# Stock Assessment Form

# Demersal species

**Reference Year: 2016**

**Reporting Year: 2017**

The stock of red mullet - *Mullus surmuletus* - around Cyprus island (GSA 25) was assessed by means of an extended Survivor Analysis (XSA) using FLR libraries. The assessment was carried out using as input data, official landings and biological data collected under the Cyprus National Data Programme, covering the period 2006-2016. Commercial CPUE from nets for the period 2009-2016. Were used for the tuning file. Yeld per recruit analysis was performed for the estimation of the reference point F0.1 as proxy of $F_{MSY}$. The results of the assessment suggest that the stock is in overfishing status. The assessment has been endorsed as "Accepted with qualitative advice''.

# Stock Assessment Form version 1.0 (January 2014)

Uploader: *Charis Charilaou*

## Stock assessment form

## Contents

# 1 Basic Identification Data

| Scientific name: | Common name: | ISCAAP Group: |
|---|---|---|
| *Mullus surmuletus* | Stripped red mullet | 33 |
| **1st Geographical sub-area:** | **2nd Geographical sub-area:** | **3rd Geographical sub-area:** |
| GSA25 | | |
| **4th Geographical sub-area:** | **5th Geographical sub-area:** | **6th Geographical sub-area:** |
| | | |
| **1st Country** | **2nd Country** | **3rd Country** |
| Cyprus | | |
| **4th Country** | **5th Country** | **6th Country** |
| | | |
| **Stock assessment method: (direct, indirect, combined, none)** | | |
| **Indirect: XSA (using commercial CPUE), Separable VPA, Y/R analysis** | | |
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# 2 Stock identification and biological information

## 2.1 Stock unit

The assessment is considered to cover a complete stock unit; it is assumed that the stock limits of the assessed *Mullus surmuletus* are in agreement with the limits of GSA 25.

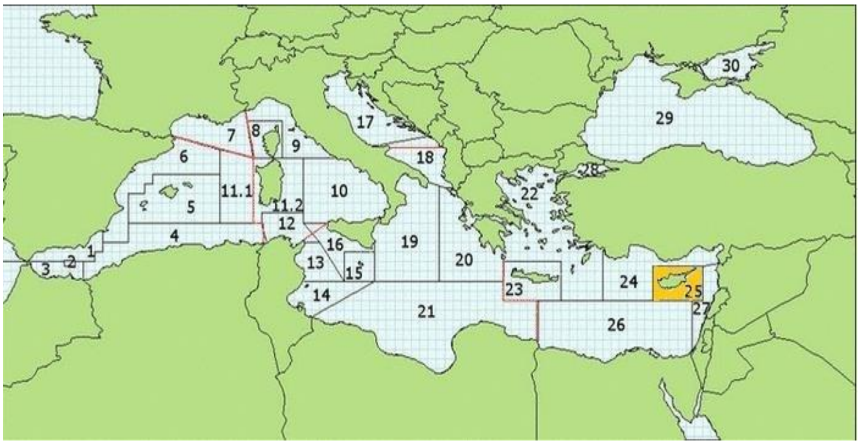



*Figure 2.1-1: Geographical location of GSA25.*

## 2.2 Growth and maturity

The following tables provide growth and maturity information on the stock, based on combined data from commercial catches and fisheries-independent survey. All information is based on data collected under the Cyprus National Data Collection Programme.

*Table 2.2-1: Maximum size, size at first maturity and size at recruitment.*

| **Somatic magnitude measured (LT, LC, etc)** | | | | **Units** | |
|---|---|---|---|---|---|
| **Sex** | **Fem** | **Mal** | **Combined** | **roduction season** | March - May |
| **Maximum size observed** | | | 33 | **Recruitment season** | Summer – early autumn |
| **Size at first maturity** | | | | **Spawning area** | Shelf |
| **Recruitment size to the fishery** | | | | **Nursery area** | Shelf |

*Table 2.2-2: M vector and proportion of matures by age (Combined sex)*

| Age | Natural mortality | Proportion of matures |
|---|---|---|
| *0* | *1.02* | *0.20* |
| *1* | *0.63* | *0.80* |
| *2* | *0.48* | *1.00* |
| *3* | *0.38* | *1.00* |
| *4* | *0.32* | *1.00* |
| *5* | *0.29* | *1.00* |
| *6+* | *0.26* | *1.00* |

As shown in Table 2.2-2, an M vector at age is used, calculated from Gislason et al. (2010)[1] equation. The growth parameters and the length weight relationship used for the estimation of M are those provided in Table 2.2-3. The proportion of matures at age were estimated using the estimated maturity ogive at length, converted to age by ALK and weighted by length distribution. Data used cover the period 2009-2016.

Different length weight relationships were applied along the years; the one provided in Table 2.2-3 refers to 2016.

*Table 2.2-3: Growth and length weight model parameters*

| | | | Sex | | | |
|---|---|---|---|---|---|---|
| | | **Units** | **female** | **male** | **Combined** | **Years** |
| **Growth model** | **$L_\infty$** | cm | | | 37.39 | 2013-2016 |
| | **K** | Years -1 | | | 0.1724 | |
| | **$t_0$** | years | | | -1.751 | |
| | **Data source** | Cyprus National Data Collection Programme under EU Data Collection Framework. | | | | |
| **Length weight relationship** | **a** | | | | 0.0078 | 2016 |
| | **b** | | | | 3.1507 | 2016 |
| | **M** (scalar) | | | | | |
| | **sex ratio** (% females/total) | | | | | |

[1] H. Gislason, N. Daan, J.C. Rice, J.G. Pope. Size, growth, temperature and the natural mortality of marine fish. Fish and Fisheries, 11 (2010), pp. 149-158

# 3 Fisheries information

## 3.1 Description of the fleet

As indicated in Table 3.1-1, the stock is exploited by different Operational Units, polyvalent vessels operating with passive gears with length basically below 12m and the trawlers in much lesser extent.

The small scale polyvalent fleet operates mainly with bottom set nets and bottom longlines, targeting demersal species. Vessels under this fleet represent the large majority of the fishing vessels in the Cyprus Fleet Register (96%). Most vessels have length 6-<12m and are allowed to operate every day all year round, with a number of restriction measures on the use of fishing gears and minimum landing sizes, according to the national and community law (see Section 3.3). During 2016 there were 325 licenses (28 with length 0-<6m, 297 with length 6-<12m).

Polyvalent vessels fishing with passive gears over 12m are mainly involved in the large pelagic fishery, but may also target demersal shelf species using nets and bottom longlines.

For the trawlers fishing in territorial waters a limited number of licenses is issued every year, and an extended closed season is employed. Since 2012 the trawlers operating in territorial waters are limited to two. Further information on the restrictions applied on this fleet is provided in Section 3.3.

As shown in Table 3.1-2, stripped red mullet in GSA25 is exploited with a number of other demersal species for all operational units.

*Table 3.1-1: Description of operational units exploiting the stock*

| | Country | GSA | Fleet Segment | Fishing Gear Class | Group of Target Species | Species |
|---|---|---|---|---|---|---|
| **Operational Unit 1** | CYP | GSA25 | C-Polyvalent small-scale vessels with engine (6-12 metres) | 07 – Gillnets and Entangling Nets | 33 – Demersal shelf species | *Mullus surmuletus* *(MUR)* |
| **Operational Unit 2** | CYP | GSA25 | B – Polyvalent small-scale vessels with engine (<6 metres) | 07 – Gillnets and Entangling Nets | 33 – Demersal shelf species | *Mullus surmuletus* *(MUR)* |
| **Operational Unit 3** | CYP | GSA25 | M – Polyvalent vessels (>12 metres) | 07 – Gillnets and Entangling Nets | 33 – Demersal shelf species | *Mullus surmuletus* (MUR) |
| **Operational Unit 4** | CYP | GSA25 | F – Trawlers (>24 metres) | 03 - Trawls | 33 – Demersal shelf species | *Mullus surmuletus* (MUR) |

*Table 3.1-2: Catch, bycatch, discards and effort by operational unit in 2016*

| Operational Units* | Fleet (n° of boats)* | Catch (T or kg of the species assessed) | Other species caught (names and weight ) | Discards (species assessed) | Discards (other species caught) | Effort (units) |
|---|---|---|---|---|---|---|
| Polyvalent small-scale vessels (6-12 metres) | 297 | 29.3 T | *Boobs boops* (81T), *Mullus barbatus* (5.5 T), *Pagellus erythrinus (6T), Sparisoma cretense (34 T),* *Pagellus acarne* (15T), *Siganus rivulatus (14T), Spicara maena (28 T),* *Serranus cabrilla* (55 T), *Diplodus sargus* (10.5T), *Spicara smaris* *(23.6 T), Octopus vulgaris (23 T), Sepia* *inalis (23T), Loligo vulgaris (5.8T)* | No discards | *Lagocephalus* spp. | 37674 (days) |
| Polyvalent small-scale vessels (0-6m) | 28 | 1 T | *Boobs boops* (4T), *Mullus barbatus* (0.2 T), *Siganus rivulatus* *(2.7T), Sparisoma cretense (2.8 T),* *Spicara smaris (2.6 T),* *Spicara maena (1 T),* *Serranus cabrilla* (3.1 T), *Octopus vulgaris* *(1.4T), Sepia officinalis (1.8T)* | No discards | *Lagocephalus* spp. | 3528 (days) |
| Polyvalent vessels (>12 metres) | 26 | 1.9 T | *Boobs boops* (0.6T), *Mullus barbatus* (0.6 T), *Spicara smaris (0.9 T)* | No discards | *Lagocephalus* spp. | 711 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Trawlers | 2 | 1.7 | *Boops boops* (12t), *Spicara smaris* (46.6t), *Pagellus erythrinus* (5t), acarne (9.6 t) *Mullus barbatus* (13.6t), Serranus cabrilla (3.2T), *Merluccius merluccius* (1.4t), *Octopus vulgaris* (1.4T) | No discards | *Boops boops, Mullus barbatus, Pagellus erythrinus, P. acarne, Spicara smaris, Serranus cabrilla, Merluccius merluccius* | 204 |
| **Total** | | 33.9 | | | | |

## 3.2 Historical trends

Figure 3.2-1 shows the trends in landings of stripped red mullet for the period 1985-2016, from the net and the trawl fishery. As shown in Figure 3.2-1, there have been high oscillations in the landings during the period 1985 -1998, followed by a decreasing trend until 2007; since 2009 landings remain at similar levels.

