NPFC-2025-SSC PS16-WP06 (Rev. 1)

2025 update on Pacific saury stock assessment in the North Pacific Ocean using Bayesian state-space production models

Toshihide Kitakado

Tokyo University of Marine Science and Technology

Corresponding author's email address: kitakado@kaiyodai.ac.jp

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 2025 median depletion level was 22.1% (80% CI: 12.7–34.4%) of the carrying capacity. Furthermore, the B-ratio (=B/Bmsy) and F-ratio (=F/Fmsy) in 2024 were 0.377 (80% CI: 0.252-0.499) and 1.085 (80% CI: 0.771–1.622), respectively. For the three-year average values, the B-ratio over 2023–2025 and the F-ratio over 2022–2024 were 0.394 (80% CI: 0.264–0.544) and 1.015 (80% CI: 0.752–1.460), respectively. In addition, the probability of the stock being in the green Kobe quadrant in 2024 was estimated to be approximately 0%, while the probabilities of being in the yellow and red Kobe quadrants were assessed as 62% and 38%, 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 15th SSC-PS meeting, the new specification for the BSSPM analysis was agreed (see SSC-PS15 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 2024

2) Standardized CPUE indices by the five Members up to 2024

3) Fishery-independent survey by Japan from 2003 to 2025

4) Joint CPUE from 1994 to 2024

Similar statistical models as those used last year were applied. Flat priors were used for all free parameters, as in previous Japanese analyses.

RESULTS

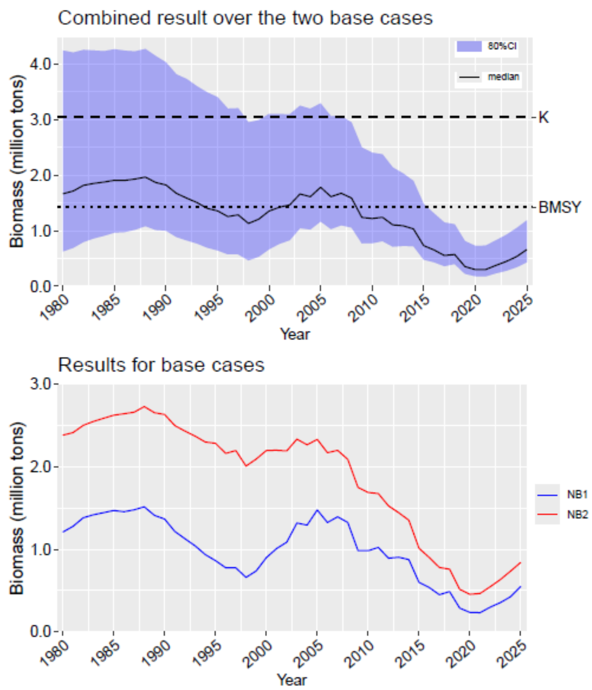
Time series and stock status

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.

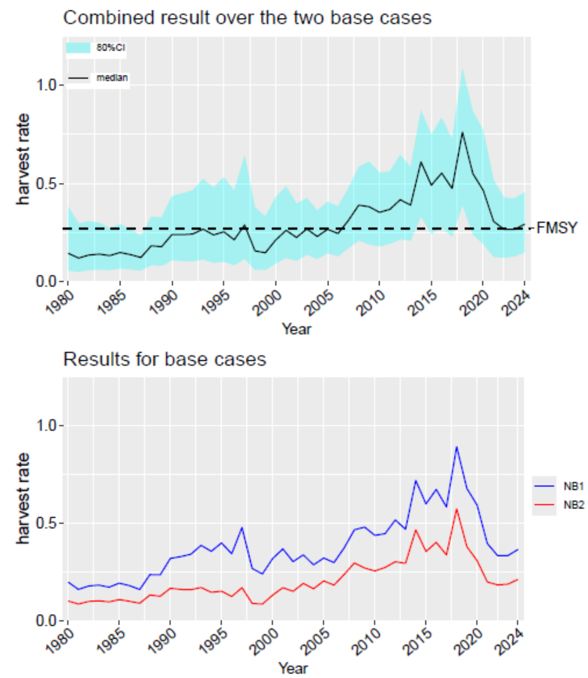
Table 1 also shows the results of key reference quantities combined over the two base cases. As for the combined base case stock assessment result, the 2025 median depletion level was 22.1% (80% CI: 12.7–34.4%) of the carrying capacity. Furthermore, the B-ratio (=B/Bmsy) and F-ratio (=F/Fmsy) in 2024 were 0.377 (80% CI: 0.252-0.499) and 1.085 (80% CI: 0.771–1.622), respectively. For the three-year average values, the B-ratio over 2023–2025 and the F-ratio over 2022–2024 were 0.394 (80% CI: 0.264–0.544) and 1.015 (80% CI: 0.752–1.460), respectively.

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 2024 was estimated to be approximately 0%, while the probabilities of being in the yellow and red Kobe quadrants were assessed as 53% and 47%, respectively.

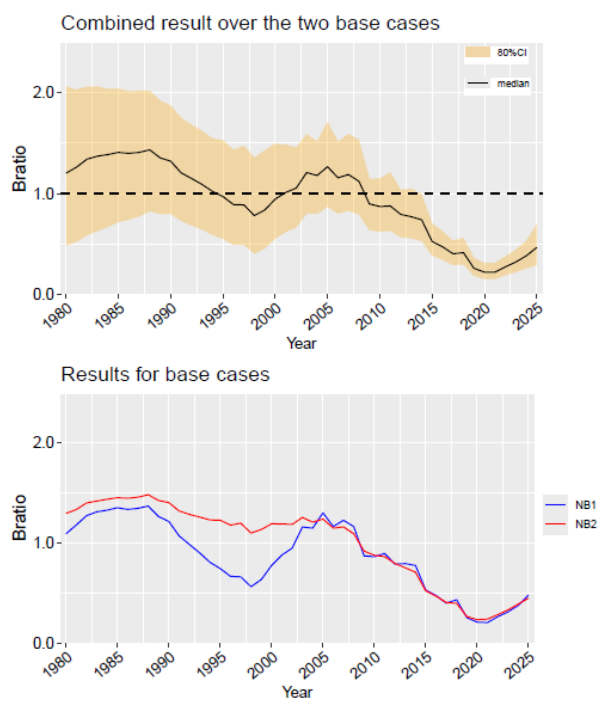
(a) Biomass



(b) Depletion level relative to K



(c) B-ratio



(d) F-ratio

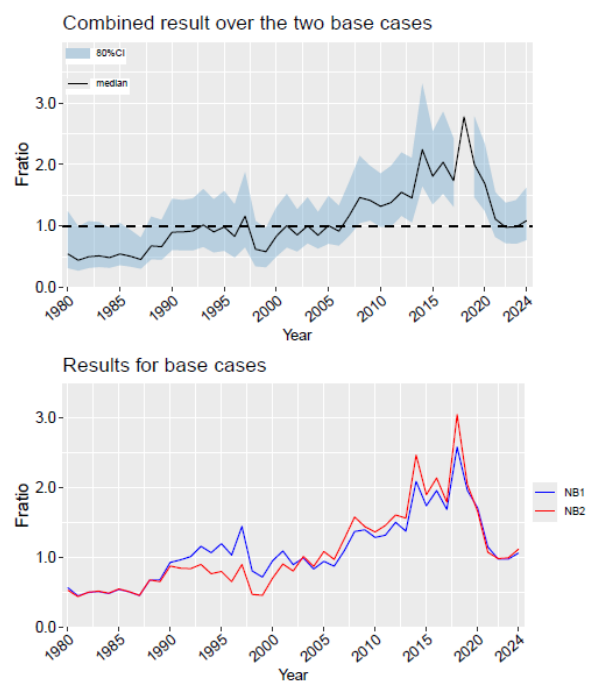


Figure 1. Results of trajectories over the two base cases of (a) biomass, (b) depletion level relative to the carrying capacity, (c) B-ratio and (d) F-ratio.

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

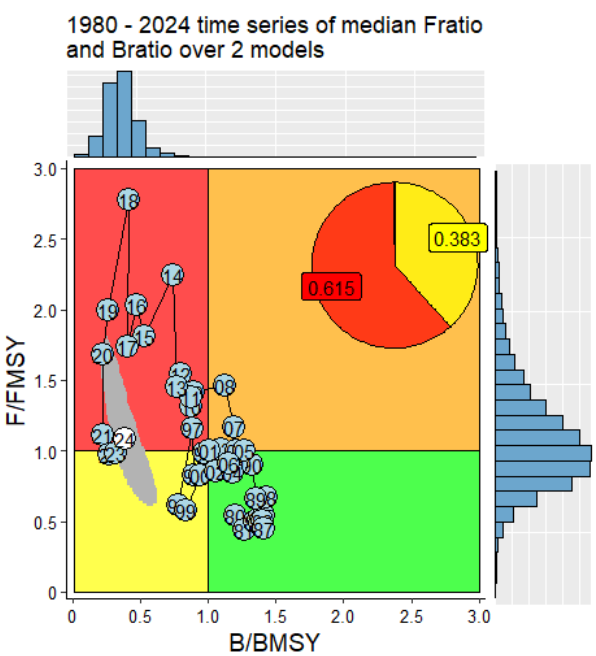
2025 update

	Mean	Median	Lower10th	Upper10th
C_2024 (million tons)	0.156	0.156	0.156	0.156
AveC_2022_2024	0.125	0.125	0.125	0.125
AveF_2022_2024	0.280	0.276	0.133	0.432
F_2024	0.298	0.292	0.149	0.454
FMSY	0.281	0.271	0.117	0.456
MSY (million tons)	0.383	0.381	0.307	0.457
F_2024/FMSY	1.153	1.085	0.771	1.622
AveF_2022_2024/FMSY	1.068	1.015	0.752	1.460
K (million tons)	3.693	3.042	1.732	6.835
B_2024 (million tons)	0.632	0.533	0.343	1.046
B_2025 (million tons)	0.759	0.661	0.433	1.186
AveB_2023_2025	0.644	0.546	0.360	1.050
BMSY (million tons)	1.684	1.419	0.882	2.929
BMSY/K	0.472	0.470	0.391	0.557
B_2024/K	0.186	0.182	0.112	0.262
B_2025/K	0.231	0.221	0.127	0.344
AveB_2023_2025/K	0.191	0.188	0.114	0.270
B_2024/BMSY	0.377	0.377	0.252	0.499
B_2025/BMSY	0.486	0.466	0.292	0.694
AveB_2023_2025/BMSY	0.403	0.394	0.264	0.544

2024 result

	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

2025 update



2024 result

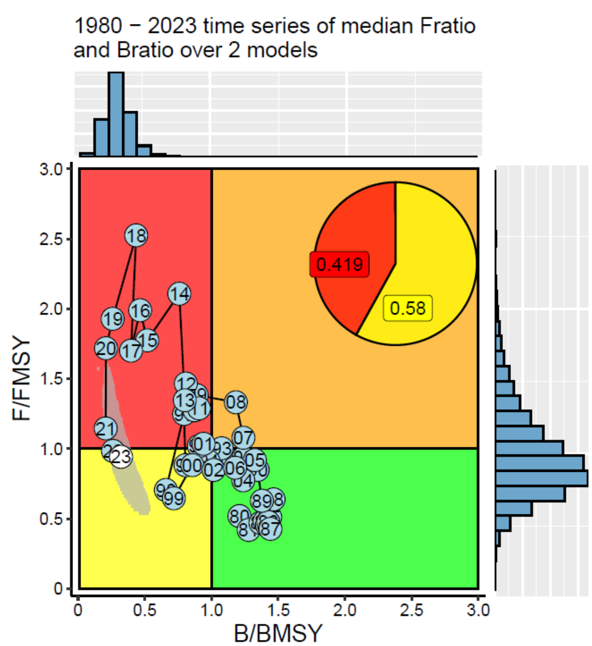


Figure 2. Kobe plot showing the time series of the median B-ratio and F-ratio for 1980–2024 in the 2025 update and for 1980–2023 in the 2024 result.

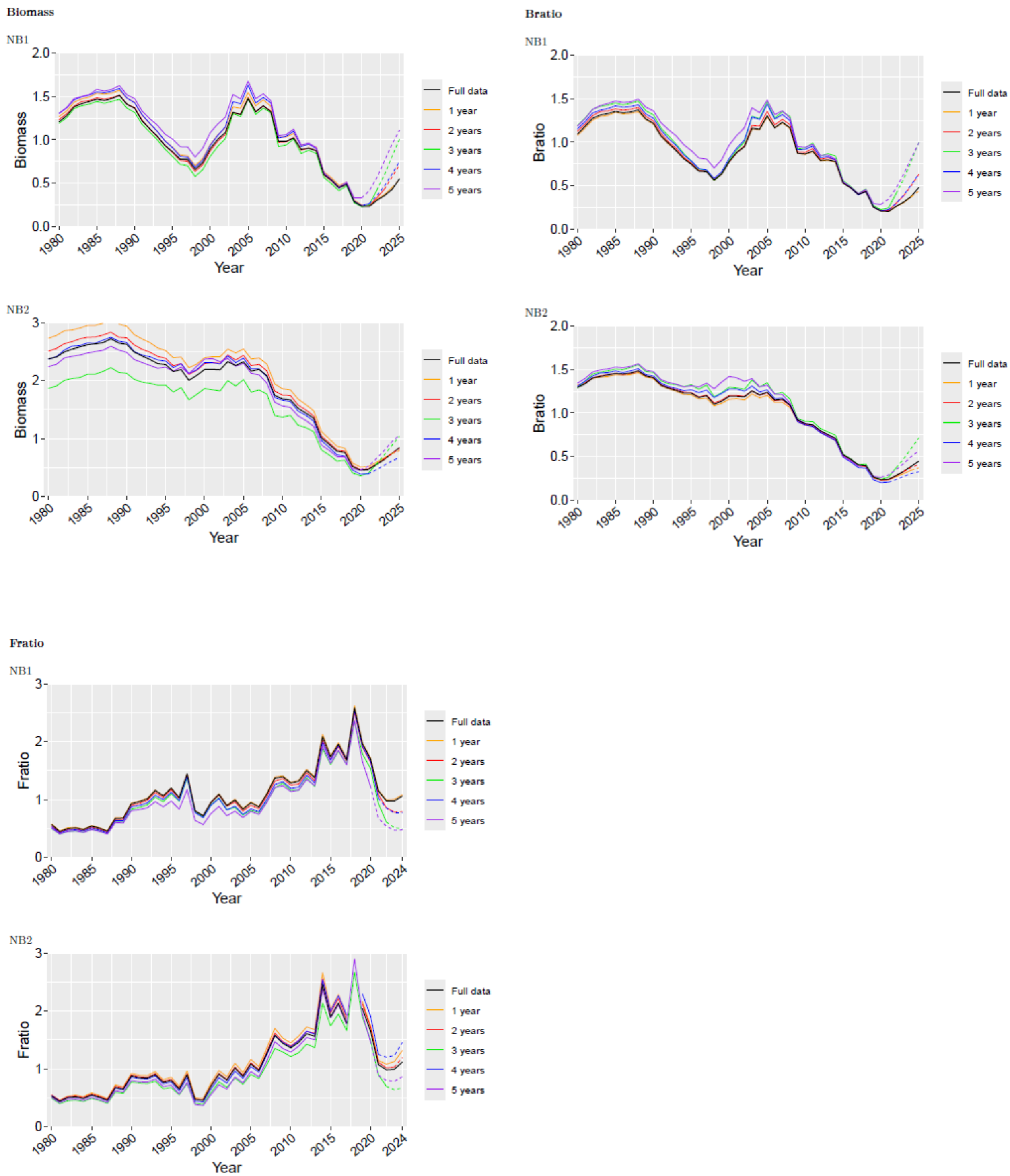


Figure 3. Results of retrospective analysis in each model.

Conclusion

1) Biomass level: The 2025 median depletion level was 22.1% (80% CI: 12.7–34.4%) of the carrying capacity, , which is slightly improved from the 20.6% (80% CI: 11.6–31.0%) observed in 2024 according to the 2024 analysis.

2) Reference points: The B-ratio (=B/Bmsy) and F-ratio (=F/Fmsy) in 2024 in the 2025 updated analysis were 0.377 (80% CI: 0.252-0.499) and 1.085 (80% CI: 0.771–1.622), respectively, compared to 0.327 (80% CI: 0.226–0.440) and 0.942 (80% CI: 0.667–1.450) in 2023 in the 2024 analysis.

3) Reference points for the recent 3-year average: The B-ratio for 2023–2025 and the F-ratio for 2023–2024 were 0.394 (80% CI: 0.264–0.544) and 1.015 (80% CI: 0.752–1.460), respectively, while 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, in last year's assessment.

4) The probability of the stock being in the green Kobe quadrant in 2024 in the 2025 update was estimated to be approximately 0%, while the probabilities of being in the yellow and red Kobe quadrants were 62% and 38%, respectively. In comparison, the probabilities for 2022 in the 2023 assessment were 58% for the yellow quadrant and 42% 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.

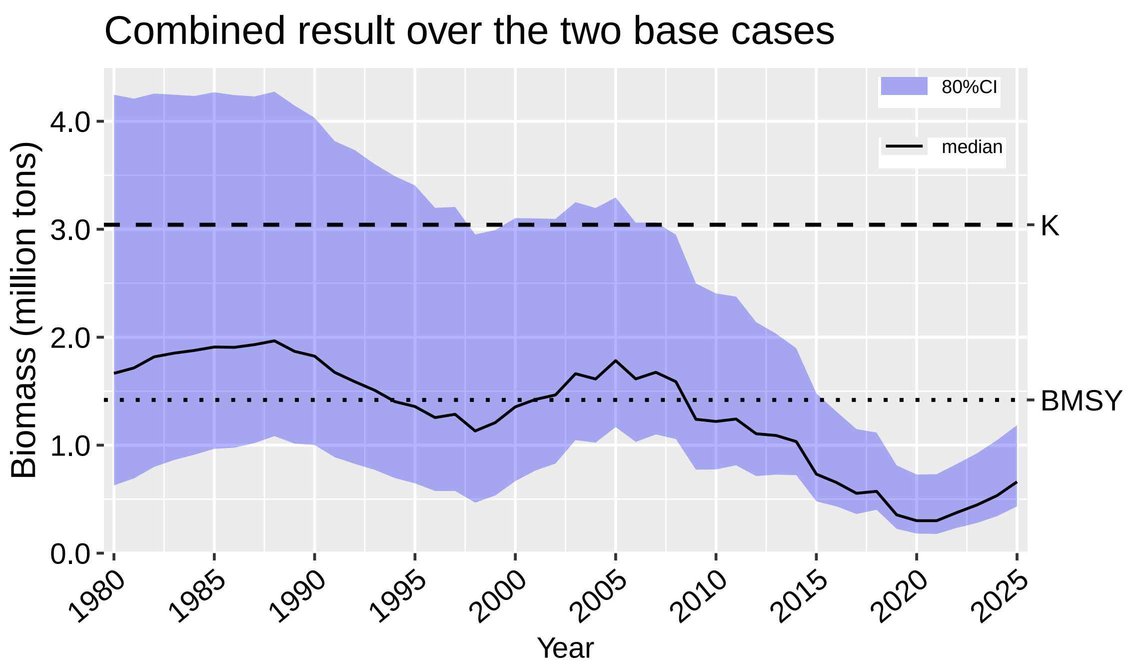
6) The retrospective bias was assessed to be small in the 2025 analysis. However, differences in key quantities between the 2024 and 2025 analyses were observed, which may be attributed to updated input data, including both fisheries-dependent and fisheries-independent indices.

