Assessment of Longtail tuna, Kawakawa, and Narrow-barred Spanish mackerel using optimised catch-only method

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Input data

Time series of aggregated catch from 1950 to 2018 for the whole Indian Ocean.

Life history parameters (LHPs): natural mortality and maximum lifespan (Table 1).

Table 1. Natural mortality and maximum lifespan for neritic tuna in Indian Ocean.

Stock	Mean M	Median M	Sd M	T_{max}
BLT	0.797	0.649	0.453	8.4
COM	0.411	0.400	0.138	4.8
FRI	0.947	0.914	0.461	3.2
GUT	0.913	0.883	0.421	8.5
KAW	0.776	0.753	0.224	6.4
LOT	0.514	0.440	0.260	9

Methods

The optimized catch-only method (OCOM) is used as the primary tool for this assessment. The R package ocom has been modified recently in several ways. (1) It now constructs population growth rate r based on either one or two life-history parameters: natural mortality M and maximum age T_{max} can be used individually or together. This improvement is based on a recent study that modelled the relationship between r and various LHPs using Bayesian error-in-variable models. (2) The prior for the final saturation S (1-depletion) is based on prediction using Boosted Regression trees (BRT) models. Users have an option to construct the S prior assuming a skewed normal distribution or a beta distribution, where the new beta distribution is the default choice. (3) Users can also manually provide priors for r, S, and the initial saturation S0. These inputs will overwrite the built-in default methods. (4) Users can also choose to use CMSY type of approach to set prior for r and S, or combined the two methods (OCOM and CMSY).

Results

Longtail tuna: the analysis used median M = 0.44 and T_{max} = 9 to construct r prior. The results are shown both in values (Table 2) and figure (Figure 1).

The final depletion level is perhaps the most uncertain parameter. Ocom allows exploring the sensitivity of the estimated S_{2018} to the prior based on BRT prediction. An unrealistically low prior can be assumed to see how low S_{2018} can possibly be given the catch history and population growth rate. To do this we manually set s.prior =c(0, 0.1). The output from this low S indicates that it is unlikely that the stock could have been depleted below 0.248 (Table 3, Figure 2).

In addition, we explored the difference between OCOM and CMSY where r prior is based on resilience, and S based on C_{2018}/C_{max} ratio. The major difference appears to be the low r values from resilience parameter (Table 4, Figure 3).

Similar description for the results can be applied to Kawakawa and Spanish mackerel (Tables 5 to 10, and Figures 4 to 9). It is worth to point out that the r prior for Spanish mackerel may be overestimated because the T_{max} = 4.8 (based on one study) may be too small. As such, it may be more appropriate to construct r prior based on M only. This leads to substantially different results (Table 11 and Figure 10). It is recommended that and small T_{max} should not be used for Spanish mackerel analysis and the results in Table 11 be adopted instead.

Table 2. Summary output from OCOM for Longtail tuna.

Param	q0.1	q0.2	q0.5	q0.8	q0.9
k	438,487	538,824	790,923	1,183,492	1,502,632
r	0.291	0.388	0.645	1.035	1.322
MSY	99,902	110,750	128,750	143,531	151,357
S	0.224	0.255	0.347	0.516	0.606
B_{msy}	219,243	269,412	395,462	591,746	751,316
F_{msy}	0.145	0.194	0.323	0.518	0.661
B_{2018}	157,306	173,029	241,837	477,807	675,717
F_{2018}	0.200	0.283	0.559	0.782	0.860
B_{2018}/B_{msy}	0.449	0.509	0.693	1.033	1.212
F_{2018}/F_{msy}	0.751	0.949	1.529	2.310	2.869

Table 3. Summary output from OCOM for Longtail tuna assuming S2018 is between 0 and 0.1.

Param	q0.1	q0.2	q0.5	q0.8	q0.9
k	416,649	509,474	726,171	1,053,267	1,246,004
r	0.298	0.390	0.669	1.065	1.362
MSY	92,961	102,686	121,404	135,673	141,895
S	0.184	0.205	0.248	0.305	0.343
B_{msy}	208,324	254,737	363,085	526,633	623,002
F_{msy}	0.149	0.195	0.334	0.533	0.681
B_{2018}	148,483	158,746	183,069	215,748	229,423
F_{2018}	0.590	0.627	0.739	0.852	0.911
B_{2018}/B_{msy}	0.368	0.410	0.497	0.610	0.685
F_{2018}/F_{msy}	1.392	1.634	2.242	3.216	3.952

Table 4. Summary output using CMSY prior settings (r based on resilience, and S based on C_{2018}/C_{max}) for Longtail tuna.

Param	q0.1	q0.2	q0.5	q0.8	q0.9
k	1,087,458	1,255,898	1,893,015	3,279,286	4,497,477
r	0.097	0.140	0.278	0.415	0.460
MSY	75,609	91,006	118,982	175,129	227,114
S	0.204	0.269	0.553	0.747	0.820
B_{msy}	543,729	627,949	946,508	1,639,643	2,248,738
F_{msy}	0.048	0.070	0.139	0.207	0.230
B_{2018}	247,151	367,952	962,845	2,288,533	3,357,792
F_{2018}	0.040	0.059	0.141	0.368	0.547
B_{2018}/B_{msy}	0.407	0.538	1.106	1.495	1.640
F_{2018}/F_{msy}	0.364	0.525	1.054	2.750	3.823

Table 5. Summary output from OCOM for Kawakawa tuna.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	384,160	455,878	711,334	1,150,617	1,529,050
r	0.425	0.555	0.888	1.398	1.644
MSY	124,114	132,970	148,825	182,811	222,505
S	0.373	0.434	0.567	0.716	0.788
B_{msy}	192,080	227,939	355,667	575,308	764,525
F_{msy}	0.212	0.277	0.444	0.699	0.822
B_{2018}	189,315	215,172	369,580	728,739	1,054,736
F_{2018}	0.156	0.225	0.444	0.763	0.867
B_{2018}/B_{msy}	0.746	0.868	1.134	1.432	1.576
F_{2018}/F_{msy}	0.467	0.630	0.983	1.416	1.750