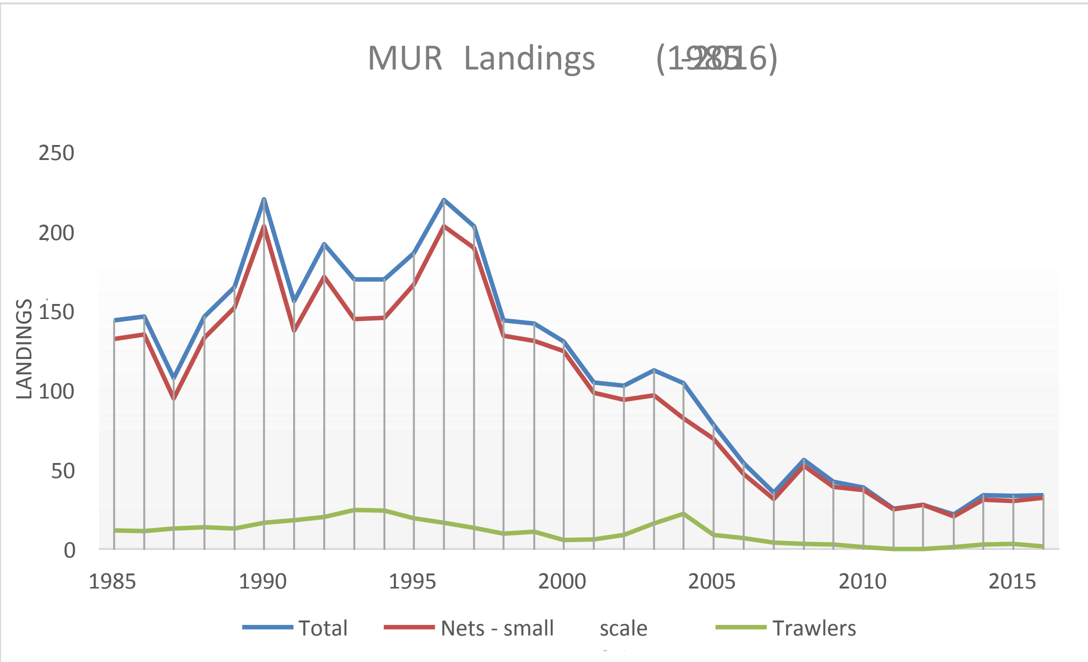



*Figure 3.2-1: Landings of stripped red mullet in GSA 25 for the period 1985-2016*

Table 3.2.1 provides the catches of M. surmulentus from both fisheries for the period 2005-2016. The catches are estimated as catches are estimated as sum of products of numbers-at-age multiplied with weight-at-age. There are no discards of this species in any fishery.

*Table 3.2-1: Stripped red mullet GSA 25. Total annual catches (t) in 2005-2016.*

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net fishery | 60.61 | 45.73 | 29.09 | 51.22 | 39.07 | 37.19 | 25.19 | 27.77 | 20.57 | 31.16 | 30.29 | 32.22 |
| Bottom trawl fishery | 8.50 | 7.07 | 4.01 | 3.93 | 3.06 | 1.62 | 0.25 | 0.22 | 1.21 | 2.85 | 3.21 | 1.70 |
| **Total** | 69.11 | 52.81 | 33.11 | 55.15 | 42.13 | 38.81 | 25.43 | 28.00 | 21.78 | 34.01 | 33.50 | 33.92 |

Information on the length and age distribution of the catches from the net fishery is provided in Figures 3.2-3 and 3.2-4 respectively. As shown in Figure 3.2-3, the mean length of the catches from the net fishery has increased during the years. The main age representing the catches is age 1 (see Fig. 3.2-4).

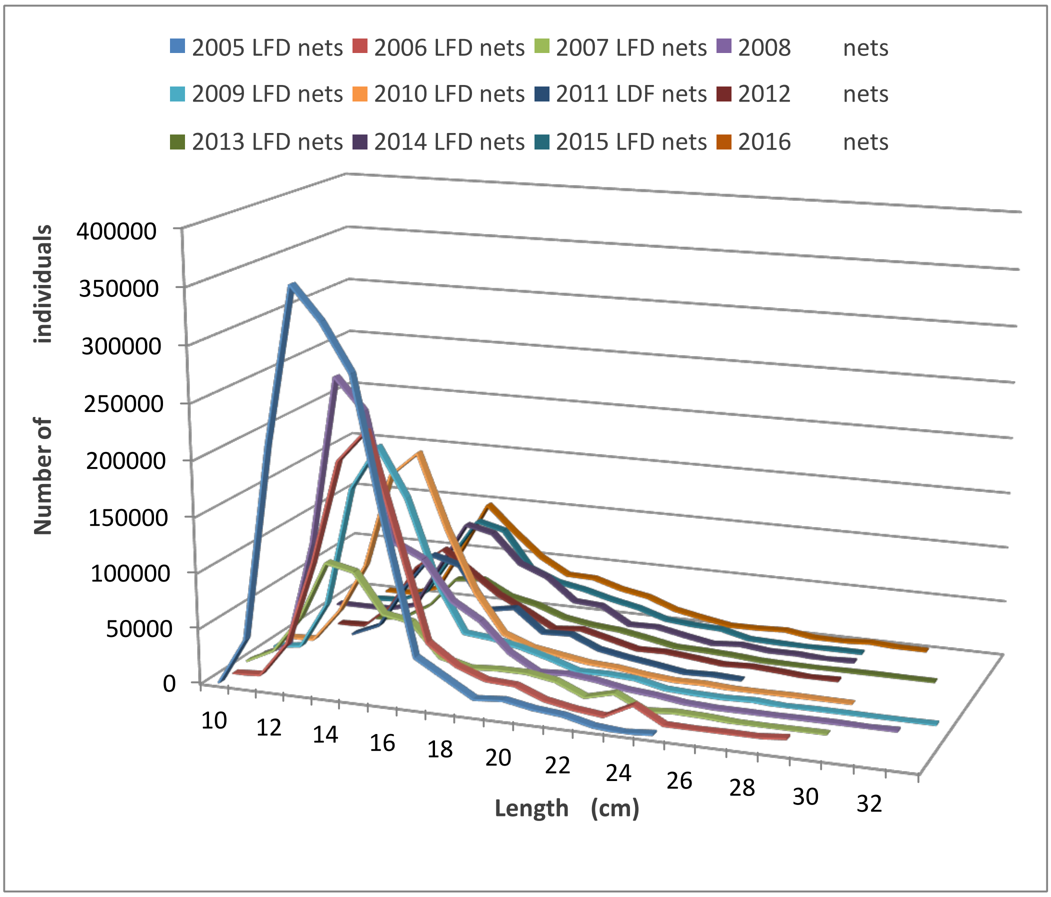



Figure 3.2-3: Length distribution of MUR catches from the net fishery in GSA25 (2005-2016)

