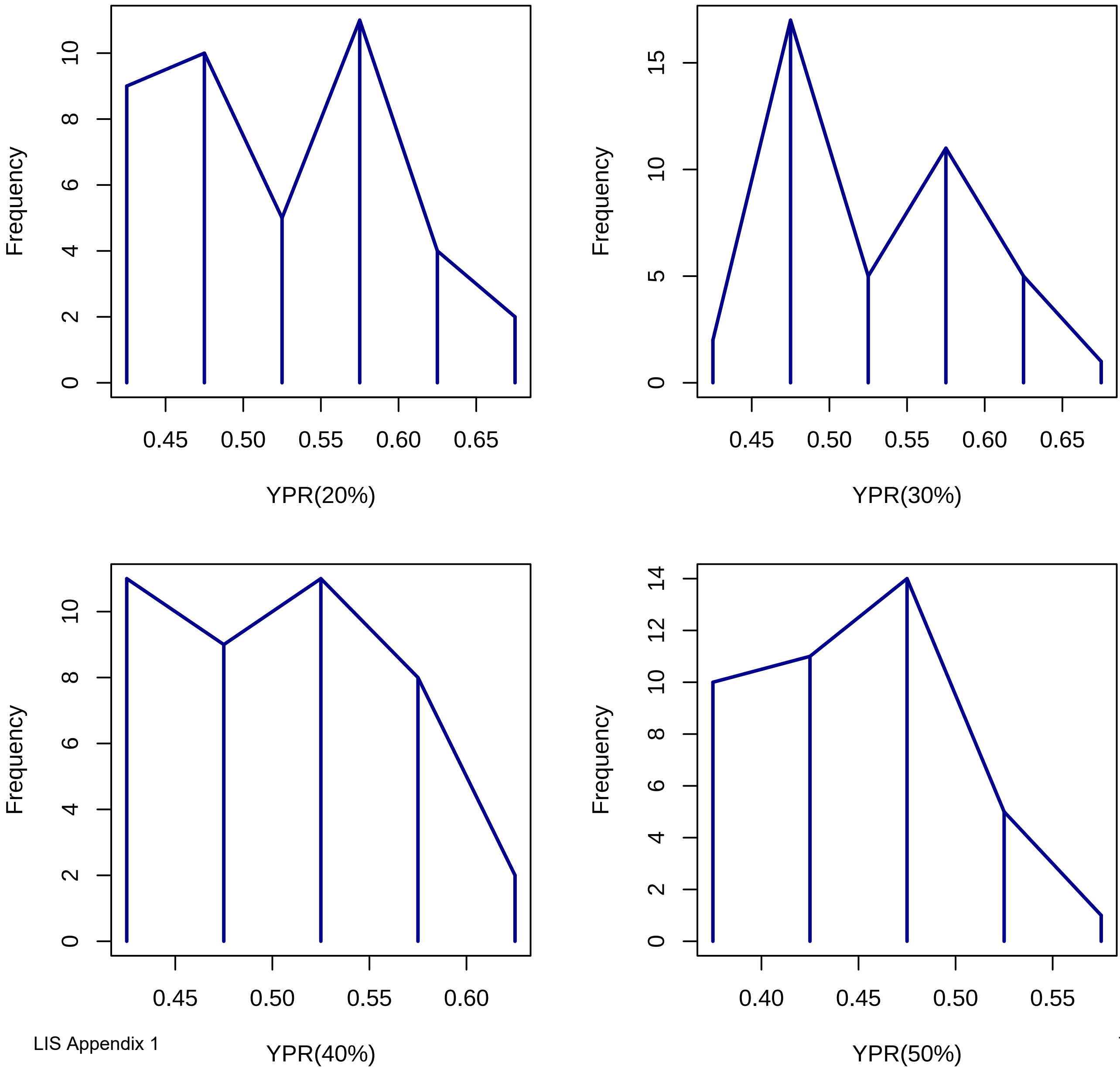

Annual F(%SPR) Reference Points
F20%
F30%
F40%
F50%
Full F (%SPR)
0.0
0.2
0.4
0.6
0.8
1.0
1990
2000
2010
2020
Year


Annual YPR(%SPR) Reference Points
YPR20%
YPR30%
YPR40%
YPR50%
0.0
0.2
0.4
0.6
0.8
YPR (%SPR)
1990
2000
2010
2020
Year

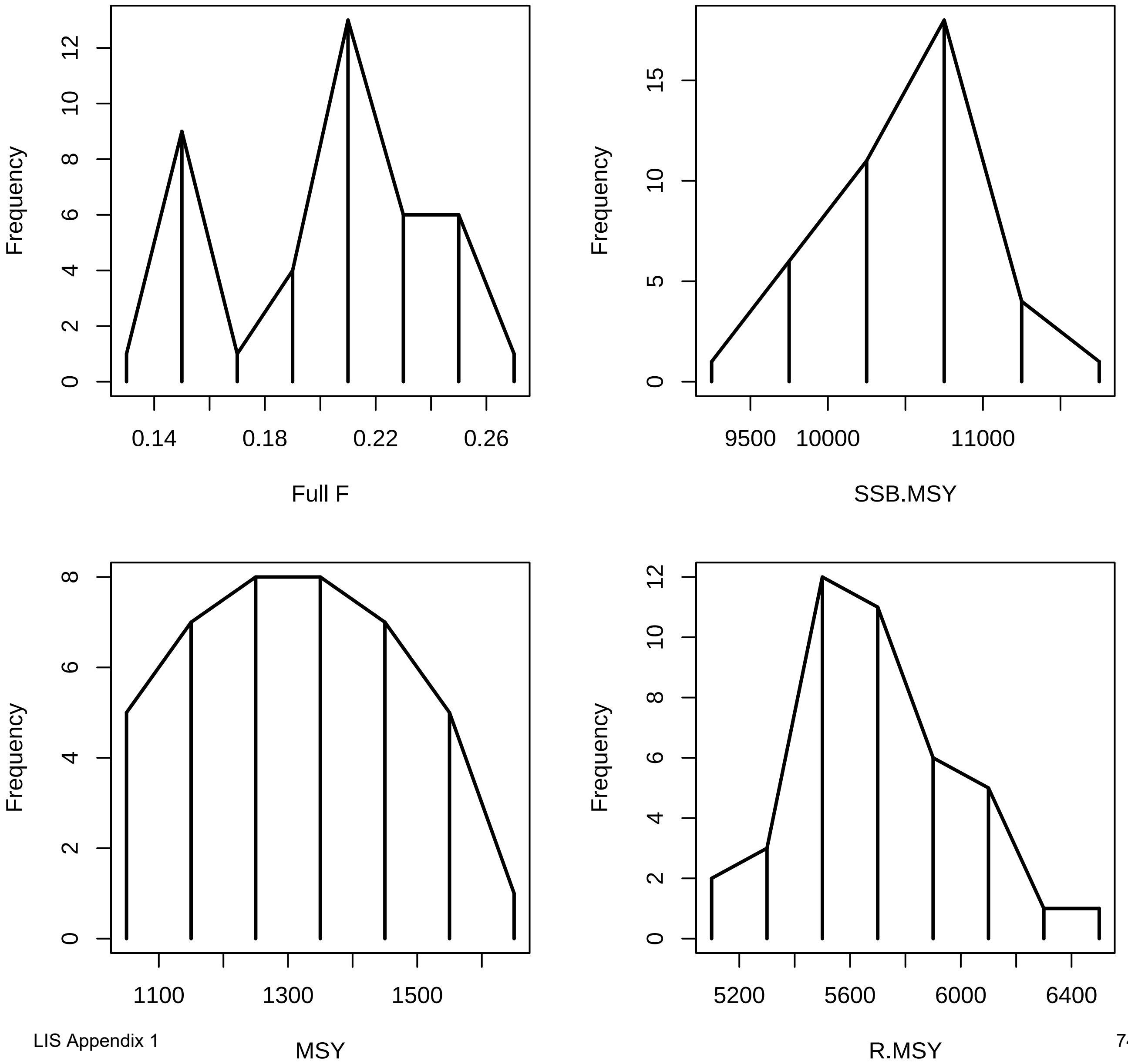
Annual F (%SPR) Reference Points



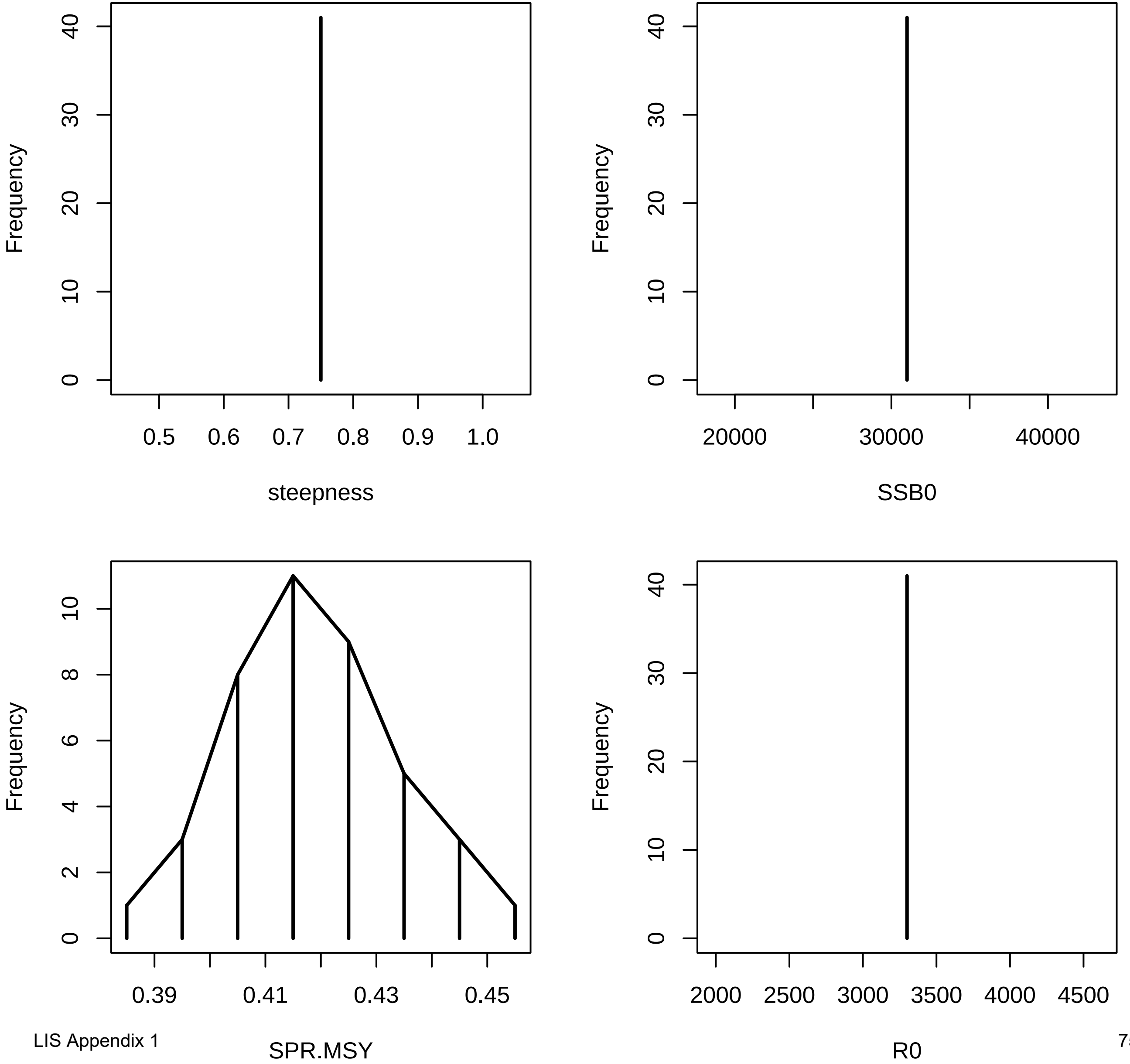
Annual YPR (%SPR) Reference Points

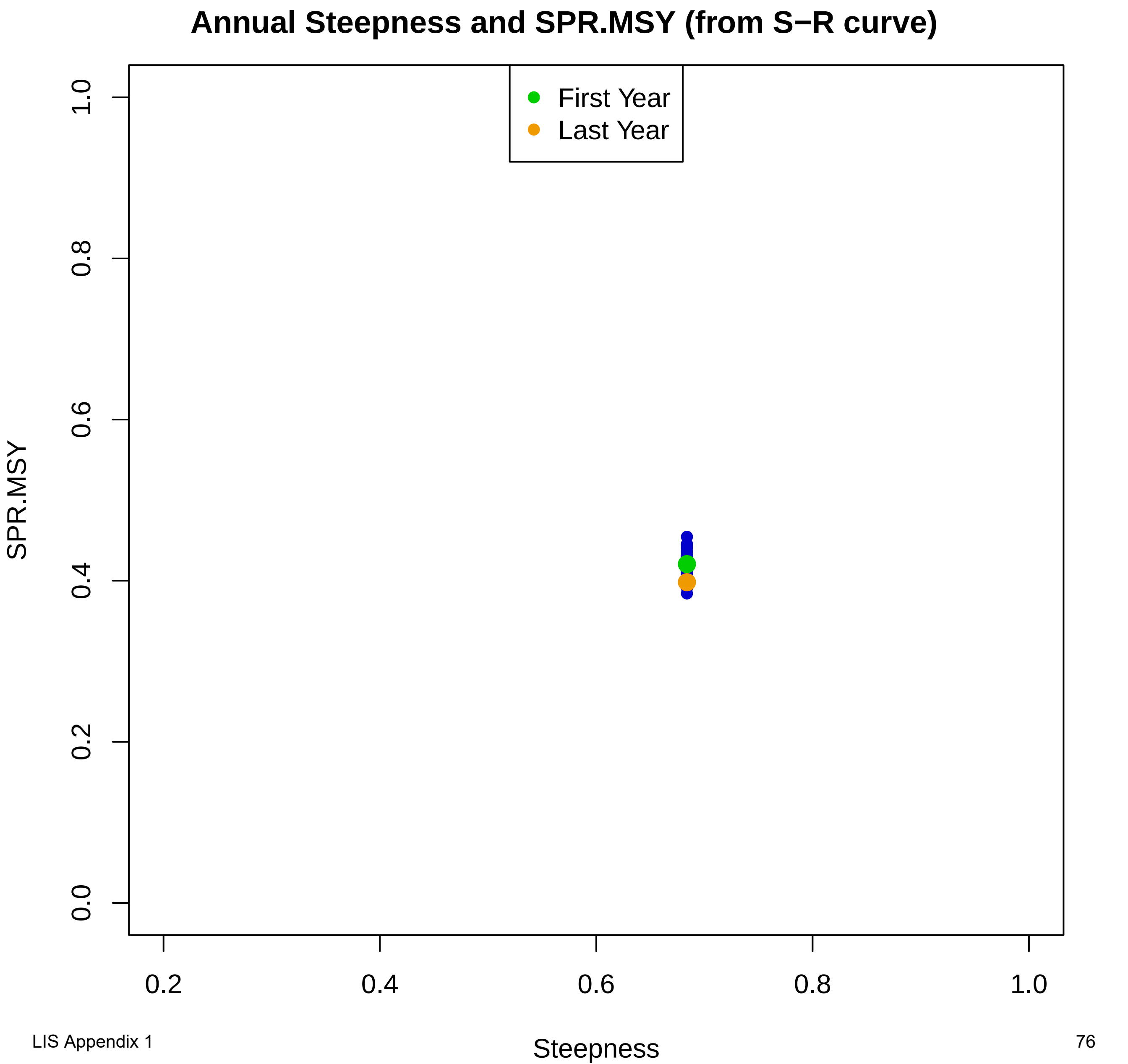


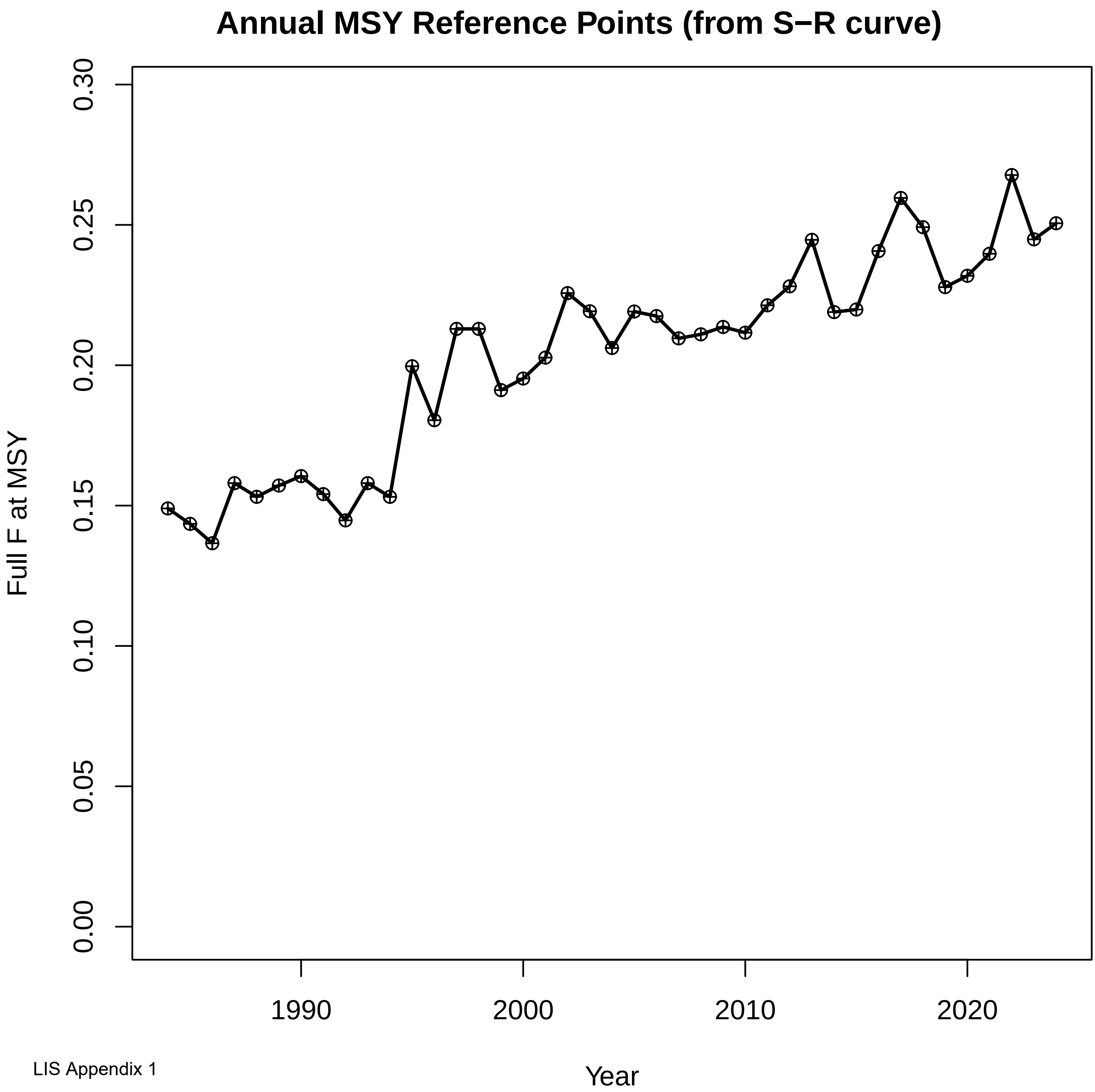
Annual MSY Reference Points (from S−R curve)

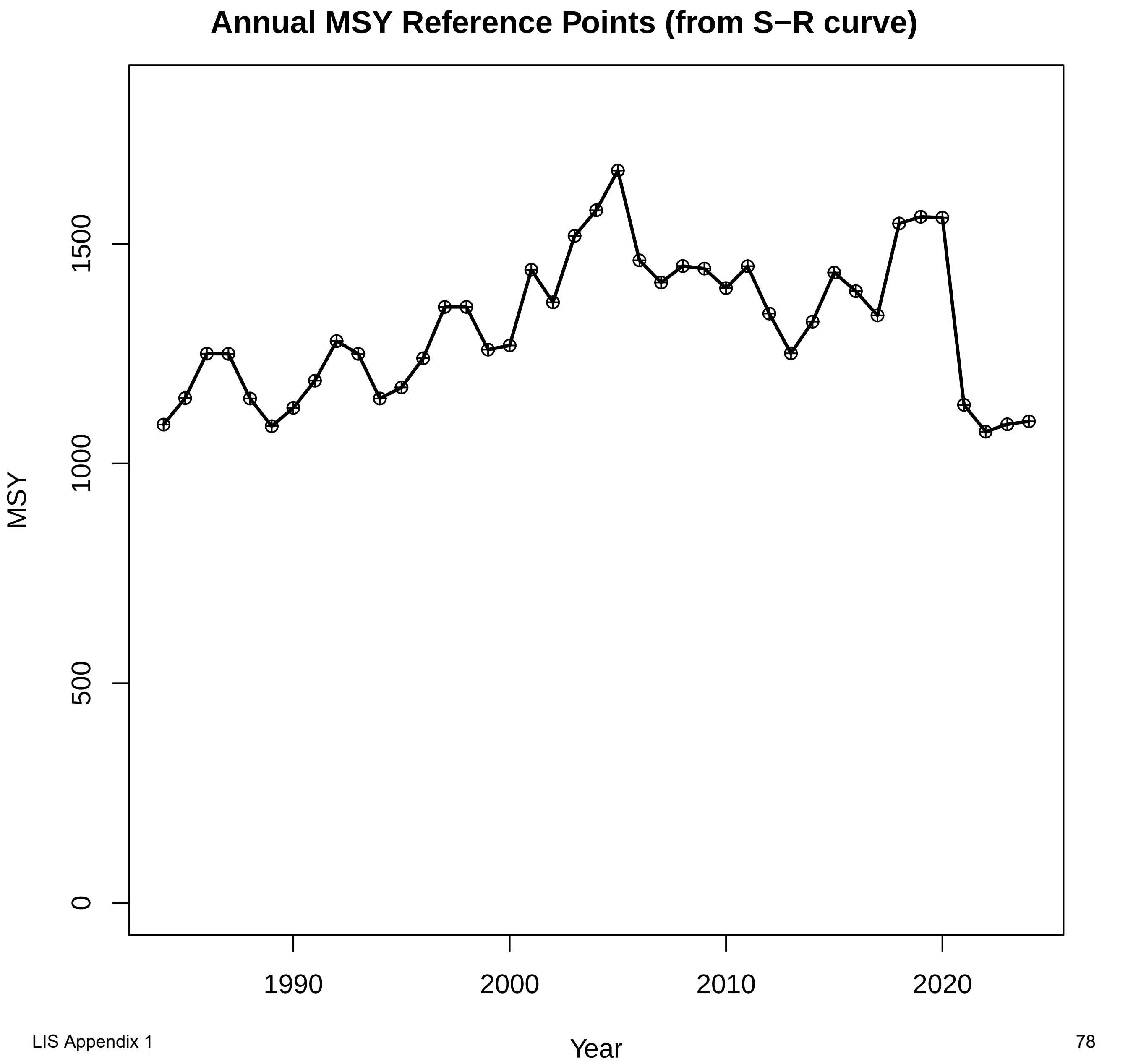


Annual MSY Reference Points (from S−R curve)

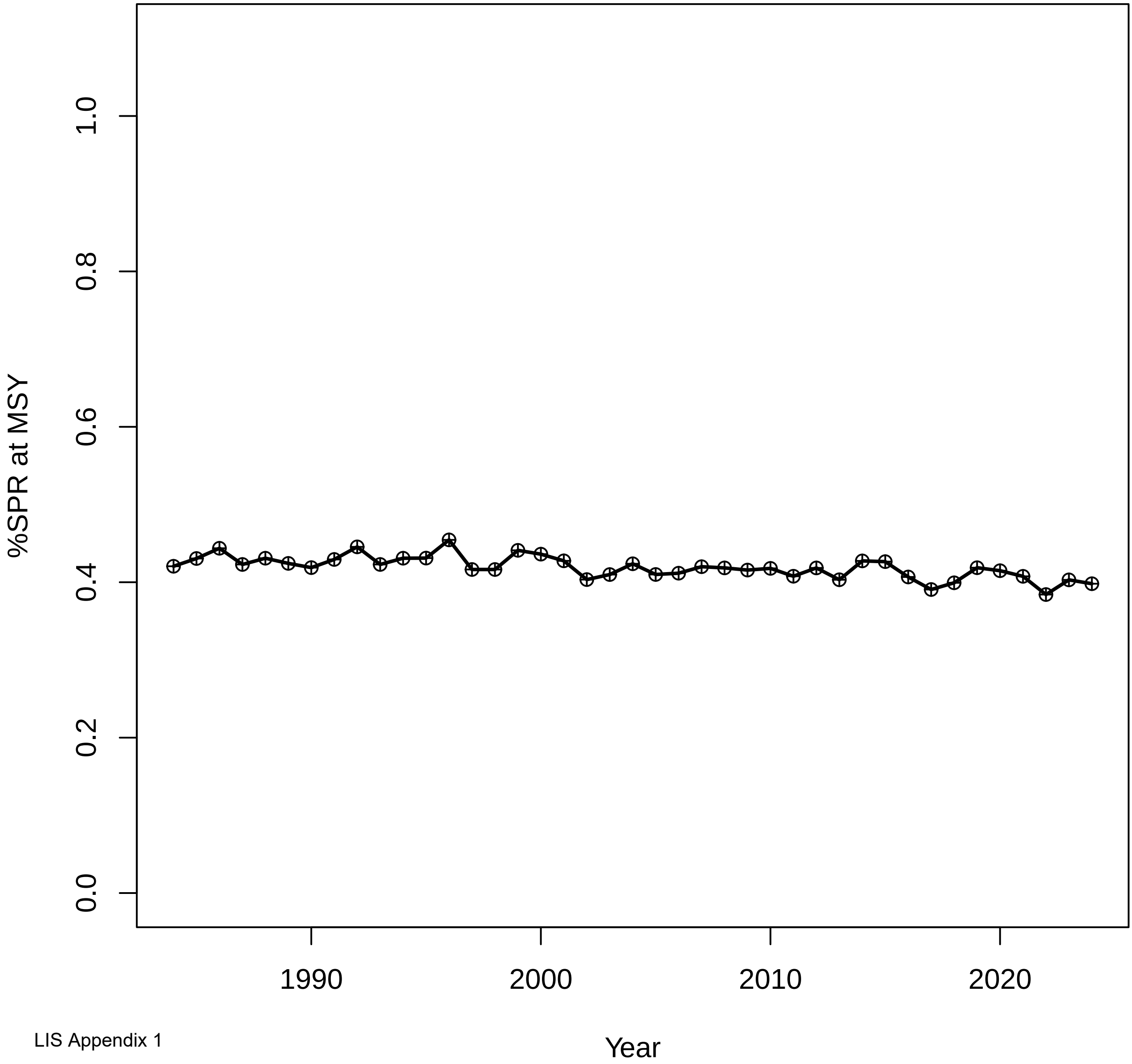


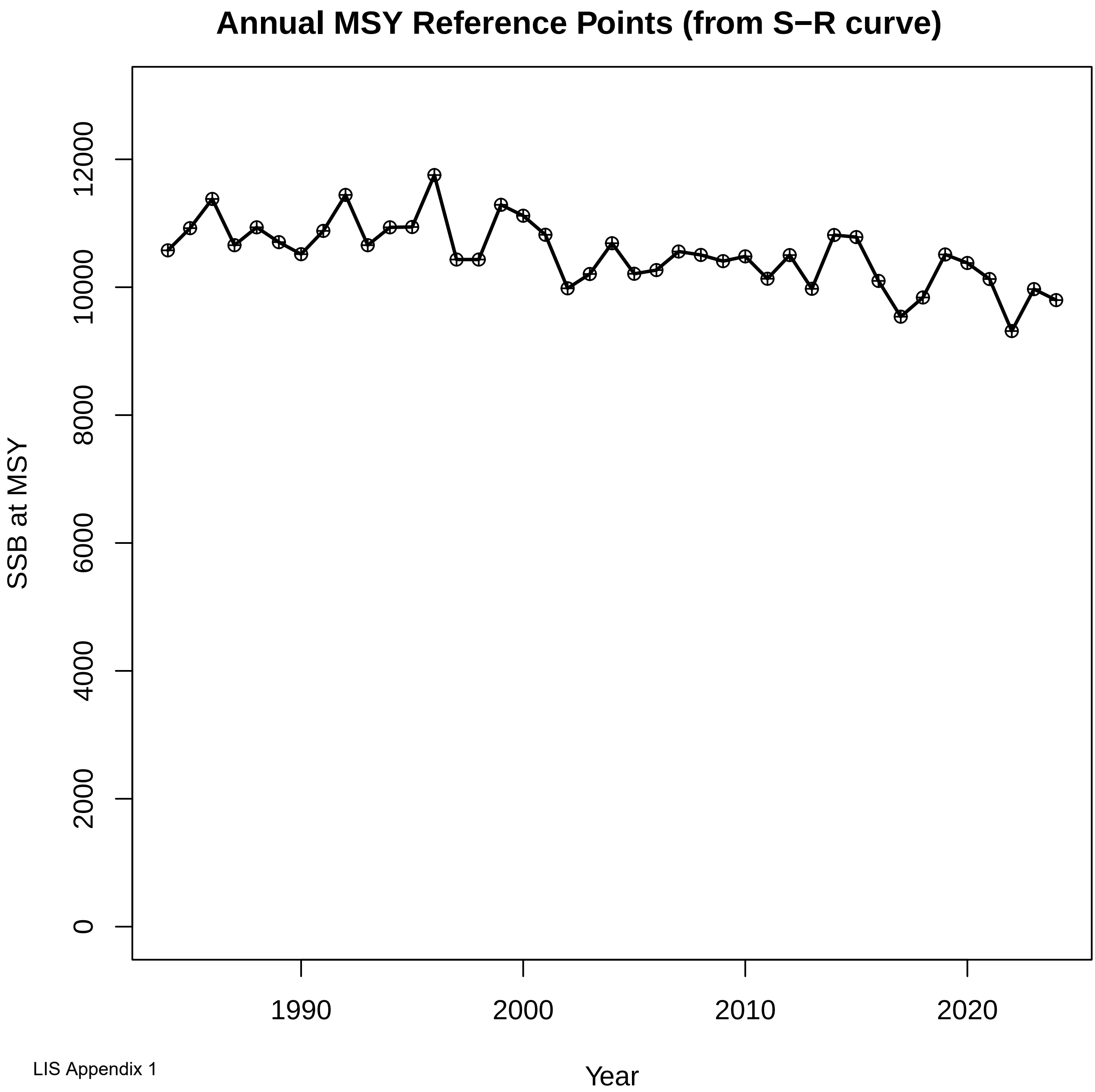

Annual Steepness and SPR.MSY (from S−R curve)
First Year
Last Year
SPR.MSY
Steepness
0.0
0.2
0.4
0.6
0.8
1.0
0.2
0.4
0.6
0.8
1.0

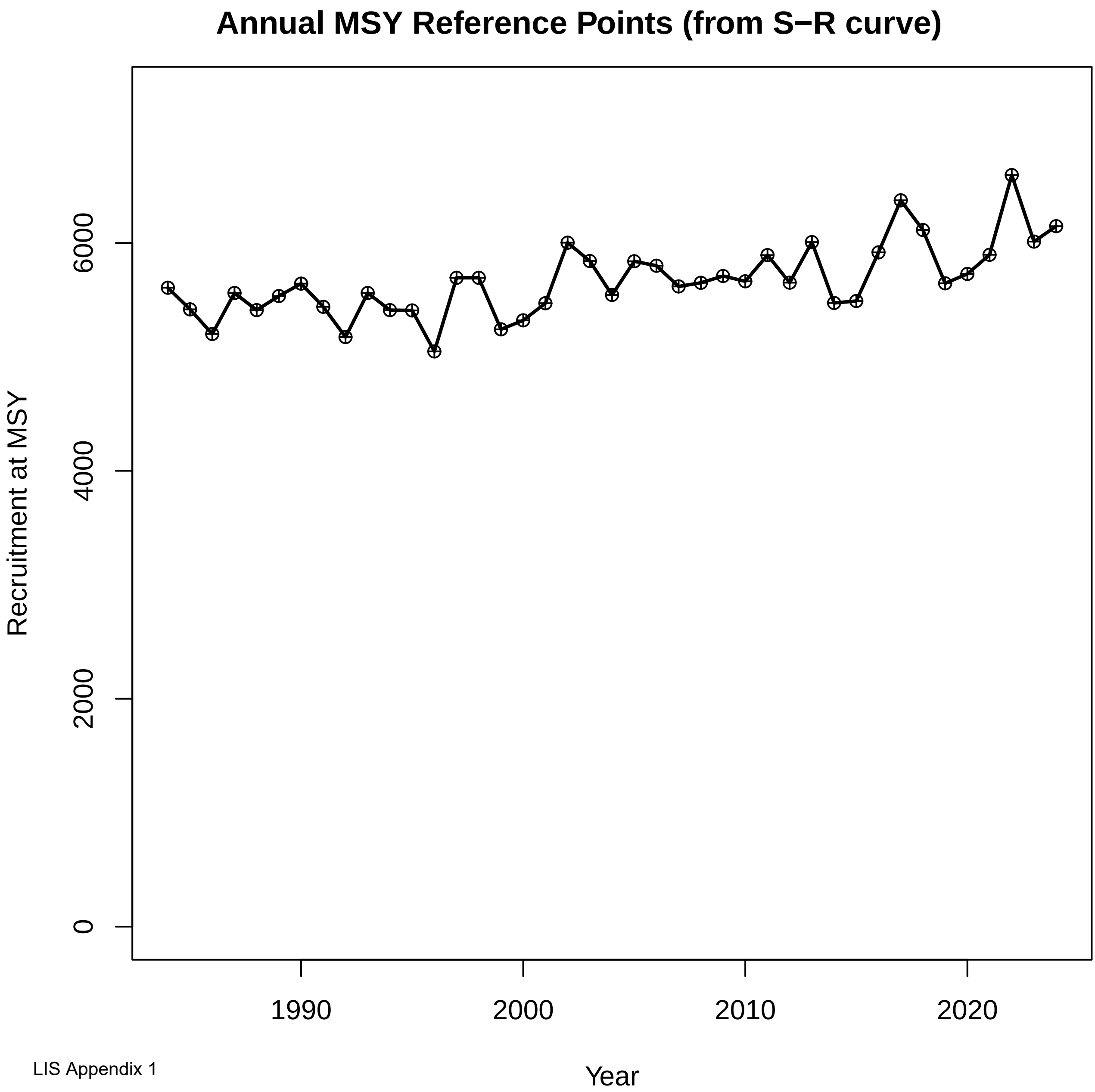

Annual MSY Reference Points (from S−R curve)
Full F at MSY
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1990
2000
2010
2020
Year

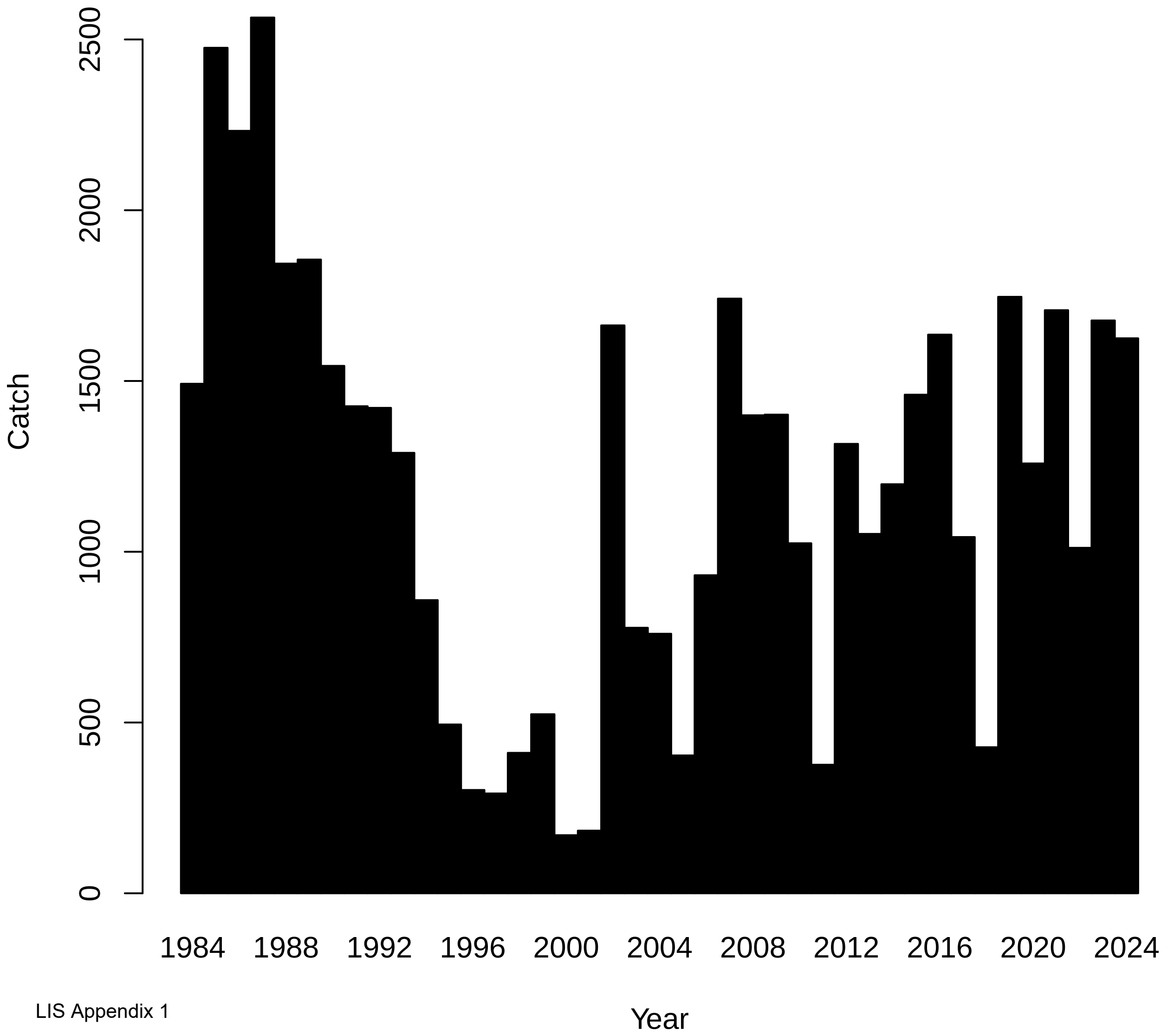

Annual MSY Reference Points (from S−R curve)
MSY
0
500
1000
1500
1990
2000
2010
2020
Year

Annual MSY Reference Points (from S−R curve)

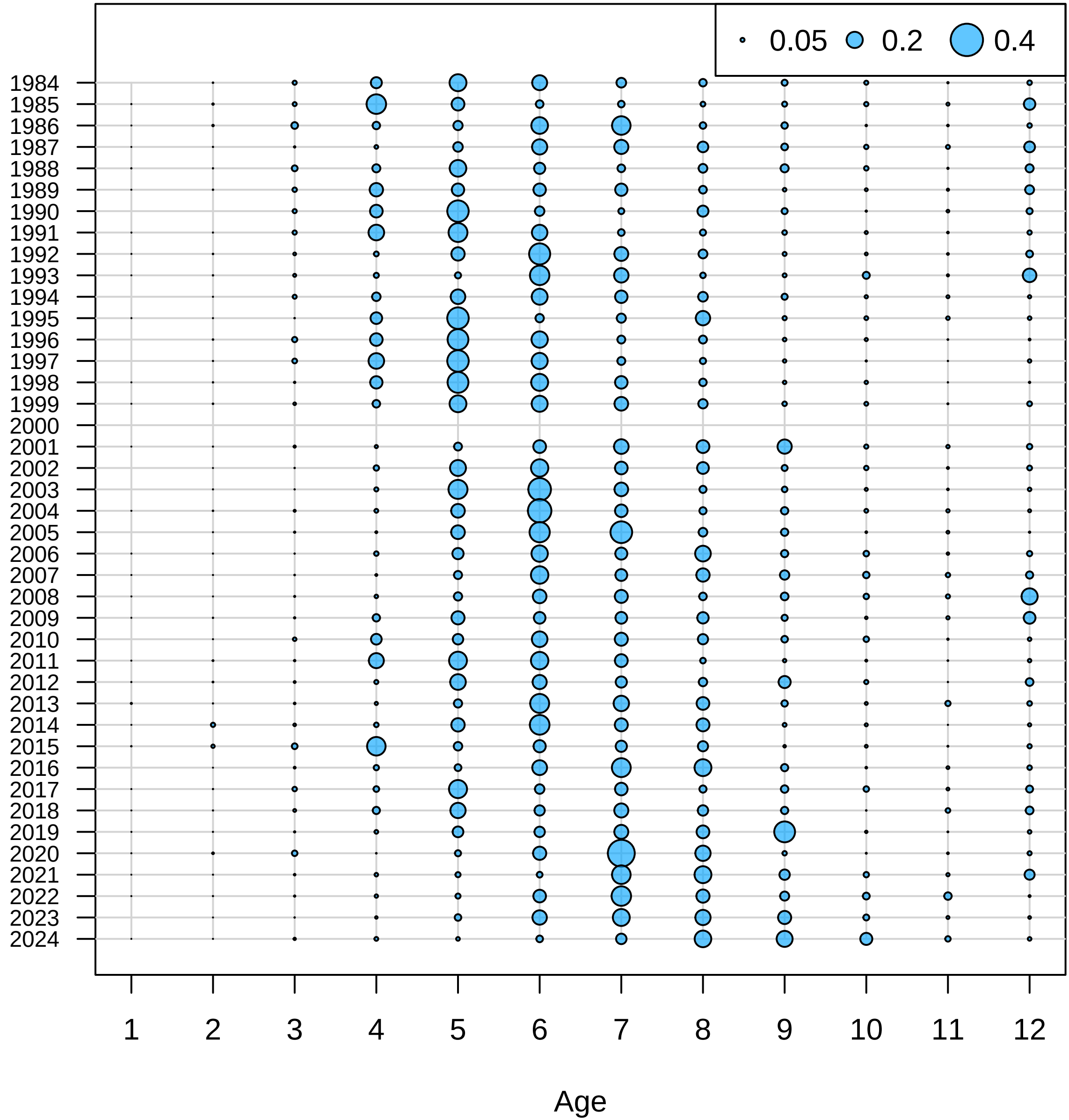


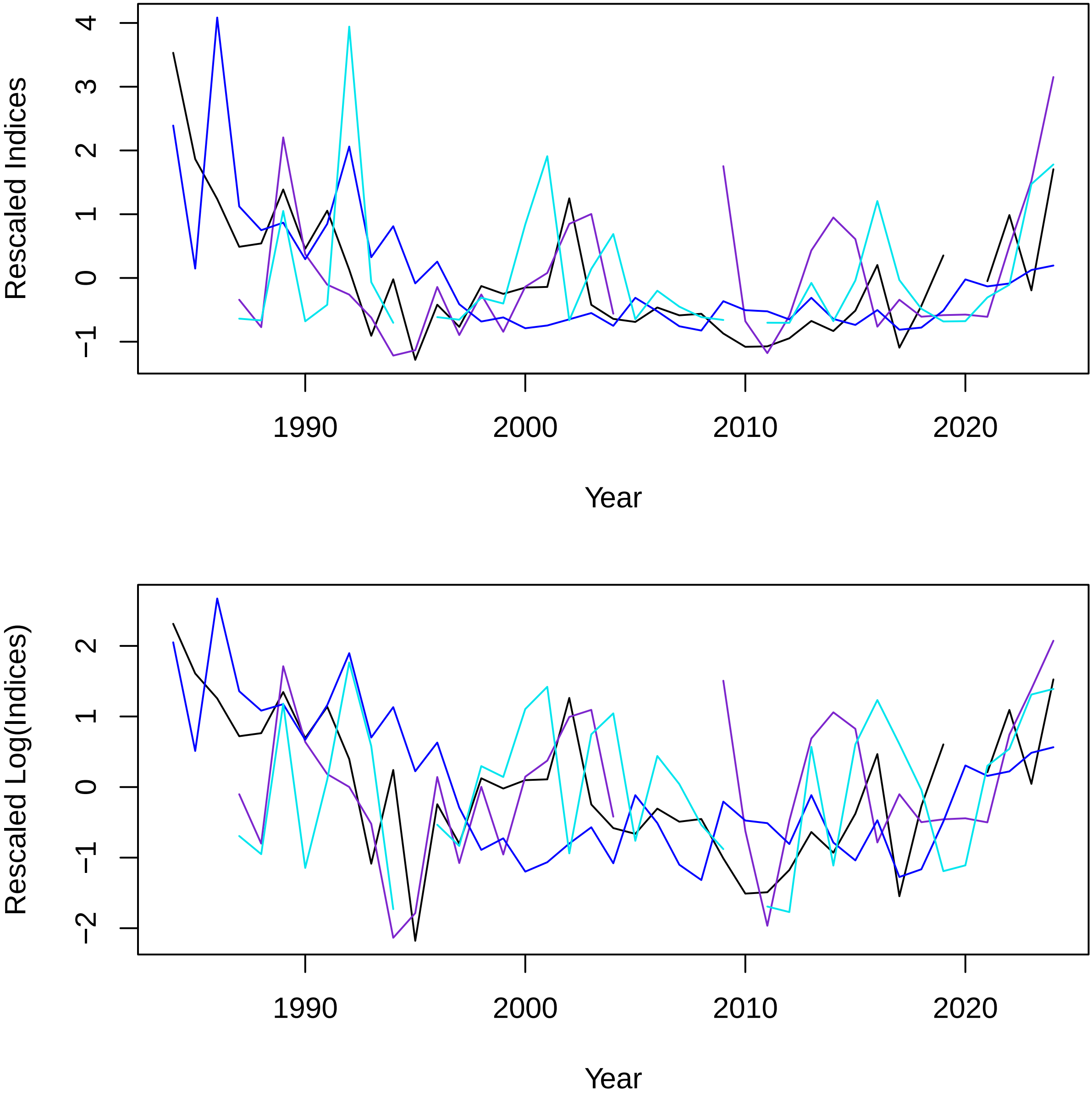

Annual MSY Reference Points (from S−R curve)
SSB at MSY
0
2000
4000
6000
8000
10000
12000
1990
2000
2010
2020
Year

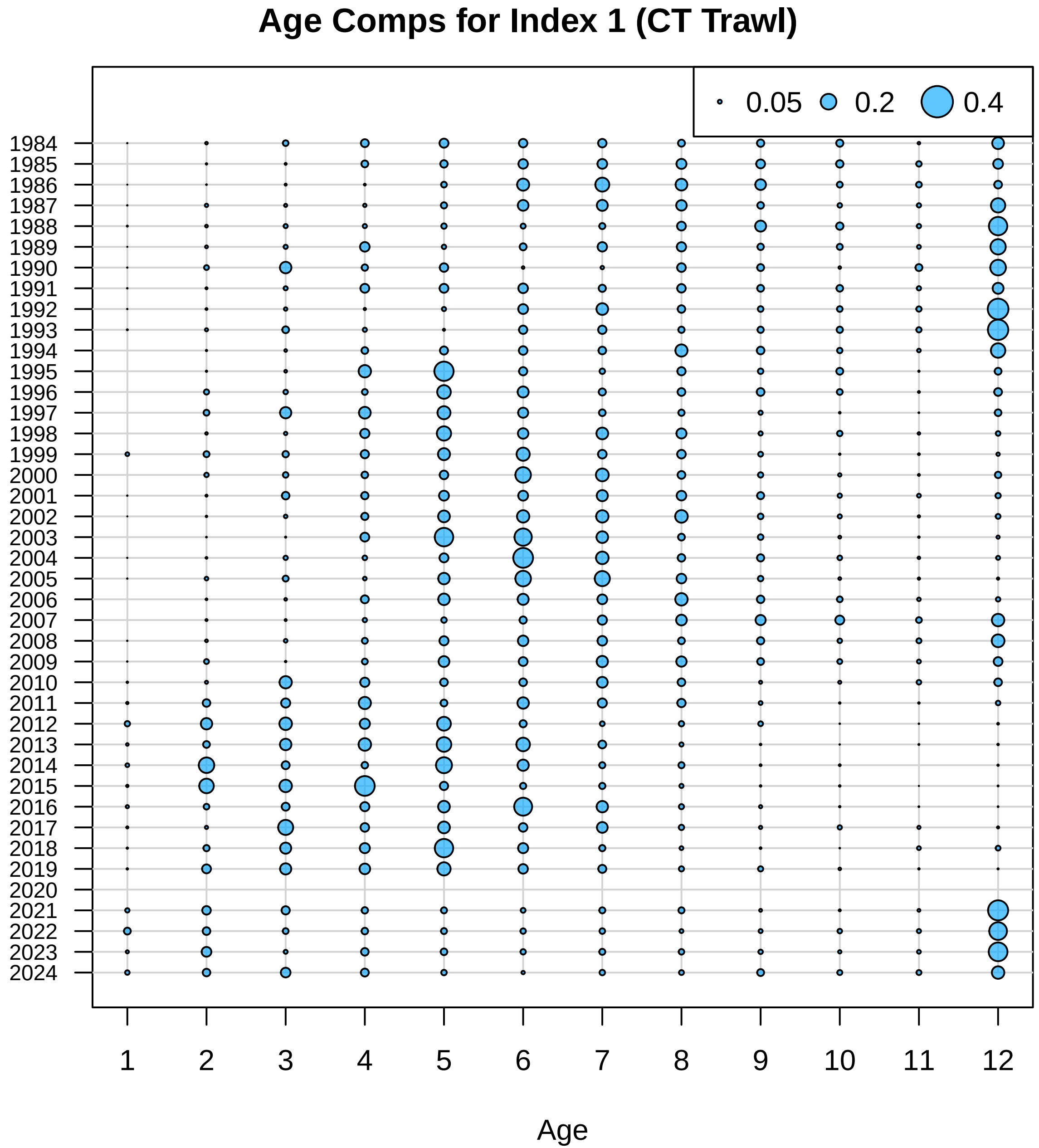

Annual MSY Reference Points (from S−R curve)
Recruitment at MSY
0
2000
4000
6000
1990
2000
2010
2020
Year


Catch
0
500
1000
1500
2000
2500
1984
1988
1992
1996
2000
2004
2008
2012
2016
2020
2024
Year

Age Comps for Catch by Fleet 1 (Rec + Com)

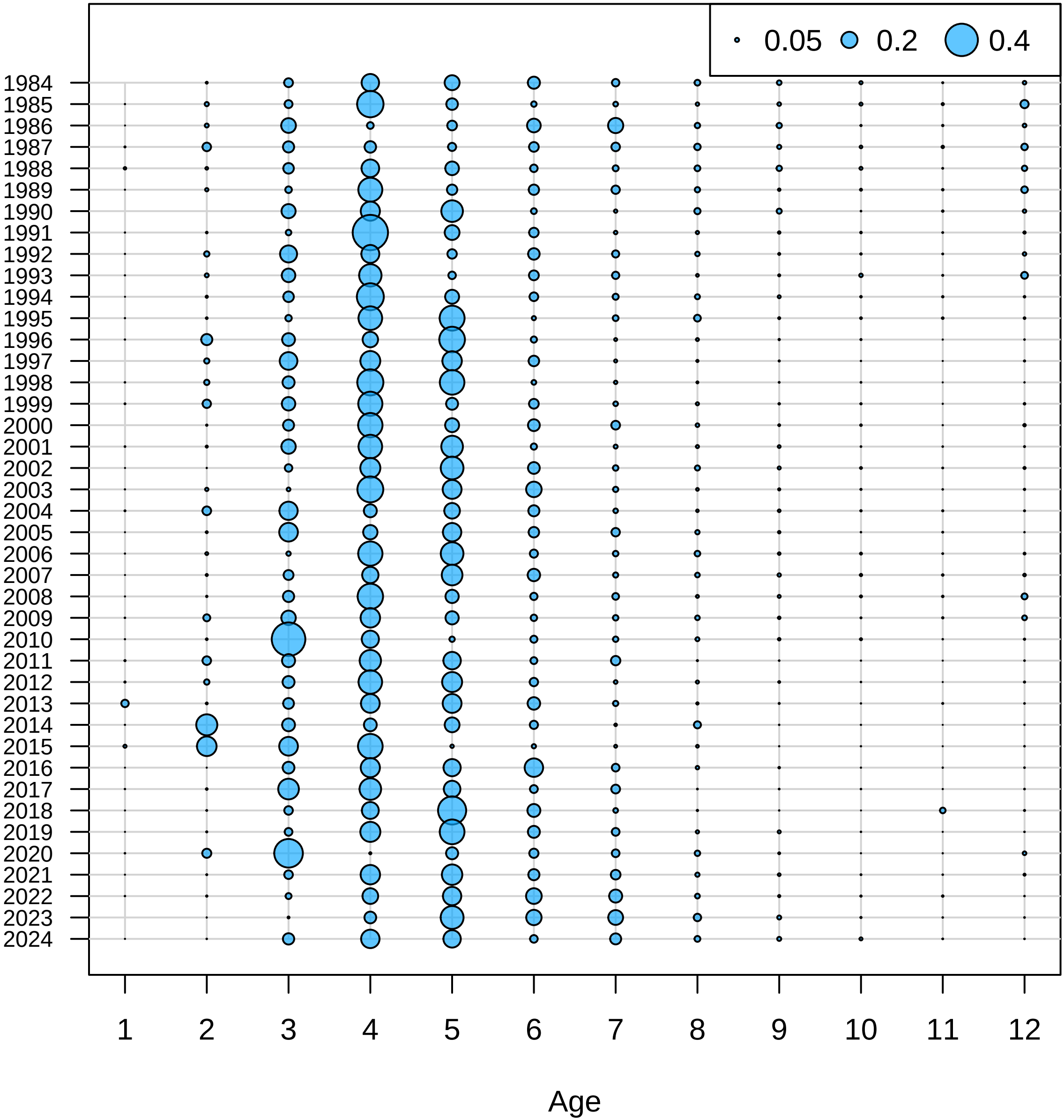


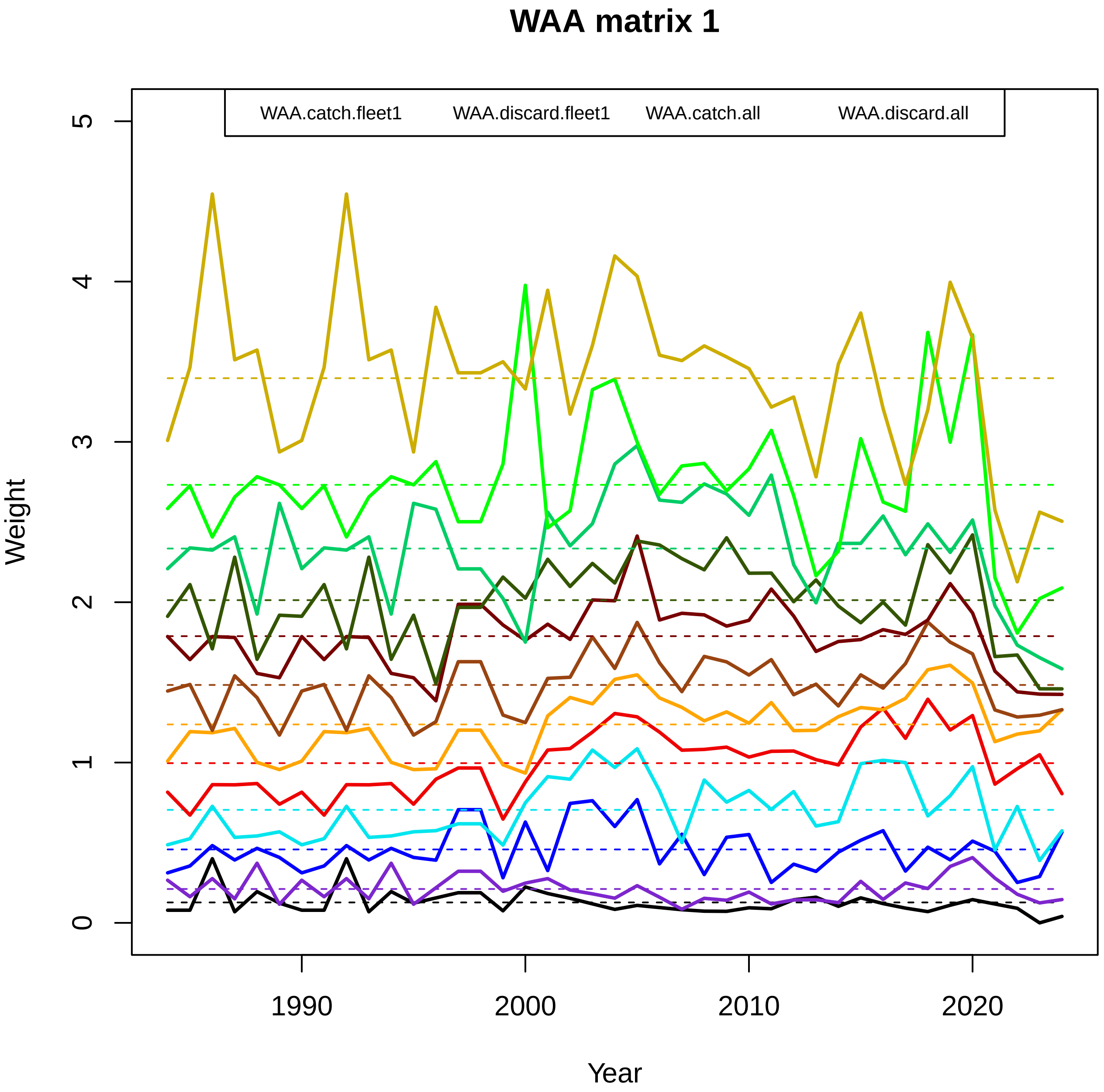

Rescaled Indices
4
3
2
1
0
−1
1990
2000
2010
2020
Year
Rescaled Log(Indices)
2
1
0
−1
−2
1990
2000
2010
2020
Year

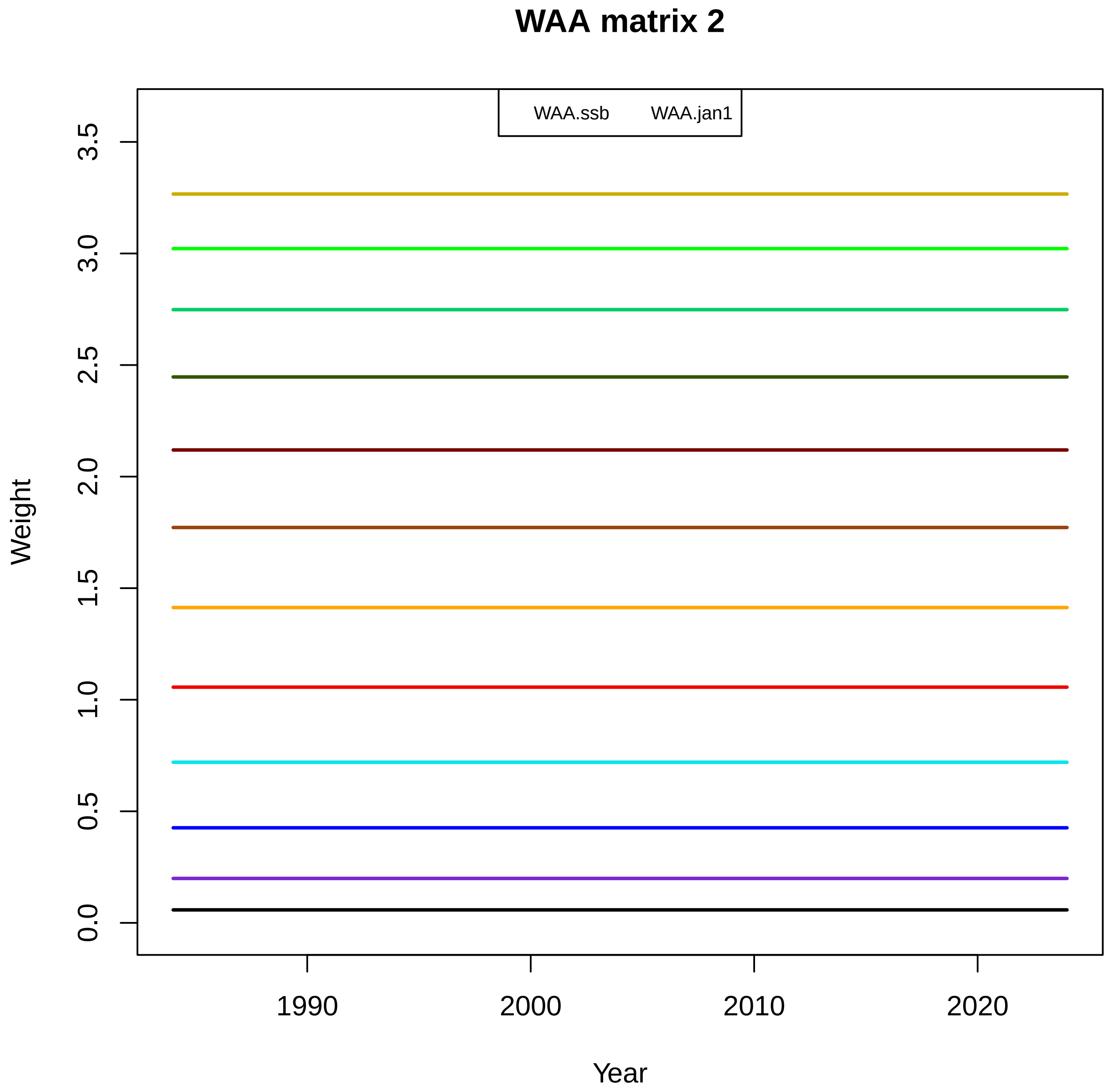


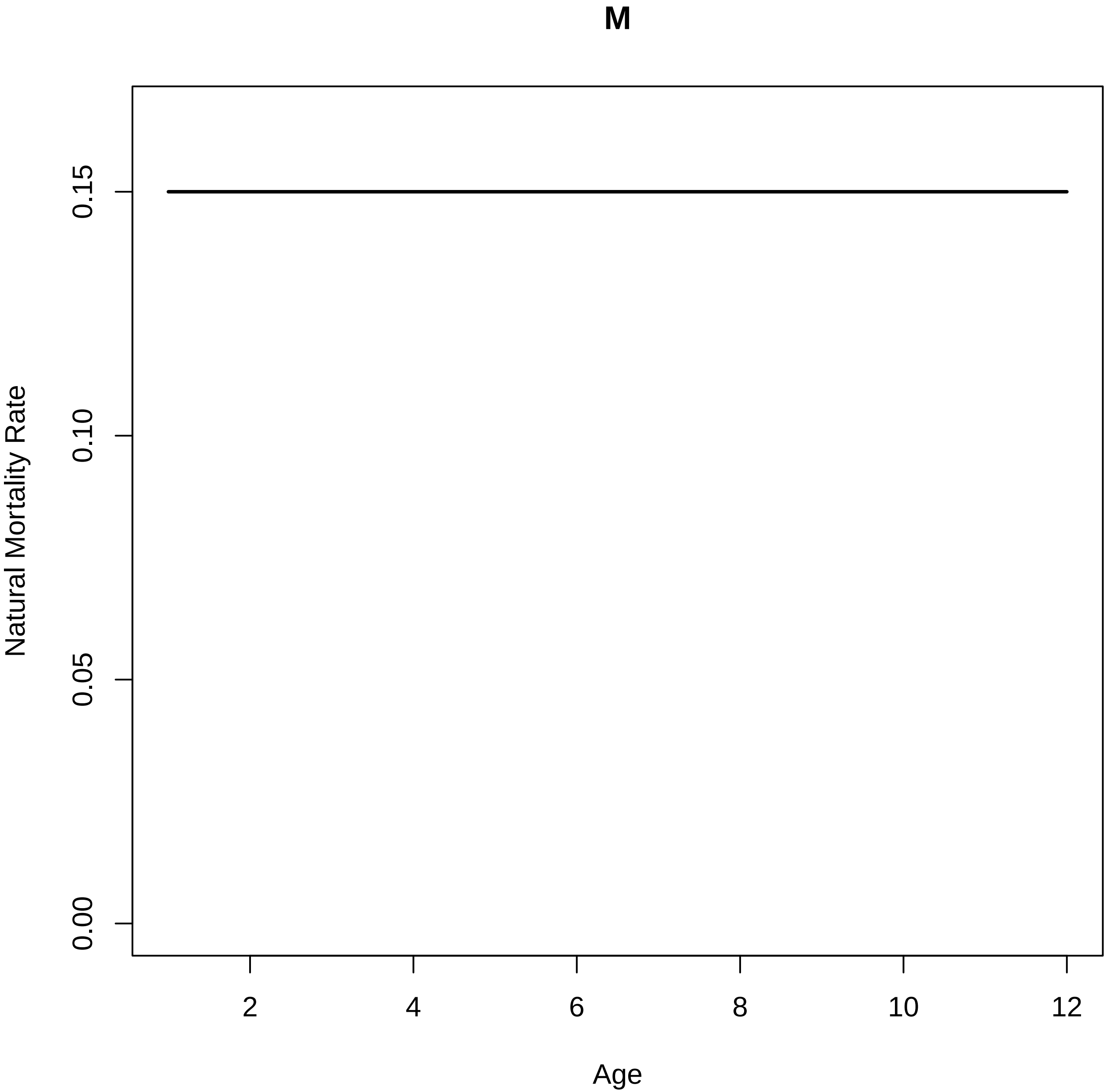
Age Comps for Index 1 (CT Trawl)
0.05
0.2
0.4
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age

Age Comps for Index 3 (MRIP CPUE)

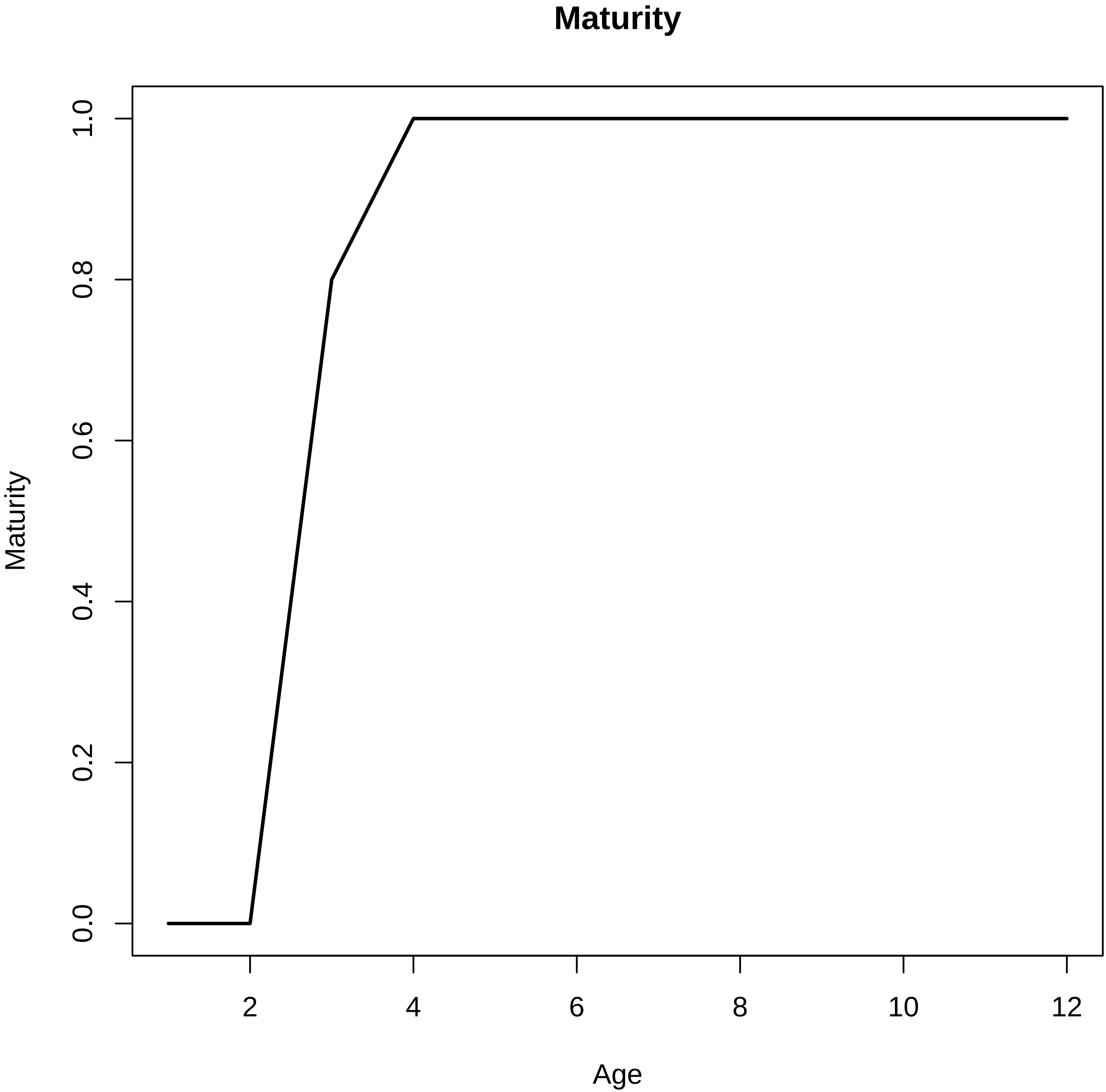



WAA matrix 1
WAA.catch.fleet1
WAA.discard.fleet1
WAA.catch.all
WAA.discard.all
Weight
0
1
2
3
4
5
1990
2000
2010
2020
Year


WAA matrix 2
WAA.ssb
WAA.jan1
Weight
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1990
2000
2010
2020
Year



M
0.15
0.10
0.05
0.00
Natural Mortality Rate
2
4
6
8
10
12
Age


Maturity
1.0
0.8
0.6
0.4
0.2
0.0
Maturity
2
4
6
8
10
12
Age

LIS Appendix 2: Retrospective Adjustment and Sensitivity Runs

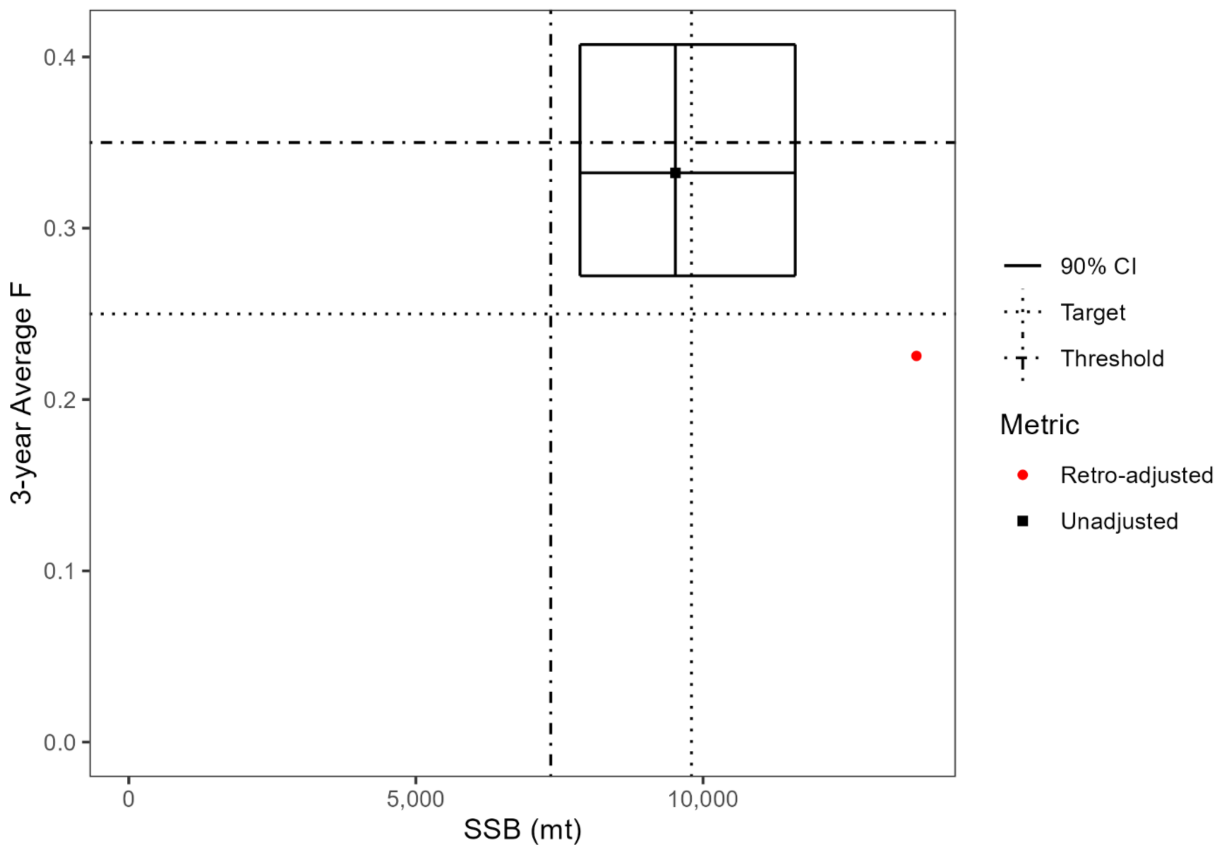
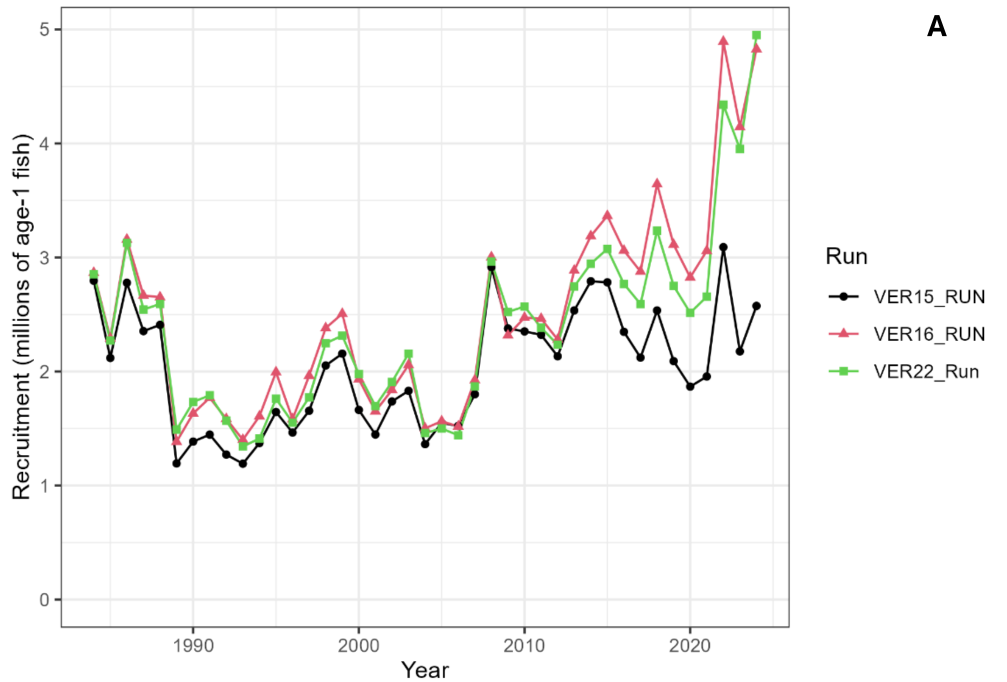


Figure A2.1. Comparison of retrospective adjusted status in 2024 with the base model status. Solid black lines indicate the 90% confidence intervals of the estimates of SSB and F in the terminal year.



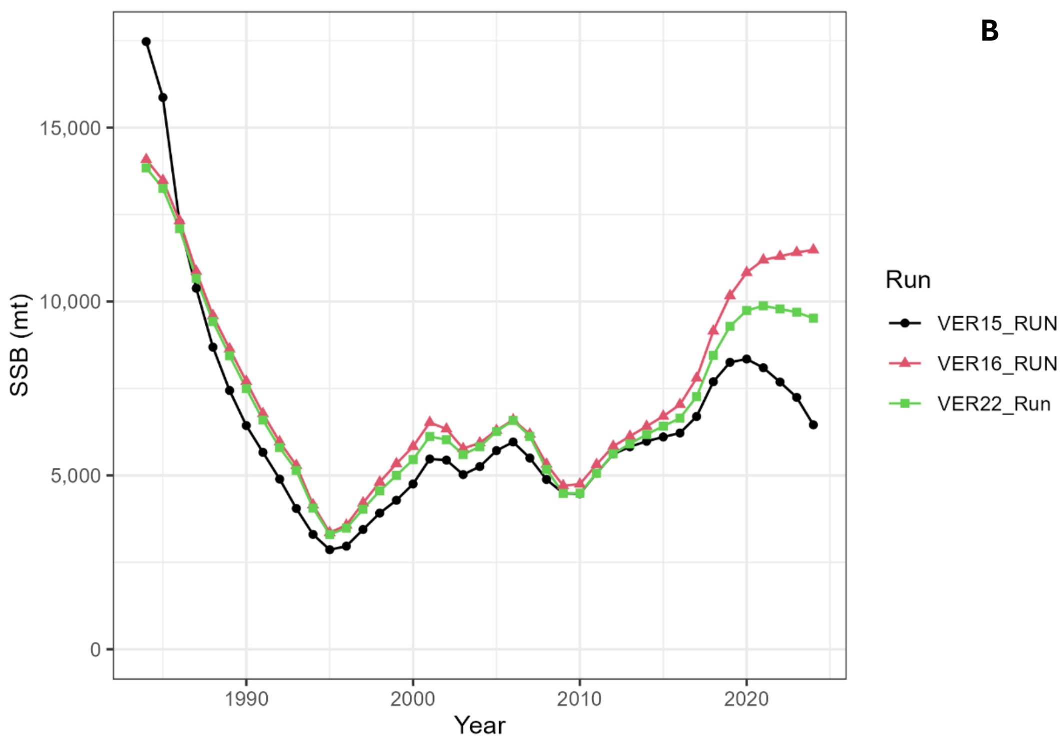


Figure A2.2. Results from the sensitivity runs for Recruitment (A) and SSB (B). VER15 excluded the NY Seine Survey, VER16 excluded the NY Trawl Survey from the model and VER22 is the final model presented in this report.

NJ-NYB Appendix 1: ASAP Input and Diagnostic Plots for the Base Run

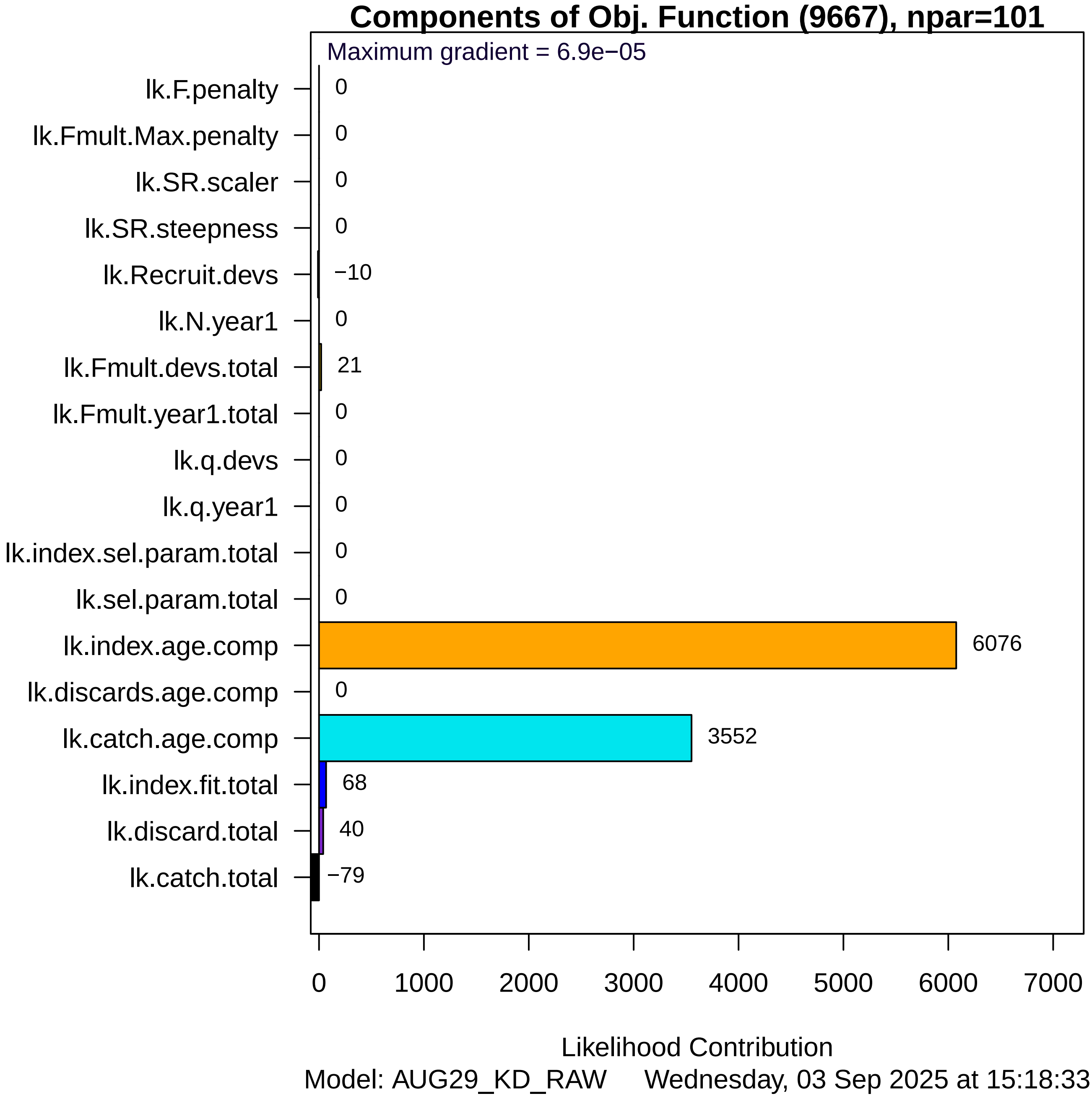
File = AUG29_KD_RAW.dat

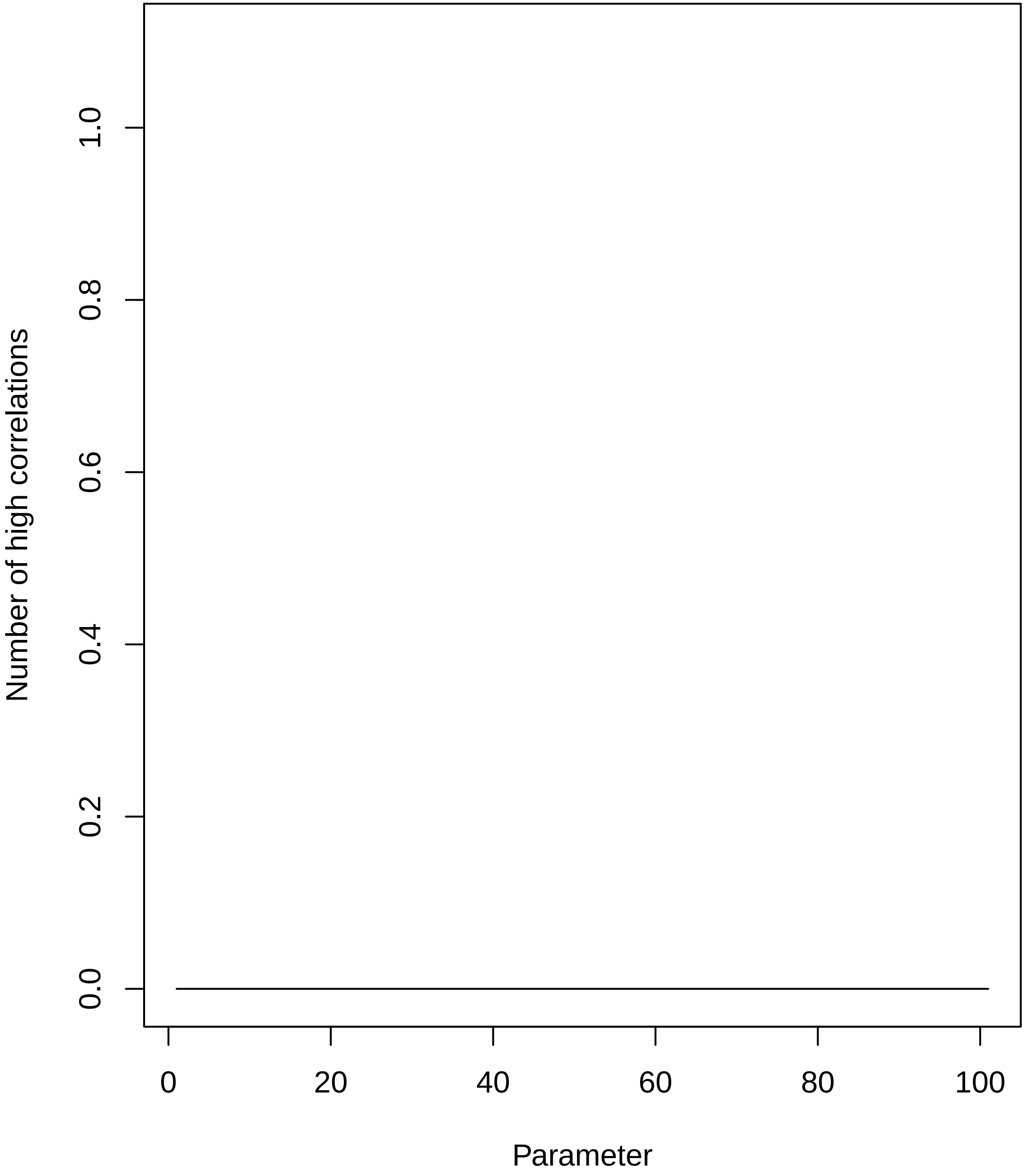
ASAP3 run on Wednesday, 03 Sep 2025 at 15:18:33

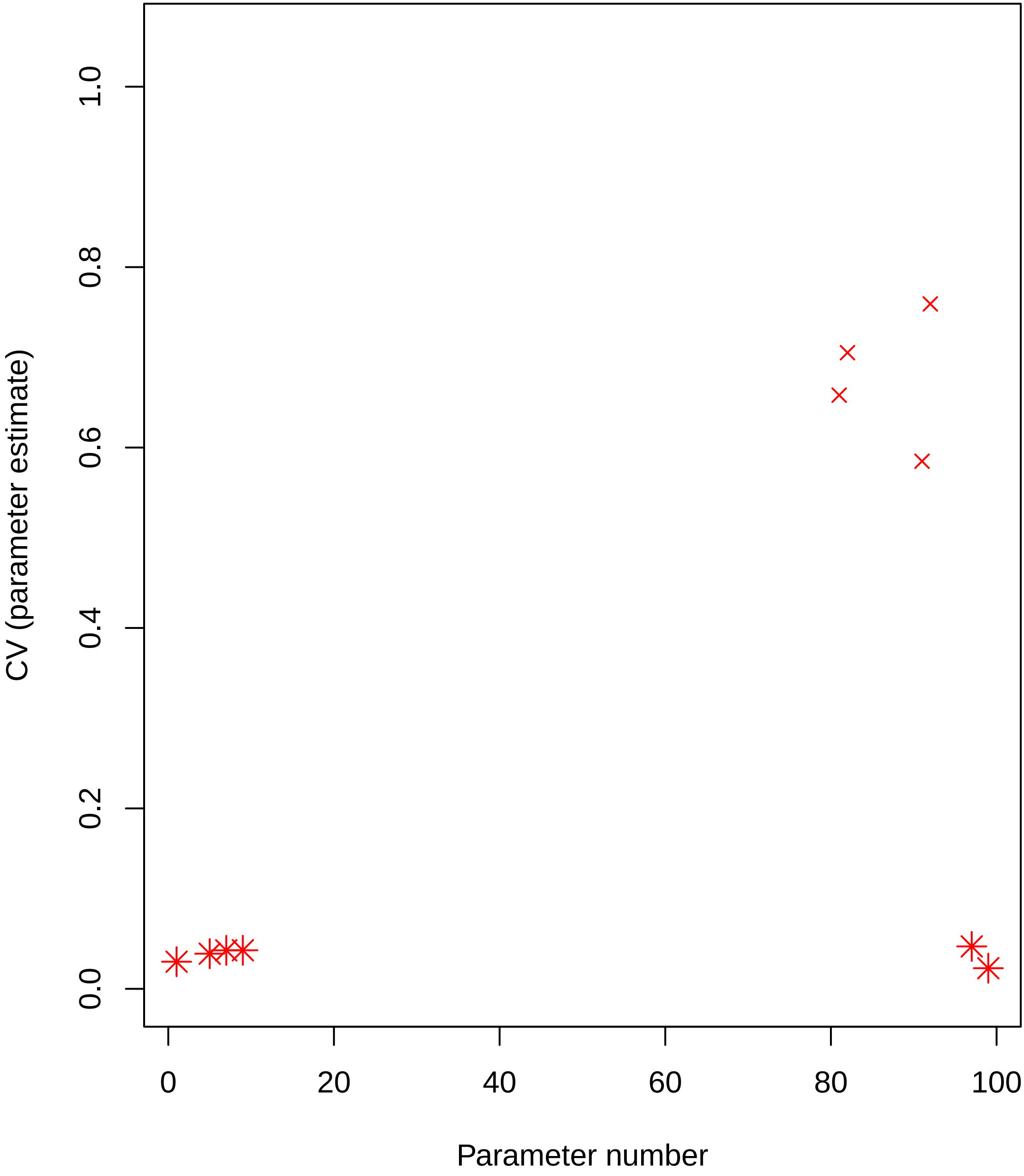
dir = base

ASAPplots version = 0.2.18

npar = 101, maximum gradient = 6.86743e−005

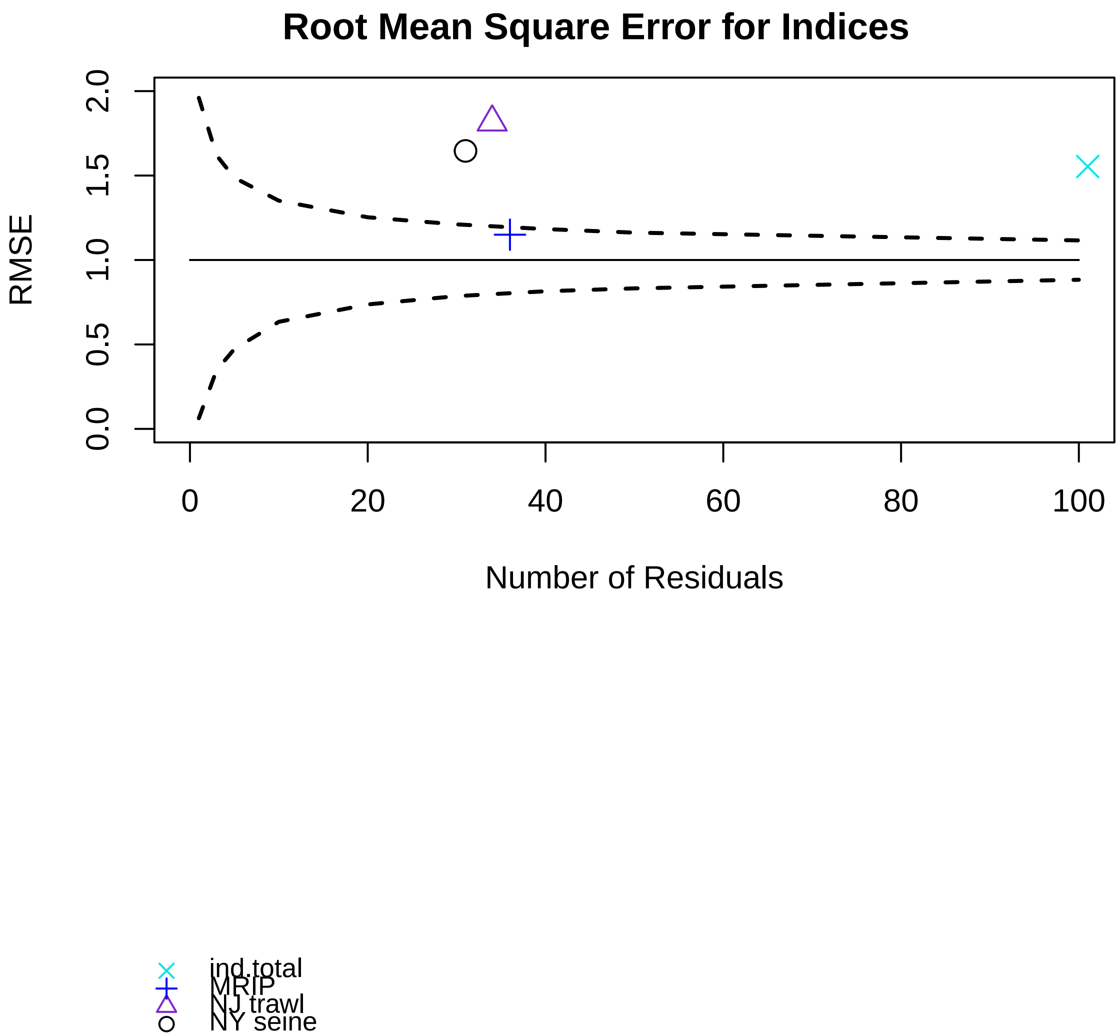

Components of Obj. Function (9667), npar=101
Maximum gradient = 6.9e−05
lk.F.penalty
lk.Fmult.Max.penalty
lk.SR.scaler
lk.SR.steepness
lk.Recruit.devs
lk.N.year1
lk.Fmult.devs.total
lk.Fmult.year1.total
lk.q.devs
lk.q.year1
lk.index.sel.param.total
lk.sel.param.total
lk.index.age.comp
lk.discards.age.comp
lk.catch.age.comp
lk.index.fit.total
lk.discard.total
lk.catch.total
0
0
0
0
−10
0
21
0
0
0
0
0
6076
0
3552
68
40
−79
0
1000
2000
3000
4000
5000
6000
7000
Likelihood Contribution
Model: AUG29_KD_RAW Wednesday, 03 Sep 2025 at 15:18:33

