Continuous approach applied to sardine recruitment survey estimate to advise on juvenile sardine TAB estimates for 2020 and the corresponding recruitment strength

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Abstract

The Bayesian-like update method suggested in FISHERIES/2020/JUN/SWG-PEL/57 is applied to the 2020 recruitment survey estimate for sardine to provide a point estimate and a posterior distribution for this (west component) recruitment strength as correspond to November of the preceding year. These are then compared to historical estimates from the most recent stock assessment. This posterior is also used to inform on possible sardine TAB revisions, though there are important caveats associated with those results.

***Note**: Throughout this document, references to assessment results for sardine recruitment refer to the **west** component of this population.*

Historical recruitment survey results are assumed to be directly proportional to the assessment estimate of recruitment for November of the previous year (see equation (4) of "A POSSIBLE STRAIGHTFORWARD APPROACH TO TAC UPDATE GIVEN A SURVEY ESTIMATE OF RECRUITMENT": FISHERIES/2020/JUN/SWG-PEL/57):

$$ln\ surv(y) = ln\ R(y) + ln\ k + eps(y) \qquad eps(y) \sim N(0, sig^2) \qquad (4)$$

where *R(y)* is the historical assessment estimate of November recruitment in calendar year *y-1* and *surv(y)* is the corresponding recruitment survey result for historical year *y*. Note that the assessment recruitment value from year *y-1* is therefore matched to the recruitment survey result for year *y*, and the years shown in the plots correspond to the year of the recruitment survey.

The approach of FISHERIES/2020/JUN/SWG-PEL/57 is designed to provide advice on how previous catch limits recommendations might be revised given results from the 2020 recruitment survey, but as part of that process they also provide posterior distributions for the corresponding November recruitment.

Results are shown for three regression options: (a) the entire 1985-2019 series, (b) a 2005-2019 series and (c) the 2005-2019 series but with the 2010 point excluded. The analyses were run for (b) as the residuals for the fit for (a) indicated a relatively strong trend with time, and for (c) as the 2010 year has been suggested to be an outlier. A plot of *surv(y)* against *R(y)* is shown for the three options in Figure 1, along with the fit from equation (4). A plot of the residuals *eps(y)* against year from the regression fit is shown in Figure 2 for all options, where $eps(y) = ln\ surv\_hat(y) - ln\ surv(y)$. The estimate of *sig* for option (a) is 0.50, for option (b) 0.64 and for option (c) 0.60.

Table 1 lists the data used in the analyses. Table 2 shows the results leading to the updated priors, which are shown in Figure 4. Table 3 lists the updated TAB values that arise when these updated priors are applied to the consequence matrices. Table 4 gives a calculation example for (a) and (b). Figure 3 provides further diagnostic plots for the fits of equation (4) to the data for option (a) and (b). Figure 5 plots the normal distribution corresponding to the last five data points from 2015-2019 which are equally weighted in providing a prior for (November) recruitment, and the posterior distributions that are estimated when the 2020 recruitment survey estimate is used to update (i.e. provide a posterior distribution) for the corresponding November recruitment (Note that the normal distribution reflecting the 2015-2019 values has been used to provide a more convenient comparison with the posterior distributions for 2020 than would a

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set of five delta functions!). Figure 6 plots of the November recruitment estimates against year to compare with the point estimates from the regressions.

Two important caveats apply to the results for TABs shown in Table 3.

a) Their computation generally requires extrapolation beyond the ranges of R(i) and TAB values for which consequence matrices were available, with some of those consequence values showing little contrast across that range of TAB values and hence diminishing computation accuracy.

b) The consequence measures themselves (three of the four are based on SSB) are not optimal choices for reflecting the impact of a changed level of juvenile sardine TAB, as changes in the predominantly 0-year-old juvenile sardine catches concerned will have relatively little impact after only one year, with that impact greater after a further year or two later.