Table 6. Summary output from OCOM for Kawakawa tuna assuming S2018 is between 0 and 0.1.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	357,961	415,928	597,310	874,771	1,043,867
r	0.405	0.522	0.869	1.366	1.645
MSY	105,780	114,132	129,767	142,016	147,170
S	0.242	0.272	0.351	0.451	0.506
B_{msy}	178,981	207,964	298,655	437,386	521,934
F_{msy}	0.203	0.261	0.435	0.683	0.822
B_{2018}	181,117	187,611	209,947	237,880	252,961
F_{2018}	0.649	0.690	0.782	0.875	0.906
B_{2018}/B_{msy}	0.485	0.544	0.703	0.902	1.012
F_{2018}/F_{msy}	1.102	1.281	1.799	2.644	3.201

Table 7. Summary output using CMSY prior settings (r based on resilience, and S based on C_{2018}/C_{max}) for Kawakawa tuna.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	803,870	916,027	1,336,847	2,085,605	2,641,414
r	0.260	0.316	0.497	0.680	0.742
MSY	117,358	126,815	151,439	211,077	268,016
S	0.385	0.499	0.633	0.777	0.836
B_{msy}	401,935	458,013	668,424	1,042,802	1,320,707
F_{msy}	0.130	0.158	0.248	0.340	0.371
B_{2018}	353,358	460,699	815,325	1,531,904	2,080,639
F_{2018}	0.079	0.107	0.201	0.356	0.464
B_{2018}/B_{msy}	0.771	0.998	1.266	1.555	1.672
F_{2018}/F_{msy}	0.367	0.501	0.857	1.316	1.823

Table 8. Summary output from OCOM for Spanish mackerel.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	392,522	446,878	647,008	962,627	1,185,060
r	0.491	0.616	0.983	1.507	1.740
MSY	132,144	141,349	157,762	172,891	187,192
S	0.270	0.307	0.402	0.540	0.633
B_{msy}	196,261	223,439	323,504	481,314	592,530
F_{msy}	0.246	0.308	0.491	0.753	0.870
B_{2018}	165,733	173,439	228,400	419,724	590,446
F_{2018}	0.262	0.369	0.678	0.892	0.934
B_{2018}/B_{msy}	0.540	0.613	0.804	1.081	1.266
F_{2018}/F_{msy}	0.654	0.850	1.240	1.750	2.130

Table 9. Summary output from OCOM for Spanish mackerel assuming S2018 is between 0 and 0.1.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	389,283	430,348	592,243	849,011	1,013,013
r	0.491	0.625	1.006	1.497	1.712
MSY	124,303	132,705	148,963	161,081	166,619
S	0.227	0.249	0.308	0.370	0.424
B_{msy}	194,642	215,174	296,122	424,505	506,507
F_{msy}	0.245	0.313	0.503	0.749	0.856
B_{2018}	162,171	166,608	182,528	211,011	230,203
F_{2018}	0.672	0.734	0.848	0.929	0.954
B_{2018}/B_{msy}	0.454	0.497	0.616	0.740	0.848
F_{2018}/F_{msy}	1.096	1.298	1.686	2.346	2.740

Table 10. Summary output using CMSY prior settings (r based on resilience, and S based on C_{2018}/C_{max}) for Spanish mackerel.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	849,286	968,905	1,378,454	2,187,245	2,819,368
r	0.260	0.318	0.502	0.689	0.750
MSY	120,894	131,861	159,370	226,505	299,202
S	0.251	0.307	0.565	0.751	0.823
B_{msy}	424,643	484,453	689,227	1,093,623	1,409,684
F_{msy}	0.130	0.159	0.251	0.345	0.375
B_{2018}	238,012	319,316	732,419	1,548,600	2,217,329
F_{2018}	0.070	0.100	0.211	0.485	0.650
B_{2018}/B_{msy}	0.502	0.614	1.129	1.501	1.646
F_{2018}/F_{msy}	0.315	0.458	0.869	1.967	2.460

Table 11. Summary output from OCOM using natural mortality M only for r.prior construction for Spanish mackerel.

param	q0.1	q0.2	q0.5	q0.8	q0.9
k	570,326	704,209	1,057,118	1,590,127	2,007,273
r	0.240	0.327	0.538	0.882	1.124
MSY	110,443	121,506	141,198	162,547	175,553
S	0.225	0.262	0.373	0.538	0.620
B_{msy}	285,163	352,104	528,559	795,064	1,003,636
F_{msy}	0.120	0.164	0.269	0.441	0.562
B_{2018}	190,809	216,884	352,105	695,600	985,370
F_{2018}	0.157	0.223	0.440	0.714	0.811
B_{2018}/B_{msy}	0.451	0.524	0.747	1.077	1.240
F_{2018}/F_{msy}	0.721	0.912	1.501	2.342	2.949