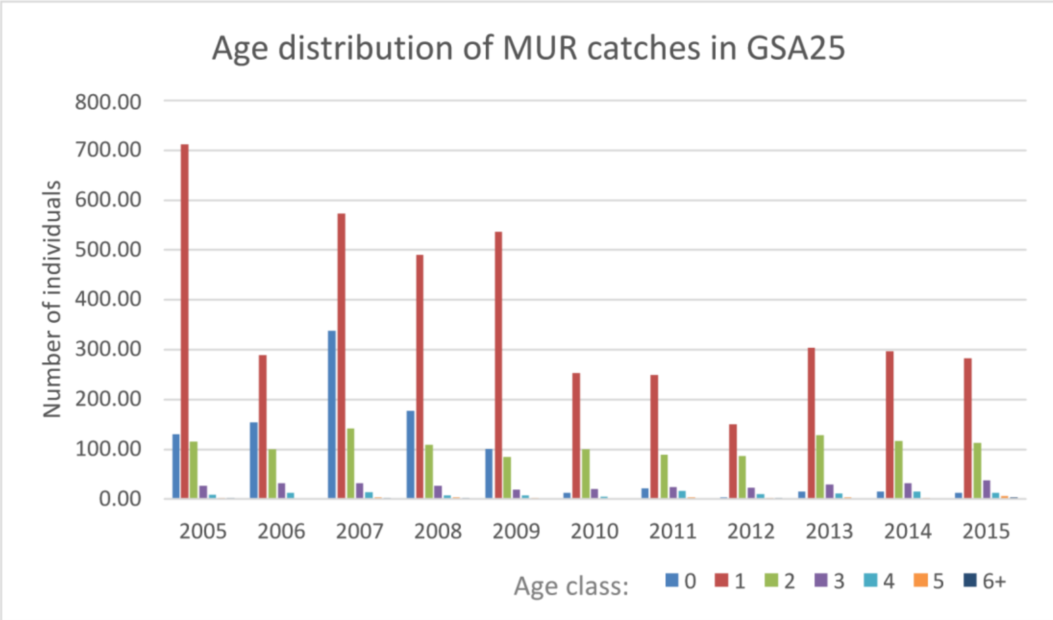
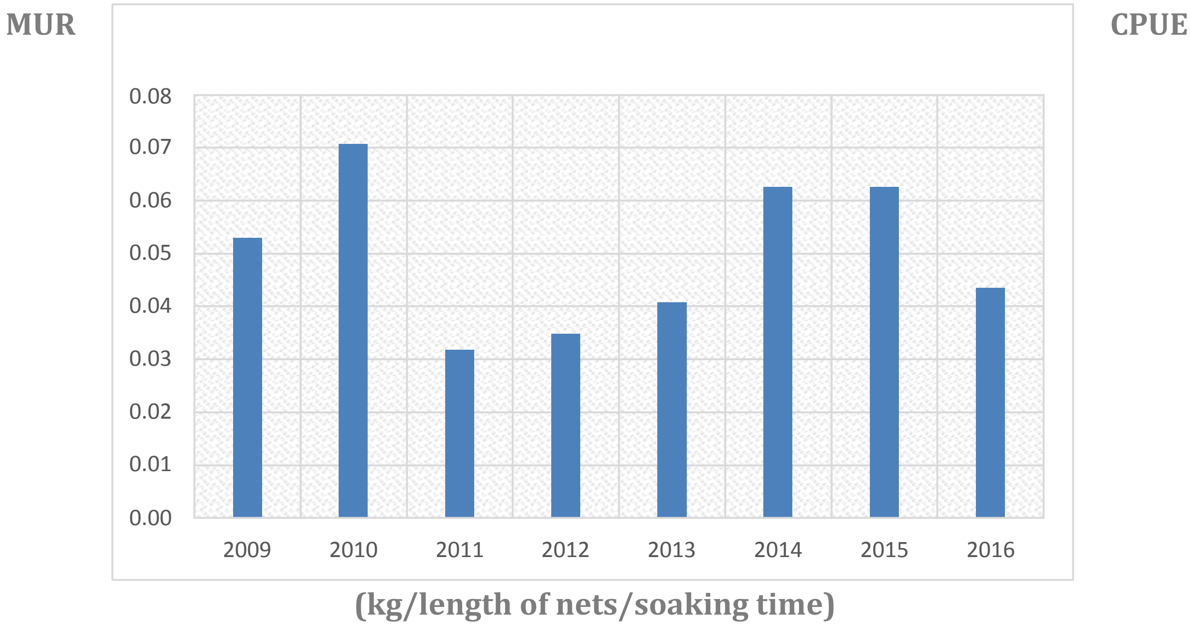



*Figure 3.2-4: Age composition of MUR catches from the net fishery in GSA 25 (2005-2016).*

Table 3.2-2 provides the commercial CPUE from nets (mainly GTR), calculated for the period 2009- 2016 as weight (kg) /size of nets/soaking time. Data used for the CPUE calculation derive from sampling fishing trips at landing sites. CPUE values were also estimated in numbers/size of nets/soaking time, based on the length distribution of the catches from the net fishery assigned in ages with the use of ALKs; these values were used as abundance indices for performing XSA analysis.

*Table 3.2-2. Commercial MUR CPUE from nets for the period 2009-2016.*



### 3.3 Management regulations

Current and past management regulations:

1. **Polyvalent small-scale vessels (0-6m, 6-12m)** ▪ Restriction of the maximum number of licenses.

Small scale inshore vessel licenses (Category A&B) are restricted to 500 by legislation; however, the maximum number is further reduced in accordance with the number of vessels that are permanently removed from the fleet through adjustment schemes.

During 2013, 107 vessels were scrapped with public aid, in accordance with an effort adjustment plan based on Article 21 (a) of Regulation (EC) 1198/2006 on the *European Fisheries Fund* –EFF. In 2014 the maximum number of licenses was reduced accordingly to 393 licenses. During 2015 additional 66 vessels were scrapped with public aid, under the Operational Programme 2014- 2020 of the European Marine and Fisheries Fund. Therefore, from 2016 the maximum number of licenses has been reduced to 327 licenses.

- Restrictions on the use of fishing gears depending on the fishing license category.

Until March 2011 minimum mesh size of nets was set at 32mm (open mesh size). From March 2011 minimum mesh size of nets is set at 38mm (open mesh size).

Maximum length of nets: For boats with license A is 5000m, for boats with license B is 3000m.

Maximum height of nets: 4m.

Restrictions on the time and duration of fishing, depending on mesh sizes.

Additional restrictions on the use of monofilament nets (mesh sizes, length of nets).

2. **Bottom Trawlers in territorial waters**

- Restriction of the maximum number of licenses. Before 2006 the maximum number of licenses was restricted to 8, while from 2006 until 2011 the maximum number was reduced to 4. From November 2011 maximum number of licenses is restricted to 2.
- Minimum mesh size: From June 2010 the 40mm diamond shape trawl net has been replaced by a diamond meshed net of 50mm at the cod-end. From November 2011 minimum mesh size of 50mm diamond in any part of the net.
- Depth and distance from the cost restrictions: Prohibition of bottom trawling at depths less than 50m and at distances less than 0.7 nautical miles off the coast.
- Seasonal and Area restrictions:

- Closed trawling period in territorial waters from 1st of June until the 7th of November (in force since the mid '80s).
- Prohibition of bottom trawling in the Zygi coastal area, at a distance of 3 nautical miles from the coast.

- Restriction of 2 areas from fishing with trawl nets, on a rotational basis (northwest part of Cyprus from 8 November – 15 February, southeastern part from 16 February – 31 May every year). Applied from November 2011.

## 3.4 Reference points

*Table 3.4-1: List of reference points and empirical reference values previously agreed (if any)*

| Indicator | Limit Reference point/empirical reference value | Value | Target Reference point/ empirical reference value | Value | Comments |
|---|---|---|---|---|---|
| B | | | | | |
| SSB | | | | | |
| F | | | | | |
| Y | | | | | |
| CPUE | | | | | |
| Index of Biomass at sea | | | | | |

## 4 Fisheries independent information

Fisheries independent information on *Mullus surmuletus* have not been used for assessment purposes. Even though such information is collected during the International Trawl Survey in the Mediterranean (MEDITS) in GSA25 since 2005, as part of the National Data Collection Programme under the EU Data Collection Framework, this species is caught in very low quantities during the survey, and the abundance indices are not considered representative to the abundance of the stock.

# 5 Ecological information

## *5.1* Protected species potentially affected by the fisheries

The protected species that are potentially affected by the fisheries are the two turtle species (*Chelonia mydas*, *Caretta caretta)* encountered in Cyprus waters, and cetaceans (*Tursiops truncatus).* The interaction of the net fisheries with cetaceans involves mostly the damage of fishing gear and caught fish eaten by the dolphins.

In general, the catch of protected species (shark species, turtles, monk seal, cetaceans) is prohibited in accordance with international obligations (including relevant GFCM recommendations), and data on incidental catches are collected.

## *5.2* Environmental indexes

No environmental indices are used in the assessment.

# 6 Stock Assessment

FLR libraries were employed in order to carry out an Extended Survivor Analysis (XSA) assessment. Separable Virtual Population Analysis was also carried out, using FLR libraries and the Lowestoft VPA suite (Darby and Flatman, 1994[1]).

## *6.1 Extended Survivor Analysis (XSA)*

### 6.1.1 Model assumptions

Different options were tested concerning catchability and shrinkage of the weighted estimates (Shrinkage weight - fse, Shrinkage ages "shk.ages", combinations on qage and rage). The final model settings that were selected for the assessment are the following:

| $F_{bar}$ | fse | rage | qage | shk.yrs | shk.age |
|---|---|---|---|---|---|
| 0-5 | 2 | 1 | 2 | 2 | 3 |

### 6.1.2 Scripts

The script has been uploaded on the GFCM sharepoint.

### 6.1.3 Input data and Parameters

The assessment by means of XSA was performed using the following input data and parameters for the period 2006-2016:

- Catch-at-age matrix
- Mean weight-at-age in the catch (and the stock)
- Natural mortality at age
- Maturity ogive at age

The relevant files used for the assessment are available on the GFCM sharepoint.

The catch-at-age matrix used in the model is provided in Table 6.1.3-1. There are no discards from this species. Length distribution of the catches was converted to age distribution with the use of ALKs.

Mean weight-at-age in the catch (Table 6.1.3-2) was estimated using the length-weight relationship and the ALK; for each age class, the average weight was weighted by the length distribution that formulated the age class. Mean weight-at-age in the stock was considered

[1] Darby, C. D., and Flatman, S. 1994. Virtual Population Analysis: version 3.1 (Windows/Dos) user guide. Info. Tech. Ser., MAFF Direct. Fish. Res., Lowestoft, (1): 85pp.

to be the same with mean weight-at-age in the catch, in the absence of information on small individuals not present in the catches. M vector at age used (Table 6.1.3-3) was calculated using Gislason et al. (2010)[1] equation. The growth parameters used for the estimation of M are those provided in Table 2.2-3. The proportion of matures at age used in the model (Table 6.1.3-3) was estimated using the maturity ogive at length, converted to age by ALK and weighted by length distribution.

