MAREA

SPECIFIC CONTRACT N° 10 "IMPROVED KNOWLEDGE OF THE MAIN SOCIO-ECONOMIC ASPECTS RELATED TO THE MOST IMPORTANT FISHERIES IN THE ADRIATIC SEA (SEDAF)"

DELIVERABLE 9

REPORT AND DISCUSSION OF THE OUTPUTS OF SCENARIO MODELLING OBTAINED USING BEMTOOL

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ANNEX I, ANNEXII AND ANNEX III ARE PROVIDED IN A SEPARATE ANNEXED DOCUMENT:
"SEDAF_D9_BEMTOOL-OUTPUTS SCENARIOS-ANNEX I_II_III"

1. EXECUTIVE SUMMARY

Three case studies were performed to assess the impact of different management scenarios in the Adriatic Sea: small pelagics case study in GSA 17, demersal case study in GSA 17 and demersal case study in GSA 18, involving fisheries of Italy, Slovenia, Croatia, Montenegro and Albania.

The BEMTOOL model was selected as appropriate tool to simulate the past/present situation and to evaluate the consequences of a suite of management scenarios from biological and socioeconomic perspectives, after projections of the stocks in the near future. SEDAF project also gave the opportunity to further upgrade BEMTOOL and implement some additional technical features (see Annex I of this document).

For Italy and Slovenia data of 2008-2013 for the estimation of the socio-economic parameters were obtained from the EU Data Collection Framework and were in line with data collected in the WP2 - Collation and review on the main socio-economic information on the main fisheries (SEDAF-D6 Report economic and structural overview). Taking into account that official Croatian socio- economic data are under revision, for the purpose of this study scientist presumed data needed for this exercise. Nevertheless, Croatian socio- economic data were obtained from the data collected and reviewed by the SEDAF project and refer to the period 2009-2012. Socio-economic data for 2008 and 2013 of Croatian fleet segments were assumed equal to 2009 and 2012 data respectively. For all fleet segments, 2014 data were assumed equal to 2013.

In the forecast scenarios the uncertainty on recruitment has been taken into account, applying for all stocks a multiplicative error on the geometric mean of recruitment computed for the last three years.

The stocks and fisheries involved, the data and parameters used for modelling, a brief description of the management scenarios and the obtained results follow for each case study.

GSA 17 small pelagic case study

The main stocks identified for the GSA 17 small pelagic case study are *E. encrasicolus* and *S. pilchardus*. Both stocks are shared among the countries of GSA 17 (Italy, Croatia, Slovenia).

The main fishing gears targeting anchovy and sardine are pelagic trawls and purse seines. 8 fleet segments targeting the selected stocks and considered for this case study are:

1. ITA_TM_VL_1218
2. ITA_TM_VL_1824
3. ITA_TM_VL_2440
4. ITA_PS_VL_2440
5. HRV_PS_VL_1218
6. HRV_PS_VL_1824
7. HRV_PS_VL_2440
8. SVN_PS_VL_1218

The selected fleet segments represent about 95% of production and revenues of anchovy and around 93% of production and revenues of sardine in GSA 17 in 2013.
The data used for the parameterization of the biological and pressure modules of BEMTOOL come from the stock assessments carried out during the Working Group on Stock Assessment of Small Pelagic of GFCM (GFCM-WGSASP report) held in November 2014.

In order to evaluate the impact of different management measures, 7 forecast scenarios have been implemented (Table 1.0.1) besides the status quo.

Table 1.0.1 Description of forecast scenarios

1 HR2 RED_E04ane2018	reduction (7%) of F towards the reference point of anchovy (E=0.4) in 2018 for each fleet segment and applied only to fishing days;
2 HR2 RED_E04ane2020	reduction (7%) of F towards the reference point of anchovy (E=0.4) in 2020 for each fleet segment and applied only to fishing days;
3 HR2 RED_E04pil2018	reduction (20%) of F towards the reference point of sardine (E=0.4) in 2018 for each fleet segment and applied only to fishing days;
4 HR2 RED_E04pil2020	reduction (20%) of F towards the reference point of sardine (E=0.4) in 2020 for each fleet segment and applied only to fishing days;
5 HR2 RED_E04pil2020_PropF_100d	reduction of F towards the reference point of sardine (E=0.4) in 2020 with higher reductions for fleet segments impacting more sardine stock, applied to fishing days (except Italian and Slovenian purse seines, because representing less than 1% of the impact);
6 HR2 RED_E04pil2020_PropF_50v50d	reduction of F towards the reference point of sardine (E=0.4) in 2020 with higher reductions for fleet segments impacting more sardine stock, applied half to fishing days and half to the number of vessels as potential withdrawal (except Italian and Slovenian purse seines, because representing less than 1% of the impact);
7 HR2 RED_Fprop_FB	fishing ban in the months with higher occurrence of offspring of sardine with higher reductions for fleet segments impacting more sardine stock. This measure is applied each year from 2015 to 2021.The fishing ban already carried out by the different fleet segments has been taken into account.

The main results of the projections are summarised in the figure 1.1 (MultiCriteria Decision Analysis outcomes) and in the tables 1.1, 1.2, and 1.3 where results are expressed as relative percentage of variation in respect to the status quo scenario.

Forecasts evidenced the following results.

- Regarding SSB all scenarios targeting the reference point of sardine gave equivalent results with improvements around +4-5% for anchovy and +8% for sardine compared to the status quo (Table 1.1).
- Catches of both stocks were not much reduced in any scenario if the overall fleet is considered, given that the variations compared to the status quo were less or equal to -8%. However, considering the focus on fleet segments, HRV_PS_1824 and HRV_PS_2440 were more penalized by the management strategies (being the more impacting on sardine stock) (Tables 1.2 and 1.3), while the other fleet segments would benefit, as expected, by the gradual rebuilding of the stocks and by the reduced competition among the fleets.
- Given the reduction of 31% in predicted fishing days, the Croatian purse seine segment 24-40 m is the most affected fleet, with a decrease of -18% in the predicted landings and of -16% in the predicted revenues.
- At the end of the forecast period, revenues and average salaries of fleet segments characterized by lower incidences of sardine in production, as the Italian pelagic trawlers 1824 m and 2440 m, benefit from the implementation of management measures aimed at a reduction of the fishing mortality of sardine, because they are less impacted in respect to the other fleet segments by these measures.
- For all fleet segments analysed, employment undergoes moderate variation across scenarios with the only exception of HR2-RED_E04pil2020_PropF_50v50d, aimed at reducing mortality rates of the

sardine stock by reducing both the number of days at sea and the number of vessels (Table 1.1). HR2-RED_E04pil2020_PropF_50v50d produced the largest positive variation in average salary with an increase of 14% for the whole fleet and an increase of 21% for the Italian pelagic trawl 1824m. However, expected employment of the whole fleet would reduce by 8% by 2021. Under a social point of view the most affected segment is the Croatian purse seine fleet 2440m with an expected drop in employment of 16% by 2021 compared with the status quo (Table 1.2 and 1.3).

- Considering only the percentage variations of the scenarios from the status quo, the best performing one is HR2-RED_E04pil2020_PropF_50v50d, that allows to obtain the best trade off among the different variables, considering the same weight for each indicator. This especially because, among the different indicators, the increase of salary overcompensates the decrease of employment.
- The internal option of BEMTOOL model performing a Multi-Criteria Decision Analysis, that combines Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP), has been used to assess the performances of the alternative fisheries management policies. According to MCDA, the scenario allowing to reach the highest overall utility is HR2-RED_E04pil2018 (0.7932), while the lowest utility is given by HR2-RED_E04pil2020_PropF_50v50d scenario that produces an utility value (0.757) slightly lower than the status quo scenario (0.7644) (Fig. 1.1). This because the MCDA attributes a higher weight to the biological indicators, but takes into account the value of the social indicators.
- The scenario that has the second higher utility is HR2-RED_E04pil2020_propF_100d (0.7896), that is very close to the best scenario in terms of overall utility. This seems to indicate that a higher reduction of F applied to the more impacting fleet segments gives overall a benefit equivalent to the reduction of 20% for all the fleet segments in 2018. Also this result can be influenced by the higher relative weight attributed by the MCDA to the biological indicators.
- The methodology and the scenarios tested cover a wide range of different options and provide a general and complete overview of the situation of small pelagics in the Adriatic Sea. The results are consistent with the advices that have been provided so far in different fora and give a more robust evaluation of the efficiency of each of the measures proposed.
- There are certainly some limitations in the approach used. In particular, one of the main issues is the difficulty in forecasting recruitment in small pelagic species. These species are in fact strongly influenced from environmental variables and the recruitment can show dramatic variability from one year to the next.
- A step forward would be to test the probability of some estimates of falling below a certain reference limit throughout a Management Strategy Evaluation (MSE). However, the measures proposed from BEMTOOL are conservative enough to be efficient against recruitment failures.

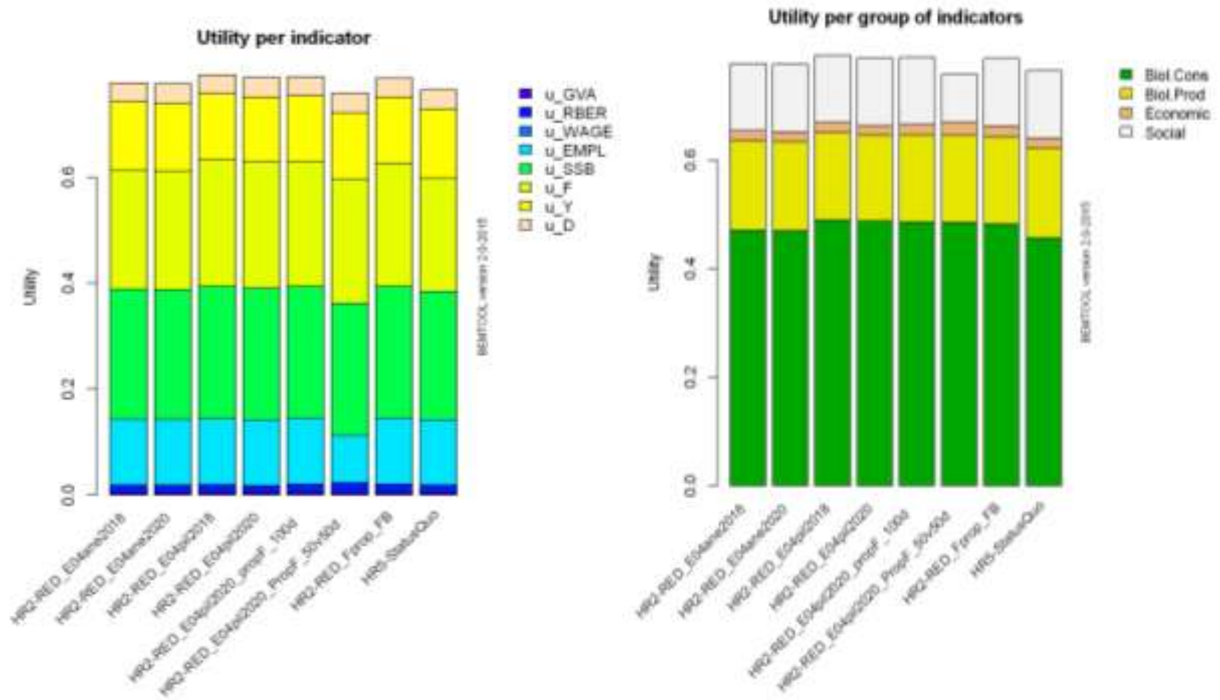

Figure 1.1 MCDA results: evaluation of the overall utility associated to each management scenario for the case study of small pelagics in GSA17.

Table 1.1 Performances of the management scenarios (% respect to status quo) simulated in terms of SSB and overall catches of anchovy and sardine, salary, CR/BER, employment and revenues. The green values are higher than +5%, the red ones are smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17.

	All fleets							
Scenario, year 2021	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	SSB Anchovy	SSB Sardine
HR2-RED_E04ane2018	1.5	0.6	-1.3	0.0	-1.3	-2.3	2.9	2.0
HR2-RED_E04ane2020	1.0	0.4	-1.6	0.0	-1.2	-3.2	2.1	3.3
HR2-RED_E04pil2018	3.2	1.1	-4.5	0.0	-5.7	-5.4	5.5	7.9
HR2-RED_E04pil2020	1.9	0.5	-5.4	0.0	-6.5	-6.9	3.5	8.3
HR2-RED_E04pil2020_propF_100d	4.4	2.3	-1.3	0.0	-2.6	-8.0	4.6	8.1
HR2-RED_E04pil2020_PropF_50v50d	14.1	6.7	-0.4	-7.6	-1.4	-6.4	4.2	7.8
HR2-RED_Fprop_FB	5.0	2.5	-1.9	0.0	-3.0	-7.2	4.7	7.6

Table 1.2 Performances of the management scenarios (% respect to status quo) simulated in terms of catches of anchovy and sardine, salary, CR/BER, employment and revenues by fleet segment (HRV_PS_1218, HRV_PS_1824, HRV_PS_2440 and ITA_PS_2440 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	**HRV_PS_1218**						**HRV_PS_1824**					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	-1.1	-1.2	-1.6	0.0	-1.6	-2.3	1.4	-3.4	-1.6	0.0	-1.6	-2.3
HR2-RED_E04ane2020	-1.6	-1.7	-2.0	0.0	-1.6	-3.2	0.7	-1.7	-2.1	0.0	-1.6	-3.2
HR2-RED_E04pil2018	-3.5	-3.7	-4.7	0.0	-6.3	-5.5	3.9	-9.3	-4.7	0.0	-6.3	-5.4
HR2-RED_E04pil2020	-4.4	-4.7	-5.6	0.0	-6.8	-7.0	2.5	-5.9	-5.6	0.0	-6.8	-7.0
HR2-RED_E04pil2020_propF_100d	7.5	8.0	6.6	0.0	6.5	9.6	4.5	-10.5	-2.4	0.0	-4.6	-1.9
HR2-RED_E04pil2020_PropF_50v50d	10.4	11.1	6.9	-2.3	7.0	10.0	13.6	-32.0	-1.7	-7.3	-3.7	-1.0
HR2-RED_Fprop_FB	7.1	7.6	5.9	0.0	4.8	9.3	6.0	-14.2	-2.4	0.0	-4.2	-1.9

Scenario, year 2021	**HRV_PS_2440**						**ITA_PS_2440**					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp..	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	1.1	1.4	-1.6	0.0	-1.5	-2.3	0.4	0.5	-1.0	0.0	-1.4	-2.4
HR2-RED_E04ane2020	0.4	0.5	-2.1	0.0	-1.6	-3.1	0.1	0.2	-1.3	0.0	-1.6	-3.3
HR2-RED_E04pil2018	3.2	4.3	-4.6	0.0	-6.3	-5.4	-1.7	-2.0	-5.2	0.0	-6.8	-5.2
HR2-RED_E04pil2020	1.7	2.3	-5.6	0.0	-6.8	-7.0	-2.3	-2.8	-5.7	0.0	-7.3	-6.8
HR2-RED_E04pil2020_propF_100d	-11.1	-14.6	-17.9	0.0	-23.1	-20.9	11.0	13.5	8.9	0.0	11.3	14.5
HR2-RED_E04pil2020_PropF_50v50d	8.4	11.1	-15.4	-15.6	-20.1	-18.0	11.5	14.1	9.3	0.0	11.8	15.0
HR2-RED_Fprop_FB	-7.9	-10.4	-15.7	0.0	-17.7	-18.3	10.7	13.1	8.6	0.0	11.4	17.4

Table 1.3 Performances of the management scenarios (% respect to status quo) simulated in terms of catches of anchovy and sardine, salary, CR/BER, employment and revenues by fleet segment (ITA_TM_1218, ITA_TM_1824, ITA_TM_2440 and SVN_PS_1218). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ITA_TM_1218						ITA_TM_1824					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	0.3	0.4	-1.1	0.0	-1.2	-2.3	5.2	7.0	-1.0	0.0	-0.8	-1.7
HR2-RED_E04ane2020	0.3	0.4	-1.1	0.0	-1.1	-3.0	4.2	5.7	-1.5	0.0	-0.6	-3.2
HR2-RED_E04pil2018	-0.6	-0.6	-4.4	0.0	-5.6	-5.3	11.8	15.9	-4.3	0.0	-5.5	-5.1
HR2-RED_E04pil2020	-1.5	-1.7	-5.2	0.0	-6.3	-6.8	9.9	13.4	-5.2	0.0	-6.2	-6.8
HR2-RED_E04pil2020_propF_100d	10.9	12.1	8.3	0.0	10.1	12.6	18.1	24.5	6.6	0.0	7.3	9.5
HR2-RED_E04pil2020_PropF_50v50d	12.4	13.7	8.6	-1.1	10.5	12.9	21.2	28.7	6.8	-2.3	7.6	9.7
HR2-RED_Fprop_FB	5.6	6.3	2.4	0.0	2.3	6.3	17.0	22.9	1.9	0.0	0.8	4.4

Scenario, year 2021	ITA_TM_2440						SVN_PS_1218					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp. .	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	2.3	2.8	-1.1	0.0	-1.2	-2.1	0.0	-1.3	0.0	0.0	-1.2	-2.4
HR2-RED_E04ane2020	2.1	2.6	-1.2	0.0	-1.0	-2.9	-0.3	-1.5	-0.4	0.0	-1.3	-3.0
HR2-RED_E04pil2018	4.7	5.7	-4.3	0.0	-5.4	-5.2	-1.0	-4.5	-1.2	0.0	-5.8	-5.2
HR2-RED_E04pil2020	3.3	4.0	-5.2	0.0	-6.3	-6.8	-2.1	-5.3	-2.4	0.0	-6.5	-6.8
HR2-RED_E04pil2020_propF_100d	9.7	11.7	3.3	0.0	3.6	5.7	12.6	10.3	14.8	0.0	12.1	15.1
HR2-RED_E04pil2020_PropF_50v50d	14.8	17.8	3.6	-4.0	4.0	6.3	13.0	10.6	15.2	0.0	12.5	15.4
HR2-RED_Fprop_FB	10.7	12.9	3.1	0.0	2.9	7.0	13.6	11.2	15.9	0.0	12.1	18.6

GSA 17 demersal case study

The main stocks identified for the GSA 17 demersal case study are *M .merluccius, S. mantis, M. barbatus* and *S. solea.* These stocks are shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia).

The main fishing gears targeting the four stocks selected for this case study are bottom trawls, small scale fisheries, longlines and rapido trawlers.

The 11 fleet segments targeting the selected stocks and considered for this case study are:

1. ITA_DTS_0612;
2. ITA_DTS_1218;
3. ITA_DTS_1840;
4. ITA_PGP_0012;
5. ITA_TBB_1218;
6. ITA_TBB_1824;
7. HRV_DFN_0612;
8. HRV_DTS_0612;
9. HRV_DTS_1218;
10. HRV_DTS_1824;
11. SVN_DFN_0612_DTS_1218.

The fleet segments ITA_PGP_0012 and SVN_DFN_0612_DTS_1218, ITA_DTS_1840 are strata representing an aggregation of fleet segments, because sharing similar characteristics. This is also to avoid unnecessary fragmentation in the analysis.

The data used for the parameterization of the biological and pressure modules of BEMTOOL come from the stock assessments carried out during the Working Group on Stock Assessment of Demersal Species at GFCM (GFCM-WGSASP) and during the STECF Expert Working Group meetings.

According to the state of exploitation of the four demersal stocks in GSA 17 case study, the ratio between $F_{current}$ and F_{MSY} is 3.3 for European hake and red mullet), 1 for spottail mantis and 1.4 for common sole. 6 forecast scenarios have been thus implemented, besides the status quo, in order to evaluate the consequences of several management strategies in terms of costs and benefits on the stocks and on the productive and economic performances of different fleet segments.

The 6 management scenarios have been implemented to reduce the overall combined fishing mortality F towards a combined F_{MSY}. This reference point was estimated as the average F_{MSY} among all the stocks, weighed using stock landing value, following the approach as for balance indicators. The reduction was applied to each fleet segment, considering the relative portion of $F_{current}$ and F_{MSY}, on the basis of fleet segment landing to overall landing of the stock. The needed reduction is 59% of the $F_{current\ combined}$ ($F_{current\ combined}$=0.76; $F_{MSY\ combined}$=0.31).

The scenarios implemented to reach the combined F_{MSY} are reported in the following table 1.0.2.

Table 1.0.2 Scenarios implemented to reach the combined F_{MSY}. in GSA17

Scenario 2 F01_2018_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 3 F01_2018_50D50V	Linear reduction of combined F towards the combined F_{MSY}, applied half to fishing days and half to the number of vessels (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218,

	because representing less than 3% of the combined F);
Scenario 4 F01_2018_FB	Gradual closure of fishing activity until 2018 in the months with higher occurrence of offspring of the four target species (July, August, September, October, November and January) (except SVN_DFN_0612_DTS_1218);
Scenario 5 F01_2020_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 6 F01_2020_50D50V	Linear reduction of combined F towards the combined F_{MSY}, applied half to fishing days and half to the number of vessels (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 7 F01_2020_FB	Gradual closure of fishing activity until 2020 in the months with higher occurrence of offspring of the four target species (July, August, September, October, November and January) (except SVN_DFN_0612_DTS_1218).

The main results of the projections carried out are reported in the figure 1.2 (MultiCriteria Decision Analysis outcomes) and in the tables 1.4, 1.5, 1.6, 1.7 where results are expressed as relative percentage of variation in respect to the status quo scenario.

- All scenarios give a remarkable increase of SSB for all the assessed stocks (Table 1.4). Recovery of hake SSB is noteworthy compared to the other species, given the characteristics of high productivity of this stock. Among the different scenarios, the best result is obtained in the Scenario 2 - F01_2018_100D, while the worst was always observed in the status quo. Scenario 4 - F01_2018_FB performed quite well, especially for SSB recovery of red mullet.
- In terms of catches, those of European hake are expected to improve in the medium term (2018 and 2020), given the high productivity and the current high level of exploitation of this stock, whilst the other stocks will be rather underutilised, because the combined F_{MSY} is fairly influenced by the hake reference point that is low compared to the other ones. The Scenario 4 - F01_2018_FB was less impacting in terms of reduction of landings, but to the cost of not reaching the reference point.
- Catches of the fleet segments ITA_DTS_0612, ITA_TBB_1218 and SVN_DFN_0612_DTS_1218 generally take advantage of the stock rebuilding following the reduction applied to the other fleet segments, given that they are not affected by the management measures (their relative impact lower than 3%), except for the scenario S. 4 - F01_2018_FB, i.e. the fishing ban, that is also applied to the first two fleet segments.
- The fleet segments more impacted by the management measures are those not targeting European hake, as the loss of other species catches is not compensated by the increase of hake productivity. This is holding for the fleet segment ITA_TBB_1840 and especially for ITA_PGP_0012.
- Considering the overall landings, the worst performance is shown by the fishing ban scenarios (Scenario 4 and Scenario 7), with a decrease of total landing of about 50%, given that these scenarios have been applied to all the fleet segments, excluding only SVN_DFN_0612_DTS_1218.
- All the fleet segments, when affected by the management measures, obtain a higher landing in the status quo scenario, but a decrease of discard respect to the status quo, reflecting the decrease of the total catch.
- Regarding landing of common sole, the highest decrease respect to the status quo is shown in the Scenarios 2 and Scenario 5 (reduction applied to the fishing activity only by 2018 and 2020) with an

overall landing about 30% lower that status quo. The most affected fleet segment are ITA_TBB_1840, which main target are spottail mantis and common sole and HRV_DFN_0612.

- Over the period 2008-2013, the economic performance of the demersal fleet in GSA 17 has generally deteriorated, reaching the lowest level in 2012. Four fleets (ITA_DTS_0612, ITA_DTS_1840, ITA_TBB_1840 and SVN_DFN_DTS_0612), suffered losses in 2012. The decrease in revenue and net profit is consistent with the drop in the total landings weight and days at sea of the whole selected fleet.
- In 2013, the ratio between current revenue and break-even revenue is much greater than 1 for most of the selected fleets, thus indicating that demersal fishery in GSA 17 is generally profitable. However, Italian demersal trawl segments 1218 m and 1840 m and Italian vessels using passive gears only, which totally account 66% of total landing weight, show ratios close to 1.
- Regarding the economic performance of the overall fleet, revenues decreases in all the scenarios of about 12% on average. Such reduction is more pronounced in the scenarios simulating fishing ban, in which revenues drop to -30%. Profitability generally show the worst performance in the fishing ban scenarios (with drop of 65% for ITA_DTS_0612 and ITA_PGP_0012), except for TTB_1840, where the values are higher than status quo. The best performances are shown in scenario 3 – F01_2018_50D50V for all fleet segments (especially for Croatian DTS_1840 reaching in 2021 a value three times the status quo). As expected, almost all the scenarios show a substantial increase of the annual average salary per man (about 50% respect to the status quo), especially those with a mix of measures (e.g. scenario 2 and scenario 5). Regarding economic indicators at fleet segment level, the Croatian trawlers 12-18 m, 18-40 m, and Italian 18-40 are more benefited in all the scenarios (except fishing ban).
- Given the reduction in the number of vessels foreseen in the mixed scenarios, it's evident that permanent withdrawal performs better for the vessels remaining in the fleet, thus revealing a conflict between economic and social objectives.
- A Multi-Criteria Decision Analysis method that combines multi-attribute utility theory (MAUT) and the Analytic Hierarchy Process (AHP), as implemented in BEMTOOL, has been used to assess the performances of the alternative fisheries management policies.
- According to MCDA, that takes into account the weights to the different indicators associated through expert judgement, the scenario that allows to reach an higher overall utility is Scenario 2 – F01_2018_100D (0.64), followed by Scenario 5 – F01_2020_100D, while the status quo scenario produces the lowest overall utility (0.39) (Fig. 1.2).
- The lack of a reliable stock-recruitment relationship that did not allow a proper forecasting of recruitment level in the projections. However, the performed scenarios took into account the variability due to the process error thus allowing a more adaptive advice for demersal fisheries in this area.
- Following the present results, the current regulations (i.e. the status quo scenario) cannot be considered suitable to reach the MSY objective for this case study. All the proposed scenarios, aimed to reach a combined F_{MSY}, produce a remarkable improvement in SSB respect to status quo. On the other hand, all the proposed scenarios would produce a decrease in catches respect to status quo, except for hake which productivity would increase.

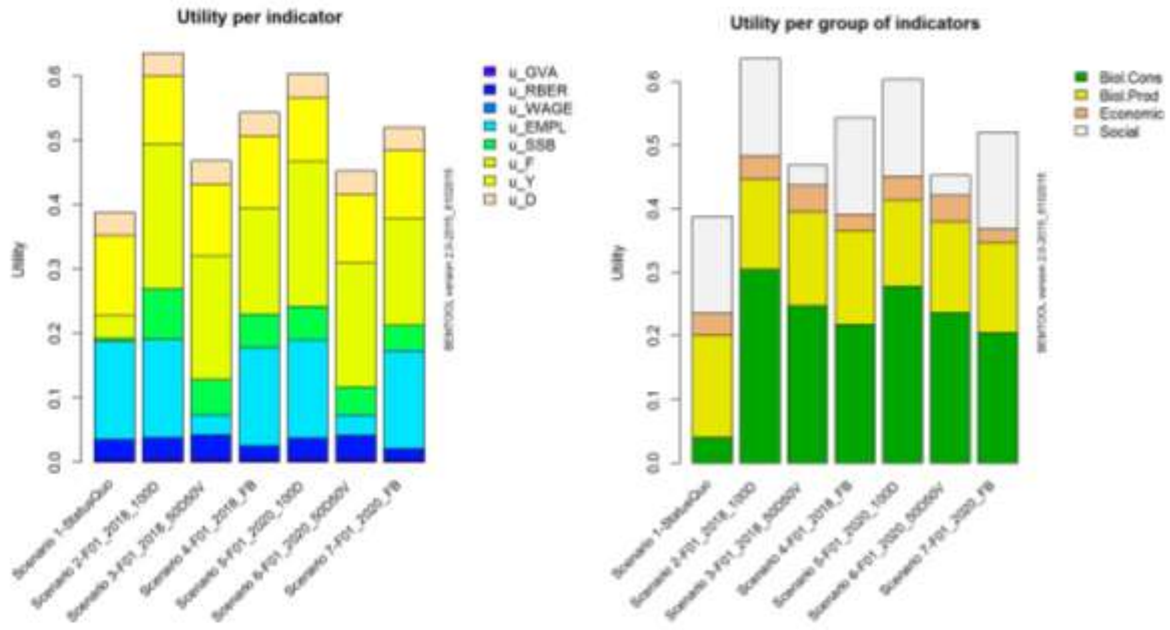

Figure 1.2 MCDA results: evaluation of the overall utility associated to each management scenario of the case study on demersal stocks in GSA17.

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Table 1.4 Performances of the management scenarios (% respect to status quo) simulated in terms of SSB and overall catches, salary, CR/BER, employment and revenues. The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ALL fleets											
	Salary	CR.BER	Rev.	Emp.	SSB hake	SSB spottail mantis	SSB red mullet	SSB sole	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
Scenario 2 - F01_2018_100D	10.7	15.7	-13.6	0.0	354.4	34.9	94.7	80.7	29.4	-35.3	-19.6	-33.9
Scenario 3 - F01_2018_50D50V	58.1	71.8	-8.6	-28.3	263.0	27.6	74.0	66.2	30.4	-28.5	-13.1	-26.4
Scenario 4 - F01_2018_FB	-21.4	-23.5	-30.5	0.0	242.7	29.0	80.5	66.1	30.2	-27.6	-13.8	-24.8
Scenario 5 - F01_2020_100D	7.7	10.4	-16.1	0.0	251.7	32.2	78.9	62.3	16.5	-37.1	-26.1	-34.5
Scenario 6 - F01_2020_50D50V	53.4	64.7	-11.1	-28.3	200.6	24.7	64.5	50.1	21.8	-30.5	-18.0	-27.8
Scenario 7 - F01_2020_FB	-24.7	-28.3	-32.9	0.0	179.4	25.6	68.6	50.7	18.2	-30.1	-19.9	-27.4

Table 1.5 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employment and revenues by fleet segment (HRV_DFN_0612, HRV_DTS_0612, HRV_DTS_1218 and HRV_DTS_1840 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	HRV_DFN_0612								HRV_DTS_0612							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	-11.3	-11.4	-13.2	0.0	41.7			-24.8	26.9	27.4	-1.9	0.0	28.3		-18.1	
S. 3 - F01_2018_50D50V	35.7	36.0	-6.1	-29.5	42.0			-16.6	84.1	85.7	2.9	-29.5	29.6		-11.6	
S. 4 - F01_2018_FB	2.3	2.3	0.3	0.0	12.8			-6.5	-23.5	-23.9	-32.4	0.0	8.2		-10.6	
S. 5 - F01_2020_100D	-17.4	-17.6	-19.0	0.0	24.9			-28.6	14.3	14.6	-10.3	0.0	15.6		-25.5	
S. 6 - F01_2020_50D50V	26.1	26.3	-12.6	-29.5	29.8			-21.5	70.4	71.8	-3.5	-29.5	21.1		-17.2	
S. 7 - F01_2020_FB	-5.1	-5.1	-6.8	0.0	0.1			-12.3	-32.0	-32.7	-38.1	0.0	-2.5		-17.5	

Scenario, year 2021	HRV_DTS_1218								HRV_DTS_1840							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	38.7	39.0	-2.0	0.0	28.3		-18.1		104.9	121.6	11.5	0.0	28.3		-18.1	
S. 3 - F01_2018_50D50V	99.6	100.4	2.7	-29.5	29.6		-11.6		184.2	213.4	14.5	-29.5	29.6		-11.6	
S. 4 - F01_2018_FB	-19.1	-19.3	-32.0	0.0	8.2		-10.6		3.3	3.7	-27.1	0.0	8.2		-10.6	
S. 5 - F01_2020_100D	24.9	25.1	-10.1	0.0	15.6		-25.5		82.2	95.2	1.7	0.0	15.6		-25.5	
S. 6 - F01_2020_50D50V	84.5	85.2	-3.4	-29.5	21.1		-17.2		161.5	187.1	7.6	-29.5	21.1		-17.2	
S. 7 - F01_2020_FB	-28.6	-28.8	-37.5	0.0	-2.5		-17.5		-11.0	-12.7	-33.2	0.0	-2.5		-17.5	

Table 1.6 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employment and revenues by fleet segment (ITA_DTS_0612, ITA_DTS_1218, ITA_DTS_1840 and ITA_PGP_0012 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ITA_DTS_0612								ITA_DTS_1218							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	54.9	70.9	32.4	0.0	212.0	48.9	75.7	24.5	37.1	41.8	-6.3	0.0	28.0	-39.0	-18.0	-47.4
S. 3 - F01_2018_50D50V	43.6	56.4	25.8	0.0	161.6	38.6	58.6	19.5	94.9	107.1	-2.2	-29.5	29.3	-31.8	-11.5	-38.1
S. 4 - F01_2018_FB	-50.6	-65.5	-51.6	0.0	16.0	-45.3	-51.3	-50.3	-6.6	-7.5	-23.7	0.0	40.6	-22.4	3.5	-28.0
S. 5 - F01_2020_100D	51.2	66.1	30.2	0.0	183.1	45.5	64.2	28.0	31.3	35.4	-9.4	0.0	15.2	-40.7	-25.3	-45.8
S. 6 - F01_2020_50D50V	40.4	52.2	23.9	0.0	144.7	35.1	52.2	17.8	88.3	99.6	-4.7	-29.5	20.8	-33.4	-16.8	-39.0
S. 7 - F01_2020_FB	-51.5	-66.6	-52.2	0.0	6.3	-46.5	-54.2	-51.9	-11.6	-13.2	-26.4	0.0	28.2	-24.8	-4.2	-28.3

Scenario, year 2021	ITA_DTS_1840								ITA_PGP_0012							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	37.1	41.8	-7.0	0.0	28.0	-39.0	-18.0	-47.4	-20.8	-23.7	-31.2	0.0		-53.9		-43.3
S. 3 - F01_2018_50D50V	94.9	107.1	-4.8	-29.5	29.3	-31.8	-11.5	-38.1	22.5	25.8	-23.6	-29.5		-45.5		-34.4
S. 4 - F01_2018_FB	-6.6	-7.5	-100.0	0.0	40.6	-22.4	3.5	-28.0	-56.1	-64.1	-54.7	0.0		-81.1		-63.8
S. 5 - F01_2020_100D	31.3	35.4	-10.2	0.0	15.2	-40.7	-25.3	-45.8	-20.7	-23.6	-31.1	0.0		-54.0		-42.2
S. 6 - F01_2020_50D50V	88.3	99.6	-8.5	-29.5	20.8	-33.4	-16.8	-39.0	20.2	23.2	-24.8	-29.5		-46.0		-35.0
S. 7 - F01_2020_FB	-11.6	-13.2	-10.0	0.0	28.2	-24.8	-4.2	-28.3	-56.4	-64.5	-55.0	0.0		-81.3		-64.0

Table 1.7 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employment and revenues by fleet segment (ITA_TBB_1218, ITA_TBB_1840 and SVN_DFN_DTS_0612 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ITA_TBB_1218								ITA_TBB_1840							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	5.2	26.4	19.0	0.0		55.6		35.5	-2.7	-3.2	-22.4	0.0		-32.6		-40.6
S. 3 - F01_2018_50D50V	23.0	21.7	15.6	0.0		42.3		29.6	46.4	54.7	-15.5	-29.5		-25.9		-32.2
S. 4 - F01_2018_FB	-100.0	-18.2	-23.9	0.0		-28.7		-39.1	20.5	24.1	-1.7	0.0		12.8		-7.3
S. 5 - F01_2020_100D	7.9	28.6	20.6	0.0		48.7		38.8	-4.1	-4.9	-23.4	0.0		-36.0		-39.8
S. 6 - F01_2020_50D50V	22.5	21.4	15.4	0.0		37.8		28.3	42.3	49.8	-17.4	-29.5		-28.9		-32.3
S. 7 - F01_2020_FB	8.6	-19.7	-25.0	0.0		-31.8		-39.6	15.9	18.7	-4.7	0.0		7.1		-9.8

Scenario, year 2021	SVN_DFN_DTS_0612							
	Salary	CR. BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	47.2	0.0	42.5	0.0		10.1	12.0	45.5
S. 3 - F01_2018_50D50V	38.2	0.0	34.4	0.0		8.1	8.7	36.9
S. 4 - F01_2018_FB	41.1	0.0	36.9	0.0		10.1	14.7	39.2
S. 5 - F01_2020_100D	42.2	0.0	37.9	0.0		9.4	10.4	40.4
S. 6 - F01_2020_50D50V	33.0	0.0	29.6	0.0		7.7	8.8	31.6
S. 7 - F01_2020_FB	35.4	0.0	31.8	0.0		9.0	12.0	33.7

GSA 18 demersal case study

The main stocks identified for the GSA 18 demersal case study are *M .merluccius, P.longirostris, N. norvegicus and M. barbatus. M. merluccius, P. longirostris* and *M. barbatus* stocks are shared among the countries belonging to GSA 18 (Italy, Albania and Montenegro), while *N. norvegicus* is essentially exploited by Italy.

The main fishing gears targeting the four selected stocks are bottom trawls, small scale fisheries, longlines.

The 10 fleet segments targeting the selected stocks and considered for this case study are:

1. ITA_DTS_0612;
2. ITA_DTS_1218;
3. ITA_DTS_1824_2440;
4. ITA_HOK_1218;
5. ITA_PGP_0006_0612;
6. ALB_DTS_1224;
7. MNE_DFN_0012;
8. MNE_DTS_0612;
9. MNE_DTS_1224;
10. MNE_HOK_0012.

The fleet segments ITA_DTS_1824_2440, ITA_PGP_0006_0612, MNE_DFN_0012, ALB_DTS_1224, MNE_DTS_1224 and MNE_HOK_0012 are strata representing an aggregation of fleet segments, because sharing similar characteristics. This is also to avoid unnecessary fragmentation in the analysis.

The data used for the parameterization of the biological and pressure modules of BEMTOOL come from the stock assessments carried out during the Working Group on Stock Assessment of Demersal Species of GFCM (GFCM-WGSASP report) held in November 2014 and during the STECF EWG 14-19 held in Rome in January 2015. According to the state of exploitation of the four demersal stocks in GSA 18 case study, the ratio between $F_{current}$ and F_{MSY} is 3.3 for European hake, 1.77 for deep water rose shrimp, 1.27 for red mullet and 6.15 for Norway lobster. 6 forecast scenarios have been implemented, besides the status quo, in order to evaluate the consequences of several management strategies in terms of costs and benefits on the stocks and on the productive and economic performances of different fleet segments.

The 6 management scenarios have been implemented to reduce the overall combined fishing mortality F towards a combined F_{MSY}. This reference point was estimated as the average F_{MSY} among all the stocks, weighed using stock landing value, following the approach as for balance indicators. The reduction was applied to each fleet segment, considering the relative portion of $F_{current}$ and F_{MSY}, on the basis of fleet segment landing to overall landing of the stock. The needed reduction is 66% of the Fcurrent combined ($F_{currentcombined}$ =0.87; $F_{MSY\ combined}$=0.3).

The scenarios implemented to reach the combined F_{MSY} are reported in the following table 1.0.2.

Table 1.0.3 Scenarios implemented to reach the combined F_{MSY}. in GSA18.

Scenario 2 F01_2018_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA PGP 0006_0612, ITA DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 3 F01_2018_50D50V	Linear reduction of combined F towards the combined F_{MSY},, applied half to fishing days and half to the number of vessels (except ITA PGP 0006_0612, ITA DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).

Scenario 4 F01_2018_FB	Gradual closure of fishing activity until 2018 in a period with higher occurrence of offspring of the four target species (June, July, August, September, October) (except Montenegrin fleets).
Scenario 5 F01_2020_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA PGP0006_0612, ITA DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 6 F01_2020_50D50V	Linear reduction of combined F towards the combined F_{MSY},, applied half to fishing days and half to the number of vessels (except ITA PGP 0006_0612, DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 7 F01_2020_FB	Gradual closure of fishing activity until 2020 in a period with higher occurrence of offspring of the four target species (except Montenegrin fleets).

The main results of the projections carried out are reported in the figure 1.3 (MultiCriteria Decision Analysis outcomes) and in the tables 1.8, 1.9, 1.10, 1.11, where results are expressed as percentage variations in respect to the status quo.

Forecast evidenced the following results.

- According to the traffic light summary tables, all the performed scenarios allow to obtain a benefit on the SSB for the 4 stocks compared to the status quo. SSB showed remarkable changes in all the different scenarios, although better performances were observed in Scenario 2 - F01_2018_100D, that was followed by in Scenario 5 - F01_2020_100D, indicating that a reduction applied in a narrower timeframe is more effective. Increase of SSB was especially observed for hake and Norway lobster that show highest increase in SSB respect to the status quo (more than 100%). The scenario less performing is the fishing ban, given that reduction applies a lower cut than it was necessary to reaching F_{MSY} combined.
- Given the gain in productivity of stocks as Norway lobster and European hake, also predicted catches for the whole fleet were improving compared to the status quo, increasing from an average of 12% for Norway lobster and 20% for European hake. Conversely the catches of red mullet and deep water pink shrimp decreased on average 18% and 6%, indicating an underutilization of such stocks.
- Revenues of the overall fleet are improving compared to the status quo in all the scenarios (+9% on average), as a result of the increased revenues of fleet segment as ITA_DTS_1824_2440. Italian longlines take the highest benefit from the reduction in the shortest time frame (revenues in 2021 are about 30% more than status quo). These fleets, together with those not affected by the management measures, compensate the negative performance of the revenues of fleet segment as ALB_DTS_1224. The fleets ITA_PGP_0006_0612, MNE_DFN_0012, MNE_DTS_0612, MNE_DTS_1224 and MNE_HOK_0012, took advantage, in all the scenarios, of the management measures applied to the other fleets, without taking any negative drawback, given that they were not or partially (ITA_PGP_0006_0612 only for the fishing ban) affected by the management rules.
- Forecasts show improvements in the average salary ranging from +17% of Scenario 7 - F01_2020_FB to + 78% of Scenario 3 - F01_2018_50D50V compared with the status quo. The higher profitability would be the one of Albania fleet, 3 times higher than status quo, and of Italian DTS_1824_2440, more than 2.5 times higher than status quo. Scenarios F01_2018_50D50V and HR2-F01_2020_50D50V produce the largest positive variations in average salaries of Albania DTS

1224 and Italian DTS_1824_182440, but also imply a remarkable reductions in the number of employees, estimated around -30% by 2021 for both scenarios. As excluded from all the scenarios, wages of all Montenegrin segments undergo variations higher than 50%, in particular longlines show very high increase across scenarios.

- The internal option of BEMTOOL model performing a Multi-Criteria Decision Analysis, that combines Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process(AHP), has been used to assess the performances of the alternative fisheries management policies (Fig. 1.3). According to MCDA, the scenario obtaining the higher rank is Scenario 2 - F01_2018_100D followed by Scenario 5 - F01_2020_100D. Indeed the utility associated to the socio-economic indicators is lower in Scenario 3 - F01_2018_50D50V and Scenario 6 - F01_2020_50D50V, that reduce the number of vessels. These scenarios are ranked as less efficient in the MCDA, as the social component is negatively affected by the expulsion of workers following the scraping of the vessels.
- The performed scenarios take into account the variability due to the process error, thus allowing a more adaptive advice for demersal fisheries in this area. Nevertheless the lack of a reliable stock-recruitment relationship did not allow a proper forecasting of recruitment level in the projections.
- Following the results of the predictions, the current regulations (i.e. the status quo scenario) cannot be considered effective to reach the MSY objective for this case study. All the proposed scenarios, aimed at reaching a combined F_{MSY}, produced an overall improvement respect to status quo for all the fleets.

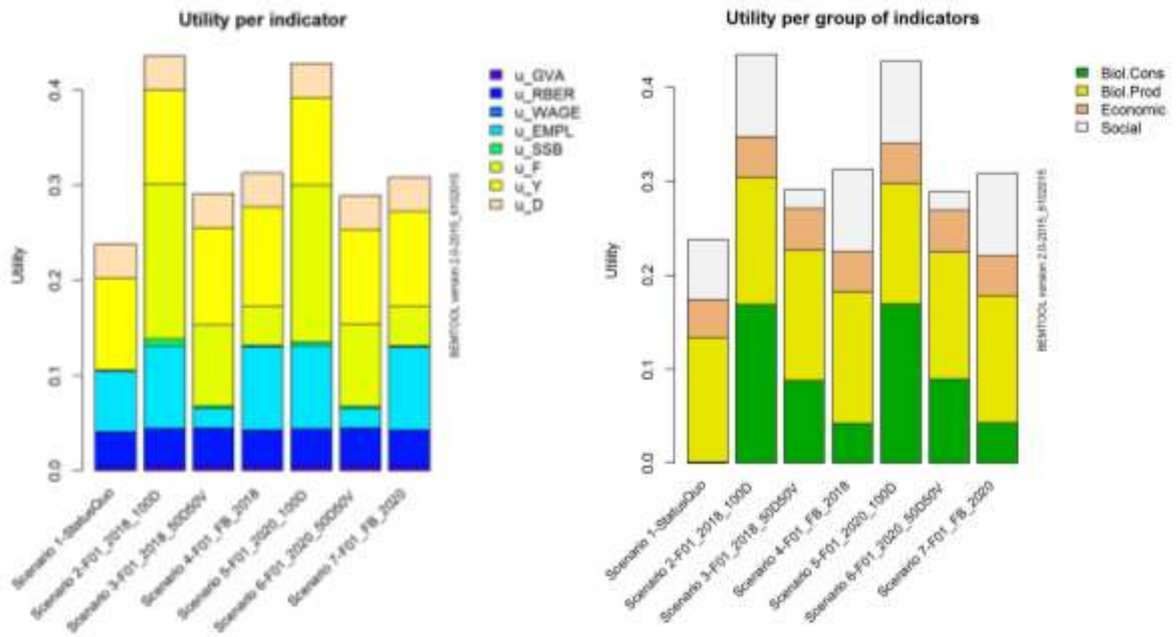


Figure 1.3 MCDA results: evaluation of the overall utility associated to each management scenario for the case study of demersal resources in the GSA18.

Table 1.8 Performances of the management scenarios (% respect to status quo) simulated in terms of SSB and overall catches, salary, CR/BER, employment and revenues. The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	**ALL fleets**											
	Salary	CR.BER	Rev	Emp	SSB red mullet	SSB hake	SSB Norway lobster	SSB pink shrimp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	41.7	49.1	12.5	6.1	103.7	336.1	308.8	149.3	-23.5	24.5	18.4	-10.7
Scenario 3 - F01_2018_50D50V	78.3	95.2	14.2	-16.9	76.6	235.4	215.5	106.5	-17.3	26.2	23.0	-4.3
Scenario 4 - F01_2018_FB	21.6	28.2	4.5	6.1	59.1	131.0	109.0	57.6	-8.4	23.4	18.9	0.4
Scenario 5 - F01_2020_100D	34.8	40.9	7.5	6.1	87.1	219.3	229.0	140.0	-28.0	12.7	-3.6	-14.4
Scenario 6 - F01_2020_50D50V	73.9	89.8	11.7	-16.9	67.4	172.5	173.2	99.4	-20.7	23.3	8.0	-6.7
Scenario 7 - F01_2020_FB	17.2	23.2	1.5	6.1	53.2	92.8	85.5	54.9	-9.7	15.0	6.4	-1.6

Table 1.9 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employment and revenues by fleet segment (ALB_DTS_1224 ITA_DTS_0612, ITA_DTS_1218 and ITA_DTS_1824_2440 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and+5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	**ALB_DTS_1224**								**ITA_DTS_0612**							
	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	102.7	108.8	-11.0	0.0	-40.2	9.7		-13.5	41.9	52.7	46.7	7.1	75.8	224.5	226.7	
Scenario 3 - F01_2018_50D50V	198.6	210.5	-4.5	-33.0	-29.4	15.9		-5.7	30.8	40.7	36.0	7.1	57.3	160.4	162.2	
Scenario 4 - F01_2018_FB	76.8	81.4	-3.0	0.0	-14.6	14.6		-13.4	-2.9	4.1	-0.2	7.1	-8.8	45.6	76.7	
Scenario 5 - F01_2020_100D	95.5	101.2	-13.3	0.0	-43.8	2.0		-16.8	37.1	47.5	42.0	7.1	65.3	194.4	159.9	
Scenario 6 - F01_2020_50D50V	192.7	204.2	-5.8	-33.0	-32.4	15.0		-8.6	28.1	37.7	33.4	7.1	50.0	153.4	124.4	
Scenario 7 - F01_2020_FB	71.7	76.0	-4.7	0.0	-15.9	7.7		-14.6	-5.1	1.6	-2.4	7.1	-10.6	36.2	55.8	

Scenario, year 2021	**ITA_DTS_1218**								**ITA_DTS_1824_2440**							
	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	-12.1	17.3	-4.7	32.3	-40.3	9.3	17.1	-15.5	65.9	74.9	7.9	1.0	-39.9	9.7	18.7	-16.0
Scenario 3 - F01_2018_50D50V	35.6	84.4	1.0	-11.3	-29.5	15.4	21.9	-7.5	149.9	169.0	13.6	-32.3	-29.3	15.9	23.4	-8.0
Scenario 4 - F01_2018_FB	-7.1	24.4	7.7	32.3	-7.8	27.6	18.5	3.9	60.6	69.0	18.1	1.0	-6.7	25.8	18.8	4.8
Scenario 5 - F01_2020_100D	-16.4	11.2	-9.0	32.3	-43.9	1.0	-4.2	-19.1	55.5	63.2	2.1	1.0	-43.7	0.8	-3.7	-19.8
Scenario 6 - F01_2020_50D50V	32.2	79.7	-1.3	-11.3	-32.7	14.2	7.2	-10.1	141.3	159.4	10.4	-32.3	-32.7	14.2	8.1	-10.8
Scenario 7 - F01_2020_FB	-10.6	19.5	4.2	32.3	-9.3	19.5	6.3	1.9	52.7	60.1	13.7	1.0	-9.0	17.8	5.9	2.9

Table 1.10 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employment and revenues by fleet segment (ITA_HOK_1218, ITA_PGP_0006_0612, MNE_DFN_0012 and MNE_DTS_0612 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	**ITA_HOK_1218**								**ITA_PGP_0006_0612**							
	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	42.2	73.5	31.4	16.6		16.6			111.6	120.1	68.7	-1.7	51.1	277.2		
Scenario 3 - F01_2018_50D50V	109.7	161.3	32.8	-21.9		-21.9			90.7	97.3	55.6	-1.7	37.9	194.3		
Scenario 4 - F01_2018_FB	-19.1	-6.3	-21.1	16.6		16.6			-7.4	-10.1	-24.5	-1.7	-31.7	-48.3		
Scenario 5 - F01_2020_100D	26.3	52.7	17.6	16.6		16.6			107.0	115.2	65.8	-1.7	47.2	244.1		
Scenario 6 - F01_2020_50D50V	95.1	142.2	24.3	-21.9		-21.9			90.4	96.9	55.4	-1.7	35.7	190.6		
Scenario 7 - F01_2020_FB	-24.6	-13.4	-25.8	16.6		16.6			-6.8	-9.4	-24.1	-1.7	-31.2	-51.4		
Scenario, year 2021	**MNE_DFN_0012**								**MNE_DTS_0612**							
	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	203.2	236.0	167.8	0.0	51.7	307.8			97.4	109.5	64.1	0.0	75.9	222.6		154.4
Scenario 3 - F01_2018_50D50V	141.5	164.4	116.9	0.0	38.2	211.4			76.1	85.6	50.2	0.0	57.2	158.1		110.0
Scenario 4 - F01_2018_FB	93.0	108.1	76.8	0.0	31.9	130.9			52.7	59.3	34.7	0.0	44.1	102.4		62.1
Scenario 5 - F01_2020_100D	168.0	195.1	138.7	0.0	47.7	248.3			94.6	106.4	62.3	0.0	65.3	200.0		144.8
Scenario 6 - F01_2020_50D50V	130.9	152.1	108.1	0.0	36.0	194.6			75.7	85.1	49.9	0.0	50.5	156.2		103.6
Scenario 7 - F01_2020_FB	83.6	97.1	69.0	0.0	33.9	111.6			50.8	57.1	33.4	0.0	44.1	91.0		59.2

Table 1.10 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employment and revenues by fleet segment (ITA_HOK_1218, ITA_PGP_0006_0612, MNE_DFN_0012 and MNE_DTS_0612 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	MNE_DTS_1224									MNE_HOK_0012								
	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp		Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	
Scenario 2 - F01_2018_100D	105.4	148.0	63.7	0.0	75.9	222.6		154.4		573.6	886.4	393.1	0.0		411.5			
Scenario 3 - F01_2018_50D50V	82.5	115.9	49.9	0.0	57.2	158.1		110.0		394.6	609.8	270.4	0.0		282.1			
Scenario 4 - F01_2018_FB	57.6	80.8	34.8	0.0	44.1	102.4		62.1		229.8	355.1	157.5	0.0		163.5			
Scenario 5 - F01_2020_100D	102.2	143.4	61.7	0.0	65.3	200.0		144.8		413.0	638.2	283.1	0.0		295.3			
Scenario 6 - F01_2020_50D50V	82.0	115.1	49.5	0.0	50.5	156.2		103.6		321.1	496.2	220.1	0.0		229.1			
Scenario 7 - F01_2020_FB	55.4	77.8	33.5	0.0	44.1	91.0		59.2		177.9	274.9	121.9	0.0		126.3			

Core findings of the project

- SEDAF was an unprecedented opportunity to provide a detailed database for socio-economic variables by country and fleet segment in Adriatic through an ad hoc data collection and through estimation process in the particular cases where the data were not available; these data will be useful for further analyses in the future and in particular to continue to take into account also the socio-economic component in the evaluation process of the state of the fisheries in Adriatic, through bio-economic models.
- The collection of detailed socio-economic data by fishing regions and fleet segments as well the comparison among homogenous fleets allowed a better understanding of quality of collected variables and an improving in methodologies of collection and analysis. In some cases as for the number of employees or for the average salary, the existence of significant differences among homogenous fleets revealed inconsistency in some of the official data and a different interpretation about the estimation of variables also evidenced by the BEMTOOL socio-economic output.
- BEMTOOL model allowed to modulate a variety of management scenarios, with different implications in terms of biological and economic consequences, also taking into account the differentiated impact on the target stocks of the various involved fleets.
- The use of the stock assessment output to parameterize BEMTOOL model revealed the need to update (e.g. *S. mantis* in GSA 17, updated to 2011) and review (e.g. small pelagic in GSA 17) several stock assessments, as well as increase the number of stock assessments in Adriatic, in order to improve the accuracy of the evaluation of resources and the corresponding catches and revenues for the relevant fisheries.

Further developments:

- modelling scenarios according to reviewed socio-economic data and updated stock assessments;
- analysing the effects of additional management measures in respect to those applied for the case studies, for example based on selectivity and considering the reaction of the sector with investments/disinvestments;
- investigating and searching for stock-recruitment relationships to properly project the recruitment in the future;
- combining bioeconomic prediction with a Management Strategy Evaluation (MSE);
- using the developed framework for the design and preparation of multiannual management plans.

2. INTRODUCTION

The objective of WP4 is to assess the impact of different management scenarios derived from the application of the recommendations of the scientific advice. Given the relevant fisheries and relevant countries by WP1, three case studies have been identified for the purpose: one for small pelagics in GSA 17 and two case studies for demersal species, one in GSA 17 and the other in GSA 18.

BEMTOOL model (Accadia et al., 2013) has been selected in order to simulate and evaluate the biological and socioeconomic consequences of the different scenarios, because implemented with a focus on the Mediterranean fisheries characteristics. BEMTOOL is a bio-economic simulation model conceived as a platform (incorporating 6 operational modules: Biological, Pressure, Economic, Behavioural, Policy/Harvest Rules and Multi-Criteria Decision Analysis – MCDA) able to simulate the effects of management measures and/or harvesting strategies in the short, medium and long-term (e.g. fishing effort limitations, mesh size restrictions, closed season). The BEMTOOL platform encompasses assessment tools (e.g. XSA, VPA, SURBA, FLR Libraries, etc.) bio-economic tools (e.g. BIRDMOD, MEFISTO, FISHRENT, AMURE IAM, BEMMFISH), simulation tools (e.g. ALADYM simulation model) and allows solutions in terms of fishing effort and/or catches, maximizing the sustainable production while avoiding discard and overfishing. SEDAF project has been considered an opportunity for BEMTOOL developers to improve the quality of the graphs and upgrade the BEMTOOL model with some additional features described in the Annex I of this document.

For each case study BEMTOOL has been parameterized with biological, pressure impact and economic parameters and fed with effort, landings and economic data to simulate the past/present situation and assess the state of the involved stocks. For each case study the projection of the current situation has been done and a set of management scenarios has been selected for the forecast simulations.
In this deliverable all the case studies have been described and for each of them the following information has been reported:

- Input of the model to the biological, pressure-impact and economic modules;
- Fitting of observed landing data and comparison with assessment results;
- Diagnosis of the stocks at the current situation;
- Projections of the status quo (with uncertainty on recruitment);
- Definition and comparison of the different management scenarios and discussion of the results.

In Annex II additional graphs with confidence intervals are reported related to all the scenarios performed, while in Annex III there are the comparison of the number of employees among the different scenarios performed.

3. *GSA 17 SMALL PELAGIC* CASE STUDY

The main stocks identified for the *GSA 17 small pelagic* case study are *E. encrasicolus* and *S. pilchardus*. Both stocks are shared among the countries belonging to GSA 17 (Italy, Croatia, Slovenia).

As concerns sardine, recent evidences from Ruggeri *et al.* (2013) confirmed the lack of genetic differentiation within the Adriatic, consistently with previous surveys based on other molecular markers, such as allozyme and mitochondrial DNA (Carvalho *et al*., 1994; Tinti *et al.,* 2002). On the other hand, for anchovy the debate is still open despite a study from Magoulas *et al.* (2006), that revealed the presence of one clade with high frequency in the Adriatic Sea (higher than 85%) with a low nucleotide diversity (around 1%), that suggests the presence of a unique stock as well.

The main fishing gears targeting anchovy and sardine are pelagic trawlers and purse seine. The former ones are more common along the western Adriatic coast, while purse seines are more present in the eastern Adriatic countries. The Italian pair trawlers tend to target anchovy (Italy is the country contributing more to catch of anchovy in the Adriatic Sea), while Croatia is the main contributor to the catch of sardine. Slovenia contribution to the small pelagic catch is much lower, due also to the dimension and organization of its fleets.

In order to take into account that the two stocks under consideration are shared among different Countries, Slovenia has been included in the case study though representing less than 1% of the total production and total revenues.

The 8 fleet segments targeting the selected stocks and considered for this case study are:

1. ITA_TM_VL_1218
2. ITA_TM_VL_1824
3. ITA_TM_VL_2440
4. ITA_PS_VL_2440
5. HRV_PS_VL_1218
6. HRV_PS_VL_1824
7. HRV_PS_VL_2440
8. SVN_PS_VL_1218

The selected fleet segments represent about 95% of production and revenues of anchovy and around 93% of production and revenues of sardine in GSA 17 in 2013 (Table1). For Italy the percentage of the production and revenues excluded by this case study is around 6 % for anchovy and 23% for sardine in 2013. For Croatia and Slovenia the percentage of excluded production and revenues is less than 2% for both target species.

Table 1 Percentages covered by the case study fleet segments.

Variable	Tot case study	Tot GSA 17	Percentage covered by the case study fleet segments
Landings Weight ANE (kg)	21 678 875	22 773 309	95%
Landings Weight PIL (kg)	66 492 066	71 409 749	93%
Landings value ANE (€)	28 470 144	29 968 294	95%
Landings value PIL (€)	29 368 317	32 290 392	91%

Source: EU DCF 2014

Nowadays, the management of these stocks is regulated through a multiannual management plan established by the General Fisheries Commission for the Mediterranean in 2012. Besides that, Italy has been enforcing for years a general regulation concerning the fishing gears and since 1988 a suspension (about one month until 2010, 60 days in 2011-2012 and 42 days in 2013) of fishing activity of pair trawlers in summer (Cingolani *et al.,* 1996). Also, a closure period is observed from 15th December to 15th January from Croatian purse seiners.

These management regulations have been taken into account to model the current situation in the case study.

3.1 SIMULATION OF THE CURRENT SITUATION

3.1.1 INPUT OF THE BIOLOGICAL MODULE

The data used for the parameterization of the biological and the pressure modules come from the stock assessments carried out during the Working Group on Stock Assessment of Small Pelagic (GFCM-WGSASP report) held in November 2014. The methodologies used is the State-Space Model (SAM, Nielsen A. and Sibert J. R., 2007) for both stocks, tuned with fishery independent information from acoustic surveys. The assessment covers the entire GSA17, combining data from Italy, Croatia and Slovenia.

For anchovy, split year assumption has been used, therefore assuming the birth date at the first of June (Cingolani *et al.,* 1993), while for sardine the calendar year has been used, assuming the birth day at the first of January.

3.1.1.1 GROWTH

The growth parameters (Sinovcic, 2000) and the length-weight relationship coefficients for the two species are listed in the Table2 and Table 3. The growth functions are for sex combined.

The life span has been set equal to 5 years (from age 0 to age 4) for anchovy, and to 7 years (from age 0 to 6) for sardine.

Table 2 Growth parameters for anchovy in GSA 17.

Parameter	Sex combined
Linf (cm)	19.4
K	0.57
t_0	-0.5
a (mm/g)	4.00E-06
b (mm/g)	3

Table 3 Growth parameters for sardine in GSA 17.

Parameter	Sex combined
Linf (cm)	20.5
K	0.46

t_0	-0.5
a (mm/g)	0.000005
b (mm/g)	3.03

3.1.1.2 RECRUITMENT

E. encrasicolus

A reliable stock recruitment relationship is not available for anchovy. For this reason a recruitment vector has been used for the simulation, whilst a constant value has been used for projections (Table 4). The recruitment used in BEMTOOL is the average between ICA and SAM stock assessment results.

Table 4 Recruitment by year used in simulation phase for anchovy in GSA 17.

Year	R (thousands)
2008	71 771 642
2009	69 580 854
2010	63 338 252
2011	73 883 494
2012	51 128 695
2013	56 514 059
2014*	59 766 278

* This value has been used for projections (geometric mean of 2011-2013)

The number of recruits entering in the population has been split by month in order to take into account the seasonal recruitment, according to the characteristics of anchovy that recruits more from May to September (Table 5). The age of recruitment has been set at 2 months.

Table 5 Proportion of recruits entering each year in the population for anchovy in GSA 17.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.025	0.05	0.1	0.15	0.15	0.15	0.15	0.15	0.05	0.025	0

For anchovy, the recruitment of 2012 has been rescaled (0.8 factor) to improve the fitting of the landing in 2013.

S. pilchardus

Also for sardine a reliable stock recruitment relationship is not available. For this reason a recruitment vector has been used for the simulation and a constant value for projections. The recruitment figures from the stock assessment results were related to age 1, being age 0 poorly represented in commercial catches. In order to have an estimate of the recruitment at age 0.5, the recruitment related to age 1 from SAM has been projected backward for a half year, assuming a total mortality of 3 (consistent with the value of natural mortality at age 0.5) and assuming that a small part of the fishing mortality impact also individuals of age 0, being present in the catches though in small part. Input recruitment is reported in the table 6.

Table 6 Recruitment by year by year used in simulation phase for sardine in GSA 17.

Year	R (thousands)
2008	25 140 734
2009	31 295 975
2010	45 823 617
2011	30 148 313
2012	41 741 233
2013	51 649 961
2014*	40 206 792

* This value has been used for projections (geometric mean of 2011-2013)

The number of recruits entering in the population has been split by month in order to take into account the seasonal recruitment, according to the characteristics of sardine that recruits more from December to April (Table 7). The age of recruitment has been set at 6 months coherently with the age class used in the assessment.

Table 7 Proportion of recruits entering each year in the population for sardine in GSA 17.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.2	0.2	0.2	0.1	0.05	0.025	0	0	0.025	0.05	0.05	0.1

3.1.1.3 MATURITY AND SEX RATIO

The size at first maturity used for anchovy is 8.14 cm TL with a maturity range of 6 mm TL (Rampa *et al.*, 2005); the size at first maturity used for sardine is 7.9 cm TL with a maturity range of 6 mm TL (Sinovcic *et al.*, 2008).

3.1.1.4 NATURAL MORTALITY

According to the assessment, the natural mortality at age was estimated using the Gislason's methodology (Gislason *et al.,* 2010) with no distinctions between sexes. Table 8 shows the values obtained for anchovy and Table 9 those for sardine.

Table 8 Natural mortality for anchovy in GSA 17.

Age	M
0	2.36
1	1.10

2	0.81
3	0.69
4+	0.64

Table 9 Natural mortality for sardine in GSA 17.

Age	M
0	2.51
1	1.1
2	0.76
3	0.62
4	0.56
5	0.52
6+	0.5

3.1.2 INPUT OF THE PRESSURE MODULE

3.1.2.1 FISHING MORTALITY

E. encrasicolus

The F-mode of ALADYM model has been used in BEMTOOL for both stocks. The overall fishing mortality by year and age from SAM model for anchovy and sardine have been split among the fleet segments according to the respective proportions in weight in the landings, thus assuming that all the fleets had the same exploitation pattern. For 2014 the same fishing mortality of 2013 has been assumed. The age range used for anchovy in the output calculation of average F was 1-2 while for sardine was 1-3, with no distinction between sexes, in agreement with the assessments. Fishing mortality by age and year is reported in the Table 11 for anchovy and in Table 12 for sardine

Table 11 Overall fishing mortality for anchovy (SAM model).

age	2008	2009	2010	2011	2012	2013
0	0.02	0.01	0.02	0.02	0.02	0.01
1	0.29	0.42	0.60	0.43	0.40	0.25
2	1.32	1.87	1.92	2.14	1.34	1.13
3	2.07	2.43	2.64	3.63	1.79	1.81
4	2.07	2.43	2.64	3.63	1.79	1.81
5	0.02	0.01	0.02	0.02	0.02	0.01

Table 12 Overall fishing mortality for sardine (SAM model).

Age	2008	2009	2010	2011	2012	2013
1	0.04	0.04	0.05	0.10	0.12	0.15
2	0.25	0.33	0.36	0.67	0.90	0.87

3	0.57	1.25	1.60	1.35	2.04	0.87
4	4.86	3.73	5.32	7.97	5.17	4.69
5	0.04	0.04	0.05	0.10	0.12	0.15
6+	0.25	0.33	0.36	0.67	0.90	0.87

3.1.2.2 EFFORT

The monthly effort variables used to simulate the past and current years by fleet segment are listed in Table 13. For 2014 the same effort as 2013 has been assumed.

Table 13 Effort for the selected fleet segment in GSA 17.

Effort Variable	ITA_TM_VL_1218						ITA_TM_VL_1824					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
average monthly GT	23	25	22	29	23	27	67	81	73	71	72	81
average monthly KW	147	152	152	172	171	171	318	321	330	343	358	358
number of vessels	32	33	38	25	47	35	25	25	25	22	21	25
annual fishing days	69	186	154	121	110	122	117	155	167	137	171	141
Effort Variable	**ITA_TM_VL_2440**						**ITA_PS_VL_2440**					
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
average monthly GT	117	117	117	116	109	109	105	114	108	114	102	87
average monthly KW	478	512	480	466	438	438	373	326	380	377	371	371
number of vessels	45	44	41	41	54	46	25	19	16	19	19	17
annual fishing days	159	169	166	143	151	165	88	91	91	77	86	63
Effort Variable	**HRV_PS_VL1218**						**HRV_PS_VL1824**					
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
average monthly GT	6	6	6	6	6	7	75	75	73	75	77	79
average monthly KW	51	51	51	51	83	89	319	319	317	283	332	340
number of vessels	43	43	43	42	45	45	59	59	61	61	57	54
annual fishing days	76	76	76	88	76	76	110	110	120	98	98	98
Effort Variable	**HRV_PS_VL2440**						**SVN_PS_VL1218**					
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
average monthly GT	155	155	151	133	136	149	10	10	12	12	12	10
average monthly KW	557	557	542	383	489	536	105	96	118	118	118	105
number of vessels	67	67	72	69	68	67	4	5	4	4	4	4
annual fishing days	110	110	132	110	110	110	96	108	120	108	72	84

3.1.2.3 LANDINGS

Landing data 2008-2013 for Italy and Slovenia were obtained from the National Programs of the EU Data Collection Framework and are in line with data collected in the WP2 - Collation and review on the main socio-economic information on the main fisheries. Croatian socio- economic data were obtained from the data collected and reviewed by the SEDAF project (SEDAF-D6 Report economic and structural overview) and refer to the period 2009-2012. Missing information in 2008 and 2013 of Croatian fleets have been estimated respectively on the basis of 2009 and 2012 landing data.

E. encrasicolus

The landing data for anchovy by fleet segment used to parameterize the model are listed in the table Table 14. For 2014 the same landing as 2013 has been assumed.

Table 14 Landing for anchovy by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	1753	8336	9508	4240	4498	2196
ITA_TM_VL_1824	5794	6317	7498	4334	2880	1813
ITA_TM_VL_2440	13373	11323	10168	7976	10368	7737
ITA_PS_VL_2440	4655	3515	2705	2564	3214	789
HRV_PS_VL_1218	1083	1145	1139	1062	564	883
HRV_PS_VL_1824	3711	3711	3285	4722	2866	3105
HRV_PS_VL_2440	6224	6224	6170	7921	4652	5134
SVN_PS_VL_1218	100	99	51	76	43	21
Total	36694	40670	40523	32894	29085	21679

According to DCF data and the recent results of MAREA LANDMED project, the discard has been considered as negligible both for pelagic trawlers and for purse seine.

S. pilchardus

The landing data for sardine by fleet segment used to parameterize the model are listed in the table Table 15. For 2014 the same landing as 2013 has been assumed.

Table 15 Landing for sardine by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	189	137	312	393	1515	2151
ITA_TM_VL_1824	557	1027	2248	2518	5138	4909
ITA_TM_VL_2440	3393	2549	3786	3733	7170	8261
ITA_PS_VL_2440	137	109	119	69	156	32
HRV_PS_VL_1218	2240	3042	2821	4839	3931	4780
HRV_PS_VL_1824	10676	10676	9449	13584	13069	15233
HRV_PS_VL_2440	18685	18685	18522	23779	24226	32531
SVN_PS_VL_1218	67	87	92	60	16	26
Total	35944	36314	37348	48975	55221	67924

According to DCF data and the recent results of MAREA LANDMED project, the discard has been be considered as negligible both for pelagic trawlers and for purse seine.

Total landing

The total landing data by fleet segment used to parameterize the model are listed in the table 16. For 2014 the same landing as 2013 has been assumed.

Table 16 Total landing by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	2519459	8817349	10746035	5675377	7625087	5261933
ITA_TM_VL_1824	6793850	7718969	10469886	7262466	9341131	6721951
ITA_TM_VL_2440	17515755	14371362	14713008	12391580	18938980	17453830
ITA_PS_VL_2440	4973287	3710416	2840449	2694943	3582849	955439
HRV_PS_VL_1218	6240221	6240221	6240221	6240221	5030039	6033892
HRV_PS_VL_1824	15420533	15420533	13648723	19620603	17260657	19677683
HRV_PS_VL_2440	26085600	26085600	25857000	33196339	30417625	40753784
SVN_PS_VL_1218	198428	235498	161067	184601	107247	68984
Total	79747133	82599948	84676389	87266130	92303615	96927496

3.1.3 INPUT OF THE ECONOMIC MODULE

Data 2008-2013 for the estimation of the socio-economic parameters for Italy and Slovenia were obtained from the National Programs of the EU Data Collection Framework and are in line with data collected in the WP2 - Collation and review on the main socio-economic information on the main fisheries. Taking into account that official Croatian socio- economic data are under revision for the purpose of this study scientist presumed data needed for this exercise. Nevertheless, Croatian socio-economic data were obtained from the data collected and reviewed by the SEDAF project and refer to the period 2009-2012. Socio-economic data for 2008 and 2013 of Croatian fleet segments data were assumed equal to 2009 and 2012 data respectively. For all fleet segments, 2014 data were assumed equal to 2013.

The economic data of the selected fleet segments used to parameterize the economic function in the projections have been reported in the following paragraphs.

3.1.3.1 REVENUES

The revenues by fleet segment for anchovy, sardine and the total revenues are reported in the tables Table 17, 18, 19. According to the revenues and the landings by fleet segment the prices in the projections have been modelled.

E. encrasicolus

Table 17 Revenues of anchovy by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	1673609	7573644	7444215	3733108	4405337	3454688
ITA_TM_VL_1824	5351637	5632733	7118840	3896844	2557411	2125463
ITA_TM_VL_2440	16341141	14090618	12507196	10086650	14897657	11158593
ITA_PS_VL_2440	10456217	7506328	4428387	4490999	5495818	3823897
HRV_PS_VL_1218	566716	566716	566716	566716	373517	968445
HRV_PS_VL_1824	2234425	2234425	2172358	3103368	2101167	2745990
HRV_PS_VL_2440	4094434	4094434	4042606	5182828	3386541	4122380
SVN_PS_VL_1218	362604	177272	138314	176687	114224	70688

Total	41080783	41876170	38418632	31237200	33331672	28470144

S. pilchardus

Table 18 Revenues of sardine by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	184366	87462	225221	302917	1232099	1042262
ITA_TM_VL_1824	403006	762618	1253694	1405249	3021998	2563310
ITA_TM_VL_2440	2820477	2450474	3236267	3123202	4961159	4826675
ITA_PS_VL_2440	125709	109718	91577	45585	126849	138378
HRV_PS_VL_1218	1862814	1862814	1862814	1862814	1360430	1956088
HRV_PS_VL_1824	4859220	4859220	4724241	6748916	4931034	6074783
HRV_PS_VL_2440	6662500	6662500	6578165	8433545	8481631	12713813
SVN_PS_VL_1218	245066	140206	219338	114100	29747	53008
Total	17163158	16935012	18191317	22036328	24144947	29368317

Total revenues

Table 19 Revenues of sardine by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	2742110	8113294	8572863	5104098	7183903	6041431
ITA_TM_VL_1824	6385558	6988394	9086260	5750189	6493183	5117546
ITA_TM_VL_2440	20084252	17153415	16631584	14039900	21366175	17416791
ITA_PS_VL_2440	11623294	7934372	4539655	4770133	6963075	5159950
HRV_PS_VL_1218	2994272	2994272	2994272	2994272	2185184	3279056
HRV_PS_VL_1824	7437141	7437141	7230554	10329363	7498727	9248474
HRV_PS_VL_2440	11467596	11467596	11322436	14515944	13420002	17905450
SVN_PS_VL_1218	792829	523187	450725	456613	301652	197824
Total	63527052	62611671	60828349	57960512	65411901	64366522

3.1.3.2 COSTS

In the following tables all the data are reported about the costs by fleet segment taken into account in the simulation phase of the case study (past and present years).