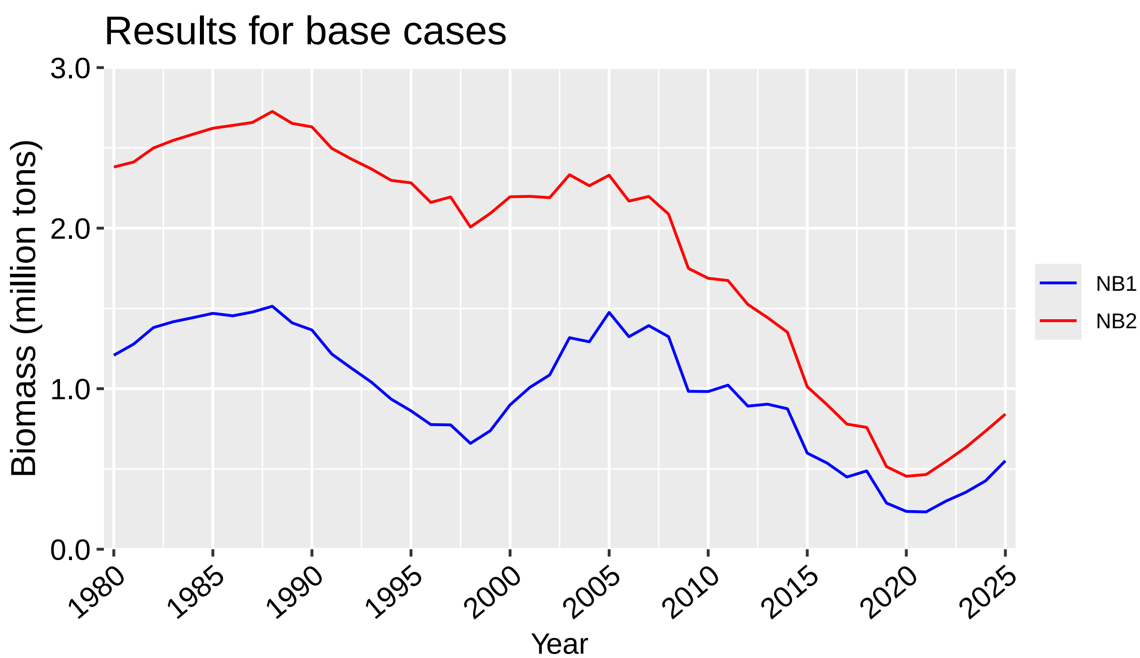
Item	Authors' note
(1) Identify the data that will be available to the stock assessment;	As shown in the main section.
(2) Evaluate data quality and quantity and potential error sources (e.g., sampling errors, measurement errors) and associated statistical properties (e.g., biased or random errors, statistical 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	Figure 3.
(8) Identify final model configuration and model runs for each scenario;	Similar approaches used in the previous years. See SSC-PS15 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-PS15 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

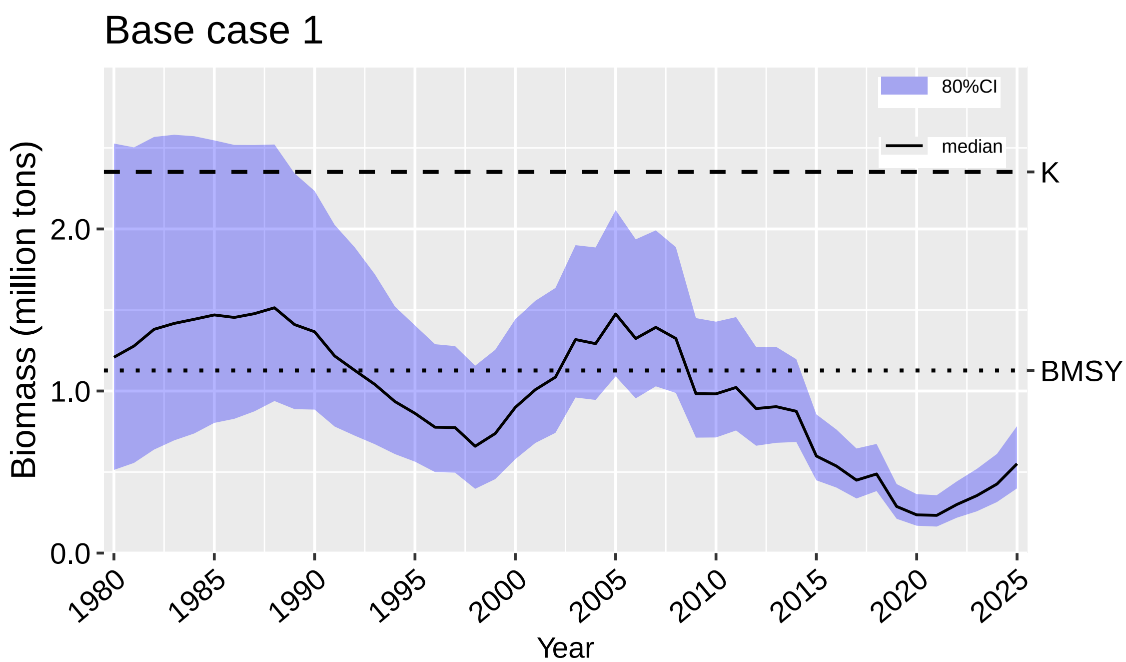
Appendix:

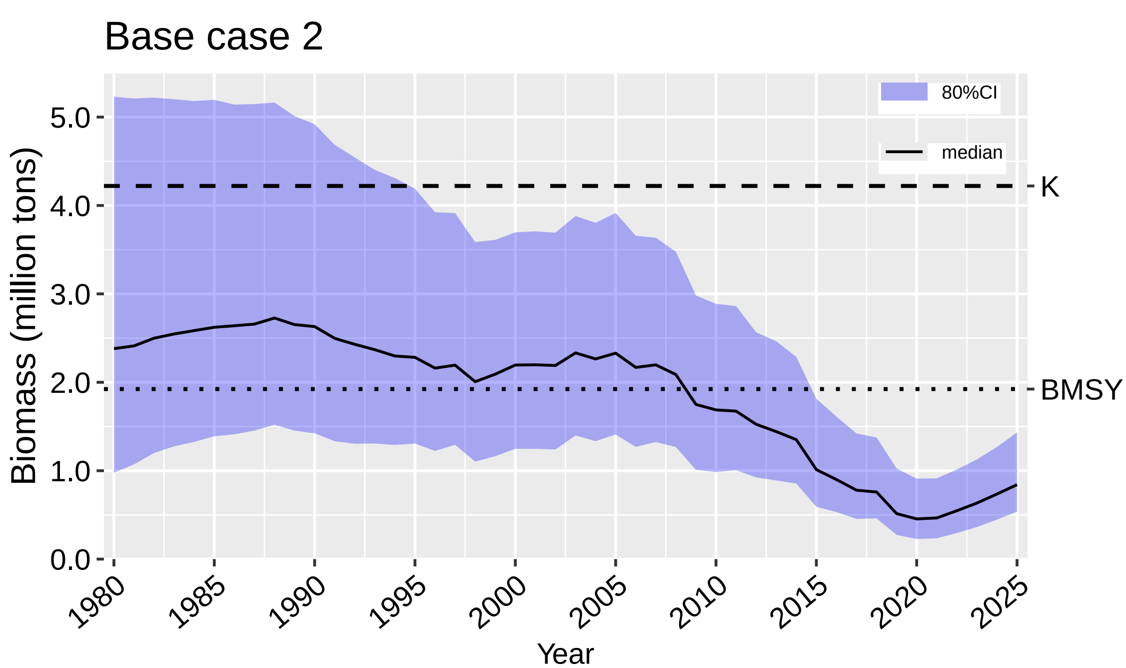
1 Time series plot

1.1 Time series Biomass

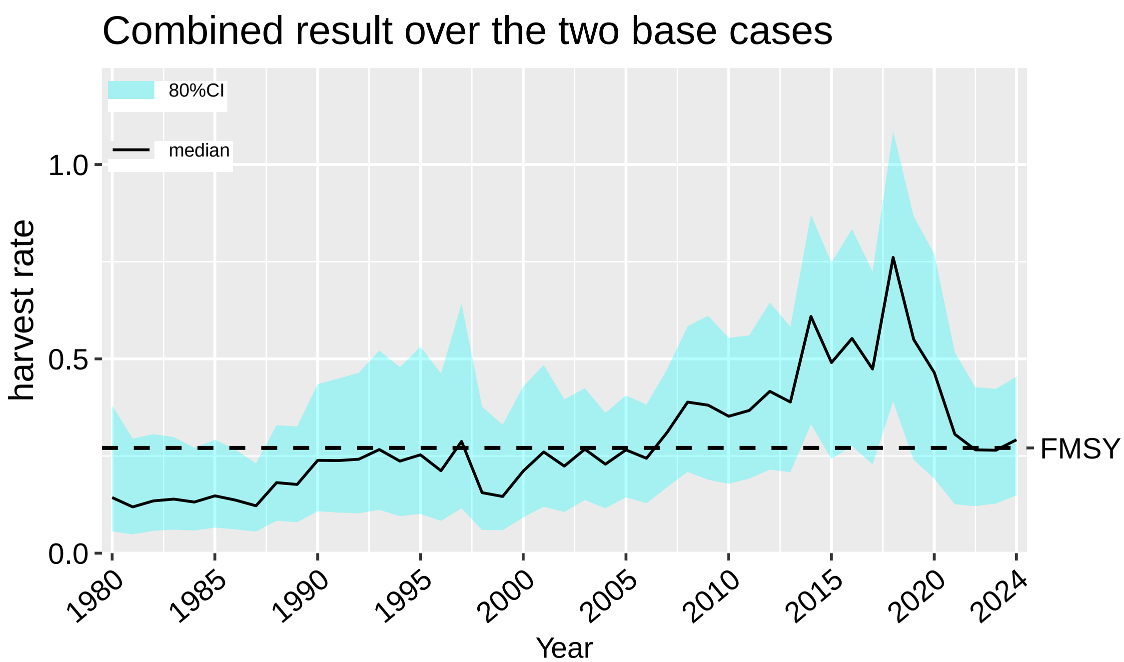


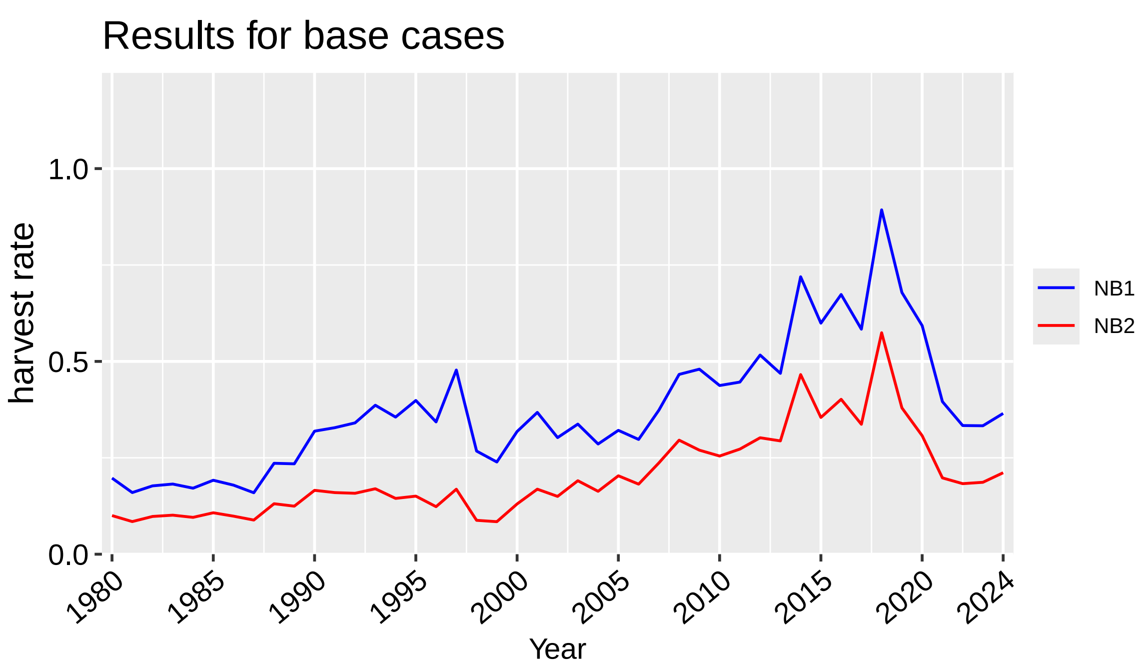


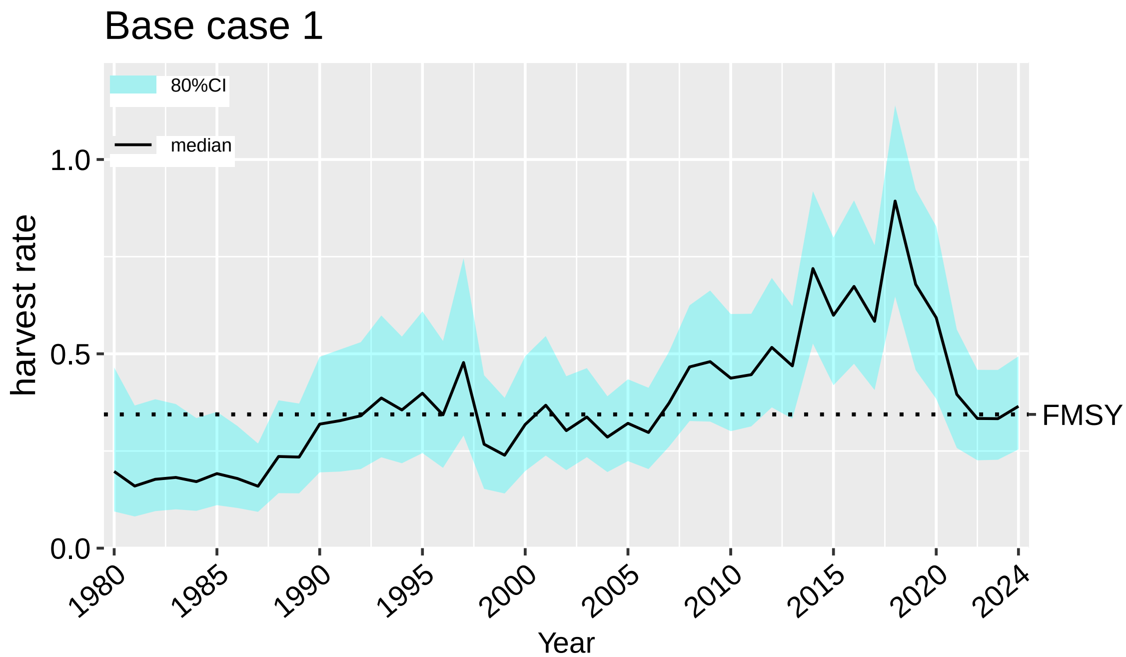

Base case 1
80%CI
median
K
BMSY
Biomass (million tons)
0.0
1.0
2.0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

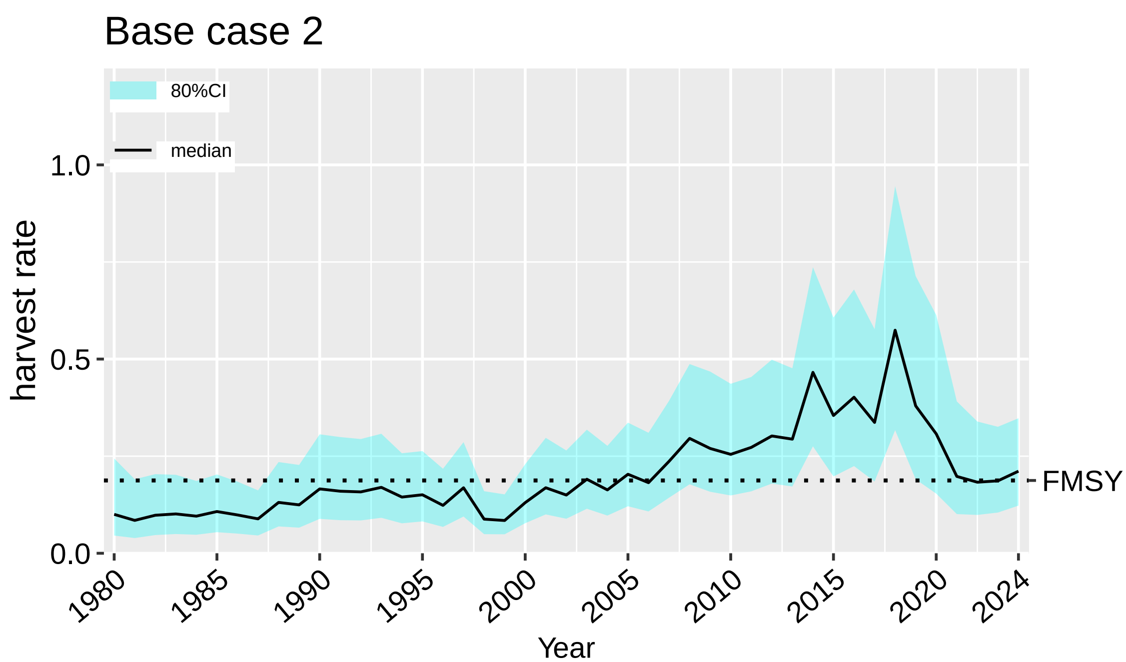

Base case 2
80%CI
median
K
BMSY
Biomass (million tons)
0.0
1.0
2.0
3.0
4.0
5.0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

