Update of the Reference case assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity

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ABSTRACT

The Reference case assessment of the Prince Edward Islands (PEI) toothfish (*Dissostichus eleginoides*) resource reported by Brandão and Butterworth (2019) is updated to take the further data now available for 2019 and 2020 into account. The differences in the results between the Reference case model of 2019 and that of 2021 are minimal. With these further two years of data available, the results show a very slightly better status for the resource in 2018, but also a slight decline in abundance over the last two years (which nevertheless still sees the resource well above B_{MSY}).

KEYWORDS: Reference case update, toothfish, Prince Edward Islands

INTRODUCTION

The assessment of the Prince Edward Islands (PEI) toothfish (*Dissostichus eleginoides*) resource carried out by Brandão and Butterworth (2019), which included data up to 2018, is updated to take the further data now available for 2019 and 2020 into account, though for the Reference case only.

The Reference case model makes use of the following data:

- Catch (removals) values, shown in Table 1 with and without the assumed cetacean predation amounts from longlines and trotlines.
- The updated series of relative abundance indices obtained from the CPUE GLMM standardisation procedure described in Brandão and Butterworth (2021) for the trotline commercial data, listed in Table 2.
- Catch-at-length information.
- Number of tags released and recaptured by age (and by fleet for the number of recaptures). A summary of the annual number of fish tagged and the recaptures is shown in Table 3.

The assessments of the toothfish resource presented in this paper have been carried out on the basis of a "fishing"-year *y*, defined to extend from 1 December of year *y*-1 to 30 November of year *y*.

RESULTS AND DISCUSSION

Table 4 shows some key results for the updated Reference case (RC2021) three-fleet assessment of the toothfish resource, as well as for the previous Reference case (RC2019) model (referred to as "new Base case" in Brandão and Butterworth (2019)). Table 5 shows the various contributions to the negative log-likelihood function for both models.

Figure 1 shows estimated trajectories of spawning biomass, spawning biomass depletion and spawning biomass relative to B_{MSY} for the Reference case model of 2019 and that of 2021. The estimated exploitable biomass trajectories for the three fleets are shown in Figure 2. Fits to the CPUE data are shown in Figure 3, while recruitment trends and recruitment residuals are plotted in Figure 4. Figure 5 shows the fit to the cumulative recapture numbers of toothfish, combining the recaptures by longlines and trotlines.

The differences in the results between the Reference case model of 2019 and that of 2021 are minimal. With a further two years of data available, the results show a very slightly better status for the resource in 2018, but also a slight decline in abundance over the last two years (which nevertheless still see the resource well above B_{MSY}).

REFERENCES

Brandão, A. and Butterworth, D.S. 2015. Spanish longline and trotline standardised CPUE series for toothfish (Dissostichus eleginoides) in the Prince Edward Islands EEZ to be used as input for the assessment. DAFF Branch Fisheries document: FISHERIES/2015/OCT/SWG-DEM/38.

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Table 1. Yearly catches of toothfish (in tonnes) estimated to have been taken from the Prince Edward Islands EEZ, which are used for the analyses conducted in this paper. Catches (strictly "removals") from the fisheries modified to include cetacean predation, are also given. Fishing years are defined as the period from December of the preceding year to November of the year indicated.