Table 20 Total variable costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	1063604	2111573	2449889	2008785	2635908	1295735
ITA_TM_VL_1824	2145098	2240255	2906460	2555495	2733456	2603544
ITA_TM_VL_2440	8422323	6601622	7023173	6963217	9382574	6812989
ITA_PS_VL_2440	2261307	1517508	1302597	1420774	1771110	824101
HRV_PS_VL_1218	171866	171866	216468	171866	197281	214475
HRV_PS_VL_1824	3603544	3603544	4194582	3164251	3120238	2993959
HRV_PS_VL_2440	5418305	5418305	7377074	5305080	5385106	5671828
SVN_PS_VL_1218	17218	45701	32926	46456	32118	38320

Total	23103265	21710374	25503169	21635924	25257791	20454951

Table 21 Other variable costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	309852	638229	799094	270177	565617	247628
ITA_TM_VL_1824	718619	903738	1086583	708015	807765	311364
ITA_TM_VL_2440	2855522	2683153	2581270	2176986	2849415	1683768
ITA_PS_VL_2440	1185758	942549	716470	663265	854491	369800
HRV_PS_VL_1218	55214	55214	55214	55214	53460	54337
HRV_PS_VL_1824	2360444	2360444	2747582	2085451	2043838	1961159
HRV_PS_VL_2440	2056438	2056438	2799860	2085451	2043838	2152659
SVN_PS_VL_1218	5870	4990	5604	8763	5966	7118
Total	9547717	9644755	10791677	8053322	9224390	6787833

Table 22 Fuel costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	753752	1473344	1650795	1738608	2070291	1048107
ITA_TM_VL_1824	1426479	1336517	1819877	1847480	1925691	2292180
ITA_TM_VL_2440	5566801	3918469	4441903	4786231	6533159	5129221
ITA_PS_VL_2440	1075549	574959	586127	757509	916619	454301
HRV_PS_VL_1218	116652	116652	161254	116652	143821	160138
HRV_PS_VL_1824	1243100	1243100	1447000	1078800	1076400	1032800
HRV_PS_VL_2440	3361867	3361867	4577214	3219629	3341268	3519169
SVN_PS_VL_1218	11348	40711	27322	37693	26152	31202
Total	13555548	12065619	14711492	13582602	16033401	13667118

Table 23 Maintenance costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	341451	350543	374666	256902	376229	301166
ITA_TM_VL_1824	301681	313421	307028	276454	272020	392587
ITA_TM_VL_2440	1005118	977129	905034	913492	1120897	1178246
ITA_PS_VL_2440	842392	631301	576226	619665	662848	18791
HRV_PS_VL_1218	161549	161549	161549	161549	190831	176190
HRV_PS_VL_1824	1409160	1409160	1415831	1250855	1397823	1358858
HRV_PS_VL_2440	1564184	1564184	1645533	1250855	1397823	1502183
SVN_PS_VL_1218	9456	19470	18470	9500	17096	13894
Total	5634991	5426757	5404337	4739272	5435567	4941915

Table 24 Total fixed costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	323459	333481	377674	258316	353956	286220

ITA_TM_VL_1824	580718	610497	582462	547411	690317	158484
ITA_TM_VL_2440	932809	923830	798286	805012	940974	622790
ITA_PS_VL_2440	535909	402282	363822	402866	474357	203378
HRV_PS_VL_1218	197481	197481	197481	197481	208366	230772
HRV_PS_VL_1824	1504923	1504923	1512047	1321008	1492815	1451202
HRV_PS_VL_2440	1670481	1670481	1757358	1321008	1492815	1604267
SVN_PS_VL_1218	1982	23945	3373	2590	1221	993
Total	5747762	5666920	5592503	4855692	5654821	4558106

Table 25 Other fixed costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	323459	333481	377674	258316	353956	286220
ITA_TM_VL_1824	580718	610497	582462	547411	690317	158484
ITA_TM_VL_2440	932809	923830	798286	805012	940974	622790
ITA_PS_VL_2440	535909	402282	363822	402866	474357	203378
HRV_PS_VL_1218	197481	197481	197481	197481	208366	202924
HRV_PS_VL_1824	1504923	1504923	1512047	1321008	1492815	1451202
HRV_PS_VL_2440	1670481	1670481	1757358	1321008	1492815	1604267
SVN_PS_VL_1218	1982	23945	3373	2590	1221	993
Total	5747762	5666920	5592503	4855692	5654821	4530258

Table 26 Labour costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	741403	3183846	3172628	1564243	2423041	2144702
ITA_TM_VL_1824	1878850	2080624	2750057	1356678	1591379	1023509
ITA_TM_VL_2440	4641090	4868782	4430297	3230790	5091402	4482947
ITA_PS_VL_2440	4174629	2615418	1336184	1338090	2185793	1914730
HRV_PS_VL_1218	271514	271514	271514	271514	236871	254192
HRV_PS_VL_1824	4927100	4927100	5132300	5262075	5364994	5173800
HRV_PS_VL_2440	4978100	4978100	5398200	5262075	5364994	5250800
SVN_PS_VL_1218	71623	180147	217697	197631	109739	63614
Total	21684309	23105531	22708877	18483096	22368213	20308294

Table 27 Depreciation costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	295005	323476	370691	413922	421209	408646
ITA_TM_VL_1824	1025203	1193317	1157258	1198260	1246142	1341602
ITA_TM_VL_2440	3262516	3717053	3522971	3058327	3709252	3356606
ITA_PS_VL_2440	2071069	2572333	2233582	2835260	1450099	1823046
HRV_PS_VL_1218	81864	81864	81864	81864	77858	79861
HRV_PS_VL_1824	3212450	3212450	3227658	5242580	3186604	3097777
HRV_PS_VL_2440	3565857	3565857	3751306	5242580	3186604	3424513

SVN_PS_VL_1218	33924.64	48430	46281	35931	27868	22649
Total	13547889	14714780	14391611	18108724	13305636	13554700

Table 28 Opportunity costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	16996	54610	41750	46207.47	39648.28577	53519.02
ITA_TM_VL_1824	51562	167617	116976	124792	123143	175323.9
ITA_TM_VL_2440	170002	624134	400336	376299	409778	484309.6
ITA_PS_VL_2440	117224	419543	234912	317388	151761	239731.2
HRV_PS_VL_1218	103620	103620	103620	103620	51418	48545
HRV_PS_VL_1824	394200.9	394200.9	394200.9	394200.9	203824.8627	170151.3
HRV_PS_VL_2440	1555156	1555156	1555156	1555156	986318.7957	856332.5
SVN_PS_VL_1218	6418.513	11884.53	4744.368	8854.554	11712.06226	15348.38
Total	2415179	3330765	2851695	2926518	1977604.006	2043261

Table 29 Total capital costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	312001	378086	412441	460129.5	460857.2858	462165
ITA_TM_VL_1824	1076765	1360934	1274234	1323052	1369285	1516926
ITA_TM_VL_2440	3432518	4341187	3923307	3434626	4119030	3840916
ITA_PS_VL_2440	2188293	2991876	2468494	3152648	1601860	2062777
HRV_PS_VL_1218	185484	185484	185484	185484	129276	131964
HRV_PS_VL_1824	3606651	3606651	3621859	5636781	3390428.863	3267928
HRV_PS_VL_2440	5121013	5121013	5306462	6797736	4172922.796	4280845
SVN_PS_VL_1218	40343	60315	51025	44786	39580	37997
Total	15963068	18045545	17243306	21035242	15283240.01	15601519

Table 30 Other income by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	325521	136832			38659	
ITA_TM_VL_1824	329852	156125			68206	
ITA_TM_VL_2440	704918	439144			398082	
ITA_PS_VL_2440					49934	
HRV_PS_VL_1218	96902	96902	96902	96902	64673	82041
HRV_PS_VL_1824	948600	948600	961600	963695	1083010	170300
HRV_PS_VL_2440	0	0	2025047	4360245	3644281	0
SVN_PS_VL_1218	0	8570	0	10466	0	0
Total	2405793	1786173	3083549	5431308	5346845	252341

Table 31 Number of employees by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013

ITA_TM_VL_1218	83	97	102	92	170	124
ITA_TM_VL_1824	110	113	109	135	148	153
ITA_TM_VL_2440	262	243	241	246	344	264
ITA_PS_VL_2440	224	170	145	152	137	142
HRV_PS_VL_1218	45	45	45	45	44	47
HRV_PS_VL_1824	473	473	493	493	529	497
HRV_PS_VL_2440	478	478	493	529	505	505
SVN_PS_VL_1218	7	16	12	18	19	16
Total	1682	1635	1640	1710	1896	1748

Table 32 Capital value by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_TM_VL_1218	1490775	1568297	1738433	1886805	1870168	1795191
ITA_TM_VL_1824	4522628	4813618	4870786	5095653	5579240	5880899
ITA_TM_VL_2440	14911190	17923840	16669745	15365561	18565833	16245221
ITA_PS_VL_2440	10281907	12048417	9781587	12959996	6875820	8041314
HRV_PS_VL_1218	2440073	2440073	2440073	2440073	1947497	2086604
HRV_PS_VL_1824	7990836	7990836	8261711	9282795	7719960	7313646
HRV_PS_VL_2440	36807905	36807905	39554763	36621415	37357276	36807905
SVN_PS_VL_1218	186100	344583	280000	315000	400000	400000
Total	78631414	83937569	83597098	83967298	80315794	78570780

3.2 FITTING OF OBSERVED LANDING DATA AND COMPARISON WITH ASSESSMENT RESULTS

The fitting of the model is quite satisfactory for both the species, with an average difference of 6.8% by year for anchovy (Table) and of -9.11 % for sardine (Table). The differences between simulated and observed data by fleet segment and year in percentage are reported in the tables 33 and 34 and in the figures 1 - 4.

Table 33 Percentage of difference between the BEMTOOL simulated landings and the observed data for anchovy.

Year	2008	2009	2010	2011	2012	2013	2014
ITA_TM_1218	-0.39	7.02	2.63	-1.68	-0.76	14.6	12.77
ITA_TM_1824	-2.72	8.77	2.98	-0.79	-2.24	12.98	12.36
ITA_TM_2440	-2.58	7.65	3.19	-0.4	-0.2	13.93	12.33
ITA_PS_2440	6.14	14.74	8.89	5	9.28	28.5	23.59
HRV_PS_1218	1.7	10.1	6.29	4.54	3.62	19.41	16.52
HRV_PS_1824	1.49	9.89	6.21	4.72	3.56	19.35	16.47
HRV_PS_2440	1.49	9.89	6.07	4.54	3.38	19.14	16.31
SVN_PS_1218	0.13	8.57	4.74	3.05	1.87	17.42	14.95

Total	**-0.16**	**8.93**	**4.17**	**1.9**	**1.58**	**16.69**	**14.5**

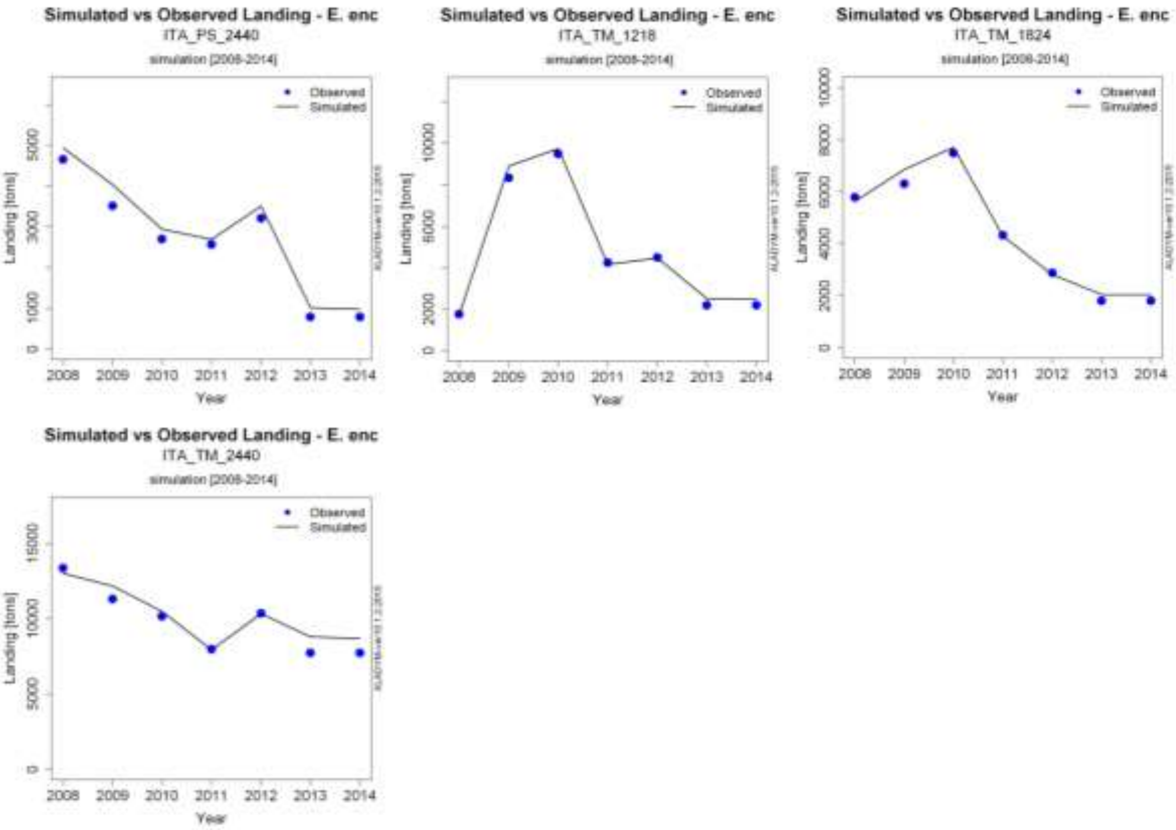


Figure 1. Comparison between simulated and observed landings by fleet segment for anchovy in GSA 17.

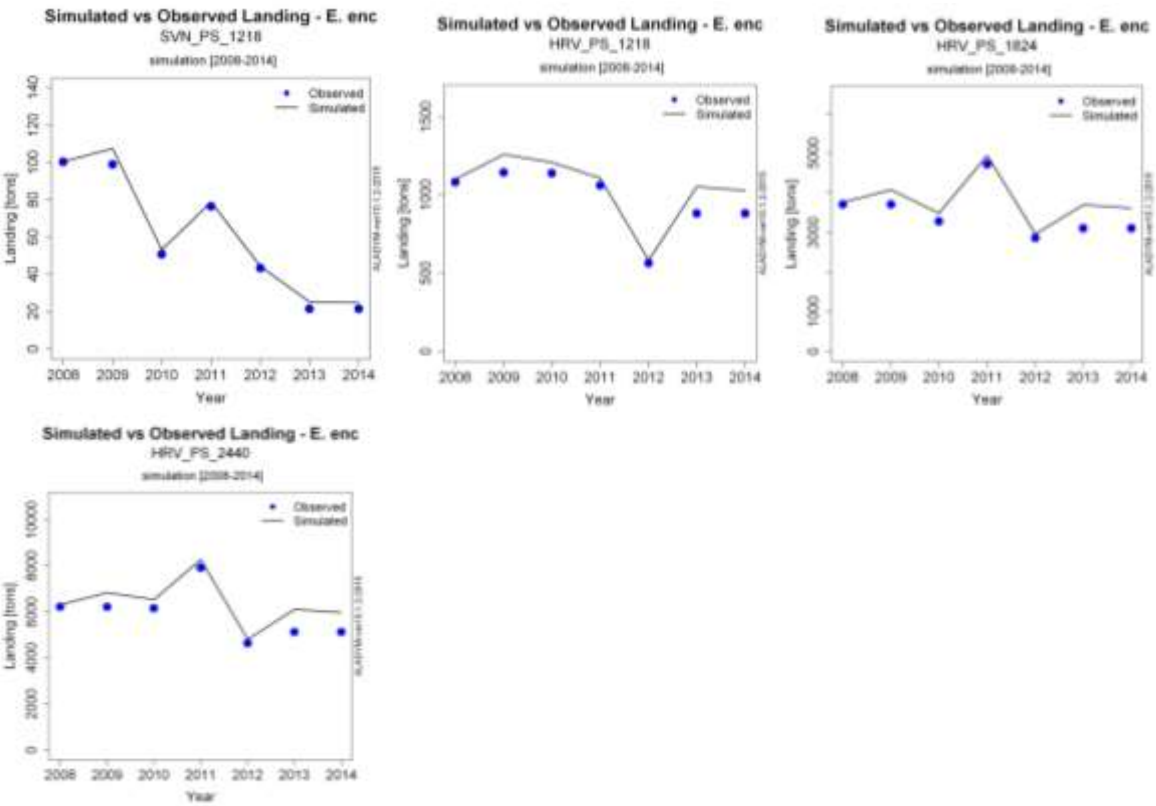


Figure 2 Comparison between simulated and observed landings by fleet segment for anchovy in GSA 17.

Table 34 Percentage of difference between the BEMTOOL simulated landings and the observed data for sardine.

Year	2008	2009	2010	2011	2012	2013	2014
ITA_TM_1218	-18.42	8.29	-6.52	-11.93	-7.16	-18	-13.43
ITA_TM_1824	-13.53	5.44	-5.3	-12.7	-7.36	-18.97	-13.79
ITA_TM_2440	-11.78	6.96	-6.35	-12.34	-7.69	-18.2	-13.53
ITA_PS_2440	-12.31	3.84	-7.46	-14.1	-9.61	-18.04	-14.48
HRV_PS_1218	-12.5	6.45	-7.87	-11.55	-7.7	-17.65	-13.54
HRV_PS_1824	-12.36	6.67	-7.78	-11.7	-7.66	-17.66	-13.54
HRV_PS_2440	-12.36	6.67	-7.62	-11.55	-7.51	-17.69	-13.54
SVN_PS_1218	-11.49	8.08	-6.05	-10.32	-6.29	-17.88	-13.44
Total	**-12.36**	**6.64**	**-7.4**	**-11.72**	**-7.57**	**-17.85**	**-13.56**

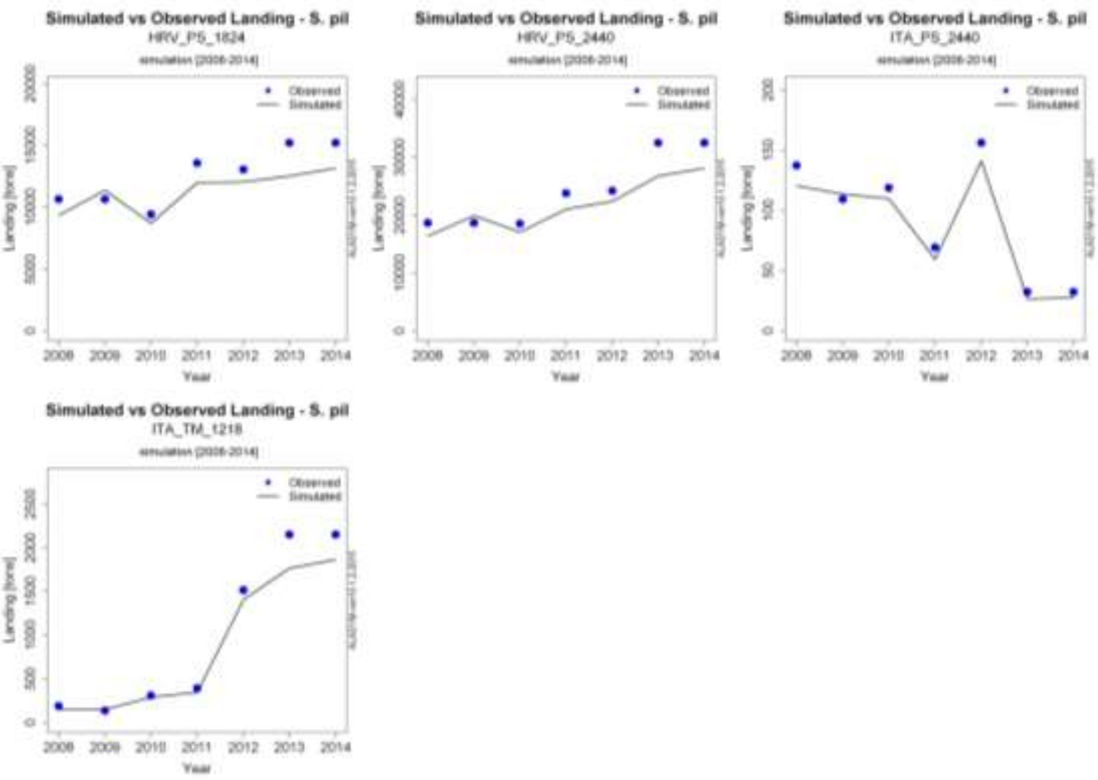


Figure 3. Comparison between simulated and observed landings by fleet segment for sardine in GSA 17.

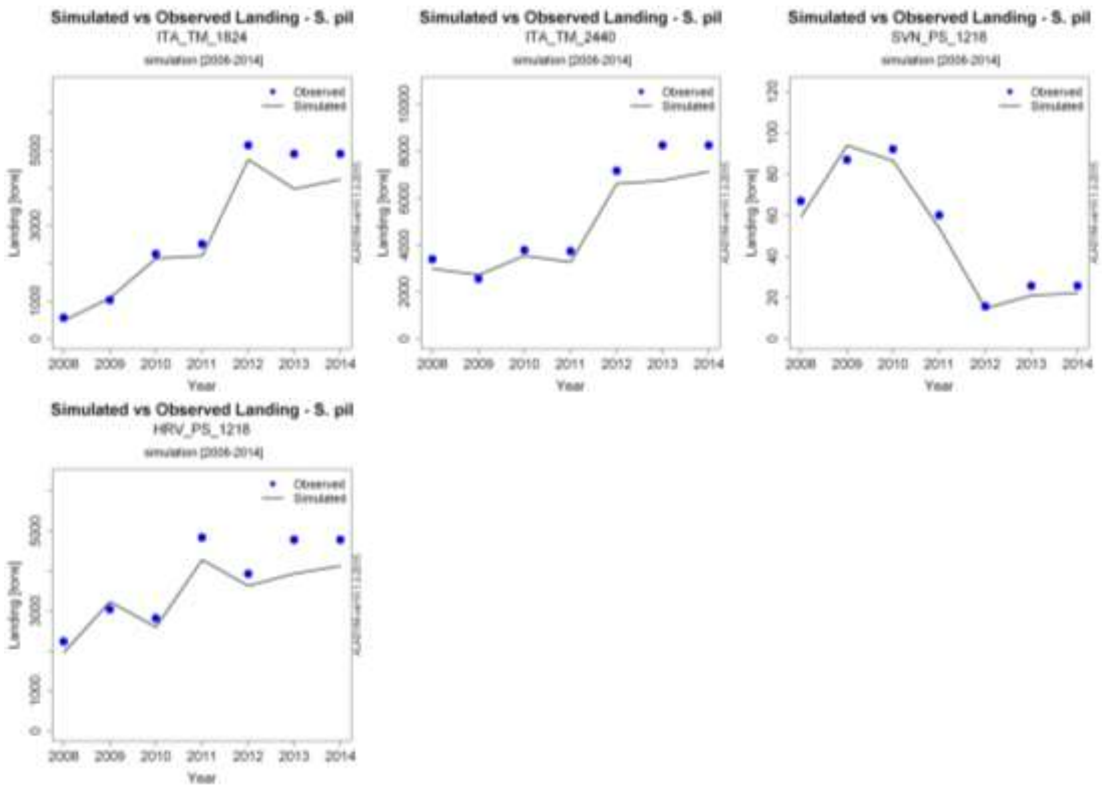


Figure 4. Comparison between simulated and observed landings by fleet segment for sardine in GSA 17.

The comparison between the Spawning Stock Biomass (SSB) from the assessment model and the BEMTOOL simulation are shown in Figure 5.

The difference in the SSB of anchovy could be due to the hypothesis of split year used in the assessment, while in BEMTOOL the calendar years have been used. Indeed, the assessment of anchovy has been performed assuming the first of June as birth date, as consequence all the input have been shifted by 6 months; in particular, the catches are constituted from the second semester of a year and the first semester of the following one. On the other hand, in BEMTOOL simulations, the production related to each calendar year has been used, in order to be consistent with the other socio-economic indicators. Thus, the input related to the anchovy stock are from the last official stock assessment and so are affected by the hypothesis of split year. Moreover, during the STECF PLENARY MEETING 15-02, held in Varese last July, STECF suggests that the timing of spawning, recruitment and maturation with respect to the fishery and assessment should be re-evaluated for the assessment of both anchovy and sardine. In particular, the report of an ad-hoc contract to support the preparation of a multiannual plan for small pelagic species in the Northern Adriatic, reviewed during the STECF PLENARY MEETING 15-02, proposed some technical changes (on proportion of mortality prior to spawning and the proportion of matures in age 0) to provide a more accurate estimation of SSB.

For sardine, the fitting of the SSB is much satisfactory as it shows a good level of agreement between BEMTOOL and SAM estimated SSB. The differences at beginning can be explained by the fact that BEMTOOL was parameterized since 2008, while the assessment has a longer time series.

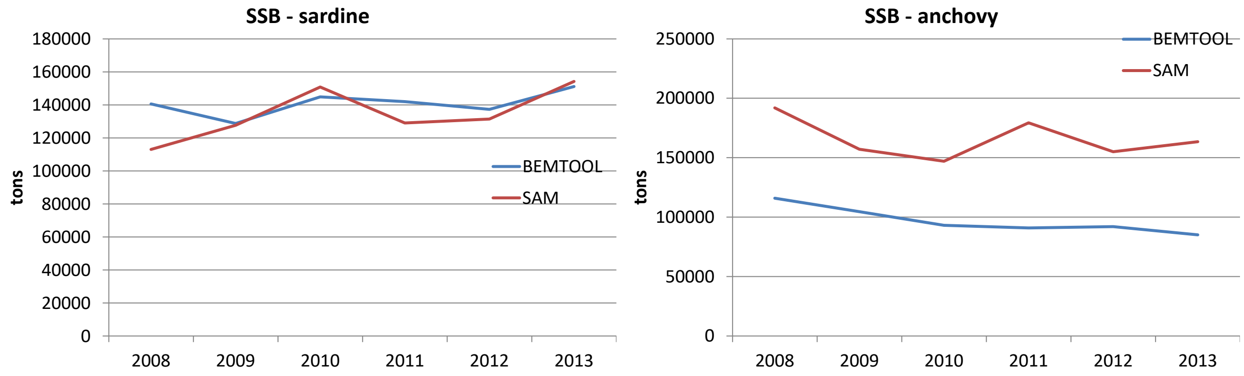


Figure 5 Comparison between BEMTOOL and stock assessment SSB by fleet segment for anchovy and sardine in GSA 17.

3.3 DIAGNOSIS OF THE STOCKS

The current F estimated by BEMTOOL, taking into account the effort modulated by month, is 0.69 for anchovy with F at level E=0.4 being 0.64. For sardine F is 0.69 with a value at level E=0.4 of 0.55. This means that in order to reach the exploitation rate of 0.4, anchovy stock would need a reduction of F of 7% and that of sardine would require an F reduction of 20% (tab. 35). For sardine the agreed precautionary reference point for SSB is also used (Bpa = 125010 tons), while for anchovy the SSB reference is the one corresponding to the level E=0.4, not existing an agreed biomass reference point yet.

Figure 6 shows the state of exploitation of the 2 small pelagic stocks in terms of fishing mortality and SSB: the anchovy stock is closer to the fishing mortality reference point (it is in the red zone), while sardine has a biomass that is greater than the precautionary reference point, even being exploited at an exploitation rate greater than the E= 0.4 (green and orange areas).

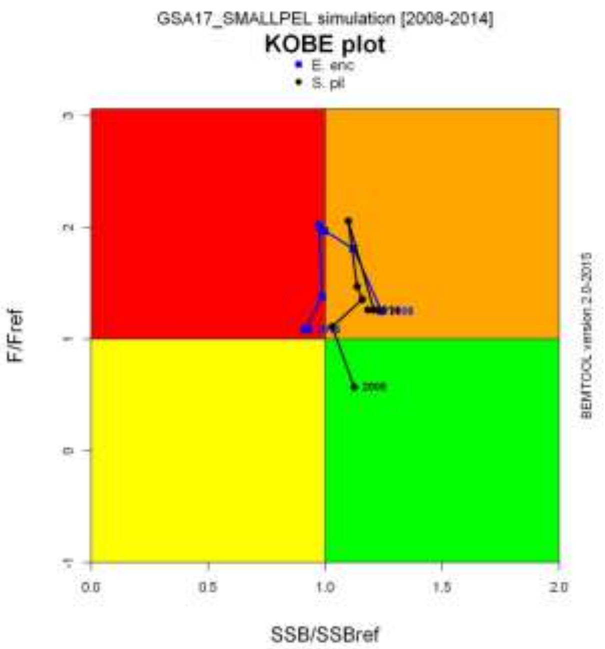


Figure 6. Kobe plot summarizing the state of exploitation for anchovy and sardine in GSA 17.

Table 35 Needed reduction by stock to reach the fishing mortality reference points in GSA 17 small pelagic fisheries.

Stock	% needed reduction (last year)	Fcurrent	Reference point	SSBcurrent	SSBref	Comments
E. enc	7	0.69	0.64	86760	93394	E = 0.4
S. pil	20	0.69	0.55	147834	125010	E = 0.4

3.4 PROJECTIONS OF STATUS QUO WITH UNCERTAINTY ON RECRUITMENT

3.4.1 INPUT OF THE BIOLOGICAL AND PRESSURE MODULES

In order to perform the projections of the stock in the future, the recruitment of anchovy and sardine has been assumed equal to the geometric mean of the last three years (respectively 59 766 278 and 40 206 792 thousands) at the beginning of the forecast phase. A multiplicative log-normal error with mean 0 and standard deviation 0.3 has been applied to the geometric mean of recruitment in order to take into account the uncertainty due to the process error that is propagated to all the indicators produced by BEMTOOL. Figure 7 shows the recruitment of anchovy and sardine with confidence interval used in all the performed scenarios.

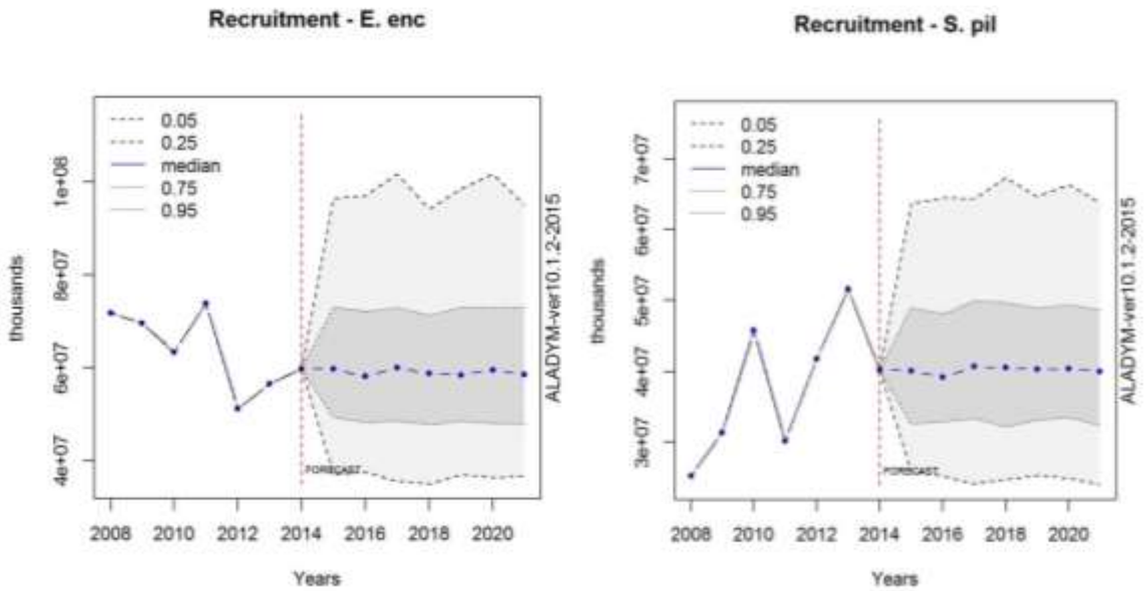


Fig. 7 Recruitment used for anchovy and sardine in the forecast scenarios with confidence intervals.

All the other biological inputs have been maintained unchanged in the projections.

For the status quo the effort has been maintained constant and equal to 2013 for all the years (until 2021).

3.4.2 INPUT OF THE ECONOMIC MODULE

Due to the presence of relevant fluctuations in the time series of most fleet segments, the socio economic parameters to be used in the forecast have been estimated on the basis of the most recent economic data available, i.e. in 2012 and 2013, as described in the next paragraphs.

3.4.2.1 PRICES DYNAMICS

The price of European anchovy and European sardine were dependent on total landings (L). In order to model this type of relationship, option one of BEMTOOL software has been selected. This option corresponds to the following equation:

$$p_{s,f,t} = p_{s,f,t-1}\left(1+\varepsilon_{s,f,landing}\frac{L_{s,f,t}-L_{s,f,t-1}}{L_{s,f,t-1}}\right)$$

where:

$p_{s,f,t}$ is the price of the target species s, for the fleet segment f at time t; (€)

$L_{s,f,t}$ is the landings of the target species s, for the fleet segment f at time t (Kg);

$\varepsilon_{s,f,landing}$ is the elasticity coefficient price-landings for species s and fleet segment f (€/kg).

According to this option the ex-vessel mean price of stock *s* landed by fleet segment *f* at time *t* is a function of the same price at time *t-1* and the relative increase of landings (at the same level of aggregation than price) from time *t-1* to time *t,* given a flexibility coefficient ε estimated for that stock and fleet segment, which represents the parameter to be estimated.

Due to the lack of reliable estimations, the flexibility coefficient was computed exogenously on the basis the existing literature on seafood demand related to small pelagic species in Northern Adriatic (Camanzi *et al.,* 2010). This study estimated price-quantity relationship equal to -0.2 for both species considered in the ex-vessel markets of the Emilia Romagna and Veneto Regions in Italy. This resulted in the parameterization reported in the table 36

Table 36 Price parameterization by fleet segment and stock in GSA 17.

Fleet segment	Model	coeff. price-landings European anchovy	coeff. price-landings European sardine
ITA_TM_VL_1218	1	-0.2	-0.2
ITA_TM_VL_1824		-0.2	-0.2
ITA_TM_VL_2440		-0.2	-0.2
ITA_PS_VL_2440		-0.2	-0.2
HRV_PS_VL_1218		-0.2	-0.2
HRV_PS_VL_1824		-0.2	-0.2
HRV_PS_VL_2440		-0.2	-0.2
SVN_PS_VL_1218		-0.2	-0.2

The low elasticity coefficients price-landings for both anchovy and sardine for all fleet segment implies that landings volume and value are little influenced by changes in prices of target species.

3.4.2.2 COSTS DYNAMICS

Variable costs

Variable costs were considered as a single item (as sum of fuel and other variable costs) and estimated in a single equation as a linear function of fishing effort EFF and the coefficient β :

$$TVC_{f,t} = \beta_f EFF_{f,t}$$

where:

$TVC_{f,t}$ are total variable costs for fleet segment *f* at time *t* (€);

$EFF_{f,t}$ is the effort (in terms of total annual days at sea) of fleet segment *f* at time *t*;

β_f is the total variable costs per unit of effort at time *t*.

Maintenance costs and fixed costs

According to option 1 of BEMTOOL model, both fixed costs OFC and maintenance costs MC are directly linked to the total annual gross tonnage GT. These functions can be represented as follows:

$MC_{f,t} = \alpha''_f GT_{f,t}$ where:

$MC_{f,t}$ are the maintenance costs for the fleet segment *f* at time *t* (€);

$GT_{f,t}$ is the annual gross tonnage;

αf' is other fixed costs per unit of *GT*.

$$OFC_{f,t} = \alpha'_f GT_{f,t}$$

where:

$OFC_{f,t}$ are the other fixed costs for the fleet segment *f* at time *t* (€);

$GT_{f,t}$ is the annual gross tonnage for fleet segment *f* at time *t*;

αf'' is the maintenance costs per unit of *GT*.

Capital costs

Depreciation costs (DC)) have been estimated as an average of the gross tonnage of the fleet segment, corresponding to option one of the BEMTOOL software.

$$DC_{f,t} = \beta'_f GT_{f,t}$$

As suggested in the 2014 Annual Economic Report on the EU Fishing Fleet "(STECF-14-16), opportunity costs of capital (*OC)* are calculated by taking into account the fixed tangible asset value (*K*) and multiplying it by the real interest (*r*).

$$OC_{f,t} = r_{f,t} K_{f,t}$$

Variable cost are directly related to the number of estimated days at sea. Similarly, fixed and capital costs are function of the estimated fleet capacity, expressed in terms of number of vessels and gross tonnage.

Labour costs

According to the prevalent income sharing system between the ship-owner and the crew, the labour cost is estimated as a percentage of the difference between total revenues and total variable costs:

$$LC_{f,t} = cs_f \left(R_{f,t} - TVC_{f,t}\right)$$

where:

$LC_{f,t}$ is the labour cost of the fleet segment *f* at *t* (€);

$R_{f,t}$ are the total revenues (target species+ other species) of the fleet segment *f* at time *t* (€);

$TVC_{f,t}$ are the total variable costs for the fleet segment *f* at time *t* (€);

cs_f is crew share for the fleet segment *f*.

Thus, labour cost are directly related to total revenues and variable cost. As highlighted in Table , the crew share ranges from 0.08 of Croatian Purse seiners 12-18 m to 0.83 of Croatian Purse seine fleet 18-24 m.

Table 37 presents the cost parameters applied to the case study broken down by fleet segment and function.

Table 37 Costs parameterization by fleet segment in GSA 17 pelagic case study

	Total variable costs per unit of effort (sea days)	crew share	maintenance costs per unit of GT	other fixed costs per unit of GT	depreciation costs per unit of GT	interest costs per unit of GT
ITA_TM_VL_1218	302	0.45	313	298	425	56
ITA_TM_VL_1824	765	0.42	196	79	829	82
ITA_TM_VL_2440	888	0.42	234	124	668	96
ITA_PS_VL_2440	1117	0.42	352	252	770	81
HRV_PS_VL_1218	70	0.08	180	207	82	50
HRV_PS_VL_1824	598	0.83	318	339	724	40
HRV_PS_VL_2440	755	0.43	151	161	344	86
SVN_PS_VL_1218	111	0.40	361	26	588	398

Revenues and total landings

Revenues by fleet segment and species are calculated by multiplying landings produced in the biological sub-model by the prices estimated on the basis of the price module.

As assessed species account for 60-90% of total revenues and production for all fleet segments, the remaining part of landings value and weight was assumed to be as a fixed percentage of the estimated revenues and production of anchovy and sardine according to option 1 of revenues modelling:

$$R_{f,t} = rr_f \sum_{s=1:n} R_{f,s,t}$$

$$L_{f,t} = ll_f \sum_{i=1:n} L_{f,i,t}$$

where:

$R_{f,t}$ is the total revenues (target species+ other species) of the fleet segment *f* at time *t* (€);

$R_{f,s,t}$ is the revenues of target species s of the fleet segment *f* at time *t* (€);

rr_f is correction factor to pass from the revenues of assessed species to the total revenues of the fleet segment *f*.

$L_{f,t}$ is the total landings weight (target species+ other species) of the fleet segment *f* at time *t* (€);

$L_{f,s,t}$ is the landings weight of target species s of the fleet segment *f* at time *t* (€);

ll_f is correction factor to pass from the landings of assessed species to the total landings of the fleet segment *f*.

Total revenues and production are thus function of the estimated landings value and weight of the two target assessed species.

Average employees per vessel

Employment in the future has been estimated by average number of employees per vessel in the fleet segment *f* (em_f) multiplied by the number of vessels for each fleet segment ($N_{f,t}$):

$$EM_{f,t} = em_f N_{f,t}$$

Capital Value

Capital value was estimated by the average value of a vessel for the fleet segment *f* at time *t*. Discount rates used are the harmonized long-term interest rates for convergence assessment calculated by the European Central Bank, available at http://www.ecb.int/stats/money/long/html/index.en.html (Tab. 38)

Table 38 Socio-economic indicators parameterization by fleet segment in GSA 17 pelagic case study.

	correction factor for landings	correction factor for revenue	average employees per vessel	value of a single vessel	discount rate
ITA_TM_VL_1218	1.34	1.34	4	51291	0.0431
ITA_TM_VL_1824	1.16	1.16	7	265678	0.0431
ITA_TM_VL_2440	1.09	1.09	6	353157	0.0431
ITA_PS_VL_2440	1.24	1.24	7	371666	0.0431
HRV_PS_VL_1218	1.12	1.12	1	46369	0.0468
HRV_PS_VL_1824	1.05	1.05	9	135438	0.0468
HRV_PS_VL_2440	1.06	1.06	8	549372	0.0468
SVN_PS_VL_1218	1.60	1.60	4	100000	0.0581

Socio-economic indicators

The current revenue to break even revenue ratio and net profit have been estimated according to the Economic performance indicator calculations provided in: "The 2014 Annual Economic Report on the EU Fishing Fleet" (STECF-14-16).

BER is calculated as Current Revenue (CR) divided by the Break Even Revenue (BER), where:

Current Revenue (CR) = income from landings + other income

Break Even Revenue (BER) = fixed costs / (1-[variable costs / current revenue])

Fixed costs include non-variable costs, annual depreciation, opportunity cost of capital.

Variable costs include crew wage, unpaid labour, energy costs, repair costs and other variable costs.

Net profit is the difference between revenue and explicit costs and opportunity costs. It includes all operational costs, such as wages, energy, repair, other variable, fixed costs and depreciation and opportunity costs of capital. It measures the efficiency of a producer in society's view by evaluating the total costs of inputs (excluding natural resource costs) in comparison to outputs or revenue. Therefore, economic profit is the primary indicator of economic performance and is often used as a proxy of resource rent in fisheries. The excess of revenue over the opportunity cost of producing the good is also referred to as supernormal or abnormal profits. Abnormal profits in a sector is an incentive for other firms to enter the industry. Zero or a negative profit may indicate high competition in the sector and can be used as one of the indicators of overcapacity.

3.4.3 RESULTS OF THE BIOLOGICAL AND PRESSURE INDICATORS IN THE STATUS QUO FORECAST

Projecting the current effort for all the fleet segments and assuming for both stocks a recruitment varying respectively from -40% to +70% for anchovy and from -40% to +68% around the geometric mean of the last three observed years, the proxy of the probability that the SSB of sardine was less than the biomass reference point (Bpa = 125 010 tons) is 35.6%. As for anchovy an agreed biomass reference is not yet agreed, thus the reference SSB is that corresponding to the level E=0.4. The proxy of the probability that the SSB of anchovy was less than this reference level is 49.2% (Figure 8). Figure 9 shows the SSB of anchovy and sardine for status quo scenarios; the SSB of anchovy after a slight increase remains quite stable until 2021, while sardine SSB shows a slight decrease until 2016 and then it remains quite stable until 2021. A similar behaviour is shown by the landings by fleet segment for the 2 stocks (Figure 10 and 11).

The slightly increasing trends in the projections until 2017 observed in SSB and landings of anchovy for all the fleet segments are due to the recruitment used in the projections, and thus from 2014 that is about 6% higher than 2013 (because of the very high value in 2011). Indeed, the first years of projections are influenced by this higher recruitment value, that is constant from 2014 and then from 2017 reach a plateau slightly higher that the value of 2013 (for landing of all the fleet segments is around 19-21% and for SSB is around 10%).

For SSB and landings of sardine stock the situation is opposite: the recruitment value used for projection and estimated as the geometric mean of the last three years is lower (around -22%) than the recruitment of 2013; for this reason both SSB and landings for all the fleet segments, after a slight decrease from 2015 to 2017 reach a plateau lower than the observed value in 2013 (for landing of all the fleet segments is around -21% and for SSB is around -12%).

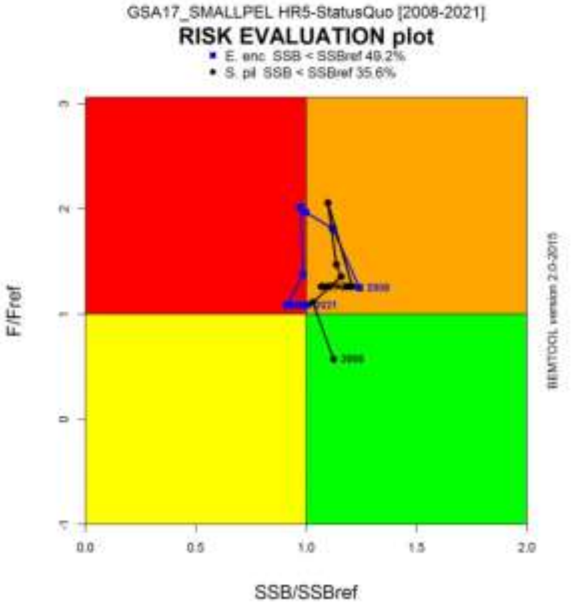


Figure 8 Kobe plot summarizing the status of anchovy and sardine in GSA 17.

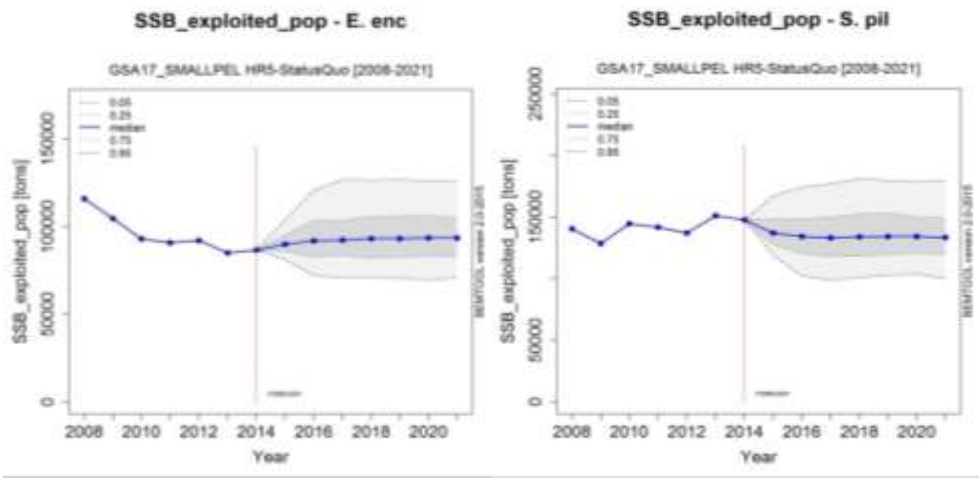


Figure 9 SSB for anchovy and sardine in the status quo scenario with confidence intervals.

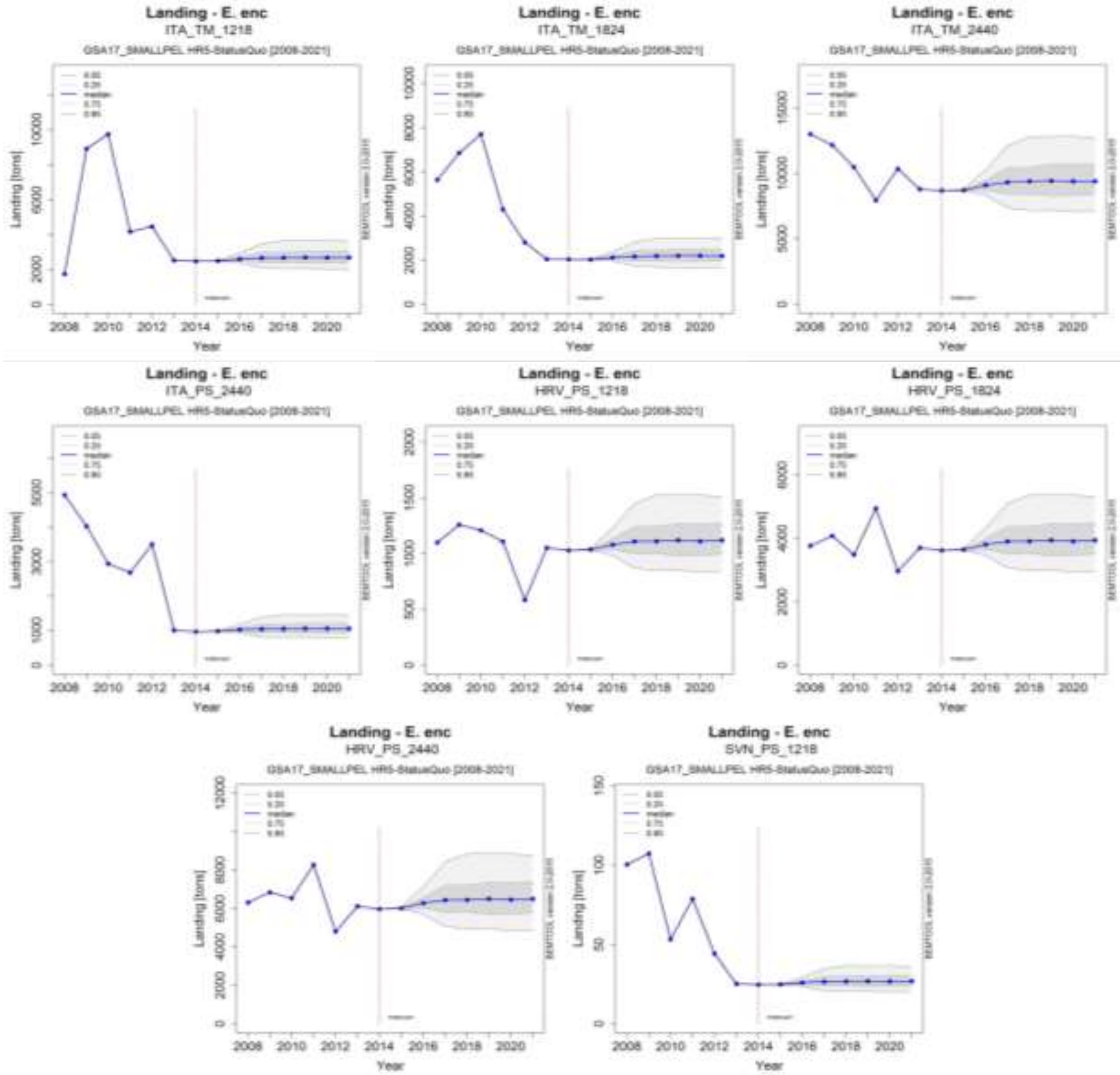
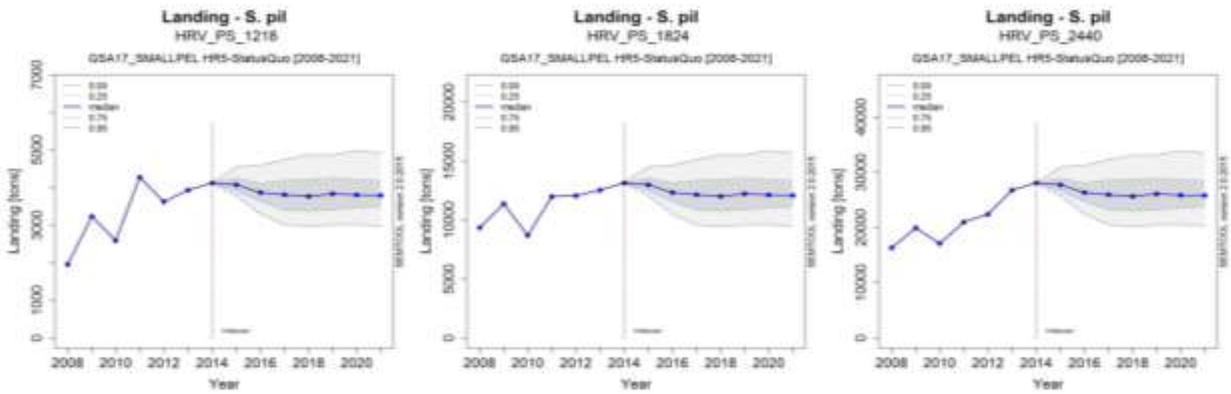


Figure 10 Landing for anchovy by fleet segment in the status quo scenario with confidence intervals.



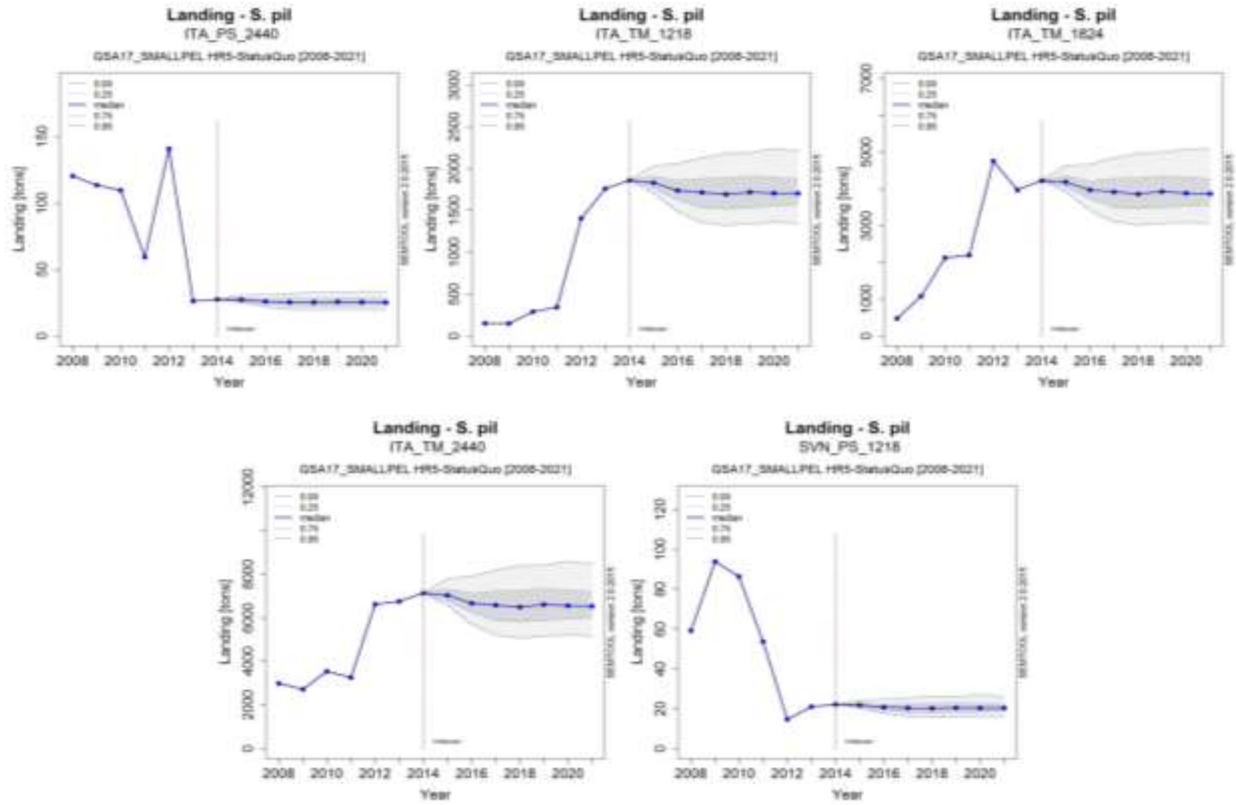


Figure 11 Landing for sardine by fleet segment in the status quo scenario with confidence intervals.

3.4.4 RESULTS OF THE SOCIO-ECONOMIC INDICATORS IN THE STATUS QUO FORECAST

Total revenues and landings of most of fleets included in the case study present a strong variability between 2008 and 2013 as highlighted in the Figure 12 12. Although between 2008 and 2013 landings of all fleet segments together increased by 1% in terms of value and by 22% in terms of weight, the fluctuations become more pronounced by fleet segment. Between 2008 and 2013 very significant differences appear for the Italian pelagic trawl segment 1218 m, the Italian purse seine segment 2440 m, the Croatian purse seiners 2440 m and the Slovenian purse seiners 1218 m both in terms of landing value and weight.

In 2013 the total fleet considered in the case study produced 97 thousand tons of total production generating 64 million euro, a + 5% in quantity and -2% in value compared to 2012. Contrary to this general trend, Italian fleet segments and Slovenian purse seiners 1218 m show a strong decrease in their productivity between 2012 and 2013.

The inclusion of uncertainty on recruitment propagated to the total production shows in 2015, variation from a -5% of the 5th quantile to a +8% of the 95th quantile compared with the median. Croatian Purse seiners 1218 m and 2440 m show the largest inter-quantile range in 2015 , from a -6% of the lower quantile to +10% of the upper quantile compared with the median values.

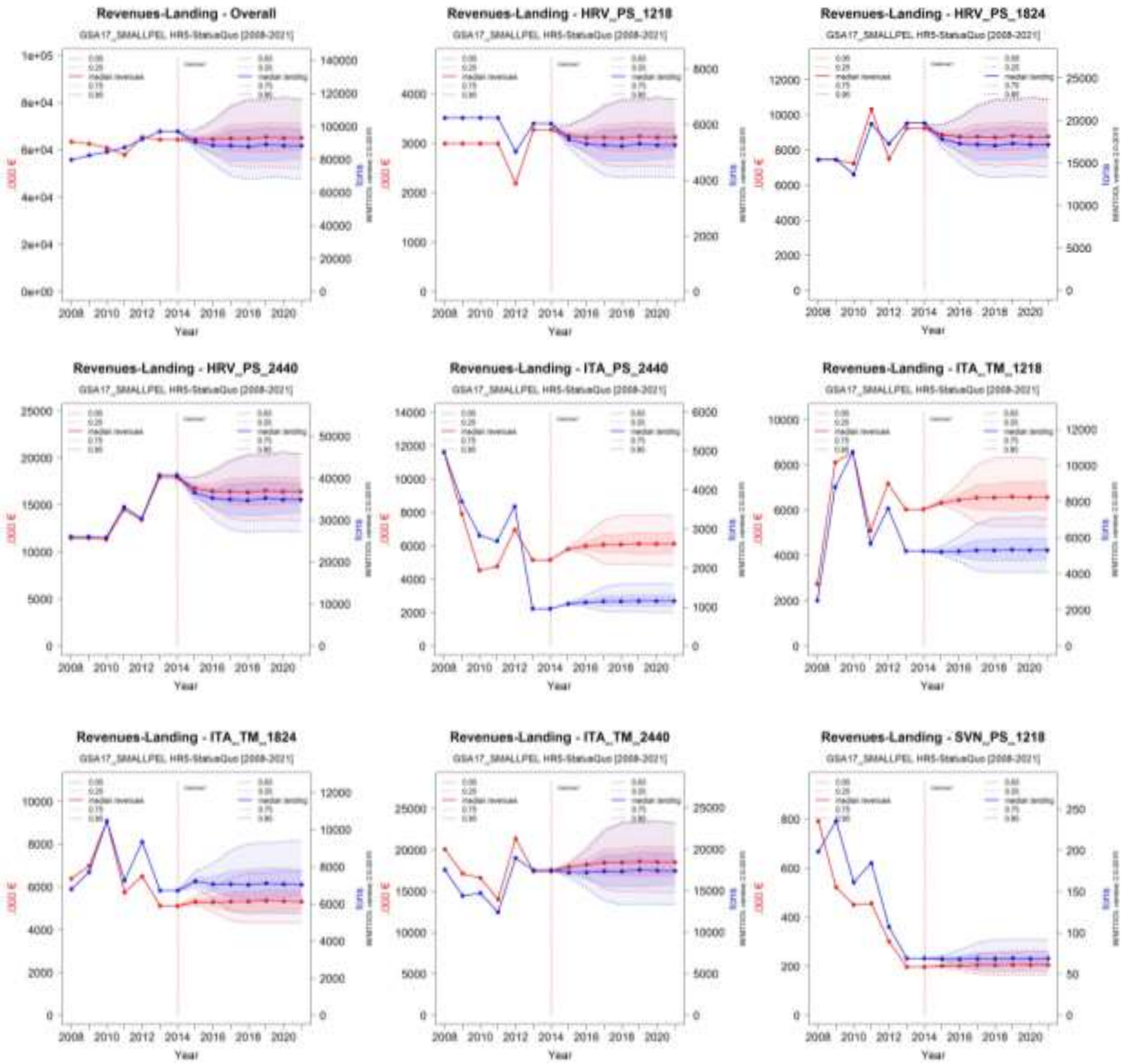


Figure 12 Landings weight and value by fleet segment with confidence intervals.

The economic efficiency of the fishing sector, calculated as net profit, is negative for the Croatian purse seiners 1824 m and 2440 m and for the Italian pelagic trawlers 1824 m between 2008 and 2013. Net profit of the whole fleet analysed remains negative in the period 2008-2013 although it increases by 80% between 2008 and 2013. In 2013, net profit of the whole fleet increases by 62% compared with 2012.

In the forecast period, net profit of all fleet investigated highlights constant or increasing trends. Taking into account the propagated uncertainty on recruitment, net profit for all fleet segments included in the case study varies from a -116% of the lower quantile to +186 % of the upper quantile compared with the median values. This range is narrower compared with the fluctuations observed in the time series. At segment level, Croatian purse seine fleet 2440 m shows the largest inter-quantile range, followed by the Italian pelagic trawlers 1824 m and 2440 m, though this range is narrower compared to the fluctuations observed in the time series.

The Current Revenue to the Break-Even Revenue ratio (CR/BER), which shows how close the current revenue is to the revenue required for the to break even, is greater than 1 for all fleet segments in 2013 with the only exception of Croatian purse seiners 1824 m and 2440 m (Figure 13). All fleet segments show increasing trend in CR/BER except the Italian pelagic trawlers 1824 m. As for total landings and revenues, Croatian Purse seiners 1218 m and 2440 m show the largest inter-quantile range in 2015.

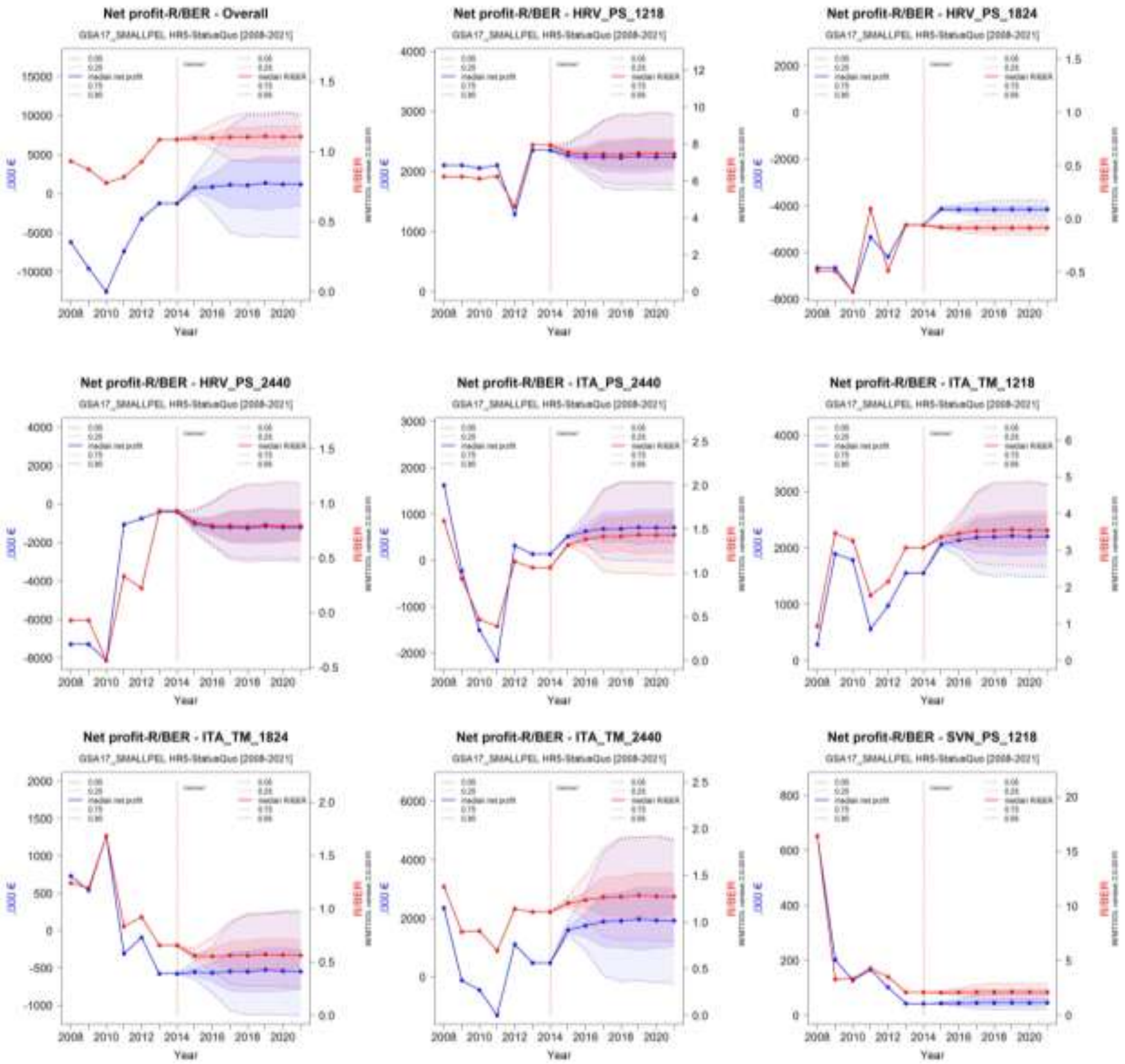


Figure 13 Net profit and Current Revenue to the Break-Even Revenue ratio by fleet segment with confidence intervals.

3.5 DEFINITION AND COMPARISON OF THE DIFFERENT MANAGEMENT SCENARIOS

According to state of exploitation of anchovy and sardine in GSA 17, 7 forecast scenarios have been performed in order to evaluate the consequences of several management strategies in terms of costs and benefits on the stocks and on the productive and economic performances of different fleet segments. These scenarios are reported in the following table 39a

Table 39a. Planned forecast scenarios for exploring different management options for small pelagic stocks in GSA17.

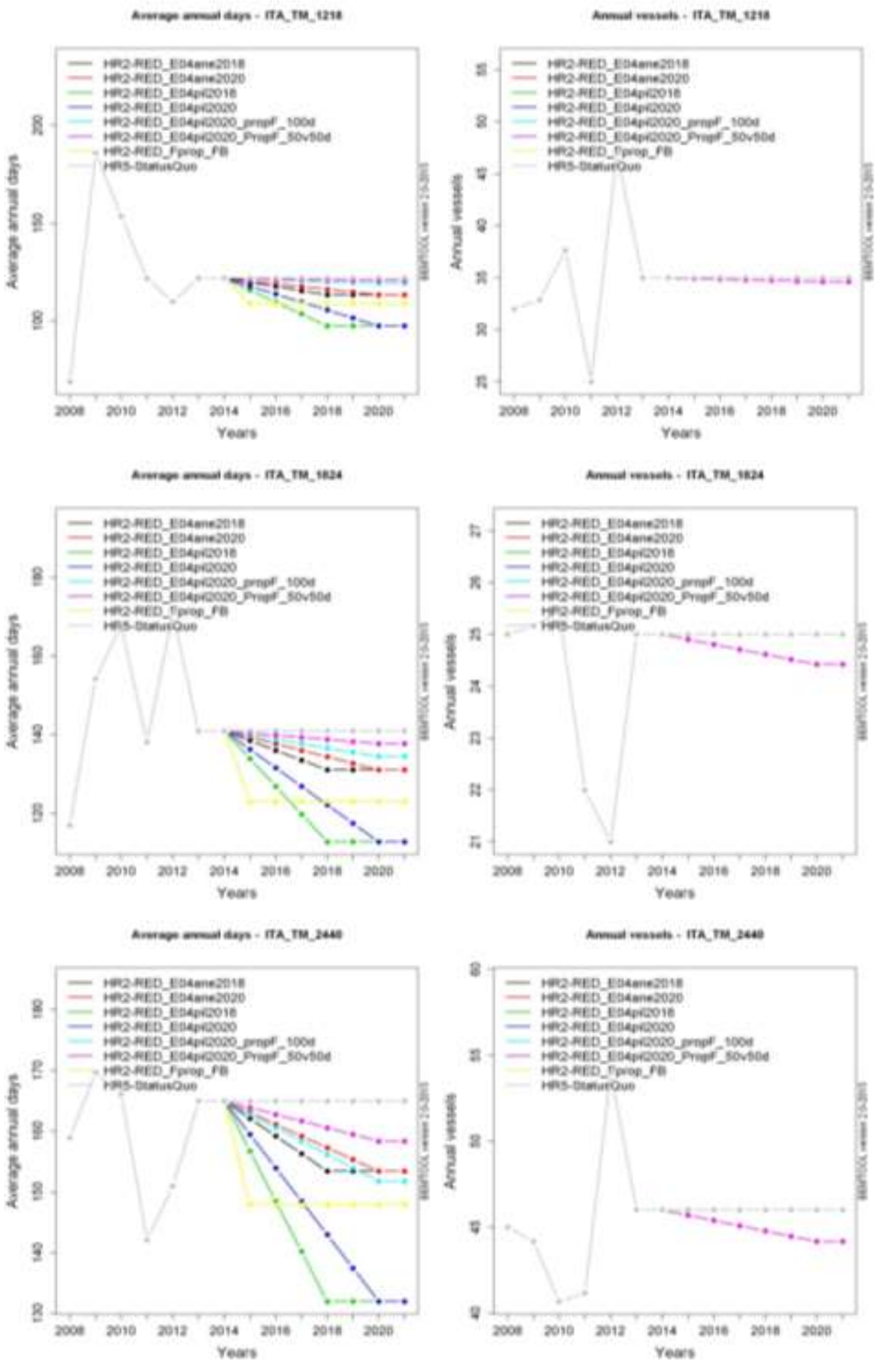
HR2 RED_E04ane2018	reduction (7%) of F towards the reference point of anchovy (E=0.4) in 2018 of the same percentage for all the fleet segments and applied only to fishing days;
HR2 RED_E04ane2020	reduction (7%) of F towards the reference point of anchovy (E=0.4) in 2020 of the same percentage for all the fleet segments and applied only to fishing days;
HR2 RED_E04pil2018	reduction (20%) of F towards the reference point of sardine (E=0.4) in 2018 of the same percentage for all the fleet segments and applied only to fishing days;
HR2 RED_E04pil2020	reduction (20%) of F towards the reference point of sardine (E=0.4) in 2020 of the same percentage for all the fleet segments and applied only to fishing days;
HR2 RED_E04pil2020_PropF_100d	reduction of F towards the reference point of sardine (E=0.4) in 2020 with percentages proportional to the impact of each fleet segment on the sardine stock, applied to fishing days (except Italian and Slovenian purse seines, because representing less than 1% of the impact);
HR2 RED_E04pil2020_PropF_50v50d	reduction of F towards the reference point of sardine (E=0.4) in 2020 with percentages proportional to the impact of each fleet segment on the sardine stock, applied half to fishing days and half to the number of vessels as potential withdrawal (except Italian and Slovenian purse seines, because representing less than 1% of the impact);
HR2 RED_Fprop_FB	fishing ban in the months with higher occurrence of offspring of sardine with percentages proportional to the impact of each fleet segment on the sardine stock. This measure is applied each year from 2015 to 2021.The fishing ban already carried out by the different fleet segments has been taken into account.

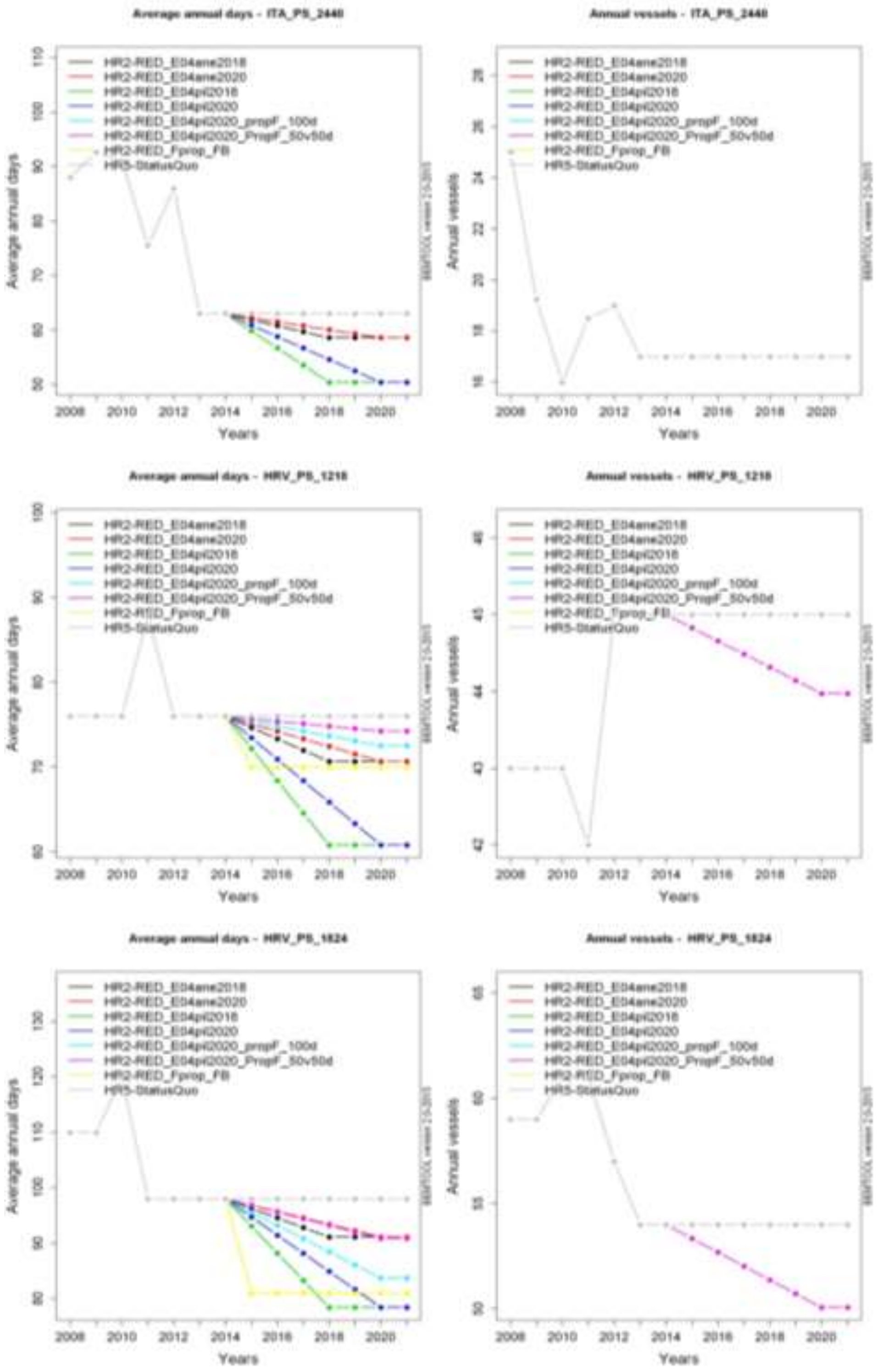
Table 39b reports the percentage of fishing mortality due to the different fleet segments.

Table 39b Percentage of fishing mortality due to the different fleet segments.

Percentage F due to the different fleet segments				
Year	**ITA_TM_1218**	**ITA_TM_1824**	**ITA_TM_2440**	**ITA_PS_2440**
2013	3.21	7.05	12.24	0.05
Year	**HRV_PS_1218**	**HRV_PS_1824**	**HRV_PS_2440**	**SVN_PS_1218**
2013	7.03	22.42	47.96	0.04

Figure 14 shows the effort change, in terms of annual fishing days and number of vessels, by fleet segment driving the performed management scenarios.


Average annual days - ITA_TM_1218
Annual vessels - ITA_TM_1218
Average annual days - ITA_TM_1824
Annual vessels - ITA_TM_1824
Average annual days - ITA_TM_2440
Annual vessels - ITA_TM_2440
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Average annual days
Annual vessels
Years


Average annual days - ITA_PS_2440
Annual vessels - ITA_PS_2440
Average annual days - HRV_PS_1218
Annual vessels - HRV_PS_1218
Average annual days - HRV_PS_1824
Annual vessels - HRV_PS_1824
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Average annual days
Annual vessels
Years

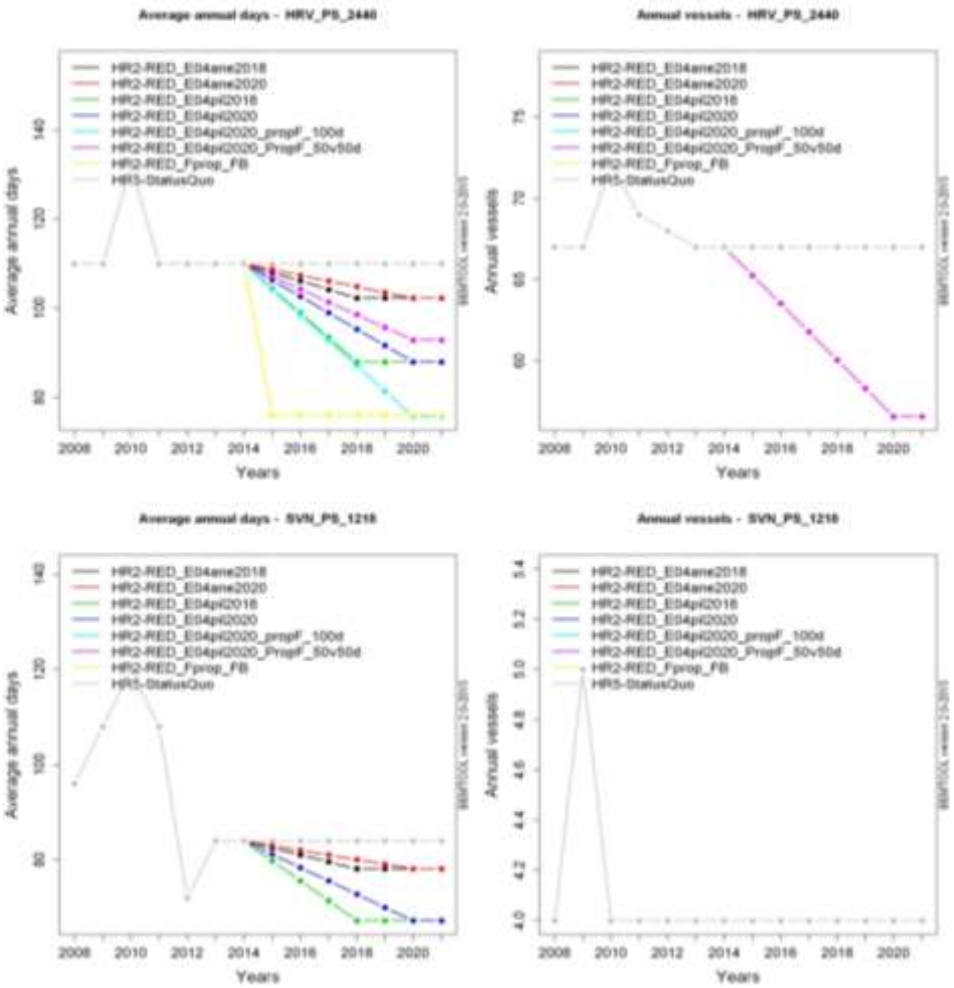


Figure 14 Effort change (fishing days and number of vessels) driving the different management scenarios by fleet segment.

3.5.1 BIOLOGICAL AND PRESSURE INDICATORS

Both SSB of anchovy and sardine show the best performance with the HR2-RED_E04pil2018 scenario and the worst result in the status quo scenario. Indeed HR2-RED_E04pil2018 would produce an SSB value 5.5 % and of 7.9% greater than the value of status quo in 2021, respectively for anchovy and sardine. These results seem consistent with the greater benefit that generally the reduction in fishing mortality produce on the indicators if applied in a short timeframe.

After HR2-RED_E04pil2018, the best scenario for anchovy stock and one of the better for sardine is HR2-RED_Fprop_FB (Figure 15). However, a higher reduction in the months with a major concentration of offspring does not seem as crucial as the proportionality of the reduction by fleet segment in this case study. Indeed, for both stocks the scenarios HR2-RED_Fprop_FB, HR2-RED_E04pil2020_propF_100d and HR2-RED_E04pil2020_propF_50d50v give results very similar in terms of SSB.