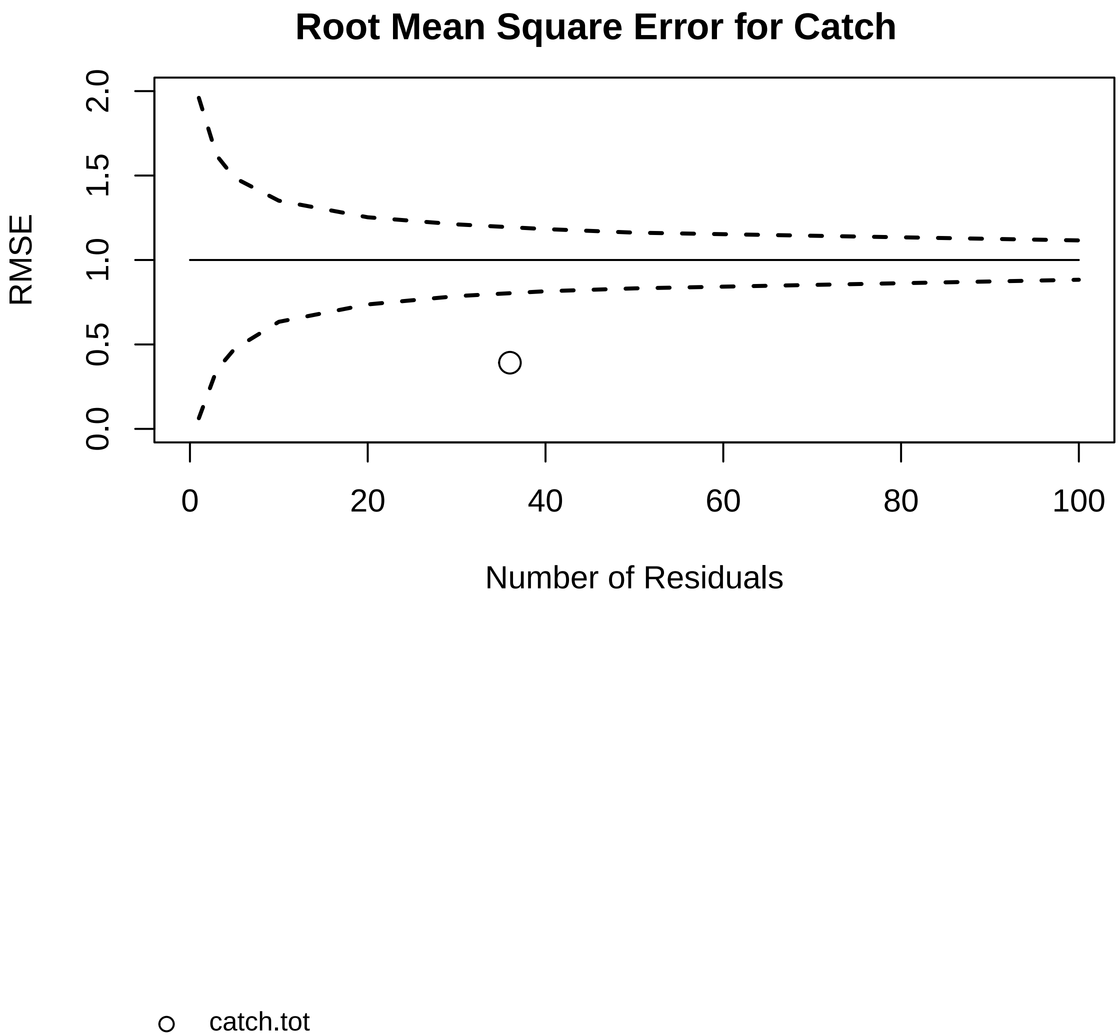

Number of high correlations
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Parameter

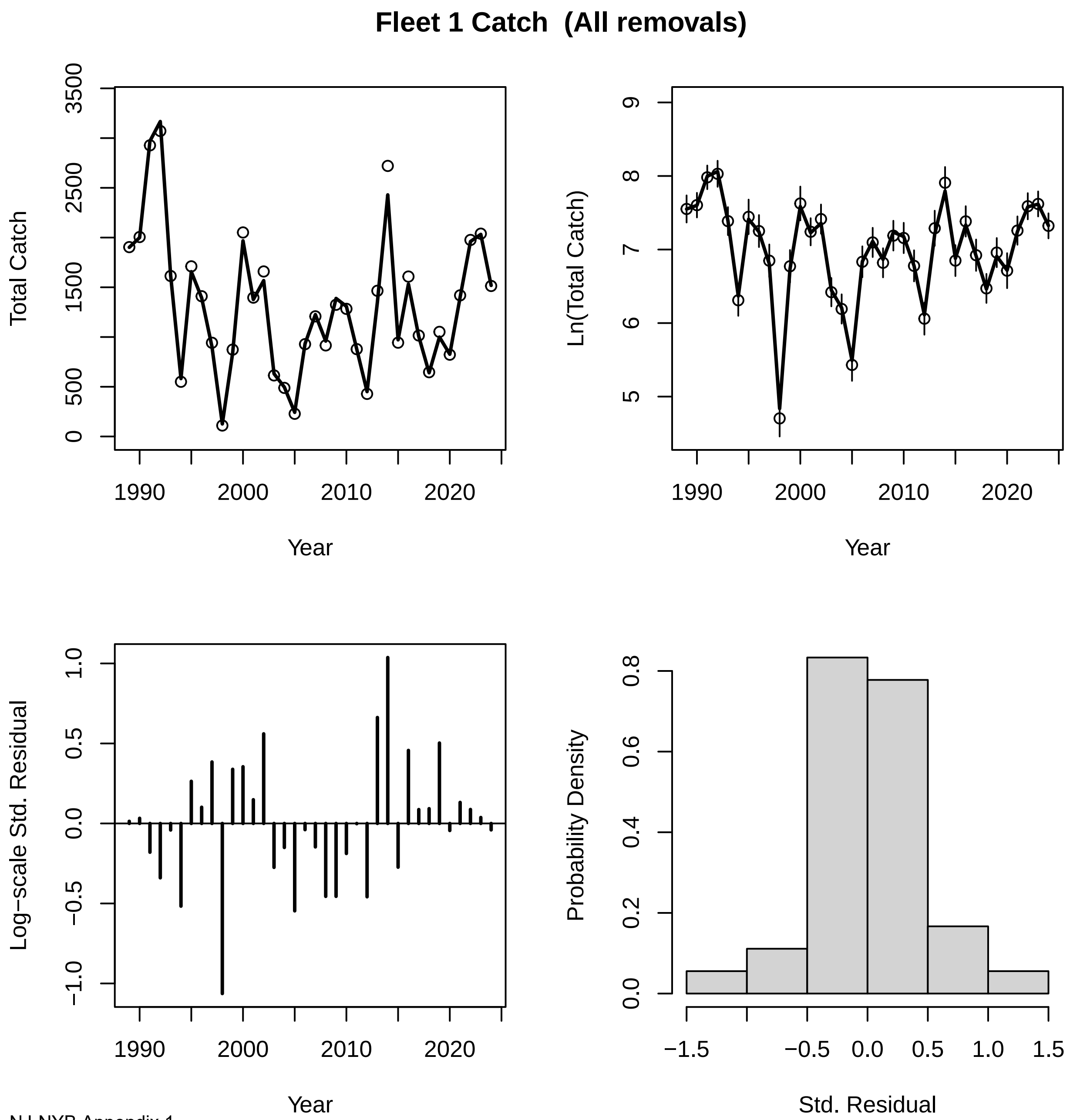

CV (parameter estimate)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Parameter number

Root Mean Square Error computed from Standardized Residuals

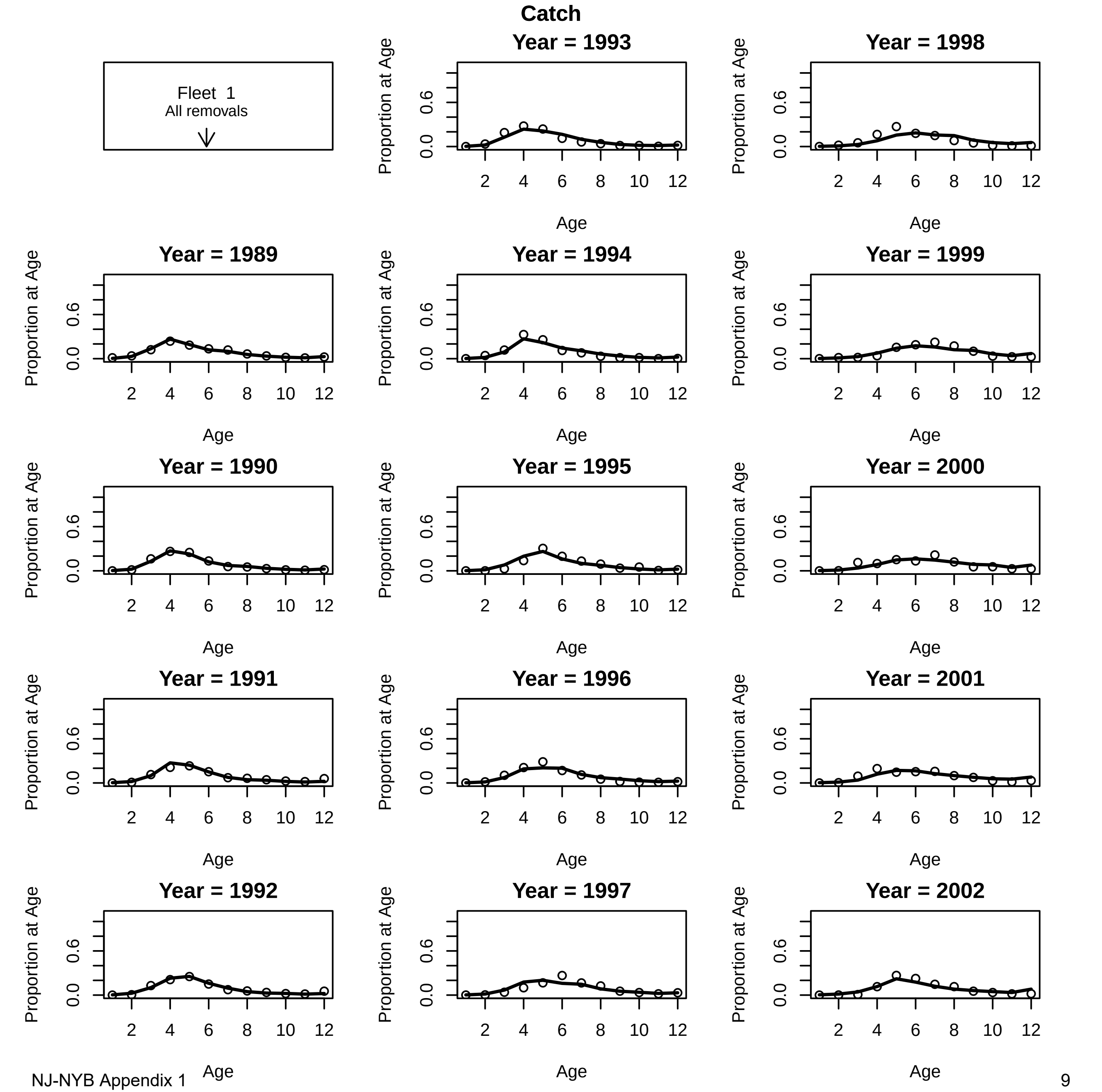
Component	# resids	RMSE
catch.tot	36	0.392
discard.tot	0	0
ind01	31	1.65
ind02	34	1.82
ind03	36	1.15
ind.total	101	1.55
N.year1	0	0
Fmult.year1	0	0
Fmult.devs.total	35	1.53
recruit.devs	36	0.62
fleet.sel.params	0	0
index.sel.params	0	0
q.year1	0	0
q.devs	0	0
SR.steepness	0	0
SR.scaler	0	0

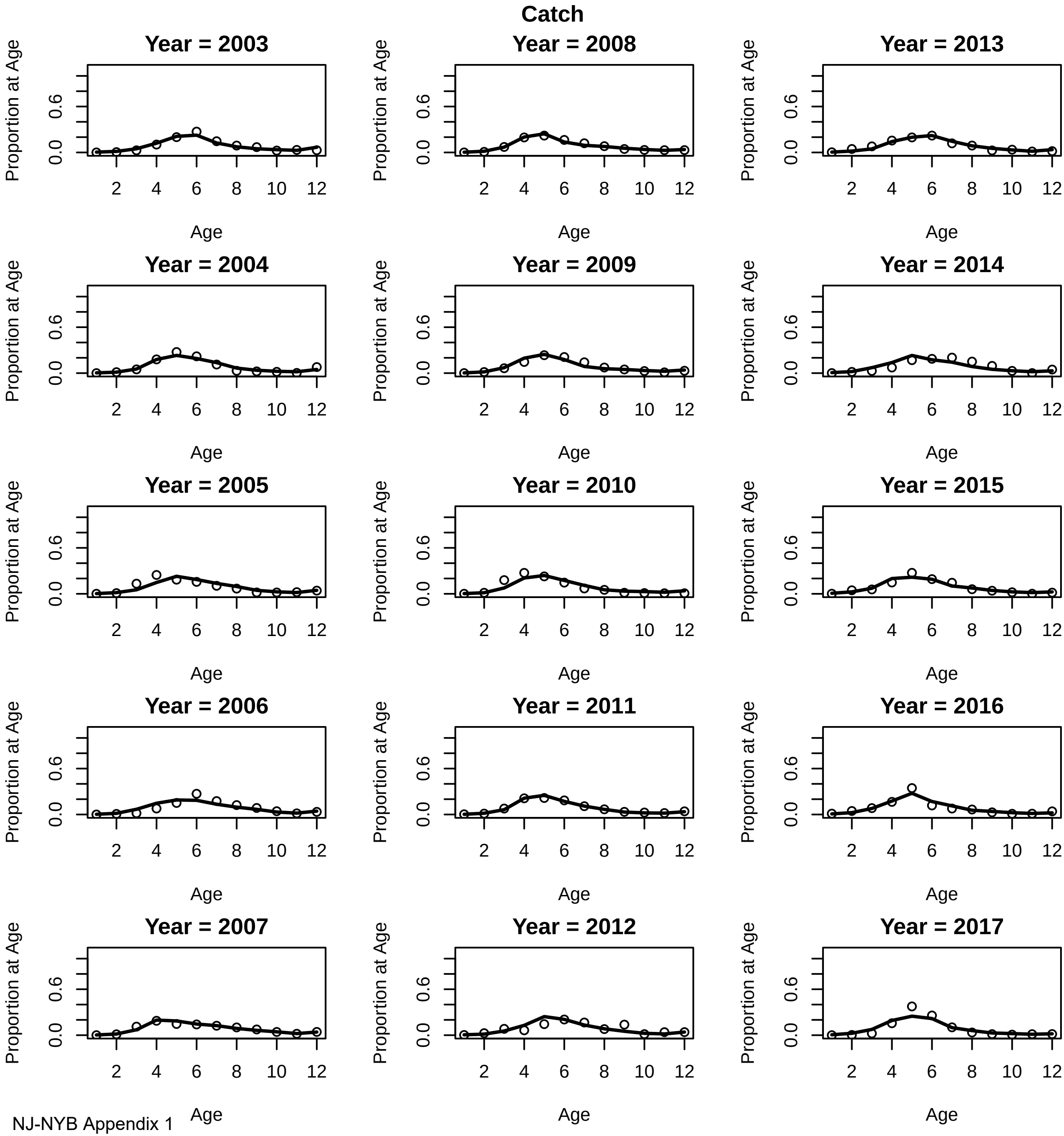

Root Mean Square Error for Indices
RMSE
0.0
0.5
1.0
1.5
2.0
0
20
40
60
80
100
Number of Residuals
ind.total
MRIP
NJ trawl
NY seine

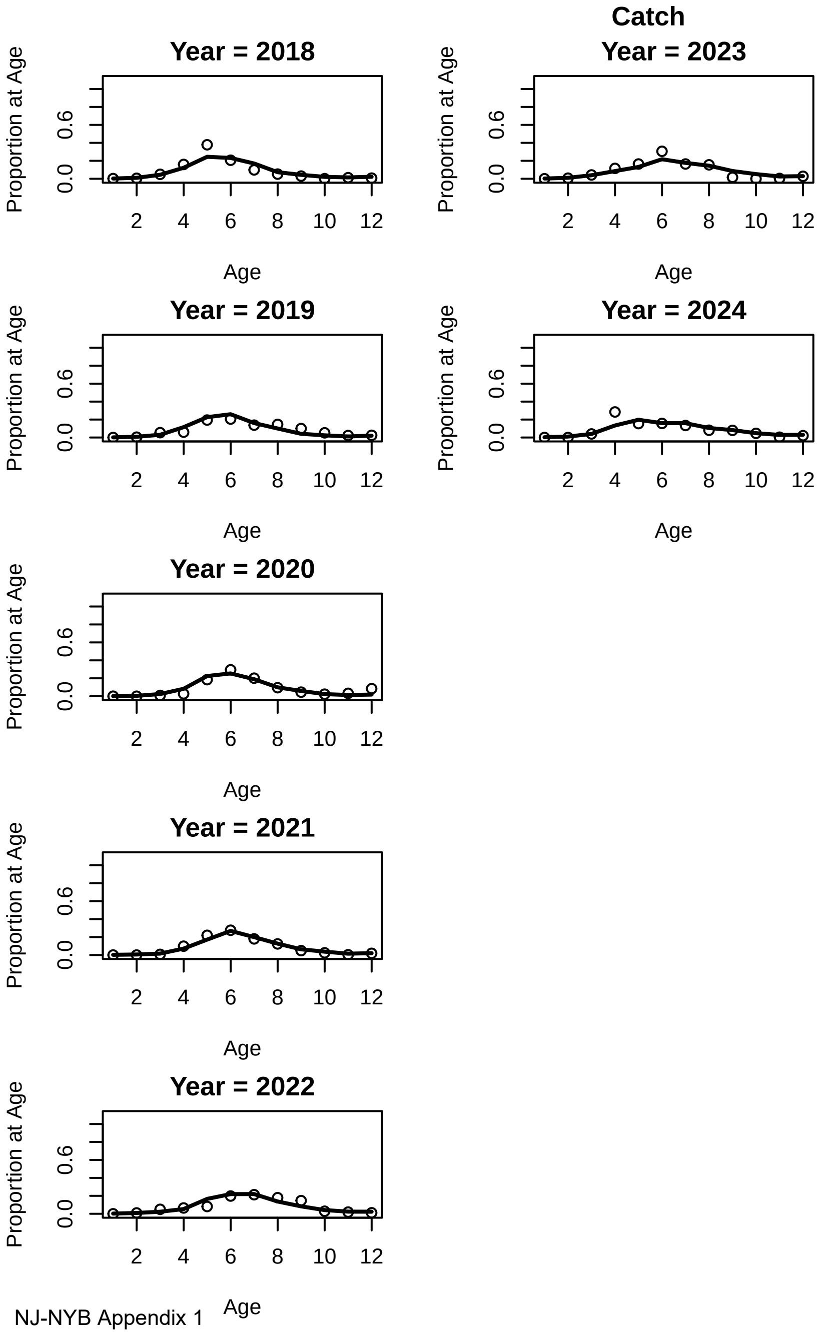

Root Mean Square Error for Catch
RMSE
0.0
0.5
1.0
1.5
2.0
0
20
40
60
80
100
Number of Residuals
catch.tot

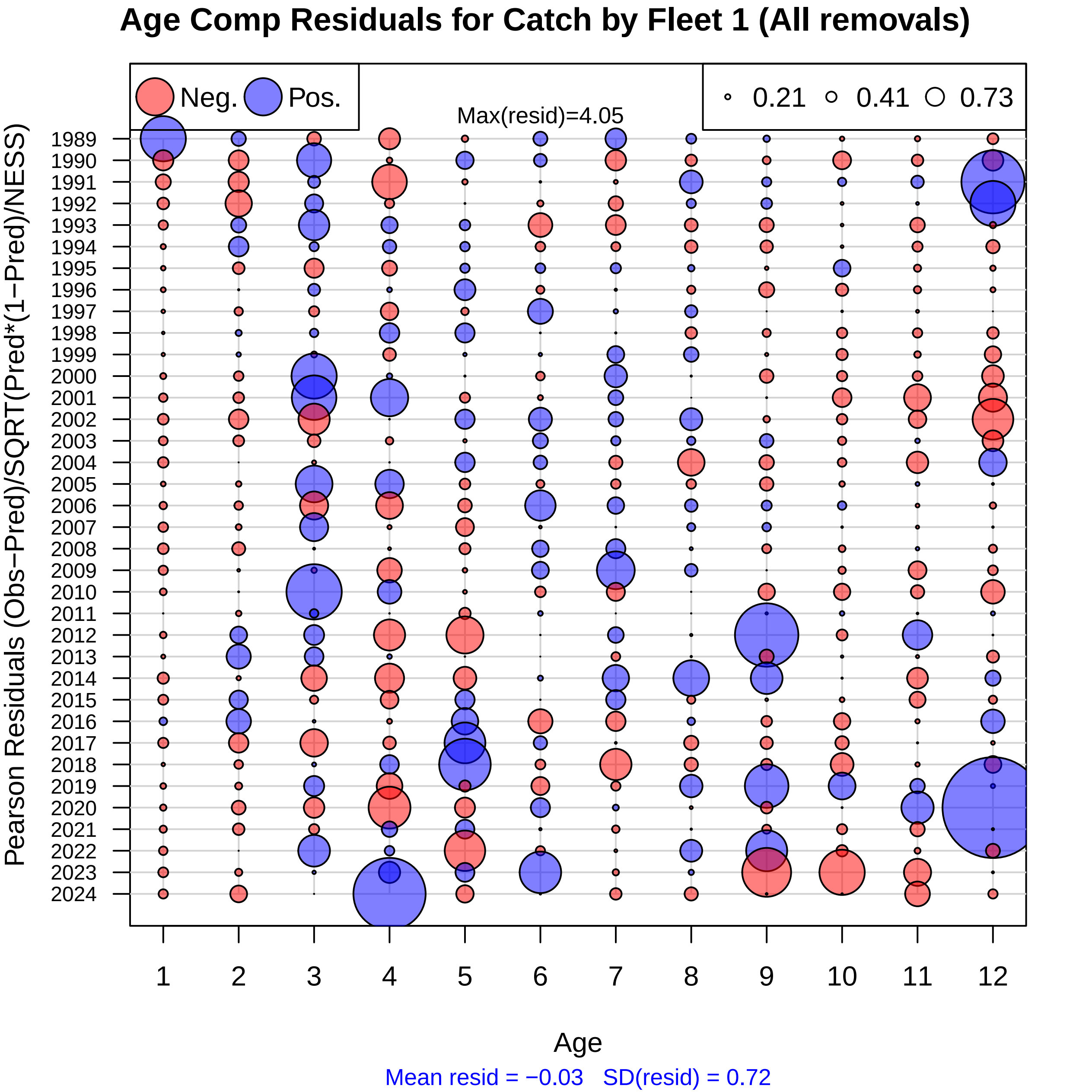


Fleet 1 Catch (All removals)
Total Catch
0
500
1500
2500
3500
1990
2000
2010
2020
Year
Ln(Total Catch)
5
6
7
8
9
1990
2000
2010
2020
Year
Log−scale Std. Residual
−1.0
−0.5
0.0
0.5
1.0
1990
2000
2010
2020
Year
Probability Density
0.0
0.2
0.4
0.6
0.8
−1.5
−0.5
0.0
0.5
1.0
1.5
Std. Residual

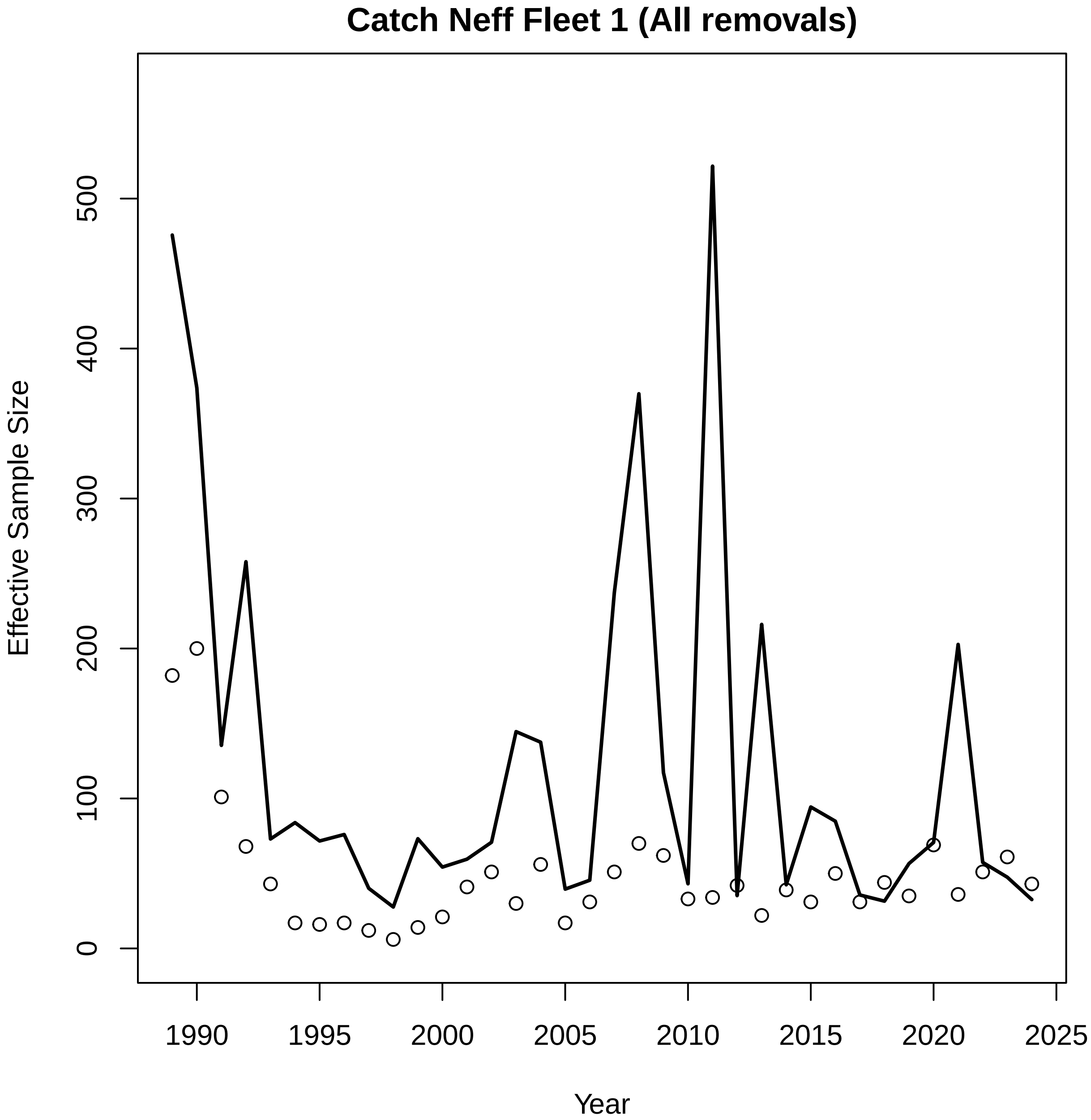

Catch
Fleet 1
All removals
Year = 1989
Year = 1990
Year = 1991
Year = 1992
Year = 1993
Year = 1994
Year = 1995
Year = 1996
Year = 1997
Year = 1998
Year = 1999
Year = 2000
Year = 2001
Year = 2002
Proportion at Age
Age

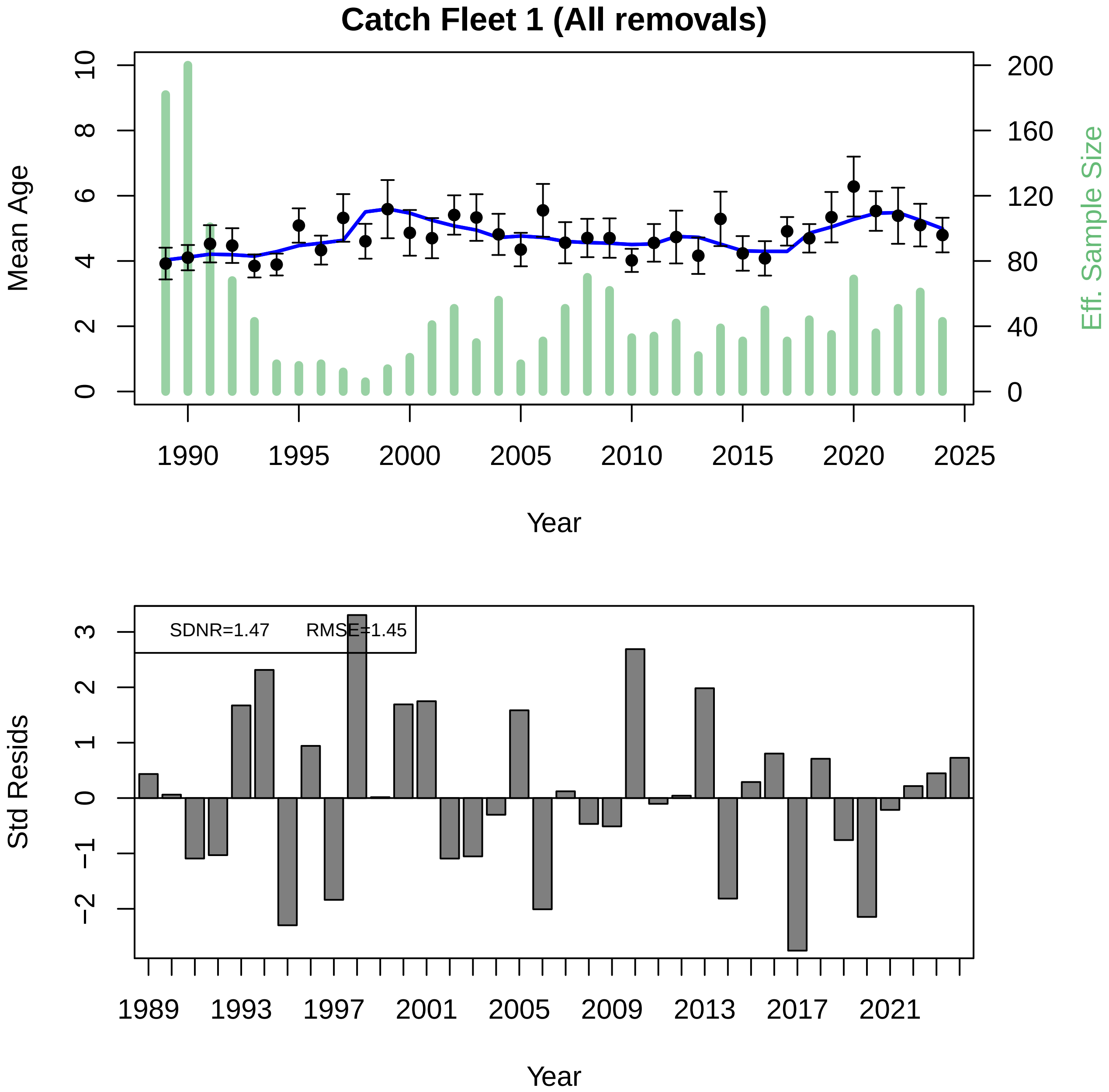

Catch
Year = 2003
Year = 2008
Year = 2013
Year = 2004
Year = 2009
Year = 2014
Year = 2005
Year = 2010
Year = 2015
Year = 2006
Year = 2011
Year = 2016
Year = 2007
Year = 2012
Year = 2017
Proportion at Age
0.0
0.6
2
4
6
8
10
12
Age


Catch
Year = 2018
Year = 2019
Year = 2020
Year = 2021
Year = 2022
Year = 2023
Year = 2024
Proportion at Age
0.0
0.6
2
4
6
8
10
12
Age

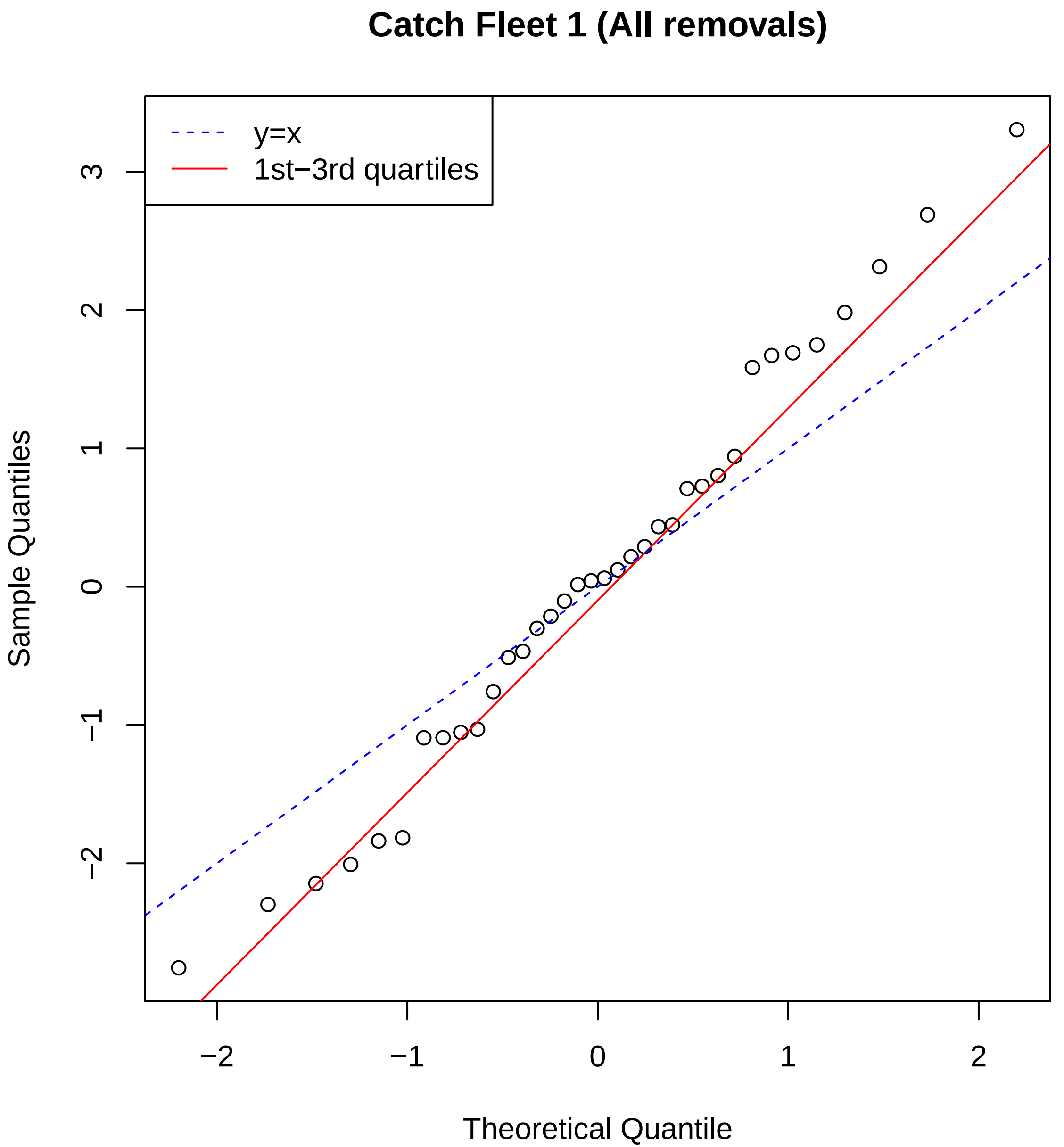


Age Comp Residuals for Catch by Fleet 1 (All removals)
Neg.
Pos.
0.21
0.41
0.73
Max(resid)=4.05
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = −0.03   SD(resid) = 0.72

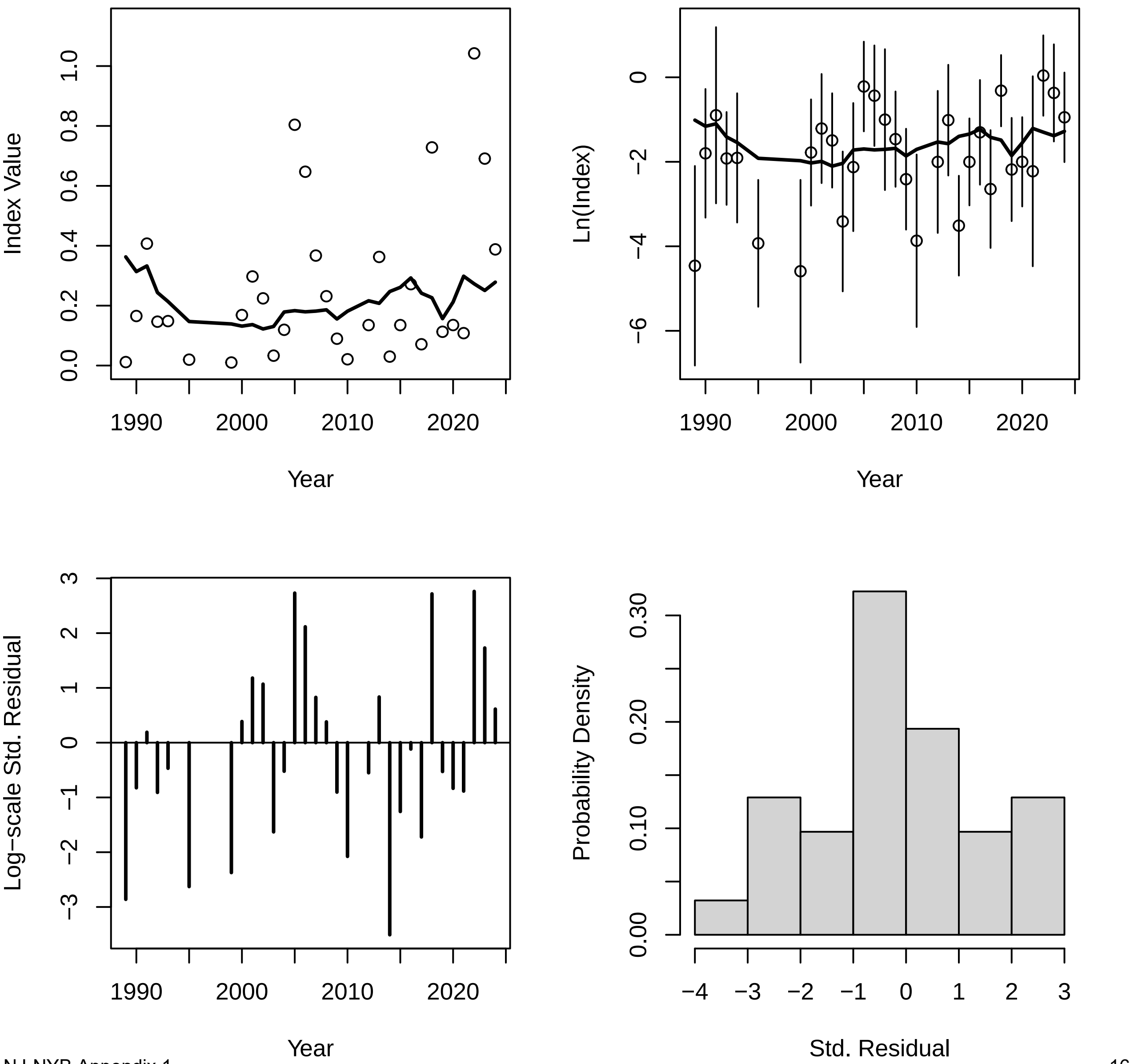

Catch Neff Fleet 1 (All removals)
Effective Sample Size
0
100
200
300
400
500
1990
1995
2000
2005
2010
2015
2020
2025
Year



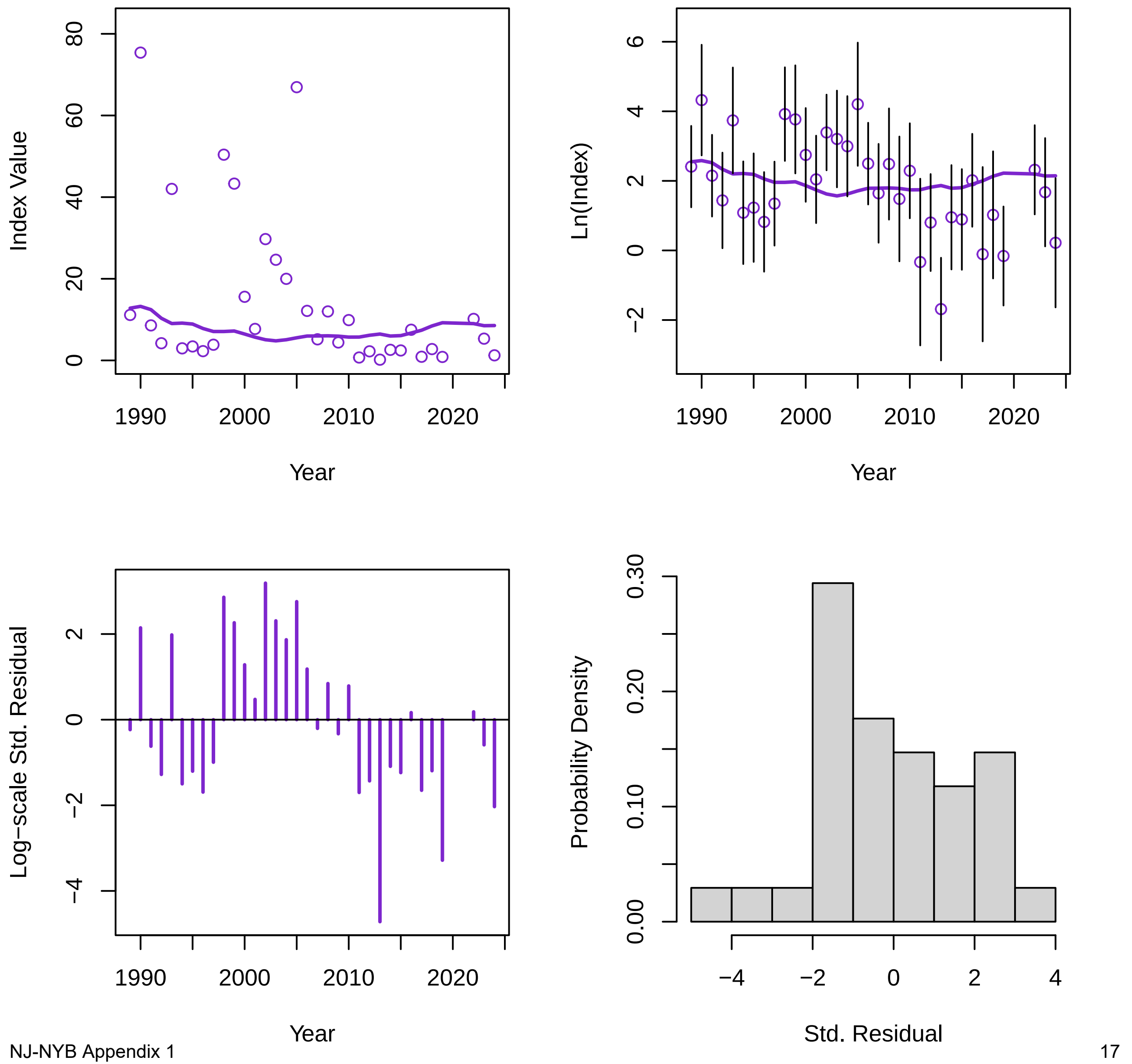
Catch Fleet 1 (All removals)
Mean Age
Eff. Sample Size
Year
Std Resids
SDNR=1.47
RMSE=1.45
Year


Catch Fleet 1 (All removals)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
−2
−1
0
1
2
3

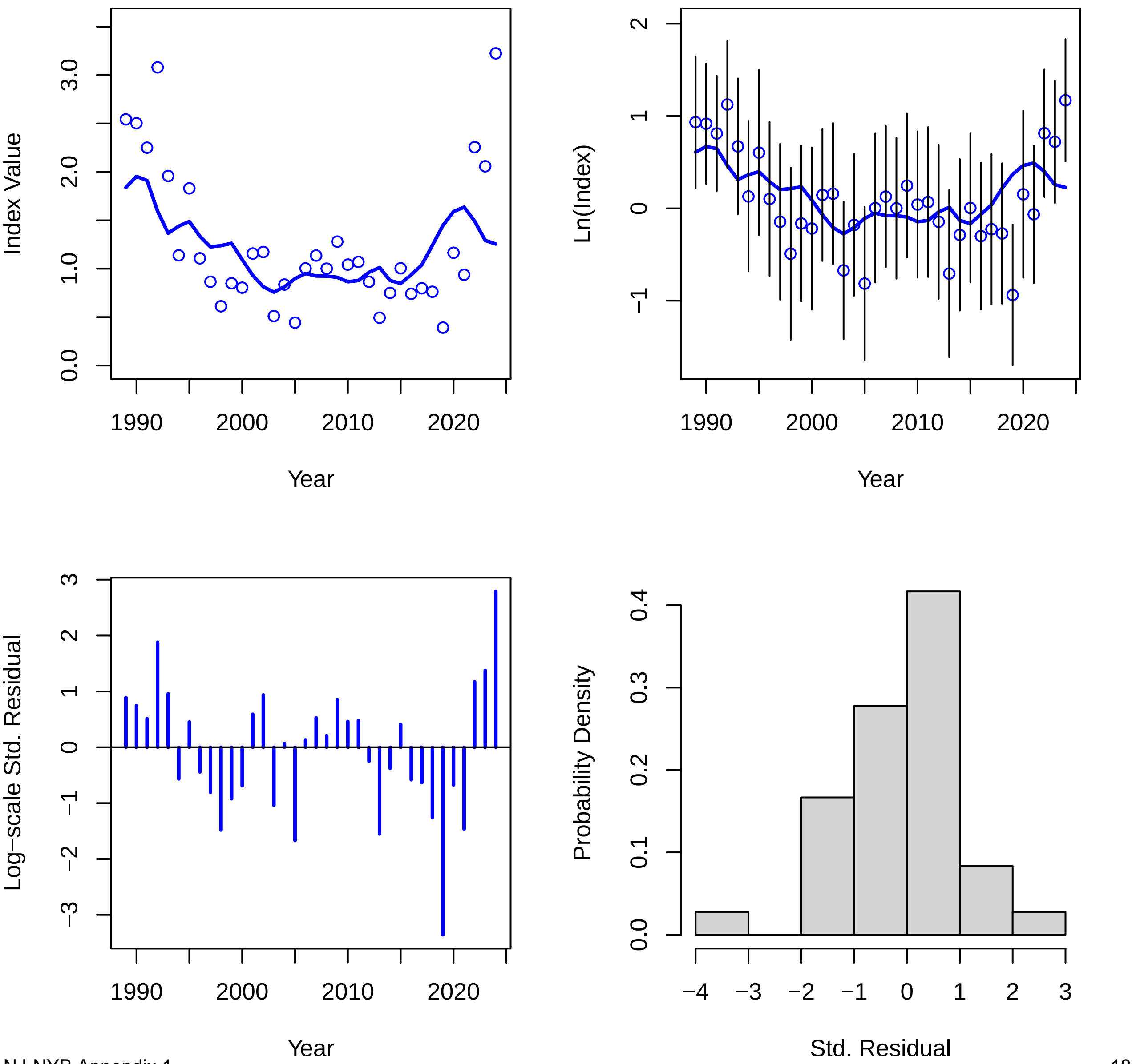
Index 1 (NY seine)

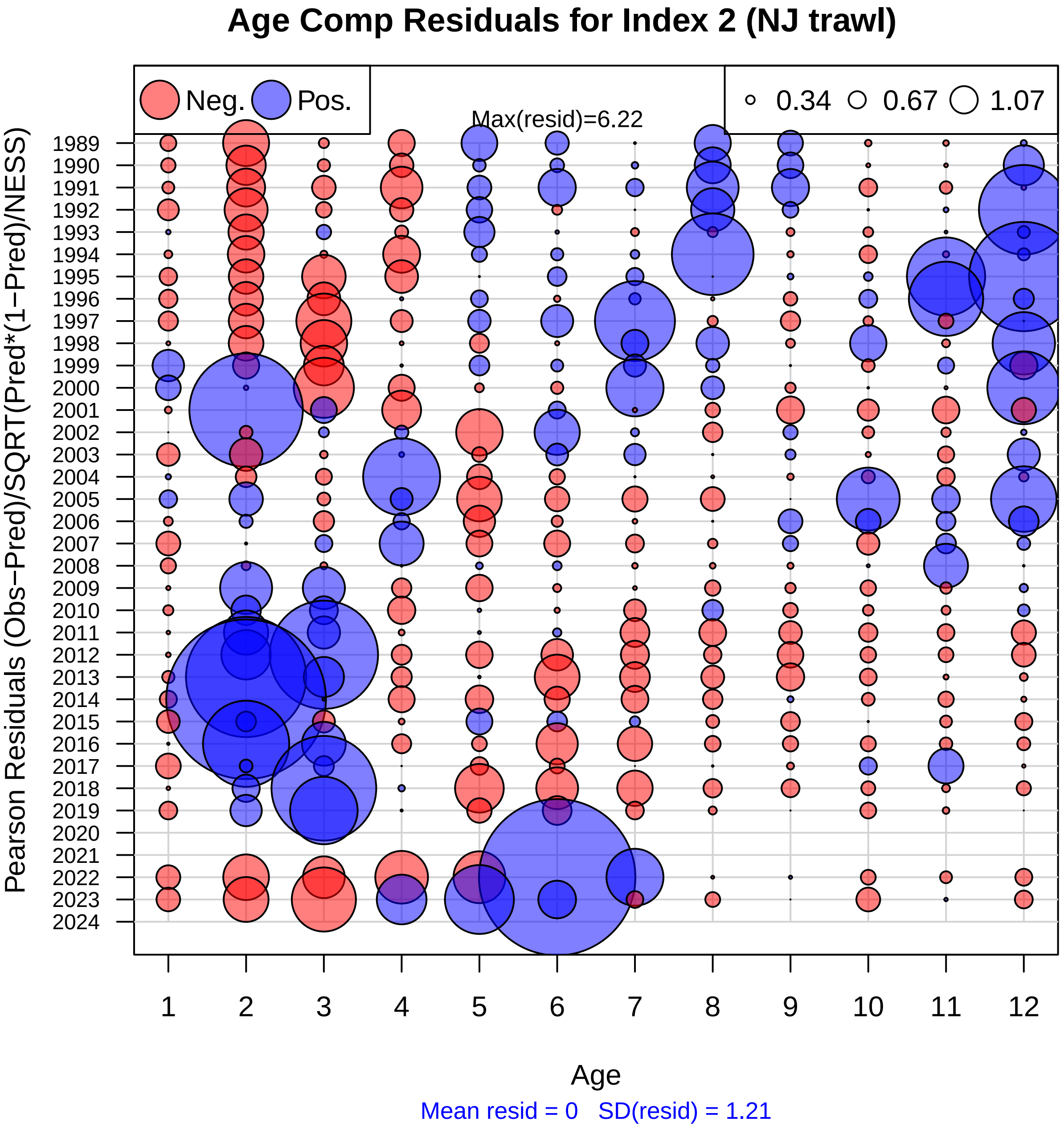


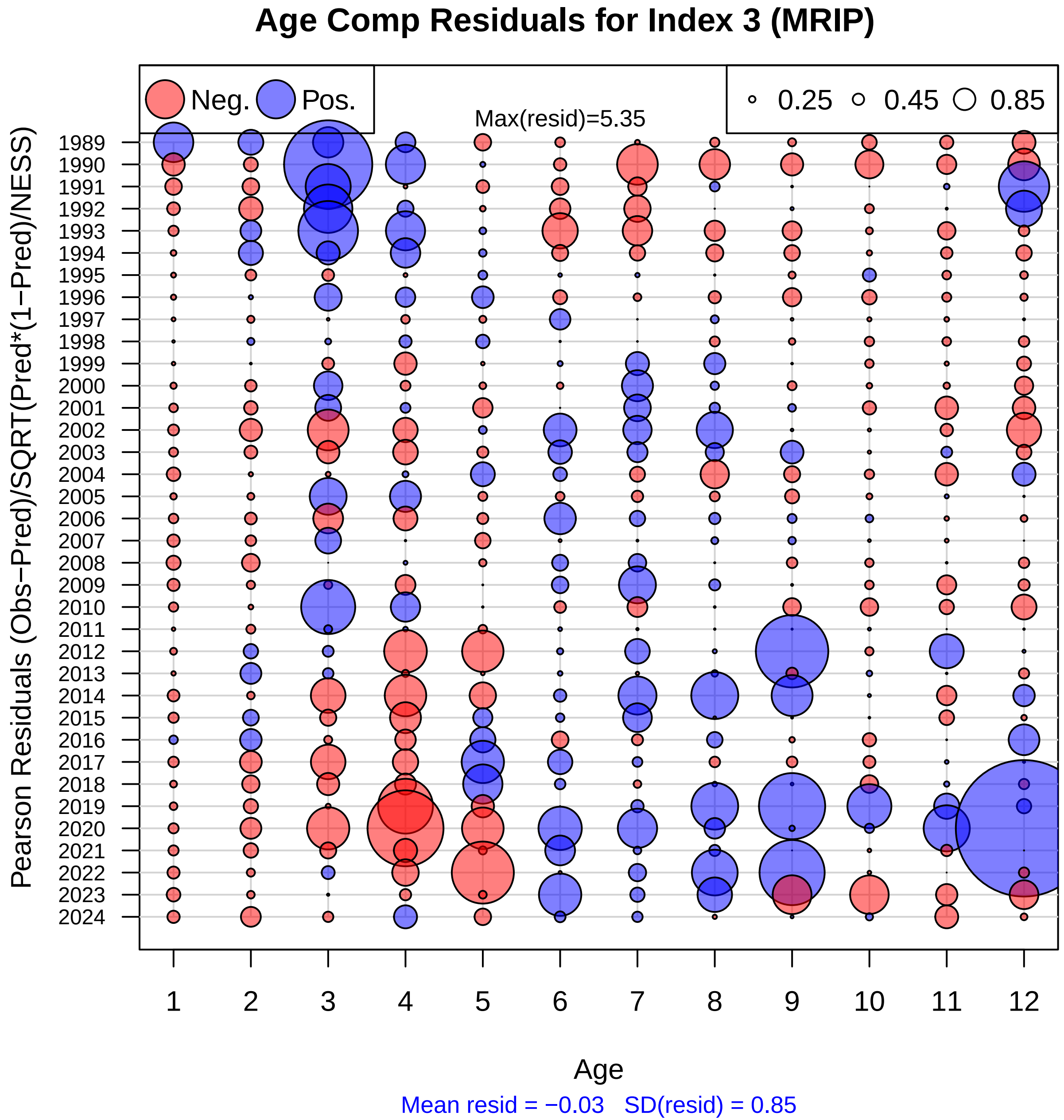
Index 2 (NJ trawl)

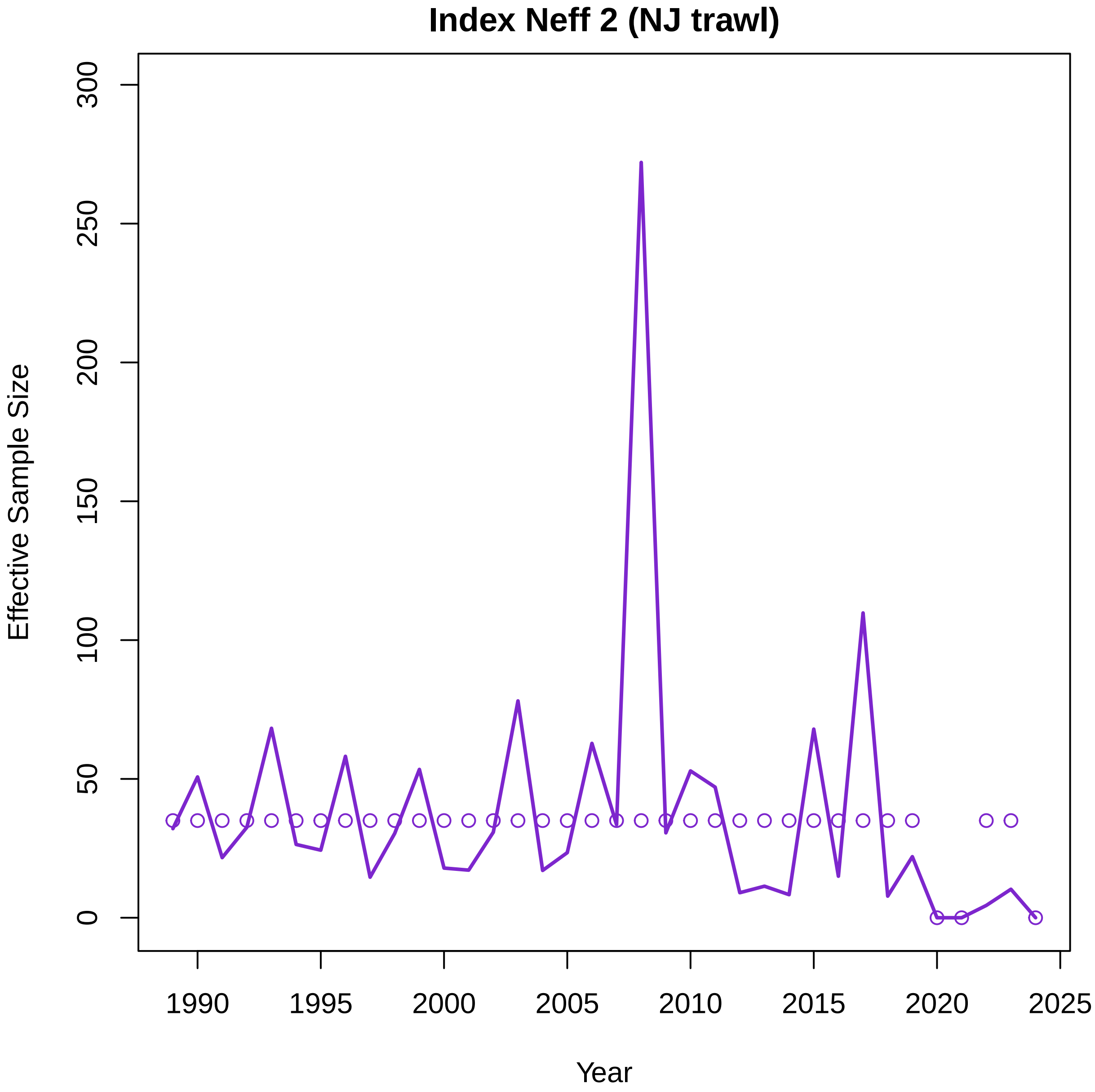


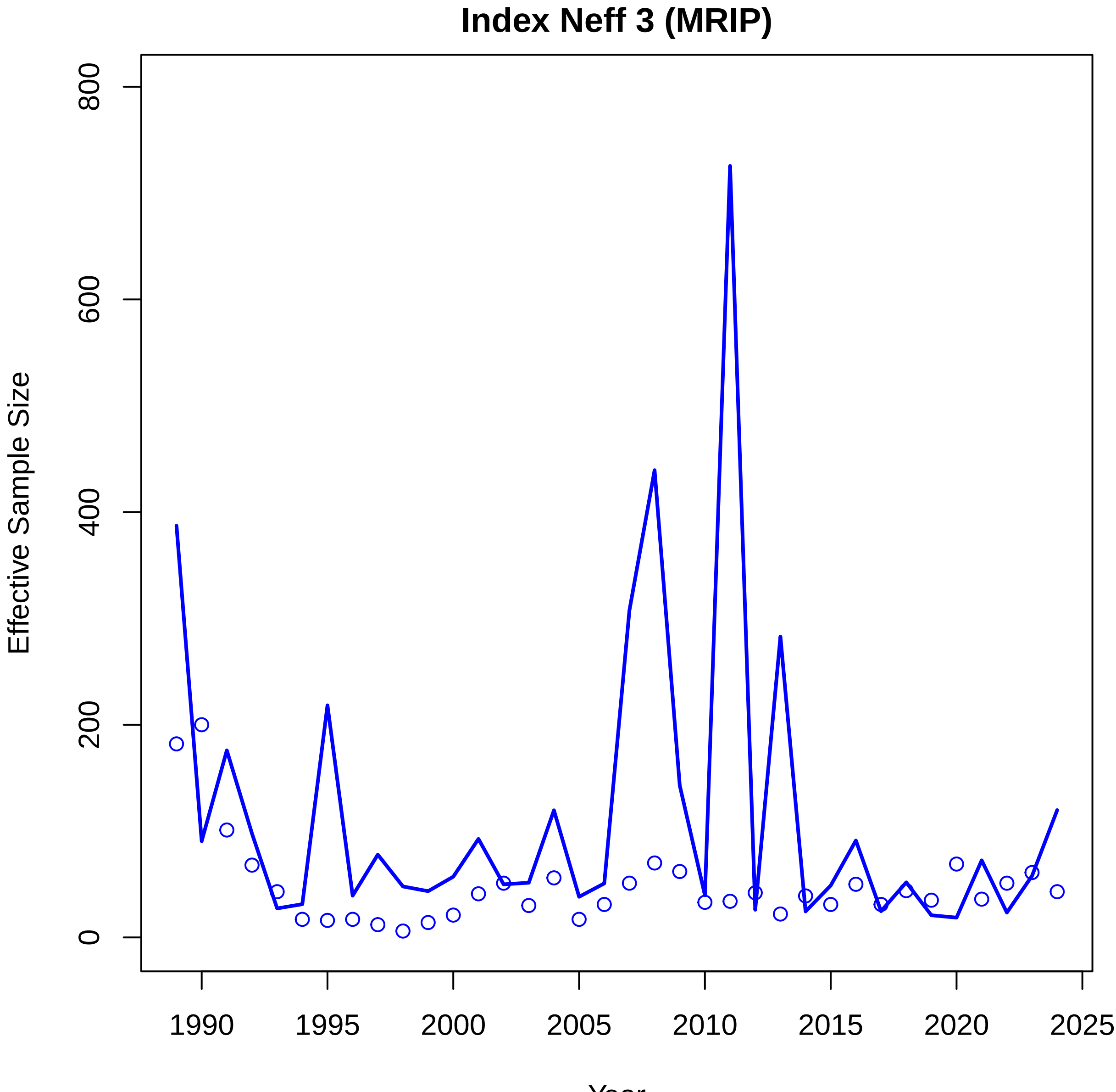
Index 3 (MRIP)

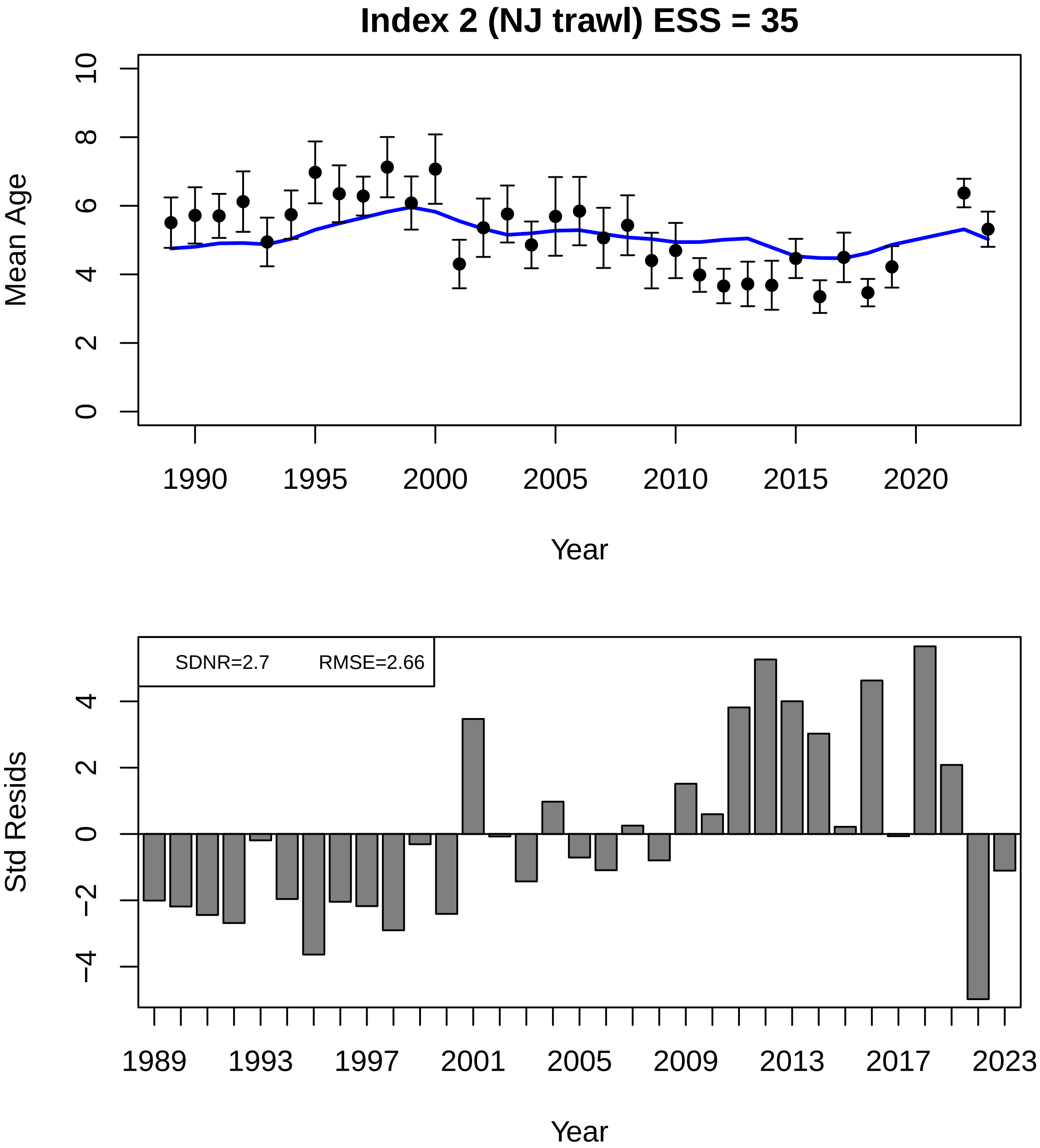

Index Value
Ln(Index)
Log−scale Std. Residual
Probability Density
Year
Std. Residual

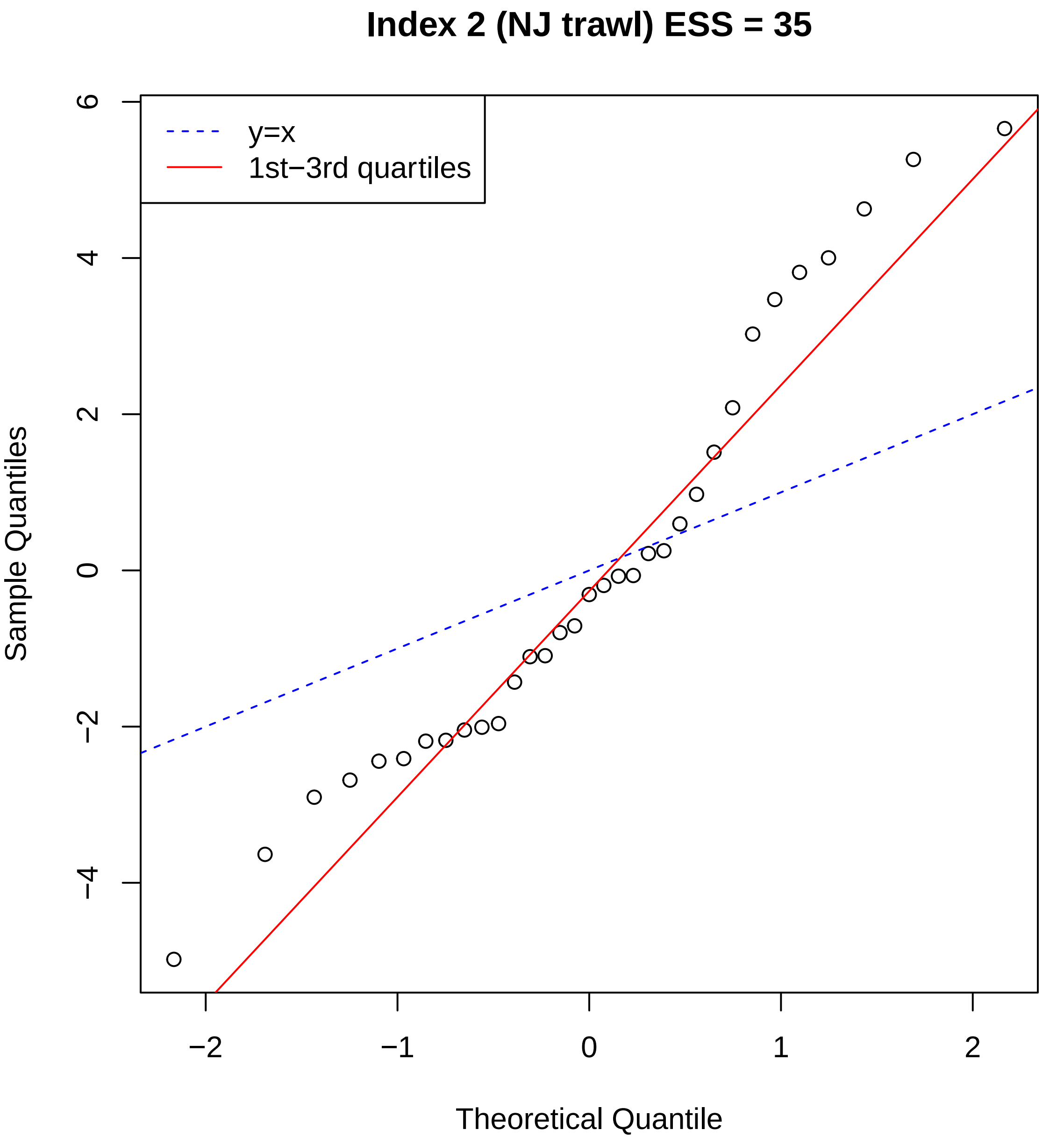

Age Comp Residuals for Index 2 (NJ trawl)
Neg.
Pos.
0.34
0.67
1.07
Max(resid)=6.22
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = 0   SD(resid) = 1.21

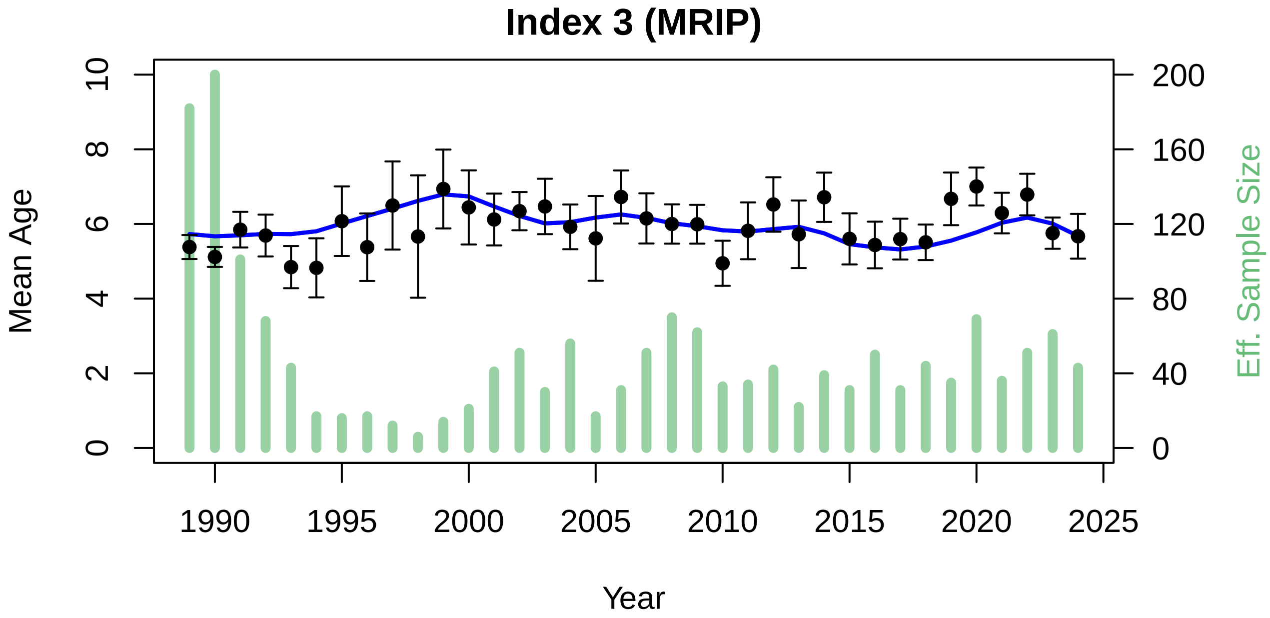

Age Comp Residuals for Index 3 (MRIP)
Neg.
Pos.
0.25
0.45
0.85
Max(resid)=5.35
Pearson Residuals (Obs−Pred)/SQRT(Pred*(1−Pred)/NESS)
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age
Mean resid = −0.03 SD(resid) = 0.85

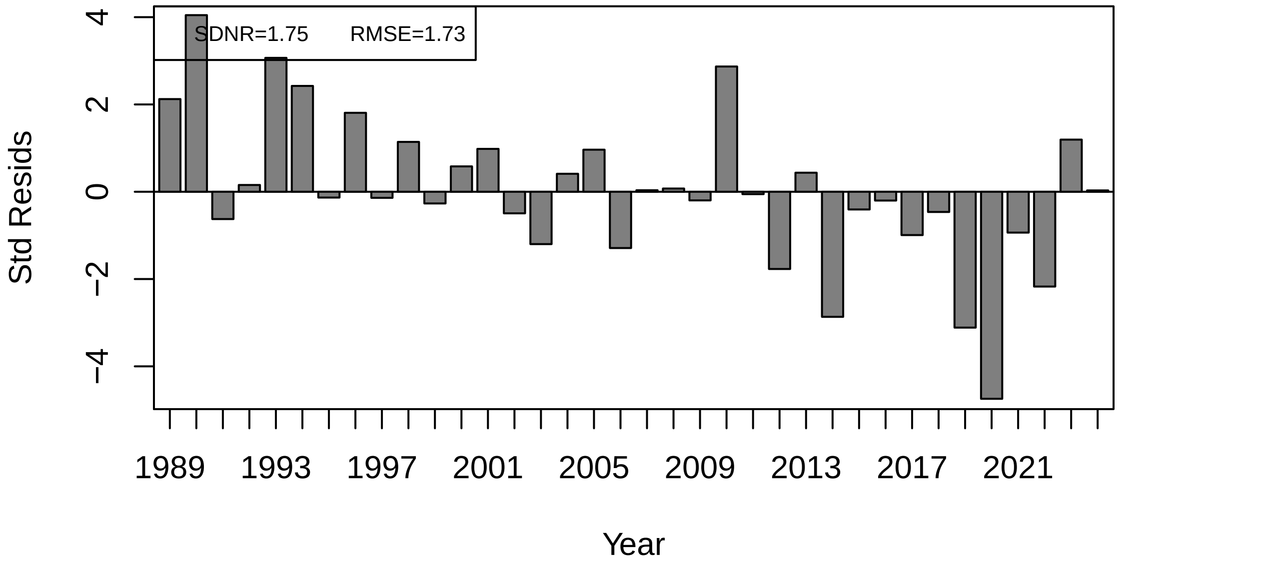

Index Neff 2 (NJ trawl)
Effective Sample Size
0
50
100
150
200
250
300
1990
1995
2000
2005
2010
2015
2020
2025
Year

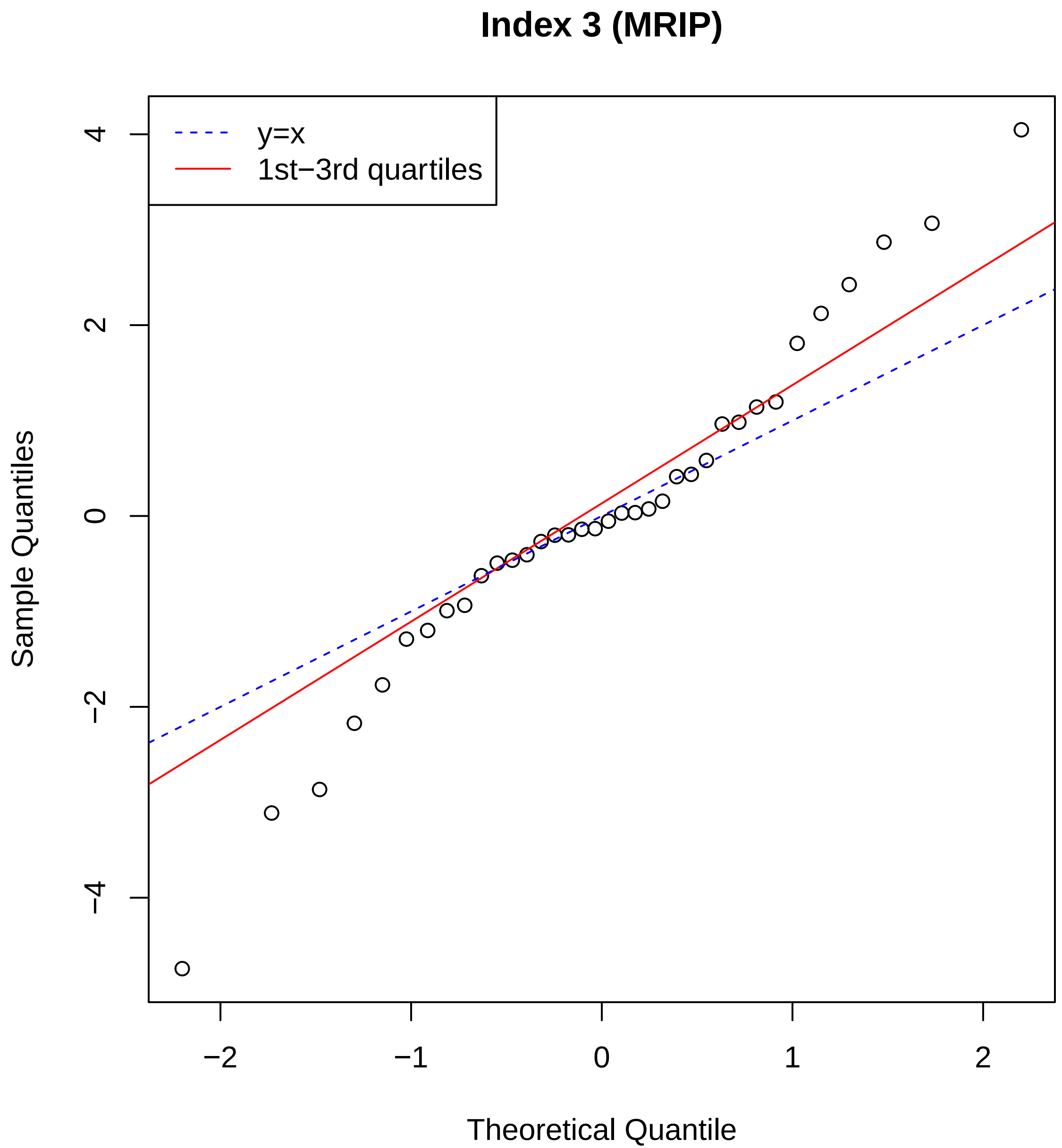

Index Neff 3 (MRIP)
Effective Sample Size
0
200
400
600
800
1990
1995
2000
2005
2010
2015
2020
2025
Year


Index 2 (NJ trawl) ESS = 35
Mean Age
0
2
4
6
8
10
1990
1995
2000
2005
2010
2015
2020
Year
SDNR=2.7
RMSE=2.66
Std Resids
−4
−2
0
2
4
1989
1993
1997
2001
2005
2009
2013
2017
2023
Year

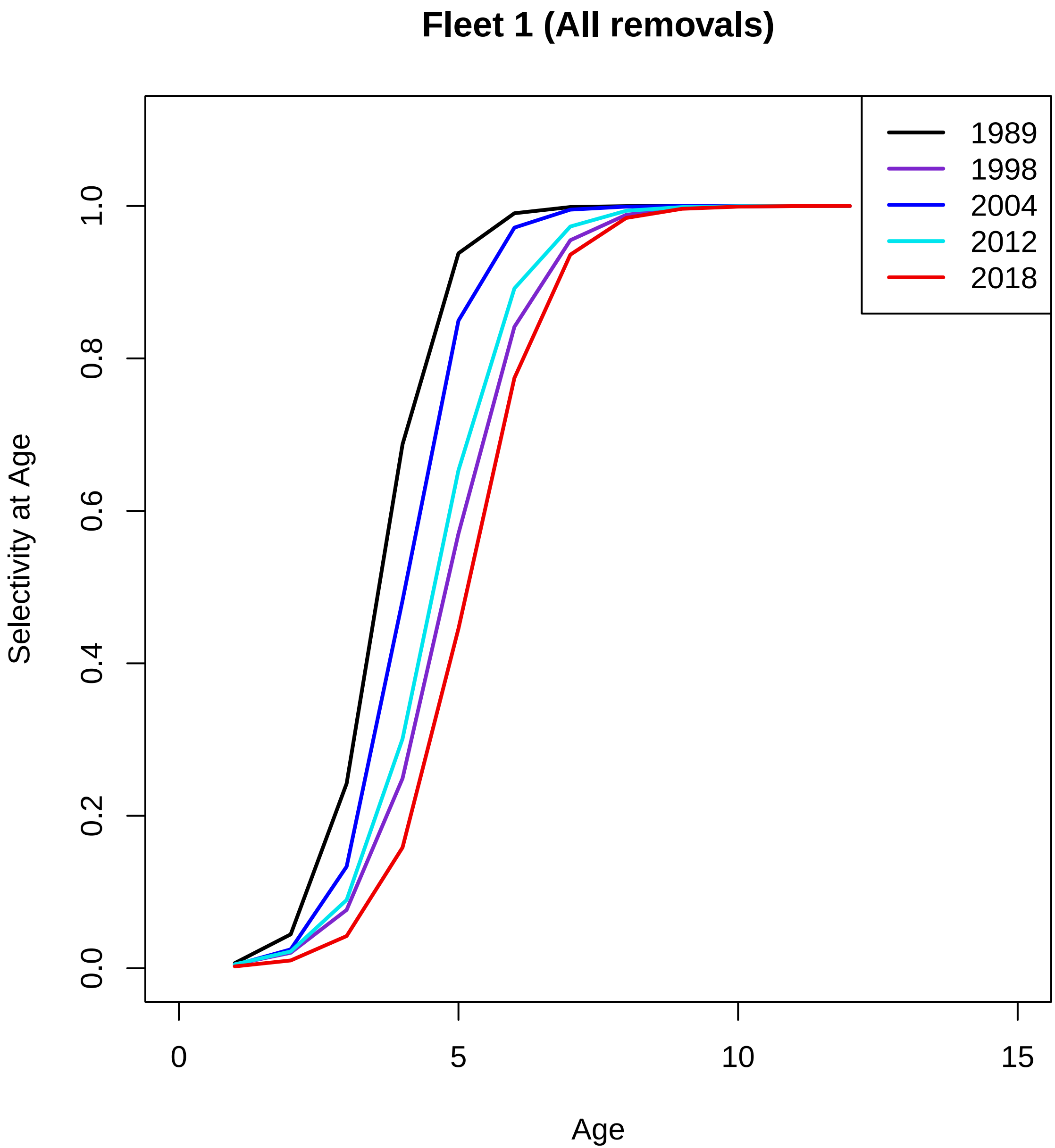

Index 2 (NJ trawl) ESS = 35
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
6
4
2
0
−2
−4
−2
−1
0
1
2

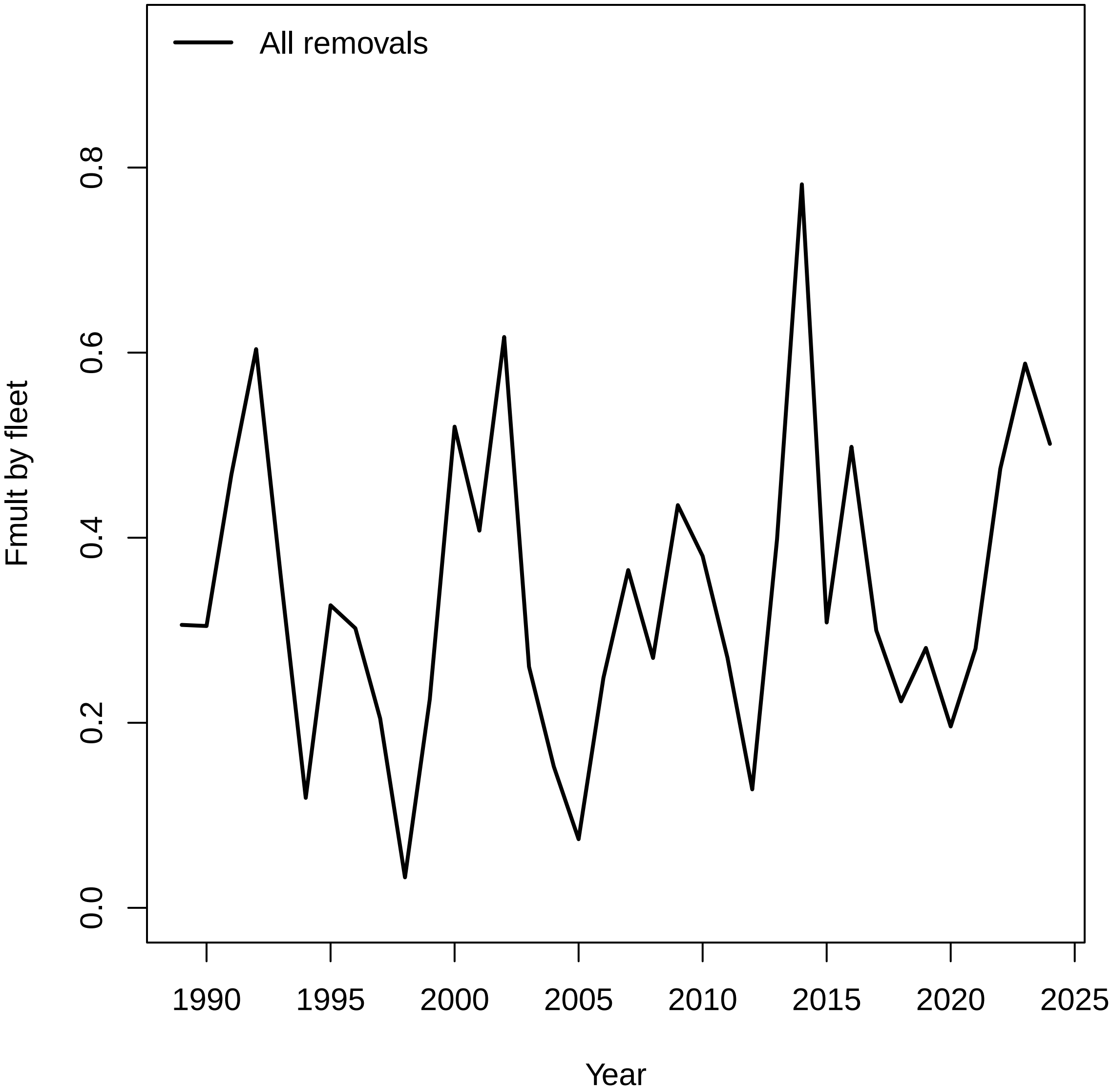

Index 3 (MRIP)
Mean Age
Eff. Sample Size
Year
0
2
4
6
8
10
0
40
80
120
160
200
1990
1995
2000
2005
2010
2015
2020
2025

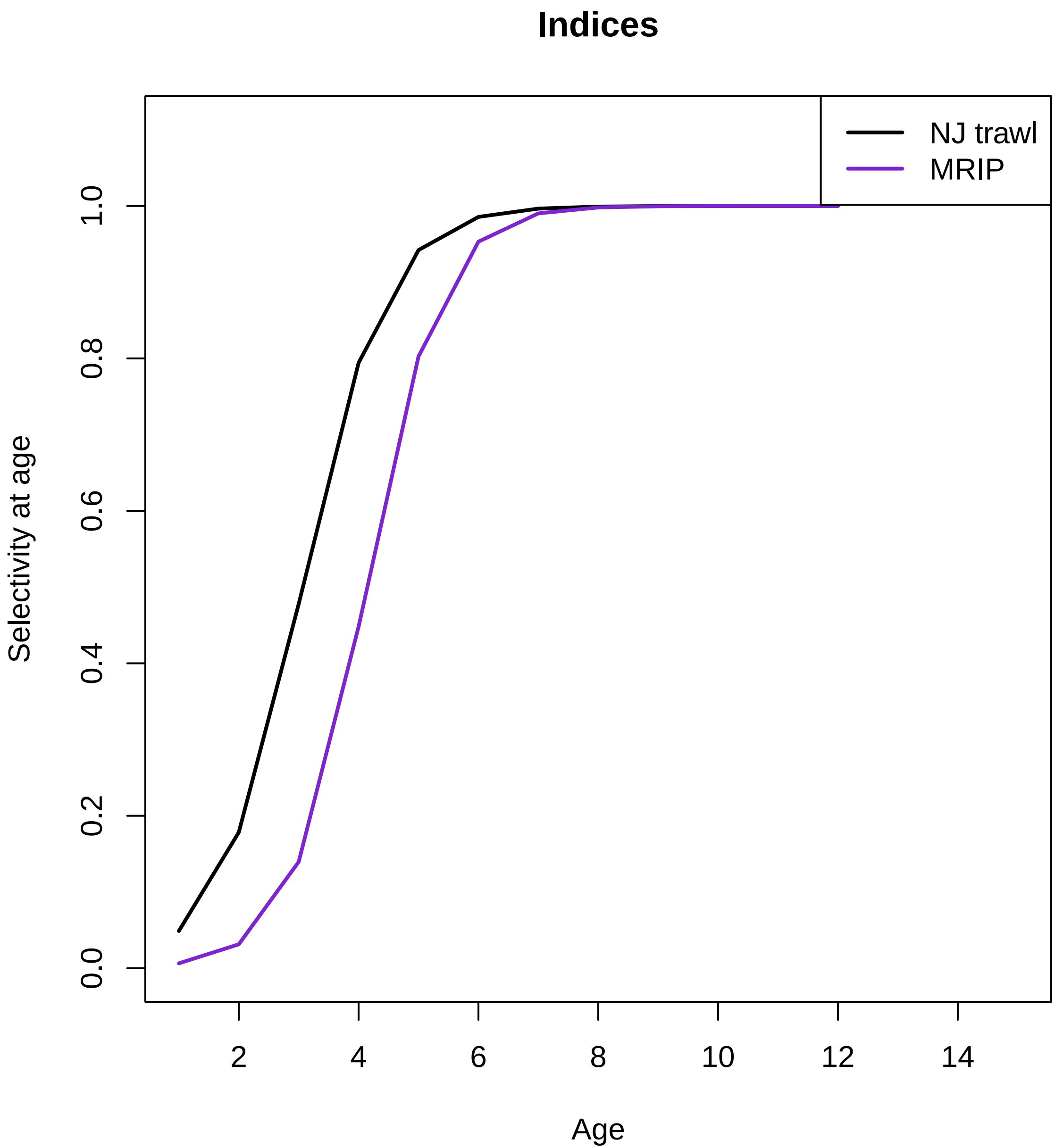

SDNR=1.75
RMSE=1.73
Std Resids
Year
−4
−2
0
2
4
1989
1993
1997
2001
2005
2009
2013
2017
2021