As regards the point estimates provided for the November recruitment corresponding to the 2020 survey result, Figure 6 shows that these are very similar to the median (16.9) for the full previous period, though below the mean (33.1). For the period from 2005 onwards, they are well above both the median (13.5) and the mean (14.9), but these estimates for 2020 must also be interpreted taking account of their fairly wide associated probability distributions as shown in Figure 5.

Table 1: Data used in the analyses. The assessment estimates for November recruitment (in billions of fish) correspond to the year before the one listed in the year column. The regression for option (a) uses the data for all years to 2019, option (b) excludes data prior to 2005 and option (c) further excludes the year 2010.

Year *y*	Assessment estimate of November recruitment for year *y-1*	Recruitment survey estimate for year *y*
1985	11.498	3.592
1986	11.143	3.691
1987	19.948	7.380
1988	2.189	0.440
1989	15.215	2.137
1990	7.643	2.502
1991	6.410	1.915
1992	23.540	5.633
1993	46.531	15.238
1994	7.575	2.654
1995	54.408	25.388
1996	11.247	3.204
1997	65.949	36.856
1998	57.663	10.716
1999	56.683	10.378
2000	56.911	20.002
2001	152.804	60.065
2002	149.894	49.153
2003	141.634	36.448
2004	18.098	4.089
2005	12.781	2.858
2006	16.736	9.506
2007	9.111	2.995
2008	18.376	4.090
2009	16.996	9.289
2010	33.847	35.569
2011	17.108	5.799
2012	24.191	7.986
2013	12.747	12.586
2014	5.780	1.985
2015	11.594	6.258
2016	6.987	0.811
2017	8.109	7.180
2019	14.145	3.540
2020		7.010

Table 2: The panels below lists the values of the assessment estimates of recruitment, **R(i)**, values (note that these refer to the November of the year prior to the one in which the recruitment survey takes place) from the last five years, the uniform prior and its normalised value, the expected recruitment survey result (surv_hat) given the regression equation (4), the likelihood of each surv_hat value given the actual June 2020 survey recruitment value (7.01), and the updated prior taking this likelihood into account.

(a) All data points				Surv(2020)	7.01	
R(i)	**P(R,i)**	**P(R,i) normalized**	**surv_hat**	**L(i|CPUE)**	**P*L**	**Pup(R,i)**
14.1447	1.000	0.2000	4.7013	0.580	0.116	0.497
11.5935	1.000	0.2000	3.8534	0.390	0.078	0.334
8.10899	1.000	0.2000	2.6952	0.128	0.026	0.109
6.98689	1.000	0.2000	2.3223	0.069	0.014	0.059
3.47028	1.000	0.2000	1.1534	0.001	0.000	0.001

(b) Excluding points for y<2005				Surv(2020)	7.01	
R(i)	**P(R,i)**	**P(R,i) normalized**	**surv_hat**	**L(i|CPUE)**	**P*L**	**Pup(R,i)**
14.1447	1.000	0.2000	5.6766	0.594	0.119	0.359
11.5935	1.000	0.2000	4.6527	0.510	0.102	0.308
8.10899	1.000	0.2000	3.2543	0.303	0.061	0.183
6.98689	1.000	0.2000	2.8040	0.222	0.044	0.134
3.47028	1.000	0.2000	1.3927	0.025	0.005	0.015

(c) Excluding 2010				Surv(2020)	7.01	
R(i)	**P(R,i)**	**P(R,i) normalized**	**surv_hat**	**L(i|CPUE)**	**P*L**	**Pup(R,i)**
14.1447	1.000	0.2000	5.2714	0.598	0.120	0.397
11.5935	1.000	0.2000	4.3207	0.482	0.096	0.320
8.10899	1.000	0.2000	3.0221	0.247	0.049	0.164
6.98689	1.000	0.2000	2.6039	0.168	0.034	0.112
3.47028	1.000	0.2000	1.2933	0.012	0.002	0.008

Table 3: Updated juvenile sardine TABs for different consequence matrices for all three options. Note that the original TAC recommendation of 34.05 kt consists of 9.4 kt TAB and 24.65 kt for other allocations. The values in the table below assume that the amount for other allocations remains unchanged at 24.65 kt with only the TAB changed. The values shown all refer to TAB only, specifically the value to which it could be increased from 9.4 kt.