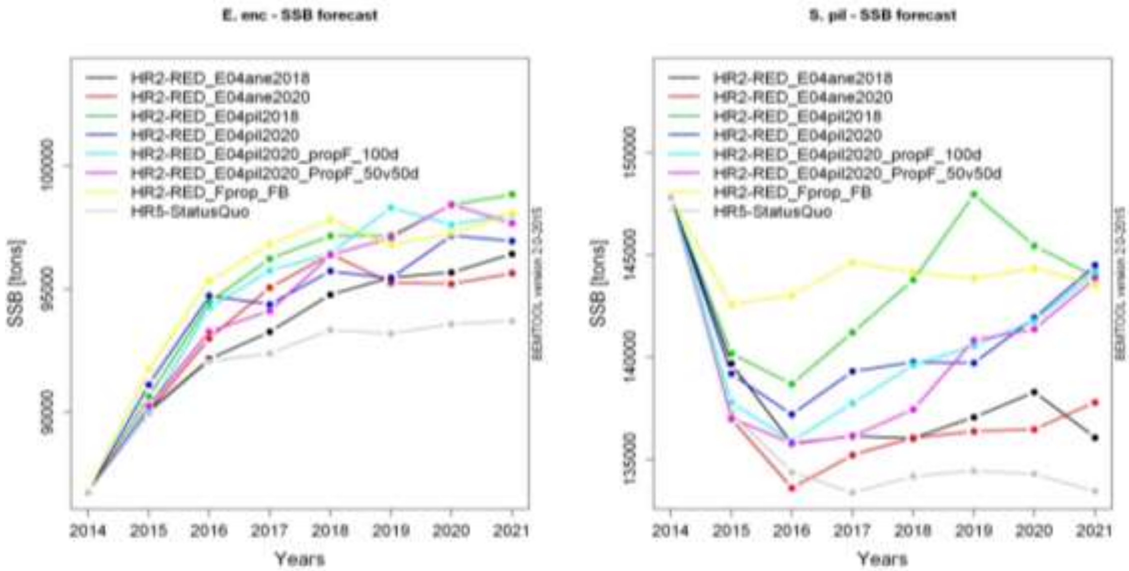
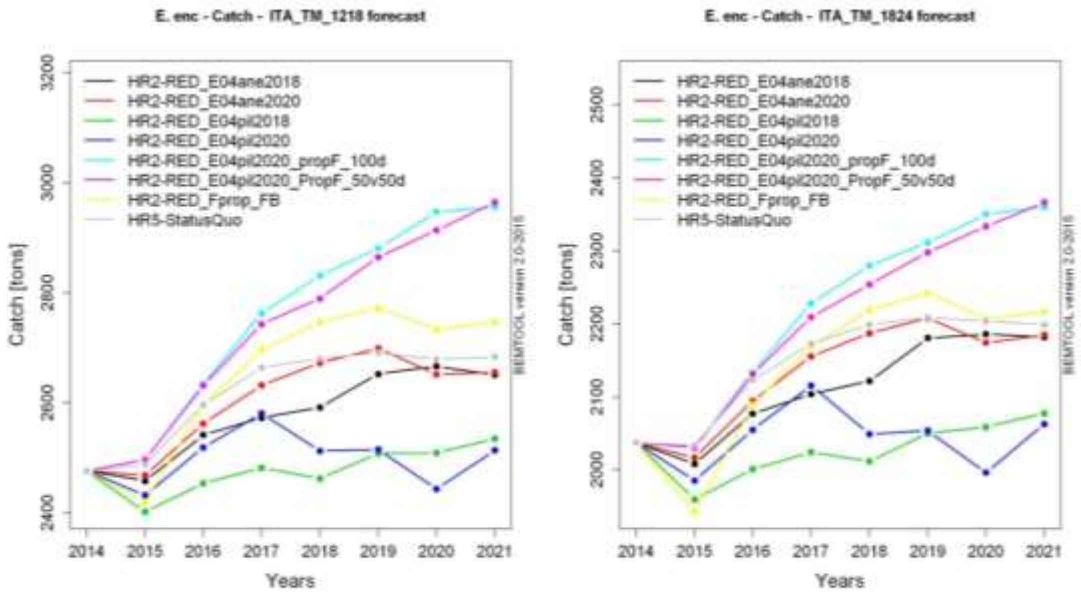


Figure 15 SSB of anchovy and sardine in GSA 17: comparison among the management scenarios.

As regards anchovy catches, the best scenario is HR2-RED_E04pil2020_PropF_50d50v for all the fleet segments, except HRV_PS_1824 and HRV_PS_2440. Regarding sardine catches, the best scenarios are HR2-RED_E04pil2020_PropF_50d50v and HR2-RED_Fprop_FB for all fleet segments, except for HRV_PS_1824 and HRV_PS_2440.

This seems quite consistent with the way the management measures have been implemented, because, HRV_PS_1824 and HRV_PS_2440 that are the fleet segments more penalized, being the more impacting on sardine stock, would obtain the best result in the status quo scenario, while the other fleet segments would obtain, as expected, an higher benefit in the other management scenarios.

The main results of the projections carried out in terms of SSB and catches of the two stocks by fleet segment are showed in the figures 16 and 17.



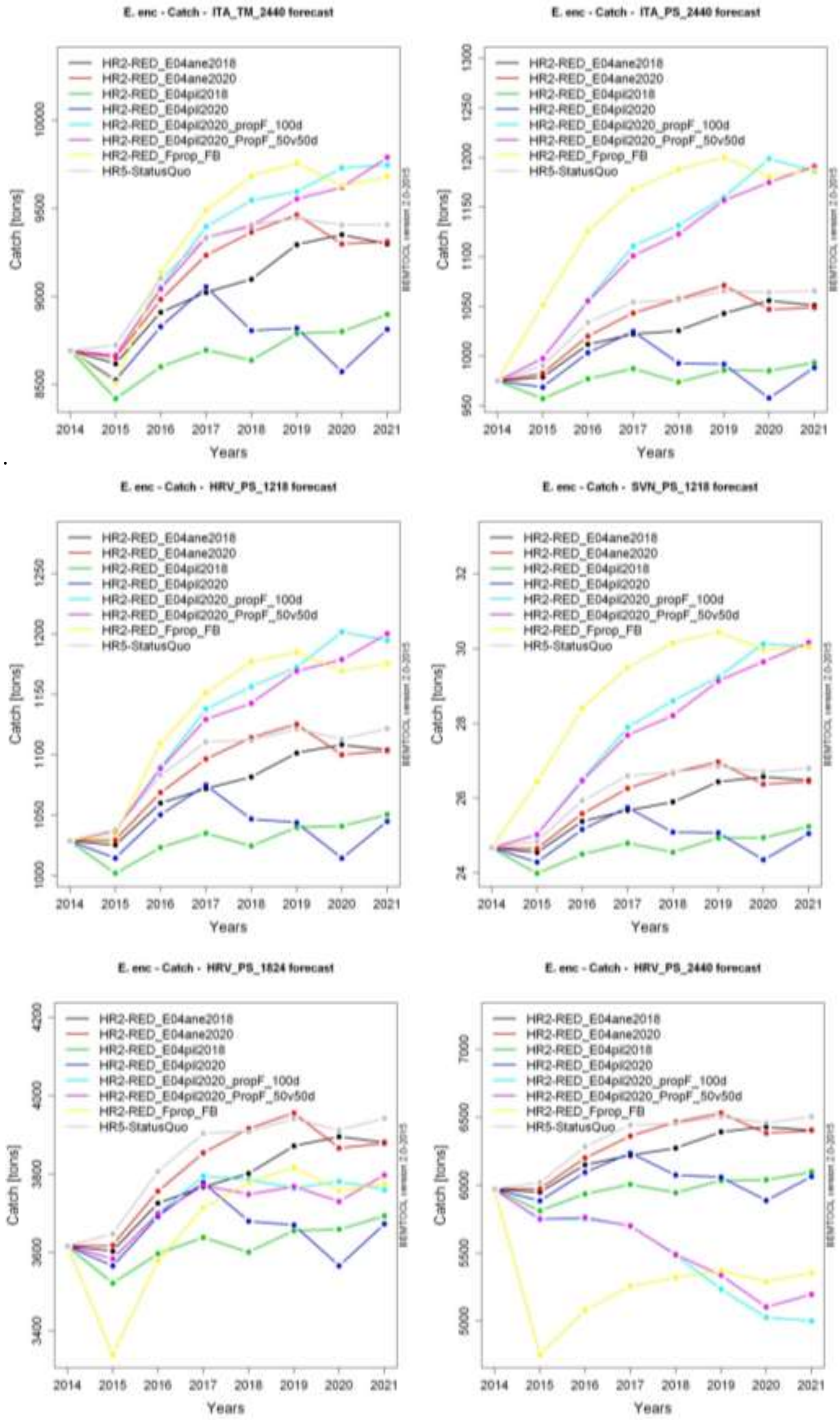
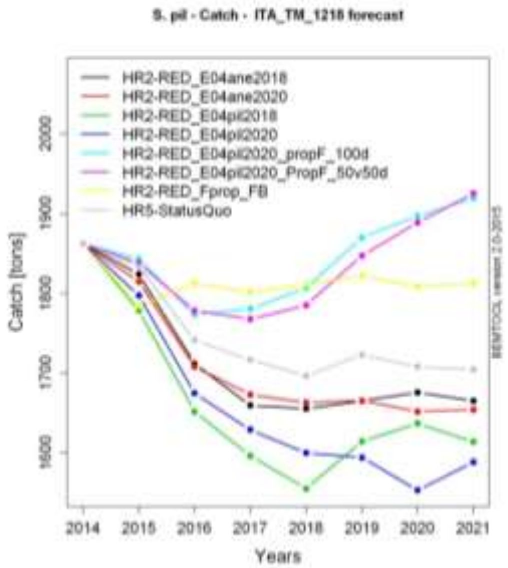
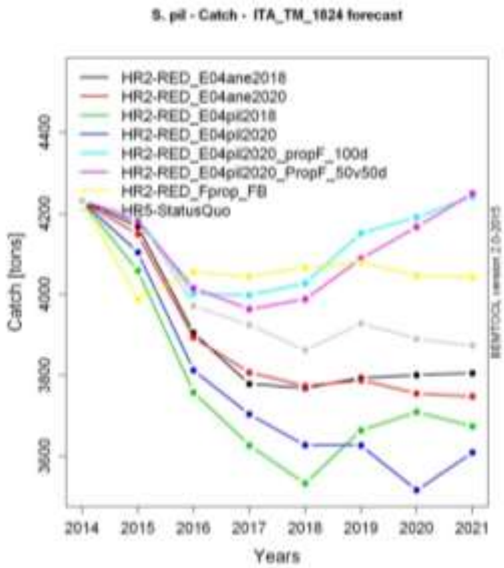
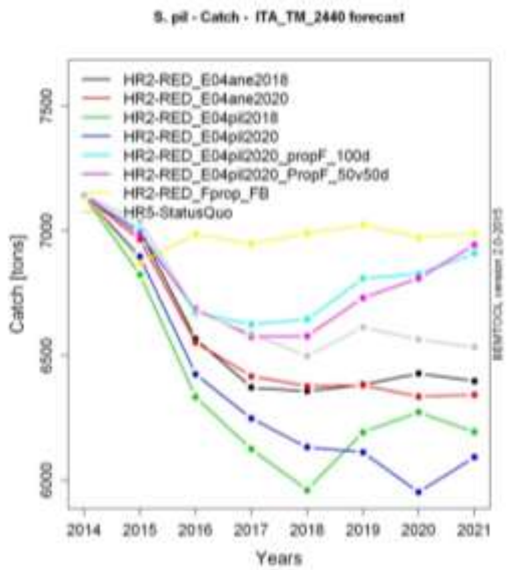
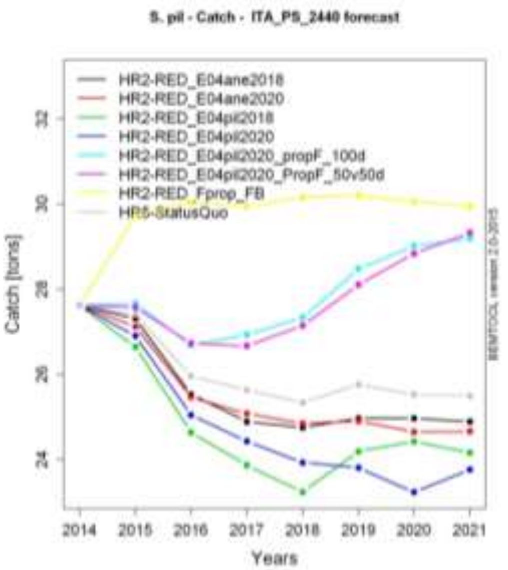


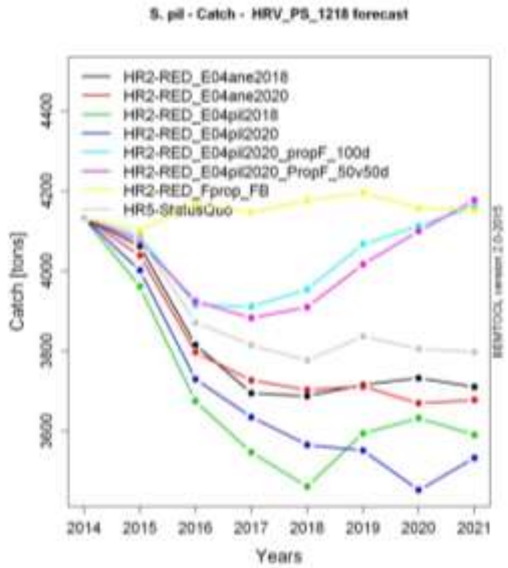
Figure 16 Catch of anchovy in GSA 17 by fleet segment: comparison among the management scenarios.

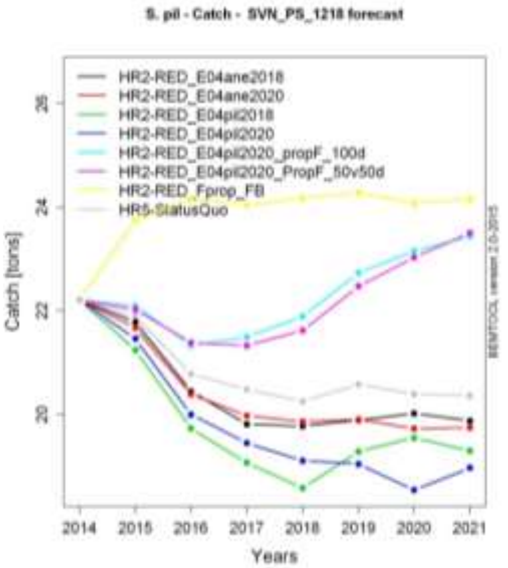

S. pil - Catch - ITA_TM_1218 forecast
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Catch [tons]
Years


S. pil - Catch - ITA_TM_1824 forecast
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Catch [tons]
Years


S. pil - Catch - ITA_TM_2440 forecast
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Catch [tons]
Years


S. pil - Catch - ITA_PS_2440 forecast
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Catch [tons]
Years


S. pil - Catch - HRV_PS_1218 forecast
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Catch [tons]
Years


S. pil - Catch - SVN_PS_1218 forecast
HR2-RED_E04ane2018
HR2-RED_E04ane2020
HR2-RED_E04pil2018
HR2-RED_E04pil2020
HR2-RED_E04pil2020_propF_100d
HR2-RED_E04pil2020_PropF_50v50d
HR2-RED_Fprop_FB
HR5-StatusQuo
Catch [tons]
Years

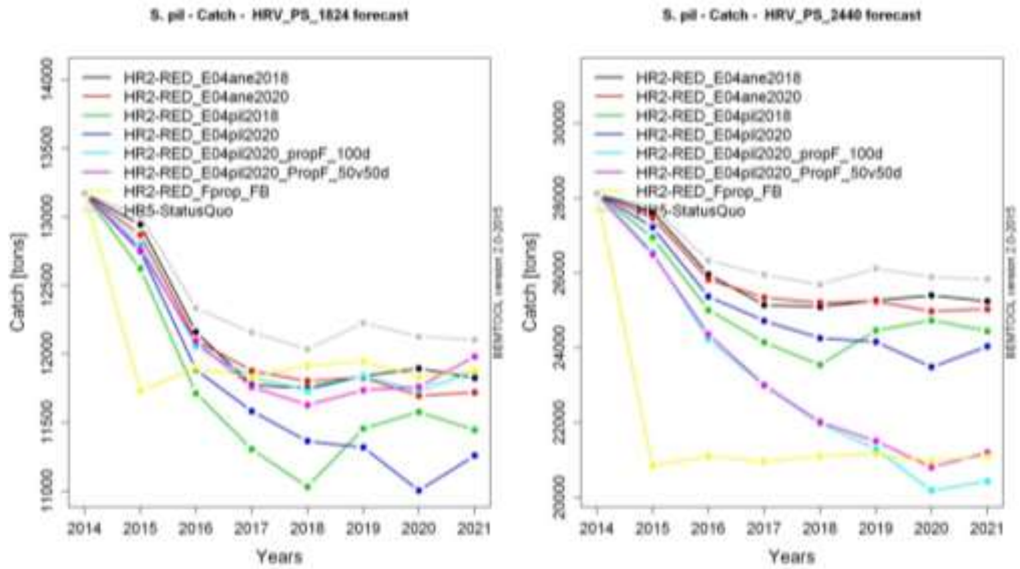


Figure 17 Catch of sardine in GSA 17 by fleet segment: comparison among the 7 management scenarios.

3.5.2 SOCIO-ECONOMIC INDICATORS

Figure 18 shows the expected impacts on total landings and revenues deriving from each of the seven scenarios. The simulation outcomes are compared with the status quo scenario.

HR2-RED_Fprop_FB has also the largest impact on production. On the overall fleet, in 2015 this scenario foresees an average reduction of 13% in landings. The most affected fleet is the Croatian purse seine segment 24-40, with a decrease of -24% in production.

HR2-RED_Fprop_FB has the largest impact on revenue. Overall, in 2015 this scenario foresees an average reduction of 7% in revenues. The most affected fleet is the Croatian purse seine segment 24-40, with a decrease of -20%.

In the long run, the impact of the fishing ban is less evident: in 2021 revenues of all fleet segments reduce by a -2% %. Given the reduction of 31% in predicted fishing days, the Croatian purse seine segment 24-40 is the most affected fleet, with a decrease of -16% in the predicted revenues.

As for the Italian purse seiners 2440 m and the Italian pelagic trawl fleets 1218m, 1824m and 2440m, HR2-RED_E04pil2020_PropF_100d and HR2-RED_E04pil2020_PropF_50v50d scenarios seem to be the management measures producing the most relevant improvements in revenues. The increasing trend of the Italian fleets is probably due to the low incidence of sardine in their production levels, being they less impacted in respect to the other fleet segments by most of the management measures implemented.

Furthermore, purse seiners are not affected by the reduction of F of sardine in HR2-RED_E04pil2020_PropF_100d and HR2-RED_E04pil2020_PropF_50v50d scenarios.

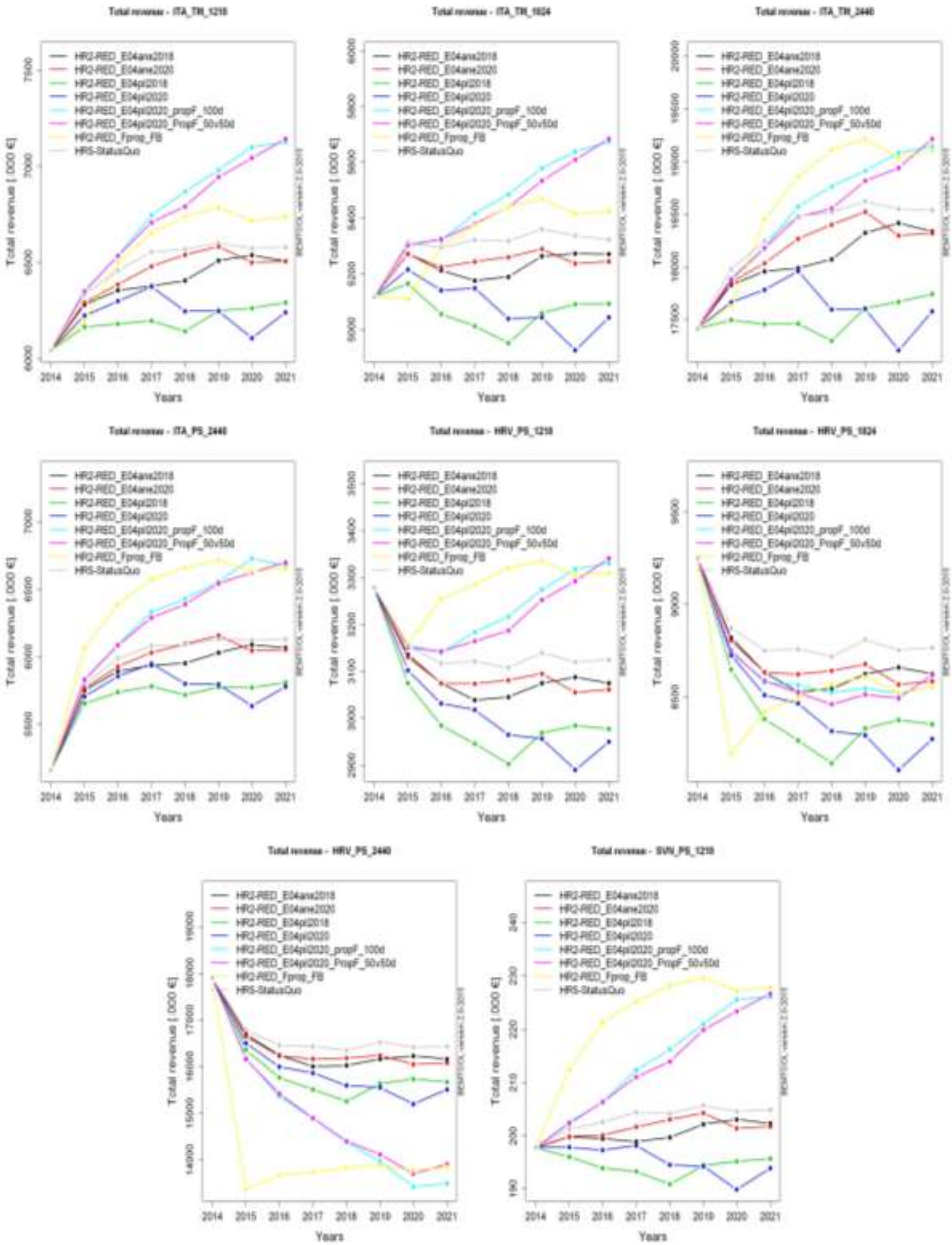


Figure 18 Revenues by fleet segment and scenario.

In 2015, the first year of simulation, the CR/BER ratio is less than 1 for five of the eight segments, thus indicating that insufficient income is generated to cover operational costs. Only Croatian purse seine fleet 1218 m, Italian pelagic trawl 1218 m and Slovenian purse seiners 1218 m are profitable, showing ratios greater than 1.

In 2021, there are not relevant differences in the R/BER ratios of all fleet segments. Generally, fleet segments characterized by a lower percentage incidence of sardine in their landings and revenues, show slight improvements in predicted R/BER ratios in scenarios HR2-RED_E04pil2020_PropF_100d, HR2-RED_E04pil2020_PropF_50v50d and 7 HR2-RED_Fprop_FB (Figure 19).

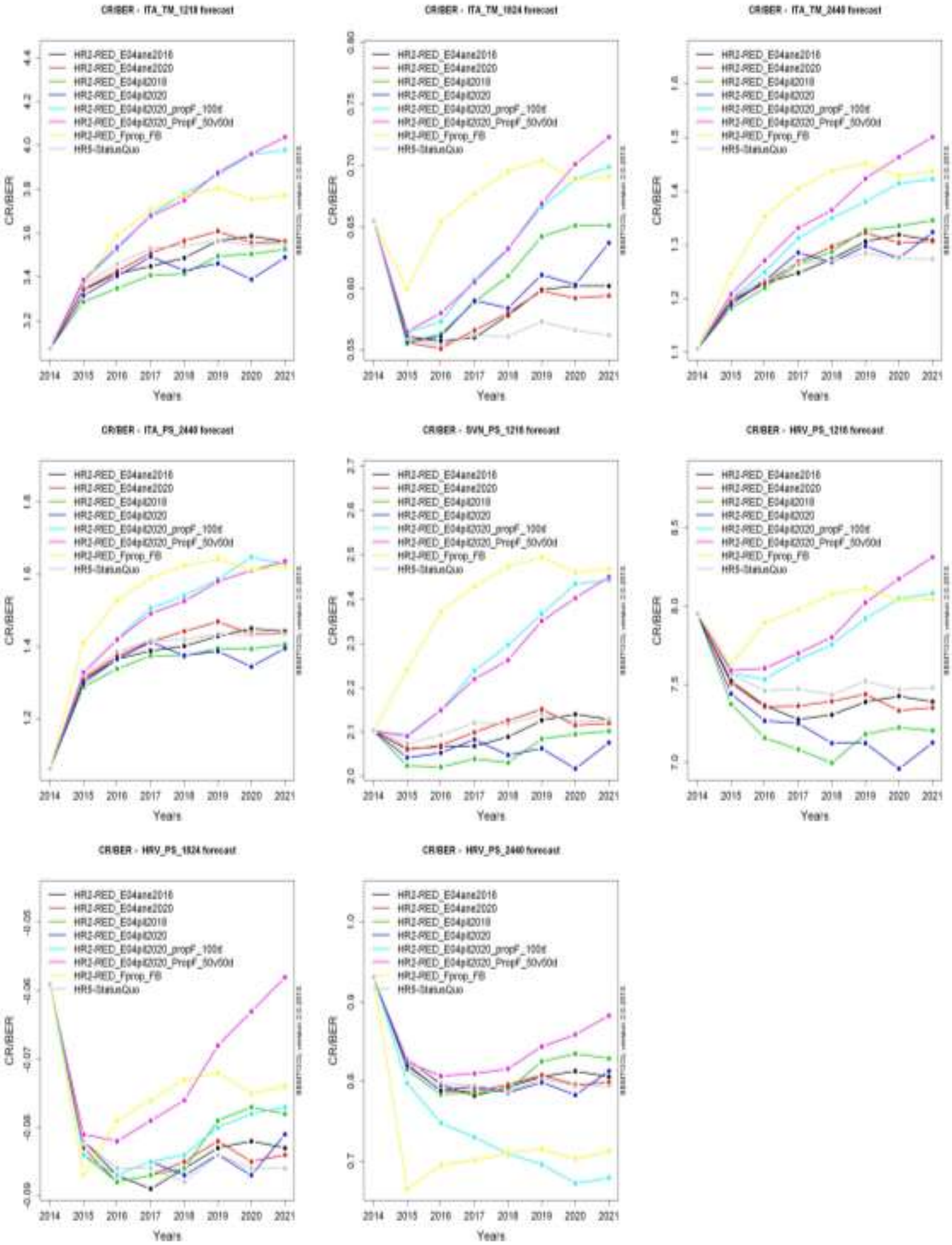


Figure 19 Current Revenue to the Break-Even Revenue ratio (R/BER) by fleet segment and scenario

Graphs in figure 20 show the effects simulated by the different scenarios on average salary per man employed. As labour costs are estimated as a fixed percentage of revenues, it is not surprising that the two indicators show similar dynamics.

As for HR2-RED_E04ane2018 and HR2-RED_E04ane2020 scenarios concerning the reduction of F of anchovy through a reduction of 7% in fishing days of all fleet segments, an increase of around 5% for both scenarios is predicted for the Italian pelagic trawl segment 1824 m. All other fleet segments show variation in the average salary lower than 3% compared with the status quo. Also the number of employees exhibits no variation in the simulation period.

As for HR2-RED_E04pil2018 and HR2-RED_E04pil2020 scenarios simulating the reduction of F of sardine through a reduction of 20% in fishing days of all fleet segments, the average salary of the Italian pelagic trawl 1824m should rise by around 10% by 2021. Predicted changes for the other fleets range from -1% of Italian pelagic trawlers 1218m and Slovenian Purse seiners 1218 m to +5% of Italian pelagic trawlers 2440 m. No variation in the number of employees is estimated for all fleet analysed.

Compared with the status quo, increases of around 20% in salary are registered in scenario HR2-RED_E04pil2020_PropF_100d, HR2-RED_E04pil2020_PropF_50v50d and HR2-RED_Fprop_FB scenarios for the Italian pelagic trawlers 1824 m as a consequence of a slight improvement in corresponding revenues. Average salary of the whole fleet would further increase by 5% by 2021. The number of employees remain stable for all fleets analysed over the simulation period.

Finally, HR2-RED_E04pil2020_PropF_50v50d aimed at reducing mortality rates by reducing the number of days at sea and the number of vessels, produce the largest positive variation in average salary with an increase of 14% for the whole fleet and an increase of 21% for the Italian pelagic trawl 1824m. However, expected employment of the whole fleet would reduce by 8% by 2021. Under a social point of view the most affected segment is the Croatian purse seine fleet 2440m with an expected drop in employment of 16% by 2021 compared with the status quo.

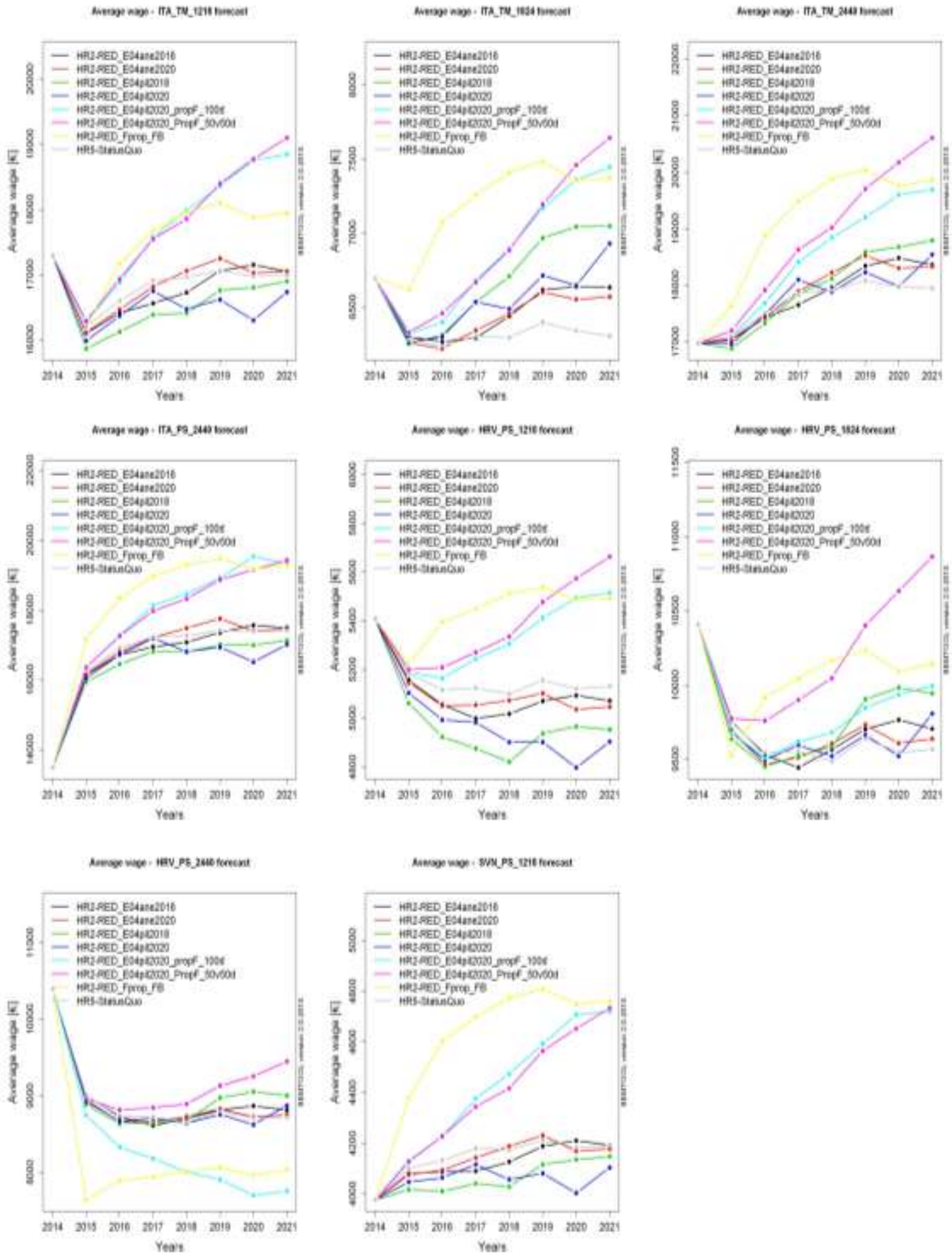


Figure 20 Average salary by fleet segment and scenario

In the Annex II to this Deliverable the graphs related to Kobe plot, SSB by stock, landing by stock and fleet segment, average salary and CR/BER with confidence intervals for all the forecast scenarios are reported. In Annex III the comparison of number of employees for the different scenarios are reported.

3.6 DISCUSSION AND CONCLUSIONS OF SMALL PELAGICS CASE STUDY

According to the traffic light approach reported in table 40 and the graph radar in figure 21, all the performed scenarios allow to obtain a benefit on the SSB for the 2 stocks under consideration respect to the status quo. The best results for both stocks were however obtained under the HR2-RED_E04pil2018 scenario, this was followed by the HR2-RED_E04pil2020_propF_100d, while the other were quite similar, excluding those based on the exploitation rate of anchovy which gave worse results.
Considering the catches of the whole fleet, in general the situation is rather stable for anchovy, while it tends to be negative for sardine in all the scenarios. The best performing scenarios is HR2-RED_E04pil2020_PropF_50v50d, that allows to obtain the best trade off among the different indicators, when considered having all the same weight (table 40).
Results show that the fleet mostly affected from management measures is the Croatian fleet segment PS_2440 (table 41). This is not surprising, considering the high share of sardine catch of such fleet segment. The fleet segment HRV_PS_1218 and those targeting anchovy (table 41) are the more benefitting from the applied management measures, as they improve their performance for most of indicators. The other fleets present an intermediate situation (table 42)

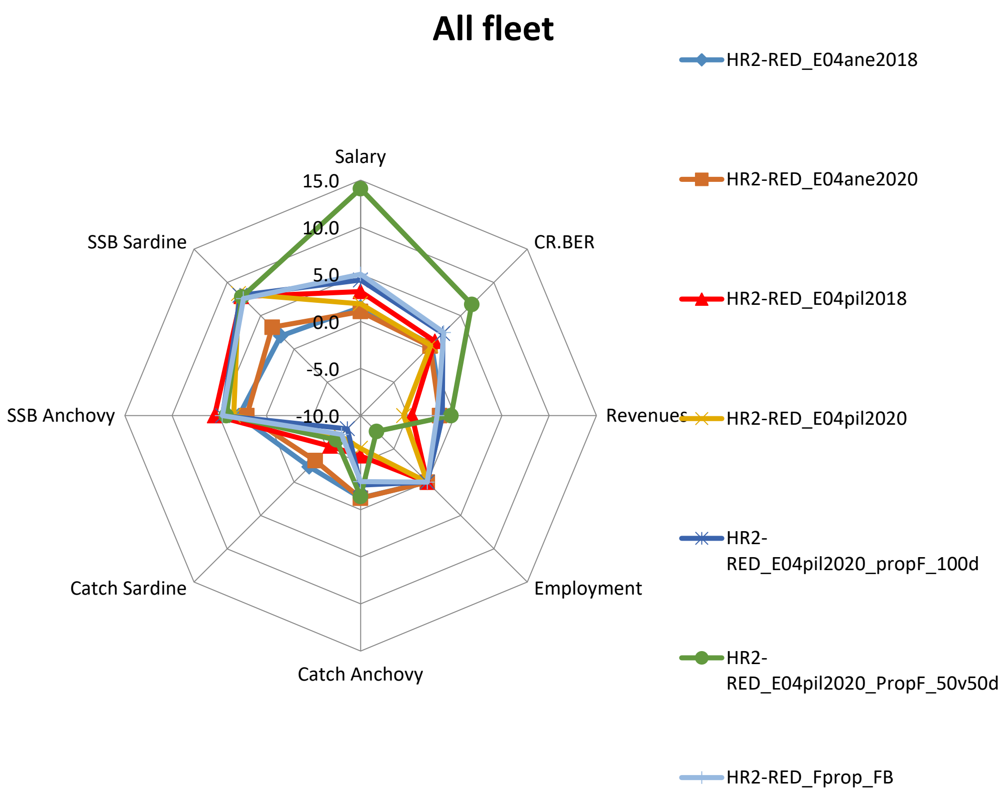


Figure 21 Radar plot for all the fleet. Each line represents a scenario and each point the corresponding percentage of each indicators respect to status quo.

Table 40 Performances of the management scenarios (% respect to status quo) simulated in terms of SSB and overall catches of anchovy and sardine, salary, CR/BER, employment and revenues. The green values are higher than +5%, the red ones are smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17.

	All fleets							
Scenario, year 2021	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	SSB Anchovy	SSB Sardine
HR2-RED_E04ane2018	1.5	0.6	-1.3	0.0	-1.3	-2.3	2.9	2.0
HR2-RED_E04ane2020	1.0	0.4	-1.6	0.0	-1.2	-3.2	2.1	3.3
HR2-RED_E04pil2018	3.2	1.1	-4.5	0.0	-5.7	-5.4	5.5	7.9
HR2-RED_E04pil2020	1.9	0.5	-5.4	0.0	-6.5	-6.9	3.5	8.3
HR2-RED_E04pil2020_propF_100d	4.4	2.3	-1.3	0.0	-2.6	-8.0	4.6	8.1
HR2-RED_E04pil2020_PropF_50v50d	14.1	6.7	-0.4	-7.6	-1.4	-6.4	4.2	7.8
HR2-RED_Fprop_FB	5.0	2.5	-1.9	0.0	-3.0	-7.2	4.7	7.6

Table 41 Performances of the management scenarios (% respect to status quo) simulated in terms of catches of anchovy and sardine, salary, CR/BER, employment and revenues by fleet segment (HRV_PS_1218, HRV_PS_1824, HRV_PS_2440 and ITA_PS_2440 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	HRV_PS_1218						HRV_PS_1824					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	-1.1	-1.2	-1.6	0.0	-1.6	-2.3	1.4	-3.4	-1.6	0.0	-1.6	-2.3
HR2-RED_E04ane2020	-1.6	-1.7	-2.0	0.0	-1.6	-3.2	0.7	-1.7	-2.1	0.0	-1.6	-3.2
HR2-RED_E04pil2018	-3.5	-3.7	-4.7	0.0	-6.3	-5.5	3.9	-9.3	-4.7	0.0	-6.3	-5.4
HR2-RED_E04pil2020	-4.4	-4.7	-5.6	0.0	-6.8	-7.0	2.5	-5.9	-5.6	0.0	-6.8	-7.0
HR2-RED_E04pil2020_propF_100d	7.5	8.0	6.6	0.0	6.5	9.6	4.5	-10.5	-2.4	0.0	-4.6	-1.9
HR2-RED_E04pil2020_PropF_50v50d	10.4	11.1	6.9	-2.3	7.0	10.0	13.6	-32.0	-1.7	-7.3	-3.7	-1.0
HR2-RED_Fprop_FB	7.1	7.6	5.9	0.0	4.8	9.3	6.0	-14.2	-2.4	0.0	-4.2	-1.9

Scenario, year 2021	HRV_PS_2440						ITA_PS_2440					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp..	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	1.1	1.4	-1.6	0.0	-1.5	-2.3	0.4	0.5	-1.0	0.0	-1.4	-2.4
HR2-RED_E04ane2020	0.4	0.5	-2.1	0.0	-1.6	-3.1	0.1	0.2	-1.3	0.0	-1.6	-3.3
HR2-RED_E04pil2018	3.2	4.3	-4.6	0.0	-6.3	-5.4	-1.7	-2.0	-5.2	0.0	-6.8	-5.2
HR2-RED_E04pil2020	1.7	2.3	-5.6	0.0	-6.8	-7.0	-2.3	-2.8	-5.7	0.0	-7.3	-6.8
HR2-RED_E04pil2020_propF_100d	-11.1	-14.6	-17.9	0.0	-23.1	-20.9	11.0	13.5	8.9	0.0	11.3	14.5
HR2-RED_E04pil2020_PropF_50v50d	8.4	11.1	-15.4	-15.6	-20.1	-18.0	11.5	14.1	9.3	0.0	11.8	15.0
HR2-RED_Fprop_FB	-7.9	-10.4	-15.7	0.0	-17.7	-18.3	10.7	13.1	8.6	0.0	11.4	17.4

Table 42 Performances of the management scenarios (% respect to status quo) simulated in terms of catches of anchovy and sardine, salary, CR/BER, employment and revenues by fleet segment (ITA_TM_1218, ITA_TM_1824, ITA_TM_2440 and SVN_PS_1218). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ITA_TM_1218						ITA_TM_1824					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	0.3	0.4	-1.1	0.0	-1.2	-2.3	5.2	7.0	-1.0	0.0	-0.8	-1.7
HR2-RED_E04ane2020	0.3	0.4	-1.1	0.0	-1.1	-3.0	4.2	5.7	-1.5	0.0	-0.6	-3.2
HR2-RED_E04pil2018	-0.6	-0.6	-4.4	0.0	-5.6	-5.3	11.8	15.9	-4.3	0.0	-5.5	-5.1
HR2-RED_E04pil2020	-1.5	-1.7	-5.2	0.0	-6.3	-6.8	9.9	13.4	-5.2	0.0	-6.2	-6.8
HR2-RED_E04pil2020_propF_100d	10.9	12.1	8.3	0.0	10.1	12.6	18.1	24.5	6.6	0.0	7.3	9.5
HR2-RED_E04pil2020_PropF_50v50d	12.4	13.7	8.6	-1.1	10.5	12.9	21.2	28.7	6.8	-2.3	7.6	9.7
HR2-RED_Fprop_FB	5.6	6.3	2.4	0.0	2.3	6.3	17.0	22.9	1.9	0.0	0.8	4.4

Scenario, year 2021	ITA_TM_2440						ITA_TM_2440 SVN_PS_1218					
	Salary	CR.BER	Rev.	Emp.	Catch Anchovy	Catch Sardine	Salary	CR.BER	Rev.	Emp. .	Catch Anchovy	Catch Sardine
HR2-RED_E04ane2018	2.3	2.8	-1.1	0.0	-1.2	-2.1	0.0	-1.3	0.0	0.0	-1.2	-2.4
HR2-RED_E04ane2020	2.1	2.6	-1.2	0.0	-1.0	-2.9	-0.3	-1.5	-0.4	0.0	-1.3	-3.0
HR2-RED_E04pil2018	4.7	5.7	-4.3	0.0	-5.4	-5.2	-1.0	-4.5	-1.2	0.0	-5.8	-5.2
HR2-RED_E04pil2020	3.3	4.0	-5.2	0.0	-6.3	-6.8	-2.1	-5.3	-2.4	0.0	-6.5	-6.8
HR2-RED_E04pil2020_propF_100d	9.7	11.7	3.3	0.0	3.6	5.7	12.6	10.3	14.8	0.0	12.1	15.1
HR2-RED_E04pil2020_PropF_50v50d	14.8	17.8	3.6	-4.0	4.0	6.3	13.0	10.6	15.2	0.0	12.5	15.4
HR2-RED_Fprop_FB	10.7	12.9	3.1	0.0	2.9	7.0	13.6	11.2	15.9	0.0	12.1	18.6

The BEMTOOL option aimed at comparing the outputs of the different scenarios, i.e. the Multi-Criteria Decision Analysis that combines Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process(AHP), has been used to assess the performances of the alternative fisheries management policies (Rossetto et al., 2015). The eight indicators used in the analysis are listed in

Table 43, along with the weighting set used to calculate the overall utility associated to each scenario. The value of the indicators in the last year of simulation (2014) is referred to as the 'current condition'. The performance of a scenario with respect to a specific objective is calculated as the value of the relevant indicator in 2021.

Table 43 Summary of the indicators used in the MCDA.

Top level hierarchy	Low level hierarchy	Indicator*	Weight
Socioeconomic	Economic	GVA, ROI or Profit	0.0080
Socioeconomic	Economic	RBER	0.0421
Socioeconomic	Social	WAGE	0.1914
Socioeconomic	Social	EMPL	0.0641
Biological	Biological conservation	SSB	0.2605
Biological	Biological conservation	F	0.2605
Biological	Biological production	Y	0.1373
Biological	Biological production	D	0.0361

* GVA: Gross Value Added; ROI: Return On Investment; RBER: Ratio of Revenues to Break-even revenues; WAGE: Average wage; EMPL: Employment; SSB: Spawning Stock Biomass; F: Fishing mortality; Y: Yield; D: Discard rate.

According to MCDA (Fig. 22), the scenario that allows to reach the highest overall utility is HR2-RED_E04pil2018 (0.7932), while the lowest utility is given by HR2-RED_E04pil2020_PropF_50v50d scenario that produces an utility value (0.757) slightly lower than the status quo scenario (0.7644). This result is different from the one obtained by the traffic light summary table (HR2-RED_E04pil2020_PropF_50v50d), because MCDA considers different weights and utility functions associated to the indicators according to expert judgement that weighed more the biological, but also the social components.

The results seem consistent with the greater benefit that generally the reduction of fishing mortality produce on the indicators if applied in a narrow range of time. These benefits are much evident on the biological and pressure indicators used in the analysis (especially SSB). Indeed the utility associated to the socio-economic indicators changes much less in the different scenarios: the employment changes only in HR2-RED_E04pil2020_PropF_50v50d scenario, that reduces the number of vessels.

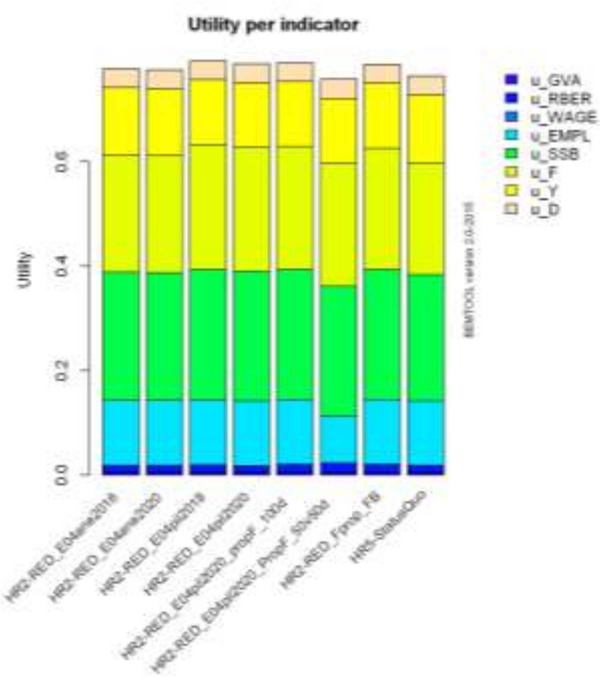
Conversely, the SSB showed more important changes in the different scenarios, indicating, on an overall basis, the HR2-RED_E04pil2018 scenario as the best in terms of utility associated to SSB. The lowest utility value associated to SSB was observed in status quo scenario. The implementation of HR2-RED_E04pil2018 scenario would bring to higher levels of SSB for both species, with a generally low decrease in the catches. The most penalized fleet segments are the Croatian purse seiner, that for the segment 2440 would see a decrease in catch of about 1500 t compared to the status quo. However, revenues changed less, with a decrease of about 6%. This result seems to indicate a higher benefit due to the reduction in a small time range of the fishing mortality for sardine stock. The advantage of applying such a management scenario to the Adriatic small pelagic fisheries is that a relatively small reduction in catches and revenue could bring to a significant increase in the spawning stock biomass of both species. Also, for one of the most important fleet (i.e. Croatian purse seiner 2440) this reduction, and therefore the loss in revenue, is much lower than the one foresees from other scenarios: it seems therefore to be sustainable from both a biological and a socio economic point of view.

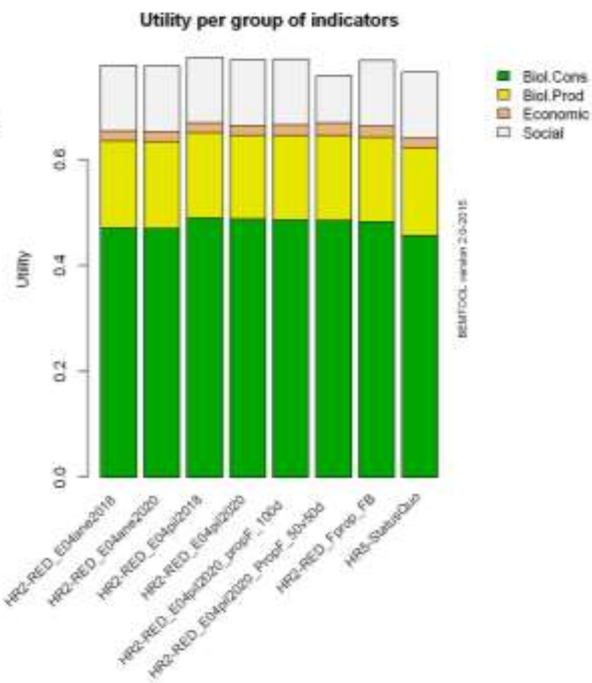
The scenario that has the second rank of utility is HR2-RED_E04pil2020_propF_100d (0.7896), that is very close to the best scenario in terms of overall utility. However, this scenario would strongly penalize the Croatian purse seiner 2440 and 1824, favouring on the other hand the other fleet segments in terms of catches and revenues, but would not bring any additional advantage in terms of SSB compared to the best scenario. This seems to indicate that the reduction driven by the relative impact of the different fleet segments, gives a benefit that is equivalent to the reduction of 20% for all the fleet segments in 2018.

The methodology and the scenarios tested cover a wide range of different options and provide a general and complete overview of the situation of small pelagics in the Adriatic Sea. The results are consistent with the advice that has been provided so far in different fora and gives a more robust evaluation of the efficiency of each of the measures proposed.

There are certainly some limitations in the approach used; in particular, one of the main issues is the difficulty in forecasting recruitment in small pelagic species. These species are in fact strongly influenced from environmental variables and the recruitment can show dramatic variability from one year to the next.

A step forward would be to test the probability of some estimates of falling below a certain reference limit throughout a Management Strategy Evaluation (MSE). However, the measure proposed from BEMTOOL are conservative enough to be efficient if against recruitment failures.





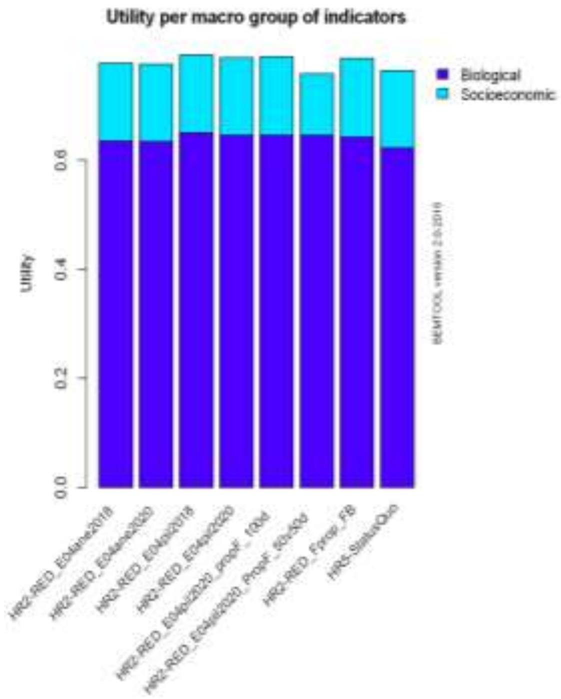


Figure 1 MCDA results: evaluation of the overall utility associated to each management scenario.

4. *GSA 17 DEMERSAL* CASE STUDY

The main stocks identified for the *GSA 17 demersal* case study are *M .merluccius, S. mantis, M. barbatus* and *S. solea.* The stocks are shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia).

The main fishing gears targeting the four stocks selected for this case study are bottom trawls, small scale fisheries, longlines and rapido trawlers.

The 11 fleet segments targeting the selected stocks and considered for this case study arelisted below:

1. ITA_DTS_0612;
2. ITA_DTS_1218;
3. ITA_DTS_1824;
4. ITA_PGP_0012;
5. ITA_TBB_1218;
6. ITA_TBB_1824;
7. HRV_DFN_0612;
8. HRV_DTS_0612;
9. HRV_DTS_1218;
10. HRV_DTS_1824;
11. SVN_DFN_0612_DTS_1218.

The data used for the parameterization of the biological module and of the pressure module of BEMTOOL come from the stock assessments carried out during the GFCM Working Group on Stock Assessment of Demersal Species (GFCM-WGSASP) meetings.

The associations between stocks and demersal fisheries for this case study are reported in Table 44.

Table 44 Associations among stocks and fleet segments for demersal fisheries in GSA 17 case study.

Stock	ITA DTS_VL0612	ITA DTS_VL1218	ITA DTS_VL1840	ITA PGP_VL0012	ITA TBB_VL1218	ITA TBB_VL1840
M. merluccius	X	X	X			
S. mantis	X	X	X	X	X	X
M. barbatus	X	X	X			
S. solea	X	X	X	X	X	X
Stock	**HRV DFN_VL0612**	**HRV DTS_VL0612**	**HRV DTS_VL1218**	**HRV DTS_VL1840**	**SVN_DFN_0612_DTS_1218**	
M. merluccius	X	X	X	X		
S. mantis					X	
M. barbatus		X	X	X	X	
S. solea	X				X	

As highlighted in table 45, in 2013 the selected fleet segments encompassed around 98% of the production and revenues of the four assessed stocks in the area. For Italy the percentage of neglected production and revenues is less than 2 % for all the four target species. For Croatia the percentage of neglected production is less than 5% for European hake and red mullet and around 35% for sole. The neglected production related to the Slovenian fleet is around 30% for all target species.

Table 45 Case study representativeness in 2013.

	ITA		HRV		SVN		TOTAL	
	Landings weight (thousands tonnes)	Landings value (million €)	Landings weight (thousands tonnes	Landings value (million €)	Landings weight (thousands tonnes	Landings value (million €)	Landings weight (thousands tonnes	Landings value (million €)
Species	GSA 17							
HKE	2225	15.26	1105	3.46	1	0.01	3330	18.72
MTS	2260	15.44	2	--	0	0.00	2263	15.45
MUT	1991	6.79	1049	1.98	2	0.01	3042	8.78
SOL	1078	12.75	166	1.67	15	0.23	1260	14.65
tot	7555	50.25	2322	7.11	19	0.25	9896	57.61
	CASE STUDY							
HKE	2200	15.13	1052	3.26			3251	18.39
MTS	2250	15.38					2250	15.38
MUT	1961	6.66	1030	1.95	2	0.01	2993	8.62
SOL	1077	12.74	107	1.17	11	0.18	1194	14.08
tot	7487	49.91	2188	6.38	14	0.19	9689	56.47

Source: EU Data Collection Framework 2014

In Italy and Slovenia management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that Adriatic has been mandatory since the late eighties. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences. Regarding passive gears of small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

Since the accession of Croatia to the EU the 1st of July 2013, the same regulations of Italy and Slovenia are implemented. Moreover, Croatia maintained regulation measures applied before 2013:

- Bottom trawl fisheries is closed one NM from the coast and island in inner sea, 2 NM around island on the open sea, and 3 NM around several island in the central Adriatic. Bottom trawl fisheries is closed also in the majority of channel area and bays.
- About 1/3 of the territorial waters is closed for bottom trawl fisheries over whole year and additionally 10% is closed from 100 to 300 days per years.

These management regulations have been taken into account to model the current situation in the case study.

4.1 SIMULATION OF THE CURRENT SITUATION

4.1.1 INPUT OF THE BIOLOGICAL MODULE

The data used for the parameterization of the biological and the pressure module for *M. merluccius* and *S. solea* come from the stock assessments carried out during the Working Group on Stock Assessment of Demersal Species (GFCM-WGSADS) held in 2014. The input for biological and pressure modules for *S. mantis* are from the Working Group on Stock Assessment of Demersal Species (GFCM-WGSADS) held in 2012, while for *M.barbatus* the stock assessment has been performed during Working Group on Stock Assessment of Demersal Species (GFCM-WGSADS) held in 2013.

The methodology used is Stock Synthesis SS3 (Methot and Wetzel, 2013) for *M. merluccius* and *S. solea;* for *M. barbatus* Extended Survivor Analyses (XSA, Darby and Flatman, 1994) has been used and finally for *S. mantis*, separable VPA has been carried out. For *S. solea* also ALADYM model (Lembo et al., 2009) has been parameterized during the STECF Expert Working Group on stock assessment held in 2014.

The assessments of *M. merluccius* is a joint assessment covering Italy and Croatia given that the species is poorly represented in Slovenia catches; *S. mantis* assessment covers Italy and Slovenia given that this species is poorly represented in Croatia catches, while *S. solea* and red mullet assessments cover Italy, Slovenia and Croatia.

4.1.1.1 GROWTH

The growth parameters and the length-weight relationship coefficients for the four species are listed in Table 46, Table 47, 48 and 49.

The life span has been set equal to 8 years for European hake (to be consistent with the SS3 assessment) and common sole, to 6 years for spottail mantis and 7 yearsfor red mullet.

For hake the fast growth pattern has been assumed that is the one agreed in STECF Expert Working Group.

Table 46 Growth parameters for European hake in GSA 17.

Parameter	Sex combined
Linf (cm)	104
K	0.2
t_0	-0.01
a (mm/g)	2.71E-06
b (mm/g)	3.2

The growth for S. mantis has been studied by Froglia et al. (1996) using indirect methods.

Table 47 Growth parameters for spottail mantis in GSA 17.

Parameter	Sex combined
Linf (mm)	41.5
K	0.49
t_0	-0.0105
a (mm/g)	0.0025

b (mm/g)	3

According to Jardas (1996), red mullet grow up to 30 cm, with females growing faster and bigger than males.

Table 48 Growth parameters for red mullet in GSA 17.

Parameter	Sex combined
Linf (cm)	26.9
K	0.295
t_0	-1.1
a (mm/g)	7.56E-06
b (mm/g)	3.076

In the Adriatic sea, growth analyses on S. solea have been made using otoliths, scales and tagging experiments. A great variability in the growth rate was noted: some specimens had grown 2 cm in one month, while others, of the same age group, needed a whole year (Piccinetti and Giovanardi, 1984). Von Bertalanffy growth equation parameters have been calculated using various methods. Within the framework of SoleMon project, growth parameters of sole were estimated through the length-frequency distributions obtained from surveys.

Table 49 Growth parameters for S. solea in GSA 17.

Parameter	Sex combined
Linf (cm)	39.6
K	0.4
t_0	-0.46
a (mm/g)	6.04E-06
b (mm/g)	3.0638

4.1.1.2 RECRUITMENT

For all the stocks a reliable stock recruitment relationship is not available, due to the shortness of the time series. For this reason a recruitment vector has been used for the simulation and a constant value for projections.

M. merluccius

The recruitment figures from the stock assessment results were related to age 0 and are from SS3 results (Table 50); the age of recruitment to the fishing grounds has been set equal to 4 months.

Table 50 Recruitment by year used in simulation phase European hake in GSA 17.

Year	R (thousands)
2008	47 498
2009	35 074
2010	28 646
2011	38 332
2012	49 106
2013	28 594

2014	28 594*

* The value of recruitment in 2014 has been assumed equal to 2013

The number of recruits entering in the population has been split by month in order to take into account the seasonal recruitment, according to the characteristics of European hake to recruit more in spring and autumn Table 51.

Table 51 Proportion of recruits entering each year in the population for hake in GSA 17.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.042	0.042	0.125	0.125	0.125	0.042	0.04	0.042	0.125	0.125	0.125	0.042

S. mantis

The recruitment figures from the stock assessment results were related to age 0 and are from separable VPA results (Table 52). The age of recruitment has been set equal to 0 months.

Table 52 Recruitment by year used in simulation phase for spottail mantis in GSA 17.

Year	R (thousands)
2008	4 079 513
2009	3 483 038
2010	3 337 315
2011	2 861 854*
2012	2 861 854
2013	2 861 854
2014	2 861 854

* The reference year of the assessment was 2011.

The number of recruits entering in the population has been split by month in order to take into account the seasonal recruitment, according to the characteristics of spottail mantis to recruit more from August to November (Table 53).

Table 53 Proportion of recruits entering each year in the population for spottail mantis in GSA 17.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0	0	0.2	0.5	0.2	0.1	0

M. barbatus

The recruitment figures from the stock assessment results were related to age 0 and are from XSA results (table 54). The age of recruitment has been set equal to 1 months.

Table 54 Recruitment by year used in simulation phase for red mullet in GSA 17.

Year	R (thousands)
2008	12 02 985
2009	850 746
2010	1 122 388
2011	1 880 597
2012	1 235 821

Year	R (thousands)
2013	1 238 912
2014	1 238 912*

* The value of recruitment in 2014 has been assumed equal to 2013

The number of recruits entering in the population has been split by month in order to take into account the seasonal recruitment, according to the characteristics of red mullet to recruit more from June to October (Table 55).

Table 55 Proportion of recruits entering each year in the population for red mullet in GSA 17.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0.15	0.2	0.3	0.2	0.15	0	0

S. solea

The recruitment figures from the stock assessment results were related to age 0 and are from SS3 results (Table 56). The age of recruitment has been set equal to 4 months.

Table56 Recruitment by year by year used in simulation phase for common sole in GSA 17.

Year	R (thousands)
2008	23 245
2009	36 652
2010	30 676
2011	36 467
2012	40 183
2013	59 360
2014	59 360*

* The value of recruitment in 2014 has been assumed equal to 2013

The number of recruits entering in the population has been split by month in order to take into account the seasonal recruitment, according to the characteristics of common sole to recruit more from July to February (Table 57).

Table 57 Proportion of recruits entering each year in the population for common sole in GSA 17.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.1	0.1	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.1

4.1.1.3 MATURITY AND SEX RATIO

The size at first maturity (Lm50%) and maturity range by species are reported in the table 58. These parameters have been estimated within DCF on biological sampling data.

Table58 Maturity parameters for the 4 stocks in demersal fisheries GSA 17 case study.

mm	Combined	
Species	Lm50%	MR =Lm75%-Lm25%

M. merluccius	300	40
S. mantis	22	5
M. barbatus	120	3
S. solea	258	24

4.1.1.4 NATURAL MORTALITY

In the following tables from 59 to 62 the natural mortality by age class for the 4 stocks is reported.

The natural mortality at age for hake was estimated using the Prodbiom method (Abella et al., 1997).

Table 59 Natural mortality for hake in GSA 17.

Age	M
0	0.94
1	0.53
2	0.4
3	0.35
4	0.32
5+	0.29

The natural mortality at age for spottail mantis was estimated using the Chen and Watanabe method (Chen and Watanabe's method, 1989).

Table 60 Natural mortality for spottail mantis in GSA 17.

Age	M
0	2.5
1	0.94
2	0.69
3	0.6
4	0.5
5	0.4

The natural mortality at age for red mullet was estimated using the Prodbiom method (Abella et al., 1997).

Table 61 Natural mortality for red mullet in GSA 17.

Age	M
1	2.03
2	0.84
3	0.37
4	0.29
5	0.26
6	0.25
7	0.24

The natural mortality at age for common sole was estimated using the Prodbiom method (Abella et al., 1997).

Table 62 Natural mortality for common sole in GSA 17.

Age	M
0	0.7
1	0.35
2	0.28
3	0.25
4	0.23
5+	0.21

4.1.1.5 TOTAL MORTALITY

The total mortality vectors used to feed BEMTOOL model are reported in the table 63.

Table63 Total mortality for hake, spottail mantis, red mullet and common sole in GSA 17.

Year	Hake	Spottail mantis	Red mullet	Common sole
2008	1.16	1.41	1.37	2.22
2009	1.22	1.54	1.64	3.15
2010	1.15	1.60	1.42	2.4
2011	1.01	2	1.99	2.26
2012	1.06	2	1.58	2.54
2013	1.37	1.6	1.26	1.41
2014	1.37	1.6	1.26	1.41

4.1.2 INPUT OF THE PRESSURE MODULE

4.1.2.1 FISHING MORTALITY

The Z-mode of ALADYM model has been used in BEMTOOL for all the stocks. The overall fishing mortality and natural mortality have been used to estimate the annual total mortality to be applied in ALADYM model.

M. merluccius

The overall fishing mortality by year and age from SS3 model is reported in Table 64. For 2014 the same fishing mortality as 2013 has been assumed. For hake the age range 0-5 was used for calculation of F average.

Table 64 Overall fishing mortality for hake in GSA 17 (SS3 model).

age	2009*	2010	2011	2012	2013
0	0.12	0.11	0.10	0.12	0.17
1	1.79	1.61	1.29	1.36	2.01
2	0.46	0.42	0.36	0.40	0.59

age	2009*	2010	2011	2012	2013
3	0.22	0.21	0.18	0.21	0.31
4	0.20	0.18	0.17	0.19	0.28
5	0.20	0.18	0.17	0.19	0.28
6+	0.20	0.18	0.17	0.19	0.28

* For 2008 the same fishing mortality of 2009 has been assumed.

S. mantis

The overall fishing mortality for spottail mantis by year and age from separable VPA model has been used (Table 65). For 2014 the same fishing mortality as 2013 has been assumed. The age range 0-2 was used for the calculation of average F .

Table65 Overall fishing mortality for spottail mantis (separable VPA model).

Age	2008	2009	2010	2011*
0	0.00	0.00	0.00	0.01
1	0.03	0.20	0.15	0.34
2	0.61	0.96	1.25	1.15
3+	1.17	1.17	1.17	1.76

* For 2012 and 2013 the same fishing mortality of 2011 has been assumed.

M. barbatus

The overall fishing mortality for red mullet by year and age from XSA model have been used (Table 66). For 2014 the same fishing mortality as 2013 has been assumed. The age range 0-5 was used for the calculation of average F .

Table 66 Overall fishing mortality for red mullet in GSA 17 (XSA model).

age	2008	2009	2010	2011	2012*
0	0.08	0.03	0.03	0.04	0.05
1	0.74	0.72	0.46	0.53	0.28
2	0.85	1.36	1.12	1.56	1.50
3	1.19	1.46	1.23	2.36	1.64
4	1.09	1.54	1.34	2.17	1.36
5	0.58	1.08	0.70	1.68	0.98
6+	0.58	1.08	0.70	1.68	0.98

* For 2013 the same fishing mortality of 2012 has been assumed.

S. solea

The overall fishing mortality for common sole by year and age from SS3 model has been used. For 2014 the same fishing mortality as 2013 has been assumed (Table 67). The age range 0-4 was used for the calculation of average F.

Table 67 Overall fishing mortality for common sole (SS3model).

Age	2008	2009	2010	2011	2012	2013
0	0.373	0.570	0.409	0.375	0.427	0.201
1	1.821	2.752	1.995	1.863	2.137	1.006
2	0.808	1.303	0.929	0.905	0.917	0.432

Age	2008	2009	2010	2011	2012	2013
3	0.660	1.203	0.853	0.955	0.752	0.354
4	0.557	0.970	0.687	0.726	0.627	0.295
5+	0.494	0.829	0.587	0.588	0.552	0.260

4.1.2.2 SELECTIVITY

The selectivity used for the 4 stocks and the 11 fleet segments have been derived from the report of GFCM stock assessment working groups and DCF data. All the selectivity parameters (in mm) are reported in the table 68.

Table 68 Selectivity used for the 4 stocks and the 11 fleet segments.

Stock	Fleet segment	Model	L50 or LMean (mm)	SR or Standard Deviation (mm)	DSL50% or Standard deviation2 (mm)
Hake	HRV_DFN_0612	Gaussian	400	95	
Hake	HRV_DTS_0612	Bi-sided	169	25	25
Hake	HRV_DTS_1218	Bi-sided	169	25	25
Hake	HRV_DTS_1840	Bi-sided	169	25	25
Hake	ITA_DTS_0612	Bi-sided	250	28	28
Hake	ITA_DTS_1218	Bi-sided	250	28	28
Hake	ITA_DTS_1840	Bi-sided	250	28	28
Red mullet	HRV_DTS_0612	Bi-sided	187	18	53
Red mullet	HRV_DTS_1218	Bi-sided	187	18	53
Red mullet	HRV_DTS_1840	Bi-sided	187	18	53
Red mullet	ITA_DTS_0612	Bi-sided	146	22	34
Red mullet	ITA_DTS_1218	Bi-sided	155	22	52
Red mullet	ITA_DTS_1840	Bi-sided	170	16	50
Red mullet	SVN_DFN_0612_DTS_1218	Bi-sided	190	17	32
Spottail mantis	ITA_DTS_0612	Classical ogive	23	5	
Spottail mantis	ITA_DTS_1218	Classical ogive	23	5	
Spottail mantis	ITA_DTS_1840	Classical ogive	23	5	
Spottail mantis	ITA_PGP_0012	Bi-sided	28	3.8	
Spottail mantis	ITA_TBB_1218	Classical ogive	26	5	
Spottail mantis	ITA_TBB_1840	Classical ogive	27	5	
Spottail mantis	SVN_DFN_0612_DTS_1218	Bi-sided	28	3.4	
Common sole	HRV_DFN_0612	Ogive with de-selection	170	15	260
Common sole	ITA_DTS_0612	Ogive with de-selection	170	15	260
Common sole	ITA_DTS_1218	Ogive with de-selection	170	15	260
Common sole	ITA_DTS_1840	Ogive with de-selection	170	15	260
Common sole	ITA_PGP_0012	Ogive with de-selection	170	15	260
Common sole	ITA_TBB_1218	Ogive with de-selection	170	15	260
Common sole	ITA_TBB_1840	Ogive with de-selection	170	15	260

Stock	Fleet segment	Model	L50 or LMean (mm)	SR or Standard Deviation (mm)	DSL50% or Standard deviation2 (mm)
Common sole	SVN_DFN_0612_DTS_1218	Ogive with de-selection	170	15	260

4.1.2.3 EFFORT

The monthly effort variables used to simulate the past and current years by fleet segment are listed in table 69. For 2014 the same effort as 2013 has been assumed.

Table69 Effort for the selected fleet segment in GSA 17.

Effort Variable	ITA_DTS_0612						ITA_DTS_1218					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
average monthly GT	6	6	6	6	5	5	18	19	21	20	20	20
average monthly KW	85	87	90	93	77	82	141	167	145	143	142	142
number of vessels	41	54	52	54	92	72	332	289	292	295	318	308
annual fishing days	145	150	122	119	114	92	136	168	149	140	110	111
Effort Variable	**ITA_DTS_1840**						**ITA_PGP_0012**					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
average monthly GT	73	76	78	79	78	78	2	2	2	2	2	2
average monthly KW	280	289	299	299	300	305	33	34	35	37	37	36
number of vessels	232	219	218	215	210	197	1713	1668	1654	1674	1595	1525
annual fishing days	164	166	163	156	150	144	112	137	134	141	136	100
Effort Variable	**ITA_TBB_1218**						**ITA_TBB_1840**					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
average monthly GT	27	27	27	28	28	28	82	81	83	81	82	80
average monthly KW	216	217	218	222	211	212	362	361	368	357	364	359
number of vessels	13	13	11	9	11	11	60	57	56	55	52	47
annual fishing days	151	159	124	104	139	147	158	171	159	131	139	131
Effort Variable	**HRV_DFN_0612**						**HRV_DTS_0612**					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
average monthly GT	4	4	4	4	4	4	7	7	7	7	7	8
average monthly KW	35	35	35	35	60	60	53	53	53	53	81	87
number of vessels	804	804	804	804	795	760	205	205	205	205	191	190
annual fishing days	96	96	96	96	96	84	60	60	60	60	48	48
Effort Variable	**HRV_DTS_1218**						**HRV_DTS_1840**					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
average monthly GT	17	17	17	17	17	18	79	79	79	79	84	86

average monthly KW	92	92	92	92	151	153	231	231	231	231	265	309
number of vessels	215	215	215	215	212	203	68	68	68	68	62	56
annual fishing days	60	60	60	60	60	60	120	120	120	120	120	132

Effort Variable	SVN_DFN_0612_DTS_1218					
	2008	2009	2010	2011	2012	2013
average monthly GT	7	7	7	8	8	7
average monthly KW	96	92	96	92	95	109
number of vessels	54	53	55	51	51	46
annual fishing days	156	156	180	180	168	180

4.1.2.4 LANDINGS

Landing were obtained from the data collected and reviewed by the SEDAF project and presented in the *WP2-Collation and review on the main socio-economic information on the main fisheries* (SEDAF-D6 Report economic and structural overview). Also GFCM stock assessment forms have been used as a source of information, especially for discards.

M. merluccius

The landing data for hake by fleet segment used to parameterize the model are listed in Table 70. For 2014 the same landing as 2013 has been assumed. The discard data from DCF have been split according to the proportions of landing by fleet (Table 71). For 2014 the same landing and discard as 2013 has been assumed.

Table 70 Landing for hake by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	4	23	13	8	8	21
ITA_DTS_1218	581	480	350	296	426	483
ITA_DTS_1840	2471	2046	1497	1148	1345	1696
HRV_DFN_0612	28	32	34	32	29	56
HRV_DTS_0612	105	149	117	133	130	134
HRV_DTS_1218	223	315	249	282	343	414
HRV_DTS_1840	185	261	206	234	306	447
Total	**3598**	**3306**	**2466**	**2134**	**2587**	**3251**

Table 71 Discard for hake by fleet segment in GSA 17 (tons).

Fleet segment	2008*	2009	2010	2011	2012	2013
ITA_DTS_0612	0	1	0	0	0	0
ITA_DTS_1218	19	14	12	11	10	7
ITA_DTS_1840	82	59	52	42	33	25
HRV_DTS_0612	40	13	7	22	45	26
HRV_DTS_1218	86	27	16	46	120	79
HRV_DTS_1840	71	22	13	39	107	86
Total	**298**	**136**	**100**	**160**	**315**	**223**

*2008-2010 Italian discard data have been derived applying an average ratio discard/landing 2011-2013 to the landing of 2008-2010. 2008-2012 Croatian discard data have been derived applying the ratio discard/landing in 2013 to the landing of 2008-2012.

The discard of hake has been modelled with a reverse ogive model for all trawler fleet segments (with parameters DL50% = 20 cm and DL75%-DL25% = 5 mm for Italian fleet segments and DL50% = 24 cm and DL75%-DL25% = 5 mm for Croatian fleet segments).

S. mantis

The landing data for spottail mantis by fleet segment used to parameterize the model are listed in Table72. For 2014 the same landing as 2013 has been assumed. The discard data from DCF have been split according to the proportions of landing by fleet segment (Table 73). For 2014 the same landing and discard as 2013 have been assumed.

Table72 Landing for spottail mantis by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	117	158	200	115	124	104
ITA_DTS_1218	1964	2145	2056	1418	1015	812
ITA_DTS_1840	789	928	983	868	655	776
ITA_PGP_0012	907	895	980	1118	1160	335
ITA_TBB_1218	10	10	19	5	12	15
ITA_TBB_1840	286	412	353	261	180	208
SVN_DFN_0612_DTS_1218	6	4	5	3	1	0
Total	**4079**	**4552**	**4595**	**3788**	**3147**	**2250**

Table 73 Discard for spottail mantis by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	24	32	23	34	25	21
ITA_DTS_1218	402	439	238	416	208	166
ITA_DTS_1840	161	190	114	255	134	159
ITA_TBB_1218	0	0	1	0	0	0
ITA_TBB_1840	9	12	11	8	5	6

*2008-2010 Italian discard data has been derived applying an average of ratio discard/landing 2011-2013 to the landing of 2008-2010.

The discard of spottail mantis has been modelled with a reverse ogive model (with parameters DL50% = 22 mm for DTS and 15 mm for TBB, with a DL75%-DL25% = 5 mm).

M. barbatus

The landing data for red mullet by fleet segment used to parameterize the model are listed in Table 74. The discard data from DCF have been split according to the proportions of landing by fleet (Table 75). For 2014 the same landing and discard as 2013 have been assumed.

Table 74 Landing for red mullet by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	47	79	46	50	52	52

ITA_DTS_1218	1355	958	593	771	694	680
ITA_DTS_1840	1787	1398	1156	987	730	1229
HRV_DTS_0612	138	148	139	196	216	193
HRV_DTS_1218	424	458	429	604	697	609
HRV_DTS_1840	180	194	182	256	302	228
SVN_DFN_0612_DTS_1218	2	3	1	6	4	2
Total	**3933**	**3237**	**2546**	**2870**	**2694**	**2993**

Table 75 Discard for red mullet by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	13	21	5	22	24	2
ITA_DTS_1218	370	261	60	339	320	31
ITA_DTS_1840	488	382	118	435	336	56
HRV_DTS_0612	21	22	21	29	32	17
HRV_DTS_1218	64	68	64	90	104	53
HRV_DTS_1840	27	29	27	38	45	20
Total	**983**	**783**	**295**	**953**	**861**	**179**

The discard of red mullet has been modelled with a reverse ogive model (with parameters DL50% = 15.7 cm for Croatian DTS and 13.2 cm for Italian DTS, with a DL75%-DL25% = 5 mm).

S. solea

The landing data for common sole by fleet segment used to parameterize the model are listed in TableTable 76. The discard for this species is negligible. For 2014 the same landing as 2013 has been assumed.

Table76 Landing for common sole by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	8	11	9	10	21	10
ITA_DTS_1218	94	194	157	101	83	120
ITA_DTS_1840	120	190	178	142	284	136
ITA_PGP_0012	455	549	534	676	843	285
ITA_TBB_1218	50	53	26	14	37	67
ITA_TBB_1840	504	686	531	380	490	458
HRV_DFN_0612	135	303	187	195	126	107
SVN_DFN_0612_DTS_1218	5	9	7	11	6	11
Total	**1371**	**1431**	**1207**	**1116**	**1091**	**1194**

Total landing

The total landing data by fleet segment used to parameterize the model are listed in the table 77. For 2014 the same landing as 2013 has been assumed.

Table 77 Total landing by fleet segment in GSA 17 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	734	783	658	575	524	612
ITA_DTS_1218	9226	9381	8233	7107	6126	5863
ITA_DTS_1840	14238	13523	11488	9752	9185	13860
ITA_PGP_0012	9734	10218	8163	9712	8097	6882
ITA_TBB_1218	628	587	424	251	716	622
ITA_TBB_1840	3021	3290	3298	3484	3284	2975
HRV_DFN_0612	708	708	708	708	610	518
HRV_DTS_0612	979	979	979	979	928	876
HRV_DTS_1218	1899	1899	1899	1899	2090	1987
HRV_DTS_1840	1351	1351	1351	1351	1367	1697
SVN_DFN_0612_DTS_1218	157	166	177	179	204	152
Total	**42675**	**42885**	**37380**	**35998**	**33132**	**36045**

4.1.3 INPUT OF THE ECONOMIC MODULE

Data for the estimation of the socio-economic parameters were obtained from the data collected and reviewed by the SEDAF project and presented in the WP2-*Collation and review on the main socio-economic information on the main fisheries* (SEDAF-D6 Report economic and structural overview). Taking into account that official Croatian socio- economic data are under revision, for the purpose of this study scientist presumed data needed for this exercise. Nevertheless, Croatian socio- economic data were obtained from the data collected and reviewed by the SEDAF project and refer to the period 2009-2012. Socio-economic data for 2008 and 2013 of Croatian fleet segments were assumed equal to 2009 and 2012 data respectively.

For all fleet segments, 2014 data were assumed equal to 2013.

4.1.3.1 REVENUES

The revenues by fleet segment for hake, spottail mantis, red mullet and common sole and the total revenues are reported in the tables from Table 78 to Table 81. Total revenues are reported in Table 82. According to the revenues and the landing by fleet segment the prices in the projections have been modelled.