Fishing Year	Legal			Illegal (IUU)	Total	
	Longline fishery	Pot fishery	Trotline fishery		Without predation	With predation
1997	2 754.9	—	—	21 350	24 104.9	24 104.9
1998	1 224.6	—	—	1 808	3 032.6	3 032.6
1999	945.1	—	—	1 014	1 959.1	1 959.1
2000	1 577.8	—	—	1 210	2 787.8	2 880.8
2001	267.8	—	—	352	619.8	661.1
2002	237.3	—	—	306	543.3	597.6
2003	251.1	—	—	256	507.1	557.8
2004	182.5	34.3	—	156	372.8	406.6
2005	142.6	141.9	—	—	284.5	298.8
2006	169.1	—	—	—	169.1	186.0
2007	245.0	—	—	—	245.0	269.5
2008	88.8	—	56.4	—	145.2	156.9
2009	41.8	—	30.7	—	72.5	78.2
2010	49.2	—	174.6	—	223.7	237.5
2011	1.0	—	290.4	—	291.4	306.0
2012	52.4	—	223.5	—	275.9	292.3
2013	49.7	—	215.6	—	265.3	281.1
2014	—	—	366.9	—	366.9	385.2
2015	—	—	431.3	—	431.3	452.9
2016	—	—	315.5	—	315.5	331.3
2017	—	—	110.8	—	110.8	116.3
2018	—	—	346.1	—	346.1	363.4
2019	—	—	269.5	—	269.5	283.0
2020	—	—	336.7	—	336.7	353.5
1997–2020 total	8 280.7	176.2	3 168.0	26 452	38 076.9	38 592.4

Table 2. Relative abundance indices for toothfish provided by the standardised commercial CPUE series for the Prince Edward Islands EEZ for the longline and trotline fisheries (Brandão and Butterworth, 2015, 2021). Fishing years are defined as the period from December of the preceding year to November of the year indicated.

Fishing Year	Longline fishery	Trotline fishery
1997	3.412	—
1998	1.467	—
1999	1.288	—
2000	1.000	—
2001	0.581	—
2002	0.706	—
2003	0.425	—
2004	0.557	—
2005	0.735	—
2006	0.614	—
2007	0.673	—
2008	0.601	—
2009	0.641	—
2010	0.531	1.209
2011	0.159	1.000
2012	0.334	1.151
2013	0.333	0.949
2014	—	0.783
2015	—	0.833
2016	—	0.545
2017	—	0.547
2018	—	0.906
2019	—	0.847
2020	—	0.687

Table 3. Summary of the number of tagged toothfish and the number of recaptures by year. The numbers in bold *italics* reflect recaptures of toothfish in their first year at large.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Numbers Tagged	175	179	120	140	74	131	206	162	254	380	473	345	115	363	285	366
Recaptures																
2005	*1*															
2006	1†															
2007	1	1	*2*													
2008																
2009			1	2												
2010			1	1												
2011			2	2		4	*1*									
2012	1	1		1		2										
2013					1		4		*1*							
2014		1	1	2		1	1	3	3 (**5†**)	*5*						
2015			1	3			1	3	9	9 (**6†**)	*6*					
2016				1		2		3		13	1(**7†**)	*2*				
2017							1	1	5	9	6	(**1†**)				
2018								2	2	9	11	6	1(**4†**)	*2*		
2019										1	5	3		1(**7†**)		
2020									2	4	5	2	1	5	3(**1†**)	*2*

† These tags, even though recaptured in the following year, had not been at large for more than a year (i.e. more than a 12 month period).

Table 4. Some key estimates for the **Reference case** three fleet (longline, trotline and pot) model when fitted to the CPUE, catch-at-length data and tag-recapture data for toothfish from the Prince Edward Islands EEZ. The estimates shown are for the pre-exploitation toothfish spawning biomass (K^{sp}), the current spawning stock depletion $\left(B^{sp}_{2020}\right)$ in terms of both K^{sp} and B_{MSY}, and the (fleet-specific) exploitable biomass $\left(B^{exp}_{2020}\right)$ at the beginning of the year 2020. For the Reference case of 2019, these estimates are given for the year 2018. Numbers in brackets represent CVs.

