West coast rock lobster updated stock assessment results for the length-based model for both area-aggregated and area-disaggregated approaches

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Summary

This document presents updated assessments of the west coast rock lobster resource using the length-based model and the most recent available data. Results are shown for both area-aggregated and area-disaggregated approaches, and for two scenarios for historic recruitment trends (RC1 and RC2). Fits of the models to the data are shown. In most instances, the area-aggregated results are quite similar to the corresponding sums of the area-disaggregated estimates.

Introduction

This document presents results of updated west coast rock lobster assessments using the size-structured modelling approach. Updated assessment results are reported for three levels of disaggregation using updated input data.

i) The West Coast area-aggregated model (the model currently used for assessment of the resource) is updated to take account of data up to and including the 2004 season. Catch data for 2005 are also incorporated, where the catch taken in each area is assumed to be the TAC allocated to each of these areas.

ii) The area-disaggregated assessments are also updated to take account of data up to and including the 2004 season (Area 1-2, Area 3-6, Area 7 and Area 8).

iii) Area 3-6 is further broken down into Area 3-4 and Area 5-6. The MCM Rock Lobster Working Group requested these assessments in order to determine whether it would be feasible to assess A3-4 independently from A5-6.

Alternative Historic Recruitment Scenarios: RC1 and RC2

RC1: This is essentially very similar to the previous stock assessment model used in assessing alternative OMPs for the resource. However, the model now includes five extra selectivity estimable parameters which have been shown to improve the fit to catch-at-size data. This model estimates recruitment in a piece-wise linear manner, with R_{1870}, R_{1920}, R_{1950}, R_{1970}, R_{1975}, R_{1980}, R_{1985}, R_{1990}, and R_{1995} being estimable parameters. Note that R_{1995} is now included as an estimable parameter, as there are several more years of data to which to fit, compared to when the existing OMP was developed. R_{2000+} is assumed to be the geometric mean of R_{1975}, R_{1980}, R_{1985}, R_{1990}, and

R_{1995} for the reference case (RC) fits to the data, although other alternative assumptions are examined for future projections.

RC2: This model is identical to RC1, except that a stock-recruit penalty term is added to the overall likelihood function (see RLWS/DEC05/ASS/7/1/2 for details). The rationale for this model is that RC1 results in recruitment estimates that lie below the replacement line for large periods of time, and it has been suggested that information from a more traditional Beverton-Holt type stock-recruit function may be useful in constraining the recruitment estimable parameters. Note that the Beverton-Holt h parameter is fixed at 0.8 for this application.

Data and Methods

The data types available for the assessment are listed in RLWS/DEC05/DAT/6/1/1. In the interests of parsimony, data tables are not reproduced here, but these data themselves are evident from Figures following which compare such data to the corresponding model estimates.

Assessments

All assessments are updated for both the RC1 and RC2 scenarios.

Replacement yields are calculated for each of the updated assessments. In each case, the replacement yield (RY) is taken to be the commercial catch that can be taken each year for the next 10-year period, so that the biomass (above 75mm carapace length) remains where it is currently estimated to be, i.e. $B_{75}(2016) = B_{75}(2006)$. Assumptions regarding the future are described in full in RLWS/DEC05/ASS/7/1/1. The most important of the assumptions are that:

a) future somatic growth rate (2005+) is the average of the 1968-2004 values, and
b) future recruitment (2000+) is the geometric mean of R_{75}, R_{80}, R_{85} and R_{90}. (assume linearity between R_{95} and R_{2000}).

RY results are also reported for an alternate future somatic growth assumption – this being that future somatic growth is the average over 1990-2004 (a more recent time period with lesser average growth).

Results

Updated area-aggregated assessments

Table 1 reports the updated area-aggregated results for both RC1 and RC2. Note that the aggregation now covers areas 1-8, rather than A3-8 as in the past, though this addition makes relatively little difference. Figure 1a shows the model fits to the trap, hoopnet and FIMS CPUE data. Figure 1b reports the fits to the F% (Female % in catch) data. Figures 1c-j report the fits to the trap, hoop, FIMS and sub-legal catch-at-size data for males and females.

Figure 2a compares RC1 and RC2 trajectories of recruitment relative to pristine, whilst Figure 2b compares the absolute recruitment values over time.

Figures 3a and 3b illustrate the relationship between recruitment (relative to pristne) and egg production (relative to pristine) for RC1 and RC2 respectively. In both plots, the replacement line is shown, and in Figure 3b the stock-recruit function which is used in the RC2 S-R penalty function is also illustrated.

Figure 4 compares the B75 (biomass above 75mm) trajectories for RC1 and RC2, and Figure 5 compares the egg production trajectories.

Figures 6a and b illustrate the estimated selectivity functions for males and females respectively.

RC1 *vs* RC2

In summary, RC1 is a model very similar to the past Reference Case assessment model, and RC2 is identical to RC1 except that a stock-recruit penalty function is added. Statistically there is not much difference between RC1 and RC2, i.e. they can both explain the observed data with similar precision but lead to rather different interpretations of recent biomass levels and fishing selectivity patterns, particularly for the female portion of the stock. The table below summarises the main differences between the two models. (S^f is female annual survival, and Egg is a measure of egg production taken to be proportional to female spawning biomass)

	RC1	**RC2**
S^f	0.91	0.95
$B_{75}(2005)$	31 912 MT	80 695 MT
$B_{75}(2005)/B_{75}(1996)$	1.00	0.86
$B_{75}(2005)/B_{75}(1970)$	0.43	0.50
$B_{75}(2005)/B_{75}(1870)$	**0.06**	**0.33**
Egg (2005)/Egg (1870)	**0.19**	**0.72**

Thus RC1 estimates there to be currently fewer lobsters, but a higher selectivity (especially of larger female lobsters), whereas RC2 estimates recent numbers of lobsters to be relatively higher than RC1, but that the selectivity is lower. The question that needs to be addressed, is whether the large cryptic female biomass of RC2 is realistic. If these female lobsters do exist in the population, is it really plausible that they cannot be “selected” by either of the fishing gears? Hoopnet gear in particular is usually deployed in shallower waters, where females predominate at certain times of the year.

Updated super-area assessments

Tables 2a and 2b report the RC1 and RC2 updated assessment results for the area disaggregated assessments. The RC2 A5-6 assessment required a constraint on the current biomass level. The level chosen was a maximum of 20 000 MT for 2005. Without this constraint, the assessment tends to push biomass to unrealistically high levels.

Figures 7a-c show the RC1 and RC2 area-disaggregated fits to trap, hoop and FIMS CPUE. Figures 8a-c compare the A3-6, A3-4 and A5-6 fits to the CPUE data.

Figures 9a and b illustrate the B75 trajectories for RC1 and RC2 respectively for the area-disaggregated assessments.

Replacement Yields

Tables 3a and 3b report the replacement yield estimates for RC1 and RC2 respectively. The total area-disaggregated (A1-8) combined RYs are compared to the RYs estimated for the comparative area-aggregated assessment. Table 4 reports similar comparisons for the B_{75}(2006) estimates. Table 5 summarises the RY estimates for A3-6, A3-4 and A3-5.

Discussion

Area-aggregated assessment
The general level of "goodness-of-fit" to data is very similar to that from the previous 2003 assessment. These updated assessments do however estimate recent biomass levels (in absolute terms) to be somewhat lower for RC1 and higher for RC2 (see Table 1). For example, the 2003 RC1 estimate of biomass in 2002 was about 36 000 MT, whereas the updated assessment estimates this value to be some 35 000 MT. The 2003 RC2 estimate of the 2002 biomass was 44 000 MT, and the updated assessment estimates this to be now some 90 000 MT.

Area-disaggregated assessments
The fits to the CPUE data (Figures 7a-c) generally show satisfactory fits. The A3-6 fit to trap and hoop CPUE does not however reproduce the recent decline in those CPUE data.

Replacement yields
The sum of the area-disaggregated RYs for RC1 is 6 645 MT – similar to that estimated by the area-aggregated assessment (7 045 MT) – for the reference case scenario for future somatic growth. The RYs under the alternate future somatic growth assumption are rather different – the area aggregated RY is some 2 667 MT and area-disaggregated 2377 MT, both less than 50% of the values estimated using the RC future somatic growth rate assumption. This highlights the sensitivity of estimates such as RYs to assumptions regarding future somatic growth rate levels.

The sum of the area-disaggregated RYs for RC2 is 8 342 MT – also similar to that estimated by the area-aggregated assessment (7 801 MT).

A3-6 vs A3-4 + A5-6 assessments

Both Tables 2a and 2b report the details of the A3-6, A3-4 and A5-6 assessments. Table 5 however provides a more direct comparison between the two approaches. For RC1, the A3-4+A5-6 values for both RY and B_{75}(2006) are very similar to those estimated for A3-6.

Figures 8a-c compare the A3-6, A3-4 and A5-6 fits to trap, hoopnet and FIMS CPUE. Note the estimated CPUE trends for A5-6 between RC1 and RC2 are very different for more recent years.

References

Melville-Smith, R. and L. Van Sittert. 2005. Historical Commercial West Coast rock lobster *Jasus lalandii* landings in South African waters. *Afr. J. mar. Sci*. 27(1): 33-44.

OLRAC. 2005. Updated male somatic growth rate estimates for input into the spatially disaggregated assessment for West Coast rock lobster. WG/09/05/WCRL17.

Table 1: Comparative contributions to –ln*L*, sigma values, biomass and egg production estimates for the area-aggregated assessments. Values in brackets are those estimated by the previous 2003 model.

Model	**RC1**	**RC2**
Female survivorship	0.91	0.95
R_{1870}	7.61 x 10^8	2.33 x 10^8
R_{1920}	0.84	1.97
R_{1950}	0.27	1.49
R_{1970}	0.12	0.43
R_{1975}	0.34	1.08
R_{1980}	0.09	0.35
R_{1985}	0.29	0.92
R_{1990}	0.36	1.20
R_{1995}	0.27	0.90
Trap CPUE σ	0.164	0.160
Hoop CPUE σ	0.205	0.218
FIMS CPUE σ	0.312	0.311
Male Trap Size σ	0.166	0.150
Female Trap Size σ	0.135	0.133
Male Hoop Size σ	0.173	0.166
Female Hoop Size σ	0.310	0.376
Male FIMS Size σ	0.072	0.071
Female FIMS Size σ	0.159	0.154
Male Sublegal size σ	0.146	0.147
Female Sublegal size σ	0.120	0.131
Trap F% σ	0.019	0.021
Hoop F% σ	0.064	0.067
FIMS F% σ	0.038	0.037
Trap CPUE –*lnL*	-31.35	-32.01
Hoop CPUE –*lnL*	-26.04	-24.58
FIMS CPUE –*lnL*	-8.65	-8.68
Male Trap Size –*lnL*	-18.25	-24.50
Female Trap Size –*lnL*	6.46	-9.09
Male Hoop Size –*lnL*	19.68	2.54
Female Hoop Size –*lnL*	57.36	56.83
Male FIMS Size –*lnL*	-90.74	-93.15
Female FIMS Size –*lnL*	-20.52	-22.22
Male Sublegal size –*lnL*	-7.07	-6.33
Female Sublegal size –*lnL*	-17.92	-15.14
Trap F% -*lnL*	3.87	4.81
Hoop F% -*lnL*	8.77	9.42
FIMS F% -*lnL*	2.93	2.79
Total –*lnL* (excl. LLF_R)	**-57.57**	**-59.35**
LLF_R [1]	-	-0.32
B_{75}(2002)	34 843 (36 287)	89 873 (44 240)
B_{75}(2005)	31 912	80 696
B_{75}(2002)/B_{75}(1870)	0.06 (0.07)	0.36 (0.23)
B_{75}(2005)/B_{75}(1870)	0.06	0.33
Egg (2002)/Egg (1870)	0.19 (0.21)	0.73 (0.65)
Egg (2005)/Egg (1870)	0.19	0.72
RY (68-04 ave growth)	7045	7801

[1] LLF_R is the penalty function that attempts to enforce recruitment to lie above the replacement line on the stock-recruitment plot.

Table 2a: Comparative contributions to –ln*L*, sigma values, biomass and egg production estimates for each super-area (model fits are RC1-like).

Model	**A1-2**	**A3-6**	**A3-4**	**A5-6**	**A7**	**A8**
Female survivorship	0.88	0.90	0.90	0.92	0.94	0.89
R_{1870}	3.60 x 10^7	6.57 x 10^8	2.87 x 10^8	2.57 x 10^8	1.14 x 10^8	3.05 x 10^8
R_{1920}	4.97	0.84	0.77	0.81	0.57	0.36
R_{1950}	0.003	0.15	0.14	0.21	0.12	0.07
R_{1970}	0.06	0.11	0.12	0.14	0.09	0.13
R_{1975}	0.01	0.17	0.20	0.20	0.21	0.39
R_{1980}	0.03	0.01	0.03	0.07	0.03	0.23
R_{1985}	0.03	0.12	0.19	0.04	0.07	0.66
R_{1990}	0.01	0.19	0.29	0.01	0.09	0.60
R_{1995}	0.02	0.04	0.08	0.001	0.20	0.36
Trap CPUE σ	-	0.284	0.311	0.530	0.208	0.128
Hoop CPUE σ	0.172	0.336	0.368	0.572	0.257	0.141
FIMS CPUE σ	-	1.312	1.337	0.406	0.791	0.198
Male Trap Size σ	-	0.167	0.187	0.259	0.268	0.218
Female Trap Size σ	-	0.169	0.150	0.190	0.131	0.260
Male Hoop Size σ	0.236	0.150	0.153	0.245	0.356	0.193
Female Hoop Size σ	0.276	0.222	0.190	0.290	0.786	0.387
Male FIMS Size σ	-	0.199	0.205	-	0.140	0.062
Female FIMS Size σ	-	0.164	-0.168	-	0.202	0.152
Male Sublegal size σ	-	-	-	-	-	0.156
Female Sublegal size σ	-	-	-	-	-	0.117
Trap F% σ	-	0.031	0.039	0.08	0.032	0.007
Hoop F% σ	0.03	0.053	0.062	0.08	0.052	0.006
FIMS F% σ	-	0.088	0.090	-	0.032	0.033
Trap CPUE –*lnL*	-	-18.17	-16.00	-3.21	-25.69	-37.90
Hoop CPUE –*lnL*	-32.79	-14.20	-12.32	-1.38	-20.61	-34.90
FIMS CPUE –*lnL*	-	10.04	10.28	-5.23	3.19	-14.63
Male Trap Size –*lnL*	-	-24.21	-8.60	35.36	65.78	-2.77
Female Trap Size –*lnL*	-	30.25	-22.97	49.34	-8.69	0.02
Male Hoop Size –*lnL*	29.47	-21.71	-26.48	48.96	33.76	12.08
Female Hoop Size –*lnL*	17.65	38.20	0.59	106.98	13.49	10.93
Male FIMS Size –*lnL*	-	23.63	26.29	-	-23.37	-103.02
Female FIMS Size –*lnL*	-	-8.83	8.54	-	-7.18	-24.91
Male Sublegal size –*lnL*	-	-	-	-	-	-3.14
Female Sublegal size –*lnL*	-	-	-	-	-	-18.03
Trap F% -*lnL*	-	6.61	5.65	7.96	6.71	3.57
Hoop F% -*lnL*	4.61	6.59	5.19	9.40	1.52	2.99
FIMS F% -*lnL*	-	4.31	4.52	-	5.22	2.59
Total –*lnL* (excl. LLF_R)	**-23.46**	**-1.09**	**-4.95**	**21.24**	**-22.28**	**-90.62**
LLF_R [2]	-	-	-	-	-	-
B_{75}(2002)	735	13 269	6 677	6 782	17 075	15 200
B_{75}(2005)	N/A	13 103	7 137	5 473	13 985	11 730
B_{75}(2002)/B_{75}(1870)	0.02	0.04	0.05	0.03	0.06	0.10
B_{75}(2005)/B_{75}(1870)	N/A	0.04	0.05	0.03	0.05	0.08
Egg (2002)/Egg (1870)	0.03	0.09	0.09	0.06	0.11	0.31
Egg (2005)/Egg (1870)	N/A	0.08	0.08	0.05	0.10	0.29
RY (68-04 ave growth)	0	2 520	2 202	586	1 031	3 094

[2] LLF_R is the penalty function that attempts to enforce recruitment to lie above the replacement line on the stock-recruitment plot.