*Table 6.1.3-1: Mullus surmuletus in GSA25 - Catch-at age numbers (thousands) used in XSA mode*

| **Age** | **Catch-at-age (thousands)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **class** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **0** | 131.30 | 152.68 | 337.91 | 176.44 | 100.54 | 12.41 | 20.55 | 3.20 | 13.82 | 13.81 | 11.82 |
| **1** | 711.82 | 288.48 | 572.27 | 490.82 | 537.29 | 251.80 | 247.91 | 149.85 | 303.95 | 296.00 | 281.55 |
| **2** | 115.01 | 99.75 | 142.67 | 107.78 | 84.81 | 100.21 | 89.49 | 86.32 | 127.62 | 115.70 | 113.09 |
| **3** | 25.36 | 31.45 | 31.13 | 25.55 | 18.79 | 20.10 | 23.60 | 22.09 | 27.91 | 31.63 | 37.70 |
| **4** | 8.30 | 11.24 | 14.17 | 7.71 | 6.61 | 4.33 | 15.73 | 10.12 | 10.68 | 15.39 | 11.99 |
| **5** | 2.03 | 0.59 | 2.31 | 2.93 | 1.23 | 0.32 | 2.87 | 1.19 | 3.38 | 1.48 | 5.73 |
| **6+** | 1.83 | 0.57 | 1.96 | 1.01 | 0.40 | 0.00 | 0.84 | 1.66 | 0.85 | 0.36 | 2.56 |

*Table 6.1.3-2: Mullus surmuletus in GSA25 - Mean weight at age (kg) in the catch (and stock) used in XSA model.*

| **Age class** | **0** | **1** | **2** | **3** | **4** | **5** | **6+** |
|---|---|---|---|---|---|---|---|
| **2006** | 0.027 | 0.046 | 0.085 | 0.155 | 0.192 | 0.309 | 0.345 |
| **2007** | 0.025 | 0.044 | 0.093 | 0.143 | 0.200 | 0.287 | 0.374 |
| **2008** | 0.026 | 0.044 | 0.086 | 0.144 | 0.191 | 0.278 | 0.406 |
| **2009** | 0.027 | 0.043 | 0.088 | 0.146 | 0.191 | 0.271 | 0.425 |
| **2010** | 0.026 | 0.046 | 0.082 | 0.137 | 0.198 | 0.298 | 0.354 |
| **2011** | 0.028 | 0.049 | 0.090 | 0.139 | 0.190 | 0.245 | 0.345 |
| **2012** | 0.028 | 0.048 | 0.088 | 0.141 | 0.205 | 0.278 | 0.345 |
| **2013** | 0.028 | 0.052 | 0.091 | 0.141 | 0.198 | 0.261 | 0.397 |
| **2014** | 0.027 | 0.051 | 0.087 | 0.137 | 0.188 | 0.258 | 0.322 |
| **2015** | 0.029 | 0.051 | 0.090 | 0.136 | 0.185 | 0.283 | 0.322 |
| **2016** | 0.027 | 0.049 | 0.090 | 0.135 | 0.196 | 0.261 | 0.353 |

[1] H. Gislason, N. Daan, J.C. Rice, J.G. Pope. Size, growth, temperature and the natural mortality of marine fish. Fish and Fisheries, 11 (2010), pp. 149-158.

*Table 6.1.3-3: Mullus surmuletus in GSA25 - Natural mortality and maturity ogive at age used in XSA model.*

| Age | Natural mortality | Proportion of matures |
|---|---|---|
| *0* | *1.02* | *0.2* |
| *1* | *0.63* | *0.8* |
| *2* | *0.48* | *1* |
| *3* | *0.38* | *1* |
| *4* | *0.32* | *1* |
| *5* | *0.29* | *1* |
| *6+* | *0.26* | *1* |

## 6.1.4 Tuning data

The tuning data used in the assessment are commercial CPUE from nets for the period 2009-2016. CPUE was calculated as numbers at age per size of nets per soaking time. Separate CPUEs for 2009- 2010 and 2011-2016 were used due to a change on the minimum mesh sizes of nets in 2011.

*Table 6.1.4-1: Mullus surmuletus in GSA25 – commercial catch-at-age (N/unit of nets/soaking hour) used as tuning data in XSA model.*

| Age class | Catch-at-age | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **0** | 0.238 | 0.184 | 0.015 | 0.026 | 0.006 | 0.017 | 0.026 | 0.011 |
| **1** | 0.648 | 0.996 | 0.315 | 0.308 | 0.286 | 0.557 | 0.542 | 0.350 |
| **2** | 0.119 | 0.147 | 0.125 | 0.110 | 0.156 | 0.230 | 0.218 | 0.143 |
| **3** | 0.030 | 0.035 | 0.025 | 0.029 | 0.041 | 0.054 | 0.063 | 0.047 |
| **4** | 0.010 | 0.012 | 0.005 | 0.019 | 0.019 | 0.021 | 0.029 | 0.017 |
| **5** | 0.004 | 0.002 | 0.0004 | 0.004 | 0.002 | 0.007 | 0.003 | 0.008 |
| **6** | 0.001 | 0.001 | 0.0000 | 0.001 | 0.002 | 0.002 | 0.001 | 0.003 |

## 6.1.5 Results

The results of the XSA assessment are shown in Figure 6.1.5-1 and Tables 6.1.5-1 – 6.1.5-3.

Current fishing mortality ($F_{current(1-5)}$) was calculated as the average of the last 3 years and has a value of 0.61. This fishing mortality value corresponds to both fisheries that exploit red mullet, but basically the net fishery.

*Table 6.1.5-1: Mullus surmuletus in GSA 25 - Stock numbers-at-age (thousands).*

| **Age class** | **Stock numbers-at-age (thousands)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **0** | 2625 | 3485 | 3473 | 3526 | 2162 | 2240 | 2120 | 2621 | 2408 | 2313 | 2550 |
| **1** | 1385 | 868 | 1165 | 1049 | 1166 | 719 | 800 | 752 | 943 | 860 | 826 |
| **2** | 265 | 218 | 252 | 203 | 201 | 229 | 199 | 245 | 291 | 281 | 242 |
| **3** | 57.66 | 73.46 | 56.59 | 43.50 | 40.76 | 57.49 | 62.69 | 52.89 | 83.89 | 79.76 | 82.57 |
| **4** | 11.25 | 18.46 | 24.23 | 12.96 | 8.62 | 12.34 | 22.69 | 23.35 | 17.90 | 34.28 | 28.39 |
| **5** | 3.34 | 1.09 | 3.83 | 5.52 | 2.84 | 0.62 | 5.26 | 3.07 | 8.33 | 3.90 | 11.78 |
| **6+** | 2.92 | 1.04 | 3.14 | 1.86 | 0.90 | 0.00 | 1.49 | 4.21 | 2.05 | 0.94 | 5.15 |

*Table 6.1.5-2: Mullus surmuletus in GSA 25 - XSA summary results.*

| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$F_{(1-5)}$** | 1.02 | 0.75 | 1.00 | 0.94 | 0.94 | 0.57 | 0.78 | 0.49 | 0.63 | 0.56 | 0.64 |
| **Stock biomass (t)** | 170.3 | 160.5 | 178.3 | 169.3 | 134.7 | 129.0 | 130.8 | 149.4 | 156.1 | 154.8 | 152.7 |
| **SSB (t)** | 68.54 | 61.12 | 64.29 | 57.87 | 55.07 | 53.39 | 55.78 | 64.37 | 70.52 | 68.90 | 66.03 |
| **Recruitment (10^3)** | 2625.3 | 3485.3 | 3473 | 3526.3 | 2161.7 | 2240 | 2119.6 | 2621 | 2408.3 | 2313.0 | 2550.0 |


Figure 6.1.5-1: Mullus surmuletus in GSA 25 - XSA results on recruitment, SSB, catch and fishing mortality.

*Table 6.1.5-3: Mullus surmuletus in GSA 25 - XSA results on F-at age matrix.*

| **Age** | **F at age** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **class** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **0** | 0.09 | 0.08 | 0.18 | 0.09 | 0.08 | 0.01 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 |
| **1** | 1.22 | 0.61 | 1.12 | 1.02 | 1.00 | 0.65 | 0.55 | 0.32 | 0.58 | 0.64 | 0.63 |
| **2** | 0.80 | 0.87 | 1.28 | 1.13 | 0.77 | 0.81 | 0.85 | 0.59 | 0.81 | 0.74 | 0.90 |
| **3** | 0.76 | 0.73 | 1.09 | 1.24 | 0.82 | 0.55 | 0.61 | 0.70 | 0.51 | 0.65 | 0.80 |
| **4** | 2.01 | 1.25 | 1.16 | 1.20 | 2.31 | 0.53 | 1.68 | 0.71 | 1.20 | 0.75 | 0.68 |
| **5** | 1.21 | 0.97 | 1.20 | 0.95 | 0.69 | 0.89 | 1.00 | 0.59 | 0.63 | 0.57 | 0.83 |
| **6+** | 1.21 | 0.97 | 1.20 | 0.95 | 0.69 | 0.89 | 1.00 | 0.59 | 0.63 | 0.57 | 0.83 |

### *6.1.6 Robustness analysis*

### 6.1.7 Retrospective analysis, comparison between model runs, sensitivity analysis, etc.

Sensitivity analysis was performed, testing different options concerning catchability and shrinkage.

The following options were tested:

- Different values and combinations of r-age and q-age (Figure 6.1.7-1),
- Different values and combinations of *shrinkage age* and *shrinkage years (Figure 6.1.7-2),*
- Different weights of shrinkage *(Figure 6.1.7-3)*.

The log-catchability residuals of the tuning data from the different runs were used for selecting the parameters of the final model. The residuals pattern of the tuning data of the selected model is shown in Figure 6.1.7-4.