Parameter estimates		Model	
		Reference case (2019)	**Reference case (2021)**
K^{sp} (tonnes)		25 582 (0.101)	25 616 (0.097)
B_{MSY} (Longline)		6236	6 250
B_{MSY} (Trotline)		6302	6 316
B^{sp}_{2018}/K^{sp}		0.414 (0.093)	0.418 (0.091)
B^{sp}_{2020}/K^{sp}		—	0.398 (0.090)
B^{sp}_{2018}/B_{MSY} (Longline)		1.698	1.715
B^{sp}_{2018}/B_{MSY} (Trotline)		1.680	1.697
B^{sp}_{2020}/B_{MSY} (Longline)		—	1.632
B^{sp}_{2020}/B_{MSY} (Trotline)		—	1.615
B^{exp}_{2018} (tonnes)	Longline	7 709 (0.108)	9 879 (0.093)
	Pot	13 280 (0.107)	14 274 (0.101)
	Trotline	10 21 (0.108)	11 687 (0.093)
B^{exp}_{2020} (tonnes)	Longline	—	9 431 (0.100)
	Pot	—	14 488 (0.097)
	Trotline	—	11 656 (0.100)

Table 5. Contributions to the negative log-likelihood for the **Reference case** models of 2019 and that of 2021 when fitted to the CPUE, catch-at-length data and tag-recapture data for toothfish from the Prince Edward Islands EEZ.

Parameter estimates		Model	
		Reference case (2019)	Reference case (2021)
-ln L: Length		-956.1	-908.5
-ln L: CPUE		-17.66	-19.16
-ln L: Recruitment		13.393	8.044
-ln L: Tagging		223.9	273.9
-ln L: Total		-736.5	-645.7
MSY (tonnes)	Longline	1 028[†]	1 032[†]
	Pot	1 134	1 138
	Trotline	1 077	1 087

[†] Based upon the average of the two selectivity functions estimated.
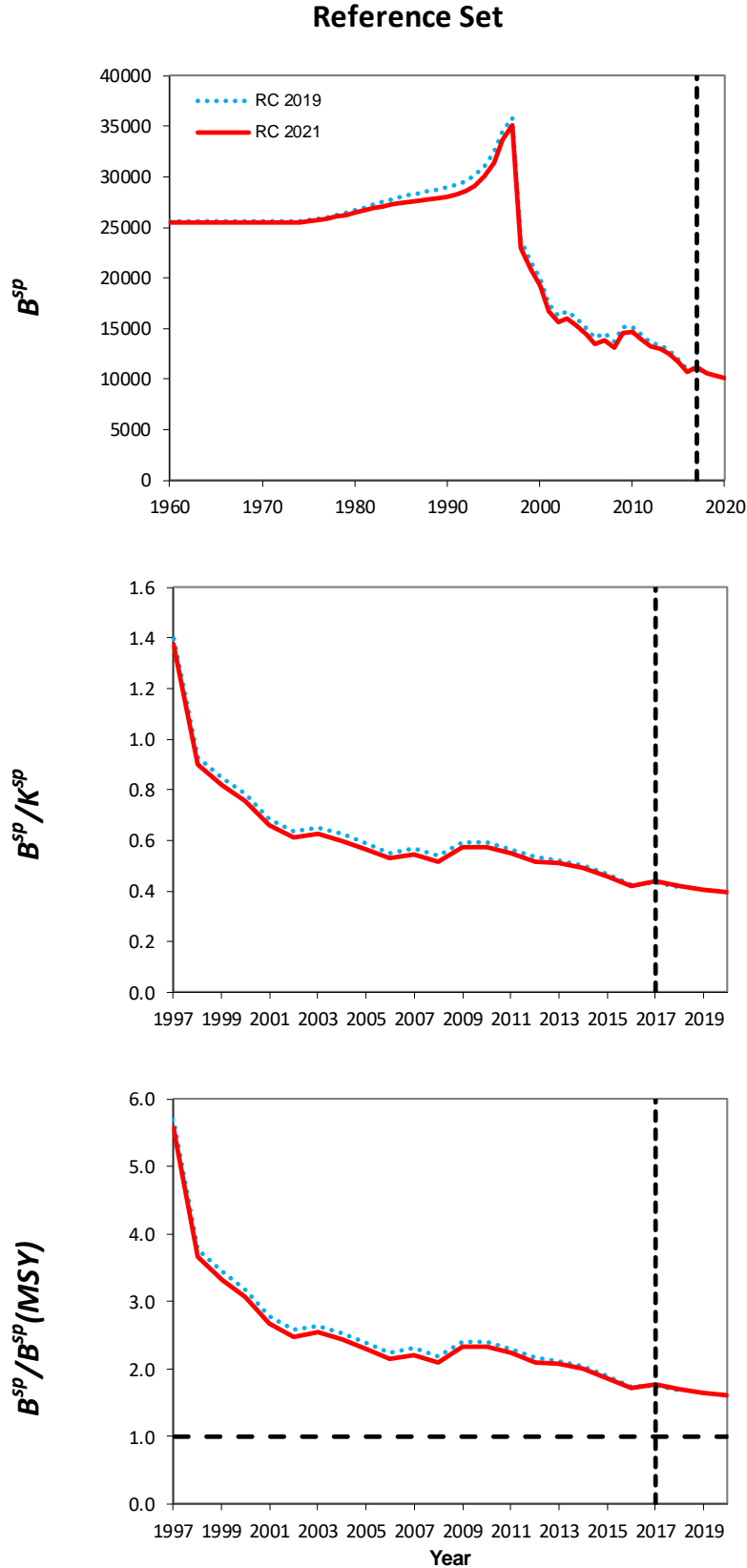
Reference Set