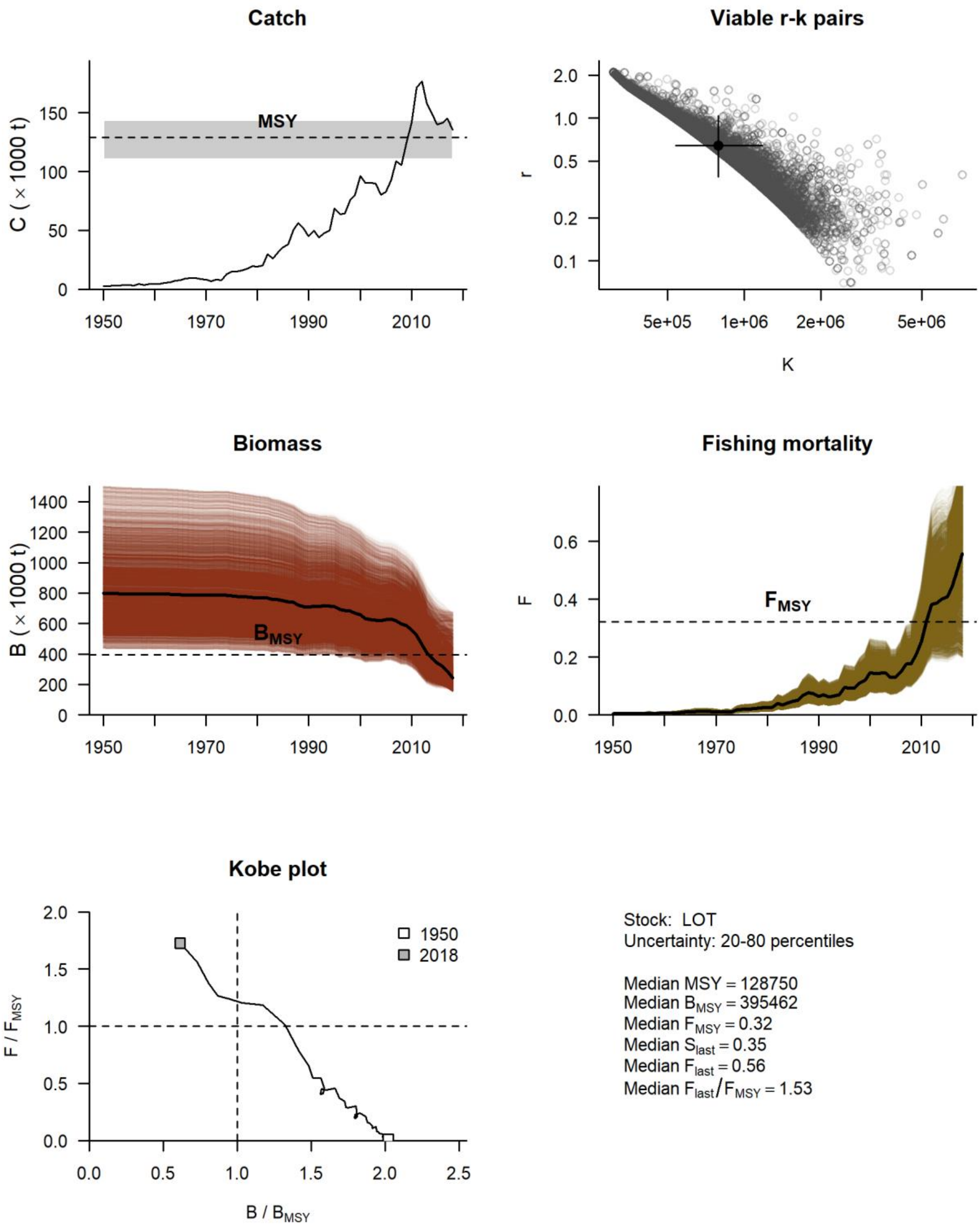

Figure 1. Results from OCOM analysis for Longtail tuna.

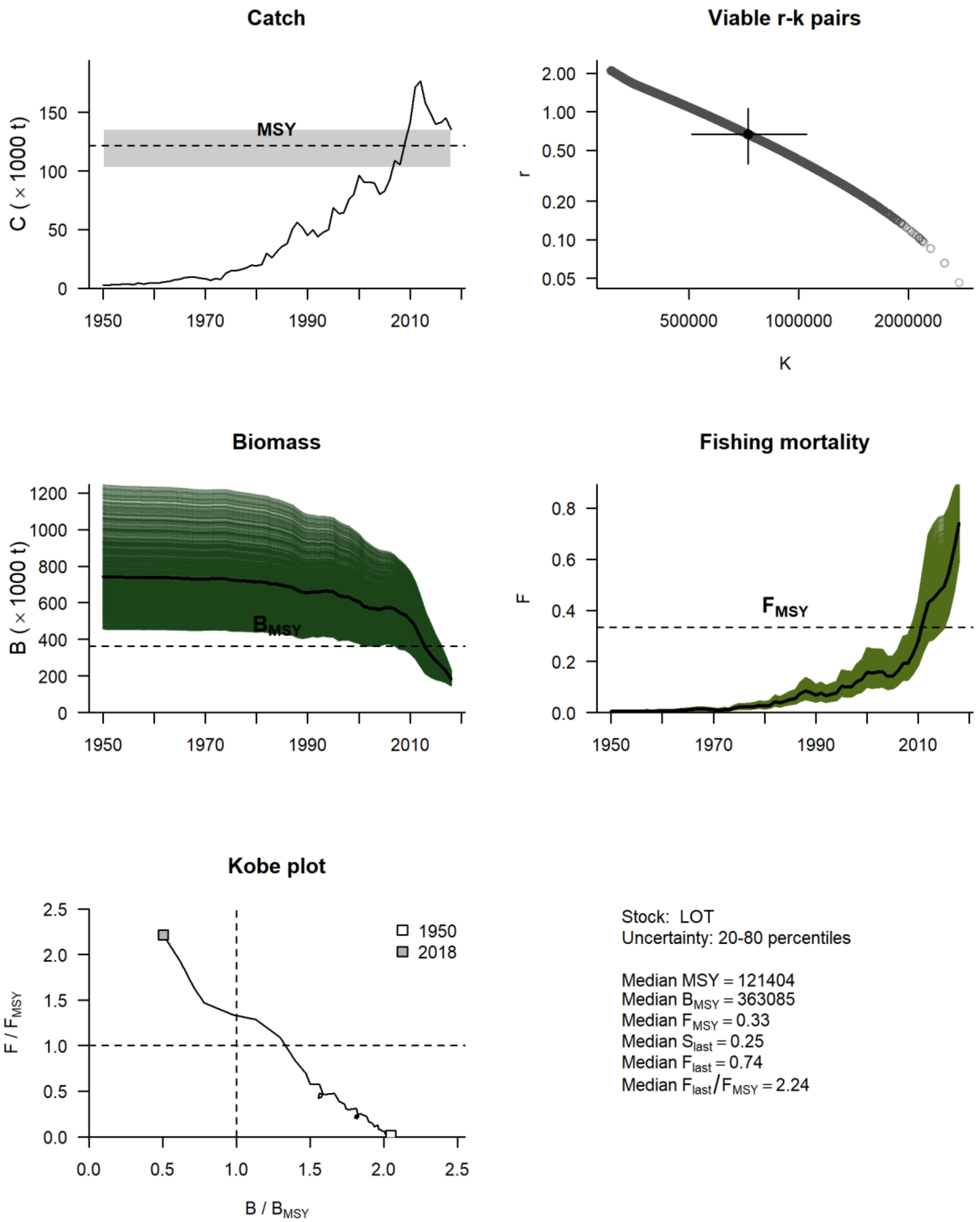

Figure 2. Results from OCOM analysis for Longtail tuna when the prior for the final year saturation S_{2018} is assumed to be very low (S.prior = c(0, 0.1)).