M. merluccius

Table 78 Revenues of hake by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	18845	183848	87377	57899	52772	127876
ITA_DTS_1218	4545790	4092885	3537982	2857204	3529280	2901924
ITA_DTS_1840	16323526	14397095	12435801	10212877	10574721	12097585
HRV_DFN_0612	24535	27509	29739	27509	36028	95107
HRV_DTS_0612	295503	417617	329491	373835	389929	427649
HRV_DTS_1218	565987	799885	631081	716606	991860	1215238

Fleet segment	2008	2009	2010	2011	2012	2013
HRV_DTS_1840	584788	826445	652045	741123	1073891	1519664
Total	**22358974**	**20745284**	**17703516**	**14987053**	**16648481**	**18385043**

S. mantis

Table 79 Revenues of spottail mantis by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	794585	991766	1045379	828804	1057897	660597
ITA_DTS_1218	13183383	13361710	10951224	9029060	6725680	5783070
ITA_DTS_1840	5194172	5676937	4650660	5107179	3782254	4114592
ITA_PGP_0012	8883707	8401451	7898468	10305496	9770359	3695630
ITA_TBB_1218	88654	72094	119689	39126	81316	135762
ITA_TBB_1840	1788300	2224517	1873619	1612934	1042956	990021
SVN_DFN_0612_DTS_1218	36705	21797	29036	19867	3691	1952
Total	**29969506**	**30750272**	**26568075**	**26942466**	**22464153**	**15381624**

M. barbatus

Table 80 Revenues of red mullet by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	151430	306442	171243	133209	172240	174727
ITA_DTS_1218	4205611	2889986	2410359	2147850	2533359	2096212
ITA_DTS_1840	8380161	6292253	5388623	3819515	3316421	4390892
HRV_DTS_0612	199985	215617	202141	284528	326353	368255
HRV_DTS_1218	604508	651760	611025	859841	1103730	1162317
HRV_DTS_1840	291808	314618	294954	414760	531870	422729
SVN_DFN_0612_DTS_1218	10201	14648	4100	22227	13826	8467
Total	**13843704**	**10685324**	**9082445**	**7681930**	**7997799**	**8623599**

S. solea

Table 81 Revenues of common sole by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	121145	241737	174031	218661	404367	113108
ITA_DTS_1218	1772890	2944349	2285555	1841981	1224273	1588264
ITA_DTS_1840	1543422	2745007	2293224	2273824	3350803	1390822
ITA_PGP_0012	6909944	9029142	9693752	13867050	15229877	4071158
ITA_TBB_1218	470888	585343	381125	200412	480533	716789
ITA_TBB_1840	7083871	10465226	7326495	5734845	5081668	4856466
HRV_DFN_0612	985205	2206881	1361015	1419965	868489	1170999
SVN_DFN_0612_DTS_1218	55939	123620	102634	155986	88777	176784
Total	**18943304**	9606445	7952427	9137434	13912990	**14084390**

Total revenues

Table 82 Total revenues by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	3766622	4569360	3358312	3527990	3715845	2743597
ITA_DTS_1218	56178945	59741233	51055208	44786424	36880397	34680597
ITA_DTS_1840	93503987	90529194	81486384	72207684	62982725	58228939
ITA_PGP_0012	66046489	79213672	66685947	78715625	66436914	38511078
ITA_TBB_1218	2355037	2281575	1641726	1155322	2603973	2559956
ITA_TBB_1840	18859278	22603484	17880667	16285033	13531894	13848922
HRV_DFN_0612	3541235	3541235	3541235	3541235	3051267	2592115
HRV_DTS_0612	4896971	4896971	4896971	4896971	4641161	4379276
HRV_DTS_1218	9496331	9496331	9496331	9496331	10450307	9935972
HRV_DTS_1840	6499271	6499271	6499271	6499271	6804442	8429748
SVN_DFN_0612_DTS_1218	814612	1002170	960689	1043295	1014657	866575
Total	**265958778**	**284374496**	**247502741**	**242155181**	**212113582**	**198369650**

4.1.3.2 COSTS

In the following tables from 83 to 95 all the data of the costs by fleet segment taken into account in the simulation phase (past and present years) are reported.

Table 83 Total variable costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	2063222	1449769	1320123	1653950	1840633	1183354
ITA_DTS_1218	24502393	17651036	18602075	22129334	13028114	15540126
ITA_DTS_1840	38233517	27765760	30900881	33423266	33559297	22096111
ITA_PGP_0012	13300369	12272753	12908200	16899228	14443878	12435490
ITA_TBB_1218	1241194	963761	741773	600631	1096835	768155
ITA_TBB_1840	9000775	7123466	7453504	7074838	7370576	5928494
HRV_DFN_0612	264700	264700	264700	287431	256083	206994
HRV_DTS_0612	1501984	1501984	1501984	1501984	1461435	1379612
HRV_DTS_1218	3597807	3597807	3597807	3597807	3992528	3794417
HRV_DTS_1840	3925992	3925992	3925992	3925992	3164068	3535537
SVN_DFN_0612_DTS_1218	368511	380063	361351	389561	420991	414332
Total	**98000464**	**76897091**	**81578390**	**91484022**	**80634438**	**61484872**

Table 84 Other variable costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	784461	467244	307501	360555	480445	437403
ITA_DTS_1218	5717206	6032877	5305550	4466249	4048053	2778326
ITA_DTS_1840	9111286	9294632	8589126	7380448	6263865	3533795
ITA_PGP_0012	5456051	6529821	5974131	6422916	5487134	3689808

ITA_TBB_1218	318316	318143	218552	149949	296774	240493
ITA_TBB_1840	1872335	2092615	1753577	1428651	1309452	1353941
HRV_DFN_0612	64343	64343	64343	61274	62249	50316
HRV_DTS_0612	30232	30232	30232	30232	66564	63449
HRV_DTS_1218	30232	30232	30232	30232	66564	61678
HRV_DTS_1840	367129	367129	367129	367129	309457	317828
SVN_DFN_0612_DTS_1218	142296	164810	151905	145590	170912	168208
Total	**23893887**	**25392078**	**22792278**	**20843225**	**18561469**	12695245

Table 85 Fuel costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	1278761	982525	1012622	1293395	1360188	745951
ITA_DTS_1218	18785187	11618159	13296525	17663085	8980061	12761800
ITA_DTS_1840	29122231	18471128	22311755	26042818	27295432	18562316
ITA_PGP_0012	7844318	5742932	6934069	10476312	8956744	8745681
ITA_TBB_1218	922878	645618	523221	450682	800061	527662
ITA_TBB_1840	7128440	5030851	5699927	5646187	6061124	4574554
HRV_DFN_0612	200357	200357	200357	226157	193834	156678
HRV_DTS_0612	1471752	1471752	1471752	1471752	1394871	1316163
HRV_DTS_1218	3567575	3567575	3567575	3567575	3925964	3732739
HRV_DTS_1840	3558863	3558863	3558863	3558863	2854611	3217709
SVN_DFN_0612_DTS_1218	226215	215253	209446	243971	250079	246123
Total	**74106577**	**51505013**	**58786112**	**70640797**	**62072969**	**54587376**

Table 86 Maintenance costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	120923	189853	162416	162516	339898	221319
ITA_DTS_1218	1960690	1799004	1834883	1783415	1878047	1776989
ITA_DTS_1840	2514554	2412164	2431320	2241158	2630652	1866792
ITA_PGP_0012	2843722	2750361	2741576	2819732	2689131	2051463
ITA_TBB_1218	56972	57024	47900	38524	48251	43091
ITA_TBB_1840	1227411	1256701	1240849	1232629	1263391	887758
HRV_DFN_0612	27432	27432	27432	29475	27076	25547
HRV_DTS_0612	28999	28999	28999	28999	41910	42460
HRV_DTS_1218	28999	28999	28999	28999	41910	42307
HRV_DTS_1840	322622	322622	322622	322622	320657	296249
SVN_DFN_0612_DTS_1218	169251	146777	203100	115274	141695	119143
Total	**9301575**	**9019936**	**9070096**	**8803343**	**9422618**	**7373118**

Table 87 Total fixed costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013

ITA_DTS_0612	132321	209084	196655	202920	450375	182362
ITA_DTS_1218	1581519	1369080	1383778	1372160	1551761	1325754
ITA_DTS_1840	2727389	2607776	2631398	2410207	2469782	1380721
ITA_PGP_0012	2667915	2592969	2589165	2691593	2468986	1978307
ITA_TBB_1218	69182	69078	58026	50699	58451	36381
ITA_TBB_1840	539697	541639	524121	515359	512034	282114
HRV_DFN_0612	31752	31752	31752	53445	31339	29569
HRV_DTS_0612	35240	35240	35240	35240	33693	34135
HRV_DTS_1218	35240	35240	35240	35240	33693	34012
HRV_DTS_1840	343560	343560	343560	343560	278569	258955
SVN_DFN_0612_DTS_1218	10314	11147	6500	12276	12185	10246
Total	**8174129**	**7846565**	**7835435**	**7722699**	**7900868**	**5552556**

Table 88 Other fixed costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	132321	209084	196655	202920	450375	182362
ITA_DTS_1218	1581519	1369080	1383778	1372160	1551761	1325754
ITA_DTS_1840	2727389	2607776	2631398	2410207	2469782	1380721
ITA_PGP_0012	2667915	2592969	2589165	2691593	2468986	1978307
ITA_TBB_1218	69182	69078	58026	50699	58451	36381
ITA_TBB_1840	539697	541639	524121	515359	512034	282114
HRV_DFN_0612	31752	31752	31752	53445	31339	29569
HRV_DTS_0612	35240	35240	35240	35240	33693	34135
HRV_DTS_1218	35240	35240	35240	35240	33693	34012
HRV_DTS_1840	343560	343560	343560	343560	278569	258955
SVN_DFN_0612_DTS_1218	10314	11147	6500	12276	12185	10246
Total	**8174129**	**7846565**	**7835435**	**7722699**	**7900868**	**5552556**

Table 89 Labour costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	569707	1450788	982352	864490	1065247	672886
ITA_DTS_1218	13092743	17487177	13609042	9642413	9720532	9734583
ITA_DTS_1840	23013327	26436918	21284634	15346383	11835591	14835059
ITA_PGP_0012	19449794	24818636	19957432	22869353	18083735	12886993
ITA_TBB_1218	479444	688281	470037	274944	787163	726257
ITA_TBB_1840	3715222	6959931	4714900	4003259	2806855	3340101
HRV_DFN_0612	318751	318751	318751	375714	330342	339630
HRV_DTS_0612	411935	411935	411935	411935	275168	341642
HRV_DTS_1218	411935	411935	411935	411935	275168	341854
HRV_DTS_1840	949250	949250	949250	949250	1034359	938573
SVN_DFN_0612_DTS_1218	390217	416146	483709	466233	636123	573758
Total	**62802325**	**80349748**	**63593977**	**55615909**	**46850283**	**580825**

Table90 Depreciation costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	247258	370915	380918	384331	580727	452024
ITA_DTS_1218	3959078	3883862	4353149	4530006	4798853	4117785
ITA_DTS_1840	12851464	13608592	13753932	12910826	13002983	11732198
ITA_PGP_0012	5807252	5898054	6113032	5705191	5985467	5509541
ITA_TBB_1218	229842	217794	228453	323717	246859	229537
ITA_TBB_1840	4472774	4523779	4232148	3664098	2780810	2657080
HRV_DFN_0612	21220	21220	21220	14831	20944	19761
HRV_DTS_0612	19881	19881	19881	19881	18801	19048
HRV_DTS_1218	19881	19881	19881	19881	18801	18979
HRV_DTS_1840	520198	520198	520198	520198	596442	548454
SVN_DFN_0612_DTS_1218	108890	115501	140010	159208	148540	124898
Total	**28257738**	**29199677**	**29782822**	**28252168**	**28199227**	**25429305**

Table91 Opportunity costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	11272	35799	35919	36378	49569	52932
ITA_DTS_1218	192405	409818	440876	465378	431246	530439
ITA_DTS_1840	665736	1511356	1504670	1480041	1255180	1591557
ITA_PGP_0012	266822	587292	586567	562358	506145	655850
ITA_TBB_1218	9883	20500	20844	28147	18483	23637
ITA_TBB_1840	229847	468347	421417	374166	265235	339033
HRV_DFN_0612	202910	202910	202910	202910	200276	188964
HRV_DTS_0612	52576	52576	52576	52576	49823	50477
HRV_DTS_1218	151151	151151	151151	151151	155500	156971
HRV_DTS_1840	564736	564736	564736	564736	533598	492796
SVN_DFN_0612_DTS_1218	82518	82518	45779	73017	67309	79559
Total	**2429856**	**4087003**	**4027445**	**3990858**	**3532364**	**4162215**

Table 92 Total capital costs by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	258530	406714	416837	420709	630296	504956
ITA_DTS_1218	4151483	4293681	4794025	4995384	5230099	4648224
ITA_DTS_1840	13517200	15119948	15258602	14390867	14258164	13323755
ITA_PGP_0012	6074074	6485346	6699599	6267549	6491612	6165391
ITA_TBB_1218	239724	238294	249296	351864	265342	253174
ITA_TBB_1840	4702621	4992127	4653566	4038264	3046045	2996113
HRV_DFN_0612	224130	224130	224130	217741	221221	208726
HRV_DTS_0612	72457	72457	72457	72457	68625	69525
HRV_DTS_1218	171032	171032	171032	171032	174301	175950

Fleet segment	2008	2009	2010	2011	2012	2013
HRV_DTS_1840	1084934	1084934	1084934	1084934	1130039	1041250
SVN_DFN_0612_DTS_1218	191408	198019	185789	232225	215849	204457
Total	**30687593**	**33286682**	**33810267**	**32243026**	**31731593**	**29591521**

Table 93 Other income by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
HRV_DFN_0612	36048	36048	35931	40581	34902	27526
HRV_DTS_0612	258560	258560	258560	258560	245053	231226
HRV_DTS_1218	626758	626758	626758	626758	689720	655774
HRV_DTS_1840	625227	625227	625227	625227	865964	297150
SVN_DFN_0612_DTS_1218	119893	145493	397673	679870	1064490	0
Total	**1666486**	**1692086**	**1944149**	**2230996**	**2900129**	**1211676**

Table 94 Number of employees by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	94	126	127	115	174	135
ITA_DTS_1218	884	1024	1023	933	875	908
ITA_DTS_1840	1118	1034	1038	957	959	917
ITA_PGP_0012	2230	2455	2633	2677	2648	2472
ITA_TBB_1218	51	53	54	32	46	47
ITA_TBB_1840	255	275	270	268	272	225
HRV_DFN_0612	43	43	43	43	54	46
HRV_DTS_0612	30	30	30	30	28	29
HRV_DTS_1218	45	45	45	45	42	44
HRV_DTS_1840	119	119	119	119	97	108
SVN_DFN_0612_DTS_1218	60	60	62	57	54	49
Total	**4929**	**5264**	**5444**	**5276**	**5248**	**4980**

Table 95 Capital value by fleet segment in GSA 17 (€).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	988721	1451917	1498179	1483818	2335272	1777618
ITA_DTS_1218	16876208	16621309	18388904	18982202	20316611	17813869
ITA_DTS_1840	58392948	61297225	62759710	60369059	59133287	53449621
ITA_PGP_0012	23403468	23819242	24465681	22937912	23845196	22025564
ITA_TBB_1218	866839	831448	869383	1148083	870764	793813
ITA_TBB_1840	20160294	18995121	17577297	15261772	12495607	11385828
HRV_DFN_0612	3320387	3320387	3320387	2224995	3283218	3138674
HRV_DTS_0612	1460143	1460143	1460143	1460143	816778	812502
HRV_DTS_1218	2388423	2388423	2388423	2388423	2549176	2440957

HRV_DTS_1840	10840089	10840089	10840089	10840089	8747500	7563300
SVN_DFN_0612_DTS_1218	2446250	2392543	2701775	2597556	2298780	2073409
Total	**141143770**	**143417847**	**146269971**	**139694052**	**136692189**	**123275155**

4.2 FITTING OF OBSERVED LANDING DATA AND COMPARISON WITH ASSESSMENT RESULTS

The fitting of the landing data by BEMTOOL model is quite satisfactory for all the species, with an average difference of -5.76% by year for hake (Figure 23-24), 0.34 for spottail mantis (Figure 25-26), 1.27 % for red mullet (Figure 27-28) and -2.68 % for common sole (Figure 29).

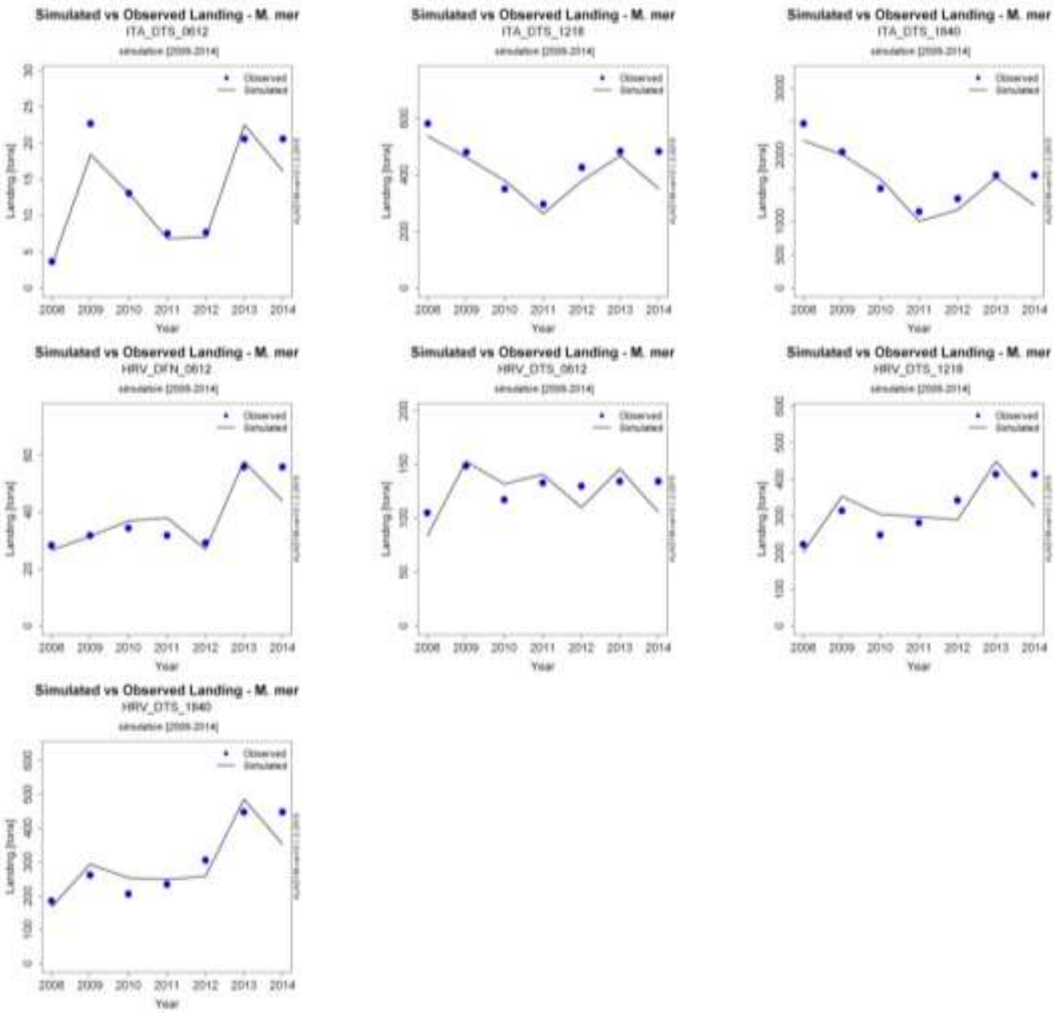


Figure 23 Comparison between simulated and observed landings by fleet segment for hake in GSA 17.

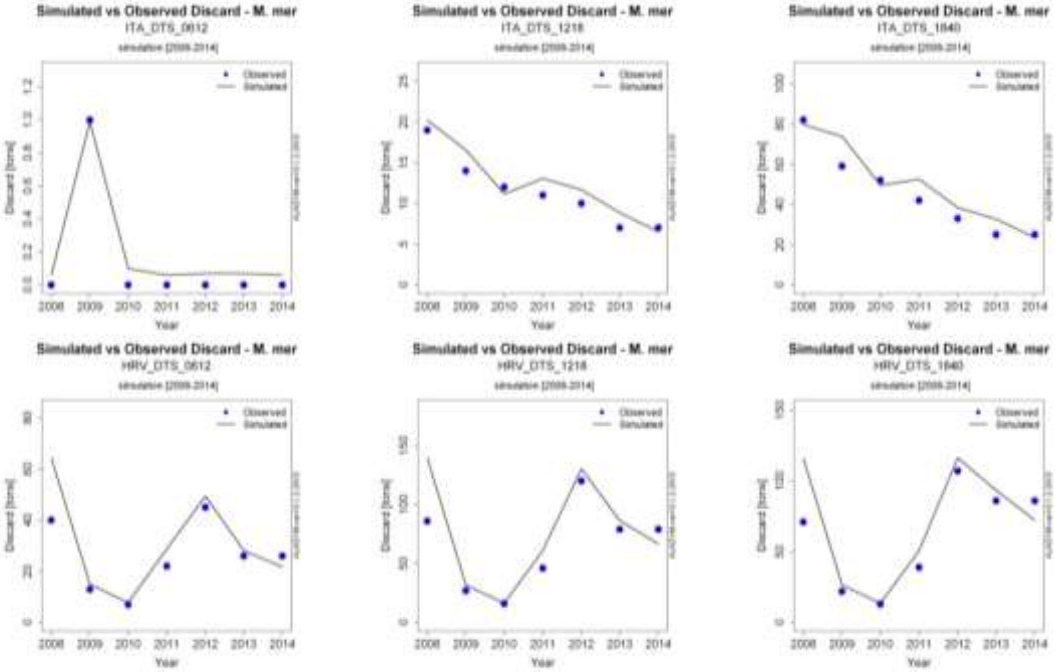


Figure 24 Comparison between simulated and observed discard by fleet segment for hake in GSA 17.

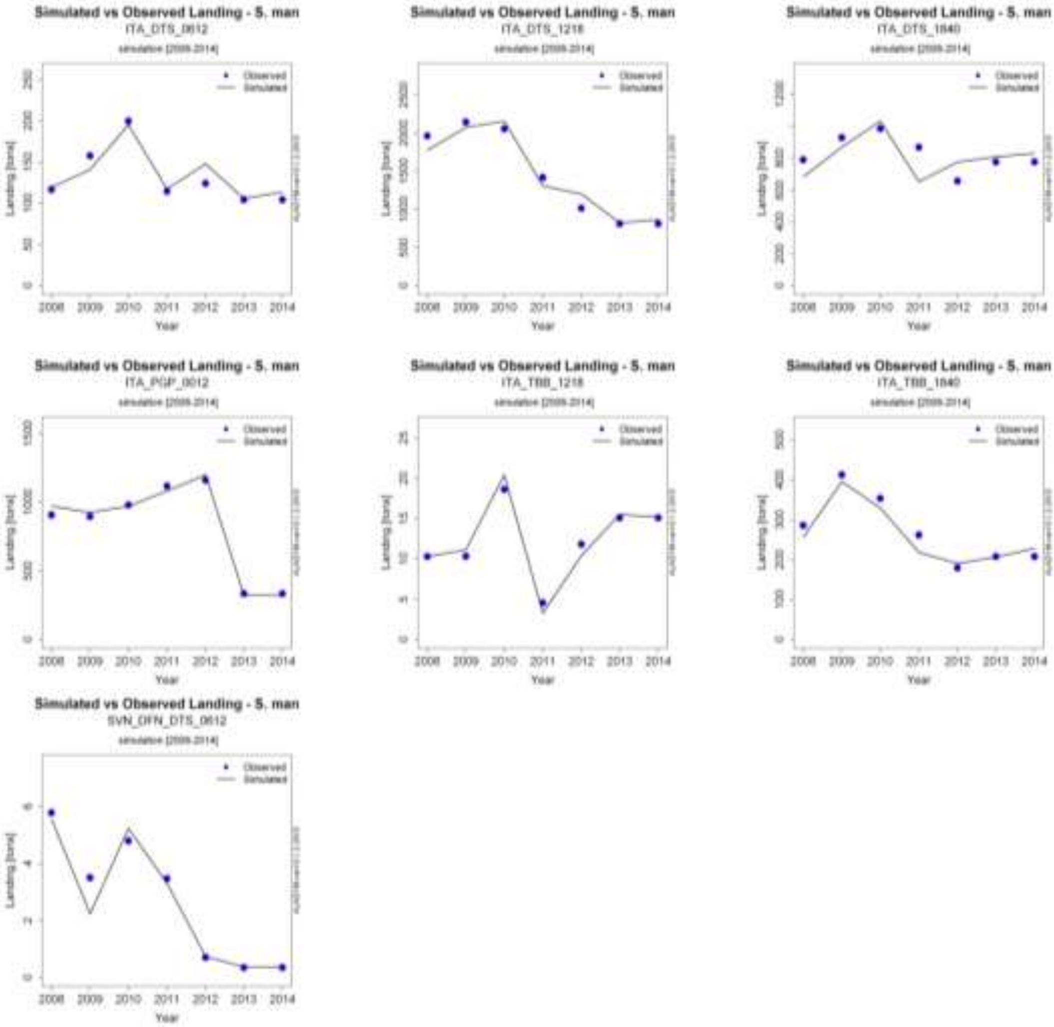


Figure 25 Comparison between simulated and observed landings by fleet segment for spottail mantis in GSA 17.

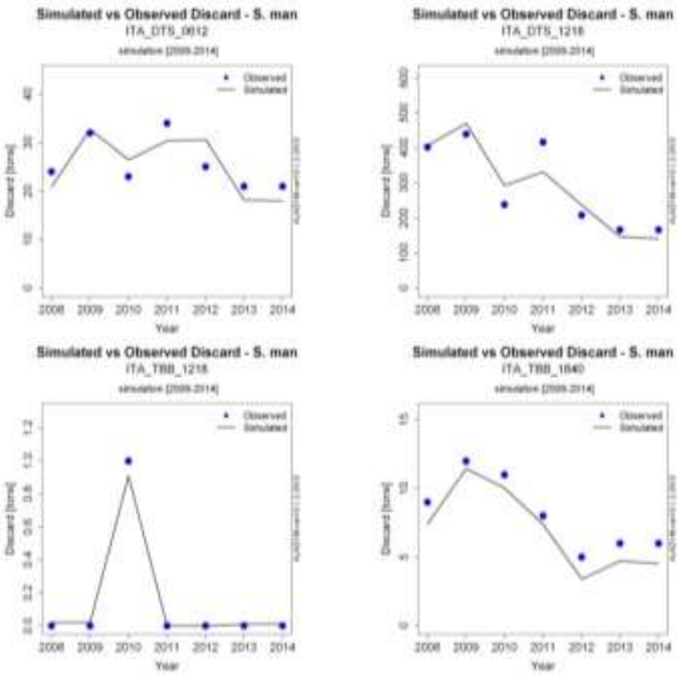


Figure 26 Comparison between simulated and observed discard by fleet segment for spottail mantis in GSA 17.

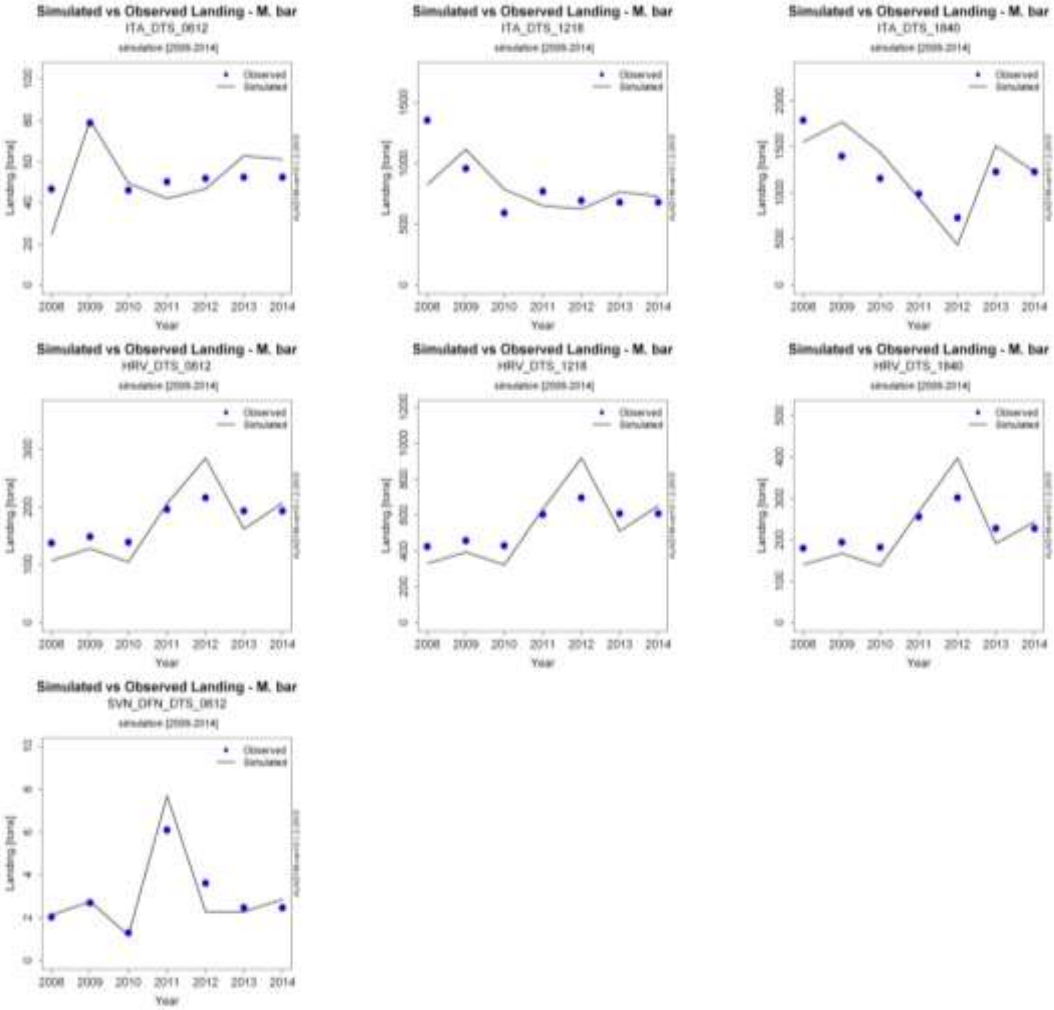


Figure 27 Comparison between simulated and observed landings by fleet segment for red mullet in GSA 17.

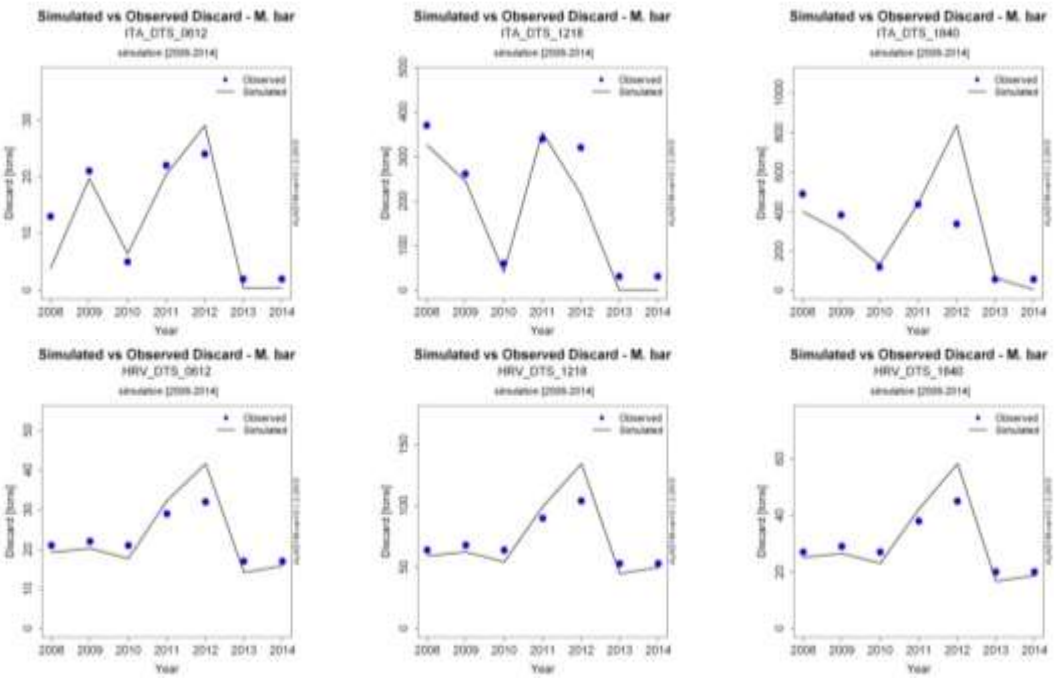


Figure 28 Comparison between simulated and observed discard by fleet segment for red mullet in GSA 17.

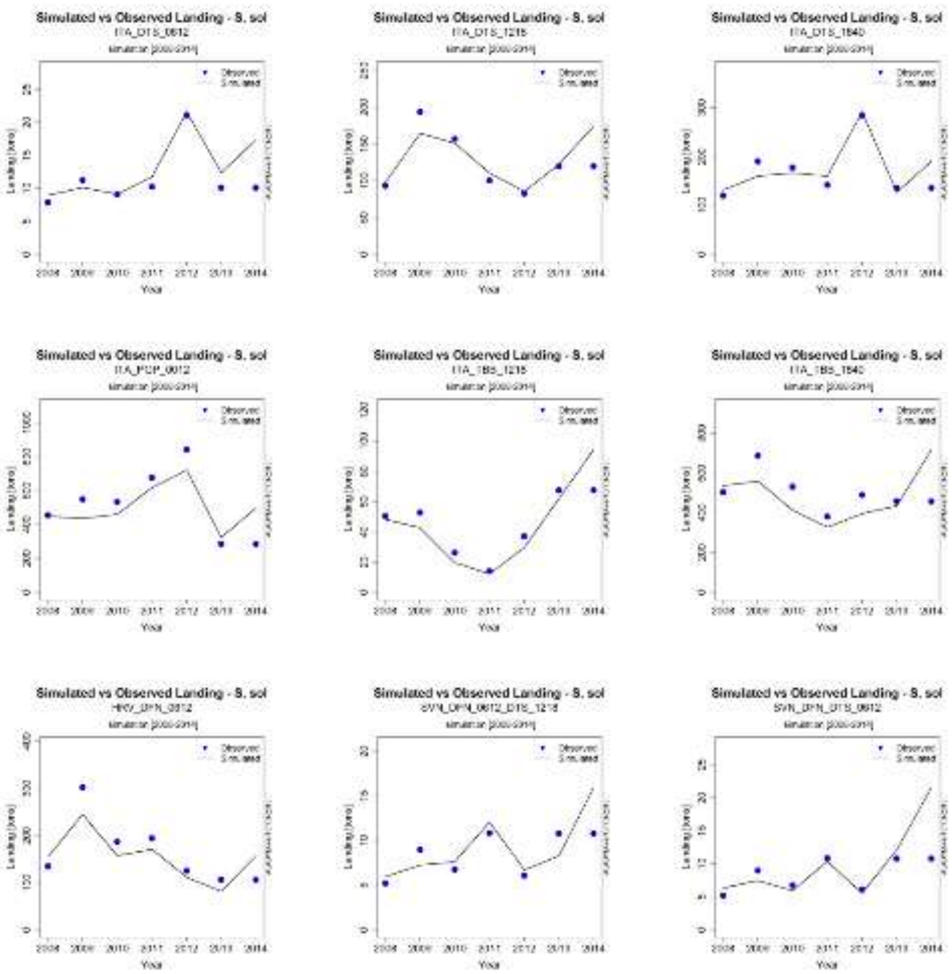


Figure 29 Comparison between simulated and observed landings by fleet segment for common sole in GSA 17.

The comparison between the Spawning Stock Biomass (SSB) from the assessment model and the BEMTOOL simulation are shown in Figure 30.

The simulated SSB of spottail mantis and hake in recent years are quite close to the ones estimated by separable VPA and SS3. The SSB for red mullet diverged only in 2011, while that of common sole from 2011 to 2013 was higher in the assessment model. It is also important to notice that the assessment of spottail mantis is updated to 2011 and the one of red mullet is updated to 2012.

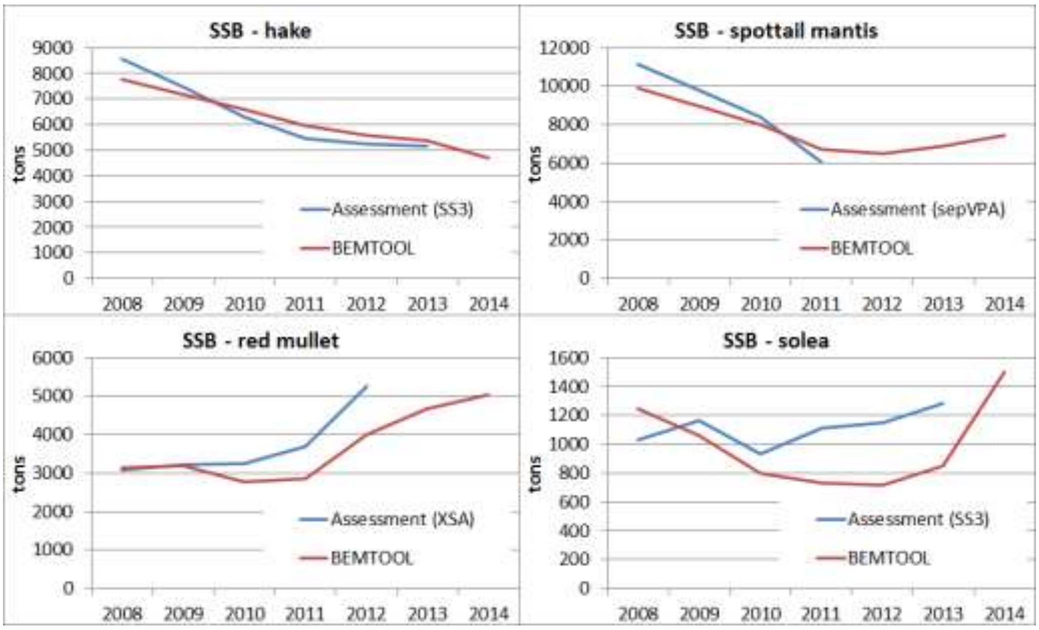


Figure 30 Comparison between BEMTOOL and stock assessment SSB for hake, spottail mantis, red mullet and common sole in GSA 17.

4.3 DIAGNOSIS OF THE STOCKS

In Figure 31 F0.1 (taken as proxy of F_{MSY}) and Fcurrent estimated by BEMTOOL for the four stocks of the case study are reported. Hake, red mullet and common sole are in the red zone, being Fcurrent higher than F_{MSY}. In this diagnosis the value of SSB corresponding to F0.1 was taken as indicative reference, in absence of agreed reference point based on biomass. Only *S .mantis* is in the green zone, being at a level of exploitation within the reference points. In the current status of the target stocks is reported in terms of fishing mortality and SSB.

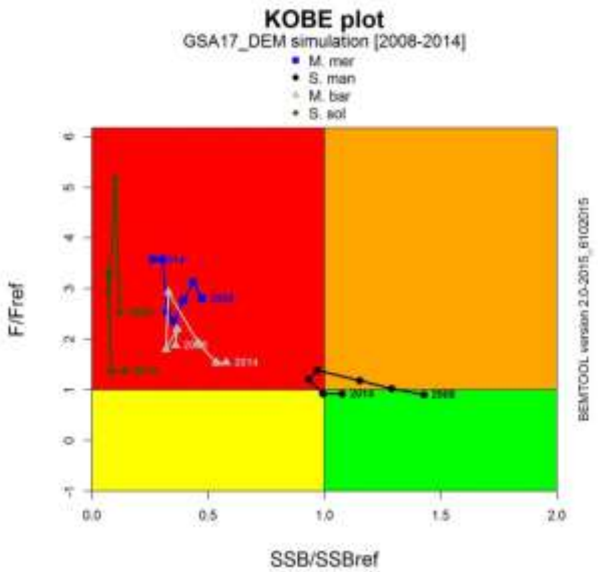


Figure 31 Kobe plot summarizing the state of exploitation for hake, spottail mantis, red mullet and common sole in GSA 17.

The reference points and current status by single stock is summarized in the table 96. Note that no meaningful stock recruitment relationship could be estimated for the main species considered.

Table 96 Current status of the target stocks.

Stock	Fcurrent	Reference point	SSBcurrent	SSBref	Comments
M. merluccius	0.66	0.2	4729	18047	F0.1
S. mantis	0.46	0.5	7469	6947	F0.1
M. barbatus	0.66	0.2	5051	8745	F0.1
S. solea	0.44	0.31	1501	10539	F0.1

The reference points of the different stocks have been combined setting a unique target (see 4.5 DEFINITION AND COMPARISON OF THE DIFFERENT MANAGEMENT SCENARIOS).

4.4 PROJECTIONS OF STATUS QUO WITH UNCERTAINTY ON RECRUITMENT

4.4.1 INPUT OF THE BIOLOGICAL AND PRESSURE MODULES

In order to perform the projections of the stock in the future, the recruitment of all the stocks has been assumed constantly equal to the last year estimated in the assessment. A multiplicative log-normal error with mean 0 and standard deviation 0.3 has been applied in order to take into account the uncertainty due to the process error that is propagated to all the indicators produced by BEMTOOL.

In the figure 32 the recruitment of the four stocks used in the case study is reported with confidence interval used in all the performed scenarios.

All the other biological inputs have been kept unchanged in the projections.

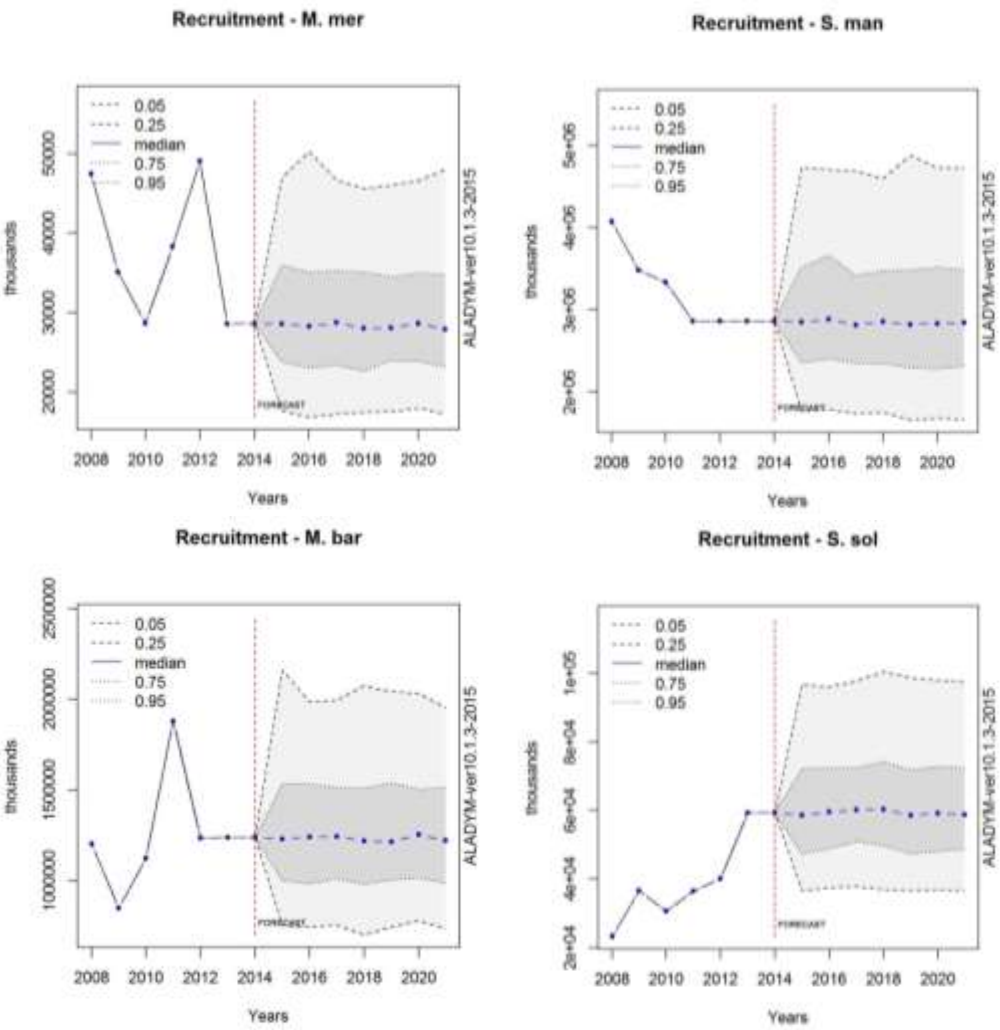


Figure 32 Recruitment used for hake, spottail mantis, red mullet and common sole in the forecast scenarios with confidence intervals.

For the status quo the effort has been maintained constant for all the years (until 2021) and equal to 2013.

4.4.2 INPUT OF THE ECONOMIC MODULE

The main equations in the socio-economic model relate to the dynamics of prices and costs. Each equation has been tested on the basis of available historical series of data in order to check that the functional relationships are correctly specified. The economic parameters of the selected fleet segments and the equations applied are given in the chapters below reported.

Given the presence of relevant fluctuations in the time series of most fleet segments, the socio economic parameters have been estimated on the basis of the most recent economic data.

For all fleets included in the case study, 2014 data were assumed equal to 2013.

4.4.2.1 PRICES DYNAMICS

Landings value were estimated on the basis of the average landed prices by the main species, for the period 2011-2013 presented in SEDAF D07 -Report on the Aspects of Fish Markets in the Adriatic Sea.

Prices are estimated by species and fleet segment as a function of landings. The functional relationship between prices and landings for each species and fleet segment has been defined using a flexibility coefficient representing the percentage change in prices due to one percent change in landings.
On the basis of the regressions operated on the data collected for the Italian fisheries, the following functional form has been adopted corresponding to option 1 of the price module:

$$p_{s,f,t} = p_{s,f,t-1}\left(1+\varepsilon_{s,f,landing}\frac{L_{s,f,t}-L_{s,f,t-1}}{L_{s,f,t-1}}\right)$$

where:

$p_{s,f,t}$ is the price of the target species s, for the fleet segment *f* at time *t*; (€)

$L_{s,f,t}$ is the landings of the target species *s*, for the fleet segment *f* at time *t* (Kg);

$\varepsilon_{s,f,landing}$ is the elasticity coefficient price-landings for species s and fleet segment f (€/kg).

Due to the lack of reliable estimations based on available data, the flexibility coefficient was computed exogenously. Sector studies (Nielsen, 2000 and Camanzi *et al.*, 2010) confirm that the flexibility coefficient normally ranges between -0.1 and -0.4 (Table 97). In this case study flexibility coefficients estimated for the Italian management plans have been applied, which estimated an average coefficient of -0.4 for all the target species.

Table 97 Price parameterization by fleet segment and stock in GSA 17 demersal case study.

Fleet segment	Model	coeff. price-landings M. merluccius	coeff. price-landings S. mantis	coeff. price-landings M. barbatus	coeff. price-landings S. solea
ITA_DTS_VL0612		-0.4	-0.4	-0.4	-0.4
ITA_DTS_VL1218		-0.4	-0.4	-0.4	-0.4
ITA_DTS_VL_1840		-0.4	-0.4	-0.4	-0.4
ITA_ PGP_VL0012		-0.4	-0.4	-0.4	-0.4
ITA TBB_VL1218		-0.4	-0.4	-0.4	-0.4
ITA TBB_VL1840	1	-0.4	-0.4	-0.4	-0.4
HRV DFN_VL0612		-0.4	-0.4	-0.4	-0.4
HRV DTS_VL0612		-0.4	-0.4	-0.4	-0.4
HRV DTS_VL1218		-0.4	-0.4	-0.4	-0.4
HRV DTS_VL1840		-0.4	-0.4	-0.4	-0.4
SVN DFN_DTS_VL0612		-0.4	-0.4	-0.4	-0.4

The flexibility coefficient price-landings was assumed equal to -0.4 for all target species, which means that given a 1% fall in the production of a given species, it is assumed an increase in price of 0.4%.

4.4.2.2 COSTS DYNAMICS

Variable costs

Variable cost are directly related to the number of estimated days at sea.

Variable costs have been classified under one heading, which is the sum of fuel costs and other variable costs. Total variable costs are a function of the fishing effort (expressed by average days at sea):

$$TVC_{f,t} = \beta_f EFF_{f,t}$$

where:

$TVC_{f,t}$ are total variable costs for fleet segment *f* at time *t* (€);

$EFF_{f,t}$ is the effort (in terms of total annual days at sea) of fleet segment *f* at time *t*;

β_f is the total variable costs per unit of effort at time *t*.

Maintenance costs and fixed costs

Maintenance costs (MC) and other fixed costs (OFC) are supposed to be proportional to the gross tonnage GT of the fleet segment, corresponding to option one of the BEMTOOL model.

$$MC_{f,t} = \alpha''_f GT_{f,t}$$

$$OFC_{f,t} = \alpha'_f GT_{f,t}$$

Capital costs

Depreciation costs DC are estimated by linear functions of the annual gross tonnage GT as well.

$$DC_{f,t} = \beta'_f GT_{f,t}$$

Following the approach of "The 2014 Annual Economic Report on the EU Fishing Fleet (STECF-14-16)", opportunity costs of capital (OC) are calculated by taking into account the fixed tangible asset value (*K*) and multiplying it by the real interest (*r*).

$$OC_{f,t} = r_{f,t} K_{f,t}$$

Table 98 presents the cost parameters applied to the case study broken down by fleet segment and function.

Table 98 Cost parameterization by fleet segment in GSA 17 demersal case study

Fleet segment	Total variable costs per unit of effort (sea days)	crew share	maintenance costs per unit of GT	other fixed costs per unit of GT	depreciation costs per unit of GT	interest costs per unit of GT
ITA_DTS_VL0612	178	0.43	591	487	1207	141
ITA_DTS_VL1218	454	0.51	286	213	662	85
ITA_DTS_VL_1840	808	0.41	123	92	770	104
ITA_ PGP_VL0012	78	0.49	705	681	1888	225
ITA TBB_VL1218	487	0.41	146	123	775	80

ITA TBB_VL1840	942	0.44	242	74	701	89
HRV DFN_VL0612	3	0.14	10	11	7	71
HRV DTS_VL0612	148	0.11	30	24	13	35
HRV DTS_VL1218	312	0.06	11	9	5	42
HRV DTS_VL1840	475	0.19	61	54	114	102
SVN DFN_DTS_VL0612	49	1.00	366	32	384	245

Fixed and capital costs are function of the estimated fleet capacity, expressed in terms of number of vessels and gross tonnage.

Labour costs

Labour cost are directly related to total revenues and variable cost. The number of employees was estimated by average number of employees per vessel in the fleet segment.

According to the prevalent income sharing system between the ship-owner and the crew, the labour cost is assumed to be proportional to revenues and total variable costs:

$$LC_{f,t} = cs_f \left(R_{f,t} - TVC_{f,t} \right)$$

where:

$LC_{f,t}$ is the labour cost of the fleet segment *f* at *t* (€);

$R_{f,t}$ are the total revenues (target species+ other species) of the fleet segment *f* at time *t* (€);

$TVC_{f,t}$ are the total variable costs for the fleet segment *f* at time *t* (€);

cs_f is crew share for the fleet segment *f*;

As highlighted in Table 98, on average the crew share is around 0.40-0.50 for the Italian fleets. Croatian fleets show crew share around 0.1-0.2 whilst for the Slovenian fleet is assumed a crew share equal to 1.

Revenues and total landings

Total revenues (total landings) are calculated as a function of the sum of the estimated landings value (landings weight) of the target assessed species for the Italian fleet segments. According to option 1 of BEMTOOL model component, total revenues and landings are proportional to the sum of the revenues and landings of target stock of the fleet segment *f* through a correction factor (rr_f and ll_f).

Option 1 :

$$R_{f,t} = rr_f \sum_{s=1:n} R_{f,s,t}$$

$$L_{f,t} = ll_f \sum_{i=1:n} L_{f,i,t}$$

where:

$R_{f,t}$ is the total revenues (target species+ other species) of the fleet segment *f* at time *t* (€);

$R_{f,s,t}$ is the revenues of target species s of the fleet segment *f* at time *t* (€);

rr_f is correction factor to estimate the total revenues of the fleet segment *f* from the revenues of assessed species;

$L_{f,t}$ is the total landings weight (target species+ other species) of the fleet segment *f* at time *t* (€);

$L_{f,s,t}$ is the landings weight of target species s of the fleet segment *f* at time *t* (€);

ll_f is correction factor to estimte the total landings of the fleet segment *f* from the landings of assessed species.

For non-Italian fleet segments, parametrization was based on the SEDAF project. In this case, total landings are calculated as a sum of landings of not assessed species, estimated as a function of the assessed species, and the landings of the assessed species. According to option 2 of the model component in BEMTOOL, total revenues are estimated as a sum of the revenues of target assessed species and the revenues of non-assessed species. The latter amount is calculated applying the average price in the last year of available data to the landings estimated as described above.

Option 2:

$$L_{other\_species,f,t} = u_f + v_f \sum_{s=1:n} L_{s,f,t}$$

where:

$L_{other\_species,f,t}$ is the landing of the other species of the fleet segment *f* at time *t*;

$L_{s,f,t}$ is the landing of the species s of the fleet segment *f* at time *t*;

u_f the amount of landings of non-target species independent on the landings of the target species;

v_f the quota of landings of non-target species dependent on the landings of the target species.

The following formulas are used to estimate total landings and total revenues:

$$L_{f,t} = L_{other\_species,f,t} + \sum_{s=1:n} L_{s,f,t}$$

$$p_{other\_species,f} = \frac{R_{f,t=last} - \sum_{s=1:n} R_{s,f,t=last}}{L_{f,t=last} - \sum_{s=1:n} L_{s,f,t=last}}$$

$$R_{f,t} = L_{other\_species,f,t} * p_{other\_species,f} + \sum_{s=1:n} (p_{s,f,t} * L_{s,f,t})$$

where:

$L_{f,t}$ is the total landing of the fleet segment *f* at time *t*;

$p_{other\_species,f}$ is the average price of the non-target species in the last year of simulation;

$R_{f,t=last}$ is the total revenues of the fleet segment *f* in the last year;

$R_{s,f,t=last}$ is the revenues of the target species s for the fleet segment *f* in the last year;

$L_{f,t=last}$ is the total landing of the fleet segment *f* in the last year;

$L_{s,f,t=last}$ is the landing of the target species s for the fleet segment *f* in the last year.

$p_{s,f,t}$ is the price of the target species s for the fleet segment *f* at time *t*.

$$p_{other\_species,f} = \frac{R_{f,t=last} - \sum_{s=1:n} R_{s,f,t=last}}{L_{f,t=last} - \sum_{s=1:n} L_{s,f,t=last}} p_{other\_species,f} R_{f,t=last} R_{s,f,t=last} L_{f,t=last} L_{s,f,t=last}$$

Average employees per vessel

Employment was estimated by average number of employees per vessel in the fleet segment *f* (em_f) multiplied by the number of vessels for each fleet segment ($N_{f,t}$):

$$EM_{f,t} = em_f N_{f,t}$$

Capital Value

Capital value was estimated by the average value of a vessel for the fleet segment *f* at time *t*. Discount rates (Table 99) used are the harmonized long-term interest rates for convergence assessment calculated by the European Central Bank, available at http://www.ecb.int/stats/money/long/html/index.en.html.

Table 99 Socio-economic indicators parameterization by fleet segment in GSA 17 demersal case study.

Fleet segment	correction factor for landings	correction factor for revenue	coefficient u landings	coefficient v landings	value of a single vessel	average employees per vessel	discount rate
ITA_DTS_0612	3.27	2.55	0	0	24672	2	0.0431
ITA_DTS_1218	2.8	2.8	0	0	57761	3	0.0431
ITA_DTS_1840	3.61	2.65	0	0	276172	5	0.0431
ITA_PGP_0012	10.82	4.9	0	0	14490	2	0.0431
ITA_TBB_1218	7.49	2.99	0	0	73843	4	0.0431
ITA_TBB_1840	4.27	2.32	0	0	238557	5	0.0431
HRV_DFN_0612			0	2.19	4130	0.06	0.0468
HRV_DTS_0612			0	1.68	4276	0.2	0.0468
HRV_DTS_1218			0	0.94	12024	0.2	0.0468
HRV_DTS_1840			0	1.51	135059	2	0.0468
SVN_DFN_0612_DTS_1218			0	10.14	45074	1	0.0581

Table 100 reports the contribute (in percentage) to the landing volume and revenues of the assessed species by fleet segment.

Table 100 Assessed species (in weight for 2013) by fleet segment in GSA 17 demersal case study

Fleet segment	% of assessed species (landings)	% of assessed species (revenues)
ITA DTS_VL0612	30.6%	4.4%
ITA DTS_VL1218	35.7%	35.7%
ITA DTS_VL1840	27.7%	37.8%
ITA PGP_VL0012	9.0%	20.2%
ITA TBB_VL1218	13.3%	33.3%
ITA TBB_VL1840	22.4%	42.2%
HRV DFN_VL0612	31.3%	48.8%
HRV DTS_VL0612	37.4%	18.2%
HRV DTS_VL1218	51.5%	23.9%
HRV DTS_VL1840	39.8%	23.0%
SVN DFN_VL0612	9.0%	21.6%

Socio-economic indicators

The current revenue to break even revenue ratio (CR/BER) and Net profit have been estimated according to the Economic performance indicator calculations provided in "2014 Annual Economic Report on the EU Fishing Fleet (STECF-14-16)".

BER is calculated as Current Revenue (CR) divided by the Break Even Revenue (BER), where:

Current Revenue (CR) = income from landings + other income

Break Even Revenue (BER) = fixed costs / (1-[variable costs / current revenue])

Net profit is the difference between revenue and explicit costs and opportunity costs. It includes all operational costs, such as wages, energy, repair, other variable, fixed costs and depreciation and opportunity costs of capital. It measures the efficiency of a producer in society's view by evaluating the total costs of inputs (excluding natural resource costs) in comparison to outputs or revenue. Therefore, economic profit is the primary indicator of economic performance and is often used as a proxy of resource rent in fisheries. The excess of revenue over the opportunity cost of producing the good is also referred to as supernormal or abnormal profits. Abnormal profits in a sector is an incentive for other firms to enter the industry. Zero or a negative profit may indicate high competition in the sector and can be used as one of the indicators of overcapacity.

4.4.3 RESULTS OF THE BIOLOGICAL AND PRESSURE INDICATORS

In the status quo scenario, projecting the current effort for all the fleet segments and assuming a recruitment varying around the last estimate from -40% to +68% for hake, from -42% to +65% for spottail mantis, from -41% to +58% for red mullet and from -38% to +64% for common sole, the proxy of the probability that the SSB of hake was less than the biomass reference point is 100%, for spottail mantis is 18.4 %, for red mullet is 100 %, and for common sole is 100% (Figure 33).

The SSB of spottail mantis and red mullet after a slight increase until 2017 remains quite stable until 2021. This is due to the low value of fishing mortality in 2013 that influences the SSB in the first years of projection. The SSB of the red mullet and spottail mantis stocks thus reaches in 2021 a value slightly higher than in 2013. SSB of hake shows a sharp decrease until 2019, due to the the high value of fishing mortality in 2013 (about 40% higher than the value of 2012), and then the SSB reaches a plateau that is -60% of the SSB value in 2013. The SSB of common sole gradually and strongly increases from 2015, due to the very high recruitment observed in the last years that consequently influenced the projection (Fig. 34).

The landing of hake after a slight decrease in 2015, due as for SSB to the increase in fishing mortality in 2013, shows a recovery in 2016 and remains stable until 2021 for all the fleet segments. This small recover of landing in 2016 is due to the recruitment value used in the projections that is able to balance the increase in fishing mortality of 2013 only in 2016 (Fig, 35). The discard slightly increases until 2016 for all the fleet segments, because of the higher recruitment from 2014, and then remains stable until 2021 (Figure 35).

Also the landing and discard of spottail mantis after a slight decrease in 2015, due to the decrease in fishing mortality of 2013, show a slight increase in 2016 and then remain stable until 2021 for all the fleet segments (Figure 36).

The landing of red mullet shows a slight increase in the first years of forecast and then remains stable until 2021 reaching values about 15% higher than the one in 2013. The discard remains quite stable until 2021 (Figure 37).

Finally, the landing of common sole, after a slight increase, remains for all the fleet segments stable until 2021. For effect of the high recruitment value observed in the last years and the great increase of the SSB, the overall landing in 2021 is predicted to be about 2 times the value of 2013 (Figure 38).

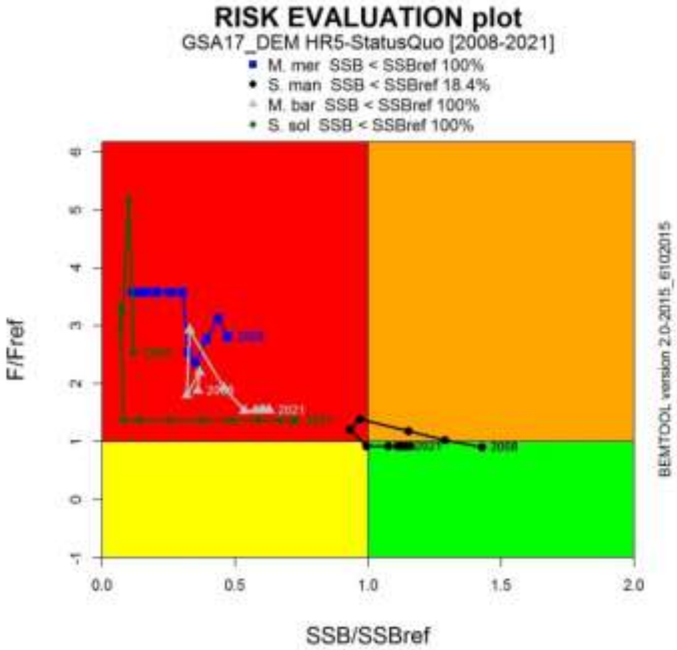


Figure 33 Kobe plot summarizing the status of hake, spottail mantis, red mullet and common sole in GSA 17 in the status quo scenario.

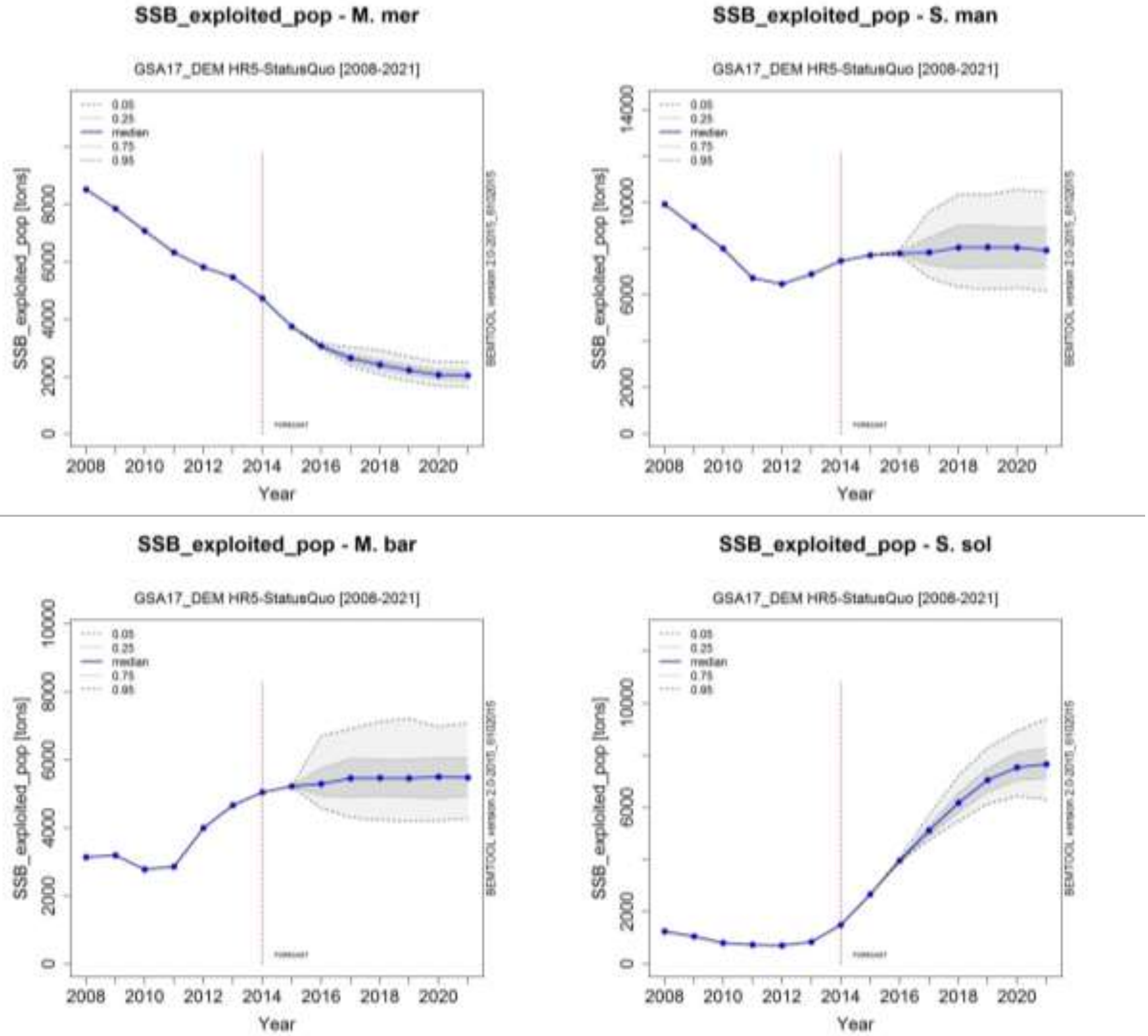
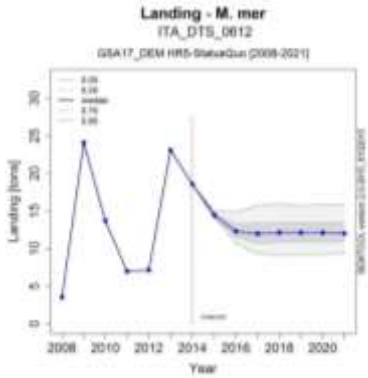
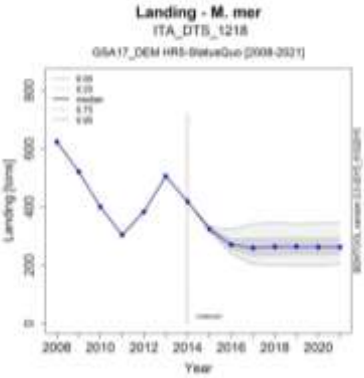
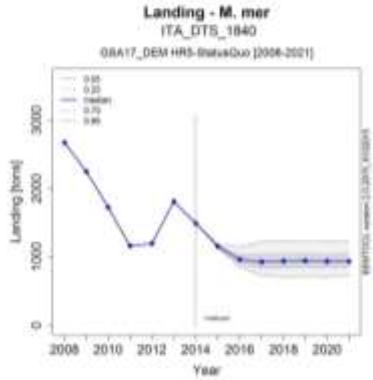
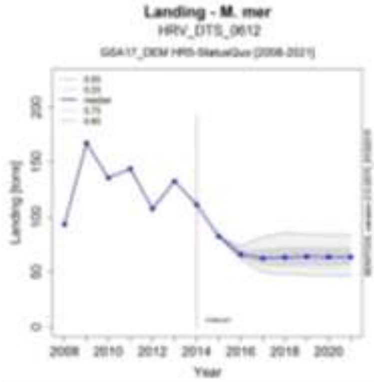


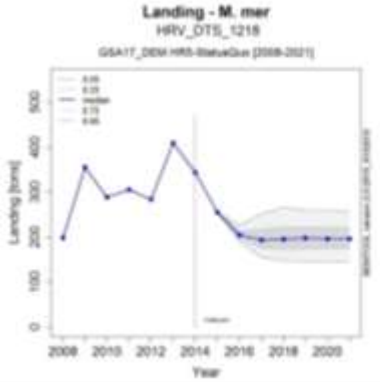
Figure 34 SSB for hake, spottail mantis, red mullet and common sole in the status quo scenario with confidence intervals.

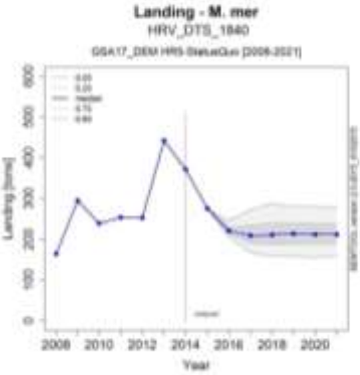

Landing - M. mer
ITA_DTS_0612
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year

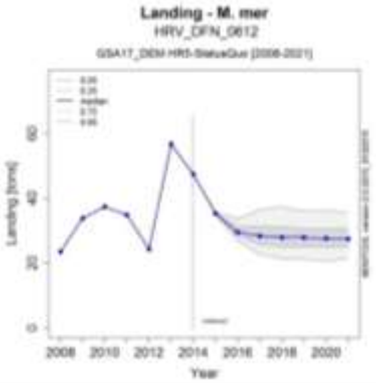

Landing - M. mer
ITA_DTS_1218
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year

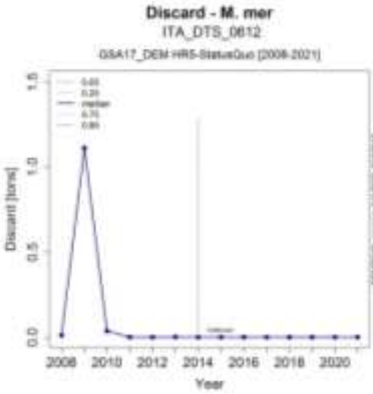

Landing - M. mer
ITA_DTS_1840
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year

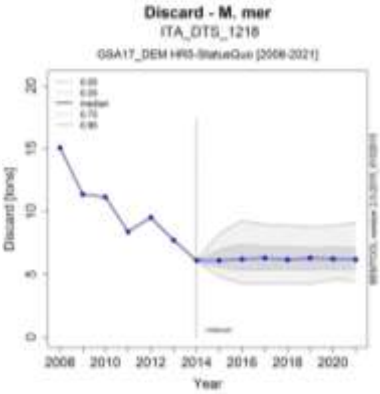

Landing - M. mer
HRV_DTS_0612
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year


Landing - M. mer
HRV_DTS_1218
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year


Landing - M. mer
HRV_DTS_1840
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year


Landing - M. mer
HRV_DFN_0612
GSA17_DEM HR5-StatusQuo [2008-2021]
Landing [tons]
Year


Discard - M. mer
ITA_DTS_0612
GSA17_DEM HR5-StatusQuo [2008-2021]
Discard [tons]
Year


Discard - M. mer
ITA_DTS_1218
GSA17_DEM HR5-StatusQuo [2008-2021]
Discard [tons]
Year

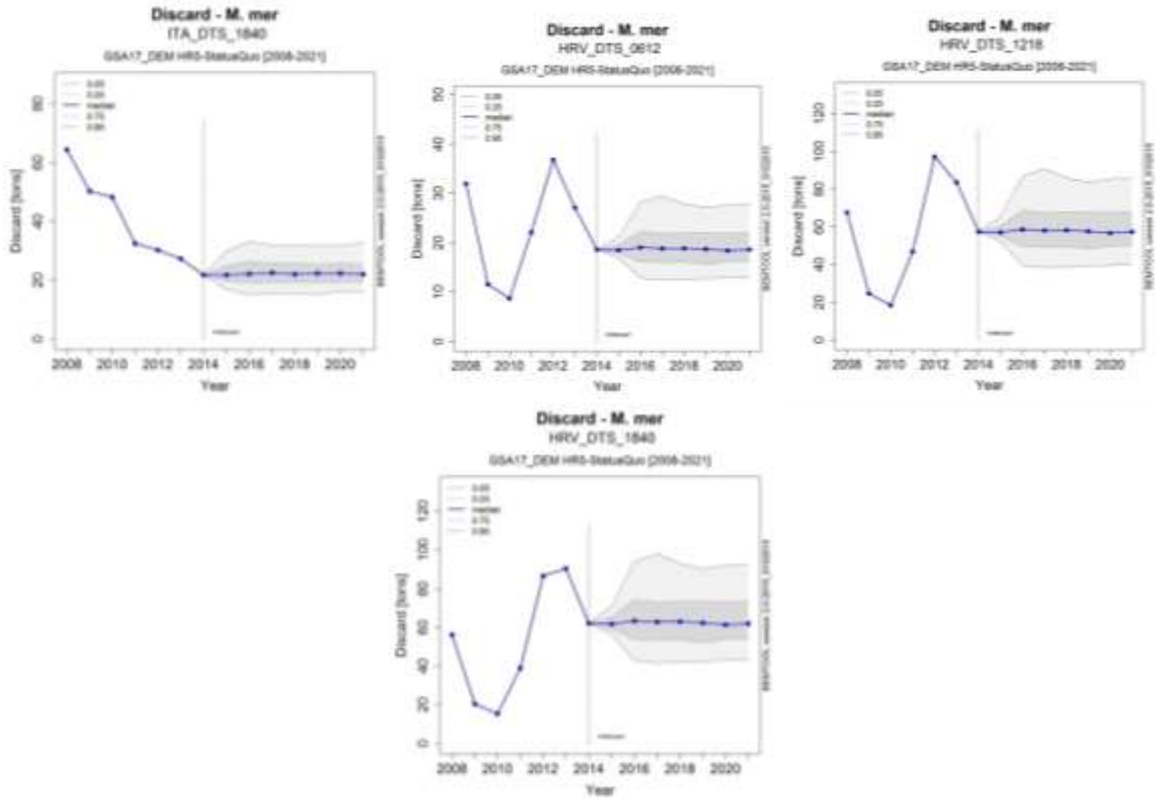
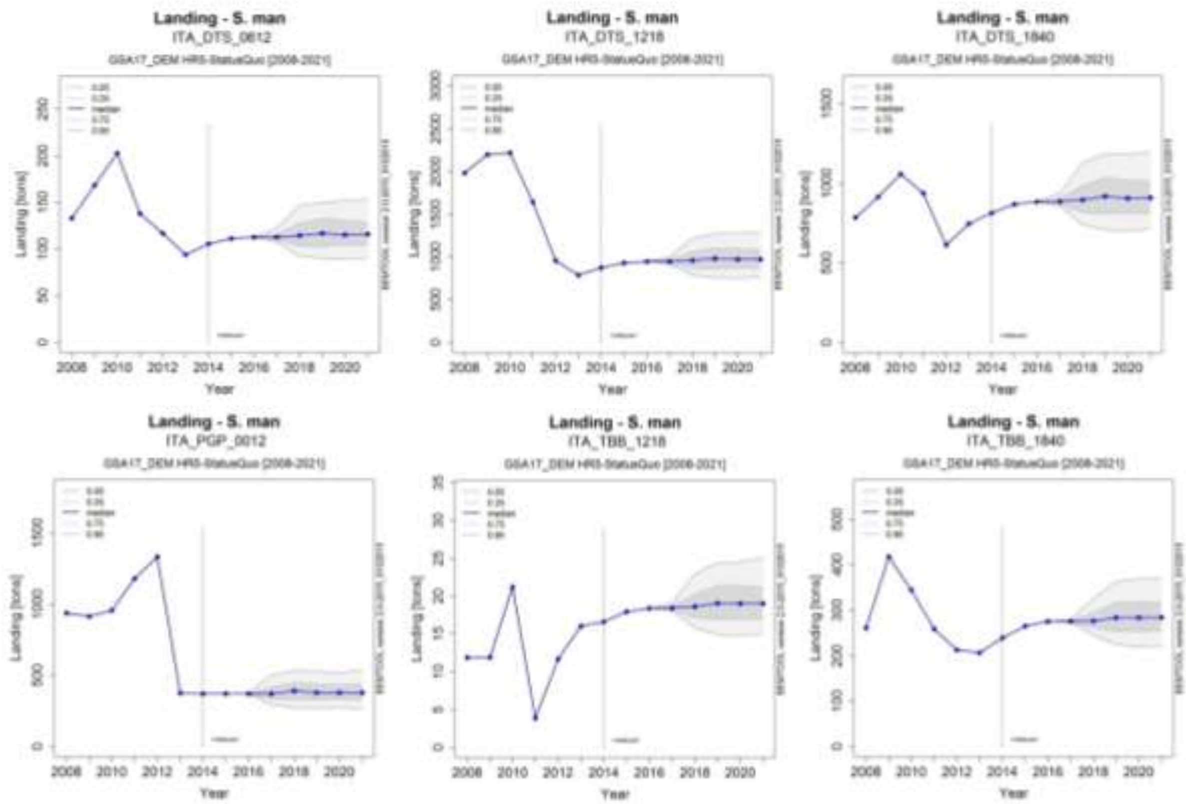


Figure 35 Landing and discard for hake by fleet segment in the status quo scenario with confidence intervals.



