North Pacific Fisheries Commission

NPFC-2024-SSC PS14-WP11

2024 update on Pacific saury stock assessment in the North Pacific Ocean using Bayesian state-space production models

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SUMMARY

The base case stock assessment for North Pacific saury has been updated. The assessment employed the state-space surplus production model, which has been used as an interim stock assessment model since SSC-PS01. This model accounts for process errors in the population dynamics and observation errors in the abundance indices. Parameter estimation was conducted within a Bayesian framework using the Markov Chain Monte Carlo method. The stock status and future projections were presented following the template agreed upon at the 5th SSC-PS meeting, with some modifications to accommodate the updated data period.

As for the combined base case stock assessment result, the 2024 median depletion level was only 20.6% (80% CI: 11.6–31.0%) of the carrying capacity. Furthermore, the B-ratio (=B/Bmsy) and F-ratio (=F/Fmsy) in 2023 were 0.327 (80% CI: 0.226–0.440) and 0.942 (80% CI: 0.667–1.450), respectively. For the three-year average values, the B-ratio over 2022–2024 and the F-ratio over 2021–2023 were 0.341 (80% CI: 0.229–0.471) and 1.026 (80% CI: 0.761–1.473), respectively. In addition, the probability of the stock being in the green Kobe quadrant in 2023 was estimated to be approximately 0%, while the probabilities of being in the yellow and red Kobe quadrants were assessed as 58% and 42%, respectively. Note that there is a large difference in the biomass series between the two base cases, whereas relative quantities, such as the B- and F-ratios and depletion level, differ little.

INTRODUCTION

The Pacific saury is one of the commercially valuable species in the North Pacific, and the North Pacific Fishery Commission (NPFC hereafter) has been the responsible organization for the management of this species since its establishment. The Small Scientific Committee for Pacific saury (SSC-PS) was established under the Scientific Committee (SC) to undertake stock assessment of the Pacific saury.

The Pacific saury is a commercially valuable species in the North Pacific. The North Pacific Fisheries Commission (hereafter referred to as NPFC) has been responsible for managing this species since its establishment. To support stock assessments of Pacific saury, the Small Scientific Committee for Pacific Saury (SSC-PS) was established under the Scientific Committee (SC).

In the 13th SSC-PS meeting, the new specification for the BSSPM analysis was agreed (see SSC-PS13 report). Here, we will report on our updated stock assessment based on the specification.

MATERIALS AND METHODS

Data set and specification of analysis

The following is the list of data set used in the analysis.

1) Time series of total reported catch up to 2023

2) Standardized CPUE indices by the five Members up to 2023

3) Fishery-independent survey by Japan from 2003 to 2024

4) Joint CPUE from 1994 to 2023

Similar statistical models as those used last year were applied, with some amendments based on PS13, including the splitting of the CPUEs from Chinese Taipei into two series. Flat priors were used for all free parameters, as in previous Japanese analyses.

RESULTS

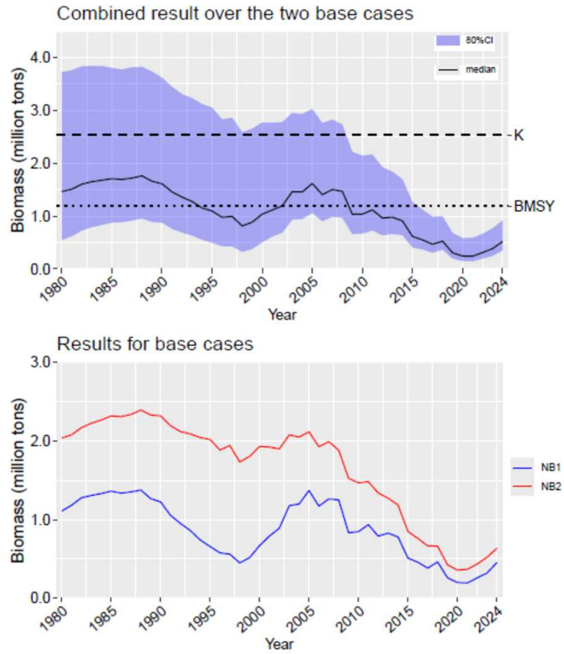
Time series and stock status

Figure 1 shows the trajectories of biomass, B- and F-ratios and depletion level relative to the carrying capacity over the two base cases (further information including the series of harvest rate is available in Appendix). The result indicated that, although there were long-term fluctuations and interannual variability in the biomass, the stock declined from high abundance period in 2003-2008 to current low levels. The exploitation rates were increasing slowly in 2000's and remained high since 2010.

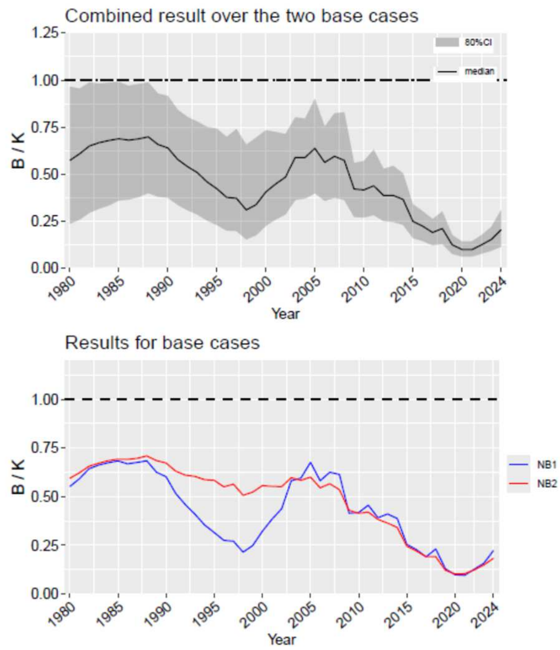
Table 1 also shows the results of key reference quantities combined over the two base cases. As for the combined base case stock assessment result, the 2023 median depletion level was only 21.0% (80%CI=10.7-34.8%) of the carrying capacity. Furthermore, B-ratio (=B/Bmsy) and F-ratio (=F/Fmsy) in 2022 were 0.337 (80%CI=0.229-0.474) and 0.799 (80%CI=0.517-1.384), respectively. For those three years average values, B-ratio over 2021-2023 and F-ratio over 2020-2022 were respectively 0.336 (80%CI=0.206-0.505) and 1.106 (80%CI=0.750-1.701).

Evidently, Figure 2, which is the Kobe plot with time series of median B-ratio and F-ratio for 1980-2023, also shows that the probability of the stock being in the green Kobe quadrant in 2023 was estimated to be approximately 0%, while the probabilities of being in the yellow and red Kobe quadrants were assessed as 58% and 42%, respectively.

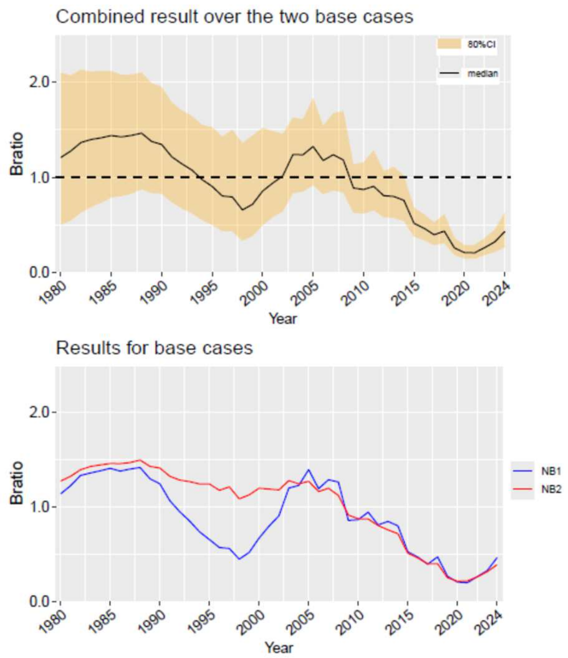
(a) Biomass



(b) Depletion level relative to K



(c) B-ratio



(d) F-ratio

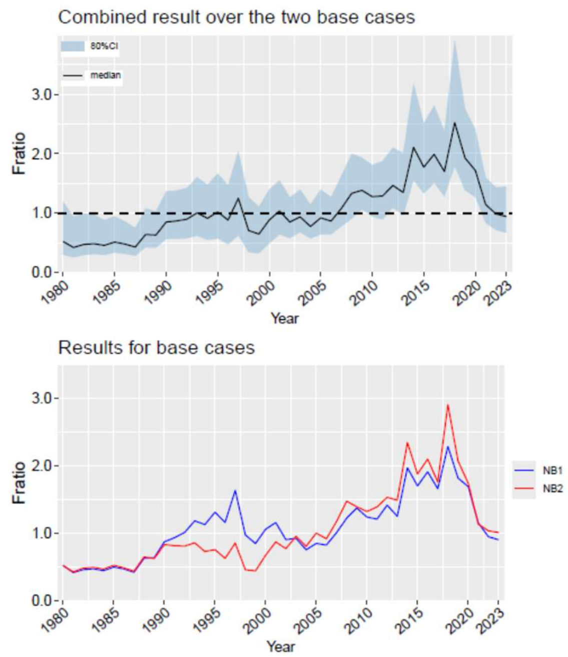


Figure 1. Results of trajectories over the two base cases of (a) biomass, (b) depletion level relative to the carrying capacity, (c) B-ratio and (d) F-ratio.

Table 1. Estimates of key reference quantities combined over the two base cases.

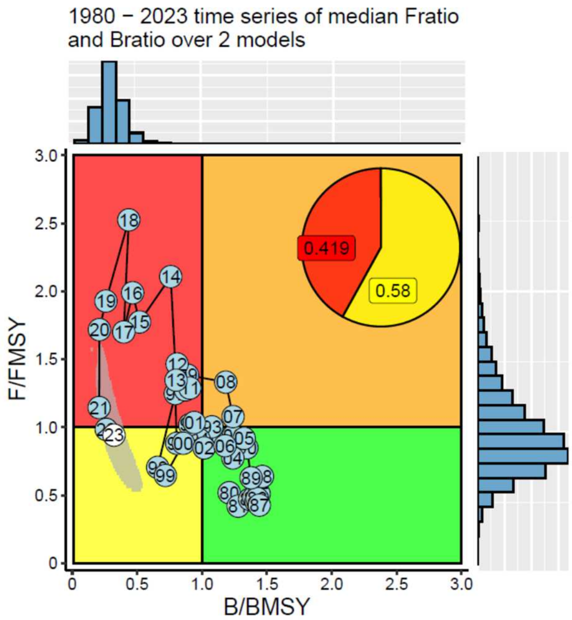
2024 update

	Mean	Median	Lower10th	Upper10th
C_2023 (million tons)	0.118	0.118	0.118	0.118
AveC_2021_2023	0.104	0.104	0.104	0.104
AveF_2021_2023	0.341	0.339	0.155	0.522
F_2023	0.311	0.307	0.154	0.472
FMSY	0.336	0.336	0.133	0.538
MSY (million tons)	0.396	0.393	0.318	0.474
F_2023/FMSY	1.013	0.942	0.667	1.450
AveF_2021_2023/FMSY	1.081	1.026	0.761	1.473
K (million tons)	3.222	2.534	1.534	6.093
B_2023 (million tons)	0.460	0.386	0.251	0.768
B_2024 (million tons)	0.595	0.521	0.353	0.918
AveB_2022_2024	0.479	0.406	0.276	0.779
BMSY (million tons)	1.477	1.190	0.775	2.653
BMSY/K	0.473	0.471	0.396	0.557
B_2023/K	0.157	0.154	0.094	0.220
B_2024/K	0.211	0.206	0.116	0.310
AveB_2022_2024/K	0.165	0.163	0.099	0.231
B_2023/BMSY	0.332	0.327	0.226	0.440
B_2024/BMSY	0.444	0.431	0.265	0.631
AveB_2022_2024/BMSY	0.347	0.341	0.229	0.471

