2008 ICCAT ANALYSIS OF MEDITERRANEAN SWORDFISH MANAGEMENT MEASURES

(*Madrid, Spain – February 25 to 29, 2008*)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat offices in Madrid. Dr. George Tserpes, meeting Chairman, opened the meeting. Mr. Papa Kebe, on behalf of Mr. Driss Meski, Executive Secretary, welcomed participants ("the Group").

The Agenda (**Appendix 1**) was adopted without changes. The List of Participants is attached as **Appendix 2** and the List of Documents presented at the meeting is attached as **Appendix 3**.

The following participants served as rapporteurs:

Agenda Item	Rapporteur
1, 6, 7	P. Pallarés
2, 3	G. Scott
4	L. Kell and J.M. Ortiz de Urbina
5	G. Tserpes

2. Analysis of data

Three documents were presented, two of them providing information from different fisheries and one dealing with the evaluation of different management measures.

SCRS/2008/025 presented detailed information regarding the Turkish swordfish fisheries operation on the Aegean Sea including technical characteristics of the gears used, catch levels, and size distribution of the catches. In addition, information was provided on the catches of other non-target species.

SCRS/2008/026 evaluated the bio-economic medium-term effects of a series of Mediterranean-wide management measures, including seasonal closures and effort reduction schemes. Results indicated that landings, spawning stock biomass, gross and net revenue were increasing with the increase of the duration of the fishery closure.

SCRS/2008/033 presented an analysis of size data collected from the Moroccan Mediterranean driftnet fishery during the 1999-2006 period. The mean size of the fish in the 2004-2006 period was equal to 133 cm, which is slightly higher than that observed from 1999-2003 (124 cm).

Partial catches by area and quarter from 2003-2005 (**Figure 2.1**) were used to partition the F-matrix from the 2007 Mediterranean swordfish assessment by fleet in order to investigate a wide range of possible management scenarios, focusing mainly on time-area closures. The catch-at-age data used in the assessment were stratified by flag, gear group, region, and quarter. Regions (eastern Mediterranean, central Mediterranean, and western Mediterranean) were defined after examining the 5x5xquarterxgear group data set ('CATDIS'). The CATDIS data were grouped by decades and mapped after aggregating catches into 3 gear categories (LL, GN, and Other gears). Nation-specific patterns (**Figure 2.2**) were examined for consistency with the expert knowledge available at the meeting. As the spatial and temporal resolution of the data are rather coarse, some uncertainties were noted, but without more detailed (1x1 x month x flag x gear) resolution additional refinements could not be accomplished at the meeting.

In the revision of CATDIS for years 2003-2005 the Group detected some errors in the gear and/or quarterly classification of catches. The Group reclassified catches applying the following rules:

- To split by quarter the Algerian LL and GN catches, use Spanish LL or Moroccan GN, respectively.
- To split by quarter the Moroccan longline catches, use Spanish LL

- As regards Turkish 2003 catches by PS, reclassify as LL and split by quarter according to the mean ratios for 2004 and 2005
- Italian catches from 2003 to 2005 classified as OTH, reclassify as GN and split them into second and third quarters (50% each)

2.1 Gap analysis

CATDIS (a Task 1 nominal catch estimate stratified by quarter and 5x5 degree squares), CAS (catch-at-size matrix) and CAA (catch-at-age matrix) are estimates fully depending on the availability, quality and level of resolution of Task 2. Therefore, a comparative analysis between Task 2 (Task 2 CE: catch and effort; Task 2 size: size sampling) information and Task 1 nominal catches (Task 1) was made, in order to identify availability, possible gaps and inconsistencies in data. This analysis incorporated a quantification of Task 2 data resolution level (time and space indicators only) based on a straightforward scoring procedure. The time period covered was from 1985 to 2005.

Task 1 and Task 2 data were stratified by year, flag and gear group. Task 2 CE and Task 2 size data was classified in two categorical variables (time and space) according to its level of resolution. The basic principle adopted was to give larger scores to higher data resolution. The categories defined for the variables were (scores in parenthesis):

- Time strata (TS): month (3), quarter (2), year (1), none (0)
- Geographical strata (GS): 1x1 squares (3); 5x5 squares (2); others (1), none (0)

Thus, assuming a multiplicative effect model and scores scaled within range [0, 5] (lower scores = poor data resolution, higher scores = better data resolution), the total score for a given Year (*i*) was calculated as:

$$S_i = \sum_{j=1}^{n}\sum_{k=1}^{m}\left(\left(5\frac{TS_{ijk}+GS_{ijh}}{S^{\max}}\right)\frac{Y_{ijk}}{Y_i}\right) \qquad \text{(j= \{1...n\} flags; k= \{1…m\} gears),}$$

where S^{max} is the maximum score obtained within the model (i.e. 1x1 squares (3) x month (3) = 9).

The results of the comparative analysis between Task 1 and Task 2 CE and Task 1 and Task 2 size are shown on **Tables 2.1.1** and **2.1.2**, respectively. Black shading indicates Task 1 with absence of Task 2 data. Gray shading indicates availability of both datasets. Whiter gray scales, indicates better time/space resolution. Various gaps and poor data resolution were identified for the most important fisheries.

The overall scores obtained for Task 2 CE and Task 2 size are shown in **Figure 2.1.1**. The weight of each major gear in the overall scores of Task 2 CE and Task 2 size are shown in **Figures 2.1.2** and **2.2.3**, respectively. In the largest portion of the time series, the scores are far below (less than 3) the minimum data requirements of an effective time-area closure analysis.

The Group identified the main problems regarding data deficiencies and pointed out that the size information is slightly better than the catch-effort one. It was considered that the situation could be improved, especially for the most recent years, by providing the relevant information.

3. Definition of scenarios

The Convention objective establishes that tuna fisheries shall be managed in a way to assure biomass levels sufficient to sustain maximum yield (MSY). In that context, the most recent Mediterranean swordfish assessment indicated that the stock is both overfished and undergoing overfishing. At its 2007 meeting, the Commission recognized that the fishing mortality needs to be reduced to move the stock toward the Convention objective of biomass levels which could support MSY, and that seasonal closures are considered to be beneficial in moving the stock condition closer to the Convention objective and agreed [Rec. 07-01] that "fishing for Mediterranean swordfish shall be prohibited in the Mediterranean Sea during the period from October 15 to November 15, 2008."

In order to further advise the Commission of the likely reduction in fishing mortality from this action, to evaluate a broader range of management options, and to identify data gaps that need to be filled to improve the scientific

advice that can be provided, the Working Group decided to focus on the following scenarios dealing with seasonal closures in different Mediterranean regions (east, west and central, see **Figure 2.3**). Regions were defined based on geographical criteria and the spatial distribution of the fishing activity of the major swordfish fishing fleets.

Scenario
1-closed area : MD-W (q4)
2- closed area : MD-C (q4)
3- closed area : MD-E (q4)
4- closed area : MD-W + MD-C (q4)
5- closed area : MD-W + MD-E (q4)
6- closed area : MD-C + MD-E (q4)
7- closed area: all (q4)
8-closed area : MD-W (q4) with 25% implementation error
9- closed area : MD-C (q4) with 25% implementation error
10- closed area : MD-E (q4) with 25% implementation error
11- closed area : MD-W + MD-C (q4) with 25% implementation error
12- closed area : MD-W + MD-E (q4) with 25% implementation error
13- closed area : MD-C + MD-E (q4) with 25% implementation error
14- closed area: all (q4) with 25% implementation error
15- closed MD-W (q1); closed (MD-C+E) (q4)
16- closed MD-W (q2); closed (MD-C+E) (q4)
17- closed MD-W (q3); closed (MD-C+E) (q4)
18- GN selectivity transitioned to LL selectivity (100%) to examine implications of changover to LL
19-Run 18 (GN select -> LL select) + (q4 closed in all MED)
20- closed area 1 month all Med in 2008 only
21-closed area 1 month all Med all years
22-closed area: MD-E & MD-C (q3) MD-W (q4)
23-closed area: All quarters 3 and 4
24-Run 23 with 25% implementation error

Note: Fishing activity in the eastern Mediterranean is limited in the fourth quarter of the year (q4) due to certain fisheries closures enforced at the national level.

For each scenario, two recruitment assumptions were applied: a constant recruitment and Beverton-Holt relationship, resulting in a total of 48 scenarios. For each of the scenarios, it was assumed that no effort was displaced in the neighboring areas.

Across the scenarios the implications of area and seasonal closures and switching from driftnets to longlines were examined. In addition measures (either constant catch or constant F) to rebuild the stock to B_{MSY} by 2030 were examined. These results are graphically demonstrated by use of 'Cobra Tracks' which provide a time-series of F/F_{MSY} and B/B_{MSY}.

4. Projections

Simulations were conducted using FLR (Kell *et al.* 2007, www.flr-project.org) by projecting the estimates of numbers-at-age from the most recent age-based assessment (ICCAT, 2007) for 25 years on the basis of the standard age-structured population equation:

$$N_{a+1,y+1} = N_{a,y}\, e^{-Za,y}$$

Where: $N_{a,y}$ is the number of fish of age a at year y, and $Z_{a,y}$ is the total mortality from age a to age $a+1$. $Z_{a,y} = M_a + F_{a,y}$, where M_a is the natural mortality at age a and $F_{a,y}$ is the fishing mortality at age a in year y. Biological parameters, mortality, natural mortality, mass-at-age were taken from the latest ICCAT assessment (SCRS/2007/016) and mass-at-age was the average of the last three years in the assessment (2003 to 2005).

Fishing mortality-at-age (F_a) is calculated as the sum of the partial fishing mortalities by gear, area and quarter. This allowed the effect of a closure to be evaluated by setting the fishing mortality in a particular area or quarter to zero. A gear change from gill nets to longlines was modeled by assuming the same CPUE, in terms of kg/day

between gears. Hence, the average fishing mortality was unaltered but the selection of the old gear was replaced by that of the new gear.

Figure 4.1 shows the status quo fishing mortality at age and **Figure 4.2** the relative change in fishing mortality-at-age under the 24 scenarios.

Two alternative stock recruitment relationships were considered (**Figure 4.3)** (i) geometric mean recruitment of the 1985-2005 period and (ii) a Beverton and Holt relationship.

The corresponding reference points, based on the two alternative stock recruitment relationships and the status quo fishing mortality are given in **Table 4.1**.

Projections were conducted 100 times for the 24 scenarios and the two stock recruitment relationships, assuming a CV equal to 30%. An example result for the first scenario is shown in **Figure 4.4**, future time series show the 25^{th}, 50^{th} and 75^{th} percentiles, thin (black) lines correspond to the status quo projection and thick (red) lines to the scenario.

Five reference scenarios were run i.e.

i) Status quo
ii) Constant F that would rebuild the stock to B_{MSY} in 2030, assuming a Beverton and Holt stock recruitment relationship
iii) Constant F that would rebuild the stock to B_{MSY} in 2030, assuming constant recruitment
iv) Constant catch that would rebuild the stock to B_{MSY} in 2030, assuming a Beverton and Holt stock recruitment relationship
v) Constant catch that would rebuild the stock to B_{MSY} in 2030, assuming constant recruitment

These five reference scenarios are present in **Figure 4.5**.

Results, by scenario, are presented in **Appendix 4**.

Table 4.2 and **Figures 4.6** and **4.7** summarize the short (2010), medium (2015) and long-term (2025) scenario results in terms of B/B_{MSY} and F/F_{MSY} estimates. The status quo scenario did not provide evidence of stock collapse although SSB was remaining at low levels. As in previous studies, results demonstrated that the longer the closure, the more beneficial it will be in the long-term. Production decreases are always expected in the short term. Scenarios 22-24 provide the highest biomass gains and fishing mortality reductions. However, only scenario 23 (global closure in quarters 3 and 6) under the constant recruitment assumption succeeds to meet the "convention" objectives within the examined period. Short closures, as the one recently imposed, it is unlikely that they will produce any positive results.

Apart from the model assumptions, the Group considers that several aspects should be taken into account when evaluating the effects of the examined scenarios. These are mostly related with data deficiencies and limitations that are summarized below.

- Basic Task 1 and Task 2 data for several important fisheries were not always available at the desirable resolution, making necessary the adoption of substitutions based on expert knowledge and assumptions not always validated. As a result the examined scenarios may not sufficiently reflect the real situation in terms of gains and losses at the regional level.
- Under-reporting of small fish (mainly 0-age) catches results in biased estimates of fishing mortality, recruitment and the selectivity of the younger ages. This might underestimate the gains from closures during the recruitment period. Under-reporting is not only due to sampling deficiencies of the fleets targeting swordfish, but also due to misreporting from other fleets targeting large pelagic species (e.g. albacore).

Regarding the enforcement of different seasonal closures by region the Group considers that the high mobility of several important fleets would possibly not allow achieving the expected mortality reductions due to spatial re-distribution of the fishing effort.

5. Recommendations

Being in line with advice previously provided, the current scenarios examined in details seasonal closures at the regional level. However, future work should consider a broader set of scenarios including other technical measures such as fishing capacity reductions, technical modifications of fishing gears and minimum landing size regulations, as well as quota scenarios. However, the Group considers that MLS and quota might be difficult to implement in the Mediterranean swordfish fisheries. In addition, future analyses of management measures should include economic aspects.

The Group also recommends that an effort should be made to obtain information that allows working towards a $1x1^0$ per month resolution regarding catch-effort and size frequency data. Information on discards should be collected on a regular basis to enable reliable estimates of 0-group catch levels.

Finally, as FLR proved to be very efficient, the Group recommends the development of training mechanisms that would allow its extensive use within the various ICCAT groups.

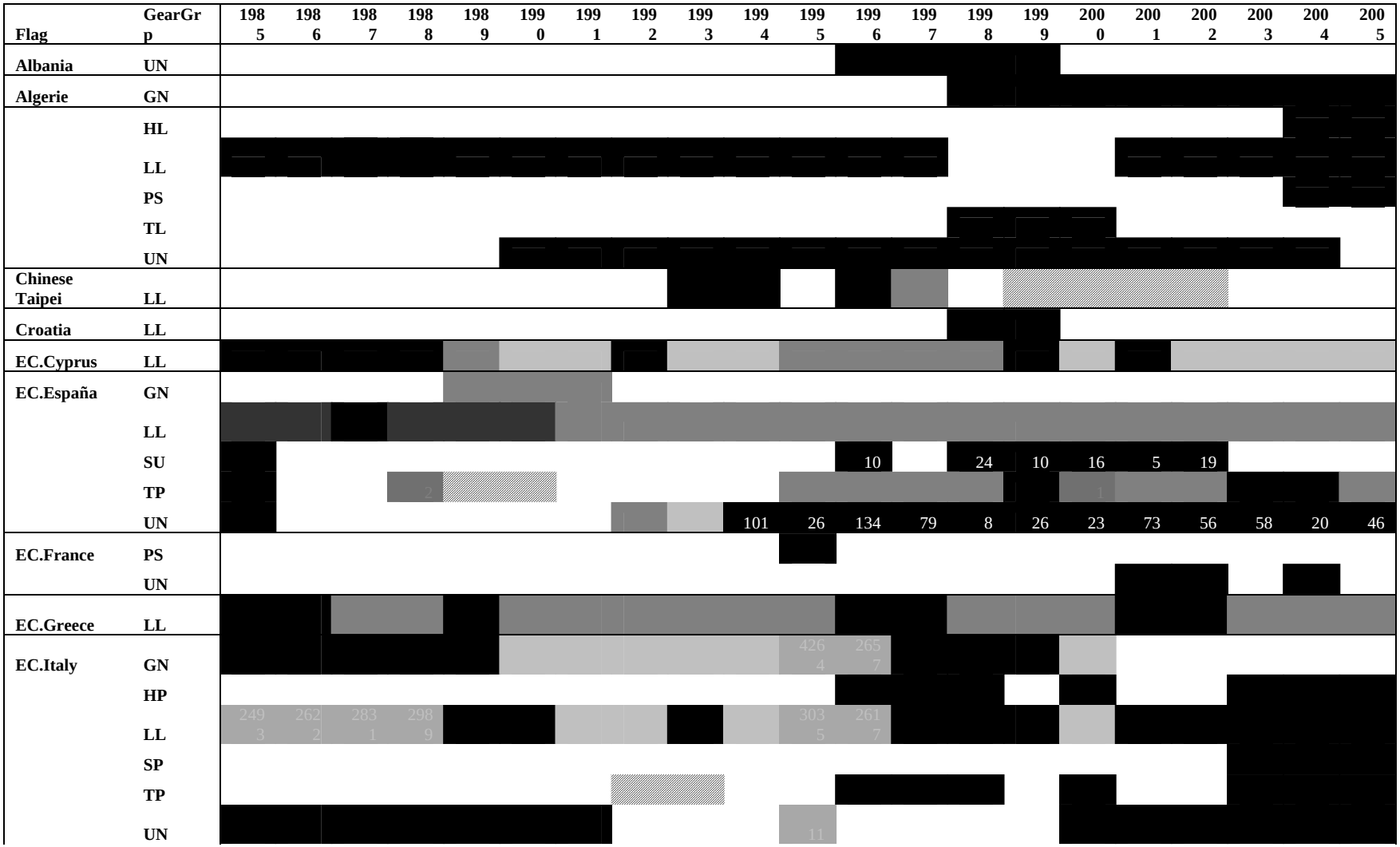
6. Other matters

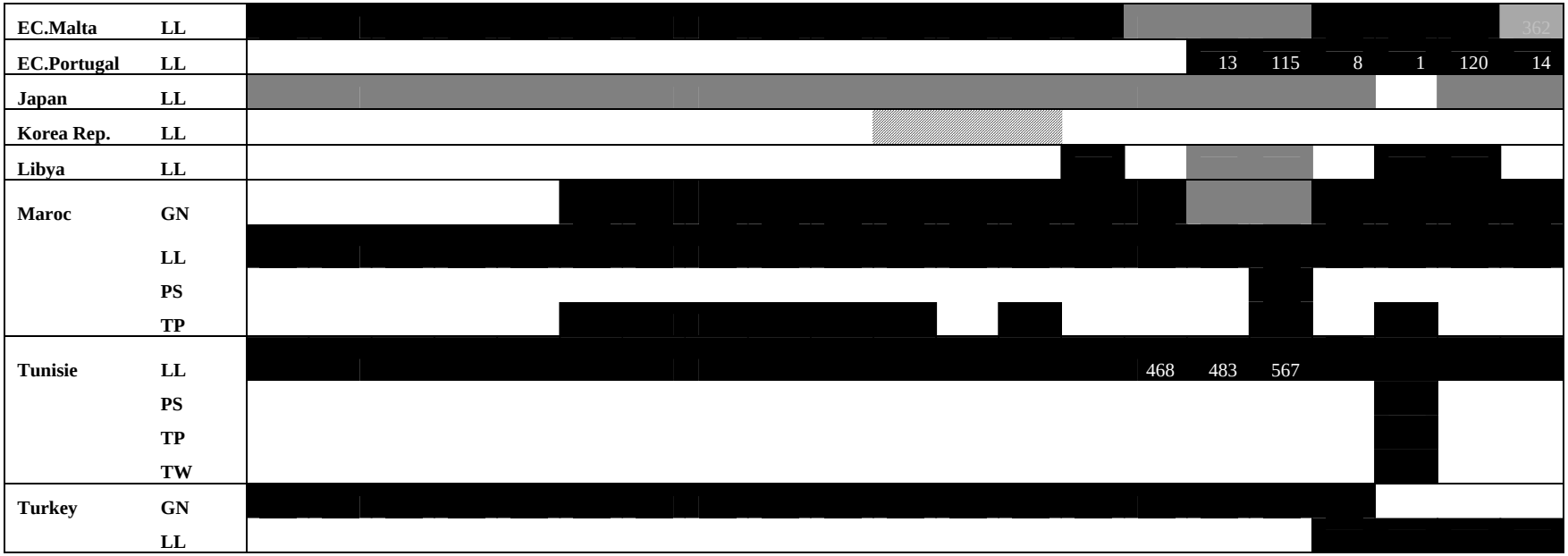
The Group discussed the interest of incorporating economic data in the analyses of Mediterranean swordfish management strategies. Some economic data from the Mediterranean swordfish longline and driftnet fisheries were available during the meeting (see **Appendix 5**), but they were considered insufficient to be included in the current analyses. This kind of data can be useful for the future analyses of the Mediterranean swordfish fisheries.

7. Adoption of the report and closure

The report was adopted by the Group and the meeting was closed.

Table 2.1.1 Mediterranean Swordfish comparative analysis between Task I and Task II catch & effort, by flag, gear group (1985 to 2005). Within the available data, a black pattern domain reflects poor data quality. A white gray table fill would reflect the optimal situacion.




EC.Malta LL
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Japan LL
Korea Rep. LL
Libya LL
Maroc GN
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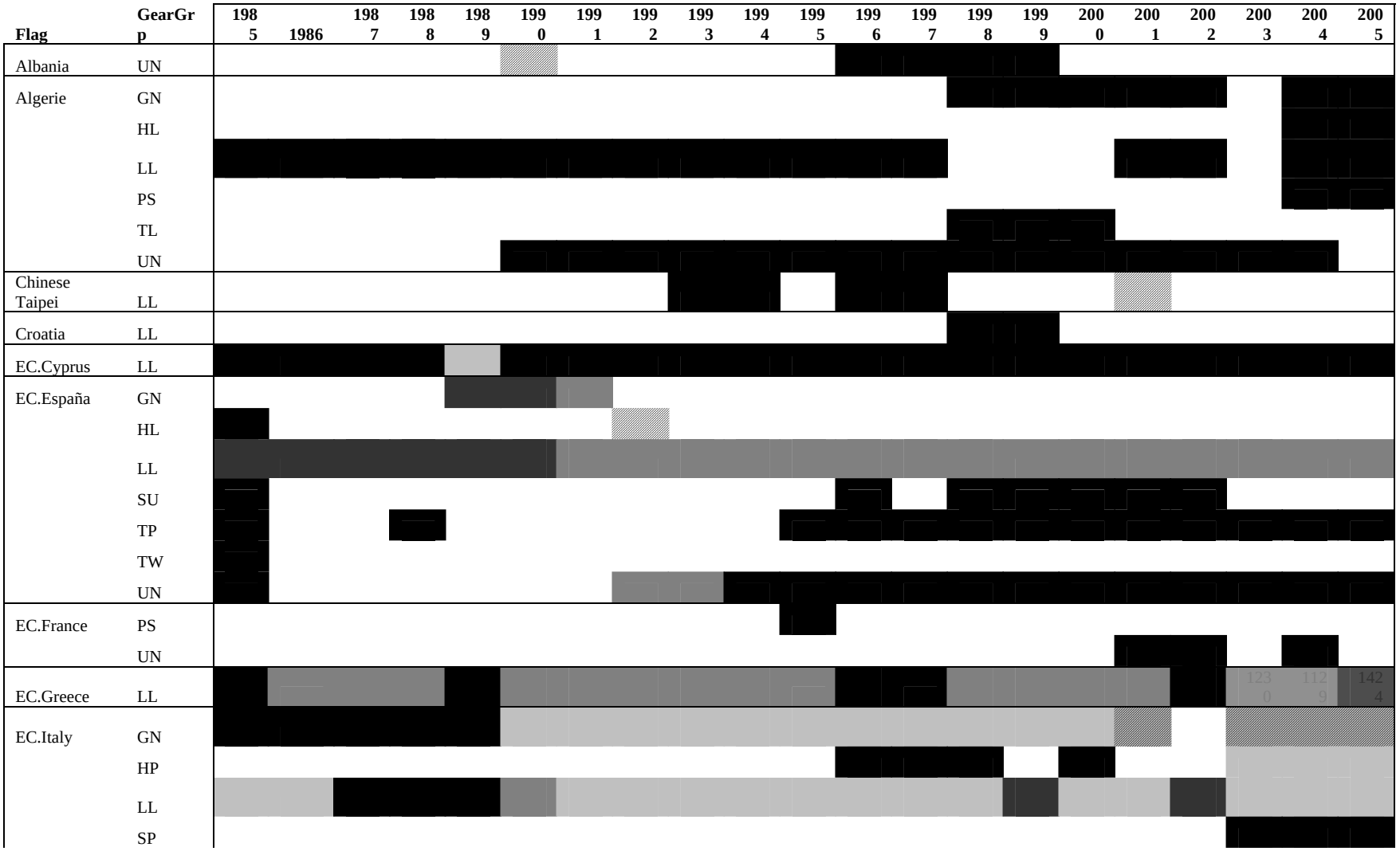
Tunisie LL
468
483
567
PS
TP
TW
Turkey GN
LL
Legend:
no data (T1&CE)
T1 & no CE
CE & no T1
Strata patterns:
geo
1x1
5x5
oth
time
mm
oth

Table 2.1.2 Mediterranean Swordfish comparative analysis between Task I and Task II size data, by flag, gear group (1985 to 2005). Within the available data, a black pattern domain reflects poor data quality. A white gray table fill would reflect the optimal situacion.



Legend:

no data (T1&CE)

T1 & no CE

CE & no T1

Strata patterns:

geo	**time**
1x1	mm
5x5	oth
oth	

Table 4.1 Mediterranean swordfish reference points, based on the two alternative stock recruitment relationships and the status quo fishing mortality.

	Beverton & Holt			*Mean recruitment*		
	F	*Yield*	*SSB*	*F*	*Yield*	*SSB*
$F_{0.1}$	0.1172	18,570	134760	0.1172	15751	114299
F_{Max}	0.1795	18,745	85090	0.1795	16511	74951
30% SPR	0.1471	18,951	107547	0.1471	16342	92741
MSY	0.1504	18,954	104892	0.1795	16512	74951

Table 4.2. Estimated mean B and F levels (as ratios to the corresponding benchmarks) for the different scenarios, in the short, medium and long term.

		HARVEST		RECRUITMENT		SSB		YIELD	
		SR relationship		*SR relationship*		*SR relationship*		*SR relationship*	
Year	Scenario	*bh*	*mn*	*bh*	*mn*	*bh*	*mn*	*bh*	*mn*
2015	1	2.19	1.79	0.74	0.95	0.25	0.40	0.72	0.91
	2	2.15	1.76	0.74	0.95	0.25	0.41	0.73	0.92
	3	2.30	1.89	0.71	0.95	0.22	0.36	0.69	0.90
	4	2.03	1.66	0.76	0.95	0.29	0.45	0.76	0.93
	5	2.18	1.79	0.74	0.95	0.25	0.40	0.72	0.91
	6	2.15	1.76	0.74	0.95	0.25	0.41	0.73	0.92
	7	2.03	1.66	0.77	0.95	0.29	0.46	0.76	0.93
	8	2.22	1.82	0.73	0.95	0.24	0.39	0.72	0.91
	9	2.19	1.79	0.73	0.95	0.24	0.39	0.72	0.91
	10	2.30	1.88	0.71	0.95	0.22	0.36	0.69	0.90
	11	2.10	1.72	0.75	0.95	0.27	0.43	0.74	0.92
	12	2.21	1.81	0.73	0.95	0.24	0.39	0.72	0.91
	13	2.19	1.79	0.73	0.95	0.24	0.39	0.72	0.91
	14	2.10	1.72	0.75	0.95	0.27	0.43	0.74	0.92
	15	2.00	1.63	0.77	0.95	0.29	0.47	0.76	0.93
	16	1.92	1.57	0.78	0.95	0.31	0.49	0.78	0.94
	17	1.89	1.54	0.79	0.95	0.32	0.51	0.79	0.94
	18	2.37	1.92	0.65	0.95	0.17	0.31	0.65	0.89
	19	2.10	1.70	0.71	0.95	0.23	0.39	0.72	0.92
	20	2.12	1.74	0.74	0.95	0.26	0.41	0.73	0.91
	21	2.12	1.74	0.75	0.95	0.26	0.42	0.74	0.92
	22	1.48	1.21	0.86	0.95	0.50	0.74	0.86	0.97
	23	1.06	0.86	0.91	0.95	0.77	1.10	0.88	0.95
	24	1.37	1.12	0.87	0.95	0.56	0.81	0.87	0.97
2020	1	2.19	1.79	0.75	0.97	0.24	0.40	0.72	0.92
	2	2.15	1.76	0.74	0.97	0.24	0.40	0.73	0.93
	3	2.30	1.89	0.71	0.97	0.21	0.36	0.68	0.91
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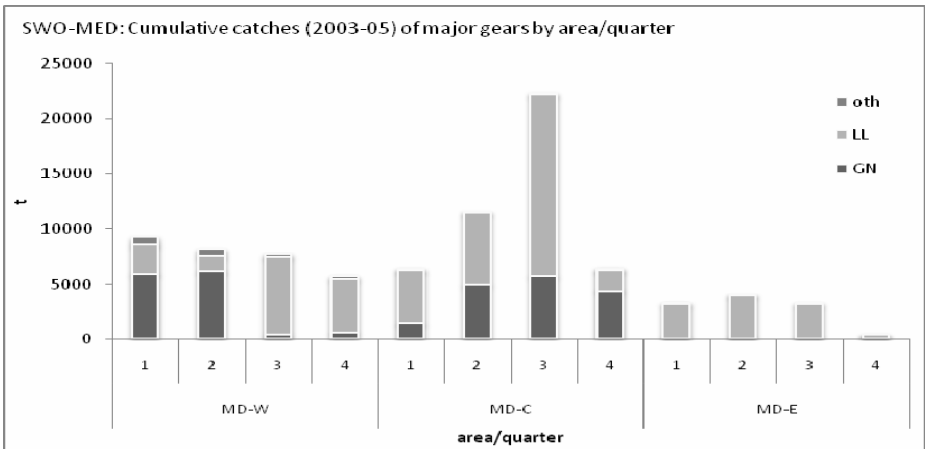


Figure 2.1 Task 1 cumulative catches between 2003 and 2005 of major gears by area/quarter (see **Figure 2.3** for the area delimitations).

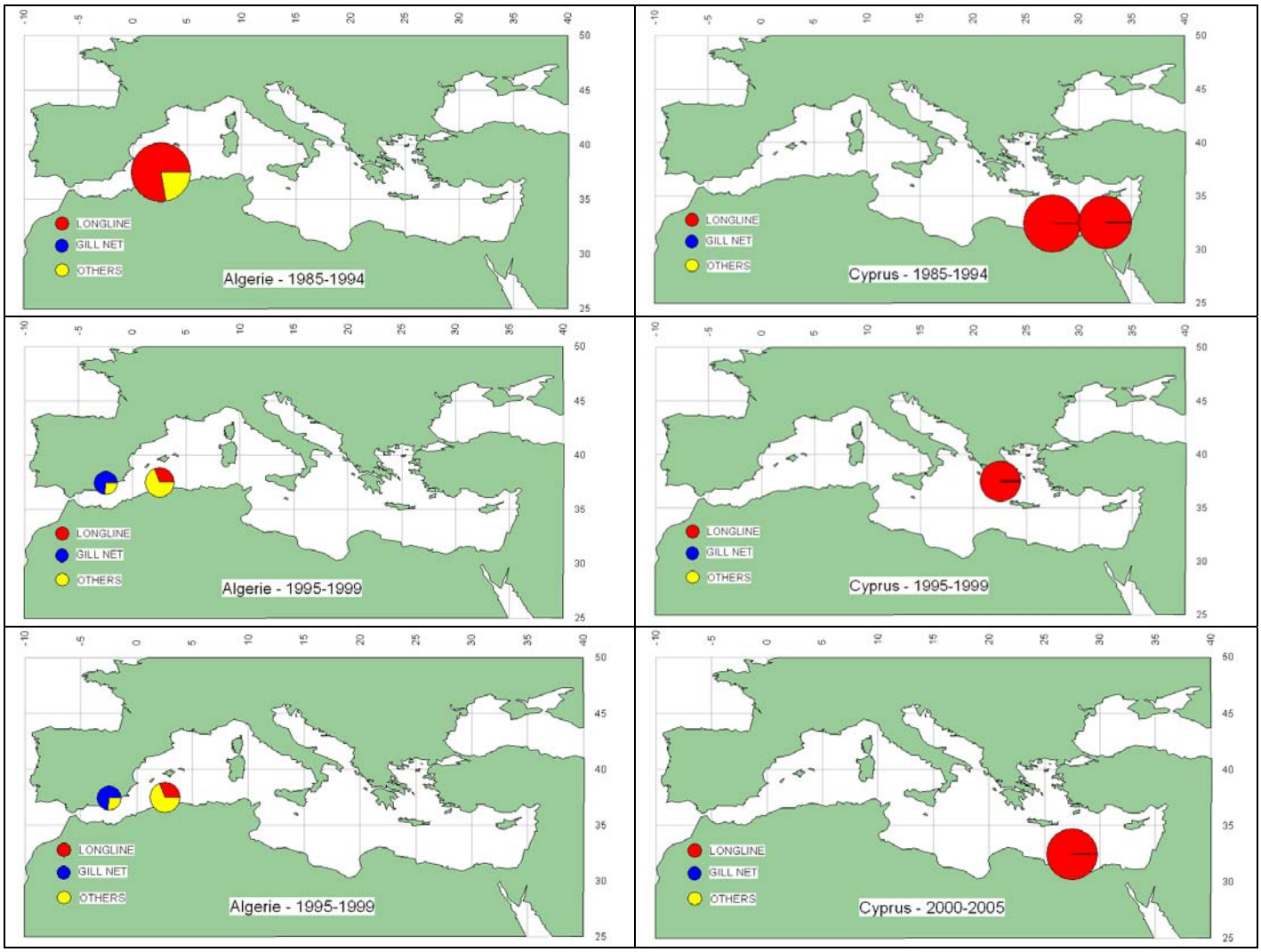
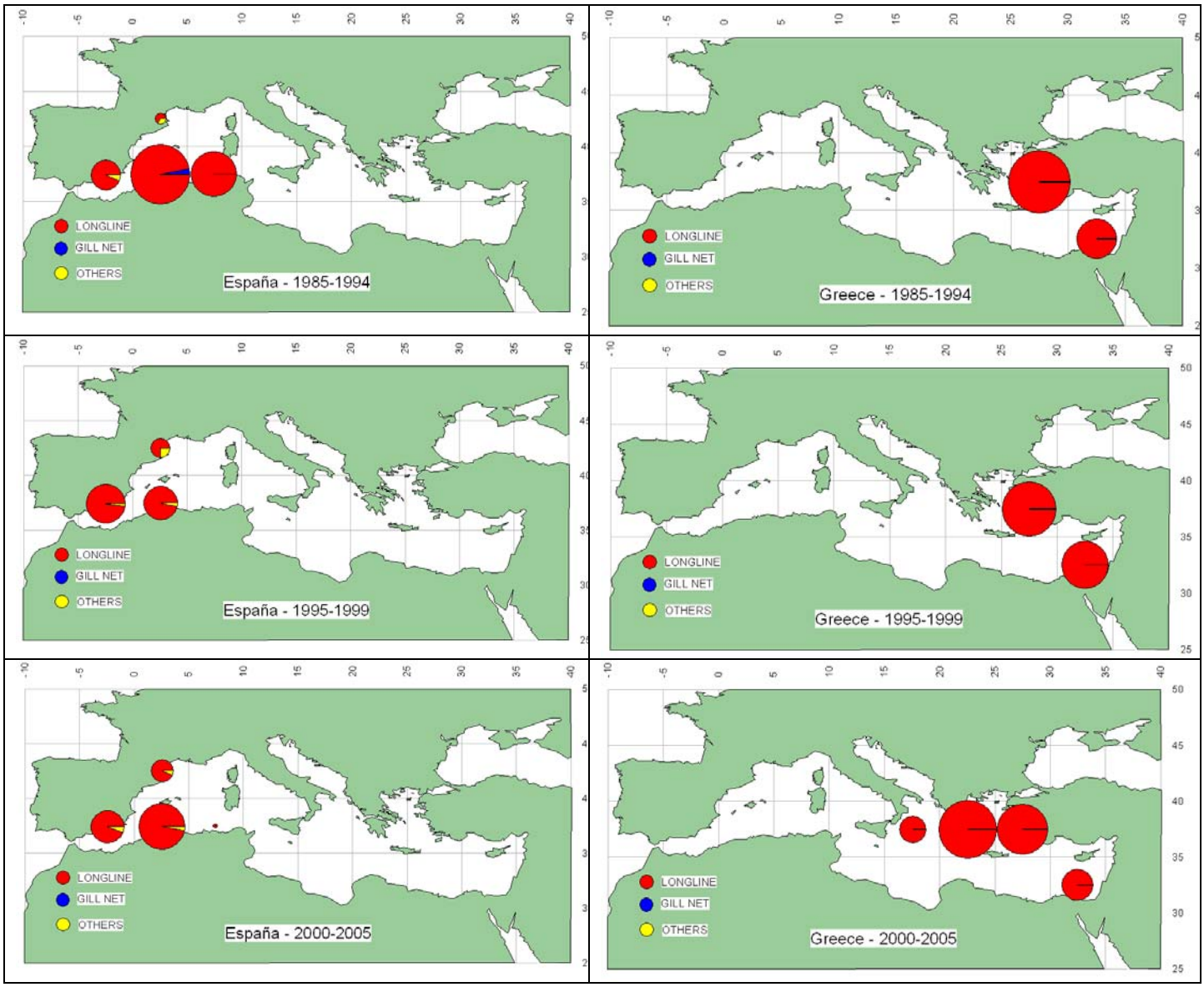


Figure 2. Average Mediterraenean swordfish catch by gear, flag and decade.