Figure 1. Comparison of the spawning biomass, spawning biomass depletion and spawning biomass relative to B_{MSY} trajectories for the **Reference case** of 2019 and that of 2021. The latter two plots are shown for a more recent time period. The vertical dashed line denotes the year up to which data was used in conditioning the OMP. The horizontal dashed line in the bottom panel denotes the value at which spawning biomass is at B_{MSY}.
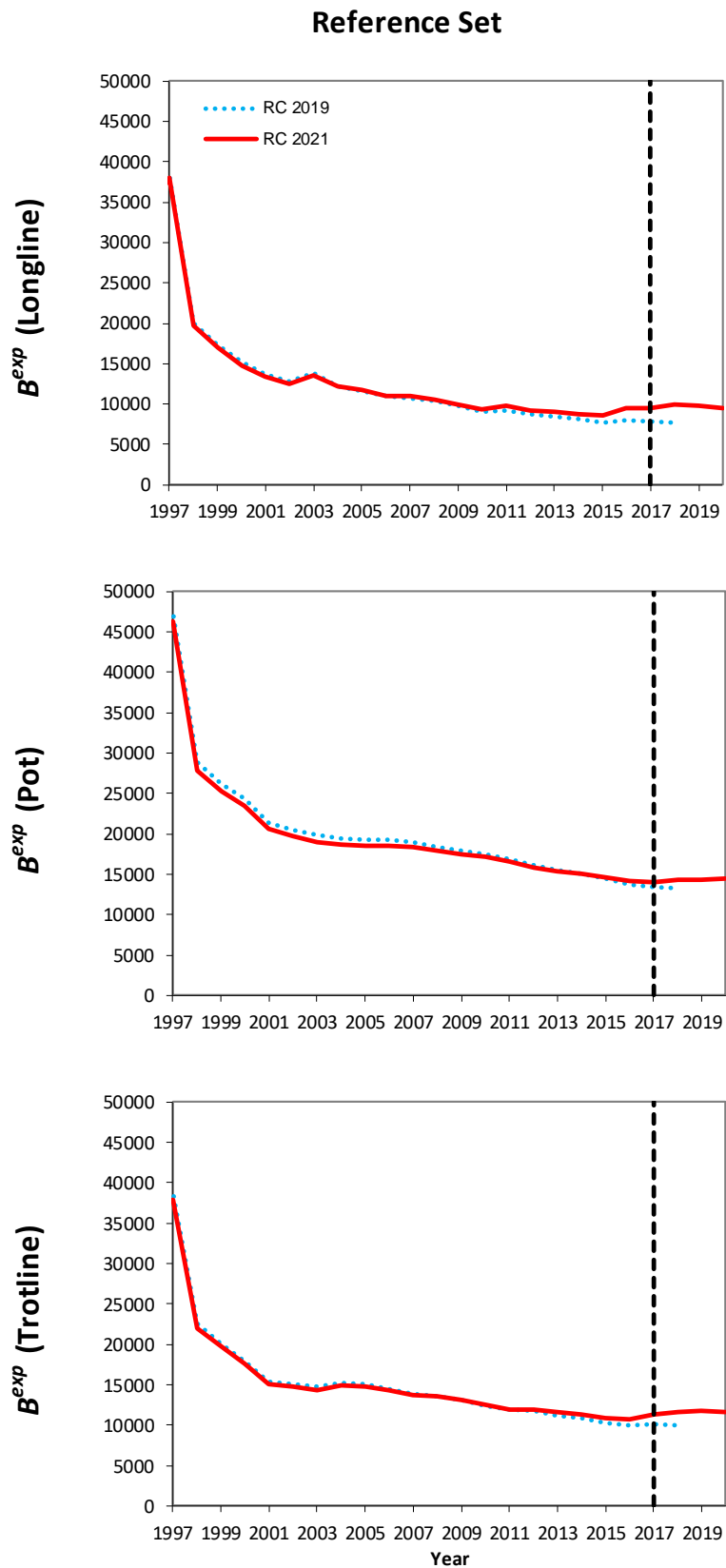
Reference Set