2023 result

	Mean	Median	Lower10th	Upper10th
C_2022 (million tons)	0.100	0.100	0.100	0.100
AveC_2020_2022	0.111	0.111	0.111	0.111
AveF_2020_2022	0.386	0.376	0.148	0.638
F_2022	0.278	0.270	0.120	0.444
FMSY	0.358	0.350	0.117	0.606
MSY (million tons)	0.403	0.399	0.309	0.496
F_2022/FMSY	0.896	0.799	0.517	1.384
AveF_2020_2022/FMSY	1.186	1.106	0.750	1.701
K (million tons)	3.284	2.518	1.412	6.575
B_2022 (million tons)	0.467	0.371	0.226	0.831
B_2023 (million tons)	0.627	0.523	0.326	1.039
AveB_2021_2023	0.489	0.390	0.245	0.849
BMSY (million tons)	1.513	1.186	0.695	2.905
BMSY/K	0.473	0.469	0.397	0.555
B_2022/K	0.156	0.151	0.088	0.228
B_2023/K	0.222	0.210	0.107	0.348
AveB_2021_2023/K	0.165	0.160	0.092	0.242
B_2022/BMSY	0.347	0.337	0.229	0.474
B_2023/BMSY	0.470	0.441	0.237	0.730
AveB_2021_2023/BMSY	0.350	0.336	0.206	0.505

2024 update



2023 result

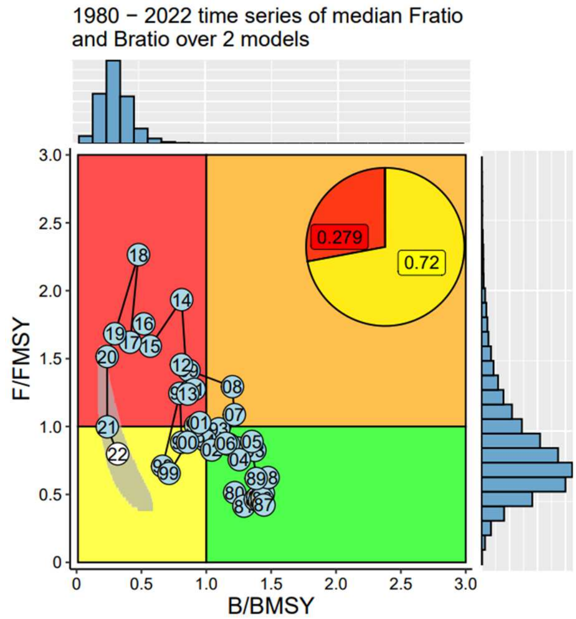


Figure 2. Kobe plot showing the time series of the median B-ratio and F-ratio for 1980–2023 in the 2024 update and for 1980–2022 in the 2023 result.

Conclusion

1) Biomass level: The 2024 median depletion level was 20.6% (80% CI: 11.6–31.0%) of the carrying capacity, which is similar to the 21.0% (80% CI: 10.7–34.8%) observed in 2023 according to the 2023 analysis.

2) Reference points: The B-ratio (=B/Bmsy) and F-ratio (=F/Fmsy) in 2023 in the 2024 update were 0.327 (80% CI: 0.226–0.440) and 0.942 (80% CI: 0.667–1.450), respectively, compared to 0.337 (80% CI: 0.229–0.474) and 0.799 (80% CI: 0.517–1.384) in 2022 in the 2023 analysis.

3) Reference points for the recent 3-year average: The B-ratio for 2022–2024 and the F-ratio for 2021–2023 were 0.341 (80% CI: 0.229–0.471) and 1.026 (80% CI: 0.761–1.473), respectively, while the B-ratio for 2021–2023 and the F-ratio for 2020–2022 were 0.336 (80% CI: 0.206–0.505) and 1.106 (80% CI: 0.750–1.701), respectively, in last year's assessment.

4) The probability of the stock being in the green Kobe quadrant in 2023 in the 2024 update was estimated to be approximately 0%, while the probabilities of being in the yellow and red Kobe quadrants were 58% and 42%, respectively. In comparison, the probabilities for 2022 in the 2023 assessment were 72% for the yellow quadrant and 28% for the red quadrant.

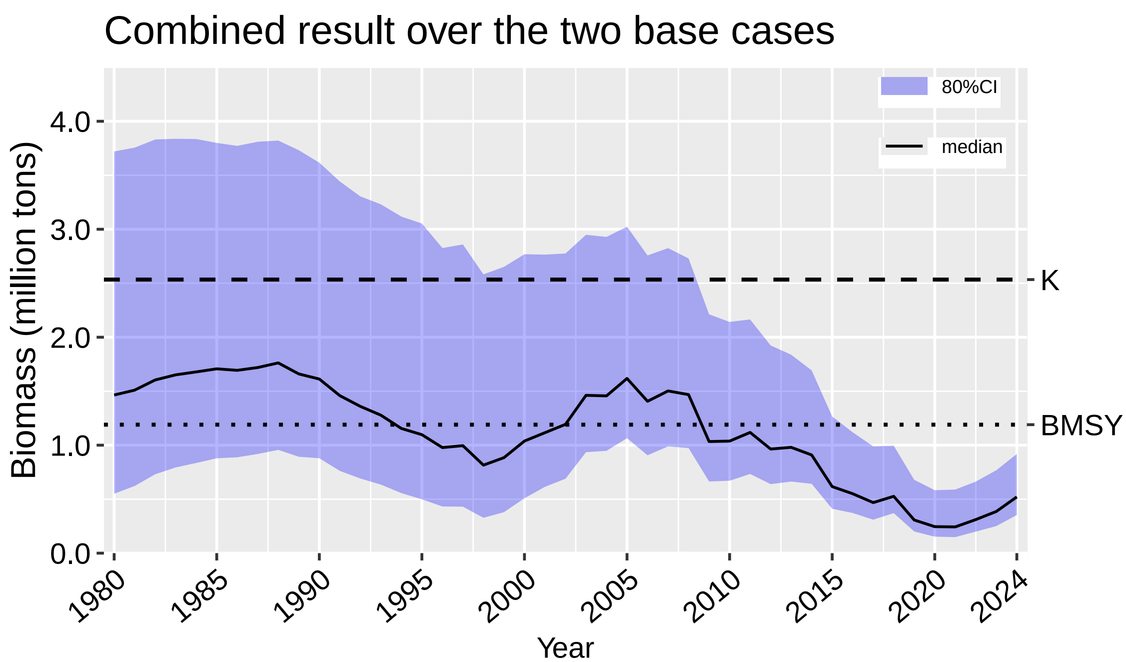
5) As was the case in the last year's assessment, there is a large difference in the biomass series between the two base cases, while there is little difference in relative quantities such as the B-/F-ratios and depletion level.

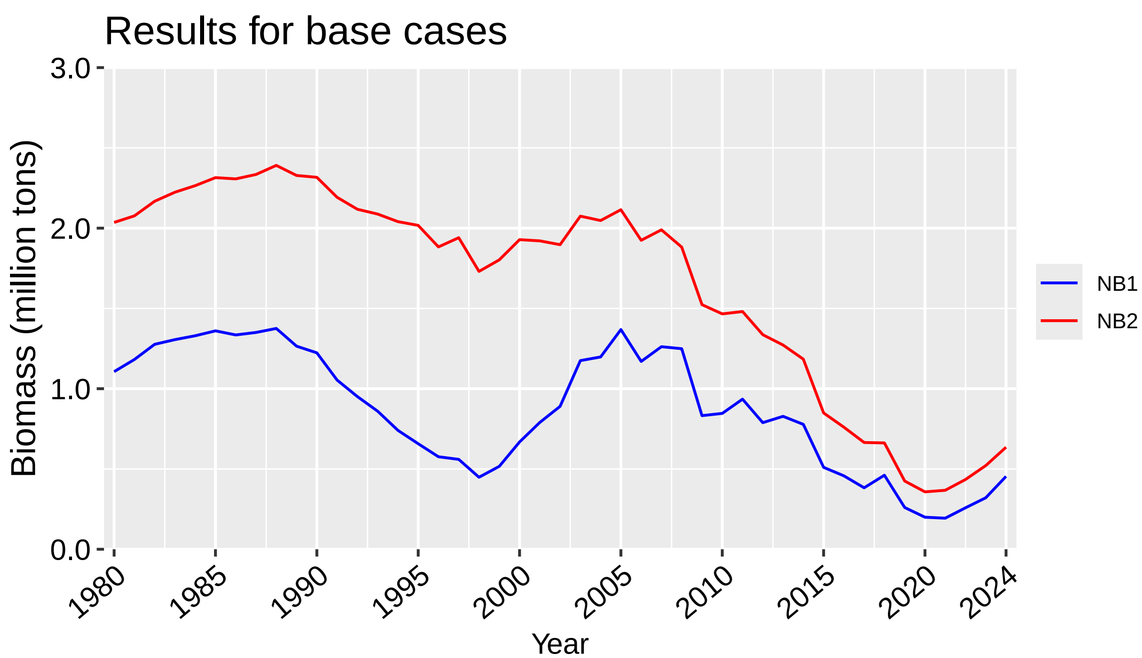
Item	Authors' note
(1) Identify the data that will be available to the stock assessment;	As shown in the main section.
(2) Evaluate data quality and quantity and potential error sources (e.g., sampling errors, measurement errors) and associated statistical properties (e.g., biased or random errors, statistical distribution) to ensure that the best available information is used in the assessment;	No errors were assumed in the catch data, while all abundance indices were assumed to have estimation errors
(3) Select population models describing the dynamics of PS stock and observational models linking population variables with the observed variables;	Biomass dynamics models with process & observation errors.
(4) Develop base case scenarios and alternative scenarios for sensitivity analyses;	Analyses of sensitivity cases were skipped.
(5) Compile input data and prior distributions for the model parameterization for the base case and alternative scenarios;	Similar approaches used in the previous years.
(6) For each scenario, fit the model to the data, diagnostics of model convergence, plot and evaluate residual patterns, compare prior and posterior distributions for key model parameters, and evaluate biological implications of the estimated parameters;	See Appendix.
(7) Develop retrospective analysis to verify whether any possible systematic inconsistencies exist among model estimates of biomass and fishing mortality	Skipped.
(8) Identify final model configuration and model runs for each scenario;	Similar approaches used in the previous years. See SSC-PS13 report for the specification.
(9) For each scenario, estimate and plot exploitable stock biomass and fishing mortality (and their relevant credibility distributions) over time;	See Appendix.
(10) For each scenario, estimate biological reference points (e.g., MSY, Bmsy, Fmsy) and its associated uncertainty;	See the main text and Appendix.
(11) Identify target and limit reference points for stock biomass and fishing mortality;	See SWG-MSE report.
(12) Have the Kobe plot for each scenario;	See the main text and Appendix.
(13) Determine if the stock is "overfished" and "overfishing" occurs for the base and sensitivity scenarios;	No definition.
(14) Finalize the base-case scenario;	See SSC-PS13 report.
(15) Develop alternative ABCs for the projection (e.g., 5-year projection);	Not available.
(16) Conduct risk analysis for each level of ABC defined in the base-case scenario;	Not available.
(17) Develop decision tables with alternative state of nature;	Not available.
(18) Determine optimal ABCs based on decision tables developed in Step (17);	Not available.
(19) Provide scientific advice on stock status and appropriate catch level to SC through SSC PS.	To be discussed during this meeting

Appendix:

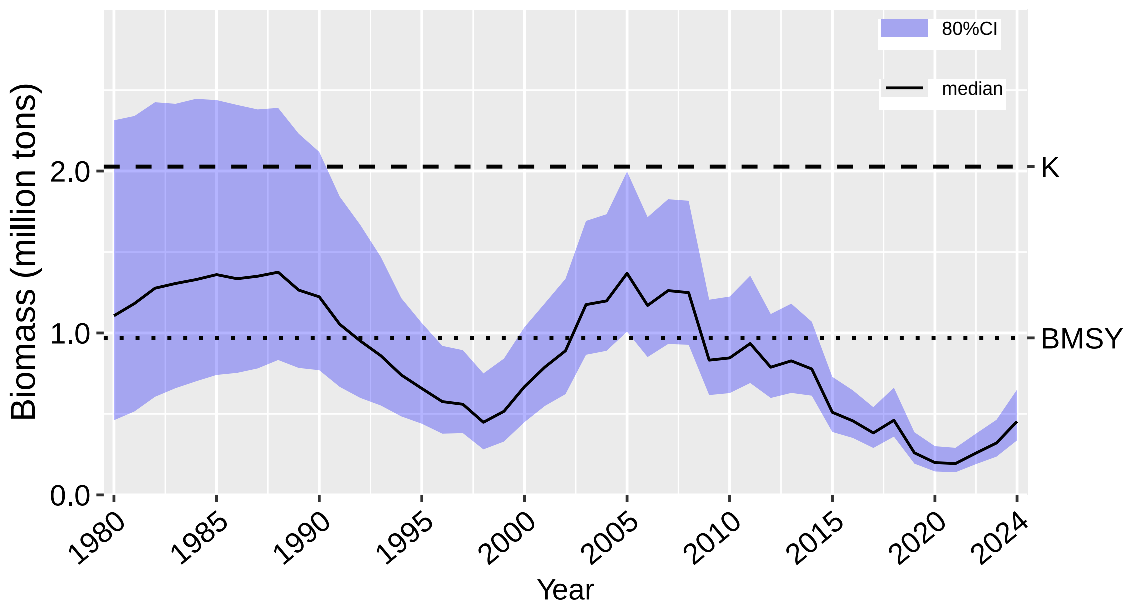
1 Time series plot

1.1 Time series Biomass

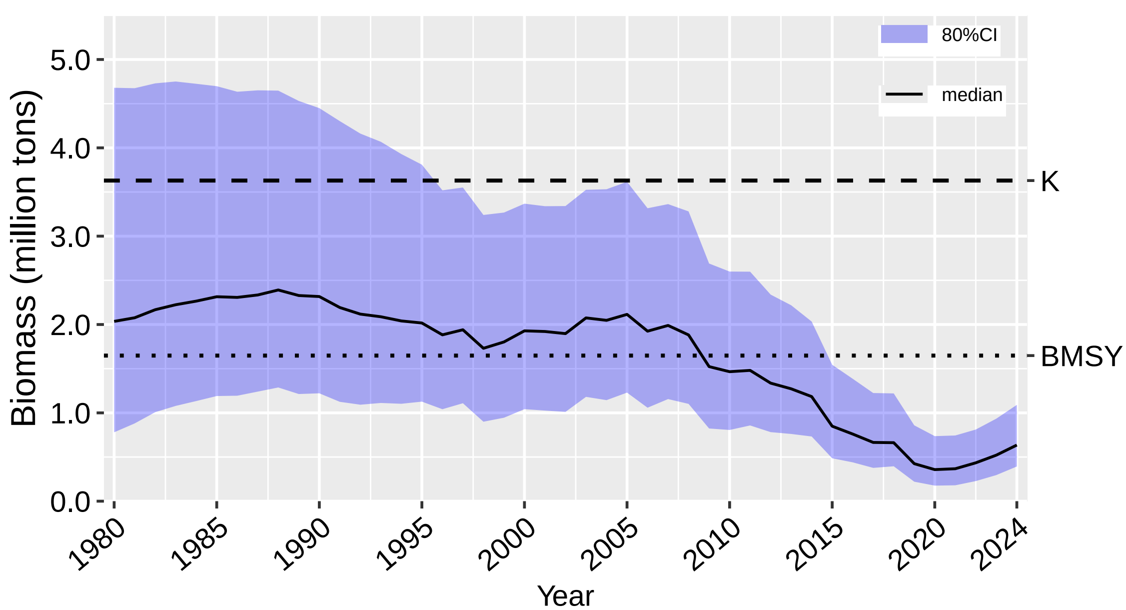




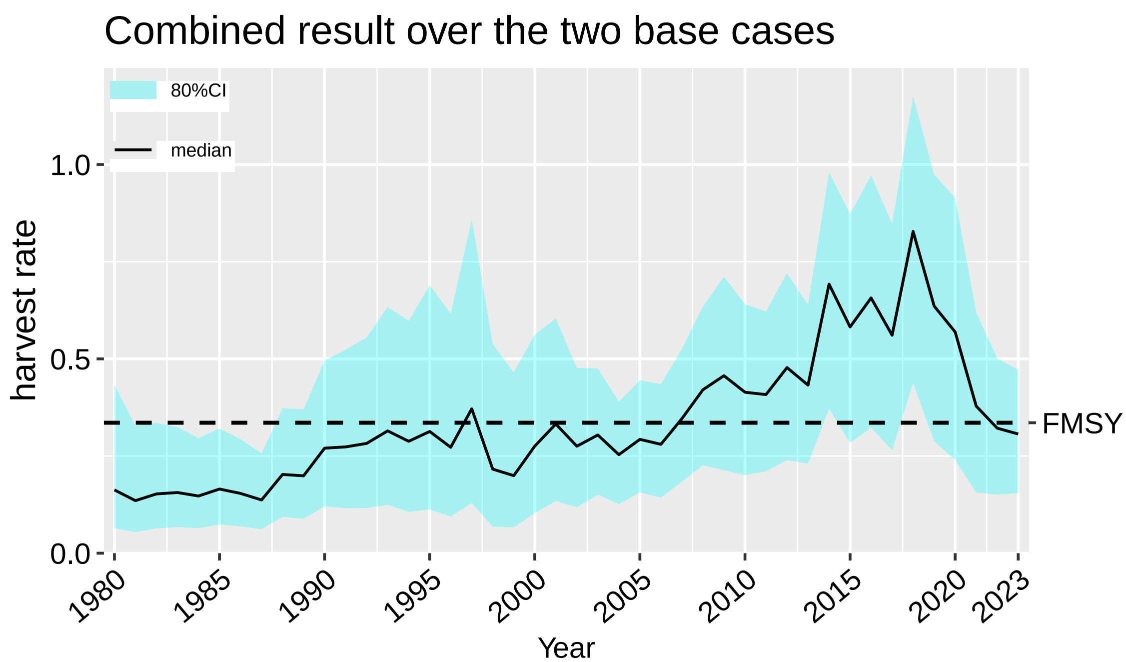
Base case 1

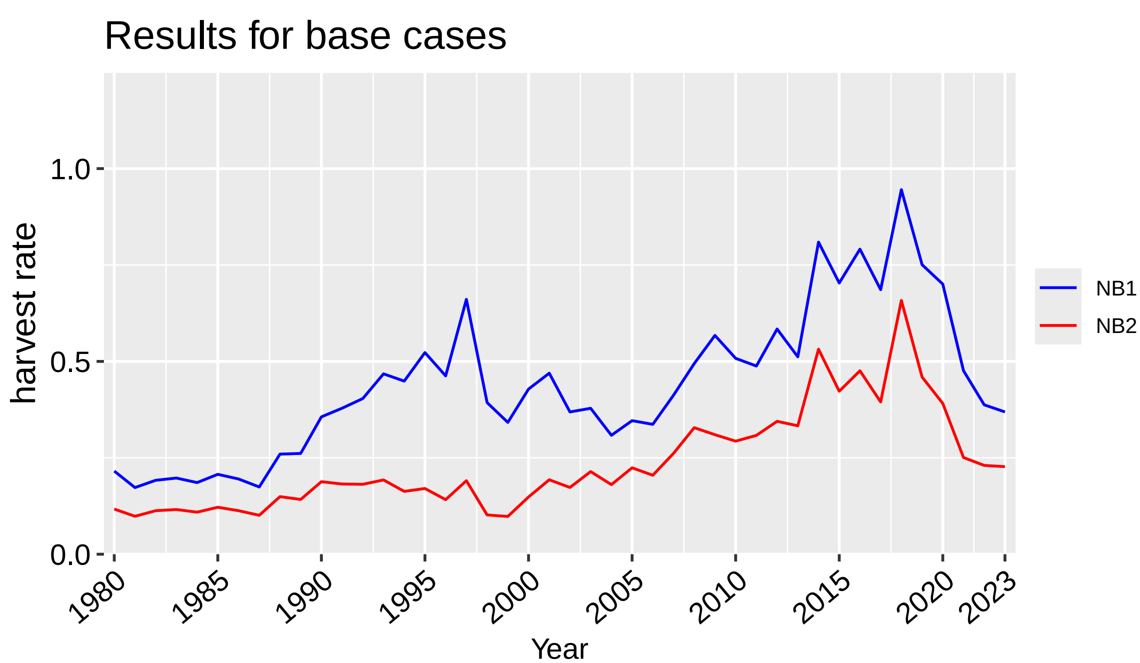


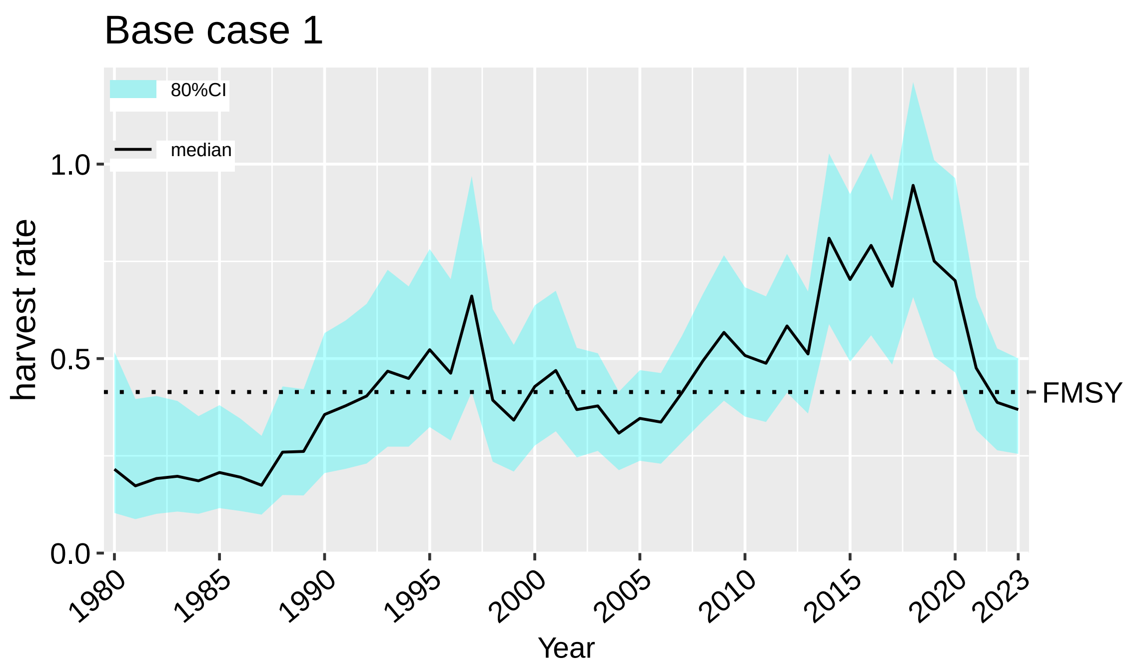
Base case 2



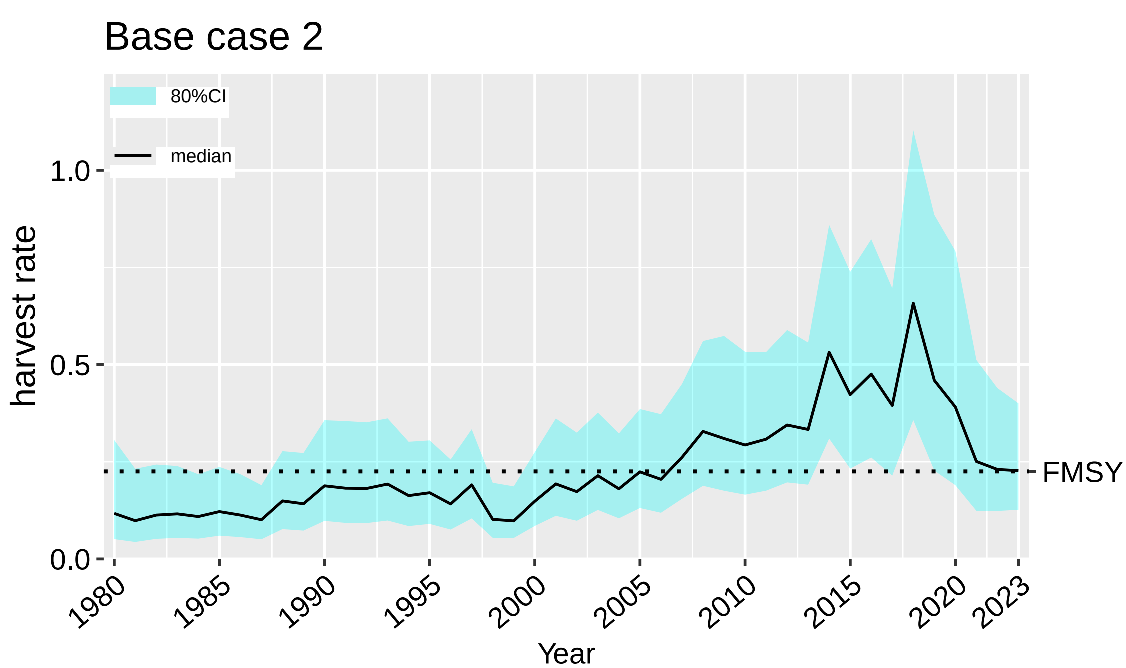
1.2 Time series Harvest rate