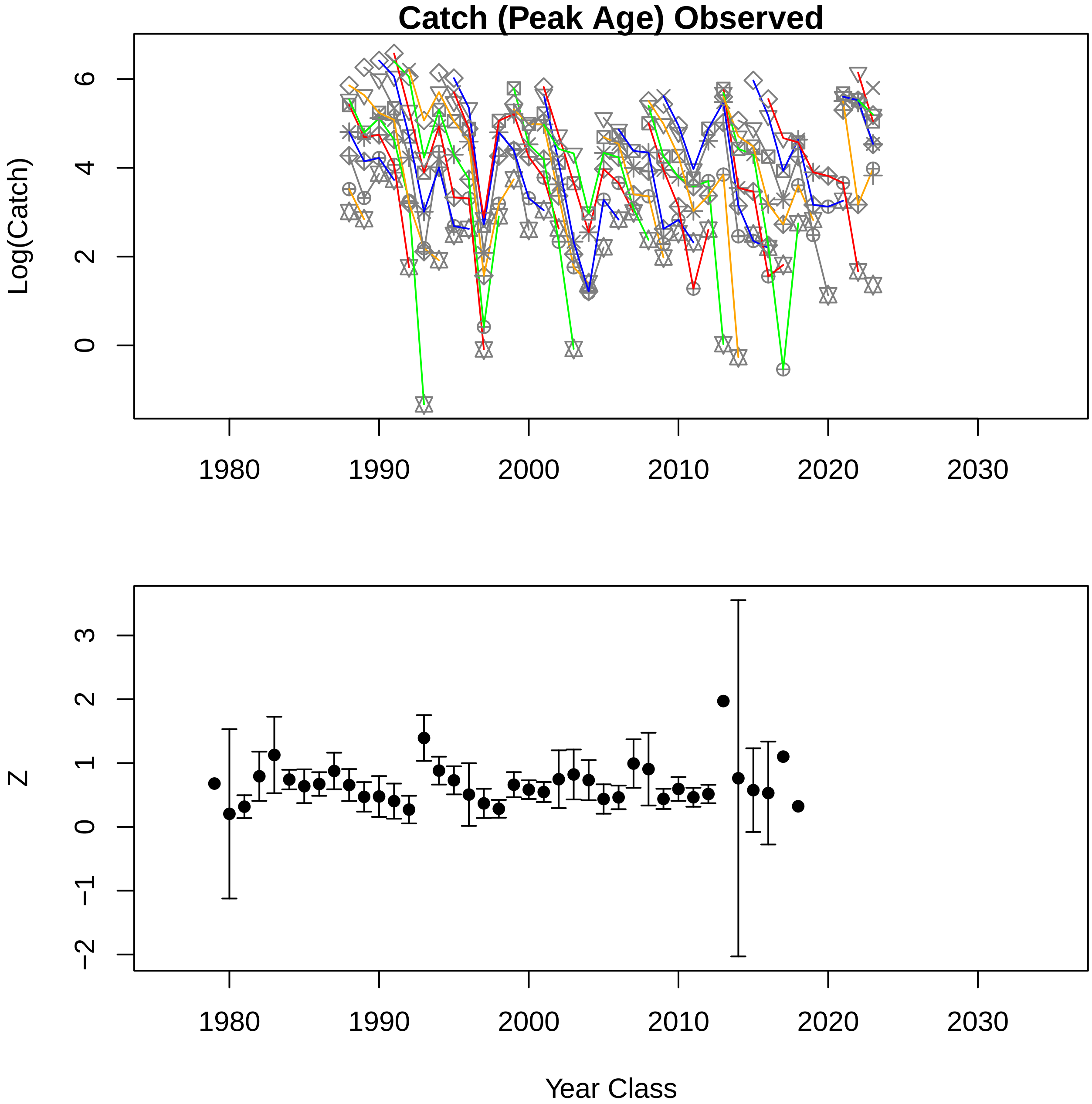


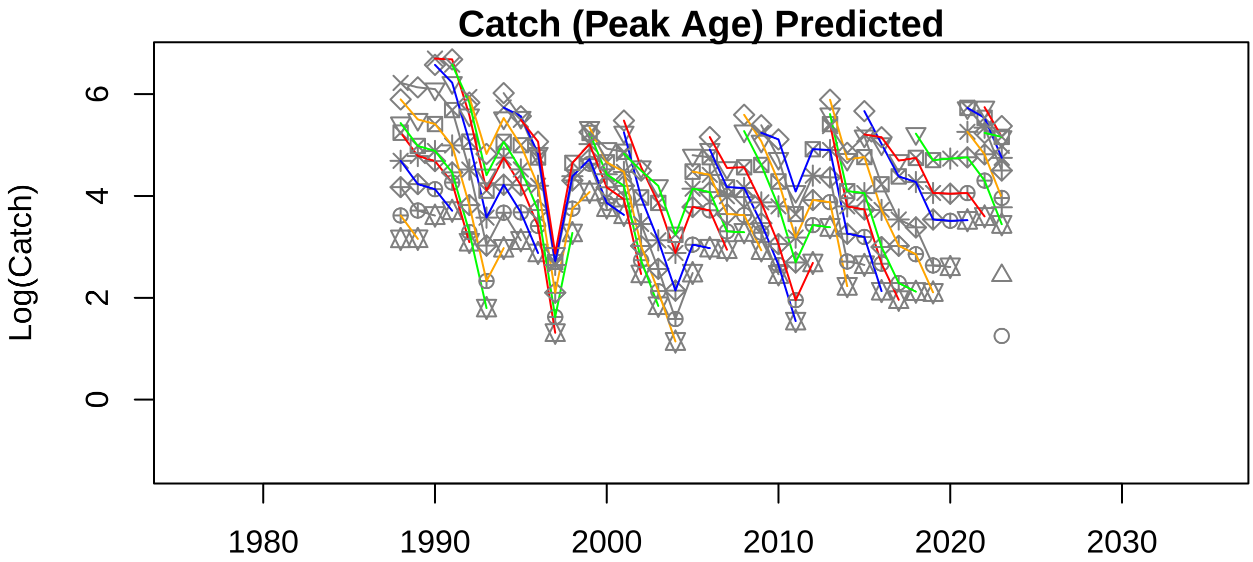
Index 3 (MRIP)
y=x
1st−3rd quartiles
Sample Quantiles
Theoretical Quantile
4
2
0
−2
−4
−2
−1
0
1
2

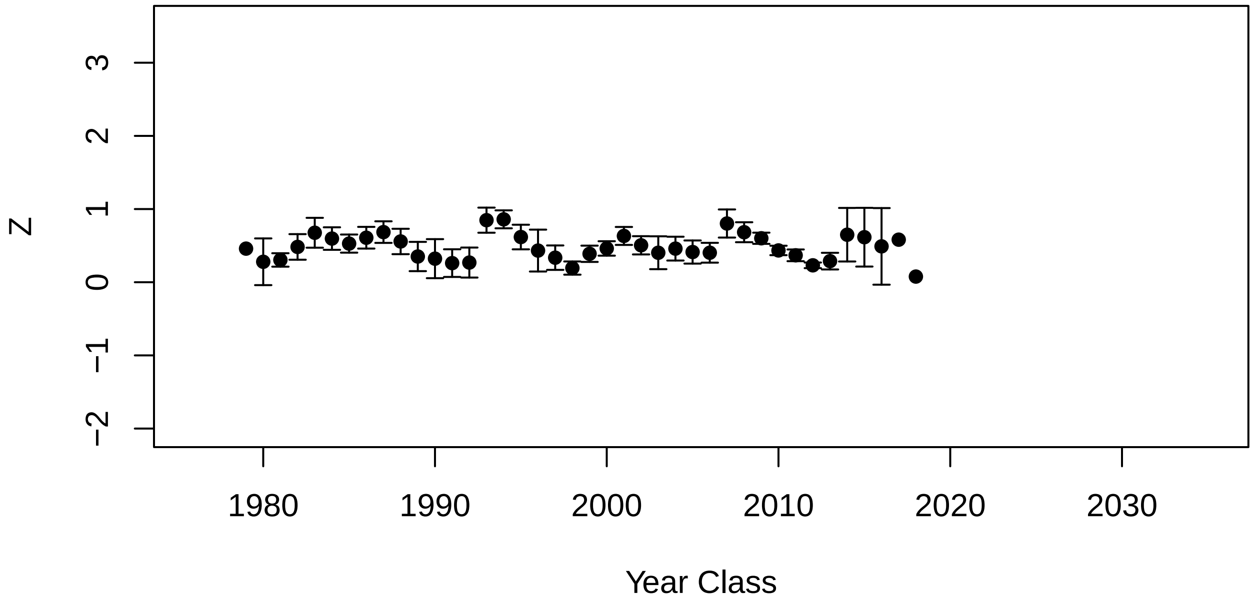

Fleet 1 (All removals)
1989
1998
2004
2012
2018
Selectivity at Age
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
Age

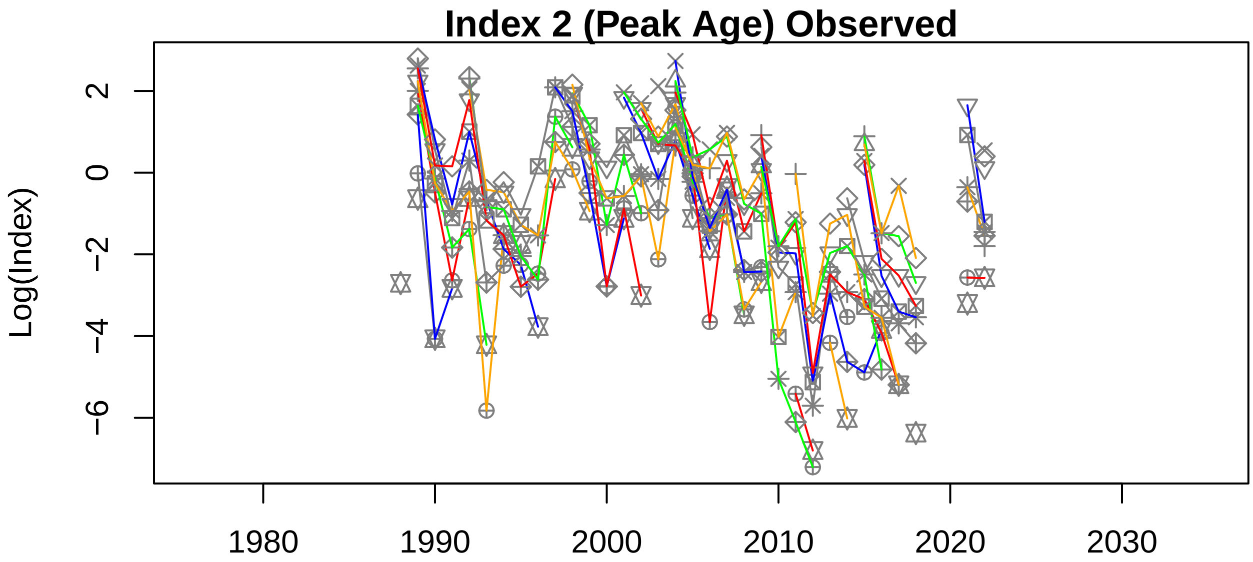

All removals
Fmult by fleet
0.0
0.2
0.4
0.6
0.8
1990
1995
2000
2005
2010
2015
2020
2025
Year

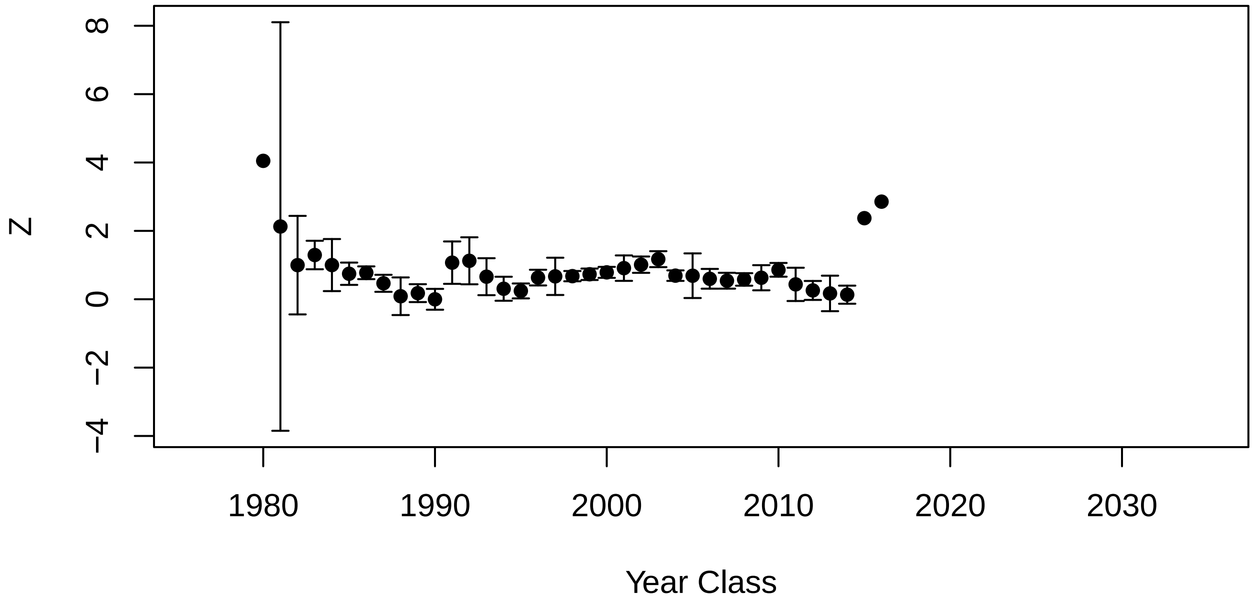

Indices
NJ trawl
MRIP
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
14
Age

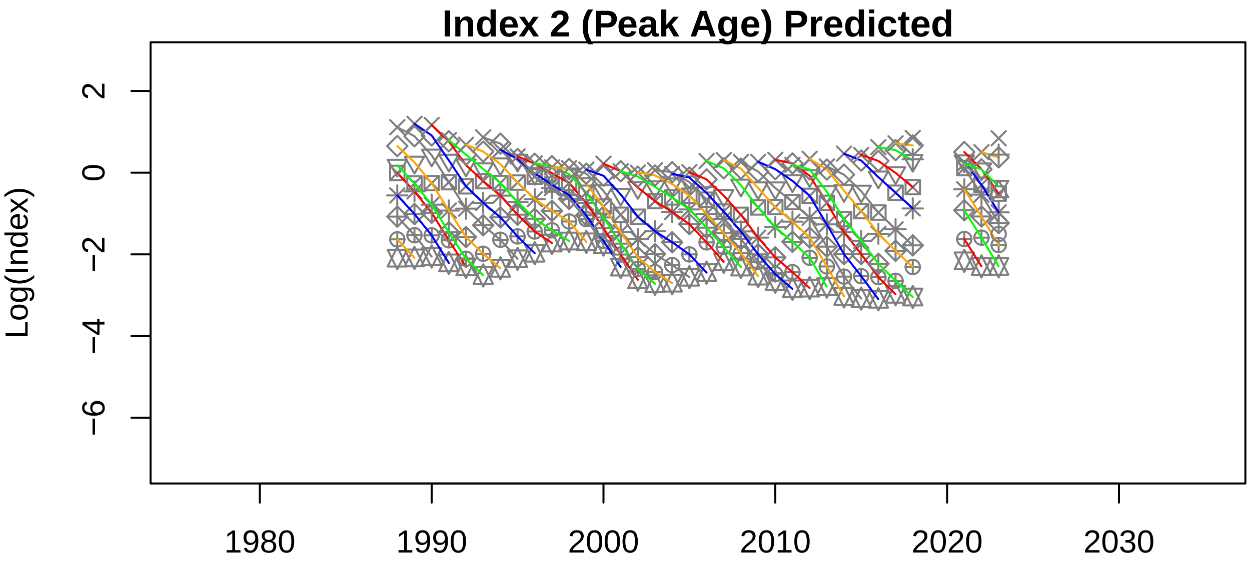

Catch (Peak Age) Observed
Log(Catch)
6
4
2
0
1980
1990
2000
2010
2020
2030
Z
3
2
1
0
−1
−2
1980
1990
2000
2010
2020
2030
Year Class

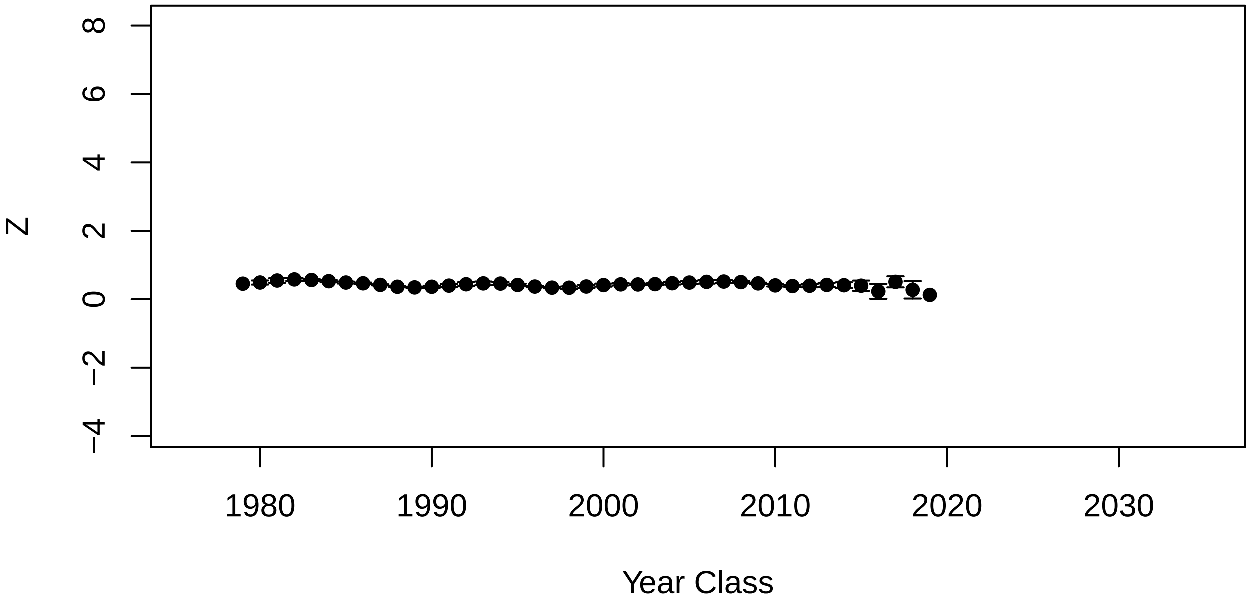

Catch (Peak Age) Predicted
Log(Catch)
0
2
4
6
1980
1990
2000
2010
2020
2030

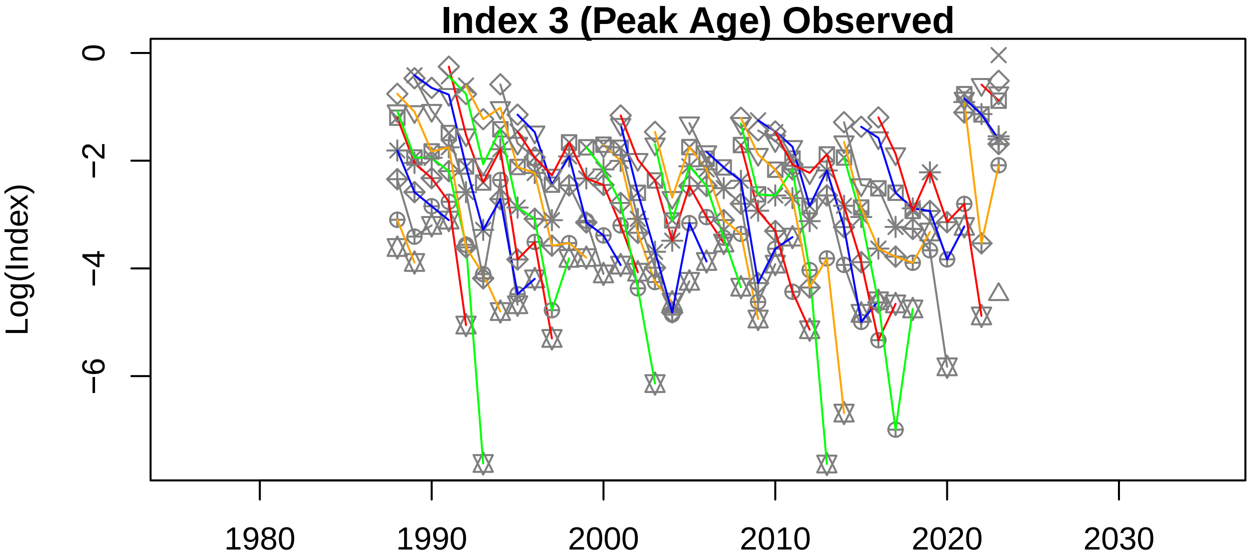

Z
−2
−1
0
1
2
3
1980
1990
2000
2010
2020
2030
Year Class

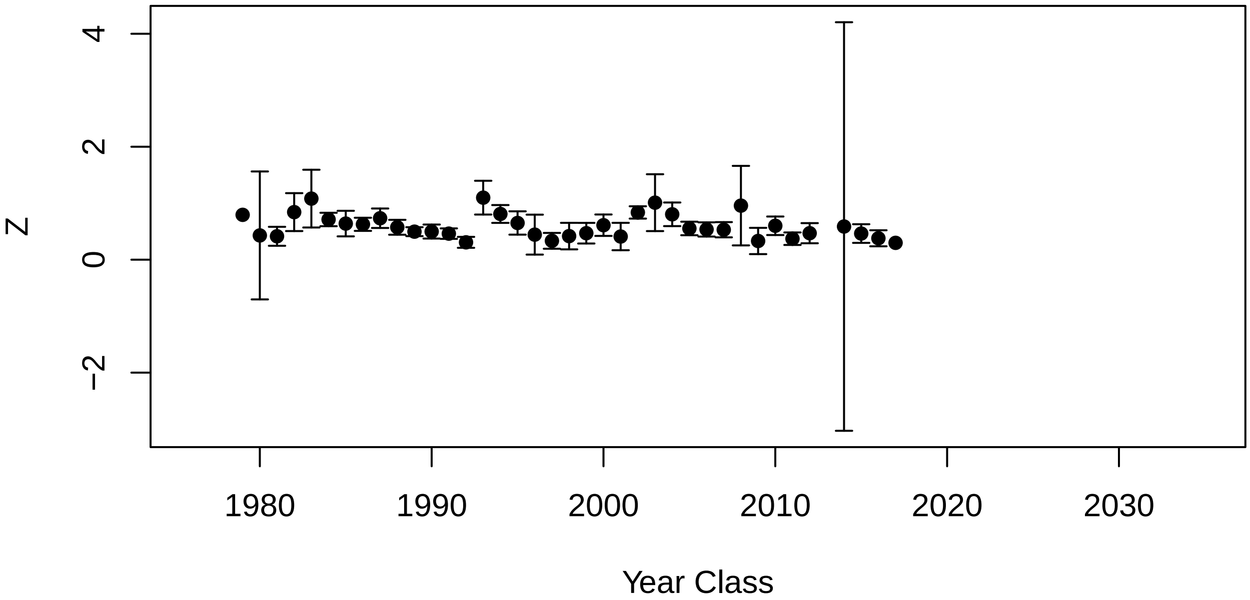

Index 2 (Peak Age) Observed
Log(Index)
2
0
−2
−4
−6
1980
1990
2000
2010
2020
2030

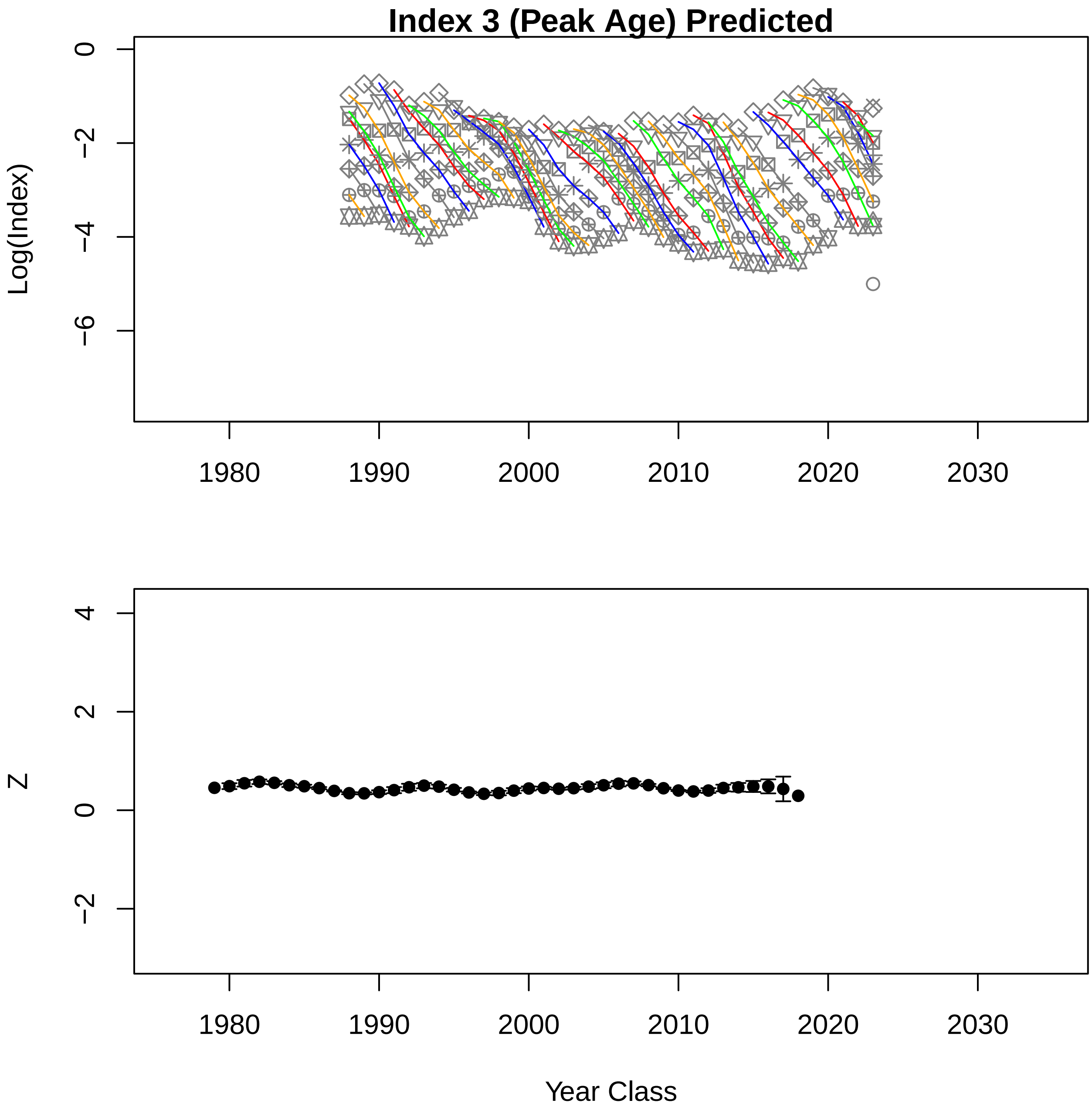

Z
8
6
4
2
0
−2
−4
1980
1990
2000
2010
2020
2030
Year Class

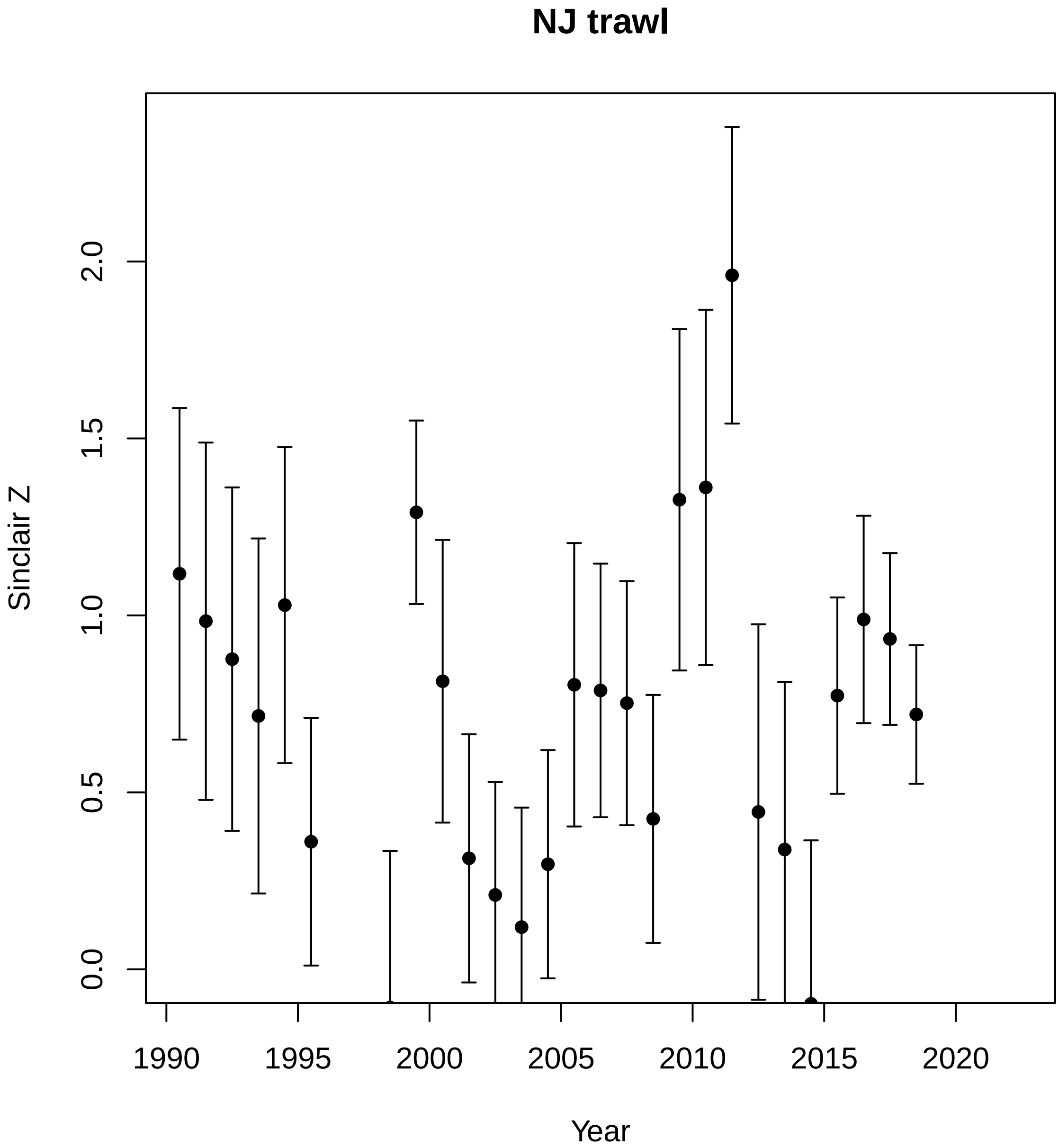

Index 2 (Peak Age) Predicted
Log(Index)
2
0
−2
−4
−6
1980
1990
2000
2010
2020
2030

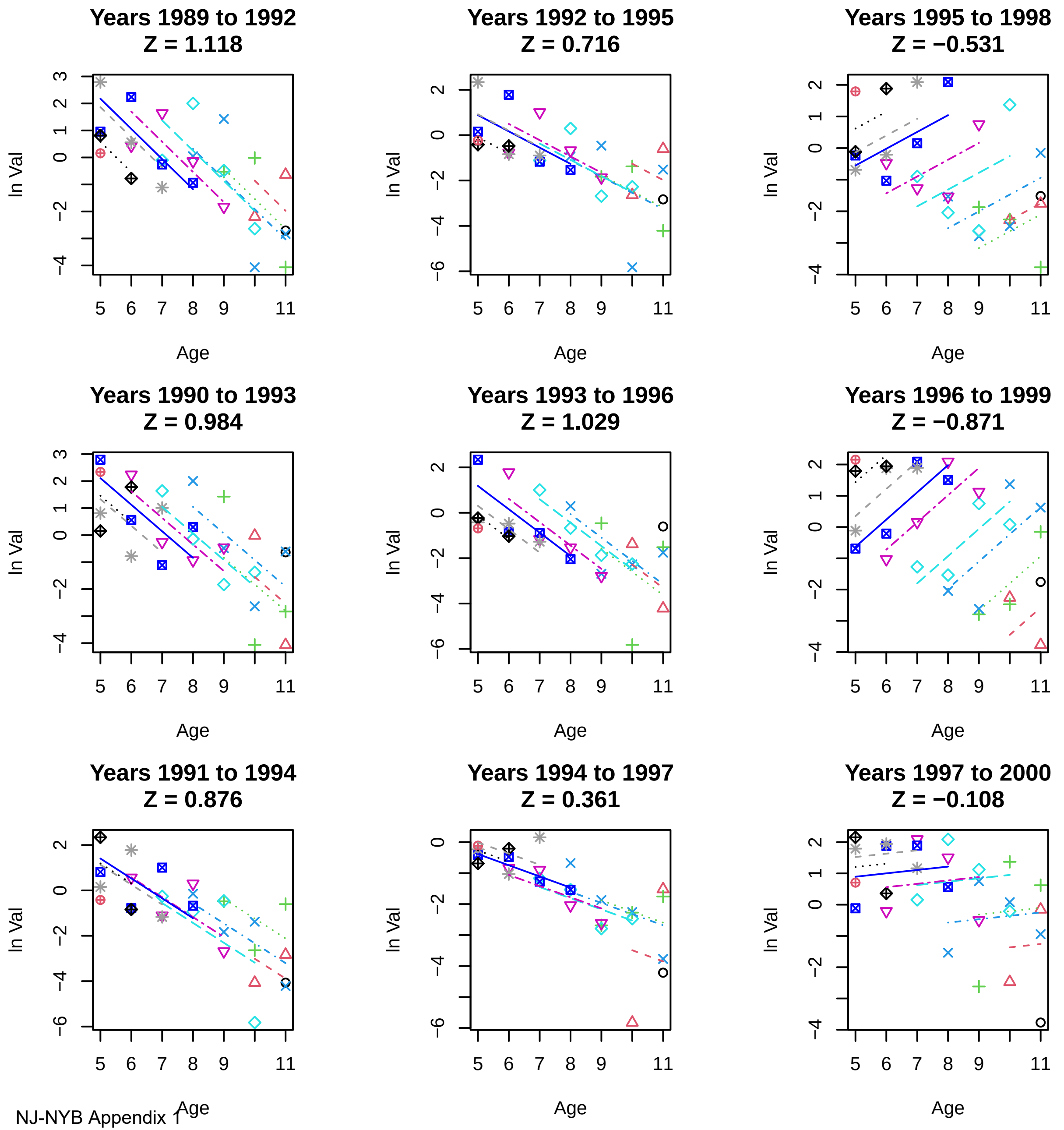

Z
8
6
4
2
0
−2
−4
1980
1990
2000
2010
2020
2030
Year Class

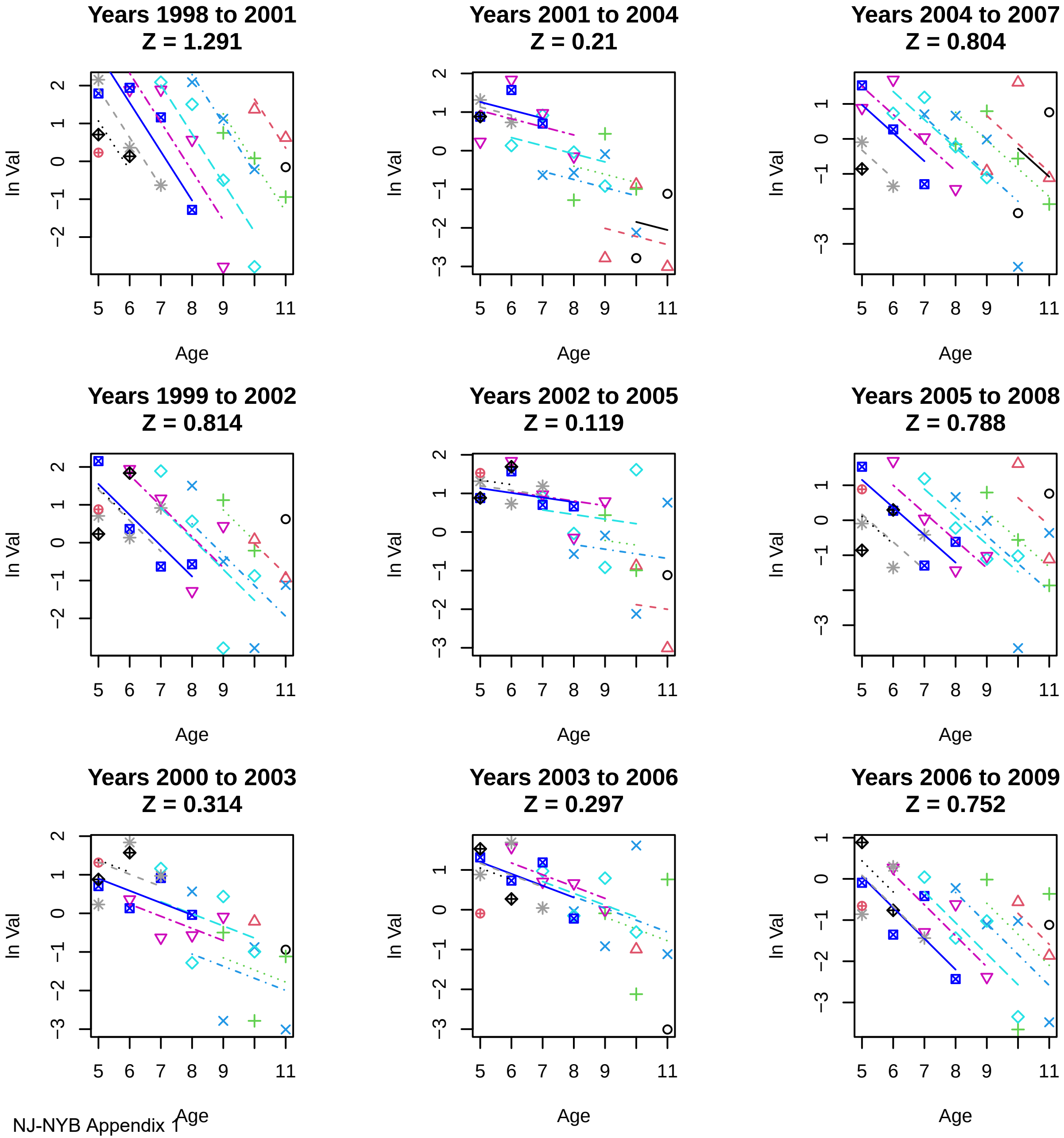

Index 3 (Peak Age) Observed
Log(Index)
0
−2
−4
−6
1980
1990
2000
2010
2020
2030

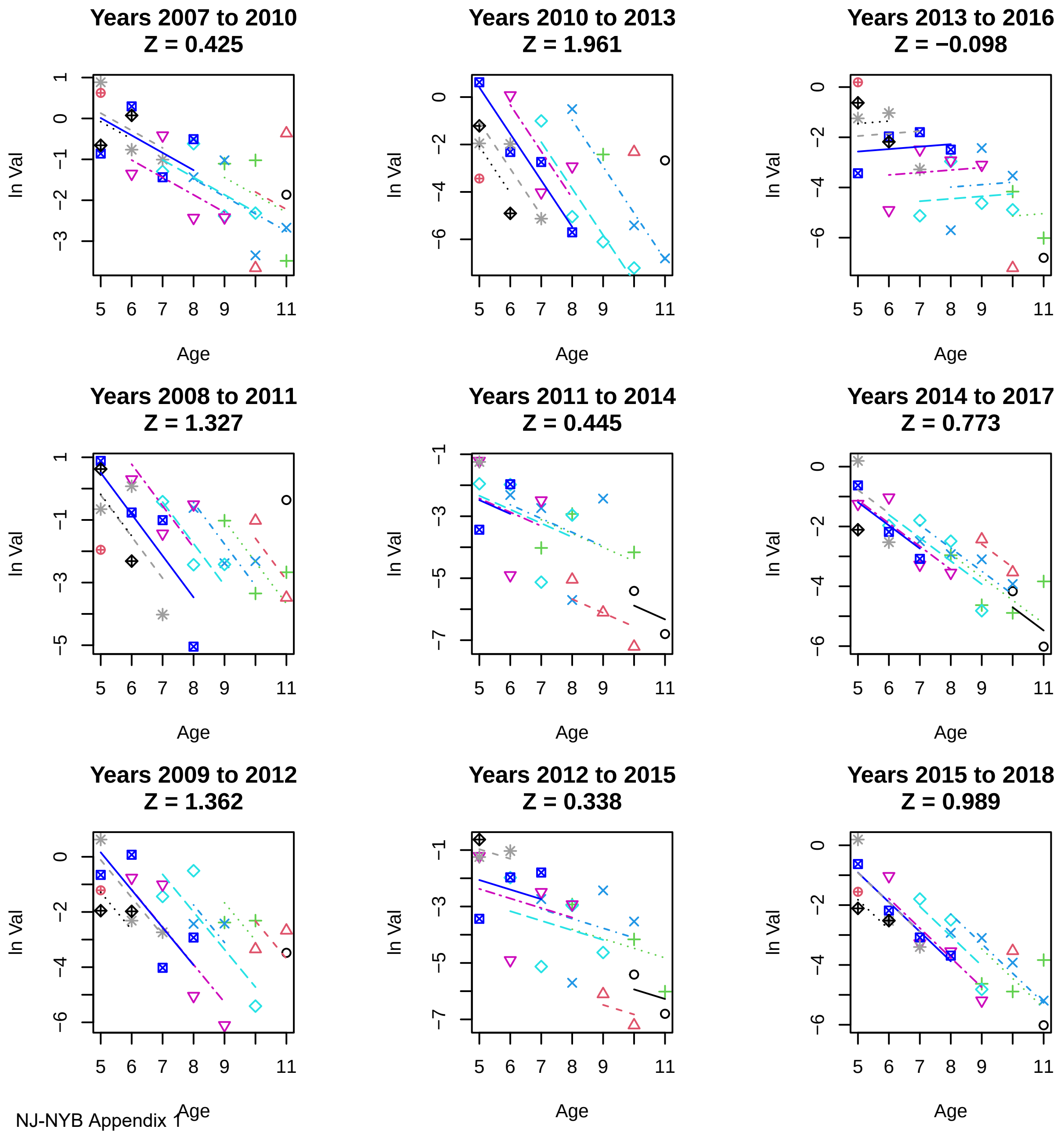

Z
4
2
0
−2
1980
1990
2000
2010
2020
2030
Year Class


Index 3 (Peak Age) Predicted
Log(Index)
0
−2
−4
−6
1980
1990
2000
2010
2020
2030
Z
4
2
0
−2
1980
1990
2000
2010
2020
2030
Year Class


NJ trawl
Sinclair Z
0.0
0.5
1.0
1.5
2.0
1990
1995
2000
2005
2010
2015
2020
Year

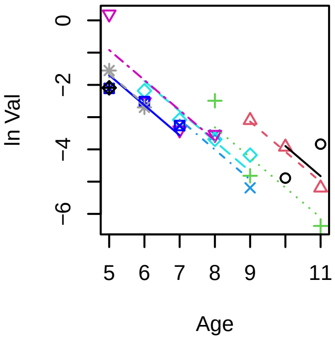

Years 1989 to 1992
Z = 1.118
Years 1992 to 1995
Z = 0.716
Years 1995 to 1998
Z = −0.531
Years 1990 to 1993
Z = 0.984
Years 1993 to 1996
Z = 1.029
Years 1996 to 1999
Z = −0.871
Years 1991 to 1994
Z = 0.876
Years 1994 to 1997
Z = 0.361
Years 1997 to 2000
Z = −0.108
ln Val
Age


Years 1998 to 2001
Z = 1.291
Years 2001 to 2004
Z = 0.21
Years 2004 to 2007
Z = 0.804
Years 1999 to 2002
Z = 0.814
Years 2002 to 2005
Z = 0.119
Years 2005 to 2008
Z = 0.788
Years 2000 to 2003
Z = 0.314
Years 2003 to 2006
Z = 0.297
Years 2006 to 2009
Z = 0.752
ln Val
Age

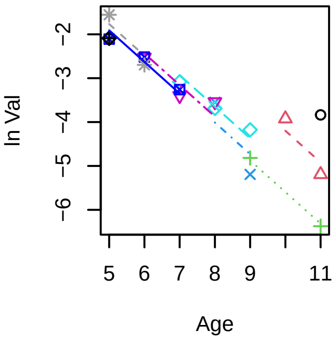


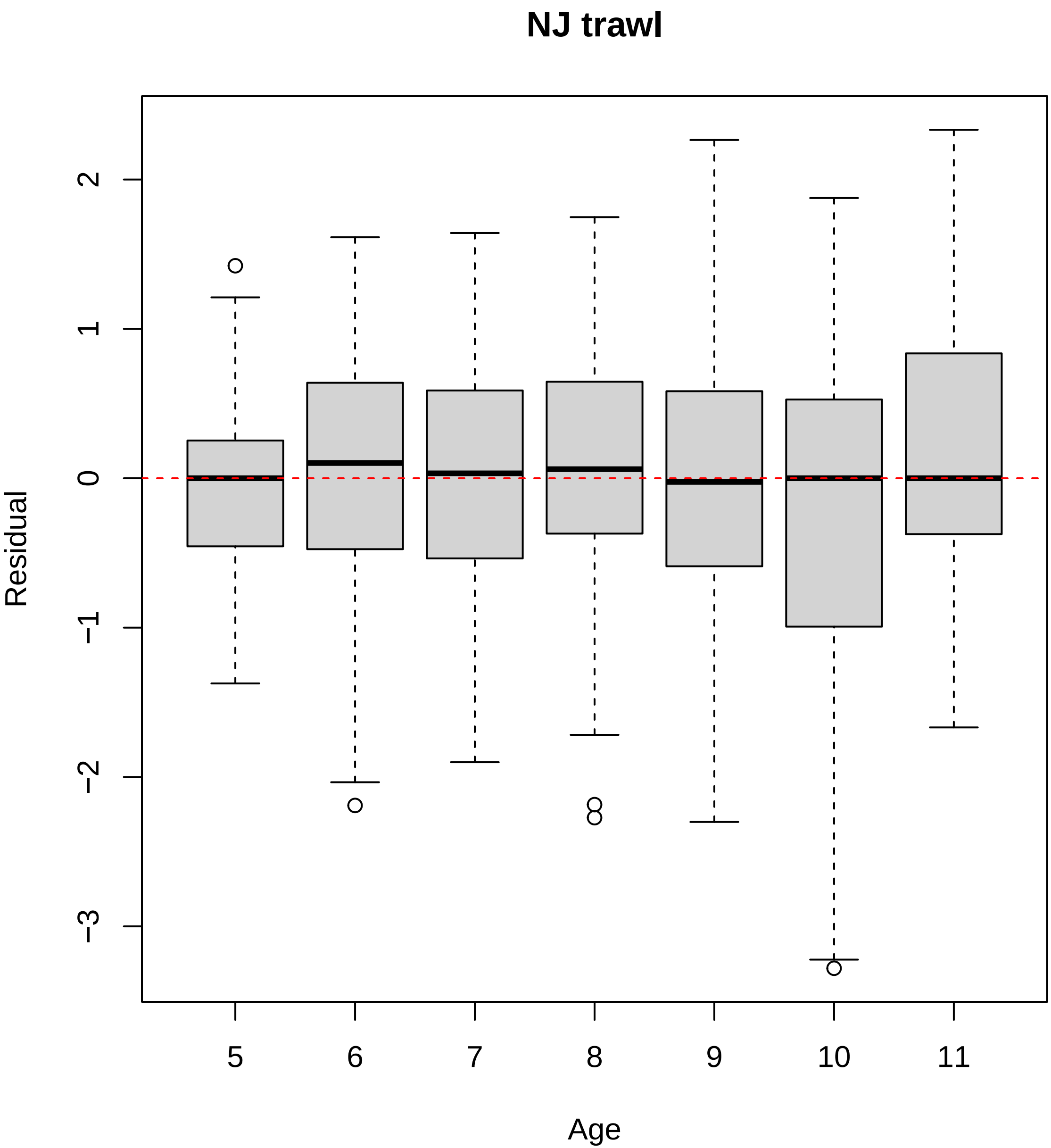
Years 2007 to 2010
Z = 0.425
Years 2010 to 2013
Z = 1.961
Years 2013 to 2016
Z = −0.098
Years 2008 to 2011
Z = 1.327
Years 2011 to 2014
Z = 0.445
Years 2014 to 2017
Z = 0.773
Years 2009 to 2012
Z = 1.362
Years 2012 to 2015
Z = 0.338
Years 2015 to 2018
Z = 0.989
ln Val
Age

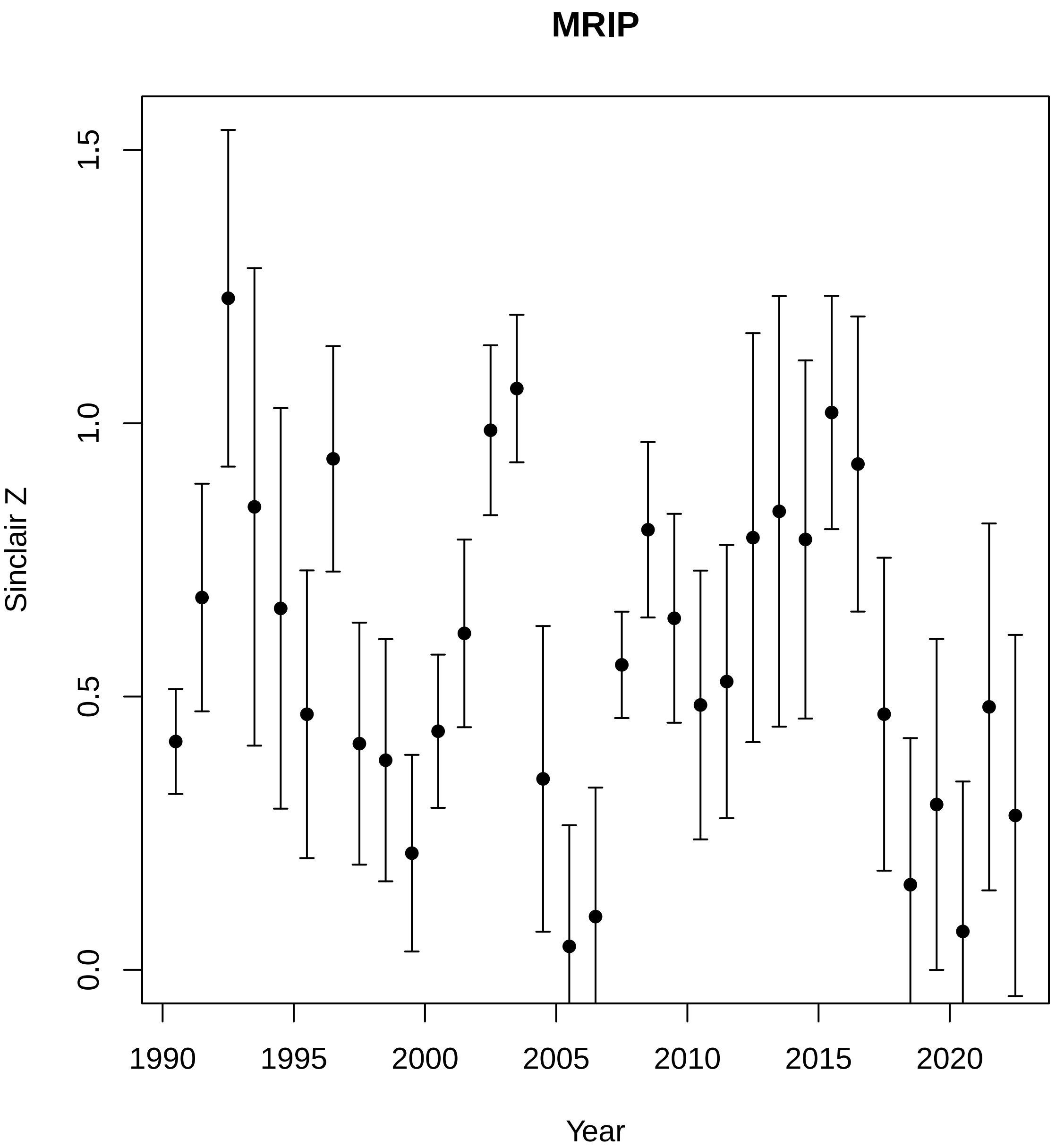
Years 2016 to 2019
Z = 0.933

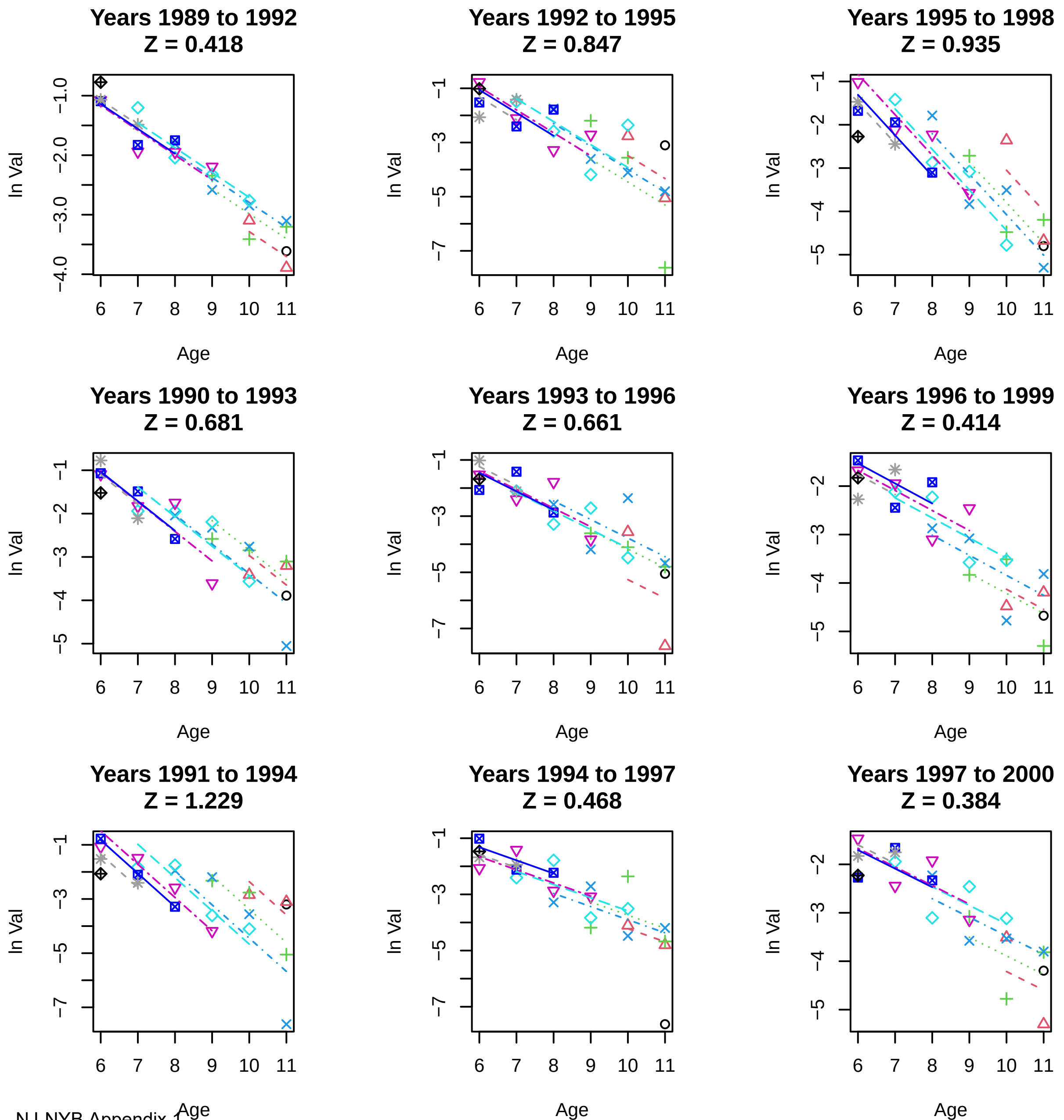


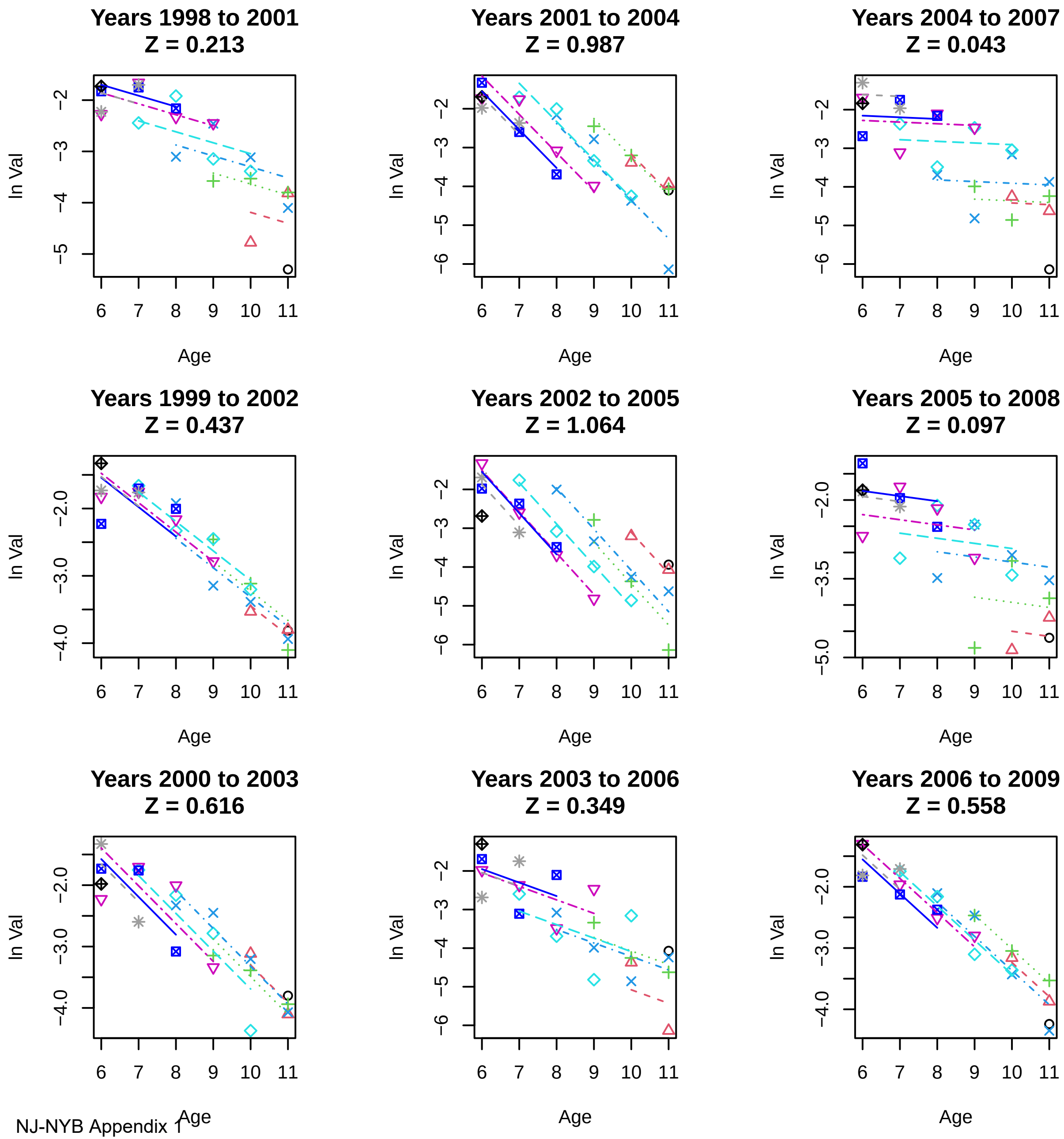
Years 2017 to 2019
Z = 0.72

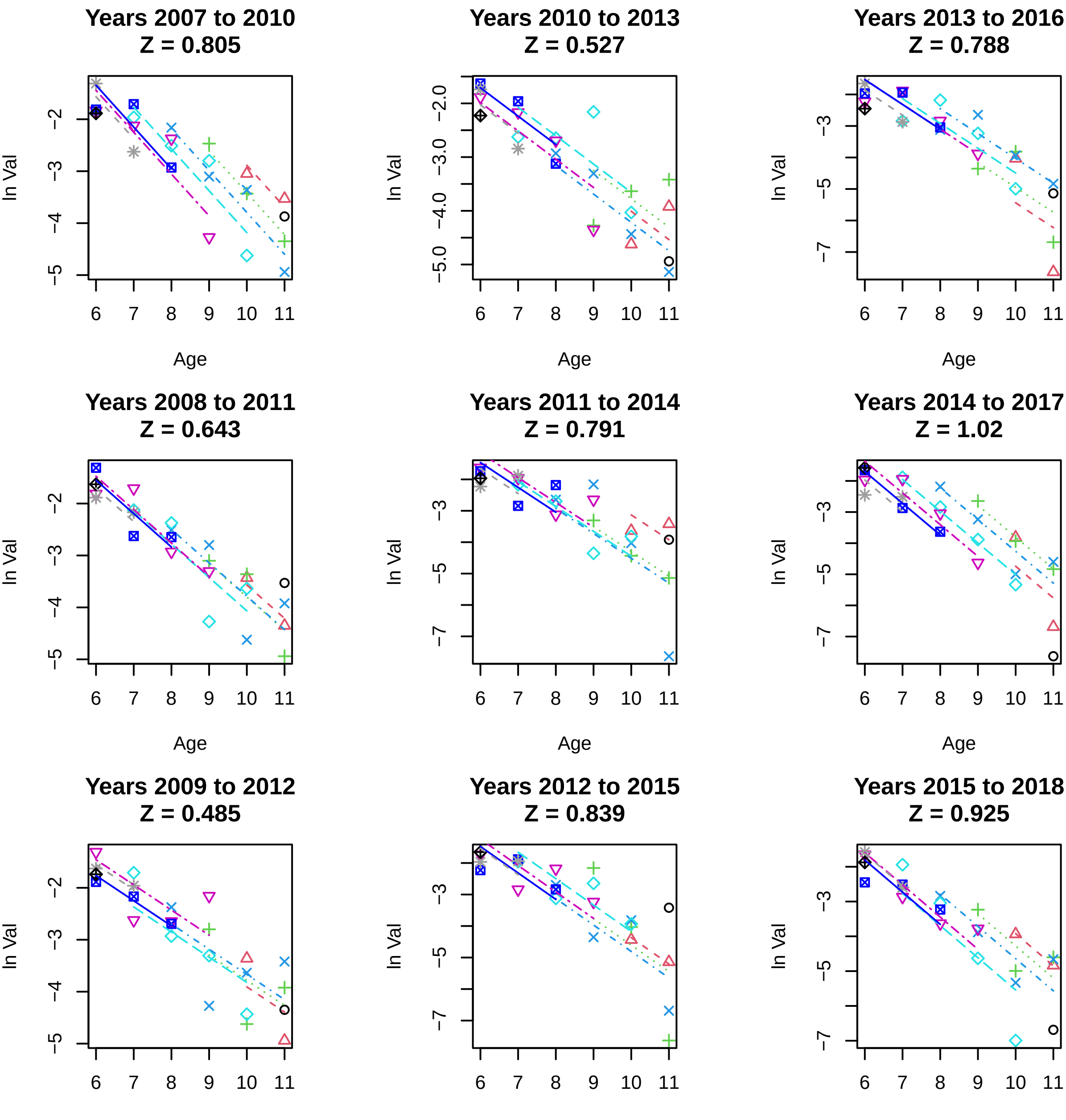


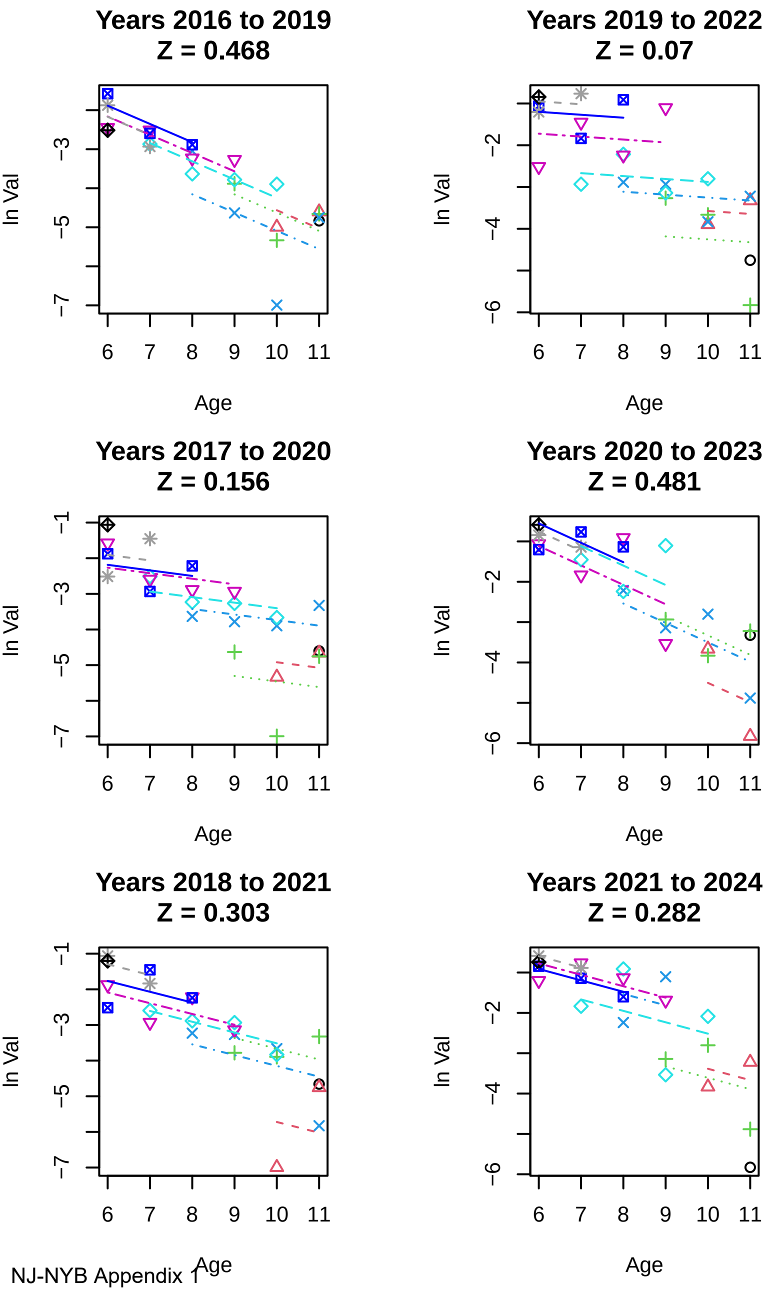

NJ trawl
Residual
2
1
0
−1
−2
−3
5
6
7
8
9
10
11
Age

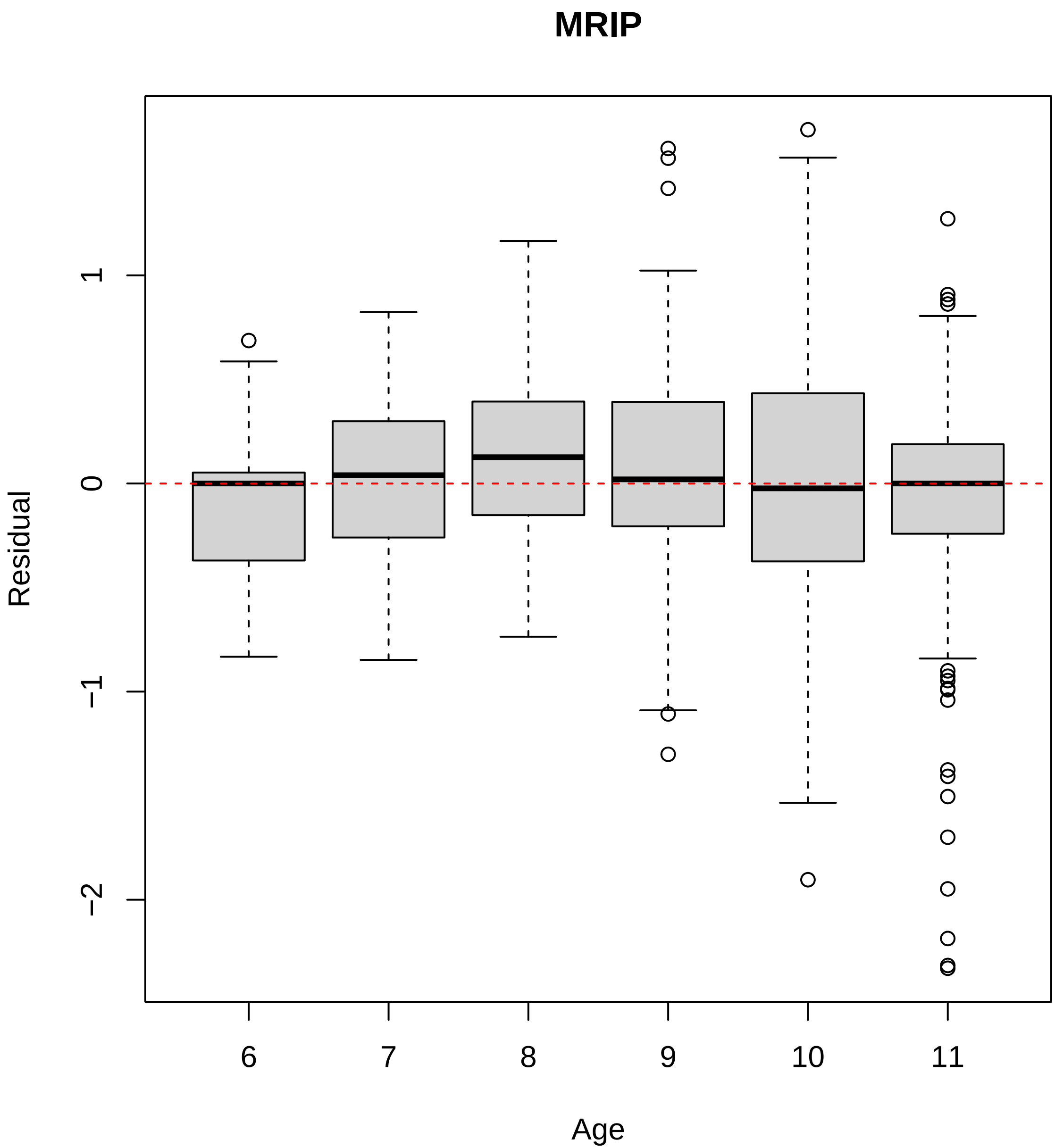

MRIP
Sinclair Z
0.0
0.5
1.0
1.5
1990
1995
2000
2005
2010
2015
2020
Year


Years 1989 to 1992
Z = 0.418
Years 1992 to 1995
Z = 0.847
Years 1995 to 1998
Z = 0.935
Years 1990 to 1993
Z = 0.681
Years 1993 to 1996
Z = 0.661
Years 1996 to 1999
Z = 0.414
Years 1991 to 1994
Z = 1.229
Years 1994 to 1997
Z = 0.468
Years 1997 to 2000
Z = 0.384
ln Val
Age

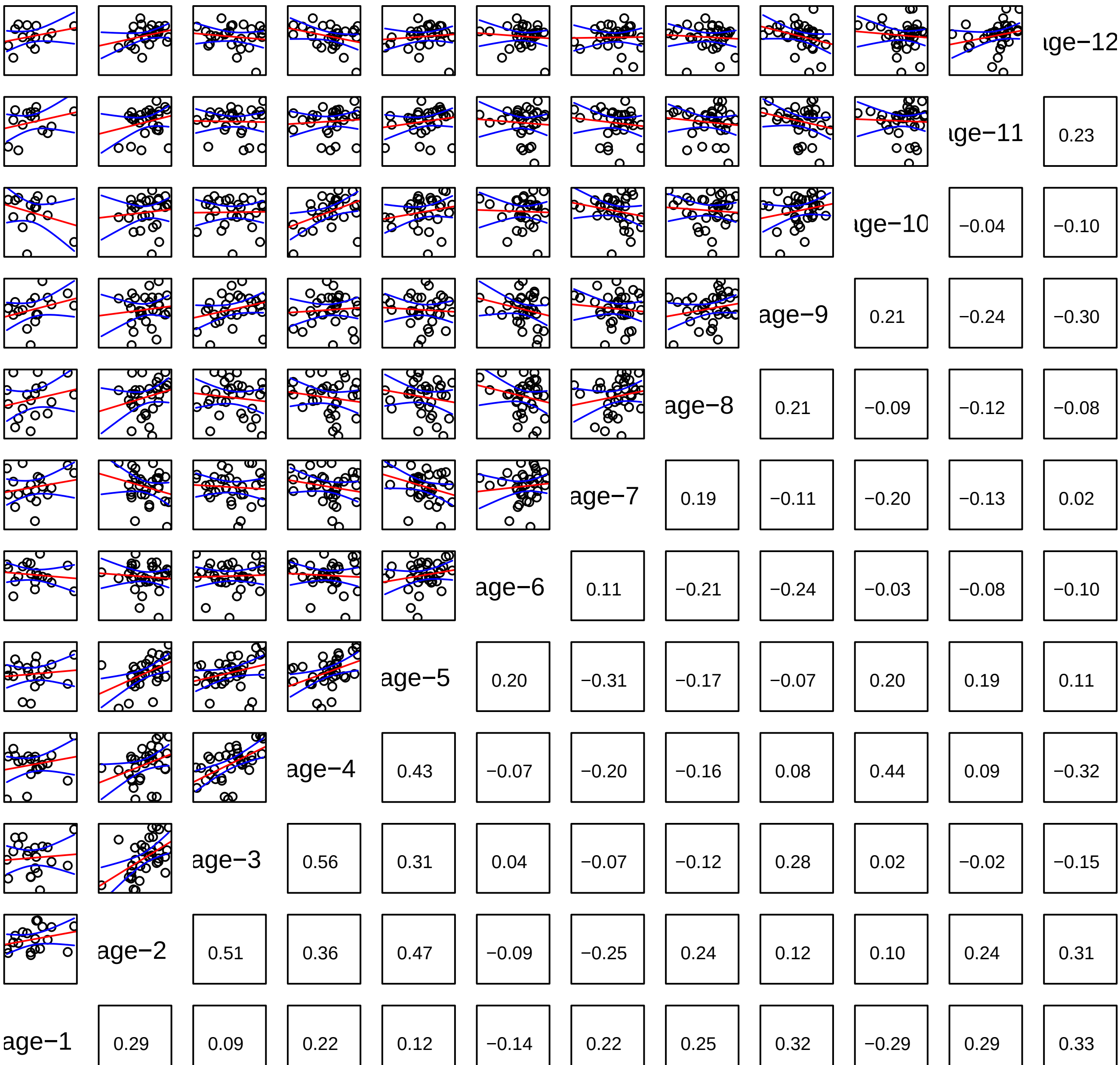

Years 1998 to 2001
Z = 0.213
Years 2001 to 2004
Z = 0.987
Years 2004 to 2007
Z = 0.043
Years 1999 to 2002
Z = 0.437
Years 2002 to 2005
Z = 1.064
Years 2005 to 2008
Z = 0.097
Years 2000 to 2003
Z = 0.616
Years 2003 to 2006
Z = 0.349
Years 2006 to 2009
Z = 0.558
ln Val
Age


Years 2007 to 2010
Z = 0.805
Years 2010 to 2013
Z = 0.527
Years 2013 to 2016
Z = 0.788
Years 2008 to 2011
Z = 0.643
Years 2011 to 2014
Z = 0.791
Years 2014 to 2017
Z = 1.02
Years 2009 to 2012
Z = 0.485
Years 2012 to 2015
Z = 0.839
Years 2015 to 2018
Z = 0.925
ln Val
Age

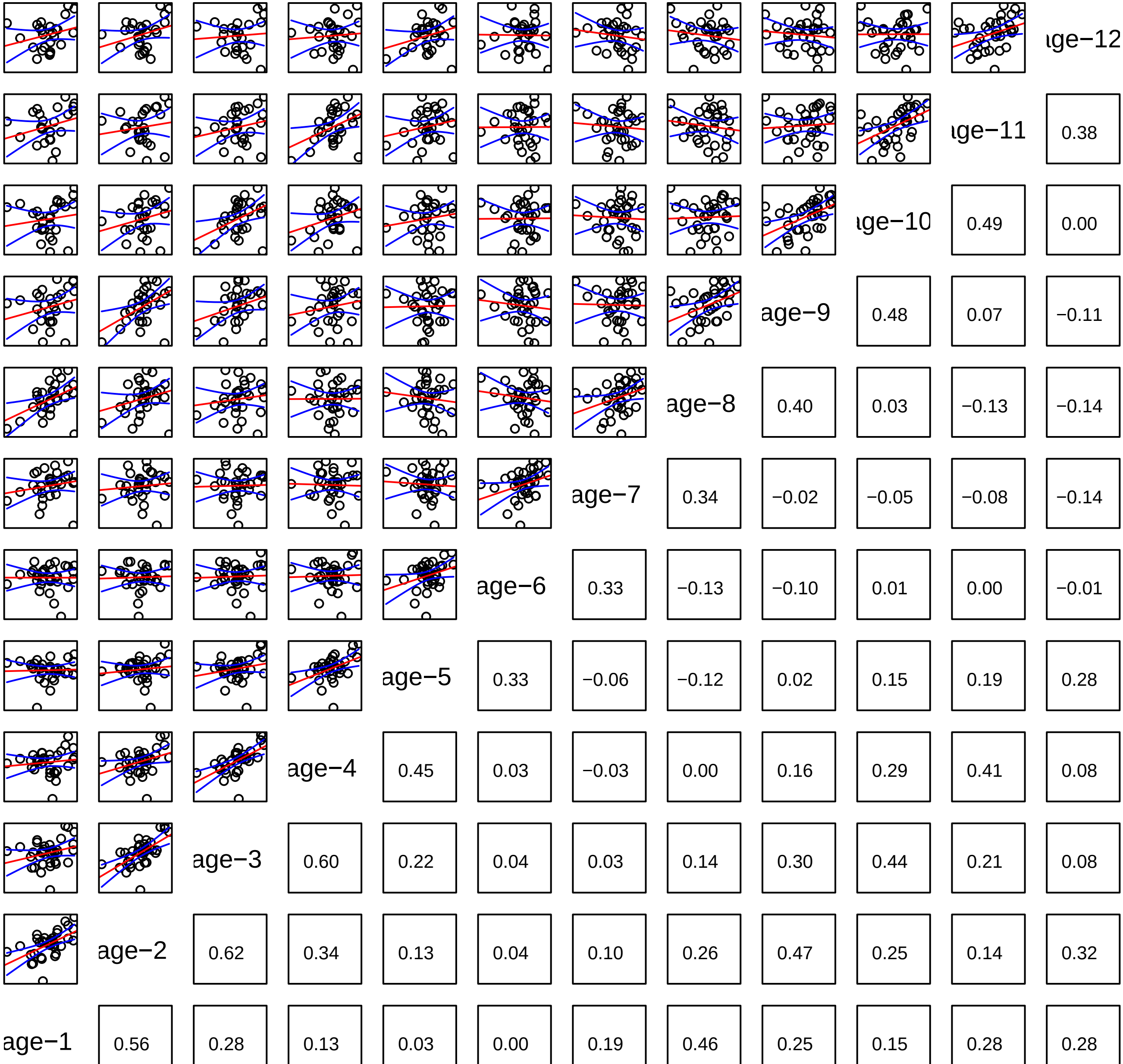

Years 2016 to 2019
Z = 0.468
Years 2019 to 2022
Z = 0.07
Years 2017 to 2020
Z = 0.156
Years 2020 to 2023
Z = 0.481
Years 2018 to 2021
Z = 0.303
Years 2021 to 2024
Z = 0.282
ln Val
Age


MRIP
Residual
1
0
−1
−2
6
7
8
9
10
11
Age

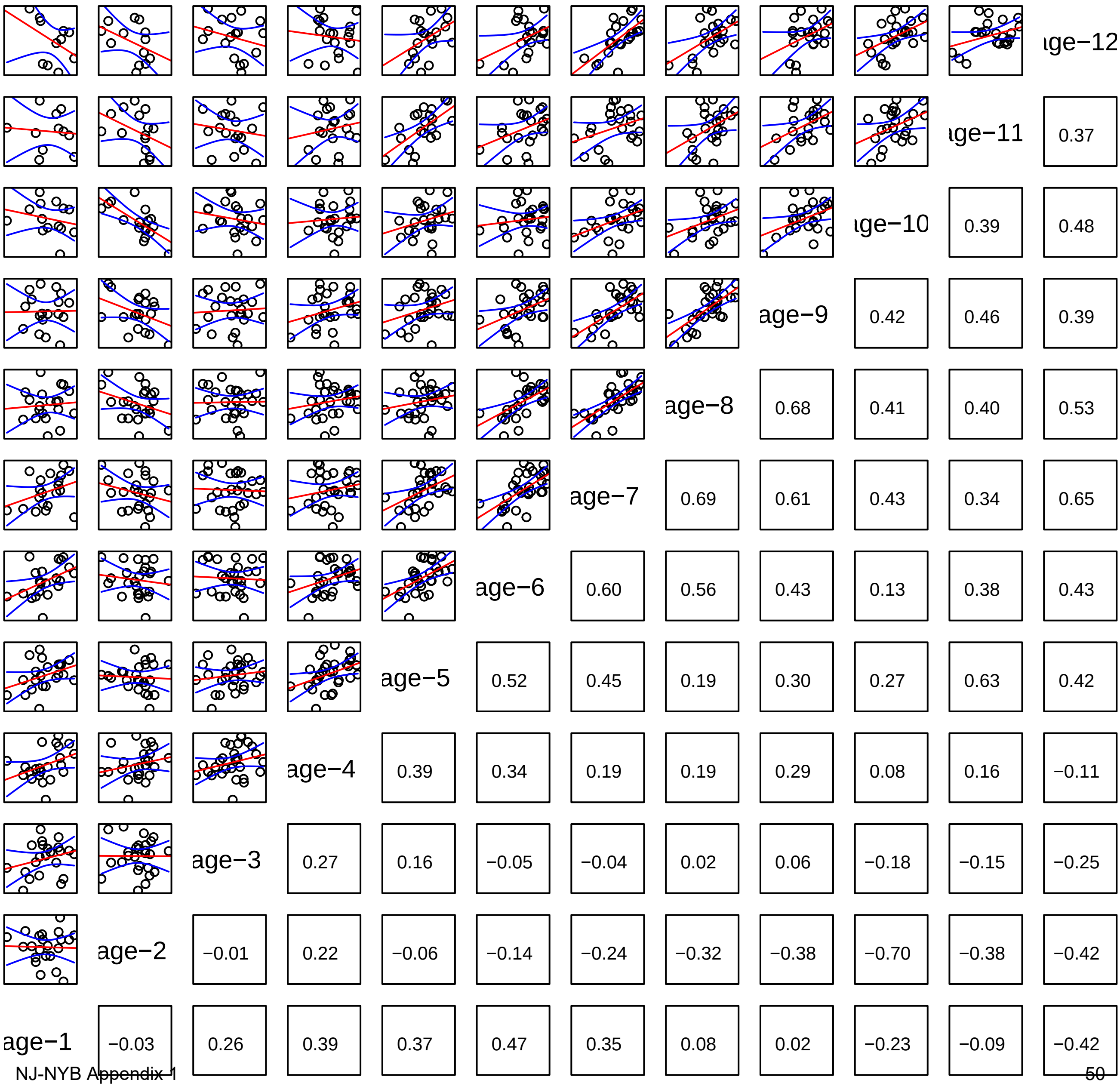
Catch Observed



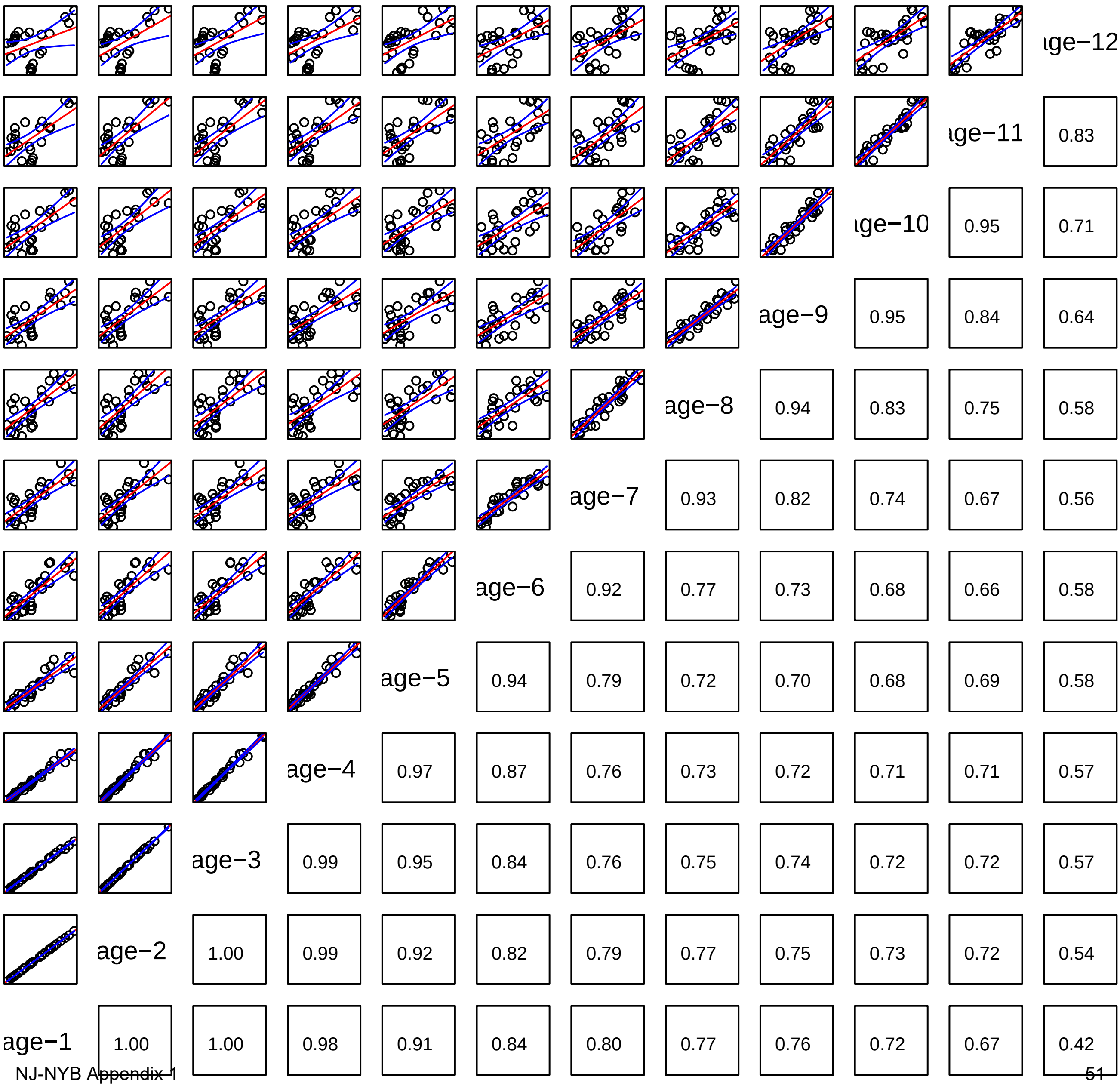
Catch Predicted



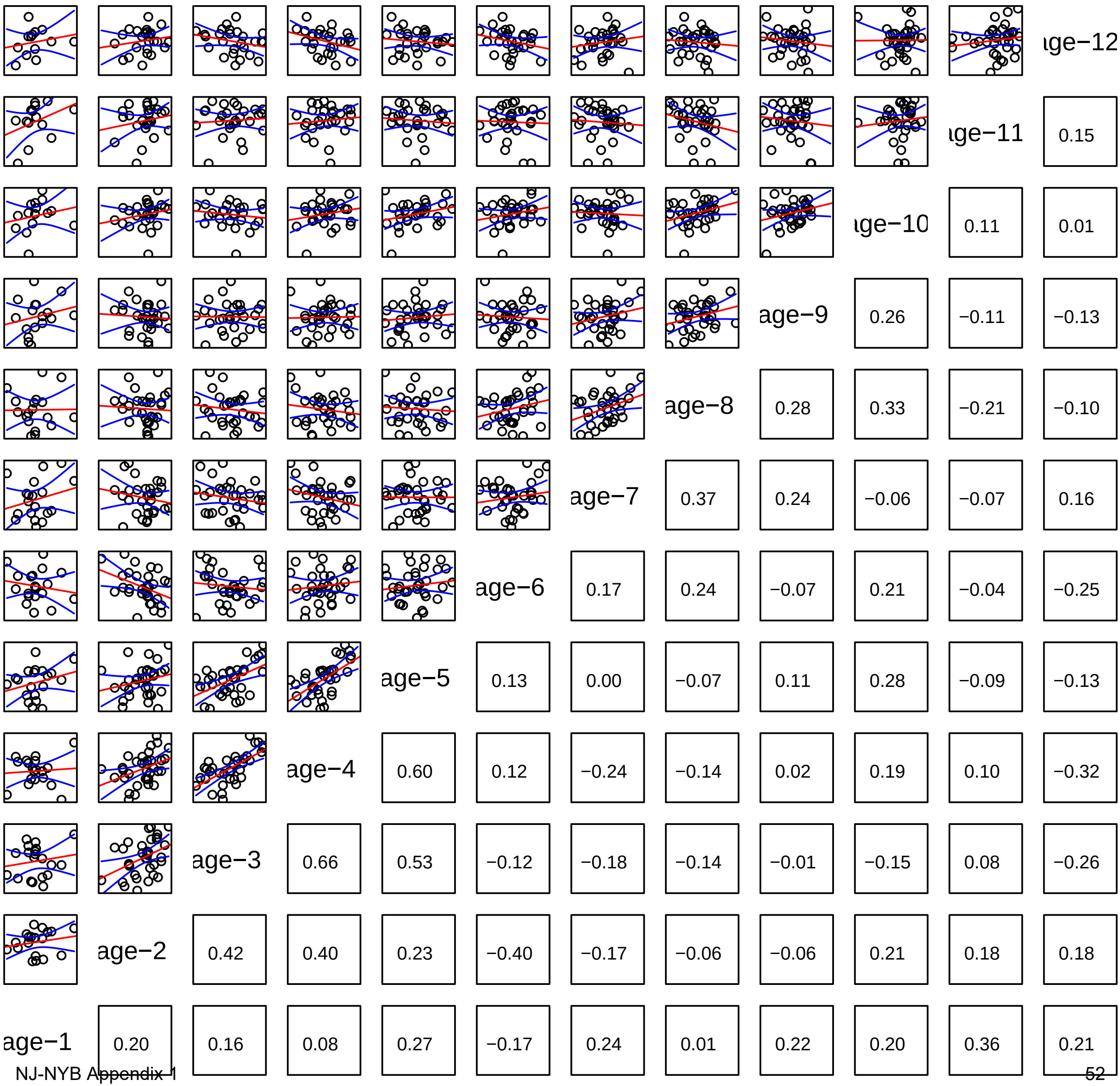
Index 2 (NJ trawl) Observed



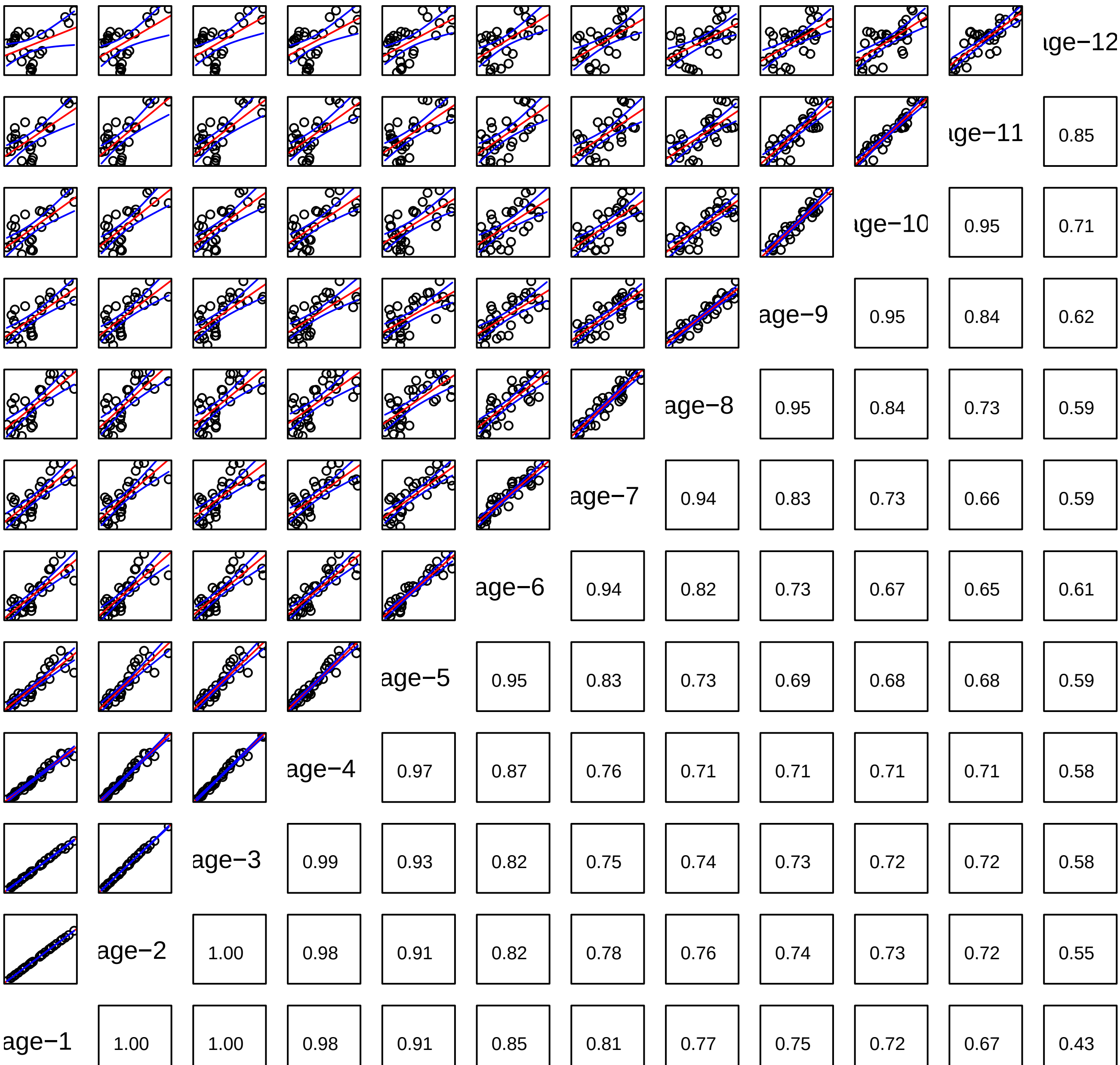
Index 2 (NJ trawl) Predicted

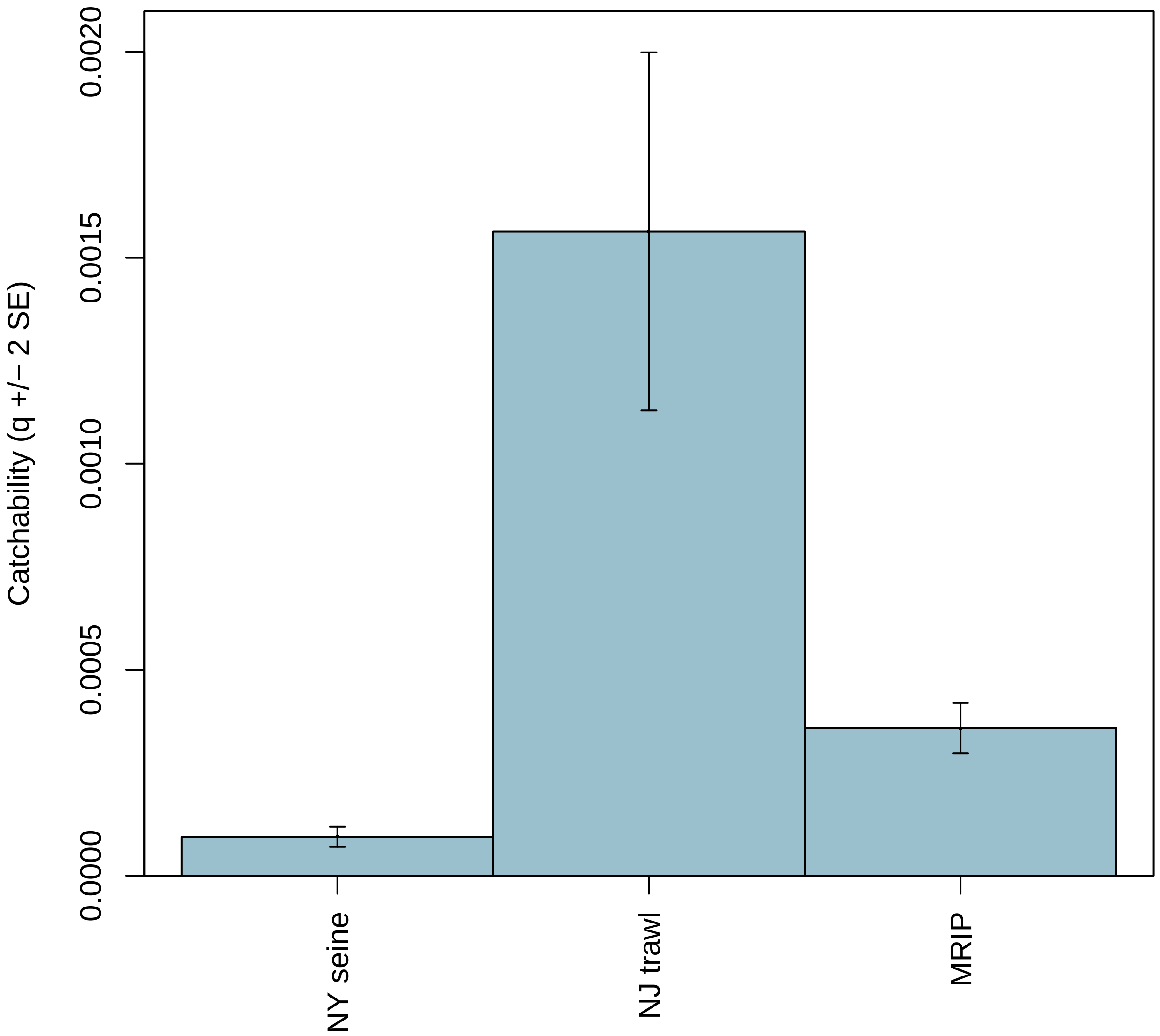


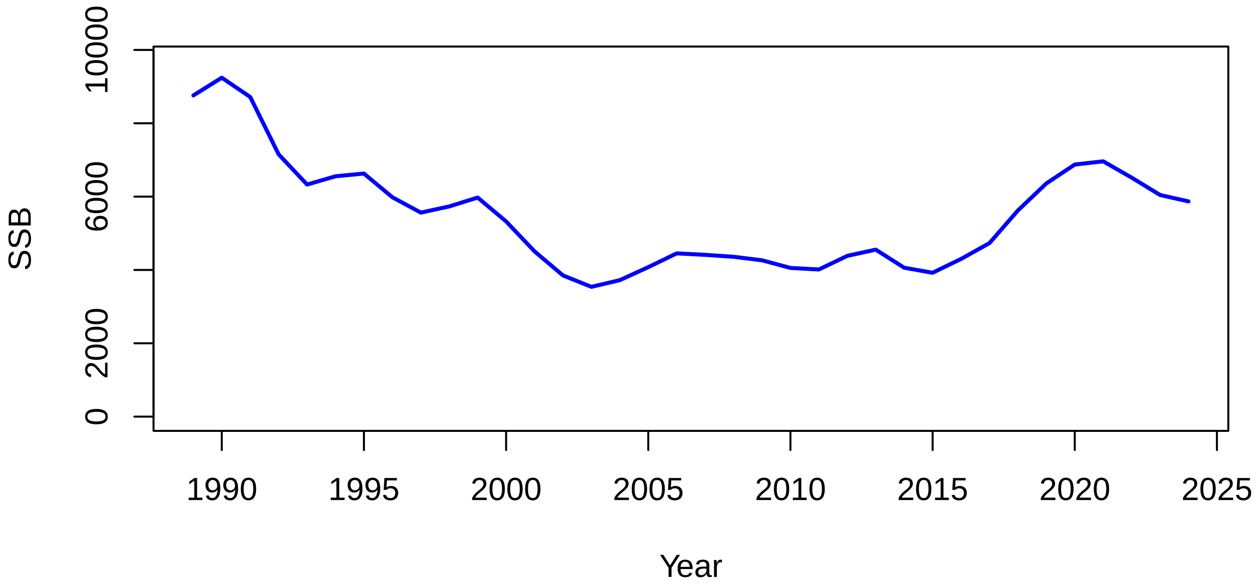
Index 3 (MRIP) Observed



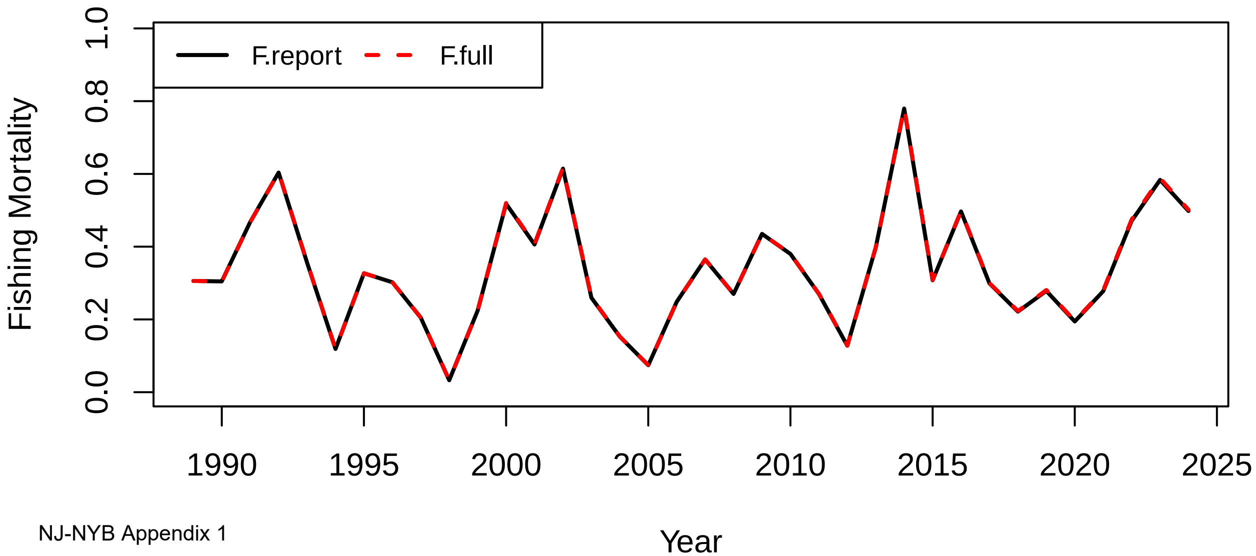
Index 3 (MRIP) Predicted



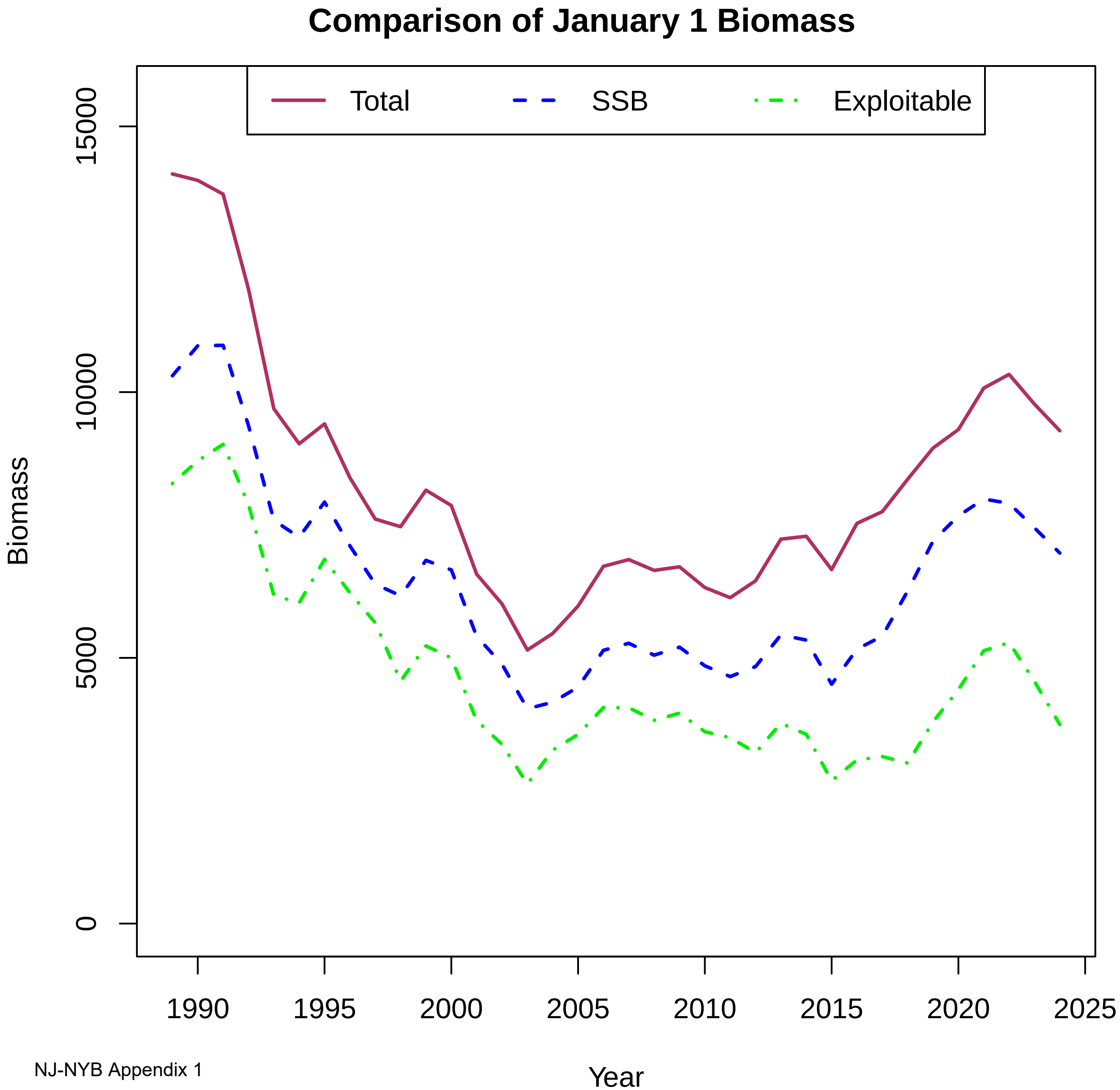

Catchability (q +/− 2 SE)
0.0000
0.0005
0.0010
0.0015
0.0020
NY seine
NJ trawl
MRIP