Figure 2. Comparison of the exploitable biomass trajectories for the longline, pot and trotline fleets for the **Reference case** of 2019 and that of 2021. The vertical dashed line denotes the year up to which data were used in conditioning the OMP.
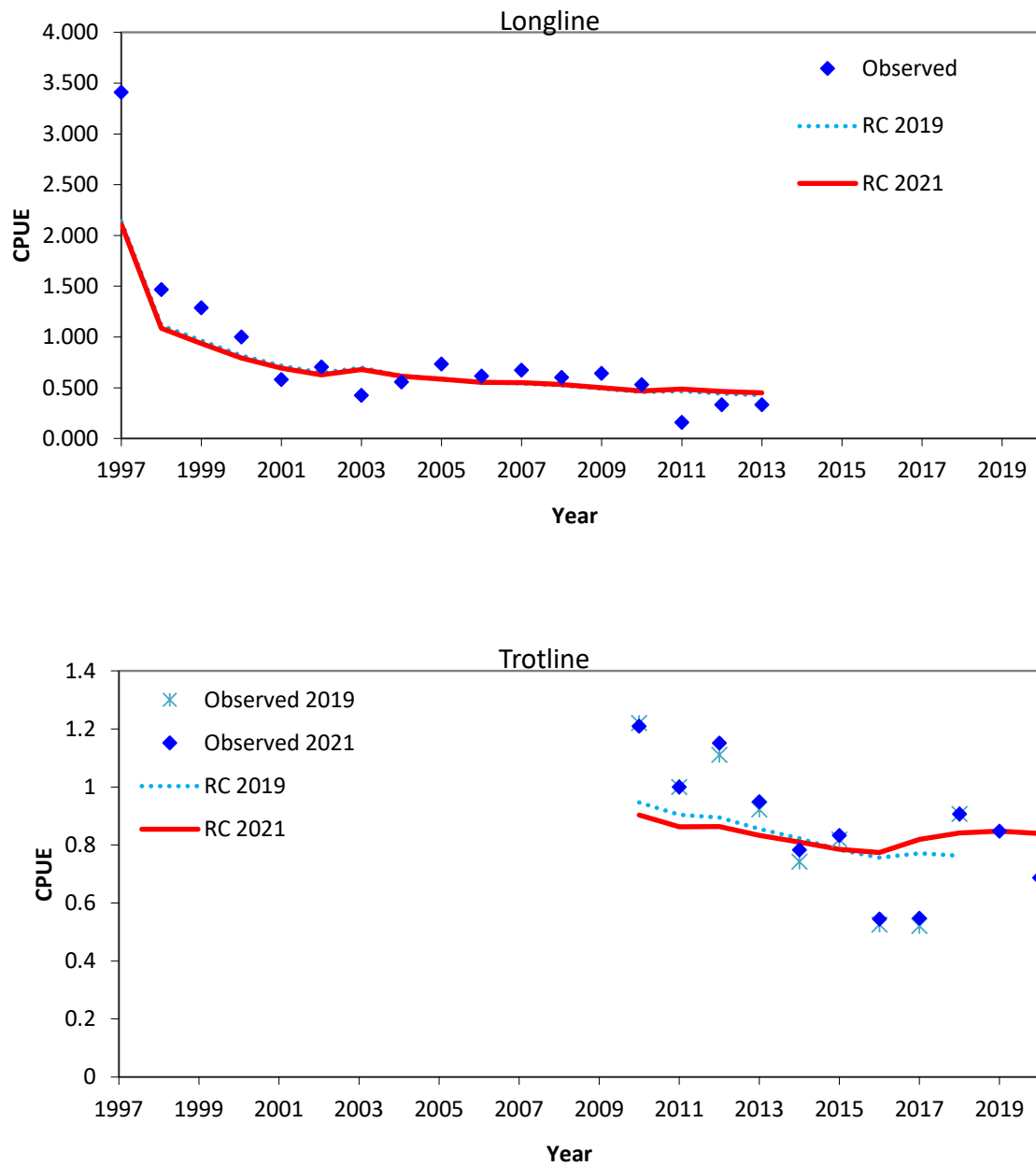