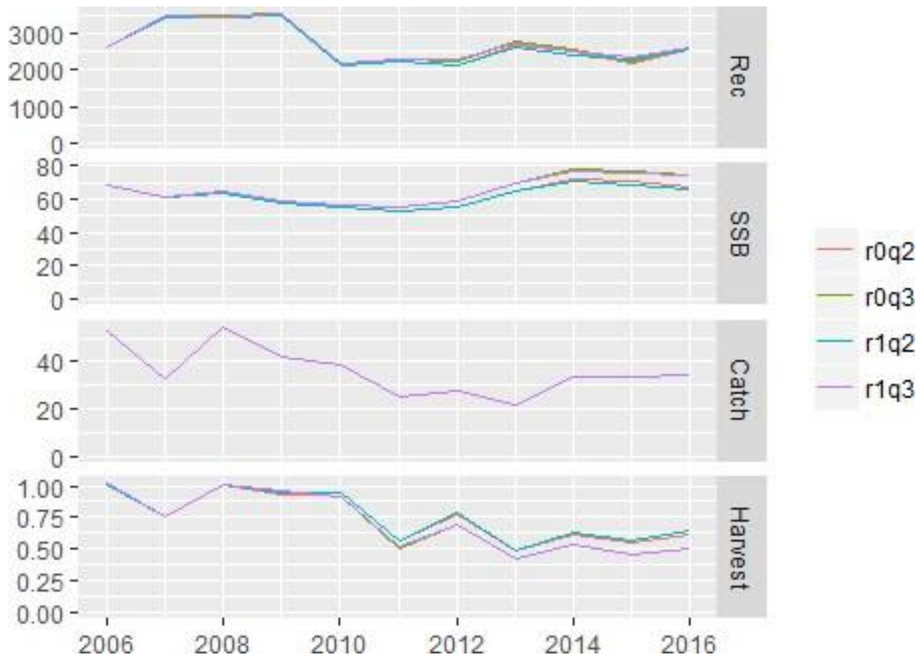



Figure 6.1.7-1: Mullus surmuletus in GSA 25 - Sensitivity analysis on qage and rage.

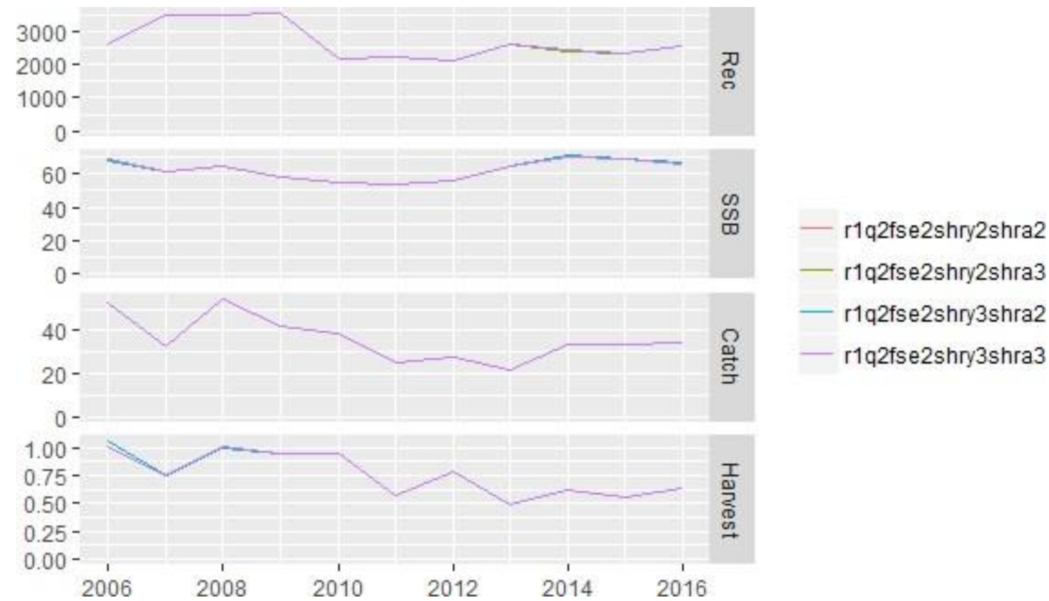


Figure 6.1.7-2: Mullus surmuletus in GSA 25 - Sensitivity on shrinkage age and shrinkage years.

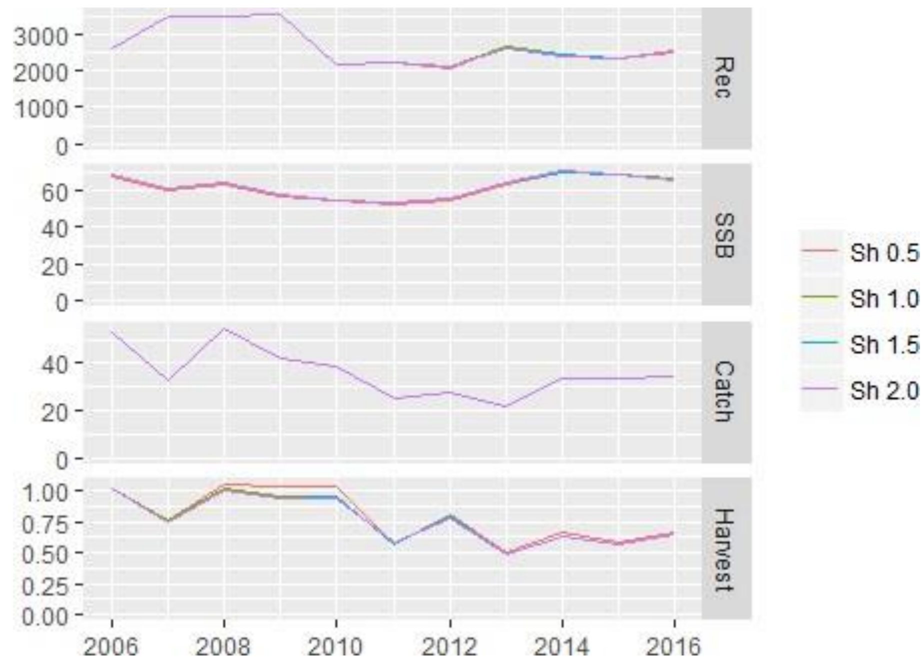


Figure 6.1.7-3: Mullus surmuletus in GSA 25 - Sensitivity on shrinkage weight.

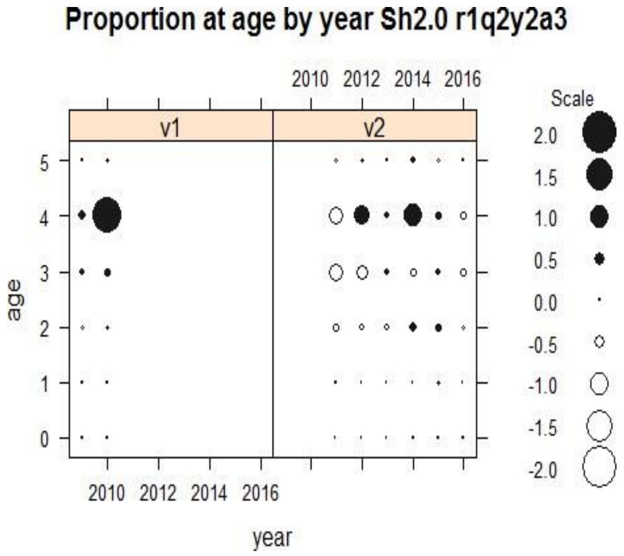



Figure 6.1.7-4: Mullus surmuletus in GSA 25 – Residuals at age for tuning data, obtained with the final settings of the model.

As mentioned before, the settings that were selected for the final assessment are:

| fse | rage | qage | shk.yrs | shk.age |
|---|---|---|---|---|
| 2.0 | 1 | 2 | 2 | 3 |

Retrospective analysis of the final model generally showed a good agreement in the trend of recruitment, spawning stock biomass (ssb) and fishing mortality (harvest) (Figure 6.1.7-5).

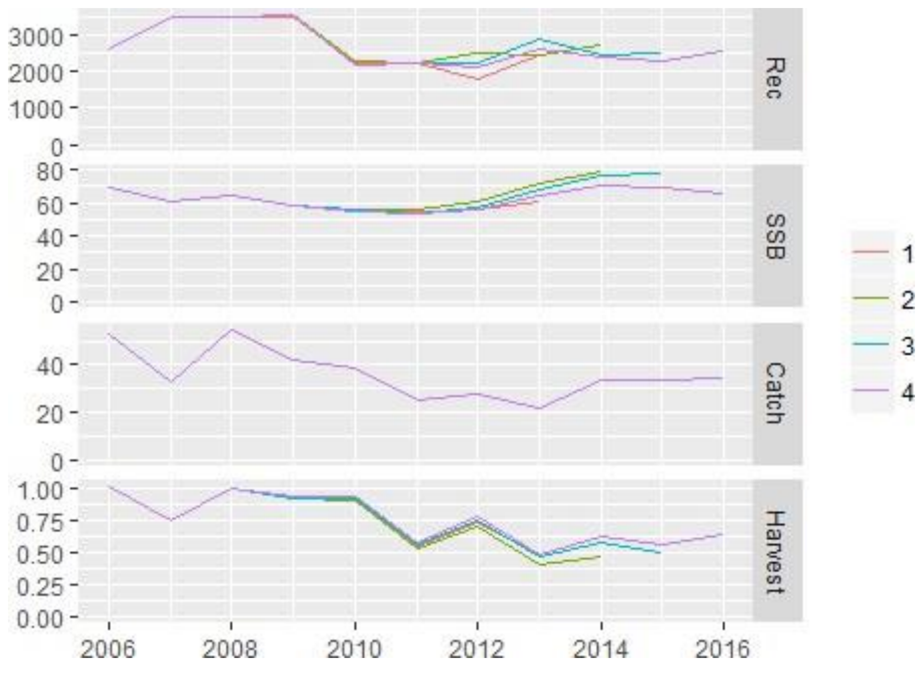



Figure 6.1.7-5: Mullus surmuletus in GSA25- XSA retrospective analysis of the final selected scenario.

