A summary of key issues relating to the fitting of FIMS data for west coast rock lobster *Jasus lalandii*.

Johnston, S.J. and Butterworth, D.S.

Summary

This document provides a summary of key issues relating to the fitting of Fisheries Independent Monitoring Survey (FIMS) data for the assessment of west coast rock lobster.

KEY WORDS: West Coast rock lobster, *Jasus lalandii*, FIMS, weighting of data in likelihood

Background documents relating to FIMS:

1. **MARAM/IWS/2022/WCRL/BG5**
2. **MARAM/IWS/2022/WCRL/BG7**

Introduction

The commercial harvesting of lobsters is by both baited traps and hoopnets. Annual CPUE, catch-at-length and F% (percentage females in catch) data are collected from the retained catches, i.e. represent the legal sized portion of the stock, which in this case are lobsters $\geq$ 75mm carapace length (CL). Further data are however also provided on an annual basis – these being from a fisheries independent monitoring survey (FIMS). The FIMS data are collected using gear with a smaller mesh size and thus the associated FIMS CPUE, catch-at-length and F% data represent not only the legal portion of the stock, but the sublegal portion as well (down to 40mm CL), making them an important source of data for the assessment models. The downside of the FIMS data is that they are associated with relatively high variance. Note that MARAM/IWS/2022/WCRL/BG9 provides full model specifications of the west coast rock lobster assessment model.

CAF recommendation and MARAM response

Consider whether the relatively high variance of the Fishery Independent Monitoring Survey (FIMS) data could be affecting trend estimates.

While increasing weighting on FIMS data could be examined, this is problematic as there is no clear objective basis to select a value other than as indicated by the inverse variance of the residuals. What seems a better approach would be to split the data to produce two separate FIMS indices: a 75+mm index and a 60mm-74mm index (possibly also a 40mm-59mm index?). These indices would each separately provide a contribution to the overall -lnL objective function, though some adjustment for likely positive co-variance amongst these series would be needed. Justifications for this approach are that different trends are likely for *these two components, first because the catch impact is much greater on the 75+mm index, and also because the 60-74mm index is heavily affected by inputs for somatic growth rates (for both males and females) over that length range. These are not well determined by the data available; consequently, the sensitivity of results to alternative inputs for those growth rates should also be examined.*

MARAM subsequently produce the following documents:

1) **MARAM/IWS/2022/WCRL/BG5 reported the following:**

Following the CAF recommendation that the FIMS index data should be split from the previous 60mm+ portion of the resource, the models presented here are fitted to two indices of FIMS abundance: B75+ and B60-74 (Note that it is only the FIMS index data which are split, not the CAL or F% data). For super-area A8+, the 2022 assessment is also run using only the single FIMS index (FIMS 60+) as in the past for comparison.

Results

- Fitting to split FIMS indices, i.e. FIMS 75+ and FIMS 60-74 compared to FIMS 60+ as previously has not made any substantial difference to the assessment results. See Table 1 to compare the A8+ results between fitting to a single FIMS index or splitting it).
- Note however that for A8+ there is a poor model fit to the FIMS 60-74 index (see Figure 1). [The Appendix reports fits to FIMS data for the other super-areas showing that it is mainly A8+ that produces poor fits to FIMS 60-74 index.] This may be indicative of somewhat better future abundance in A8+ to be expected than is suggested by the results reported here. **MARAM/IWS/2022/WCRL/BG7** investigates this further by up-weighting the FIMS 60-64 index in the model fitting procedure.
- Figure 3 shows the catch-at-length residuals. Model fits to percent females in the catch are shown in the Appendix Figure A5. See Appendix Figure A6 which shows the estimated selectivity functions for A8+.

2) **MARAM/IWS/2022/WCRL/BG7 reported the following:**

For super-area A8+ (for which the RC shows a poor fit to the FIMS 60-74 data), the FIMS 60-74 data were up-weighted in the model fit by either a factor of 2 or 5.

Results

Up-weighting of FIMS 60-74 data

Table 2 and Figures 4 and 5 report results of increasing the weight of the FIMS 60-74 data in the log likelihood. Up-weighting by a factor of 2 makes little difference, but up-weighting by a factor of 5 does make a notable difference resulting in a better fit to the FIMS 60-74 data (Figure 4). This is however at the cost of worse fits to all the other data. The figures show that in order to improve the fit to the more recent FIMS 60-74 data, recruitment in 2007 is increased quite substantially, and given the lag effect between recruitment and 60mm CL lobsters, this allows for an increase in the FIMS 60-74 data around 2015. However, this strong recruitment pulse feeds into the larger sized lobsters over subsequent years, resulting in the estimated 75mm+ indices being far to high (and misfit to the observed trap, hoop and FIMS 75+ data).

A sensitivity was run where the FIMS 60-74 data are up-weighted by a factor of five, but ALSO a decrease in natural survivorship for lobsters 75mm+ for years 2017+ is estimated. Note that the RC assumption is that natural survivorship is 0.90 for lobsters 75mm+ CL. Table 2 shows these results (last column). Here, and in Figure 7, you can see that a more sensible model fit is obtained all round, where the FIMS 60-74 data are fitted satisfactorily, and the recent 75mm+ CPUEs are now estimated to fit to the observed recent downturn in those CPUE values (particularly for Trap and Hoop CPUE). For this sensitivity, survivorship for the 75mm CL+ lobsters is reduced to 0.68 for 2017+.

Questions for the Panel

(1) How best to select an appropriate weighting for the split FIMS data in the likelihood?

References

MARAM/IWS/2022/WCRL/BG5. Johnston SJ and Butterworth DS. (2022). Updated 2022 assessments of the west coast rock lobster resource. FISHERIES/2022/AUG/SWG/WCRL/23.

MARAM/IWS/2022/WCRL/BG7. Johnston SJ and Butterworth DS. (2022). Further assessment results for the 2022 updated assessment of west coast rock lobster. FISHERIES/2022/AUG/SWG/WCRL/24.

MARAM/IWS/2022/WCRL/BG9. Johnston SJ. And Butterworth, D.S. (2022). The size-structured (length-based) stock assessment methodology applied to west coast rock lobster.

Table 1: **A8+** assessment results for the two different poaching scenarios (LS(2021)=850mt or 200mt). Results are sown the the RC fit to FIMS 60+ as well as a sensitivity to fitting to both a FIMS 60mm-74mm and FIMS 75mm+ carapace lengths. The values in parentheses next to the –lnL values are the associated σ values for the fit to those data.

	2022 **Fit to FIMS 60+**		**2022** **Fit to split FIMS**	
	LS 200	**LS 850**	**LS 200**	**LS 850**
-lnL total	-51.99	-55.391	-53.577	-54.648
Trap CPUE –lnL (σ)	-36.27 (0.221)	-36.80 (0.218)	-37.03 (0.217)	-37.24 (0.215)
Hoop CPUE –lnL (σ)	-35.77 (0.219)	-36.27 (0.215)	-35.82 (0.218)	-35.99 (0.217)
FIMS 60+ CPUE –lnL (σ)	-4.81 (0.514)	-4.88 (0.513)	-	-
FIMS 75+ CPUE –lnL (σ)	-	-	**-10.75 (0.419)**	**-10.88 (0.417)**
FIMS 60-74 CPUE –lnL (σ)	-	-	**4.86 (0.718)**	**4.52 (0.709)**
Male Trap CAL –lnL (σ)	78.59 (0.335)	76.76 (0.332)	77.99 (0.333)	77.79 (0.329)
Feale Trap CAL –lnL (σ)	38.56 (0.448)	38.32 (0.445)	38.19 (0.443)	38.37 (0.445)
Male Hoop CAL –lnL (σ)	-2.85 (0.185)	-3.08 (0.183)	-3.07 (0.184)	-3.19 (0.183)
Female Hoop CAL –lnL (σ)	7.28 (0.478)	7.27 (0.479)	7.27 (0.479)	7.29 (0.478)
Male FIMS CAL –lnL (σ)	-57.62 (0.150)	-57.92 (0.150)	-56.40 (0.150)	-56.83 (0.150)
Feale FIMS CAL –lnL (σ)	-9.59 (0.184)	-8.94 (0.183)	-4.63 (0.185)	-9.14 (0.185)
R_2004	0.277	0.278	0.272	0.275
R_2007	0.166	0.160	0.127	0.138
R_2010	0.334	0.330	0.333	0.333
$\bar{x}$	0.533	0.545	0.550	0.551
B75m(2020) (B75m(2020)/K)	5804 (0.024)	5622 (0.023)	5292 (0.022)	5229 (0.022)
B75m(2020)/B75m(2026)	0.425	0.415	0.425	0.391
B75m(2021) (B75m(2021)/K)	6278 (0.026)	5878 (0.024)	5630 (0.024)	5401 (0.023)
B75m(2021)/B75m(2006)	0.460	0.434)	0.420	0.404
	xnn.for xa82.res	xnn.for xa82.res	nn.for a82.res	nn.for a82.res