	(a) All data points			(b) Exclude y<2005			(c) Exclude 2010		
Updated TAB	5%	20%	50%	5%	20%	50%	5%	20%	50%
Multiplicative delta in effSSB	25.23	23.04	28.09	24.03	19.88	23.52	24.63	20.92	25.00
Additive delta in effSSB	29.31	38.27	38.45	18.06	21.29	22.20	20.09	24.54	25.32
Additive delta in B	52.34	62.83	52.34	32.81	41.49	32.81	37.62	47.14	37.62
Relative Multiplicative delta	17.47	12.77	11.86	11.94	12.06	11.55	12.26	12.78	11.67

Table 4: Calculation example for (iii) Additive delta in B 20%. The yellow highlighted cell shows the target Ccrit value for the original 34.05 kt recommendation (including a 9.4 kt TAB), and the green highlighting marks the cells that have been used for the linear extrapolation to obtain the updated TAB. The column headers refer to the TAB. Note that the example for (c) as not been included here.

(a) Additive delta in B- 20% for all data									
	7.4	8.4	9.4	10.4	11.4	12.4			
14.1	25.000	24.000	24.000	23.000	22.000	22.000			
11.6	8.000	8.000	7.000	6.000	6.000	5.000			
8.1	-14.000	-15.000	-15.000	-16.000	-17.000	-17.000			
7.0	-22.000	-22.000	-23.000	-23.000	-24.000	-25.000			
3.5	-44.000	-45.000	-46.000	-46.000	-47.000	-47.000			
Ccrit(j)	-9.400	-10.000	-10.600	-11.200	-12.000	-12.400	m	c	TAC update
Ccrit(j) update	12.209	11.602	11.208	10.268	9.602	9.209	-2.55	60.50	62.8

(b) Additive delta in B- 20%, excluding points for y<2005									
	7.4	8.4	9.4	10.4	11.4	12.4			
14.1	25.000	24.000	24.000	23.000	22.000	22.000			
11.6	8.000	8.000	7.000	6.000	6.000	5.000			
8.1	-14.000	-15.000	-15.000	-16.000	-17.000	-17.000			
7.0	-22.000	-22.000	-23.000	-23.000	-24.000	-25.000			
3.5	-44.000	-45.000	-46.000	-46.000	-47.000	-47.000			
Ccrit(j)	-9.400	-10.000	-10.600	-11.200	-12.000	-12.400	m	c	T update
Ccrit(j) update	5.274	4.716	4.259	3.408	2.716	2.274	-2.26	42.19	41.5