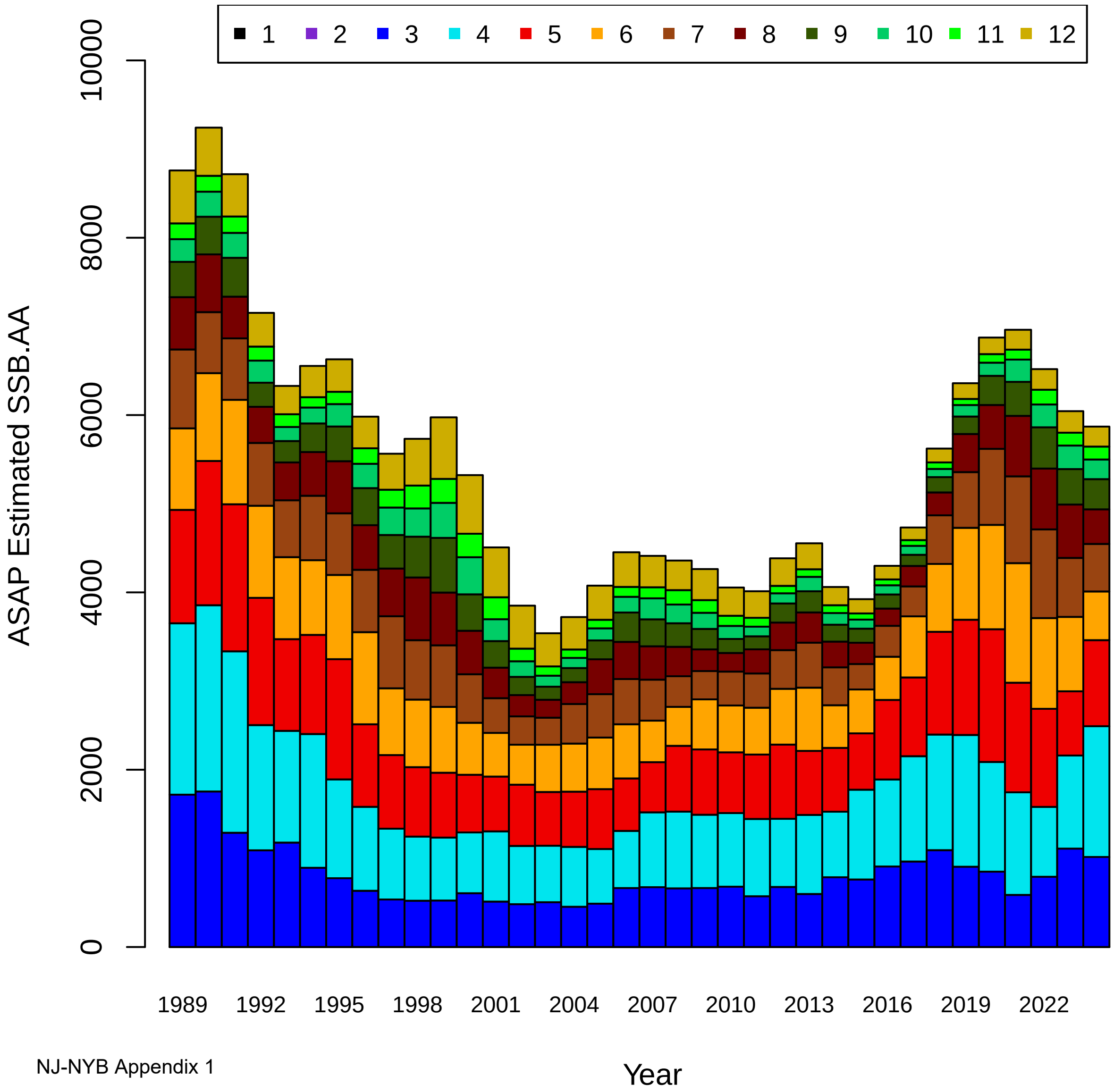


10000
6000
2000
0
SSB
1990
1995
2000
2005
2010
2015
2020
2025
Year

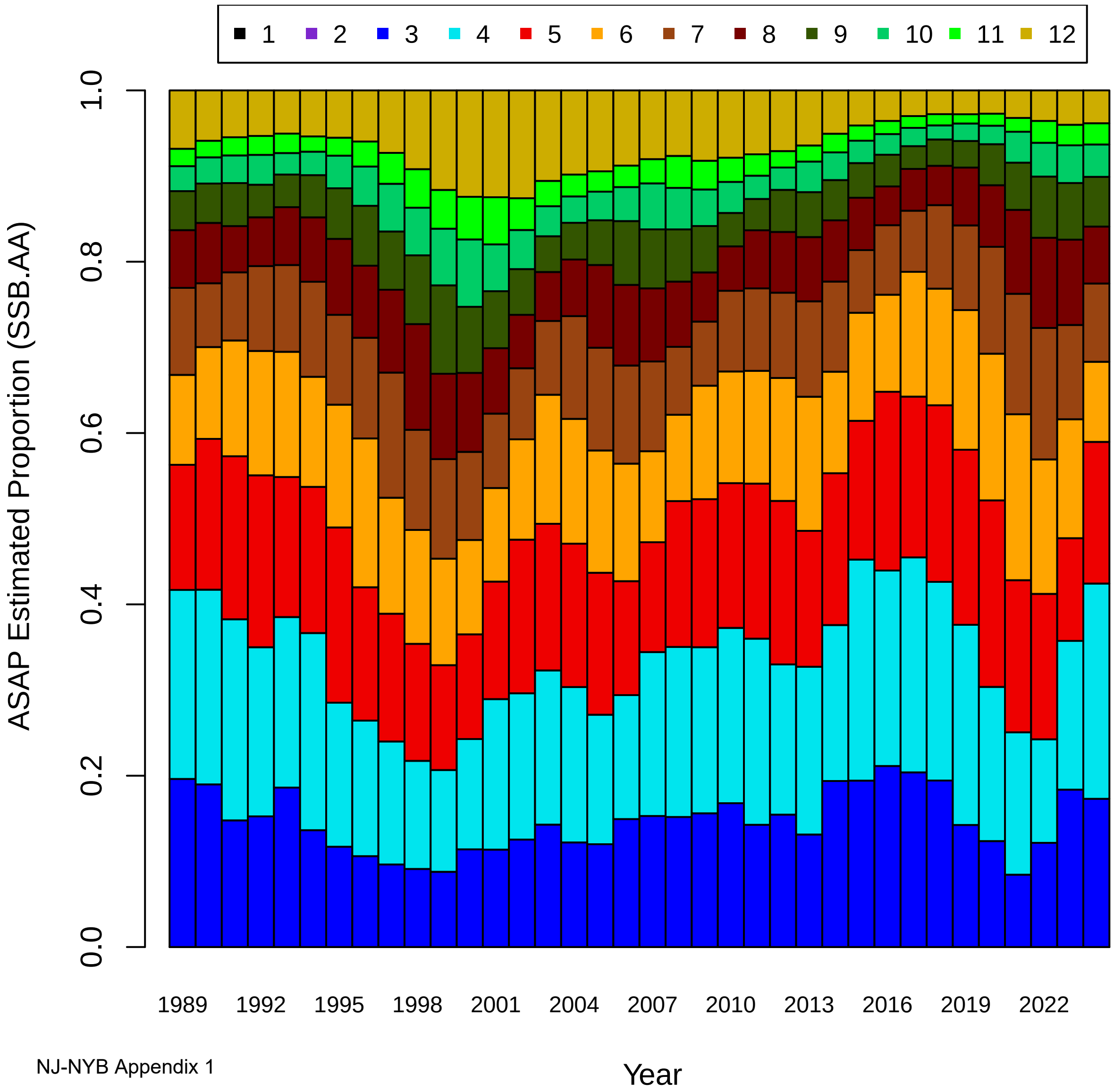


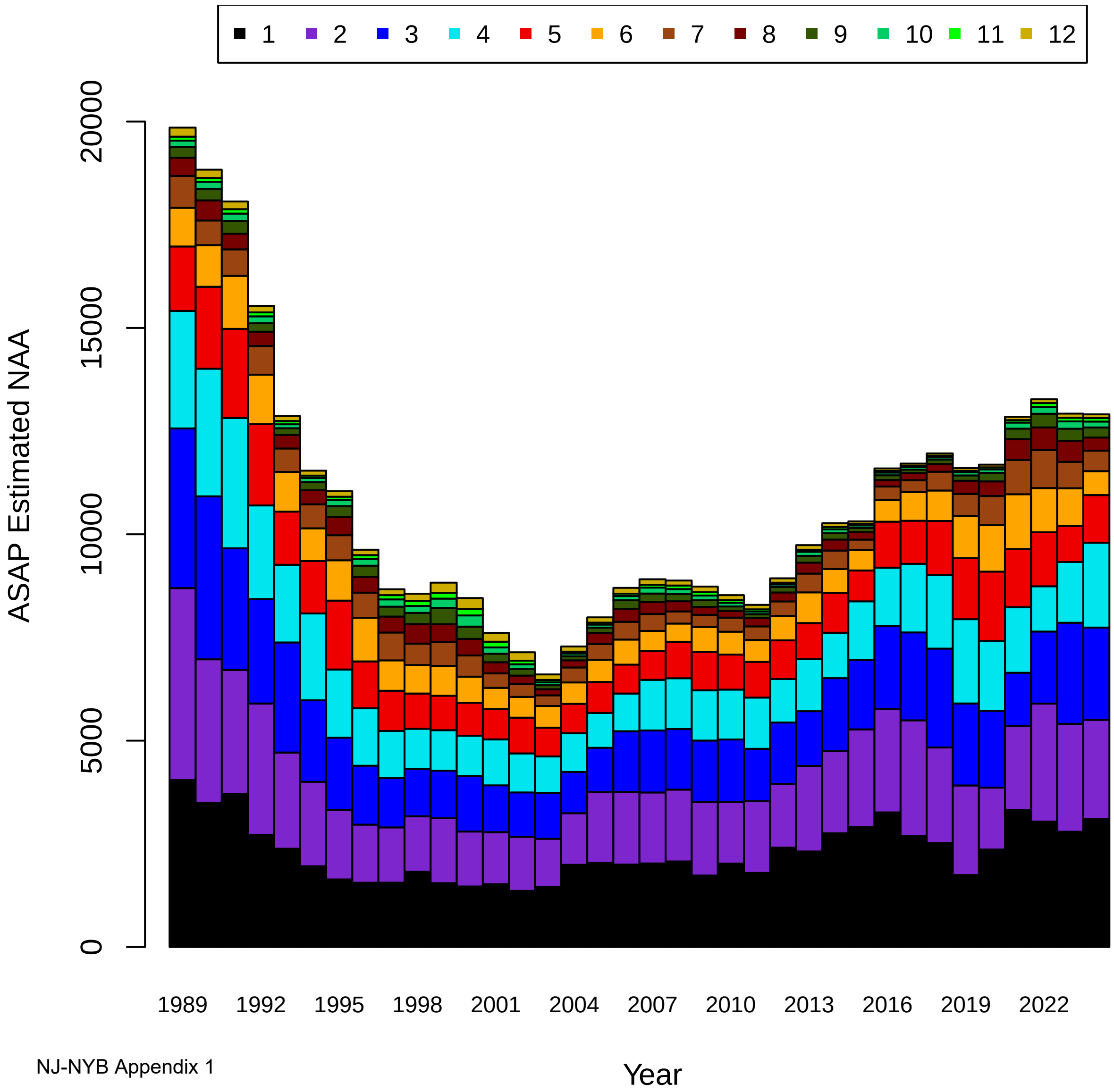
F.report
F.full
1.0
0.8
0.6
0.4
0.2
0.0
Fishing Mortality
1990
1995
2000
2005
2010
2015
2020
2025
Year

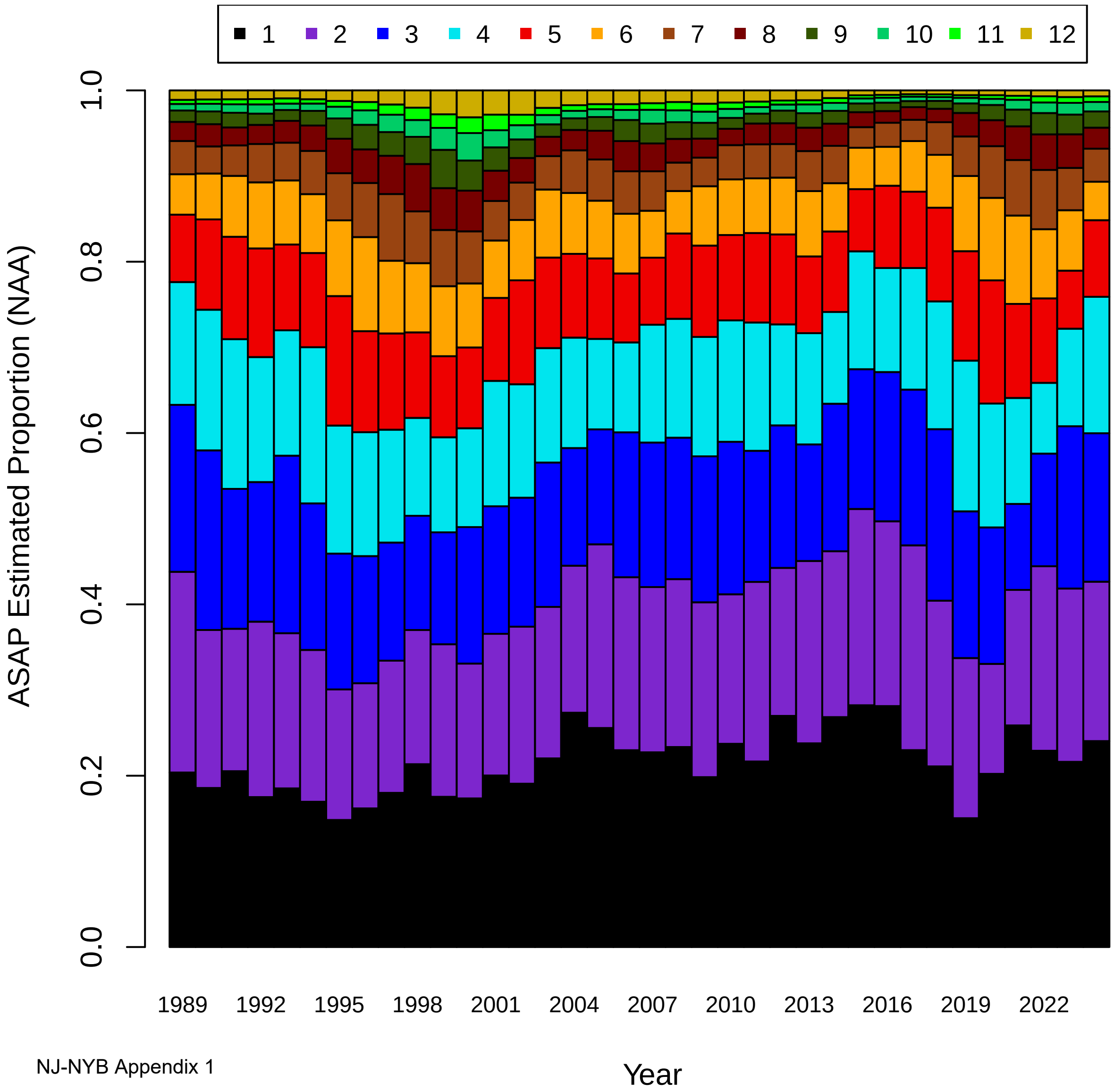

Comparison of January 1 Biomass
Total
SSB
Exploitable
Biomass
0
5000
10000
15000
1990
1995
2000
2005
2010
2015
2020
2025
Year

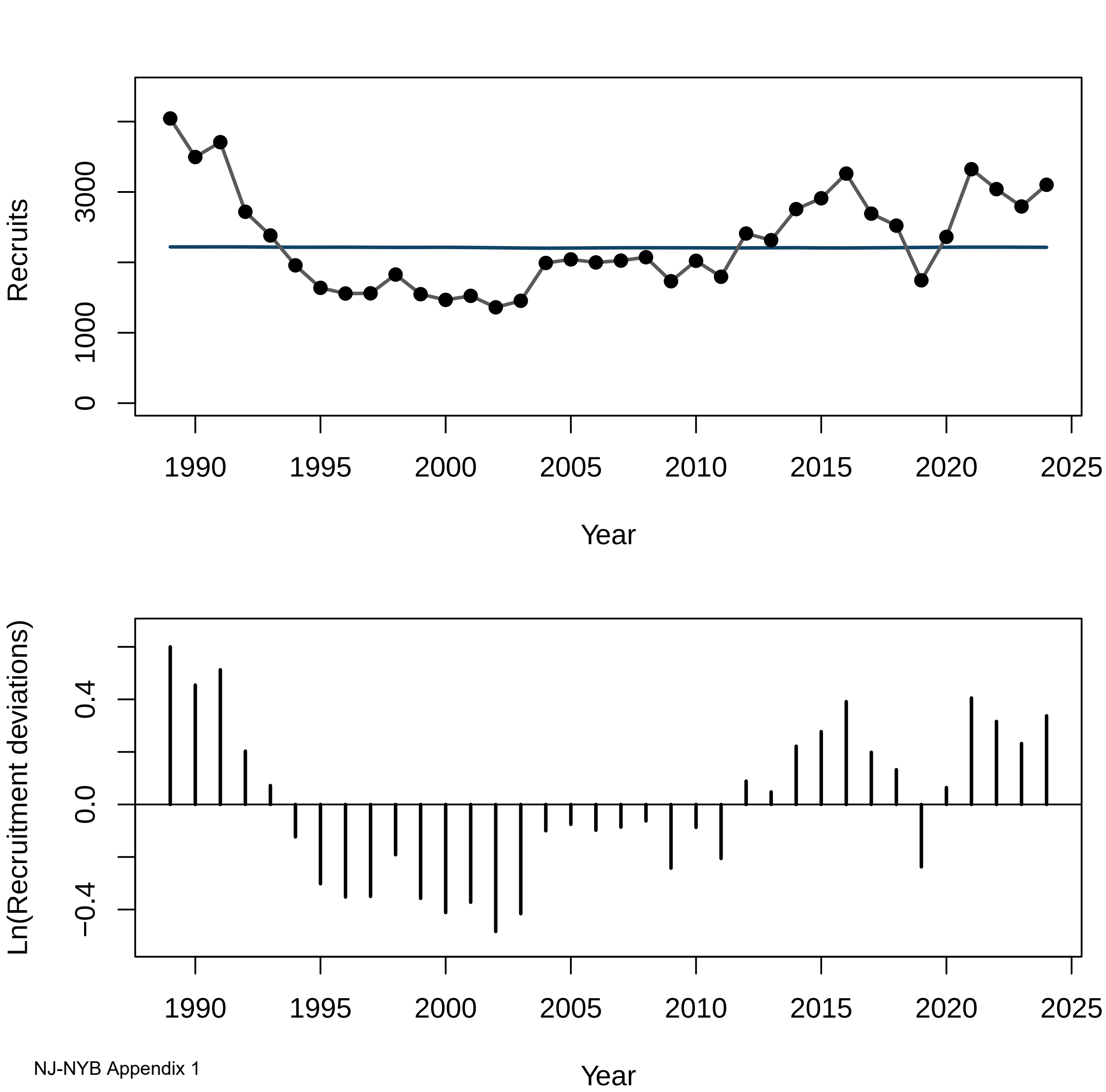


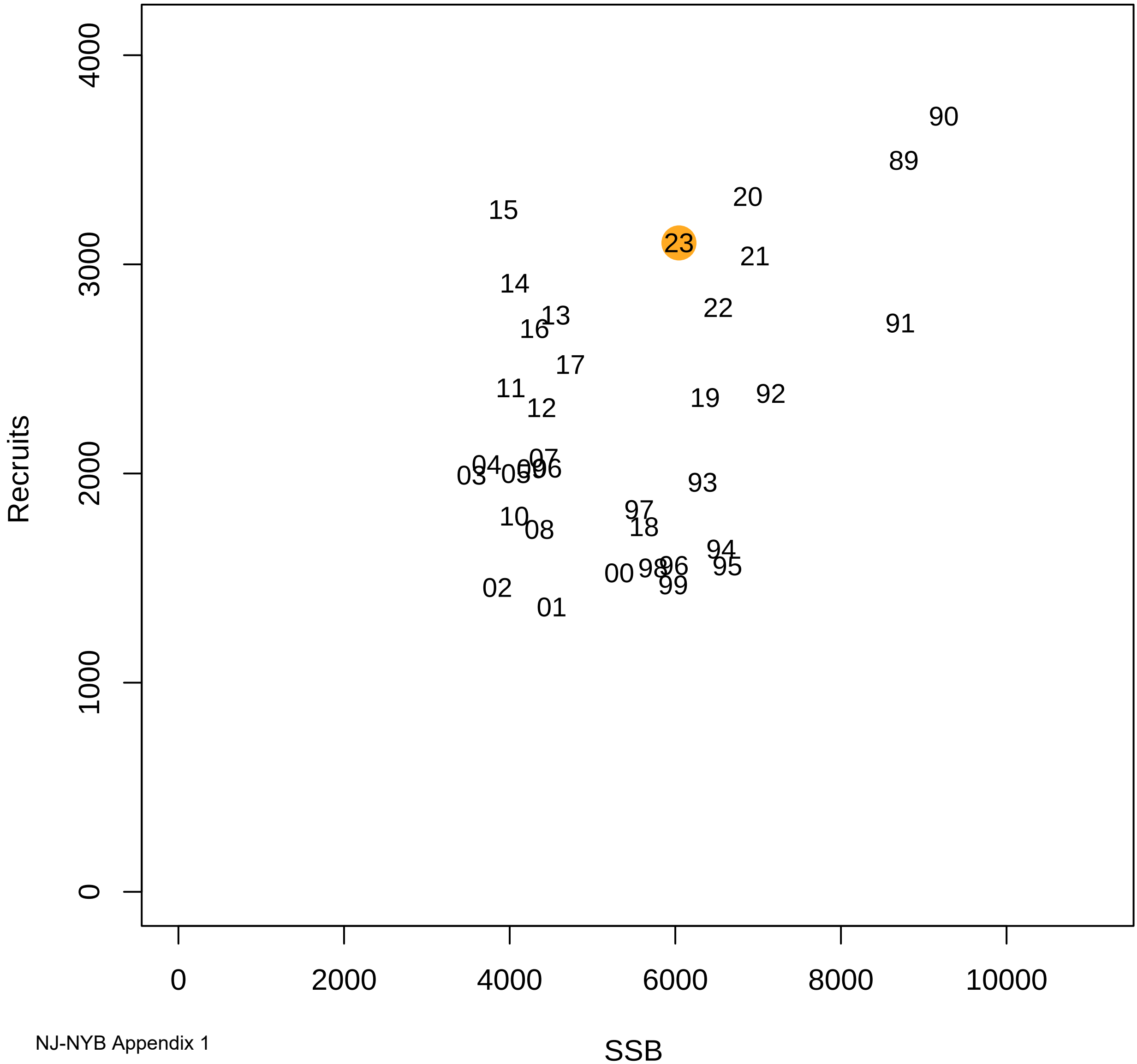
1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated SSB.AA
0
2000
4000
6000
8000
10000
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022
Year


1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated Proportion (SSB.AA)
0.0
0.2
0.4
0.6
0.8
1.0
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022
Year

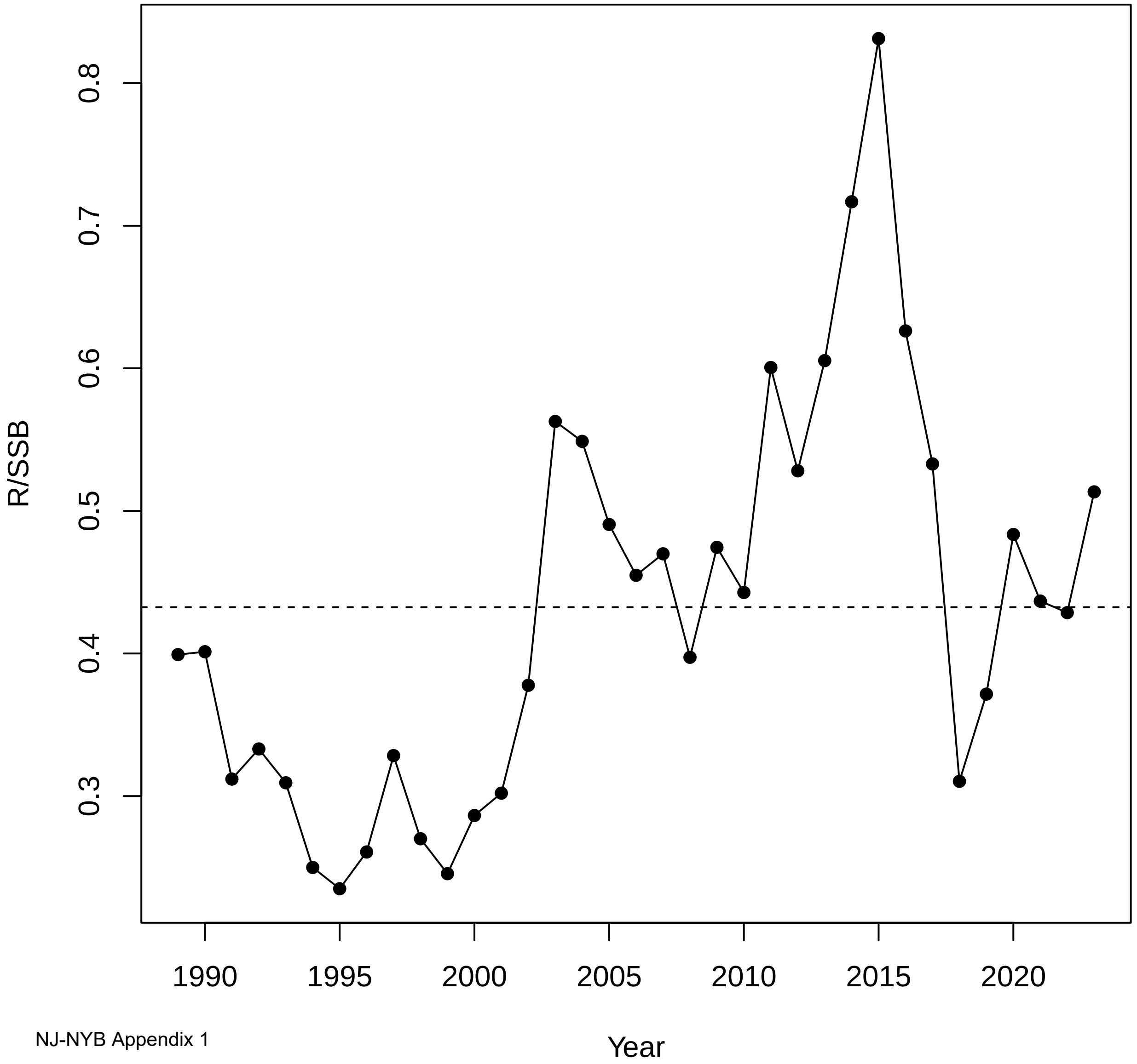

1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated NAA
0
5000
10000
15000
20000
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022
Year

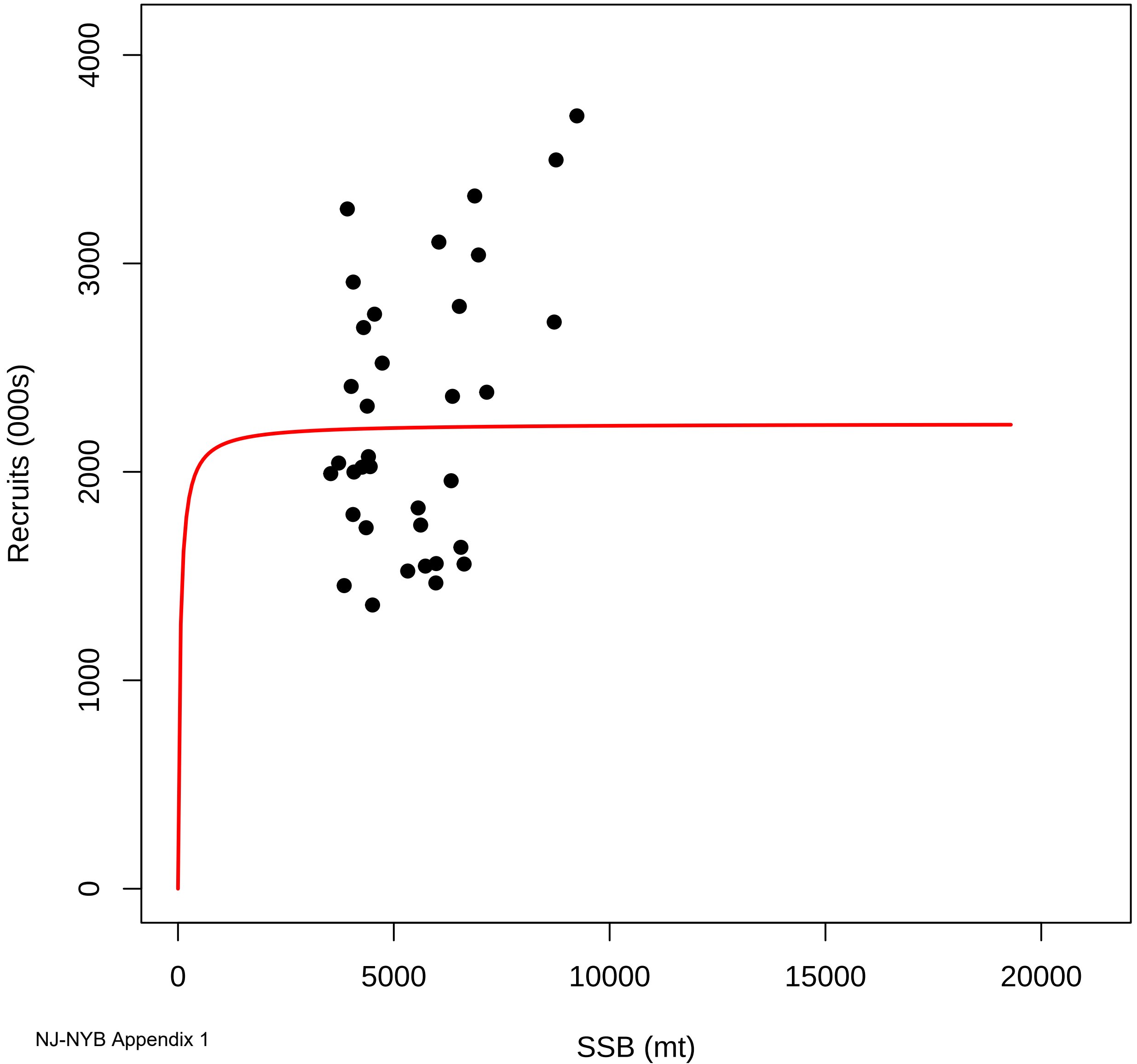

1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated Proportion (NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022
Year

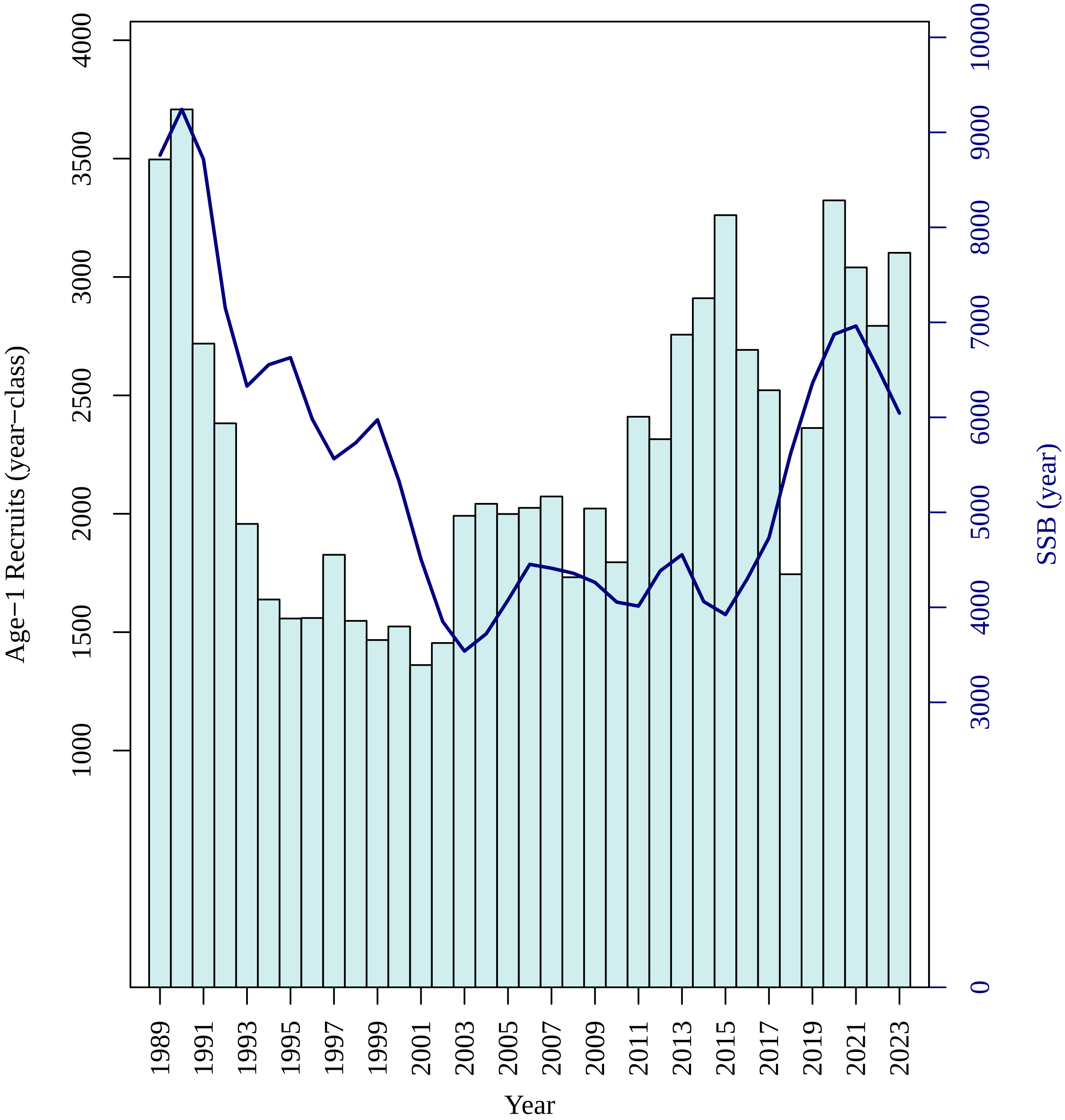

Recruits
0
1000
3000
1990
1995
2000
2005
2010
2015
2020
2025
Year
Ln(Recruitment deviations)
−0.4
0.0
0.4
1990
1995
2000
2005
2010
2015
2020
2025
Year



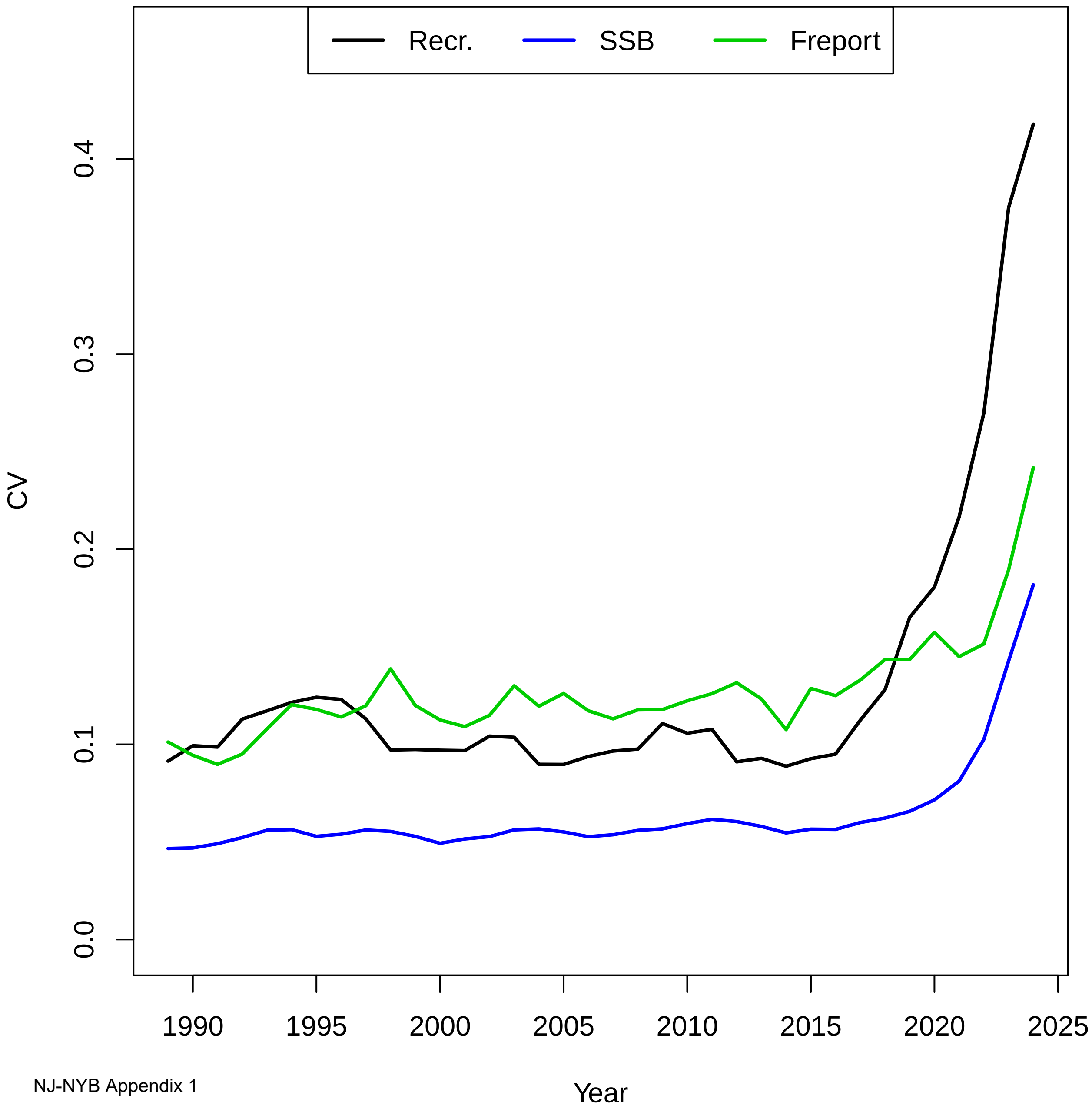
Recruits
SSB
0
1000
2000
3000
4000
0
2000
4000
6000
8000
10000
90
89
20
15
23
21
14
22
13
16
91
17
11
19
92
12
07
04
06
03
05
09
93
97
10
18
08
94
96
95
00
98
99
02
01

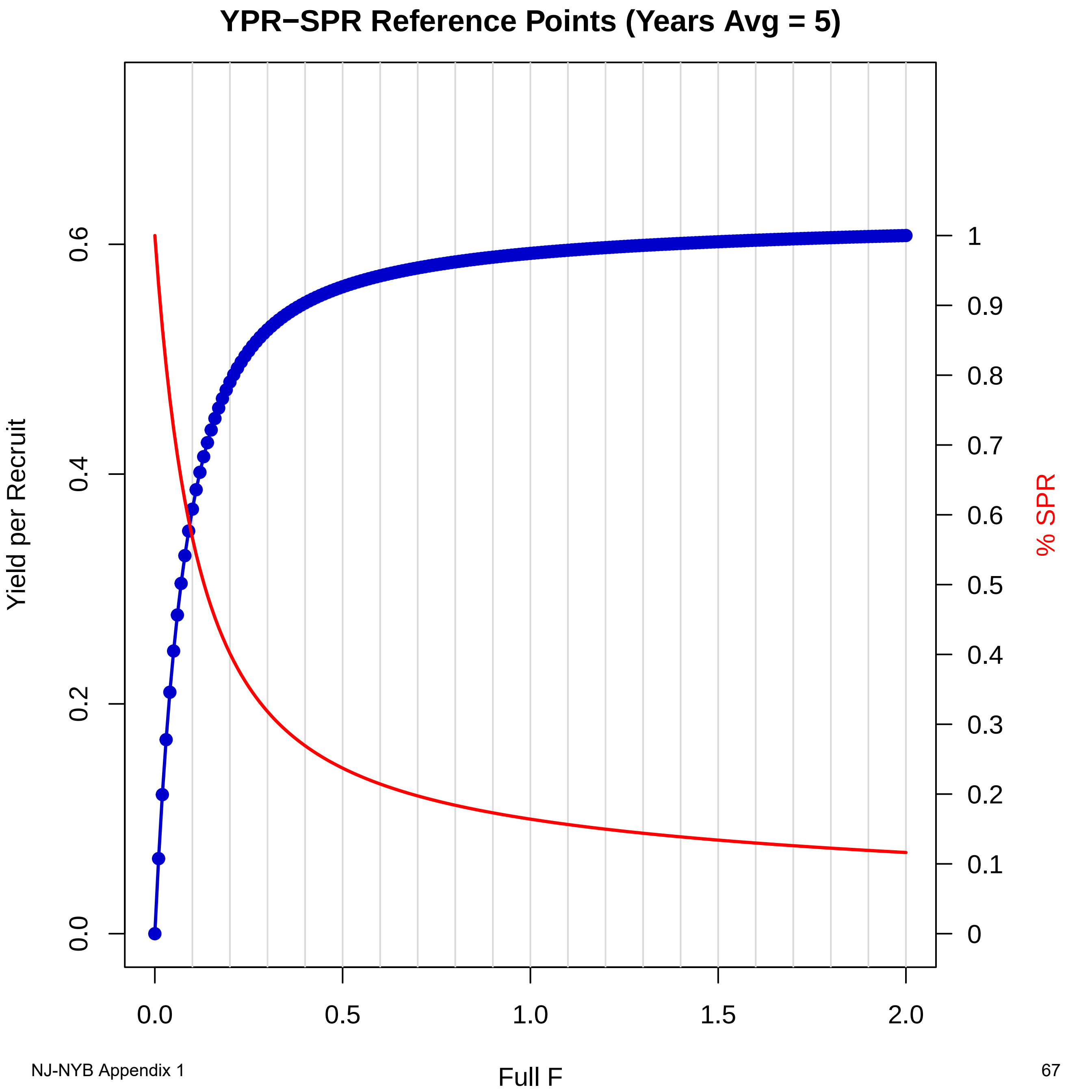

R/SSB
0.3
0.4
0.5
0.6
0.7
0.8
1990
1995
2000
2005
2010
2015
2020
Year


Recruits (000s)
0
1000
2000
3000
4000
0
5000
10000
15000
20000
SSB (mt)



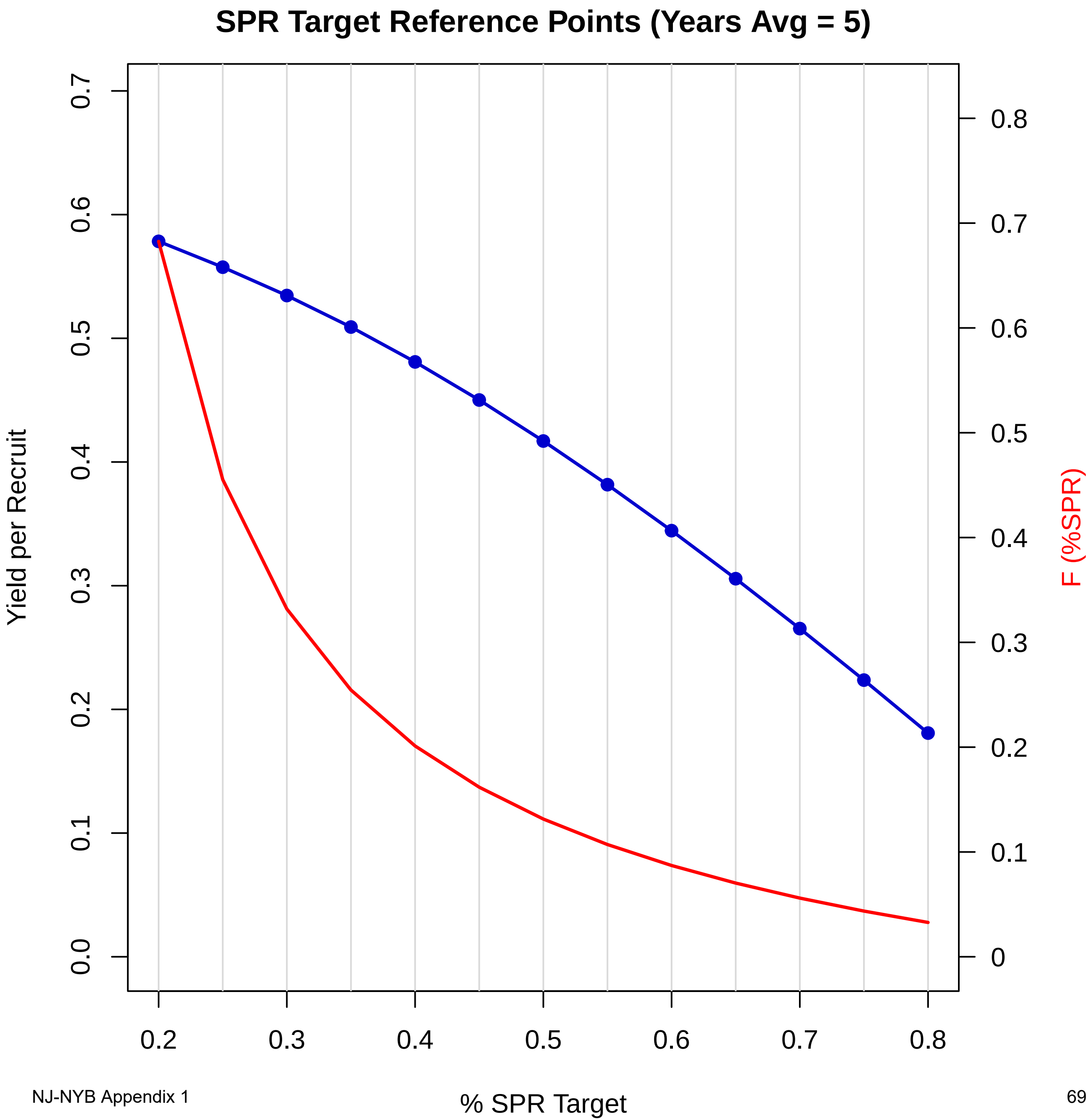
Age−1 Recruits (year−class)
4000
3500
3000
2500
2000
1500
1000
SSB (year)
10000
9000
8000
7000
6000
5000
4000
3000
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
Year


Recr.
SSB
Freport
0.0
0.1
0.2
0.3
0.4
CV
1990
1995
2000
2005
2010
2015
2020
2025
Year


YPR−SPR Reference Points (Years Avg = 5)
Yield per Recruit
% SPR
Full F
0.0
0.2
0.4
0.6
0.5
1.0
1.5
2.0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

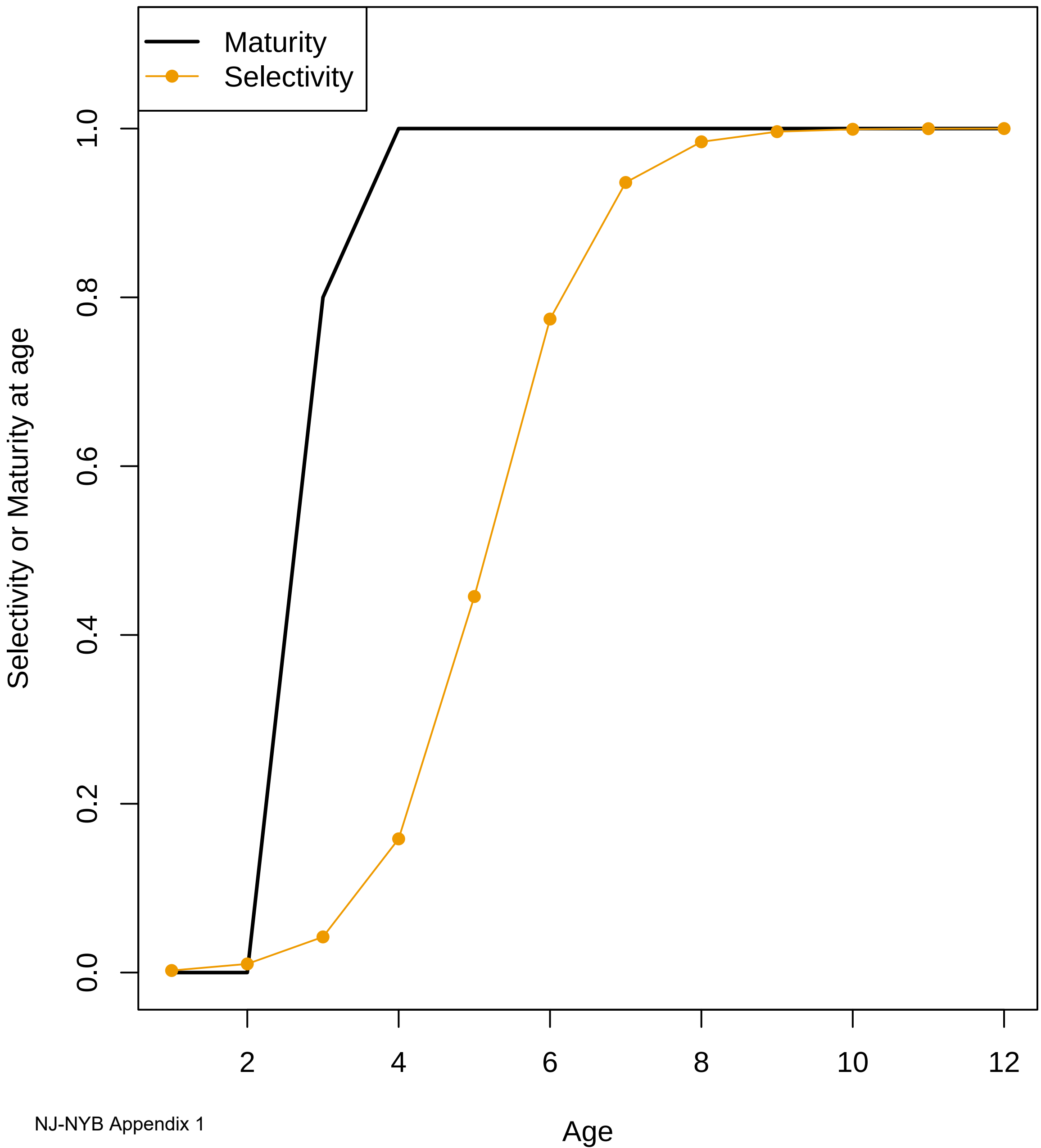
YPR−SPR Reference Points (Years Avg = 5)

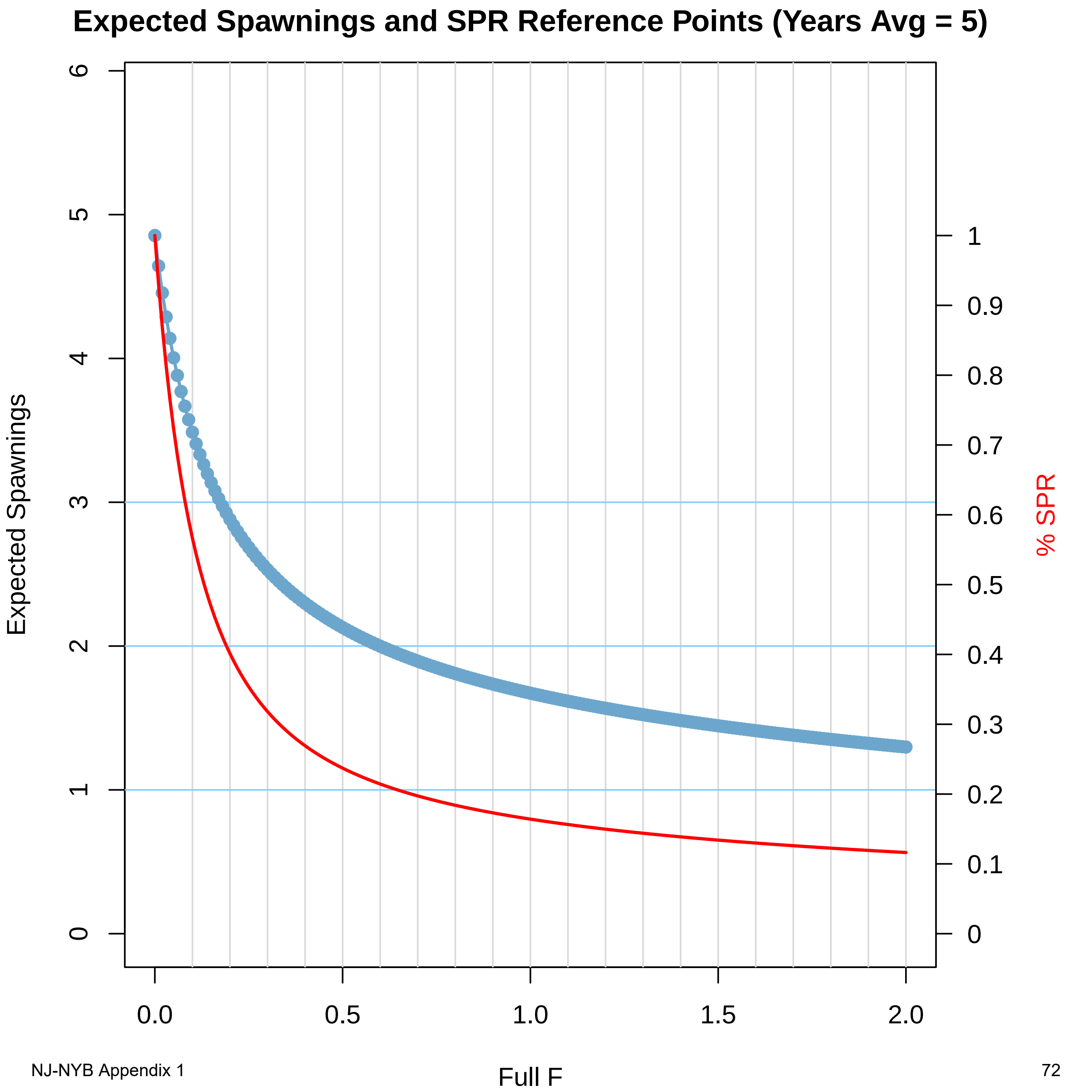
F	YPR	SPR	F	YPR	SPR	F	YPR	SPR
0	0	1	0.35	0.5389	0.2909	0.7	0.5794	0.1973
0.01	0.0653	0.9295	0.36	0.5412	0.2861	0.71	0.58	0.1959
0.02	0.121	0.8679	0.37	0.5433	0.2816	0.72	0.5806	0.1944
0.03	0.1689	0.8138	0.38	0.5453	0.2773	0.73	0.5811	0.193
0.04	0.2102	0.7659	0.39	0.5472	0.2732	0.74	0.5817	0.1916
0.05	0.246	0.7233	0.4	0.549	0.2692	0.75	0.5822	0.1903
0.06	0.2774	0.6853	0.41	0.5507	0.2654	0.76	0.5827	0.189
0.07	0.3048	0.651	0.42	0.5523	0.2618	0.77	0.5832	0.1877
0.08	0.329	0.6201	0.43	0.5539	0.2583	0.78	0.5837	0.1864
0.09	0.3504	0.5921	0.44	0.5553	0.2549	0.79	0.5842	0.1852
0.1	0.3695	0.5667	0.45	0.5568	0.2517	0.8	0.5847	0.184
0.11	0.3864	0.5434	0.46	0.5581	0.2485	0.81	0.5851	0.1828
0.12	0.4016	0.5222	0.47	0.5594	0.2455	0.82	0.5856	0.1816
0.13	0.4151	0.5026	0.48	0.5607	0.2426	0.83	0.586	0.1805
0.14	0.4274	0.4846	0.49	0.5619	0.2398	0.84	0.5864	0.1794
0.15	0.4384	0.468	0.5	0.563	0.2371	0.85	0.5868	0.1783
0.16	0.4484	0.4527	0.51	0.5642	0.2345	0.86	0.5872	0.1772
0.17	0.4575	0.4384	0.52	0.5652	0.232	0.87	0.5876	0.1761
0.18	0.4657	0.4252	0.53	0.5663	0.2295	0.88	0.588	0.1751
0.19	0.4733	0.4128	0.54	0.5672	0.2272	0.89	0.5884	0.1741
0.2	0.4802	0.4013	0.55	0.5682	0.2249	0.9	0.5888	0.1731
0.21	0.4865	0.3905	0.56	0.5691	0.2227	0.91	0.5891	0.1721
0.22	0.4923	0.3804	0.57	0.57	0.2205	0.92	0.5895	0.1712
0.23	0.4976	0.3709	0.58	0.5709	0.2184	0.93	0.5898	0.1702
0.24	0.5026	0.362	0.59	0.5717	0.2164	0.94	0.5902	0.1693
0.25	0.5071	0.3536	0.6	0.5725	0.2144	0.95	0.5905	0.1684
0.26	0.5114	0.3457	0.61	0.5733	0.2125	0.96	0.5908	0.1675
0.27	0.5153	0.3383	0.62	0.5741	0.2106	0.97	0.5912	0.1666
0.28	0.519	0.3312	0.63	0.5748	0.2088	0.98	0.5915	0.1658
0.29	0.5224	0.3245	0.64	0.5755	0.207	0.99	0.5918	0.1649
0.3	0.5256	0.3182	0.65	0.5762	0.2053	1	0.5921	0.1641
0.31	0.5286	0.3121	0.66	0.5769	0.2036	1.01	0.5924	0.1632
0.32	0.5315	0.3064	0.67	0.5776	0.202	1.02	0.5927	0.1624
0.33	0.5341	0.301	0.68	0.5782	0.2004	1.03	0.593	0.1616
0.34	0.5366	0.2958	0.69	0.5788	0.1989	1.04	0.5932	0.1608


SPR Target Reference Points (Years Avg = 5)
Yield per Recruit
F (%SPR)
% SPR Target
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

SPR Target Reference Points (Years Avg = 5)

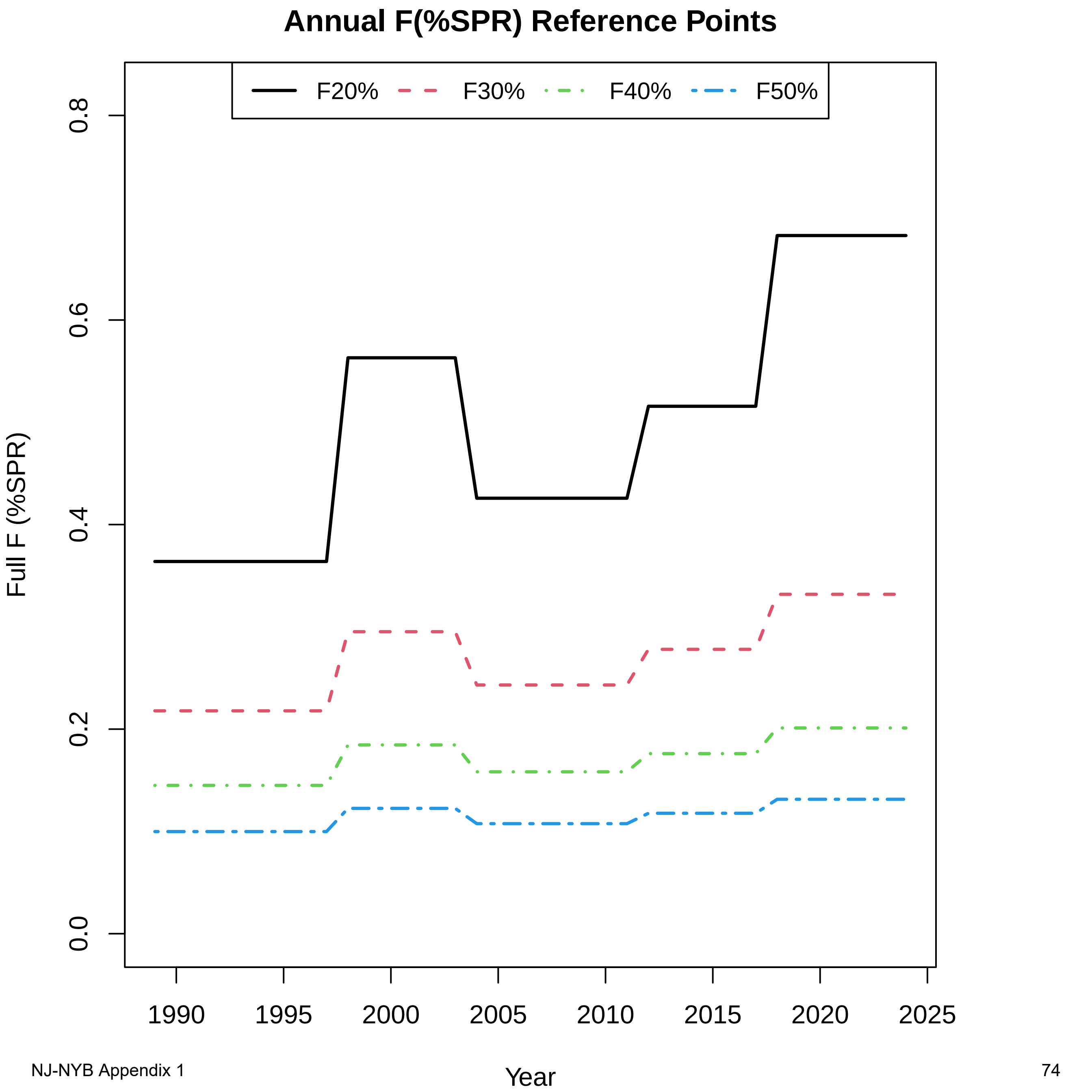
% SPR	F(%SPR)	YPR
0.2	0.6826	0.5784
0.25	0.4553	0.5575
0.3	0.3319	0.5346
0.35	0.2545	0.5091
0.4	0.2012	0.4809
0.45	0.1618	0.4501
0.5	0.1314	0.417
0.55	0.1071	0.3817
0.6	0.0871	0.3445
0.65	0.0703	0.3056
0.7	0.056	0.2653
0.75	0.0436	0.2237
0.8	0.0328	0.1809

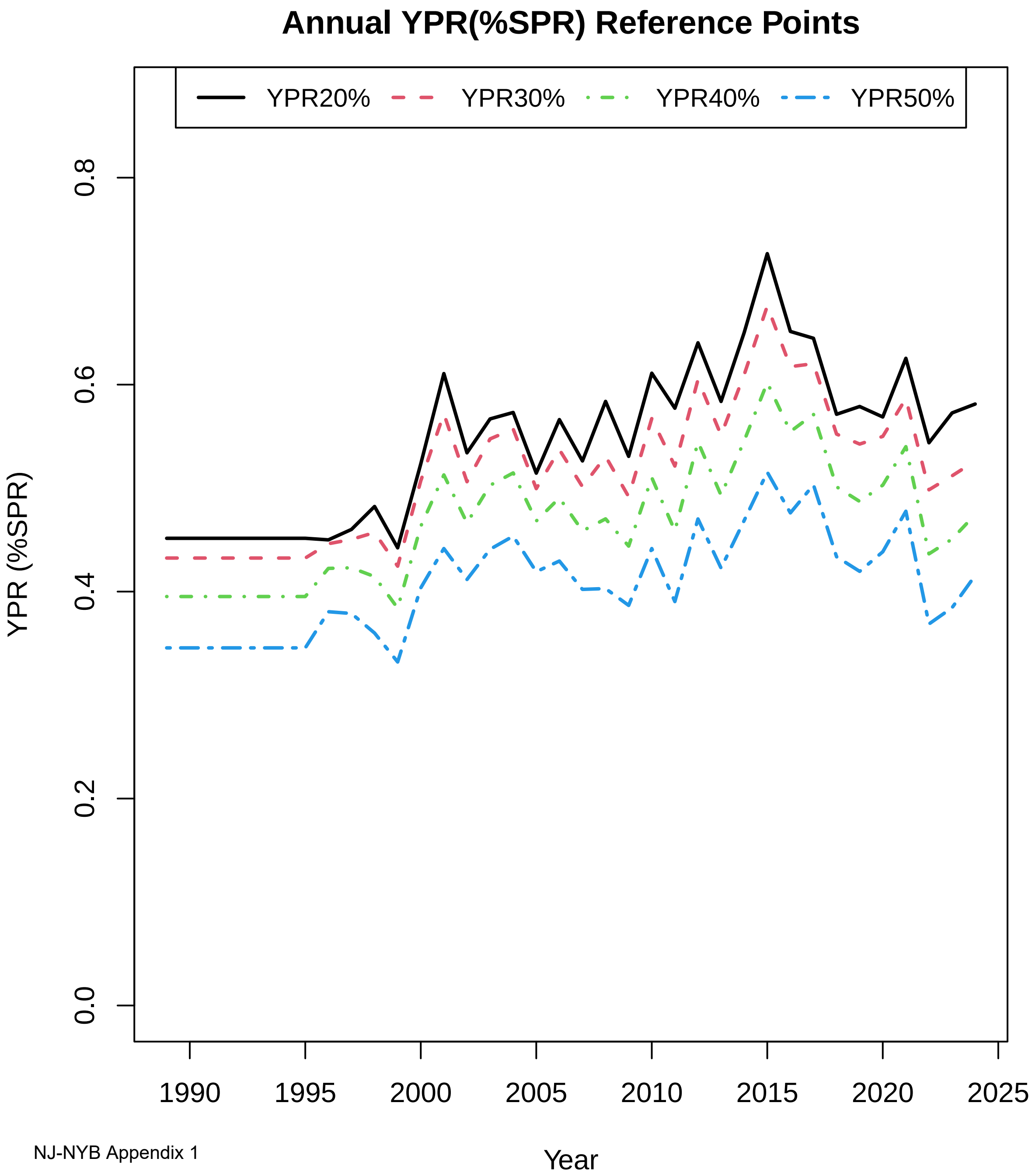

Maturity
Selectivity
Selectivity or Maturity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
Age

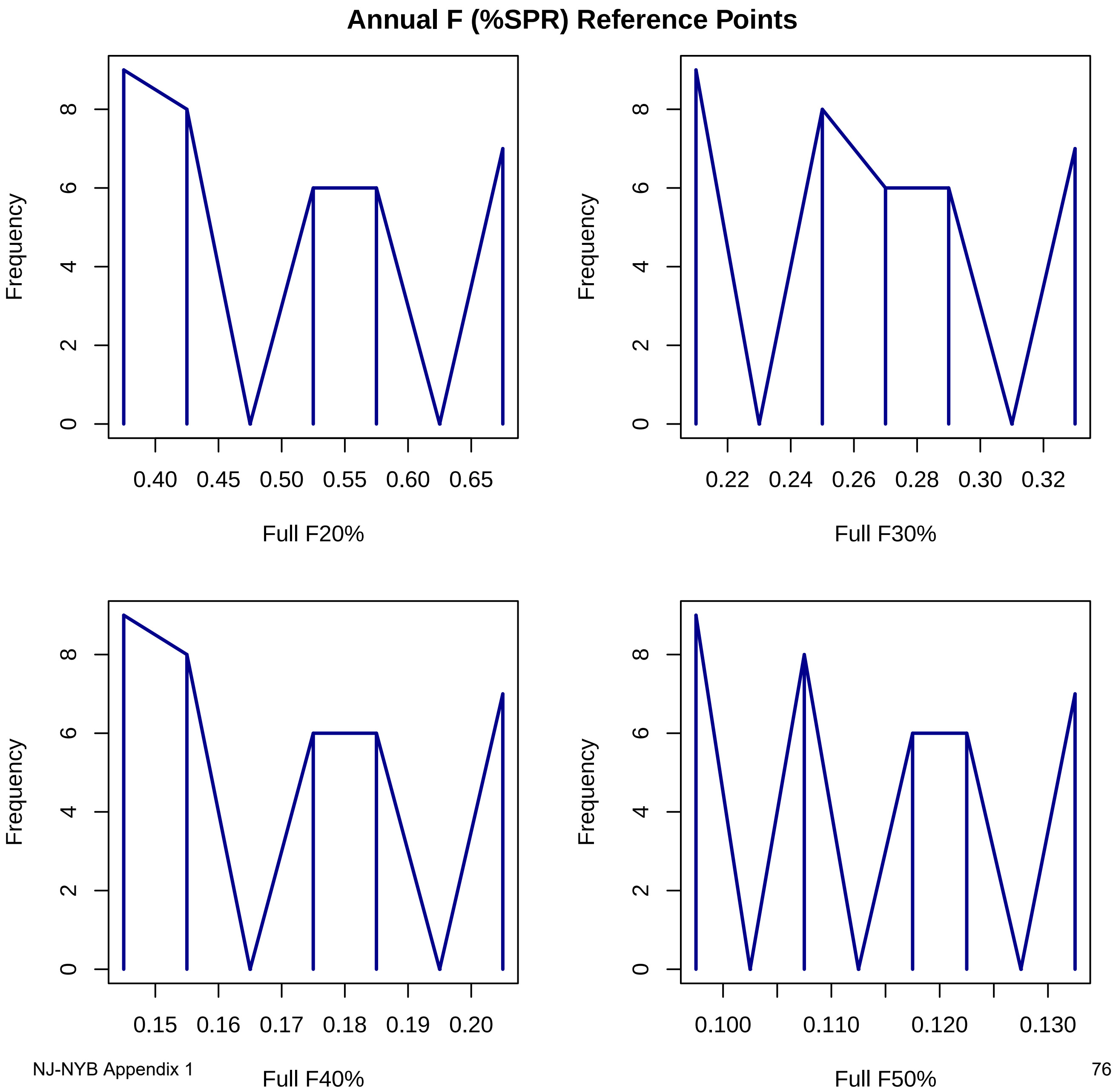

Expected Spawnings and SPR Reference Points (Years Avg = 5)
Expected Spawnings
% SPR
Full F
0
1
2
3
4
5
6
0.0
0.5
1.0
1.5
2.0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Expected Spawnings & SPR Reference Points (Years Avg = 5)

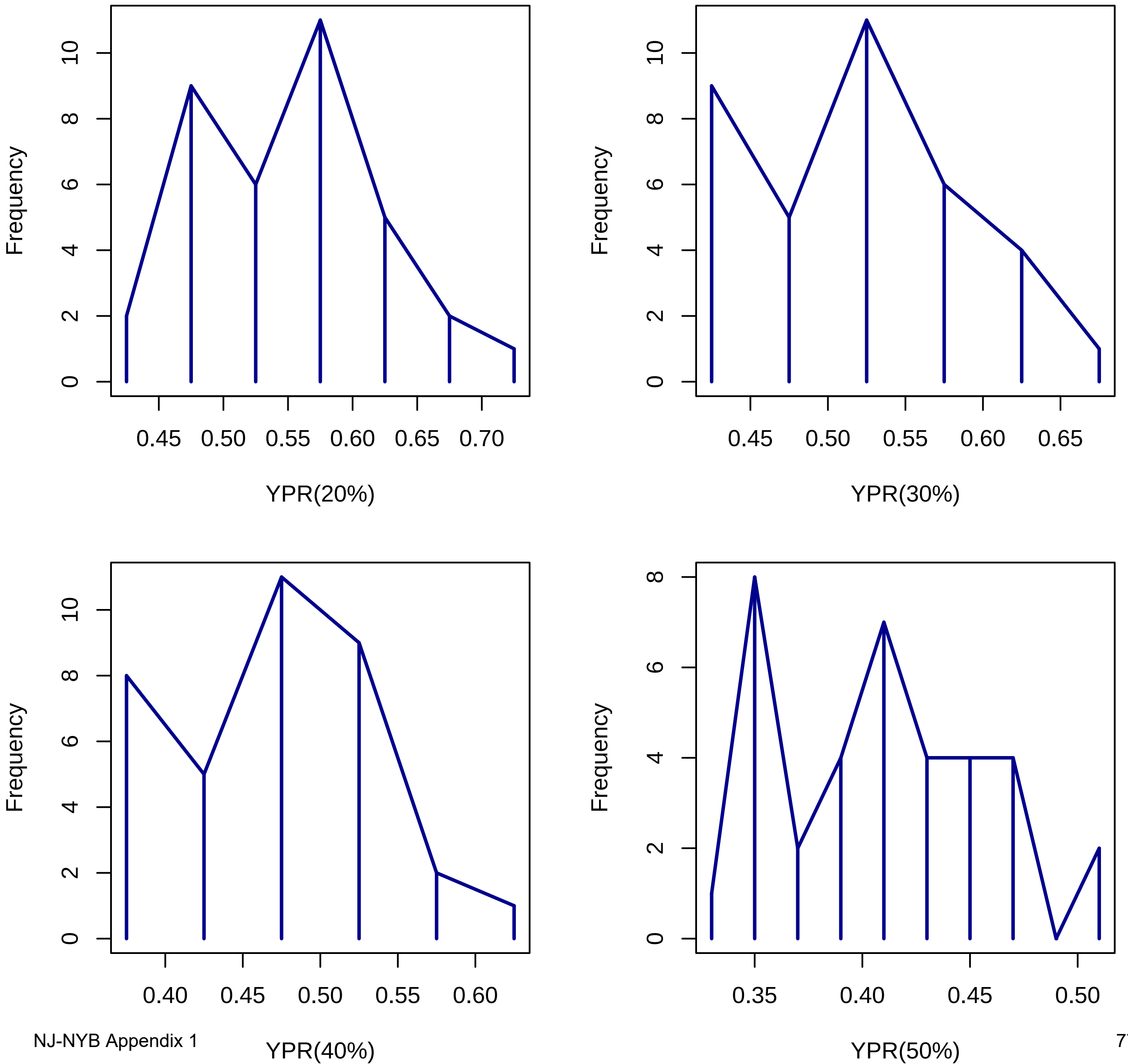
F	E[Sp]	SPR	F	E[Sp]	SPR	F	E[Sp]	SPR
0	4.8546	1	0.35	2.4042	0.2909	0.7	1.8952	0.1973
0.01	4.643	0.9295	0.36	2.3815	0.2861	0.71	1.8858	0.1959
0.02	4.4559	0.8679	0.37	2.3596	0.2816	0.72	1.8767	0.1944
0.03	4.2891	0.8138	0.38	2.3384	0.2773	0.73	1.8677	0.193
0.04	4.1395	0.7659	0.39	2.3179	0.2732	0.74	1.8588	0.1916
0.05	4.0045	0.7233	0.4	2.2981	0.2692	0.75	1.8501	0.1903
0.06	3.882	0.6853	0.41	2.2789	0.2654	0.76	1.8416	0.189
0.07	3.7703	0.651	0.42	2.2602	0.2618	0.77	1.8332	0.1877
0.08	3.6679	0.6201	0.43	2.2422	0.2583	0.78	1.825	0.1864
0.09	3.5739	0.5921	0.44	2.2246	0.2549	0.79	1.8169	0.1852
0.1	3.487	0.5667	0.45	2.2076	0.2517	0.8	1.8089	0.184
0.11	3.4066	0.5434	0.46	2.191	0.2485	0.81	1.8011	0.1828
0.12	3.3319	0.5222	0.47	2.1749	0.2455	0.82	1.7933	0.1816
0.13	3.2623	0.5026	0.48	2.1593	0.2426	0.83	1.7857	0.1805
0.14	3.1973	0.4846	0.49	2.144	0.2398	0.84	1.7783	0.1794
0.15	3.1363	0.468	0.5	2.1292	0.2371	0.85	1.7709	0.1783
0.16	3.0791	0.4527	0.51	2.1147	0.2345	0.86	1.7637	0.1772
0.17	3.0253	0.4384	0.52	2.1007	0.232	0.87	1.7565	0.1761
0.18	2.9746	0.4252	0.53	2.0869	0.2295	0.88	1.7495	0.1751
0.19	2.9266	0.4128	0.54	2.0735	0.2272	0.89	1.7426	0.1741
0.2	2.8812	0.4013	0.55	2.0604	0.2249	0.9	1.7357	0.1731
0.21	2.8382	0.3905	0.56	2.0476	0.2227	0.91	1.729	0.1721
0.22	2.7973	0.3804	0.57	2.0351	0.2205	0.92	1.7224	0.1712
0.23	2.7584	0.3709	0.58	2.0229	0.2184	0.93	1.7158	0.1702
0.24	2.7213	0.362	0.59	2.011	0.2164	0.94	1.7094	0.1693
0.25	2.686	0.3536	0.6	1.9993	0.2144	0.95	1.703	0.1684
0.26	2.6522	0.3457	0.61	1.9879	0.2125	0.96	1.6967	0.1675
0.27	2.62	0.3383	0.62	1.9768	0.2106	0.97	1.6905	0.1666
0.28	2.589	0.3312	0.63	1.9658	0.2088	0.98	1.6844	0.1658
0.29	2.5594	0.3245	0.64	1.9551	0.207	0.99	1.6784	0.1649
0.3	2.531	0.3182	0.65	1.9446	0.2053	1	1.6724	0.1641
0.31	2.5036	0.3121	0.66	1.9343	0.2036	1.01	1.6666	0.1632
0.32	2.4774	0.3064	0.67	1.9242	0.202	1.02	1.6608	0.1624
0.33	2.4521	0.301	0.68	1.9144	0.2004	1.03	1.655	0.1616
0.34	2.4277	0.2958	0.69	1.9047	0.1989	1.04	1.6494	0.1608

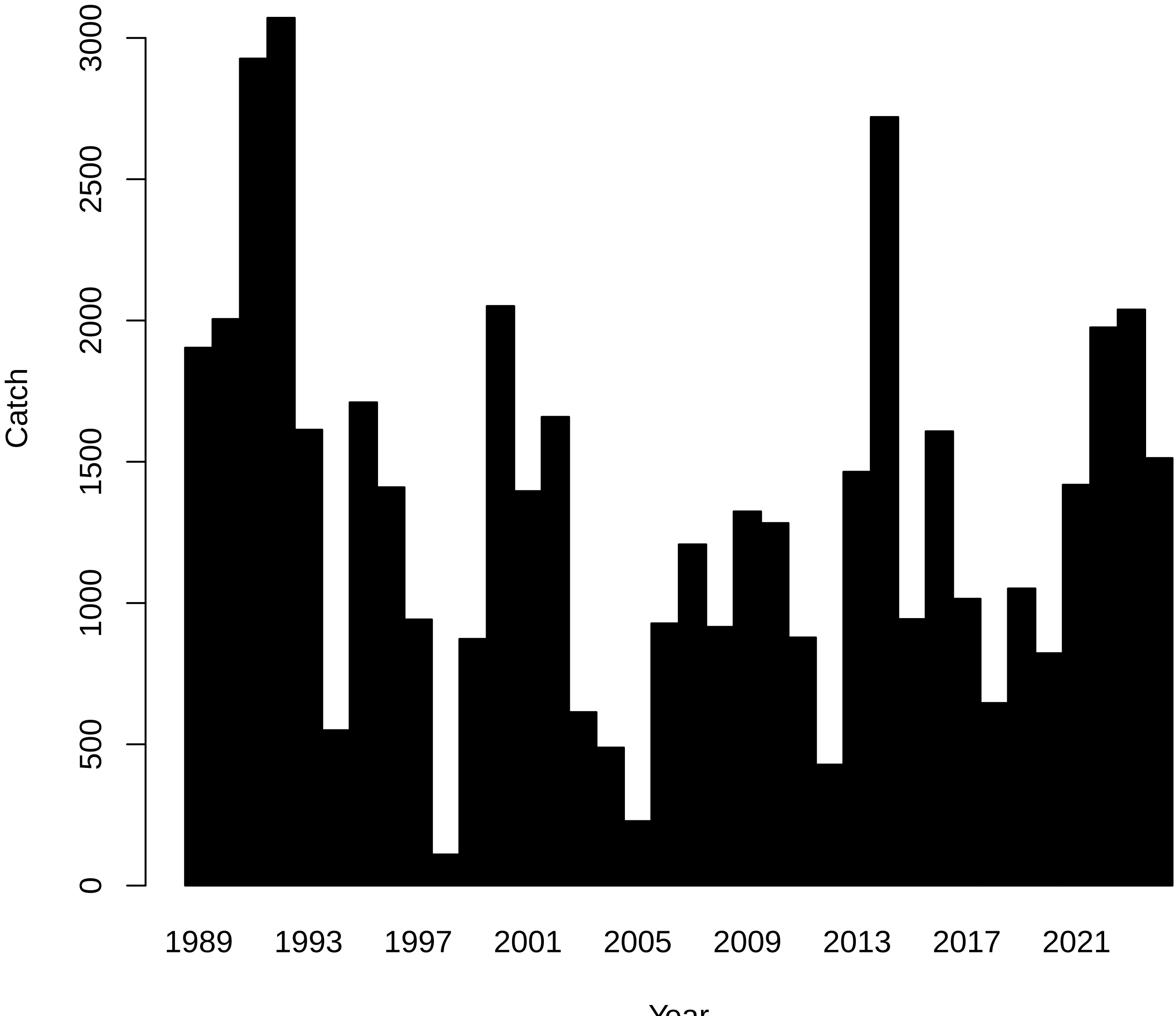

Annual F(%SPR) Reference Points
F20%
F30%
F40%
F50%
Full F (%SPR)
0.0
0.2
0.4
0.6
0.8
1990
1995
2000
2005
2010
2015
2020
2025
Year