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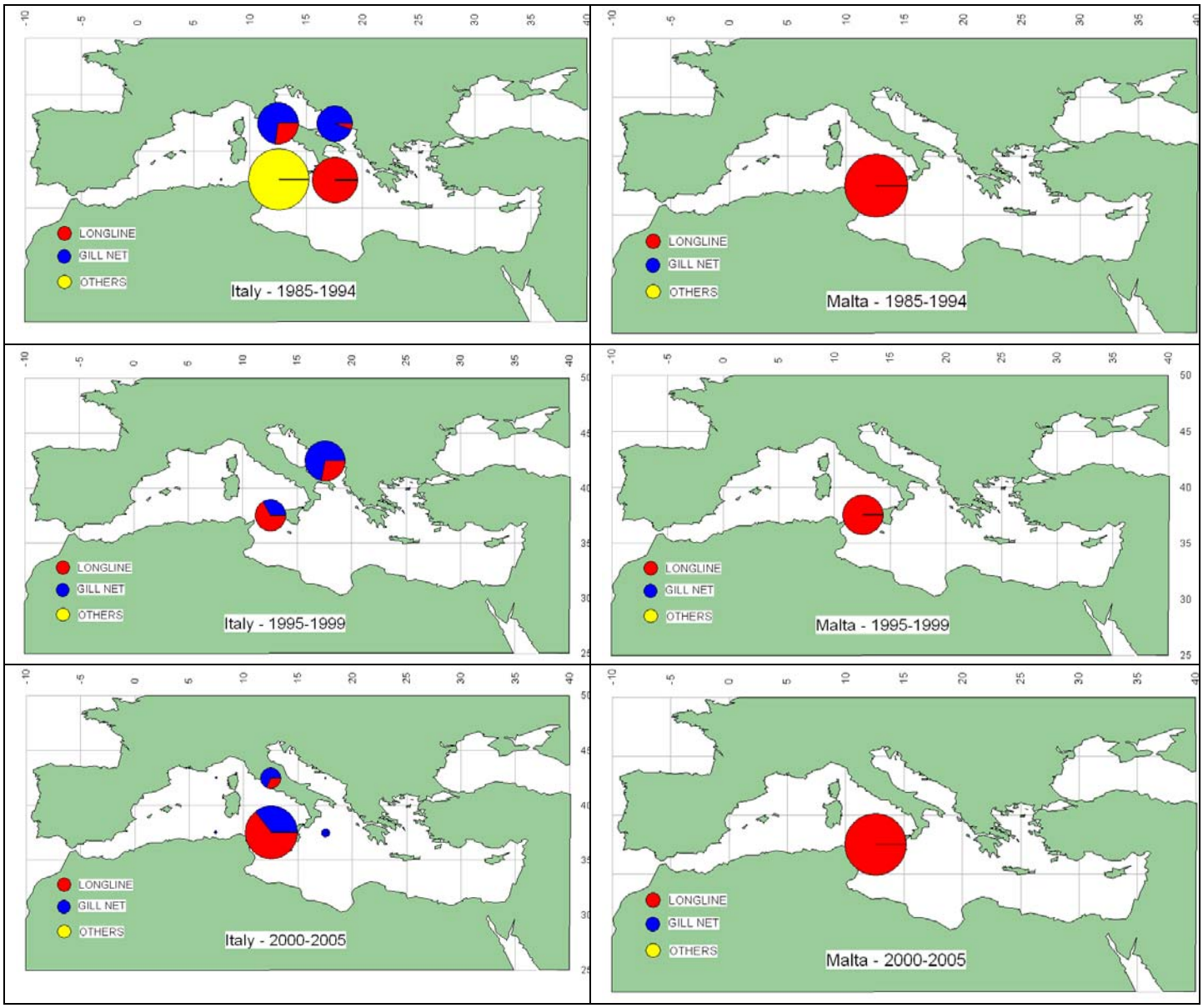

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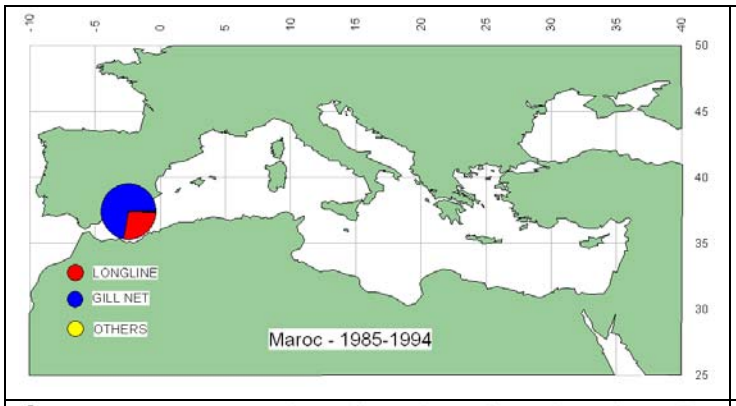
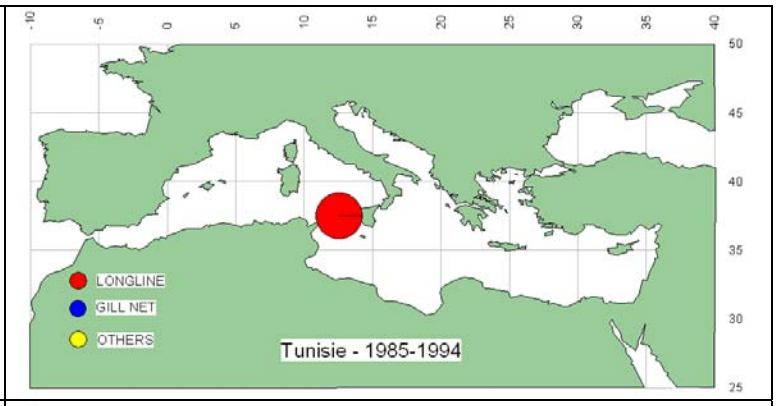
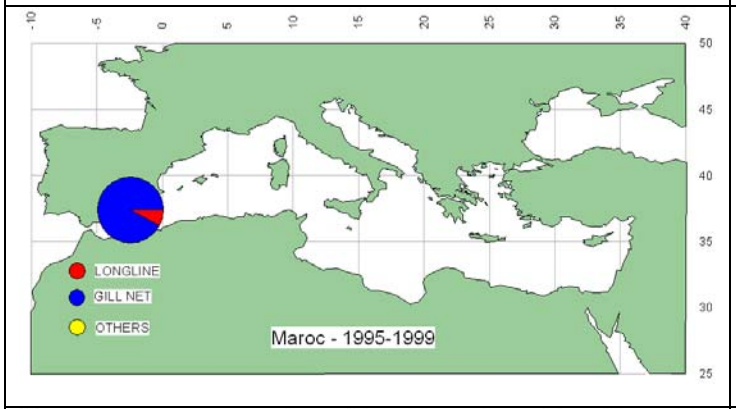
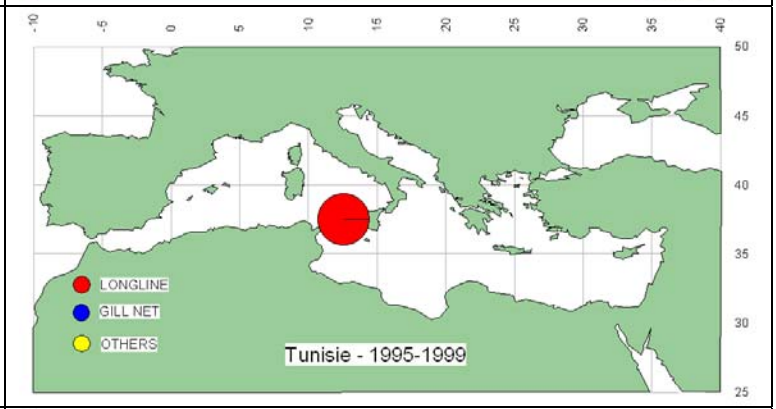
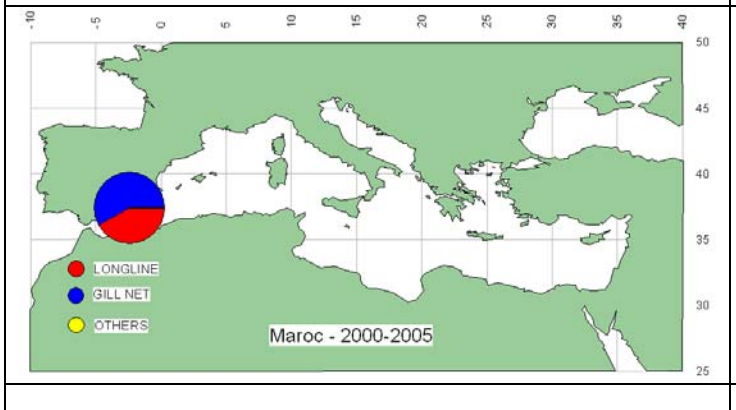

LONGLINE
GILL NET
OTHERS
Maroc - 1985-1994


LONGLINE
GILL NET
OTHERS
Tunisie - 1985-1994


LONGLINE
GILL NET
OTHERS
Maroc - 1995-1999


LONGLINE
GILL NET
OTHERS
Tunisie - 1995-1999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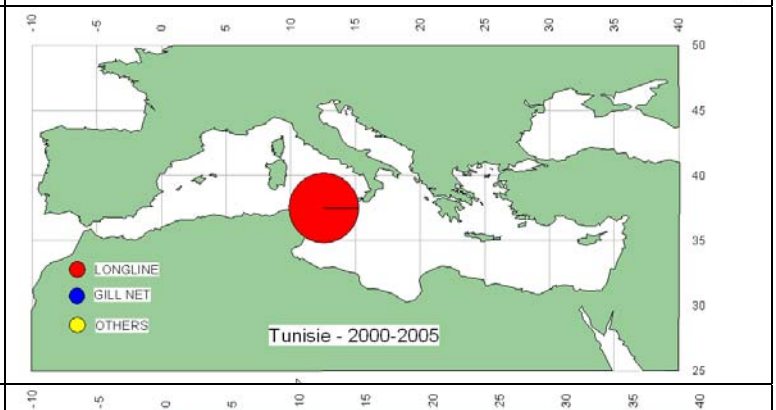
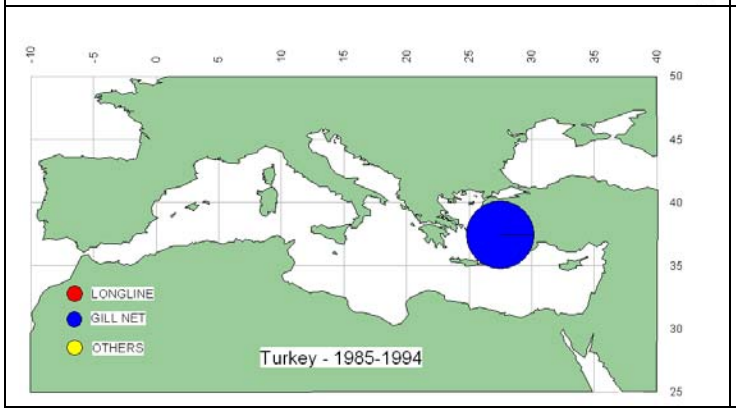
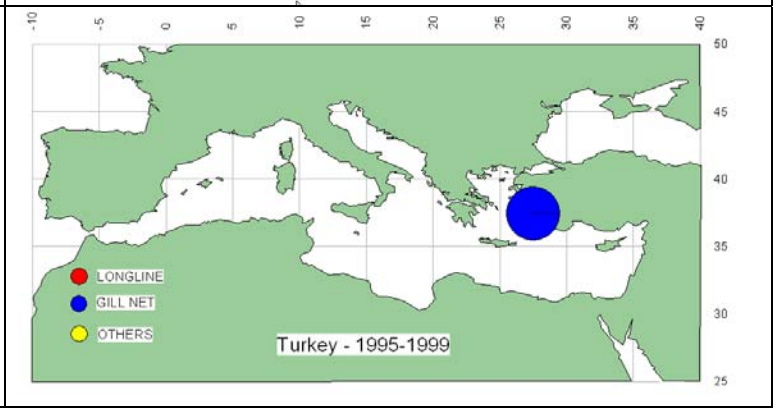
GILL NET
OTHERS
Maroc - 2000-2005


LONGLINE
GILL NET
OTHERS
Tunisie - 2000-2005


LONGLINE
GILL NET
OTHERS
Turkey - 1985-1994


LONGLINE
GILL NET
OTHERS
Turkey - 1995-1999

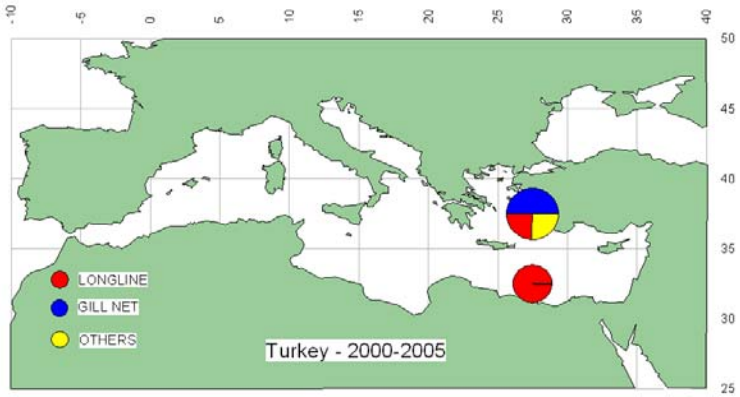


Figure 2 (cont.)

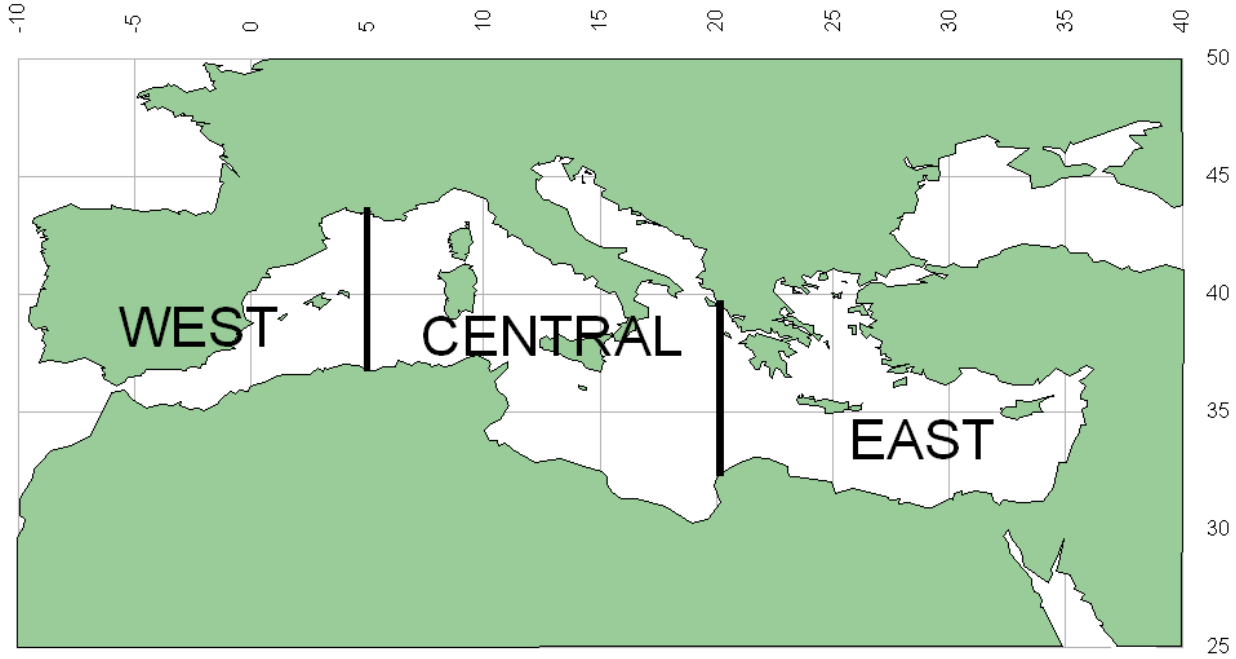


Figure 2.3 Areas considered in the different management scenarios for the Mediterranean swordfish stock evaluated.

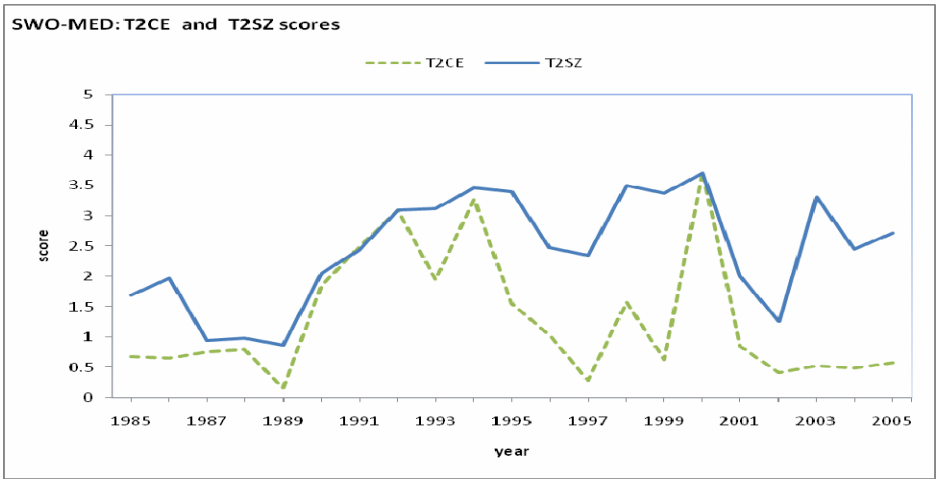


Figure 2.1.1 Overall Task-2 (T2CE and T2SZ) scores obtained in gap analysis (higher scores corresponds better data resolution)

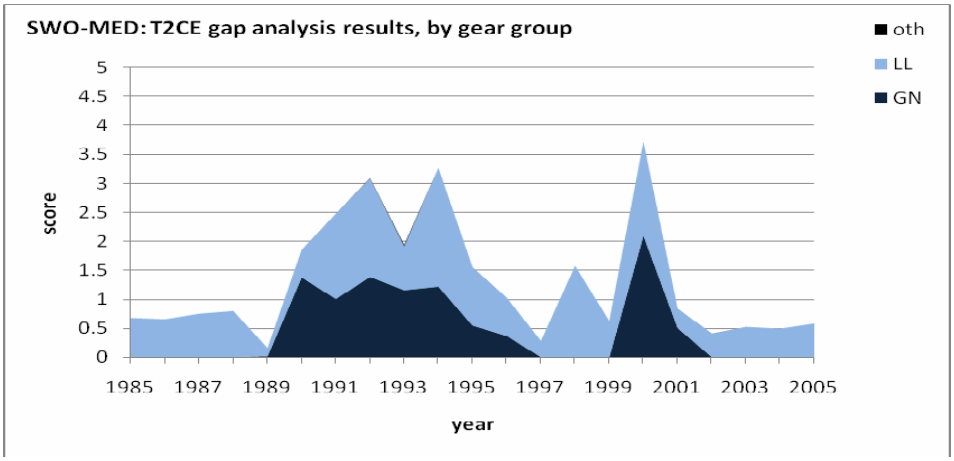


Figure 2.1.2 Task 2CE cumulative scores by gear, obtained in gap analysis (higher scores corresponds better data resolution).

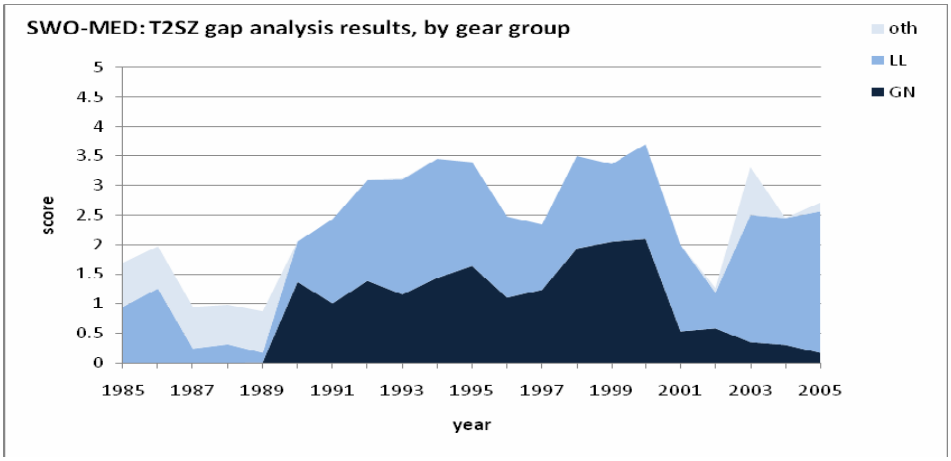


Figure 2.1.3 Task 2CE cumulative scores by gear, obtained in gap analysis (higher scores corresponds better data resolution).

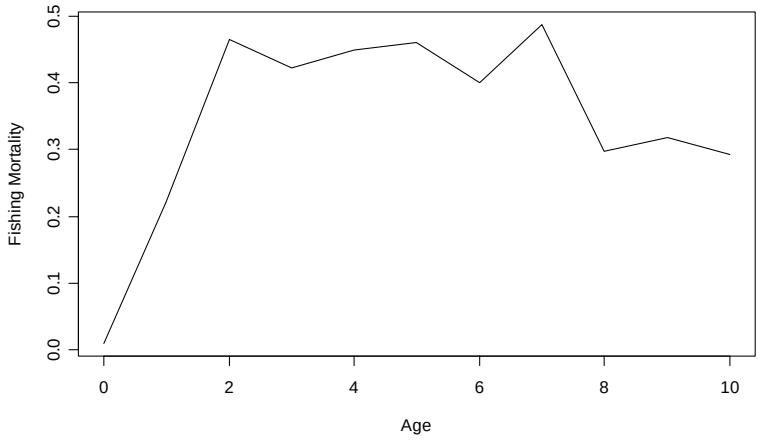


Figure 4.1 Fishing mortality at age based upon the status quo fishing mortality from the 2006 assessment.

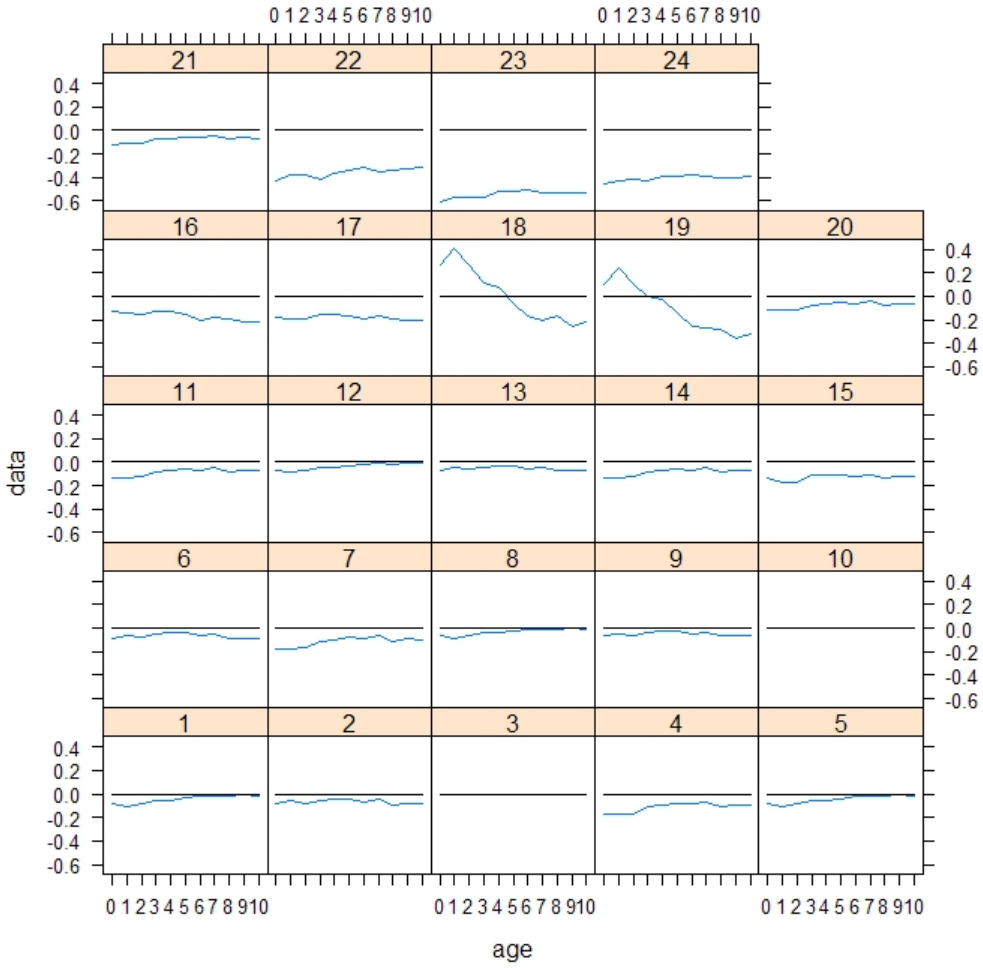


Figure 4.2. Relative change in fishing mortality-at-age under the 24 scenarios.

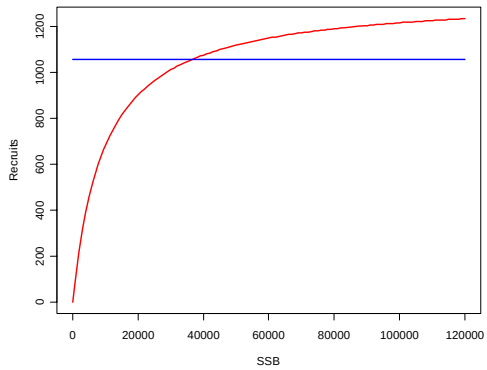


Figure 4.3. Stock recruitment relationships.

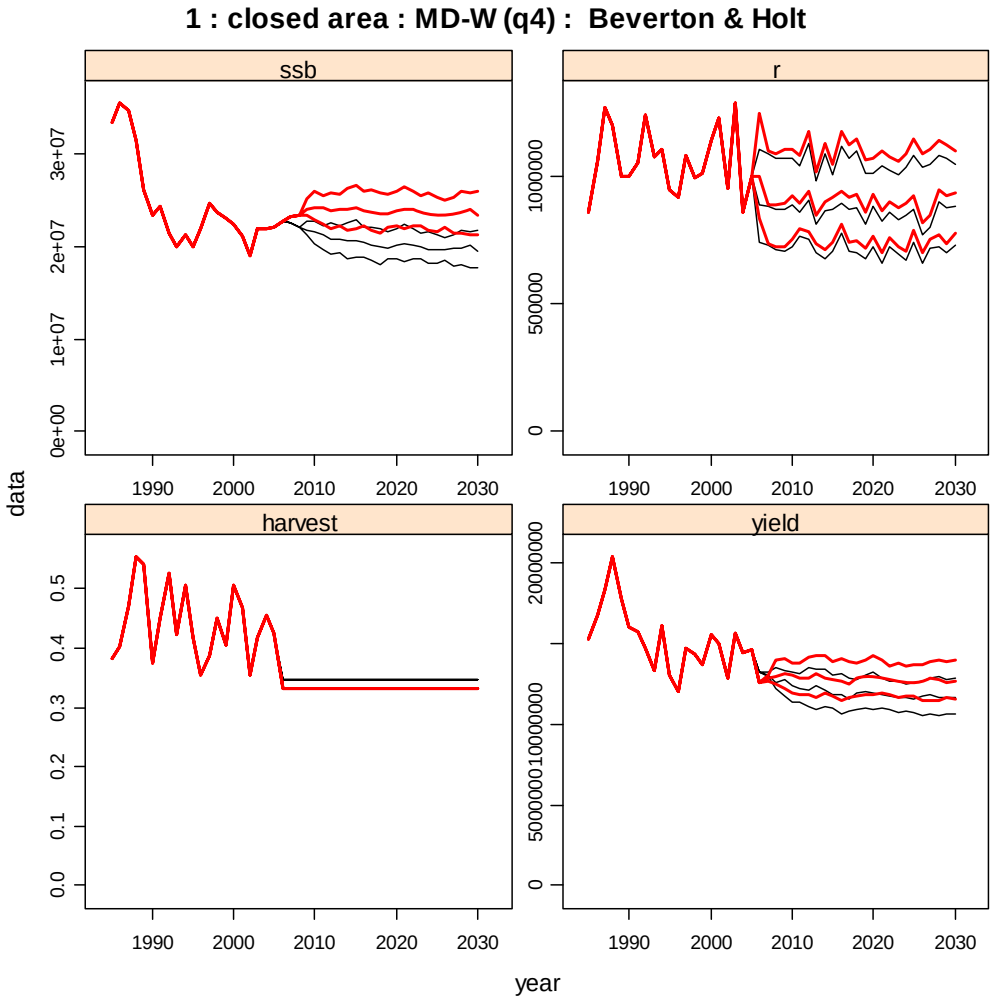


Figure 4.4 An example of a projection for the 1st scenario, a closure in the Western Mediterranean in the fourth quarter. Time series with the the 25th, 50th and 75th percentiles are shown for ssb, r, fishing mortality and yield, thin (black) lines correspond to the status quo projection and thick (red) lines to the scenario.

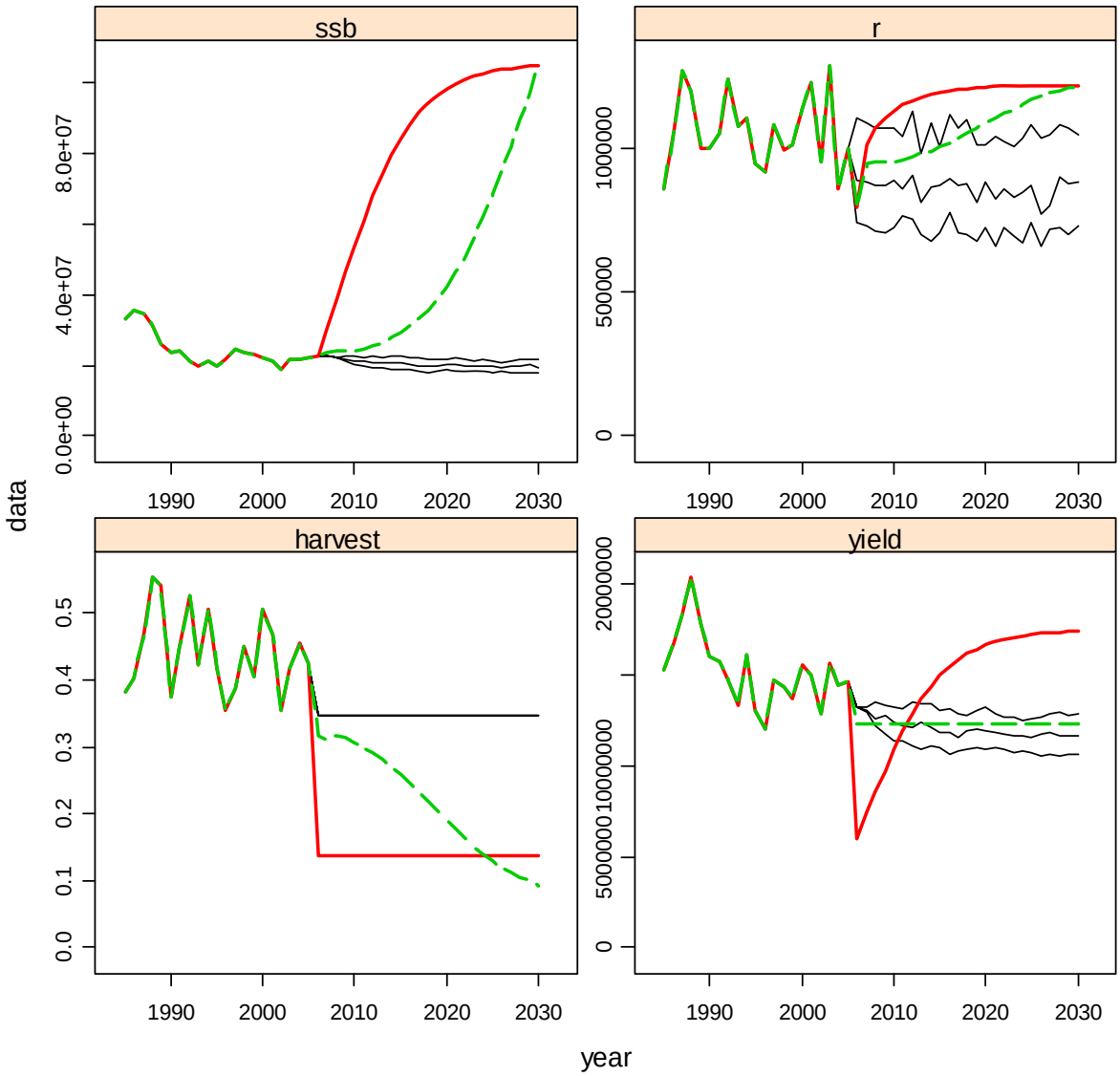
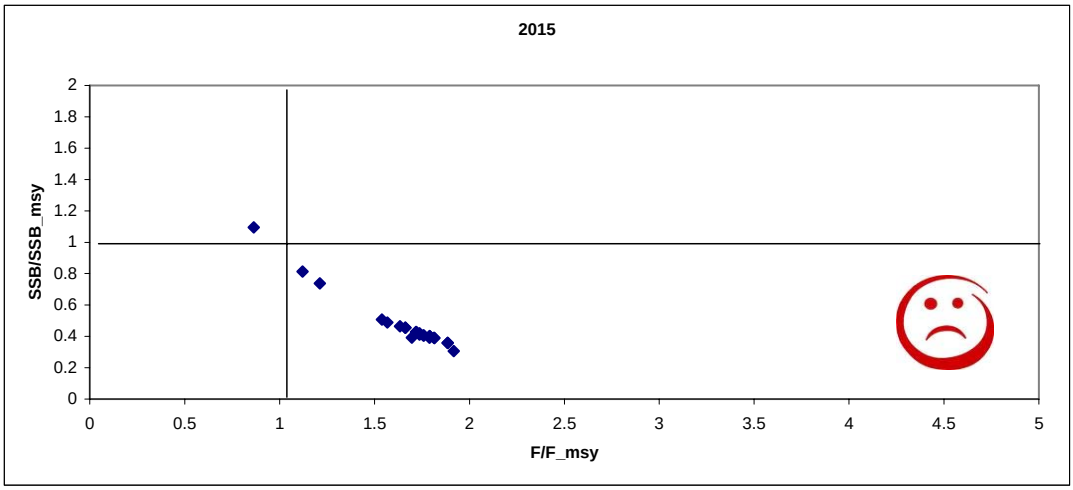
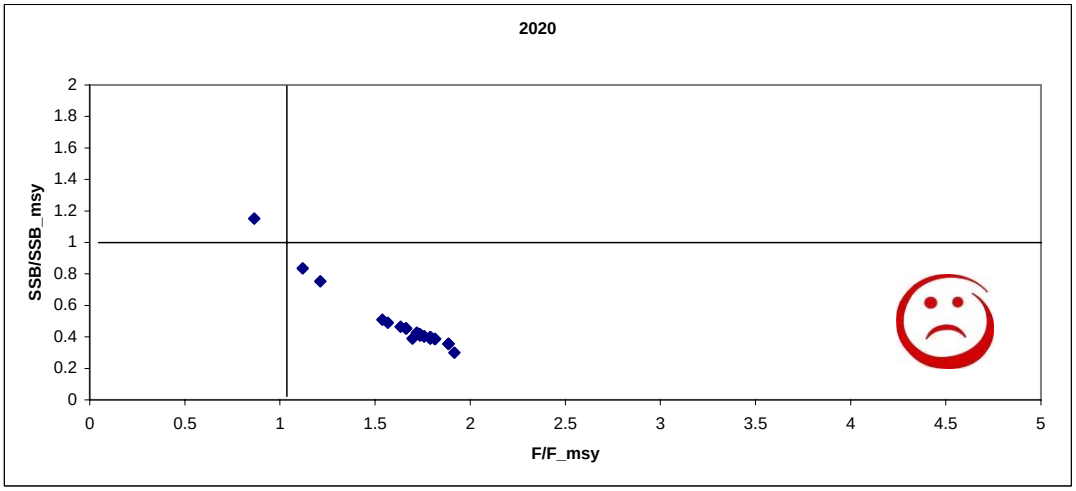


Figure 4.5 A comparison with the status quo projection (thin lines) of a constant effort strategy (thick line) and a constant catch strategy (dashed line).





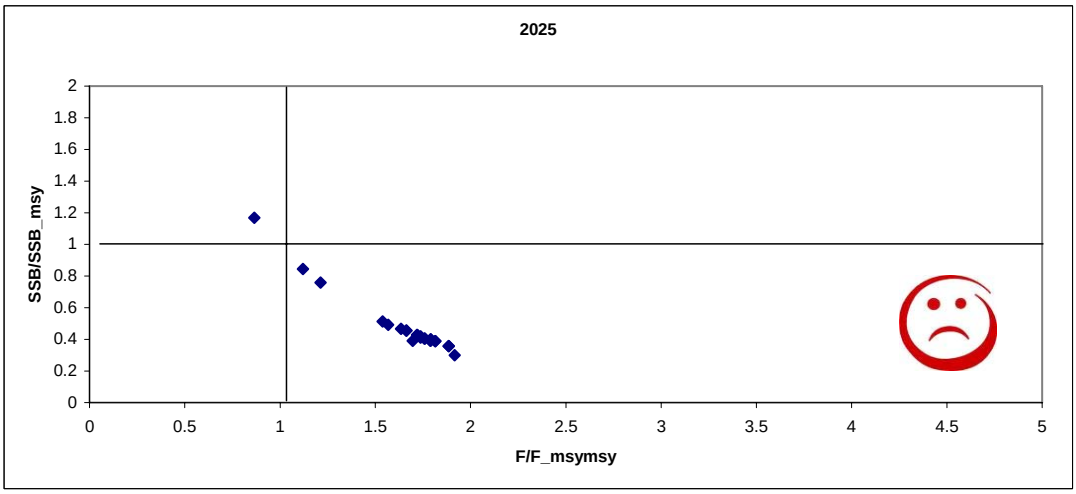


Figure 4.6 Mean B/B_{MSY} and F/F_{MSY} outcomes from each scenario in the short, medium and long term assuming constant recruitment.

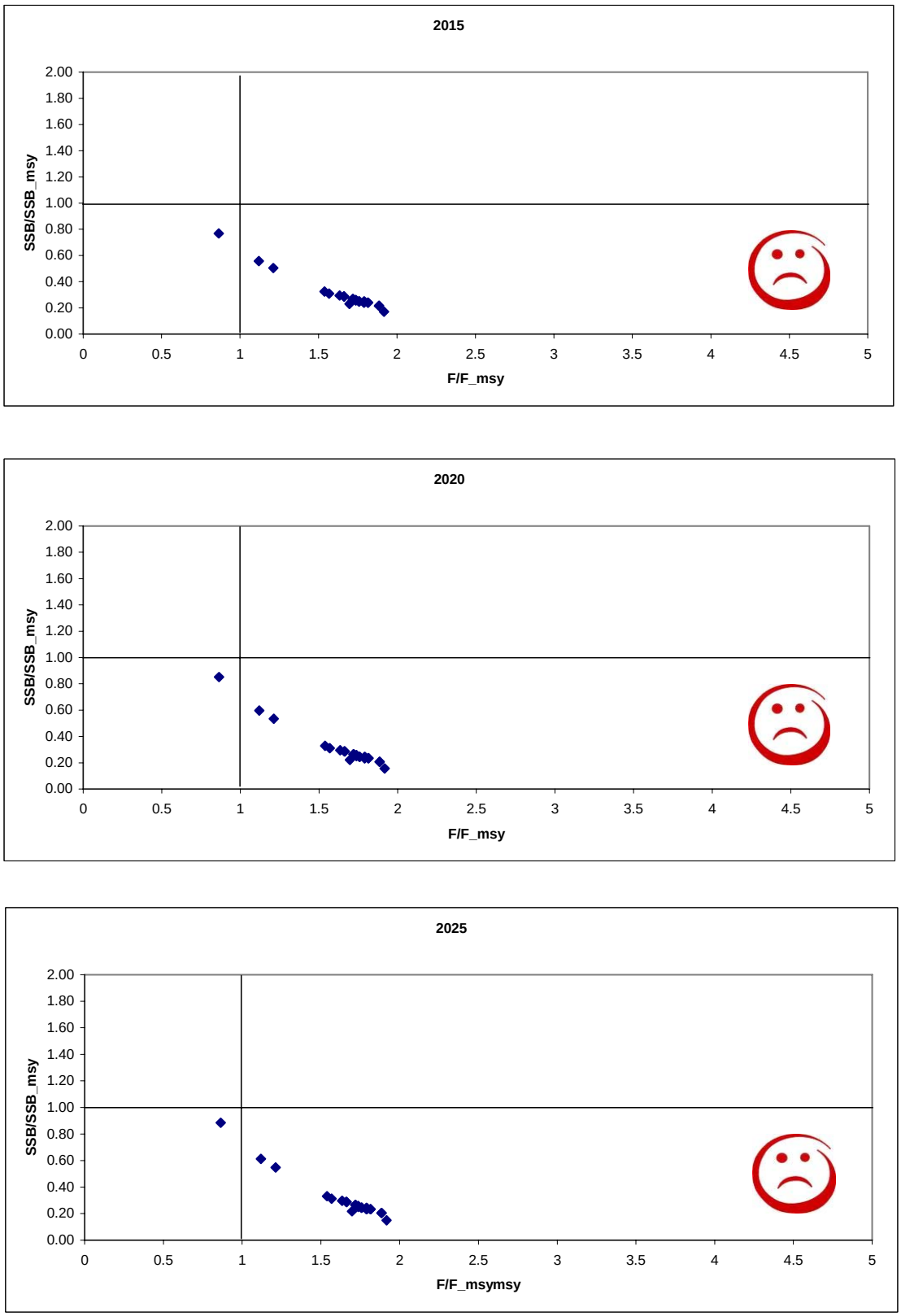


Figure 4.7 Mean B/B_{MSY} and F/F_{MSY} outcomes from each scenario in the short, medium and long term assuming BH recruitment.

Appendix 1

Agenda

1. Opening, adoption of the Agenda and meeting arrangements.
2. Analysis of data
3. Definition of scenarios
4. Projections
5. Recommendations
6. Other matters
7. Adoption of the report and closure

Appendix 2

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Pallarés, Pilar
Palma, Carlos

Appendix 3

List of Documents

SCRS/2008/025 Swordfish (*Xiphias gladius* L.) Fishery in Turkish Aegean Sea. CEYHAN, T. and O. Akyol.

SCRS/2008/026 A bioeconomic evaluation of different management measures for the Mediterranean wordfish. TSERPES, G., E. Tzanatos, P. Peristeraki and L. Kell.

SCRS/2008/033 Analysis of the size data of sworfish *(Xiphias gladius)* caught by the Moroccan driftnet fishery operating in the Mediterranean Sea, period 1999-2006. ABID, N. and M. Idrissi.

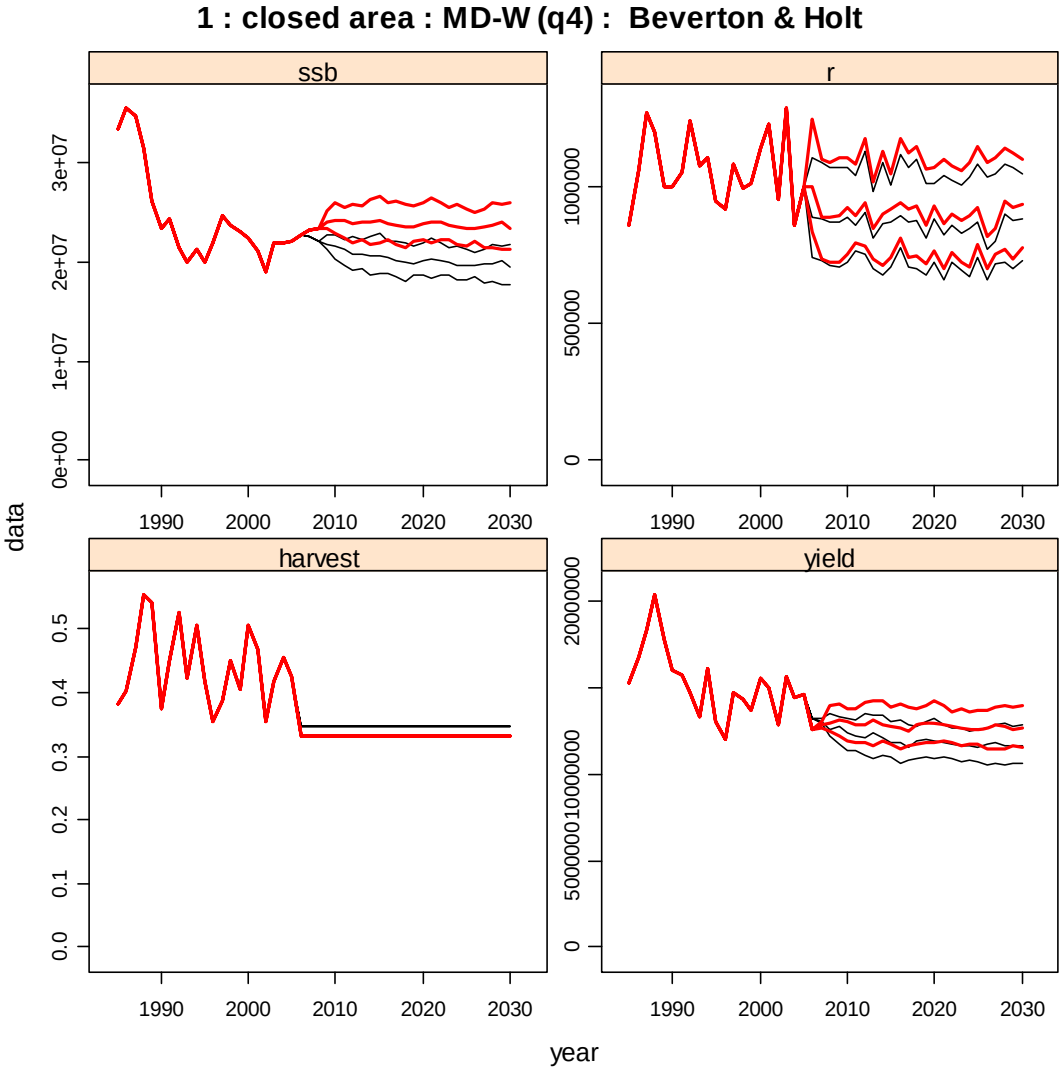
Appendix 4

Detailed Results from the Scenario Runs

Time series with the 25th, 50th and 75th percentiles are shown for SSB, r, fishing mortality and yield, thin lines correspond to the status quo projection and thick lines to the scenario.