Figure 3. Exploitable biomass and the GLM-standardised CPUE indices to which the model is fit (the predicted values are exploitable biomass multiplied by the estimated catchability q to express them in CPUE units) for the **Reference case** of 2019 and that of 2021.
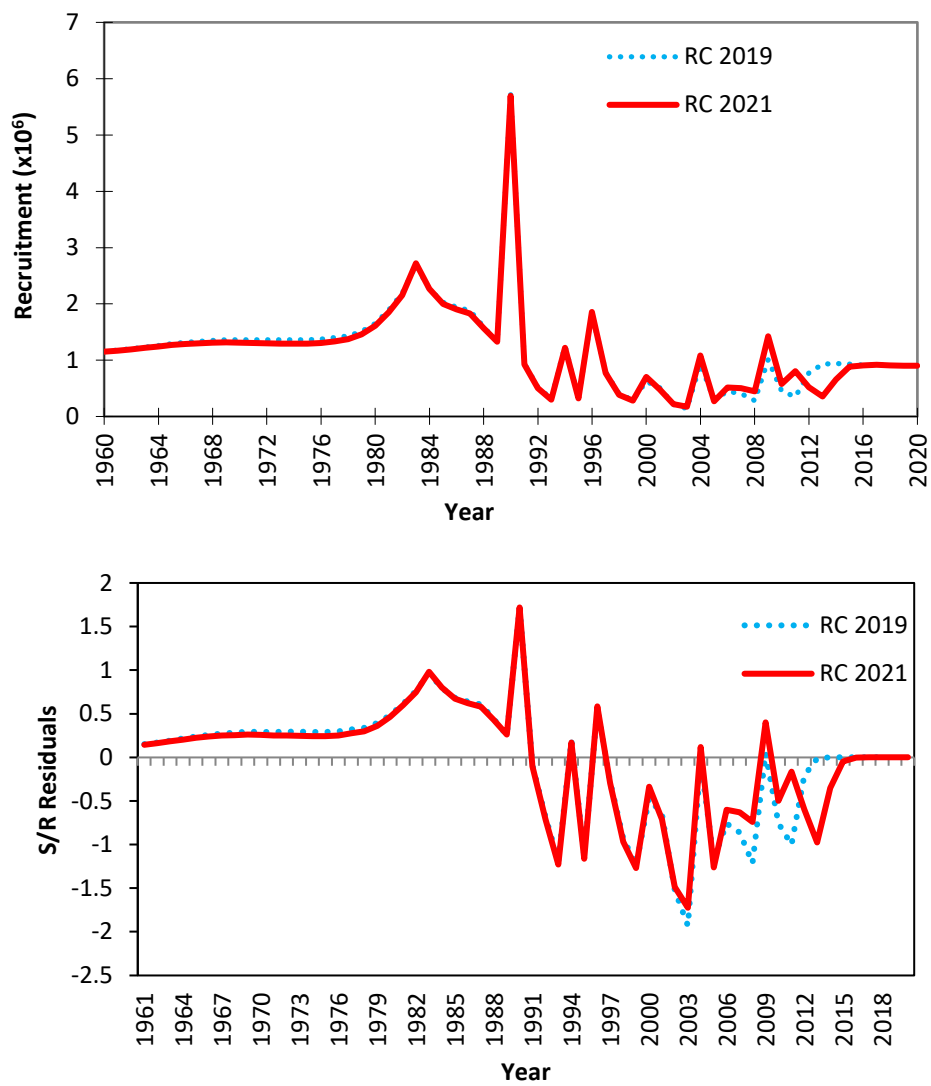