1.2 Time series Harvest rate

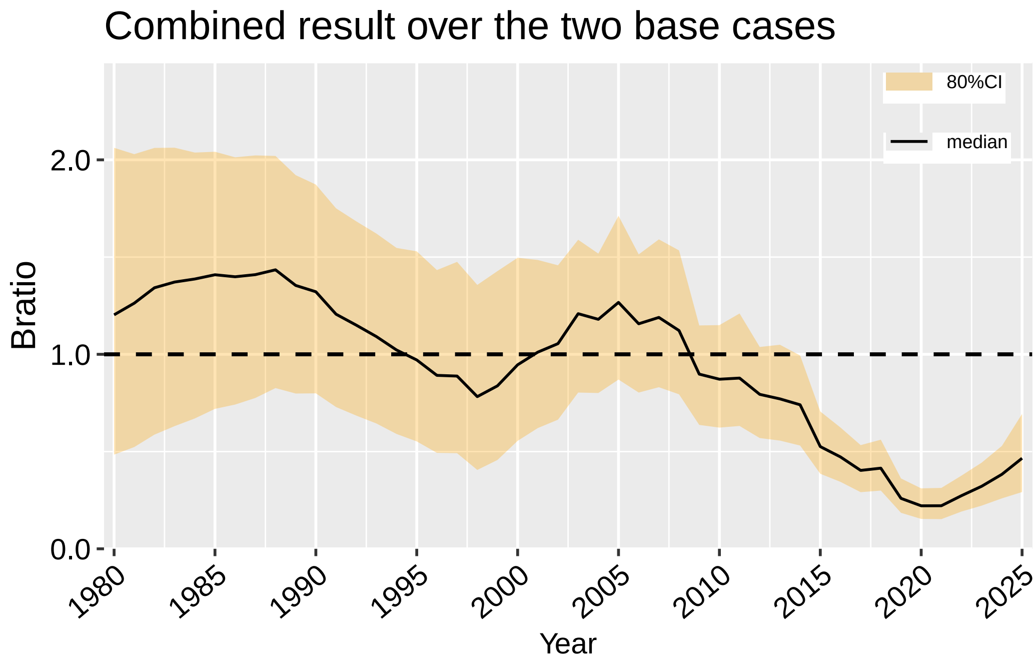


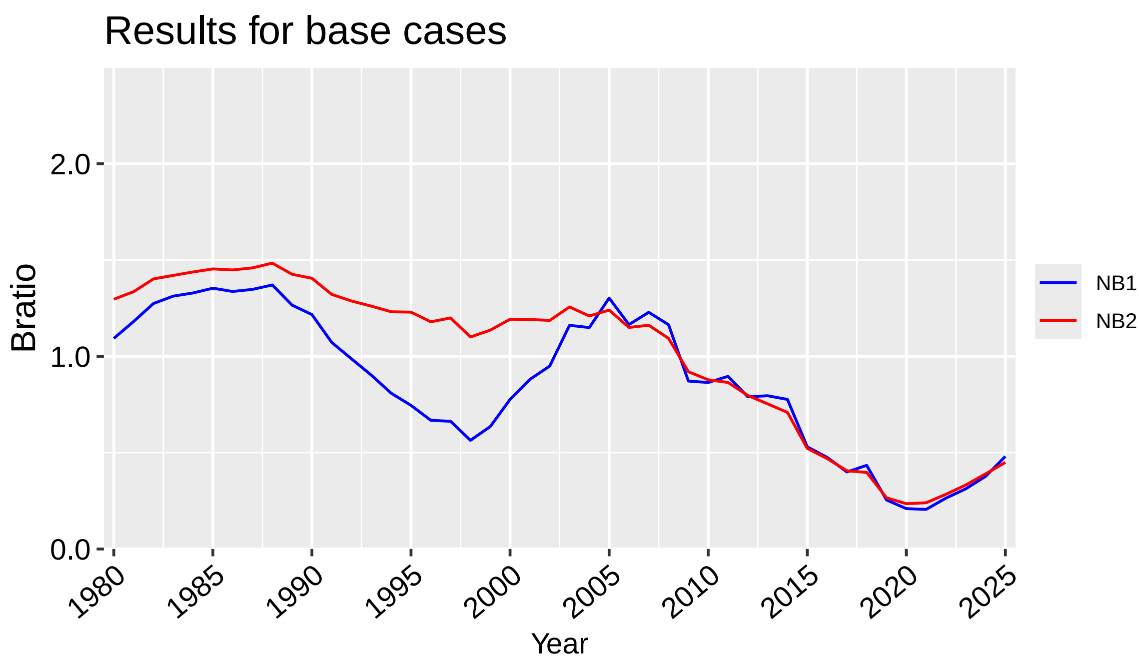



Base case 1
80%CI
median
harvest rate
1.0
0.5
0.0
FMSY
1980
1985
1990
1995
2000
2005
2010
2015
2020
2024
Year

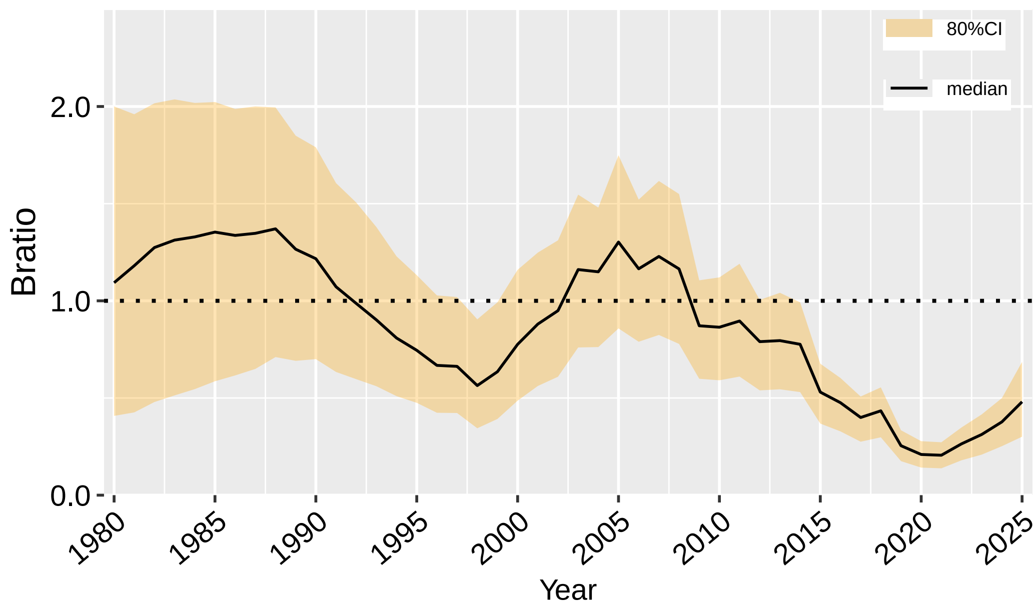

Base case 2
80%CI
median
harvest rate
1.0
0.5
0.0
FMSY
1980
1985
1990
1995
2000
2005
2010
2015
2020
2024
Year