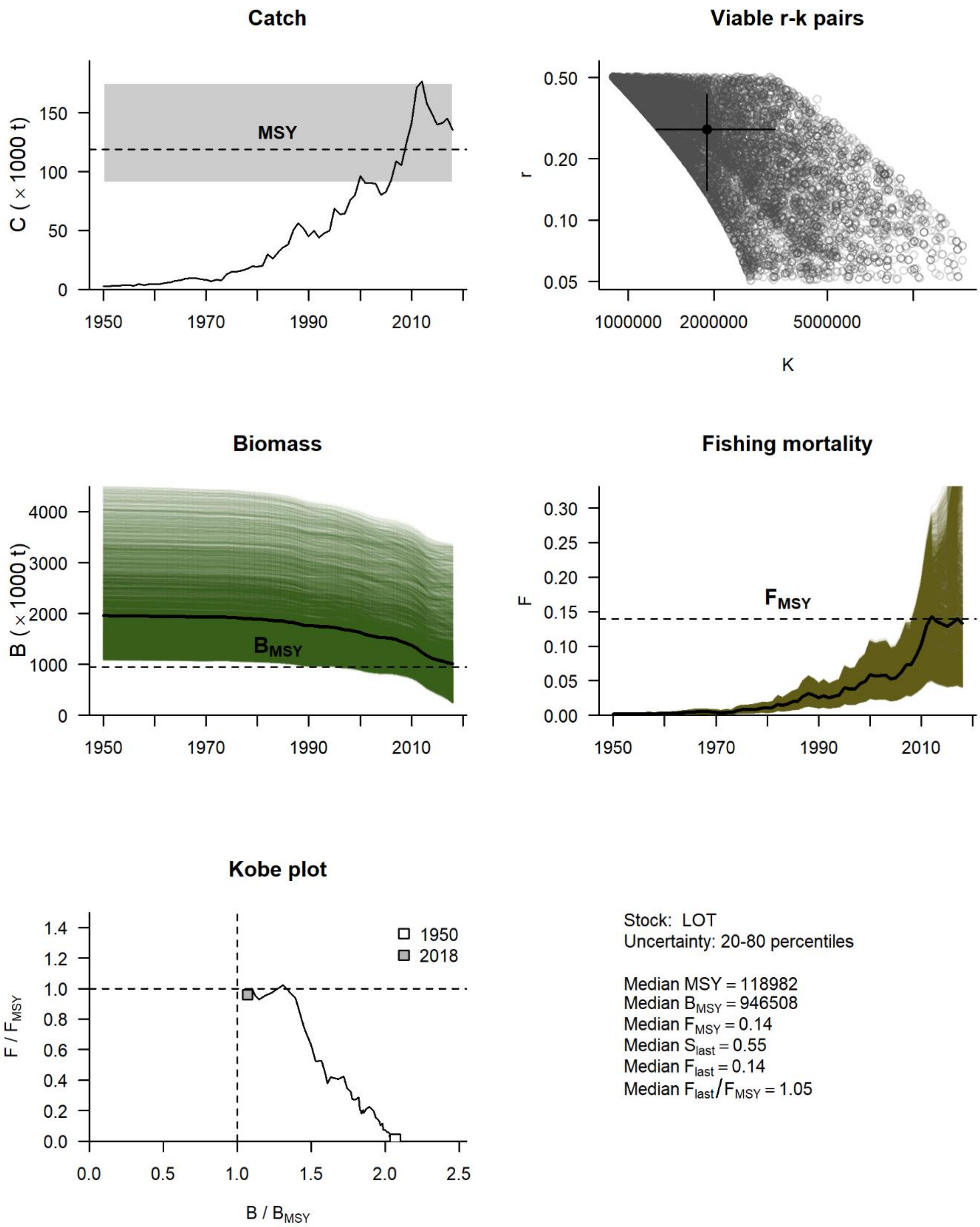

Figure 3. Results for Longtail tuna from CMSY setting of prior r and S.