Table 2b: Comparative contributions to –ln*L*, sigma values, biomass and egg production estimates for each super-area (model fits are RC2-like).

Model	**A1-2**	**A3-6**	**A3-4**	**A5-6**	**A7**	**A8**
Female survivorship	0.85	0.94	0.93	0.95	0.95	0.92
R_{1870}	3.22×10^8	1.62×10^8	7.48×10^7	2.41×10^7	2.11×10^7	1.07×10^8
R_{1920}	1.55	1.84	1.78	0.72	1.37	0.75
R_{1950}	1.64	1.61	1.38	0.20	1.25	0.35
R_{1970}	0.55	0.48	0.54	0.14	0.45	0.36
R_{1975}	0.36	0.61	0.69	0.20	1.06	1.14
R_{1980}	0.37	0.20	0.27	0.06	0.33	0.61
R_{1985}	0.37	0.49	0.66	0.06	0.27	1.78
R_{1990}	0.30	0.94	1.10	0.06	0.45	1.70
R_{1995}	0.47	0.50	0.60	0.09	0.96	1.00
Trap CPUE σ	-	0.300	0.318	0.440	0.198	0.126
Hoop CPUE σ	0.247	0.369	0.382	0.497	0.257	0.148
FIMS CPUE σ	-	1.382	1.371	0.133	0.797	0.202
Male Trap Size σ	-	0.195	0.202	0.150	0.246	0.195
Female Trap Size σ	-	0.158	0.130	0.740	0.164	0.261
Male Hoop Size σ	0.557	0.155	0.152	0.157	0.404	0.185
Female Hoop Size σ	0.268	0.310	0.266	0.779	0.785	0.340
Male FIMS Size σ	-	0.182	0.194	-	0.141	0.062
Female FIMS Size σ	-	0.155	0.152	-	0.196	0.122
Male Sublegal size σ	-	-	-	-	-	0.159
Female Sublegal size σ	-	-	-	-	-	0.154
Trap F% σ	-	0.04	0.06	0.095	0.03	0.008
Hoop F% σ	0.037	0.06	0.09	0.097	0.06	0.006
FIMS F% σ	-	0.09	0.10	-	0.08	0.033
Trap CPUE –*lnL*	-	-16.86	-15.46	-7.69	-26.86	-37.64
Hoop CPUE –*lnL*	-23.36	-11.92	-11.07	-4.80	-20.64	-33.80
FIMS CPUE –*lnL*	-	10.70	10.60	-19.73	3.28	-14.27
Male Trap Size –*lnL*	-	7.80	2.39	-35.67	61.98	-12.87
Female Trap Size –*lnL*	-	8.28	-32.79	139.86	5.66	-3.64
Male Hoop Size –*lnL*	139.46	0.35	-26.28	-2.32	43.47	4.78
Female Hoop Size –*lnL*	6.60	42.72	9.49	180.25	14.44	8.34
Male FIMS Size –*lnL*	-	12.20	18.18	-	-22.99	-103.39
Female FIMS Size –*lnL*	-	-17.50	-16.04	-	-0.95	-34.65
Male Sublegal size –*lnL*	-	-	-	-	-	-0.82
Female Sublegal size –*lnL*	-	-	-	-	-	-8.52
Trap F% -*lnL*	-	9.71	11.66	11.13	5.63	4.15
Hoop F% -*lnL*	6.35	7.66	7.99	12.90	2.36	2.51
FIMS F% -*lnL*	-	5.05	5.16	-	5.12	2.42
Total –*lnL* (excl. LLF_R)	**-2.40**	**9.73**	**4.38**	**21.96**	**-20.96**	**-91.71**
LLF_R [3]	6.78	5.24	0.82	17.30	-1.96	0.64
B_{75}(2002)	15 000*	36 881	10 946	3 505	9 392	17 087
B_{75}(2005)	13 630	35 519	11 222	3 962	7 244	13 225
$B_{75}(2002)/B_{75}(1870)$	0.43	0.29	0.24	0.01	0.16	0.26
$B_{75}(2005)/B_{75}(1870)$	0.39	0.28	0.23	0.01	0.12	0.20
Egg (2002)/Egg (1870)	0.44	0.50	0.52	0.03	0.26	0.84
Egg (2005)/Egg (1870)	0.40	0.47	0.50	0.03	0.24	0.81
RY (68-04 ave growth)	0	2 332	1 323	1 493	2 020	3 990

* Constraint placed so that *B*(2005)<= 15 000 MT.

[3] LLF_R is the penalty function that attempts to enforce recruitment to lie above the replacement line on the stock-recruitment plot.

Table 3a: RC1 RYs (MT).

Super-area	RC somatic growth 1968-2004 ave	1990-2004 average somatic growth
A1-2	0	0
A3-6	2 520	776
A7	1 031	425
A8	3 094	1 176
Total (A1-8)	**6 645**	**2 377**
Area-aggregated	**7 045**	**2 667**

Table 3b: RC2 RYs (MT).

Super-area	RC somatic growth (68-04 average)
A1-2	0
A3-6	2 332
A7	2 020
A8	3 990
Total (A1-8)	**8 342**
Area-aggregated	**7 801**

Table 4: B_{75}(2006) estimates (MT).

Super-area	RC1	RC2
A1-2	5 74	0
A3-6	13 513	36 270
A7	13 912	7 259
A8	11 511	13 050
Total (A1-8)	**39 510**	**56 579**
Area-aggregated	**33 357**	**81 186**

Table 5: Comparison of RYs and B_{75}(2006) estimates between the A3-6 assessments, and the A3-4 and A5-6 assessments.

		RC1	RC2
RYs	**A3-4**	2 202	1 323
	A5-6	586	1 493
	A3-4+A5-6	**2 788**	**2 816**
	A3-6	**2 520**	**2 332**
B_{75}(2006)	**A3-4**	7 502	11 789
	A5-6	5 428	20 839
	A3-4+A5-6	**12 930**	**32 628**
	A3-6	**13 515**	**36 270**

Figure 1a: RC1 and RC2 fits to trap, hoop and FIMS CPUE data for the updated area-aggregated assessments.

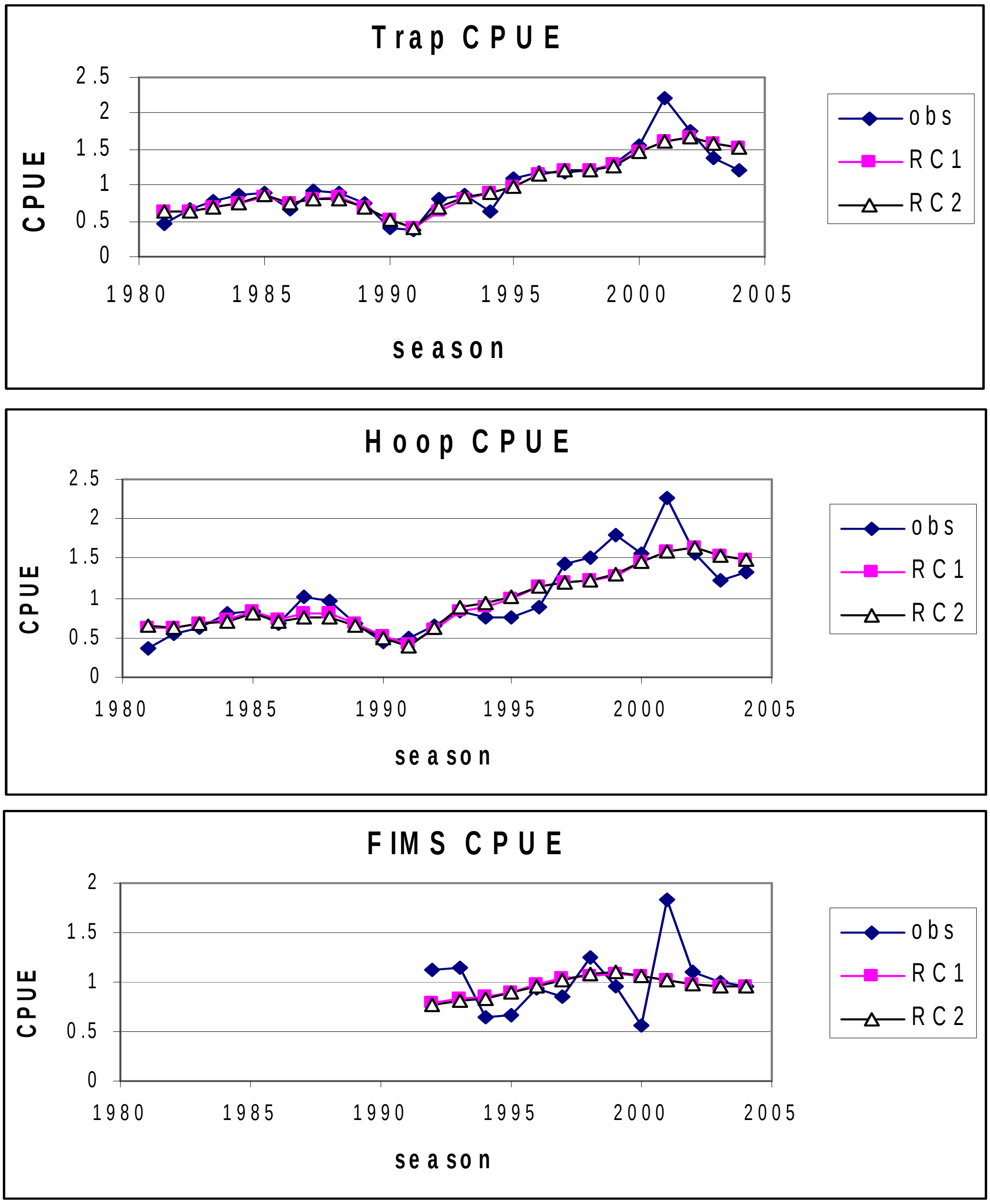


Figure 1b: RC1 and RC2 fits to trap, hoop and FIMS F% (percent females in catch) data for the updated area-aggregated assessments.