1.3 Time series Bratio

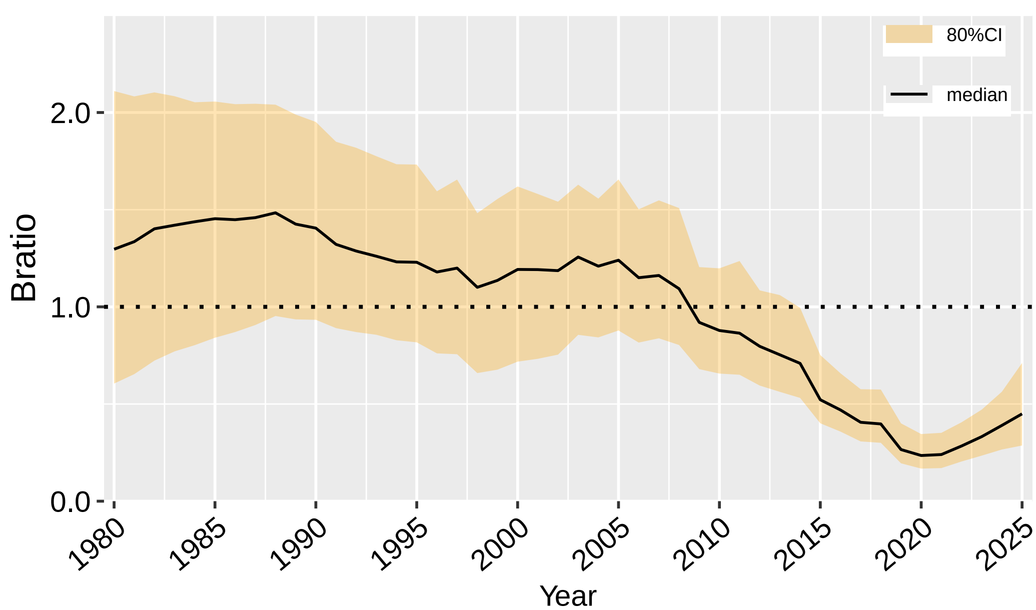




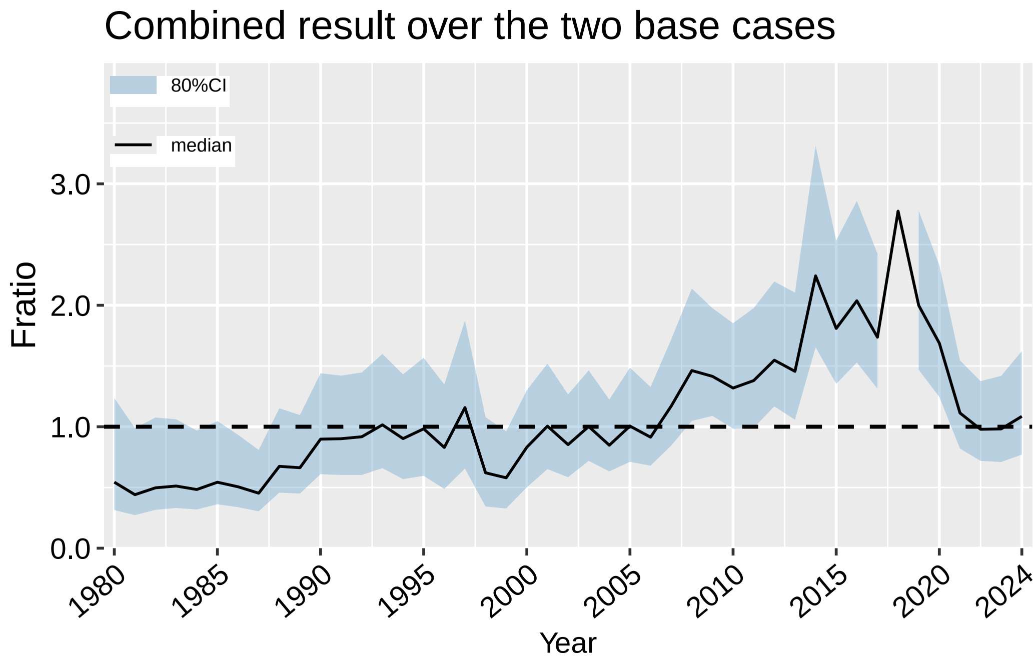
Base case 1

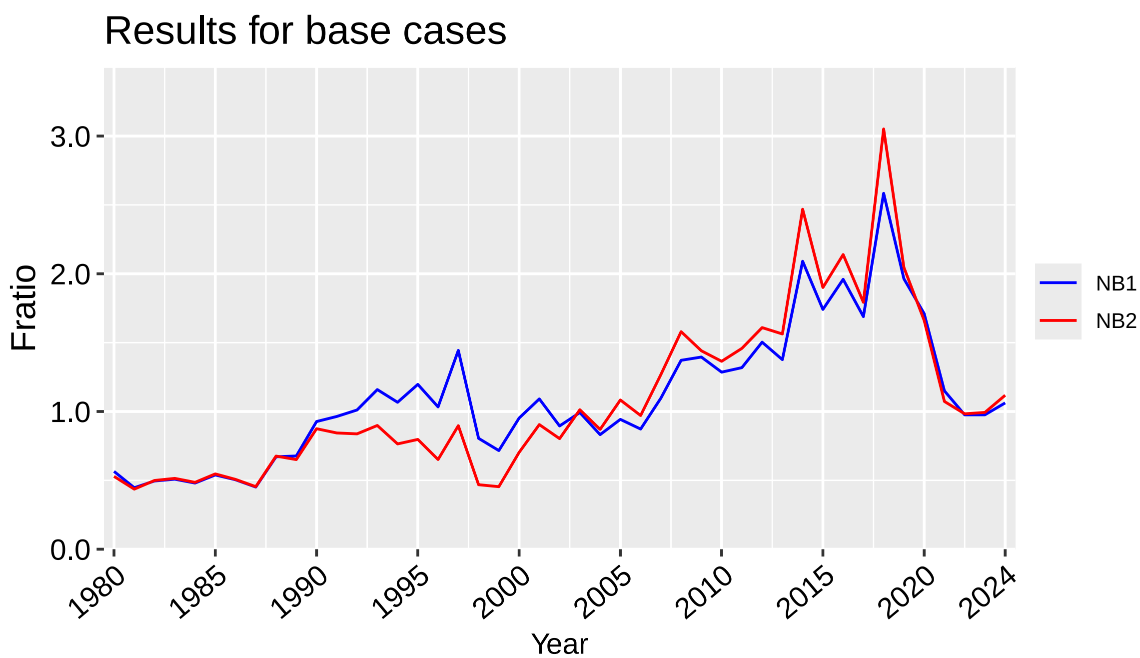


Base case 2

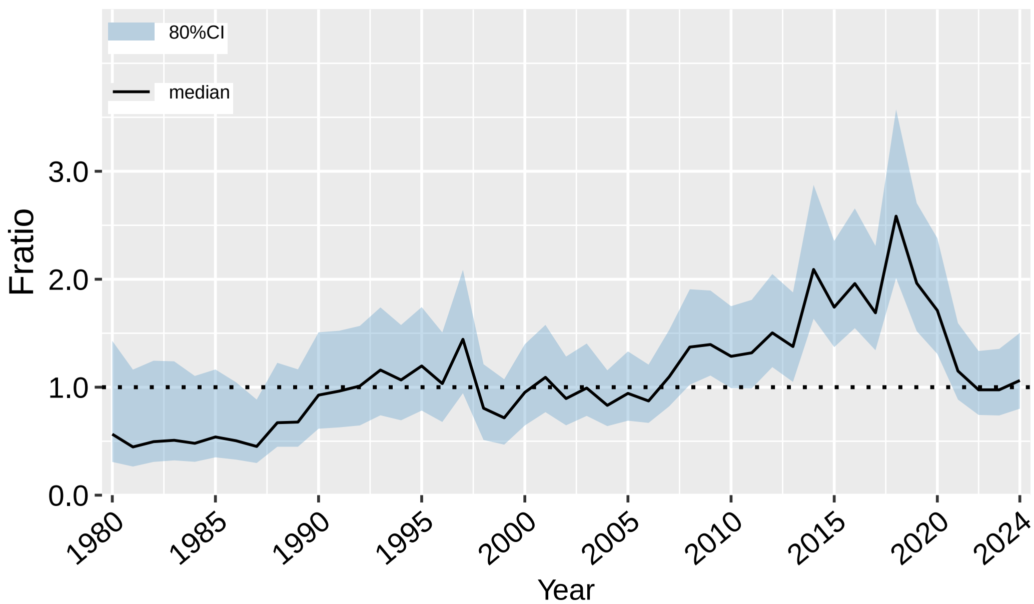


1.4 Time series Fratio

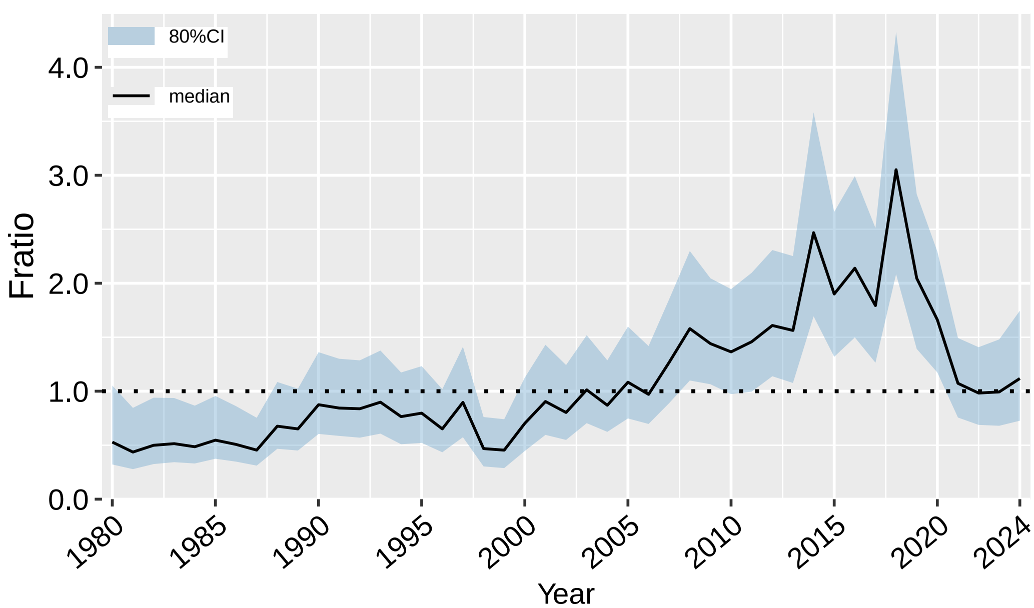




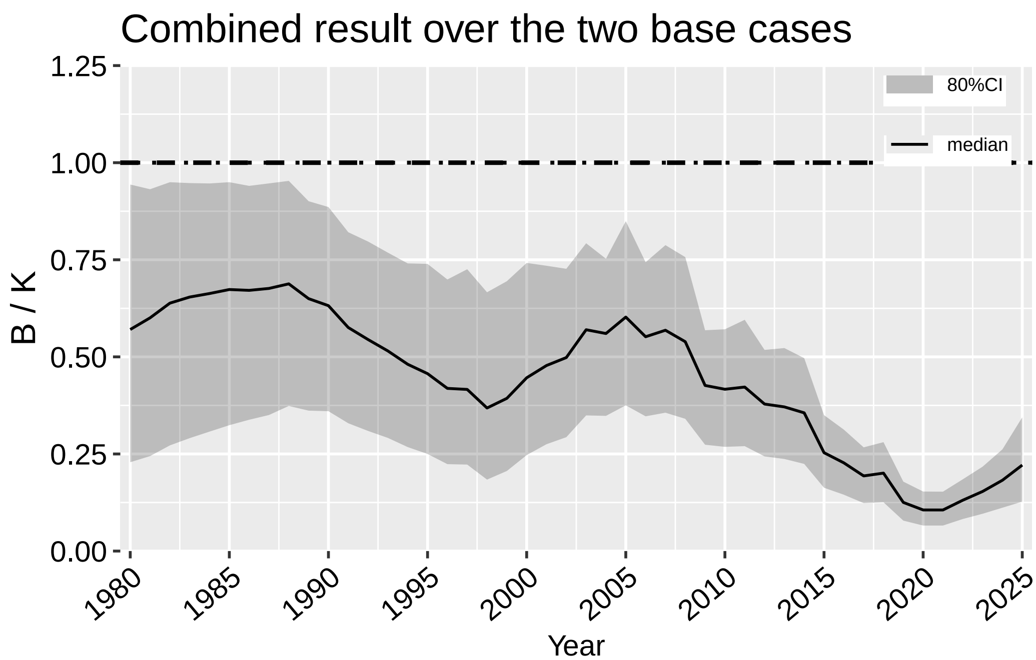
Base case 1

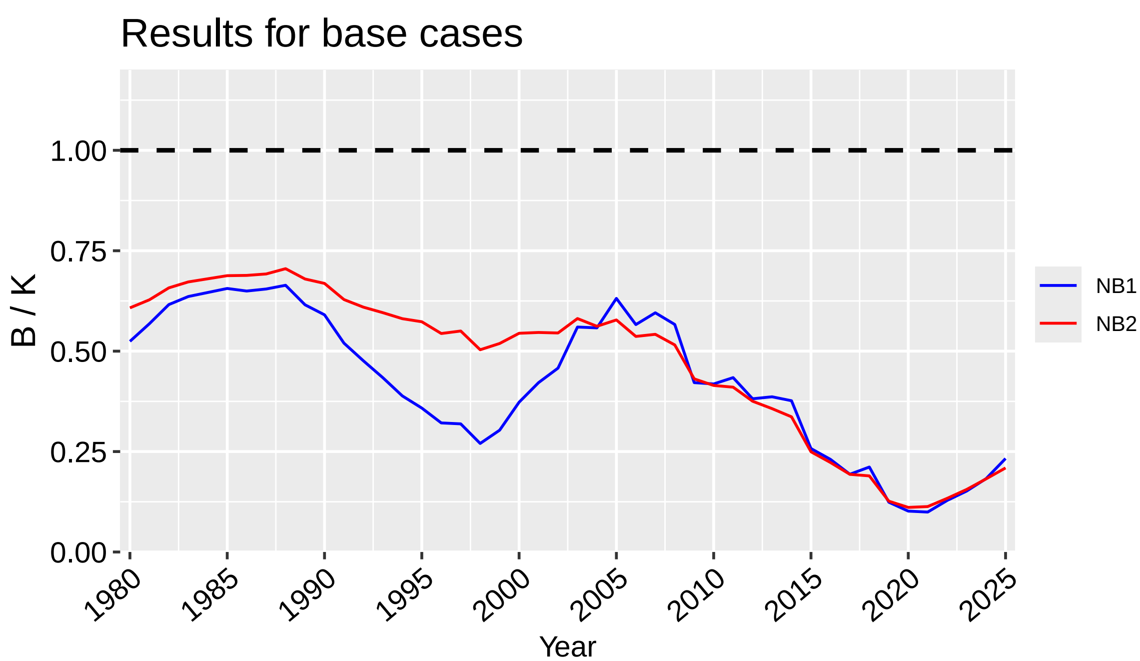


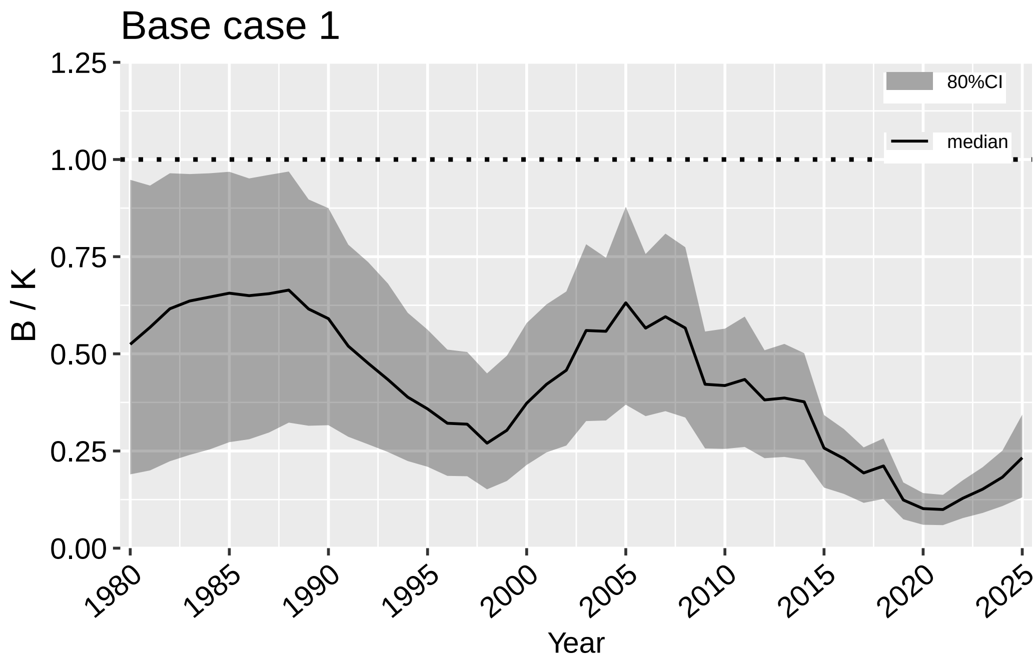
Base case 2

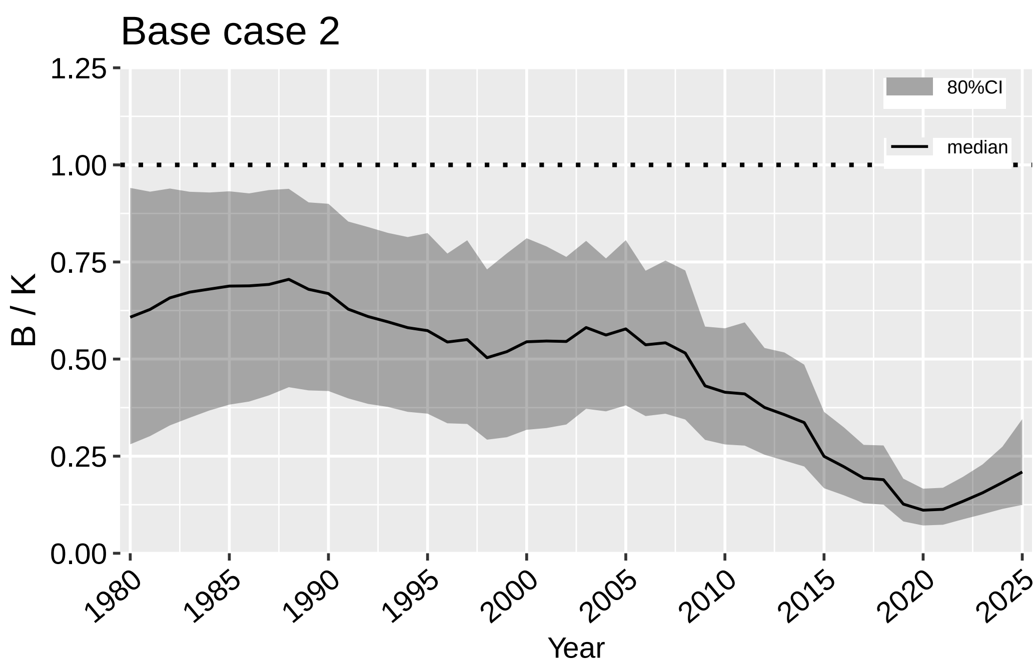


1.5 Time series B/K

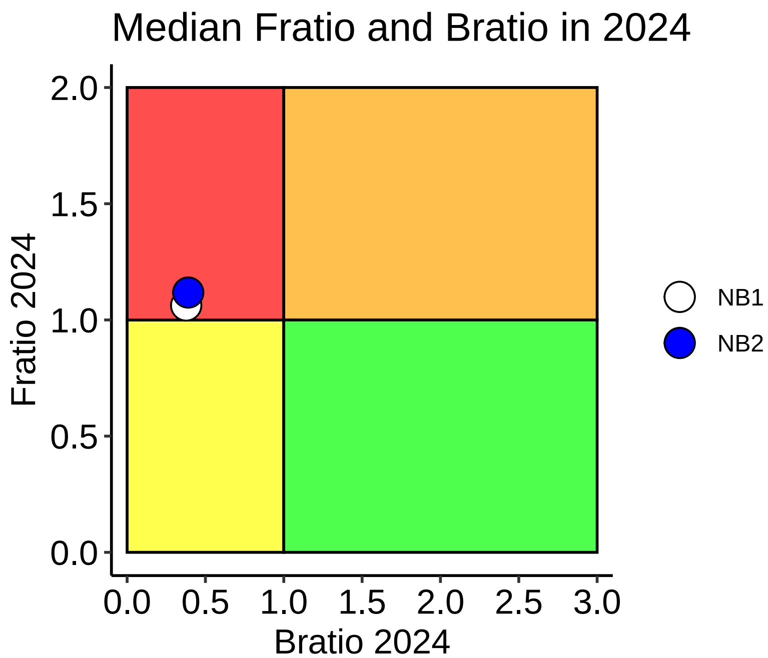




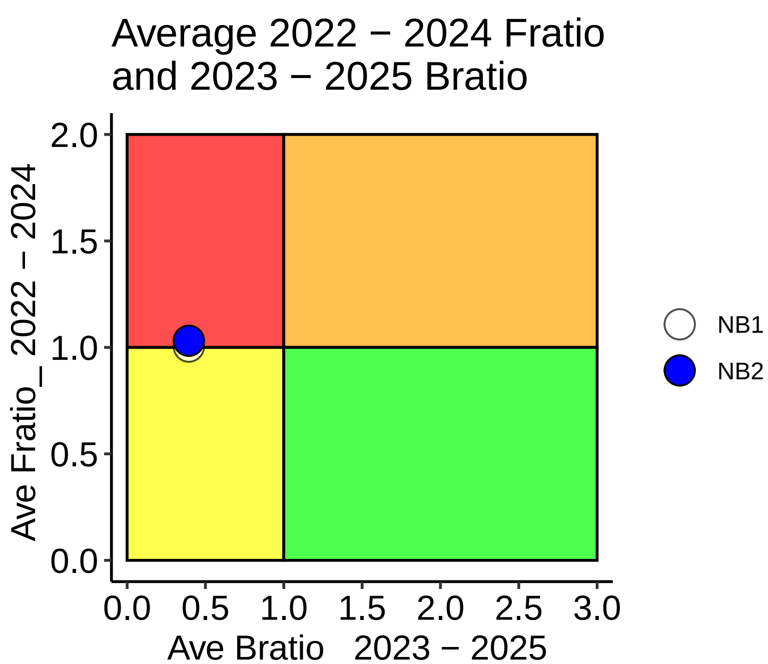

Base case 1
80%CI
median
B / K
1.25
1.00
0.75
0.50
0.25
0.00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year


Base case 2
80%CI
median
B / K
1.25
1.00
0.75
0.50
0.25
0.00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

2 Kobe plot

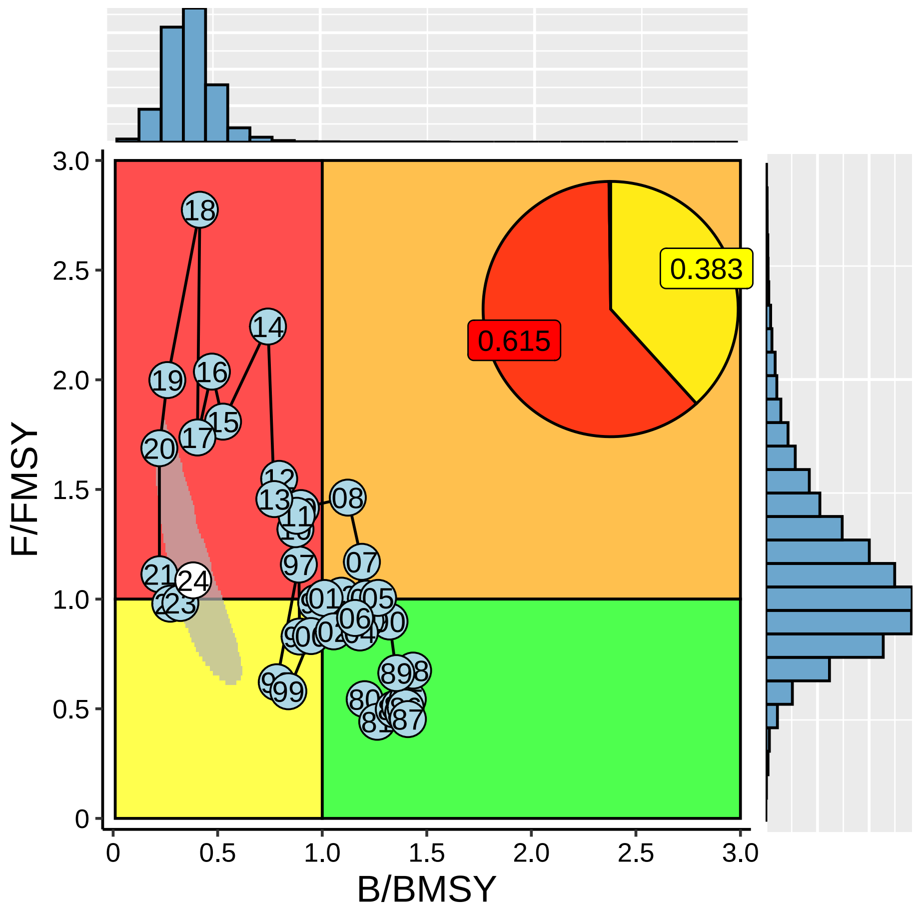


Median Fratio and Bratio in 2024
Fratio 2024
2.0
1.5
1.0
0.5
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0
Bratio 2024
NB1
NB2



Average 2022 − 2024 Fratio
and 2023 − 2025 Bratio
Ave Fratio_ 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
Ave Bratio_ 2023 − 2025
NB1
NB2

1980 − 2024 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_2024 (million tons)	0.156	0.156	0.156	0.156
AveC_2022_2024	0.125	0.125	0.125	0.125
AveF_2022_2024	0.280	0.276	0.133	0.432
F_2024	0.298	0.292	0.149	0.454
FMSY	0.281	0.271	0.117	0.456
MSY (million tons)	0.383	0.381	0.307	0.457
F_2024/FMSY	1.153	1.085	0.771	1.622
AveF_2022_2024/FMSY	1.068	1.015	0.752	1.460
K (million tons)	3.693	3.042	1.732	6.835
B_2024 (million tons)	0.632	0.533	0.343	1.046
B_2025 (million tons)	0.759	0.661	0.433	1.186
AveB_2023_2025	0.644	0.546	0.360	1.050
BMSY (million tons)	1.684	1.419	0.882	2.929
BMSY/K	0.472	0.470	0.391	0.557
B_2024/K	0.186	0.182	0.112	0.262
B_2025/K	0.231	0.221	0.127	0.344
AveB_2023_2025/K	0.191	0.188	0.114	0.270
B_2024/BMSY	0.377	0.377	0.252	0.499
B_2025/BMSY	0.486	0.466	0.292	0.694
AveB_2023_2025/BMSY	0.403	0.394	0.264	0.544

Base case 1

	Mean	Median	Lower10th	Upper10th
C_2024 (million tons)	0.156	0.156	0.156	0.156
AveC_2022_2024	0.125	0.125	0.125	0.125
AveF_2022_2024	0.349	0.346	0.240	0.462
F_2024	0.370	0.365	0.254	0.494
FMSY	0.348	0.344	0.211	0.489
MSY (million tons)	0.401	0.393	0.339	0.467
F_2024/FMSY	1.116	1.062	0.801	1.502
AveF_2022_2024/FMSY	1.049	1.004	0.784	1.375
K (million tons)	2.765	2.352	1.611	4.434
B_2024 (million tons)	0.450	0.426	0.315	0.612
B_2025 (million tons)	0.578	0.551	0.400	0.784
AveB_2023_2025	0.468	0.445	0.335	0.629
BMSY (million tons)	1.277	1.127	0.822	1.904
BMSY/K	0.478	0.478	0.399	0.557
B_2024/K	0.182	0.183	0.108	0.251
B_2025/K	0.236	0.233	0.131	0.344
AveB_2023_2025/K	0.190	0.191	0.112	0.263
B_2024/BMSY	0.377	0.377	0.252	0.499
B_2025/BMSY	0.491	0.481	0.301	0.686
AveB_2023_2025/BMSY	0.394	0.394	0.261	0.522

Base case 2

	Mean	Median	Lower10th	Upper10th
C_2024 (million tons)	0.156	0.156	0.156	0.156
AveC_2022_2024	0.125	0.125	0.125	0.125
AveF_2022_2024	0.211	0.194	0.110	0.336
F_2024	0.226	0.211	0.123	0.348
FMSY	0.213	0.187	0.095	0.371
MSY (million tons)	0.365	0.363	0.282	0.446
F_2024/FMSY	1.191	1.118	0.727	1.745
AveF_2022_2024/FMSY	1.087	1.031	0.713	1.533
K (million tons)	4.621	4.221	2.178	7.811
B_2024 (million tons)	0.814	0.736	0.447	1.268
B_2025 (million tons)	0.939	0.842	0.537	1.434
AveB_2023_2025	0.819	0.736	0.459	1.268
BMSY (million tons)	2.090	1.923	1.098	3.347
BMSY/K	0.466	0.462	0.386	0.557
B_2024/K	0.191	0.182	0.114	0.274
B_2025/K	0.226	0.209	0.125	0.345
AveB_2023_2025/K	0.193	0.184	0.115	0.280
B_2024/BMSY	0.408	0.390	0.266	0.563
B_2025/BMSY	0.482	0.449	0.286	0.711
AveB_2023_2025/BMSY	0.413	0.394	0.268	0.573