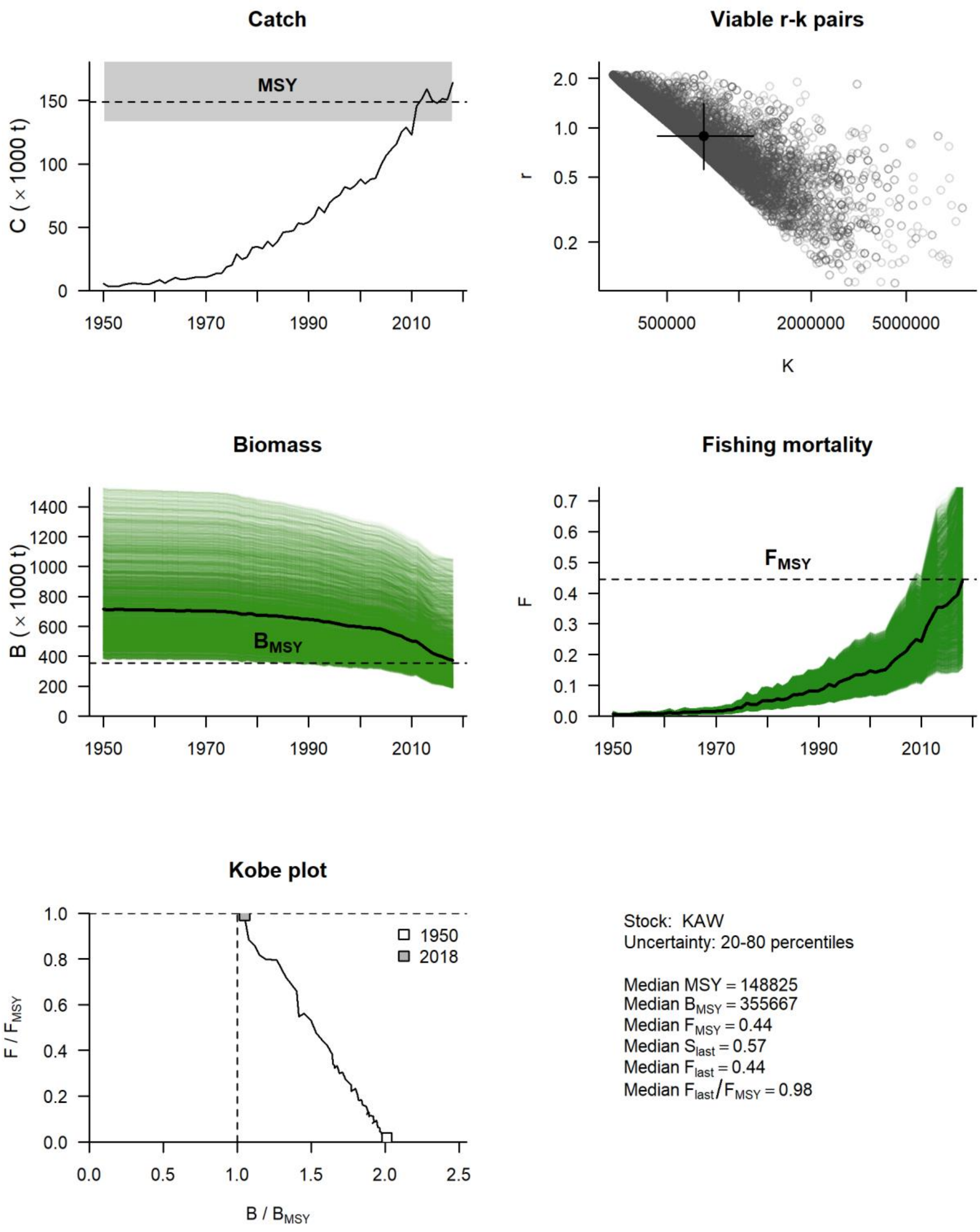

Figure 4. Results from OCOM analysis for Kawakawa tuna.

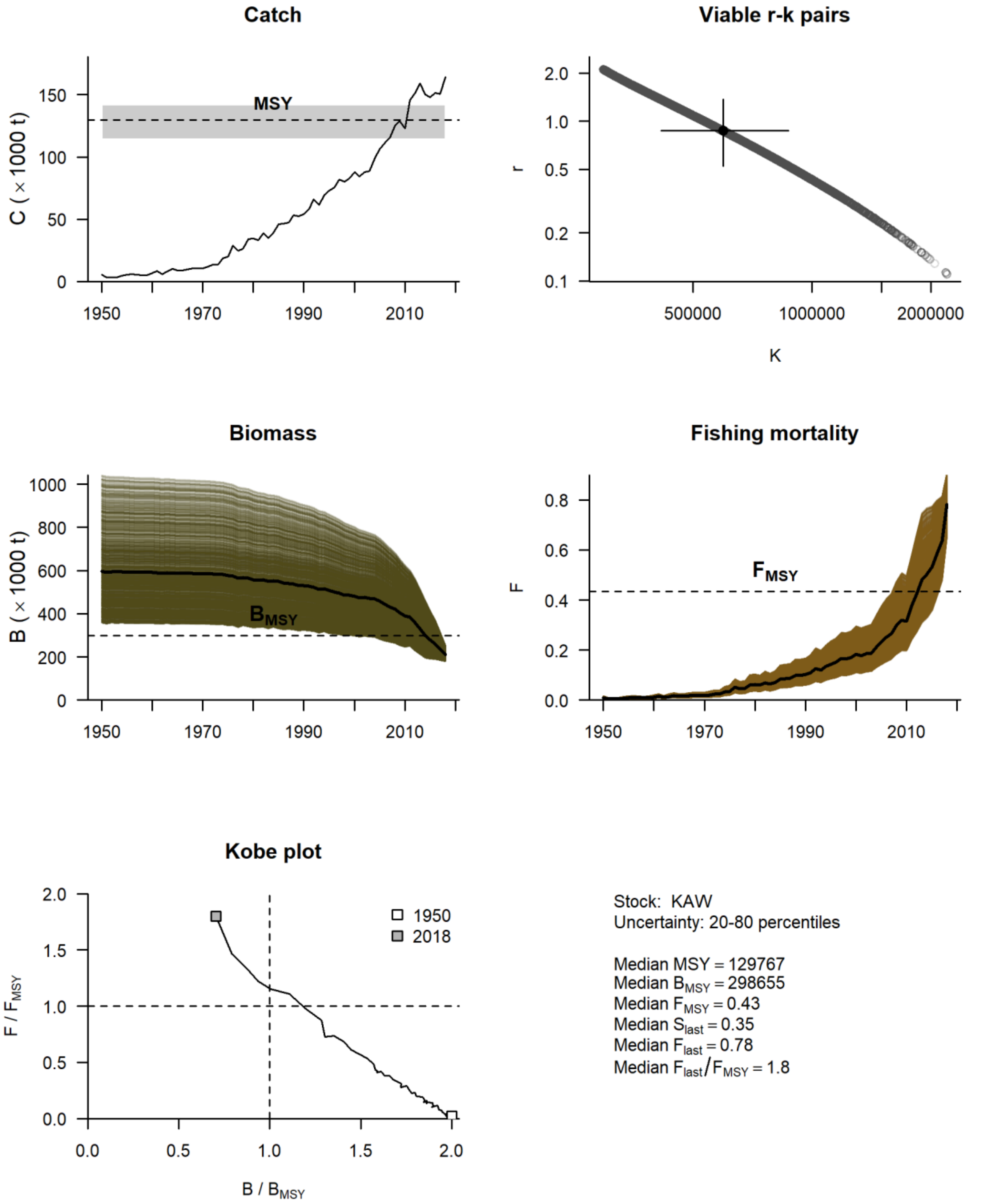

Figure 5. Results from OCOM analysis for Kawakawa tuna when the prior for the final year saturation S_{2018} is assumed to be very low (S.prior = c(0, 0.1)).