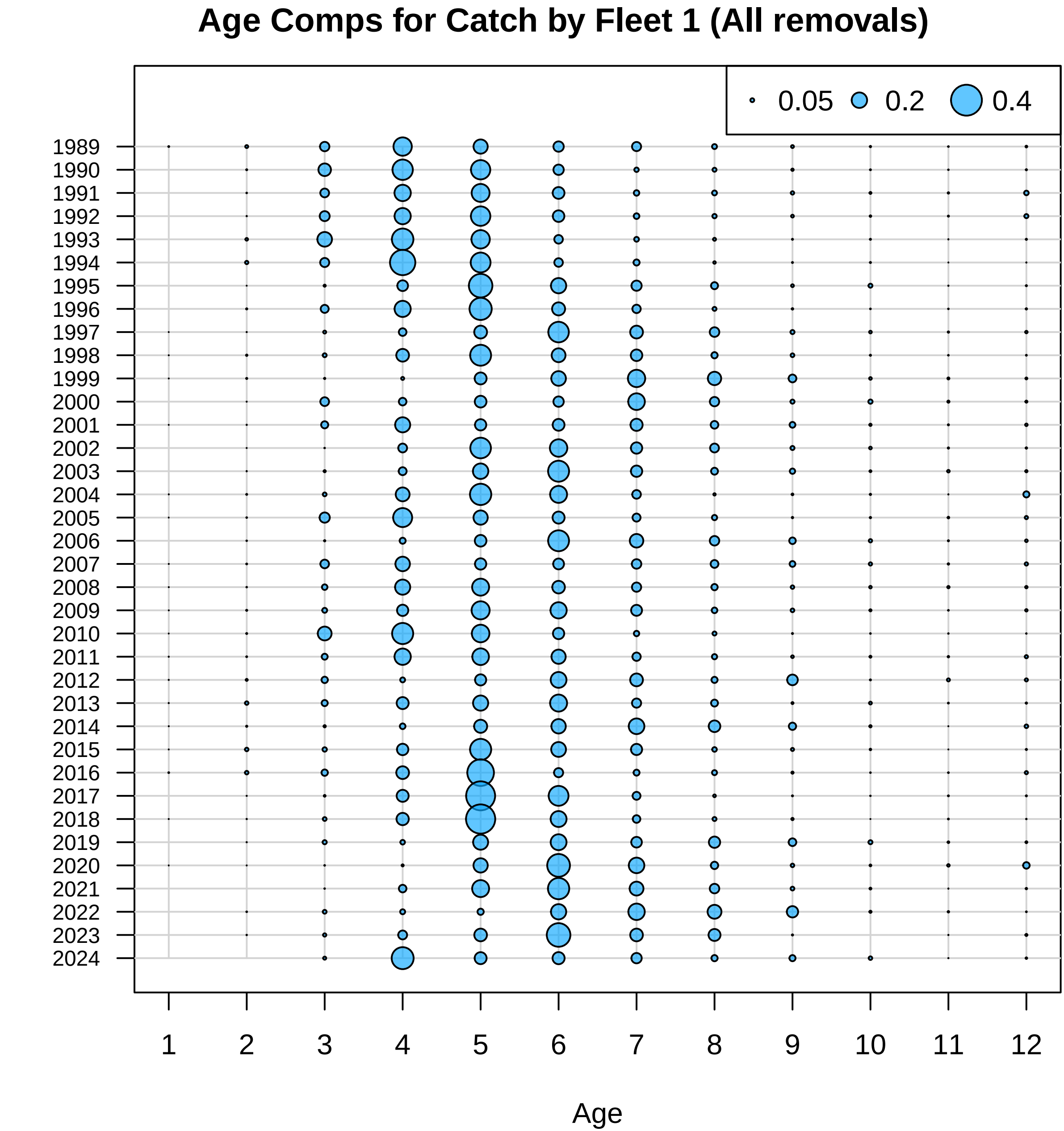

Annual YPR(%SPR) Reference Points
YPR20%
YPR30%
YPR40%
YPR50%
YPR (%SPR)
0.0
0.2
0.4
0.6
0.8
1990
1995
2000
2005
2010
2015
2020
2025
Year

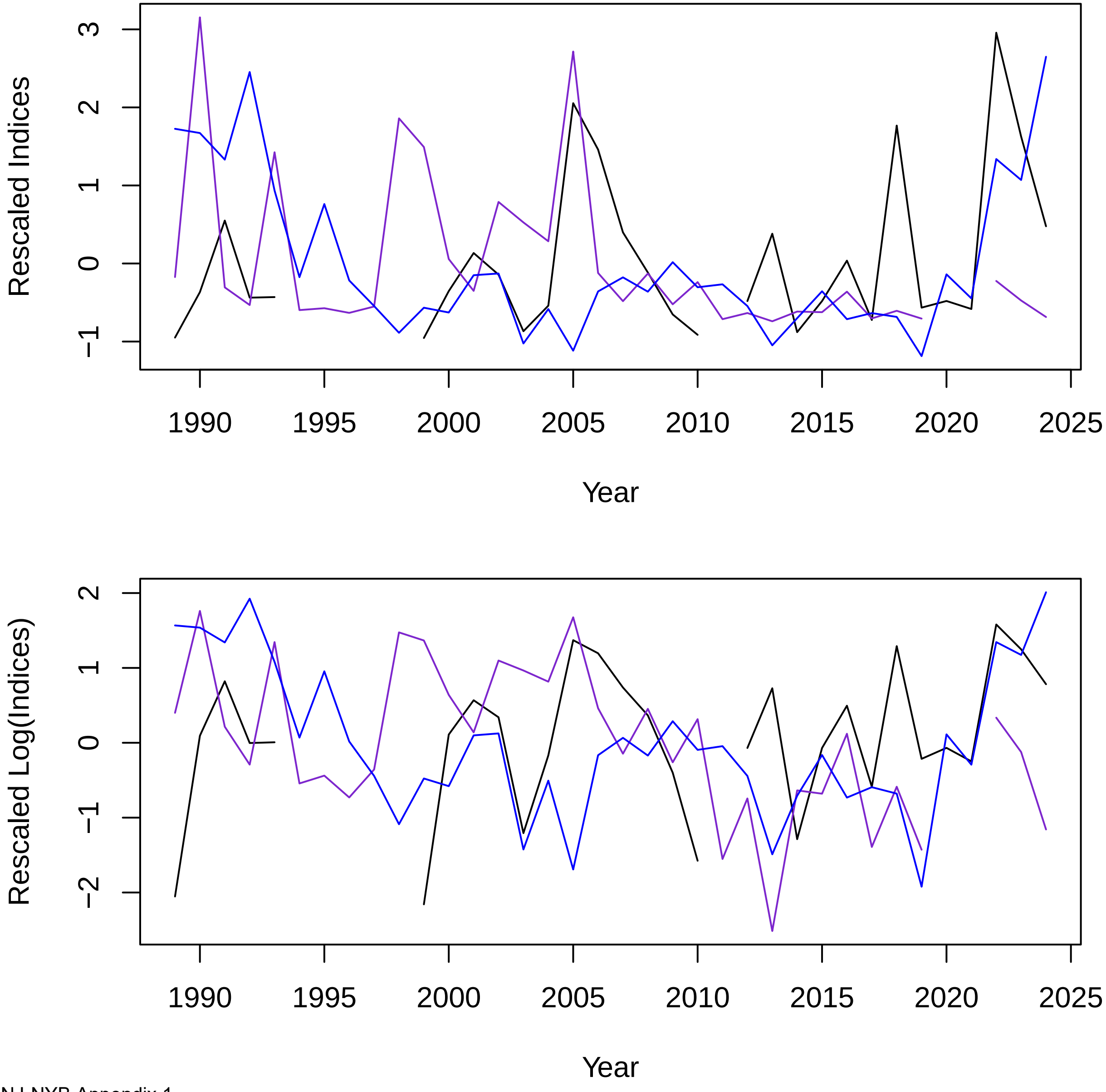

Annual F (%SPR) Reference Points
Frequency
0
2
4
6
8
0.40
0.45
0.50
0.55
0.60
0.65
Full F20%
0.22
0.24
0.26
0.28
0.30
0.32
Full F30%
0.15
0.16
0.17
0.18
0.19
0.20
Full F40%
0.100
0.110
0.120
0.130
Full F50%

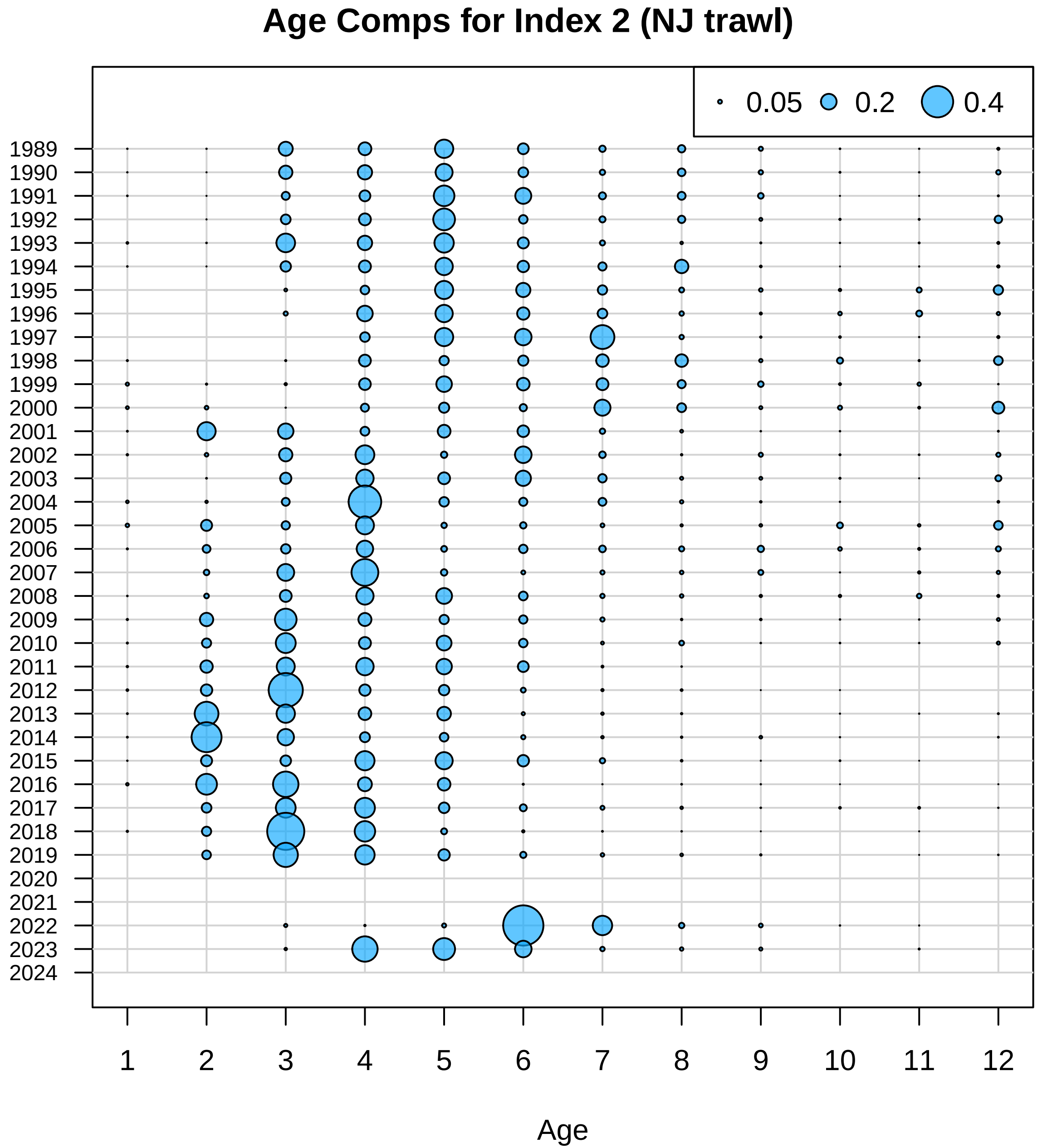
Annual YPR (%SPR) Reference Points

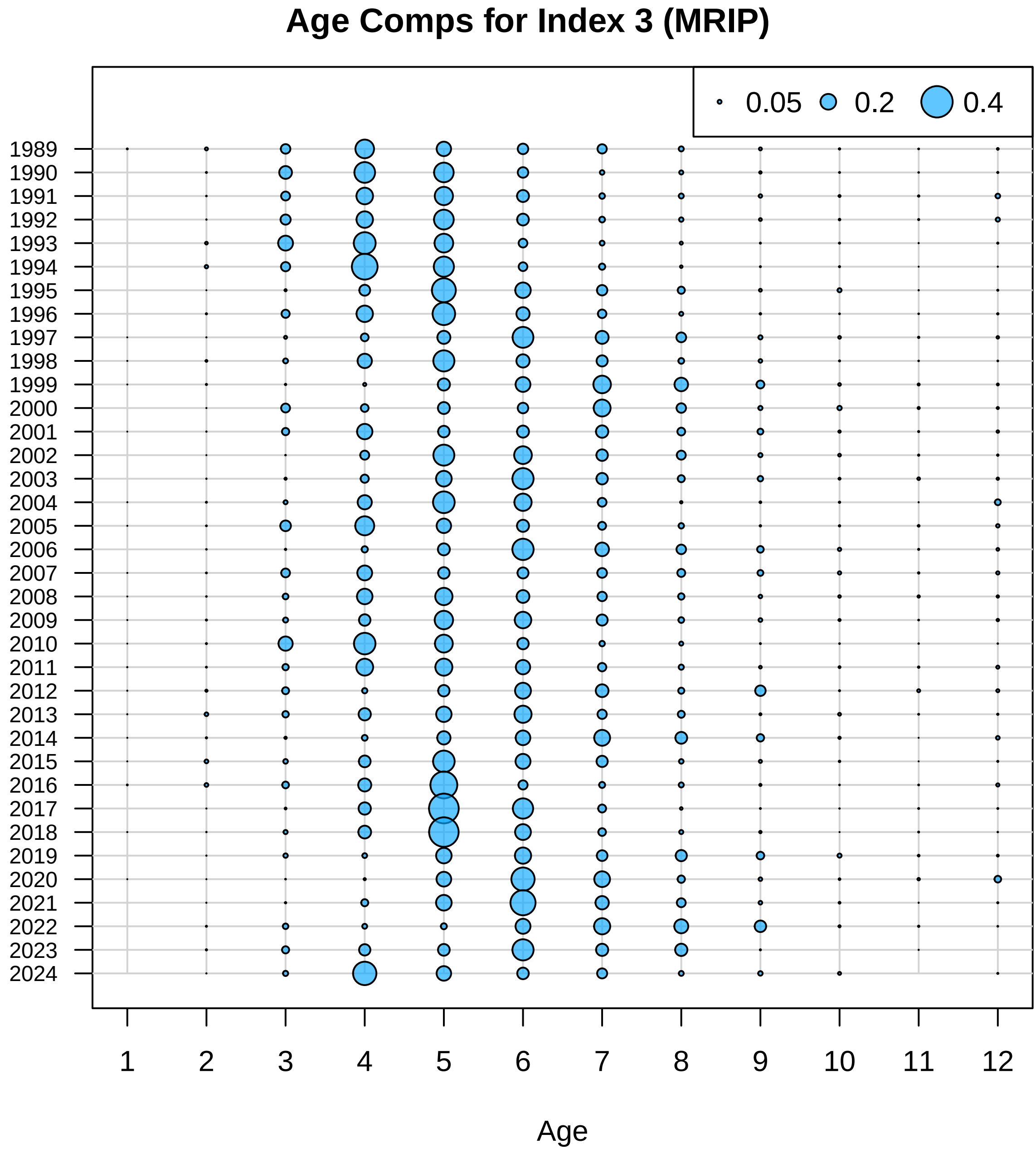


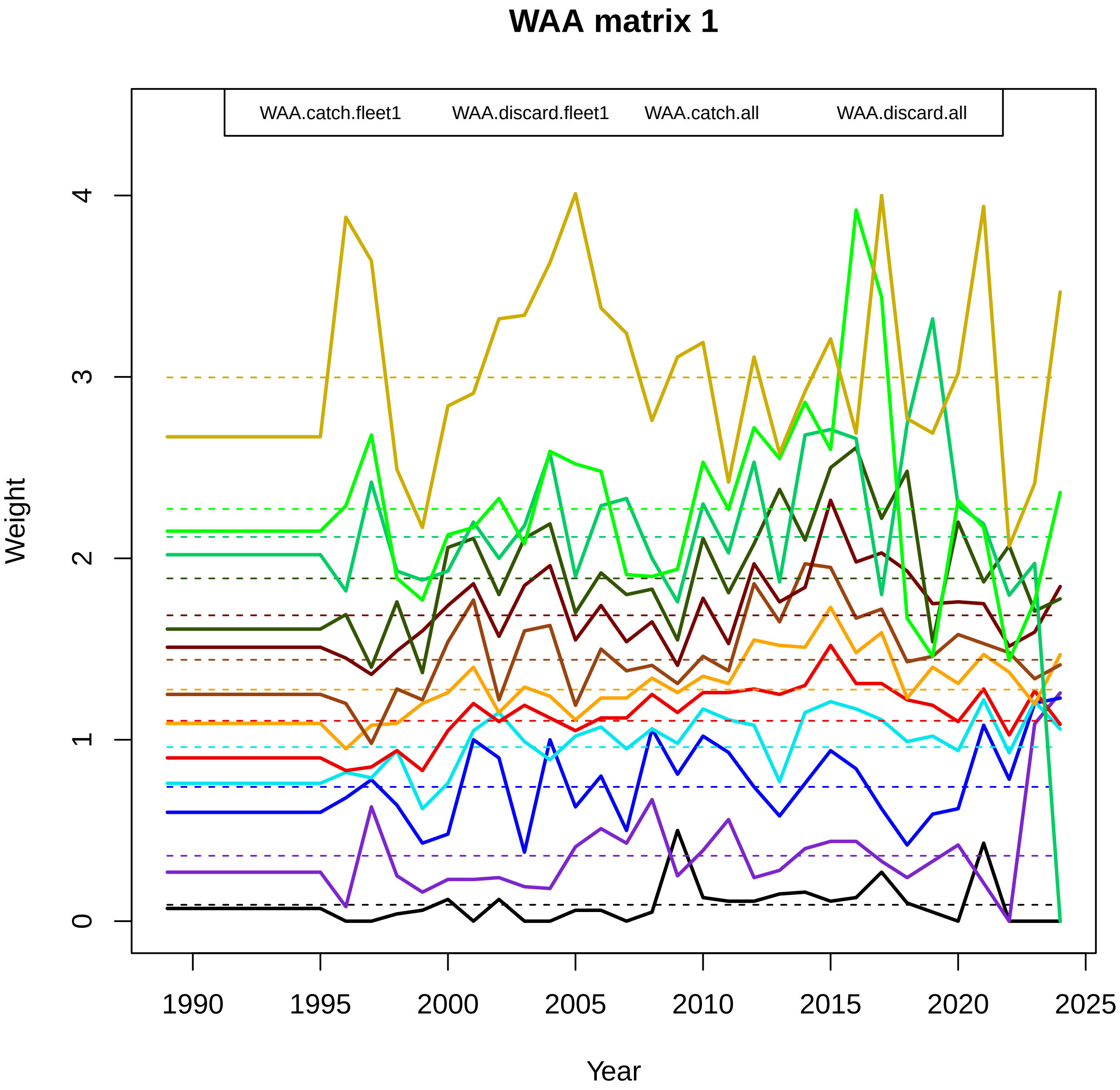

0
500
1000
1500
2000
2500
3000
Catch
1989
1993
1997
2001
2005
2009
2013
2017
2021
Year

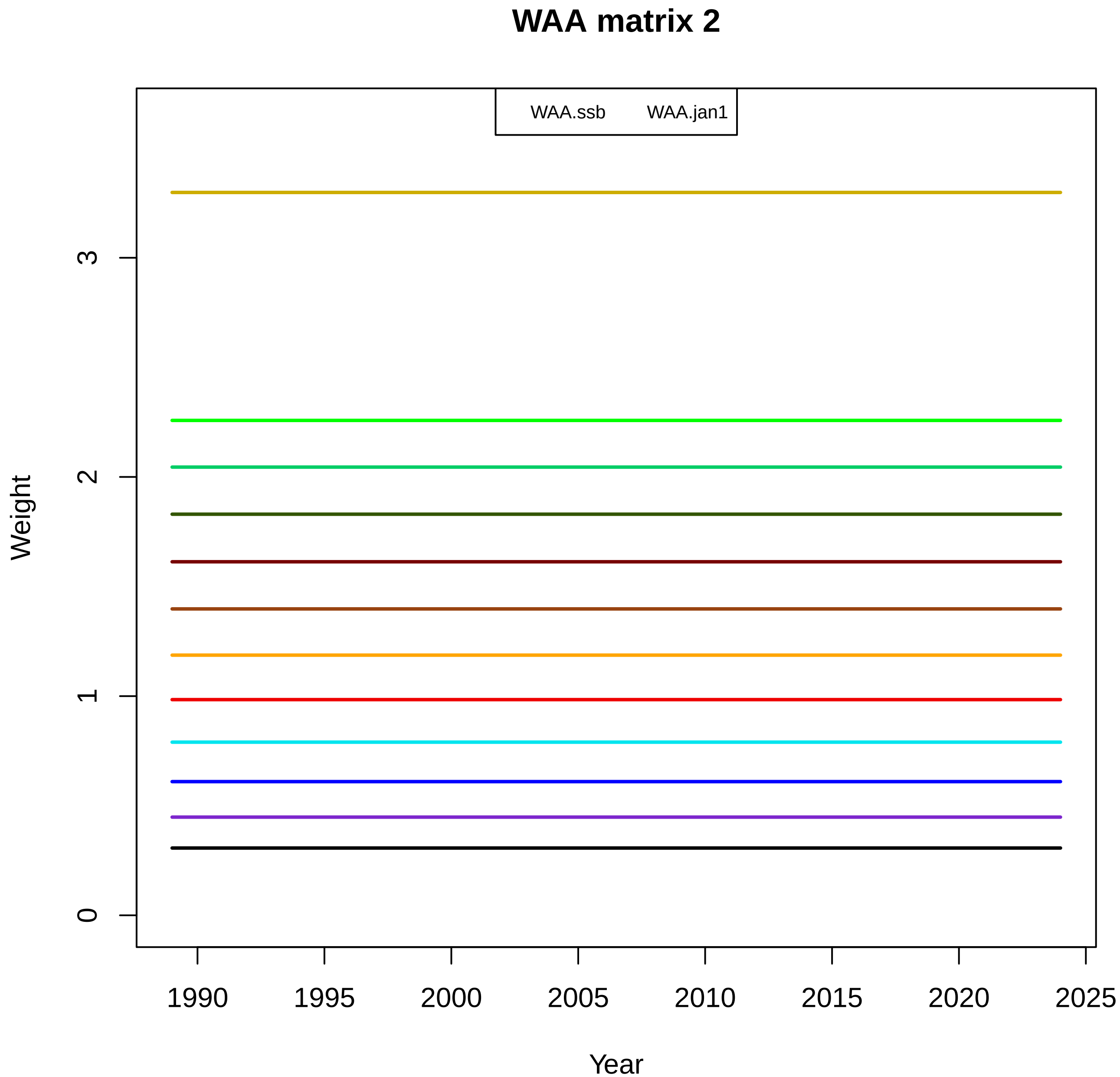

Age Comps for Catch by Fleet 1 (All removals)
0.05
0.2
0.4
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age

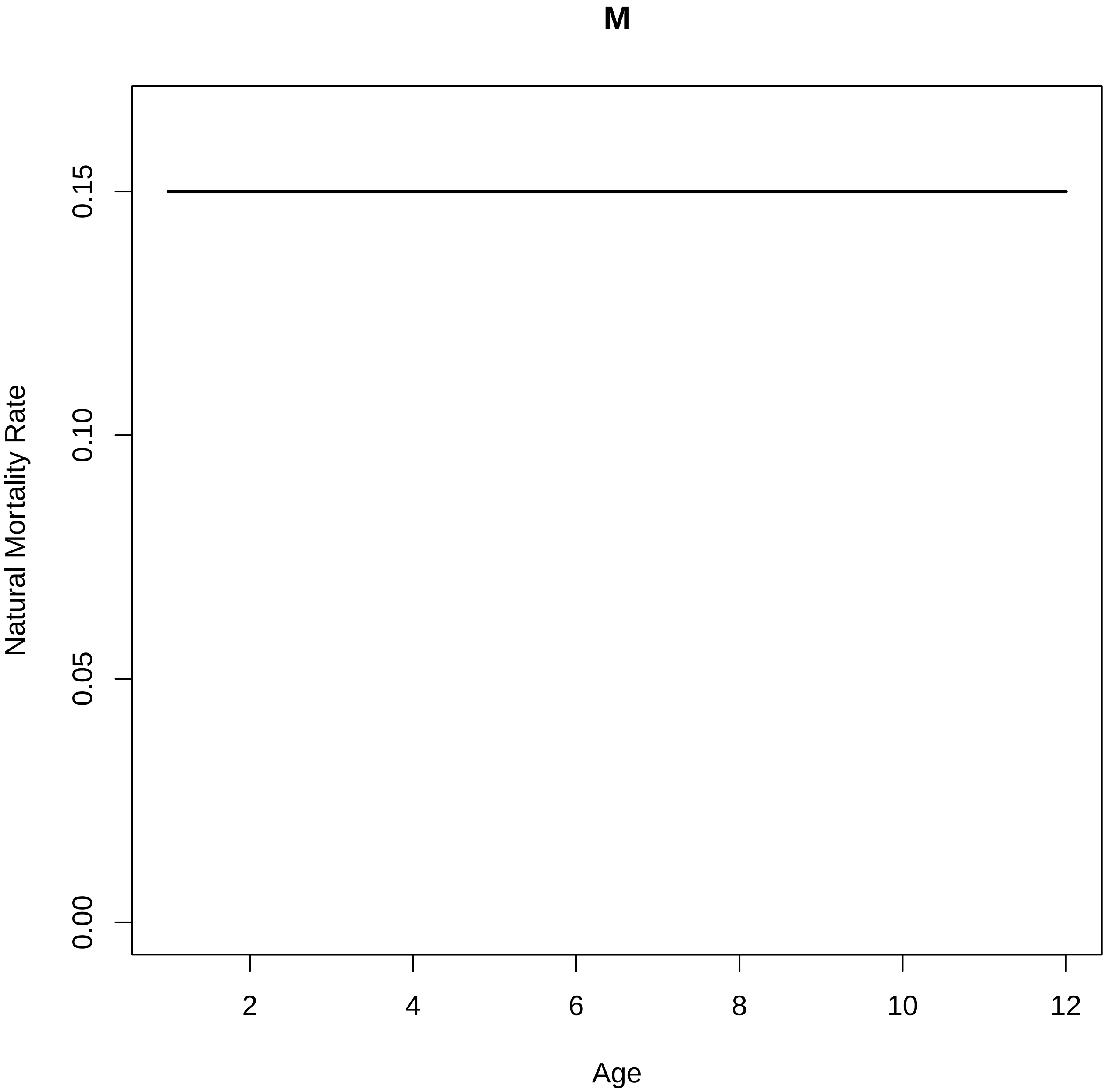

Rescaled Indices
3
2
1
0
−1
1990
1995
2000
2005
2010
2015
2020
2025
Year
Rescaled Log(Indices)
2
1
0
−1
−2
1990
1995
2000
2005
2010
2015
2020
2025
Year

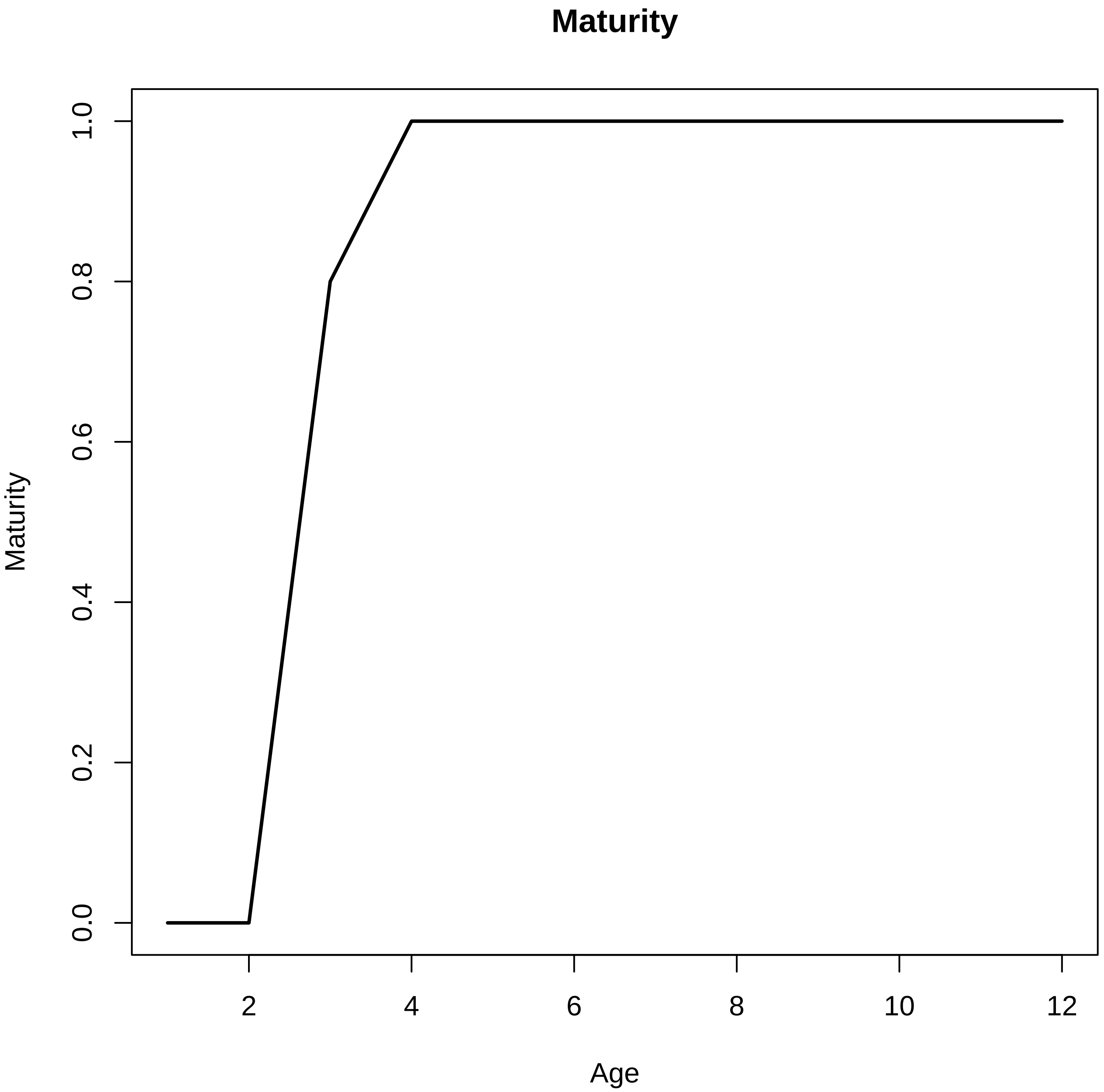

Age Comps for Index 2 (NJ trawl)
0.05
0.2
0.4
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age


Age Comps for Index 3 (MRIP)
0.05
0.2
0.4
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age

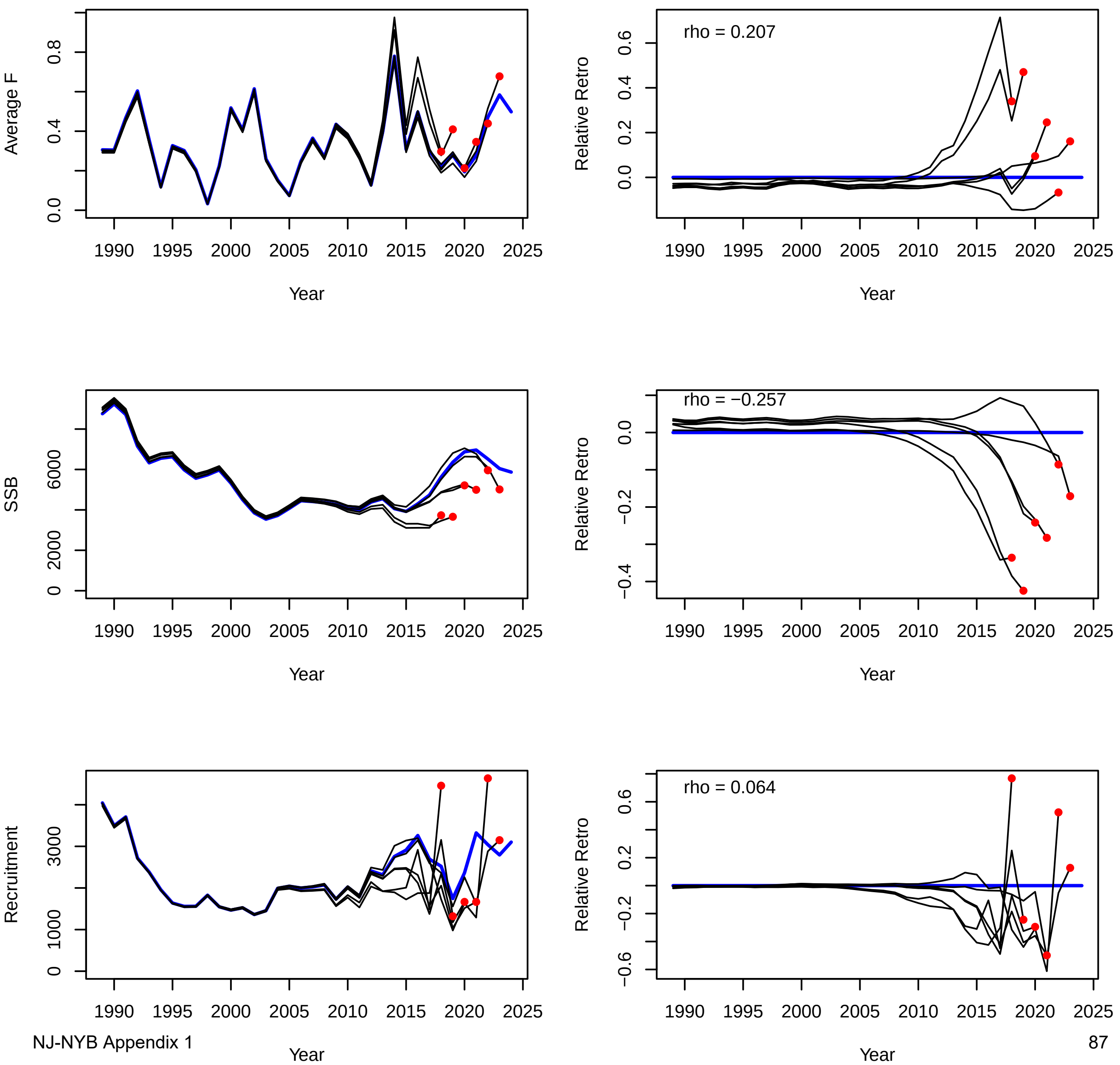

WAA matrix 1
WAA.catch.fleet1
WAA.discard.fleet1
WAA.catch.all
WAA.discard.all
Weight
0
1
2
3
4
Year
1990
1995
2000
2005
2010
2015
2020
2025


WAA matrix 2
WAA.ssb
WAA.jan1
Weight
0
1
2
3
1990
1995
2000
2005
2010
2015
2020
2025
Year

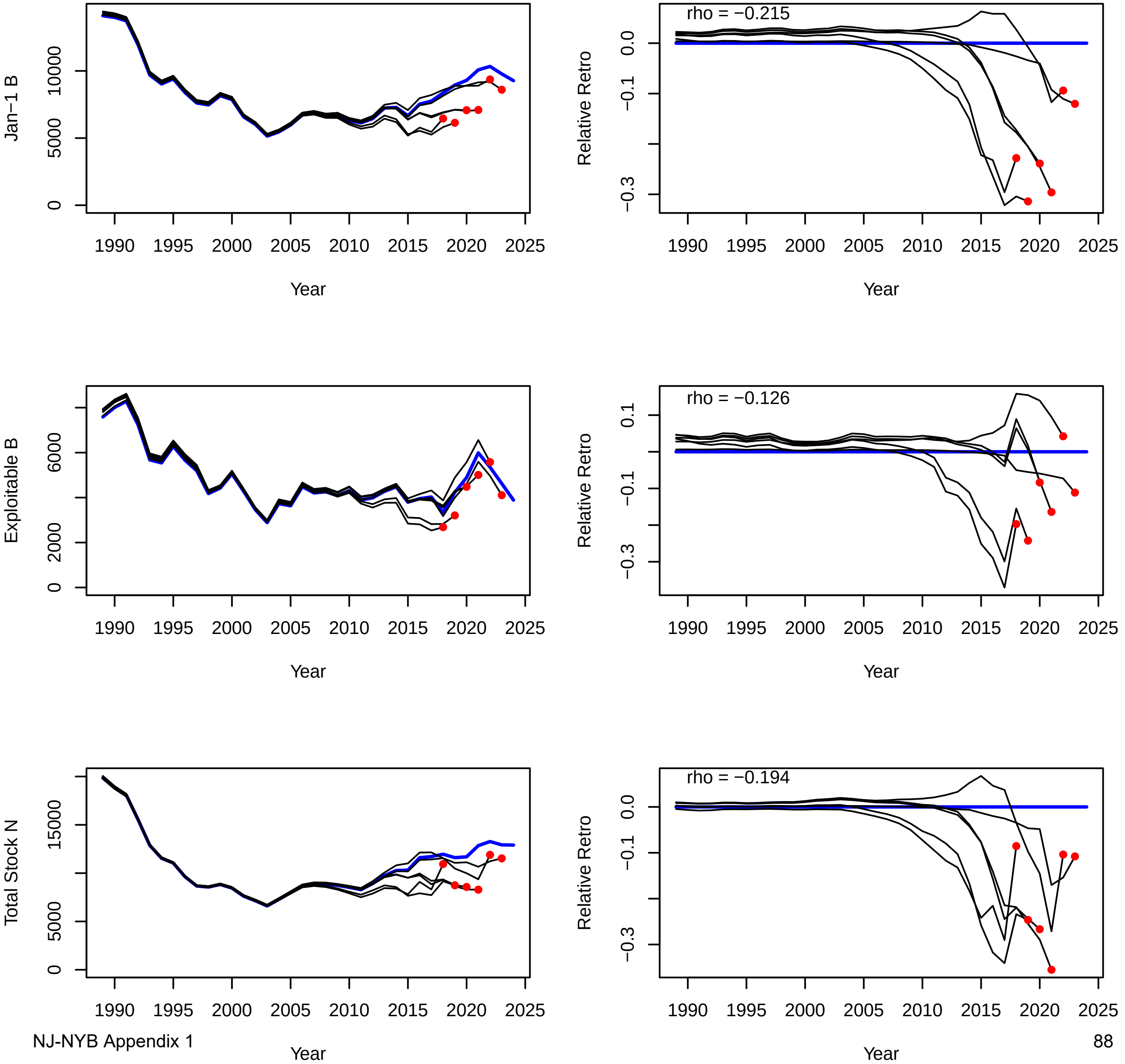

M
Natural Mortality Rate
0.00
0.05
0.10
0.15
2
4
6
8
10
12
Age


Maturity
Maturity
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
Age

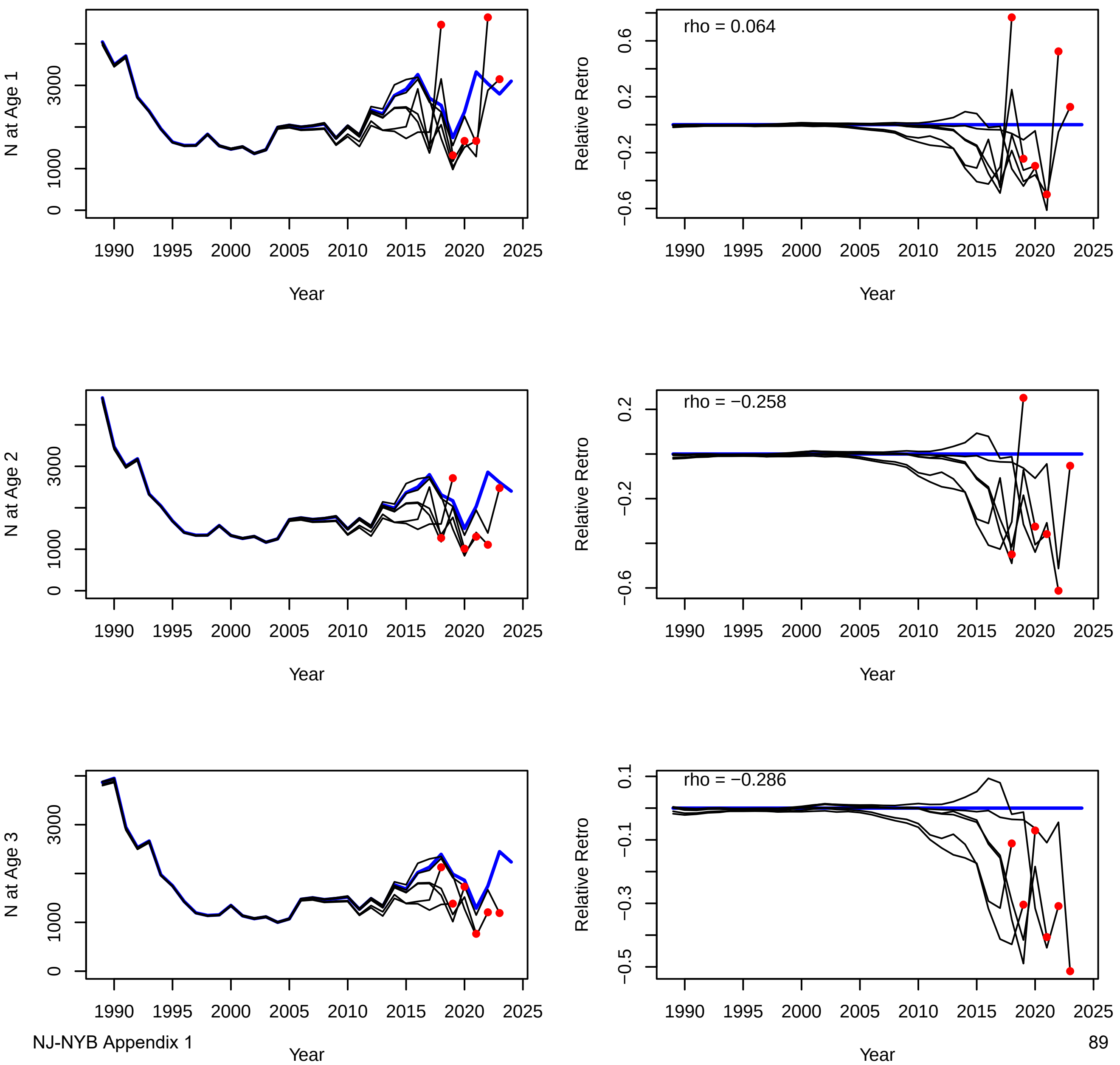
F, SSB, R


Average F
Relative Retro
rho = 0.207
SSB
Relative Retro
rho = −0.257
Recruitment
Relative Retro
rho = 0.064
Year
1990
1995
2000
2005
2010
2015
2020
2025

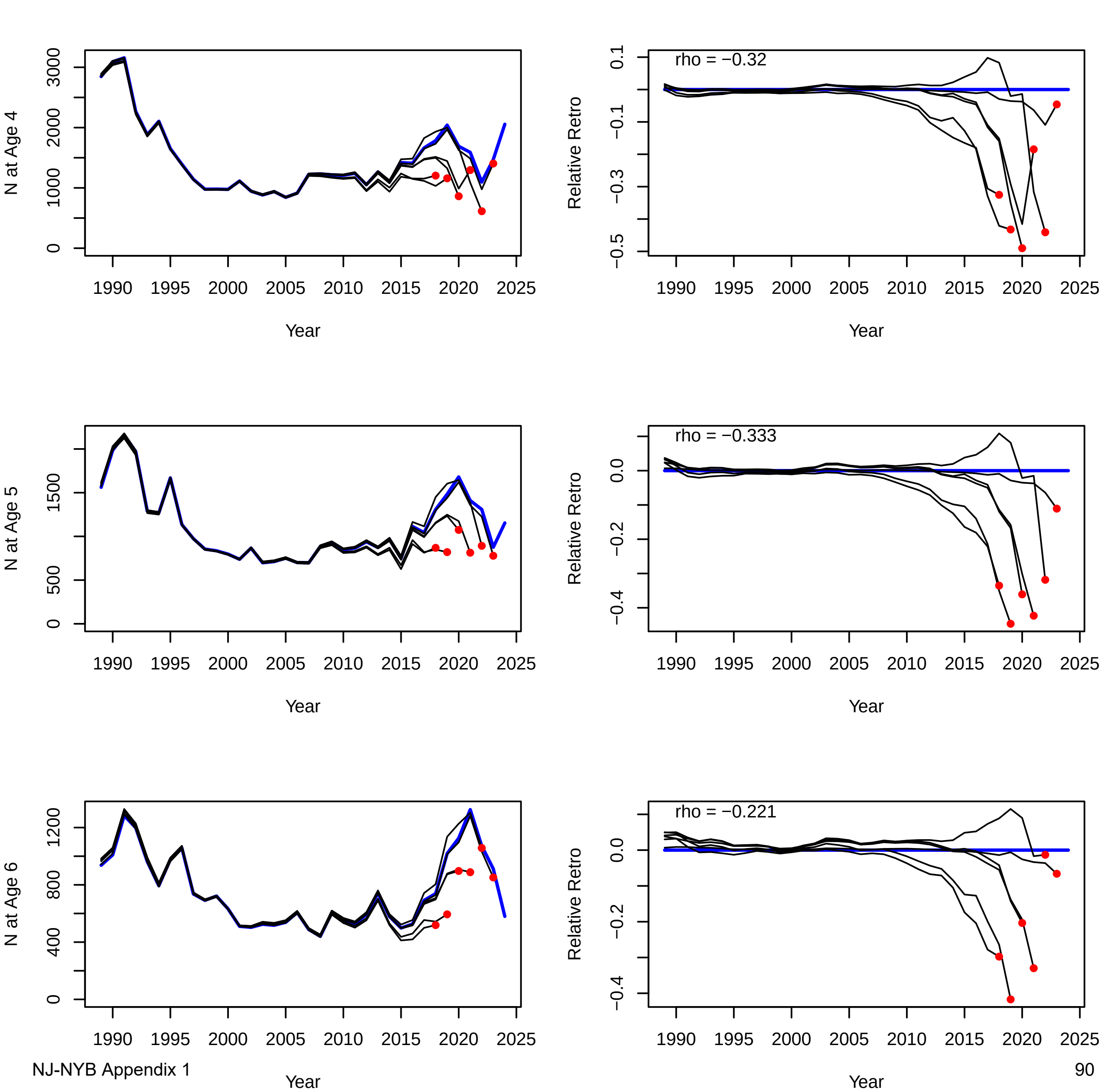
Jan−1 B, Exploitable B, Total Stock N



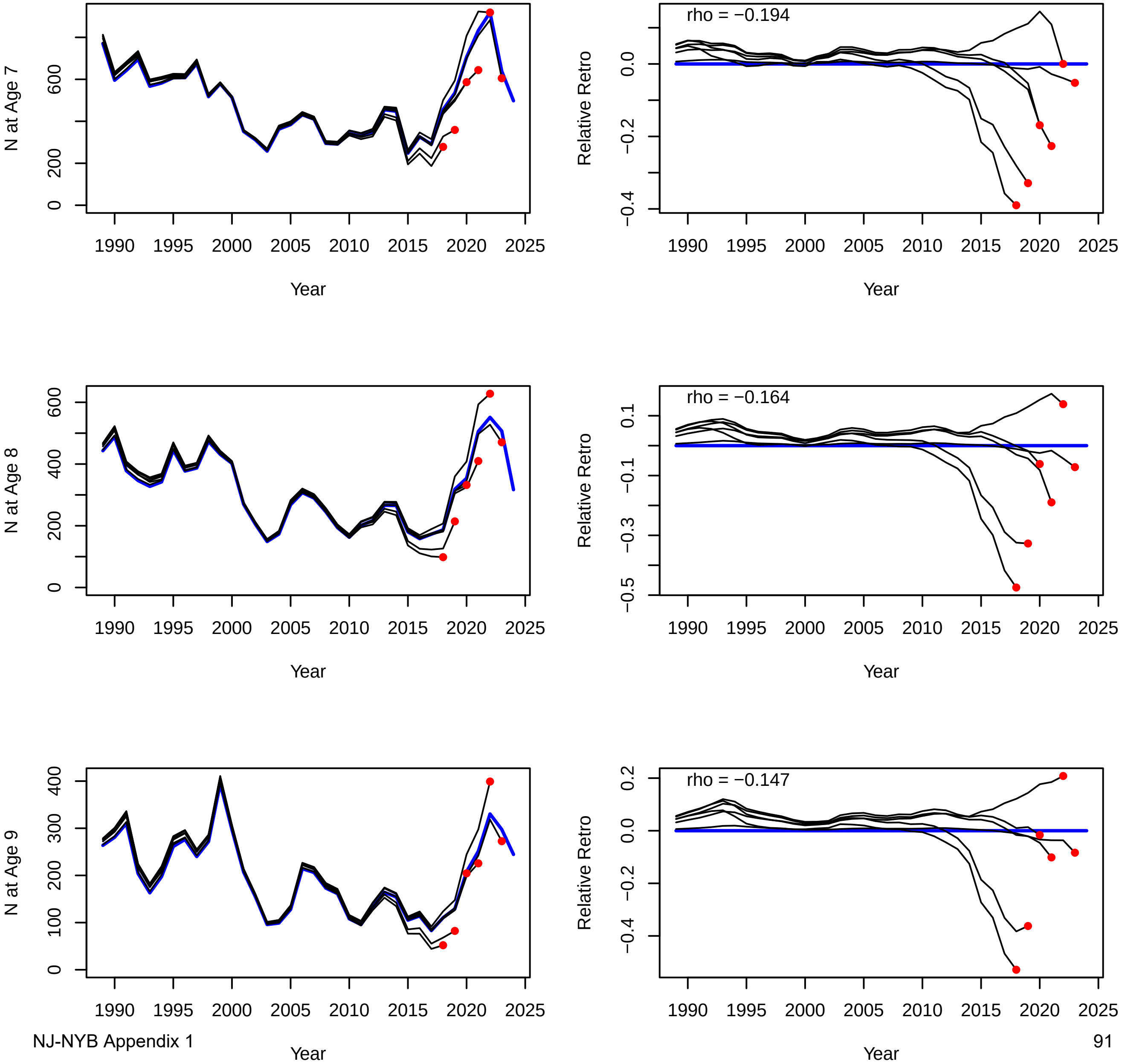
Stock Numbers at Age



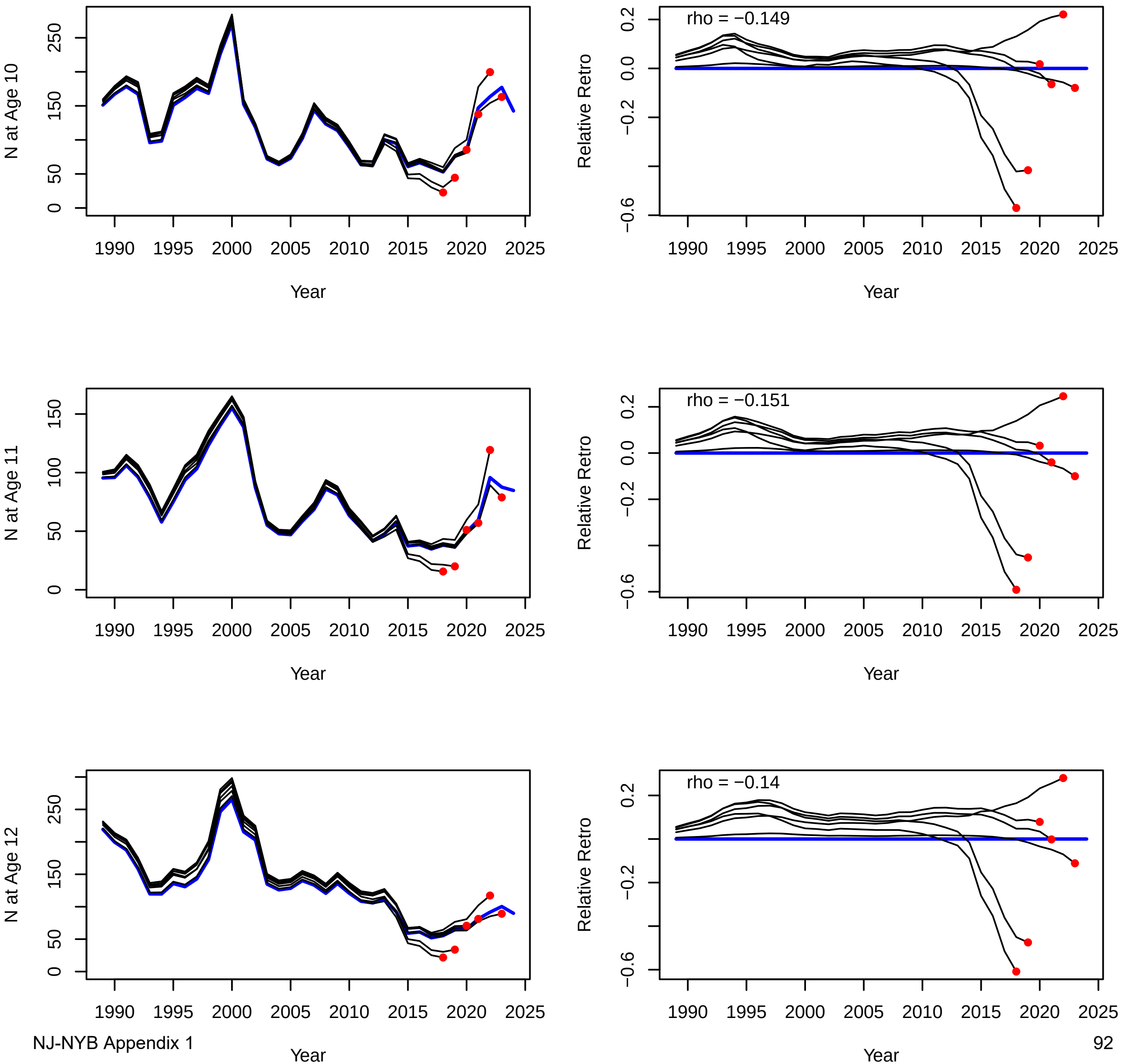
Stock Numbers at Age



Stock Numbers at Age



Stock Numbers at Age



NJ-NYB Appendix 2: Retrospective Adjustment and Sensitivity Runs

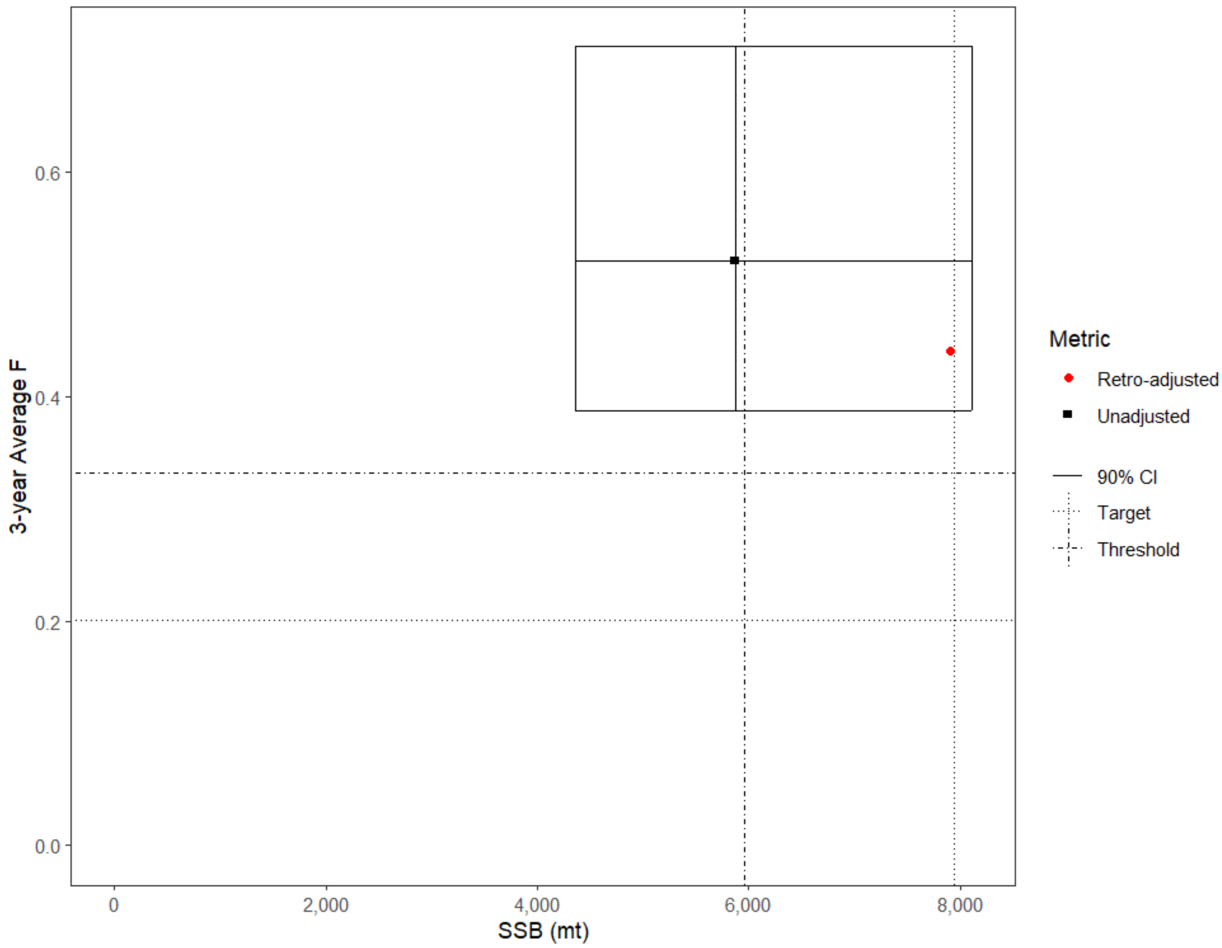
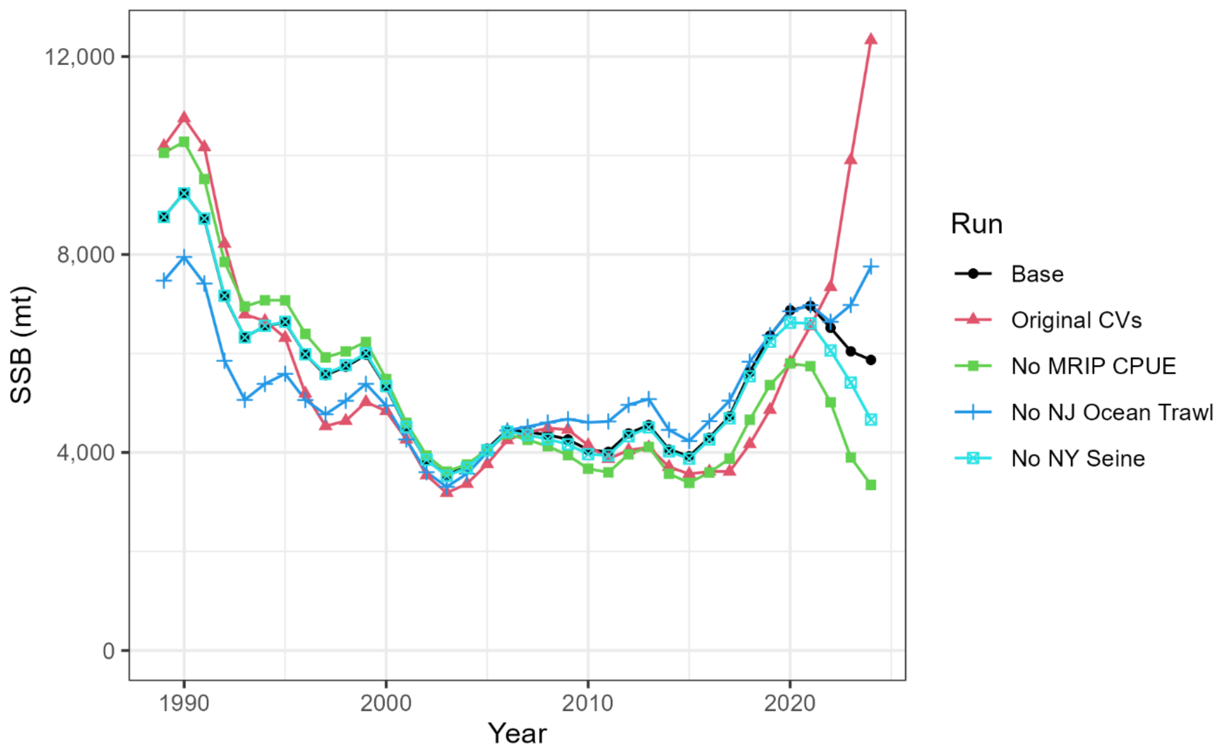


Figure A2.1. Comparison of retrospective adjusted status with the base model status. Solid black lines indicate the 90% confidence intervals of the estimates of SSB and F.



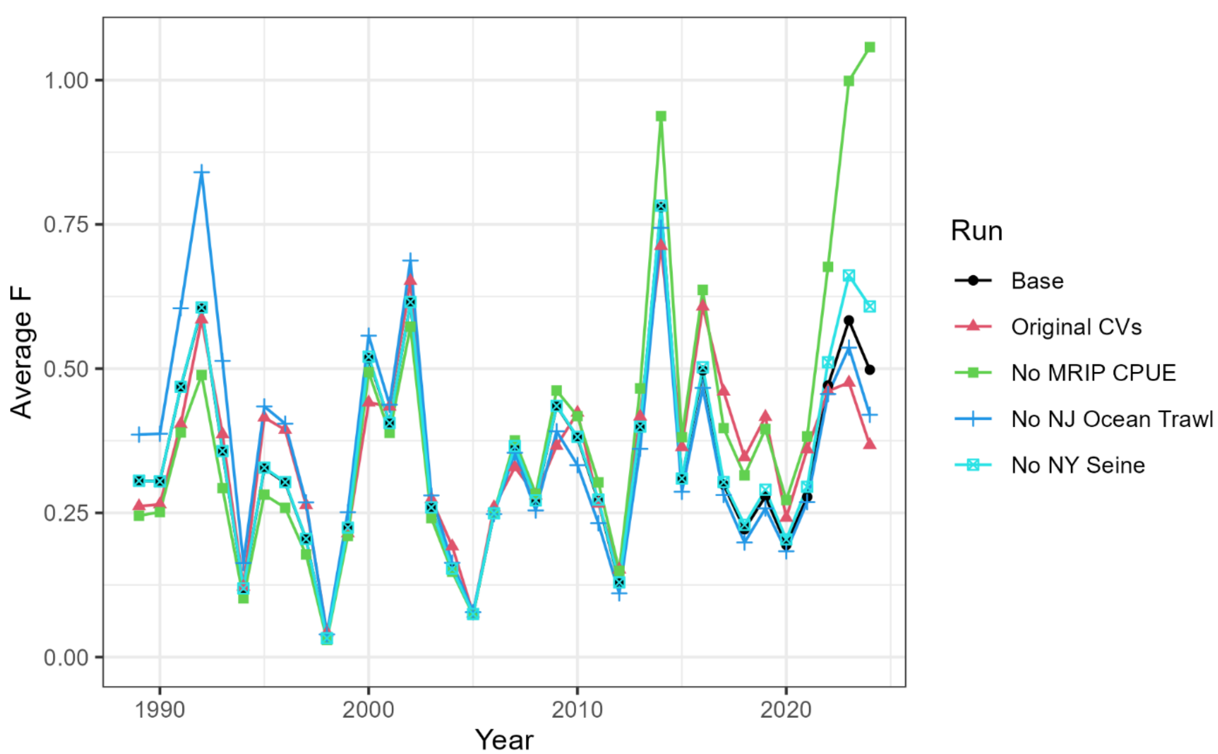
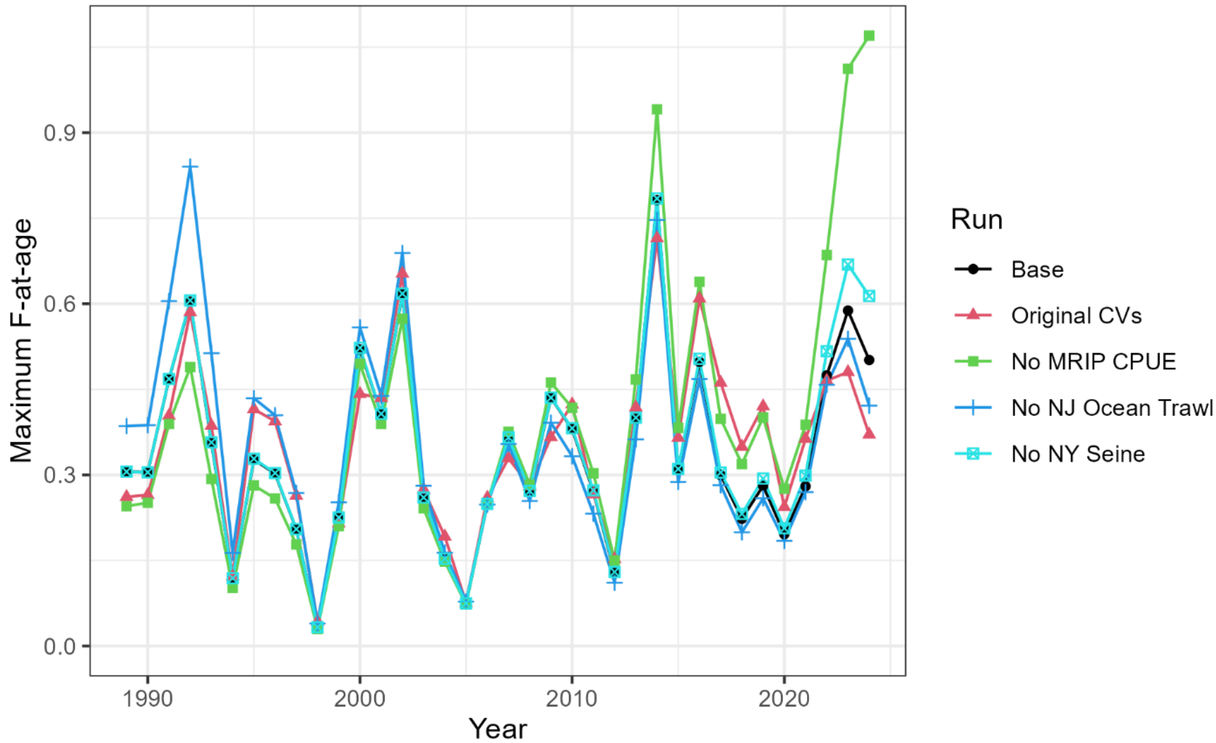


Figure A2.2. Spawning stock biomass (top) and average F (bottom) for sensitivity runs including the base run with the original CVs for the catch and indices and runs dropping one index at a time.



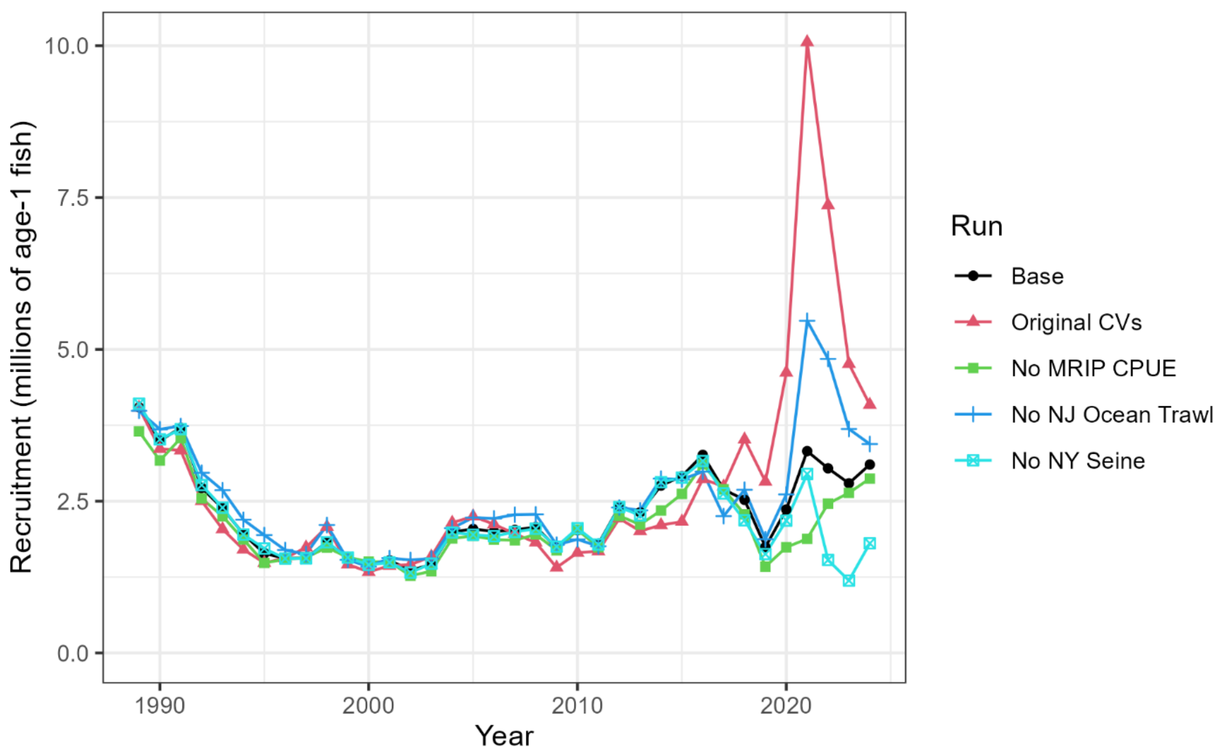


Figure A2.3. Maximum F-at-age (top) and recruitment (bottom) for sensitivity runs including the base run with the original CVs for the catch and indices and runs dropping one index at a time.

DMV Appendix 1: ASAP Input and Diagnostic Plots for the Base Run

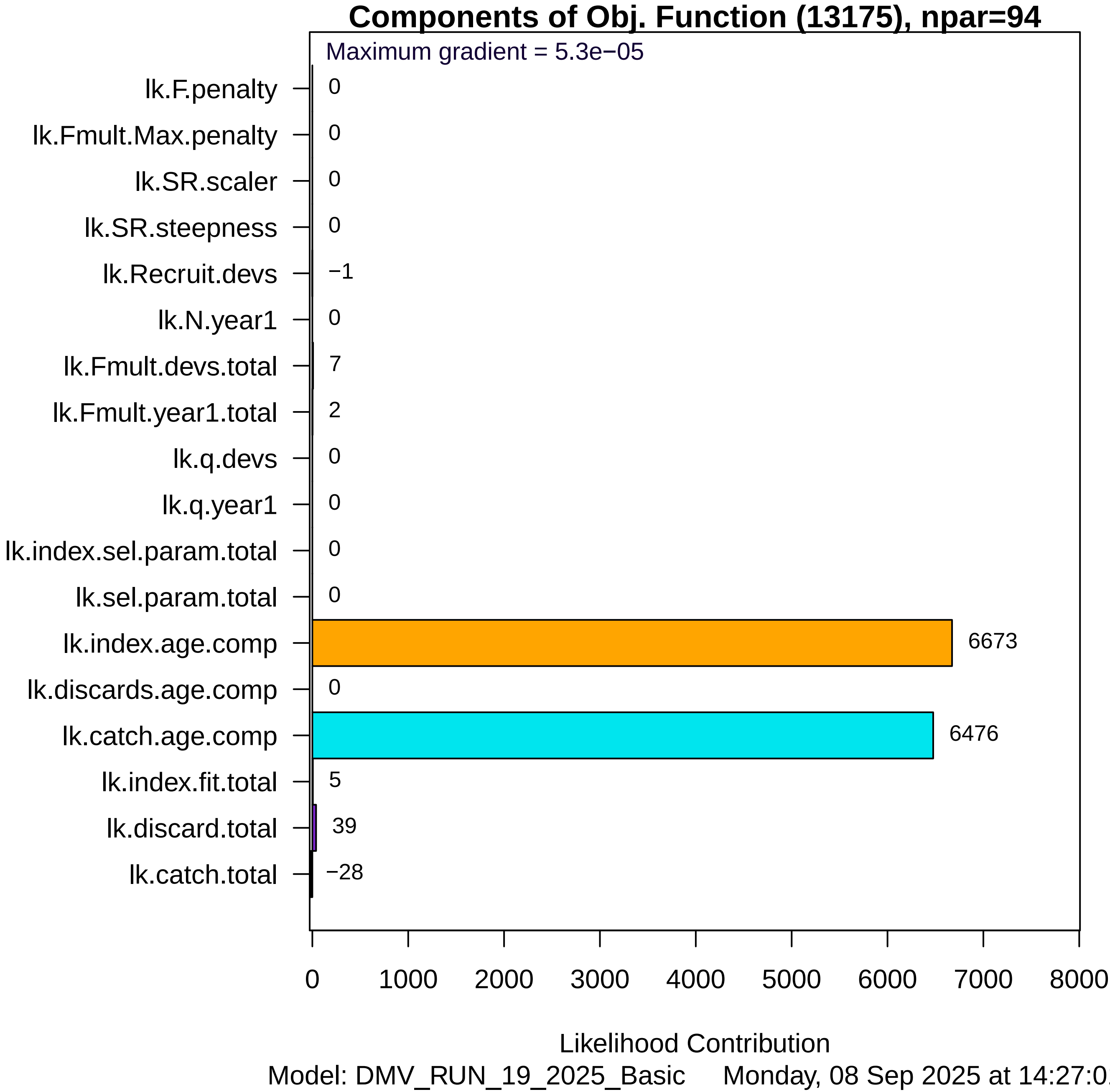
File = DMV_RUN_19_2025_Basic.dat

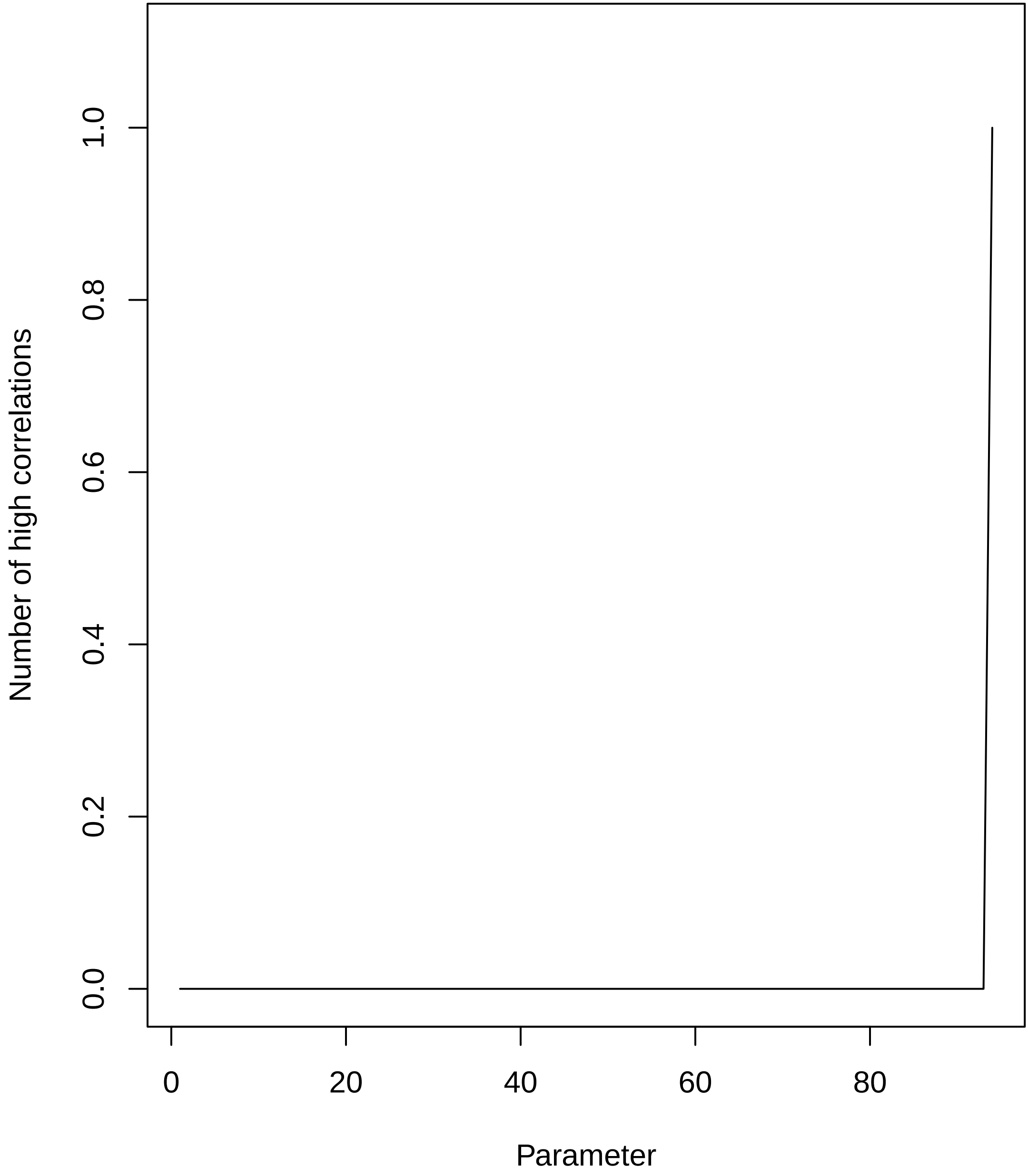
ASAP3 run on Monday, 08 Sep 2025 at 14:27:01

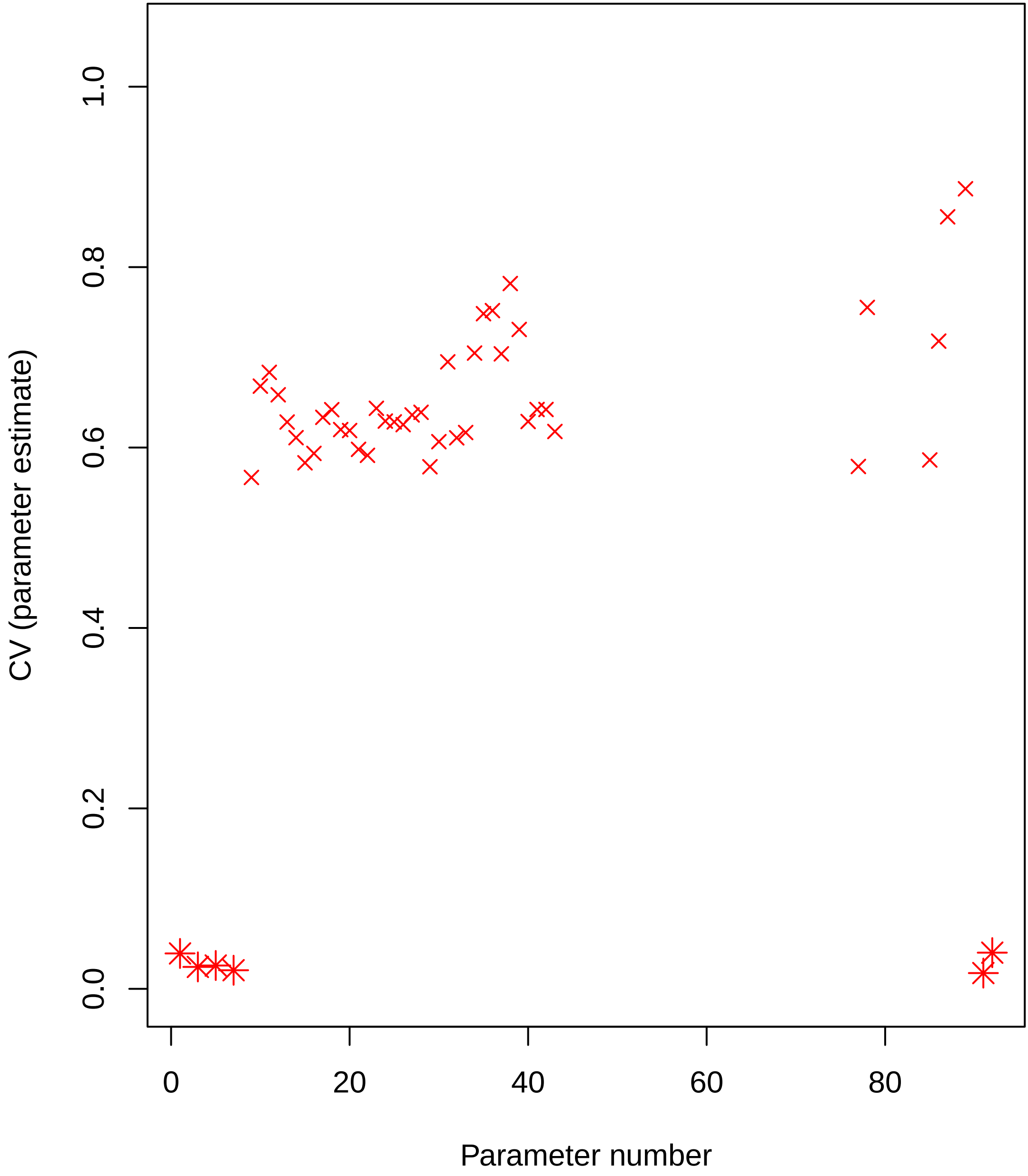
rive − STATE OF DELAWARE\MAFMC\Tautog SAS\2025 Assessment Update

ASAPplots version = 0.2.18

npar = 94, maximum gradient = 5.26744e−005

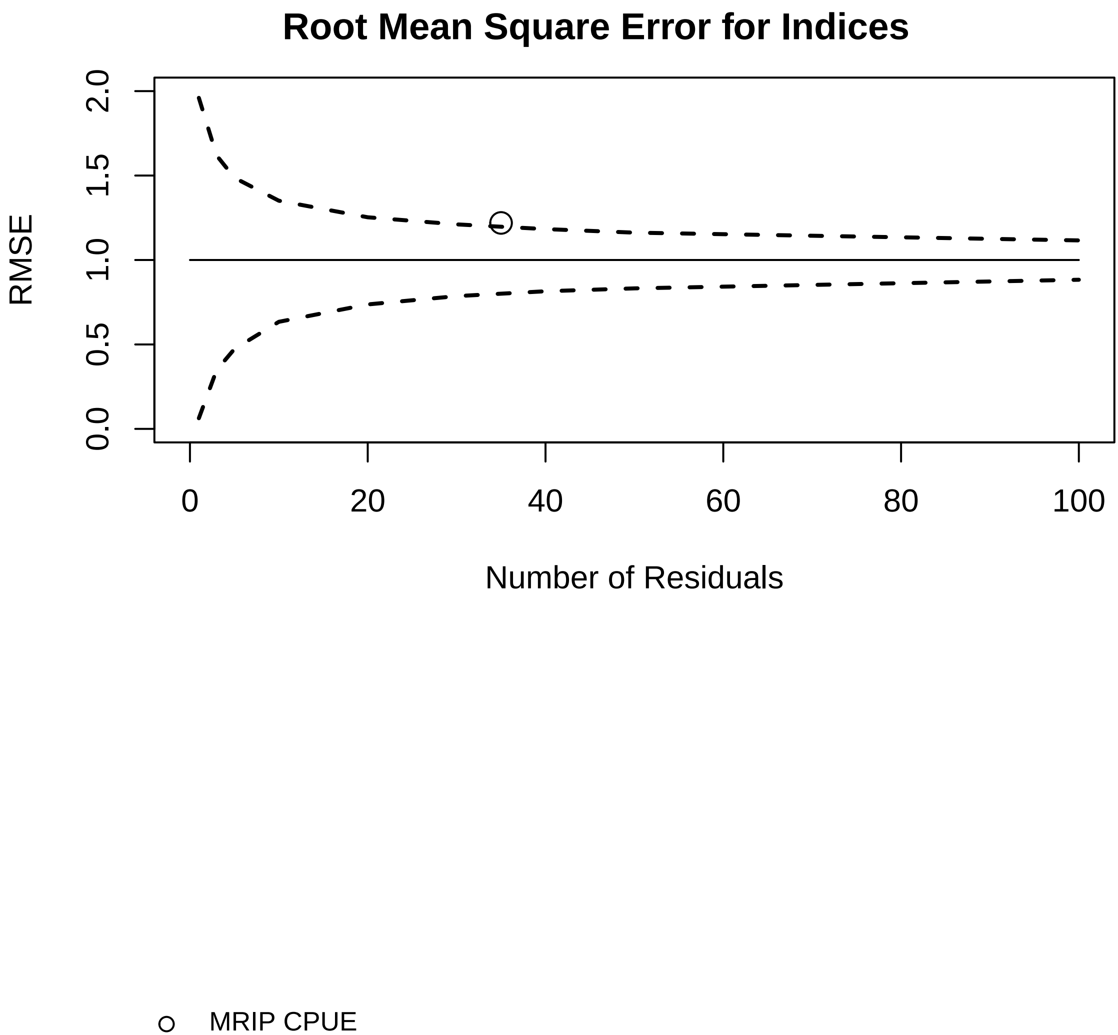

Components of Obj. Function (13175), npar=94
Maximum gradient = 5.3e−05
lk.F.penalty
lk.Fmult.Max.penalty
lk.SR.scaler
lk.SR.steepness
lk.Recruit.devs
lk.N.year1
lk.Fmult.devs.total
lk.Fmult.year1.total
lk.q.devs
lk.q.year1
lk.index.sel.param.total
lk.sel.param.total
lk.index.age.comp
lk.discards.age.comp
lk.catch.age.comp
lk.index.fit.total
lk.discard.total
lk.catch.total
0
0
0
0
−1
0
7
2
0
0
0
0
6673
0
6476
5
39
−28
0
1000
2000
3000
4000
5000
6000
7000
8000
Likelihood Contribution
Model: DMV_RUN_19_2025_Basic Monday, 08 Sep 2025 at 14:27:01

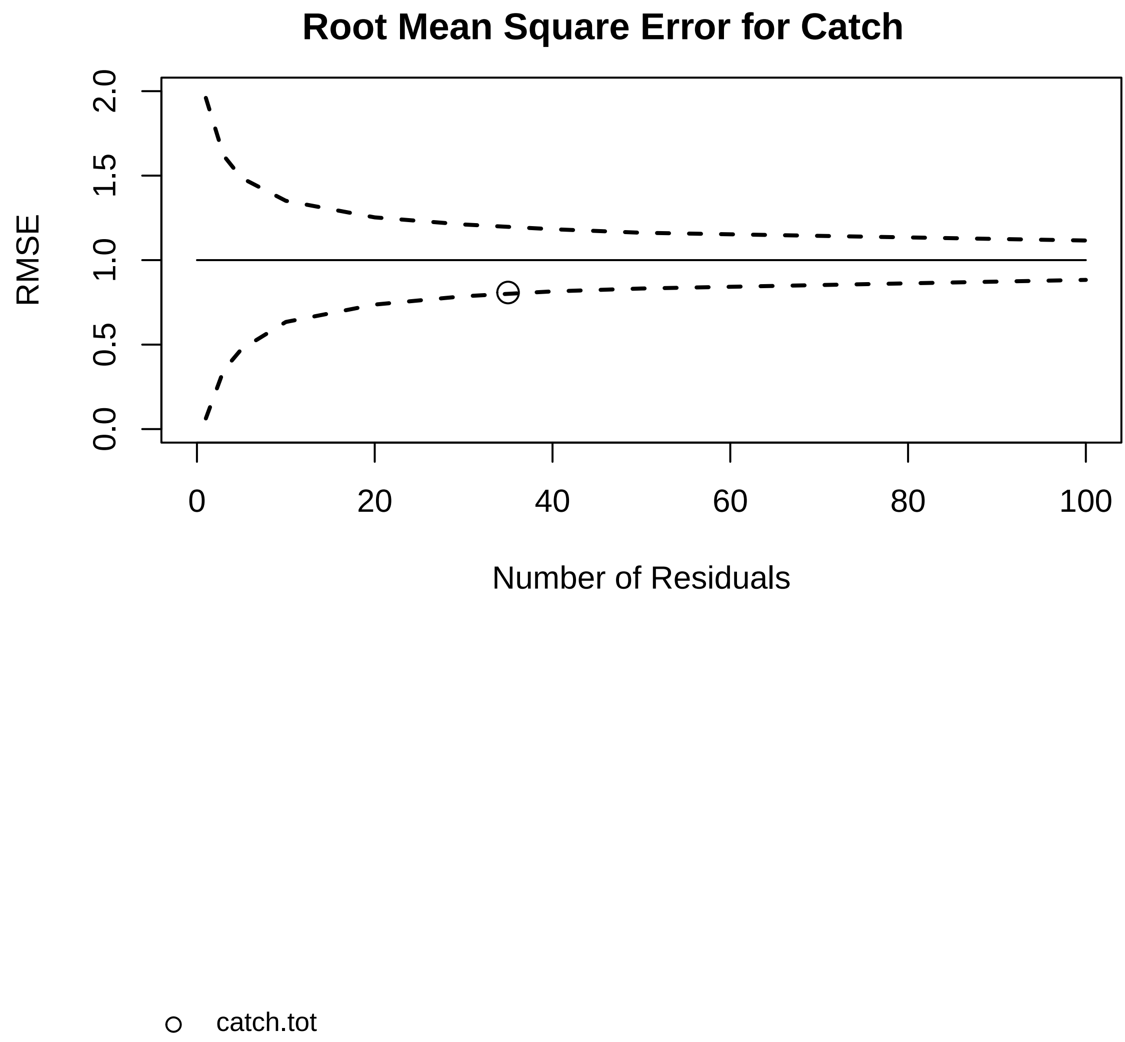

1.0
0.8
0.6
0.4
0.2
0.0
Number of high correlations
0
20
40
60
80
Parameter


CV (parameter estimate)
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
Parameter number

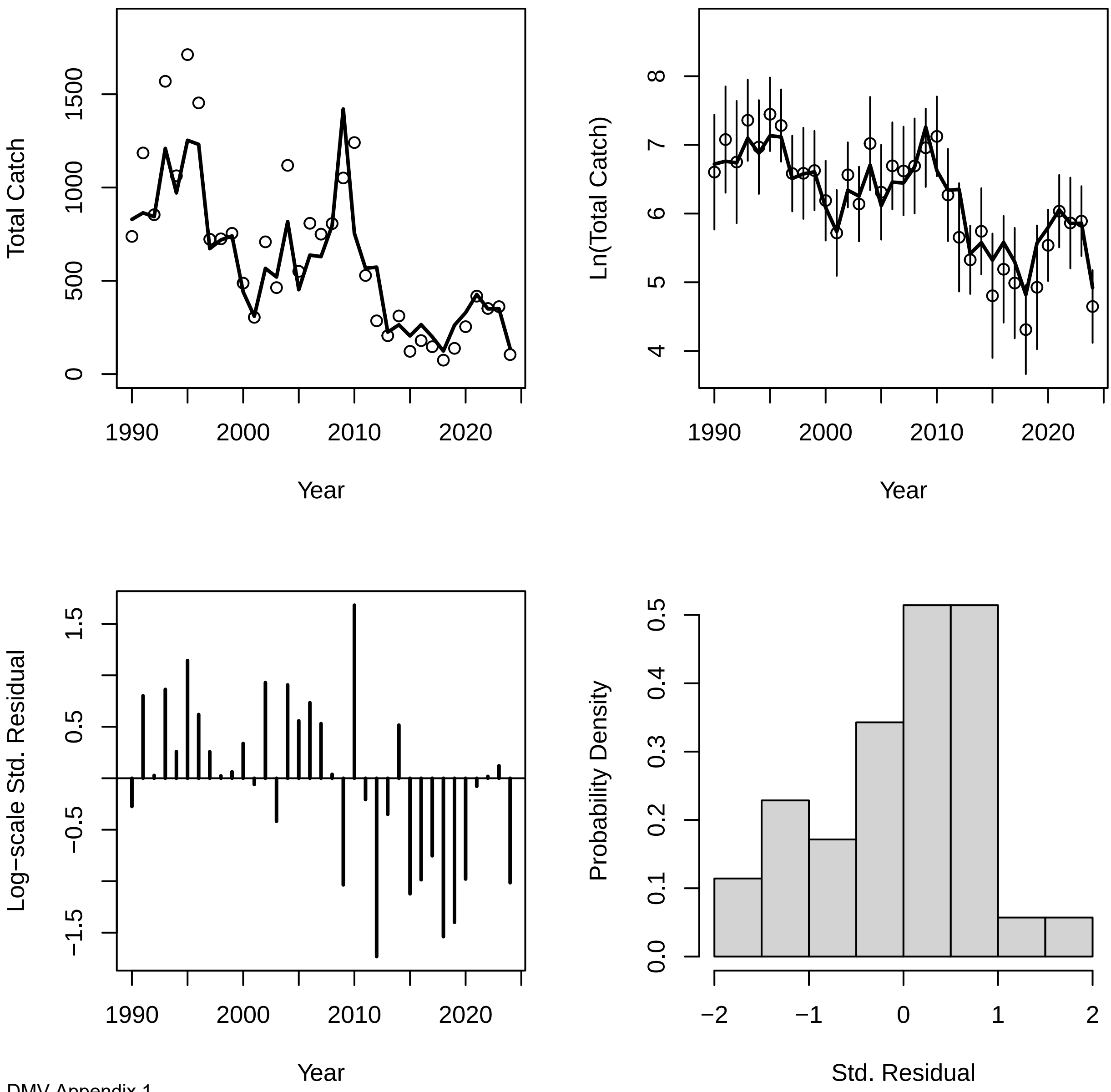
Root Mean Square Error computed from Standardized Residuals