Concerning natural mortality (M), different methods were used for estimating M vectors by age, specifically ProdBiom (Abella et. Al, 1997)[1], Chen & Watanabe (1989)[2] and Gislason (2010)[3]. The different estimations of the M vector are provided in Figure 6.1.7-6. M values resulting from ProdBiom method were rejected due to the low resulting values, and were not used in the model. Instead, the assessment model was run using the M vector resulting from the other two methods; comparison of the results of the two assessments is shown in Figure 6.1.7-7. The two models provide the same trends on recruitment (R), spawning stock biomass (SSB) and fishing mortality (F), though the values obtained with the Gislason method are higher for R and SSB and lower for F. M vectors are higher.

Table 6.1.7-1 provides the values of Fcurrent and $F_{0.1}$ (reference point used as proxy of $F_{MSY}$), obtained from the two XSA runs with the Chen & Watanabe and Gislason and M vector. Both values are similar; it was decided to use the Gislason M vector for the final run of the XSA model.

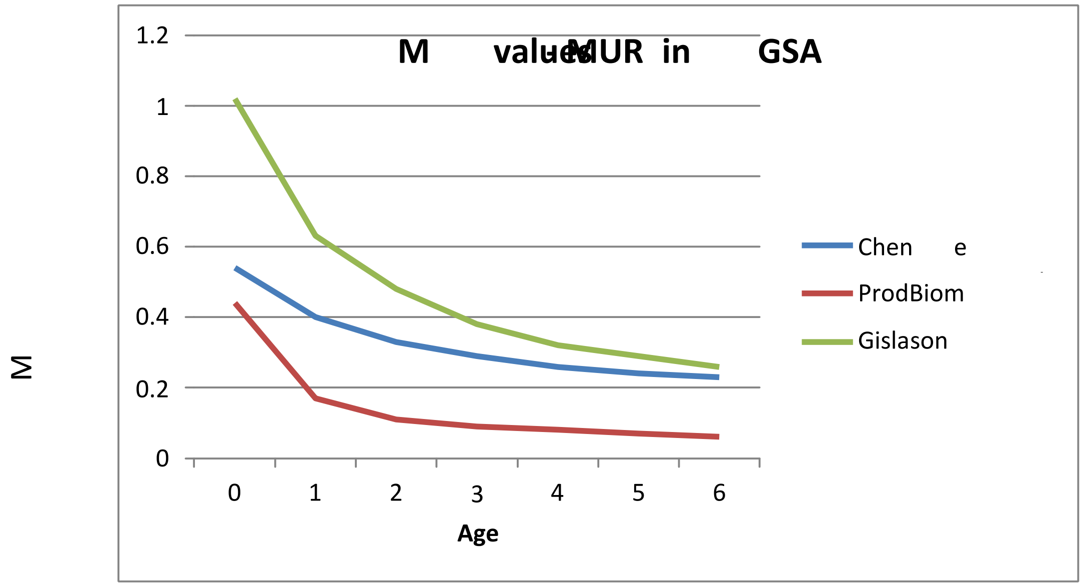



Figure 6.1.7-6: Mullus surmuletus in GSA25 - Natural mortality vectors from ProdBiom, Gislason and Chen & Watanabe

[1] Abella, A., Caddy, J.F., Serena F. (1997). Do natural mortality and availability decline with age? An alterantive yield paradigm for juvenile fisheries, illustrated by the hake *Merluccius merluccius* fishery in the Mediterranean. IFREMER Aquatic Living Resources. 10: 257-269

[2] Chen, S. and Watanabe, S. (1989) Age dependence of natural mortality coefficient in fish population dynamics.

Nippon Suisan Gakkaishi, 55, 205-208. doi:10.2331/suisan.55.205

[3] Gislason, H., Daan, N., Rice, J.C., J.G. Pope J.G.. Size, growth, temperature and the natural mortality of marine fish. Fish and Fisheries, 11 (2010), pp. 149-158

*Table 6.1.7-1: Mullus surmuletus in GSA 25 - Summary table of Fcurrent and F0.1 values from XSA models with different M vector.*

| **XSA Model** | **$F_{0.1}$** | **$F_{current}$** |
|---|---|---|
| M vector - ProdBiom method | ----- | ---- |
| M vector - Chen & Watanabe method | 0.20 | 0.64 |
| M vector - Gislason | 0.23 | 0.61 |

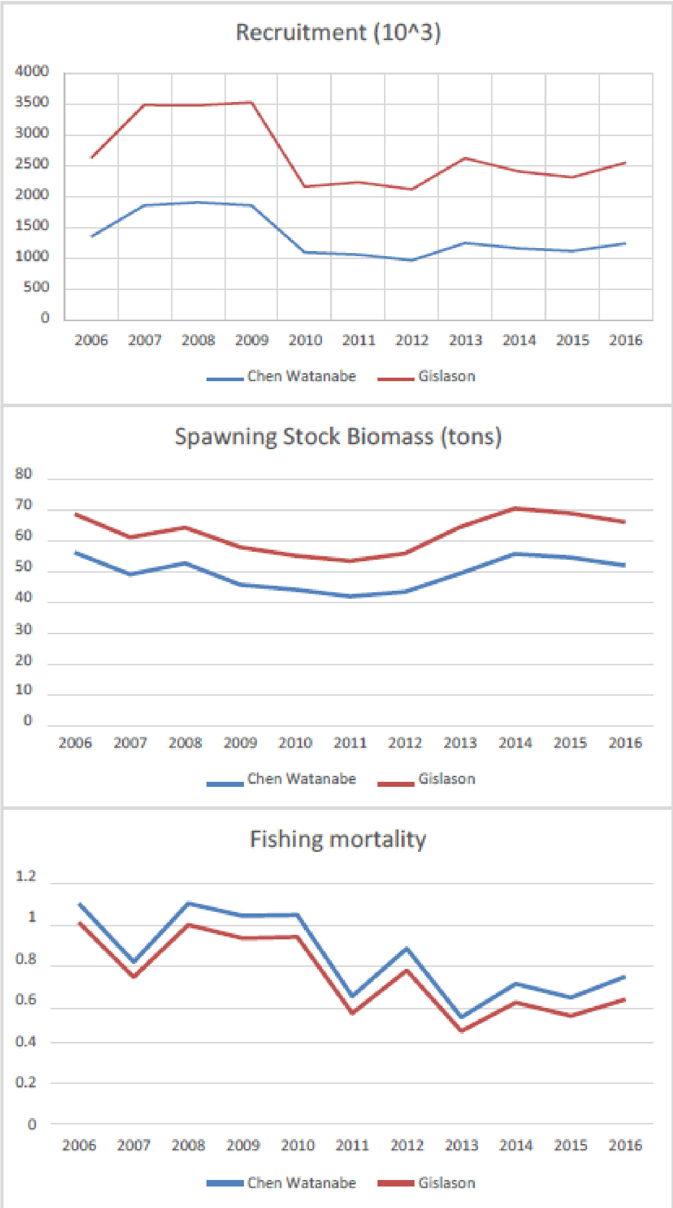



Figure 6.1.7-7: Mullus surmuletus in GSA25 – XSA results on Recruitment, Spawning stock Biomass and Fishing mortalit from the two XSA runs with different M vectors.

## *6.1.8 Assessment quality*

Input data derive from the official landings and effort data collected by the Department of Fisheries and Marine Research, and from the biological data collected under the Cyprus National Data Collection Programme. It is considered that the best available data have been used.

However, the internal consistency of the CPUE index used in the assessment was found very low, indicating that the results of the XSA model may not be reliable.

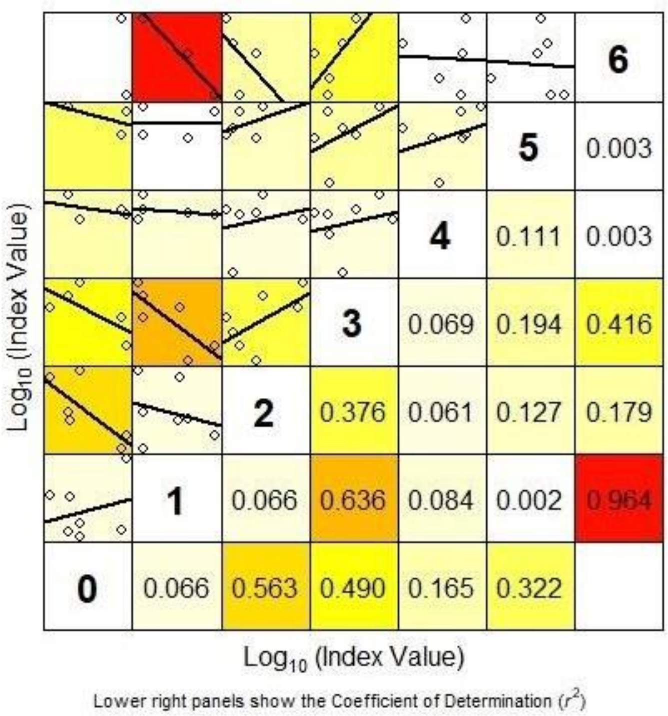



Figure 6.1.8-1: Mullus surmuletus in GSA25- Internal consistency of tuning data used in XSA model

## *6.2 Separable Virtual Population Analysis*

A Separable Virtual Population Analysis was run both by using an R script and the Lowestoft VPA suite (Darby and Flatman, 1994[1]). It was chosen to present the results from the Lowestoft VPA suite, since it contains more diagnostics than the available R script that was used.