Table 2: **A8+** results for the RC (split FIMS) and alternate scenarios (all assuming LS=850). The values in parentheses next to the –lnL values are the associated σ values for the fit to those data. The RC (split FIMS) assessment results are shown in the first shaded column. Pink shading indicates a WORSE fit than the RC, and green shading shows a BETTER fit than the RC.

	Reference case (split FIMS)	**RC but up-weight FIMS 60-74 by factor of 2**	**RC but up-weight FIMS 60-74 by factor of 5**	**RC but up-weight FIMS 60-74 by factor of 5 and Increase M 2017+**
-lnL total	-58.392	[-68.98]	[-118.5]	[-84.94]
Trap CPUE –lnL (σ)	-37.42 (0.214)	-36.20 (0.222)	-25.44 (0.300)	-37.60 (0.213)
Hoop CPUE –lnL (σ)	-36.01 (0.217)	-35.94 (0.217)	-27.02 (0.280)	-37.95 (0.205)
FIMS 75+ CPUE –lnL (σ)	-10.90 (0.416)	-9.90 (0.435)	-3.02 (0.546)	-8.76 (0.448)
FIMS 60-74 CPUE –lnL (σ)	**4.59 (0.711)**	**3.35 (0.681)**	**-8.33 (0.455)**	**-4.48 (0.520)**
Male Trap CAL –lnL (σ)	41.02 (0.335)	38.31 (0.329)	98.50 (0.594)	37.54 (0.330)
Female Trap CAL –lnL (σ)	38.42 (0.446)	38.74 (0.450)	32.55 (0.385)	37.52 (0.436)
Male Hoop CAL –lnL (σ)	-3.02 (0.183)	-2.81 (0.184)	17.97 (0.333)	-2.88 (0.186)
Female Hoop CAL –lnL (σ)	7.27 (0.478)	7.30 (0.479)	7.74 (0.482)	7.29 (0.479)
Male FIMS CAL –lnL (σ)	-56.79 (0.150)	-58.31 (0.150)	-23.09 (0.171)	-43.57 (0.150)
Female FIMS CAL –lnL (σ)	-8.99 (0.185)	-9.23 (0.187)	5.51 (0.236)	5.14 (0.208)
R_2004	0.274	0.280	0.416	0.322
R_2007	0.135	0.173	0.701	0.622
R_2010	0.333	0.329	0.351	0.338
$\bar{x}$	0.550	0.545	0.578	0.559
Survivorship 75mm+ 2017+	0.90 fixed	0.90 fixed	0.90 fixed	**0.68**
B75m(2021) (B75m(2021)/K)	5 371 (0.023)	5 892 (0.025)	22 266 (0.092)	4415 (0.019)
	nn.for a88.res	Upwtg.res	Upwt5.res	Nat.res

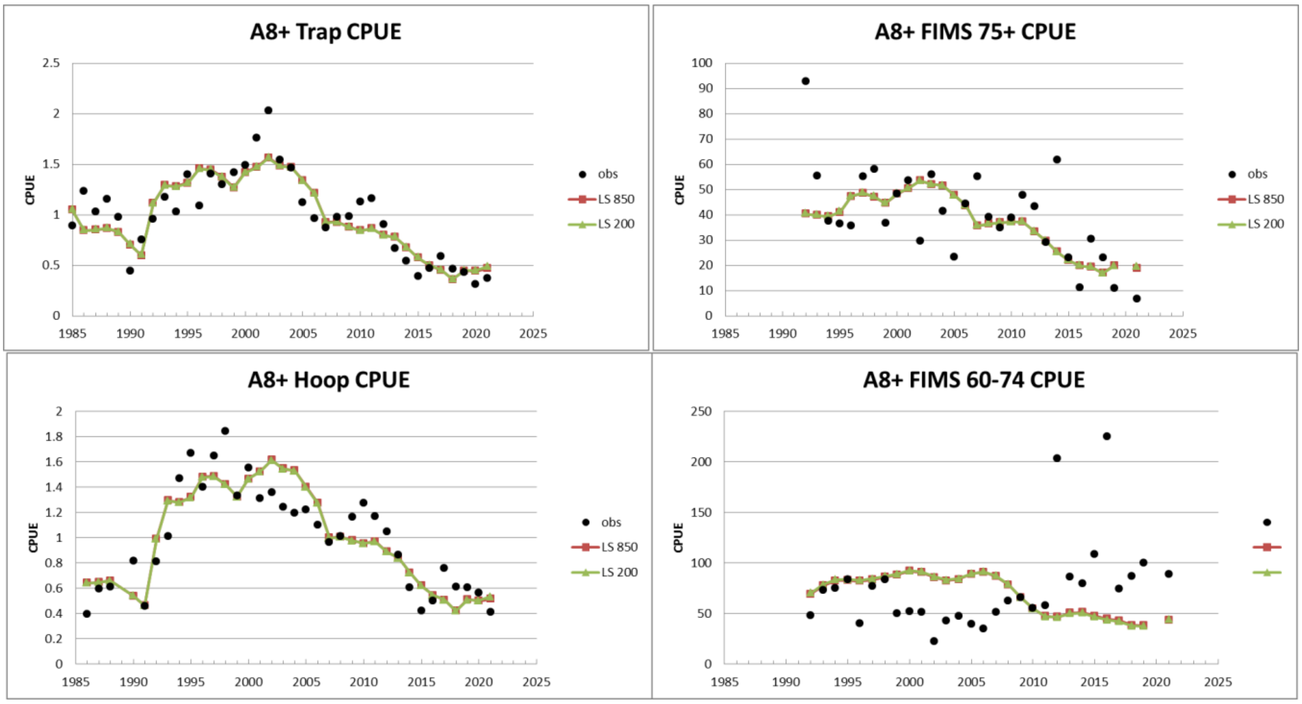

Figure 1: Comparison of fits to **A8+** CPUE and FIMS (split 75+ and 60-74) for the 2022 assessments.