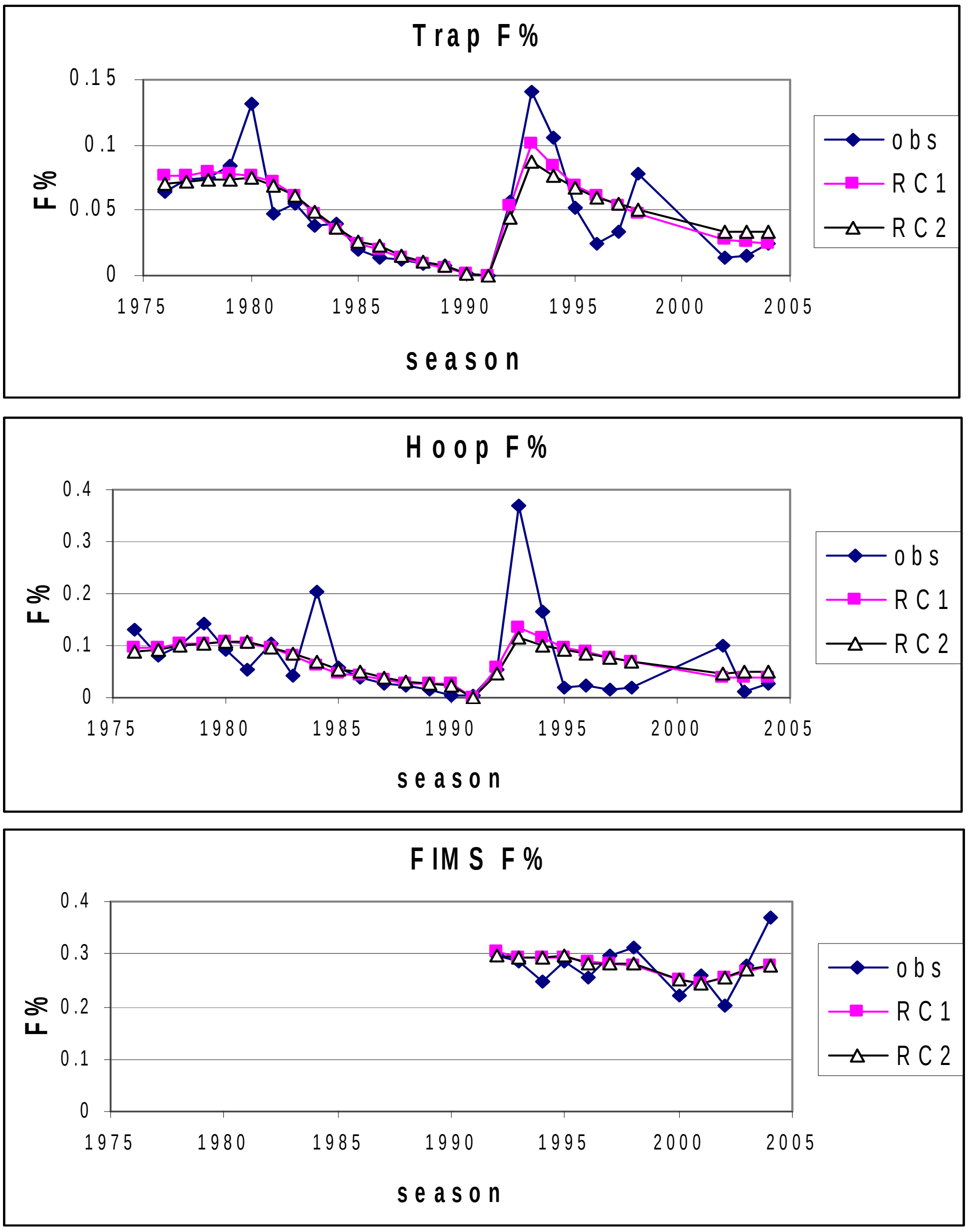
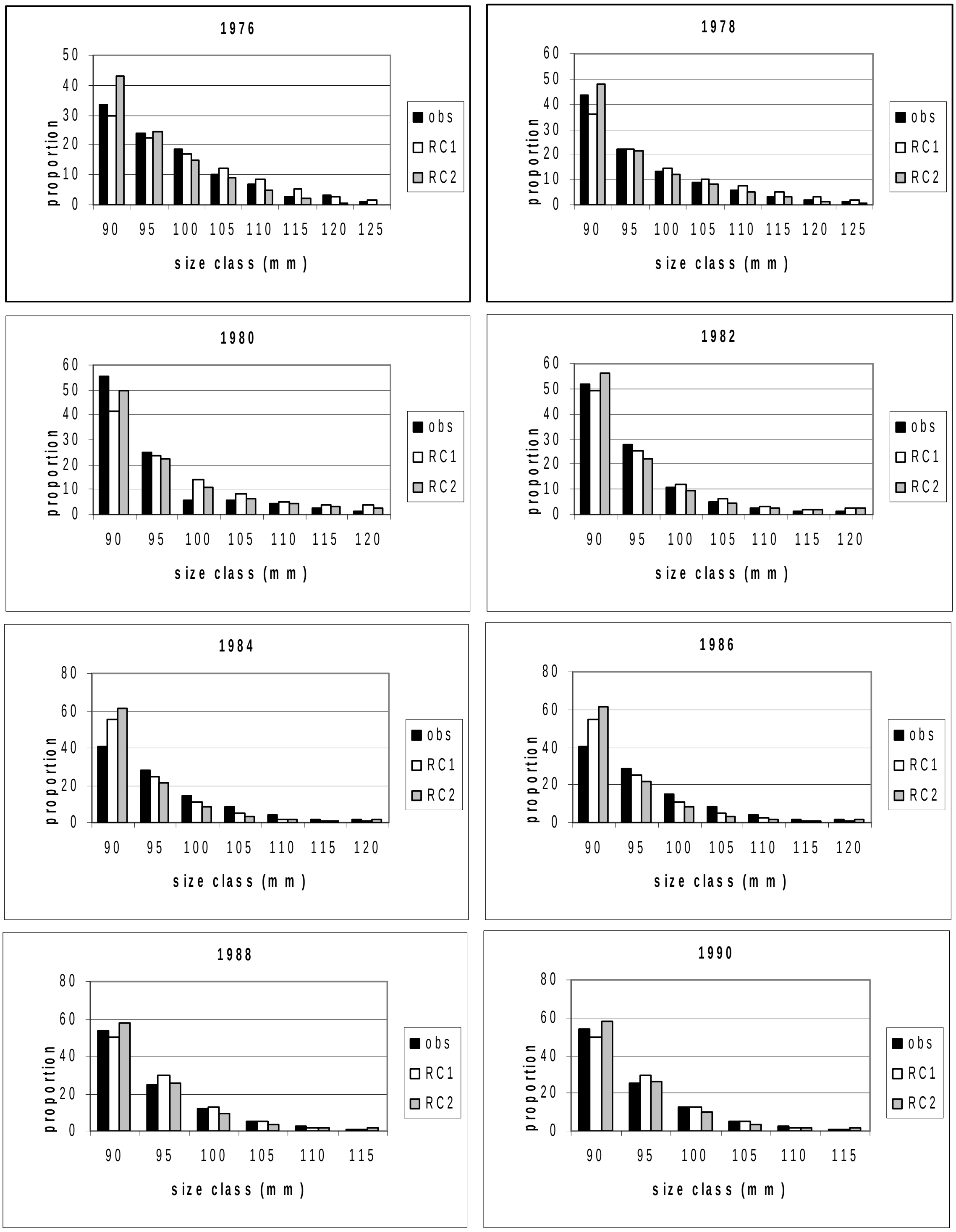
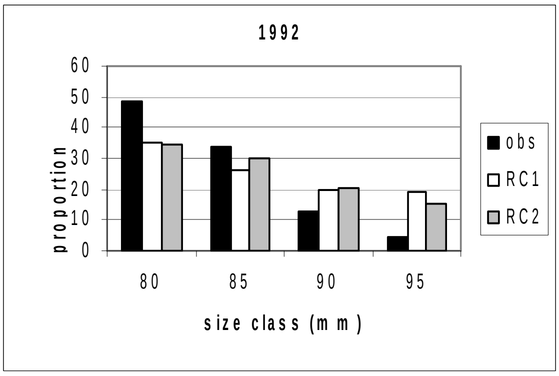


Figure 1c: RC1 and RC2 fits to trap male catch-at-size data for the area-aggregated assessment (not every year is shown here and later in the interest of saving trees!).




1992
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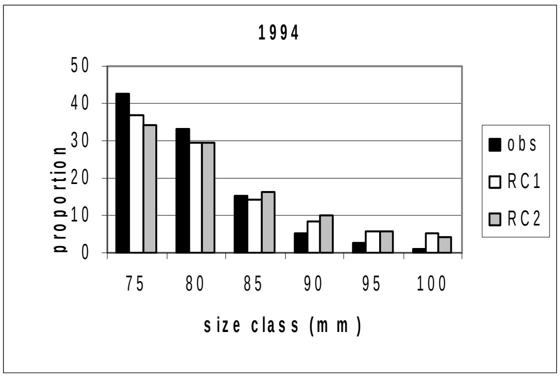
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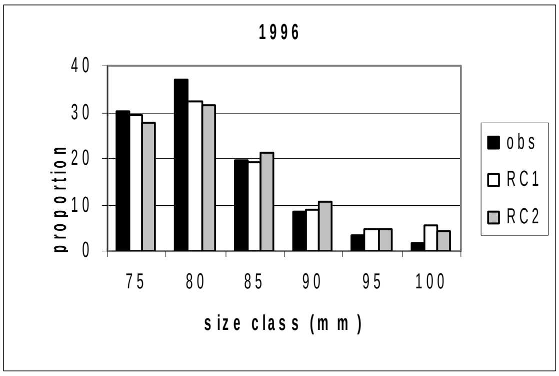
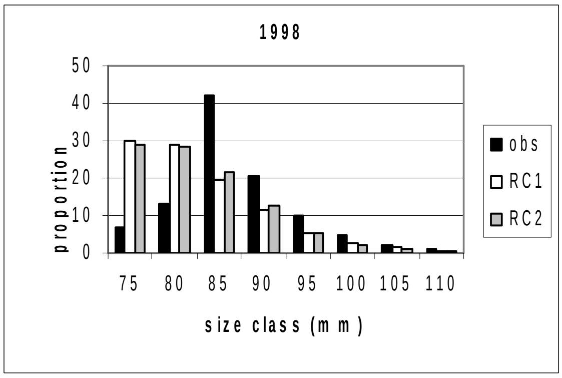
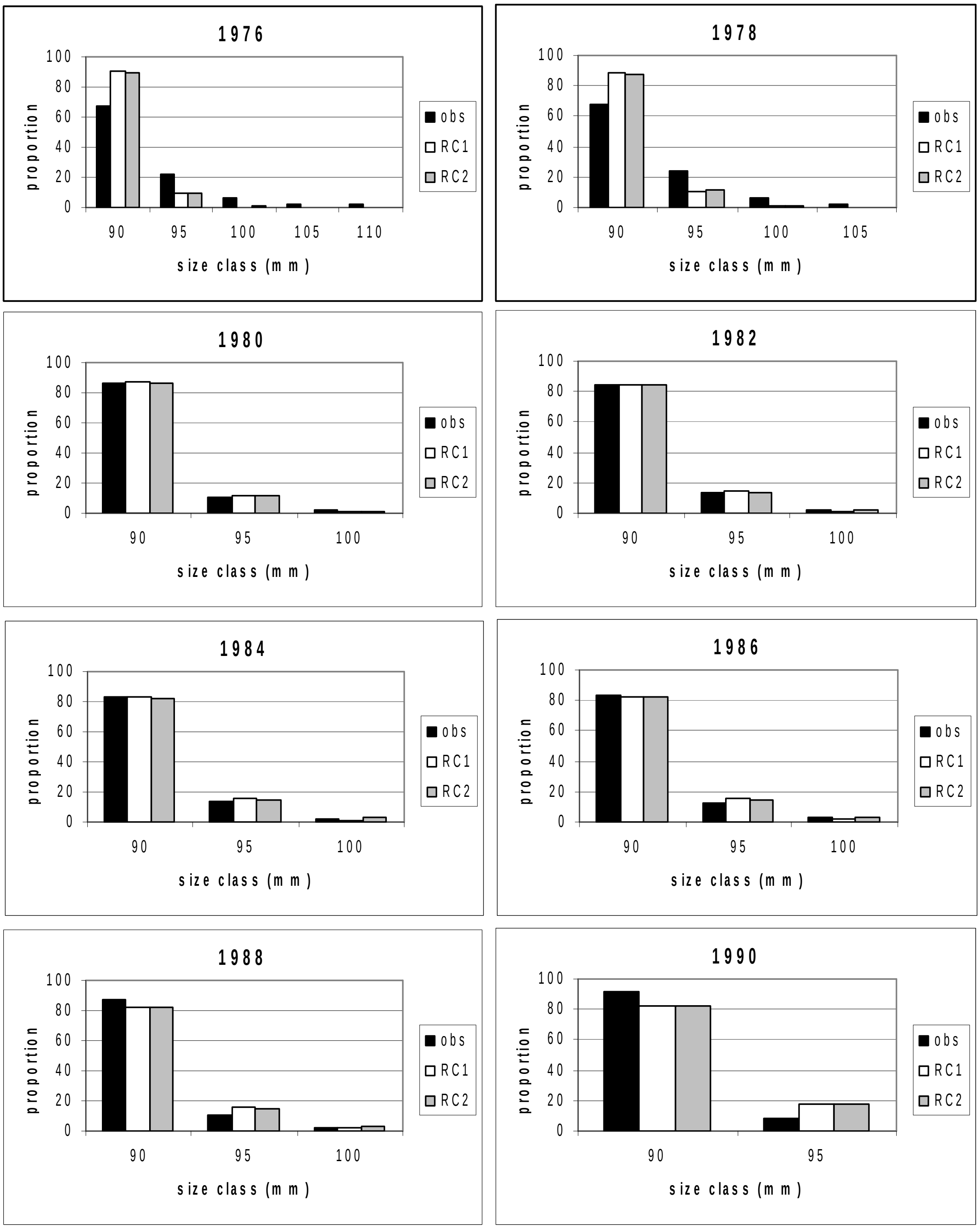

1996
proportion
size class (mm)
obs
RC1
RC2

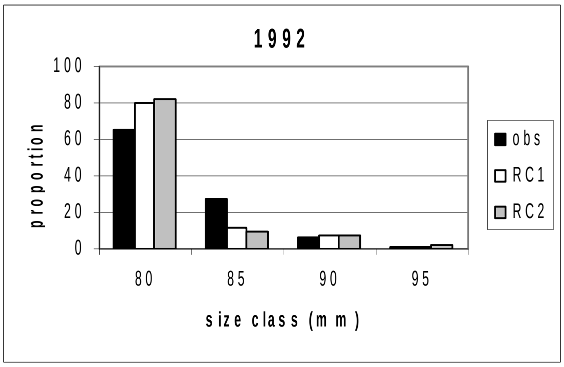

1998
proportion
size class (mm)
obs
RC1
RC2

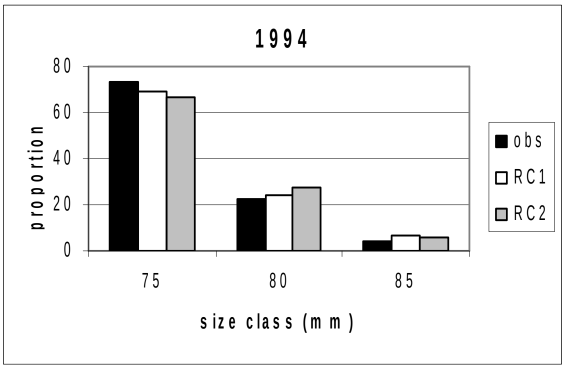

2002
proportion
size class (mm)
obs
RC1
RC2

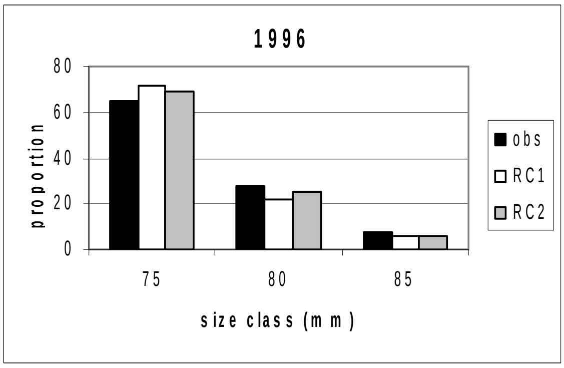

2004
proportion
size class (mm)
obs
RC1
RC2

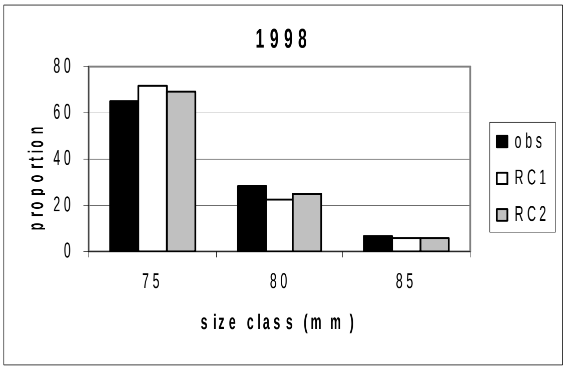
Figure 1d: RC1 and RC2 fits to trap female catch-at-size data for the area-aggregated assessment.