4 Summary of estimates of parameters

Base case 1

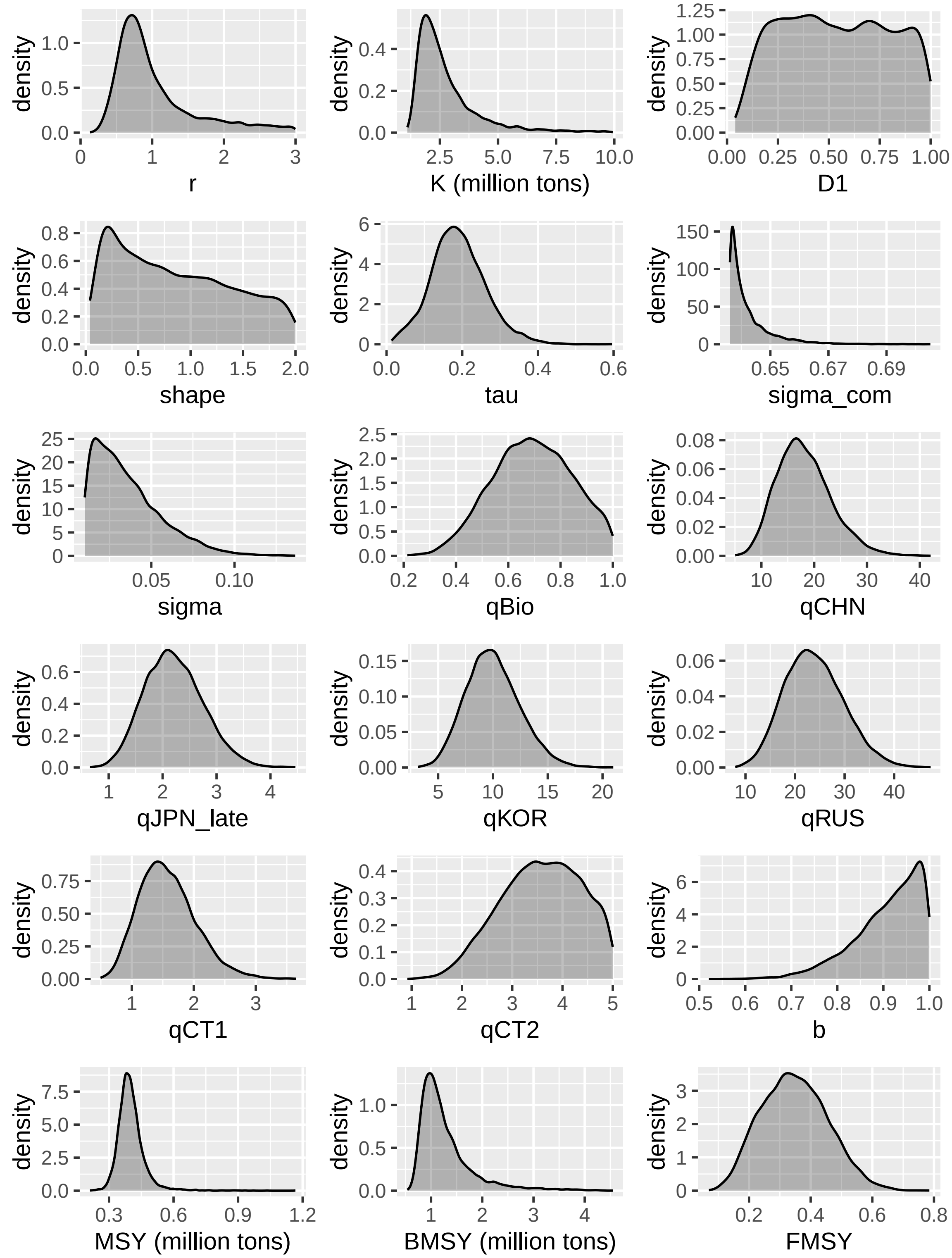
	Mean	Median	Lower10th	Upper10th
r	1.032	0.844	0.522	1.908
K (million tons)	2.765	2.352	1.611	4.434
qCHN	18.111	17.606	11.920	24.908
qJPN2	2.211	2.179	1.538	2.921
qKOR	9.998	9.844	6.979	13.219
qRUS	23.889	23.529	16.545	31.757
qCT1	1.577	1.530	1.034	2.180
qCT2	3.576	3.607	2.495	4.620
qBio	0.692	0.692	0.492	0.896
Shape	0.861	0.782	0.179	1.693
sigma_com	0.642	0.639	0.636	0.652
sigma	0.036	0.031	0.014	0.065
tau	0.190	0.186	0.103	0.282
FMSY	0.348	0.344	0.211	0.489
BMSY (million tons)	1.277	1.127	0.822	1.904
MSY (million tons)	0.401	0.393	0.339	0.467
b	0.908	0.925	0.805	0.987

Base case 2

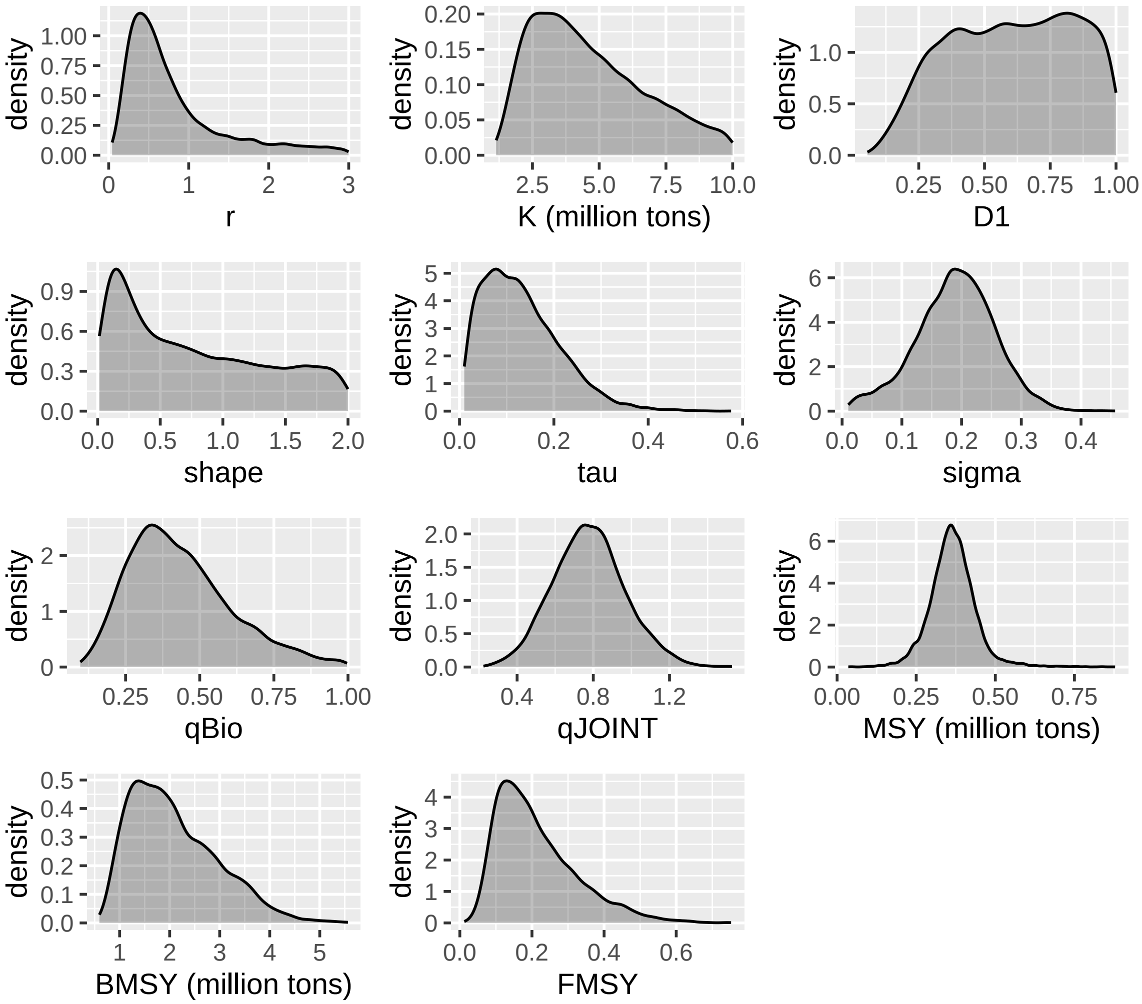
	Mean	Median	Lower10th	Upper10th
r	0.809	0.598	0.251	1.779
K (million tons)	4.621	4.221	2.178	7.811
qJOINT	0.778	0.774	0.536	1.024
qBio	0.436	0.407	0.237	0.682
Shape	0.773	0.644	0.101	1.698
sigma	0.190	0.192	0.105	0.270
tau	0.131	0.119	0.037	0.241
FMSY	0.213	0.187	0.095	0.371
BMSY (million tons)	2.090	1.923	1.098	3.347
MSY (million tons)	0.365	0.363	0.282	0.446
b	0.572	0.561	0.397	0.762

5 Posterior distributions

Base case 1



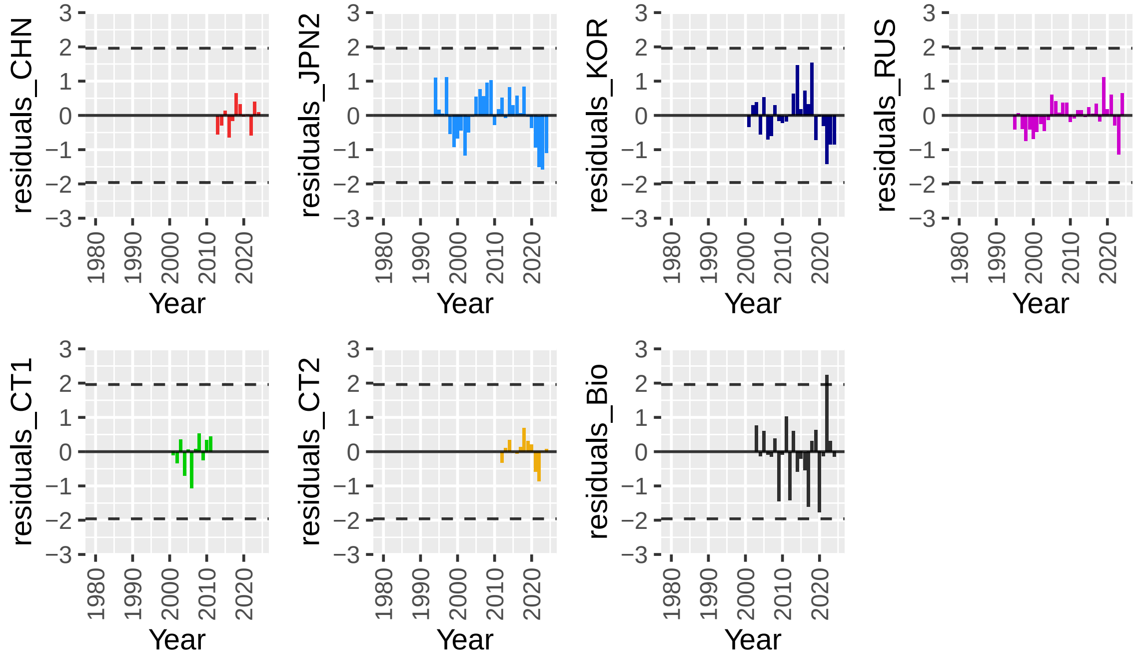
Base case 2


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

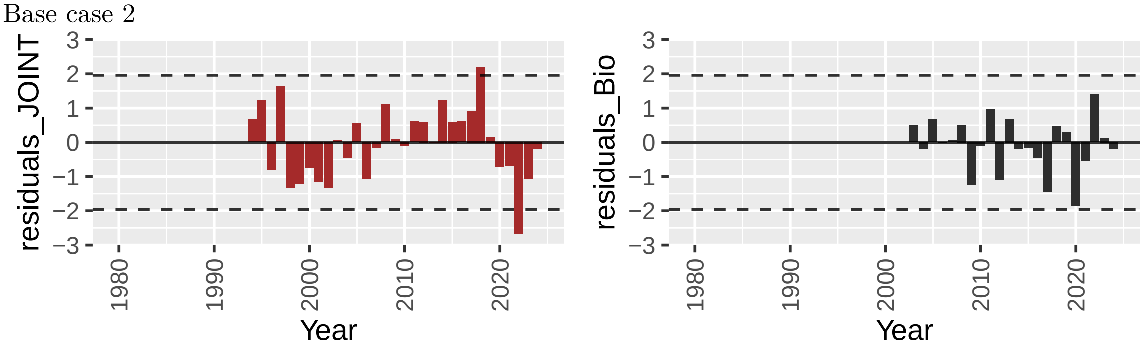
6 Diagnosis

6.1 Standardized residuals plot

Base case 1



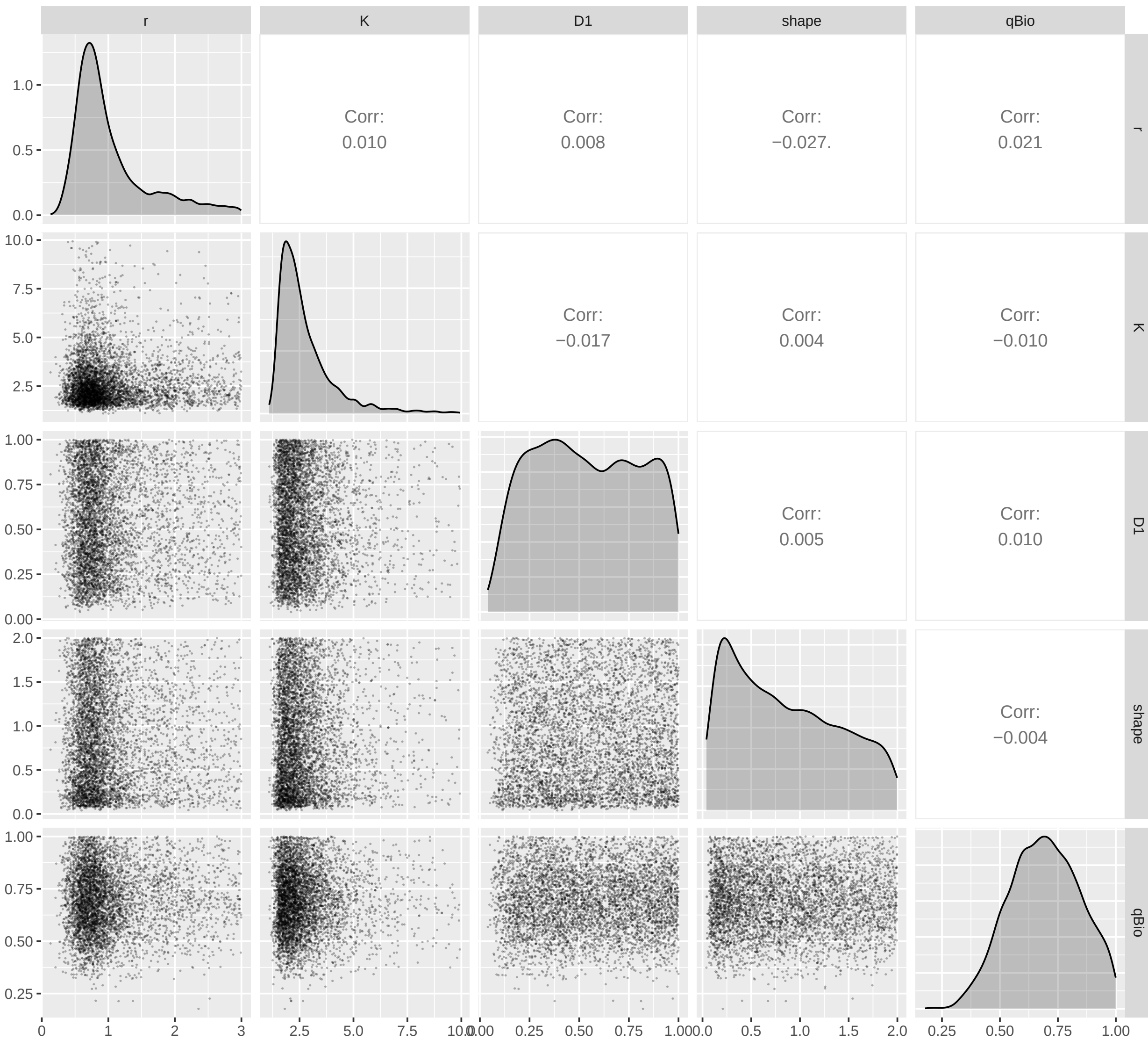
Base case 2



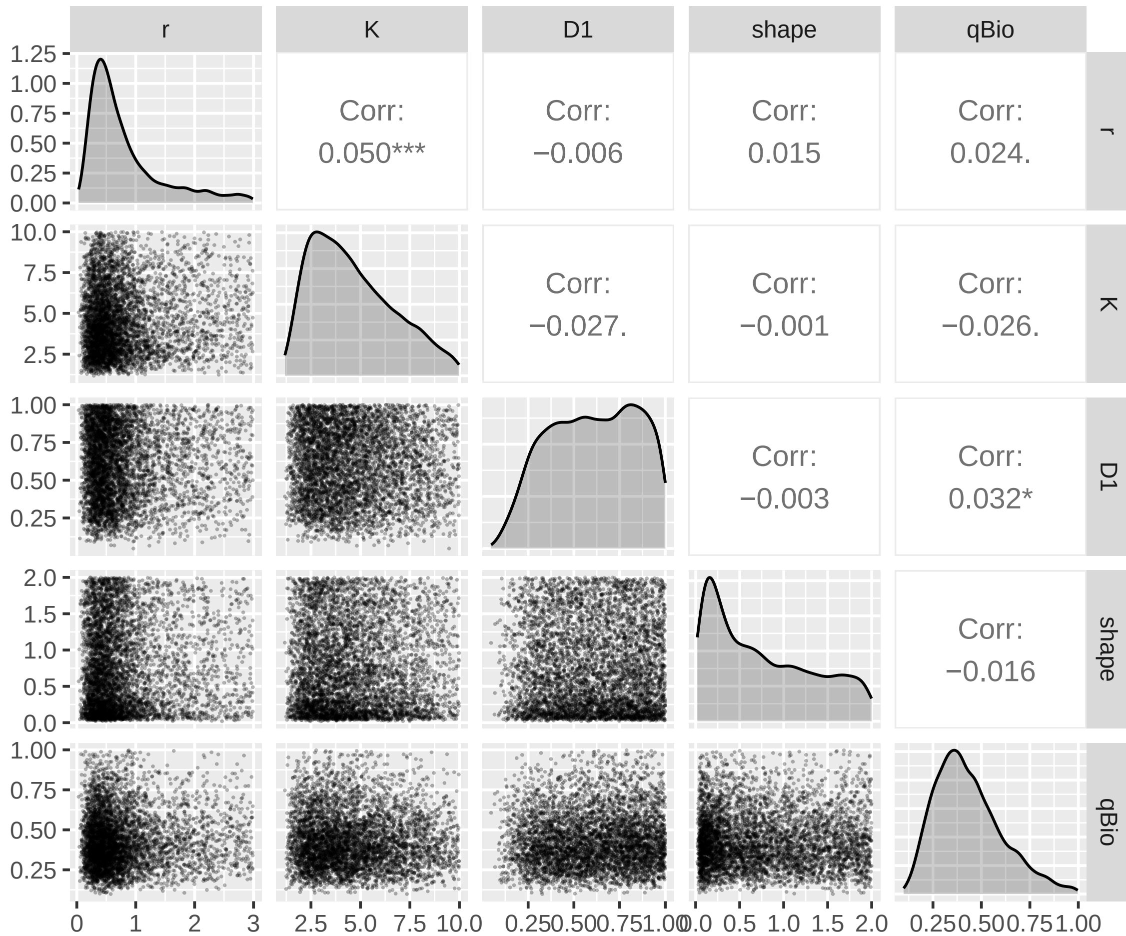
6.2 Correlation

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

Base case 1



Base case 2



r
K
D1
shape
qBio
Corr:
0.050***
Corr:
−0.006
Corr:
0.015
Corr:
0.024.
Corr:
−0.027.
Corr:
−0.001
Corr:
−0.026.
Corr:
−0.003
Corr:
0.032*
Corr:
−0.016