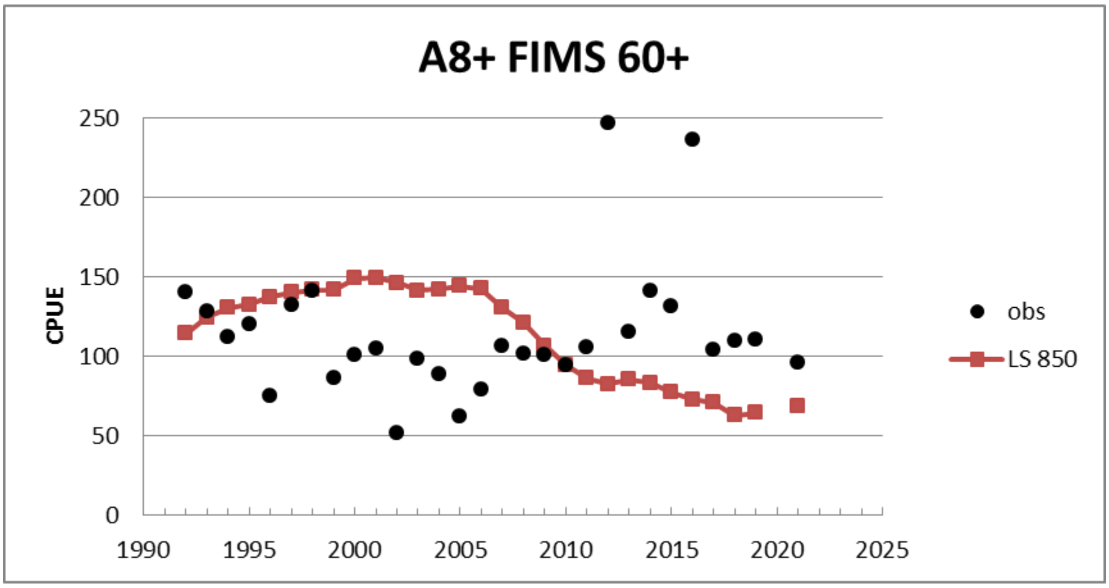

Figure 2: Comparison of fits to **A8+** FIMS 60+ for the 2022 assessments scenario where we fit to the original FIMS 60+ (i.e. do not fit to split FIMS).

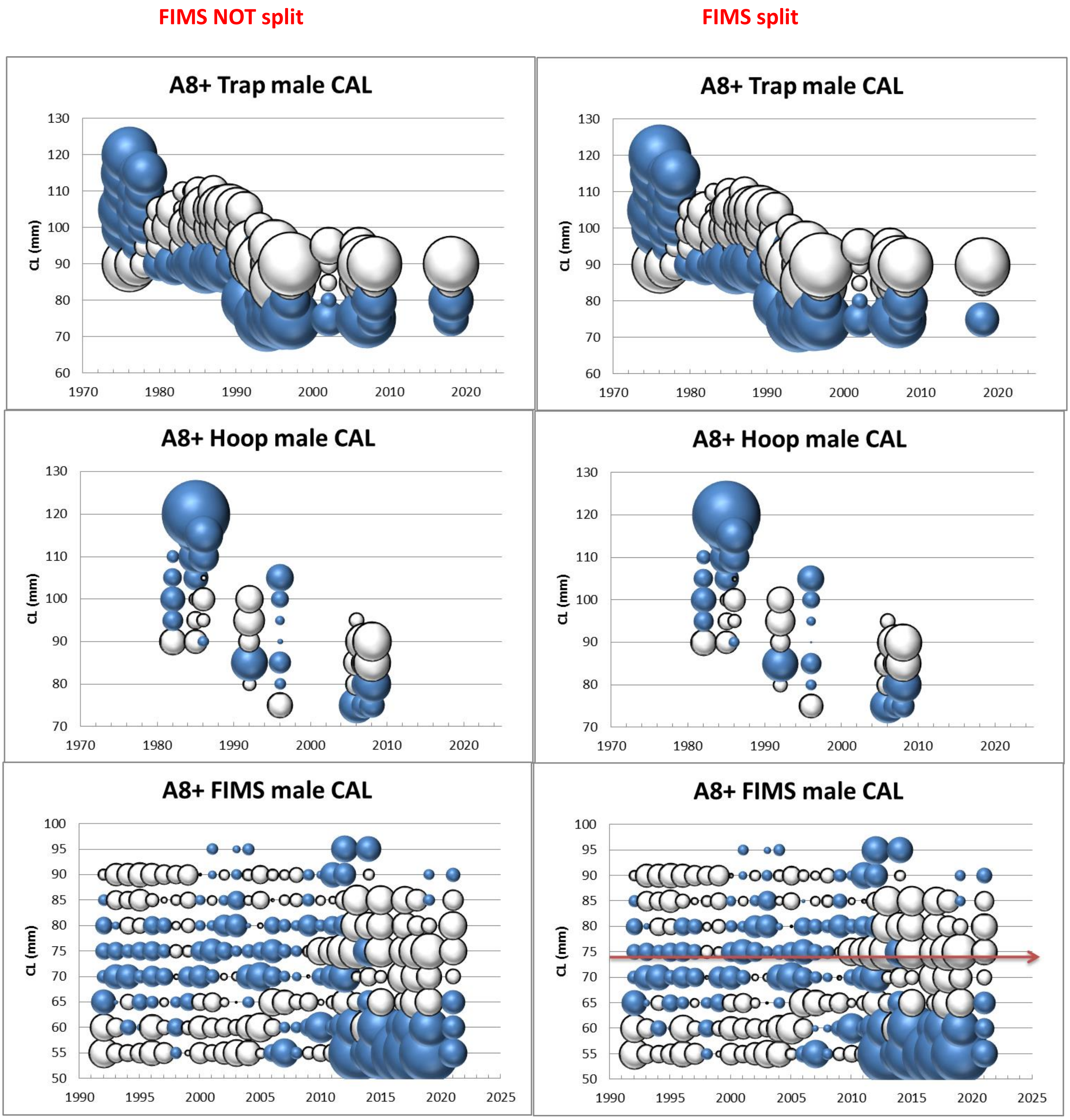

Figure 3a: A8+ MALE CAL residuals (no split versus split FIMS, LS 850). Red horizontal arrow indicates length at which the FIMS CPUE data are split.

Figure 3b: A8+ FEMALE CAL residuals (no split versus split FIMS, LS 850). Red horizontal arrow indicates length at which the FIMS CPUE data are split.