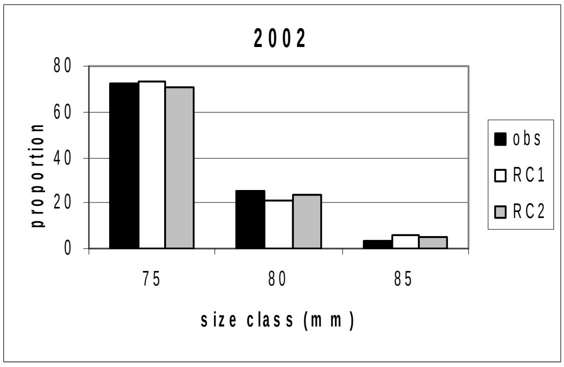



1992
proportion
size class (mm)
80
85
90
95
obs
RC1
RC2


1994
proportion
size class (mm)
75
80
85
obs
RC1
RC2

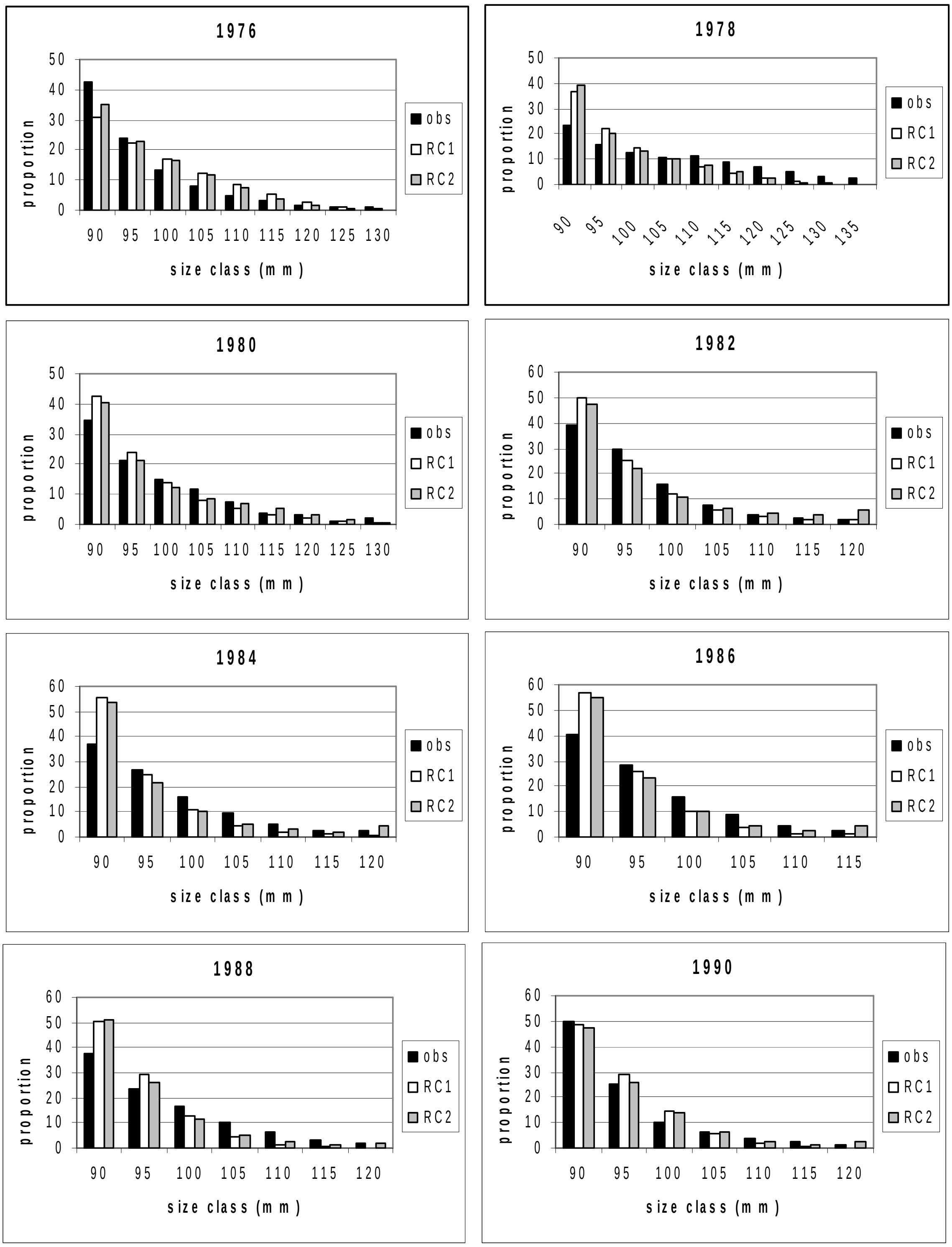

1996
proportion
size class (mm)
75
80
85
obs
RC1
RC2


1998
proportion
size class (mm)
75
80
85
obs
RC1
RC2


2002
proportion
size class (mm)
75
80
85
obs
RC1
RC2


2004
proportion
size class (mm)
75
80
85
obs
RC1
RC2

Figure 1e: RC1 and RC2 fits to hoop male catch-at-size data for the area-aggregated assessment.



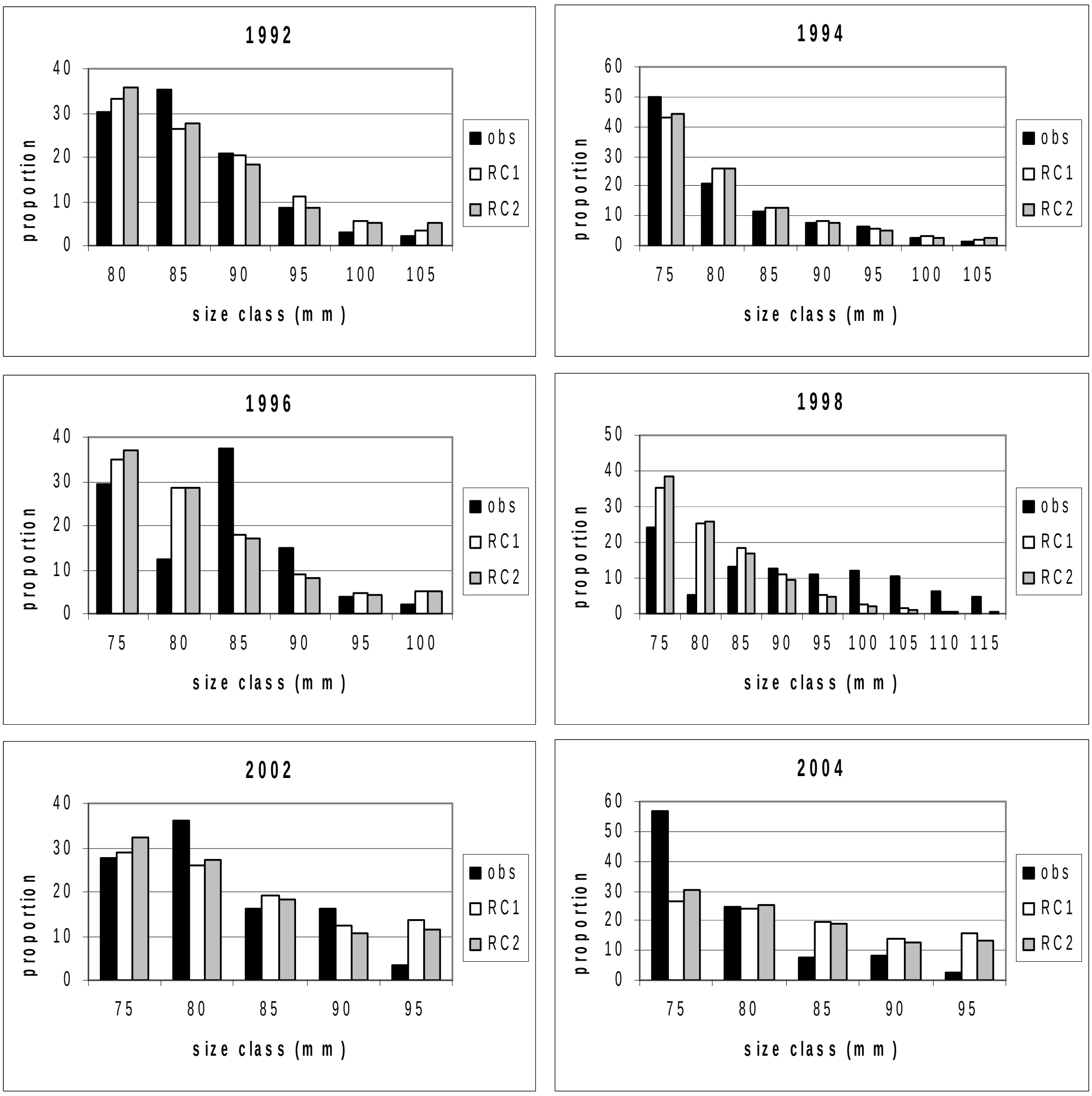
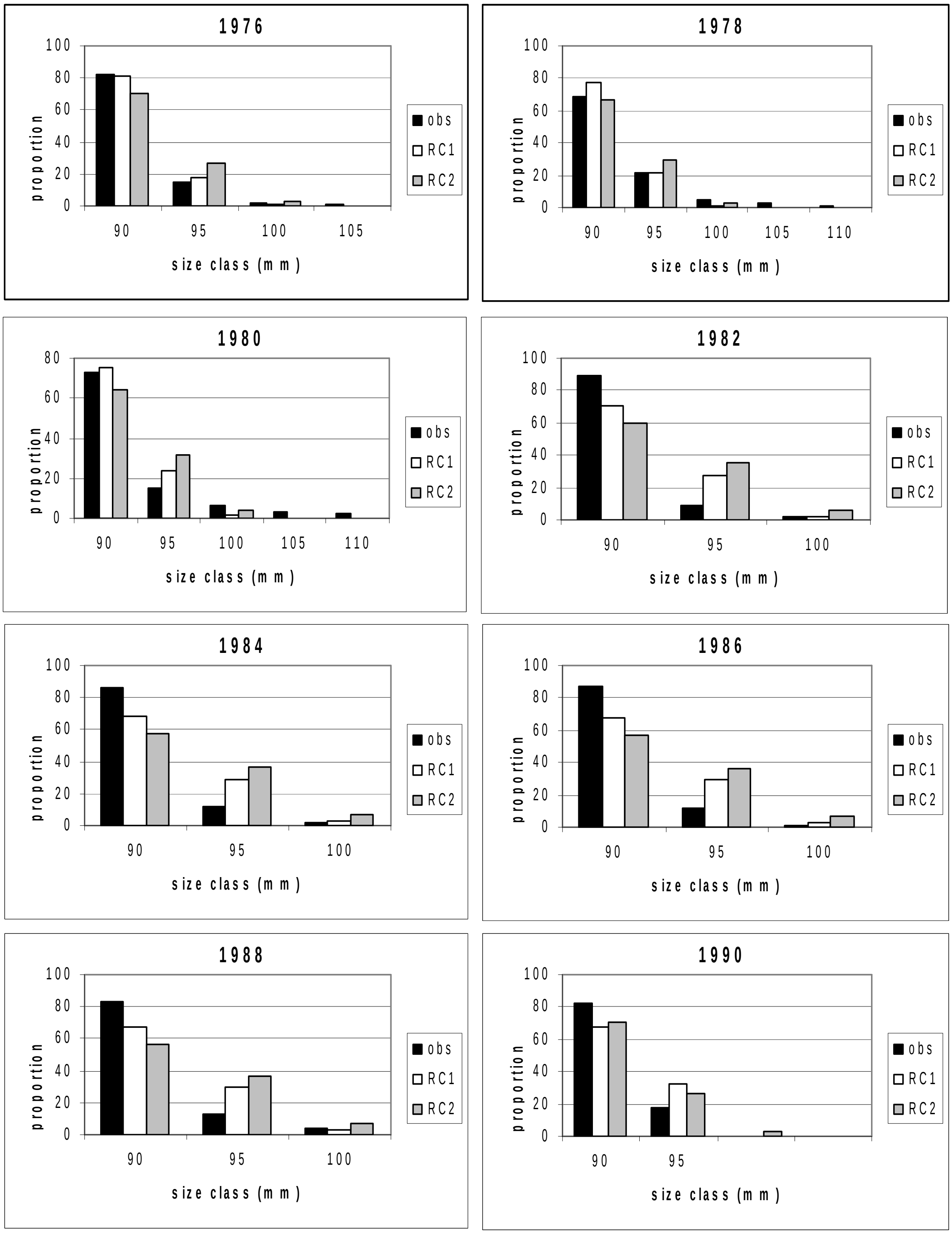
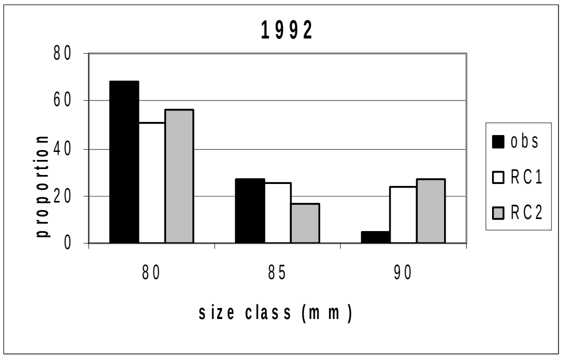
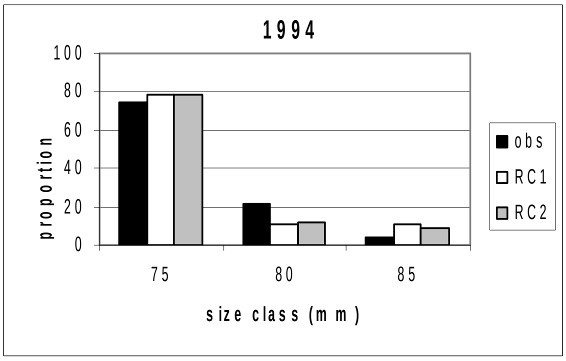
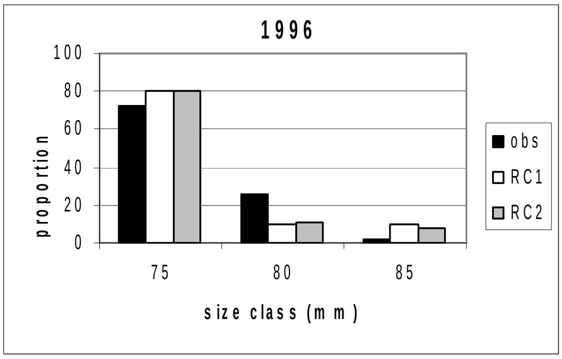

1992
1994
1996
1998
2002
2004
proportion
size class (mm)
obs
RC1
RC2

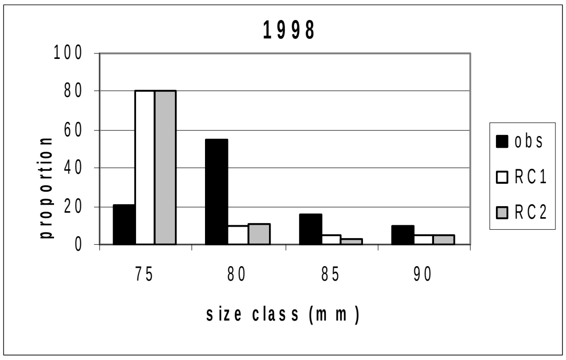
Figure 1f: RC1 and RC2 fits to hoop female catch-at-size data for the area-aggregated assessment.