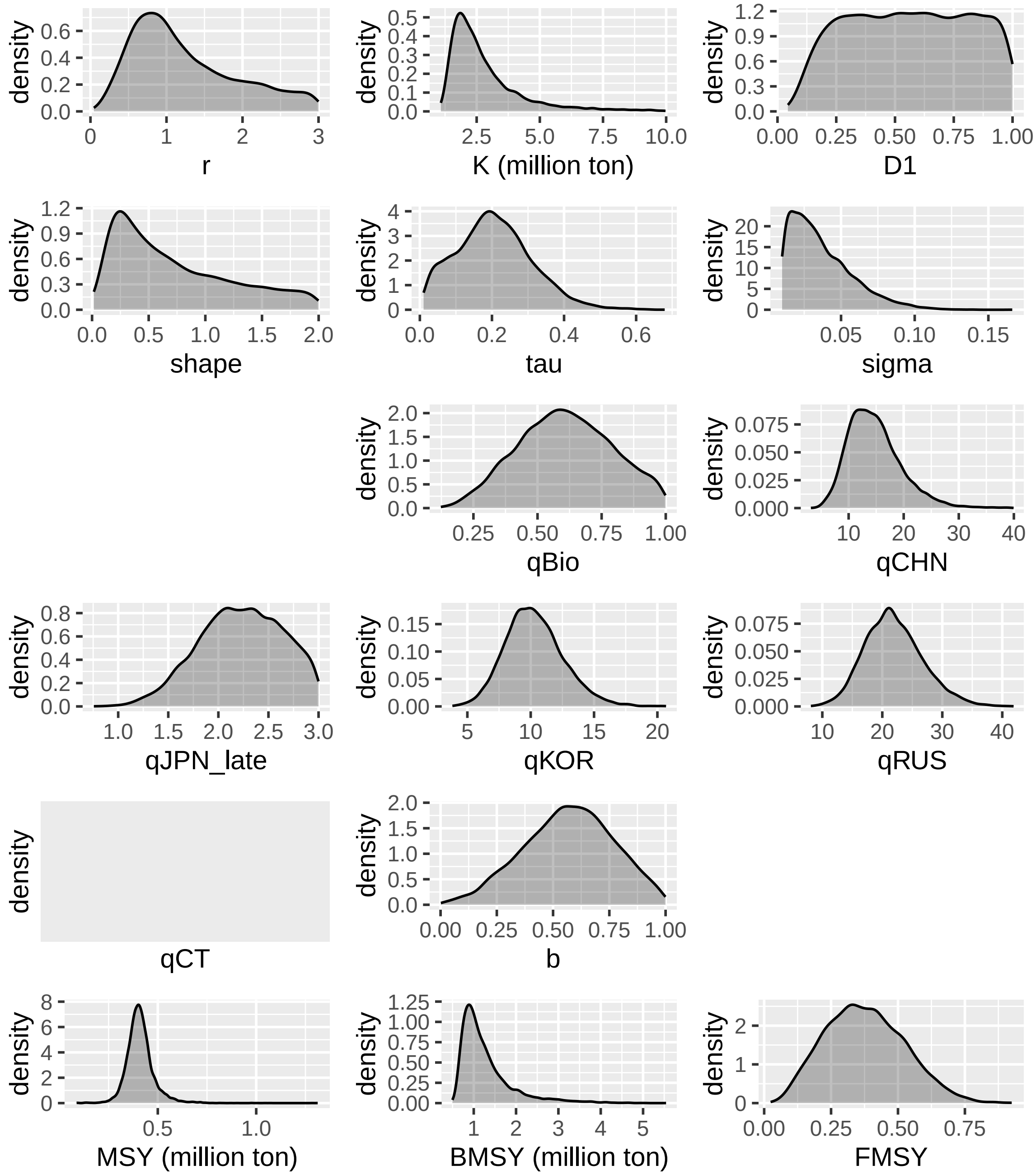
Appendix2:

Retrospective analysis

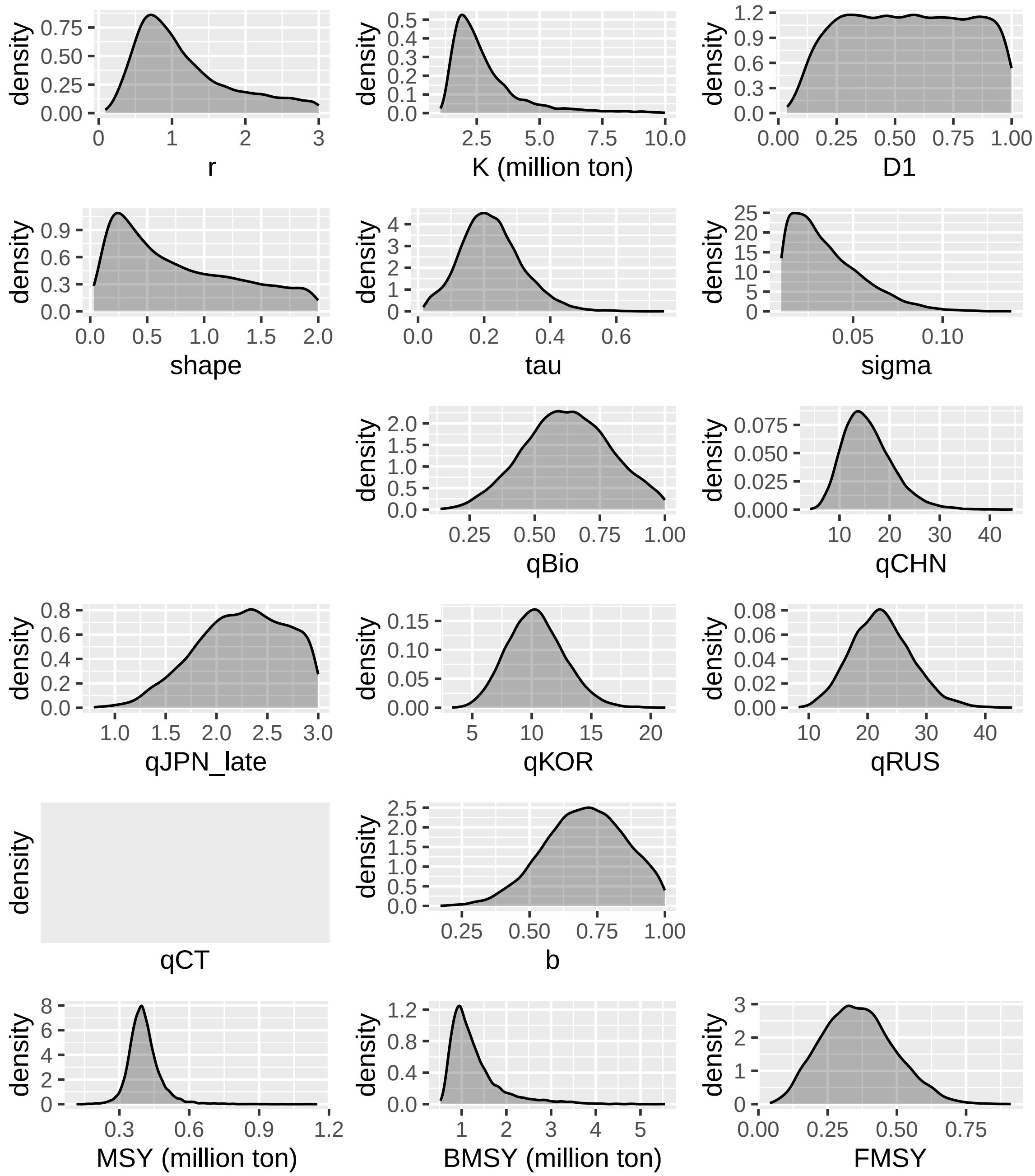
Contents

Posterior distributions

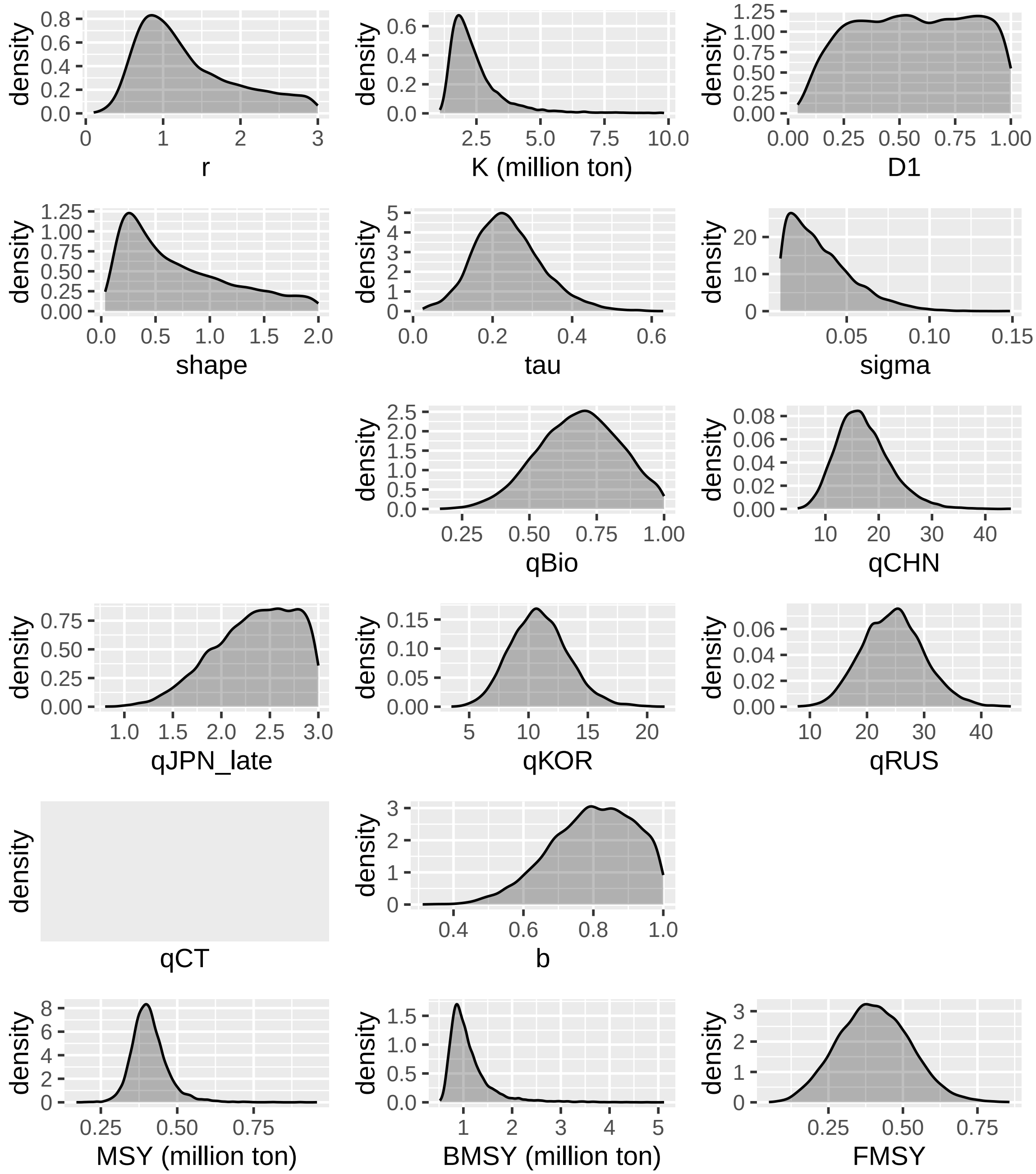
NB1 5 years



NB1 4 years

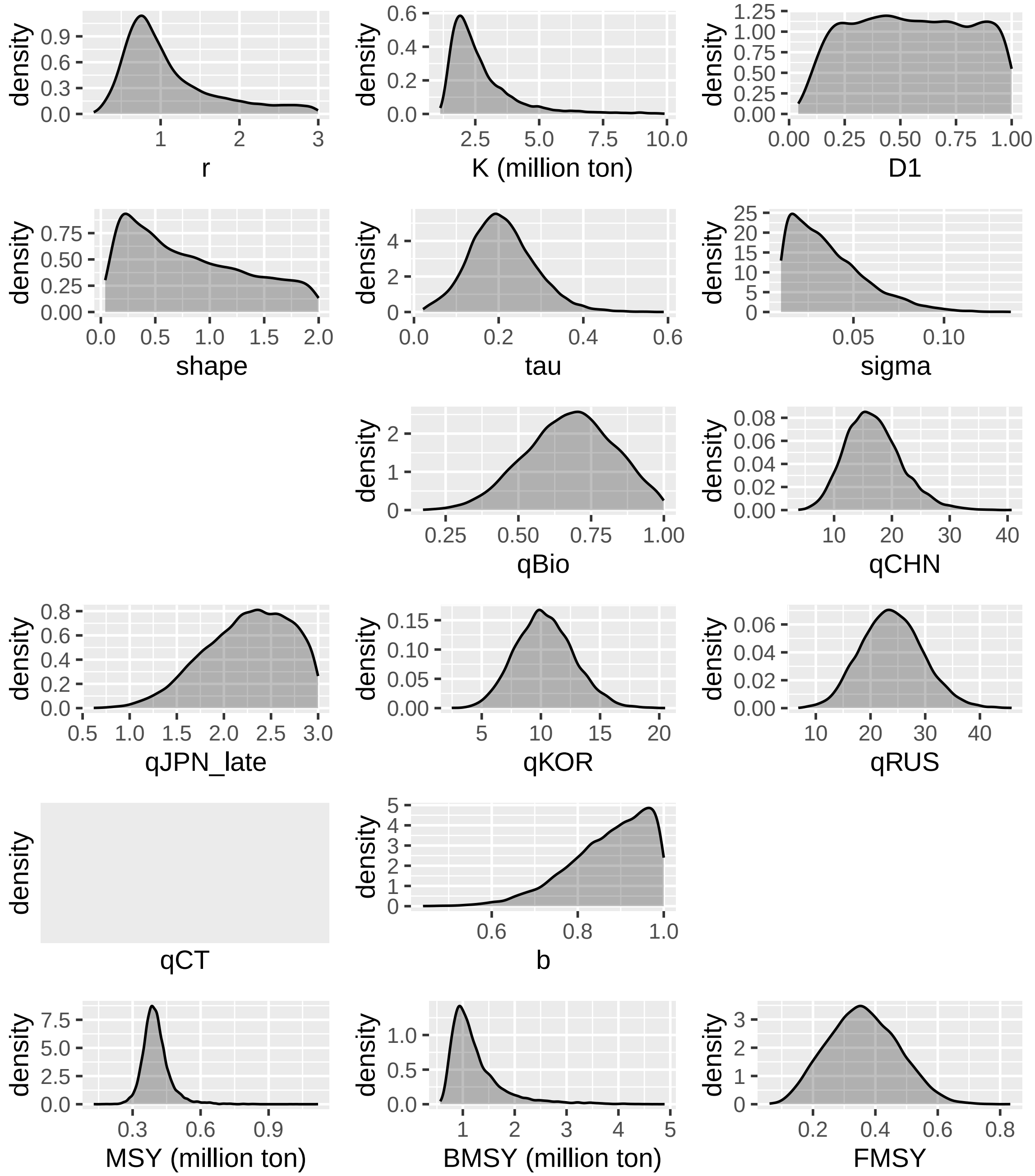

density
r
K (million ton)
D1
shape
tau
sigma
qBio
qCHN
qJPN_late
qKOR
qRUS
qCT
b
MSY (million ton)
BMSY (million ton)
FMSY

NB1 3 years



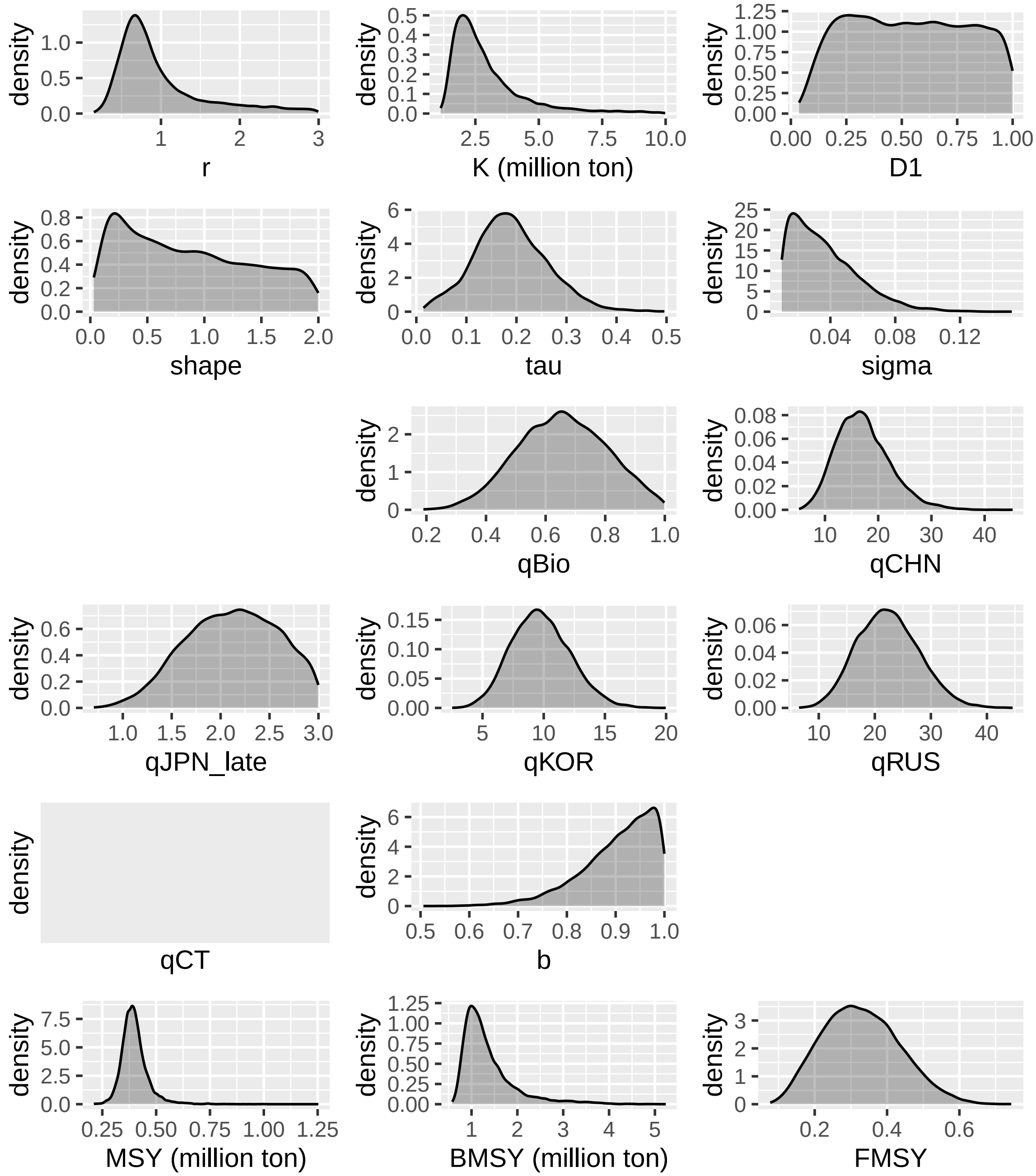
density
0.0 0.2 0.4 0.6 0.8
0 1 2 3
r
density
0.0 0.2 0.4 0.6
2.5 5.0 7.5 10.0
K (million ton)
density
0.00 0.25 0.50 0.75 1.00 1.25
0.00 0.25 0.50 0.75 1.00
D1
density
0.00 0.25 0.50 0.75 1.00 1.25
0.0 0.5 1.0 1.5 2.0
shape
density
0 1 2 3 4 5
0.0 0.2 0.4 0.6
tau
density
0 10 20
0.05 0.10 0.15
sigma
density
0.0 0.5 1.0 1.5 2.0 2.5
0.25 0.50 0.75 1.00
qBio
density
0.00 0.02 0.04 0.06 0.08
10 20 30 40
qCHN
density
0.00 0.25 0.50 0.75
1.0 1.5 2.0 2.5 3.0
qJPN_late
density
0.00 0.05 0.10 0.15
5 10 15 20
qKOR
density
0.00 0.02 0.04 0.06
10 20 30 40
qRUS
density
qCT
density
0 1 2 3
0.4 0.6 0.8 1.0
b
density
0 2 4 6 8
0.25 0.50 0.75
MSY (million ton)
density
0.0 0.5 1.0 1.5
1 2 3 4 5
BMSY (million ton)
density
0 1 2 3
0.25 0.50 0.75
FMSY