[1] Darby, C. D., and Flatman, S. 1994. Virtual Population Analysis: version 3.1 (Windows/Dos) user guide. Info. Tech. Ser., MAFF Direct. Fish. Res., Lowestoft, (1): 85pp.

### 6.2.1 Model assumptions

Separable VPA determines values of fishing mortality from a matrix of catch-at-age data, on the assumption that the exploitation pattern is constant. The model requires natural mortality values, a reference age for unit selection, terminal F assigned to the reference age in the last year and terminal selection value (S) assigned to the oldest true age for all years.

After many trial runs, the final model selected had the following values:

| Reference age | Terminal F | Terminal S |
|---|---|---|
| 2 | 0.7 | 0.2 |

### 6.2.2 Input data and Parameters

The assessment by means of Separable VPA was performed using the input data and parameters already described in 6.1.3 (Catch-at-age matrix, Mean weight-at-age in the catch (and stock), Natural mortality at age, Maturity ogive at age).

Considering that the method assumes a constant exploitation pattern, and following some trials, it was decided to use data for the period 2011-2016, due to a change on the minimum mesh sizes of nets in 2011 which applies until present.

### 6.2.3 Results

The results of the Separable VPA assessment are shown in Figure 6.2.3-1 and Tables 6.2.3-1 – 6.2.3- 3.

*Table 6.2.3-1: Mullus surmuletus in GSA 25 - Stock numbers-at-age (thousands) based on Separable VPA analysis.*

| Age class | Stock numbers-at-age (thousands) | | | | | |
|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| 0 | 2674 | 2419 | 2867 | 2661 | 2398 | 1878 |
| 1 | 872 | 957 | 860 | 1032 | 951 | 856 |
| 2 | 321 | 281 | 329 | 349 | 328 | 291 |
| 3 | 110 | 120 | 103 | 135 | 115 | 112 |
| 4 | 34 | 59 | 62 | 52 | 70 | 53 |
| 5 | 4 | 21 | 29 | 37 | 29 | 37 |
| 6+ | 0 | 6 | 40 | 9 | 7 | 16 |

*Table 6.2.3-2: Mullus surmuletus in GSA 25 – Separable VPA summary results.*

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| **F** (1-5) | 0.30 | 0.36 | 0.25 | 0.36 | 0.38 | 0.46 |
| **Stock biomass (t)** | 167 | 175 | 207 | 196 | 183 | 159 |
| **SSB (t)** | 78 | 89 | 111 | 101 | 94 | 86 |
| **Recruitment (10^3)** | 2674 | 2419 | 2867 | 2661 | 2398 | 1878 |

*Table 6.2.3-3: Mullus surmuletus in GSA 25 – Separable VPA results on F-at age matrix.*

| Age class | F at age | | | | | |
|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| **0** | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| **1** | 0.50 | 0.44 | 0.27 | 0.52 | 0.56 | 0.60 |
| **2** | 0.51 | 0.52 | 0.41 | 0.63 | 0.60 | 0.68 |
| **3** | 0.25 | 0.27 | 0.30 | 0.29 | 0.40 | 0.52 |
| **4** | 0.16 | 0.38 | 0.21 | 0.27 | 0.30 | 0.31 |
| **5** | 0.09 | 0.17 | 0.05 | 0.11 | 0.06 | 0.19 |
| **6+** | 0.09 | 0.17 | 0.05 | 0.11 | 0.06 | 0.19 |

As shown in Figure 6.2.3-1, from 2013 Recruitment and SSB have a decreasing trend, while F has an increasing trend.

Current fishing mortality ($F_{current(1-5)}$) was calculated as the average of the last 3 years and has a value of 0.40. This fishing mortality value corresponds to both fisheries that exploit red mullet, but basically the net fishery.

## *6.2.4 Assessment quality*

Input data derive from the official landings data collected by the Department of Fisheries and Marine Research, and from the biological data collected under the Cyprus National Data Collection Programme. It is considered that the best available data have been used.

Figure 6.2.4-1 suggests that the Separable VPA analysis has a good fit on the catch-at-age data.

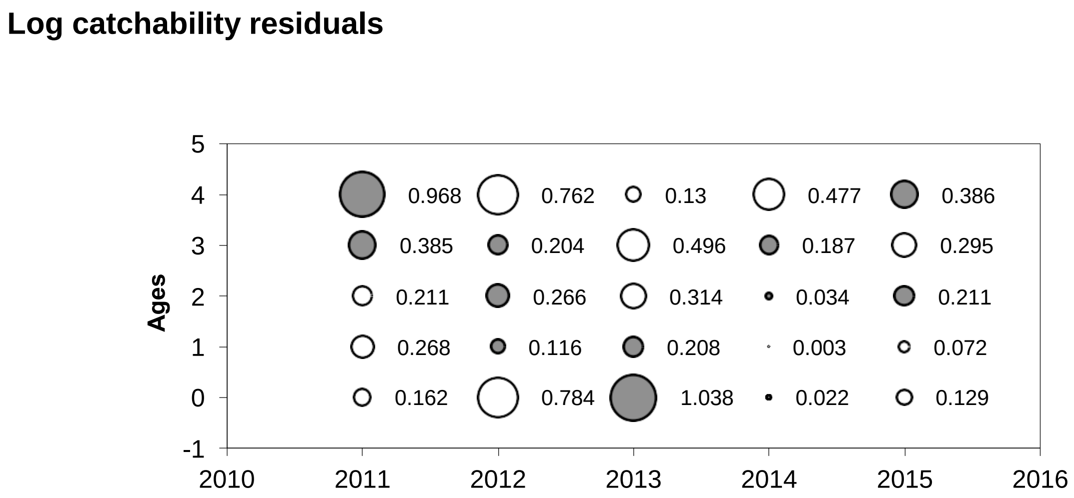



*Figure 6.2.4-1: Matrix of log catchability residuals.*

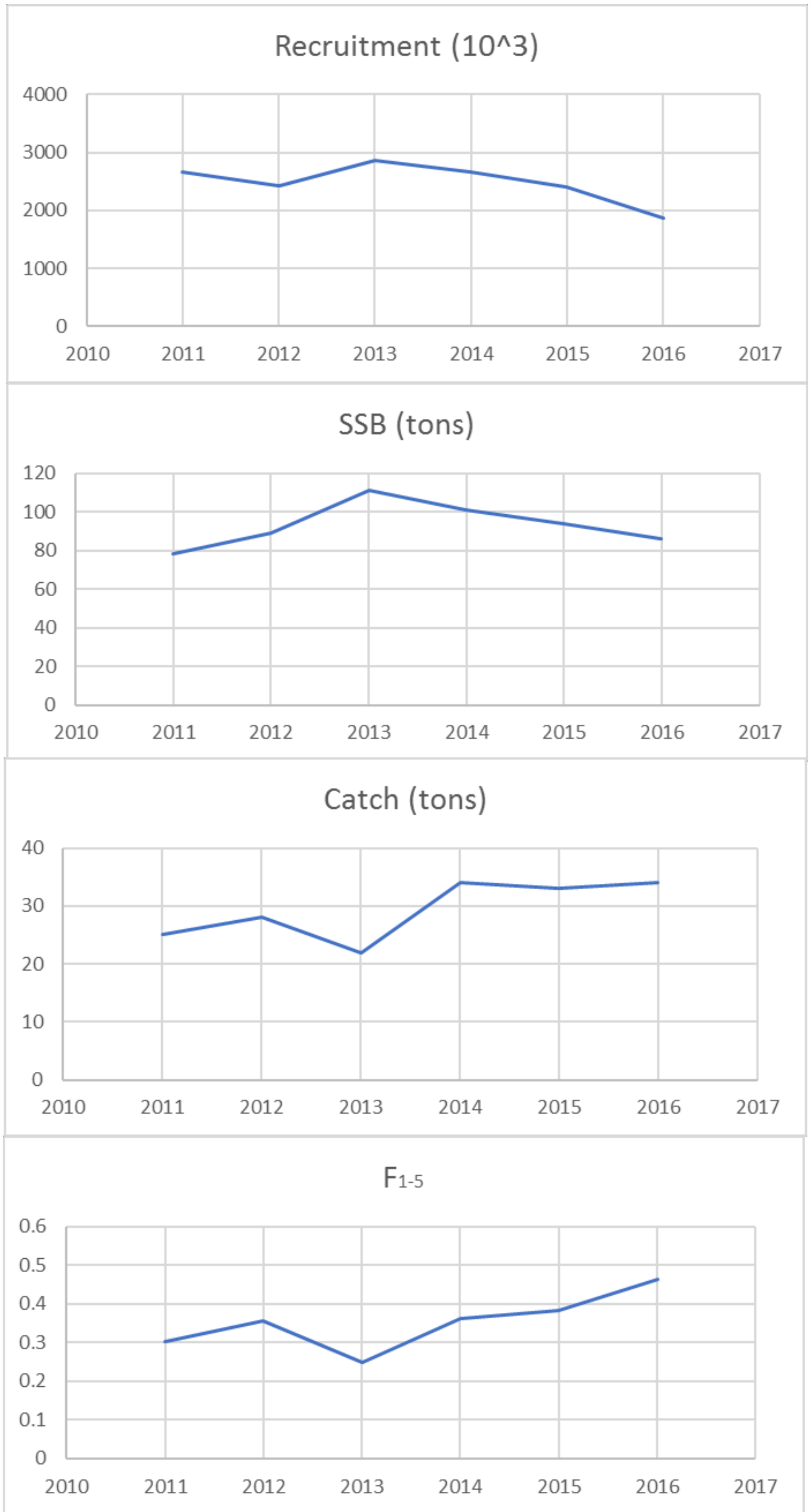



*Figure 6.2.3-1: Mullus surmuletus in GSA 25 – Separable VPA results on recruitment, SSB and fishing mortality.*

## 6.3 Yield per Recruit Analysis

### 6.3.1 Yield per recruit analysis based on results from XSA model

Yield per recruit analysis was carried out based on the results from the XSA model, using FLR Libraries. Current fishing mortality was considered as the mean F for ages 1-5 during the last 3 years (2014-2016). The calculated F0.1 reference point (0.23) is lower than the $F_{current}$ (0.61). The results of the analysis are presented in Figure 6.3-1.