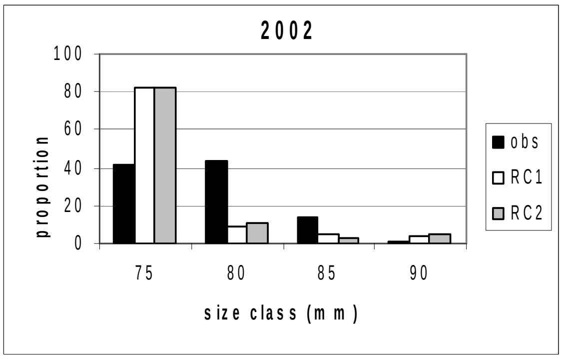



1992
proportion
size class (mm)
80
85
90
obs
RC1
RC2


1994
proportion
size class (mm)
75
80
85
obs
RC1
RC2


1996
proportion
size class (mm)
75
80
85
obs
RC1
RC2


1998
proportion
size class (mm)
75
80
85
90
obs
RC1
RC2


2002
proportion
size class (mm)
75
80
85
90
obs
RC1
RC2

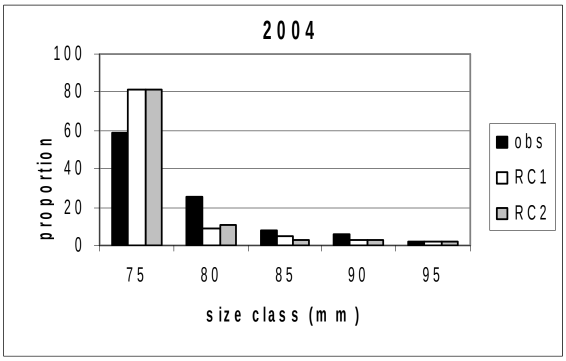

2004
proportion
size class (mm)
75
80
85
90
95
obs
RC1
RC2

Figure 1g: RC1 and RC2 fits to FIMS male catch-at-size data for the area-aggregated assessment.

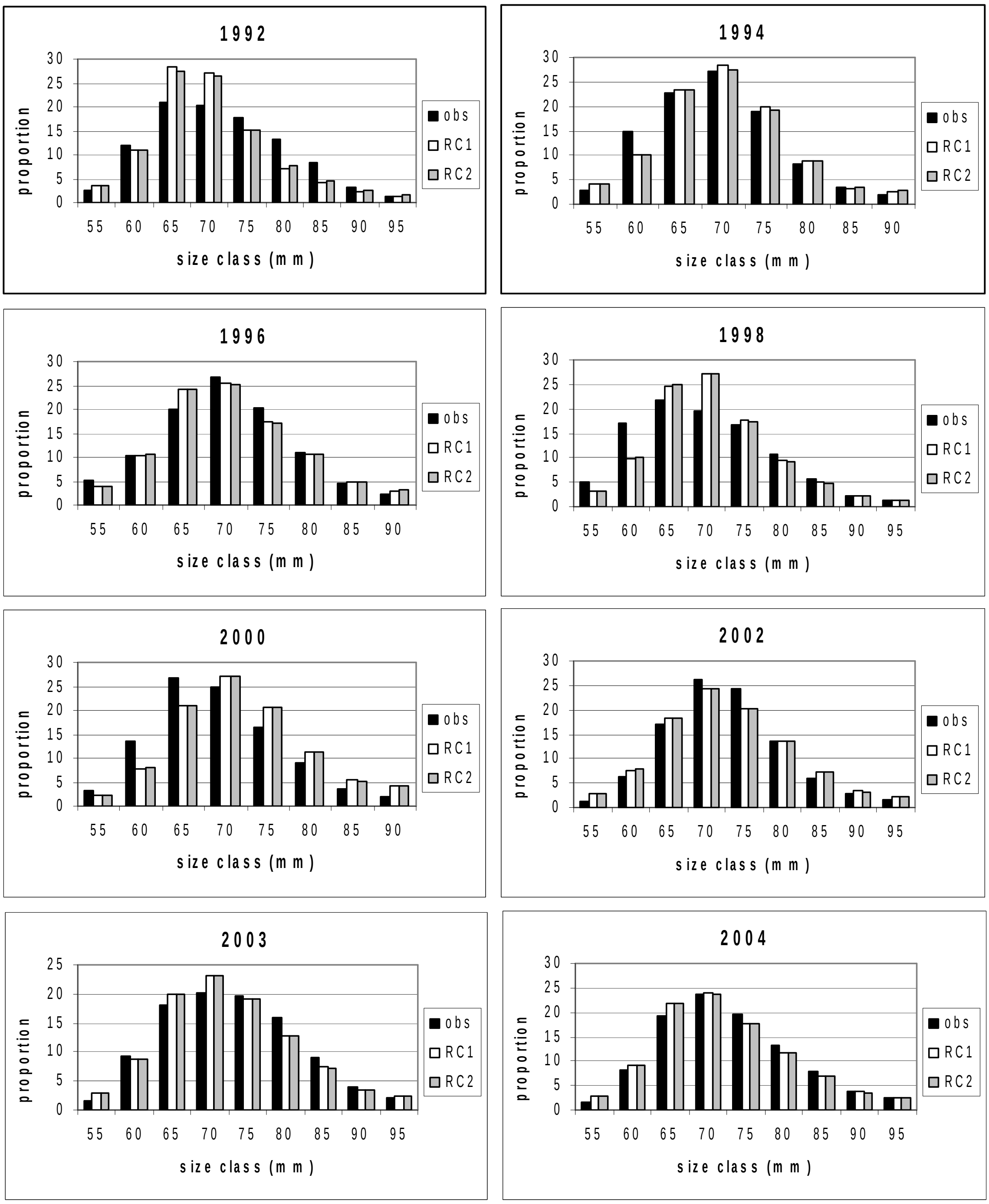


Figure 1h: RC1 and RC2 fits to FIMS female catch-at-size data for the area-aggregated assessment.

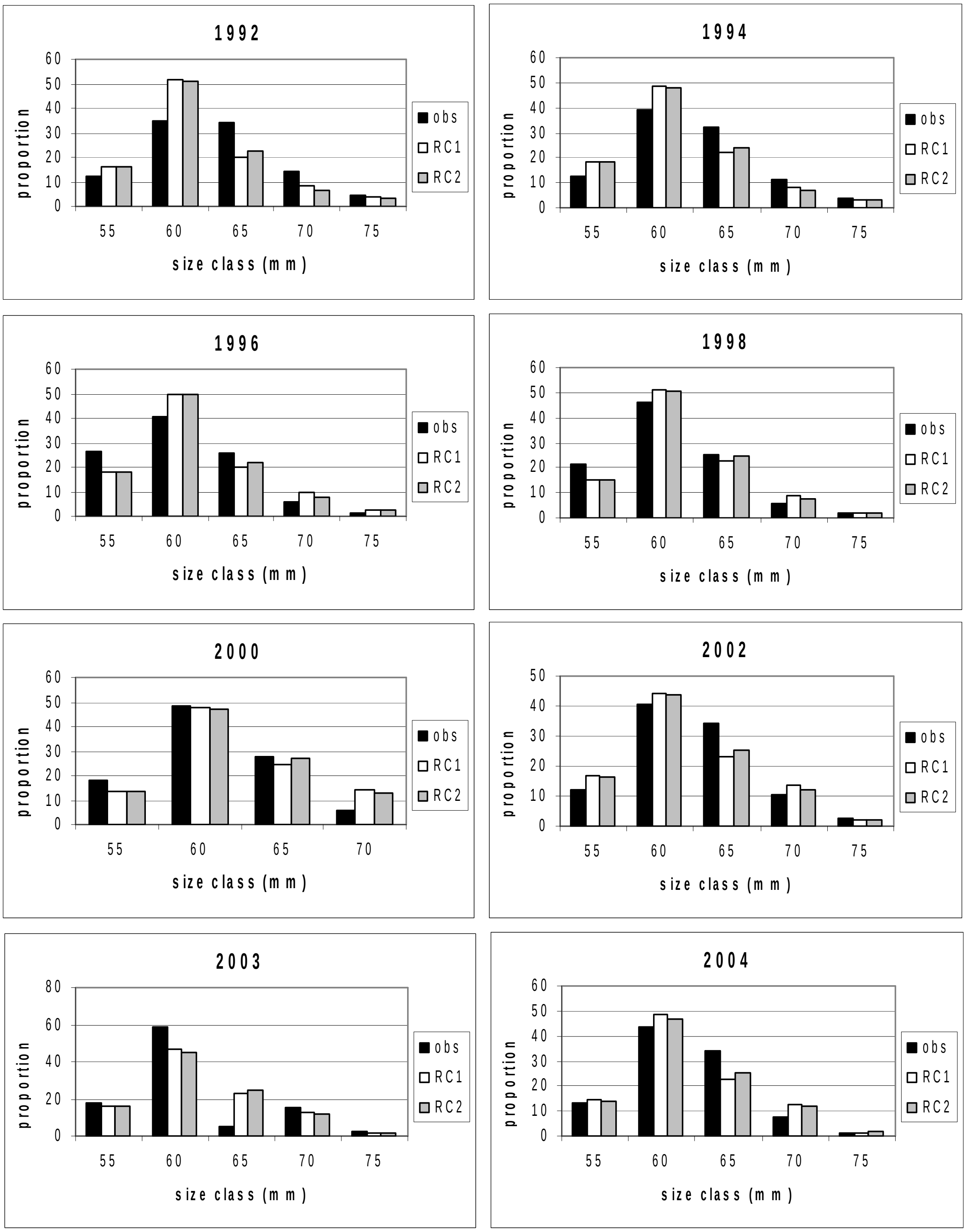


Figure 1i: RC1 and RC2 fits to sublegal male catch-at-size data for the area-aggregated assessment.

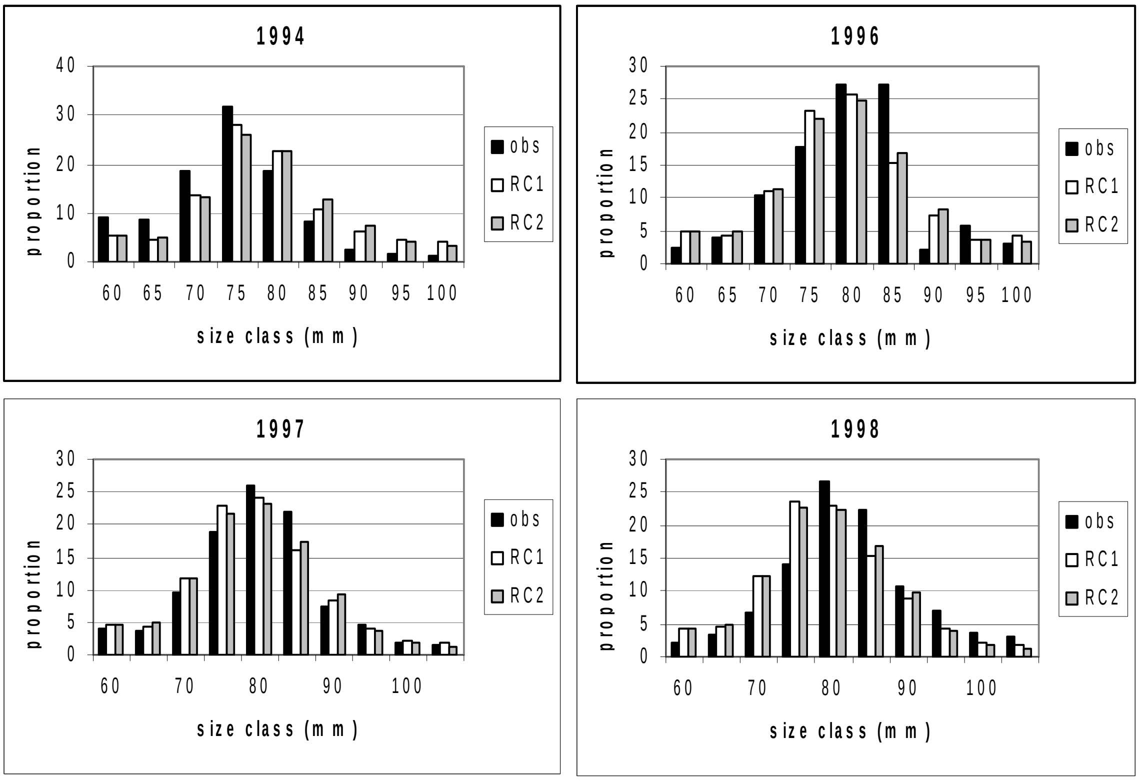


Figure 1j: RC1 and RC2 fits to sublegal female catch-at-size data for the area-aggregated assessment.

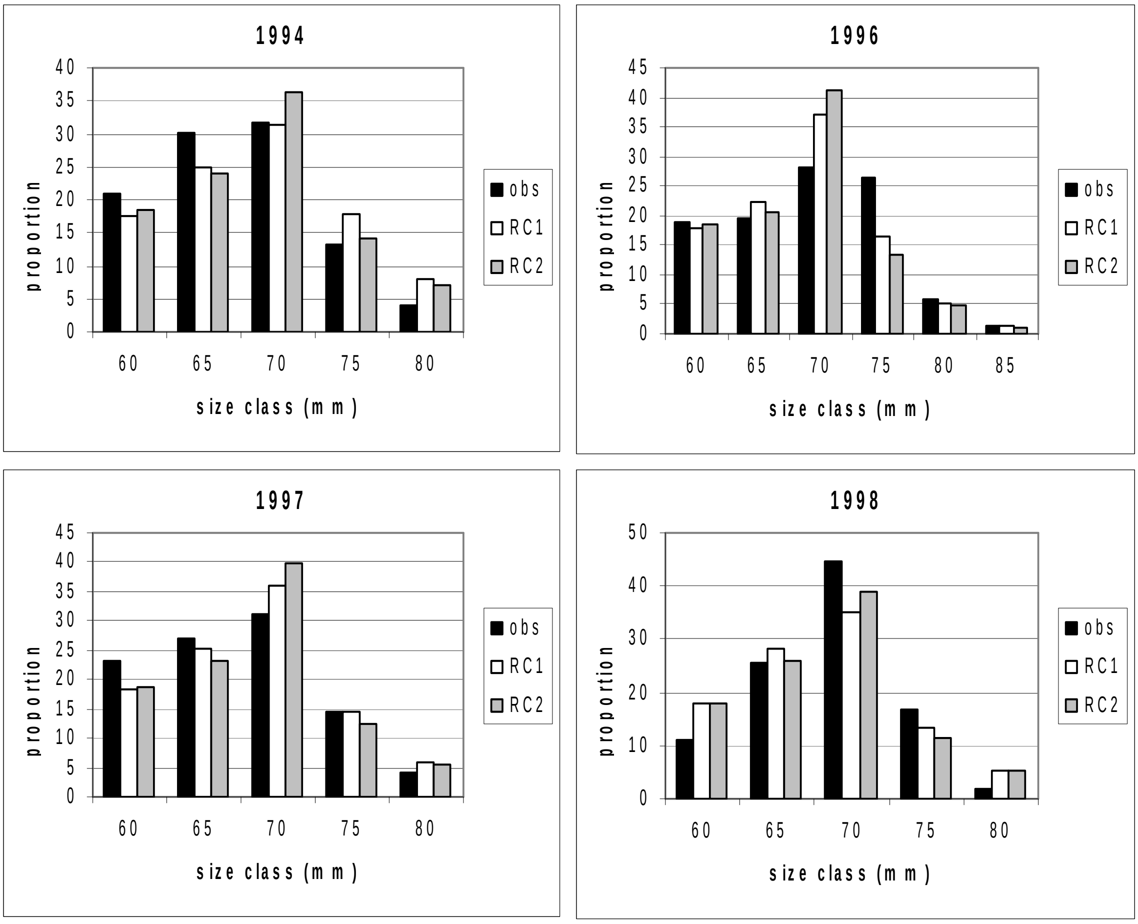


Figure 2a: Comparison between RC1 and RC2 recruitment trends relative to pristine values for the area-aggregated assessment.