NB1 2 years

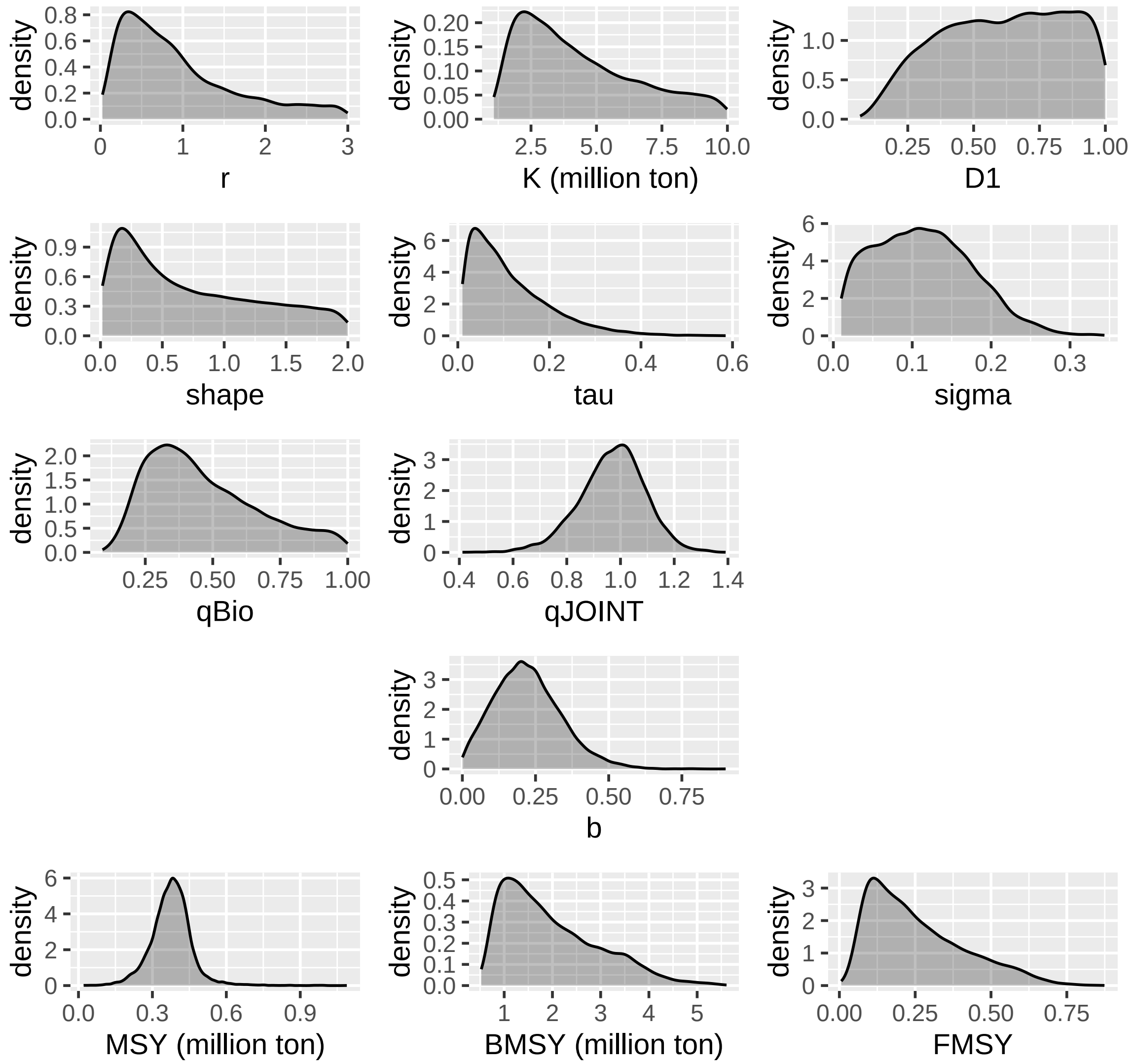


density
r
K (million ton)
D1
shape
tau
sigma
qBio
qCHN
qJPN_late
qKOR
qRUS
qCT
b
MSY (million ton)
BMSY (million ton)
FMSY

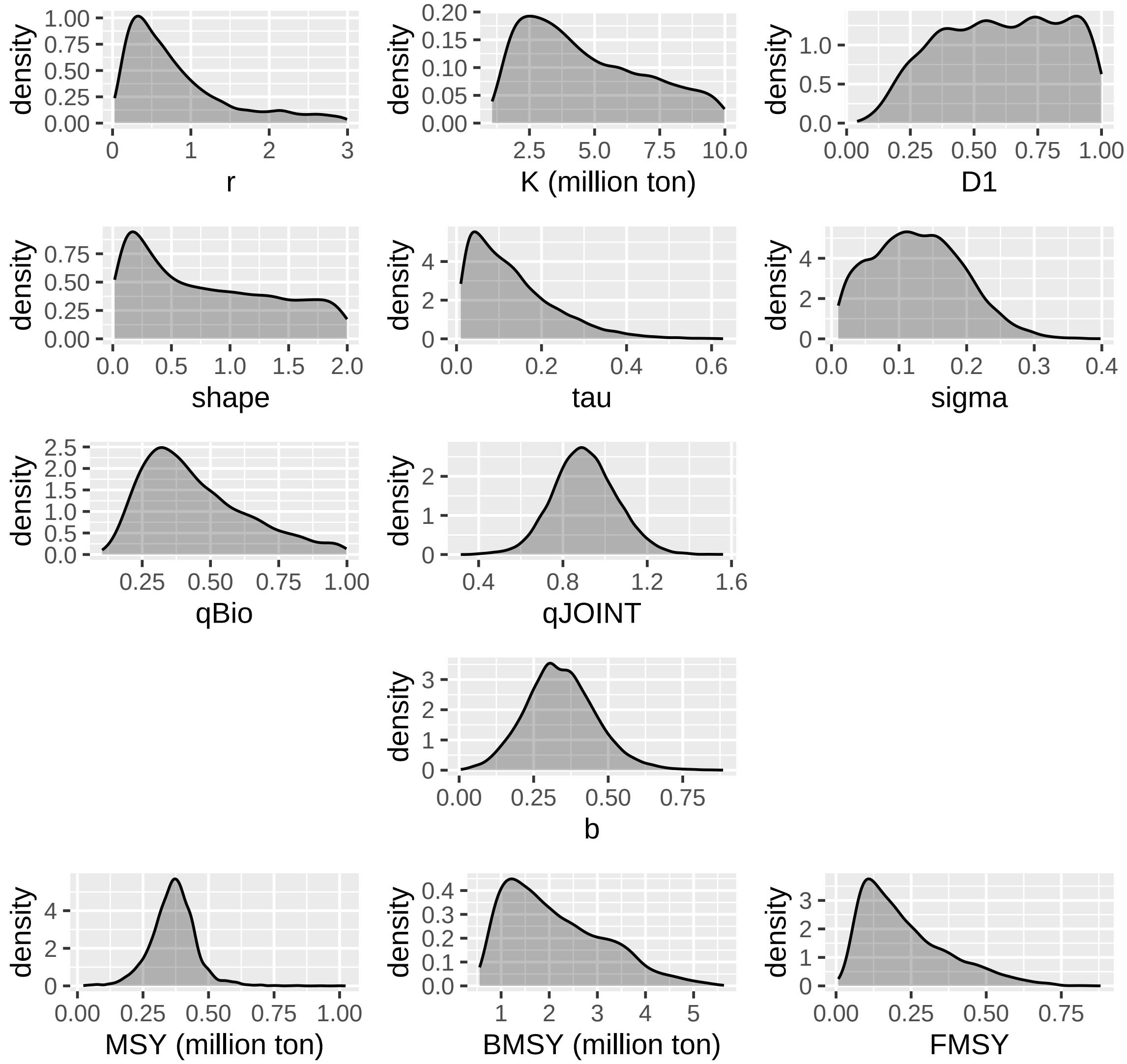
NB1 1 years


density
r
K (million ton)
D1
shape
tau
sigma
qBio
qCHN
qJPN_late
qKOR
qRUS
qCT
b
MSY (million ton)
BMSY (million ton)
FMSY

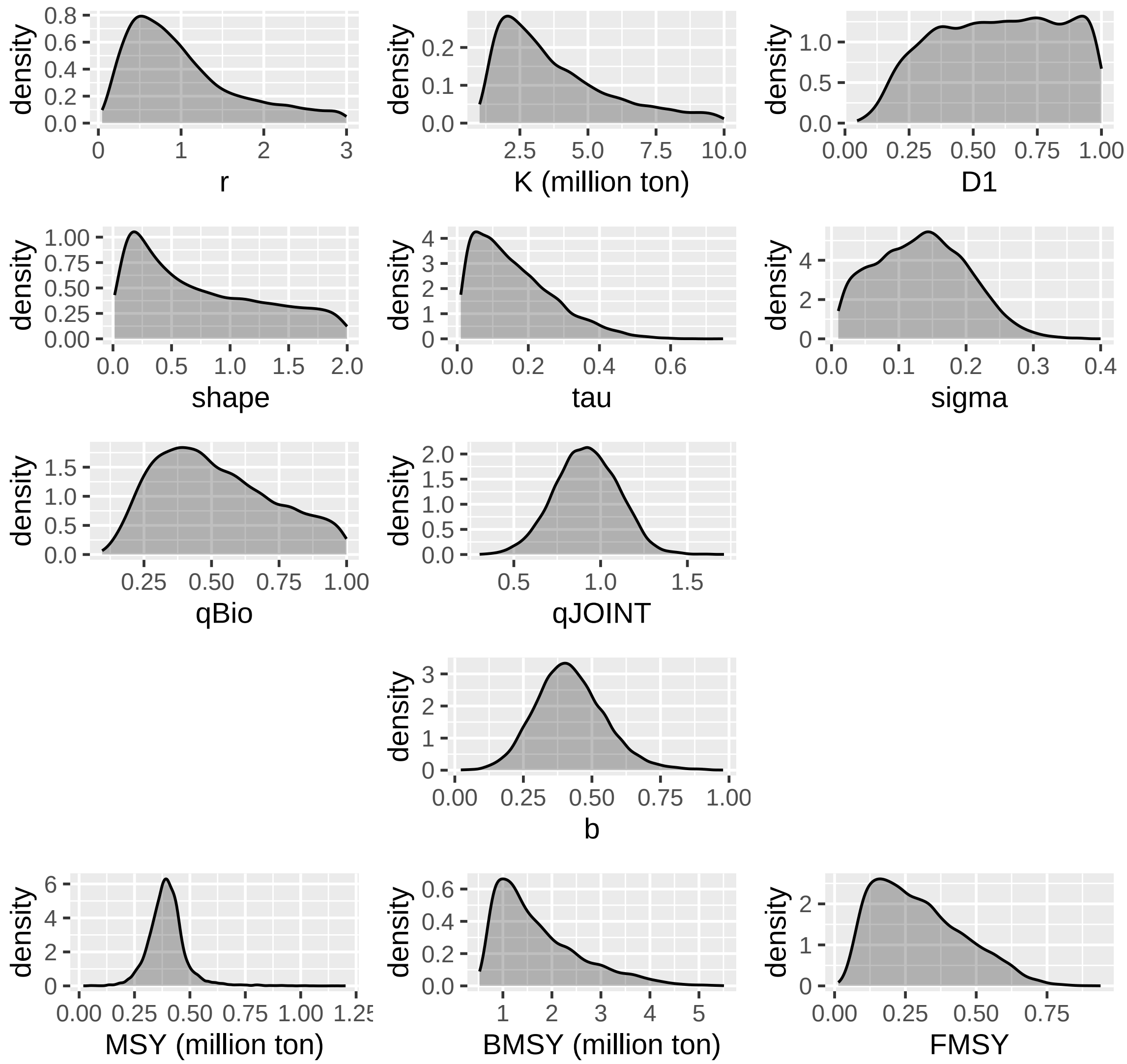
NB2 5 years


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

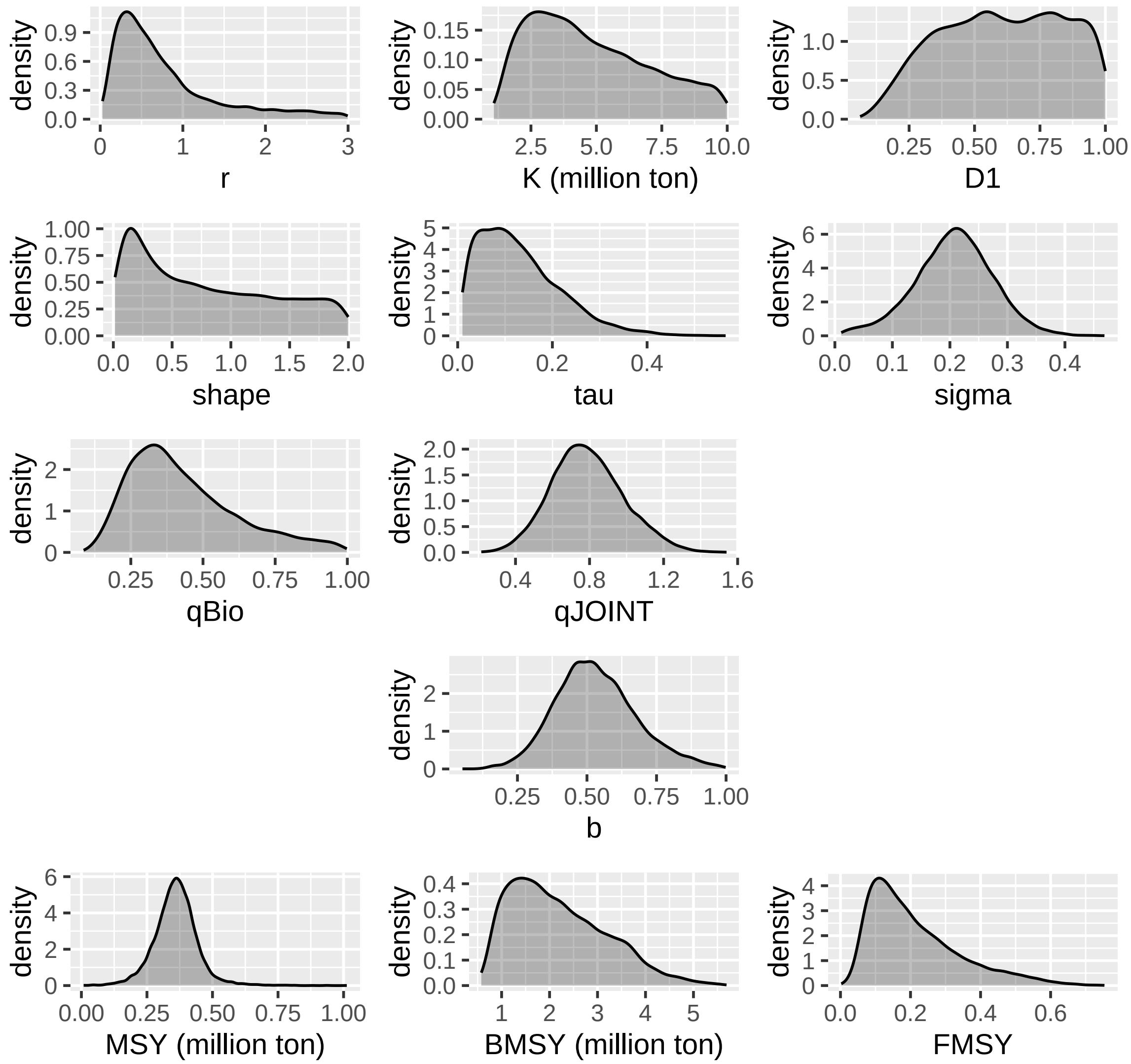
NB2 4 years


density
0.00 0.25 0.50 0.75 1.00
0 1 2 3
r
0.00 0.05 0.10 0.15 0.20
2.5 5.0 7.5 10.0
K (million ton)
0.0 0.5 1.0
0.00 0.25 0.50 0.75 1.00
D1
0.00 0.25 0.50 0.75
0.0 0.5 1.0 1.5 2.0
shape
0 2 4
0.0 0.2 0.4 0.6
tau
0 2 4
0.0 0.1 0.2 0.3 0.4
sigma
0.0 0.5 1.0 1.5 2.0 2.5
0.25 0.50 0.75 1.00
qBio
0 1 2
0.4 0.8 1.2 1.6
qJOINT
0 1 2 3
0.00 0.25 0.50 0.75
b
0 2 4
0.00 0.25 0.50 0.75 1.00
MSY (million ton)
0.0 0.1 0.2 0.3 0.4
1 2 3 4 5
BMSY (million ton)
0 1 2 3
0.00 0.25 0.50 0.75
FMSY