Figure 1.1. Closed area : MD-W (q4).

a) Beverton & Holt



b) Constant recruitment

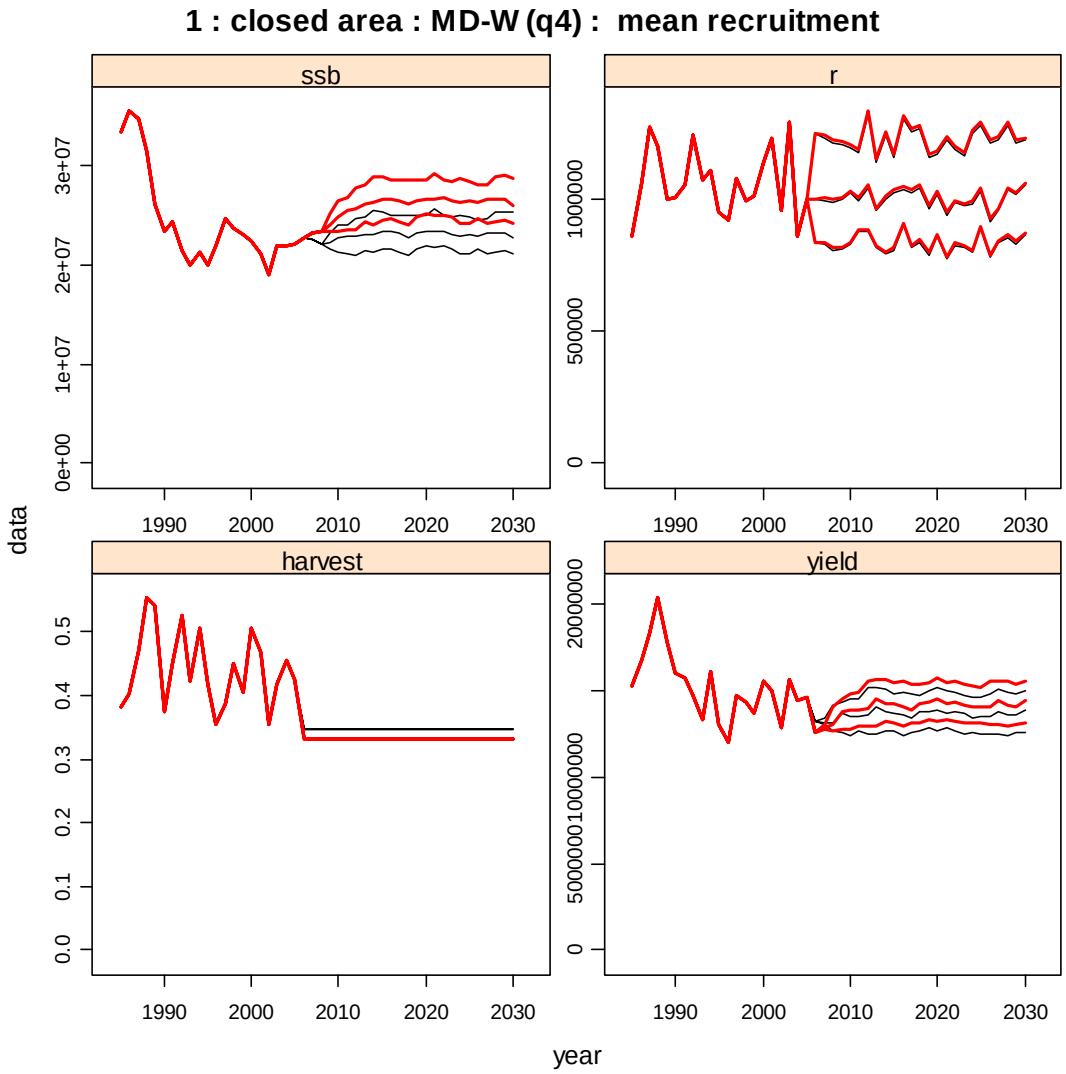
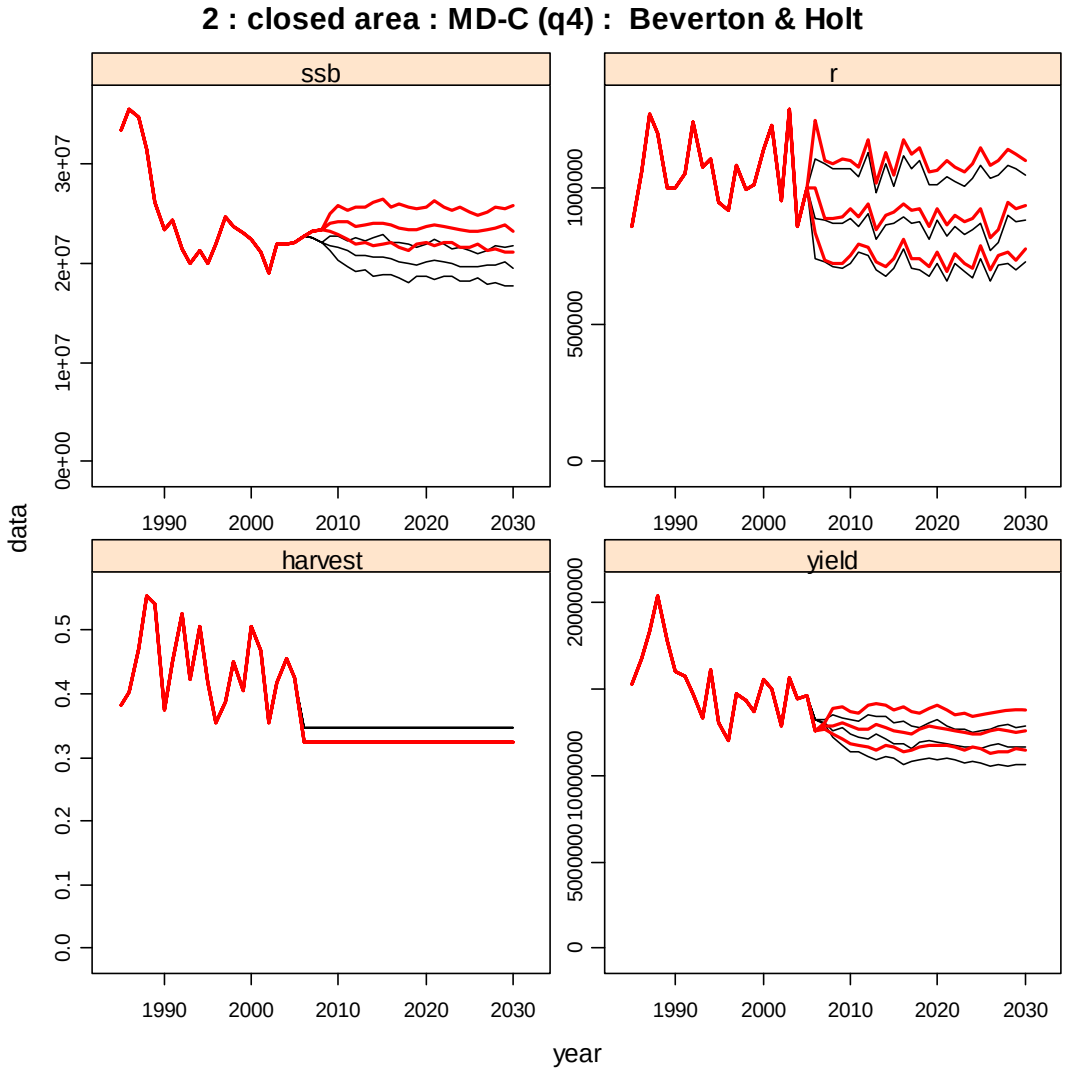


Figure 1.2. Closed area : MD-C (q4).

a) Beverton & Holt



b) Constant recruitment

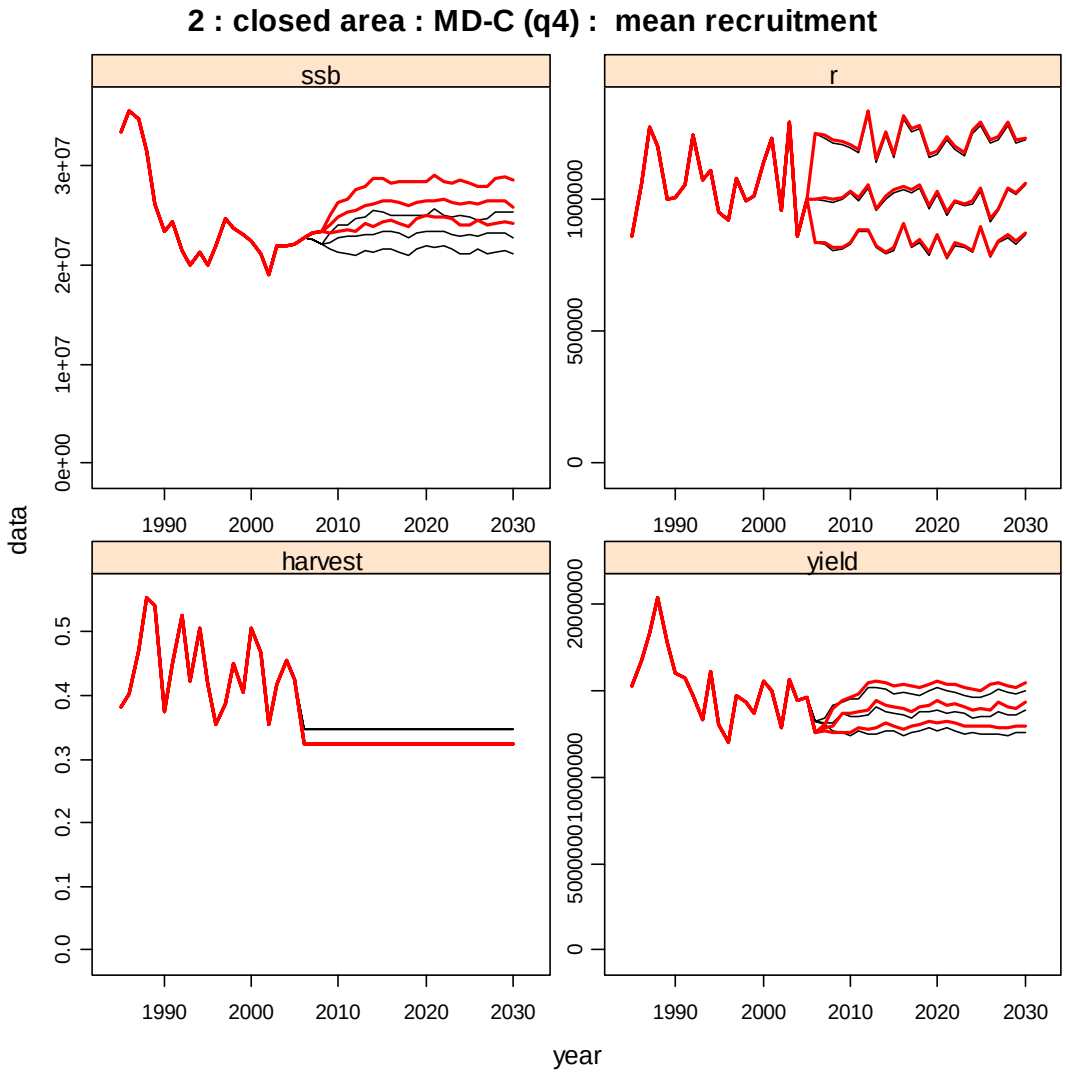
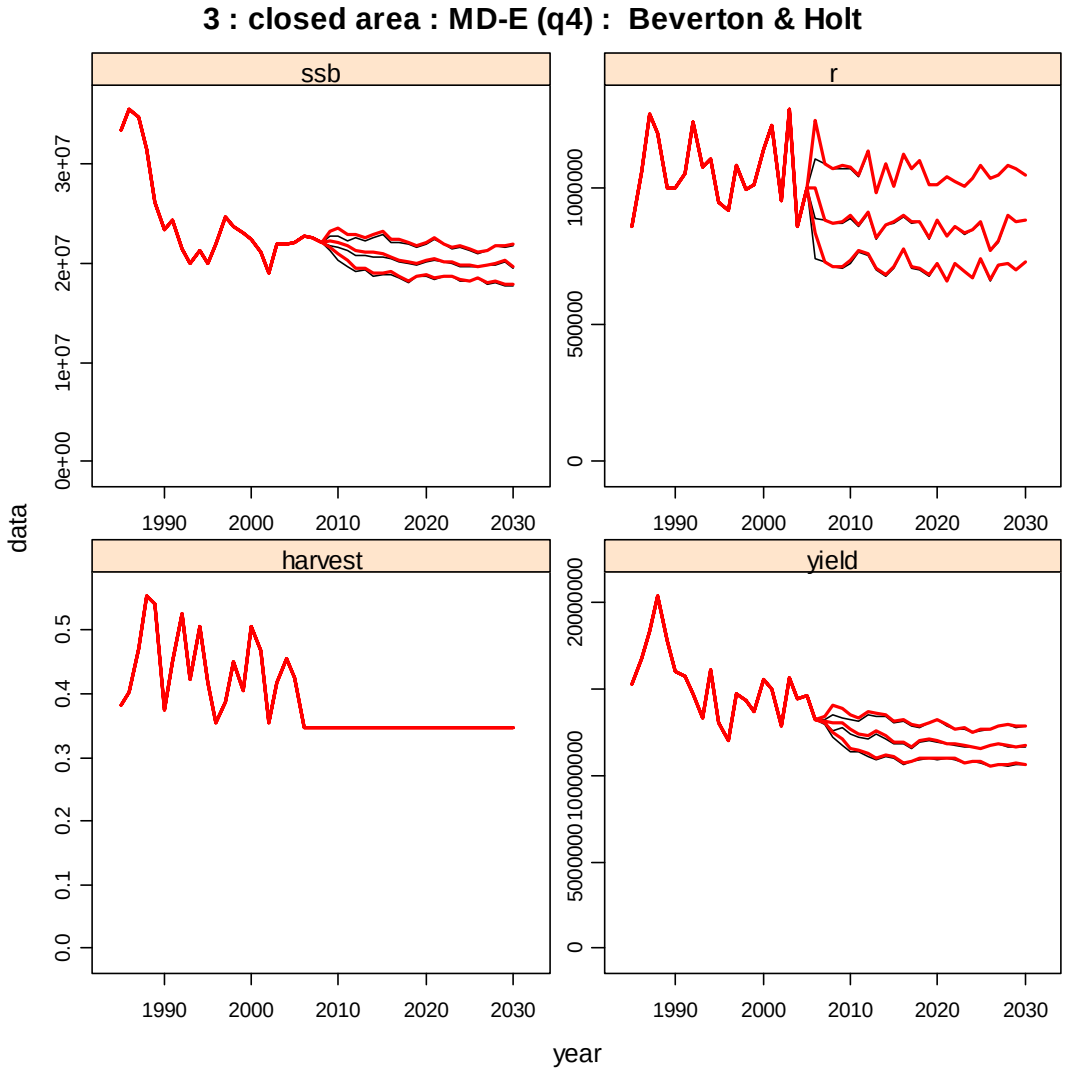


Figure 1.3. Closed area : MD-E (q4).

a) Beverton & Holt



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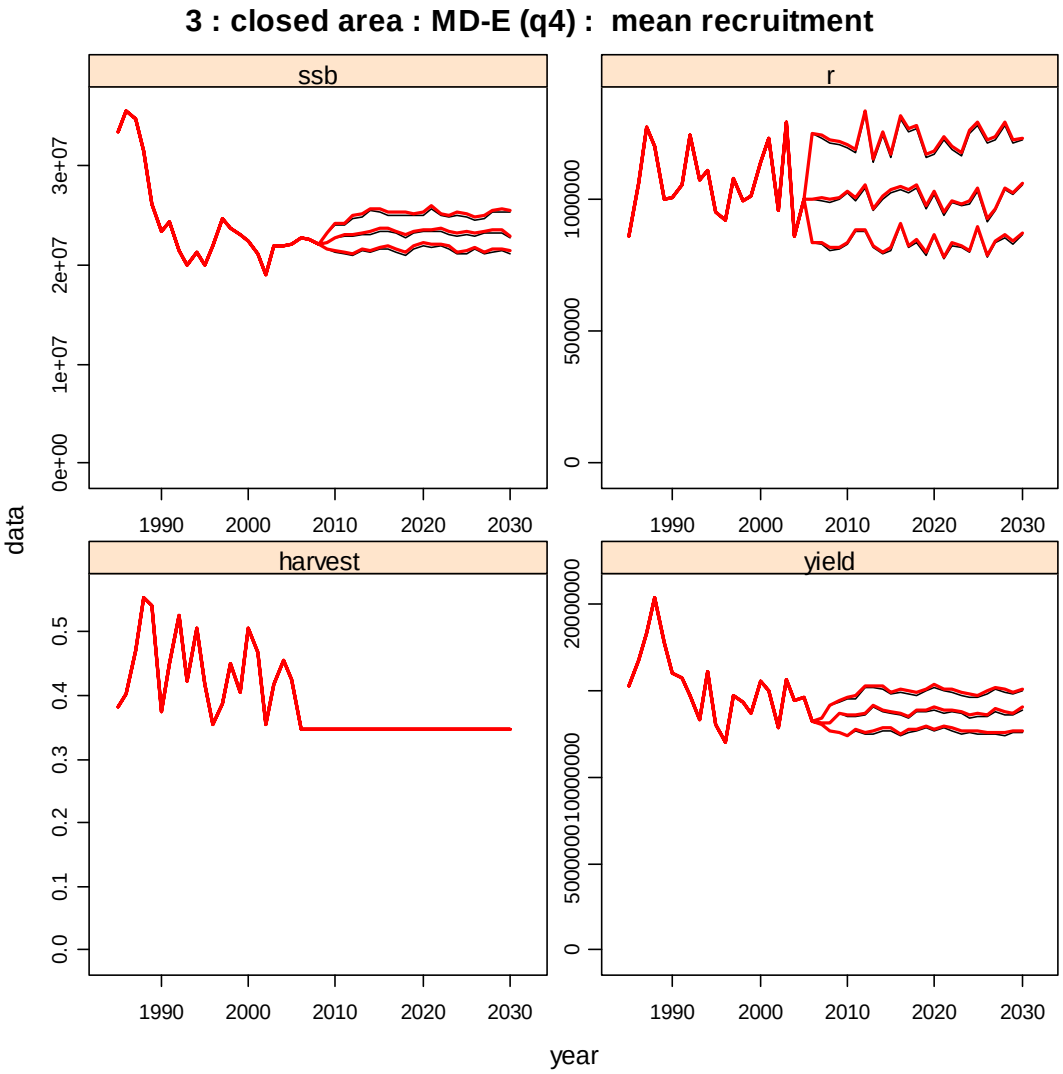
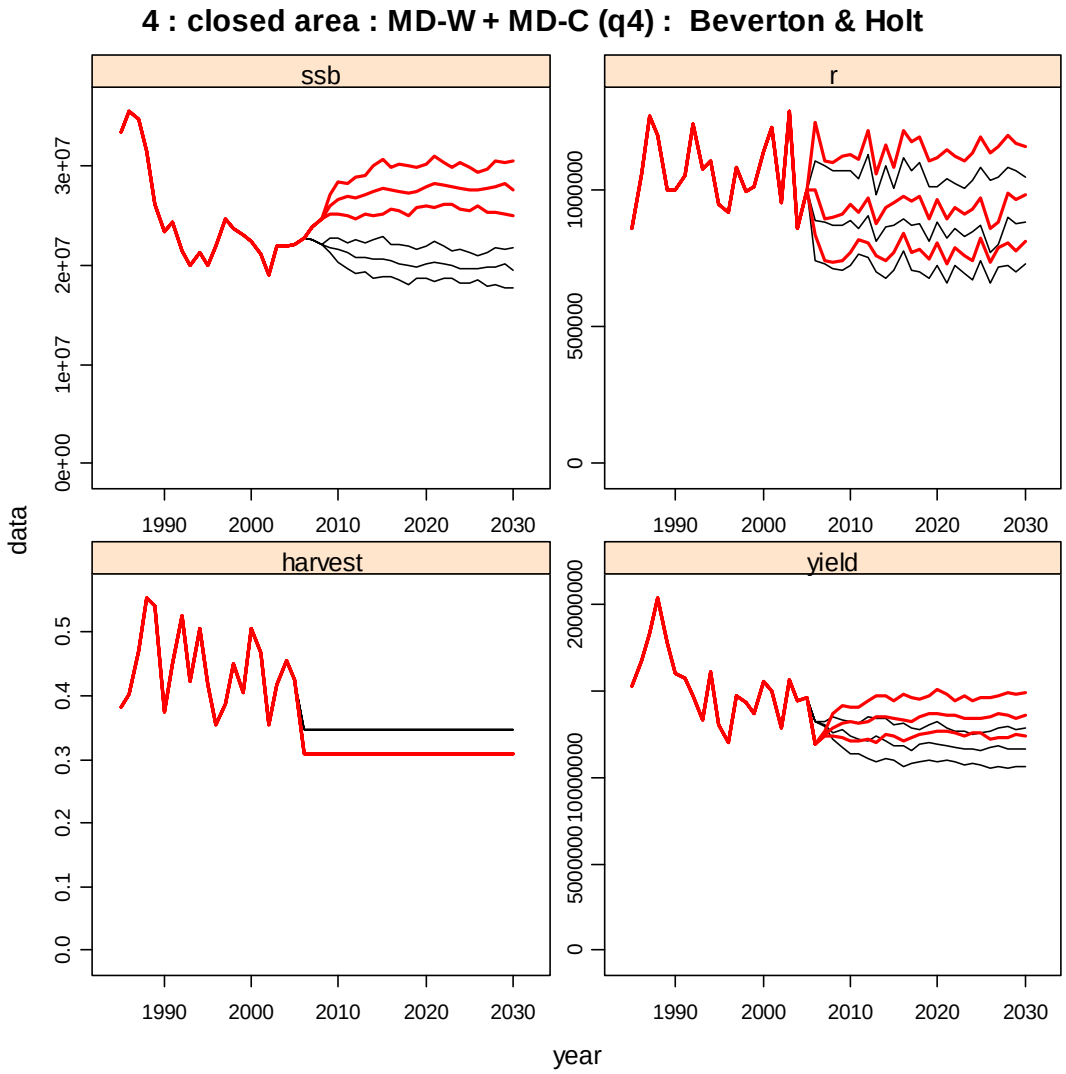


Figure 1.4. Closed area : MD-W + MD-C (q4).

a) Beverton & Holt



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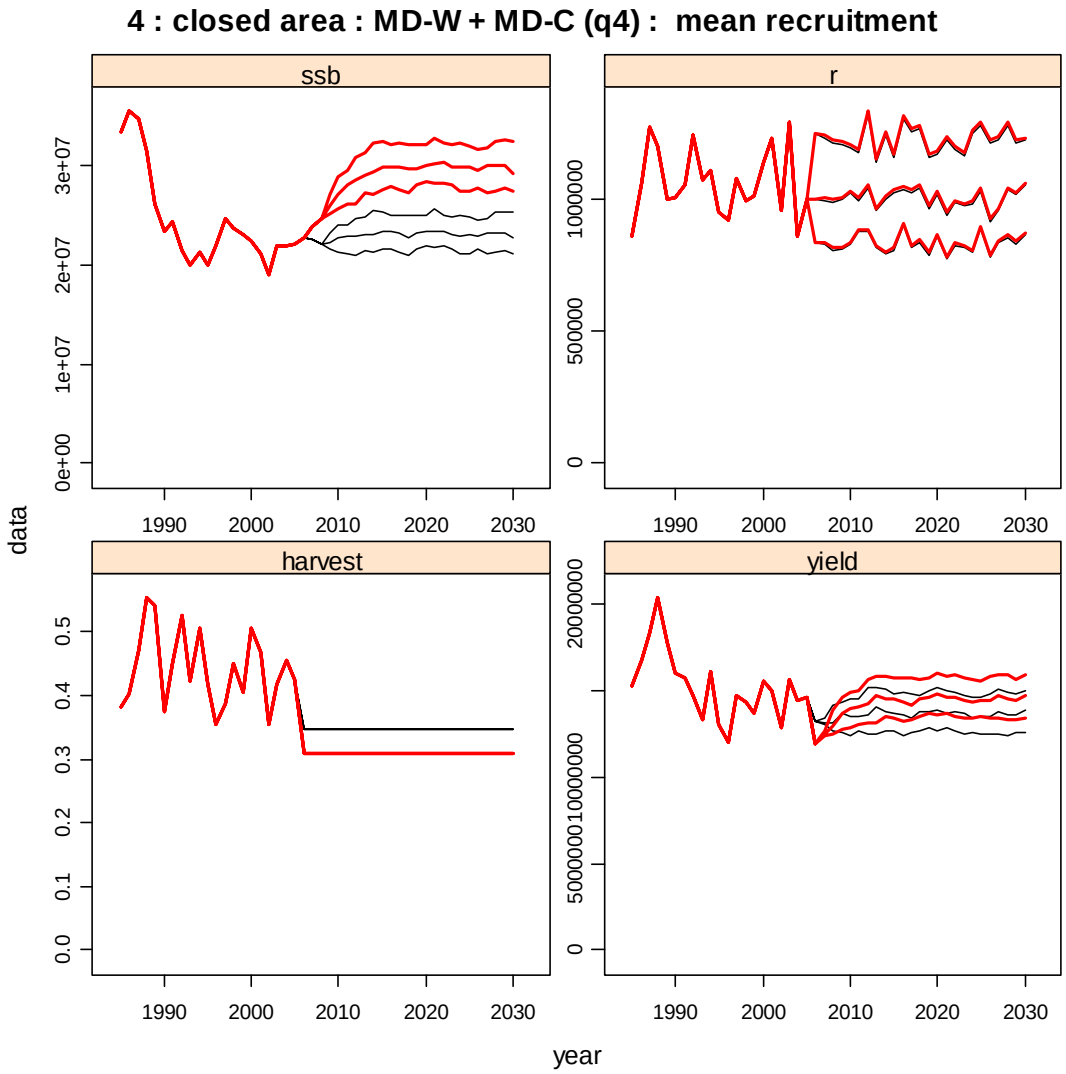
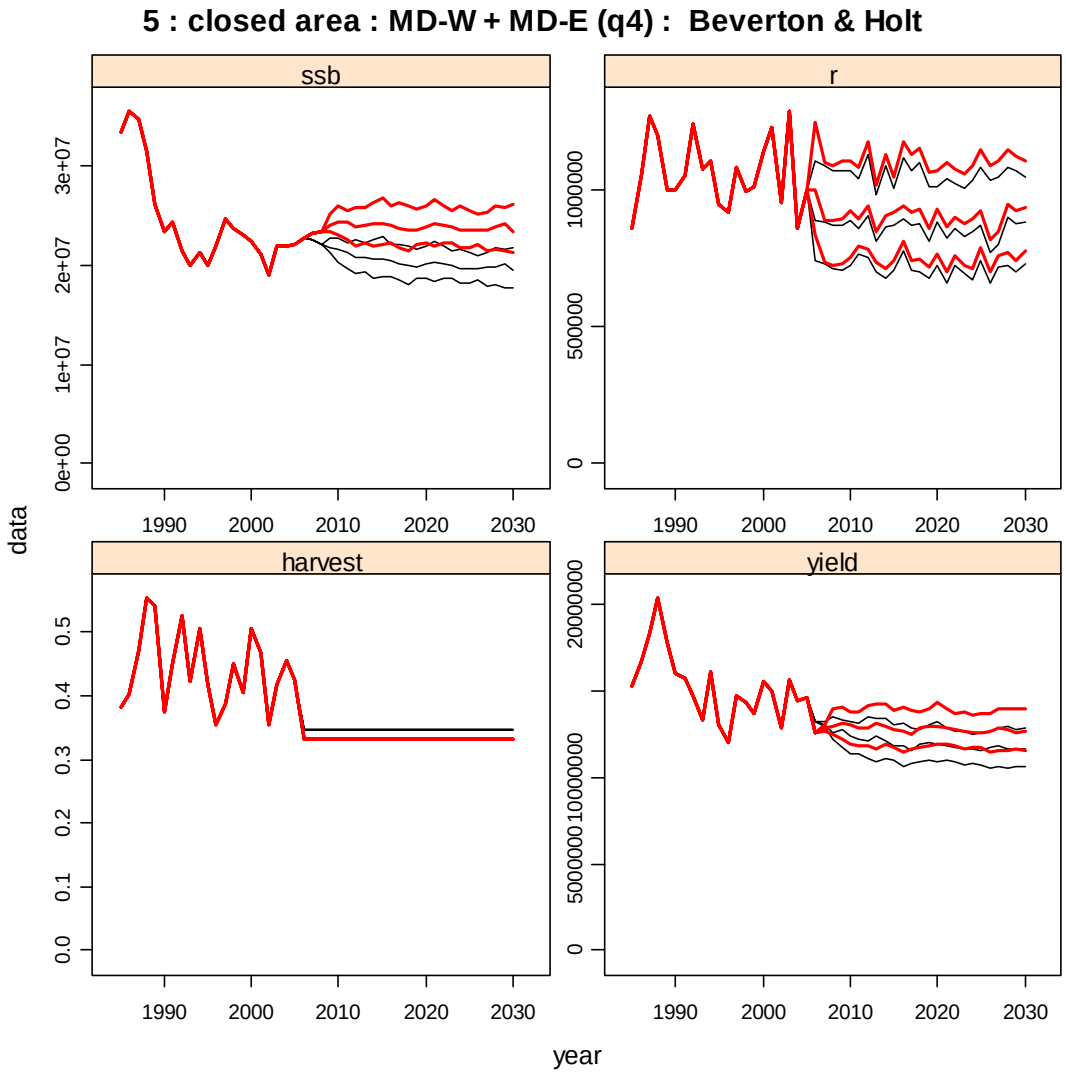


Figure 1.5. Closed area : MD-W + MD-E (q4).

a) Beverton & Holt



b) Constant recruitment

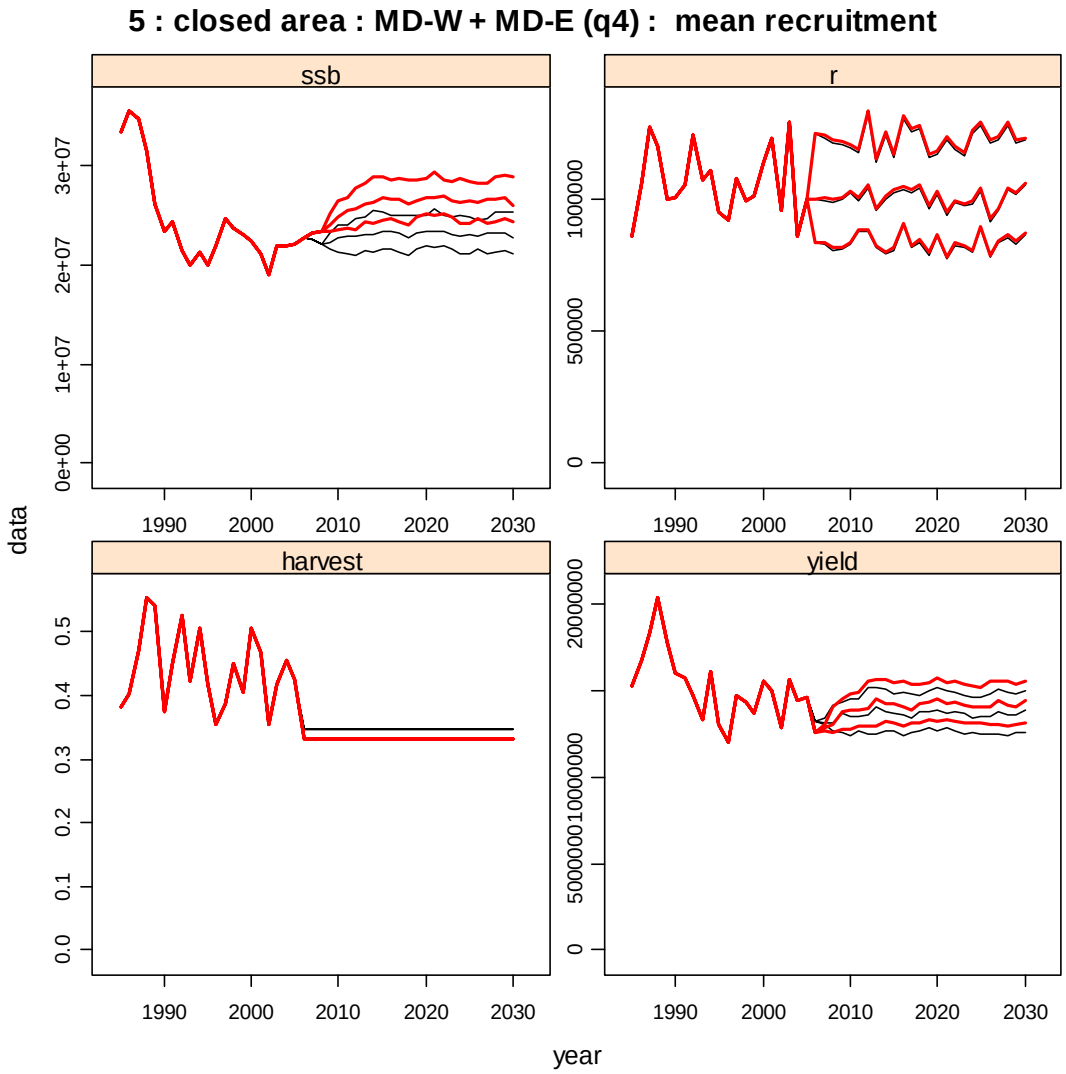
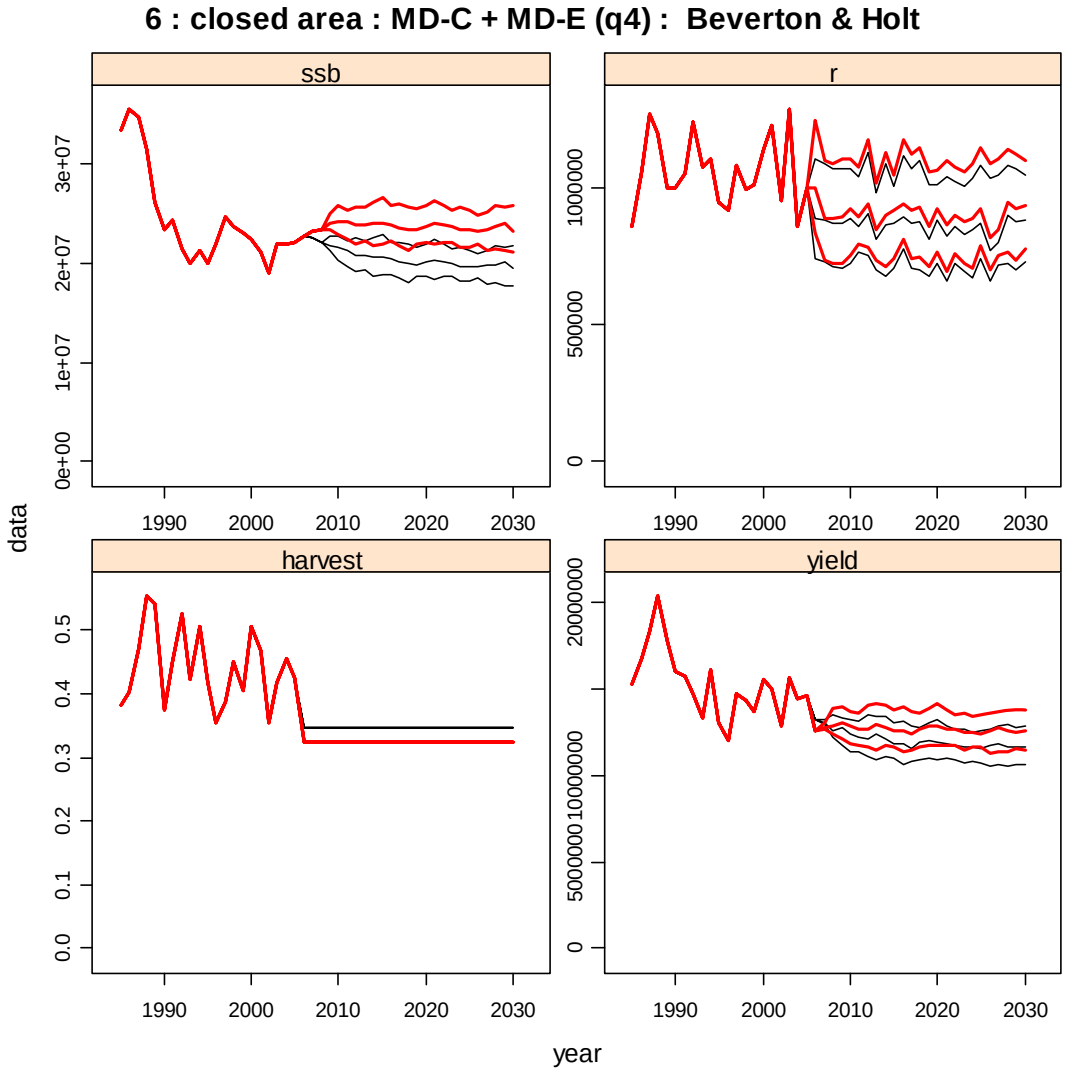


Figure 1.6. Closed area : MD-C + MD-E (q4).

a) Beverton & Holt



b) Constant recruitment

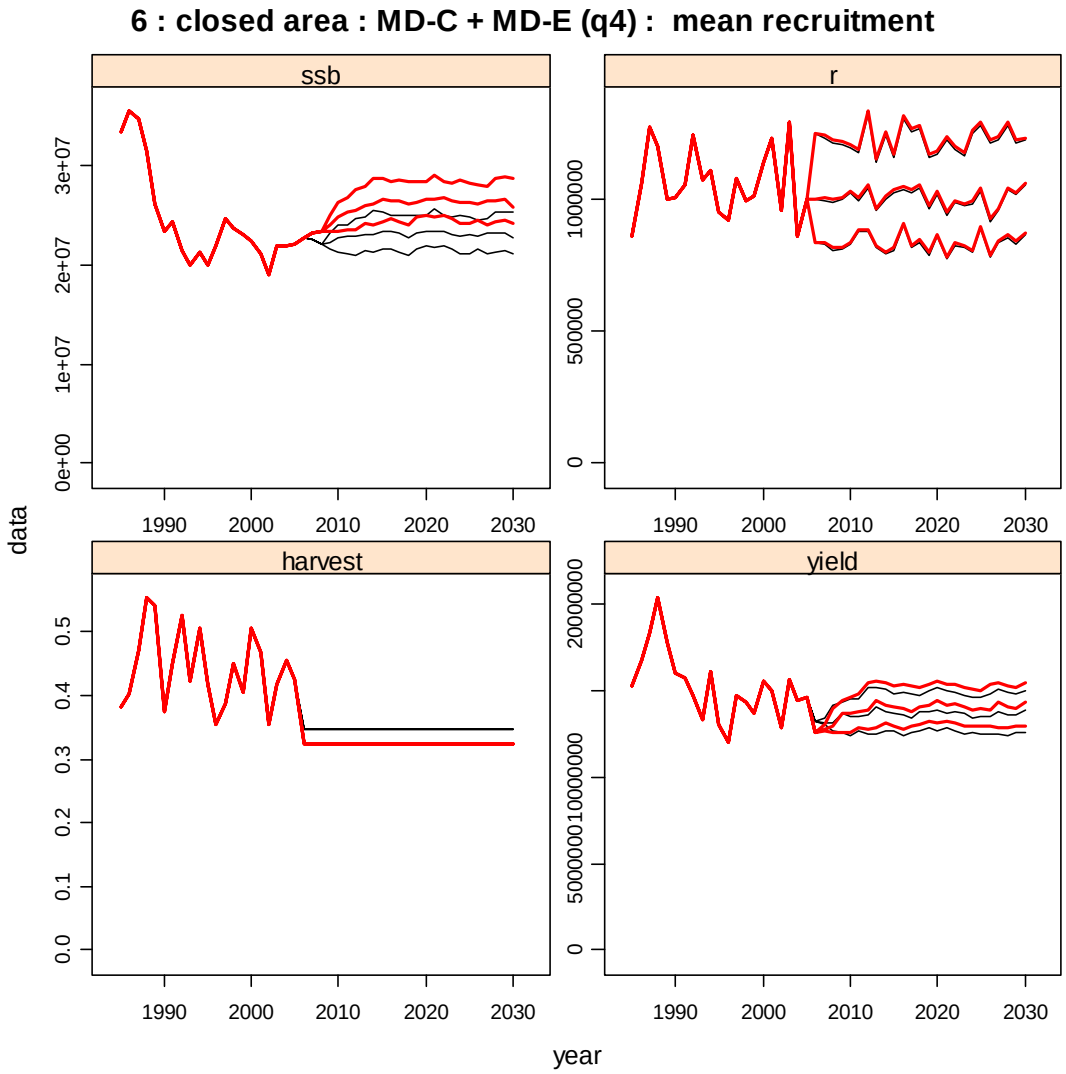
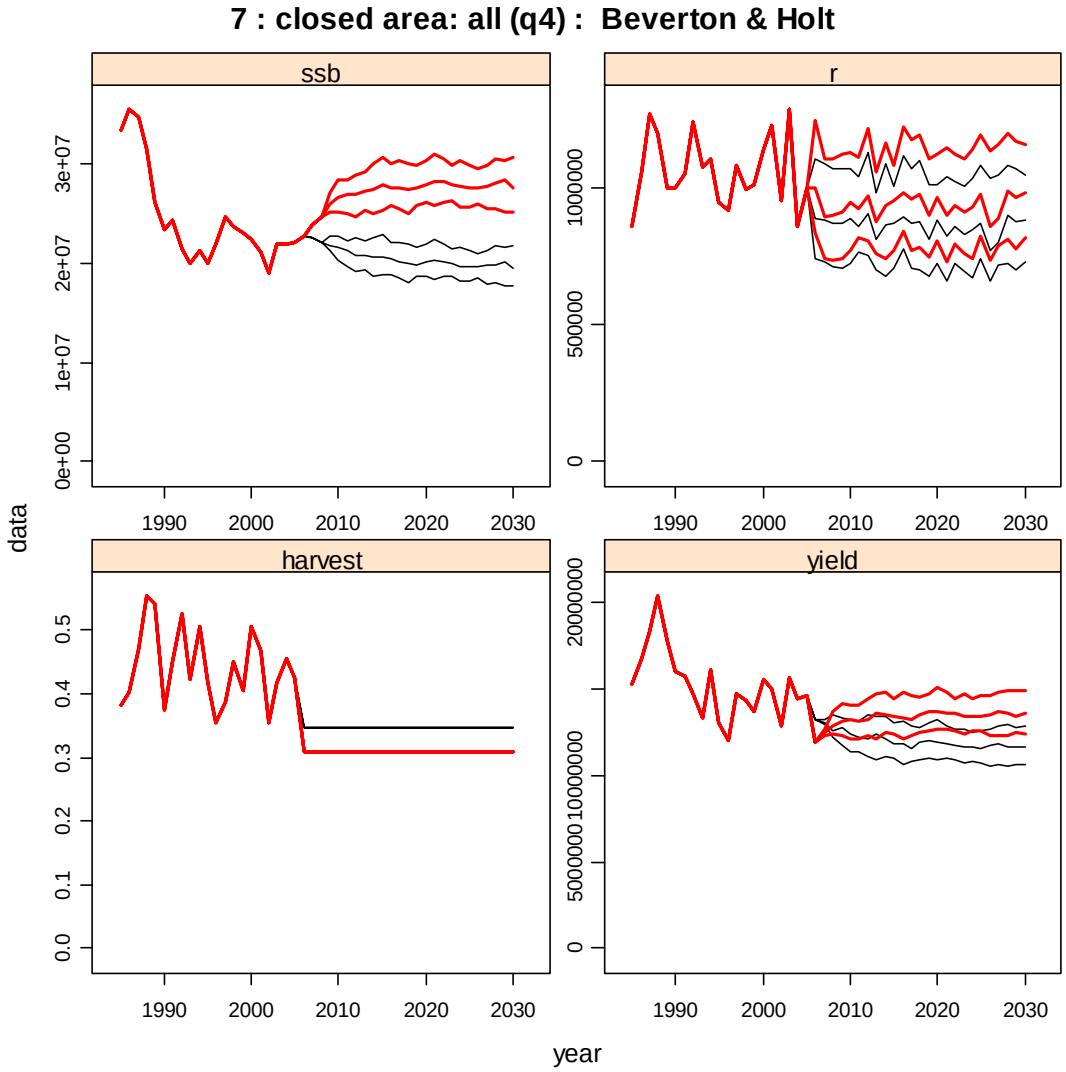