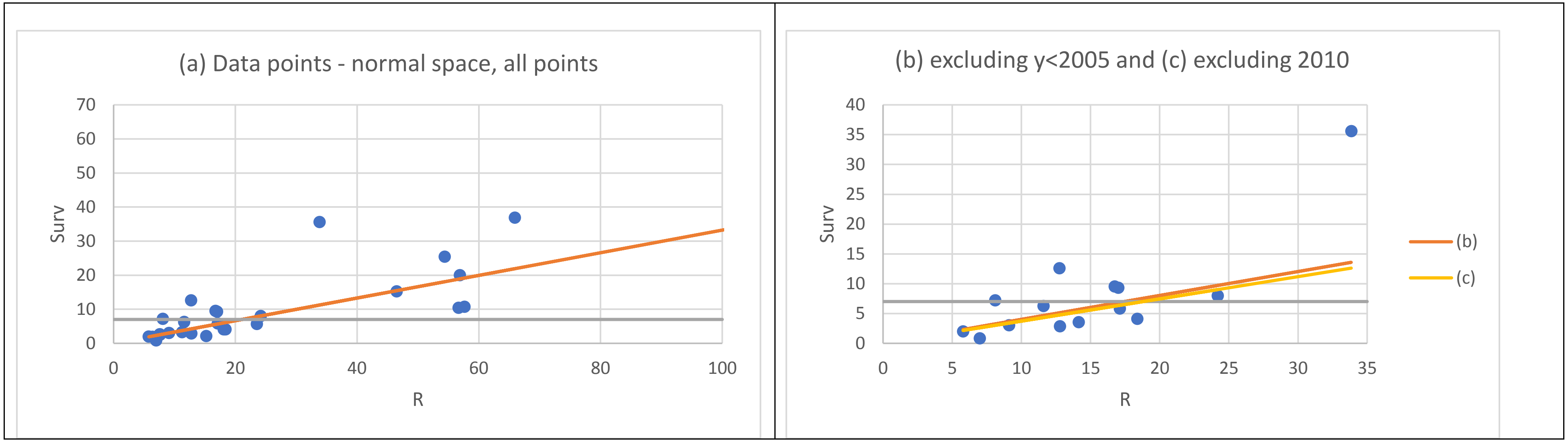


Figure 1: Plots of the data points in normal space for (a) 1985-2019, (b) 2005-2019 and (c) 2005-2019, but excluding 2010. The 2020 survey result is indicated by the grey horizontal line.

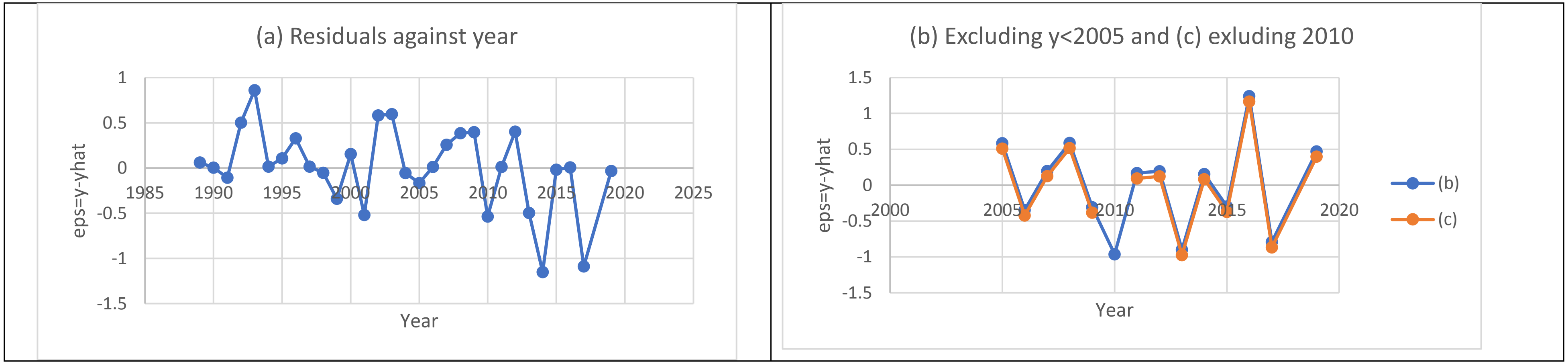


Figure 2: Plots of the residuals of the fit of equation (4) against year for (a) 1985-2019, (b) 2005-2019 and (c) 2005-2019, but excluding 2010.