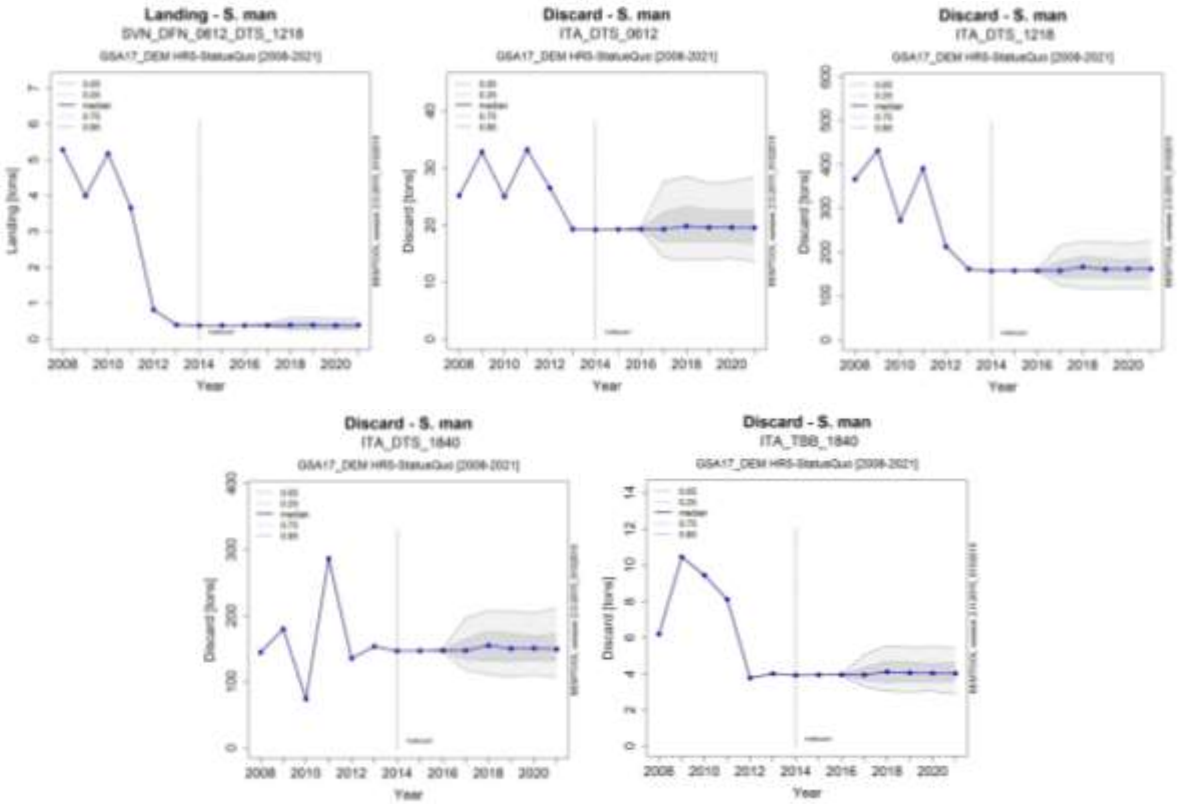
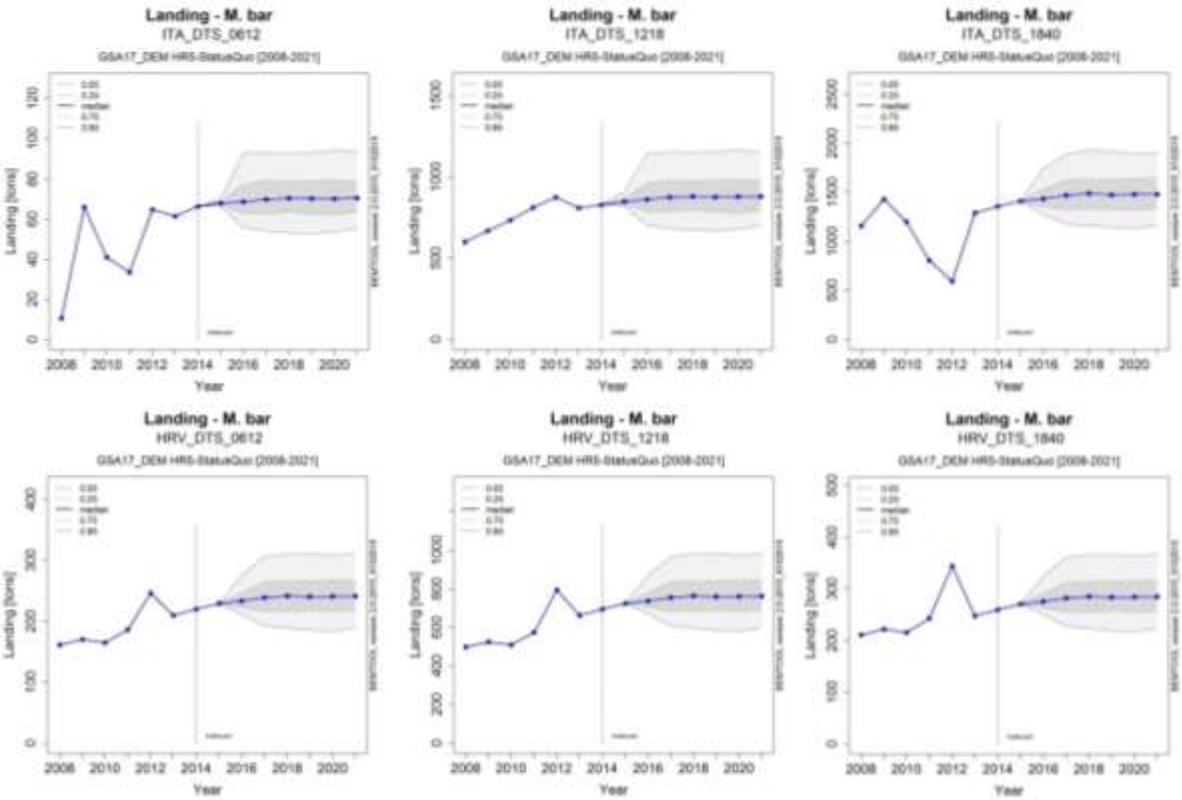


Figure 36 Landing and discard for spottail mantis by fleet segment in the status quo scenario with confidence intervals.



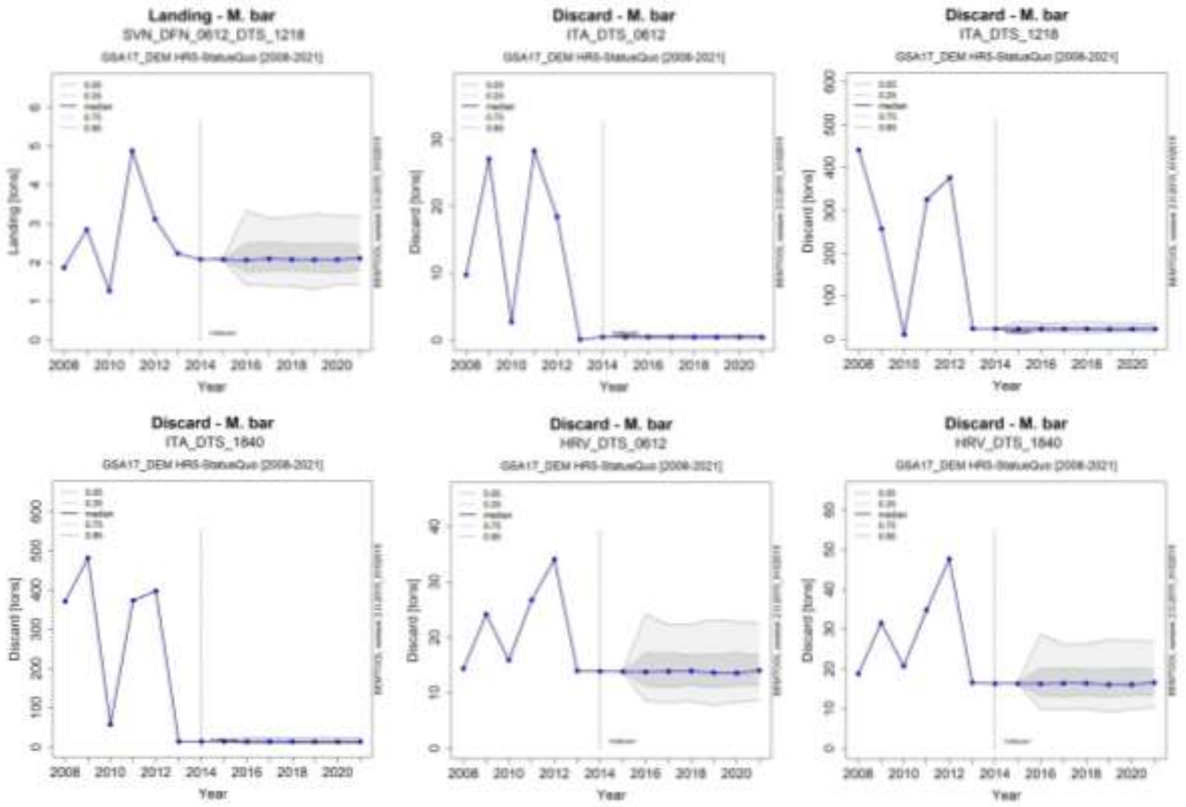


Figure 37 Landing and discard for red mullet by fleet segment in the status quo scenario with confidence intervals.

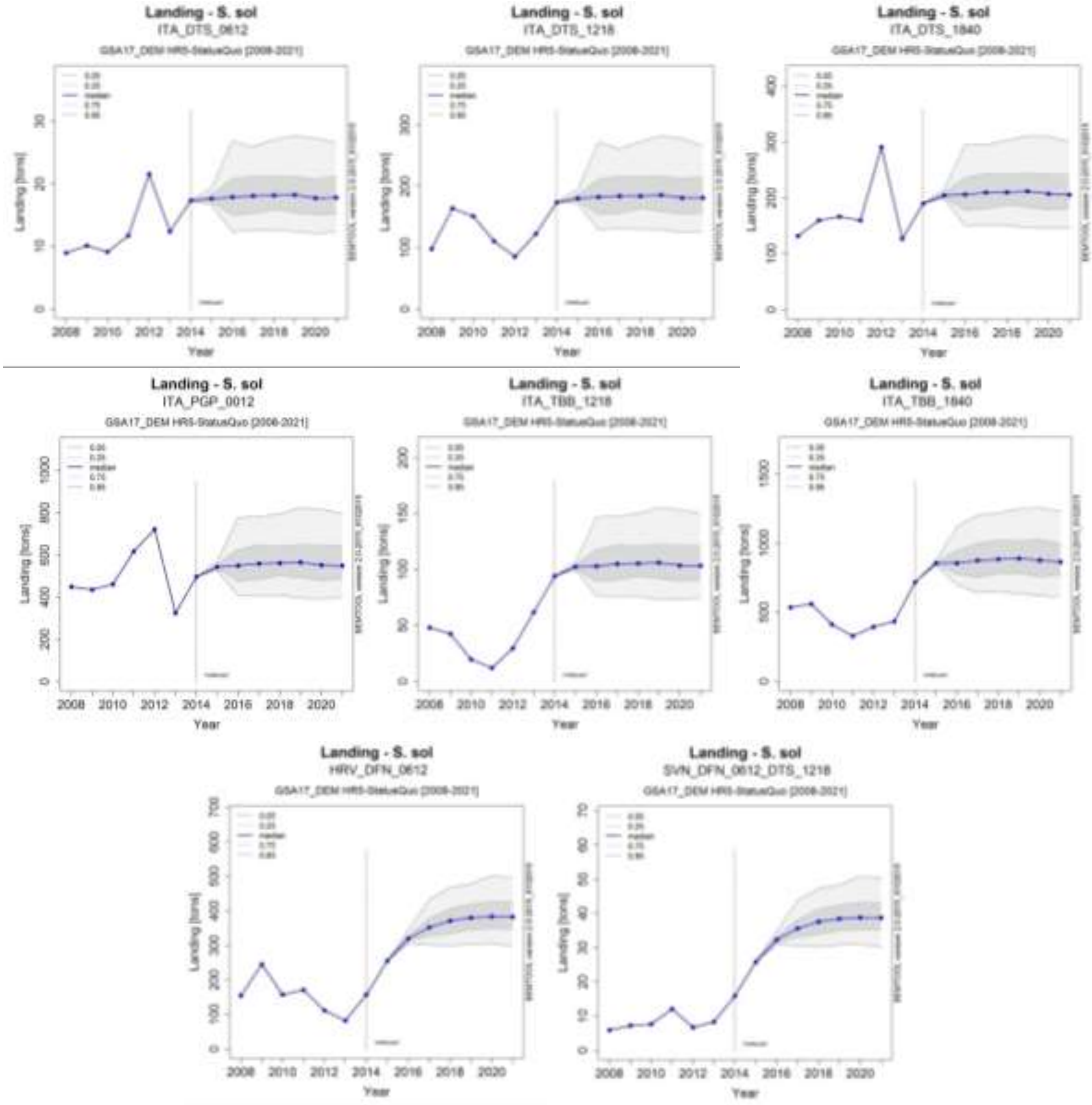


Figure 38 Landing for common sole by fleet segment in the status quo scenario with confidence intervals.

4.4.4 RESULTS OF THE SOCIO-ECONOMIC INDICATORS

In 2013 the fleets considered in the case study produced 36 thousand tons of total production generating 177 million euro, an increase by 9% in quantity and a decrease by 17% in value compared to 2012. The most important fleet segment is the Italian demersal trawlers VL1840, accounting for a third of total revenues. Other relevant fleet segments are the Italian small scale vessels lower than 12m and the Italian demersal trawlers VL1218, which account for around 20% of total revenues each. In 2013 the Italian fleet produced 85% of total landings, both in weight and value, while the Croatian fleet produced around 14% and the Slovenian fleet less than 1%.

As reported in figure 39, total revenues of demersal fleets operating in GSA 17 show a negative trend in the period 2008-2013. Comparing 2013 to 2008, total landings and revenues have registered a decrease by 16% and 34% respectively. The three main fleet segments mentioned above have registered reductions in revenues by around 40% in the period under analysis.

In the forecast period, total landings for the overall fishing sector show an increasing trend with a variation by 15% in weight and just 1% in value in 2021 compared to 2013. The slight increase in revenues is due to the reduction in landings prices. Among the main fleet segments, the strongest increase is registered for the Italian small scale vessels lower than 12m (46% in weight and 14% in value), while landings of the Italian demersal trawlers VL1840 are expected to decrease by 8% in weight and 13% in value. The Croatian demersal trawlers are expected to register a decrease in landings and revenues, while the Croatian drift netters and the Slovenian demersal fleet would register an increase in fish production.

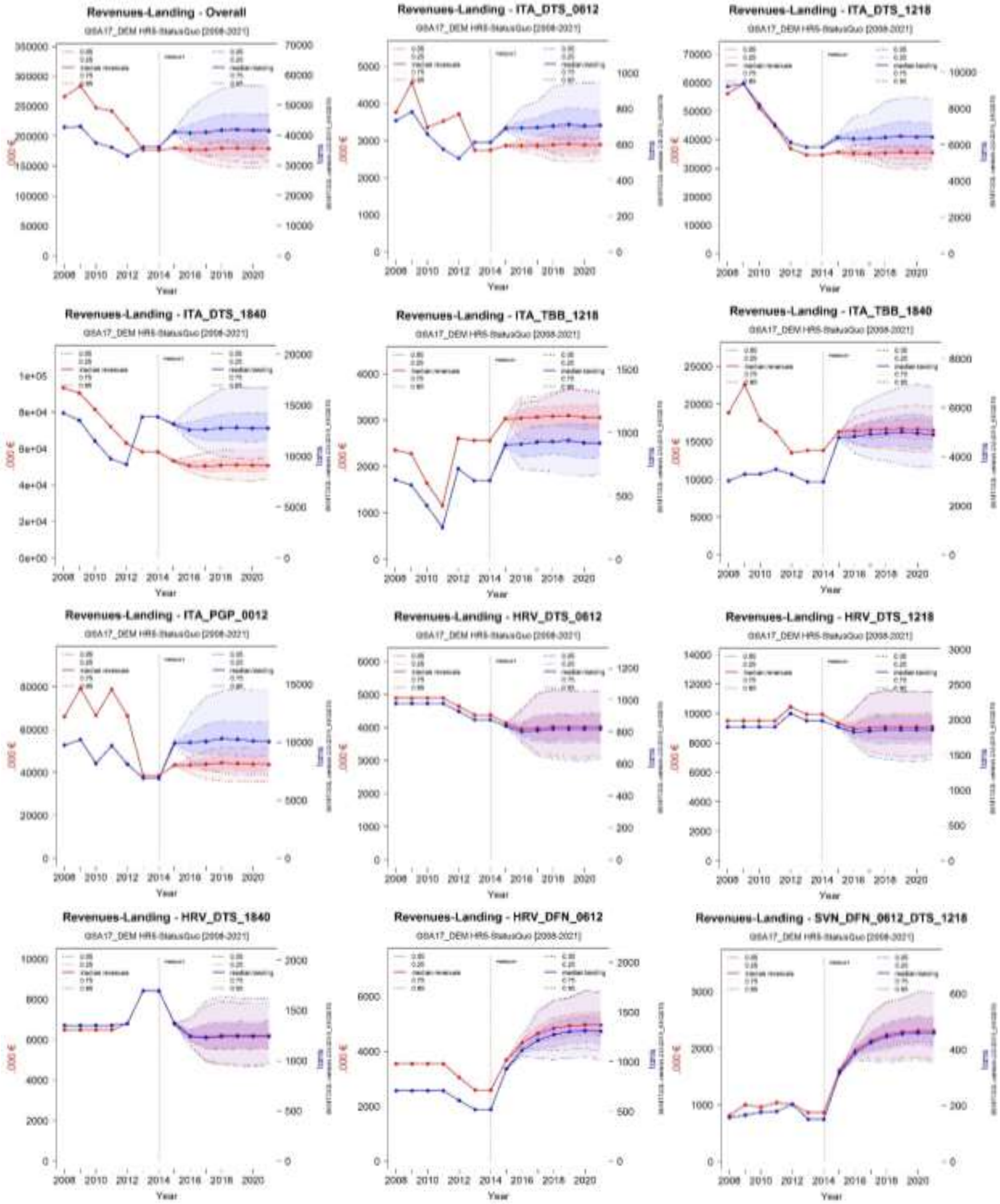


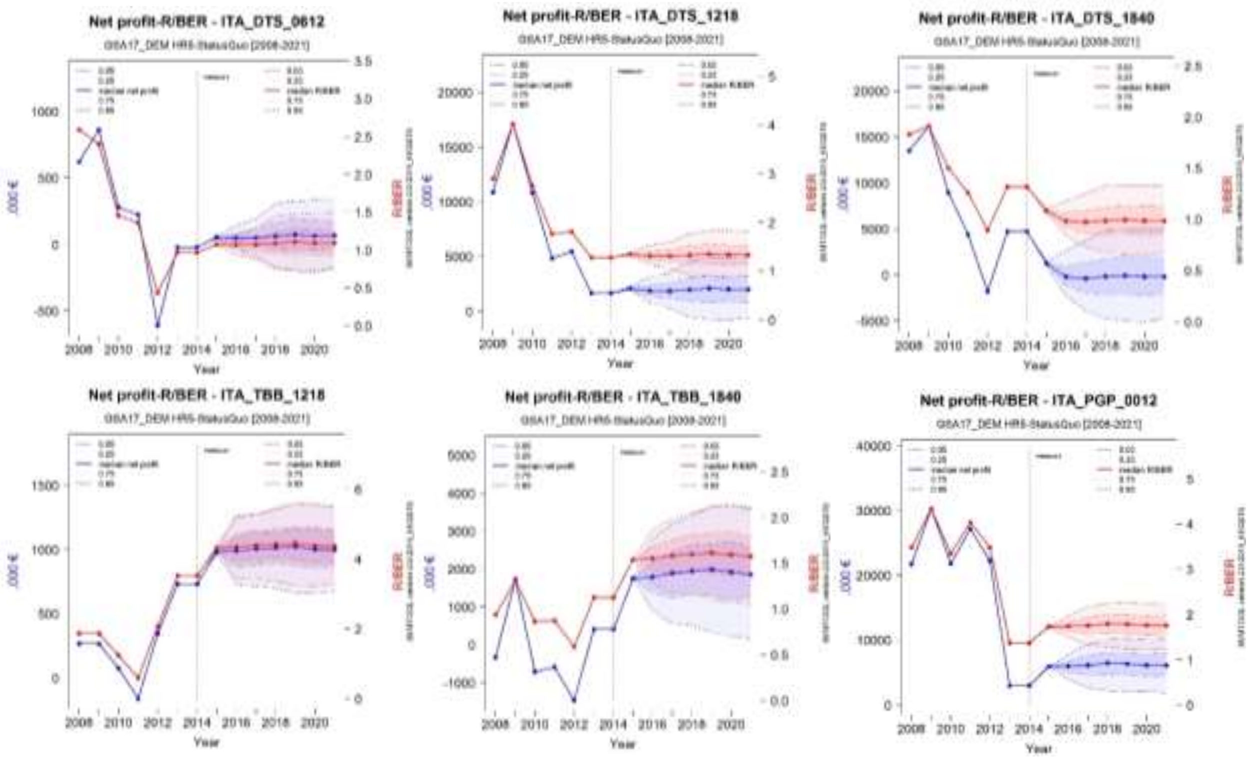
Figure 39 Landings weight and value by fleet segment and quantile.

In 2013 the economic efficiency of the fishing sector, calculated in terms of net profit, is slightly positive for all fleet segments with the exception of the Italian demersal trawlers VL0612 and the Slovenian demersal fleet. However this performance in 2013 did not reach the past levels (2008-2010) for some fleet segments. The whole demersal fleet operating in GSA 17 show positive values for net profit in the period 2008-2013. Negative values are registered mainly in the period 2010-2012 for some Italian fleet segments; in particular for the Italian beam trawlers VL1840. In 2013, net profit for the whole demersal fleet in the area shows a reduction by almost 40% compared to 2012.

In the forecast period, net profit for the overall fishing sector is stable (Fig. 40). Compared with 2013, net profit does not show significant variation in 2021. However, at fleet segment level, variations are relevant. Net profit for the Italian demersal trawlers VL0612 is expected to become positive, while the Slovenian demersal fleet is expected to reduce its net loss by more than a half. On the contrary, the Italian demersal trawlers VL1840, which registers in the current situation a positive net profit, is expected to have a negative performance in the future. For the other Italian fleet segments as well as the Croatian drift netters, the economic performance is expected to be positive or invariant in the forecast period. The other Croatian fleet segments would register a declining trend in their profits.

In 2013 the ratio between current and break-even revenues (CR/BER), which shows how current revenues are sufficient to cover variable and fixed costs, is greater than 1 for all fleet segments with the exception of the Italian demersal trawlers VL0612 and the Slovenian demersal fleet. This indicator shows an improvement if compared with 2012, when, in addition to the fleet segments mentioned above, also the Italian demersal trawlers VL1840 and the Italian beam trawlers VL1840 registered values lower than 1.

The ratio between current and break-even revenues (CR/BER) in the forecast period shows a positive trend for all Italian fleet segments with the exception of the demersal trawlers VL1840, which is expected to register a value lower than 1 in 2021. The Croatian demersal trawlers show a reduction in 2021 if compared to 2014.



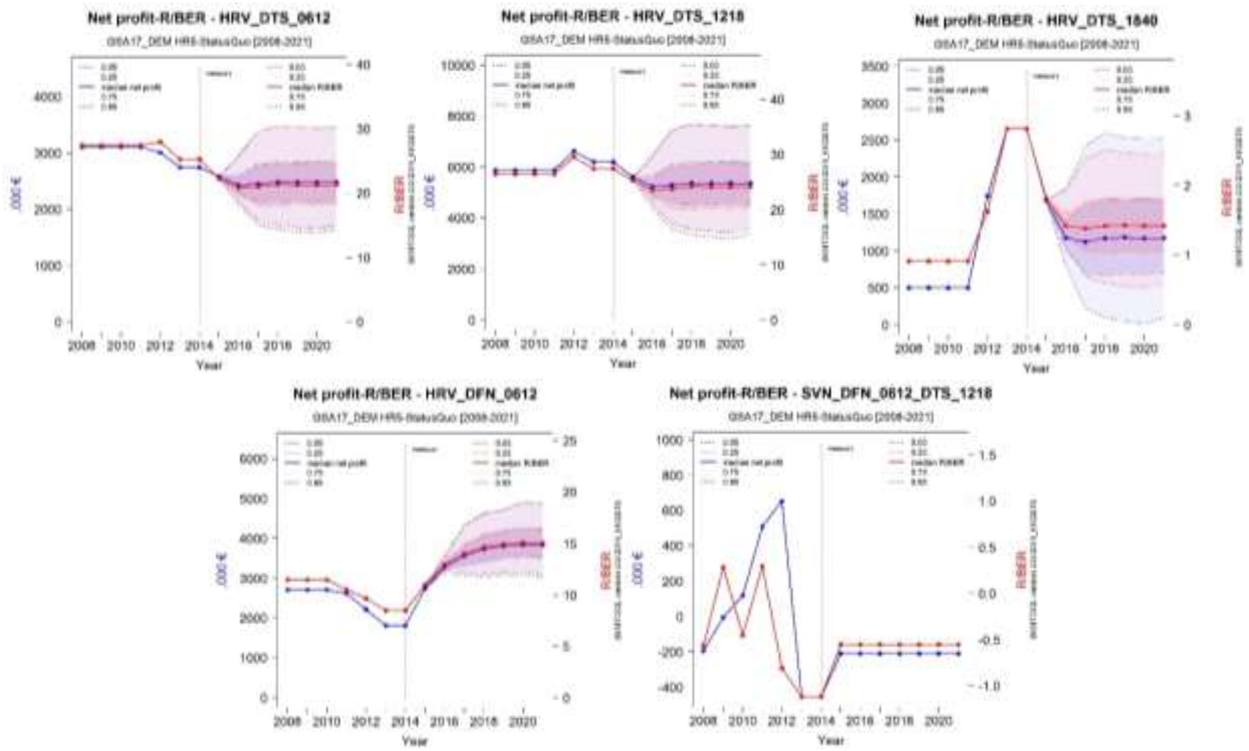


Figure 40 Net profit and Current Revenue to the Break-Even Revenue ratio by fleet segment and quantile

4.5 DEFINITION AND COMPARISON OF THE DIFFERENT MANAGEMENT SCENARIOS

According to state of exploitation of the four demersal stocks in GSA 17 case study, 6 forecast scenarios, besides the status quo, have been performed, in order to evaluate the consequences of several management strategies in terms of costs and benefits on the stocks and on the productive and economic performances of different fleet segments.

The 6 management scenarios have been implemented with the aim to reduce the overall combined fishing mortality towards a combined reference point, estimated as follows:

$$F_{2013,f,combined} = \frac{\sum_{s=1}^{4}(LandValue_{2013,s} * F_{2013,f,s})}{\sum_{s=1}^{4} LandValue_{2013,s}}$$

$$F_{2013,combined} = \sum_{f=1}^{10} F_{2013,f,combined}$$

$$F_{msy,combined} = \frac{\sum_{s=1}^{4}(LandValue_{2013,s} * F_{msy,s})}{\sum_{s=1}^{4} LandValue_{2013,s}}$$

where:

$F_{2013,f,combined}$ is the fishing mortality combined (taking into account all the target species together) for the fleet segment f in 2013;

$F_{2013,combined}$ is the overall fishing mortality combined (taking into account all the target species together) in 2013;

$Fmsy_{,combined}$ is a combination of the reference point Fmsy of all the species;

$LandValue_{2013,\, s}$ is the overall value of landing of species s.

Management scenarios (Table 101) have been implemented to reduce the overall combined fishing mortality F towards a combined F_{MSY}. This reference point was estimated as the average F_{MSY} among all the stocks, weighed using stock landing value, following the approach as for balance indicators. The reduction was applied to each fleet segment, considering the relative portion of Fcurrent and F_{MSY}, on the basis of fleet segment landing to overall landing of the stock. The needed reduction is 59% of the Fcurrent combined ($Fcurrent_{combined}$=0.76; $F_{MSY\ combined}$=0.31). This reduction has been applied according to the proportions of combined fishing mortality by fleet segment (table 102).

Table 101 Scenarios implemented to reach the combined F_{MSY}. in GSA17

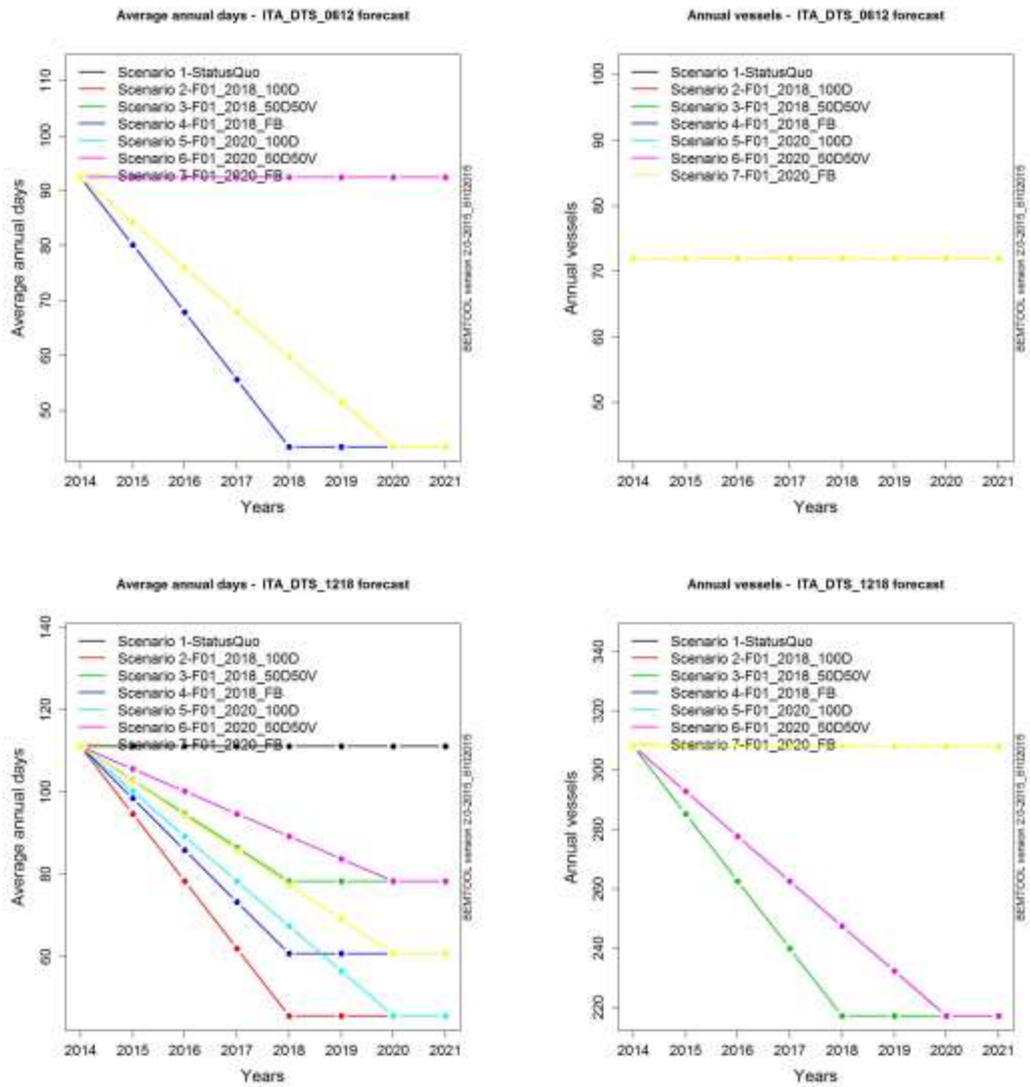
Scenario 2 F01_2018_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 3 F01_2018_50D50V	Linear reduction of combined F towards the combined F_{MSY}, applied half to fishing days and half to the number of vessels (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 4 F01_2018_FB	Gradual closure of fishing activity until 2018 in the months with higher occurrence of offspring of the four target species (July, August, September, October, November and January) (except SVN_DFN_0612_DTS_1218);
Scenario 5 F01_2020_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 6 F01_2020_50D50V	Linear reduction of combined F towards the combined F_{MSY}, applied half to fishing days and half to the number of vessels (except ITA DTS_0612 and ITA TBB_1218 and SVN_DFN_0612_DTS_1218, because representing less than 3% of the combined F);
Scenario 7 F01_2020_FB	Gradual closure of fishing activity until 2020 in the months with higher occurrence of offspring of the four target species (July, August, September, October, November and January) (except SVN_DFN_0612_DTS_1218).

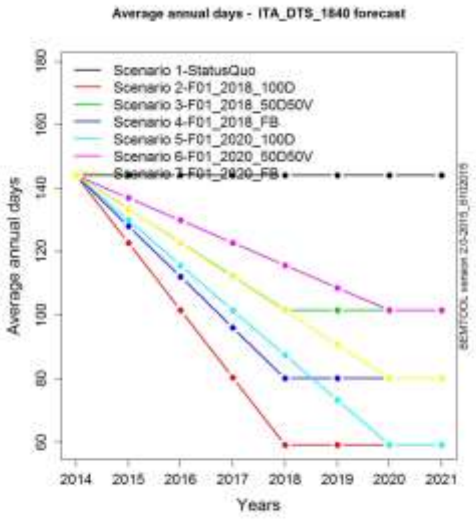
Table 102 F current combined by fleet segment, percentage of F combined due to each fleet segment and reduction applied.

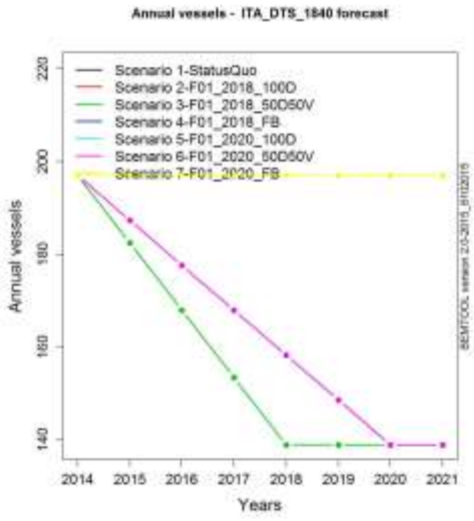
Fleet segment	F current combined by fleet segment	% F current combined by fleet segment	% of reduction applied (in scenarios 2, 3, 5 and 6)	% of reduction applied (in scenarios 4 and 7)
ITA_DTS_0612	0.01	1.46	0	53
ITA_DTS_1218	0.12	15.83	59	45
ITA_DTS_1840	0.21	26.99	59	44

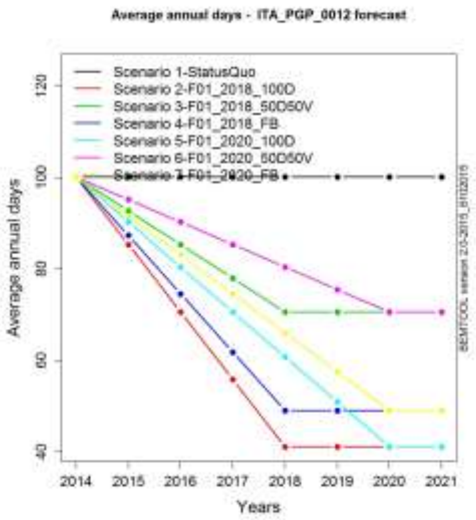
Fleet segment	F current combined by fleet segment	% F current combined by fleet segment	% of reduction applied (in scenarios 2, 3, 5 and 6)	% of reduction applied (in scenarios 4 and 7)
ITA_PGP_0012	0.07	8.57	59	51
ITA_TBB_1218	0.01	1.54	0	42
ITA_TBB_1840	0.09	12.37	59	43
HRV_DTS_0612	0.03	3.90	59	50
HRV_DTS_1218	0.03	4.42	59	50
HRV_DTS_1840	0.10	13.76	59	50
HRV_DFN_0612	0.08	10.88	59	50
SVN_DFN_DTS_0612	0.002	0.28	0	0

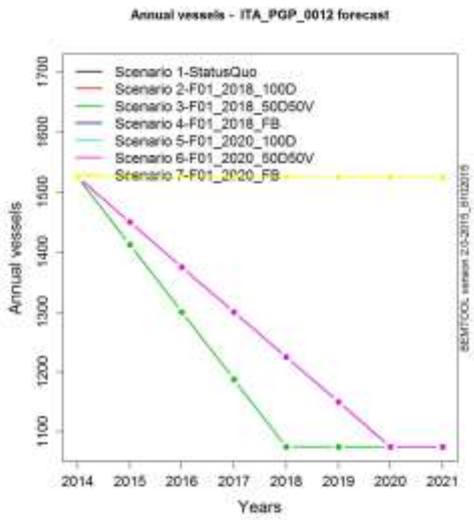
Figure 41 shows the effort change, in terms of annual fishing days and number of vessels, by fleet segment.

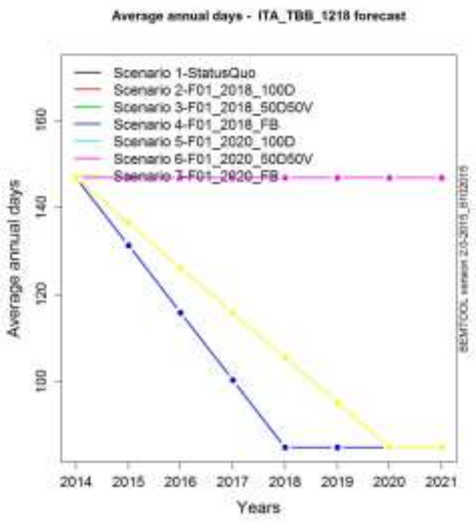


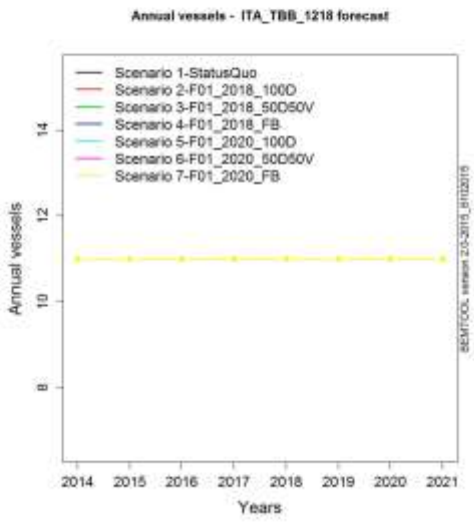

Average annual days - ITA_DTS_1840 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Average annual days
Years


Annual vessels - ITA_DTS_1840 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Annual vessels
Years


Average annual days - ITA_PGP_0012 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Average annual days
Years


Annual vessels - ITA_PGP_0012 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Annual vessels
Years


Average annual days - ITA_TBB_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Average annual days
Years


Annual vessels - ITA_TBB_1218 forecast
Scenario 1-StatusQuo
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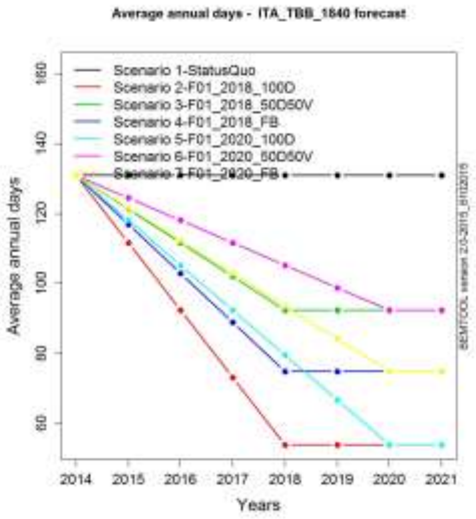
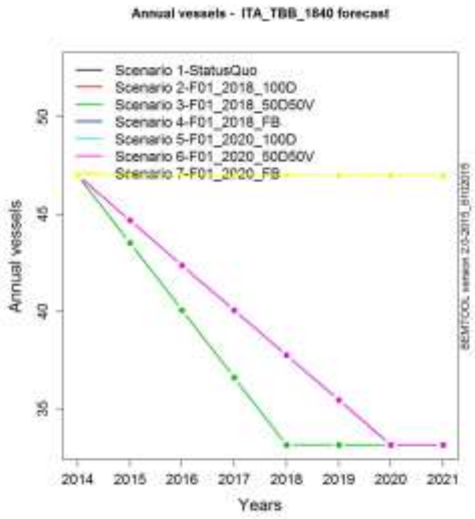
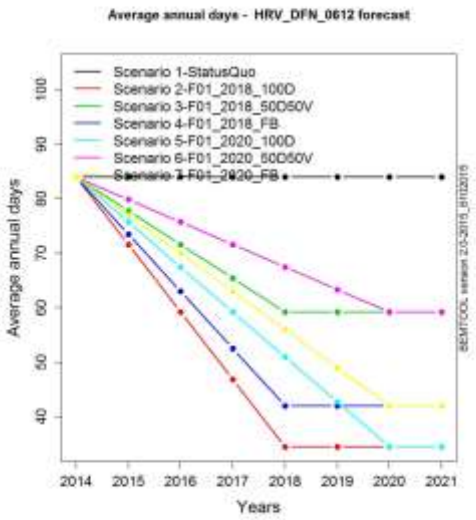
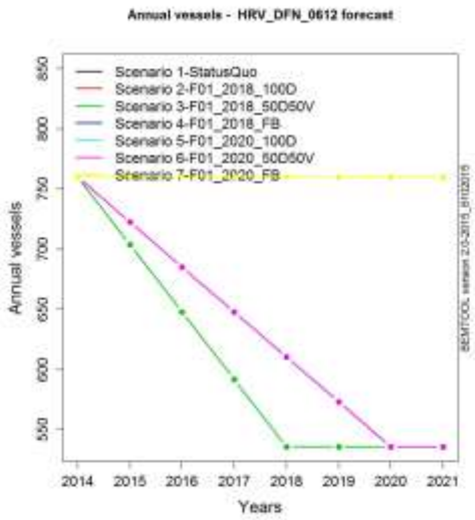
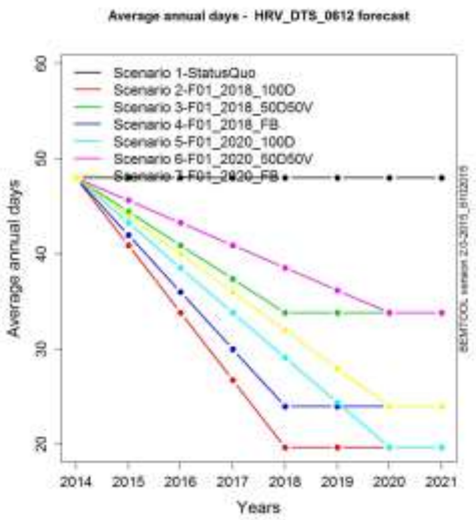
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Annual vessels
Years

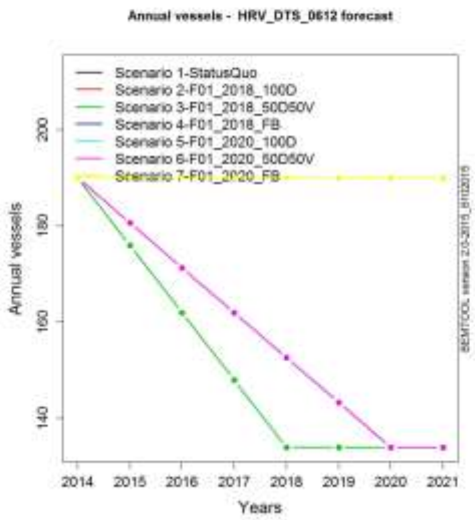

Average annual days - ITA_TBB_1840 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Average annual days
Years


Annual vessels - ITA_TBB_1840 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Annual vessels
Years


Average annual days - HRV_DFN_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Average annual days
Years


Annual vessels - HRV_DFN_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Annual vessels
Years


Average annual days - HRV_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Average annual days
Years


Annual vessels - HRV_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_2018_FB
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_2020_FB
Annual vessels
Years

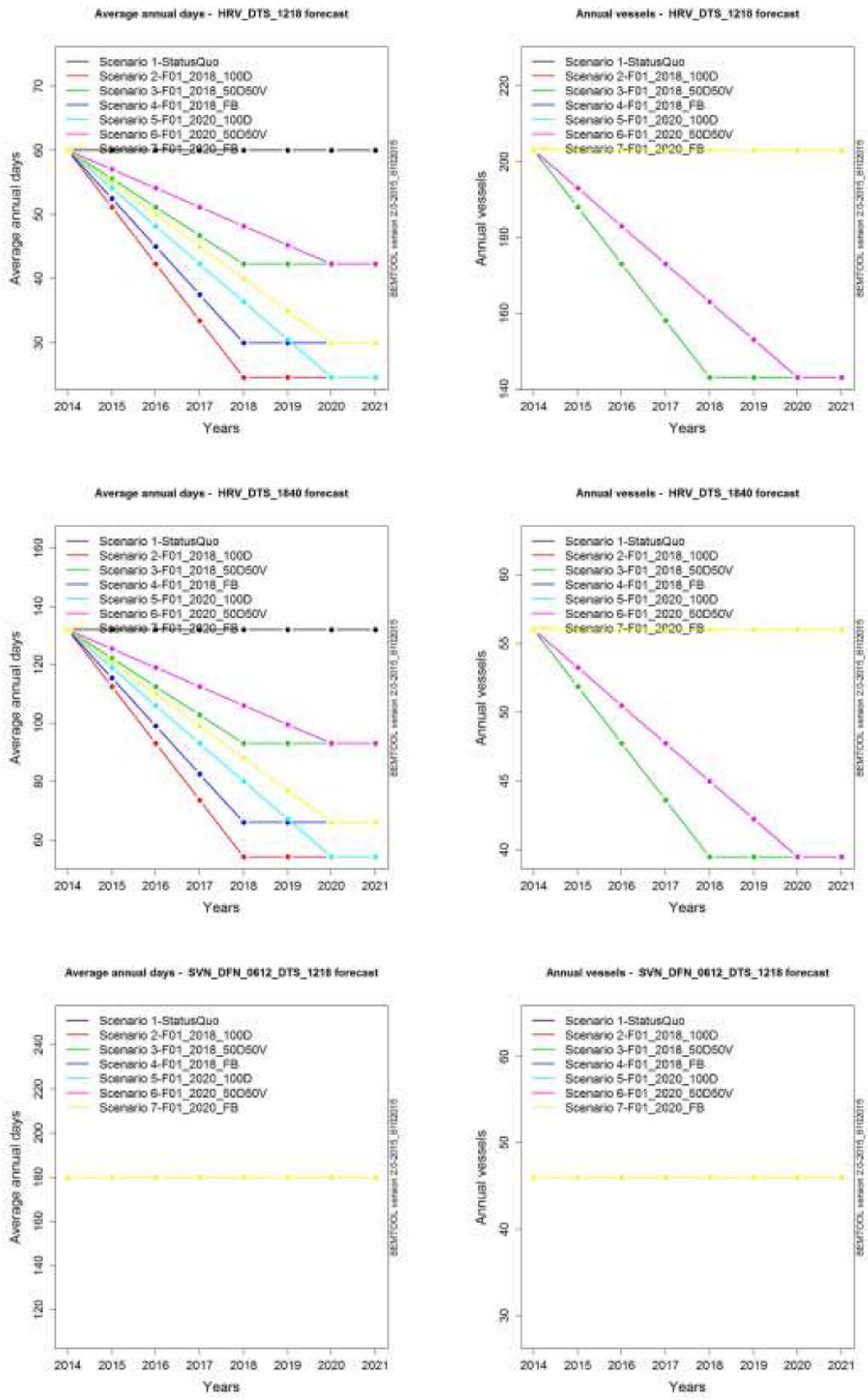


Figure 41 Effort change (fishing days and number of vessels) driving the different management scenarios by fleet segment.

4.5.1 BIOLOGICAL AND PRESSURE INDICATORS

The main results of the projections carried out in terms of SSB of the four stocks are showed in the figure 42.

The SSB of hake shows in all the scenarios a considerable increase until 2021: the highest value is shown by Scenario 2 - F01_2018_100D (about 4.5 time the status quo in 2021), while the minor increase of SSB is shown in Scenario 7 – F01_2020_FB and Scenario 6 – F01_2020_50D50V, however nearly three times the status quo. Fishing ban scenarios reach lower increase compared to the other ones, because the reduction of effort is not as as high as that applied to reach the Fmsy combined.

For spottail mantis the higher SSB value is obtained with Scenario 2 - F01_2018_100D (in 2021 the SSB is 34% higher than the status quo), while the worst ,excluding the status quo, is the value in Scenario 6 – F01_2020_50D50V, very similar to the SSB in Scenario 7 – F01_2020_FB.

The best performance for SSB of red mullet is shown by Scenario 2 - F01_2018_100D, whilst the less performant result is observed in the Scenario 6 – F01_2020_50D50V . However, all the scenarios show SSB higher than status quo scenario (from 65% of the worst result to 95% of the best scenario).
Finally, the SSB of common sole is the highest in the Scenario 2 - F01_2018_100D (in 2021 80 % higher than the status quo) and the lowest in Scenario 6 – F01_2020_50D50V scenario (excluding the status quo).

This result seems to indicate that, all the stocks benefit more in the case of reduction applied in a short timeframe and on fishing activity only (Scenario 2).

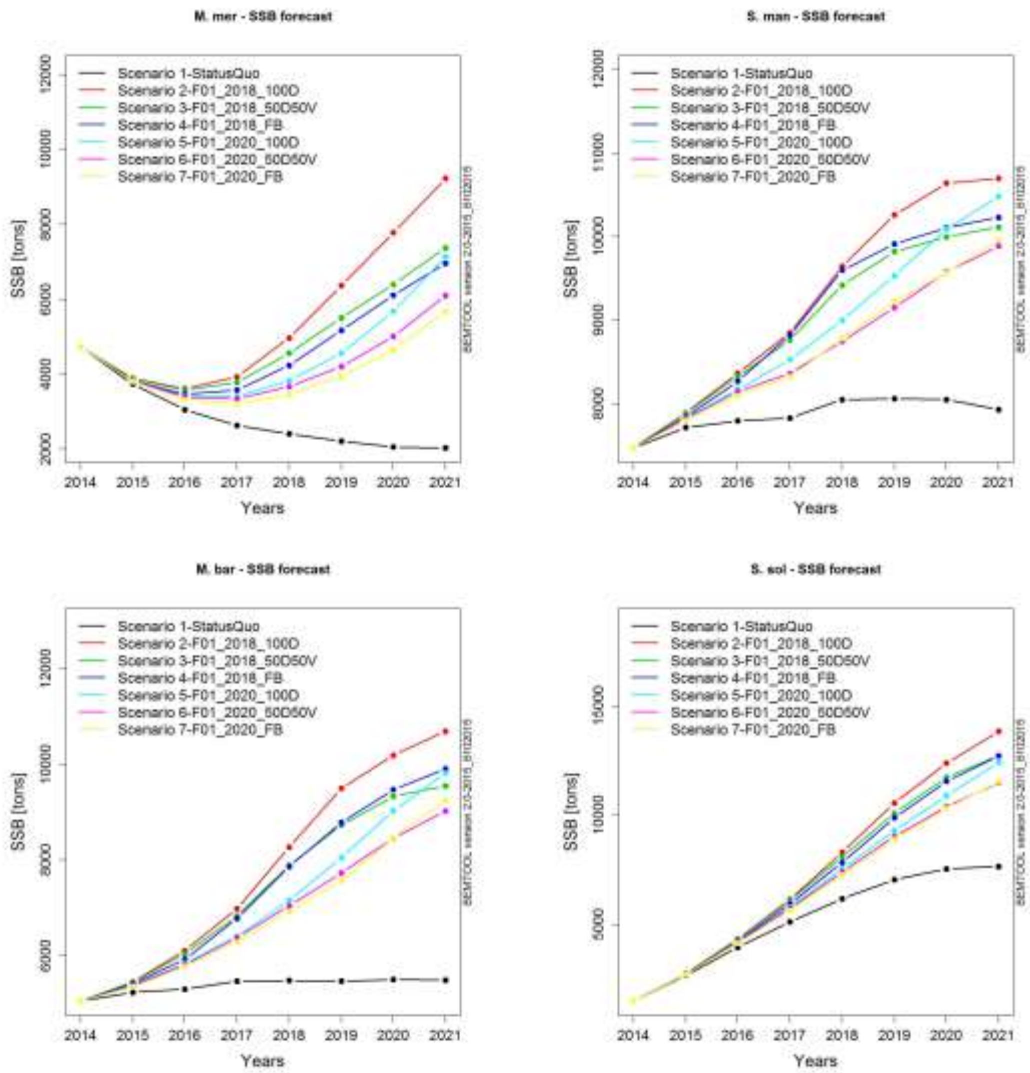


Figure 42 SSB of hake, spottail mantis, red mullet and common sole in GSA 17: comparison among the management scenarios.

In terms of catches of hake, the scenarios better performing are generally the those characterized by a reduction applied in a short timeframe (Scenario 2 F01_2018_100D and Scenario 3 - F01_2018_50D50V) with an increase of the overall landing of about 36% respect to the status quo. For all the fleet segments, the fishing ban scenarios (Scenario 4 and Scenario 7) show a recovery of the landings of hake after 2018 and 2020 (respectively for Scenario 4 and Scenario 7), reaching in 2021 values lower than status quo. Moreover, in all the scenarios the discard decreases for all the fleet segments.
For all the other species, except hake, catches are subject to remarkable decrease that can change depending on species and scenarios, thus these stocks would become underutilised. Strongest reduction will regard spottail mantis shrimp and commone sole, with percentage between -25 and -35%.

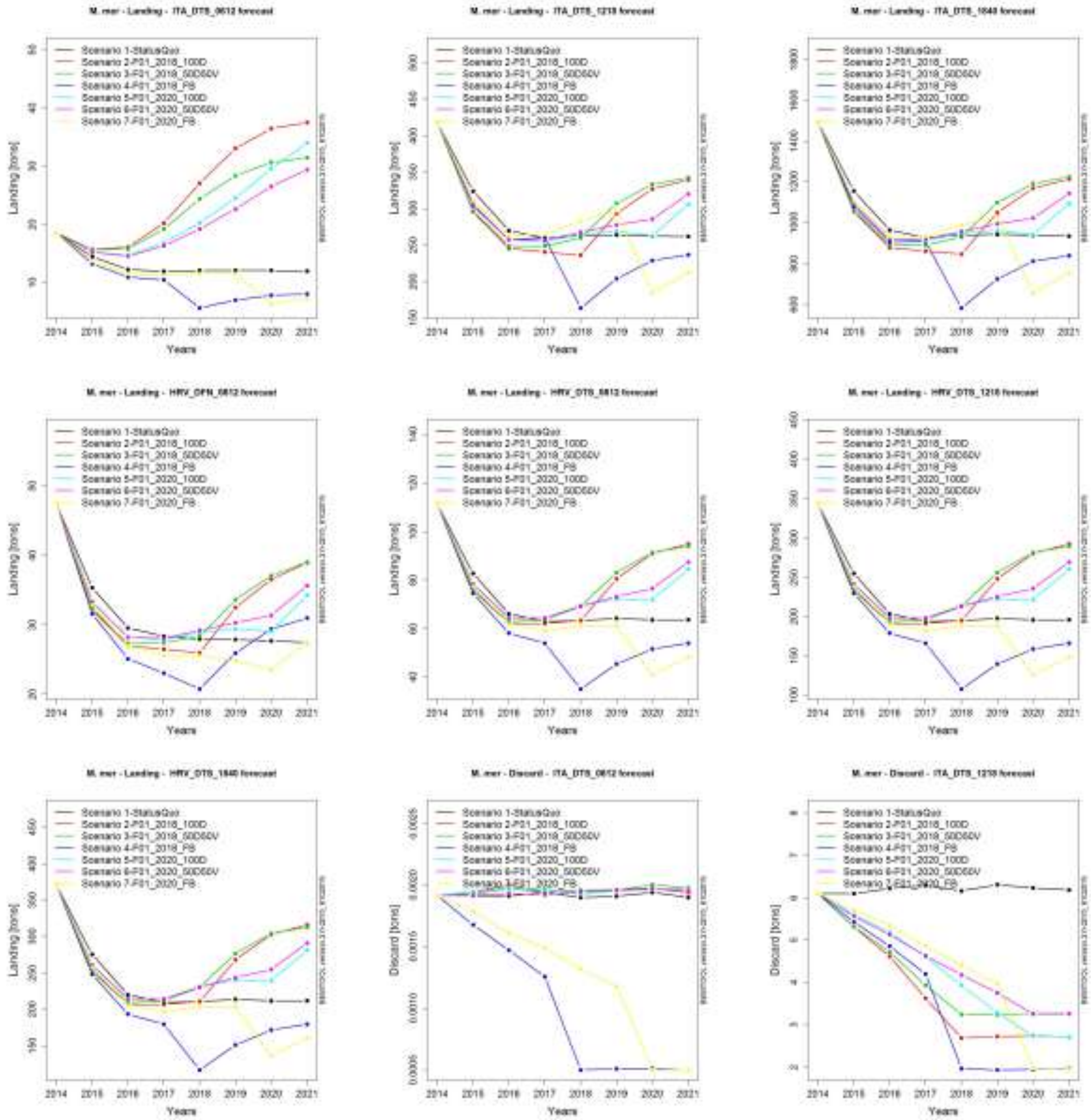
The fleet segments more impacted by the management measures are those not targeting European hake, as the loss of other species catches is not compensated by the increase of hake productivity. This is holding for the fleet segment ITA_TBB_1840 and especially for ITA_PGP_0012.

Regarding landing of common sole, the most affected fleet segment are ITA_TBB_1840, which main target are spottail mantis and common sole and HRV_DFN_0612.

A comparison among the different scenarios of the main results of the projections in terms of predicted catches of the four stocks by fleet segment are showed in the figure from 43 to 46.

All the fleet segments, when affected by the management measures, obtain a higher landing in the status quo scenario, but a decrease of discard respect to the status quo, reflecting the decrease of the total catch.

Catches of the fleet segments ITA_DTS_0612, ITA_TBB_1218 and SVN_DFN_0612_DTS_1218 generally take advantage of the stock rebuilding following the reduction applied to the other fleet segments, given that they are not affected by the management measures (their relative impact lower than 3%), except for the scenario S. 4 - F01_2018_FB, i.e. the fishing ban, that is also applied to the first two fleet segments.



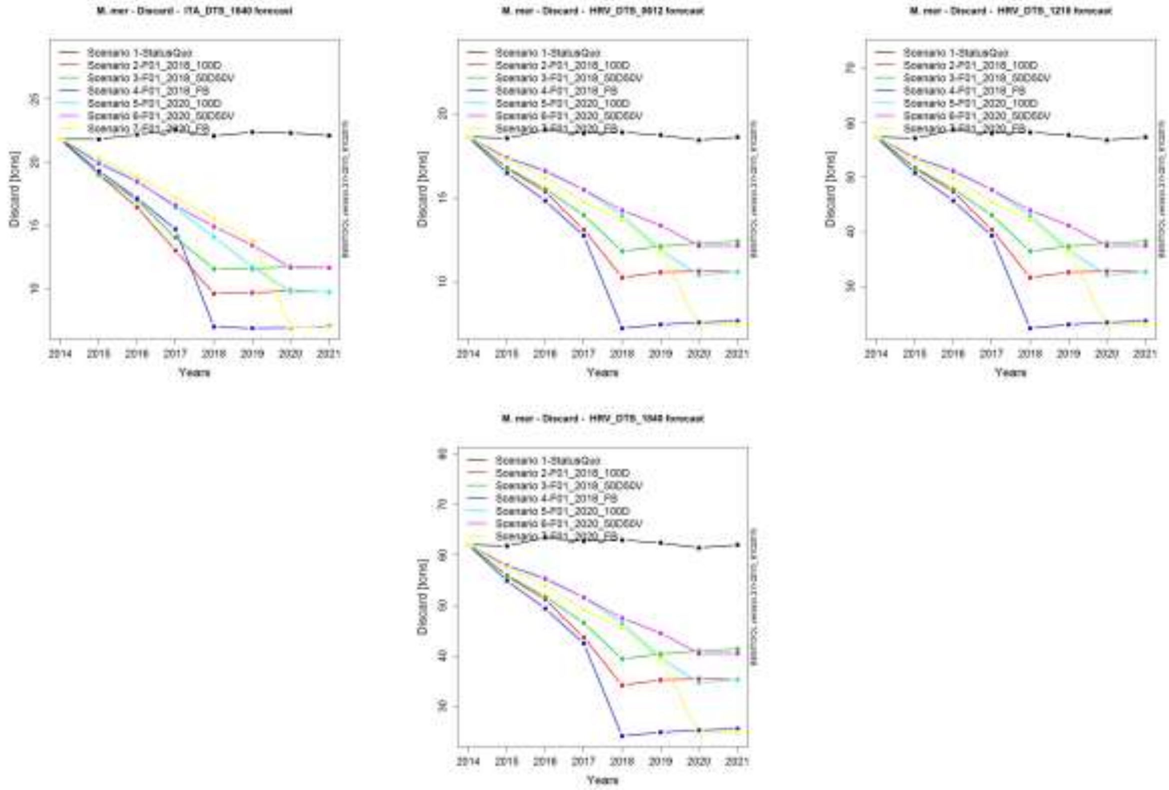
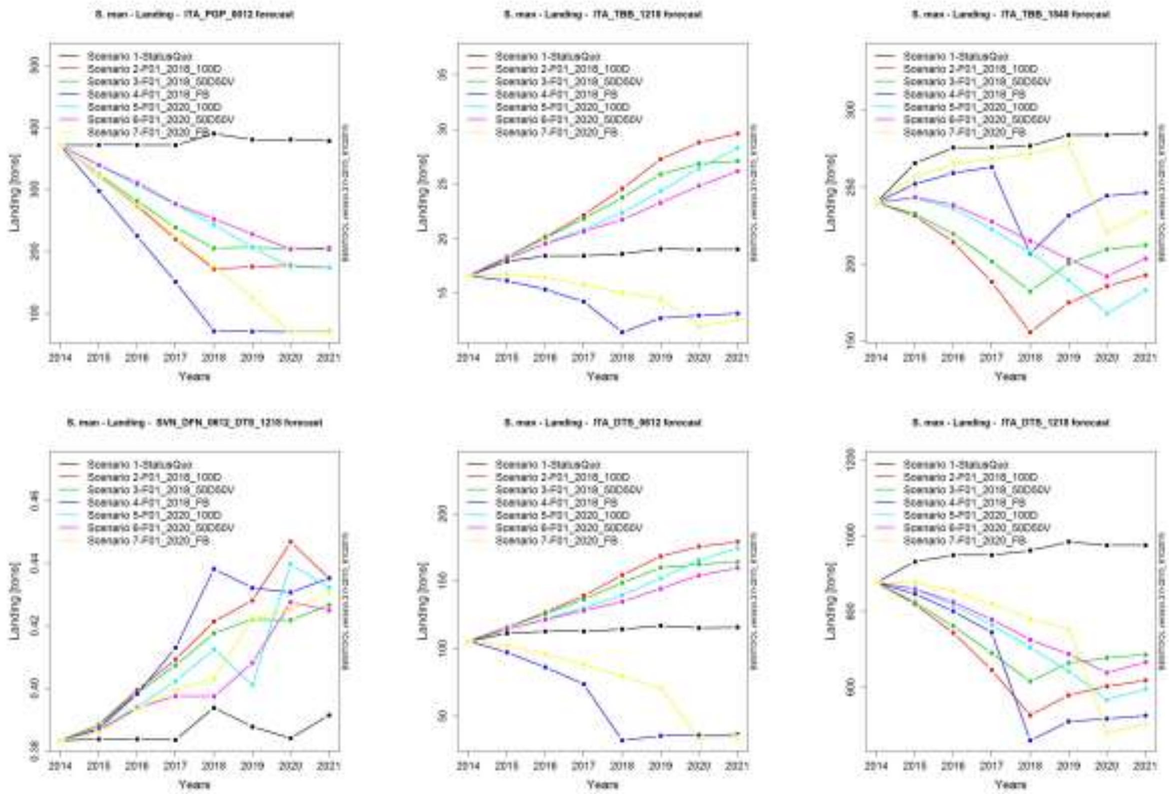


Figure 43 Landing and discard for hake by fleet segment: comparison among the different management scenarios.



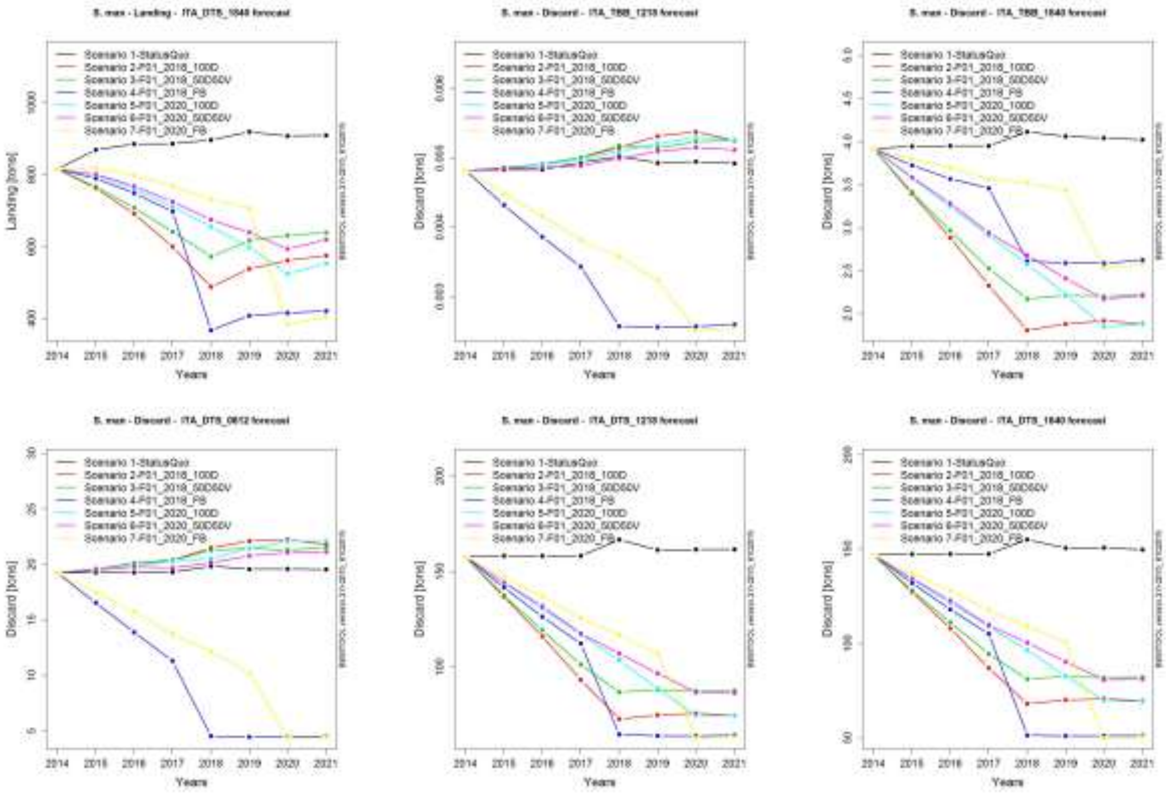
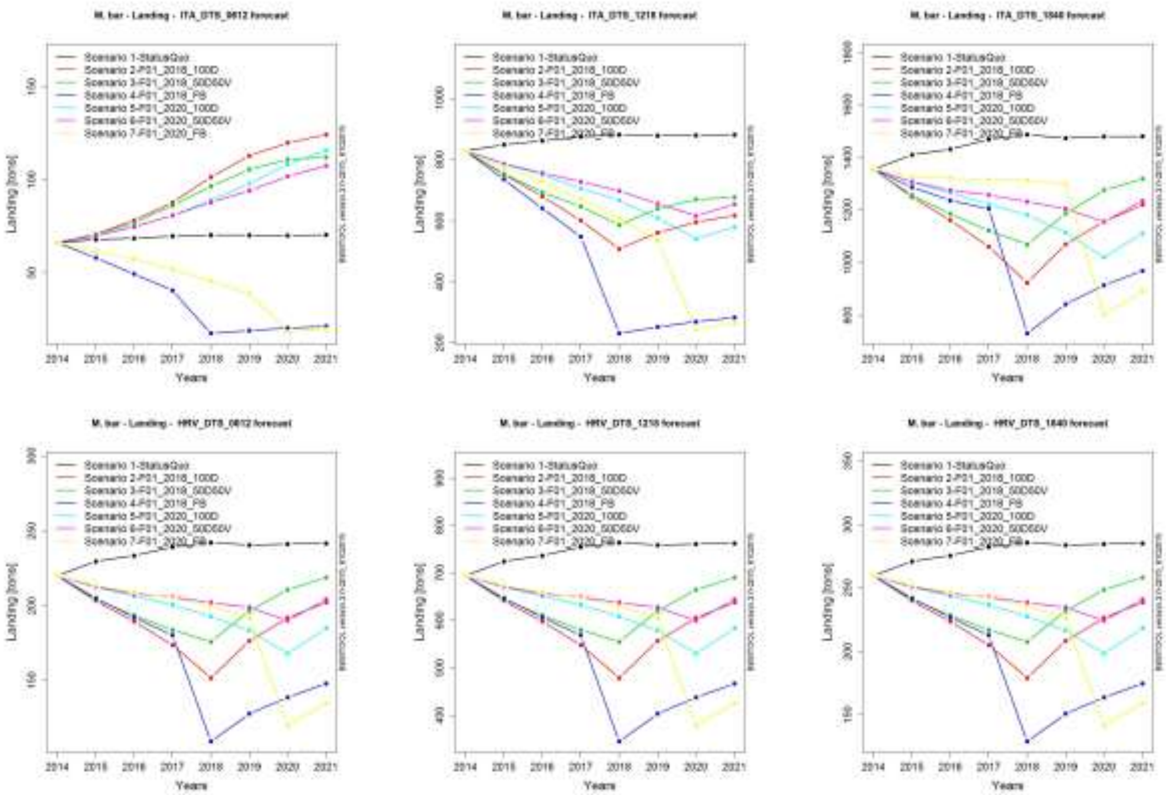


Figure 44 Landing and discard for spottail mantis by fleet segment: comparison among the different management scenarios.



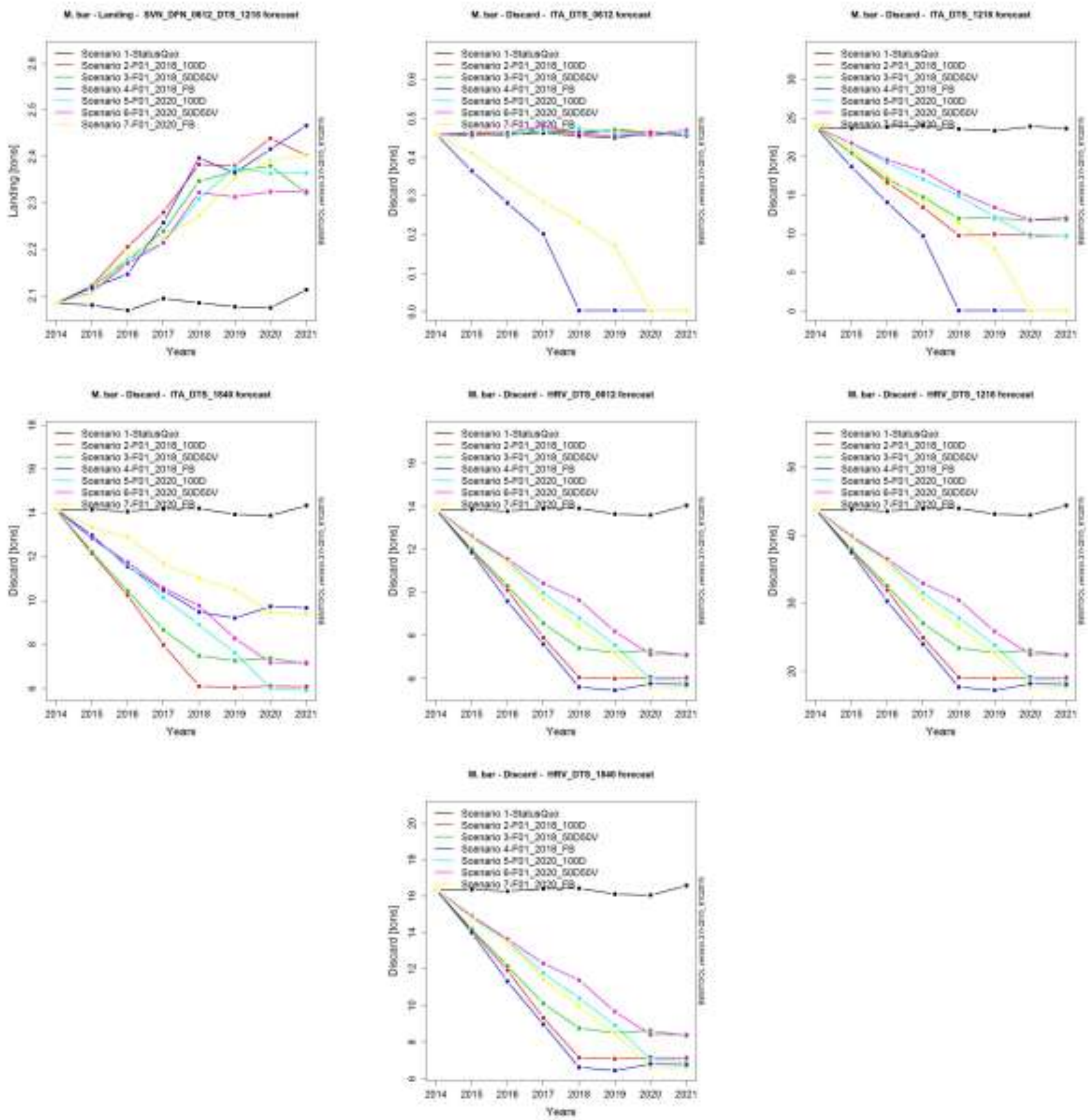


Figure 45 Landing and discard for red mullet by fleet segment: comparison among the different management scenarios.

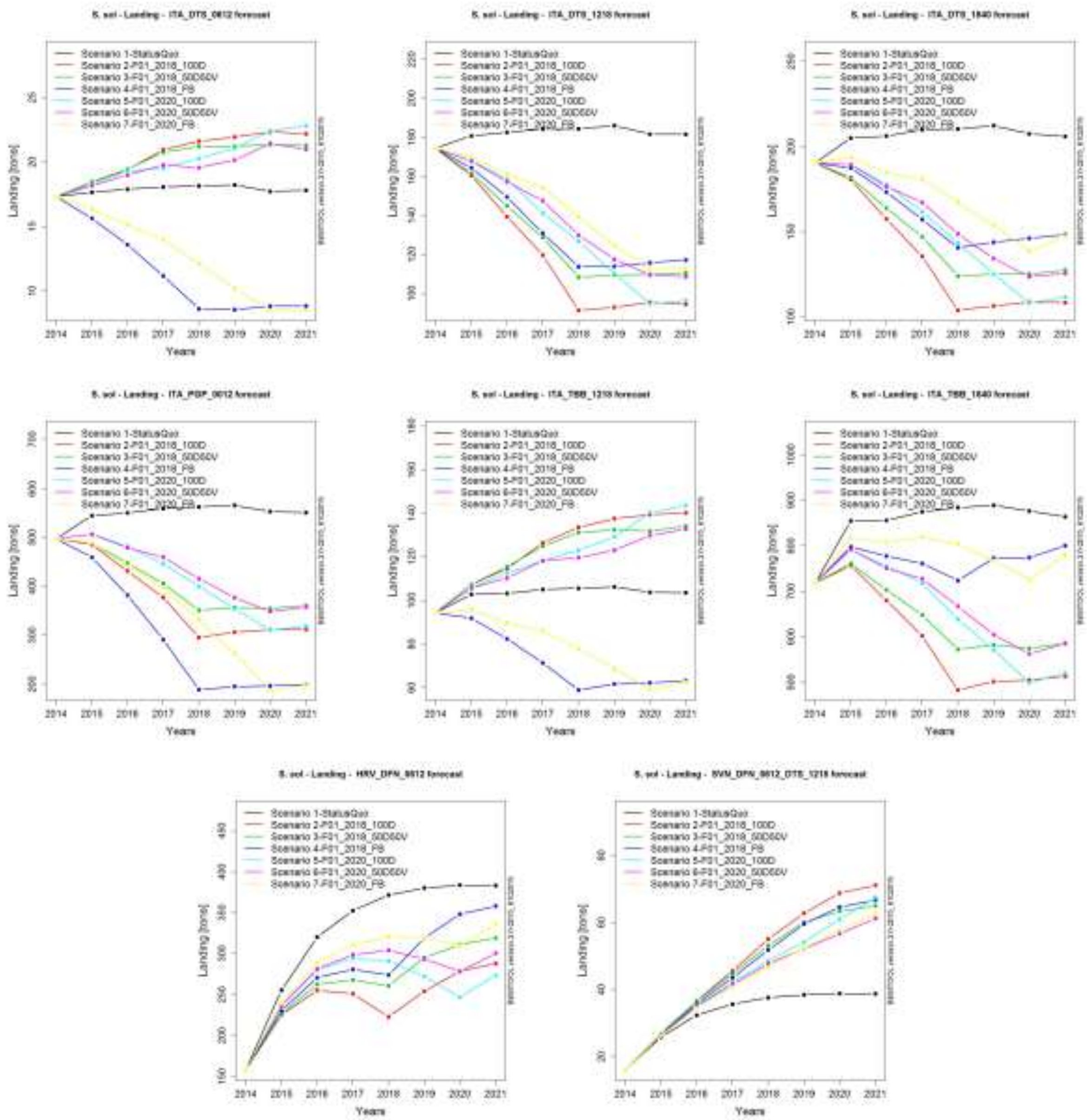
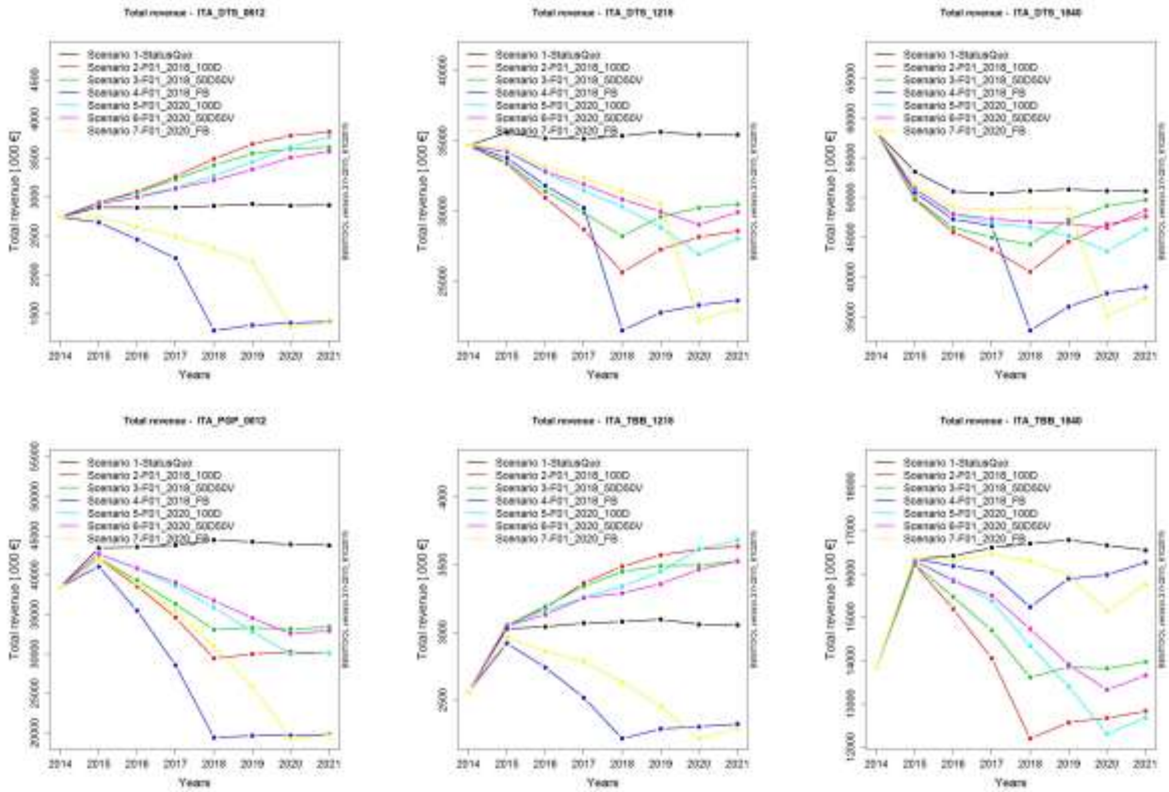


Figure 46 Landing for common sole by fleet segment: comparison among the different management scenarios.