Figure 1.7. Closed area: all (q4).

a) Beverton & Holt



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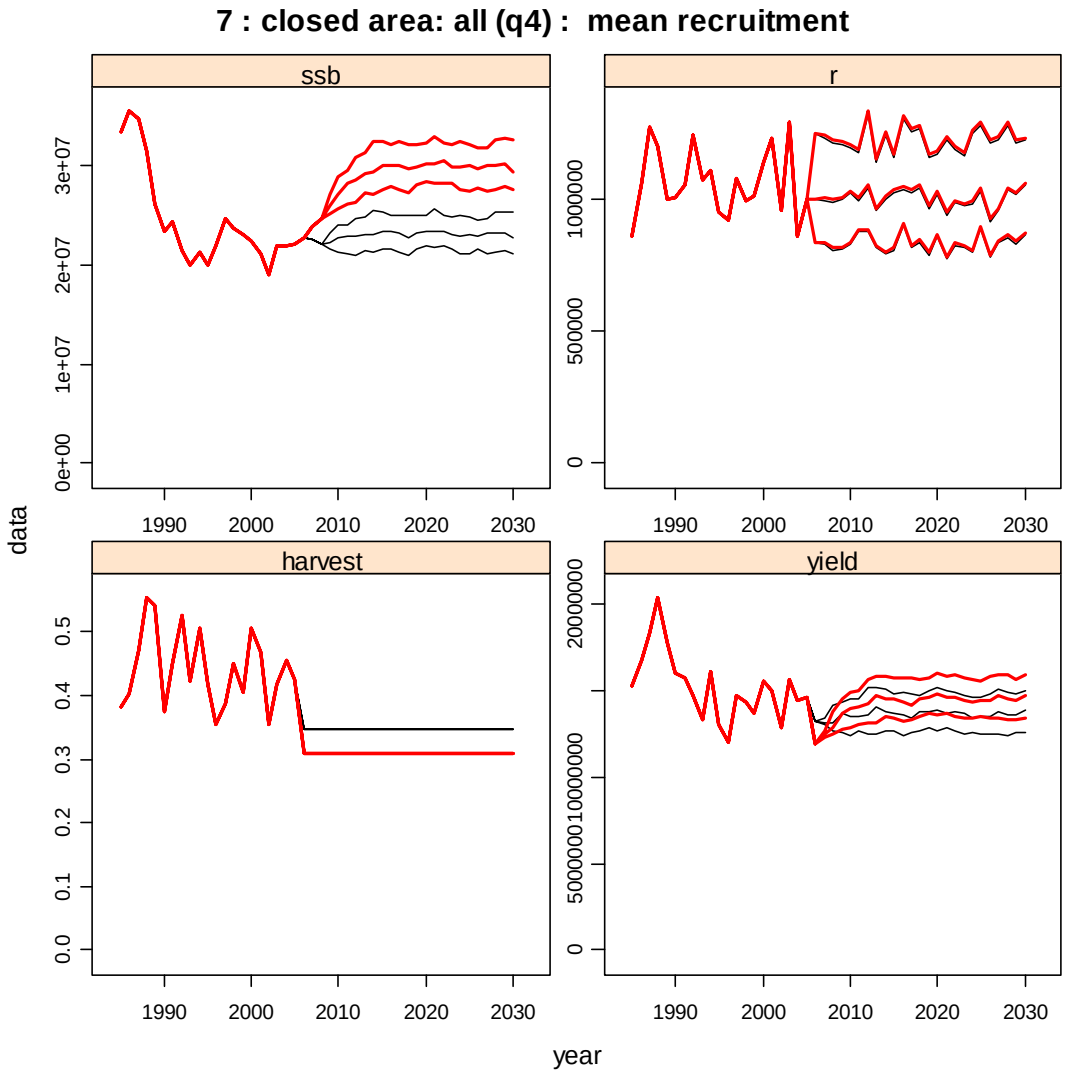
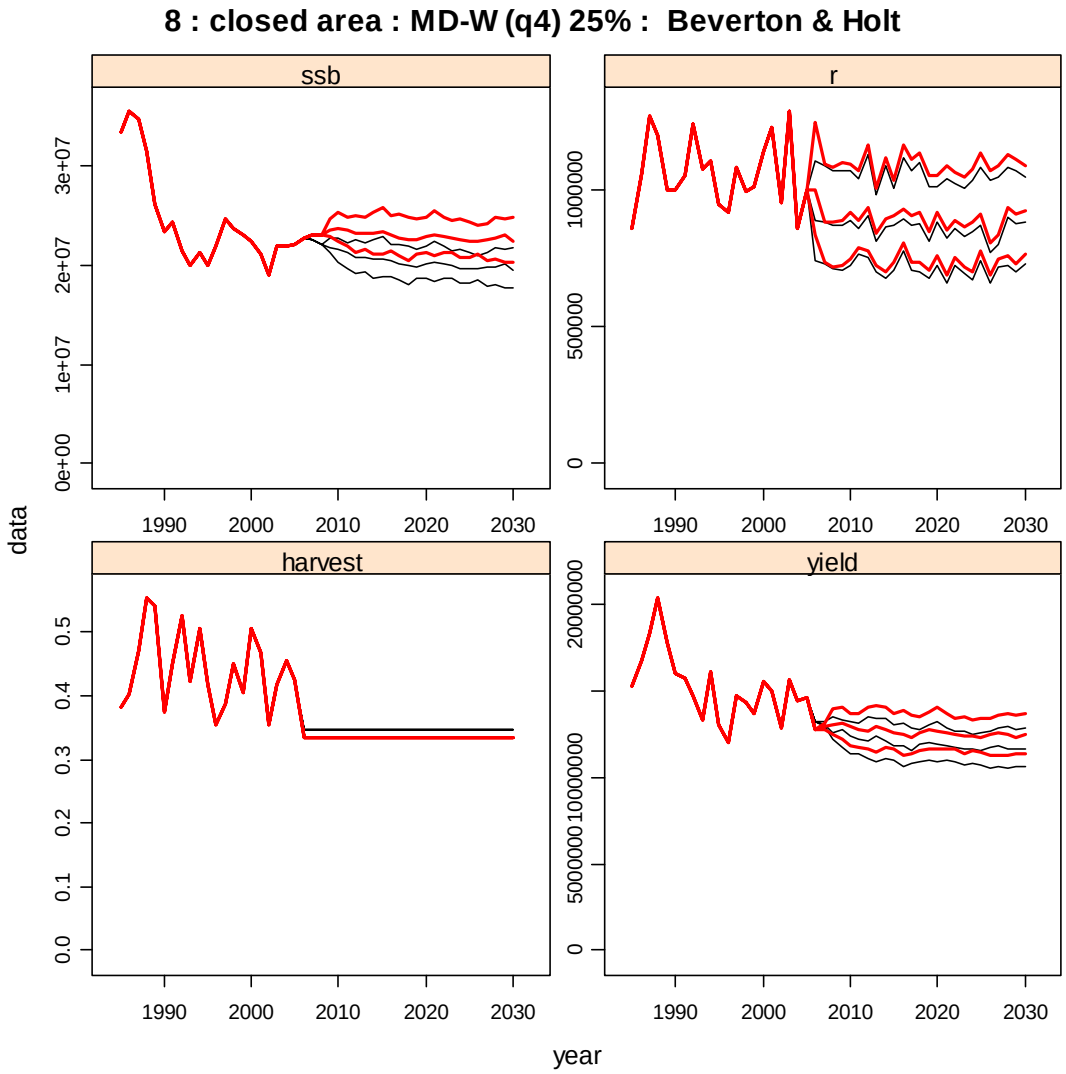


Figure 1.8. Closed area: MD-W (q4) with 25% implementation error.

a) Beverton & Holt



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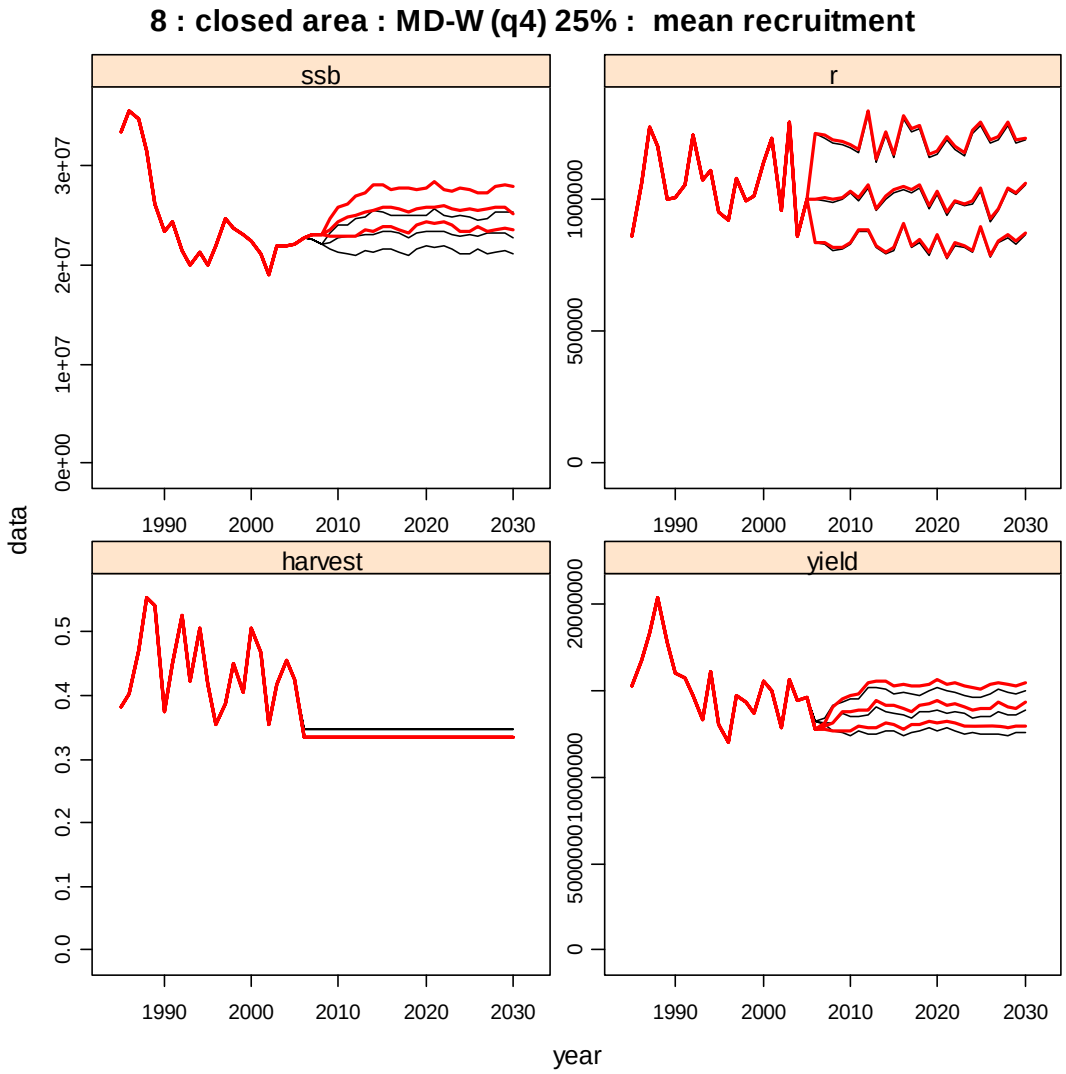
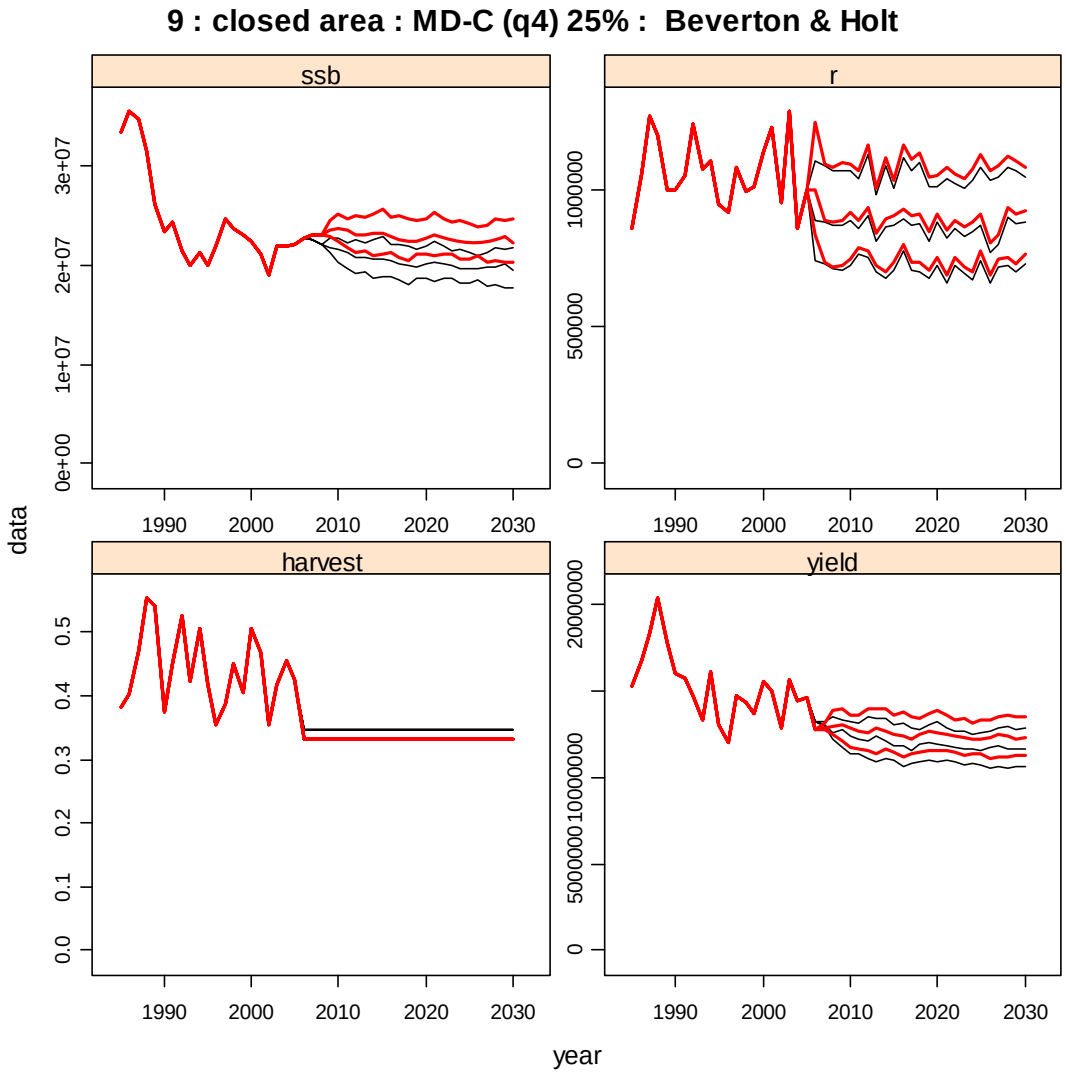


Figure 1.9. Closed area : MD-C (q4) with 25% implementation error.

a) Beverton & Holt



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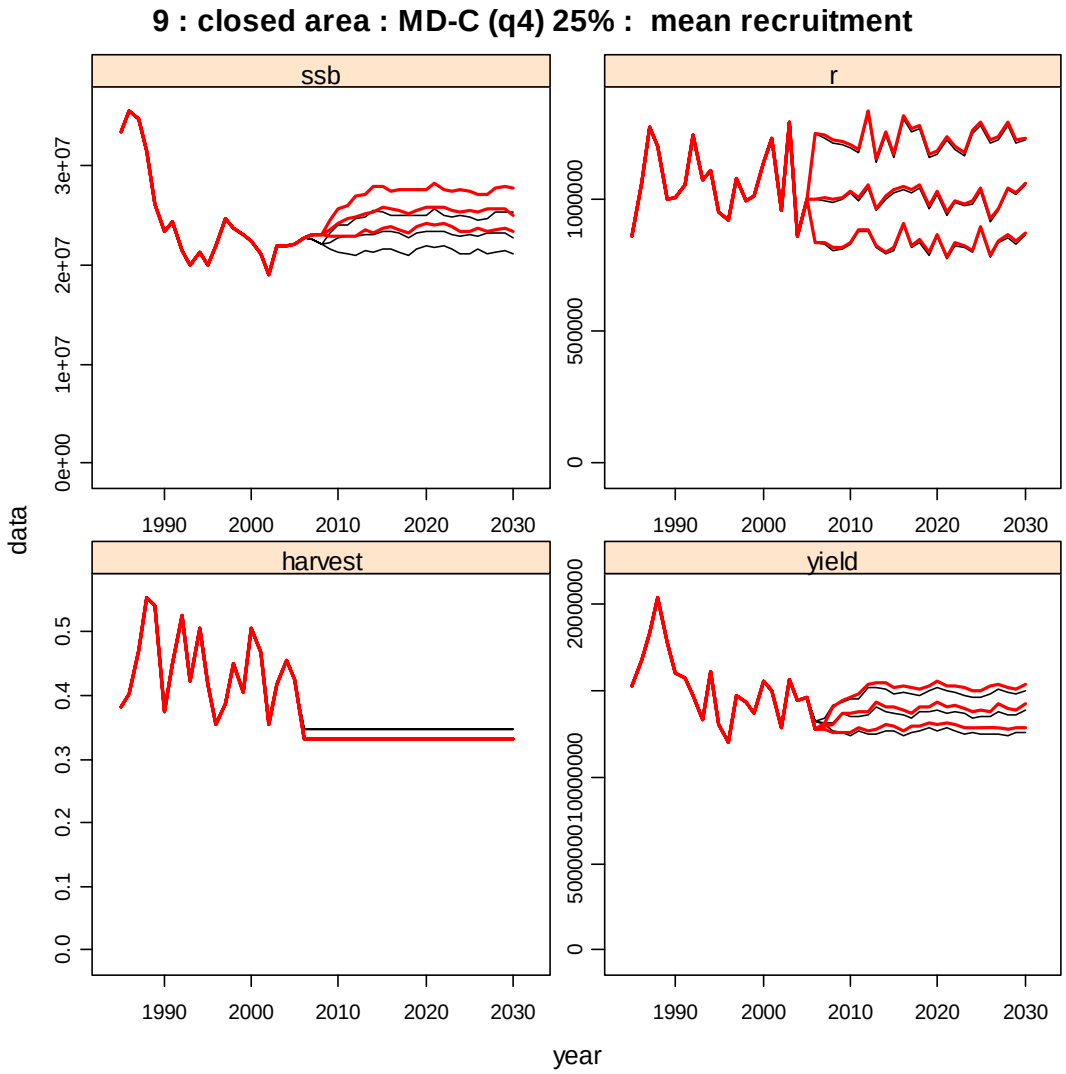
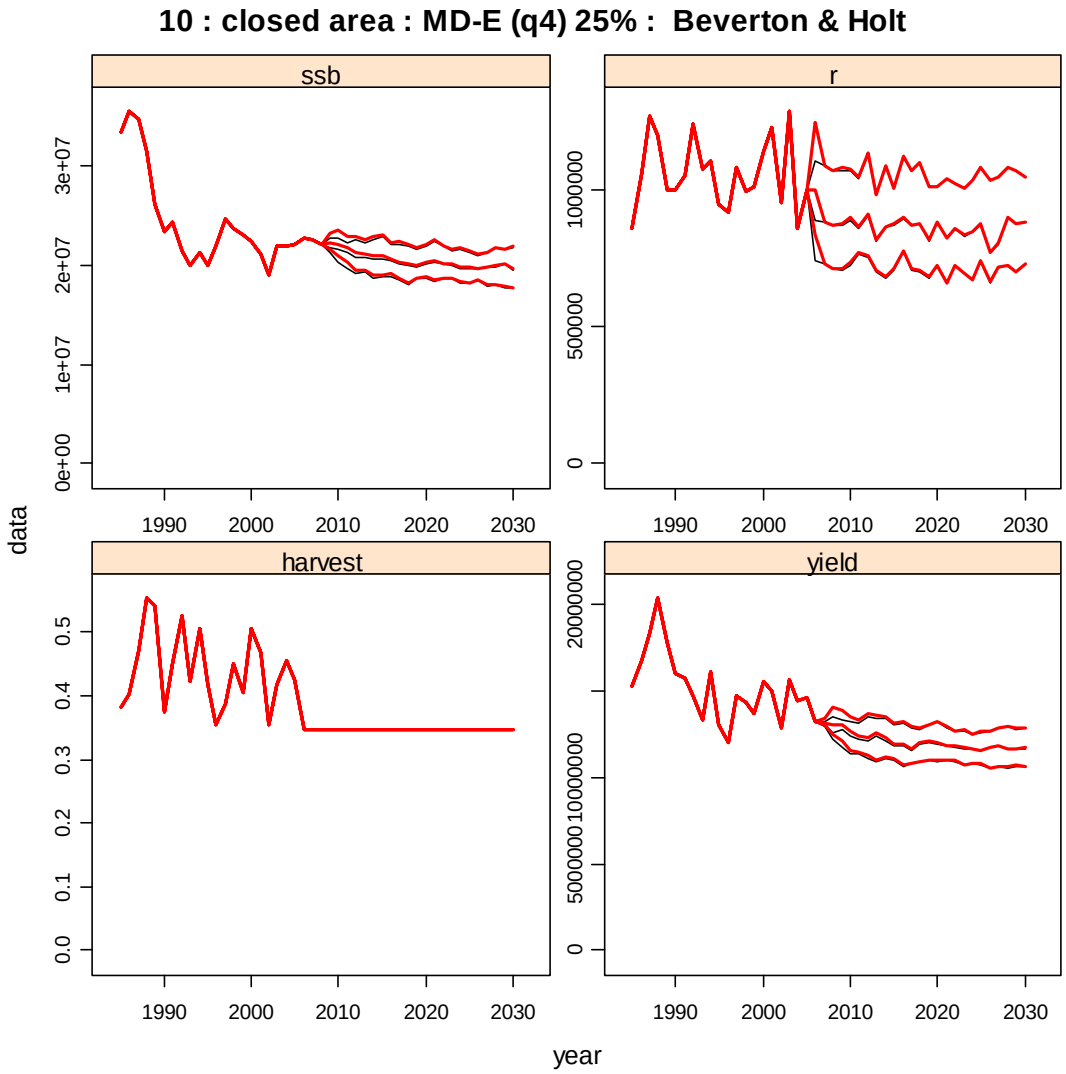


Figure 1.10. Closed area : MD-E (q4) with 25% implementation error.

a) Beverton & Holt



b) Constant recruitment

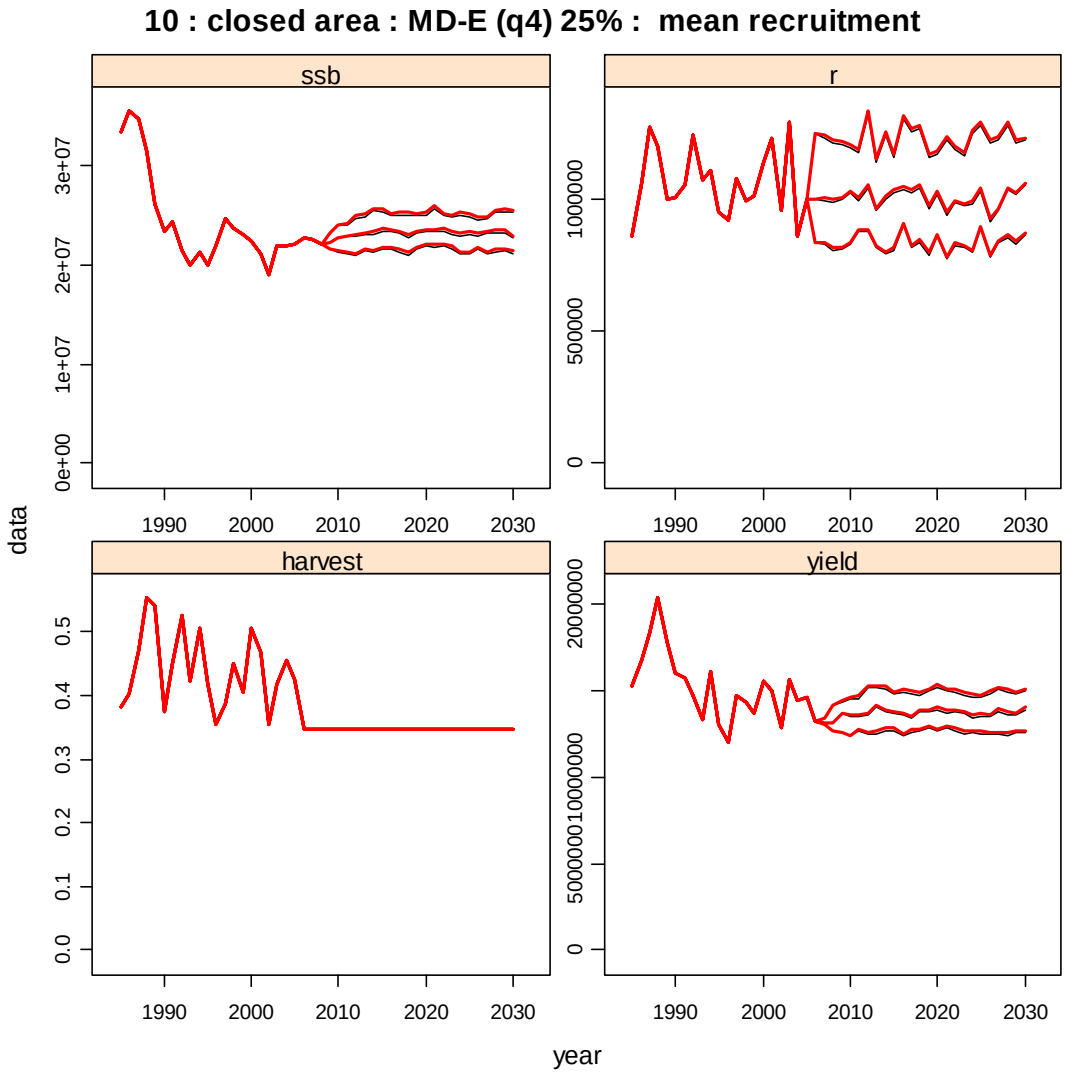
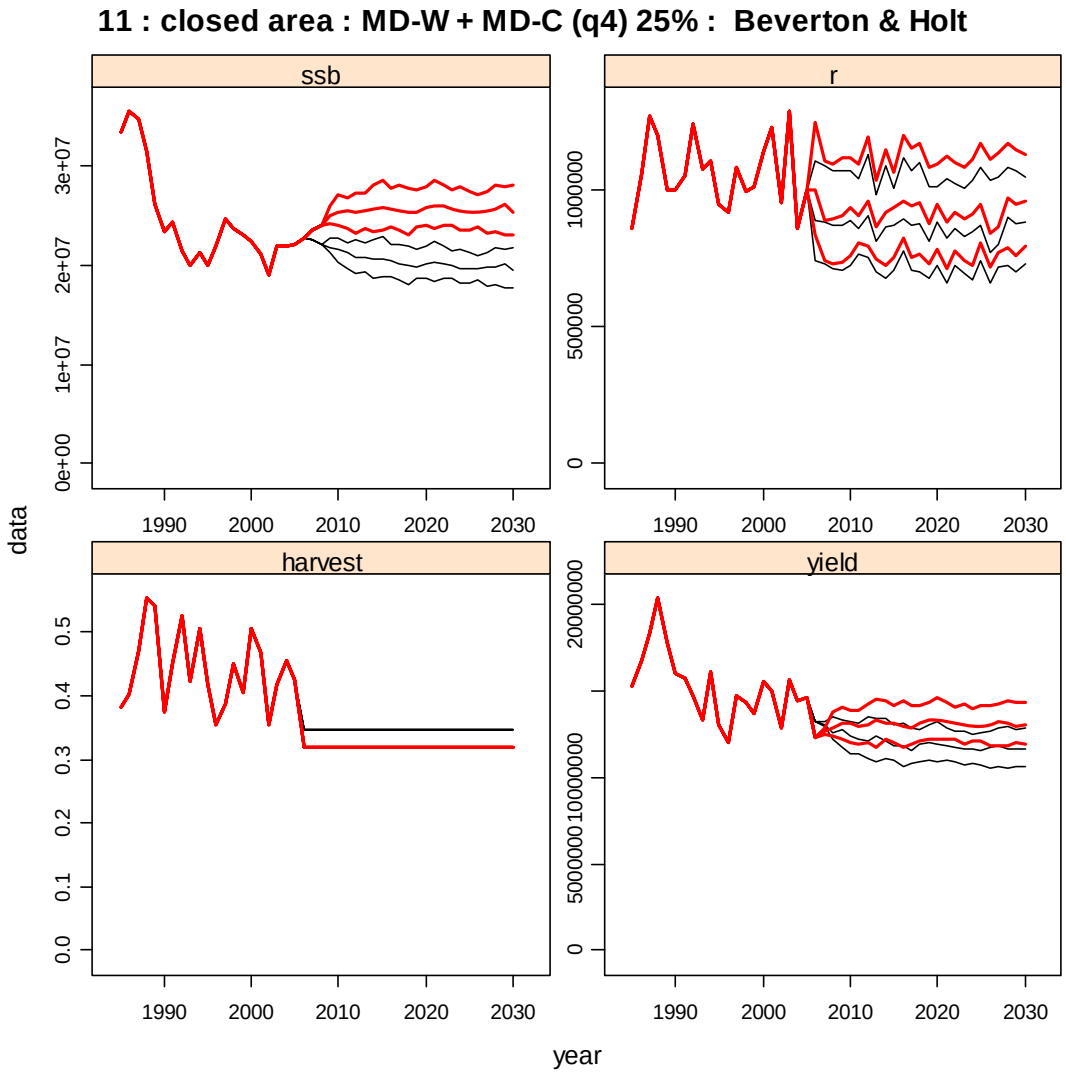


Figure 1.11. Closed area : MD-W + MD-C (q4) with 25% implementation error.

a) Beverton & Holt



b) Constant recruitment

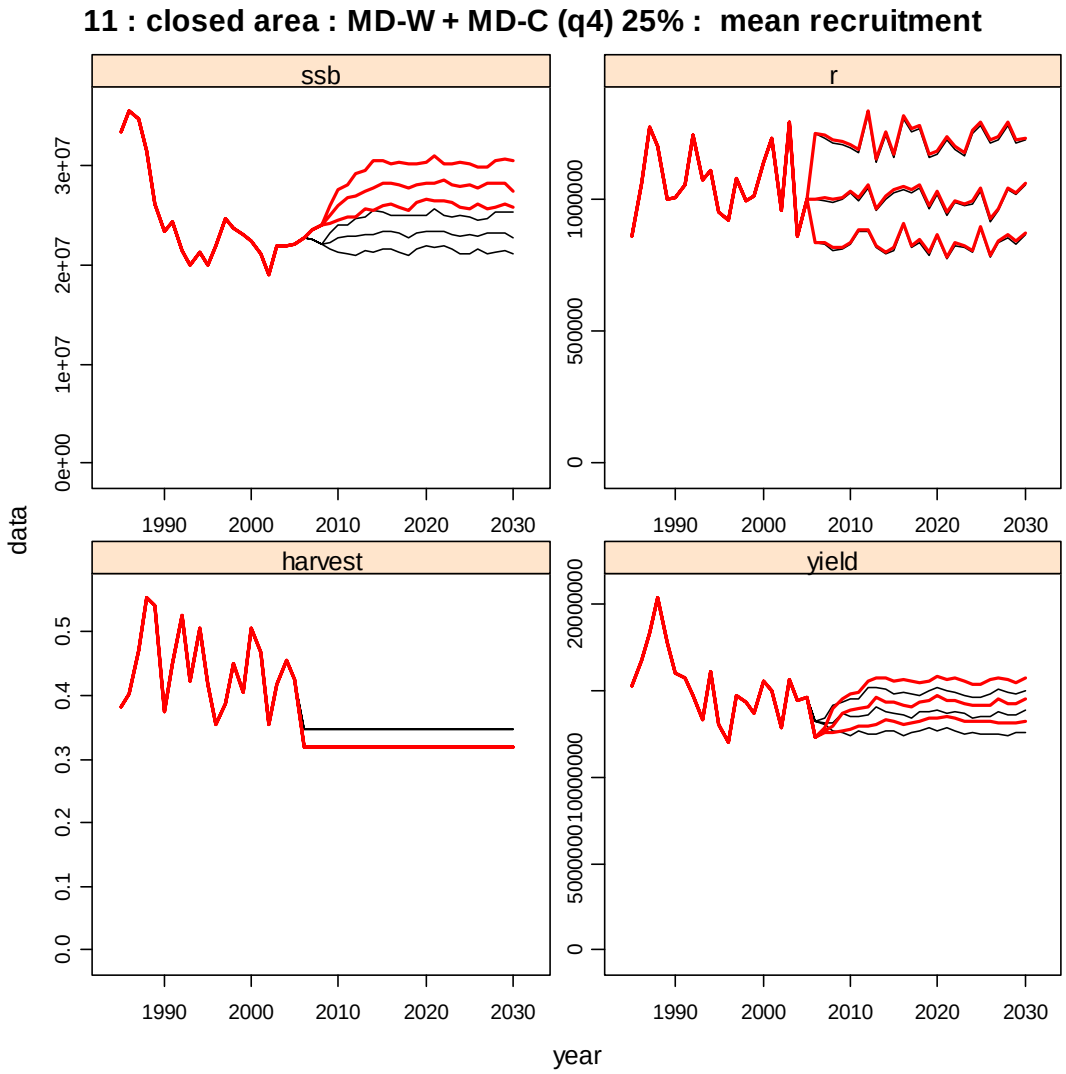
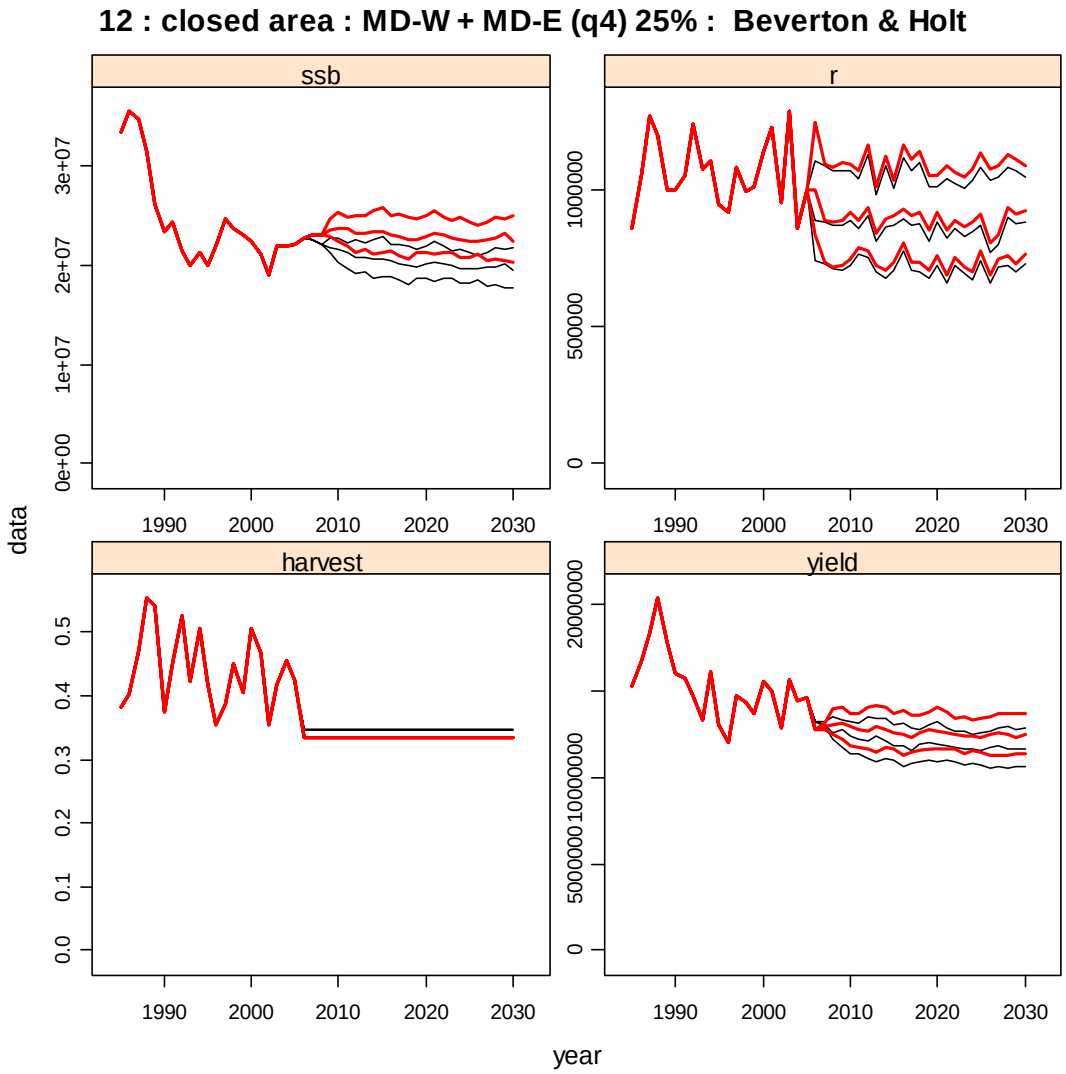


Figure 1.12. Closed area : MD-W + MD-E (q4) with 25% implementation error.