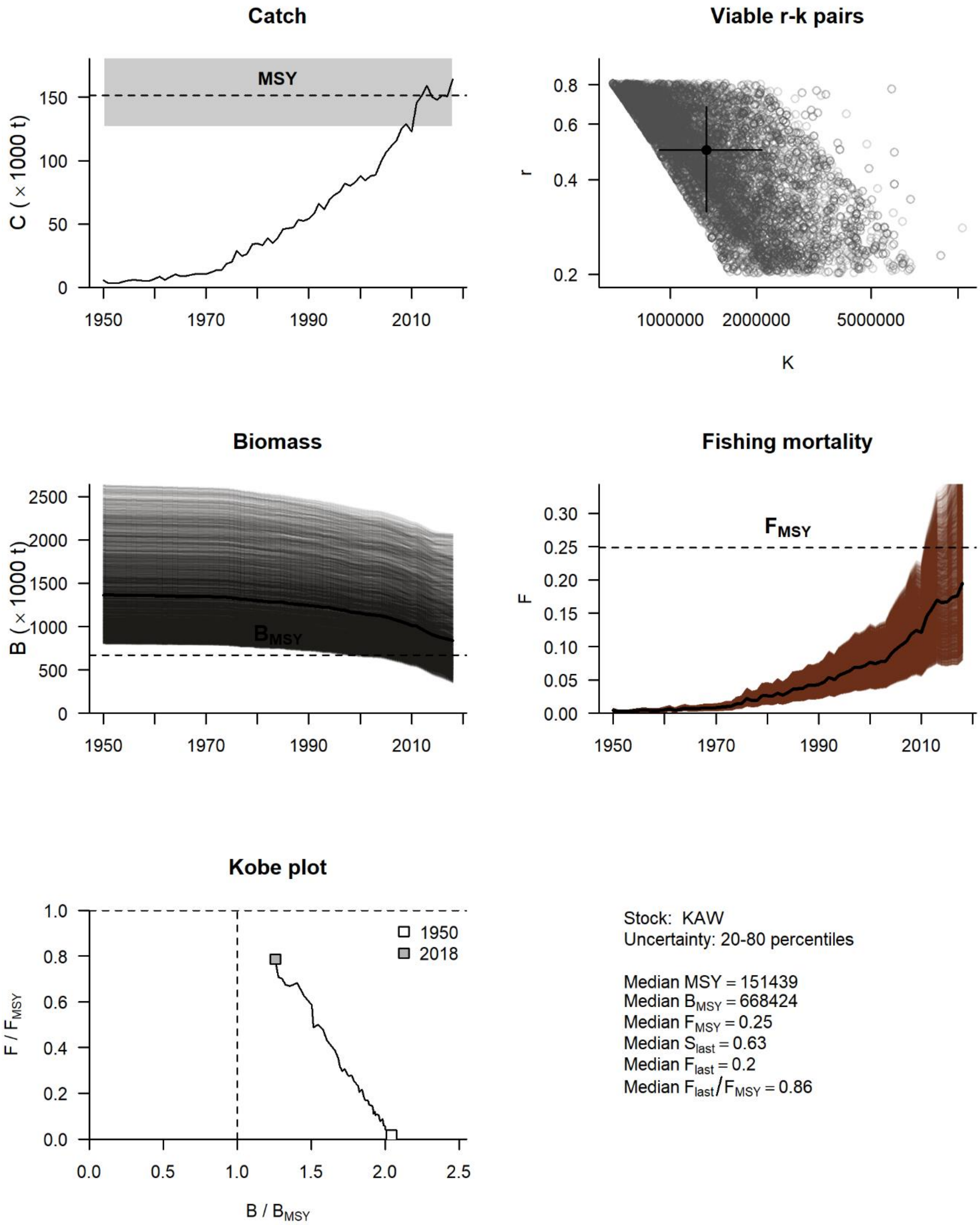

Figure 6. Results for Kawakawa tuna from CMSY setting of prior r and S.

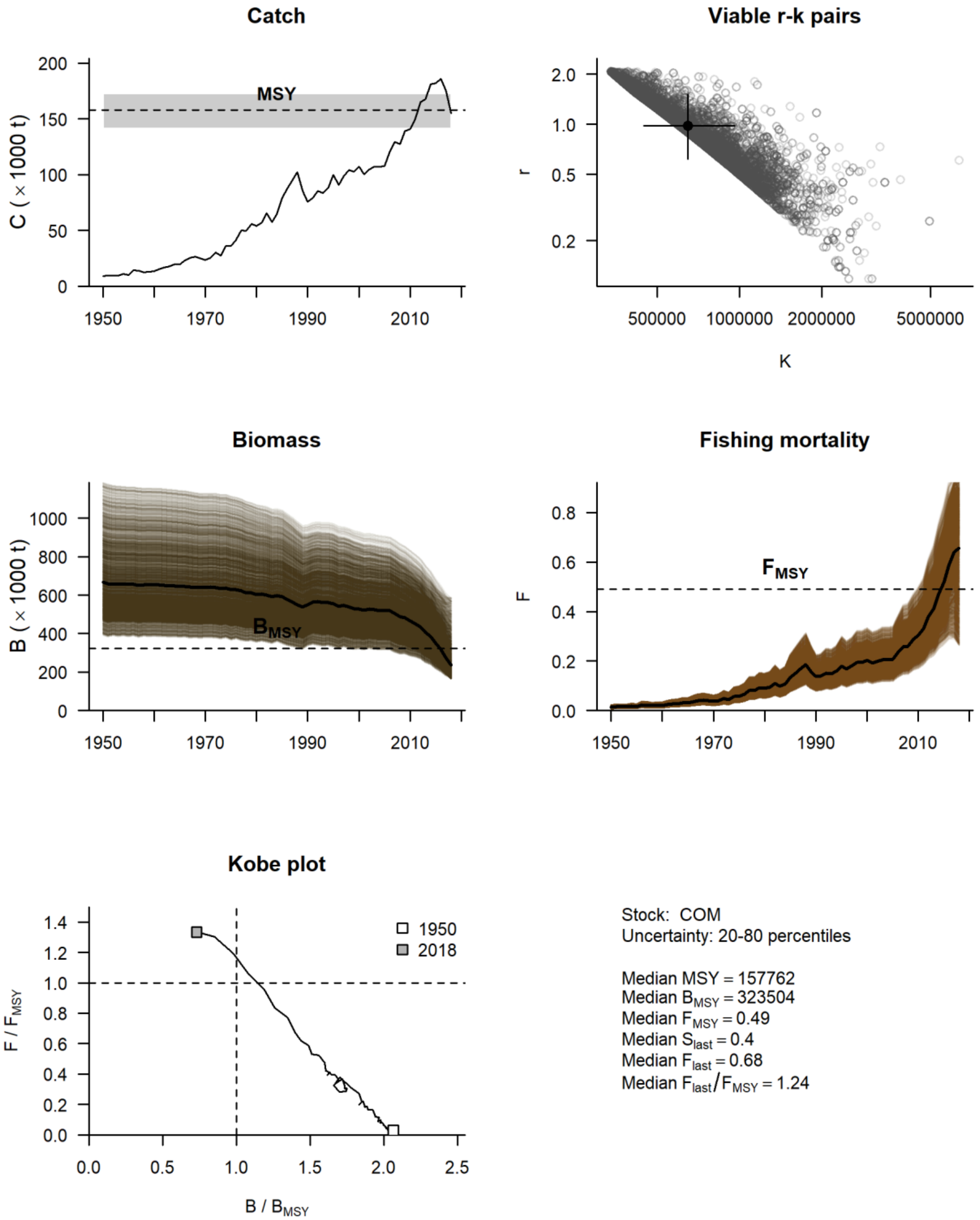

Figure 7. Results from OCOM analysis for Spanish mackerel.