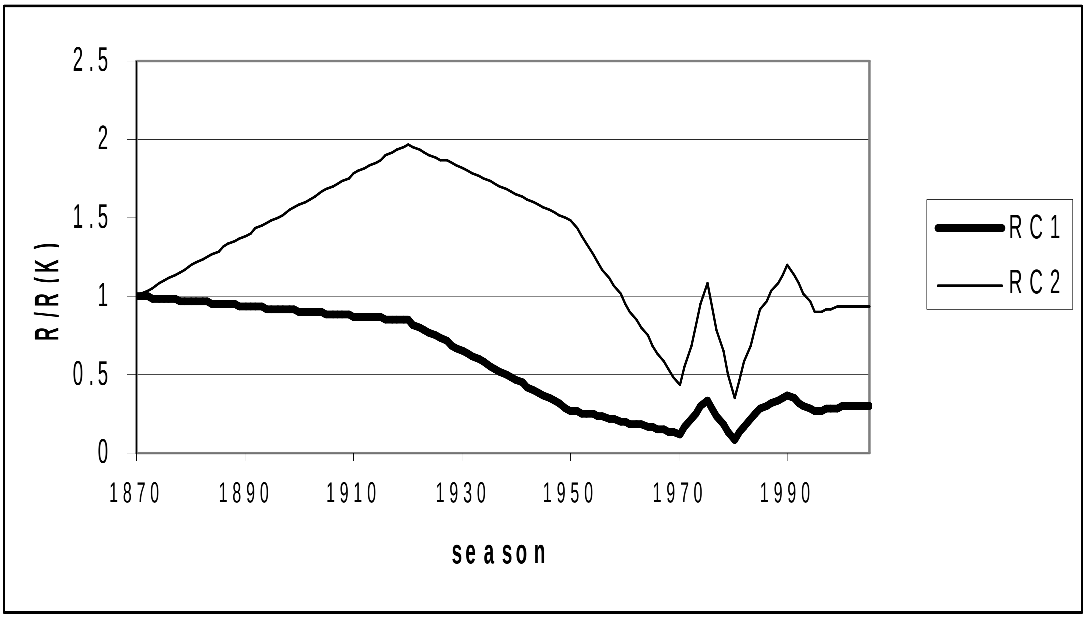


Figure 2b: Comparison between RC1 and RC2 absolute recruitment trends for the area-aggregated assessment.

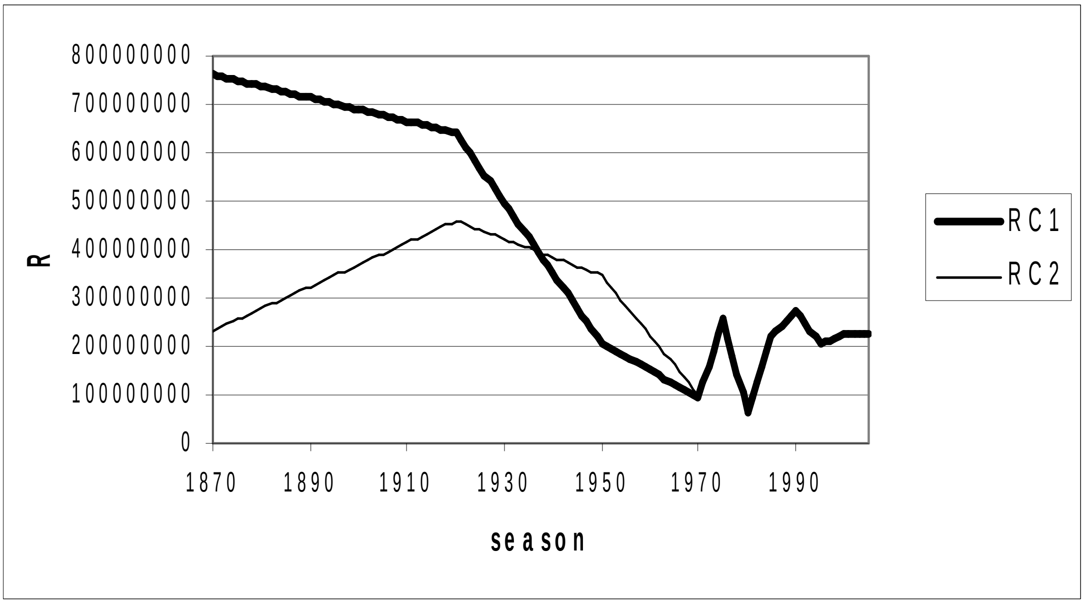


Figure 3a: RC1 recruitment plotted against egg production, both expressed as proportions of pristine levels (for the area-aggregated assessment). The straight line shows the replacement line.

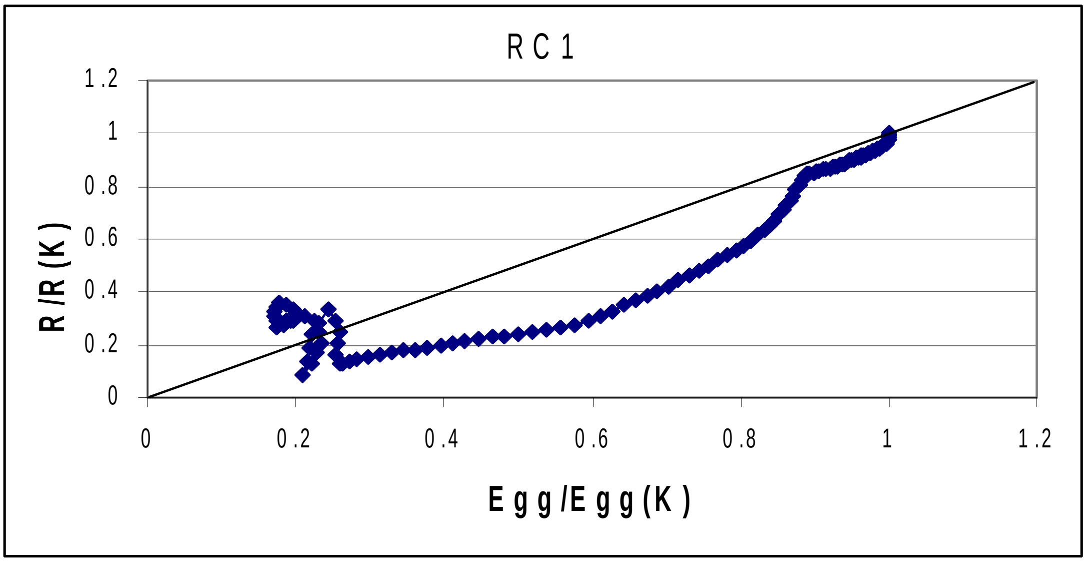


Figure 3b:RC2 recruitment plotted against egg production, both expressed as proportions of pristine levels (for the area-aggregated assessment). The straight line shows the replacement line. The curve is the Beverton-Holt stock recruit curve (*h* fixed = 0.8).

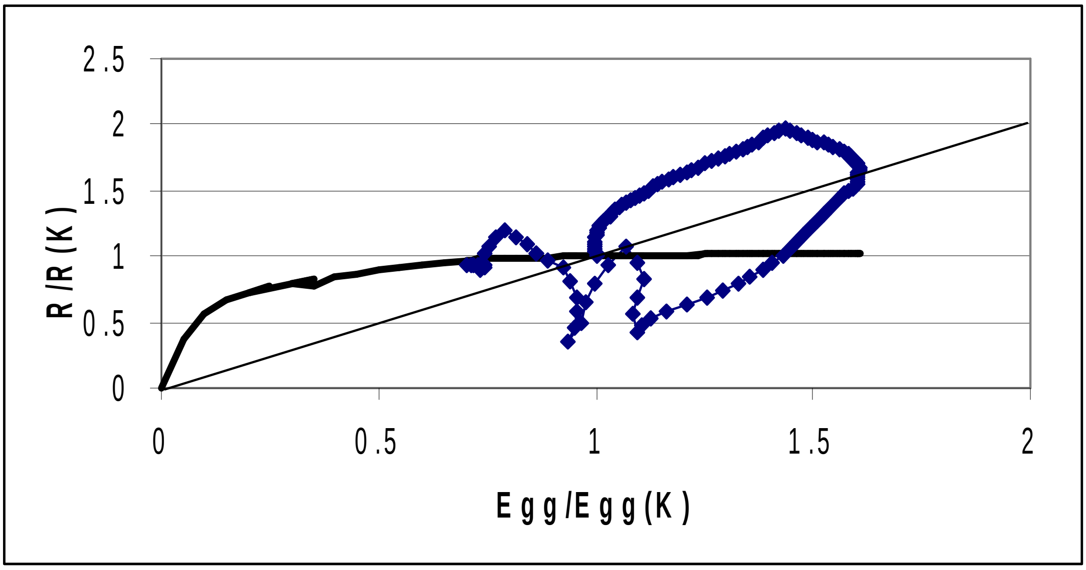


Figure 4: Comparison between B_{75} trends between RC1 and RC2 for the area-aggregated assessment.

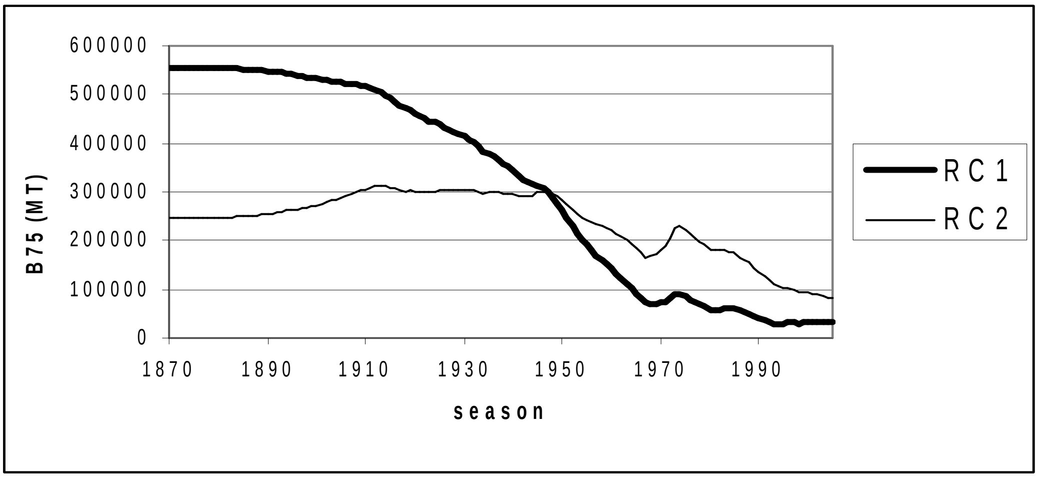


Figure 5: Comparison between egg production (relative to pristine) between RC1 and RC2 for the area-aggregated assessment.

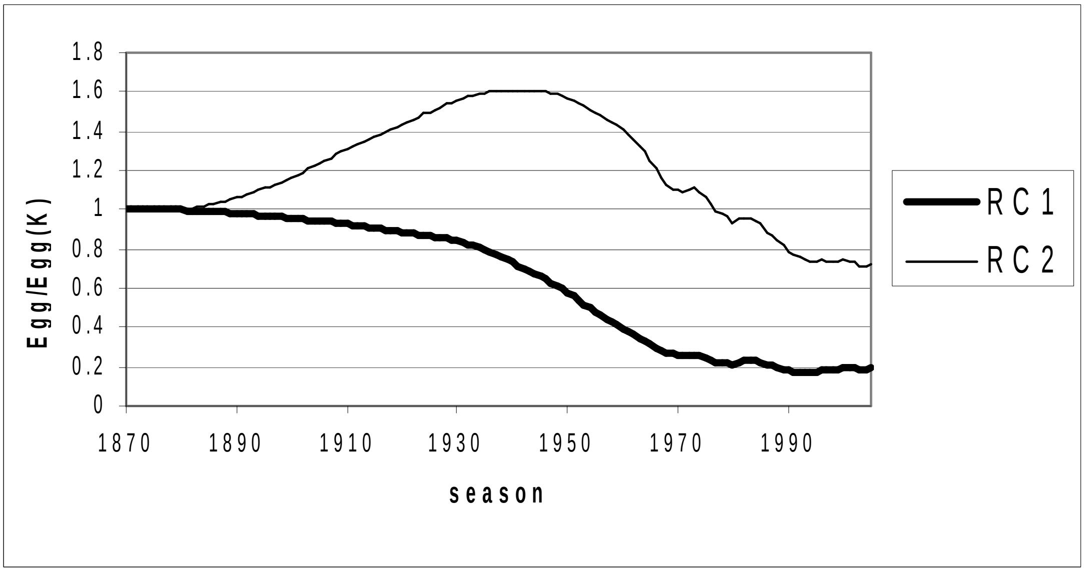


Figure 6a: Comparison between RC1 and RC2 male selectivity functions for the area-aggregated assessment.