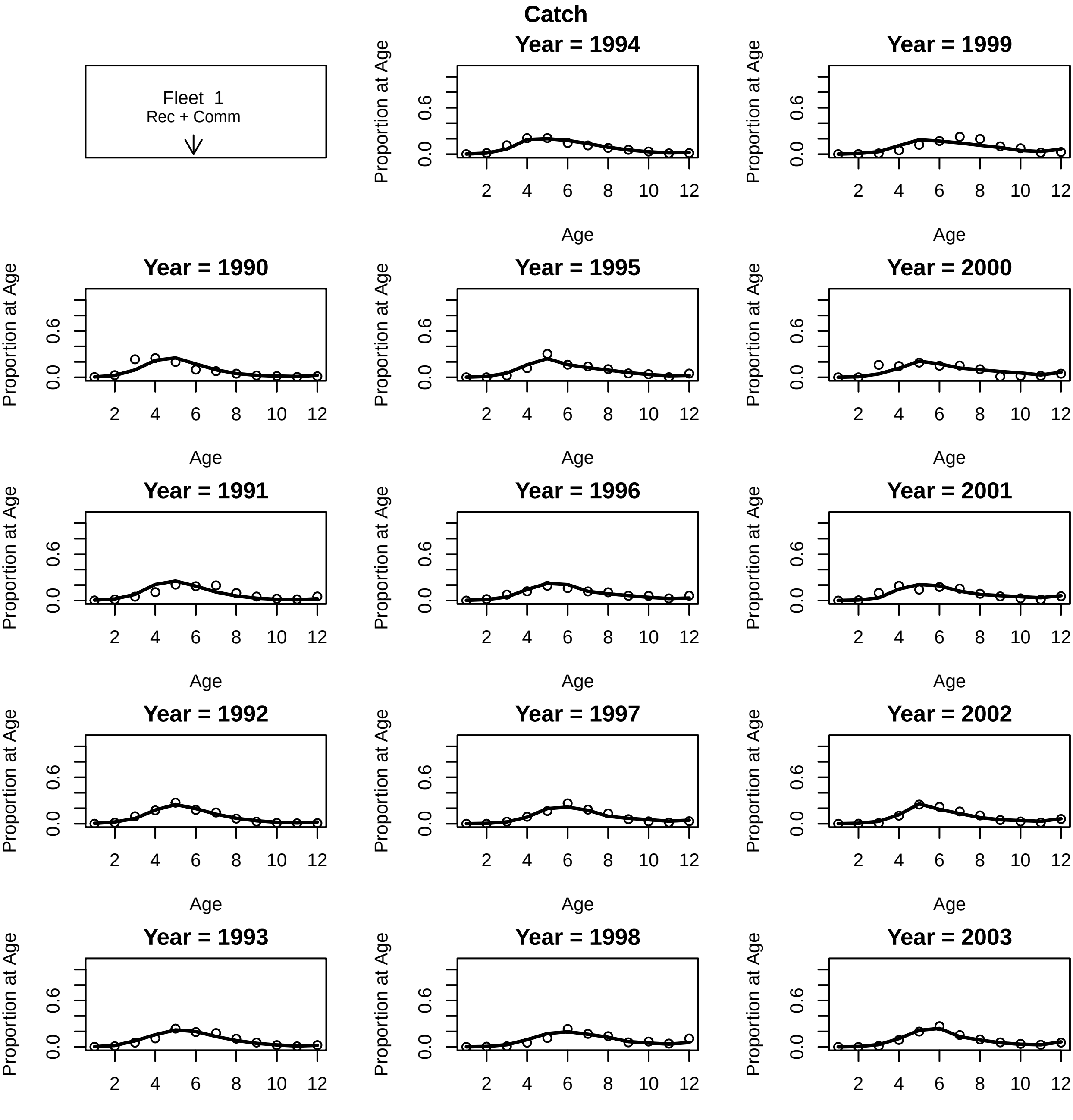
Component	# resids	RMSE
catch.tot	35	0.808
discard.tot	0	0
ind.total	35	1.22
N.year1	0	0
Fmult.year1	1	2.81
Fmult.devs.total	34	0.948
recruit.devs	35	1.21
fleet.sel.params	0	0
index.sel.params	0	0
q.year1	0	0
q.devs	0	0
SR.steepness	0	0
SR.scaler	0	0

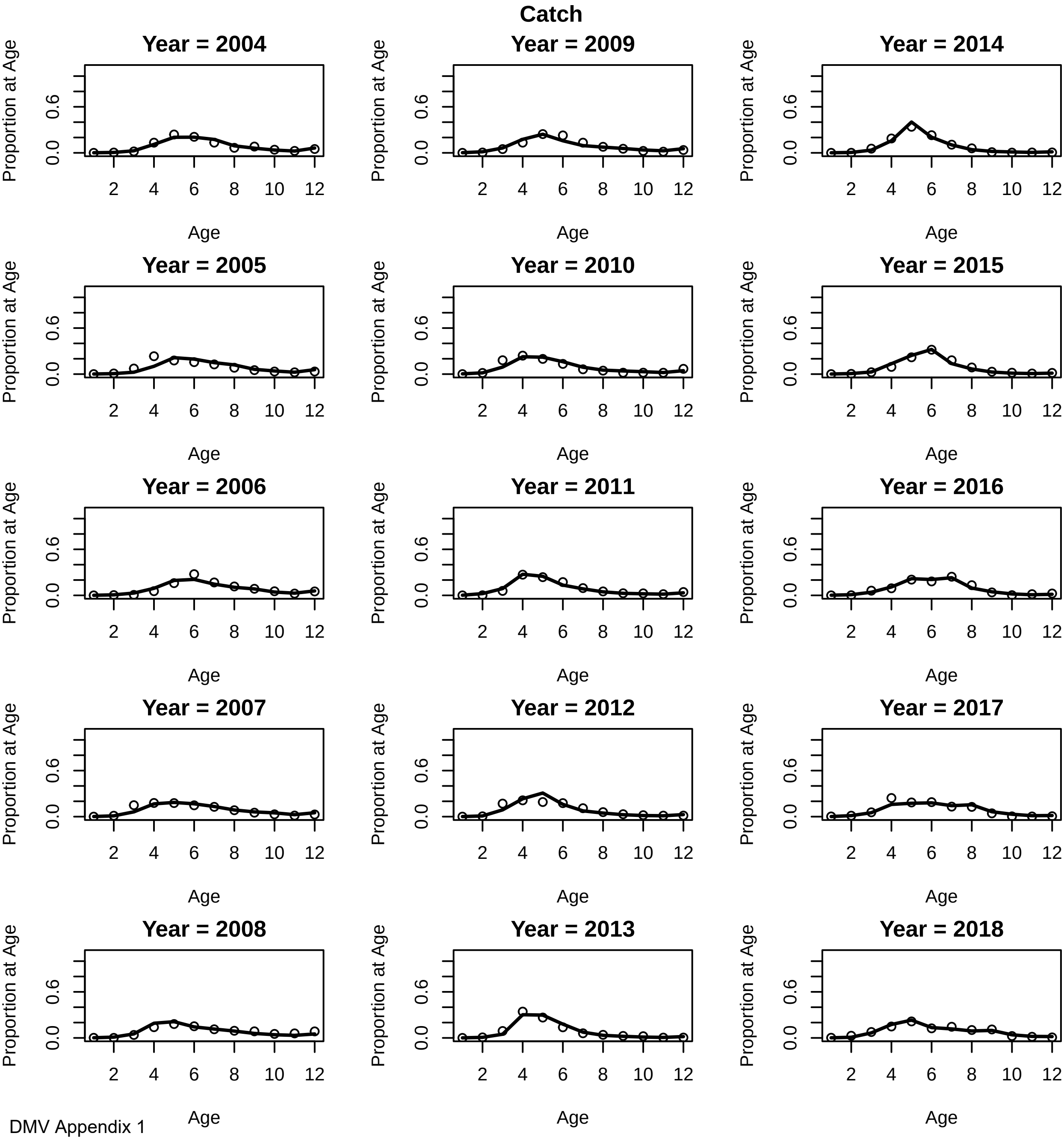

Root Mean Square Error for Indices
RMSE
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Number of Residuals
MRIP CPUE

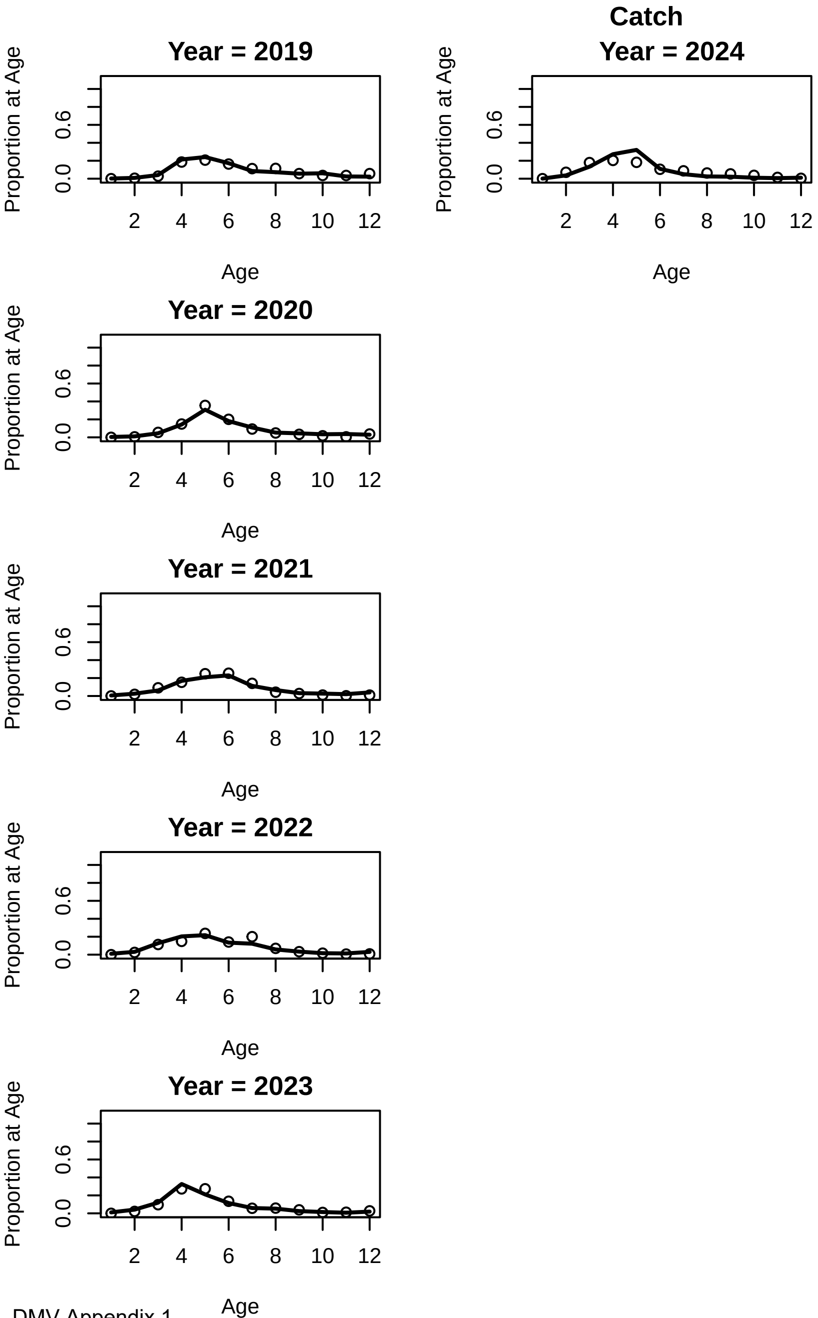

Root Mean Square Error for Catch
RMSE
0.0
0.5
1.0
1.5
2.0
0
20
40
60
80
100
Number of Residuals
catch.tot

Fleet 1 Catch (Rec + Comm)



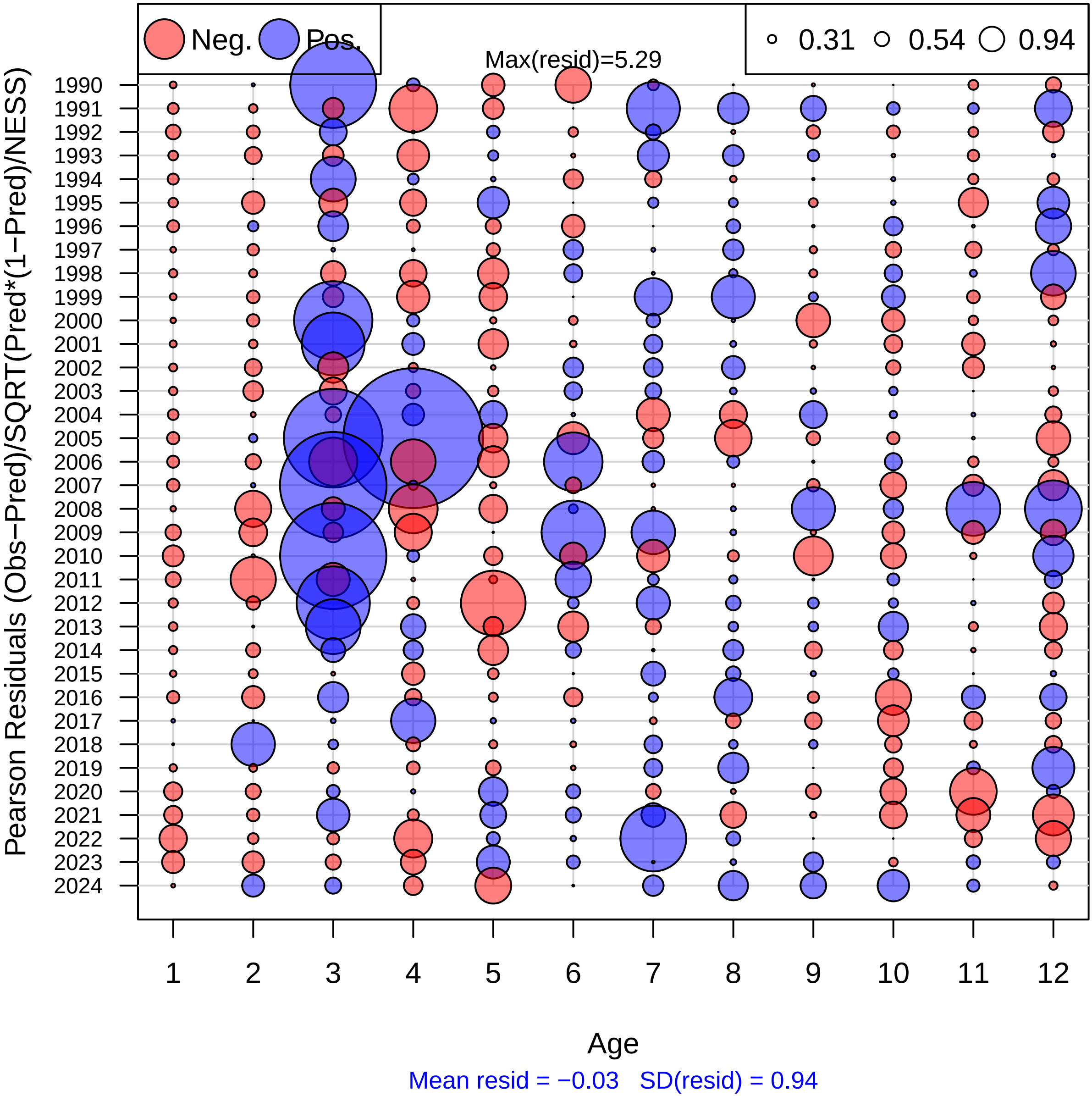

Catch
Fleet 1
Rec + Comm
Year = 1990
Year = 1991
Year = 1992
Year = 1993
Year = 1994
Year = 1995
Year = 1996
Year = 1997
Year = 1998
Year = 1999
Year = 2000
Year = 2001
Year = 2002
Year = 2003
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

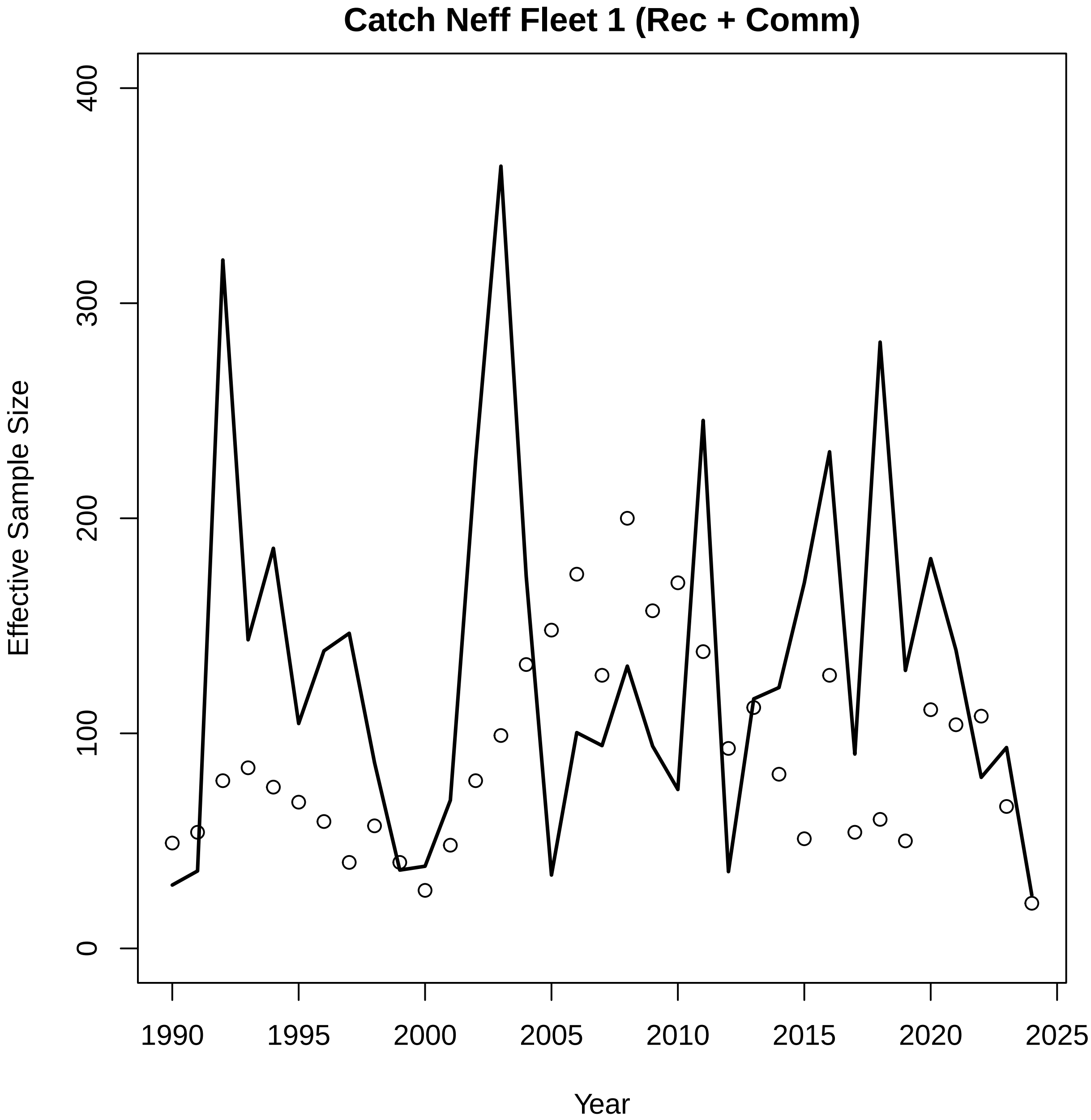

Catch
Year = 2004
Year = 2009
Year = 2014
Year = 2005
Year = 2010
Year = 2015
Year = 2006
Year = 2011
Year = 2016
Year = 2007
Year = 2012
Year = 2017
Year = 2008
Year = 2013
Year = 2018
Proportion at Age
0.0
0.6
Age
2
4
6
8
10
12

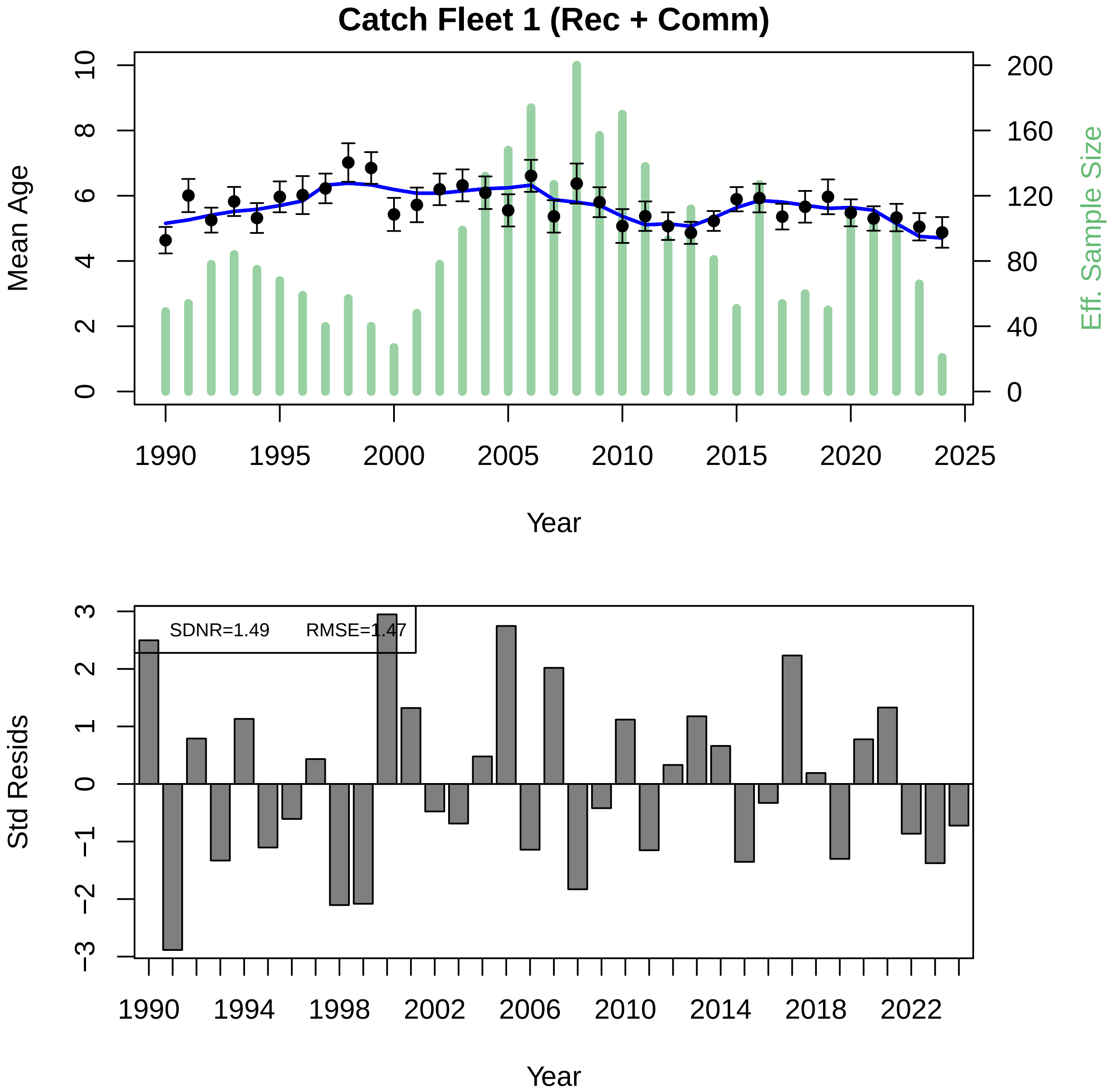


Catch
Year = 2019
Year = 2024
Year = 2020
Year = 2021
Year = 2022
Year = 2023
Proportion at Age
0.0
0.6
2
4
6
8
10
12
Age

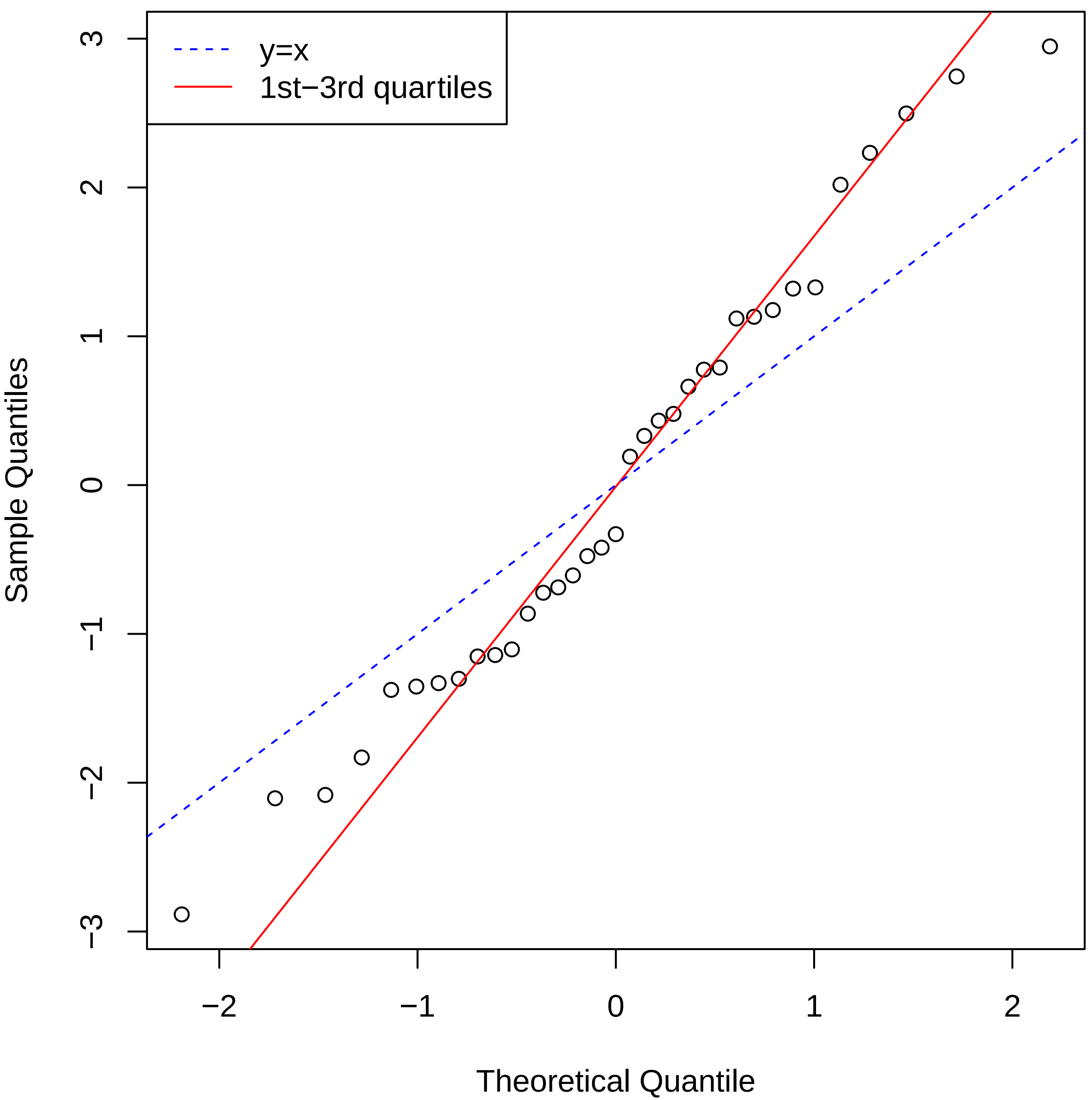
Age Comp Residuals for Catch by Fleet 1 (Rec + Comm)



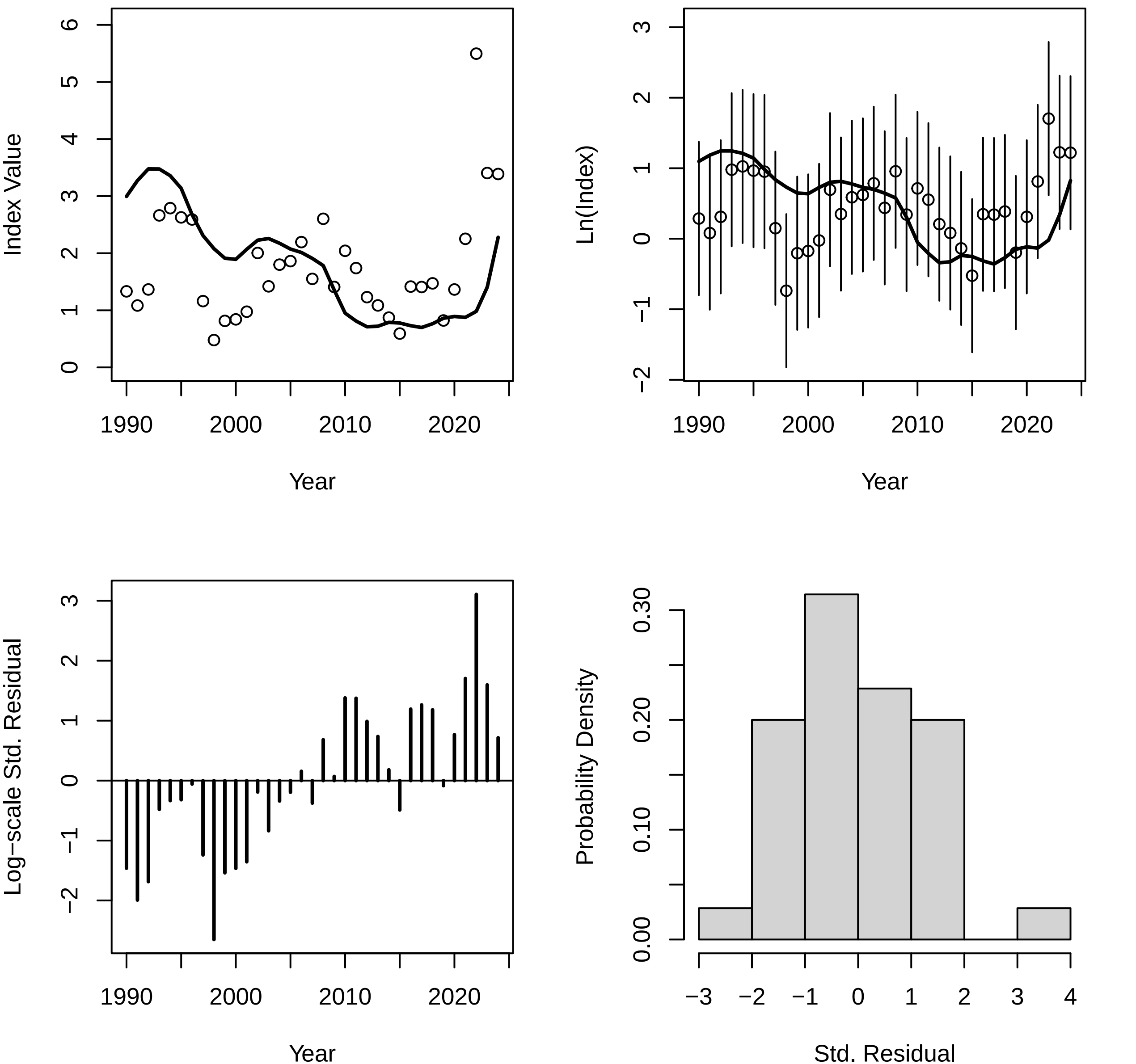

Catch Neff Fleet 1 (Rec + Comm)
Effective Sample Size
0
100
200
300
400
1990
1995
2000
2005
2010
2015
2020
2025
Year


Catch Fleet 1 (Rec + Comm)
Mean Age
Eff. Sample Size
Year
SDNR=1.49
RMSE=1.47
Std Resids
Year

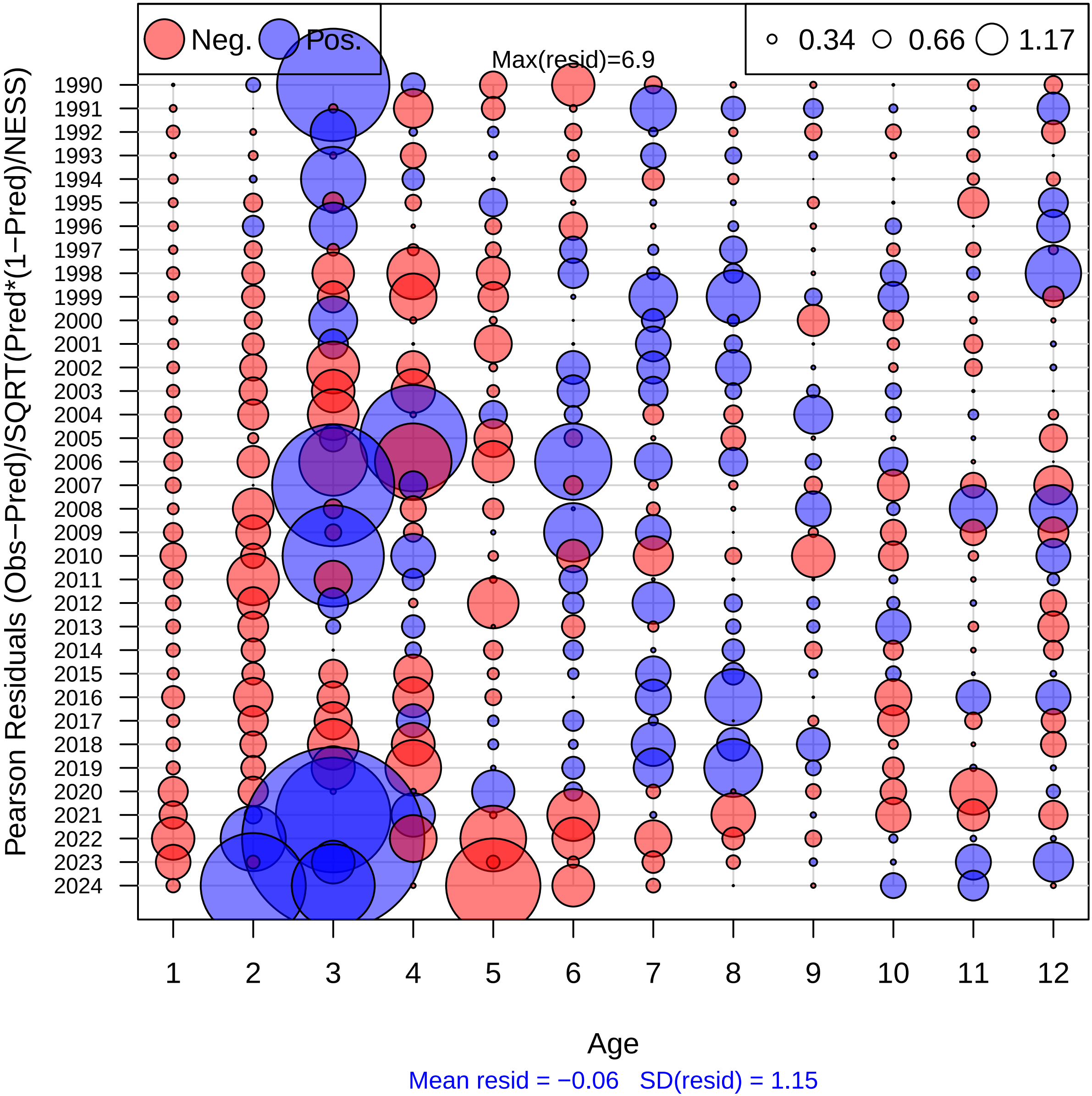
Catch Fleet 1 (Rec + Comm)

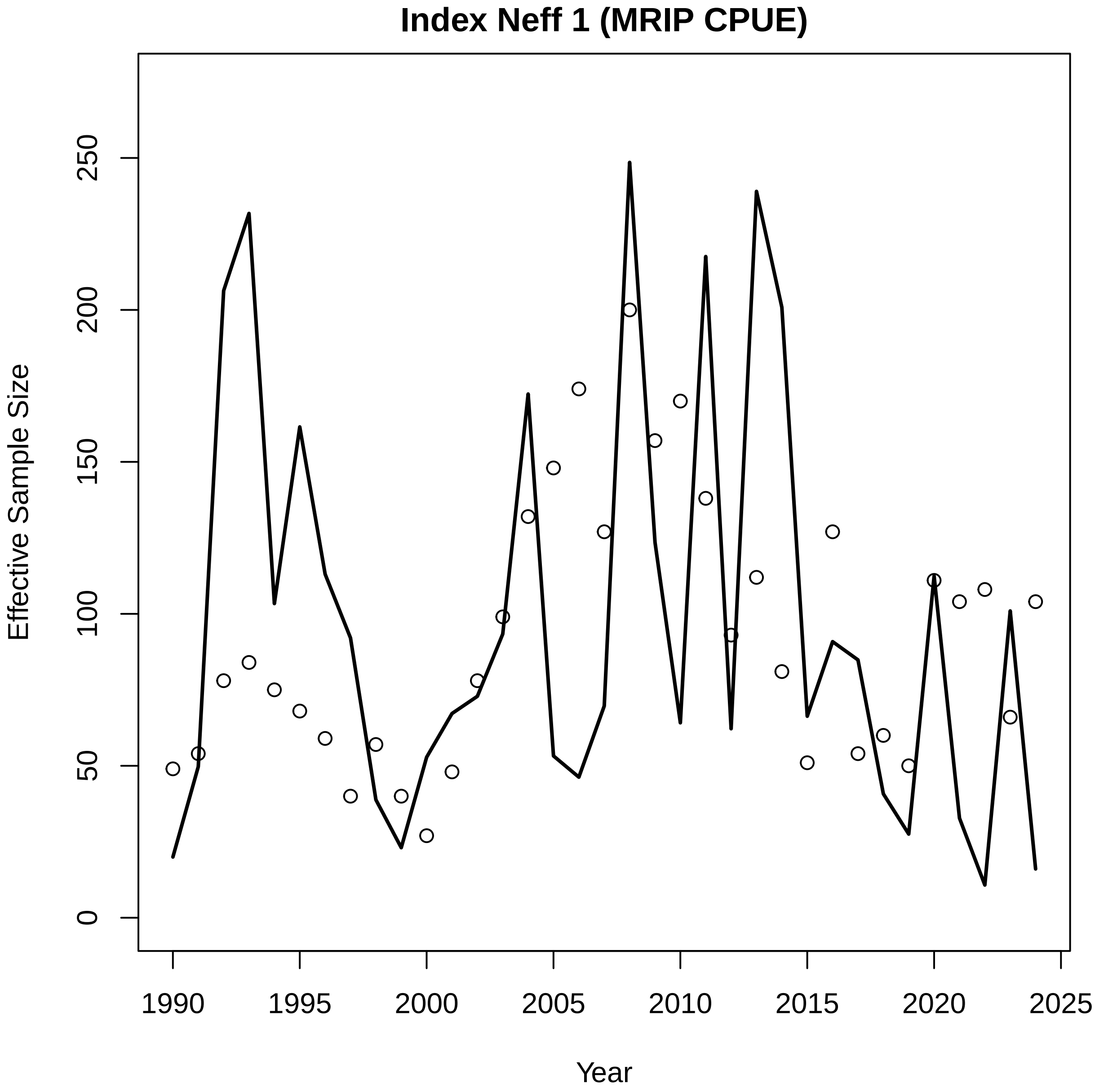


Index 1 (MRIP CPUE)

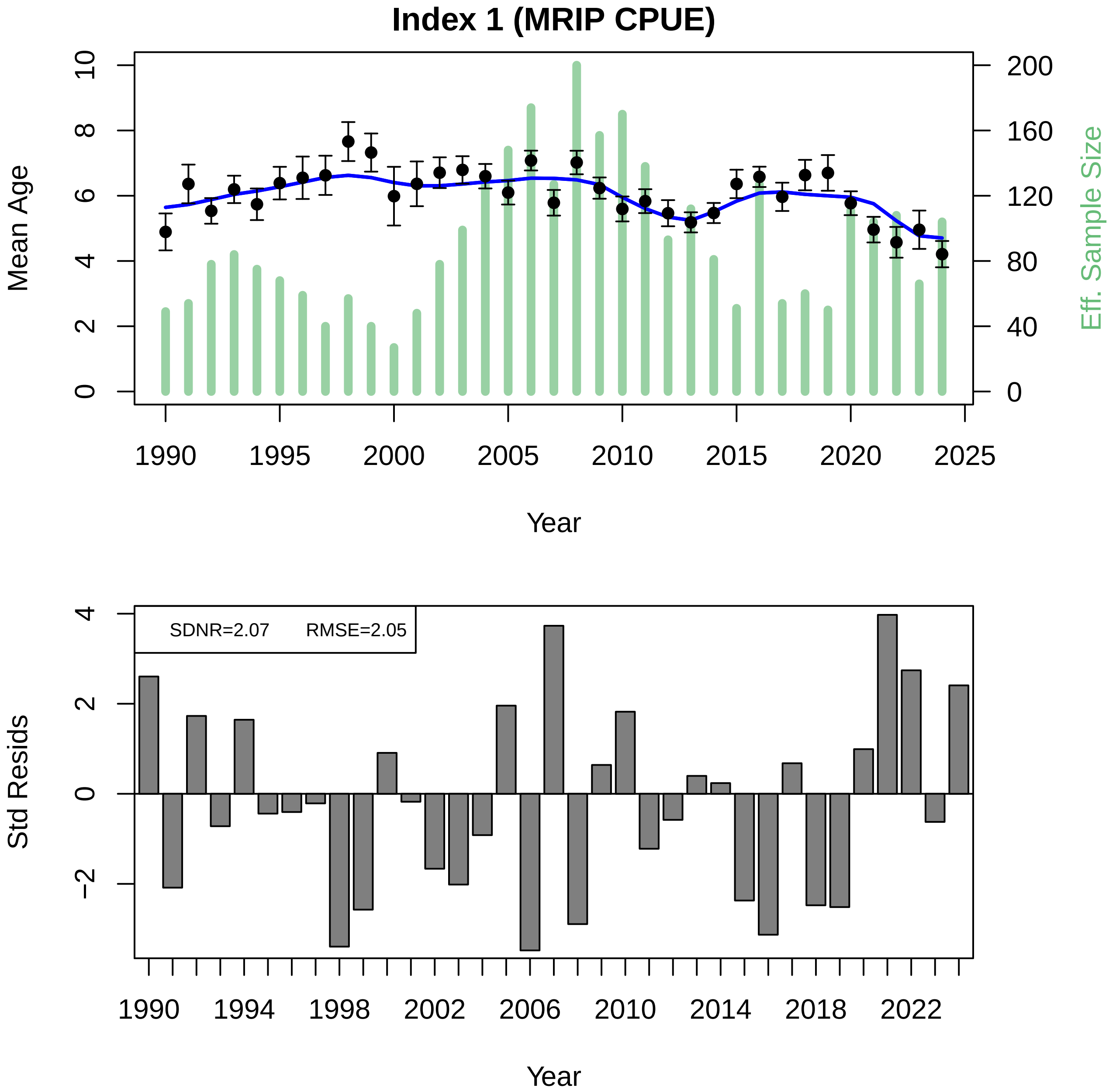


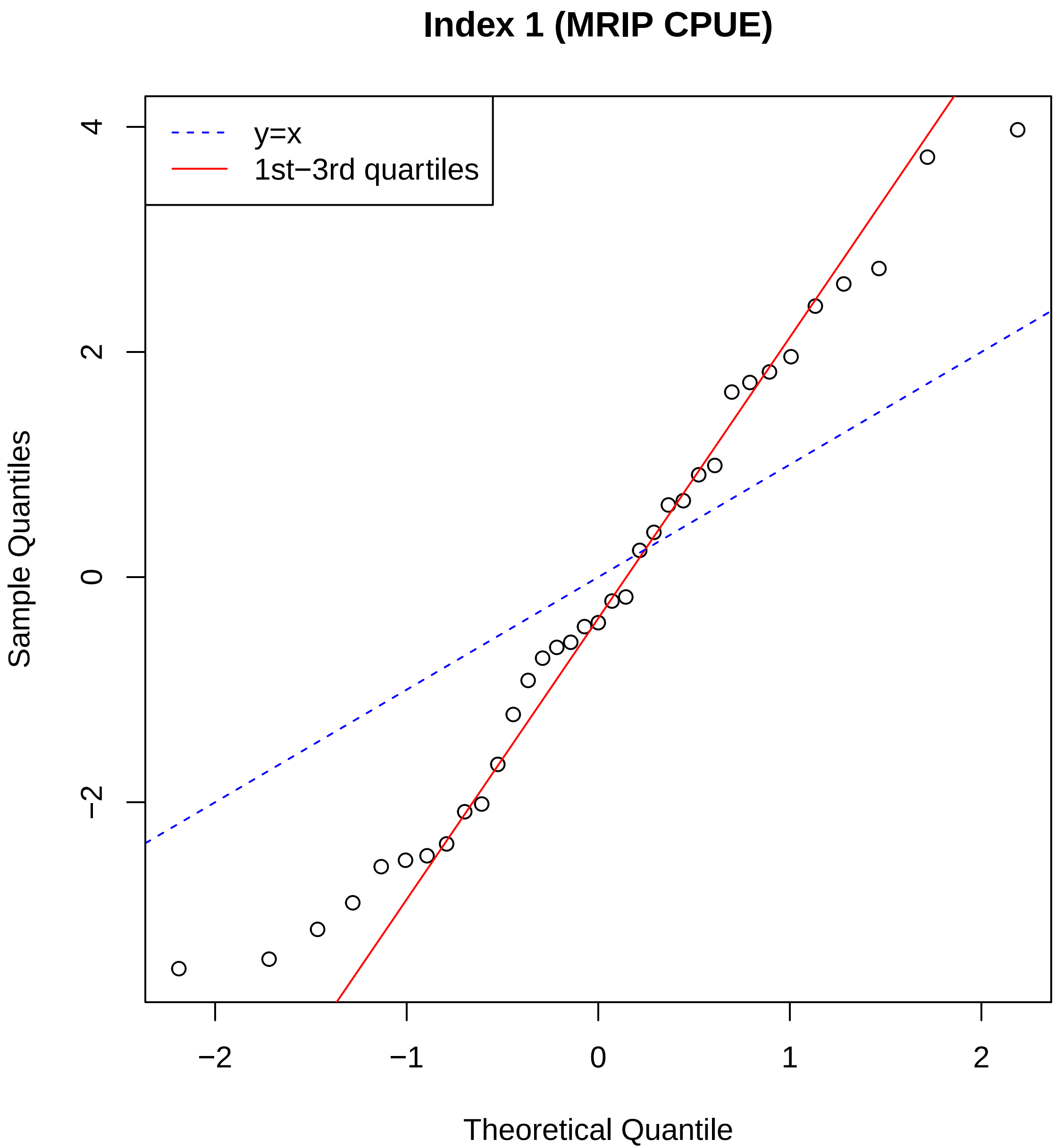
Age Comp Residuals for Index 1 (MRIP CPUE)

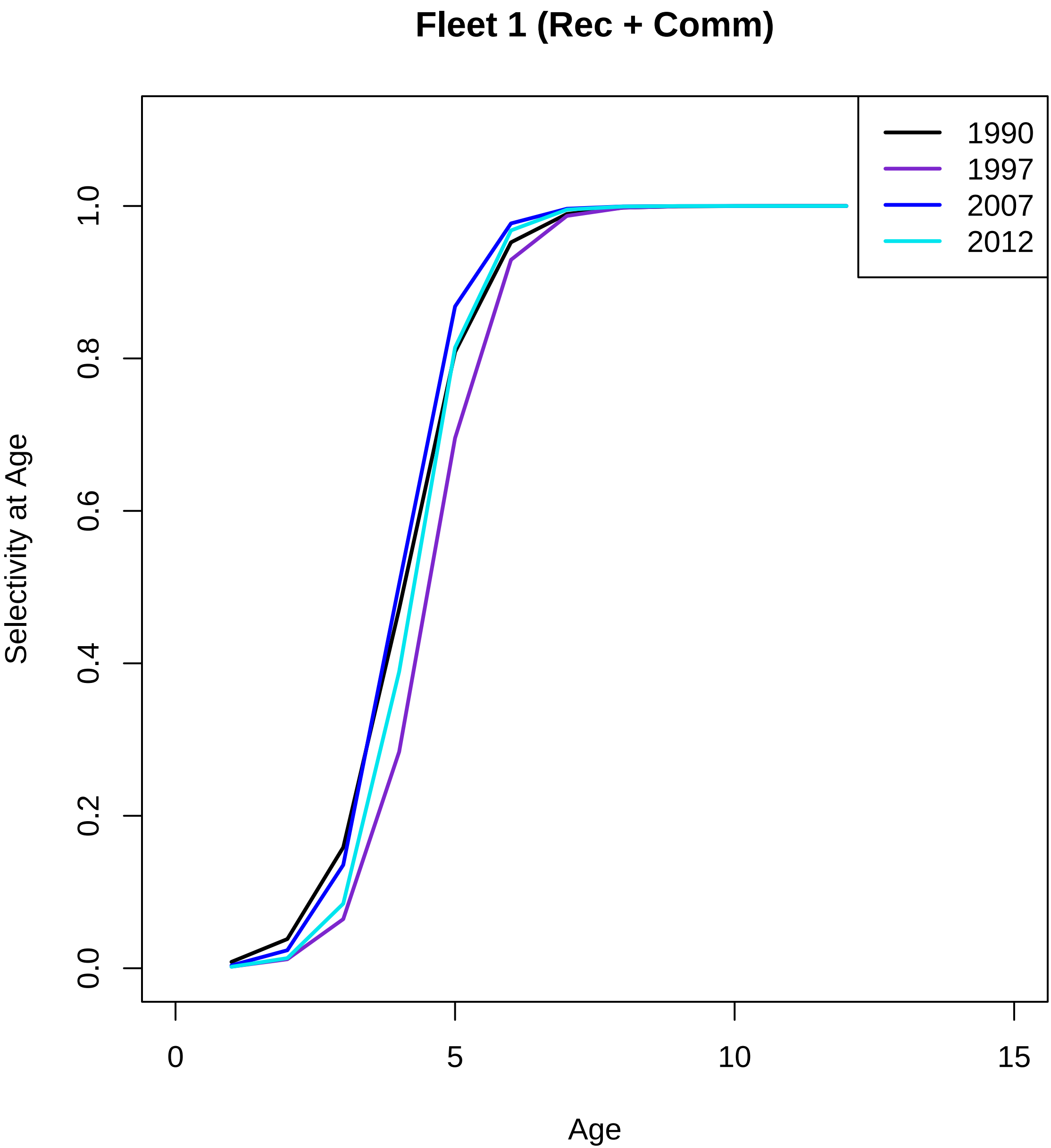


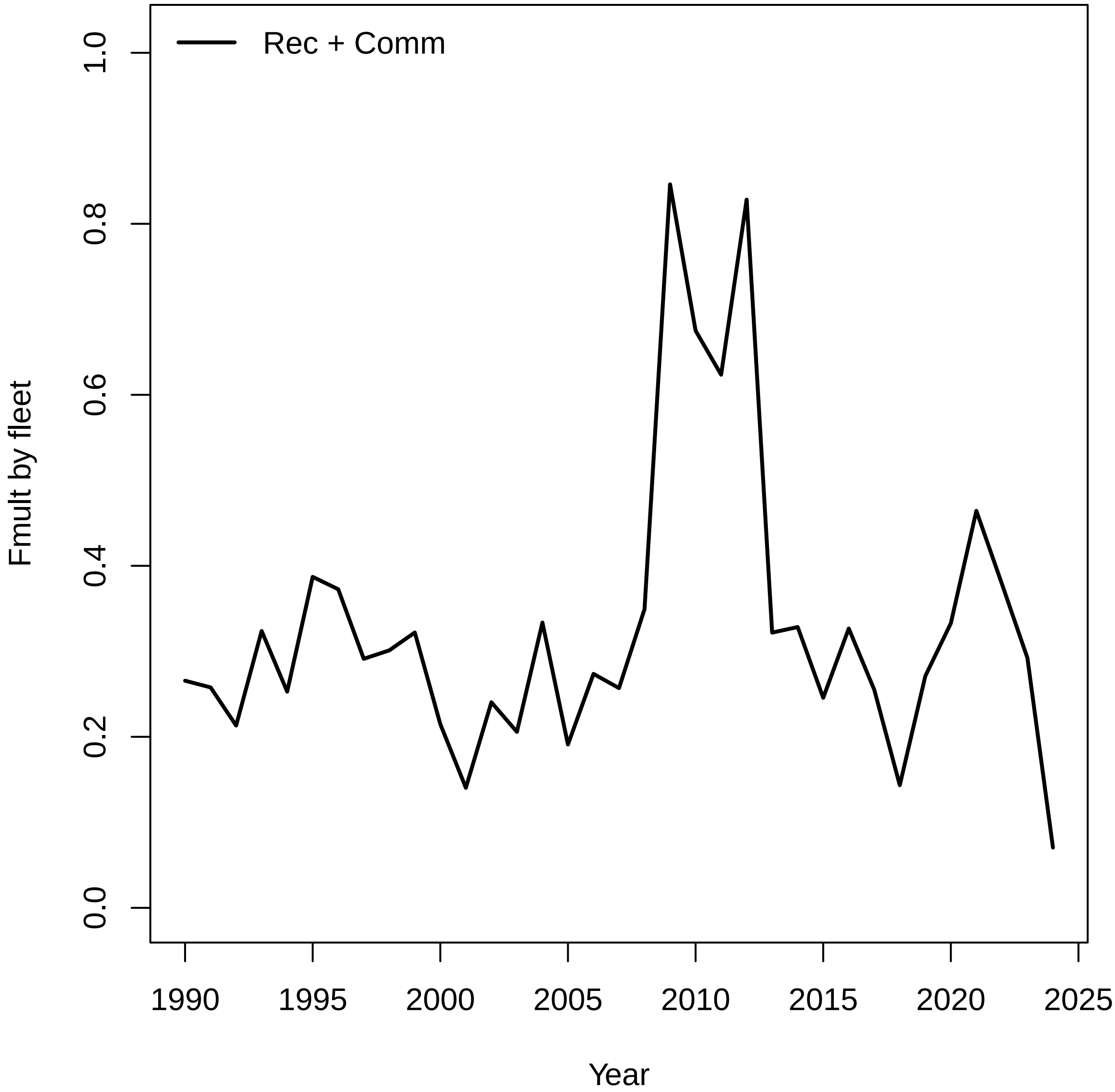


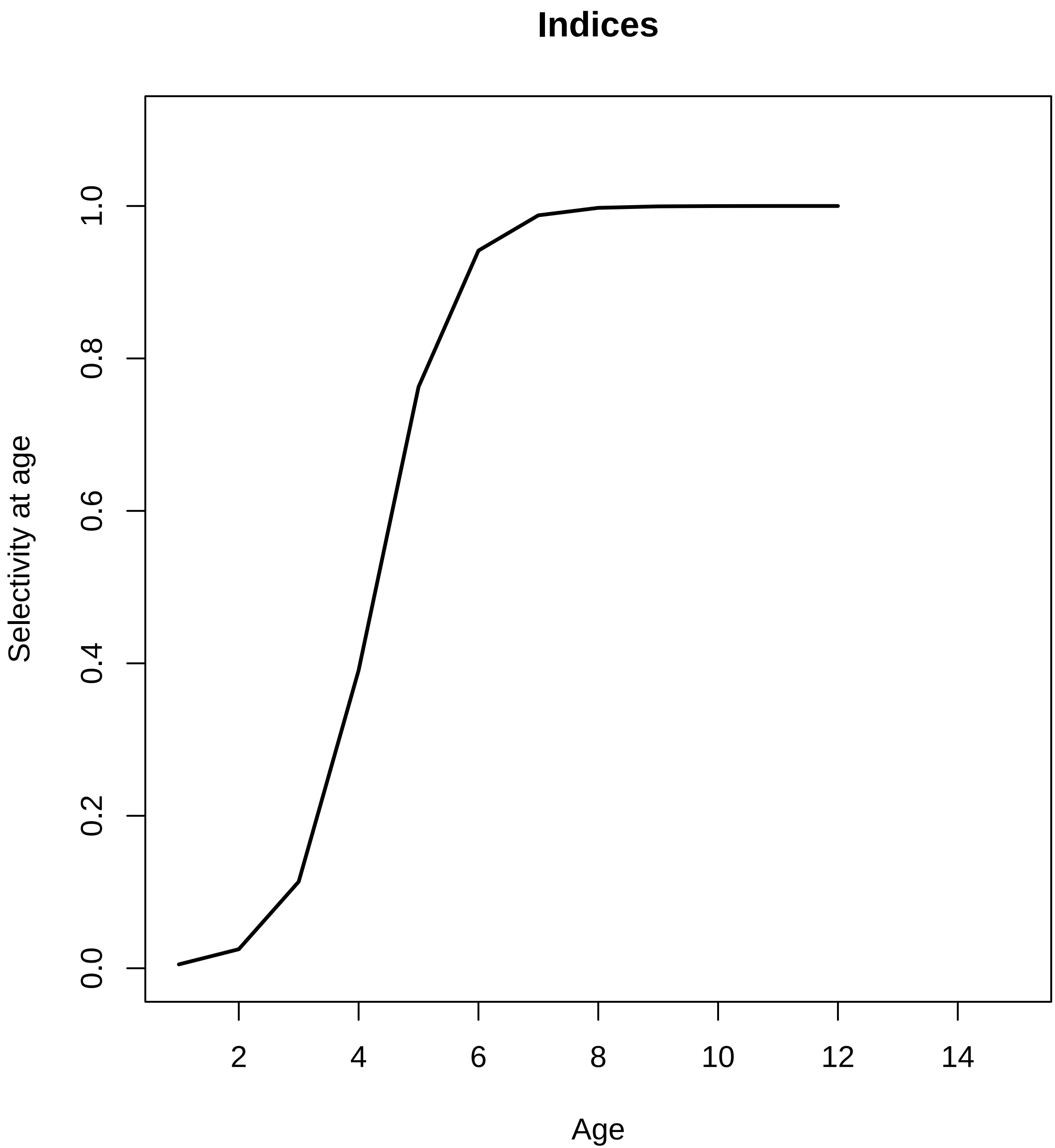
Index Neff 1 (MRIP CPUE)
Effective Sample Size
0
50
100
150
200
250
1990
1995
2000
2005
2010
2015
2020
2025
Year

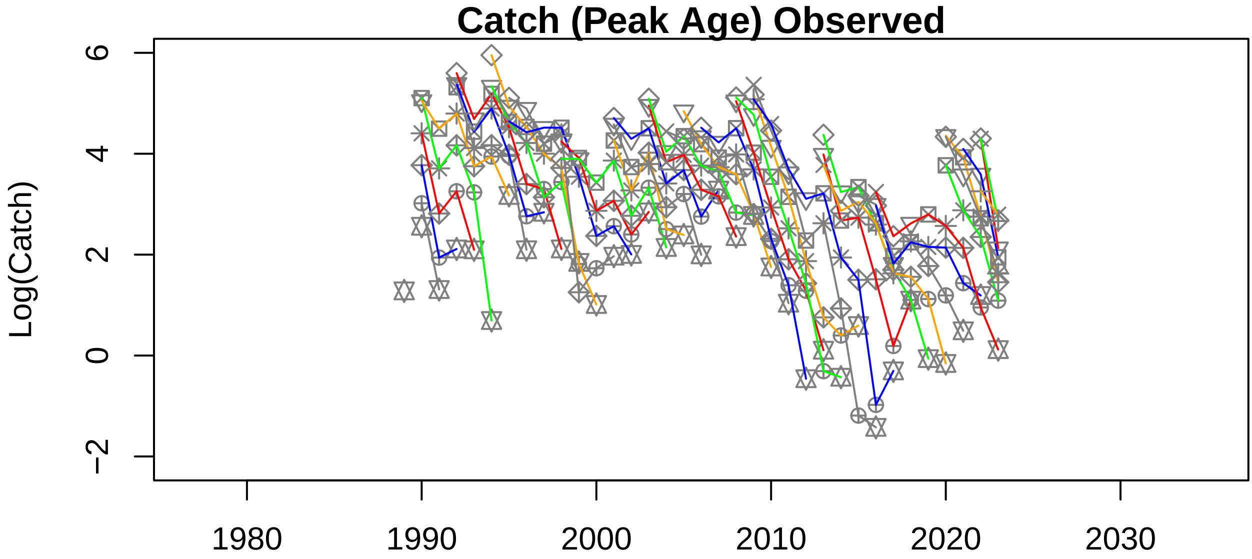

Index 1 (MRIP CPUE)
Mean Age
Eff. Sample Size
Year
SDNR=2.07
RMSE=2.05
Std Resids
Year

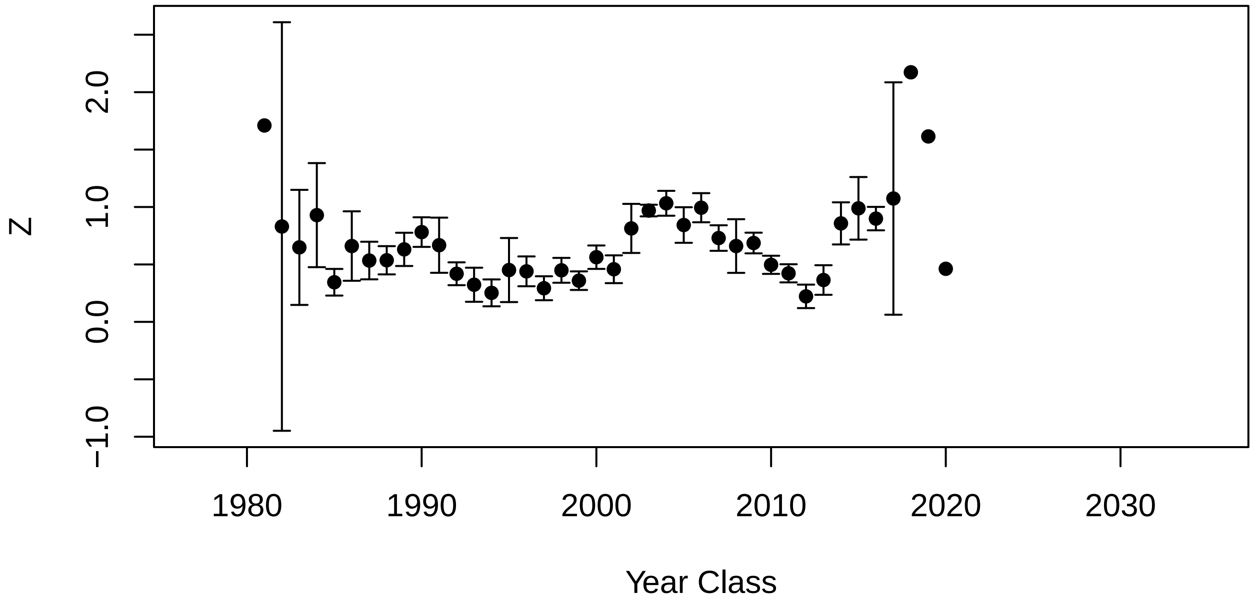

Index 1 (MRIP CPUE)
y=x
1st−3rd quartiles
Sample Quantiles
−2
0
2
4
Theoretical Quantile
−2
−1
0
1
2

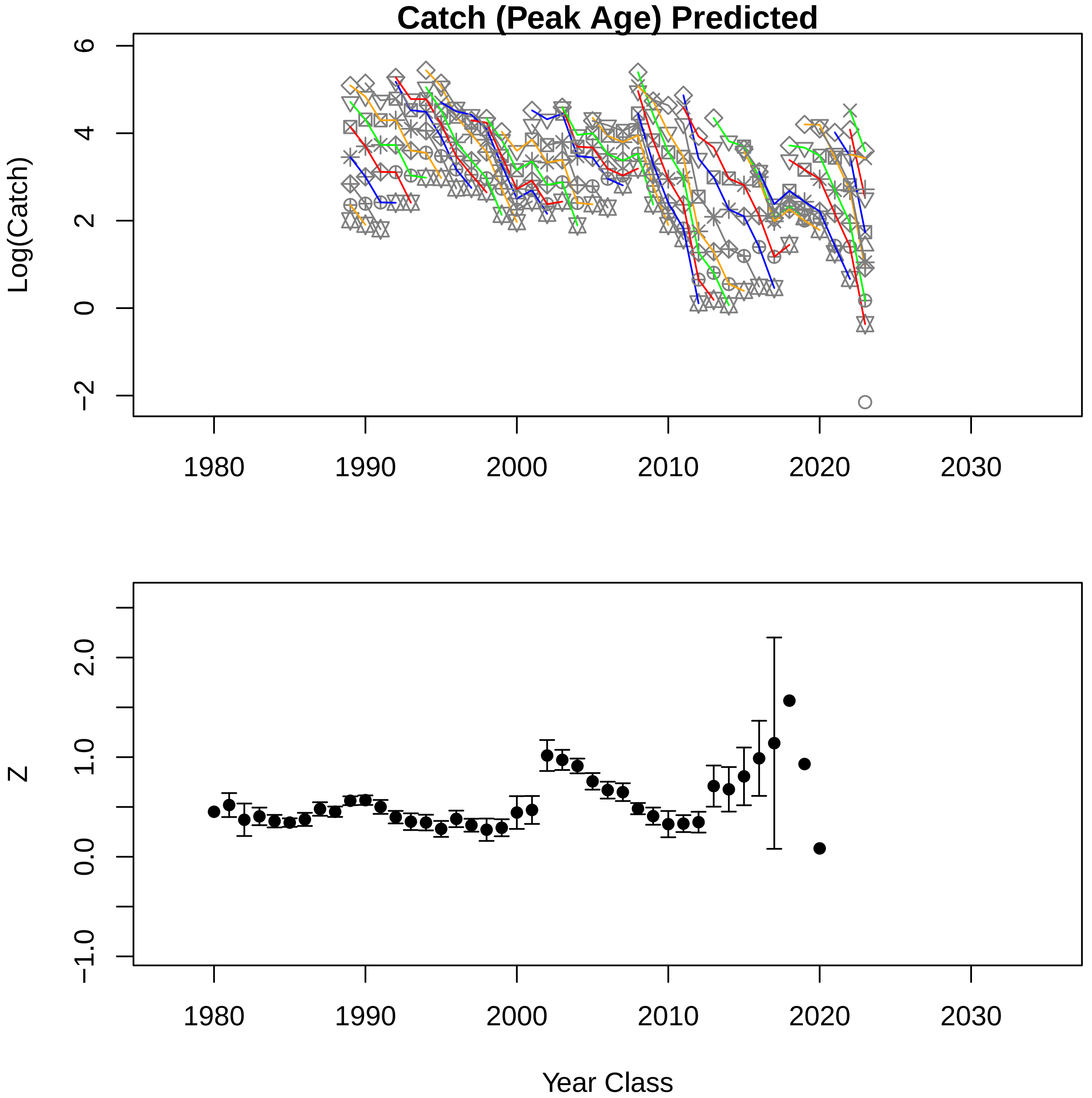

Fleet 1 (Rec + Comm)
1990
1997
2007
2012
Selectivity at Age
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
Age


Rec + Comm
Fmult by fleet
0.0
0.2
0.4
0.6
0.8
1.0
1990
1995
2000
2005
2010
2015
2020
2025
Year

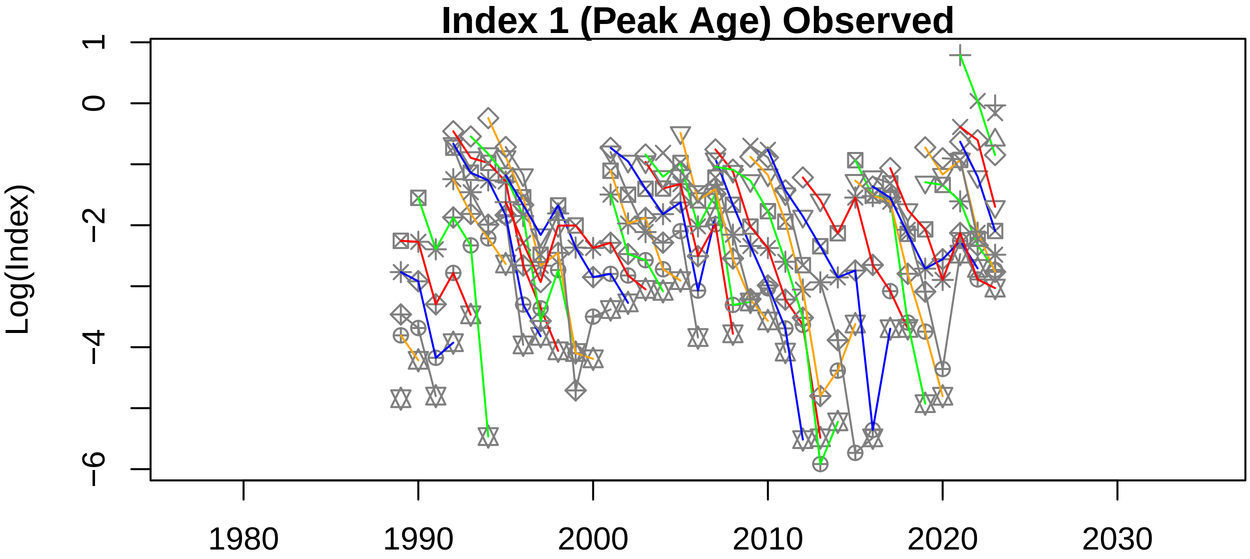

Indices
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
14
Age

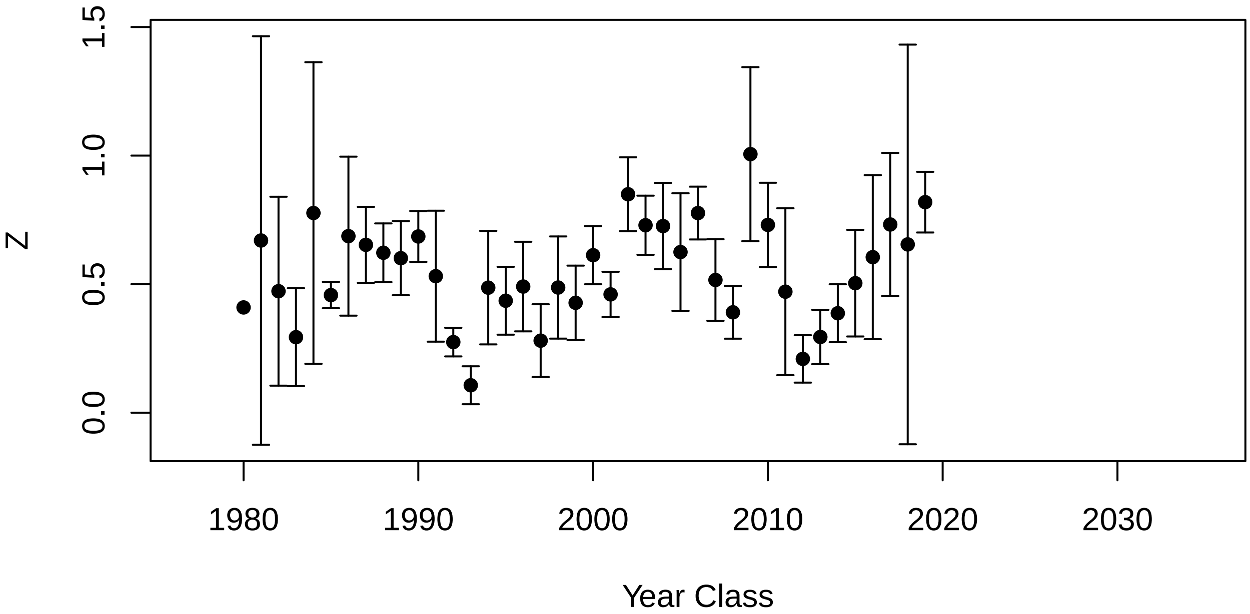

Catch (Peak Age) Observed
Log(Catch)
6
4
2
0
−2
1980
1990
2000
2010
2020
2030

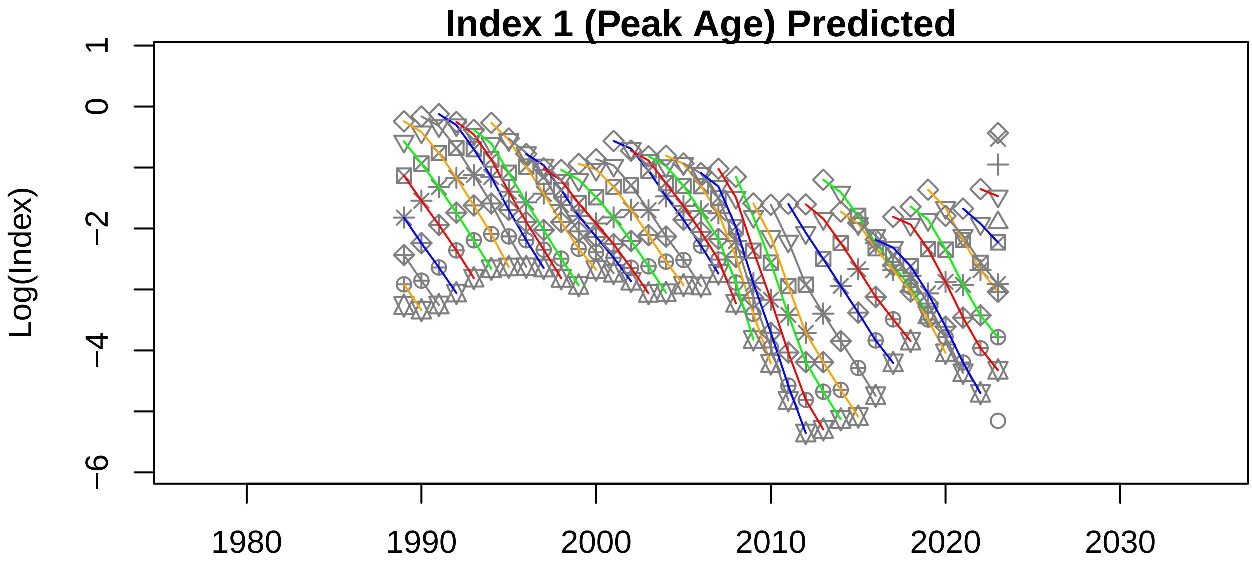

Z
2.0
1.0
0.0
−1.0
1980
1990
2000
2010
2020
2030
Year Class

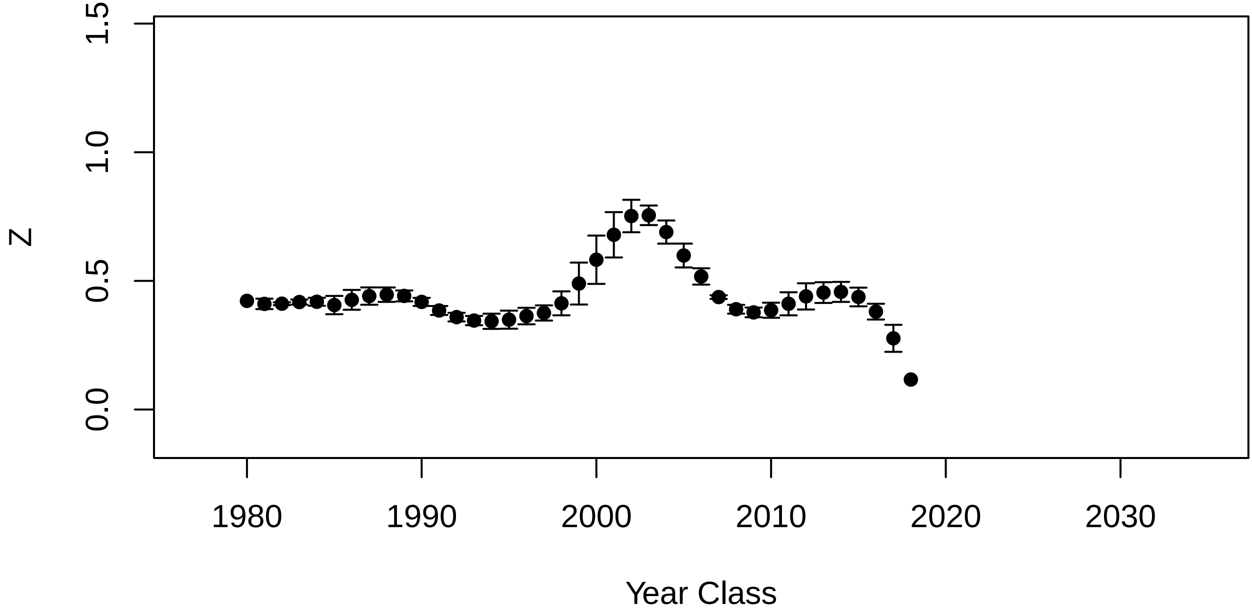


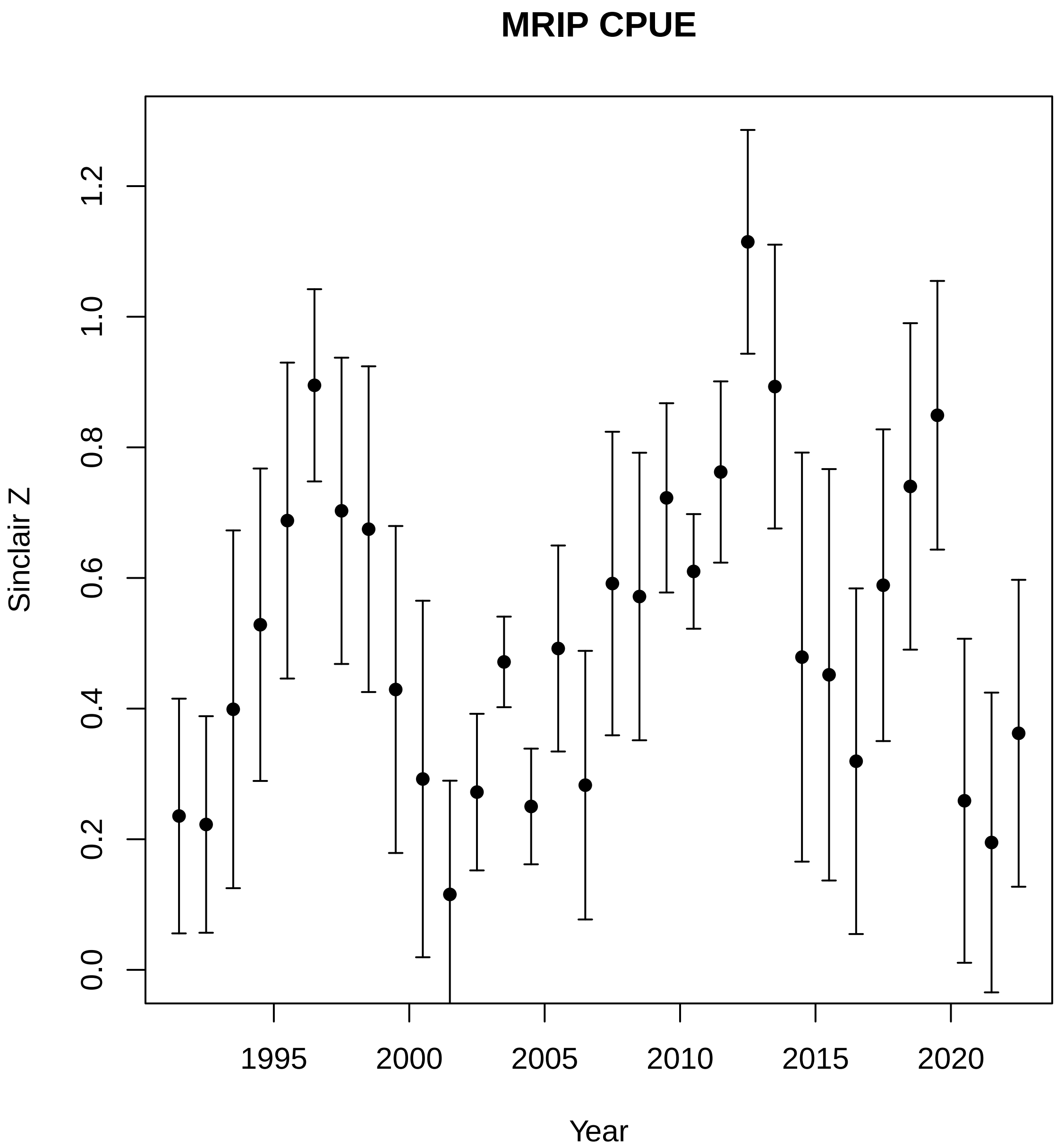
Catch (Peak Age) Predicted
Log(Catch)
6
4
2
0
−2
1980
1990
2000
2010
2020
2030
Z
2.0
1.0
0.0
−1.0
1980
1990
2000
2010
2020
2030
Year Class

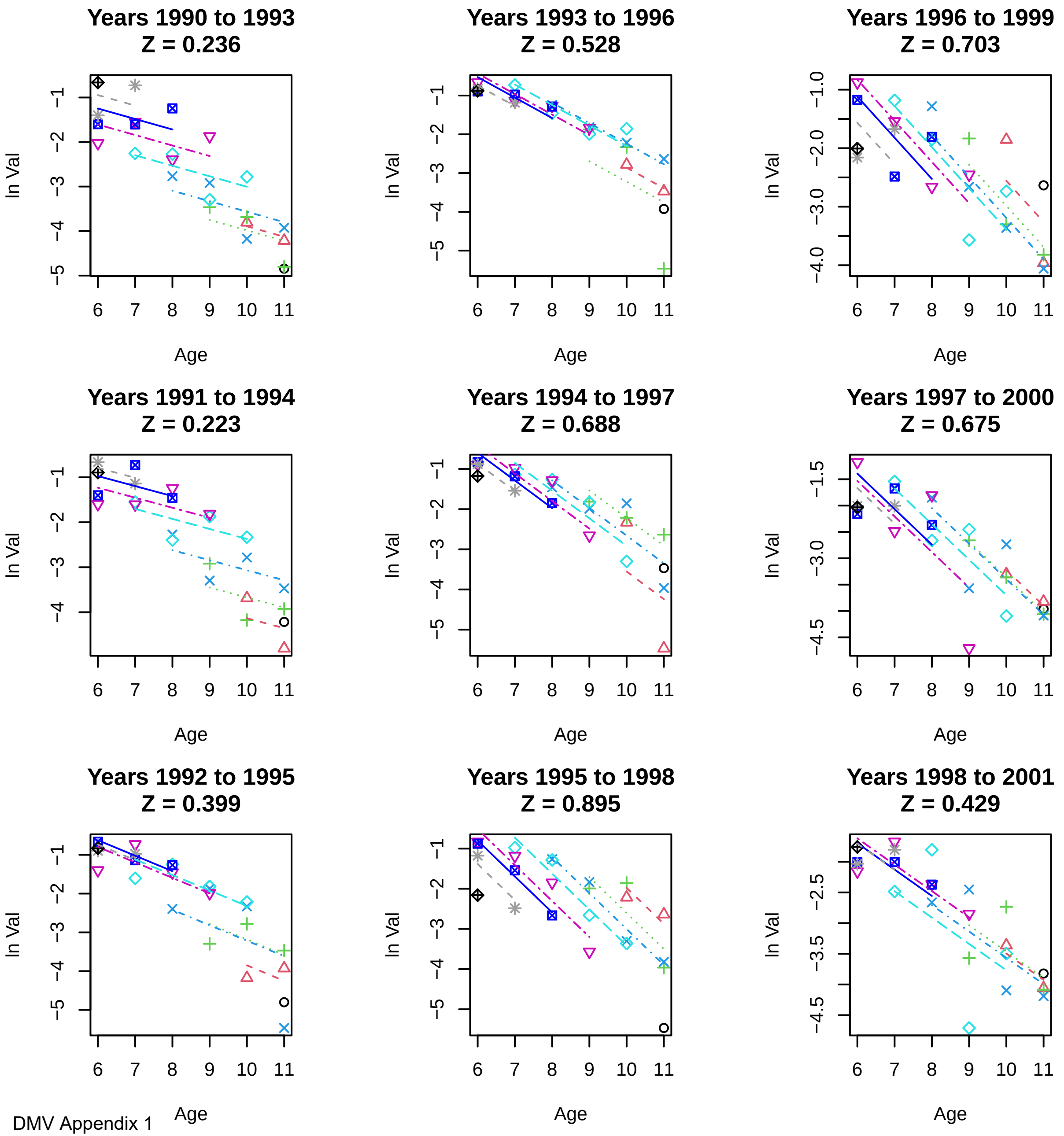

Index 1 (Peak Age) Observed
Log(Index)
1
0
−2
−4
−6
1980
1990
2000
2010
2020
2030

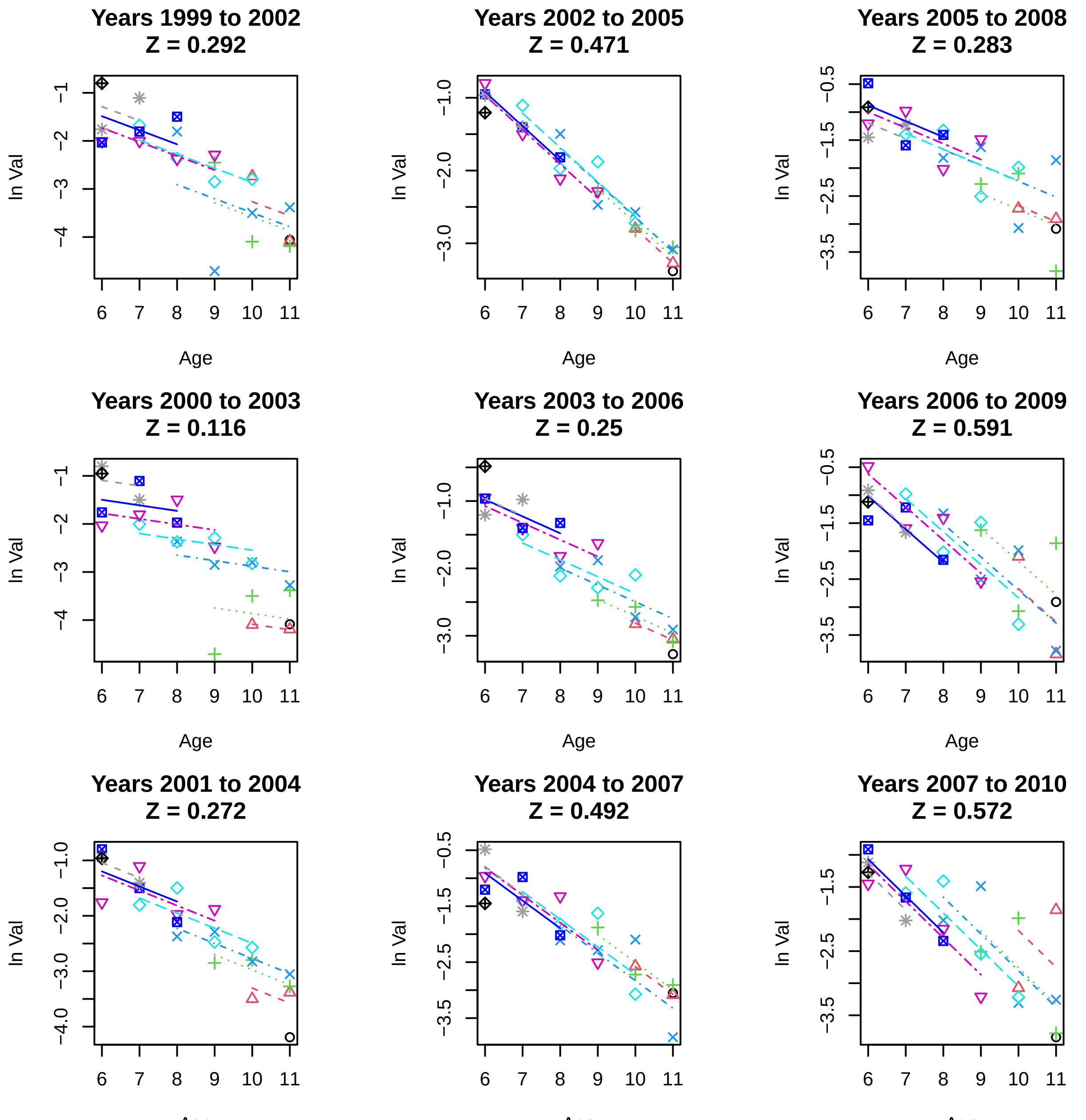

Z
1.5
1.0
0.5
0.0
1980
1990
2000
2010
2020
2030
Year Class


Index 1 (Peak Age) Predicted
Log(Index)
1
0
−2
−4
−6
1980
1990
2000
2010
2020
2030

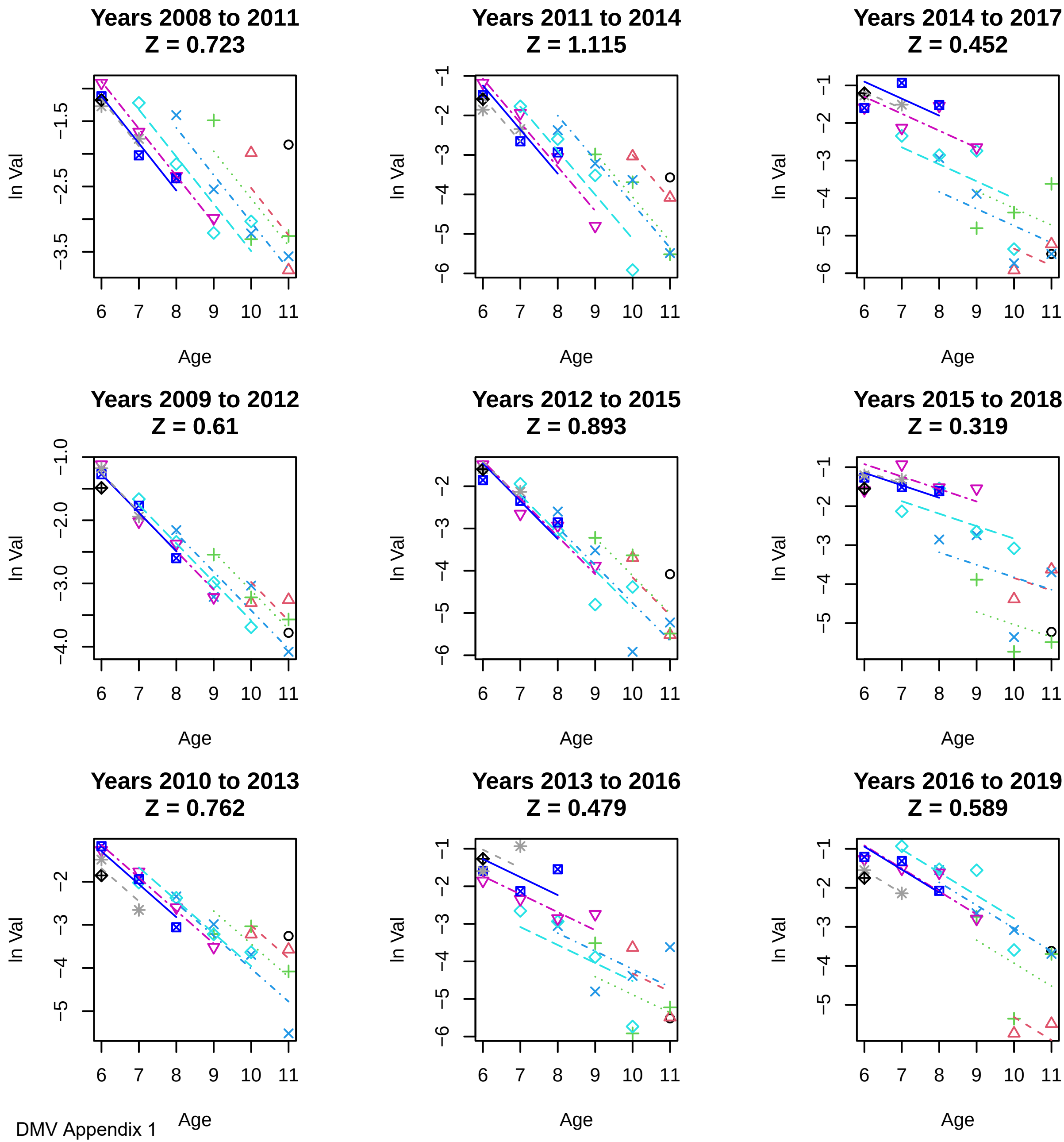

Z
1.5
1.0
0.5
0.0
1980
1990
2000
2010
2020
2030
Year Class

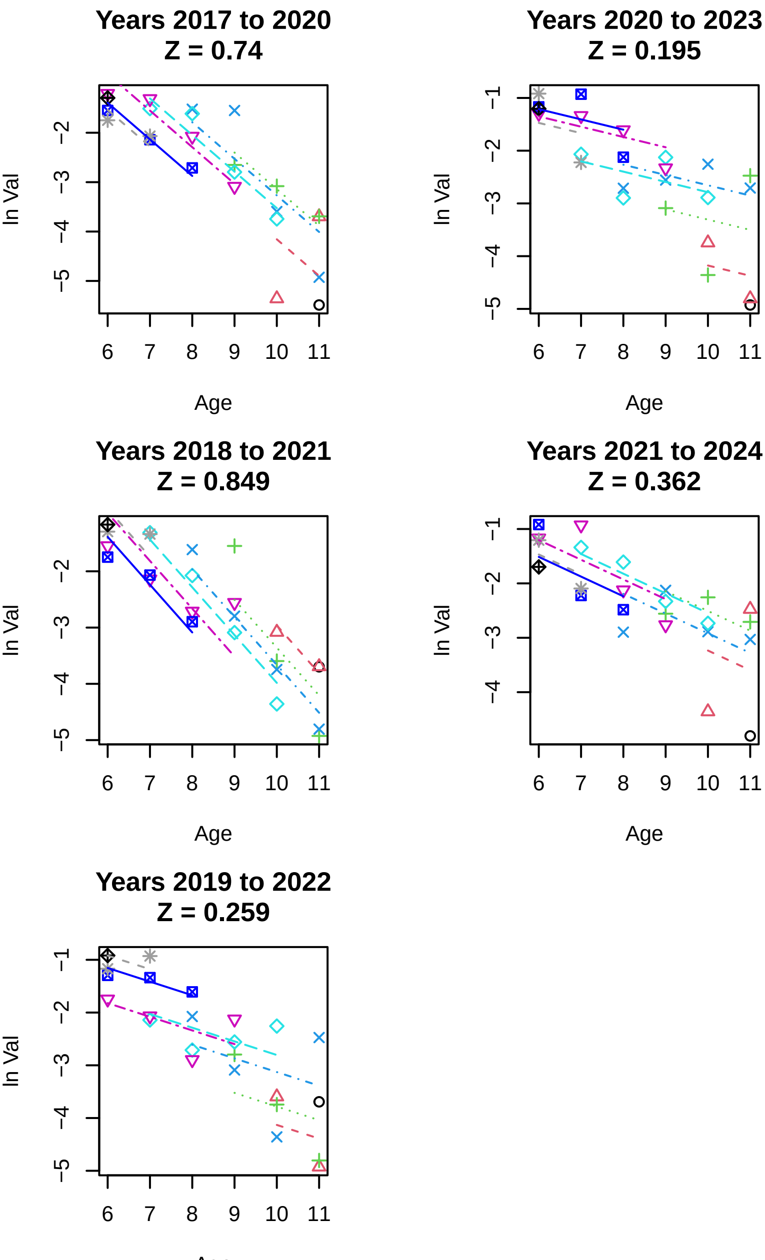

MRIP CPUE
Sinclair Z
Year
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1995
2000
2005
2010
2015
2020