4.5.2 SOCIO-ECONOMIC INDICATORS

Detailed evaluation of the impact of the various policies on total revenues is presented in the Figure 47. This evaluation shows how at the end of the forecast period, all scenarios would lead to a decrease of total revenues (from about 30% in scenario 4 and 7, i.e. fishing ban scenarios) to 10% for scenarios 3 and 6 (reduction applied half on number of vessels and half on fishing days) compared with the status quo for the whole fleet analysed.

Fleet segments not affected or partially affected by the reductions (i.e. SVN_DFN_DTS_0612, ITA_TBB_1218 and ITA_DTS_0612) show in the most part of scenarios an increase of the total revenues reaching a value 74% higher than the status quo (Scenario 2 – F01_2018_100D). Italian DTS_0612 and TBB_1218 show values of revenues higher than status quo in all the scenarios, except in the fishing ban scenarios (Scenario 4 and Scenario 7) reaching respectively about 30% and 20% increase of revenues compared to the status quo. Among the fleet segments affected by the reduction, the Croatian demersal trawlers 18_40 would see a slight increase the total revenues compared to the status quo in the Scenario 2 – F01_2018_50D50V., 3 and 6 (reduction applied both to fishing days and vessels). Scenario 4 and Scenario 7 have the largest negative impact on total revenues of Italian trawlers between 6 m and 12 m and Italian small scale fleet, showing a drop of about 50% in both scenarios. Generally after the application of the technical measures simulated in the six scenarios, all the fleets seem to recovery until 2021 reaching at least the status quo, except Italian small scale and Italian trawlers between 12 m and 18 m that in 2021 reach values of landing lower than status quo of about 40% and 20% (average between scenarios, with lower values in gradual closure of fishing activity).



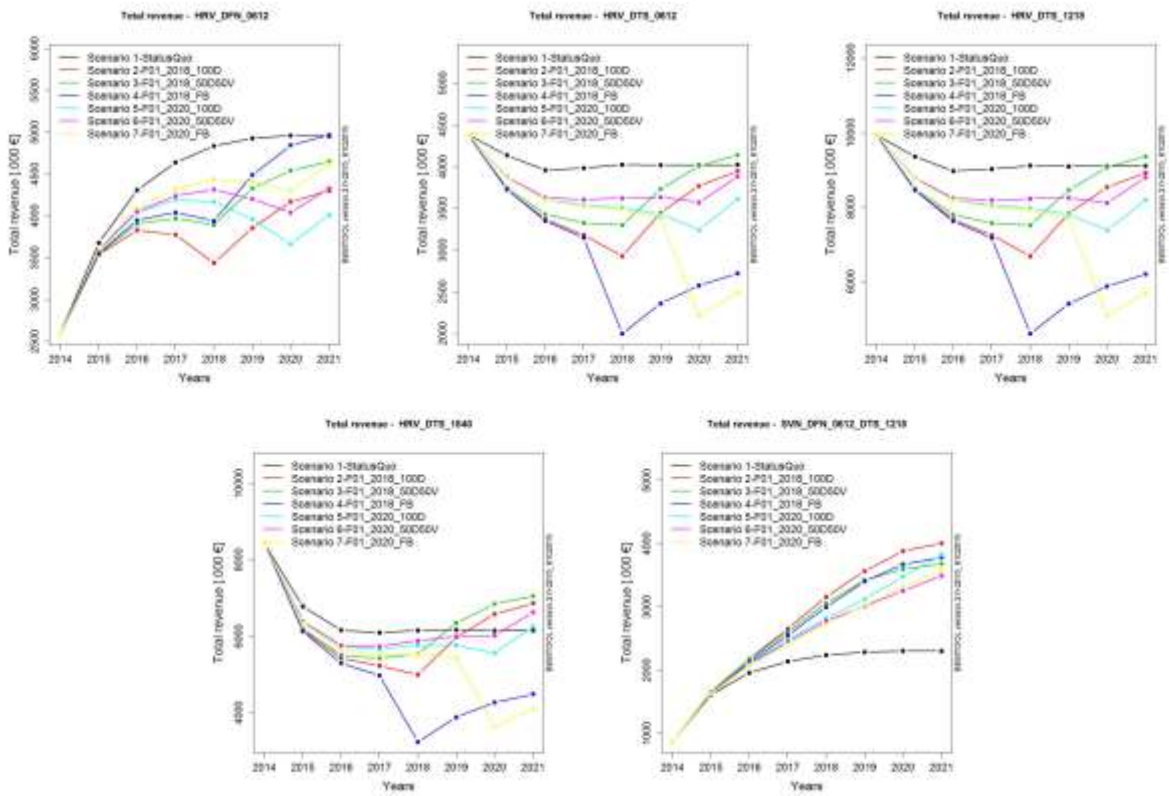


Figure 47 Revenues by fleet segment and scenario.

Forecasts of CR/BER ratio for the overall fleet show a good performance, being its change positive for almost all the scenarios and fleet segments (Figure 48). It becomes negative only when the scenarios based on fishing ban are applied. The only fleet segment that sees the deterioration of its profitability in all the scenarios except S3 and S6 is ITA_PGP_0012. The best performance of this indicator appear evident in the scenario 3 – F01_2018_50D50V and in the scenario 6 – F01_2020_50D50V for all fleet segments.

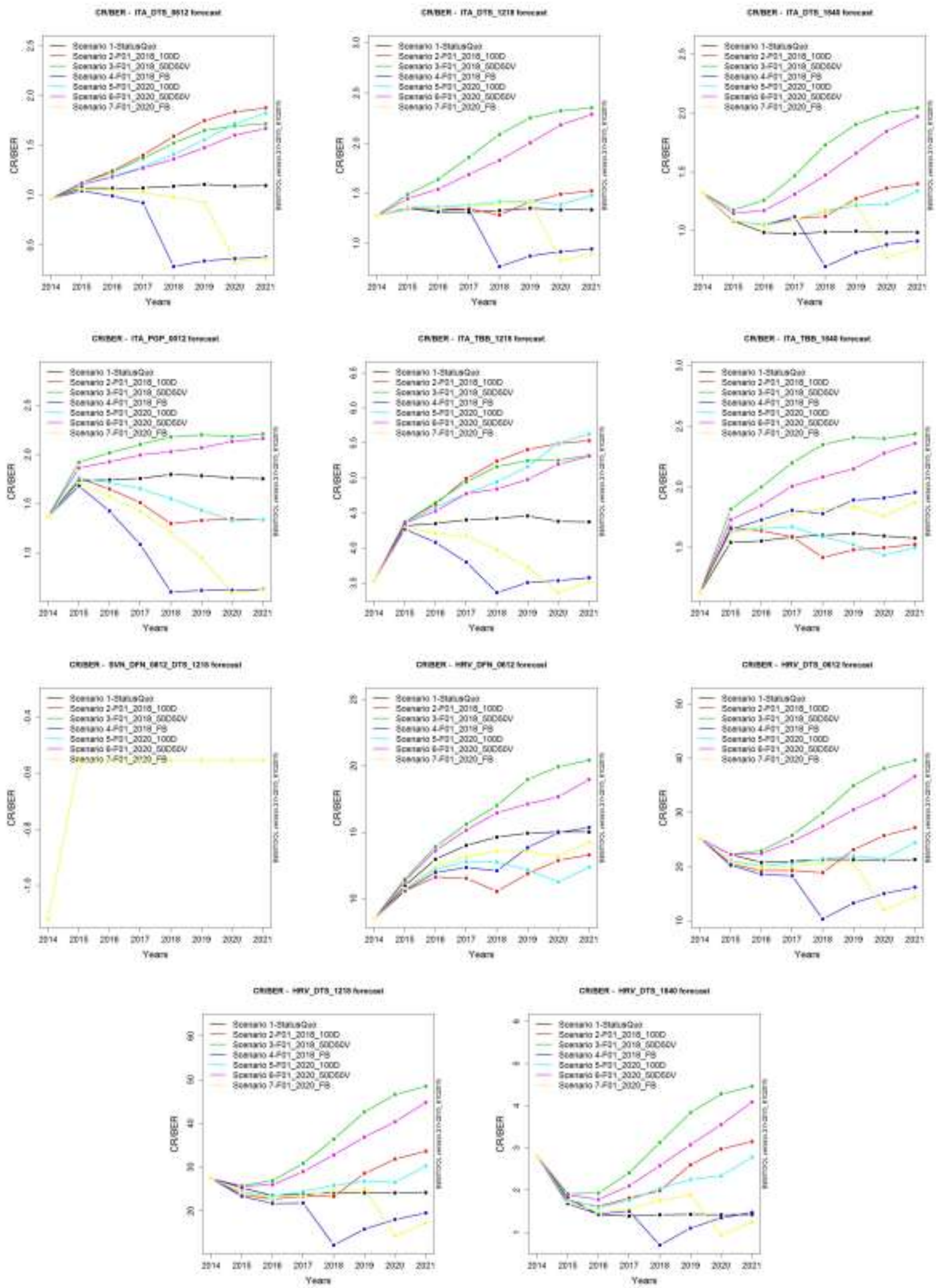
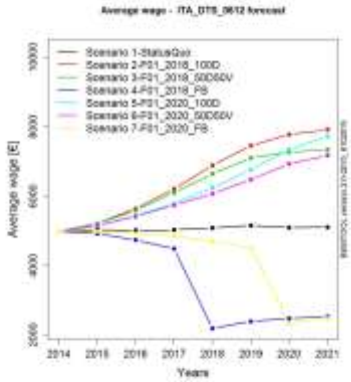


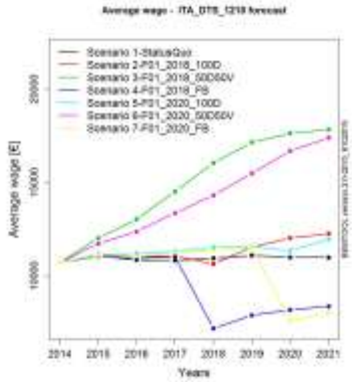
Figure 48 Current Revenue to the Break-Even Revenue ratio (R/BER) by fleet segment and scenario.

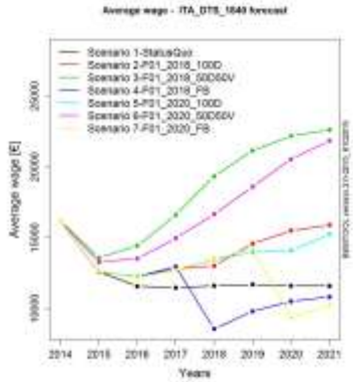
Figure 49 shows the simulated effects of the scenarios on average salary per man employed.

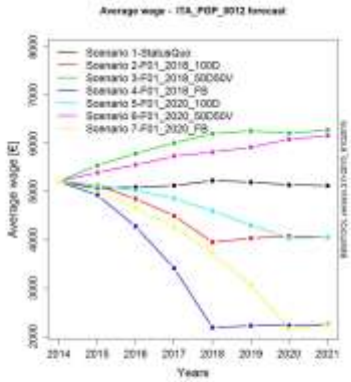
For the overall fleet almost all the scenarios performed show a substantial increase of the annual average salary per man (about 20% respect to the status quo), except for the scenarios based on the fishing ban. The higher values are observed in the scenarios where both number of vessels and fishing days are reduced (Scenario 3 and Scenario 6). However, when the number of employees is considered, the Scenario 3 – F01_2018_50D50V and Scenario 6 - F01_2020_50D50V produce the larger negative effects on employment with reductions of about 30%.

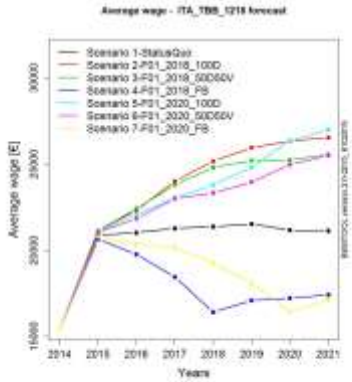
At fleet segment level, the Croatian trawlers 12-18 m and 18-40 m, Italian 18-40 and TBB 18-40 take higher advantage in all the scenarios (except fishing ban scenarios). Regardless from the scenario, improvement compared to the status quo are considerable for the fleet segment SVN_DFN_DTS_0612, given that it is not affected by the management measures.

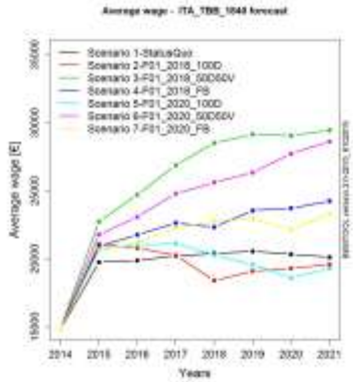












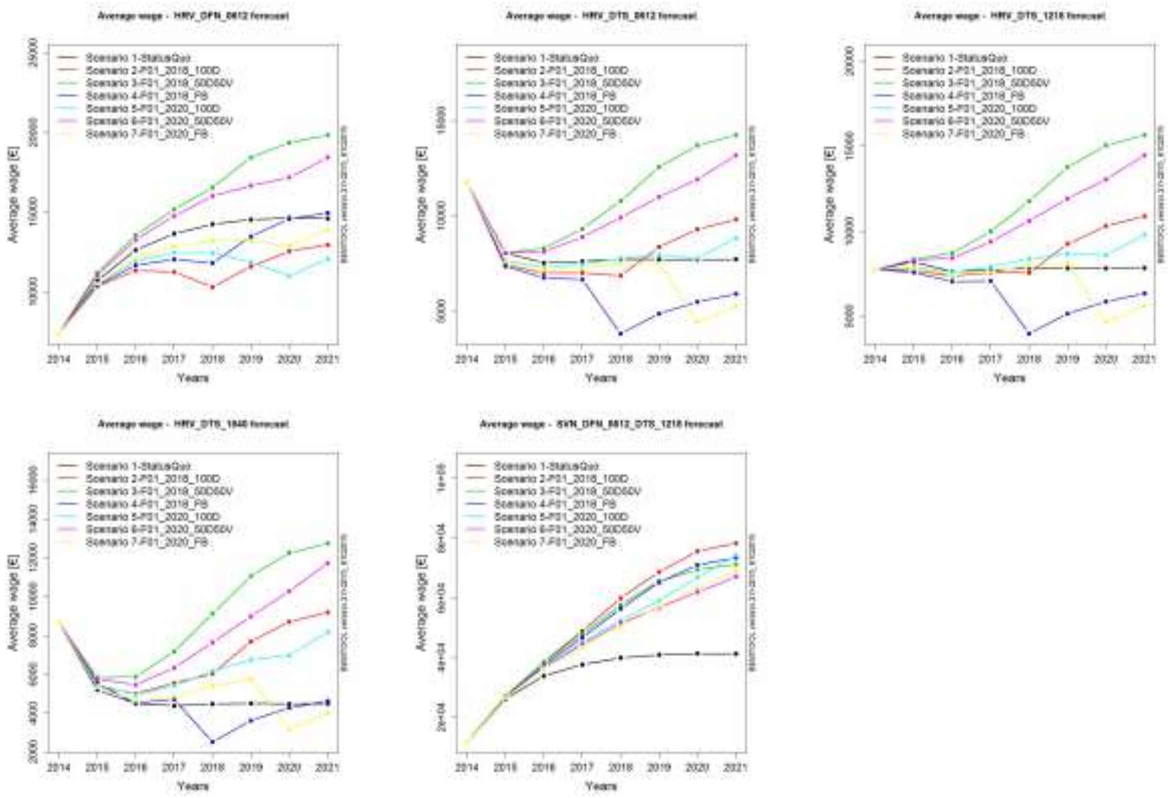


Figure 49 Average salary by fleet segment and scenario.

In Annex II the graphs related to Kobe plot, SSB by stock, landing by stock and fleet segment, average salary and CR/BER with confidence intervals for all the forecast scenarios are reported. In Annex III the comparison of number of employees for the different scenarios is reported.

4.6 DISCUSSION AND CONCLUSIONS ON DEMERSAL CASE STUDY OF GSA 17

According to the traffic light summary tables (from 103 to 106), all the performed scenarios allow to obtain a benefit on the SSB of the 4 stocks under consideration. In particular, the analysis carried out for all fleet segments showed that the best management option is the reduction of effort towards the F combined until 2018 acting only on fishing days. Such management measures would determine, on average, the highest increase in SSB for the fours species with catches that decrease in all the stocks of about 30%, except for hake reaching catches higher than status quo (15-30%).

The increase in productivity of hake stock is remarkable (Fig. 50).

On an overall basis, the best performing scenarios is Scenario 2 - F01_2018_100D, in terms of increase in SSB, catches and socio-economic indicators of all the fleet. It allows to obtain the best trade-off among the different indicators, considering the same weight for each of them, as showed in Table 110. However, as also discussed in the following paragraphs, the traffic light summary tables do not take into account the weight of the different components of the system (biological, economic and social), as instead the Multicriteria Decision Analysis does.

The reduction of effort applied half on vessels and half on fishing days seems better than the other scenarios, especially if applied in the shortest time frame (until 2018), for Croatian trawlers and DTS_1218 and DTS 1840 among the Italian fleet segments.

The fleet segments DTS_0612, TBB_1218 take advantage by all scenarios, except fishing ban, because are not affected by the management measures, the fleet segment SVN_DFN_DTS_0612 takes instead advantage from all the scenarios.

Regardless of the scenarios the fleet segment most impacted by the management measures is, in particular, ITA_PGP_0012, but also ITA_DTS_1840 and ITA_TBB_1840 are remarkably impacted; the latter because its target is not European hake, but only spottails mantis shrimp and sole, thus ITA_TBB_1840 is penalised by the underutilization of these two stocks, the former because the loss due the three species: red mullet, spottail mantis and commone sole is not balanced by the gain of production due to European hake. For Croatian trawlers instead, given that their main target is not spottail mantis shrimp, or commone sole, the loss due to red mullet catches can be compensated by the increased productivity of European hake.

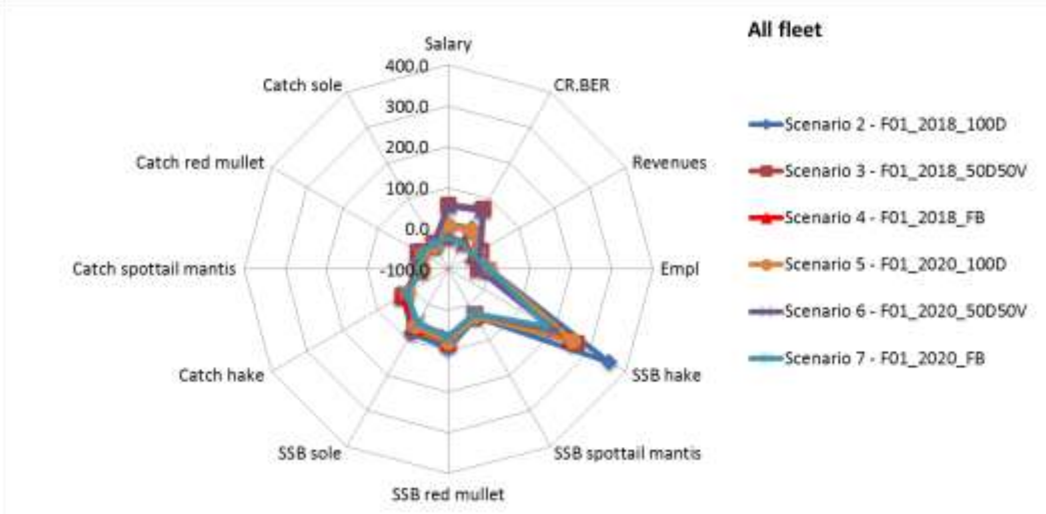


Figure 50 Radar plot for all the fleet. Each line represents a scenario and each point the corresponding percentage of each indicators compared to status quo.

Table 103 Performances of the management scenarios (% respect to status quo) simulated in terms of SSB and overall catches, salary, CR/BER, employement and revenues. The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. GSA17

Scenario, year 2021	ALL fleets											
	Salary	CR.BER	Rev.	Emp.	SSB hake	SSB spottail mantis	SSB red mullet	SSB sole	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
Scenario 2 - F01_2018_100D	10.7	15.7	-13.6	0.0	354.4	34.9	94.7	80.7	29.4	-35.3	-19.6	-33.9
Scenario 3 - F01_2018_50D50V	58.1	71.8	-8.6	-28.3	263.0	27.6	74.0	66.2	30.4	-28.5	-13.1	-26.4
Scenario 4 - F01_2018_FB	-21.4	-23.5	-30.5	0.0	242.7	29.0	80.5	66.1	30.2	-27.6	-13.8	-24.8
Scenario 5 - F01_2020_100D	7.7	10.4	-16.1	0.0	251.7	32.2	78.9	62.3	16.5	-37.1	-26.1	-34.5
Scenario 6 - F01_2020_50D50V	53.4	64.7	-11.1	-28.3	200.6	24.7	64.5	50.1	21.8	-30.5	-18.0	-27.8
Scenario 7 - F01_2020_FB	-24.7	-28.3	-32.9	0.0	179.4	25.6	68.6	50.7	18.2	-30.1	-19.9	-27.4

Table 104 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employement and revenues by fleet segment (HRV_DFN_0612, HRV_DTS_0612, HRV_DTS_1218 and HRV_DTS_1840 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	HRV_DFN_0612								HRV_DTS_0612							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	-11.3	-11.4	-13.2	0.0	41.7			-24.8	26.9	27.4	-1.9	0.0	28.3		-18.1	
S. 3 - F01_2018_50D50V	35.7	36.0	-6.1	-29.5	42.0			-16.6	84.1	85.7	2.9	-29.5	29.6		-11.6	
S. 4 - F01_2018_FB	2.3	2.3	0.3	0.0	12.8			-6.5	-23.5	-23.9	-32.4	0.0	8.2		-10.6	
S. 5 - F01_2020_100D	-17.4	-17.6	-19.0	0.0	24.9			-28.6	14.3	14.6	-10.3	0.0	15.6		-25.5	
S. 6 - F01_2020_50D50V	26.1	26.3	-12.6	-29.5	29.8			-21.5	70.4	71.8	-3.5	-29.5	21.1		-17.2	
S. 7 - F01_2020_FB	-5.1	-5.1	-6.8	0.0	0.1			-12.3	-32.0	-32.7	-38.1	0.0	-2.5		-17.5	

Scenario, year 2021	HRV_DTS_1218								HRV_DTS_1840							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	38.7	39.0	-2.0	0.0	28.3		-18.1		104.9	121.6	11.5	0.0	28.3		-18.1	
S. 3 - F01_2018_50D50V	99.6	100.4	2.7	-29.5	29.6		-11.6		184.2	213.4	14.5	-29.5	29.6		-11.6	
S. 4 - F01_2018_FB	-19.1	-19.3	-32.0	0.0	8.2		-10.6		3.3	3.7	-27.1	0.0	8.2		-10.6	
S. 5 - F01_2020_100D	24.9	25.1	-10.1	0.0	15.6		-25.5		82.2	95.2	1.7	0.0	15.6		-25.5	
S. 6 - F01_2020_50D50V	84.5	85.2	-3.4	-29.5	21.1		-17.2		161.5	187.1	7.6	-29.5	21.1		-17.2	
S. 7 - F01_2020_FB	-28.6	-28.8	-37.5	0.0	-2.5		-17.5		-11.0	-12.7	-33.2	0.0	-2.5		-17.5	

Table 105 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employement and revenues by fleet segment (ITA_DTS_0612, ITA_DTS_1218, ITA_DTS_1840 and ITA_PGP_0012 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ITA_DTS_0612									ITA_DTS_1218								
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole		Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	
S. 2 - F01_2018_100D	54.9	70.9	32.4	0.0	212.0	48.9	75.7	24.5		37.1	41.8	-6.3	0.0	28.0	-39.0	-18.0	-47.4	
S. 3 - F01_2018_50D50V	43.6	56.4	25.8	0.0	161.6	38.6	58.6	19.5		94.9	107.1	-2.2	-29.5	29.3	-31.8	-11.5	-38.1	
S. 4 - F01_2018_FB	-50.6	-65.5	-51.6	0.0	16.0	-45.3	-51.3	-50.3		-6.6	-7.5	-23.7	0.0	40.6	-22.4	3.5	-28.0	
S. 5 - F01_2020_100D	51.2	66.1	30.2	0.0	183.1	45.5	64.2	28.0		31.3	35.4	-9.4	0.0	15.2	-40.7	-25.3	-45.8	
S. 6 - F01_2020_50D50V	40.4	52.2	23.9	0.0	144.7	35.1	52.2	17.8		88.3	99.6	-4.7	-29.5	20.8	-33.4	-16.8	-39.0	
S. 7 - F01_2020_FB	-51.5	-66.6	-52.2	0.0	6.3	-46.5	-54.2	-51.9		-11.6	-13.2	-26.4	0.0	28.2	-24.8	-4.2	-28.3	

Scenario, year 2021	ITA_DTS_1840									ITA_PGP_0012								
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole		Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	
S. 2 - F01_2018_100D	37.1	41.8	-7.0	0.0	28.0	-39.0	-18.0	-47.4		-20.8	-23.7	-31.2	0.0		-53.9		-43.3	
S. 3 - F01_2018_50D50V	94.9	107.1	-4.8	-29.5	29.3	-31.8	-11.5	-38.1		22.5	25.8	-23.6	-29.5		-45.5		-34.4	
S. 4 - F01_2018_FB	-6.6	-7.5	-100.0	0.0	40.6	-22.4	3.5	-28.0		-56.1	-64.1	-54.7	0.0		-81.1		-63.8	
S. 5 - F01_2020_100D	31.3	35.4	-10.2	0.0	15.2	-40.7	-25.3	-45.8		-20.7	-23.6	-31.1	0.0		-54.0		-42.2	
S. 6 - F01_2020_50D50V	88.3	99.6	-8.5	-29.5	20.8	-33.4	-16.8	-39.0		20.2	23.2	-24.8	-29.5		-46.0		-35.0	
S. 7 - F01_2020_FB	-11.6	-13.2	-10.0	0.0	28.2	-24.8	-4.2	-28.3		-56.4	-64.5	-55.0	0.0		-81.3		-64.0	

Table 106 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employement and revenues by fleet segment (ITA_TBB_1218, ITA_TBB_1840 and SVN_DFN_DTS_0612 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA17

Scenario, year 2021	ITA_TBB_1218								ITA_TBB_1840							
	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole	Salary	CR.BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	5.2	26.4	19.0	0.0		55.6		35.5	-2.7	-3.2	-22.4	0.0		-32.6		-40.6
S. 3 - F01_2018_50D50V	23.0	21.7	15.6	0.0		42.3		29.6	46.4	54.7	-15.5	-29.5		-25.9		-32.2
S. 4 - F01_2018_FB	-100.0	-18.2	-23.9	0.0		-28.7		-39.1	20.5	24.1	-1.7	0.0		12.8		-7.3
S. 5 - F01_2020_100D	7.9	28.6	20.6	0.0		48.7		38.8	-4.1	-4.9	-23.4	0.0		-36.0		-39.8
S. 6 - F01_2020_50D50V	22.5	21.4	15.4	0.0		37.8		28.3	42.3	49.8	-17.4	-29.5		-28.9		-32.3
S. 7 - F01_2020_FB	8.6	-19.7	-25.0	0.0		-31.8		-39.6	15.9	18.7	-4.7	0.0		7.1		-9.8

Scenario, year 2021	SVN_DFN_DTS_0612							
	Salary	CR. BER	Rev.	Emp.	Catch hake	Catch spottail mantis	Catch red mullet	Catch sole
S. 2 - F01_2018_100D	47.2	0.0	42.5	0.0		10.1	12.0	45.5
S. 3 - F01_2018_50D50V	38.2	0.0	34.4	0.0		8.1	8.7	36.9
S. 4 - F01_2018_FB	41.1	0.0	36.9	0.0		10.1	14.7	39.2
S. 5 - F01_2020_100D	42.2	0.0	37.9	0.0		9.4	10.4	40.4
S. 6 - F01_2020_50D50V	33.0	0.0	29.6	0.0		7.7	8.8	31.6
S. 7 - F01_2020_FB	35.4	0.0	31.8	0.0		9.0	12.0	33.7

The BEMTOOL option aimed at comparing the outputs of the different scenarios, represented by the Multi-Criteria Decision Analysis that combines Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP), has been used to assess the performances of the alternative fisheries management policies (Rossetto et al., 2015).

The eight indicators used in the analysis are listed in table 107, along with the weighting set used to calculate the overall utility associated to each scenario. The value of the indicators in the last year of simulation (2014) is referred to as the 'current condition'. The performance of a scenario with respect to a specific objective is calculated as the value of the relevant indicator in 2021.

Table 107 Summary of the indicators used in the MCDA

Top level hierarchy	Low level hierarchy	Indicator*	Weight
Socioeconomic	Economic	GVA, ROI or Profit	0.0080
Socioeconomic	Economic	RBER	0.0421
Socioeconomic	Social	WAGE	0.1914
Socioeconomic	Social	EMPL	0.0641
Biological	Biological conservation	SSB	0.2605
Biological	Biological conservation	F	0.2605
Biological	Biological production	Y	0.1373
Biological	Biological production	D	0.0361

* GVA: Gross Value Added; ROI: Return On Investment; RBER: Ratio of Revenues to Break-even revenues; WAGE: Average wage; EMPL: Employment; SSB: Spawning Stock Biomass; F: Fishing mortality; Y: Yield; D: Discard rate.

According to the MCDA (Figure 51), the scenario that allows to reach a higher overall utility is Scenario 2 – F01_2018_100D (0.64), while the status quo scenario produces the lowest overall utility (0.39). This result is coherent with the one obtained from the traffic light summary table, considering the overall fleets. These results seem consistent with the greater benefit that generally the reduction in fishing mortality produce on the indicators if applied in a short timeframe. These benefits are much evident on the biological and pressure indicators used in the analysis (SSB, and Yield). From the socio-economic point of view, the scenarios of reduction of effort applied only to the fishing activity show better performances if compared to the scenarios that reduce also the number of vessels, given the reduced impact on the employment component.

The SSB showed important changes in all the different scenarios, indicating the Scenario 2 – F01_2018_100D as the best for all the species, in particular for European hake stock which productivity increases extraordinarily, while the lowest SSB values was observed in status quo scenario.

Considering that the SSB indicators is with F the one that has a higher weight in the MCDA analysis, it is not surprising that this scenarios resulted the best one. Almost the same utility is shown by the same scenario but in a timeframe until 2020. The scenarios reducing effort half on fishing days and half on vessels seems instead to perform worse than the others (on average, total utility 0.46 versus 0.53), given the severe impact on the employment.

Following the present results, the current regulations (i.e. the status quo scenario) cannot be considered suitable to reach the MSY objective for this case study. All the proposed scenarios, aimed to reach a combined Fmsy, produce a remarkable improvement in SSB respect to status quo. On the other hand, all the proposed scenarios would produce a decrease in catches respect to status quo, except for hake which productivity would notably increase.

Nevertheless given the lack of a reliable stock-recruitment relationship that did not allow a proper forecasting of recruitment level in the projections, the performed scenarios take into account the variability due to the process error and thus are considered to ease the more adaptive advice for demersal fisheries for this area.

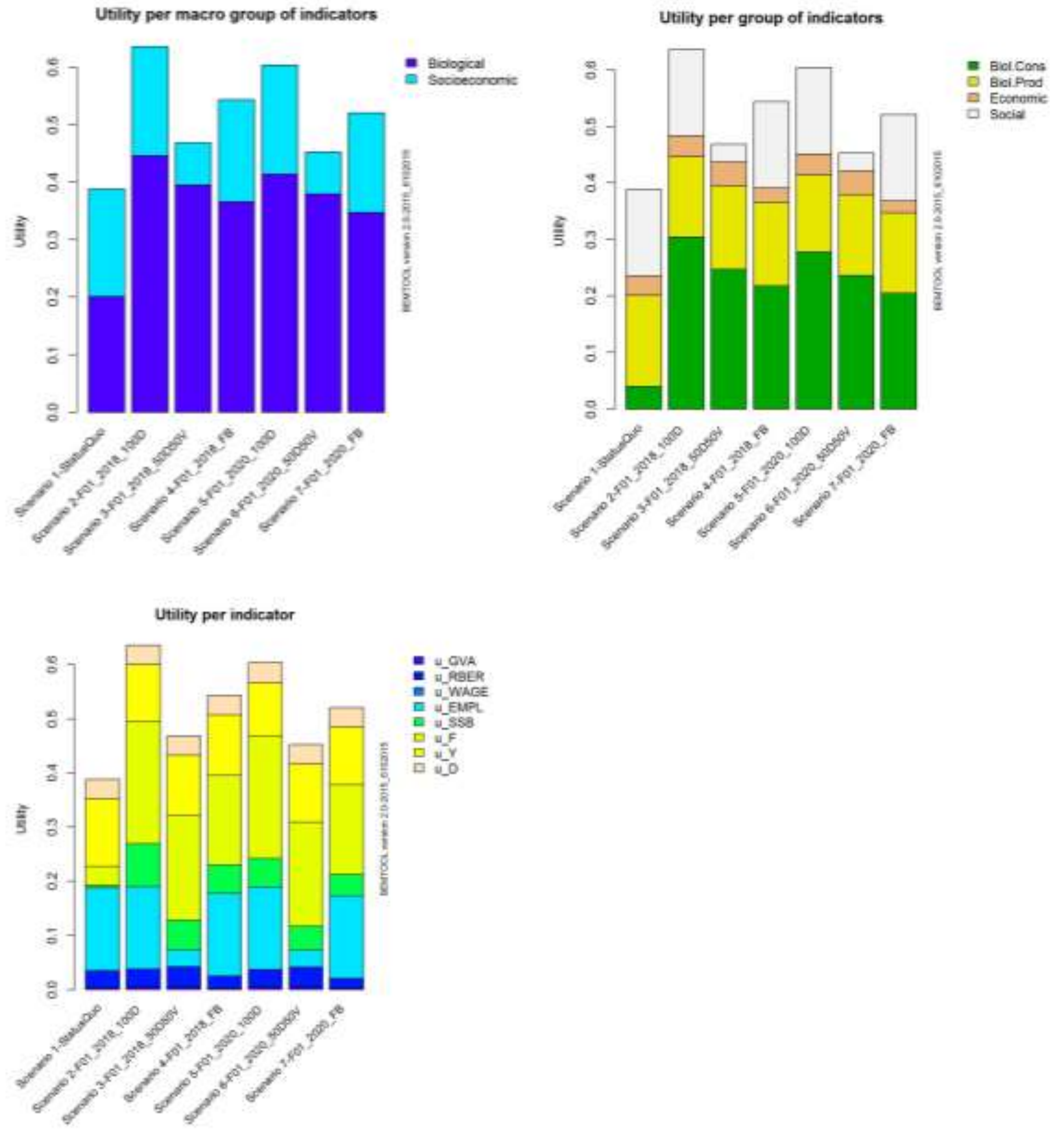


Figure 51 MCDA results: evaluation of the overall utility associated to each management scenario.

5. GSA 18 DEMERSAL CASE STUDY

The main stocks identified for the GSA 18 demersal case study are *M .merluccius, P.longirostris, M. barbatus* and *N. norvegicus.* The first three stocks are shared among the countries belonging to GSA 18 (Italy, Albania and Montenegro), while *N. norvegicus* is essentially exploited by Italy.

The main fishing gears targeting the four stocks selected for this case study are bottom trawls, small scale fisheries and longlines.

10 fleet segments targeting the selected stocks and considered for this case study are:

1. ITA_DTS_0612;
2. ITA_DTS_1218;
3. ITA_DTS_1824_2440;
4. ITA_HOK_1218;
5. ITA_PGP_0006_0612;
6. ALB_DTS_1224;
7. MNE_DFN_0012;
8. MNE_DTS_0612;
9. MNE_DTS_1224;
10. MNE_HOK_0012.

The fleet segments ITA_DTS_1824_2440, ITA_PGP_0006_0612, MNE_DFN_0012, ALB_DTS_1224, MNE_DTS_1224 and MNE_HOK_0012 are strata representing an aggregation of fleet segments, because sharing similar characteristics. This is also to avoid unnecessary fragmentation in the analysis.

The association between stocks and demersal fisheries for this case study are reported inTable 108.

Table 108 Associations among stocks and fleet segments for demersal fisheries in GSA 18 case study.

Stock	**ITA_DTS_ VL0612**	**ITA_DTS_ VL1218**	**ITA_DTS_ VL1824-2440**	**ITA_HOK_ VL1218**	**ITA_PGP_V L0006-0612**
M. merluccius	X	X	X	X	X
P. longirostris	X	X	X		
N. norvegicus	X	X	X		
M. barbatus	X	X	X		X
Stock	**ALB_DTS_ 1224**	**MNE_DFN _VL0012**	**MNE_DTS _VL0612**	**MNE_DTS _VL1224**	**MNE_HOK_ VL0012**
M. merluccius	X	X	X	X	X
P. longirostris	X		X	X	
N. norvegicus					
M. barbatus	X	X	X	X	

In 2013, according to the data collected in SEDAF (WP1), the selected fleet segments represent around 99% of production and revenues of the four assessed species in GSA18. According to EU Data Collection Framework 2014, for Italy, the percentage of the production and revenues neglected by this case study is less than 0.01% for the four assessed species.

In Italy management regulations are based on technical measures, as closed number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that in southern Adriatic has been mandatory since the late eighties. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences. Regarding small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet. In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zones (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) offshore Bari (180 km^2, between about 100 and 180 m depth) along the mainland, , and in the vicinity of Tremiti Islands (115 km2 along the bathymetry of 100 m) on the northern border of the GSA, where a marine protected area (MPA) had been established in 1989. In the vicinity of Tremiti Islands only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the area offshore Bari the trawling fishery is allowed from November 1st to March 31 and the small scale fishery all year round. Recreational fishery using no more than 5 hooks is allowed in both the areas. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of 24+ m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.

In Albania, a new law “On fishery” has been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE ; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000 as well as the GFCM recommendations. The legal regime governing access to marine resources is being regulated by a licensing system. Regarding conservation and management measures, minimum legal sizes and minimum mesh sizes is those reflected in the EU Regulations. Albania has already an operational vessel register system. It is forbidden to trawl at less than 3 nautical miles (nm) from the coast or inside the 50m isobath when this distance is reached at a smaller distance from the shore.

These management regulations have been taken into account to model the current situation in the case study.

5.1 SIMULATION OF THE CURRENT SITUATION

5.1.1 INPUT OF THE BIOLOGICAL MODULE

The data used for the parameterization of the biological and the pressure module for *M. merluccius* and *P. longirostris* come from the stock assessments carried out during the Working Group on Stock Assessment of Demersal Species (GFCM-WGSADS report) held in November 2014. The input for biological and pressure modules for *N. norvegicus* are from the STECF Expert Working Group EWG 14-19 held in January 2015, while for *M.barbatus* the stock assessment performed during the STECF EWG 14-19 has been integrated with the Albanian data collected in SEDAF project, carrying out an *ad hoc* assessment to feed the model for this stock.

The methodologies used are Extended Survivor Analyses (XSA, Darby and Flatman, 1994) for *P. longirostris*, *M. barbatus* and *N. norvegicus* stocks, while for *M. merluccius* a4a statistical catch at age model (Jardim et al., 2015) has been used. For *M. merluccius*, *M.barbatus* and *P. longirostris* also ALADYM model (Lembo et al., 2009) has been parameterized during the above-mentioned working groups.

The assessments of *M. merluccius*, *M.barbatus* and *P. longirostris* cover the whole GSA18, combining data from Italy, Albania and Montenegro.

5.1.1.1 GROWTH

The growth parameters and the length-weight relationship coefficients for the four species are listed in Table 109, 110, 111, 112.

The life span has been set equal to 15 years for European hake and Norway lobster, to 4 years for deep-water pink shrimp and equal to 6 years for red mullet.

Table 109 Growth parameters for European hake in GSA 18.

Parameter	Sex combined
Linf (cm)	104
K	0.2
t_0	-0.01
a (mm/g)	3.01E-06
b (mm/g)	3.1553

Table 110 Growth parameters for deep-water pink shrimp in GSA 18.

Parameter	Sex combined
Linf (mm)	45
K	0.6
t_0	-0.2
a (mm/g)	0.003409
b (mm/g)	2.434

Table 111 Growth parameters for Norway lobster in GSA 18.

Parameter	Females	Males
Linf (mm)	61	80
K	0.17	0.18
t_0	-0.5	-0.5
a (mm/g)	0.0006	0.0004
b (mm/g)	3.0576	3.1323

Table 112 Growth parameters for Red mullet in GSA 18.

Parameter	Sex combined
Linf (cm)	30
K	0.4

Parameter	Sex combined
t_0	-0.3
a (mm/g)	6.38E-06
b (mm/g)	3.1134

5.1.1.2 RECRUITMENT

For all the stocks a reliable stock recruitment relationship is not available, given also the shortness of the time series. For this reason a recruitment vector has been used for the simulation (past and present time) and a constant value for the projections.

M. merluccius

The recruitment figures from the stock assessment results were related to age 0 and are from XSA results (Tab. 113).

The age at recruitment has been set equal to 2 months.

Table 113 Recruitment by year by year used in simulation phase European hake in GSA 18.

Year	R (thousands)
2007	238060
2008	183211
2009	171632
2010	174251
2011	115997
2012	173821
2013	90732
2014*	90732

* This value has been assumed equal to 2013

The number of recruits entering in the population has been monthly split in order to take into account the seasonal recruitment, according to the characteristics of European hake recruiting more in spring and autumn (Table 114).

Table 114 Proportions of recruits entering each year in the population for hake in GSA 18.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	0.05	0.15	0.15	0.05	0.05	0	0	0.15	0.15	0.1	0.1

P. longirostris

The recruitment figures from the stock assessment results were related to age 0 and are from XSA results (**Table 115).**

The age of recruitment has been set equal to 0 months.

Table 115 Recruitment by year by year used in simulation phase for pink shrimp in GSA 18.

Year	R (thousands)
2007	730 047

Year	R (thousands)
2008	748 124
2009	806 637
2010	714 594
2011	481 417
2012	555 999
2013	714 582
2014*	714 582

* This value has been assumed equal to 2013

The number of recruits entering in the population has been monthly split in order to take into account the seasonal recruitment, according to the characteristics of pink shrimp recruiting more from April to October (Table 116).

Table 116 Proportions of recruits entering each year in the population for pink shrimp in GSA 18.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0	0

N. norvegicus

The recruitment figures from the stock assessment results were related to age 1 (being poorly represented the individuals of age 0 in the catches) and are from XSA results (Table 117). The recruitment of 2011 has been rescaled with a factor 0.85 in order to be more consistent with the expected values from the simulation. The age of recruitment has been set equal to 13 months.

Table 117 Recruitment by year used in simulation phase for Norway lobster in GSA 18.

Year	R (thousands)
2007	97 020
2008	66 445
2009	66 963
2010	49 477
2011	42 941
2012	33 924
2013	36 058
2014*	36 058

* This value has been assumed equal to 2013

The number of recruits entering in the population has been monthly split in order to take into account the seasonal recruitment, according to the characteristics of Norway lobster to recruit more from May to August (Table 118).

Table 118 Proportions of recruits entering each year in the population for Norway lobster in GSA 18.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0.1	0.4	0.4	0.1	0	0	0	0

M. barbatus

The recruitment figures from the stock assessment results were related to age 0 and are from XSA results (Table 119). The recruitment of 2011 has been rescaled with a factor 1.4 in order to take into account the level of the production.

The age of recruitment has been set equal to 2 months.

Table 119 Recruitment by year by year used in simulation phase for red mullet in GSA 18.

Year	R (thousands)
2007	202 570
2008	140 994
2009	122 228
2010	115 096
2011	320 305
2012	413 728
2013	255 246
2014*	255 246

* This value has been assumed equal to 2013

The number of recruits entering in the population has been monthly split in order to take into account the seasonal recruitment, according to the characteristics of Norway lobster to recruit more from May to September (Table 120).

Table 120 Proportions of recruits entering each year in the population for red mullet in GSA 18.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0.05	0.3	0.3	0.3	0.05	0	0	0

5.1.1.3 MATURITY AND SEX RATIO

The size at first maturity (Lm50%) and maturity range by species are reported in the table 121. These parameters have been estimated within DCF on biological sampling data.

Table 121 Maturity parameters for the 4 stocks in demersal fisheries GSA 18 case study

Length in mm	Lm50%			MR =Lm75%-Lm25%		
Species	Males	Females	Combined	Males	Females	Combined
M. merluccius			333			36
N. norvegicus	29.4	23.8		1	2	
P. longirostris			17			2.4
M. barbatus			110			7.5

5.1.1.4 NATURAL MORTALITY

The natural mortality at age was estimated using the Prodbiom method (Abella et al., 1997). In the tables from 122 to 125 the natural mortality rates by age class for the 4 stocks are reported.

Table 122 Natural mortality for hake in GSA 18.

Age	M
0	1.25

1	0.53
2	0.40
3	0.35
4	0.32
5	0.30
6	0.29
7	0.28
8	0.27
From 9 to 15	0.26

Table 123 Natural mortality for pink shrimp in GSA 18.

Age	M
0	1.41
1	0.81
2	0.7
From 3 to 4	0.65

Table 124 Natural mortality for Norway lobster in GSA 18.

Age	M
1	0.24
2	0.2
3	0.19
4	0.18
5	0.17
From 6 to 15	0.16

Table 125 Natural mortality for red mullet in GSA 18.

Age	M
0	1.51
1	1.03
2	0.71
3	0.65
From 4 to 6	0.62

5.1.1.5 TOTAL MORTALITY

The total mortality (Tab. 126) for *M. merluccius, P. longirostris* and *N. norvegicus* has been derived from the overall fishing mortality reported in the next paragraph (INPUT OF THE PRESSURE MODULE).

Table 126 Total mortality by stock in GSA 18

Stock	2007	2008	2009	2010	2011	2012	2013
M. merluccius	1.97	2.03	2	2.06	2.26	1.87	1.72
P. longirostris	2.14	2.17	2.1	2.29	2.59	2.39	2.59
N. norvegicus	1.12	1	1.02	1.07	1.02	0.67	1.02

For 2014 the same total mortality as 2013 has been assumed. Simulation for *M. barbatus* has been parameterized using the fishing mortality as input.

5.1.2 INPUT OF THE PRESSURE MODULE

5.1.2.1 FISHING MORTALITY

The F-mode of ALADYM model has been used in BEMTOOL for *M. barbatus*.

M. merluccius

The overall fishing mortality by year and age from XSA model for hake (Tab. 127) has been split among fleet segments according to the proportions in weight in the landing of the different fleet segments. For 2014 the same fishing mortality as 2013 has been assumed. The age range used for calculation of average F for hake was 0-5 years.

Table 127 Overall Fishing mortality for hake in GSA 18 (XSA model).

age	2007	2008	2009	2010	2011	2012	2013
0	0.43	0.29	0.34	0.35	0.41	0.58	0.46
1	2.66	2.64	2.52	2.45	2.78	2.15	2.23
2	0.56	0.71	0.76	0.95	1.02	0.86	0.48
3	0.30	0.60	0.44	0.64	0.59	0.86	0.22
4	0.92	0.63	0.35	0.70	0.39	0.22	0.29
5	0.21	0.62	0.73	0.35	1.57	0.34	0.14
6+	0.21	0.62	0.73	0.35	1.57	0.34	0.14

P. longirostris

The overall fishing mortality for pink shrimp by year and age from XSA model (Tab. 128) has been split among the fleet segments according to the proportions in weight in the landing of the different fleet segments. For 2014 the same fishing mortality as 2013 has been assumed. The age range used for calculation of average F for deep-water pink shrimp was 0-2.

Table 128 Overall fishing mortality for pink shrimp (XSA model).

Age	2007	2008	2009	2010	2011	2012	2013
0	0.252	0.255	0.229	0.255	0.301	0.298	0.323

Age	2007	2008	2009	2010	2011	2012	2013
1	2.177	2.335	2.122	2.463	2.997	2.616	3.005
2	1.282	1.230	1.246	1.460	1.768	1.566	1.749
3+	1.282	1.230	1.246	1.460	1.768	1.566	1.749

N. norvegicus

The overall fishing mortality for Norway lobster by year and age from XSA model (Tab. 129) has been split among fleet segments according to the proportions in weight in the landing of the different fleet segments. For 2014 the same fishing mortality as 2013 has been assumed. The age range used for calculation of average F for Norway lobster was 1-6.

Table 129 Overall fishing mortality for Norway lobster in GSA 18 (XSA model).

age	2007	2008	2009	2010	2011	2012	2013
1	0.401	0.182	0.289	0.223	0.202	0.238	0.137
2	1.110	0.887	0.860	0.873	0.826	0.489	0.850
3	1.166	1.052	1.183	1.122	1.152	0.611	1.108
4	1.195	0.931	1.118	1.165	1.119	0.614	1.118
5	0.877	1.161	0.872	1.129	0.928	0.550	1.001
6+	0.923	0.774	0.807	0.871	0.845	0.491	0.891

M. barbatus

The overall fishing mortality for red mullet by year and age from XSA model (Tab. 130) has been split according to the proportions in weight in the landing of the different fleet segments, assuming that the selectivity of the Eastern side of GSA 18 is the same as Western side. For 2014 the same fishing mortality of 2013 has been assumed. The age range used for the calculation of average F for red mullet was 0-2.

Table 130 Overall fishing mortality for red mullet (XSA model).

Age	2007	2008	2009	2010	2011	2012	2013
0	0.451	0.243	0.419	0.429	0.084	0.800	0.379
1	2.320	2.020	2.372	1.527	1.045	2.151	0.967
2	1.409	0.256	0.807	0.309	1.080	0.674	0.331
3+	1.409	0.256	0.807	0.309	1.080	0.674	0.331

5.1.2.2 SELECTIVITY TABLE

In the following tables the selectivity used for the modelization of the past/present years are reported by species and fleet segment.

Table 131 – Selectivity parameters for hake in GSA 18 (length in mm).

Fleet segment	Period	Model	L50 or Mean	SR or Standard Deviation	DSL50% or Standard deviation2
ITA_DTS_0612	2007-2010	Ogive with deselection	89.1	8	500
	2011-2014	Ogive with deselection	117.4	10	500
	2015-2021 (StatusQuo)	Ogive with deselection	117.4	10	500

Fleet segment	Period	Model	L50 or Mean	SR or Standard Deviation	DSL50% or Standard deviation2
ITA_DTS_1218	2007-2010	Ogive with deselection	89.1	8	500
	2011-2014	Ogive with deselection	117.4	10	500
	2015-2021 (StatusQuo)	Ogive with deselection	117.4	10	500
ITA_DTS_1824_2440	2007-2010	Ogive with deselection	89.1	8	500
	2011-2014	Ogive with deselection	117.4	10	500
	2015-2021 (StatusQuo)	Ogive with deselection	117.4	10	500
ITA_HOK_1218 *	2007-2014	Normal	469	165	
	2015-2021	Normal	445	165	
ITA_PGP_0006_0612	2007-2021	Normal	350	150	
ALB_DTS_1224	2007-2010	Ogive with deselection	89.1	8	500
	2011-2014	Ogive with deselection	117.4	10	470
	2015-2021 (StatusQuo)	Ogive with deselection	117.4	10	500
MNE_DFN_0012	2007-2021	Normal	350	150	
MNE_DTS_0612	2007-2012	Ogive with deselection	89.1	8	500
	2013-2014	Ogive with deselection	117.4	9	450
	2015-2021 (StatusQuo)	Ogive with deselection	117.4	10	500
MNE_DTS_1224	2007-2012	Ogive with deselection	89.1	8	500
	2013-2014	Ogive with deselection	117.4	9	450
	2015-2021 (StatusQuo)	Ogive with deselection	117.4	10	500
MNE_HOK_0012 *	2007-2014	Normal	469	185	
	2015-2021	Normal	445	185	

* In the selectivity function used for Italian hook, the mean varies in the years according the mean size in the observed data: in the table the average (on the values between 445 and 515 mm) is reported The same selectivity has been assumed for the Montenegrin hook.

Table 132 – Selectivity parameters of deep water rose shrimp in GSA 18 (length in mm).

Fleet segment	Period	Model	L50	SR
ITA_DTS_0612, ITA_DTS_1218, ITA_DTS_1824_2440, ALB_DTS_1224	2007-2010	Classical ogive	12.1	4
	2011-2014	Classical ogive	16	5
	2015-2021 (StatusQuo)	Classical ogive	16	5
MNE_DTS_0612, MNE_DTS_1224	2007-2012	Classical ogive	12.1	4
	2013-2014	Classical ogive	16	5
	2015-2021 (StatusQuo)	Classical ogive	16	5

Table 133 – Selectivity parameters for Norway lobster in GSA 18 (length in mm).

Fleet segment	Period	Model	L50	SR
ITA_DTS_0612	2007-2010	Classical ogive	14.87	5
	2011-2014	Classical ogive	17.94	6
	2015-2021 (StatusQuo)	Classical ogive	17.94	6
ITA_DTS_1218	2007-2010	Classical ogive	14.87	5
	2011-2014	Classical ogive	18.72	6
	2015-2021 (StatusQuo)	Classical ogive	18.72	6
ITA_DTS_1824_2440	2007-2010	Classical ogive	14.87	5
	2011-2014	Classical ogive	18.72	6
	2015-2021 (StatusQuo)	Classical ogive	18.72	6

5.1.2.3 EFFORT

The monthly effort variables used to simulate the past and current years by fleet segment are listed in Table 134. For 2014 the same effort as 2013 has been assumed.

Table 134 Effort for the selected fleet segment in GSA 18.

Effort Variable	ITA_DTS_0612							ITA_DTS_1218						
	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
average monthly GT	7	7	6.42	7	6	7	6	18	18	18.4	19	19	19	19
average monthly KW	58	58	57	57	57	56	56	129	129	130	130	130	131	131
number of vessels	35	35	35.4	38	38	39	39	325	325	324	299	302	287	287
annual fishing days	135	135	165	136	100	106	141	140	140	184	162	156	156	171
Effort Variable	**ITA_DTS_1824_2440**							**ITA_HOK_1218**						
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
average monthly GT	62	62	63	64	62.3	62	62	17	17	17.5	17	17.5	19	19
average monthly KW	296	296	297	295	294	290	290	168	168	174	161	173	184	184
number of vessels	117	117	118	120	114	95	95	34	34	33.3	44	42.6	27	27
annual fishing days	163	163	174	161	146	146	156	97	97	98	110	112	96	102
Effort Variable	**ITA_PGP_0006_0612**							**ALB_DTS_1224**						
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
average monthly GT	2	2	2	2.17	2.17	2	2	37	37	37	37	37	37	37
average monthly KW	17	17	16	17	17	17	17	232	232	232	232	232	232	232
number of vessels	489	489	486	490	485	477	481	164	164	164	164	164	164	164
annual fishing days	156	156	167	172	172	151	159	144	144	144	144	144	144	144

Effort Variable	MNE_DFN_0012							MNE_DTS_0612						
	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
average monthly GT	2	2	2	2	2	2	2	13	13	13	13	13	11	11
average monthly KW	29	29	29	29	28	27	23	147	147	147	147	147	130	130
number of vessels	37	37	37	37	38	37	47	3	3	3	3	3	4	4
annual fishing days	144	144	144	144	144	144	132	60	60	60	60	36	48	48
Effort Variable	**MNE_DTS_1224**							**MNE_HOK_0012**						
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
average monthly GT	30	30	30	29	27	27	27	2	2	2	2	2	2	3
average monthly KW	167	167	167	187	205	205	205	46	46	46	46	46	43	61
number of vessels	15	15	15	15	13	13	13	10	10	10	10	10	11	13
annual fishing days	132	132	120	120	96	60	84	48	48	48	48	48	36	132

5.1.2.4 LANDINGS

Landings were obtained from the data collected and reviewed by the SEDAF project and presented in the *WP2-Collation and review on the main socio-economic information on the main fisheries* deliverable (SEDAF-D6 Report economic and structural overview). Also GFCM stock assessment forms have been used as source of information for landings, in particular for Albanian fleet segment. Landing data of 2007 for Italy were obtained from the National Programs of the EU Data Collection Framework.

M. merluccius

The landing data for hake by fleet segment used to parameterize the model are listed in Table 135.For 2014 the same landing as 2013 has been assumed.

Table 135 Landings for hake by fleet segment in GSA 18 (tons).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	26	100	97	84	41	34	45
ITA_DTS_1218	1326	1782	1774	1902	2120	1631	1475
ITA_DTS_1824_2440	2145	1761	1677	1411	1152	847	859
ITA_HOK_1218	607	491	335	463	363	297	152
ITA_PGP_0006_0612	51	118	223	160	175	295	36
ALB_DTS_1224	390	390	456	375	402	280	280
MNE_DFN_0012	1	1	1	1	1	1	3
MNE_DTS_0612	7	7	6	6	4	5	5
MNE_DTS_1224	52	52	46	40	33	34	37
MNE_HOK_0012	1	1	1	1	1	1	4
Total	**4605**	**4702**	**4616**	**4443**	**4290**	**3427**	**2895**

P. longirostris

The landing data for pink shrimp by fleet segment used to parameterize the model are listed in Table 136. For 2014 the same landing as 2013 has been assumed.

Table 136 Landings for pink shrimp by fleet segment in GSA 18 (tons).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	7	14	12	7	6	0	0
ITA_DTS_1218	439	374	486	439	463	264	401
ITA_DTS_1824_2440	417	378	441	441	401	259	332
ALB_DTS_1224	309	309	275	409	328	335	335
MNE_DTS_0612	5	5	5	5	4	3	4
MNE_DTS_1224	34	34	31	28	23	19	24
Total	**1211**	**1114**	**1250**	**1329**	**1224**	**880**	**1097**

N. norvegicus

The landing data for Norway lobster by fleet segment used to parameterize the model are listed in Table 137. For 2014 the same landing as 2013 has been assumed.

Table 137 Landings for Norway lobster by fleet segment in GSA 18 (tons).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	0	6	16	12	4	1	1
ITA_DTS_1218	276	390	464	458	342	186	407
ITA_DTS_1824_2440	1024	609	613	553	413	271	426
Total	**1300**	**1005**	**1093**	**1023**	**759**	**458**	**834**

M. barbatus

The landing data for red mullet by fleet segment used to parameterize the model are listed in Table 138. The discard data from DCF have been split according to the proportions of landing by fleet (Table 139). For 2014 the same landing and discard as 2013 has been assumed.

Table 138 Landings for red mullet by fleet segment in GSA 18 (tons).

Fleet segment	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	187	98	92	37	8	356
ITA_DTS_1218	1139	686	655	472	417	1423
ITA_DTS_1824_2440	354	130	208	92	70	308
ITA_PGP_0006_0612	123	47	77	45	38	9
ALB_DTS_1224	171	149	154	90	110	280
MNE_DFN_0012	1	1	1	1	1	1
MNE_DTS_0612	4	4	4	4	4	4
MNE_DTS_1224	34	34	32	31	29	31
Total	**2012**	**1149**	**1223**	**772**	**675**	**2413**

Table 139 Discards for red mullet by fleet segment in GSA 18 (tons).

Fleet segment	2007	2008	2009	2010	2011	2012	2013

ITA_DTS_0612	7	2	1	1	0	92	2
ITA_DTS_1218	42	14	6	10	3	368	10
ITA_DTS_1824_2440	13	3	2	2	1	80	1
Total	**62**	**19**	**9**	**13**	**4**	**540**	**13**

Total landing

The total landing data by fleet segment used to parameterize the model are listed in the table 140. For 2014 the same landings as 2013 has been assumed.

Table 140 Total landing by fleet segment in GSA 18 (tons).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	615744	615744	857447	686929	246769	629184	773321
ITA_DTS_1218	7885629	7885629	9723540	8270698	7301481	6747679	10195643
ITA_DTS_1824_2440	5696367	5696367	6308621	5463875	4524591	3516813	4678231
ITA_HOK_1218	814490	814490	592481	956996	720657	399728	448921
ITA_PGP_0006_0612	2082431	2082431	2382681	1959768	1655646	1460856	2178870
ALB_DTS_1224	1931100	1931100	1931100	1931100	1931100	1931100	1931100
MNE_DFN_0012	40900	40900	39966	37620	35641	45112	98661
MNE_DTS_0612	24756	24756	24756	24756	15625	16485	21000
MNE_DTS_1224	243386	243386	242273	229673	179910	133676	170490
MNE_HOK_0012	12652	12652	10266	10067	10246	10717	47889
Total	**19347455**	**19347455**	**22113131**	**19571482**	**16621666**	**14891350**	**20544126**

5.1.3 INPUT OF THE ECONOMIC MODULE

Data for the estimation of the socio-economic parameters were obtained from the data collected and reviewed by the SEDAF project and presented in the WP2-*Collation and review on the main socio-economic information on the main fisheries* (SEDAF-D6 Report economic and structural overview). Data for Italy were obtained from the National Programs of the EU Data Collection Framework.

5.1.3.1 REVENUES

The revenues by fleet segment for hake, deep water rose shrimp, Norway lobster and red mullet and the total revenues are reported in the tables from 141 to 145. In the projections the prices have been modelled according to the revenues and the landings by fleet segment .

M. merluccius

Table 141 Revenues (€) of hake by fleet segment in GSA 18.

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	153747	661950	683816	538520	319520	207173	239591
ITA_DTS_1218	9719703	12899611	12860962	12596042	15532568	11809150	9088955
ITA_DTS_1824_2440	12768786	10498047	10267345	9582396	8240404	5593675	5449324
ITA_HOK_1218	4829178	3758971	2463968	3319797	2654494	2177049	965633

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_PGP_0006_0612	350879	854021	1595260	1108433	1219651	2028464	241968
ALB_DTS_1224			2551966	2006421	2342480	1699976	1566644
MNE_DFN_0012	6467	6467	6319	5948	5635	7133	15600
MNE_DTS_0612	28360	28360	25000	22120	22250	23450	30360
MNE_DTS_1224	207640	207640	183000	161880	162800	171550	222180
MNE_HOK_0012	6024	6024	4888	4793	4878	5102	22800
Total	**28070784**	**28921091**	**30642524**	**29346350**	**30504680**	**23722722**	**17843055**

P. longirostris

Table 142 Revenues (€) of deep water pink shrimp by fleet segment in GSA 18.

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	45327	123397	116603	59464	44888		
ITA_DTS_1218	3419357	3111109	4116866	3992087	4357451	2162511	3150100
ITA_DTS_1824_2440	3170473	2575118	2712769	2576203	2230997	1459994	2189339
ALB_DTS_1224	1103571	1103571	982157	1314630	1171414	1196443	1435731
MNE_DTS_0612	38360	38360	35070	31780	30000	27630	35370
MNE_DTS_1224	234640	234640	214760	194320	183600	169470	216540
Total	**8011728**	**7186195**	**8178225**	**8168484**	**8018350**	**5016048**	**7027080**

N. norvegicus

Table 143 Revenues (€) of Norway lobster by fleet segment in GSA 18.

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612		84250	351617	240113	84430	13147	21499
ITA_DTS_1218	3887578	5856320	8111656	7937126	5678787	3065829	7092458
ITA_DTS_1824_2440	14854608	9793585	10569459	9353280	6975577	4565471	7081325
Total	**18742186**	**15734155**	**19032732**	**17530519**	**12738794**	**7644447**	**14195282**

M. barbatus

Table 144 Revenues (€) of red mullet by fleet segment in GSA 18.

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	577136	365473	364903	228476	54759	1905951	588059
ITA_DTS_1218	4782188	3272793	3253069	3448661	3153548	7295214	3864743
ITA_DTS_1824_2440	1673256	687724	876440	621392	483639	1127748	657021
ITA_PGP_0006_0612	495230	319969	468141	437355	412881	60706	297872
ALB_DTS_1224	955643	831392	864113	482313	642547	1698749	1382927
MNE_DFN_0012	6218	6218	6076	5720	5419	6859	15000
MNE_DTS_0612	17240	17240	16520	15800	14640	20000	20000
MNE_DTS_1224	134760	134760	129080	123400	114560	156500	156500
Total	**8641671**	**5635569**	**5978342**	**5363117**	**4881993**	**12271727**	**6982122**

Total revenues

Table 145 Total revenues (€) by fleet segment in GSA 18.

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	3001552	3648726	5052209	4315292	1776503	3550741	5241690
ITA_DTS_1218	45109083	49820026	63335208	59143739	51941289	43548673	66490023
ITA_DTS_1824_2440	49773660	35206146	37796485	35143062	29909888	21833166	28585849
ITA_HOK_1218	8023505	6062132	4391556	7483942	6061471	3119017	3812736
ITA_PGP_0006_0612	14512222	15434210	17997073	16365904	14497744	11731366	17922828
ALB_DTS_1224	10691833	10691833	10691833	10691833	10691833	10691833	10691833
MNE_DFN_0012	310840	310840	303741	285912	342153	433005	789288
MNE_DTS_0612	118828	118828	118828	118828	81562	103855	132300
MNE_DTS_1224	1263876	1263876	1038234	1038234	924003	926284	1146626
MNE_HOK_0012	101216	101216	82130	80537	81971	99377	337800
Total	**132906615**	**122657833**	**140807297**	**134667283**	**116308417**	**96037317**	**135150973**

5.1.3.2 COSTS

In the tables from 146 to 158 all the data of costs by fleet segment used in the simulation phase of the case study (past and present years) are reported.

Table 146 Total variable costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	1678005	1678005	1585531	1625206	1311031	643151	578178
ITA_DTS_1218	24508782	24508782	20637367	19709251	25366455	22726120	15666826
ITA_DTS_1824_2440	15013922	15013922	13936511	15346519	13048105	13361661	10154205
ITA_HOK_1218	1480476	1480476	1075483	1869986	2141063	1084605	1108913
ITA_PGP_0006_0612	4190678	4190678	3419332	3940417	4513157	3826029	5463445
ALB_DTS_1224	7760446	7760446	7760446	7760446	7760446	7760446	7760446
MNE_DFN_0012	117050	117050	116071	122334	116770	115120	117903
MNE_DTS_0612	49524	49524	49524	49524	31424	51535	45250
MNE_DTS_1224	824017	824017	855628	804807	533116	313590	483804
MNE_HOK_0012	37530	37530	31246	31985	33432	32200	113992
Total	**55660430**	**55660430**	**49467139**	**51260475**	**54854999**	**49914457**	**41492962**

Table 147 Other variable costs by fleet segment in GSA 17 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	456323	456323	601279	527753	284646	427450	120216
ITA_DTS_1218	6462418	6462418	8170908	7177311	6494454	4269565	2249456
ITA_DTS_1824_2440	3562159	3562159	3795119	3572177	2963867	2344191	846810
ITA_HOK_1218	592216	592216	517495	813276	800883	435233	351995

ITA_PGP_0006_0612	1523219	1523219	1577160	1561324	1398982	1241341	1306945
ALB_DTS_1224	41565	41565	41565	41565	41565	41565	41565
MNE_DFN_0012	30895	30895	30592	32533	30315	30055	28775
MNE_DTS_0612	8701	8701	8701	8701	5521	9054	7950
MNE_DTS_1224	102749	102749	114479	106550	65125	38717	61984
MNE_HOK_0012	19062	19062	15899	16267	16997	16389	58085
Total	**12799307**	**12799307**	**14873197**	**13857457**	**12102355**	**8853560**	**5073781**

Table 148 Fuel costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	1221682	1221682	984252	1097453	1026385	215701	457962
ITA_DTS_1218	18046364	18046364	12466459	12531940	18872001	18456555	13417370
ITA_DTS_1824_2440	11451763	11451763	10141392	11774342	10084238	11017470	9307395
ITA_HOK_1218	888260	888260	557988	1056710	1340180	649372	756918
ITA_PGP_0006_0612	2667459	2667459	1842172	2379093	3114175	2584688	4156500
ALB_DTS_1224	7718881	7718881	7718881	7718881	7718881	7718881	7718881
MNE_DFN_0012	86155	86155	85479	89801	86455	85065	89128
MNE_DTS_0612	40823	40823	40823	40823	25903	42481	37300
MNE_DTS_1224	721268	721268	741149	698257	467991	274873	421820
MNE_HOK_0012	18468	18468	15347	15718	16435	15811	55907
Total	**42861123**	**42861123**	**34593942**	**37403018**	**42752644**	**41060897**	**36419181**

Table 149 Maintenance costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	115013	115013	114943	123963	113225	124795	49926
ITA_DTS_1218	1521050	1521050	1513415	1402304	1334177	1263096	1933308
ITA_DTS_1824_2440	1195323	1195323	1194835	1211051	1161732	972031	814274
ITA_HOK_1218	252649	252649	252088	336200	337170	156281	251269
ITA_PGP_0006_0612	869942	869942	869711	875075	800313	698906	630335
ALB_DTS_1224	106000	106000	106000	106000	106000	106000	106000
MNE_DFN_0012	67749	67749	67749	67749	68803	61784	70536
MNE_DTS_0612	6638	6638	6638	6638	6638	7600	7600
MNE_DTS_1224	202900	202900	202900	193655	170493	170493	161317
MNE_HOK_0012	45596	45596	45596	45596	45596	49477	67290
Total	**4382860**	**4382860**	**4373875**	**4368231**	**4144147**	**3610463**	**4091855**

Table 150 Total fixed costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	137945	137945	137595	148393	142725	149389	74896
ITA_DTS_1218	1902281	1902281	1892330	1753400	1698764	1093381	1207736
ITA_DTS_1824_2440	1533762	1533762	1534018	1554859	1419262	1248194	687032
ITA_HOK_1218	169925	169925	170387	227239	231363	84173	222317

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_PGP_0006_0612	661990	661990	666158	670315	656124	406633	729973
ALB_DTS_1224	28000	28000	28000	28000	28000	28000	28000
MNE_DFN_0012	17146	17146	17146	17146	17290	15293	17042
MNE_DTS_0612	3459	3459	3459	3459	3459	3961	3961
MNE_DTS_1224	71271	71271	71271	66777	65859	65859	58384
MNE_HOK_0012	5027	5027	5027	5027	5027	5156	8535
Total	**4530806**	**4530806**	**4525391**	**4474615**	**4267873**	**3100039**	**3037876**

Table 151 Other fixed costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	137945	137945	137595	148393	142725	149389	74896
ITA_DTS_1218	1902281	1902281	1892330	1753400	1698764	1093381	1207736
ITA_DTS_1824_2440	1533762	1533762	1534018	1554859	1419262	1248194	687032
ITA_HOK_1218	169925	169925	170387	227239	231363	84173	222317
ITA_PGP_0006_0612	661990	661990	666158	670315	656124	406633	729973
ALB_DTS_1224	28000	28000	28000	28000	28000	28000	28000
MNE_DFN_0012	17146	17146	17146	17146	17290	15293	17042
MNE_DTS_0612	3459	3459	3459	3459	3459	3961	3961
MNE_DTS_1224	71271	71271	71271	66777	65859	65859	58384
MNE_HOK_0012	5027	5027	5027	5027	5027	5156	8535
Total	**4530806**	**4530806**	**4525391**	**4474615**	**4267873**	**3100039**	**3037876**

Table 152 Labour costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	863851	863851	1545958	1199638	180961	1296634	1310422
ITA_DTS_1218	11450780	11450780	19817848	18308466	12229739	8184645	13982843
ITA_DTS_1824_2440	8303330	8303330	9905317	8186396	6779967	3465103	6394780
ITA_HOK_1218	1318147	1318147	1424643	2411854	1653157	715997	571910
ITA_PGP_0006_0612	4145822	4145822	6528796	5703888	4132561	2901013	4340713
ALB_DTS_1224	1497506	1497506	1497506	1497506	1497506	1497506	1497506
MNE_DFN_0012	69261	69261	69261	69261	69261	66902	93051
MNE_DTS_0612	36512	36512	36512	36512	36512	45640	22820
MNE_DTS_1224	190748	190748	190748	165586	160866	160866	162129
MNE_HOK_0012	47198	47198	47198	47198	47198	51128	56653
Total	**27923155**	**27923155**	**41063787**	**37626305**	**26787728**	**18385434**	**28432827**

Table 153 Depreciation costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	252082	252082	283322	297522	286999	283059	245920
ITA_DTS_1218	4560996	4560996	4872362	4633501	4275580	3919414	3624218
ITA_DTS_1824_2440	7285371	7285371	7785318	8131889	8879613	6301739	5500316

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_HOK_1218	553440	553440	621428	581475	515835	401831	382866
ITA_PGP_0006_0612	1628783	1628783	1727541	5939100	5872477	4498694	3686756
ALB_DTS_1224	1021800	1021800	1021800	1021800	1021800	1021800	1021800
MNE_DFN_0012	7784	7784	7784	7784	7946	7213	8374
MNE_DTS_0612	3766	3766	3766	3766	3766	4312	4312
MNE_DTS_1224	45164	45164	45164	43705	35082	35082	35082
MNE_HOK_0012	2324	2324	2324	2324	2324	2464	3645
Total	**15361510**	**15361510**	**16370809**	**20662866**	**20901422**	**16475608**	**14513289**

Table 154 Opportunity costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	11072	11072	37086	26778	27132	23942	40732
ITA_DTS_1218	245130	245130	803057	527217	502597	422845	753227
ITA_DTS_1824_2440	374241	374241	1218150	869417	944959	615113	1070808
ITA_HOK_1218	26988	26988	86667	56998	51853	37223	66942
ITA_PGP_0006_0612	72755	72755	236380	600243	605186	449162	757245
ALB_DTS_1224	209205	209205	209205	209205	209205	209205	209205
MNE_DFN_0012	8924	8924	8924	8924	9063	8138	9289
MNE_DTS_0612	3373	3373	3373	3373	3373	3862	3862
MNE_DTS_1224	54151	54151	54151	51081	48387	48387	43884
MNE_HOK_0012	4183	4183	4183	4183	4183	4552	6126
Total	**1010022**	**1010022**	**2661176**	**2357419**	**2405938**	**1822429**	**2961320**

Table 155 Total capital costs by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	263153	263153	320409	324299	314132	307001	286651
ITA_DTS_1218	4806126	4806126	5675419	5160718	4778177	4342259	4377445
ITA_DTS_1824_2440	7659612	7659612	9003468	9001306	9824572	6916852	6571124
ITA_HOK_1218	580428	580428	708095	638473	567688	439054	449808
ITA_PGP_0006_0612	1701538	1701538	1963921	6539343	6477663	4947856	4444001
ALB_DTS_1224	1231005	1231005	1231005	1231005	1231005	1231005	1231005
MNE_DFN_0012	16708	16708	16708	16708	17009	15351	17663
MNE_DTS_0612	7139	7139	7139	7139	7139	8174	8174
MNE_DTS_1224	99315	99315	99315	94786	83469	83469	78966
MNE_HOK_0012	6507	6507	6507	6507	6507	7016	9771
Total	**16371531**	**16371531**	**19031986**	**23020284**	**23307361**	**18298037**	**17474608**

Table 156 Other income by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	283089	283089	85422		146456	130659	
ITA_DTS_1218	2813976	2813976	1073439		2321762	1812217	

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_1824_2440	1278598	1278598	647827		1094093	870573	
ITA_HOK_1218					10309		
ITA_PGP_0006_0612				18678	19903	11828	
ALB_DTS_1224							
MNE_DFN_0012							3200
MNE_DTS_0612							5000
MNE_DTS_1224							2000
MNE_HOK_0012							
Total	**4375663**	**4375663**	**1806688**	**18678**	**3592523**	**2825277**	**10200**

Table 157 Number of employees by fleet segment in GSA 18 (€).

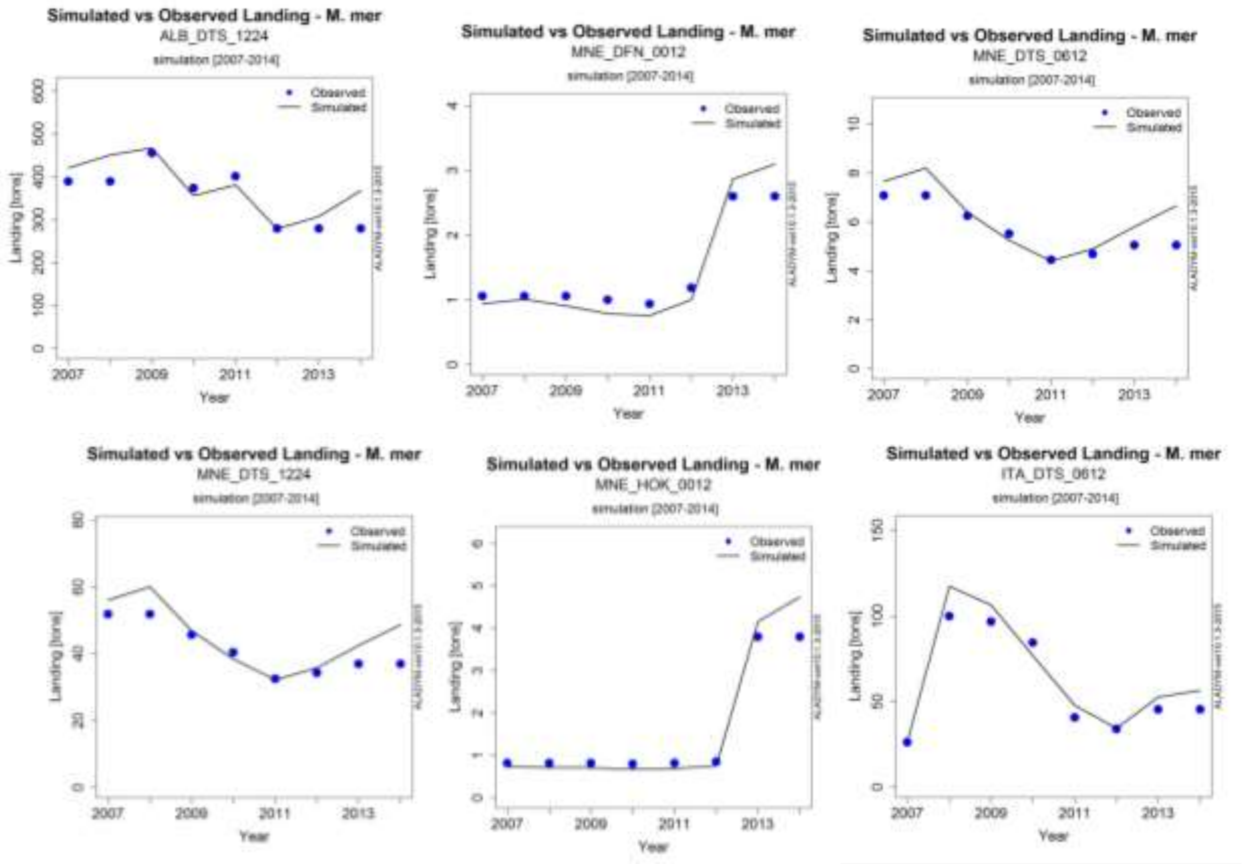
Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	74	74	74	73	81	77	70
ITA_DTS_1218	795	795	853	857	785	708	708
ITA_DTS_1824_2440	467	467	479	484	422	354	368
ITA_HOK_1218	150	150	72	73	171	144	147
ITA_PGP_0006_0612	887	887	879	891	878	844	866
ALB_DTS_1224	1026	1026	1026	1026	1026	1026	1026
MNE_DFN_0012	70	70	70	70	70	68	97
MNE_DTS_0612	8	8	8	8	8	10	5
MNE_DTS_1224	46	46	46	40	39	39	39
MNE_HOK_0012	18	18	18	18	18	19	24
Total	**3541**	**3541**	**3525**	**3540**	**3498**	**3289**	**3350**

Table 158 Capital value by fleet segment in GSA 18 (€).