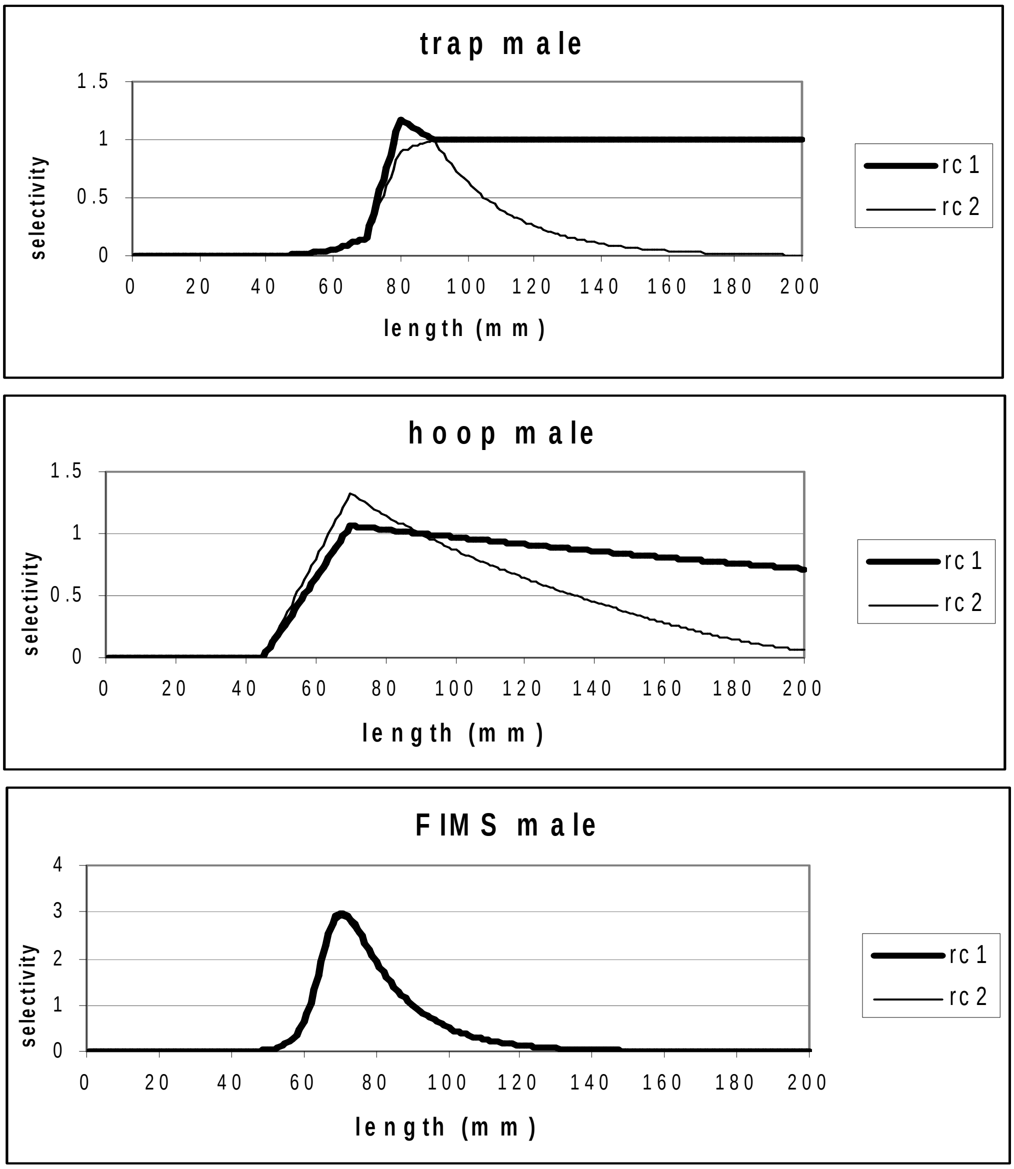
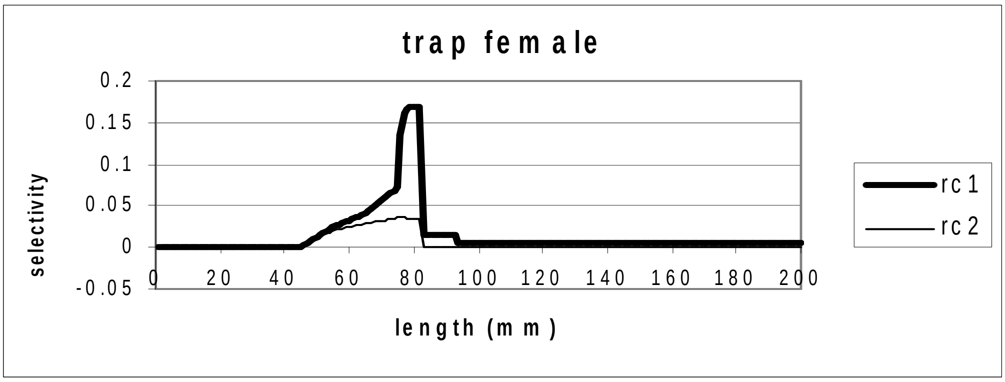
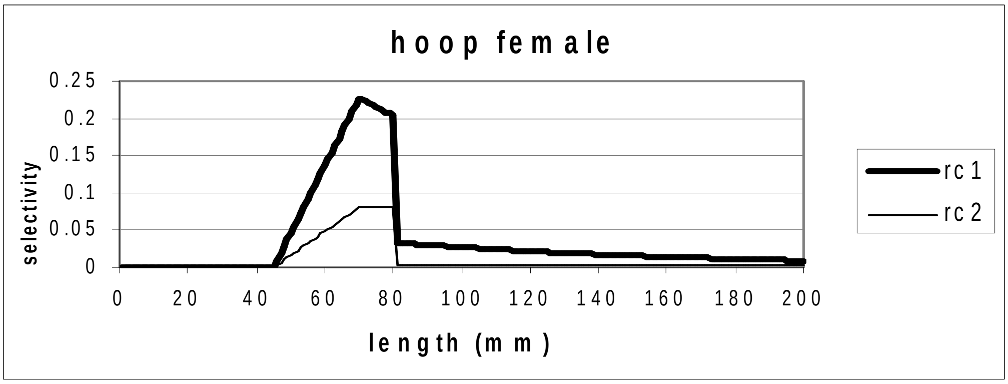


Figure 6b: Comparison between RC1 and RC2 trap female functions (1992+) for the area-aggregated assessment. Note that selectivities are comparable to those for males in Figure 6a, and the normalisation is to male selectivity of 1 at a carapace length of 90mm.





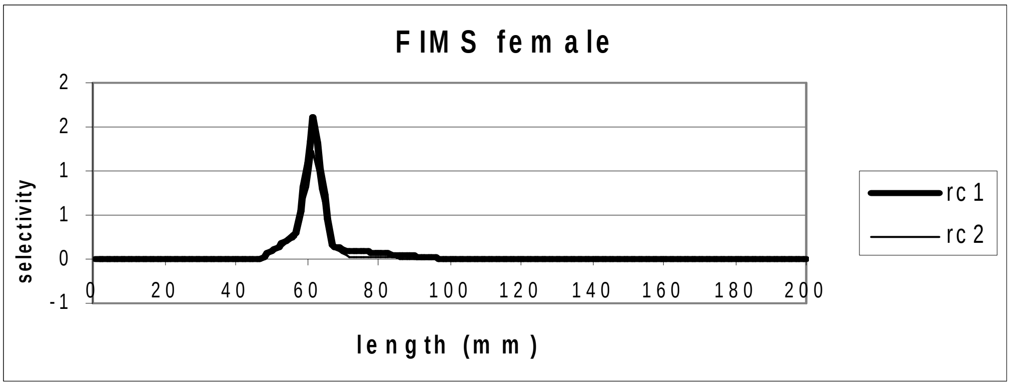


Figure 7a: Area-disaggregated fits to trap CPUE (RC1 and RC2) (No trap data available for A1-2).

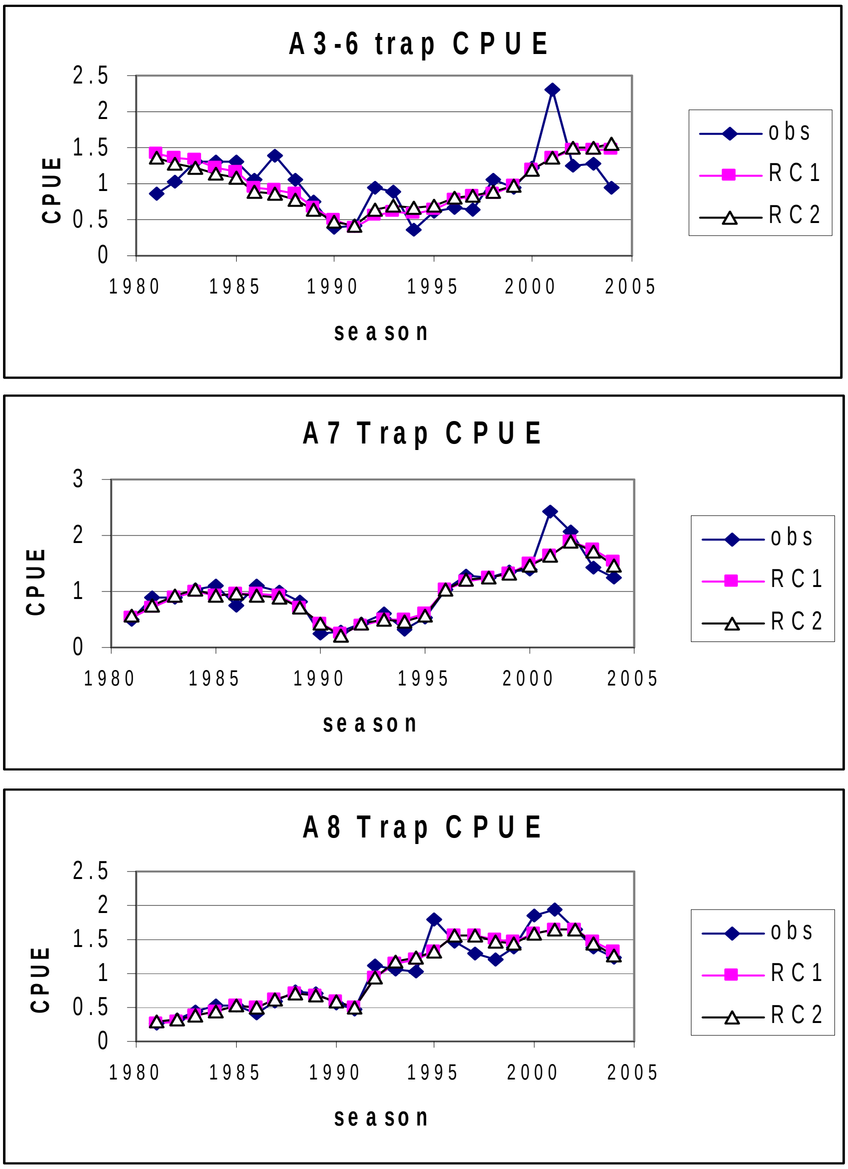


Figure 7b: Area-disaggregated fits to hoop CPUE (RC1 and RC2).

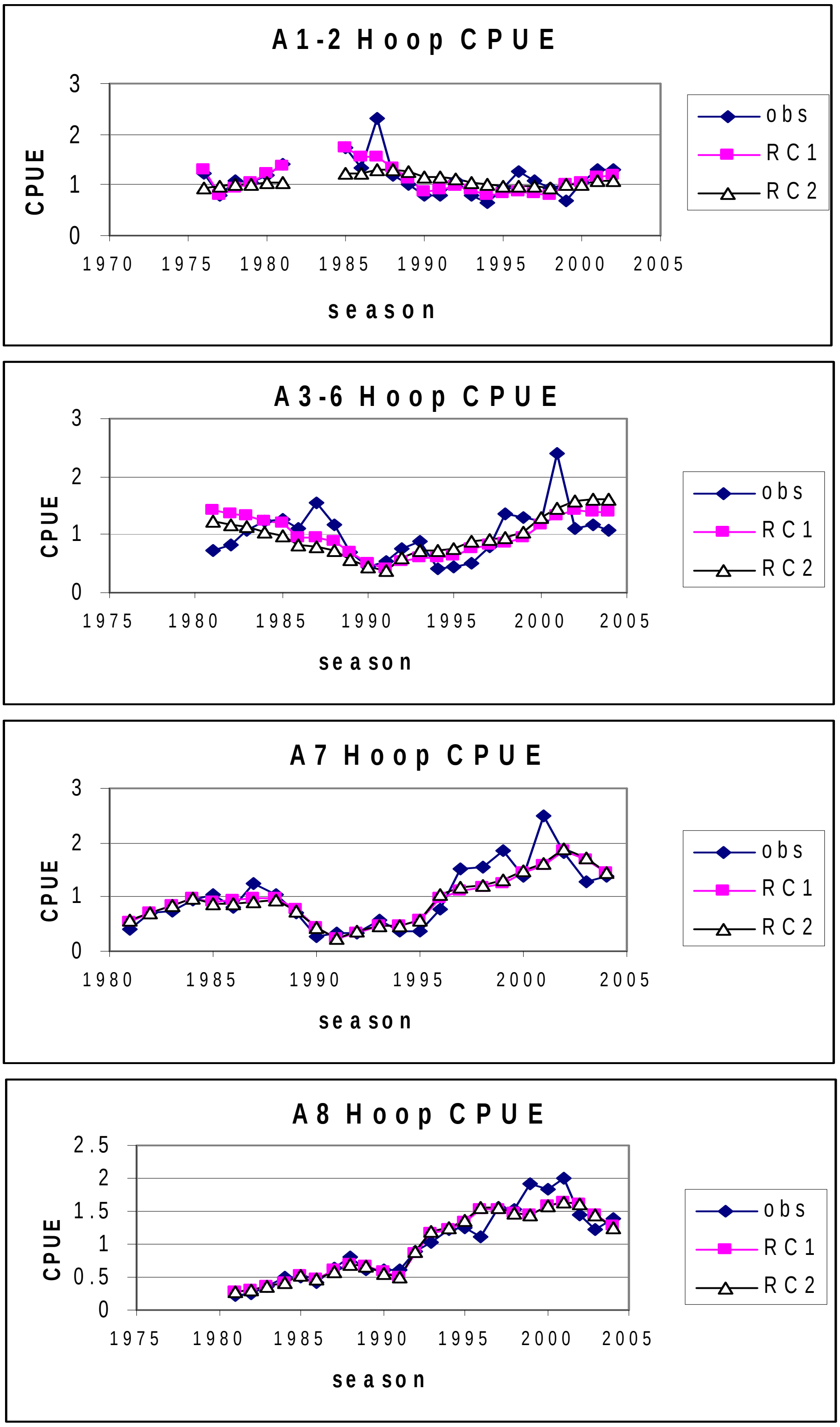
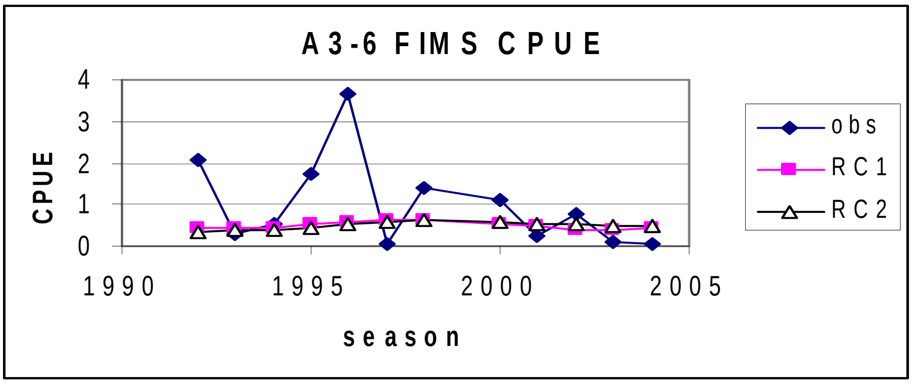
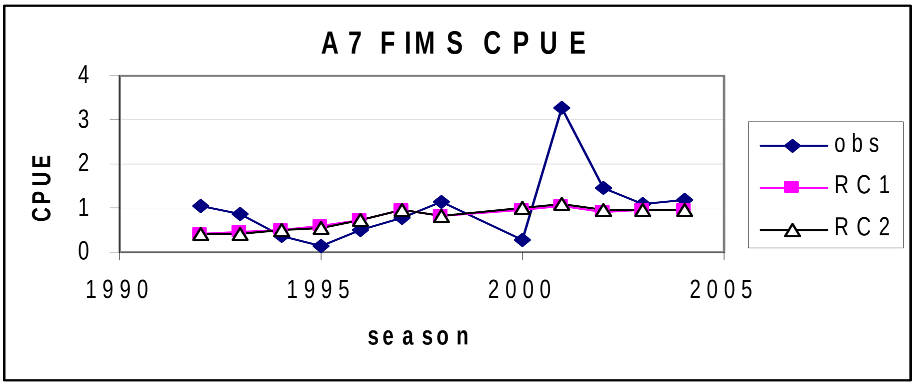


Figure 7c: Area-disaggregated fits to FIMS CPUE (RC1 and RC2). (No FIMS available for A1-2.)