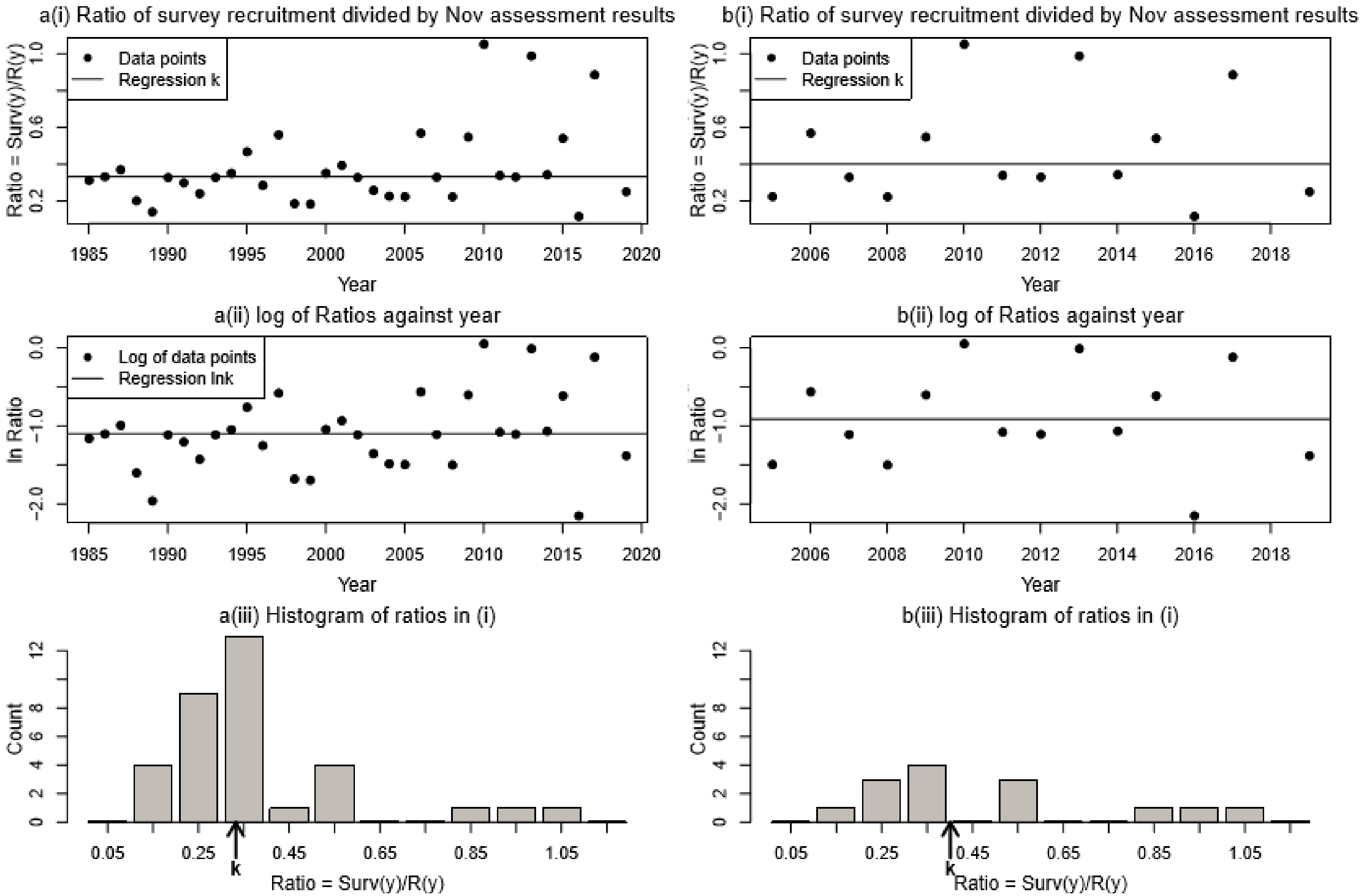
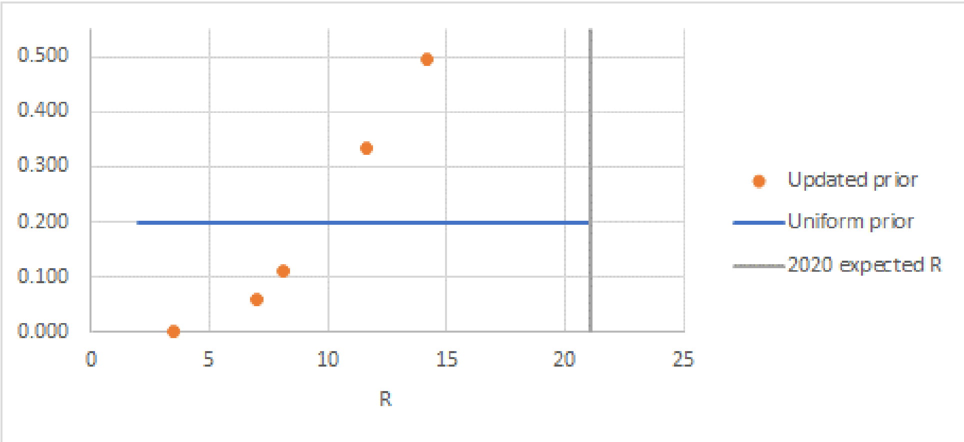
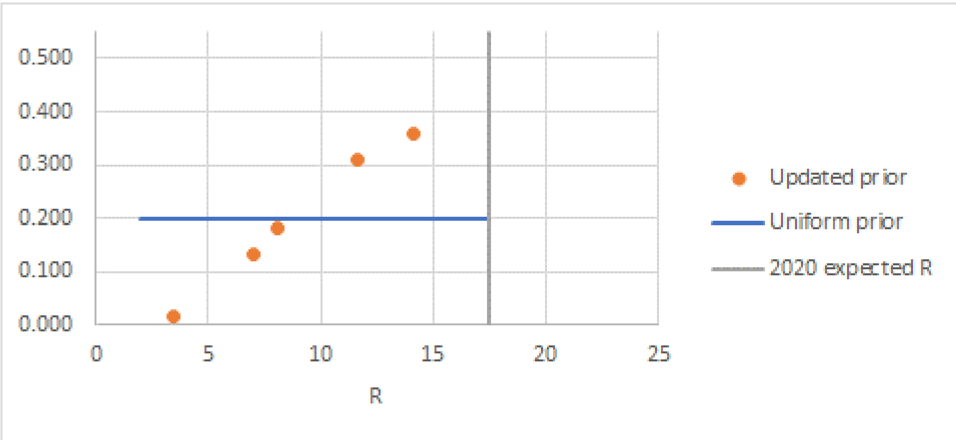