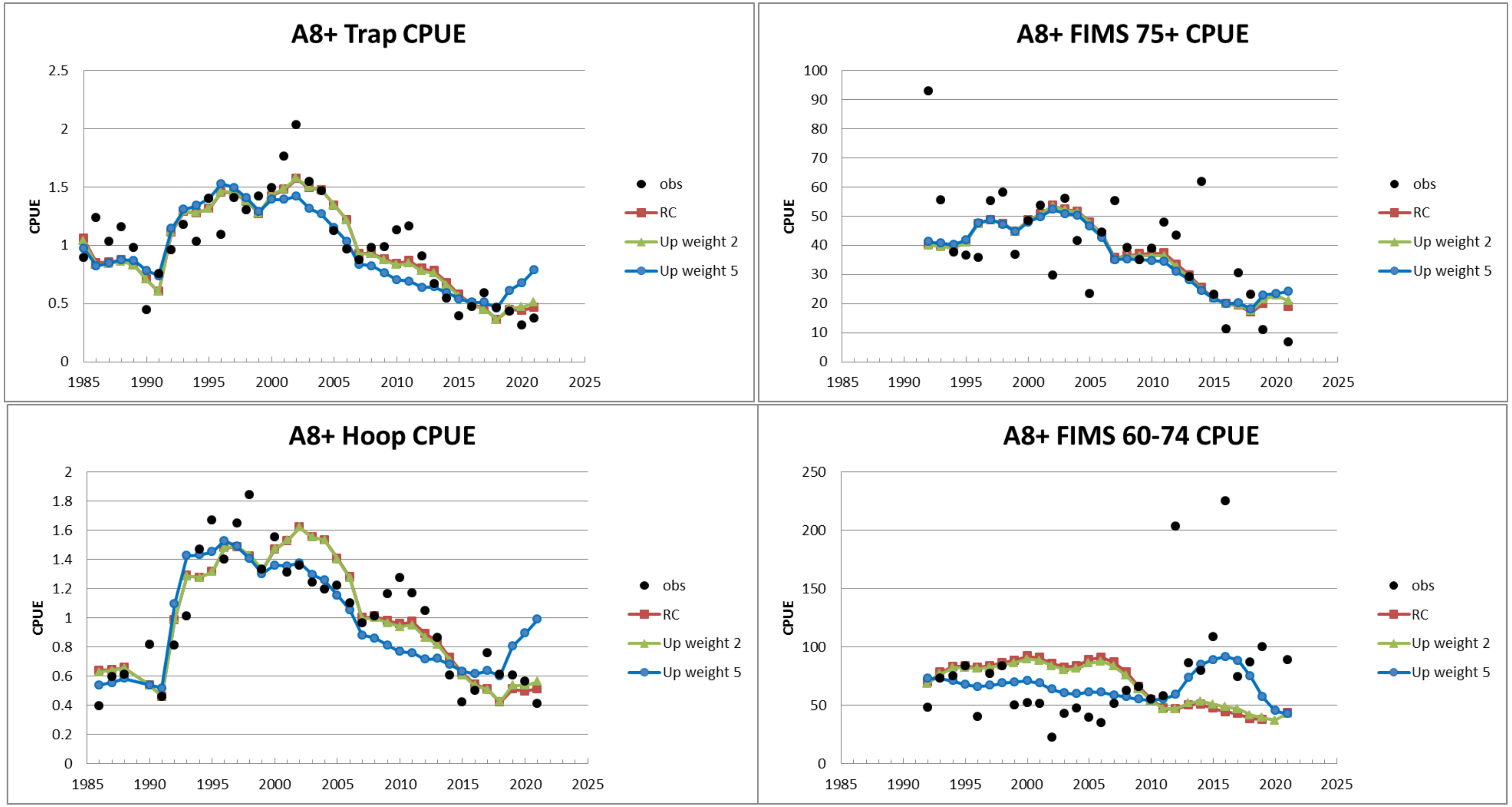

Figure 4: Comparative CPUE plots for the RC and the scenarios where the FIMS 60-74 data are up weighted (for LS 850).

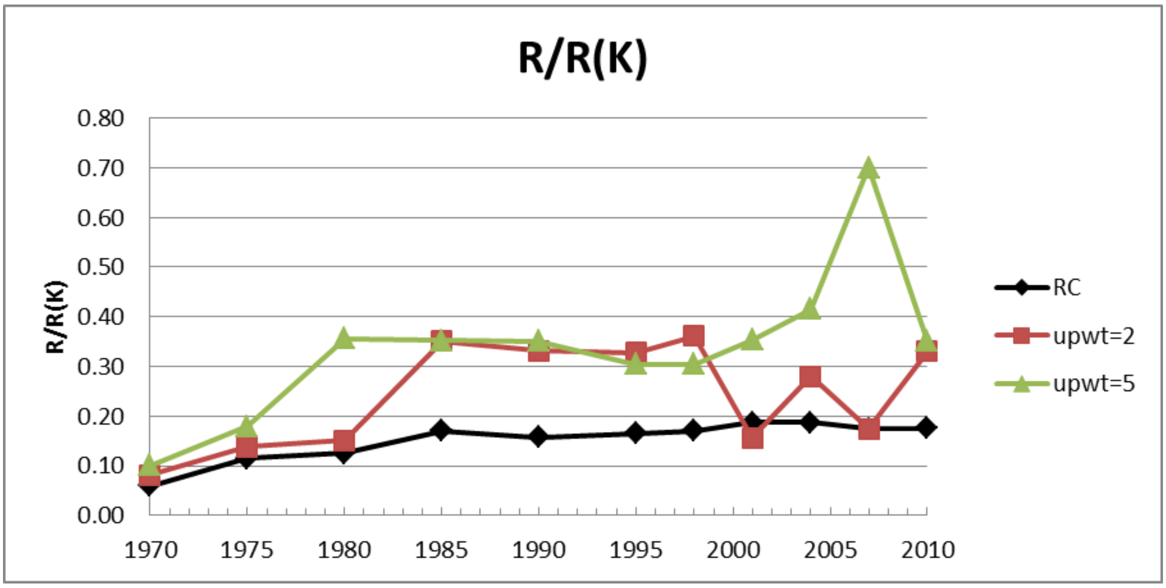

Figure 5: Comparative Recruitment plots for the RC and the scenarios where the FIMS 60-74 data are up weighted (for LS 850).

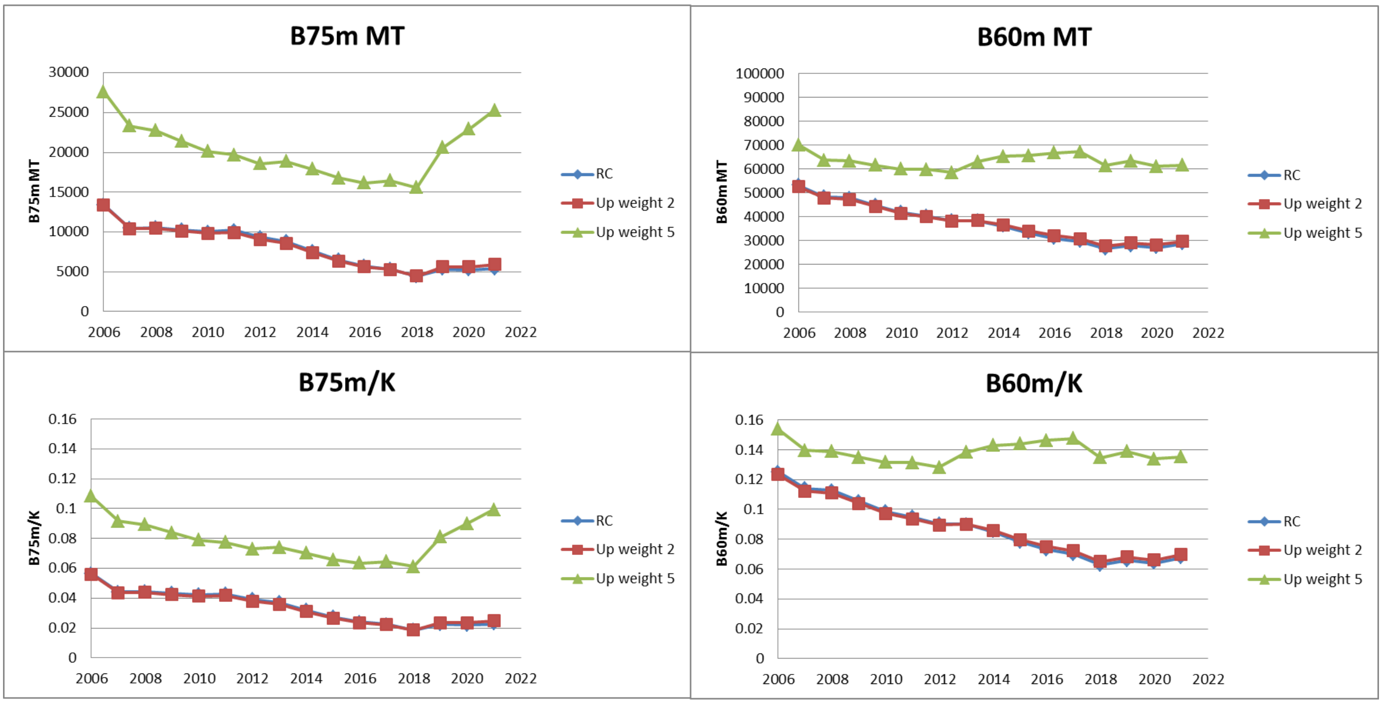

Figure 6: Comparative B75m and B60 plots for the RC and the scenarios where the FIMS 60-74 data are up weighted (for LS 850). Note that results for the RC and an up-weight of 2 are not distinguishable in these plots.