Fleet segment	2007	2008	2009	2010	2011	2012	2013
ITA_DTS_0612	971109	971109	1065045	1115014	1107897	1084753	942865
ITA_DTS_1218	21500849	21500849	23062152	21952973	20522723	19157855	17435809
ITA_DTS_1824_2440	32825382	32825382	34982768	36201947	38585814	27868937	24787234
ITA_HOK_1218	2367179	2367179	2488891	2373348	2117330	1686455	1549577
ITA_PGP_0006_0612	6381493	6381493	6788342	24993712	24711749	20350213	17528820
ALB_DTS_1224	6640000	6640000	6640000	6640000	6640000	6640000	6640000
MNE_DFN_0012	230084	230084	230084	230084	232820	222925	264600
MNE_DTS_0612	82500	82500	82500	82500	82500	110000	110000
MNE_DTS_1224	1445833	1445833	1445833	1445833	1240833	1240833	1250000
MNE_HOK_0012	127476	127476	127476	127476	127476	135833	174500
Total	**72571905**	**72571905**	**76913091**	**95162887**	**95369142**	**78497804**	**70683405**

5.2 FITTING OF OBSERVED LANDING DATA AND COMPARISON WITH ASSESSMENT RESULTS

Fitting of the landing data simulated by BEMTOOL model is quite satisfactory for all the species, with an average difference compared to the observed landings of 4% by year for hake (Fig. 52), 4% for pink shrimp (Fig. 53), -7% for Norway lobster (Fig. 54) and of 0.5 % for red mullet (Fig. 55).



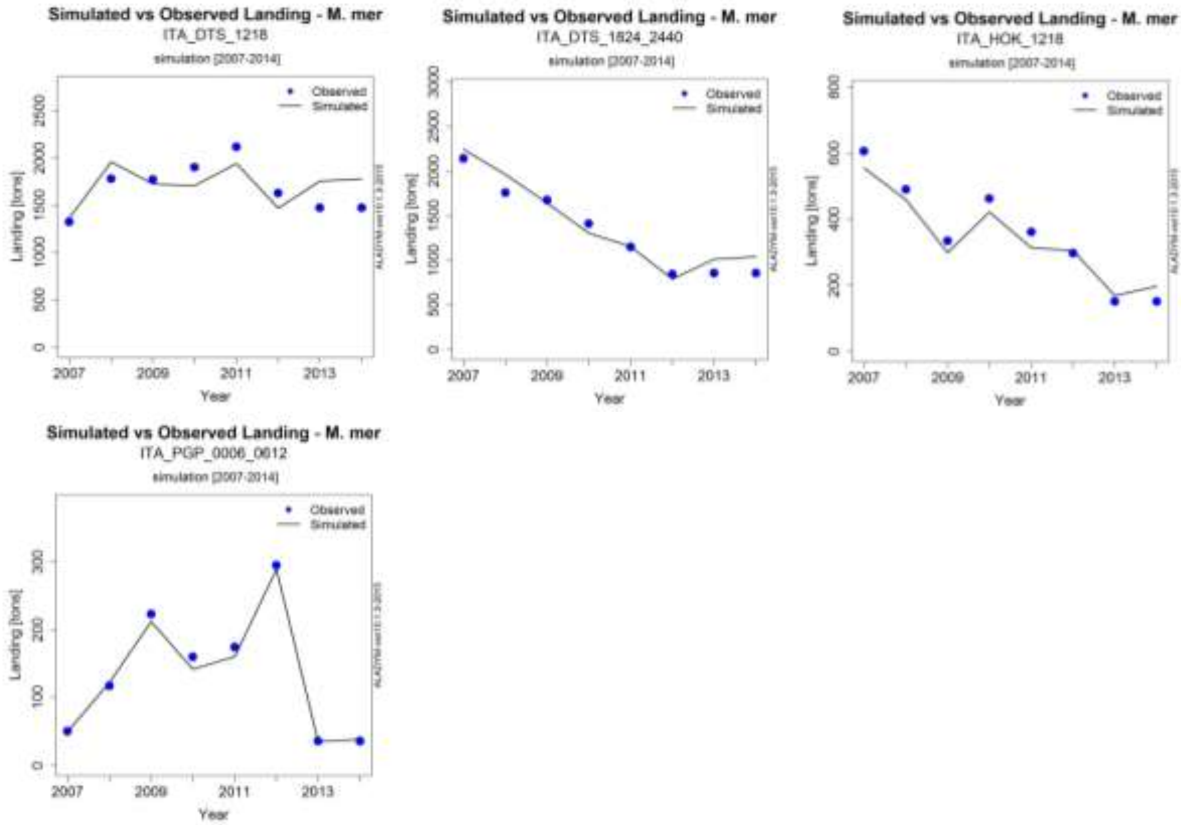


Figure 52 Comparison between simulated and observed landings by fleet segment for hake in GSA 18.

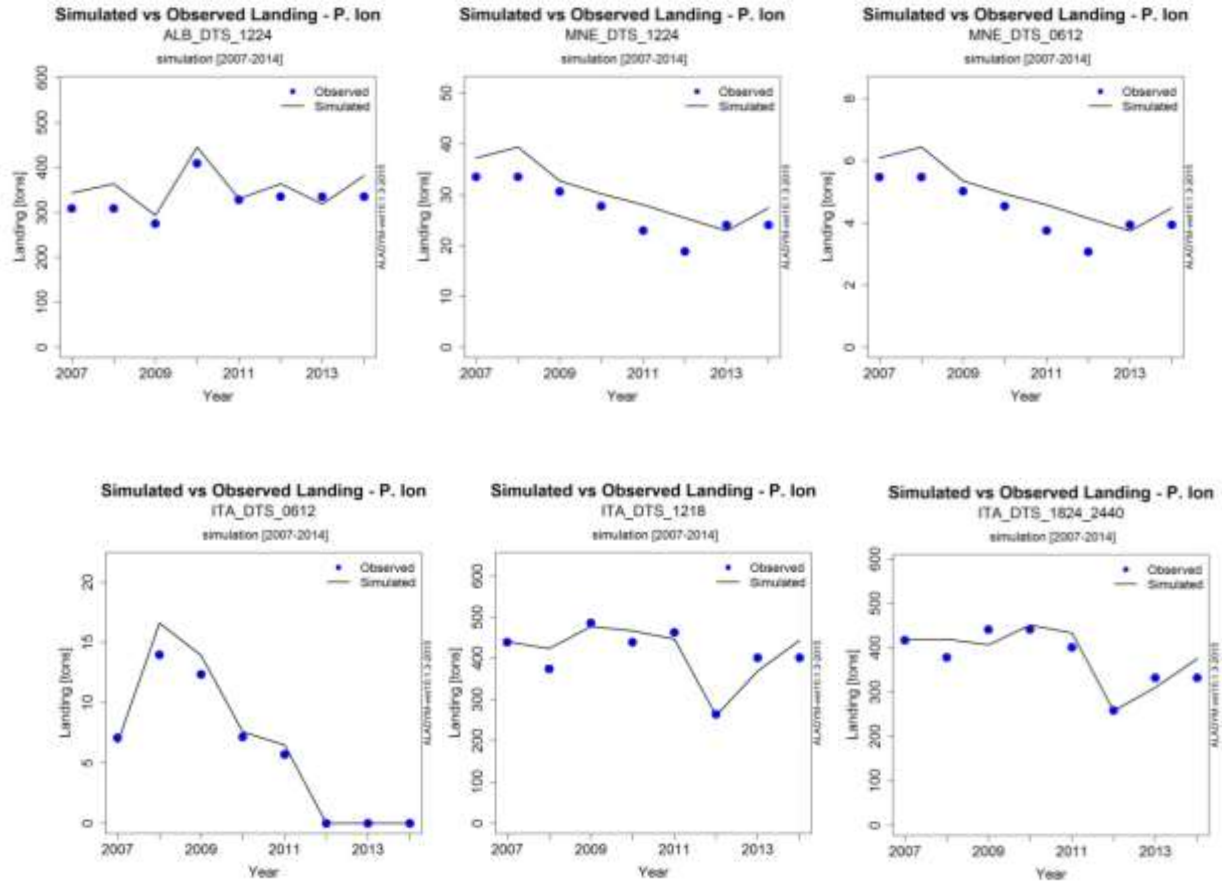


Figure 53 Comparison between simulated and observed landings by fleet segment for deep water pink shrimp in GSA 18.

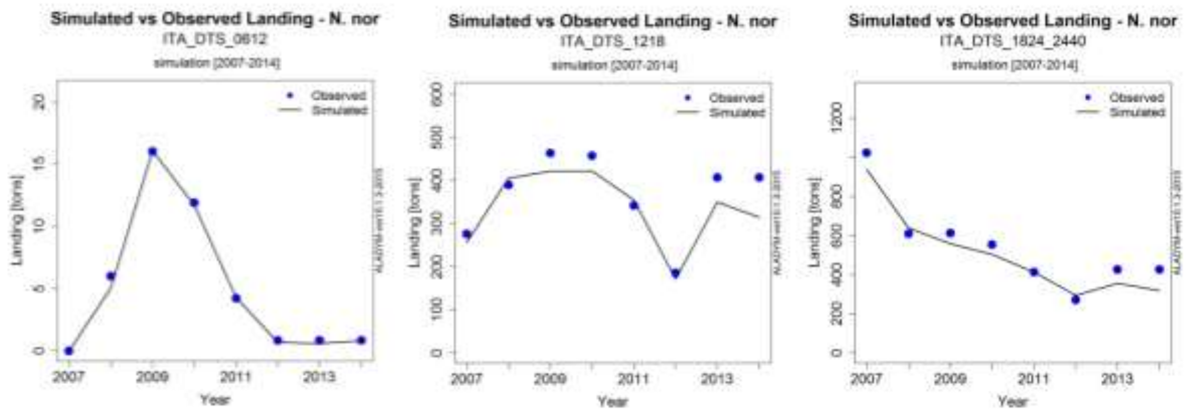


Figure 54 Comparison between simulated and observed landings by fleet segment for Norway lobster in GSA 18.

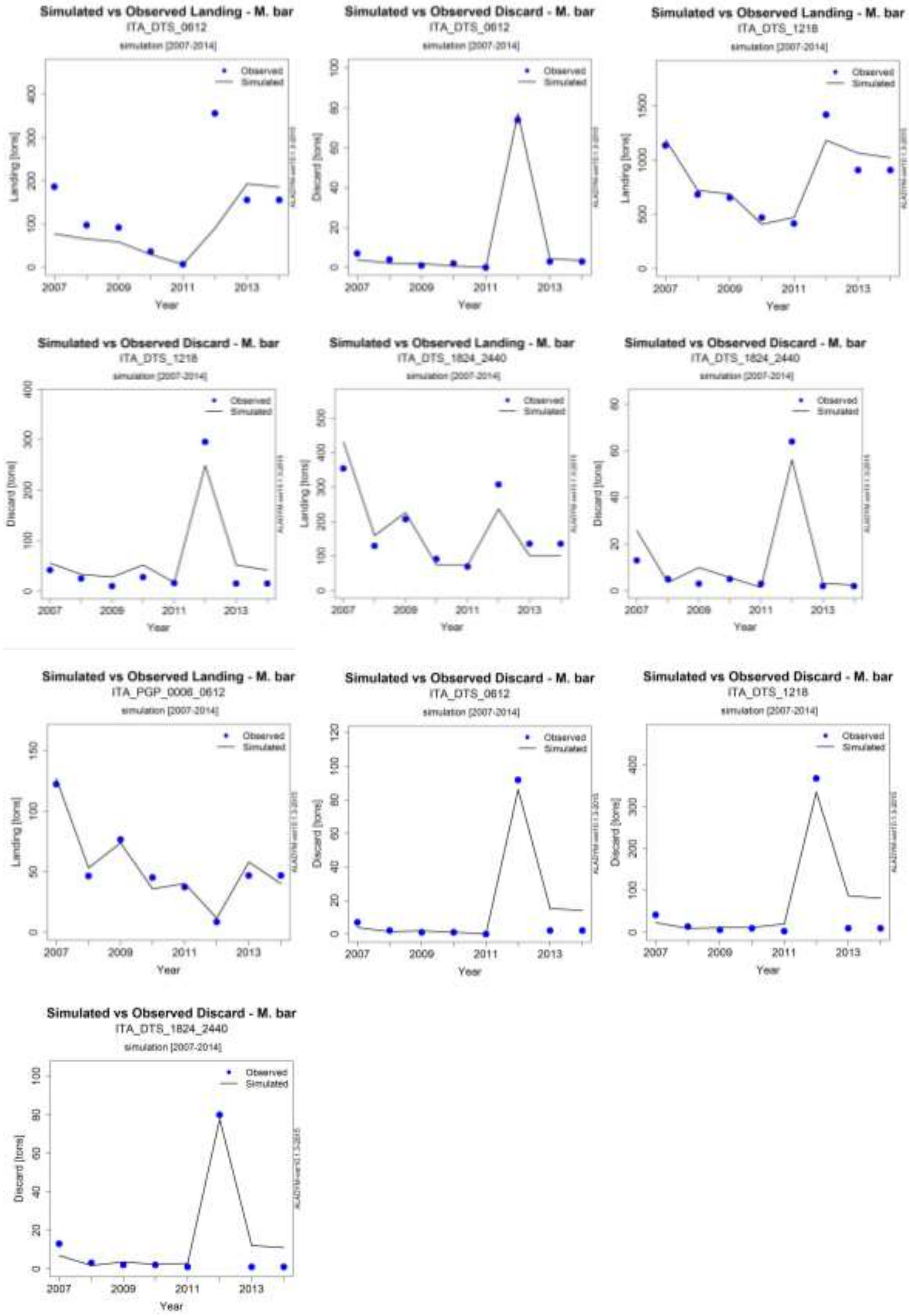


Figure 55 Comparison between simulated and observed landings and discards by fleet segment for red mullet in GSA 18.

The comparison between the Spawning Stock Biomass (SSB) from the assessment model and the BEMTOOL simulations is shown in Figure 56.

The simulated SSB of hake in quite close to the one estimated by XSA; as regards deep water rose shrimp, BEMTOOL estimates an SSB much lower than the SSB estimated by XSA (around 1/3): this is due to different time scale of the 2 models (XSA has yearly time scale while BEMTOOL works by month). Indeed the individual weight of pink shrimp varies considerably especially in the first year of life (from 0.2 g to 7.5 g according to the selected growth parameters), making the approximation of the individual weight at year time scale of age class and thus the estimation of SSB in XSA less accurate respect to BEMTOOL. Nevertheless, the general trend is common between the two models.

For Norway lobster and red mullet, the fitting of SSB is quite satisfactory showing a good level of agreement for estimated SSB between BEMTOOL and XSA.

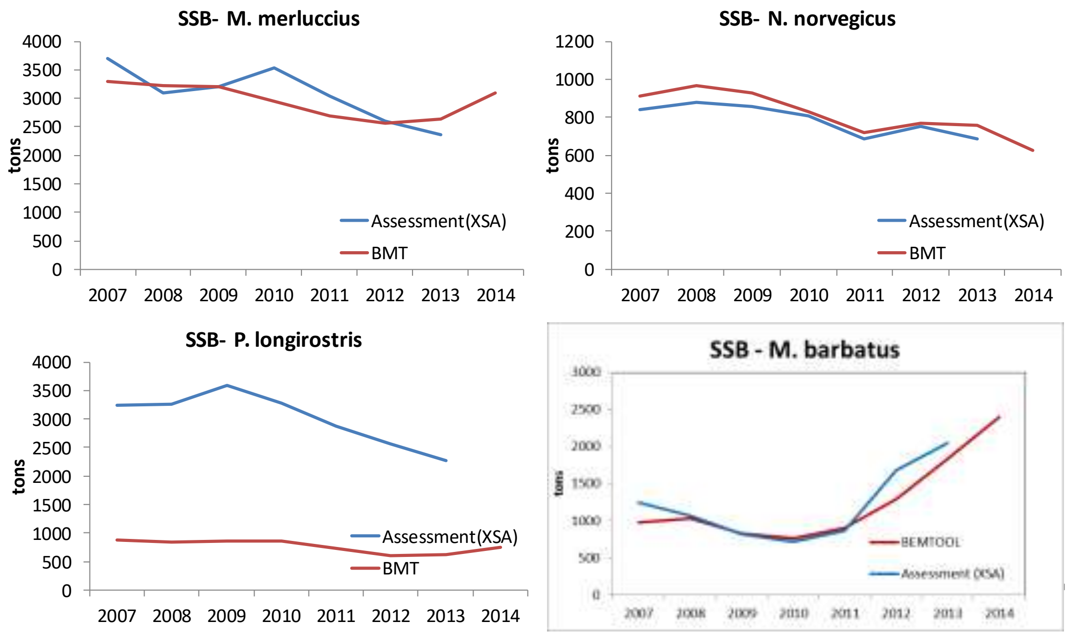


Figure 56 Comparison between BEMTOOL and stock assessment SSB by fleet segment for hake, Norway lobster, pink shrimp and red mullet in GSA 18.

5.3 DIAGNOSIS OF THE STOCKS

In Table 159 F current values re-estimated by BEMTOOL and F_{MSY} from the assessment of the four stocks of the case study are reported. In the Table 159 a reference value of SSB is also reported, that is the SSB estimated by BEMTOOL at level of F = F0.1 under steady state assumptions.

Figure 57 shows the Kobe plot related to the state of exploitation of the 4 demersal stocks in terms of fishing mortality and SSB. All the stocks are in the red zone of the kobe plot, being the current SSB lower than the reference SSB and F higher than F_{MSY} for almost all the stocks except red mullet.

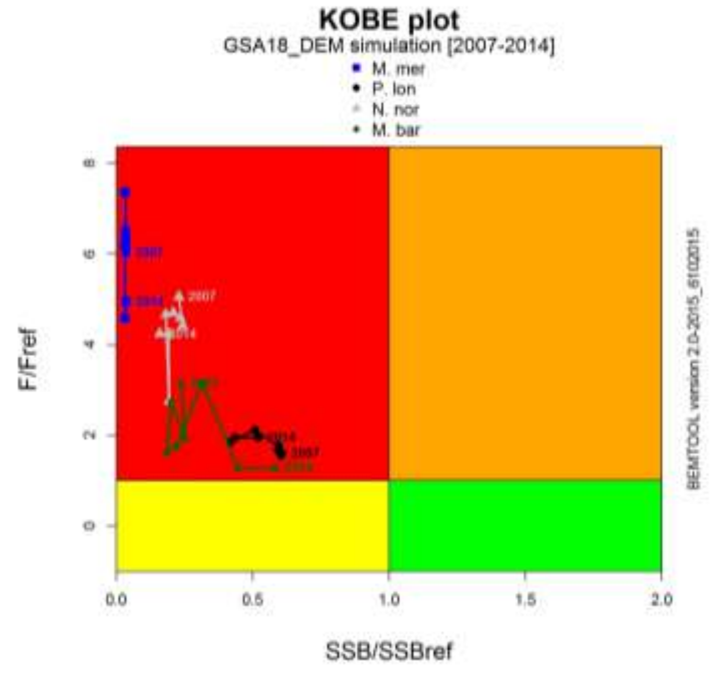


Figure 57 Kobe plot summarizing the state of exploitation for hake, Norway lobster, deep water pink shrimp and red mullet in GSA 18.

Table 159 Fcurrent, FMSY, and SSB by stock in GSA18.

Stock	$F_{current}$	F_{MSY}	SSBcurrent	SSBref
M. merluccius	0.66	0.2	3470	96430
P. longirostris	1.31	0.74	745	1435
N. norvegicus	0.8	0.13	627	3984
M. barbatus	0.57	0.45	2400	4125

According to the state of exploitation of the four demersal stocks in GSA 18 case study, the ratio between $F_{current}$ and F_{MSY} is 3.3 for European hake, 1.77 for deep water rose shrimp, 1.27 for red mullet and 6.15 for Norway lobster. 6 forecast scenarios have been thus implemented (see chapter 5.5), besides the status quo, in order to evaluate the consequences of several management strategies in terms of costs and benefits on the stocks and on the productive and economic performances of different fleet segments.

A combined fishing mortality has been used to plan the forecast scenarios (see chapter 5.5 DEFINITION AND COMPARISON OF THE DIFFERENT MANAGEMENT SCENARIOS for details).

5.4 PROJECTIONS OF STATUS QUO WITH UNCERTAINTY ON RECRUITMENT

5.4.1 INPUT OF THE BIOLOGICAL AND PRESSURE MODULES

In order to perform the projections of the stock in the future, the recruitment of all the stocks has been assumed constantly equal to the last year. A multiplicative log-normal error with mean 0 and standard deviation 0.3 has been applied in order to take into account the uncertainty due to the process error that is propagated to all the indicators produced by BEMTOOL. Figure 58 shows the recruitment of the four stocks with confidence interval used in all the performed scenarios.

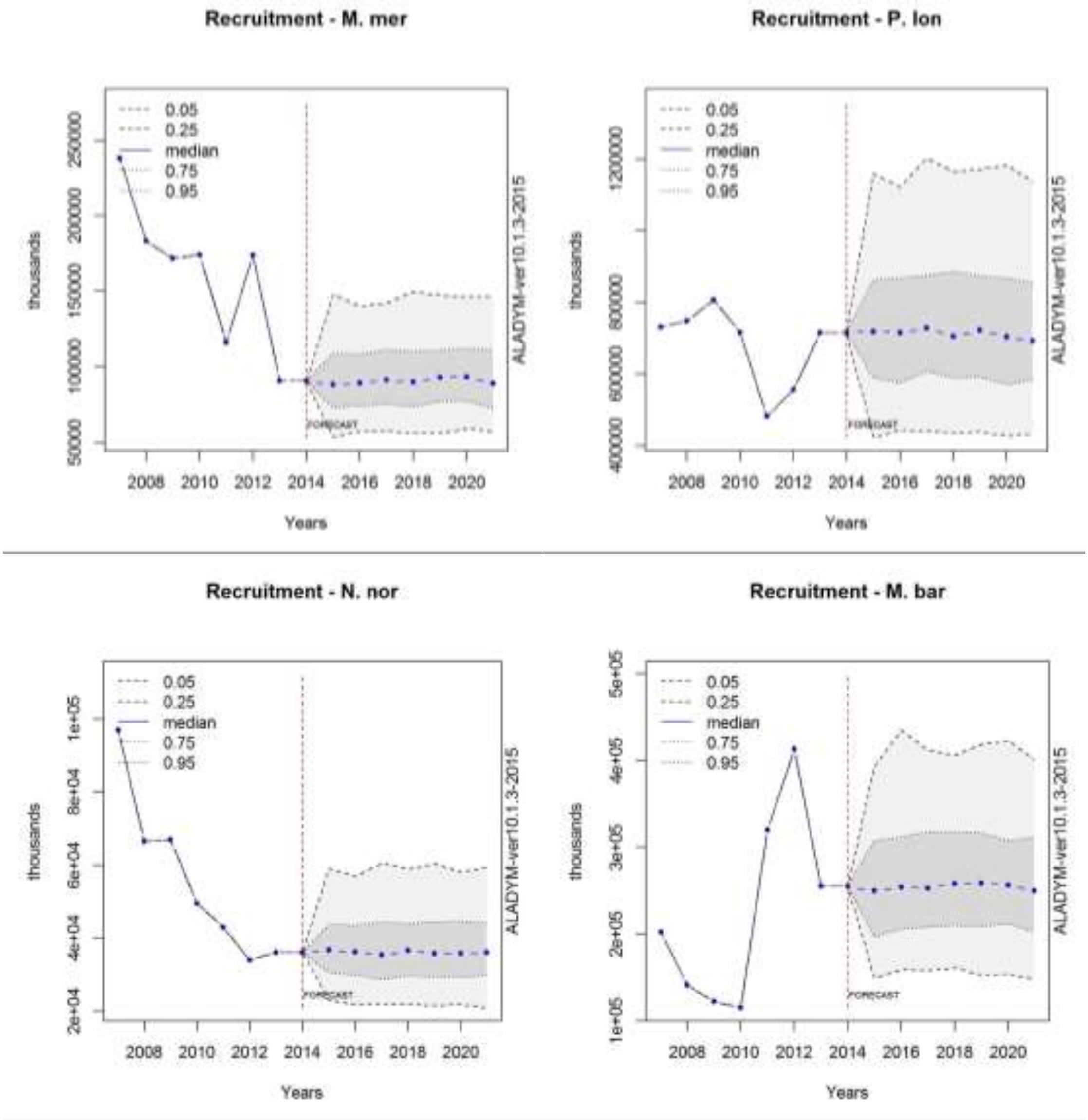


Figure 58 Recruitment with confidence intervals used for hake, deep water pink shrimp, Norway lobster and red mullet in the forecast scenarios.

All the other biological inputs have been maintained unchanged in the projections.

For the status quo the effort has been maintained constant for all the years (until 2021) and equal to 2013.

5.4.2 INPUT OF THE ECONOMIC MODULE

The main equations in the socio-economic model are related to the dynamics of prices and costs. Each equation has been tested on the basis of available historical series of data in order to check that the functional relationships are correctly specified. The economic parameters of the selected fleet segments and the equations applied are given below.

Due to the presence of relevant fluctuations in the time series of most fleet segments, the socio economic parameters have been estimated on the basis of the most recent economic data available in 2012 and 2013.

Socio-economic parameters of the Albanian demersal trawl segment 1224 m were available only for 2012. Therefore, socio-economic parameters of the other years were estimated on the basis of 2012.

For all fleets included in the case study, 2014 data were assumed equal to 2013.

5.4.2.1 PRICES DYNAMICS

Prices are estimated by species and fleet segment as a function of landings. The functional relationship between prices and landings for each species and fleet segment has been defined using a flexibility coefficient representing the percentage change in prices due to one percent change in landings.

The following functional form has been adopted corresponding to option 1 of the price module:

$$p_{s,f,t} = p_{s,f,t-1}\left(1+\varepsilon_{s,f,landing}\frac{L_{s,f,t}-L_{s,f,t-1}}{L_{s,f,t-1}}\right)$$

where:

$p_{s,f,t}$ is the price of the target species *s*, for the fleet segment *f* at time *t*; (€)

$L_{s,f,t}$ is the landings of the target species *s*, for the fleet segment *f* at time *t* (Kg);

$\varepsilon_{s,f,landing}$ is the elasticity coefficient price-landings for species *s* and fleet segment *f* (€/kg).

Due to the lack of reliable estimations based on available data, the flexibility coefficient was computed exogenously. Sector studies (Nielsen, 2000 and Camanzi *et al.,* 2010) confirm that the flexibility coefficient normally ranges between -0.1 and -0.4. In this case study flexibility coefficients estimated for the Italian management plans have been applied, which estimated an average coefficient of -0.4 for all target species (Tab. 160).

Table 160 Price parameterization by fleet segment and stock in GSA 18 demersal case study.

Fleet segment	Model	coeff. price-landings M. merluccius	coeff. price-landings P. longirostris	coeff. price-landings N. norvegicus	coeff. price-landings M. barbatus
ITA_DTS_VL0612	1	-0.4	-0.4	-0.4	-0.4
ITA_DTS_VL1218		-0.4	-0.4	-0.4	-0.4
ITA_DTS_VL1824-2440		-0.4	-0.4	-0.4	-0.4
ITA_HOK_VL1218		-0.4	-0.4	-0.4	-0.4
ITA_PGP_VL0006-0612		-0.4	-0.4	-0.4	-0.4
ALB_DTS_1224		-0.4	-0.4	-0.4	-0.4
MNE_DFN_VL0012		-0.4	-0.4	-0.4	-0.4
MNE_DTS _VL0612		-0.4	-0.4	-0.4	-0.4
MNE_DTS_VL1224		-0.4	-0.4	-0.4	-0.4
MNE_HOK_VL0012		-0.4	-0.4	-0.4	-0.4

The flexibility coefficient price-landings was assumed equal to -0.4 for all target species, which means that given a 1% fall in the production of a given species, it is assumed an increase in price of 0.4%.

Average prices of target species for Albania and Montenegro have been sourced from the tables "Average landed prices by the main species 2011-2013" presented in the SEDAF D07 -Report on the Aspects of Fish Markets in the Adriatic Sea.

5.4.2.2 COSTS DYNAMICS

Variable costs

Variable costs have been classified under one heading, which is the sum of fuel costs and other variable costs. Total variable costs are a function of the fishing effort (expressed by average days at sea):

$$TVC_{f,t} = \beta_f E_{f,t}$$

where:

$TVC_{f,t}$ are total variable costs for fleet segment *f* at time *t* (€);

$E_{f,t}$ is the effort (in terms of total annual days at sea) of fleet segment *f* at time *t*;

β_f is the total variable costs per unit of effort at time *t*

Variable costs are directly related to the number of estimated days at sea. Fixed and capital costs are function of the estimated fleet capacity, expressed in terms of number of vessels and gross tonnage.

Variable costs include crew wage, unpaid labour, energy costs, repair costs and other variable costs.

Maintenance costs and fixed costs

Maintenance costs (MC) and other fixed costs (OFC) are supposed to be proportional to the gross tonnage (GT) of the fleet segment, corresponding to option one of the BEMTOOL software.

$$MC_{f,t} = \alpha''_f GT_{f,t}$$

$$OFC_{f,t} = \alpha'_f GT_{f,t}$$

Capital costs

Fixed and capital costs are function of the estimated fleet capacity, expressed in terms of number of vessels and gross tonnage.

Depreciation costs DC are estimated by linear functions of the annual gross tonnage GT as well.

$$DC_{f,t} = \beta'_f GT_{f,t}$$

Following the approach of "2014 Annual Economic Report on the EU Fishing Fleet "(STECF-14-16), opportunity costs of capital (OC) are calculated by taking into account the fixed tangible asset value (*K*) and multiplying it by the real interest (*r*).

$$OC_{f,t} = r_{f,t} K_{f,t}$$

Fixed costs include non-variable costs, annual depreciation, opportunity cost of capital.

Labour costs

Labour cost are directly related to total revenues and variable cost.

According to the prevalent income sharing system between the ship-owner and the crew, the labour cost is assumed to be proportional to revenues and total variable costs:

$$LC_{f,t} = cs_f \left(R_{f,t} - TVC_{f,t} \right)$$

where:

$LC_{f,t}$ is the labour cost of the fleet segment *f* at *t* (€);

$R_{f,t}$ are the total revenues (target species+ other species) of the fleet segment *f* at time *t* (€);

$TVC_{f,t}$ are the total variable costs for the fleet segment *f* at time *t* (€);

cs_f is crew share for the fleet segment *f*;

As highlighted in Table , on average the crew share is around 0.30 for most fleets included in the case study. The maximum crew share is estimated for the Albanian demersal trawlers 1224 m and is equal to 0.51.

Revenues and total landings

For the fleet segments ITA_DTS_VL1218, ITA_DTS_VL1824-2440, ALB_DTS_1224, MNE_DTS _VL0612 and VL1224, where the assessed target species are a relevant part of the total landings and revenues, the total revenues and the total landings are calculated respectively as function of the sum of the estimated landings value and the sum of estimated landings weight of the target assessed species. Differently, in case of ITA_DTS_VL0612, ITA_HOK_VL1218, ITA_PGP_VL0006-0612, MNE_DFN_VL0012 and MNE HOK 0012 fleet segments, where the target species consists of a minor part of the total landings and revenues, the total revenues and the total landings are calculated as sum of landings of not assessed species , estimated as function of the assessed species, and the sum of landings of the assessed species. For fleet segments where assessed species account for a consistent part (on average 45% of the total landing) of total landings value and weight (ITA_DTS_VL1218, ITA_DTS_VL1824-2440, ALB_DTS_1224, MNE_DTS _VL0612 and MNE_DTS_VL1224) revenues by fleet segment and species have been estimated by multiplying landings produced in the biological sub-model by the prices estimated on the basis of the price module.

According to option 1 of this component, total revenues and landings are proportional by a correction factor (rr_f and ll_f) to the sum of the revenues and landings by target stock of the fleet segment *f*.

Option 1 :

$$R_{f,t} = rr_f \sum_{s=1:n} R_{f,s,t}$$

$$L_{f,t} = ll_f \sum_{i=1:n} L_{f,i,t}$$

where:

$R_{f,t}$ is the total revenues (target species+ other species) of the fleet segment *f* at time *t* (€);

$R_{f,s,t}$ is the revenues of target species s of the fleet segment *f* at time *t* (€);

rr_f is correction factor to pass from the revenues of assessed species to the total revenues of the fleet segment *f*.

$L_{f,t}$ is the total landings weight (target species+ other species) of the fleet segment *f* at time *t* (€);

$L_{f,s,t}$ is the landings weight of target species s of the fleet segment *f* at time *t* (€);

ll_f is correction factor to pass from the landings of assessed species to the total landings of the fleet segment *f*.

For the other fleets included in the case study (ITA_DTS_VL0612, ITA_HOK_VL1218, ITA_PGP_VL0006-0612, MNE_DFN_VL0012 and MNE HOK 0012), where assessed species have a minor incidence on total production (on average 15% of the total landing), landings by fleet segment have been estimated by applying the option 2 of this component:

Option 2:

$$L_{other\_species,f,t} = u_f + v_f \sum_{s=1:n} L_{s,f,t}$$

where:

$L_{other\_species,f,t}$ is the landing of the other species of the fleet segment *f* at time *t*;

$L_{s,f,t}$ is the landing of the species s of the fleet segment *f* at time *t*;

u_f correlation between the landings of the target species and the landing of the non-target species

v_f scale parameter which holds the conversion of landings of the target species to the landing of the non-target species.

The following formulas are applied to pass from the landing of the other species to the total landing as well as to the total revenues:

$$L_{f,t} = L_{other\_species,f,t} + \sum_{s=1:n} L_{s,f,t}$$

$$p_{other\_species,f} = \frac{R_{f,t=last} - \sum_{s=1:n} R_{s,f,t=last}}{L_{f,t=last} - \sum_{s=1:n} L_{s,f,t=last}}$$

$$R_{f,t} = L_{other\_species,f,t} * p_{other\_species,f} + \sum_{s=1:n} (p_{s,f,t} * L_{s,f,t})$$

where:

$L_{f,t}$ is the total landing of the fleet segment *f* at time *t*;

$p_{other\_species,f}$ is the average price of the non-target species in the last year of simulation;

$R_{f,t=last}$ is the total revenues of the fleet segment *f* in the last year;

$R_{s,f,t=last}$ is the revenues of the target species s for the fleet segment *f* in the last year;

$L_{f,t=last}$ is the total landing of the fleet segment *f* in the last year;

$L_{s,f,t=last}$ is the landing of the target species s for the fleet segment *f* in the last year.

$p_{s,f,t}$ is the price of the target species s for the fleet segment *f* at time *t*.

Average employees per vessel

Employment was estimated by average number of employees per vessel in the fleet segment *f* (em_f) multiplied by the number of vessels for each fleet segment ($N_{f,t}$):

$$EM_{f,t} = em_f N_{f,t}$$

Capital Value

Capital value was estimated by the average value of a vessel for the fleet segment *f* at time *t*. Discount rates used are the harmonized long-term interest rates for convergence assessment calculated by the European Central Bank, available at http://www.ecb.int/stats/money/long/html/index.en.html.

Socio-economic indicators

Table 161 and Table 162 present the cost and the economic indicator parameters applied to the case study broken down by fleet segment and function.

Table 161 Cost parameterization by fleet segment in GSA 18 demersal case study

Fleet segment	Total variable costs per unit of effort (sea days)	crew share	maintenance costs per unit of GT	other fixed costs per unit of GT	depreciation costs per unit of GT	interest costs per unit of GT
ITA_DTS_VL0612	105	0.28	213	320	1051	174
ITA_DTS_VL1218	320	0.28	355	221	665	138
ITA_DTS_VL1824-2440	688	0.35	138	117	934	182
ITA_HOK_VL1218	396	0.21	490	433	746	130
ITA_PGP_VL0006-0612	71	0.35	655	759	3832	787
ALB_DTS_1224	326	0.51	17	5	168	34
MNE_DFN_VL0012	20	0.14	750	181	89	99
MNE_DTS _VL0612	251	0.26	173	90	98	88
MNE_DTS_VL1224	443	0.24	460	166	100	125
MNE_HOK_VL0012	68	0.25	1725	219	93	157

Table 162 Socio-economic indicators parameterization by fleet segment in GSA 18 demersal case study.

Fleet segment	correction factor for landings	correction factor for revenue	coefficient u landings	coefficient v landings	value of a single vessel	average employees per vessel	discount rate
ITA_DTS_VL0612			0.01	2.8	24,176	1.8	0.043
ITA_DTS_VL1218	3.2	2.9			60,752	2.5	0.043
ITA_DTS_VL1824-2440	2.1	1.7			260,918	3.9	0.043

ITA_HOK_VL1218			0.02	2.0	57,392	5.4	0.043
ITA_PGP_VL0006-0612			0.01	25.2	36,442	1.8	0.043
ALB_DTS_1224	2.2	2.4			40,488	6.3	0.032
MNE_DFN_VL0012			0.01	16.6	5,630	2.1	0.035
MNE_DTS _VL0612	1.6	1.5			27,500	1.3	0.035
MNE_DTS_VL1224	1.8	1.9			96,154	3.0	0.035
MNE_HOK_VL0012			0.01	11.6	13,423	1.8	0.035

The current revenue to break even revenue ratio (CR/BER) and Net profit have been estimated according to the Economic performance indicator calculations provided in "2014 Annual Economic Report on the EU Fishing Fleet" (STECF-14-16).

BER is calculated as Current Revenue (CR) divided by the Break Even Revenue (BER), where:

Current Revenue (CR) = income from landings + other income

Break Even Revenue (BER) = fixed costs / (1-[variable costs / current revenue])

Net profit is the difference between revenue and explicit costs and opportunity costs. It includes all operational costs, such as wages, energy, repair, other variable, fixed costs and depreciation and opportunity costs of capital. It measures the efficiency of a producer in society's view by evaluating the total costs of inputs (excluding natural resource costs) in comparison to outputs or revenue. Therefore, economic profit is the primary indicator of economic performance and is often used as a proxy of resource rent in fisheries. The excess of revenue over the opportunity cost of producing the good is also referred to as supernormal or abnormal profits. Abnormal profits in a sector is an incentive for other firms to enter the industry. Zero or a negative profit may indicate high competition in the sector and can be used as one of the indicators of overcapacity.

5.4.3 RESULTS OF THE BIOLOGICAL AND PRESSURE INDICATORS

The proxy of the probability that the SSB of hake is less than the biomass reference point is 100%, for deep water rose shrimp is 99.8%, for Norway lobster is 100%, and for red mullet is 97.6% (Figure 59).

Figure 60 shows the SSB of the four stocks for the status quo scenario. In this scenario the SSB of Norway lobster after a slight decrease remains quite stable until 2021 reaching a plateau that is respectively -33% respect to the value of 2013, while SSB of red mullet shows an increase until 2017 and then it remains quite stable until 2021 (in 2021 SSB is 62% of the value in 2013) (Figure 60). The decrease of Norway lobster SSB is due to the increase in fishing mortality from 2013 (in 2013 the fishing mortality is +57% respect to 2012 value). The SSB of hake slightly increases from 2015 to 2021 reaching in 2021 a SSB value that is 1.2 times the value of 2013. The increase of SSB of red mullet in the short term is due the low fishing mortality assessed in 2013.

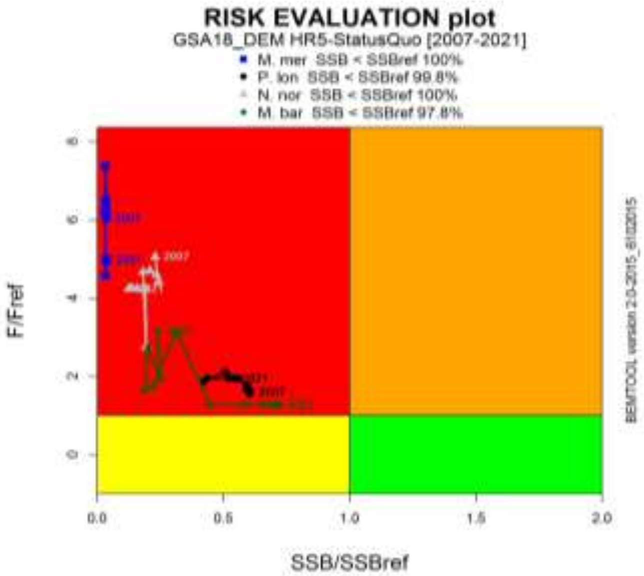


Figure 59 Kobe plot summarizing the status of hake, deep water pink shrimp, Norway lobster and red mullet in GSA 18.

Errore. L'origine riferimento non è stata trovata. Figure 60. SSB for hake, deep water rose shrimp, Norway lobster and red mullet in the status quo scenario with confidence intervals.

In the status quo scenario, projecting the current effort for all the fleet segments and assuming a recruitment varying around the value of the last year in the time series, the landings change in respect to those in 2013 of -16% for European hake, 25% for deep water pink shrimp, -25% for Norway lobster and from +37% for red mullet (Figures from 61 to 65). The landing of hake and Norway lobster decreases for all the fleet segments until 2016 and remains stable until 2021. In 2021 the overall landing of hake is about 16% lower than the level of 2013, while the overall landing of Norway lobster in 2021 is about 26% lower than the value of 2013. The catch of red mullet and pink shrimp increases until 2021 respectively of about 37% and 25%. Discard of red mullet is quite stable untile 2021.

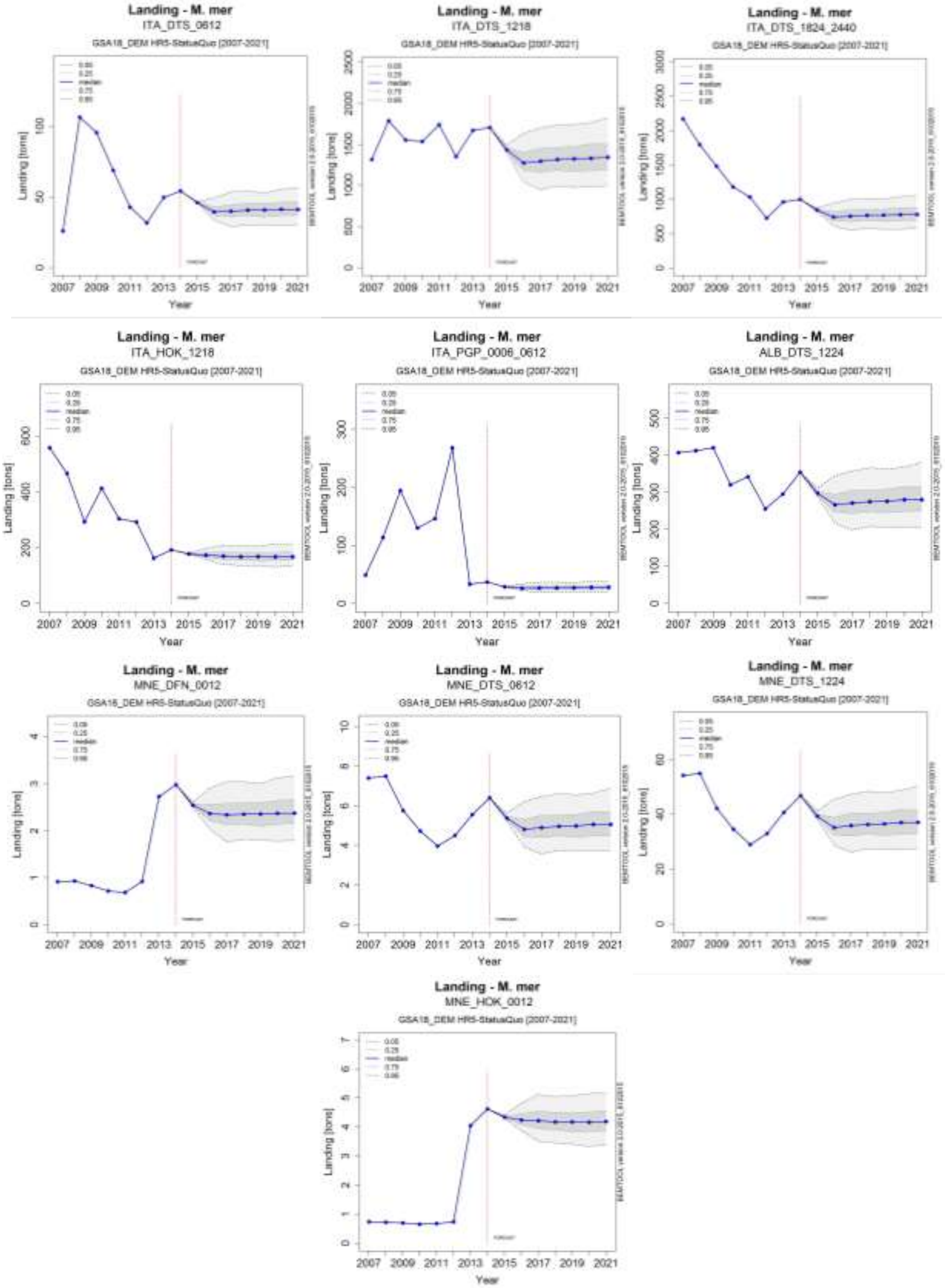


Figure 61 Landing for hake by fleet segment in the status quo scenario with confidence intervals.

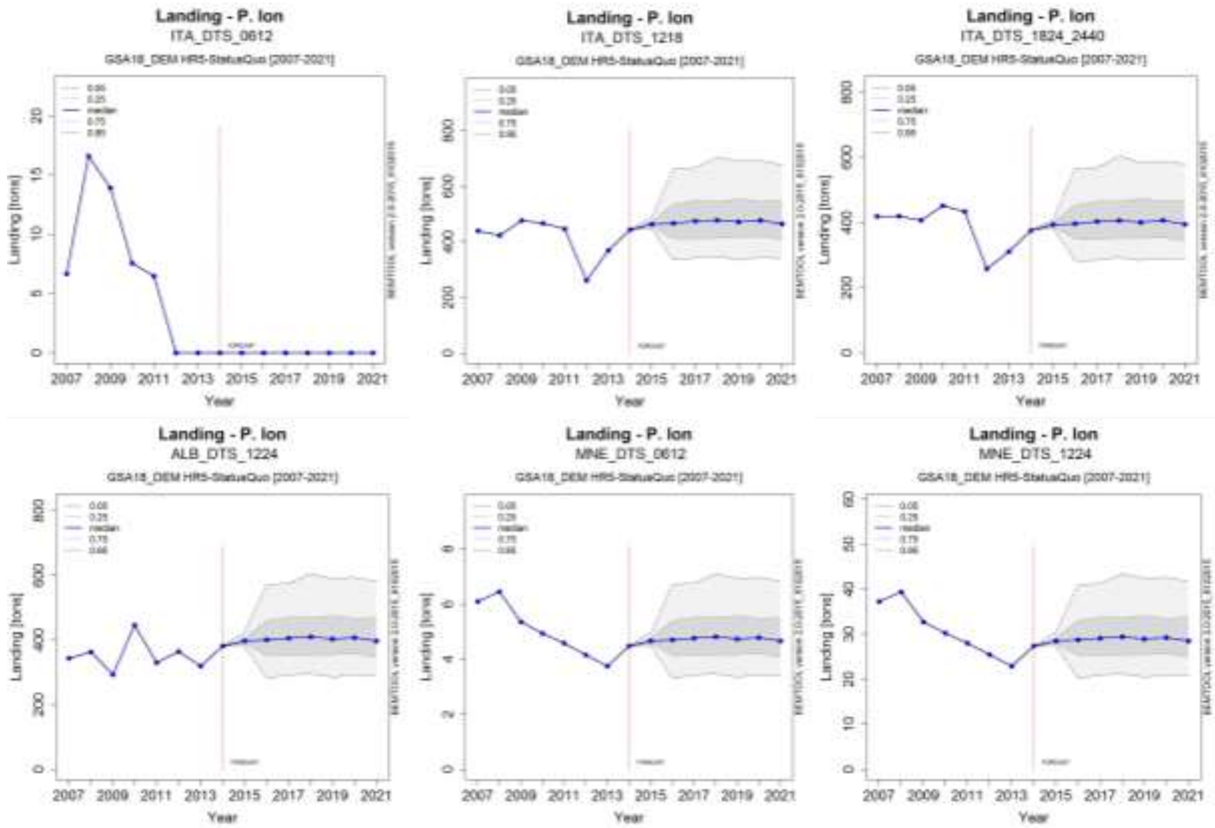


Figure 62 Landing for pink shrimp by fleet segment in the status quo scenario with confidence intervals.

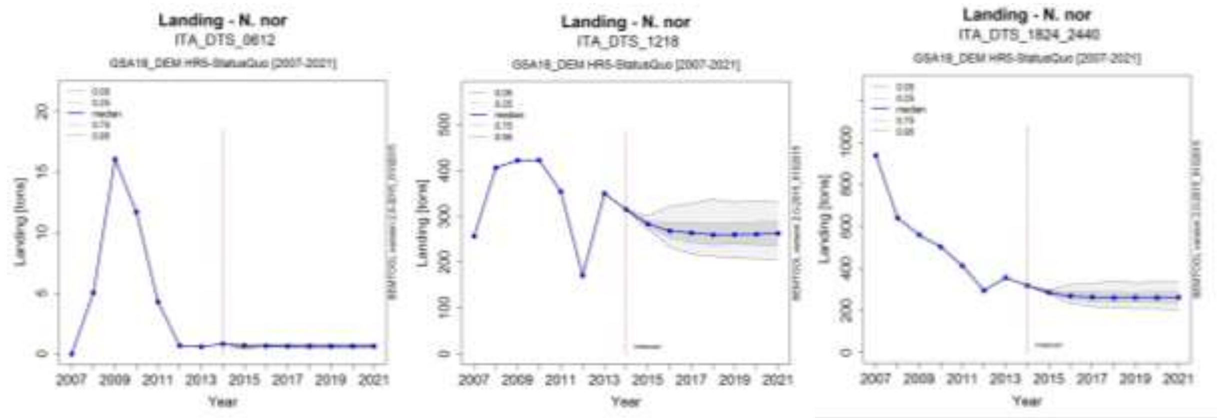


Figure 63 Landing for Norway lobster by fleet segment in the status quo scenario with confidence intervals.

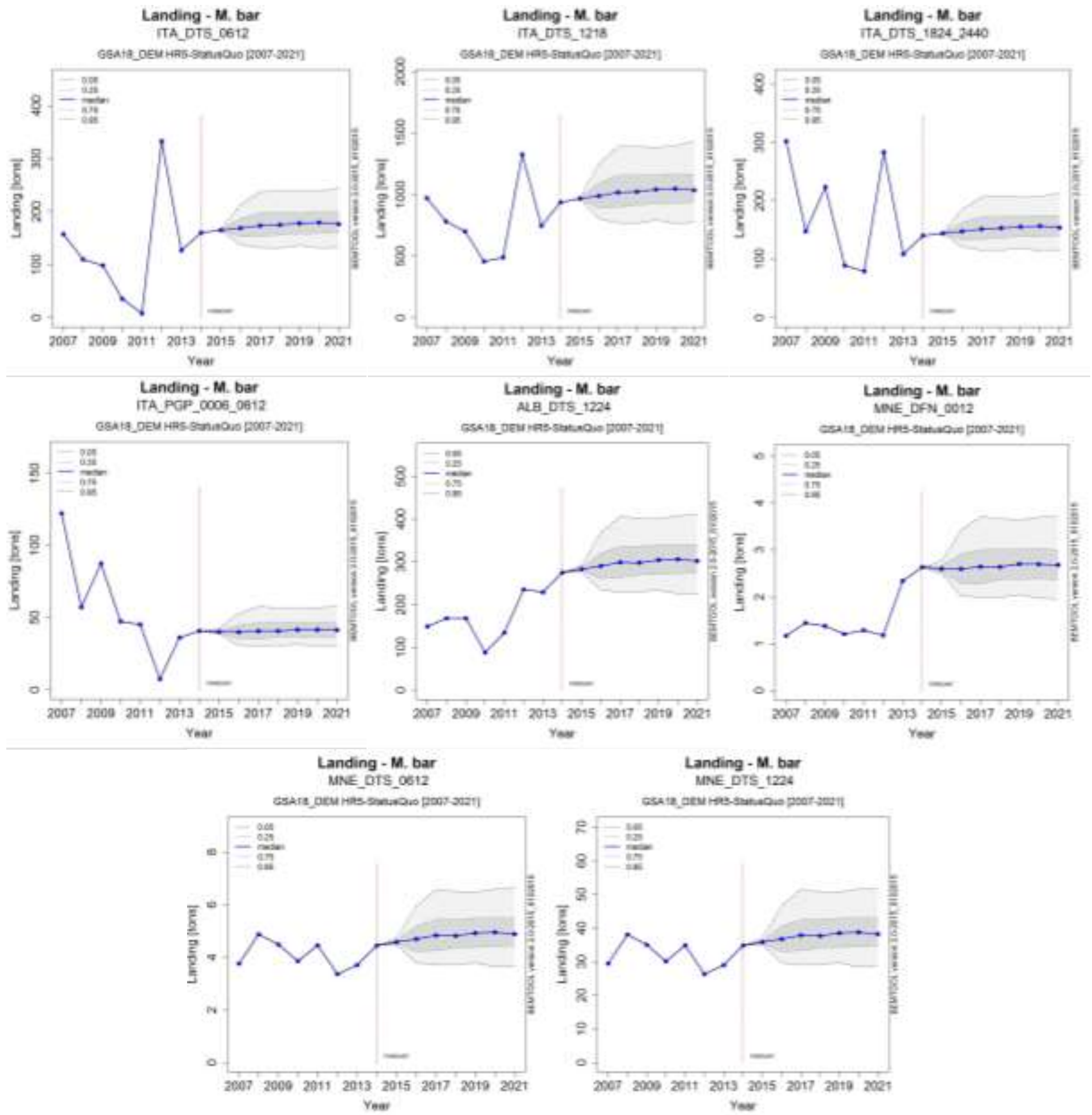


Figure 64 Landing for red mullet by fleet segment in the status quo scenario with confidence intervals.

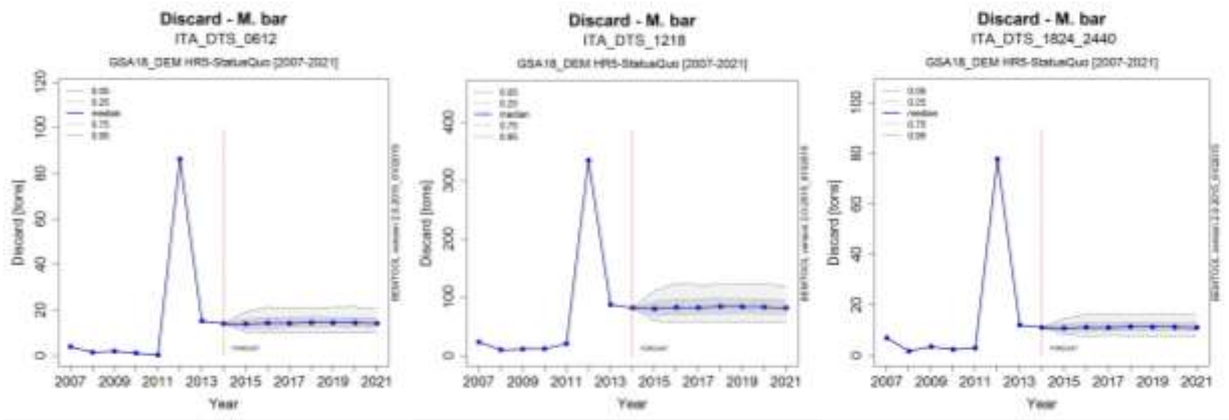


Figure65 Discard for red mullet by fleet segment in the status quo scenario with confidence intervals.

5.4.4 RESULTS OF THE SOCIO-ECONOMIC INDICATORS

In 2013 the fleets considered in the case study produced 20.5 thousand tons of total production generating 135 million euro, an increase by 38% in quantity and 41% in value compared to 2012. The most important fleet segment is the Italian demersal trawlers VL1218, accounting for almost a half of total revenues. Other relevant fleet segments are the Italian demersal trawlers VL1824 and VL2440, which account for around 20% of total revenues, and the Italian small scale fleet lower than 12m with 13% of total revenues. In 2013 the Italian fleet produced around 90% of total landings, while the Albanian fleet produced less than 10% and the Montenegrin fleet less than 2%.

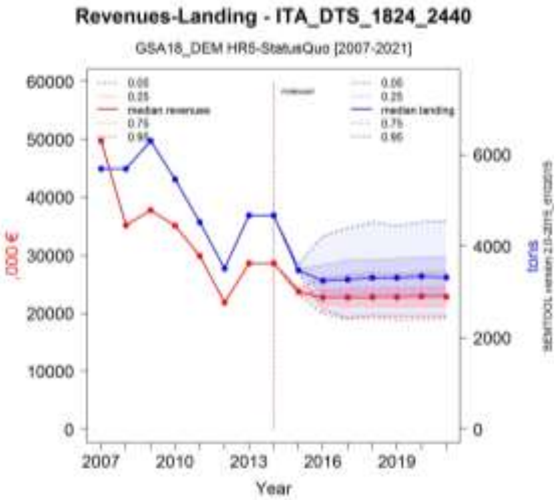
As reported in Figure 66, total revenues of demersal fleets operating in GSA 18 show a negative trend in the period 2010-2012 with a fast recovery in 2013. Comparing 2013 to 2007, revenues are almost the same with a small increase by around 2%. The main fleet segments show opposite trends: strong increases for the Italian demersal trawlers VL0612 and VL1218 are counterbalanced by strong decreases for the Italian demersal trawlers VL1824-2440 and vessels using hooks VL1218. Landings in weight show movements similar to revenues with an increase from 2007 to 2013 for the whole fleet by 6%.

Overall, the uncertainty on recruitment has consistent effects on the total landings in the long run period. In 2021, the difference between the lower quantile (5%) and the median quantile (or status quo) is equal to -25%. The difference between the upper quantile (95%) and the median quantile is equal to +37%. Similarly, the inter-quantile range of revenues is equal to -19% for the difference between the lower quantile and the median quantile and to +22% for the difference between the upper quantile and the median quantile.


Revenues-Landing - Overall
GSA18_DEM HR5-StatusQuo [2007-2021]
,000 €
tons
Year


Revenues-Landing - ITA_DTS_0612
GSA18_DEM HR5-StatusQuo [2007-2021]
,000 €
tons
Year


Revenues-Landing - ITA_DTS_1218
GSA18_DEM HR5-StatusQuo [2007-2021]
,000 €
tons
Year


Revenues-Landing - ITA_DTS_1824_2440
GSA18_DEM HR5-StatusQuo [2007-2021]
,000 €
tons
Year


Revenues-Landing - ITA_HOK_1218
GSA18_DEM HR5-StatusQuo [2007-2021]
,000 €
tons
Year


Revenues-Landing - ITA_PGP_0006_0612
GSA18_DEM HR5-StatusQuo [2007-2021]
,000 €
tons
Year

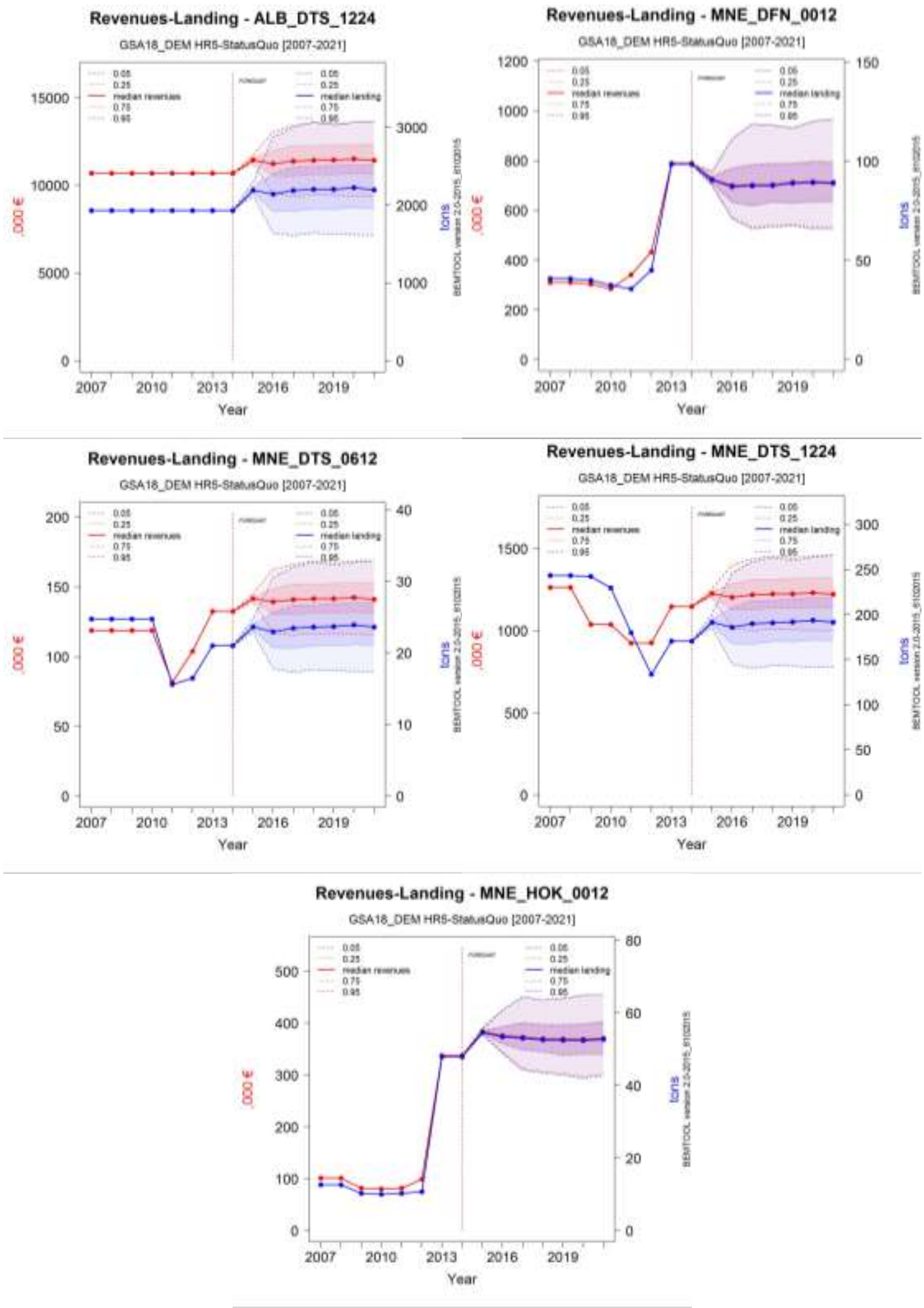


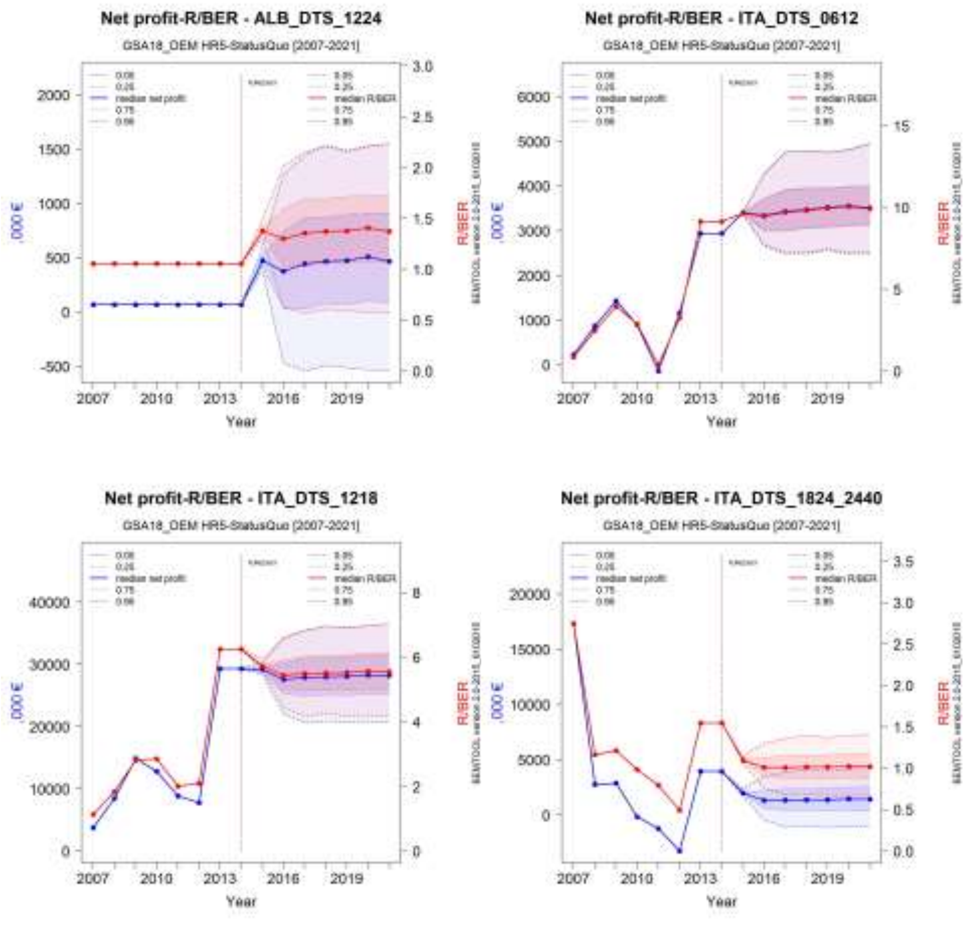
Figure 66 Landings weight and value by fleet segment with uncertainty.

In 2013 the economic efficiency of the fishing sector, calculated in terms of net profit, is positive. The whole demersal fleet operating in GSA 18 shows positive values for net profit in the period 2007-2013. Negative values are registered mainly in the period 2010-2012 for some Italian and Montenegrin fleet segments. The Italian demersal trawlers VL1824-2440 and small scale fleet under 12m show the worst performance in that period. The Montenegrin demersal trawlers VL1224 and vessels using hooks VL0012 registered negative values also in the period 2007-2009. Nevertheless, in 2013 all fleet segments included in the case study show positive values for net profits.

In the forecast period, net profit for the overall fishing sector is expected to decrease by 10% in 2021 compared to 2013. With the exceptions of the Italian demersal trawlers VL0612 (+19%), the Italian vessels using hooks VL1218 (+25%), the Montenegrin vessels using hooks VL0012 and Albania demersal trawlers 1224 (both +29%), all fleet segments are expected to register a declining net profit. The net profit for Albania would substantially increase until 2021 (Figure 67).

In 2013 the ratio between current and break-even revenues (CR/BER), which shows how current revenues are sufficient to cover variable and fixed costs, is greater than 1 for all fleet segments. Values lower than 1 are registered in the period 2010-2012 for the Italian demersal trawlers VL1824-2440 and small scale fleet under 12m. The worst performance with values lower than 1 or negative is registered for the Montenegrin demersal trawlers VL1224 in the period 2007-2011 and the Montenegrin vessels using hooks VL0012 in the period 2007-2012.

The ratio between current and break-even revenues (CR/BER) in the forecast period shows a decrease until 2016 for Italian DTS_1218, DTS_1824_2440 and small scale and Montenegrin DFN followed by a stable trend until 2021. This indicators is generally less influenced by the uncertainty on the recruitment. The profitability of the other fleet segments is stable or slightly increases in the first years of forecast and reaches the stability thereinafter, until 2021 (Figure 67).



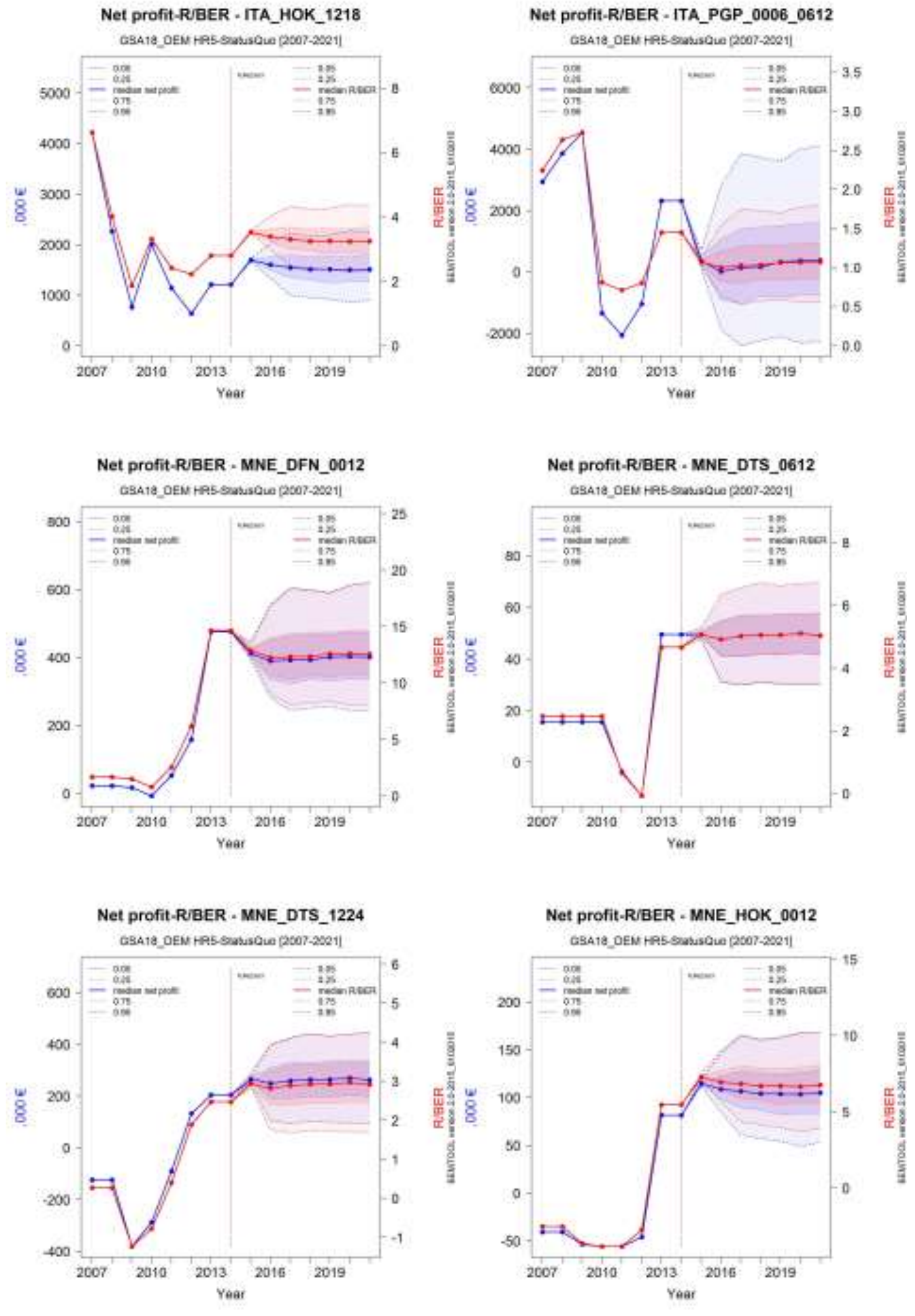


Figure 67 Net profit and Current Revenue to the Break-Even Revenue ratio by fleet segment with uncertainty.

5.5 DEFINITION AND COMPARISON OF THE DIFFERENT MANAGEMENT SCENARIOS

According to the state of exploitation of the four demersal stocks in GSA 18 case study, 6 forecast scenarios have been performed in order to evaluate the consequences of several management strategies in terms of costs and benefits for the renewal of stocks, fishery sustainability and productive and economic performances of different fleet segments. The 6 scenarios have been implemented with the aim to reduce the overall combined fishing mortality towards a combined reference point. This reference point was estimated as the average F_{MSY} among all the stocks, weighed using stock landing value, following the approach as for balance indicators. Estimation method was applied as follows.

$$F_{2013,f,combined} = \frac{\sum_{s=1}^{4}(LandValue_{2013,s} * F_{2013,f,s})}{\sum_{s=1}^{4} LandValue_{2013,s}}$$

$$F_{2013,combined} = \sum_{f=1}^{10} F_{2013,f,combined}$$

$$F_{MSY,combined} = \frac{\sum_{s=1}^{4}(LandValue_{2013,s} * F_{MSYs})}{\sum_{s=1}^{4} LandValue_{2013,s}}$$

where:

$F_{2013,f,combined}$ is the fishing mortality combined (taking into account all the target species together) for the fleet segment *f* in 2013;

$F_{2013,combined}$ is the overall fishing mortality combined (taking into account all the target species together) in 2013;

$F_{0.1,combined}$ is a combination of the reference point F_{MSY} of all the species;

$Land_{2013,\,s}$ is the overall landing of species s.

The value of the overall combined fishing mortality is for GSA 18 0.87, while the combined F0.1 is 0.30. A reduction of 66% on the overall fishing mortality would be needed. The reduction was applied to each fleet segment, considering the relative portion of $F_{current}$ and F_{MSY}, on the basis of fleet segment landing to overall landing of the stock (Table 163). Italian DTS_0612, small scale ITA_PGP_0006_0612 and all the Montenegrin fleets have not been reduced, because their combined fishing mortality represented less than the 3% of the overall combined fishing mortality.

Table 163 Fcurrent combined by fleet segment, percentage of F combined due to each fleet segment and reduction applied.

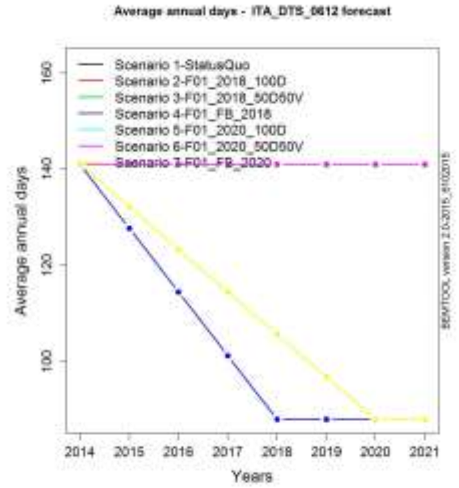
Fleet segment	F current combined by fleet segment	% F current combined by fleet segment	% of reduction applied (in scenarios 2, 3, 5 and 6)	% of reduction applied (in scenarios 4 and 7)
ITA_DTS_0612	0.013	1.5	0	38
ITA_DTS_1218	0.375	43.2	66	37
ITA_DTS_1824_2440	0.269	31.0	66	37
ITA_HOK_1218	0.040	4.5	66	65
ITA_PGP_0006_0612	0.010	1.2	0	52
ALB_DTS_1224	0.145	16.6	66	42
MNE_DFN_0012	0.001	0.1	0	0
MNE_DTS_0612	0.002	0.2	0	0
MNE_DTS_1224	0.014	1.6	0	0
MNE_HOK_0012	0.001	0.1	0	0

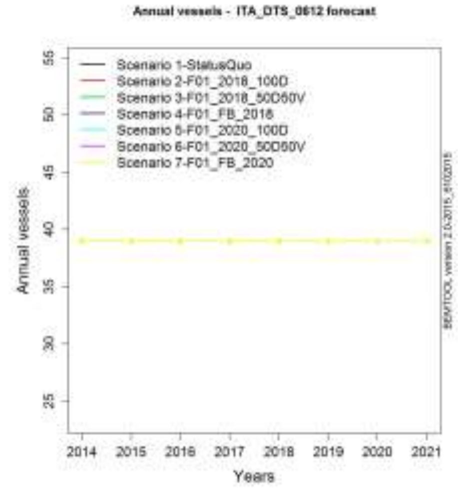
The scenarios implemented to reach the combined F_{MSY} are reported in the following table 164.

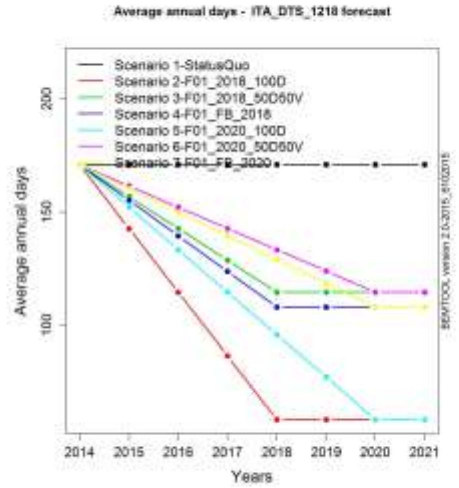
Table 164 Scenarios implemented to reach the combined F_{MSY}. in GSA18.

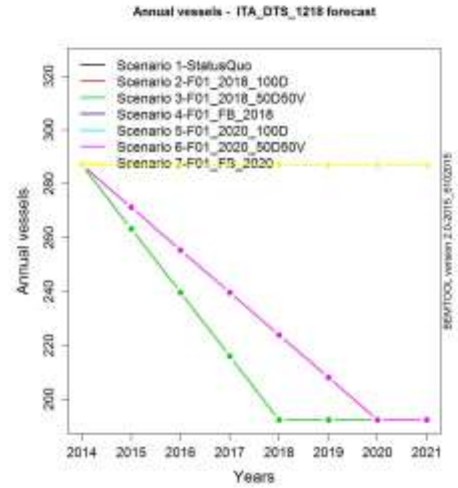
Scenario 2 F01_2018_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA PGP 0006_0612, ITA DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 3 F01_2018_50D50V	Linear reduction of combined F towards the combined F_{MSY},, applied half to fishing days and half to the number of vessels (except ITA PGP 0006_0612, ITA DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 4 F01_2018_FB	Gradual closure of fishing activity until 2018 in a period with higher occurrence of offspring of the four target species (June, July, August, September, October) (except Montenegrin fleets).
Scenario 5 F01_2020_100D	Linear reduction of combined F towards the combined F_{MSY}, applied to fishing days (except ITA PGP0006_0612, ITA DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 6 F01_2020_50D50V	Linear reduction of combined F towards the combined F_{MSY},, applied half to fishing days and half to the number of vessels (except ITA PGP 0006_0612, DTS_0612 and all the Montenegrin fleets because representing less than 3% of the combined F).
Scenario 7 F01_2020_FB	Gradual closure of fishing activity until 2020 in a period with higher occurrence of offspring of the four target species (except Montenegrin fleets).