a) Beverton & Holt



b) Constant recruitment

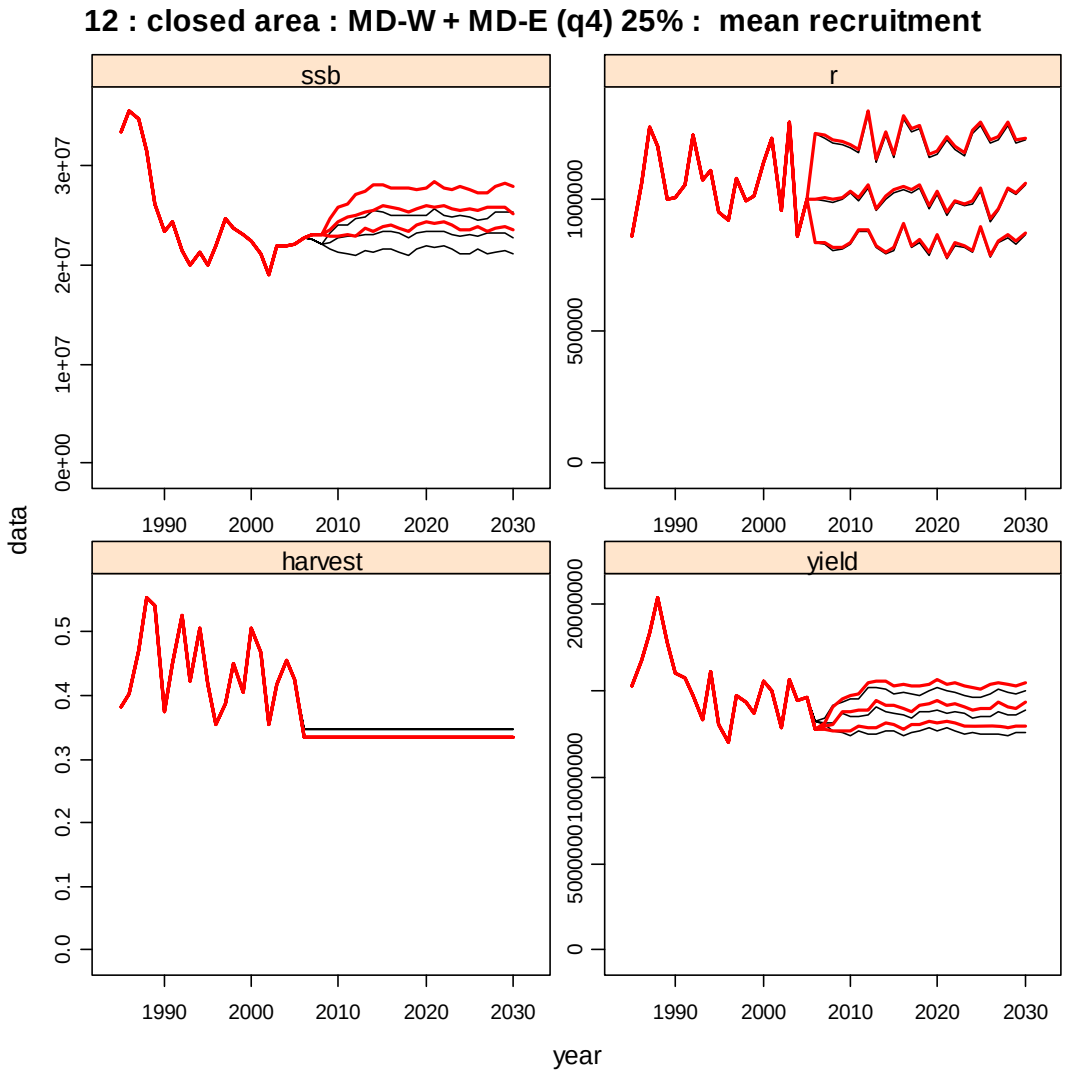
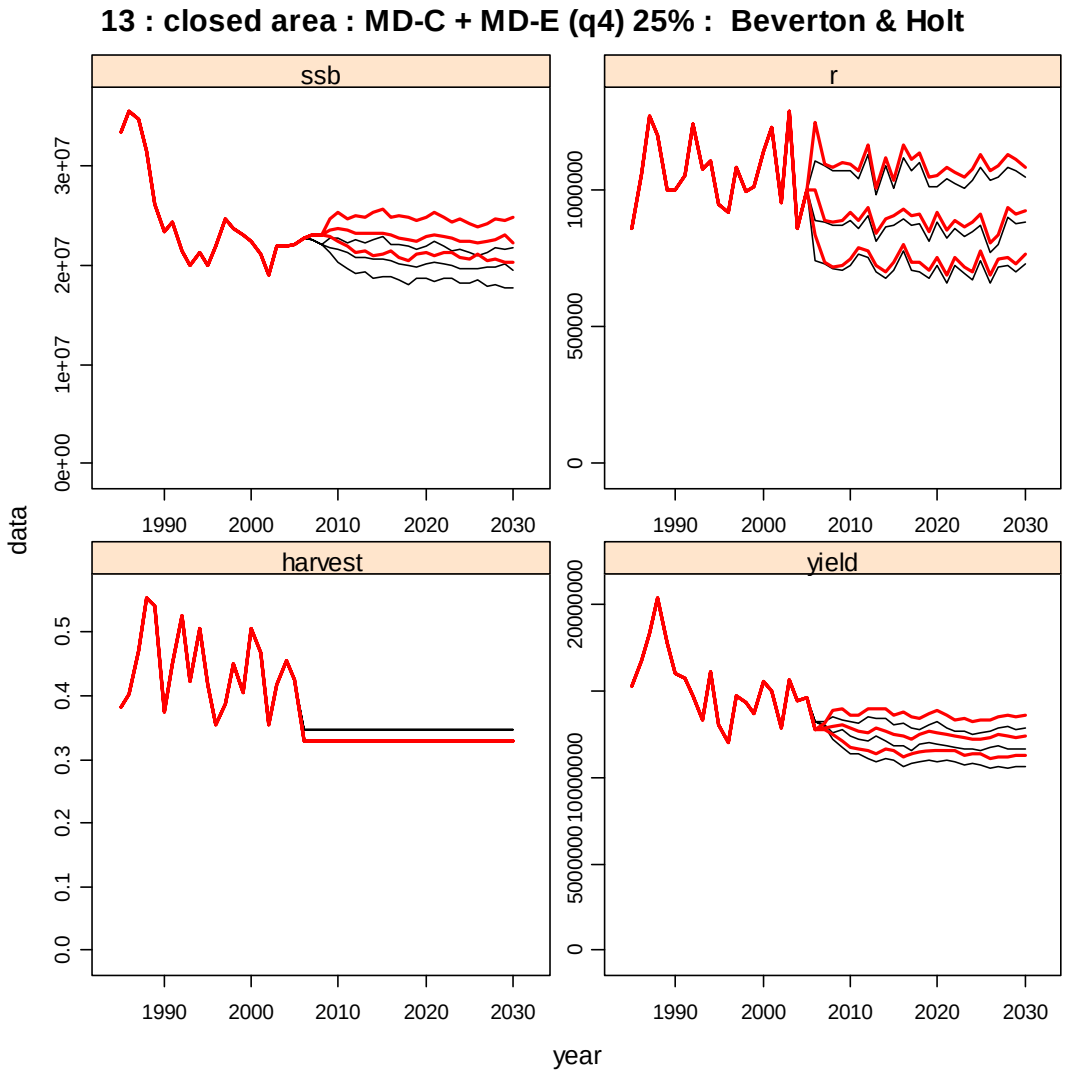


Figure 1.13. Closed area : MD-C + MD-E (q4) with 25% implementation error.

a) Beverton & Holt



b) Constant recruitment

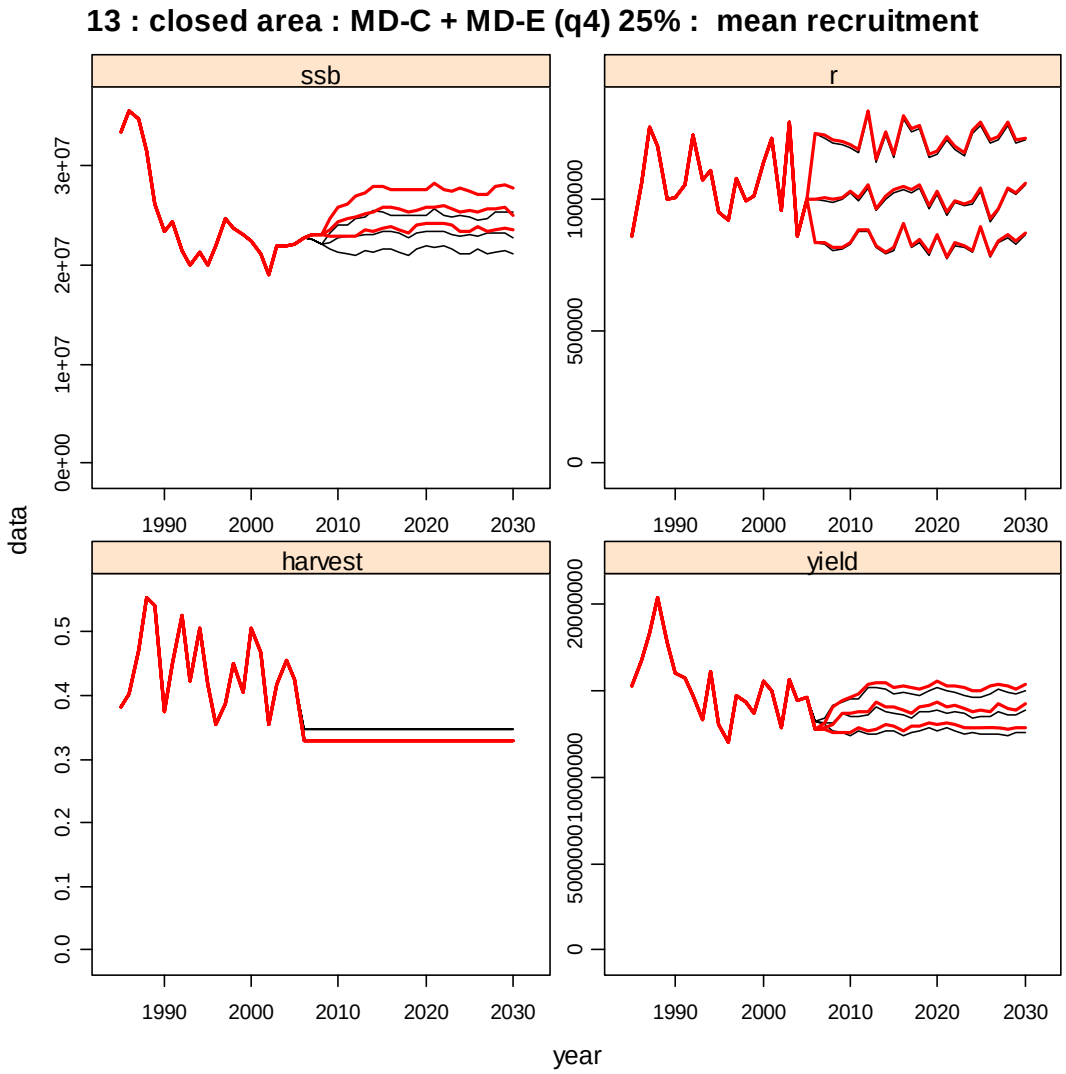
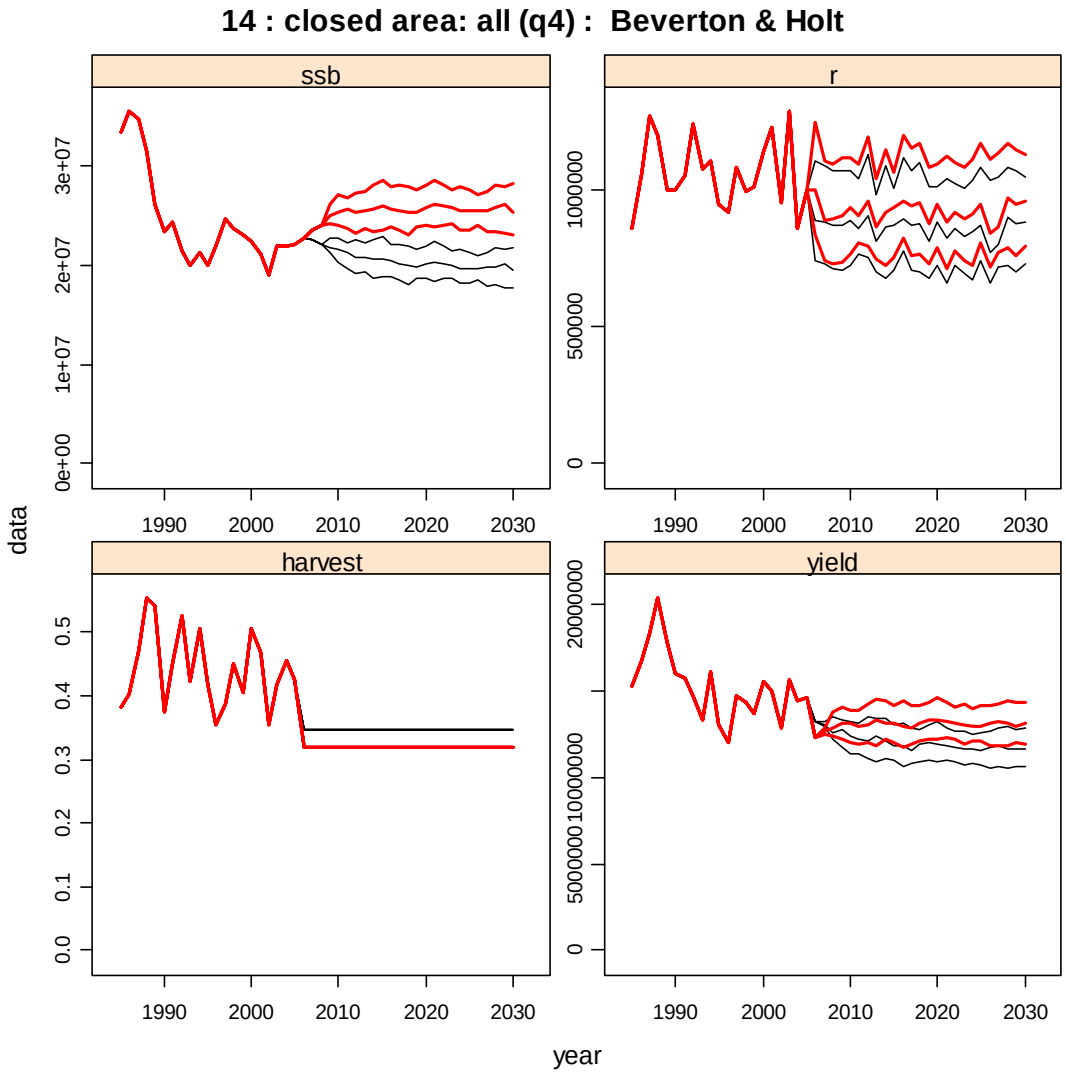


Figure 1.14. Closed area: all (q4) with 25% implementation error.

a) Beverton & Holt



b) Constant recruitment

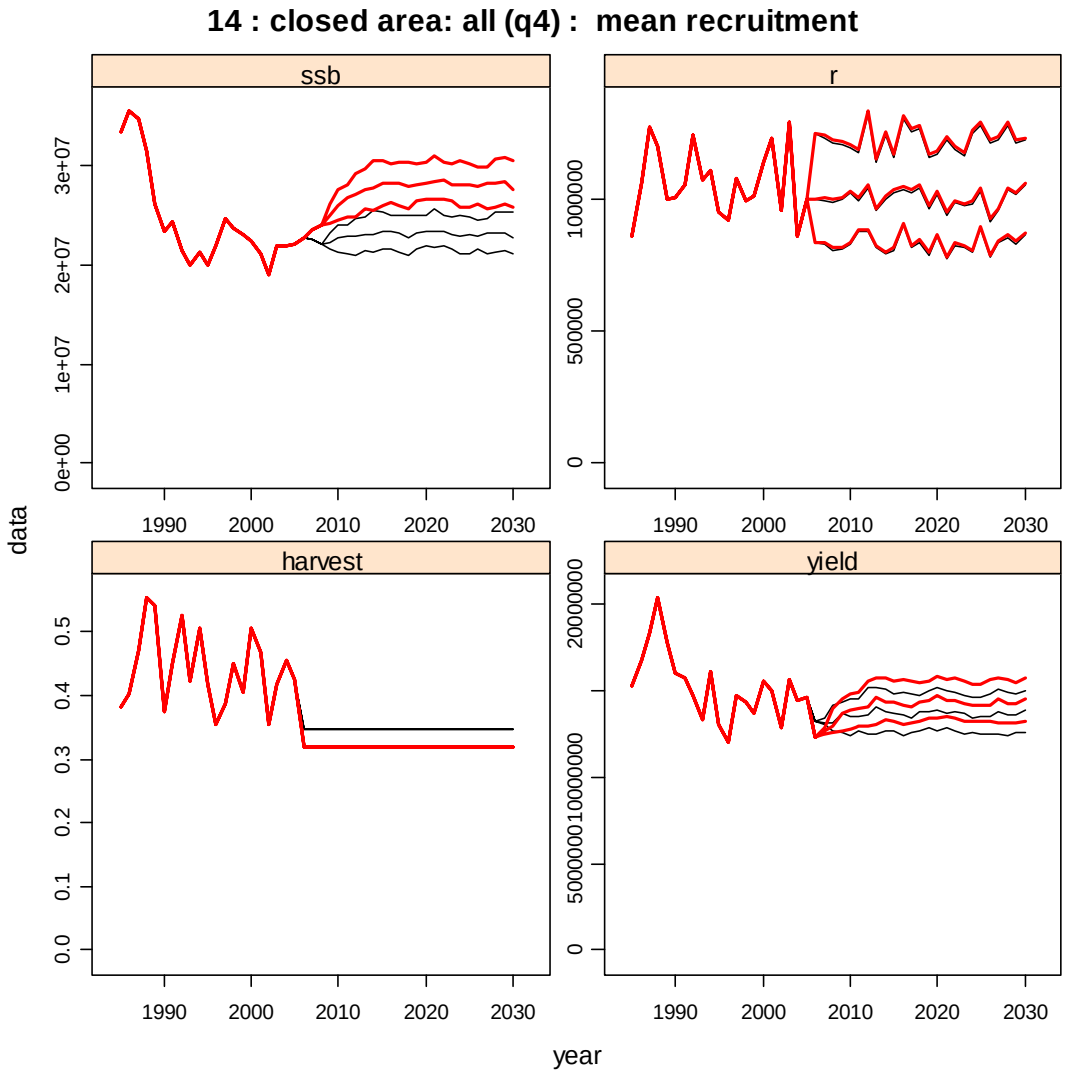
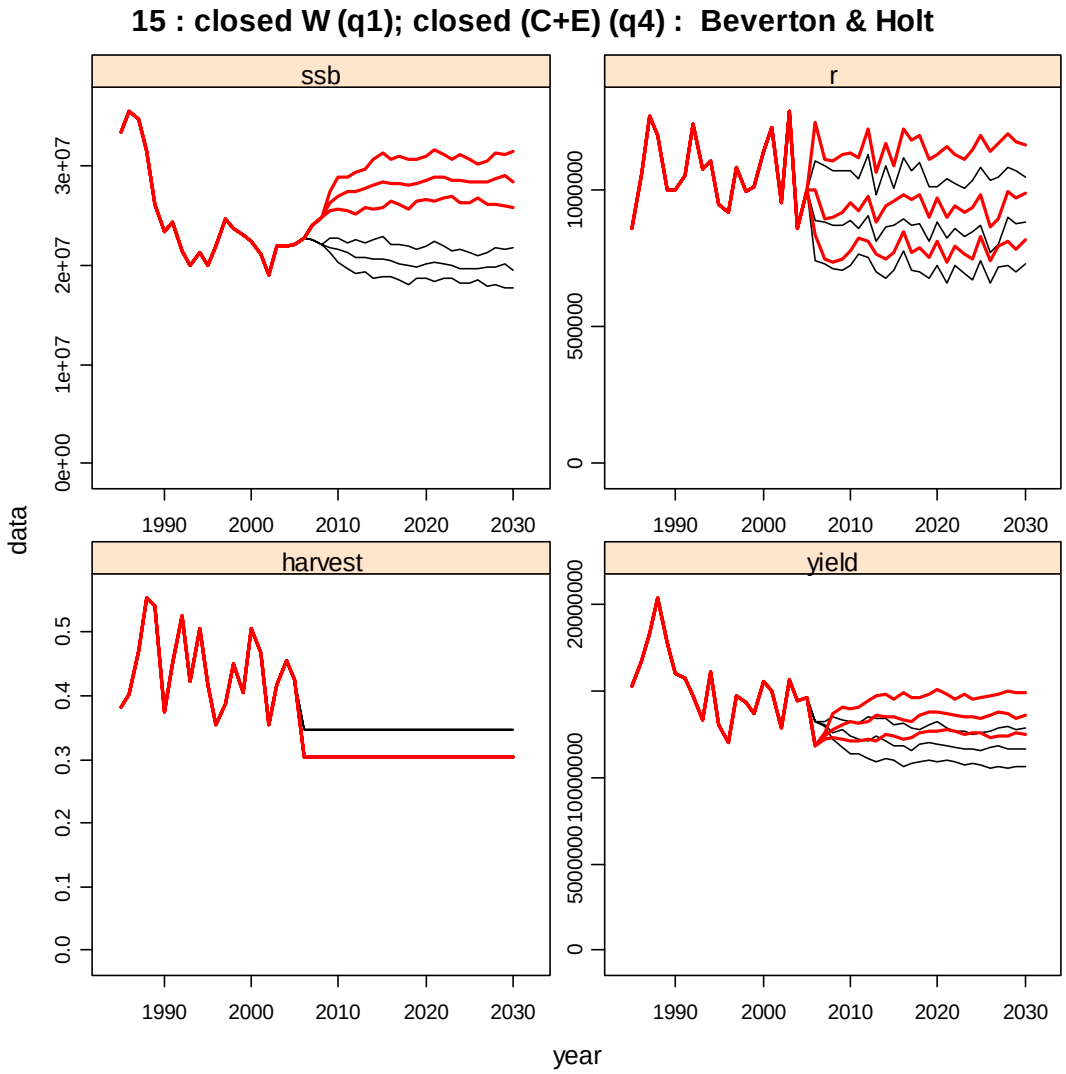


Figure 1.15. Closed MD-W (q1); closed (MD-C+E) (q4).

a) Beverton & Holt



b) Constant recruitment

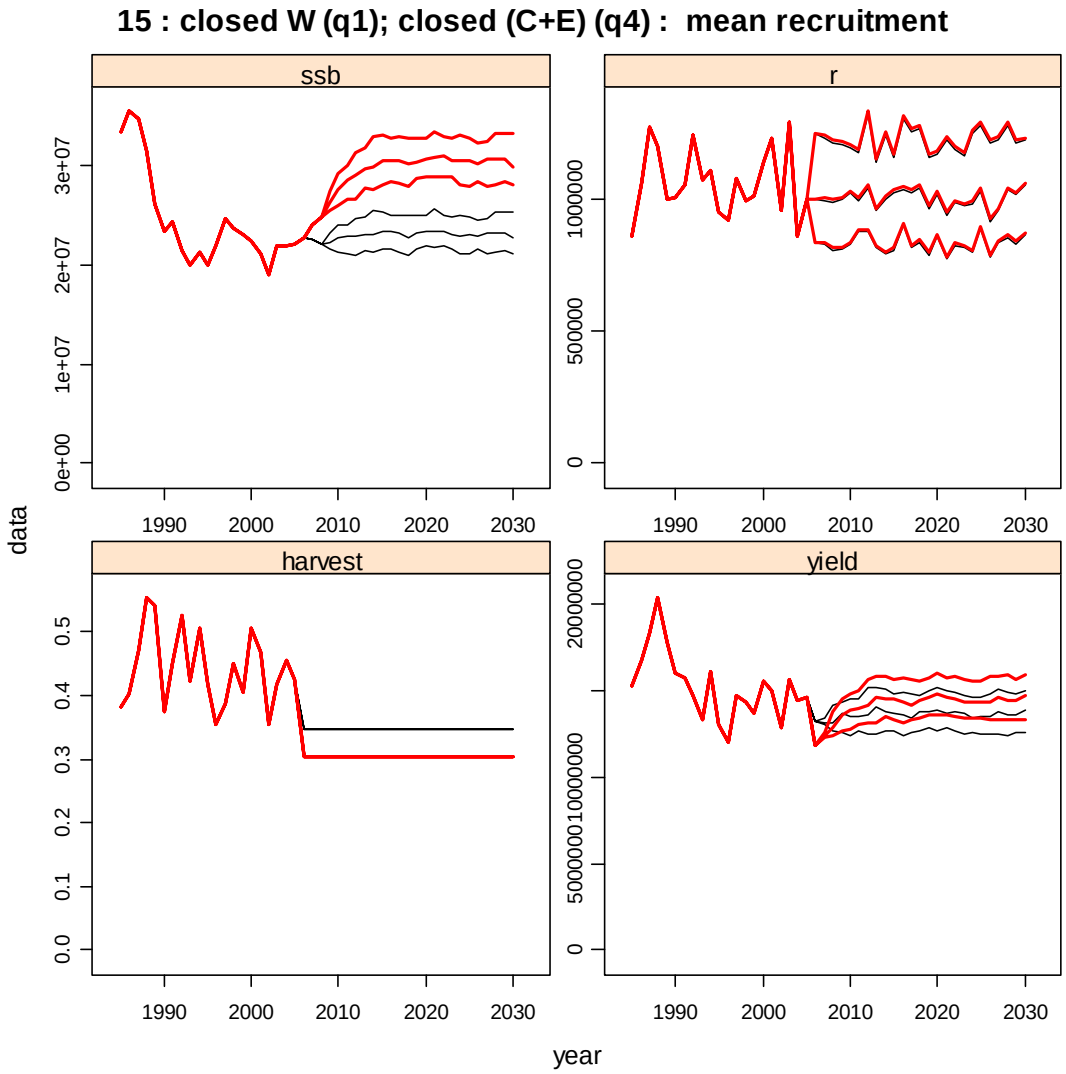
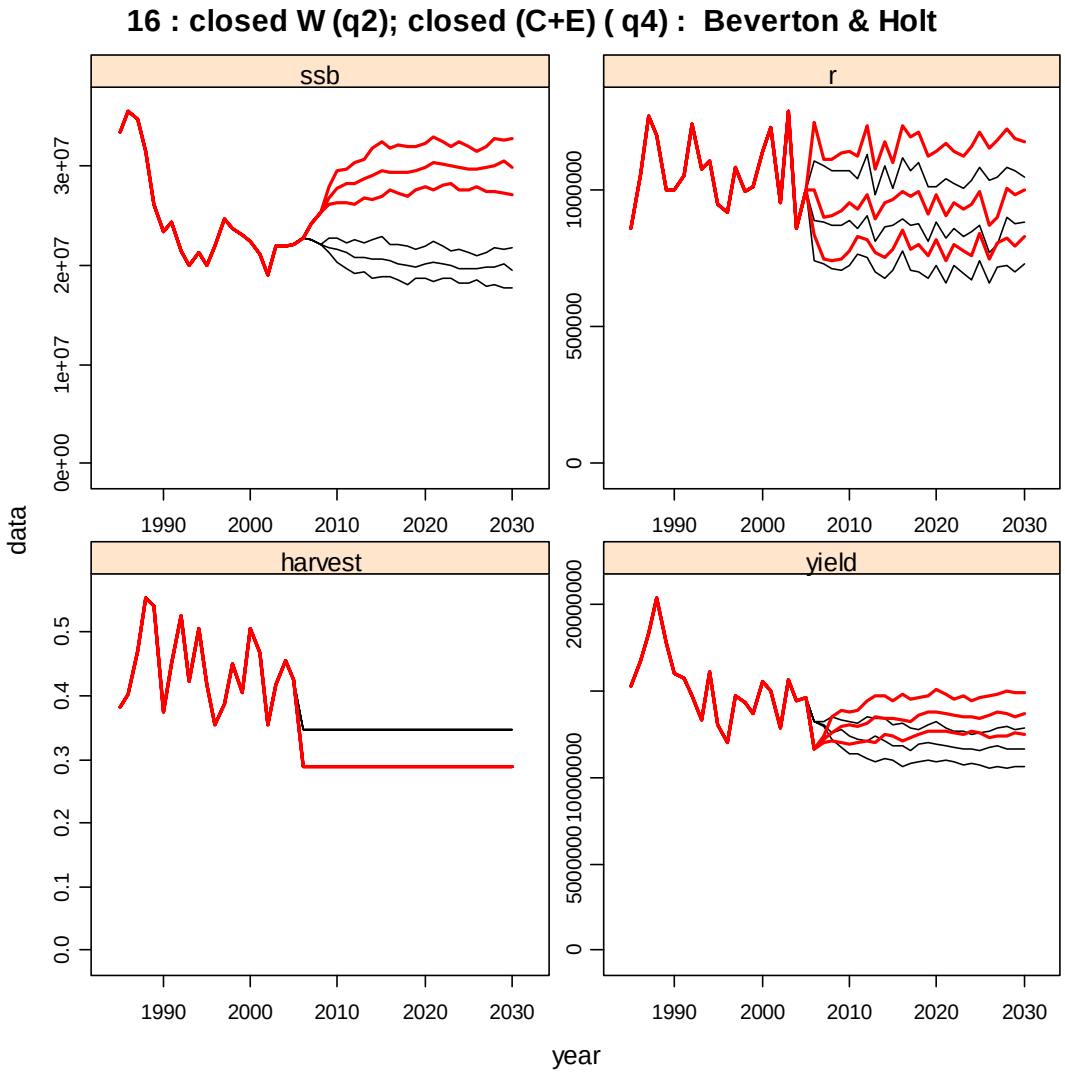


Figure 1.16. Closed MD-W (q2); closed (MD-C+E) (q4).

a) Beverton & Holt



b)

Constant recruitment

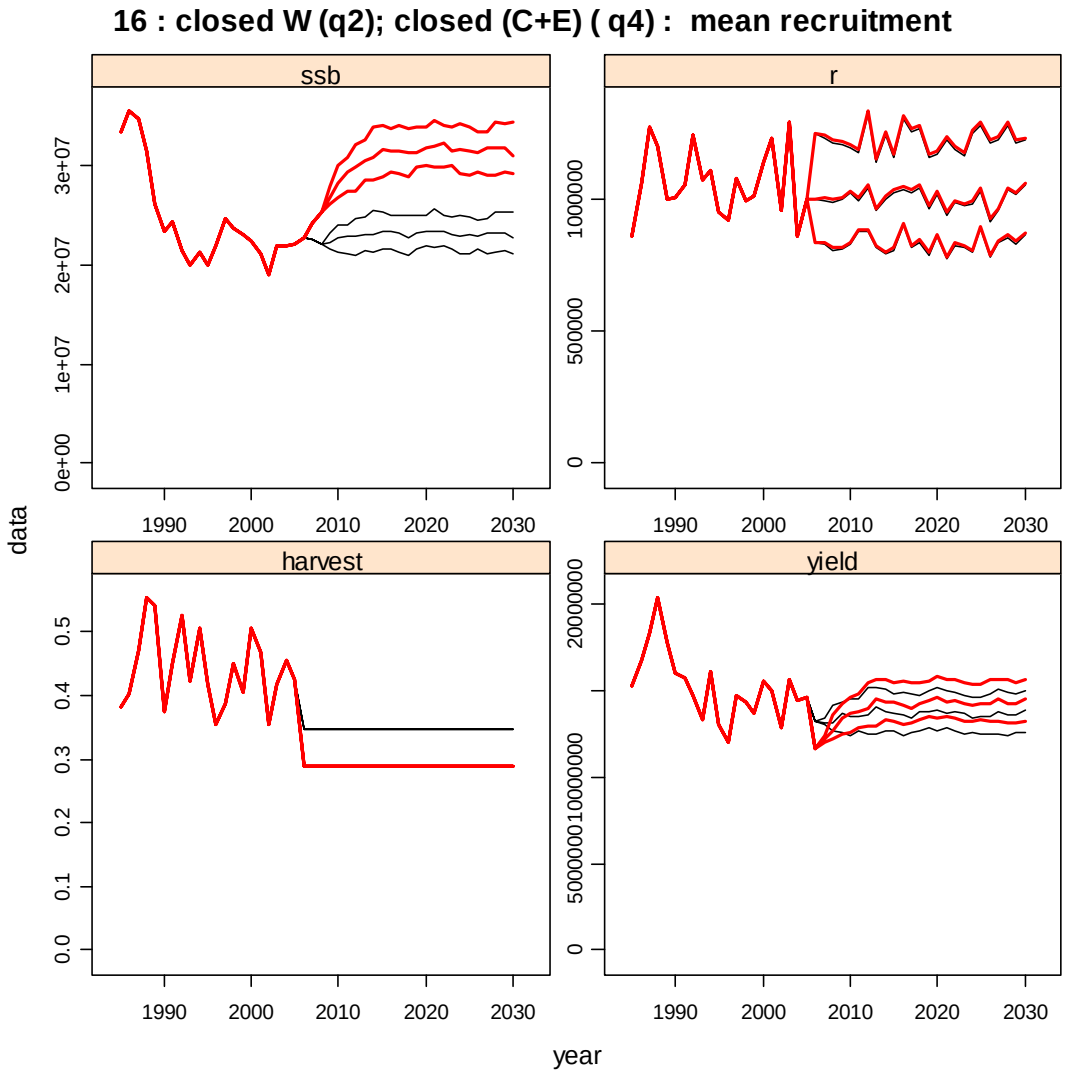
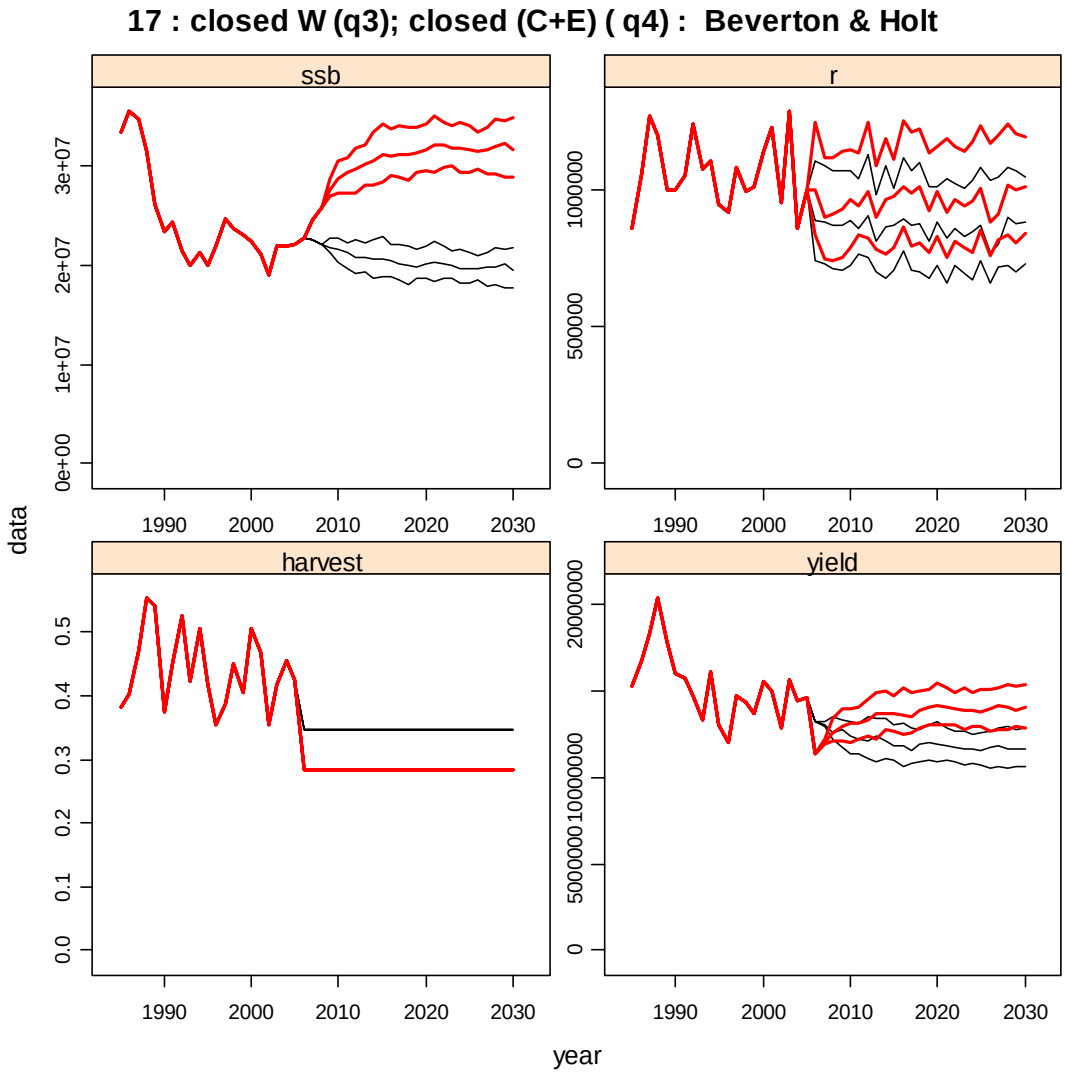


Figure 1.17. Closed MD-W (q3); closed (MD-C+E) (q4).

a) Beverton & Holt



b) Constant recruitment

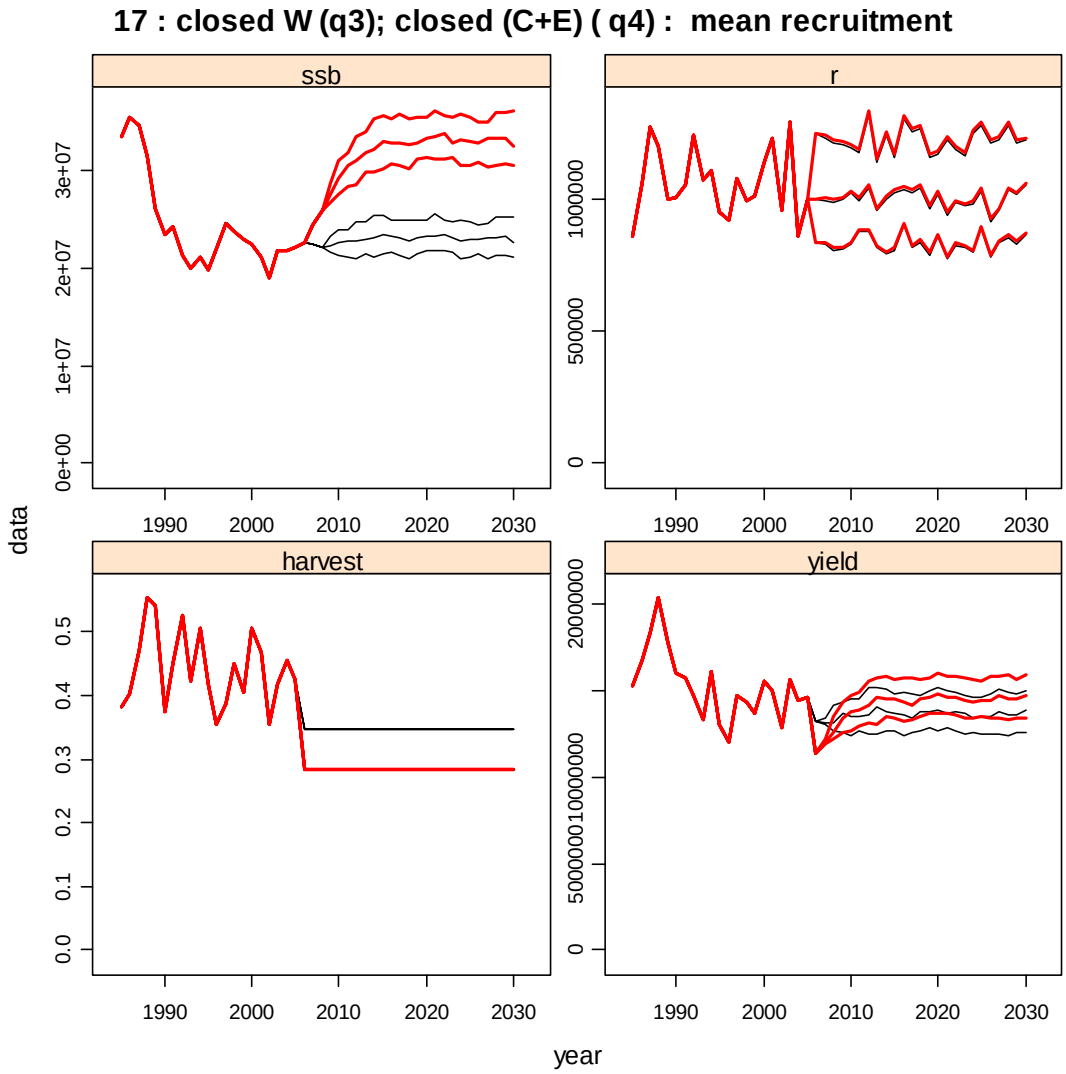
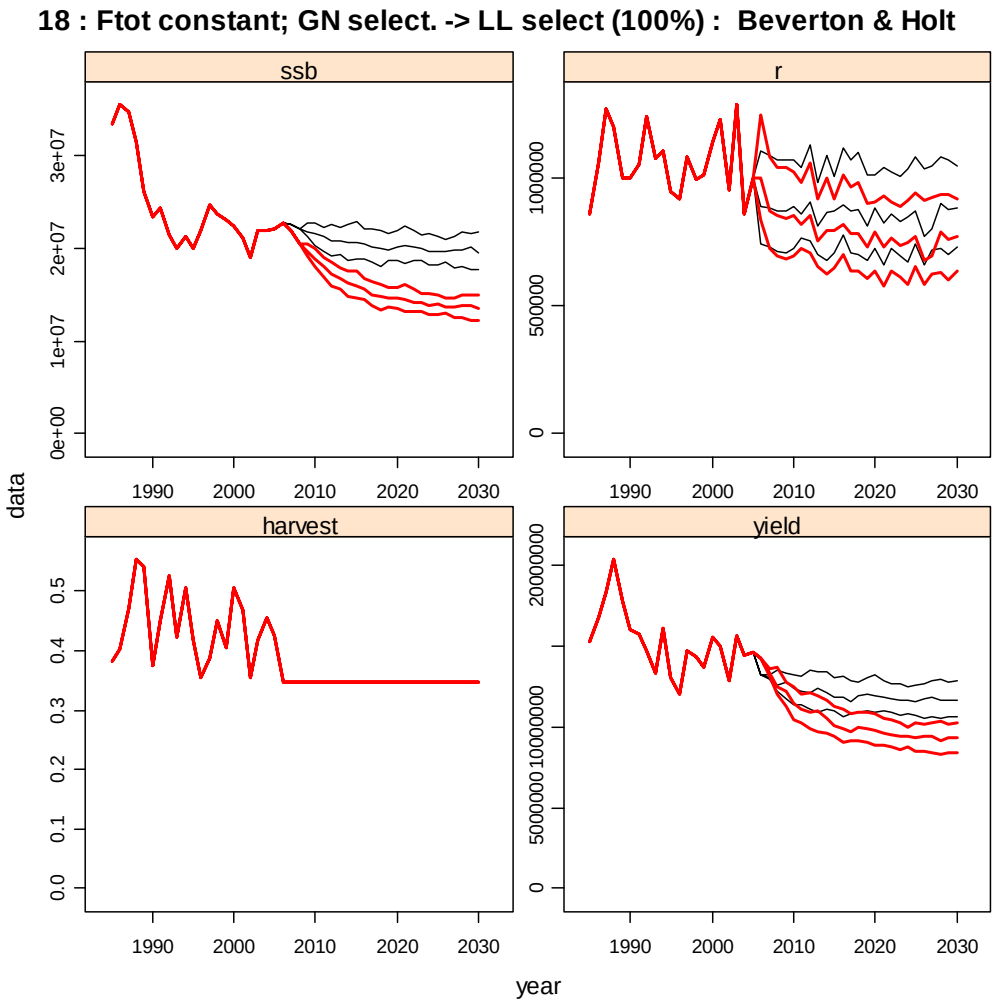