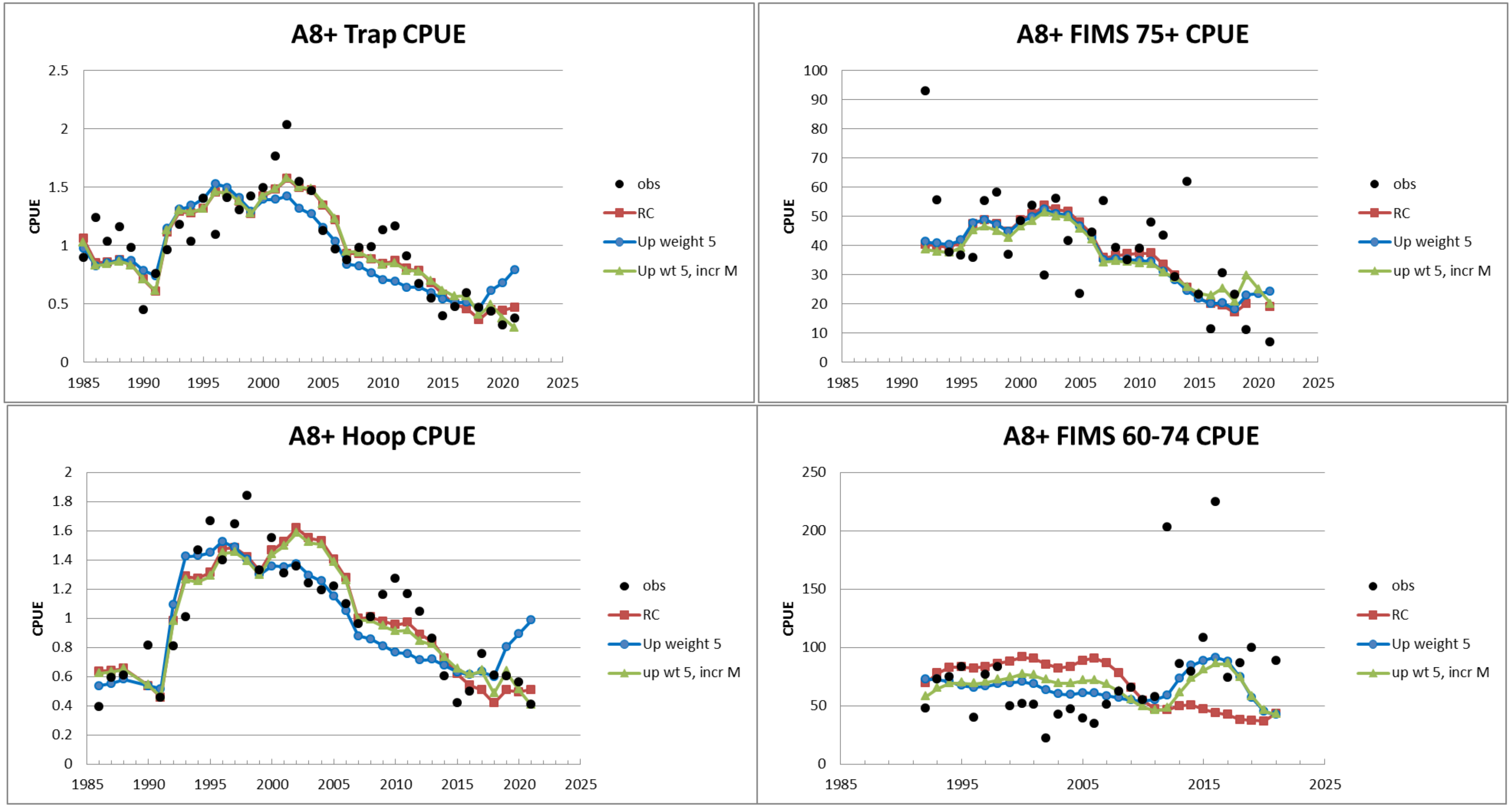

Figure 7: Comparative CPUE plots for the RC, FIMS 60-74 data are up weighted by a factor of 5, and FIMS 60-75 data up-weighted by a factor of 5 as well as decreasing the natural survivorship for 75mm lobsters 2017+ (for LS 850)

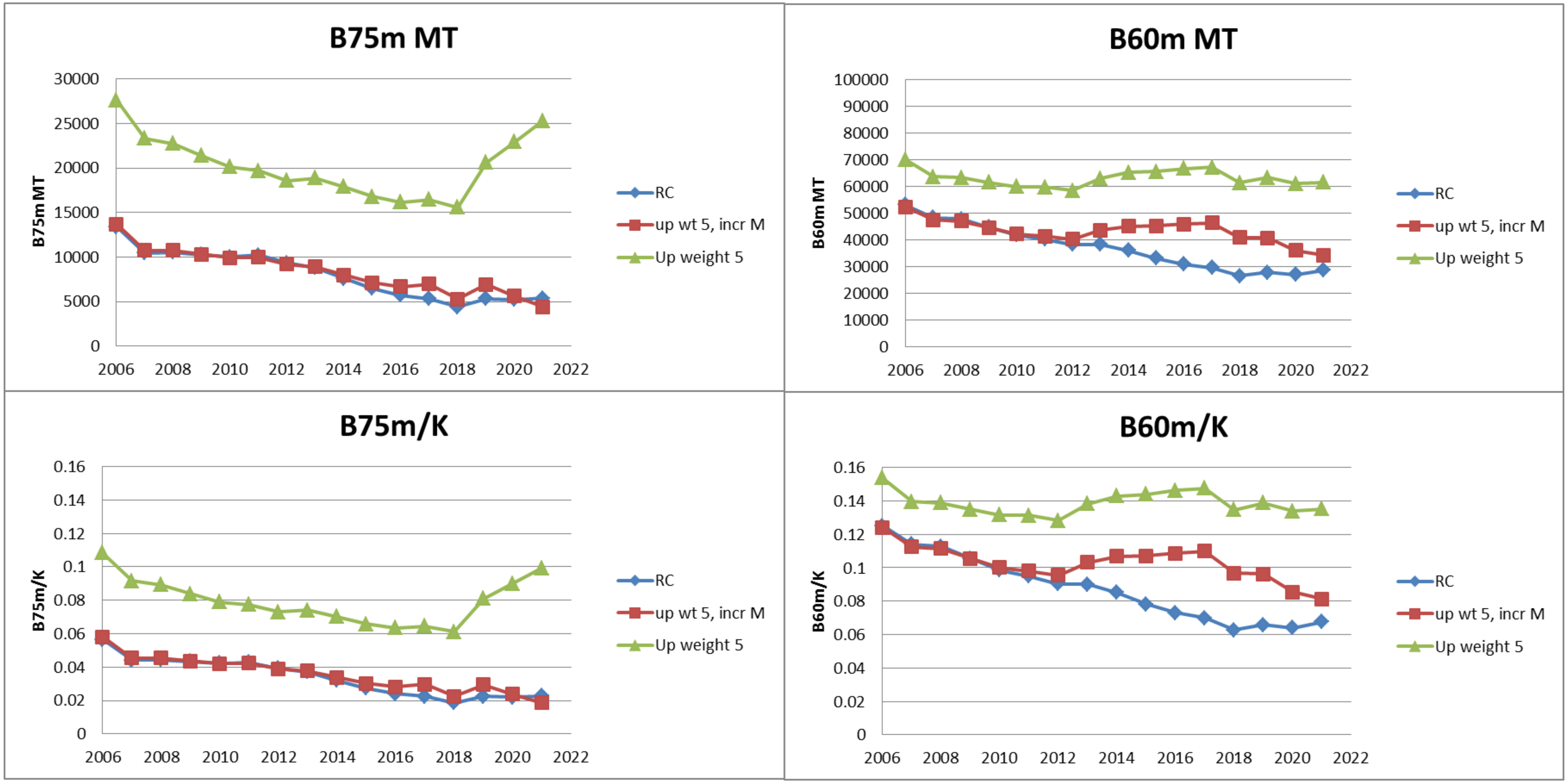

Figure 8: Comparative B75m and B60 plots for the RC, the model where the FIMS 60-74 data are up weighted by a factor of 6 and the model where the FIMS 60-74 data are up-weighted by a factor of five and as decreasing the natural survivorship for 75mm lobsters 2017+ (for LS 850).