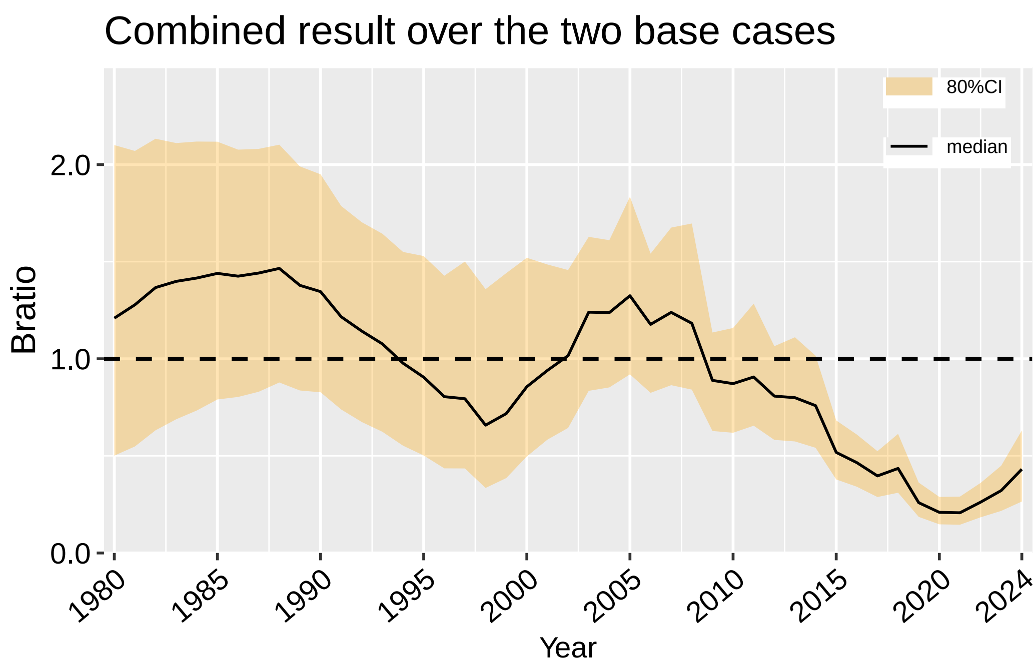


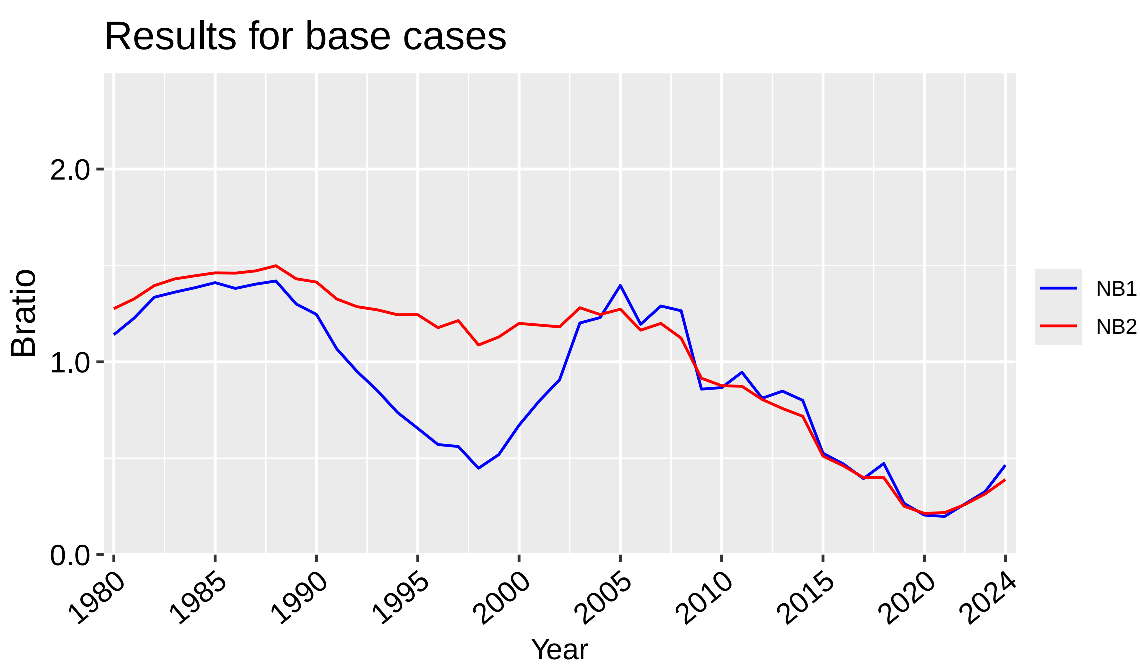
Base case 1
80%CI
median
harvest rate
1.0
0.5
0.0
FMSY
1980
1985
1990
1995
2000
2005
2010
2015
2020
2023
Year



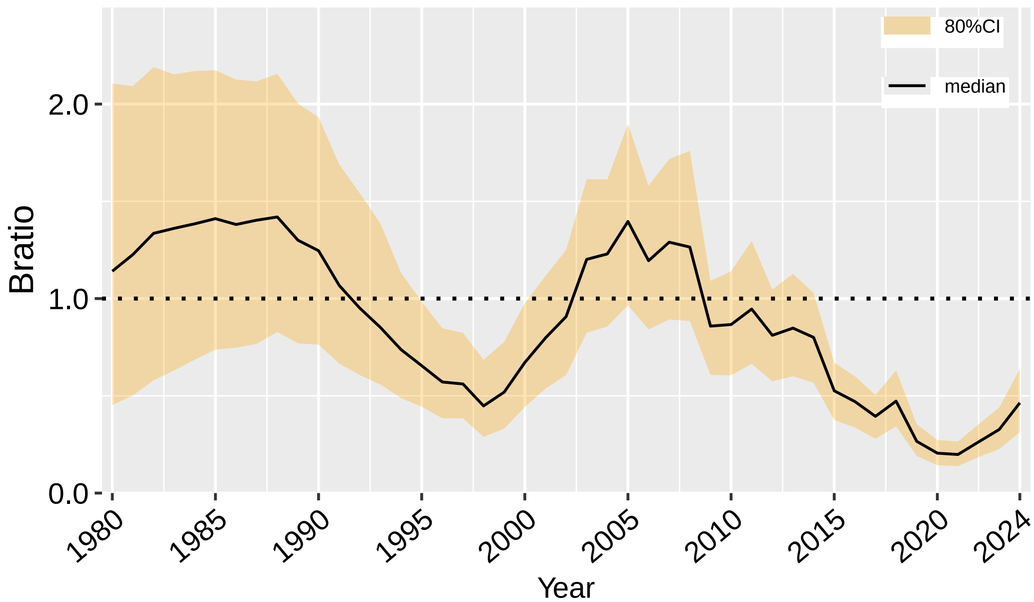
Base case 2
80%CI
median
harvest rate
1.0
0.5
0.0
FMSY
1980
1985
1990
1995
2000
2005
2010
2015
2020
2023
Year