Figure 3: Further diagnostic plots related to the data used for the fits of equation 4, showing those for 1985 to 2019 on the left and for 2005 to 2019 on the right. Plot (ii) in terms of the logarithms of the ratios is added with a view to greater symmetry in a situation where the values in (i) are necessarily positive. The estimates of *k* from equation (4) are indicated.

(a) Priors for analysis including all data points



(b) Priors for analysis excluding data points for y<2005.



(c) Priors for analysis excluding data points for y<2005, and also excluding 2010.

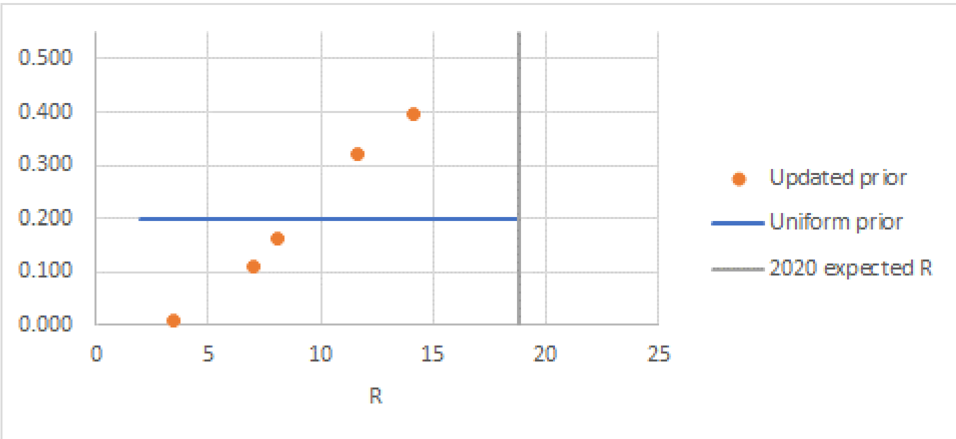


Figure 4: Plot of the uniform prior and the updated prior against recruitment R. The expected R value for the 2020 survey result is marked on the horizontal axis, where this value for R (21.09 for option (a), 17.47 for option (b) and 18.81 for option (c)) is derived from the regression fit of equation (4).