Appendix: Model fits to split FIMS data (as well as trap and hoopnet CPUE) for A7, A5+6, A3+4 and A1+2. [taken from **MARAM/IWS/2022/WCRL/BG7].**

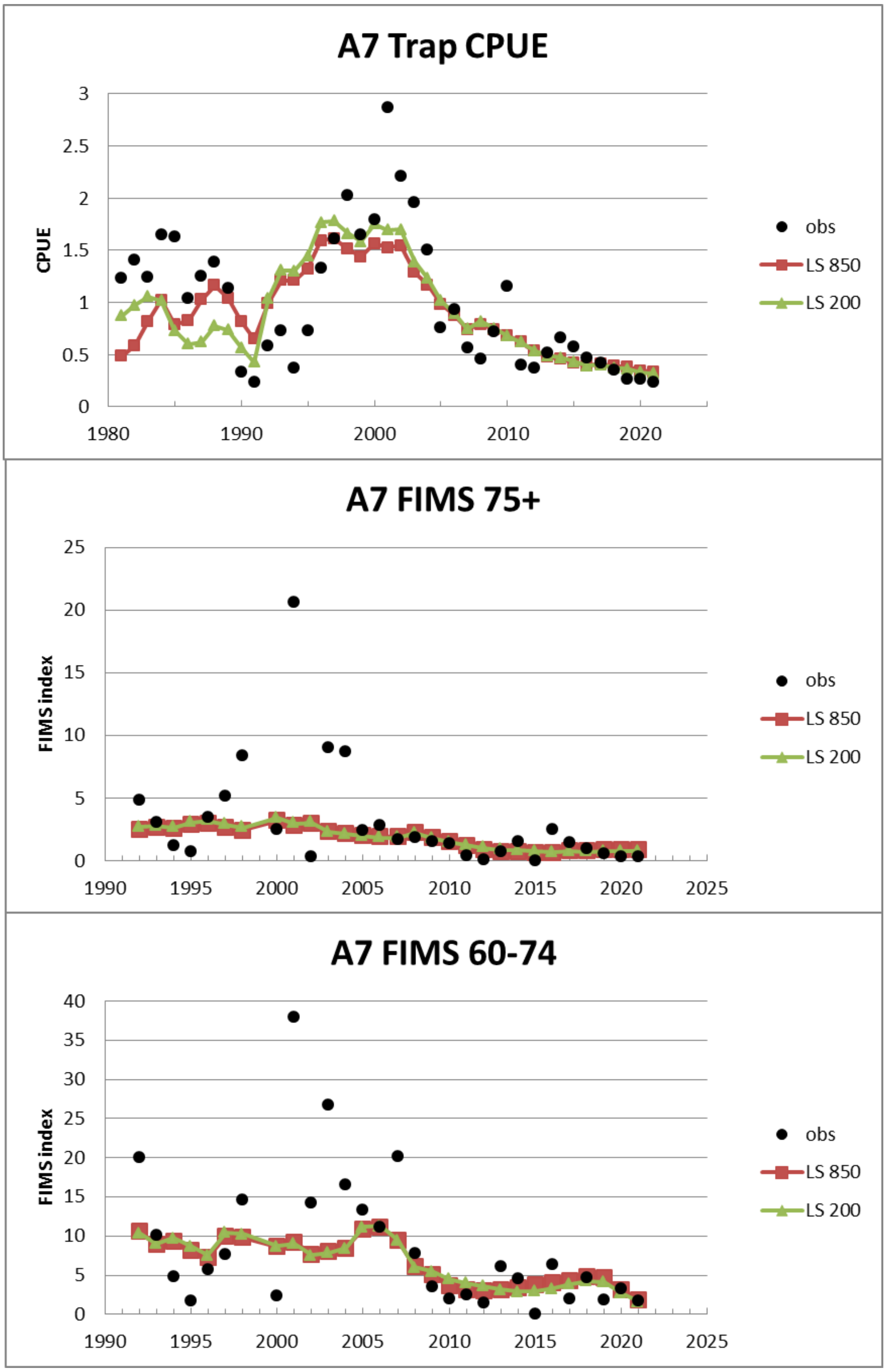

Figure A1: Comparison of fits to **A7** CPUE and FIMS for the updated 2022 assessments.

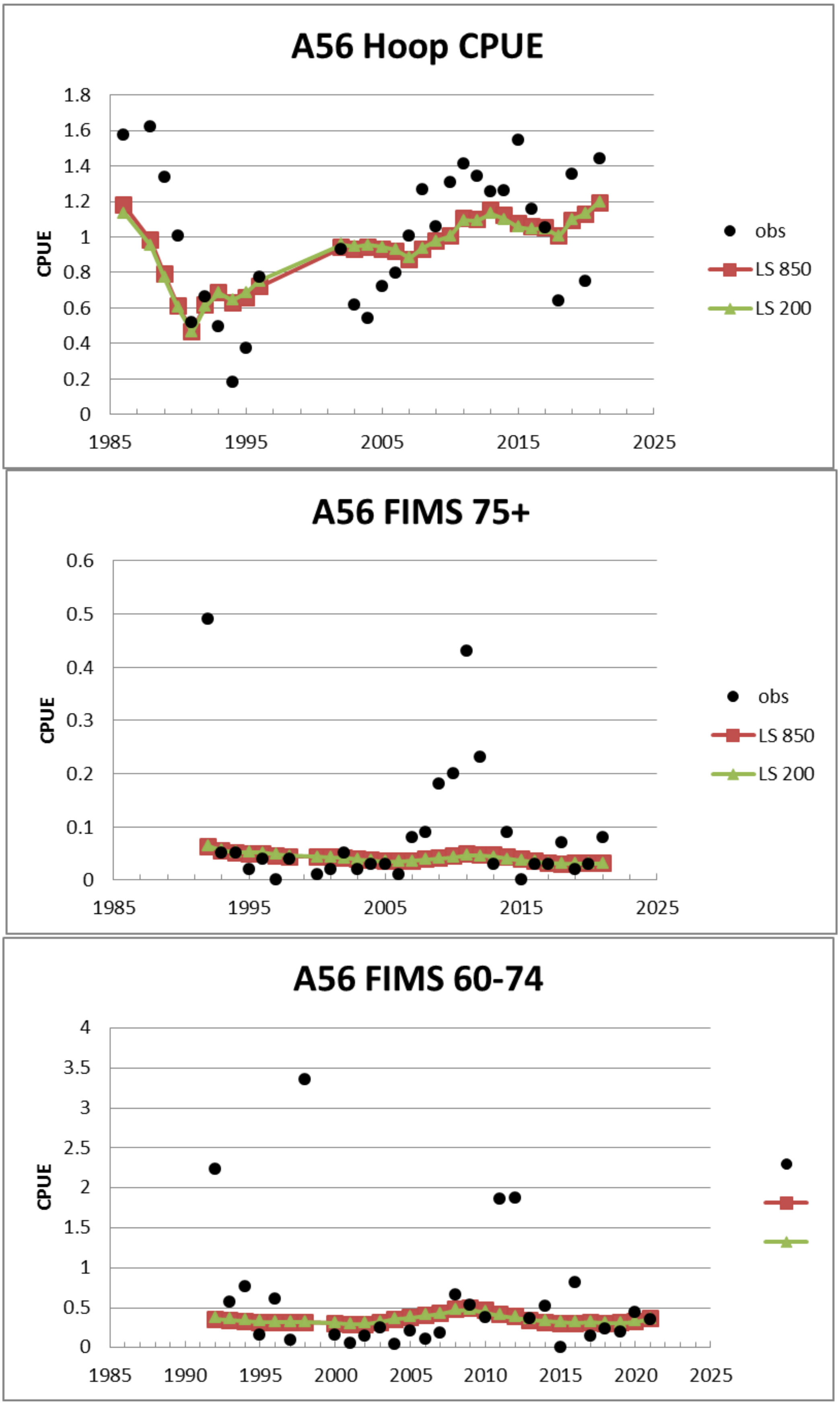

Figure A2: Comparison of fits to **A56** CPUE and FIMS for the 2021 assessments.