1.3 Time series Bratio

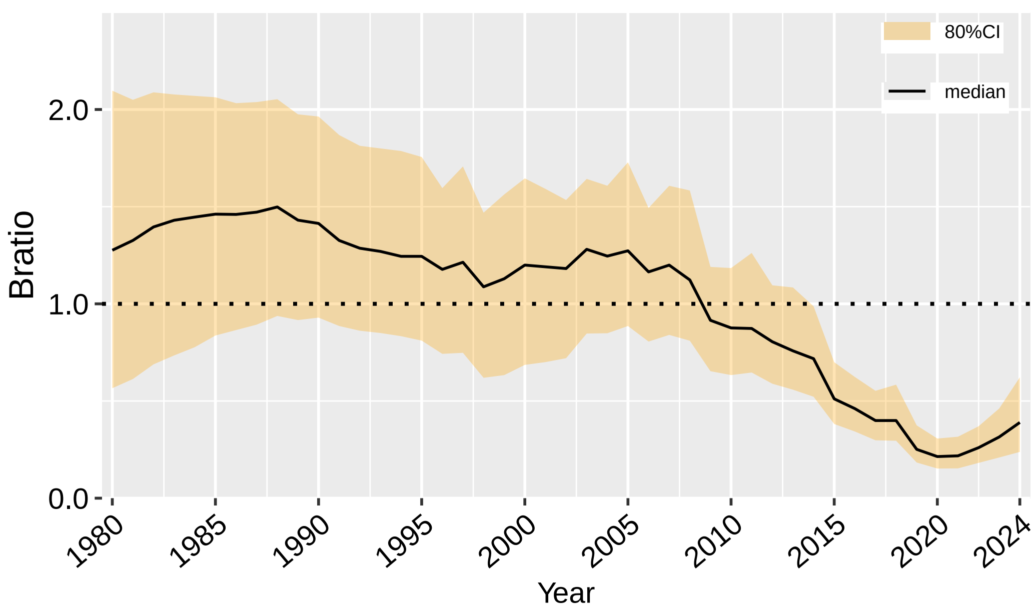




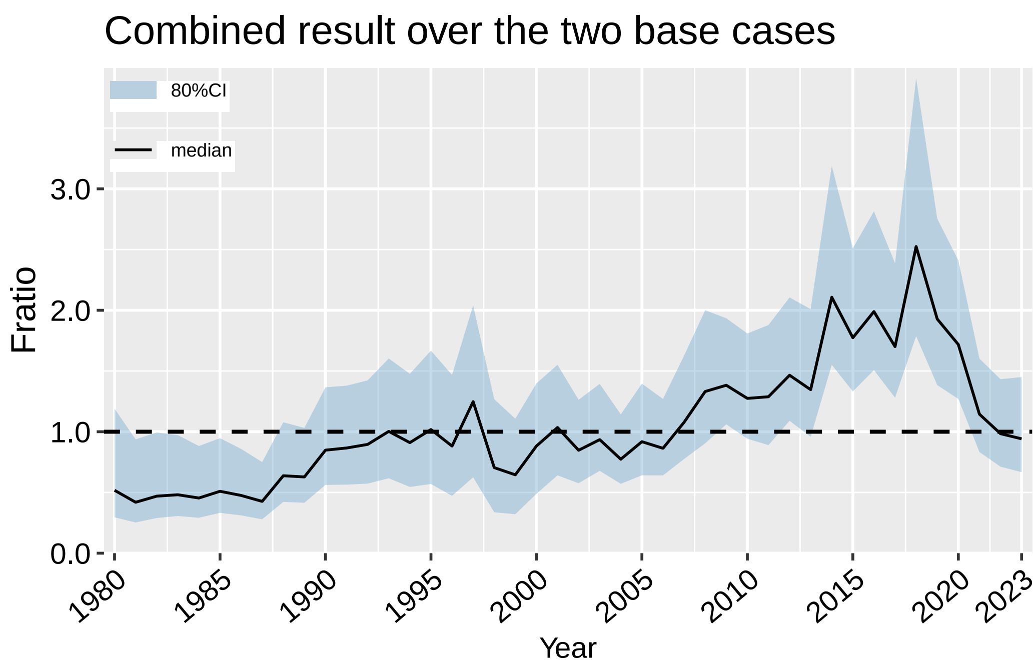
Base case 1

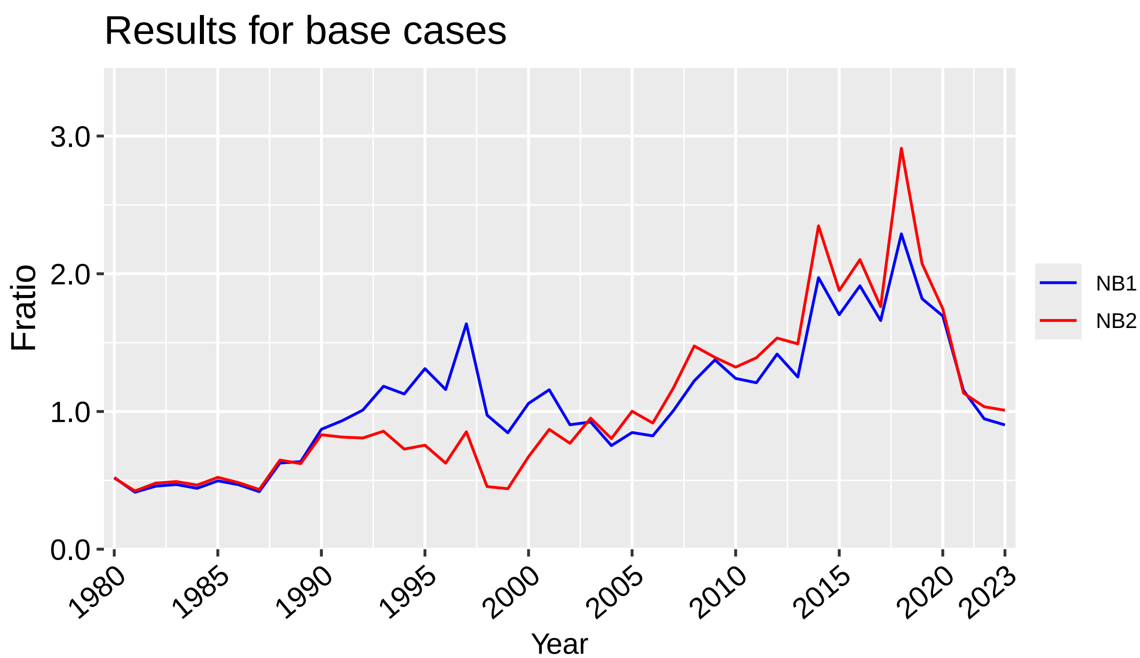


Base case 2

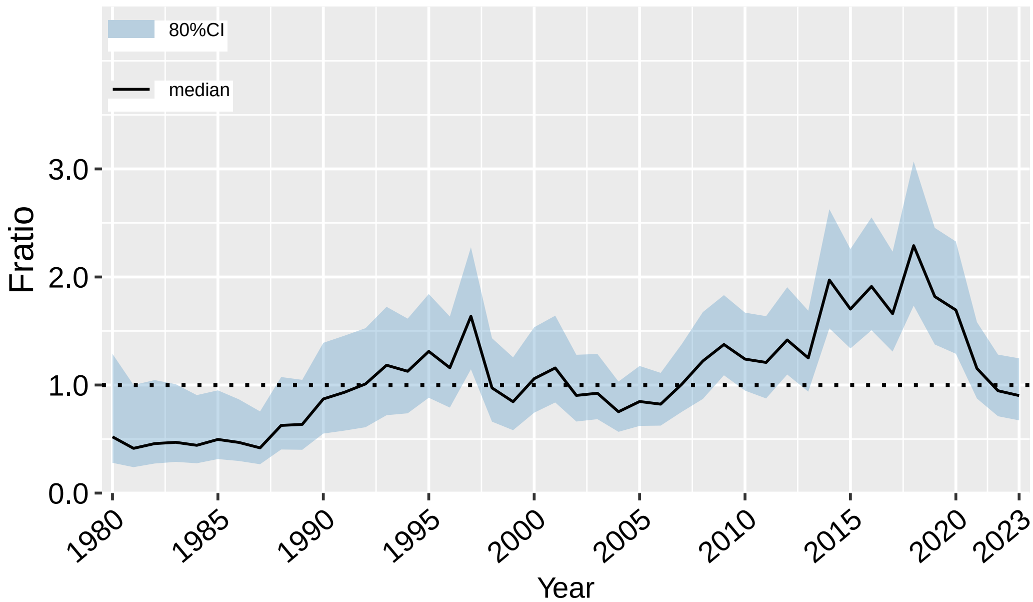


1.4 Time series Fratio

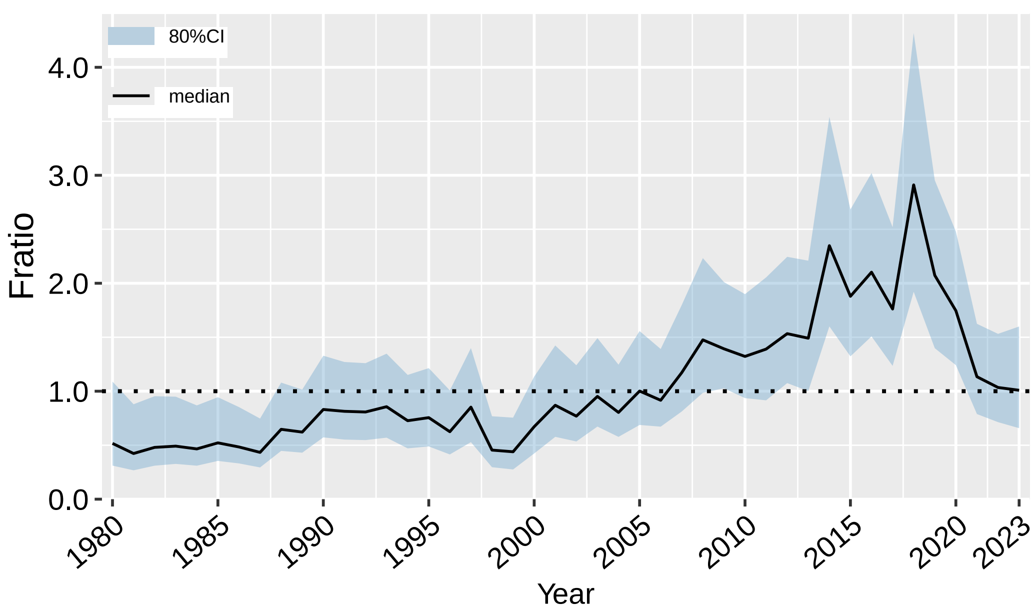




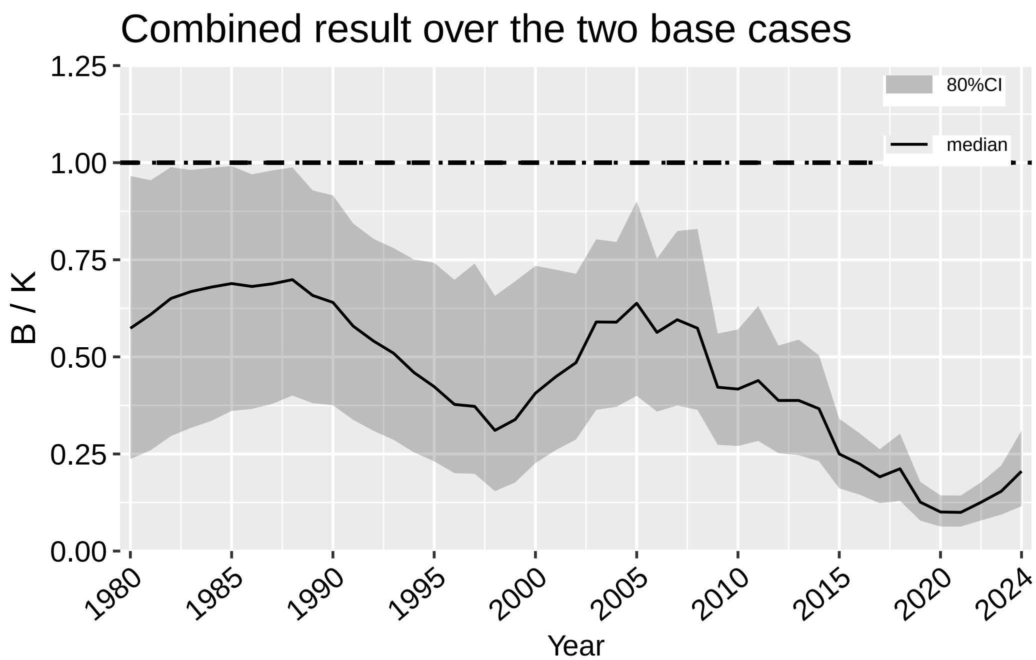
Base case 1

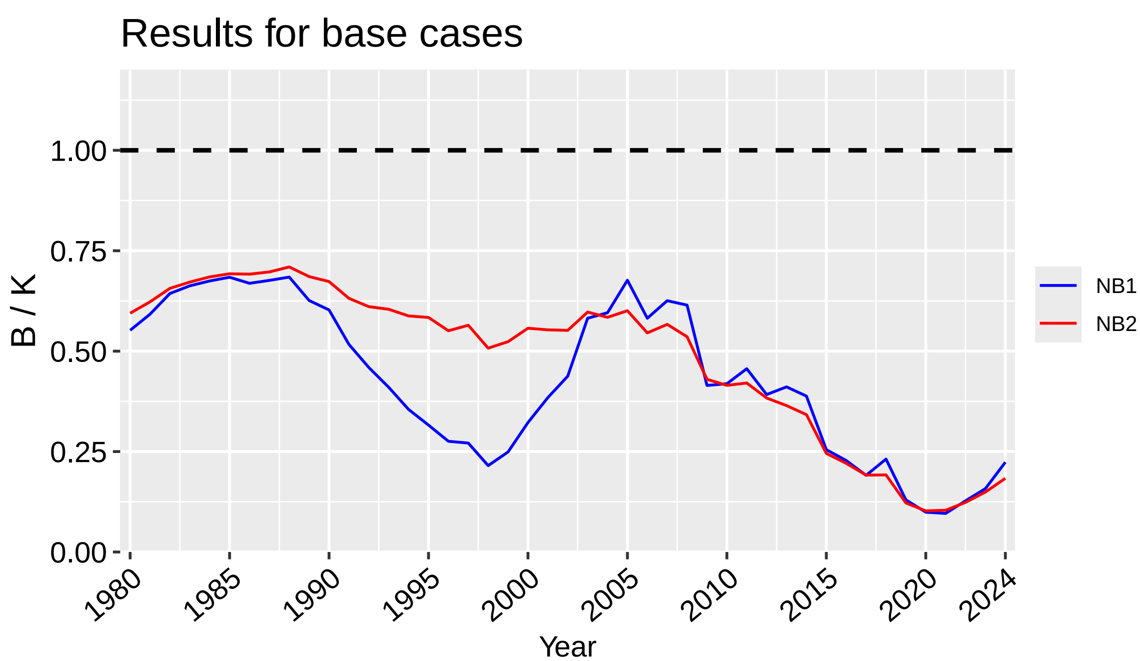


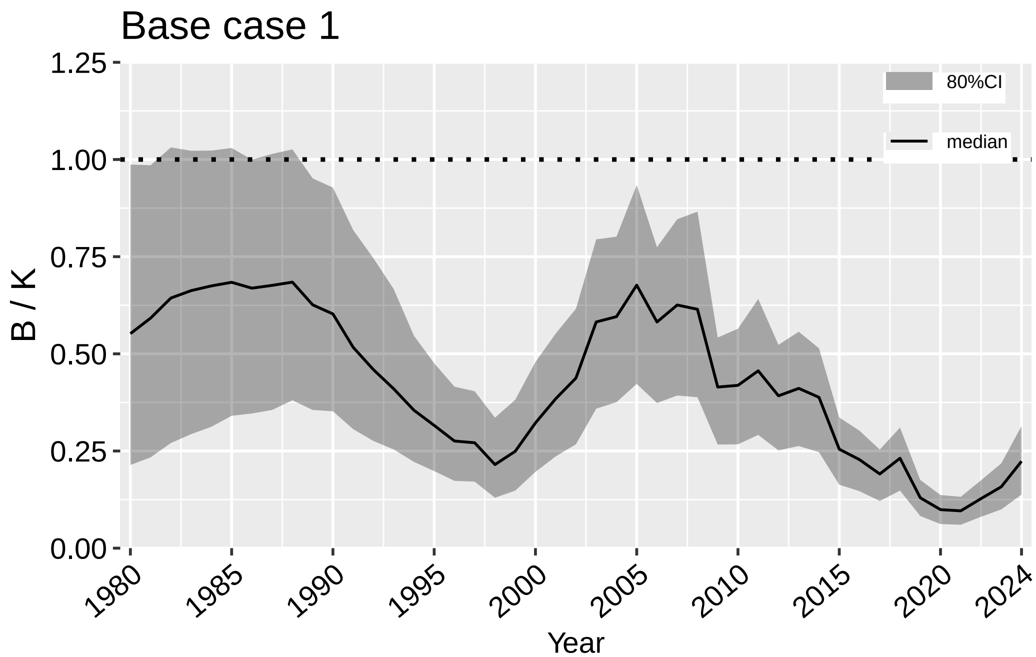
Base case 2

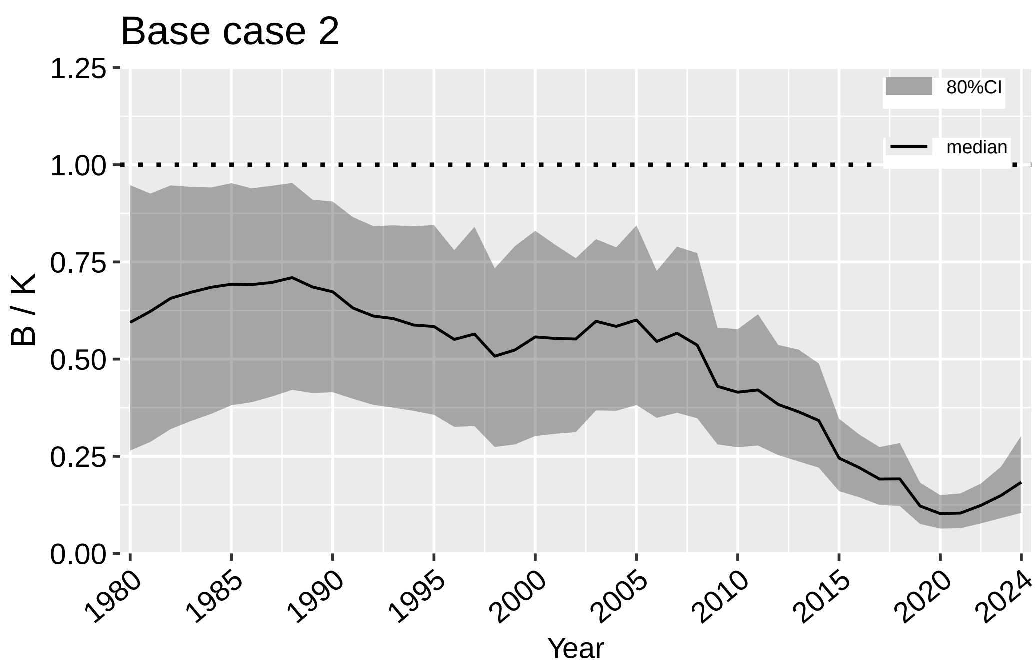


1.5 Time series B/K

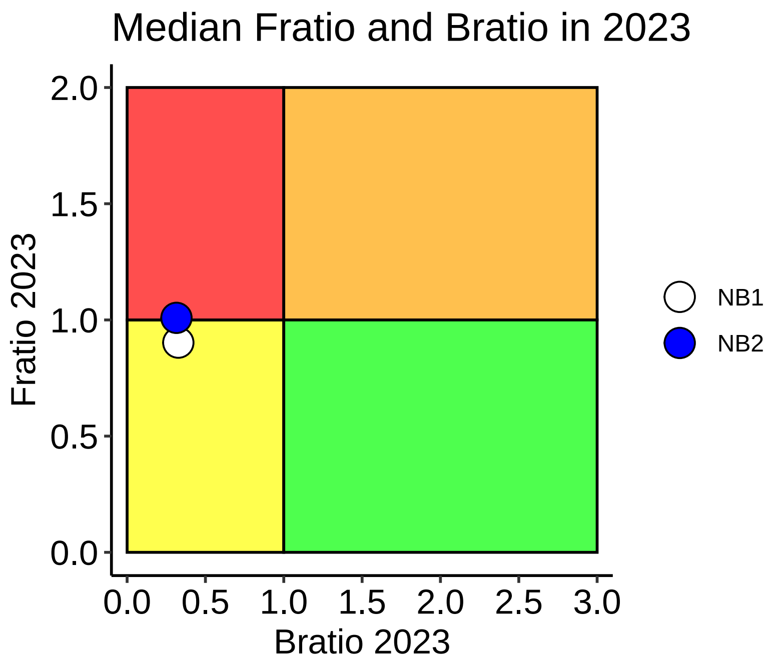


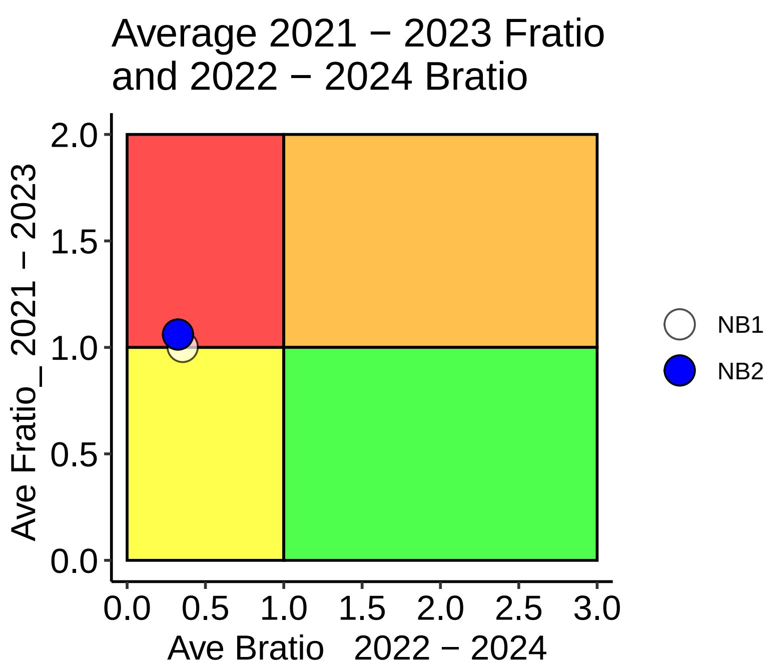



Base case 1
B / K
1.25
1.00
0.75
0.50
0.25
0.00
80%CI
median
1980
1985
1990
1995
2000
2005
2010
2015
2020
2024
Year

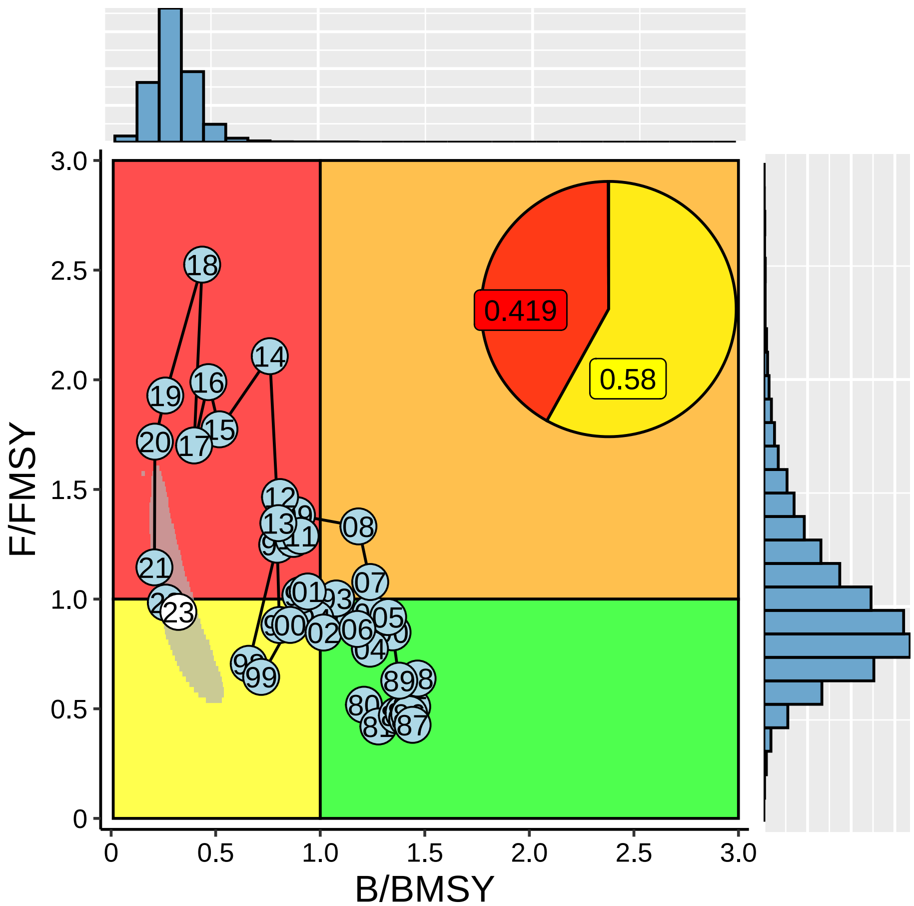

Base case 2
B / K
1.25
1.00
0.75
0.50
0.25
0.00
80%CI
median
1980
1985
1990
1995
2000
2005
2010
2015
2020
2024
Year

2 Kobe plot


Median Fratio and Bratio in 2023
Fratio 2023
Bratio 2023
2.0
1.5
1.0
0.5
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0
NB1
NB2


Average 2021 − 2023 Fratio
and 2022 − 2024 Bratio
Ave Fratio_ 2021 − 2023
Ave Bratio_ 2022 − 2024
2.0
1.5
1.0
0.5
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0
NB1
NB2

1980 − 2023 time series of median Fratio and Bratio over 2 models



3 Summary of reference points

Over 2 new base case models

	Mean	Median	Lower10th	Upper10th
C__2023 (million tons)	0.118	0.118	0.118	0.118
AveC__2021__2023	0.104	0.104	0.104	0.104
AveF__2021__2023	0.341	0.339	0.155	0.522
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B__2024/BMSY	0.444	0.431	0.265	0.631
AveB__2022__2024/BMSY	0.347	0.341	0.229	0.471