Figure 1.18. GN selectivity transitioned to LL selectivity (1 00%) to examine implications of changover to LL.

a) Beverton & Holt



b) Constant recruitment

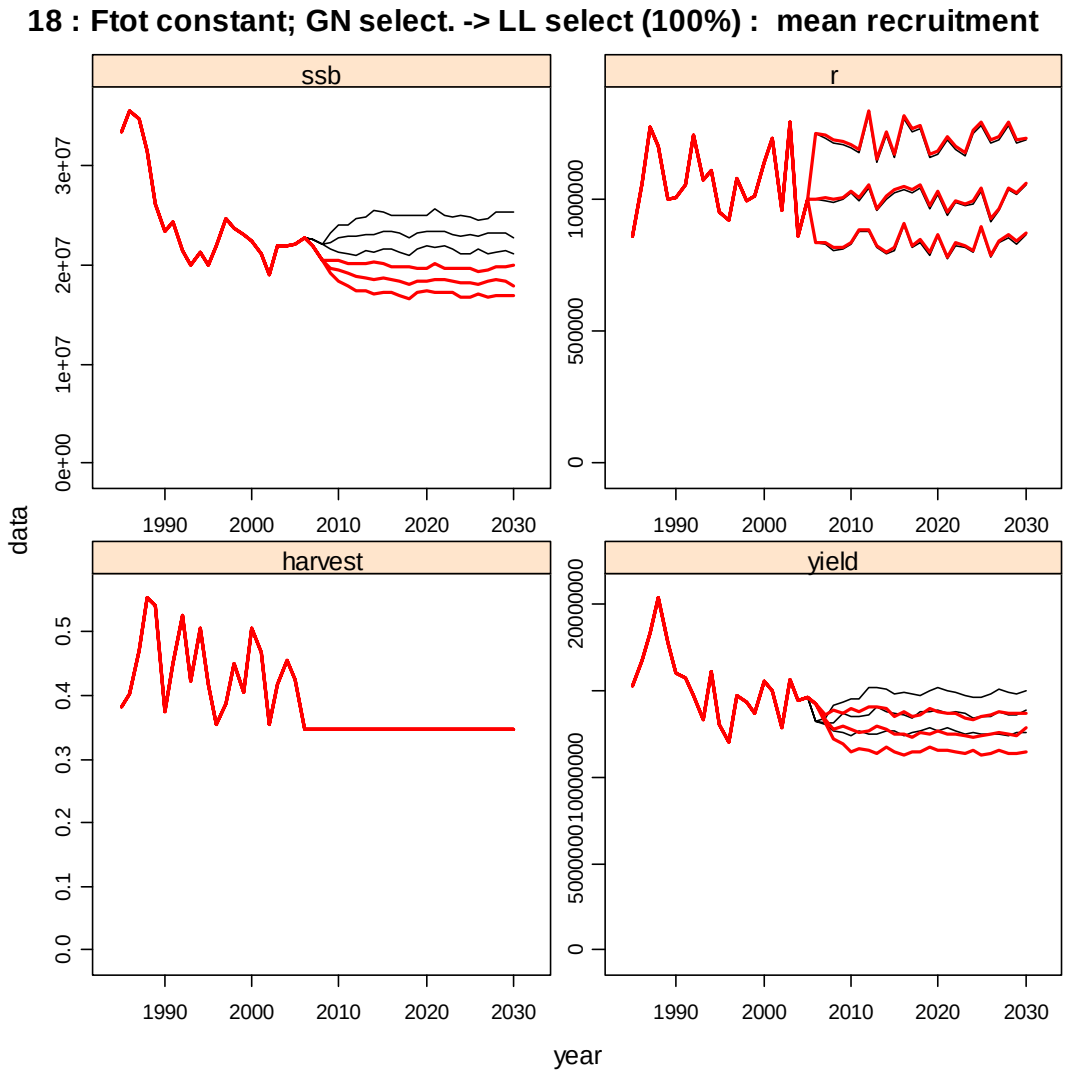
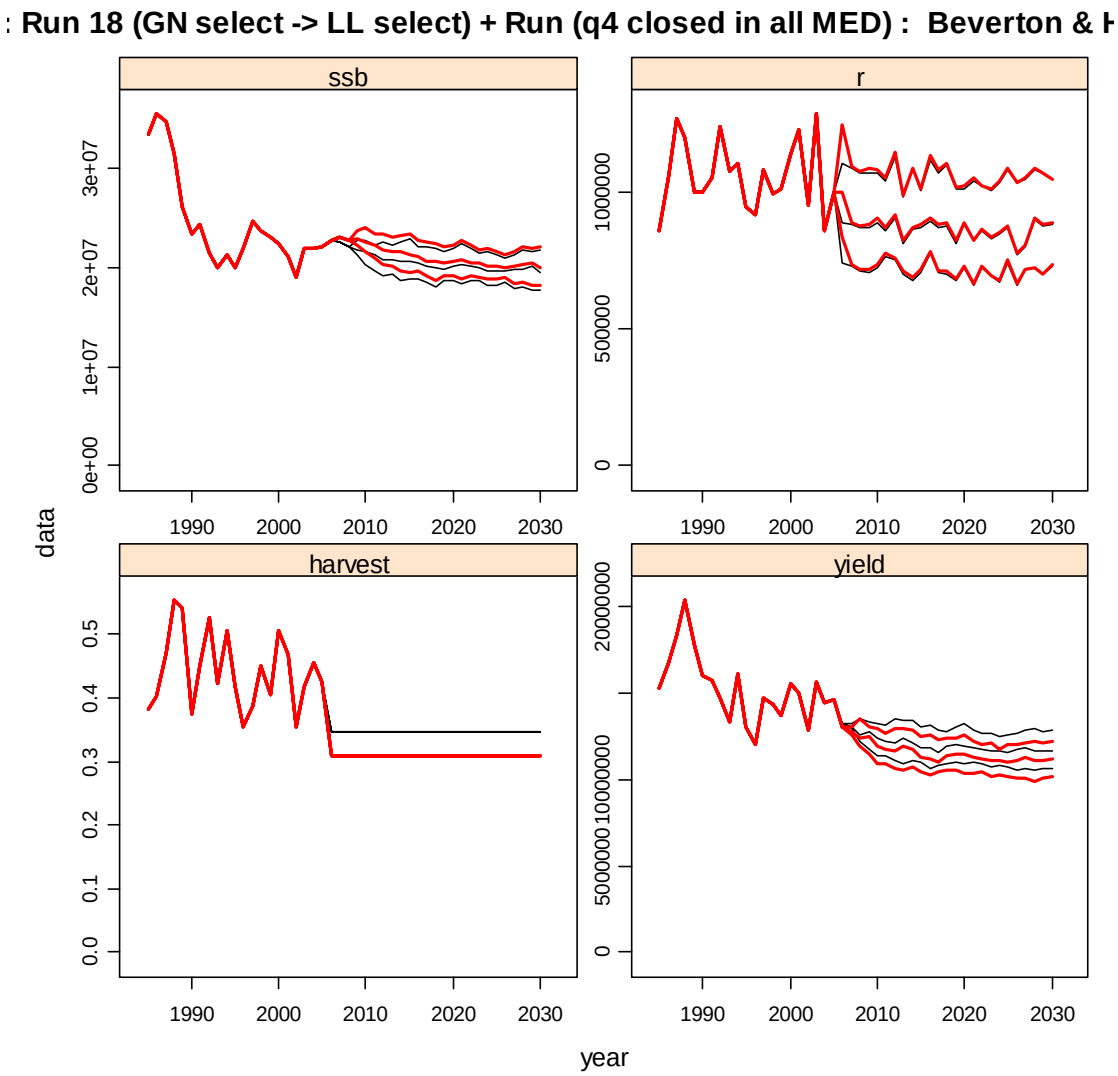


Figure 1.19. Run 18 (GN select -> LL select) + (q4 closed in all MED).

a) Beverton & Holt



b) Constant recruitment

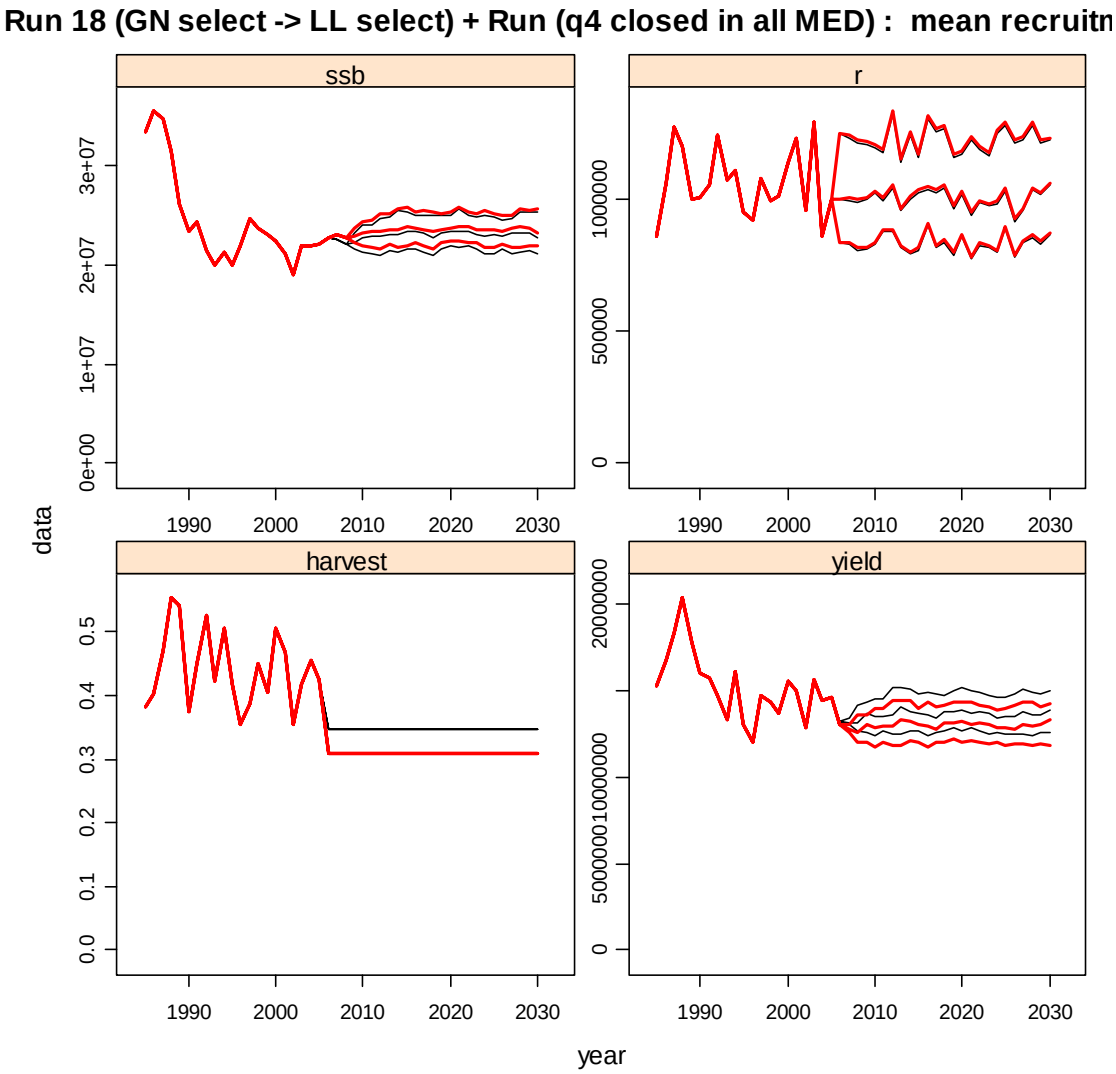
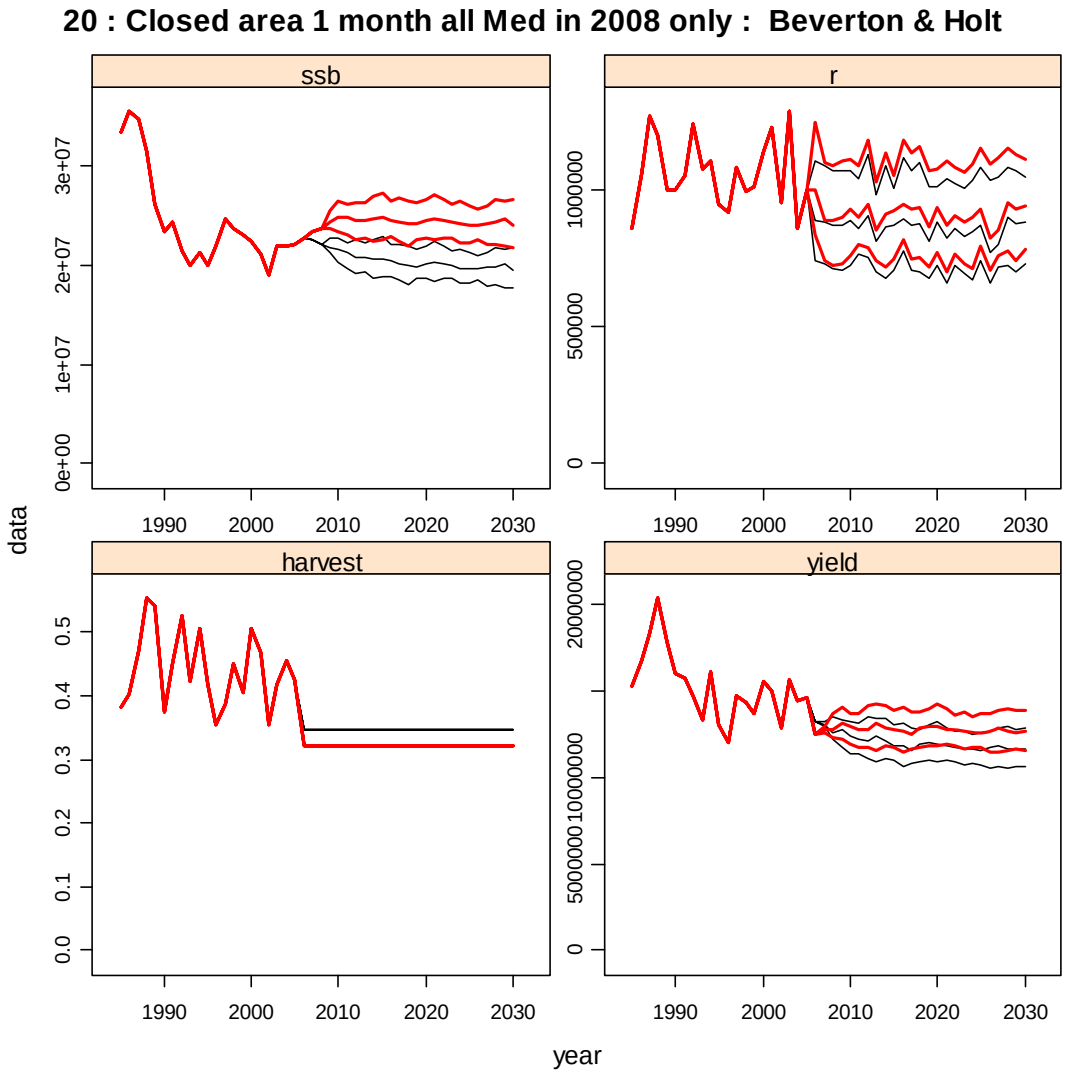


Figure 1.20. Closed area 1 month all Med in 2008 only.

a) Beverton & Holt



b) Constant recruitment

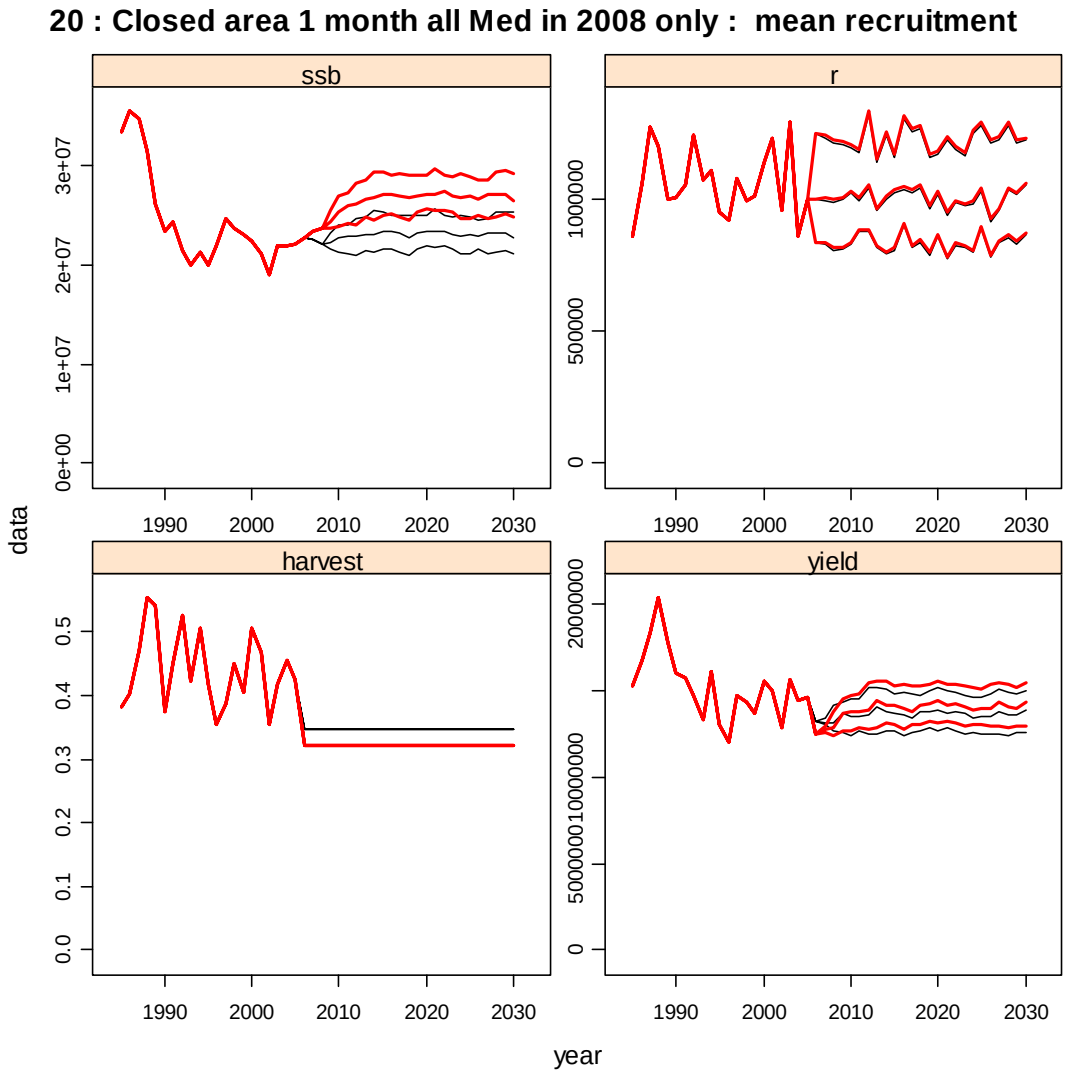
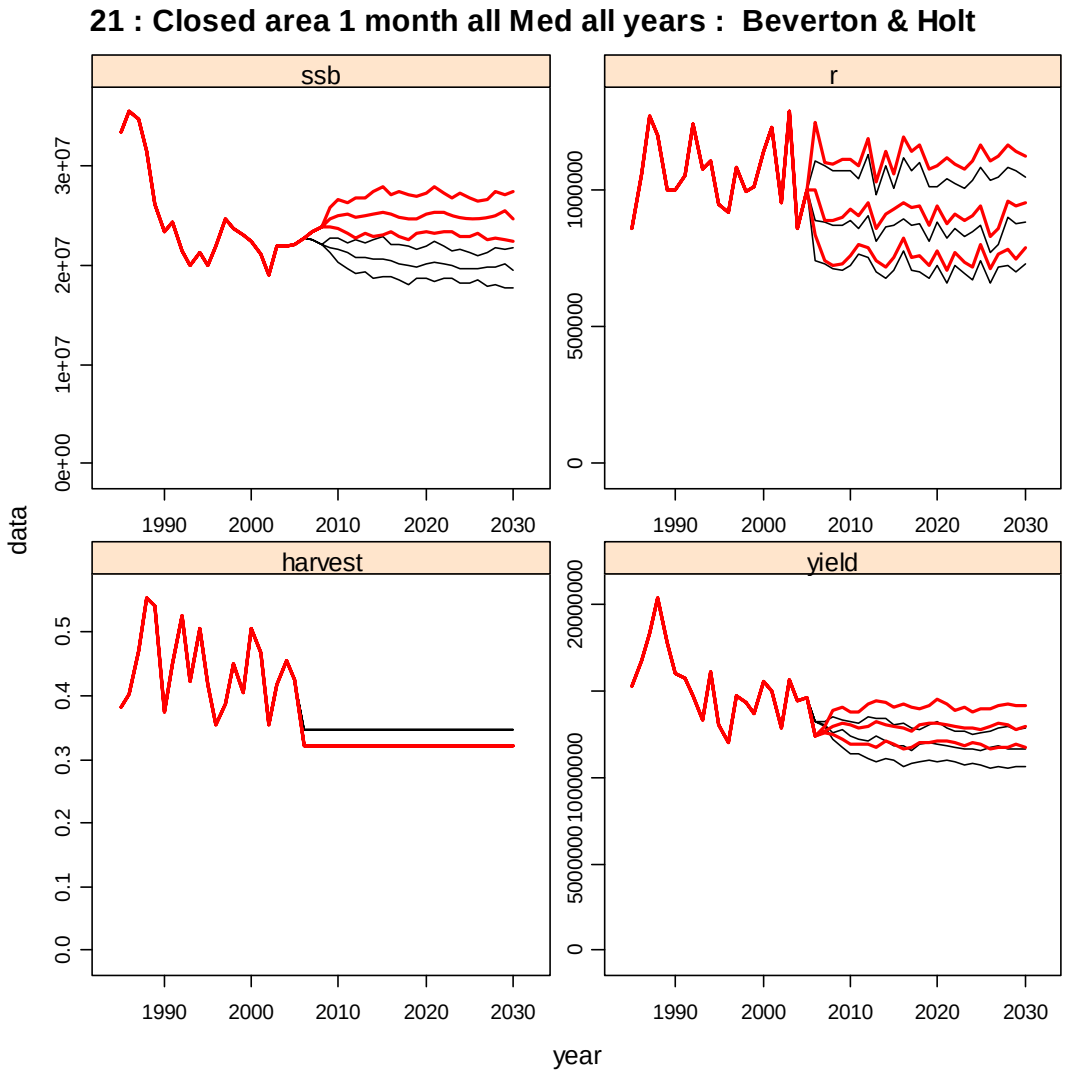


Figure 1.21. Closed area 1 month all Med all years.

a) Beverton & Holt



b) Constant recruitment

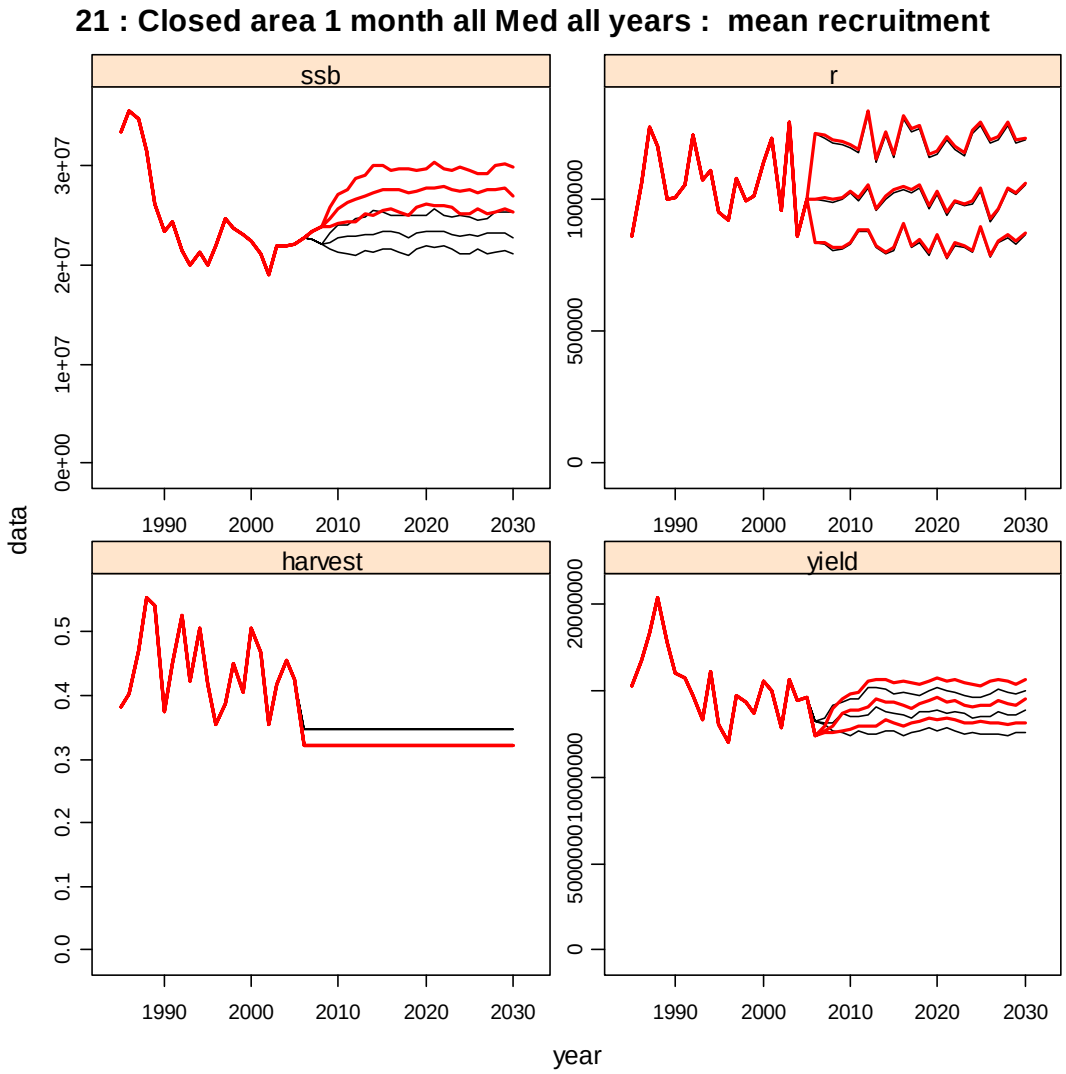
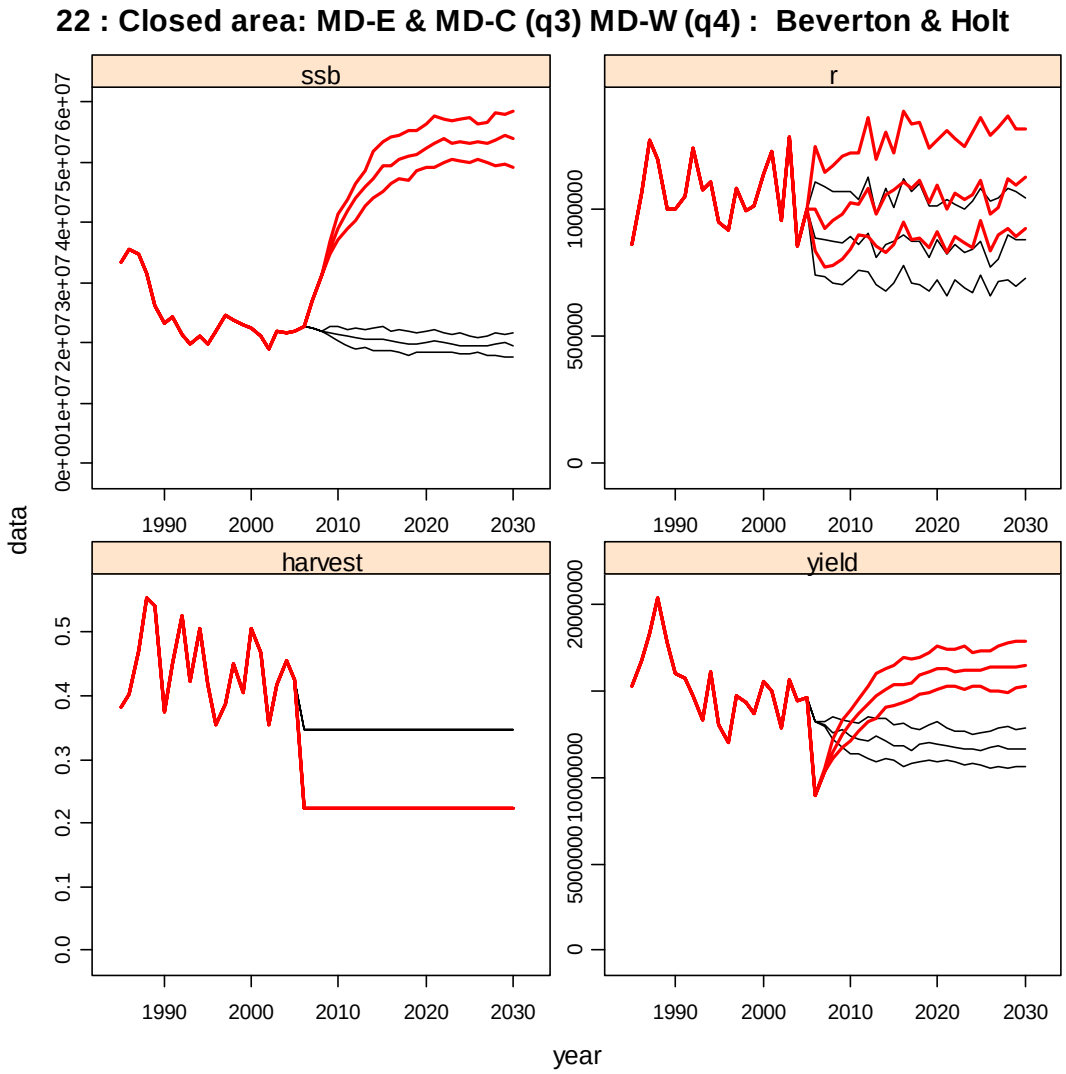


Figure 1.22. Closed area: MD-E & MD-C (q3) MD-W (q4).

a) Beverton & Holt



b) Constant recruitment

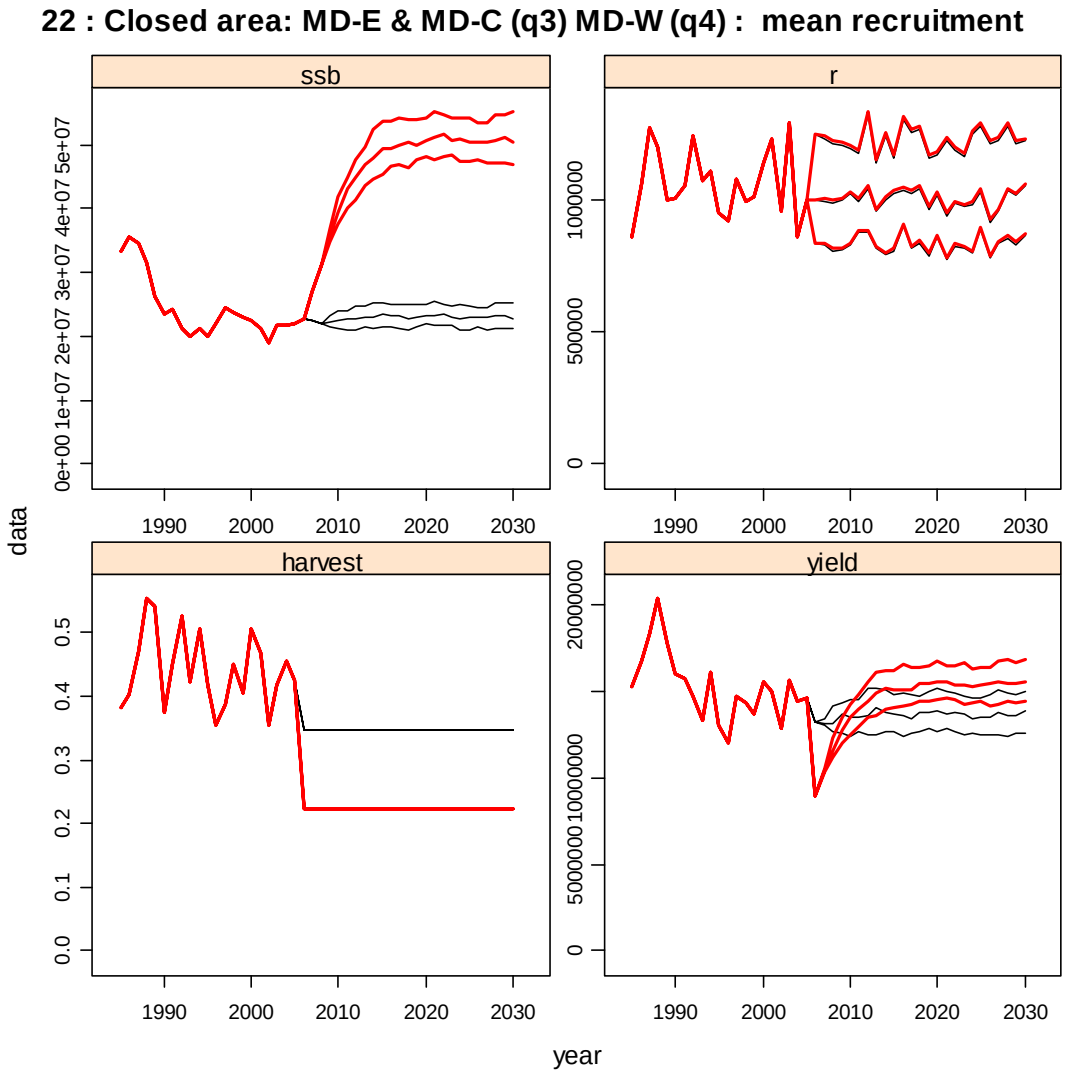
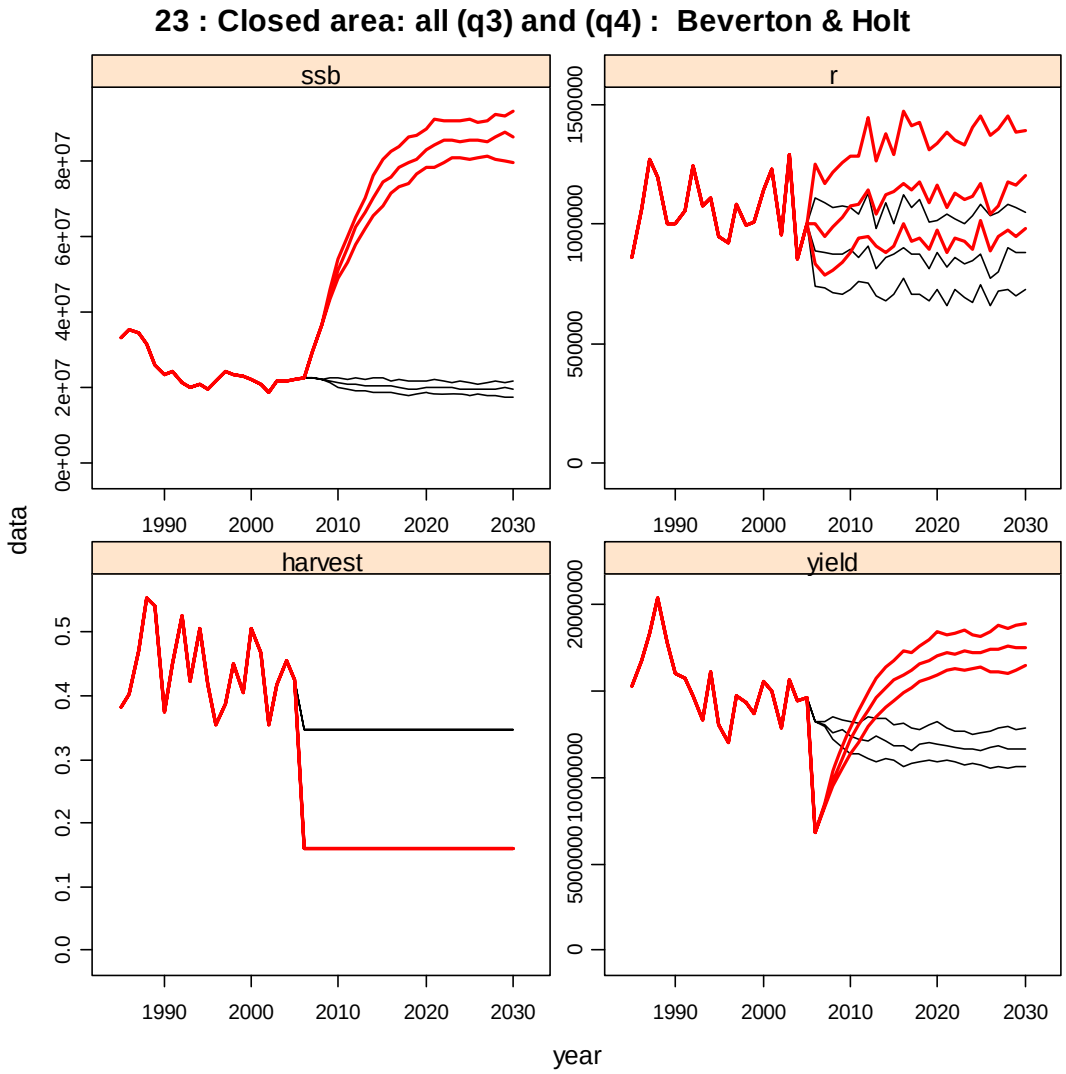


Figure 1.23. Closed area: All quarters 3 and 4.