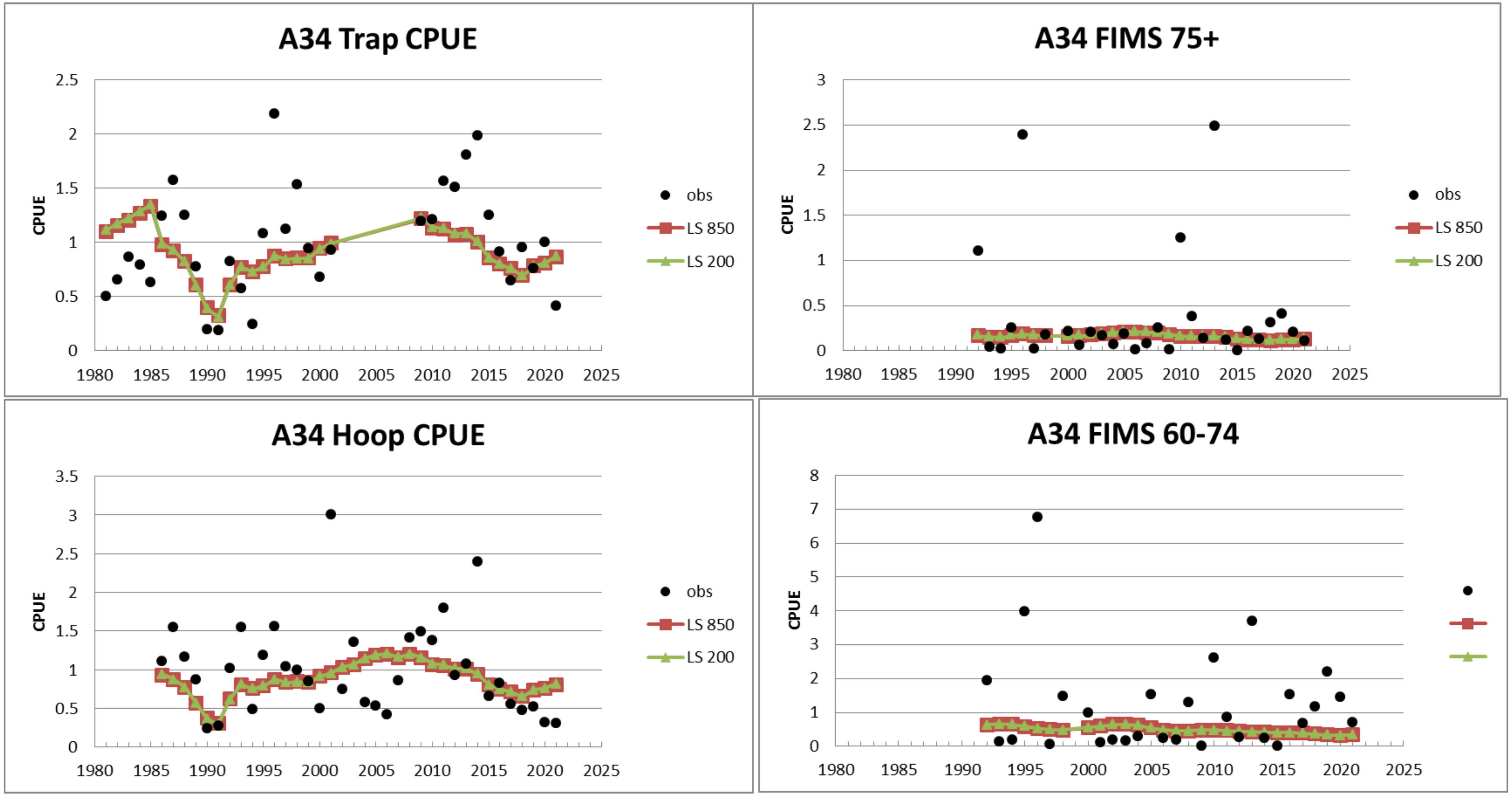

Figure A3: Comparison of fits to **A34** CPUE and FIMS for the 2022 assessments.

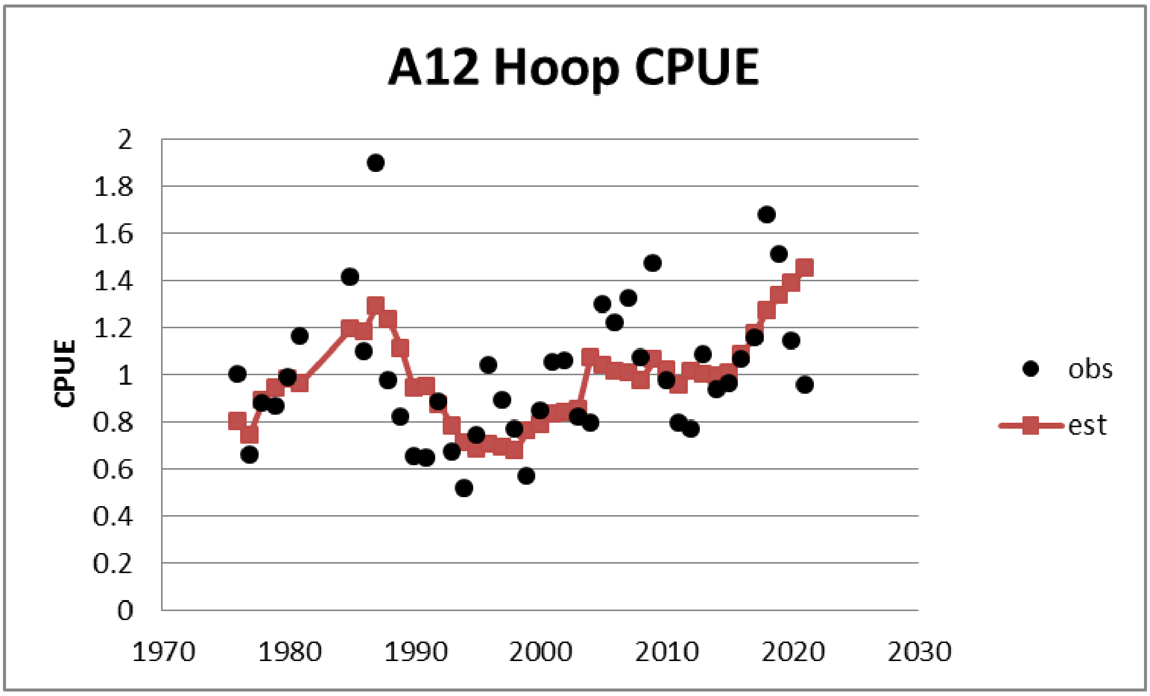

Figure A4: Comparison of fits to **A12** CPUE for the 2022 assessment (no poaching is assumed to occur in A12).