Base case 1

	Mean	Median	Lower10th	Upper10th
C_2023 (million tons)	0.118	0.118	0.118	0.118
AveC_2021_2023	0.104	0.104	0.104	0.104
AveF_2021_2023	0.417	0.415	0.286	0.548
F_2023	0.374	0.369	0.255	0.500
FMSY	0.415	0.414	0.265	0.563
MSY (million tons)	0.412	0.405	0.347	0.481
F_2023/FMSY	0.938	0.902	0.673	1.247
AveF_2021_2023/FMSY	1.040	1.002	0.783	1.345
K (million tons)	2.330	2.027	1.446	3.529
B_2023 (million tons)	0.340	0.321	0.237	0.464
B_2024 (million tons)	0.480	0.454	0.337	0.650
AveB_2022_2024	0.365	0.345	0.264	0.488
BMSY (million tons)	1.082	0.970	0.732	1.545
BMSY/K	0.477	0.476	0.402	0.556
B_2023/K	0.159	0.158	0.100	0.218
B_2024/K	0.226	0.224	0.138	0.314
AveB_2022_2024/K	0.171	0.171	0.109	0.230
B_2023/BMSY	0.332	0.327	0.226	0.440
B_2024/BMSY	0.471	0.464	0.313	0.638
AveB_2022_2024/BMSY	0.357	0.354	0.249	0.467

Base case 2

	Mean	Median	Lower10th	Upper10th
C_2023 (million tons)	0.118	0.118	0.118	0.118
AveC_2021_2023	0.104	0.104	0.104	0.104
AveF_2021_2023	0.265	0.237	0.126	0.447
F_2023	0.248	0.227	0.127	0.400
FMSY	0.258	0.225	0.104	0.465
MSY (million tons)	0.380	0.376	0.296	0.465
F_2023/FMSY	1.088	1.009	0.658	1.599
AveF_2021_2023/FMSY	1.122	1.060	0.738	1.562
K (million tons)	4.114	3.630	1.792	7.427
B_2023 (million tons)	0.580	0.521	0.296	0.935
B_2024 (million tons)	0.710	0.636	0.393	1.090
AveB_2022_2024	0.593	0.533	0.312	0.939
BMSY (million tons)	1.872	1.648	0.905	3.216
BMSY/K	0.469	0.466	0.389	0.557
B_2023/K	0.154	0.149	0.091	0.223
B_2024/K	0.196	0.183	0.104	0.303
AveB_2022_2024/K	0.159	0.154	0.093	0.232
B_2023/BMSY	0.328	0.315	0.209	0.462
B_2024/BMSY	0.416	0.390	0.238	0.622
AveB_2022_2024/BMSY	0.338	0.325	0.215	0.476

4 Summary of estimates of parameters

Base case 1

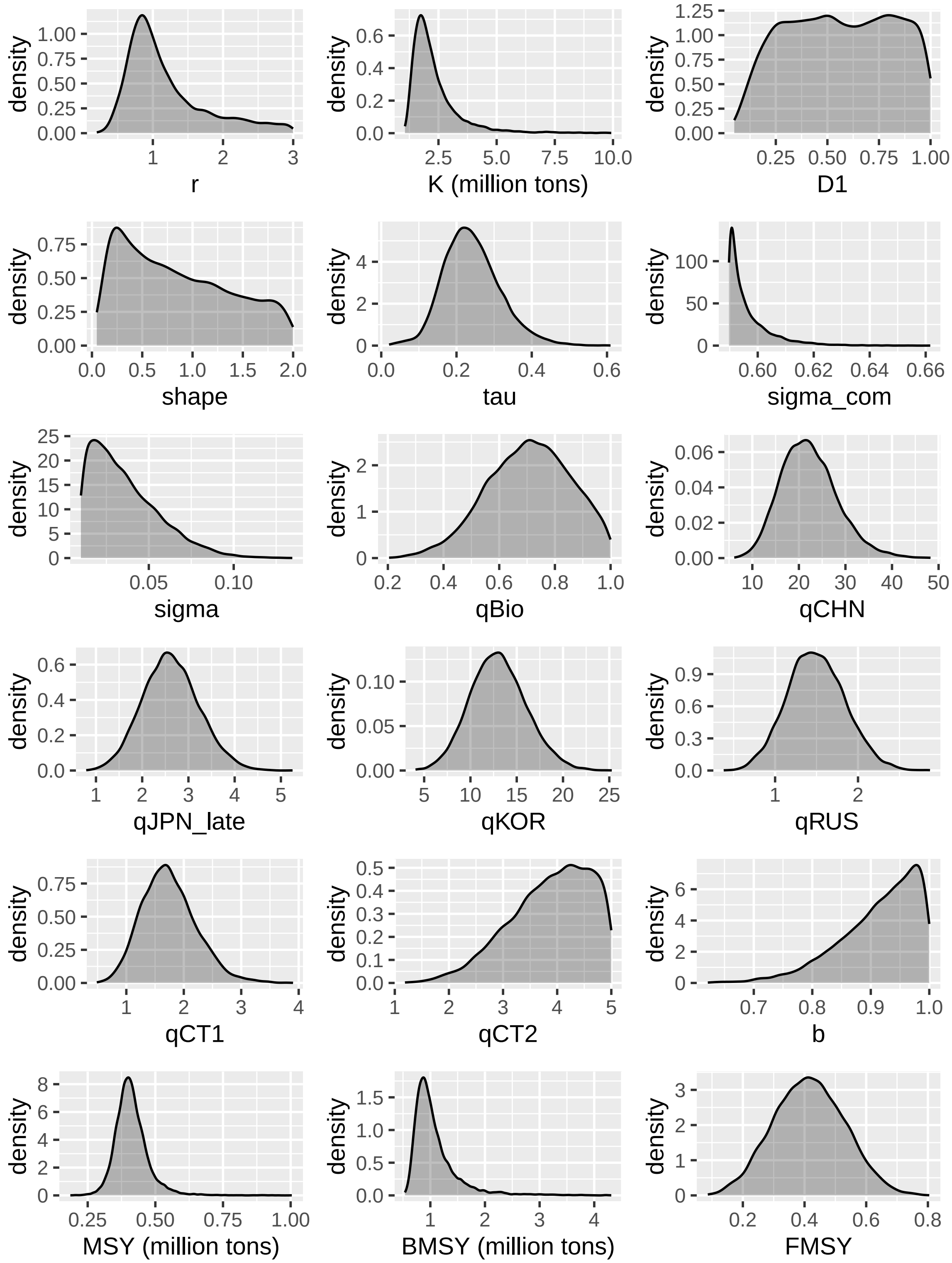
	Mean	Median	Lower10th	Upper10th
r	1.186	1.004	0.639	2.112
K (million tons)	2.330	2.027	1.446	3.529
qCHN	22.238	21.764	14.933	30.233
qJPN2	2.621	2.601	1.856	3.410
qKOR	13.007	12.903	9.216	16.963
qRUS	1.496	1.484	1.055	1.953
qCT1	1.745	1.709	1.172	2.370
qCT2	3.876	3.976	2.830	4.779
qBio	0.706	0.712	0.509	0.903
Shape	0.854	0.764	0.203	1.681
sigma_com	0.596	0.594	0.590	0.607
sigma	0.036	0.032	0.014	0.065
tau	0.241	0.235	0.153	0.338
FMSY	0.415	0.414	0.265	0.563
BMSY (million tons)	1.082	0.970	0.732	1.545
MSY (million tons)	0.412	0.405	0.347	0.481
b	0.914	0.928	0.819	0.987

Base case 2

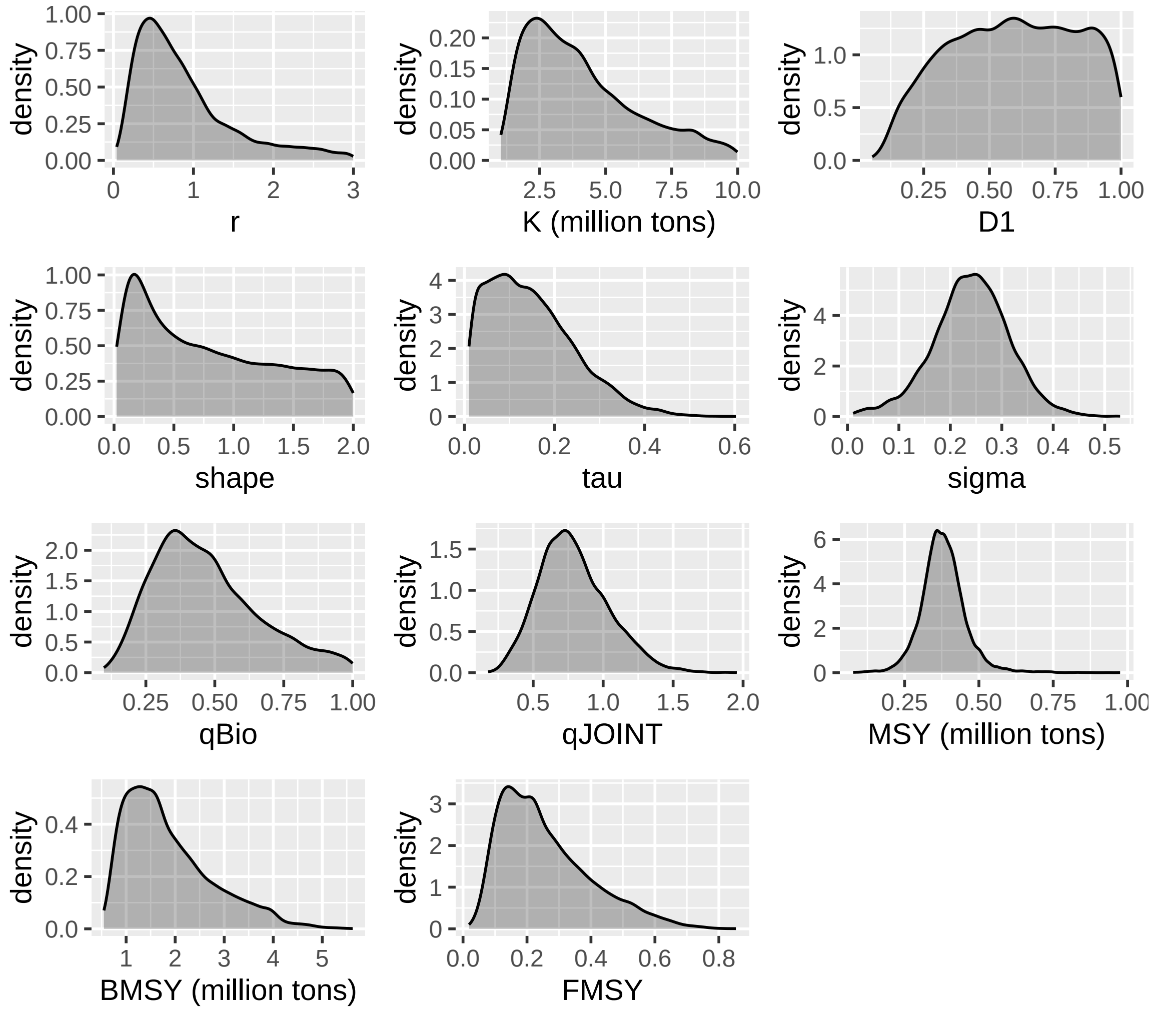
	Mean	Median	Lower10th	Upper10th
r	0.883	0.709	0.277	1.801
K (million tons)	4.114	3.630	1.792	7.427
qJOINT	0.789	0.760	0.493	1.130
qBio	0.469	0.437	0.248	0.751
Shape	0.795	0.680	0.122	1.697
sigma	0.240	0.242	0.146	0.332
tau	0.149	0.134	0.035	0.282
FMSY	0.258	0.225	0.104	0.465
BMSY (million tons)	1.872	1.648	0.905	3.216
MSY (million tons)	0.380	0.376	0.296	0.465
b	0.725	0.728	0.537	0.916