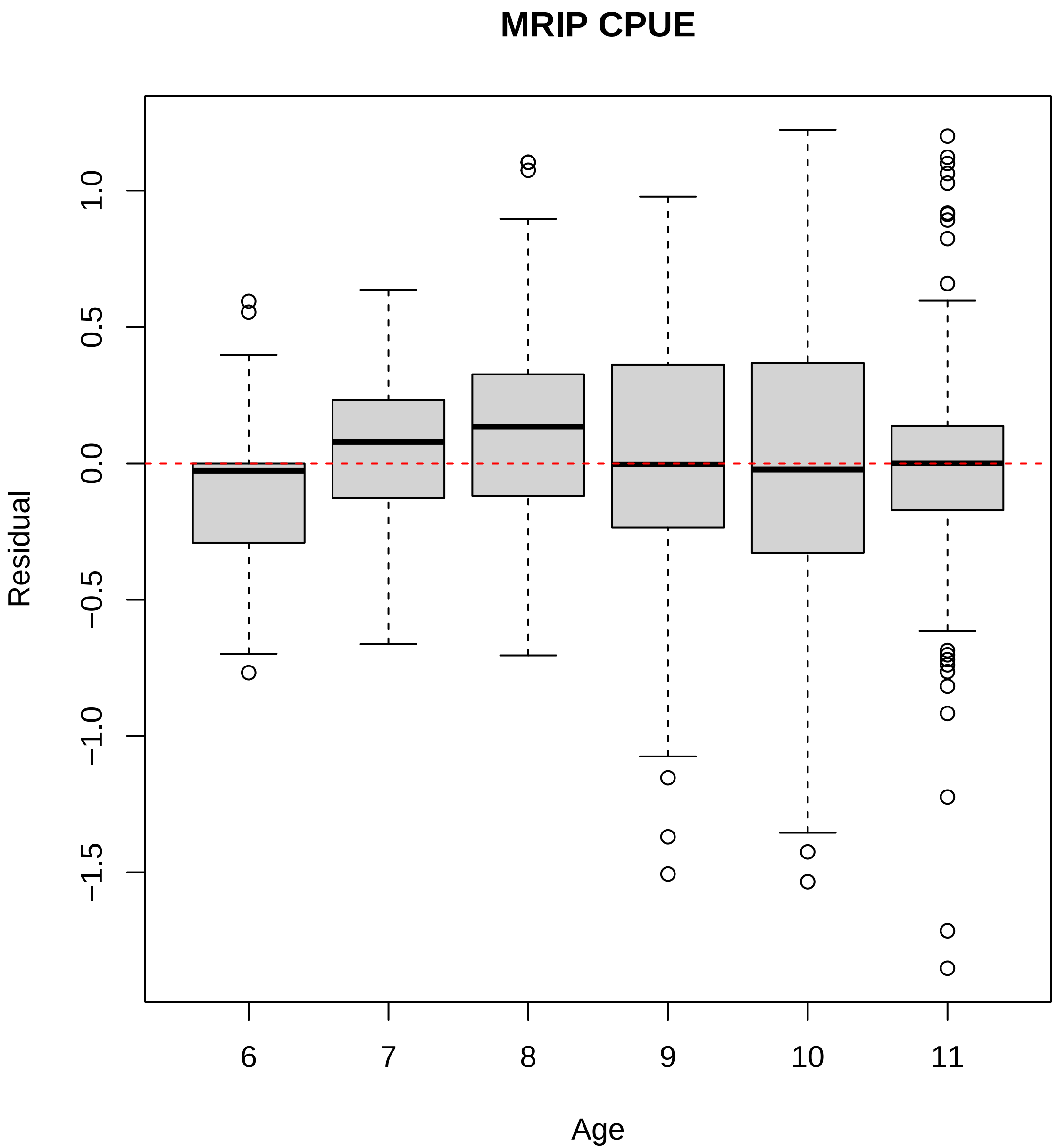

Years 1990 to 1993
Z = 0.236
Years 1993 to 1996
Z = 0.528
Years 1996 to 1999
Z = 0.703
Years 1991 to 1994
Z = 0.223
Years 1994 to 1997
Z = 0.688
Years 1997 to 2000
Z = 0.675
Years 1992 to 1995
Z = 0.399
Years 1995 to 1998
Z = 0.895
Years 1998 to 2001
Z = 0.429
ln Val
Age



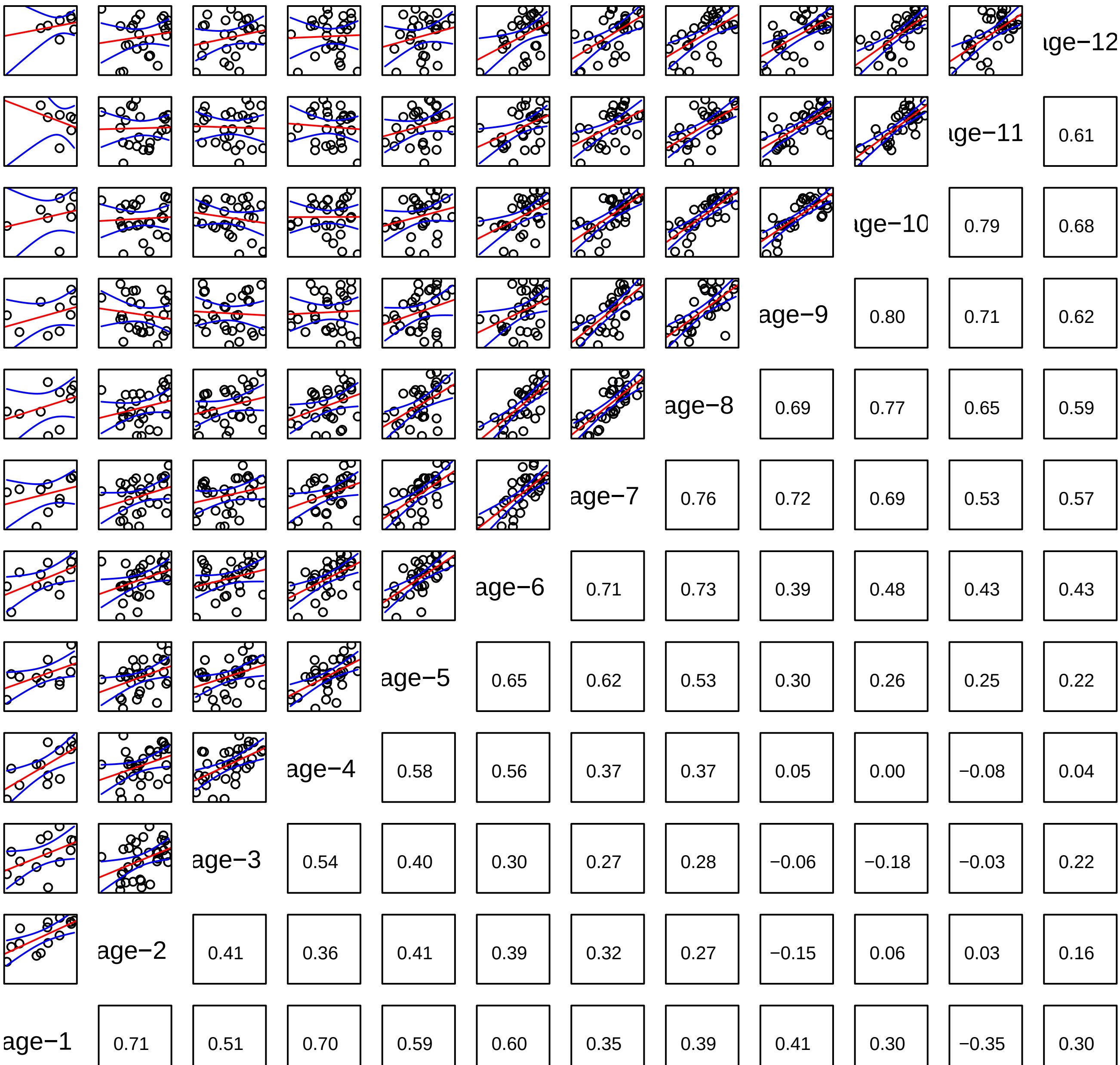
Years 1999 to 2002
Z = 0.292
Years 2002 to 2005
Z = 0.471
Years 2005 to 2008
Z = 0.283
Years 2000 to 2003
Z = 0.116
Years 2003 to 2006
Z = 0.25
Years 2006 to 2009
Z = 0.591
Years 2001 to 2004
Z = 0.272
Years 2004 to 2007
Z = 0.492
Years 2007 to 2010
Z = 0.572
ln Val
Age
6 7 8 9 10 11


Years 2008 to 2011
Z = 0.723
Years 2011 to 2014
Z = 1.115
Years 2014 to 2017
Z = 0.452
Years 2009 to 2012
Z = 0.61
Years 2012 to 2015
Z = 0.893
Years 2015 to 2018
Z = 0.319
Years 2010 to 2013
Z = 0.762
Years 2013 to 2016
Z = 0.479
Years 2016 to 2019
Z = 0.589
ln Val
Age
6
7
8
9
10
11

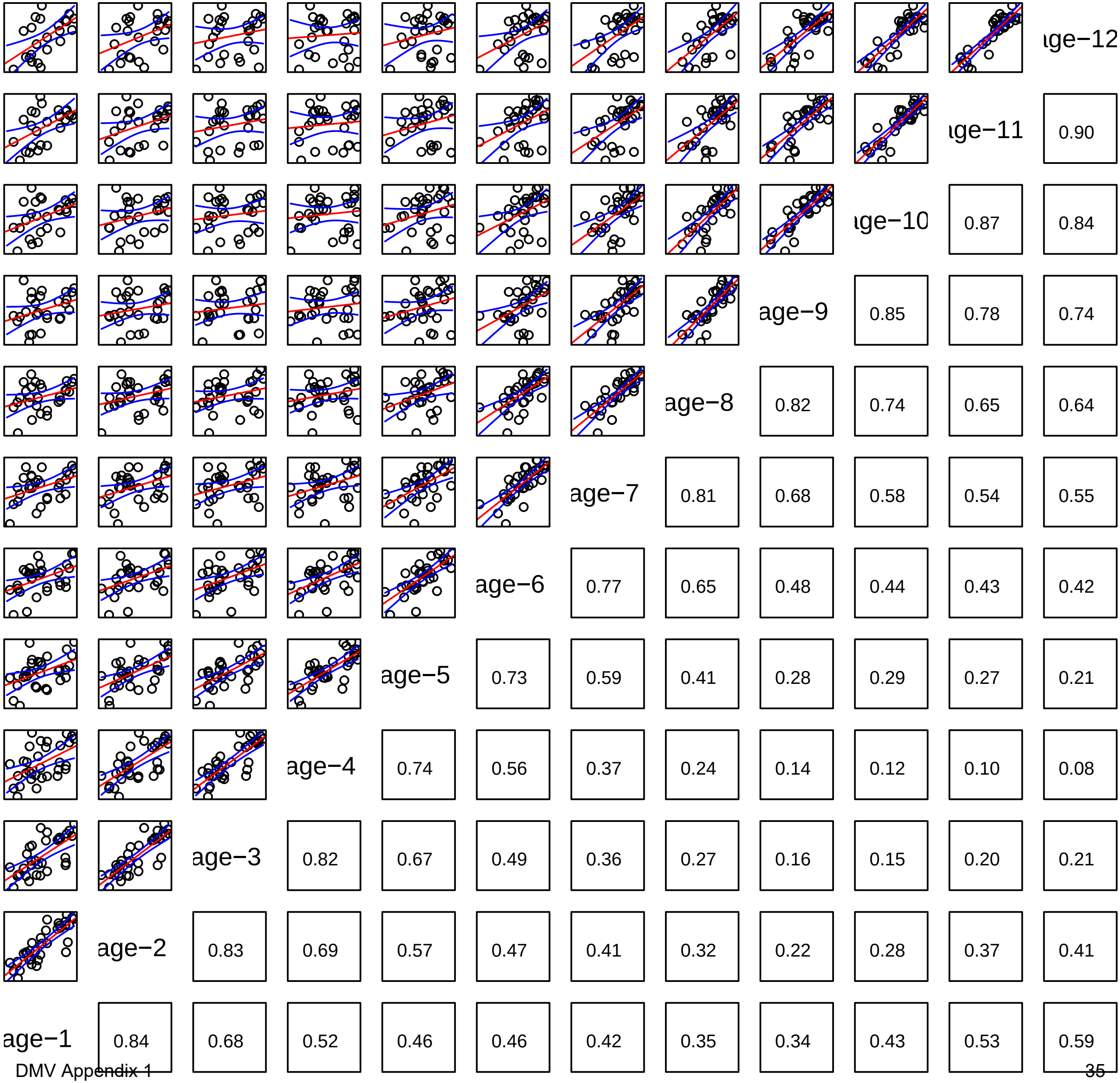

Years 2017 to 2020
Z = 0.74
Years 2020 to 2023
Z = 0.195
Years 2018 to 2021
Z = 0.849
Years 2021 to 2024
Z = 0.362
Years 2019 to 2022
Z = 0.259
ln Val
Age
6 7 8 9 10 11
−1 −2 −3 −4 −5


MRIP CPUE
Residual
1.0
0.5
0.0
−0.5
−1.0
−1.5
6
7
8
9
10
11
Age

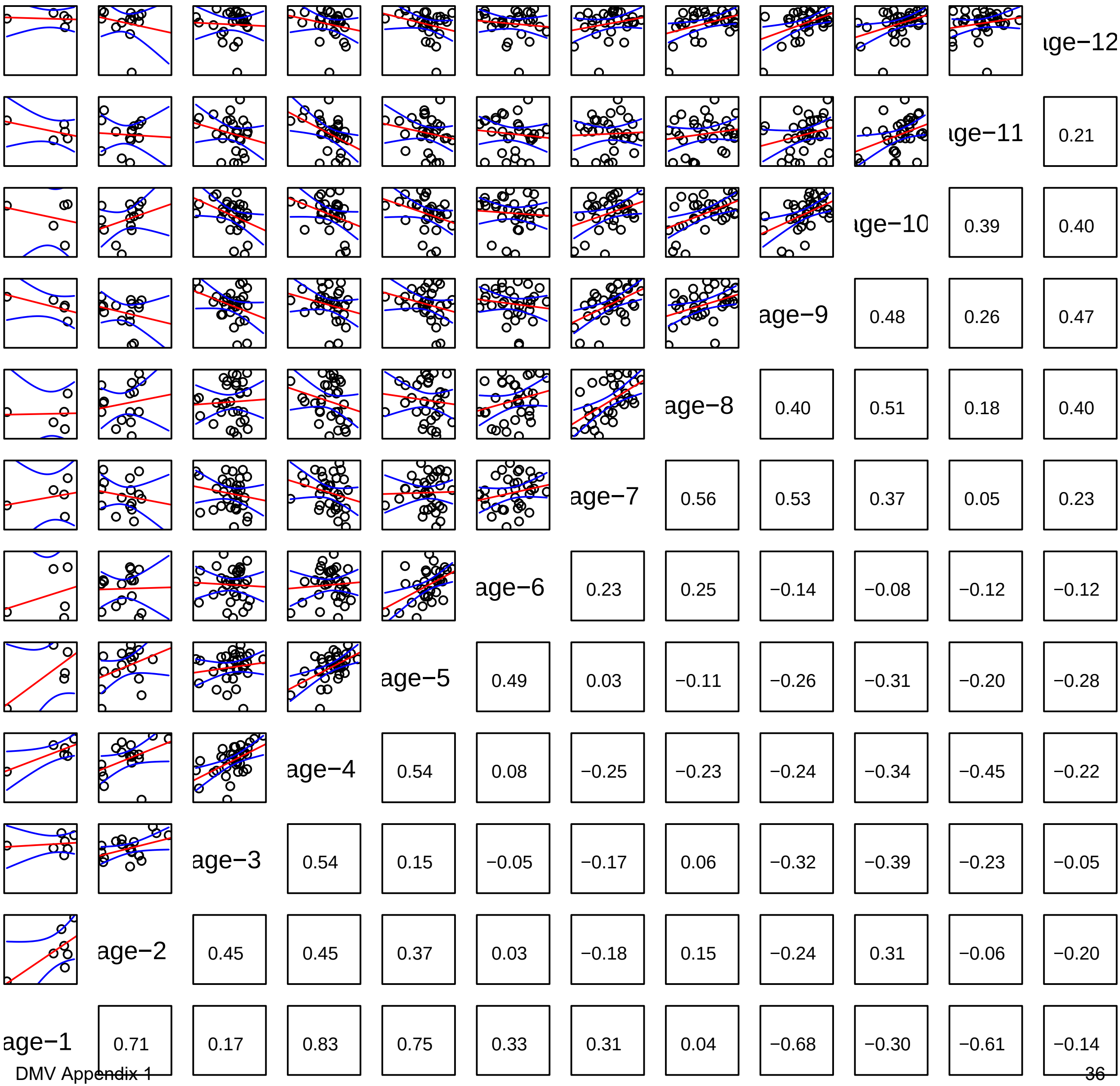
Catch Observed



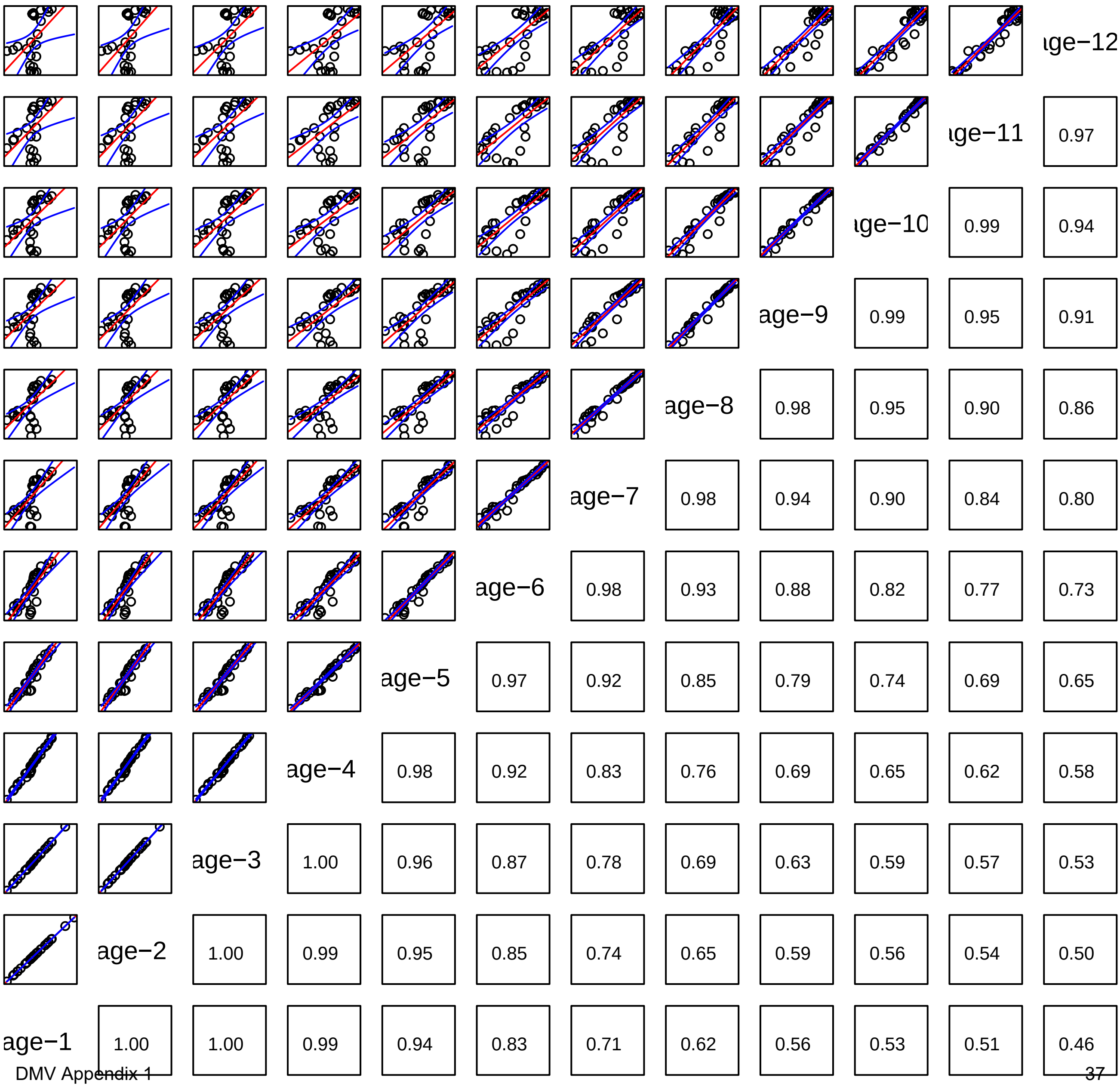
Catch Predicted

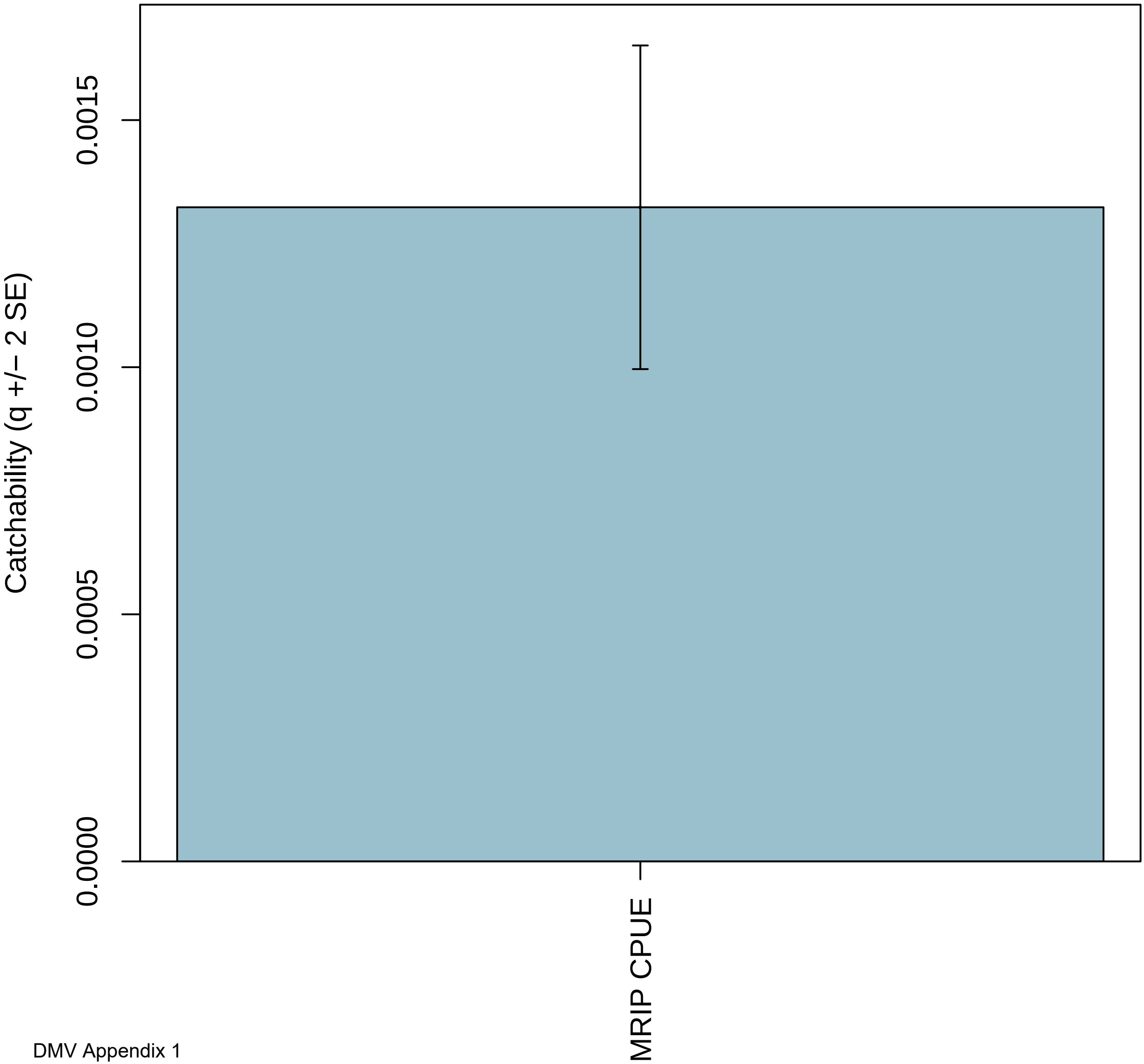


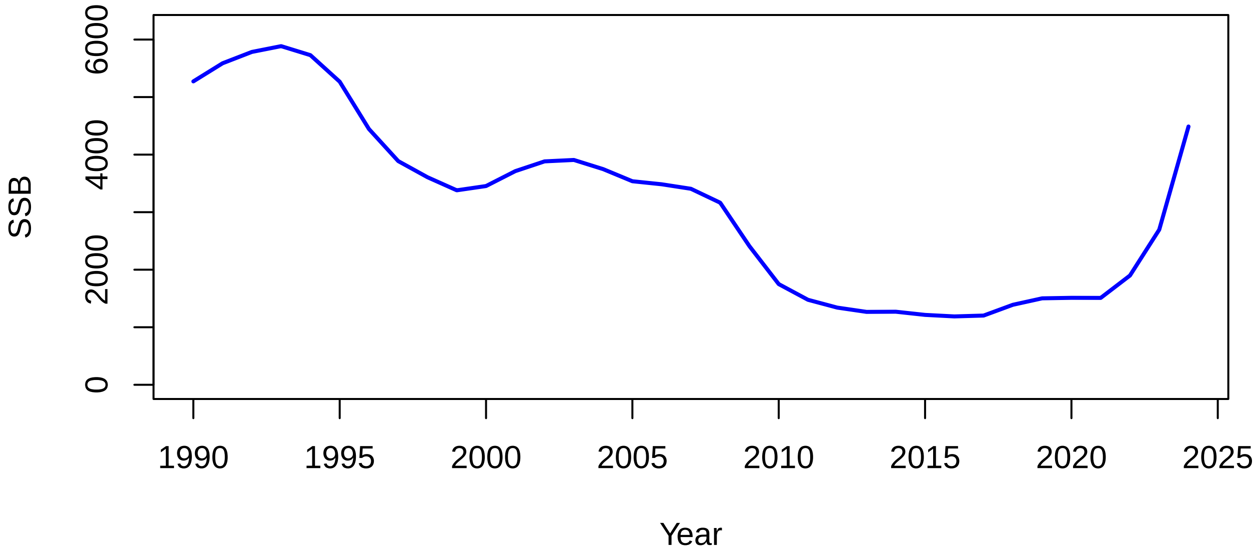
Index 1 (MRIP CPUE) Observed



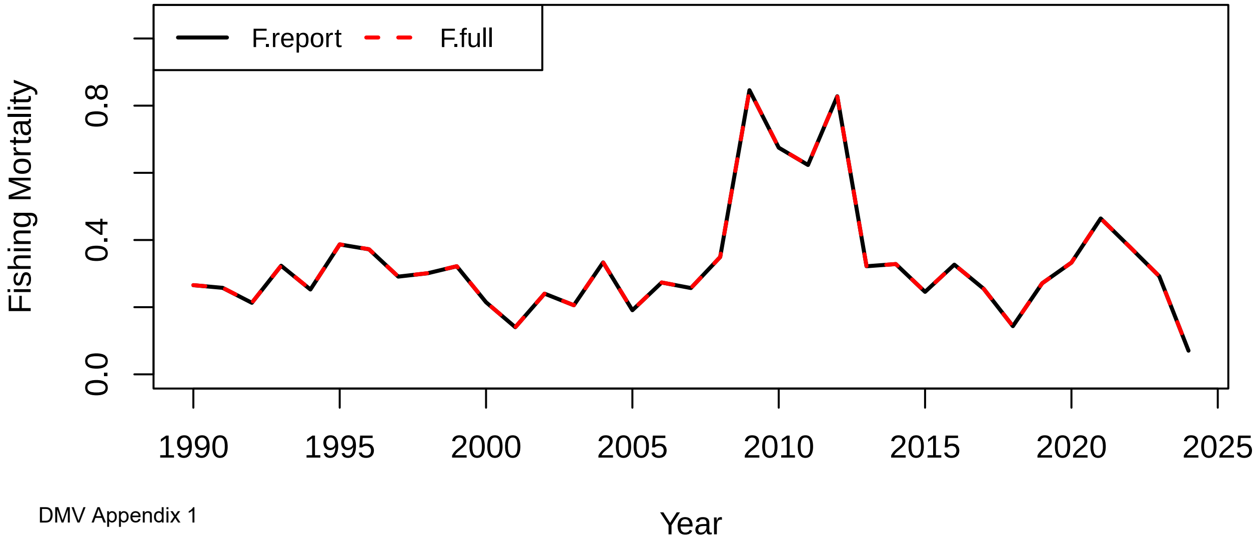
Index 1 (MRIP CPUE) Predicted



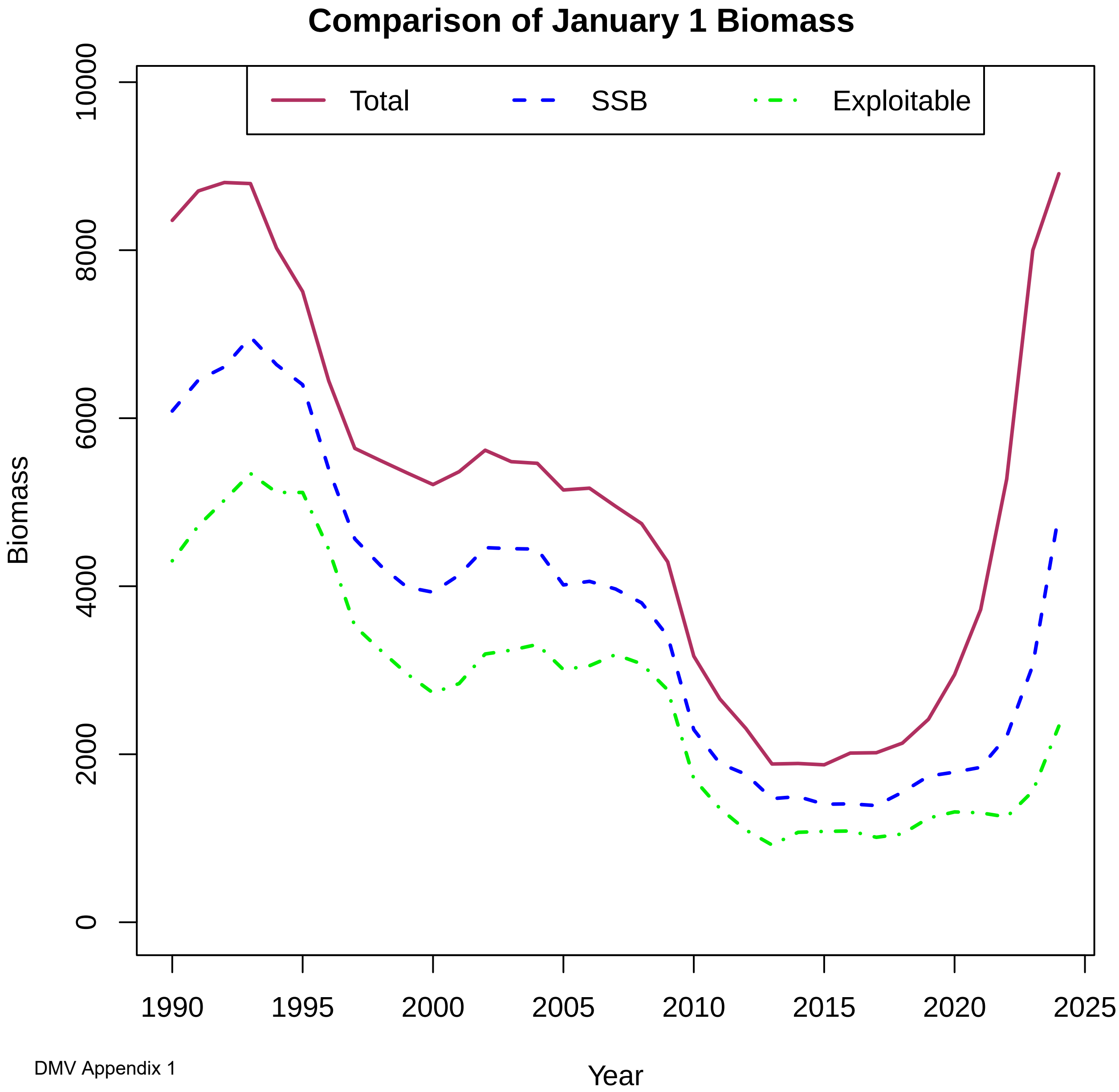

Catchability (q +/− 2 SE)
0.0000
0.0005
0.0010
0.0015
MRIP CPUE

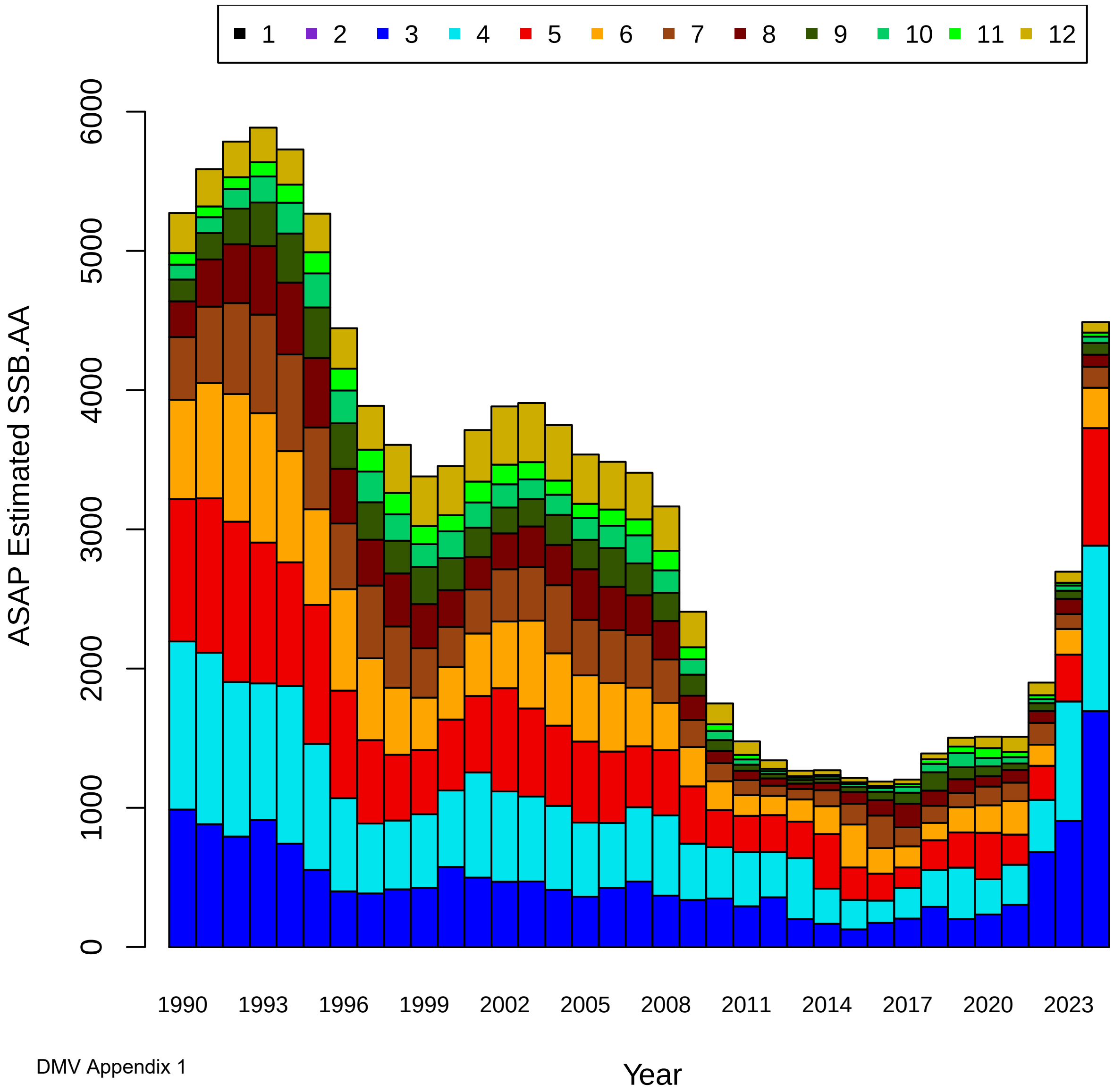


6000
4000
2000
0
SSB
1990
1995
2000
2005
2010
2015
2020
2025
Year

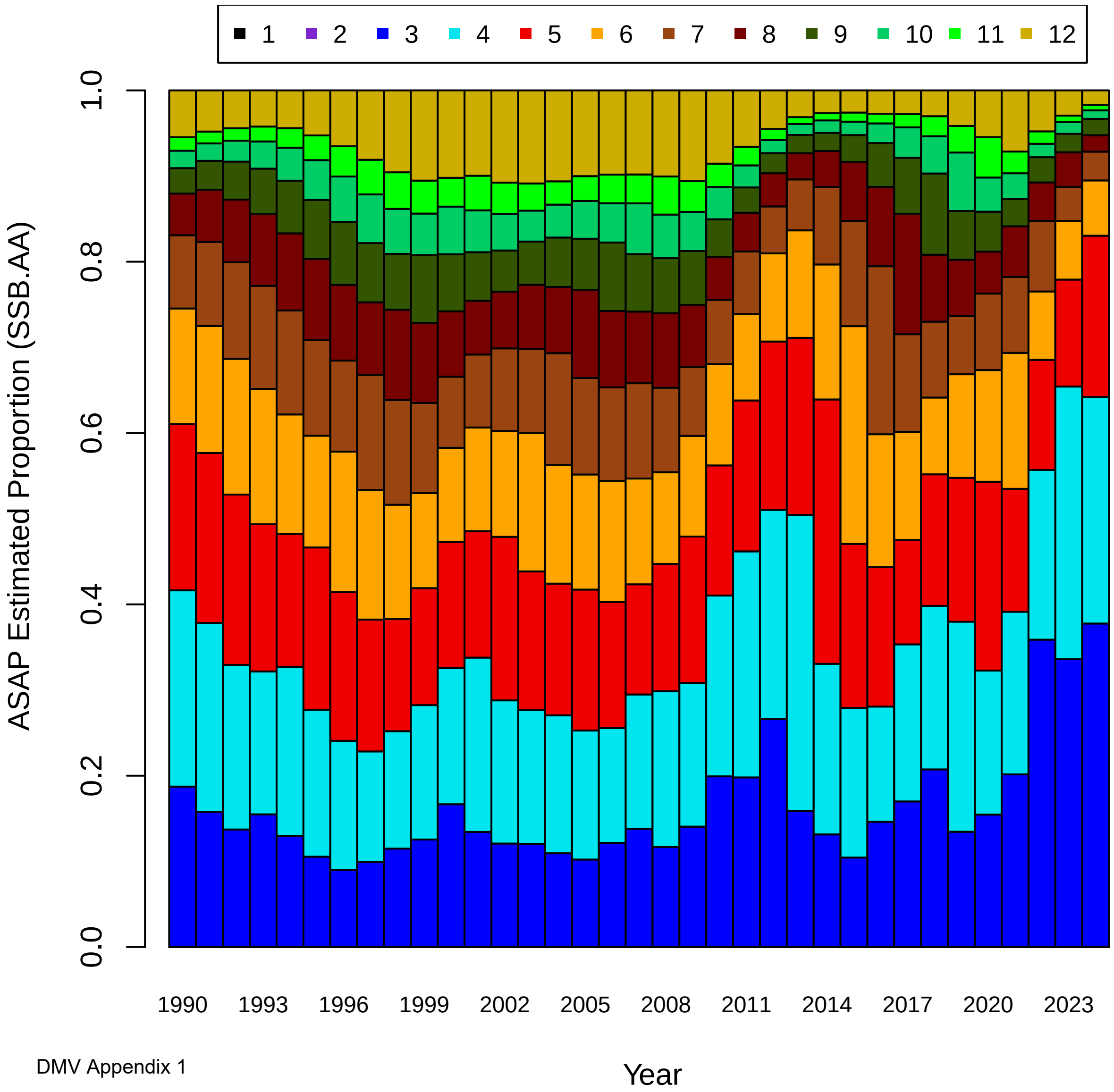


F.report
F.full
0.8
0.4
0.0
Fishing Mortality
1990
1995
2000
2005
2010
2015
2020
2025
Year

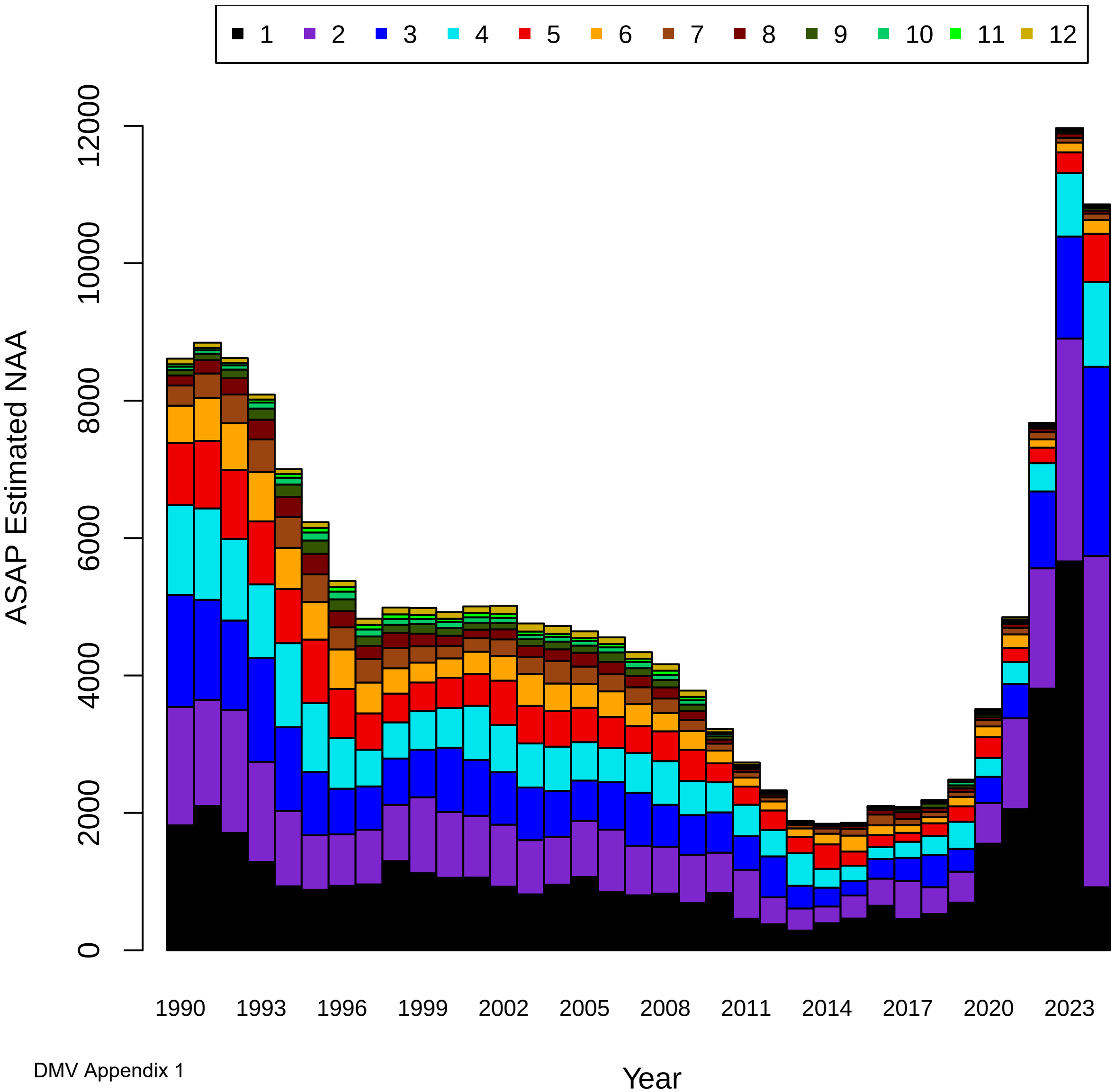

Comparison of January 1 Biomass
Total
SSB
Exploitable
Biomass
0
2000
4000
6000
8000
10000
Year
1990
1995
2000
2005
2010
2015
2020
2025

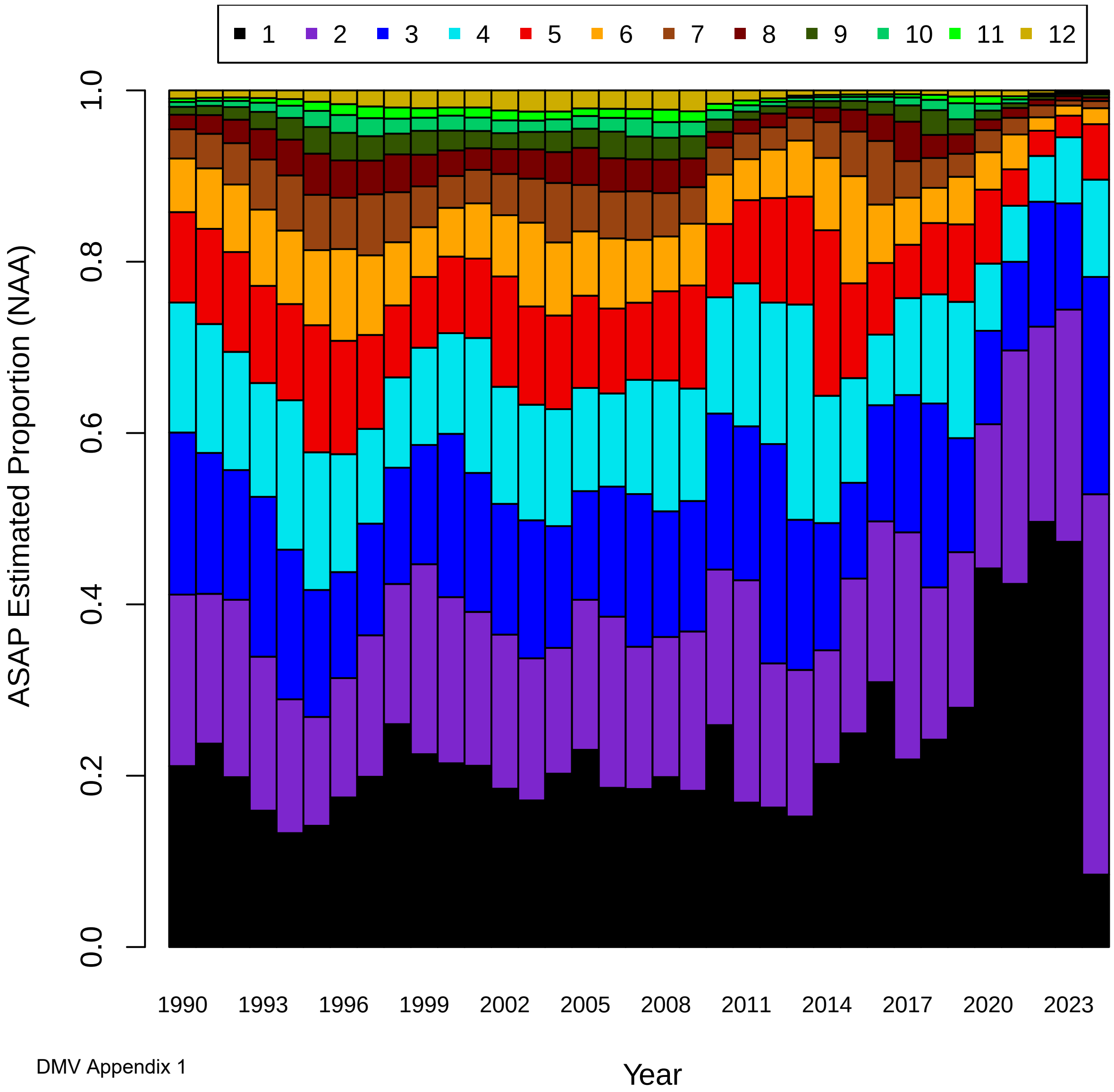


1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated SSB.AA
0
1000
2000
3000
4000
5000
6000
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
2023
Year

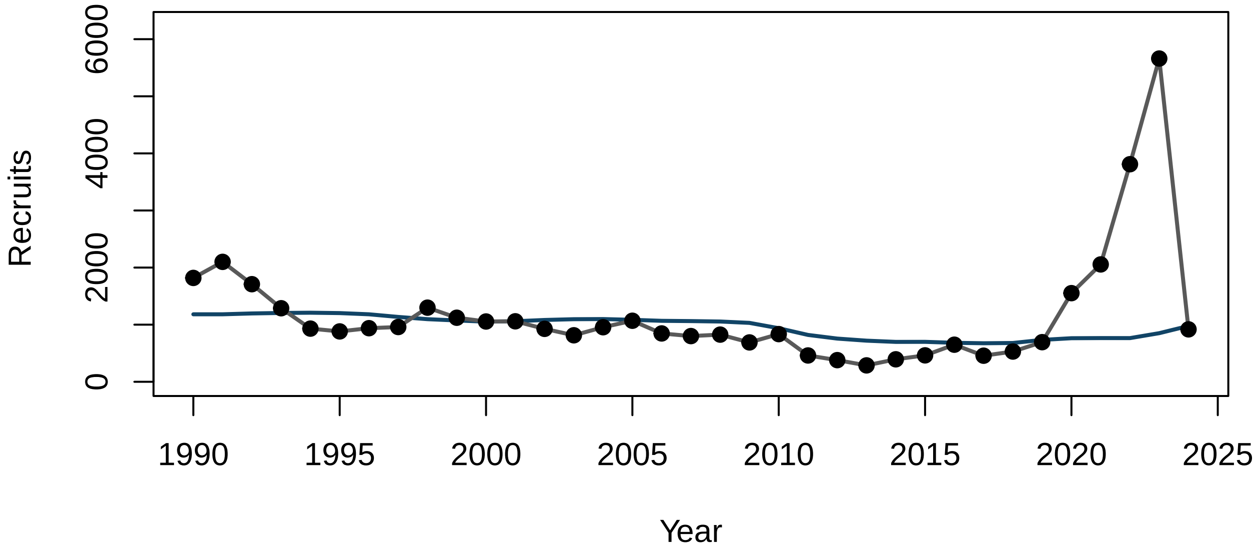


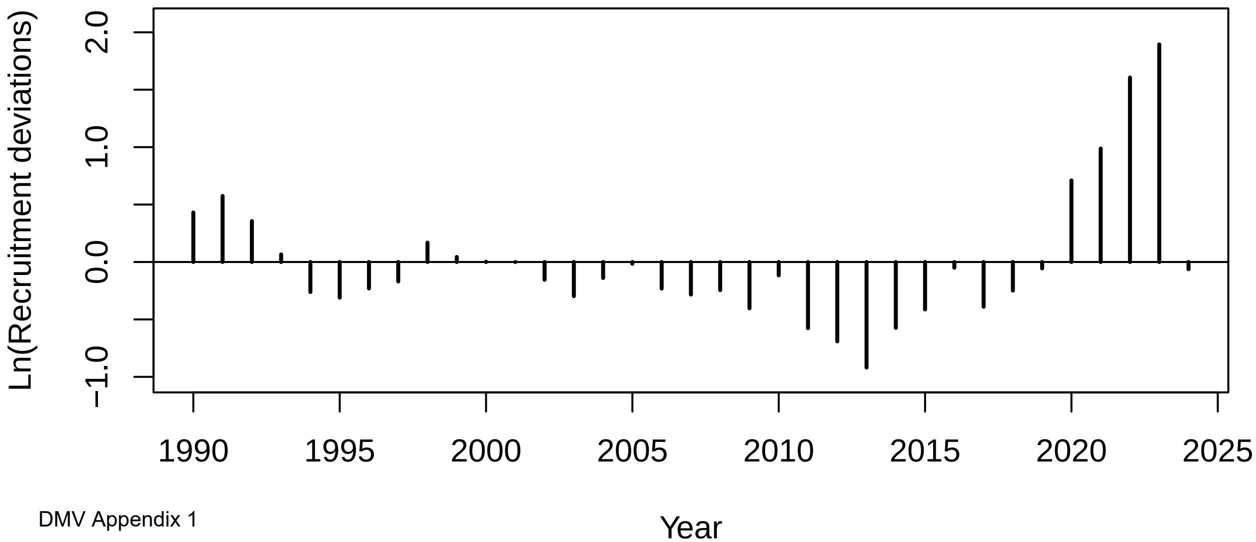
1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated Proportion (SSB.AA)
0.0
0.2
0.4
0.6
0.8
1.0
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
2023
Year

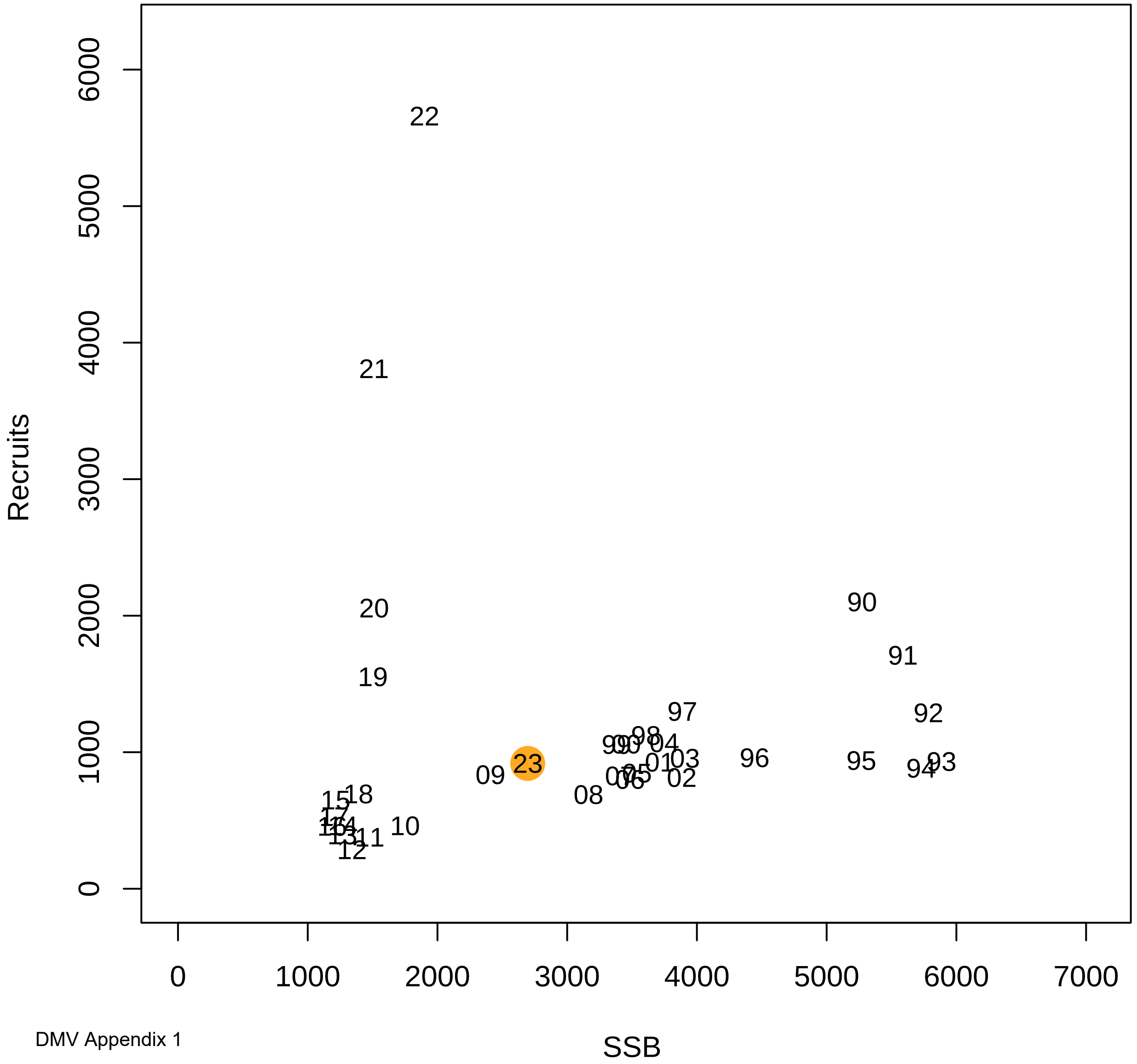

1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated NAA
0
2000
4000
6000
8000
10000
12000
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
2023
Year

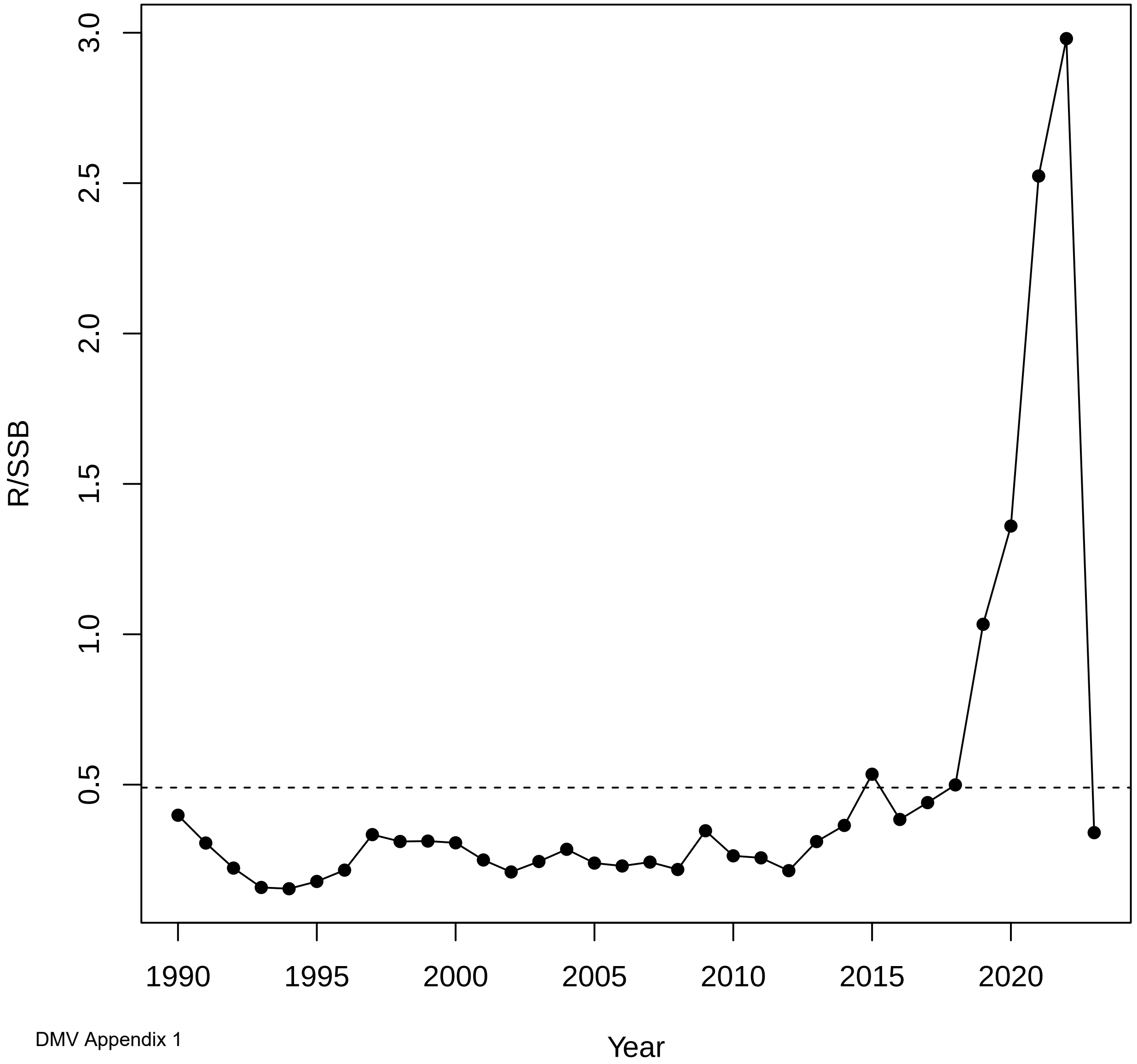


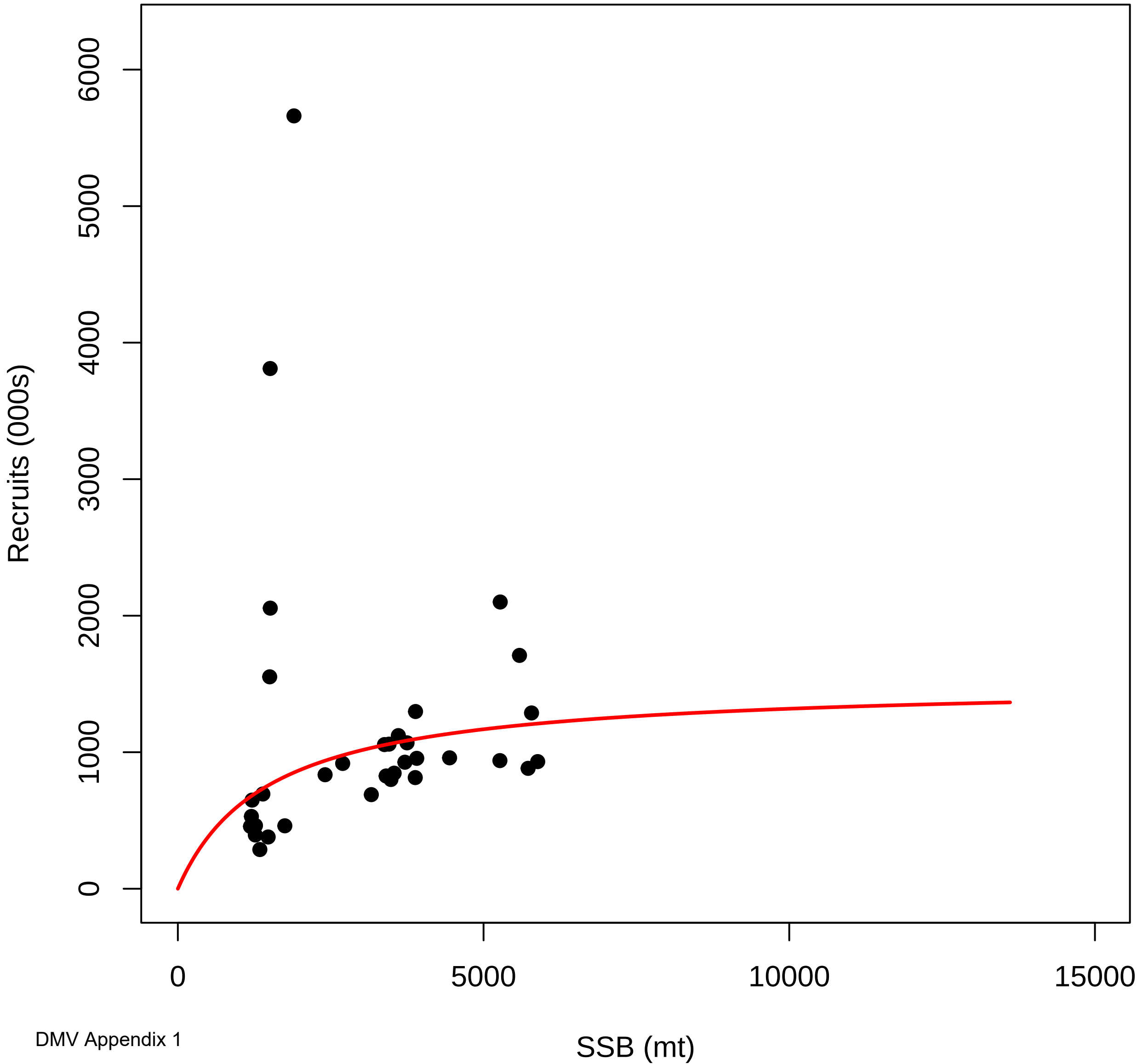
1
2
3
4
5
6
7
8
9
10
11
12
ASAP Estimated Proportion (NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
2023
Year

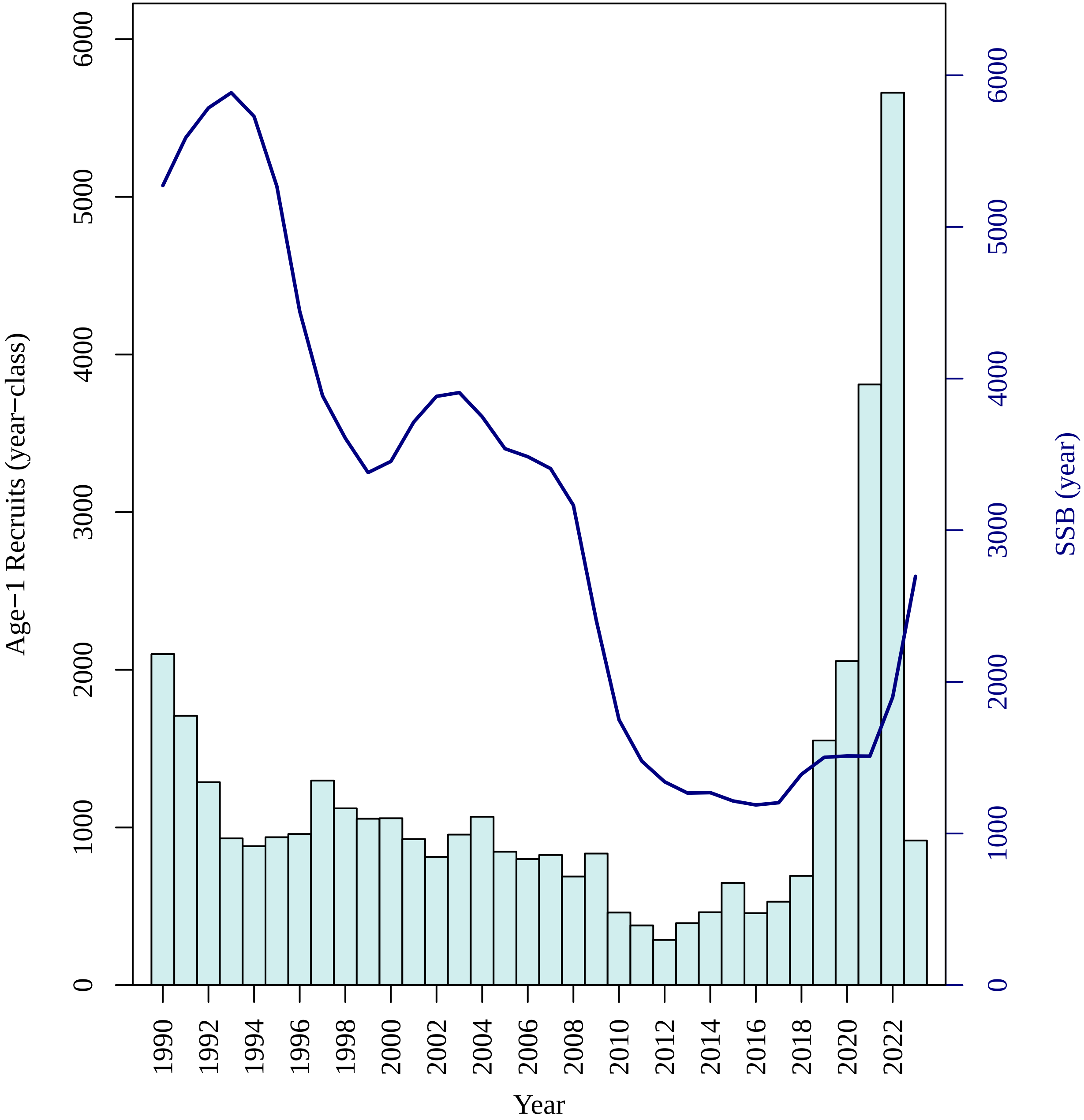

Recruits
0
2000
4000
6000
1990
1995
2000
2005
2010
2015
2020
2025
Year


Ln(Recruitment deviations)
−1.0
0.0
1.0
2.0
1990
1995
2000
2005
2010
2015
2020
2025
Year

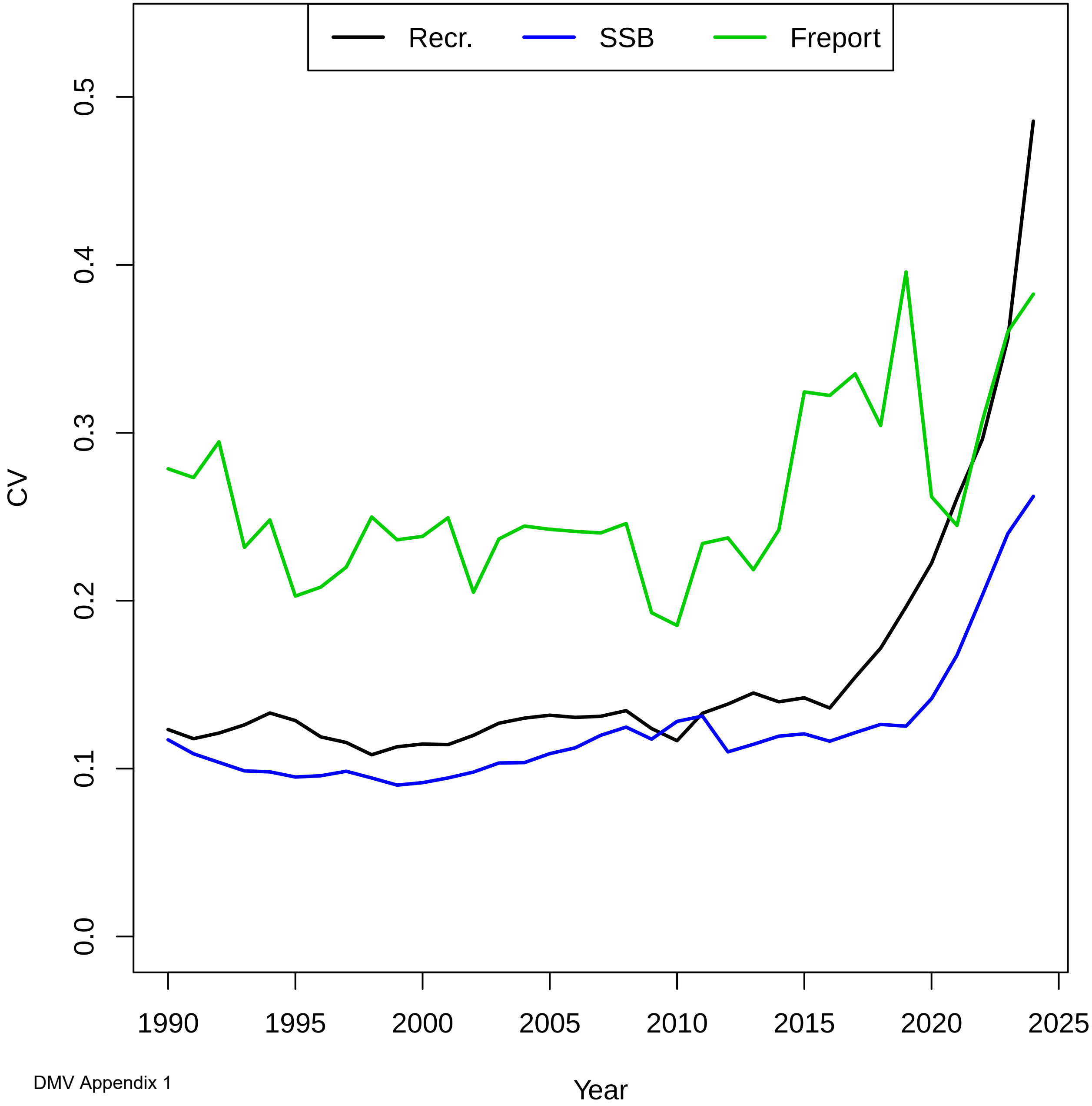

Recruits
SSB
0
1000
2000
3000
4000
5000
6000
7000
22
21
20
19
90
91
92
97
96
95
93
94
23
09
08
02
03
04
10
18
15
11
12

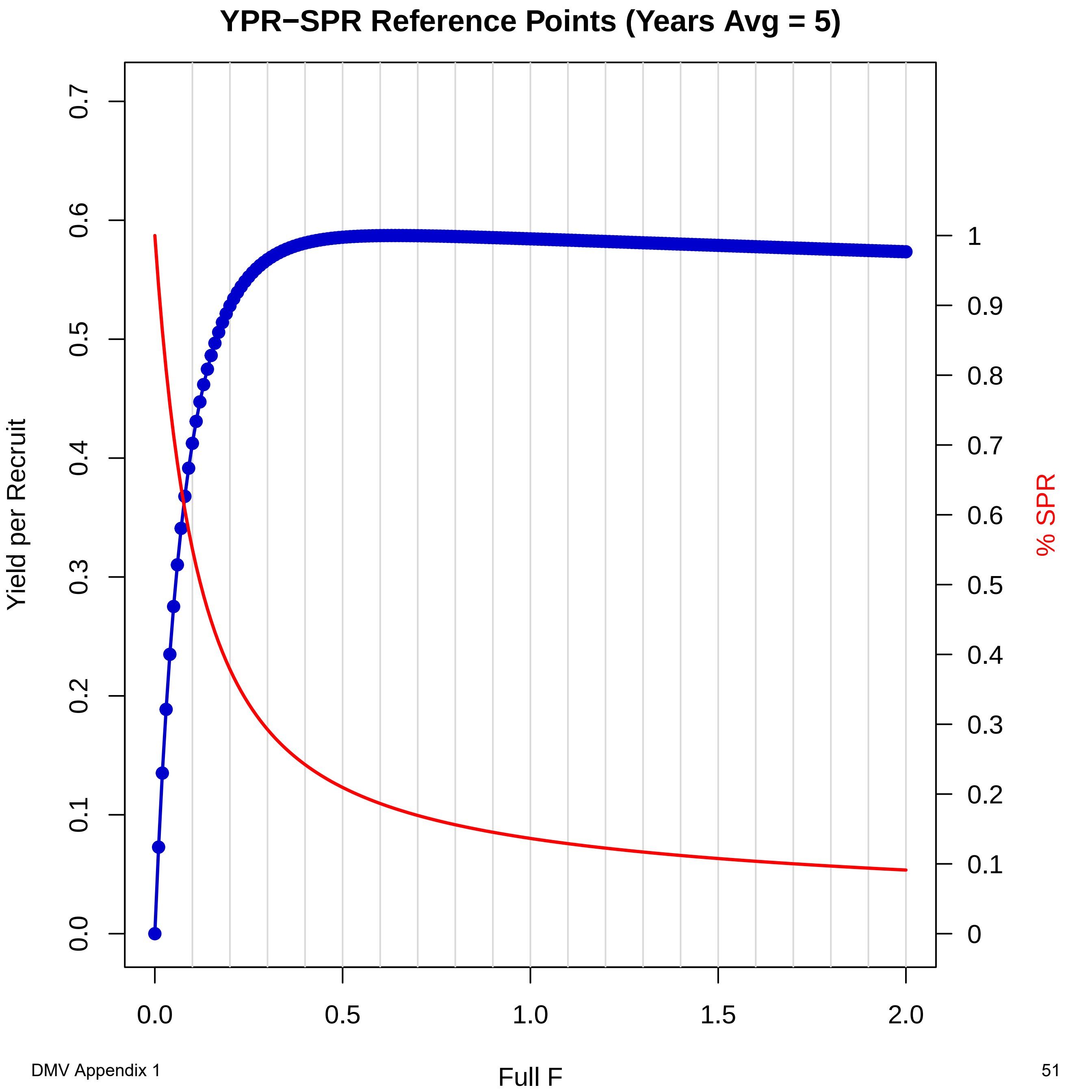

3.0
2.5
2.0
1.5
1.0
0.5
R/SSB
1990
1995
2000
2005
2010
2015
2020
Year


Recruits (000s)
0
1000
2000
3000
4000
5000
6000
0
5000
10000
15000
SSB (mt)



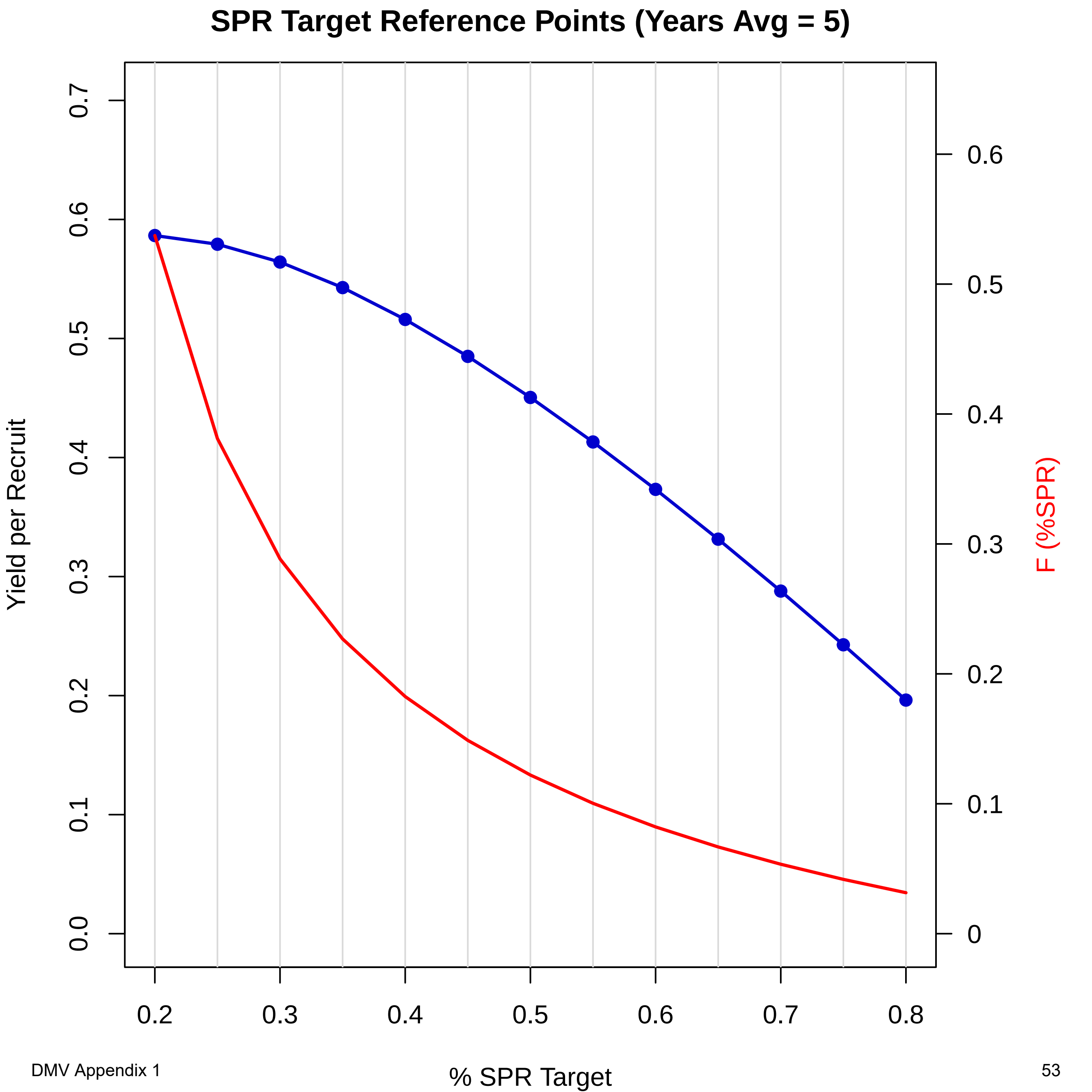
Age−1 Recruits (year−class)
0
1000
2000
3000
4000
5000
6000
SSB (year)
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Year


Recr.
SSB
Freport
CV
0.0
0.1
0.2
0.3
0.4
0.5
1990
1995
2000
2005
2010
2015
2020
2025
Year


YPR−SPR Reference Points (Years Avg = 5)
Yield per Recruit
% SPR
Full F
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.0
0.5
1.0
1.5
2.0

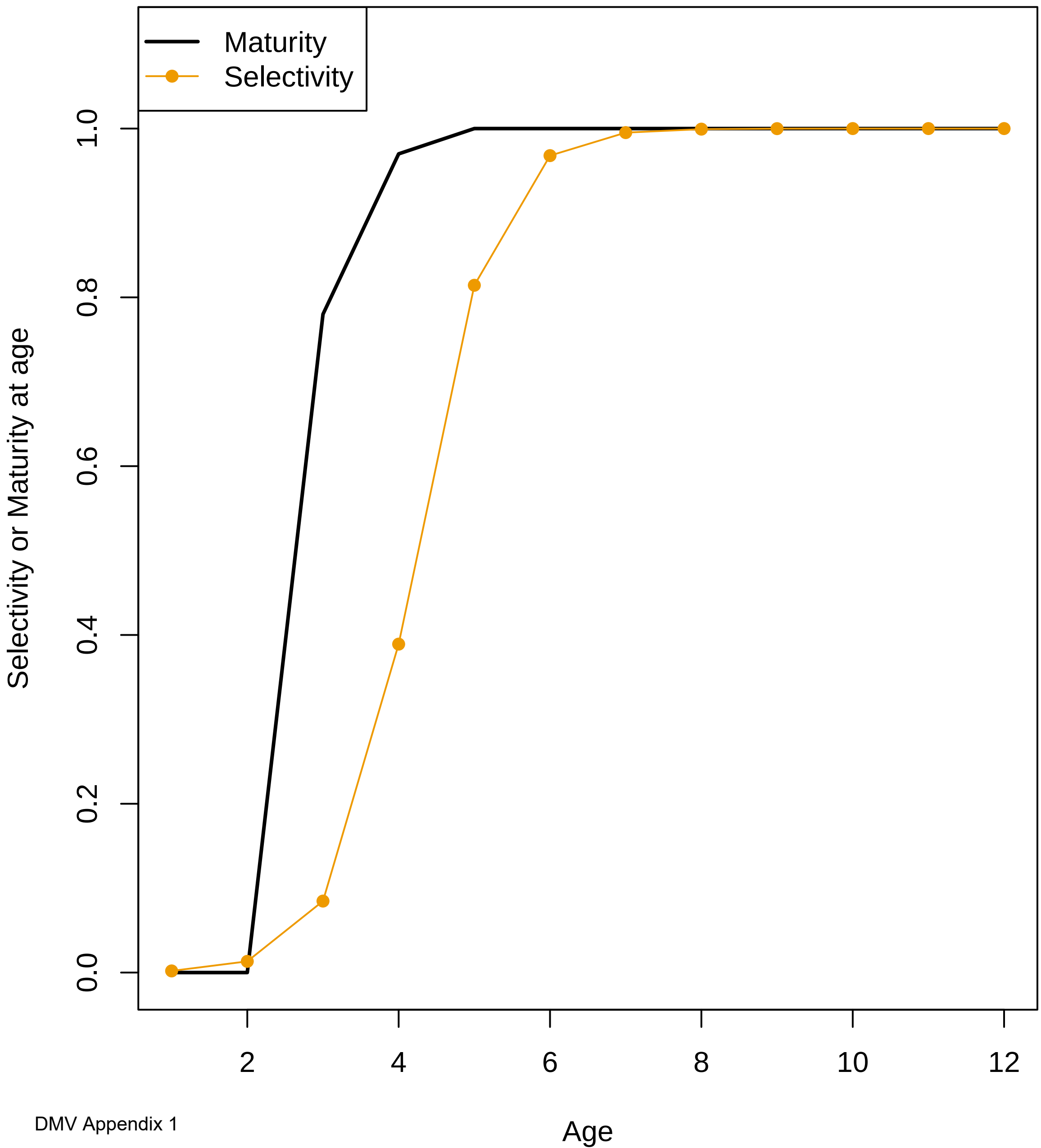
YPR−SPR Reference Points (Years Avg = 5)

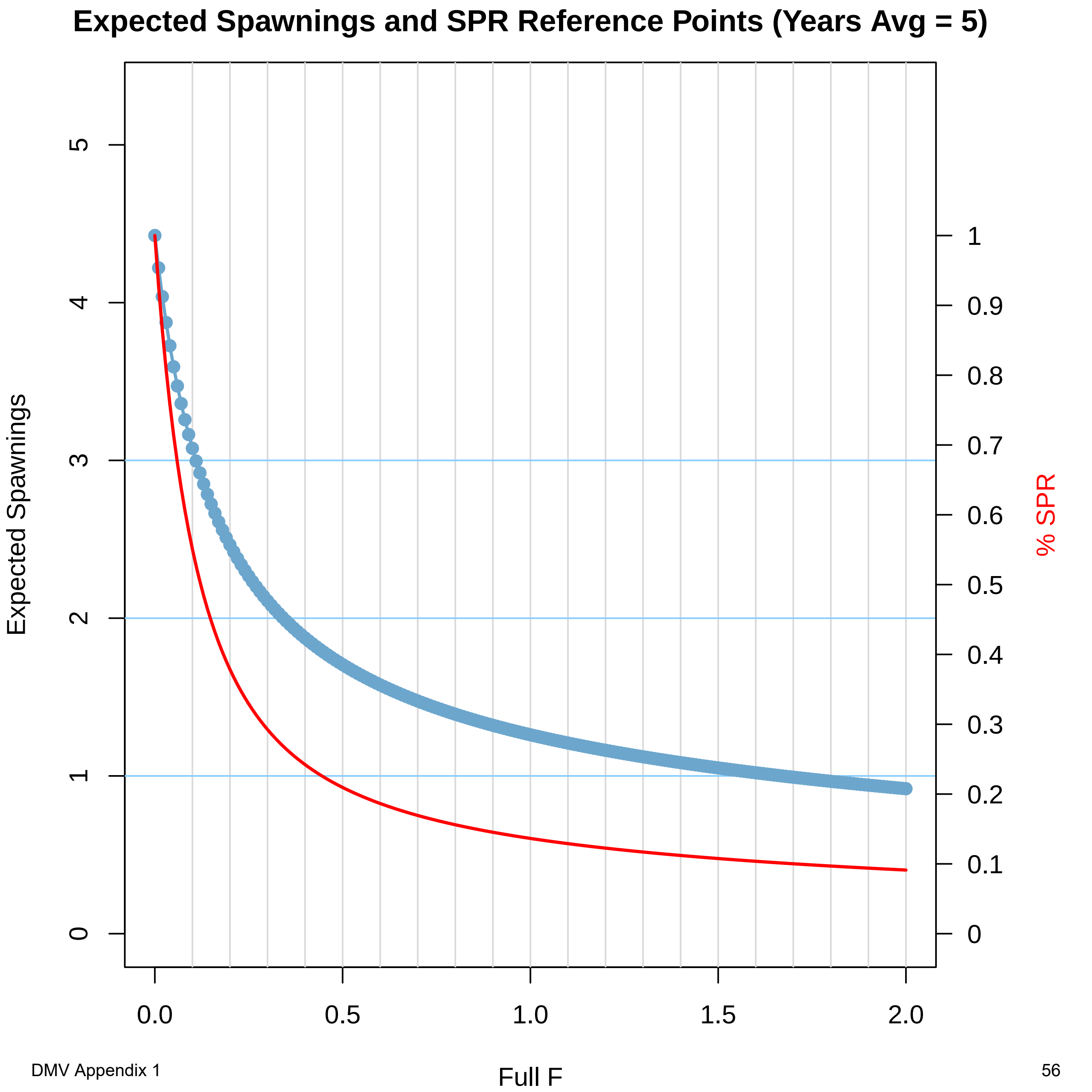
F	YPR	SPR	F	YPR	SPR	F	YPR	SPR
0	0	1	0.35	0.5756	0.2643	0.7	0.587	0.1693
0.01	0.0728	0.9275	0.36	0.5769	0.2595	0.71	0.587	0.1679
0.02	0.1351	0.864	0.37	0.578	0.2549	0.72	0.5869	0.1664
0.03	0.1886	0.8081	0.38	0.5791	0.2505	0.73	0.5868	0.165
0.04	0.235	0.7584	0.39	0.58	0.2462	0.74	0.5868	0.1636
0.05	0.2752	0.7142	0.4	0.5809	0.2422	0.75	0.5867	0.1623
0.06	0.3102	0.6745	0.41	0.5816	0.2383	0.76	0.5866	0.161
0.07	0.3409	0.6389	0.42	0.5823	0.2346	0.77	0.5866	0.1597
0.08	0.3678	0.6067	0.43	0.5829	0.231	0.78	0.5865	0.1585
0.09	0.3915	0.5775	0.44	0.5835	0.2276	0.79	0.5864	0.1572
0.1	0.4124	0.5509	0.45	0.5839	0.2243	0.8	0.5863	0.156
0.11	0.4309	0.5266	0.46	0.5844	0.2211	0.81	0.5863	0.1548
0.12	0.4473	0.5044	0.47	0.5848	0.218	0.82	0.5862	0.1537
0.13	0.4618	0.4841	0.48	0.5851	0.2151	0.83	0.5861	0.1526
0.14	0.4748	0.4653	0.49	0.5854	0.2122	0.84	0.586	0.1515
0.15	0.4863	0.448	0.5	0.5857	0.2095	0.85	0.5859	0.1504
0.16	0.4966	0.432	0.51	0.586	0.2068	0.86	0.5858	0.1493
0.17	0.5058	0.4171	0.52	0.5862	0.2043	0.87	0.5857	0.1483
0.18	0.5141	0.4033	0.53	0.5864	0.2018	0.88	0.5856	0.1473
0.19	0.5215	0.3905	0.54	0.5865	0.1994	0.89	0.5855	0.1463
0.2	0.5281	0.3785	0.55	0.5867	0.1971	0.9	0.5854	0.1453
0.21	0.534	0.3673	0.56	0.5868	0.1948	0.91	0.5853	0.1443
0.22	0.5394	0.3568	0.57	0.5869	0.1926	0.92	0.5852	0.1434
0.23	0.5442	0.347	0.58	0.587	0.1905	0.93	0.5851	0.1425
0.24	0.5485	0.3378	0.59	0.587	0.1885	0.94	0.585	0.1416
0.25	0.5524	0.3291	0.6	0.5871	0.1865	0.95	0.5849	0.1407
0.26	0.556	0.3209	0.61	0.5871	0.1845	0.96	0.5848	0.1398
0.27	0.5591	0.3132	0.62	0.5871	0.1827	0.97	0.5847	0.1389
0.28	0.562	0.3059	0.63	0.5872	0.1808	0.98	0.5846	0.1381
0.29	0.5646	0.299	0.64	0.5872	0.1791	0.99	0.5845	0.1373
0.3	0.5669	0.2924	0.65	0.5872	0.1773	1	0.5844	0.1364
0.31	0.569	0.2862	0.66	0.5871	0.1757	1.01	0.5843	0.1356
0.32	0.5709	0.2804	0.67	0.5871	0.174	1.02	0.5842	0.1349
0.33	0.5727	0.2748	0.68	0.5871	0.1724	1.03	0.5841	0.1341
0.34	0.5742	0.2694	0.69	0.587	0.1709	1.04	0.5839	0.1333


SPR Target Reference Points (Years Avg = 5)
Yield per Recruit
F (%SPR)
% SPR Target
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
0.1
0.2
0.3
0.4
0.5
0.6
0.2
0.3
0.4
0.5
0.6
0.7
0.8

SPR Target Reference Points (Years Avg = 5)