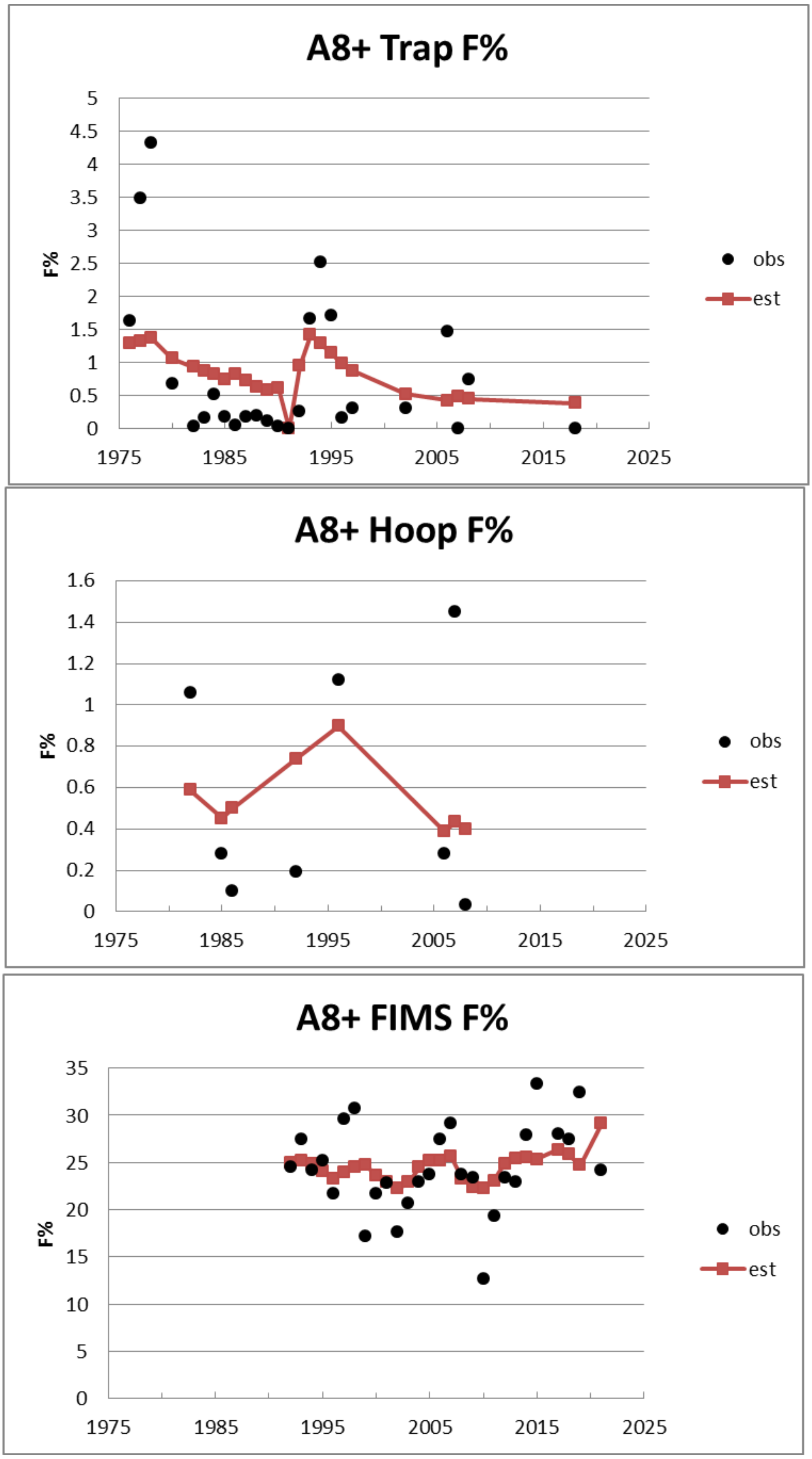

Figure A5: A8+ fits for F% data (LS 850).

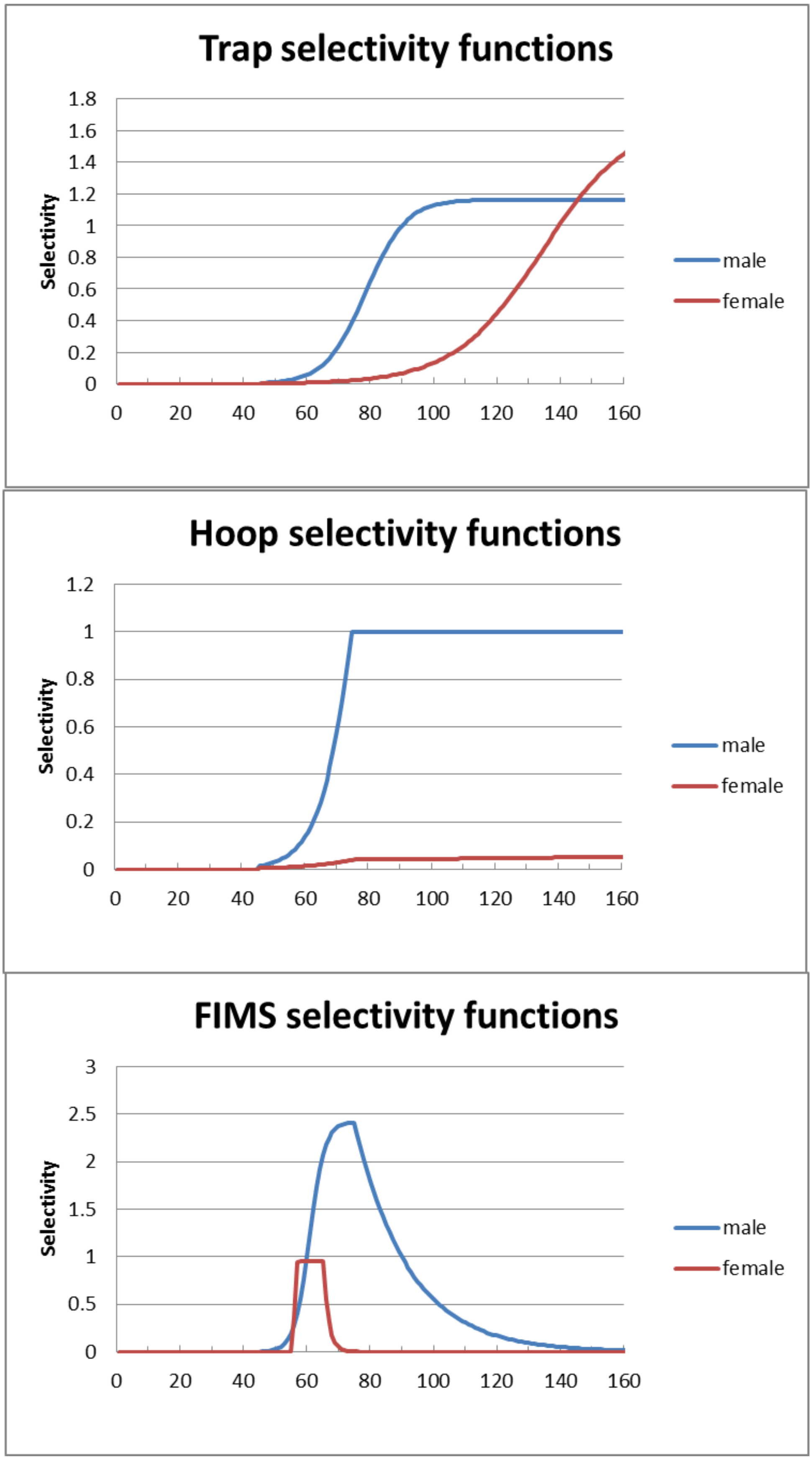

Figure A6: **A8+** selectivity functions (LS 850). Note that females grow far more slowly than males and grow only just over 75mm CL, whereas males grow faster and reach larger sizes > 130mm CL.