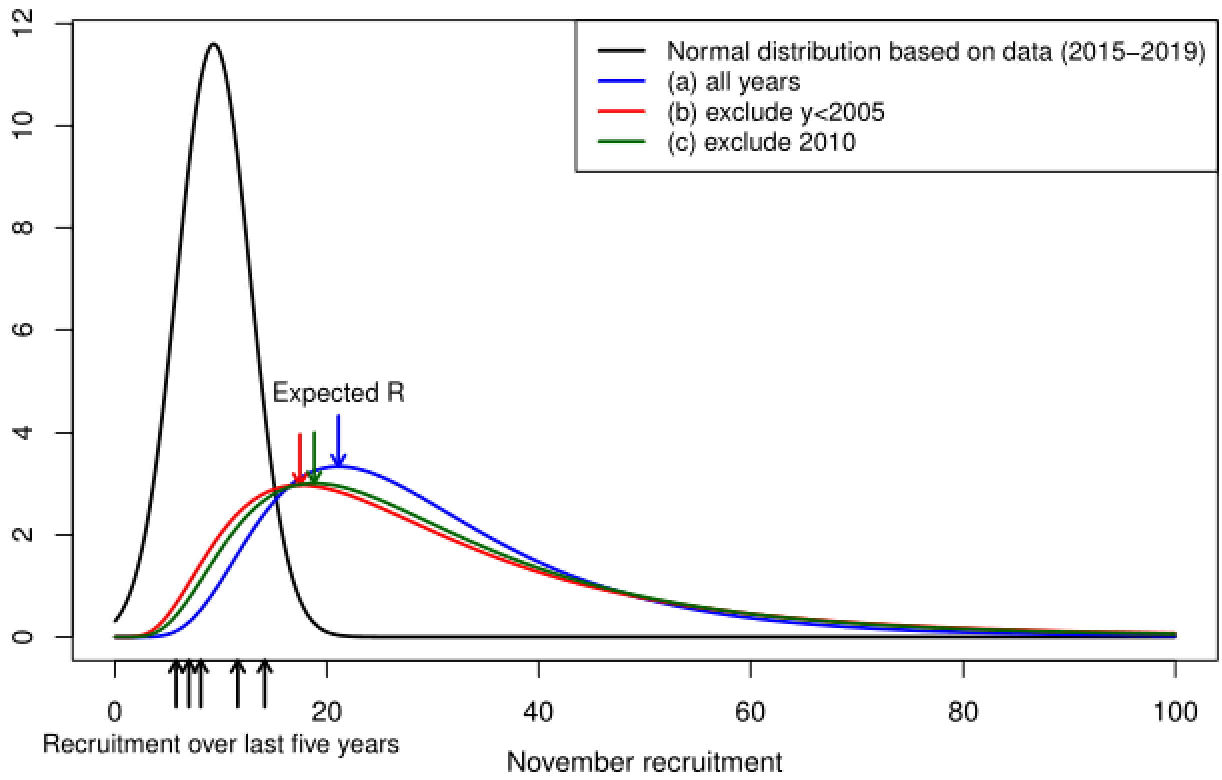


Figure 5: Probability density function plots for the normal distribution corresponding the last five data points from 2015-2019 used to provide a prior and the posterior distributions that are estimated when the 2020 recruitment survey estimate is used for updating through use of the regressions. The expected November recruitment estimates corresponding to the 2020 recruitment survey estimate of 7.01 are indicated by the coloured arrows, and the last five November recruitment estimates (2015-2019) are marked by black arrows on the horizontal axis.