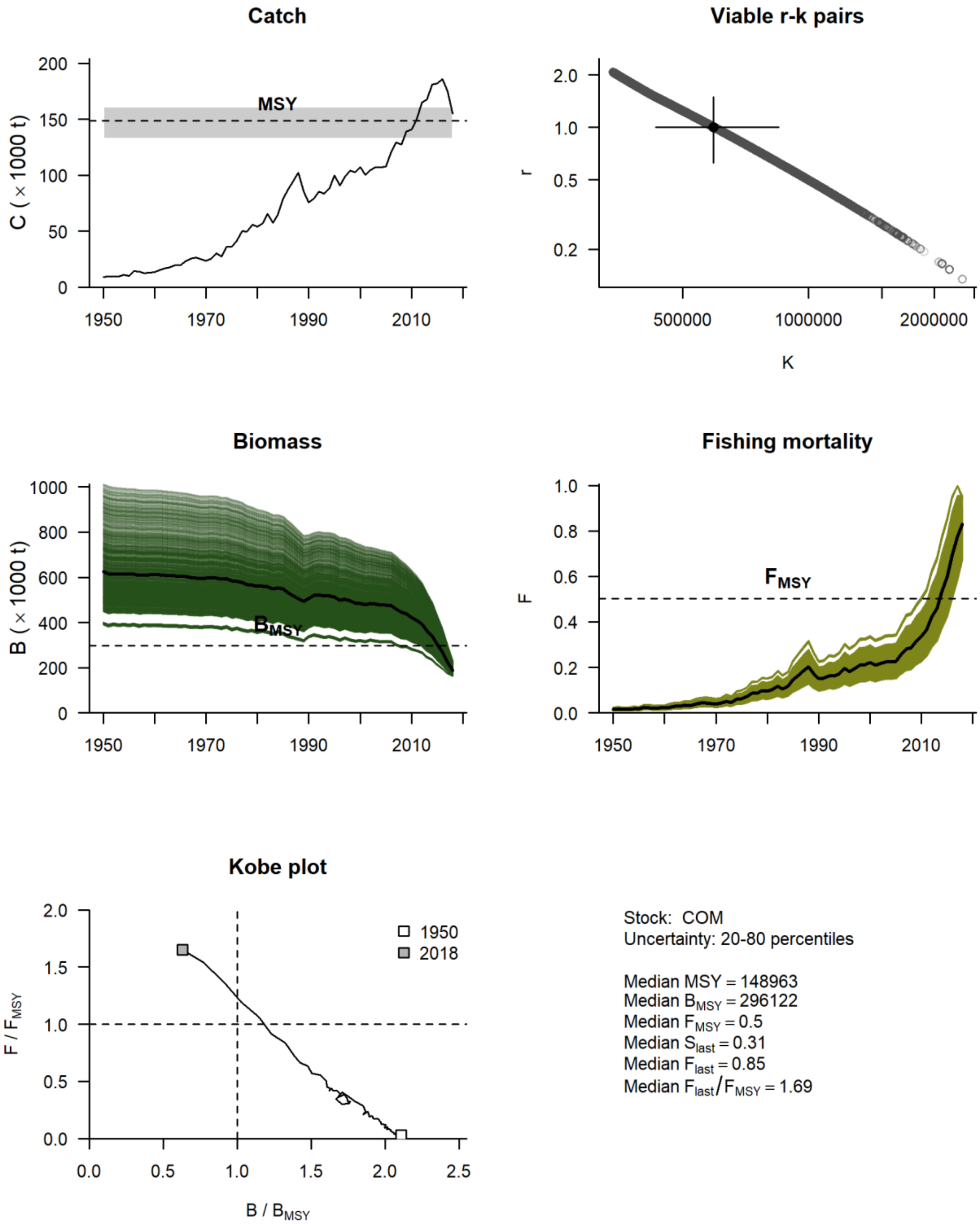

Figure 8. Results from OCOM analysis for Spanish mackerel when the prior for the final year saturation S_{2018} is assumed to be very low (S.prior = c(0, 0.1)).