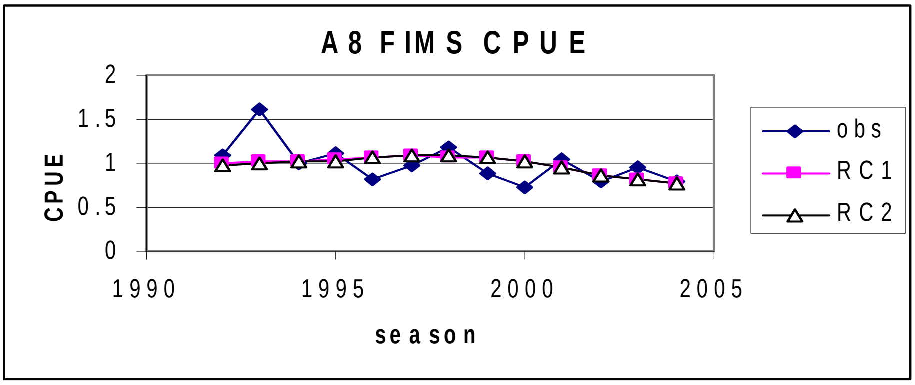


Figure 8a: Comparison between A3-6, A3-4 and A5-6 trap CPUE fits.

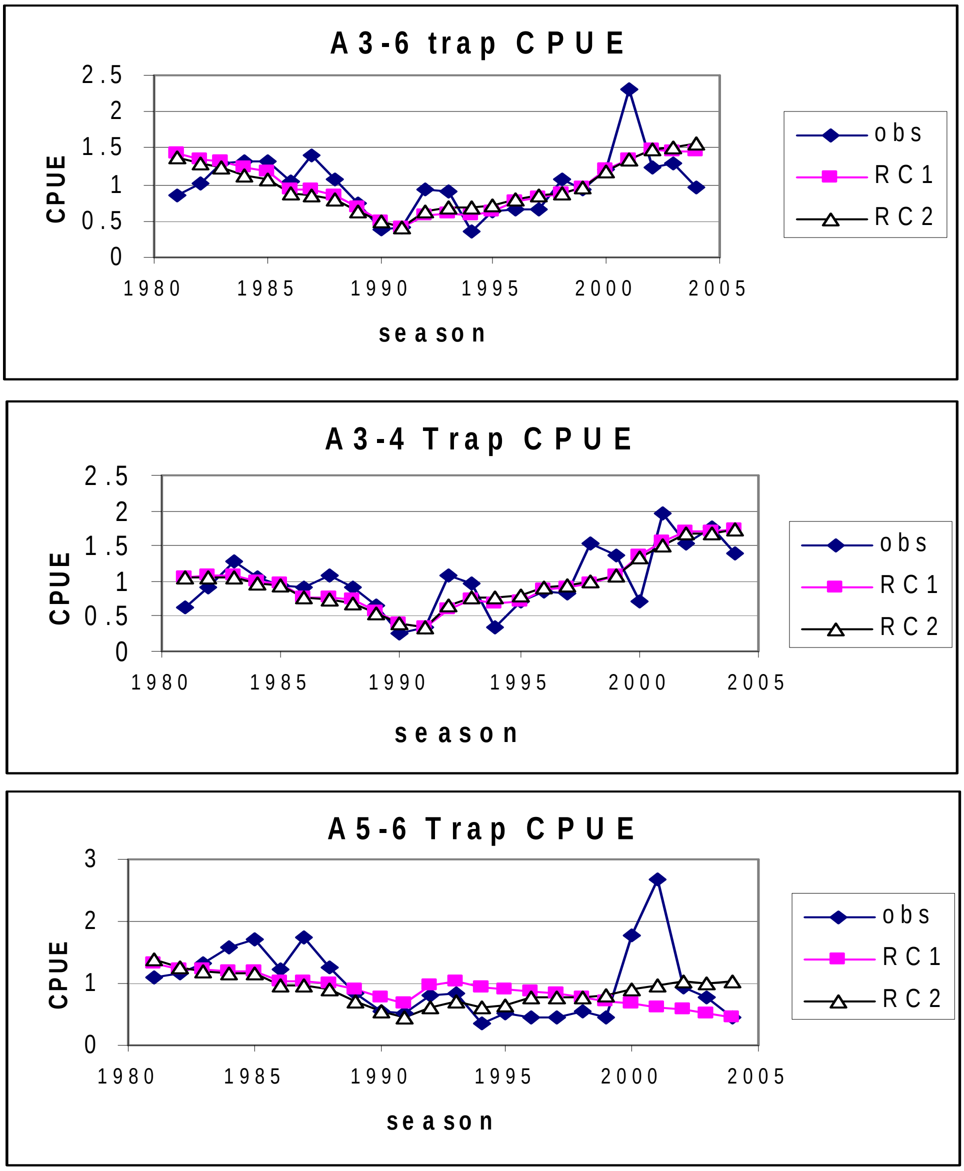


Figure 8b: Comparison between A3-6, A3-4 and A5-6 hoop CPUE fits.

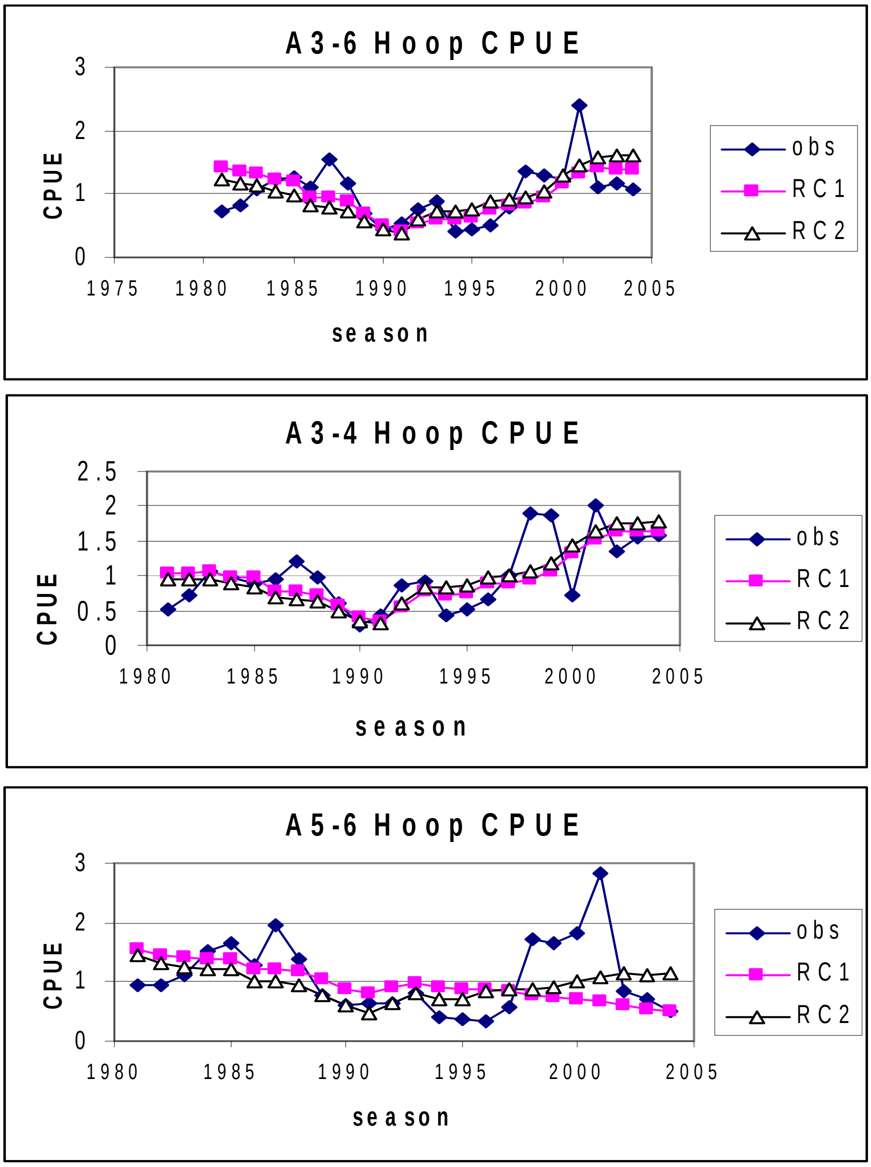
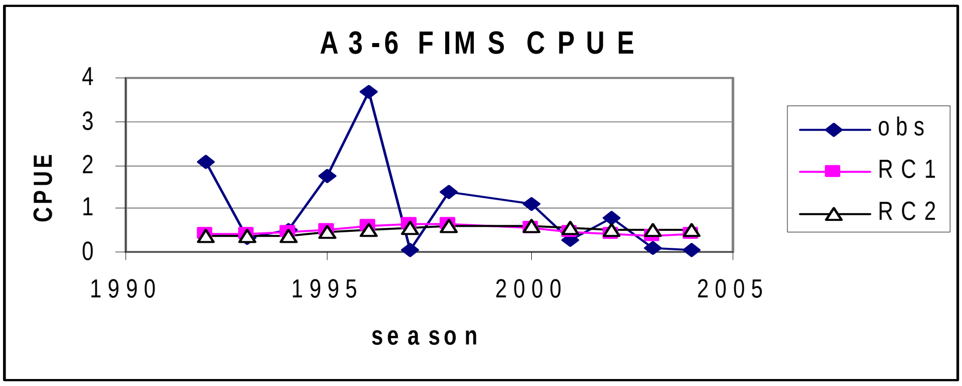


Figure 8c: Comparison between A3-6 and A3-4 FIMS CPUE fits (no FIMS for A5-6 available).



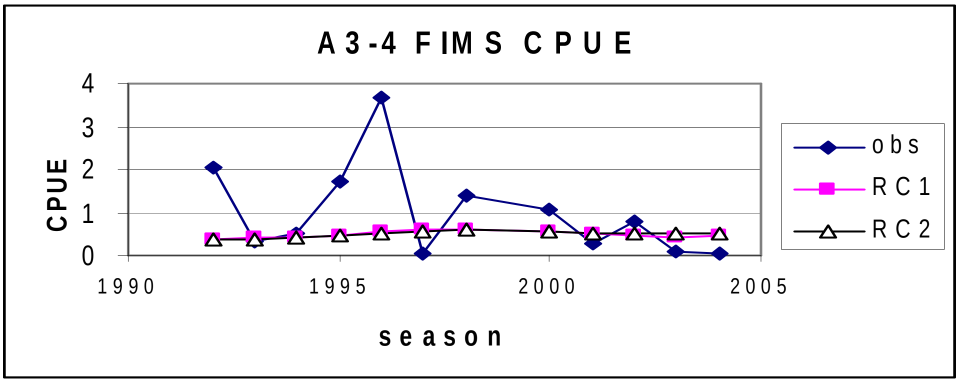
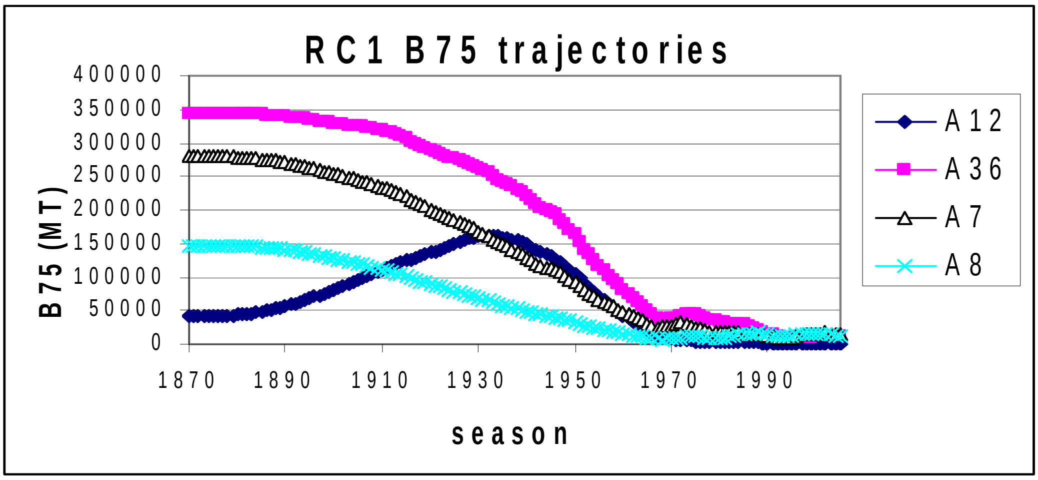


Figure 9a: RC1 area-aggregated estimates of B75 (bottom plot from 1960+ only).



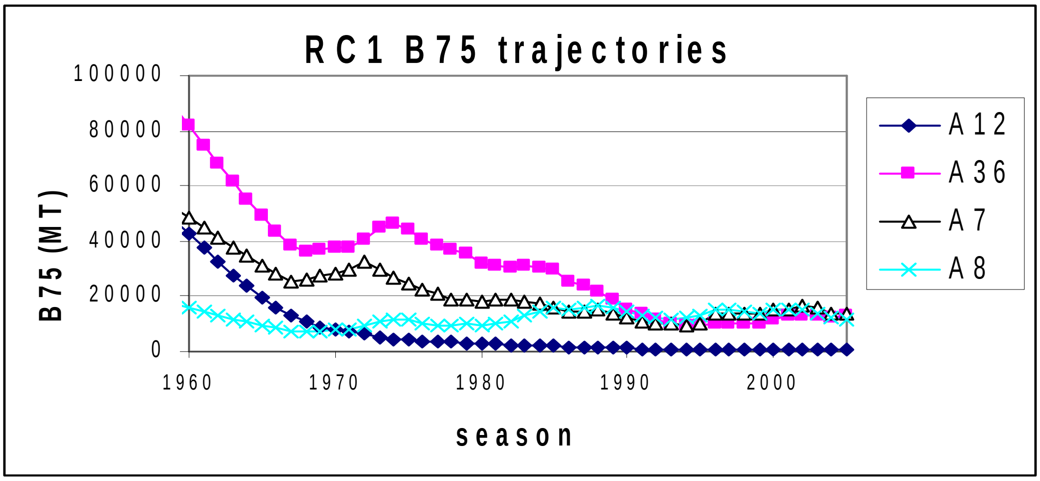


Figure 9b: RC2 area-disaggregated estimates of B75 (bottom plot from 1960+ only).