a) Beverton & Holt



b) Constant recruitment

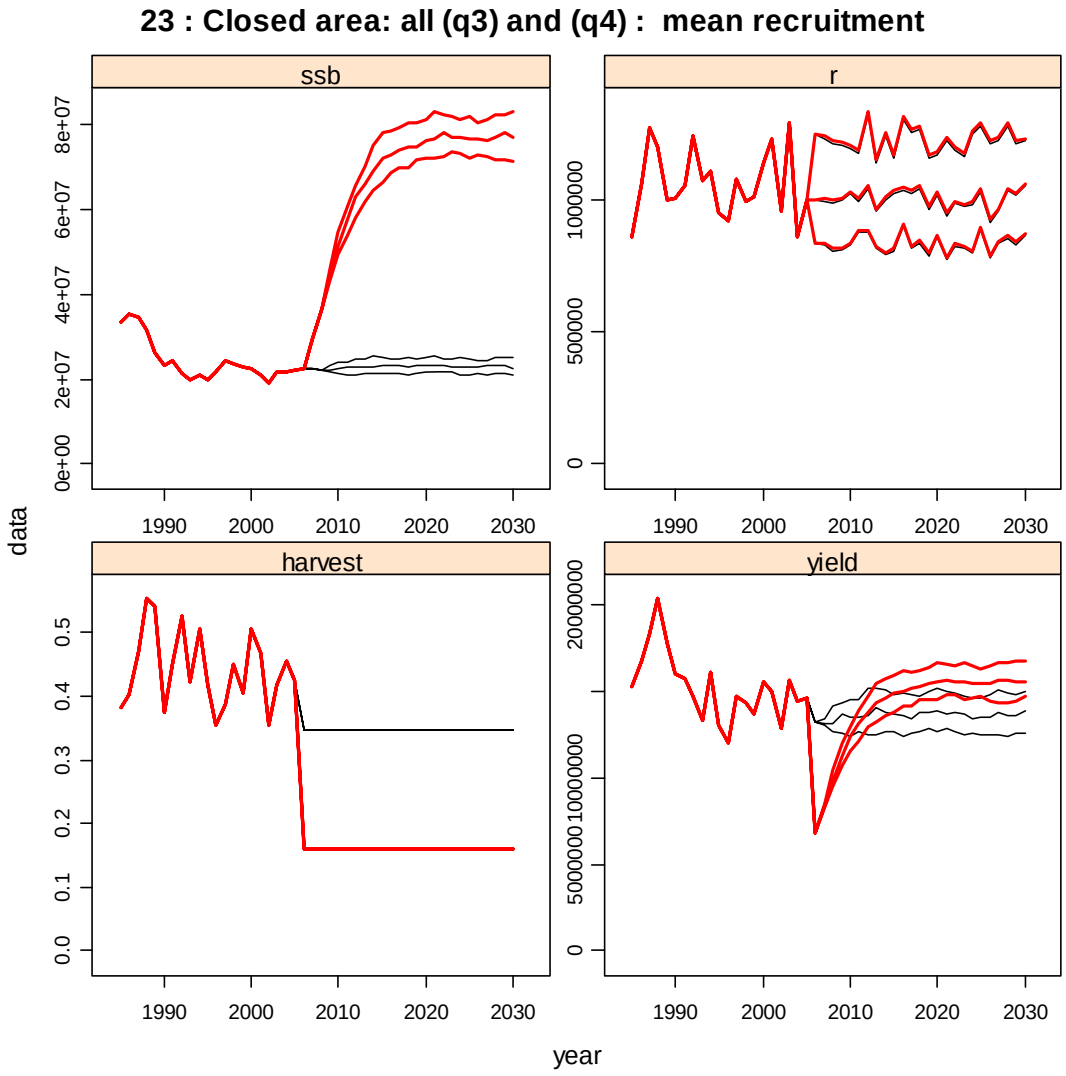
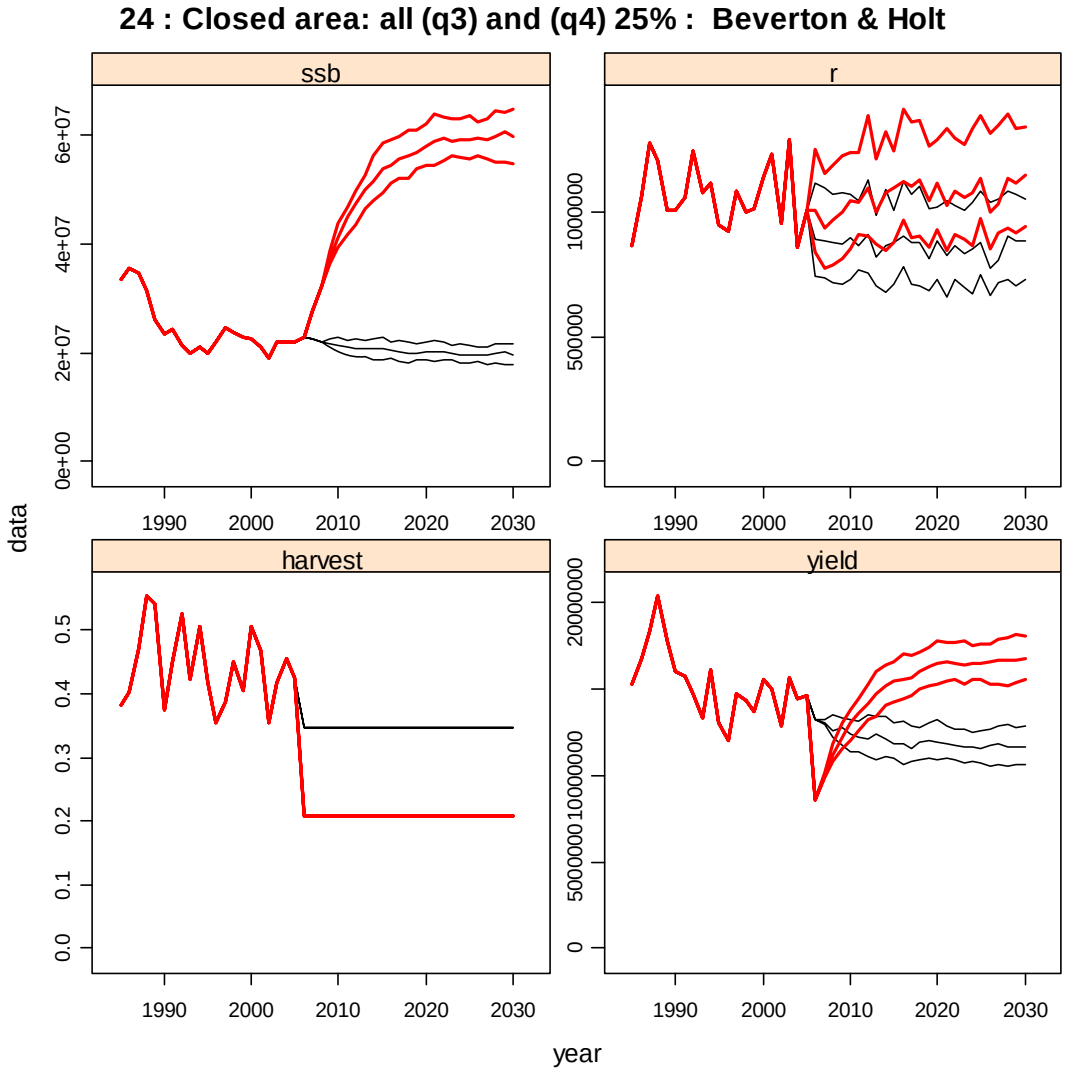
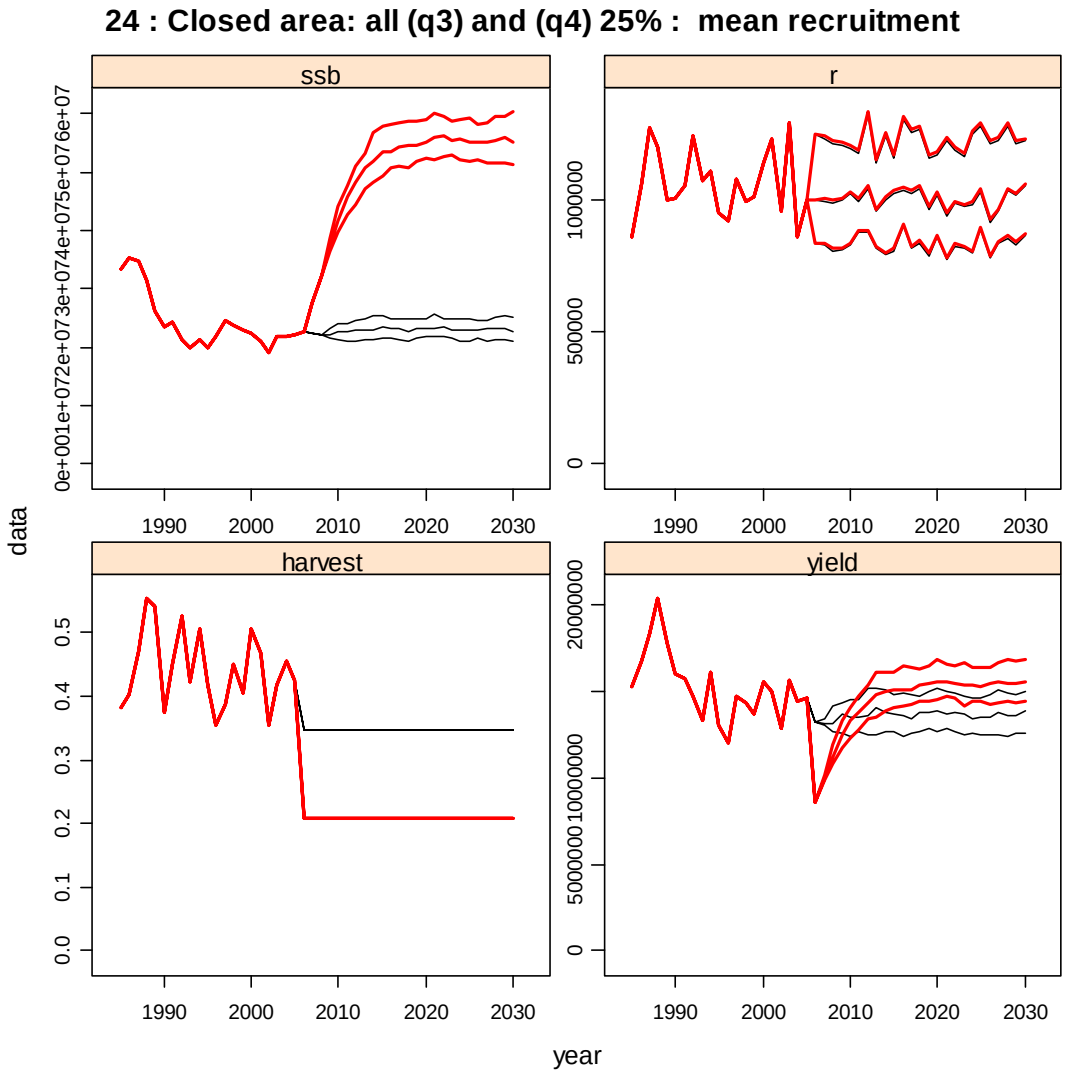


Figure 1.24. As run 23 with 25% implementation error.

a) Beverton & Holt



b) Constant recruitment



Cobra plots showing:

i) Constant F that would rebuild the stock to B_{MSY} in 2030, assuming a Beverton and Holt stock recruitment relationship (blue dashed line)

ii) Constant F that would rebuild the stock to B_{MSY} in 2030, assuming constant recruitment (red dashed line)

iii) Constant catch that would rebuild the stock to B_{MSY} in 2030, assuming a Beverton and Holt stock recruitment relationship (blue solid line)

iv) Constant catch that would rebuild the stock to B_{MSY} in 2030, assuming constant recruitment (red solid line)

v) Scenario assuming a Beverton and Holt stock recruitment relationship (blue dots)

vi) Scenario assuming constant recruitment (triangles)

Figure 2.1. Closed area : MD-W (q4).

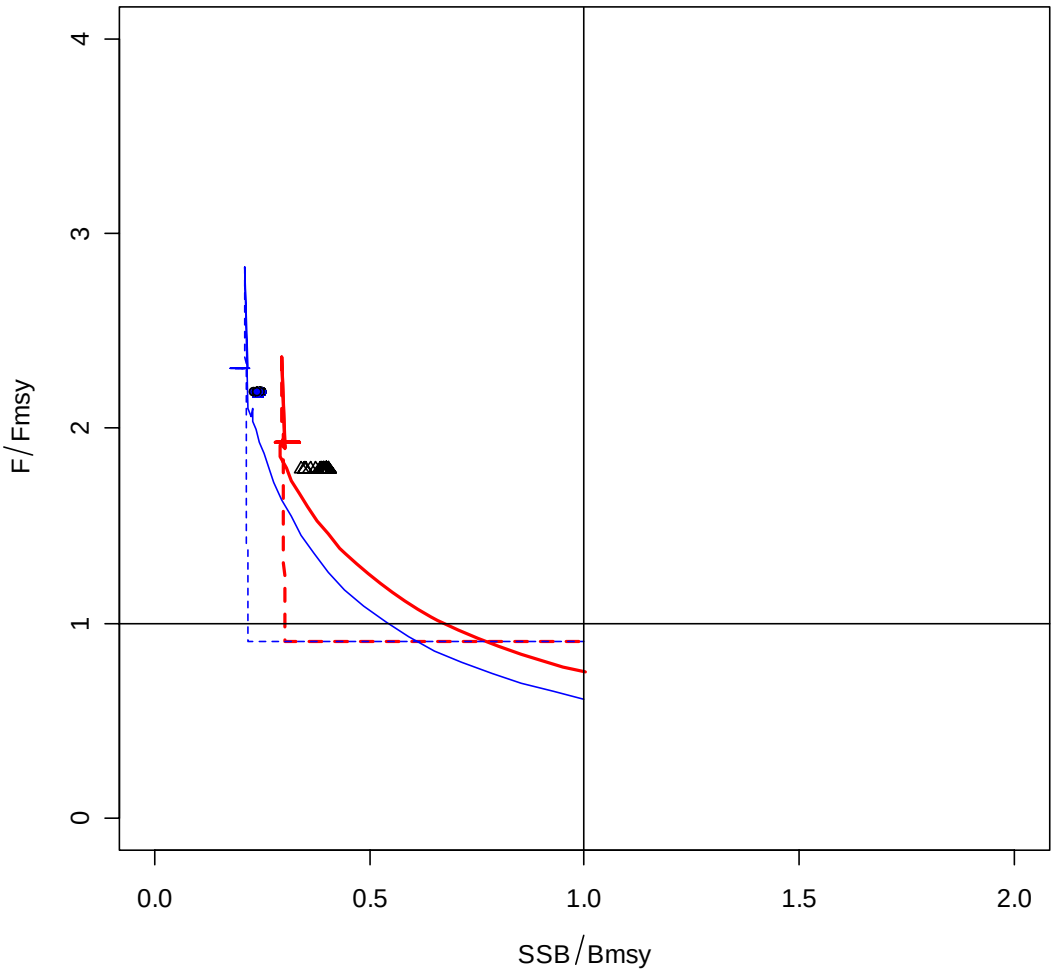


Figure 2.2. Closed area : MD-C (q4).

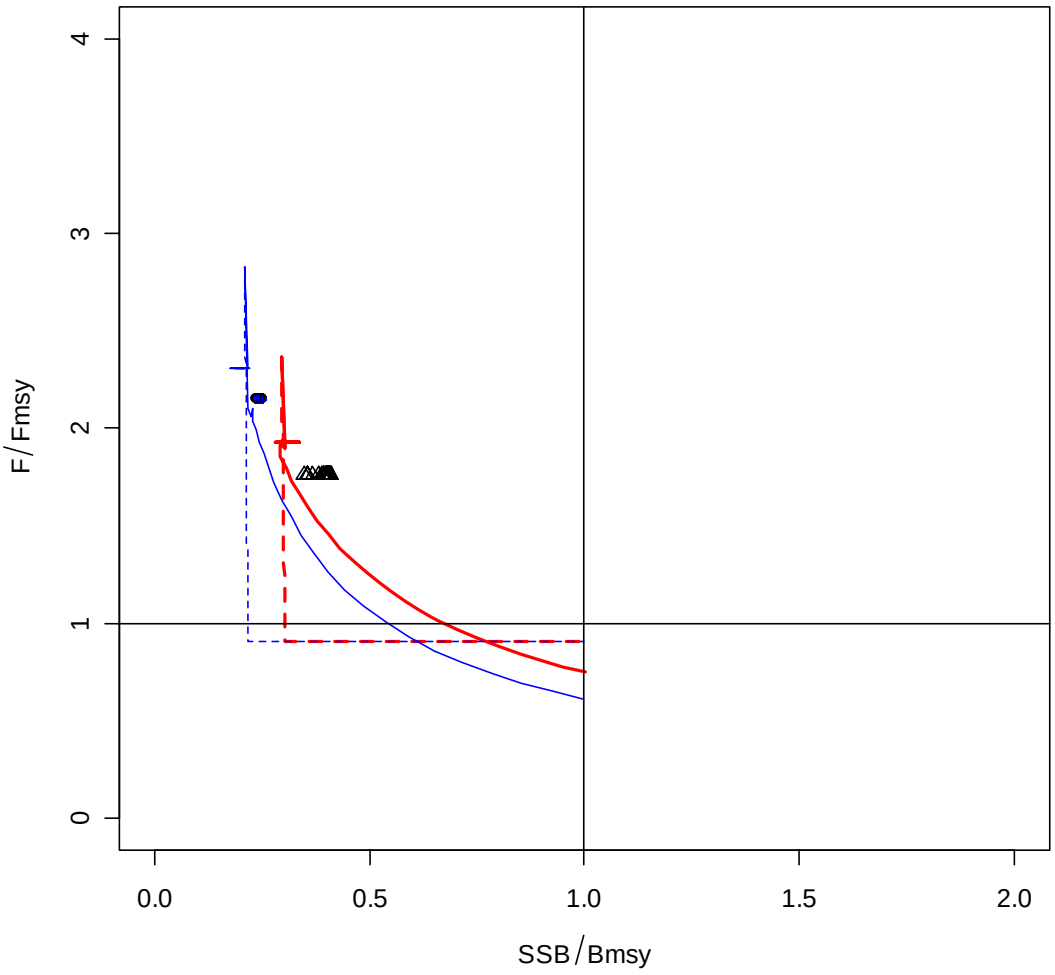


Figure 2.3. Closed area : MD-E (q4).

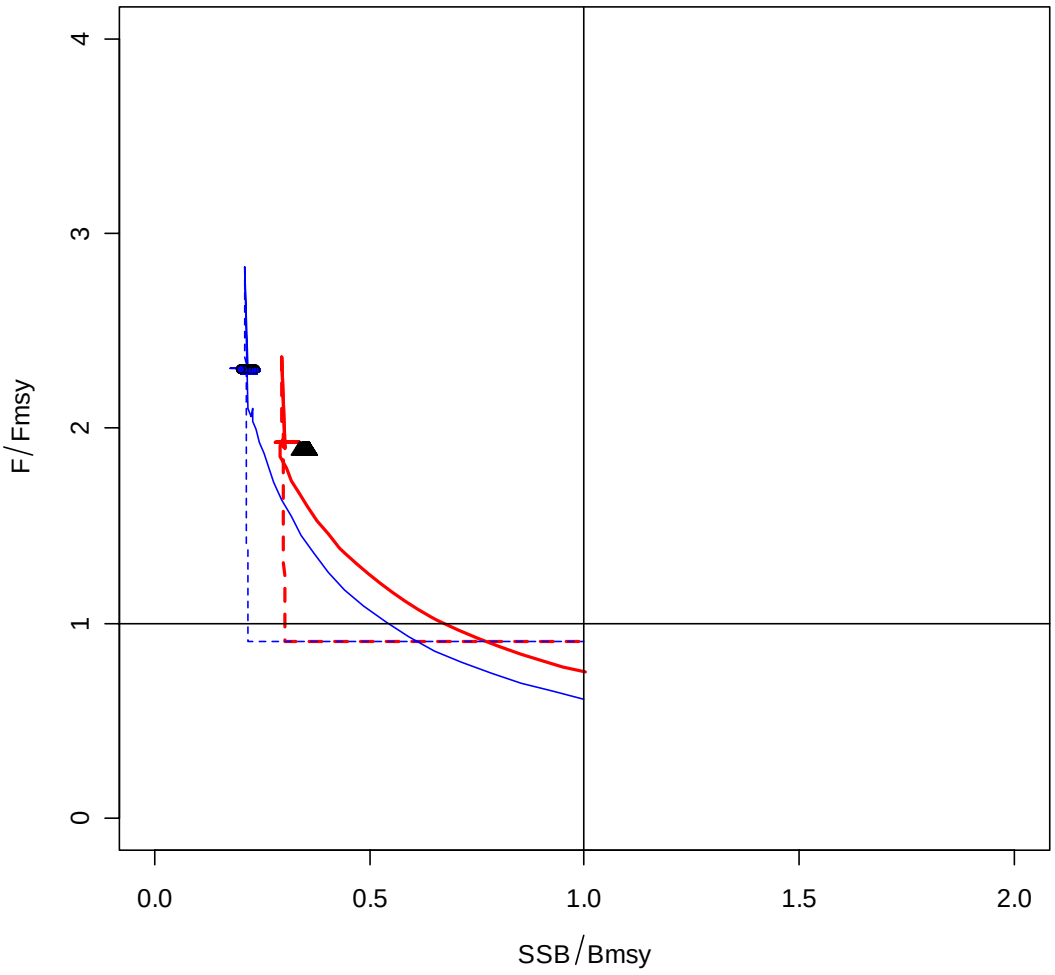


Figure 2.4. Closed area : MD-W + MD-C (q4).

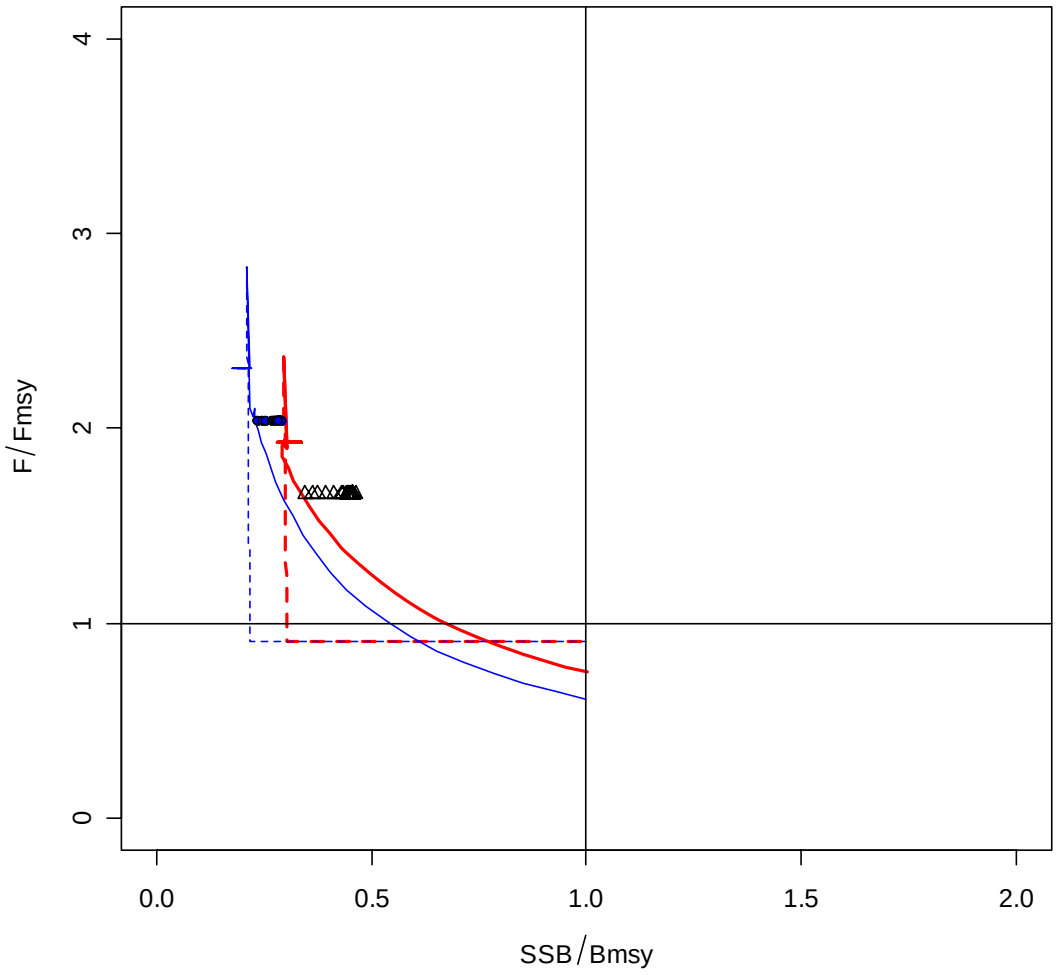


Figure 2.5. Closed area : MD-W + MD-E (q4).

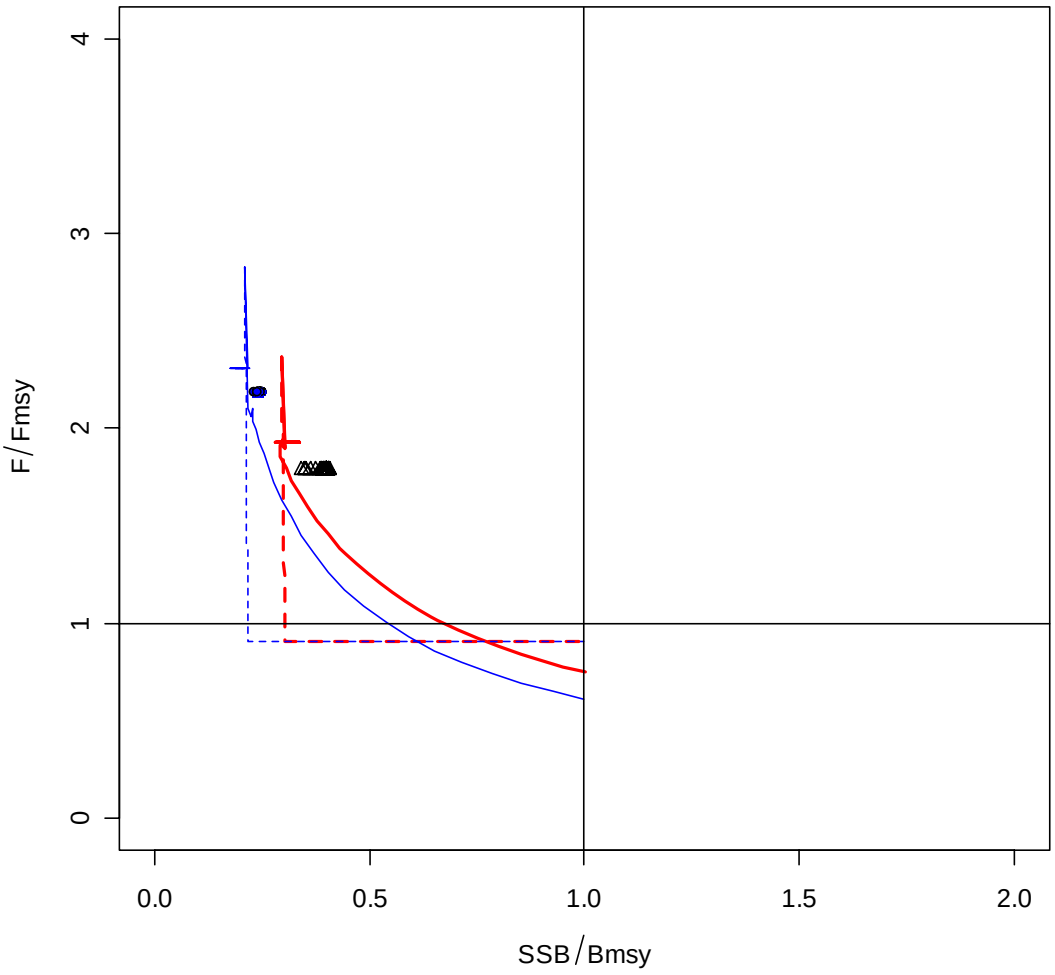


Figure 2.6. Closed area : MD-C + MD-E (q4).

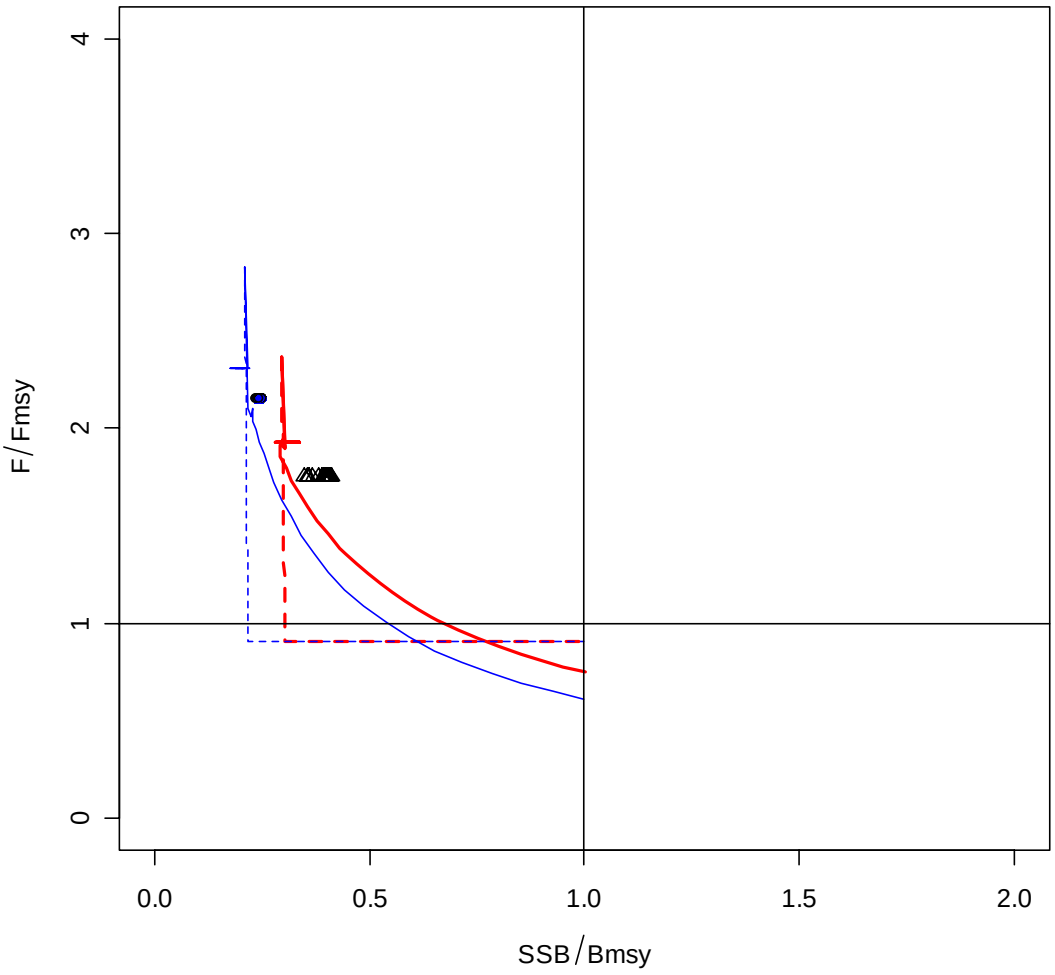


Figure 2.7. Closed area: all (q4).

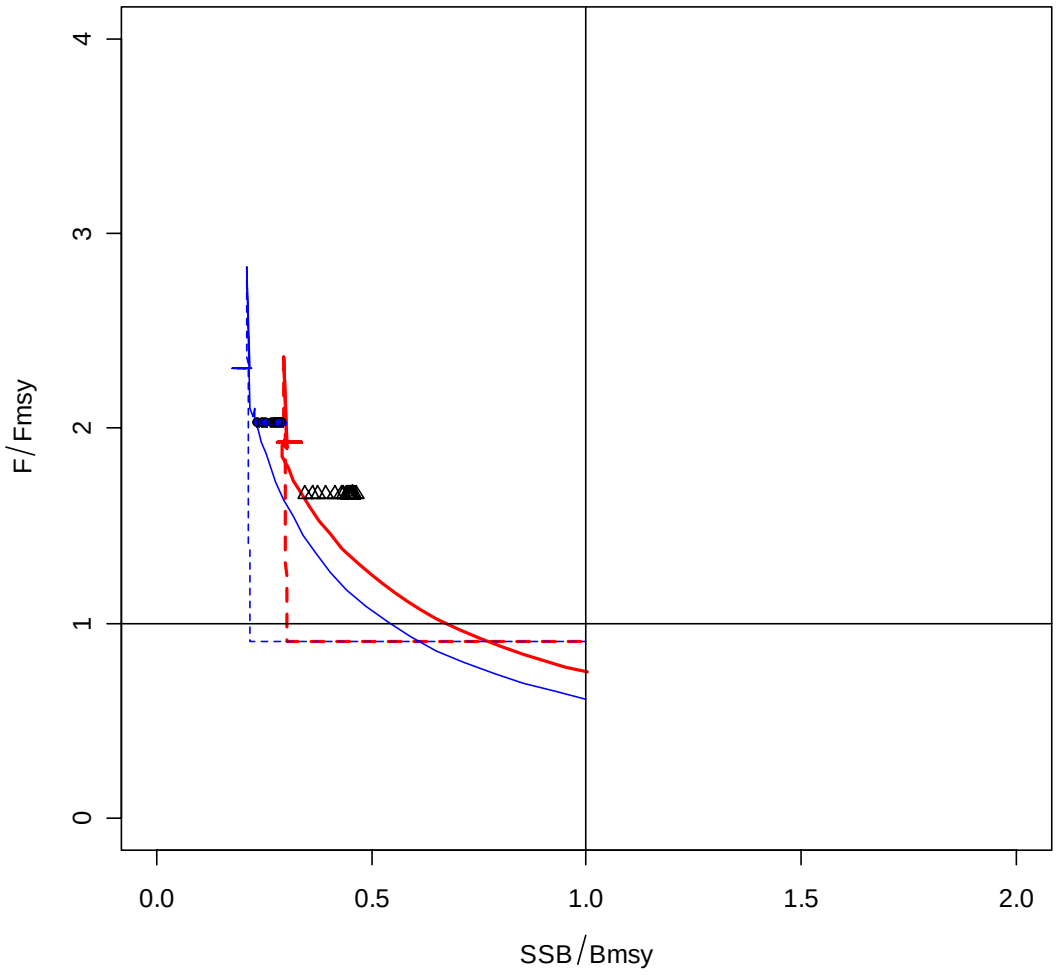


Figure 2.8. Closed area : MD-W (q4) with 25% implementation error.

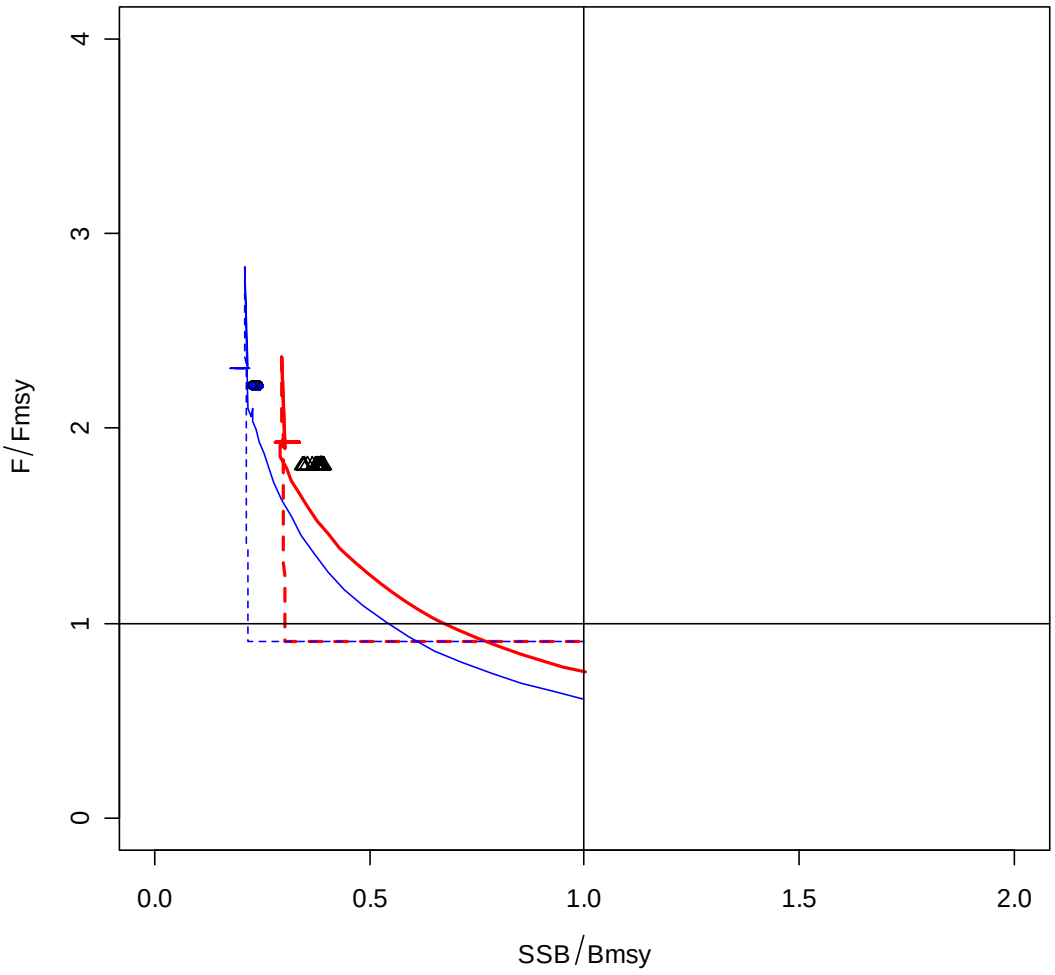


Figure 2.9. Closed area: MD-C (q4) with 25% implementation error.

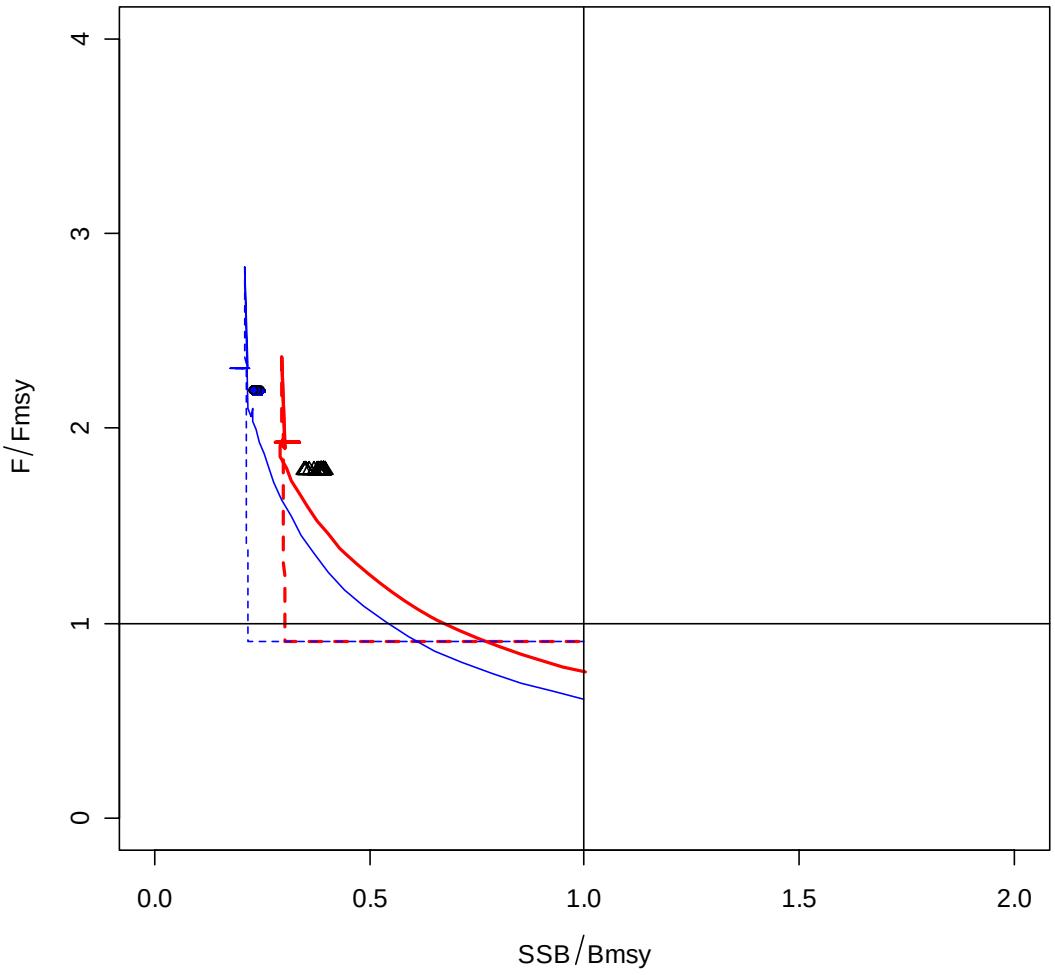


Figure 2.10. Closed area: MD-E (q4) with 25% implementation error.

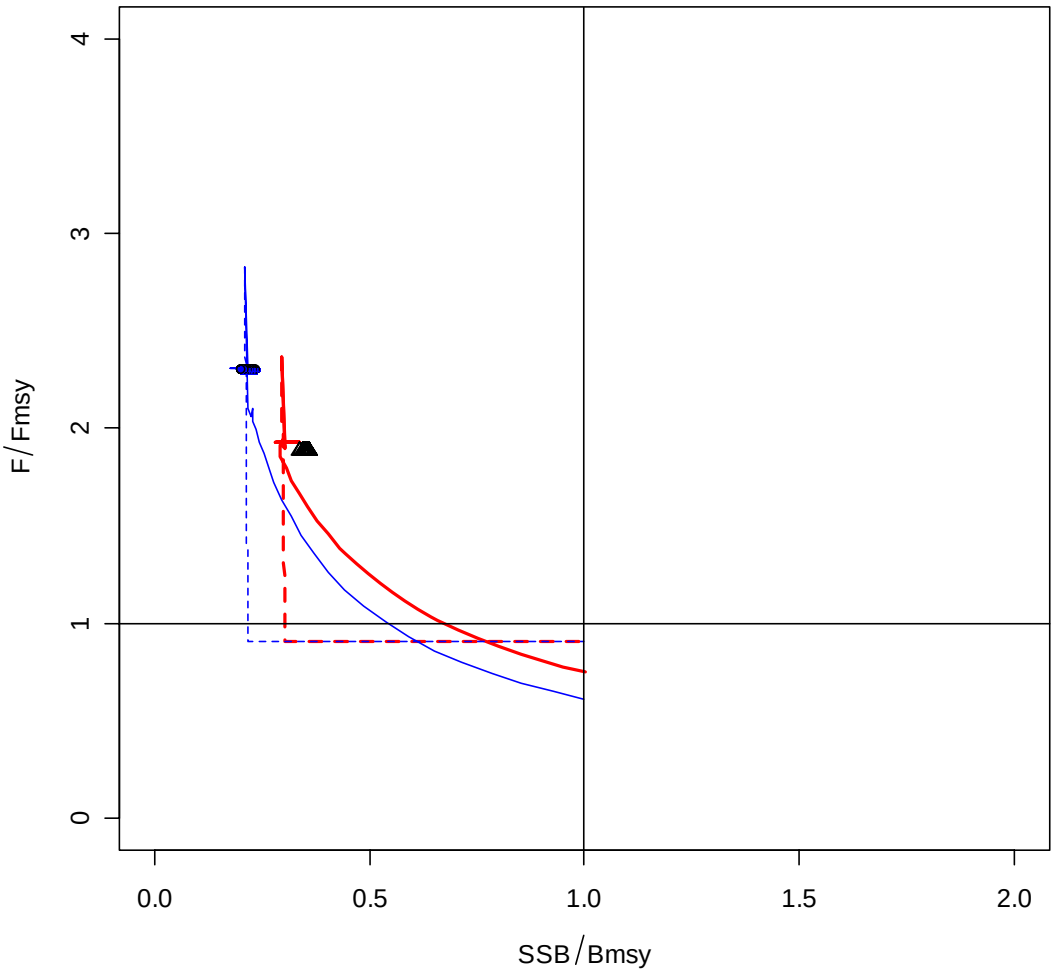


Figure 2.11. Closed area: MD-W + MD-C (q4) with 25% implementation error.