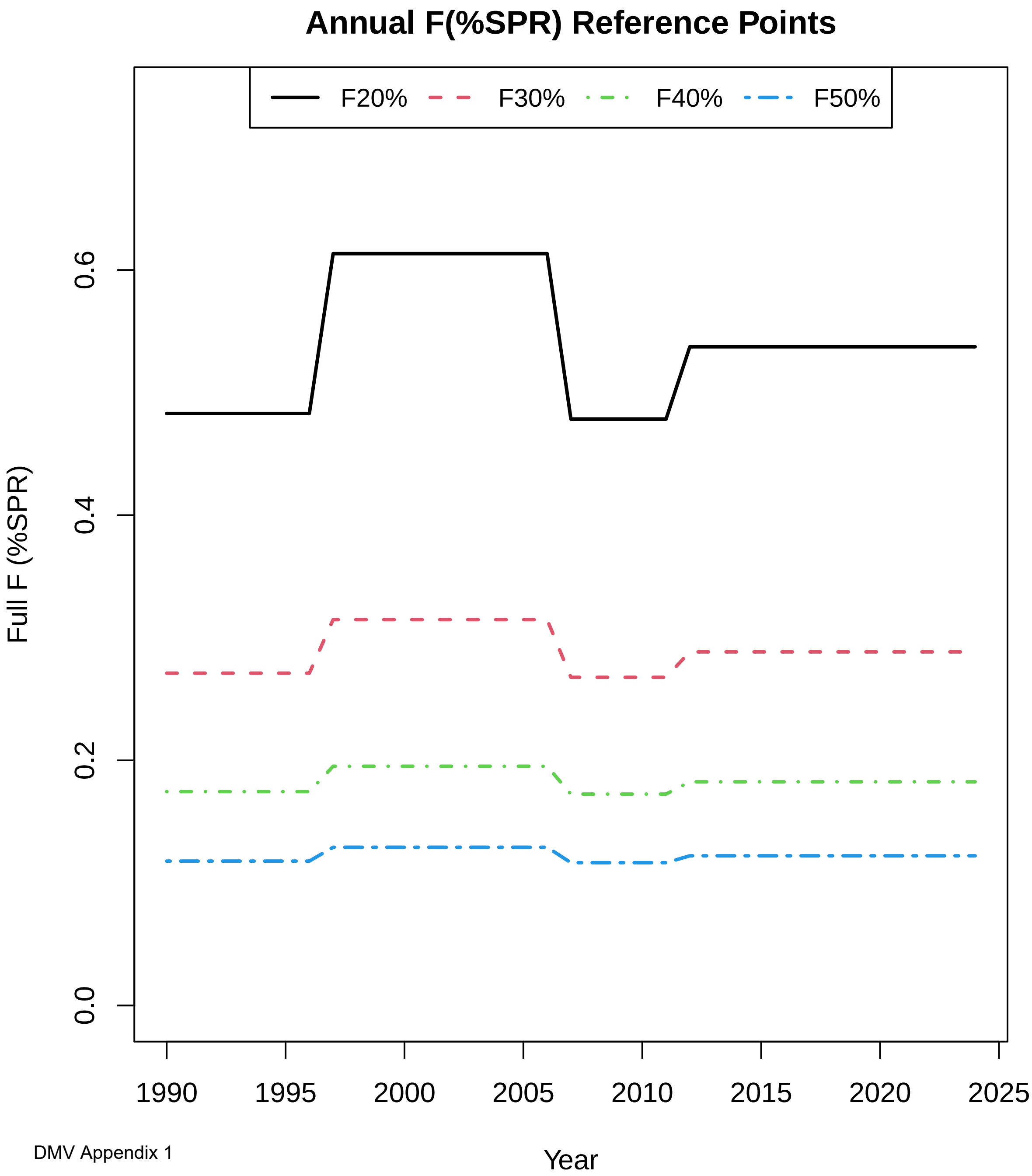
% SPR	F(%SPR)	YPR
0.2	0.5374	0.5865
0.25	0.3811	0.5792
0.3	0.2885	0.5642
0.35	0.2269	0.5428
0.4	0.1825	0.516
0.45	0.1488	0.485
0.5	0.1221	0.4505
0.55	0.1003	0.4131
0.6	0.0822	0.3733
0.65	0.0668	0.3314
0.7	0.0535	0.2878
0.75	0.0418	0.2427
0.8	0.0315	0.1962

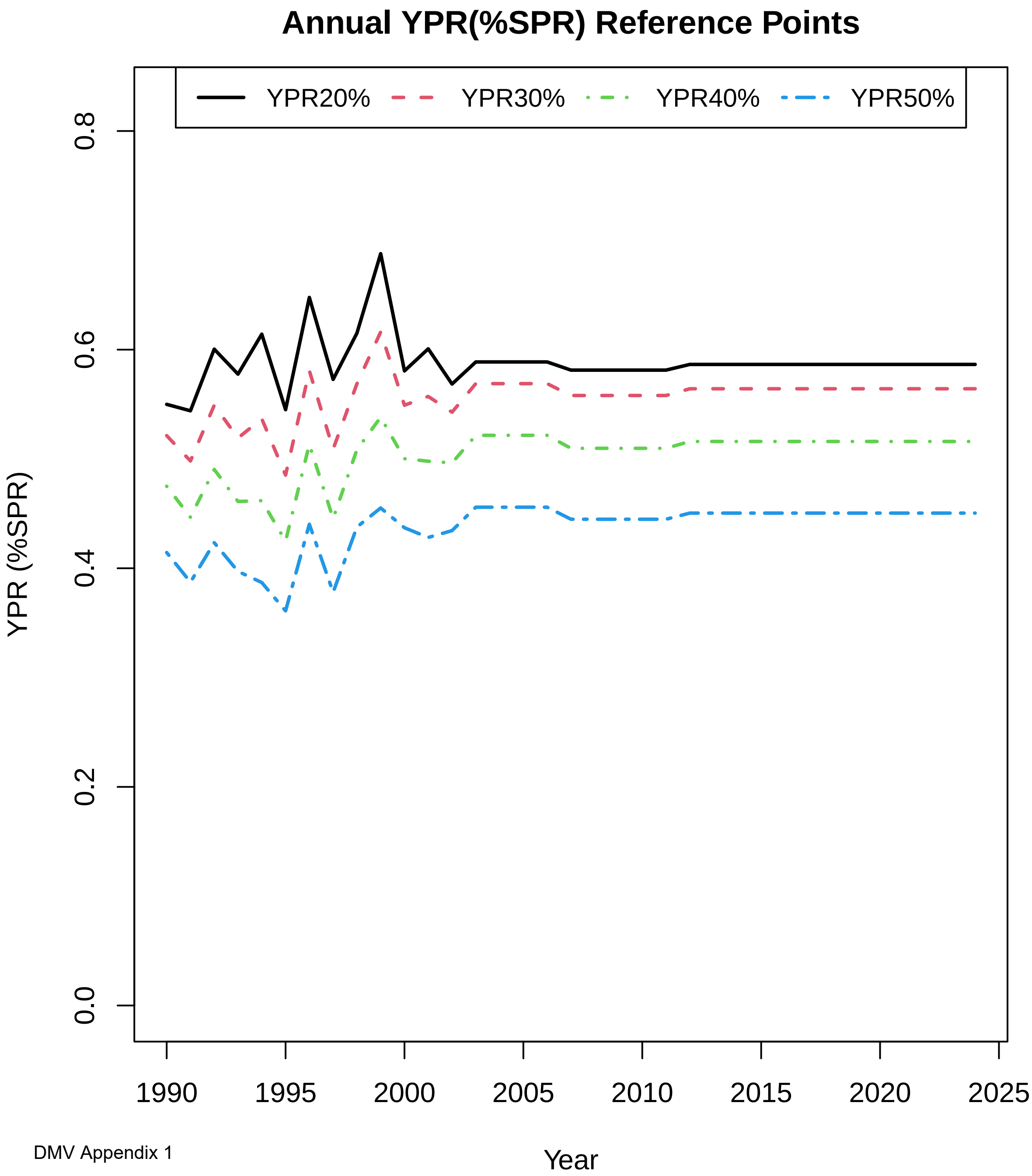

Maturity
Selectivity
Selectivity or Maturity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
Age


Expected Spawnings and SPR Reference Points (Years Avg = 5)
Expected Spawnings
% SPR
Full F
0
1
2
3
4
5
0.0
0.5
1.0
1.5
2.0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

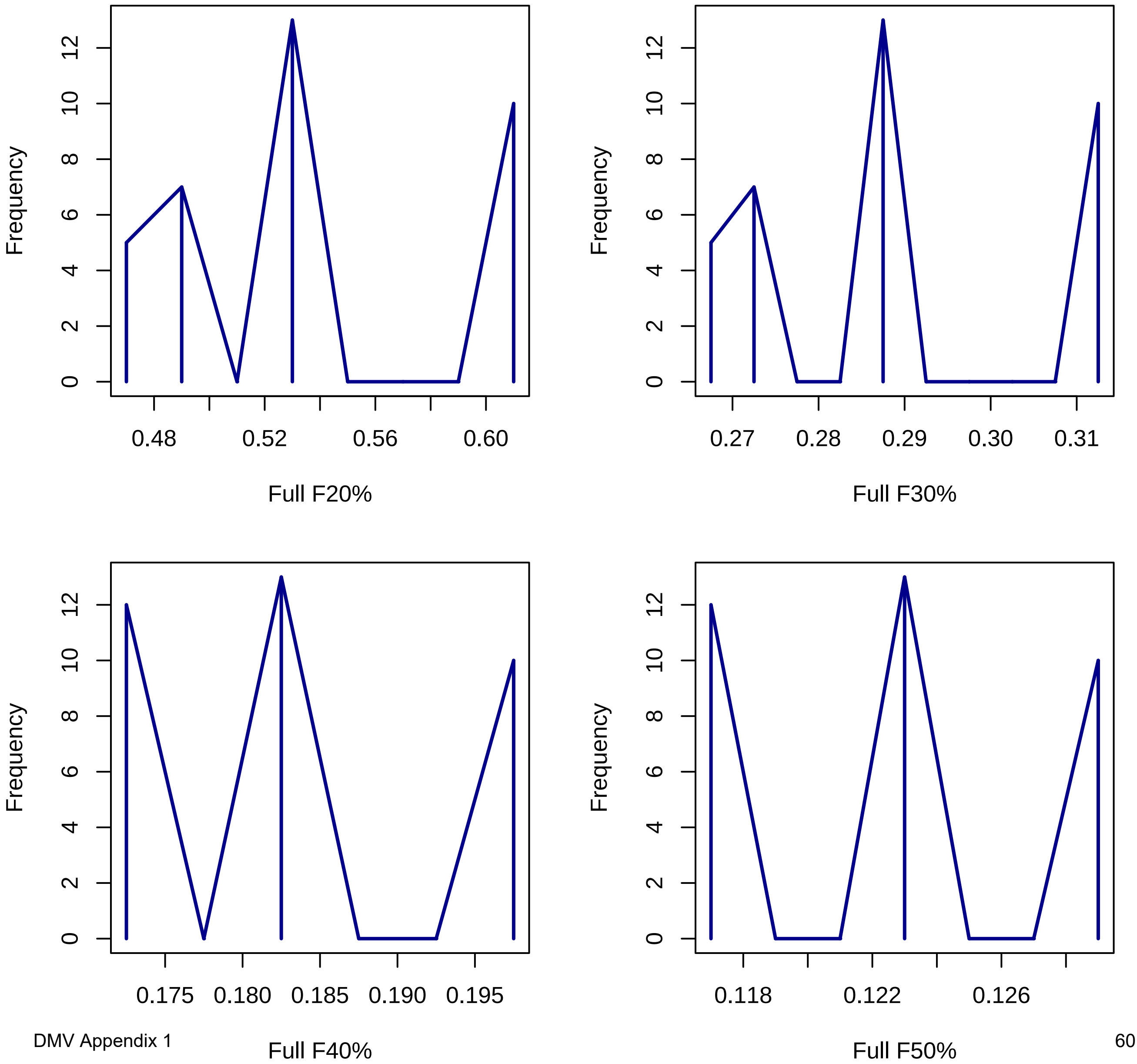
Expected Spawnings & SPR Reference Points (Years Avg = 5)

F	E[Sp]	SPR	F	E[Sp]	SPR	F	E[Sp]	SPR
0	4.4253	1	0.35	1.9814	0.2643	0.7	1.4749	0.1693
0.01	4.2203	0.9275	0.36	1.9586	0.2595	0.71	1.4658	0.1679
0.02	4.0378	0.864	0.37	1.9365	0.2549	0.72	1.4569	0.1664
0.03	3.8743	0.8081	0.38	1.9152	0.2505	0.73	1.4481	0.165
0.04	3.7269	0.7584	0.39	1.8945	0.2462	0.74	1.4395	0.1636
0.05	3.5933	0.7142	0.4	1.8746	0.2422	0.75	1.4311	0.1623
0.06	3.4716	0.6745	0.41	1.8553	0.2383	0.76	1.4228	0.161
0.07	3.3603	0.6389	0.42	1.8366	0.2346	0.77	1.4147	0.1597
0.08	3.258	0.6067	0.43	1.8185	0.231	0.78	1.4067	0.1585
0.09	3.1638	0.5775	0.44	1.8009	0.2276	0.79	1.3989	0.1572
0.1	3.0766	0.5509	0.45	1.7839	0.2243	0.8	1.3912	0.156
0.11	2.9957	0.5266	0.46	1.7673	0.2211	0.81	1.3837	0.1548
0.12	2.9205	0.5044	0.47	1.7512	0.218	0.82	1.3762	0.1537
0.13	2.8503	0.4841	0.48	1.7356	0.2151	0.83	1.3689	0.1526
0.14	2.7846	0.4653	0.49	1.7204	0.2122	0.84	1.3617	0.1515
0.15	2.723	0.448	0.5	1.7056	0.2095	0.85	1.3547	0.1504
0.16	2.6651	0.432	0.51	1.6913	0.2068	0.86	1.3477	0.1493
0.17	2.6106	0.4171	0.52	1.6772	0.2043	0.87	1.3409	0.1483
0.18	2.5591	0.4033	0.53	1.6636	0.2018	0.88	1.3341	0.1473
0.19	2.5105	0.3905	0.54	1.6503	0.1994	0.89	1.3275	0.1463
0.2	2.4645	0.3785	0.55	1.6373	0.1971	0.9	1.321	0.1453
0.21	2.4209	0.3673	0.56	1.6247	0.1948	0.91	1.3146	0.1443
0.22	2.3794	0.3568	0.57	1.6123	0.1926	0.92	1.3082	0.1434
0.23	2.34	0.347	0.58	1.6003	0.1905	0.93	1.302	0.1425
0.24	2.3024	0.3378	0.59	1.5885	0.1885	0.94	1.2959	0.1416
0.25	2.2666	0.3291	0.6	1.577	0.1865	0.95	1.2898	0.1407
0.26	2.2324	0.3209	0.61	1.5658	0.1845	0.96	1.2839	0.1398
0.27	2.1996	0.3132	0.62	1.5548	0.1827	0.97	1.278	0.1389
0.28	2.1683	0.3059	0.63	1.544	0.1808	0.98	1.2722	0.1381
0.29	2.1383	0.299	0.64	1.5335	0.1791	0.99	1.2665	0.1373
0.3	2.1095	0.2924	0.65	1.5232	0.1773	1	1.2608	0.1364
0.31	2.0819	0.2862	0.66	1.5131	0.1757	1.01	1.2553	0.1356
0.32	2.0553	0.2804	0.67	1.5033	0.174	1.02	1.2498	0.1349
0.33	2.0298	0.2748	0.68	1.4936	0.1724	1.03	1.2444	0.1341
0.34	2.0051	0.2694	0.69	1.4841	0.1709	1.04	1.2391	0.1333

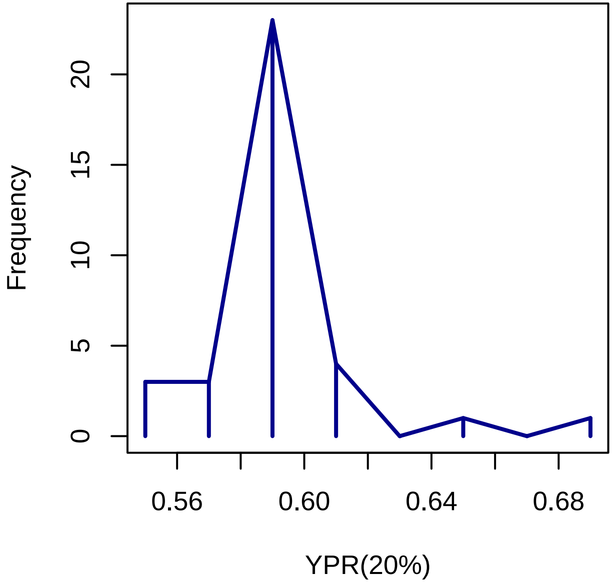

Annual F(%SPR) Reference Points
F20%
F30%
F40%
F50%
Full F (%SPR)
0.0
0.2
0.4
0.6
1990
1995
2000
2005
2010
2015
2020
2025
Year

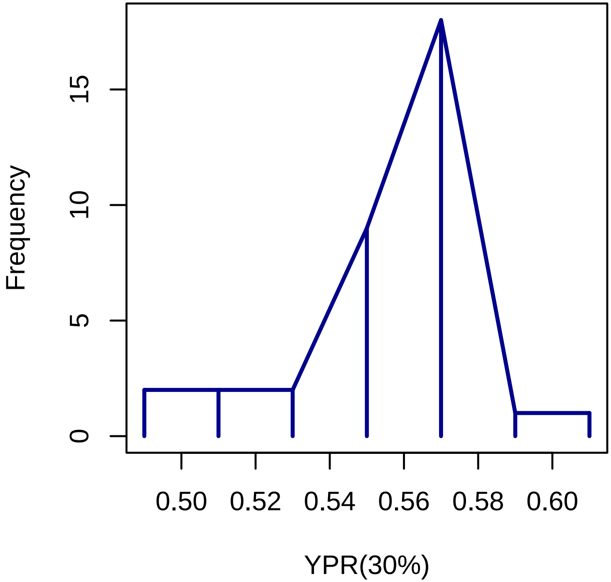

Annual YPR(%SPR) Reference Points
YPR20%
YPR30%
YPR40%
YPR50%
0.0
0.2
0.4
0.6
0.8
YPR (%SPR)
1990
1995
2000
2005
2010
2015
2020
2025
Year

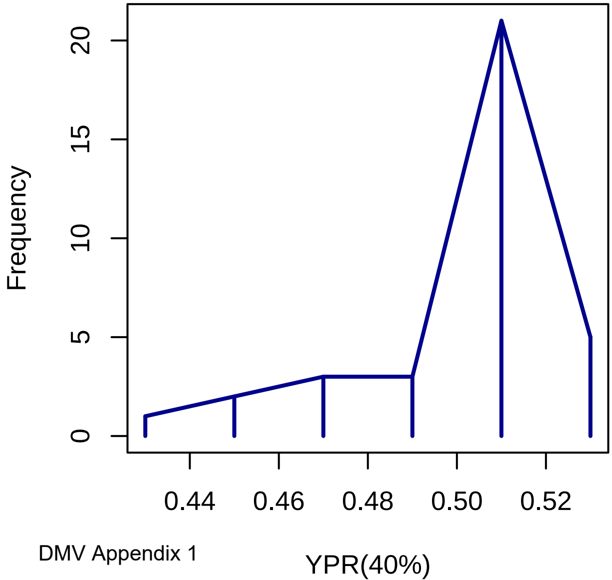
Annual F (%SPR) Reference Points

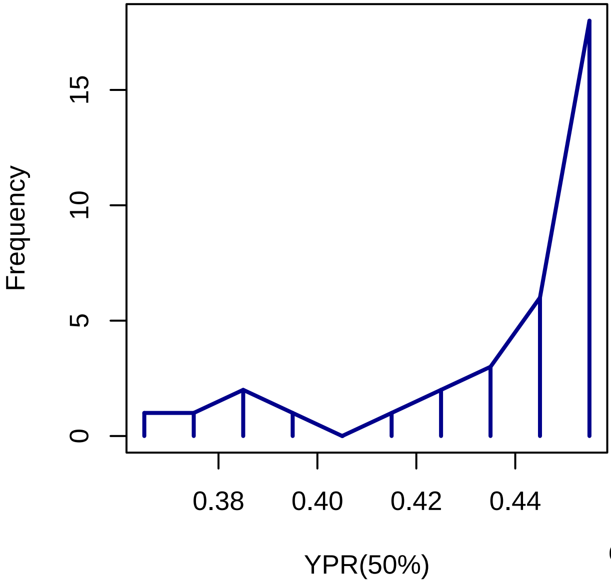


Annual YPR (%SPR) Reference Points

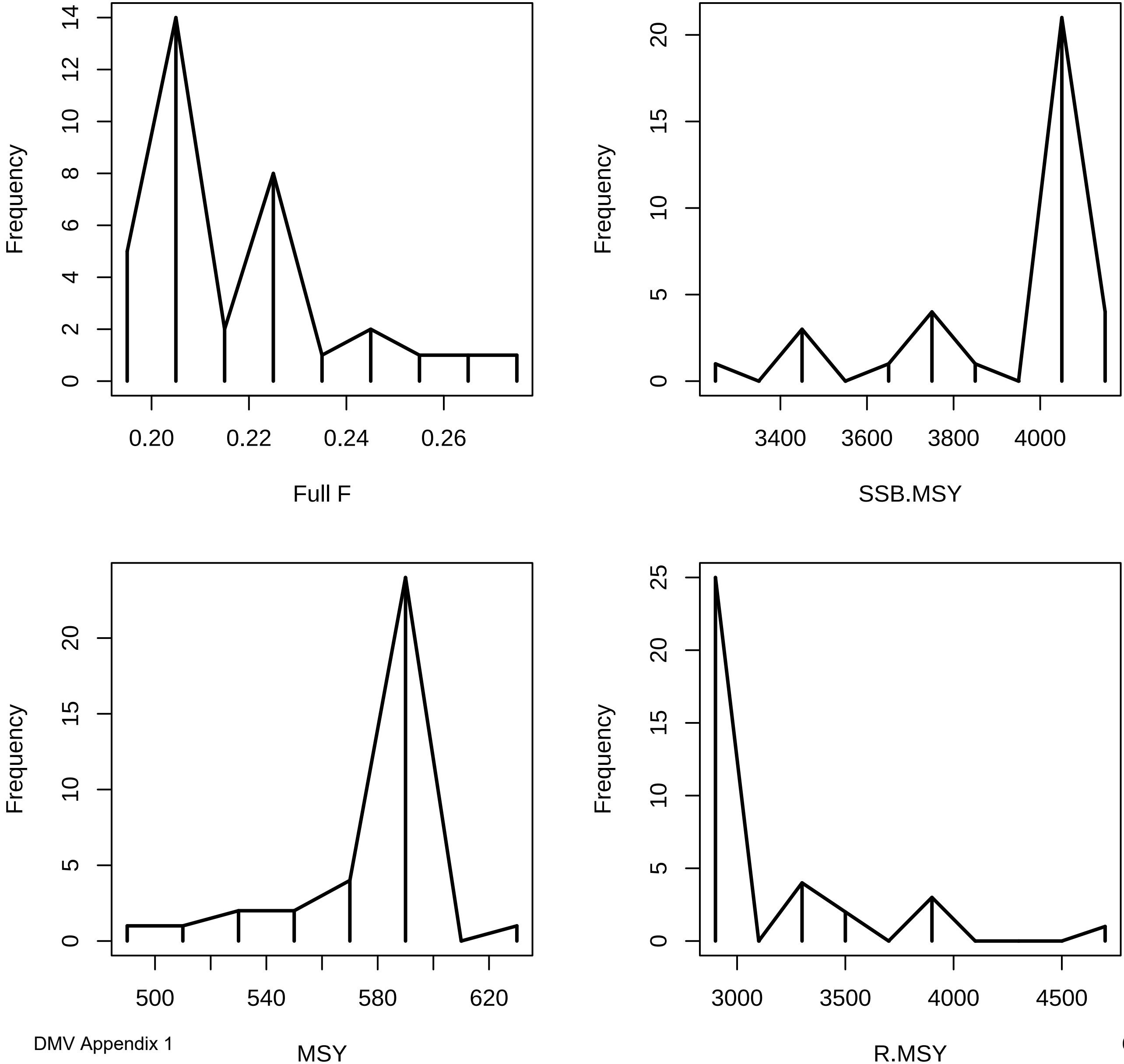




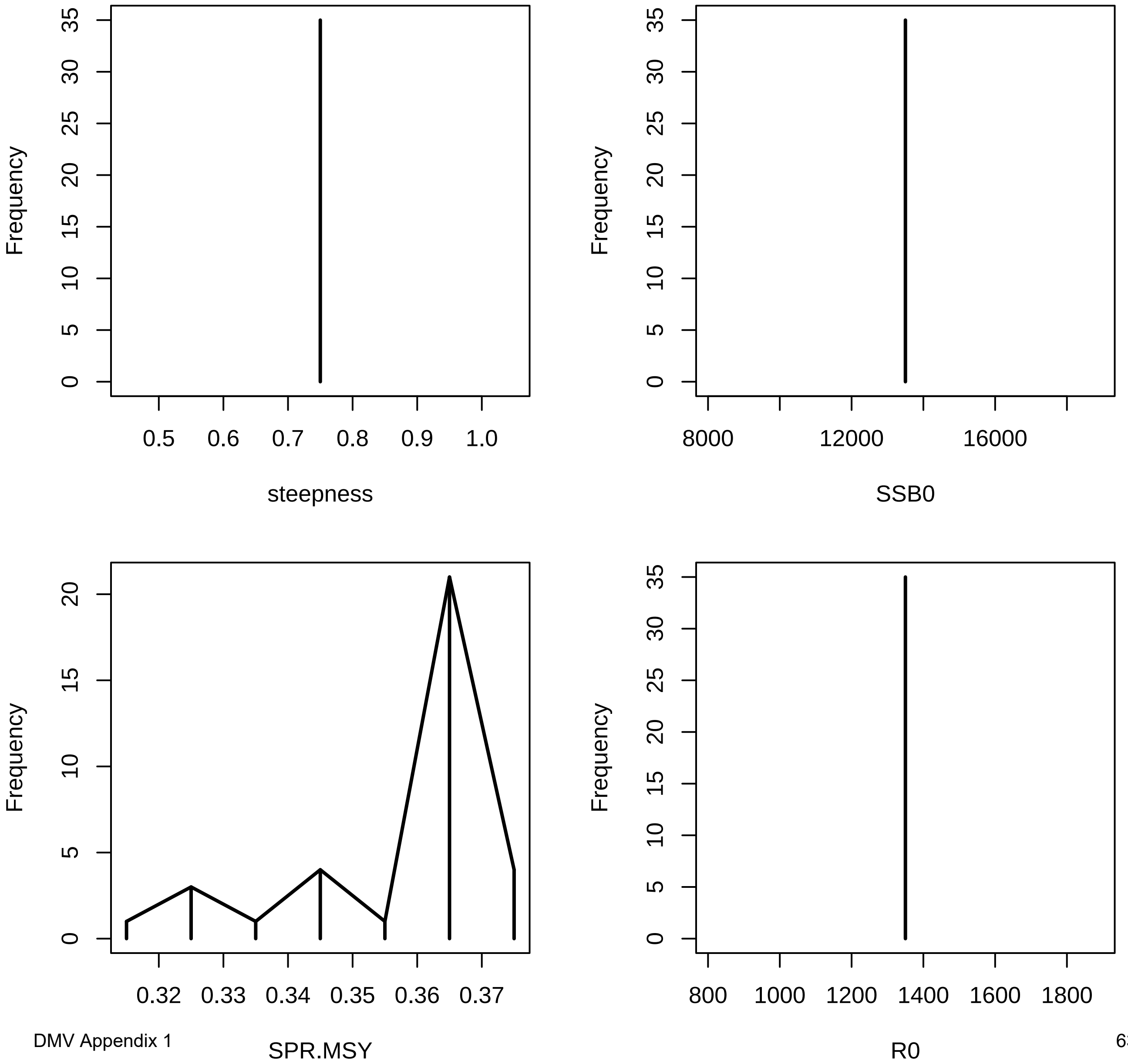


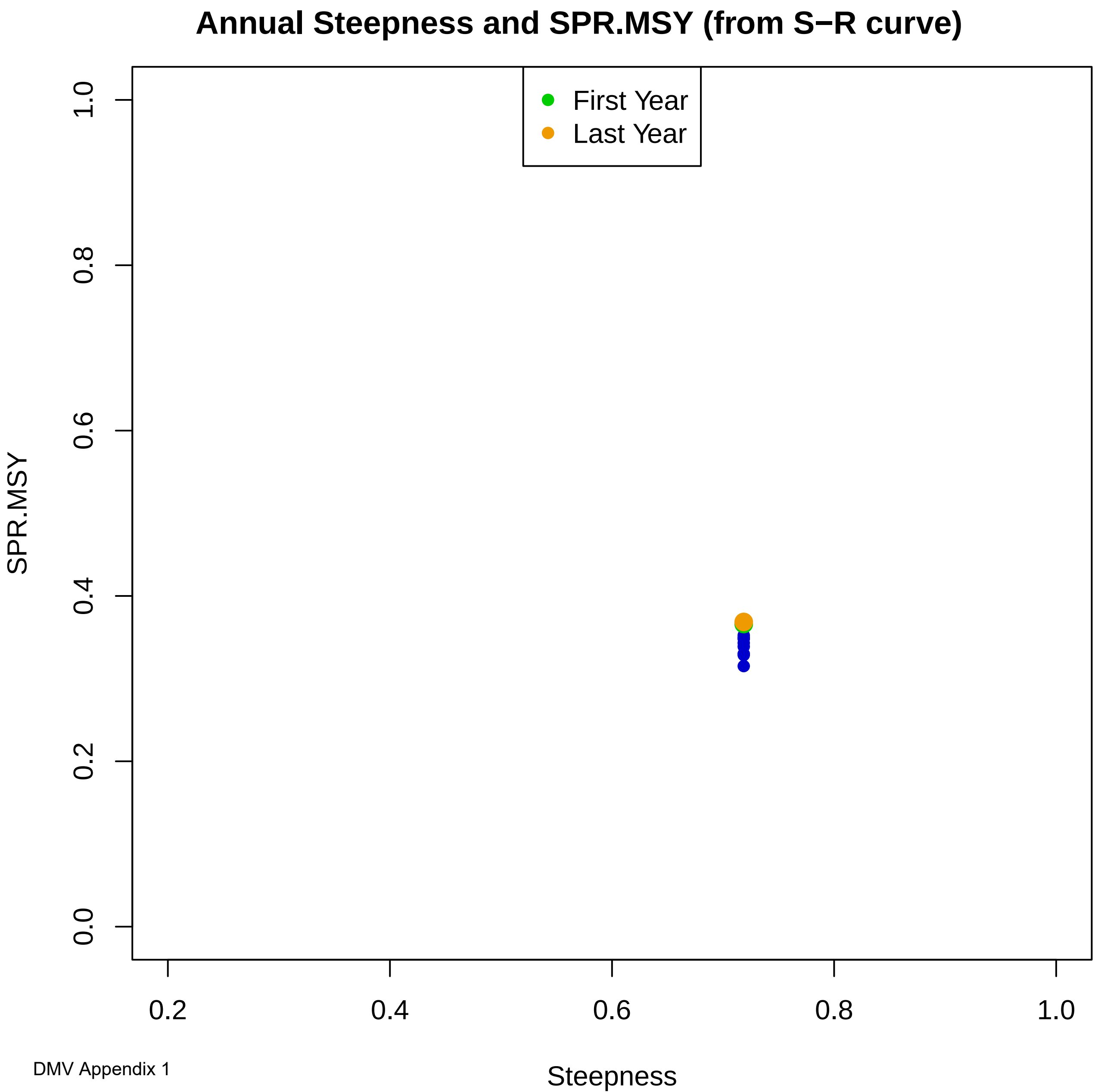


Annual MSY Reference Points (from S−R curve)

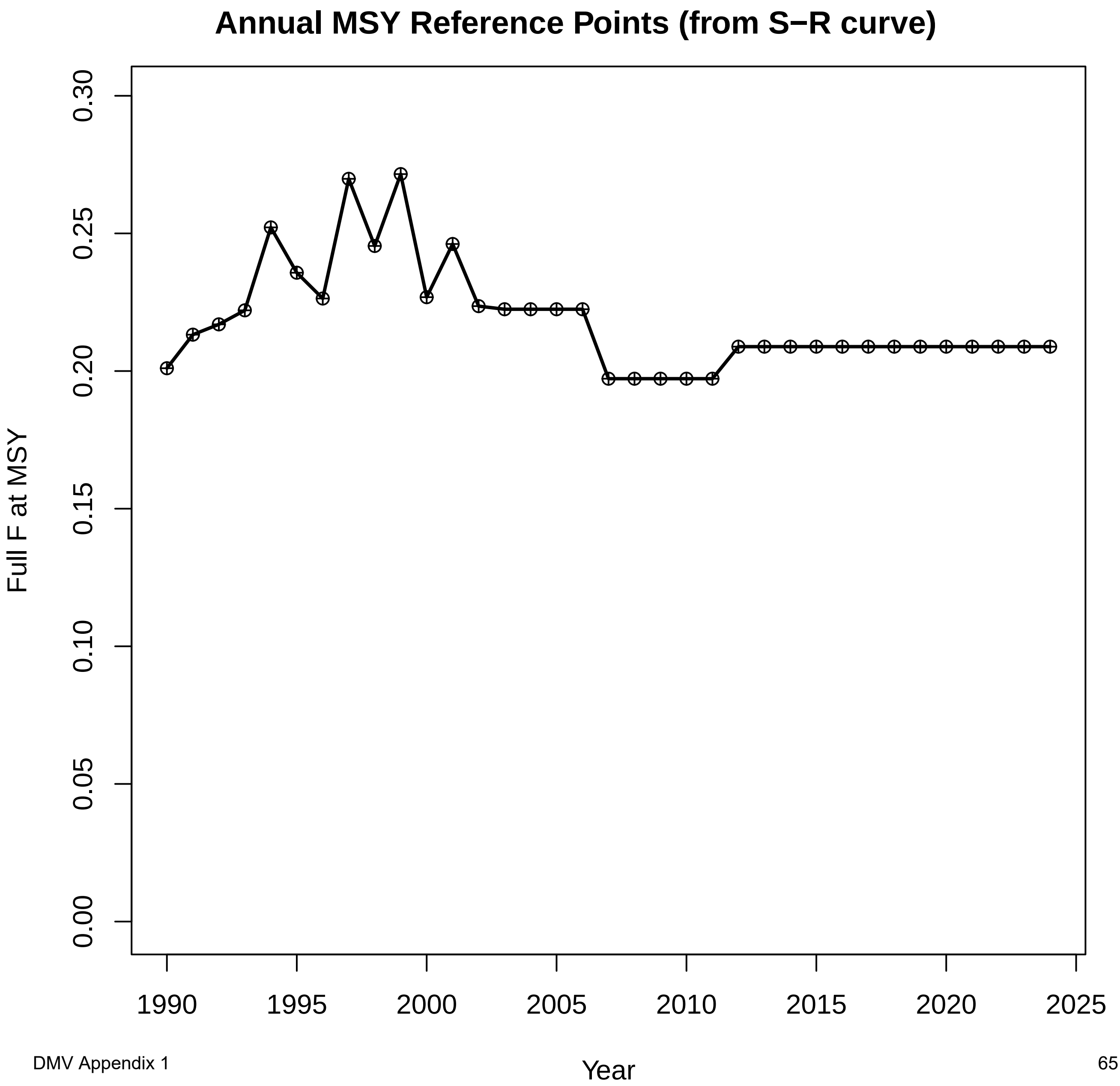


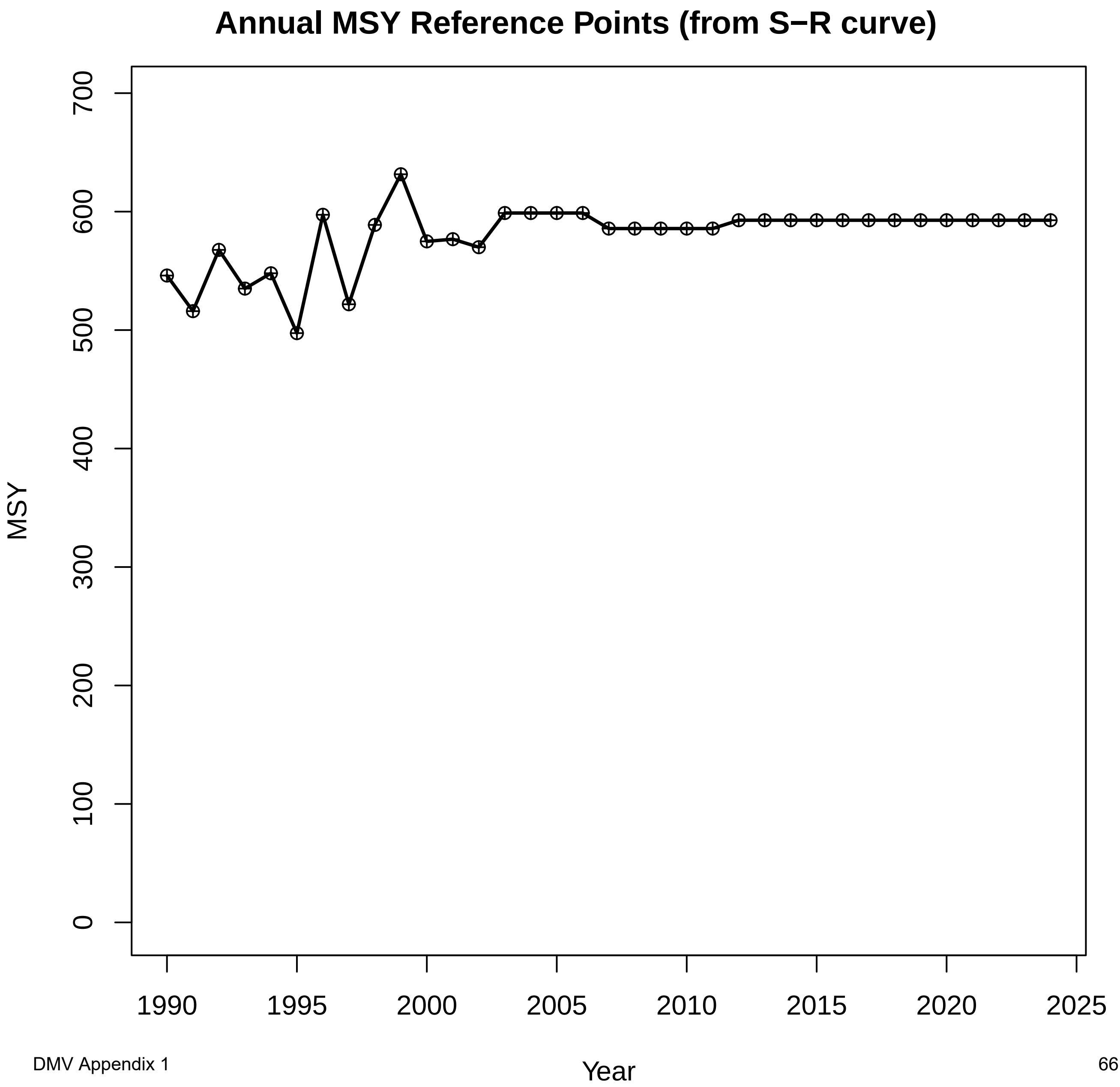
Annual MSY Reference Points (from S−R curve)

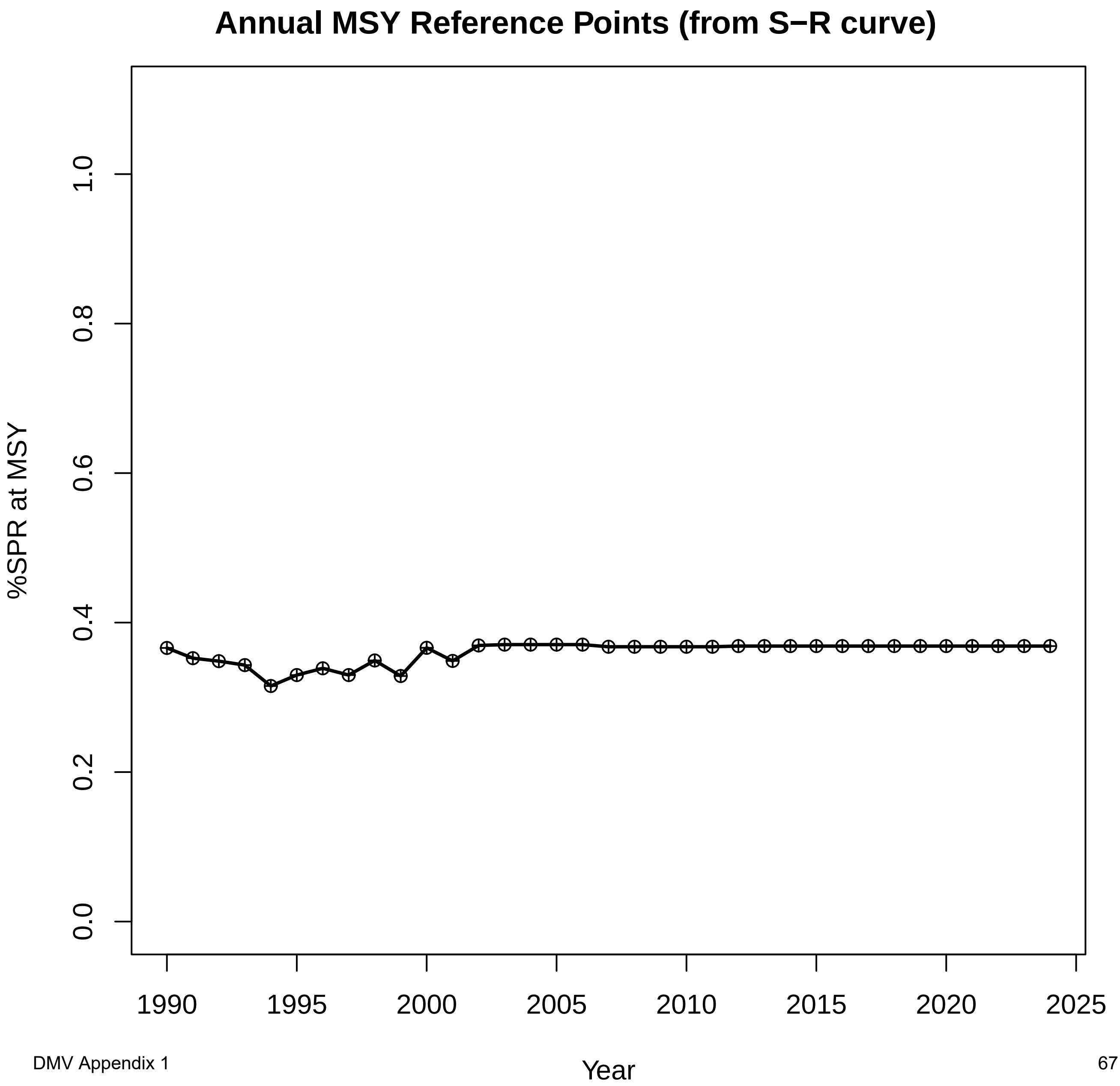


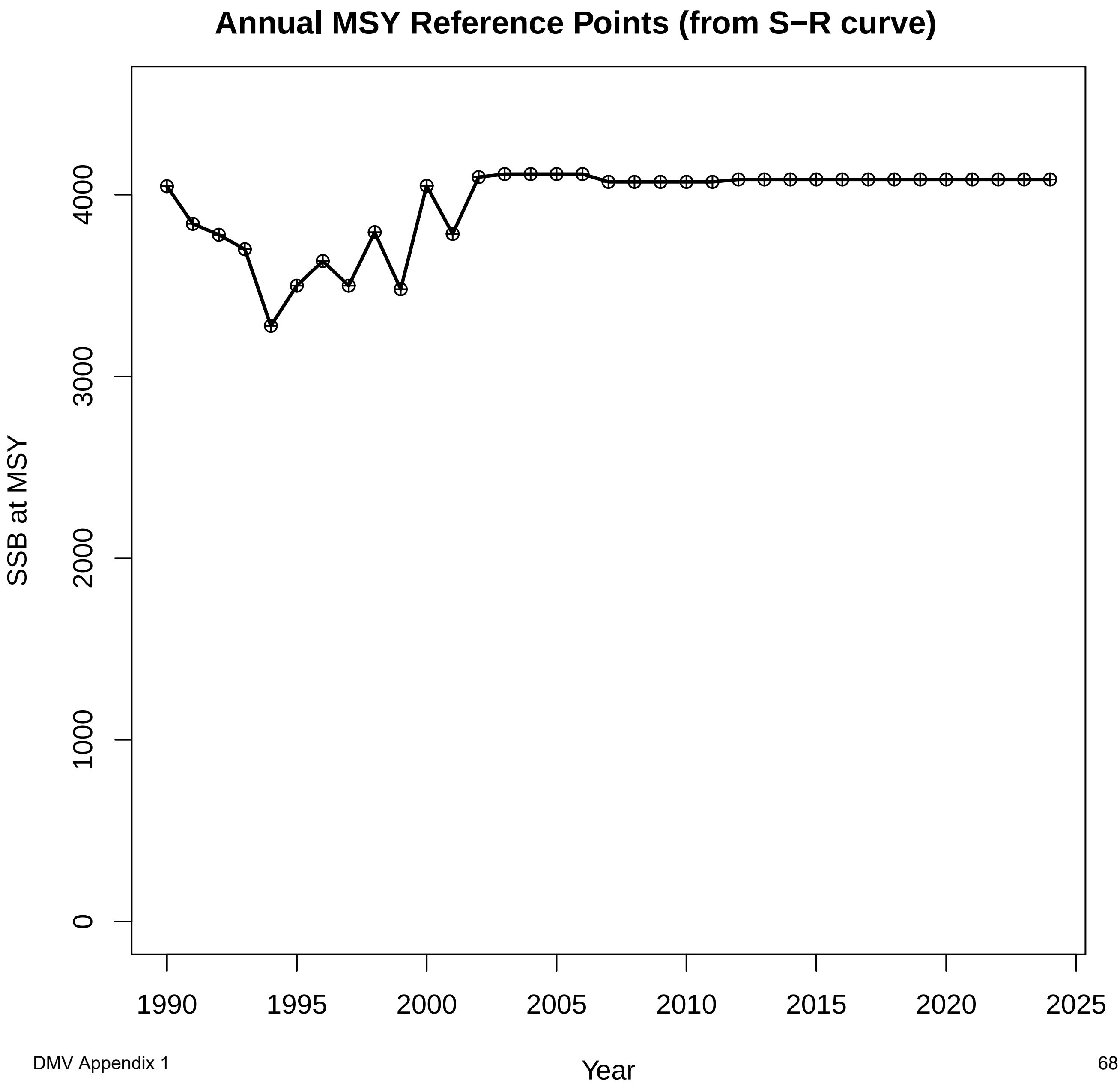


Annual Steepness and SPR.MSY (from S−R curve)
First Year
Last Year
SPR.MSY
Steepness
0.0
0.2
0.4
0.6
0.8
1.0
0.2
0.4
0.6
0.8
1.0

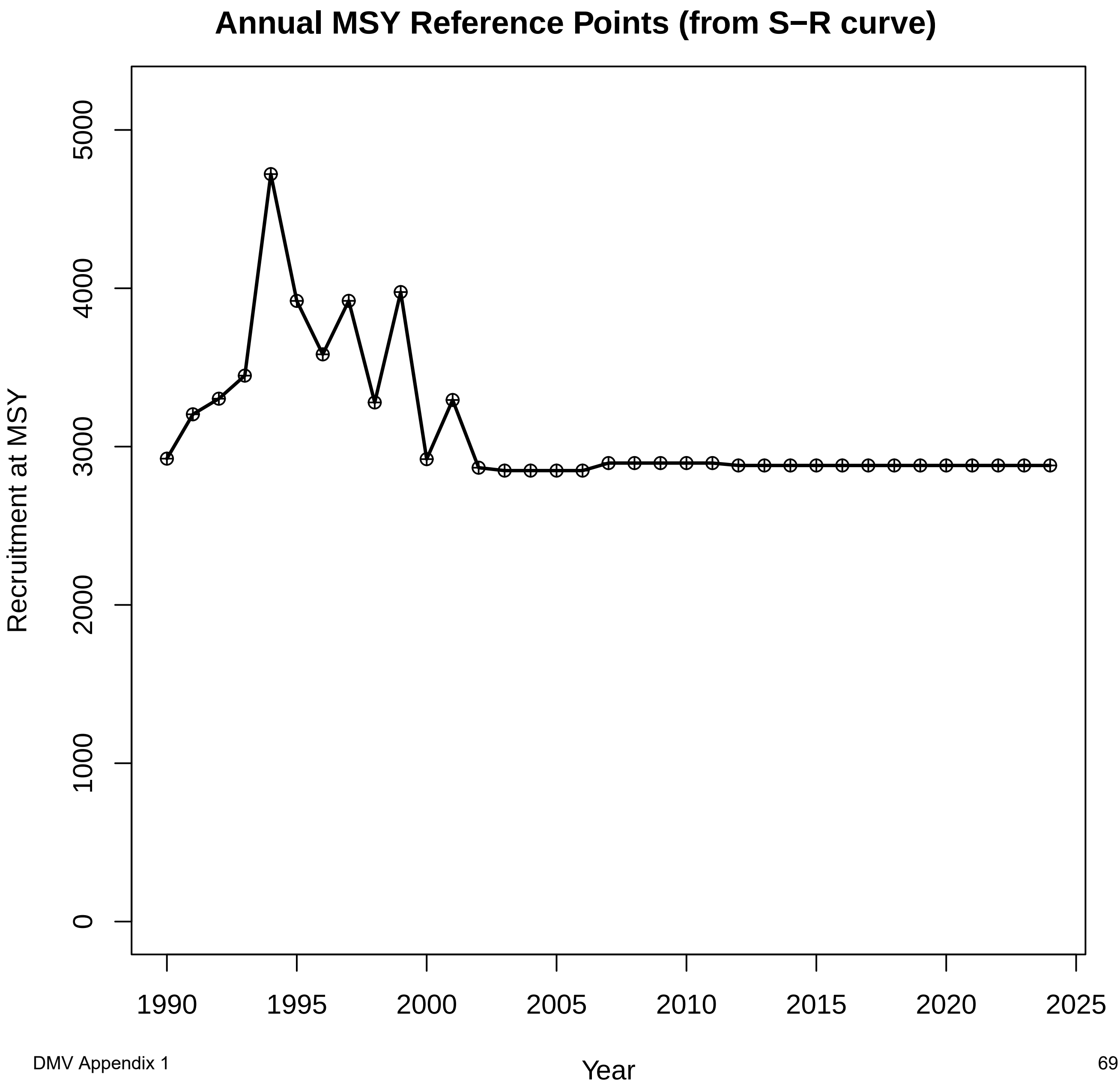

Annual MSY Reference Points (from S−R curve)
Full F at MSY
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Year
1990
1995
2000
2005
2010
2015
2020
2025

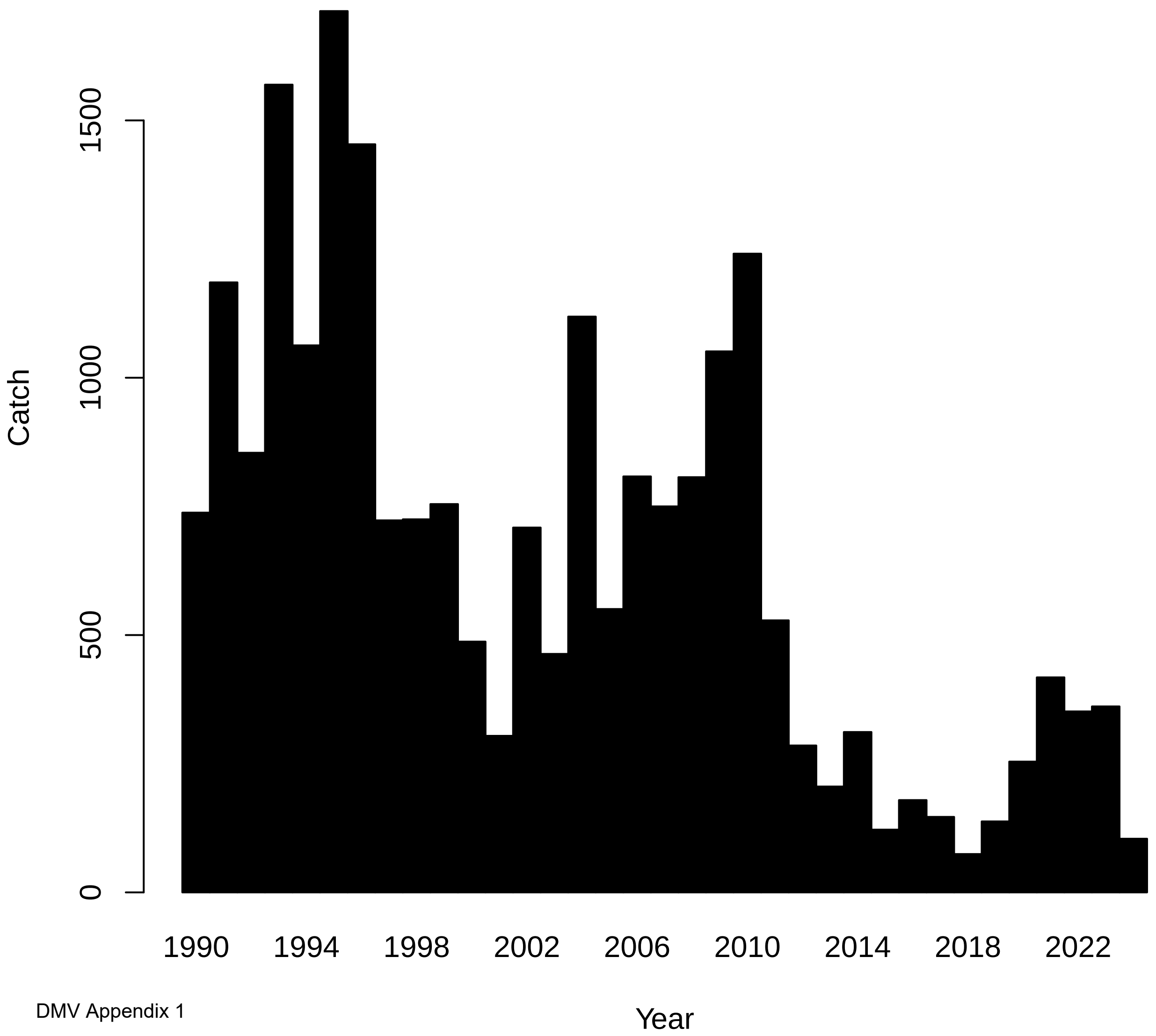

Annual MSY Reference Points (from S−R curve)
MSY
0
100
200
300
400
500
600
700
1990
1995
2000
2005
2010
2015
2020
2025
Year

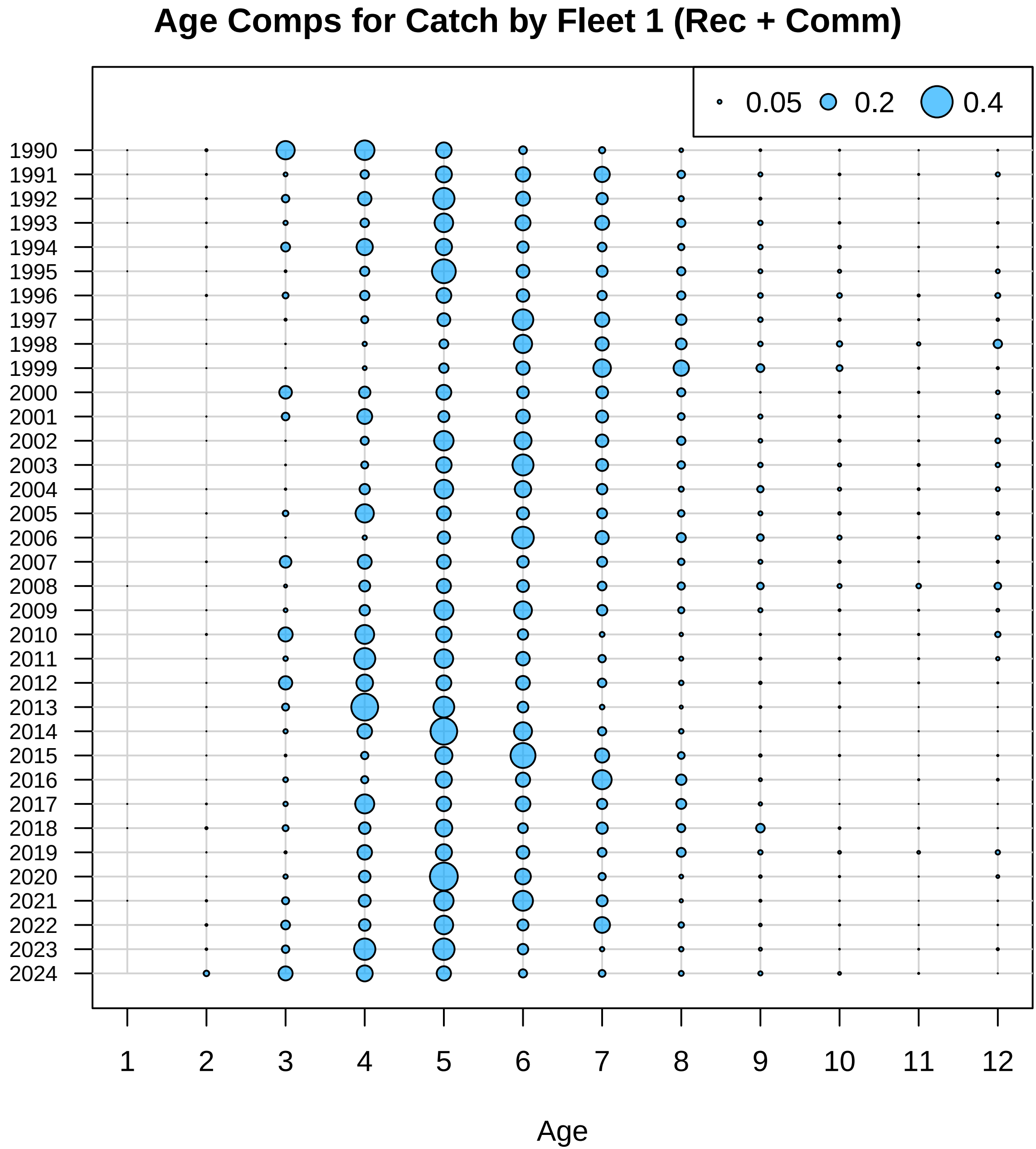

Annual MSY Reference Points (from S−R curve)
%SPR at MSY
0.0
0.2
0.4
0.6
0.8
1.0
1990
1995
2000
2005
2010
2015
2020
2025
Year

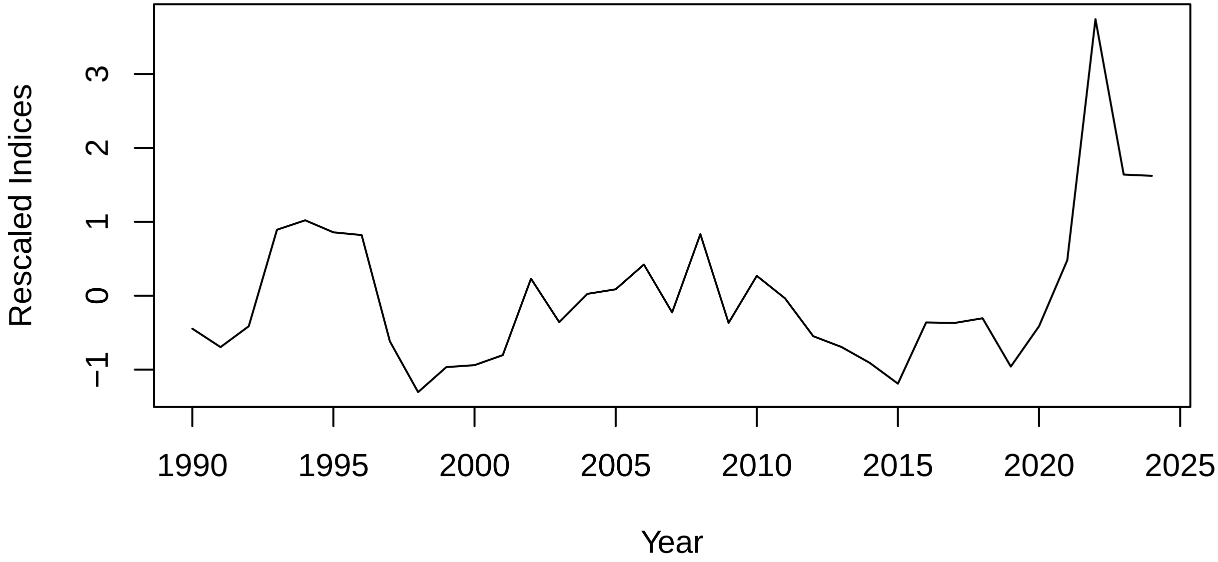


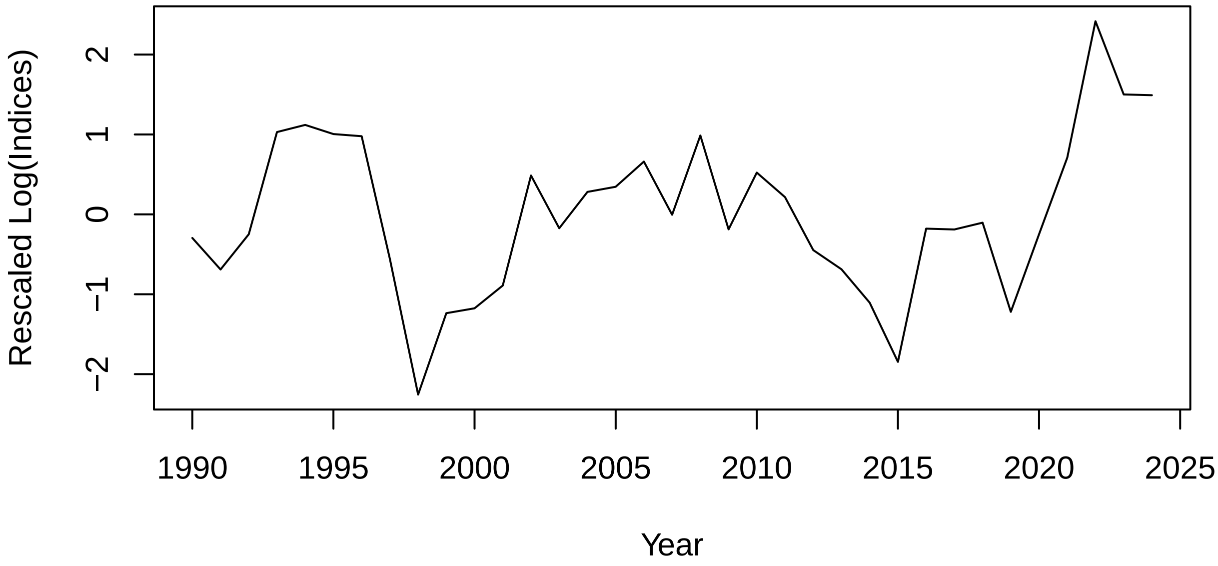
Annual MSY Reference Points (from S−R curve)
SSB at MSY
0
1000
2000
3000
4000
1990
1995
2000
2005
2010
2015
2020
2025
Year


Annual MSY Reference Points (from S−R curve)
Recruitment at MSY
0
1000
2000
3000
4000
5000
1990
1995
2000
2005
2010
2015
2020
2025
Year

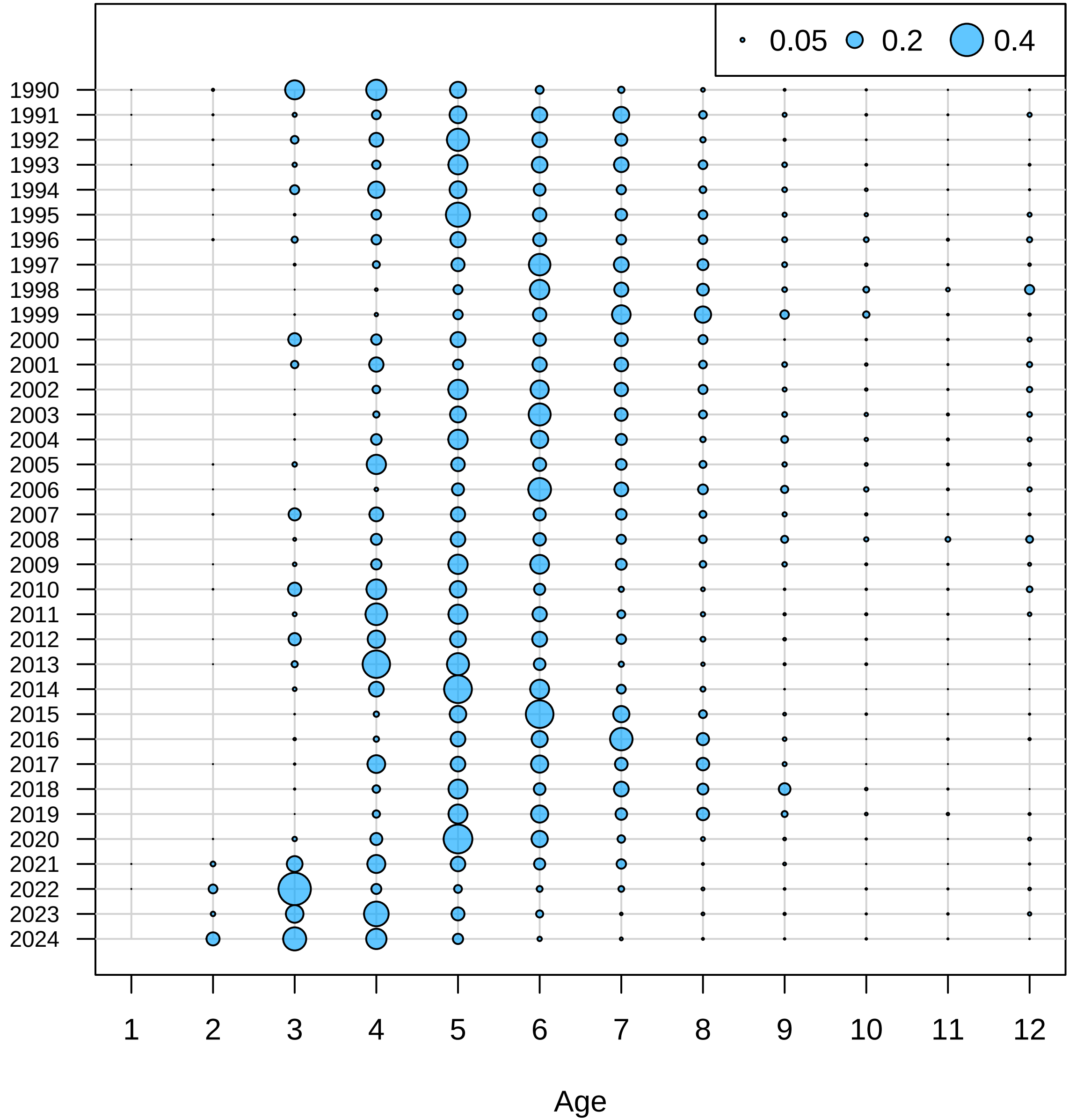

Catch
0
500
1000
1500
1990
1994
1998
2002
2006
2010
2014
2018
2022
Year

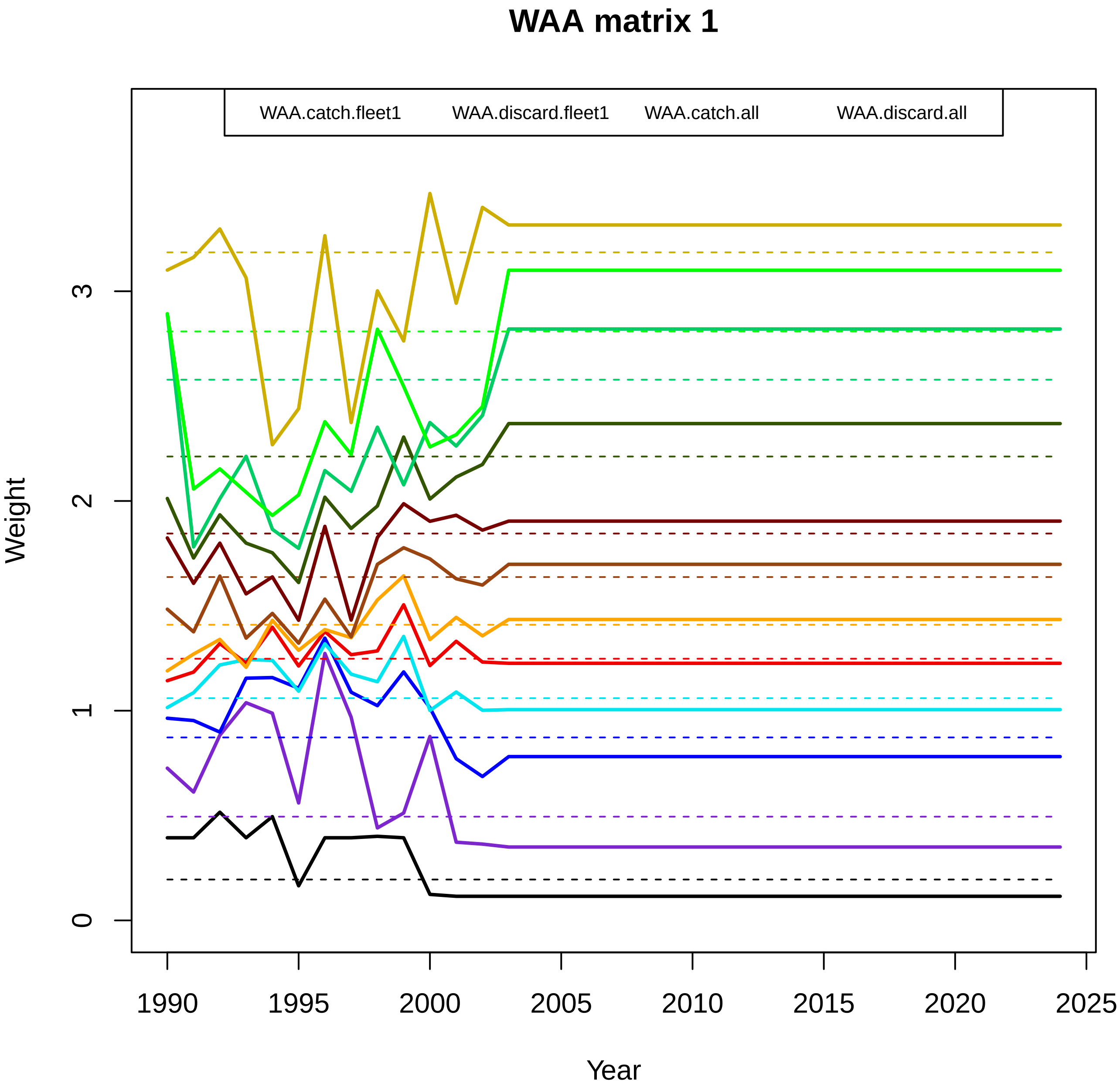

Age Comps for Catch by Fleet 1 (Rec + Comm)
0.05
0.2
0.4
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
1
2
3
4
5
6
7
8
9
10
11
12
Age

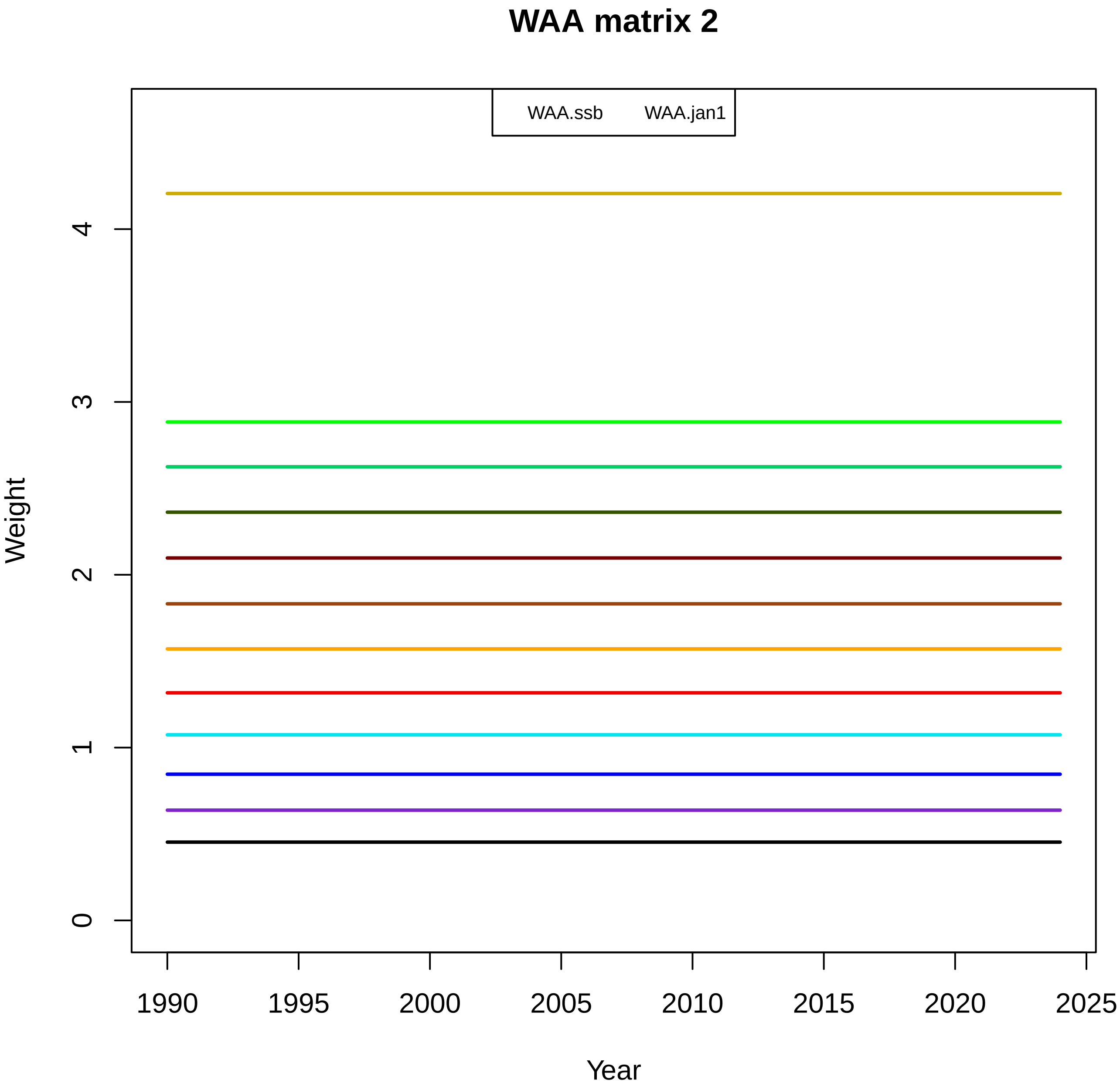

Rescaled Indices
3
2
1
0
−1
1990
1995
2000
2005
2010
2015
2020
2025
Year

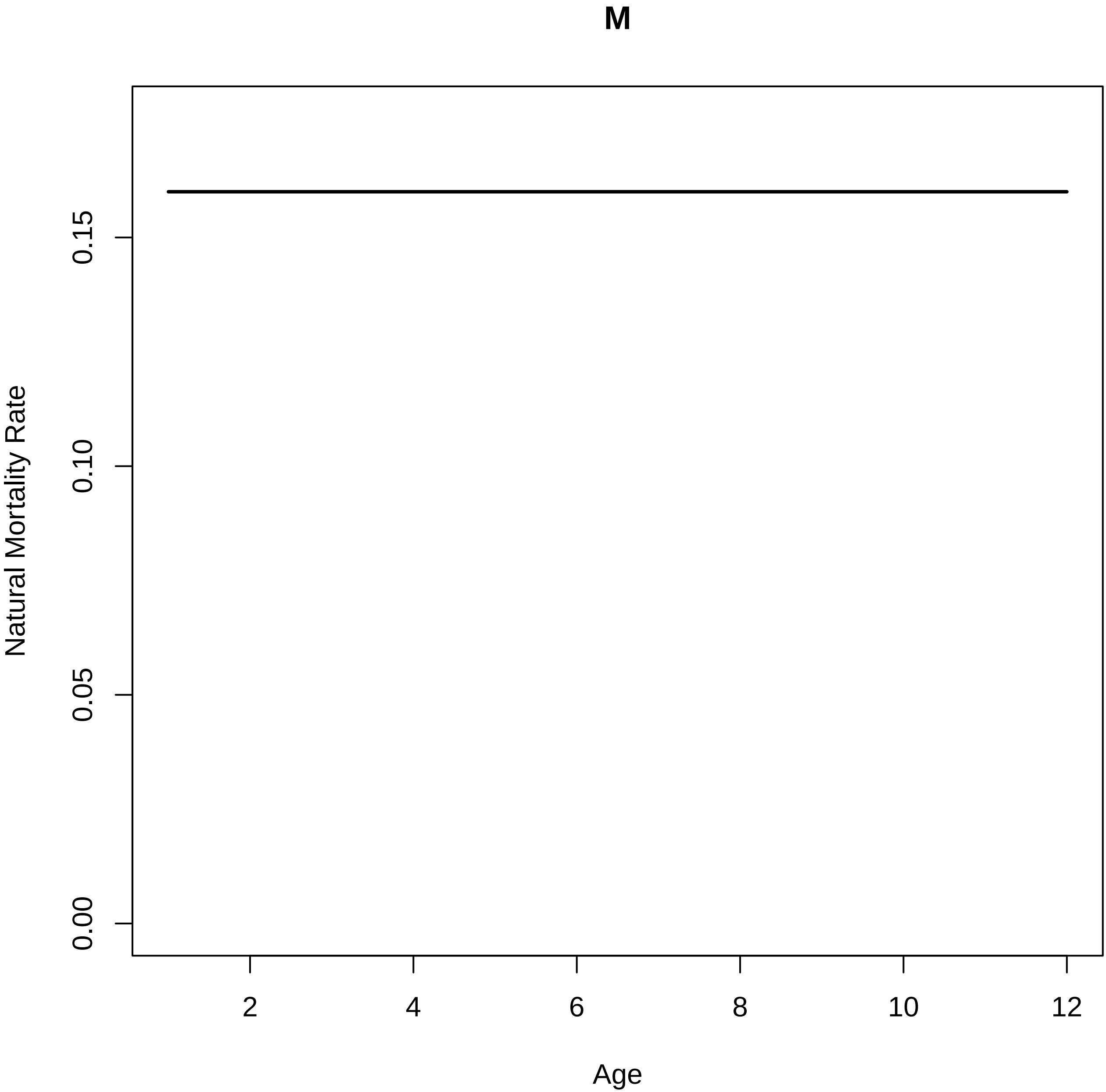

Rescaled Log(Indices)
2
1
0
−1
−2
1990
1995
2000
2005
2010
2015
2020
2025
Year

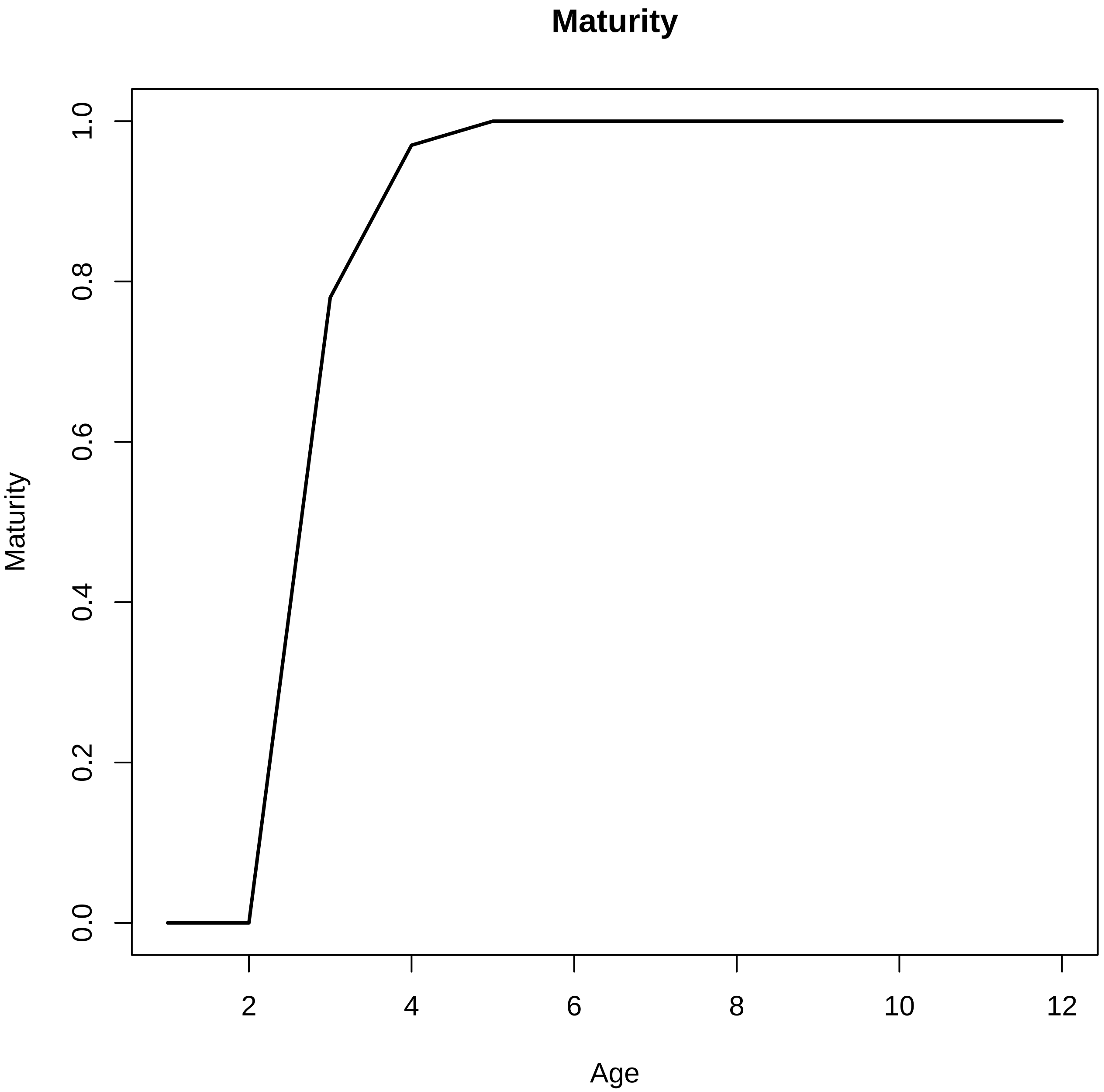
Age Comps for Index 1 (MRIP CPUE)




WAA matrix 1
WAA.catch.fleet1
WAA.discard.fleet1
WAA.catch.all
WAA.discard.all
Weight
0
1
2
3
1990
1995
2000
2005
2010
2015
2020
2025
Year


WAA matrix 2
WAA.ssb
WAA.jan1
Weight
0
1
2
3
4
Year
1990
1995
2000
2005
2010
2015
2020
2025


M
Natural Mortality Rate
0.00
0.05
0.10
0.15
2
4
6
8
10
12
Age


Maturity
1.0
0.8
0.6
0.4
0.2
0.0
Maturity
2
4
6
8
10
12
Age

DMV Appendix 2: Retrospective Adjustment and Sensitivity Runs

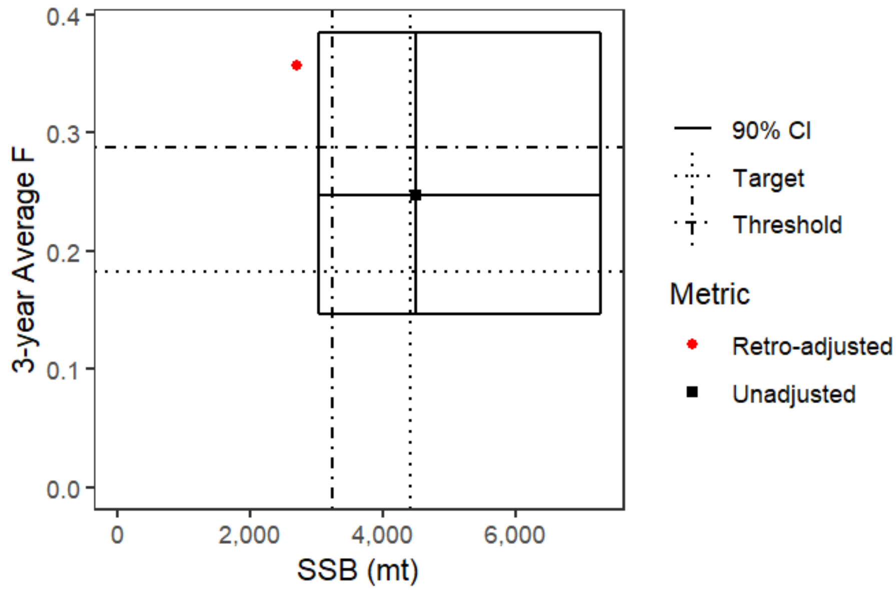


Figure A2.1. Unadjusted (black square) and adjusted for retrospective bias (red circle) 2024 estimates of F and SSB. 90% confidence limit intervals for F and SSB shown as a box around the unadjusted data point, corresponding target and limit SSB shown as vertical lines and target and limit F as horizontal lines.

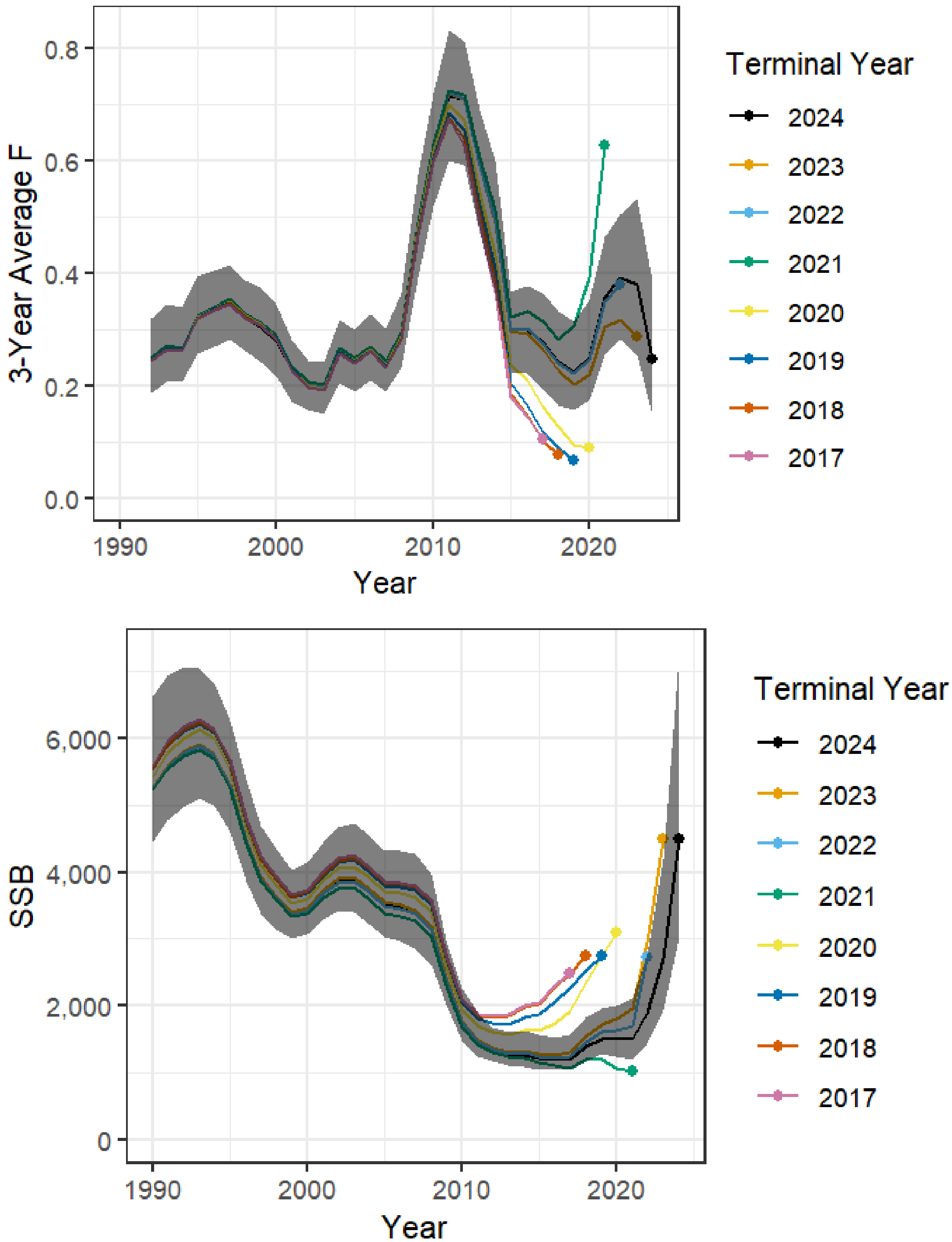
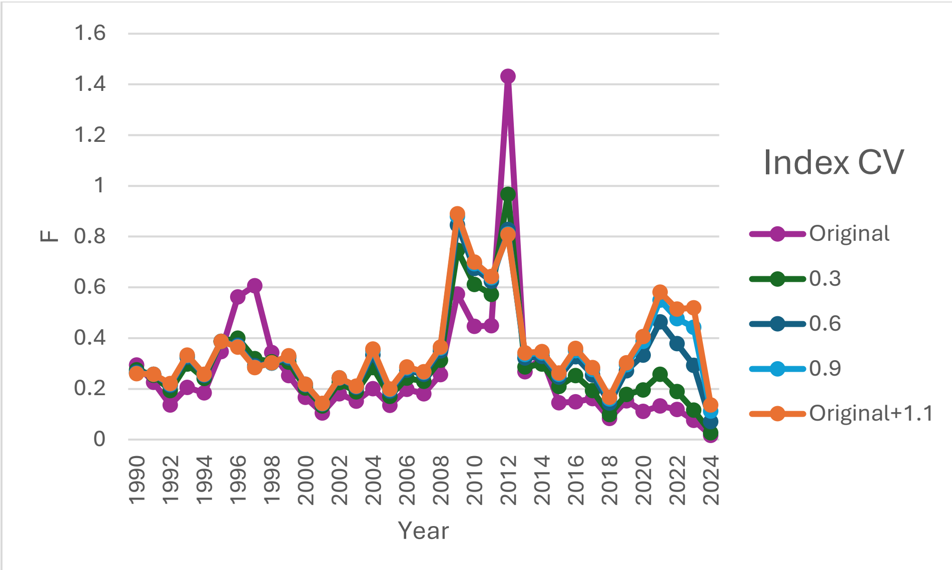


Figure A2.2. Retrospective estimates of F and SSB compared to the 2024 base run with the 90% confidence intervals.

Table A2.1 Summary of sensitivity runs focused on varying the index CV. Original CVs were based on the GLM-standardized CVs, which had a mean of 0.1027 and a standard deviation of 0.0081.

Input Parameters Changed		Objective Function	RMSE					SSB Terminal Year	Mohn's Rho	
					Fmult					
Index CV	Catch CV		Catch	Index	Year 1	Devs	Recruitment Devs		F	SSB
1.2	original	13172.5	0.7195	0.8844	2.8597	0.9138	1.0836	2260.52	0.3248	-0.0693
original+1	original	13172	0.7238	0.9185	2.8553	0.9166	1.0948	2412.38	0.28	-0.0146
1.1	original	13172.1	0.7242	0.9208	2.855	0.9169	1.0954	2420.16	0.28	0.0641
1	original	13171.8	0.7309	0.9629	2.8492	0.906	1.1095	2624.26	0.2309	0.1674
0.9	original	13171.7	0.7407	1.012	2.842	0.9252	1.1267	2891.5	0.1295	0.3363
0.8	original	13172	0.7655	1.0695	2.833	0.9309	1.148	3251.66	-0.0377	0.5221
0.7	original	13172.8	0.7766	1.1378	2.8213	0.9382	1.1753	3754.55	-0.1769	0.6708
0.6	original	13174.6	0.8083	1.2194	2.8063	0.9478	1.2111	4488.87	-0.3187	0.6708
0.5	original	13178	0.8555	1.3178	2.787	0.961	1.2599	5,623.15	-0.4923	0.82
0.4	original	13184.5	0.9257	1.4401	2.7613	0.9801	1.328	7,489.41	-0.55	0.8765
0.3	original	13197.1	1.0348	1.612	2.7289	1.0118	1.4164	10,677.20	-0.5283	0.7085
0.2	original	13226.3	1.2306	1.9549	2.6677	1.0793	1.487	16,424.50	-0.3725	0.3322
original	original	13340.4	1.7241	3.0134	2.5907	1.2237	1.4365	15,093.10	-0.416	0.3489
0.1	original	13352	1.764	3.0745	2.5564	1.2491	1.4577	15,856.60	-0.3867	0.321



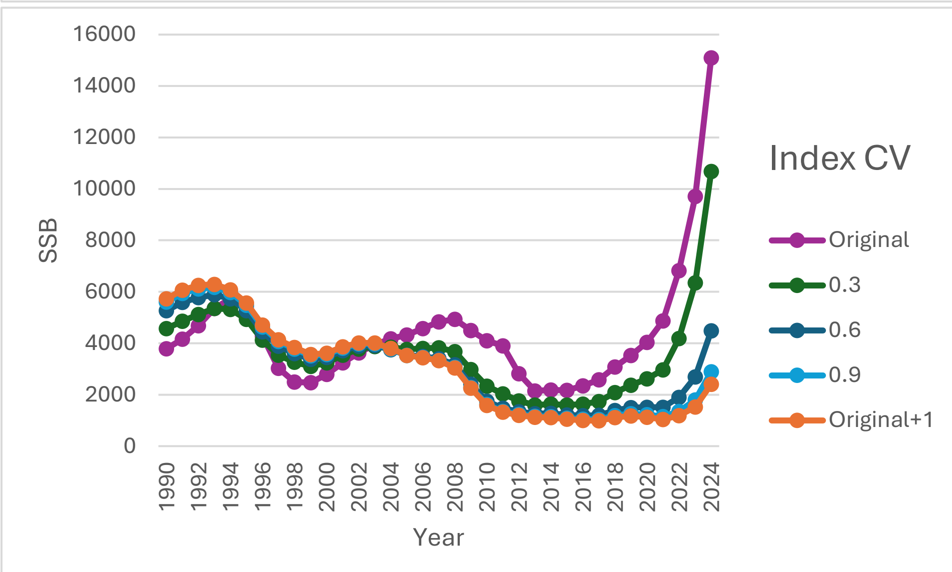


Figure A2.3. Spawning stock biomass (top) and annual *F* (bottom) estimates from ASAP runs with different CV values for the MRIP index.