However, due to the poor internal consistency of the tuning data, it was decided that the estimated reference point from the XSA model will not be considered for scientific advice.

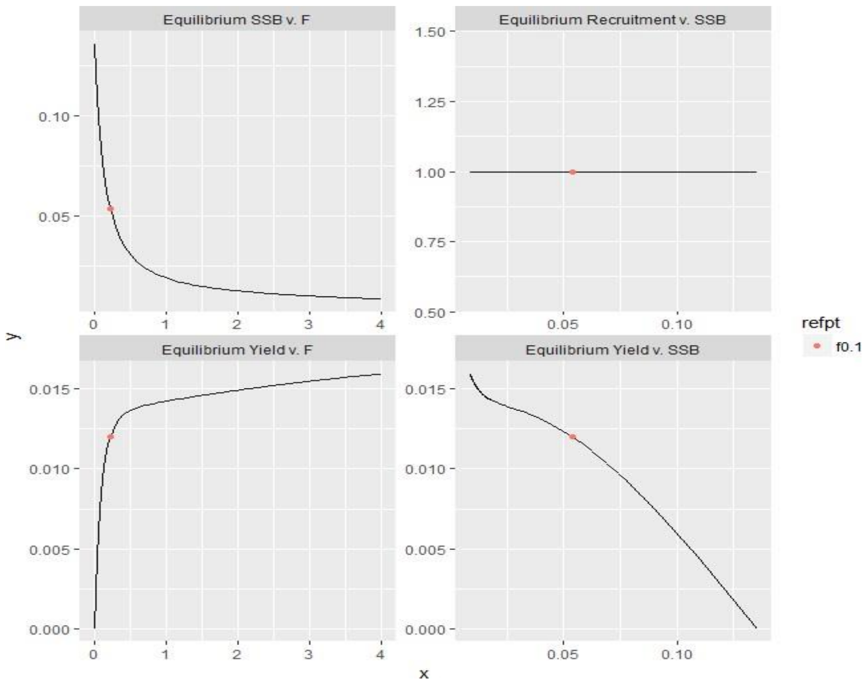



*Figure 6.3.1-1: Mullus surmuletus in GSA25 - Yield per Recruit analysis based on results from XSA model.*

### 6.3.2 Yield per recruit analysis based on results from Separable VPA model

Yield per recruit analysis was also carried out based on the results from Separable VPA model, using FLR Libraries. Current fishing mortality was considered as the mean F for ages 1-5 during the last 3 years (2014-2016). The calculated F0.1 reference point (0.39) is slightly lower than the $F_{current}$ (0.40).

The results of the analysis are presented in Figure 6.3.2-1.

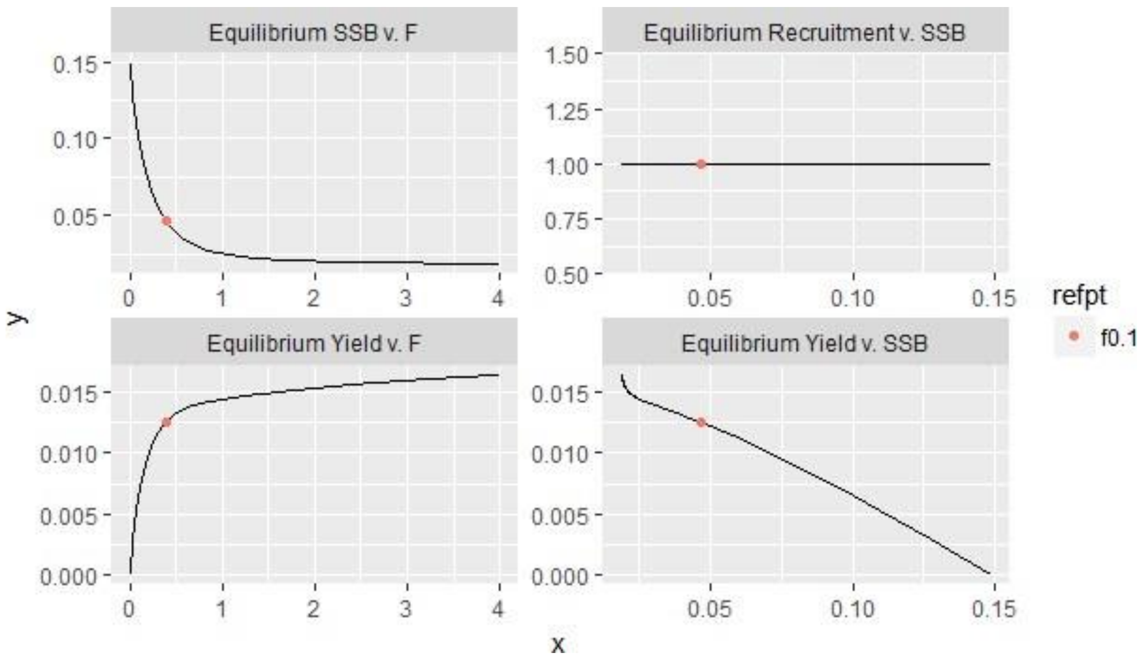



*Figure 6.3.2-1: Mullus surmuletus in GSA25 - Yield per Recruit analysis based on results from Separable VPA model.*

# 7 Stock predictions

## *7.1* Short term predictions

No short term predictions were carried out for this stock.

## *7.2* Medium term predictions

No medium term predictions were carried out for this stock.

## *7.3* Long term predictions

No long term predictions were carried out for this stock.

## 8 Draft scientific advice

The Working Group decided to endorse the assessment of the XSA model as "Accepted with qualitative advice", which is the approach agreed during the meeting when the assessments provide an indication of the perception on the trend of a stock, when it is not possible to obtain quantitative estimates by means of analytical assessment methods or any other relevant approach. Therefore, the summary table below provides only qualitative information on the status of the stock.

| **Based on** | **Indicator** | **Analytic al reference point (name and value)** | **Current value from the analysis (name and value)** | **Empirical reference value (name and value)** | **Trend (time period)** | **Stock Status** |
|---|---|---|---|---|---|---|
| **Fishing mortality** | $F_{2014-2016}$ | | | | D (2006-2016) ($p<0.05$) | IO |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Stock abundance** | SSB $_{2014-2016}$ | | | | N | |
| | | | | | | |
| **Recruitment** | | | | | | |
| **Final Diagnosis** | | In overfishing status. | | | | |

## 8.1 Explanation of codes

**Trend categories**

1) N - No trend
2) I - Increasing
3) D – Decreasing
4) C - Cyclic

**Stock Status Based on Fishing mortality related indicators**

1) **N - Not known or uncertain** – Not much information is available to make a judgment;
2) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
3) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
4) **IO –In Overfishing status**– fishing mortality or effort above the value of the agreed fishing mortality or effort based Reference Point. An agreed range of overfishing levels is provided;

**Range of Overfishing levels based on fishery reference points**

In order to assess the level of overfishing status when $F_{0.1}$ from a Y/R model is used as LRP, the following operational approach is proposed:

- If Fc*/$F_{0.1}$ is below or equal to 1.33 the stock is in **($O_L$): Low overfishing**
- If the Fc/$F_{0.1}$ is between 1.33 and 1.66 the stock is in **($O_I$): Intermediate overfishing**
- If the Fc/$F_{0.1}$ is equal or above to 1.66 the stock is in **($O_H$): High overfishing** *Fc is current level of F

5) **C- Collapsed**- no or very few catches;

**Based on Stock related indicators**

1) **N - Not known or uncertain:** Not much information is available to make a judgment
2) **S - Sustainably exploited:** Standing stock above an agreed biomass based Reference Point;
3) **O - Overexploited**: Standing stock below the value of the agreed biomass based Reference Point. An agreed range of overexploited status is provided;

**Empirical Reference framework for the relative level of stock biomass index**

- **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **($O_L$)**
- **Relative intermediate biomass:** Values falling within this limit and 66th percentile **($O_I$)**
- **Relative high biomass:** Values higher than the 66th percentile **($O_H$)**

4) **D – Depleted**: Standing stock is at lowest historical levels, irrespective of the amount of fishing effort exerted;
5) **R –Recovering:** Biomass are increasing after having been depleted from a previous period;

***Agreed definitions as per SAC Glossary***

***Overfished (or overexploited)*** *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

***Stock subjected to overfishing (or overexploitation)*** *- A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*