5 Posterior distributions

Base case 1



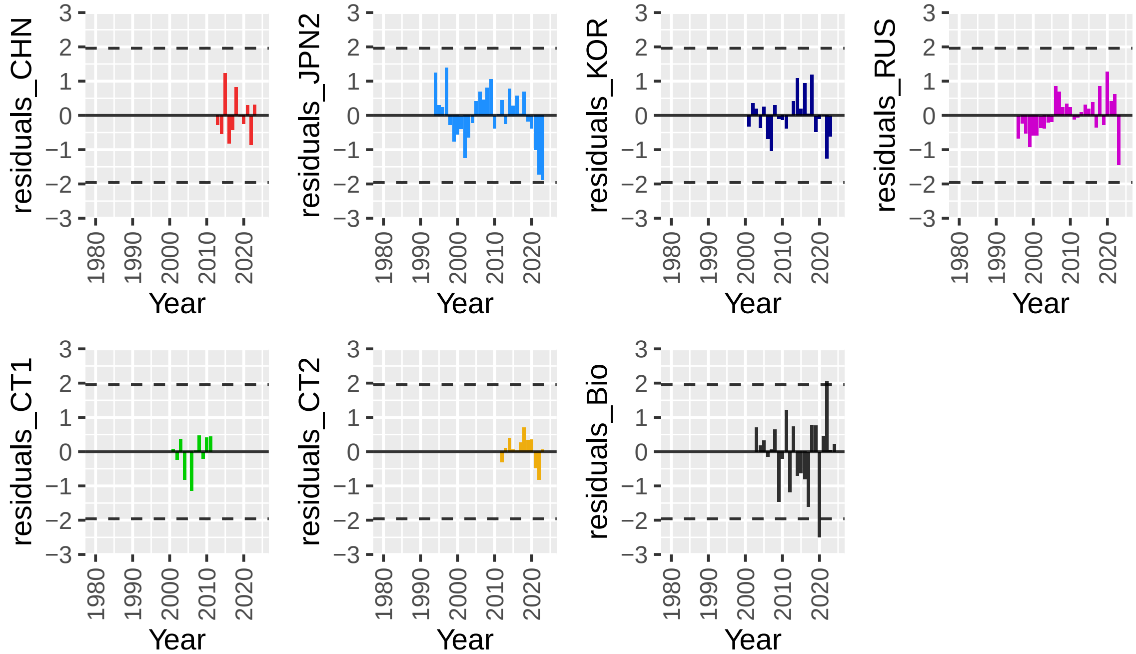
Base case 2


density
r
K (million tons)
D1
shape
tau
sigma
qBio
qJOINT
MSY (million tons)
BMSY (million tons)
FMSY

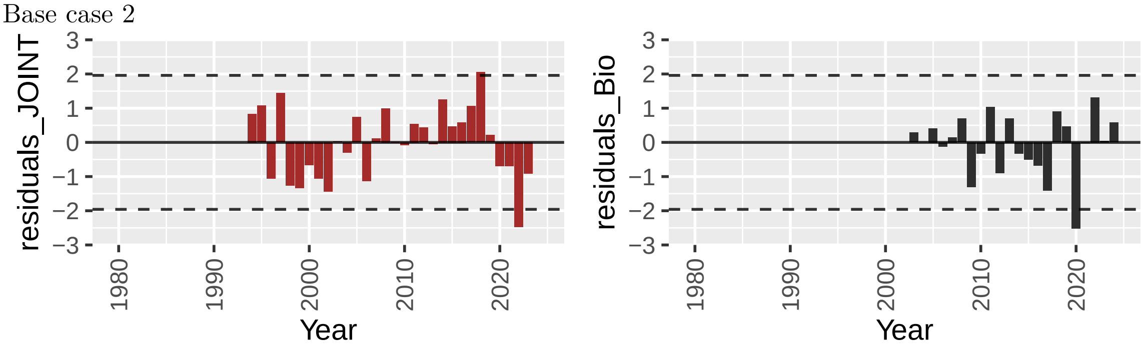
6 Diagnosis

6.1 Standardized residuals plot

Base case 1



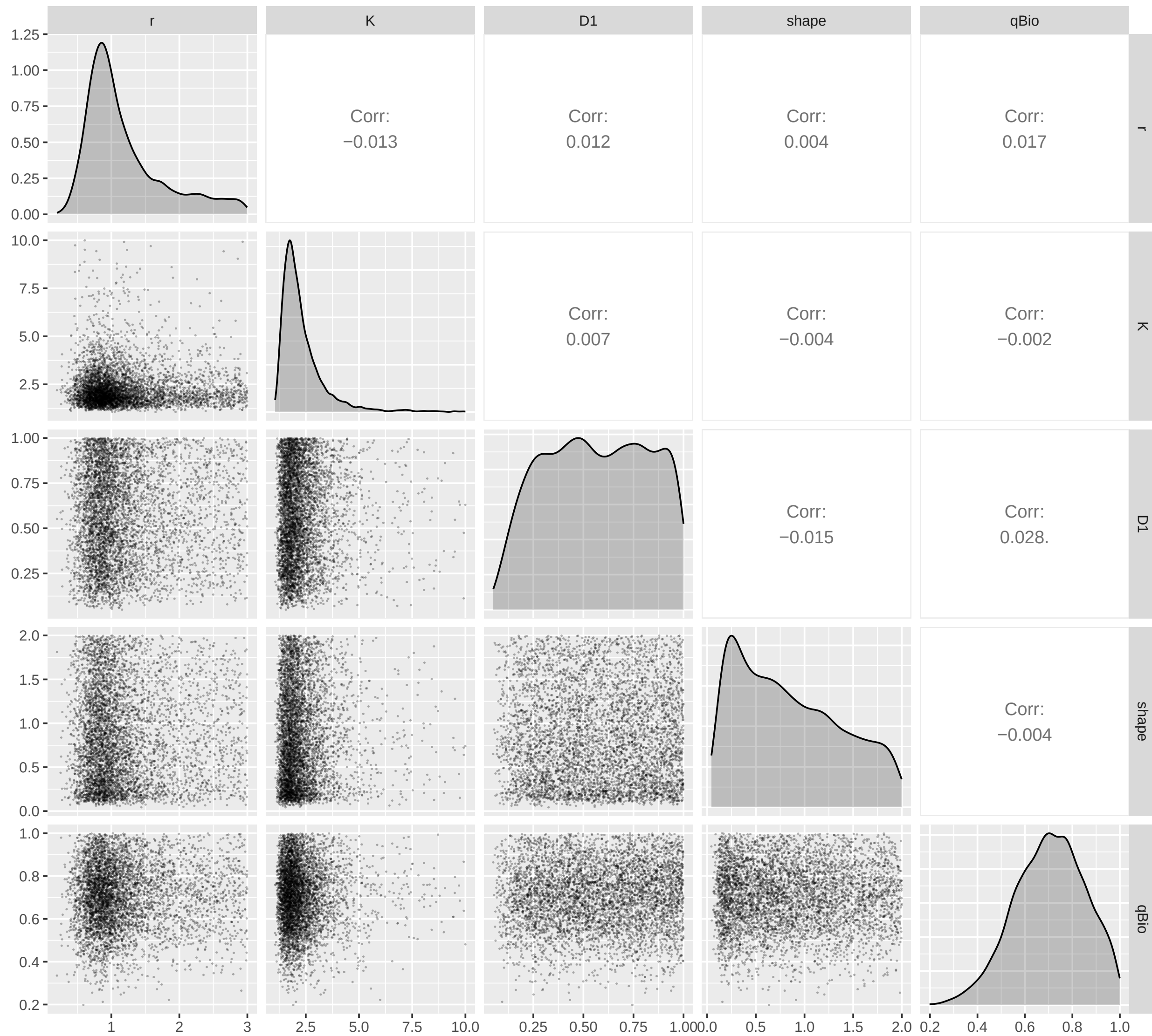
Base case 2



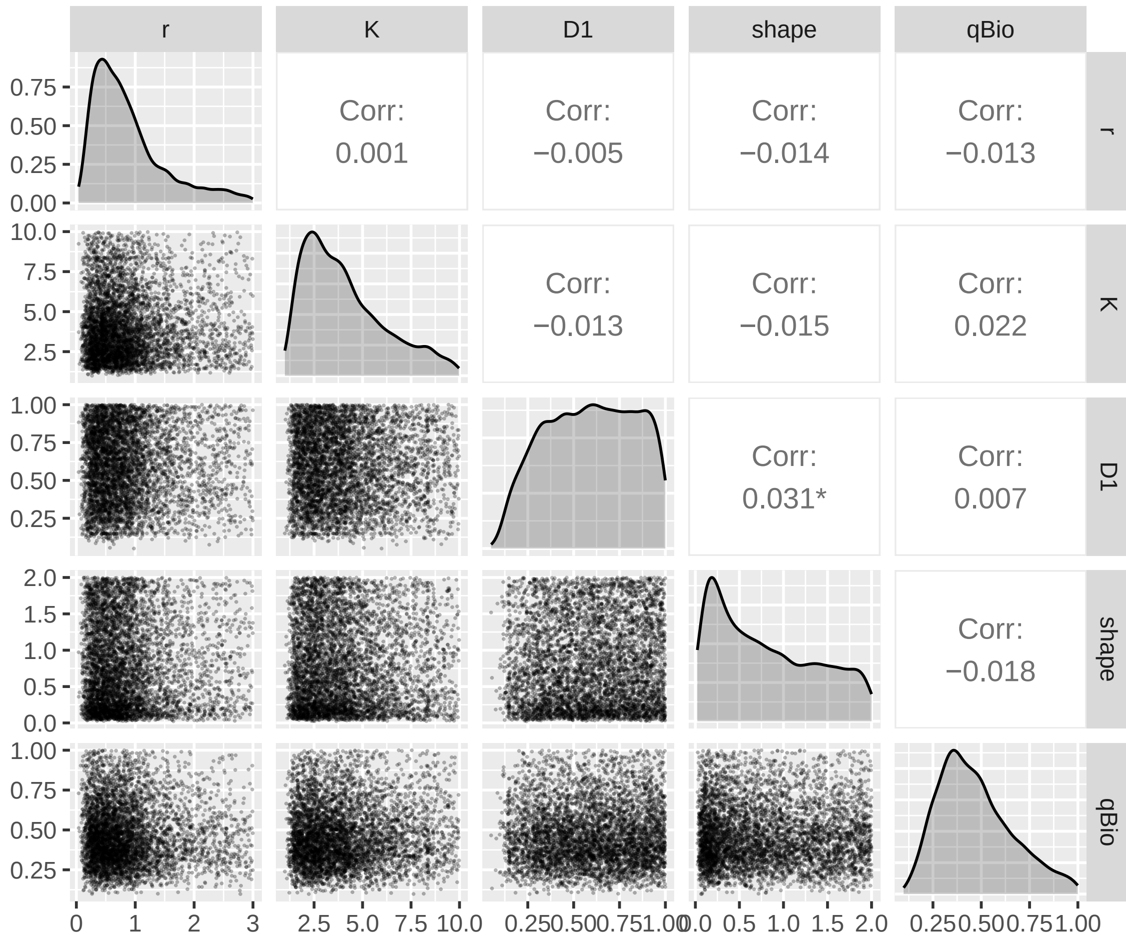
6.2 Correlation

1,000 MCMCsamples from a total of 10,000 samples

Base case 1



Base case 2


r
K
D1
shape
qBio
Corr: 0.001
Corr: −0.005
Corr: −0.014
Corr: −0.013
Corr: −0.013
Corr: −0.015
Corr: 0.022
Corr: 0.031*
Corr: 0.007
Corr: −0.018