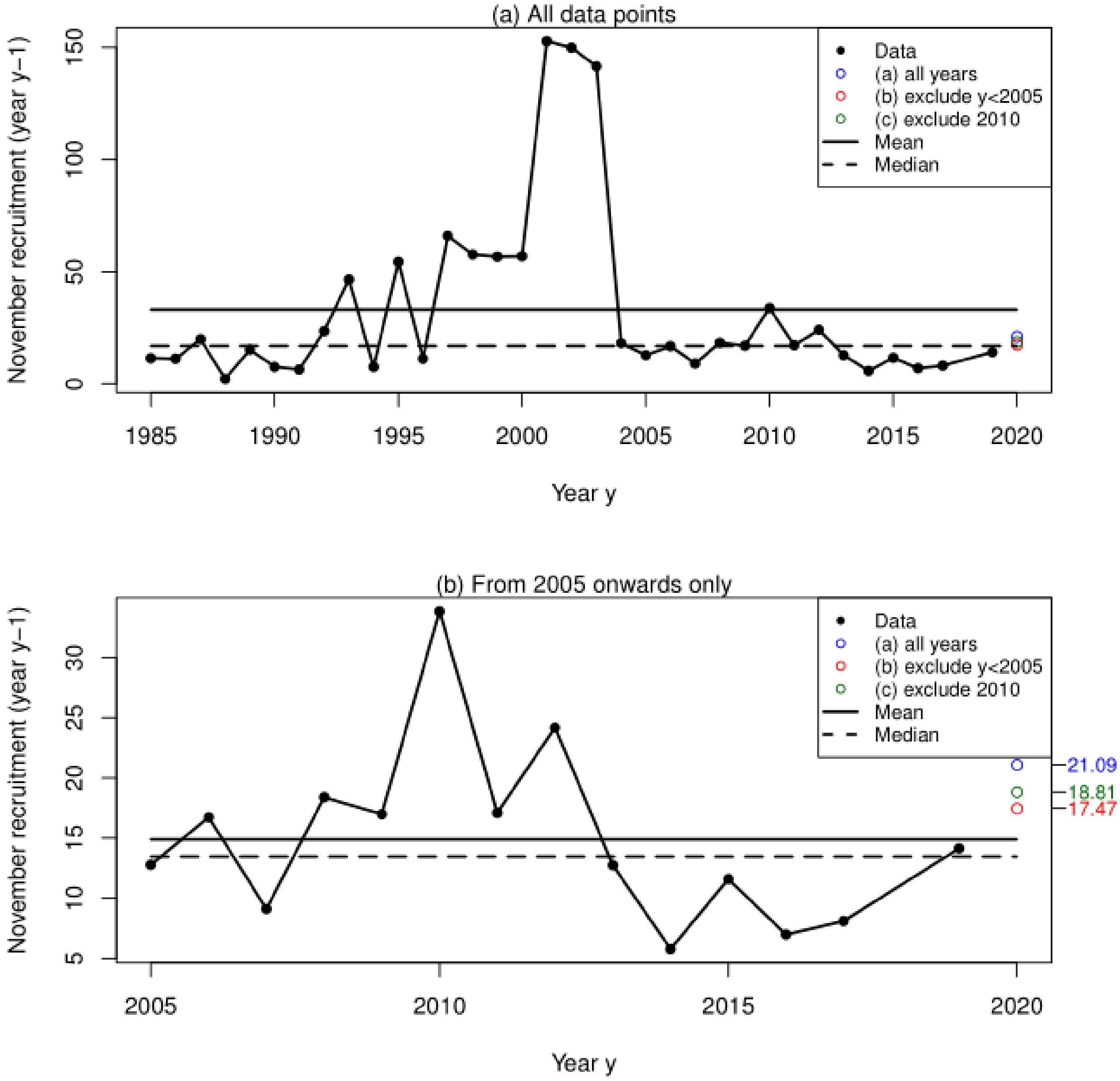


Figure 6: Plots of the November recruitment estimates against year, showing their mean and medians, as well as the estimates of 2020 recruitment based on the 2020 survey estimate of 7.01 for all three options. Results are shown for all data, and for 2005 onwards, to 2019. Note that the November recruitment corresponds to the year prior to the corresponding value shown on the horizontal axis.