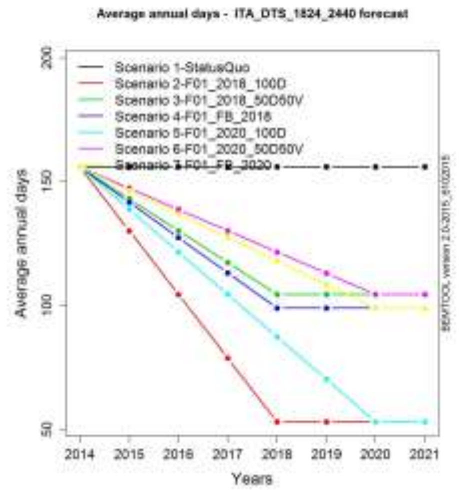
Figure 68 shows the effort change, in terms of annual fishing days and number of vessels by fleet segment driven by the performed management scenarios.

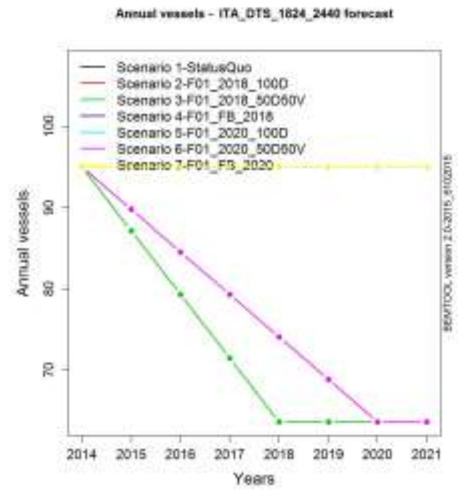

Average annual days - ITA_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years

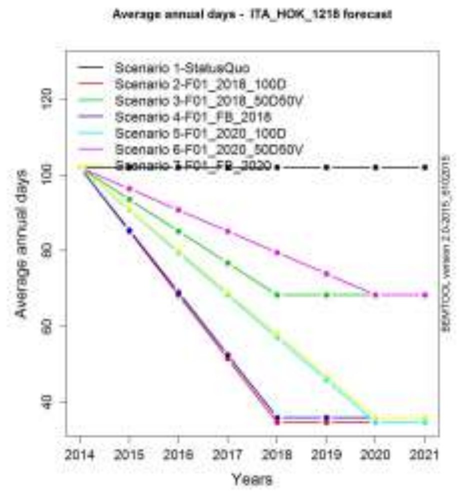

Annual vessels - ITA_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

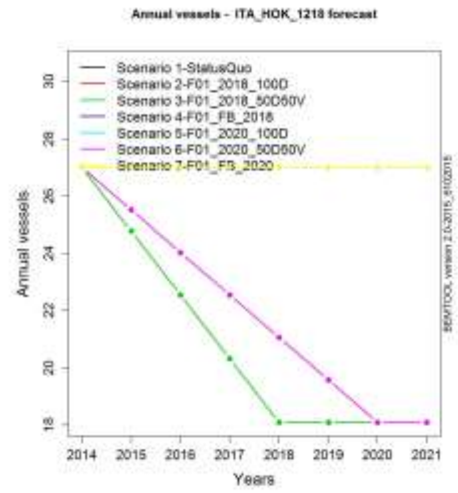

Average annual days - ITA_DTS_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years

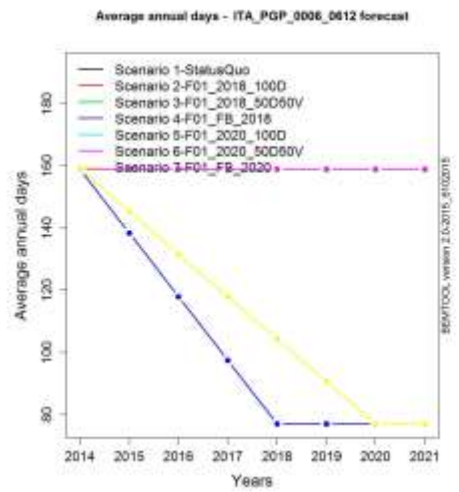

Annual vessels - ITA_DTS_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

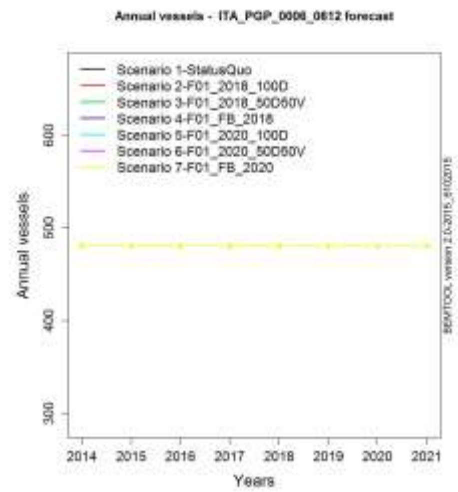

Average annual days - ITA_DTS_1824_2440 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years

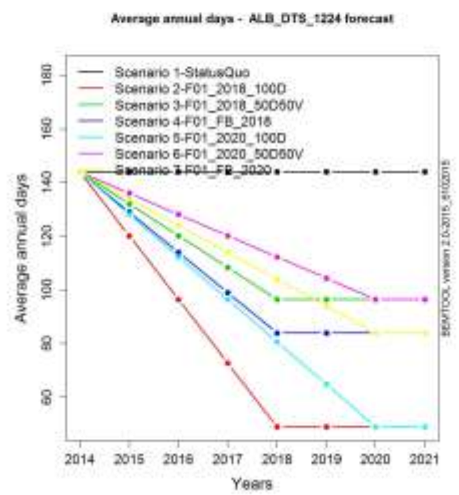

Annual vessels - ITA_DTS_1824_2440 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

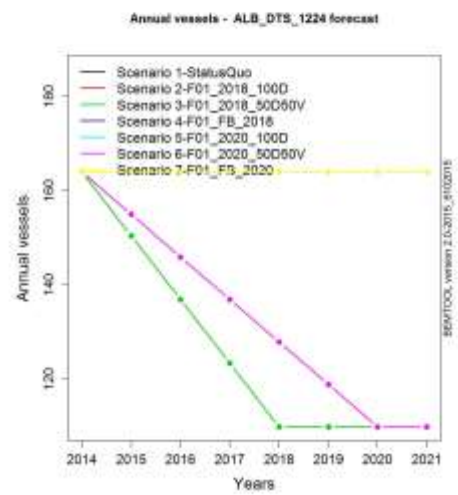

Average annual days - ITA_HOK_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years

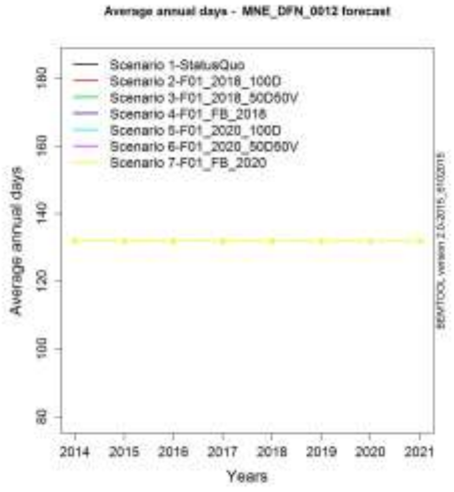

Annual vessels - ITA_HOK_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

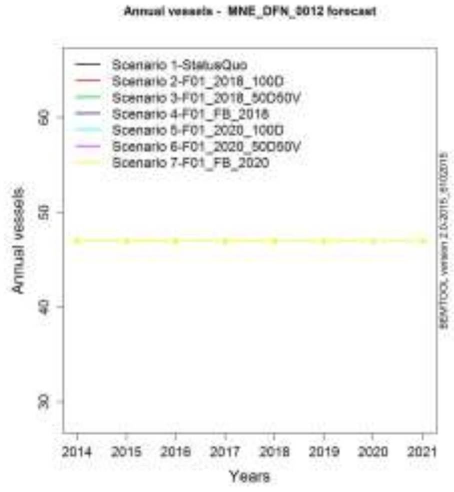

Average annual days - ITA_PGP_0006_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years

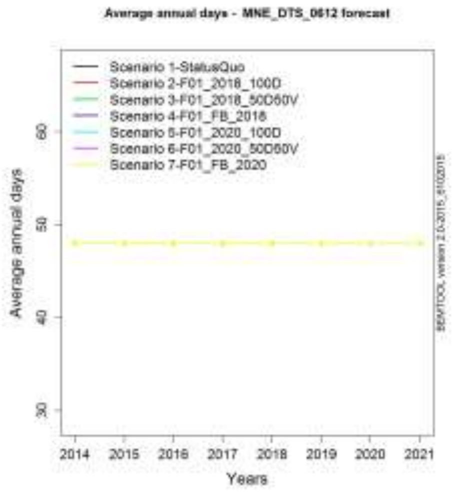

Annual vessels - ITA_PGP_0006_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

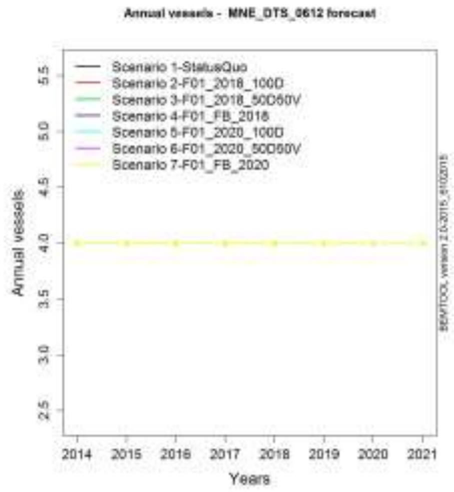

Average annual days - ALB_DTS_1224 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years

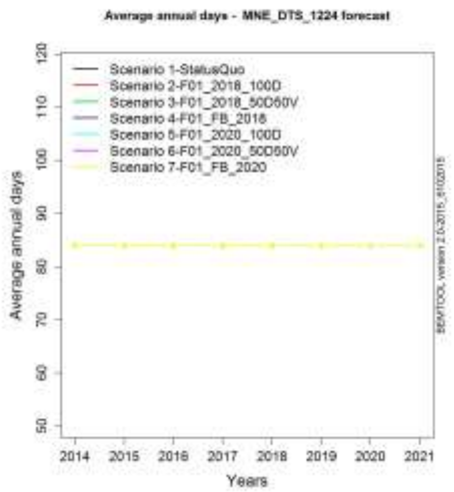

Annual vessels - ALB_DTS_1224 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

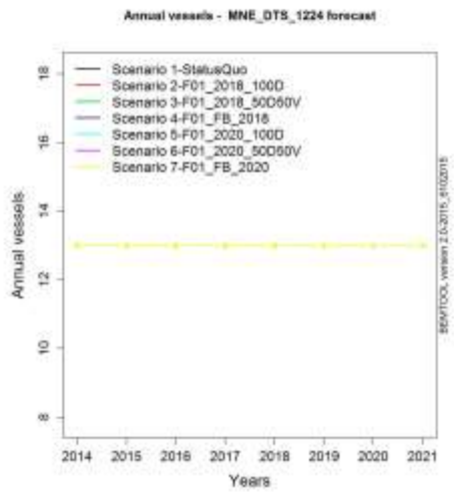

Average annual days - MNE_DFN_0012 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years


Annual vessels - MNE_DFN_0012 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years


Average annual days - MNE_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years


Annual vessels - MNE_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years


Average annual days - MNE_DTS_1224 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average annual days
Years


Annual vessels - MNE_DTS_1224 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
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Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Annual vessels
Years

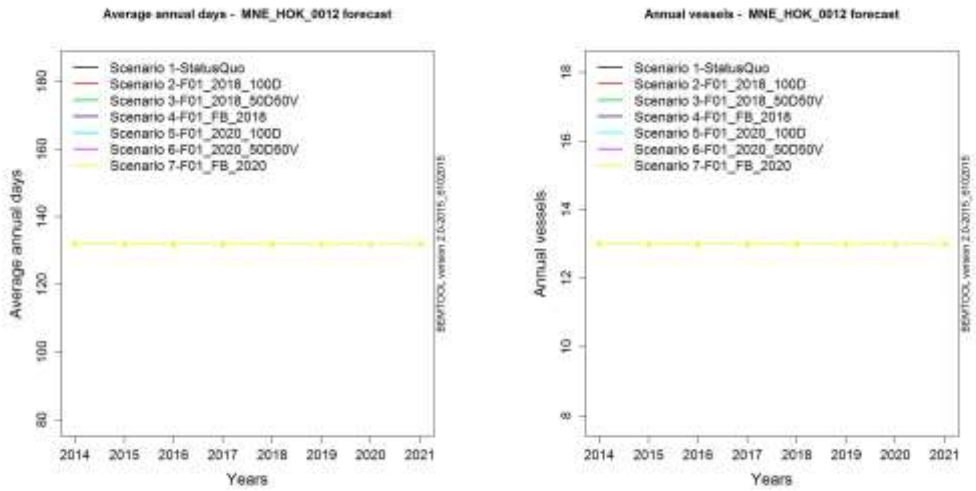


Figure 68 Effort change (fishing days and number of vessels) driving the different management scenarios by fleet segment.

5.5.1 BIOLOGICAL AND PRESSURE INDICATORS

All the performed scenarios allow to obtain a benefit on the SSB for the 4 stocks compared to the status quo. SSB showed remarkable changes in all the different scenarios, although better performances were observed in Scenario 2 - F01_2018_100D, that was followed by in Scenario 5 - F01_2020_100D, indicating that a reduction applied in a narrower timeframe is more effective. Increase of SSB was especially observed for hake and Norway lobster that show highest increase in SSB respect to the status quo (more than 100%). The scenario less performing is the fishing ban, given that reduction applies a lower cut than it was necessary to reaching FMSY combined (Figure 69 and table 165).

The main results of the projections in terms of catches of the four stocks by fleet segment are showed in the figures from 70 (hake) to 73 (red mullet).

Given the gain in productivity of stocks as Norway lobster and European hake, also predicted catches for the whole fleet were improving compared to the status quo, increasing from an average of 12% for Norway lobster and 20% for European hake. Conversely the catches of red mullet and deep water pink shrimp decreased on average 18% and 6%, indicating an underutilization of such stocks.

The fleet segments less impacted by the management measures, in terms of landings were ITA_DTS_0612 and ITA_PGP_0006_0612, that saw a decrease of landings of hake and red mullet only when the fishing ban scenarios was applied, as such scenario was also extended to them. Conversely, Montenegrin fleet, as expected, only took advantage in terms of increasing catches by the enforcement of the management rules.

Regarding hake the landing shows higher value when reduction on effort is applied in the shortest timeframe (Scenario 2 and Scenario 3), reaching value of about 25% higher than those observed in the status quo scenario.

At fleet segment level, landings of hake are only reduced for the fleet ITA_HOK_1218 in the scenarios reducing both fishing days and vessels (scenario 3 and 6) because this fleet segment will be affected by

scraping. Instead, hake catches are reduced for ITA_PGP_0006_0612 in the fishing ban scenarios, because this fleet segment will be affected by this management measure only.
Catches of Norway lobster have a similar pattern to that of hake.

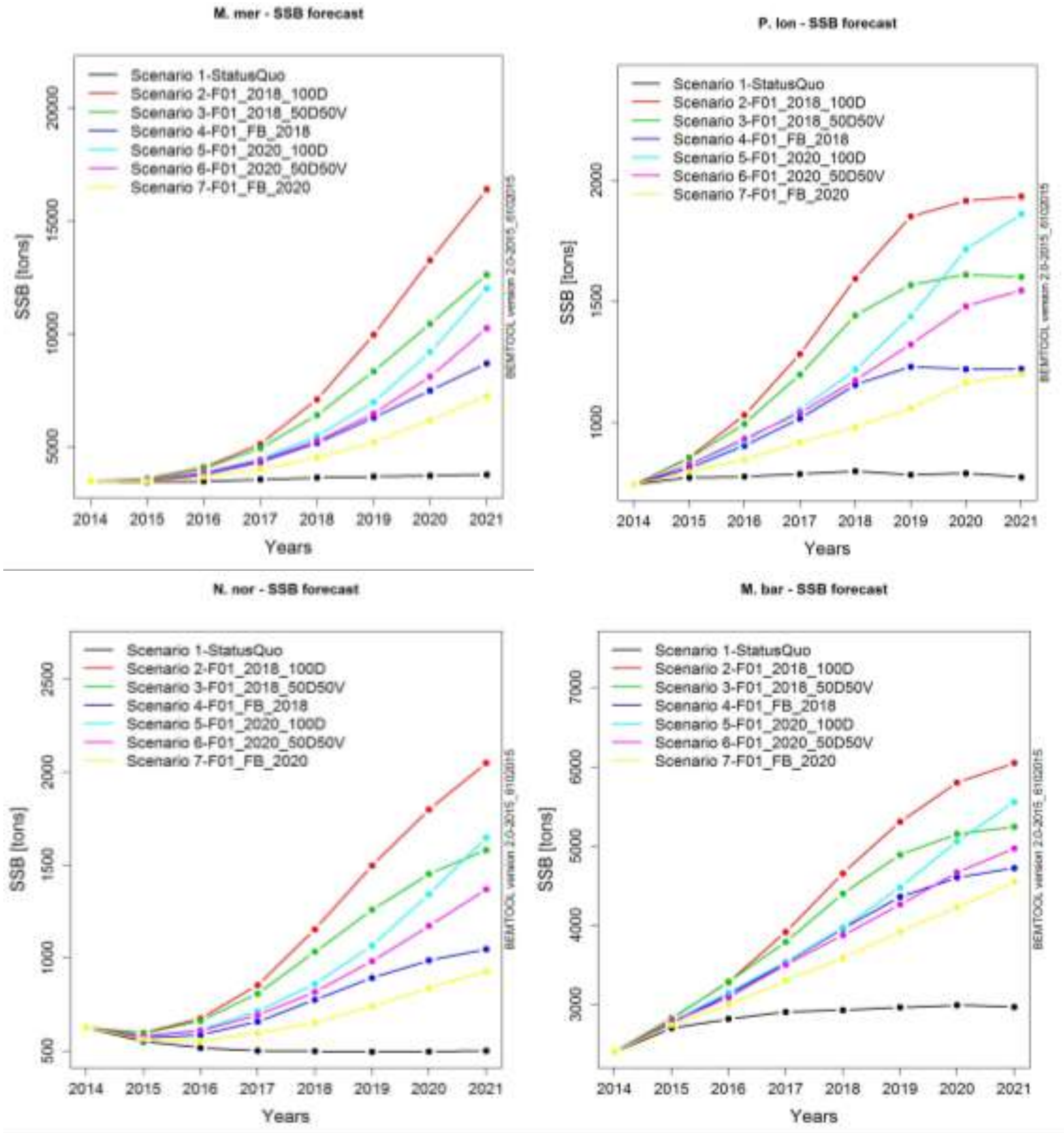


Figure 69 SSB of hake, pink shrimp, Norway lobster and red mullet in GSA 18: comparison among the management scenarios.

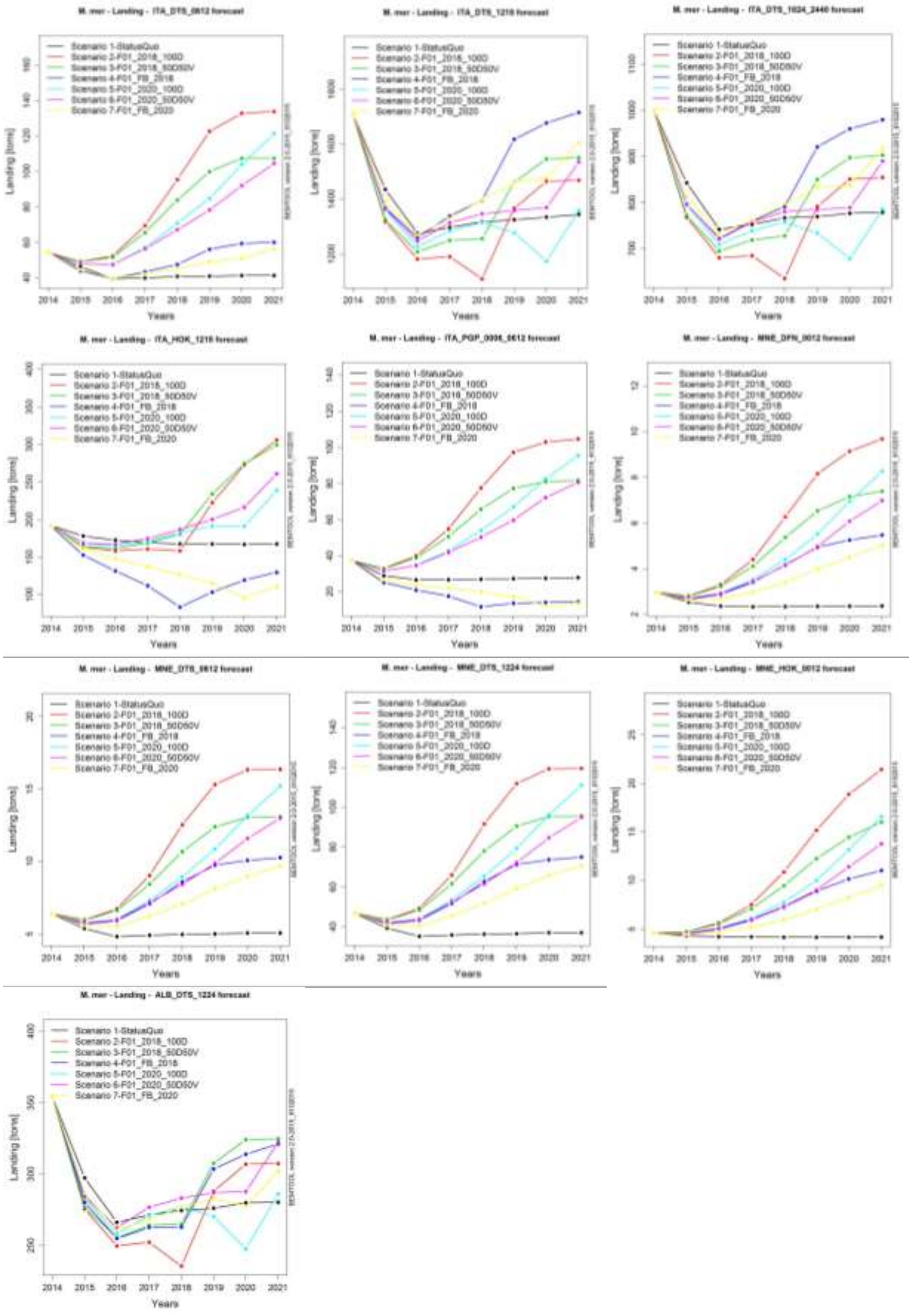


Figure 70 Landing for hake by fleet segment: comparison among the management scenarios.

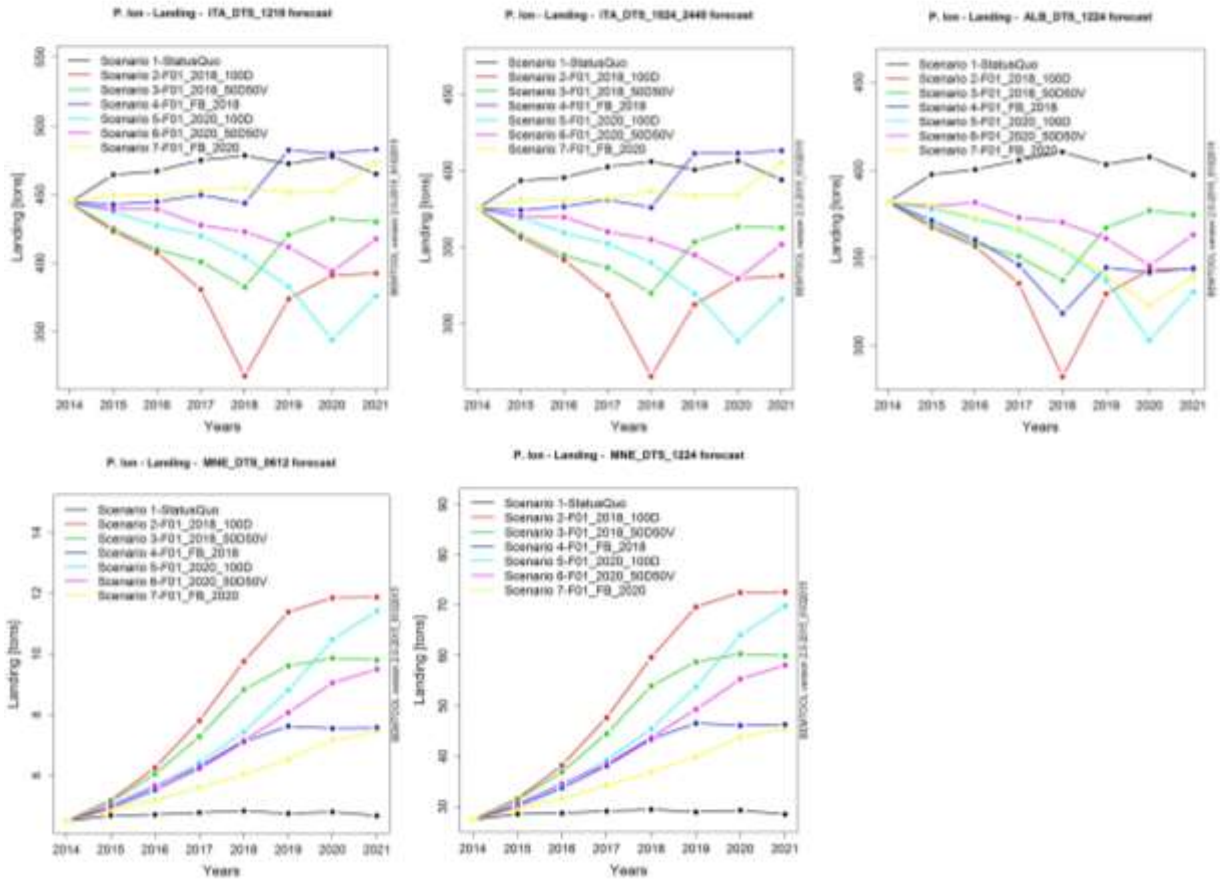


Figure 71 Catch for deep water rose shrimp shrimp by fleet segment: comparison among the different management scenarios.

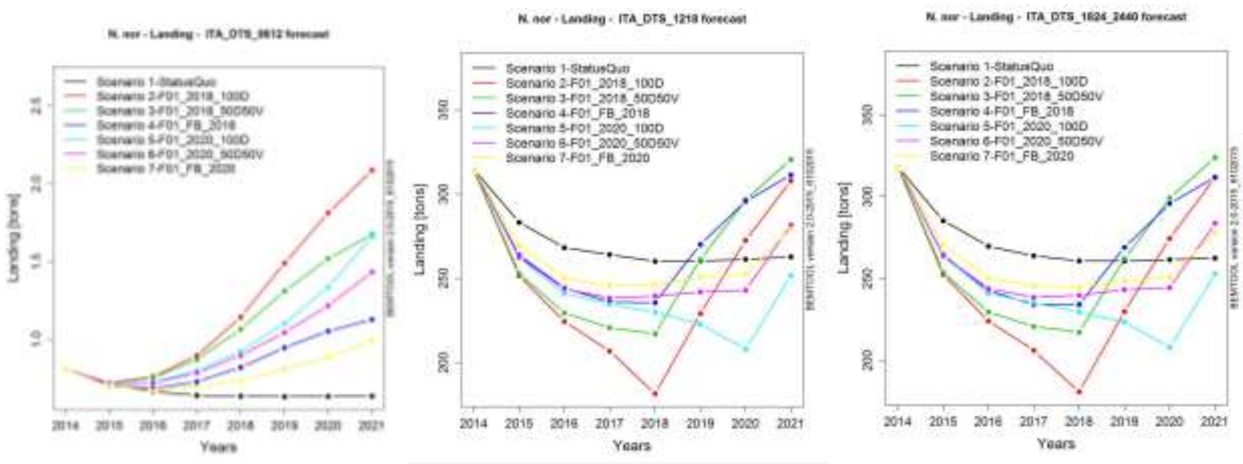


Figure 72 Landing for Norway lobster by fleet segment: comparison among the different management scenarios.

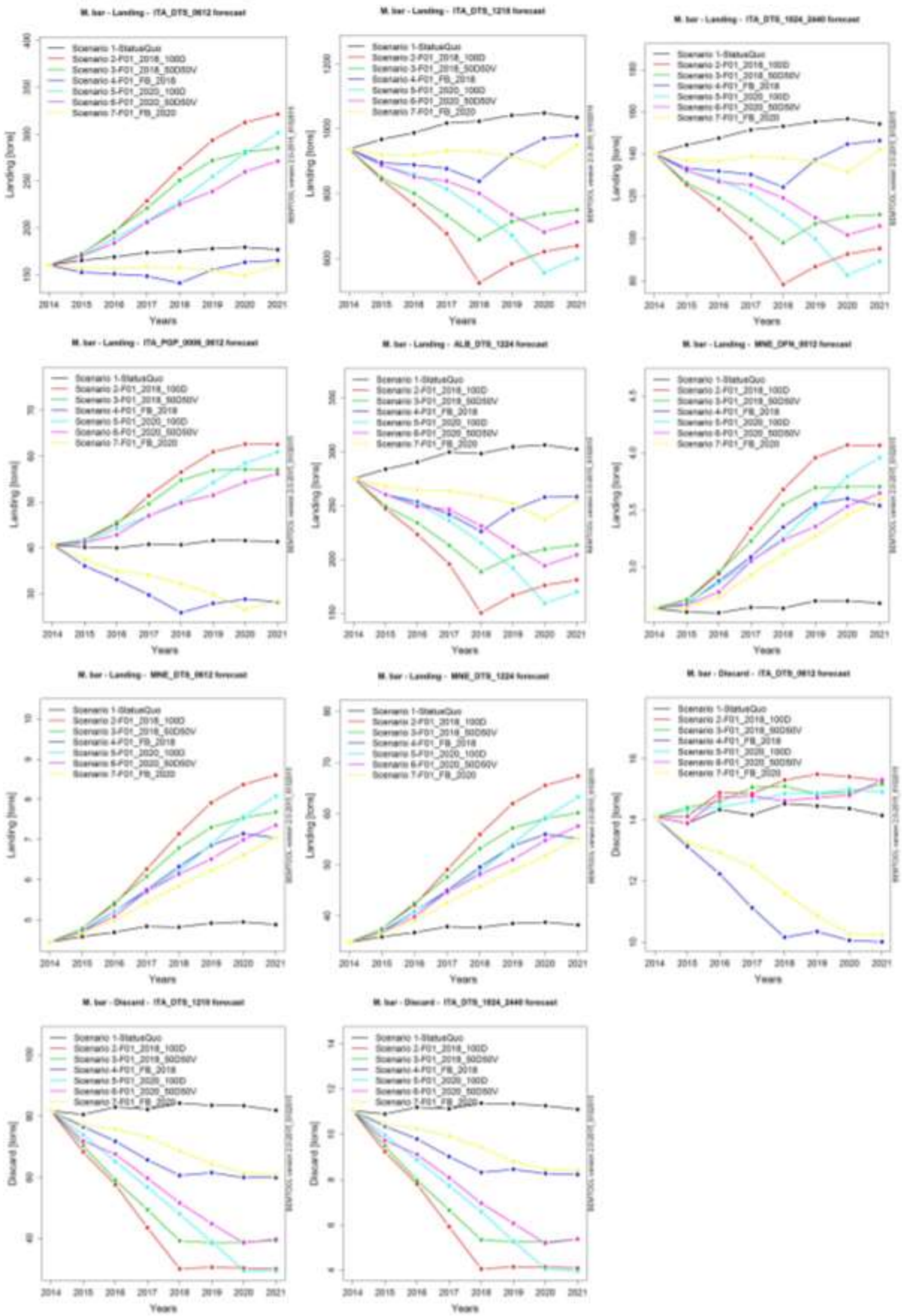


Figure 73 Landing and discard for red mullet by fleet segment: comparison among the different management scenarios.

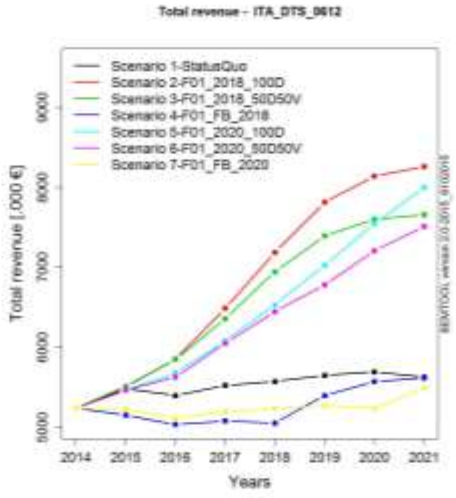
5.5.2 SOCIO-ECONOMIC INDICATORS

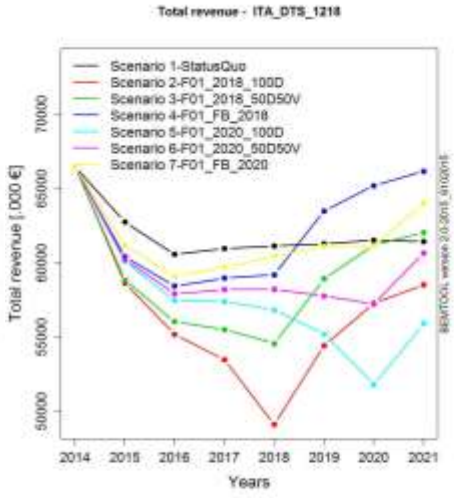
Revenues of the overall fleet are improving compared to the status quo in all the scenarios (+9% on average), as a result of the increased revenues of fleet segment as ITA_DTS_1824_2440. Italian longlines take the highest benefit from the reduction in the shortest time frame (revenues in 2021 are about 30% more than status quo). These fleets, together with those not affected by the management measures, compensate the negative performance of the revenues of fleet segment as ALB_DTS_1224 (about 10% lower than status quo). The fleets ITA_PGP_0006_0612, MNE_DFN_0012, MNE_DTS_0612, MNE_DTS_1224 and MNE_HOK_0012, took advantage, in all the scenarios, of the management measures applied to the other fleets, without taking any negative drawback, given that they were not or partially (ITA_PGP_0006_0612 only for the fishing ban) affected by the management rules (Fig. 74 and tables from 165-168).

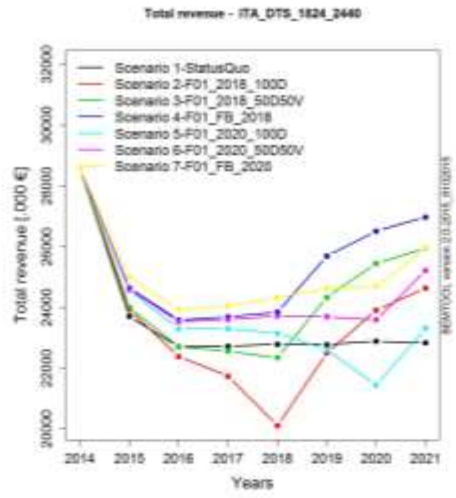
Overall Scenario 3 - F01_2018_50D50V and Scenario 2 - F01_2018_100D produce larger impacts on revenues, with an expected increase of 14-12% compared to the status quo. However scenario 3 and scenario 6 have also a negative impact on employement (-16% for the whole fleet), as a result of scraping and expulsion of workers from the sector.

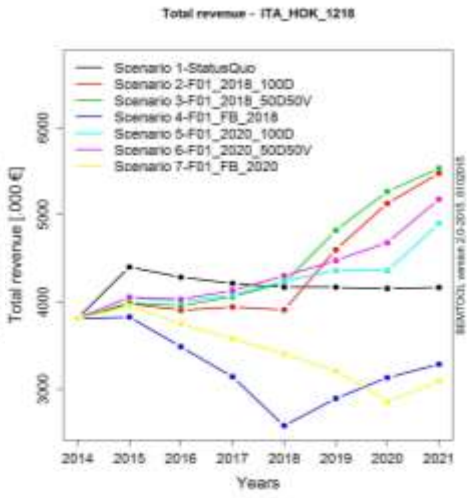
Fishing ban (until 2018 and 2020) has a negative impact on the Italian small scale fleet ITA_PGP_0006_0612, with an average reduction in revenues of 24% in 2021. Indeed this is the only management rule applied to this fleet.

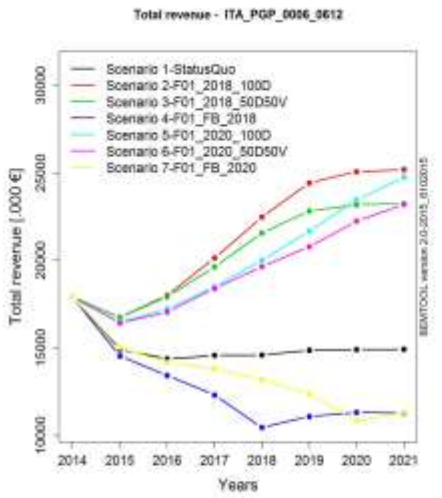
As expected, all other fleets and in particular Italian DTS_0612 and Montenegrin fleetsbenefit in terms of revenues as they are excluded from the implemented technical measures.

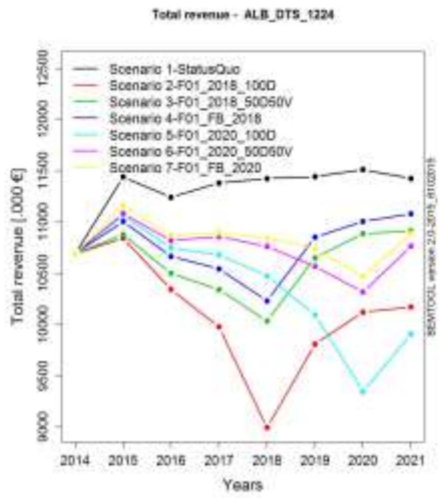

Total revenue - ITA_DTS_0612
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Total revenue [,000 €]
Years


Total revenue - ITA_DTS_1218
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Total revenue [,000 €]
Years


Total revenue - ITA_DTS_1824_2440
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Total revenue [,000 €]
Years


Total revenue - ITA_HOK_1218
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Total revenue [,000 €]
Years


Total revenue - ITA_PGP_0006_0612
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Total revenue [,000 €]
Years


Total revenue - ALB_DTS_1224
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Total revenue [,000 €]
Years

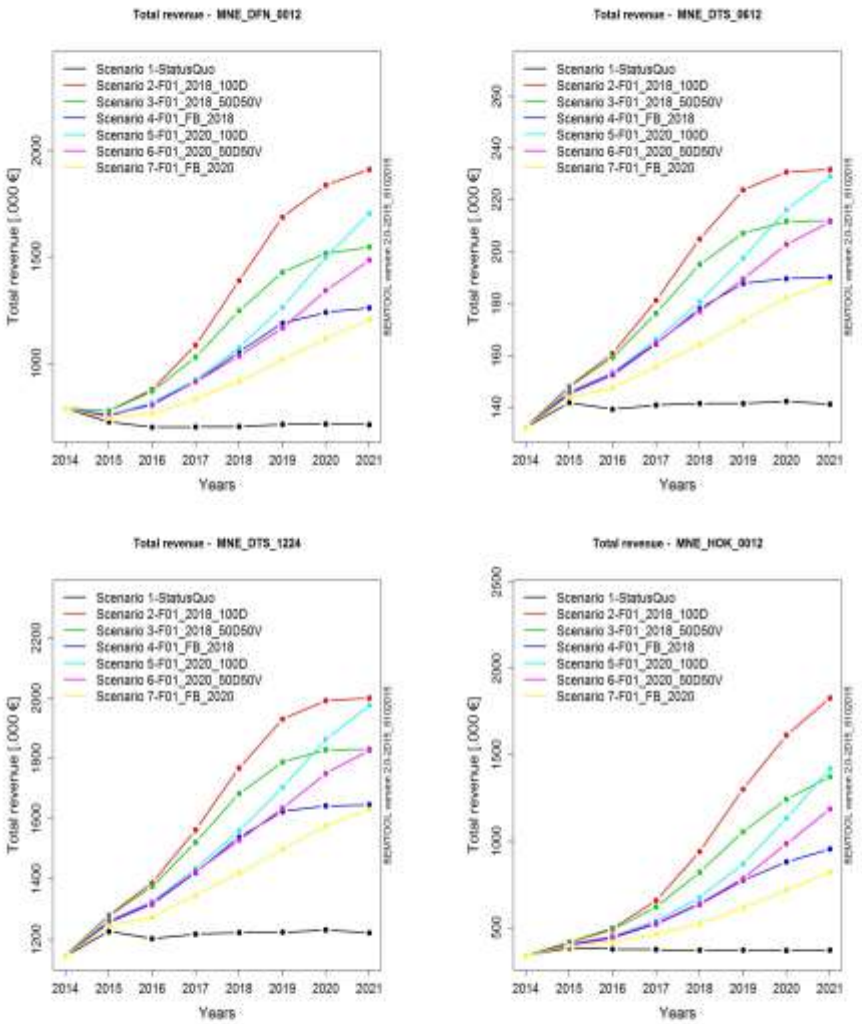


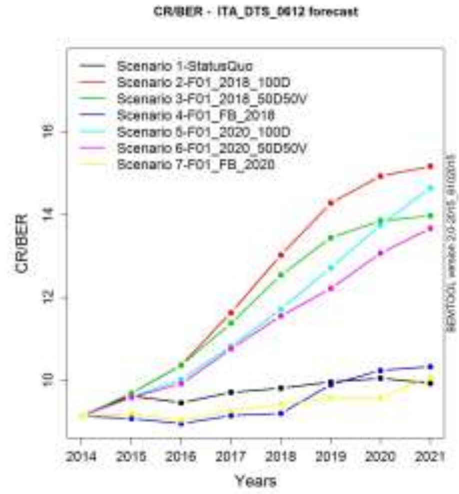
Figure 74 Revenues by fleet segment and scenario.

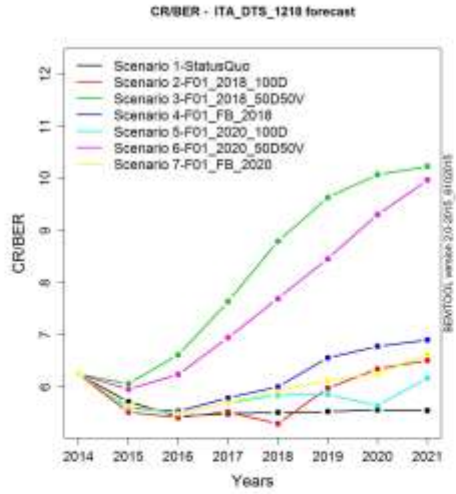
The ratio between current revenue and break-even revenue (Figure 75 and tables 165-168) is greater than 1 for all the selected fleets, thus indicating that demersal fishery in GSA 18 is generally profitable. Furthermore in 2013, all selected fleets show significant improvements compared to 2012 with largely positive CR/BER ratios.

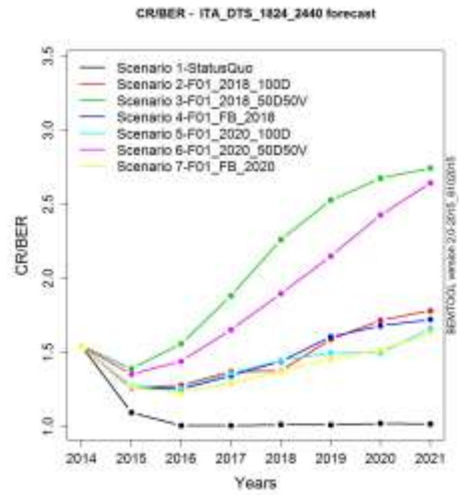
In the simulated period, CR/BER ratios follow the same trends of revenues. Generally all the CR/BER ratios in 2021 are expected to be higher than the status quo in all the forecast scenarios for all fleet segments, except for Italian longlines and small scale fleets (i.e. ITA_HOK_1218 and ITA_PGP_0006_0612), for which the fishing ban scenarios are performing worse than the status quo (about -10%, on average).

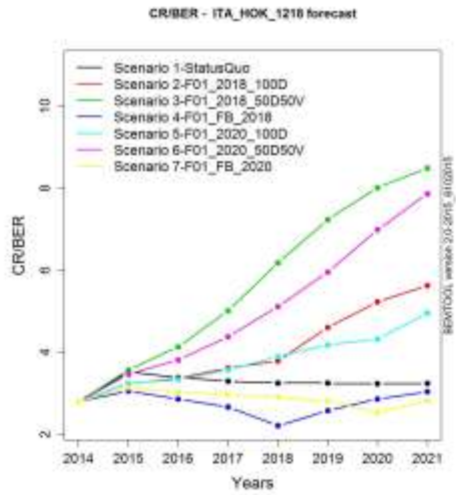
Forecasts show an increase of profitability for all the fleet segments in the scenarios acting on reduction of vessels and fishing days in the shortest timeframe (scenario 3); the higher profitability would be for the Albania fleet and for Italian DTS_1824_2440. Anyway, these results must be analysed considering that in these mixed scenarios 33% of vessels are withdrawn from the fleet so employement will be negatively effected.

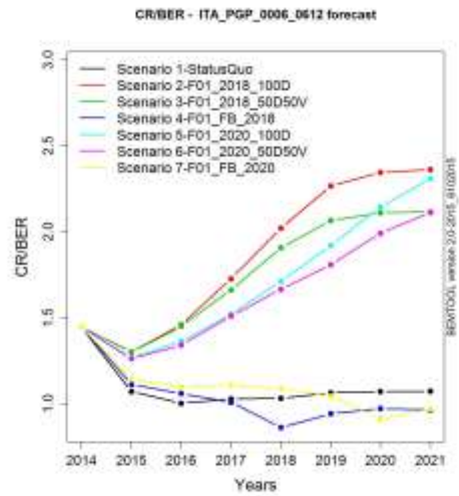
At the end of the simulation period, the positive effects on CR/BER ratios is more evident for Montenegrin fleets, because excluded from the enforcement of all the management measures.

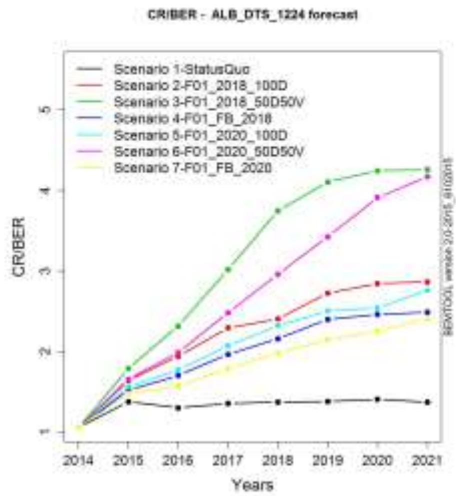

CR/BER - ITA_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
CR/BER
Years


CR/BER - ITA_DTS_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
CR/BER
Years


CR/BER - ITA_DTS_1824_2440 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
CR/BER
Years


CR/BER - ITA_HOK_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
CR/BER
Years


CR/BER - ITA_PGP_0006_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
CR/BER
Years


CR/BER - ALB_DTS_1224 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
CR/BER
Years

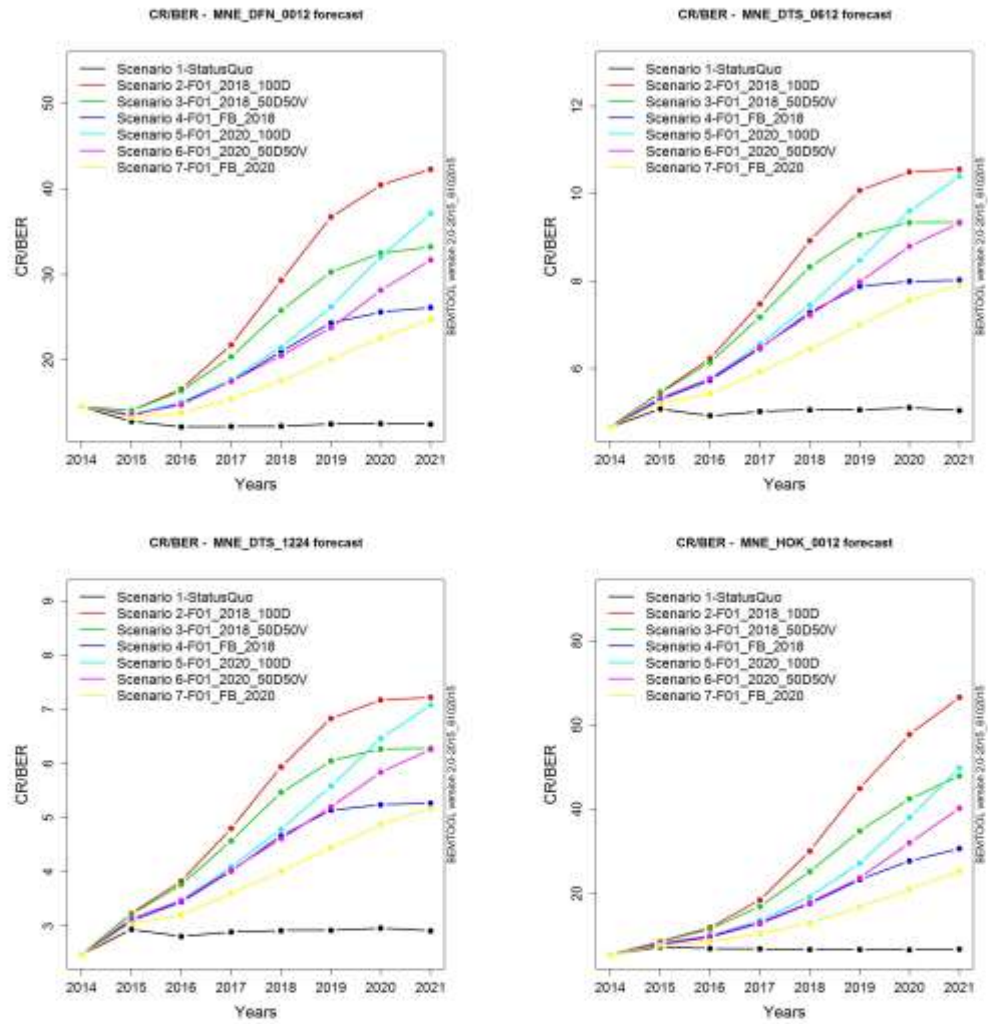
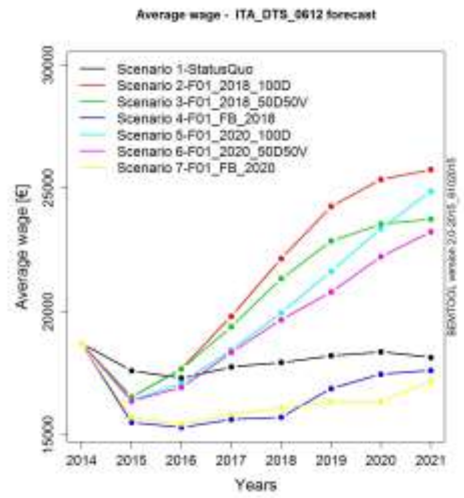


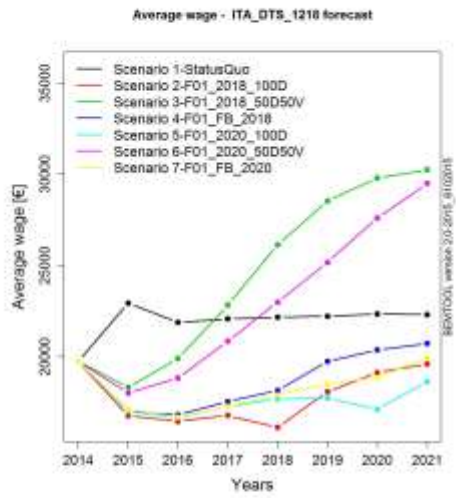
Figure 75 Current Revenue to the Break-Even Revenue ratio (R/BER)by fleet segment and scenario

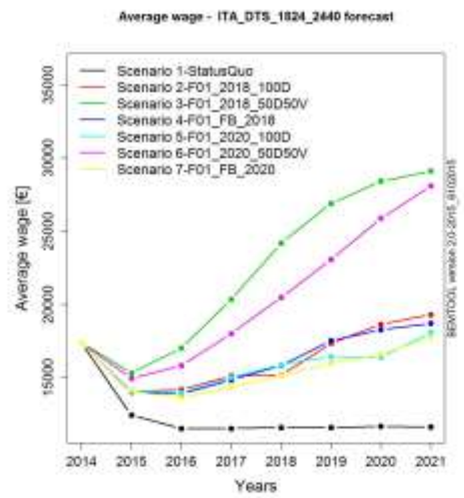
According to the status quo scenario, average salary for the overall fleet would further increase by 10% until 2021.

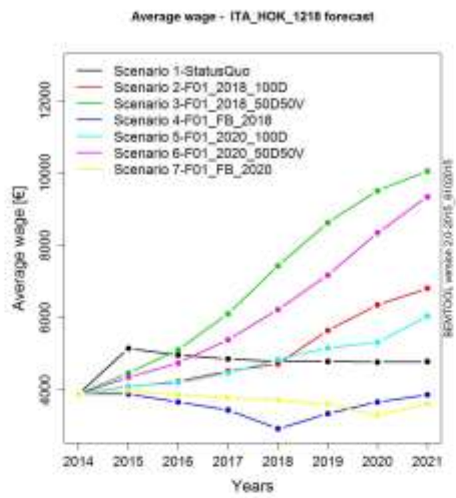
Simulations performed for the vessels belonging to all fleets included in the case study (**Figure 76** and tables 165-168) show improvements in the average salary ranging from +17% of scenario 7 - F01_2020_FB, to + 78% of Scenario 3 - F01_2018_50D50V compared with the status quo.

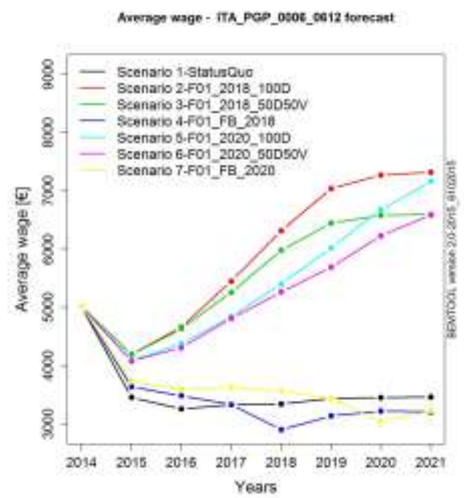
The higher profitability would be the one of Albania fleet, 3 times higher than status quo, and of Italian DTS_1824_2440, more than 2.5 times higher than status quo. Scenarios F01_2018_50D50V and HR2-F01_2020_50D50V produce the largest positive variations in average salaries of Albania DTS 1224 and Italian DTS_1824_182440, but also imply a remarkable reductions in the number of employees, estimated around -30% by 2021 for both scenarios. As excluded from all the scenarios, wages of all Montenegrin segments undergo variations higher than 50%, in particular longlines show very high increase across scenarios.

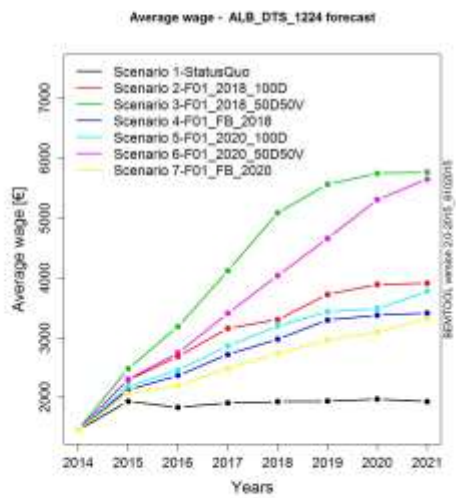

Average wage - ITA_DTS_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average wage [€]
Years


Average wage - ITA_DTS_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average wage [€]
Years


Average wage - ITA_DTS_1824_2440 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average wage [€]
Years


Average wage - ITA_HOK_1218 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average wage [€]
Years


Average wage - ITA_PGP_0006_0612 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average wage [€]
Years


Average wage - ALB_DTS_1224 forecast
Scenario 1-StatusQuo
Scenario 2-F01_2018_100D
Scenario 3-F01_2018_50D50V
Scenario 4-F01_FB_2018
Scenario 5-F01_2020_100D
Scenario 6-F01_2020_50D50V
Scenario 7-F01_FB_2020
Average wage [€]
Years

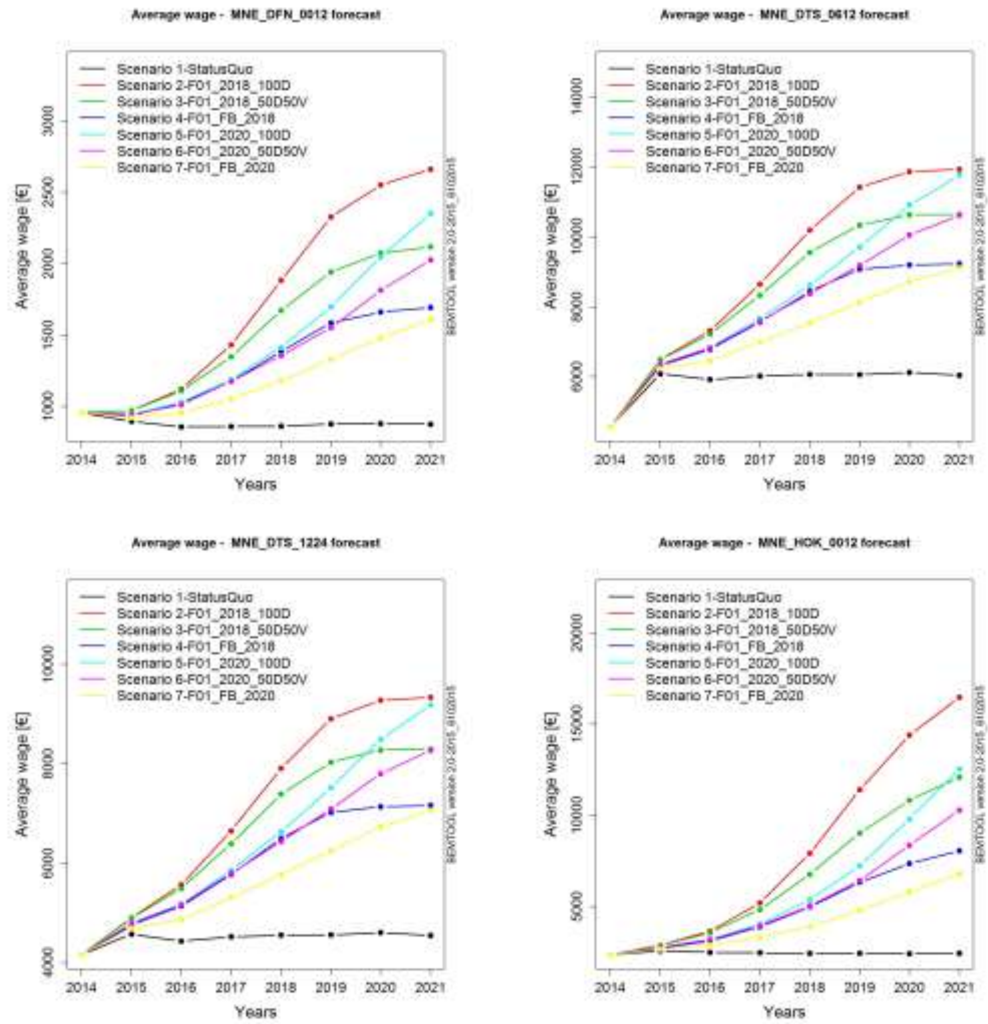


Figure 76 Average salary by fleet segment and scenario

The main results of the projections carried out are reported as percentage respect to status quo in 2021 in the tables from 165 to 168.

In Annex II the graphs related to Kobe plot, SSB by stock, landing by stock and fleet segment, average salary and CR/BER with confidence intervals for all the forecast scenarios are reported. In Annex III the comparison of number of employees for the different scenarios is reported.

5.6 DISCUSSION AND CONCLUSIONS

According to the traffic light summary tables (from 165 to 168), all the performed scenarios allow to obtain a benefit on the SSB for the 4 stocks compared to the status quo. SSB showed remarkable changes in all the different scenarios, although better performances were observed in Scenario 2 - F01_2018_100D, especially for hake and Norway lobster that show highest increase in SSB respect to the status quo. This scenario was followed by in Scenario 5 - F01_2020_100D, indicating that a reduction applied in a narrower timeframe is more effective. Besides for SSB, HR2-F01_2018_100D is the best performing scenario also for catches and socio-economic indicators of all the fleets, allowing to obtain the best trade-off among the different variables, as showed also in the radar plot for the all fleet (Fig. 77).

Considering the catches of the whole fleet, there is a decrease of the catches of deep water pink shrimp and red mullet in all the scenarios, that is more evident in case of reduction of activity in long term (2020). Given the gain in productivity of stocks as Norway lobster and European hake, also predicted catches for the whole fleet were improving compared to the status quo, increasing from an average of 12% for Norway lobster and 20% for European hake. Conversely the catches of red mullet and deep water pink shrimp decreased on average 18% and 6%, indicating an underutilization of such stocks.

This result is consistent with the Multi-Criteria Decision Analysis, performed by BEMTOOL and reported in Figure 78. MCDA allows to evaluate which is the most efficient scenario, as it takes into account also utility functions and weights associated to each indicator, according to an expert judgement, that creates differences among indicators when comparing a set of management options.

The performed scenarios allow to obtain an improvement of the indicators for all the fleet segments, except ITA_DTS_1218, for which the reduction of fishing mortality until 2020 (Scenario 5) shows a score lower than status quo, due to a decrease of total revenues and salary (Table 166).
Also Italian small scale (ITA_PGP_0006_0612) and longlines (ITA_HOK_1218) show lower performance than status quo in fishing ban scenarios, as the economic indicators would decrease compared to the status quo.

All the other fleet segments are less impacted by the management measure and benefit from the effects of the implementation of management measures.

Scenario 3 - F01_2018_50D50V and Scenario 2 - F01_2018_100D produce the best results both in terms of social and economic indicators with an expected increase of 14% in the total revenues and respectively,about 80% and 40% for average salary, compared with the status quo. Scenario 3 has however a negative impact on the employment with a decrease of about 16%.

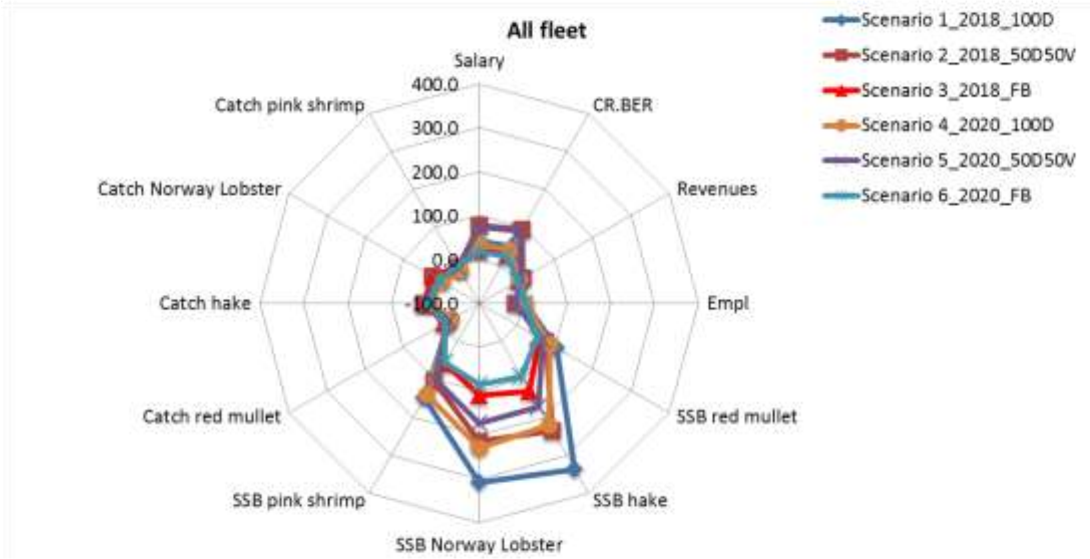


Figure 77 Radar plot for all the fleet. Each line represents a scenario and each point the corresponding percentage of each indicators in comparison to status quo.

Table 165 Performances of the management scenarios (% respect to status quo) simulated in terms of SSB and overall catches, salary, CR/BER, employement and revenues. The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	ALL fleets											
	Salary	CR.BER	Rev	Emp	SSB red mullet	SSB hake	SSB Norway lobster	SSB pink shrimp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	41.7	49.1	12.5	6.1	103.7	336.1	308.8	149.3	-23.5	24.5	18.4	-10.7
Scenario 3 - F01_2018_50D50V	78.3	95.2	14.2	-16.9	76.6	235.4	215.5	106.5	-17.3	26.2	23.0	-4.3
Scenario 4 - F01_2018_FB	21.6	28.2	4.5	6.1	59.1	131.0	109.0	57.6	-8.4	23.4	18.9	0.4
Scenario 5 - F01_2020_100D	34.8	40.9	7.5	6.1	87.1	219.3	229.0	140.0	-28.0	12.7	-3.6	-14.4
Scenario 6 - F01_2020_50D50V	73.9	89.8	11.7	-16.9	67.4	172.5	173.2	99.4	-20.7	23.3	8.0	-6.7
Scenario 7 - F01_2020_FB	17.2	23.2	1.5	6.1	53.2	92.8	85.5	54.9	-9.7	15.0	6.4	-1.6

Table 166 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employement and revenues by fleet segment (ALB_DTS_1224 ITA_DTS_0612, ITA_DTS_1218 and ITA_DTS_1824_2440 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and+5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	ALB_DTS_1224								ITA_DTS_0612							
	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	102.7	108.8	-11.0	0.0	-40.2	9.7		-13.5	41.9	52.7	46.7	7.1	75.8	224.5	226.7	
Scenario 3 - F01_2018_50D50V	198.6	210.5	-4.5	-33.0	-29.4	15.9		-5.7	30.8	40.7	36.0	7.1	57.3	160.4	162.2	
Scenario 4 - F01_2018_FB	76.8	81.4	-3.0	0.0	-14.6	14.6		-13.4	-2.9	4.1	-0.2	7.1	-8.8	45.6	76.7	
Scenario 5 - F01_2020_100D	95.5	101.2	-13.3	0.0	-43.8	2.0		-16.8	37.1	47.5	42.0	7.1	65.3	194.4	159.9	
Scenario 6 - F01_2020_50D50V	192.7	204.2	-5.8	-33.0	-32.4	15.0		-8.6	28.1	37.7	33.4	7.1	50.0	153.4	124.4	
Scenario 7 - F01_2020_FB	71.7	76.0	-4.7	0.0	-15.9	7.7		-14.6	-5.1	1.6	-2.4	7.1	-10.6	36.2	55.8	

Scenario, year 2021	ITA_DTS_1218								ITA_DTS_1824_2440							
	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	-12.1	17.3	-4.7	32.3	-40.3	9.3	17.1	-15.5	65.9	74.9	7.9	1.0	-39.9	9.7	18.7	-16.0
Scenario 3 - F01_2018_50D50V	35.6	84.4	1.0	-11.3	-29.5	15.4	21.9	-7.5	149.9	169.0	13.6	-32.3	-29.3	15.9	23.4	-8.0
Scenario 4 - F01_2018_FB	-7.1	24.4	7.7	32.3	-7.8	27.6	18.5	3.9	60.6	69.0	18.1	1.0	-6.7	25.8	18.8	4.8
Scenario 5 - F01_2020_100D	-16.4	11.2	-9.0	32.3	-43.9	1.0	-4.2	-19.1	55.5	63.2	2.1	1.0	-43.7	0.8	-3.7	-19.8
Scenario 6 - F01_2020_50D50V	32.2	79.7	-1.3	-11.3	-32.7	14.2	7.2	-10.1	141.3	159.4	10.4	-32.3	-32.7	14.2	8.1	-10.8
Scenario 7 - F01_2020_FB	-10.6	19.5	4.2	32.3	-9.3	19.5	6.3	1.9	52.7	60.1	13.7	1.0	-9.0	17.8	5.9	2.9

Table **167** Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER and revenues by fleet segment (ITA_HOK_1218, ITA_PGP_0006_0612, MNE_DFN_0012 and MNE_DTS_0612 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	**ITA_HOK_1218**								**ITA_PGP_0006_0612**							
	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	42.2	73.5	31.4	16.6		16.6			111.6	120.1	68.7	-1.7	51.1	277.2		
Scenario 3 - F01_2018_50D50V	109.7	161.3	32.8	-21.9		-21.9			90.7	97.3	55.6	-1.7	37.9	194.3		
Scenario 4 - F01_2018_FB	-19.1	-6.3	-21.1	16.6		16.6			-7.4	-10.1	-24.5	-1.7	-31.7	-48.3		
Scenario 5 - F01_2020_100D	26.3	52.7	17.6	16.6		16.6			107.0	115.2	65.8	-1.7	47.2	244.1		
Scenario 6 - F01_2020_50D50V	95.1	142.2	24.3	-21.9		-21.9			90.4	96.9	55.4	-1.7	35.7	190.6		
Scenario 7 - F01_2020_FB	-24.6	-13.4	-25.8	16.6		16.6			-6.8	-9.4	-24.1	-1.7	-31.2	-51.4		

Scenario, year 2021	**MNE_DFN_0012**								**MNE_DTS_0612**							
	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	Salary	CR.BER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp
Scenario 2 - F01_2018_100D	203.2	236.0	167.8	0.0	51.7	307.8			97.4	109.5	64.1	0.0	75.9	222.6		154.4
Scenario 3 - F01_2018_50D50V	141.5	164.4	116.9	0.0	38.2	211.4			76.1	85.6	50.2	0.0	57.2	158.1		110.0
Scenario 4 - F01_2018_FB	93.0	108.1	76.8	0.0	31.9	130.9			52.7	59.3	34.7	0.0	44.1	102.4		62.1
Scenario 5 - F01_2020_100D	168.0	195.1	138.7	0.0	47.7	248.3			94.6	106.4	62.3	0.0	65.3	200.0		144.8
Scenario 6 - F01_2020_50D50V	130.9	152.1	108.1	0.0	36.0	194.6			75.7	85.1	49.9	0.0	50.5	156.2		103.6
Scenario 7 - F01_2020_FB	83.6	97.1	69.0	0.0	33.9	111.6			50.8	57.1	33.4	0.0	44.1	91.0		59.2

Table 168 Performances of the management scenarios (% respect to status quo) simulated in terms of catches, salary, CR/BER, employement and revenues by fleet segment (ITA_HOK_1218, ITA_PGP_0006_0612, MNE_DFN_0012 and MNE_DTS_0612 fleet segments). The green values are higher than +5%, the red ones are the smaller than -5% and the yellow ones are between -5% and +5%. Rev=Revenues; Emp=Employment. GSA18.

Scenario, year 2021	**MNE_DTS_1224**									**MNE_HOK_0012**								
	Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp		Salary	CR.B ER	Rev	Emp	Catch red mullet	Catch hake	Catch Norway lobster	Catch pink shrimp	
Scenario 2 - F01_2018_100D	105.4	148.0	63.7	0.0	75.9	222.6		154.4		573.6	886.4	393.1	0.0		411.5			
Scenario 3 - F01_2018_50D50V	82.5	115.9	49.9	0.0	57.2	158.1		110.0		394.6	609.8	270.4	0.0		282.1			
Scenario 4 - F01_2018_FB	57.6	80.8	34.8	0.0	44.1	102.4		62.1		229.8	355.1	157.5	0.0		163.5			
Scenario 5 - F01_2020_100D	102.2	143.4	61.7	0.0	65.3	200.0		144.8		413.0	638.2	283.1	0.0		295.3			
Scenario 6 - F01_2020_50D50V	82.0	115.1	49.5	0.0	50.5	156.2		103.6		321.1	496.2	220.1	0.0		229.1			
Scenario 7 - F01_2020_FB	55.4	77.8	33.5	0.0	44.1	91.0		59.2		177.9	274.9	121.9	0.0		126.3			

The BEMTOOL option aimed at comparing the outputs of the different scenarios, represented by the Multi-Criteria Decision Analysis that combines Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP) has been used to assess the performances of the alternative fisheries management policies (Rossetto et al., 2015).

The eight indicators used in the analysis are listed in Table 169, along with the weighting set used to calculate the overall utility associated to each scenario. The value of the indicators in the last year of simulation (2014) is referred to as the 'current condition'. The performance of a scenario with respect to a specific objective is calculated as the value of the relevant indicator in 2021.

Table 169 Summary of the indicators used in the MCDA

Top level hierarchy	Low level hierarchy	Indicator*	Weight
Socioeconomic	Economic	GVA, ROI or Profit	0.0080
Socioeconomic	Economic	RBER	0.0421
Socioeconomic	Social	WAGE	0.1914
Socioeconomic	Social	EMPL	0.0641
Biological	Biological conservation	SSB	0.2605
Biological	Biological conservation	F	0.2605
Biological	Biological production	Y	0.1373
Biological	Biological production	D	0.0361

* GVA: Gross Value Added; ROI: Return On Investment; RBER: Ratio of Revenues to Break-even revenues; WAGE: Average wage; EMPL: Employment; SSB: Spawning Stock Biomass; F: Fishing mortality; Y: Yield; D: Discard rate.

Also according to MCDA, the scenario that allows to reach an higher overall utility is Scenario 2 - F01_2018_100D (0.44), followed by Scenario 5 - F01_2020_100D, while the lowest utility is obtained in the status quo (0.24).

These results seem consistent with the greater benefit that generally the reduction in fishing mortality produce on the indicators if applied in a narrow timeframe. These benefits are more evident on the biological and pressure indicators used in the analysis (SSB, F, Yield). Indeed, the utility associated to the socio-economic indicators is lower in Scenario 3 - F01_2018_50D50V and Scenario 6 - F01_2020_50D50V, both reducing the number of vessels. These scenarios are ranked as less efficient in the MCDA, as the social component is negatively affected by the expulsion of workers following the scraping of the vessels, despite the biological indicators show a high utility.

The mixed scenarios, i.e. those reducing both fishing days and vessels, and fishing ban scenarios show similar results in terms of overall utility.

Nevertheless the lack of a reliable stock-recruitment relationship did not allow a proper forecasting recruitment level in the projections, thus the scenarios performed take into account the variability due to the process error and are hence considered to ease the more adaptive advice for demersal fisheries for this area.

Following the results, the current regulations (i.e. the status quo scenario) cannot be considered for this case study suitable to reach the MSY objective.

All the proposed scenarios, aimed to reach a combined Fmsy, produce an improvement compared to status quo for all the fleets.

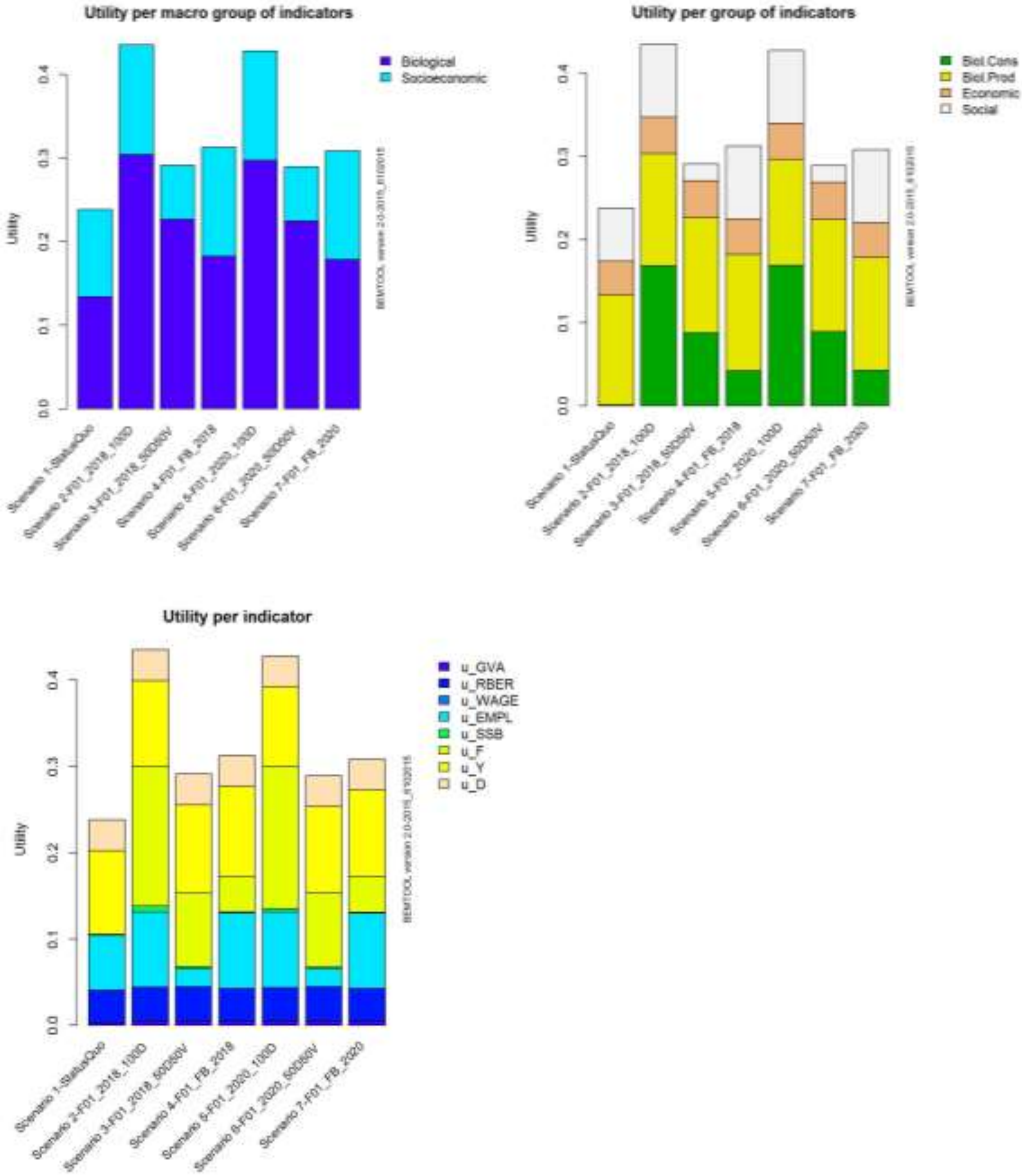


Figure 78 MCDA results: evaluation of the overall utility associated to each management scenario.

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