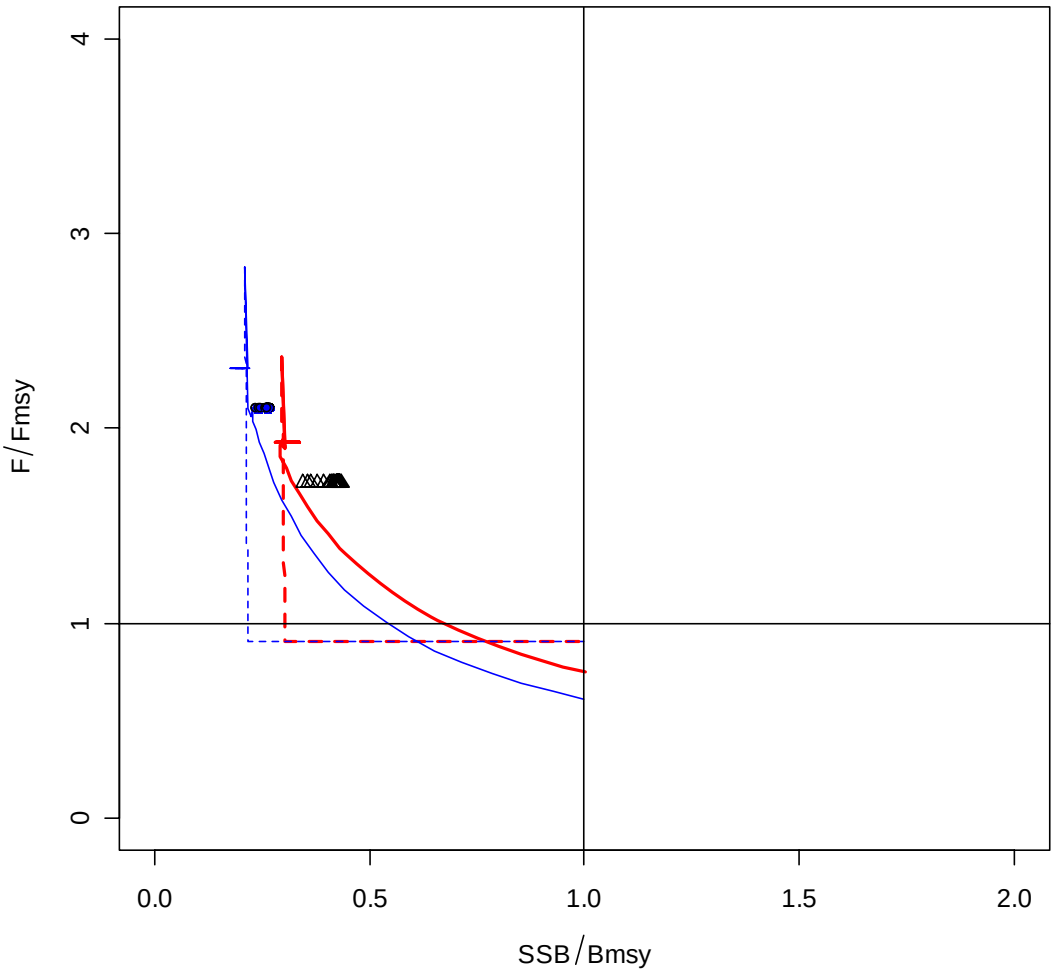


Figure 2.12. Closed area: MD-W + MD-E (q4) with 25% implementation error.

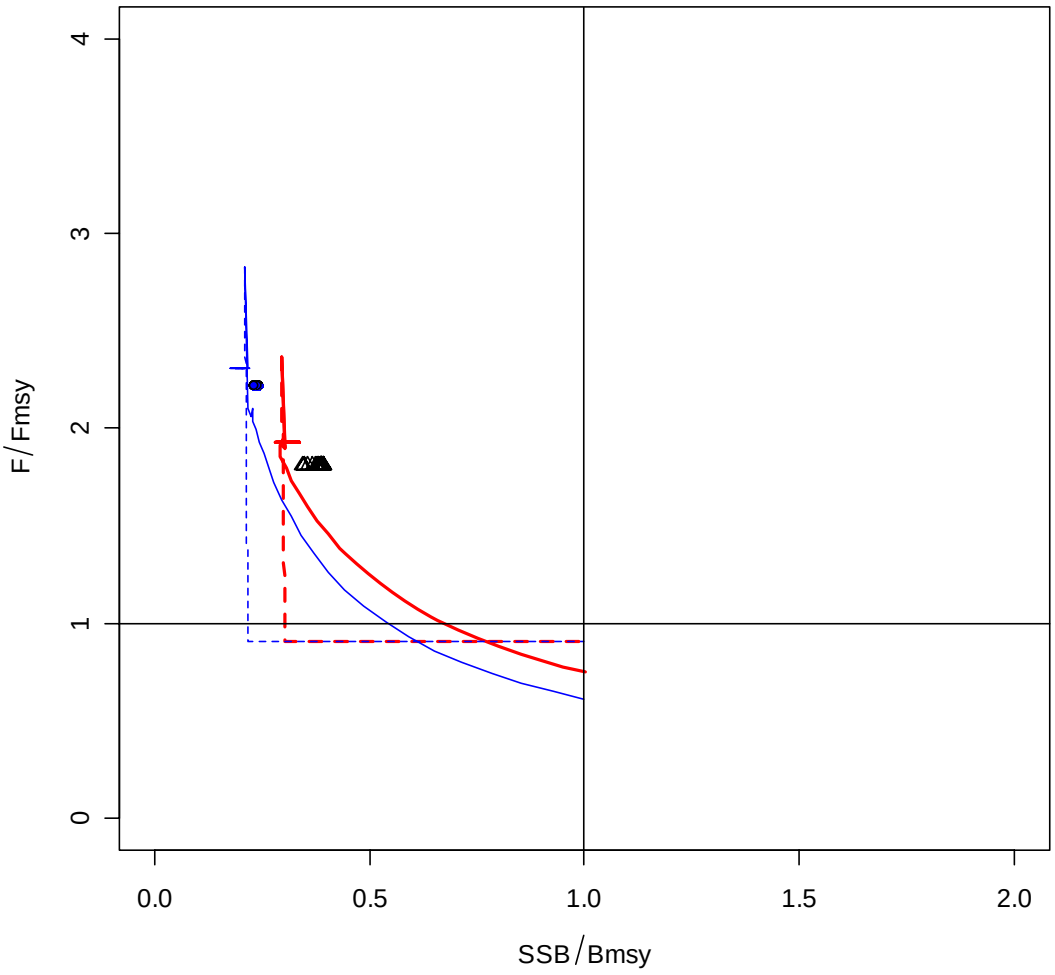


Figure 2.13. Closed area: MD-C + MD-E (q4) with 25% implementation error.

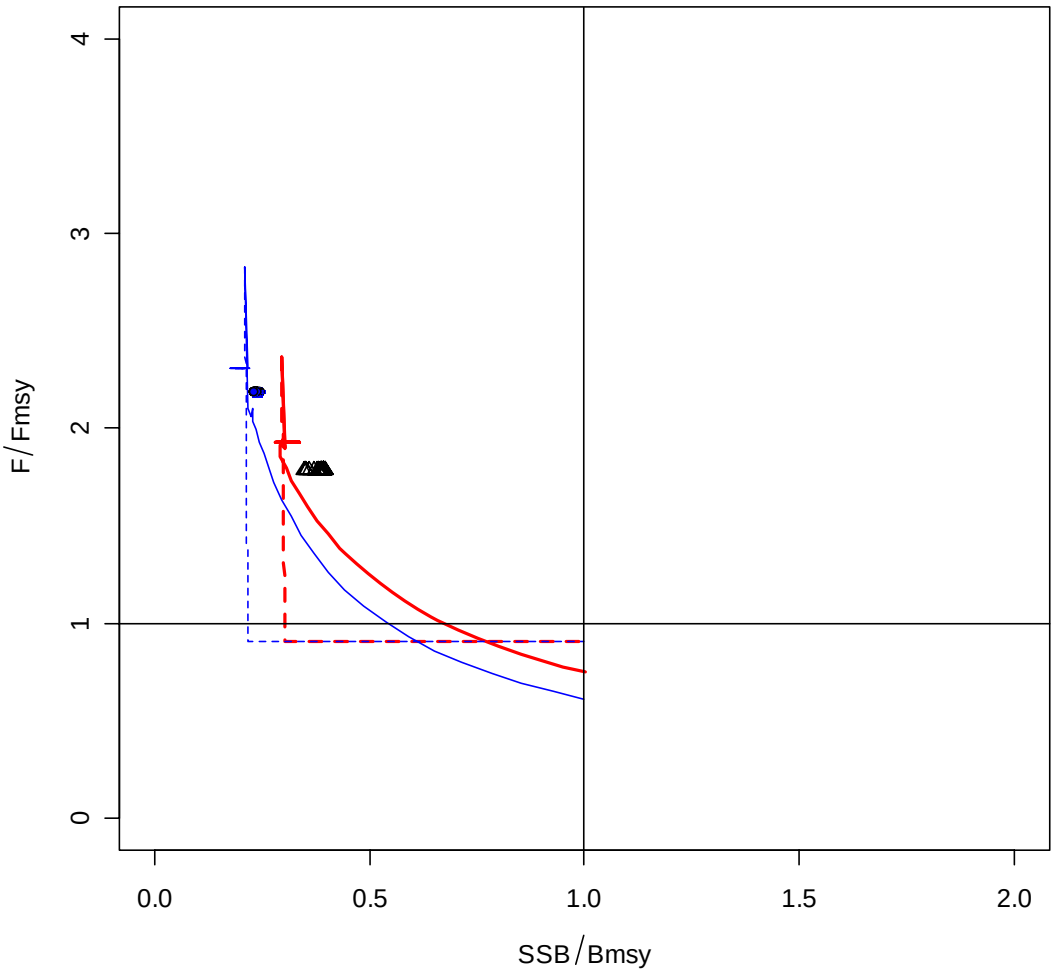


Figure 2.14. Closed area: all (q4) with 25% implementation error.

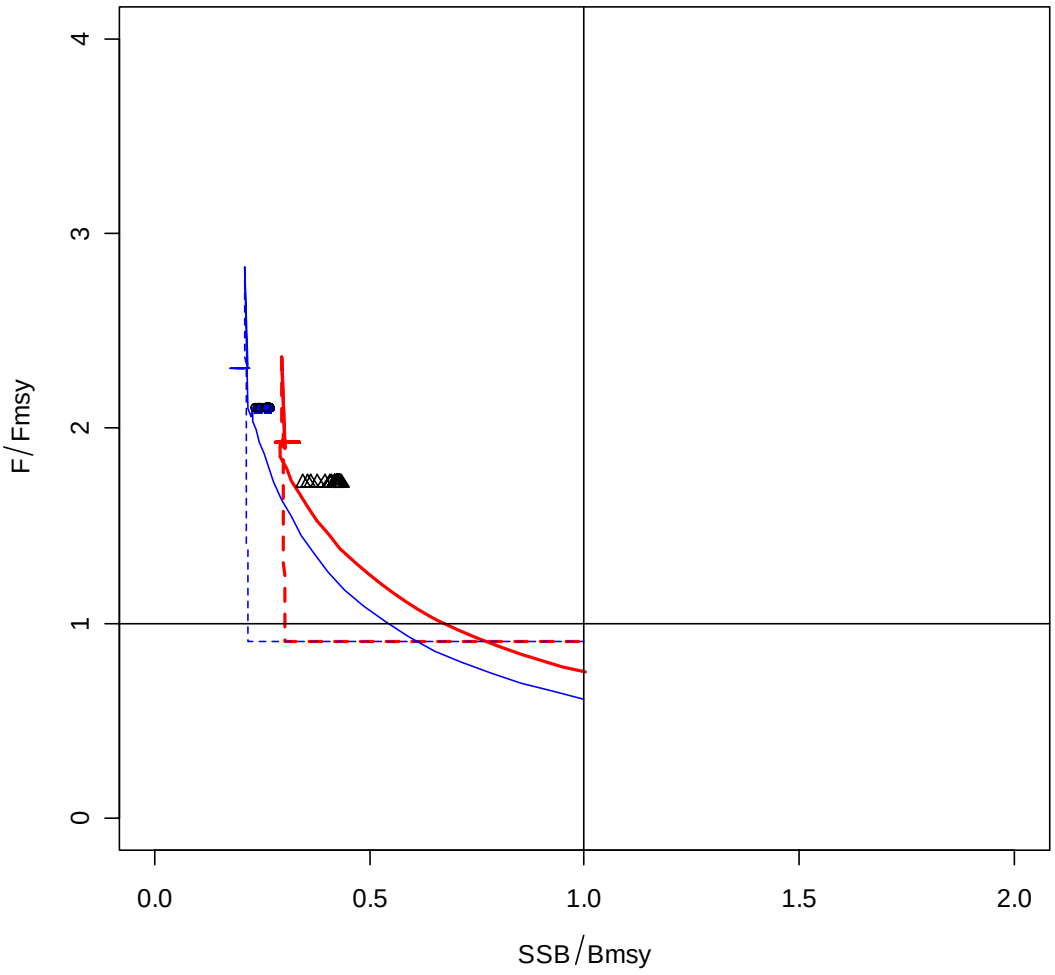


Figure 2.15. Closed MD-W (q1); closed (MD-C+E) (q4).

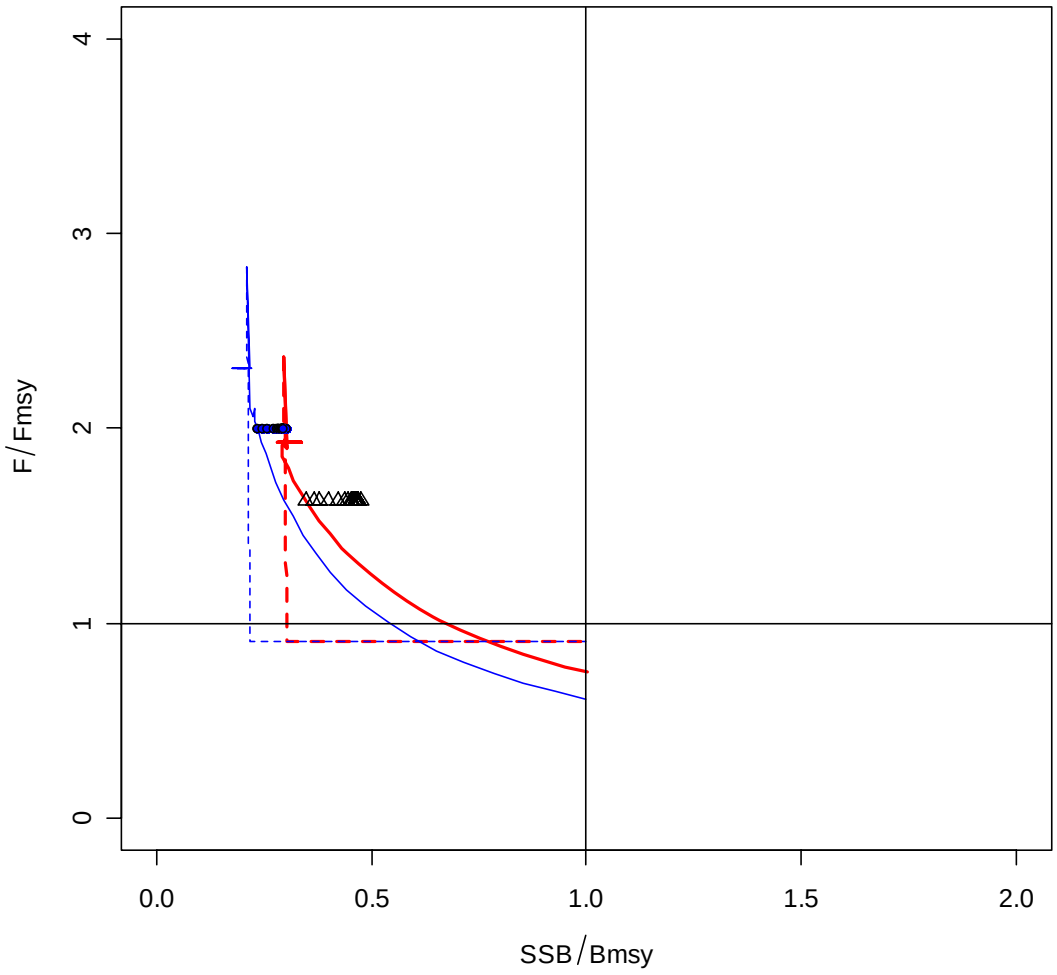


Figure 2.16. Closed MD-W (q2); closed (MD-C+E) (q4).

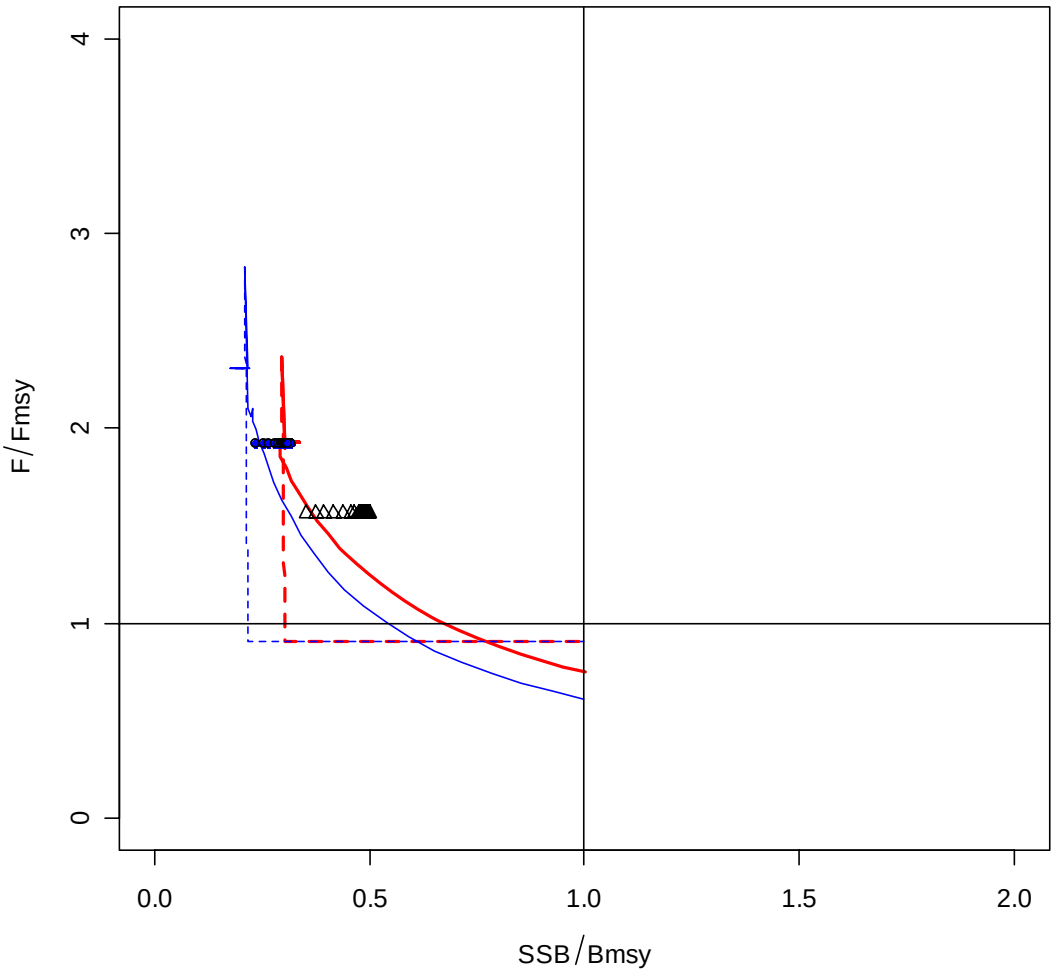


Figure 2.17. Closed MD-W (q3); closed (MD-C+E) (q4).

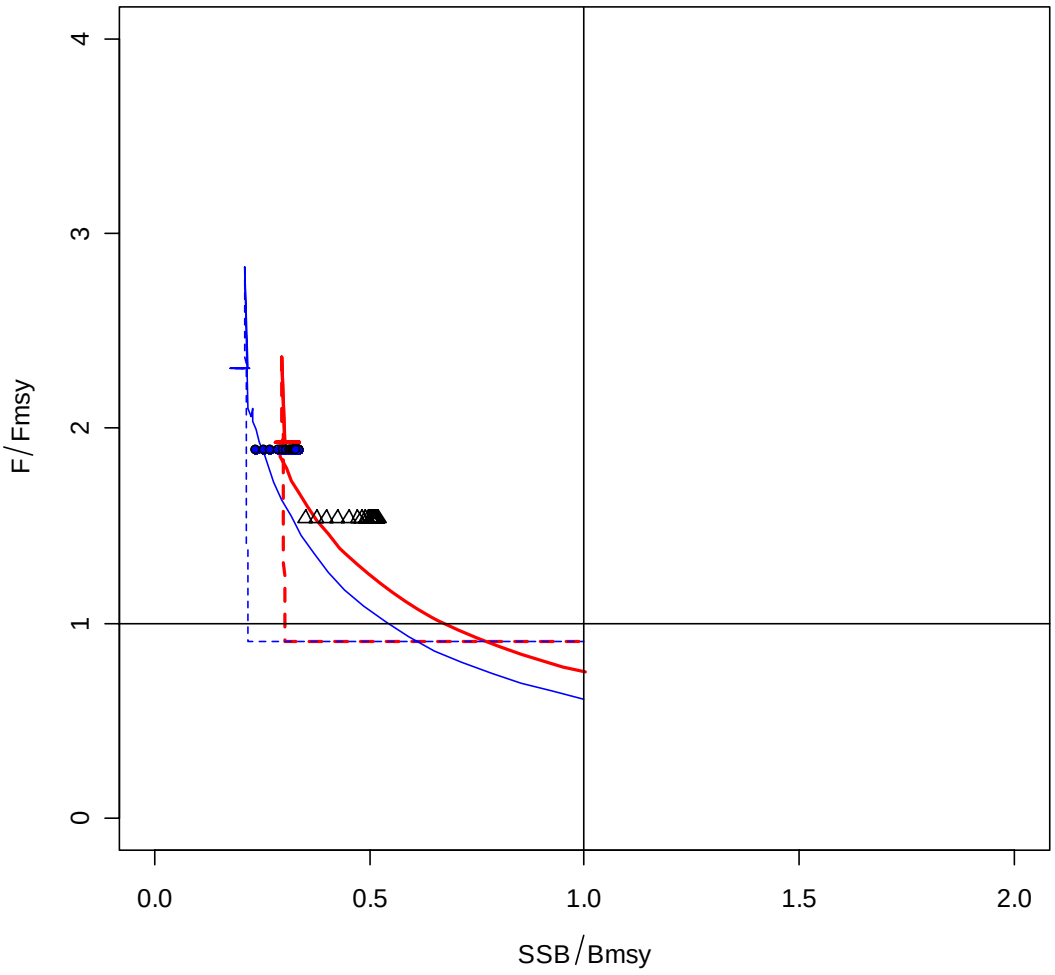


Figure 2.18. GN selectivity transitioned to LL selectivity (100%) to examine implications of changover to LL.

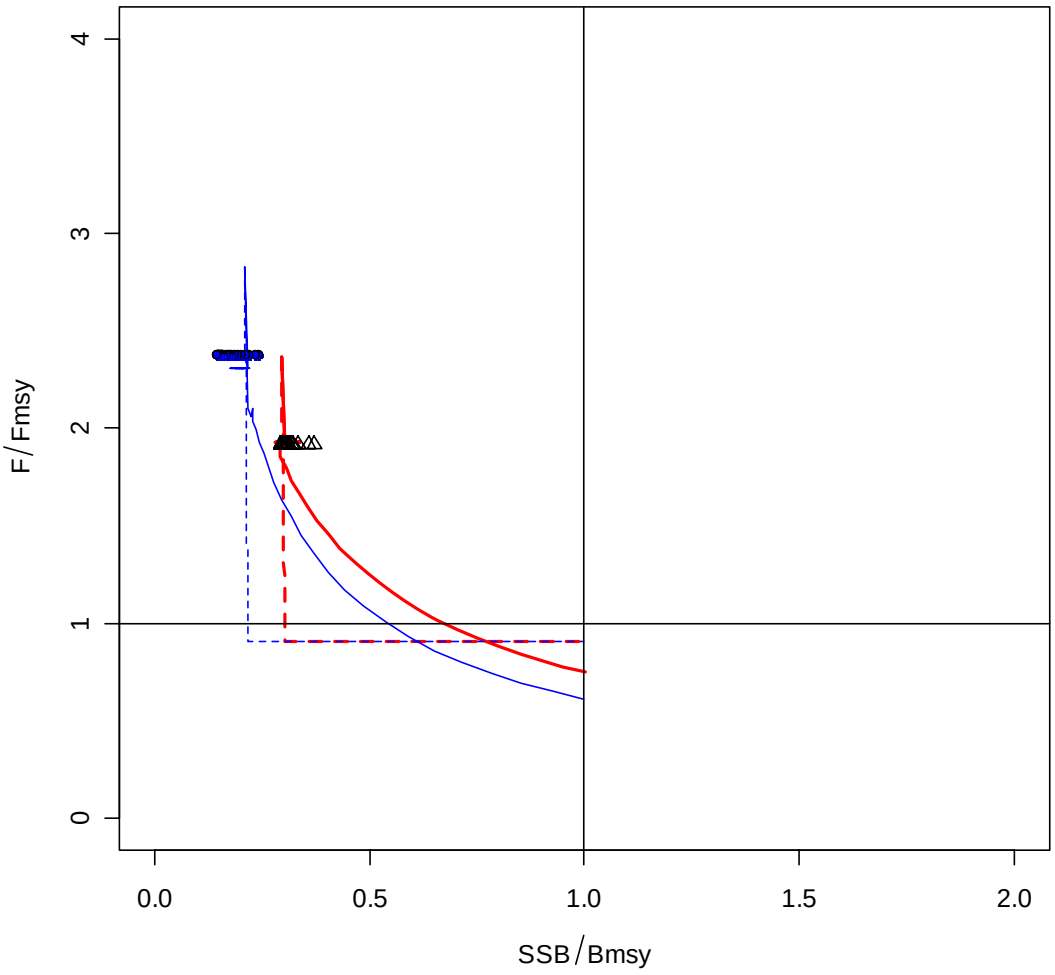


Figure 2.19. Run 18 (GN select -> LL select) + (q4 closed in all MED).

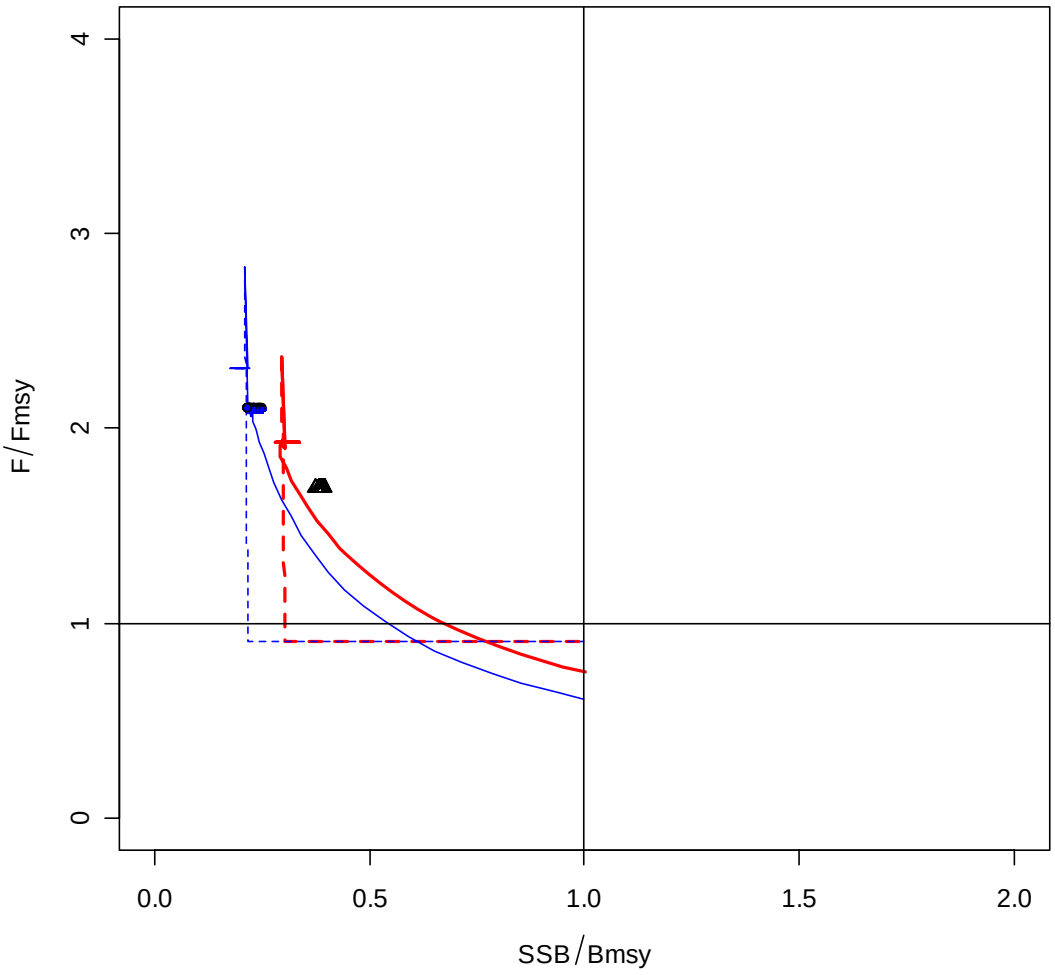


Figure 2.20. Closed area 1 month all Med in 2008 only.

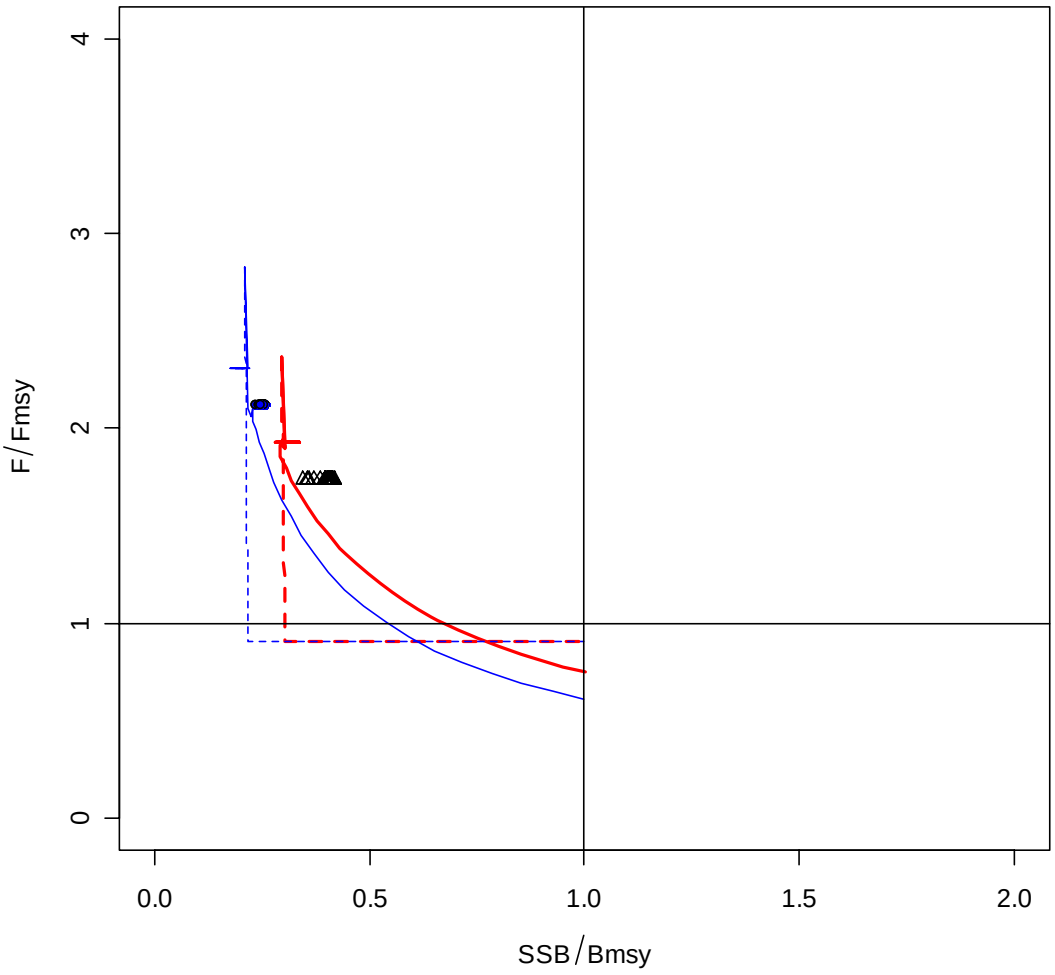


Figure 2.21. Closed area 1 month all Med all years.

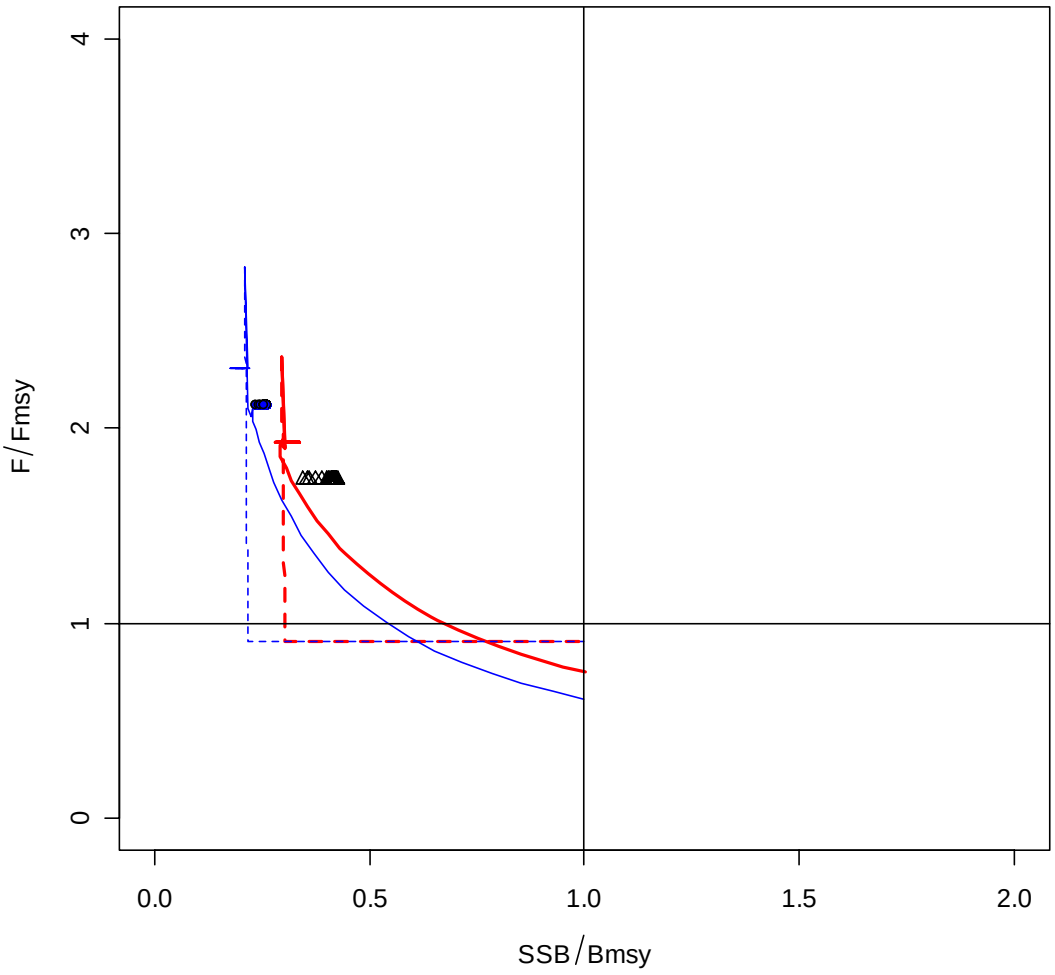


Figure 2.22. Closed area: MD-E & MD-C (q3) MD-W (q4).

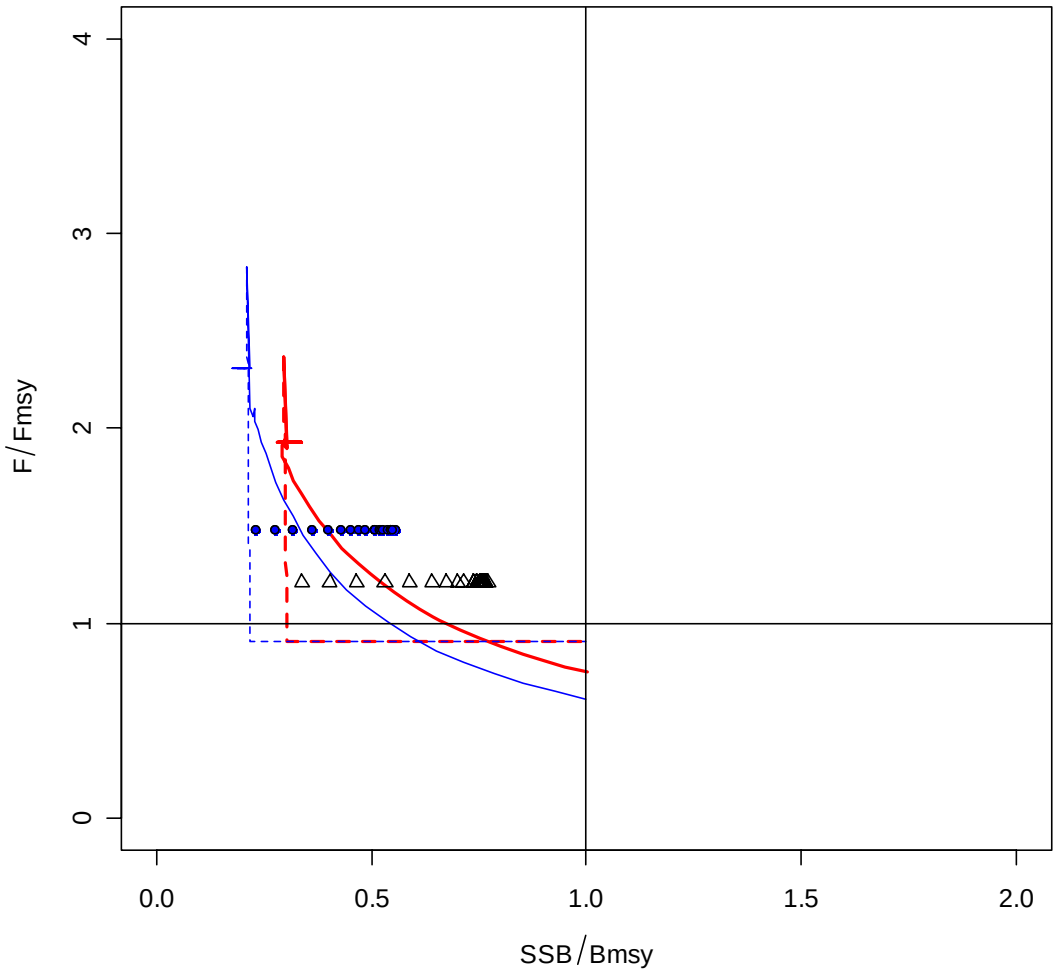


Figure 2.23. Closed area: All quarters 3 and 4.

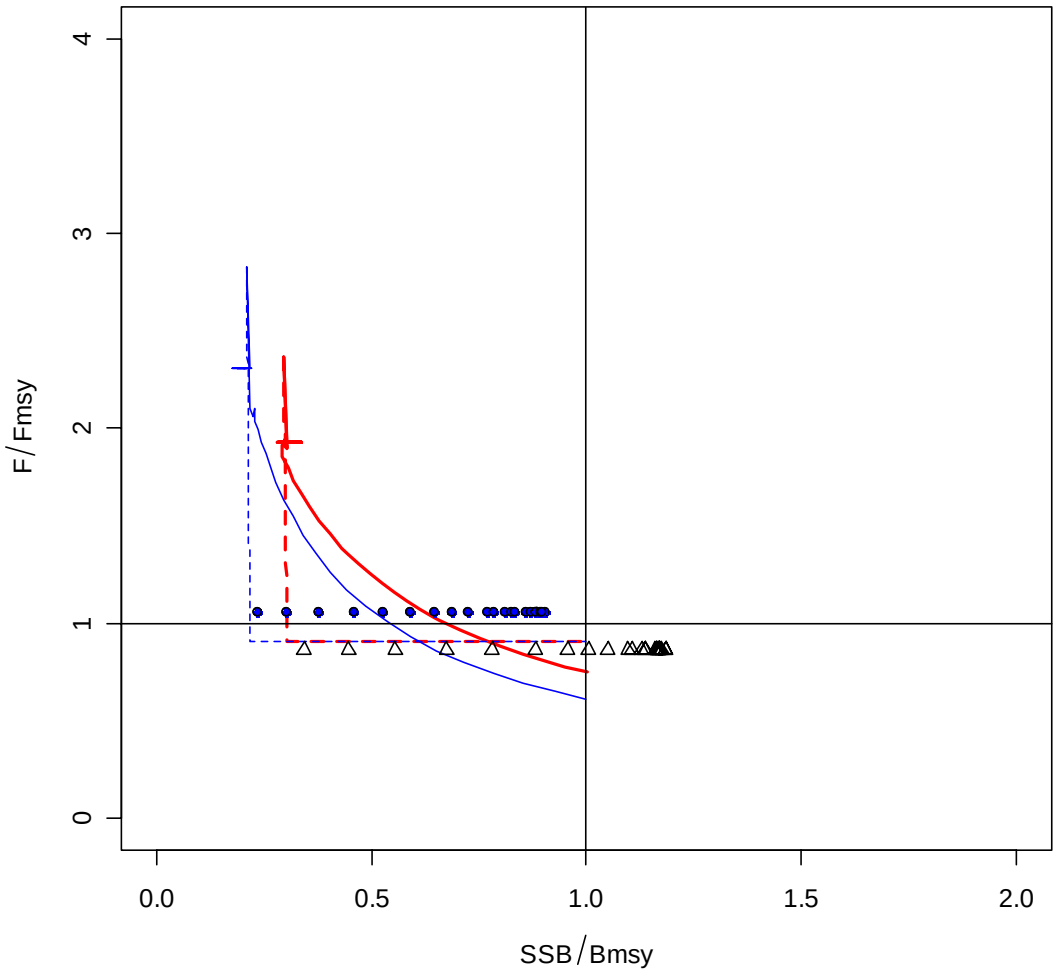


Figure 2.24. As run 23 with 25% implementation error.