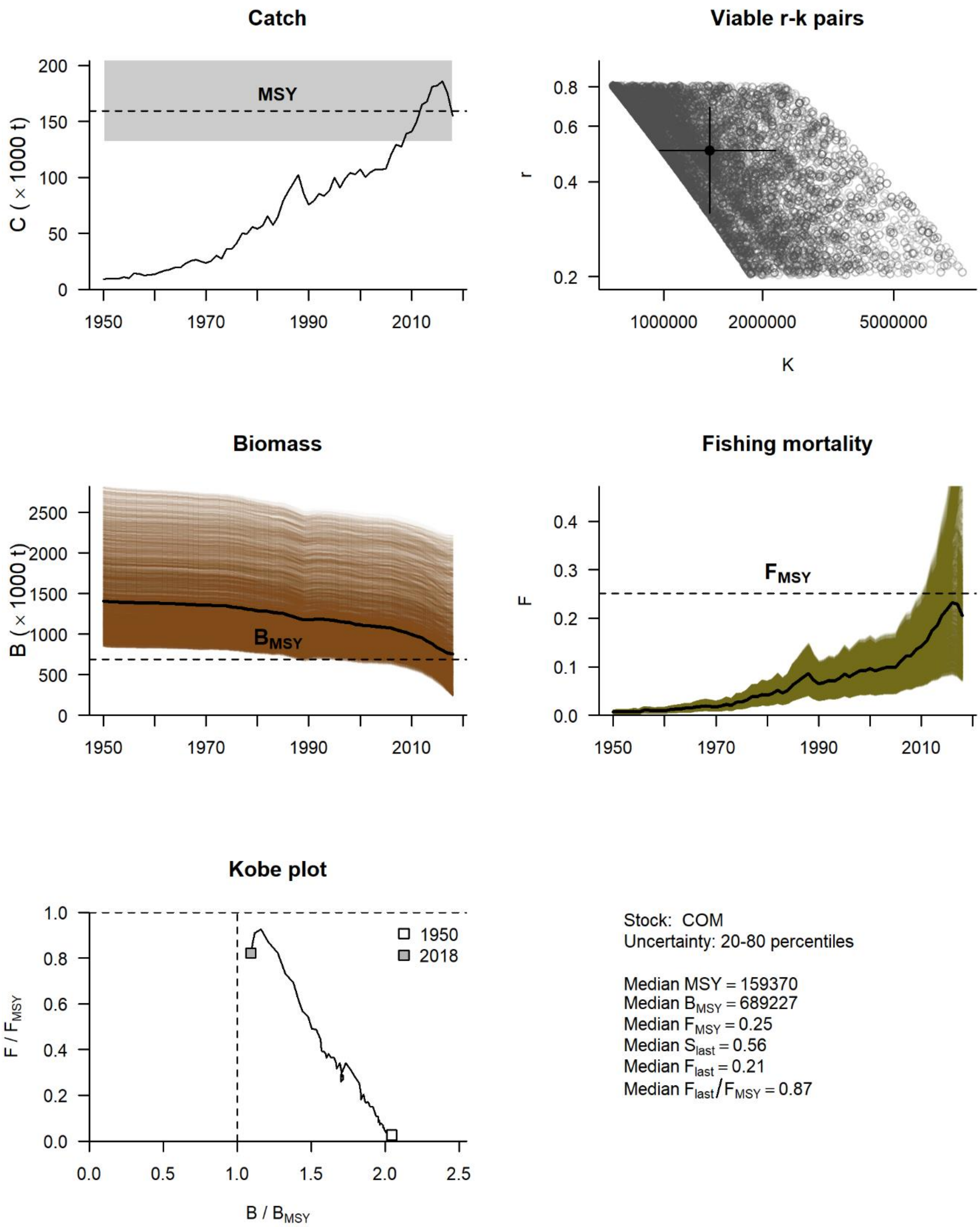

Figure 9. Results for Spanish mackerel from CMSY setting of prior r and S.

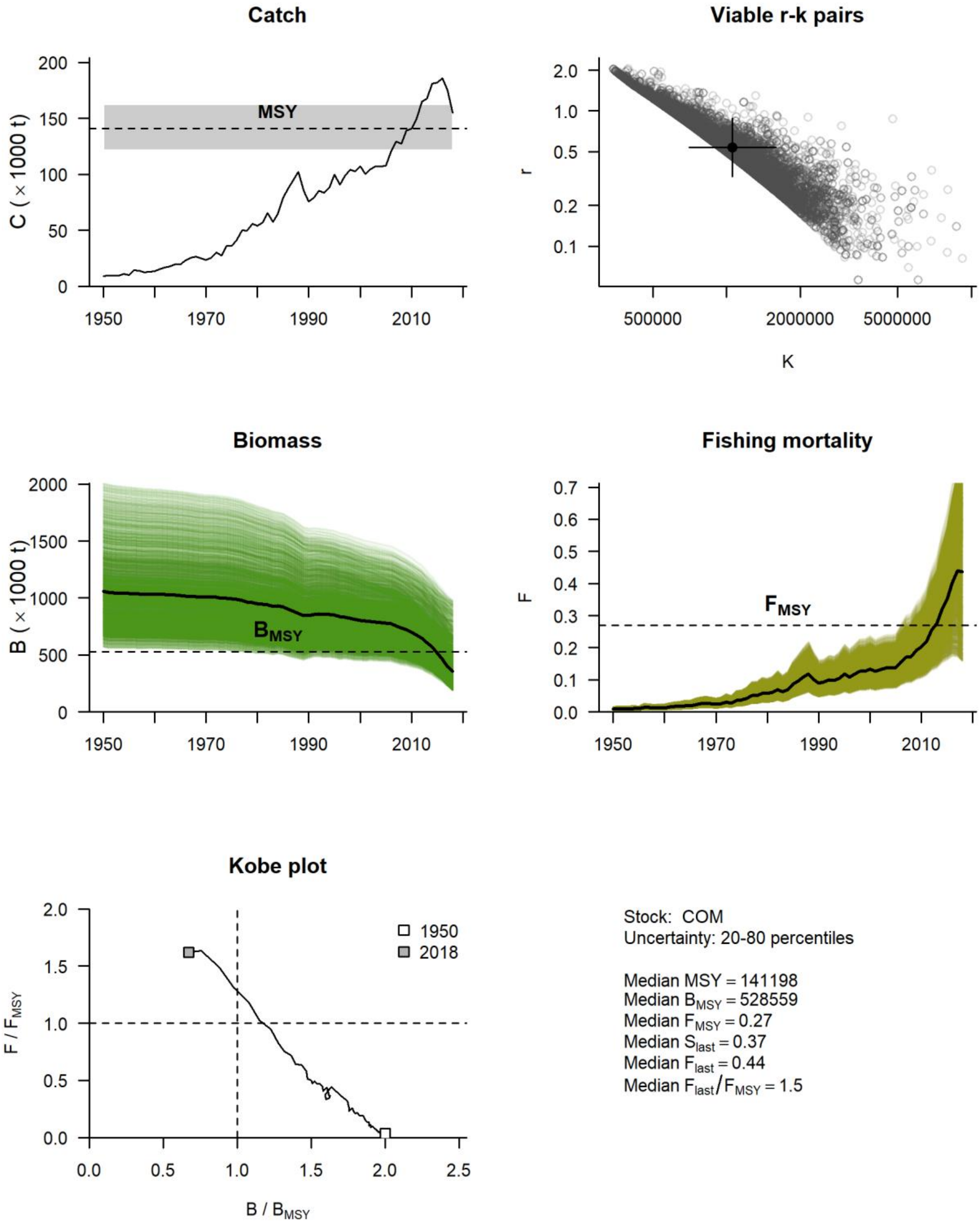

Figure 10. Results from OCOM analysis for Spanish mackerel when the prior for the population growth rate is constructed from natural mortality M only with using lifespan T_{max}.