Figure 4. Estimated recruitment numbers and recruitment residuals for the **Reference case** of 2019 and that of 2021.
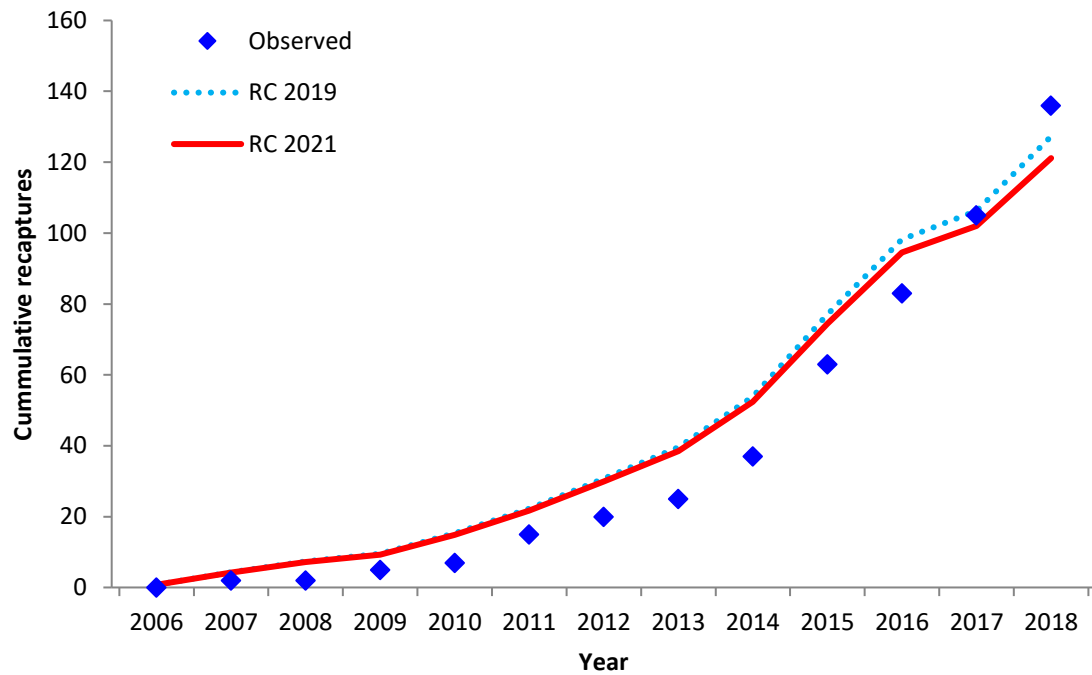
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Figure 5. Observed (diamonds) and model predicted cumulative recapture numbers of toothfish for the **Reference case** model of 2019 and that of 2021.