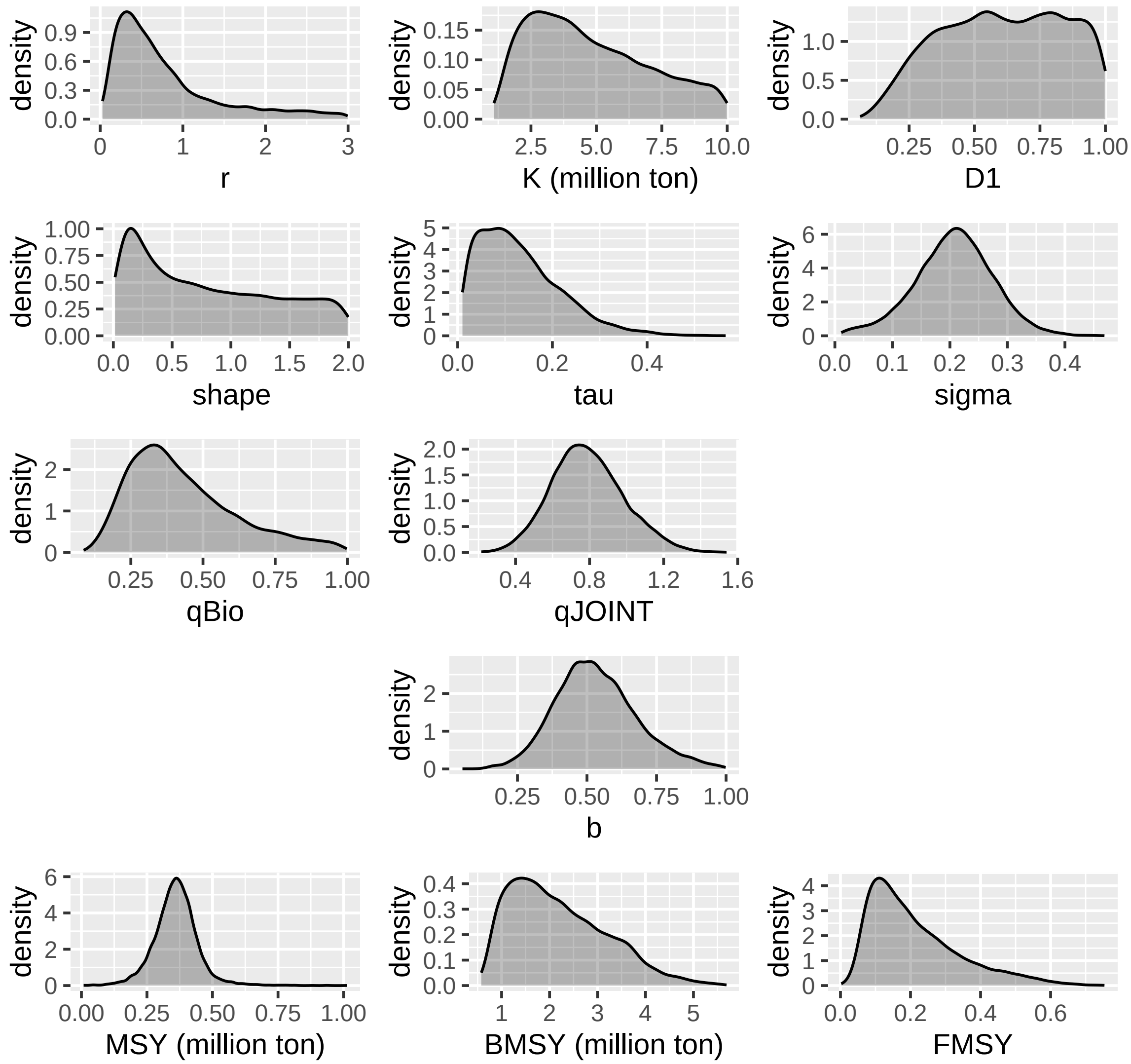
NB2 3 years


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

NB2 2 years

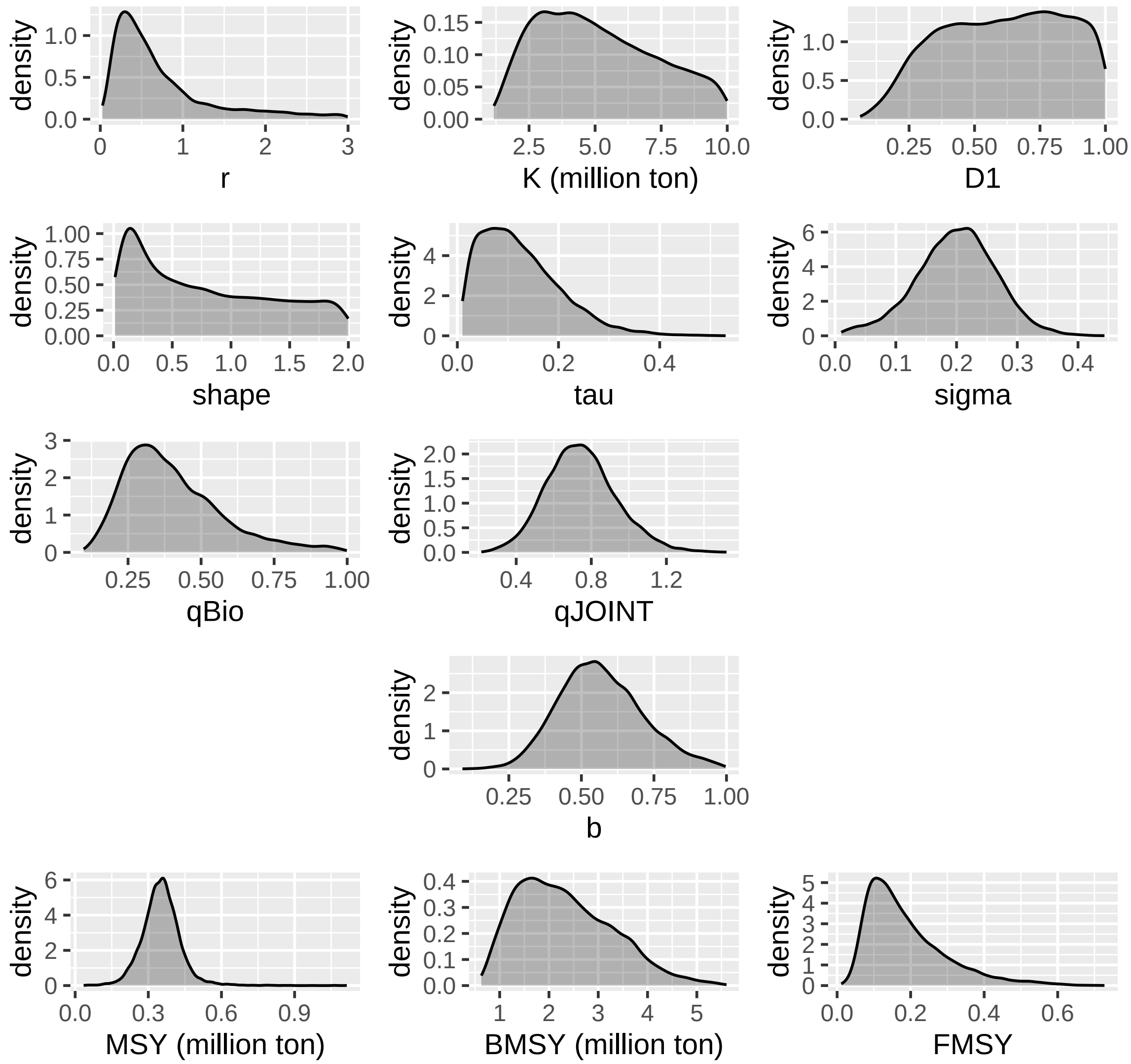

density
r
K (million ton)
D1
shape
tau
sigma
qBio
qJOINT
b
MSY (million ton)
BMSY (million ton)
FMSY

NB2 2 years



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

NB2 1 years

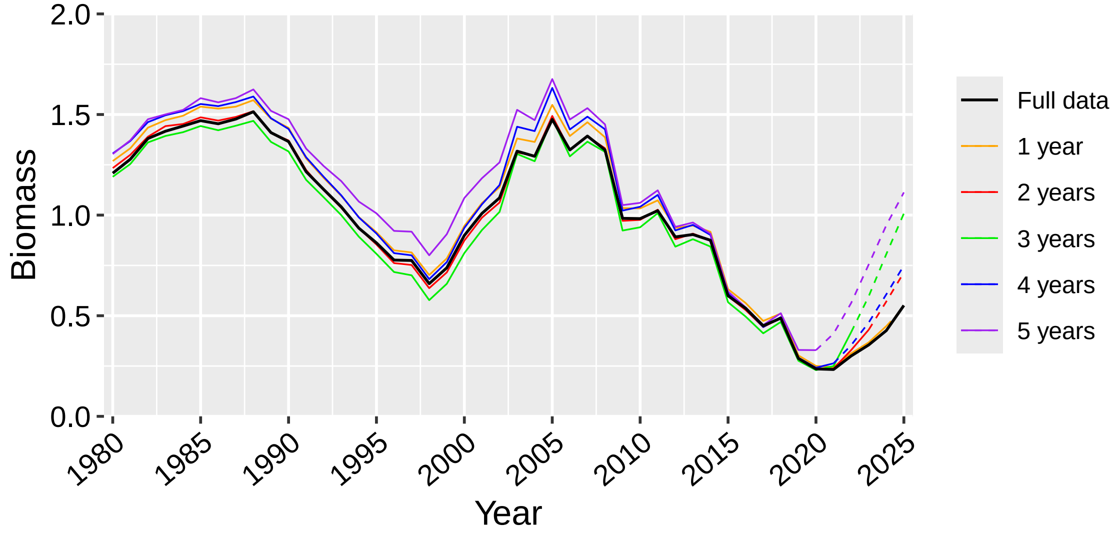

density
r
K (million ton)
D1
shape
tau
sigma
qBio
qJOINT
b
MSY (million ton)
BMSY (million ton)
FMSY

Results of parameters

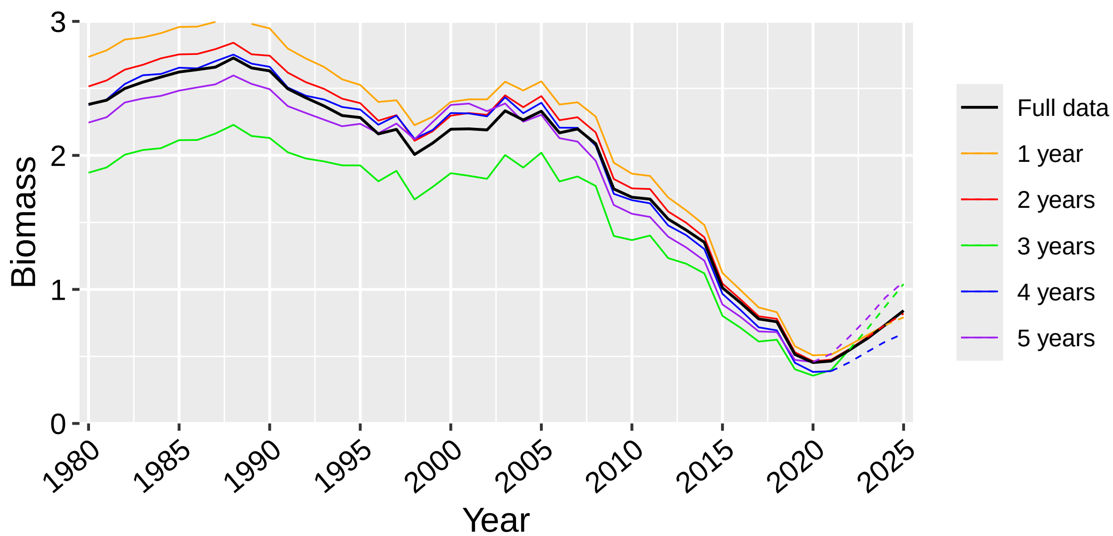
	1year		2years		3years		4years		5years	
	NB1	NB2	NB1	NB2	NB1	NB2	NB1	NB2	NB1	NB2
r	0.794	0.523	0.916	0.579	1.139	0.846	0.983	0.617	1.059	0.748
K (million ton)	2.500	4.821	2.319	4.378	2.158	3.193	2.398	4.131	2.370	3.803
qCHN	16.677		16.417		16.621		15.074		14.114	
qJPN2	2.134		2.295		2.392		2.279		2.239	
qKOR	9.656		10.239		10.821		10.251		10.117	
qRUS	22.204		23.764		24.547		22.176		21.540	
qCT										
qJOINT		0.738		0.778		0.918		0.900		0.977
qBio	0.656	0.369	0.684	0.390	0.690	0.482	0.626	0.402	0.607	0.421
Shape	0.790	0.653	0.700	0.673	0.570	0.614	0.623	0.685	0.579	0.584
sigma	0.032	0.201	0.031	0.209	0.030	0.135	0.030	0.125	0.032	0.111
tau	0.184	0.110	0.203	0.115	0.233	0.137	0.215	0.107	0.201	0.090
FMSY	0.323	0.159	0.357	0.178	0.401	0.272	0.355	0.191	0.370	0.218
BMSY (million ton)	1.195	2.202	1.097	2.020	0.998	1.465	1.119	1.920	1.093	1.731
MSY (million ton)	0.392	0.352	0.395	0.360	0.403	0.392	0.398	0.367	0.404	0.378
b	0.920	0.556	0.890	0.522	0.806	0.413	0.708	0.336	0.576	0.214

Biomass

NB1

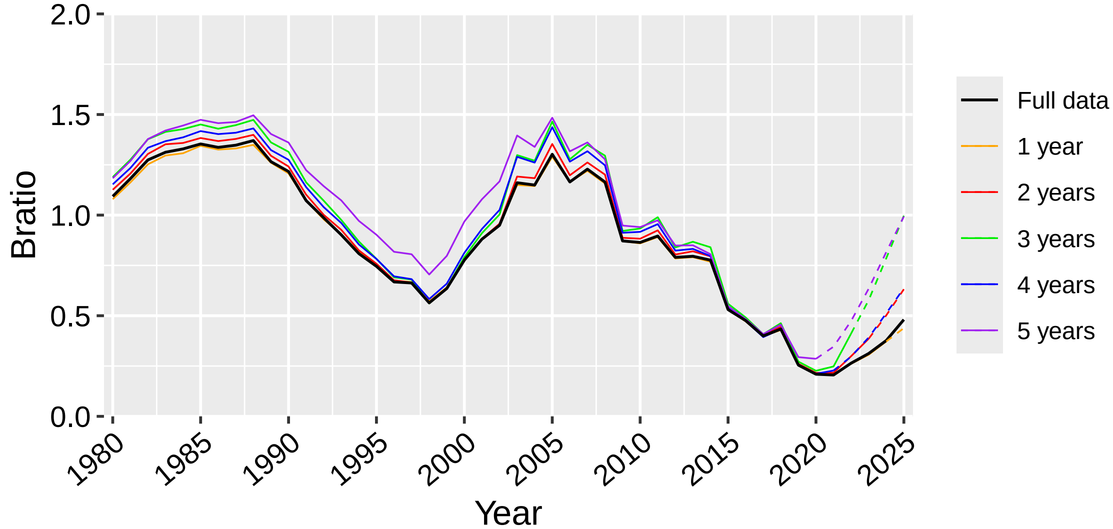


NB2

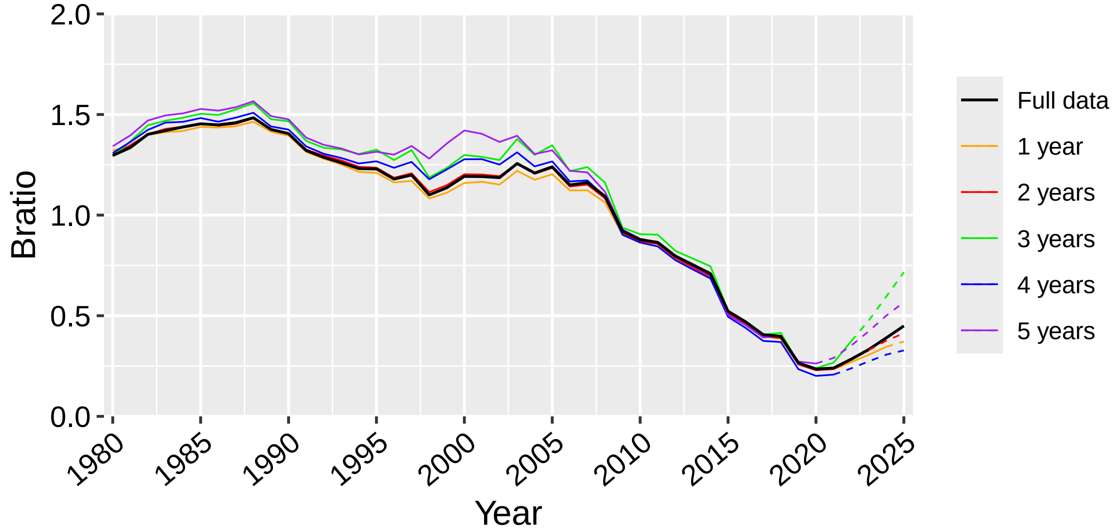


Bratio

NB1

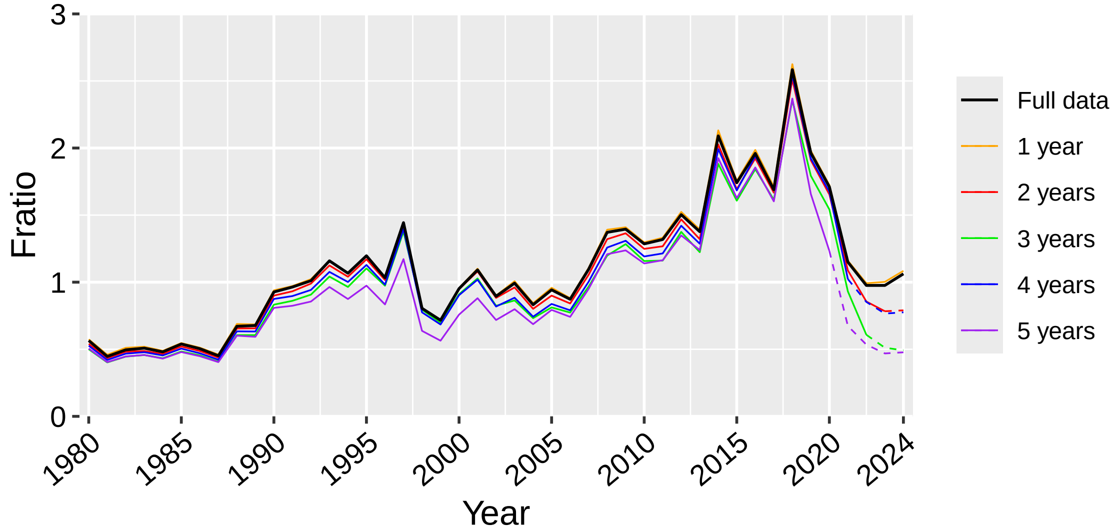


NB2



Fratio

NB1



NB2